GUAM POWER AUTHORITY

2022 INTEGRATED RESOURCE PLAN

GUAM POWER AUTHORITY
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2022 Integrated Resource Plan Volume I:

Generation System Reliability, Adequacy, and Resiliency

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1 Introduction

This document analyzes GPA's generation system reliability when both the Ukudu Combined Cycle Combustion Turbine Power Plant and the Piti Diesel Power Plant under Guam Ukudu Power (GUP) are reliably online and Cabras 1&2 has been retired. This analysis determines the performance level for reliable generation required to meet target generation system reliabilities, reserve margin policies, and trigger points for when GPA must add generation to support its reliability targets. Furthermore, this document provides a guideline for the transition of GPA's energy production from mostly supplied by synchronous generation burning fossil fuels to one highly dependent on inverter-based generation such as solar PV.

2 Situation Analysis

As an island grid system, GPA must maintain adequate generation capacity reserves when its main power producing units or plants are unavailable. For most of the past 25 years, GPA had over 100% of generation reserves and still shed load due to the unavailability of sufficient generation in 2010. A large number of these reserves had not been well maintained and saw very limited operation. The GPA system has been very dependent on Performance Management Contracts (PMC) and Independent Power Producers (IPP) to provide reliable generation.[1] Post Cabras 3&4 commissioning, GPA's issue has not been insufficiency of generation. It remains keeping its aging, owned-plants reliable and in good working condition.

2.1 GPA Generation Fleet Age

Figure 2-1 shows the capacity-weighted average age at retirement for fossil fuel plants sourced from S&P Global Market Intelligence in Duquiatan's (2019) article: "Average age of US power plant fleet flat for 4th-straight year in 2018."[2] Relevant to GPA, the columns for Oil-fired Steam Turbines (Oil ST) and Oil-fired Other (Oil other) allow a comparison with GPA's

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[1] Gaynor Dumat-ol Daleno. (2016). GPA power plants in 'poor condition' URL: https://www.guampdn.com/news/local/gpa-power-plants-in-poor-condition/article_9ecc46c3-cc7a-597b-a392-93fa31bb3103.html

[2] Anna Duquiatan. (2019). Average age of US power plant fleet flat for 4th-straight year in 2018. URL: https://www.spglobal.com/marketintelligence/en/news-insights/trending/gfjqeFt8GTPYNK4WX57z9g2

generation fleet age. The Oil-fired Other category consists of generator technologies comprised of internal combustion and gas turbines. Figures 2-2 and 2-3 compare the age of GPA legacy units in 2023 to the Weighted Average Retirement Age information in Figure 2-1 for the pertinent Technology and fuel category.

Capacity-weighted average age at retirement for fossil fuel plants (years)

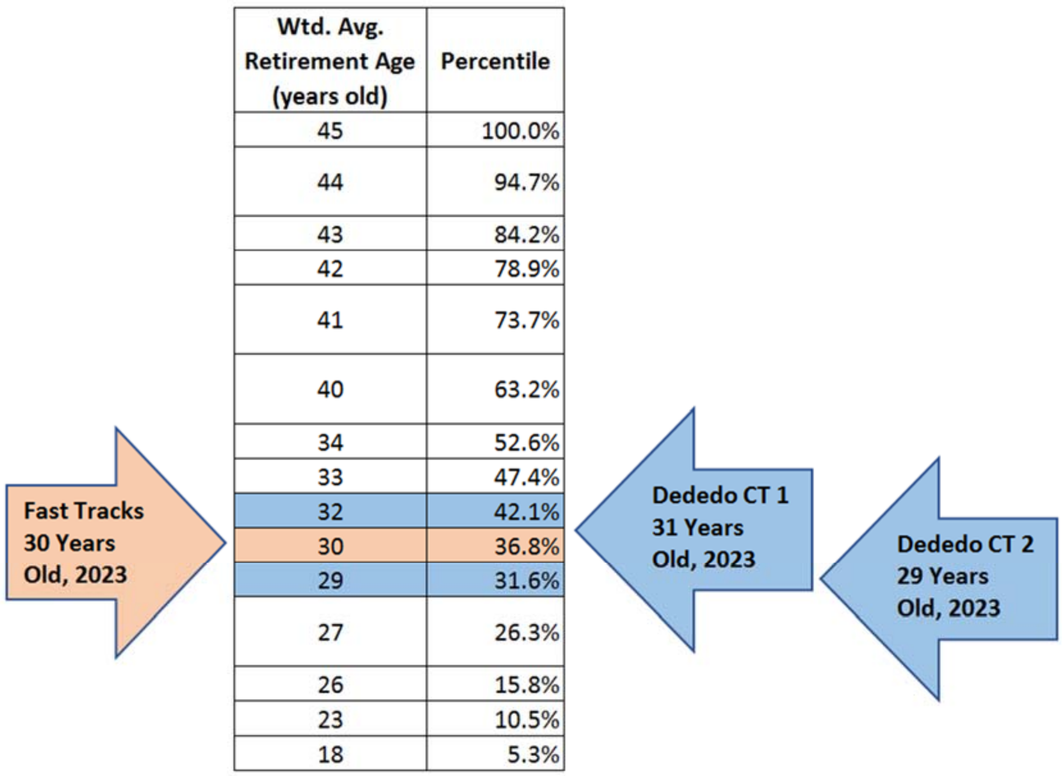
Year retired	Coal	Gas CC	Gas ST	Gas GT	Gas other*	Oil ST	Oil other**
2018	41	30	56	36	25	NA	44
2017	49	28	52	21	37	44	40
2016	51	36	49	39	26	NA	43
2015	55	33	48	34	18	60	44
2014	53	33	54	34	38	47	41
2013	50	15	50	35	41	52	41
2012	52	30	55	38	29	48	42
2011	55	28	53	18	40	49	40
2010	50	19	45	22	44	41	32
2009	42	22	42	19	40	48	26
2008	51	26	39	13	34	59	34
2007	50	29	45	17	37	58	30
2006	53	12	45	12	21	47	27
2005	53	25	48	16	23	53	18
2004	55	24	35	29	29	50	29
2003	44	31	47	21	32	52	27
2002	51	22	44	7	43	43	45
2001	51	23	44	25	14	32	33
2000	44	28	38	16	29	56	23

Data compiled Dec. 21, 2018.
NA = not available
Fuel categorizations are determined by the primary fuel group of power plant units in S&P Global Market Intelligence's database. Where broken out, technology is determined by the generation technology of the unit.
* Largely comprises combustion technologies.
** Includes CC technologies and various technology types such as internal combustion and gas turbine.
CC = combined cycle; ST = steam turbine; GT = gas turbine
Source: S&P Global Market Intelligence

Figure 2-1. Capacity-Weighted Average Age at Retirement for Fossil Fuel Plants

Wtd. Avg. Retirement Age (years old)	Percentile
60	100.0%
59	94.1%
58	88.2%
56	82.4%
53	76.5%
52	70.6%
50	58.8%
49	52.9%
48	47.1%
47	35.3%
44	23.5%
43	17.6%
41	11.8%
32	5.9%

Figure 2-2. Comparison of the Age of Cabras 1&2 (2023) to the Historical Retirement Age in each Year from 2000 to 2018



Wtd. Avg. Retirement Age (years old)	Percentile
45	100.0%
44	94.7%
43	84.2%
42	78.9%
41	73.7%
40	63.2%
34	52.6%
33	47.4%
32	42.1%
30	36.8%
29	31.6%
27	26.3%
26	15.8%
23	10.5%
18	5.3%

Figure 2-3. Comparison of the Age of Dededo CT 1&2 and GPA's Fast Track Generation (2023) to the Historical Retirement Age in each Year from 2000 to 2018

Figure 2-2 shows that in 2023, the year slated for Cabras 1&2 retirement, the generators would be around the 50th percentile of average retirement age in the United States from 200 through 2018. The 50th percentile means that about half the units retired from 2000 to 2018 were older or younger than the age of Cabras 1&2 in 2023.

Figure 2-3 shows that age of Dededo CT 1&2 and the Fast Track Units in 2023 fall within the 31st and 42nd percentile. Fast Track Units include Talofofo, Tenjo Vista, and Pulantat (MDI) diesel generators and Macheche and Yigo CTs. The 50th percentile for generator retirement age in this category falls between 33 and 34 years old.

2.2 GPA Generation Fleet Funding Commitments

Piti 8&9 improved its plant availability form about 89% in 2017 to 96.4% in 2021. GPA has approved over $32.4 MM in capital improvement projects, performance improvement projects, and major maintenance for the period FY 2019 through FY 2023.

GPA's Generation Division provided the information in Table 2-1. The red text indicates the number is from a proposed budgets and not an approved budget. GPA will be committing about $51 MM for Capital Improvement Projects (CIP), Performance Improvement Projects (PIP), and major maintenance to improve power plant performance over the period FY 2019 through FY 2023.

Table 2-1. Approved Fiscal years 2019 to 2023 Power Plant Budgets[3]
for CIP, PIP and Major Maintenance

Red Text is Proposed Budget.

Plant	Budget					Total (USD)
	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	
Cabras 1 & 2	2,570,000	6,169,904	3,179,247	6,163,833	4,833,833	**22,916,817**
Gas CT	1,808,428	313,242	5,694,549	2,311,412	1,580,000	**11,707,631**
Piti #7	No Info Provided	No Info Provided	2,207,740	**5,610,000**	**4,610,000**	**12,247,740**
Diesel	No Info Provided	1,776,373	1,238,000	1,238,000	No Info Provided	**4,252,373**
Yigo Diesel	No Info Provided					
Total	**$ 4,378,428**	**$ 8,259,519**	**$ 12,319,536**	**$ 15,323,245**	**$ 11,023,833**	**$ 51,124,561**

Source: GPA Generation Division

2.3 Historical GPA Power Plant Availability Performance

Equivalent Availability Factor (EAF) is one factor used to evaluate unit performance, in particular its reliability. EAF is the sum of a unit's output capacity multiplied by its operating hours, or its production energy, and the unit's available capacity multiplied by the hours it is available to operate but was not dispatched divided by the maximum capacity of the unit by the number of hours in the evaluation period which is typically a year. Table 2-2 shows the EAF for generator units currently in the GPA generation mix from FY 2017 through April FY 2021. Various trends are evident from Table 2-2.

[3] Email from Ju H. Kim to Ronald Okada, Generation Manager dated October 20, 2021 12:10 PM

Cabras 1&2 and Piti 8&9 are baseload units. These units have much higher capacity factors than peaking or reserve units. Because they are dispatched whenever they are available, the EAFs shown in Table 2-2 are truly indicative of the operational state of the generating units.

Cabras 1 availability performance is low but stable. Cabras 2 performance is in decline. This places even greater pressure for GPA to complete the Ukudu Power Plant soonest. Continued decline of the availability of Cabras 1 and 2 power plant places an alarming strain on the remaining GPA reserve generation. Piti 8&9 availability performance is stable.

Peaking and reserve units have much lower capacity factors (Table 2-2). Peaking units are typically run during the peak hours or prior to the Hagatna BESS, run to provide frequency regulation and spinning reserve during the solar PV production hours. Therefore, the EAF statistics may not be as good indicators of unit operational capability.

Piti 7 performance has significantly declined. Tenjo units 3 and 6 are no longer available. Achieving legacy unit EAFs greater than 90% will be a real challenge for GPA. GPA is confident that it can achieve this goal.

GPA shed load due to insufficient generation on May 14, 2021 and June 3, 2021. This highlights the challenge and importance for keeping generation units more reliable and operational. As the GPA system evolves into an inverter-dominated grid whose power production depends on the weather and cloud cover, keeping generation reliable and available for those truly rainy and cloudy days becomes more critically important. In order to reduce rates, GPA must create cost savings including retirement of costly power plants.

Table 2-2. Historical GPA Generation Availability

ANNUAL EAF	FY2017	FY2018	FY2019	FY2020	FY2021 (through April 2021)
Cabras Unit #1	73%	59%	73%	70%	73%
Cabras Unit #2	79%	67%	68%	60%	60%
MEC/Piti Unit #8	90%	92%	83%	94%	88%
MEC/Piti Unit #9	87%	93%	87%	90%	92%
Dededo CT #1	50%	99%	99%	80%	94%
Dededo CT #2	50%	99%	100%	96%	100%
Macheche CT	76%	86%	90%	99%	98%
TEMES CT	97%	87%	82%	74%	58%
Yigo CT	81%	83%	79%	93%	91%
Manenggon Diesel #1	73%	89%	82%	86%	80%
Manenggon Diesel #2	8%	63%	47%	99%	100%
Talofofo Diesel #1	100%	89%	87%	93%	100%
Talofofo Diesel #2	93%	86%	96%	81%	99%
Tenjo Unit #1	2%	71%	69%	77%	99%
Tenjo Unit #2	22%	92%	80%	51%	97%
Tenjo Unit #3	81%	29%	16%	47%	0%
Tenjo Unit #4	95%	86%	25%	96%	97%
Tenjo Unit #5	99%	0%	40%	94%	97%
Tenjo Unit #6	95%	91%	82%	39%	0%
Yigo Diesel Power Plant (formerly Aggreko)	98%	96%	93%	92%	76%

Table 2-3. Historical GPA Generation Capacity Factor

Annual Capacity Factor	FY2017	FY2018	FY2019	FY2020	FY2021 (through April 2021)
Cabras Unit #1	54%	53%	67%	64%	65%
Cabras Unit #2	66%	60%	64%	57%	55%
Piti Unit #8	83%	82%	72%	86%	80%
Piti Unit #9	80%	84%	75%	80%	85%
Dededo CT #1	4%	6%	2%	1%	5%
Dededo CT #2	3%	6%	4%	2%	6%
Macheche CT	29%	25%	28%	27%	31%
Piti 7 CT	13%	12%	14%	10%	11%
Yigo CT	21%	25%	26%	22%	21%
Manenggon Diesel #1	5%	1%	1%	0%	0%
Manenggon Diesel #2	0%	1%	1%	0%	0%
Talofofo Diesel #1	26%	18%	11%	2%	4%
Talofofo Diesel #2	23%	17%	12%	1%	4%
Tenjo Unit #1	1%	23%	15%	13%	13%
Tenjo Unit #2	7%	27%	20%	11%	12%
Tenjo Unit #3	17%	6%	7%	11%	0%
Tenjo Unit #4	29%	23%	6%	23%	15%
Tenjo Unit #5	31%	1%	8%	23%	14%
Tenjo Unit #6	33%	28%	18%	13%	0%
Yigo Diesel Generators	48%	46%	43%	35%	33%

3 Scope of Work

The scope of work for this analysis includes:

- Develop a capacity state-probability distribution model for each fossil fuel-fired generation technology comprising the GPA generation mix;
- Develop a capacity state-probability distribution model for the GPA generation system comprised of fossil fuel-fired generation technology;
- Calculate the Peak Load Carrying Capability (PLCC) and Reserve Margins (RM) for the GPA fossil fuel-fired generation system to achieve GPA reliability targets;
- Perform a robustness analysis for PLCC as a function of GPA Legacy power plant equivalent availability factor (EAF);

- Determine the impact on PLCC of the retirement of GPA generation plants;
- Develop a Load Duration Curve for Forecast Loads;
- Calculate the Loss of Load Expectation (LOLE), Loss of Energy Expectation (LOEE), Energy Index Reliability (EIR), Energy Index of Unavailability (EIU)
- Develop a capacity state-probability distribution model for Energy Shifting Battery Energy Storage Systems (ES BESS);
- Determine the levels of ES BESS required to meet GPA reliability targets.
- Investigate the case of sustained outages of the Ukudu Power Plant;
- Results Discussion;
- Recommendations;
- Capital Plan.

4 Power Plant Capacity State-Probability Distribution Model Without Energy Shifting Battery Energy Storage Systems (ES BESS)

This section discusses the analytical methodology for developing a power plant capacity state - probability distribution model. It also presents the model result for each set of GPA generation units.

4.1 Power Plant Capacity State-Probability Distribution Model: Analytical Methodology

As a prelude to this analysis, GPA groups like legacy generation technologies into power plant groupings. It then develops the power plant capacity state models for each of these "power plants". Table 4-1 summarizes these power plant groupings.

This analysis assumes a two-state model for each generation model. The unit is either ON or OFF. In the ON-state, the unit is at maximum capacity. In the OFF-state, the unit has zero power capability (0 MW). The probability, p, that the unit is in the ON-state is set to the EAF. The probability, q, that the unit is in the OFF-state is Unity minus the EAF. The base case assumes a 90% or 0.9 EAF for legacy units, a 96% or 0.96 EAF for the Ukudu Power Plant, and a 95% or 0.95 EAF for the KEPCO Diesel Generation Power Plant.

Table 4-1. Power Plant Grouping Summary

Plant Group	Power Plants in Group	Unit Capacity (MW)	Number of Units	Total Capacity (MW)	Make
TalTenjo	Talofofo Diesel Power Plant Tenjo Diesel Power Plant	4.4	8	35.2	Caterpillar
MacYigo	Macheche CT Power Plant Yigo CT Power Plant	20	2	40	LM 2500 GE Aeroderivative (Stewart & Stevenson)
MDI	Manenggon Diesel Power Plant	2	5	10	Wartsila
Piti7	Piti 7 CT Power Plant	40	1	40	GE Frame 6 Industrial CT
Piti89	Piti 8&9 Slow Speed Diesel Power Plant	44	2	88	Mann B&W
Ukudu	Ukudu Combined Cycle CT Power Plant	Steam 57 CT 47	1 3	198	Siemens (Industrial CT)
YigoDG	Yigo Diesel Power Plant	1.13	39	44.07	Cummins
DedCT	Dededo CT Power Plant	22	2	44	GE Frame 5 Industrial CT (Turbotechnia)
KEPCODG	KEPCO Diesel Power Plant (Piti)	2.6	15	39	Cummins
Total (MW)				538.27	

In statistics, "a permutation is an arrangement of all or part of a set of objects, with regard to the order of the arrangement."[4]

For each permutation calculate the total capacity state of the power plant and the probability of that permutation occurring. The permutation capacity state is the sum of capacity in MW for all the units in the ON-state. The probability of occurrence of the permutation is the product of all the probabilities for each state for the ON or OFF-state that they are in for this permutation.

The next step in the development of the power plant capacity state model is to combine the common capacity states and sum the probabilities for those common capacity states. Doing so for every capacity state among the set of permutation cases creates a capacity state probability pair for the entire power plant. This collection of unique capacity states and probability pairs is the Power Plant Capacity State – Probability Distribution Model.

As a general observation, there are permutations with different ON and OFF-states that yield the same capacity state value. We apply the binomial distribution formula[5] to compute the

[4] Stat Trek.com (2021). Statistics Dictionary. URL: https://stattrek.com/statistics/dictionary.aspx?definition=permutation#:~:text=A%20permutation%20is%20an%20arrangement,2%20letters%20from%20that%20set.&text=When%20they%20refer%20to%20permutations%2C%20statisticians%20use%20a%20specific%20terminology. (Last Accessed May 25, 2021)

[5] Stephanie Glen. "Binomial Distribution: Formula, What it is and How to use it" From StatisticsHowTo.com: Elementary Statistics for the rest of us! https://www.statisticshowto.com/probability-and-statistics/binomial-theorem/binomial-distribution-formula/ (Last Accessed May 25, 2021)

capacity state probability for all GPA units except the Ukudu power plant. We treat the Ukudu Power Plant capacity-state calculations differently. The maximum capacity state of the steam unit is dependent on how many simple cycle combustion turbines are on.

4.2 Power Plant Capacity State-Probability Distribution Model: Base Case Results

Appendix A shows the calculations and results for each "power plant" for the base case and robustness analysis cases. Figures 4-2 through 4-10 show the results for the base case:

- Legacy Unit EAF = 0.9 or 90%
- Ukudu Power Plant EAF = 0.965 or 96.5%
- KEPCO Diesel Power Plant EAF = 0.95 or 95%.

Table 4-2. Talofofo – Tenjo Diesel Power Plant Grouping Capacity State – Probability Distribution Model

TalTenjoStates

STATE	MWstate	P(MWstate)
1	0	1.0000E-08
2	4.4	7.2000E-07
3	8.8	2.2680E-05
4	13.2	4.0824E-04
5	17.6	4.5927E-03
6	22	3.3067E-02
7	26.4	1.4880E-01
8	30.8	3.8264E-01
9	35.2	4.3047E-01
Sanity Check		1.0000E+00

Table 4-3. Macheche CT – Yigo CT Power Plant Grouping Capacity State – Probability Distribution Model

MacYigoStates

STATE	MWstate	P(MWstate)
1	0	0.0100
2	20	0.1800
3	40	0.8100
Sanity Check		1.0000

Table 4-4. MDI (Pulantat) Diesel Power Plant Capacity State – Probability Distribution Model

MDIStates

STATE	MWstate	P(MWstate)
1	0	0.0100
2	5	0.1800
3	10	0.8100
Sanity Check		1.0000

Table 4-5. Piti 7 CT Power Plant Capacity State – Probability Distribution Model

Piti7States

STATE	MWstate	P(MWstate)
1	0	0.1000
2	40	0.9000
Sanity Check		1.0000

Table 4-6. Piti 8&9 Slow Speed Diesel Power Plant Capacity State – Probability Distribution Model

Piti8&9States

STATE	MWstate	P(MWstate)
1	0	0.0100
2	40	0.1800
3	80	0.8100
Sanity Check		1.0000

Table 4-7. Dededo CT Power Plant Capacity State – Probability Distribution Model

DededoCTStates

STATE	MWstate	P(MWstate)
1	0	0.0100
2	22	0.1800
3	44	0.8100
Sanity Check		1.0000

Table 4-8. Ukudu CC CT Power Plant Grouping Capacity State – Probability Distribution Model

UkuduStates

STATE	MWstate	P(MWstate)
1	**0**	0.000043
2	47	0.000125
3	66	0.003432
4	94	0.003432
5	132	0.094483
6	141	0.031494
7	198	0.866991
Sanity Check		1.000000

Table 4-9. KEPCO Diesel Power Plant Grouping Capacity State – Probability Distribution Model

KDG States		
STATE	**MW_{state}**	**P(MWstate)**
1	0	1.000000E-15
2	2.6	1.350000E-13
3	5.2	8.505000E-12
4	7.8	3.316950E-10
5	10.4	8.955765E-09
6	13	1.773241E-07
7	15.6	2.659862E-06
8	18.2	3.077841E-05
9	20.8	2.770056E-04
10	23.4	1.939040E-03
11	26	1.047081E-02
12	28.6	4.283515E-02
13	31.2	1.285054E-01
14	33.8	2.668959E-01
15	36.4	3.431519E-01
16	39	2.058911E-01
Sanity Check		1.000000E+00

Table 4-9. Yigo Diesel Power Plant Grouping Capacity State – Probability Distribution Model

YigoDGStates		
STATE	**MW_{state}**	**P(MWstate)**
1	0	1.000000E-39
2	1.13	3.510000E-37
3	2.26	6.002100E-35
4	3.39	6.662331E-33
5	4.52	5.396488E-31
6	5.65	3.399788E-29
7	6.78	1.733892E-27
8	7.91	7.356654E-26
9	9.04	2.648396E-24
10	10.17	8.210026E-23
11	11.3	2.216707E-21
12	12.43	5.259641E-20
13	13.56	1.104525E-18
14	14.69	2.064612E-17
15	15.82	3.450851E-16
16	16.95	5.176276E-15
17	18.08	6.987973E-14
18	19.21	8.508885E-13
19	20.34	9.359773E-12
20	21.47	9.310511E-11
21	22.6	8.379460E-10
22	23.73	6.823274E-09
23	24.86	5.024411E-08
24	25.99	3.342326E-07
25	27.12	2.005395E-06
26	28.25	1.082914E-05
27	29.38	5.247966E-05
28	30.51	2.274118E-04
29	31.64	8.771600E-04
30	32.77	2.994443E-03
31	33.9	8.983328E-03
32	35.03	2.347257E-02
33	36.16	5.281327E-02
34	37.29	1.008253E-01
35	38.42	1.601344E-01
36	39.55	2.058870E-01
37	40.68	2.058870E-01
38	41.81	1.502419E-01
39	42.94	7.116721E-02
40	44.07	1.642320E-02
Sum		1.000000E+00

5 GPA Generation System Capacity State-Probability Distribution Model Without Energy Shifting Battery Energy Storage Systems (ES BESS)

This section discusses the analytical methodology for developing the GPA Generation System capacity state - probability distribution model. It also presents the model result for each set of GPA generation units. This work scope builds upon the power plant capacity state-probability distribution models results discussed in Section 4.

5.1 GPA Generation System Capacity State-Probability Model: Analytical Methodology

The GPA Generation System capacity state permutation depends on the capacity state of each of the power plants in the generation mix. For each GPA Generation System permutation calculate the total system capacity state and the probability of that permutation occurring. The permutation capacity state is the sum of capacity states in MW for all the power plants. The probability of occurrence of the permutation is the product of all the probabilities for each power plant state.

The next step in the development of the GPA system capacity state- probability distribution model is to combine the common capacity states and sum the probabilities for those common capacity states. Doing so for every capacity state among the set of permutation cases creates a unique capacity state probability pair for the entire system. This collection of unique capacity states and probability pairs is the GPA Generation System Capacity State-Probability Distribution Model (CSPDM).

GPA uses the inhouse EXCEL-VBA application, ***Plant Capacity State - Probability Distribution Model – VBA.xlsm***, to develop the probability distribution model. Appendix B is a printout of the VBA code used in the EXCEL application. Appendix C contains the Users' Manual for the tool.

5.2 GPA Generation System Capacity State-Probability Distribution Model: Base Case Results

Figure 5-1 shows the GPA Generation System Capacity State Probability Distribution Model results for the base case:

- Legacy Unit EAF = 0.9 or 90%
- Ukudu Power Plant EAF = 0.965 or 96.5%
- KEPCO Diesel Power Plant EAF = 0.95 or 95%.

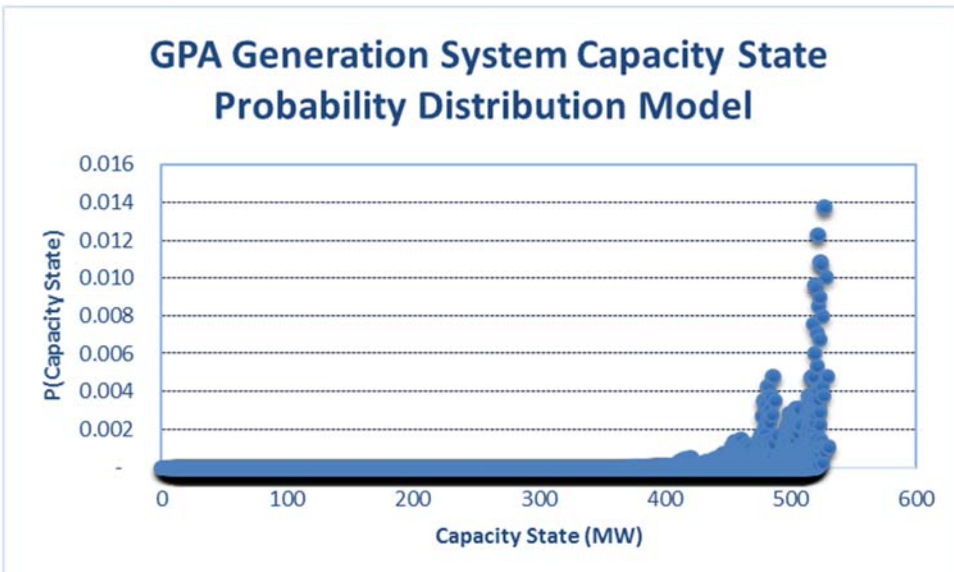


Figure 5-1. GPA System Capacity State Probability Distribution Model: Base Case

6 Base Case Peak Load Carrying Capability (PLCC) and Reserve Margin (RM)

GPA uses the inhouse tools, ***qryPreProcessedDataPass2 – PLCC.xlsx*** and ***Plant Capacity State - Probability Distribution Model – VBA.xlsm***, to compute the peak load carrying capability (PLCC) and reserve margin (RM) for the GPA Generation System. Figure 6-1 shows the results for the base case:

- Legacy Unit EAF = 0.9 or 90%
- Ukudu Power Plant EAF = 0.965 or 96.5%
- KEPCO Diesel Power Plant EAF = 0.95 or 95%.

Sanity Check	1.000000

Target LOLE (days/Year)	0.22222222

Interpolation

	330.73999	0.221544	
X		0.222222	
	330.75	0.222401	
d=		-0.00792	
x=		330.748	PLCC

Interpolation is automated

LOLE = 1 day / 4.5 Years

Assumes every hour is equal to 330.75 MW

Reserve Margin

60.32%	with respect to PLCC
37.63%	with respect to Installed Capacity
199.52	MW

Figure 6-1. Base Case PLCC and Reserve Margin

In Figure 6-1, Sanity Check is the sum of the all the capacity state probabilities. This sum should exactly equal one (1). The term “x’ is interpolated value for PLCC. The term “d” is (x - 330.73999).

Reserve Margin with respect to PLCC = 100 % X (Total Installed Capacity – PLCC) / PLCC

Reserve Margin with respect to Installed Capacity =

100 % X (Total Installed Capacity – PLCC) / Total Installed Capacity

7 Robustness Analysis for PLCC as a Function of GPA Legacy Power Plant EAF

GPA uses the inhouse tools, ***qryPreProcessedDataPass2 – PLCC.xlsx*** and ***Plant Capacity State - Probability Distribution Model – VBA.xlsm***, to compute the peak load carrying capability (PLCC) and reserve margin (RM) for the GPA Generation System for a variety of Legacy Unit EAFs. Table 7-1 summarizes the results of this robustness analysis of PLCC as a function of GPA Legacy Power Plant EAF.

Table 7-1. Robustness Analysis Results

1/LOLE	0.222222	Days/Year	**LOLE**	One Day in 4.5 Years

Legacy Unit EAF	PLCC (MW)	Decline in PLCC (MW)	Incremental Decline in PLCC (MW)	Incremental Decline in PLCC (MW/% EAF)	Installed Capacity (MW)	Reserve Margin (% of PLCC)	Reserve Margin (% of Installed Capacity)	Reserve Capacity (MW)	System Two Largest Units (MW)
95.0%	354.75	-	-	-	530.27	49.48%	33.10%	175.52	114.00
90.0%	330.75	24.00	24.00	4.80		60.32%	37.63%	199.52	
85.0%	308.89	45.86	21.86	4.37		71.67%	41.75%	221.38	
75.0%	271.82	82.93	37.07	3.71		95.08%	48.74%	258.45	
50.0%	200.01	154.74	71.81	2.87		165.13%	62.28%	330.26	

Given that two systems have the same installed capacity and same generation technologies, less reliable generation systems are less efficient in supporting system peak loads. In the base case at 90% Legacy Unit EAF, to increase PLCC by one MW of system load requires that GPA install an additional 1.6032 MW. At 95% Legacy Unit EAF, to serve one MW of system load requires that GPA install only and additional 1.4948 MW.

A five percent improvement from 90% to 95% EAF in legacy power plant EAF improves PLCC by 24 MW. In rough terms, this is equivalent to a capacity deferment of 38.48 MW[6]. In terms of avoided capital investment, this amounts to a deferral of $55,642,080[7].

A five percent decrease in legacy power plant EAF from 90% to 85% EAF reduces PLCC by 21.86 MW from the base case (90% EAF). It also increases the reserve margin required to achieve a one day in 4.5 years loss-of-load-expectation (LOLE).

Poor generation reliability performance significantly increases both capital and operations & maintenance (O&M) costs.

8 Impact on PLCC of the retirement of Legacy GPA Generation Plants

In this section, GPA investigates the impact of legacy power plants on peak load carrying capability and reserve margin. Table 8-1 summarizes the results of this investigation. This analysis assumes a 90% EAF for all legacy generation units.

Note that MacYigo, Piti7, and YigoDG power plant groupings all provide 40 MW maximum capacity. However, the number and capacity size differ between the three plants. Piti7 is a single 40 MW unit. MacYigo are two 20-MW units, and YigoDG is comprised of 39 small Cummins diesels. Retiring the each of these power plants results in different PLCC values. Retiring Piti7 results in a 302.94 MW PLCC. Retiring MacYigo results in a 299.14 MW PLCC. Finally, Retiring YigoDG results in a 291.62 MW PLCC. This illustrates that the same capacity power plants with smaller generation units contribute more to reliability than power plants comprised of larger generation units. Retiring the power plants with the more granular units results in a penalty to PLCC.

Using this information, GPA should consider the impacts on generation system reliability as well as fuel efficiency in prioritizing generation for retirement. For example, retiring Pit7 instead of YigoDG buys the GPA generation system an additional 11.78 of PLCC.

[6] 24 MW times (1 + 0.6032)

[7] Avoided Capacity cost is $1,446/kW from LEIDOS Report

Table 8-1. Impact of Legacy Generation Plant Retirement on Generation System Reliability

Plant Retired	Retired Capacity (MW)	Installed Capacity	PLCC (MW)	Reserve Margin (%)	Reserve (MW)	2-Largest Units (MW)
None	0	530.27	330.75	60.32%	199.52	114
Piti 8&9	88	450.27	271.67	65.74%	178.60	
TalTenjo	35.2	495.07	298.81	65.68%	196.26	
MacYigo	40	490.27	299.14	63.89%	191.13	
MDI	10	520.27	321.75	61.70%	198.52	
Piti7	40	490.27	302.94	61.83%	187.33	
YigoDG	40	486.20	291.16	66.99%	195.04	
DedCT	44	486.27	295.62	64.49%	190.65	

Table 8-2. Rule of Thumb for Generator Unit Size

System Peak Load	7%	15%
(MW)	(MW)	(MW)
260	18.2	39
280	19.6	42
300	21	45
320	22.4	48
340	23.8	51

9 Develop a Load Duration Curve for Forecast Loads

GPA develops Load Duration Curves (LDC) to compute Loss of Load Expectation (LOLE) and Loss of Energy Expectation (LOEE) in section 10. Additionally, GPA uses Load Duration Curves adjusted for solar PV output estimates for Phase I and II Renewable Energy Power Purchase Agreements to analyze the impact of solar PV on generation costs and dispatch.

9.1 Analytical Methodology for Developing Load Duration Curve for Forecast Years

This section discusses the analytical methodology for creating the System Hourly Load Duration Curve (LDC) for specific load forecast years using the Hourly Load Forecast developed by Utility Financial Services, LLC and the hourly Phase I and Phase II solar PV PPA production projections provided by the project developers as part of their bid proposal. The Hourly Load Forecast already accounts for net metering output.

GPA subtracts the total of Phase I and online Phase II hourly PV production estimates from the hourly load forecast. The adjusted hourly load forecast values are exported into an ACCESS database table. A summary query is created to obtain the load duration curve values.

Figure 9-1 shows the FY 2023 load duration curve unadjusted for Phase I and II solar PV outputs without BESS for the Hourly Forecast Low Scenario. The source of this data is the workbook Tab "Hourly Forecast Low"' in UFS file: Hourly Load Forecast V7 (1).xlsx.

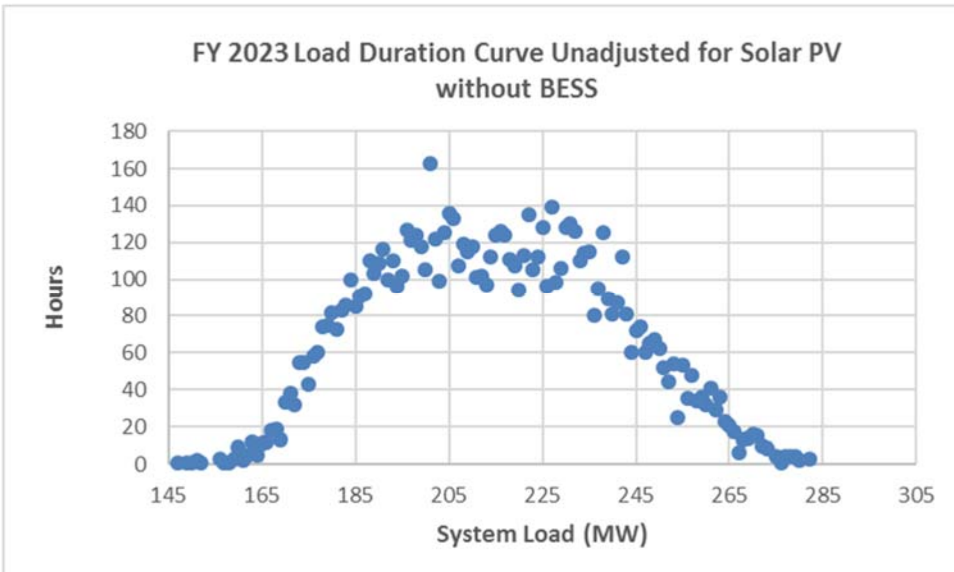


Figure 9-1 FY 2023 LDC Unadjusted for Solar PV without BESS Hourly Forecast Low Scenario

Table 9-1 Phase I and KEPCO Phase II Solar PV Hourly Outputs (FY 2023)

Month	Year	H0600	H0700	H0800	H0900	H1000	H1100	H1200	H1300	H1400	H1500	H1600	H1700	H1800
10	2022	2.39	20.44	38.12	51.54	58.87	58.80	59.00	59.49	51.03	36.59	21.84	4.91	-
11	2022	0.73	19.95	39.78	55.15	64.69	67.00	68.22	66.45	58.11	45.22	23.82	2.49	-
12	2022	0.06	12.15	31.62	49.62	60.24	66.77	65.09	64.50	55.77	43.67	24.44	2.83	-
1	2023	-	8.72	28.00	46.30	57.22	63.91	65.32	63.99	59.97	45.70	27.67	8.58	0.01
2	2023	0.01	10.74	32.49	50.40	64.21	67.21	69.29	66.97	64.41	52.82	34.42	12.99	0.06
3	2023	0.62	18.23	41.85	60.38	70.10	72.70	72.36	70.80	66.95	58.45	39.27	17.68	0.38
4	2023	1.98	23.10	44.89	61.12	70.39	72.28	71.77	70.62	68.25	59.58	39.95	16.14	0.33
5	2023	5.96	28.35	48.68	64.45	71.30	70.44	70.30	70.73	65.05	53.57	37.47	16.69	0.65
6	2023	5.88	26.42	46.04	60.20	69.36	70.81	72.04	71.72	67.64	54.37	38.35	19.47	1.53
7	2023	2.88	22.60	40.34	54.49	65.08	63.16	62.28	60.69	56.54	45.68	31.49	14.86	1.07
8	2023	1.49	18.65	36.69	52.26	57.87	58.99	57.99	55.47	50.49	42.22	29.99	13.73	0.53
9	2023	1.29	17.39	34.57	46.99	55.26	60.18	60.86	60.37	53.39	41.20	26.20	9.69	0.07

Table 9-1 shows the total Phase I and KEPCO Phase II solar PV outputs for FY 2023 using information provided during these bids as a planning guide for each month. GPA uses the data in Table 9-1 to adjust the FY 2023 hourly generation forecast by subtracting the appropriate estimated hourly solar PV outputs from the generation hourly forecast. Figure 9-2 shows the result of this adjustment. Load Duration Curves adjusted for Phase I and II Solar PV outputs will need to use the appropriate fiscal year information to create a matched set. Figure 9-3 shows the load duration curve for daylight hours from 06:00 (6 am) to 18:00 (6 pm).

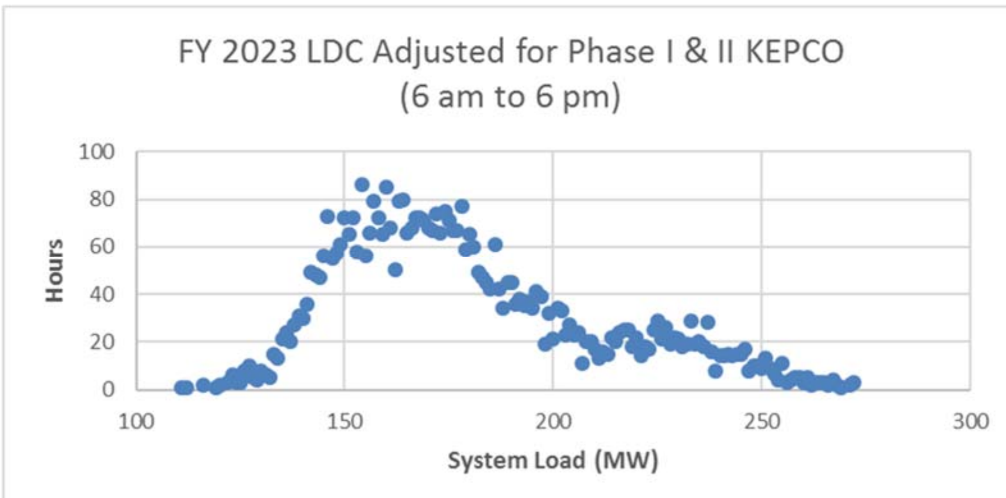


Figure 9-2 FY 2023 LDC Adjusted for Phase I & II (KEPCO) Solar PV Outputs Hourly Forecast Low Scenario

9.2 Load Duration Curve for Forecast Years FY 2025, 2030, 2035, and 2040

This section develops the System Hourly Load Duration Curve for load forecast years FY 2025, 2030, 2035, and 2040.

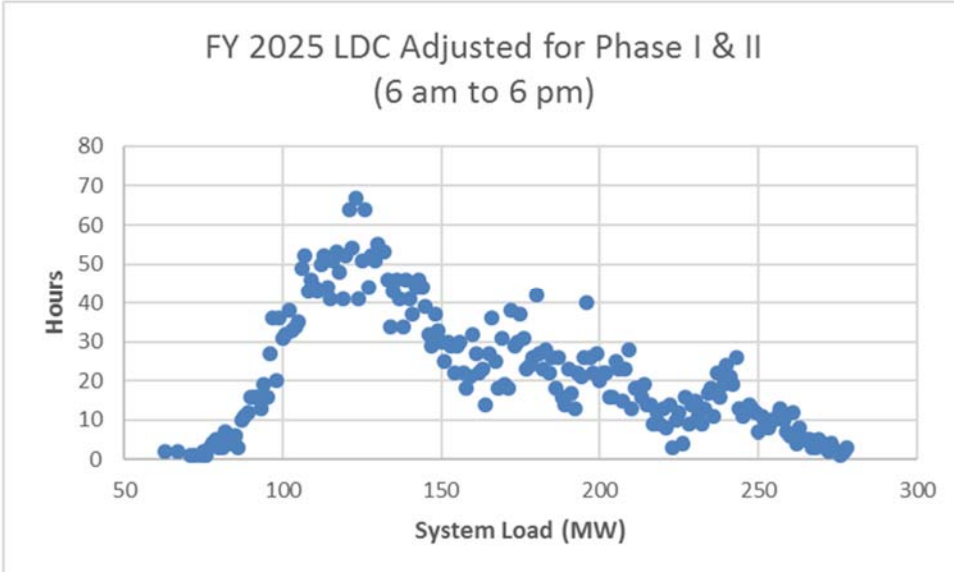


Figure 9-3 FY 2025 LDC Adjusted for Phase I & II (KEPCO) Solar PV Outputs Hourly Forecast Low Scenario

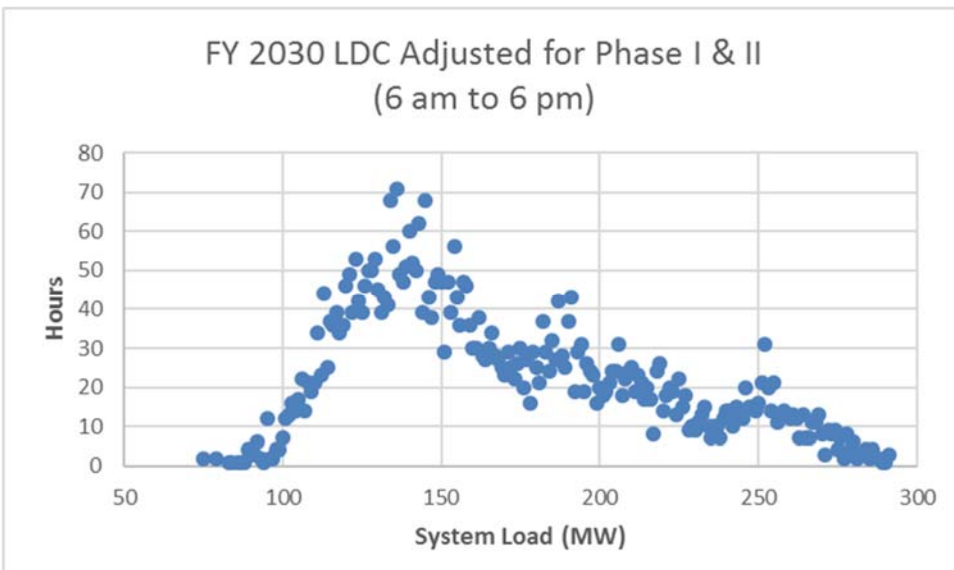


Figure 9-4 FY 2030 LDC Adjusted for Phase I & II (KEPCO) Solar PV Outputs Hourly Forecast Low Scenario

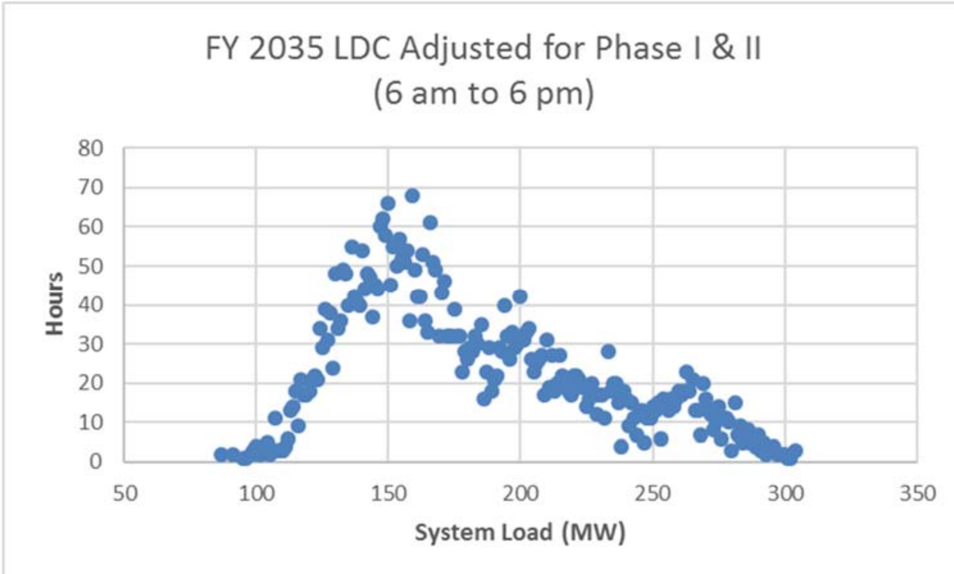


Figure 9-5 FY 2035 LDC Adjusted for Phase I & II (KEPCO) Solar PV Outputs Hourly Forecast Low Scenario

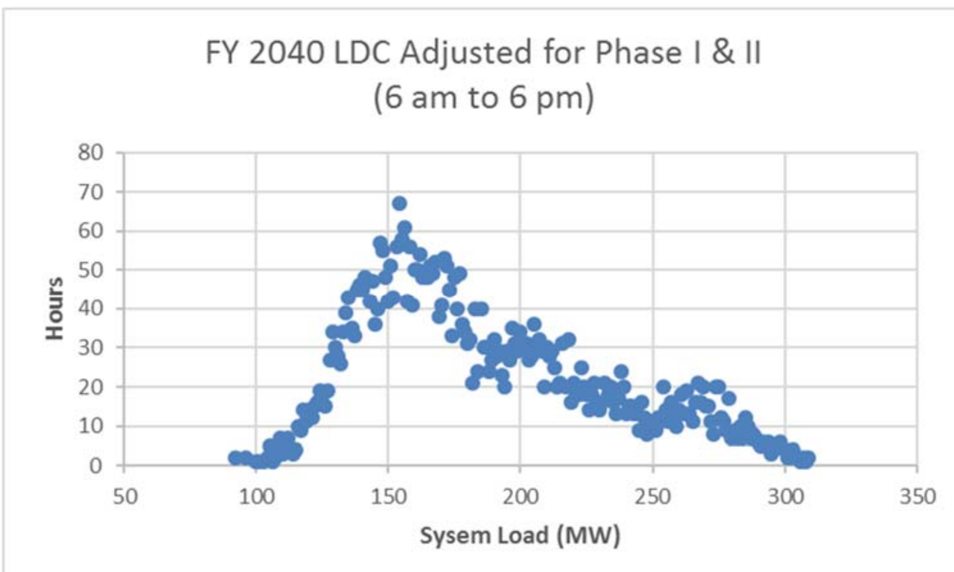


Figure 9-6 FY 2040 LDC Adjusted for Phase I & II (KEPCO) Solar PV Outputs Hourly Forecast Low Scenario

9.3 Evolution of the GPA Duck Curve aka the Kill the Duck Strategy

Figure 9-7 shows the evolution of the GPA Duck Curve from 2017 to 2020. GPA's Phase II Renewable Projects and growth of net metering or customer renewable systems tied to the grid will grow the GPA duck curve. All future GPA utility-scale renewable energy will provide firm power via energy-shifting BESS. GPA will dispatch this energy typically outside of daylight hours.

Years ago, the planning team remarked to a CCU Board member that GPA may someday blow by Hawaii and California with respect to renewable energy. The CCU Board member asked how that was possible since Hawaii had so many problems and issues with increasing solar PV and wind penetration on their grids. The reply was that we should not follow Hawaii and avoid these problems in advance of them happening or grossly affecting the reliability and stability of the GPA grid. GPA's tool kit for killing the duck curve include:

- Energy Shifting BESS (ES BESS);
- Spinning Reserve and Frequency Regulation BESS;
- Demand Response (DR);
- Flexible Generation;
- Time-of-Use (TOU) Rates;
- Daytime Charging Electric Vehicles (EV);
- Reduction of Existing Generation Minimum Operating Levels;
- Synchronous Condensers;
- Solar Irradiance Sensor Network;
- Grid Controller.

Intermittent renewable energy systems DC-coupled with Energy Shifting BESS will not allow additional intermittent energy into the grid thus halting the depth of the duck curve. Spinning reserve and frequency regulation BESS can be used to charge during the day to "use up" intermittent renewable energy produced from solar PV or wind turbine generators. All BESS can contribute to spinning reserve, frequency regulation, daytime grid-charging, and other grid services.

Demand Response can adjust customer demand up or down however needed by the grid. Flexible Generation can better follow the changes in demand especially when large intermittent sources of power are on the grid. Time-of-Use Rates can provide incentives for changing customer electricity-use behavior to match the needs of the grid. Daytime charging of Electric Vehicles prevents curtailment of synchronous generation and solar PV during excessive solar PV production events when solar PV production is high and daytime loads are low.

Reduction of legacy generation unit minimum operating levels allows more synchronous generation to remain online during the day especially during excessive solar PV production events. This results in these generators to continue to remain online and provide short-circuit MVA to maintain grid stability, provide sufficient fault current for system protection to operate properly, and prevent the cessation of grid-tied inverters.

GPA's Grid Controller optimizes all of the above resources to provide the most benefit at the least cost.

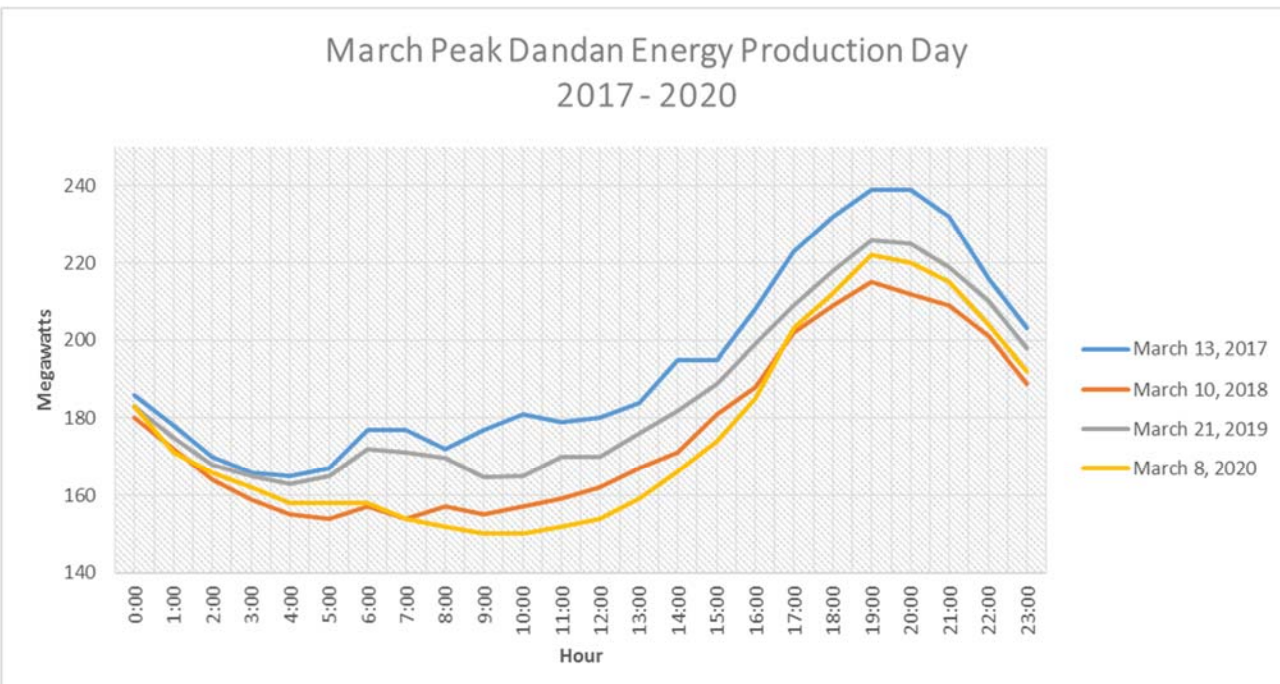


Figure 2-7. GPA Duck Curve 2017 to 2020 Peak Production Day in March

10 Excess Solar PV Generation (ESPVG) Events

Excess solar PV generation events are periods when Solar PV input into the grid:

- Exceeds the system load;
- Is less than the system load but reduces the amount of synchronous generation online to the point where:
  - GPA cannot maintain a Short Circuit Ratio (SCR) sufficient for grid-tied inverter-based generation to achieve commutation;
  - GPA cannot maintain sufficient short circuit current for system faults;
  - GPA energy production costs increase significantly;
  - GPA must take all synchronous generation offline and operate synchronous condensers.

10.1 Excess Solar PV Generation Mitigation Strategies

When solar PV production exceeds the system load it is often referred to as solar PV overgeneration. "During overgeneration conditions, the supply of power could exceed demand, and without intervention, generators and certain motors connected to the grid would increase rotational speed, which can cause damage."[8] GPA system operators must carefully balance supply with demand when solar PV overgeneration occurs. "The overgeneration risk occurs when conventional dispatchable resources cannot be backed down further to accommodate the supply of variable generation (VG)."[9] Solar PV "overgeneration has a relatively simple technical solution, often referred to as curtailment."[10]

Unlike California, GPA does not have tie-lines to other states to pay other state or territory utilities to take on the excess solar PV generation. Additionally, GPA cannot rely on off-island resources for short circuit capability. However, GPA must balance generation and load demand almost instantaneously and keep sufficient Short circuit MVA online to keep the power system stable and with normal operating ranges. GPA must either almost instantaneously create more load or curtail solar PV.

Potential options for GPA to avoid the system stability issues due to excessive solar PV generation include:

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[8] Paul Denholm, Matthew O'Connell, Gregory Brinkman, and Jennie Jorgenson. (2015). Overgeneration from Solar Energy in California: A Field Guide to the Duck Chart. National Renewable Energy Laboratory. URL: https://www.nrel.gov/docs/fy16osti/65023.pdf. p. 1.
[9] Ibid.
[10] Ibid.

- GPA can manually ask solar PPA contractors to curtail their inverter outputs into the grid;
- GPA can also curtail net metering systems remotely from the grid by either disconnecting them at the meter via the AMI system;
- GPA can create more load by using battery energy storage systems that charge from the grid;
- GPA can install a Grid Controller to:
    - Recognize the excessive solar PV event before it causes system problems;
    - Automatically send control signals to solar PPA facilities to curtail;
    - Automatically send control signals to curtail net metering systems outfitted with the appropriate communications and controls;
    - Automatically send control signals to energy-shifting BESS and other BESS to connect to and start charging from the GPA grid.

The daytime load duration curves for FY 2025 and 2030 indicate that some daytime loads adjusted for solar PV contracts fall below 79.2 MW. The Ukudu Power Plant minimum output at 79.2 MW still meets the Short Circuit MVA requirement. GPA should curtail solar PV or employ other mitigation strategies during these hours. In FY 2025, GPA estimates TBD daytime load hours will fall below 79.2 MW. In FY 2030, GPA estimates TBD daytime load hours will fall below 79.2 MW. GPA should install a solar irradiance sensor array and system to forecast solar PV output for the next hour for advanced alerts for excessive solar PV events.

10.1.1 Solar PV Curtailment

This section discusses GPA options for solar PV curtailment as a solution to the problems posed by excess solar PV generation events.

GPA's Phase I and II renewable energy contracts allow curtailment. These contracts allow GPA to curtail up to two percent (2%) of system available energy without charge per contract year. Curtailment beyond 2% requires GPA to pay for the curtailed energy. GPA should curtail the higher cost solar PV first if the curtailment is within the allotted 2% of energy production. If all higher costing contracts have exhausted the 2% allotment, the lowest cost solar PV contract will yield the lowest out of pocket expense.

GPA's Authority Policy (AP)-072: Net Metering Program Interconnection Policy contains no specific provision for curtailment during excess solar PV generation events. However, clause 6.5 below[11] describes GPA's right to disconnect net metering facilities from GPA's system:

> 6.5 GPA shall have the right to disconnect the Customer Facility from GPA's system at the disconnect switch:
>
> 6.5.1 To maintain safe electrical operating conditions; or
>
> 6.5.2 in the event the Customer Facility does not meet required standards; or
>
> 6.5.3 if the Facility at any time adversely affects GPA's operation of its electrical system or the quality of GPA's service to GPA customers.

Clause 6.5 and sub-clauses provide GPA the right to disconnect or "curtail" net metering systems during an excessive solar PV generation event. Furthermore, GPA can exercise this provision without compensation to the net metering system. Additionally, GPA's right to disconnect customers to preserve system stability has precedent in the GPA's implementation of its underfrequency load shedding (UFLS) system protection. GPA has used UFLS for decades.

Prior to the installation of Smart Grid Advanced Metering Infrastructure (AMI) and smart meters, GPA did not have the capability for wide area curtailment or disconnection of net metering systems. Since 2014, however, GPA has had this capability. GPA can configure a load shed group for 200 Ampere rated meters using the AMI system for NEM curtailment specifically for use during excess solar PV generation events.

In the case where curtailment is necessary, GPA, the Consolidated Commission on Utilities (CCU), the Public Utilities Commission (PUC), and customers should consider the question of why should GPA curtail its low cost solar PV PPAs for high costing net metering energy. Going forward, the integration of battery storage systems, multimode inverters, and capabilities for two-way communication with and control of net metering system inverters by GPA should be required by GPA AP-072 for all new net metering installations.

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[11] Guam Power Authority. **(2021**). Authority Policy (AP)-072: Net Metering Program Interconnection Policy

10.1.2 Demand Response Program: Instantaneous Load

This section discusses dispatching instantaneous load additions comprised of BESS as a solution to the problems posed by excess solar PV generation events. Operating energy-shifting BESS to charge from the grid during the Excessive Solar PV Events shifts renewable energy daytime production outside of the solar PV production hours, allows a more economic dispatch of fossil-fueled power plants, ensures that sufficient Short Circuit MVA is available to maintain grid stability and inverter commutation. Charging the Ukudu BESS and other BESS systems such as the Talofofo and Hagatna BESS during these events provides instantaneous load to increase the dispatch of GPA generation especially that of the Ukudu Power Plant to reduce fuel costs and ensure sufficient Short Circuit MVA. Table 10-1 summarizes the Battery Energy Storage Resource GPA will have available by 2024. If all goes to Plan, GPA will have about 481 MW of Battery Energy Storage Systems providing immense value to the stability, reliability, and greening of GPA's grid.

Another source of instantaneous load is electric vehicle charging. GPA must have control of EV charging to:

- Prevent EV charging from increasing peak nighttime loads requiring additions of more generation capacity;
- Optimize EV charging outside of the peak period flattening the system load shape and increasing system load factor resulting in more efficient use of GPA synchronous generation where these units are dispatched near or at peak efficiencies at all times.

Table 10-1. BESS Resource Summary (2024)

Project	Capacity (MW)	Energy Storage	Type
Hagatna ESS	24	6.0	Frequency Regulation / Contingency
Talofofo ESS	16	16.0	Renewable Integration (ramp control)
KEPCO 60MW (Phase II Renewable)	32	32.0	Renewable Integration (ramp control)
HANWAH 60MW (Phase II Renewable)	40	65.0	Renewable Integration (ramp control) with limited shifting
Phase III (Naval Base Guam)	30	148.0	ENERGY SHIFTING (Engie Proposal – Bid Under Protest)
Phase III (South Finegayan)	30	146.3	ENERGY SHIFTING (Engie Proposal – Bid Under Protest)
Ukudu Power Plant	25	7.5	Spinning Reserve ("15MW for at least 30 minutes" per ECA Sch 1)
Total		420.8	

10.2 Excessive Solar PV Event Cost Considerations

Figure 10-1 illustrates the cost analysis for excessive solar PV events. GPA compares the costs between following scenarios:

- Energy generated by the Ukudu Power Plant at 188 MW dispatch or at unadjusted loads below 188 MW;
- Curtailed dispatch of the Ukudu Power Plant (UPP) dispatched below 188 MW plus the replacement energy from renewable energy.
    - Since GPA does not have a lot of energy produced by its wind turbine generator (WTG) which is essentially cost free, GPA will ignore its contribution in this analysis;
    - GPA will consider the costs when the replacement energy is comprised of the highest costing solar PV PPA energy, and when it is comprised of the highest costing solar PV PPA energy and net metering.

Table 10-1 shows the projected net metering contribution that is accounted for in GPA's load forecast. Additional net metering above this projected amount will increase the impact of excessive solar PV generation including forcing GPA to operate synchronous condensers or curtail solar PV production sources.

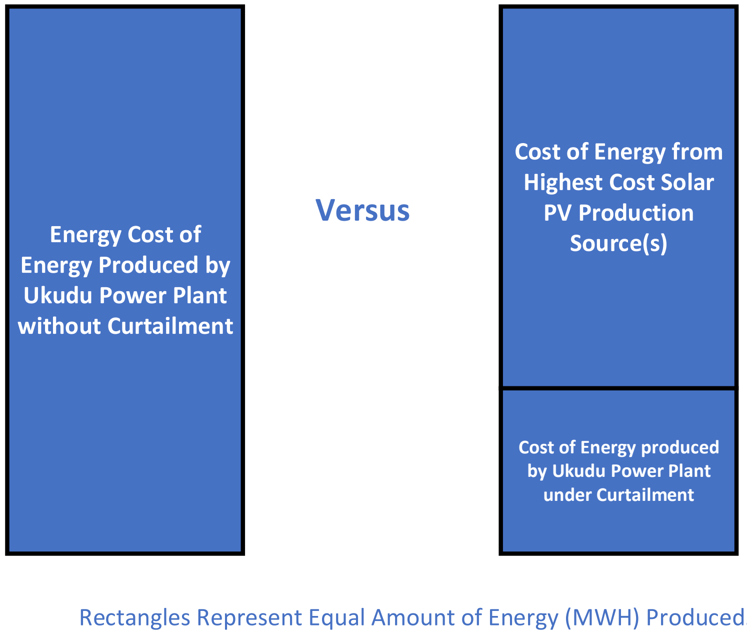

Figure 10-1. Cost Analysis Methodology for Excessive Solar PV Events (FY2024 to FY 2040)

10.3 Excessive Solar PV Event Impacts on FY 2023 Generation Costs, Generation Dispatch, and System Stability

This section investigates the impact of Solar PV after the KEPCO Phase II is online and before the Ukudu Power Plant and Phase II Hanwha System are online. The minimum FY 2023 estimated daytime load of 111 MW is used for this analysis. The corresponding unadjusted load is 181 MW.

Table 10-1. Forecast Net Metering Production

Fiscal	NEM KWH	YOY Growth Rate (%)	Estimated NEM PV Capacity (MW)
2020	36,816,045		26.27
2021	37,276,246	1.250%	26.60
2022	37,747,721	1.265%	26.93
2023	38,230,681	1.279%	27.28
2024	38,725,341	1.294%	27.63
2025	39,231,918	1.308%	27.99
2026	39,750,637	1.322%	28.36
2027	40,281,724	1.336%	28.74
2028	40,825,412	1.350%	29.13
2029	41,381,939	1.363%	29.52
2030	41,951,546	1.376%	29.93
2031	42,534,480	1.390%	30.35
2032	43,130,994	1.402%	30.77
2033	43,741,345	1.415%	31.21
2034	44,365,794	1.428%	31.65
2035	45,004,611	1.440%	32.11
2036	45,658,067	1.452%	32.58
2037	46,326,442	1.464%	33.05
2038	47,010,021	1.476%	33.54
2039	47,709,093	1.487%	34.04
2040	48,423,956	1.498%	34.55

The analysis only considers loads during the 6 am to 6 pm period for which GPA would need to curtail the output of the GPA power plants. Table 10-2 tabulates the analysis results. The FY 2023 additional fuel cost per KWH because of GPA power plant curtailment is $0.0032/kWh using the base FY 2023 RFO and ULSD landed price forecast. This additional unit cost difference is small. The Volume I analysis used the fuel costs associated with the utility Financial Solutions, LLC (UFS) fuel forecast. The IRP Volume 2: Generation Expansion Plan uses the LEIDOS Fuel Forecast. The two forecasts are the same for the landed natural gas prices. The UFS forecast for ULSD is anywhere from 18.1% higher to 5.2% lower than the LEIDOS forecast for the years 2025, 2030, 2035, and 2040. Appendix H compares the two forecasts including scaling factors to convert generation fuel costs from one forecast to the other.

Table 10-2. Fuel Cost Impact

FY 2023 Cost of Solar PV Impact at Lowest Daytime Load							
Units online	Unadjusted Load - 181 MW			Unadjusted Load - 111 MW			Cost Difference ($)
	SC MVA	Dispatch (MW)	Fuel Cost ($)	SC MVA	Dispatch (MW)	Fuel Cost ($)	
Cabras 1	396	40.0	$ 6,927.00	330	25.0	$ 4,557.25	$ 2,369.75
Cabras 2	396	32.5	$ 6,115.94	330	25.0	$ 4,929.82	$ 1,186.12
Piti 8	264	42.0	$ 5,270.13	220	31.5	$ 3,920.43	$ 1,349.70
Piti 9	264	44.2	$ 5,646.18	220	29.5	$ 3,709.71	$ 1,936.47
Yigo Diesel Power Plant	240	1.3	$ 223.28				$ 223.28
Talofofo Diesel Power Plant	52.8	6	$ 900.10				$ 900.10
Tenjo Vista Diesel Power Plant	156	15	$ 2,250.75				$ 2,250.75
Totals	1768.8	181.0	$ 27,333.38	1100	111.0	$ 17,117.21	$ 10,216.17
Unit Cost of Energy (Fuel)	$ 0.1510			$ 0.1542			

GPA must have at least 750 MVA of Synchronous Generation Short Circuit MVA to keep the system stable and ensure that inverter-based generation can operate. This applies to the GPA system at the addition of the Phase II Solar PV projects.

Since the daytime loads do not fall below 109 MW, the Ukudu Power Plant if commissioned can remain online and provide sufficient Short Circuit MVA. Otherwise, GPA must have at least an aggregate of 150 MW online from other synchronous generation. Table 10-3 lists the Short Circuit MVA capabilities of each synchronous generation unit. Note that the minimum dispatch of Ukudu Power Plant that meets the 750 MVA criteria is 79.2 MW with two simple cycle units and the steam turbine. With all three simple cycle combustion turbines and the steam turbine, the minimum Ukudu Power Plant output is 118.5 MW. This configuration provides 990 Short-Circuit MVA for the system. GPA should curtail PV or charge ESS during the daylight hours once Phase III is commissioned. It is also recommended that at night Phase I & Phase II solar PV inverters should be disconnected from the grid to reduce the requirement for Short Circuit MVA. The Hanwha system has some energy-shifting BESS. Once this system discharges, GPA may consider disconnecting this inverter as well.

This analysis assumes a net metering growth rate (Table 10-1). Larger NEM growth will increase the cost of Ukudu curtailment. GPA will have to install synchronous condensers to provide the required Short Circuit MVA for Excess Generation Events or curtail solar PV. The

Renewable Integration Studies that GPA and its consultants estimate the cost of a new synchronous condenser at $34 million dollars.

GPA should consider converting Piti 7, Macheche CT, Yigo CT, and Dededo CT for Synchronous Condenser Operation for approximately 620 SC MVA. GPA has the option to retire these plants for power production and still convert the units for synchronous condenser operation.

Table 10-3. GPA Generation Short-Circuit MVA Contribution

Generation Unit/Plant	Nameplate Capacity (MW)	Estimated Short Circuit MVA (MVA)	Minimum Load (MW)
Ukudu Power Plant (All CTs)	198	990	118.5
Ukudu Power Plant (2 CTs)	151	755	79.2
Ukudu Power Plant (1 CTs)	104	520	65
Piti 8&9	88	440	56
Piti 8	44	220	28
Piti 9	44	220	28
Dededo CT 1&2	44	220	20
Dededo CT 1	22	110	10
Dededo CT 2	22	110	10
Macheche CT	20	100	8
Yigo CT	20	100	8
Piti 7 CT	40	200	10
Cabras 1&2 (Retired on Ukudu Power Plant COD)	132	660	50
Cabras 1	66	330	25
Cabras 2	66	330	25
Yigo Diesel Power Plant	40	200	1
KEPCO Diesel Power Plant	42	210	2.75
Tenjo Vista Diesel Power Plant	26	130	2
Talofofo Diesel Power Plant	8.8	44	2
MDI (Pulantat) Diesel Power Plant	10	50	2

10.4 Excessive Solar PV Event Impacts on Generation Costs, Generation Dispatch, and System Stability After Ukudu Power Plant is Online

This section investigates the impact of excessive Solar PV on the GPA power system after the Phase II Hanwha and Ukudu Power Plant are online. GPA limits its investigations to fiscal years, 2025, 2030, 2035, and 2040. NEM Energy costs is a shared cost between scenarios. NEM Energy is the most expensive energy block under the ULSD fuel use scenarios. In 2025, the NEM energy block will shift an estimated $10,239,530.60 at 26.1 cents/KWH including $3,923,191.80 in base rates to GPA non-NEM customers. Tables 10-4 through 10-9 show the results of this analysis.

Table 10-4. Cost of Energy Produced by Ukudu Power Plant without Curtailment

Fiscal Year	Annual Hours of Ukudu Curtailment	Energy Block @ 188 MW (MWH)	UPP Fuel Cost of Production @ 188 MW ($)		Hours Unadjusted Daytime Load <188 MW	Energy Block @ <188 MW (MWH)	UPP Fuel Cost of Production - Unadjusted System Loads < 188 MW ($)		UPP Variable O&M ($) (ULSD)	UPP Variable O&M ($) (Gas)	Total Energy Cost	
			ULSD	Gas			ULSD	Gas			ULSD	Gas
2025	3187	599,156	$ 59,898,916		173	31,398	$ 3,148,758		$ 1,024,019		$ 64,071,693	$ -
2030	3286	617,768	$ 81,557,853	$ 41,972,961	64	11,694	$ 1,547,836	$ 796,578.63	$ 1,037,580	$ 972,731	$ 84,143,268	$ 43,742,271
2035	3321	624,348	$ 99,560,556	$ 50,262,492	20	3,653	$ 584,043	$ 294,850.25	$ 1,050,700	$ 985,031	$101,195,299	$ 51,542,373
2040	3321	624,348	$ 121,238,950	$ 56,482,261	11	1,999	$ 389,279	$ 181,355.75	$ 1,063,651	$ 997,173	$122,691,881	$ 57,660,790

Table 10-5. Cost of Energy Produced by Ukudu Power Plant with Curtailment

Fiscal Year	Curtailed UPP Energy Block (MWH)	Curtailed UPP Cost of Production ($)		Curtailed UPP Variable O&M - ULSD ($)	Curtailed UPP Variable O&M - Gas ($)	Curtailed UPP Energy Cost - ULSD ($)	Curtailed UPP Energy Cost - Gas ($)
		ULSD	Gas				
2025	473,450	$ 48,396,666.23		$ 768,882.80		$ 49,165,549.03	-
2030	460,306	$ 62,426,229.12	$ 32,127,055.70	$ 758,750.00	$ 711,328.12	$ 63,184,979.12	32,838,384
2035	439,646	$ 71,560,085.50	$ 36,126,638.28	$ 735,565.30	$ 689,592.47	$ 72,295,650.81	36,816,231
2040	431,180	$ 85,400,692.74	$ 39,786,093.67	$ 732,221.98	$ 686,458.10	$ 86,132,914.72	40,472,552

Table 10-6. Solar PV Energy Block Supplied as Replacement Energy under Ukudu Curtailment

Fiscal Year	Ukudu Power Plant Energy Block (MWH)		Energy Block Supplied by Solar PV as Replacement Energy (MWH)
	Uncurtailed	Curtailed	
2025	630,554	473,450	157,104
2030	629,462	460,306	169,156
2035	628,001	439,646	188,355
2040	626,347	431,180	195,167

Table 10-7. Cost of Replacement Energy Produced by Solar PV

Fiscal Year	Energy Block Supplied by Solar PV (MWH)	Phase I GlidePath (5.65 MW)		Phase I GlidePath (20 MW)		Phase II KEPCO Energy Cost		Phase II Hanwha A Energy Cost		Phase II Hanwha B Energy Cost		Total Cost of Replacement Energy ($)	Based on Average Cost of PPAs
		Energy Block (MWH)	Energy Cost ($)	Energy Block (MWH)	Energy Cost ($)	Energy Block (MWH)	Energy Cost ($)	Energy Block (MWH)	Energy Cost ($)	Energy Block (MWH)	Energy Cost ($)		
2025	157,104	11,053.84	$ 2,323,822.21	38,732.34	$ 7,937,136.96	107,317.46	$ 9,245,073.23	-	$ -	-	$ -	$ 19,506,032.39	$ 16,181,500.80
2030	169,156	10,691.39	$ 2,237,410.83	37,773.75	$ 7,936,831.74	120,690.79	$ 11,147,144.01	-	$ -	-	$ -	$ 21,321,386.58	$ 18,131,812.13
2035	188,355	10,408.24	$ 2,435,411.54	36,838.94	$ 7,935,659.83	120,294.84	$ 11,677,321.11	20,813.45	$ 1,058,182.48	-	$ -	$ 23,106,574.95	$ 21,069,690.39
2040	195,167	10,148.20	$ 2,510,757.33	35,925.10	$ 7,932,801.28	120,294.84	$ 12,395,711.66	28,799.11	$ 1,473,741.14	-	$ -	$ 24,313,011.42	$ 22,759,739.96

Table 10-8. Curtailed versus Uncurtailed Ukudu Power Plant Energy Costs

(Solar PV Energy Costs Allocated to More Expensive PPAs first)

	Fiscal Year	Uncurtailed Ukudu Energy Cost ($)	Curtailed Ukudu Energy Cost ($)	Total Cost of Replacement Energy ($)	Total Curtailed Energy Cost ($)	Curtailed minus Uncurtailed UPP Energy Costs ($)
Ultra Low Sulfur Diesel	2025	$ 64,071,693.15	$ 49,165,549.03	$ 19,506,032.39	$ 68,671,581.43	$ 4,599,888.28
	2030	$ 84,143,268.15	$ 63,184,979.12	$ 21,321,386.58	$ 84,506,365.70	$ 363,097.55
	2035	$ 101,195,299.47	$ 72,295,650.81	$ 23,106,574.95	$ 95,402,225.76	$ (5,793,073.71)
	2040	$ 122,691,880.66	$ 86,132,914.72	$ 24,313,011.42	$ 110,445,926.13	$ (12,245,954.53)

	Fiscal Year	Uncurtailed Ukudu Energy Cost ($)	Curtailed Ukudu Energy Cost ($)	Total Cost of Replacement Energy ($)	Total Curtailed Energy Cost ($)	Uncurtailed versus Curtailed UPP Energy Costs ($)
Natural Gas	2025	No Gas Available				
	2030	$ 43,742,270.70	$ 32,838,383.83	$ 21,321,386.58	$ 54,159,770.40	$ 10,417,499.71
	2035	$ 51,542,373.36	$ 36,816,230.76	$ 23,106,574.95	$ 59,922,805.71	$ 8,380,432.35
	2040	$ 57,660,789.94	$ 40,472,551.78	$ 24,313,011.42	$ 64,785,563.19	$ 7,124,773.25

Table 10-9. Curtailed versus Uncurtailed Ukudu Power Plant Energy Costs

(Using Average Phase I & II Energy Costs)

Ultra Low Sulfur Diesel	Fiscal Year	Uncurtailed Ukudu Energy Cost ($)	Curtailed Ukudu Energy Cost ($)	Total Cost of Replacement Energy ($)	Total Curtailed Energy Cost ($)	Curtailed minus Uncurtailed UPP Energy Costs ($)
	2025	$ 64,071,693.15	$ 49,165,549.03	$ 16,181,500.80	$ 65,347,049.83	$ 1,275,356.69
	2030	$ 84,143,268.15	$ 63,184,979.12	$ 18,131,812.13	$ 81,316,791.25	$ (2,826,476.90)
	2035	$ 101,195,299.47	$ 72,295,650.81	$ 21,069,690.39	$ 93,365,341.19	$ (7,829,958.28)
	2040	$ 122,691,880.66	$ 86,132,914.72	$ 22,759,739.96	$ 108,892,654.67	$ (13,799,225.99)

Natural Gas	Fiscal Year	Uncurtailed Ukudu Energy Cost ($)	Curtailed Ukudu Energy Cost ($)	Total Cost of Replacement Energy ($)	Total Curtailed Energy Cost ($)	Uncurtailed versus Curtailed UPP Energy Costs ($)
	2025	No Gas Available				
	2030	$ 43,742,270.70	$ 32,838,383.83	$ 18,131,812.13	$ 50,970,195.95	$ 7,227,925.26
	2035	$ 51,542,373.36	$ 36,816,230.76	$ 21,069,690.39	$ 57,885,921.14	$ 6,343,547.78
	2040	$ 57,660,789.94	$ 40,472,551.78	$ 22,759,739.96	$ 63,232,291.73	$ 5,571,501.79

10.5 Net Metering System Costs passed onto non-Net Metering Customers

The reduction in forecasted load due to net metering systems is not included as part of the analysis. It is considered a sunk cost common to both adjusted and unadjusted load duration scenarios. However, it is a cost that should be accounted for. Table 10-10 shows the estimated NEM costs shifted to non-NEM customers.

Table 10=10. Estimated NEM Costs Paid by Non-NEM Customers

Fiscal Year	Estimated KWH	Estimated KW	Estimated Cost to Non-NEM Customers ($)	Estimated NEM Base Rate Avoidance ($)
2023	38,230,681	27.28	$ 9,741,175.87	$ 5,919,936.09
2024	38,725,341	27.63	$ 9,848,831.43	$ 5,969,016.34
2025	39,231,918	27.99	$ 10,246,847.01	$ 6,325,149.05
2026	39,750,637	28.36	$ 9,400,090.05	$ 5,433,558.48
2027	40,281,724	28.74	$ 9,703,185.41	$ 5,665,310.06
2028	40,825,412	29.13	$ 9,983,576.77	$ 5,884,672.52
2029	41,381,939	29.52	$ 10,241,760.01	$ 6,117,528.25
2030	41,951,546	29.93	$ 10,656,457.35	$ 6,391,837.07
2031	42,534,480	30.35	$ 11,076,994.93	$ 6,666,638.41
2032	43,130,994	30.77	$ 11,491,809.34	$ 6,930,156.73
2033	43,741,345	31.21	$ 11,976,869.10	$ 7,258,139.99
2034	44,365,794	31.65	$ 12,482,613.61	$ 7,600,798.31
2035	45,004,611	32.11	$ 13,026,401.28	$ 7,975,251.24
2036	45,658,067	32.58	$ 13,529,964.95	$ 8,302,983.60
2037	46,326,442	33.05	$ 14,114,567.08	$ 8,704,999.54
2038	47,010,021	33.54	$ 14,698,103.61	$ 9,098,926.34
2039	47,709,093	34.04	$ 15,472,177.18	$ 9,676,087.39
2040	48,423,956	34.55	$ 16,099,179.34	$ 10,098,583.42

11 Grid Short Circuit Ratio

The short-circuit ratio (SCR) is calculated to measure the strength of an area grid. The SCR metric traditionally represented a power grid's voltage stiffness. Having a low short-circuit ratio indicates low system strength conditions that can exacerbate system perturbations and disturbances and potentially impact protection system coordination relay settings.[12]

The generation resource mix transitioning from synchronous generation burning fossil fuels to inverter-based generation such as solar PV plants will have a profound impact on the transmission reliability and will require energy policy, system planning, and system operation considerations as the resource mix evolves including voltage performance, frequency response, and system stability (i.e., fault induced delayed voltage recovery in addition to voltage stability).[13] SCR becomes significantly more important as non-synchronous, inverter-based generation supplants synchronous generation on GPA's weak grid. A weak grid is defined as a low short-circuit MVA grid.

In a weak grid, during a grid transient such as a line fault, the voltage waveforms at the point of interconnection (POI) with the inverter become distorted enough for the inverters to lose their phase lock with the grid POI voltages.[14] The inverter reaction is to protect itself by shutting down or blocking commutation (cessation). But, this causes significant problems for weak grids such as large imbalances between online generation and system demand and severe undervoltages that could lead to blackouts.

"Synchronous machine fault current and short-circuit behavior has been established and is well understood in comparison to nonsynchronous plants."[15] "Conventional generators ride through transient events, providing both frequency and voltage regulation in terms of reactive

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[12] NERC. (2020). Operating Reserve Management: Version 3. URL: https://www.nerc.com/comm/RSTC_Reliability_Guidelines/Operating_Reserve_Management_Guideline_V3_Final.pdf. (Accessed January 9, 2021) p. iv

[13] Ibid.

[14] Electric Power Systems, Inc. (2018). Guam Power Authority System Improvement Plan for Renewables. Anchorage, Alaska. p.29.

[15] NERC. (2020). Operating Reserve Management: Version 3. URL: https://www.nerc.com/comm/RSTC_Reliability_Guidelines/Operating_Reserve_Management_Guideline_V3_Final.pdf. (Accessed January 9, 2021) p. iv

power, in order to stabilize the grid and survive the transient."[16] As renewable energy, inverter-based generation supplants synchronous generation, "it is this frequency and control during transient events that is lost as synchronous generation is lost."[17] One of the major misconceptions regarding solar PV among the Guam public, commercial interests, and politicians is believing that synchronous generation and inverter-based generation behave the same and contribute equally to grid stability, grid transient response, and power quality. They are not the same. There are distinct advantages and disadvantages to each technology regarding use and value to the grid. For example, GPA has installed spinning reserve BESS putting to use the advantage this technology has for this application.

System short-circuit strength is measured by calculating the short-circuit ratio at a resource's point of interconnection (POI). The short-circuit ratio (SCR) is used in order to develop an understanding of the reliability implications and to quantify the risks associated with high-level integration and penetration of inverters into the bulk electrical system (BES). The strength of a system (the measure of voltage stiffness) with inverter based technologies differs from the strength of a system with just synchronous generation. The SCR is a screening measure to identify weak areas of the grid at a specified point (i.e. bus). Therefore, a system consisting of numerous generators and transmission lines will have a different SCR at each bus.

11.1 Pre-Phase III and Ukudu Power Plant Short Circuit MVA Requirements

These requirements apply to the GPA system after Phase II solar PV systems are online and prior to the commissioning of the Ukudu Power Plant. Table 11-1 illustrates the calculations. A minimum 750 Short-Circuit MVA is required at all times as long as the inverters listed are interconnected to the grid. The criteria is a 2.0 Composite-SCR. Therefore, 750 SC-MVA is marginal. However, achieving a larger 2.47 Composite-SCR increases fuel costs as more plants are brought online close to their minimums.

[16] Electric Power Systems, Inc. (2018). Guam Power Authority System Improvement Plan for Renewables. Anchorage, Alaska. p.29.
[17] Ibid

Table 11-1. Pre-Phase III Short-Circuit MVA Requirement[18]

Load Flow Bus Number	Inverter-Based Generation Source	POI KV	Inverter MVA	Dispatch 1			Dispatch 2		
				SC-MVA at POI	Generation Dispatch	Generation SC-MVA	SC-MVA at POI	Generation Dispatch	Generation SC-MVA
2018	GlidePath (Dandan)	34.5	25		Cabras 1	330		Cabras 1	330
2701	Hanwha (at Apra)	115	100		Macheche CT	100		Macheche CT	100
2501	KEPCO (Mangilao)	34.5	92		Yigo CT	100		Yigo CT	100
2111	Hagatna BESS	34.5	24		Piti 8	220		Piti 8	220
2003	Talofofo BESS	34.5	16					Piti 7	200
Totals			257			750			950
Composite-SCR				1.92			2.47		
Weighted-SCR				1.35			1.63		

11.2 Future Short Circuit MVA Requirements

The *Guam Power Authority System Improvement Study for Renewables* recommends, for each utility-scale inverter addition, "detailed switching studies be conducted by the inverter manufacturers to ensure proper operation"[19] because SCRs based on the 2.0 CSCR criterion are marginal. The report also notes: "inverter manufacturers will not typically share their detailed switching models for their equipment for the purposes of grid wide studies, due to intellectual property issues. Therefore, the inverter manufacturers have to be relied upon for conducting the switching studies."[20]

As NEM penetration increases and long before GPA utility-scale inverter-based generation projects come on line, GPA must ensure that detailed and exhaustive system impact studies are completed. These studies must include determinations of sufficient Short-Circuit MVA under various available generation mix dispatches and loads. Additionally, GPA must fast track synchronous condenser procurement and commissioning to ensure reliable and stable operation of the GPA grid.

Table 11-2 shows the required system Short-Circuit MVA with only Ukudu Power Plant online for the FY 2025 GPA system with Phase I, II, and III renewable projects online as well as the Ukudu BESS. GPA should perform these calculations under different dispatches of units for the year the Ukudu Power Plant performs its 23-day steam turbine outages. It is presumed that

[18] Ibid. p. 32
[19] Ibid. p. 31-32
[20] Ibid.

Phase IV is online at that time. At present GPA does not know where the Phase IV through VII points of interconnects will be. Therefore, this report does not calculate CSCRs for those additions.

Table 11-2. Minimum Short-Circuit MVA Requirement:

Phase III & Ukudu BESS Online (FY 2024)

Load Flow Bus Number	Inverter-Based Generation Source	POI KV	Inverter MVA	Dispatch 1		
				SC-MVA at POI	Generation Dispatch	Generation SC-MVA
2018	GlidePath (Dandan)	34.5	25		Ukudu	990
2701	Hanwha (at Apra)	115	100			
2501	KEPCO (Mangilao)	34.5	92			
2111	Hagatna BESS	34.5	24			
2003	Talofofo BESS	34.5	16		Synchronous Condenser	
	Ukudu BESS	115	25			
	NBG ES BESS	34.5	30			
	South Finegayan	34.5	30			
Totals			342			990
Composite-SCR						
Weighted-SCR						

11.3 GPA Short Circuit MVA Requirements Considering Growth of NEM

Inverter-based systems including net metering systems do not provide a lot of short circuit support as synchronous generation. A 2017 paper by Bhatt and Kumar concludes that with the large-scale integration of solar PV generators, the fault level of existing system changes significantly which may affect the reliability of the protection system."[21] There is a growing body of studies and reports that support this assertion. Bhatt and Kumar assert that "strength of]the] grid (weak/strong) also affects the fault level of the system."[22] Singe GPA grid strength is weak, GPA should be considerably concerned.

GPA has the public charge to provide reliable power. Bhatt and Kumar acknowledge that in "an urban smart distribution system reliability is [the] prime consideration,"[23] and suggest that "comprehensive analysis is required in order to assess the possible threat on the system stability

[21] Bhatt, P.K., Kumar, S.Y. Comprehensive Assessment of Fault Current Contribution in Smart Distribution Grid with Solar Photovoltaic. Technol Econ Smart Grids Sustain Energy 2, 7 (2017). https://doi.org/10.1007/s40866-017-0023-8. P. 13.

[22] Ibid

[23] Ibid

and reliability."[24] Clarifying on the paper's use of the word "possible," the phrase "magnitude of" should be substituted to clarify the point. Distributed inverter-based generation on will have impacts on distribution systems. The magnitude and severity of these effects is the question.

The Bhatt and Kumar paper indicates that the neutral grounding in the distribution system with solar PV integrated into the system plays a major role in limiting the fault current when the fault involves ground.[25] The paper finds that the resistance grounding of neutral assists in controlling the fault current.[26]

12 Scheduling Generation Outages

Every five years, the Ukudu Power Plant must take a nominally 23-day steam turbine maintenance overhaul outage. This will place an enormous stress on the remainder of GPA generation to serve system loads during the prolonged outage. GPA must expand the resources it uses for operating and planning reserves[27]. This section discusses planning reserves supporting planned outages particularly the Ukudu Steam Turbine Outages and other major generation outages.

Reserves supporting planned outages include but may not be limited to:

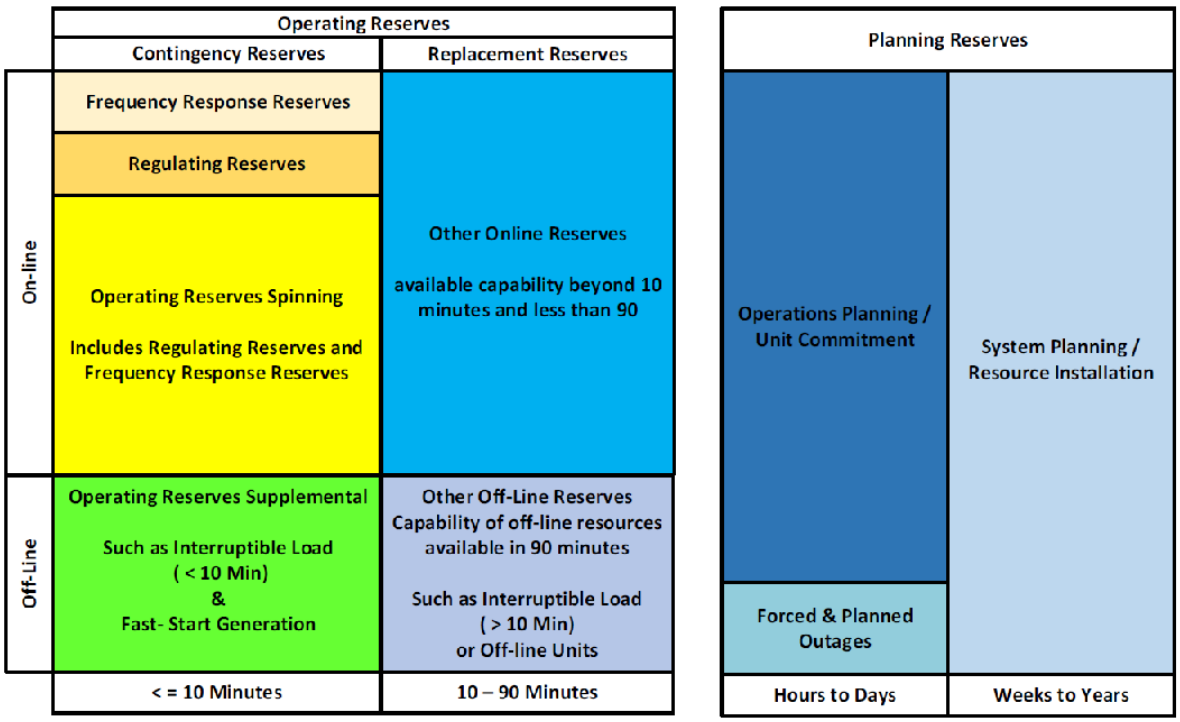
- Conventional Generation;
- Demand Response;
- Energy-Shifting Battery Energy Storage Systems (BESS);
- Interruptible or Curtailable Load.

Power plant OEMs define what are major and minor outages for the generators they manufacture. But, GPA should definition outages as major or minor for with respect to power system operations and reliability. For example, Talofofo Diesel Power Plant O&M OEMs may refer to major and minor unit and plant outages but in terms of the system it is a minor as the reduction in total system available capacity is very small.

GPA defines a major generation outage as follows:

[24] Ibid
[25] Ibid
[26] Ibid
[27] Ibid.

"A major generation outage is defined as an outage of any single unit or power plant lasting at least 14 days, with a maximum gross single-unit or aggregate power plant nameplate capacity greater than ten percent of the highest five-year System Peak Demand (MW) or 36 MW whichever is less."



Source: Operating Reserve Management: Version 3 (NERC)

Figure 12-1. Operating Reserves[28]

12.1 Generation Outage Planning Considerations

GPA must carefully plan major generation outages well in advance of the outage. GPA, its Performance Management Contractors (PMC), and Independent Power Producers (IPP) should start the execution of the outage plan perhaps two years in advance. The greatest risk for GPA is procurement protests. Moving the procurement risk to Contractors has been game changing for GPA. GPA should continue to do so.

[28] NERC. (2020). Operating Reserve Management: Version 3. URL: https://www.nerc.com/comm/RSTC_Reliability_Guidelines/Operating_Reserve_Management_Guideline_V3_Final.pdf. (Accessed January 9, 2021). page 5

GPA should prudently:

- Schedule major generation plant outages during periods of lower system loads and energy consumption;
- Ensure that sufficient conventional generation, energy shifting BESS capabilities, interruptible and curtailable load, and demand response resources are available to support the generation outage;
- Avoid scheduling multiple plant outages simultaneously. Insofar as practical, GPA should stagger major outages to different fiscal years. For GPA, Murphy has often been an optimist.

12.2 Scheduling Generation Outages: System Peak Considerations

Figure 12-1 and 12-2 show the historical daily system peaks from calendar year 2011 through 2020. These figures serve to provide insights into the seasonality of GPA system peaks for the purpose of scheduling major generation outages.

Figures 12-1 and 12-2 are intensity charts for system peak load. Blue tinted cells in the figures indicate lower than average daily system peak loads. This means that generation outages on these days stress reserve generation less. White tinted cells are days having moderate system peak loads. Red tinted cells indicate days of higher than average system peak loads. These are the high generation resource stress days. The color scales are computed over the entire daily system peaks from 2018 through 2020.

The data for CY 2018 was redacted for July 5, 2018 for outages. The data for September 10 through 14 was missing so data from the previous week for the same day of the week was substituted for the missing data.

CY	January																													
2018	228	240	238	236	224	229	229	238	236	240	243	237	233	234	238	237	244	242	239	234	236	245	246	232	229	225	225	223	231	238	225
2019	199	228	223	219	200	212	216	213	217	212	209	209	210	215	207	206	218	213	206	202	209	211	220	224	210	212	200	188	203	198	208
2020	208	218	216	215	219	224	218	219	217	225	221	219	222	218	209	221	215	217	211	221	217	211	214	212	214	205	220	225	211	223	227

CY	February																												
2018	236	230	228	227	235	233	232	238	217	227	233	241	237	232	234	231	230	225	238	234	233	236	228	226	230	235	234	228	
2019	217	208	210	219	221	226	222	209	214	216	220	218	218	218	218	220	211	216	208	208	207	206	175	192	211	221	226	224	
2020	200	199	200	219	224	229	227	221	225	230	217	209	214	208	206	210	218	218	215	220	213	218	219	221	214	221	222	218	215

CY	March																													
2018	234	234	231	227	226	231	221	224	219	215	220	231	233	238	242	244	237	233	238	238	231	238	227	225	222	234	228	233	234	230	229
2019	220	221	197	231	227	228	229	228	224	228	226	228	224	226	218	216	228	230	225	224	226	226	218	221	234	232	227	229	229	228	228
2020	217	217	233	232	230	223	221	222	225	230	233	228	228	225	224	222	230	230	224	220	208	210	213	213	212	204	211	205	210	218	217

CY	April																												
2018	234	235	233	234	237	218	232	231	237	235	242	247	238	229	215	233	239	238	236	225	216	227	236	263	242	241	233	231	232	239
2019	239	233	235	226	224	234	236	239	238	242	243	235	236	230	233	237	239	236	232	233	231	243	237	244	238	236	231	236	233	239
2020	215	213	206	211	204	217	219	216	218	220	221	217	224	224	220	213	220	215	214	220	220	226	222	227	218	209	218	223	228	228

CY	May																													
2018	222	240	237	228	229	233	238	237	235	236	225	235	236	249	239	233	214	220	225	236	240	229	237	241	237	237	237	242	242	244	241
2019	235	231	234	233	238	242	246	249	247	242	240	232	240	241	248	248	225	238	241	245	243	244	223	233	242	241	237	250	249	254	247
2020	213	206	219	223	216	223	220	222	229	225	197	221	227	228	223	217	201	226	232	241	239	235	233	232	234	239	239	236	235	210	211

CY	June																												
2018	232	232	209	226	226	222	214	209	224	217	225	236	242	244	226	232	232	246	227	238	227	237	236	238	246	230	220	233	228	229
2019	243	241	236	245	241	255	248	240	236	245	248	250	252	246	242	239	246	243	241	239	227	234	242	237	243	245	243	243	246	248
2020	231	237	235	231	210	211	225	228	235	242	234	235	234	234	235	235	237	241	241	238	236	244	229	241	241	237	237	229	239	239

Figure 12-1 January through June 2018 to 2020 Daily System Peak Load Intensity Chart

CY	July																													
2018	232	242	210	193	189	185	194	219	236	228	209	210	211	228	212	208	224	228	222	212	211	211	226	230	238	225	226	228	206	218	228
2019	244	251	243	238	229	237	238	247	245	250	237	242	227	241	233	221	237	228	228	216	229	240	243	209	242	228	235	221	222	227	237
2020	212	223	229	221	233	234	237	231	236	232	220	234	233	224	235	236	231	225	225	234	214	233	235	233	234	202	208	204	228	234	231

CY	August																													
2018	206	191	197	189	207	218	231	225	225	234	216	223	239	226	208	208	226	228	195	199	184	212	224	207	218	231	222	238	231	238	225
2019	253	212	208	201	197	192	205	226	233	234	248	248	243	232	203	230	235	235	231	244	241	245	235	221	241	211	227	239	242	238	237
2020	233	222	235	234	237	235	237	210	223	228	243	227	213	236	222	211	227	239	227	218	237	231	226	206	222	239	205	197	200	221	220

CY	September																												
2018	207	221	225	220	232	218	230	231	230	225	220	232	218	230	217	229	236	240	227	229	201	198	203	230	208	237	231	229	215	209
2019	238	242	240	233	221	224	211	211	206	234	219	221	224	221	192	216	218	218	230	218	235	235	238	243	227	204	234	240	218	222
2020	201	234	242	244	233	223	227	227	226	231	225	232	217	203	220	184	204	228	219	217	181	207	220	223	229	236	224	237	220	222

CY	October																													
2018	235	233	235	233	228	240	228	240	231	242	240	243	234	216	234	217	200	233	224	219	213	238	241	201	230	226	224	233	240	238	238
2019	235	225	233	222	229	238	207	209	220	229	227	207	224	233	245	245	234	226	217	243	237	234	247	235	232	234	228	204	236	240	235
2020	218	225	208	230	235	226	228	226	201	219	201	216	238	231	226	225	214	232	232	232	234	213	219	228	228	210	233	234	239	217	227

CY	November																												
2018	240	230	223	229	232	234	241	218	213	221	226	235	237	236	235	224	223	235	238	235	224	198	227	224	231	235	228	224	232	219
2019	212	235	243	245	241	243	242	229	228	229	221	238	241	240	234	235	207	220	225	233	238	227	217	227	231	209	191	209	224	230
2020	235	245	246	244	224	241	235	233	238	242	211	231	237	238	214	238	231	231	234	235	236	238	204	232	231	222	228	198	219	226

CY	December																													
2018	227	233	229	236	236	237	236	229	230	233	234	237	235	229	223	222	219	230	226	205	227	220	223	228	200	214	225	217	215	212	207
2019	219	233	236	229	227	224	223	223	225	232	235	234	235	225	229	227	228	225	219	224	213	212	225	223	208	219	222	220	219	213	218
2020	228	222	219	225	229	229	225	227	209	217	223	211	225	218	220	224	230	221	221	231	223	227	207	221	215	225	220	219	223	225	224

Figure 12-2 July through December 2018 to 2020 Daily System Peak Load Intensity Chart

Analyzing the intensity charts for low load months, March and December have consistent low daily peak periods. Thus, they are the primary candidates for scheduling major generation outages considering only peak loads.

12.3 Scheduling Generation Outages: Energy-Shifting BESS Considerations

Figure 12-3 and 12-4 use the historical daily energy production from the Dandan Solar PV Plant to provide an insight into the Energy Production seasonality for future solar PV plus energy-shifting BESS.

Figures 12-3 and 12-4 are intensity charts for energy-shifted solar PV production. Blue tinted cells in the figures indicate lower than average daily energy production. This means that solar PV plus energy-shifting BESS systems would support less load and energy on those days. White tinted cells are days having moderate energy production. Red tinted cells indicate days of higher than average energy production. During these days, a solar PV plus energy-shifting BESS would provide greater support for loads. Note that from August 11 through 17, 2020, the Dandan facility was shut down for the whole day and for part of the day on August 18, 2020.

Observing figures 12-3 and 12-4, January would not be a good month to schedule a major generation outage and expect a large amount of support from solar PV plus energy-shifting battery energy storage systems.

March historical data shows high solar PV energy production for several consecutive days. This higher March energy production is consistent in three out of four fiscal years.

The months of July through November have volatile energy production having several strings of mixed high and low days throughout the month. They are not good candidates for generation outage scheduling.

March is a good candidate for both lower daily system peaks and high solar PV energy production.

CY	January																													
2017	119	119	94	128	128	90	145	140	107	107	96	109	108	131	117	93	96	75	98	122	142	93	122	118	122	74	127	127	123	116	110
2018	115	147	157	145	97	150	146	130	117	145	159	139	134	129	149	143	138	157	118	140	133	116	143	99	148	142	152	166	163	158	113
2019	111	156	129	130	84	148	152	126	136	115	112	123	158	160	119	83	118	104	88	111	111	103	133	132	83	120	96	60	108	125	120
2020	122	98	107	151	132	157	97	134	94	119	98	95	126	138	120	146	145	159	141	139	120	84	111	155	136	85	119	113	108	142	138

CY	February																											
2017	90	118	93	116	98	118	131	103	129	126	102	101	90	98	94	61	93	112	99	126	140	125	115	126	122	110	133	116	
2018	140	149	156	127	139	139	130	150	110	111	155	157	139	127	149	158	137	124	173	146	150	138	121	150	165	156	149	128	
2019	140	119	123	138	132	150	127	121	130	158	130	177	152	115	169	170	156	151	128	125	135	107	1	31	93	31	29	29	
2020	77	62	41	130	155	172	141	157	166	148	150	137	167	141	145	143	157	174	161	154	129	158	148	149	129	152	158	178	153

CY	March																													
2017	135	110	151	135	140	134	109	136	125	133	158	157	179	138	96	107	53	27	124	112	135	0	145	153	160	133	131	144	103	98	129
2018	148	169	152	159	126	163	172	173	184	188	186	184	166	162	165	170	185	168	151	172	164	158	145	161	123	180	121	182	118	118	128
2019	63	152	143	157	153	164	154	166	162	143	151	130	146	157	119	120	163	172	135	165	188	170	138	169	155	147	182	186	140	183	151
2020	119	113	142	162	160	178	189	193	168	183	189	153	139	173	191	176	155	148	159	173	100	156	180	181	162	147	160	136	168	164	163

CY	April																												
2017	108	138	133	130	128	121	135	136	149	135	135	133	139	125	137	130	134	134	144	150	134	149	126	61	105	106	131	141	142	139
2018	124	125	134	160	167	113	70	129	143	174	153	149	153	148	76	156	149	153	146	169	139	166	142	175	145	139	121	139	148	153
2019	161	119	170	135	103	151	171	176	184	170	168	174	167	149	160	150	154	178	187	179	175	152	150	169	131	167	163	160	146	146
2020	166	172	169	163	133	153	174	178	169	179	176	174	177	160	174	133	181	155	147	156	142	164	182	175	150	123	144	172	161	157

CY	May																													
2017	140	131	135	133	135	122	161	121	132	132	123	132	127	123	119	113	114	125	129	129	124	116	124	126	111	126	119	119	122	120	124
2018	62	147	164	145	155	153	151	148	141	147	147	118	137	174	155	163	99	104	166	177	158	120	165	181	160	164	153	154	132	159	153
2019	146	127	152	142	163	176	167	174	173	168	158	180	187	173	168	89	125	151	155	124	124	142	127	156	176	175	145	160	137	175	163
2020	145	112	170	167	135	155	151	146	176	141	35	185	172	158	143	122	58	147	180	145	164	166	163	158	168	147	153	175	182	120	113

CY	June																												
2017	134	138	139	119	111	123	132	145	118	139	113	142	137	135	131	120	132	120	50	33	120	112	122	117	85	102	117	93	51	143
2018	141	156	80	130	100	84	64	126	153	88	125	173	168	160	114	181	164	160	131	153	136	160	162	162	158	144	96	180	139	151
2019	156	155	124	155	157	164	171	146	134	169	149	140	156	159	162	153	158	171	162	159	115	148	144	145	149	163	154	156	161	150
2020	164	164	149	147	99	97	161	161	173	161	163	135	169	151	132	140	150	157	147	161	166	155	120	148	154	160	158	158	184	159

Figure 12-3 January through June 2017 to 2020 Daily Dandan Solar PV Facility Energy Production (MWH): Energy Production Intensity Chart

12.4 Scheduling Generation Outages: Demand Response (DR) Resources

GPA adopts Navigant's definition of demand response:

"Demand response in electricity is defined as load response called for by others and price response managed by end-use customers. Load response includes: direct load control, such as of residential air conditioners; partial or curtailable load reductions; and complete load interruptions. Those calling for load response include: independent system operators (ISOs), load serving entities (LSEs), and utility distribution companies (UDCs). Price response includes real-time pricing, dynamic pricing, coincident peak pricing, time-of-use rates and demand bidding or buyback programs.”[29]

CY	July																													
2017	133	79	81	133	99	81	119	132	128	88	113	116	130	132	131	67	64	128	92	131	123	139	89	136	148	85	132	127	143	103	130
2018	147	155	89	54	0	7	27	140	163	144	96	94	93	165	105	75	139	176	27	27	117	122	126	127	132	125	120	148	33	118	140
2019	128	158	159	119	99	143	175	177	86	161	122	150	135	145	126	118	176	125	85	103	160	138	164	24	160	117	150	128	55	139	162
2020	97	149	167	145	151	168	167	154	170	157	128	171	163	114	159	158	140	157	136	159	78	141	161	138	166	69	83	125	147	165	146
CY	August																													
2017	134	112	131	151	128	163	139	147	137	100	86	135	148	158	157	149	129	73	92	110	119	153	168	79	102	49	136	106	101	88	144
2018	73	19	87	32	106	116	151	131	102	139	113	114	144	101	99	64	142	110	31	47	16	131	169	73	160	115	114	176	149	145	116
2019	146	35	98	30	37	31	85	103	121	105	122	128	155	103	34	135	137	142	140	156	122	172	134	91	157	76	129	171	144	142	138
2020	166	106	143	125	155	157	156	85	142	138	0	0	0	0	0	0	0	24	108	125	171	188	117	84	171	184	85	86	91	177	121
CY	September																													
2017	168	165	169	114	180	173	148	68	15	93	175	147	70	129	115	150	117	157	175	88	152	174	145	40	92	133	144	180	184	127	
2018	103	163	163	136	160	125	169	153	150	20	0	121	80	100	153	155	140	39	107	148	47	53	70	145	37	147	150	116	116	92	
2019	170	169	112	148	80	95	50	89	83	144	81	88	95	62	8	96	86	93	139	105	146	165	147	153	121	37	157	143	79	95	
2020	86	175	163	168	162	140	149	154	166	122	151	172	17	78	111	18	82	151	101	165	20	152	162	138	183	169	107	143	84	117	
CY	October																													
2017	65	99	56	163	147	139	158	135	5	29	135	98	82	85	95	129	99	28	110	177	177	74	160	13	6	101	162	160	133	140	162
2018	143	160	175	151	137	161	163	152	139	153	99	156	127	59	134	103	42	155	104	106	154	146	163	63	84	118	158	154	162	156	154
2019	119	120	178	181	140	126	22	49	59	125	128	88	123	152	164	169	173	139	98	161	132	129	165	125	156	137	97	154	149	111	138
2020	128	127	129	150	174	111	140	97	36	135	36	136	154	149	102	90	119	143	134	156	158	112	119	143	140	66	131	140	117	70	141
CY	November																													
2017	25	33	152	127	133	133	135	133	115	101	40	142	149	88	58	153	132	127	140	138	141	126	124	128	149	139	147	146	114	79	
2018	154	103	105	136	128	154	178	58	125	160	139	156	175	171	139	110	131	149	134	155	138	57	130	136	148	152	124	125	148	95	
2019	66	131	170	140	90	142	96	142	128	145	77	173	176	178	119	156	51	109	145	152	133	127	93	130	127	83	10	105	129	132	
2020	136	163	148	147	70	119	156	123	149	154	46	128	143	146	115	156	121	123	156	172	165	150	54	116	124	132	126	56	116	111	
CY	December																													
2017	132	124	125	138	99	128	128	10	138	131	127	139	138	112	122	52	136	145	133	130	97	117	132	119	135	154	136	101	62	134	120
2018	143	138	89	121	120	124	0	128	140	101	95	116	96	118	129	117	89	114	117	27	107	103	109	123	74	108	139	122	131	133	125
2019	88	139	136	123	115	119	150	150	149	151	125	118	143	114	110	132	122	114	105	133	90	117	126	115	140	152	165	151	141	95	116
2020	111	112	125	129	129	135	120	118	77	101	155	152	157	114	115	129	133	117	138	139	152	138	112	133	132	130	131	110	143	139	159

Figure 12-4 July through December 2017 to 2020 Daily Dandan Solar PV Facility Energy Production (MWH): Energy Production Intensity Chart

GPA is the de facto Balancing Authority for Guam. Under NERC, the Balancing Authority is the responsible entity that integrates resource plans ahead of time, maintains demand and resource balance within a Balancing Authority Area, and supports interconnection frequency in real time.”[30]

[29] Navigant Consulting. (2003.). Blueprint for Demand Response in Ontario. URL: https://www.smartgrid.gov/files/documents/Blueprint_for_Demand_Response_in_Ontario_200308.pdf (Accessed January 1, 2021)
[30] North American Electric Reliability Corporation (NERC). (2012). Glossary of Terms Used in NERC Reliability Standards. URL: file:///C:/Users/jcruz/Desktop/Documents/--

Guam's Balancing Authority Area is the whole of Guam except for stand-alone islanded power systems, if any. A Balancing Authority Area is 'the collection of generation, transmission, and loads within the metered boundaries of the balancing authority. The balancing authority maintains load-resource balance within this area."[31] This means frequency and voltage control for the whole bulk power system.

12.4.1 Direct Load Control (DLC)

GPA is conducting feasibility studies for direct load control of customer appliances including but not limited to:

- Water Heater DLC Programs;
- Street Light Dimming Control;
- Energy-Shifting ESS for Large Demand Commercial Customers (Schedule P).

GPA has piloted direct control of water heaters in its Energy Efficient House Project for the University of Guam's Center for Island Sustainability/Sea Grant Office Building. GPA is working out the details to provide backhaul communications to control field devices using GPA's AMI Tier 1 radio mesh network or GPA's Tier 2 radio mesh network. Approximately 15 to 25% of residential energy use is for water heating.[32]

Table 12-1 shows the number of single-phase customers for rate schedule R, S, and G. The total number that potentially can be used toward a Hot Water Heater Demand Response Program is 48,118 customers. The eligibility requirements can be refined through a much smaller pilot project of a few hundred water heaters. Table 12-2 illustrates the first-year program costs. Table 12-3 shows the NPV of the Hot Water Demand Response Program if GPA paid for all front-end capex costs for the controller devices. Note that the Aquanta control devices already qualify for a $60 rebate under the Energy Sense Rebate Program. Therefore, it is not

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%20%20%20IRP%20Document/Document/Demand%20Response/pa_Stand_Glossary%20of%20Terms_glossary_of_terms.pdf (Accessed January 1, 2021)

[31] National Renewable Energy Laboratories (NREL). (2015). Balancing Area Coordination: Efficiently Integrating Renewable Energy into The Grid. URL: https://www.nrel.gov/docs/fy15osti/63037.pdf (Accessed January 1, 2021)

[32] National Renewable Energy Laboratories (NREL). (2001). Water Heating: Energy-efficient strategies for supplying hot water in the home. URL: https://www.nrel.gov/docs/fy01osti/26465.pdf (Last accessed January 09, 2021).

inconceivable to have customers share in the purchase of the devices. Table 12-3 assumes a ten-year program life.

Table 12-1. Potential Hot Water Heater Demand Response Program Candidates.

Rate	Description	Service Agreement Count
ERES-R	Electric Residential Schedule R	44,893
ESGS-S	Electric Small Government Service-Non-Demand -Schedule S	485
EGEN-G	Electric Small General Non-Demand -Schedule G	2,740
Total		48,118

Table 12-2. Potential Hot Water Heater Demand Response Program First Year Costs.

Item	Quantity	Unit Price	Units	Cost ($)
Hardware Cost (AQ-CA-E100-ESL-LS)	24,059	$ 113.00	$/Device	$ 2,718,667.00
Annual Fleet Service Fee	1	$ 51,868.00	Lot	$ 51,868.00
Non-Recurring Engineering Fees	1	$ 20,000.00	Lot	$ 20,000.00
L_G Integration	1	$ 50,000.00	Lot	$ 50,000.00
Contingency	1	$284,053.50	Lot	$ 284,053.50
Total First Year Cost				$ 3,124,588.50

Table 12-3. Potential Hot Water Heater Demand Response Program NPV Savings – Assumes 10-Year Program.

	Parameter	Amount
Project Cost PV	Aqanta Project Capex including contingency	$ 3,072,720.50
	Annual Recurring Cost (Fleet Service Fee)	$ 51,868.00
	Device Life (Years)	5
	Discount Rate (%)	7.0%
	Replace Field Devices at end of life	$ 3,072,720.50
	Project NPV Cost ($)	$4,847,404.83
Avoided Capacity	Avoided Capacity Cost ($/KW)	$1,446.00
	Avoided Capacity (KW)	12.03
GPA Benefits PV	Avoided Capacity ($)	$ 21,340,333.00
NPV Savings		$ 16,492,928.17

The Brattle Group report for the National Rural Electric Cooperative Association (NRECA) reports a 0.5 KW reduction per residential water heater for peak shaving.[33] GPA's single-phase residential customers comprise about 44,893 customers. Schedule G and Schedule S customers are nondemand government and commercial customers, respectively. Collectively, single-phase schedule S and G comprise 3,225 customers. Referring to Table 12-3, if 50% of single-phase R, G, and S customers had a direct controlled water heater, GPA may be able to shave up to 12.03 MW from system peak: a $16.5 MM avoided capacity cost. This assumes a use period of up to four (4) hours prior to returning the water heater to service. The Brattle Group report states that "a 50-gallon tank can be interrupted for up to four hours with little risk of running out of hot water."[34] For 80-gallon tanks, curtailment is possible up to 16 hours per day.[35]

A Demand Response Program with 50% subscription (23,000 water heaters) would cost approximately $3.0 MM for a three-year rollout and a recurring annual fleet management fee of

[33] The Brattle Group. (2016). The Hidden Battery: Opportunities in Electric Water Heating. URL: https://brattlefiles.blob.core.windows.net/files/7167_the_hidden_battery_-_opportunities_in_electric_water_heating.pdf (Last Accessed January 20, 2021) p. 15

[34] Ibid.

[35] Ibid.

$55,750 thereafter. The Aquanta Measurement & Verification report states that the use of the Aquanta controllers reduces annual customer energy usage for water heating by about 19% or 493 KWh.[36] Appendix F shows the economic feasibility of the program.

The addition of 5-pin or 7-pin Landis + Gyr Streetlight Controllers expands the use of the Tier 1 radio mesh to support distribution automation applications as well as streetlight dimming controls. The total coincident peak load for public streetlights is 1.13 MW[37]. A 5-pin streetlight controller supports dimming. The 4th and 5th pins are used for dimming when a LED fixture has the requisite dimming drivers. A 7-pin streetlight controller supports smart city and other future applications using the 6th and 7th pins. A 3-pin streetlight controller simply supports streetlight revenue metering and streetlight health information reporting. These controllers have been available from Landis+Gyr (Americas market) since June 18, 2018.

GPA's DSM section is investigating a program incentivizing installation of Energy-Shifting BESS (ES BESS) for Large Demand Commercial Customers to reduce demand charges. GPA should address incentivizing additional ES BESS capacity and energy as direct control demand response for use during peak management events and UFLS. For peak management events, the operation of these BESS can be staggered to cover several hours. Table 12-4 illustrates an example for a BESS supporting a 250 KW demand reduction and one-hour energy requirement.

12.4.2 Interruptible and Curtailable Load Resources

GPA interruptible and curtailable load resources include:

- The ability to place GWA facilities on back-up generation;
- Customers subscribed to a GPA Interruptible Load Program;
    - Customers agree to disconnect from grid upon GPA request and maintain their house loads on their back-up generation;
    - Customers agree to curtail their loads upon GPA request.

[36] Opinion Dynamics. (2021). Aquanta Measurement & Verification. Boston, MA. p. 1
[37] GPA Distribution Section. (2021). DPW StreetLight Count_08Jun2021 with pivot.xls

Table 12-4. Demand Reduction BESS Economics

Demand Charge Reduction (Hotels)

Parameter	Value
Nominal Discount Rate	7.00%
Monthly Discount Rate	0.58%
BESS Size (KW)	250
BESS Size (KWH)	256
BESS Life (years)	25
BESS Capital Cost ($)	$ 461,837.00
BESS O&M Cost ($/Month)	$ 416.67
Number of Compounding Periods	300
Demand Reduction (KW)	250
Demand Charge ($/KW)	$ 8.94
Monthly Demand Charges Savings ($/month)	$ 2,235.00
Demand Charges Savings - Nominal Dollars	$ 563,220.00
Avoided Capacity Cost ($/KW)	$ 1,446.00
Present Value of Demand Savings ($)	$ 316,223.23
GPA Avoided Capacity Cost ($)	$ 361,500.00
NPV Benefits($)	$ 677,723.23
NPV Costs ($)	$ (520,789.88)
Total NPV of Investment ($)	$ 156,933.35
Proposed Rebate Amount ($) - Low Considering Nominal Benefits, 10% of Capital Costs	$ 46,183.70
Proposed Rebate Amount ($) - Med Considering only Capital Costs	$ 100,337.00
Proposed Rebate Amount ($) - High Considering Total NPV Demand Savings versus NPV Costs	$ 204,566.65
Round-trip Charging cost not included. Depends on use pattern. Can be charged during excessive Solar PV events as part of Demand Response Program.	

GPA should create a dashboard for the top 25 large demand customers to keep track of candidates for the interruptible load program. This dashboard should be updated at quarterly. It should also be used to as part of the tool set for outage planning. Table 12-4 shows the resource characteristics for a large hotel on San Vitores Road for several periods throughout the day for everyday in September 2019. This particular hotel has a small standard deviation over each 6-hour range. This indicates demand consistency over these periods. This hotel would be a reliable and consistent resource for peak management.

12.4.2.1 Interruptible Load Resources: GWA Facilities on Back-Up Generation

The AGMETS and the GWA Engineering Division have discussed a general needs and scoping assessment for adding GWA facilities with back-up generation as a GPA demand response program.

The easiest implementation for demand response is to manually switch GWA facilities to back-up power in the anticipation of a peak management issue such as inadequate generation reserves. However, a manual implementation would not help support underfrequency load shedding events. It would also not prevent backflow issues when switching to backup power and back again to island power.

GWA and GPA should explore installing equipment to remotely transfer GWA facility power between island and backup generation power. GWA and GPA should install UFLS relays at these facilities as well. The addition of relay control and SCADA control allows use of GWA facilities with back-up generation as part of the first stage of underfrequency load shedding (UFLS) block displacing other customers to later UFLS stages. SCADA control would allow the transfer of these facilities to back to island power.

The manual, automatic, or remote-control transfer of GWA facilities to and from island power results in fluid backflows during the transition to and from back-up power. After transfer back to island power, GWA must expend additional time and money to pump these backflow volumes back up through its systems. Therefore, GWA and GPA should consider installations of an appropriate Uninterruptible Power System (UPS) or Battery Energy Storage System (BESS) to ride through these transitions. The GWA facility equipped with these devices would draw power from the UPS/BESS at all times preventing backflows.

In addition to preventing backflows during power source transitions, a UPS/BESS would also remediate voltage imbalances at the GPA point of interconnection (POI). The proposed study would also investigate other power quality or configuration/installation issues to determine the root causes of the many motor burn outs GWA has experienced.

Table 12-5. Peak 15-Minute Hotel Load over 6-Hour Periods Throughout the Day

Date	Peak 15-minute Load over Time Range (KW)			
	00:00-06:00	06:00-12:00	12:00-18:00	18:00-24:00
9/1/2019	654.72	770.88	802.56	820.48
9/2/2019	669.12	840.00	828.16	817.60
9/3/2019	720.96	823.68	778.56	790.72
9/4/2019	645.12	738.24	787.20	793.92
9/5/2019	620.16	792.00	793.60	828.16
9/6/2019	663.04	741.12	830.40	884.80
9/7/2019	648.00	819.52	814.08	852.16
9/8/2019	629.76	786.88	790.08	839.68
9/9/2019	627.84	784.00	818.56	858.24
9/10/2019	638.40	776.32	783.36	858.24
9/11/2019	664.00	825.28	828.16	879.36
9/12/2019	623.68	819.52	782.08	846.72
9/13/2019	666.88	801.60	844.80	870.40
9/14/2019	648.96	809.92	826.24	872.32
9/15/2019	671.04	868.80	853.12	868.80
9/16/2019	651.52	825.28	870.40	888.64
9/17/2019	695.68	842.88	844.48	857.28
9/18/2019	704.32	858.24	887.68	900.48
9/19/2019	690.88	846.40	820.48	856.32
9/20/2019	690.24	790.08	835.20	872.32
9/21/2019	669.12	821.76	823.36	867.84
9/22/2019	662.40	851.20	813.12	857.28
9/23/2019	651.84	832.96	808.32	868.80
9/24/2019	672.64	813.76	813.12	853.44
9/25/2019	676.80	833.92	815.68	844.80
9/26/2019	688.32	825.28	796.80	876.16
9/27/2019	670.08	810.88	838.08	871.36
9/28/2019	664.96	826.56	822.40	880.32
9/29/2019	655.36	796.48	781.12	847.68
9/30/2019	627.52	799.36	777.28	853.12
Average (KW)	662.11	812.43	816.95	855.91
Standard Deviation (KW)	24.14	30.59	26.86	25.22
Maximum (KW)	720.96	868.80	887.68	900.48
Minimum (KW)	620.16	738.24	777.28	790.72

The GWA facility online UPS should have the following features:

- On-Line Double Conversion;
- Dynamic Online Mode (up to 99% efficiency, higher reliability);
- Input/Output Voltage, 480 V;
- Transformer-Free Form Design;
- Lithium-Ion (Li-ion) Batteries;
- Modular Configuration.

GPA will work with GWA on a feasibility study that satisfies GPA's need for Demand Response resources as well as for GWA's requirements for better power quality beginning on the first quarter of FY 2022 including shared costs allocations.

12.4.2.2 Interruptible Load Program

GPA should re-establish[38] an Interruptible Load Program (ILP) aimed specifically for supporting major generation outages. Appendix F contains the summary information for the FY 2016 ILP.

Customers sign up to participate in a GPA Interruptible Load Program. Customers are compensated by GPA for their participation. Participating customers get paid a stand-by retainer when not actively providing the interruptible load service. When they disconnect from the grid or curtail their house loads, GPA pays them a variable charge for the energy.

Customers may provide two types of services as an ILP participant:

- Total Interrupted Load: customers agree to disconnect from grid upon GPA request and maintain their house loads on their back-up generation;
- Curtailed Interruptible Load: customers agree upon GPA request to reduce their house loads by a pre-agreed amount.

A well-resourced and managed GPA Interruptible Load Program is likely to have the greatest benefit during Ukudu Power Plant Steam Turbine outages.

12.4.3 Why not Air Conditioning Direct Load Control Programs

Many would consider it a no brainer for GPA to apply direct load control to residential and small commercial air conditioning. Air conditioning is the biggest end-use for GPA customers. However, GPA discussed this application with Siemens, GPA's UESC partner. Siemens advised: "there is no easy way to control most of the residential/light commercial ACs in Guam with the installed technology without smart local thermostats. At a minimum, if at all possible, a DR program would require smart thermostats and dedicated WiFi Internet connectivity at each location integrated with L&G's AMI."[39] Further discussions provided additional information:

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[38] In FY2016, GPA created an Interruptible Load Program (ILP) to support island loads after the explosion at Cabras 3&4.

[39] Discussions and emails between GPA and Siemen's Alex Ramos, PE.

"The issue mainly goes back to having an existing wired thermostat. Most installations of split systems in Guam utilize an infrared remote control. The program that's described in the link you provided swaps out an existing wired thermostat with a smart thermostat. In Guam, you would need to run wires direct to the unit (if it even allows it) to connect a smart thermostat. The ability to connect a thermostat via wires varies between manufacturers."

12.4.4 Customer Behavioral Load Shifting

Another means to reduce the impacts of excessive solar PV generation is to incentivize customers to shift energy-use into the daylight hours through time-of use rates and other incentives. Marketing this shift at times where there is a high probability of renewable energy oversupply is an option. Marketing programs shaping public energy by highlighting social responsibility may be used to engender this transition. Using the renewable energy rather than curtailing it is much preferable. Reducing BESS requirements for storing this excess energy helps GPA keep costs and rates down as well.

13 Capacity State - Probability Distribution Model for Energy Shifting Battery Energy Storage Systems (ES BESS)

GPA developed a capacity-state probability distribution model for energy-shifting BESS using historical daily production data for the Dandan Solar PV facility. Since the ES BESS will be charging from solar PV arrays during the approximately 12 hours of daylight, the daily average capacity for the system is the total energy (MWH) production during the day divided by the remaining 12 hours of night. The average capacity for any future ES BESS can be estimated using the following:

ES_BESS_MW = Dandan_Day_MW (ES_BESS_Annual_MWH / Dandan_Annual_MWH)

Where,

ES_BESS_MW = ES BESS Day Average Capacity (MW)

Dandan_Day_MW = Dandan Day Average Capacity (MW)

ES_BESS_Annual_MWH = ES BESS Annual Energy Production

Dandan_Annual_MWH = Dandan Annual Energy Production.

GPA does not consider the round-trip charge-discharge efficiencies in the model. GPA will bid ES BESS PPA's based on the inverter output. Therefore, the above relationships hold.

From the 2018 through 2020 Dandan data, GPA can construct several production models using:

- Average daily values;
- Minimum daily values;
- Maximum daily values.

For the generation reliability analysis, GPA will use the minimum production model. Table 13-1 shows the ES BESS Minimum Production Capacity-State-Probability Model for Phase III. The peak load carrying capability of the GPA system with Phase III is 341.4 MW at one day in 4.5 years LOLE. The system peak forecast for FY 2040 is 340 MW.

Table 13-1. ES BESS Normalized Capacity-State-Probability Model

Minimum Production Model		
State, k	**MW(k)**	**P(MW(k))**
1	-	0.010929
2	0.044	0.183060
3	0.429	0.051913
4	0.500	0.068306
5	0.571	0.133880
6	0.643	0.120219
7	0.714	0.169399
8	0.786	0.136612
9	0.857	0.106557
10	0.929	0.016393
11	1.000	0.002732

Table 13-1. ES BESS Phase III Capacity-State-Probability Model

Minimum Production Model		
State, k	**MW(k)**	**P(MW(k))**
0	-	0.010929
1	0.845	0.183060
2	8.320	0.051913
3	9.707	0.068306
4	11.094	0.133880
5	12.481	0.120219
6	13.867	0.169399
7	15.254	0.136612
8	16.641	0.106557
9	18.028	0.016393
10	19.414	0.002732
Phase III		

Table 13-2. ES BESS Phase III & IV Capacity-State-Probability Model

Minimum Production Model		
State, k	**MW(k)**	**P(MW(k))**
0	-	0.010929
1	3.826	0.183060
2	37.675	0.051913
3	43.954	0.068306
4	50.233	0.133880
5	56.512	0.120219
6	62.791	0.169399
7	69.070	0.136612
8	75.349	0.106557
9	81.628	0.016393
10	87.908	0.002732
Phase III & IV		

Table 13-3.   ES BESS Phase III, IV, & V Capacity-State-Probability Model

Minimum Production Model		
State, k	MW(k)	P(MW(k))
0	-	0.010929
1	6.807	0.183060
2	67.029	0.051913
3	78.200	0.068306
4	89.372	0.133880
5	100.543	0.120219
6	111.715	0.169399
7	122.886	0.136612
8	134.058	0.106557
9	145.229	0.016393
10	156.401	0.002732
Phase III, IV, & 5		

14 Using BESS to Improve GPA Reliability and System Stability

Energy-Shifting BESS (ES BESS) offers many potential benefits for GPA system reliability and stability including:

- Power for Customer Loads;
- Volt/Var Management;
- Spinning Reserve;
- Frequency Regulation;
- Contributions to System Peak Load Carrying Capability.

GPA can operate ES BESS to serve as additive loads by charging during the daytime during excessive solar PV events. This reduces the need for solar PV curtailment. It allows greater dispatch of synchronous generation to provide greater fuel efficiency and lower fuel costs. greater dispatch of Ukudu and other power plants increases the amount of available short-circuit current MVA to support system stability and greater grid strength.

Working in tandem with remote/auto start generation, The Hagatna, Talofofo, and Ukudu BESS can provide additional security against generation trips and solar PV dropouts. At the onset of generation drop-out, the BESS would discharge to arrest the system frequency decay. Having been configured to operate off a KF relay, reserve unit combustion turbine or diesel power plants with remote/auto start capability would immediately start and come up to full output to take over from the short duration BESS. GPA E&TS has suggested this mode of operation and submitted its implementation for funding since 2019. The System Impact Study for the Ukudu Power Plant confirms the efficacy of this arrangement. The System Impact Study recommends that the KEPCO Diesel Power Plant trip upon the trip of any Ukudu unit to arrest the frequency decay cooperatively with the Hagatna and Talofofo BESS. The report also recommends that upon trip of any Ukudu unit, the Ukudu BESS should immediately discharge power into the grid.[40]

14.1 GPA Renewable Energy Acquisition Requirements for Phase IV and Beyond

The following are the recommended requirements for GPA power purchase agreements bids for utility-scale renewable energy starting with Phase IV:

- Specify Annual Energy Supplied to GPA;
    - Transformer will be sized to nearest standard MVA accommodating average; Daily Energy divided by 12 hours;
    - Power output to grid limit of system limited to Transformer MVA;
- Utility Grid Support Functions;
    - Frequency Regulation;
    - Spinning Reserve Response;
    - Volt-Var Support;
- Provision to provide power during the day;
    - During Ukudu Power Plant 23-day steam turbine outage;
    - BESS continues to provide frequency regulation and spinning reserve;
    - Ability to provide power from the system from the solar PV Source bypassing the battery;
    - Ability to charge from grid if needed;
        - Excessive Solar PV Events;
- Interface with Grid Controller;
    - Plant Dispatch;
    - BESS Charge Management;
    - Curtailment;

[40] Electric Power Systems, Inc. (2019). Ukudu System Impact Study. Anchorage, Alaska.

    - Volt-Var Optimization;
    - Stability Optimization;
    - Excessive Solar PV Event Handling;
    - Cost Optimization;
- Provision of Synchronous Condenser Services (Bid $/KW and O&M costs;
    - Size of Synchronous Condenser to be determined by System Impact Study
    - Bid to Reference Specification of Twice the MVA of the Proposed Inverters.

14.2 GPA Spinning Reserve

It is a misstatement that GPA did not think of energy storage for intermittency. In 2009, GPA completed an energy storage feasibility study. The "killer apps" for GPA use of energy storage are spinning reserve and frequency regulation. A battery energy storage system (BESS) for spinning reserve and frequency regulation can counteract renewable generation intermittency. BESS reaction times to changes in frequency are very fast. GPA's Agana BESS can start injecting power into the grid within 200 milliseconds.

GPA's Phase I Energy Storage System Projects experience indicates that variable generation coupled with fast acting energy storage can improve the stability of the GPA power system.

GPA is eliminating the variability or intermittency in its future renewable integration acquisitions by requiring energy shifting battery energy storage systems (ES BESS) to store the variable output and make the renewable resource solidly dispatchable.

Each addition of ES BESS will contribute to frequency regulation and spinning reserve. This will eliminate almost all underfrequency load shedding and tighten the current +/- 0.15 Hertz BESS control of system frequency. Figure 14-1 shows the GPA system frequency control with and without the Agana/Hagatna ESS. Figure 14-2 shows the shaping and firming effect of the Talofofo BESS of the Dandan Solar PV plant output. Figure 14-3 shows that without the Talofofo BESS operating, the Agana BESS activates to stabilize system frequency despite a 21 MW PV dropout.

On August 3, 2021, GPA presented its renewable energy strategy, renewable integration experiences, and its vision for the future GPA power grid to engineering students from the University of Pittsburg, Mascaro Center for Sustainable Innovation. GPA provided this response to one of the attending students' questions:

“Many political pundits and commercial interests use people’s misperception that inverter-based generation is the same as synchronous generation. It is not. They differ in many different ways. It is up to the engineers to understand these differences and to take advantage of these differences. Inverter-based generation and synchronous generation have their various strengths. Look at what GPA did. GPA used the strengths of battery energy storage for spinning reserve. GPA has been truly innovative.”[41]

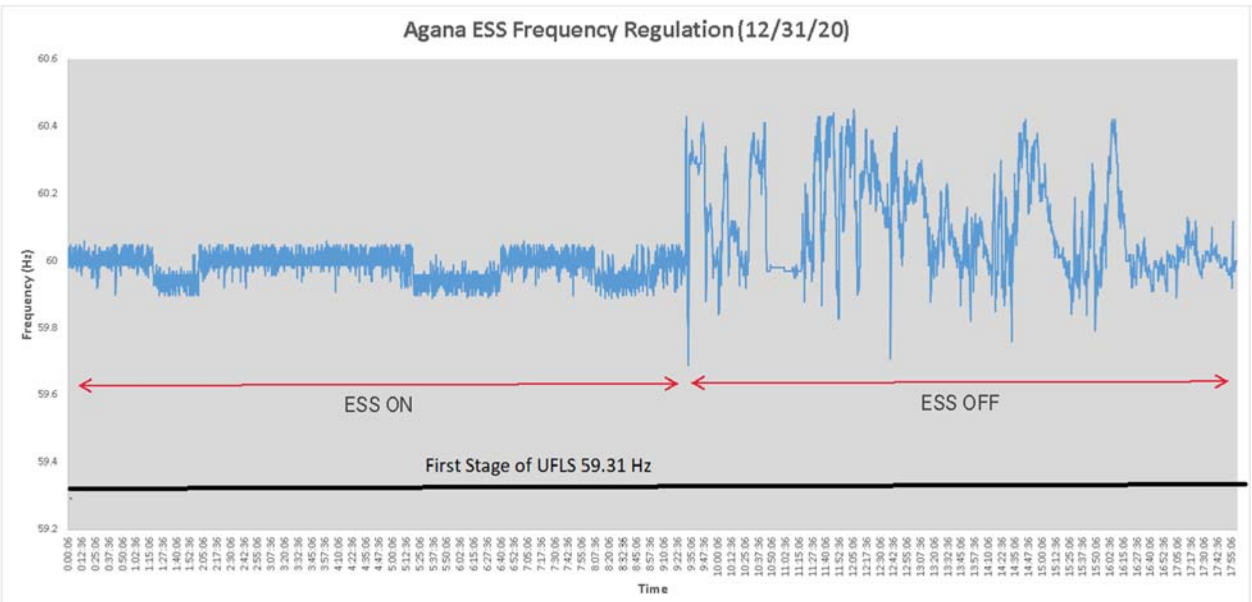

Figure 14-1. GPA System Frequency Regulation with and without Agana/Hagatna BESS

[41] John J. Cruz, Jr., PE response to University of Pittsburgh student question at GPA GM presentation to students.

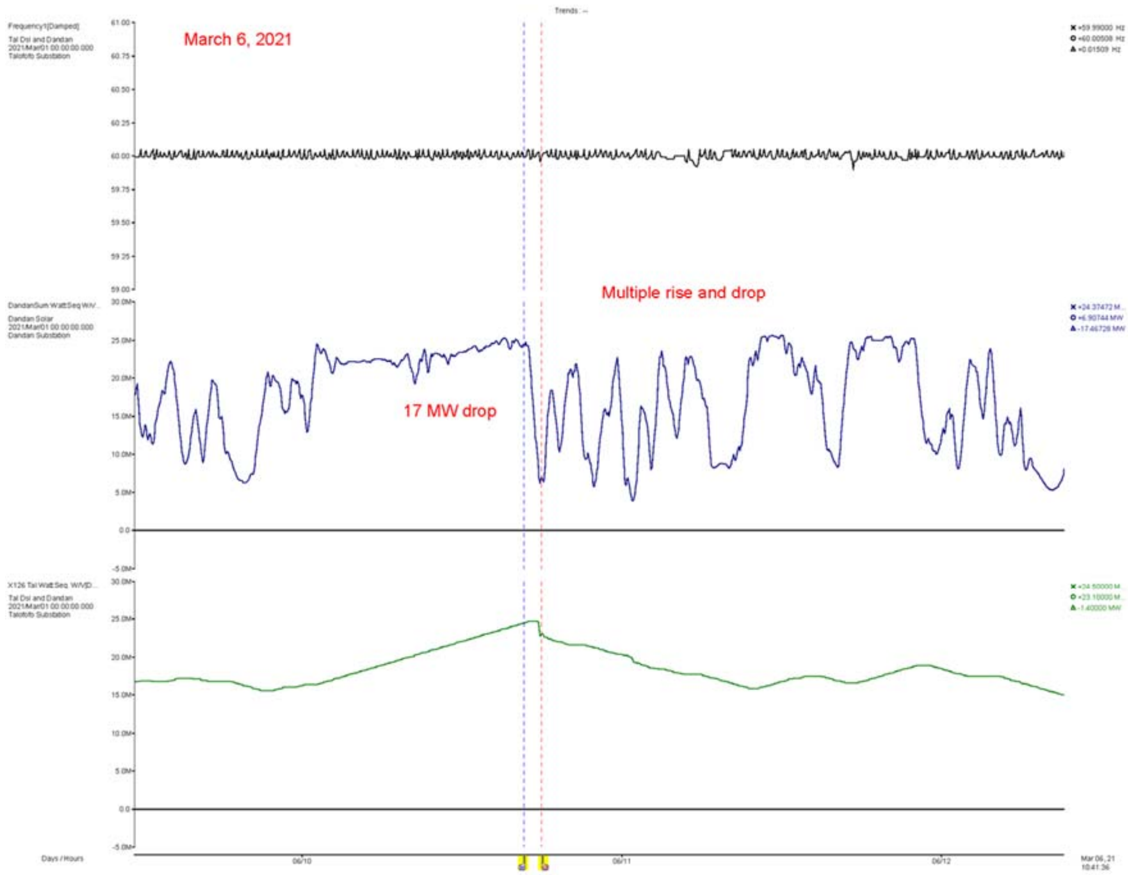

Figure 14-2. Talofofo BESS Smoothing Solar PV Plant Intermittency and Dropouts

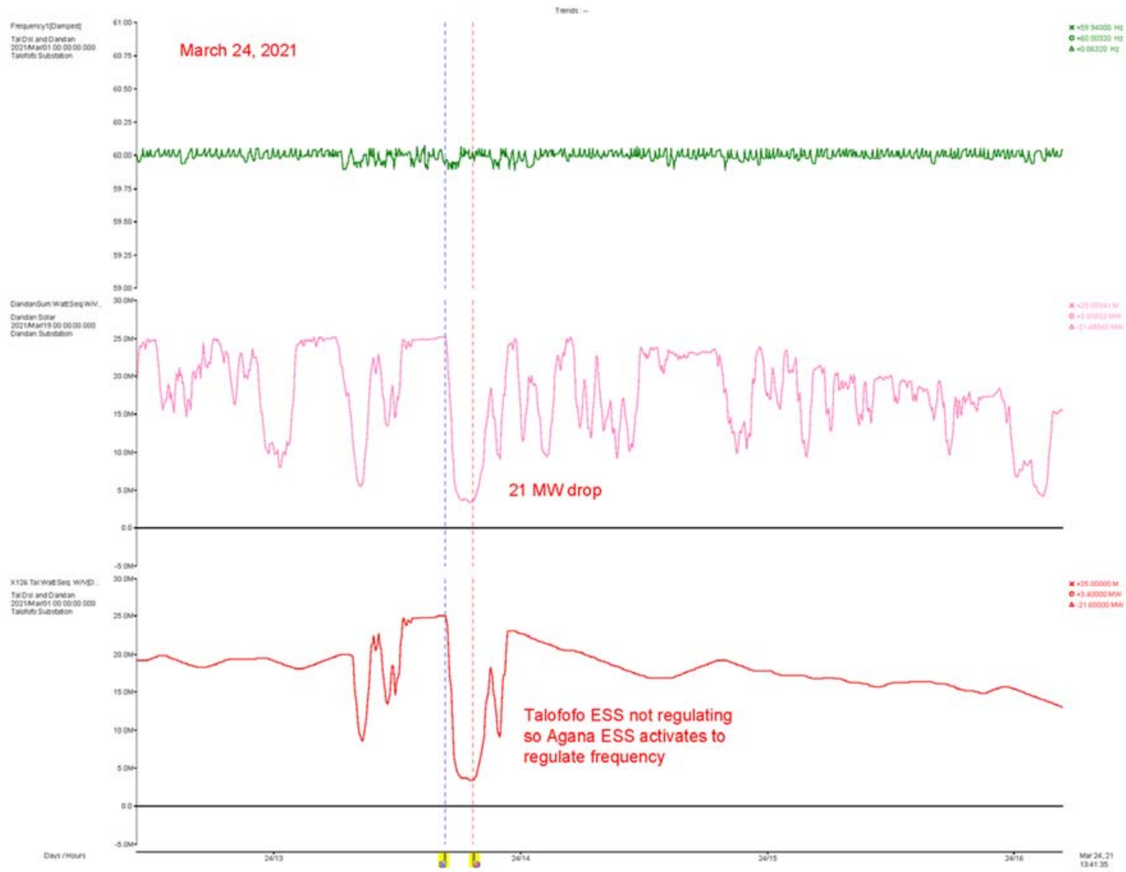

Figure 14-3. Talofofo BESS not Operating. Agana BESS activates to Smooth Frequency

14.3 BESS and Remote Start/Autostart Power Plants

The Ukudu System Impact Study recommends that on the trip of large generation units suach as those at Ukudu that the Ukudu BESS immediately start injecting power into the grid to arrest system frequency decay as well as for the KEPCO diesel and other fast start power plants start up automatically to ensure that the spinning reserve batteries do not completely discharge and to more quickly manage the post-transient recovery period.[42] The System Improvement Study (Renewable Integration Study) also recommends placing fast start power plants on remote start/stop/autostart.[43] GPA should also consider autostart synchronous condensers to support system voltages during this period as well.

[42] Electric Power Systems, Inc. (2020). Ukudu Power Plant System Impact Study. Anchorage, Alaska.
[43] Electric Power Systems, Inc. (2020). System Improvement Study. Anchorage, Alaska.

14.4 GPA Renewable Energy Acquisition Roadmap

Economics and system reliability and stability should decide the levels of renewable penetration for the GPA grid as GPA has made the commitment to transform its grid and grid operations to allow for high penetration of renewable energy. All future utility-scale renewable energy projects providing intermittent, variable output power must provide energy-shifting BESS. GPA must execute the recommended system improvement projects so that only economics and not technical concerns limit the penetration of renewable energy on the GPA system. For this report, solar PV is a proxy representing all renewable technologies. GPA's renewable energy acquisition program is technology neutral as required by the Guam Public Utilities Commission. Proponents have submitted proposals for geothermal and wind-based renewable energy. However, the first Wind Project awarded could not meet the commercial operation date sunset provision and the contract was terminated. The other non-solar PV bids were much higher than the awarded contracts and rejected.

Figures 14-1 through 14-5 show the Energy Capacity Targets for future GPA renewable energy bids for low and high forecasts and meeting a 50% renewable energy production by 2030 and 100% by 2040. The Annual Energy Block (MWh) is the energy requirement for the aggregate bid. Phase IV and Phase V bids each will award one contract for the full Annual Energy Block. Phase VI will award two contracts for half of the Annual Energy Block each.

Phase V and VII operate as slack procurements where the amount of energy bid for can be decreased or increased as needed to meet the renewable portfolio standards (RPS) targets. But GPA must plan generation retirements carefully and ensure there are sufficient resources to support the Ukudu Power Plant steam turbine outage in 2028/29.

Table 14-1. Roadmap to 50% Renewable Energy – Low Load Forecast

FY 2030 Low Load Forecast

Parameter	Value
2030 Gross Energy Production (MWH)	2,019,492.80
NEM + GPA PPAs	451,559.44
Minimum Phase IV & V (MWH)	558,186.96
Percent Renewables	50.00%
Target	50.00%
Objective Function	0.00%

Phase	Annual Energy Block (MWH)	Target COD	FY 2030 MWH
Phase IV (MWH)	300,000.00	2025 Dec 31	289,645.97
Phase V (MWH)	300,000.00	2029 Dec 31	300,000.00
FY 2030 Total MWH			589,645.97

Table 14-2. Roadmap to 50% Renewable Energy – High Load Forecast

FY 2030 High DC Load Forecast

Parameter	Value
2040 Gross Energy Production (MWH)	2,160,380.68
NEM + GPA PPAs	451,559.44
Minimum Phase IV & V (MWH)	628,630.89
Percent Renewables	50.00%
Target	50.00%
Objective Function	0.00%

Phase	Annual Energy Block (MWH)	Target COD	FY 2030 MWH
Phase IV (MWH)	300,000.00	2025 Dec 31	289,645.97
Phase V (MWH)	350,000.00	2029 Dec 31	350,000.00
FY 2030 Total MWH			639,645.97

Table 14-3. Roadmap to 100% Renewable Energy – Low Load Forecast

FY 2040 Low Load Forecast

Parameter	Value
2040 Gross Energy Production (MWH)	2,143,329.57
NEM + GPA PPAs	999,248.85
Minimum Phase IV & V (MWH)	1,144,080.72
Percent Renewables	100.00%
Target	100.00%
Objective Function	0.00%

Phase	Annual Energy Block (MWH)	Target COD	FY 2030 MWH
Phase VI (MWH)	575,000.00	2035 Dec 31	555,154.78
Phase VII (MWH)	600,000.00	2039 Dec 31	600,000.00
FY 2040 Total MWH			1,155,154.78

Table 14-4. Roadmap to 100% Renewable Energy – High Load Forecast

FY 2040 Low Load Forecast

Parameter	Value
2040 Gross Energy Production (MWH)	2,284,589.35
NEM + GPA PPAs	999,248.85
Minimum Phase IV & V (MWH)	1,285,340.64
Percent Renewables	100.00%
Target	100.00%
Objective Function	0.00%

Phase	Annual Energy Block (MWH)	Target COD	FY 2030 MWH
Phase VI (MWH)	575,000.00	2035 Dec 31	555,154.78
Phase VII (MWH)	750,000.00	2039 Dec 31	750,000.00
FY 2040 Total MWH			1,305,154.78

Table 14-5. GPA Renewable Acquisition Projects: Phase IV through VII

Target Fiscal Year	Renewable Energy Production Target (%)	Forecast	Phase IV MWH/year (One Contract)	Phase V MWH/year (One Contract)	Phase VI MWH/year (Two Contracts)	Phase VII MWH/year (Two Contracts)
2030	50%	Low	300,000.00	300,000.00		
		High	300,000.00	350,000.00		
2040	100%	Low			575,000.00	600,000.00
		High			575,000.00	750,000.00

Note: Phase VI & VII award two contracts at half the annual MWH/year each.

14.5 Addition of Energy-Shifting Battery Energy Storage Systems (ES BESS) Improvements to System Peak Load Carrying Capability

Table 14-6 shows the peak load carrying capability of the GPA system with each addition of energy-shifting energy storage systems. The Table stops at the addition of Phase IV. At that point, the additions of Phase III and IV improve the base case system PLCC to 364.45 MW and present an opportunity for legacy generation retirement and conversions of some of them to synchronous condensers (combustion turbines).

Table 14-6. PLCC Improvements with the Addition of Energy-Shifting BESS

Energy-Shifting BESS Additions to Baseline System	Installed Capacity (MW)	PLCC (MW)	Reserve Margin (%)		Reserve (MW)
			PLCC	Installed Capacity	
Base Case	530.27	330.75	60.32%	37.63%	199.52
Phase III	549.68	341.46	60.98%	37.88%	208.22
Phase III + IV	618.00	360.32	71.51%	41.70%	257.68
Phase III + IV + V	686.67	367.28	87.05%	46.54%	319.39
Phase III + IV + V + VI	818.00	372.78	119.44%	54.43%	445.23
Phase III + IV + V + VI + VII	955.00	377.78	152.79%	60.44%	577.22

The asymptotic behavior of PLCC computed for later additions of solar PV plus energy-shifting battery energy storage systems may be due to modeling all phases of Solar PV + ES BESS as one generation facility. The takeaway of this exercise is that additions of ES BESS-based renewable energy generation will add greater reliability to the GPA system out past the forecasted load for 2040.

The IRP although having a planning horizon of twenty years is really about making decisions within the first ten-year period. Technology advances will greatly change what is possible. The hype media and lobbyists will spin tales about what can be done now based on technologies that have some development in front of them to make them realistic commercial choices. GPA has a mandate to provide affordable, reliable power. It is our responsibility. GPA's strategy has been to ride the technology capability curve up while riding the cost of technology curve down. This is a responsible, sustainable strategy.

14.6 Legacy Plant Retirement PLCC Impacts with Phase III & IV ES BESS

Table 14-7 shows the impacts of retiring legacy generation plant on peak load carrying capability after the addition of Phase III and IV solar PV plus energy-shifting battery energy storage systems.

Table 14-7. Legacy Plant Retirement PLCC Impacts with Phase III & IV ES BESS

Legacy Power Plant Retired	Legacy Generation EAF (%)	Retired Capacity (MW)	Installed Capacity (MW)	PLCC (MW)	Reserve Margin (%)		Synchronous Generation Reserve (MW)
					PLCC	Installed Capacity	
Base Case No ES BESS	90.0%	0	530.27	330.75	60.32%	37.63%	199.52
+ Phase III	90.0%	0	549.68	341.46	60.98%	37.88%	199.52
+ Phase III + IV	90.0%	0	618.00	360.32	71.51%	41.70%	199.52
+ Phase III + IV - MacYigo	90.0%	40	578.00	328.62	75.89%	43.14%	159.52
	95.0%			349.75	65.26%	39.49%	
+ Phase III + IV - Piti7	90.0%	40	578.00	331.52	74.35%	42.64%	159.52
	95.0%			352.35	64.04%	39.04%	
+ Phase III + IV - DedCT	90.0%	44	574.00	325.65	76.26%	43.27%	155.52
	95.0%			346.01	65.89%	39.72%	
+ Phase III + IV - Piti 8&9	90.0%	80	538.00	292.66	80.42%	44.57%	119.52
	95.0%			315.48	70.53%	41.36%	
+ Phase III + IV + V - Piti 8&9	95.0%	80	607.00	319.48	90.00%	47.37%	119.52
+ Phase III + IV + V + VI - Piti 8&9	95.0%	80	738.00	325.19	126.94%	55.94%	119.52
+ Phase III + IV + V + VI + VII - Piti 8&9	95.0%	80	875.00	331.05	164.31%	62.17%	119.52

Note that improving legacy plant availability significantly improves PLCC by a little more than 20 MW.

15 Sustained Outages of the Ukudu Power Plant on GPA Generation System Reliability

The steam turbine maintenance for the new Ukudu Power Plant is expected every four to five years after commissioning while the plant is operating on ultra-low sulfur diesel (ULSD) fuel. When converted to natural gas, the intervals will be every six to seven years. The duration of the steam turbine outage is approximately 23 days. The Ukudu steam turbine outage is the worst case planned major generation outage.

The steam turbine outage at the Ukudu Power Plant will require the gas turbine units to be offline or operated as simple cycle units within the permittable annual emissions limit. The analysis performed in sections 12.2 and 12.3 indicate that March is the best candidate for the Ukudu steam turbine outage. March has consistent low daily loads across a four-year historical period coinciding with high solar PV energy production energy-shifting potential. However, the plant is not obligated to commit to outages within this period and maintenance schedules are subject to recommendations and maintenance requirements of the applicable original equipment manufacturers of the various components of the facility. Insofar as possible, GPA should work with KEPCO to schedule steam turbine outages within March to minimize potential problems with system power supply and stability.

The Ukudu Power Plant Energy Conversion Agreement (ECA) restricts the scheduling of a major overhaul of the Reserve Facility for the Ukudu Power Plant coinciding with the steam turbine outage to avoid the significant loss of available generation capacity. This is a major contractual element to ensure that sufficient generation resources will be available for this outage.[44]

Simple cycle operation of the gas turbines at the Ukudu Power Plant significantly impacts the operation limits based on the proposed minor source air permit with 100 tons emission per year per pollutant. The emission rate of nitrogen oxides (NOx) in a gas turbine simple cycle mode is about 18 times more than the operation of each combined cycle unit, both at maximum output, and has the greatest impact on operation limits.

A one-hour operation of a simple cycle gas turbine at maximum output reduces the available production hours of the combined cycle plant by 6.25 hours with each combined cycle unit operating at maximum output or equivalently is an 18.75-hour reduction of a single combined cycle unit at its maximum output. Emissions limits are based on a twelve-month rolling period.

For a 23-day steam turbine outage, running one Ukudu gas turbine in simple cycle mode reduces the Ukudu power plant available permit hours by 3,450 hours. This is not practical. Therefore, a steam turbine outage will likely force an outage of the whole power plant (198 MW). This is the worst-case scenario. Not running the plant at full output could buy GPA additional run hours for the year.

15.1 Ukudu Steam Turbine Outages and Maintaining Short Circuit Ratio

GPA must have at least 750 MVA of Synchronous Generation Short Circuit MVA to keep the system stable and ensure that inverter-based generation can operate. This applies to the GPA system at the addition of the Phase II Solar PV projects. [45]

With all three combustions and the steam generator online, the Ukudu Power plant can provide up to 990 Short-Circuit MVA. Ukudu can provide 750 Short-Circuit MVA with two

[44] **SPORD to provide Contract citation**
[45] Electric Power Systems, Inc. (2018). Guam Power Authority System Improvement Plan for Renewables. Anchorage, Alaska. Table 5-1.

simple cycle units and the steam turbine online with a minimum load of 79.2 MW. The minimum load with three gas turbines is 118.5 MW. However, the efficiency is better using two gas turbines at that load and below. Therefore, GPA may as required make some accommodation with KEPCO on the operation of their plant to provide SC-MVA as they have contract guarantees for plant efficiency.

As more NEM and GPA inverter-based generation systems are connected to the grid, GPA will have to operate synchronous condensers along with the Ukudu Power Plant. With increasing renewable inverter-based generation, fewer synchronous generation will operate and provide short-circuit contribution. GPA will become increasingly reliant on synchronous condensers to provide grid stability and short circuit current. At some point as does Kauai Island Utility Cooperative, GPA will operate with synchronous condensers and all renewable energy.[46]

A steam turbine outage will likely force an outage of the whole power plant (198 MW). Thus, other generation would need to support the required Short Circuit Ratio requirement. A minimum 150 MW of total non-Ukudu generation is required to be online at all times. GPA may have to curtail daytime solar PV or employ other mitigation strategies during the Ukudu steam turbine outages to meet the minimum dispatch requirements for these non-Ukudu generation units. Other strategies include disconnecting the inverters of solar PV plants without energy-shifting capability at night. This will decrease the amount of Short Circuit MVA required. As long as inverters are connected to the grid they affect the SCR requirements.[47,48]

One drawback with legacy generation such as Piti 8&9 is the high minimum loads that these units have to maintain. As greater renewable energy inverter-based generation is integrated into the grid, these high minimums will force these synchronous generation units offline or lead to significant curtailment of inverter based systems. Ivan Matek, a former GPA marine engineer, brought a potential solution for allowing Piti 8&9 to operate at 25% to 30% of their maximum continuous rating (MCR). This would allow additional headroom to potentially keep Piti 8&9 to supply SC-MVA.

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[46] Fernandes, M. (2019). KIUC tests grid with solely renewable generation. https://www.bizjournals.com/pacific/news/2019/12/17/kiuc-tests-grid-with-solely-renewable-generation.html (Last Accessed July 4, 2021)

[47] Phone call between John J. Cruz Jr., PE and David Burlingame, PE.

[48] North American Electric Reliability Corporation (NERC). (2018). Short-Circuit Modeling and System Strength. URL: https://www.nerc.com/pa/RAPA/ra/Reliability%20Assessments%20DL/Short_Circuit_whitepaper_Final_1_26_18.pdf. (Last accessed June 22, 2018).

In response to questions regarding low load operation, Brian Jensen from Burmeister & Wain Scandinavian Contractor A/S (BWSC) replied that "there are different options for low load operation - depending on whether it will be a (somewhat permanent solution), or it should be able to go back up to 90-100% load at times." [49]

Depending on the scenario there are different possibilities, such as:

- "Turbocharger cut out
- "Rematching of the engine/turbocharger, to operate optimized at for instance 25% load.
- "Including EPL (Engine Power Limitation) system."[50]

The following other options must be checked if they were developed for the 90-bore:

- EcoCam
- EcoNozzle.[51]

Furthermore, "if GPA decides to operate at this low load, electronic Cylinder LO System would be strongly required (as you otherwise would overlubricate heavily, which would be even worsened by operating on ULSD)."[52]

Figure 14-1. KUIC Tesla Solar Power Plant (left). GPA AGMETS tours facility (right) (2017)

[49] Jensen, B. (2021). Burmeister & Wain Scandinavian Contractor A/S (BWSC) email response.
[50] Ibid.
[51] Ibid.
[52] Ibid.

16 FRONTIER: Building Resiliency

GPA is a participant in the two-year, federally funded FRONTIER project. FRONTIER stands for "Framework for Overcoming Natural Threats to Islanded Energy Resilience." This section summarizes the project's core purpose, its long-term goals, project schedule, and current threat scenario models, and analytical results.

This section and subsections discusses the preliminary results presented by the FRONTIER Team at the June 10, 2021 (ChST) GPA Local Advisory Group Workshop. At the end of the two-year grant period, the FRONTIER Team will issue a final report and provide GPA access to the online decision support tools to evaluate strategic investments in power system reliability and resilience.

The United States Department of Energy under the umbrella of its Energy Transitions Initiative funded this project in response to multiple states and territories expressing: "the need for technical assistance as they seek to improve the resilience of energy systems in response to an evolving threat and hazard environment."[53] The project's long-term goal is to provide "access to online, decision support tools to assist utility planners and policymakers as they consider investments in power system reliability and resilience."[54]

The FRONTIER Project is led by "Lawrence Berkeley National Laboratory and Argonne National Laboratory, along with partners at Carnegie Mellon University and Northern Arizona University,"[55] and "two demonstration site partners, Alaska Power and Telephone (AP&T) and Guam Power Authority (GPA)."[56] Table 16-1 shows the Project Timeline. Figure 16-1 shows the FRONTIER Project Leads by organization.

16.1 FRONTIER Project Core Purpose

The FRONTIER Core Purpose is to provide technical assistance in improving energy system resilience to states and territories in the face of evolving threats and hazards by

[53] National Renewable Energy Laboratory (NREL). (2020). FRONTIER Project Fact Sheet. p 1.
[54] Ibid, p.1.
[55] Ibid, p.1.
[56] Ibid, p.1.

developing and providing access to online decision support tools to assist utility planners and policymakers evaluate strategic investments in power system reliability and resilience.[57, 58]

16.2 FRONTIER: FRONTIER Local Advisory Group (FLAG)

The FRONTIER Project is advised by the FRONTIER Local Advisory Group (FLAG) comprised of Guam Stakeholders. Table 16-2 lists the FLAG members. FRONTIER has conducted two FLAG workshops (January 15, 2021 & June 10, 2021 ChST).

16.3 FRONTIER: GPA Subject Matter Expert (SME) Panel

A deep, experienced panel of GPA subject matter experts (SMEs) supports the FRONTIER Project (Table 16-3). This panel provides information, reviews information from the technical team, validates assumptions and models against their own analyses modeling and observed operational experience.

Table 16-1. Project Timeline

Project Milestones	Dates
Establish Project Management	Summer 2020
Initial Stakeholder Engagement	Fall 2020
Data Gathering and Scenario Design	Fall 2020
Electric Grid Disruption Modeling	Fall 2020 / Winter 2021
Power Restoration Modeling	Winter 2021 / Spring 2021
Model Supply Chain Interdependencies and Ancillary Information	Summer 2021
Create Database of Resilience Options (Costs and Benefits)	Summer 2021
Customer Surveys to Estimate Direct Costs of Power Outages	Fall/Winter 2021
Develop Community Support Index	Fall/Winter 2021
Release of Alpha-version of FRONTIER Tool	Summer 2022

[57] Ibid. p. 1
[58] Liz Craig. (2021). GPA Local Advisory Group Workshop (June 10, 2021 ChST). FRONTIER Project: Frontier Workshop 6.8.21_GPA.pptx. slide 6

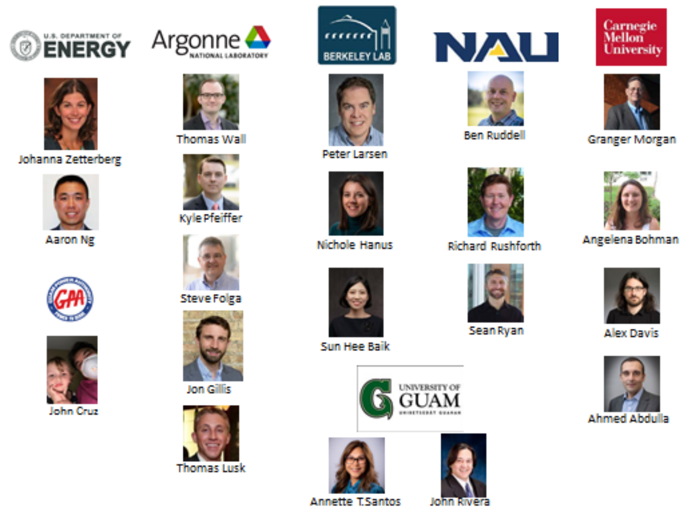

Figure 16-1 FRONTIER Organizational Leads

Table 16-2. FRONTIER Local Advisory Group (FLAG) Membership

Name	Title	Organization
Arlene M. Aromin, P.E.	Utilities Director	Naval Facilities Engineering Command, Marianas
Victoria K. Zialcita, P.E.	One-Guam Electric Program Coordinator	Naval Facilities Engineering Command, Marianas
Allison R. Rutter, P.E.	Regional Energy Program Manager	ARE Department, J4; Joint Region Marianas
Warren White	Installation Energy Manager (IEM)	Naval Base Guam
Donald Tilton, PhD	Installation Energy Manager (IEM)	Anderson Air Force Base/CTR USN PACAF 36 CES/CEC
Catherine S. Castro	President	Guam Chamber of Commerce
Mary Rhodes	President	Guam Hotel & Restaurant Association (GHRA)
J. Austin Shelton III, Phd	Executive Director	UOG Center for Island Sustainability Office of Research & Sponsored Programs
Annette T. Santos, DBA	Dean / Associate Professor of Management	School of Business & Public Administration, University of Guam
John J. Rivera, PHd	Assistant Professor; Chair for the University of Guam's MPA Program	School of Business & Public Administration, University of Guam
Rebecca J. Respicio	Director	Guam Energy Office
Mayor Melissa B. Savares (Dededo)	President	Mayors Council of Guam
Ambrosio Constantino, MPA	Disaster Program Manager	American Red Cross Guam Chapter

Table 16-3. GPA Subject Matter Expert Panel

	GPA Subject Matter Expert (SME)	Title	Organization
Engineering	Joven G. Acosta, PE (electrical)	Manager, Engineering	E&TS/Engineering
	Irwin B. Loyola, PE (electrical)	Engineering Supervisor	E&TS/Engineering/Substation
	Vincent J Sablan, PE (electrical)	Engineering Supervisor	E&TS/Engineering/Distribution
	Louis C. Camacho, PE (electrical)	Engineer III	E&TS/Engineering/Distribution
	Antonio S. Gumataotao	Right of Way Supervisor	E&TS/Engineering/Real Estate
Strategic Planning & Operations Researcch Division (SPORD)	Jennifer G. Sablan, PE, CEM (mechanical)	Manager, SPORD	E&TS/SPORD
	Lorraine O. Shinohara, PE, CEM (electrical)	Engineering Supervisor	E&TS/SPORD/Strategic Planning & Energy Contracting (SPEC)
	Roel A. Cahinhinan, PE, CEM, GICSP (electrical)	Engineering Supervisor	E&TS/SPORD/System and Smart Grid Planning (SASGP)
	Francis J. Iriarte, PE, CEM (mechanical)	Engineering Supervisor	E&TS/SPORD/Demand-Side Management & Green Programs
	"Paz" Maria A. Tison, PE, CEM (mechanical)	Special Projects Engineer	E&TS/SPORD/Strategic Planning & Energy Contracting (SPEC)
	Albert N. Florencio	Engineer III	E&TS/SPORD/Fuel Planning & Operations
Information Technology	Melvyn K. Kwek, CISA, GISCP	Chief Information Technology Officer	E&TS/Information Technology Department
	Michelle S. Castro, Security +	Information Security Administrator	E&TS/Information Technology Department/Information Security
	Eileen Bihag	Database Administrator	E&TS/Information Technology Department/Applications Support
PIO	Patricia Long Diego	Communications Manager (A)	Public Information Officer
E&TS	John J. Cruz Jr., PE, CEM	Assistant General Manager, Engineering & Technical Services (AGMETS)	E&TS

16.4 FRONTIER: Guam Threat Scenarios

The FRONTIER Project developed the following threat scenarios with Guam Power Authority and the Guam FLAG:

- Earthquake Threat
  - Magnitude 7.8 Earthquake
  - Tsunami of 2.13 m (7 ft 0 in), non-destructive
  - Ground motion
  - Earthquake-induced landslides and liquefaction
- Tsunami Threat
  - Postulates a general inundation area using HAZUS based upon assumed parameters
  - 1849 earthquake (M7.5) generated maximum wave depths in Guam estimated at 6.1m (~20 ft).
  - Focused on tsunami to approach from west (generated by 9+ or greater magnitude earthquakes in Japan or Alaska)

- Typhoon Threat
    - Evaluated use of historic and/or potential future typhoons, selected Typhoon Paka (1997) as basis for scenario
    - Peak wind gusts measured 171mph (Apra Harbor), 236 mph (Andersen AFB)
- Fuel Supply Chain Disruption
    - Threat/hazard agnostic disruption to inbound fuel supply
    - Assumes full reliance on available on-island fuel inventories
    - Affects generation at fossil-based generation facilities, ranging from:
        - Widespread blackouts
        - Regional brownouts, demand management
        - Degraded power quality.

Although Fuel Supply Chain Disruption is not a natural disaster, the potential for and consequence severity level supported its inclusion.

16.5 Fuel Supply Chain Disruption

Although Fuel Supply Chain Disruption is not a natural disaster, the potential for and direct and consequential impacts raised this threat scenario to critical importance. This section and subsections draws liberally and heavily from the work of Steve Folga and Tom Lusk of Argonne National Laboratory.

16.5.1 Preliminary Fuels Supply Chain Analysis for Guam Power Authority (GPA)[59]

This preliminary analysis is based on public data and data provided by GPA. It is subject to revision after receipt of additional GPA data on fuel contracts and contingency planning scenarios. This analysis incorporates information provided at virtual meetings with GPA and visits to the Energy Information Administration (EIA) and GPA websites.

Public information on GPA's petroleum generating stations includes:

- GPA's electricity is generated mainly from burning residual fuel oil (RFO) and ultra-low sulfur diesel (ULSD) fuel;

[59] Steve Folga and Tom Lusk

- The majority of Guam's electricity is generated by four base-load generators burning heavy residual fuel oil (RFO);
- GPA uses Ultra-Low Sulfur Diesel at its combustion turbines and medium speed diesel plants;
- GPA has awarded significant solar PV power purchase agreements to meet the Guam RPS goal of 50% of energy production from renewable or carbon neutral sources;
- GPA will convert its 88 MW Piti 8&9 slow speed diesel power plant to use ULSD;
- GPA will move away from using RFO at its petroleum-fired power plants and towards using ULSD and natural gas.

Tables 16-5 and 16-6 provide information on GPA's current fuel contracts.

16.5.2 Storage and Fuel Contracts for GPA Power Plants

GPA has approximately 80 days of residual fuel oil storage for power plant operations including:

- Over 500 thousand barrels of residual fuel oil storage at the GPA Bulk Fuel Storage Facility in Piti;
- Day tank fuel storage at Cabras 1&2 and Piti 8&9.

GPA has approximately 40 days of low sulfur residual fuel oil (1.19% S) and 40 days of high sulfur residual storage (2.00% S) in the two Bulk Fuel Storage Facility tanks (1934 & 1935). GPA must keep two grades of RFO to comply with USEPA Cabras-Piti Area Intermittent Control Strategy (CPAICS).[60] "Under the CPAICS, the GPA is allowed to use higher sulfur fuel at its Cabras-Piti facility whenever 15-minute average wind direction and wind speeds are within acceptable limits. Outside these acceptable limits, the GPA must use LSFO. This arrangement saves ratepayers approximately $3.5 million annually [2006 dollars]."[61] After the Ukudu Power Plant is online, GPA will no longer use RFO and the Bulk Fuel Storage Facility tanks will store

[60] Cornell Law School. (). 40 CFR § 69.11 - New exemptions. URL: https://www.law.cornell.edu/cfr/text/40/69.11#a_3_i (Accessed June 12, 2021)
[61] Pacific Power Association. (2006). United States of America Insular Areas Energy Assessment Report. URL: https://www.doi.gov/sites/doi.gov/files/migrated/oia/reports/upload/U-S-Insular-Area-Energy-Assessment-Report-2006.pdf. p. 42.

up to 80 days of ULSD specifically for the Ukudu facility. The Ukudu facility will also have storage capacity for 30-days ULSD supply.

GPA rents 190 thousand barrels for ULSD storage from Tristar. GPA also maintains diesel storage at each of its petroleum-fueled generating stations where:

- Each generator has typically 3-days of onsite storage without refueling;
- The storage tanks at each power plant are topped-off each day.

Table 16-4. GPA Petroleum-Fired Power Plants

Group	Power Plant	Technology	Commissioned	Original Nameplate Capacity (MW)	Capacity Deration (MW)	Primary Fuel	Notes
Legacy Generation	Cabras 1&2	Steam Turbine	1974, 1975	132	110	RFO	**2024 Retirement**
	Piti 8&9	Slow Speed Diesel	1999	88	88	RFO	
						ULSD	**2021 Conversion**
	Dededo CT 1&2	Simple Cycle Industrial Combustion Turbine (Frame 5)	1992, 1994	46	46	ULSD	
	Macheche CT	Simple Cycle Aeroderivative Combustion Turbine (LM2500)	1993	22	20	ULSD	
	Yigo CT	Simple Cycle Aeroderivative Combustion Turbine (LM2500)	1993	22	20	ULSD	
	Piti 7	Simple Cycle Industrial Combustion Turbine (Frame 6)	1998	40	40	ULSD	
	Talofofo 1&2	Medium Speed Diesel	1993	8.8	8.8	ULSD	
	Manengon (MDI) 1&2	Medium Speed Diesel	1994	10	10	ULSD	
	Tenjo #1, 2, 3, 4, 5, 6	Medium Speed Diesel	1993	26.4	26.4	ULSD	
NEW	Ukudu Power Plant	Combined Cycle Industrial Combustion Turbine	2023/2024	198	198	ULSD, Natural gas	
	KEPCO Power Plant	Medium Speed Diesel	2023/2024	39	39	ULSD	

Group	Power Plant	Street Address	City	Territory	Latitude	Longitude
Legacy Generation	Cabras 1&2	322 Cabras Highway	Piti	GU	13.3949	144.7071
	Piti 8&9	180 Cabras Highway	Piti	GU	13.46319	144.68957
	Dededo CT 1&2	Marine Drive (Route 1) Lot 10122	Dededo	GU	13.51573	144.85174
	Macheche CT	Harmon Loop Road (Route 27)	Dededo	GU	13.51074	144.82689
	Yigo CT	Lot 7054-5, Route 1	Yigo	GU	13.54461	144.89285
	Piti 7	178 Cabras Highway	Piti	GU	13.46292	144.68846
	Talofofo 1&2	Route 4A, Parcel A	Talofofo	GU	13.35306	144.75243
	Manengon (MDI) 1&2	Lot#5, Block 17	Yona	GU	13.41962	144.74985
	Tenjo #1, 2, 3, 4, 5, 6	Lot 19, Tract 2411, Off Route 2A, Tenjo Vista	Santa Rita	GU	13.40458	144.68168
NEW	Ukudu Power Plant		Dededo	GU		
	KEPCO Power Plant		Piti	GU	13.46116	144.68529

Tables 16-7 provides information on GPA's current fuel storage tank contracts. Table 16-8 provides information on GPA bulk fuel tanks at GPA Power Plants.

Table 16-5. GPA ULSD Fuel Contracts

Diesel Fuel Oil No.2 Supply Contract

Contract Number	Contract Period	Contract Status	Mode of Delivery	Contractor/ Supplier	Fixed Premium Fee Cost ($/gal)								
					Bulk Supply	Yigo Dsl (Aggr)	Yigo CT	Macheche CT	Dededo CT	Piti 7	Baseloads	MDI	Talofofo
GPA-047-21	Jan 2022-Dec 2023	Under Solicitation*	Ocean Tanker	TBD	TBD								
GPA-008-18	Jan 2024-Dec 2024	3rd of 3 Yr Extn	Road Tanker	IP&E Guam				$0.230	$0.230				
GPA-008-18	Jan 2024-Dec 2024	3rd of 3 Yr Extn	Road Tanker	Mobil Oil Guam		$0.240	$0.240			$0.228	$0.273	$0.273	$0.273
GPA-008-18	Jan 2023-Dec 2023	2nd of 3 Yr Extn	Road Tanker	IP&E Guam				0.227	0.227				
GPA-008-18	Jan 2023-Dec 2023	2nd of 3 Yr Extn	Road Tanker	Mobil Oil Guam		0.235	0.235			0.224	0.268	0.268	0.268
GPA-008-18	Jan 2022-Dec 2022	1st of 3 Yr Extn	Road Tanker	IP&E Guam				$0.224	$0.224				
GPA-008-18	Jan 2022-Dec 2022	1st of 3 Yr Extn	Road Tanker	Mobil Oil Guam		$0.231	$0.231			$0.219	$0.262	$0.262	$0.262
GPA-008-18	Jan 2020-Dec 2021	2 Yr Base	Road Tanker	IP&E Guam				$0.221	$0.221				
GPA-008-18	Jan 2020-Dec 2021	2 Yr Base	Road Tanker	Mobil Oil Guam		$0.226	$0.226			$0.215	$0.257	$0.257	$0.257

Table 16-6. GPA RFO Fuel Contracts

Residual Fuel Oil No.6 Supply Contract

Contract Number	Contract Period	Contract Status	Mode of Delivery	Contractor/ Supplier	Fixed Premium Fee ($/MT)	
					2.00% HSFO	1.19% LSFO
GPA-050-20	Sep 2023-Aug 2025	2Yr Extn (Optional)	Ocean Tanker	Hyundai	71.690	124.690
GPA-050-20	Sep 2020-Aug 2023	3 Yr Base	Ocean Tanker	Hyundai	71.690	124.690

Table 16-7. GPA Fuel Tank Lease Contracts

RFO Tank Lease

Contract Number	Contract Period	Contract Status	Storage Capacity (bbls)	Contractor/ Supplier	Annual Fee $/Yr
TTGI-SA-2013	Sep 2021-Aug 2022	4th of 4 Yr Extn	422,150	Tristar	$1,933,820.14
TTGI-SA-2013	Sep 2020-Aug 2021	3rd of 4 Yr Extn	422,150	Tristar	$1,859,442.44

(a) Residual Fuel Oil (RFO) Tank Lease Contracts (Tristar)

ULSD Tank Lease

Contract Number	Contract Period	Contract Status	Storage Capacity (bbls)	Contractor/ Supplier	Annual Fee $/Yr
TTGI-SA-2018-01	Jan 2023-Dec 2023	5th Yr Extn	392,000	Tristar	Under negotiation
TTGI-SA-2018-01	Jan 2019-Dec 2022	4 Yr Extn	196,000	Tristar	$1,176,000.00

(b) Ultralow Sulfur Diesel (ULSD) Fuel Oil Tank Lease Contracts (Tristar)

Table 16-8. GPA Fuel Storage Tanks at Power Plants

Plant Fuel Storage Tanks

A. LSFO (at 100% LSFO burning)

Name of Plant	Description	Tank No.	Type	Nom. Dia. ft-in	Nom. Height / Length ft-in	Tank Capacity (barrels)	Tank Capacity (gallons)	STORAGE CAPACITY (Tank Capacity x 80% Pumpable contents) (barrels)	STORAGE CAPACITY (Tank Capacity x 80% Pumpable contents) (gallons)
Cabras 1 & 2	Daytank	DT-2	Vert	45-00	39-00	10,000	420,000	8,000	336,000
Piti 8 & 9	Daytank	TA-FO-05	Vert	45-00	39-00	10,000	420,000	8,000	336,000
	Service Tank	TA-FO-03	Vert	20-00	19-00	1,000	42,000	800	33,600
TOTAL PLANT LSFO						**21,000**	**882,000**	**16,800**	**705,600**

B. HSFO (at 100% MSFO burning)

Name of Plant	Description	Tank No.	Type	Nom. Dia. ft-in	Nom. Height / Length ft-in	Tank Capacity (barrels)	Tank Capacity (gallons)	STORAGE CAPACITY (Tank Capacity x 80% Pumpable contents) (barrels)	STORAGE CAPACITY (Tank Capacity x 80% Pumpable contents) (gallons)
Cabras 1 & 2	Daytank	DT-1	Vert	45-00	39-00	10,000	420,000	8,000	336,000
Piti 8 & 9	Daytank	TA-FO-04	Vert	45-00	39-00	10,000	420,000	8,000	336,000
	Service Tank	TA-FO-02	Vert	20-00	19-00	1,000	42,000	800	33,600
TOTAL PLANT HSFO						**21,000**	**882,000**	**16,800**	**705,600**
TOTAL PLANT RFO						**42,000**	**1,764,000**	**33,600**	**1,411,200**

C. Diesel

Name of Plant		Tank No.	Type	Nom. Dia. ft-in	Nom. Height / Length ft-in	Tank Capacity (barrels)	Tank Capacity (gallons)	STORAGE CAPACITY (Tank Capacity x 80% Pumpable contents) (barrels)	STORAGE CAPACITY (Tank Capacity x 80% Pumpable contents) (gallons)
Cabras 1 & 2 (Bsld)	Daytank	DT-1	Vert	20-00	22-11	1,286	53,998	1,029	43,198
Piti 8 & 9 (Bsld)	Daytank	TA-LO-05	Vert	13-00	15-00	1,000	42,000	800	33,600
Piti 7	Daytank	DT-1	Vert	31-00	23-00	3,215	135,026	2,572	108,021
	Service Tank	ST-1	Hor	08-02	36-06	332	13,930	265	11,144
	Service Tank	ST-2	Hor	08-02	36-06	332	13,930	265	11,144
Dededo CT	Raw Tank	Tk 110	Vert	33-00	26-00	3,943	165,613	3,155	132,490
	Purified Tank	Tk 120	Vert	33-00	26-00	3,943	165,613	3,155	132,490
Macheche CT	Raw Tank	Tk 110	Vert	24-11	23-11	2,081	87,406	1,665	69,925
	Raw Tank	Tk 120	Vert	24-11	23-11	2,081	87,406	1,665	69,925
	Purified Tank	Tk 130	Hor	10-00	39-04	528	22,167	422	17,734
	Purified Tank	Tk 140	Hor	10-00	39-04	528	22,167	422	17,734
Yigo CT	Raw Tank	Tk 120	Hor	12-00	35-00	695	29,190	556	23,352
	Purified Tank	Tk 130	Hor	10-00	39-05	527	22,120	421	17,696
	Purified Tank	Tk 140	Hor	10-00	39-05	527	22,120	421	17,696
Yigo Diesel (Aggreko)	Raw Tank	Tk 110	Hor	12-00	35-00	695	29,190	556	23,352
Tenjo FT	Service Tank	Tk-1	Hor	12-00	35-00	697	29,253	557	23,402
	Service Tank	Tk-2	Hor	12-00	35-00	697	29,253	557	23,402
	Daytank	Tk-3	Vert	26-00	32-00	3,014	126,579	2,411	101,263
Talofofo FT	Daytank	1	Hor	12-00	35-00	694	29,157	555	23,326
Manengon (MDI) FT	Daytank	DT-1	Vert	13-00	50-00	1,187	49,874	950	39,899
	Daytank	DT-2	Vert	13-00	50-00	1,187	49,874	950	39,899
	Daytank	DT-3	Vert	13-00	50-00	1,187	49,874	950	39,899
	Service Tank	ST-1	Hor			119	5,000	95	4,000
TOTAL PLANT DIESEL						30,494	1,280,740	**24,395**	**1,024,592**
TOTAL PLANT FUELS							@ 80%	**57,995**	**2,435,792**

16.5.3 Fuel Distribution into Guam

Guam has no fossil energy resources and meets nearly all of its energy needs with imported petroleum products. In 2019, about 31% of the petroleum consumed on the island was motor gasoline and 28% was jet fuel. Diesel—used mostly to generate electricity— accounted for about 24%, residual fuel oil's share was 15%, and propane made up the remaining 2% of the island's petroleum consumption. Most petroleum products are imported from Asian countries.

Largest percentage of oil imports comes from Singapore (37%), followed by Japan (23%) and South Korea (18%). Figure 16-2 shows the 2019 Refined Petroleum Product Import Costs into Guam. Table 16-9 shows the various sea shipping transit times from various Asian ports to Guam. Figure 16-3 shows the maritime routes to Guam from various Asian ports. The size and width of the arrows indicates the relative value of imported product volume from these ports.

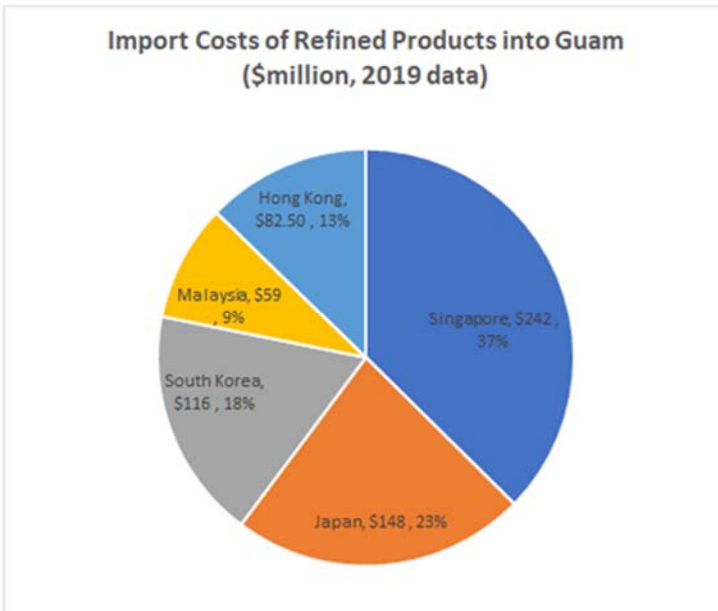

Figure 16-2. 2019 Refined Petroleum Product Import Costs into Guam

Table 16-9. Sea Shipping Transit Times to Guam

Sea Shipment Times After Cargo Loading	
Origin	Transit Time to Guam
Asia	4 - 6 days
Hawaii	7 days
West Coast	13 days

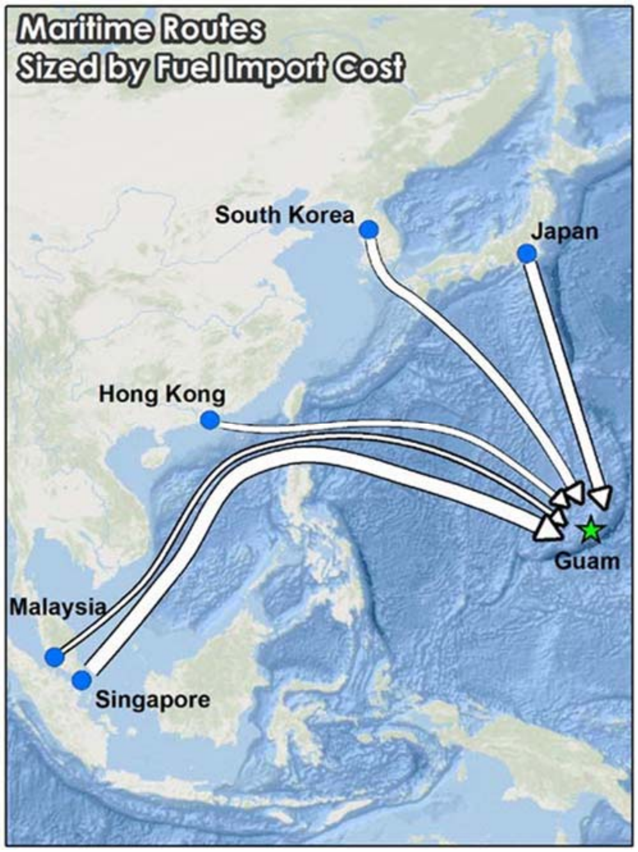

Figure 16-3. Maritime Routes to Guam from Various Asian Ports

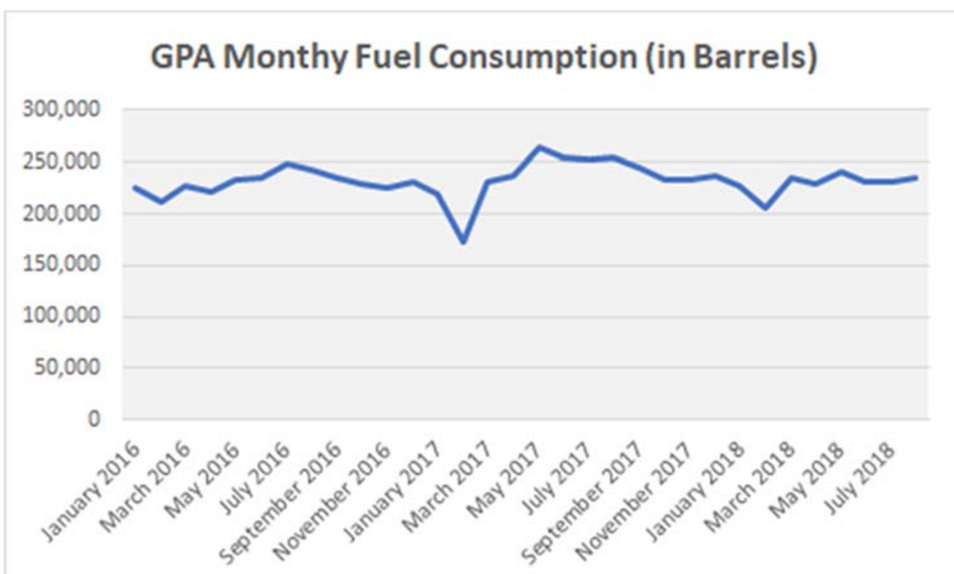

Figure 16-4. GPA Monthly Fuel Consumption (January 2016 to July 2018)

GPA's average monthly fuel consumption from 2016 to 2018 was approximately 230 thousand barrels: minimum of ~173 thousand barrels, maximum of 263 thousand barrels. Figure 16-4 indicates the GPA Monthly Fuel Consumption from January 2016 to July 2018.

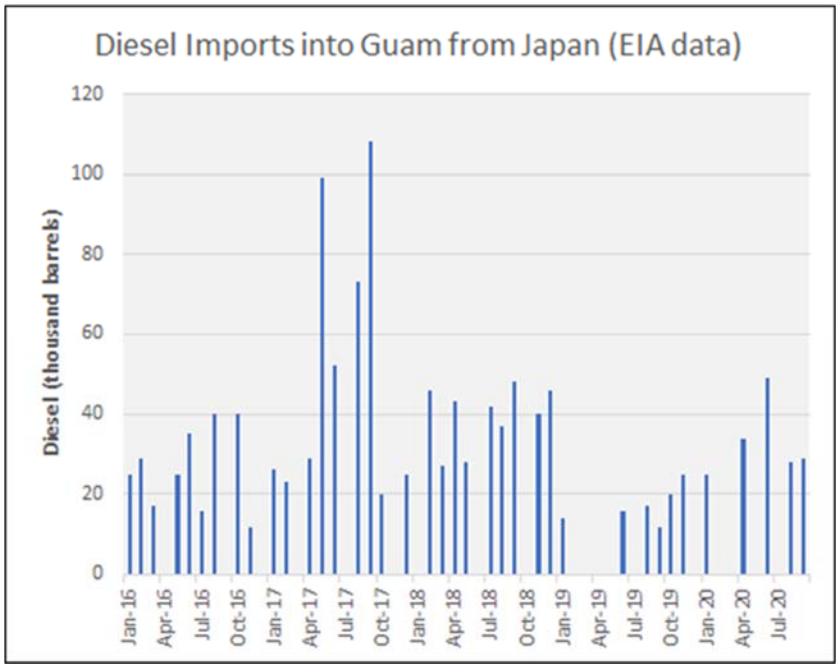

Figure 16-5. Diesel Imports into Guam from Japan (EIA data)

Figure 16-5 shows diesel imports from Japan into Guam from January 2016 to July 2020. EIA import data indicates that diesel fuel shipments from Japan occur on a routine basis during summer months:

- Nearly every month;
- Lower frequency of shipments during winter;
- Average monthly shipment of 34.3 thousand barrels (~1.4 million gallons).

Guam's gasoline suppliers receive their shipment of oil once a month, from Singapore refineries. In fiscal 2014, Mobil brought in 1.8 million barrels of oil to Guam. Additionally, Shell (IP&E), 76 and two other suppliers brought more than 5 million barrels of oil into Guam.

EIA import data shows that all petroleum products are shipped through Guam's only port, located at Apra.

16.5.4 Apra Harbor

The Jose D. Leon Guerrero Commercial Port in Apra Harbor is the only commercial seaport in the Territory of Guam and the primary seaport in Micronesia. The Port's 50-acre marine industrial terminal consists of oil tanks and pipelines, warehouses, a cement silo, and light-gauge sheds. Figure 16-6 illustrates the fuel receiving infrastructure at the Port of Guam

Liquid bulk fuels from Mobil Oil Guam Inc. from the Golf Pier marine transfer facility ("Golf Pier") are delivered to its respective storage tanks at the Mobil Cabras Terminal. Similarly, liquid fuels are transferred from Berth F-1 via terminal pipelines to the Cabras Distribution Terminal (SPPC/IP& E Lot 2 Tank Farm). Two other petroleum companies unload their products at F-1 Pier; South Pacific Petroleum Corporation (SPPC) distributing the 76 brand and Isla Petroleum & Energy Holdings, LLC. (IP&E) representing the Shell brand.

Figure 16-6. Fuel Receiving Infrastructure at the Port of Guam

16.5.5 Bulk Fuel Facilities in Guam

There are five bulk fuel storage facilities in Guam, located near Apra port. Table 16-10 identifies these facilities and their characteristics. These do not include Department of Defense fuel facilities.

Table 16-10. Five Bulk Fuel Storage Facilities Operating in Guam

Characteristics of the Five Bulk Fuel Storage Facilities Operating in Guam

Plant Name	Owner	Street Address	City	State	Contents	Number Tanks	Capacity (barrels)	Latitude	Longitude
GPA Bulk Fuel Storage Facility	GPA, operated by IP&E	East Shore of Agra Harbor	Piti	GU	RFO	2	536,000	13.46110	144.68620
Tristar Agat Terminal	Tristar Guam	Agat Terminal Route 2a, Sta. Rita Industrial Drive	Agat	GU	Gasoline, diesel, jet fuel, LPG	25	4,200,000	13.41980	144.69016
Cabras Distribution Terminal (SPPC/IP& E Lot 2 Tank Farm)	IP&E	1118 Cabras Highway	Piti	GU	Gasoline, diesel, jet fuel	2 or 6?	150,000	13.46364	144.66415
Mobil Cabras Terminal - Tank Farm A	Mobil Oil Guam	1180 Cabras Highway	Piti	GU	Gasoline, diesel	7	N/A	13.46520	144.66305
Mobil Cabras Terminal - Tank Farm C	Mobil Oil Guam	1180 Cabras Highway	Piti	GU	N/A	5	215,000	13.46407	144.66300
Tristar Terminals Guam Inc F-1 Fuel Pier	Tristar Guam	F1 Pier Tract 2411	Piti	GU	Gasoline, diesel, jet fuel, LPG	2	N/A	13.45988	144.66145

Tristar Agat terminal is one of the largest fuel storage terminals in the world, covering 237 acres and with a storage capacity of 4.2 million barrels. These tanks are connected to the nearby port oil jetty through 8 kilometers of pipeline.

GPA resupplies its Bulk Fuel Storage Facility using fuel stored at the Tristar Agat Terminal. These LSFO and HSFO storage tanks have a total capacity of 422,150 barrels. GPA uses them as holding tanks for fuel shipments prior to testing for quality and compatibility. GPA sells the excess fuel stored at the Agat Terminal to third parties for fuel oil bunkering purposes. The GPA Bulk Fuel Storage Facility also has a 5,000-gallon diesel fuel tank for the pump station.

Generally, the fuel holding capacity on Guam is in excess of 30 days of supply for all types of petroleum fuels, much less than GPA's fuel reserve capability for its use.

16.5.6 RFO Supply Chain for GPA Facilities

GPA Bulk Fuel Storage Facility has two aboveground storage tanks designated as Tanks 1934 and 1935. Each tank has a design capacity of 268,000 barrels (11.2 million gallons). Note, the design capacity is greater than the actual useful storage provided as some of the fuel at the bottom cannot be pumped out by the installed pumps.

GPA Delivery Pump Station delivers residual fuel oil going out of the GPA Bulk Fuel Storage Facility to two GPA power generation units via a combination of underground and supported aboveground pipelines:

- Cabras 1&2 (6-inch steel pipeline);
- Piti 8&9 (6-inch steel pipeline).

Until its retirement in January 2015, Tanguisson Power Plant received RFO via an 8-inch steel pipeline from the Bulk Fuel Storage Facility.

GPA is building a new ULSD and natural gas pipeline from the Bulk Fuel Storage Facility to the Ukudu Power Plant in mostly the same rights-of-way as the pipeline to Tanguisson. Additionally, GPA is completing an upgrade and construction of new ULSD fuel pipeline infrastructure from the Bulk Storage Tank Facility to Piti 8&9 and Piti 7 Power Plants. The Bulk Storage Tank Facility will be converted entirely for ULSD service when Ukudu Power Plant is commissioned (2023). GPA will no longer use RFO at that point.

Figure 16-7. GPA Bulk Fuel Storage Facility
(Delivery Pump Station located adjacent to the site office)

16.5.7 ULSD Supply Chain for GPA Facilities

No. 2 diesel fuel is one of the most common fuel source for standby power generation and often used for peak power generation by GPA and startup fuel for Cabras 1&2 and Piti 8&9. Diesel fuel for GPA power plant operations is provided by two sources:

- IP&E;

- Mobil Guam.

Figure 16-8 shows the most-likely road routes taken by tanker trucks to resupply the GPA power plants. Table 16-11 lists the ULSD provider fuel supply locations.

After the Cabras 3&4 Power Plant explosion in August 2015, resupply of GPA medium speed diesels and combustion turbines was a logistical nightmare. SPORD was in constant contact with ULSD suppliers and PSCC personnel to figure out the logistical issues. One of the largest issues was that both ULSD suppliers did not have sufficient fuel tank capacity to support GPA fuel needs whenever GPA took its large generator units down for maintenance outages such as one of the Cabras Steam Turbines or the Piti/MEC 8&9 slow speed diesels. Additionally, fuel tankers and tanker truck drivers are in limited supply on Guam. Furthermore, tanker truck drivers must adhere to safety regulations that limit the amount of time they are on the road as well as very strict penalties and enforcements against alcohol and drug use.

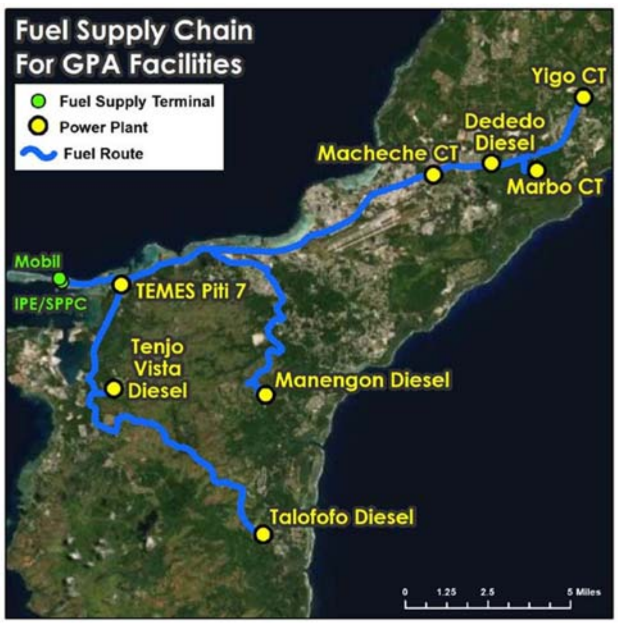

Figure 16-8. Most-Likely Road Routes ULSD Resupply
by Tanker Trucks to GPA Power Plants.

As a result of these experiences, GPA now keeps a lease agreement with Tristar for 190 thousand barrels of ULSD storage. Additionally, the Ukudu Power Plant will have a tanker truck loading gantry to shorten the refueling time for northern medium speed diesels and combustion turbines. This ameliorates the northern generation refueling delays experienced by tanker trucks due to road closures for repairs or for Guam Liberation Day (July 21) parades.

Table 16-11. ULSD Fuel Supply Locations

GPA Power Plant	Fuel Supply Location
Dededo CT	SPPC/IP&E Lot 2 Tank Farm
Macheche CT	
Tenjo Vista 1, 2, 3, 4, 5, & 6	
Yigo CT	Mobil Cabras Terminal
Manengon (MDI) 1&2	
Talofofo 1&2	
Piti 7 CT	

16.5.8 Potential Fuel Supply Chain Bottlenecks

Potential critical facilities for fuel distribution to GPA generating plant include:

- Apra Harbor Gulf Pier
- Apra Harbor Berth F-1
- GPA Bulk Fuel Storage Facility and Delivery Pump Station
- Tristar Agat Terminal
- Cabras Distribution Terminal (SPPC/IP& E Lot 2 Tank Farm)
- Mobil Cabras Terminal
- ExxonMobil Singapore Refinery
- Japan (multiple ports)
- South Korea (multiple ports)

Many of these facilities are located near water and could be disrupted by an earthquake / tsunami. Figure 16-9 shows the location of potential fuel supply bottlenecks for fuel resupply to GPA generators.

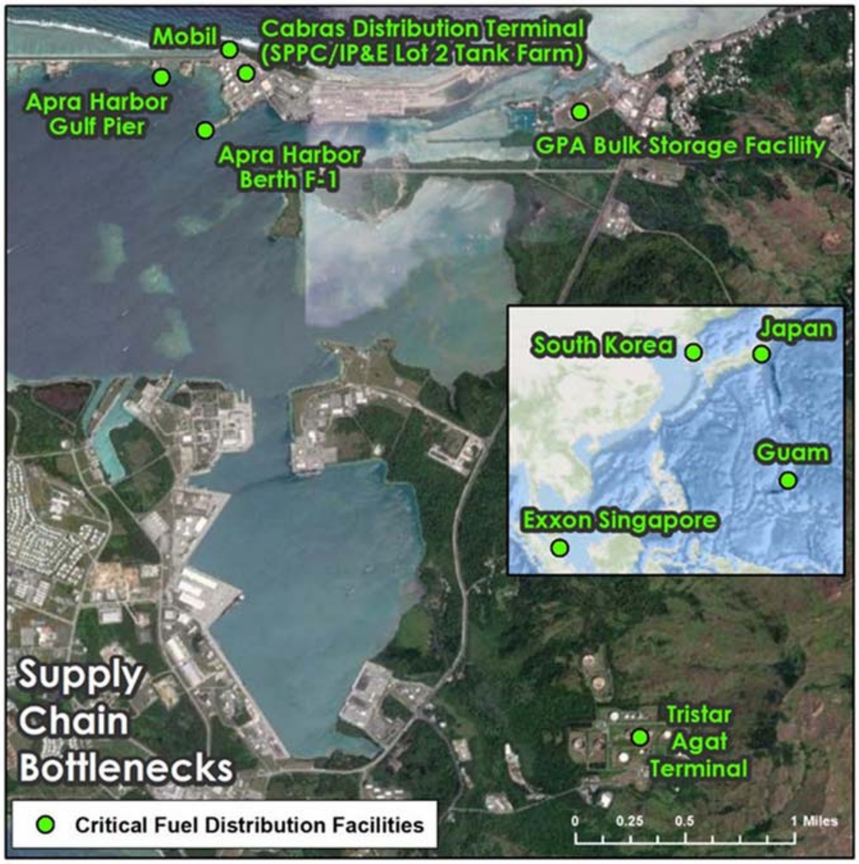

Figure 16-9. Potential Fuel Supply Chain Bottlenecks for Resupply to GPA Generators

16.5.9 Potential Port Disruption Scenarios

Typhoons, earthquakes, tsunamis, and other disasters occur periodically on Guam. These could temporarily incapacitate the Port and cause significant damage to the existing petroleum infrastructure. The Port could sustain significant damage as a result of a major seismic event or from a tsunami generated by local or distant seismic activity.

Port facilities were designed to military standards and built to withstand the extremely high wind conditions caused by typhoons. However, damaging either of the fuel piers and rendering them inoperable will cripple the entire island and will adversely impact continuity of fuel distribution.

Another possible hazard is a major petroleum tank fire. Guam experienced a major petroleum tank fire on December 8, 2002 as a result of Supertyphoon Pongsona. Three tanks exploded and burned, destroying virtually all supplies of gasoline and jet fuel on Guam. Fire blocked access to gasoline supplies for Guam and caused the shutdown of Apra Harbor.

16.6 Guam Earthquake Impact on Electric Power Infrastructure

This section and subsections borrows liberally from the work of Edgar Portante, Steve Folga, Leah Talaber, Tom Lusk in the Decision and Infrastructure Science Division Systems Modeling Group at Argonne National Laboratories.

16.6.1 Earthquake Scenario Description

The earthquake threat scenario elements characteristics assume:

- A 7.8 magnitude earthquake occurs at 6:34 p.m. Guam local time during a day in August 2021;
- The Earthquake epicenter is at 12.982°N 144.801°E about 30 kilometers off the southern coast of Guam;
- The scenario is based on the August 8,1993 earthquake in Guam

The 1993 earthquake occurred at the same time a tropical storm was lashing Guam with high winds and heavy rains. This analysis does not assume that a typhoon is happening simultaneously.

16.6.2 Assumptions

The earthquake threat scenario assumes:

- All electric assets in Guam are assumed to be seismically unanchored;
- Transmission and distribution power lines are assumed to be above-ground unless otherwise specified by GPA;
- Electric assets subjected to a 50% or more probability of experiencing moderate damage are assumed to be out of service. Assets assumed to have slight / minor or no damage would remain in service;
- A line is assumed to be out of service when one of its substations is out of service due to moderate or greater damage;
- Transmission line towers are assumed to withstand shaking intensity of up to 70% g;
- Transmission lines shut down (“trip”) when exposed to abnormal voltage variation, frequency variation, or heating (overloading).

16.6.3 Methods of Earthquake Measurement

Table 16-12 shows perceived shaking, potential damage, and instrumental intensity rating for various values of perceived ground acceleration (PGA) and peak ground velocity (PGV)

PGA is equal to the maximum ground acceleration occurring during earthquake shaking at a location; it is most intense near the earthquake epicenter. PGA is usually expressed as a percentage of the gravitational acceleration constant (i.e., g = 32.2 feet/sec2).

Peak Ground Velocity (PGV) is the greatest speed of shaking that occurs at a particular point during an earthquake. It is often applied in determining the liquefaction potential at a given point.

Permanent Ground Deformation (PGD) is defined as large-scale ground displacements and can be caused by soil liquefaction, ground sliding, or earthquake fault movements.

Table 16-12 Perceived Earthquake Intensity and Potential Damage versus PGA and PGV

PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	*<.17*	*.17-1.4*	*1.4-3.9*	*3.9-9.2*	*9.2-18*	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	*16-31*	*31-60*	*60-116*	*>116*
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

Soil liquefaction occurs when a saturated or partially saturated soil substantially loses strength and stiffness in response to an applied stress, such as shaking during an earthquake.

Earthquake shaking can cause landslides resulting in slopes becoming unstable by inertial loading or by causing a loss of strength in slope materials. However, available data did not include potential landslides.

Aboveground vertical facilities such as substations, power plants, and transmission towers are most vulnerable to PGA, and sometimes PGD, if located in liquefiable or landslide zones. Underground pipelines and electric cables are vulnerable to PGV and PGD.

16.6.4 USGS Shake Map of Earthquake Scenario

Figure 16-10 shows the USGS Shake Map for the Guam earthquake scenario. Observations drawn from the Shake Map include:

- The entire island of Guam is within the direct impact zone of the seismic event;
- The most intense shaking would be experienced in the southernmost portion of the island with PGA reaching to as much as 50% g;
- Electric assets in the northern part of the island are at risk of moderate damage with PGA as high as 40% g, while those in the southern portion would experience extensive damaged;
- Electric substations and power plants experiencing moderate and greater damaged levels are assumed to cease operation.

16.6.5 Liquefaction and Landslide Impacts of Seismic Scenario

Liquefaction and landslide impacts on electric assets expected to be limited. Liquefaction triggered by this earthquake is estimated to be limited in severity and (or) spatial extent as nearly all of Guam's surface would be described as firm soil or rock. Landslides triggered by this earthquake are estimated to be limited in number and (or) spatial extent. Most rockslides are expected to be small enough to be nondamaging. Figure 16-11 shows the liquefaction susceptibility throughout Guam.

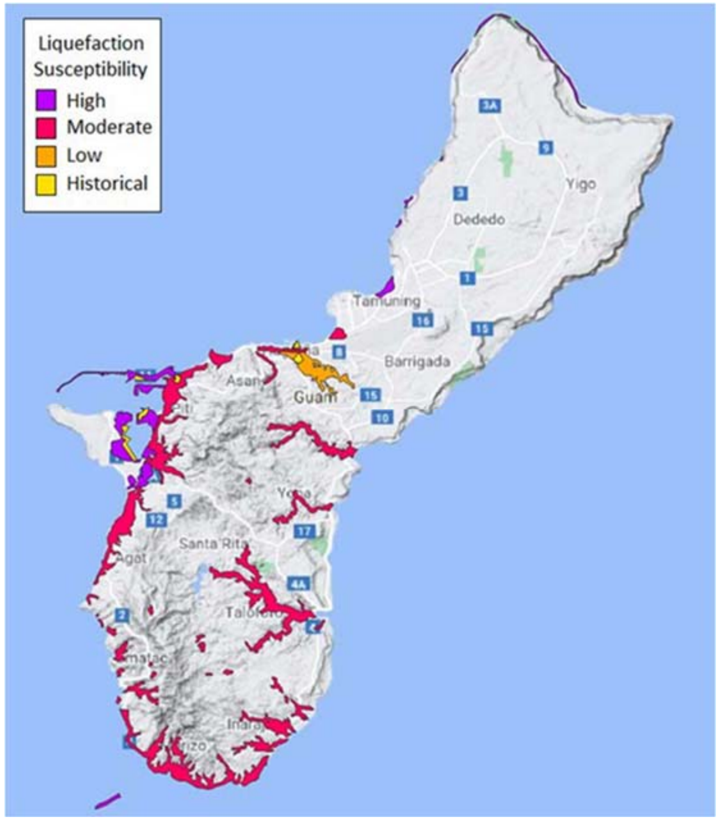

Figure 16-10. Liquefaction Susceptibility Throughout Guam

16.6.6 Seismic Impacts on Guam Electric Sector Infrastructure: Initial Results

Table 16-13 shows the initial results of FRONTIER simulations of the earthquake scenario impacts on Guam's electric sector.

Table 16-13. Estimated Earthquake Impacts on Guam's Electric Sector

Estimated Earthquake Impacts on Guam's Electric Sector				
Earthquake Impacts	Minor Damage	Moderate Damage	Extensive Damage	Significant Settlement
Power Plants	0	12	1	1
Substations	0	37	4	4
Transmission Structures	1,240	0	0	79
Distribution Poles	19,455	351	0	226

FRONTIER simulations estimate moderate damage estimated for GPA generating plants except for Talofofo Diesel Plant (8.6 MW). Cabras Power Plant could be affected by settlement.

Therefore, it is a potential unit of concern until retired. Piti 7 and Piti 8&9 Power Plant foundation construction included driven concrete pilings. The Cabras Power Plant is built on reclaimed land. The area used to be a lagoon. The surrounding area contains wetlands.

Almost all of GPA's substations and power plants would experience moderate to extensive damage level including:

- Possibility of large substation transformers to have shifted on their base pads;
- Extensive damage at substations located closest to earthquake epicenter.

The simulations estimate minor damage to power poles or transmission towers especially the possibility of settlement at a few poles and other tower structures.

16.6.7 Seismic Impacts on GPA Electric Operations

Figure 16-11 shows the results of FRONTIER simulation of electric outages as an immediate result of a major seismic event. Entire island of Guam would be in total blackout as result of the event as it was after the 1993 earthquake. GPA would experience a 100% load loss in the aftermath of the event. Almost all of GPA's substations and power plants would experience moderate to extensive damage level causing them to cease operation.

16.7 Next Steps

The next steps in the FRONTIER Project include:

- Laboratory research team activities:
  - Power restoration modeling (Summer/Fall 2021)
  - Customer surveys (Fall/Winter 2021)
- Future feedback from FLAG:
  - Database of resilience options (Fall 2021)
  - Community support for resilience options (Winter 2021).

GPA is especially interested in the results of the customer surveys as they will become the basis of customer outage costs based on duration of outages. Similar work was performed by Peter Larsen and LBNL on the Interruption Cost Estimator Tool modeled for the fifty states and Puerto Rico. "The Interruption Cost [62] Estimate (ICE) Calculator is a tool designed for electric

[62] Lawrence Berkeley National Laboratory and Nexant, Inc. (2016). ICE Calculator. URL: https://www.icecalculator.com/home (Accessed January 9 2021)

reliability planners at utilities, government organizations or other entities that are interested in estimating interruption costs and/or the benefits associated with reliability improvements." Resiliency projects should account for both GPA and customer costs as well as impacts to the Guam economy.

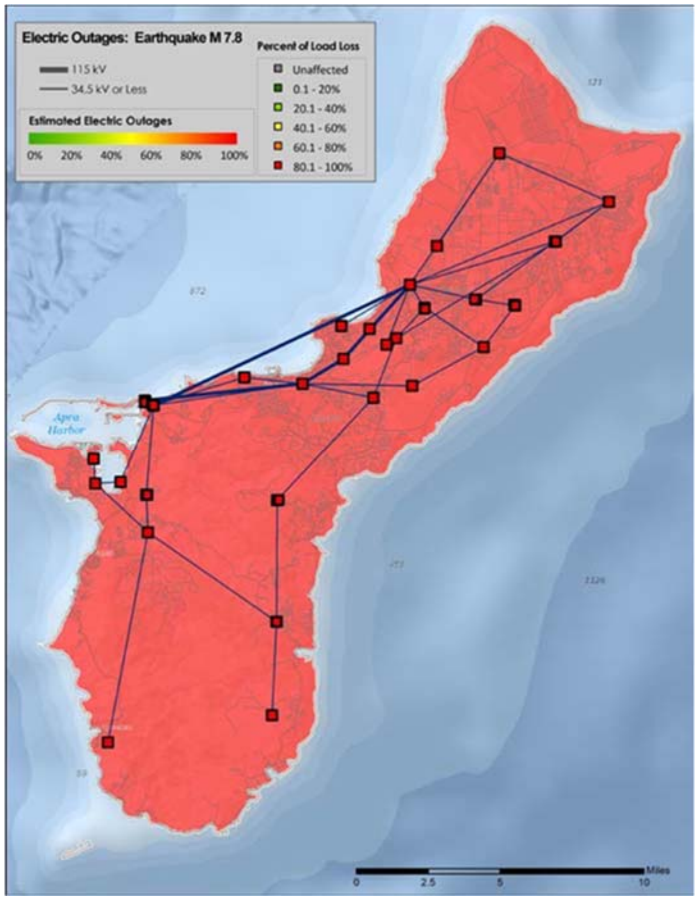

Figure 16-11. Electric Outages as an Immediate Result of Seismic Event

17 Grid Controller

GPA's Renewable Integration Studies[63] recommend Automatic Generation Control (AGC). However, GPA finds that that is a minimum requirement and recommends a Grid

[63] Electric Power Systems, Inc. (2018). System Improvement Study.

Controller with AGC as one of its control functions. The grid controller would perform many of the control and optimizations discussed in this volume of the IRP. The Grid Controller suite of functions include but may not be limited to:

- Automatic Generation Control and Resource Commitment system of existing and future fossil fuel-fired generation, renewable energy generation, energy storage, and demand response resources;
- Security Constrained Economic Dispatch of existing and future resources including but not limited to:
    - Fossil Fuel-Fired Generation
    - Energy-Shifting Storage
    - Battery Energy Storage Systems
    - Variable Renewable Energy Generation (Curtailment)
    - Firm Renewable Energy Generation
    - Demand Response Resources/Interruptible Loads
    - Electric Vehicle V2G Charging Systems
    - Synchronous Condensers
    - Short Circuit Ratio (SCR) Constraints
- Optimal Control of Battery Energy Storage System (BESS) Charging (Economic and Stability Objective Function);
- Optimize BESS Operation in Contingency (Spinning Reserve) Mode with Remote Start Generation;
- Solar PV Curtailment;
- Dispatch of Demand Response Resources;
- Use of Real-Time Post-Processing of Synchrophasor Information to Provide Advanced Warning of Impending System Instabilities and Take Remedial Action to Prevent these Instabilities from Progressing;
- Post-Disturbance System Restoration.

Appendix G contains a draft scope for the GPA grid controller. GPA estimates a budget of $1.5 million for the initial capital costs & licensing fees for the Grid Controller. GPA should bid the Grid Controller as a request for proposal (RFP) as it did for AGC almost a decade ago. There will need for development, engineering services, and system tuning during the life of the contract. The system should be operated as a service with equipment owned and operated by the Contractor.

18 System Protection

GPA's Renewable Integration Studies include the system impact studies, renewable integration interconnection studies, energy-storage feasibility study, and the System Improvement Study (SIS). The System Improvement Study provides several recommendations to ensure that the GPA system can safely and reliably integrate large amounts of renewable energy. GPA conducted the System Improvement Study with the United States Department of the Navy. The study was completed in 2018. The Navy requested that GPA limit the distribution of the report because they believe that others will malicious intent can use the information to attack the GPA grid as the report clearly details and discusses GPA grid vulnerabilities. This section concentrates on the system protection recommendations made by the SIS.

The most urgent and fundamentally important recommendation is reducing transmission fault clearances. This means isolating transmission system short circuits as quickly as possible. Inverter-based generation does not supply as much short circuit current as synchronous generation. The lack of short circuit current may result in severe undervoltages throughout the grid and eventually lead to system voltage collapse.

Current transmission fault clearing times are on the order of 20 cycles. With a high penetration of inverter-based generation, these long clearing times are likely to lead to voltage-collapse and blackouts. The SIS recommends that GPA reduce fault clearing times on the:

- 115 KV transmission system to no more than 5 cycles or one-twelfth of a second (83.3 milliseconds); and,
- 34.5 KV transmission system to no more than 6 cycles or one-twelfth of a second (83.3 milliseconds);
- The clearing times at both ends of the transmission line should be the same.[64]

[64] Electric Power Systems, Inc. (2018). Guam Power Authority System Improvement Plan for Renewables. Anchorage, Alaska. p.7.

These recommendations require the following upgrades to substation equipment:

- 115 KV breakers to 3-cycle breakers as a replacement for 5-cycle breakers (many already have 3-cycle breakers);
- Relay upgrades;
- Installation of new SEL ICON communication and mirror-bit communications multiplexing; and
- High bandwidth, high reliability, cybersecure fiber optic communications between substations.

18.1 Under Frequency Load Shedding

The underfrequency load shedding (UFLS) system is the last line of defense to prevent system blackout due to a load-generation imbalance. UFLS is significantly important to islanded grids, especially GPA. GPA's grid has the steepest frequency decay as a result of a trip of the largest generation unit on its system compared to power systems on the main Hawaiian Islands. In the recent past, the number of daily and weekly activations of the GPA UFLS scheme indicate GPA's vulnerability to blackouts triggered by loss of generation or solar PV drop outs. This vulnerability is the reason GPA constructed Battery Energy Storage Systems at Hagatna and Talofofo.

Many islanded systems have observed that the Underfrequency Load Shedding (UFLS) system protection becomes less effective during periods of high distributed generation. "*IEEE Guide for the Application of Protective Relays Used for Abnormal Frequency Load Shedding and Restoration*, has clearly mentioned that tripping feeders that have active DG certainly diminishes the beneficial affect of load shedding, and can even have negative impact by eliminating sources of generation that supports system inertia."[65] This occurs because the DG will decrease the net load on each substation feeder. This in turn decreases the total load in each stage of UFLS that can be tripped. Therefore, the UFLS would need to load shed more customers. Or alternatively, trip customers on feeders with less NEM more often.

For the GPA system as recommended by GPA's System Improvement Study/Renewable Integration Study, if the proposed levels of ESS through Phase III are configured to provide grid

[65] Das, K., Nitsas, A., Altin, M., Hansen, A. D., & Sørensen, P. E. (2017). Improved Load Shedding Scheme considering Distributed Generation. I E E E Transactions on Power Delivery, 32(1), 515-524. https://doi.org/10.1109/TPWRD.2016.2536721

frequency support, these risks are mitigated. However, it is recommended that GPA continue to observe the net feeder loading and installed DG/PV to assess the impact of DG on UFLS stages. If the actual capacity of DG/PV significantly exceeds the forecasted DG/PV estimates, the impact on UFLS will become more significant.

GPA recommends designing and implementing an adaptive underfrequency load shedding scheme that accounts for NEM operation during the day and not at night in order to minimize the number of customers load shed.

Additionally, the study should investigate the use of Distribution Load Shedding Relays (DLSR) as part of automatically forming the Umatac microgrid. GPA should investigate the potential benefits for microgrid islanding.

18.2 Under Voltage Load Shedding

Note that during future generation conditions with significant amounts of inverter based generation and energy storage, the strength of the grid will be significantly less than it is today, and the fault induced voltage dips on the grid will be more severe[66]. During under voltage conditions, the ability of the inverter based systems (both PV and ESS) to provide real power support is reduced.[67] Fast clearing of transmission faults is critical in this new future grid.

In addition to Adaptive Underfrequency Load Shedding, GPA should investigate the use of Under Voltage Load Shedding (UVLS) as a countermeasure against system voltage collapse. As in both UFLS and UVLS, there are three principal considerations:

- The amount to be shed;
- The timing of the load shed; and
- The location of the load to be shed.[68]

The amount of load shed must be optimized:

- Insufficient load shedding will not to be effective in arresting voltage collapse;

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[66] Electric Power Systems, Inc. (2018). Guam Power Authority System Improvement Plan for Renewables. Anchorage, Alaska. p.9.

[67] Ibid.

[68] Nizam, M., Mohamed, A. and Hussain, A. (2007) "An Adaptive Undervoltage Load Shedding Against Voltage Collapse Based Power Transfer Stability Index," Journal of Electrical Engineering and Technology. The Korean Institute of Electrical Engineers, 2(4), pp. 420–427. doi: 10.5370/jeet.2007.2.4.420.

- Over load shedding may result in transitioning the system from an under voltage to an over frequency condition as the resulting system will have more generation than load.[69]

The timing of the load shedding event is also very important:

- "The minimum amount of time allowed before load shedding scheme is triggered is the time taken for the detection of the onset voltage collapse;
- "The maximum amount of time allowed before a load shedding scheme is triggered is the time is taken for all the intervening system components to attempt system recovery."[70]

Finally, determining the location where load should be shed in order to prevent voltage collapse is very important. Determination of the weakest system bus which tends to be the most susceptible to voltage collapse is often the most appropriate candidate for initial load shed.[71]

There are three under voltage load shedding methods: Fixed Shed Fixed Delay (FSFD); Variable Shed Variable Delay (VSVD), and Adaptive UVLS based on Power Transfer Stability Index (PTSI).[72]

The Nazim et. al. (2007) paper concludes that the Adaptive UVLS based PTSI controller seems to be most appropriate among the three uncoordinated schemes providing faster accurate response and greater sensitivity of control.[73]

"Power Transfer Stability Index (PTSI) is actually an indicator for detection of voltage stability."[74] GPA should investigate if this method can be used to detect and prevent voltage stability issues before they become a problem initiating load shedding. If so, GPA should explore if it may be appropriate to include the functionality in the grid controller,

The goals for both UFLS and UVLS are to provide effective control while minimizing the amount of load and customers shed.

[69] Ibid. p 320.
[70] Ibid. p. 420-421.
[71] Ibid p. 421.
[72] Ibid. p. 420.
[73] Ibid. p.426
[74] Ibid p. 421

18.3 Fault Induced Delayed Voltage Recovery (FIDVR)

Guam is an ideal climate for Fault Induced Delayed Voltage Recovery (FIDVR) to occur on its power system. Guam has a warm/hot climate where air conditioning is highly utilized. Thus, a large component of GPA load is air conditioning

"Fault Induced Delayed Voltage Recovery (FIDVR) refers to unexpected delay in the recovery of voltage to its nominal value following the normal clearing of a fault."[75] The root cause of FIDVR is "stalled residential air conditioning (AC) units (powered by single-phase induction motors)."[76] The FIDVR effect increases both the real and reactive power demand on the load after a fault. Figure 18-1 shows the sequence of events during a FIDVR event.

"FIDVR is characterized by depressed system voltage voltages for a prolonged period of time following a system fault:

- "Transmission, sub-transmission, or distribution system fault causes depression in system voltage
- "After fault has been cleared (whether normal or delayed clearing), voltage remains at significantly reduced levels for several seconds
- "Voltages slowly return to acceptable levels after many seconds
- "Voltage overshoot may occur due to capacitor switching and load tripping."[77]

FIDVR depression of system voltages is of even greater concern as GPA adds more inverter-based generation such as utility scale systems and net metering systems. Inverter-based generation does not supply as significant amounts of short-circuit current as does synchronous generation.

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[75] Lawrence Berkeley National Labs (Consortium for Electric Reliability Technology Solutions). (2019). Fault-Induced Delayed Voltage Recovery (FIDVR). URL: https://certs.lbl.gov/initiatives/fidvr

[76] Ibid.

[77] North American Electric Reliability Corporation. (2015). Fault Induced Delayed Voltage Recovery (FIDVR) Advisory. URL: https://www.nerc.com/comm/PC/Synchronized%20Measurement%20Subcommittee/FIDVR%20Alert%2007-2015.pdf (Last accessed January 9, 2019)

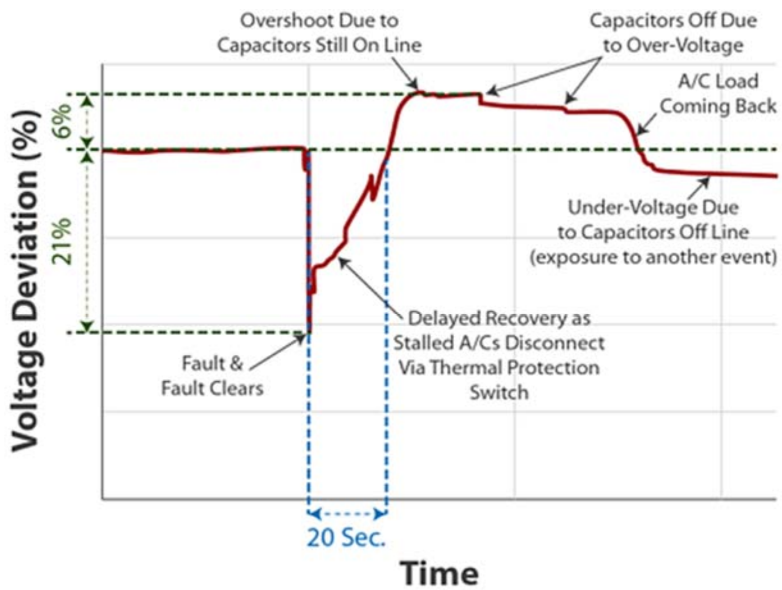

Figure 18-1. FIDVR Event Voltage Deviation Sequence of Events[78]

Although FIDVR may not generally speaking pose significant threat to the reliability of the United States Bulk Transmission System[79], it is of significant importance to the GPA power grid. The FIDVR effect increases both the real and reactive power demand on the load throughout the GPA system during and right after a fault event. Event recording from GPA have shown FIDVR events "where the load can rise by approximately 20% in real power demand due to a line fault" taking 10 to 20 seconds to dissipate.[80]

The FIDVR voltage rise causes system frequency to decay after the fault has been cleared and the initial set of UFLS has occurred. FIDVR also causes depressed voltage throughout the GPA systems. This under voltage is exacerbated "by two factors – automatic disconnection of system capacitors due to high system voltages and automatic reconnection of load back onto the system."[81] "This undervoltage could cause another series of similar or worse system events if additional faults occur prior to the system returning to normal voltage."[82]

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[78] Lawrence Berkeley National Labs (Consortium for Electric Reliability Technology Solutions). (2019). Fault-Induced Delayed Voltage Recovery (FIDVR). URL: https://certs.lbl.gov/initiatives/fidvr
[79] Ibid.
[80] Electric Power Systems, Inc. (2018). Guam Power Authority System Improvement Plan for Renewables. Anchorage, Alaska. p.29.
[81] R. J. Bravo, R. Yinger and P. Arons, "Fault Induced Delayed Voltage Recovery (FIDVR) indicators," 2014 IEEE PES T&D Conference and Exposition, 2014, pp. 1-5, doi: 10.1109/TDC.2014.6863324.
[82] Ibid.

At customers with rooftop solar PV systems which have not ridden through the event or have not recovered, the loads that were supplied by their PV systems will have to be provided by GPA. This will also compound the effects associated with FIDVR.

GPA should be cautious of high speed reclosing on onto a fault. Glidewell and Patel (2012) find that "if the voltage recovery following clearing of a fault is slow and if the fault is permanent in nature, auto-reclosing on to a fault could increase voltage recovery time significantly"[83]

The temporary rise in real power due to FIDVR is most effectively mitigated by using Battery Energy Systems such as the Hagatna and Talofofo BESS to supply this additional load. All future GPA BESS will add to additional mitigation for the impact of FIDVR. In addition to mitigating the impact of FIDVR, using the Hagatna and Talofofo BESS for emergency frequency and voltage support reduces frequency swings on the GPA system and mitigates the number of load-shed events on the system. Ensuring future BESS additions contribute to making GPA's power system a very reliable, stable, and resilient one. BESS are an integral part of GPA's renewable energy transformation. Mitigating FIDVR using BESS that are already part of planned investments reduces GPA capital outlays.

Control schemes integrating coordinated control of distributed energy resource smart inverters and automated switching capacitors have been evaluated and proposed in the FIDVR literature.[84] Wang and de León conclude that "the quantitative analysis shows that relying on DERs solely is not enough to eliminate FIDVR completely and that the mitigation effect largely depends on the penetration of DER and RAC [Residential Air Conditioners]."[85] Unless additional issues with FIDVR manifest themselves outside the remediation of BESS, GPA should not pursue these avenues.

Note that in modern power systems with "integrated high-level inverter interfaced power generation, such as the wind and photovoltaic power, and their low voltage ride through (LVRT)

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[83] J. D. Glidewell and M. Y. Patel, "Effect of high speed reclosing on fault induced delayed voltage recovery," 2012 IEEE Power and Energy Society General Meeting, 2012, pp. 1-6, doi: 10.1109/PESGM.2012.6344608.
[84] W. Wang and F. de León, "Quantitative Evaluation of DER Smart Inverters for the Mitigation of FIDVR in Distribution Systems," in IEEE Transactions on Power Delivery, vol. 35, no. 1, pp. 420-429, Feb. 2020, doi: 10.1109/TPWRD.2019.2929547.
[85] Ibid. p. 428

requirement makes the voltage recovery criterion more stringent."[86] [87] GPA must ensure that NEM systems are meeting the ride-through requirements stipulated as part of interconnecting to the GPA grid. GPA must verify this at the initial inspection of the NEM systems and periodically throughout the interconnected life of that system.

Zhang et al, (2012) report that "to mitigate the FIDVR threats, a solution at the planning stage is to reinforce the power network with dynamic VAR compensation devices, such as SVC and STATCOM," but "such devices remain very expensive, and their wide installation is usually limited by the investment budget and substation space."[88] Zhan et al. posit that at the "post-fault control stage, an effective solution is to deploy fast detection of FIDVR and emergency control (EC) (e.g., load shedding)."[89] The Zhang et al. (2019) paper aims at earlier assessment of FIDVR since:

- Control action timing is critical to the control effectiveness;
- The earlier the control actions are armed, the higher chance the deviated voltage can be recovered in time.[90]

The point of discussing the Zhang et al. (2019) proposed probabilistic self-adaptive FIDVR assessment method and Nazim's et. al. (2007) Adaptive UVLS based on Power Transfer Stability Index (PTSI) is that FIDVR, under voltage, and loss of generation/PV dropouts severely impact the GPA system. The key areas for GPA investigation include:

- Predicting events and executing meaningful remedial intervention before they trigger large load shedding events; and
- Automated systems making fast assessments without impairing accuracy leading to quicker actions to remediate the threats;

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[86] Y. Zhang, Y. Xu, Z. Y. Dong and P. Zhang, "Real-Time Assessment of Fault-Induced Delayed Voltage Recovery: A Probabilistic Self-Adaptive Data-Driven Method," in IEEE Transactions on Smart Grid, vol. 10, no. 3, pp. 2485-2494, May 2019, doi: 10.1109/TSG.2018.2800711. p. 2485
[87] We are going to disregard the South Australia blackout reference cited in Zhang et. al. (2019) and take the salient points applicable to GPA in the body of the paper.
[88] Ibid. p. 2485
[89] Ibid. p. 2485.
[90] Ibid.

- Real-time assessment of voltage stability using networks of Phasor Measurement Unit (PMU) and synchrophasor information.[91]
- Investigate neutral grounding in the distribution system as recommended in Bhatt et. al.[92]

With all the inverter-based systems that GPA will add into the GPA grid, GPA must get ahead of potential power system stability issues and fix them before they become severe problems.

18.4 Synchrophasors and Grid Stability

"Using synchrophasor measurements and high-speed communications software, "utilities and grid balancing authorities "can operate renewable energy and grid systems at a level that is a quantum leap beyond the analog way most grids are operated today."[93] At the heart of this capability are synchrophasor networks:

- "Phasor measurement units (PMUs) provide real-time data about the condition of the grid up to 60 times a second – faster than the blink of an eye, and 23,900 percent faster than conventional SCADA systems, which provide the data only once every …" [two to ten] " … seconds. PMU measurements record grid conditions with great accuracy and offer insight into grid stability or stress."

Synchrophasors are measurements of power system sinusoidal waveform that are synchronized in time, and expressed as phasors. With a very accurate time reference source to synchronize these measurements throughout the power system, utilities can use synchrophasor measurements to determine useful information about how the grid is operating.

With a sufficient synchrophasor measurement network, a control system may monitor power flows across the power network in real-time. By measuring changes in the phase shift across parts of the grid, these systems can estimate areas of stress and future threats to system

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[91] S. P. Singh. (2017). "On-line Assessment of Voltage Stability using Synchrophasor Technology" Indonesian Journal of Electrical Engineering and Computer Science Vol. 8, No. 1, October 2017, pp. 1 ~ 8. DOI: 10.11591/ijeecs.v8.i1.p1-8.

[92] Bhatt, P.K., Kumar, S.Y. Comprehensive Assessment of Fault Current Contribution in Smart Distribution Grid with Solar Photovoltaic. Technol Econ Smart Grids Sustain Energy 2, 7 (2017). https://doi.org/10.1007/s40866-017-0023-8. P. 13.

[93] Becky Wheeler. (2021). Renewables challenging your grid's stability? There's an app for that. URL: https://energycentral.com/o/pxise-energy-solutions/renewables-challenging-your-grid%E2%80%99s-stability-there%E2%80%99s-app (Last accessed July 30, 2021.

stability. Synchrophasor data postprocessing of can be performed in real time. Postprocessing can extract information about low-frequency system modes, and by examining whether the amplitudes of these modes are changing, provide advance warning of impending instability so that appropriate actions can be taken in time. These capabilities using a grid controller are well within the state of the art.[94] [95] 'Grids now have vastly expanded functionality, control and analytics to dramatically improve the integration of renewables" bringing us much closer to a 100% clean energy future.[96]

The time for corrective action is shorter than a human response allows. Integrating these functions into the grid controller is warranted.

18.5 The Smart Grid Advantage

Modern twenty-first utilities operate on information as much as fuel to deliver reliable electric power service affordably. GPA is ahead of many of its peers in having installed and continuing to improve and add applications to a reliable, resilient communications infrastructure and smart grid applications. GPA has used these smart grid systems to reduce outages such as placing a recloser in the Umatac distribution system under SCADA remote control. This particular circuit was a problematic one that tripped often. In the past, GPA would send linemen to troubleshoot the issues but most of the time the problems were of a temporary nature that closing in on the circuit would have been appropriate action, These systems can support greater grid reliability.

Implementing adaptive protection schemes require information from throughout the grid. They require fast, reliable, secure communications. GPA is expanding its Tier 1, 2, and 3 communications systems that it shares with the Guam Waterworks Authority. Tier 3 and 2 are radio mesh networks. Tier 1 is a fiber optic network with multiple rings most of which is buried two or more feet and encased in concrete encased conduits.

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[94] Discussions between PXISE and GPA AGMETS

[95] Becky Wheeler. (2021). Renewables challenging your grid's stability? There's an app for that. URL: https://energycentral.com/o/pxise-energy-solutions/renewables-challenging-your-grid%E2%80%99s-stability-there%E2%80%99s-app (Last accessed July 30, 2021.

[96] Ibid.

19 Electric Vehicle Charge Management

Part of building a reliable, stable, and resilient system is being able to fund the necessary capex and O&M expenses required. Electrification of Guam's transportation is a considerable future revenue source to provide this funding while reducing rates for all GPA customers. However, the penetration of EV chargers throughout the GPA distribution system is not without hazard. For example, DC fast chargers several to a location or clustered closely on a feeder will impose harmonics issues on the distribution system. Uncontrolled EV penetration without GPA EV charging management will result in greater needs for generation capacity.

GPA and Guam Regional Transit Authority have set strategic goals to electrify their heavy-duty vehicle fleets. The private sector will eventually follow their lead. Nadel and Huether (2021) state that electric charging infrastructure for fleets and truck stops is a critical issue.[97] Nadel and Huether (2021) report: "The fact that charging stations suitable for heavy-duty vehicles are virtually nonexistent today is one of the largest obstacles to heavy-duty EV adoption. We must prioritize utility rate design and promotion of managed charging if we want to make EV operating costs attractive while being fair to all ratepayers "[98] Therefore GPA must take an active role early to engender its strategic goal for electrification of Guam's transportation industry while finding solutions to the technical issues imposed by EV penetration.

The use of huge industrial chargers will not be long-time coming. Cel Baubata, Executive Manager of the Guam Regional Transit Authority (GRTA), is a man of action. But, he also has the insight that planning to ensure that any visionary action is prudent and helps ensure successful execution. Babauta's vision is to transform GRTA and perhaps the Guam transportation industry to electric vehicles. This is a vision shared by GPA. Having secured federal grants, Babauta will break ground within a year and half to bring several all-electric buses for use by GRTA to serve the Guam community. He has reached out to Guam Power Authority for support. Support that GPA feels honored to provide.

[97] Nadel, S., and P. Huether. 2021. Electrifying Trucks: From Delivery Vans to Buses to 18-Wheelers. Washington, DC: American Council for an Energy-Efficient Economy. www.aceee.org/research-report/t2102. P. iv

[98] Ibid.

19.1 Electric Vehicles for Guam

The long awaited EV explosion is coming soon. Bloomberg Technology reported that: "Consultant Ernst & Young LLP now sees EV sales outpacing fossil fuel-burners in 12 years in Europe, China and the U.S. -- the world's largest auto markets. And by 2045, non-EV sales are seen plummeting to less than 1% of the global car market, EY forecast using an AI-powered prediction tool."[99]

Guam has two things going for it when it comes to EV adoption:

- High fuel prices;
- Shorter daily driving distances reducing range anxiety.

What Guam has not had a lot is EV support from dealerships. For many years, Nissan was the only dealership to sell plug-in, all-electric vehicles: the Nissan Leaf. Within the last four years, Cars Plus began selling the Kona all electric vehicle. In August 2021, GPA met with Triple J and others regarding supporting Triple J's soon to be launched all-electric vehicle sales.

A strong market for electric vehicles is both a major benefit for GPA as well as a source for potential problems if GPA does not get involved in a major launch of EVs on Guam.

The following subsection discuss:

- Customer education points to pave the way to greater adoption of electric vehicles;
- EV charging control strategies to mitigate issues with mass EV charging and using them to improve the reliability and resiliency of GPA's grids.

GPA must educate customers to support greater adoption of electric vehicles on Guam. This educational outreach should include:

- Smart Electric Vehicle Charging Strategy;
- Electric Vehicle Battery Life and How to Extend It;
- Providing Opportunities for Potential Customers to Drive an EV.

19.1.1 Smart Electric Vehicle Charging Strategy

Many detractors of electric vehicle point at the long charging times to maintain full battery charge. However, topping off the battery every day is not an efficient charging strategy and adds

[99] Brett Haensel and Keith Naughton. (2021). Electric Vehicles Seen Reaching Sales Supremacy by 2033, Faster Than Expected. Bloomberg Technology. URL: https://www.bloomberg.com/news/articles/2021-06-22/shift-to-electric-cars-coming-faster-than-expected-study-shows

time to charging. It also quickens battery degradation and leads to a sooner end of life.[100] The most efficient and least destructive charging strategy is to keep the EV battery state-of-charge (SoC) between 20% to 80% of charge. Table 19-1 compares the average autonomy rate per hour of charging for different charge regimens. Charging EVs by keeping the battery state-of-charge between 20% to 80% provides the most value.

Table 19-1. Average Autonomy Rate (range/hour of charging)[101]

Charging (% SOC)	km per charging hour	miles per charging hour
20- 100	60.50	37.81
80 - 100	42.00	26.25
20 - 80	71.00	44.38

19.1.2 Extending Electric Vehicle Battery Life Strategy

Kong et al. (2018) state in their paper, "State of Health [SOH] Estimation for Lithium-Ion Batteries," that:

> "Many studies have suggested that temperature and discharge/charge current rate are the primary factors causing battery aging."[102]

The takeaway from the Kong et al. (2018) paper is that "SOH is a complex issue for which temperature and discharge/charge current rate are primary factors"[103] that users of EVs have some control over. This leads us to Andrew Ryan's (2021) article, "Make your electric

[100] Emmanouil D. Kostopoulos, George C. Spyropoulos, John K. Kaldellis. (2020). Real-world study for the optimal charging of electric vehicles. Energy Reports, Volume 6, 2020. Pages 418-426. ISSN 2352-4847, https://doi.org/10.1016/j.egyr.2019.12.008. (https://www.sciencedirect.com/science/article/pii/S2352484719310911)
[101] Ibid.
[102] XiangRong Kong, Arman Bonakdarpour, Brian T. Wetton, David P. Wilkinson, Bhushan Gopaluni, (2018). State of Health Estimation for Lithium-Ion Batteries, IFAC-PapersOnLine, Volume 51, Issue 18, 2018, Pages 667-671, ISSN 2405-8963, https://doi.org/10.1016/j.ifacol.2018.09.347. (https://www.sciencedirect.com/science/article/pii/S2405896318320329)
[103] Ibid.

vehicle battery last longer."[104] This article cites three strategies for keeping EV batteries heathier and lasting longer:

- Manage the state of battery charge;
- Avoid extreme heat.;
- Limit the amount of rapid charge sessions.[105]

Manage the state of battery charge by keeping it within the 20% to 80% range. This is the charging sweet spot.

The use of DC rapid chargers in conjunction with hot climates presents issues for vehicle lithium-ion batteries. A high temperature climate region is one having temperatures higher than 80.6 degrees Fahrenheit more than five days a year. This definition certainly applies to Guam.

Enel X reports:

> "However, the combination of frequent DC rapid-charging in hot ambient temperature settings can accelerate the battery's loss of capacity. You should try to only use DC rapid-charge stations when you need to, and use slow charging stations for daily recharging at home."[106]

Although "EVs feature systems to cool the batteries when they rise in temperature, … Enel X recommends drivers take steps to protect the battery if they are used in areas where temperatures frequently exceed"[107] 80.6°F. These steps include:

- "Not … [leaving] the car parked in direct sunlight for long periods of the day when the temperatures are very high;
- "Not … [leaving] a fully-charged EV sitting unprotected for prolonged periods in extreme heat;"
- Not needlessly charge an electric vehicle past 80% on high heat days.[108]

[104] Andrew Ryan. (2021). Make your electric vehicle battery last longer. Fleet News. URL: https://www.fleetnews.co.uk/electric-fleet/charging-and-infrastructure/make-your-electric-vehicle-battery-last-longer
[105] Ibid.
[106] Ibid.
[107] Ibid.
[108] Ibid.

19.2 Managing Electric Vehicle Charging on Guam

This section discusses how GPA must manage EV adoption to improve generation system reliability and resiliency rather than degrade it. Deb et al. (2018) state:

> "The detrimental impact of EV charging station loads on the electricity distribution network cannot be neglected. The high charging loads of the fast charging stations results in increased peak load demand, reduced reserve margins, voltage instability, and reliability problems. Further, the penalty paid by the utility for the degrading performance of the power system cannot be neglected"[109].

There are three potential negative issues with mass EV penetration into the grid: charging demand, harmonics, and phase voltage unbalance. A fourth issue: EV charging power sourcing is both an opportunity and a potential problem.

19.2.1 Uncontrolled Electric Vehicle Charging Can Lead to Generation Capacity Additions

If GPA does not have control over EV charging, EV charging can build up a considerable increase in system peak demand. This would require GPA to build more capacity and potentially increase rates. Assuming a negligible EV sales in today's market, for EV sales to reach 50% of new light duty vehicle sales by 2033, the sales growth rate must be about 3.44%/year. Assuming the light duty vehicle new car market is 8,000 per year results in 9,473 electric vehicles added within the first five years assuming these vehicles remain operable. Assume that each EV requires charging at 4.4 kW and that they all charge coincident with GPA system peak. This will increase GPA's system peak demand by 41.68 MW.

19.2.2 Uncontrolled Electric Vehicle Charging Can Lead to Problems with System Harmonics

GPA must investigate Level I and II chargers as higher penetration levels evolve. "One of the challenges associated with EV battery charging comes from the potentially high harmonic currents associated with the conversion of ac power system voltages to dc EV battery voltages. Harmonic currents lead to increased losses in distribution circuits and reduced life expectancy of

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[109] Sanchari Deb, Kari Tammi, Karuna Kalita, and Pinakeshwar Mahanta (2018). Impact of Electric Vehicle Charging Station Load on Distribution Network. Energies 2018, 11, 178; doi:10.3390/en11010178. URL: file:///C:/Users/jcruz/Downloads/energies-11-00178.pdf

such power distribution components as capacitors and transformers. Harmonic current injections also cause harmonic voltages on power distribution networks. These distorted voltages can affect power system loads.[110]

However, GPA may have more immediate issues with DC fast chargers especially where several are installed in the same location or clustered closely together on a feeder. Large chargers for buses or industrial heavy machinery may also be a concern. "If there are many electric vehicles in fast charging at the same time, the voltage distortion should exceed the admissible limit. Using photovoltaic (PV) to charge electric vehicles is a good solution to charge EVs.[111] GPA should explore the use of localized Solar PV resources with Battery Energy Storage as part of a solution for industrial fast charging. GPA envisions that these PV systems be non-net metering and not connected to the GPA grid.

Canvassing through the technical literature on EV Chargers and their impact on the distribution system reveals several guideline rules of thumb. Rodrigo et al. (2018) paper[112] concludes with the following rules of thumb:

- For feeders having a random distribution of EV chargers along it, "up to 30% of EV charger penetration at nominal load and up to 40% of EV charger penetration can be absorbed to the distribution feeder without violating IEEE 519 prescribed limits."[113]
- "If the EV chargers are clustered together 20% of EV penetration can be absorbed considering harmonic profile at source as well as PCC [point-of-common-coupling]."[114]

"Different techniques can be used for reduction harmonic current. The most common are line filters (using passive components: inductors and capacitors) and active electronic circuitry."[115] GPA should require distribution engineers and SPORD planners to train on modeling of harmonic equipment such as EV chargers and in determining harmonic mitigation

[110] Staats, P. T., "The harmonic impact of electric vehicle battery charging", PhDT, 1997.
[111] V. Nguyen, T. Tran-Quoc and S. Bacha, "Harmonic distortion mitigation for electric vehicle fast charging systems," 2013 IEEE Grenoble Conference, 2013, pp. 1-6, doi: 10.1109/PTC.2013.6652435.
[112] A. S. Rodrigo and V. G. C. Priyanka, "Impact of High Penetration of EV Charging on Harmonics in Distribution Networks," 2018 Moratuwa Engineering Research Conference (MERCon), 2018, pp. 340-344, doi: 10.1109/MERCon.2018.8421990.
[113] Ibid.
[114] Ibid.
[115] A. Bosak, A. Bosak, L. Kulakovskyi and T. Oboronov, "Impact of EV Chargers on Total Harmonic Distortion in the Distribution System Network," 2019 IEEE 6th International Conference on Energy Smart Systems (ESS), 2019, pp. 329-333, doi: 10.1109/ESS.2019.8764244.

strategies in the distribution system. Minimally, GPA should perform measurements and analysis on GPA should perform harmonic analysis on proposed clusters of EV chargers whenever it can verify such clusters in advance. Working closely with charger companies and EV dealerships will be key too this and enforcing standards and rules regarding EV charging on the GPA system.

19.2.3 Electric Vehicle Battery Charging and 3-Phase Power Supply Unbalance

High penetrations of residential Level 1 and Level II chargers will impose voltage problems on GPA's distribution system. "Increased EV penetration may result in sustained secondary service under-voltage conditions, violation of under-voltage limits, and three-phase power supply unbalance, which would deteriorate the service."[116] "ANSI C84.1-2011 [61] provides the national standard for voltage regulation. As per the standard, typically, the service voltage should range within ±5% of the nominal voltage rating and the three-phase voltage unbalance should not exceed 3%."[117] Note that GWA facilities with motor pump loads require three-phase voltage unbalance within 1%. Uncontrolled installation of these chargers may require reconfigurations of feeders to correct the unbalance. GPA should plan ahead and work with EV dealerships, charger providers, and customers to ensure that these problems are anticipated and mitigated from the very beginning.

19.2.4 Electric Vehicle Battery Charging Sourcing

Solar PV energy production is stochastic depending on the weather. Installing these types of resources to serve these new loads at minimum solar PV production periods may result in curtailing the resource during high production days. Curtailments may require GPA to pay for energy not taken increasing customer energy costs. A better solution may be to charge EVs by increasing the dispatch of GPA synchronous generation as needed in conjunction with the already planned developments of utility-scaled solar PV.

Solar PV systems are at risk for damage from typhoon high winds. Good design and installation execution for high winds can certainly be done to prevent damages from PV panel

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[116] Anamika Dubey and Surya Santoso (2015). Electric Vehicle Charging on Residential Distribution Systems: Impacts and Mitigations. IEEE. URL: https://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=7264982
[117] Ibid.

uplift. However, one also must consider what may be carried by high winds and smashes into solar PV panels. The planning team has observed that Guam's Pacific Solar has an excellent racking system for high wind loading. Pacific Solar lost three systems during a recently typhoon in the CNMI while its competitors lost about a quarter of their systems. Pacific Solar's three systems were damaged by flying debris not wind uplift.

GPA must take conservative views and strategies with respect to typhoons and other natural disasters, especially since the Guam transportation system will become highly dependent on GPA as EV penetration increases.

Some of the vehicle charging load could also be supplied by large commercial rooftop systems as well. These would not be net metering systems. They would be installed for electric vehicle charging and not connected to GPA's grid. There will be room for both GPA and Private PV systems for EV Charging. Other EV vehicle charging sources can come from energy storage systems that would charge at off-grid periods and then discharge while charging electric vehicles.

20 Conclusions and Recommendations

This section provides conclusions and recommendations to the range of topics covered in this volume of the IRP including:

- High Generation Reliability Program;
- Peak Load Carrying Capability with and without Energy-Shifting BESS;
- Retirements of Legacy Units with and without Energy-Shifting BESS;
- Excess Solar PV Generation (ESPVG) Event Management;
- Grid Short-Circuit Ratio Management;
- Management of Major Generation Outages;
- Building Demand Response Resources;
- Energy-Shifting Battery Energy Storage Systems;
- Build Flexibility into Future Contracts;
- System Protection;
- Grid Controller.

20.1 High Generation Reliability Program.

GPA must improve the reliability of its legacy generation units. As shown in Table 7-1, a five percent increase or decrease in legacy generation has a significant impact on reliability as measured by the system peak load carrying capacity. More reliable generation systems make better efficient use of resources than less reliable systems.

GPA has not been meeting the EAF performance requirements proposed by GPA's Quality Management Plan (QMP) for Prudent Fuel Use. A major reason for this is the catastrophic failure of the Cabras 3&4 Plant. The Guam Public Utility Commission (PUC) adopted GPA's *Quality Management Plan (QMP) for Prudent Fuel Use* in 2004. As part of its order, the PUC made update and submittal of the QMP recommended control charts for fuel efficiency and generation reliability mandatory as part of GPA LEAC filings.

Going forward GPA, the CCU, and the PUC must adopt aggressive standards for generation reliability and efficiency setting a high bar and laser-focus on performance. The PUC and the CCU should mandate critical performance reviews of generation system performance including but not limited to:

- Generation System Fuel Efficiency for Synchronous Generation;
- Operational Readiness;
    - Short-Circuit MVA;
    - Forced Outage Rate (FOR);
    - Availability Factor (AF);
    - Operational Reserve Management;
    - Maintenance Outage Planning.

Suggested Key Performance Indicators (KPI) for Generation:

- Operational Reserve (MW);
    - Operational reserve ≥ 200 MW Synchronous Generation
- Online Short-Circuit MVA;
    - Online Short-Circuit MVA ≥ 990 SC-MVA
    - System Impact Study for Inverter-Based Generation Additions Should Determine Minimum online SC-MVA.
- Fuel Efficiency (Gallons/KWH and MMBTU/MWH);

- Fuel Efficiency ≥ TBD Gallons/KWH (ULSD)
  - Fuel Efficiency ≥ TBD MMBTU/MWH (Natural Gas)
- Major Outage Planning Status;
- Weighted Generation System Equivalent Availability Factor.

Finally, GPA must revise its reserve margin policy to:

"GPA must keep sufficient generation installed reserve to support at least a one day in four-and-a-half-years loss of load expectation or 200 MW whichever is greatest."

GPA's current policy uses the sum of the two largest units instead of 200 MW. The recommended policy change is due to the coverage for the outage of the Ukudu Power Plant during steam turbine outages.

GPA should aggressively plan for and achieve 95% availability for legacy generation by 2029 prior to the first Ukudu steam turbine outage. Table 19-1 shows that Piti 8&9 under private management achieved 96.48% availability after "implementing the CIP/PIP/MOH program" proposed by MEC"[118] (Appendix S). For future Performance Management Contracts over Piti 8&9, GPA should require a minimum 96% EAF for the contractual guarantee of EAF.

Table 19-1. Piti 8&9 ECA Guarantees and Performance Reported by MEC[119]

ECA Guarantees		2017	2018	2019	2020	2021
Capacity Factor	65%	79.61%	78.43%	74.08%	74.84%	85.52%
Availability	90%	89.30%	90.61%	92.30%	93.36%	96.48%
Reliability	96%	97.15%	97.17%	95.77%	95.77%	97.78%

20.2 Peak Load Carrying Capability with and without Energy-Shifting BESS

The addition of Phase IV to the base case generation mix increases peak load carrying capability to over 364 MW far beyond the 2040 forecasted system peak. This provides an opportunity to retire legacy generation or convert them to synchronous condenser operation.

[118] R.T. Manzano July 22, 2021 email to GPA AGMETS, John J. Cruz Jr., P.E.
[119] Ibid.

GPA must take great care and exercise prudent judgement between the commissioning of Phase IV and the first Ukudu Power Plant steam turbine outage. Renewable wind and solar PV power is at the mercy of weather. KIUC's experience should provide a measure of caution and spur solid discussions on risk mitigation.[120] On July 22, 2019, KIUC began load shedding customers in waves due to cloudy and rainy weather despite "recent addition of solar and battery storage" which "helped KIUC maintain power Sunday and Monday, but with clouds obscuring the sun officials say they have been forced to turn off customer power in waves."[121]

Perhaps the most conservative action is waiting to retire Piti 8&9 until after the steam turbine outage. The retirement of Piti 8&9 has the largest impact on the base case system PLCC. During this period, GPA can build up its interruptible and curtailable load, demand response, customer load-shifting resources to meet the steam turbine outage challenge. However, the Piti8&9 power plant is a very attractive candidate for retirement because of its large annual fixed costs.

During the interim period between the present and the first Ukudu Power Plant steam turbine outage, GPA should target conversion of legacy combustion turbines to meet the short-circuit MVA requirement challenges as GPA moves quickly to transitioning to greater than 50% inverter-based generation bu 2030. As an option, these plants can be fully converted to synchronous condenser operation and their prime movers removed. This means they can be a source of reactive grid support but not a supply of real power.

The retirement of MDI Diesel Power Plant has little impact on PLCC. However, it provides backup to the Leo Palace Resort. These and other things must be considered before triggering the plant's retirement.

20.3 Retirements of Legacy Units

The retirement of MDI (Pulantat) Diesel Power Plant has the least impact on peak load carrying capability as expected. Retiring Piti 8&9 has the largest impact. Retiring Piti 8&9 and MDI results in a 397.2 MW synchronous generation mix. This is just below the proposed new

[120] Walton, R. (2019). Island-wide outage on Kaua'i: Clouds block solar recovery after generator's cable failure. URL: https://www.utilitydive.com/news/island-wide-outage-on-kauai-clouds-block-solar-recovery-after-generators/559289/ (Last accessed July 4, 2021)
[121] Ibid.

reserve policy of Ukudu Power Plant plus 200 MW. Therefore, any further retirement of additional synchronous generation capacity may likely trigger the need to replace the retired generation to satisfy the reliability criteria.

20.3.1 Legacy Piti 8&9 Options

As more renewable energy is integrated into the grid, Piti 8&9 operation will change significantly from baseload generation to primarily reserve generation and as a source of SC-MVA when required.

Ukudu will provide most of the energy from synchronous generators. At some point it will typically be the only synchronous generation online throughout the day.

During Excess Solar PV Production events, either GPA will have to curtail solar PV plants so that it can keep synchronous generators online, or use synchronous condensers in addition to some synchronous generation to provide sufficient SC-MVA to keep the system stable. With Piti 8&9 minimum load limits at around 50% (24 MW), Piti 8&9 is unlikely to be used to supply real power and SC-MVA during these events. But at 25% load, it becomes well suited for this operation able to provide 22 MW of real power and 440 MW SC-MVA. This minimizes the curtailment of solar PV during these events. Note that the minimum loading for Ukudu Power Plant with two combustion turbines is 79.2 MW.

Analyzing the information in Table 10-3, Piti 8&9, retrofitted to operate at a minimum 25% loading continuously, has a SC-MVA to minimum load ratio of 20 as does Piti 7. This is greater than all other legacy generation that will remain with GPA after the Ukudu Power Plant commissioning.

During the Ukudu plant steam turbine outage (every five to six years), the whole plant is likely to be outaged because running the CTs in simple cycle generates too much NOX. At this point, Piti 8&9, retrofitted for 25% minimum load operation, is a good operational candidate to provide baseload power during the 23-day steam turbine outage at lower fuel costs.

The 2022 IRP Volume II: Generation Expansion Plan will analyze the economics of a Piti 8&9 Retirement.

20.3.2 Legacy Combustion Turbine Options

GPA has several options for the disposition of its legacy combustion turbine fleet:

- Retire the power plant outright;

- Convert the power plants for synchronous condenser operation while refurbishing the plant for additional years of operation;
- Convert the power plants for synchronous condenser operation and remove their prime movers;
- Convert the power plants for synchronous condenser operation and preserve and mothball their prime movers.

GPA should convert these legacy combustion turbines to synchronous generation to support:

- System need for short-circuit MVA as renewable energy penetration increases to 50% and beyond;
- Support for short-circuit MVA during Ukudu steam turbine outages as the system potentially loses the availability of 990 SC MVA.

Yigo CT not being in a protective building is an issue in discussions about retirements. This consideration should be addressed if GPA decides to keep it.

Table 20-1 shows the impact of retiring legacy combustion turbines on the system peak load carrying capability (PLCC) with the addition of Phase III and IV Energy-Shifting BESS solar PV power plants.

Note that improving the EAF of legacy generation from 90% to 95% significantly improves PLCC. By retirement and conversion, GPA means the prime mover and associated systems not necessary for the generation unit to operate as a synchronous condenser are decommissioned. The IRP Volume II: Generation Expansion Plan will investigate the costs and economics of conversion to synchronous condenser operation and any replacement generation costs if required. GPA should keep a minimum of 200 MW in reserve to provide reliable power during the Ukudu steam turbine outage.

Modeling the Energy-Shifting BESS power plants as one plants results in a lower peak load carrying capability than modeling them as separate power plants. Modeling the system with two ES BESS power plants combining Phase II, IV, & V as one plant and Phase VI & V as the other, increases the PLCC with the retirement of Piti 8&9 to 365.8 MW for a LOLE of 1 day in

4.5 years. For a LOLE of 1 day in ten years, the PLCC supported by the system is 350.8 MW. Therefore, GPA can claim a better than one day in ten years for 2040 (340 MW).

Table 20-1. Impact on PLCC of Legacy Combustion Turbines Retirement (Phase III & IV Online)

Legacy Power Plant Retired	ESS Model	Legacy Generation EAF (%)	Retired Capacity (MW)	Installed Capacity (MW)	PLCC (MW)	Reserve Margin (%)		Synchronous Generation Reserve (MW)
						PLCC	Installed Capacity	
Base Case No ES BESS		90.0%	0	530.27	330.75	60.32%	37.63%	199.52
+ Phase III		90.0%	0	549.68	341.46	60.98%	37.88%	199.52
+ Phase III + IV	All ES BESS Phases modeled as one plant	90.0%	0	618.00	360.32	71.51%	41.70%	199.52
+ Phase III + IV - MacYigo		90.0%	40	578.00	328.62	75.89%	43.14%	159.52
		95.0%			349.75	65.26%	39.49%	
+ Phase III + IV - Piti7		90.0%	40	578.00	331.52	74.35%	42.64%	159.52
		95.0%			352.35	64.04%	39.04%	
+ Phase III + IV - DedCT		90.0%	44	574.00	325.65	76.26%	43.27%	155.52
		95.0%			346.01	65.89%	39.72%	
+ Phase III + IV - Piti 8&9		90.0%	80	538.00	292.66	80.42%	44.57%	119.52
		95.0%			315.48	70.53%	41.36%	
+ Phase III + IV + V - Piti 8&9		95.0%	80	607.00	319.48	90.00%	47.37%	119.52
+ Phase III + IV + V + VI - Piti 8&9		95.0%	80	738.00	325.19	126.94%	55.94%	119.52
+ Phase III + IV + V + VI + VII - Piti 8&9		95.0%	80	875.00	331.05	164.31%	62.17%	119.52
+ Phase III + IV + V + VI + VII - Piti 8&9	Modeled as two ESS Power Plants: Phase III, IV, & V and Phase VI & VII	95.0%	80	875.00	365.85	164.31%	62.17%	119.52

20.3.3 Legacy Combustion Turbine Conversion to Synchronous Condensers

GPA has had internal discussions regarding using synchronous condensers in the transformation of GPA to provide a high renewable energy future. We have even discussed this with KIUC early in their planning stage as well. There is high concordance in our respective approaches. KIUC retrofitted its steam-injected gas turbine generator at Kapaia Power Station for synchronous condenser operation allowing "the generator to provide inertia, fault current, voltage support and frequency stabilization to the grid without burning fuel."[122] When the KIUC system requires real power from the generator, KIUC restarts the turbine to again supply power to the grid within five minutes.[123]

[122] Kauai Island Utility Cooperative. (2019). KIUC Powers Kauaʻi with 100% Renewable Energy. URL: https://website.kiuc.coop/sites/kiuc/files/documents/pr20191216%20KIUC%20powers%20Kauai%20with%20100%20percent%20renewable%20energy_0.pdf (Last accessed January 22, 2021)

[123] Ibid.

This report recommends completing conversion of legacy combustion turbines Machehc and Yigo CTs or Piti 7 to synchronous condenser operation by 2024. GPA can choose to retire the prime movers for these converted plants or maintain them.

The priority for combustion turbine conversion to synchronous generation operation is in order of highest to lowest priority is:

1. Macheche CT
2. Yigo CT
3. Piti 7 CT
4. Dededo CT.

The combination of Piti 7, Macheche CT, Yigo CT, and Piti 8&9 provide about 840 SC MVA that can be dispatched during the Ukudu steam turbine outage. If Piti 8&9 are retrofitted for low (25%) continuous load operation, then the total real power dispatch during excessive solar PV production events is 48 MW.

20.3.4 Legacy Diesel Power Plants and Units Support Southern Microgrids

Talofofo Diesel Power Plant has the potential for supporting a microgrid for Yona and Talofofo. This is line with the GPA General Manager's strategic vision. The Yigo Diesel Power Plant has been part of discussions to build more resiliency in the southern part of the island and as GPA owned and operated backup at the Marine Base. GPA is planning to move 15-MW to Umatac Substation as part of a microgrid. GPA conversations with DoD have brought forth the idea for moving 25 MW of Yigo Diesel Power Plant generation behind the fence as backup to the Marine Base. This report recommends not retiring these power plants because of the above potential uses of these assets.

20.4 Excess Solar PV Generation (ESPVG) Event Management

The first key to successful excess solar PV generation event management is situational awareness. The second key is automation.

The excess solar PV generation event management process includes is the following:

- Forecast;
- Prepare;
- Measure;

- Act;
- Adjust.

20.4.1 First Key: Situational Awareness

The first key to successful excess solar PV generation event management is situational analysis. Situational awareness provides the tools for the assembling the resources needed, executing the event management, and adjusting the system to keep operations within normal operating parameters of frequency and voltage.

In order to take proper action to manage an excess solar PV generation event, one must know:

- How much solar PV power will be sent to the grid one-day ahead, one hour ahead, and now;
- How much short-circuit MVA is online, available as reserve, and needed in real-time;
- Real-time system voltage stability and potential threats;
- Real-time behavior of the system after curtailments, changes to the amount of synchronous generation online and short-circuit MVA, triggering of demand-response, and other actions.

In order to achieve this level of situational awareness, GPA recommends:

- Building a high speed solar irradiance sensor network to compute the real-time output of net metering systems into the grid and to forecast solar PV production dips;
- Leverage smart grid resources such as the GPA wireless and fiber communication networks;
- Leverage existing metering information sources such as the quantum meters GPA has installed on every generator, feeder, and bulk transmission transformer;
- Integrate these systems into the GPA Grid Controller.

20.4.2 Second Key: Automation

The first key to successful excess solar PV generation event management is situational awareness. The second key is automation. When asked to participate in Hawaiian Electric

Company's SHINES[124] work group by Dr. Dora Nakufuji, GPA's representative remarked that the amount of information that the project was collecting for use by system dispatchers may cause information overload. GPA also remarked that for weaker systems like GPA's, the system could change so quickly during many events as to be beyond the reaction time for manual intervention. GPA posited that for islanded systems with high inverter-based generation penetration a fly-by-wire grid capability may be required beyond conventional relay intervention. This was the seminal moment for GPA's Grid Controller Concept. GPA should initiate procurement of the Grid Controller and Solar Irradiance Sensor Network prior to the end of calendar year 2021.

GPA has had several conversations and discussions with potential Grid Controller candidates regarding the state of the art of similar control systems in the market and the general requirements GPA may be looking for. One of the biggest claims on the state of the art I sytems being able to identify potential areas of grid instability and act to alleviate those conditions prior to them becoming a serious threat to grid stability.

20.5 Grid Short-Circuit Ratio Management

GPA should require that all inverters integrated into the GPA system be capable of operation with a Composite Short-Circuit Ratio (CSCR) of at least 2.0. Conversations with EPS indicate that emerging utility scale inverters with operation capability at or below 1.8 SCR are or soon will be available.

GPA should also require that all solar PV systems tied to GPA's grid be DC-Coupled to the inverter. This will reduce the amount of SC MVA that GPA needs to supply to keep the grid stable.

GPA must determine the size of additional synchronous condensers for each new inverter-based generation addition as part of the System Impact Study beginning with Phase IV. With curtailment, GPA can maintain sufficient short-circuit MVA with the Ukudu Power Plant online after the addition of Phase III.

[124] Electric Power Research Institute. (2020). Hawaiian Electric SHINES Project. URL: https://techportal.epri.com/demonstrations/demo/ig/LTO8bwSRkYpBkHX1G1ads1fYHT9zZ1TtaA8cV9OP6fIzcNjBqOITJ1YsurefF9Jy (Last accessed May 2021).

GPA should begin conversion of legacy combustion turbines to synchronous condenser operation prior to Phase IV going online.

20.6 Net Metering Systems Management

GPA must ensure that NEM systems meet GPA's ride-through requirements. This includes:

- Physical inspections of inverter programming prior to initial interconnecting at the POI;
- Random inspection of inverter settings;
- Development of a check for non-compliant inverter behavior using smart grid AMI and Advanced Grid Analytics applications.

GPA has recently met with a solar PV contractor about interfacing with some of their customer systems to provide the above information as well as to sample solar PV system output. This could provide an excellent pilot leading to GPA control of these inverters to support the GPA grid stability and voltage management.

20.7 Management of Major Generation Outages

GPA should adopt or modify and adopt a definition for major generation outages to provide focus on the critical importance that these outages have to system reliability and their strain on GPA management of logistics.

GPA should develop a quality management plan (QMP) for the management of major generation outages as it has done for prudent fuel use and the reduction of system technical losses and unaccounted-for energy (UFE). GPA submitted these QMPs in response to PUC orders regarding GPA performance vis-à-vis high fuel costs and system losses. Performing to these QMPS have greatly improved GPA performance in those areas and saved customers tens of millions of dollars. For example, GPA reduced its system losses from fifteen percent or more to about six percent currently. Each percent decrease in real technical losses amounts to the same percent decrease or savings to GPA's fuel expenses.

GPA should plan major outages around March as it typically has load peak demand and high solar PV production.

20.8 Building Demand Response Resources

GPA should immediately investigate and implement the following Demand-Response resources prior to the first Ukudu steam turbine outage in 2028/2029:

- Direct Load Control Program;
- Interruptible and Curtailable Load Program;
- Large Commercial Building Frequency Regulation Services;
- Automate GWA as a Demand Response resource.

Direct Load Control is discussed in detail in section 12.3.1. The discussion concentrates on DLC solutions for capacity deficits or operational reserves.

GPA has recently approached large customers who participated in the interruptible load program in late CY 2015 and early CY 2016. Several expressed, in very quick fashion, no desire to participate as their backup generation failed during or soon after their participation because of the high use of their generation during the program. The initial overall health of customer backup generation may have contributed to this. But GPA should take this feedback at heart when designing a new program. Recommendations for consideration include:

- Limitations on hours run per year;
- Validation of backup generation health and completion of recommended maintenance;
- Consideration of backup generation age and run-hours;
- Test use of backup generation several months prior to Ukudu steam turbine outage to ensure capability and reliability;
- Bonuses for above contract maximum run-hours.

Hao et al. (2012) describe "how regulation services can be obtained by exploiting the inherent flexibility of HVAC (Heating, Ventilation, Air Conditioning) systems in commercial buildings."[125] Since "Hotel Row" adjacent to Tumon Bay is populated with large commercial hotel buildings, The density and size of these building with large HVAC systems makes the area an excellent location to pilot these concepts for Guam.

[125] Hao, He & Middelkoop, Timothy & Barooah, Prabir & Meyn, Sean. (2012). How Demand Response from Commercial Buildings can Provide the Regulation Needs of the Grid. 2012 50th Annual Allerton Conference on Communication, Control, and Computing, Allerton 2012. 10.1109/Allerton.2012.6483455

Using GWA for UFLS while removing other customers from the UFLS stages would likely improve customer satisfaction with GPA as customers experiencing outages tend to rate GPA lower. The ability to place GWA loads on backup generation can also reduce outages due to capacity deficits especially during Ukudu Power Plant steam turbine outages.

20.9 Energy-Shifting Battery Energy Storage Systems

GPA should build great flexibility into future renewable energy acquisition and stand-alone BESS contracts.

GPA should consider centralized and decentralized uses of BESS to improve grid stability and reduce customer outages. Centralized operation means operations under the control of the Grid Controller. Decentralized operations means operations under the control of fast-acting relays.

GPA should follow the recommended renewable road map outlined in section 14.

20.10 System Protection

Hoke et al. (2021) reports: "Methods to detect faults and protect the power system and its were designed for synchronous machine fault current characteristics."[126] As more inverter-based generation (IBG) is added to the GPA power system, GPA will have to make adjustments to ensure that its system protection will operate correctly. This includes:

- Limiting transmission fault clearing times to 5 cycles or less;
- Mitigating and responding to Fault Induced Delayed Voltage Recovery (FIDVR);
- Upgrading underfrequency load shedding (UFLS) protection;
- Creating undervoltage load shedding (UVLS) protection;
- Operating synchronous condensers to provide short-circuit MVA to keep the GPA grid stable and grid-following (GFL) inverters commutating;
- Operating synchronous condensers to provide short-circuit current for system faults;
- Incorporating synchrophasor information to detect pending issues of instability and prevent them from threatening the system stability;

[126] A. Hoke, V. Gevorgian, S. Shah, P. Koralewicz, R. W. Kenyon and B. Kroposki, "Island Power Systems With High Levels of Inverter-Based Resources: Stability and Reliability Challenges," in IEEE Electrification Magazine, vol. 9, no. 1, pp. 74-91, March 2021, doi: 10.1109/MELE.2020.3047169.

GPA has a significant vulnerability to Fault Induced Delayed Voltage Recovery (FIDVR). The use of BESS to mitigate and respond to these events is critical and most effective.

GPA should investigate and implement Adaptive Underfrequency Load Shedding and Adaptive Undervoltage Load shedding. As more customer inverter-based generation is installed on GPA's distribution system, the less effective UFLS becomes. As more inverter-based systems are integrated into the grid, the problems associated with voltage collapse increase during transmission faults. Development of adaptive strategies for GPA's power system protection should explore the use of artificial intelligence.[127]

GPA should incorporate synchrophasor measurements into the grid controller to detect impending grid stability issues and take action to correct issues before they actively threaten the system. The grid controller should provide quick detection, fast assessment, and fast meaningful action.

Hoke et al. (2021) reports: "Currently, a prevalent solution to addressing protection system needs in island systems that have high levels of IBRs involves installing synchronous condensers or converting displaced synchronous generators into synchronous condensers."[128] The use of synchronous condensers is one of the recommendations in GPA's Renewable Integration Report.

GPA will maintain its focus on future technology advancements especially in the area of grid-forming inverters. "Grid following (GFL) inverters can negatively affect protection system[s]." [129] Lin (2020) states that grid-forming (GFM) inverters may be able to alleviate these issues."[130] However, Lin caveats that there are lot of open research questions that remain to be answered and validated/studied.[131]

GPA's Phase III project requires an inverter that can provide blackstart capability and support a microgrid. GPA and Navy will work together to enable a microgrid for Naval Base

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[127] A. A. Bittencourt, M. R. de Carvalho and J. G. Rolim, "Adaptive Strategies in Power Systems Protection Using Artificial Intelligence Techniques," 2009 15th International Conference on Intelligent System Applications to Power Systems, 2009, pp. 1-6, doi: 10.1109/ISAP.2009.5352943.

[128] A. Hoke, V. Gevorgian, S. Shah, P. Koralewicz, R. W. Kenyon and B. Kroposki, "Island Power Systems With High Levels of Inverter-Based Resources: Stability and Reliability Challenges," in IEEE Electrification Magazine, vol. 9, no. 1, pp. 74-91, March 2021, doi: 10.1109/MELE.2020.3047169. p. 80.

[129] Yashen Lin. (2020). Grid-Forming Inverters – Enabling the Next Generation Grid. NREL PEGI Workshop (October, 13, 2020). URL: https://www.nrel.gov/aries/assets/pdfs/pegi-lin.pdf

[130] Ibid.

[131] Inid.

Guam and South Finegayan. All future GPA renewable energy acquisitions will require GFM inverters initially to support microgrids.

20.11 Grid Controller

Much of the analysis and recommendations performed in GPA System Impact Studies and the Renewable Integration Study/System Improvement Plan support the need for a Grid Controller. GPA should bid the Grid Controller under a multi-step bid prior to the end of calendar year 2021 and complete the initial project by 2024. Appendix G contains the draft Grid Controller Scope of Work. GPA has completed the procurement specifications. GPA intends to procure the Grid Controller using a request for proposal procurement vehicle. This is the exact same method used to procure automatic generation control under Engineering.

The grid controller incorporates artificial intelligence (AI) with smart grid enabled grid sensors to provide real-time reactive and proactive grid resilience. GPA's grid will become much more complex as it relies more on renewable energy and inverter-based resources. AI is a power tool to manage this complexity. Veritone (2021) reports that "artificial intelligence allows utilities to be both reactive and proactive when it comes to managing complexity, adapting to change, coping with changing energy supply and demand, and improving resilience."[132] Furthermore, this report states: "AI can prevent more outages and help accelerate outage recovery." This is precisely the intent of the Grid Controller. GPA's consultants providing system dynamic studies have throughout the years that GPA's lack of automatic generation control is one of the root causes for many power quality issues as well as increasing system restoration times for UFLS events.

The literature supports the feasibility for AI in GPA's Grid Controller concept. Malik (2018) presents several examples of AI applications in power systems.[133] Ren et al. (2021) discusses the use of AI for transient stability preventive control (TSPC). TSPC "ensures that power systems have a sufficient stability margin by adjusting power flow before faults occur."[134]

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[132] Veritone. (2021). Predictive Grid Modeling and Control: How Utilities Can Leverage AI to Dynamically Manage Complex Grids. URL: https://microgridknowledge.com/wp-content/uploads/2021/08/VERITONE-UTILITY-DIVE-PLAYBOOK_web-2.pdf

[133] Om Malik. (2018). Artificial Intelligence Applications in Power Systems. IEEE. URL: http://site.ieee.org/sas-pesias/files/2018/05/Artificial-Intelligence-Applications-in-Power-Systems_Slides.pdf

[134] Ren, J.; Li, B.; Zhao, M.; Shi, H.; You, H.; Chen, J. Optimization for Data-Driven Preventive Control Using Model Interpretation and Augmented Dataset. Energies 2021, 14, 3430. https://doi.org/10.3390/en14123430

Kim (2021) report on an AI convolutional neural network (CNN)-based event classification using measured synchrophasor data to classify transient events and provide fast decisions in successive event conditions to stabilize the power system.[135] GPA discussions with David Jeon and Tim Allen of PXISE during the Phase I Energy Storage System Project have confirmed GPA's research on the state of the art relevant to its Grid Controller concepts.

20.12 Future Watch

GPA must keep up on technology especially that of large grid-forming inverters, bifacial solar technology, and concentrating solar power (CSP). The first are already part of GPA's renewable energy acquisition specifications starting with Phase III. All future acquisitions require energy shifting storage. The latter two will be decided upon by the proponents that bid for GPA renewable energy power purchase agreements. The private sector evaluation of the technical risks, performance requirements, and system technology costs will provide what technology will come to the forefront.

"Grid-forming inverters are able to operate AC grids with or without rotating machines."[136] "Because grid-forming inverters can create a waveform at a specified frequency, they can provide the basis of a synchronous AC power system …"[137] with or without synchronous generation. This means a large grid-forming inverter could provide the master voltage and frequency waveform that other inverters and synchronous generation can synchronize to. "Grid-forming inverters are already used in many zero-inertia microgrid systems (typically less than 10 MW) that do not use synchronous generators."[138]

The experiences garnered from developing microgrids from the Phase III systems will provide guidelines for other Guam microgrids.

[135] Kim, D.-I. Complementary Feature Extractions for Event Identification in Power Systems Using Multi-Channel Convolutional Neural Network. Energies 2021, 14, 4446. https://doi.org/10.3390/en14154446
[136] Unruh P, Nuschke M, Strauß P, Welck F. Overview on Grid-Forming Inverter Control Methods. Energies. 2020; 13(10):2589. https://doi.org/10.3390/en13102589
[137] Denholm, Paul, Trieu Mai, Rick Wallace Kenyon, Ben Kroposki, and Mark O'Malley. 2020. Inertia and the Power Grid: A Guide Without the Spin. Golden, CO: National Renewable Energy Laboratory. NREL/TP-6120-73856. https://www.nrel.gov/docs/fy20osti/73856.pdf. P. 34.
[138] Ibid.

As the state of the art for grid-forming inverters advances, it may become an important piece for GPA's grid transformation towards 100% renewable energy. However, GPA should be patient and prudent. Incorporating this technology may be a matter of when. But not right now. A recent paper by the National Renewable Energy Laboratories (NREL) provides this caveat:

> "A large zero-inertia power system would require inverters that could independently form a grid voltage and frequency—and maintain this voltage and frequency without an explicit communications network (Figure 20c). The field of grid-forming inverters is rapidly advancing (Lin et al. 2020; Ackerman et al. 2017). However, as discussed previously, the potential need for zero-inertia systems has yet to be explored in detail, particularly in grids with significant synchronous renewable or other low-carbon resources. The costs (or need) to develop a system that can reliably operate under near zero-inertia conditions has yet to be analyzed in detail, particularly in comparison to maintaining the current synchronous-based system with sufficient modification to accommodate very high levels of VG penetration."[139]

Bifacial solar PV technology can be more efficient than conventional monofacial solar modules. Therefore, proponents using this technology may require less land. "For example, Cuevas et al.[140] have demonstrated a bifacial gain up to 50% relative to identically oriented and tilted monofacial modules."[141] Deline et al. (2019)[142] concludes:

- "Bifacial PV is becoming mainstream with GW's of installed projects;
- "Energy gain depends on the site configuration and surface albedo. Models like SAM, PVSyst and Bifacial_Radiance can assist with system design and power estimation;
- "1-axis tracker validation is underway at NREL, showing good initial match with model, and energy gain of 6% and 9% annually for PERC and Si-HJT;
- "LCOE of bifacial systems is competitive with monofacial systems now, even with initial cost adder of 5-6 ¢/W. Post-tariff, bifacial is a clear winner."

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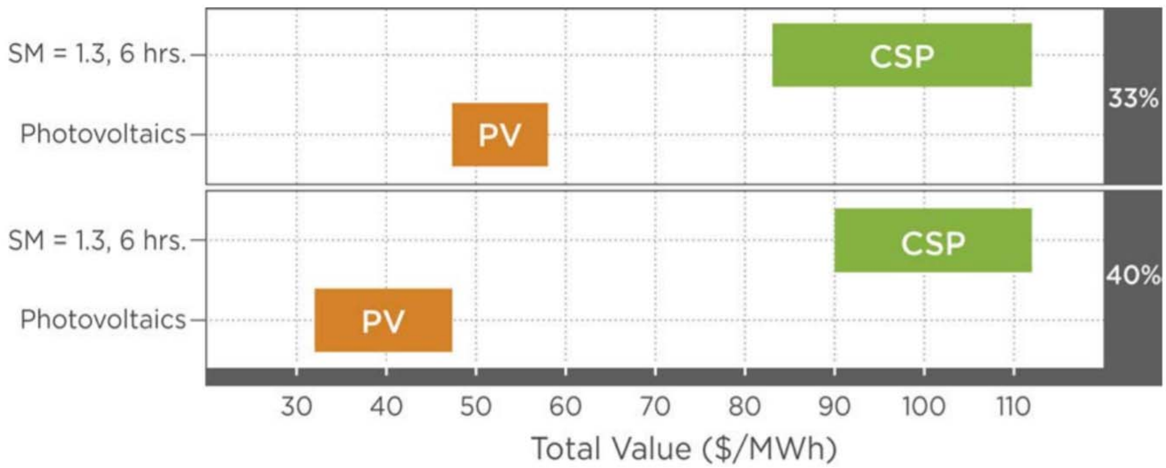
[139] Ibid. p 35

[140] A. Cuevas, A. Luque, J. Eguren, and J. del Alamo, "50% more output power from an albedo-collecting flat panel using bifacial solar cells," Sol. Energy, vol. 29, no. 5, pp. 419–420, 1982

[141] 94. Sun, Xingshu & Khan, Mohammad & Deline, Chris & Alam, Muhammad. (2017). Optimization and Performance of Bifacial Solar Modules: A Global Perspective. Applied Energy. 212. 10.1016/j.apenergy.2017.12.041.

[142] Chris Deline, Silvana Ayala Peláez, Bill Marion, Bill Sekulic, Michael Woodhouse, and Josh Stein. (2019). Bifacial PV System Performance: Separating Fact from Fiction. NREL. NREL/PR-5K00-74090.

Concentrating solar power (CSP) with thermal storage has a greater value than solar PV by itself. Mehos et al. (2016)[143] concludes that for renewable portfolio standards (RPS) of 33% and 40% CSP is much more valuable than PV. Figure 23-1 reproduces a chart from this report.



Total value, which includes operational and capacity value, of CSP with thermal energy storage and PV under 33% and 40% RPS scenarios

SM = solar multiple

Source: On the Path to SunShot: Advancing Concentrating Solar Power Technology, Performance, and Dispatchability. (NREL)

Figure 23-1. Value of Solar PV versus Concentrating Solar Power Under 33% and 40% RSP Scenarios

GPA has a primary mandate for providing reliable power. Therefore, although close to or at the cutting edge of commercially available technology, GPA should avoid being at the bleeding edge. The island's economy and our national defense depend on GPA continuing to provide reliable power.

GPA, its management, the Commission on Consolidated Utilities (CCU), and the Guam Public Utilities Commission (PUC) should guard against those advocating the state-of-the-art has

[143] Mehos, Mark, Craig Turchi, Jennie Jorgenson, Paul Denholm, Clifford Ho, and Kenneth Armijo. 2016. On the Path to SunShot: Advancing Concentrating Solar Power Technology, Performance, and Dispatchability. Golden, CO: National Renewable Energy Laboratory. NREL/TP-5500-65688. http://www.nrel.gov/docs/fy16osti/65688.pdf

already arrived and that we can go to 100% renewable energy today. It will take time. GPA will have to invest in many changes and new technologies. GPA must wait until the state of the art is mature enough to integrate into our power system. GPA is progressing quickly but prudently towards that goal. Many national organizations outside of Guam laud GPA as visionary and innovative regarding our strategy and march to grid transformation and high renewable energy penetration.

21 Strategy

GPA's strategy regarding renewable energy has been to ride the technology capability curve up while riding the cost of technology curve down. This is a responsible, sustainable strategy.

The Integrated Resource Plan is a strategic document. The IRP although having a planning horizon of twenty years is really about making decisions within the first ten-year period.

Technology advances will greatly change what is possible. The hype media, lobbyists, and commercial concerns with "dogs in the hunt" will spin tales about what can be done now based on technologies that have some development in front of them to make them realistic commercial choices. GPA has a mandate to provide affordable, reliable power. It is our responsibility. The investments that we make must be appropriate for our system, Guam, and our funding capabilities. They must be prudent.

The GPA renewable energy strategy is:

- Holistic and Systematic;
- Aligned with Engineering and Business Quality Management.

21.1 GPA's Holistic Renewable Energy Strategy

GPA's renewable energy strategy is holistic. It includes investigation into how renewable energy fits into the GPA power system, what transformations must occur to accommodate more renewable energy into the grid while improving power quality, system stability, and electric service reliability. Renewable energy on the power grid is part of the power system. Each part of this system interacts and has interdependencies between the parts. Careful consideration must take place to understand these interdependencies and interactions so that you keep the system sustainable. This is really such a fundamental part of sustainability but one that is often missed by the "adherents" of sustainability.

This approach is insightful as you cannot separate the current grid from the future grid abruptly. It would cost too much and the technology is not there. Many political and commercial interests want GPA to demolish the current grid and replace it now. This is misguided, imprudent and probably self-serving. Deming remarked: "There is an excuse for ignorance, but there is no way to avoid the consequences."[144] GPA hopes to avoid these consequences.

21.2 GPA Strategy Aligned with Engineering and Business Quality Management

GPA's renewable energy strategy as GPA is implementing it is an example of the Plan-Do-Check-Act (PDCA) approach for continually improving processes, products, or services, and for resolving problems.[145]

Based on the scientific method of problem-solving popularized by Dr. W. Edwards Deming, PDCA "involves systematically testing possible solutions, assessing the results, and implementing the ones that have shown to work."[146] Many consider Deming to be the father of modern quality control.

The PDCA Cycle provides a simple and effective approach for solving problems and managing change. It enables businesses to develop hypotheses about what needs to change, test these hypotheses in a continuous feedback loop, and gain valuable learning and knowledge. It promotes testing improvements on a small scale before updating company-wide procedures and work methods.

21.3 GPA Grid Transformation Solutions

The Integrated Resource Plan has a direct tie to GPA's Strategic Plan. One of the Strategic Objectives for GPA is Grid Transformation. Figure 21-1 is a graphic representing the elements of GPA's evolving Grid Transformation.

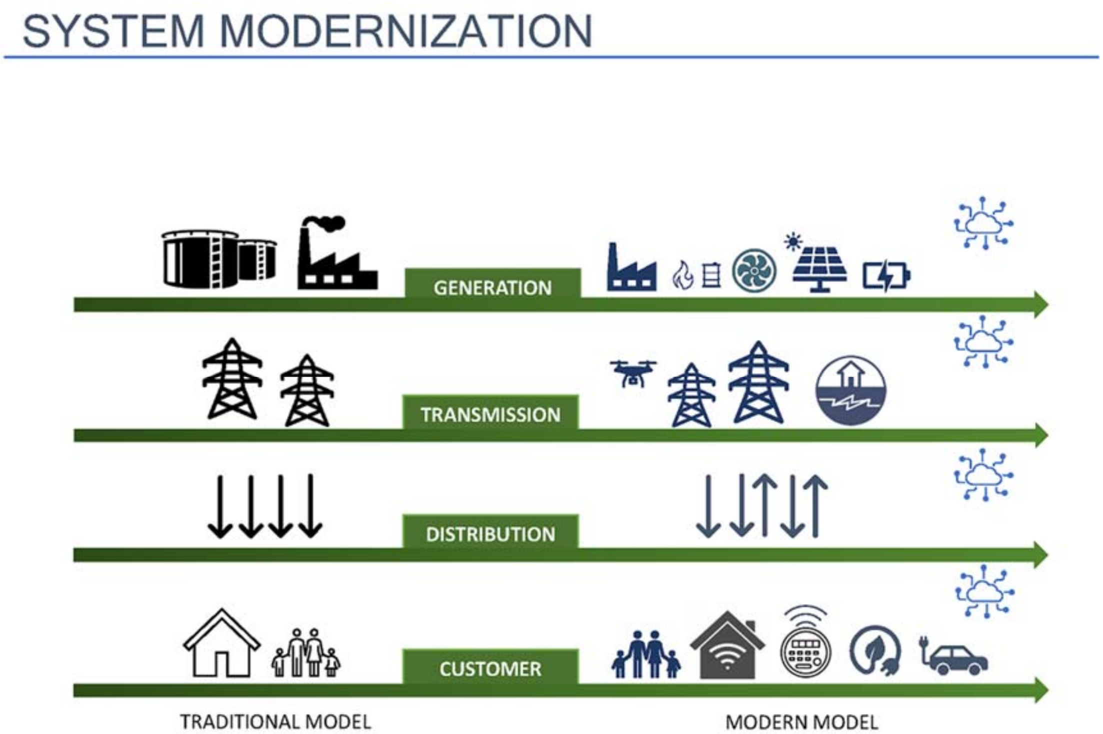
---

[144] Best M, Neuhauser DW Edwards Deming: father of quality management, patient and composerBMJ Quality & Safety 2005;14:310-312.

[145] Nawras Skhmot. (2017). Using the PDCA Cycle to Support Continuous Improvement (Kaizen). URL: https://theleanway.net/the-continuous-improvement-cycle-pdca (Accessed July 4, 2021).

[146] Ibid

Figure 21-2 provides a summary of GPA's Grid Solutions for Grid Transformation. Figure 21-2 provides a graphic for communicating the tactics for Grid Transformation to employees, customers and regulators.



Source: GPA General Manager Presentation to University of Pittsburgh Students

Figure 21-1. GPA Grid Transformation

GPA's Grid Transformation includes.

- Moving from fossil fuel principally residual fuel oil generation to cleaner gas and ultralow sulfur diesel fired synchronous generation, solar PV and other renewable energy, synchronous condensers, and battery energy storage systems;
- Moving from our current transmission and distribution systems to smart grid enabled systems and more underground systems;
- Moving from a unidirectional power flows on the distribution system to bi-directional flows as system protection systems technology evolve;
- Moving from a relationship with Customers who receive power to a more interactive relationship with customers as partners in supplying power and providing grid services to keep the grid stable and affordable;

- Deploying additional power system sensors such as phasor measurement units (PMU) to get the right information to the right people and systems to take the right actions immediately;
- Moving from reactive response to system conditions to proactive response.

22 Capital Plan

Table 22-1 shows the overall Budgets for the capital improvement projects recommended in Volume I of the 2022 IRP.

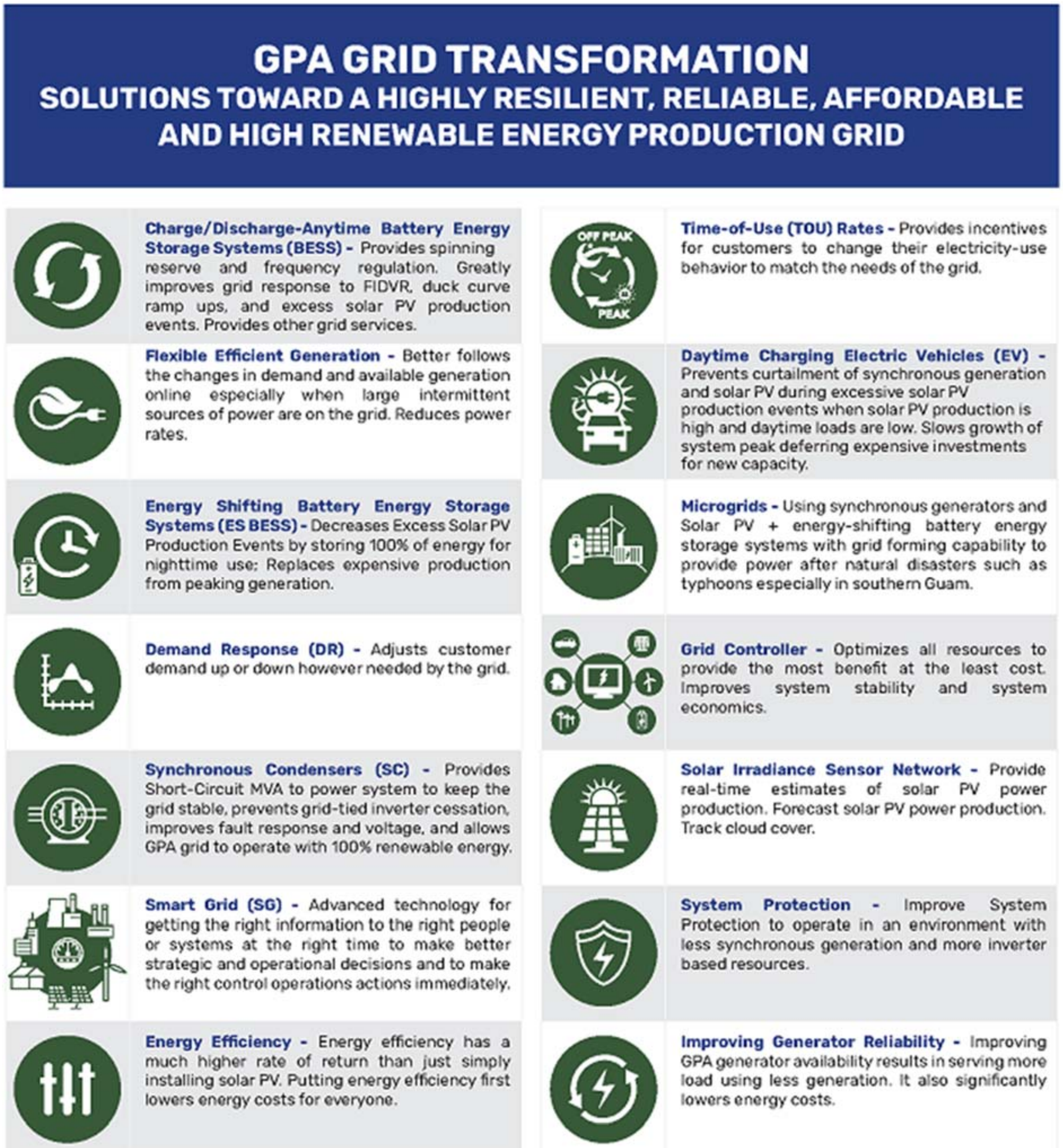


Figure 21-2. GPA Grid Solutions for Grid Transformation

Table 22-1. Recommended CIP Projects

Project Priority	Project Name	Project Description	Total Project Budget ($)	Priority Total
1	Relay Upgrade	Implement RIS recommendation for reduced fault clearing time.	$ 5,000,000.00	$ 5,700,000.00
	Adaptive Underfrequency Load Shedding (UFLS)	AUFLS study	$ 50,000.00	
		AUFLS imlementation	$ 300,000.00	
	Adaptive Under Voltage Load Shedding (UVLS)	AUVLS study	$ 50,000.00	
		AVULS imlementation	$ 300,000.00	
2	Synchronous Condenser Conversions (Based on Leidos Report, 11/12/2021)	Macheche CT - Add clutch	$ 7,732,335.96	$ 229,969,211.01
		Macheche CT - Demo CT and add motor/static start	$ 5,485,680.22	
		Yigo CT - Add clutch (assumed same costs as Macheche)	$ 7,732,335.96	
		Yigo CT - Demo CT and add motor/static start (assumed same cost as Macheche)	$ 5,485,680.22	
		Dededo CT - Add clutch	$ 7,732,335.96	
		Dededo CT - Demo CT and add motor/static start	$ 5,485,680.22	
		Piti 7 CT - Add clutch	$ 9,747,650.70	
		Piti 7 CT Demo CT and add motor/static start	$ 6,598,280.25	
	Stand-alone Synchronous Condenser	230 MVA	$ 42,719,231.52	
	Standalone BESS	75 MW/300 MWH Standalone BESS	$ 131,250,000.00	
3	Grid Controller	Implementation of RIS Recommendation	$ 1,500,000.00	$ 3,300,000.00
	Synchrophasor Network	Provide Information for Grid Controller to detect impending system instabilities	$ 1,800,000.00	
4	Malojloj - Hagatna 115 KV Line	Implementation of RIS Recommendation	$ 46,000,000.00	$ 46,000,000.00
5	Demand Response Programs	Customer ESS Pilot Project: Use BESS to reduce demand charges for large customers. (Energy Sense Funds)	$ 500,000.00	$ 6,124,588.50
		Water Heater DLC Programs	$ 3,124,588.50	
		Streetlight Dimming Control	$ 2,500,000.00	
	Demand Response with GWA	Use of GPA backup generation as demand response resource.	TBD	
6	Remote Start/Stop/Autostart	Tenjo Vista Power Plant	$ 430,000.00	$ 3,280,000.00
		Yigo CT	$ 950,000.00	
		Macheche CT	$ 950,000.00	
		Dededo CT		
		Piti 7 CT	$ 950,000.00	
7	Umatac Microgrid	Relocation and resiting 15-MW from Yigo to Umatac	$ 4,145,200.00	$ 4,220,200.00
		Self-forming Microgrid bid specifications	$ 75,000.00	
8	Bus EV Charging Infrastructure	Bus EV Managed Charging	TBD	
8	Solar Irradiance Sensor Network	Procure Razon Solar Irradiation Sensors	$ 61,425.00	$ 151,425.00
		Build out Sensor network. Configure data communications from sensors to SCADA. Configure SCADA displays and database.	$ 10,000.00	
		Configure data communications from irradiance sensors to L+G AGA to compute real-time NEM PV output.	$ 80,000.00	
	TOTAL CIPs (Assumes CT Converted to Synch Cond and removed from service as a power plant + Standalone Synch Cond.)		$ 298,745,424.51	
	TOTAL CIPs (No Standalone Synchronous Condenser; CTs converted to Sysnchronous Condenser operations but are still power plants)		$ 232,970,872.09	

23 Clarifications, Caveats, and Things to Think Upon

This section discusses clarifications, caveats, and offers food for critical thought on several issues related to the themes of generation system reliability, adequacy, and resiliency covered in volume I of the 2022 IRP including:

- The misconception that the value of renewable penetration will forever have a large positive economic and environmental value;
- GPA's Strategy of Utility-Scale Systems;
- New Technologies and the "100% Solar PV Right Now!" Movement.

23.1 The Economics of Renewable Energy

There is a gross misconception in the public that the value of renewable penetration will always have a large positive economic and environmental value. This is acknowledged by many credible sources as false.

Sivaram and Kann (2016) state that: "Solar power is increasingly economical, but its value to the grid decreases as its penetration grows, and existing technologies may not remain competitive."[147] This is echoed throughout the literature. For example, the MIT Energy Initiative report "The Future of Solar Energy - An Interdisciplinary Study" remarks: "LCOE is an inadequate measure for assessing the competitiveness of PV, or for comparing PV with CSP or conventional generation sources, because the value per kilowatt-hour (kWh) of PV generation depends on many features of the regional electricity market, including the level of PV penetration. The more PV capacity is online in a given market, for instance, the less valuable is an increment of PV generation."[148]

[147] Sivaram, V., Kann, S. Solar power needs a more ambitious cost target. Nat Energy 1, 16036 (2016). https://doi.org/10.1038/nenergy.2016.36
[148] Massachusetts Institute of Technology, Energy Initiative. (2015). The Future of Solar Energy: An Interdisciplinary MIT Study. URL: https://mitei.mit.edu/futureofsolar (Last Accessed January 2020)

23.2 The Strategy of Utility-Scale Systems

GPA's renewable energy acquisition strategy rides the technology capability up and the cost reduction curve down. It is predicated on getting the most renewable energy at the lowest cost. "On cost, the MIT study found that utility-scale solar is inherently less expensive than residential-scale, and is likely to remain less expensive despite foreseeable cost reductions in residential. Therefore, utility-owned projects are a more affordable pathway to meeting renewable energy requirements."[149] GPA leverages new technology capabilities as those capabilities become commercially available and viable for the GPA system. Beginning with Phase III, all GPA renewable energy acquisitions of renewable intermittent generation will be required to have energy-shifting battery energy storage systems to eliminate intermittency and shift energy to when it is needed unlike net metering systems that produce energy only during daylight hours. GPA is a night-time peaking system. Therefore, net metering systems do not defer generation or transmission capacity. Only four of 66 GPA distribution feeders peak during daylight hours. Therefore, net metering systems without energy storage cannot defer distribution system capacity for 94% of GPA's distribution system feeders. Contrastingly, GPA's Energy-shifting BESS projects can defer generation and transmission capacity.

23.3 New Technologies and the "100% Solar Right Now!" Movement

GPA takes measured steps towards increasing renewable energy penetration on its grid so that it can take advantage of advances in technology and reductions in technology cost. Converting to 100% right now robs GPA's customers of the aforementioned advantages. Additionally, the GPA system is not capable of accepting more solar than the Phase II projects until it completes several recommended projects including the new Ukudu power plant.

GPA has received many inputs from the public on renewable energy and energy storage. For example, one person suggested that GPA should consider using "flow batteries". GPA performed an energy storage feasibility study several years prior in 2009 that indicated that "flow battery" technology's 60% round-trip efficiencies are not economic but lithium battery technologies are. Others pointed out the 1.41-MW solar PV plus 60 Tesla Powerpcaks at Ta'u,

[149] Julia Pyper. (2015) Ditching Net Metering Is in the 'Best Interest' of Solar, Say MIT Economists. URL: https://www.greentechmedia.com/articles/read/MIT-Economists-Say-We-Should-Ditch-Net-Metering

Ofu, and Olosega[150] in the American Samoa Manu'a Islands group[151] as irrefutable proof of the viability of going 100% solar PV for Guam now. However, the Ofu solar battery storage area caught fire.[152] Additionally, the cost of electricity service fueled by diesel generators for the Manu'a islands was much more than for Guam. There is still work ahead for the industry and Guam to get to 100% renewable energy.

Recently, GPA has received criticism that GPA does not need any conventional synchronous generation and can move immediately to 100% solar PV through the use of grid-forming inverters. NREL's Lin et al. (2020) reports: "Replacing synchronous machines with grid-forming inverters at the transmission level will, in general, be the most mature iteration of grid-forming usage. This phase has a relatively long timeline (~10–30 years) and will be achieved only once a research base of protection, controls, and interoperability has been established and a robust standards environment defining the required functionality of grid-forming inverters on the bulk grid exists. … In other words, the maturation process of grid-forming inverters will most likely unfold in a staged approach with lessons learned as well as operational experience and expertise gained throughout many years."[153] Note that GPA's Phase III Renewable Acquisition Bid requires grid forming inverters.

GPA's strategy relies on the market comprised of the renewable energy bidders to determine what the "best" cost-effective solution is. Real world solutions will minimize overall risks choosing the technology that has the least risk and cost while optimizing performance to meet the bid requirements. As new technologies gain acceptance and prove themselves, they will show up on proposals for renewable energy. GPA will prudently allow for being on or near the cutting edge of technology but not the bleeding edge.

---

[150] Daniel Lin. (2017). How a Pacific Island Changed From Diesel to 100% Solar Power. URL: https://www.nationalgeographic.com/science/article/tau-american-samoa-solar-power-microgrid-tesla-solarcity

[151] West Coast Collaborative. (2017). DERA 2016: American Samoa Achieves 100% Renewable Energy on Ta'u Island. URL: https://www.westcoastcollaborative.org/files/grants/2016/american-samoa-solar-storage-factsheet-2016.pdf.

[152] Radio New Zealand. (2019). Fire in American Samoa takes out solar power grid. URL: https://www.rnz.co.nz/international/pacific-news/392936/fire-in-american-samoa-takes-out-solar-power-grid

[153] Lin, Yashen, Joseph H. Eto, Brian B. Johnson, Jack D. Flicker, Robert H. Lasseter, Hugo N. Villegas Pico, Gab-Su Seo, Brian J. Pierre, and Abraham Ellis. 2020. Research Roadmap on Grid-Forming Inverters. Golden, CO: National Renewable Energy Laboratory. NREL/TP-5D00-73476. https://www.nrel.gov/docs/fy21osti/73476.pdf. p. 33

Many technologies brought up in Guam PUC public meetings are not ready for use on GPA's system, or have met with disaster[154] although highly touted by these sources. The reality is, however, that GPA recognizes the value of new technology. GPA is quick to exploit this value given the constraints of resources and the Government of Guam's procurement process. For example, GPA;s Phase I Energy Storage System Project uses battery energy storage system technology to augment GPA spinning reserve, improve frequency regulation, and reduce the impact of solar PV intermittency. GPA completed an Energy Storage System Feasibility Study in 2009.[155] Once, GPA obtained bond funding for the project, the acquisition of GPA's Phase I ESS Project was procured in parallel with GPA's Phase I Renewable Energy Acquisition. The use of BESS for spinning reserve is a novel and excellent use of the advantages provided by the technology.

Will going to 100% renewable energy eliminate the need for synchronous generation? The answer is likely "no". GPA must be prudent. In 2019, Kaua'i Island Utility Cooperative (KIUC) suffered rolling blackouts simply because "solar production has struggled to meet peak demand."[156] One alternative is to significantly overbuild solar and other renewable energy production.

GPA could move to almost eliminate its energy production GHG production, especially carbon-emissions. Going carbon-free is in line with the US Department of Energy Solar Futures Study. Figure 23-1 shows the Solar Futures Study 2050 generation mix.

Replacing GPA fossil fuel-fired synchronous generation by zero-carbon synchronous generation such as nuclear may eliminate most of the carbon greenhouse emissions on Guam. However, small modular reactors (SMR), although fast tracked by the US Department of Energy (US DOE), are still in development. Since 2014, GPA has kept contact with NuScale, one of the recipients of US DOE cost-shared funding, in their development of SMR technology. "The first

[154] Radio New Zealand. (2019). Fire in American Samoa takes out solar power grid. URL: https://www.rnz.co.nz/international/pacific-news/392936/fire-in-american-samoa-takes-out-solar-power-grid
[155] Electric Power Systems, Inc., (2009). GPA Energy Storage Feasibility Study. Anchorage, Alaska.
[156] Walton, R. (2019). Island-wide outage on Kaua'i: Clouds block solar recovery after generator's cable failure. URL: https://www.utilitydive.com/news/island-wide-outage-on-kauai-clouds-block-solar-recovery-after-generators/559289/ (Last accessed July 4, 2021)

NuScale Power Module™ will begin generating power in 2029, with the remaining modules coming online for full plant operation by 2030."[157]

2050 Generation Mix		
Technology	**US Demand Contribution Percent (%) Range)**	
Solar (PV & CSP)	44%	45%
Wind	40%	45%
Nuclear	4%	5%
Hydropower	3%	5%
Combustion Turbines (on zero-carbon synthetic fuels)	2%	4%
BioPower/Geothermal	1%	

Source: Solar Futures Study (2021, NREL)

Figure 23-1. U.S. DOE Solar Futures Study 2050 Generation Mix.

[157] NuScale. (2021). The Carbon Free Power Project. URL: https://www.nuscalepower.com/projects/carbon-free-power-project

ACKNOWLEDGEMENTS

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Note: Strategic Planning & Operations Research Division (SPORD)

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Mayor Melissa B. Savares (Dededo)	President	Mayors Council of Guam
Ambrosio Constantino, MPA	Disaster Program Manager	American Red Cross Guam Chapter

External Reviews and Discussions			
Name	**Title**	**Organization**	**Related Work for GPA**
Dave Burlingame, PE	Principal	Electric Power Systems, Inc.	Energy Storage Feasibility Study (2009); System Impact Studies, Renewable Integration Study/System Improvement Plan
Dr. James Cote, PE	Principal Engineer	Electric Power Systems, Inc.	
Andriano E. Balajadia, P.E.	Principal	A.E. Balajadia Consulting Engineer	
Mark Beauchamp, CPA	President & Founder	Utility Financial Services, LLC	NEM Study (2021), Cost of Service Studies, Energy Sense Rebate Reset (2021), GPA EV Roadmap (2021 with Sheffield)
Christopher Lund	Financial, Business & Technology Consultant	Utility Financial Services, LLC	
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Timothy Allen	Chief of Commercial Development and Product Strategy	PXISE Energy Solutions	Subcontractor to LG CNS on Phase I ESS Project
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James Rosenberg II	Director of Business Development	blink	Discussions on EV Charging Infrastructure
Yashen Lin	Senior Researcher	National Renewable Energy Laboratory	Discussions on various NREL reports espcially Grid Forming Inverters

Appendix A: Power Plant Capacity State Probability Distribution Models

LEGACY PLANT EAF = 95%

TalTenjoStates

STATE	MWstate	P(MWstate)
1	-	3.906250E-11
2	4.40	5.937500E-09
3	8.80	3.948438E-07
4	13.20	1.500406E-05
5	17.60	3.563465E-04
6	22.00	5.416467E-03
7	26.40	5.145643E-02
8	30.80	2.793349E-01
9	35.20	6.634204E-01

MacYigoStates

STATE	MWstate	P(MWstate)
1	-	2.500000E-03
2	20.00	9.500000E-02
3	40.00	9.025000E-01

MDIStates

STATE	MWstate	P(MWstate)
1	-	2.500000E-03
2	5.00	9.500000E-02
3	10.00	9.025000E-01

Piti7States

STATE	MWstate	P(MWstate)
1	-	5.000000E-02
2	40.00	9.500000E-01

Piti8&9States

STATE	MWstate	P(MWstate)
1	-	2.500000E-03
2	40.00	9.500000E-02
3	80.00	9.025000E-01

YigoDGStates		
STATE	MWstate	P(MWstate)
1	-	1.818989E-51
2	1.13	1.347871E-48
3	2.26	4.865815E-46
4	3.39	1.140223E-43
5	4.52	1.949781E-41
6	5.65	2.593208E-39
7	6.78	2.792021E-37
8	7.91	2.500853E-35
9	9.04	1.900648E-33
10	10.17	1.243869E-31
11	11.30	7.090052E-30
12	12.43	3.551471E-28
13	13.56	1.574486E-26
14	14.69	6.213163E-25
15	15.82	2.192359E-23
16	16.95	6.942469E-22
17	18.08	1.978604E-20
18	19.21	5.086176E-19
19	20.34	1.181123E-17
20	21.47	2.480358E-16
21	22.60	4.712681E-15
22	23.73	8.101323E-14
23	24.86	1.259387E-12
24	25.99	1.768618E-11
25	27.12	2.240249E-10
26	28.25	2.553884E-09
27	29.38	2.612820E-08
28	30.51	2.390247E-07
29	31.64	1.946344E-06
30	32.77	1.402710E-05
31	33.90	8.883829E-05
32	35.03	4.900434E-04
33	36.16	2.327706E-03
34	37.29	9.381362E-03
35	38.42	3.145515E-02
36	39.55	8.537828E-02
37	40.68	1.802430E-01
38	41.81	2.776717E-01
39	42.94	2.776717E-01
40	44.07	1.352760E-01

DededoCTStates

STATE	MWstate	P(MWstate)
1	-	2.500000E-03
2	22.00	9.500000E-02
3	44.00	9.025000E-01

LEGACY PLANT EAF = 90%

TalTenjoStates

STATE	MWstate	P(MWstate)
1	-	1.000000E-08
2	4.40	7.200000E-07
3	8.80	2.268000E-05
4	13.20	4.082400E-04
5	17.60	4.592700E-03
6	22.00	3.306744E-02
7	26.40	1.488035E-01
8	30.80	3.826375E-01
9	35.20	4.304672E-01

MacYigoStates

STATE	MWstate	P(MWstate)
1	-	1.000000E-02
2	20.00	1.800000E-01
3	40.00	8.100000E-01

MDIStates

STATE	MWstate	P(MWstate)
1	-	1.000000E-02
2	5.00	1.800000E-01
3	10.00	8.100000E-01

Piti7States

STATE	MWstate	P(MWstate)
1	-	1.000000E-01
2	40.00	9.000000E-01

Piti8&9States

STATE	MWstate	P(MWstate)
1	-	1.000000E-02
2	40.00	1.800000E-01
3	80.00	8.100000E-01

YigoDGStates		
STATE	MWstate	P(MWstate)
1	-	1.000000E-39
2	1.13	3.510000E-37
3	2.26	6.002100E-35
4	3.39	6.662331E-33
5	4.52	5.396488E-31
6	5.65	3.399788E-29
7	6.78	1.733892E-27
8	7.91	7.356654E-26
9	9.04	2.648396E-24
10	10.17	8.210026E-23
11	11.30	2.216707E-21
12	12.43	5.259641E-20
13	13.56	1.104525E-18
14	14.69	2.064612E-17
15	15.82	3.450851E-16
16	16.95	5.176276E-15
17	18.08	6.987973E-14
18	19.21	8.508885E-13
19	20.34	9.359773E-12
20	21.47	9.310511E-11
21	22.60	8.379460E-10
22	23.73	6.823274E-09
23	24.86	5.024411E-08
24	25.99	3.342326E-07
25	27.12	2.005395E-06
26	28.25	1.082914E-05
27	29.38	5.247966E-05
28	30.51	2.274118E-04
29	31.64	8.771600E-04
30	32.77	2.994443E-03
31	33.90	8.983328E-03
32	35.03	2.347257E-02
33	36.16	5.281327E-02
34	37.29	1.008253E-01
35	38.42	1.601344E-01
36	39.55	2.058870E-01
37	40.68	2.058870E-01
38	41.81	1.502419E-01
39	42.94	7.116721E-02
40	44.07	1.642320E-02

DededoCTStates

STATE	MWstate	P(MWstate)
1	-	1.000000E-02
2	22.00	1.800000E-01
3	44.00	8.100000E-01

LEGACY PLANT EAF = 85%

TalTenjoStates

STATE	MWstate	P(MWstate)
1	-	2.562891E-07
2	4.40	1.161844E-05
3	8.80	2.304323E-04
4	13.20	2.611567E-03
5	17.60	1.849860E-02
6	22.00	8.386030E-02
7	26.40	2.376042E-01
8	30.80	3.846925E-01
9	35.20	2.724905E-01

MacYigoStates

STATE	MWstate	P(MWstate)
1	-	2.250000E-02
2	20.00	2.550000E-01
3	40.00	7.225000E-01

MDIStates

STATE	MWstate	P(MWstate)
1	-	2.250000E-02
2	5.00	2.550000E-01
3	10.00	7.225000E-01

Piti7States

STATE	MWstate	P(MWstate)
1	-	1.500000E-01
2	40.00	8.500000E-01

Piti8&9States

STATE	MWstate	P(MWstate)
1	-	2.250000E-02
2	40.00	2.550000E-01
3	80.00	7.225000E-01

YigoDGStates		
STATE	MWstate	P(MWstate)
1	-	7.371555E-33
2	1.13	1.629114E-30
3	2.26	1.754012E-28
4	3.39	1.225860E-26
5	4.52	6.251885E-25
6	5.65	2.479914E-23
7	6.78	7.963280E-22
8	7.91	2.127333E-20
9	9.04	4.821956E-19
10	10.17	9.411743E-18
11	11.30	1.599996E-16
12	12.43	2.390298E-15
13	13.56	3.160505E-14
14	14.69	3.719671E-13
15	15.82	3.914511E-12
16	16.95	3.697038E-11
17	18.08	3.142482E-10
18	19.21	2.409236E-09
19	20.34	1.668619E-08
20	21.47	1.045083E-07
21	22.60	5.922135E-07
22	23.73	3.036269E-06
23	24.86	1.407725E-05
24	25.99	5.896122E-05
25	27.12	2.227424E-04
26	28.25	7.573242E-04
27	29.38	2.310810E-03
28	30.51	6.304802E-03
29	31.64	1.531166E-02
30	32.77	3.291127E-02
31	33.90	6.216573E-02
32	35.03	1.022727E-01
33	36.16	1.448863E-01
34	37.29	1.741562E-01
35	38.42	1.741562E-01
36	39.55	1.409836E-01
37	40.68	8.876746E-02
38	41.81	4.078505E-02
39	42.94	1.216396E-02
40	44.07	1.767413E-03

DededoCTStates

STATE	MWstate	P(MWstate)
1	-	2.250000E-02
2	22.00	2.550000E-01
3	44.00	7.225000E-01

LEGACY PLANT EAF = 75%

TalTenjoStates

STATE	MWstate	P(MWstate)
1	-	1.525879E-05
2	4.40	3.662109E-04
3	8.80	3.845215E-03
4	13.20	2.307129E-02
5	17.60	8.651733E-02
6	22.00	2.076416E-01
7	26.40	3.114624E-01
8	30.80	2.669678E-01
9	35.20	1.001129E-01

MacYigoStates

STATE	MWstate	P(MWstate)
1	-	6.250000E-02
2	20.00	3.750000E-01
3	40.00	5.625000E-01

MDIStates

STATE	MWstate	P(MWstate)
1	-	6.250000E-02
2	5.00	3.750000E-01
3	10.00	5.625000E-01

Piti7States

STATE	MWstate	P(MWstate)
1	-	2.500000E-01
2	40.00	7.500000E-01

Piti8&9States

STATE	MWstate	P(MWstate)
1	-	6.250000E-02
2	40.00	3.750000E-01
3	80.00	5.625000E-01

YigoDGStates		
STATE	MWstate	P(MWstate)
1	-	3.308722E-24
2	1.13	3.871205E-22
3	2.26	2.206587E-20
4	3.39	8.164372E-19
5	4.52	2.204380E-17
6	5.65	4.629199E-16
7	6.78	7.869638E-15
8	7.91	1.112992E-13
9	9.04	1.335590E-12
10	10.17	1.380110E-11
11	11.30	1.242099E-10
12	12.43	9.823872E-10
13	13.56	6.876710E-09
14	14.69	4.284719E-08
15	15.82	2.387201E-07
16	16.95	1.193600E-06
17	18.08	5.371202E-06
18	19.21	2.180076E-05
19	20.34	7.993612E-05
20	21.47	2.650513E-04
21	22.60	7.951540E-04
22	23.73	2.158275E-03
23	24.86	5.297585E-03
24	25.99	1.174682E-02
25	27.12	2.349364E-02
26	28.25	4.228855E-02
27	29.38	6.831227E-02
28	30.51	9.867327E-02
29	31.64	1.268656E-01
30	32.77	1.443643E-01
31	33.90	1.443643E-01
32	35.03	1.257367E-01
33	36.16	9.430252E-02
34	37.29	6.001069E-02
35	38.42	3.177037E-02
36	39.55	1.361587E-02
37	40.68	4.538624E-03
38	41.81	1.103990E-03
39	42.94	1.743141E-04
40	44.07	1.340878E-05

DededoCTStates

STATE	MWstate	P(MWstate)
1	-	6.250000E-02
2	22.00	3.750000E-01
3	44.00	5.625000E-01

LEGACY PLANT EAF = 50%

TalTenjoStates

STATE	MWstate	P(MWstate)
1	-	3.906250E-03
2	4.40	3.125000E-02
3	8.80	1.093750E-01
4	13.20	2.187500E-01
5	17.60	2.734375E-01
6	22.00	2.187500E-01
7	26.40	1.093750E-01
8	30.80	3.125000E-02
9	35.20	3.906250E-03

MacYigoStates

STATE	MWstate	P(MWstate)
1	-	2.500000E-01
2	20.00	5.000000E-01
3	40.00	2.500000E-01

MDIStates

STATE	MWstate	P(MWstate)
1	-	2.500000E-01
2	5.00	5.000000E-01
3	10.00	2.500000E-01

Piti7States

STATE	MWstate	P(MWstate)
1	-	5.000000E-01
2	40.00	5.000000E-01

Piti8&9States

STATE	MWstate	P(MWstate)
1	-	2.500000E-01
2	40.00	5.000000E-01
3	80.00	2.500000E-01

YigoDGStates		
STATE	MWstate	P(MWstate)
1	-	1.818989E-12
2	1.13	7.094059E-11
3	2.26	1.347871E-09
4	3.39	1.662374E-08
5	4.52	1.496137E-07
6	5.65	1.047296E-06
7	6.78	5.934677E-06
8	7.91	2.797776E-05
9	9.04	1.119110E-04
10	10.17	3.854714E-04
11	11.30	1.156414E-03
12	12.43	3.048728E-03
13	13.56	7.113699E-03
14	14.69	1.477461E-02
15	15.82	2.743855E-02
16	16.95	4.573092E-02
17	18.08	6.859638E-02
18	19.21	9.280687E-02
19	20.34	1.134306E-01
20	21.47	1.253707E-01
21	22.60	1.253707E-01
22	23.73	1.134306E-01
23	24.86	9.280687E-02
24	25.99	6.859638E-02
25	27.12	4.573092E-02
26	28.25	2.743855E-02
27	29.38	1.477461E-02
28	30.51	7.113699E-03
29	31.64	3.048728E-03
30	32.77	1.156414E-03
31	33.90	3.854714E-04
32	35.03	1.119110E-04
33	36.16	2.797776E-05
34	37.29	5.934677E-06
35	38.42	1.047296E-06
36	39.55	1.496137E-07
37	40.68	1.662374E-08
38	41.81	1.347871E-09
39	42.94	7.094059E-11
40	44.07	1.818989E-12

DededoCTStates

STATE	MWstate	P(MWstate)
1	-	2.500000E-01
2	22.00	5.000000E-01
3	44.00	2.500000E-01

Ukudu and KEPCO Diesel Power Plants

Plant	Unit EAF
Ukudu	0.96
KEPCODG	0.95

UkuduStates

STATE	MWstate	P(MWstate)
1	-	4.306902E-05
2	47.00	1.246780E-04
3	66.00	3.432194E-03
4	94.00	3.432194E-03
5	132.00	9.448300E-02
6	141.00	3.149433E-02
7	198.00	8.669905E-01

KEPCODGStates		
STATE	MWstate	P(MWstate)
1	-	3.051758E-20
2	2.60	8.697510E-18
3	5.20	1.156769E-15
4	7.80	9.524063E-14
5	10.40	5.428716E-12
6	13.00	2.269203E-10
7	15.60	7.185810E-09
8	18.20	1.755391E-07
9	20.80	3.335243E-06
10	23.40	4.928747E-05
11	26.00	5.618772E-04
12	28.60	4.852576E-03
13	31.20	3.073298E-02
14	33.80	1.347523E-01
15	36.40	3.657562E-01
16	39.00	4.632912E-01

ESS State Models

State, k	MW(k)	P(MW(k))
1	-	0.010929
2	0.044	0.183060
3	0.429	0.051913
4	0.500	0.068306
5	0.571	0.133880
6	0.643	0.120219
7	0.714	0.169399
8	0.786	0.136612
9	0.857	0.106557
10	0.929	0.016393
11	1.000	0.002732
Dandan		

State, k	MW(k)	P(MW(k))
0	-	0.010929
1	0.845	0.183060
2	8.320	0.051913
3	9.707	0.068306
4	11.094	0.133880
5	12.481	0.120219
6	13.867	0.169399
7	15.254	0.136612
8	16.641	0.106557
9	18.028	0.016393
10	19.414	0.002732
Phase III		

State, k	MW(k)	P(MW(k))
0	-	0.010929
1	3.826	0.183060
2	37.675	0.051913
3	43.954	0.068306
4	50.233	0.133880
5	56.512	0.120219
6	62.791	0.169399
7	69.070	0.136612
8	75.349	0.106557
9	81.628	0.016393
10	87.908	0.002732
Phase III & IV		

State, k	MW(k)	P(MW(k))
0	-	0.010929
1	6.807	0.183060
2	67.029	0.051913
3	78.200	0.068306
4	89.372	0.133880
5	100.543	0.120219
6	111.715	0.169399
7	122.886	0.136612
8	134.058	0.106557
9	145.229	0.016393
10	156.401	0.002732
Phase III, IV, & V		

State, k	MW(k)	P(MW(k))
0	-	0.010929
1	12.520	0.183060
2	123.291	0.051913
3	143.840	0.068306
4	164.388	0.133880
5	184.937	0.120219
6	205.485	0.169399
7	226.034	0.136612
8	246.582	0.106557
9	267.131	0.016393
10	287.679	0.002732
Phase III, IV, V, & VI		

State, k	MW(k)	P(MW(k))
0	-	0.010929
1	18.482	0.183060
2	182.000	0.051913
3	212.333	0.068306
4	242.666	0.133880
5	272.999	0.120219
6	303.333	0.169399
7	333.666	0.136612
8	363.999	0.106557
9	394.332	0.016393
10	424.666	0.002732
Phase III, IV, V, VI, & VII		

Appendix B: Plant Capacity State - Probability Distribution Model – VBA.xlsm VBA Code

```
Private Sub CommandButton1_Click()

Dim TalTenjoStates1(9) As Variant
Dim TalTenjoStates2(9) As Variant
Dim MacYigoStates1(3) As Variant
Dim MacYigoStates2(3) As Variant
Dim MDIStates1(3) As Variant
Dim MDIStates2(3) As Variant
Dim Piti7States1(2) As Variant
Dim Piti7States2(2) As Variant
Dim Piti89States1(3) As Variant
Dim Piti89States2(3) As Variant
Dim UkuduStates1(7) As Variant
Dim UkuduStates2(7) As Variant
Dim YigoDGStates1(40) As Variant
Dim YigoDGStates2(40) As Variant
Dim DedCTStates1(3) As Variant
Dim DedCTStates2(3) As Variant
Dim KEPCODGStates1(16) As Variant
Dim KEPCODGStates2(16) As Variant
Dim ESSStates1(11) As Variant
Dim ESSStates2(11) As Variant
Dim TalTenjoN As Integer
Dim MacYigoN As Integer
Dim MDIN As Integer
Dim Piti7N As Integer
Dim Piti89N As Integer
Dim UkuduN As Integer
Dim YigoDGN As Integer
Dim DedCTN As Integer
Dim KEPCODGN As Integer
Dim ESSN As Integer
Dim kth As Double
Dim RowOverflow As Double
Dim kthRow As Double
Dim RowOverflowOffset As Double
```

```
Dim i As Integer
Dim nPermutations As Double
Dim MWState As Single
Dim Probk As Double
Dim X As Double
Dim cnn As Object
Dim rst As Object
Dim dbPath As String
Dim Tblname As String
Dim sql As String

'Disable the screen flickering.
Application.ScreenUpdating = False

'Set number of Permutations
nPermutations = 6531840

'Single path name, position of the file should never change
dbPath = "C:\Users\jcruz\Desktop\Documents\--   IRP Document\Generation Reliability - HW\VBA\Reliability
Data Processing.accdb"

'Set the name of the ACCESS Table
Tblname = "tblPreProcessedData"

'Create the ADODB connection object.
Set cnn = CreateObject("ADODB.connection")

'Open the connection
cnn.Open "Provider=Microsoft.ACE.OLEDB.12.0;Data Source=" & dbPath

'Create the SQL statement to retrieve the table data (the entire table).
sql = "SELECT * FROM " & Tblname

'Create the ADODB recordset object.
Set rst = CreateObject("ADODB.Recordset")

'Set the necessary recordset properties.
```

```
rst.CursorType = 1   'adOpenKeyset on early binding
rst.LockType = 3     'adLockOptimistic on early binding

'Open the recordset.
rst.Open sql, cnn

'Set Focus to Tab "Plant Capacity States"
Sheets("Plant Capacity States").Activate

' Initialize Arrays
' MW State
For i = 0 To 8
   TalTenjoStates1(i) = Sheets("Plant Capacity States").Range("F" & i + 7).Value2
 Next i

For i = 0 To 2
   MacYigoStates1(i) = Sheets("Plant Capacity States").Range("F" & i + 19).Value2
Next i

For i = 0 To 2
   MDIStates1(i) = Sheets("Plant Capacity States").Range("F" & i + 25).Value2
Next i

For i = 0 To 1
   Piti7States1(i) = Sheets("Plant Capacity States").Range("F" & i + 31).Value2
Next i

For i = 0 To 2
   Piti89States1(i) = Sheets("Plant Capacity States").Range("F" & i + 36).Value2
Next i

For i = 0 To 6
   UkuduStates1(i) = Sheets("Plant Capacity States").Range("F" & i + 42).Value2
Next i

For i = 0 To 39
   YigoDGStates1(i) = Sheets("Plant Capacity States").Range("F" & i + 52).Value2
```

```
Next i

For i = 0 To 2
   DedCTStates1(i) = Sheets("Plant Capacity States").Range("F" & i + 95).Value2
Next i

For i = 0 To 15
   KEPCODGStates1(i) = Sheets("Plant Capacity States").Range("F" & i + 101).Value2
Next i

For i = 0 To 10
   ESSStates1(i) = Sheets("Plant Capacity States").Range("F" & i + 120).Value2
Next i

' Initialize Arrays
' Probability of MW State
For i = 0 To 8
   TalTenjoStates2(i) = Sheets("Plant Capacity States").Range("G" & i + 7).Value2
Next i

For i = 0 To 2
   MacYigoStates2(i) = Sheets("Plant Capacity States").Range("G" & i + 19).Value2
Next i

For i = 0 To 2
   MDIStates2(i) = Sheets("Plant Capacity States").Range("G" & i + 25).Value2
Next i

For i = 0 To 1
   Piti7States2(i) = Sheets("Plant Capacity States").Range("G" & i + 31).Value2
Next i

For i = 0 To 2
   Piti89States2(i) = Sheets("Plant Capacity States").Range("G" & i + 36).Value2
Next i

For i = 0 To 6
```

```
    UkuduStates2(i) = Sheets("Plant Capacity States").Range("G" & i + 42).Value2
Next i

For i = 0 To 39
    YigoDGStates2(i) = Sheets("Plant Capacity States").Range("G" & i + 52).Value2
Next i

For i = 0 To 2
    DedCTStates2(i) = Sheets("Plant Capacity States").Range("G" & i + 95).Value2
Next i

For i = 0 To 15
    KEPCODGStates2(i) = Sheets("Plant Capacity States").Range("G" & i + 101).Value2
Next i

For i = 0 To 10
    ESSStates2(i) = Sheets("Plant Capacity States").Range("G" & i + 120).Value2
Next i

'Set Focus to Tab "Program Output"
Sheets("Program Output").Activate

' Output the header for the data
kth = 2
kthRow = 2
RowOverflow = 0
RowOverflowOffset = 1
Sheets("Program Output").Cells(1, 1) = "MW_State"
Sheets("Program Output").Cells(1, 2) = "P(MW_State)"
Sheets("Program Output").Cells(1, 3) = "k"

'Step through States
For TalTenjoN = 0 To 8
    For MacYigoN = 0 To 2
        For MDIN = 0 To 2
            For Piti7N = 0 To 1
                For Piti89N = 0 To 2
```

```
For UkuduN = 0 To 6
   For YigoDGN = 0 To 39
      For DedCTN = 0 To 2
         For KEPCODGN = 0 To 15
            MWState = TalTenjoStates1(TalTenjoN) + _
                     MacYigoStates1(MacYigoN) + _
                     MDIStates1(MDIN) + _
                     Piti7States1(Piti7N) + _
                     Piti89States1(Piti89N) + _
                     UkuduStates1(UkuduN) + _
                     YigoDGStates1(YigoDGN) + _
                     DedCTStates1(DedCTN) + _
                     KEPCODGStates1(KEPCODGN)

            Probk = TalTenjoStates2(TalTenjoN) * _
                     MacYigoStates2(MacYigoN) * _
                     MDIStates2(MDIN) * _
                     Piti7States2(Piti7N) * _
                     Piti89States2(Piti89N) * _
                     UkuduStates2(UkuduN) * _
                     YigoDGStates2(YigoDGN) * _
                     DedCTStates2(DedCTN) * _
                     KEPCODGStates2(KEPCODGN)

            RowOverflow = kthRow Mod 1048575
            If RowOverflow = 0 Then
                  kthRow = 2
                  RowOverflowOffset = RowOverflowOffset + 3
                  Sheets("Program Output").Cells(1, RowOverflowOffset) = "MW_State"
                  Sheets("Program Output").Cells(1, RowOverflowOffset + 1) = "P(MW_State)"
                  Sheets("Program Output").Cells(1, RowOverflowOffset + 2) = "k"
            End If

            Sheets("Program Output").Cells(kthRow, RowOverflowOffset) = MWState
            Sheets("Program Output").Cells(kthRow, RowOverflowOffset + 1) = Probk
            Sheets("Program Output").Cells(kthRow, RowOverflowOffset + 2) = kth - 1
```

```
                  rst.AddNew
                  rst!MWState = MWState
                  rst!ProbOfMWstate = Probk
                  rst.Update

                  kth = kth + 1
                  kthRow = kthRow + 1

                Next KEPCODGN
              Next DedCTN
            Next YigoDGN
          Next UkuduN
        Next Piti89N
      Next Piti7N
    Next MDIN
  Next MacYigoN
Next TalTenjoN

'Close the recordet and the connection.
rst.Close
cnn.Close

'Release the objects.
Set rst = Nothing
Set cnn = Nothing

'Re-enable the screen.
Application.ScreenUpdating = True

End Sub
```

Appendix C: Plant Capacity State - Probability Distribution Model – VBA.xlsm Users' Manual

Engineering & Technical Services Department

Generation Reliability Analysis Tool Handbook

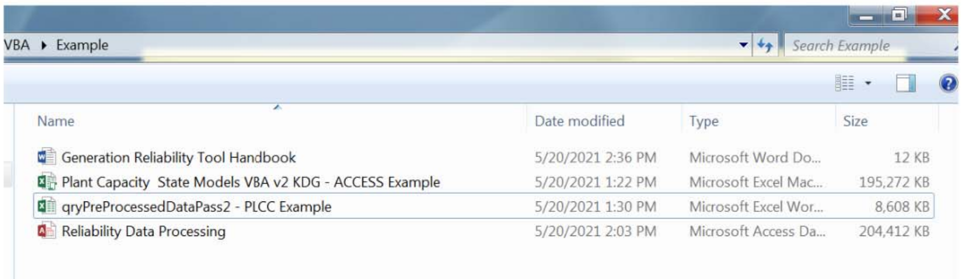
By:

John J. Cruz Jr., PE

AGMETS

Step 1

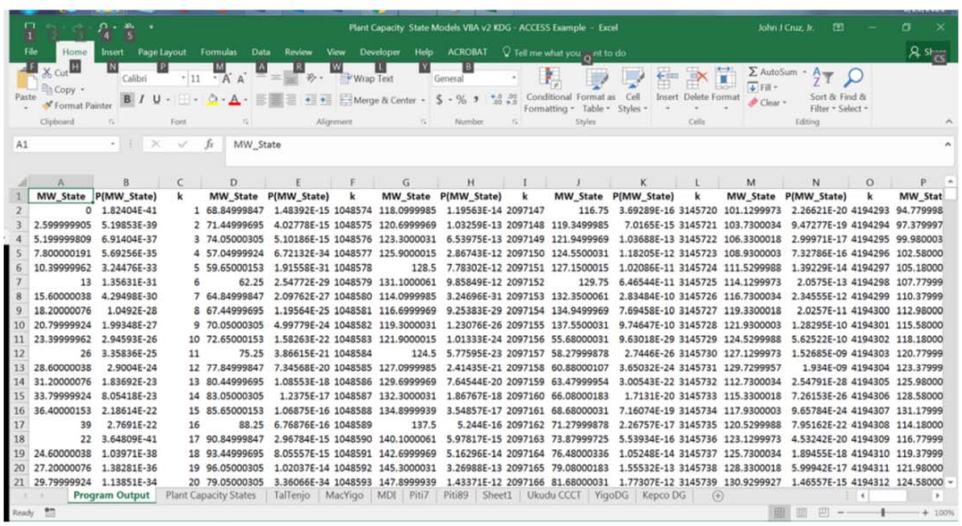
Place the files you need to perform the calculations in a folder.



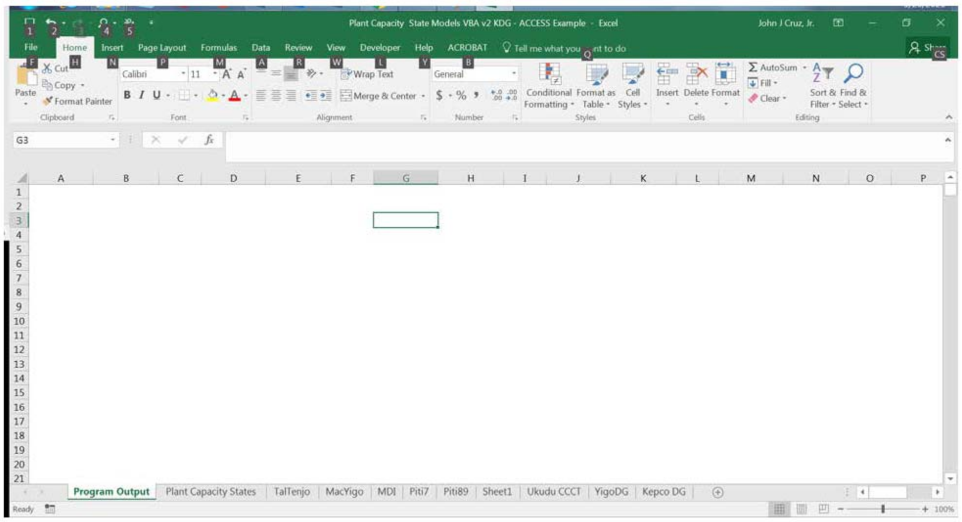
You need the two EXCEL Files and the ACCESS file.

Step 2.

Open and modify the Plant Capacity State Model VBA v2 KDG – ACCESS Example.xlsx file.

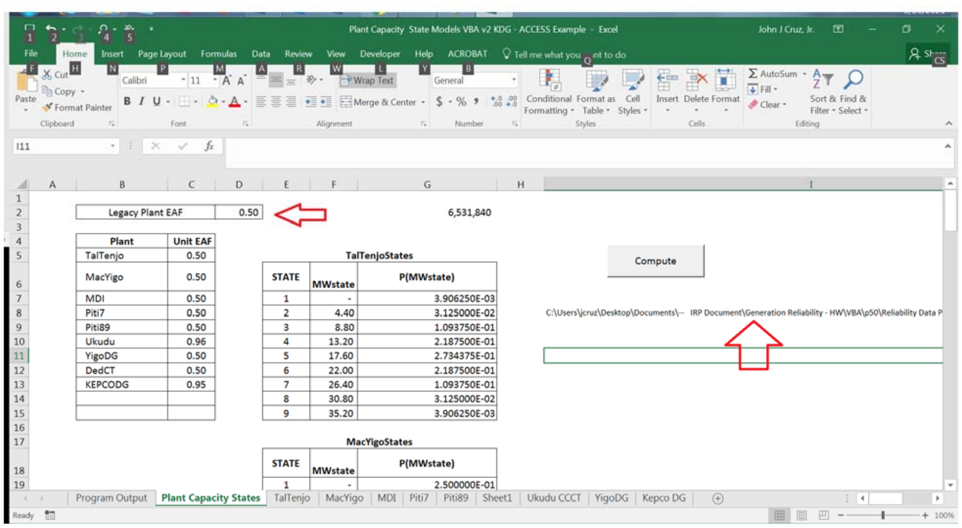


You may need to clear the data from the <Program Output> Tab for new Data.



Step 3

Set up Analysis Scenario and specify the path to the Reliability Data Processing ACCESS file.

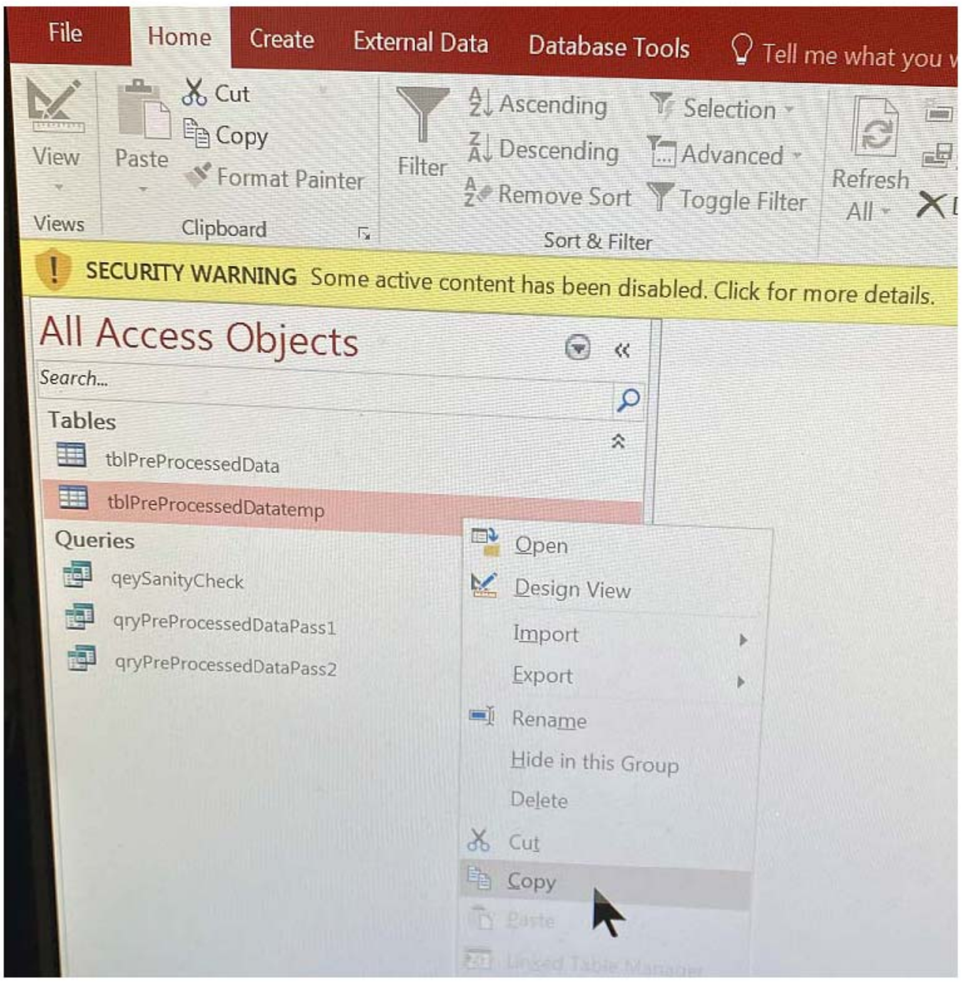


- Enter the Legacy Plant EAF for the scenario you are going to calculate.
- Enter the path to the ACCESS File where the Calculations will be output to.

Step 4

Make sure the ACCESS file Table **tblPreProcessedData** is empty.

Copy **tblPreProcessedDatatemp** to replace the **tblPreProcessedData** Table



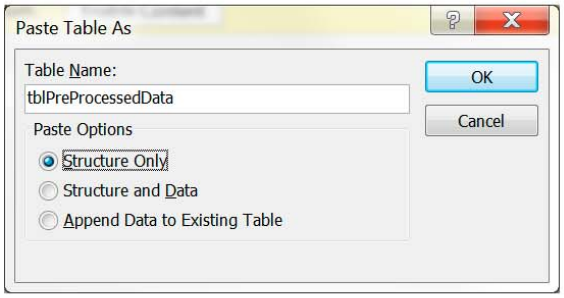
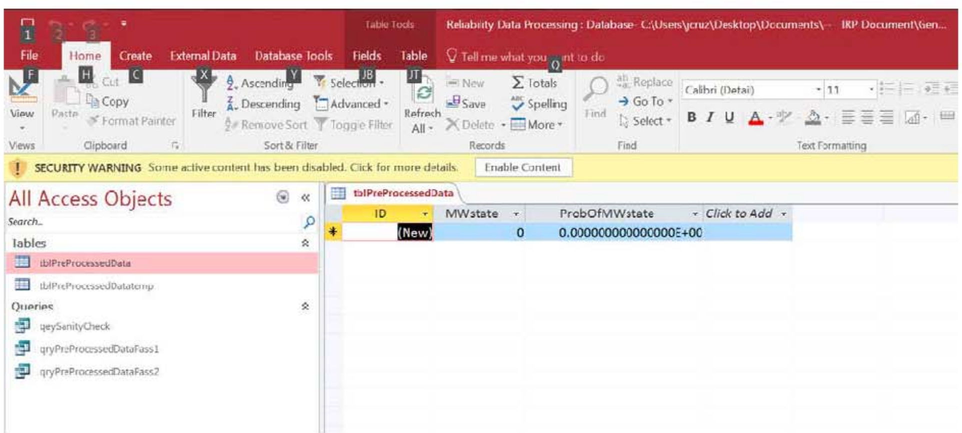
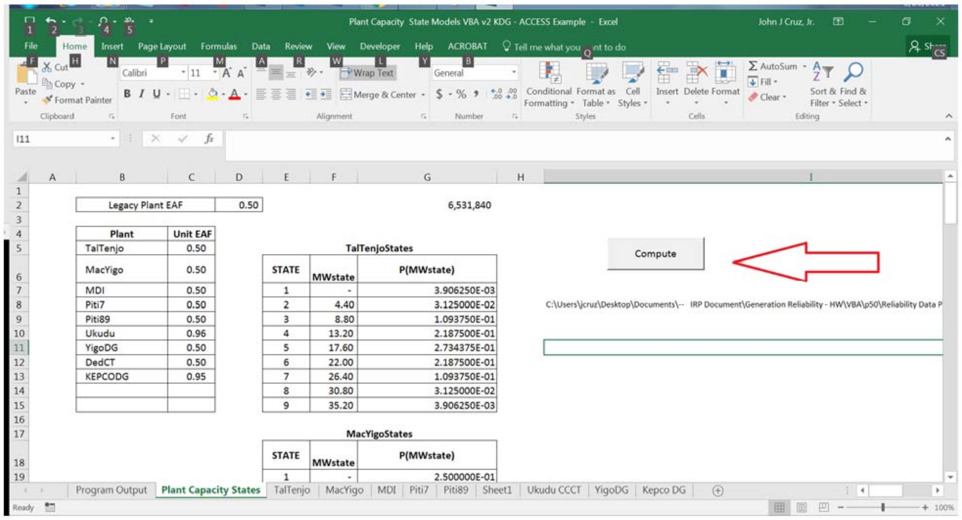


Table is now empty and ready for new data.



Step 5

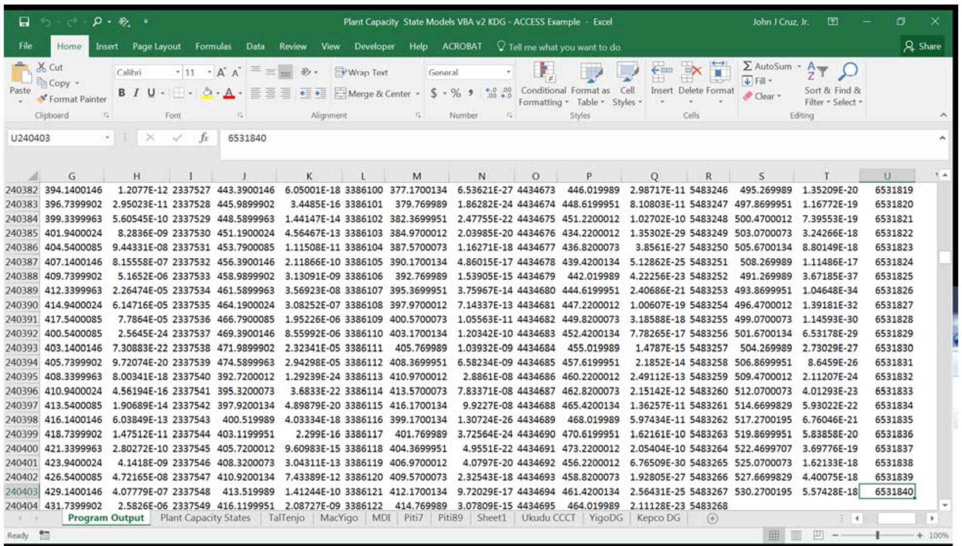
Click on <Compute> Button to start EXCEL VBA program



Step 6

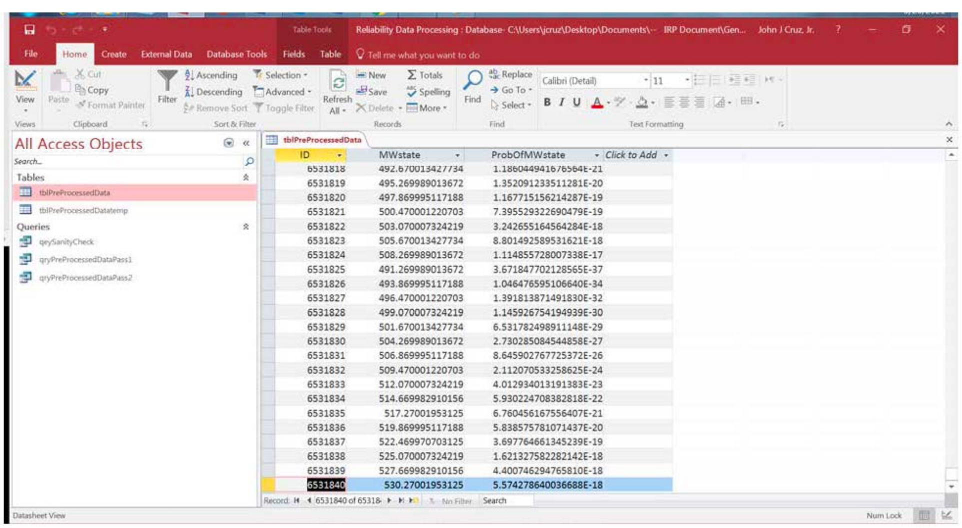
Check if Program ran properly.

Check <Program Output> tab.



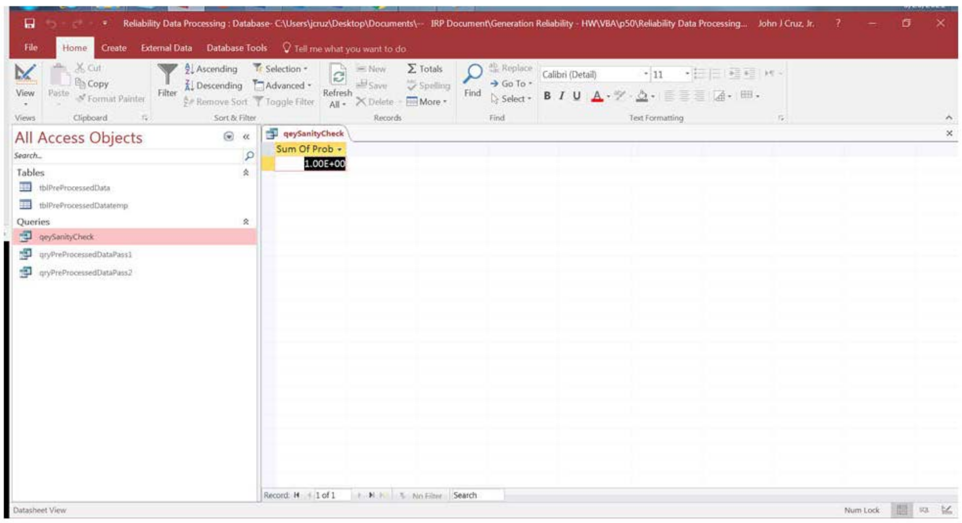
In this case, the last output data is indexed 6531840. Is this what was expected? It is.

Check if the ACCESS File has the same data.



Same number of records. Good Job!

Sanity Check is Unity. Excellent!



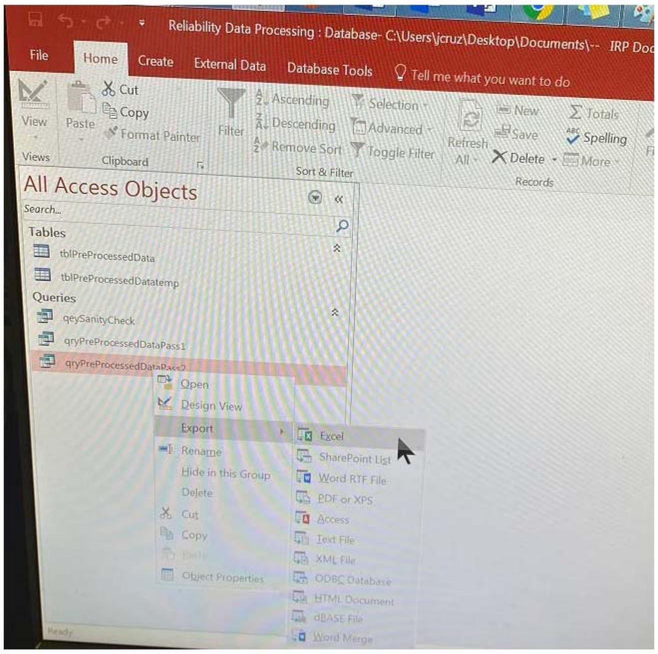
Step 7

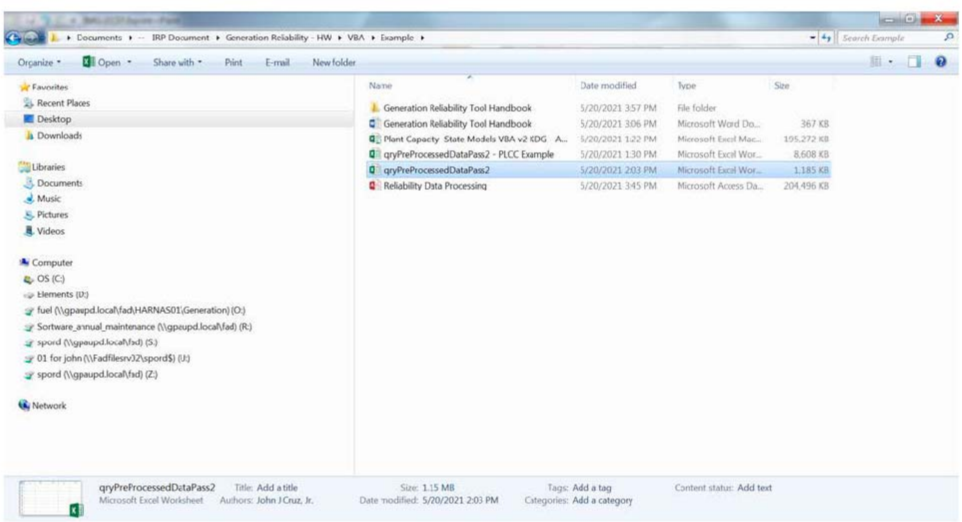
Run the **qryPreProcessedDataPass1** query.

Now run the **qryPreProcessedDataPass2** query.

Step 8

Export **qryPreProcessedDataPass2** to EXCEL



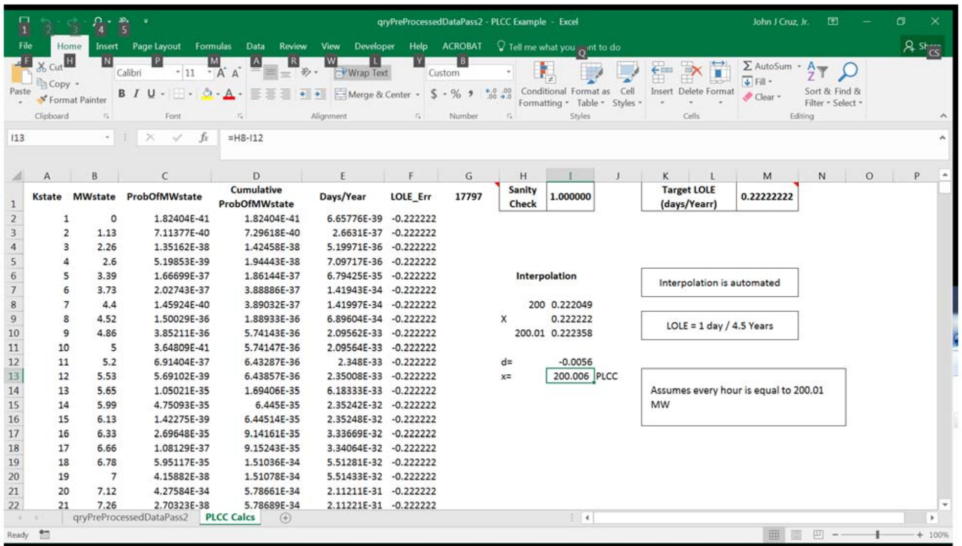


Step 9

Open EXCEL file **qryPreProcessedDataPass2.xlsx** and **qryPreProcessedDataPass2 - PLCC Example.xlsx.**

Copy the data from **qryPreProcessedDataPass2.xlsx** and Paste Link into the **qryPreProcessedDataPass2** Tab in **qryPreProcessedDataPass2 - PLCC Example.xlsx.**

The **qryPreProcessedDataPass2 - PLCC Example.xlsx** Tab **<PLCC Calcs> has the PLCC Calculation Results.**



Kstate	MWstate	ProbOfMWstate	Cumulative ProbOfMWstate	Days/Year	LOLE_Err	17797
1	0	1.82404E-41	1.82404E-41	6.65776E-39	-0.222222	
2	1.13	7.11377E-40	7.29618E-40	2.6631E-37	-0.222222	
3	2.26	1.35162E-38	1.42458E-38	5.19971E-36	-0.222222	
4	2.6	5.19853E-39	1.94443E-38	7.09717E-36	-0.222222	
5	3.39	1.66699E-37	1.86144E-37	6.79425E-35	-0.222222	
6	3.73	2.02743E-37	3.88886E-37	1.41943E-34	-0.222222	
7	4.4	1.45924E-40	3.89032E-37	1.41997E-34	-0.222222	
8	4.52	1.50029E-36	1.88933E-36	6.89604E-34	-0.222222	
9	4.86	3.85211E-36	5.74143E-36	2.09562E-33	-0.222222	
10	5	3.64809E-41	5.74147E-36	2.09564E-33	-0.222222	
11	5.2	6.91404E-37	6.43287E-36	2.348E-33	-0.222222	
12	5.53	5.69102E-39	6.43857E-36	2.35008E-33	-0.222222	
13	5.65	1.05021E-35	1.69406E-35	6.18333E-33	-0.222222	
14	5.99	4.75093E-35	6.445E-35	2.35242E-32	-0.222222	
15	6.13	1.42275E-39	6.44514E-35	2.35248E-32	-0.222222	
16	6.33	2.69648E-35	9.14161E-35	3.33669E-32	-0.222222	
17	6.66	1.08129E-37	9.15243E-35	3.34064E-32	-0.222222	
18	6.78	5.95117E-35	1.51036E-34	5.51281E-32	-0.222222	
19	7	4.15882E-38	1.51078E-34	5.51433E-32	-0.222222	
20	7.12	4.27584E-34	5.78661E-34	2.11211E-31	-0.222222	
21	7.26	2.70323E-38	5.78689E-34	2.11221E-31	-0.222222	

Done for now.

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Appendix E: Grid Controller Draft Scope

Section 4

4 Scope of Work

This contract is for a base term of ten years with three five-year extensions. GPA may elect to elect to execute one or more of these extensions early within the first contract year. This contract includes engineering professional services.

This section describes the scope of work for this design-build multi-step bid for an autonomous power system grid controller. The prevailing Proponent must provide:

- An autonomous power system grid controller having most of the functions listed in these specifications implemented at customer sites;
- Ability to support a ten-year operations and maintenance support contract of the autonomous power system grid controller system including modifying the base product specifically for use by GPA and tuned for GPA's grid at GPA's request at project start and in the future;
- Ability to provide a ten-year of more warranty on the system provided and all modifications made to this system;
- This contract includes engineering professional services requiring registration with the Guam Board of Registration for Professional Engineers, Architects, and Land Surveyors. GPA is seeking professional engineering services with the following specific background:
    - Technical feasibility for battery energy storage systems as applied to islanded grids;
    - Owners engineer service for the construction and commissioning of large utility-scale BESS systems for firming and shaping of intermittent renewable energy outputs (10 MW/10 MWH minimum size);
    - Owners engineer service for the construction and commissioning of large utility-scale BESS systems for spinning reserve (20 MW/5 MWH minimum size);
    - Renewable Integration Studies for islanded grids with system peaks between 70 to 300 MW to determine system improvements to support a high penetration of intermittent renewable energy;
    - Advanced Underfrequency Load Shedding (AUFLS) design and implementation for islanded power systems;
    - Expert at GE PSLF and GE PSDS.

4.1 Background

The Guam Power Authority (GPA) has committed to a significant transformation of its power system to include significant renewable, flexible generation, energy storage, synchronous condensers, and electric vehicles vehicle-to-grid (V2G) charging.

GPA completed a Renewable Integration Study to determine the necessary infrastructure and systems required to ensure power system stability and reliable operation while increasing renewable energy penetration. One of the Study recommendations is for Automatic Generation Control (AGC). Further discussion on AGC foresees a requirement for the evolution of AGC to include control of other systems including renewable energy generation, energy storage systems, and demand response resources. GPA requires an autonomous control system to optimally control these systems while keeping the GPA grid stable and reliable.

4.1.1 Renewable Energy

GPA has executed renewable energy Power Purchase Agreements (PPAs) to supply 25% of customer electricity by 2021. Furthermore, GPA has since committed to increasing the share of its energy production from renewable energy to 50% or greater by 2030.

4.1.2 Energy Storage

GPA has begun to integrate significant energy storage systems into its grid beginning with a 40-MW/22 MWH Battery Energy Storage System (BESS) split between Talofofo and Agana Substations for variable renewable energy firming and shaping as well as for spinning reserve (contingency operation), respectively. Project commercial operation is scheduled for October 2019.

GPA's new 198-MW flexible generation project also includes commissioning a BESS with the combined cycle combustion turbine plant to help prevent underfrequency load shedding.

4.1.3 Electric Vehicle Infrastructure

Additionally, GPA has committed to electrification of Guam's transportation sector starting with replacing GPA's light-duty vehicle fleet with all-electric vehicles. GPA would need to control and manage electric vehicle charging to avoid increasing GPA system peak and flatten its load profile making optimal use of generation assets. Two alternatives for achieving these objectives include time-of-use rates and direct control of chargers.

4.2 Related GPA Projects

GPA is performing or planning to execute the following activities related to the grid controller scope:

- System Protection Upgrade;
  - Reduce transmission fault critical clearing times to 5 cycles and 6 cycles on the 115 KV and 34.5 KV transmission systems, respectively
- Remote Start/Stop of Reserve Units;
- Control of GWA Facilities with Generator Backup (Demand Response);
- Adaptive Underfrequency Load Shedding Scheme;
- 198-MW Flexible Generation Plant; and,
- Fiber Optic Communications to all Power Plants and Substations.

4.3 Scope of Work: Grid Controller General Functional Requirements

Guam Power Authority seeks an autonomous power system grid controller providing the following general functions:

- Automatic Generation Control and Resource Commitment system of existing and future fossil fuel-fired generation, renewable energy generation, energy storage, and demand response resources;
- Security Constrained Economic Dispatch of existing and future resources including but not limited to:
    - Fossil Fuel-Fired Generation
    - Energy-Shifting Storage
    - Battery Energy Storage Systems
    - Variable Renewable Energy Generation (Curtailment)
    - Firm Renewable Energy Generation
    - Demand Response Resources/Interruptible Loads
    - Electric Vehicle V2G Charging Systems
    - Synchronous Condensers
    - Short Circuit Ratio (SCR) Constraints
- Optimal Control of Battery Energy Storage System (BESS) Charging (Economic and Stability Objective Function);
- Optimize BESS operation in contingency (spinning reserve) mode with remote start generation;
- Solar PV curtailment
- Dispatch of Demand Response Resources
- Post-disturbance system restoration.

This system must optimize grid operations for system stability, reliability, and cost.

4.3.1 Automatic Generation Control

AGC based frequency performance is mainly a function of the capability of the generating units, and the tuning within the AGC. The resulting frequency control is dependent on machine inertias and governor response. Contractor must provide the generator tuning study services.
The System must be able to control GPA grid system frequency to within +/- 0.050 Hz during steady-state conditions. System must be configurable to allow setting system frequency regulation from +/- 0.05 Hz to +/- 0.1 Hz in steps of 0.01 Hz.

After a system disturbance that effects system frequency is cleared, the System must restore the grid system frequency to 60 Hz within **one** minute in line with GPA Standard BAL-002

The System must be capable of controlling individual units in various modes to achieve both steady state and large disturbance frequency control. Control of the units must include normal control modes, including active regulation, frequency assist, ramping, etc.

The system must coordinate the control of all available resources, and when in steady state conditions, return the dispatch of all resources to security constrained economic dispatch conditions.

4.3.2 BESS Charging Optimization

Optimize BESS operation in contingency (spinning reserve) mode with remote start generation to "catch" the battery before it completely discharges. Remote Start units will support the contingency BESS operation. The system is required to maintain the state of charge within several BESSs in order to optimize the contingency response of the system, and to then re-charge each BESS after an event has occurred, to prepare for the next outage. The system must also optimize the overall response such that no BESS reaches a condition where it must reduce output so quickly that a low state of charge condition results in a frequency excursion on the grid.

4.3.3 Solar PV Curtailment

GPA will potentially have over 210 MW capacity of non-Energy Shifted Solar PV by the end of calendar year 2023 from renewable energy mainly solar PV. Potentially at GPA day time low load coincident with heavy solar PV energy production, GPA may have to curtail PV output to maintain sufficient regulation and short-circuit current in the system. The System must be capable of tracking and forecasting PV power production as well as GPA load in every 15 minutes and controlling utility scale PV plant curtailment as required. The System must provide and record the appropriate energy accounting for each solar PV system curtailed including energy curtailed in kilowatt-hours and cost of the curtailed energy in dollars. The System shall be configurable to include the appropriate energy tariff for each system curtailed and any dead band prior to any curtailment charges being applied.

In support of the PV curtailment program, the System must provide weather sensors and "Cloud trackers" to forecast PV resource output.

4.3.4 Remote Control of GPA Demand Response Resources

The System must be capable of dispatching Demand Response Resources. Currently Planned Demand Response Resources include Guam Waterworks Authority backup generation. This interruptible load resource is ideal as:

- GPA operates and maintains about 12 MW of backup generation for various Guam Waterworks Authority (GWA) facilities throughout the island;
    - GWA intends to bring these backup systems under SCADA remote control;
    - GPA would like to leverage this opportunity for Demand Response
- Any future Demand-Response Resource.

4.4 Post-Disturbance System Restoration

After a System Disturbance where GPA has shed load, the System may relinquish autonomous control of the resources under its normal control to GPA Power System Control Operators for any restorative actions. The PROPONENT must work with GPA to establish work processes related to Post-Disturbance System Restoration.

During system restoration, the system will be responsible for frequency control using resources defined by the system operator. It shall maintain system frequency without committing additional resources unless frequency deviates greater than those allowed in GPA-BAL-002.

4.5 Grid Operations and Planning (O&P) Standards for Reliability and Stability

The System must follow the following GPA Grid Operations Standards for Reliability and Stability:

- GPA-BAL-001 Real Power Balancing Control Performance
  - Provides the standard for frequency control in the power system
- GPA-BAL-002 Disturbance Control Performance
  - Sets the requirement and response of Contingency Reserves for the system
  - Sets the standard for contingency reserves
  - Ensure GPA system can return to normal operation following activation of contingency reserves
- GPA-BAL-003 Frequency Response and Bias
  - Measures and calculates frequency response and bias
- GPA-BAL-005 Automatic Generation Control
  - Provides standard for generation control and deployment of regulation reserve
- GPA-TPL-001-4 Transmission Planning Standard
  - Defines requirements of transmission system planning
  - Sets performance criteria for planning studies
  - Defines contingencies and allowable loss of load
- GPA-BAL-502 Planning Resource Adequacy Analysis, Assessment and Documentation
  - Establishes criteria for resource planning, including reserve margin and reserve criteria
- GPA-MOD-025 Verification of Real and Reactive Power Capability
  - Defines testing and reporting requirements for real and reactive resources in steady-state conditions
- GPA-MOD-026 Verification of Models and Data for Generation Excitation Control Systems or Plant Volt/Var Control Functions
  - Defines the testing, reporting and modeling requirements for the dynamic response of the excitation system or plant Volt/Var system used for generators, ESS or other systems
- GPA-MOD-027 Verification of Models and Data for Turbine/Governor and Load Control or Active Power/Frequency Control Functions
  - Defines the testing, reporting and modeling requirements for the dynamic response of the real power control system or plant system used for generators, ESS or other real power systems
- GPA-MOD-032 Data for Power System Modeling and Analysis
  - Establishes consistent modeling requirements for development of planning cases required to support the transmission system. Would include transformers, interconnection lines etc for conventional and Renewable generation resources.
- GPA-MOD-033 Steady-State and Dynamic System Model Validation
  - Establishes validation criteria and requirements of system models with actual events of the system
- GPA-PRC-006 Automatic Under-frequency Load Shedding (UFLS)
  - Establishes requirements for the design and implementation of the Underfrequency Load Shedding system.

4.6 Reporting

The controller should automatically generate all reports and statistics required for the GPA Grid Operations Standards for Reliability and Stability.

4.7 Source Code Requirements

A process and procedure must be developed for ensuring source code protections meet a best practice control set based on a Reference Architecture applicable to the GPA coding environment and selected controls for the zoning outlined in a Purdue model and the IEC 62243 reference model.

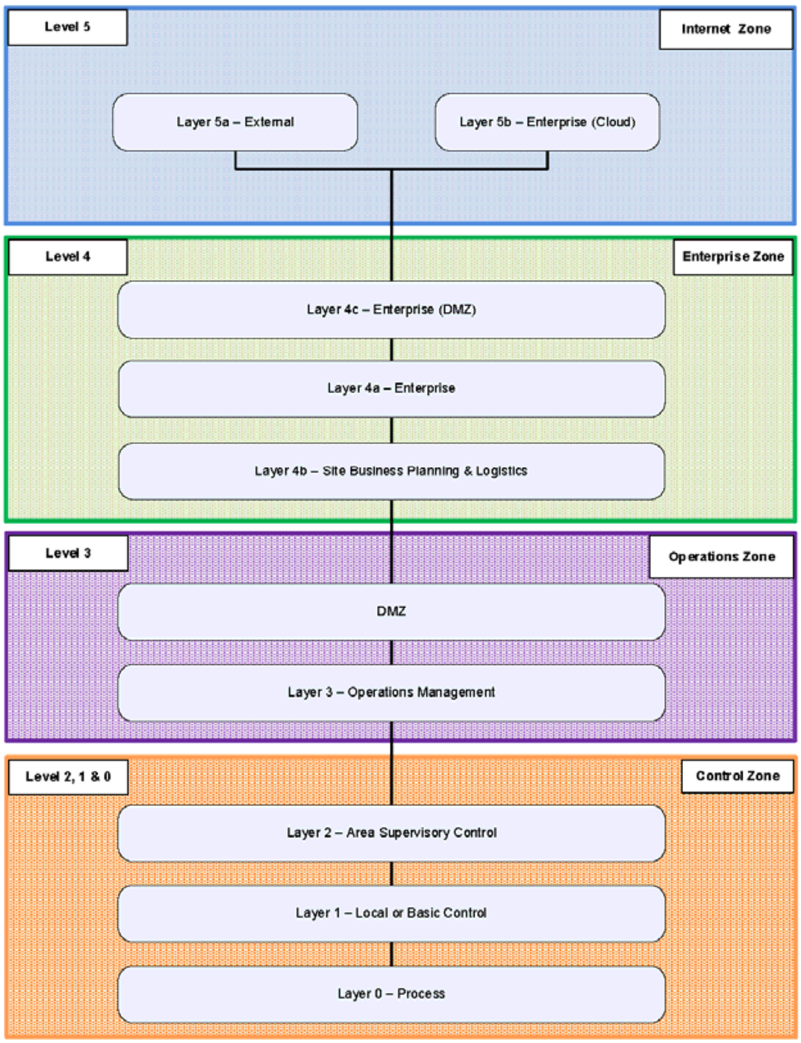

Figure 1. IEC 62243 Reference Model.

4.8 Non-Proprietary Software

A process for vetting non-proprietary software shall be developed to ensure that the secure software development cycle was applied to the following phases:

- Requirements definition;
- Design;
- Development;
- Testing;
- Implementation.

Additionally, a process for testing the software shall be employed prior to introduction into IT and OT environments.

4.9 Cybersecurity Critical Infrastructure Standards (CIP)

A unified control framework (UCF) must be developed and implemented which includes NIST, NERC CIP, IEC 61850, and ISO 27002 controls. The identified UCF crosswalk and controls will be selected for each zone and implemented based on a Purdue Model Reference Architecture and key data flows for the reference architecture will need to be mapped between Zones which includes an operations network DMZ in addition to an enterprise DMZ. Segmenting these areas will provide the enhanced level of security necessary for operations without placing onerous restrictions on the remainder of the organization.

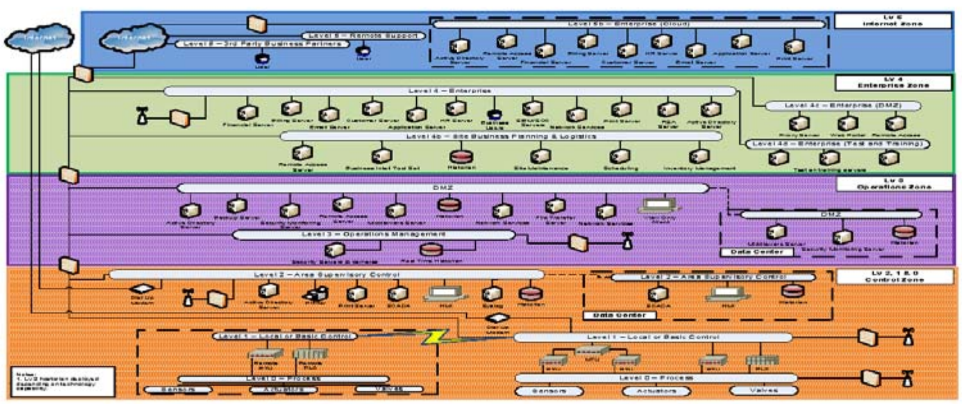

Figure 2. Purdue Model Reference Architecture

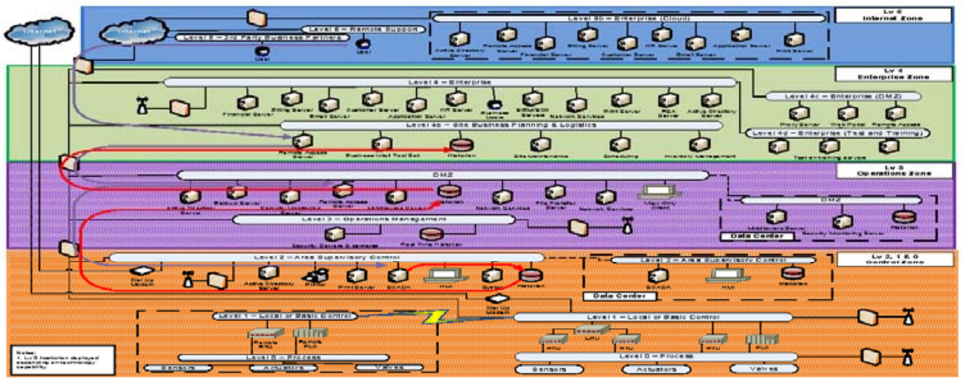

Figure 3. Key Data Flows Reference Architecture

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Appendix F: Residential Water Heater Direct Load Control Program Economics

Savings Computation

Demand Savings	Water Heater Controllers	KW Reduction/ Device	KW Reduction	Avoided Capacity Savings $
	26000	0.50	13,000.00	$ 23,062,000.00
Annual Energy Savings	Water Heater Controllers	Annual Energy KWh Reduction/ Device	Residential Rate ($/KWh)	Total Annual Energy Savings ($)
	26000	493	$ 0.20	$ 2,563,600.00

Met Present Value Analysis

Costs	
Capital Costs	$ 3,370,125.00
Annual Recurring Cost	$ 55,750.00
Benefits	
Avoided Capacity Savings[1]	$ 23,062,000.00
Annual Energy Savings ($)	$ 2,563,600.00
NPV Savings	
NPV Savings (Capital)	$ 19,691,875.00
NPV Savings (Recurring))	$ 26,568,198.63
Total NPV Savings	$ 46,260,073.63

Device Life	20
Discount Rate (%)	7.0%

Appendix G: Grid Transformation Project Annual Cost Flow

Project Number	Project Name	Project Budget ($) by Project Year							Total Project Budget ($)
		2021	2022	2023	2024	2025	2026	2027	
1	Relay Upgrade		$ 1,500,000	$ 1,500,000	$ 1,000,000	$ 1,000,000			$ 5,000,000
2	Adaptive Underfrequency Load		$ 50,000						$ 50,000
3	Shedding (UFLS)			$ 100,000	$ 100,000	$ 100,000			$ 300,000
4	Adaptive Under Voltage Load		$ 50,000						$ 50,000
5	Shedding (UVLS)			$ 100,000	$ 100,000	$ 100,000			$ 300,000
6	Umatac Microgrid					$ 4,145,200			$ 4,145,200
7			$ 75,000						$ 75,000
8	Grid Controller		$ 750,000	$ 250,000	$ 250,000	$ 125,000	$ 125,000		$ 1,500,000
9	Malojloj - Hagatna 115 KV Line			$ 4,600,000	$ 15,000,000	$ 15,000,000	$ 11,400,000		$ 46,000,000
10						$ 5,456,769			$ 5,456,769
							$ 6,042,431		$ 6,042,431
11	Synchronous Condenser Conversions				$ 11,004,682				$ 11,004,682
									$ -
						$ 2,928,022			$ 2,928,022
12									$ -
13	Piti 8&9 Low Output Operation Retrofit			$ 75,000	$ 75,000				$ 150,000
14	Generation Expansion Plan Projects								$ -
15	Synchrophasor Network				$ 600,000	$ 600,000	$ 600,000		$ 1,800,000
16			$ 61,425						$ 61,425
17	Solar Irradiance Sensor Network		$ 10,000						$ 10,000
18			$ 80,000						$ 80,000
19				$ 500,000					$ 500,000
20	Demand response Programs			$ 1,076,708	$ 956,958	$ 956,958			$ 2,990,625
21			$ 625,000	$ 625,000	$ 625,000	$ 625,000			$ 2,500,000
22	Demand Response with GWA								$ -
19					$ 430,000				$ 430,000
20	Remote Start/Stop/Autostart				$ 475,000	$ 475,000			$ 950,000
21					$ 475,000	$ 475,000			$ 950,000
22					$ 475,000	$ 475,000			$ 950,000
	Annual Totals	$ -	$3,201,425.00	$8,826,708.33	$31,566,640.60	$32,461,949.42	$18,167,430.78	$ -	
		Total CIP Program							$ 94,224,154.13

Appendix H: Utility Financial Solutions Fuel Forecast Versus LEIDOS Fuel Forecast

Table H-1. Utility Financial Solutions Fuel Forecast

Year	UFS					
	Landed ULSD ($/MMBTU)			Landed LNG ($/MMBTU)		
	Low	Base	High	Low	Base	High
2021	11.916	13.263	14.113	7.280	7.880	8.340
2022	12.312	13.946	15.036	6.951	7.608	8.153
2023	**12.688**	**14.374**	**15.497**	**7.411**	**8.155**	**8.772**
2024	12.977	14.702	15.852	7.843	8.666	9.345
2025	**13.254**	**15.017**	**16.192**	**8.106**	**8.968**	**9.680**
2026	13.549	16.710	17.204	8.315	9.229	9.947
2027	13.765	16.845	18.407	8.486	9.417	10.172
2028	14.353	17.893	19.364	8.679	9.640	10.410
2029	15.194	18.758	20.389	8.914	9.904	10.702
2030	**15.790**	**19.831**	**21.597**	**9.171**	**10.206**	**11.035**
2031	16.593	20.689	22.801	9.466	10.543	11.413
2032	17.144	21.625	23.963	9.803	10.940	11.858
2033	17.973	22.397	25.250	10.136	11.320	12.289
2034	18.712	23.181	26.554	10.467	11.700	12.721
2035	**19.294**	**23.953**	**27.402**	**10.805**	**12.093**	**13.156**
2036	20.059	24.892	28.466	11.109	12.441	13.541
2037	20.815	25.873	29.818	11.392	12.765	13.904
2038	21.824	26.958	30.813	11.649	13.053	14.214
2039	22.093	27.645	31.755	11.875	13.313	14.501
2040	**23.393**	**29.169**	**33.524**	**12.122**	**13.589**	**14.802**

Table H-2. Utility Financial Solutions versus LEIDOS Fuel Forecast

	UFS						LEIDOS - nominal $		Scaling Factor: LEIDOS/UFS	
Year	Landed ULSD ($/MMBTU)			Landed LNG ($/MMBTU)			Landed ULSD ($/MMBTU)	Landed LNG ($/MMBTU)	ULSD	Gas
	Low	Base	High	Low	Base	High	Base	Base	Base	Base
2025	13.254	15.017	16.192	8.106	8.968	9.680	14.490	8.970	0.965	1.000
2030	15.790	19.831	21.597	9.171	10.206	11.035	16.250	10.210	0.819	1.000
2035	19.294	23.953	27.402	10.805	12.093	13.156	21.150	12.090	0.883	1.000
2040	23.393	29.169	33.524	12.122	13.589	14.802	30.680	13.590	1.052	1.000

Appendix I: Piti 8&9 CIP and O&M Information

Piti 8&9 Power Plant

Item	Unit	Needed Repairs	Funding Required ($)	Estimated Outage Duration for Repairs	Unit Derations	Running Condition/Operating Limits
1	DE9	2021 Major Overhaul, Cylinder Liner Replacements	See CIP/PIP Schedule	21 Days	DE9 Offline	DE9 Offline
2	DE8	Engine Bedplate - Welding of Cracks		7 Days[1]	DE8 Offline	DE8 Offline
3	DE9	Engine Bedplate - Welding of Cracks		7 Days[2]	DE9 Offline	DE9 Offline
4	DE8	Engine Chain Tensioners - Check & Repair		4 Days[1]	DE8 Offline	DE8 Offline
5	DE9	Engine Chain Tensioners - Check & Repair		4 Days[2]	DE9 Offline	DE9 Offline
6	DE9	Scavenging Air Coolers - Replacement HT Air Coolers #1&2		5 Days[3]	DE9 Offline	DE9 Offline
7	DE8	Engine Foundation - Inspection with Report & Repairs		5 Days[1]	DE8 Offline	DE8 Offline
8	DE9	Engine Foundation - Inspection with Report & Repairs		5 Days[2]	DE9 Offline	DE9 Offline
9	DE8	Bearings Replacement (Main, Thrust,Crosshead,Crankpin & Canshaft		4 Days[1]	DE8 Offline	DE8 Offline
10	DE9	Bearings Replacement (Main, Thrust,Crosshead,Crankpin & Canshaft		4 Days[2]	DE9 Offline	DE9 Offline
11	DE9	DCS Upgrade		3 Days[4]	DE9 Offline	DE9 Offline
12	DE8	DCS Upgrade		1 Day	DE8 Offline	DE8 Offline
13	DE8	2022 Major Overhaul, Liner Replacements, Generator Inspection		21 Days	DE8 Offline	DE8 Offline
14	DE8	Upgrade of Generator Excitation Panel		12 Days[1]	DE8 Offline	DE8 Offline
15	DE9	Upgrade of Generator Excitation Panel		12 Days	DE9 Offline	DE9 Offline
16	DE8	ULSD Conversion, Engine works		13 days		
17	DE9	ULSD Conversion, Engine works		13 days	DE9 Offline	DE9 Offline
18	DE8	*Replace Lubrication System with HJ SIP System (For Approval)		15 Days[5]	DE8 Offline	DE8 Offline
19	DE9	*Replace Lubrication System with HJ SIP System (For Approval)		15 Days[6]	DE9 Offline	DE9 Offline
20	DE8	Step-up/Aux Transformer Fire Fighting System Repair		3 Days[7]	DE8 Offline	DE8 Offline
21	DE9	Step-up/Aux Transformer Fire Fighting System Repair		3 Days[8]	DE9 Offline	DE9 Offline
22	DE9	2023 Major Overhaul, Liner Replacements, Generator Inspection		21 Days	DE9 Offline	DE9 Offline
23						
24						
25						
26		NOTES:				
27		1 - Can be done concurrently with DE8 2022 MOH				
28		2 - Can be done concurrently with DE9 2023 MOH				
29		3 - Can be done concurrently with DE9 Scheduled PMS				
30		4 - Planned to be done concurrently with DE9 2021 MOH				
31		5 - Can be done concurrently with DE8 ULSD Engine works				
32		6 - Can be done concurrently with DE9 ULSD Engine works				
33		7 - Can be done concurrently with DE8 PMS Schedule				
34		8 - Can be done concurrently with DE9 PMS Schedule				

Source: Rino Manzano, Marianas Electric Company

Approved GPA Budget on CIP/PIP/MOH & ULSD Conversion vs Costs
As of July 31, 2021

Account Code	CIP/PIP & Major Maintenance for 2019-2023	Classification	Approved GPA Budget (w/ 10%Contingency, 10%EPC & 4%COM)	100% Projects Completed as of 07/31/2021	CIP/PIP/MOH/ULSD Conversion In Progress		Variance
					% Completed as of 07/31/2021	Total Actual Cost + Commited Cost to Complete	
	1 Diesel Engine						
1821-001	Replace 20pc cylinder liners, 20 piston & rods assemblies	R	$ 1,755,349		80%	$ 1,939,397	$ (184,048)
1821-002	Upgrade Engine Governor System	R	112,860	106,367			6,493
1821-003	Engine Frame	LE	200,640			-	200,640
1821-004	Engine Bedplates	LE	250,800		75% Completed but found additional cracks for repair	240,258	10,542
1821-005	Engine Chain Tensioners	R	125,400		75%	59,021	66,379
1821-006	Exchange of All Scavenging Air Coolers	R	532,519		80%	649,409	(116,890)
1821-007	Inspection of Engine Foundation with report and repairs	LE	103,199		0%	103,866	(667)
1821-008	Exchange of All Main Bearings	R	303,919		75%	233,170	70,749
1821-009	Exchange of All Thrust Bearings	R	249,696		75%	41,706	207,991
1821-010	Exchange of All Crosshead Bearings	R	429,319		75%	235,044	194,276
1821-011	Exchange of All Crankpin Bearings	R	248,593		75%	134,280	114,313
1821-012	Exchange of All Camshaft Bearings	R	223,513		75%	47,714	175,799
1821-013	Procure cylinder liner measuring instrument LDM	LE	35,739	3,472			32,267
Sub-total			**4,571,547**	**109,838**		**3,683,864**	**777,845**

Source: Rino Manzano, Marianas Electric Company

Approved GPA Budget on CIP/PIP/MOH & ULSD Conversion vs Costs
As of July 31, 2021

Account Code	CIP/PIP & Major Maintenance for 2019-2023	Classification	Approved GPA Budget (w/ 10%Contingency, 10%EPC & 4%COM)	100% Projects Completed as of 07/31/2021	CIP/PIP/MOH/ULSD Conversion In Progress		Variance
					% Completed as of 07/31/2021	Total Actual Cost + Commited Cost to Complete	
	1 Diesel Engine						
1821-001	Replace 20pc cylinder liners, 20 piston & rods assemblies	R	$ 1,755,349		80%	$ 1,939,397	$ (184,048)
1821-002	Upgrade Engine Governor System	R	112,860	106,367			6,493
1821-003	Engine Frame	LE	200,640			-	200,640
	2 Electrical System/Generators /Transformers						
1822-001	Upgrade DCS Control System with new Workstations	R	81,510		75%	77,090	4,420
1822-002	Inspection and upgrade of Generator Excitation panel	R	376,200		50%	444,844	(68,644)
1822-003	Replace Transformer Cell Concrete Structure	R → LE	195,624			-	195,624
1822-004	Purchase new 13.8 KV Circuit breaker	LE	22,873	14,060			8,813
	Sub-total		**676,207**	**14,060**		**521,934**	**140,213**
	3 Engine Auxiliary Equipment						
1823-001	Replace Cylinder Lubricators w/HJ SIP System	LE	1,448,638		0%	1,307,753	140,885
1823-002	Replace all Plate Heat Exchangers	R	267,252		85%	260,733	6,520
1823-003	Replace Hot Water and HT pumps	R	124,146	74,700			49,446
1823-004	Replace Control Air Compressor	R	79,002	30,963			48,039
1823-005	Install add'l HFO Separator	LE	61,446	17,062			44,384
1823-006	Replace Fuel Pre-Heaters	R	188,100	153,275			34,825
	Sub-total		**2,168,585**	**276,000**		**1,568,486**	**324,099**

Source: Rino Manzano, Marianas Electric Company

Approved GPA Budget on CIP/PIP/MOH & ULSD Conversion vs Costs
As of July 31, 2021

Account Code	CIP/PIP & Major Maintenance for 2019-2023	Classification	Approved GPA Budget (w/ 10%Contingency, 10%EPC & 4%COM)	100% Projects Completed as of 07/31/2021	CIP/PIP/MOH/ULSD Conversion In Progress		Variance
					% Completed as of 07/31/2021	Total Actual Cost + Commited Cost to Complete	
	4 Steam System						
1824-001	Replace all steam circulating pumps	LE	86,526		95%	62,324	24,202
1824-002	Replace leaking/defect boiler sections	LE	213,180			-	213,180
1824-003	Replace Boiler Damper	LE	48,033	11,814			36,219
1824-004	Replace insulation and cladding on boiler	LE	125,400	6,919			118,481
1824-005	Inspection of Steam Drum with report and repairs	LE	63,884			-	63,884
1824-006	Inspection of Deaerator with report and repairs	LE	63,884	8,380			55,503
1824-007	Replace All Sootblowers (40 pc)	R	512,361	120,935			391,426
Sub-total			**1,113,268**	**148,048**		**62,324**	**902,896**

Source: Rino Manzano, Marianas Electric Company

Approved GPA Budget on CIP/PIP/MOH & ULSD Conversion vs Costs
As of July 31, 2021

Account Code	CIP/PIP & Major Maintenance for 2019-2023	Classification	Approved GPA Budget (w/ 10%Contingency, 10%EPC & 4%COM)	100% Projects Completed as of 07/31/2021	CIP/PIP/MOH/ULSD Conversion In Progress		Variance
					% Completed as of 07/31/2021	Total Actual Cost + Commited Cost to Complete	
	5 BOP's						
1825-001	Replace 16pc LT radiator cooler elements	R	1,850,004	1,724,605			125,398
1825-002	Replace all HT and JW radiator coolers	R	1,733,028	1,240,770			492,258
1825-003	Replace all ventilation fans	LE	433,884	62,828			371,056
1825-004	PHB Louvers	LE	125,400	104,042			21,358
1825-005	Engine Room Ventilation System	LE	112,860			-	112,860
1825-006	Upgrade/replace Oily Water System (AL Sep)	LE	256,180		0%	257,835	(1,656)
1825-007	Oil in Water monitoring	LE	16,011		0%	16,115	(103)
1825-008	Replace Starting Air Compressor	R	61,446	34,056			27,390
1825-009	Replace submersible pumps	LE	55,679	36,383			19,296
1825-010	Raw/Treated Water Tanks Repair/Repaint	LE	250,800	126,778			124,022
1825-011	High Sulfur Storage Tank Inspection/Repair (SPCC)	LE	265,848	-			265,848
1825-012	Replace RO Plant	R	415,530		0%	418,216	(2,686)
1825-013	Fire Protection System Upgrade	LE	125,400		0%	767,589	(642,189)
	Sub-total		**5,702,070**	**3,329,463**		**1,459,756**	**912,851**
	Total CIP/PIPs		**$ 14,231,677**	**$ 3,877,409**		**$ 7,296,364**	**$ 3,057,904**
1826-000	**Major Maintenance/Overhaul Cost 2019-2023**		**4,084,215**	**1,268,395**	**40%**	**2,682,811**	**133,009**
CIP/PIPs & Major Maintenance/Overhaul Costs			**$ 18,315,892**	**$ 5,145,804**		**$ 9,979,175**	**$ 3,190,913**

Source: Rino Manzano, Marianas Electric Company

Approved GPA Budget on CIP/PIP/MOH & ULSD Conversion vs Costs
As of July 31, 2021

Account Code	CIP/PIP & Major Maintenance for 2019-2023	Classification	Approved GPA Budget (w/ 10%Contingency, 10%EPC & 4%COM)	100% Projects Completed as of 07/31/2021	CIP/PIP/MOH/ULSD Conversion In Progress		Variance
					% Completed as of 07/31/2021	Total Actual Cost + Commited Cost to Complete	
Additional CIP/PIPs - APPROVED:							
1821-014	Cylinder Liner Temperature Monitoring System Upgrade	R		89,001			(89,001)
1821-015	Exhaust Valve 3 sets	R		122,822			(122,822)
1821-016	Turning Gear for DE9	R		91,160			(91,160)
1821-017	Turbocharger Silencer 1ea	R		152,652			(152,652)
1821-018	Controller for Fuel Automatic Fiter Unit (2ea)	LE		6,821			(6,821)
1821-019	Welding Repair Scavending Air Receiver DE8&9	R			0%	80,316	(80,316)
1821-020	Cylinder Covers	R		203,638			(203,638)
1825-014	Replacement of MV Room ACU	LE		41,363			(41,363)
Additional CIP/PIPs - APPROVED				**707,457**		**80,316**	**(787,773)**
Additional Major Overhaul Parts - APPROVED:							
	Turbocharger Rotor Assembly 1ea	R		149,629			(149,629)
	Fuel Oil Pump Assembly 5ea	R		144,848			(144,848)
	Fuel Oil Pump Shock Absorber 5ea	R		57,461			(57,461)
	Additional MOH Parts - APPROVED			**351,938**	-	-	**(351,938)**

Source: Rino Manzano, Marianas Electric Company

Approved GPA Budget on CIP/PIP/MOH & ULSD Conversion vs Costs
As of July 31, 2021

Account Code	CIP/PIP & Major Maintenance for 2019-2023	Classification	Approved GPA Budget (w/ 10%Contingency, 10%EPC & 4%COM)	100% Projects Completed as of 07/31/2021	CIP/PIP/MOH/ULSD Conversion In Progress		Variance
					% Completed as of 07/31/2021	Total Actual Cost + Commited Cost to Complete	
Requested Additional CIP/PIPs - PENDING GPA's APPROVAL:							
1821-021	Cylinder Liners 10ea	R			0%	431,156	(431,156)
1825-015	Replacement of LV Room ACU	LE			0%	35,988	(35,988)
Additional CIP/PIPs - PENDING APPROVAL						**467,144**	**(467,144)**
TOTAL CIP/PIPs & Major Maintenance/Overhaul Costs			**$ 18,315,892**	**$ 6,205,199**		**$ 10,526,635**	**$ 1,584,058**
ULSD Conversion (with 10% EPC Fee)			**14,141,045**			**14,141,045**	-
Add: FX Rate Variance (Euro to USD)						**770,506**	(770,506)
GRT on 10% EPC Fee						**65,244**	(65,244)
Total ULSD Conversion			**$ 14,141,045**			**$ 14,976,795**	**$ (835,750)**
TOTAL CIP/PIP/MOH & ULSD CONVERSION			**$ 32,456,937**	**$ 6,205,199**		**$ 25,503,430**	**$ 748,308**

Source: Rino Manzano, Marianas Electric Company

2022 Integrated Resource Plan Volume II:

Generation Expansion Plan

10/27/2021

LORRAINE O. SHINOHARA, PE — DATE

ENGINEERING SUPERVISOR

STRATEGIC PLANNING & ENERGY CONTRACTING

10/28/21

JENNIFER G. SABLAN, PE — DATE

SPORD MANAGER

10/28/2021

JOHN J. CRUZ JR., PE — DATE

ASSISTANT GENERAL MANAGER

ENGINEERING & TECHNICAL SERVICES

11/1/2021

JOHN M. BENAVENTE, PE — DATE

GENERAL MANAGER

Version History

Description	Date
Original	11/01/2021
Amendment 1	01/13/2022

Table of Contents

1. Introduction

As part of the GPA Integrated Resource Plan (IRP), this document describes the recommended generation expansion plan through 2040 based on load and fuel forecasts, generation operational costs and availability, compliance requirements with the United States Environmental Protection Agency (US EPA) and Guam laws regarding renewable portfolio standards. The assumptions made to arrive at this recommendation are also discussed.

2. Situation Analysis

Guam Power Authority (GPA) is a public corporation and an enterprise fund of the Government of Guam. The Guam Power Authority Act of 1968 established GPA in May 1968. Guam Code 12 Chapter 8 sets the legal definitions, empowerments and limitations for GPA.

GPA is governed by the Consolidated Commission on Utilities (CCU), a five-member board elected for staggered four-year terms. Additionally, GPA's rates are regulated by the Guam Public Utilities Commission (Guam PUC), a seven-member board appointed by the Governor and confirmed by the Legislature to serve six-year terms.

GPA currently serves about 52,000 customers with 420 MW of oil-fired generation capacity and 25.3 MW of renewable generation capacity. In 2020, GPA had a peak demand of 247 MW and an annual budget of approximately $400 million with fuel oil purchases totaling more than half of GPA's budget.

Recent changes to the US EPA environmental rules and regulations shaped the decisions on future resource options and actions needed for GPA's current power plants. These requirements have led GPA to convert the fuel for GPA's Cabras 1&2 Steam Turbine Power Plant (Cabras) from 2% Sulfur and 1.19% Sulfur Residual Fuel Oil to 0.2% Sulfur Residual Fuel Oil by 2023. Cabras will subsequently be retired about six months after the new Ukudu Power Plant (Ukudu) starts commercial operation, around November 2023, but no later than April 2024. Additionally, the fuel for GPA's Piti 8&9 Slow-speed Diesel Power Plant (Piti 8&9) will be converted from 2% Sulfur and 1.19% Sulfur Residual Fuel Oil to Ultra-Low Sulfur Diesel Fuel no later than July 31, 2022. The details of the environmental rules and regulations are further discussed in Volume III of this report.

GPA is committed to achieving a 25% renewable energy mix by 2024, 50% by 2030 and 100% by 2045 to meet the Renewable Portfolio Standards set forth in Guam Public Law 35-46. These mandates have also heavily affected the planned resources for the analysis period.

To meet the 50% renewable energy mix target, the following Renewable Resource Acquisitions (RRA) are either already in place or planned:

1. 60 MW of solar power via Energy Purchase Agreement online by February 2022 (Phase II Renewable Resource Acquisition)
2. 60 MW of solar power via Energy Purchase Agreement online by January 2024 (Phase II Renewable Resource Acquisition)
3. 30 MW + 30 MW load-shifting energy from solar power via Energy Purchase Agreement online by May 2024 (Phase III Renewable Resource Acquisition)
4. Planned annual purchase of 300,000 MWh via Energy Purchase Agreement to be awarded and integrated into the system by 2025 and dispatched between 6PM to 6AM (Phase IV Renewable Resource Acquisition), but dispatching conditions will differ once in operation, based on the system requirements
5. Planned annual purchase of 300,000 MWh via Power Purchase Agreement to be awarded and integrated into the system by 2030, assumed to be dispatched at a fixed MW load for 24 hours for modeling purposes, but actual dispatching will differ once in operation (Phase V Renewable Resource Acquisition)

In addition to the Phase II through Phase V RRAs, GPA is planning the following to meet the 100% renewable energy mix target:

- Planned annual purchase of 575,000 MWh via Energy Purchase Agreement to be awarded and integrated into the system by 2036 (Phase VI Renewable Resource Acquisition)
- Planned annual purchase of 600,000 MWH via Energy Purchase Agreement to be awarded and integrated into the system by 2040 (Phase VII Renewable Resource Acquisition)

3. Assumptions

The following assumptions were made regarding existing conditions and future events to develop the load and fuel forecasts as well as the generation expansion analysis:

- The analysis planning horizon is 20 years with the base year being 2021.
- GPA used some older information on proposed and existing capital costs from datasets some going back to 2015. GPA used an escalation rate of 6% to bring these cost estimates to the 2021 base year. Beyond the base year, GPA applied a Capital Cost Escalation rate of 3%.
- Labor cost escalation and implicit price deflation rates were used for the operating and maintenance costs.
- Two load forecast scenarios were evaluated:
  - Baseline, with the impact of the pandemic considered for 2021 thru 2023
  - Baseline with Data Center, which assumes the addition of a Data Center as one of GPA's major customers that increases the peak loads variably during the study period
- Three fuel price forecast scenarios for ULSD and LNG were evaluated:
  - Baseline
  - Low
  - High
- At the time of the analysis, GPA was in negotiations with the current RFO Supplier for the change in costs for the change in sulfur content. The prevailing negotiated cost at the time of the analysis (2nd Quarter of 2021) was used.
- Landed fuel costs as provided by the consultant were used in completing the analysis (no operating costs or maintenance costs for fuel supply system included). No additional costs for Piti 8&9 and Ukudu were added since supply will come directly from GPA's bulk storage facility. However, for the northern and southern power plants, additional costs were assumed based on existing premium fees with current suppliers,

since these plants will continue to be supplied by on-island fuel supply companies. (GPA does not have fuel trucking capabilities.)

- For the LNG scenarios, GPA used a 2011 study for the estimated capital expenditures and annual operating costs for a regasification facility. The costs in the study were escalated to 2027 dollars using an escalation rate of 6% per year. Additionally, current expenses for fuel handing (F-1 Dock, etc.) were also used, assuming a minimum escalation rate per year.
- For the Waste-to-Energy candidate unit, GPA used the $/MMBTU industry standard for Municipal Solid Waste as provided by the consultant.

3.1 Existing GPA Units

It was assumed that all existing GPA power plants will be operational throughout the study period, with annual maintenance schedules based on normal operating scenarios, adjusted (increased) during the years where major maintenance or capital improvement projects are planned. Conservative (low) forced outage rates were assumed, based on estimates provided by the consultant in the 2015 Leidos Report found in Appendix C.

3.2 Ukudu Power Plant, KEPCO Diesel Generators

For the new Ukudu Power Plant, including the KEPCO Diesel Generators (40-MW emergency-use diesel units), existing contract costs were used. Appendix H contains sections of the contract with data used in the generation expansion analysis.

4. Load Forecast

GPA contracted Utility Financial Solutions, LLC (UFS) to develop the forecast for GPA total energy sales and peak demand. Long-term econometric projections were based on monthly observations using historical data from 2007 – 2020 over the forecast period of 2020 through 2040. This includes projections of monthly energy consumption (kWh) and peak monthly demands (kW).

The initial analysis, which accounted for civilian and Navy growth, showed that GPA can expect a growth rate for total energy sales (kWh) of 2.3 % between 2021 and 2025, 1.4% between 2021 and 2031, and 0.8% between 2021 and 2040. Peak demands (kW) are projected to grow at an annual average rate of 3.0% between 2021 and 2025, 2.0% between 2021 and 2030, and 1.3% between 2021 and 2040. The graphs below show the historical and initial projected energy sales and peak demand respectively within the study period of 2007 - 2040.

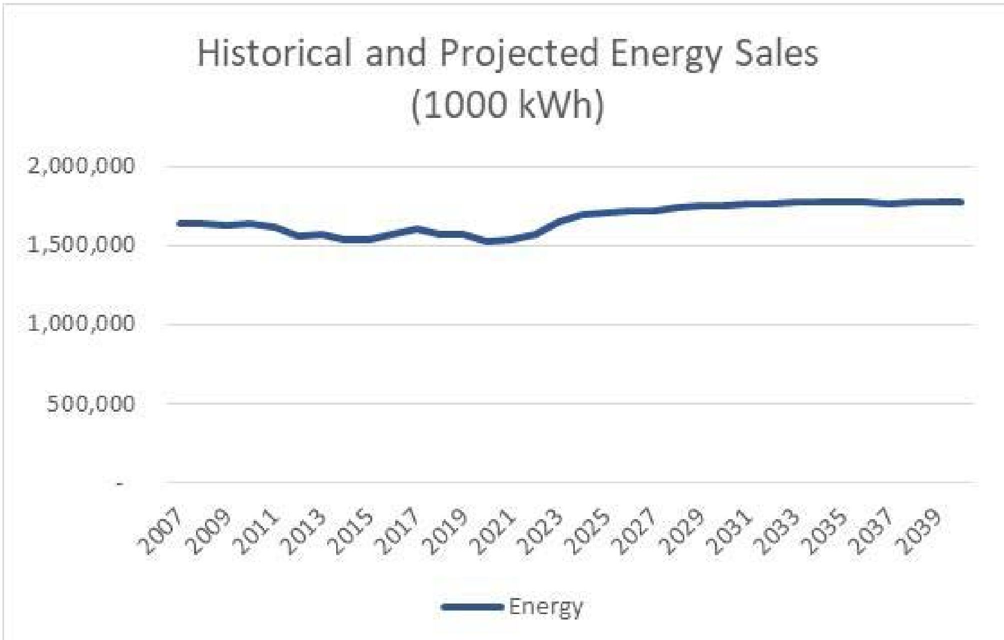

Figure 4-1. Historical and Projected Energy Sales (1000 kWh)

Figure 4-2. Historical and Projected Load (1000 kW)

A review of the initial analysis resulted in the following corrections that were subsequently applied:

- Adjustments for the impact of the COVID-19 pandemic such as the decline in tourism, Guam's main economic driver
- Adjustments for severe weather conditions between 2016 and 2020 that were not accounted for in the initial forecast
- Addition of the potential major customer entering the market with a Data Center within the first few years of the study period, which will variably impact the annual peak demands

Two new load forecast scenarios for hourly peak demand (MW) were developed for the IRP forecast period:

- Baseline
- Baseline with Data Center

The succeeding chart illustrates the historical annual peak load (MW) and the two forecasts used in the Integrated Resource Plan.

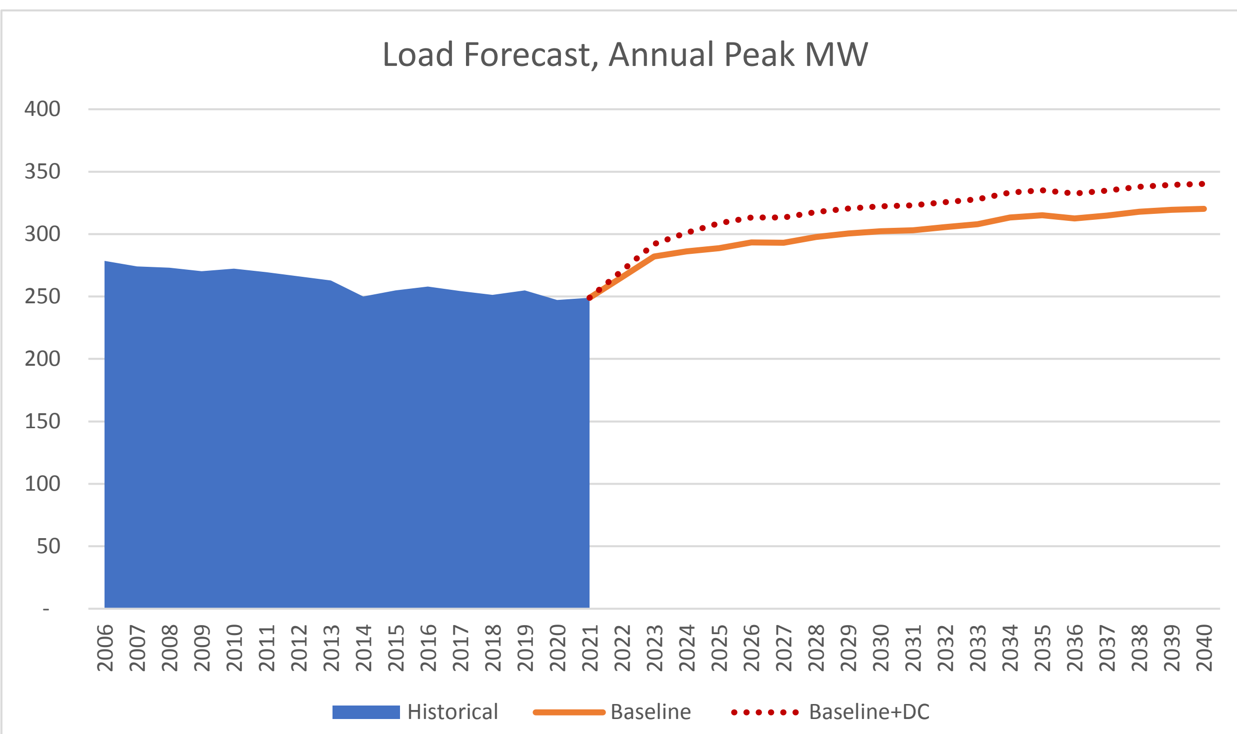

Figure 4-3. Historical and Projected Annual Peaks (MW)

The UFS Report in Appendix A discusses this forecast and the assumptions and methodology used in detail.

5. Fuel Forecast

GPA contracted Leidos Engineering, LLC (Leidos) to develop the annual fuel price forecast for 2% sulfur No. 6 residual fuel oil (HSFO), 1.19% sulfur No. 6 residual fuel oil (LSFO), 0.2% sulfur RFO (ULSFO), ultra-low sulfur No. 2 distillate fuel oil (ULSD), and liquefied natural gas (LNG) for the period between January 1, 2021 and December 31, 2050, including monthly prices from 2021 through 2025. Additionally, each product fuel forecast includes projections for Base Case, Low Case, and High Case. The following is a brief summary of the forecast methodology and prices:

- GPA has historically entered fuel purchase agreements with contract periods effective from the range of one to three years.
- Prices for the liquid fuels are indexed to the Mean of Platts Singapore (MOPS) plus a premium
- Historical correlation between U.S. Gulf Coast (USGC) and MOPS prices for ULSD and RFO were considered to determine MOPS refined products pricing. The results showed acceptable correlation of 98.8% and 97.5% for ULSD and RFO respectively, allowing USGC to be used as a proxy for MOPS product prices.
- ULSD and RFO prices were based on near-term forward prices and long-term forecast prices for West Texas Intermediate (WTI) crude oil.
- Shipping estimates were based on shipping costs from USGC to Guam for long-term premium that GPA would be charged for landed petroleum products.

Table 5-1 shows the resulting estimated prices for selected years and Compound Annual Growth Rate (CAGR) for ULSD and RFO with three different sulfur contents.

2020 dollars per MMBtu								
Product Type	2021	2025	2030	2035	2040	2045	2050	CAGR
ULSD	14.20	14.72	17.35	18.84	20.65	21.49	22.43	1.6%
RFO (2.0% sulfur)	12.06	12.41	14.52	15.68	17.10	17.73	18.42	1.5%
RFO (1.19% sulfur)	12.89	13.32	15.63	16.92	18.50	19.21	20.00	1.5%
RFO (0.2% sulfur)	13.96	14.48	17.06	18.51	20.28	21.10	22.01	1.6%
Nominal dollars per MMBtu								
Product Type	2021	2025	2030	2035	2040	2045	2050	CAGR
ULSD	14.49	16.25	21.15	25.35	30.68	35.26	40.62	3.6%
RFO (2.0% sulfur)	12.30	13.70	17.70	21.10	25.41	29.08	33.37	3.5%
RFO (1.19% sulfur)	13.15	14.70	19.06	22.78	27.48	31.52	36.23	3.6%
RFO (0.2% sulfur)	14.23	15.98	20.79	24.91	30.13	34.62	39.87	3.6%

Table 5-1. Landed Petroleum Products Prices

For LNG prices, Leidos utilized Leidos Fourth Quarter 2020 Henry Hub forecast of natural gas prices along with assumptions regarding cost to liquefy natural gas and the cost to ship LNG from USGC to Guam. The Henry Hub interconnects with nine interstate and three intrastate pipelines and has historically functioned as a point of market liquidity in the North American natural gas market. Moreover, Henry Hub is now becoming a reference point for many internationally delivered LNG cargos including delivery to New York Mercantile Exchange (NYMEX) natural gas features and OTC swaps traded on Intercontinental Exchange (ICE).

Near-term forecast prices are aligned to reflect natural gas prices on the NYMEX forward curve through 2022. From 2023 to 2045, Henry Hub prices forecast prices to average $4.68 per MMBtu in nominal dollars ($3.48 per MMBtu in real 2020 dollars). With the expectation of a large amount of associated and wet gas production and the large and relatively inexpensive gas resource base at Marcellus and Utica shale, gas prices through the forecast period are expected to remain relatively low. Figure 5-1 below shows the Leidos fourth Quarter 2020 Henry hub natural gas price forecast in nominal dollars and real 2020 dollars.

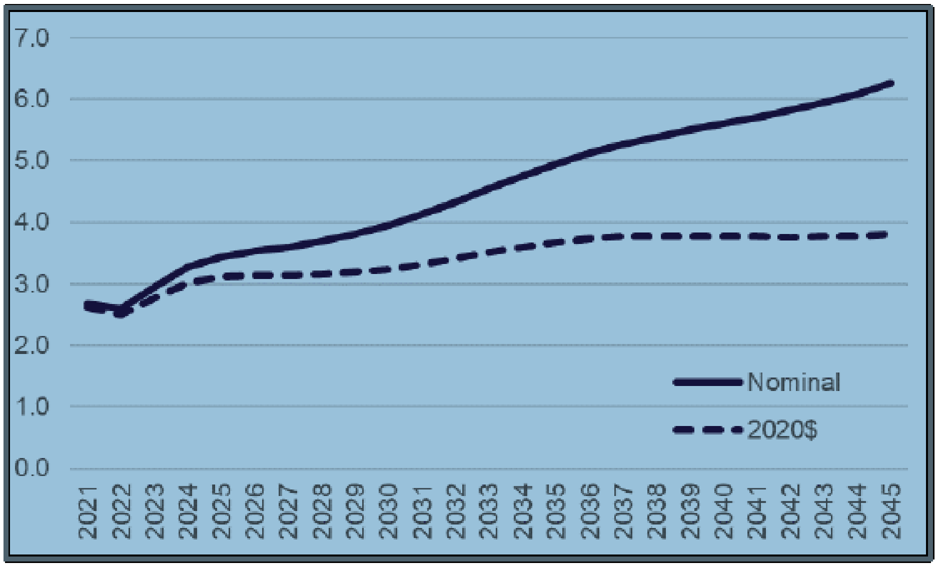

Figure 5-1. Henry Hub Natural Gas Price Forecast ($ per MMBtu)

The transformation from Henry hub natural gas prices into USGC LNG prices assumed that USGC LNG prices would trade at a long-term price of Henry Hub plus 25% plus $2.50 per MMBtu. LNG shipping costs were estimated based on a steam turbine powered tanker with a capacity of 160,000 cubic meters LNG, which utilizes both marine fuel oil and LNG boil off gas as fuel. Table 5-2 below shows assumptions used to calculate LNG shipping costs from USGC to Guam. Table 5-3 shows the projected Henry Hub prices, calculated USGC LNG prices, and landed LNG prices for selected forecast years as well as the Compound Annual Growth Rate (CAGR).

	Value	Units
Shipping Distance	9,500	Nautical Miles
Vessel Speed	19	Knots
Days in Port	3	Days
Round Trip Shipping Days	45	Days
Charter Rate (annual average)	$55,000	Dollars per day
Panama Canal Cost	$850,000	Round Trip Transit
Port Costs	$100,000	Dollars per day
Insurance Cost	$2,700	Dollars per day
Broker Fee	2% of Charter Cost	
Marine Fuel Oil Consumption	46.65	Metric Tons per day
LNG Boil Off	5,440	MMBtu per day
Retained LNG (return voyage)	4% of vessel capacity	

Table 5-2. LNG Shipping Assumptions

2020 dollars per MMBtu								
Product Type	2021	2025	2030	2035	2040	2045	2050	CAGR
Henry Hub	2.83	3.11	3.24	3.68	3.77	3.82	4.88	1.9%
USGC LNG	5.99	6.34	6.50	7.05	7.16	7.22	8.56	1.2%
Landed LNG	7.73	8.12	8.37	8.99	9.15	9.23	10.67	1.1%
Nominal dollars per MMBtu								
Product Type	2021	2025	2030	2035	2040	2045	2050	CAGR
Henry Hub	2.89	3.43	3.95	4.95	5.60	6.26	8.85	3.9%
USGC LNG	6.11	7.00	7.93	9.49	10.64	11.85	15.50	3.3%
Landed LNG	7.88	8.97	10.21	12.09	13.59	15.14	19.33	3.1%

Table 5-3. Henry Hub and LNG Prices

WTI crude oil prices and Henry Hub process were used to calculate product prices from a high and low forecast. High forecast consisted of long-term WTI crude oil prices from AEO low Oil and Gas Supply Case and Henry Hub prices from the Leidos Fourth Quarter Gas Price Case. Table 5-4 shows the High and Low forecasts as referenced from the Base Case. Table 5-5 shows results for landed prices from High and Low forecasts.

Forecast Assumption	High Case	Low Case
Estimated Ultimate Recovery ("EUR") per well for offshore, tight oil and oil bearing shale formations (EIA AEO).	50% higher than the reference case.	50% Lower than the reference case.
Rate of technological improvement (EIA AEO)	50% higher than the reference case.	50% Lower than the reference case.
Initial unproved oil resources (EIA AEO)	156 billion barrels higher than the reference case.	133 billion barrels lower than the reference case.
Initial WTI Crude Oil Prices (2022 through 2025)	8% higher	12% Lower
Henry Hub Price Forecast (Leidos Q4)	15% higher than the base case.	18% lower than the base case.

Table 5-4. High and Low Forecast Assumptions

-

High Case (2020 dollars per MMBtu)								
Product Type	2021	2025	2030	2035	2040	2045	2050	CAGR
ULSD	15.04	15.78	18.84	21.47	23.66	25.23	26.43	2.0%
RFO (2.0%) Sulfur	12.76	13.28	15.74	17.85	19.57	20.79	21.69	1.8%
LNG	8.18	8.77	9.05	9.78	9.96	10.07	11.73	1.3%
Low Case (2020 dollars per MMBtu)								
Product Type	2021	2025	2030	2035	2040	2045	2050	CAGR
ULSD	12.88	13.12	14.11	15.53	16.98	18.39	19.48	1.4%
RFO (2.0%) Sulfur	10.99	11.10	11.89	13.02	14.17	15.29	16.13	1.3%
LNG	7.14	7.34	7.52	8.03	8.16	8.24	9.43	1.0%
High Case (nominal per MMBtu)								
Product Type	2021	2025	2030	2035	2040	2045	2050	CAGR
ULSD	15.34	17.42	22.96	28.90	35.15	41.40	47.88	4.0%
RFO (2.0%) Sulfur	13.02	14.66	19.19	24.02	29.08	34.10	39.29	3.9%
LNG	8.34	9.68	11.03	13.16	14.80	16.52	21.25	3.3%
Low Case (nominal per MMBtu)								
Product Type	2021	2025	2030	2035	2040	2045	2050	CAGR
ULSD	13.14	14.49	17.21	20.91	25.23	30.18	35.29	3.5%
RFO (2.0%) Sulfur	11.21	12.25	14.49	17.52	21.05	25.08	29.22	3.4%
LNG	7.28	8.11	9.17	10.81	12.12	13.52	17.08	3.0%

Table 5-5. High and Low Case Landed Prices

Figure 5-2 below is an illustration of the forecasts compared with the actual fuel cost Mean of Platt's Singapore for January 2021. Table 5-6 displays the Baseline Fuel Forecast used in the analysis.

The Leidos 2021 Fuel Price Forecast Report in Appendix B further discusses the fuel price forecast in detail.

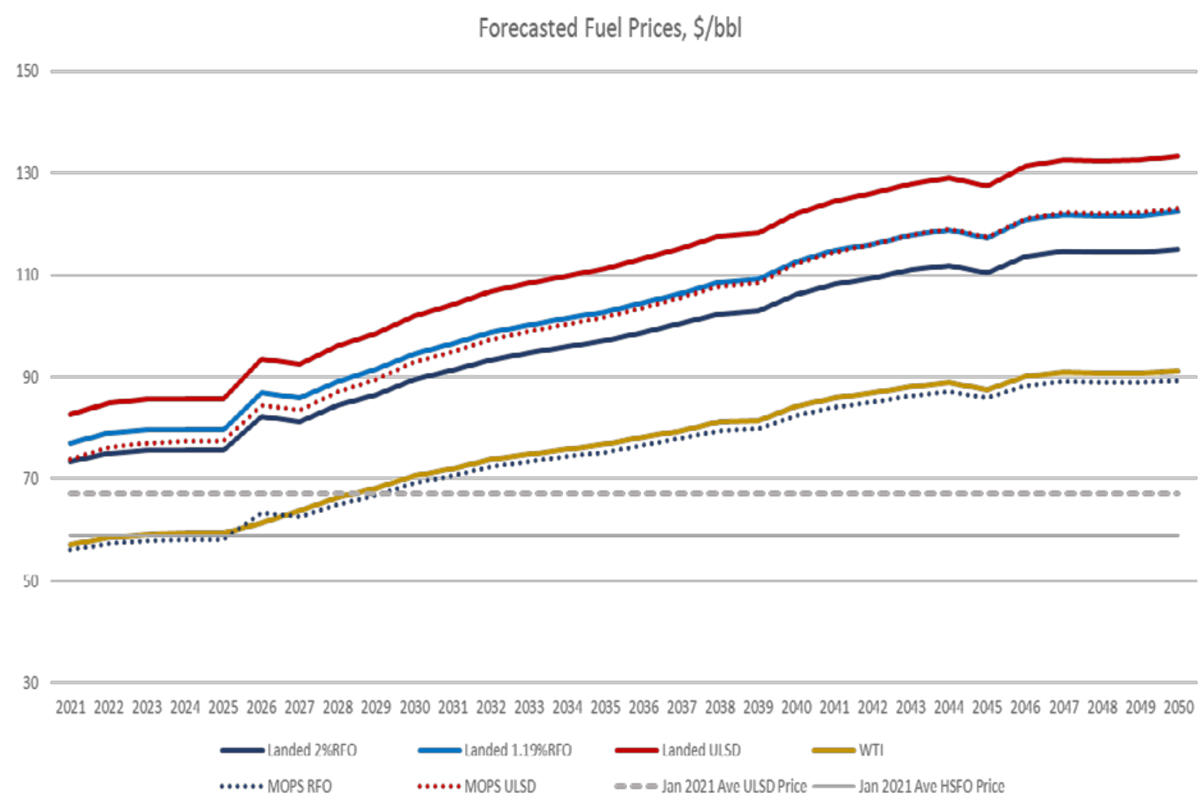

Figure 5-2. Forecasted Fuel Prices, $/bbl VS Jan 2021 MOPS and GPA Average Fuel Cost

UNIT	FUEL TYPE	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Dededo CT	ULSD	16.12	16.80	17.23	17.56	17.88	19.60	19.73	20.80	21.68	22.78	23.66	24.61	25.40	26.20	26.98	27.94	28.94	30.05	30.75	32.31
Macheche CT	ULSD	16.12	16.80	17.23	17.56	17.88	19.60	19.73	20.80	21.68	22.78	23.66	24.61	25.40	26.20	26.98	27.94	28.94	30.05	30.75	32.31
Manenggon Diesel	ULSD	16.38	17.06	17.49	17.82	18.14	19.86	19.99	21.06	21.94	23.04	23.92	24.87	25.66	26.46	27.24	28.20	29.20	30.31	31.01	32.57
Piti 7 CT	ULSD	16.07	16.75	17.18	17.51	17.83	19.55	19.68	20.75	21.63	22.73	23.61	24.56	25.35	26.15	26.93	27.89	28.89	30.00	30.70	32.26
Talofofo Diesel	ULSD	16.38	17.06	17.49	17.82	18.14	19.86	19.99	21.06	21.94	23.04	23.92	24.87	25.66	26.46	27.24	28.20	29.20	30.31	31.01	32.57
Tenjo Diesel	ULSD	16.38	17.06	17.49	17.82	18.14	19.86	19.99	21.06	21.94	23.04	23.92	24.87	25.66	26.46	27.24	28.20	29.20	30.31	31.01	32.57
Yigo CT	ULSD	16.16	16.84	17.27	17.60	17.92	19.64	19.77	20.84	21.72	22.82	23.70	24.65	25.44	26.24	27.02	27.98	28.98	30.09	30.79	32.35
Piti 8&9	ULSD	12.56	13.34[1] 15.17[2]	15.60	15.93	16.25	17.97	18.10	19.17	20.05	21.15	22.03	22.98	23.77	24.57	25.35	26.31	27.31	28.42	29.12	30.68
Ukudu 1,2 and 3	ULSD	14.49	15.17	15.60	15.93	16.25	17.97	18.10	19.17	20.05	21.15	22.03	22.98	23.77	24.57	25.35	26.31	27.31	28.42	29.12	30.68
Cabras 1&2	RFO	12.56	13.34	16.39	16.73	16.73	16.73	16.73	16.73	16.73	16.73	16.73	16.73	16.73	16.73	16.73	16.73	16.73	16.73	16.73	16.73
For Evaluation:																					
Waste-to-Energy Facility	MSW	7.02	9.53	10.14	10.14	10.14	10.14	10.14	10.14	10.14	10.14	10.14	10.14	10.14	10.14	10.14	10.14	10.14	10.14	10.14	10.14
Conversion to LNG	LNG	9.21	8.94	9.48	10.00	10.30	10.56	10.75	10.97	11.23	11.54	11.87	12.27	12.65	13.03	13.42	13.77	14.10	14.38	14.64	14.92

[1] Through June 2022
[2] Starting July 2022

Table 5-6. Forecasted Baseline Fuel Prices, $/bbl

6. Existing Generation Unit Cost Model

The cost models for GPA's existing generation units were created using information from the following:

- GPA Finance Division's Cost to Produce per kWh reports, from FY 2017 through FY 2020
- Energy Conversion Agreement (ECA) extension with Marianas Energy Corporation for the Piti 8&9 Power Plant
- Performance Management Contract with TEMES Guam, Inc. for the Cabras 1&2 Power Plant
- Performance Management Contract extension with TEMES Guam, Inc for the Combustion Turbine Power Plants: Dededo CT, Macheche CT and Yigo CT
- Ukudu Power Plant contract

6.1 Fixed Costs

To determine the fixed costs, GPA calculated the labor costs for each unit and added, where applicable, the fixed management fees for the units under a performance management contract. However, for Piti 8&9, the fixed costs (which include labor costs among others) indicated in the Energy Conversion Agreement extension were used.

For Yigo Diesel Generators, it was assumed that GPA would enter into a management contract for these units in 2022 using the cost from the highest bidder from the cancelled solicitation. This showed a sudden increase in costs starting in 2022.

Appendix F (Table F-1) shows the costs entered in the baseline database for analysis.

6.2 Variable O&M Costs

To determine the variable O&M costs, GPA evaluated the variable operation and maintenance costs for each plant using GPA Finance's Cost to Produce per kWh report. The $/MWH for the fiscal year reflecting normal operating conditions for the unit were used for 2021 onwards, except for Piti 8&9 (variable O&M costs in the ECA extension were used), and Ukudu (costs provided in Appendix H were used). Appendix F (Table F-2) shows the costs entered in the baseline database for analysis. For Ukudu, costs provided in Appendix H were used.

Fuel costs and costs associated with the fuel supply system or those that are charged under LEAC are not included in the variable O&M cost for each unit.

6.1. Capacity Fees

Capacity fees for Ukudu illustrated in Appendix H were used in the analysis.

6.2. Capital Expenditures

Capital expenditures based on the 2015 Leidos Report in Appendix C were used. It was assumed that the CIP for the CT Units will be done after 2024, staggered so that no more than 2 units were undergoing a CIP completion per year.

For Yigo CT, some CIPs are already being completed in 2021, therefore costs were adjusted to deduct the work already being completed.

For Yigo Diesel Generators, it was assumed that these units will be standby units past 2024. All maintenance work is included in the monthly fixed costs and the variable O&M assumed for the units.

Appendix F (Table F-3) shows the costs entered in the baseline database for analysis.

7. Candidate Generation Additions Cost Models

In coordination with GPA, Leidos Engineering, LLC (Leidos) developed unit characteristics for candidate generation additions. These unit characteristics include performance, capital cost, and operation and maintenance (O&M) cost projections. New installation construction schedule information is based on permitting starting in July 2020.

General assumptions were made in the development of data for each of the new generation units. One of which was that construction-related costs and O&M costs are presented in 2019$. Construction costs have a 7 percent contingency as part of direct costs, including owner costs at 15 percent of direct costs. Additionally, the plant direct construction costs include costs for plant side switchgear and transformer to increase the voltage to 34.5 kV, as well as a 34.5 kV breaker, 3 disconnects, 34.5 kV switchgear and control panel, control house, and fencing. Cost estimates have been adjusted to include 20 percent uplift from mainland pricing to account for working on Guam unless noted otherwise. Furthermore, O&M costs represent non-fuel production-related costs, including subcategories for variable O&M (VOM), Fixed O&M (FOM), and major maintenance. However, FOM does not include owner costs such as property taxes, insurance, or finance-related costs. Lastly, non-union labor will be used.

Appendix D contains the Leidos report discussing each candidate generation addition in detail.

7.1. Ocean Thermal Energy Conversion (OTEC)

Ocean thermal energy conversion technology (OTEC) utilizes temperature differences between sea water surface level and at large depths of at least 1000 meters to support closed-loop organic rankine cycle (ORC) operations. The working fluid (ammonia), which has a lower boiling point than water, is condensed within a heat exchanger. Concurrently, the heat exchanger is cooled by deep ocean water. From there, the working fluid is pumped to pressure and enters the surface water heat exchanger where it absorbs heat and vaporizes. The fluid passes through a turbine, generating electricity, and then the cycle repeats. For efficient operation, ocean water temperature differential of at least 25 degrees Celsius is preferred.

The unit characteristics for OTEC installation on Guam is based on a project in Hawaii, operated by Makai Ocean Engineering, scaled up to 10 MW. The 20 percent cost addition was not used due to the use of the Hawaii project's capital costs. A staff of 12 is recommended to support site operations 24 hours per day and seven days a week.

7.2. Sea Water Air Conditioning (SWAC)

Sea water air conditioning (SWAC) takes advantage of the cold thermal reservoir of the ocean to regulate land-based air conditioning. This project would essentially reduce electrical load currently provided by air conditioning services. Cool sea water is pumped through miles of pipes to a land-based heat exchanger, extracting heat from the closed fresh water loop that is used in air conditioners.

The 2006 Makai study was referenced when developing the 2022 IRP unit characteristics, including escalation of capital costs at 2 percent rather than 20 percent. A staff of 6 to 8 is recommended to support operations during normal business hours with the exception of on call staff over nights and weekends.

7.3. Battery Energy Storage Systems (BESS)

The battery energy storage system (BESS) utilizes lithium-ion based battery chemistry. BESS are able to provide real power or frequency regulation with sub-cycle speed reaction times. Although lithium-ion batteries have been in use for decades, their application in battery storage at a utility scale has been fairly recent. Therefore, long-term degradation has not yet been tested by field operations.

BESS unit characteristics are based on a time shift application with a four-hour duration, where the BESS will be charged at times of low energy costs and discharged at times of high energy costs. Energy capacity degradation has been determined to be approximately 3 percent annually, resulting in a useful life of less than 10 years. The facility is assumed to be unmanned, with the exception of a technical staff to be deployed to conduct maintenance.

7.4. Pumped-Storage Hydropower (PSH)

Pumped-storage hydro (PSH) power utilizes water dynamics between two water reservoirs with differing elevations. The water from the upper reservoir moves down to the lower reservoir as it passes through a turbine generating electricity. Pumps are used to fill the upper reservoir during times of low energy costs and water is released from the upper reservoir during times of high energy costs. PSH facilities are generally more efficient when there is a large elevation difference between reservoirs.

GPA 2022 IRP has assumed two reservoirs of approximately 200 acre-feet with a gross head of approximately 300 feet, or 100 meters. Siting on Guam proves to be difficult due to the lack of elevation difference and open area required for the upper and lower reservoirs. A staff of 6 to 8 is recommended to support operations during normal business hours with the exception of on call staff over nights and weekends.

7.5. Compressed Air Energy Storage (CAES)

Compressed air storage energy storage (CAES) is a way to store energy in the form of compressed air for use at a later time. At times of low power costs, the plant will compress air. The compressed air is then stored in large underground caverns, which can accommodate the high pressures and large volumes of compressed air. When power generation is needed, the compressed air is used to feed combustion turbines. However, the diabatic configuration does not utilize the heat generated during compression and the heat lost during expansion to improve cycle efficiency. Consequently, efficiencies will be limited to 50 or 60 percent.

Unit characteristics were prepared for a small 5 MW, 10 MWh, diabatic CAES system utilizing a large, high-pressure (1000 psi or 70 Bar) storage tank with a volume of approximately 300,000 gallons, or 1000 cubic meters. A staff of 6 to 8 is recommended to support operations during normal business hours with the exception of on call staff over nights and weekends.

7.6. Flywheels

A flywheel is designed to convert electric energy to kinetic energy and also works contrariwise. The flywheel primarily consists of a common connection joint called the “hub”, a permanent magnet motor generator (PMMG), rim, two angular contact/rolling element bearings, a magnetic bearing, and housing. As the flywheel absorbs electrical energy, the rotation speed of the flywheel increases to a peak of 16,000 revolutions per minute (RPM). The PMMG can likewise inject electric energy into the grid, but this reduces the rotational speed of the flywheel. The amount of energy in each fly wheel is directly proportional to the square of rotational speed.

Unit characteristics are based on a containerized flywheel system, in which the module is designed to only generate 100 kW of electricity for 15 minutes, or 25 kWh of electricity. The facility should include 50 modules, producing 5 MW and 1.25 MWh. The facility is assumed to be unmanned, with the exception of a technical staff to be deployed to conduct maintenance.

7.7. Waste to Energy (WTE)

Municipal solid waste (MSW) has been a recurring problem for Guam. Ordot Dump had been non-compliant with the Clean Water Act for several years, until it eventually closed in 2011. The Layon Landfill was then opened and is currently in operation. This leads to the high potential of a waste-to-energy (WTE) facility to be developed on Guam. However, two challenges when developing a successful waste-to-energy facility are the constant heat content and the separation of non-combustibles in the MSW.

Between 40,000 and 140,000 tons of MSW is currently directed to the Layon Landfill. Theoretically, MSW can be used as a fuel supply for WTE facilities with a capacity rating of approximately 5 MW. A staff of 12 to 15 is recommended to support operations for 24 hours at the site daily.

7.8. Fuel Cell

A fuel cell produces electricity and heat through an electrochemical reaction between a fuel (generally hydrogen) and oxygen. Similar to a battery, a fuel cell can gather energy; however, a fuel cell can discharge continuously.

There are six main types of fuel cells: alkaline fuel cell (AFC), solid oxide fuel cell (SOFC), phosphoric acid fuel cell (PAFC), proton exchange membrane fuel cell (PEMFC), molten carbonate fuel cells (MCFC), and direct methanol fuel cell (DMFC). However, the unit characteristics are only based on SOFCs. SOFCs use a solid ceramic compound such as calcium oxide or zirconium oxide as the electrolyte. SOFCs operate in temperatures in the range of about 800 degrees Celsius to 1000 degrees Celsius and can have efficiencies of more than 60 percent. Using four SOFC cells with 250 kW available each, a 1 MW facility can be produced. SOFC's high operating temperatures allow for use of various hydrocarbon fuels while eliminating the need for external reforming. The waste from high temperature operations can be recycled to make additional electricity, further enhancing overall efficiency to more than 80 percent.

A fuel cell has an estimated availability of five years before needing a replacement strategy. Note that this was not included in the O&M projections. The facility is assumed to be unmanned, with the exception of a technical staff to be deployed to conduct maintenance.

7.9. Fuel Cell Cogen

Concurrent generation of hot water is a potential external addition to the fuel cell facility. This project allows utilization of the waste heat of the fuel cell. Installation includes an air to water heat exchanger and a small closed-loop water system to utilize the heat to increase water temperature or any other similar application. Similar to the fuel cell facility, this facility is also assumed to be unmanned, except for technical staff being deployed to conduct maintenance.

7.10. Synchronous Condenser

A synchronous condenser is a DC-excited synchronous motor, with a shaft that is not connected to anything but instead spins freely. It is meant to adjust conditions on the electrical transmission or distribution system that it is connected to. A voltage regulator controls the field to either generate or absorb reactive power as needed to adjust the grid voltage or improve power factor. The kinetic energy stored in the rotor can help stabilize the power system during short circuit events, large intermittent loads, or other rapid fluctuations of loads. The installation and operation are identical to large electric motors and generators.

In coordination with GPA, the Macheche CT generator is assumed to be retrofitted with a clutch to allow it to serve as a synchronous condenser. The clutch will be installed between the turbine and generator which requires removal and reinstallation of the generator, foundation, electrical power, control, cooling, etc. No additional O&M costs, above the O&M costs currently incurred by the facility, are assumed.

7.11. Dual-fuel Reciprocating Engines

Reciprocating engines use the chemical energy in fuels to generate rotational mechanical energy. Dual-fuel engines are designed to be compatible with different fuels, such as diesel and liquefied natural gas. Reciprocating engines connected to generators can provide electrical energy. At a larger scale, a dual-fuel reciprocating engine generator can be a stability upgrade for electrical grids with intermittent production from renewable energy sources such as wind and solar. Additionally, its quick-start capability allows timely responses to shortfalls in utility energy production.

It is assumed that the utility-scale installation of a dual-fuel medium-speed reciprocating (MSR) engine will be operated in conjunction with the existing 24 MW/6 MWh battery energy storage system to respond to electric grid needs in the event of a baseload unit trip. GPA requires the MSR to ramp up to full load in under 5 minutes so that the BESS does not fully discharge before another generator is brought into service to support the grid. This facility is to be operated at about 300 hours annually as a contingency backup service. Due to minimal operations, the facility is assumed to be unmanned, except for technical staff deployed to conduct maintenance.

7.12. Small Modular Reactor Update

The reduction in costs of solar, wind, and other renewable resources coupled with associated tax incentives along with the lack of resolution on how to accommodate spent fuel hindered the development of the small modular reactor (SMR). However, GPA and NuScale Power, LLC, prepared some basic conceptual design and cost information, which was used as the basis for unit characteristics in the 2012 GPA IRP. Nevertheless, the development and deployment of SMRs have not progressed significantly. To date, there have been no SMR deployments in the

U.S. due to its multiple levels of permits and large capital investments. Furthermore, nuclear fuel disposal or recycling processes are currently unavailable on Guam.

7.13. Waste Oil Options

The handling of waste oil has been challenging for GPA. Not only is GPA responsible for receiving and disposing oil from GPA power generating facilities, but also from various other sources on-island.

GPA blends waste oil with residual fuel oil as fuel for the Cabras 1 & 2 power plants. With the impending retirement of Cabras 1 & 2, Piti 8&9 is to be converted to fire on ULSD and/or liquefied natural gas, which is expected to reduce the amount of waste oil from Piti 8&9. A detailed constituent analysis will provide insight into the development of waste oil purification for its re-usability. However, fuel requirements for slow speed reciprocating (SSR) engines, medium speed reciprocating (MSR) engines and combustion turbine generators (CTG) are more restrictive than for boilers such as those of Cabras 1 & 2.

It is also worth noting that if GPA were to install a WTE facility, the waste oil can be implemented into the facility's fuel supply.

In order to efficiently make use of waste oil, further research is necessary to identify the combustibility of waste oil. Although it is unlikely that waste oil will be refined enough to be of the same grade as ULSD, it is possible for sufficient purification to be blended in small portions with ULSD for combustion in GPA SSRs, MSRs, or CTGs.

8. Approach to Expansion Planning

GPA followed the same methodology utilized in the previous Integrated Resource Plan to complete the generation expansion analysis. As part of the comprehensive analytical approach, GPA completed the following tasks:

- Reviewed planning environment and established parameters to guide the analysis
- Developed planning, scenario, and modeling inputs and assumptions
- Considered compliance costs and requirements with Region IX of the United States Environmental Protection Agency (US EPA) and the Guam Environmental Protection Agency (Guam EPA), including the Consent Decree for GPA and the Guam State

Implementation Plan, and some recommendations from the 2018 Environmental Strategic Plan (Volume III)

- Considered current Guam laws regarding renewable portfolio standards
- Solicited stakeholder input through stakeholder meetings
- Ensured adequate load and resource balance by comparing the demand forecast and current and future resource assumptions
- Defined candidate resource options, including supply-side and demand-side management options
- Explored and characterized the effects to reliability of generation retirement singly and in combination using the generation reliability analysis software tool
- Used the capacity expansion optimization tool, ABB Capacity Expansion, to determine the optimal portfolio of least cost options that eliminates annual capacity deficits according to capacity reserve margin requirements
- Used scenario analyses to help determine the optimal portfolio that is robust across the range of alternative demand and fuel price outcomes
- Evaluated the cost effects of generation retirements
- Selected a preferred portfolio using the evaluation criteria: cost, risk, system reliability, and environmental impact

In 2016, GPA's previous generation expansion software, Strategist, was acquired and subsequently discontinued by ABB Enterprise Software; and replaced with new software, ABB Capacity Expansion (CE). The database from Strategist was migrated to CE. However, the following were updated based on the most recent data available:

- Fuel Price Forecast
- Load (Peak Demand) Forecast
- Operating Costs per Unit
    - Variable O&M

    - Fixed O&M (modeled as Monthly Fixed Costs)
    - Major O&M / Capital Improvement Costs (modeled as Annual Fixed Costs)
- New Units Added
    - Ukudu Power Plant
    - Yigo Diesel Generators
    - KEPCO Diesel Generators

The optimal generation expansion plan was determined based on the lowest system cost and the following conservative assumptions:

- 20-year planning horizon
- Optimum availability for all units
- Optimum forced outage rate (no more than 5%)
- Capital improvement projects for combustion turbine units will commence in 2024, once the Ukudu units are online, in the following order:
    - Yigo C.T. (2024)
    - Macheche C.T. (2025), Conversion to Synchronous Condenser (2026)
    - Piti 7 (2026)
    - Dededo C.T. 1 (2027)
    - Dededo C.T. 2 (2028)
- New candidate resources will be available starting 2026, assuming at least 5 years to solicit proposals and complete construction
- Minimum reserve margin requirement of 75%
    - Calculated as the ratio of the total MW capacity from existing and new resources to the system peak load
- Candidate resource options included in all scenarios:
    - Dual-fired Reciprocating Engine

    - Battery Energy Storage System
    - Pumped Hydro Storage
    - Waste-to-Energy Facility
    - Ocean Thermal Energy Conversion
    - Sea Water Air Conditioning
- Candidate resource options included in the LNG conversion scenarios, since they are fired using LNG:
    - Compressed Air Energy Storage
    - Fuel Cell
    - Fuel Cell Cogen
- Candidate resources that were evaluated, but upon further analysis and based on most recent information, were excluded in the CE runs:
    - Flywheel
    - Small Modular Reactor

The synchronous condenser option was evaluated as system stability support for the additional renewable resources, and not as a resource for additional capacity. Therefore, GPA assumed that Macheche CT will be converted to a generator/synchronous condenser unit, with the ability to switch operation as needed. Capital costs for converting this unit into a generator with a synchronous condenser were included and reflected in the system costs for each run.

GPA's Phase I and Phase II Renewable Resource Acquisitions are modeled at maximum capacity per hour based on the maximum MW capacity provided by the contractors, and with annual $/MWh costs. These resources do not provide firm power; however, they reduce the load requirements based on the maximum capacities provided. The Phase III RRA is similar to Phase I and Phase II with the only difference being that the maximum capacities are deducted from the load during the evening hours, as opposed to the actual hour that the energy was produced, which was the case for Phase I and Phase II.

The Renewable Resource Acquisitions (Phases IV through VII) planned for the future are modeled as fixed hourly dispatches which effectively reduce the required MWh from the conventional units and the candidate generating unit additions, except for Phase VII which was modeled to provide the balance of the MW demand not yet provided by Phases I-VI. For these Phases, it was assumed that the cost per MWh would be $100 for the entire study period.

The baseline scenario was used to determine if any additional resources are needed to meet capacity requirements and the minimum 75% reserve margin, based on confirmed available units and resources. The following additional scenarios were completed to see the impact of various resource plans and options:

- (Scenario A) Baseline scenario (base load and base fuel)
- (Scenario B) Baseline with existing units up to Phase III RRA
- (Scenario C) Baseline with existing units including Phase III, IV and V RRA
- (Scenario D) Scenario C with Piti 8&9 retiring in 2030
- (Scenario E) Scenario C with Piti 7 retiring in 2024
- (Scenario I) Baseline with existing units including Phase III, IV, V and VI RRA
- (Scenario J) Baseline with existing units including Phase III, IV, V, VI and VII RRA

The following additional scenarios were completed using the load forecast with the addition of the Data Center:

- (Scenario F) High load scenario (“DC”) with base fuel costs
- (Scenario G) Scenario F with Phase III RRA
- (Scenario H) Scenario F with Phase III, IV and V RRA

Using the consultant’s report for LNG Conversion in Appendix F to determine the capital costs and annual operating expenses for a regasification facility, GPA then evaluated the impact of converting from ULSD to LNG. Two sets of runs were made, one for a 30-year amortization schedule, and another assuming a 22-year amortization which is the remaining years in the ECA assuming LNG conversion starts in 2027 (ECA is a 25-year contract). The following are the additional scenarios:

- (Scenario LNG-1) Scenario A with LNG conversion, 30-year amortization
- (Scenario LNG-2) Scenario A with LNG conversion, 30-year amortization & with additional proposed units (CAES, Fuel Cell, Fuel Cell Cogen)
- (Scenario LNG-3) Scenario A with LNG conversion, 22-year amortization
- (Scenario LNG-4) Scenario A with LNG conversion, 22-year amortization & with additional proposed units (CAES, Fuel Cell, Fuel Cell Cogen)
- (Scenario LNG-5) Scenario C with LNG conversion, 22-year amortization
- (Scenario LNG-6) Scenario LNG-3 with the high load scenario ("DC")
- (Scenario LNG-7) Scenario LNG-6 with the Phase III, IV and V RRA

To supplement the reliability study results from Volume 1 of the IRP, the following several scenarios were completed. It was assumed (for simplicity) that the retirements all occur in 2024.

- (Scenario R-1) Baseline without ES BESS (same as Scenario A)
- (Scenario R-2) Baseline with existing units up to Phase III RRA (same as Scenario B)
- (Scenario R-3) Scenario A with Phase III and IV RRA; Macheche CT and Yigo CT retired
- (Scenario R-4) Scenario A with Phase III and IV RRA; Piti 7 retired
- (Scenario R-5) Scenario A with Phase III and IV RRA; Dededo CT retired
- (Scenario R-6) Scenario A with Phase III and IV RRA; Piti 8&9 retired
- (Scenario R-7) Scenario C with Piti 8&9 retired
- (Scenario R-8) Scenario R-7 with Phase VI RRA
- (Scenario R-9) Scenario R-8 with Phase VII RRA

Retirement of various units was also evaluated to check the impact each unit has on the reserve margin and unit additions. The first units evaluated were Piti 8&9, for which two sets of retirement scenarios were completed: one with Scenario A and the other with Scenario C. The units were retired starting in 2024 through 2031 to see the impact of delaying the retirement on the system cost and new unit additions. The same study was done for Piti 7. For the other units, only staggered retirements from 2024 through 2031 using Scenario A were completed, which illustrated the impact of delaying unit retirement on system cost and new unit additions.

9. Base Case Expansion Plans

The following is the summary of the generation expansion analysis results, based on assumptions discussed in this IRP. The analysis results are available in Appendix G. However, the following additional studies are recommended to determine the optimal generation expansion plan:

- The impact of solar resources on daily dispatching
- The impact of spinning reserve and short-circuit MVA requirements on the future resource model.

The tables for the analysis results of each scenario are provided in Appendix G. Each table shows the following:

- Scenario Name
- Fuel Price Forecast used in scenario (Base Forecast or Base Forecast with ULSD price not escalated beyond 2030)
- Net Present Value of System Cost, in $MM
- For each Scenario, the difference of the Net Present Value of System Cost with the Baseline Scenario, in $MM
    - A negative number indicates that the particular scenario's NPV System Cost is greater than the baseline and thus, an additional cost instead of savings
- Lowest Reserve Margin (in %) observed after 2024
    - Years 2021-2024 were excluded because these years are considered "status quo" i.e. no additional units
- Type and number of units built
    - Years 2021-2025 will not show any units being built because GPA assumed that there will be a 4 to 5-year requirement for any unit to be built if a solicitation would be issued today.

9.1. Base Case Scenarios

The baseline Scenario A results indicate that new candidate resources are not needed before 2040. This analysis assumes the baseline fuel price and load forecasts are used, the Cabras Units are retired, the Ukudu Units commence operation in November 2023, Phase II RRA is included, and all existing generation units are available and not retired before 2040. This also assumes that these units' operation conditions are comparable, if not better, than current conditions.

The following are the analysis results for Scenarios B, C, D and E:

- (Scenario B) The addition of Phase III RRA lowers the system cost. The installation of new candidate resources is not recommended during the planning period.
- (Scenario C) The addition of Phase III, IV and V RRAs lowers the system cost and increases the reserve margin. The installation of new candidate resources is not recommended during the planning period.
- (Scenario D) The addition of Phase III, IV and V RRA and the retirement of Piti 8&9 in 2030 lower the system cost and decrease the reserve margin compared to Scenario C. The installation of new candidate resources is not recommended during the planning period.
- (Scenario E) The addition of Phase III, IV and V RRA and the retirement of Piti 7 in 2024 lower the system cost and decrease the reserve margin compared to Scenario C. However, the system cost is higher than Scenario D. The installation of new candidate resources is not recommended during the planning period.
- (Scenario I) The addition of Phase VI RRA to Scenario C lowers the system cost and increases the reserve margin further. The installation of new candidate resources is not recommended during the planning period.
- (Scenario J) The addition of Phase VII RRA to Scenario I lowers the system cost further. The installation of new candidate resources is not recommended during the planning period.

9.2. High Load & Base Fuel Scenarios

The following are the analysis results for Scenarios F, G and H, which include the impact of the high peak demand forecast (Baseline + Data Center):

- (Scenario F) The high peak demand forecast increases the system cost compared to the baseline Scenario A. The installation of new candidate resources is not recommended during the planning period.
- (Scenario G) The addition of Phase III RRA to Scenario F lowers the system cost compared to Scenario F. The installation of new candidate resources is not recommended during the planning period
- (Scenario H) The addition of Phase III, IV and V RRAs to Scenario F lowers the system cost compared to Scenario F. The installation of new candidate resources is not recommended during the planning period.

9.3. Liquefied Natural Gas (LNG) Scenarios

The following are the analysis results for Scenarios LNG-1 through LNG-5, which include the impact of the conversion to LNG:

- (Scenario LNG-1) This is Scenario A with the conversion to LNG and operation of a regasification facility commencing in 2027. Assuming a 30-year amortization, this scenario has a lower system cost compared to Scenario A. The installation of new candidate resources is not recommended during the planning period.
- (Scenario LNG-2) This is Scenario A with the conversion to LNG, operation of a regasification facility commencing in 2027, and addition of the LNG-fired candidate resources as options. Assuming a 30-year amortization, this scenario has a lower system cost compared to Scenario A. The installation of new candidate resources is not recommended during the planning period.
- (Scenario LNG-3) This is Scenario A with the conversion to LNG and operation of a regasification facility commencing in 2027. Assuming a 22-year amortization, this scenario has a lower system cost compared to Scenario A. However, the system cost is higher compared to the 30-year amortization scenario. The installation of new candidate resources is not recommended during the planning period.
- (Scenario LNG-4) This is Scenario A with the conversion to LNG, operation of a regasification facility commencing in 2027, and addition of the LNG-fired candidate resources as options. Assuming a 22-year amortization, this scenario has a lower system cost compared to Scenario A. However, the system cost is higher compared to the 30-year

amortization scenario. The installation of new candidate resources is not recommended during the planning period.

- (Scenario LNG-5) This is Scenario C with the conversion to LNG and operation of a regasification facility commencing in 2027. Assuming a 22-year amortization, this scenario has a lower system cost compared to Scenario C. The installation of new candidate resources is not recommended during the planning period. The estimated fuel consumption in MMBTU is lowered significantly compared to other scenarios without Phase III, IV and V RRAs.
- (Scenario LNG-6) This scenario shows the impact of conversion to LNG together with the high peak demand forecast. In this case, the ULSD and LNG prices are not escalated beyond 2030. Assuming a 22-year amortization, the high peak demand forecast increases the system cost compared to Scenario LNG-3. The installation of new candidate resources is not recommended during the planning period.
- (Scenario LNG-7) This is Scenario LNG-6 with the addition of Phase III, IV and V RRA. This scenario has a lower system cost compared to Scenario LNG-6. The installation of new candidate resources is not recommended during the planning period.

9.4. Reliability Study Scenarios

The reliability study scenarios completed in Volume I of the IRP were similarly modeled and executed in Capacity Expansion for analysis. The evaluation included determining the impacts to system cost, meeting required reserve margin, and determining if any new unit(s) need to be built. The following are the analysis results for reliability study Scenarios R-1 through R-9:

- (Scenario R-1) The results for this scenario are the same as Scenario A
- (Scenario R-2) The results for this scenario are the same as Scenario B
- (Scenario R-3) With Phase III and IV RRAs included, the retirement of Yigo CT and Macheche CT lowers the system cost compared to Scenario A. The installation of new candidate resources is also not recommended during the planning period.
- (Scenario R-4) With Phase III and IV RRAs included, the retirement of Piti 7 CT lowers the system cost compared to Scenario A. The installation of new candidate resources is not recommended during the planning period.

- (Scenario R-5) With Phase III and IV RRAs included, the retirement of Dededo CT 1&2 lowers the system cost compared to Scenario A. The installation of new candidate resources is not recommended during the planning period.
- (Scenario R-6) With Phase III and IV RRAs included, the retirement of Piti 8&9 lowers the system cost compared to Scenario A. The installation of new candidate resources is not recommended during the planning period.
- (Scenario R-7) With Phase III, IV and V RRAs included, the retirement of Piti 8&9 lowers the system cost compared to Scenario A. The installation of new candidate resources is not recommended during the planning period.
- (Scenario R-8) With Phase III, IV, V and VI RRAs included, the retirement of Piti 8&9 lowers the system cost compared to Scenario A. The installation of new candidate resources is not recommended during the planning period.
- (Scenario R-9) With Phase III, IV, V, VI and VII RRAs included, the retirement of Piti 8&9 lowers the system cost compared to Scenario A. The installation of new candidate resources is not recommended during the planning period.

9.5. Piti 8&9 Retirement

The impact of retiring Piti 8&9 between 2024 to 2031 was also investigated. Scenario A was executed, with Piti 8&9 scheduled to retire starting 2024. Results show that the system cost is lowest when the units retire in 2031. The diesel reciprocating units are also recommended to be built in 2033. Appendix G illustrates the complete results. Scenario C was then executed with the addition of Phase III, IV and V RRAs. The results showed the largest savings/lowest system cost when Piti 8&9 are retired in 2024, and new candidate resources are not recommended to be built.

9.6. Piti 7 Retirement

The impact of retiring Piti 7 between 2024 to 2031 was investigated next. Scenario A was executed, with Piti 7 CT scheduled to retire starting 2024. The results showed that the system cost is lower the sooner Piti 7 CT is retired. Furthermore, new units are not required throughout the study period. When Phase III, IV and V RRAs (Scenario C) are included, the system cost further drops, with the lowest cost during the retirement of Piti 7 CT in 2024. New candidate resources are also not required in these cases.

9.7. Tenjo 1-6 Retirement

Scenario A was executed with all Tenjo Units (6 units) scheduled to retire starting 2024. Results showed that the system cost is lower when the Tenjo Units are retired sooner, even without Phase III RRA onwards. New candidate resources are not recommended to be built.

9.8. Yigo C.T. Retirement

Scenario A was executed, with Yigo CT scheduled to retire starting 2024. Results showed that the system cost is lower when Yigo CT is retired sooner, even without Phase III RRA onwards. New candidate resources are not recommended to be built.

10. Expansion Plan Robustness Analysis

Additional scenarios were completed to test the conditions of uncertainty such as fuel prices and unit retirements.

To test the impact of fuel prices, two additional scenarios were completed for Scenario A: one with the high fuel price forecast and another with the low fuel price forecast. As expected, the system costs were lower in the low fuel price scenario than the base case. The scenario with high fuel price had significant increase in net present value over baseline. Several scenarios were also re-evaluated with base fuel price forecast at a fixed rate from 2030 onwards; results showed increase in savings due to the “fixed” fuel price forecast in all the re-evaluated scenarios.

To test the impact of various unit retirements, several combinations of units were tested to retire in 2024 (earliest retirement date). The units were chosen according to capacity and the impact on system cost and unit additions were analyzed. Focus was also given on units or unit combinations that were not previously explored in the analysis illustrated in section 9, in combination with Piti 8 and 9 retiring in 2029.

Results are shown in Appendix G.

11. Conclusions and Recommendations

GPA's baseline scenario includes all existing units, the GPA wind turbine generator, and Phase I and Phase II Renewable Resource Acquisitions. The Cabras units will be retired or deactivated within six months after the new 198-MW Ukudu Power Plant commences operation in November 2023. All units will be using ULSD from 2024 through 2040, which is the end of the study period. All units, except Cabras 1&2, will be available and operational through 2040.

Results indicate that with the new 198-MW Ukudu Power Plant and additional 40-MW Diesel Power Plant coming online in November 2023, and no units retired except Cabras 1&2, GPA will not need additional new units, especially with the additional Renewable Resource Acquisitions planned as early as 2024.

The new Renewable Resource Acquisitions, from Phase III to Phase V have the following additional impacts:

- Overall costs over the study period are lowered
- GPA meets the 50% renewable energy mix goal
- Fuel consumption is lowered

The addition of RRA Phases VI and VII further lowers the cost and allows GPA to nearly achieve the 100% renewable energy mix goal by 2040.

However, the following need to be examined in detail using the latest and best available information:

- Capital improvements needed for the existing units to ensure availability as modeled in the IRP (availabilities less than the assumed may lead to new units being required)
- Optimum schedule for Unit retirements
- Reliability and system stability on a daily dispatching level as the amount of generation from renewable resources increase
- System improvements needed due to short-circuit MVA requirements, such as the conversion of existing GPA combustion turbine units to synchronous condensers, or the addition of stand-alone synchronous condenser units for GPA.

12. Generation Expansion Capital Plan

GPA's Generation Expansion Capital Plan includes the following:

- Commence 30 MW + 30 MW load-shifting energy from solar power via Energy Purchase Agreement online by May 2024 (Phase III Renewable Resource Acquisition)
- Solicitation of a 300,000 MWh per year Renewable Energy Purchase Agreement to be awarded and integrated into the system by 2025 as an energy-shifting, firm capacity resource (Phase IV Renewable Resource Acquisition)
- Solicitation of a 300,000 MWh per year Renewable Energy Purchase Agreement to be awarded and integrated into the system by 2030 as an energy-shifting, firm capacity resource (Phase V Renewable Resource Acquisition)
- Solicitation of a 575,000 per year MWh Renewable Energy Purchase Agreement to be awarded and integrated into the system by 2036 as an energy-shifting, firm capacity resource (Phase VI Renewable Resource Acquisition)
- Solicitation of a 600,000 MWh per year Renewable Energy Purchase Agreement to be awarded and integrated into the system by 2040 as an energy-shifting, firm capacity resource (Phase VII Renewable Resource Acquisition)
- Evaluation of capital improvements needed to extend the life of the existing units through 2040, and determine possible retirements
- An updated study for LNG conversion especially with the new RRAs in place

Additional analysis and studies are being completed to supplement this IRP:

- System Impact studies for each new Renewable Energy Purchase Agreement
- Short Circuit MVA Requirements
- Conversion of GPA's Combustion Turbine Units into Synchronous Condensers

ACKNOWLEDGEMENTS

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Harvey J. Camacho

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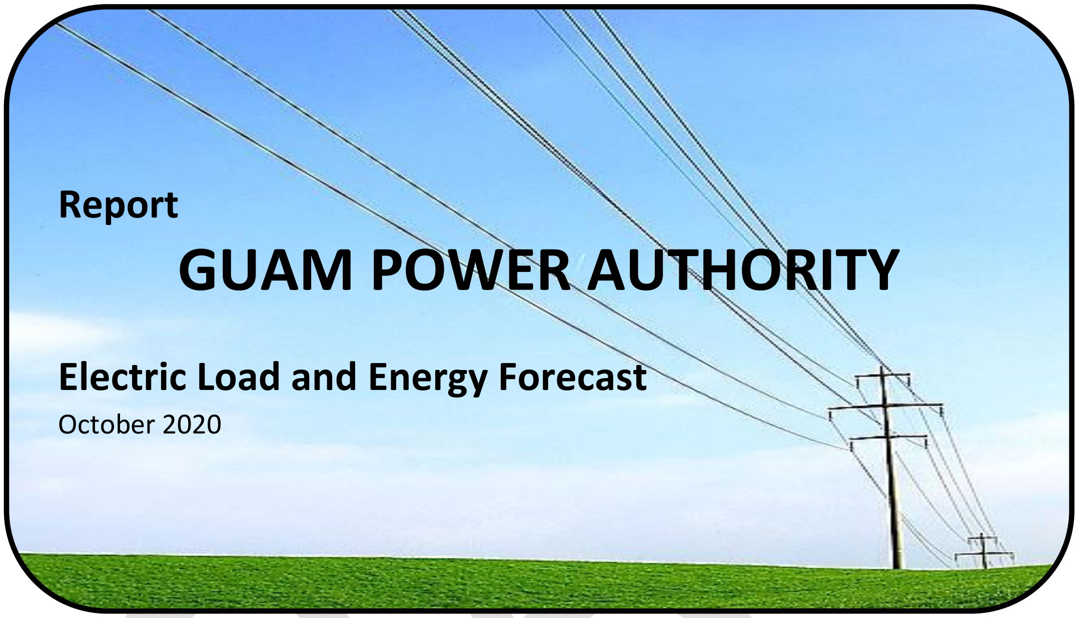
Appendix A: LOAD FORECAST

UFS Econometric Model for GPA Report 10142020.pdf



Report

GUAM POWER AUTHORITY

Electric Load and Energy Forecast

October 2020

UFS
Utility Financial Solutions, LLC

Specializing in Cost of Service, Rate Design, and Financial Analysis

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Utility Financial Solutions, LLC

July 2019

John J. Kim
CFO
Guam Power Authority

Dear Mr. Kim;

We are pleased to present an econometric modeling and long-term forecasting study for Guam Power Authority (GPA). This report was prepared to provide the GPA with a comprehensive examination and projection of future load growth and energy consumption between 2020 – 2040.

The specific purpose of this study is to identify and project the overall trend of GPA capacity and energy in future years to assist in planning future generation capacity needs.

This report includes a discussion on the statistical models developed to fit historical usage patterns using several data sets including: demographics, weather, installation of renewables, and energy efficiency programs. The statistical models utilized independent variables that had significant impact on energy sales and GPA's peak demands.

The models developed produced forecasted projections. Variations will occur between forecasts and actuals and some variations may be significant. Certain assumptions used in development of the models are based on current best estimates and may not materialize. In addition, unforeseen events can and will occur and have the potential to significantly alter the trends currently shown in the forecasts.

This report is intended for information and use by utility and management for the purposes stated above and is not intended to be used by anyone except the specified parties.

UFS intends to be a resource to you in the future. Please do not hesitate to contact us with questions. Thank you for the opportunity to work with Guam Power Authority.

Sincerely,

Utility Financial Solutions, LLC
Mark Beauchamp
CPA, MBA, CMA
185 Sun Meadow Ct
Holland, MI 49424

Table of Contents

Project Overview

Utility Financial Solutions completed long-term econometric projections over the forecast period of 2020 through 2040 for Guam Power Authority. UFS forecasts included:

1) projection of peak monthly demands (kW), and
2) projection of monthly energy consumption (kWh)

An econometric model identifies relationships between demographic and/or weather variables (such as population, employment, temperature and degree days) and demand and energy consumption of customers served by GPA. The average growth results of the forecast are listed in the table below and summarize the increases in peak demand and energy consumption.

Civilian Growth	***Energy***	***Peak***
5 Year	2.0%	2.0%
10 Year	1.3%	1.5%
Forecast Period	0.7%	1.1%

Navy Growth	***Energy***	***Peak***
5 Year	3.7%	6.2%
10 Year	1.9%	3.3%
Forecast Period	1.0%	1.8%

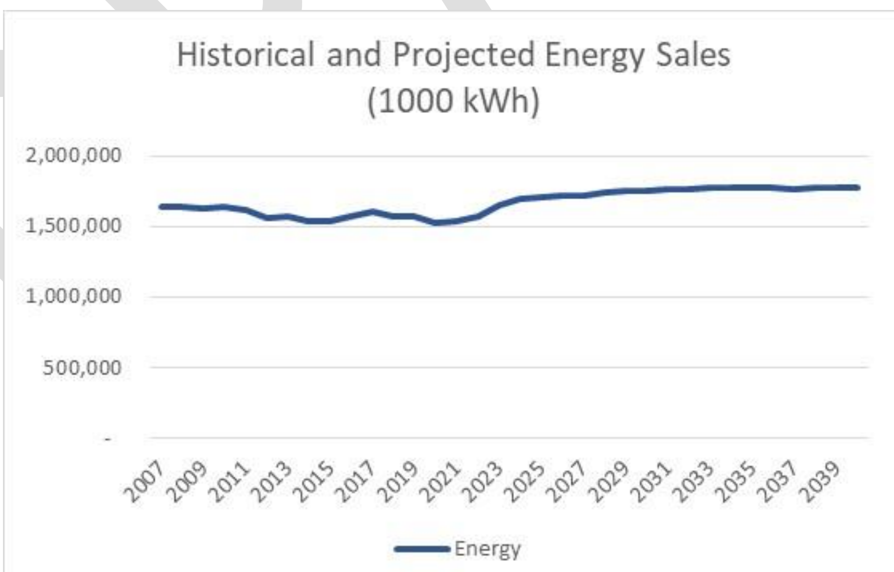
Total System Growth	***Energy***	***Peak***
5 Year	2.3%	3.0%
10 Year	1.4%	2.0%
Forecast Period	0.8%	1.3%

Energy Projection (kWh's)

GPA total energy sales are projected to grow at a rate of 2.3% for the period between 2021 – 2025; 1.4% between 2021 and 2031, and 0.8% between 2021 and 2040. The table below shows annual energy sales projections.

The historical and projected data was based on monthly observations. The graph below depicts monthly energy consumption with 2007 – 2020 historical data and 2021 – 2040 forecasted values.

Historical		Projected		Projected	
Year	Energy Sales	Year	Energy Sales	Year	Energy Sales
2007	1,635,714	2020	1,523,826	2033	1,770,100
2008	1,637,252	2021	1,538,820	2034	1,774,373
2009	1,624,383	2022	1,575,781	2035	1,778,457
2010	1,637,663	2023	1,654,422	2036	1,778,478
2011	1,618,291	2024	1,690,073	2037	1,767,731
2012	1,564,208	2025	1,708,468	2038	1,770,209
2013	1,566,410	2026	1,712,527	2039	1,773,999
2014	1,534,866	2027	1,722,261	2040	1,772,521
2015	1,539,584	2028	1,742,998		
2016	1,575,777	2029	1,749,980		
2017	1,610,093	2030	1,755,229		
2018	1,567,052	2031	1,760,125		
2019	1,568,336	2032	1,765,096		

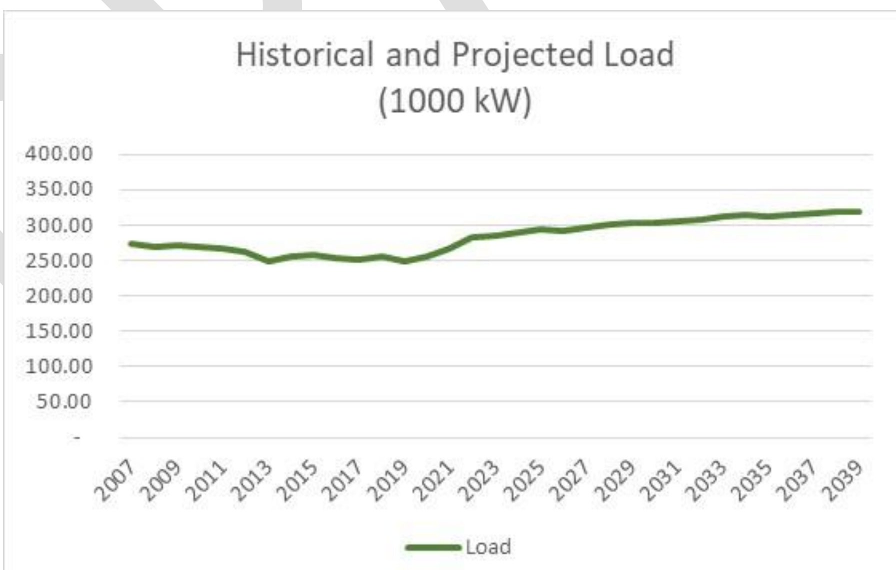


Peak Demand Projection (kW's)

GPA demands are projected to grow at a rate of 3.0% for the period between 2021 – 2025; 2.0% between 2021 and 2030, and 1.3% average growth rate between 2021 and 2040. The table below is the projected annual peak demands.

Historical		Projected		Projected	
Year	Load	Year	Load	Year	Load
2007	274.17	2020	249.37	2033	307.98
2008	272.98	2021	255.83	2034	313.25
2009	270.39	2022	267.91	2035	315.12
2010	272.22	2023	281.94	2036	312.50
2011	269.51	2024	286.14	2037	314.93
2012	266.32	2025	288.82	2038	317.97
2013	262.74	2026	293.26	2039	319.51
2014	250.16	2027	293.19	2040	320.23
2015	255.00	2028	297.61		
2016	257.98	2029	300.56		
2017	254.37	2030	302.36		
2018	251.23	2031	303.13		
2019	255.00	2032	305.70		

The historical and projected data was based on monthly observations. The graph below depicts monthly peak demand with 2007 – 2020 historical data and 2021 – 2040 forecasted values.



The following sections include the statistical tests and results of the forecasts.

Statistical Tests

To ensure statistical validity of the models, several tests were performed. The following tests substantiate that changes occurring in dependent variables (Energy Sales and Peak Demand) are properly explained with changes in the independent variables (population, cooling degree days, etc). Gauss-Markov assumptions are parameters used to confirm the coefficients in the model are the best linear unbiased estimates[1]. The first four assumptions ensure unbiasedness, while the last provides the lowest variance.

Gauss-Markov Assumptions

1. **Linearity in the parameters** – A linear relationship between the independent and dependent variables must exist to ensure integrity in the resulting models. The linear relationships are tested using observations and the **Ramsay Test.**
2. **Error Term Expected Value is 0** – To ensure an unbiased relationship exists between variables the error terms expected value must be zero. To help ensure an unbiased relationship exists a constant is used to absorb any differentials between the independent variables.
3. **Homoskedasticity** - Variance in error terms between actual and projected observations implies uncertainty in the model. If substantial variations occur, it may imply an omitted variable exists. An **ARCH** test was used to test homoscedasticity.
4. **Error Term is Independently Distributed** – If an independent variable is highly correlated with previous values of itself it signals serial or auto correlation exists. A **Serial Correlation LM test** was used to identify if serial correlation exists.
5. **Each variable is uncorrelated with the error term** – If independent variables are correlated with the error term, it implies omission of an important variable, or an incorrect functional form. A **Ramsay Test** was used to test for this error.

Multicollinearity

Multicollinearity is an inefficiency that occurs when two independent variables are highly correlated with each other, which can lead to unreliable and unstable regression coefficients. To test for this inefficiency, we used the Variance Inflation Indicators (VIFs). These indicators measure how much of the variance of a coefficient is inflated due to linear dependence on other predictors. These measurements may be safely ignored for monthly dummy variables. Lower VIFs are desired.

[1] Best linear unbiased estimates mean the estimated coefficients on the independent variables have the lowest variance (best) and the expected value of the sample mean is equal to the true value of the population mean (unbiased).

Four additional statistics are important to note:

1. Adjusted R-Squared: This statistic measures how well the independent variables measure the dependent variable. Adjusted R-Squared adjusts for the number of independent variables used.
2. Akaike Info Criterion (AIC): A predictor of forecasting capability of the model. We want to minimize this value.
3. Schwarz Criterion (SIC): Another predictor of forecasting capability, but SIC penalizes models that include independent variables of little explanatory power. We also want to minimize this value.
4. Durbin-Watson Stat: In addition to the LM test for Serial Correlation, Durbin-Watson is another measure of the relationship between the dependent variable and previous lags of itself within the residuals. We look for a DW statistic of 2, implying no serial correlation exists.

The additional statistics are found on the bottom portion of the output data for each model.

Model Specification

To build each model, historical data from 2007 through 2019 was used. Independent variables were tested against historical data and included based on t-statistic and significance level. Specific listings of independent variables used in each model can be found on pages 7 and 8.

Due to the nature of energy and demand data, auto-regressive and moving-average terms were required to alleviate serial correlation (correlation to previous lags of the dependent variable). This issue can cause statistically invalid results. The subsequent models are referred to as ARIMA(p,I,q) models and are described in more detail on page 9.

In addition, a breaking linear regression was used to accurately model the historical energy and demand for the Navy class. A breaking linear regression allows the independent variables to be broken up between time intervals and a separate line segment is then fitted to each interval.

Additionally, manual adjustments were made for both the historical data sets and the forecasted values to properly account for the effects of energy efficiency programs and distributed generation. After providing GPA with an initial set of models for both energy and demand, modifications were made to better reflect market knowledge of GPA. These adjustments are explained in detail on page 10.

Civilian Energy Projection Output

Dependent Variable: CIVILIANE
Method: ARMA Generalized Least Squares (Gauss-Newton)
Date: 08/12/19 Time: 11:21
Sample: 2006M07 2018M04
Included observations: 142
Convergence achieved after 41 iterations
Coefficient covariance computed using outer product of gradients
d.f. adjustment for standard errors & covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	19516653	1.44E+08	0.135911	0.8921
CDDNORM	42480.07	10721.05	3.962304	0.0001
POP(-1)	426.1024	894.3717	0.476426	0.6346
LEAC(-6)	-34988523	12879732	-2.716557	0.0075
@MONTH=2	-8712445.	1145752.	-7.604128	0.0000
@MONTH=3	-427646.9	1025923.	-0.416841	0.6775
@MONTH=4	-446921.7	1100541.	-0.406093	0.6854
@MONTH=5	5394094.	1358003.	3.972079	0.0001
@MONTH=6	2862212.	1301936.	2.198428	0.0298
@MONTH=7	3446436.	1174048.	2.935516	0.0040
@MONTH=8	1538952.	1050123.	1.465497	0.1453
@MONTH=9	-196630.2	1030897.	-0.190737	0.8490
@MONTH=10	964172.1	1066752.	0.903839	0.3678
@MONTH=11	-959865.1	1108261.	-0.866100	0.3881
@MONTH=12	2824278.	1095525.	2.578014	0.0111
AR(1)	0.991920	0.019286	51.43132	0.0000
MA(1)	-0.844679	0.064995	-12.99598	0.0000

R-squared	0.823548	Mean dependent var	1.05E+08
Adjusted R-squared	0.800962	S.D. dependent var	5959975.
S.E. of regression	2658965.	Akaike info criterion	32.54895
Sum squared resid	8.84E+14	Schwarz criterion	32.90282
Log likelihood	-2293.976	Hannan-Quinn criter.	32.69275
F-statistic	36.46292	Durbin-Watson stat	1.982638
Prob(F-statistic)	0.000000		

Inverted AR Roots	.99
Inverted MA Roots	.84

The Energy Model Independent variables are as follows:

- CDDNORM: Normalized Cooling Degree Days
- POP(-1): Lagged Population forecast from World Bank
- LEAC(-6): Six-month lag LEAC cost
- Monthly Dummy Variables February through December (January is omitted with the inclusion of constant, C to avoid perfect collinearity)
- Auto-Regressive Terms (AR): AR(1)
- Moving-Average Terms (MA): MA(1)

Navy Energy Projection Output

Dependent Variable: NAVYE
Method: Least Squares with Breaks
Date: 08/12/19 Time: 11:38
Sample (adjusted): 2006M07 2018M08
Included observations: 146 after adjustments
Break type: Bai-Perron tests of L+1 vs. L sequentially determined breaks
Breaks: 2009M04, 2013M07
Selection: Trimming 0.15, , Sig. level 0.05

Variable	Coefficient	Std. Error	t-Statistic	Prob.
2006M07 - 2009M03 -- 33 obs				
C	20643.77	6522.905	3.164813	0.0021
CDDNORM	8.845366	13.29399	0.665366	0.5073
LEAC(-6)	36582.82	13018.23	2.810121	0.0059
LEAC	-7648.784	12584.67	-0.607786	0.5447
@MONTH=2	-2464.959	1105.055	-2.230620	0.0279
@MONTH=3	-1618.884	958.2103	-1.689487	0.0942
@MONTH=4	1747.177	1162.615	1.502799	0.1360
@MONTH=5	-294.9673	1233.660	-0.239099	0.8115
@MONTH=6	-854.2142	1221.600	-0.699259	0.4860
@MONTH=7	207.9830	969.9638	0.214423	0.8306
@MONTH=8	1348.148	937.0473	1.438719	0.1533
@MONTH=9	-1005.365	938.1380	-1.071660	0.2864
@MONTH=10	34.48048	945.8477	0.036455	0.9710
@MONTH=11	-961.9766	962.0443	-0.999930	0.3197
@MONTH=12	24.30454	981.7949	0.024755	0.9803
2009M04 - 2013M06 -- 51 obs				
C	25408.32	4135.716	6.143631	0.0000
CDDNORM	13.57975	8.286646	1.638751	0.1044
LEAC(-6)	-19640.86	8953.164	-2.193734	0.0305
LEAC	-84.57056	8188.333	-0.010328	0.9918
@MONTH=2	-2084.300	885.9960	-2.352493	0.0206
@MONTH=3	-437.9123	890.3538	-0.491841	0.6239
@MONTH=4	96.51921	908.4653	0.106244	0.9156
@MONTH=5	615.7027	1161.471	0.530106	0.5972
@MONTH=6	-125.0310	1109.144	-0.112728	0.9105
@MONTH=7	547.0841	982.1216	0.557043	0.5787
@MONTH=8	1812.899	869.8251	2.084211	0.0397
@MONTH=9	87.93544	836.6145	0.105109	0.9165
@MONTH=10	373.2208	885.4816	0.421489	0.6743
@MONTH=11	-835.1205	939.2831	-0.889104	0.3761
@MONTH=12	2020.697	902.2258	2.239680	0.0273
2013M07 - 2018M08 -- 62 obs				
C	26978.59	3704.670	7.282319	0.0000
CDDNORM	-1.232585	6.780294	-0.181789	0.8561
LEAC(-6)	1077.510	5676.905	0.189806	0.8498
LEAC	4184.900	6617.582	0.632391	0.5286
@MONTH=2	-3478.191	823.5459	-4.223433	0.0001
@MONTH=3	-629.6525	722.0297	-0.872059	0.3852
@MONTH=4	-552.8590	748.6037	-0.738520	0.4619
@MONTH=5	226.2935	892.9250	0.253429	0.8005
@MONTH=6	-447.3202	844.8858	-0.529445	0.5977
@MONTH=7	-652.7258	792.9191	-0.823193	0.4123
@MONTH=8	-147.8836	722.7134	-0.204623	0.8383
@MONTH=9	-46.26401	734.3237	-0.063002	0.9499
@MONTH=10	-321.1752	755.3926	-0.425177	0.6716
@MONTH=11	-61.90274	787.7964	-0.078577	0.9375
@MONTH=12	872.1081	775.4935	1.124585	0.2634

R-squared	0.791447	Mean dependent var	28034.55
Adjusted R-squared	0.700592	S.D. dependent var	2079.636
S.E. of regression	1137.938	Akaike info criterion	17.15978
Sum squared resid	1.31E+08	Schwarz criterion	18.07938
Log likelihood	-1207.664	Hannan-Quinn criter.	17.53343
F-statistic	8.711130	Durbin-Watson stat	1.912868
Prob(F-statistic)	0.000000		

The Energy Model Independent variables are as follows:

- CDDNORM: Normalized Cooling Degree Days
- LEAC: LEAC Cost forecasted
- LEAC(-6): Six-month lag LEAC cost
- Monthly Dummy Variables February through December (January is omitted with the inclusion of constant, C to avoid perfect collinearity)

Civilian Load Projection Output

Dependent Variable: CIVLOAD
Method: ARMA Generalized Least Squares (Gauss-Newton)
Date: 01/28/20 Time: 09:30
Sample: 2007M01 2017M12
Included observations: 132
Convergence achieved after 7 iterations
Coefficient covariance computed using outer product of gradients
d.f. adjustment for standard errors & covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-976126.9	229262.9	-4.257675	0.0000
POP	7.516388	1.452632	5.174322	0.0000
@TREND	-407.9434	56.42682	-7.229602	0.0000
@MONTH=2	-381.6441	1610.575	-0.236961	0.8131
@MONTH=3	2511.572	1736.821	1.446074	0.1509
@MONTH=4	9898.889	1817.654	5.445970	0.0000
@MONTH=5	14759.12	1868.100	7.900603	0.0000
@MONTH=6	12032.61	1896.338	6.345183	0.0000
@MONTH=7	9135.379	1906.584	4.791490	0.0000
@MONTH=8	12732.43	1900.266	6.700339	0.0000
@MONTH=9	11316.21	1876.365	6.030922	0.0000
@MONTH=10	11812.59	1831.152	6.450908	0.0000
@MONTH=11	10248.78	1757.129	5.832684	0.0000
@MONTH=12	7442.032	1640.429	4.536639	0.0000
AR(1)	0.715168	0.150350	4.756697	0.0000
MA(1)	-0.408766	0.196107	-2.084401	0.0393

R-squared	0.803138	Mean dependent var	207954.2
Adjusted R-squared	0.777682	S.D. dependent var	9270.286
S.E. of regression	4370.994	Akaike info criterion	19.71815
Sum squared resid	2.22E+09	Schwarz criterion	20.06758
Log likelihood	-1285.398	Hannan-Quinn criter.	19.86015
F-statistic	31.54978	Durbin-Watson stat	1.998207
Prob(F-statistic)	0.000000		

Inverted AR Roots	.72
Inverted MA Roots	.41

The Demand Model independent variables are as follows:

- POP: Population forecast from World Bank
- Monthly Dummy Variables February through December (January is omitted with the inclusion of constant, C to avoid perfect collinearity)
- Auto-Regressive Terms (AR): AR(1)
- Moving-Average Terms (MA): MA(1)

Navy Load Projection Output

Dependent Variable: NAVYLOAD
Method: Least Squares with Breaks
Date: 08/12/19 Time: 12:02
Sample (adjusted): 2006M07 2018M12
Included observations: 150 after adjustments
Break type: Bai-Perron tests of L+1 vs. L sequentially determined breaks
Breaks: 2010M03, 2013M10, 2016M10
Selection: Trimming 0.15, , Sig. level 0.05

Variable	Coefficient	Std. Error	t-Statistic	Prob.
2006M07 - 2010M02 -- 44 obs				
C	31.49163	4.569600	6.891550	0.0000
CDD2	0.014545	1.175503	0.012373	0.9902
LEAC(-6)	101.1701	1.365849	74.07122	0.0000
LEAC	-25.55342	1.236039	-20.67365	0.0000
@MONTH=1	-0.489472	1.265712	-0.386716	0.6999
@MONTH=2	1.505941	1.378125	1.092746	0.2774
@MONTH=3	-3.548820	1.316566	-2.695513	0.0084
@MONTH=4	1.897834	1.189784	1.595108	0.1142
@MONTH=5	-2.116076	1.148062	-1.843172	0.0686
@MONTH=6	1.604813	1.139346	1.408539	0.1624
@MONTH=7	0.444305	1.139870	0.389785	0.6976
@MONTH=8	2.278378	1.139598	1.999282	0.0486
@MONTH=9	0.880136	0.008954	98.29420	0.0000
@MONTH=10	0.238310	11.86583	0.020084	0.9840
@MONTH=11	0.020583	13.54359	0.001520	0.9988
2010M03 - 2013M09 -- 43 obs				
C	64.41160	7.169413	8.984223	0.0000
CDD2	-0.014208	1.362198	-0.010430	0.9917
LEAC(-6)	-28.87296	1.709974	-16.88503	0.0000
LEAC	-14.92429	1.279451	-11.66461	0.0000
@MONTH=1	0.359193	1.244568	0.288609	0.7735
@MONTH=2	-4.973386	1.324397	-3.755207	0.0003
@MONTH=3	-2.951434	1.279001	-2.307608	0.0233
@MONTH=4	0.936957	1.310117	0.715170	0.4764
@MONTH=5	-0.573963	1.276998	-0.449463	0.6542
@MONTH=6	-0.148769	1.315391	-0.113099	0.9102
@MONTH=7	-0.739067	1.378465	-0.536152	0.5932
@MONTH=8	1.528533	1.351853	1.130695	0.2612
@MONTH=9	0.138090	0.014074	9.811668	0.0000
@MONTH=10	-0.789688	13.27663	-0.059480	0.9527
@MONTH=11	-2.363101	14.35513	-0.164617	0.8696
2013M10 - 2016M09 -- 36 obs				
C	46.93099	7.942519	5.908829	0.0000
CDD2	-0.005952	1.437362	-0.004141	0.9967
LEAC(-6)	-2.891954	1.772002	-1.632026	0.1062
LEAC	2.620104	1.357505	1.930088	0.0567
@MONTH=1	-1.271806	1.310988	-0.970113	0.3346
@MONTH=2	-2.049565	1.368090	-1.498121	0.1376
@MONTH=3	-1.829354	1.395890	-1.310528	0.1934
@MONTH=4	-0.143253	1.408393	-0.101714	0.9192
@MONTH=5	1.213876	1.467281	0.827296	0.4103
@MONTH=6	2.086616	1.485925	1.404254	0.1637
@MONTH=7	-0.993532	1.363530	-0.728647	0.4681
@MONTH=8	-0.408604	1.365224	-0.299294	0.7654
@MONTH=9	1.765605	0.012914	136.7219	0.0000
@MONTH=10	-0.009453	14.81909	-0.000638	0.9995
@MONTH=11	0.539753	13.25728	0.040714	0.9676
2016M10 - 2018M12 -- 27 obs				
C	63.08791	15.36036	4.107190	0.0001
CDD2	-0.044919	1.718034	-0.026146	0.9792
LEAC(-6)	2.176842	2.908429	0.748460	0.4561
LEAC	-5.306910	1.788694	-2.966918	0.0039
@MONTH=1	-1.406708	1.671654	-0.841506	0.4023
@MONTH=2	-3.256085	2.271631	-1.433369	0.1552
@MONTH=3	3.366616	1.681864	2.001718	0.0483
@MONTH=4	-1.714675	1.693614	-1.012435	0.3140
@MONTH=5	1.764238	1.559463	1.131311	0.2609
@MONTH=6	-3.189580	1.820748	-1.751797	0.0832
@MONTH=7	-0.199741	1.316441	-0.151728	0.8797
@MONTH=8	-1.330289	1.315530	-1.011219	0.3146
@MONTH=9	-3.056216	0.028906	-105.7307	0.0000
@MONTH=10	1.128114	48.01924	0.023493	0.9813
@MONTH=11	3.742998	42.20723	0.088681	0.9295

R-squared	0.932695	Mean dependent var	45.40953
Adjusted R-squared	0.888572	S.D. dependent var	4.809383
S.E. of regression	1.605409	Akaike info criterion	4.073809
Sum squared resid	231.9605	Schwarz criterion	5.278063
Log likelihood	-245.5357	Hannan-Quinn criter.	4.563059
F-statistic	21.13883	Durbin-Watson stat	2.108281
Prob(F-statistic)	0.000000		

The Demand Model independent variables are as follows:

- CDD2: Cooling Degree Days forecasted
- LEAC: LEAC Cost forecasted
- LEAC(-6): Six-month lag LEAC cost
- Monthly Dummy Variables February through December (January is omitted with the inclusion of constant, C to avoid perfect collinearity)

When evaluating the regression equation, the farthest column on the right gives the p-value for the significance of our parameters. A highly significant parameter typically shows a p-value of less than .05, however, the effect of an insignificant variable on forecasting capability (AIC/SIC criterion) are also considered. For example, despite the insignificance of population in the demand model, population lowered the AIC and SIC when included – indicating a valid relationship when forecasting. Additionally, concern over insignificance of a few monthly dummy variables is also safely ignored. It would not make economic sense to remove them, therefore despite their insignificance, they will remain in the model as to not jeopardize theoretical validity.

Independent Variables

Independent variable data sets were generated through the following sources:

World Bank.: An independent firm that specializes in long-run economic and demographic data projections by county in the U.S..

Weather Bank: Historical weather data, such as temperatures and cooling degree days, were provided by Weather Bank.

GPA Staff: Additional variables such as savings due to energy efficiency and distributed generation were supplied by GPA. Navy load forecasts were supplied by GPA staff through the Navy.

Mathematical Explanation of ARIMA Terms:

ARIMA(p,i,q) Model

$$d_i(Y_t) = C + \sum_{n=1}^{p} \varphi_P Y_{t-p} + a_t - \sum_{n=1}^{p} \theta_p a_{t-p}$$

p: Number of AR terms used (i.e. AR(1) … AR(5))
q: Number of MA terms used (i.e. MA(1))
Yt: Current Energy Value
C: Constant term
φ: Coefficient on AR term
a_t: Current Residual value

The Auto Regressive portion of this model corresponds to the first mathematical sum and the Moving Average component refers to the second sum. Auto Regressive (AR) components make slight adjustments to the forecasted values by modeling a relationship between the dependent variable and previous lags of itself. The Moving Average (MA) component makes a slight adjustment for dependent variable correlation to error terms. Please note that the error terms were estimated with the Gauss-Newton method. The "I" term within the ARIMA model stands for "Integration." We would consider this model i=1 because the energy data was first differenced. First differencing the data creates a stationary time-series process, which is essential for the use of ARMA terms in forecasting.

To not model ARMA relationships can cause severe model misspecification, serial correlation, and data inefficiencies.

Manual Adjustments

The models were generated using data from 2007 through 2020. To adjust for the exclusion of energy efficiency and distributed generation data within the original dataset, actual kWh savings were added back to the energy modeling and forecasting. Following the forecast, kWh savings were subtracted from the data sets from 2007 through 2040. Due to evening timeframe of GPA system peaks, it was determined that solar did not have a material affect on civilian demand. Therefore the adjustments were made to kWh consumption forecasting only.

Savings from energy efficiency and distributed generation programs were estimated with a growth assumption of 2.0%. Solar degradation was estimated at 0.75% per year from the time of individual solar install. The annual kWh savings used in the historic data and modeling is provided in the table below.

	Estimated kWh Loss (accumulated)	Loss Growth
2020	36,816,045	
2021	37,276,246	1.3%
2022	37,747,721	1.3%
2023	38,230,681	1.3%
2024	38,725,341	1.3%
2025	39,231,918	1.3%
2026	39,750,637	1.3%
2027	40,281,724	1.3%
2028	40,825,412	1.3%
2029	41,381,939	1.4%
2030	41,951,546	1.4%
2031	42,534,480	1.4%
2032	43,130,994	1.4%
2033	43,741,345	1.4%
2034	44,365,794	1.4%
2035	45,004,611	1.4%
2036	45,658,067	1.5%
2037	46,326,442	1.5%
2038	47,010,021	1.5%
2039	47,709,093	1.5%
2040	48,423,956	1.5%

Additionally, UFS took a conservative approach to forecasting the effects of COVID-19. At the time of this report, it is unknown what effects the pandemic may have over the next year. The percentages below show the impacts on the forecast itself, not a month to month decline. These percentages were applied to the Civilian Energy and Load and are projected to persist through the end of calendar year 2022.

Year	Month	Estimated Energy Reduction	Estimated Demand Reduction
2021	10	-6.0%	-8.6%
2021	11	-6.0%	-8.6%
2021	12	-6.0%	-8.6%
2021	1	-5.0%	-7.1%
2021	2	-5.0%	-7.1%
2021	3	-5.0%	-7.1%
2021	4	-5.0%	-7.1%
2021	5	-5.0%	-7.1%
2021	6	-5.0%	-7.1%
2021	7	-4.0%	-5.7%
2021	8	-4.0%	-5.7%
2021	9	-4.0%	-5.7%
2022	10	-3.8%	-5.4%
2022	11	-3.5%	-5.0%
2022	12	-3.3%	-4.6%
2022	1	-3.0%	-4.3%
2022	2	-2.8%	-3.9%
2022	3	-2.5%	-3.6%
2022	4	-2.3%	-3.2%
2022	5	-2.0%	-2.9%
2022	6	-1.8%	-2.5%
2022	7	-1.5%	-2.1%
2022	8	-1.3%	-1.8%
2022	9	-1.0%	-1.4%
2023	10	-0.8%	-1.1%
2023	11	-0.5%	-0.7%
2023	12	-0.3%	-0.4%

From October 2019 through June 2020, the Navy peak demand forecast was 20% higher than realized load and 5.5% higher than realized energy. This forecast was provided by the Navy, however manual adjustments were made through the completion of FY2020 and FY2021 to estimate the impacts of COVID-19. The original Navy provided forecast was then used for FY2022 - FY2024. This forecast is attached in the appendix.

Year	Month	Navy Energy Reduction	Navy Demand Reduction
2021	10	-2.0%	-15%
2021	11	-1.0%	-10%
2021	12	-1.0%	-10%
2021	1	-1.0%	-10%
2021	2	-0.5%	-5%
2021	3	-0.5%	-5%
2021	4	-0.5%	-5%
2021	5	-0.5%	-5%
2021	6	-0.5%	-5%
2021	7	-0.5%	-5%
2021	8	-0.5%	-5%
2021	9	-2.0%	-5%
2022	10	-2.0%	-5%
2022	11	-1.0%	-5%
2022	12	-1.0%	-5%
2022	1	-1.0%	-5%
2022	2	-0.5%	-5%
2022	3	-0.5%	-5%
2022	4	-0.5%	-5%
2022	5	-0.5%	-5%
2022	6	-0.5%	-5%
2022	7	-0.5%	-5%
2022	8	-0.5%	-5%
2022	9	-0.5%	-5%
2023	10	-0.5%	-5%
2023	11	-0.5%	-5%
2023	12	-0.5%	-5%

Temperature Forecast

The temperature forecast is performed following the Double Season Block Bootstrap Resampling method, outlined in Rob J Hyndman and Shu Fan's research in forecasting for long-term peak electricity demand. Using hourly historic temperature observations, seasonal blocks of length 240 (20 days) were allotted for the years of historical data, thus breaking each year into approximately 36 blocks.

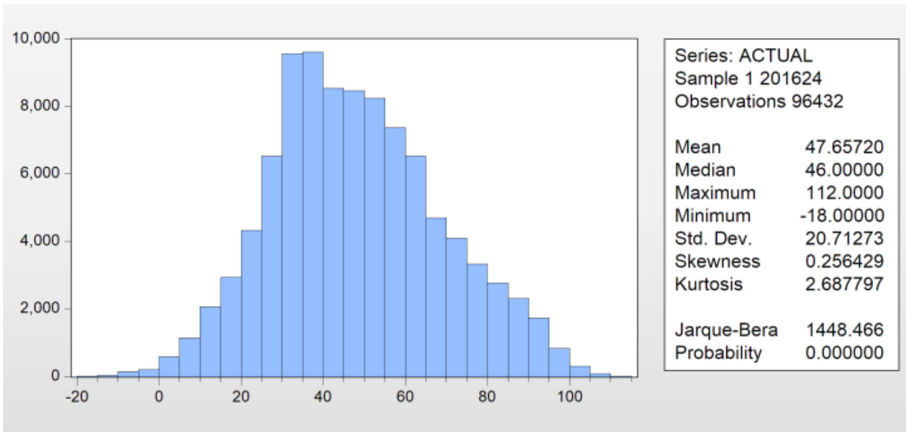
Year 2007	B1: 2007	B2:2007	B3:2007	…	B36: 2007
Year 2008	B1: 2008	B2:2008	B3:2008	…	B36: 2008
Year 2009	B1: 2009	B2:2009	B3:2009	…	B36: 2009
.					
.					
.					
Year 2017	B1: 2017	B2:2017	B3:2017	…	B36: 2017

To forecast, the sample blocks are contained within block number, but come from a randomly selected year. For example, in year 2019, block 1 temperatures may come from 2007, block 2 temperatures 2015, block 3 from 2009, and so on. Since the years are randomly selected, we have a large range of possible series combinations. A series may comprise the following:

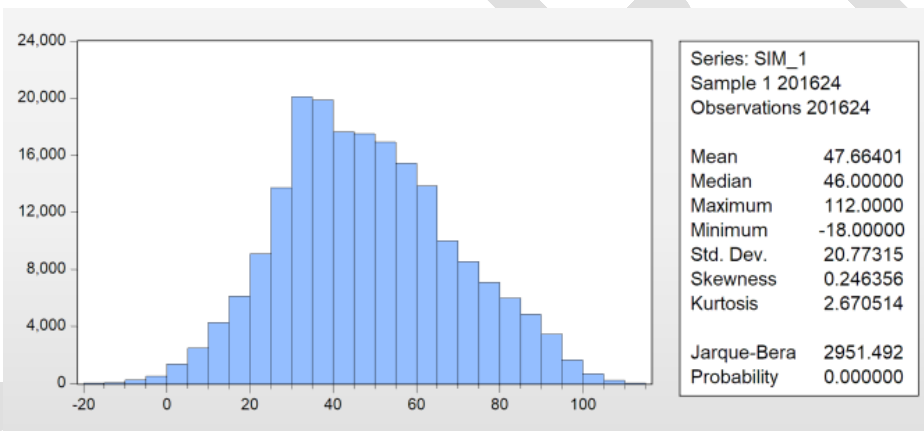
Forecast Y1	B1: 2007	B2:2015	B3:2009	…	B36: 2013
Forecast Y2	B1: 2015	B2:2009	B3:2015	…	B36: 2010
Forecast Y3	B1: 2014	B2:2014	B3:2013	…	B36: 2009
.					
.					
.					
Forecast Y20	B1: 2008	B2:2017	B3:2016	…	B36: 2015

Related cooling and heating degree days were calculated from the resulting sample. This method ensures integrity of seasonality and allows for a probability distribution that more closely mirrors actual temperature data opposed to other methods of weather forecasting, such as moving average. This is shown with sample data in the charts on the following page.

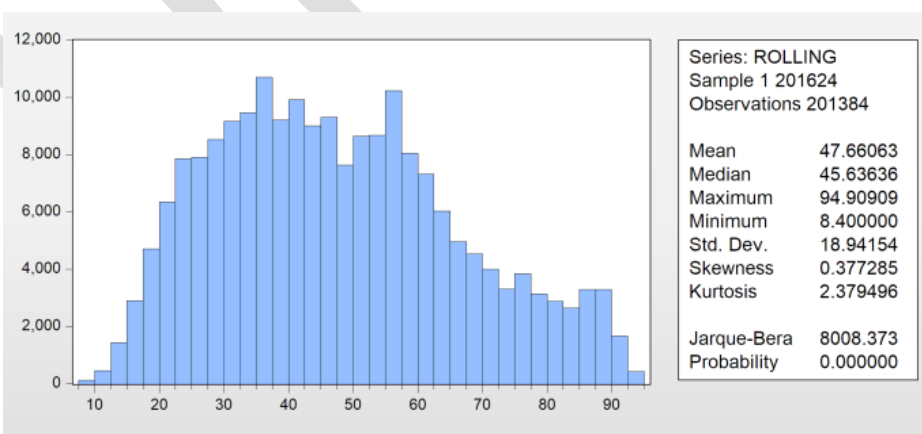
Sample historic temperature distribution is shown below:



Sample double season block bootstrap temperature forecast closely mirrors the distribution above:



Sample Moving average forecast does not closely mirror the actual historical distribution:



GPA Questions

Utility Financial Solutions discussed the results of the econometric modeling study with GPA. Attached are questions asked with formal answers provided by UFS in March of 2020.

1. **Total Energy – Does this include DSM Program?**

   Yes – please see the section titled "Manual Adjustments" for further information.

2. **Annual Growth – Why is forecasted annual growth negative in 2021, 2022, 2037? The Navy increases – due to build up?**

   Pages 11 and 12 describe the Double Bootstrap Block Resampling method outlined as best practice for forecasting weather patterns used in load forecasting. Due to the random nature of weather patterns, the forecasts are not smoothed out, but instead use historical data to generate a sample that mirrors the historical temperature distribution realized. Since this method is not normalized, we will have highs and lows, which can greatly affect weather usage. Due to the effect of temperature on energy usage, some years will see slightly negative growth while the majority of years will see positive growth. Though we can not be certain which years will see more drastic weather patterns, using this methodology provides a more accurate long-term trend.

3. **Customers – ALL, is this monthly MWH per rate class?**

   - Columns E – R show monthly number of customers by rate class
   - Columns S – AB show the percent for each rate class of the total customers
   - Columns AE – AP show the total annual customers by rate class
   - Columns AR - BC show the growth in customers by rate class annually
   - Columns BG – BS show the total forecasted number of customers by rate class annually

Appendix: Navy Projection Provided

GUAM POWER AUTHORITY
PURCHASE FORECAST UPDATE (SEP 2019)
FY 2020 - FY 2024

	Fiscal Year				
	2020	**2021**	**2022**	**2023**	**2024**
Total Demand* (MW)	524	549	556	584	594
Total Energy (MWh)	324,646	339,083	343,446	360,848	367,926

Note: *Sum of the monthly conjunctive demand billed for the 12 months of the fiscal year.

Appendix B: FUEL PRICE FORECAST

GPA 2021 Fuel Forecast (030821).pdf

INDEPENDENT MARKET CONSULTANT'S REPORT

2021 FUEL PRICE FORECAST

Report Prepared for

Guam Power Authority

P.O. Box 2977

Hagatna, GU 96932

March 8, 2020

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Introduction

The Guam Power Authority ("GPA") engaged Leidos Engineering, LLC ("Leidos") to prepare a fuel price forecast in accordance with the Master Professional Services Agreement dated March 14, 2011 (the "MPSA") and the Task Authorization No. 10 dated December 23, 2020. Leidos developed an annual fuel price forecast for the following products (landed on Guam) for the period from January 1, 2021 through December 31, 2050, with monthly prices for the first 48 months:

- 2% sulfur No. 6 residual fuel oil (HSFO);
- 1.19% sulfur No. 6 residual fuel oil (LSFO);
- 0.2% sulfur RFO (ULSFO);
- Ultra-Low Sulfur No. 2 distillate fuel oil (ULSD); and
- LNG.

Leidos also developed a Base Case, Low Case, and High Case for each product. This report (the "Report") summarizes the methodology and assumptions utilized in developing the forecast for each product. This Report is solely for the information of and assistance to the GPA and should not be used for any other purpose or by any other party, except for those parties who have entered into a third party use of work products agreement with Leidos. The Report has been developed based on the needs of the GPA, and incorporates our analysis of the information made available to us by the GPA, including documents, written correspondence and/or oral communications. Further, the level of detail presented in the Report reflects our interactions with the GPA through the course of our review, thus it does not reflect a comprehensive record of our analysis nor a complete accounting of information we received. Accordingly, other readers of the Report that have not been involved over the course of our review could find the information contained herein to be incomplete.

Certain statements included in this Report constitute forward looking statements. The achievement of certain results or other expectations contained in such forward looking statements involve known and unknown risks, uncertainties and other factors which may cause actual results, performance or achievements described in the Report to be materially different from any future results, performance or achievements expressed or implied by such forward looking statements. We do not plan to issue any updates or revisions to the forward looking statements if or when our expectations, or events, conditions or circumstances on which such statements are based, occur. No warranty, guarantee, or promise, express or implied, related to any future results, performance, or achievements associated with such forward looking statements is provided.

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Petroleum Price Forecast Methodology

Historical Analysis

The GPA has historically entered into fuel purchase agreements with contract periods that have ranged from one to three years. Prices for liquid fuels delivered under these fuel purchase agreements are indexed to the Mean of Platts Singapore ("MOPS") prices plus a premium that varies by the type of refined product provided. MOPS is the average of a set of Singapore-based refined oil product price assessments published by S&P Global Platts. S&P Global Platts is a provider of energy and commodities information and a source of benchmark price assessments in the physical commodity markets.

In order to perform a forecast of MOPS refined products prices we first examined the historical correlation between U.S. Gulf Coast ("USGC") and MOPS prices for ultra-low sulfur diesel ("ULSD") and residual fuel oil ("RFO"). We examined monthly average historical ULSD fuel prices from January 2010 through December 2020. As shown in figure 1, we found USGC and MOPS ULSD price to be 98.8 percent correlated. We also examined the monthly average differentials between the two price points. As shown in figure 2, the monthly average price differentials do not exhibit a positive or negative directional bias. We performed similar analysis on RFO fuel prices and found them to be 97.5 percent correlated. The slightly lower historical correlation is likely attributable to the fact that RFO fuel has lower traded volumes than ULSD. We also found that RFO historical monthly average price differential are not generally skewed toward a positive or negative direction. As a result of this analysis, we concluded that USGC refined products prices are an acceptable proxy for MOPS refined products prices.

Figure 1: Historical USGC and MOPS ULSD Monthly Average Price ($ per bbl)

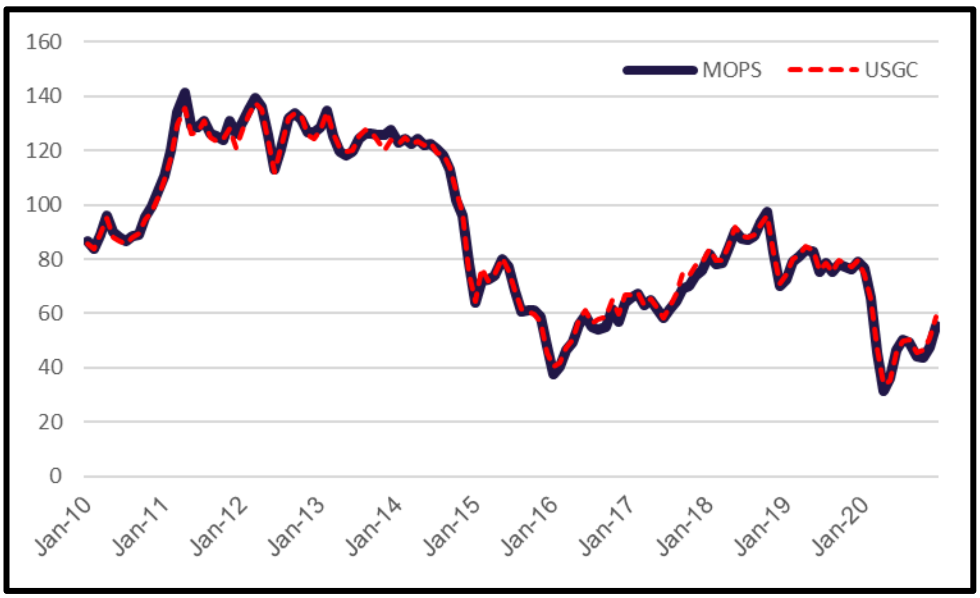
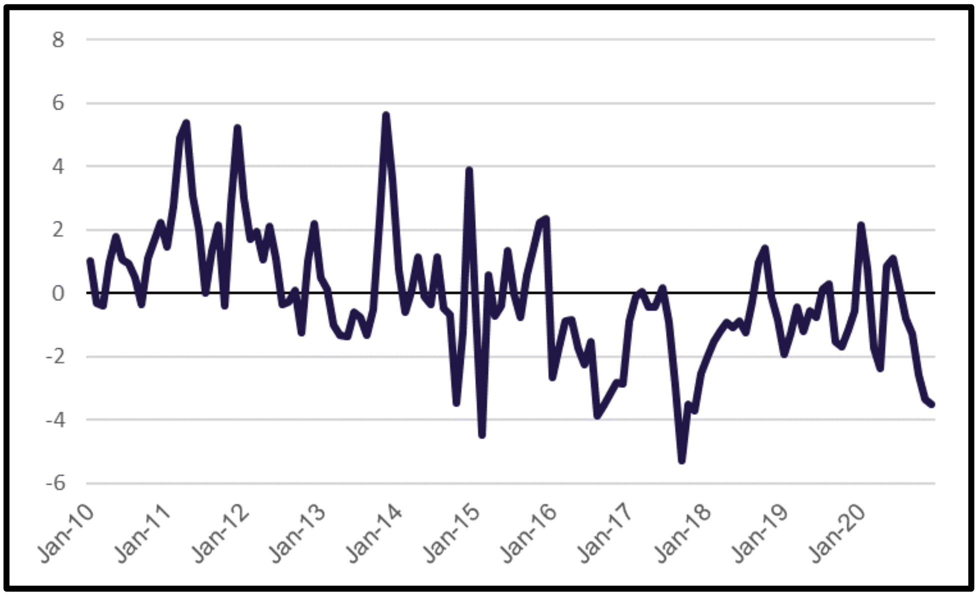


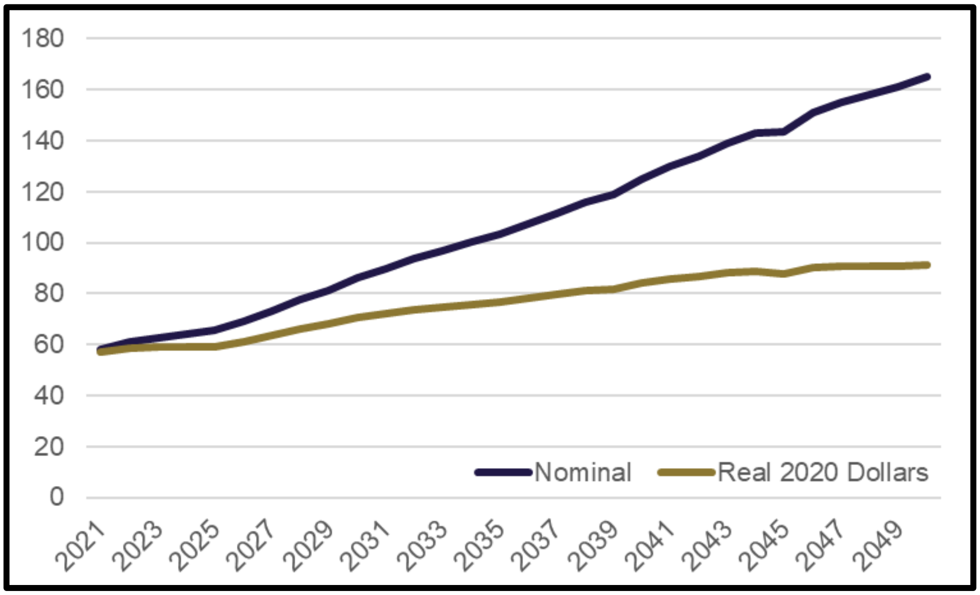
Figure 2: Historical USGC and MOPS ULSD Monthly Average Price Differential ($ per bbl)



Refined Petroleum Products Price Formation

In order to forecast ULSD and RFO fuel prices we utilized both near term forward prices and long term forecast prices for West Texas Intermediate ("WTI") crude oil. For monthly WTI prices through December 2021 we utilized the NYMEX forward curve from the February 17, 2021 settlement date. For long-term (2027 through 2050) WTI crude oil prices, we utilized the Energy Information Administration ("EIA") Annual Energy Outlook ("AEO") 2021 Reference Case forecast of WTI crude oil prices. For the five-year intermediate period from 2022 through 2026, we assumed that WTI crude oil prices would trend from the 2021 NYMEX values to the EIA AEO forecast values. Figure 3 shows the annual WTI crude oil prices that were assumed in our analysis in both nominal and real 2020 dollars per barrel. WTI crude oil prices are expected to increase at a compound annual growth rate ("CAGR") of 1.6 percent in real terms. Nominal oil prices are expected to increase at a CAGR of 3.6 percent, which includes 2 percent nominal inflation.

Figure 3: Forecast WTI Crude Oil Price ($ per bbl)



Because ULSD and RFO are refined petroleum that are made from crude oil, we projected prices for USGC ULSD and 3.5 percent sulfur RFO as derivatives of the WTI prices. We assumed that USGC ULSD would be priced at an average premium to WTI crude oil of 33 percent while 3.5 percent sulfur RFO was assumed to be priced at a 2 percent discount to WTI crude oil. We also projected prices for refined petroleum products with a range of sulfur contents by utilizing a weighted average of the ULSD and 3.5 percent sulfur RFO price. This assumes that petroleum marketers would be willing to blend custom fuel types without charging a significant premium for such custom blends.

GPA currently pays a premium of $9.03 per bbl above the MOPS index price for delivered ULSD and $10.70 per bbl for delivered high sulfur RFO. Based on our estimates of refined petroleum shipping costs we expect that these premiums reflect the cost of shipping refined petroleum products from the USGC to Guam. While this does not mean that the fuels consumed by GPA are sourced from the USGC, it does imply that petroleum marketers strategically price the premium for fuel delivered to Guam based on the estimated transportation cost from the USGC. For example, we estimate that at price of $80 per bbl for ISO 2020 (0.5 percent sulfur) marine fuel oil, the cost to ship ULSD from the USGC to Guam, utilizing a Handymax class tanker, is approximately $9 per bbl. This value is approximately equivalent GPA's current contract premium for ULSD. Shipping ULSD to Guam from Asian sources such as Singapore would likely be much lower at an estimated cost of approximately $2.15 per bbl. Based on this analysis we utilized estimated shipping costs from the USGC to Guam, to estimate the long-term premium that GPA would be charged for landed petroleum products. In real 2020 dollars, the estimated premium for ULSD ranges from $8.85 to $10.25 per bbl over the forecast period, resulting in a CAGR of 0.5 percent. Similarly, the estimated premium for RFO ranges from $10.49 to $12.10 (2020 dollars per bbl) over the forecast period, which also results in a CAGR of 0.5 percent.

Utilizing the estimated ULSD and RFO commodity prices in conjunction with the estimated price premiums, we calculated landed price estimates for ULSD and RFO with three different sulfur contents (2.0, 1.19, and 0.2 percent). Table 1 shows the resulting estimated prices for selected years for each of these products.

Table 1
Landed Petroleum Products Prices

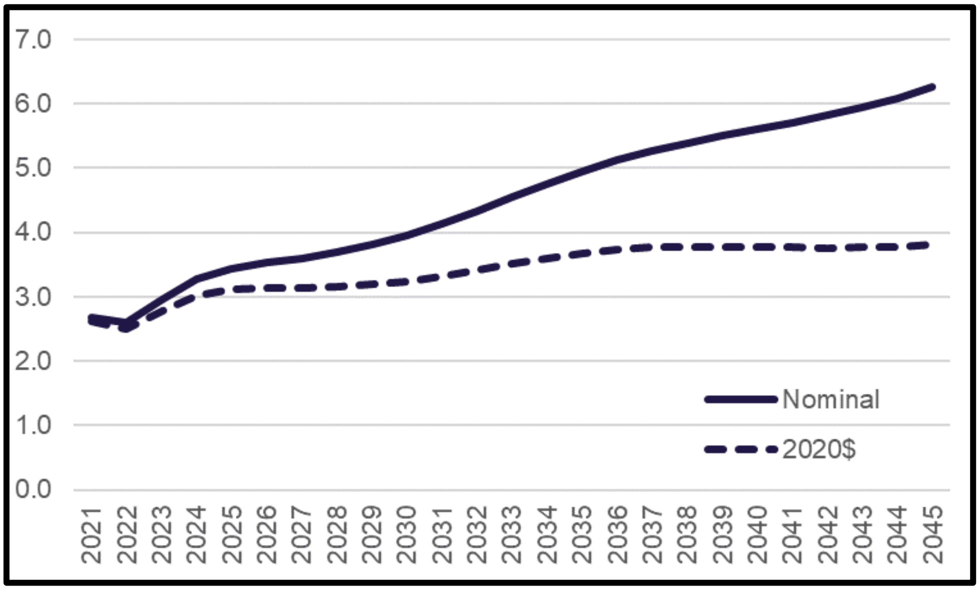
2020 dollars per MMBtu								
Product Type	**2021**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**	**CAGR**
ULSD	14.20	14.72	17.35	18.84	20.65	21.49	22.43	1.6%
RFO (2.0% sulfur)	12.06	12.41	14.52	15.68	17.10	17.73	18.42	1.5%
RFO (1.19% sulfur)	12.89	13.32	15.63	16.92	18.50	19.21	20.00	1.5%
RFO (0.2% sulfur)	13.96	14.48	17.06	18.51	20.28	21.10	22.01	1.6%
Nominal dollars per MMBtu								
Product Type	**2021**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**	**CAGR**
ULSD	14.49	16.25	21.15	25.35	30.68	35.26	40.62	3.6%
RFO (2.0% sulfur)	12.30	13.70	17.70	21.10	25.41	29.08	33.37	3.5%
RFO (1.19% sulfur)	13.15	14.70	19.06	22.78	27.48	31.52	36.23	3.6%
RFO (0.2% sulfur)	14.23	15.98	20.79	24.91	30.13	34.62	39.87	3.6%

LNG Price Formation

We estimated landed LNG prices by utilizing the Leidos Fourth Quarter 2020 Henry Hub forecast of natural gas prices in conjunction with certain assumptions regarding the cost to liquefy natural gas and the cost to ship LNG from the USGC to Guam. The Henry Hub is located in Erath, Louisiana and is owned and operated by Sabine Pipe Line LLC. The Henry Hub interconnects with nine interstate and three intrastate pipelines and has historically functioned as a point of market liquidity in the North American natural gas market. As a result of this historical market liquidity, Henry Hub is the official delivery mechanism and pricing point for CME's New York Mercantile Exchange ("NYMEX") natural gas futures contract as well as the OTC swaps traded on Intercontinental Exchange ("ICE"). Due to growth in LNG exports from the U.S., Henry Hub is now becoming a reference point for many internationally delivered LNG cargos.

Figure 4 shows the Leidos Fourth Quarter 2020 Henry Hub natural gas price forecast in nominal dollars and real 2020 dollars. Near-term forecast prices are aligned to reflect natural gas prices on the NYMEX forward curve through 2022. After this initial period the forecast transitions to a fundamental calculation of market prices which is a function of expected market demand and estimated marginal natural gas production costs. From 2023 through 2045, Henry Hub prices are forecast to average \$4.68 per MMBtu in nominal dollars (\$3.48 per MMBtu in real 2020 dollars). Gas prices through the forecast period are expected to remain relatively low due to two fundamental factors. The first fundamental factor is an expectation of a large amount of associated and wet gas production that will be produced as a result of drilling for crude oil and natural gas liquids. While oil production has temporarily declined due to the global pandemic, we expect North American oil production to gradually rebound and contribute significantly to the natural gas supply mix over the long term. The second fundamental factor is the large and relatively inexpensive dry gas resource base that exists within the Marcellus and Utica shale plays. By 2045, Henry Hub prices average approximately \$6.26 per MMBtu in nominal terms (approximately \$3.82 per MMBtu in real 2020 dollars). This represents a compound annual growth rate of 3.5 percent from 2023 through 2045 which includes 2.0 percent nominal inflation. For more information on the fundamental drivers of our natural gas forecast see the Appendix of the report.

Figure 4: Henry Hub Natural Gas Price Forecast ($ per MMBtu)



In order to transform projected Henry Hub natural gas prices into USGC LNG prices, we assumed that USGC LNG prices would trade at a long-term price of Henry Hub plus 25% plus $2.50 per MMBtu. This assumption is consistent with the rates that are typically charged by liquefaction project developers for long-term off-take capacity. LNG shipping costs were estimated based on a steam turbine powered tanker with a capacity of 160,000 cubic meters LNG, utilizing both marine fuel oil and LNG boil-off gas as fuel. Table 2 shows assumptions used to calculate LNG shipping costs from the USGC to Guam. Table 3 shows projected Henry Hub prices, calculated USGC LNG prices, and landed LNG prices for selected forecast years.

Table 2
LNG Shipping Assumptions

	Value	Units
Shipping Distance	9,500	Nautical Miles
Vessel Speed	19	Knots
Days in Port	3	Days
Round Trip Shipping Days	45	Days
Charter Rate (annual average)	$55,000	Dollars per day
Panama Canal Cost	$850,000	Round Trip Transit
Port Costs	$100,000	Dollars per day
Insurance Cost	$2,700	Dollars per day
Broker Fee	2% of Charter Cost	
Marine Fuel Oil Consumption	46.65	Metric Tons per day
LNG Boil Off	5,440	MMBtu per day
Retained LNG (return voyage)	4% of vessel capacity	

Table 3
Henry Hub and LNG Prices

Product Type	2021	2025	2030	2035	2040	2045	2050	CAGR
2020 dollars per MMBtu								
Henry Hub	2.83	3.11	3.24	3.68	3.77	3.82	4.88	1.9%
USGC LNG	5.99	6.34	6.50	7.05	7.16	7.22	8.56	1.2%
Landed LNG	7.73	8.12	8.37	8.99	9.15	9.23	10.67	1.1%

Product Type	2021	2025	2030	2035	2040	2045	2050	CAGR
Nominal dollars per MMBtu								
Henry Hub	2.89	3.43	3.95	4.95	5.60	6.26	8.85	3.9%
USGC LNG	6.11	7.00	7.93	9.49	10.64	11.85	15.50	3.3%
Landed LNG	7.88	8.97	10.21	12.09	13.59	15.14	19.33	3.1%

High and Low Forecast Results

In order to bracket the forecast prices for landed petroleum products and LNG we also calculated petroleum products prices and landed LNG prices using WTI crude oil prices and Henry Hub prices from a High and Low forecast. For the High forecast, we utilized long-term WTI crude oil prices from the AEO Low Oil and Gas Supply case and Henry Hub prices from the Leidos Fourth Quarter Gas Price Case. For the Low forecast, we utilized long-term WTI crude oil prices from the AEO High Oil and Gas Supply case and Henry Hub prices from the Leidos Fourth Quarter Low Gas Price Case. Assumptions that differentiate the High and Low forecast from the Base Case are presented in Table 4. Results for landed prices from the High and Low forecast are shown in Table 5.

Table 4
High and Low Forecast Assumptions

Forecast Assumption	High Case	Low Case
Estimated Ultimate Recovery ("EUR") per well for offshore, tight oil and oil bearing shale formations (EIA AEO).	50% higher than the reference case.	50% Lower than the reference case.
Rate of technological improvement (EIA AEO)	50% higher than the reference case.	50% Lower than the reference case.
Initial unproved oil resources (EIA AEO)	156 billion barrels higher than the reference case.	133 billion barrels lower than the reference case.
Initial WTI Crude Oil Prices (2022 through 2025)	8% higher	12% Lower
Henry Hub Price Forecast (Leidos Q4)	15% higher than the base case.	18% lower than the base case.

Table 5
High and Low Case Landed Prices

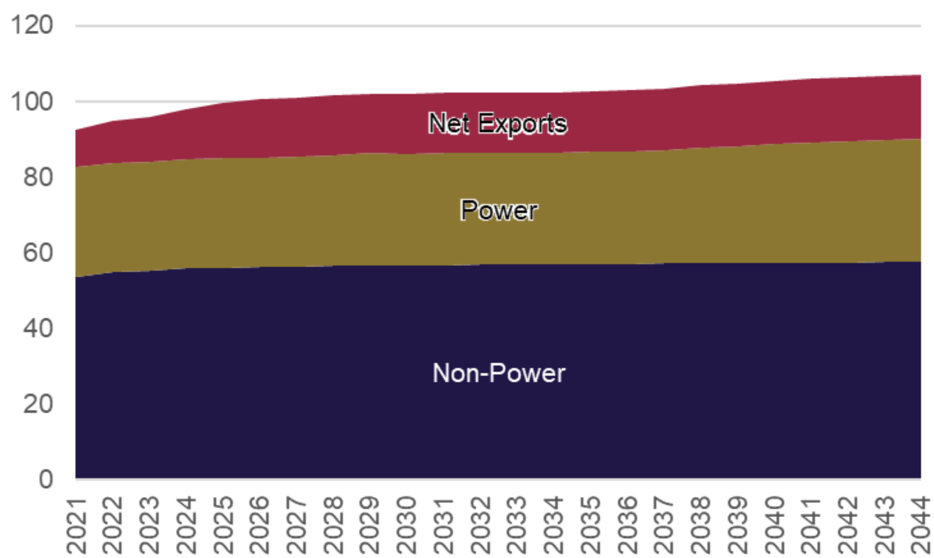
High Case (2020 dollars per MMBtu)								
Product Type	2021	2025	2030	2035	2040	2045	2050	CAGR
ULSD	15.04	15.78	18.84	21.47	23.66	25.23	26.43	2.0%
RFO (2.0%) Sulfur	12.76	13.28	15.74	17.85	19.57	20.79	21.69	1.8%
LNG	8.18	8.77	9.05	9.78	9.96	10.07	11.73	1.3%
Low Case (2020 dollars per MMBtu)								
Product Type	2021	2025	2030	2035	2040	2045	2050	CAGR
ULSD	12.88	13.12	14.11	15.53	16.98	18.39	19.48	1.4%
RFO (2.0%) Sulfur	10.99	11.10	11.89	13.02	14.17	15.29	16.13	1.3%
LNG	7.14	7.34	7.52	8.03	8.16	8.24	9.43	1.0%
High Case (nominal per MMBtu)								
Product Type	2021	2025	2030	2035	2040	2045	2050	CAGR
ULSD	15.34	17.42	22.96	28.90	35.15	41.40	47.88	4.0%
RFO (2.0%) Sulfur	13.02	14.66	19.19	24.02	29.08	34.10	39.29	3.9%
LNG	8.34	9.68	11.03	13.16	14.80	16.52	21.25	3.3%
Low Case (nominal per MMBtu)								
Product Type	2021	2025	2030	2035	2040	2045	2050	CAGR
ULSD	13.14	14.49	17.21	20.91	25.23	30.18	35.29	3.5%
RFO (2.0%) Sulfur	11.21	12.25	14.49	17.52	21.05	25.08	29.22	3.4%
LNG	7.28	8.11	9.17	10.81	12.12	13.52	17.08	3.0%

Appendix

Natural Gas Demand

The Fourth Quarter 2020 forecast of natural gas demand exhibits modest increases over the forecast period. For the twelve month period from November 2019 through October 2020 the EIA reports that total natural gas consumption, including net exports, for the lower 48 contiguous states was 33.3 Tcf which equates to an average daily value of 91.2 Bcfd. This represents a 2.4 percent increase from year ago levels. This increase is largely attributable to increases in LNG exports, pipeline exports to Mexico and demand for power generation. Total natural gas consumption over the 25 year forecast period grows at a CAGR of approximately 0.5 percent resulting in a total consumption of 41.4 Tcf, which is equivalent to a daily average volume of 113 Bcfd, by the year 2045. Much of the near-term demand growth occurs due to increased exports both in the form of LNG and pipeline gas.

Figure A-1: Lower 48 Forecast Natural Gas Consumption (Bcfd)



Source: Leidos.

One of the primary drivers of near term natural gas demand growth is exports. Table A-1 shows the status of LNG export facilities in the lower 48 U.S. contiguous states. As shown in the table 10.15 Bcfd of LNG export capacity is currently operational with another 5.25 Bcfd of capacity under construction or having achieved a final investment decision ("FID"). The projects under construction are expected to go into service incrementally between now and 2025. Our current forecasts methodology assumes that all liquefaction projects that have achieved FID are completed resulting in a total installed LNG Liquefaction capacity of approximately 15.4 Bcfd by 2025. We assume that this liquefaction capacity realizes a long term utilization rate of approximately 82 percent of peak capacity resulting in an average LNG export volume of approximately 12.6 Bcfd post 2025.

1: LNG Export Facilities

Facility Name	Company Name	Baseload Capacity (Bcfd)	Peak Capacity (Bcfd)	Status
Cove Point LNG	Dominion	0.69	0.76	Operational
Sabine Pass LNG (Trains 1 - 5)	Cheniere Energy	2.96	3.45	Operational
Corpus Christi LNG (Trains 1 & 2)	Cheniere Energy	1.19	1.32	Operational
Cameron LNG (Trains 1, 2 & 3)	Sempra	1.78	2.12	Operational
Freeport LNG (Trains 1 - 3)	Freeport LNG	1.98	2.14	Operational
Elba Island	Southern LNG	0.33	0.36	Operational
Corpus Christi LNG (Train 3)	Cheniere Energy	0.60	0.66	Under Construction
Golden Pass	ExxonMobil	2.03	2.20	Under Construction
Calcasieu Pass LNG	Venture Global LNG	1.32	1.70	Under Construction
Sabine Pass LNG (Train 6)	Cheniere Energy	0.59	0.69	Under Construction
Operational Total		8.93	10.15	
Under Construction Total		4.54	5.25	
Total		13.47	15.40	

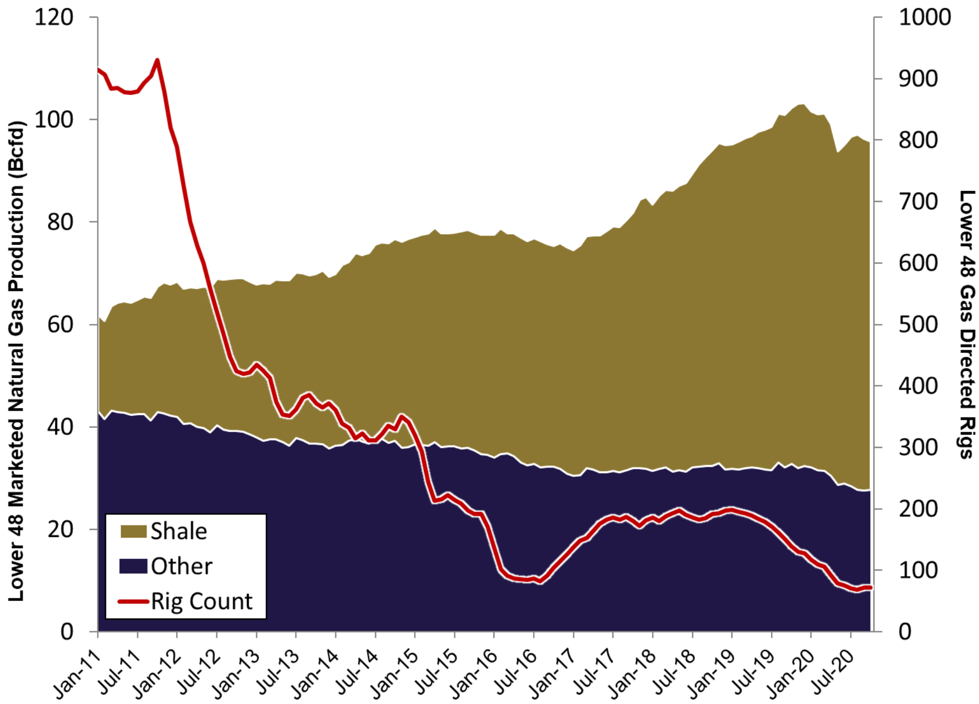
In addition to LNG exports we expect pipeline exports to be a driver of near term demand growth. For the twelve-month period from November 2019 through October 2020 the EIA reports that the U.S. exported 2.9 Tcf of gas via pipeline to Canada and Mexico. This equates to an average daily value of 8.0 Bcfd and represents a 3.8 percent increase over year ago levels. Approximately 32 percent of exported gas went to Canada and 68 percent went to Mexico. We expect total pipeline exports to grow to 10 Bcfd by 2030, a 25 percent increase over current levels. We expect the primary driver of this increase to be demand from Mexico as Mexico continues to transition away from oil-fired power generation capacity and also displaces international LNG imports with less expensive pipeline imports from the U.S.

For the twelve-month period beginning November 2019 and ending October 2020, the EIA reports that natural gas consumed for power generation in the U.S. lower 48 states was 11.7 Tcf. This equates to an average daily volume of 32 Bcfd and represents a 5.2 percent increase from year ago levels. We note that current power-sector consumption levels are a response to very low natural gas prices. Power sector natural gas consumption will likely decline in 2021 as gas prices increase. The Leidos Fourth Quarter 2020 Base Case forecast which was performed utilizing our integrated EEA model, resulted in a power sector gas demand CAGR of approximately 0.5 percent over the forecast period. The forecast results in a total volume of 11.9 Tcf (32.5 Bcfd) by 2045. Changes in load growth as well as the competitiveness of renewable generation technology versus gas-fired generation technology are all factors that will impact realized versus forecasted power sector gas demand.

Gas Supply

Since the advent of the widespread commercial application of horizontal drilling in conjunction with hydraulic fracturing, which first occurred on a commercial scale in the Barnett Shale in approximately 2007, the outlook for U.S. natural gas production has changed dramatically. This increase is the result of the continued refinement of this technology as well as its application to a broader array of geologic formations across North America. Figure A-2 shows historical monthly dry natural gas production in the U.S. lower 48 states since 2011. The figure depicts the new efficiency of natural gas producers who have continued to grow production despite the utilization of a relatively low number of drilling rigs. Exploration and production companies have continued to increase efficiency by identifying the most productive drilling areas, maximizing lateral length and fracture stages and increasing the number of wells per well pad. While production has recently declined, this decline is in response to pandemic related demand destruction that temporarily resulted in very low market prices and is not a reflection on capability to producer natural gas.

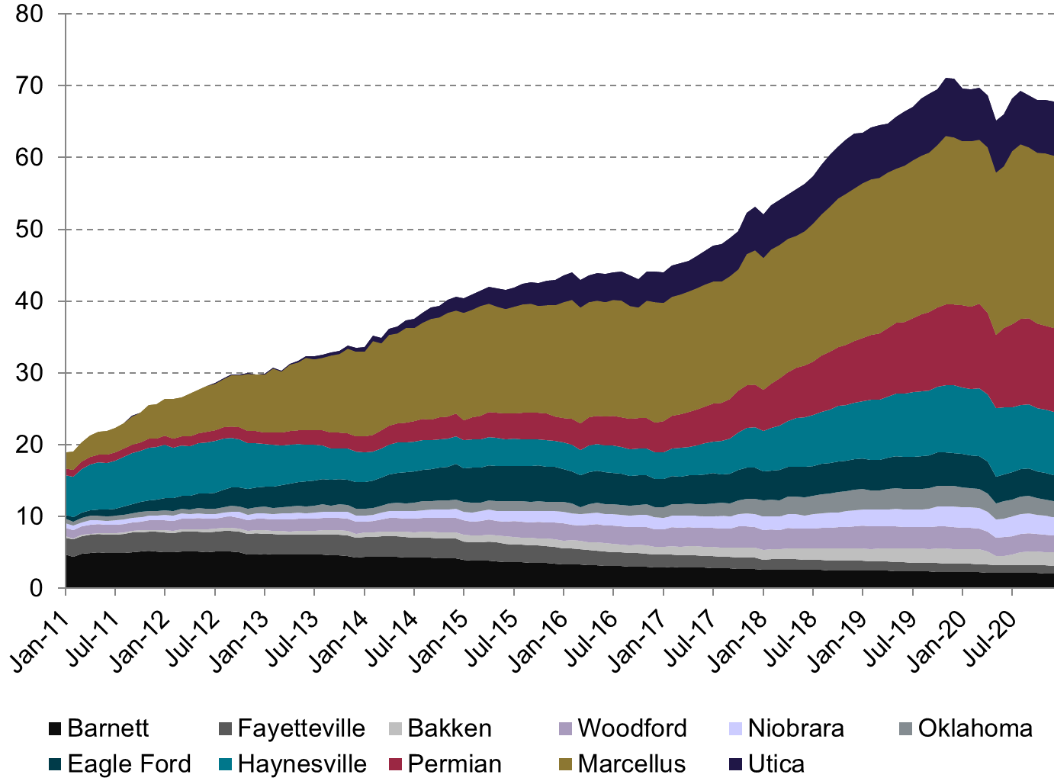
Figure A-2: Lower 48 Dry Natural Gas Production and Rig Count



Source: Leidos.

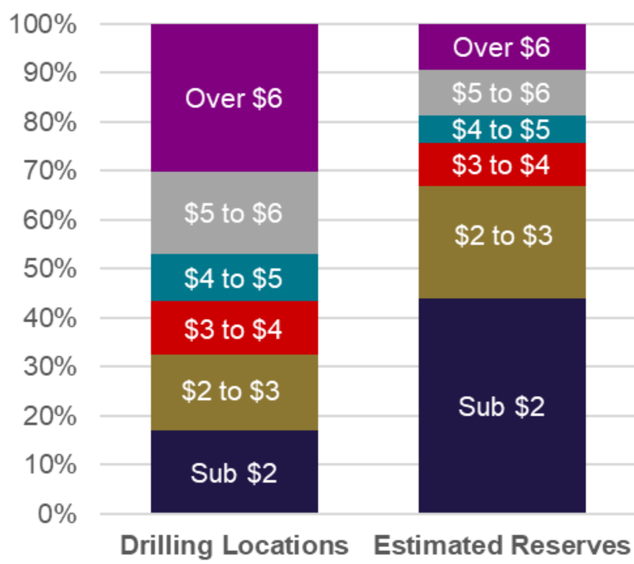
Among the major shale plays in the lower 48 contiguous states only a few have been able to post continued year over year production gains during what has largely been sub-$3 price levels since 2014. Figure A-3 shows production from major shale plays in the lower 48 States. As can be seen from the figure, the bulk of the shale gas production growth has come from the Marcellus, Utica, Haynesville and Permian plays. We note that the Permian is primarily an oil shale play, the Haynesville is primarily a dry gas play and the Marcellus and Utica formations contain a range of wet gas and dry gas geologic resources.

Figure A-3: Dry Natural Gas Production from Major Shale Plays (Bcfd) (1)



Source: EIA. Billion cubic feet per day ("Bcfd").

Figure A-4: U.S. Lower 48 Dry Gas Drilling Inventory and Estimated Reserves



Source: BTU Analytics

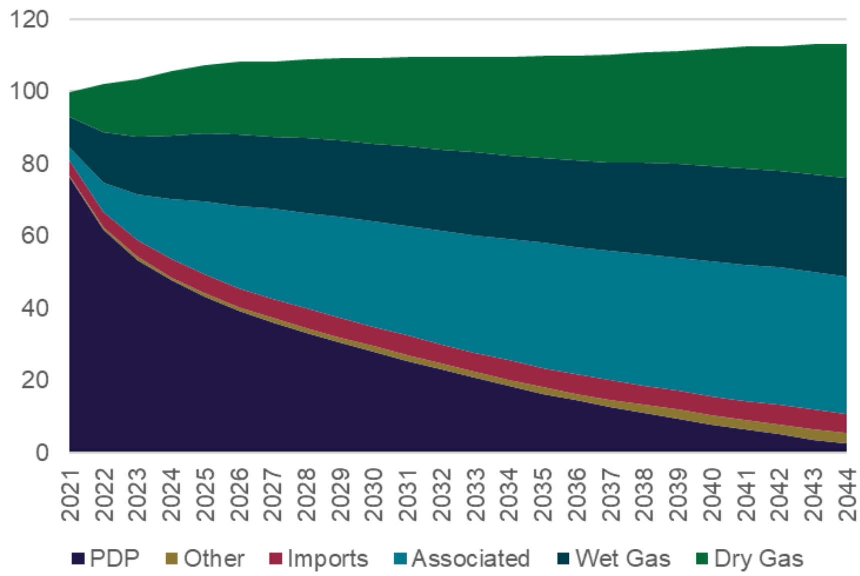
We utilize third party data and analysis provided by BTU Analytics to estimate long-term natural gas production costs. While these estimated natural gas production costs are a function of many factors the primary factor that drives long term gas price escalation is the fact that shale formations are not uniform across their resource base. As a result, a larger number of wells and therefore a larger capital investment is required to bring certain portions of the shale gas resource base to market. In our long-term gas price forecast, we assume that drilling and production costs are known and that producers move from low cost drilling locations to higher cost drilling locations in order to meet market demand as efficiently as possible. Figure A-4 shows a representation of combined U.S. lower 48 dry shale drilling locations broken down by their required well head production cost and the percentage of the estimated reserves that those drilling locations represent. As shown in the figure, drilling locations that are economic at below $2 per MMBtu represent about 17 percent of remaining drilling locations but 44 percent of estimated reserves. As these relatively low cost drilling locations are drawn down over the forecast period, producers are required to move into less productive drilling locations. We assume that long term equilibrium market prices will increase to justify the larger capital expenditure required to bring gas from less productive drilling locations to market.

A second factor that is critical to the formation of our long-term price forecast is understanding how associated natural gas production and wet gas production will occur over the forecast period. Associated natural gas is methane that is co-produced from wells that are drilled for crude oil production. Wet gas production occurs from wells that are primarily drilled to target commodities such as ethane, propane and butane. Methane produced from wells drilled to produce crude oil or natural gas liquids are much less responsive to natural gas market prices because the methane produced from these wells is largely a by-product of the production of other commodities. For example, natural gas production from oil bearing shale formations in the Permian basin has increased from approximately 1 Bcfd in 2011 to current levels of over 11 Bcfd. This represents a more than 10 Bcfd increase that is largely the result drilling for crude oil.

Figure A-5 shows total U.S. natural gas supply by type in Bcfd. PDP represents production from all types of existing wells. Because these wells are existing they require very little additional investment in order to continue producing natural gas. Other production represents natural gas production that occurs outside of shale formations. Imports represent natural gas that is imported to the U.S. as a result of prevailing market prices. Imports are largely composed of pipeline imports from Canada, however a very small amount of sustained LNG imports do occur in New England during the peak winter months. Associated gas and wet gas is gas produced from wells that are targeting commodities other than methane such as crude oil and ethane. Dry gas is gas produced from shale wells that are primarily targeting methane as a production commodity. A fundamental outcome of the expectation of a relatively large forecast of wet and associated gas production is that less dry gas production is required to meet market demand. Without this expectation of relatively large wet and associated gas production levels, market prices would be higher because dry gas producers would exhaust their drilling locations more quickly and be required to produce gas from less productive resource types that require greater capital investment. The large and relatively low cost dry shale gas resource base coupled with a relatively large outlook for wet and associated gas production results in low natural gas prices over the forecast period.

All long term natural gas price forecast incorporate some form of E&P sector technological improvement. Historically the technological improvement that occurred from the advent of horizontal drilling in conjunction with hydraulic fracturing was tremendous and reduced market prices from sustained price levels above $7 per MMBtu to less than $3 per MMBtu. While exploration and production companies continue to make marginal improvements in this process, we expect that producers are approaching the limits of potential improvement in this process. As a result, we assume that no major technological improvements occur through the year 2030. After 2030 we assume a one-time 20 percent increase in technological improvement occurs and is implemented over a three year period. We expect that increasing natural gas market price levels post 2030 will warrant this increase in technological improvement. We also note that our assumed one time increase in technological improvement of 20 percent is relatively small when compared to the rate of technological improvement that has occurred in the E&P sector through the advent of horizontal drilling coupled with hydraulic fracturing. As a result of this assumed 20 percent increase in technological improvement we expect market prices to remain below $4 in real 2020 dollars by the end of the forecast period in the year 2045. To the extent that actual technological improvement in the E&P sector is different from these assumptions, realized long-term gas prices could be different from our current forecast.

Figure A-5: Total U.S. Natural Gas Supply by Type (Bcfd)



Source: BTU Analytics

Units: Nominal $ per bbl (2% annual inflation)

	WTI			MOPS ULSD			MOPS RFO (3.5% Sulfur)			ULSD Premium			RFO Premium			Landed ULSD			Landed RFO (2.0% Sulfur)			Landed RFO (1.19% Sulfur)			Landed RFO (0.2% Sulfur)		
Date	Low	Base	High	Low	Base	High	Low	Base	High	Low	Base	High	Low	Base	High	Low	Base	High	Low	Base	High	Low	Base	High	Low	Base	High
Mar-21	53.80	61.14	66.03	69.94	79.48	85.84	52.73	59.92	64.71	9.03	9.03	9.03	10.70	10.70	10.70	78.97	88.51	94.87	70.10	78.29	83.76	73.69	82.43	88.25	78.09	87.50	93.77
Apr-21	53.82	61.16	66.05	69.97	79.51	85.87	52.74	59.94	64.73	9.03	9.03	9.03	10.70	10.70	10.70	79.00	88.54	94.90	70.12	78.32	83.78	73.71	82.45	88.28	78.11	87.52	93.79
May-21	53.47	60.76	65.62	69.51	78.99	85.31	52.40	59.54	64.31	9.03	9.03	9.03	10.70	10.70	10.70	78.54	88.02	94.34	69.72	77.87	83.30	73.29	81.98	87.77	77.66	87.01	93.24
Jun-21	52.96	60.18	64.99	68.85	78.23	84.49	51.90	58.98	63.69	9.03	9.03	9.03	10.70	10.70	10.70	77.88	87.26	93.52	69.15	77.22	82.60	72.68	81.28	87.02	77.01	86.27	92.44
Jul-21	52.38	59.52	64.28	68.09	77.38	83.57	51.33	58.33	63.00	9.03	9.03	9.03	10.70	10.70	10.70	77.12	86.41	92.60	68.50	76.48	81.80	71.99	80.50	86.17	76.26	85.42	91.52
Aug-21	51.77	58.83	63.54	67.30	76.48	82.60	50.73	57.65	62.27	9.03	9.03	9.03	10.70	10.70	10.70	76.33	85.51	91.63	67.83	75.71	80.97	71.27	79.68	85.28	75.49	84.54	90.57
Sep-21	51.17	58.15	62.80	66.52	75.60	81.64	50.15	56.99	61.55	9.03	9.03	9.03	10.70	10.70	10.70	75.55	84.63	90.67	67.16	74.95	80.15	70.55	78.87	84.41	74.72	83.66	89.63
Oct-21	50.60	57.50	62.10	65.78	74.75	80.73	49.59	56.35	60.86	9.03	9.03	9.03	10.70	10.70	10.70	74.81	83.78	89.76	66.52	74.23	79.37	69.87	78.09	83.57	73.99	82.83	88.73
Nov-21	50.10	56.93	61.48	65.13	74.01	79.93	49.10	55.79	60.25	9.03	9.03	9.03	10.70	10.70	10.70	74.16	83.04	88.96	65.96	73.59	78.68	69.28	77.41	82.84	73.34	82.10	87.94
Dec-21	49.65	56.42	60.93	64.54	73.35	79.21	48.66	55.29	59.71	9.03	9.03	9.03	10.70	10.70	10.70	73.57	82.38	88.24	65.46	73.02	78.06	68.74	76.81	82.18	72.77	81.45	87.23
Jan-22	50.15	56.99	61.55	65.28	74.19	80.12	49.15	55.85	60.32	9.05	9.05	9.05	10.70	10.70	10.70	74.33	83.24	89.17	66.06	73.71	78.81	69.41	77.56	83.00	73.51	82.29	88.14
Feb-22	50.68	57.59	62.20	65.97	74.97	80.96	49.67	56.44	60.95	9.05	9.05	9.05	10.70	10.70	10.70	75.02	84.02	90.01	66.65	74.38	79.53	70.04	78.28	83.77	74.19	83.06	88.97
Mar-22	51.69	58.74	63.44	67.29	76.46	82.58	50.66	57.57	62.17	9.05	9.05	9.05	10.70	10.70	10.70	76.34	85.51	91.63	67.78	75.66	80.92	71.24	79.65	85.25	75.49	84.53	90.57
Apr-22	52.82	60.02	64.82	68.75	78.13	84.38	51.76	58.82	63.53	9.05	9.05	9.05	10.70	10.70	10.70	77.80	87.18	93.43	69.04	77.10	82.46	72.59	81.18	86.90	76.93	86.18	92.34
May-22	53.86	61.21	66.11	70.12	79.68	86.05	52.79	59.99	64.78	9.05	9.05	9.05	10.70	10.70	10.70	79.17	88.73	95.10	70.21	78.43	83.90	73.84	82.59	88.43	78.28	87.70	93.99
Jun-22	54.86	62.34	67.33	71.41	81.15	87.64	53.76	61.09	65.98	9.05	9.05	9.05	10.70	10.70	10.70	80.46	90.20	96.69	71.33	79.69	85.27	75.02	83.94	89.89	79.55	89.15	95.56
Jul-22	55.38	62.93	67.97	72.09	81.92	88.48	54.27	61.68	66.61	9.05	9.05	9.05	10.70	10.70	10.70	81.14	90.97	97.53	71.91	80.35	85.98	75.64	84.65	90.65	80.22	89.92	96.38
Aug-22	55.55	63.13	68.18	72.31	82.17	88.75	54.44	61.86	66.81	9.05	9.05	9.05	10.70	10.70	10.70	81.36	91.22	97.80	72.10	80.57	86.21	75.85	84.88	90.90	80.44	90.16	96.64
Sep-22	55.11	62.62	67.63	71.73	81.51	88.04	54.00	61.37	66.28	9.05	9.05	9.05	10.70	10.70	10.70	80.78	90.56	97.09	71.60	80.00	85.60	75.32	84.28	90.25	79.87	89.51	95.94
Oct-22	54.67	62.12	67.09	71.16	80.86	87.33	53.57	60.88	65.75	9.05	9.05	9.05	10.70	10.70	10.70	80.21	89.91	96.38	71.11	79.44	85.00	74.79	83.68	89.60	79.31	88.87	95.25
Nov-22	54.40	61.82	66.77	70.82	80.47	86.91	53.31	60.58	65.43	9.05	9.05	9.05	10.70	10.70	10.70	79.87	89.52	95.96	70.81	79.11	84.64	74.48	83.32	89.22	78.97	88.49	94.84
Dec-22	54.41	61.83	66.77	70.82	80.48	86.92	53.32	60.59	65.44	9.05	9.05	9.05	10.70	10.70	10.70	79.87	89.53	95.97	70.82	79.11	84.64	74.48	83.33	89.22	78.97	88.49	94.84
Jan-23	54.41	61.83	66.78	70.92	80.59	87.04	53.32	60.59	65.44	9.06	9.06	9.06	10.70	10.70	10.70	79.98	89.65	96.10	70.87	79.17	84.70	74.56	83.41	89.32	79.08	88.61	94.97
Feb-23	54.41	61.83	66.78	70.92	80.59	87.04	53.32	60.59	65.44	9.06	9.06	9.06	10.70	10.70	10.70	79.98	89.65	96.10	70.87	79.17	84.70	74.56	83.41	89.32	79.08	88.61	94.97
Mar-23	54.47	61.89	66.85	70.99	80.68	87.13	53.38	60.66	65.51	9.06	9.06	9.06	10.70	10.70	10.70	80.05	89.74	96.19	70.93	79.24	84.78	74.62	83.49	89.40	79.15	88.69	95.06
Apr-23	54.69	62.15	67.12	71.28	81.00	87.48	53.59	60.90	65.77	9.06	9.06	9.06	10.70	10.70	10.70	80.34	90.06	96.54	71.18	79.52	85.08	74.89	83.79	89.72	79.43	89.02	95.40
May-23	55.38	62.93	67.96	72.18	82.03	88.59	54.27	61.67	66.60	9.06	9.06	9.06	10.70	10.70	10.70	81.24	91.09	97.65	71.95	80.40	86.03	75.71	84.72	90.73	80.32	90.02	96.49
Jun-23	56.40	64.09	69.22	73.51	83.54	90.22	55.27	62.81	67.83	9.06	9.06	9.06	10.70	10.70	10.70	82.57	92.60	99.28	73.09	81.70	87.43	76.93	86.11	92.23	81.63	91.52	98.10
Jul-23	56.46	64.15	69.29	73.59	83.62	90.31	55.33	62.87	67.90	9.06	9.06	9.06	10.70	10.70	10.70	82.65	92.68	99.37	73.16	81.77	87.51	77.00	86.18	92.31	81.70	91.60	98.19
Aug-23	56.23	63.90	69.01	73.30	83.29	89.96	55.11	62.62	67.63	9.06	9.06	9.06	10.70	10.70	10.70	82.36	92.35	99.02	72.91	81.49	87.21	76.73	85.88	91.99	81.42	91.27	97.84
Sep-23	55.24	62.77	67.79	72.00	81.82	88.37	54.14	61.52	66.44	9.06	9.06	9.06	10.72	10.72	10.72	81.06	90.88	97.43	71.81	80.24	85.85	75.55	84.54	90.54	80.14	89.82	96.28
Oct-23	54.96	62.46	67.46	71.64	81.41	87.92	53.86	61.21	66.11	9.06	9.06	9.06	10.72	10.72	10.72	80.70	90.47	96.98	71.50	79.88	85.47	75.22	84.17	90.13	79.79	89.42	95.84
Nov-23	54.99	62.49	67.49	71.68	81.45	87.97	53.89	61.24	66.14	9.06	9.06	9.06	10.72	10.72	10.72	80.74	90.51	97.03	71.53	79.92	85.51	75.26	84.21	90.17	79.82	89.46	95.88
Dec-23	55.24	62.77	67.79	72.00	81.82	88.37	54.14	61.52	66.44	9.06	9.06	9.06	10.72	10.72	10.72	81.06	90.88	97.43	71.81	80.24	85.85	75.55	84.54	90.54	80.14	89.82	96.28
Jan-24	55.40	62.95	67.99	72.30	82.16	88.73	54.29	61.69	66.63	9.07	9.07	9.07	10.75	10.75	10.75	81.37	91.23	97.80	72.05	80.50	86.14	75.82	84.84	90.86	80.44	90.16	96.64
Feb-24	55.61	63.19	68.25	72.58	82.48	89.07	54.50	61.93	66.88	9.07	9.07	9.07	10.75	10.75	10.75	81.65	91.55	98.14	72.28	80.77	86.43	76.07	85.13	91.17	80.72	90.47	96.98
Mar-24	55.66	63.26	68.32	72.65	82.56	89.16	54.55	61.99	66.95	9.07	9.07	9.07	10.75	10.75	10.75	81.72	91.63	98.23	72.35	80.84	86.51	76.14	85.21	91.25	80.79	90.56	97.07
Apr-24	55.89	63.51	68.59	72.95	82.89	89.53	54.77	62.24	67.22	9.07	9.07	9.07	10.75	10.75	10.75	82.02	91.96	98.60	72.60	81.13	86.82	76.41	85.51	91.58	81.08	90.89	97.43
May-24	56.70	64.43	69.58	74.00	84.09	90.82	55.56	63.14	68.19	9.07	9.07	9.07	10.75	10.75	10.75	83.07	93.16	99.89	73.50	82.16	87.93	77.37	86.61	92.77	82.12	92.07	98.70
Jun-24	57.68	65.55	70.79	75.29	85.55	92.40	56.53	64.24	69.38	9.07	9.07	9.07	10.75	10.75	10.75	84.36	94.62	101.47	74.61	83.41	89.28	78.55	87.95	94.21	83.39	93.51	100.26
Jul-24	57.77	65.65	70.90	75.40	85.68	92.54	56.62	64.34	69.48	9.07	9.07	9.07	10.75	10.75	10.75	84.47	94.75	101.61	74.70	83.52	89.40	78.66	88.07	94.34	83.50	93.64	100.40
Aug-24	57.47	65.31	70.53	75.01	85.24	92.06	56.32	64.00	69.12	9.07	9.07	9.07	10.75	10.75	10.75	84.08	94.31	101.13	74.37	83.14	88.99	78.30	87.66	93.90	83.11	93.20	99.92
Sep-24	56.46	64.15	69.29	73.68	83.73	90.43	55.33	62.87	67.90	9.07	9.07	9.07	10.75	10.75	10.75	82.75	92.80	99.50	73.23	81.85	87.59	77.08	86.28	92.41	81.81	91.71	98.32
Oct-24	56.17	63.83	68.94	73.32	83.31	89.98	55.05	62.56	67.56	9.07	9.07	9.07	10.75	10.75	10.75	82.39	92.38	99.05	72.91	81.49	87.21	76.75	85.90	92.00	81.44	91.30	97.87
Nov-24	56.20	63.87	68.97	73.35	83.35	90.02	55.08	62.59	67.59	9.07	9.07	9.07	10.75	10.75	10.75	82.42	92.42	99.09	72.95	81.53	87.25	76.78	85.94	92.04	81.48	91.34	97.92
Dec-24	56.46	64.15	69.29	73.68	83.73	90.43	55.33	62.87	67.90	9.07	9.07	9.07	10.75	10.75	10.75	82.75	92.80	99.50	73.23	81.85	87.59	77.08	86.28	92.41	81.81	91.71	98.32
Jan-25	56.63	64.35	69.50	74.01	84.10	90.83	55.50	63.06	68.11	9.08	9.08	9.08	10.80	10.80	10.80	83.09	93.18	99.91	73.50	82.15	87.92	77.38	86.61	92.77	82.13	92.08	98.72
Feb-25	56.75	64.49	69.65	74.17	84.28	91.02	55.62	63.20	68.26	9.08	9.08	9.08	10.80	10.80	10.80	83.25	93.36	100.10	73.64	82.31	88.08	77.52	86.78	92.95	82.29	92.26	98.91
Mar-25	56.81	64.55	69.72	74.24	84.37	91.12	55.67	63.26	68.32	9.08	9.08	9.08	10.80	10.80	10.80	83.32	93.45	100.20	73.70	82.38	88.16	77.59	86.86	93.03	82.37	92.35	99.00
Apr-25	57.04	64.82	70.00	74.54	84.71	91.49	55.90	63.52	68.60	9.08	9.08	9.08	10.80	10.80	10.80	83.62	93.79	100.57	73.96	82.67	88.48	77.87	87.17	93.37	82.66	92.68	99.36
May-25	57.76	65.64	70.89	75.48	85.78	92.64	56.60	64.32	69.47	9.08	9.08	9.08	10.80	10.80	10.80	84.56	94.86	101.72	74.77	83.59	89.47	78.73	88.15	94.43	83.59	93.74	100.50
Jun-25	58.82	66.85	72.19	76.88	87.36	94.35	57.65	65.51	70.75	9.08	9.08	9.08	10.80	10.80	10.80	85.96	96.44	103.43	75.96	84.95	90.94	80.00	89.60	95.99	84.96	95.30	102.19
Jul-25	58.88	66.91	72.26	76.95	87.45	94.44	57.70	65.57	70.82	9.08	9.08	9.08	10.80	10.80	10.80	86.03	96.53	103.52	76.02	85.02	91.02	80.07	89.67	96.08	85.04	95.38	102.28
Aug-25	58.65	66.65	71.98	76.65	87.10	94.07	57.48	65.32	70.54	9.08	9.08	9.08	10.80	10.80	10.80	85.73	96.18	103.15	75.77	84.73	90.70	79.80	89.36	95.74	84.74	95.05	101.92
Sep-25	57.61	65.47	70.71	75.30	85.56	92.41	56.46	64.16	69.29	9.08	9.08	9.08	10.80	10.80	10.80	84.38	94.64	101.49	74.60	83.41	89.27	78.56	87.95	94.22	83.41	93.53	100.28
Oct-25	57.33	65.14	70.36	74.92	85.14	91.95	56.18	63.84	68.95	9.08	9.08	9.08	10.80	10.80	10.80	84.00	94.22	101.03	74.28	83.04	88.88	78.21	87.56	93.79	83.03	93.11	99.82
Nov-25	57.44	65.27	70.49	75.07	85.30	92.13	56.29	63.96	69.08	9.08	9.08	9.08	10.80	10.80	10.80	84.15	94.38	101.21	74.41	83.18	89.03	78.35	87.71	93.96	83.18	93.27	100.00
Dec-25	57.66	65.52	70.76	75.35	85.63	92.48	56.50	64.21	69.35	9.08	9.08	9.08	10.80	10.80	10.80	84.43	94.71	101.56	74.65	83.46	89.33	78.61	88.01	94.28	83.46	93.59	100.34

Units: Nominal $ per MMBtu (2% annual inflation)

	Assumed Heat Content (MMBtu per bbl)
ULSD	5.825
RFO (2% Sulfur)	6.089
RFO (1.19% Sulfur)	5.982
RFO (0.2% Sulfur)	5.851

	Landed ULSD			Landed RFO (2.0% Sulfur)			Landed RFO (1.19% Sulfur)			Landed RFO (0.2% Sulfur)			Henry Hub			U.S. Gulf Coast LNG			LNG Shipping Cost			Landed LNG		
Date	Low	Base	High	Low	Base	High	Low	Base	High	Low	Base	High	Low	Base	High	Low	Base	High	Low	Base	High	Low	Base	High
Mar-21	13.56	15.20	16.29	11.51	12.86	13.76	12.32	13.78	14.75	13.35	14.95	16.03	2.19	2.57	2.95	5.24	5.71	6.19	1.55	1.62	1.67	6.79	7.33	7.86
Apr-21	13.56	15.20	16.29	11.52	12.86	13.76	12.32	13.78	14.76	13.35	14.96	16.03	2.07	2.56	2.95	5.09	5.70	6.18	1.41	1.48	1.54	6.49	7.19	7.72
May-21	13.48	15.11	16.20	11.45	12.79	13.68	12.25	13.70	14.67	13.27	14.87	15.94	2.05	2.58	2.97	5.07	5.73	6.21	1.39	1.47	1.53	6.46	7.20	7.74
Jun-21	13.37	14.98	16.06	11.36	12.68	13.57	12.15	13.59	14.55	13.16	14.74	15.80	2.09	2.62	3.02	5.12	5.78	6.27	1.41	1.49	1.54	6.52	7.27	7.81
Jul-21	13.24	14.83	15.90	11.25	12.56	13.44	12.03	13.46	14.40	13.03	14.60	15.64	2.14	2.69	3.09	5.18	5.86	6.36	1.42	1.50	1.56	6.60	7.36	7.92
Aug-21	13.10	14.68	15.73	11.14	12.43	13.30	11.91	13.32	14.26	12.90	14.45	15.48	2.16	2.71	3.12	5.20	5.89	6.40	1.44	1.52	1.58	6.64	7.41	7.97
Sep-21	12.97	14.53	15.57	11.03	12.31	13.16	11.79	13.18	14.11	12.77	14.30	15.32	2.15	2.70	3.11	5.19	5.88	6.39	1.56	1.64	1.70	6.75	7.52	8.08
Oct-21	12.84	14.38	15.41	10.92	12.19	13.03	11.68	13.05	13.97	12.64	14.16	15.16	2.19	2.73	3.14	5.23	5.91	6.42	1.92	2.00	2.05	7.15	7.91	8.47
Nov-21	12.73	14.26	15.27	10.83	12.09	12.92	11.58	12.94	13.85	12.53	14.03	15.03	2.26	2.79	3.21	5.33	5.99	6.51	2.06	2.13	2.19	7.38	8.12	8.71
Dec-21	12.63	14.14	15.15	10.75	11.99	12.82	11.49	12.84	13.74	12.44	13.92	14.91	2.40	2.92	3.36	5.50	6.15	6.70	2.07	2.14	2.20	7.57	8.29	8.90
Jan-22	12.76	14.29	15.31	10.85	12.11	12.94	11.60	12.97	13.87	12.56	14.06	15.06	2.61	3.02	3.48	5.82	6.33	6.89	1.99	2.06	2.12	7.81	8.39	9.02
Feb-22	12.88	14.42	15.45	10.95	12.22	13.06	11.71	13.09	14.00	12.68	14.20	15.21	2.55	2.95	3.40	5.73	6.24	6.80	1.77	1.84	1.90	7.51	8.08	8.70
Mar-22	13.11	14.68	15.73	11.13	12.43	13.29	11.91	13.31	14.25	12.90	14.45	15.48	2.36	2.81	3.23	5.50	6.06	6.59	1.63	1.70	1.76	7.14	7.77	8.35
Apr-22	13.36	14.97	16.04	11.34	12.66	13.54	12.13	13.57	14.53	13.15	14.73	15.78	1.96	2.45	2.81	5.01	5.61	6.07	1.52	1.59	1.65	6.52	7.20	7.72
May-22	13.59	15.23	16.33	11.53	12.88	13.78	12.34	13.81	14.78	13.38	14.99	16.06	1.91	2.40	2.76	4.94	5.55	6.00	1.52	1.60	1.65	6.46	7.15	7.65
Jun-22	13.81	15.48	16.60	11.71	13.09	14.00	12.54	14.03	15.03	13.60	15.24	16.33	1.94	2.43	2.80	4.98	5.59	6.05	1.53	1.60	1.66	6.51	7.20	7.71
Jul-22	13.93	15.62	16.74	11.81	13.20	14.12	12.65	14.15	15.15	13.71	15.37	16.47	1.98	2.47	2.84	5.02	5.63	6.10	1.53	1.61	1.67	6.56	7.24	7.76
Aug-22	13.97	15.66	16.79	11.84	13.23	14.16	12.68	14.19	15.20	13.75	15.41	16.52	1.99	2.48	2.85	5.04	5.65	6.11	1.53	1.61	1.67	6.57	7.26	7.78
Sep-22	13.87	15.55	16.67	11.76	13.14	14.06	12.59	14.09	15.09	13.65	15.30	16.40	1.98	2.46	2.83	5.03	5.63	6.09	1.57	1.65	1.71	6.60	7.28	7.80
Oct-22	13.77	15.44	16.55	11.68	13.05	13.96	12.50	13.99	14.98	13.55	15.19	16.28	2.01	2.49	2.86	5.06	5.66	6.12	1.93	2.01	2.07	6.99	7.67	8.19
Nov-22	13.71	15.37	16.47	11.63	12.99	13.90	12.45	13.93	14.91	13.50	15.12	16.21	2.10	2.57	2.96	5.17	5.77	6.25	2.07	2.15	2.21	7.24	7.92	8.46
Dec-22	13.71	15.37	16.48	11.63	12.99	13.90	12.45	13.93	14.92	13.50	15.12	16.21	2.29	2.74	3.15	5.41	5.97	6.49	2.09	2.16	2.22	7.50	8.14	8.71
Jan-23	13.73	15.39	16.50	11.64	13.00	13.91	12.46	13.94	14.93	13.51	15.14	16.23	2.36	2.87	3.31	5.55	6.19	6.73	2.02	2.10	2.16	7.57	8.29	8.90
Feb-23	13.73	15.39	16.50	11.64	13.00	13.91	12.46	13.94	14.93	13.51	15.14	16.23	2.32	2.83	3.26	5.50	6.14	6.67	1.80	1.88	1.94	7.30	8.01	8.61
Mar-23	13.74	15.41	16.51	11.65	13.01	13.92	12.47	13.96	14.94	13.53	15.16	16.25	2.28	2.78	3.20	5.46	6.08	6.60	1.66	1.74	1.80	7.12	7.82	8.40
Apr-23	13.79	15.46	16.57	11.69	13.06	13.97	12.52	14.01	15.00	13.58	15.21	16.31	2.29	2.79	3.21	5.46	6.08	6.61	1.58	1.66	1.72	7.04	7.74	8.32
May-23	13.95	15.64	16.76	11.82	13.20	14.13	12.66	14.16	15.17	13.73	15.39	16.49	2.34	2.85	3.28	5.53	6.16	6.70	1.59	1.67	1.73	7.11	7.83	8.43
Jun-23	14.18	15.90	17.04	12.00	13.42	14.36	12.86	14.39	15.42	13.95	15.64	16.77	2.40	2.93	3.37	5.60	6.26	6.81	1.60	1.68	1.74	7.20	7.94	8.55
Jul-23	14.19	15.91	17.06	12.01	13.43	14.37	12.87	14.41	15.43	13.96	15.65	16.78	2.44	2.97	3.42	5.65	6.32	6.88	1.60	1.68	1.74	7.25	8.00	8.62
Aug-23	14.14	15.85	17.00	11.97	13.38	14.32	12.83	14.36	15.38	13.91	15.60	16.72	2.45	2.99	3.44	5.67	6.34	6.90	1.60	1.68	1.74	7.27	8.02	8.65
Sep-23	13.92	15.60	16.73	11.79	13.18	14.10	12.63	14.13	15.13	13.70	15.35	16.45	2.47	3.01	3.47	5.69	6.37	6.94	1.64	1.72	1.79	7.33	8.09	8.72
Oct-23	13.85	15.53	16.65	11.74	13.12	14.04	12.57	14.07	15.07	13.64	15.28	16.38	2.50	3.05	3.51	5.73	6.42	6.99	2.01	2.09	2.15	7.74	8.51	9.15
Nov-23	13.86	15.54	16.66	11.75	13.13	14.04	12.58	14.08	15.07	13.64	15.29	16.39	2.57	3.13	3.60	5.81	6.52	7.11	2.15	2.23	2.30	7.96	8.75	9.40
Dec-23	13.92	15.60	16.73	11.79	13.18	14.10	12.63	14.13	15.13	13.70	15.35	16.45	2.63	3.20	3.68	5.89	6.60	7.21	2.16	2.24	2.31	8.04	8.85	9.51
Jan-24	13.97	15.66	16.79	11.83	13.22	14.15	12.67	14.18	15.19	13.75	15.41	16.52	2.65	3.23	3.71	5.96	6.69	7.29	2.08	2.17	2.23	8.04	8.85	9.53
Feb-24	14.02	15.72	16.85	11.87	13.27	14.20	12.72	14.23	15.24	13.80	15.46	16.57	2.60	3.17	3.65	5.91	6.62	7.22	1.86	1.94	2.00	7.76	8.56	9.22
Mar-24	14.03	15.73	16.86	11.88	13.28	14.21	12.73	14.24	15.25	13.81	15.48	16.59	2.56	3.12	3.59	5.85	6.55	7.14	1.72	1.80	1.86	7.57	8.35	9.00
Apr-24	14.08	15.79	16.93	11.92	13.32	14.26	12.77	14.29	15.31	13.86	15.53	16.65	2.56	3.12	3.59	5.85	6.55	7.14	1.63	1.71	1.78	7.48	8.27	8.92
May-24	14.26	15.99	17.15	12.07	13.49	14.44	12.93	14.48	15.51	14.03	15.73	16.87	2.62	3.19	3.67	5.92	6.64	7.24	1.64	1.72	1.79	7.56	8.36	9.03
Jun-24	14.48	16.24	17.42	12.25	13.70	14.66	13.13	14.70	15.75	14.25	15.98	17.13	2.68	3.27	3.76	6.00	6.74	7.35	1.65	1.74	1.80	7.65	8.48	9.16
Jul-24	14.50	16.27	17.44	12.27	13.72	14.68	13.15	14.72	15.77	14.27	16.00	17.16	2.72	3.31	3.81	6.05	6.79	7.41	1.65	1.74	1.81	7.70	8.53	9.22
Aug-24	14.43	16.19	17.36	12.21	13.65	14.62	13.09	14.65	15.70	14.20	15.93	17.08	2.71	3.31	3.81	6.05	6.79	7.41	1.65	1.74	1.81	7.70	8.53	9.22
Sep-24	14.21	15.93	17.08	12.03	13.44	14.39	12.89	14.42	15.45	13.98	15.67	16.80	2.72	3.32	3.81	6.05	6.80	7.42	1.69	1.78	1.85	7.74	8.58	9.26
Oct-24	14.14	15.86	17.00	11.98	13.38	14.32	12.83	14.36	15.38	13.92	15.60	16.73	2.74	3.34	3.84	6.08	6.83	7.45	2.07	2.15	2.22	8.14	8.98	9.67
Nov-24	14.15	15.87	17.01	11.98	13.39	14.33	12.83	14.37	15.39	13.93	15.61	16.73	2.79	3.41	3.92	6.14	6.91	7.55	2.21	2.30	2.37	8.35	9.21	9.92
Dec-24	14.21	15.93	17.08	12.03	13.44	14.39	12.89	14.42	15.45	13.98	15.67	16.80	2.84	3.46	3.98	6.20	6.98	7.63	2.21	2.30	2.37	8.42	9.28	10.00
Jan-25	14.26	16.00	17.15	12.07	13.49	14.44	12.93	14.48	15.51	14.04	15.74	16.87	2.84	3.47	3.99	6.26	7.04	7.69	2.14	2.23	2.30	8.40	9.27	9.99
Feb-25	14.29	16.03	17.19	12.09	13.52	14.47	12.96	14.51	15.54	14.06	15.77	16.90	2.78	3.39	3.90	6.18	6.95	7.58	1.90	1.99	2.06	8.09	8.94	9.65
Mar-25	14.30	16.04	17.20	12.10	13.53	14.48	12.97	14.52	15.55	14.08	15.78	16.92	2.72	3.32	3.81	6.10	6.85	7.47	1.76	1.85	1.92	7.87	8.70	9.39
Apr-25	14.36	16.10	17.26	12.15	13.58	14.53	13.02	14.57	15.61	14.13	15.84	16.98	2.70	3.30	3.79	6.09	6.83	7.45	1.67	1.76	1.83	7.76	8.59	9.27
May-25	14.52	16.28	17.46	12.28	13.73	14.69	13.16	14.74	15.78	14.29	16.02	17.18	2.75	3.35	3.86	6.14	6.90	7.53	1.68	1.77	1.84	7.82	8.67	9.36
Jun-25	14.76	16.56	17.76	12.48	13.95	14.94	13.37	14.98	16.05	14.52	16.29	17.46	2.80	3.42	3.93	6.21	6.98	7.62	1.69	1.78	1.85	7.90	8.76	9.47
Jul-25	14.77	16.57	17.77	12.49	13.96	14.95	13.39	14.99	16.06	14.53	16.30	17.48	2.83	3.45	3.97	6.25	7.02	7.67	1.69	1.78	1.85	7.94	8.80	9.52
Aug-25	14.72	16.51	17.71	12.44	13.92	14.90	13.34	14.94	16.00	14.48	16.24	17.42	2.83	3.45	3.96	6.24	7.02	7.66	1.69	1.78	1.85	7.93	8.80	9.51
Sep-25	14.49	16.25	17.42	12.25	13.70	14.66	13.13	14.70	15.75	14.25	15.98	17.14	2.83	3.45	3.96	6.24	7.01	7.66	1.73	1.82	1.89	7.97	8.84	9.55
Oct-25	14.42	16.17	17.34	12.20	13.64	14.60	13.07	14.64	15.68	14.19	15.91	17.06	2.84	3.47	3.99	6.26	7.04	7.69	2.11	2.20	2.27	8.37	9.24	9.96
Nov-25	14.45	16.20	17.37	12.22	13.66	14.62	13.10	14.66	15.71	14.22	15.94	17.09	2.90	3.53	4.06	6.33	7.12	7.78	2.26	2.35	2.42	8.58	9.47	10.20
Dec-25	14.49	16.26	17.43	12.26	13.71	14.67	13.14	14.71	15.76	14.26	15.99	17.15	2.94	3.59	4.12	6.38	7.19	7.86	2.26	2.36	2.43	8.64	9.54	10.29

Units: Nominal $ per bbl (2% annual inflation)

		WTI			MOPS ULSD			MOPS RFO (3.5% Sulfur)			ULSD Premium			RFO Premium			Landed ULSD			Landed RFO (2.0% Sulfur)			Landed RFO (1.19% Sulfur)			Landed RFO (0.2% Sulfur)	
Year	Low	Base	High	Low	Base	High	Low	Base	High	Low	Base	High	Low	Base	High	Low	Base	High	Low	Base	High	Low	Base	High	Low	Base	High
2021	52.41	58.32	62.26	67.51	75.36	80.31	51.37	57.15	61.01	9.03	9.03	9.03	10.70	10.70	10.70	76.54	84.39	89.34	68.28	74.88	79.27	71.62	78.66	83.35	75.72	83.29	88.34
2022	53.63	60.94	65.82	69.81	79.33	85.68	52.56	59.73	64.50	9.05	9.05	9.05	10.70	10.70	10.70	78.86	88.38	94.73	69.95	78.13	83.58	73.56	82.28	88.09	77.98	87.36	93.62
2023	55.24	62.77	67.79	72.00	81.82	88.37	54.14	61.52	66.44	9.06	9.06	9.06	10.71	10.71	10.71	81.06	90.88	97.43	71.80	80.23	85.85	75.55	84.54	90.53	80.14	89.82	96.28
2024	56.46	64.15	69.29	73.68	83.73	90.43	55.33	62.87	67.90	9.07	9.07	9.07	10.75	10.75	10.75	82.75	92.80	99.50	73.23	81.85	87.60	77.08	86.28	92.41	81.81	91.71	98.32
2025	57.61	65.47	70.71	75.30	85.56	92.41	56.46	64.16	69.30	9.08	9.08	9.08	10.80	10.80	10.80	84.38	94.64	101.49	74.60	83.41	89.27	78.56	87.95	94.22	83.41	93.53	100.28
2026	57.75	69.04	74.69	76.94	95.22	98.08	57.62	71.31	73.45	9.44	10.07	10.17	11.14	11.88	12.00	86.38	105.29	108.24	76.32	92.67	95.23	80.39	97.77	100.49	85.38	104.03	106.95
2027	59.65	73.24	80.13	78.16	95.97	105.00	58.46	71.77	78.53	9.62	10.23	10.54	11.35	12.07	12.44	87.78	106.20	115.54	77.52	93.44	101.51	81.67	98.60	107.19	86.76	104.93	114.15
2028	62.14	77.74	84.23	81.53	102.00	110.51	60.90	76.19	82.54	9.87	10.58	10.87	11.65	12.48	12.83	91.40	112.58	121.38	80.64	98.93	106.53	84.99	104.45	112.54	90.33	111.22	119.90
2029	65.74	81.43	88.60	86.36	106.98	116.41	64.42	79.80	86.83	10.18	10.89	11.21	12.01	12.85	13.23	96.54	117.86	127.62	85.06	103.46	111.89	89.71	109.29	118.25	95.40	116.43	126.06
2030	68.25	86.01	93.77	89.78	113.15	123.36	66.88	84.29	91.90	10.44	11.25	11.60	12.32	13.27	13.68	100.22	124.40	134.96	88.22	109.07	118.19	93.08	115.27	124.97	99.03	122.87	133.29
2031	71.66	89.65	98.92	94.39	118.09	130.30	70.23	87.85	96.94	10.75	11.56	11.98	12.68	13.64	14.14	105.14	129.65	142.28	92.44	113.57	124.46	97.58	120.07	131.67	103.88	128.05	140.51
2032	73.96	93.61	103.86	97.55	123.47	136.98	72.48	91.74	101.78	11.00	11.90	12.36	12.98	14.04	14.59	108.56	135.36	149.35	95.37	118.47	130.51	100.71	125.30	138.13	107.25	133.68	147.47
2033	77.47	96.84	109.33	102.31	127.90	144.40	75.92	94.91	107.15	11.32	12.20	12.77	13.36	14.40	15.07	113.63	140.10	157.17	99.72	122.51	137.21	105.35	129.63	145.28	112.25	138.35	155.18
2034	80.58	100.12	114.87	106.55	132.40	151.90	78.96	98.12	112.57	11.62	12.51	13.18	13.71	14.76	15.55	118.18	144.91	165.09	103.62	126.62	143.98	109.51	134.02	152.52	116.73	143.09	162.99
2035	82.99	103.34	118.40	109.89	136.83	156.78	81.33	101.27	116.03	11.89	12.82	13.51	14.04	15.13	15.94	121.78	149.65	170.29	106.70	130.66	148.41	112.80	138.35	157.26	120.28	147.77	168.11
2036	86.19	107.27	122.86	114.27	142.23	162.90	84.47	105.12	120.40	12.21	13.17	13.88	14.40	15.54	16.38	126.48	155.39	176.78	110.72	135.56	153.94	117.09	143.59	163.18	124.92	153.42	174.51
2037	89.35	111.38	128.57	118.62	147.87	170.68	87.56	109.15	125.99	12.52	13.53	14.31	14.78	15.96	16.89	131.14	161.39	184.99	114.69	140.68	160.95	121.35	149.06	170.68	129.50	159.34	182.60
2038	93.59	115.93	132.70	124.42	154.10	176.40	91.72	113.61	130.05	12.89	13.91	14.68	15.21	16.41	17.32	137.31	168.01	191.08	119.96	146.32	166.12	126.98	155.10	176.21	135.58	165.86	188.59
2039	94.61	118.73	136.60	125.93	158.04	181.81	92.72	116.36	133.86	13.11	14.22	15.03	15.47	16.78	17.74	139.04	172.26	196.85	121.43	149.92	171.01	128.56	158.96	181.46	137.29	170.04	194.28
2040	100.10	125.17	144.07	133.41	166.82	192.01	98.10	122.66	141.19	13.55	14.69	15.56	15.98	17.34	18.36	146.96	181.51	207.57	128.19	157.81	180.15	135.78	167.40	191.24	145.09	179.16	204.84
2041	103.81	130.07	146.81	138.54	173.58	195.92	101.74	127.47	143.88	13.90	15.10	15.87	16.40	17.82	18.73	152.44	188.68	211.79	132.85	163.91	183.70	140.77	173.93	195.07	150.49	186.22	209.00
2042	107.09	134.21	150.78	143.10	179.34	201.48	104.95	131.53	147.77	14.24	15.48	16.24	16.80	18.27	19.17	157.34	194.82	217.72	137.02	169.11	188.72	145.24	179.51	200.45	155.32	192.27	214.84
2043	110.43	138.89	157.89	147.75	185.82	211.24	108.22	136.11	154.73	14.58	15.89	16.77	17.21	18.75	19.78	162.33	201.71	228.01	141.26	174.96	197.46	149.78	185.78	209.82	160.24	199.06	224.97
2044	115.17	142.86	164.44	154.29	191.38	220.29	112.86	140.00	161.15	15.00	16.27	17.27	17.70	19.20	20.37	169.28	207.65	237.56	147.17	179.98	205.56	156.12	191.18	218.50	167.09	204.90	234.38
2045	119.56	143.61	169.38	160.38	192.64	227.20	117.17	140.74	165.99	15.40	16.51	17.70	18.17	19.48	20.88	175.78	209.15	244.90	152.69	181.21	211.77	162.03	192.51	225.17	173.48	206.37	241.61
2046	124.53	150.91	176.11	167.25	202.69	236.53	122.03	147.89	172.59	15.83	17.05	18.21	18.68	20.12	21.49	183.08	219.74	254.74	158.89	190.20	220.10	168.68	202.15	234.12	180.68	216.80	251.30
2047	128.54	155.21	181.21	172.87	208.73	243.69	125.97	152.11	177.58	16.23	17.46	18.66	19.15	20.60	22.02	189.10	226.19	262.35	163.99	195.65	226.52	174.15	208.01	241.01	186.60	223.16	258.79
2048	130.75	157.91	184.72	176.07	212.64	248.73	128.14	154.75	181.02	16.54	17.80	19.04	19.52	21.00	22.46	192.61	230.43	267.77	166.94	199.21	231.06	177.33	211.84	245.91	190.06	227.33	264.12
2049	135.06	161.03	190.50	182.10	217.12	256.85	132.36	157.81	186.69	16.96	18.16	19.52	20.01	21.43	23.04	199.05	235.28	276.37	172.40	203.28	238.32	183.18	216.22	253.72	196.40	232.10	272.59
2050	139.39	165.06	195.34	188.18	222.84	263.71	136.60	161.76	191.44	17.38	18.57	19.97	20.51	21.91	23.57	205.56	241.40	283.69	177.89	208.44	244.47	189.08	221.78	260.33	202.81	238.13	279.79
CAGR	3.4%	3.7%	4.0%	3.6%	3.8%	4.2%	3.4%	3.7%	4.0%	2.3%	2.5%	2.8%	2.3%	2.5%	2.8%	3.5%	3.7%	4.1%	3.4%	3.6%	4.0%	3.4%	3.6%	4.0%	3.5%	3.7%	4.1%

Units: 2020 dollars per bbl

	WTI			MOPS ULSD			MOPS RFO (3.5% Sulfur)			ULSD Premium			RFO Premium			Landed ULSD			Landed RFO (2.0% Sulfur)			Landed RFO (1.19% Sulfur)			Landed RFO (0.2% Sulfur)		
Year	Low	Base	High	Low	Base	High	Low	Base	High	Low	Base	High	Low	Base	High	Low	Base	High	Low	Base	High	Low	Base	High	Low	Base	High
2021	51.38	57.18	61.04	66.19	73.88	78.74	50.36	56.03	59.81	8.85	8.85	8.85	10.49	10.49	10.49	75.04	82.74	87.59	66.94	73.41	77.72	70.22	77.12	81.72	74.24	81.66	86.61
2022	51.55	58.58	63.26	67.10	76.25	82.35	50.52	57.41	62.00	8.70	8.70	8.70	10.28	10.28	10.28	75.80	84.95	91.05	67.24	75.10	80.33	70.70	79.08	84.67	74.95	83.97	89.99
2023	52.05	59.15	63.88	67.85	77.10	83.27	51.01	57.97	62.61	8.54	8.54	8.54	10.09	10.09	10.09	76.39	85.64	91.81	67.66	75.60	80.89	71.19	79.66	85.31	75.52	84.64	90.72
2024	52.16	59.27	64.01	68.07	77.36	83.54	51.11	58.08	62.73	8.38	8.38	8.38	9.93	9.93	9.93	76.45	85.74	91.92	67.65	75.62	80.92	71.21	79.71	85.37	75.58	84.73	90.83
2025	52.18	59.30	64.04	68.20	77.50	83.70	51.14	58.11	62.76	8.22	8.22	8.22	9.78	9.78	9.78	76.42	85.72	91.92	67.57	75.54	80.86	71.15	79.66	85.33	75.54	84.71	90.82
2026	51.28	61.31	66.32	68.32	84.55	87.09	51.16	63.32	65.22	8.38	8.94	9.03	9.89	10.55	10.65	76.70	93.49	96.12	67.77	82.29	84.56	71.38	86.82	89.23	75.82	92.38	94.97
2027	51.93	63.76	69.76	68.04	83.55	91.41	50.89	62.48	68.37	8.37	8.91	9.18	9.88	10.51	10.83	76.42	92.45	100.59	67.48	81.34	88.37	71.10	85.84	93.31	75.53	91.35	99.37
2028	53.04	66.35	71.89	69.59	87.06	94.32	51.98	65.03	70.45	8.43	9.03	9.28	9.94	10.65	10.95	78.01	96.09	103.60	68.82	84.43	90.92	72.54	89.15	96.05	77.10	94.93	102.34
2029	55.01	68.13	74.14	72.27	89.51	97.40	53.91	66.77	72.66	8.52	9.11	9.38	10.05	10.75	11.07	80.78	98.62	106.79	71.18	86.57	93.62	75.06	91.45	98.95	79.83	97.43	105.48
2030	55.99	70.56	76.93	73.65	92.82	101.20	54.87	69.15	75.39	8.57	9.22	9.51	10.11	10.89	11.23	82.22	102.05	110.71	72.37	89.48	96.95	76.36	94.56	102.52	81.24	100.80	109.35
2031	57.63	72.10	79.56	75.92	94.97	104.79	56.48	70.66	77.97	8.64	9.30	9.64	10.20	10.97	11.37	84.56	104.27	114.43	74.35	91.34	100.10	78.48	96.57	105.90	83.54	102.98	113.01
2032	58.32	73.81	81.89	76.92	97.35	108.01	57.15	72.33	80.25	8.68	9.38	9.75	10.24	11.07	11.50	85.60	106.73	117.76	75.20	93.41	102.91	79.41	98.80	108.92	84.56	105.41	116.28
2033	59.89	74.86	84.52	79.09	98.87	111.62	58.69	73.37	82.83	8.75	9.43	9.87	10.33	11.13	11.65	87.84	108.30	121.49	77.09	94.71	106.07	81.44	100.21	112.31	86.77	106.95	119.96
2034	61.07	75.88	87.06	80.76	100.34	115.12	59.85	74.36	85.32	8.81	9.48	9.99	10.39	11.19	11.79	89.56	109.83	125.11	78.53	95.96	109.12	82.99	101.57	115.59	88.47	108.45	123.53
2035	61.66	76.78	87.97	81.65	101.67	116.49	60.43	75.24	86.21	8.84	9.53	10.04	10.43	11.24	11.84	90.49	111.19	126.52	79.28	97.09	110.27	83.81	102.79	116.85	89.37	109.79	124.91
2036	62.78	78.14	89.50	83.24	103.60	118.66	61.53	76.58	87.71	8.89	9.59	10.11	10.49	11.32	11.93	92.14	113.20	128.77	80.65	98.75	112.14	85.30	104.59	118.87	90.99	111.76	127.12
2037	63.81	79.54	91.82	84.71	105.60	121.90	62.53	77.95	89.98	8.94	9.66	10.22	10.55	11.40	12.06	93.65	115.26	132.12	81.91	100.47	114.94	86.66	106.45	121.89	92.49	113.79	130.41
2038	65.53	81.17	92.91	87.11	107.90	123.51	64.22	79.54	91.05	9.02	9.74	10.28	10.65	11.49	12.13	96.14	117.64	133.78	83.99	102.45	116.31	88.91	108.59	123.38	94.93	116.13	132.05
2039	64.94	81.50	93.76	86.44	108.48	124.80	63.65	79.87	91.89	9.00	9.76	10.32	10.62	11.52	12.18	95.44	118.24	135.12	83.35	102.91	117.39	88.24	109.11	124.56	94.24	116.72	133.36
2040	67.37	84.23	96.95	89.78	112.26	129.22	66.02	82.55	95.01	9.12	9.89	10.47	10.76	11.67	12.36	98.90	122.15	139.69	86.27	106.20	121.23	91.38	112.65	128.70	97.64	120.57	137.85
2041	68.49	85.82	96.86	91.40	114.52	129.26	67.12	84.10	94.93	9.17	9.97	10.47	10.82	11.76	12.36	100.57	124.49	139.73	87.65	108.14	121.20	92.88	114.76	128.70	99.29	122.86	137.89
2042	69.27	86.81	97.53	92.56	116.00	130.32	67.89	85.08	95.58	9.21	10.02	10.51	10.87	11.82	12.40	101.77	126.02	140.83	88.63	109.39	122.07	93.95	116.12	129.66	100.46	124.37	138.97
2043	70.03	88.08	100.13	93.69	117.84	133.96	68.63	86.32	98.12	9.25	10.08	10.63	10.91	11.89	12.55	102.94	127.92	144.59	89.58	110.95	125.22	94.99	117.82	133.06	101.61	126.23	142.67
2044	71.60	88.82	102.23	95.92	118.98	136.96	70.17	87.04	100.19	9.32	10.12	10.73	11.00	11.94	12.67	105.25	129.10	147.69	91.50	111.90	127.80	97.06	118.86	135.85	103.88	127.39	145.72
2045	72.88	87.54	103.24	97.75	117.42	138.49	71.42	85.79	101.18	9.39	10.06	10.79	11.08	11.87	12.73	107.14	127.48	149.27	93.07	110.45	129.08	98.76	117.34	137.25	105.74	125.79	147.27
2046	74.41	90.18	105.24	99.95	121.12	141.35	72.93	88.38	103.13	9.46	10.19	10.88	11.16	12.02	12.84	109.41	131.31	152.23	94.95	113.66	131.53	100.80	120.80	139.90	107.97	129.56	150.17
2047	75.31	90.93	106.16	101.28	122.29	142.77	73.80	89.11	104.04	9.51	10.23	10.93	11.22	12.07	12.90	110.78	132.52	153.70	96.07	114.63	132.71	102.03	121.86	141.20	109.32	130.74	151.61
2048	75.10	90.70	106.10	101.13	122.13	142.87	73.60	88.89	103.98	9.50	10.22	10.93	11.21	12.06	12.90	110.63	132.36	153.80	95.89	114.42	132.72	101.85	121.68	141.25	109.16	130.57	151.70
2049	76.05	90.68	107.27	102.54	122.26	144.64	74.53	88.87	105.13	9.55	10.23	10.99	11.27	12.07	12.97	112.09	132.49	155.63	97.08	114.47	134.20	103.15	121.76	142.87	110.60	130.70	153.50
2050	76.95	91.13	107.84	103.89	123.02	145.59	75.41	89.30	105.69	9.59	10.25	11.03	11.32	12.10	13.01	113.48	133.27	156.61	98.21	115.07	134.96	104.39	122.44	143.72	111.96	131.46	154.46
CAGR	1.4%	1.6%	2.0%	1.6%	1.8%	2.1%	1.4%	1.6%	2.0%	0.3%	0.5%	0.8%	0.3%	0.5%	0.7%	1.4%	1.7%	2.0%	1.3%	1.6%	1.9%	1.4%	1.6%	2.0%	1.4%	1.7%	2.0%

Units: Nominal $ per MMBtu (2% annual inflation)

	Assumed Heat Content (MMBtu per bbl)
ULSD	5.825
RFO (2% Sulfur)	6.089
RFO (1.19% Sulfur)	5.982
RFO (0.2% Sulfur)	5.851

	Landed ULSD			Landed RFO (2.0% Sulfur)			Landed RFO (1.19% Sulfur)			Landed RFO (0.2% Sulfur)			Henry Hub			U.S. Gulf Coast LNG			LNG Shipping Cost			Landed LNG		
Year	Low	Base	High	Low	Base	High	Low	Base	High	Low	Base	High	Low	Base	High	Low	Base	High	Low	Base	High	Low	Base	High
2021	13.14	14.49	15.34	11.21	12.30	13.02	11.97	13.15	13.93	12.94	14.23	15.10	2.46	2.89	3.23	5.58	6.11	6.53	1.70	1.77	1.81	7.28	7.88	8.34
2022	13.54	15.17	16.26	11.49	12.83	13.73	12.30	13.75	14.73	13.33	14.93	16.00	2.14	2.61	3.00	5.23	5.81	6.30	1.73	1.80	1.86	6.95	7.61	8.15
2023	13.92	15.60	16.73	11.79	13.18	14.10	12.63	14.13	15.13	13.70	15.35	16.45	2.42	2.95	3.40	5.63	6.29	6.85	1.78	1.86	1.93	7.41	8.15	8.77
2024	14.21	15.93	17.08	12.03	13.44	14.39	12.89	14.42	15.45	13.98	15.67	16.80	2.68	3.27	3.76	6.01	6.74	7.35	1.84	1.92	1.99	7.84	8.67	9.35
2025	14.49	16.25	17.42	12.25	13.70	14.66	13.13	14.70	15.75	14.25	15.98	17.14	2.81	3.43	3.95	6.22	7.00	7.64	1.88	1.97	2.04	8.11	8.97	9.68
2026	14.83	17.97	18.47	12.53	15.10	15.52	13.44	16.23	16.69	14.59	17.67	18.17	2.89	3.53	4.06	6.38	7.17	7.83	1.94	2.06	2.12	8.32	9.23	9.95
2027	15.07	18.10	19.70	12.73	15.20	16.53	13.65	16.34	17.78	14.83	17.80	19.37	2.96	3.60	4.14	6.51	7.32	8.00	1.98	2.10	2.18	8.49	9.42	10.17
2028	15.69	19.17	20.68	13.24	16.08	17.33	14.21	17.30	18.65	15.44	18.85	20.33	3.03	3.69	4.24	6.65	7.48	8.18	2.02	2.15	2.23	8.68	9.64	10.41
2029	16.57	20.05	21.73	13.97	16.80	18.18	15.00	18.08	19.58	16.30	19.72	21.36	3.12	3.81	4.38	6.83	7.69	8.41	2.08	2.21	2.30	8.91	9.90	10.70
2030	17.21	21.15	22.96	14.49	17.70	19.19	15.56	19.06	20.68	16.92	20.79	22.57	3.24	3.95	4.55	7.04	7.93	8.67	2.13	2.28	2.36	9.17	10.21	11.03
2031	18.05	22.03	24.19	15.18	18.41	20.20	16.31	19.83	21.77	17.75	21.65	23.78	3.38	4.12	4.74	7.27	8.20	8.98	2.19	2.34	2.44	9.47	10.54	11.41
2032	18.64	22.98	25.38	15.66	19.19	21.16	16.83	20.68	22.83	18.33	22.59	24.95	3.56	4.34	4.99	7.55	8.53	9.34	2.25	2.41	2.51	9.80	10.94	11.86
2033	19.51	23.77	26.70	16.38	19.82	22.24	17.61	21.38	23.99	19.18	23.36	26.24	3.72	4.54	5.22	7.82	8.85	9.70	2.31	2.47	2.59	10.14	11.32	12.29
2034	20.29	24.57	28.03	17.02	20.47	23.32	18.31	22.08	25.18	19.95	24.14	27.54	3.89	4.74	5.45	8.09	9.16	10.05	2.37	2.54	2.67	10.47	11.70	12.72
2035	20.91	25.35	28.90	17.52	21.10	24.02	18.86	22.78	25.94	20.56	24.91	28.39	4.06	4.95	5.69	8.37	9.49	10.41	2.43	2.61	2.74	10.81	12.09	13.16
2036	21.71	26.31	29.98	18.18	21.88	24.90	19.57	23.63	26.90	21.35	25.85	29.46	4.20	5.12	5.89	8.61	9.77	10.73	2.49	2.67	2.81	11.11	12.44	13.54
2037	22.51	27.31	31.37	18.84	22.69	26.02	20.28	24.51	28.12	22.13	26.84	30.81	4.32	5.27	6.06	8.84	10.02	11.01	2.56	2.74	2.89	11.39	12.77	13.90
2038	23.57	28.42	32.38	19.70	23.59	26.84	21.23	25.49	29.02	23.17	27.92	31.81	4.42	5.39	6.20	9.03	10.24	11.25	2.62	2.81	2.96	11.65	13.05	14.21
2039	23.87	29.12	33.34	19.94	24.14	27.61	21.49	26.10	29.87	23.46	28.61	32.75	4.51	5.50	6.32	9.21	10.44	11.48	2.67	2.87	3.03	11.88	13.31	14.50
2040	25.23	30.68	35.15	21.05	25.41	29.08	22.70	27.48	31.47	24.80	30.13	34.52	4.59	5.60	6.44	9.38	10.64	11.69	2.74	2.95	3.11	12.12	13.59	14.80
2041	26.17	31.88	35.85	21.82	26.38	29.63	23.53	28.55	32.08	25.72	31.31	35.20	4.68	5.71	6.56	9.56	10.85	11.92	2.80	3.02	3.17	12.36	13.86	15.09
2042	27.01	32.90	36.83	22.50	27.20	30.42	24.28	29.45	32.95	26.54	32.31	36.17	4.77	5.82	6.69	9.75	11.06	12.15	2.86	3.08	3.24	12.61	14.14	15.39
2043	27.87	34.05	38.57	23.20	28.13	31.82	25.04	30.46	34.48	27.39	33.44	37.87	4.87	5.94	6.83	9.95	11.29	12.40	2.93	3.16	3.32	12.88	14.44	15.72
2044	29.06	35.04	40.17	24.17	28.92	33.12	26.10	31.33	35.90	28.56	34.41	39.44	4.99	6.08	6.99	10.17	11.54	12.68	3.00	3.23	3.41	13.17	14.77	16.09
2045	30.18	35.26	41.40	25.08	29.08	34.10	27.09	31.52	36.98	29.65	34.62	40.65	5.14	6.26	7.20	10.44	11.85	13.03	3.08	3.29	3.49	13.52	15.14	16.52
2046	31.43	37.05	43.06	26.10	30.52	35.44	28.20	33.09	38.44	30.88	36.37	42.27	5.49	6.69	7.70	10.96	12.47	13.72	3.17	3.40	3.61	14.13	15.87	17.33
2047	32.46	38.12	44.33	26.93	31.38	36.45	29.11	34.04	39.55	31.89	37.42	43.51	5.95	7.25	8.34	11.62	13.25	14.61	3.27	3.52	3.73	14.89	16.77	18.35
2048	33.07	38.81	45.22	27.42	31.93	37.16	29.64	34.64	40.34	32.48	38.10	44.39	6.50	7.92	9.11	12.39	14.17	15.65	3.38	3.63	3.86	15.76	17.80	19.52
2049	34.17	39.61	46.66	28.31	32.56	38.32	30.62	35.34	41.60	33.57	38.88	45.80	7.04	8.59	9.88	13.16	15.09	16.70	3.49	3.75	4.00	16.64	18.84	20.70
2050	35.29	40.62	47.88	29.22	33.37	39.29	31.61	36.23	42.67	34.66	39.87	46.99	7.26	8.85	10.18	13.51	15.50	17.16	3.57	3.83	4.09	17.08	19.33	21.25
CAGR	3.5%	3.6%	4.0%	3.4%	3.5%	3.9%	3.4%	3.6%	3.9%	3.5%	3.6%	4.0%	3.8%	3.9%	4.0%	3.1%	3.3%	3.4%	2.6%	2.7%	2.9%	3.0%	3.1%	3.3%

Units: 2020 dollars per MMBtu

Assumed Heat Content (MMBtu per bbl)	
ULSD	5.825
RFO (2% Sulfur)	6.089
RFO (1.19% Sulfur)	5.982
RFO (0.2% Sulfur)	5.851

	Landed ULSD			Landed RFO (2.0% Sulfur)			Landed RFO (1.19% Sulfur)			Landed RFO (0.2% Sulfur)			Henry Hub			U.S. Gulf Coast LNG			LNG Shipping Cost			Landed LNG		
Year	Low	Base	High	Low	Base	High	Low	Base	High	Low	Base	High	Low	Base	High	Low	Base	High	Low	Base	High	Low	Base	High
2021	12.88	14.20	15.04	10.99	12.06	12.76	11.74	12.89	13.66	12.69	13.96	14.80	2.41	2.83	3.17	5.47	5.99	6.40	1.67	1.74	1.77	7.14	7.73	8.18
2022	13.01	14.58	15.63	11.04	12.33	13.19	11.82	13.22	14.15	12.81	14.35	15.38	2.06	2.51	2.88	5.02	5.58	6.05	1.66	1.73	1.78	6.68	7.31	7.84
2023	13.11	14.70	15.76	11.11	12.42	13.29	11.90	13.32	14.26	12.91	14.47	15.50	2.28	2.78	3.20	5.30	5.93	6.45	1.68	1.76	1.81	6.98	7.68	8.27
2024	13.12	14.72	15.78	11.11	12.42	13.29	11.90	13.32	14.27	12.92	14.48	15.52	2.48	3.02	3.47	5.55	6.23	6.79	1.70	1.78	1.84	7.25	8.01	8.63
2025	13.12	14.72	15.78	11.10	12.41	13.28	11.89	13.32	14.26	12.91	14.48	15.52	2.55	3.11	3.57	5.64	6.34	6.92	1.70	1.79	1.85	7.34	8.12	8.77
2026	13.17	15.95	16.40	11.13	13.41	13.78	11.93	14.41	14.82	12.96	15.69	16.13	2.57	3.13	3.60	5.66	6.37	6.95	1.72	1.83	1.88	7.38	8.20	8.83
2027	13.12	15.76	17.15	11.08	13.24	14.39	11.88	14.23	15.48	12.91	15.50	16.87	2.57	3.14	3.61	5.67	6.37	6.96	1.72	1.83	1.89	7.39	8.20	8.86
2028	13.39	16.36	17.65	11.30	13.73	14.79	12.13	14.76	15.92	13.18	16.09	17.36	2.58	3.15	3.62	5.68	6.39	6.98	1.73	1.84	1.91	7.41	8.23	8.88
2029	13.87	16.78	18.18	11.69	14.06	15.22	12.55	15.13	16.38	13.64	16.50	17.87	2.61	3.19	3.67	5.72	6.44	7.03	1.74	1.85	1.92	7.46	8.29	8.95
2030	14.11	17.35	18.84	11.89	14.52	15.74	12.76	15.63	16.96	13.88	17.06	18.52	2.66	3.24	3.73	5.77	6.50	7.11	1.75	1.87	1.94	7.52	8.37	9.05
2031	14.52	17.71	19.46	12.21	14.81	16.24	13.12	15.95	17.51	14.28	17.41	19.13	2.72	3.32	3.81	5.85	6.60	7.22	1.76	1.88	1.96	7.61	8.48	9.18
2032	14.69	18.12	20.01	12.35	15.13	16.69	13.27	16.31	18.00	14.45	17.81	19.67	2.80	3.42	3.93	5.96	6.73	7.37	1.77	1.90	1.98	7.73	8.63	9.35
2033	15.08	18.37	20.64	12.66	15.32	17.19	13.61	16.52	18.55	14.83	18.06	20.28	2.88	3.51	4.04	6.05	6.84	7.50	1.79	1.91	2.00	7.84	8.75	9.50
2034	15.38	18.62	21.24	12.90	15.51	17.67	13.87	16.74	19.08	15.12	18.30	20.87	2.95	3.59	4.13	6.13	6.94	7.62	1.80	1.92	2.02	7.93	8.87	9.64
2035	15.53	18.84	21.47	13.02	15.68	17.85	14.01	16.92	19.27	15.27	18.51	21.10	3.02	3.68	4.23	6.22	7.05	7.74	1.81	1.94	2.04	8.03	8.99	9.78
2036	15.82	19.17	21.84	13.25	15.94	18.14	14.26	17.21	19.60	15.55	18.83	21.46	3.06	3.73	4.29	6.27	7.11	7.81	1.82	1.95	2.05	8.09	9.06	9.86
2037	16.08	19.51	22.40	13.45	16.20	18.58	14.49	17.50	20.09	15.81	19.16	22.00	3.09	3.77	4.33	6.31	7.16	7.86	1.82	1.96	2.07	8.14	9.12	9.93
2038	16.50	19.90	22.67	13.79	16.51	18.79	14.86	17.85	20.32	16.22	19.55	22.27	3.10	3.78	4.34	6.32	7.17	7.88	1.83	1.97	2.07	8.16	9.14	9.95
2039	16.39	19.99	22.89	13.69	16.57	18.95	14.75	17.92	20.50	16.11	19.64	22.48	3.10	3.77	4.34	6.32	7.17	7.88	1.83	1.97	2.08	8.15	9.14	9.95
2040	16.98	20.65	23.66	14.17	17.10	19.57	15.28	18.50	21.18	16.69	20.28	23.23	3.09	3.77	4.33	6.31	7.16	7.87	1.84	1.98	2.09	8.16	9.15	9.96
2041	17.27	21.03	23.65	14.40	17.40	19.55	15.53	18.83	21.16	16.97	20.66	23.23	3.09	3.76	4.33	6.31	7.16	7.86	1.85	1.99	2.09	8.16	9.15	9.95
2042	17.47	21.28	23.82	14.56	17.59	19.68	15.70	19.05	21.31	17.17	20.90	23.40	3.08	3.76	4.33	6.31	7.15	7.86	1.85	2.00	2.10	8.16	9.15	9.95
2043	17.67	21.59	24.46	14.71	17.84	20.18	15.88	19.32	21.86	17.37	21.21	24.01	3.09	3.77	4.33	6.31	7.16	7.86	1.86	2.00	2.11	8.17	9.16	9.97
2044	18.07	21.78	24.98	15.03	17.98	20.59	16.23	19.48	22.32	17.75	21.39	24.52	3.10	3.78	4.35	6.33	7.18	7.88	1.87	2.01	2.12	8.19	9.18	10.00
2045	18.39	21.49	25.23	15.29	17.73	20.79	16.51	19.21	22.54	18.07	21.10	24.77	3.13	3.82	4.39	6.36	7.22	7.94	1.88	2.00	2.13	8.24	9.23	10.07
2046	18.78	22.14	25.73	15.59	18.24	21.18	16.85	19.78	22.97	18.45	21.74	25.26	3.28	4.00	4.60	6.55	7.45	8.20	1.90	2.03	2.16	8.45	9.48	10.36
2047	19.02	22.33	25.97	15.78	18.39	21.36	17.06	19.94	23.17	18.68	21.93	25.49	3.49	4.25	4.89	6.81	7.76	8.56	1.92	2.06	2.19	8.73	9.82	10.75
2048	18.99	22.29	25.97	15.75	18.34	21.34	17.03	19.90	23.17	18.66	21.88	25.50	3.73	4.55	5.23	7.11	8.14	8.99	1.94	2.08	2.22	9.05	10.22	11.21
2049	19.24	22.30	26.28	15.94	18.34	21.58	17.24	19.90	23.43	18.90	21.89	25.79	3.97	4.84	5.56	7.41	8.50	9.40	1.96	2.11	2.25	9.37	10.61	11.66
2050	19.48	22.43	26.43	16.13	18.42	21.69	17.45	20.00	23.56	19.14	22.01	25.94	4.01	4.88	5.62	7.46	8.56	9.47	1.97	2.12	2.26	9.43	10.67	11.73
CAGR	1.4%	1.6%	2.0%	1.3%	1.5%	1.8%	1.4%	1.5%	1.9%	1.4%	1.6%	2.0%	1.8%	1.9%	2.0%	1.1%	1.2%	1.4%	0.6%	0.7%	0.8%	1.0%	1.1%	1.3%

Appendix C: 2016 Leidos Report

Final IRP Modeling Support 6.30.16.pdf

Final Report

IRP Modeling Support Study

Prepared for Guam Power Authority

June 30, 2016

leidos

Final Report

IRP Modeling Support Study

Prepared for Guam Power Authority

June 30, 2016

leidos

Leidos Engineering, LLC would like to acknowledge
the cooperation, assistance, and support of GPA's staff
in the creation of this report.
Thank you.

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List of Tables

Section 1
INTRODUCTION

The Guam Power Authority (GPA) engaged Leidos Engineering, LLC to assist in the preparation of an integrated resource plan (IRP) in accordance with the Master Professional Services Agreement dated March 14, 2011 (the MPSA) and the Task Authorization No. 11 dated December 23, 2015 both between Leidos and GPA. In coordination with GPA, Leidos developed unit characteristics, including performance, capital cost, and operation and maintenance (O&M) cost projections for both the existing power generating resources as well as potential new power generating resources. The existing resources, which include boiler and steam turbine generators (STGs), slow speed reciprocating (SSR) engines, combustion turbine generators (CTGs), and medium speed reciprocating (MSRs) engines, are listed in the table below.

Table 1: Summary of GPA Generation Resources

Plant	Units	Technology	Nominal Capacity	Primary Fuel	Install Date
Cabras	Unit 1	Boiler/STG	65 MW (1)	HFO/RFO (2)	1974
	Unit 2	Boiler/STG	65 MW	HFO/RFO	1975
	Unit 3	SSR	40 MW	HFO/RFO	1995
Dededo	Unit 1	CTG	22 MW	ULSD (3)	1992
	Unit 2	CTG	22 MW	ULSD	1993
Macheche	Unit 1	CTG	20 MW	ULSD	1993
Manenggon	Unit 1 & 2	MSR	4.4 MW each	ULSD	1993
Piti	Unit 7	CTG	40 MW	ULSD	1997
	Unit 8	SSR	45 MW	ULSD	1999
	Unit 9	SSR	45 MW	ULSD	1999
Talofofo	Unit1 & 2	MSR	5 MW each	ULSD	1994
Tenjo	Units 1-6	MSR	4.4 MW each	ULSD	1994
Yigo	Unit 1	CTG	20 MW	ULSD	1993

(1) Megawatts ("MW")
(2) Heavy Fuel Oil ("HFO"), Residual Fuel Oil ("RFO")
(3) Ultra-Low Sulfur Diesel ("ULSD")

The unit characteristics developed for the existing units included the following scenarios.

- Existing units as-is

- Existing units with capital expenditures in the future to improve efficiency and/or extend operating life, excluding the addition of air quality control systems (AQCS)
- Existing units with capital expenditures in the future to improve efficiency and/or extend operating life, including the addition of AQCS
- Certain existing units converted to fire ULSD, excluding capital expenditures by the end of 2017
- Certain existing units converted to fire ULSD, excluding capital expenditures by the end of 2017 and the installation of AQCS
- Certain existing units converted to fire liquefied natural gas (LNG), excluding capital expenditures, to coincide with potential LNG availability by the end of 2017
- Certain existing units converted to fire LNG with capital expenditures in the future to improve efficiency and/or extend operating life, excluding the addition of AQCS
- The addition of new power generating units

The unit characteristics developed for the installation of new generating resources included the following.

- Small MSR firing on ULSD
- Small MSR firing on LNG
- Small MSR firing on ULSD with heat recovery steam generator (HRSG)
- Small MSR firing on LNG with HRSG
- Large two-unit MSR firing on ULSD
- Large two-unit MSR firing on LNG
- Large two-unit MSR firing on ULSD with HRSG
- Large two-unit MSR firing on LNG with HRSG
- Six different CTGs firing on ULSD
- Six different CTGs firing on LNG
- Four different CTGs in 1x1 combined cycle firing on ULSD
- Four different CTG in 1x1 combined cycle firing on LNG
- Stationary utility-scale photovoltaic (PV) solar
- On-shore wind
- Low head hydro
- Micro hydro
- Biomass firing on wood pellets
- Biomass firing on green waste

- Municipal solid waste
- Biofuel from waste sludge processing
- Fuel cell
- Small modular nuclear reactor (SMR)
- Geothermal
- Ocean thermal energy conversion
- Sea water air conditioning
- Ocean tidal
- Ocean wave

1.1 General Assumptions

Numerous assumptions were made in developing the data for each of the resources. The general assumptions are listed below, but other assumptions and more specific detail is provided in the sections that follow. Further, a comprehensive presentation of the assumptions was provided to GPA in the spreadsheet titled *"GPA IRP Assumptions(063016 Final).xls"* to support the IRP modeling process.

- Construction related costs and O&M costs are presented in 2015$
- Non-union labor will be used
- Construction costs include 7 percent contingency as part of the direct costs
- Construction costs include owner costs at 15 percent of direct costs
- Cost estimates have been adjusted to include a 20 percent uplift from mainland pricing to account for working on Guam
- O&M costs represent non-fuel production related costs, including subcategories for variable O&M (VOM), Fixed O&M (FOM), and major maintenance
- FOM does not include owner costs such as property taxes, insurance, or finance related costs
- Capital expenditures do not include major maintenance of the CTGs or STGs

Section 2
EXISTING UNITS

2.1 Boiler/STG Units

Our projections of the performance of the boiler/STG units are based on performance test data and historical operating data, with adjustment for the various scenarios, as applicable. Similarly our capital expenditure and O&M cost projections are based on historical O&M data, including cost data, in addition to our experience with other units of similar vintage utilizing similar technology. We note TRC, GPA's environmental consultant, reported that AQCS may need to be added to the boiler/STG units to maintain environmental compliance with National Ambient Air Quality Standards (NAAQS) by no later than 2017, or earlier if extensions cannot be obtained. Without obtaining an exemption or the addition of AQCS, the units could be subject to shut down by the Environmental Protection Agency (EPA). Performance and cost information related to the AQCS was provided by TRC. While TRC reported that a wet scrubber or a dry scrubber with a baghouse could be installed to meet NAAQS, for the purposes of the IRP we have assumed that the potential AQCS addition for the boiler/STG units would consist of a limestone forced oxidation wet flue gas desulfurization (wet FGD) unit, due to its lower capital costs and smaller footprint requirements. To that end, TRC projected that the water consumption, lime consumption, and waste disposal, and subsequently the O&M costs, would be slightly higher for the wet FGD versus the dry scrubber. We have also estimated the cost to convert the units to fire on ULSD or LNG, which TRC reported would minimize the required AQCS equipment that would need to be installed, or eliminate the need to add AQCS equipment. The cost estimates for the ULSD and LNG conversions include only the labor and materials associated with new equipment and modifications to existing equipment on-site to support firing on ULSD or LNG.

2.1.1 Cabras 1 and 2

The Cabras 1 and 2 units, each with a nominal net capacity rating of 65 MW are located near Apra Harbor and fire on either high sulfur (HS) or low sulfur (LS) residual fuel oil (RFO) depending on the wind direction. LS RFO is utilized during periods of time when the wind direction is toward the island to minimize the impact of emissions on Guam. Additionally waste oil from the island is blended into the HS RFO fuel supply to avoid treatment or off-island disposal. The units entered commercial operation over 40 years ago.

Based on data provided for the units and our observations the performance of both units is suffering. Capital expenditures going forward are needed to repair or replace the motor control centers (MCCs), fans and fan motors, air heaters, feedwater heaters, major motors and pumps, condensers, tanks, water treatment equipment, and the structure containing the units itself. While the suggested renewals and replacements are expected to result in only a minor improvement in performance of the units, the renewals and replacements are expected to improve the reliability and extend the life of the units. The "As-is" and "As-is with Capital Expenditures" scenarios have limited life expectancy (2017) due to the pending NAAAQS regulations, if AQCS are not installed. Similarly, the "ULSD" and "LNG" scenarios also have a limited life expectancy without capital expenditures due to the need for renewals and replacements described above.

The tables below present the unit characteristics for Cabras 1 and 2 for the scenarios previously described. We note that the installation of the Wet FGD is estimated to cost approximately $92,800,000 for each unit and the O&M costs are estimated to increase by approximately $3,500,000 annually for each unit as well. Conversion to fire on ULSD and LNG is estimated to cost $800,000 and $13,250,000 for each unit, respectively.

We estimate the capital expenditures to be approximately $2,000,000 annually for each unit going forward.

Table 2: Cabras 1 Unit Characteristics

Option/Existing Plant	Units	As is	W Capex	W Capex AND AQCS	ULSD	LNG	LNG W Capex
COD	Date	1974	1974	1974	1974	1974	1974
Retirement	Date	2017	2017	>25 yrs	2020	2020	>25 yrs
Max Net Capacity	MW	64.0	64.0	63.0	64.0	61.5	63.0
Min Net Capacity	MW	16.0	16.0	15.8	16.0	15.4	15.8
HR @ Max	Btu/kWh	11,221	10,997	10,705	11,243	11,508	11,326
HR @ Min	Btu/kWh	11,423	11,195	10,898	11,446	11,715	11,530
Mature FOR	%	6.0	6.0	6.0	6.0	6.0	6.0
Scheduled Maintenance	Weeks	3	3	3	3	3	3
Scheduled Maintenance	%	6.0	6.0	6.0	6.0	6.0	6.0
Max Capacity Factor	%	88.0	88.0	88.0	88.0	88.0	88.0
Primary Fuel		RFO	RFO	RFO	ULSD	LNG	LNG
Full Load NOX	lb/MMBtu	0.3133	0.3133	0.3133	0.160	0.186	0.186
Full Load CO	lb/MMBtu	0.0333	0.0333	0.0333	0.033	0.082	0.082
Full Load SO2	lb/MMBtu	1.6530	1.6530	0.1653	0.0014	0.0006	0.0006
Full Load CO2	lb/MMBtu	166.0000	166.0000	166.0000	162.0000	117.0000	117.0000
Full Load VOC	lb/hr	5.0700	5.0700	5.0700	5.0700	3.9430	3.9430
Full Load PM	lb/hr	86.5400	86.5400	86.5400	16.0875	5.4485	5.4485
VOM	$/MWh	5.00	5.00	14.00	5.00	4.75	4.75
FOM	$/kW-yr	56.00	56.00	75.00	56.00	53.20	53.20
MM Accrual	$/MWh	NA	1.71	1.71	1.71	1.71	1.71

Table 3: Cabras 2 Unit Characteristics

Option/Existing Plant	Units	As is	W Capex	W Capex AND AQCS	ULSD	LNG	LNG W Capex
COD	Date	1975	1975	1975	1974	1975	1975
Retirement	Date	2017	2017	>25 yrs	2020	2020	>25 yrs
Max Net Capacity	MW	59.2	60.7	59.8	58.9	58.2	59.7
Min Net Capacity	MW	14.8	15.2	14.9	14.7	14.6	14.9
HR @ Max	Btu/kWh	11,678	11,445	11,342	11,702	11,977	11,788
HR @ Min	Btu/kWh	11,497	11,267	11,166	11,912	11,792	11,605
Mature FOR	%	6.0	6.0	6.0	6.0	6.0	6.0
Scheduled Maintenance	Weeks	3	3	3	3	3	3
Scheduled Maintenance	%	6.0	6.0	6.0	6.0	6.0	6.0
Max Capacity Factor	%	88.0	88.0	88.0	88.0	88.0	88.0
Primary Fuel		RFO	RFO	RFO	ULSD	LNG	LNG
Full Load NOX	lb/MMBtu	0.3133	0.3133	0.3133	0.160	0.186	0.186
Full Load CO	lb/MMBtu	0.0333	0.0333	0.0333	0.033	0.082	0.082
Full Load SO2	lb/MMBtu	1.6590	1.6590	0.1659	0.0014	0.0006	0.0006
Full Load CO2	lb/MMBtu	166.0000	166.0000	166.0000	162.0000	117.0000	117.0000
Full Load VOC	lb/hr	4.6800	4.6800	4.6800	4.6792	3.6391	3.6391
Full Load PM	lb/hr	80.1000	80.1000	80.1000	14.8474	5.0285	5.0285
VOM	$/MWh	5.00	5.00	14.00	5.00	4.75	4.75
FOM	$/kW-yr	56.00	56.00	75.00	56.00	53.20	53.20
MM Accrual	$/MWh	NA	1.85	1.85	1.85	1.85	1.85

2.2 Slow Speed Reciprocating Units

Our projections of the performance of the SSR units are based on performance test data and historical operating data, with adjustment for the various scenarios, as applicable. Similarly our capital expenditure and O&M cost projections are based on historical O&M data, including cost data, in addition to our experience with other units of similar vintage utilizing similar technology. TRC reported that AQCS need to be added to the SSR units to maintain environmental compliance with Reciprocating Internal Combustion Engines (RICE) Maximum Achievable Control Technology (MACT), if an exemption cannot be obtained. Without obtaining an exemption or the addition of AQCS the units could be subject to shut down by the EPA. Performance and cost information related to the AQCS was provided by TRC. If an exemption is not obtained the units will require one of two modifications. One alternative includes the installation of a dry scrubber, baghouse and oxidation catalyst and switch to burning ultra-low sulfur (ULS) RFO (0.5 percent). GPA reported difficulty in sourcing a supply of ULS RFO and TRC reported that it is not aware of a reciprocating engine currently installed including a dry scrubber and baghouse. A second alternative includes the installation of an oxidation catalyst, the potential installation of a selective catalytic reduction system (SCR), and a switch to burning ULSD, which would have minimal capital cost, but would add significant incremental fuel cost relative to the "As-is" scenario. Either case would result in an incremental fuels cost increase relative to the "As-is" scenario and, in the case of adding a dry scrubber and baghouse, the O&M costs would be higher as well. For the purposes of the IRP the SSRs have been modeled to burn ULSD along with the installation of a SCR and an oxidation catalyst, which would support compliance with both RICE MACT and NAAQS requirements. We expect the conversion to fire on ULSD to require only minor adjustments to the unit. However, conversion to fire on LNG would be more intensive. Therefore, we have also estimated the cost to convert the units to fire on LNG. The cost estimates for the LNG conversions include only the labor and materials associated with new equipment and modifications to existing equipment on-site to support firing on LNG.

2.2.1 Cabras 3

The Cabras 3 unit, has a nominal net capacity rating of 40 MW is located near Apra Harbor and fire on either HS or LS RFO depending on the wind direction. LS RFO is utilized during periods of time when the wind direction is toward the island to minimize the impact of emissions on Guam. The units entered commercial operation over 20 years ago.

Based on data provided for the units and our observations the performance of both units has degraded slightly relative to the nameplate rating due to normal wear and tear. Capital expenditures going forward are needed to repair or replace the control system, cooling systems, sea water coolers, building and stack structural components, investigate and remedy potential foundation issues, and to add a turbocharger cleaning system. While the suggested renewals and replacements are expected to result in only a minor improvement in performance of the units, the renewals and replacements are expected to improve the reliability and extend the life of the units. The "As-is" and "As-is with Capital Expenditures" scenarios have limited life expectancy due to RICE MACT regulations, if AQCS are not installed. Similarly, the "ULSD" and "LNG" scenarios also have a limited life expectancy without capital expenditures due to the need for renewals and replacements described above.

The table below presents the unit characteristics for Cabras 3 for the scenarios previously described. We note that the installation of the dry scrubber and baghouse, along with an oxidation catalyst, is estimated to cost approximately $112,500,000 for each unit and the O&M costs are estimated to increase by approximately $3,250,000 annually for each unit as well. Conversion to fire on ULSD is not expected to have significant costs in itself, but the installation of a SCR and oxidation catalyst is estimated to cost $6,500,000. Conversion to fire on LNG is estimated to cost $14,900,000.

We estimate the capital expenditures to be approximately $1,000,000 annually going forward.

Table 4: Cabras 3 Unit Characteristics

Option/Existing Plant	Units	As is	W Capex	W Capex AND AQCS	ULSD	ULSD W SCR AND CO	LNG	LNG W Capex
COD	Date	1995	1995	1995	1995	1995	1995	1995
Retirement	Date	2017	2017	>25 yrs	2020	2020	2020	>25 yrs
Max Net Capacity	MW	37.7	37.7	37.2	37.7	37.7	36.7	36.7
Min Net Capacity	MW	19.0	19.0	19.0	19.0	19.0	19.0	19.0
HR @ Max	Btu/kWh	9,130	9,130	9,250	9,130	9,130	9,380	9,380
HR @ Min	Btu/kWh	9,221	9,221	9,343	9,130	9,130	9,474	9,474
Mature FOR	%	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Scheduled Maintenance	Weeks	4	4	4	4	4	4	4
Scheduled Maintenance	%	8.0	8.0	8.0	8.0	8.0	8.0	8.0
Max Capacity Factor	%	89.5	89.5	89.5	89.5	89.5	89.5	89.5
Primary Fuel		RFO	RFO	RFO	ULSD	ULSD	LNG	LNG
Full Load NOX	lb/MMBtu	2.3881	2.3881	2.3881	3.2000	0.6400	3.1700	3.1700
Full Load CO	lb/MMBtu	0.1447	0.1447	0.0434	0.8500	0.2550	0.3860	0.3860
Full Load SO2	lb/MMBtu	1.3945	1.3945	0.4184	0.0015	0.0015	0.0006	0.0006
Full Load CO2	lb/MMBtu	166.0000	166.0000	166.0000	162.0000	162.0000	117.0000	117.0000
Full Load VOC	lb/hr	3.8000	3.8000	3.8000	30.9781	18.5869	41.3041	41.3041
Full Load PM	lb/hr	52.2000	52.2000	52.2000	34.4201	34.4201	16.6249	16.6249
VOM	$/MWh	5.00	5.00	13.50	5.00	14.00	5.00	5.00
FOM	$/kW-yr	40.00	40.00	70.00	40.00	40.00	40.00	40.00
MM Accrual	$/MWh	NA	3.65	3.65	3.65	3.65	3.65	3.65

2.2.2 Piti 8 and 9

The Piti 8 and 9 units, each with a nominal net capacity rating of 45 MW are located near Apra Harbor and fire on either HS or LS No. 6 RFO depending on the wind direction. LS RFO is utilized during periods of time when the wind direction is toward the island to minimize the impact of emissions on Guam. The units entered commercial operation over 15 years ago.

Based on data provided for the units and our observations, the performance of both units has degraded slightly relative to the nameplate rating due to normal wear and tear. Capital expenditures going forward are needed. While the suggested renewals and replacements are expected to result in only a minor improvement in performance of the units, the renewals and replacements are expected to improve the reliability and extend the life of the units. The "As-is" and "As-is with Capital Expenditures" scenarios have limited life expectancy due to RICE MACT regulations, if AQCS are not installed. Similarly, the "ULSD" and "LNG" scenario for PITI 8 also has a limited life expectancy due to the need for renewals and replacements described above.

The tables below present the unit characteristics for Piti 8 and 9 for the scenarios previously described. We note that the installation of the dry scrubber and baghouse, along with an oxidation catalyst, is estimated to cost approximately $112,500,000 for each unit and the O&M costs are estimated to increase by approximately $3,250,000 annually for each unit as well. Conversion to fire on ULSD is not expected to have significant costs in itself, but the installation of a SCR and oxidation catalyst is estimated to cost $6,500,000. Conversion to fire on LNG is estimated to cost $14,900,000.

We estimate the capital expenditures to be approximately $1,000,000 annually going forward.

Table 5: Piti 8 Unit Characteristics

Option/Existing Plant	Units	As is	W Capex	W Capex AND AQCS	ULSD	ULSD W SCR AND CO	LNG	LNG W Capex
COD	Date	1999	1999	1999	1999	1999	1999	1999
Retirement	Date	2017	2017	>25 yrs	2020	2020	2020	>25 yrs
Max Net Capacity	MW	43.2	43.2	42.6	43.2	42.2	42.2	42.2
Min Net Capacity	MW	21.0	21.0	21.0	21.0	21.0	21.0	21.0
HR @ Max	Btu/kWh	8,690	8,690	8,804	8,690	8,896	8,896	8,896
HR @ Min	Btu/kWh	8,777	8,777	8,892	8,777	8,985	8,985	8,985
Mature FOR	%	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Scheduled Maintenance	Weeks	2.25	2.25	2.25	2.25	2.25	2.25	2.25
Scheduled Maintenance	%	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Max Capacity Factor	%	93.0	93.0	93.0	93.0	93.0	93.0	93.0
Primary Fuel		RFO	RFO	RFO	ULSD	ULSD	LNG	LNG
Full Load NOX	lb/MMBtu	2.1430	2.1430	2.1430	3.2000	0.6400	3.1700	3.1700
Full Load CO	lb/MMBtu	0.1176	0.1176	0.0353	0.8500	0.2550	0.3860	0.3860
Full Load SO2	lb/MMBtu	1.3425	1.3425	0.4028	0.0015	0.0015	0.0006	0.0006
Full Load CO2	lb/MMBtu	166.0000	166.0000	166.0000	162.0000	162.0000	117.0000	117.0000
Full Load VOC	lb/hr	3.1500	3.1500	3.1500	33.7867	20.2720	45.0490	45.0490
Full Load PM	lb/hr	66.9000	66.9000	66.9000	37.5408	37.5408	18.1322	18.1322
VOM	$/MWh	5.00	5.00	13.50	5.00	11.25	5.00	5.00
FOM	$/kW-yr	100.00	100.00	115.00	100.00	100.00	100.00	100.00
MM Accrual	$/MWh	NA	2.75	2.75	2.75	2.75	2.75	2.75

Table 6: Piti 9 Unit Characteristics

Option/Existing Plant	Units	As is	W Capex	W Capex AND AQCS	ULSD	ULSD W SCR AND CO	LNG	LNG W Capex
COD	Date	1999	1999	1999	1999	1999	1999	1999
Retirement	Date	2017	2017	>25 yrs	2020	2020	2020	>25 yrs
Max Net Capacity	MW	43.2	43.2	42.6	43.2	42.2	42.2	42.2
Min Net Capacity	MW	21.0	21.0	21.0	21.0	21.0	21.0	21.0
HR @ Max	Btu/kWh	8,690	8,690	8,804	8,690	8,896	8,896	8,896
HR @ Min	Btu/kWh	8,777	8,777	8,892	8,777	8,985	8,985	8,985
Mature FOR	%	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Scheduled Maintenance	Weeks	2.25	2.25	2.25	2.25	2.25	2.25	2.25
Scheduled Maintenance	%	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Max Capacity Factor	%	93.0	93.0	93.0	93.0	93.0	93.0	93.0
Primary Fuel		RFO	RFO	RFO	ULSD	ULSD	LNG	LNG
Full Load NOX	lb/MMBtu	2.1430	2.1430	2.1430	3.2000	0.6400	3.1700	3.1700
Full Load CO	lb/MMBtu	0.1176	0.1176	0.0353	0.8500	0.2550	0.3860	0.3860
Full Load SO2	lb/MMBtu	1.3425	1.3425	0.4028	0.0015	0.0015	0.0006	0.0006
Full Load CO2	lb/MMBtu	166.0000	166.0000	166.0000	162.0000	162.0000	117.0000	117.0000
Full Load VOC	lb/hr	3.1500	3.1500	3.1500	33.7867	20.2720	45.0490	45.0490
Full Load PM	lb/hr	66.9000	66.9000	66.9000	37.5408	37.5408	18.1322	18.1322
VOM	$/MWh	5.00	13.50	15.75	5.00	11.25	5.00	5.00
FOM	$/kW-yr	100.00	115.00	100.00	100.00	100.00	100.00	100.00
MM Accrual	$/MWh	NA	2.75	2.75	2.75	2.75	2.75	2.75

2.3 Medium Speed Reciprocating Units

Our projections of the performance of the MSR units are based on performance test data and historical operating data, with adjustment for the various scenarios, as applicable. Similarly our capital expenditure and O&M cost projections are based on historical O&M data, including cost data, in addition to our experience with other units of similar vintage utilizing similar technology. It is our understanding that the MSR units have all had AQCS equipment installed in the past few years to meet RICE MACT.

2.3.1 Manenggon 1 and 2

The Manenggon 1 and 2 units, with a nominal net capacity rating of 4.4 MW each are located on the southeast side of the island and are leased by GPA from a resort. The units fire on ULSD. The units entered commercial operation over 20 years ago.

Based on data provided for the units and our observations, the performance of both units has degraded slightly due to normal wear and tear. No significant capital expenditures are foreseen at this time. However, a certain level of capital expenditures, approximately $100,000 for each unit, has been forecasted to maintain the performance and reliability, as well as to extend the life of the units.

The table below presents the unit characteristics for the Manenggon MSR units for the scenarios previously described.

Table 7: Manenggon 1 and 2 Unit Characteristics

Option/Existing Plant	Units	As is	W Capex
COD	Date	1994	1994
Retirement	Date	2020	>25 yrs
Max Net Capacity	MW	10.4	10.4
Min Net Capacity	MW	2.6	2.6
HR @ Max	Btu/kWh	9,290	9,290
HR @ Min	Btu/kWh	9,990	9,990
Mature FOR	%	4	4
Scheduled Maintenance	Weeks	2	2
Scheduled Maintenance	%	4.0	4.0
Max Capacity Factor	%	92.0	92.0
Primary Fuel		ULSD	ULSD
Full Load NOX	lb/MMBtu	1.0195	1.0195
Full Load CO	lb/MMBtu	0.0186	0.0186
Full Load SO2	lb/MMBtu	0.0013	0.0013
Full Load CO2	lb/MMBtu	162.0000	162.0000
Full Load VOC	lb/hr	0.5600	0.5600
Full Load PM	lb/hr	1.7500	1.7500
VOM	$/MWh	8.00	8.00
FOM	$/kW-yr	55.00	55.00
MM Accrual	$/MWh	NA	3.98

2.3.2 Talofofo 1 and 2

The Talofofo 1 and 2 units, with a nominal net capacity rating of 5 MW each are located on the southeast side of the island and are leased by GPA from a resort. The units fire on ULSD. The units entered commercial operation over 20 years ago.

Based on data provided for the units and our observations the performance of both units has degraded slightly due to normal wear and tear. No significant capital expenditures are foreseen at this time. However, a certain level of capital expenditures, approximately $100,000 for each unit, has been forecasted to maintain the performance and reliability, as well as to extend the life of the units.

The table below presents the unit characteristics for the Talofofo MSR units for the scenarios previously described.

Table 8: Talofofo 1 and 2 Unit Characteristics

Option/Existing Plant	Units	As is	W Capex
COD	Date	1994	1994
Retirement	Date	2020	>25 yrs
Max Net Capacity	MW	8.6	8.6
Min Net Capacity	MW	2.1	2.1
HR @ Max	Btu/kWh	9,770	9,770
HR @ Min	Btu/kWh	10,500	10,500
Mature FOR	%	4	4
Scheduled Maintenance	Weeks	2	2
Scheduled Maintenance	%	4.0	4.0
Max Capacity Factor	%	92.0	92.0
Primary Fuel		ULSD	ULSD
Full Load NOX	lb/MMBtu	0.9941	0.9941
Full Load CO	lb/MMBtu	0.0189	0.0189
Full Load SO2	lb/MMBtu	0.0029	0.0029
Full Load CO2	lb/MMBtu	162.0000	162.0000
Full Load VOC	lb/hr	0.3150	0.3150
Full Load PM	lb/hr	2.7900	2.7900
VOM	$/MWh	8.00	8.00
FOM	$/kW-yr	55.00	55.00
MM Accrual	$/MWh	NA	7.84

2.3.3 Tenjo 1-6

The Tenjo MSR units, with a total nominal net capacity rating of 4.4 MW each are located on the southwest side of the island and fire on ULSD. The units entered commercial operation over 20 years ago.

Based on data provided for the units and our observations, the performance of the units have degraded slightly due to normal wear and tear and been further impacted by the generator and cooler limitations. Capital expenditures going forward of approximately $100,000 for each unit are needed to repair or replace the stacks and address the generator and cooler limitations and to maintain performance and reliability of the units, as well as to extend the life of the units

The table below presents the unit characteristics for the Tenjo MSR units for the scenarios previously described.

Table 9: Tenjo 1-6 Unit Characteristics

Option/Existing Plant	Units	As is	W Capex
COD	Date	1994	1994
Retirement	Date	2020	>25 yrs
Max Net Capacity	MW	25.9	26.4
Min Net Capacity	MW	2.2	2.2
HR @ Max	Btu/kWh	9,600	9,600
HR @ Min	Btu/kWh	10,320	10,320
Mature FOR	%	2.5	2.5
Scheduled Maintenance	Weeks	2	2
Scheduled Maintenance	%	4.0	4.0
Max Capacity Factor	%	93.5	93.5
Primary Fuel		ULSD	ULSD
Full Load NOX	lb/MMBtu	0.2907	0.2907
Full Load CO	lb/MMBtu	0.0069	0.0069
Full Load SO2	lb/MMBtu	0.0016	0.0016
Full Load CO2	lb/MMBtu	162.0000	162.0000
Full Load VOC	lb/hr	0.3350	0.3350
Full Load PM	lb/hr	1.6200	1.6200
VOM	$/MWh	8.00	8.00
FOM	$/kW-yr	55.00	55.00
MM Accrual	$/MWh	NA	7.84

2.4 Combustion Turbine Generators

Our projections of the performance of the CTG units are based on performance test data and historical operating data, with adjustment for the various scenarios, as applicable. Similarly our capital expenditure and O&M cost projections are based on historical O&M data, including cost data, in addition to our experience with other units of similar vintage utilizing similar technology. TRC reported that AQCS may need to be added to the CTG units in the event that capital expenditures trigger CTG MACT. This would require the addition of an oxidation catalyst and potentially a selective catalytic reduction (SCR) system. Without obtaining an exemption or the addition of AQCS the units could be subject to shut down by the EPA. We have included estimates for the installation of AQCS equipment including an SCR and an oxidation catalyst. We have also estimated the cost to convert the Piti 7 CTG to fire on LNG since it is located near Apra Harbor.

2.4.1 Dededo 1 and 2

The two Dededo CTG units, each with nominal net capacity rating of 22.0 MW are located in the north central part of the island near Dededo and fire on ULSD. The units entered commercial operation over 20 years ago.

Neither unit is currently operational. Based on data provided for the units and our observations the performance of units can only be estimated, as the units have not operated for several years. With regard to capital improvements, in addition to the need to repair the Unit 2 generator and the Unit 1 switchgear, other equipment was in need of repair or replacement including the control system, stacks, the fin fan coolers, the black start diesel generator, and the water injection skids. The control system is dated and procurement of replacement parts and service are likely to become more challenging in the future. While the suggested renewals and replacements are expected to result in only a minor improvement in performance of the units, the renewals and replacements are needed to return the units to service, maintain reliability, and extend the life of the units.

The tables below present the unit characteristics for the Dededo CTG units for the scenarios previously described. We note that the installation of the SCR and oxidation catalyst is estimated to cost approximately $2,500,000 for each unit.

We estimate the capital expenditures to be approximately $15,000,000 to return both units to service and perform necessary renewals and replacements in the near term and recommend capital expenditures of $200,000 annually for each unit thereafter.

Table 10: Dededo 1 and 2 Unit Characteristics

Option/Existing Plant	Units	Unit 1 As is	Unit 1 W Capex	Unit 1 W Capex AND AQCS	Unit 2 As is	Unit 2 W Capex	Unit 1 W Capex AND AQCS
COD	Date	1992	1992	1992	1992	1992	1992
Retirement	Date	2020	>25 yrs	>25 yrs	2020	>25 yrs	>25 yrs
Max Net Capacity	MW	22.0	22.0	22.0	22.0	22.0	22.0
Min Net Capacity	MW	11.0	11.0	11.0	11.0	11.0	11.0
HR @ Max	Btu/kWh	13,280	13,280	13,280	13,280	13,280	13,280
HR @ Min	Btu/kWh	15,670	15,670	15,670	15,670	15,670	15,670
Mature FOR	%	3.0	3.0	3.0	3.0	3.0	3.0
Scheduled Maintenance	Weeks	3	3	3	3	3	3
Scheduled Maintenance	%	6.0	6.0	6.0	6.0	6.0	6.0
Max Capacity Factor	%	91.0	91.0	91.0	91.0	91.0	91.0
Primary Fuel		ULSD	ULSD	ULSD	ULSD	ULSD	ULSD
Full Load NOX	lb/MMBtu	0.2400	0.2400	0.0480	0.2400	0.2400	0.0480
Full Load CO	lb/MMBtu	0.0760	0.0760	0.0228	0.0760	0.0760	0.0228
Full Load SO2	lb/MMBtu	0.0929	0.0929	0.0929	0.0929	0.0929	0.0929
Full Load CO2	lb/MMBtu	162.0000	162.0000	162.0000	162.0000	162.0000	162.0000
Full Load VOC	lb/hr	0.1198	0.1198	0.0719	0.1198	0.1198	0.0719
Full Load PM	lb/hr	3.5059	3.5059	3.5059	3.5059	3.5059	3.5059
VOM	$/MWh	6.00	6.00	7.00	6.00	6.00	7.00
FOM	$/kW-yr	12.50	12.50	12.50	12.50	12.50	12.50
MM Accrual	$/MWh	NA	7.10	7.10	NA	7.10	7.10

2.4.2 Macheche

The Macheche CTG unit, with nominal net capacity rating of 20 MW is located in the north central part of the island near Macheche and fires on ULSD. The unit entered commercial operation over 20 years ago.

Based on data provided for the units and our observations, the performance of the unit is limited on blade path spread due to a faulty variable stator vane (VSV) adjustment mechanism. With regard to capital improvements, in addition to the need to repair the VSV adjustment mechanism, other equipment was in need of repair or replacement including the control system, water treatment skid, water injection skid, and the black start diesel generator. The control system is dated and procurement of replacement parts and service are likely to become more challenging in the future. While the suggested renewals and replacements are expected to result in only a minor improvement in performance of the units, the renewals and replacements are expected to improve the reliability and extend the life of the units. The "As-is" scenario has limited life expectancy due to the needed renewals and replacements discussed above.

The table below presents the unit characteristics for the Macheche CTG for the scenarios previously described. We note that the installation of the SCR and oxidation catalyst is estimated to cost approximately $2,500,000 for each unit.

We estimate the capital expenditures to be approximately $4,100,000 to perform necessary renewals and replacements in the near term and recommend capital expenditures of $200,000 annually thereafter.

Table 11: Macheche Unit Characteristics

Option/Existing Plant	Units	As is	W Capex	W Capex AND AQCS
COD	Date	1993	1993	1993
Retirement	Date	2020	>25 yrs	>25 yrs
Max Net Capacity	MW	19.0	19.0	19.0
Min Net Capacity	MW	10.0	10.0	10.0
HR @ Max	Btu/kWh	10,500	10,500	10,500
HR @ Min	Btu/kWh	12,390	12,390	12,390
Mature FOR	%	3.0	3.0	3.0
Scheduled Maintenance	Weeks	2.25	2.25	2.25
Scheduled Maintenance	%	5.0	5.0	5.0
Max Capacity Factor	%	92.0	92.0	92.0
Primary Fuel		ULSD	ULSD	ULSD
Full Load NOX	lb/MMBtu	0.2005	0.2005	0.0401
Full Load CO	lb/MMBtu	0.0401	0.0401	0.0120
Full Load SO2	lb/MMBtu	0.0075	0.0075	0.0075
Full Load CO2	lb/MMBtu	162.0000	162.0000	162.0000
Full Load VOC	lb/hr	0.0818	0.0818	0.0491
Full Load PM	lb/hr	4.6000	4.6000	4.6000
VOM	$/MWh	6.00	6.00	7.00
FOM	$/kW-yr	13.00	13.00	13.00
MM Accrual	$/MWh	NA	8.22	8.22

2.4.3 Piti 7

The Piti 7 CTG unit, with nominal net capacity rating of 40 MW is located near Apra Harbor and fires on ULSD. The unit has been operational for nearly 20 years.

Based on data provided for the units and our observations the performance of the unit has degraded slightly relative to the nameplate rating due to normal wear and tear. With regard to capital improvements, the control system needs to be upgraded as it is dated and procurement of replacement parts and service are likely to become more challenging in the future. While the suggested renewals and replacements are expected to result in only a minor improvement in performance of the unit, the renewals and replacements are expected to improve the reliability and extend the life of the unit.

The table below presents the unit characteristics for the Piti 7 CTG for the scenarios previously described. We note that the installation of the SCR and oxidation catalyst is estimated to cost approximately $2,500,000 for each unit. The conversion to fire on LNG is estimated to cost $2,200,000.

We estimate the capital expenditures related to the DCS upgrade to cost $2,200,000, which could be split over the next 4 or 5 years as the procurement and installation is completed. We recommend capital expenditures of $200,000 annually thereafter.

Table 12: Piti 7 Unit Characteristics

Option/Existing Plant	Units	As is	W Capex	W Capex AND AQCS	LNG	LNG W Capex
COD	Date	1997	1997	1997	1997	1997
Retirement	Date	>25 yrs	>25 yrs	>25 yrs	>25 yrs	>25 yrs
Max Net Capacity	MW	39.3	39.3	39.3	39.3	39.3
Min Net Capacity	MW	20.0	20.0	20.0	20.0	20.0
HR @ Max	Btu/kWh	11,800	11,800	11,800	11,800	11,800
HR @ Min	Btu/kWh	13,900	13,900	13,900	13,900	13,900
Mature FOR	%	3.0	3.0	3.0	3.0	3.0
Scheduled Maintenance	Weeks	3	3	3	3	3
Scheduled Maintenance	%	6.0	6.0	6.0	6.0	6.0
Max Capacity Factor	%	91.0	91.0	91.0	91.0	91.0
Primary Fuel		ULSD	ULSD	ULSD	LNG	LNG
Full Load NOX	lb/MMBtu	0.2400	0.2400	0.0480	0.1300	0.1300
Full Load CO	lb/MMBtu	0.0760	0.0760	0.0228	0.0300	0.0300
Full Load SO2	lb/MMBtu	0.0015	0.0015	0.0015	0.0006	0.0006
Full Load CO2	lb/MMBtu	162.0000	162.0000	162.0000	117.0000	117.0000
Full Load VOC	lb/hr	0.1900	0.1900	0.1140	0.9700	0.9700
Full Load PM	lb/hr	5.5600	5.5600	5.5600	3.0600	3.0600
VOM	$/MWh	6.00	6.00	6.00	6.00	6.00
FOM	$/kW-yr	98.00	98.00	98.00	98.00	98.00
MM Accrual	$/MWh	NA	3.98	3.98	3.98	3.98

2.4.4 Yigo

The Yigo CTG unit, with nominal net capacity rating of 20 MW is located in the northeastern part of the island near Yigo and fires on ULSD. The units entered commercial operation over 20 years ago.

The unit is not currently operational. Based on data provided for the units and our observations, the unit is in need of overhaul. With regard to capital improvements, in addition to the needed overhaul, other equipment was in need of repair or replacement including the control system, water treatment skid, water injection skid, and the black start diesel generator. The control system is dated and procurement of replacement parts and service are likely to become more challenging in the future. Further, the CTG package itself and the building housing the water treatment equipment need replacement due to severe corrosion. While the suggested renewals and replacements are expected to result in only a minor improvement in performance of the units, the renewals and replacements are expected to improve the reliability and extend the life of the units. The "As-is" scenario has limited life expectancy due to the needed renewals and replacements discussed above.

The table below presents the unit characteristics for the Yigo CTG for the scenarios previously described. We note that the installation of the SCR and oxidation catalyst is estimated to cost approximately $2,500,000 for each unit.

We estimate the capital expenditures to be approximately $12,500,000 to perform necessary renewals and replacements in the near term (excluding the costs of the overhaul required to return the unit to service) and recommend capital expenditures of $200,000 annually for each unit thereafter.

Table 13: Yigo Unit Characteristics

Option/Existing Plant	Units	As is	W Capex	W Capex AND AQCS
COD	Date	1993	1993	1993
Retirement	Date	2020	>25 yrs	>25 yrs
Max Net Capacity	MW	19.0	19.0	19.0
Min Net Capacity	MW	10.0	10.0	10.0
HR @ Max	Btu/kWh	10,500	10,500	10,500
HR @ Min	Btu/kWh	12,390	12,390	12,390
Mature FOR	%	3.0	3.0	3.0
Scheduled Maintenance	Weeks	2.25	2.25	2.25
Scheduled Maintenance	%	5.0	5.0	5.0
Max Capacity Factor	%	92.0	92.0	92.0
Primary Fuel		ULSD	ULSD	ULSD
Full Load NOX	lb/MMBtu	0.2105	0.2105	0.0421
Full Load CO	lb/MMBtu	0.0760	0.0760	0.0228
Full Load SO2	lb/MMBtu	0.0017	0.0017	0.0017
Full Load CO2	lb/MMBtu	162.0000	162.0000	162.0000
Full Load VOC	lb/hr	0.0818	0.0818	0.0491
Full Load PM	lb/hr	8.3000	8.3000	8.3000
VOM	$/MWh	6.00	6.00	7.00
FOM	$/kW-yr	13.00	13.00	13.00
MM Accrual	$/MWh	NA	8.22	8.22

Section 3
NEW UNITS

Leidos developed unit characteristics for a wide variety of potential new generating resources. In addition to the general assumptions listed previously several common assumptions were made relating to the new resources. Some data such as the construction cost breakdown, draw schedules, heat rates curves, and fuel heat content has been provided to GPA, but is not presented in the text or tables herein due to the volume of information.

The plant direct costs include costs to support an electrical interconnection of the new resource to the grid, but the transmission or distribution lines interconnecting the plant site with the existing transmission or distribution infrastructure are not included in the plant costs. Instead substation expansion costs and transmission line costs are provided separately herein. For any new installation with a net capacity estimated to be less than 50 MW, the plant direct construction costs include costs for 13.8 kV switchgear and 13.8 to 34.5 KV GSU transformer. For any new installation with a net capacity of greater than 50 MW, the plant direct construction costs include costs for 13.8 kV switchgear and 13.8 to 115 KV GSU transformer. Further, the total plant construction costs include costs a 34.5 KV breaker, 3 disconnects, 34.5 KV switchgear and control panel, control house and fencing for plants with net capacity ratings of less than 50 MW, and 3, 115 KV breakers, 7 disconnects, 115 KV switchgear and control panel, control house and fencing for plants with net capacity ratings of greater than 50 MW.

Additional common assumptions for the new resources are listed below.

- New installation construction schedule information is based on permitting starting in July 2016
- New installations include fin fan coolers or air cooled condensers for heat rejection to minimize water consumption
- New CTG-based installations include inlet cooling to maintain unit performance during ambient conditions with high temperatures

The table below presents the unit characteristics developed for the potential new generating resources to support modeling against the various scenarios of the existing units in the IRP.

Table 14: New Unit Characteristics

Technology		MSR ULSD	MSR LNG	MSR W HRSG ULSD	MSR W HRSG LNG	2x MSR ULSD	2x MSR LNG	2x MSR W HRSG ULSD	2x MSR W HRSG LNG
Nominal Capacity	MW	5	5	6	6	35	35	39	39
Space Required	Acres	5 to 10	5 to 10	5 to 10	5 to 10	5 to 10	5 to 10	5 to 10	5 to 10
Capital Cost	$000	13,248	13,248	21,804	21,804	78,315	78,315	127,995	127,995
Capital Cost	$/kW	2,548	2,548	3,759	3,759	2,225	2,225	3,307	3,307
Total Schedule Duration	Months	19	19	25	25	21	21	23	23
COD	Date	Jan-18	Jan-18	Aug-18	Aug-18	Apr-18	Apr-18	Aug-18	Aug-18
Capacity Degradation	%	1%	1%	1%	1%	1%	1%	1%	1%
Heat Rate Degradation	%	1%	1%	1%	1%	1%	1%	1%	1%
Max Net Capacity	MW	5.1	5.1	5.7	5.7	34.8	34.8	38.3	38.3
Min Net Capacity	MW	2.1	2.1	2.3	2.3	6.3	6.3	6.9	6.9
HR (HHV) @ Max	Btu/kWh	8,858	8,796	7,941	7,886	8,128	8,135	7,393	7,399
HR (HHV) @ Min	Btu/kWh	11,639	11,559	10,435	10,363	11,137	12,445	10,130	11,320
Mature FOR	%	1.0	1.0	2.0	2.0	2.0	2.0	2.0	2.0
Scheduled Maintenance	%	2.0	2.0	4.0	4.0	5.0	5.0	5.0	5.0
Max Capacity Factor	%	97.0	97.0	94.0	94.0	93.0	93.0	93.0	93.0
Primary Fuel		ULSD	LNG	ULSD	LNG	ULSD	LNG	ULSD	LNG
Secondary Fuel		LNG	ULSD	LNG	ULSD	LNG	ULSD	LNG	ULSD
Full Load NOX	lb/MMBtu	0.0740	0.0250	0.7400	0.0250	0.0730	0.0120	0.0730	0.0120
Full Load CO	lb/MMBtu	0.1110	0.0990	0.1110	0.0990	0.1100	0.0980	0.1100	0.0980
Full Load SO2	lb/MMBtu	0.0015	0.0006	0.0015	0.0006	0.0015	0.0006	0.0015	0.0006
Full Load CO2	lb/MMBtu	162.7000	117.0000	162.7000	117.0000	162.7000	117.0000	162.7000	117.0000
Full Load VOC	lb/hr	1.75	1.53	1.75	1.53	5.85	5.10	5.85	5.10
Full Load PM	lb/hr	1.63	0.71	1.63	0.71	5.43	2.36	5.43	2.36
VOM	$/MWh	6.42	6.42	6.42	6.42	6.42	6.42	6.42	6.42
FOM	$/kW-yr	42.00	42.00	42.00	42.00	26.40	26.40	26.40	26.40
MM	$/MWh	15.30	15.30	14.59	14.59	5.73	4.78	5.73	4.78

Technology		Mars 100 ULSD	Mars 100 LNG	Titan 250 ULSD	Titan 250 LNG	Titan 250 1x1 ULSD	Titan 250 1x1 LNG	LM2500 ULSD	LM2500 LNG
Nominal Capacity	MW	11	11	22	22	28	28	34	34
Space Required	Acres	5 to 10	5 to 10	5 to 10	5 to 10	5 to 10	5 to 10	5 to 10	5 to 10
Capital Cost	$000	21,390	21,390	35,190	35,190	68,655	68,655	55,614	55,614
Capital Cost	$/kW	1,999	1,893	1,637	1,629	2,497	2,470	1,655	1,655
Total Schedule Duration	Months	19	19	21	21	25	25	27	27
COD	Date	Jan-18	Jan-18	Apr-18	Apr-18	Aug-18	Aug-18	Oct-18	Oct-18
Capacity Degradation	%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%
Heat Rate Degradation	%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%
Max Net Capacity	MW	10.3	10.9	20.7	20.8	26.5	26.8	32.4	32.4
Min Net Capacity	MW	5.2	5.5	8.3	8.3	11.9	12.1	16.2	16.2
HR (HHV) @ Max	Btu/kWh	11,583	11,822	10,247	10,136	8,171	8,083	9,881	10,133
HR (HHV) @ Min	Btu/kWh	16,320	16,657	13,936	13,785	11,112	10,992	12,352	12,666
Mature FOR	%	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Scheduled Maintenance	%	4.0	4.0	4.0	4.0	6.0	6.0	4.0	4.0
Max Capacity Factor	%	94.0	94.0	94.0	94.0	92.0	92.0	94.0	94.0
Primary Fuel		ULSD	LNG	ULSD	LNG	ULSD	LNG	ULSD	LNG
Secondary Fuel		LNG	ULSD	LNG	ULSD	LNG	ULSD	LNG	ULSD
Full Load NOX	lb/MMBtu	0.0500	0.0990	0.0500	0.0990	0.0500	0.0990	0.0500	0.0990
Full Load CO	lb/MMBtu	0.0033	0.0150	0.0033	0.0150	0.0033	0.0150	0.0033	0.0150
Full Load SO2	lb/MMBtu	0.0015	0.0006	0.0015	0.0006	0.0015	0.0006	0.0015	0.0006
Full Load CO2	lb/MMBtu	162.7000	117.0000	162.7000	117.0000	162.7000	117.0000	162.7000	117.0000
Full Load VOC	lb/hr	0.0478	0.2707	0.0850	0.4437	0.0867	0.4553	0.1282	0.6899
Full Load PM	lb/hr	1.44	0.85	2.55	1.39	2.60	1.43	3.84	2.17
VOM	$/MWh	1.37	1.37	1.37	1.37	1.66	1.66	1.37	1.37
FOM	$/kW-yr	134.68	128.93	77.12	76.83	54.70	54.56	53.98	53.98
MM	$/MWh	8.04	7.92	6.57	6.56	7.86	7.84	5.77	5.77

Technology		LM2500 1x1 ULSD	LM2500 1x1 LNG	Frame 6B ULSD	Frame 6B LNG	Frame 6B 1x1 ULSD	Frame 6B 1x1 LNG	LM6000 ULSD	M6000 LNG
Nominal Capacity	MW	48	48	43	44	65	67	55	55
Space Required	Acres	5 to 10	5 to 10	5 to 10	5 to 10	5 to 10	5 to 10	5 to 10	5 to 10
Capital Cost	$000	103,155	103,155	73,416	73,416	130,479	130,479	76,935	76,935
Capital Cost	$/kW	2,158	2,163	1,723	1,669	2,014	1,947	1,412	1,399
Total Schedule Duration	Months	31	31	30	30	34	34	30	30
COD	Date	Feb-19	Feb-19	Jan-19	Jan-19	May-19	May-19	Jan-19	Jan-19
Capacity Degradation	%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%
Heat Rate Degradation	%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%
Max Net Capacity	MW	46.1	46.0	41.1	42.5	62.5	64.7	52.6	53.1
Min Net Capacity	MW	16.1	16.1	20.6	21.2	35.6	36.9	26.3	26.5
HR (HHV) @ Max	Btu/kWh	7,137	7,319	11,368	11,594	7,626	7,777	9,494	9,588
HR (HHV) @ Min	Btu/kWh	9,635	9,880	13,374	13,640	8,971	9,150	12,152	12,273
Mature FOR	%	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Scheduled Maintenance	%	6.0	6.0	4.0	4.0	6.0	6.0	4.0	4.0
Max Capacity Factor	%	92.0	92.0	94.0	94.0	92.0	92.0	94.0	94.0
Primary Fuel		ULSD	LNG	ULSD	LNG	ULSD	LNG	ULSD	LNG
Secondary Fuel		LNG	ULSD	LNG	ULSD	LNG	ULSD	LNG	ULSD
Full Load NOX	lb/MMBtu	0.0500	0.0990	0.0500	0.0990	0.0500	0.0990	0.0500	0.0990
Full Load CO	lb/MMBtu	0.0033	0.0150	0.0033	0.0150	0.0033	0.0150	0.0033	0.0150
Full Load SO2	lb/MMBtu	0.0015	0.0006	0.0015	0.0006	0.0015	0.0006	0.0015	0.0006
Full Load CO2	lb/MMBtu	162.7000	117.0000	162.7000	117.0000	162.7000	117.0000	162.7000	117.0000
Full Load VOC	lb/hr	0.1317	0.7075	0.1869	1.0338	0.1907	1.0560	0.1997	1.0687
Full Load PM	lb/hr	3.95	2.22	5.61	3.25	5.72	3.32	5.99	3.36
VOM	$/MWh	1.66	1.66	1.37	1.37	1.66	1.66	1.37	1.37
FOM	$/kW-yr	47.67	47.70	44.65	43.52	43.80	43.38	36.68	36.41
MM	$/MWh	7.01	7.01	5.39	5.34	6.56	6.48	5.02	5.00

Technology		LM6000 1x1 ULSD	LM6000 1x1 LNG	6F ULSD	6F LNG	6F 1x1 ULSD	6F 1x1 LNG	Solar PV	On-shore Wind
Nominal Capacity	MW	69	70	50	52	73	76	10	20
Space Required	Acres	5 to 10	5 to 10	5 to 10	5 to 10	5 to 10	5 to 10	50 to 80	500 to 700
Capital Cost	$000	126,615	126,615	82,455	82,455	143,865	143,865	29,670	60,030
Capital Cost	$/kW	1,830	1,814	1,652	1,586	1,971	1,893	2,967	3,002
Total Schedule Duration	Months	34	34	30	30	34	34	15	30
COD	Date	May-19	May-19	Jan-19	Jan-19	May-19	May-19	Oct-18	Jan-19
Capacity Degradation	%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	9.4%	NA
Heat Rate Degradation	%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	NA	NA
Max Net Capacity	MW	66.8	67.4	48.2	50.2	70.4	73.3	9.1	20.0
Min Net Capacity	MW	24.7	24.9	19.3	20.1	37.3	38.9	0	0
HR (HHV) @ Max	Btu/kWh	7,573	7,648	10,015	10,227	7,038	7,179	NA	NA
HR (HHV) @ Min	Btu/kWh	10,223	10,325	11,783	12,032	8,280	8,446	NA	NA
Mature FOR	%	2.0	2.0	2.0	2.0	2.0	2.0	0.5	2.0
Scheduled Maintenance	%	6.0	6.0	4.0	4.0	6.0	6.0	1.0	2.0
Max Capacity Factor	%	92.0	92.0	94.0	94.0	92.0	92.0	20.0	35.0
Primary Fuel		ULSD	LNG	ULSD	LNG	ULSD	LNG	Sunlight	Wind
Secondary Fuel		LNG	ULSD	LNG	ULSD	LNG	ULSD	NA	NA
Full Load NOX	lb/MMBtu	0.0500	0.0990	0.0500	0.0990	0.0500	0.0990	NA	NA
Full Load CO	lb/MMBtu	0.0033	0.0150	0.0033	0.0150	0.0033	0.0150	NA	NA
Full Load SO2	lb/MMBtu	0.0015	0.0006	0.0015	0.0006	0.0015	0.0006	NA	NA
Full Load CO2	lb/MMBtu	162.7000	117.0000	162.7000	117.0000	162.7000	117.0000	NA	NA
Full Load VOC	lb/hr	0.2023	1.0818	0.1929	1.0777	0.1983	1.1057	NA	NA
Full Load PM	lb/hr	6.07	3.40	5.79	3.39	5.95	3.48	NA	NA
VOM	$/MWh	1.66	1.66	1.37	1.37	1.66	1.66	0.00	0.00
FOM	$/kW-yr	42.97	42.86	39.35	38.08	42.29	41.78	30.00	60.00
MM	$/MWh	6.06	6.04	5.15	5.08	6.20	6.10	4.53	In FOM

Technology		Micro Hydro	Stoker / Fluidized bed	Stoker / Fluidized bed	MSW	Fuel Cell	Nuclear SMR	OTEC	SWAC
Nominal Capacity	MW	1	10	10	10	1	90	10	12
Space Required	Acres	NA	10 to 25	10 to 25	10 to 25	0.1	50 to 60	15 to 25	3 to 5
Capital Cost	$000	7,590	82,800	91,770	78,855	13,455	855,931	145,281	148,328
Capital Cost	$/kW	7,590	8,280	9,177	7,886	13,455	9,510	14,528	12,361
Total Schedule Duration	Months	NA	48	48	48	6	96	48	42
COD	Date	NA	Jul-20	Jul-20	Jul-20	Jan-17	Jul-24	Jul-20	Jan-20
Capacity Degradation	%	NA	1.0%	1.0%	1.0%	0.0%	1.0%	1.0%	1.0%
Heat Rate Degradation	%	NA	1.5%	1.5%	1.5%	0.0%	1.5%	1.5%	1.5%
Max Net Capacity	MW	1.0	9.9	9.9	9.9	1.0	89.1	9.9	11.88
Min Net Capacity	MW	NA	5.0	5.0	5.0	0.4	29.4	5.0	5.9
HR (HHV) @ Max	Btu/kWh	NA	15,225	17,001	16,240	5,750	NA	NA	NA
HR (HHV) @ Min	Btu/kWh	NA	NA	NA	NA	6,200	NA	NA	NA
Mature FOR	%	NA	7.0	8.0	8.0	0.5	2.0	6.0	3.0
Scheduled Maintenance	%	NA	8.0	8.0	8.0	0.5	8.0	6.0	4.0
Max Capacity Factor	%	90.0	85.0	84.0	84.0	99.0	90.0	88.0	93.0
Primary Fuel		NA	Wood Pellets	Veg Waste	MSW	LNG	NA	Seawater	Seawater
Secondary Fuel		NA	NA	NA	NA	Biogas	NA	NA	NA
Full Load NOX	lb/MMBtu	NA	NA	NA	NA	0.0020	NA	NA	NA
Full Load CO	lb/MMBtu	NA	NA	NA	NA	0.0200	NA	NA	NA
Full Load SO2	lb/MMBtu	NA	NA	NA	NA	negligible	NA	NA	NA
Full Load CO2	lb/MMBtu	NA	NA	NA	NA	135.0000	NA	NA	NA
Full Load VOC	lb/hr	NA	NA	NA	NA	0.0200	NA	NA	NA
Full Load PM	lb/hr	NA	NA	NA	NA	0.00	NA	NA	NA
VOM	$/MWh	0.00	8.40	9.60	12.60	0.00	1.59	11.66	2.12
FOM	$/kW-yr	42.00	132.00	144.00	216.00	468.00	211.97	307.35	84.79
MM	$/MWh	6.77	5.57	5.57	5.57	In FOM	1.57	8.10	6.31

3.1 MSRs

Unit characteristics were developed for the potential installation of new simple-cycle and combined-cycle MSR units based on the use of Caterpillar 6CM46DF for the single unit options and Mann/Fairbanks Morse 18VDF machines. The units have dual fuel capability and can be fired on either ULSD or LNG. The combined-cycle options would include an HRSG, a STG, a condenser, fin fan coolers for heat rejection, associated pumps, piping, electrical and control equipment, and an interconnection to the grid. The assumptions include an SCR for both simple-cycle and combined-cycle installations.

3.2 CTGs

Unit characteristics were developed for the potential installation of new simple-cycle and combined-cycle units based on the use of the following CTGs firing on ULSD and LNG.

- Solar Mars 100
- Solar Titan 250
- General Electric (GE) LM2500
- GE Frame 6B
- GE LM6000
- GE 6F

The CTGs are to be equipped with inlet cooling to maintain performance during periods of hot ambient conditions, SCRs, fin fan coolers for heat rejection, other balance of plant equipment and an interconnection to the grid. The combined-cycle options would include an HRSG, a STG, an air cooled condenser, and associated pumps, piping, electrical and control equipment. The assumptions include an SCR for both simple-cycle and combined-cycle installations.

3.3 Solar

Unit characteristics were developed for the potential installation of a stationary photovoltaic solar project. The plant would include panels, panel mounts, collection systems, inverters and interconnection to the grid.

3.4 Wind

Unit characteristics were developed for the potential installation of a wind project. The plant would include approximately ten wind turbines (2 MW each), collection systems, and interconnection to the grid.

3.5 Hydro

Leidos investigated the potential of installing a low-head hydro resource. The application requires large volume of water, with low head such as a low damn or lock on a large river. Leidos does not believe this type of siting is available on Guam. This opinion is consistent with a 2006 report issued by the United States Department of the Interior. Therefore, the technology is not a viable alternative for GPA.

Leidos also investigated the potential of installing a micro hydro resource. This type of resource utilizes smaller volumes of water in high head applications such as a waterfall. The installation requires the stream to be diverted into a piping system prior to being passed through a turbine. The hydrology on Guam may be able to support a small turbine with capacity factors being limited seasonally. However, this would require installation of several hundred feet of pipe down the side of a mountain or steep hill and the installation of an electrical line to interconnect the remote facility to the existing transmission and distribution infrastructure. Unit characteristics were developed for the potential installation of a 1 MW micro hydro plant including approximately 800 feet of piping and 2 miles of electrical interconnection.

3.6 Biomass

Unit characteristics were developed for the potential installation of two types of biomass resources, one that would burn wood pellets and a second that would burn green vegetation. Biomass heat content, moisture, ash, and other constituents can vary significantly based on the source. In order to properly characterizer a biomass plant the constituents of the biomass should be studied in detail. For the purposes of this assignment assumptions were made as to the heat content of the biomass supply. The data presented is based on fluidized bed technology. The size of the biomass resources was estimated based on the tonnage of biomass required and the capability of obtaining the biomass on Guam, coupled with the ability to achieve capacity factors over 70 to 80 percent. It was assumed that the wood pellets would be delivered ready for use and no preprocessing would be required.

3.7 Municipal Solid Waste

Unit characteristics were developed for the potential installation of a MSW resource. MSW heat content, moisture, ash, and other constituents can vary significantly based on the supply source. In order to properly characterizer a MSW plant the constituents of the MSW should be studied in detail. For the purposes of this assignment assumptions were made as to the heat content of the MSW supply. The data presented is based on fluidized bed technology. The size of the resource was estimated based on the tonnage of MSW required and the capability of obtaining the MSW on Guam, coupled with the ability to achieve capacity factors over 70 to 80 percent.

3.8 Biofuel

Leidos performed a high-level evaluation to determine if making power from the sludge from the wastewater treatment plants on Guam was feasible and if additional more detailed evaluations would be valuable. As part of this evaluation we considered (1) the implementation of algae ponds and / or the use of a hydrothermal liquefaction system (HTL) for the conversion of sludge to heavy oils and (2) the use of a press for dewatering the sludge. In both cases, the biomass material would be burned in a fluidized bed boiler to generate steam, which would be used to make power.

With regard to the implementation of algae ponds, Algae Systems, LLC provided a presentation on how algae ponds and HTL could be incorporated into the water treatment systems of Guam as a holistic solution. Leidos recognizes the benefit of the installation of algae ponds for treating wastewater to reduce chemical usage. However, as this resource evaluation was focused on GPA resources we do not believe algae ponds would be of significant benefit in this limited role.

With regard to power generation from sludge, approximately 1,960 dry tons per year of sludge is available as a resource. The sludge contains approximately 70 percent water. Leidos concluded that additional water removal from the sludge would be necessary to prepare the sludge for feeding to a fluidized bed boiler. Therefore, two methods for water reduction were considered, (1) the use of an HTL unit and (2) the use of a filter press followed by drying.

The HTL unit has the capability of receiving high moisture content feedstocks and converting the biomass portion to heavy oils, gas, char, and water. However, for this evaluation, the ability to make the potentially higher value heavy oils is not considered a benefit as it is to be used solely as a fuel source for steam generation and not transportation fuels. Ultimately, the HTL is a dewatering step. Based on our previous experiences with HTL units we believe the water product from the HTL has the potential to contain a large portion of the hydrocarbon fuel trapped in an emulsion and dissolved in the water, which would reduce the amount of hydrocarbons in the supply to the fluidized bed boiler and make it difficult to discharge the water without further treatment. Two options are available to recapture the heating value of the hydrocarbons in the phase water; (1) a solvent extraction unit which breaks the emulsion and returns the hydrocarbons to the oil phase (a very low miscible solvent should be used to minimize contamination of the water stream); and (2) the use of a catalytic hydrothermal gasification (CHG) unit to convert the hydrocarbons in the water stream to fuel gas. Based on other small flow HTL/solvent extraction or CHG units with which we are familiar, Leidos believes this unit to have an installed cost of several million dollars. The high cost of the HTL unit does not make this option feasible as a dewatering step.

We also evaluated if a dewatering press, which is a much less expensive and complex process than an HTL, could produce a dried cake for use in a fluidized bed boiler for steam generation. Our evaluation concluded that a cake dried to 50 percent moisture would not be a good fuel for a fluidized bed boiler due to (1) the low heating value of the sewage sludge (which we estimated to be approximately 6,400 Btu/lb on an ash-free dry basis), (2) the high ash content (10-20 percent), and (3) the need for additional drying. We estimated that approximately 25 percent of the potential steam production from the fluidized bed boiler would be consumed in drying the sludge.

In summary, the use of algae ponds could be cost effective in reducing the inorganics in wastewater and reducing chemical usage at the wastewater treatment plant, but this consideration is outside the scope of this evaluation. Further, an HTL / solvent extraction unit is technically feasible for converting sludge to heavy oils, gas, and char. However, the use of an HTL unit as a dewatering step to produce a product for steam generation is not cost effective. Should the sludge be converted to heavy oils, gas, and char to avoid disposal costs, then the small amount of fuel produced could potentially be used in a blended fashion with other fuel sources to generate power. Finally, a press followed by drying would potentially be required to prepare the sludge to a form necessary for use in a fluidized bed boiler. The amount of sludge available would only generate on the order of 100 kWh of power.

3.9 Fuel Cell

A fuel cell produces electricity and heat through an electrochemical reaction between a fuel (generally hydrogen) and oxygen. A fuel cell consists of an electrolyte between two electrodes with connectors for collecting the generated current. A fuel cell is similar to a battery, but while a battery can either be charging or discharging, a fuel cell can be fed fuel and discharge continuously. The electrochemical reaction does require a source of hydrogen, which is generally produced with a reformer from fossil fuels like natural gas. Unit characteristics were developed for a small fuel cell. The cell was oversized to allow for degradation to take place while maintaining the system capacity over time.

3.10 Small Modular Reactor

Unfortunately, since we issued our letter report on SMRs in 2011, the development and marketing of SMRs has not advanced. Unit characteristics were developed for the potential installation of a SMR based on a data from a confidential supplier provided in 2011 and escalated to reflect current pricing. The SMR proposed is modular in nature with the reactors installed below ground in containment and the STG located adjacent to the reactors at grade level. The major maintenance costs represent the costs of refueling and disposal. Permitting and licensing would present a major challenge to the installation of an SMR on Guam.

3.11 Geothermal

Leidos investigated the potential of installing a geothermal resource. The application requires both geothermal energy and flow. A 2011 study commissioned by the United States Navy indicates that the geothermal resource on Guam is marginal at best. This opinion is consistent with a 2006 report issued by the United States Department of the Interior. Therefore, the technology is not a viable alternative for GPA.

3.12 Ocean Thermal Energy Conversion

Unit characteristics were developed for the potential installation of a OTEC system utilizing a land-based organic rankine cycle, meaning the turbine and electric power generation is installed on land. An organic rankine cycle is similar to a steam cycle, except that it uses an organic fluid in place of water. The organic working fluid, which has a lower boiling point and higher vapor pressure than water, is used to transfer heat from an external source into a closed loop system. The assumptions for the OTEC system included a condensing heat exchanger utilizing cold ocean water and an evaporating heat exchanger utilizing warmer ocean water near the surface as well as the pump and pipes to convey the working fluid. The resource requires a large pipe 20-30 inches in diameter and several miles long to be looped into the ocean to condense the working fluid with cold deep ocean water and evaporate the working fluid with warm surface ocean water. Currently, there is one 120 kW OTEC system in operation. Scale-up to a 10 MW system would present a major challenge to the installation of an OTEC resource on Guam.

3.13 Sea Water Air Conditioning

Unit characteristics were developed for the potential installation of a SWAC system to exchange the heat from a land-based cooling loop with the cold water from the ocean. The assumptions include a large heat exchanger to be installed on land to transfer the heat from a closed loop system on land to the cold ocean water in a separate open loop. The resource requires two large pipes 3 to 5 feet in diameter and several miles long to be submerged in the ocean. Currently, there are a handful of SWAC systems in operation, including those that utilize lake water.

3.14 Ocean Tidal

Leidos investigated the potential of installing a basin capture type ocean tidal resource. The application requires a large seaside basin to capture the high tides and then release them at low tide to generate electricity, similar to a low head hydro facility. Guam tides peak at less than 3 feet, which would limit head and require a large capture basin footprint. Leidos does not believe this type of siting is available on Guam. This opinion is consistent with a 2006 report issued by the United States Department of the Interior. Therefore, the technology is not a viable alternative for GPA.

3.15 Ocean Wave

Leidos investigated the potential of installing an ocean wave resource. This application requires high wave intensity to turn underwater turbines. Unfortunately, it requires higher wave intensity than exists at Guam. This opinion is consistent with a 2006 report issued by the United States Department of the Interior. Therefore, the technology is not a viable alternative for GPA.

3.16 Electrical Interconnections

GPA indicated that one potential location for the installation of potential new resources is near the existing Harmon substation. To support the IRP modeling Leidos developed cost estimates for expanding both the 34.5 kV and the 115 kV busses of the Harmon substation to allow for interconnection of a new generating resource. Further, Leidos developed costs estimates for transmission lines and distribution lines to support the connection of a new resource with the Harmon substation.

The cost to expand the Harmon substation to include a new position at the 34.5 kV level and the 115 KV level is estimated to be $460,000 and $885,000, respectively.

The cost to install 34.5 kV overhead distribution line utilizing guyed steel or concrete poles is estimated to be $300,000 per mile. The cost to install 115 kV overhead transmission line utilizing guyed steel or concrete poles is estimated to be $415,000 and $320,000 per mile, respectively. The cost to install 115 kV overhead transmission line utilizing anchor bolted steel is estimated to be $910,000 per mile.

3.17 Fuel Supply Pipelines

To support the IRP modeling Leidos developed cost estimates for the installation of two gas pipelines to connect a potential new LNG regasification facility near Apra Harbor to (1) the Cabras/Piti area (approximately 5 miles) and (2) the Harmon area (approximately 18 miles). Both pipelines were assumed to be 12 inches in diameter, underground, carbon steel pipelines, with operating pressures of about 600 psig. The pipelines were assumed to be routed along existing roadways. The estimate did not include costs for rock excavation or dewatering. The costs of the 5 mile and 18 mile pipelines are estimated to be $2,000,000 per mile.

Appendix D: 2020 Leidos Report

GPA 2020 IRP Support (102621).pdf

October 26, 2021

Via E-mail (mtison@gpagwa.com)

Ms. Paz A. Tison
Guam Power Authority
Gloria B. Nelson Public Service Bldg.,
688 Route 15
Mangilao, Guam 96913

Subject: GPA 2020 IRP Unit Characteristic Assumptions

Dear Ms. Tison:

Presented herein is the report (the "Report") prepared for the Guam Power Authority ("GPA") to support the development of its 2020 integrated resource plan ("IRP"). In coordination with GPA, Leidos Engineering, LLC ("Leidos") developed unit characteristics, including performance, capital cost, and operation and maintenance ("O&M") cost projections for potential new power generating resources. At the request of GPA, Leidos has also provided discussion related to the status of the deployment of small modular reactor ("SMR") nuclear technology and potential options GPA has for use of waste oil collected on-island going forward.

This Report was prepared in accordance with the GPA Contract No. GPA-RFP-17-002 dated July 24, 2017 (the "Agreement") and the associated Task Order No. 17-09 dated November 25, 2019 (the "TO"), both between Leidos Engineering, LLC ("Leidos") and GPA. This Report is solely for the information of and assistance to GPA and should not be used for any other purpose or by any other party except for those parties who have entered into to a third party use of work products agreement with Leidos. The Report has been developed based on the needs of GPA, and incorporates our analysis of information made available to us by GPA, including documents, written correspondence, and/or oral communications, as well as publicly available information, an certain proprietary data of Leidos. Further, the level of detail presented in the Report reflects the results of our interactions with GPA through the course of our review, thus it does not reflect a comprehensive record of our analysis nor a complete accounting of the information we reviewed.

In the preparation of this Report and the opinions presented in this Report, we have made certain assumptions with respect to conditions which may exist or events which may occur in the future. While we believe these assumptions to be reasonable for the purpose of this Report, they are dependent upon future events, and actual conditions may differ from those assumed. In addition, we have used and relied upon certain information provided to us by others. While we believe the use of such information and assumptions to be reasonable for the purposes of this Report, we offer no other assurances with respect thereto, and some assumptions may vary significantly due to unanticipated events and circumstances. To the extent that actual future conditions differ from those assumed herein or provided to us by others, the actual results will vary from those projected herein. We do not plan to issue any updates or revisions to the Report if or when changes to our expectations, or events, conditions or circumstances on which such statements are based, occur. No warranty, guarantee, or promise, express or implied, related to any future results, performance, or achievements associated with opinions included herein is provided. This Report includes a summary our work up to the date of the Report. Thus, changed conditions occurring or becoming known after such date could affect the material presented to the extent of such changes.

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Background

GPA operates as the sole electric utility service provider in the United States ("U.S.") Territory of Guam ("Guam"), an island located in the western Pacific Ocean approximately 3,800 miles west-southwest of Honolulu, Hawai'i, 1,550 miles south-southeast of Tokyo, Japan and 1,600 miles east of Manila, the Philippines. The island, which is the western-most territory of the U.S., is approximately 30 miles long and ranges from 5 to 8.5 miles wide with a total land area of approximately 212 square miles.

GPA presently provides electric generation, transmission, and distribution service throughout the island, with the exception of distribution of power on the military bases. Current electric utility operations on Guam date back to the post-World War II period when electric power production facilities consisted of individual diesel-fired plants located at the then existing principal military load centers. In 1950 portions of the power system, which historically and presently serves the other military facilities on the island, including Andersen Air Force Base, were transferred by the U.S. Navy (the "Navy") to the Government of Guam. In general, the transferred facilities consisted of those portions of the system which were devoted to civilian use and were considered surplus to the needs of the military. Subsequently, the Government of Guam created the Public Utility Agency of Guam ("PUAG") as the agency responsible for operation and maintenance of electric power and other utility services provided by the Government of Guam. In 1968, GPA was established by an act of the Legislature of Guam as a public corporation and an autonomous instrumentality of the Government of Guam. The Legislature provided for the transfer of the electric utility assets of PUAG to GPA, which officially commenced operations on April 1, 1969. Additional Navy generation, transmission and distribution facilities were transferred to GPA by the PUC in August 1996. The PUC is an independent regulatory commission, comprised of seven appointed commissioners, which regulates the rates and rate impacting procurements of GPA, amongst other utility service providers on Guam.

Today GPA is regulated by the PUC and governed by the Consolidated Commission on Utilities (the "CCU"). The CCU was created in 2001 by Public Law 26-76, which sets forth the management and oversight structure of GPA and Guam Waterworks Authority.

Collectively, GPA has rights to dispatch generating units that have an aggregate nameplate capacity rating of approximately 390 mega-watts ("MW"). The existing resources, which include boiler and steam turbine generators ("STGs"), combustion turbine generators ("CTGs"), slow speed reciprocating ("SSR") engines, and medium speed reciprocating ("MSRs") engines, are listed in Table 1 below.

Essentially all of GPA's generating resources are fired with fuel oil products (residual fuel oil No. 6 and fuel oil No. 2). Volatility in fuel oil prices has had a significant impact on GPA's financial resources and need for working capital. GPA has a program to adjust rates periodically to address changes in fuel costs known as the Levelized Energy Adjustment Clause (the "LEAC"), and has embarked on a fuel price hedging program.

GPA is responsible for the transmission, distribution, metering and accounting of electrical power to consumers. GPA operates and maintains overhead and underground power lines and associated hardware, substation equipment, energy/revenue meters and relay protective devices. In addition, GPA provides new power installations, line extensions, work clearances and miscellaneous power-related services to its customers. GPA follows the standards of the National Electrical Manufacturers Association ("NEMA") / American National Standards Institute ("ANSI") C84 for delivery of power and imbalance regulation.

Table 1
Summary of GPA Generation Resources

Plant	Units	Technology	Nominal Capacity	Primary Fuel	Install Date
Cabras	Unit 1	Boiler/STG	65 MW	HFO/RFO (1)	1974
	Unit 2	Boiler/STG	65 MW	HFO/RFO	1975
Dededo	Unit 1	CTG	22 MW	ULSD (2)	1992
	Unit 2	CTG	22 MW	ULSD	1993
Macheche	Unit 1	CTG	20 MW	ULSD	1993
Manenggon	Unit 1 & 2	MSR	4.4 MW each	ULSD	1993
Piti	Unit 7	CTG	40 MW	ULSD	1997
	Unit 8	SSR	45 MW	ULSD	1999
	Unit 9	SSR	45 MW	ULSD	1999
Talafofo	Unit1 & 2	MSR	5 MW each	ULSD	1994
Tenjo	Units 1-6	MSR	4.4 MW each	ULSD	1994
Yigo	Unit 1	CTG	20 MW	ULSD	1993

(1) Heavy Fuel Oil ("HFO"), Residual Fuel Oil ("RFO")
(2) Ultra-Low Sulfur Diesel ("ULSD")

The power delivery system includes 29 substations connected through approximately 175 miles of 115 kilovolt ("kV") and 34.5 kV transmission lines. The substations supply 65 distribution feeders with approximately 2,500 miles of line, over 60 percent of which is rated at 13.8 kV. GPA serves approximately 48,500 customers, having a peak load of approximately 270 MW and consisting primarily of residential and commercial customers, governmental entities, and the Navy. Power delivery is controlled from the Power System Control Center ("PSCC") located adjacent to the Cabras Power Plant.

General Assumptions

Numerous assumptions were made in developing the data for each of the resources. The general assumptions are listed below, but other assumptions and more specific detail resource option data are provided in the sections that follow. Further, a comprehensive presentation of the assumptions was provided to GPA in March 2020 in the spreadsheet titled *"332353 GPA 2020 IRP Assumptions(032720).xls",* which is included in Appendix A, to support the IRP modeling process.

- Construction related costs and O&M costs are presented in 2019$
- Non-union labor will be used
- Construction costs include 7 percent contingency as part of the direct costs

- The plant direct construction costs include costs for plant side switchgear and transformer to increase the voltage to 34.5 KV, as well as a 34.5 KV breaker, 3 disconnects, 34.5 KV switchgear and control panel, control house and fencing
- Construction costs include owner costs at 15 percent of direct costs
- Cost estimates have been adjusted to include a 20 percent uplift from mainland pricing to account for working on Guam, unless noted otherwise
- O&M costs represent non-fuel production related costs, including subcategories for variable O&M (VOM), Fixed O&M (FOM), and major maintenance
- FOM does not include owner costs such as property taxes, insurance, or finance related costs
- New installation construction schedule information is based on permitting starting in July 2020

New Resource Unit Characteristics

Ocean Thermal Energy Conversion (OTEC)

Ocean thermal energy conversion technology ("OTEC") utilizes the temperature differences between sea water at the surface and depths of 1,000 meters or more to condense and evaporate the fluid of a closed-loop organic rankine cycle ("ORC") while passing it through a turbine to generate electricity. A working fluid (ammonia) with a lower boiling point than water is utilized for the cycle. The working fluid is condensed within a heat exchanger, cooled by the deep ocean water. From there, it is pumped to pressure and then it enters the surface water heat exchanger where it absorbs heat and vaporizes. The fluid expands through a turbine, and then the cycle is repeated. An ocean water temperature differential of at least 25 degrees Celsius ("°C") is preferred for efficient operation. While ORC technology is mature, its use with OTEC is not commonly deployed at commercial/utility scale. Currently, Makai Ocean Engineering ("Makai") is operating a 100 kilowatt ("kW") turbine in Hawaii, which is the largest operating OTEC deployment worldwide.

Unit characteristics were developed for the potential installation of an ("OTEC") system in Guam based on the Hawaii project scaled up to 10 MW. Since the capital cost of the Hawaii Project was used as the basis of the pricing of the GPA resource, the 20 percent cost adder was not used. We have assumed a staff of approximately 12 would be needed to support operations while staffing the site 24 hours per day seven days per week. The high capital costs and potential environmental impacts of OTEC deployments has inhibited commercial scale development of the technology.

Sea Water Air Conditioning (SWAC)

Similar to the OTEC technology, sea water air condition ("SWAC") utilizes the cold thermal reservoir of the ocean to regulate land-based air conditioning. Cool sea water is pumped through miles of pipes to a land-based heat exchanger, where it extracts heat from the closed fresh water loop that is used in air conditioning services. Makai provided GPA with a feasibility study in 2006 to provide a SWAC system with up to 16,000-tons of cooling to serve the hotels in the Tumon Bay area with expected capital costs of approximately $100,000,000. The proposal included pipe routing across the marine sanctuary. As with OTEC, Hawaii has been working with a developer for a SWAC system to serve the buildings of downtown Honolulu for several years. Recent press releases indicate that the SWAC is expected to provide 25,000-tons of cooling and have a capital cost of approximately $250,000,000. While several SWAC systems are currently operational worldwide, the nuances of siting have resulted in minimal deployments.

We have used the 2006 Makai study as the basis for the 2020 IRP unit characteristics, including escalation of the capital costs at 2.0 percent, but not the 20 percent cost adder. We note that this represents a lower capital cost than scaling of the Hawaii project for the reduced cooling tonnage of the system proposed for GPA by Makai. Further, we have based the electrical equivalent on the quoted 8.4 MW, which appears to include a utilization factor of 25 percent or less. We have assumed a staff of approximately six to eight would be needed to support operations while staffing the only during normal business hours with a staff member on call over nights and weekends. The high capital costs and potential environmental impacts of SWAC deployments have limited commercial scale development of the technology.

Battery Energy Storage (BESS)

Unit characteristics were developed for the potential installation of a battery energy storage system ("BESS") utilizing lithium-ion based battery chemistry. Lithium-ion BESS in modular DC blocks has emerged as a popular choice for energy storage. Improving economies of scale through mass production endeavors, such as the Tesla Giga-factory, has contributed to lower cost lithium-ion batteries. BESS have a wide range of capabilities from providing real power or frequency regulation with reaction times at sub-cycle speeds. While lithium-ion batteries have been in commercial use for decades, their application in stationary battery storage applications at the utility scale has only occurred over the past 10 years. Further, battery technology is mature, but the impacts of long-term throughput degradation have not yet been verified by field operations.

At the direction of GPA we have developed the BESS unit characteristics based on a time shift application with a four hour duration, whereby the BESS would be charged at times when energy costs were low and discharged when energy costs were high. Energy capacity degradation of a BESS is approximately 3 percent annually, which results in an estimated useful life of less than 10 years unless capacity augmentation in later years or upfront oversizing is employed, neither of which has been included in our assumptions for the 2020 IRP. We have assumed that the facility would be unmanned, with technical staff deployed only to conduct preventative or corrective maintenance.

Pumped-Storage Hydropower (PSH)

Pumped-storage hydro ("PSH") power is a type of hydroelectric energy storage that utilizes two water reservoirs at different elevations that can generate power as water moves down from the upper reservoir through a turbine to the lower reservoir. Pumps are used to fill the upper reservoir during times when power prices are low and the water is released form the upper reservoir when power prices are high. PSH facilities are more effective when they have a large elevation difference between the reservoirs and the reservoirs can hold large volumes of water. PSH is mature technology, but deployed in limited capacity worldwide due to the siting nuances.

For the GPA 2020 IRP we have assumed that the gross head available on–island is approximately 300 feet or 100 meters. In order to support a two unit, constant speed facility with a total capacity of 25 MW with a two-hour operating duration, two reservoirs of approximately 200 acre-feet are needed, which each reservoir having a surface area of approximately 20 acres and a depth of 10 feet or similar. A similar reservoir combination could support a smaller capacity rating and a longer duration. It is unclear if siting on Guam would prove to be successful with the need for the elevation change and open area required for the upper and lower reservoirs. The configuration we used as the basis of our assumptions has a high capital cost, but we would expect it to be higher on a $/kW basis for a smaller installation using smaller reservoirs or tanks. We have assumed a staff of approximately six to eight would be needed to support operations while staffing the only during normal business hours with a staff member on call over nights and weekends.

Compressed Air Energy Storage (CAES)

Compressed air energy storage ("CAES") is a way to store energy in the form of compressed air for use at a later time. CAES plants compress air when power prices are low. The compressed air is generally stored in large underground caverns, which can accommodate high pressures and large volumes of compressed air. In the simplest of configurations, when power generation is needed, the compressed air is used to feed a combustion turbine. Since the air is already compressed, assuming at low to no cost, then the efficiency of the cycle is improved relative to a standard combustion turbine Brayton cycle. Unfortunately, with this diabatic configuration the heat generated during compression and the heat lost during expansion are not utilized to improve cycle efficiency. Therefore, efficiencies will be limited to 50 or 60 percent. Larger CAES systems that employ heat storage (adiabatic configurations) can have efficiencies of approximately 70 percent. CAES technology is mature, but siting nuances have limited deployments worldwide. Currently there are two major CAES installations utilizing underground storage in operation with several others in development. For the avoidance of doubt, a small-scale CASE plant, with tanked compressed air storage like the one serving as the basis of the unit characteristics for the GPA 2020 IRP has never been built.

We have prepared unit characteristics for a small, 5 MW, 10 megawatt-hour ("MWh"), diabatic CAES system utilizing a large, high-pressure (1,000psi or 70 Bar) storage tank with a volume of approximately 300,000 gallons, or 1,000 cubic meters, rather than a cavern. We have assumed a staff of approximately six to eight would be needed to support operations while staffing the only during normal business hours with a staff member on call over nights and weekends.

Flywheels

A flywheel consists primarily of a hub, permanent magnet motor generator ("PMMG"), rim, two angular contact/rolling element bearings, a magnetic bearing, and housing. A flywheel is designed to convert electric energy to kinetic energy and kinetic energy to electric energy. The amount of energy in each flywheel is directly proportional to the square of rotational speed, so as the flywheel absorbs electric energy, the rotation speed of the flywheel increases to a peak of 16,000 revolutions per minute ("RPM"). Conversely, as the PMMG injects electric energy into the grid, the rotational speed of the flywheel is reduced. Flywheel technology is mature, but monetizing the production of the facility in a manner to cover the capital cost has proven to be a challenge from a practical standpoint.

We have based the unit characteristics for the 2020 IRP on a containerized flywheel system, with each module designed to generate no less than of 100 kW of electricity for 15 minutes, or 25 kWh of electricity. As such the total facility will have 50 modules and be rated at 5 MW and 1.25 MWh. We have assumed that the facility would be unmanned, with technical staff deployed only to conduct preventative or corrective maintenance.

Waste to Energy (WTE)

Guam has historically had challenges in dealing with municipal solid waste ("MSW"). In fact the Ordot Dump was out of compliance with the Clean Water Act for several years. However, in 2011 the Ordot Dump was closed and the Layon Landfill was opened. Further, in April 2019 a court order partially ended the 11-year federal receivership over Guam's solid waste and disposal services. Per the order, administrative and managerial responsibility over the day-to-day operations of the Guam Solid Waste Authority ("GSWA") was returned to the Government of Guam while the receiver continues its technical work to complete the post-closure plan for the Ordot Dump. That said, the potential for a waste-to-energy facility on Guam is at an all-time high. MSW facilities have been utilized worldwide for decades and the technology is mature.

Obtaining MSW with a relatively constant heat content and the separation of non-combustibles in the MSW are two key challenges to the successful operations of a WTE facility.

Based on data provided by GPA, we understand that the between 40,000 and 140,000 tons of MSW is currently being directed to the Layon Landfill. High level estimates indicate that the MSW could be used as the fuel supply for a WTE facility with a capacity rating of approximately 5 MW. We have assumed a staff of approximately 12 to 15 would be needed to support operations while staffing the site 24 hours per day seven days per week.

Fuel Cell

A fuel cell produces electricity and heat through an electrochemical reaction between a fuel (generally hydrogen) and oxygen. A fuel cell consists of an electrolyte between two electrodes with connectors for collecting the generated current. A fuel cell is similar to a battery, but while a battery can either be charging or discharging, a fuel cell can be fed fuel and discharge continuously. The electrochemical reaction does require a source of hydrogen, which is generally produced with a reformer from fossil fuels like natural gas.

Fuel cell types are generally classified according to the nature of the electrolyte they use. Each type requires particular materials and fuels and is suitable for different applications. There are six main types of fuel cells: alkaline fuel cell ("AFC"), solid oxide fuel cell ("SOFC"), phosphoric acid fuel cell ("PAFC"), proton exchange membrane fuel cell ("PEMFC"), molten carbonate fuel cells ("MCFC"), and direct methanol fuel cell ("DMFC"). AFC, MCFC, and PAFC all use liquid electrolytes, whereas, PEMFC, DMFC, and SOFC use solid electrolytes. Fuel cell technology is considered mature with significant deployments in both the residential and utility space worldwide.

For the GPA 2020 IRP we have developed unit characteristics based on the use of SOFCs. SOFCs use a solid ceramic compound such as calcium oxide or zirconium oxide as the electrolyte. SOFCs typically have operating temperatures in the range of about 800 "°C" to 1,000°C (about 1,470 degrees Fahrenheit ("°F") to 1,830°F) and can have efficiencies of more than 60 percent. SOFC cells with outputs up to 300 kW are available and we have assumed four, 250 kW fuel cells would be combined to make a 1 MW facility. The high operating temperatures of SOFCs means that fuels can be reformed with the fuel cell itself, eliminating the need for external reforming and allowing the use of various hydrocarbon fuels (e.g., pipeline natural gas, renewable fuel). The waste heat, resulting from the high operating temperatures, can be recycled to make additional electricity with the potential to enhance overall efficiency to more than 80 percent.

Cell output does degrade with time. As such we have assumed the system would be oversized to allow for the rated capacity to be available for a period of five years. After the initial five years of operation a cell replacement strategy would need to be employed, which has not been included in our O&M projections. We have assumed that the facility would be unmanned, with technical staff deployed only to conduct preventative or corrective maintenance.

Fuel Cell Cogen

We have developed unit characteristics for a cogeneration version of the facility described above that would utilize the waste heat of the fuel cell to produce hot water. The installation would include an air to water heat exchanger and a small closed-loop water system to utilize the heat in the form of hot water for building heat or similar application. Consistent with the fuel cell facility without cogeneration, we have assumed that the fuel cell cogeneration facility would be unmanned, with technical staff deployed only to conduct preventative or corrective maintenance.

Synchronous Condenser

A synchronous condenser is a DC-excited synchronous motor, with a shaft that is not connected to anything but instead spins freely. Its purpose is not to convert electric power to mechanical power or vice versa, but to adjust conditions on the electrical transmission or distribution system to which it is connected. Its field is controlled by a voltage regulator to either generate or absorb reactive power as needed to adjust the grid voltage or to improve power factor. The condenser installation and operation is identical to large electric motor and generator.

Increasing the field excitation of the device results in its furnishing reactive power (measured in units of var) to the system. Its principal advantage is the ease with which the amount of correction can be adjusted. The kinetic energy stored in the rotor of the machine can help stabilize a power system during rapid fluctuations of loads such as those created by short circuits or large intermittent loads. Installations can be deployed in stand-alone fashion or the generator of a combustion turbine generator set can be employed by installing a clutch between the turbine and the generator to de-couple the generator for use as a synchronous condenser.

At the direction of GPA, we have assumed that the Macheche combustion turbine generator would be retrofitted with a clutch to allow it to serve as a synchronous condenser. We have assumed that the existing generator would not need to be replaced, but instead the existing generator would be removed from its foundation, the foundation would be demolished and reinstalled to allow room for a clutch to be installed between the turbine and the generator. After modifying the foundations, the generator and clutch would be installed along with electrical power and control, cooling, etc connections extended to the new generator location. We have assumed that there are no additional O&M costs associated with the retrofit of the unit to have the clutch over and above the O&M costs currently being incurred by the facility.

Dual-Fuel Reciprocating Engines

Reciprocating engines generate rotational mechanical energy from chemical energy stored in fuels. The fuel is injected into a piston chamber where it is combusted with air, rapidly increasing the pressure within the chamber. The high pressure forces the piston towards the crankshaft, expanding the chamber. The linear motion of the piston is converted to rotational motion by the crankshaft. Reciprocating engines can be spark-ignited, where a spark plug ignites the fuel-air mixture, or compression-ignited, where the air is heated by compression of the piston to a high enough temperature to ignite the fuel-air mixture. The ignition mechanism is primarily determined by the fuel type. Engines that are designed to accept different fuels, such as diesel and liquified natural gas, are referred to as dual-fuel engines. Reciprocating engines can be engaged with generators to provide electrical energy. Larger scale reciprocating engine generators are emerging as a popular stability upgrade to electrical grids with intermittent production from renewable energy sources such as wind or solar. The quick-start capability allows these generators to promptly respond to shortfalls in utility energy production.

For the GPA 2020 IRP, we have gathered information related to the costs and feasibility of a utility scale installation of dual-fuel MSRs for use in conjunction with the existing 24 MW/6 MWh battery energy storage system ("BESS") to respond to electric grid needs in the event of a baseload unit trip. GPA requires that the MSRs be able to ramp to full load in under 5 minutes so that the BESS does not fully discharge, while the baseload generating unit that tripped is returned to service, or an alternate generating resource is started. The projections in Appendix A are based on the Wärtsilä Model 20V34DF-B unit, which is a dual fuel unit nominally rated at 9.3 MW. We have assumed the MSRs will initially run on ULSD, but their fuel flexibility allows operation on LNG in the future. To meet the request of GPA, we have assumed that three units will be installed to supply a degraded net total capacity of 27.9 MW to the electrical grid. The MSRs can be installed with remote start capability and can ramp to full load in 2 minutes from startup.

Multiple units with staggered maintenance outages provide a highly reliable power supply and an estimated availability of approximately 99.5 percent. We have assumed the MSRs will operate approximately 300 hours annually in contingency backup service. As a result of minimal operating hours, we have assumed the facility will be unmanned with O&M staff dispatched during operations or in the need of maintenance. Further, we have assumed that no major maintenance will be required as the MSRs will accumulate less than 10,000 operating hours over 30 years.

It is important to note that the location of the installation of the MSRs (at an existing power generating facility or a new site) and the flexibility to operate the MSRs at higher capacity factors are key drivers in the permitting process. Therefore, if the MSRs are pursued, siting and operating projections should be assessed carefully to properly permit the MSRs and result in maximum operating flexibility.

Small Modular Reactor Update

In March 2011, almost immediately after the issuance of our report to GPA on the status of SMR in February 2011, the Fukushima nuclear disaster occurred. Additionally, fracking in the United States since 2011 has resulted in a significant increase in natural gas production creating low long-term price projections for relatively clean natural gas. Further, decreasing costs of solar, wind and other renewable resources coupled with associated tax incentives have led to a significant increase in the installation of renewable resources. These factors along with the lack of resolution on how to accommodate spent fuel have negatively impacted the progress of the development of SMRs. While GPA and NuScale Power, LLC, a develop of SMR technology, executed a memorandum of understanding in 2012 and NuScale prepared some basic conceptual design and cost information, which was used as the basis of the unit characteristics employed in the 2012 GPA IRP, the development and deployment of SMRs has not progressed significantly.

Back in 2012, NuScale proposed modular SMR with the reactors installed below ground in containment and the STG located adjacent to the reactors at grade level. To date, no SMR has been deployed for utility use in the US. Development of SMRs requires large investment for high overnight capital costs as well as multiple levels of difficult permitting and federal design approval. So far NuScale Power’s 45 MW reactor design has been the most successful in the approval process. The DOE is in a partnership with the Utah Associated Municipal Power Supply and NuScale Power to develop and deploy a commercial NuScale SMR at the Idaho National Laboratory by 2026. Idaho National Laboratory was chosen for the site in part because the campus houses very experienced nuclear operators. Currently, the DOE and the Tennessee Valley Authority are evaluating the siting permit for a NuScale SMR at the Clinch River site. Permitting and licensing present a major challenge in the U.S, and they will likely challenge the installation of an SMR on Guam. Moreover, spent nuclear fuel must be buried or recycled using processes that are currently unavailable on Guam.

Waste Oil Options

GPA is responsible for receiving and disposing of waste oil not only from the GPA power generating facilities, but also from various other sources on- island. GPA reports that it currently accepts approximately 750,000 gallons of waste oil annually, with a majority of that oil (approximately 85 percent) being lubricating oil and HFO sludge from the Piti 8 & 9 power plant. However, other types of oil including lubricating oil from automobiles, cooking oil, and transformer oil is also received. GPA reports that the various waste oil received is not segregated, but instead aggregated, after which it is tested for certain hazardous constituents, such as polychlorinated biphenyls ("PCBs").

Currently, GPA blends the waste oil with RFO and burns it in the Cabras 1 & 2 power plant. GPA is developing a new combined-cycle power plant and has plans to retire the Cabras 1 & 2 power plant in the next few years so a new method of handling the waste oil is needed. Fortunately, along with the retirement of the Cabras 1& 2 power plant, the Piti 8 & 9 power plant is to be converted to fire on ULSD and / or liquefied natural gas ("LNG"), which is expected to reduce the amount of waste oil from the Piti 8 & 9 power plant significantly and result in a total waste oil volumes in the range of approximately 50,000 gallons annually. As noted in Table 1 above, the remaining GPA power plants include SSRs and MSRs along with CTGs.

While GPA currently knows the general waste oil stream being received and has the waste oil sampled for metals and hazardous materials, in order to determine how heavy the waste oil is, and its combustibility, the waste oil should be sampled and tested to produce a carbon distribution or a distillation curve. This detailed constituent analysis will provide insight into the type and level of purification that will be required to support re-use of the waste oil, perhaps by blending with ULSD for use in other GPA power plants. However, the fuel requirements for SSRs, MSRs, and CTGS are more restrictive than for boilers such as those of the Cabras 1 & 2 power plant.

For a better understanding of the challenges of handling the waste oil we have provided some discussion below on the various types of waste oil currently received by GPA.

- Used cooking oil contains a combination of fatty acids and glycerine and can be used as a feedstock for biodiesel production (with the addition of methanol). The resulting product can be used in the diesel engines. An alternative is the production of renewable diesel by the addition of hydrogen, which is a licensed process. Production of biodiesel using smaller plant is plausible, and the warm weather in Guam would eliminate a concern with biodiesel cold weather cloud point. However, the used cooking oil would need to be segregated from the other waste oil in order to determine the volume received.

- Used Lubricating oils contain longer chain hydrocarbons and additives with a typical boiling point curve from 350°C to 630°C. For comparison, a typical diesel fuel curve starts at 130°C and ends at approximately 400°C. There are commercial methods to re-refine the lubricating oils into new base oils (most of the additives are lost in the re-refining process). The potential use in a SSR, MSR, or CTG would require removal of the heavier components (higher boiling point hydrocarbons) and the "sludges" that accumulate in the oils. There are also technologies that are in development to process the lubricating oils to a diesel type fuel. However, there are byproducts such as asphalts which would then need to be disposed of.

- Transformer oils are typically hydrocarbon based oils that are somewhat heavier than diesel fuels. The used oils typically contain byproducts that are the result of the oils "breaking down" by the heat of the transformer. These oils are heavier than diesel fuel and would need processing similar to the used motor oils in order to be blended with ULSD and burned in SSRs, MSRs, or CTGs.

It should be noted that the waste oil could be used to supplement the fuel supply of a WTE facility if GPA proceeds with a WTE facility as described above.

Due to the small volumes and poor heat content it is unlikely that a sustainable marketing effort could be employed for the waste oil either as-is or after refining/purification on-island or elsewhere.

In summary, a more detail analysis of the waste oil should be obtained by GPA, perhaps over several months to identify the combustibility of the waste oil. It is unlikely that the waste oil will be able to be refined to be of the same grade as ULSD, but it could potentially refined sufficiently to be blended in small percentages with ULSD for combustion in the GPA SSRs, MSRs or CTGs.

GPA 2020 IRP Unit Characteristic Assumptions
March 27, 2020
Appendix A

Resource Assumptions												
Date	**Mar-20**											
Project	**Guam 2020 IRP**											
Option		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Plant Description		OTEC	SWAC	Li-Ion BESS	Pumped Hydro	CAES	Flywheels	WTE	Fuel Cell	Fuel Cell Cogen	Sync Cond	Diesel Recip
Technology		Land Based ORC	Once Through	Time shift / Peak	Dual 20 Acre	Tank - with LNG fired		MSW	SOFC	CHP - 100 gpm of hot	Retrofit Macheche	Fast start for outage
Location		Guam	Guam	Guam	Guam	Guam	Guam	Guam	Guam	Guam	Guam	Guam
Ownership rate	%	100	100	100	100	100	100	100	100	100	100	100
Nominal Capacity	MW	10	8.4	5	25	5	5	5	1	1	20	28
Space Required	Acres	0.5 to 1	1 to 3	0.25	50 to 60	5 to 10	3 to 5	10 to 15	0.1	0.1	0.1	5 to 10
Plant Direct Costs	$000	85,777	**131,948**	$ 11,000	$ 100,000	$ 14,000	20,893	$ 47,000	$ 5,500	$ 6,050	$ 3,000	$ 28,358
Plant Direct Costs	$/kW	$ 8,578	$ 15,708	$ 2,200	$ 4,000	$ 2,800	$ 4,179	$ 9,400	$ 5,500	$ 6,050	$ 150	$ 1,012
Interconnections Costs	$000	$ 1,000	$ 500	$ 500	$ 1,000	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 1,000
Owner Costs @ 15%	$000	$ 13,017	$ 19,867	$ 1,725	$ 15,150	$ 2,175	$ 3,209	$ 7,125	$ 900	$ 983	$ 525	$ 4,404
Capital Cost	$000	$ 99,794	$ 152,315	$ 13,225	$ 116,150	$ 16,675	$ 24,602	$ 54,625	$ 6,900	$ 7,533	$ 4,025	$ 33,762
Capital Cost	$/kW	$ 9,979	$ 18,133	$ 2,645	$ 4,646	$ 3,335	$ 4,920	$ 10,925	$ 6,900	$ 7,533	$ 201	$ 1,204.93
Guam Adjustment	1.2	$ 1.00	$ 1.00	$ 1.20	$ 1.20	$ 1.20	$ 1.20	$ 1.20	$ 1.20	$ 1.20	$ 1.20	$ 1.20
Capital Cost	$000	$ 99,794	$ 152,315	$ 15,870	$ 139,380	$ 20,010	$ 29,523	$ 65,550	$ 8,280	$ 9,039	$ 4,830	$ 40,514
Capital Cost	$/kW	$ 9,979	$ 18,133	$ 3,174	$ 5,575	$ 4,002	$ 5,905	$ 13,110	$ 8,280	$ 9,039	$ 242	$ 1,446
Permitting	Months	36	36	12	36	36	24	24	18	18	18	18
Start of Eng to CO	Months	24	36	12	24	24	18	30	12	18	18	12
Total Schedule Duration	Months	48	60	18	48	48	36	48	24	30	30	24
COD	Date	Jul-24	Jul-25	Jan-22	Jul-24	Jul-24	Jul-23	Jul-24	Jul-22	Jan-23	Jan-23	Jul-22
Retirement	Date	Jul-54	Jul-55	Jan-32	Jul-54	Jul-54	Jul-53	Jul-54	Jul-27	Jan-28	Jan-53	Jul-52
Capacity Degradation	%	0.5%	0.5%	0.0%	0.0%	3.0%	0.2%	1.0%	0.0%	0.0%	0.0%	0.5%
Heat Rate Degradation	%	NA	NA	3.0%	NA	2.5%	NA	1.0%	0.0%	0.0%	0.0%	0.5%
Max Net Capacity	MW	10.0	8.4	5	25.0	4.9	5.0	5.0	1.0	1.0	20.0	27.9
Min Net Capacity	MW	5.0	4.2	0.3	10.0	2.4	0.0	2.5	0.25	0.25	10.0	4.6
HR @ Max	Btu/kWh (HHV)	NA	NA	NA	NA	8,250	NA	16,240	6,100	6,100	NA	8,383
HR @ Min	Btu/kWh (HHV)	NA	NA	NA	NA	12,000	NA	16,850	6,200	6,200	NA	9,389
New FOR for 1st yr	%	8.0	3.0	1.0	3.0	4.0	10.0	10.0	1.0	1.0	1.0	1.0
Mature FOR	%	6.0	3.0	0.5	2.0	3.0	8.0	8.0	0.5	0.5	0.5	0.5
Scheduled Maintenance	Weeks	3	2	1	2	3	4	4	1	1	1	0
Scheduled Maintenance	%	6.0	4.0	0.5	4.0	6.0	8.0	8.0	0.5	0.5	0.5	0.0
Max Capacity Factor	%	88.0	93.0	99.0	94.0	91.0	84.0	84.0	99.0	99.0	99.0	99.5
Water Consumption	gpm	440,000	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
Primary Fuel		Seawater	Seawater	Grid	Grid	LNG	Grid	MSW	LNG	LNG	Grid	ULSD
Fuel Heating Value	Btu/CF								1,020	1,020		
Fuel Heating Value	MMBtu/MCF								1.02	1.02		
Fuel Sulfur Content	% or gr/100 scf								0.0010	0.0010		
Full Load NOX									0.002 lb/MWh	0.0020		11.22 lb/hr/engine
Full Load CO									0.035 lb/MWh	0.0350		3.42 lb/hr/engine
Full Load SO2									negligible	negligible		0.15 lb/hr/engine
Full Load CO2									750 lb/MWh	750		14530 lb/hr/engine
Full Load VOC									0.02 lb/MWh	0.0200		2.93 lb/hr/engine
Full Load PM									0 lb/MWh	0.00		5.47 lb/hr/engine

Resource Assumptions												
Date	**Mar-20**											
Project	**Guam 2020 IRP**											
Option		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Plant Description		OTEC	SWAC	Li-Ion BESS	Pumped Hydro	CAES	Flywheels	WTE	Fuel Cell	Fuel Cell Cogen	Sync Cond	Diesel Recip
Technology		Land Based ORC	Once Through	Time shift / Peak	Dual 20 Acre	Tank - with LNG fired		MSW	SOFC	CHP - 100 gpm of hot	Retrofit Macheche	Fast start for outage
Generation	MWh	76,703	68,091	7,300	18,250	3,541	36,718	36,424	8,672	8,672	173,448	8,364
VOM	$/yr	$ 1,000,000	$ 400,000	$ 182,500	$ 250,000	$ 75,000	$ 500,000	$ 1,000,000	$ -	$ 12,000	$ -	$ 16,296
Driver MM	$/yr	$ 166,667	$ -	$ -	$ 200,000	$ 83,333	$ 320,000	$ 333,333	$ -	$ -	$ -	$ -
BOP MM	$/yr	$ 1,000,000	$ 600,000	$ 20,000	$ 50,000	$ 20,000	$ 15,000	$ 200,000	$ -	$ 10,000	$ -	$ -
MM	$/yr	$ 1,166,667	$ 600,000	$ 20,000	$ 250,000	$ 103,333	$ 335,000	$ 533,333	$ -	$ 10,000	$ -	$ -
VOM w/ MM	$/yr	$ 2,166,667	$ 1,000,000	$ 202,500	$ 500,000	$ 178,333	$ 835,000	$ 1,533,333	$ -	$ 22,000	$ -	$ 16,296
FOM	$/yr	$ 3,000,000	$ 1,500,000	$ 50,000	$ 1,500,000	$ 1,000,000	$ 140,000	$ 2,500,000	$ 265,000	$ 300,000	$ -	$ 250,000
Guam Adjustment		1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20
VOM	$/yr	$ 1,200,000	$ 480,000	$ 219,000	$ 300,000	$ 90,000	$ 600,000	$ 1,200,000	$ -	$ 14,400	$ -	$ 19,555
MM	$/yr	$ 1,400,000	$ 720,000	$ 24,000	$ 300,000	$ 124,000	$ 402,000	$ 640,000	$ -	$ 12,000	$ -	$ -
VOM w/ MM	$/yr	$ 2,600,000	$ 1,200,000	$ 243,000	$ 600,000	$ 214,000	$ 1,002,000	$ 1,840,000	$ -	$ 26,400	$ -	$ 19,555
FOM	$/yr	$ 3,600,000	$ 1,800,000	$ 60,000	$ 1,800,000	$ 1,200,000	$ 168,000	$ 3,000,000	$ 318,000	$ 360,000	$ -	$ 300,000
Total Non-Fuel O&M	$/yr	$ 6,200,000	$ 3,000,000	$ 303,000	$ 2,400,000	$ 1,414,000	$ 1,170,000	$ 4,840,000	$ 318,000	$ 386,400	$ -	$ 319,555
Total Non-Fuel O&M	$/MWh	$ 80.83	$ 44.06	$ 41.51	$ 131.51	$ 399.38	$ 31.86	$ 132.88	$ 36.67	$ 44.56	$ -	$ 38.21
VOM	$/MWh	$ 15.64	$ 7.05	$ 30.00	$ 16.44	$ 25.42	$ 16.34	$ 32.95	$ -	$ 1.66	$ -	$ 2.34
MM	$/MWh	$ 18.25	$ 10.57	$ 3.29	$ 16.44	$ 35.02	$ 10.95	$ 17.57	$ -	$ 1.38	$ -	$ -
FOM	$/kW-yr	$ 361.81	$ 215.36	$ 12.00	$ 72.00	$ 247.42	$ 33.67	$ 606.06	$ 318.00	$ 360.00	$ -	$ 10.76
Notes:												
All costs in 2019$												
Non-union construction												
EPC Costs include 7% contingency												
Capital costs does NOT include financing costs												
Schedule dates are based on permitting commencement in July 2020												
FOM does NOT include land cost, property taxes, insurance, or debt service												

Appendix E: 2011 RW Beck Report – LNG Conversion

Final Report Guam LNG Study.pdf

LNG Study

Guam Power Authority

November 2011

R·W·BECK

An SAIC Company

LNG Study

Guam Power Authority

November 2011

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Section 1
BACKGROUND AND GENERAL COMMENTS

This report provides a preliminary feasibility study for the importation of liquefied natural gas (LNG) on Guam and the use of natural gas as a fuel source for some of Guam Power Authority's (GPA) generation fleet. The study was undertaken as part of GPA's Integrated Resource Planning (IRP) activities, and the recommendations advocating fuel diversification resulting from its August 2008 IRP study and report. The efforts conducted during the current study to examine LNG as a potential fuel diversification strategy for GPA were approved by Resolution No. 2011-23 by the Guam Consolidated Commission on Utilities on May 10, 2011. GPA and the CCU recognize that sole reliance on oil as a fuel source and the increasing and volatile nature of fuel oil prices need to be addressed, while considering a variety of potential generation resource and fuel options and the costs/benefits associated with each.

R. W. Beck, a Science Applications International Corporation (SAIC) company, and its sub consultants, CH·IV International and Winzler & Kelly, (hereinafter collectively R. W. Beck) have worked with GPA staff to develop the preliminary sizing of the LNG import facilities and associated send out requirements based on predicted natural gas usage both initially and for possible future growth and expansion. In coordination with GPA, R. W. Beck has made a preliminary evaluation of potential sites identified by GPA and others for LNG import facilities considering both land based and floating regasification options. R. W. Beck has developed a preliminary basis of design for the import terminal and associated facilities including storage capacity, regasification capacity, treating and conditioning capacity, gas distribution pipeline size and general routing. Based on this preliminary basis of design, R. W. Beck has developed a high-level capital and operating cost estimate and installation schedule. Also, on a preliminary, desktop basis R. W. Beck has selected a land based LNG carrier offloading site and configuration outside of Apra Harbor and a floating site inside Apra Harbor.

In addition to estimating the capital and operating costs of the LNG terminal, storage, and pipeline facilities, R. W. Beck estimated the capital investments required to convert certain GPA generation units from oil-fueled to natural gas-fueled configurations. We also examined the change that would occur to operations and maintenance costs, unit efficiency, and emissions post conversion. Fuel markets, supplies, transportation, and contracting trends were examined and have been provided as part of this report. Base, Low, and High Case LNG and oil price forecasts were also developed.

Using the cost data developed for the LNG facilities, unit conversions, and fuels, R. W. Beck created a simplified financial model to assess the feasibility of GPA switching from oil to LNG as its primary fuel source. The model allows GPA to examine various scenarios and better understand how changes in primary drivers will change the costs and benefits of an LNG strategy for fuel diversification.

R. W. Beck study approach, methodology, results, and recommendations are the subjects of this report.

The R. W. Beck project team conducted this LNG study in close cooperation with GPA management and staff over several months. The R. W. Beck project team sincerely appreciates all of GPA's management and staff support. We thank them for their willingness to help, their guidance, knowledge, and commitment to the study's success.

Section 2
PRELIMINARY SIZING, CONFIGURATION, AND SITING

The study team, consisting of representatives from GPA, R. W. Beck, CH·IV, and Winzler & Kelly, looked at several potential sites on the island during a visit on June 22-24, 2011. In addition to visiting potential sites, the team also discussed potential sites with representatives from the Navy, US Coast Guard and Guam Port Authority. Sites at the east and west ends of the existing commercial docks inside the Harbor, the "Hotel" wharf inside the Harbor, the Rock Quarry ("parking lot") area outside the Harbor and the Tanguisson area on the northwest coast were physically inspected. In reviewing the sites, we assumed that the needed LNG storage and other facilities would require approximately 30 to 40 acres of land to provide reasonable spacing of equipment and accommodate a safe exclusion zone.[1]

Our preliminary impressions after the site visit were as follows:

1. The west end of the existing commercial dock inside Apra Harbor and the existing fuel dock provide no room for an LNG storage tank and the existing trestle and dock may not accommodate LNG loading arms or cryogenic piping racks. Finally, consideration of an exclusion zone would probably eliminate this site if all the above issues were solved.
2. The existing "Hotel" wharf located further west of the existing commercial dock inside the Harbor is a built-up area previously used to off-load munitions by the military. This site has good access to deep water within the harbor and could be expanded (see 4 below). The site is currently under lease that may not be renewed, but this could present a problem if the current lease holder has plans. The site is relatively small (even with expansion) and may only accommodate a smaller terminal or possibly act as a natural gas landing point for a floating LNG terminal import option.
3. The east end of the existing commercial dock inside Apra Harbor moving near Cabras power plants only provides access to shallow water and would require extensive dredging for access by LNG carriers. In addition, this location may dictate a long run of cryogenic piping from the storage tank to the dock.

[1] An exclusion zone is an area that is off-limits to the public because a hazardous substance has been or could be released. LNG terminal exclusion zones are required by the U.S. regulation 49 CFR 193. This regulation was developed, at least in part, in response to elements of the 1978 Energy Act regarding remote siting of LNG import terminals. The methodology chosen by Department of Transportation to meet those "remote siting" requirements was, and remains, safe separation distances between the facility and the public sufficient to keep the public out of harm's way.
Reference:
Havens, J. (Conference Chair) and Lederman, P. (Conference Vice-Chair) (2009, August 24-26). Answering Safe Siting Questions for Liquefied Natural Gas Import Terminals. Second American Institute of Chemical Engineers - Canadian Society of Chemical Engineers LNG Technical Conference. Lecture conducted from Canadian Society of Chemical Engineers, Montreal, Quebec, Canada.

4. The Port has identified expansion areas west of the existing commercial dock area that could be created by filling in existing shallows that would provide new docking space. The new spaces are relatively small and would be expensive to create and permit.
5. The Tanguisson power plant site is distant from the gas demand, space is restricted, and a loading jetty/trestle would have to cross an offshore reef to reach deep water. The area is near a public park that may impact an exclusion zone.
6. The Rock Quarry or "parking lot" site is located immediately north of the Cabras-Piti power plants across Highway 11 outside of Apra Harbor. This site appears to be relatively large, isolated and very close to the primary users of the natural gas – Cabras Units 1, 2, 3 & 4. Currently, the site is partially being used for a scrap salvage operation. The site may need to be built-up to a higher grade for typhoon and tsunami protection. It appears deep water is relatively close to shore but is outside the protected harbor fronting on open ocean.

Based on all of the above, the team focused on developing the feasibility of using the Rock Quarry site for a land-based LNG terminal. The terminal would consist of an offshore dock connected via a trestle supporting cryogenic piping to a single land based storage tank. The site can easily accommodate the vaporization facility and a relatively short natural gas pipeline to the power plants. A variable will be evaluation of metocean data to determine the operational window for off-loading LNG carriers. A small operational window dictates larger storage and higher costs. The Hotel Wharf and adjacent areas were considered the next best site. As outlined in the project scope, floating facilities were also considered.

The preliminary design will be based on a nominal gas load of 34,000 MMBTU/day (equivalent to 34 million standard cubic feet per day (scfd) of natural gas of 1,000 BTU/scf quality) and a minimum of 30 to 60 days storage. This gas consumption is based on GPA's forecast of potential natural gas usage for electric generation provided on July 6, 2011.

Section 3
PROPOSED LAND-BASED LOCATION

Description

The primary option investigated for landing of imported LNG on Guam for the purpose of providing natural gas fuel for the Guam Power Authority electrical generating stations and possibly other uses, was based on a conventional land-based LNG Import Terminal design. See Exhibit A, Site Layout and Exhibit B, Process Flow Diagram. This would consist of a marine unloading platform and approach trestle suitable for offloading LNG cargos from smaller standard LNG Carriers to a conventional full containment LNG storage tank. A tank size of 90,000 cubic meters ($m^{3)}$ or 566,000 Barrels gross capacity was selected to provide up to 60 days of supply to ride out any weather related conditions that would prevent safe cargo transfer for refilling.[2] From storage, the LNG would be pumped at pipeline distribution pressure (500 to 1000 psig) to the vaporizers where the baseload design send out of 34 mmscfd would be heated in a shell and tube heat exchanger to convert the liquid LNG back into natural gas suitable for pipeline distribution. The heat would be provided by gas fired packaged heaters and an ethylene glycol and water based heat transfer fluid circulation system. See Exhibit C, Vaporizer Study. A boil off gas compression system would be used to capture vaporized LNG from the tank and terminal and control storage tank pressures. The facility would also have all necessary utilities, diking, buildings, safety systems, security, etc. necessary to support the import terminal operation. An area for loading of LNG tractor trailers to allow distribution of LNG to generating locations not connected to the pipeline distribution system and to other potential LNG users on the island has also been included in the preliminary design.

As discussed above, based on a site visit and discussions with GPA, the Coast Guard, and the Guam Port Authority, a site currently owned by the Port Authority was identified as the most viable. The site was an old limestone quarry and we understand it may be available from the Port for long term lease. Although it lies outside the protected Apra Harbor and only has unprotected open water access, it is ideally located adjacent to the existing Cabras/Piti power station. This was also the only site identified with enough room to accommodate a terminal of this size with sufficient buffering from existing land uses. A more detailed design analysis and site review

[2] R. W. Beck has developed its estimates of preliminary storage and ship sizes in line with the level of effort possible for this type of feasibility analysis. These are reasonable estimates for the purposes of examining the feasibility of LNG usage for GPA. Optimization of the storage tank size, ship size, and shipping schedule will require very detailed engineering and economic analysis based on actual technical and commercial circumstances, not feasibility-level estimates, and will depend on a number of factors that at this point are not definitive. This type of optimization can only be conducted as part of the Front End Engineering and Design following definitive evaluations of supply proposals

may identify other potential sites. The cost estimates and plot plan layout presented for this option are based on using the rock quarry site.

The preliminary design for the marine trestle, platform and mooring was based, in part, on the LNG terminal located in the Dominican Republic (DR). The DR facility serves larger vessels and LNG capacities than anticipated for Guam, so the preliminary design for Guam was scaled back accordingly. The DR facility appears to be sized for vessels up to 340 m (1100 ft) in overall length. The design basis for the Guam facility was based on the LNG carrier Belanak of approximately 75,000 m^3 capacity with an overall length of 257 meters. Operating wind load was set at 25 mph. Water depth at the breasting and mooring dolphins was assumed at 40 feet.

The smaller design vessel results in potentially lower design vessel loads for berthing and mooring as compared with the DR marine terminal, and the same number of, but more closely spaced, mooring and breasting dolphins. Total length, but not number, of access bridges between dolphins would also be reduced relative to the DR facility. The DR facility is sized for four unloading arms plus one future unloading arms whereas the Guam facility will require only three loading arms. Thus, the unloading platform plan area is reduced by about one-sixth relative to the DR facility. Finally, the bathymetry of the proposed site suggests that that Guam marine terminal trestle will need to be on the order of 400 feet long in order to provide sufficient water depth to serve the Belanak and similar sized vessels.

Capital Costs

The fixed capital cost estimate represents the facilities as described in a preliminary Design Basis. The Design Basis included a preliminary Process Flow Diagram and a general layout Plot Plan. The costs are for a complete installed and commissioned facility. At this early phase of the project there were certain assumptions and exclusions that were made to allow completion of the estimate. These include:

- The estimate is based on other similar projects and site specific geotechnical data may indicate the need for more expensive civil and foundation work.
- The estimate does not include any unusual startup costs such as purchase of hydrotest water supply for the LNG storage tank testing. Under a hydrotest, the tank would be filled with water to test for leaks and strength. Hydrotesting is part of permitting and costs vary widely. The cost of such testing will not substantially impact the results of our analysis.
- Permitting costs include Federal DOT/FERC permit as well as other Federal and local permits and are assumed to be consistent with permitting of similar LNG Import Facilities in Puerto Rico.
- All labor costs are typical of equivalent US Gulf Coast costs and will need to be updated subject to a complete local labor cost survey.
- Estimate is based on the use of a Full Containment LNG Storage Tank (FCT), which consists of an outer wall surrounding an inner tank. If the cryogenic liquid escapes the inner tank, the outer tank is designed to hold the liquid. If it is determined a Single Containment Tank (SCT) design is possible, the cost estimate could be reduced by approximately $15,000,000 before overheads.

- Estimate is based on the description of the facility described in the CH·IV preliminary design basis document for the land-based option (Exhibit D, Preliminary Design Basis) including use of shell and tube glycol/water vaporization system as the recommended technology (any other installed option would increase the vaporizer system costs).

In order to transport natural gas from the LNG terminal near the Cabras power plant, underground pipelines must be constructed. The pipelines would operate at relatively high pressures of 500 to 1,000 psig to minimize pipe size and eliminate the need for compression at the destination points. Possible destination points include the Tanguisson, Piti, Tenjo Vista, Dededo, Yigo and Macheche. Depending on the volume and distance, the pipeline could vary from 4" in diameter to 8" in diameter. The pipeline would be buried welded steel with suitable corrosion protection systems. Although GPA has possession of the right of way for the existing 8" diameter black oil line from Cabras to Tanguisson, new right of way for the other destinations would have to be obtained.

The pipeline distance to Tanguisson from the marine terminal area is approximately 17 miles. The pipeline distance to Piti is ¾ mile, to Tenjo Vista 3.7 miles, to Dededo about 16 miles, to Yigo 20 miles, and to Macheche about 15 miles. One pipeline could serve Piti, Tanguisson, Dededo, Yigo and Macheche with branch lines to the smaller destinations and another pipeline would be required to serve Tenjo Vista as it is in the opposite direction. See Exhibit E, Pipe Routes.

A unit price has been developed for a cross-country pipeline of an average diameter of 6". In 1997, a pipeline was constructed by the Navy from Tiyan to Andersen AFB. This was a 10" diameter welded steel buried pipeline that was 16.1 miles long. The per-foot price for that pipeline was $106/foot. The Navy intends to construct a parallel pipeline along the same route in 2014. The estimated per foot price for that 10" diameter welded steel pipeline is $349/foot. Typical pipeline cost estimating would estimate a pipeline at $40 per inch diameter per lineal foot. Using the $349/foot Navy estimate and subtracting 4" of diameter at $40 per yields a price of $189/foot. Because it is uncertain when the natural gas pipeline would be constructed, for the purposes of this report, a lineal foot price of $240/foot was used.

Operating Costs

An estimate of Operating Costs for the proposed facility described above and in the referenced documents is based on a self-supported terminal operation with no integration of the terminal operation with the nearby GPA power generating station at Cabras/Piti. Some significant operational savings may be realized through the use of waste heat from the power plant for vaporization and direct personnel support from the power plant or other GPA staff. All O&M salary and labor costs are typical of equivalent US Gulf Coast and will need to be updated with a complete local labor cost survey.

The annual costs in 2011 dollars are summarized in Table 3-1. Staffing assumes 20 personnel assigned to the facility including a plant manager, O&M manager, safety manager, administrative assistant, purchasing manager, four shift supervisors, eight operators, two maintenance technicians, and an electronics technician. Fuel use is based on an assumed consumption of 2% of throughput and power consumption of 300 KW.

Table 3-1: Shore Based Terminal Estimated Annual Operating Costs (2011 $)

Fixed Costs	
Salaries & Burden	$1,498,500
Other Fixed Costs[3]	$2,076,837
Demurrage Costs	$480,000
Maintenance Costs	$4,153,674
Variable Costs	
Fuel Gas @ $12.95/MMBtu	$3,530,162
Power Cost @ $0.153/kWh	$402,988
Other Variable Costs	$141,667
Total Annual Operating Costs	$12,283,828

In addition to these annual operating costs, we assumed Port of Guam fees of $0.0638 per MMBtu would be paid. These costs are based on the $0.40 per Barrel Port fees GPA has been paying and the historical MMBtu per Barrel for FY 2010.

Feasibility Discussion, Execution Risks

There is risk involved in constructing and operating a marine terminal in open ocean conditions. The use of a fixed marine platform mooring system and trestle for LNG Carrier unloading outside the protected harbor on the open ocean side of Cabras Island introduces the risk of delays. Carriers may arrive and weather conditions prevent unloading for a period of time. To mitigate this risk, the design will provide, as far as possible, 1) accommodations to minimize the wind and wave effects to the facility and 2) excess LNG storage capacity to allow for most foreseeable delays based on historical wind and wave data available. Most docking facilities on Guam are within Apra Harbor, because of the rough conditions that can occur along the coast. The proposed marine terminal site is on the leeward side of the island. Coastal engineering analysis has been performed and that analysis is included as Exhibit F, Downtime Analysis. It can be seen in the study that while wind is not a significant factor, storm induced waves are a factor that will limit the times the marine terminal can operate particularly during the months of November through March. Estimates of terminal downtime were based on allowable vessel motions. It is expected that a ship similar to the Belanak would deliver LNG to Guam. The analysis predicts an average downtime of 33% for the Belanak, with higher downtime in the months of December and

[3] Other fixed costs include General and Administrative costs, training, safety, security, environmental, contract maintenance for unusual requirements, grounds keeping, and janitorial services. Maintenance includes normal maintenance and overhauls.

January. For purposes of evaluating the terminal economics, we have estimated total downtime days per year for the site and included eight days of demurrage costs in the operating cost estimate. This totaled $480,000 based on $60,000 per day demurrage cost.

The selected location was assumed to be available from the Guam Port Authority and would be subject to an agreeable long-term lease to allow for construction and operation of the LNG Import Terminal. The operating cost estimate does not include a value for the site lease. There is currently a scrap metal business using part of the site and it was assumed that and any other existing agreements with the Port would be cancelled and this business relocated to another site.

Significant cost and schedule impacts are included to account for the anticipated one year permit process required by the Federal Energy Regulatory Commission. Impacts are based on R. W. Beck and industry experience as it has been applied to similar LNG facilities in the mainland U.S. and the U.S. protected island of Puerto Rico. A protracted permitting process could drive up construction costs and complicate LNG supply commitments.

Based on preliminary calculations and estimates for a required exclusion zone and using a full containment LNG tank design, we expect the location will accommodate the storage tank as shown on the Plot Plan. This must be confirmed during detailed design studies performed as part of the permit application.

Technology, Constructability

The marine unloading, LNG storage tank, vaporization systems and boil off gas[4] handling technology chosen in the preliminary design is well understood and proven in the industry with many examples and documented experience over a long period.

Although the local seismic requirements are known to be high, it is believed that with careful engineering and design optimization that these conditions can be met as required by codes. The typhoon and tsunami potential for this facility have also been considered in this preliminary design, but design details must be confirmed to comply with codes and standards for the permitting of the facility. As mentioned earlier, the cost estimate does not include extraordinary expenditures to remedy site geotechnical deficiencies or storm and wave events that exceed available historical data.

While it is likely that almost all of the necessary materials and equipment will have to be shipped to site; it is anticipated that local skilled and unskilled labor, construction equipment and material supply will be used to the greatest extent possible. We expect a significant portion of the facilities can be prefabricated off island.

Costs

The estimated capital costs in 2011 dollars are summarized in Table 3-2, and total $207 million for the terminal and storage facilities. This estimate also includes a short

[4] Boil off gas results because tanks are not perfectly insulated, as such, all cryogenic liquids stored in tanks result in a small amount of leaking gas, which is captured, compressed, and then used.

gas pipeline (approximately one mile) from the Rock Quarry site to the Cabras and Piti power plant sites.

Table 3-2: Shore Based Terminal Capital Cost (2011 $)

RFP and Contracting	$450,000
Permitting	$9,000,000
Front End Engineering & Design (for Permitting)	$2,000,000
Engineering, Procurement & Construction	$109,031,309
Marine - Shoreline Protection	$3,500,000
Marine - Trestle, Platform, Mooring	$38,700,000
Engineering & Project Management	$24,334,696
Contingency (10%)	$18,656,601
LNG Tank Minimum Inventory (Heel)	$1,112,423
Total	$206,785,029

We estimate the cost to construct an eight-inch pipeline the 16 miles to the Tanguisson power plant from the Cabras/Piti plants will add $20,433,600 to the above capital costs. Extension of the gas distribution system from Cabras/Piti to Tenjo will add an additional $4,694,400 to the above capital costs. If the system were only extended from Cabras/Piti to Macheche, Dededo, and Yigo the capital cost increase is estimated to be $24,220,800. If we assume the line to Tanguisson is existing, then to extend service to Macheche, Dededo, and Yigo would cost $7,642,800.

Section 4
PROPOSED FLOATING SOLUTION

A second option has been considered in this study of technologies for providing natural gas onto the island of Guam involving the use of a Floating Storage and Regasification Unit (FSRU). For this option a purpose built or repurposed small ship or barge mounted FSRU would be permanently moored at a specific site within the Apra Harbor commercial area. See Exhibit G, Offshore Site Layout. Included would be on-board LNG storage, ship-to-FSRU transfer for refilling the storage tanks and topside vaporization units. This would allow the delivery of natural gas at specified flow rates, pressure and temperature to shore for connection to a distribution pipeline network to supply GPA power generating facilities. The natural gas would be delivered to shore via a subsea pipeline and connect at the shoreline to the land-side pipeline distribution system.

While the FRSU will be moored to fixed permanent anchors or mooring pilings offshore within the harbor, under emergency or abnormal conditions it could be moved. The FSRU is a floating barge design and it can be disconnected from the anchoring system, gas supply line to shore and any power or communications cables and moved from its fixed mooring to a safer location by use of tugs. This will require some planning and likely take more than a day to accomplish. Emergency conditions such as a severe typhoon event (perhaps with winds in excess of the unit design) should be considered, where potential FSRU damage or risk to the public needs to be mitigated. It is assumed that during the time it is not at its mooring location and connected to the gas supply line that there would be no natural gas supply to shore and GPA generators would revert to backup liquid fuel systems. The ability to easily move or relocate the FSRU is also a benefit should the need for it at that location no longer be required, or if it has reached the end of its useful life.

Based on the commercial model we have observed for other projects now in development and the unique nature of small scale FSRU's, the FSRU is typically owned and operated by a third party. In the simplest arrangement, the FSRU operator is responsible for transporting the LNG from the export point, delivering and transferring of the LNG to the fix-moored FSRU and delivering a contracted amount of natural gas through a subsea pipeline at agreed pressure and temperature to a pipe flange at the shoreline. All the equipment necessary to deliver the gas to shore would be installed, owned, operated and maintained by the FSRU provider and the GPA would pay a tolling fee to utilize the supply system. Based on our experience with other small scale LNG import facilities, Purchase of the LNG at the export point may be for the account of GPA or the FSRU operator. Additional details of the contractual arrangements can be found elsewhere in the report.

Since natural gas is the only product to come on shore, the land-based facilities for this option would require only gas metering and facilities required for the pipeline operation such as pressure control and pipeline inspection gauge launching equipment.[5] Also an operator process control building, monitoring panel, office, personnel security station and FSRU communications equipment for close coordination between the pipeline system and the FSRU operations has been included. A small boat used for shuttling personnel and supplies back and forth to the FSRU will likely be co-located with the pipeline metering and operations facilities on shore at Hotel Wharf.

As the need for truck deliveries of LNG on Guam is to be evaluated, a truck loading station can be added to the land-based facilities with a smaller barge or dedicated workboat mounted LNG bullet storage tank that could be shuttled between the FSRU and the Hotel Wharf where it is tied up and then connected via flex hoses to a conventional truck loading station. Trucks could be filled during the day shift when the pipeline control room operator is present.

Capital Costs

The fixed capital cost estimate represents only the shore facilities described above. Small scale FSRU's are not common and very few potential vendors are pursuing that market. One technically feasible system has been designed by Gasfin Development S. A. ("Gasfin"), a Luxemburg company. Their commercial model provides for a tolling arrangement rather than a sale of their proprietary system. We have therefore evaluated the economics of this supply solution by applying an estimated range of tolling fees to the LNG plus the capital for the shore facilities. Based on our experience with other projects and some limited discussions with Gasfin, we have estimated tolling fees in the range of $6/MMBTU to $8/MMBTU plus fuel and losses of 7% of overall LNG throughput. These fees would be in addition to the cost of gas at a supply point such as Indonesia, Papua New Guinea, Singapore or Australia. A general layout provided in the Plot Plan is for the complete installed and commissioned facility. At this early phase of the project, there were certain assumptions and exclusions that were made to allow completion of the estimate. These include:

- Estimate does not include the FSRU and its marine appurtenances such as anchoring, subsea natural gas pipeline, marine civil structures or any dredging, it is assumed this is part of the FSRU cost and is reflected in the tolling fee.
- Estimate assumes existing Hotel Wharf is used and no major civil or marine works on the site are required for the land-based facilities
- Estimate does not include offsite utility supplies / takeaways
- Estimate does not include truck loading station and bullet tank storage that can be added later when trucking needs are identified

[5] Pipeline inspection gauges or "pigs" are used to perform various maintenance operations on oil and gas pipelines. "Pigging", or the practice of using pipeline inspection gauges is accomplished by inserting the pig into a 'pig launcher' (or 'launching station') - a funnel shaped Y section in the pipeline. The launcher / launching station is then closed and the pressure of the product in the pipeline is used to push it along down the pipe until it reaches the receiving trap - the 'pig catcher' (or receiving station). http://en.wikipedia.org/wiki/Pipeline_inspection_gauge

- The estimate does not include any unusual startup costs
- Estimated Permitting costs include Federal DOT/FERC permit as well as other Federal and local permits

All labor costs are typical of equivalent US Gulf Coast costs and will need to be updated subject to a complete local labor cost survey.

Operating Costs

The operating cost estimate as shown in Table 4-1 for the FSRU based option is based on the assumption that the onshore interconnection and metering skid location would be permanently manned by a single technician on a 24/7 basis. This would result in an annual salary cost of approximately $243,000 (4 technicians, each working a 12-hour shift pattern) and a routine (scheduled) maintenance cost of approximately $250,000 per year. Administration, supervision, purchasing, health, safety, environmental, etc. would be provided from existing GPA staff as needed, so no full time personnel were budgeted for this facility.

Obviously, the addition of truck loading or GPA operation of a shuttle boat by the full time operator would increase the annual maintenance costs, but are not included at this time.

Table 4-1: Floating Terminal Annual Operating Cost (2011 $)

Fixed Costs	
Salaries & Burden	$243,000
Other Fixed Costs	$250,000
Variable Costs	
Tolling Fee @ $6/MMBTU & 34,000 MMBTUD	$74,460,000
Fuel and Other Losses 7% of 34,000 MMBTUD at $10/MMBTU	$8,687,000
Total Annual Operating Costs	$83,640,000

Feasibility Discussion, Execution Risks

The basic concepts of the FSRU are proven with around ten conventional LNG Carrier based systems currently installed and in service over the past 8 years. These facilities use both offshore SPM buoy systems and locations where the FSRU is directly tied to a wharf or marine structure where gas is delivered to shore. These existing FSRUs have been designed around larger gas capacities of 100 mmscfd and up that helps justify the high demurrage expenses associated with continuous dedicated use of an LNG Carrier to one location.

A purpose built small scale FSRU concept with pressurized LNG bullet tanks in the hull and ambient air vaporizers installed on deck to provide a system to meet smaller demand applications has not been constructed to date. The Gasfin barge mounted system has been developed to the point where several applications have progressed to detailed engineering and it is possible there will be operating units in place by the time GPA will need to make a final decision regarding the use of this technology. The basic equipment components, LNG bullet tanks, LNG pumps, ambient air vaporizers, subsea gas pipelines and ship-to-ship LNG transfer arms are industry proven equipment in other related LNG applications. Although the technology risks are relatively small, we must emphasize that the lack of commercial operating experience with small scale FSRU's makes even a range of tolling fees subject to some variation.

Therefore the risks associated with introducing this new combination of technology are minimized.

The permitting process that will be applied to an FSRU located inside of Apra Harbor is not totally clear and represents some risk to the project. This concept is not something the FERC regulators have any experience in reviewing and approving. Probably the most similar permit application was for the Broadwater Project in Long Island Sound more than 10 years ago and that permit was withdrawn about 7 years ago and never received full approval. That project was an order of magnitude larger than a potential Guam FSRU. There may also be some clarification required regarding how and what regulations will be applied to this type of project inside waters that are clearly within FERC's jurisdiction. We have budgeted for a typical full FERC permit to include those impacts to the project cost and schedule.

Technology, Constructability

Since this will be a purpose built small scale FSRU it will be designed and built in a shipyard, probably in Korea and transported over water to site. So the critical engineering, construction and testing will be done prior to the FSRU leaving the shipyard for its permanent mooring location in Guam. This should limit any on-site design or startup problems with the unit.

The subsea pipeline between the FSRU and shore is a very conventional application and installation of concrete coated carbon steel pipe transporting warm natural gas, so no unusual technology issues are anticipated. However, there is one concern regarding an issue related to the proposed location of the FSRU, the area where the subsea pipeline will be installed on the seafloor is noted as an area of the harbor within a circle identified as "Unexploded Ordinance" where Hotel Wharf has a history of being an unloading point for military munitions. This could mean extra expense to clear or otherwise assure no obstacles of concern in the pipeline route.

Costs

Estimated capital costs for the shore-based facilities needed to receive, measure, and distribute the natural gas from a small scale FSRU are summarized in Table 4-2. This estimate includes a short gas pipeline from the Hotel Wharf site to the Cabras and Piti power plant sites.

Table 4-2: Floating Terminal Capital Costs (2011 $)

Equipment, Piping, Electrical, Buildings	$5,907,411
Permitting	$500,000
Gas Pipeline – Hotel Wharf to Cabras/Piti	$3,801,600
Engineering & Project Management	$1,455,452
Contingency (10%)	$1,165,846
Total	$12,824,309

We have not included a value for an LNG heel because we expect a small scale FSRU will use bullet tanks that will allow essentially complete use of all the LNG with a very small heel.

Section 5
PERMITTING AND CONSTRUCTION SCHEDULE

The critical path for permitting the Guam LNG terminal project will be through the Federal Energy Regulatory Commission (FERC). Numerous local permits will be required, but we think the FERC process will be the longest and will require the applicant observe all local permitting processes. Offshore-based terminals (beyond three miles from shore) are permitted through the US Coast Guard and the Maritime Administration of the US Department of Commerce (MARAD). Therefore, even if the successful supply scheme involves a floating system in Apra Harbor, the FERC process will control. The FERC permitting process is divided into two major categories: pre-filing and formal filing. From FERC approval to enter the pre-filing process to submittal of the formal permit application can be no sooner than 180 days. From receipt of the formal application to issuance of a final FERC order is typically 12 to 18 months with most projects running closer to 18 months. The total duration (from FERC approval to enter pre-filing process to issuance of a final order) is 18 to 24 months – experience is closer to 24 months. The schedule outlined below is aggressive; we have assumed that the small scale of the project and local support will accelerate the process.

Initiate and Execute RFP Process	Months 1 thru 10
FERC Permitting	Months 8 thru 22
Front End Engineering and Design (FEED)	Months 11 thru 16
Design and Construction	Months 8 thru 50
Start-up	Month 50

An integral part of the process is an Environmental Impact Study (EIS) and we note that large scale EIS's have recently been prepared by the Federal Government for the Guam Military Build-Up and for the Port of Guam's Deep Draft Wharf project. These efforts may provide some help with the LNG terminal EIS.

The steps in the FERC permitting process are outlined below:

Initial Consultation Meeting

- Present purpose and need
- Describe what engineering (if any) has been performed to date
- Provide expected schedule to enter into pre-filing process

Pre-filing Request

- Issue request to FERC to enter into mandatory pre-filing process
- FERC will likely provide a response to pre-filing request within 2 – 4 weeks
- Pre-filing process allows for dialogue between applicant and FERC until the application is filed

Initial Draft of Resource Report 1

- Project Description
- Details of affected landowners
- Details of local permit requirements
- Details of schedule

Draft Resource Reports Issued

- Usually 2 or more drafts of Resource Reports 1 through 12
- Usually 1 draft of Resource Report 13 – Engineering Design
- Respond to FERC data requests to prepare final versions of Resource Reports

Filing Application

- No sooner than 180 days since FERC approved request to enter into Pre-filing process
- FERC review commences – including consultation with participating agencies (USCG, ACOE, FWS, NMFS, etc.)

Draft EIS

- Issued by FERC and includes public comment period (90 day)

Final EIS

- Issued by FERC and includes responses to public comments and also data requests issued to applicant

Order

- Includes FERC's decision
- Includes conditions that must be met at important stages of the project
- Note that the Order will not be issued until all consultation with participating agencies has been completed and necessary documentation received, e.g. USCG has issued a satisfactory Waterway Suitability Recommendation (WSR), NMFS / FWS etc. have issued an acceptable Biological Opinion

Implementation Plan

- Initial Implementation Plan must be issued within 60 days of the order
- Acknowledges the conditions described within the order
- Describes applicants plan of action with respect to each condition
- Includes project schedule and describes the requirement for monthly reports to FERC

Initial Site Preparation

- Applicant issues request to commence initial site preparation and will need to demonstrate completion of applicable conditions from order and implementation plan
- FERC will provide authorization

Commencement of Construction

- Applicant issues request to commence construction and will need to demonstrate completion of applicable conditions from order and implementation plan
- FERC will provide authorization

Commencement of Commissioning

- Applicant issues request to commence commissioning and will need to demonstrate completion of applicable conditions from order and implementation plan
- FERC will provide authorization

Commencement of Service

- Applicant issues request to commence service (first LNG in) and will need to demonstrate completion of applicable conditions from order and implementation plan

Section 6
UNITS CONVERTED AND SYSTEM INTEGRATION

GPA currently meets its electrical demand with power generated from units at 10 facilities located on Guam. The facilities and the units are described in Table 6-1. We note that certain generating units have third party operating agreements with Pruvient, MEC, or TEMES, as noted.

Table 6-1: Summary of GPA Generation Resources

Unit	Technology	Fuel	Capacity, MW	Service Date
Cabras 1	Boiler & Steam Turbine (ST)	RFO No. 6	66	1974
Cabras 2	ST	RFO No. 6	66	1975
Cabras 3	Slow Speed Reciprocating	RFO No. 6	40	1996
Cabras 4	Slow Speed Reciprocating	RFO No. 6	40	1996
Piti 8 (MEC)	Slow Speed Reciprocating	RFO No. 6	44	1999
Piti 9 (MEC)	Slow Speed Reciprocating	RFO No. 6	44	1999
Piti 7 (TEMES)	Combustion Turbine (CT)	Diesel No. 2	40	1997
Tanguisson 1 (PRU)	Boiler & ST	RFO No. 6	26.5	1976
Tanguisson 2 (PRU)	Boiler & ST	RFO No. 6	26.5	1976
Tenjo Recip 1-6	Medium Speed Reciprocating	Diesel No. 2	4.4 ea/26.4 total	1994
Dededo CT 1	CT	Diesel No. 2	23	1992
Dededo CT 2	CT	Diesel No. 2	23	1994
Dededo Recip 1-4	Medium Speed Reciprocating	Diesel No. 2	2.5 ea/10 total	1972
Macheche CT	CT	Diesel No. 2	21	1993
Marbo CT	CT	Diesel No. 2	16	1993
Yigo CT	CT	Diesel No. 2	21	1993
Talofofo Recip 1 & 2	Medium Speed Reciprocating	Diesel No. 2	5 ea/10 total	1994
Pulantat Recip 1 & 2	Medium Speed Reciprocating	Diesel No. 2	4.4 ea/8.8 total	1993

The discussion below summarizes the potential conversion of these units to burn natural gas from imported LNG or oil, or in some cases, just natural gas. The majority of GPA's energy demand has been met in recent history with the units at the Cabras, Piti, and Tanguisson facilities. We note that through discussions and at the direction of GPA, we have excluded the Dededo, Talofofo, and Pulantat reciprocating engines and the Marbo CTs from our analysis because of the location of these facilities or the fact that those units are not currently operational. A summary of our estimates of the conversion costs along with the pre-conversion and post-conversion unit performance and O&M costs is provided in Exhibit H, Conversion Data.

Several of the existing units have recently been inspected to determine what, if any, capital projects are needed to maintain or extend the useful life of the units. Based on the data provided by GPA, the Dededo CTs and the Yigo CT will require significant capital expenditures to support conversion to firing on natural gas in addition to the conversion costs alone. Further, capital expenditures over and above the conversion costs should be considered for the Cabras and Tanguisson units as well, to support life extension of those units, if the capital is expended to make the fuel conversion.

Reciprocating Engine Units

The reciprocating engines within the GPA system include low-speed, two-stroke ("2S") units firing residual fuel oil No. 6 ("RFO") and medium-speed, four-stroke ("4S") units firing No. 2 diesel or light fuel ("LFO"). In order to fire natural gas as the primary fuel yet retain the ability to fire RFO if needed, the units would have to be converted to a compression ignition dual fuel configuration in which natural gas is fired with a small percentage of pilot LFO to initiate ignition. This means that the engine would fire approximately 95 to 98 percent of the full load fuel using natural gas and the remaining 2 to 5 percent of LFO (LFO is easier to use as pilot fuel compared to RFO). The units could switch from natural gas to RFO by reducing load and ramping up after the switch. The GPA low-speed 2S units can be converted to a dual fuel, compression ignition configuration. However, the medium-speed 4S engines cannot be converted to a dual fuel configuration, only to a single fuel spark ignited configuration to support firing only on natural gas. We have discussed the conversion with various manufacturers and have provided estimates on performance and costs. A summary of the reciprocating engines in the GPA fleet are presented in the Table 6-2. The capacity values represent unit performance pre-conversion.

Table 6-2: Summary of GPA Reciprocating Engine Units

Location	Units	Type	Fuel Type	Manufacturer	Model	Unit Rated Capacity (MW)
Cabras	3	2S	RFO	Hanjung B&W	12K80MC-S	38.4
Cabras	4	2S	RFO	Hanjung B&W	12K80MC-S	38.4
Piti(MEC)	8	2S	RFO	Mitsui-MAN B&W	10K90MC-S	44.2
Piti(MEC)	9	2S	RFO	Mitsui-MAN B&W	10K90MC-S	44.2
Tenjo	6 ea	4S	LFO	Caterpillar	3616	4.4

Slow-Speed Engines

The four low-speed units, including the two Cabras 12K80MC-S and the two PITI/MEC 10K90MC-S, would be converted to dual fuel operation using a high-pressure gas injection system that is injected directly into the cylinder (this is a different injection system from the medium-speed units which would generally operate with low-pressure natural gas). Since the fuel oil valves remain in place, the converted 2S engines can operate at full load under either the dual fuel mode (firing on natural gas with a small percentage of LFO) or the oil mode (firing RFO only). The converted 2S engine is also capable of operating at its overload mode, subject to the normal limitations.

Under a new natural gas system, natural gas would be supplied to the low-speed facilities at approximately 1,000 psi. Additional gas compressors would be required for each facility to raise the pressure to approximately 4,300 psi for injection into the engine. The motor size of these compressors is approximately 500 kWe per 2S engine.

The dual fuel conversion design developed by the manufacturer not only addresses the physical equipment to introduce the gas into the engine, but also addresses the safety issues associated with using a high-pressure, gaseous fuel. The primary new engine components include new cylinder covers along with gas and oil valves, a sealing oil system to prevent leakage from the high-pressure gas valves, double walled pipe with interstitial gas detection, an outdoor venting system and an additional gas control and safety system. We have not performed a safety analysis of these systems associated with a gas conversion, but only mention them to note that the manufacturer has a plan to address safety issues when using high pressure natural gas.

Regarding performance, we note that based on information provided by MAN and BWSC, an EPC contractor specializing in diesel engine power projects, there is no discernible change in both power output and fuel consumption (i.e., heat rate) of the engines. However, the gas compressor will lower the net power output by approximately 500 kW per unit. This lower net output will have a slight effect on the net heat rate.

MAN estimates that the conversion to dual fuel will reduce emissions of NO_X, CO_2, and SO_2. NO_X and CO_2 will be reduced from the 100 percent RFO fuel emissions by approximately 10 percent and 15 percent, respectively, while SO_2 emissions will be reduced by approximately 95 percent. These values may change depending on the actual fuel and gas properties and the final pilot oil (percent) usage. We did not estimate the reduction from the water/HFO emulsion emissions.

The estimate to convert these units is based on a budgetary EPC cost that provides OEM parts and labor. The EPC estimate includes all the components required for dual fuel operation assuming the natural gas is delivered to each facility's site boundary. A high-pressure gas compressor (one for each low-speed unit) is included. It is assumed that there are no hazardous materials that need disposal at either site. Due to the preliminary nature of the estimate, there is a wide range in costs. Each engine is expected to range from \$10 million to \$13.5 million (US\$). Additional costs will be required to support preliminary engineering, permitting, retention of an EPC contractor to perform the work, and owner oversight; these costs have been included in our estimates as presented in Exhibit H. It is expected that the conversion project will require approximately two months of engine outage to accomplish the required modifications.

Since natural gas is a cleaner burning fuel than RFO, it would appear that the maintenance intervals could be extended. However, MAN does not project an extended interval for a converted dual fuel engine at this time. In addition, since little or no RFO would be fired, it is expected that the cost of operating and maintaining the RFO clean-up and disposal would be significantly reduced. These cost reductions would be offset by the additional maintenance costs of the high-pressure gas compressors. Therefore, overall, MAN estimates the maintenance costs of the dual fuel low-speed units will be approximately equal to the maintenance costs of the RFO low-speed units until further operational history is developed.

Medium-Speed Engines

The six medium-speed 4S units utilize low-pressure gas, in the range of 75 to 100 psi, which is injected along with the combustion air and is compressed in the cylinder. The medium-speed units are not able to match the compression ratio used with diesel oil firing when utilizing low-pressure natural gas and so must lower the compression ratio to achieve the optimal combustion. In general, the lower compression ratios result in a reduction in net power output by 25 to 30 percent versus LFO operation. In addition, the heat rates increase by approximately 5 percent.

Caterpillar reported it did not offer a conversion of the 3616 to support dual fuel operation (it only offers a spark ignited version of the 3616) and that it knows of no aftermarket vendor that has a proven conversion design to support dual fuel operation. Therefore, we have assumed that the Caterpillar 3616 could be converted to fire on natural gas only. The conversion cost estimates are based on a range of potential costs and include both parts and labor for the conversion as well as costs for preliminary engineering, permitting, retention of an EPC contractor to perform the work, and owner oversight.

The estimate to convert these units is based on a budgetary EPC cost that provides OEM parts and labor. The EPC estimate includes all the components required for conversion to fire on natural gas assuming the gas is delivered to each facility's site boundary at approximately 100 psi. It is assumed that there are no hazardous materials that need disposal at any site. Additional costs will be required to support preliminary engineering, permitting, retention of an EPC contractor to perform the work, and owner oversight and these costs have been included in our estimates as presented in Exhibit H. It is expected that the conversion project will require approximately two months of engine outage to accomplish the required modifications.

While certain maintenance intervals can be extended while firing natural gas, due to the preliminary nature of this estimate, the overall O&M costs are not projected to be significantly different than the LFO fired O&M costs.

Boiler and Steam Turbine Units

The GPA fleet currently has four units configured with boilers and STs that fire RFO. These units are listed in Table 6-3.

Table 6-3: Summary of GPA Boiler/ST Units

Location	Units	Fuel Type	Boiler Manufacturer	ST Manufacturer	Unit Rated Capacity (MW)
Cabras	1	RFO	B&W	GE	61
Cabras	2	RFO	B&W	GE	60
Tanguisson (PRU)	1	RFO	Combustion Engineering	GE	24.8
Tanguisson (PRU)	2	RFO	Combustion Engineering	GE	24.8

Prior to undergoing a major capital expenditure for fuel conversion capability, GPA should further investigate the costs and risks of extending the life of the units configured with boilers and STs. The boilers are made of code regulated pressure parts that are costly to repair. RFO has corrosive constituents (sulfur and vanadium), which are known to attack to boiler tube metals, casing, and ductwork. Replacement of some major pressure part components, such as the steam drum, may be considered a fatal flaw to any conversion. An update to the condition assessment performed in 2000 and perhaps refurbishment and or replacement of critical components performed in addition to those implemented over the past 10 years should be considered. Information to determine the presence of asbestos and remediation plan for its containment and removal should also be developed by GPA. These costs are separate and above any conversion costs, and are not considered in the fuel conversion costs described herein. The conversion cost estimates included in Exhibit H are based on a range of potential costs and include both parts and labor for the conversion, as well as costs for preliminary engineering, permitting, retention of an EPC contractor to perform the work, and owner oversight. It is expected that the conversion project will require approximately four to six months of unit outage to accomplish the required modifications.

For the current analysis, limited background information was available regarding the boiler design, furnace design, heating surface arrangements, and other critical design areas to allow an engineered solution to design the modifications required to produce the expected conversion costs. While there is a reasonable expectation that the furnace volume will be adequate for firing natural gas fuel and an engineered solution to maintain steam outlet conditions is possible, conversion to natural gas firing would result in measureable changes to the furnace performance, furnace exit gas temperature, superheater ("SH") and reheater ("RH") absorption, SH tube metal temperatures, RH tube metal temperatures, attemperation spray quantities, boiler efficiency, as well as many other boiler design and operating parameters. For this reason, a detailed engineering study is required to understand the capability and expected performance of the existing boiler when firing a different fuel.

The existing burners, windbox, and air supply ductwork will require extensive modification to support fuel conversion, much of which will be dependent upon the required pollutant emissions output requirements. New piping, valves, burner management and flame safety system will be required to fire safely the new fuel. The existing control system may require upgrading, depending upon the extent of work that has been completed. All of these costs are included in our estimates for the conversion. A comprehensive training program will be necessary to train the operators in the safe operation of the boilers with the new fuel. The basic operating practices for the majority of the plant systems will not change, but start-up and shut down methods, as well as ramping the units will change.

Emissions requirements will determine the emissions controls equipment necessary to achieve regulatory requirements. The use of advanced burner designs with flue gas recirculation has been considered for this effort. Additional emission control technology, such as selective catalytic or non-catalytic reduction equipment has not been considered to meet the emissions requirements.

It is a reasonable expectation that the boilers will be able to produce their rated steam capacity and temperatures, provided pressure part modifications to the SH and RH are done. Without the modifications, load will be limited by high steam temperatures. Boiler efficiency when firing natural gas will be approximately three percent lower than the boiler efficiency when firing RFO. The boiler efficiency firing RFO is approximately 85 percent; the boiler efficiency when firing natural gas will be approximately 82 percent.

The boilers would be capable of firing on either natural gas or RFO after conversion and fuels switching could be completed with the units on-line.

Combustion Turbine Units

The CTs units within the GPA system LFO can be converted to have dual fuel capability. In order to fire natural gas as the primary fuel yet retain the ability to fire diesel oil if needed, the units would need to have dual fuel combustors installed. It should be noted that fuel switching would require unit shut down to support a change in fuel as the unit could not switch fuel while staying on line. The units could be restarted after minor control switching after the shut down and then restarted and ramped to load (less than one hour). The CTs are not expected to have significant change in capacity or heat rate after conversion. A summary of the CT units in the GPA fleet are presented in the Table 6-4. The capacity values represent unit performance pre-conversion.

Table 6-4: Summary of GPA CT Units

Location	Units	Fuel Type	Manufacturer	Model	Unit Rated Capacity (MW)
Piti (MEC)	7	LFO	GE	Frame 6B	38.4
Dededo	1	LFO	GE	Frame 5	22
Dededo	2	LFO	GE	Frame 5	22
Yigo	1	LFO	GE	LM2500	21
Macheche	1	LFO	GE	LM 2500	21

The estimate to convert these units is based on discussions with GE and includes budgetary EPC cost that provides OEM parts and labor. The EPC estimate includes all the components required for conversion to support dual fuel capability assuming the natural gas is delivered to each facility's site boundary at approximately 600 psi. Parts would include new burners and other combustion components, as well as auxiliary skid to regulate natural gas flow to the units. It is assumed that there are no hazardous materials that need disposal at any site. It is expected that the conversion project will require approximately two months of unit outage time to accomplish the required modifications.

Certain maintenance intervals can be extended while firing natural gas due to less impact on the internals relative to firing on LFO. Due to the preliminary nature of this estimate, the overall O&M costs have been projected to be slightly lower than the LFO fired O&M costs to account for the longer intervals.

Section 7
POTENTIAL SUPPLY SOURCES AND GAS QUALITY

Background

LNG characteristics vary depending on the source; the composition and thus the heating value and physical properties will be different from one location to the next and will even vary slightly from within the same location. The establishment of a design basis for an LNG plant will require an LNG composition analysis to define the limitations of the receiving and vaporizing equipment. Geographical location typically plays a significant role in the determination of the LNG import source but the equipment should be designed to handle various import sources regardless of location in order to maintain an advantageous degree of market flexibility.

For simplicity, the world-wide LNG export industry may be split into three areas: the Atlantic Basin, the Pacific Basin, and the Middle East. The 2010 statistics indicate a fairly even distribution of export from each of the three geographical areas with the Pacific Basin leading the pack, see Figure 7-1 for an export distribution chart. Typical LNG information is given for each of the three main geographical areas. The Pacific Basin is highlighted in greater detail due to the geographical proximity to Guam and the extensive supply locations within this area.

It may be helpful to keep in mind the following approximate conversions in reviewing LNG statistical data. Exact conversions are a function of the specific composition of the LNG under analysis.

One metric ton (or tonne) = 2,205 pounds

One million BTU's = one MMBTU = one thousand standard cubic feet = one MCF

One million metric tonne per year (mtpa) = 48.7 billion standard cubic feet (BCF)

One mtpa = 133,400 MMBTU/day

34,000 MMBTU/day = 0.25 mtpa

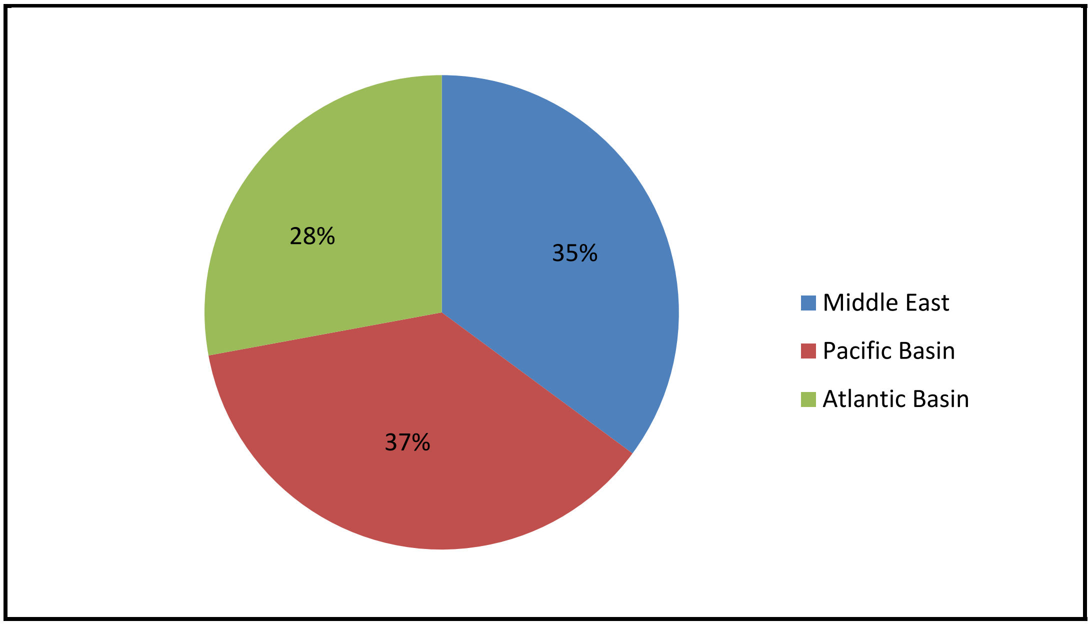


Figure based on data from The International Group of Liquefied Natural Gas Importers (GIIGNL) 'The LNG Industry 2010'

Figure 7-1: 2010 LNG Export Distributions

Pacific Basin

Guam is located in the Pacific Basin and therefore sources also located in the Pacific Basin would be optimal based on geography alone. The Pacific Basin has many established liquefaction and export terminals and is projecting a large expansion in the near future so there is good reason to believe that LNG import to Guam would be supplied from one of the sources in the Pacific Basin.

Existing Sources (as of 2Q 2011)

The following Pacific Basin countries are exporting LNG as of January 2011:

- Australia, 24.3 mtpa capacity
- Brunei, 7.2 mtpa capacity
- Indonesia, 33.7 mtpa capacity
- Malaysia, 24.0 mtpa capacity
- Peru, 4.4 mtpa capacity
- Russia, 9.6 mtpa capacity
- United States (discontinuing service, but potential for future LNG export)

Refer to Table 7-4 for information on the Pacific Rim LNG characteristics according to source.

Projected Sources

The following sources have been projected and are currently under construction:

- Australia: (4) conventional LNG liquefaction projects have been approved and (3) are under construction. The total additional capacity is anticipated to be 48.5 mtpa and will come online in stages from 2013 to 2016.
- Indonesia: (1) LNG liquefaction project has been approved for a total capacity of 2.0 mtpa and is set to come online in 2014.
- Papua New Guinea: (2) conventional LNG liquefaction projects have been approved and (1) is under construction. The total additional capacity is anticipated to be 10.6 mtpa and will come online from 2014 to 2015.
- US West Coast and Canada: Several proposed export projects are under development and may come online in 2014 and beyond.

LNG Characteristics

LNG sources in the Pacific Basin typically have approximately 90% methane and mid-range heating values. Overall the composition is fairly consistent. Table 7-1 illustrates the heavy, light, and average LNG compositions for the Pacific Basin sources. A complete summary is provided in Table 7-4.

Table 7-1: Pacific Basin LNG Characteristics

	Australia: Withnell Bay Northwest Shelf	Russia: Sakhalin Island Sakhalin LNG	Totals: Pacific Basin Totals/Averages
Capacity (mtpa)	16.40	9.60	104.50
Est. Distance to Guam (mi)	3300	2300	3100
C_1 (mol %)	87.4	93.0	91.3
C_2 (mol %)	8.3	4.6	6.0
C_3 (mol %)	3.4	2.1	1.8
C_4+ (mol %)	0.8	0.2	0.7
N_2 (mol %)	0.1	0.1	0.2
Wobbe Index (BTU/scf)	1382	1302	1374
Heating Value (BTU/scf)	1150	1050	1130

Data gathered from GIIFNL 'The LNG Industry 2010'

Middle East

The Middle East is a significant distance from Guam and yet it has over 30% of the world's natural gas reserves without a reasonable local demand. Qatar has been the leading exporter worldwide for 2009 to 2010 and is on par to continue leading other exporting nations. Currently the Middle East exports a large quantity of LNG to countries such as Korea, Japan, China and Taiwan; all of which share similar geographical location to Guam.

Existing Sources

The following Middle Eastern countries are exporting LNG as of January 2011:

- Abu Dhabi, 5.7 mtpa capacity
- Oman, 11.0 mtpa capacity
- Qatar, 76.8 mtpa capacity
- Yemen, 6.7 mtpa capacity

LNG Characteristics

LNG sources in the Middle East are typically at the heavier side of the LNG spectrum, but the overall composition for the area is consistent. Table 7-2 illustrates two common LNG compositions for the Middle East sources.

Table 7-2: Middle East LNG Characteristics

	Qatar: Ras Laffan QatarGas LNG	Yemen: Bal Haf Yemen LNG	Totals: Middle East Totals/Averages
Capacity (10^6 tpy)	76.8	6.70	100.20
Est. Distance to Guam (mi)	7400	7000	7350
C_1 (mol %)	90.10	93.3	89.3
C_2 (mol %)	6.20	5.7	7.5
C_3 (mol %)	2.30	0.9	1.7
C_4+ (mol %)	1.00	0.1	1.1
N_2 (mol %)	0.40	0.0	0.2
Wobbe Index (BTU/scf)	1361	1382	1337
Heating Value (BTU/scf)	1117	1033	1096

Data gathered from GIIGNL 'The LNG Industry 2010'

Atlantic Basin

The Atlantic Basin LNG export countries would not currently be considered an optimal LNG source for Guam due to the additional shipping costs. However, the Panama Canal is set to expand to accommodate LNG ships by 2014, which would make the journey from the US Gulf coast or Trinidad not so extensive. Given the projections of US shale gas reserves and the relationships developed between Atlantic Basin LNG exporters and the US and territories, import to Guam from the Atlantic Basin could become feasible.

Existing Sources

The following Atlantic Basin countries are exporting LNG as of January 2011:

- Algeria, 20.7 mtpa capacity
- Equatorial Guinea, 3.4 mtpa capacity
- Egypt, 12.0 mtpa capacity
- Libya, 2.5 mtpa capacity
- Nigeria, 22.2 mtpa capacity
- Norway, 4.1 mtpa capacity
- Trinidad & Tobago, 15.1 mtpa capacity

LNG Characteristics

LNG sources in the Atlantic Basin are typically on the lighter side of the LNG spectrum. The US has influenced this to some degree due to the stringent pipeline quality demanded of US natural gas. However, several African countries have come online in recent years that do not have such the light compositions. Table 7-3 illustrates the common LNG compositions for the Atlantic Basin sources. Table 7-4 shows potential Guam LNG source characteristics.

Table 7-3: Atlantic Basin LNG Characteristics

	Algeria: Arzew Sonatrach LNG	Egypt: Damietta SEGAS	Totals: Atlantic Basin Totals/Averages
Capacity (10^6 tpy)	2.50	4.80	79.95
Est. Distance to Guam (mi)	10,200.00	9600.00	
C_1 (mol %)	88.00	97.70	92.20
C_2 (mol %)	9.00	1.80	6.00
C_3 (mol %)	2.00	0.20	1.20
C_4+ (mol %)	0.50	0.20	0.30
N_2 (mol %)	0.50	0.10	0.30
Wobbe Index (BTU/scf)	1360.00	1328.00	1303.00
Heating Value (BTU/scf)	1120.00	1036.00	1109.00

Data gathered from GIIGNL 'The LNG Industry 2010'

Table 7-4: Potential Guam LNG Source Characteristics, Country Averages

	Projected LNG Sources for Guam								
	Malaysia	**Indonesia**	**Australia**	**Russia**	**United States**	**Canada**	**Papua New Guinea**	**Peru**	**Qatar**
2010 Country Export Total (Millon Tonnes)	23.69	23.50	18.40	4.96	None	None	None	1.21	56.71
2011 Total Country Export Capacity (Million Tonnes)	24.00	33.70	20.00	9.60	Projected 2015	Projected 2014	Projected 2014	4.40	76.80
Approximate Distance to Guam (miles)	3900.00	2000.00	3300.00	2300	5500	5000	2600	7400	7400
C1 - Average (mol %)	91.35	91.09	87.40	93.00	Gas Composition and Heating Value will conform to US Pipeline Standards	TBD	TBD	89.10	90.10
C2 - Average (mol %)	4.30	5.51	8.30	4.60				10.30	6.20
C3 - Average (mol %)	2.95	2.48	3.40	2.10				0.10	2.30
C4+ - Average (mol %)	1.40	0.88	0.80	0.20				0.00	1.00
N2 - Average (mol%)	0.00	0.04	0.10	0.10				0.50	0.40
Wobbe Index (BTU/scf)	1364.00	1355.00	1382.00	1302.00				1316	1361
Higher Heating Value (BTU/scf)	1123.00	1107.00	1150.00	1050.00	950 - 1100			1088	1117

Data gathered from GIINGL 'The LNG Industry 2010'

Coal Forecast

Overview

Coal provided nearly 30% of global primary energy needs in 2010, its highest share since 1970. After global coal consumption was essentially flat in 2009, predominantly due to the effect of the global economic downturn, coal demand increased by 7.6% in 2010.

Responding to this surge in demand, global coal production grew by 6.3% in 2010. Coal reserves are widely available in many countries around the world and remain plentiful with over 100 years supply at the 2010 demand level. The Asia-Pacific region led the production growth in 2010, accounting for over 88% of the total global growth, and China (the world's largest producer and consumer of coal) saw the highest annual growth rate at 9%; however, Australia and Indonesia are the world's leading coal exporting countries and would be the likely sources for Guam. The Asia-Pacific region also accounted for the majority of the consumption growth in 2010 with a nearly 80% share of the total demand increase[6] led by Japan, China, and South Korea the top three importers of coal.[7]

Despite these broad statements about global coal markets, coal is not a homogeneous commodity. The global trade of coal varies by the quality and type of coal and its end use. For example, typically Indonesian coal has a lower calorific value than Australian coal, and depending on the design of a particular power plant it may not be able to substitute high-calorific coal with the low-calorific alternative. Reflecting these differences, historically, coal prices have been a function of regional market conditions and varied considerably across different markets. Table 8-1 shows historical coal prices for several regions.

[6] BP Statistical Review of World Energy, June 2011
[7] World Coal Association Statistics

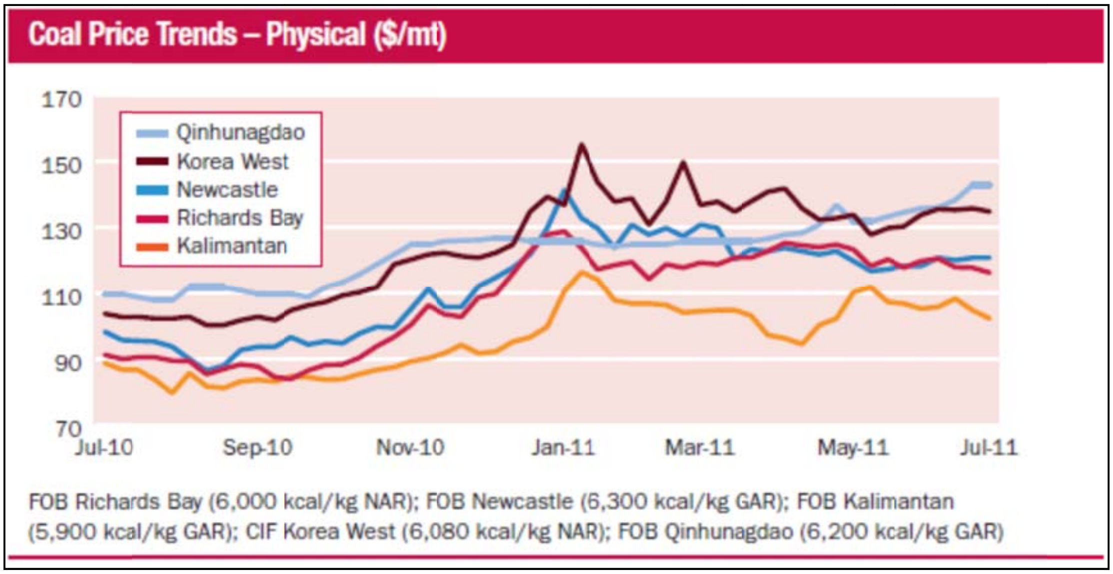
Table 8-1: Historical Coal Prices (US $ per MMBtu)

Year	Northwest Europe marker price	US Central Appalachian coal spot price index	Australian Thermal Coal	Japan steam coal import cif price
2001	1.64	1.90	1.30	1.52
2002	1.33	1.26	1.01	1.48
2003	1.83	1.46	1.05	1.39
2004	3.03	2.46	2.12	2.06
2005	2.55	2.66	1.91	2.52
2006	2.70	2.38	1.97	2.53
2007	3.74	1.94	2.63	2.80
2008	6.22	4.50	5.09	4.92
2009	2.97	2.58	2.88	4.41
2010	3.89	2.71	3.97	4.22

Source: R.W. Beck

The Newcastle (NEWC) global coal index introduced in July 2002 is a standard price index used to value Australian coal and also considered the benchmark for the Asia-Pacific thermal (or steam) coal market. Indonesian coal has been traditionally sold at a discount of 15%-20% to Australian coal partly due to poor infrastructure, weather problems which can make deliveries unreliable and also because some Indonesian mining firms sold to their affiliates at a lower price to by-pass taxes. New mining and coal laws passed by the Indonesian government in 2008-2009 require all future exports and taxes to be based on a benchmark coal price calculated as a combination of four different price indices (globalcoal NEWC, Newcastle Export Index, Platts-1 index, and Indonesian coal price index) and the new pricing structure is expected to increase the average Indonesian coal price and reduce the historical discount to Australian prices. Despite this, recent price data indicates that Indonesian coal is currently selling at a substantial discount to the Asian benchmark price (see Figure 8-1).[8]

[8] According to the monthly average of Platts 90-day forward benchmark coal price assessment, for Apr-Jun 2011, Indonesian coal price was about 13% lower than Australian coal.



Source: Platts International Coal Report, July 2011; Kalimantan represents Indonesian price

Figure 8-1: Coal Price Trends – Physical ($/mt)

Even if Indonesian prices increase relative to Australian prices, Indonesia freight rates and operating costs will likely result in lower delivered (CIF) prices to important markets. In addition, typically an import from Australia has to be loaded to a Panamax size vessel and customers who cannot receive larger vessels are more likely to meet their demand from Indonesia.[9]

Table 8-2 shows a comparison of recent freight rates and vessel size from Australia and Indonesia. It is clear that Australian freight rate is almost 50% higher than that of Indonesia for deliveries to the Asia-Pacific region.

[9] Manila Bulletin Publishing Corporation (http://www.mb.com.ph/node/249806/indone)

Current Vessel Fixtures					
Vessel	Quantity (Mt)	Origin/Destination	Loading Dates	Rate	Charterer
Australia					
TBN	80,000	Port Kembla/Taiwan	August 13-26	$13.98	Taipower
TBN	125,000	Newcastle/Samcheonpo	June 16-25	$10.39	Kepco
TBN	125,000	Gladstone/Kojeong	June 5-15	$9.29	Kepco
TBN	75,000	Dalrymple Bay/Ecind	May 18-28	$20.28	SAIL
Mineral Star	75,000	Hay Point/Vizag A/O Gangavaram	May 25-June 3	$21	RINL
TBN	150,000	Newcastle/Kwangyang	May 21-30	$12.23	Posco
Nord Mariner	50,000	Gladstone/Paradip	May 16-26	$26.50	MMTC
TBN	125,000	Newcastle/Taiwan	May 18-31	$12.40	Taipower
TBN	125,000	Newcastle/Dangjin	May 10-19	$10.95	Kepco
Orsola Bottiglieri	155,000	Dalrymple Bay/Rotterdam	May 1-15	$14.30	TKS
Indonesia					
TBN	70,000	Samarinda/Taiwan	August 21-30	$6.51	Taipower
TBN	80,000	Samarinda/Taiwan	August 5-14	$6.20	Taipower
TBN	80,000	Muara Satu/Taiwan	August 10-19	$6.63	Taipower
TBN	80,000	Samarinda/Taiwan	August 10-19	$6.45	Taipower
TBN	80,000	Samarinda/Taiwan	July 21-30	$6.08	Taipower
TBN	125,000	Taboneo/Samcheonpo	June 26-July 1	$6.30	Kepco
TBN	40,000	CIS Pacific/EC India	June 10-20	$35	Avani Resources
TBN	80,000	Maura Pantai/Taiwan	May 1-10	$5.75	Taipower
TBN	80,000	Maura Pantai/Taiwan	May 16-25	$6.05	Taipower
TBN	125,000	Banjarmasin/Taiwan	May 6-15	$5.84	Taipower
TBN	70,000	Maura Pantai/Taiwan	May 13-22	$6.13	Taipower
TBN	70,000	Samarinda/Taiwan	May 30-June8	$6.95	Taipower

Source: Platts International Coal Report, July 2011

Figure 8-2: Current Vessel Fixtures

The nuclear plant shutdown in Japan, extreme weather conditions in some of the largest supply regions and economic recovery after the global economic turndown have greatly affected coal prices in the Asia-Pacific region over the past year. Xstrata, the world's largest coal exporter, along with many other suppliers in Australia with mines near Queensland were forced to disrupt deliveries after Australia experienced its worst flood in 30 years during last December and January. Xstrata experienced additional supply disruptions due to heavy rainfall and associated damages, and Indonesia was affected by flooding as well.

These supply disruptions coincided with sharply higher demand in Europe and North Asia following a colder than expected winter, which led many utilities to replenish coal stocks. To recover from the nuclear power plant shut down, Citibank estimated that Japan could need seven million metric tons more thermal coal this year than the 102 million metric tons it imported last year.[10] As a result of these events, Australia's Newcastle port's thermal coal spot price steadily rose from $3.85/MMBtu in August 2010 before peaking at around $5.53/MMBtu in January compared to an average of $4.13/MMBtu in January 2010 and $3.41/MMBtu at the same period in 2009. However, Newcastle prices dropped to $4.81/MMBtu by mid-February 2011. This

[10] Barclays Capital has a more modest forecast for a two million-ton increase in Japan's imports this year.

reasonably fast price stabilization is probably more due to a demand drop due to the economic downturn rather than the speediness of supply recovery. The market reaction was very different from what happened in the aftermath of the Queensland flooding in 2008, when Newcastle spot prices rose to $5.65/MMBtu in January, increasing by over $1.60/MMBtu in less than a month, and then peaking at $8.02/MMBtu by July.

In April 2011, Xstrata agreed to sell Australian thermal coal to a Japanese utility for 12 months at $5.20/MMBtu, which exceeded the current spot price for Australian coal ($4.94/MMBtu), and is 13% higher than the previous settlement price of $4.61/MMBtu for 2010-2011. In another contract negotiation, Chinese miners and Japanese utilities have been discussing a long-term thermal coal price for the financial year that started in April. The price for thermal coal is expected to be around $5.81/MMBtu free on board (FOB), up from last year's $4.63/MMBtu (as of June, yet to be finalized). The price, if finalized, is approximately $25/per ton higher than Asia's benchmark price and is expected to include China's 10 percent export tax on coal. South Korea, the world's third-largest thermal coal buyer after Japan and China, is considering to increase Indonesian coal use to more than half of imports in a bid to cut costs at loss-making state utility Korea Electric Power Corp (KEPCO).

Traders said even with freight cost added, final prices of Indonesian coal are still approximately $0.40 per MMBtu lower than other origins.[11] In recent years, Indian and Chinese companies have particularly targeted major coal exporters in Indonesia and Australia, looking for both transportation and coal assets.

Outlook

According to a recent forecast by the International Energy Agency, global coal demand is expected to rise through 2020 and then decline as new opportunities emerge, and environmental policies evolve, to substitute to other fuels. Given the abundant supply and proven production technology, coal supply is not expected to be constrained for many years. However, much greater uncertainly lies regarding global demand for coal in future, and the general consensus view is for coal’s share of global primary energy supply to decrease in the longer term.

GPA’s 2008 IRP discussed both Australian coal and Indonesian coal as potential sources of Guam’s future needs. The 2008 IRP coal price assumptions expected $2.32/MMBtu for FOB Australian coal and $1.81/MMBtu for FOB Indonesian coal (Cost before freight). As discussed above, the recent market prices for these coals have been substantially higher. However, many of the drivers for the current elevated prices are expected to be transient. Accordingly, many analysts predict Australian coal prices to decrease to below $4.01/ MMBtu by 2013 (in 2013 $).[12]

[11] http://www.sharenet.co.za/news/SKorea_turns_to_Indonesia_coal_to_close_cost_gap/5084bba0836fb8e2c801b7552571014a

[12] For example, Goldman Sachs projects Newcastle price to be $102/ metric ton by 2013 and then drop to $80/ metric ton after that. Similarly, World Bank predicts nominal price for Australian coal to be around $ 100/ metric ton in 2013 followed by continued slight declines.

GPA's 2008 IRP projected an Australian freight rate of $0.70/MMBtu and Indonesian freight rate of $0.48/MMBtu for 2010. Recent freight rates are generally consistent with these numbers.

Table 8-2 summarizes R.W. Beck's projection for future coal prices for Guam. We expect Indonesian coal will continue to enjoy its current discount to the Asian benchmark price and that freight rates for delivery of coal to Guam from Indonesia compared to Australia will provide an additional cost advantage.

Table 8-2: Coal Price Forecast for Guam (2010 $/MMBtu)

	Thermal Coal Prices		Panamax Freight Rates		Delivered Price of Thermal Coal to Guam	
Year	Australia	Indonesia	Australia	Indonesia	Australia	Indonesia
2011	5.02	4.64	0.54	0.38	5.55	5.02
2012	4.56	4.22	0.65	0.45	5.21	4.67
2013	4.13	3.82	0.71	0.50	4.85	4.32
2014	3.70	3.42	0.70	0.49	4.40	3.91
2015	3.48	3.21	0.69	0.48	4.17	3.70
2016	3.26	3.01	0.68	0.47	3.94	3.48
2017	3.29	3.04	0.68	0.47	3.97	3.51
2018	3.33	3.07	0.67	0.47	4.00	3.54
2019	3.36	3.11	0.67	0.46	4.03	3.57
2020	3.39	3.14	0.66	0.46	4.05	3.59
2021	3.43	3.17	0.65	0.46	4.08	3.62
2022	3.46	3.20	0.65	0.45	4.11	3.65
2023	3.48	3.22	0.65	0.45	4.13	3.67
2024	3.51	3.24	0.64	0.44	4.15	3.69
2025	3.53	3.26	0.63	0.44	4.16	3.70
2026	3.55	3.28	0.62	0.43	4.17	3.71
2027	3.56	3.29	0.62	0.43	4.18	3.72
2028	3.57	3.30	0.61	0.43	4.18	3.73
2029	3.58	3.31	0.61	0.42	4.19	3.73
2030	3.58	3.31	0.60	0.42	4.19	3.73
2031	3.58	3.31	0.60	0.41	4.18	3.72
2032	3.58	3.31	0.59	0.41	4.17	3.72
2033	3.57	3.30	0.59	0.40	4.16	3.71
2034	3.56	3.29	0.58	0.40	4.14	3.69
2035	3.55	3.28	0.58	0.39	4.12	3.67

Source: R.W. Beck

Note: It was beyond the scope of this effort to prepare a detailed freight rate forecast; however, we believe the freight rates used in the 2008 IRP remain reasonable and consistent with current market prices.

Oil Forecast

Overview

While oil remains the world's leading fuel with over a 1/3 share of global energy consumption, oil continues to lose market share. 2010 marked the 11th consecutive year of decline in oil's market share.

Global oil consumption grew by 3.1% in 2010, after falling for two consecutive years, to reach a record level of 87.4 million barrels/day. This was the largest percentage increase for oil since 2004 but still the weakest global growth rate among the fossil fuels. The overall contraction in world oil demand of 1.3 million barrels/day in 2009 hides the stark differences between the OECD and non-OECD and between Asia and the rest of the world. The growth areas for oil demand were led by China, and followed by rest of the non-OECD Asia and the Middle East.

Global oil production growth was broadly based in all regions except Europe and Eurasia, and increased by 2.2% in 2010, but failed to match the rapid growth in consumption. Production growth was widely spread between OPEC and non-OPEC countries, and for the first time non-OECD refinery throughput exceeded those of OECD. OPEC production cuts implemented in 2008 were maintained throughout 2010, although output not subject to quota limitations resulted in an increase of 2.5%. The largest increases were in Nigeria and Qatar. Oil production outside OPEC grew by 1.8%, the largest increase since 2002. Growth was led by China (recorded its largest production increase in history) the US, and Russia. Norway saw the world's largest decline. Non-OPEC countries accounted for 58.2% of global oil production in 2010, roughly the same share as in 2000.[13]

World's proved oil reserves in 2010 were sufficient to meet approximately 46 years of current demand.

Crude oil prices were fairly stable through the first three quarters of 2010, averaging $77/barrel (approximately $13.2/MMBtu), but in the fourth quarter of 2010, prices began to rise due to rapid demand growth and declining stocks; prices averaged $90/barrel ($15.5/MMBtu) in December. The price spikes observed in early 2011 generally reflect political developments in North Africa and the Middle East, which resulted in the substantial loss of Libyan oil production and exports. In addition, due to disturbances in Yemen some crude oil production was shut down in March, as well as smaller volumes interrupted in Oman, Gabon and Côte d'Ivoire (all non-OPEC countries). In addition, fears of larger supply disruptions in major OPEC oil producers caused oil prices to be bid up. Finally, most of the world's spare oil production capacity, estimated currently at around 6 million barrels/day, is held by Saudi Arabia. To meet future level of demand growth will require continued investment in oil production across the globe, a process many believe has stalled and high prices, at least to some extent, reflect this perception.

[13] BP Statistical review of World Energy, June 2011

The supply response from OPEC countries to the price spike has been limited, mainly because of weak demand for the medium-sour crude that OPEC has in spare capacity, and because the supply disruptions occurred during the seasonal downturn in demand due to refinery maintenance. The pickup in global demand has drawn-down OPEC's spare capacity (excluding Libya, Iraq, Venezuela and Nigeria) by 1 million barrels/day compared to the end of 2010. Because of the loss of Libyan distillate-rich sweet crudes, the distillate market worldwide has tightened.[14]

Table 8-3 shows some important global crude oil prices over the past 10 years. Unlike coal, oil is a global market where different price series tend to closely follow each other. Also, crude oil prices typically dictate the movements in refined product prices.

Table 8-3: Spot Crude Prices (US $ per MMBtu)

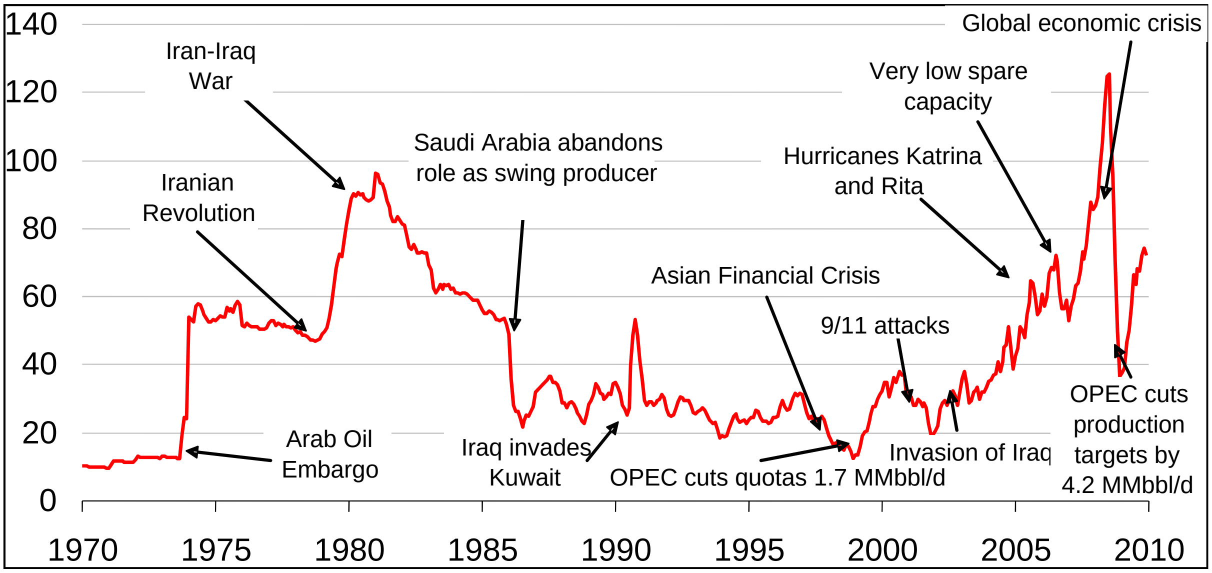
Year	Dubai	Brent	Nigerian Forcados	West Texas Intermediate
2001	3.94	4.21	4.12	4.47
2002	4.10	4.31	4.26	4.51
2003	4.63	4.97	4.87	5.36
2004	5.81	6.59	6.48	7.15
2005	8.53	9.40	9.47	9.76
2006	10.63	11.23	11.41	11.38
2007	11.78	12.47	12.67	12.45
2008	16.30	16.76	17.25	17.25
2009	10.61	10.63	10.77	10.68
2010	13.49	13.70	13.78	13.70

Source: R.W. Beck

Outlook

Oil prices respond to many uncertain factors including but not limited to inventories, global economic growth and energy policy, geo-political risks, OPEC's decisions, non-OPEC supply growth, speculations and investments, and exchange rates/inflation. Some of these issues, like OPEC decisions and non-OPEC supply, affect long-term prices. Historically, geopolitical and economic events have driven large movements in world oil prices (see Figure 8-3).

[14] Global Economic Prospects, Vol. 3, World Bank, June 2011



Source: EIA, February 18, 2010; Tancred Lidderdale

Figure 8-3: World Oil Price (2009$/barrel)

Current projections of future long-term oil prices vary widely based on different assumptions mainly regarding future technology benefits and innovation (supply and demand side), environmental policies, and other risks discussed above.

Table 8-4 summarizes some frequently cited crude oil price projections.

Table 8-4: Projection of World Oil Prices (2009 $ per MMBtu)

Projection	2009	2015	2020	2025	2030	2035
AEO2011	10.66	16.26	18.58	20.20	21.16	21.48
5-year annual growth rate		7.3%	2.7%	1.7%	0.9%	0.3%
AEO2010 (Reference case)		16.25	18.79	19.96	21.43	23.11
5-year annual growth rate		7.3%	3.0%	1.2%	1.4%	1.5%
Deutsche Bank		13.93	15.77	17.15	18.12	18.75
5-year annual growth rate		4.6%	2.5%	1.7%	1.1%	0.7%
ICF Q4 2010 Integrated Energy		13.38	13.38	13.38	13.38	13.38
5-year annual growth rate		3.9%	0.0%	0.0%	0.0%	0.0%
World Bank June 2011		15.83	13.42	--	--	--
5-year annual growth rate		6.8%	-3%	--	--	--
INFORUM		15.64	17.58	18.72	20.11	21.50
5-year annual growth rate		6.6%	2.4%	1.3%	1.4%	1.3%
IEA (current policy scenario)		16.16	18.91	20.63	22.35	23.20
5-year annual growth rate		7.2%	3.2%	1.8%	1.6%	0.8%
EVA		14.96	15.81	17.14	19.05	--
5-year annual growth rate		5.8%	1.1%	1.6%	2.1%	--
IHSGI		15.55	14.81	13.78	14.15	--
5-year annual growth rate		6.5%	-1.0%	-1.4%	0.5%	--

Source: R.W. Beck, various forecasts from public sources

IEA and others assume both supply and demand for oil will become increasingly insensitive to higher prices due to growing demand in heavily subsidized markets and lack of alternate technologies to support fuel switching. On the other hand, others, such as the World Bank, expect the current high prices will encourage development of additional oil supply resources and also some switching away from oil leading to stable or declining prices.

GPA typically uses the following fuels: High Sulfur Fuel Oil (HSFO), Low Sulfur Fuel Oil (LSFO), and Number 2 diesel distillate or heating oil (HO). For the HSFO and LSFO, the contracts are typically based on same commodity price indices, but use a higher fixed fee adder on top of the commodity base price for LSFO. Table 8-5 presents the historical commodity price for these petroleum products paid by GPA.

Table 8-5: Historical Guam Commodity Price

	$/Barrel		$/MMBtu	
Year	HSFO	HO	HSFO	HO
2008	78	-	12.40	-
2009	49	111	7.79	111
2010	72	113	11.43	113
2011	93	138	14.86	138

Source: GPA Financials; R.W. Beck

Note: Price excludes fixed formula adder; 2011 data until May

GPA's 2008 IRP base case assumed a 2% increase in global oil production capacity and accordingly projected that by the end of 2008 the strong growth in oil productive capacity would cause sharp downward pressure on oil prices. Accordingly, the residual oil price for Guam was projected to be around $50/barrel ($7.96/MMBtu) and for Diesel approximately $77/barrel ($13.40/MMBtu) in 2008 (nominal dollars). As Figure 8-3 showed, prices evolved quite differently for the reasons discussed previously and global outlook for oil changed accordingly.

Table 8-6 summarizes R.W. Beck's Low Case, Base Case, and High Case outlook for petroleum products that will be purchased by GPA under similar contractual terms as present. The forecast is based on GPA's historical petroleum product purchase prices and R.W. Beck's outlook for long-term global oil market prices.

In the Base Case, R. W. Beck expects oil prices to continue to trade at relatively high level for another year or two before declining toward 2008 price levels around 2015. We expect prices to continue to rise in real terms at an annual average rate of 1.4% beyond 2015.

There are a number of uncertainties which could cause prices to diverge from this outlook including large supply-shocks that can have significant impacts on oil prices and economic activity, as in the past, changes in environmental policies that could curb non-OPEC production growth in resource-intensive areas, e.g., offshore, oil sands, and shale-rock fracturing (these sources account for more than one-third of global oil supplies), OPEC policies, and impact to supply and demand from emerging technologies.

These uncertainties are reflected in the Low Case and High Case petroleum price forecasts in Table 8-6. The Low Case and High Case were developed based on stochastic simulations involving a combination of econometric and statistical analyses of a large sample of historical oil prices at annual and monthly granularity to estimate historical price volatility. The Base Case forecast prices were used as the explicit starting point to model calculations so that the resulting Low Case represents the 25th percentile and the resulting High Case represents the 75th percentile around the Base Case. As such, the price range defined by the Low Case and High Case derives a 50% confidence interval representing the range of potential future prices around the Base Case.

Post 2015, the long-term real annual growth rate for the oil prices in the Low Case is approximately 0.5% compared to approximately 2.5% under the High Case. As a result, under the Low Case the delivered oil prices are nearly flat in real terms over the forecast period while in the High Case prices increase by approximately 150% in real terms over the forecast period.

Table 8-6: Fuel Oil Delivered Price Forecast (2010 $ per MMBtu)

	Base Case			Low Case			High Case		
Year	HSFO	LSFO	HO	HSFO	LSFO	HO	HSFO	LSFO	HO
2011	-	-	-						
2012	14.96	15.53	22.88	12.00	12.45	18.35	22.89	23.76	35.02
2013	14.25	14.82	21.74	11.29	11.74	17.22	22.26	23.15	33.95
2014	13.58	14.15	20.65	10.64	11.08	16.17	21.63	22.53	32.88
2015	12.95	13.51	19.62	10.03	10.46	15.19	20.99	21.91	31.81
2016	13.27	13.84	20.15	10.17	10.60	15.43	21.90	22.83	33.24
2017	13.61	14.18	20.70	10.31	10.74	15.68	22.82	23.77	34.70
2018	13.96	14.52	21.26	10.46	10.89	15.94	23.77	24.73	36.20
2019	14.31	14.88	21.83	10.62	11.04	16.20	24.73	25.72	37.73
2020	14.68	15.24	22.42	10.78	11.20	16.47	25.72	26.72	39.30
2021	14.91	15.48	22.80	10.85	11.26	16.59	26.48	27.49	40.50
2022	15.15	15.72	23.19	10.91	11.32	16.70	27.25	28.27	41.70
2023	15.39	15.96	23.58	10.98	11.39	16.83	28.01	29.05	42.92
2024	15.63	16.20	23.98	11.05	11.46	16.95	28.79	29.83	44.14
2025	15.88	16.45	24.38	11.13	11.53	17.08	29.56	30.62	45.38
2026	16.02	16.59	24.61	11.13	11.52	17.08	30.13	31.20	46.27
2027	16.16	16.73	24.83	11.12	11.52	17.09	30.69	31.77	47.15
2028	16.31	16.88	25.07	11.12	11.51	17.10	31.25	32.34	48.03
2029	16.45	17.02	25.30	11.12	11.51	17.11	31.80	32.90	48.90
2030	16.59	17.16	25.53	11.13	11.51	17.12	32.34	33.45	49.76
2031	16.64	17.21	25.61	11.07	11.44	17.03	32.68	33.80	50.29
2032	16.69	17.26	25.68	11.00	11.38	16.94	33.02	34.14	50.81
2033	16.74	17.31	25.76	10.94	11.32	16.85	33.34	34.47	51.32
2034	16.78	17.35	25.84	10.89	11.26	16.76	33.65	34.79	51.80
2035	16.83	17.40	25.92	10.83	11.19	16.67	33.95	35.10	52.27

Source: R. W. Beck

LNG Forecast

Overview

Natural gas provided 24% of global primary energy need in 2010 and grew by 7.4%, its most rapid consumption growth since 1984. Consumption growth was led by the US, Russia, China and followed by the other Asian countries.

Global production of natural gas increased by 7.3% in 2010, led by Russia, US, and Qatar. World natural gas proved reserves in 2010 were sufficient to meet 58.6 years of global production as the reserve-to-production ratio declined in each region driven by rising production.

Natural gas trade grew by 10.1% in 2010, led by strong upsurge (more than 22.6%) in LNG shipments. LNG exports were dominated by the Middle East. Qatar, the world's largest LNG exporter had an export growth of 53.2%. Pipeline shipments grew by 5.4%, led by Russia. LNG now accounts for 30.5% of global gas trade. [15] Among LNG importers the largest volumetric growths were in South Korea, UK, and Japan and Japan continues to be world's largest LNG importer.

World's excess production capacity for LNG was about 30% last year (up from less than 5% in 2003), mostly caused by the startup of the Qatar LNG project.[16]

Table 8-7 presents a summary of recent gas prices (including LNG) for locations in the Americas, Europe and Asia. . As we will discuss in more detail below, natural gas and LNG pricing in these locations reflect considerable regional differences due to significant variations in regional infrastructure, domestic production capability and pricing mechanisms.

Table 8-7: Natural Gas Prices (US $ Per MMBtu)

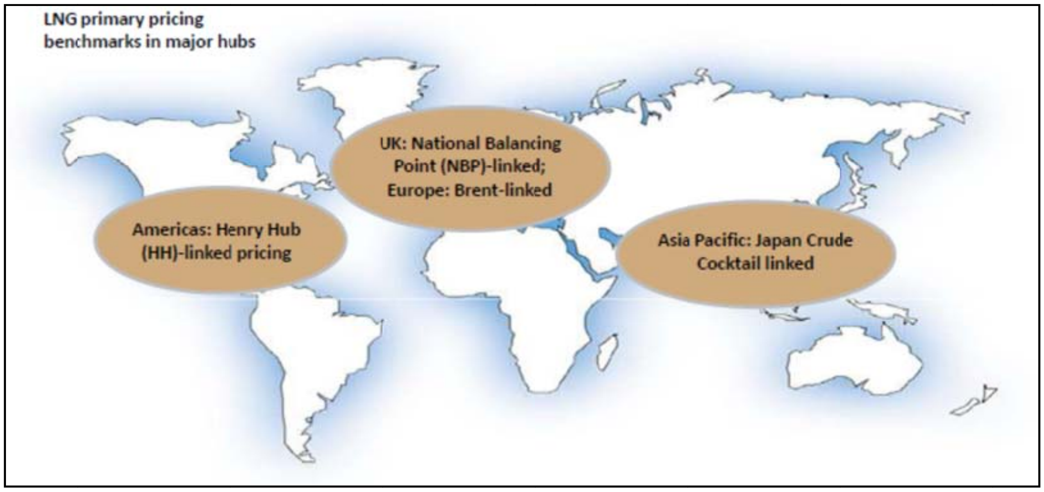
	LNG	Natural Gas		
Year	Japan cif	European Union cif	UK (Heren NBP Index)	US Henry Hub
2001	4.64	3.66	3.17	4.07
2002	4.27	3.23	2.37	3.33
2003	4.77	4.06	3.33	5.63
2004	5.18	4.32	4.46	5.85
2005	6.05	5.88	7.38	8.79
2006	7.14	7.85	7.87	6.76
2007	7.73	8.03	6.01	6.95
2008	12.55	11.56	10.79	8.85
2009	9.06	8.52	4.85	3.89
2010	10.91	8.01	6.56	4.39

Source: R.W. Beck

Figure 8-4 illustrates the range in LNG pricing benchmarks across major LNG hubs. Natural gas prices in the US and UK are typically linked to spot gas pricing at Henry Hub and National Balancing Point (NBP), respectively. On the contrary, continental Europe and Asia Pacific gas/LNG pricing are generally tied to crude benchmarks, Brent for Europe, and JCC (Japan Crude Cocktail) for Asia Pacific.

[15] BP Statistical review of World Energy, June 2011

[16] Global LNG Development in 2010. (n.d.). *Global LNG* Info. http://www.globallnginfo.com/develop2010.htm



Source: Dubai Mercantile Exchange

Figure 8-4: Global LNG Pricing Benchmarks

The pipeline infrastructure between UK and Continental Europe provides linkage between the two markets giving some access to each region to both crude-indexed and spot gas priced supply. However, no such gas-linked pricing mechanism exists in the Asia-Pacific region. The existing JCC-linked pricing structure in the Asia-Pacific provides for efficient risk management in absence of a suitable gas futures market in the region.

Originally, LNG pricing was linked to a reliable crude price because natural gas did not have a global and liquid market like crude oil. Also, gas and oil were considered close substitutes in the power generation and heating sectors. Despite oil price volatility, and changing fuel substitutability, the oil-benchmarked prices have prevailed due to the liquidity of traded oil products and associated hedging advantages. LNG projects are usually built to operate for 20 years or more and are expensive to build, thus the ease of managing future price risk is a fundamental consideration for investments in LNG projects. Most of the LNG production has historically sold under long term contracts of more than 10 years. In the Asia Pacific region each contract is written using a separate indexing formula based on the negotiation between buyers and seller. Many past contracts in the Asia Pacific region relied on the JCC-linkage for LNG pricing under a formula or price structure called an S-curve. S-curve pricing typically dampens the gas pricing relative to oil when oil prices are high, thus guarding the buyer against extremely high prices, and prevents gas prices from falling substantially when oil prices plummet.

2010 saw a significant recovery in LNG demand and with it prices, after prices plunged across the globe in 2009 from the double-digit figures of the year before. Large new LNG production trains that were built in Qatar, and started coming online in 2009, were originally expected to head towards North America on the basis of falling US demand, and declining US and Canadian production. But the recession and an upsurge in U.S. domestic shale gas production confounded those assumptions. By 2010, the U.S. became one of the least attractive markets for global LNG.

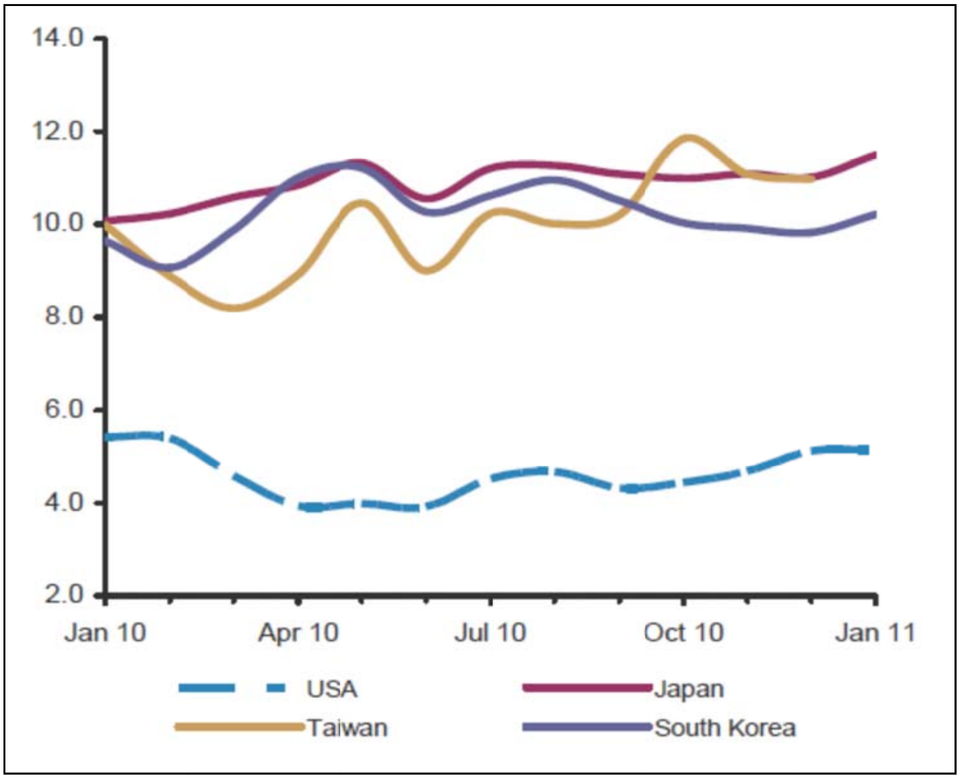
The un-contracted, excess LNG was also rejected by the Asian buyers on most part due to a sharp decline in industrial demand due to the recession. Asian spot LNG markets also experienced a drop in liquidity; the winter of 2008-2009 saw almost no spot trade in the region, a sharp contrast to the numerous spot trades in 2007 and 2008. Even during post-winter months of 2009, the Asian spot market remained quiet apart from a few deals made by India and China. Even though low priced spot LNG cargos were attractive there simply was no room to take them for the Asian buyers whose long-term, contracted portfolios already looked too heavy for the reduced demand levels.

As a result of these unusually reluctant U.S. and Asian buyers who were unwilling to compete for the spot LNG cargos, the excess LNG instead headed for Europe where a surge of new import capacity, particularly in the UK, came online right around this time. The European importers who typically hold long-term take-or-pay gas contracts indexed to oil products, were not only hit by the reduced demand due to recession, but under the take-or-pay contracts they were paying for oil-indexed gas at a premium to the cheaper un-contracted LNG that gained easy access to the continental Europe due to improved transmission between markets. Accordingly, there was a global convergence of gas and spot LNG prices hovering around $4 to $5 per MMBtu signifying U.S. prices had dropped to about half of the previous year's peak, UK prices to about a third, and Asian spot LNG prices to about a fifth.[17]

In 2010 Asian LNG demand bounced back strongly due to a quick recovery from the recession, and extreme weather conditions. The year started with one of the coldest winters on record across Asia. Given almost no storage availability, Asian buyers considerably increased their demand for LNG cargos. For example, Japan hit its highest ever monthly LNG import volume in March 2010. While the Atlantic economies struggled to get back to meaningful economic growth, much of Asia experiences an industrial resurgence, bringing along a renewed demand for LNG. Going into summer there was some demand for spot cargos in Japan due to nuclear plant outages but then Japan was hit with the hottest summer on record. Spot LNG buying picked up, and utilities also started increasing their contracted supplies when possible.[18] Platt's Japan Korea Marker (JKM) for *spot* LNG delivered into Japan and Korea averaged $6.97/MMBtu for year 2010 through November, which was 50% higher than the year before. Figure 8-5 shows the LNG prices (for contracted deliveries) paid by the major Asian importing countries in 2010.

[17] Platts Insight: 2011 Asia Energy Outlook

[18] By September, one Japanese utility was paying above $9/MMBtu for spot LNG, the highest for the year thus far.



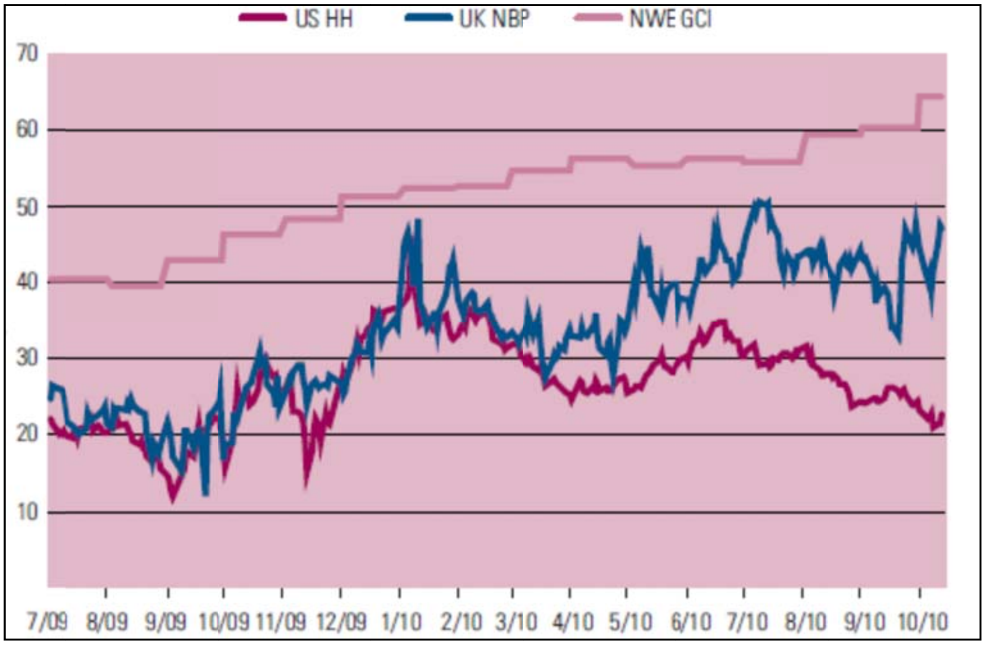
Source: LNG One World, Drewry 2011

Figure 8-5: LNG Prices ($/ MMBtu)

In winter of 2010, UK also experienced record winter temperatures but the NBP prices remained generally stable due to its ability to rely heavily on storage, which had already been filled up with ample gas supply coming from the newly revamped LNG import facilities. However, strong draw on storage set up the country for steady LNG demand for the following months.

Major European importers were left with expensive supply under their take-or-pay contract indexed to oil as oil price started to rise from the 2009 level, demand was still low due to a sluggish economic recovery, and improved transferability between markets, including between UK and the continental Europe, put contracted gas under direct competition with lower cost spot gas supply. Usually, during winter spot gas prices are higher than oil-indexed prices resulting in flows from the continent to the UK, while in summer spot gas is attracted to the continent as oil-indexed prices become more expensive. However, in 2010, oil-linked prices remained consistently higher during both summer and winter igniting a debate in Europe over indexed contract pricing and the overall market structure.[19] Figure 8-6 shows a comparison of monthly gas prices (in pence/therm) in Europe, UK, and US.

[19] Platts Insight, 2011 Global Energy Outlook



Source: Platts

Figure 8-6: Gas prices for UK spot, oil-linked Europe and Henry Hub (p/th)

As the above discussion shows, even though 2010 showed a global resurgence in LNG demand, and prices, the revival in UK and Europe have taken slightly different trajectory than in the Asia Pacific region. Additionally, in the US, almost disconnected from oil as well as other competing fuels, Henry Hub prices are now reflecting North American demand and indigenous supply.

In 2011, demand in the Pacific Basin LNG market has spiked in the wake of the March 11th tsunami that hit Japan resulting in an initial outage of 11 GW of generation capacity including the complete meltdown of units 1 through 3 at the 4.7 GW Fukushima Daiichi Nuclear Power Plant. Japan will likely experience elevated demand for LNG for the next few years as a result of this disaster. In addition to this short-term elevation in LNG demand, the broader Pacific Basin LNG market is expected to experience tremendous structural demand growth. This structural growth in demand will result as developing countries in the Pacific Basin seek cleaner forms of power generation than the traditional coal-fired units that have been heavily relied on within this region. Additional demand growth will also occur as new perceptions of the environmental risks associated with nuclear generation capacity cause developed and developing countries to switch from nuclear heavy generation capacity build out plans to build out plans that are more weighted toward gas-fired generation capacity.

Currently the only pipeline capable of importing large volumes of gas into Asian consumer markets is the Central Asia – China Gas Pipeline. The Central Asia – China Gas Pipeline is a 1,139-mile mega project consisting of dual 42-inch pipelines capable of transporting up to 3.9 Bcf/day of natural gas from Turkmenistan, Uzbekistan and Kazakhstan into northern China. The pipeline began initial service in December 2009 with the completion of the first of the two parallel 42-inch outer diameter pipelines. The second line is expected to be completed later this year.

Since the Central Asia – China Gas Pipeline began operations in late 2009; average throughput on the system has been approximately 725 MMcf/day[20]. Unlike the Nord Stream project in Europe that will deliver large volumes of natural gas into western European markets with well-developed distribution infrastructure, it will likely be several years before the Central Asia – China Gas pipeline is able to operate at high utilization levels. Full utilization of the pipeline capacity will likely require further infrastructure development within China to move these pipeline import volumes into major consuming regions in Eastern China. China is currently in the process of greatly expanding its natural gas pipeline network, which is expected to grow from current levels of approximately 22,000 miles of installed pipe to over 62,000 miles of installed pipe by 2015.

In addition to the Central Asian Pipeline, China is also constructing the 1.2 Bcfd Sino-Myanmar pipeline that is expected to be complete in mid-2013. The pipeline which will deliver produced gas from Myanmar is being developed in conjunction with an oil pipeline that will largely deliver oil imported from the Middle East via deepwater ports in Myanmar. Besides projects that are currently under construction, Gazprom has proposed the Altai Pipeline that would have a capacity of 6.8 Bcf/day of natural gas from Siberia to Northwestern China. Recent talks between Russia and China failed to result in a mutually agreeable long-term gas price making the timing of this project uncertain. Construction was originally scheduled to begin later this year.

Assuming any new Russian pipeline projects do not come online until post-2020, the Pacific Basin region will require about 12.8 Bcf/day of new LNG imports by 2020. This calculation assumes that the region requires total import volumes of 17.6 Bcf/day by 2020 and that the 3.9 Bcf/day Central Asian – China Gas Pipeline and the 1.2 Bcf/day Sino-Myanmar Pipeline operates at a 95% load factors delivering average gas volumes of 4.8 Bcf/day.

In the past couple of years, Chinese companies have signed up for future deliveries of LNG from Australia and Papua New Guinea, the latter being the first instance where a Chinese, rather than a Korean or Japanese companies have signed enough off-take agreements to underpin the financing of an Asian LNG project. In addition, Russia and Uzbekistan are under consideration for future suppliers for China. Russia is negotiating a long-term contract but it is stalled due to no agreement on pricing.

A list of LNG Liquefaction projects in the Pacific Basin that are under construction or in planning phase by a major exploration and production company and considered to have strong potential for completion is provided in Table 8-9. Many of the projects that are in planning have signed long-term contracts for liquefaction volumes. As is shown, the total volume from these projects is approximately 12.0 Bcf/day. So, unless the Pacific Basin can attract a significantly larger share of LNG exports from the Middle East, it is likely that the region will require that most of the liquefaction projects listed to be completed before 2020.

[20] As of June 14th 2011

Table 8-8: Pacific Basin Liquefaction Projects

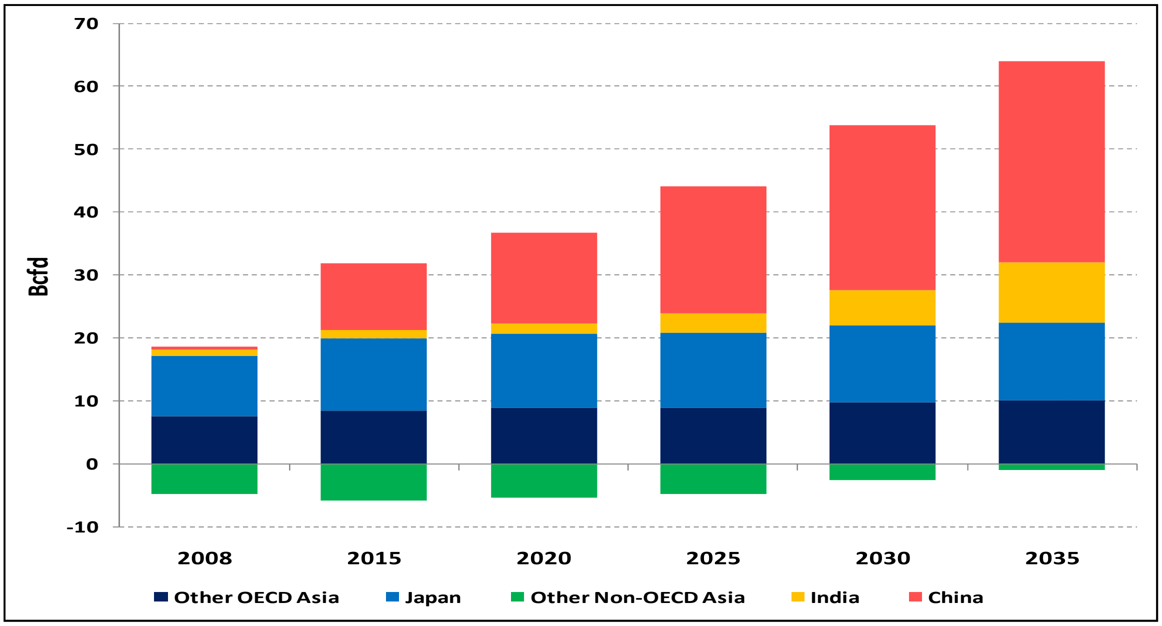
Project Name	Project Location	Capacity (Bcfd)	Target Start-up Date
Pluto LNG	NW Australia	0.61	2012
Gorgon LNG	NW Australia	2.13	2014
Queensland Curtis LNG	NE Australia	1.20	2014
PNG LNG	Papua New Guinea	0.89	2014
Gladstone LNG	NE Australia	1.10	2015
Australia Pacific LNG	NE Australia	1.00	2015
Wheatstone (Phase 1)	NW Australia	1.26	2016
Gorgon LNG (Phase 2)	NW Australia	0.70	2016
Ichthys LNG	NW Australia	1.20	2017
Prelude FLNG	NW Australia (Offshore)	0.51	2017
Bonaparte FLNG	NW Australia (Offshore)	0.28	2018
Sunrise FLNG	NW Australia (Offshore)	0.51	2018
Wheatstone (Phase 2)	NW Australia	0.64	2019
Total		12.0	

Source: R.W. Beck

Outlook

Figure 8-7 shows International Energy Agency's (IEA's) projected imports for the Pacific Basin for China, India, Japan, OECD Asia[21] and Non-OECD Asia[22]. As can be seen from the figure, demand for natural gas imports in the Pacific Basin is expect to grow by over 17 Bcf/day by 2020 and by over 49 Bcf/day by 2035 when compared to 2008 levels. Most of this incremental demand for imports occurs in China. China is expected to account for about 80% or 14 Bcfd of the incremental 17.6 Bcf/day growth in regional import requirements. In addition to China, demand growth in Non-OECD Asia contributes to an annual average 6.2% decline in net exports through 2035. In other words, demand growth from resource poor Non-OECD countries such as Thailand, Singapore, Bangladesh, Vietnam, Sri Lanka and the Philippines nearly overcomes the production capabilities of Non-OECD Asian resource rich countries such as Malaysia, Indonesia and Papua New Guinea by 2035. While some of the forecasted import volumes presented in this report will come from new pipeline imports the majority of these volumes will need to come from new LNG imports.

[21] Figures for OECD Asia are exclusive of Japan.
[22] Figures for Non-OECD Asia are exclusive of China and India.

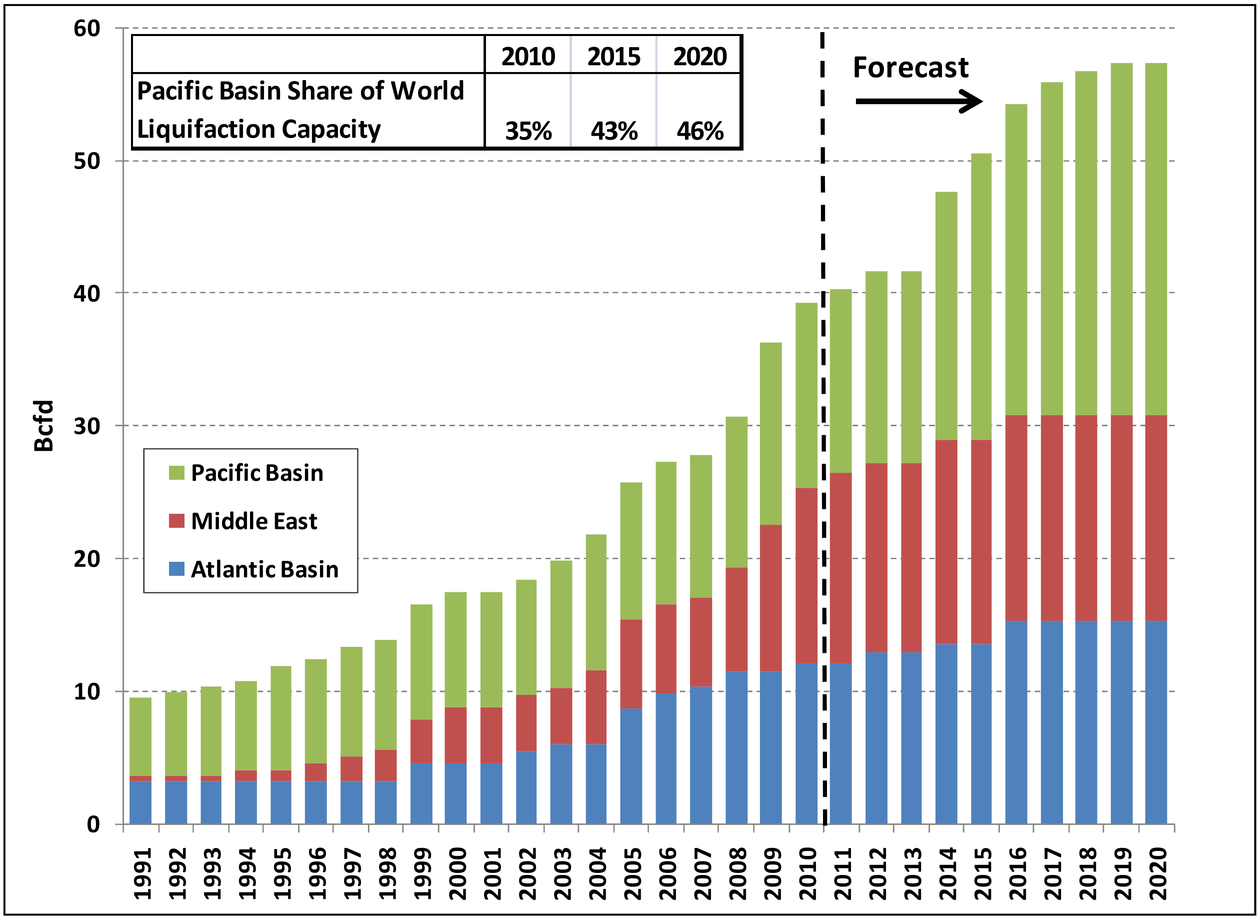


Bcfd	2008	2015	2020	2025	2030	2035	CAGR 2008 to 2020	CAGR 2020 to 2035	CAGR 2008 to 2035
Japan	9.7	11.4	11.8	11.9	12.3	12.3	1.7%	0.3%	0.9%
Other OECD Asia	7.5	8.5	8.9	9.0	9.8	10.2	1.4%	0.9%	1.1%
China	0.5	10.6	14.5	20.1	26.2	32.0	32.8%	5.4%	16.8%
India	1.0	1.4	1.5	3.1	5.5	9.6	4.0%	12.9%	8.9%
Other Non-OECD Asia	-4.8	-5.8	-5.3	-4.7	-2.6	-0.9	0.8%	-11.4%	-6.2%
Asia Total	13.8	26.1	31.4	39.4	51.2	63.2	7.1%	4.8%	5.8%

Source: IEA WEO "Golden Age of Gas Scenario 2011 early release"

Figure 8-7: Pacific Basin Project Net Imports

As a result of the high demand growth, the Pacific Basin's share of world liquefaction capacity is expected to increase. Figure 8-8 shows historical and projected world LNG liquefaction capacity with statistics for Pacific Basin liquefaction capacity as a share of world capacity. As is shown in the figure, the share of global liquefaction located in the Pacific Basin is expected to increase from current levels of approximately 35% of world capacity to nearly 50% of world capacity by 2020.



Source: R.W. Beck

Figure 8-8: Global LNG Liquefaction Capacity

It is important to understand the economics behind the investments made for developing new liquefaction projects before introducing discussions on LNG price outlook. As shown in Table 8-8, most of the new liquefaction projects under development in the region are located in Australia. These projects are proving to be capital intensive. For example, Woodside recently delayed startup of its Pluto LNG project by one year and announced a cost overrun of almost $1 billion. Total costs for the liquefaction project are now estimated at $15.7 billion for the 610 MMcf/day single train facility.

Table 8-9 provides a rough estimate for the delivered cost of LNG based on the economics of the Pluto project. As is shown in the figure, the estimated cost of delivered gas from the Pluto project is between $9 and $10 per MMBtu. Financial analysts expect that Woodside will need to realize long-term oil prices in excess of $100 per barrel to make the project a commercial success.

Table 8-9: Cost Estimate for Delivered LNG from Pluto Project

Cost Type	$ per MMBtu
Resource Development Costs[23]	3.00 to 4.00
Liquefaction Costs[24]	5.55
Shipping Costs[25]	0.45
Total	9.00 to 10.00

Source: R.W. Beck

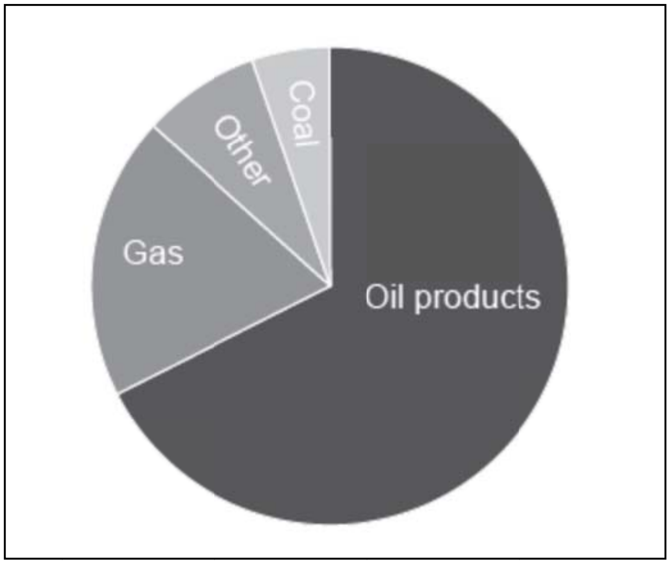
While Woodside may be able to improve the economics of the project by adding a second liquefaction train; essentially the second train could piggy back on most of the development costs of the first train, cost over runs on the project have made it such that Woodside may now be unable to issue the necessary bonds for the planned second train without affecting its credit rating.

We discussed above how improved transmission between UK and the continental Europe has put oil-indexed gas supply at direct competition with spot priced gas supply in recent years, and given that spot NBP prices have been consistently lower than the oil-indexed prices over the past several months, and across both summer and winter seasons, there is increased debate on whether the time has come to move away from the traditional oil-indexation pricing. Major gas importers in Europe -- like Ruhrgas in Germany, GDF Suex in France, and Eni in Italy -- have been desperately trying to get rid of the surplus gas they did not need and reduce the oil-indexed prices they had to pay for gas they could not avoid under the take-or-pay contracts. Some gas pricing was transferred from oil to gas hub prices. Norway's Statoil extracted better terms for its own sales and marketing operations in continental Europe in exchange for granting some price relief to buyers.[26] However, Gazprom and Ruhrgas continued to sell at price levels based on oil prices even if the sales volumes were lower than expected although some influence from spot gas pricing has been reported in recent Gazprom long-term contracts.

Before turning our focus on to the Asian LNG pricing it is important to understand the direction in which traditional oil-indexation pricing in headed in the European markets. During the drastic low demand in early 2009, leading long-term suppliers to Europe, like Russian giant Gazprom, considered adding elements of spot price in their deals with European customers. However, as volumes started recovering later in that year, they firmly shifted back to their traditional contracting practice. Russian energy minister Sergi Shamtko told reporters in early 2010 that by no means the system of long-term contracts that they created over the years be destroyed.[27] In the past year, another take-or-pay contract indexed to oil products was signed for the supply of first gas through the Nord Steam Pipeline, which runs from Russia to Germany via the Baltic Sea. Figure 8 shows indexation in the long-term contract for global sales in

[23] Includes E & P costs such as seismic imaging, well drilling and surface facilities such as gathering systems, etc.
[24] Based on 95% capacity factor, 40-year operating life and a 7% investment opportunity cost.
[25] Based on a 165,000 cubic meter vessel, average daily shipping cost of $70,000 and a round trip of 26 days.
[26] Platts, 2011 Global Energy Outlook
[27] Financial Times, Feb 23, 2010

2010 for Norway's Statoil, another major supplier of gas to Europe. It is quite clear that about two-thirds of its long-term sales portfolio is indexed to oil.



Source: Statoil

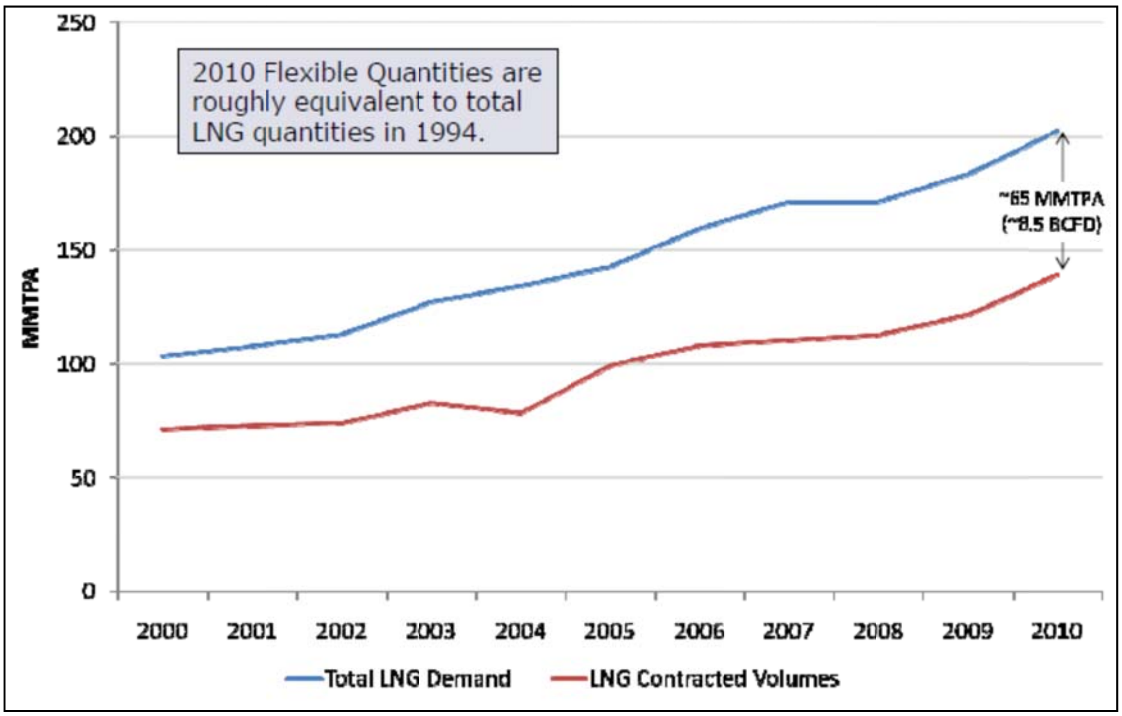
Figure 8-9: Indexation in the Long Term Gas Sales Contracts in 2010 for Statoil

Based on review of publicly available data, long-term contracts in continental Europe still continue to be heavily indexed to oil products, as has been the case historically. However, it is also important to keep in mind that there is an increasing interest, especially among the European buyers, to include elements of spot gas pricing in their long term contracts. But for the European buyers the challenges lie in convincing a handful of existing suppliers to change an established contracting practice that have been in place for years, especially if the supply glut of the recent past, and availability of cheaper spot LNG turn out to be short term market characteristics.

Asia Pacific gas buyers, unlike Europe, have far less gas supply security and optionality due to lack of inter-market gas pipeline infrastructure, and scarcity of domestic production compared to the growing demand in the region. When LNG is headed to Asia, it does not face competition from an alternate source of available gas at a different price. In addition, it is important to keep in mind the cultural factor that Asian buyers in traditional markets such as Japan and Korea generally value maintaining long-term supply security, and hence, long-term relations with their suppliers. Absent a steady and liquid regional gas market, both buyers and sellers have been happy with the current arrangement of oil-indexed long-term contracts, each contract having its own separate indexation rules. Typically, these contracts are reviewed every 5 years or have other opportunities for price "re-openers". With limited alternative resources, buyers have been willing to pay a premium to attract steady supply over the long term, and producers, most of them having interest in both gas and oil, felt comfortable with oil-indexed pricing.

The recent turmoil in the European gas market revealed that spot gas prices there tended to be below oil-indexed prices, and that led to some questions, whether Asian buyers are paying a premium over what a competitive gas price should have been in the region had there been a liquid, competitive market. It is important to note here though, a competitive price for Asia is unlikely to be what either NBP or Henry Hub reflect, as market fundamentals vary widely across these global market centers.

Demand for LNG in Asia Pacific has been growing and is expected to grow further; most of this demand is met by contracted volumes as opposed to spot purchases, although the share of the latter has increased gradually. At present, Japan has terminals with total import capacity of approximately 177 million metric ton/year, versus long-term contract volumes of just over 57 million metric ton/year. Similarly, total capacity for South Korea is 44.4 million metric ton/year and long-term contract represents 25.5 million metric ton/year of those. Taiwan's ability to take on spot supply is even more constrained with 10.4 million metric ton/year of total capacity and long-term contracts for 8.7 million metric ton/year.[28] Even though spot trades were quite visible in the past year given the readily available un-contracted LNG cargos, so was the trend in term contracting. Figure 9 presents a global picture of total LNG demand and contracted volumes.



Source: Galway Energy Advisors

Figure 8-10: 2010 LNG Demand and Contracted Volumes

It is important to remember that short-term and long-term deals are made for fundamentally different reasons. Long-term deals for buyers represent energy security and hedge (both price and quantity) against future uncertainty. Producers need long-term contracts to justify multi-billion dollars investments to investors and lenders for a project whose life spans over two decades. On the contrary, spot deals often signify

[28] Platts Asia Energy Outlook, 2011

windfall gains for either party, or buffer against unexpected near term market risks (for example, over production for the seller, or unexpected surge in demand for a utility customer). Thus, spot deals should not be considered a substitute for long-term contracts for most market participants; instead it is fair to say that they complement each other.

We will now focus our discussion on what the market has so far revealed regarding the future of oil-indexed pricing in the Asia Pacific region. Earlier this year, executives with three of the world's large energy corporations with significant footings in the LNG business, Exxon Mobil, Chevron, and ConocoPhillips, said publicly that a large chunk of their natural gas output is locked under fixed long-term contracts that closely follow oil prices. For example, Chevron Chief Executive John Watson said at the company's securities meeting "Our Asian LNG sales contracts are linked to oil prices, and provide us with realizations that are near oil parity." Chevron has five LNG projects and two potential expansions within the Asia-Pacific region, including the Gorgon project, expected to produce in 2014. Gorgon is the biggest upstream investment ever undertaken, to the tune of \$37 billion.[29] A Vice President for Australian energy giant Santos said last month that Asia's need for energy security will keep regional LNG volumes tied up in long-term contracts under oil price indexing in the foreseeable future. Santos recently began construction of its \$16 billion dollar Gladstone LNG project on Curtis Island near Queensland. Santos and its partners made their final investment decision on the 7.8 million metric ton/year project in January 2011. First shipments from the two-train projects are expected in 2015. South Korea's Kogas and Malaysia's Petronas have signed 20-year offtake agreements for the project.[30] Chief executive of Royal Dutch Shell, another global energy giant, said last month that price of LNG will depend on the price of oil, especially in Asia.[31]

Looking beyond corporate predictions, it is fair to say that analysts have a much broader set of views regarding the continuation of oil linkage for Asian LNG pricing. However, our research shows a general consensus even among analysts that European prices are more likely to start a move away from oil-indexation, if at all, before Asia starts moving in that direction because of the market fundamentals we have discussed earlier.

Ultimately, the complexity of developing a large-scale LNG export facilities in Australia or elsewhere in the world means that even projects secured by long-term contracts that are indexed to oil face significant financial risks. The market implication is that only LNG projects that are backed by major market participants and have sold a high percentage of their project capacity through long-term, Oil-indexed contracts are likely to proceed to completion. The increase in spot market liquidity

[29] Ordonez, I. (2011, April 8). DownstreamToday.com - US Oil Majors Highlight LNG's Link to High Oil Prices. *DownstreamToday.com - News and Information for the Downstream Oil and Gas Industry*.

[30] Asia's long-term LNG contracts to remain linked to oil: Santos VP - Natural Gas | Platts News Article & Story. (n.d.). *Energy Products & Services, Oil, Coal Insight, Natural Gas Shipping, Electric Power Methodology Analysis, Metals, Petrochemical, Reference - Platts.* http://www.platts.com/RSSFeedDetailedNews/RSSFeed/NaturalGas/8966402

[31] Mijuk, G. (2011, May 20). Shell CEO: LNG Prices To Depend On Oil Prices | Fox Business. *Fox Business | Business News & Stock Quotes - Saving & Investing.* http://www.foxbusiness.com/markets/2011/05/20/shell-ceo-lng-prices-depend-oil-prices/

will imply that a new LNG project may successfully move forward even if its entire capacity has not been contracted for long-term, but spot market deals are nearly not enough to support new investment. Thus, oil-indexed long-term contracts are likely to remain the norm in the Asia Pacific, and the most reliable way for customers to secure long-term LNG supply.

Nonetheless, the high levels of expected demand growth in Asian markets coupled with the volume inflexibility of long-term contracts will likely result in lumpy but large and highly variable spot market for LNG cargoes in Asia. With limited flexibility in its capability to store LNG at downstream locations the Asian market will likely experience periods during seasonally low demand when the spot price for LNG cargoes drops significantly lower than its long-term oil indexed value. The growing spot market may provide additional possibilities for Guam to buy opportunistically LNG cargoes during periods of seasonally low demand.

However, given the lack of predictability of Asian spot trade's liquidity, and price volatility, relying only on spot transactions may not be a feasible option, even for small quantities of LNG. As the experience of past few years show, global LNG supply and demand follow each other, but with a lag. Typically the market goes through cycles of excess demand and spot prices skyrocket, Asia pays a premium over other markets during such periods due to lack of alternative supplies. But then, there are also times when supply inventories exceed incremental demand, and thus producers are more willing to send their cargoes for a cheaper price to the relatively most expensive destination.

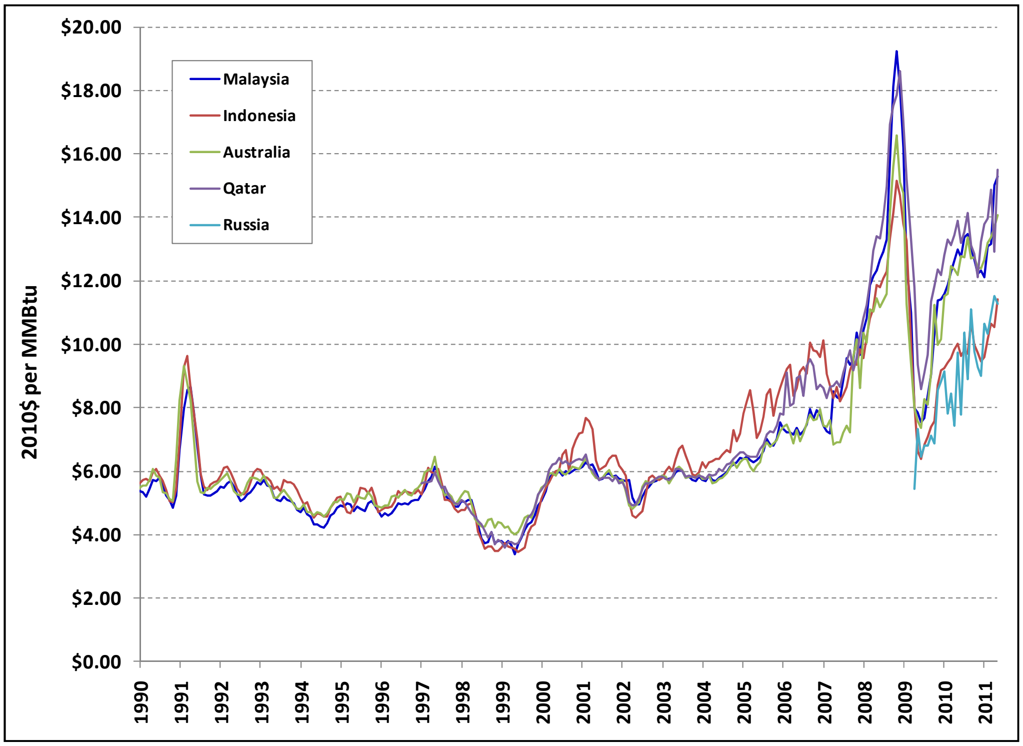
R.W. Beck's forecast for delivered LNG prices for Guam are based on expected prices for JCC, and its association with Japanese LNG import prices. The rationale for linking Guam LNG price to Japanese LNG prices is as follows:

- Marginal LNG production in the Pacific Basin market will come from expensive new liquefaction trains being developed in Australia.
- Due to the expense of these projects, virtually all of the new capacity created by the project will need to be secured through long-term contracts with importers. Project developers will have little appetite to assume the financial risks associated with un-contracted capacity. As a result, long-term supply and demand will remain in-balance.
- In the medium term, Japan will remain the apex consumer of LNG in the Pacific Rim market both in terms of volume and willingness to pay.
- In a balanced market environment, consumers in Guam will need to compete with Japanese prices in order to attract supplies.

Long-term contract LNG pricing in Japan is assumed to remain linked to oil prices through S-curve contract mechanisms.

- Contract mechanisms for LNG will likely adjust over time from historical levels as the outlook for future oil prices is significantly higher than historical oil prices. These adjustments do not represent a wide spread de-linking from the oil market for Pacific Basin LNG.

- Over the past six years Japanese LNG import prices have averaged $9.7732 per MMBtu while JCC crude has averaged $74.11 per bbl ($13.51 per MMBtu) resulting in a price ratio of LNG to Oil of 7.6. Forecast oil prices are expected to average $98.06 per bbl ($17.87 per MMBtu) while LNG is expect to average $12.16 per MMBtu resulting in a price ratio of 8.06.
- Recent import data indicates that prices for LNG imports have begun to ease from historical relationships (See Figure 8-11). Since 2009, import values of LNG sourced from Russia and Indonesia have exhibited a discount relative to cargoes from other major exporting countries.
- Guam LNG prices are estimated to be discounted to Japanese price levels by $0.30 per MMBtu based on the assumption that Guam can realize a transportation discount relative to Japanese consumers.



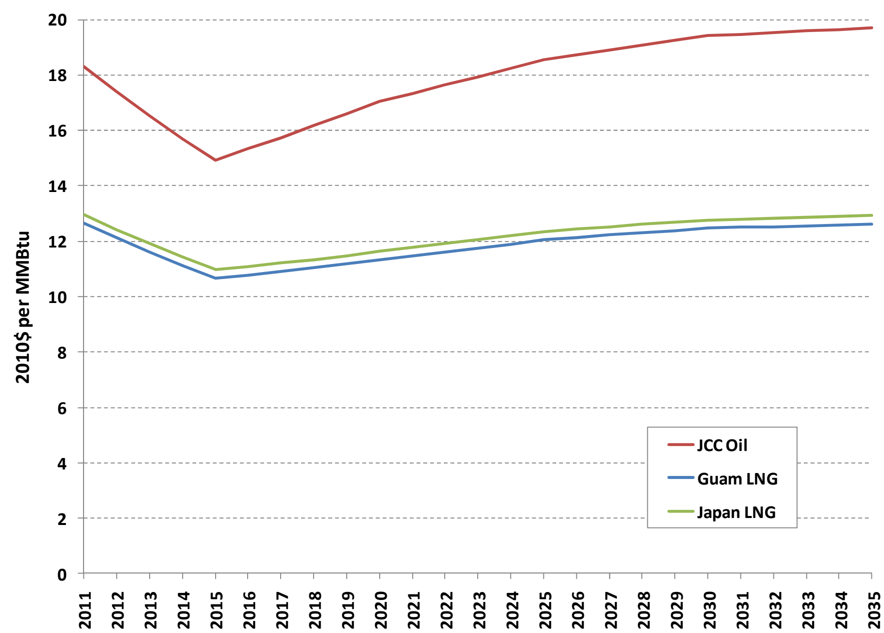
Source: Japanese Ministry of Finance

Figure 8-11: Japanese LNG Import Values by Major Exporter (2010$ per MMBtu)

R.W. Beck's forecast for delivered LNG price to Guam is presented in Figure 8-11. We note that in a tight market to attract the marginal cargo from Japan, Guam will have to pay LNG import prices comparable to Japanese import price, especially given the relatively small quantity of LNG demand expected at Guam. However, it might be possible to negotiate a price slightly lower than the Japanese import price, as we see for South Korea and Taiwan, depending on the negotiations between specific buyers and sellers. In 2010, average Japanese import price for LNG was about a $1 to

[32] Represents the volume-weighted price of imports of from major exporters to Japan such as Malaysia, Indonesia, Australia, Qatar, and Russia.

$1.5/MMBtu higher than that paid by South Korea and Taiwan.[33] However, even South Korea and Taiwan sign long term contracts indexed to JCC, although each contract differ in its oil-linkage formula both within and across countries. Japanese LNG import pricing is the most reliable, and widely cited public data source, and we feel comfortable linking our price forecast for Guam to Japanese import prices.



	JCC Oil Price	Japan LNG Price	Guam LNG Price
2005	56.38	7.21	-
2006	69.25	8.22	-
2007	72.77	8.75	-
2008	105.07	13.26	-
2009	61.63	9.57	-
2010	79.54	11.62	-
2011	100.52	12.95	12.65
2012	95.49	12.42	12.12
2013	90.72	11.91	11.61
2014	86.18	11.43	11.13
2015	81.88	10.97	10.67
2016	84.09	11.08	10.78
2017	86.37	11.21	10.91
2018	88.71	11.34	11.04
2019	91.11	11.48	11.18
2020	93.58	11.62	11.32
2021	95.16	11.76	11.46
2022	96.77	11.91	11.61
2023	98.40	12.05	11.75
2024	100.06	12.20	11.90
2025	101.75	12.35	12.05
2026	102.69	12.43	12.13
2027	103.65	12.52	12.22
2028	104.61	12.60	12.30
2029	105.58	12.69	12.39
2030	106.56	12.77	12.47
2031	106.87	12.80	12.50
2032	107.19	12.83	12.53
2033	107.51	12.86	12.56
2034	107.84	12.89	12.59
2035	108.16	12.92	12.62
Average	98.06	12.16	11.86

Source: R.W. Beck

Figure 8-12: R.W. Beck Forecast Guam Landed LNG Price (2010$ per MMBtu)

Figure 8-12 presents R.W. Beck's projection for landed LNG prices (excluding cost of re-gasification and any domestic transportation) that Guam will have to pay to attract reliable LNG supply over a long-term period. These values differ significantly from Guam's 2008 IRP projections of LNG commodity prices; the LNG market has evolved since the time of the 2008 IRP. For example, LNG prices were projected to be $5.92/MMBtu for Guam in 2010, whereas realized prices in the Pacific Basin have been almost double that value for that year. Our projections are based on the current market dynamics, and our expectation of future market directions. However, as we have noted all through our discussion, this is certainly not the only possible future outcome. The current state of global natural gas market was very different from what most experts predicted even a few years ago. Even the changes that have taken place in each individual markets like the US, Europe and Asia were in most part unexpected. Billions of dollars were invested in places like Qatar and Australia with strong expectations of rising prices that have been a disappointment to these producers in most part, so far. Numerous re-gasification terminals were set into motion in the US expecting substantial LNG imports; some of them are now applying to become LNG exporters. Some of the major risks to the price forecast presented above include the assumptions regarding future demand and supply balance, both globally and

[33] LNG One World, Drewry

regionally, future of oil price movements, and continued indexation on LNG to the oil products in the Asia Pacific region.

Factors that could cause LNG prices in Asia to de-link from crude oil include broad expansion of shale gas production in Europe and Asia leading to a global supply glut of natural gas as currently experienced in North America. Such a scenario could lead to more influence of Henry Hub and NBP prices in long-term LNG contracts and a large increase in the spot market for LNG. However, this is seen as unlikely as many proposed LNG liquefaction projects in the Pacific Basin are relatively expensive projects and would not be viable in a significantly lower gas price environment.

Keeping in mind the risks and uncertainty associated with many factors that can influence future LNG prices for Guam, R. W. Beck developed a High LNG Price Case and a Low LNG Price Case, in addition to the Base Case. Table 8-11 presents R.W. Beck's Base Case, High Case, and Low Case LNG delivered price projections for Guam. (Note: The prices are "CIF" to deliver the LNG to Guam but do not include the cost of regasification and any additional on-island pipeline transportation costs.) The Low Case reflects a scenario of amply LNG supply and reduced LNG prices relative to the prevailing oil prices. The High Case reflects a scenario where LNG supply is tight and LNG prices are higher compared to prevailing oil prices.

Table 8-10: R.W. Beck Forecasts of Landed LNG Prices for Guam (2010 $ per MMBtu)

Year	Base Case Guam LNG Landed Price	High Case Guam LNG Landed Price	Low Case Guam LNG Landed Price
2011	12.65	13.10	12.31
2012	12.12	12.89	11.39
2013	11.61	12.69	10.53
2014	11.13	12.48	9.74
2015	10.67	12.28	9.01
2016	10.78	12.61	9.25
2017	10.91	12.96	9.50
2018	11.04	13.31	9.76
2019	11.18	13.67	10.02
2020	11.32	14.04	10.29
2021	11.46	14.27	10.47
2022	11.61	14.51	10.64
2023	11.75	14.76	10.82
2024	11.90	15.01	11.01
2025	12.05	15.26	11.19
2026	12.13	15.40	11.30
2027	12.22	15.55	11.40
2028	12.30	15.69	11.51
2029	12.39	15.84	11.61
2030	12.47	15.98	11.72
2031	12.50	16.03	11.76
2032	12.53	16.08	11.79
2033	12.56	16.13	11.83
2034	12.59	16.18	11.86
2035	12.62	16.22	11.90

Source: R.W. Beck

LNG Contract Terms

The contractual cornerstone of LNG trade in the Pacific Basin and other markets is the LNG Sale and Purchase Agreement (SPA). The LNG SPA apportions the risks along the LNG value chain from upstream production and liquefaction to downstream regasification and distribution. The essential components of long-term or short-term LNG contracts are the quantity, price, duration, gas quality, and transportation responsibility (FOB, CIF or ex-ship).

Quantity

Long-term LNG contracts typically include an “annual contract quantity” (ACQ), which specifies the quantity of LNG that the buyer must purchase under a “take or pay" structure. This quantity is usually expressed in millions of British thermal units (MMBtu).

Most long-term contracts allow for the "buildup" of deliveries during the initial period of the contract. During the buildup period, delivered quantities are lower than the ACQ to allow the importing market to absorb and find buyers for the new supply and to accommodate potential delays in the completion of the liquefaction plant. These build up volumes are not subject to take-or-pay requirements. Once the buildup period has ended the ACQ remains constant over the duration of the contract but may be subject to some adjustments including:

- *Volume Flexibility Provisions:* these allow the buyer to reduce the ACQ obligation by a fixed amount, usually about 5%. Some contracts limit the number of adjustments or the aggregate adjustments that the buyer can make during the duration of the contract.
- *Round up/round down provisions:* these address uneven annual quantities due to LNG shipments that come before or after the actual turn of the contract year due to scheduling issues.
- *Excess quantity provisions:* these govern who has the rights to excess quantities from an LNG liquefaction plant that performs better than expected or when a buyer in a multiple buyer project reduces imports within its take-or-pay limits.
- *Make up quantity provisions:* these may occur when the LNG buyer is unable to take some or all of the take-or-pay portion of its ACQ. In this case, the LNG buyer must still pay the LNG seller a price (equal to or less than the contract price) for the untaken LNG. In return, the seller may be required to offer the buyer deliveries equivalent to the untaken volumes at a later date. In some cases, there may be a limit after which makeup quantities must be taken or forfeited.
- *Re-destination flexibility:* these may be provided to a buyer with a dedicated annual volume under a long-term contract in order to accommodate volume flexibility and make-up quantity provisions. However, such rerouting flexibility on a given LNG cargo is often limited to protect the seller from being forced into competition with itself at the alternate destination.

Price

In the major Pacific Basin LNG markets of Japan, Taiwan and Korea, LNG contracts are typically linked to JCC for pricing long-term LNG supply. JCC is the average price of all crude oil imports into Japan, as reported by Japanese Customs and published monthly by the Japanese government.

The typical formula for an indexed price that uses S-curve is as follows:

P (LNG, \$/MMBtu) = a + b* JCC (\$/bbl)

a: constant part or base price;

b: slope or coefficient.

Base price refers to a term that represents various non-oil factors which vary regardless of oil price fluctuations, but usually a constant determined by contract negotiation. Oil parity is the LNG price that would be equal to that of crude oil on a barrel of oil equivalent basis. A coefficient of 0.1724 results in full oil parity. In other words, at full oil parity, oil price on a per MMBtu basis equals the per MMBtu price of LNG, reflecting 100% oil indexation.

As we discussed earlier, an S-curve balances the buyer's risk from high prices (reduces the effective LNG price at high oil prices) with that of seller's loss from very low oil prices (creating a price floor for LNG). Although Pacific Basin contracts are linked to crude oil, the linkage varies from contract to contract and has evolved over time. While specific terms of LNG contracts are closely guarded and kept confidential, the general pricing structures are fairly well detailed through industry sources.

- 1986 - 2000

  Prior to 2000, the contract structure provided buyers protection above \$40 (\$/Barrel for crude oil) and sellers below \$20 (\$/Barrel for crude oil).

  A typical pricing formula used between 1986-2000 was: P (LNG) = 0.1485*JCC + 0.7 to 0.9. US LNG export contracts from Alaska to Japan were typically based on this structure. These contracts with indexation values between 0.1485 - 0.1558 represent about 86% - 92% of the Btu parity price of crude oil.

- 2001-2003

  In early 2002, some long-term contracts were written in the Pacific Basin, known as Guangdong pricing, where the coefficient b, was 0.0525. For example, a few Australia supply contracts to serve China's Guangdong LNG import terminal were written as, P (LNG) = 0.0525*JCC + 1.55. This pricing reflected the competition from coal in the Chinese target market. This represented about 30% of the Btu parity price of crude oil. This relatively low price for LNG in the Asian market turned out to be short-lived.

- 2005-present

  In the mid-2000s, gas demand rose along with oil prices, granting suppliers more negotiating leverage. By 2008, oil indexation in the Pacific Basin had returned to approximately 90% of the Btu parity price of crude oil.

  Today's market still maintains a high degree of oil linkage. Asia Pacific LNG prices are predominantly based on formula that provide for 11%-15% of the oil prices in dollars per barrel. There appears to be less use of S-curve formula and more direct linkage of the LNG price to Asian oil prices. Recent deals are understood to have been priced at 14.85% JCC, with additional supply currently being negotiated at the same level. Qatar is now also understood to be willing to accept 14.85% JCC as a price from 'established" Asian buyers although Qatar representatives have discussed they believe LNG should be obtaining even higher prices closer to parity with crude oil on a Btu basis.[34]

A driver for the recent strength in Asian LNG prices which appears to be reflected in the current negotiations for long-term contracts is the Fukushima disaster and resulting shutdown of Japan's nuclear power generation fleet and ongoing uncertainty regarding the timing and level of restarts of these nuclear units. If Japan moves away from reliance on nuclear power its LNG import requirements will surge placing significant pressure on global LNG supply. As a result, LNG suppliers currently feel they have significant negotiating leverage.

Duration

Traditionally LNG contracts have had durations of 20 years or longer in order to give the LNG buyer security of supply and to give the LNG seller a stable cash flow that allows an appropriate return on investment and can secure long-term financing.

Security of supply is particularly important for Far East Asian LNG importers, such as Japan, Korea, and Taiwan that have scarce indigenous resources and are highly dependent on imported fuel. While average contract durations in the Atlantic Basin have shortened in recent years, Pacific markets are expected to continue contracting LNG on a long-term basis. The primary term of the contract will exclude any buildup period, which is treated separately. Often, provisions are included that allow duration of the SPA to be extended for a certain period (e.g. 5 years) by either the buyer or seller. This extension may be on the same terms as in the initial term of the contract, or may allow limited reopening of essential commercial terms (price or quantity).

Gas Quality

LNG SPAs specify a range of acceptable gas quality (gross calorific value and/or Wobbe Index limits). Contracts typically give the LNG buyer the right to reject a cargo of off-quality LNG, but this right is rarely exercised. Instead, contracts may include provisions that mandate that the seller reimburse the buyer for the costs of treating the LNG to bring it into the specified gas quality range. Traditional Pacific Basin regasification markets such as Japan, South Korea, and Taiwan require rich LNG streams (i.e. with high energy content). Some major LNG sellers are now modifying their LNG liquefaction plants to produce differentiated streams of LNG to enable them to customize LNG blends for different markets.

Transportation

LNG SPAs specify the party responsible for arranging for the delivery of the ACQ. Most SPAs specify delivery on an "ex-ship" or "CIF" (Cost, Insurance, and Freight)

[34] Cheniere Sabine Pass related analysis; Wood Mackenzie study for Alaska Gasline Port Authority (July 2011); Tudor Pickering Holt & Co; Gas Strategies; KOGAS

basis meaning that the seller has responsibility for transporting LNG volumes form the liquefaction plant to the buyer's import terminal.

Delivery on an "FOB" (Free on Board) basis, on the other hand, gives shipping responsibility to the buyer.

Under an ex-ship or CIF contract, the buyer is responsible for providing a safe port at the LNG import terminal at which LNG carriers can enter and exit under all normal conditions. The seller is required to ensure that the LNG carriers used are compatible with this berth, have up-to-date measurement equipment, are of the proper size, and satisfy the operating and quality standards specified in the SPA.

Other

Other terms and conditions that apply to long-term LNG contracts have much in common with contracts in other markets. Such terms relate to cargo scheduling, invoicing and payment, LNG quantity measurement, title transfer, force majeure conditions, dispute resolution, and events of default, including the allocation of liabilities, liquidated or stipulated damages, early termination damages, and choice of law.

Section 9
OTHER LOCAL MARKETS FOR LNG

As part of our analysis, we examined other potential uses for LNG on Guam, besides GPA's generation of power.

In addition to evaluating GPA's potential LNG usage for power generation, R. W. Beck evaluated other potential LNG consumers on Guam. We believe the most likely potential consumers are the Navy, government fleet vehicles, and commercial vehicles.

Civilian Usage

It is expected that LNG, if used for anything outside electric power generation, would most commonly be used as a means of fuel diversification for fleet vehicles, be they government-owned or commercial.

Natural Gas Vehicles (NGVs) operate in one of three modes: dedicated, bifuel, or dual-fuel. For the purposes of this assessment, we are looking at primarily dedicated NGVs which run on only natural gas.

A compressed natural gas (CNG) fuel system transfers high-pressure natural gas from the storage tank to the engine while reducing the pressure of the gas to the operating pressure of the engine's fuel-management system. The natural gas is injected into the engine intake air the same way gasoline is injected into a gasoline-fueled engine. The engine functions the same way as a gasoline engine: the fuel-air mixture is compressed and ignited by a spark plug and the expanding gases produce rotational forces that propel the vehicle. On the vehicle, natural gas is stored in tanks as CNG, or in some heavy-duty vehicles, as LNG, a more expensive option. The form chosen is often dependent on the range a driver needs. More natural gas can be stored in the tanks as LNG than as CNG[35].

Although natural gas vehicles are similar to gasoline or diesel vehicles with regard to power, acceleration, and cruising speed, the driving range of NGVs is generally less. This is because with natural gas, less overall energy content can be stored in the same size tank as the more energy-dense gasoline or diesel fuels. However, extra natural gas storage tanks or the use of cryogenic LNG tanks can help increase range for larger vehicles[36].

NGVs can produce significantly lower carbon monoxide, nitrogen oxide, nonmethane hydrocarbon, particulate matter, and other toxic emissions, as well as greenhouse gas

[35] U.S. Department of Energy: Energy Efficiency & Renewable Energy. (04/2010). *Vehicle Technologies Program: Natural Gas Basics*. Retrieved July 17, 2011, from www.afdc.energy.gov/afdc/pdfs.

[36] U.S. Department of Energy: Energy Efficiency & Renewable Energy. (04/2010). *Vehicle Technologies Program: Natural Gas Basics*. Retrieved July 17, 2011, from www.afdc.energy.gov/afdc/pdfs.

emissions than their gasoline and diesel counterparts. Also, because CNG fuel systems are completely sealed, CNG vehicles produce no evaporative emissions[37].

Conversion Process

While there are a number of non-certified CNG systems available, certification of most newer model year vehicles is legally required by EPA and in California, the CARB (California Air Resources Board). A limited number of vehicles are currently certified for CNG conversion and each conversion must meet stringent EPA requirements. Installation of an engine conversion package and fuelling system may be done after the vehicle has been in service or when the vehicle is first purchased. EPA and CARB require that small vehicle manufacturers (SVMs) provide appropriate documentation and training to installers of their systems, commonly referred to as "qualified system retrofitters" (QSR).

Installation by a non-qualified installer could damage the retrofit equipment or the engine (or both), compromise vehicle performance, or render the vehicle unsafe to operate. EPA- or CARB-certified engine conversion systems are not sold to untrained/unapproved installers. Some SVMs prefer to install their systems themselves at their corporate facilities while other SVMs choose not to install their own equipment – opting instead to sell their systems only through QSRs. Typically, the QSR is responsible for obtaining the fuel storage system components (cylinders, high-pressure tubing, pressure release device (PRD), brackets, protective plates, etc.) and installing these components in accordance with the National Fire Protection Association's (NFPA) Vehicular Fuel Systems Code (NFPA 52).

A Certificate of Conformity (certificate) from EPA or an Executive Order (EO) from CARB applies to a specific engine family. To obtain a Certificate or EO, the retrofit system manufacturer (SVMs) must submit substantial emissions performance data and related documentation to EPA and/or CARB for review. Additionally, new converters may be asked to submit a converted vehicle for rigorous testing to verify this data. This testing assures that the retrofitted vehicle meets the same stringent emissions requirements of the original equipment manufacturers (OEM). The testing also ensures that the retrofit system works seamlessly with the OEM's on-board diagnostics system.

Non-certified systems usually do not meet this important criterion and may fail state or local emissions tests. The process of engineering, manufacturing, installing, pre-testing and then submitting a proposed retrofit system to an EPA and or CARB approved laboratory for certification is a time-consuming and expensive process that may cost as much as $200,000 or more per engine family. SVMs recoup this R&D investment by amortizing the cost across the expected sales volume, adding it to the price they charge for the various conversion kits.

Cost of Conversion

The cost of converting a gasoline vehicle to run on natural gas typically includes the SVM's retrofit system, fuel tanks and related tubing/brackets, and the installation. The

[37] www.afdc.energy.gov

amount of fuel capacity requested by the customer (and thus the number, type, dimensions and configuration of the fuel tanks) significantly impacts cost since CNG cylinders are relatively expensive. Natural Gas Vehicles for America (NGVAmerica), a national organization dedicated to the development of a growing, sustainable and profitable market for vehicles powered by natural gas or hydrogen, estimates that the cost of conversion ranges from $12,000 to $18,000 per vehicle[38].

Due to the high cost and technical complexity of converting gasoline vehicles to CNG, we do not recommend that GPA rely on the conversion of Guam's government fleet, public transportation fleet, or civilian owned vehicles from gasoline to CNG to bolster LNG demand. There are relatively few vehicles that would be eligible for conversion on Guam and the choice to convert those vehicles would require a high upfront cost with insufficient payback over the vehicle's life.

Navy Usage

Representatives of GPA and the study team met with Jack Brown, Utilities & Energy Manager for NAVFAC[39] Marianas, to discuss the goal of this study and to elicit the Navy's thoughts on how it may be able to use natural gas on Guam. The information provided does not imply commitment by the Navy to use natural gas on Guam; each potential use described would have to be evaluated on its own economic merits. The following represent potential options identified for usage of natural gas:

- The Navy maintains a fleet of 950 vehicles. Approximately 700 of these are light trucks and sedans; these vehicles could be converted to operate with compressed natural gas.
- The Navy maintains a significant amount of housing stock in barrack structures and residential units. It is possible that some of the heating and cooling related loads could be converted to natural gas.
- The Navy maintains steam plants to support its hospital and certain naval vessels. The largest steam plant uses an average of 36,000 MMBtu per year. It is possible that the boilers could use natural gas as a fuel source.
- The Navy maintains the Orote power plant for backup electricity should GPA be unable to supply electricity. Switching this plant from fuel oil to natural gas would require a significant investment and would likely not be an economic choice because of its low annual production.

Usage on Other Islands

The United States Commonwealth of the Northern Mariana Islands (CNMI) is completely dependent on fossil fuels to meet its energy supply needs, with the exception of a few small renewable energy projects. Saipan, the largest island of the CNMI, has a total of 31 villages as well as multiple sub-areas and neighborhoods with

[38] http://www.ngvamerica.org/pdfs/FAQs_Converting_to_NGVs.pdf
[39] Naval Facilities Engineering Command

an estimated island-wide population of 48,317 people. Located approximately 120 miles (190 kilometers) north of Guam, Saipan is a popular tourist destination in the Pacific. In years past, the main economic driving force in Saipan was garment manufacturing, driven largely by foreign contract workers (mainly from China). In addition to many foreign-owned and run companies, many well-known U.S. brands also operated garment factories in Saipan for much of the last three decades. However, there are not currently any garment manufacturers on the island, with the last one having closed on January 15, 2009, [40] and tourism has become the island's primary source of revenue. Despite being a popular tourist destination, Saipan's economic outlook remains bleak. Saipan, as well as the rest of the islands in the CMNI, does not produce or consume natural gas.[41] As such, there is no infrastructure for natural gas. The CNMI uses fossil fuels for electricity production, transportation, and space cooling, water heating, and self-generation by the commercial sector[42]. In 2010, the Commonwealth Utilities Corporation (CUC) imported a total of 554,811 barrels of diesel fuel for power generation[43] or an average of 1,520 barrels per day.

American Samoa is located within the geographical region of Oceania, south of Guam, with an estimated population of 55,519 people. The primary sources of employment are the public sector, the single remaining tuna cannery, and the rest of the private sector. American Samoa does not currently produce or consume natural gas and has an estimated consumption of 4,400 (2010 estimate)[44] barrels of petroleum per day. Like Guam, American Samoa uses fuel oil products for the generation of electricity.

The Independent State of Samoa (formerly Western Samoa), is also located within the geographical region of Oceania and sits roughly halfway between Hawaiʻi and New Zealand. The population was estimated to be approximately 193,161 in July 2011[45]. The total land area is 2,934 km² (1,133 sq mi) (slightly smaller than the U.S. state of Rhode Island), consisting of the two large islands of Upolu and Savai'i which account for 99% of the total land area, and eight small islets. Although the population is estimated to be more than twice of that of its neighbor, American Samoa, the Independent State of Samoa consumes substantially less petroleum with an estimated consumption of 1,000 barrel per day (2010 estimate).[46] Like Guam, Samoa uses fuel oil products for the generation of electricity.

If an LNG regasification facility is constructed on Guam, it may be possible to use the

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[40] Eugenio, H. V. (n.d.). Saipan Tribune. Saipan Tribune. Retrieved September 30, 2011, from http://www.saipantribune.com/newsstory.aspx?newsID=105838&cat=1

[41] Northern Mariana Islands - Ap - U.S. Energy Information Administration (EIA). (n.d.). U.S. Energy Information Administration (EIA). Retrieved September 30, 2011, from http://www.eia.gov/state/territory-energy-profiles-analysis.cfm?sid=CQ

[42] United States. Dept. of Energy. National Renewable Energy Laboratory. *Commonwealth of the Northern Mariana Islands Initial Technical Assessment Report*. By Ian Baring-Gould, Randolph Hunsberger, Charles Visser, and Philip Voss. July 2011. Web. 2 November 2011.

[43] United States. Dept. of Energy. National Renewable Energy Laboratory. *Commonwealth of the Northern Mariana Islands Initial Technical Assessment Report*. By Ian Baring-Gould, Randolph Hunsberger, Charles Visser, and Philip Voss. July 2011. Web. 2 November 2011.

[44] Australia-Oceania: Samoa. (n.d.). *CIA - The World Factbook*. Retrieved October 4, 2011, from https://www.cia.gov/library/publications/the-world-factbook/geos/ap.html

[45] Australia-Oceania: Samoa. (n.d.). *CIA - The World Factbook*. Retrieved October 4, 2011, from https://www.cia.gov/library/publications/the-world-factbook/geos/ws.html

[46] Australia-Oceania: Samoa. (n.d.). *CIA - The World Factbook*. Retrieved October 4, 2011, from https://www.cia.gov/library/publications/the-world-factbook/geos/ws.html

new facility as a part of a distribution system for the delivery of containerized LNG or natural gas transport to the nearby islands. No analysis has been undertaken in this study to determine the method or economics of such an approach.

While these and other islands may have a future need for natural gas, R. W. Beck believes that the economic feasibility of GPA using natural gas for generation and its decisions to pursue the development of LNG should be based solely on GPA usage, and not rely on the possible demand of outside users as part of its decision making.

Section 10
LNG FEASIBILITY MODEL

The cost estimates and changes in generation unit performance discussed in the earlier sections of this report were used to develop an Excel-based spreadsheet model to evaluate the financial feasibility of building an LNG terminal and associated infrastructure and converting certain of GPA's plants to LNG. The financial results were also dependent on incorporating changes related to EPA's MACT costs post LNG conversion, the impact of the construction schedules, various financial assumptions, and other related data. The simplified LNG Feasibility Model (the model) allows GPA to easily evaluate a number of generation conversion scenarios, fuel price scenarios, construction scenarios, and to clearly illustrate how costs differ between the "status quo" scenario which assumes GPA continues to fuel with oil its generation units under their existing configuration vs. a "post conversion" scenario where GPA imports LNG and converts a portion of its generation units to be fueled with natural gas. The approach and assumptions used in developing the model along with the results are outlined in this section.

Approach

The model is designed to help users assess the change in GPA's annual debt service costs, operating and maintenance costs, fuel costs, and emissions costs resulting from the building of the LNG terminal, storage, and pipeline facilities; the conversion of the units; as well as evaluating the change in EPA MACT mitigation costs under the status quo and post conversion scenarios. The model, while rather detailed, is not extraordinarily complicated. As such, it makes some simplifying assumptions and it is designed merely to illustrate the difference between the status quo and post conversion scenarios, meaning it is not designed to capture all of GPA's costs. Specifically, it does not track those costs which are assumed not to change between the scenarios, such as the fuel and operating costs of units that are not being considered for conversion.

Four generating unit conversion scenarios were developed to evaluate the overall costs of converting certain generating units to LNG as shown in Table 10-1. The basis for the selection of these scenarios included the units with the highest historical production levels, units that the military will fund to refurbish, and input from GPA management and staff.

Table 10-1: Generating Units Converted in Each Scenario

Scenario 1	Scenario 2	Scenario 3	Scenario 4
Cabras 1 & 2	Cabras 1 & 2	Cabras 1 & 2	Cabras 1 & 2
Cabras 3& 4	Cabras 3& 4	Cabras 3& 4	Cabras 3& 4
TEMES (Piti 7)	TEMES (Piti 7)	TEMES (Piti 7)	TEMES (Piti 7)
MEC (Piti 8 & 9)	MEC (Piti 8 & 9)	MEC (Piti 8 & 9)	MEC (Piti 8 & 9)
	Tanguisson 1 & 2	Tanguisson 1 & 2	Tanguisson 1 & 2
		Tenjo Vista	Tenjo Vista
			Dededo CT 1 & 2
			Yigo CT
			Macheche CT

Other than the difference in units converted, the other underlying cost and performance assumptions for each of the scenarios were exactly the same. The long-term total cost projections were developed for FYs 2016-2045 (the study period). These projections factored in capital costs, construction schedules, generator and LNG O&M costs, generator production, generator efficiency and fuel consumption, fuel price forecasts, generator and terminal operating and maintenance expenses, EPA costs associated with reducing mercury emissions, and debt service.

Although the model was developed to evaluate the costs at a high level, it is also designed to model sensitivities associated with multiple variables such as various fuel forecasts (Base, Low, and High), inclusion or exclusion of the EPA costs, the start of construction, and so forth. However, it is not a dispatch model and does not forecast changes in generating unit dispatch based on the conversion or load growth.

Assumptions

Various assumptions were made in developing the model. In general terms, the principal assumptions used in developing the projections are as follows.

Plant Operating Data

The generating unit performance under the existing configurations and post conversion configurations are discussed in Section 7. This includes information on each unit's capacity, heat rates, planned maintenance rates, equivalent forced outages, fuel usage, etc. The performance of each unit under the existing and post conversion configurations and the impacts on the overall operating costs were incorporated into the model.

The annual production for each unit (MWh) used in the model is based on average historical production data from FYs 2007-2010 as shown in Table 10-2. The total production levels are assumed to remain unchanged over the study period and between the existing and post conversion configuration. However, each generation unit will have a slight decline in capacity post-conversion. To keep the amount of energy produced annually constant between the status quo and post conversion scenarios, it was assumed that the most inexpensive units to operate, Cabras 3 & 4, would increase their generation slightly to make up for the decrease in generation of the other units. This means that for all units other than Cabras 3 & 4, capacity factors remain the same between the scenarios and from the beginning to the end of the study period. Cabras 3 & 4 show a slight increase in capacity factor between the existing configuration scenarios and the post conversion scenarios, but the increase is no more than 2 percent.

Table 10-2: Average Historical Production by Unit, FYs 2007-2010 (MWh)

Generating Units	Average Production
MEC (Piti 8 & 9)	601,235
Cabras 1 & 2	577,832
Cabras 3 & 4	472,770
Tanguisson 1 & 2	167,276
TEMES (Piti 7)	20,546
Tenjo Vista	16,759
Macheche CT	2,907
Dededo CT 1	1,845
Yigo CT	360
Dededo CT 2	19
Total	1,861,550

Fuel Forecast

Fuel forecasts for three types of fuel were incorporated into the model: RFO or high sulfur fuel oil (HSFO), Number 2 diesel distillate or heating oil (HO), and LNG. Section 9 of this report includes fuel forecasts for these three fuel types. The HSFO and HO forecasts are shown in Table 8-6, and the LNG forecast is provided in Table 8-10. These costs were escalated from 2010 to 2011 dollars and then into nominal dollars in the model assuming an annual inflation rate of 2.4 percent. Each of these forecasts is shown with a base case, low case and a high case. All three cases for each fuel type were incorporated into the model to assess the sensitivities of the fuel on the feasibility of converting to LNG fuel. The average fuel costs in FYs 2016-2045 are shown in Table 10-3.

Table 10-3: Average Fuel Costs, FYs 2016-2045

	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Total MWh	1,672,384	1,839,660	1,856,419	1,861,550
Existing Configuration ($/MWh)				
Base Case	$264.90	$274.30	$275.12	$275.65
Low Case	$174.33	$180.51	$181.09	$181.45
High Case	$523.18	$541.76	$543.27	$544.28
Post LNG Conversion ($/MWh)				
Base Case	$200.46	$207.76	$207.53	$207.59
Low Case	$187.40	$194.22	$194.01	$194.06
High Case	$255.36	$264.66	$264.37	$264.44

Capital Expenditures

Earlier sections of the report detail the capital costs associated with the construction of the LNG terminal at the rock quarry site, the pipeline costs from the terminal to distant generating units and the costs for converting existing generating plants to use LNG as a fuel source. All of the capital costs have been modeled to reflect an annual inflation rate of 2.4 percent and a monthly interest rate of 0.5 percent to account for interest during construction.

The capital costs for the LNG terminal at the rock quarry site are estimated to be approximately $207 million (2011$), which is shown in Table 3-2 in Section 3. These costs have been modeled to reflect inflation and interest accrued during construction, which increases the expenditures for the terminal capital costs to $244 million from start to completion of construction. The phases of the terminal, storage, and pipeline construction schedule are provided in Section 6, which is anticipated to occur over a 50-month duration.

Relatively long pipelines will also be required to transport the natural gas from the LNG terminal to the generating units in Scenarios 2-4. It was assumed that the pipeline would cost approximately $240 per linear foot (2011$). The capital costs to install the pipelines to each generating unit are provided in Section 3. Assuming inflation and interest during construction are included, the total pipeline costs are shown in Table 10-4. The pipeline costs for the Cabras and Piti generating units was included in the LNG terminal capital costs. It was assumed that the pipelines would be constructed over a 12-month period and would be completed when the terminal commences operation in April 2016.

Section 7 outlines the capital costs associated with converting the generating units to use natural gas. These costs were also escalated with inflation and include accrued interest during construction in the model. The total capital costs in nominal dollars are shown in Table 10-4. The construction schedule for each of these units varies from 39 months to 48 months.

Table 10-4: Total Capital Costs (Millions of $)

	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Existing Configuration	$0	$0	$0	$0
Post LNG Conversion				
Terminal – Rock Quarry Site	$243	$243	$243	$243
Pipeline to Distant Generating Units	0	24	29	38
Generating Unit Conversion	92	108	115	121
Total Post Conversion	$335	$375	$387	$402

It is assumed that LNG project will commence in February 2012, and the terminal, storage, pipeline and unit conversions will be operational April 1, 2016.

Emission Costs

Annual Air Pollutant Emission Costs

Air pollutant emission costs were also included in the overall operating costs. The emission testing results under the existing configurations were provided by GPA and estimates for emission levels under the post LNG configuration were determined and incorporated into the model. GPA is required to pay $6.00 per ton per pollutant base rate, with a minimum of $500 per annual fee per their permits. Emissions modeled included nitrous oxides (NOx), carbon monoxide (CO), sulfur dioxide (SO_2), volatile organic compounds (VOC), and particulate matter (PM).

EPA EGU MACT Costs

The U. S. Environmental Protection Agency (EPA) proposed regulations to reduce mercury emissions through the use of electric generating unit maximum achievable control technology (EGU MACT). The capital and operating costs associated with these regulations have been developed by GPA staff and incorporated into the model for optional inclusion.

The capital costs required to comply with these regulations include costs for installing electrostatic precipitators and dry sorbent injectors. The capital cost assumptions used in the model are based on unit cost data provided in a letter written by Governor Edward J. B. Calvo to the EPA in August 2011 requesting a re-evaluation of these regulations[47]. The EPA used these unit costs in its Regulatory Impact Analysis for MACT, which were cited from average cost data provided by the Edison Electric Institute. The unit costs used in the model are $153 per kilowatt for the electrostatic precipitators for a 25 megawatt sized generating unit and $42.35 per kilowatt for the dry sorbent injection controls. The electrostatic precipitators are retrofitted to oil fired generation units that vary in size, and the unit cost for the next generation unit size of

[47] Calvo, Edward J.B. "Docket ID Nos. EPA-HQ-OAR-2009-0234; EPA-HQ-OAR-2011-0044." Letter to Honorable Lisa P. Jackson, U.S. Environmental Protection Agency. 4 Aug. 2011. Office of the Governor of Guam, Adelup, Guam.

100 megawatts is $143 per kilowatt. GPA assumed a 35 percent construction cost escalator applied to these unit costs to account for the cost differential between the mainland and Guam, which was factored into the assumptions used in the model. These capital costs were assumed to be fully financed. The debt service assumptions are discussed later in this section.

The operating costs were also provided by GPA in the letter written by the Governor. It was estimated that the annual unit cost would be $6.70 per kilowatt to cover the maintenance of the fabric filters and operating and maintenance costs associated with the dry sorbent injection controls, which is mostly related to the electricity required to run these controls.

Parasitic losses associated with the MACT equipment were also factored into the emissions related costs. It was assumed that the parasitic losses due to the MACT equipment usage are three percent.

These costs were modeled to begin concurrently with the timing of the terminal and plant conversion in service dates.

Debt Service

Table 10-5 shows projected annual debt service payments. The capital costs, including the EPA MACT capital costs, have been modeled to be fully financed through a revenue bond issuance. The terms of the bond reflect those of the 2010 Senior Revenue Bonds, which assume a 6 percent interest rate, and a 30 year term. A 3.83 percent original issuance discount (cost of issuance) was included. The amount of interest accrued during construction was included in the total amount financed for the LNG conversion, terminal and pipeline capital costs. It was assumed that this interest rate during construction would be equal to the bond issuance rate.

Table 10-5: Annual Debt Service (Millions of $)

	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Existing Configuration				
EPA MACT Capital Costs (1)	$7.5	$7.5	$7.5	$7.5
Post LNG Conversion				
LNG Conversion, Terminal and Pipeline Capital Costs	$25.3	$28.2	$29.2	$30.3
EPA MACT Capital Costs (2)	0.9	0.0	0.0	0.0
Total Post Conversion	$26.2	$28.2	$29.2	$30.3

Note:
(1) Scenario 1 only includes Cabras 1 & 2, Cabras 3 & 4, TEMES (Piti 7) and MEC (Piti 8 & 9) to reflect the units that will be converted to LNG.
(2) Scenario 1 only includes Tanguisson 1 & 2, since this unit will not convert to LNG under this scenario.

Operating Costs

The operating costs for the terminal, storage, and pipeline are provided in Table 3-1 in Section 3. The fixed operating costs for the terminal, storage, and pipeline are escalated at an annual inflation rate of 2.4 percent. The terminal, storage, and pipeline variable operating costs, power cost, and other variable costs are also escalated with inflation. The fuel costs associated with the LNG terminal were projected using the

R. W. Beck LNG fuel forecast. The Port of Guam fees for importation of LNG are estimated to be $ 0.064 per MMBtu, growing at inflation, based on GPA's average FY 2010 MMBtu per barrel of oil and a port fee of $0.40 per barrel. It was assumed that the power and fuel requirements for the terminal would remain unchanged over the projection period. The first full year of terminal operating expenses is modeled for FY 2017, and the costs in this year are approximately $15 million for all four scenarios.

The operations and maintenance costs for the generating units were included in the model for the existing configuration and modified to reflect costs under the post LNG conversion as discussed in Section 7. These operating and maintenance costs are escalated at an annual inflation rate of 2.4 percent. The average unit costs for both configurations over the study period are shown in Table 10-6.

Table 10-6: Average Generating Unit Operating and Maintenance Costs, FYs 2016-2045

	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Total MWh	1,672,384	1,839,660	1,856,419	1,861,550
Existing Configuration ($/MWh)	$30.22	$30.50	$31.62	$32.52
Post LNG Conversion ($/MWh)	$29.55	$29.82	$30.50	$31.35

Results

Table 10-7 shows the results of the four scenarios under the Base Case fuel prices. The average costs in $ per MWh for each of the scenarios are provided to illustrate the primary cost drivers and how they change. The net present values shown are for 30 years of total costs as of 2016, which include all of the corresponding costs shown under the average unit costs. Under the Base Case fuel prices, each scenario shows total costs are lower post LNG conversion, meaning the savings attributable to the difference in fuel prices and lower EPA MACT mitigation costs are greater than the increase in costs due to debt service on the capital costs, reductions in unit capacity, and decreases in efficiency. Figure 10-1 shows the difference in cost for Scenario 4, which shows the greatest saving post conversion of any of the scenarios using Base Case Fuel prices.

Table 10-7: Base Case Fuel Results Summary, FYs 2016-2045

	Scenario 1		Scenario 2		Scenario 3		Scenario 4	
	Existing	Post LNG	Existing	Post LNG	Existing	Post LNG	Existing	Post LNG
Average Unit Costs								
Converted Plant Production (MWh)	1,672,384	1,672,384	1,839,660	1,839,660	1,856,419	1,856,419	1,861,550	1,861,550
Generating Unit O&M Costs ($/MWh)	$30.22	$29.55	$30.50	$29.82	$31.62	$30.50	$32.52	$31.35
LNG Facility O&M Costs ($)	n/a	$12.90	n/a	$11.86	n/a	$11.76	n/a	$11.73
Emission Costs ($/MWh)	$7.11	$0.97	$6.48	$0.06	$6.42	$0.06	$6.40	$0.06
Debt Service ($/MWh) (1)	n/a	$15.37	n/a	$15.60	n/a	$15.99	n/a	$16.57
Fuel Cost, Base Case ($/MWh)	$273.89	$201.55	$282.47	$207.76	$283.21	$207.53	$283.72	$207.59
Total Costs ($/MWh)	$311.22	$260.35	$319.44	$265.09	$321.25	$265.83	$322.64	$267.30
Average Daily Fuel Usage (MMBtu)	43,818	44,578	49,959	50,822	50,356	51,229	50,512	51,384
NPV 30 Yrs.Total Costs (Millions of $, in 2016)	$6,115	$5,191	$6,902	$5,812	$7,005	$5,883	$7,055	$5,933
NPV of Costs/(Savings) of LNG Conversion (Million of $)		($924)		($1,090)		($1,122)		($1,121)
Ratio of Post LNG to Existing Configuration Total Costs		85%		84%		84%		84%

Note: (1) Includes terminal, storage, pipeline and unit conversion capital costs.

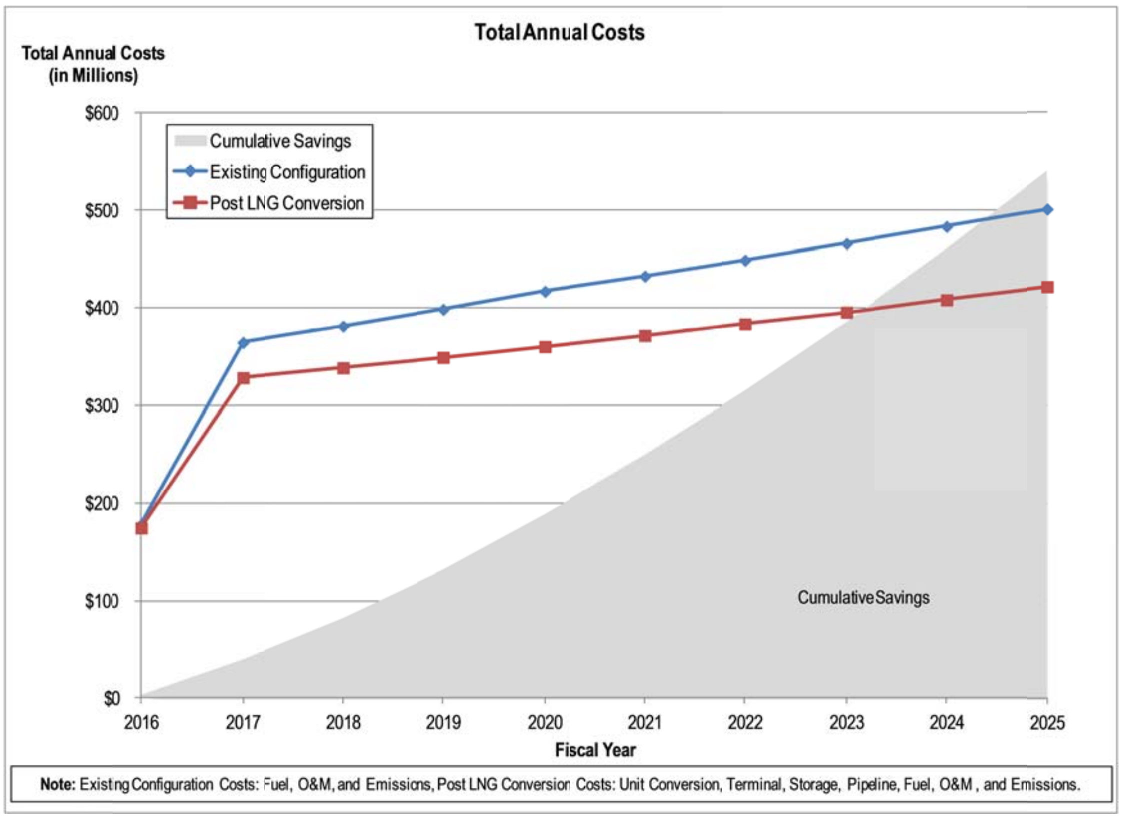


Figure 10-1: Scenario 4 Total Annual Costs, Existing Configuration vs. Post LNG Conversion

Tables 10-8 and 10-9 show the same information as Table 10-7 for the Low and High fuel price scenarios, respectively. The financial results under the Low Case fuel forecast indicate conversion to LNG would be difficult. This is because there is simply not enough of a fuel cost savings between oil and LNG to warrant the capital cost investment under the low price scenario.

Table 10-8: Low Case Fuel Results Summary, FYs 2016-2045

	Scenario 1		Scenario 2		Scenario 3		Scenario 4	
	Existing	Post LNG	Existing	Post LNG	Existing	Post LNG	Existing	Post LNG
Average Unit Costs								
Converted Plant Production (MWh)	1,672,384	1,672,384	1,839,660	1,839,660	1,856,419	1,856,419	1,861,550	1,861,550
Generating Unit O&M Costs ($/MWh)	$30.22	$29.55	$30.50	$29.82	$31.62	$30.50	$32.52	$31.35
LNG Facility O&M Costs ($)	n/a	$12.64	n/a	$11.62	n/a	$11.53	n/a	$11.50
Emission Costs ($/MWh)	$7.11	$0.97	$6.48	$0.06	$6.42	$0.06	$6.40	$0.06
Debt Service ($/MWh) (1)	n/a	$15.37	n/a	$15.60	n/a	$15.99	n/a	$16.57
Fuel Cost, Low Case ($/MWh)	$180.24	$188.12	$185.88	$194.22	$186.41	$194.01	$186.76	$194.06
Total Costs ($/MWh)	$217.58	$246.65	$222.86	$251.32	$224.45	$252.08	$225.68	$253.54
Average Daily Fuel Usage (MMBtu)	43,818	44,578	49,959	50,822	50,356	51,229	50,512	51,384
NPV 30 Yrs.Total Costs (Millions of $, in 2016)	$4,411	$4,886	$4,968	$5,473	$5,049	$5,541	$5,090	$5,590
NPV of Costs/(Savings) of LNG Conversion (Million of $)		$476		$504		$492		$501
Ratio of Post LNG to Existing Configuration Total Costs		111%		110%		110%		110%

Note: (1) Includes terminal, storage, pipeline and unit conversion capital costs.

Table 10-9: High Case Fuel Results Summary, FYs 2016-2045

	Scenario 1		Scenario 2		Scenario 3		Scenario 4	
	Existing	Post LNG	Existing	Post LNG	Existing	Post LNG	Existing	Post LNG
Average Unit Costs								
Converted Plant Production (MWh)	1,672,384	1,672,384	1,839,660	1,839,660	1,856,419	1,856,419	1,861,550	1,861,550
Generating Unit O&M Costs ($/MWh)	$30.22	$29.55	$30.50	$29.82	$31.62	$30.50	$32.52	$31.35
LNG Facility O&M Costs ($)	n/a	$13.88	n/a	$12.74	n/a	$12.64	n/a	$12.60
Emission Costs ($/MWh)	$7.11	$0.97	$6.48	$0.06	$6.42	$0.06	$6.40	$0.06
Debt Service ($/MWh) (1)	n/a	$15.37	n/a	$15.60	n/a	$15.99	n/a	$16.57
Fuel Cost, High Case ($/MWh)	$540.92	$257.52	$557.89	$264.66	$559.26	$264.37	$560.22	$264.44
Total Costs ($/MWh)	$578.26	$317.29	$594.87	$322.88	$597.29	$323.55	$599.14	$325.03
Average Daily Fuel Usage (MMBtu)	43,818	44,578	49,959	50,822	50,356	51,229	50,512	51,384
NPV 30 Yrs.Total Costs (Millions of $, in 2016)	$10,976	$6,264	$12,417	$7,010	$12,584	$7,090	$12,659	$7,144
NPV of Costs/(Savings) of LNG Conversion (Million of $)		($4,713)		($5,408)		($5,494)		($5,515)
Ratio of Post LNG to Existing Configuration Total Costs		57%		56%		56%		56%

Note: (1) Includes terminal, storage, pipeline and unit conversion capital costs.

Table 10-10 shows the results under the Base Case fuel scenario without the inclusion of the EPA MACT costs. The LNG conversion is still financially feasible without the inclusion of the impacts of MACT; however, the cost savings between the existing configuration and post conversion scenarios have decreased.

Table 10-10: Base Case Fuel without EPA MACT Results Summary, FYs 2016-2045

	Scenario 1		Scenario 2		Scenario 3		Scenario 4	
	Existing	Post LNG	Existing	Post LNG	Existing	Post LNG	Existing	Post LNG
Average Unit Costs								
Converted Plant Production (MWh)	1,672,384	1,672,384	1,839,660	1,839,660	1,856,419	1,856,419	1,861,550	1,861,550
Generating Unit O&M Costs ($/MWh)	$30.22	$29.55	$30.50	$29.82	$31.62	$30.50	$32.52	$31.35
LNG Facility O&M Costs ($)	n/a	$12.90	n/a	$11.86	n/a	$11.76	n/a	$11.73
Emission Costs ($/MWh)	$0.11	$0.06	$0.11	$0.06	$0.11	$0.06	$0.11	$0.06
Debt Service ($/MWh) (1)	n/a	$15.37	n/a	$15.60	n/a	$15.99	n/a	$16.57
Fuel Cost, Base Case ($/MWh)	$273.89	$201.55	$282.47	$207.76	$283.21	$207.53	$283.72	$207.59
Total Costs ($/MWh)	$304.22	$259.44	$313.07	$265.09	$314.94	$265.83	$316.35	$267.30
Average Daily Fuel Usage (MMBtu)	43,818	44,578	49,959	50,822	50,356	51,229	50,512	51,384
NPV 30 Yrs.Total Costs (Millions of $, in 2016)	$5,963	$5,172	$6,750	$5,812	$6,852	$5,883	$6,902	$5,933
NPV of Costs/(Savings) of LNG Conversion (Million of $)		($791)		($938)		($969)		($969)
Ratio of Post LNG to Existing Configuration Total Costs		87%		86%		86%		86%

Note: (1) Includes terminal, storage, pipeline and unit conversion capital costs. Only includes the annual air pollutant emission costs.

Section 11
OTHER FUEL/GENERATION OPTIONS

GPA is currently investigating the feasibility to convert its existing fleet of boilers, turbines and diesel engines from operating on fuel oil to operate on LNG. The LNG would be brought into the island via special tanker. An alternative to LNG is to gasify coal to produce either a liquid fuel (methanol or FT Diesel), a synthetic natural gas (SNG) or DME which is similar to LPG (propane). The coal would also need to be brought into the island by ship. The geographic dispersion of the power production fleet lends itself to the production of a liquid fuel that can be easily transported and stored. Coal gasification would allow GPA to realign its fuel purchases from the volatile and high cost oil market to the more stable and lower price coal market. The tradeoff for the use of the lower cost coal is the higher capital cost of converting that coal to the desired products.

Coal gasification is a proven technology that can convert coal to variety of products. The basic goal of gasification is to convert relatively low-value commodities such as coal, petroleum coke ("petcoke") or biomass into higher value products. This is accomplished by reacting the feedstock with oxygen or air to form a synthetic gas comprised of carbon monoxide ("CO"), hydrogen ("H2"), CO_2, methane ("CH4") and trace components consisting of sulfur species, nitrogen ("N2") species and some inerts. This raw gas from the gasifier is commonly referred to as synthesis gas ("syngas"). The syngas, once cleaned, can be used to fire a gas turbine for power production via a combined-cycle arrangement, or further reacted to form a multitude of chemical products.

The conversion of coal to high value products via gasification typically centers on four items: gasoline, Fischer-Tropsch ("F-T") liquids (diesel), ammonia (and derivatives) and SNG. In addition, the basic gasification process generates several byproducts that may be sold to increase the revenues of the facility. These include slag, sulfur/sulfuric acid, CO_2 and possibly oxygen, N2, argon (from the air separation unit) and steam. Figure 11-1 shows the potential slate and sources of products and byproducts from a generic gasification facility.

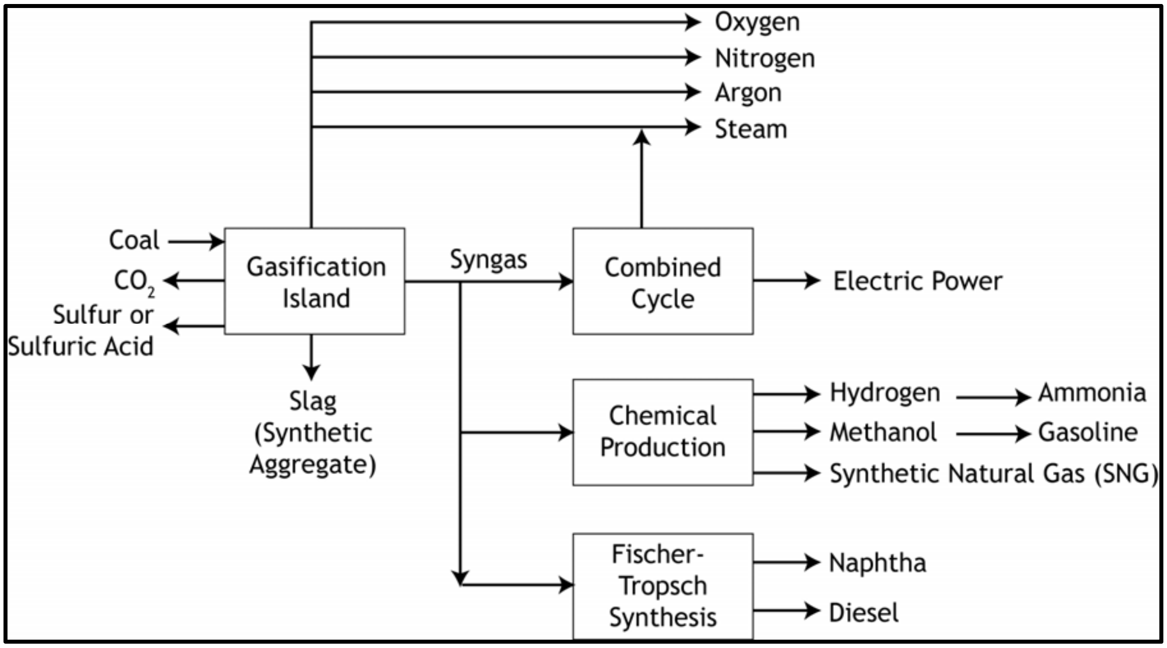


Figure 11-1: Gasification Potential Products

The manufacture of each of the chemical products begins with the production of syngas, which must be cleaned and adjusted to a H2/CO ratio which favors the particular product reactions. Figure 11-2 is a high-level block flow diagram showing the basic steps to producing the clean syngas. These basic steps are essentially the same for the production of all the products, with some minor differences depending on the type of gasifier used and the desired final product.

The production of this clean syngas is the core to any of the potential product paths and is the major capital cost of the project. The incorporation of the additional equipment to produce the specific product, although important, requires less capital.

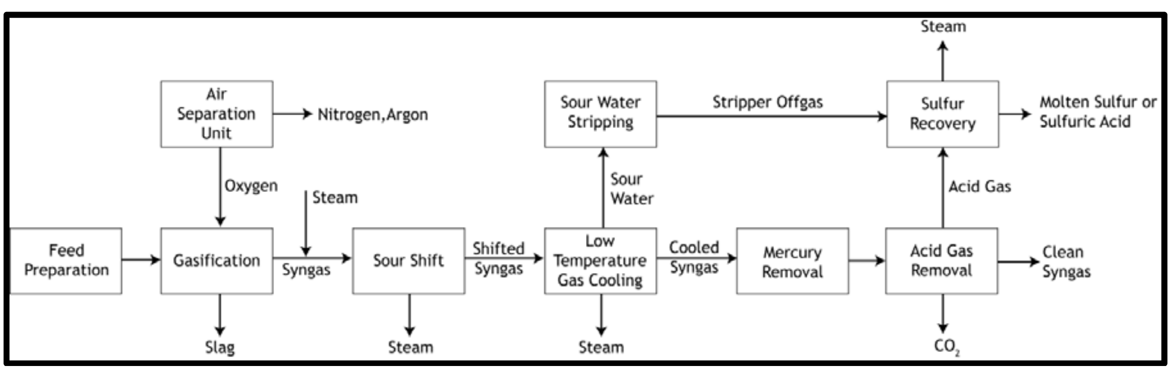


Figure 11-2: Syngas Production Block Flow Diagram

The following is a brief description of the process to generate syngas. The first step is to prepare the coal for the gasifier. Depending on the type of gasifier, the coal is ground and either mixed with water to form a slurry or dried for feeding into the gasifier. The slurry is pumped into the gasifier, or the dry feed is pneumatically conveyed in the case of a dry feed gasifier.

An air separation unit ("ASU") separates oxygen from N2 and argon in air and provides oxygen to the gasifier. The ASU is a cryogenic process that produces 99.5 percent purity liquid oxygen. The liquid oxygen is pumped up to gasifier pressure and then vaporized and fed to the gasifier. N2 is available for plant use. The ASU may also be designed to purify argon or other noble gases as additional products and/or be oversized to sell additional oxygen.

Several reactions occur in the gasifier, which converts the coal and oxygen into syngas principally consisting of H2 CO, CO_2, along with CH4, N2, argon and water. The sulfur in the coal reacts to form hydrogen sulfide ("H_2S") and carbonyl sulfide ("COS") in the syngas. The N2 in the coal is converted to ammonia and N2. The mineral matter in the coal and any fluxing agent form a molten slag.

Each of the various chemical products requires a specific ratio of H2 to CO based on the reaction stoichiometry. In order to adjust this ratio, a portion or all of the syngas is fed to one or more reactors containing a metal sulfide catalyst to promote the water gas shift reaction:

$CO + H_2O \leftrightarrow CO_2 + H2$

The shift reaction is exothermic. The heat generated by the reaction can be used to produce steam or to heat water or some other medium in the process.

The shift reactors can be located before or after the sulfur compounds are removed from the syngas, a step known as acid gas removal ("AGR"). When the shift is prior to the AGR, it is referred to as a "Sour Shift." When it is after the AGR, it is a "Sweet Shift." In the case of chemicals production, the overall process is usually more efficient when utilizing a Sour Shift.

The syngas leaving the shift reactors is cooled in a series of shell and tube heat exchangers. This cooling removes most of the water in the syngas. In addition, most of the ammonia and a small portion of CO_2 and H_2S are absorbed in the water. The condensed water is sent to sour water treatment. The low-temperature heat removed prior to AGR is used within the process.

The cooled syngas passes through a mercury removal system consisting of a sulfated activated carbon bed prior to AGR. There are several commercial processes which can be used for AGR, but the two most common for chemicals production are Selexol (licensed from UOP) or Rectisol (licensed from Linde or Lurgi). The AGR system utilizes a solvent to remove sulfur compounds (H_2S and COS). The AGR also removes CO_2 to levels suitable for feeding the chemical production unit. The CO_2 is either vented or can be compressed and sold as a product (i.e., for enhanced oil recovery ("EOR")).

The recovered acid gases (H_2S and COS) are sent to sulfur recovery. Sulfur recovery can consist of either a standard Claus Sulfur Recovery Unit ("SRU") to convert the acid gases to elemental sulfur or a Wet Sulfuric Acid Plant ("WSA") to produce sulfuric acid for sale.

As discussed previously, the production of each chemical entails the same basic process steps. The differences between the various products lie within the shift (to obtain the desired H2/CO ratio) and integration of the steam systems with the particular chemical production unit. Once the syngas is produced, different processing steps are required to generate the final products.

For the purpose of refueling the GPA fleet, methanol and DME or diesel would be the preferred products. As previously discussed, certain units of the fleet cannot be converted to methanol. Those units could be converted to DME. Methanol and DME can be made at the same time. DME is a made from methanol by a subsequent catalytic reaction. Thus, the amount of each product made is only dependent on the end users. Methanol is less expensive to manufacture and can be stored as a liquid at atmospheric conditions. DME is similar to propane and must be stored under pressure. The production of FT diesel is more involved than the production of methanol. FT typically produces both a diesel product and a wax product. Facilities can be designed to maximize diesel production, however; some wax is formed and external hydrogen may be required.

The economics of a coal gasification system is dependent on the plant location. An important cost is the delivered price of coal. Mine mouth operations have cost advantages over plants that need to pay for transportation. In addition, the economics of a typical facility are enhanced by the sale of byproducts. These include a sulfur product (elemental sulfur or sulfuric acid), a CO_2 product (typically used for enhanced oil recovery ("EOR")), a slag product (typically used for road base or landfill cover) and Argon (from the ASU). Depending on the location of the facility, these revenues could offset more than one half of the non-fuel, non-capital cost of operations.

For example, a United States ("U.S.") based mine mouth plant, producing gasoline, located in an area that can use the CO_2 for EOR and has the following general operating cost structure as shown in Table 11-1:

Table 11-1: Percent of Total Costs

Cost Type	Percent of Total Costs
Return of capital	49.4%
Cost of operations	28.8%
Cost of coal	21.8%
Total Operating Costs (TOC)	100%

The sale of the byproducts is worth approximately 20 percent of the TOC and the lower coal costs (as compared to the Indonesian coal for Guam) are worth approximately 16 percent of TOC. This is represents a reduction in the required selling price of the fuel product of approximately 36 percent, over a plant that is in a location where these advantages are not accessible. Where the U.S. based mine mouth facility could produce gasoline and provide for recovery of capital at approximately $97/bbl (the equivalent of $81/bbl of crude oil), a similar facility on Guam would need an oil price equivalent of $110/bbl.

The difficulty on Guam is that the byproducts may have no value (CO_2 and Argon), or the transportation costs will significantly reduce their value or net back less than zero (sulfur and slag) to the facility. Coupled with the higher costs of the coal this can result in a product costs (return of capital + all operational coats) that exceed the purchase price of oil in the near term. At the point in time, that the debt is retired (say 20 years), the coal gasification plant would be highly competitive with oil imports.

The above analysis is an example of producing gasoline from coal. This configuration does not take into account a potentially different plant configuration producing methanol or FT diesel which would alter the economics to some extent. Also the capability of GPA to finance at a lower interest rate than assumed may present a different situation. However, the potential competitive nature of a coal gasification facility is highly dependent on the price of oil. In order to obtain better site-specific information for GPA that would allow a more complete analysis of this option. We would recommend that in the request for proposal that is to be issued for the LNG plant, an alternative be included to address the fuel switching issue by allowing vendors to provide information on coal gasification to a liquid fuel to substitute for the present diesel and residual fuel usage.

Section 12
ACQUISITION STRATEGIES

Introduction

There are a number of approaches that GPA could employ to bring LNG resources to the island. Since the development of fixed land-based or floating LNG terminal facilities are based on very specialized engineering and construction competencies, we believe any approaches that would rely on significant participation by GPA directly in the engineering, project management or construction would not be feasible due to lack of on-island expertise. Rather, a more feasible and risk balanced approach would to be to undertake an acquisition strategy based on Request for Proposal (RFP) approach. In moving in this direction, there are a number of implementation strategies that can be explored. Each has a significant advantages and challenges. Our primary descriptions of reasonable strategies generally fall into the following approaches.

Design Build or Design, Build and Operate

In this approach, GPA would proceed with an RFP to prequalified firms to undertake the development, construction and commissioning of an LNG regasification facility. The goal of this RFP would be to let a contract to the successful bidder to:

- Acquire the land or land rights for the site of the LNG facility;
- Undertake the permitting, engineering and procurement for the facility;
- Undertake the commissioning and testing of the facility;
- Provide warranties and guarantees on performance and workmanship; and

A number of strategy aspects will need to be addressed during the development of the RFP approach. Some of the strategy issues include:

- Should the firm that takes on the EPC responsibility, directly or through a subcontractor, also be responsible for the long-term operations and maintenance of the facility? Should this be an option within the RFP process?
- What minimum level of warranties and guarantees will be requested? How will this trade off to liquidated damages terms.
- Will GPA seek a fixed price contract or recognizing the risk premiums that maybe applied, will a risk sharing approach be undertaken?

A Tolling Approach with Commodity Contract

Perhaps the most aggressive approach for GPA would be to structure an RFP for a long-term delivery of natural gas at a GPA defined delivery point, such as the Cabras location. The bidder would be responsible for the EPC functions, permitting, financing and long-term procurement of the LNG. The RFP would specify:

- The expected quantity and range of variability of natural gas to be delivered to Cabras;
- Pricing mechanism for the delivered natural gas to [the Cabras location] which would reflect the bidders costs for the commodity and return of investment in the regasification facilities;
- The quality and delivery parameters for the natural gas delivered;
- Expected term of the agreement; and
- Expected guarantees and liquidated damages approaches

Based on the analysis undertaken herein, a possible procurement strategy would focus on GPA undertaking a RFP process for four separate bids:

- Secure the construction and commissioning of an LNG regasification facility on Guam;
- Secure a long-term LNG fuel supply contract for GPA for all or a major portion of GPA's needs;
- Secure construction and commissioning of modifications to certain GPA power plants to operate burn natural gas as their fuel supply; and
- Secure construction and commissioning of natural gas pipeline to certain GPA power plants to operate burn natural gas as their fuel supply.

In undertaking the RFPs, it is recognized that there may be advantages to GPA in linking the procurement of long-term fuel supply contract with the provision of the regasification facility and correspondingly it may be beneficial to allow for both requests to be combined as a single bid response. However, a respondent to the RFP is unlikely to provide firm costs for providing a facility and also a firm tolling basis. We also believe that a turnkey gas supply provider is most likely to be a producer of LNG while the facility provider unconnected to supply will likely be an EPC company. Also these two types of entities have very different risk tolerances.

Section 13
BROAD RISK ASSESSMENT

As discussed in this report, it appears that the development of an LNG regasification facility on Guam, as previously discussed in GPA's IRP of 2008, may provide substantial benefits to the customers of GPA and the citizens of Guam as a whole. Benefits may include:

- A substantial long-term reduction in the cost of electricity on the island by way of lower fuel costs for GPA power plants. The LNG facility will provide natural gas to some of GPA's power plants and displace the majority of fuel oil that is used for electric generation. In addition to lower costs, it is possible that the volatility of the cost of fuel may also be reduced, if a long-term contract for LNG supply can be secured.
- A significant reduction in emissions associated with the generation of electricity. Implementing the LNG strategy will result in significant reductions in sulfur dioxide, nitrous oxides, heavy metals, and particulate matter.
- Introduction of an alternative energy source on the island that could be used to displace the use of fuel oil, diesel and gasoline in the transportation sector as well as other commercial and military uses.

The development of an LNG regasification facility is a significant infrastructure project. When seen in combination with the conversion of existing GPA power plants and the possible development of natural gas distribution pipelines, this activity is a complex project and may require more than $300 million of investment by GPA or by third parties on GPA's behalf. There are significant risks associated with all major infrastructure projects. Outlined below are some of the major risk issues surrounding this development and some of the strategies to minimize these risks to GPA and its customers.

Project Development Risk

The effective development of an LNG regasification terminal is a complex project and requires specialized skills and experience. Important requirements of a project of this type include:

- Significant and specialized regulatory and permitting requirements that include maritime considerations. Experience with the Coast Guard and the DOT/FERC are necessary components.

- Although widely employed, transportation, storage and regasification technology is a specialized engineering discipline and is resident in only a few firms worldwide. Each facility is individually designed and executed.
- There are very limited sites available for the facility. Siting a facility in the Apra Harbor area will be challenging and require significant local coordination, permitting and design engineering to accomplish a feasible approach.
- Development of the project will require coordinated, parallel development of a long-term supply agreement with development of the required transportation and terminal infrastructure, and the conversion of generation units and/or installation of new units.

Some of the approaches GPA can undertake to reduce the risk of project development include:

- A Design Build (DB) or Design, Build, and Operate (DBO) contracting approach can be executed in such a way as to move most of the project development responsibility and risk on the selected contractor. While the developer will be primarily responsible for development, GPA will need to actively manage and support the selected developer. Recently GPA has undertaken a Program Management Office approach to some of its complex capital expansion programs and it is possible GPA's support of the selected firm can be conducted through a PMO as well. Proper allocation of the development risk will be important to the overall risk management of the project and mitigation of risk to GPA and its customers.
- This study is an important tool in enhancing the understanding of the potential project by GPA, its stakeholders, and potential DB and DBO bidders. An increased understanding of the project will assist potential bidders in more thoughtfully evaluating how they should approach the project and in turn, allow GPA and its stakeholders to understand better the LNG development project they will be sponsoring.
- Initiation of a parallel LNG supply development effort is critical to project success. The pricing and supply security of LNG must be well understood and thoroughly vetted early in the project.

Project Execution Risk

As mentioned previously a LNG gasification facility is an individually designed facility and utilizes specialized engineering and technology skills. Certain technologies or configurations are proprietary to one vendor or one engineering firm. Correspondingly, significant care must be taken in the engineering, design, procurement and construction of the facilities. Given the risks associated with proper execution of the engineering, procurement and construction, a number of approaches can be used to minimize execution risk. Primary strategies include:

- As mentioned earlier, one approach is to procure the project with a DB contract. This type of contract is also referred to as an Engineer, Procure, and Construct (EPC) contract. The ability to negotiate a fixed price contract with guarantee of performance and liquidated damages would be the most likely goal for GPA. While it is not generally possible to have a "risk free" contract, market dynamics should allow the RFP process and subsequent negotiations to result in a contract with most of the costs "fixed" and a reasonable level of risk mitigation terms for GPA.
- While there will be a number of disciplines, crafts and vendors involved in the construction of the LNG facility, we believe there is a sufficient number of experienced firms that can bid total project responsibility. The very large firms with significant experience building LNG facilities may find this project too small to pursue. Considering the small number of LNG terminals of this size actually operating, GPA will probably have to consider contracting with smaller firms with analogous experience, i.e. LNG peaking facilities or marine propane terminals. The ability to contract with one lead contractor that will be responsible for the total scope of the project will help reduce GPA's risks.

Long-Term Commodity Contract Risk

This report provides a significant discussion of the current market for contracting supply of LNG and its delivery to Guam. In the Pacific Rim, there is a history of long-term contracts negotiated with terms similar to the mechanisms that have been used by the Japanese in contracting for long-term supply of LNG. As described herein, the historical pricing mechanisms link the pricing of LNG to an oil price index with a 'collar' pricing approach that typically limits upside and downside movement in the negotiated index price. As mentioned in the fuel supply discussion, there are a number of market factors that will come into play when the terms of the long-term supply contract are negotiated, including the upcoming availability of new supply projects and Guam's geographical location relative to new supply locations. As with most long-term supply contracts of this nature, there important risk factors that need to be considered in future negotiations. Some of the major items include:

- Within the framework of most Pacific Rim long-term LNG contracts there remains a level of price volatility in the pricing mechanism. This price exposure can be additionally managed by the use of financial instruments to hedge the upside price exposure in the contract. This is essentially a "price insurance" strategy that can be employed. In many respects it would be similar to the hedging approaches GPA currently employees in its current fuel oil program.

- The creditworthiness, supply reliability, and financial strength of GPA's counterparty in a long-term fuel supply contract will be very important. Long-term contracts with collars can create a situation where, depending on market conditions, the market price for LNG could be significantly higher than the upside limit on the supply contract's pricing. In a situation where the supplier is selling below market prices and should the supplier need to purchase from the market to meet future contract obligations, the negative cash flows of the circumstances could create a risk of the counterparty's ability or willingness to meet its supply obligations. In managing this type of risk, it will important that the early contracting procedures and subsequent negotiations examine or include consideration of the suppliers':
  - Long-term physical supply reliability, both for the commodity and transportation and their risk management programs;
  - Financial strength of the counterparty and their risk management programs to deal with supply and price risk; and
  - Consideration of third party financial guarantee (or other similar obligation) of the fuel supplier's ability to meet its supply and pricing obligations.

Coordination of Conversion of Existing Power Plants

Another important consideration in implementing an LNG strategy for GPA is the issue of the conversion of a number of existing GPA power plants to burn natural gas as the primary fuel source. In carrying out this strategy there will be some fairly critical timing issues that may be involved. It will be important to assure that power plant conversions are accomplished contemporaneously with the commissioning of the LNG regasification facility and the conversions will accommodate the specific gas quality guarantees that may be included in a source LNG commodity contract. Some of the approaches that will be important to examine to mitigate this risk include:

- In a similar fashion as described previously regarding the contracting for DB (or EPC) contractor, it will be equally important to contract with a firm that will have the technical skills and experience for handling work on a number of different unit types and conditions and be able to provide guarantees on output, heat rate performance and unit availability. Modifications to existing power plants can be a challenging undertaking.
- The analysis performed in this study looked at converting certain units in GPA's existing fleet and no detailed look was undertaken on the order or timing of the conversions. In addition, the analysis did not look at the possibility of the construction of a new, efficient combined cycle combustion turbine power plant (CCCT) as an alternative to converting some or most of GPA's generation units. A new CCCT plant, due to its significantly more

efficient heat rate will further decrease GPA's aggregate fuel costs and potentially reduce the number of existing power plants that would need to be converted. GPA's current efforts to update its IRP to reflect the LNG assumptions and results of this report will provide the appropriate framework to examine if the implementation of a new CCCT is economically feasible. In addition, the current IRP update may be helpful in defining the order and timing of the existing power plant conversions.

- As mentioned in this report's detailed discussion of converting the existing power plants, the ability of certain power plants to be dual fueled will be an important factor in reducing the timing risk associated with the completing the LNG facilities and the conversions on a coordinated schedule. The ability to convert existing units early on and to continue to fire them with fuel oil post conversion will help reduce timing risk.
- To the extent converted facilities are dual fueled the need for absolute LNG supply reliability is reduced and the costs associated with this higher reliability are reduced. This is because a potential supply that must be 100% reliable will cost more than those with a lesser reliability standard.

Project Performance Risks

The operation and maintenance of the LNG regasification facility, the natural gas pipelines, and the converted power plants all introduce a new set of skills and experience requirements that do not currently exist within GPA. It is assumed that an operation and maintenance contract for the LNG regasification facility will be awarded to an experienced firm. As mentioned previously, the terminal O & M contract could be an option to the DB contract. In addition, it may be possible to extend the terminal O & M contract to cover the natural gas pipelines as well. In addition to issues that surround the prudent operations of the facilities some additional risk factors include:

- As discussed in the description of the first alternative of the LNG option, this configuration will employ an LNG tanker receiving facility that is located outside of Apra Harbor. And as discussed in the report of the Marine engineer, this type of facility will be subject to the inclement weather during certain times of the year. Correspondingly, it is possible to experience extended periods of time when a tanker may not be able to offload. To mitigate this risk, the size of the LNG storage tank is design to accommodate a reserve to help mitigate the risk of a tanker not being able to land when needed. The design of the carrier and the marine offloading facility can also be designed to accommodate periods of extreme weather and sea conditions to the extent economically feasible. In addition to these physical measures, we believe it will be prudent to assure that GPA will have operationally sufficient generation capacity by way of standby fuel oil units or the ability use fuel oil in "dual fueled" plants. This would allow significant reduction of natural gas usage in an emergency situation. This is an operating contingency that will require GPA to maintain its alternative operating capability.

- GPA's current plants use fuel oil and the plant personnel are trained in the proper maintenance and operation of these facilities. The conversion of certain plants to use natural gas will require changes in operating procedures, safety training, and other skills. While we do not believe these changes are unduly difficult, it will require additional staff training and modifications to operating procedures to ensure efficient and safe operations.
- While the current generating facilities use flammable liquid fuels, the introduction of natural gas will require the use of appropriate Codes and Standards that would apply to the installation, operation and safety procedures associated with natural gas in this industrial environment. The necessary engineering, design and maintenance of natural gas pipeline and fuel systems is well understood, specifically addressed by various Code and Regulatory bodies (including U. S. DOT) and widely available from existing sources in the U. S. Mainland. This means that the safety risks for handling and burning of natural gas are mitigated to the same extent as in the current North American marketplace.

GPA Financial and Regulatory Risk

The development and commissioning of the LNG regasification facility, gas pipelines and the conversion of certain of GPA's existing power plants represent a significant capital investment for GPA. In addition, this would be an additional $300 million investment that could overlap GPA's already significant capital investment program scheduled for the 2012-2016 time period. An additional unknown is the capital expenditure program related to the Department of Defense's build out which may occur at the same time. While the DOD build out will be funded by others, nonetheless, it will be a significant pull on GPA resources. These items will also have a direct impact on GPA's cost of service, revenue requirements, and resulting ratemaking process. From this perspective, some additional risk mitigation approaches may include:

- It will be important to seek PUC approval of the LNG strategy as the program progresses. This would include approval of the RFP process, the selection process and the subsequent rate treatment in both base rates and LEAC. A collaborative approach with the PUC and other stakeholders will help shape a better project approach and reduce issues due to lack of communication and misunderstanding of the issues and associated risks.
- Given the nature of the facilities, it is reasonable to expect that the DB contract could also include financing the facility. This would reduce GPA's need to

finance the project directly. It is possible to structure the arrangement as a "tolling" contract wherein GPA would pay an annual fixed cost payment for the facility or a quantity throughput charge. This would allow GPA to avoid direct financing of the design and construction of the facility. However, GPA would have to consider that the cost of capital for a third party would likely be higher than the cost of capital GPA would face if it issued tax exempt bonds to finance the project. Of course, GPA will want to examine carefully the costs and benefits of any financing strategy.

- Optionally, should a tolling arrangement be contracted with a credit-worthy firm with low credit risk, it may be possible for GPA to issue tax-exempt bonds to 'prepay' the annual tolling charges. This would potentially allow GPA to reduce the annual cost of the tolling arrangement and reduce costs to its customers.

Section 14
FINDINGS AND RECOMMENDATIONS

Based on the information gathered, research, and analysis presented herein, R. W. Beck's findings include:

- There is a feasible land-based configuration for a LNG regasification facility available for Guam. A possible location would be the quarry site. The facility could be constructed and commissioned for a cost of approximately $207 million in 2011 dollars and could be constructed and commissioned approximately 50 months from project kickoff. Additional costs would be incurred for interest during construction, the conversion of the units, and pipelines to the converted units. Total capital investment, assuming the Cabras units and the Piti units are converted, would accumulate to $335 by April 2016, the assumed operational date of the terminal and units.
- There is an alternative approach to a land-based facility. This would be a floating storage and regasification (FSRU) unit that could be located inside Apra Harbor. Such a facility could be located near the Hotel Wharf. Since there is a limited history of installations and limited firms that can construct these facilities, this report provides a possible range of tolling costs for such a facility. Lead time to construct and commission an FSRU is similar to that of a land-based system and may be shorter.
- Based on the analysis of future LNG prices, future oil prices and the costs to construct and operate the land-based and the costs to convert GPA's existing generation to operate on natural gas, it appears that an LNG strategy could significantly reduce the cost of power to GPA's customers. In Scenario 1 presented, the present worth savings to GPA's customers would be approximately $924 million as of the operational start date in 2016. This represents 30 years of total operating, fuel, emissions, and debt service costs under the LNG option compared with these costs under the existing GPA plant configuration where generation continues to be fueled with oil. These costs reflect those associated with the Cabras and Piti units and are not reflective of the costs of GPA's generation units, which were not converted in this scenario.
- As described herein, there are potential new EPA emissions regulations which may impact GPA current generation operations. The costs associated with these regulations were based on GPA's analysis of the cost impacts the new regulations would require, and include capital as well as operating costs. These costs were included as part of the analysis. Should these new

regulations not be adopted, an LNG strategy would have a present worth savings to GPA's customers of approximately $791 million.

- The implementation of an LNG strategy will have a significant beneficial impact on the amount of emissions currently produced by GPA in the generation of electricity. In the base case analysis emissions of 34,000 tons could be reduced by 47% in the aggregate in 2017. Other emissions, such as [heavy metals, etc] would be significantly reduced as well.
- As described in the LNG market analysis section of this report, there appears to be significant new and recent LNG production capacity that will come online in the next few years and much of this capacity could serve GPA's needs. In addition, the price forecast herein presents a substantial long-term price advantage of LNG compared to the equivalent $ per MMBtu cost for high sulfur fuel oil. Historically, in the Pacific Rim market, there has been a linkage of LNG pricing to that of oil. There is some limited evidence that this pricing relationship may be changing and that LNG developers are looking to find long-term commitments for their upcoming new capacity. This supply situation may present a favorable buying opportunity for buyers in the next few years. However, the resolution of Japan's nuclear policy and energy consumption growth in China and India may have a substantial impact on regional demand for LNG.
- The specific recommendations on the timing and selection of which GPA generation units should be converted should be undertaken within the framework of GPA's update to its IRP Strategist model. This level of refinement will be helpful in defining a subsequent strategy on unit conversion timing.

Based on the above findings we are of the opinion that GPA should undertake a Request for Proposal process to:

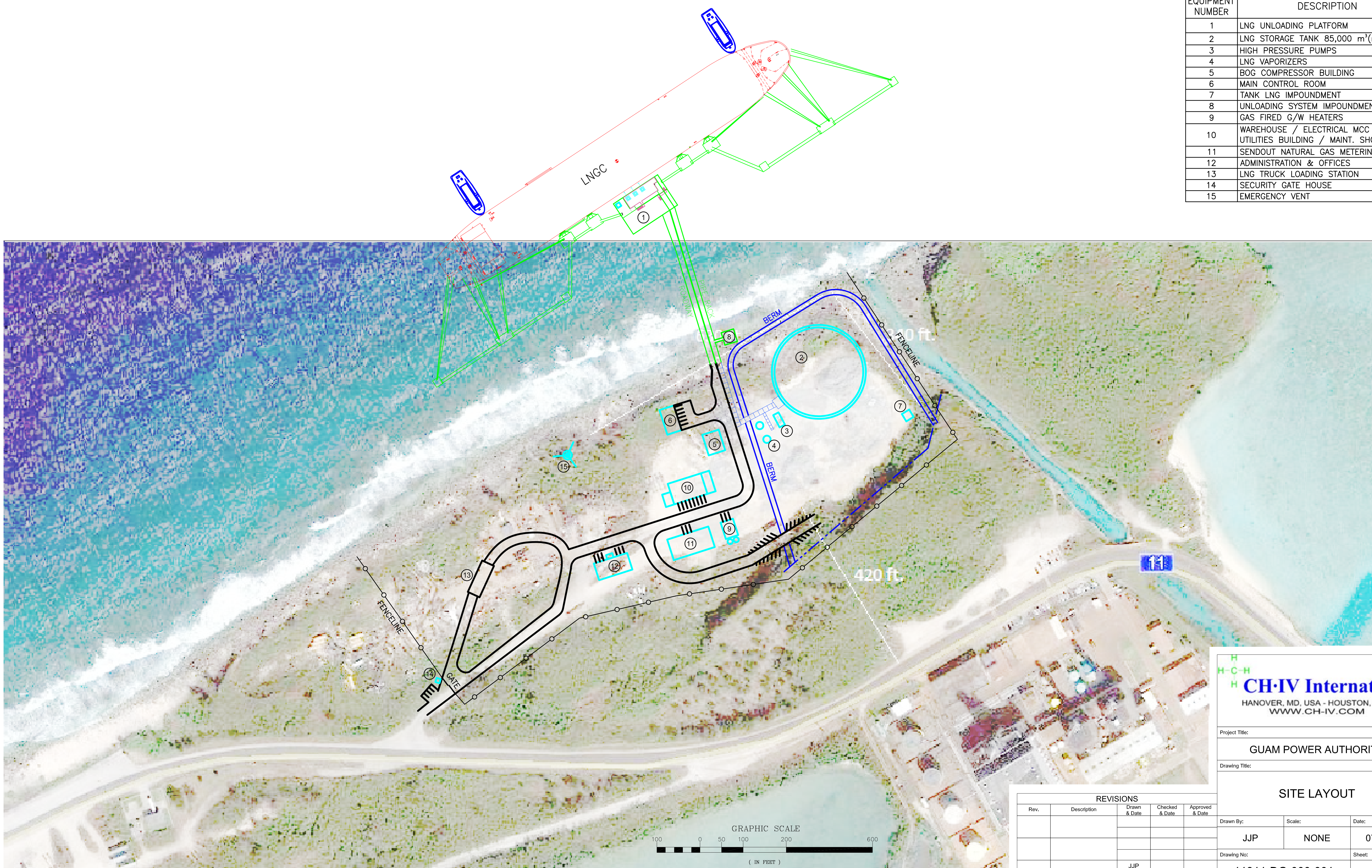
- Secure the construction and commissioning of an LNG regasification facility on Guam;
- Secure a long-term LNG fuel supply contract for GPA for all or a major portion of GPA's needs;
- Secure construction and commissioning of modifications to certain GPA power plants to operate burn natural gas as their fuel supply; and
- Secure construction and commissioning of natural gas pipeline to certain GPA power plants to operate burn natural gas as their fuel supply.

In undertaking the RFPs, it is recognized that there may be advantages to GPA in linking the procurement of long-term fuel supply contract with the provision of the regasification facility and correspondingly it may be beneficial to allow for both requests to be combined as a single bid response.

We also recommend that prior to the issuance of the RFP, GPA takes the necessary steps to secure the considered site(s) so as to provide for the most fair and open proposal process and so there is no locational advantage/disadvantage to any particular proponent.

Section 15
EXHIBITS

EXHIBIT A
Site Layout



EQUIPMENT NUMBER	DESCRIPTION
1	LNG UNLOADING PLATFORM
2	LNG STORAGE TANK 85,000 m^3(net)
3	HIGH PRESSURE PUMPS
4	LNG VAPORIZERS
5	BOG COMPRESSOR BUILDING
6	MAIN CONTROL ROOM
7	TANK LNG IMPOUNDMENT
8	UNLOADING SYSTEM IMPOUNDMENT
9	GAS FIRED G/W HEATERS
10	WAREHOUSE / ELECTRICAL MCC / UTILITIES BUILDING / MAINT. SHOP
11	SENDOUT NATURAL GAS METERING AREA
12	ADMINISTRATION & OFFICES
13	LNG TRUCK LOADING STATION
14	SECURITY GATE HOUSE
15	EMERGENCY VENT

REVISIONS

Rev.	Description	Drawn & Date	Checked & Date	Approved & Date
A		JJP 07/18/11		

CH·IV International
HANOVER, MD, USA - HOUSTON, TX, USA
WWW.CH-IV.COM

Project Title: GUAM POWER AUTHORITY

Drawing Title: SITE LAYOUT

Drawn By:	Scale:	Date:
JJP	NONE	07/18/11

Drawing No:	Sheet:
11911-DG-000-001	1 OF 1

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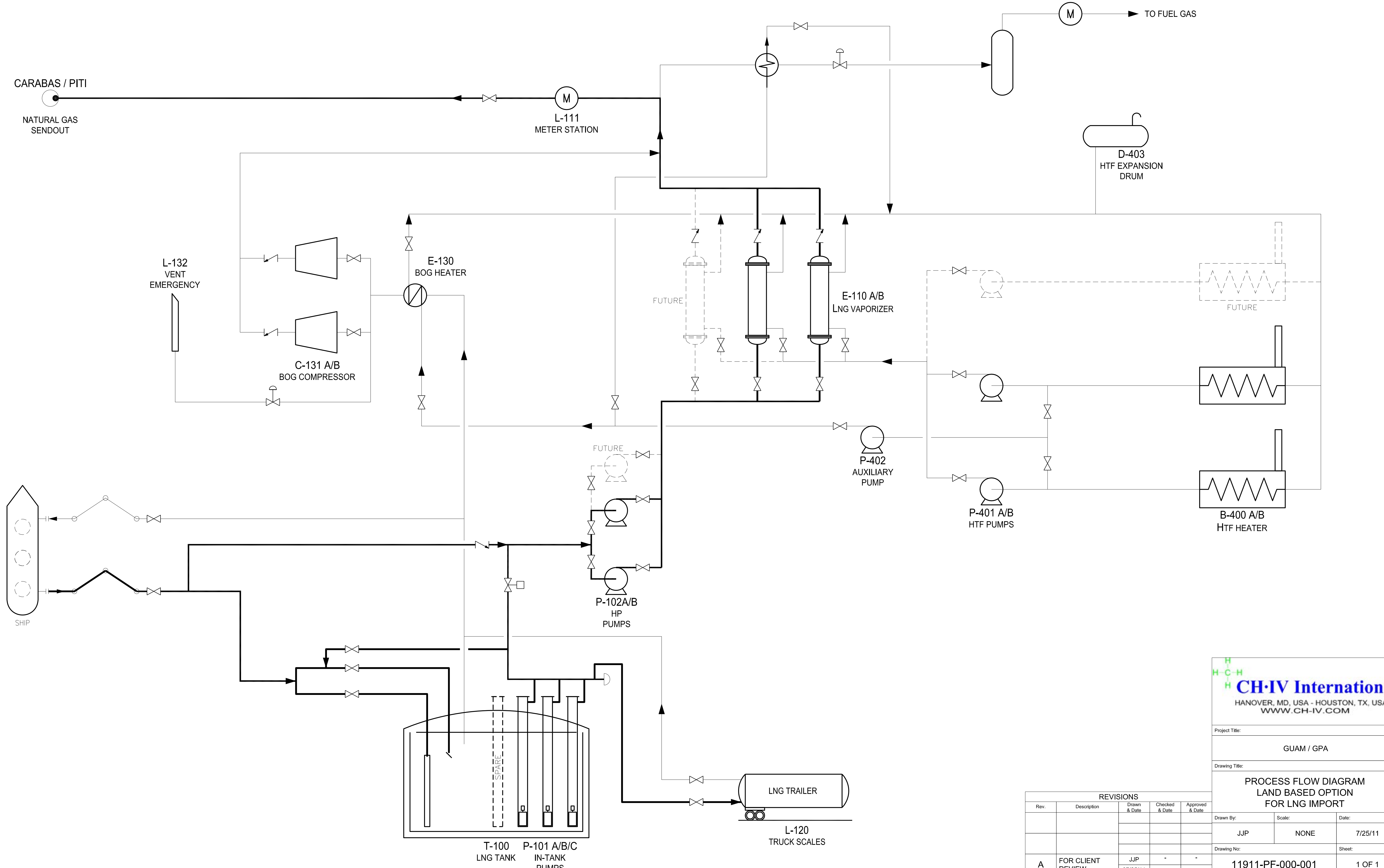
EXHIBIT B

Process Flow Design



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Project Title: GUAM / GPA

Drawing Title: PROCESS FLOW DIAGRAM
LAND BASED OPTION
FOR LNG IMPORT

Drawn By:	Scale:	Date:
JJP	NONE	7/25/11

Drawing No:	Sheet:
11911-PF-000-001	1 OF 1

REVISIONS

Rev.	Description	Drawn & Date	Checked & Date	Approved & Date
A	FOR CLIENT REVIEW	JJP 07/25/11	- -	- -

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EXHIBIT C

Vaporization Study

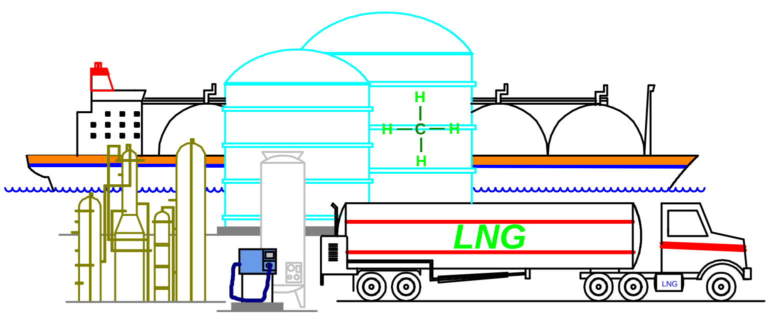
LNG VAPORIZATION OPTIONS STUDY

GUAM LNG IMPORT TERMINAL

~ Feasibility Study ~

Prepared for ~

Prepared by ~



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CH·IV International

GUAM LNG
LNG VAPORIZATION STUDY

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GUAM LNG
LNG VAPORIZATION STUDY

1 INTRODUCTION

Guam Power Authority (GPA) has asked RW Beck/SAIC to evaluate imported Liquefied Natural Gas (LNG) as an alternative fuel source to generate electricity on the island of Guam. For a conventional land-based import terminal solution, LNG will be stored in one 85,000 cubic meter (net) aboveground LNG storage tank and the LNG must be pressurized, heated and vaporized before it can be distributed and used as fuel for existing power generating units that have been modified to use natural gas. A base-load natural gas sendout of 34 mmscfd is considered for this facility which would translate into a vaporizer heat duty requirement of approximately 25 mmBtu/hr.

1.1 Objective

The objective of this report is to review recognized vaporization options for the LNG Receiving and Regasification Terminal. Various commercially proven methods exist for LNG vaporization: submerged combustion vaporizers (SCVs), open rack vaporizers (ORVs), shell & tube heat exchangers utilizing heat transfer fluid (HTF) and newer designs that are also available which use ambient air to provide the necessary heat for vaporization. These four vaporizing methods are evaluated based on performance, environmental impacts, physical characteristics, fixed capital costs and operating expenses.

2 BACKGROUND

The choice of a vaporization system is an important early decision in the development of an LNG import terminal since it impacts capital expenditure, operating costs, operating flexibility, reliability, effluents and air emissions; as well as public perception and regulatory compliance.

Historically, base-load LNG import and regasification terminals have generally used either Open Rack Vaporizers (ORV) or Submerged Combustion Vaporizers (SCV) for LNG regasification purposes. ORVs are widely used in Asia and Europe and are well proven in baseload LNG regasification service using seawater as a heat source. SCVs are more typically used in North America due to compact size and relatively lower initial capital cost. Smaller LNG operations such as LNG Peakshaving facilities often use shell & tube heat exchangers with external Heat Transfer Fluid (HTF) heaters.

Recent developments in alternative vaporizer technologies include various designs that use ambient air as a heat source for vaporization of LNG and custom vaporizers utilizing waste heat recovery.

GUAM LNG
LNG VAPORIZATION STUDY

3 SUBMERGED COMBUSTION VAPORIZERS (SCV'S)

In a SCV, the LNG is vaporized in a hot water bath which is directly heated by natural gas. SCVs are typically designed to use fuel gas or low pressure boil off gas from the terminal. High pressure LNG flows through a stainless steel tube bundle that is submerged in a water bath heated with exhaust gases generated from a separate combustion burner section of the SCV unit. The combustion burner is fueled by low-pressure gas from tank boil off and/or sendout gas and regulated to a reduced pressure. The hot exhaust gases from this combustion are sparged directly into the water bath and create a relatively low temperature (typically in the range of 50° to 60°F) thermally stable warm water bath for the vaporization coils. The water transfers the heat from the combustion process to the LNG. The vaporized LNG exits the coils as natural gas at pipeline pressure for downstream transmission. The SCV offers simplicity and has become the vaporization choice for most of the new and existing U.S. regasification terminals. Figure 1 is a schematic for the SCV process:

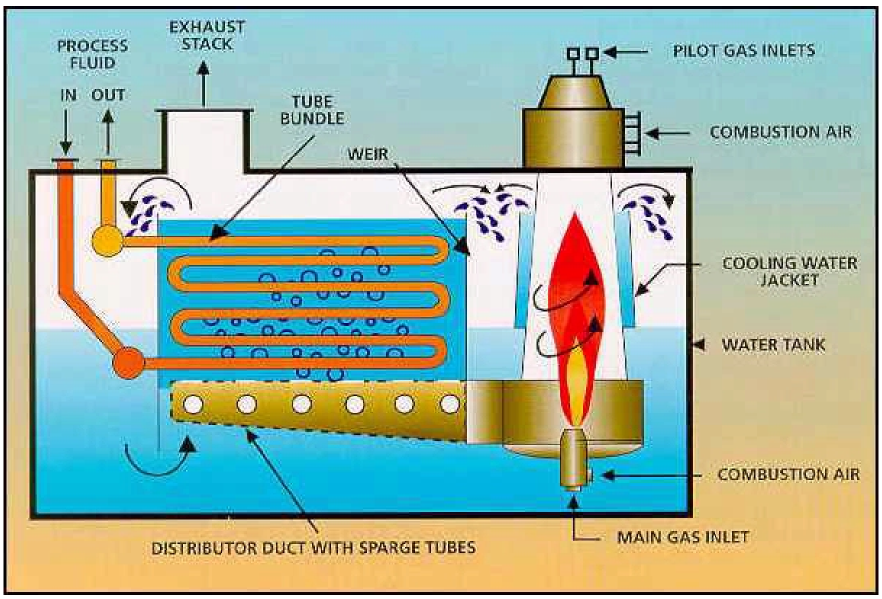

Figure 1: Schematic of Submerged Combustion Vaporizer (SCV)

3.1 Performance

SCVs have very high thermal efficiencies (above 97%) because the combustion products are bubbled directly into the water bath hence all the available heat is transferred directly to the water bath and in humid environments the heat from the condensation of water vapor in the air improves thermal efficiency. Gas outlet temperatures for SCVs range from 35°F to 60°F. Since the water bath is at high thermal capacity, stable operation is always achievable, even for sudden start-ups, shutdowns, or deviations in load. Significant electric power is also required to run the combustion air blower and the water circulation pumps. Also turndown may be somewhat limited.

3.2 Emissions and Effluents

Due to the combustion process NO_x, CO and other greenhouse gases are produced when the SCVs are in operation. Table 1 contains the expected air emissions[1] from an SCV unit designed with conventional low NOx combustion burners.

Table 1: Typical Emissions from SCV Unit

Gas	PPMVD @ 3% Excess O_2
NOx	<30
CO	<40
VOC	<10

Reducing these emissions (especially the NO_x) beyond the levels above, if necessary, will require the use of a selective catalytic reduction (SCR). Besides the additional capital cost, SCRs do not operate efficiently with SCVs and therefore could be a determining factor when selecting a vaporizer.

Particulate Matter (PM 10) is also emitted at a rate of 0.0015 lb/mmBtu. During SCV operation the water in the bath becomes acidic as it absorbs combustion products such as CO_2. The pH of the water bath is monitored and controlled by introducing alkaline chemicals such as caustic soda or sodium carbonate (soda ash).

Byproduct water is also produced as a part of the SCV process for two reasons: Water is created as a product of combustion, and typically the outlet vapor temperatures are controlled at a low enough temperature such that there is a net condensation effect from the incoming combustion air to the discharge exhaust vapor. A single SCV unit rated for approximately 25 mmBtu/hr produces an expected water overflow rate of about 50 gpm.

3.3 Physical Characteristics

While smaller and lighter than an equivalent ORV type, SCV arrangements present considerable requirements in terms of space and weight bearing capacity in their supporting structures. An SCV unit with a capacity of 34 mmscfd will have a minimum footprint of 250 ft^2. Stack heights can vary based on owner requirements. The layout of multiple SCVs can be seen in Figure 2 (7 units shown):

1 Provided by Selas Fluids Processing Corporation of Blue Bell, PA.

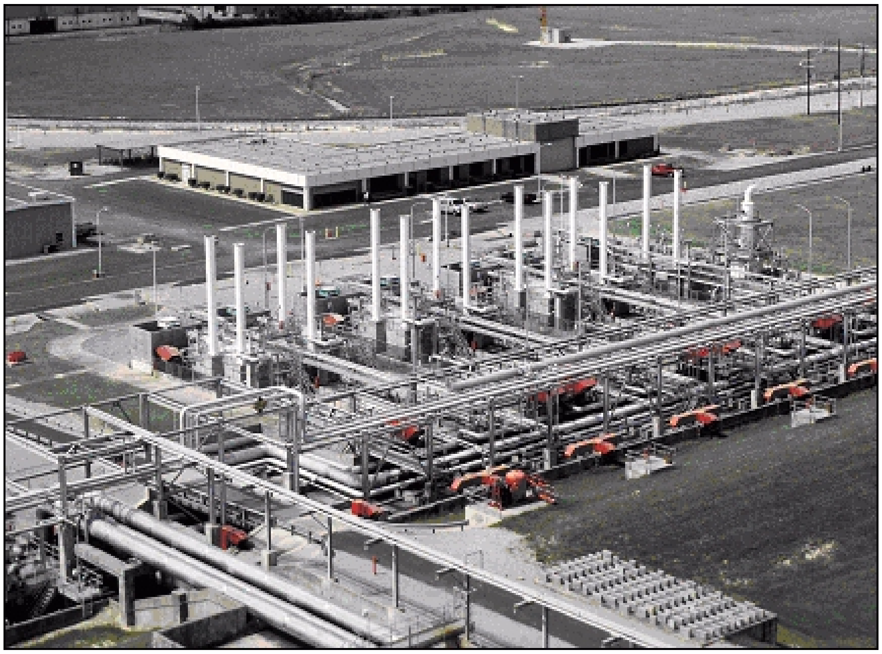

Figure 2: SCV Installation, 1.0 bscfd capacity

3.4 Capital and Operating Costs

SCV baseload units usually have a capacity range of 60 mmscfd – 210 mmscfd although smaller capacity units are available. Typical-size 180 mmscfd units have a purchase price of somewhat less than an equivalent ORV. This amount takes into account the cost of ancillary equipment such as the air blower, water circulation pump, fuel gas combustor, controls and associated piping. This cost does not include an SCR unit for exhaust gases which may significantly increase the cost of an SCV unit. The greatest disadvantage of using SCVs over an ORV is the operating costs. Current technology is such that fuel consumption is in the range of 1.3% to 1.8% of terminal throughput. The annual power consumption costs for the air blowers are also significant due to the motor size and required excess air.

4 OPEN RACK VAPORIZERS (ORVS)

The ORV uses seawater as the heat source to vaporize the LNG. These vaporizers are composed of banks of vertical aluminum alloy tubes welded into panels. High pressure LNG is pumped through the inside of the tubes, while warm sea water flows down along the outer tube surfaces. Heat is transferred from the warm sea water to the colder LNG, warming and re-gasifying the LNG flow to produce natural gas at the design sendout temperature and pressure.

4.1 Performance

ORVs have proven reliability and they do not require the burning of natural gas fuel for operation. The LNG outlet temperature will vary with the seawater inlet temperature but the ORVs are usually designed to deliver minimum 40°F natural gas. Electric power is also required to run the seawater circulation pumps. A typical ORV is shown in Figure 3:

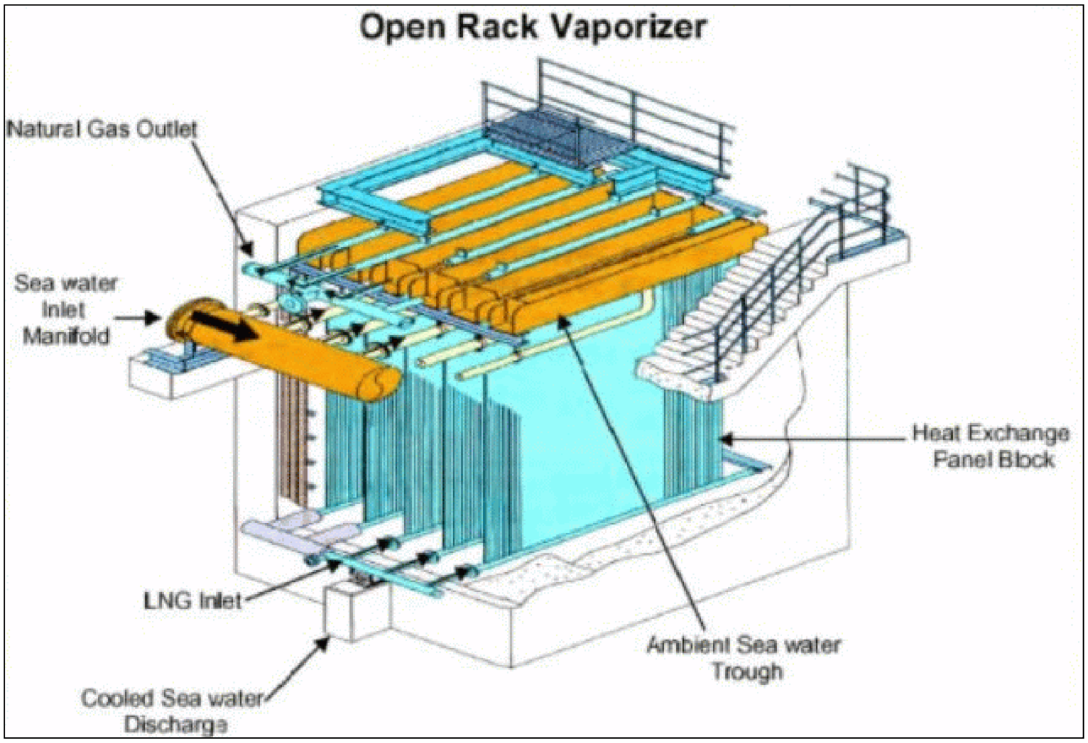

Figure 3: Schematic of an Open Rack Vaporizer (ORV)

4.2 Emissions and Effluents

Chlorination of the seawater is used to prevent or reduce bio-fouling. Typically, sodium hypochlorite would be injected continuously to maintain a concentration of 0.2 ppm. In order to shock the system, elevated concentrations of 2.0 ppm would be injected for 20 minutes every 8 hours, during ORV operation. De-chlorination of the effluent may be required to meet environmental standards. Also there may be limits for the discharge temperature differential below the inlet temperature due to marine environment impacts. However, even with chlorination there is a need to periodically shutdown the units for removal of biofouling and sediment accumulations. This means at least one spare unit is needed to allow for this cleaning cycle. In the case of the GPA facility, 2 x 100% (34 mmscfd each) ORVs would be recommended.

The lack of combustion is a positive for ORV technology; emissions do not include harmful products of combustion or particulate matter. Seawater return temperature is typically the main issue of environmental concern as the seawater will typically reduce in temperature by as much as 10 - 13°F.

4.3 Physical Characteristics

ORV arrangements require considerable amounts of space and consideration must also be given to weight-bearing capacity in their supporting structures. While the GPA vaporizers at 2 x 100% would be considerably smaller; Figure 4 illustrates a typical 2 unit ORV system at 120 T/hr each or approximately 135 mmscfd each:

Figure 4: Typical 2 each Open Rack Vaporization (ORV) Arrangement

Consideration must also be given to the electrical power requirements to run seawater intake pumps, which would typically be the largest consumer of power in a LNG import terminal using this type of vaporization system. Also consideration must be given to the seawater intake, treating and discharge infrastructure required for once-through seawater use.

4.4 Capital and Operating Costs

ORVs typically cost at least 1.3 times the amount of an SCV. This does not include the infrastructure costs for pumping, filtering, treating and discharging once-through seawater. However, the long-term operating cost is a fraction of the normal SCV fuel cost.

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5 SHELL & TUBE VAPORIZER

Many technologies exist for shell & tube vaporizers but the basic principles remain the same: LNG is pumped through the tube side of a conventional shell & tube heat exchanger, while a heat transfer fluid runs in a continuous loop from a heat source to the shell side of the unit, thus vaporizing the LNG. The main variations among shell & tube exchangers are the source of heat and the heat exchange medium.

5.1 Common Shell & Tube Configurations

5.1.1 Glycol/Water (G/W) Solution Vaporizer

The heat exchange medium for shell & tube LNG vaporizers has traditionally been a G/W solution. The G/W solution has excellent heat transfer characteristics and it can operate over a wide range of temperatures and pressures. A typical 50/50 percent mixture of G/W freezes at temperatures below -40°F so the potential of freezing is minimized. The G/W system is typically used in conjunction with a fired heater although various waste heat sources could also be used to heat the G/W solution such as waste heat or ambient air. G/W solution vaporizers are commonly used in the small to large capacity LNG Peakshaving units in North America; however they have also gained favor in LNG import facilities that use indirect ambient air heaters. Typically the shell and tube vaporizers can be located at a distance from the G/W heaters allowing for flexibility in locating the equipment on the available site plan. Figure 5 below illustrates a typical vertical G/W Shell & Tube configuration. See Figure 6 below for typical G/W heater installation:

Figure 5: 3 x 30 mmscfd Each Shell & Tube LNG Vaporizer Installation

Figure 6: Redundant gas-fired package heaters supporting small G/W vaporizer installation

5.1.2 Intermediate Fluid Vaporizer (IFV)

The IFV uses a two step process to achieve LNG vaporization and heating. First, LNG is pumped through tubes which are suspended in an intermediate heat transfer chamber. Seawater is pumped through a separate bank of tubes at the bottom of the intermediate heat transfer chamber. The heat transfer fluid is vaporized (boiled) by the seawater heat, it is then condensed by the LNG in the upper tube bundle. The heat transfer fluid is chosen based on its vaporization temperature and typically propane or butane is used. The intermediate fluid condensation transfers a large quantity of heat (heat of vaporization) from the heat transfer fluid into the LNG, effectively vaporizing it. The use of a properly chosen intermediate fluid also prevents any freezing of the seawater because it is not in direct contact with the LNG. The vaporized natural gas then flows through a heating chamber where it is raised to a suitable sendout temperature by the incoming warm seawater. An example of the IFV process is illustrated in Figures 7 and 8:

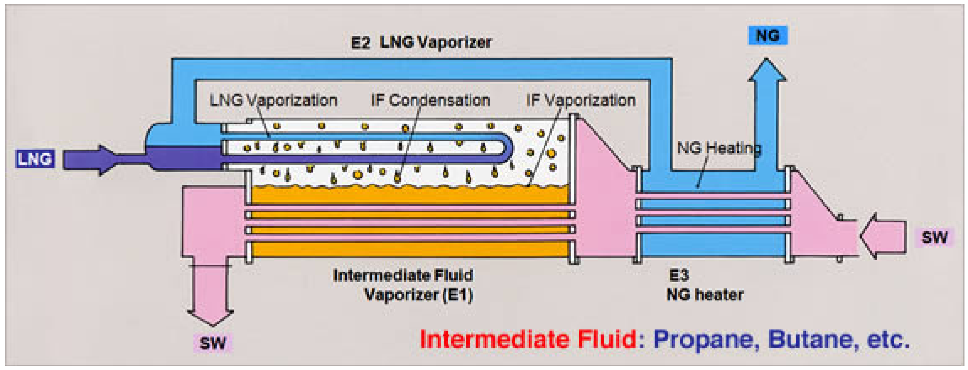

Figure 7: Schematic of an IFV type Shell & Tube Vaporizer

Figure 8: Typical self-contained IFV installation using seawater for heat source (See Fig 7 for schematic diagram)

IFVs are used commonly in Japan however they create an additional risk due to the presence of a highly combustible intermediate fluid and the capital cost is greater due to seawater handling infrastructure, similar to the ORV units.

5.1.3 Low Pressure (LP) Steam Shell & Tube Vaporizer

Low pressure steam or other heated fluid from nearby power facilities may be used directly in the shell side of the LNG vaporizer as a heat transfer medium. The waste heat stream can also be used indirectly to heat HTF in an intermediate heat exchanger. This can be a considerable cost savings through reduced need to burn natural gas; however an auxiliary boiler will usually be required during start-up and periods when the power plant waste heat is not available. The use of steam directly as a heat transfer media introduces the risk of freezing in the vaporizer and it is also more difficult to control. While possible, the use of steam directly is typically an unfavorable solution. More commonly the waste heat from a power plant would be used to heat a transfer fluid.

5.2 Performance

Shell and tube heat exchangers could be described as the workhorse of the LNG Peakshaving community for small to medium sendout volumes, 10 to 150 mmscfd. There are many installations of various forms across North America and they are optimal for smaller sendout installations due to their simple controls and operation, reliability, flexibility, easy startup, good turndown, proven capability, and overall low capital cost.

5.3 General Physical Requirements

Since these types of vaporizers are typically vertical in configuration, this arrangement requires relatively small amounts of space when compared to other available vaporization technologies. Also the fired heaters can be located at almost any distance from the vaporizers. However, the inclusion of fired heaters or heat source configurations requires additional space that can negate the effects of any space saving advantages of this technology.

IFV shell and tube heat exchangers are horizontal in arrangement and also require significant seawater handling equipment. Additional equipment for intermediate fluid storage is also typical. Overall the IFVs take a considerable amount of space.

5.4 Emissions and Effluents

The emissions from a shell & tube exchanger depend entirely on the heat source for the unit. A system that utilizes waste heat from a nearby facility will generate little negative effects. A seawater IFV unit would require similar seawater pumping infrastructure as the ORV, it would be slightly chlorinated and it would be returned at a reduced temperature.

The vertical shell-and tube exchanger utilizing a gas-fired G/W heat source would produce only the air emissions associated with the packaged heater. Typical air emissions data for a 25 mmBtu/hr low NOx burner associated with a Gas-Fired Heater is presented in Table 2:

Table 2: Rated Air Emissions from Gas-Fired Heater

Gas	PPMVD @ 3% Excess O_2
NOx	<12
CO	<40
VOC	<10

It should be noted that Gas-Fired Heaters are very compatible with SCRs due to the high temperature of the exhaust. Hence, SCRs work very efficiently when installed on packaged Gas-Fired Heaters and are capable of reducing NO_x and CO emissions rates even further.

5.5 Capital and Operating Costs

The capital cost of the G/W shell and tube arrangement with fired heaters is typically less than SCV and ORV units for smaller systems, but loses its advantage for the larger capacity systems. Operating costs will include the natural gas usage and power consumption charges which are based on horsepower requirements for the HTF circulation pumps and combustion air blowers. Overall the operating cost is typically a little higher than an SCV unit due to being slightly less thermally efficient, unless waste heat can be utilized.

IFV type shell & tube exchangers would be somewhat higher in capital cost and they would use a significant amount of electricity to pump the seawater through the system, similar to an ORV. Operating costs overall would be considerably less than a system using gas fired heaters as no natural gas is burned.

Vaporizer systems that use waste heat are very advantageous with regard to operating costs however they typically require more capital expenditure in the form of auxiliary equipment and customized engineering. Systems using ambient air as the heat source fall under the category of "Indirect Ambient Air Vaporizers."

6 AMBIENT AIR VAPORIZATION

Ambient Air vaporization systems draw heat to vaporize LNG from the surrounding ambient air. There are two primary methods of implementing the ambient air vaporization concept: direct and indirect vaporization. In both methods, the temperature at which the vaporized LNG leaves the system is heavily dependent on the ambient temperature of the surrounding environment. In the case of direct ambient air vaporization, the length of time the vaporizer has been on-line also is a factor. As a result of this drawback, in most climates, during cooler seasons and as unit heat transfer efficiency declines, added supplemental heat may be required for the vaporized LNG to meet the minimum specified gas sendout temperature. Different methods of providing supplemental heat are discussed later in this section.

6.1 Direct Ambient Air Vaporizers (AAV)

At the heart of this technology is a very simple cryogenic liquid vaporizer. Such vaporizers have been used in liquid nitrogen, and other liquid gas service for over fifty years. In typical AAVs, the cryogenic liquid is passed through a manifold that divides the flow into a number of vaporizer units where a series of smaller flows are directed through individual vaporizer tubes. Each tube has aluminum fins for increased heat exchange area and is in direct contact with the ambient air. Figure 9 shows a schematic of a typical forced-draft Direct Ambient Air Vaporizer.

With forced-draft Direct AAVs, airflow into the unit is controlled by fans installed on top of the vaporizer. Each vaporizer unit can be shrouded on each side for the air to move through the vaporizer. Direct forced draft AAV are approximately 1.7 times more effective than Natural Draft AAVs, i.e., those not utilizing fans, thus requiring fewer units for the same heat duty. Figure 9 illustrates the Direct Forced Draft AAV concept while Figures 10 and 11 show pictures of a typical Direct Forced Draft AAV installation.

While AAVs are in operation, water condensation, frost and/or ice will build up on the surfaces of the units because -260°F LNG is vaporized directly against the ambient air. The longer a unit runs, the more frost and/or ice builds, which gradually reduces the performance of the unit. Hence, AAV units need to be periodically shut down and de-iced. Defrosting in the Guam location would simply require shutting off the LNG flow and leaving the fan operating pushing warm air over the ice build-up. This defrosting cycle also results in some condensed nearly pure water effluent that can be recovered or safely discharged, normally without environmental concern.

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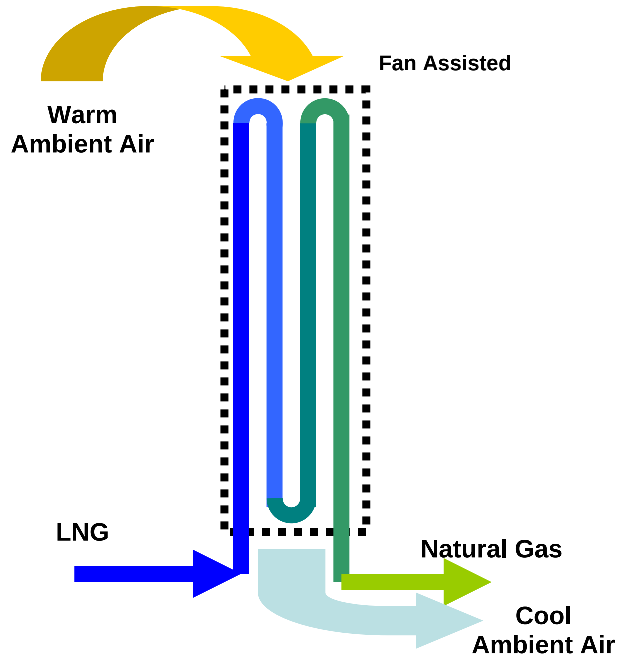


Figure 9: Schematic of a Force-Draft Ambient Air Vaporizer

Figure 10: Direct Forced Draft Ambient Air Vaporizers - without shrouds

Figure 11: Direct Forced Draft Ambient Air Vaporizers - with shrouds

6.2 Indirect Ambient Air Vaporizer

This section describes one vaporization method that involves the indirect use of ambient air heat exchangers to vaporize LNG. That is, LNG is not directly vaporized by ambient air, but instead heat from the ambient air is transferred to a heat transfer fluid which in turn transfers heat to the LNG.

This type of vaporization system has the following components: Shell and Tube Heat Exchangers, Fin-fan Air Heaters or Reverse Cooling Towers and a Heat Transfer Fluid (HTF) loop. Fin-Fan Air Heaters are used to heat the HTF which is then sent to the LNG shell and tube vaporizer. The cooled HTF is collected in a surge tank and pumped back to the Air Heaters. A schematic illustrating a typical AAV-HTF process is shown below in Figure 11.

This vaporization arrangement is in operation at the Dahej LNG import terminal in India and at the Lake Charles LNG terminal in Louisiana. Another variation of this technology is being used at the Freeport LNG project where Reverse Cooling Towers are used instead of the Fin-Fan Heaters.

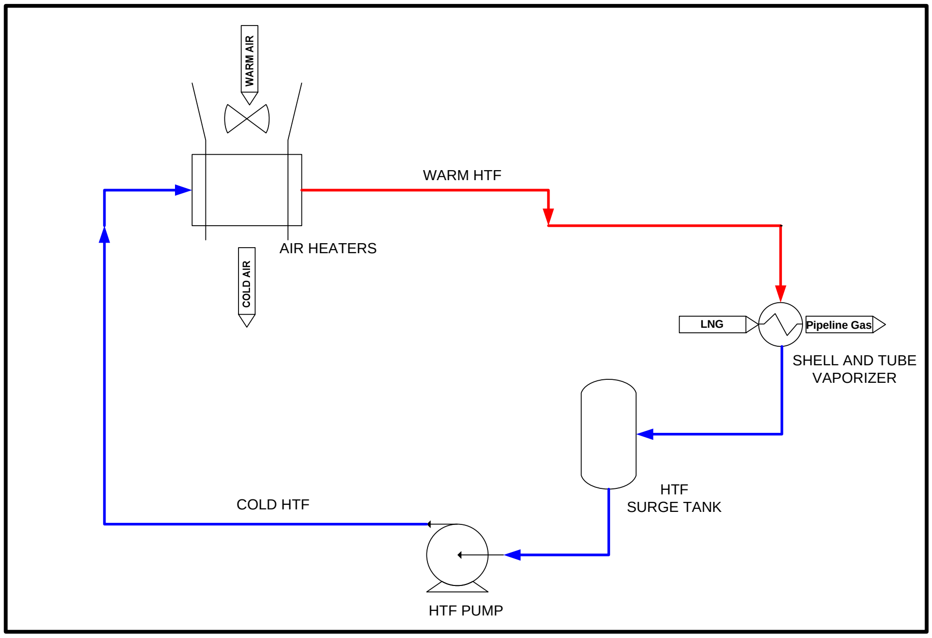


Figure 12: Schematic of AAV-HTF system using Air Heat Exchangers

6.3 Performance Comparison

The efficiency of the AAVs is dependent not only on ambient conditions but on other factors such as run time and amount of units in operation. Consider a single AAV unit: at the onset of operation, the temperature of the outlet stream is the same as the ambient temperature. As the run time increases, the unit begins to frost and/or ice up, thus reducing the amount of heat being transferred to the LNG. A significant amount of heat transfer is still achieved, but the temperature of the outlet stream reduces as time passes.

The performance of Forced Draft AAVs is similar to the Natural Draft AAVs, except that the airflow through these units is greater than the airflow Natural Draft AAVs are capable of achieving. Hence, fewer units will be required to achieve the same level of efficiency. Overall they have higher operating cost because they consume electrical power to run the fans.

While both natural draft and forced draft ambient air vaporization of liquefied gases, including LNG has been used for many years in small peakshaving and temporary LNG supply applications, it has not been applied to a continuous baseload LNG delivery system of the size proposed for GPA. However, with sufficient spare vaporizers included with the installation, CH·IV believes this risk can be mitigated.

Regarding Indirect AAVs, typical heating towers in operation in the U.S. Gulf Coast area are capable of delivering about 90% of the annual heat load. We believe in Guam this could be even higher. This availability is also applicable to Fin Fan Air Heat exchangers. These vaporization systems also have a significant electrical load for both air fans and HTF pumps.

All of the above AAV systems generally require some kind of back up gas-fired heating system when ambient temperatures are lower or sendout rates are higher than the design conditions. This is to supplement and provide trim heating for control of the minimum natural gas temperature leaving the facility. Additional capital cost is required to provide the backup systems.

6.4 Effluents Comparison

One of the advantages of using ambient air vaporizers is that they do not produce any air emissions other than water vapor fog. The fog generation must be understood to know if it would be a problem for the nearby surroundings. However, all ambient air vaporization methods create effluents[2] that need to be properly handled. Direct Ambient Air Vaporizers cause frost and/or ice build up on the tube bundles of each unit as a result of the freezing of condensed water from the ambient air that forms on the tubes. During the defrost cycle, all the water and ice falls off the unit and must be properly discharged. It may be necessary to design a system that mitigates the ice formation and reduces the defrost cycle time of AAVs especially on days when the rate of ice formation is high, i.e., calm, mildly warm, humid days.

Operation of Indirect Ambient Air Vaporizations systems can also create significant effluent streams. However, since air does not come in direct contact with the tubes containing LNG, there is no ice formation. The HTFs used in Indirect AAV systems do not get cold enough (after exchanging heat with the LNG) to cause significant cooling for ice formation. Nevertheless, the amount of fresh water formed by condensation of humidity in the air is still significant. A method for handling and disposing the cold condensed water is required.

6.5 Physical Characteristics

AAV arrangements present considerable requirements in terms of space and weight bearing capacity in their supporting structures. In Natural Drafts AAVs, the area requirement is exacerbated by the need to regenerate iced-up units, which, given availability requirements, may call for extra units to run while others are being de-iced. The typical ratio of units in operation to units de-icing is 2:1; meaning that if four AAV

2 For the purposes of this study, ice shall be considered and referred to as an effluent.

modules are required for the design vaporization rate, then a minimum of two additional modules would be required to allow for a de-icing cycle, resulting in six total modules or 150% of the design requirement. A standard sized transportable modular unit rated for about 10 mmscfd is approximately 12 x 12 x 42 ft. Each exchanger module weighs approximately 52,000 lbs when dry and can withstand ice loading up to 60,000 lbs. To meet the GPA needs, six (6) vaporizer module units would be required assuming they were each rated for at least 9 mmscfd.

The physical characteristics of Forced Draft designs are similar to Natural Draft AAVs. However, in the case of Forced Draft AAVs, fewer units would be required. De-icing would still be necessary however so the 2:1 ratio of units in service to units off line and de-icing would still apply.

The AAV-HTF system presents a significant demand on its supporting infrastructure because it requires space for the separate air handling units and the LNG vaporizer units.

6.6 Capital and Operating Costs

Capital costs for the Natural Draft AAV arrangement are high, estimated at approximately 1.4 times the capital costs of an SCV unit. Operating costs on the other hand would be low. The power input for these units is zero. There are no moving parts in the vaporizers and they are, for practical purposes, maintenance free. The only costs involved in operation would be those required to handle the effluents from the vaporizers.

The estimated total capital costs for Forced Ambient Air vaporizers are a little higher than the costs for Natural Draft AAVs. Operating costs for Forced Draft AAVs would be higher because of the amount of horsepower needed to run the fans for each unit.

Indirect AAVs require significantly higher capital cost. Shell and tube heat exchangers, fin-fan ambient air exchangers plus an HTF circulation system push up the equipment costs. Also, as stated earlier, Reverse Cooling Towers are massive structures and would require substantial capital investment for construction and operation. Power consumption costs due to ancillary equipment such as fans and pumps should also be taken into account, making this vaporization system very capital intensive.

7 CONCLUSIONS AND RECOMMENDATION

When considering optimum vaporization arrangements for the project, it is essential to weigh each alternative against the engineering, fixed capital cost, operating costs and regulatory realities governing the project. In the case of the proposed facility in Guam, the overall natural gas output requirement is relatively small at 34 mmscfd. Table 3 provides a qualitative look at the positives and negatives inherent to the vaporizers mentioned above.

It is CH·IV's recommendation when viewing this project from a feasibility perspective, that the best choice for LNG vaporization would be redundant (2 x 100%) gas-fired Water/Glycol heaters supplying redundant (2 x 100%) shell & tube heat exchangers. While an economic, reliability and operability analysis could be performed during the FEED phase evaluating some of the other vaporizer technologies, we believe our recommendation provides the correct balance of simplicity, flexibility, turndown, economy, reliability, performance and optional waste heat integration to move the project along.

GUAM LNG
LNG VAPORIZATION STUDY

Table 3: Qualitative Comparison of Vaporization Systems 34 mmscfd Capacity, Most Desirable - 5

	Estimated Capital Cost	Estimated Operating Costs	Effluents	Emissions	Turndown	Safety	Ease of Use	Footprint
SCVs	3	2	3	2	2	3	3	5
ORVs	1	4	2	5	3	4	4	2
S&T – G/W	5	2	5	3	4	4	4	5
S&T - IFV	2	4	2	5	3	1	4	2
S&T – LP Steam	5	4	4	5	4	3	3	4
AAV - Direct	3	4	3	4	5	4	2	2
AAV - Indirect	2	3	3	4	4	3	2	1

EXHIBIT D

Preliminary Design Basis

GPA Guam LNG Terminal Project

PRELIMINARY PROJECT DESIGN BASIS

LAND-BASED OPTION

by

CH·IV International

REV NUMBER:	**0**					
ISSUE PURPOSE:	Draft for Client Review					
DATE:	29 JULY 2011					
BY:	JAK					
CHECKED:						
APPROVED:						

Section **Page**

List of Tables

1 GENERAL

This document outlines the basic preliminary design criteria to be used for the proposed GPA Guam LNG Import Terminal (“Terminal”).

Guam Power Authority has asked RW Beck/SAIC to evaluate alternative fuel sources to generate electricity on the island of Guam. Currently use of liquid fuels such as Diesel and heavy fuel oil are used and the related costs have caused electricity costs to rise. One of the alternatives to be considered is the use of imported Liquefied Natural Gas (LNG) as a source for natural gas to be used in the generation of electricity. Part of the study is also to identify which facilities can be converted to natural gas fuel or to maintain a dual fuel capability. Two potential LNG import options are to be considered, a land-based conventional LNG Terminal and a self-contained FSRU (Floating Storage and Regasification Unit). This document is specific to the land-based conventional option. A separate document will address the FSRU design specifics that differ from the terminal described in this document.

The land-based Import Terminal option will be sized as a base-load regasification facility designed to receive approximately 0.3 Million Tons Per Annum (MTPA) of imported LNG via oceangoing LNG carriers from various suppliers and will be designed with an initial base-load natural gas sendout capacity of approximately 34 mmscfd. LNG will be stored in one 85,000 cubic meter (net) aboveground LNG storage tank and will be vaporized into natural gas via a vaporization system and exported from the Terminal via a sendout pipeline, designed for distribution to various GPA power plants and potentially other domestic and commercial users.

It is anticipated that there will be a need for LNG truck loading facilities for the purpose of delivering LNG to remote locations on the island not immediately accessible to a natural gas pipeline distribution system to be developed. There is also a potential market for LNG as vehicle fuel for use by the military and other commercial and municipal users. This would also need LNG truck deliveries to provide the LNG to vehicle fueling stations and satellite natural gas users. The design shall include facilities for one truck loading spot (expandable to two) to be supplied by Pumps from the LNG storage tank.

The scope of this document includes the on-shore LNG Import Terminal up to its battery limits and the piping systems and associated equipment on the marine facility. Excluded from the scope of this document are the details for the marine facility structure itself and the off-site natural gas sendout piping system.

1.1 Reference Documents

The document is supported by the following project specific documents:

- Terminal Preliminary Layout Plot Plan (Drawing No. 11911-DG-000-001)

- Process Flow Diagram (Document No. 11911-PF-000-001)

1.2 Definitions of Units and Conversion Factors

The units used for this project are English units. See Appendix B for a table of units and conversion factors.

1.3 Glossary of Terms and Abbreviations

See Appendix C for a Glossary of Terms and Abbreviations used throughout this document and those documents referenced in Section 1.1 of this Design Basis.

1.4 Design LNG Compositions

The Import Terminal shall be designed to receive LNG from several possible LNG production facilities. Table 1.4 presents the range of compositions that will be used in the design of the Import Terminal systems and equipment.

Table 1.4 Design LNG Compositional Range

Component	LNG Units	Light Composition	Heavy Composition
Source		Peru	Australia
Methane	Mol %	89.05%	86.11%
Ethane	Mol %	10.38%	9.04%
Propane	Mol %	0.02%	3.60%
n-Butane	Mol %	0.00%	0.42%
i-Butane	Mol %	0.00%	0.52%
n-Pentane	Mol %	0.00%	0.01%
i-Pentanes	Mol %	0.00%	0.00%
Nitrogen	Mol %	0.54%	0.30%
Molecular Weight		17.57	18.76
Gross Heating Value	Btu/scf	1088.3	1156.5
Hydrogen Sulfide	ppm by vol.	nil	nil
Total Sulfur	ppm	nil	nil
Mercaptan Sulfur	ppb	nil	nil

2 DESIGN CODES AND STANDARDS

The Terminal shall be designed in accordance with DOT 49 CFR 193, Latest Edition and NFPA 59A, "Standard for the Production, Storage, and Handling of Liquefied Natural Gas (LNG)," 2001 and 2006 editions by reference in DOT 49 CFR 193.

A complete listing of other codes and standards to be used in the design, construction and operation of the Terminal will be provided during preliminary engineering. Additional codes and standards may be applicable and substitutions for the listed codes and standards may be used during the preparation of the Terminal FEED. All applicable local codes and standards that have not been included in the list shall be satisfied in the design.

3 TERMINAL DESIGN CAPACITY

3.1 Sendout Requirements

- A Base-load rate of approximately 34 mmscfd (net of internal shrinkage and any consumption, if applicable, within the Terminal). Plot plan space and tie-ins for future expansion of the sendout shall be included.
- A Peak-Load sendout rate that will be defined during Front End Engineering Design (FEED) subsequent to preparation of Terminal Heat and Material Balance Drawings.

3.2 Vaporization Facilities

- Baseload Natural Gas Sendout Rate .... 34 mmscfd
- Peak Load Natural Gas Sendout Rate .... TBD during FEED
- Minimum Natural Gas Sendout Rate
  (no venting, no carrier unloading) .... TBD during FEED
- Vaporization Heat Requirements .... TBD during FEED
- Glycol/Water Supply Temp to LNG Vaporizer .... TBD during FEED
- Glycol/Water Return Temp to Heater .... TBD during FEED
- Battery Limit Natural Gas Maximum Discharge Pressure .... 1000 psig
- Battery Limit Natural Gas Discharge Temperature .... 40 °F

3.3 LNG Truck Loading Facilities

- Number of Loading Stations .... 1 (expandable to 2)
- Loading Rate Each Station .... 300 gpm

3.4 Gas Transmission Line

- Diameter of Pipeline Leaving Site .... TBD during FEED
- Maximum Allowable Working Pressure: TBD during FEED (in accordance with pipeline design)
- Normal Operating Pressure at Pipeline Interconnect .... TBD during FEED

3.5 Design Sendout Cases:

The following design sendout cases will be simulated during the preparation of FEED.

Case 1 - Zero Sendout, No Carrier Unloading

Case 2 - Minimum Sendout Rate required for full vapor handling (no venting/flaring), No Carrier Unloading

Case 3 - Minimum Sendout Rate required for full vapor handling (no venting/flaring), With Carrier Unloading

Case 4 - Peak Sendout, With Carrier Unloading

Case 5 - Peak Sendout, No Carrier Unloading

4 TERMINAL MODES OF OPERATION

The following describes the normal operating modes of the Terminal

4.1 LNG Sendout without Carrier Unloading

When operating in this mode the in-tank, column mounted LNG pumps will circulate LNG through a small diameter circulation line to the marine facility and back through the LNG transfer pipeline to the LNG storage tanks in order to keep these piping systems cold. LNG is also sent from the storage tank to the BOG condenser and suction drum of the HP pumps prior to vaporization and sendout.

In this operating mode boiloff gas (BOG) is continuously generated in the LNG storage tanks due to heat leak into the system piping, heat leak through the insulated tank walls, and heat added by the in-tank LNG pumps. BOG will be compressed by the BOG Compressors and sent to the sendout line.

4.2 LNG Sendout with Carrier Unloading

A single LNG carrier will moor at the unloading berth. Following berthing, hook up of the unloading arms and testing of the ESD systems the unloading arms will be cooled. The LNG carrier will use onboard pumps to transfer the LNG through the unloading arms and the LNG transfer pipeline to the LNG storage tank.

During carrier unloading, vapor in the LNG storage tanks will be displaced by the LNG pumped into the storage tanks. Some of the displaced vapor will be returned to the carrier by the vapor return system, a vapor return pipeline and a vapor return arm connected to the carrier. Vapor return rate will be controlled to maintain the pressure in the carrier’s tanks.

Additional BOG will be generated due to the heat added by the carrier’s transfer pumps and the heat leak into the tank and piping systems. Any excess BOG not returned to the carrier will be compressed by BOG compressors and sent to the sendout line.

5 BASIS OF DESIGN AND SITE CONDITIONS

5.1 Barometric Pressure

- Average Barometric Pressure (at MSL) .... TBD mbar
- Maximum Average Barometric Pressure (at MSL) .... TBD mbar
- Minimum Average Barometric Pressure (at MSL) .... TBD mbar
- Maximum Rate of Change per Hour of Barometric Pressure.................. TBD mbar

5.2 Air Temperature

- Maximum Design Temperature ....TBD °F
- Minimum Design Temperature ....TBD °F
- Basis for heat leak calculations...95°F

5.3 Wind Speeds

- Basis for heat leak calculations...10 mph
- LNG Storage Tank Wind Velocity Design Basis ....TBD during FEED
- Process Equipment Wind Velocity Design Basis ....TBD during FEED
- Buildings Wind Velocity Design Basis[2] ....TBD during FEED

5.4 Seawater Temperature

- Annual Maximum ....TBD during FEED
- Annual Minimum..TBD during FEED
- Annual Average ....TBD during FEED

5.5 Seismic Information

- Seismic Zone ....TBD during FEED

5.6 Tsunami

- Tsunami Protection ....TBD during FEED

6 DESIGN LIFE

The minimum design life for all facilities, excluding marine, shall be 25 years. After 25 years operation, the Terminal may be subject to a program of refurbishment to extend the life. Equipment and components normally subject to wear and deterioration need not have a life of 25 years. These pieces of equipment shall, however, be designed to have maximum practical life and shall be designed so as not to prevent Terminal operation at full load except for scheduled maintenance activities arranged in accordance with the operating and maintenance instructions. For marine structures and facilities the minimum design life shall be 40 years.

7 PROCESS DESCRIPTION

7.1 LNG Unloading

LNG will be delivered to the single unloading berth on the marine facility in carriers that are expected to range in size up to 85,000 m^3. The following parameters shall be assumed in the preparation of the Terminal FEED

7.1.1 LNG Carrier Design Requirements

- The Terminal will have a single berth and unloading platform.
- The Terminal will be capable of unloading LNG at a maximum rate of 7,500 m^3/hr via 2 x 16" LNG unloading arms. A single 16" vapor return arm will be used to return vapors displaced from the LNG storage tank to the carrier.
- The minimum available pressure at the carrier's LNG unloading manifold flange is 330 feet of head (approximately 65 psig, but is a function of LNG specific gravity).

7.1.2 Terminal Design Requirements – Boil Off Gas (BOG)

During carrier unloading, vapor in the LNG storage tanks will be displaced by the newly added LNG. The displaced vapor will be returned to the carrier through a vapor return line and a vapor return arm connected to the carrier in order to maintain the pressure in the carrier's tanks. Additional Boil Off Gas (BOG) will be generated due to the heat added by the carrier's transfer pumps and the heat leak into the LNG storage tanks and piping systems. Any BOG not returned to the carrier will be compressed by BOG Compressors and sent to the sendout pipeline. The following parameters shall be considered in the preparation of the Terminal FEED:

- The maximum allowable saturation pressure of a carrier's cargo on arrival at the Terminal is 2.5 psig.
  Note: this is the equilibrium pressure.
- The vapor return requirements from the Terminal to the carrier, as measured at the carrier's vapor return flange, are:
  - The maximum required vapor flow returned to the carrier is to include a normal boiloff rate from the carrier. A design boiloff rate of 0.15% of the full contents per day at 95°F ambient for newer carriers and a maximum boiloff rate of 0.25% of the full contents per day at 95°F

ambient for older carriers is to be considered in the preparation of the FEED.

- Design pressure at carrier vapor return flange = 1.45 psig.
- Maximum temperature at carrier vapor return flange = -180°F

7.2 LNG Storage

The terminal shall have a total, net LNG storage capacity of 85,000 m^3. This represents approximately 60 days of supply at rated sendout.

The 85,000 m^3 (net) LNG storage tank will be a flat-bottomed, vertical, cylindrical, single containment design. The choice in LNG storage tank design is described in the LNG Storage Tank Design Assessment document (TBD).

The LNG storage tank and foundation design shall be based on the results of the site specific geotechnical investigation and site specific seismic hazard evaluation.

If the outer tank base is in direct contact with the ground, a tank foundation heating system will be provided to prevent subsoil freezing and frost heave below the tank. The base heating system for the tank will be fully redundant.

The maximum allowable design vacuum on the tank will be determined by the tank designer but shall not be less than 2.0" w.c. A tank pressure maintenance system will be provided to prevent vacuum conditions from occurring during normal operation. A vacuum relief system will be installed on the tank and will be sized for the worst case conditions. A tank design maximum allowable operating pressure of 2.0 psig is recommended to allow free flow of vapor back to the LNGC during unloading without the need for blowers.

The heat leak into the LNG storage tank will give a maximum boiloff of 0.05% per day at 95°F ambient temperature, based on pure methane and a full tank (to be confirmed by site data during preparation of the FEED).

The storage tank will be designed to handle the full discharge rate from the LNG carrier through either top or bottom fill connections.

Instrumentation will be provided for continuous level, temperature and density measurements throughout the level of the tank inventory to monitor for stratification of the tank contents. Features shall be provided in the design to rapidly circulate the stored LNG to thoroughly mix the contents, should stratification start to develop.

7.3 LNG Pumps

There will be two LNG pumping systems installed at the Terminal:
Low Pressure (LP) Circulation Pumps and High Pressure (HP) Sendout Pumps.

The LP Circulation Pumps are column mounted submerged motor type and will be located inside and near the bottom of the LNG storage tanks. These will circulate a small quantity (approximately 300 gpm) of LNG continuously out to the marine unloading platform and returning to the HP Sendout Pump suction or directly into the storage tank to keep the unloading lines in the cold condition. These LP Pumps will also be used for the Truck Loading Supply.

The HP Sendout Pumps will be multi-stage centrifugal submerged motor type, vessel mounted and will be located outside and near the bottom of the LNG storage tank.

All pumps will be provided with an individual minimum flow recycle line and flow control to protect the pump from insufficient cooling and to maintain bearing lubrication at low flow rates. All pumps will have remotely monitored pressure, flow, vibration and motor amperage signals.

All pumps will be designed to be isolated and safely maintained without requiring other pumps to be removed from service. The LP and HP Pumps will be removable for maintenance while maintaining an operating level in the LNG storage tank.

HP pumps will be sized such that a single pump will be needed for the base load sendout of 34 mmscfd and a second pump will be maintained as a 100% standby.

The HP Pumps will discharge into a common manifold supplying the LNG vaporizers. Valves will be provided to safely isolate each pump from the system for maintenance purposes.

7.4 LNG Vaporization

The choice of a vaporization system is an important first step in the development of a LNG import terminal, since it impacts capital expenditure, operating costs, operating flexibility and reliability, air emissions, potential water discharges as well as public perception and regulatory compliance. A separate report on the different vaporization technologies is provided in document 11911-TS-000-002.

The process of transforming LNG back to a gaseous state requires the introduction of heat energy. Heat sources include ambient temperature sources (air or seawater), above-ambient temperature sources such as burning fuel either directly or to heat an intermediate fluid, and integrated heat sources, e.g. utilizing waste heat from an adjacent power facility. In any arrangement, LNG absorbs heat as it passes through thermal conductors that are surrounded by a higher temperature medium. As the LNG is heated, it vaporizes into natural gas, which is then delivered to customers via distribution pipelines at controlled flow rates, pressures and temperatures. There are many heating mediums in general use for this type of process and the particulars of the energy exchange process may be governed by any number of alternative vaporization processes currently available.

Historically, LNG import terminals have generally used either Open Rack Vaporizers (ORV) or Submerged Combustion Vaporizers (SCV) for LNG regasification purposes. ORVs use once through seawater as the heat source, are widely used in Asia and Europe, and are well proven in baseload LNG regasification service. When compared to other vaporization technologies, the higher emissions from SCV vaporizers and marine environment concerns associated with ORV vaporizers have prompted requirements to evaluate alternative vaporization systems. Recent developments in alternative vaporizer technologies include ambient air vaporizers with supplemental heating, shell and tube vaporizers with or without intermediate fluid with heat being supplied from an integrated facility, and/or combinations of each. There now exists proven design and operating experience for these alternative systems.

Primary objectives in the choice of a vaporization system are to minimize environmental concerns, optimize overall system cost effectiveness, maximize operating efficiency and reliability while considering the site location, prevailing ambient conditions, and also the operational requirements for the Import Terminal. The evaluation criteria that will be performed during the final selection of vaporization technology shall include:

- Source of heat: For the proposed Guam project, approximately XX mmBtu/hr of heat is required to vaporize approximately 34 mmscfd of LNG to a battery limit temperature of 40°F.
- Environmental issues: The impact to the environment from emissions and effluents will be an extremely important consideration in selecting a suitable vaporization system for the Terminal. In general, when compared to other vaporization systems, SCV vaporizers by virtue of their design and operating principle produce emissions and effluents in quantities that are generally of concern for the environment and may require the use of best available control techniques to reduce emissions in accordance with regulatory requirements. ORV vaporizers use seawater as their source of heat, which requires the withdrawal of seawater from the ocean and the return of seawater at a temperature significantly cooler than the surrounding ambient seawater temperature. Indirect ambient air vaporizers do not produce air emissions directly; however the power required for their support systems such as pumps and fans indirectly produces emissions and effluents which may require consideration. On the other hand Direct Natural Draft or Forced Draft Ambient Air Vaporizers produce no emissions but can produce significant quantities of water generated from melting ice formed on the surface of the vaporizer while in service. Air-born fog can also be a by-product of Ambient Air Vaporizers. Integration with an external heat source (e.g. a nearby power generating facility) can reduce emissions directly associated with the vaporization system.
- Efficiency issues: If there is an external source of heat (e.g. an adjacent power facility) and there is sufficient heat available to vaporize the required quantities of LNG then integrating both facilities can bring symbiotic benefits.

- Equipment costs: Capital and operating costs are significant factors that should be considered in the selection of vaporization systems. Indirectly associated with operating cost is the cost of heat generation.

For this preliminary study it is recommended for the design base-load sendout requirements given that a shell and tube vaporizer with 50% Glycol-Water heat transfer solution and gas fired water heaters be used. A 2 x 100% equipment installation is recommended. This provides a simple, reliable, relatively low cost, thermally efficient (approximately 98%) vaporization system that can be expanded later if required and can also easily be adopted to accept integration of power plant waste heat sources in the future.

Waste heat from the nearby power facility at the Cabras and Piti Power Station should be investigated regarding its use to warm an intermediate glycol water solution, which will in turn vaporize the LNG in shell and tube heat exchangers in a closed loop system. Integration of the power facility with the Import Terminal vaporization will maximize cycle efficiency, will likely be the most cost effective solution and will minimize emissions directly associated with the vaporization system.

7.5 Vapor Handling

Vapor handling equipment includes BOG Compressors, and a vapor return line used during LNG carrier unloading. Additional BOG from the LNG Tank will be generated due to the heat added by the carrier's transfer pumps and the heat leak into the tank and piping systems. Any excess BOG not returned to the carrier will be compressed by the BOG Compressors and will be used as fuel or sent to the natural gas sendout pipeline.

During extended periods of zero sendout or with loss of the BOG Compressors and the LNG storage tanks operating near their pressure relief setpoint, excess BOG vapor will be safely vented or flared through a specially designed Emergency Vent or Flare Stack.

No venting or flaring of methane during normal operations will occur. All LNG and Natural Gas relief valves excluding LNG Storage Tank, Fuel Gas Drum (if applicable) and the LNG Vaporizer process relief valves will be vented into a closed vent flare system that is common with the LNG storage tank vapor space.

8 TERMINAL RELIABILITY AND EQUIPMENT SPARING PHILOSOPHY

The Terminal will be designed to operate with an availability of 98 - 99% and will assume a minimum (n+1) sparing philosophy for all process equipment critical to gas sendout and carrier unloading for the base-load sendout cases.

9 UTILITY / AUXILIARY SYSTEMS

The FEED for the Terminal will include the following utility and auxiliary systems, as required, to support the operation of the Terminal in each of the operating cases defined.

- Electrical Power Generation and Distribution, including: Power Substations, Transformers, Switchgear, Multiple Voltage Distribution, Emergency Standby Generation and UPS Systems.
- Nitrogen
- Potable Water
- Service Water
- Mechanical Handling Systems including Fixed Cranes and Lifting Devices
- Sanitary Sewer and Waste Water Treatment (if required)
- Storm Sewer and Drainage
- Utility Air and Instrument Air
- Diesel Fuel Oil Storage and Distribution (if applicable)
- Firewater and fire mitigation systems
- Heat Transfer Fluid Storage and Makeup System (if applicable)

10 CIVIL DESIGN

The FEED for the Terminal will include, at minimum, the following areas:

- Soil Improvement
- Foundations
- Paving
- Curbing (both roadway and LNG diversion, where appropriate)
- LNG Containment and Impoundment Design and Insulation Needs
- Pipe Supports
- Buildings
- Culvert / Bridge / Piping / Road Requirements
- Shoreline Stabilization and Improvement
- Equipment Grouting
- Fencing

11 INSTRUMENTATION AND CONTROL SYSTEMS

11.1 Design Considerations

A Terminal Plant Control and Monitoring System (PCMS) will be designed during the preparation of the FEED that will consist of field instrumentation and a number of microprocessor based sub-systems that will be located in strategically placed control centers throughout the Terminal. Primary operator interfaces will be provided at the Main Control Room (MCR) and at the Platform Control Room (PCR).

Sub-systems that make up the PCMS will include the Distributed Control System (DCS), Safety Instrumented System (SIS), Hazard Detection and Mitigation System (HDMS), Chromatographic Analyzer System, Gas Metering System, LNG Tank Gauging System, Vibration Monitoring System, and the Marine Instrumentation System.

The DCS will include a Supervisory Station that will be located in the Main Control Room (MCR) and will access (Read Only) process monitoring and alarm data. The Supervisory Station will be used to generate various operational and management reports. The DCS will communicate with each instrument sub-system via Modbus RTU protocol, utilizing Ethernet or serial connections, or hard-wired connections.

The Terminal will be controlled primarily from the MCR, which will be the primary operator interface and monitoring center for the Terminal. The MCR will be equipped with pushbuttons that activate the Emergency Shutdown (ESD) system. Operations personnel in the MCR will monitor critical alarms and process variables and will be able to manually shutdown the unloading operation.

The Platform Control Room will be the control center for unloading operations and will be located on the unloading platform and manned during LNG unloading operations. The PCR will be equipped with pushbuttons that activate the ESD system.

Local Control Station (LCS) shelters will be located in the vicinity of packaged equipment and will contain instrument cabinets and packaged equipment cabinets.

Field instruments will be connected via remote distributed I/O panels located in weatherproof enclosures or via marshalling racks in equipment rooms.

A completely independent, stand-alone, high integrity Safety Instrumented System (SIS) will be designed to implement process safety related interlocks.

A stand-alone independent Hazard Detection and Mitigation System (HDMS) will be designed to continuously monitor and alert the Technician of hazardous conditions throughout the Import Terminal due to fire or LNG/NG leaks. A more detailed description of the HDMS system is included in Section 12 of this Design Basis.

An LNG Storage Tank Gauging and Monitoring System will be installed that will consist of a microprocessor based networked inventory management system that will consolidate all level, temperature and density measurement associated with the LNG storage tank. The system will be interfaced with the DCS via non-redundant Ethernet or serial link.

A Vibration Monitoring System will be designed to monitor shaft vibration, axial displacement, and bearing temperatures of major rotating machines. A dedicated machine monitoring workstation will be provided in the MCR. Common alarms will be provided on the DCS. Trip signals will be hard-wired to the machine safeguarding system and alarmed on the DCS.

A Marine Monitoring System will be designed to aid LNG carrier berthing and navigation and will include the following control systems that will be provided and monitored at the PCR:

- Mooring Line Load Monitoring System;
- LNG carrier Berthing Monitoring System;
- Weather Monitoring System; and
- Unloading Arm Monitoring and ERS System

12 HAZARD DETECTION AND MITIGATION SYSTEMS

12.1 Design Considerations

The following considerations will be made during the preparation of the Terminal FEED.

12.1.1 Hazard Detection System

A comprehensive hazard monitoring system shall be provided. Elements of this system may include:

- Flammable gas detectors
- High and low temperature detectors
- Smoke detectors
- UV/IR flame detectors
- Manual local emergency shutdown (ESD) activation push buttons

All hazard signals will alarm both in the control room and locally. Local signals will be both audible and visual (strobe lights) and have distinctive alarms and colors for fire and flammable gas (leak) hazards. Where appropriate a hazard trip may initiate automatic shutdown of equipment and systems and may activate the ESD system.

The Hazard Detection and Mitigation Philosophy document will be developed during FEED engineering and will define the hazard detection equipment that will be installed at the Terminal and how it will integrate with the DCS system.

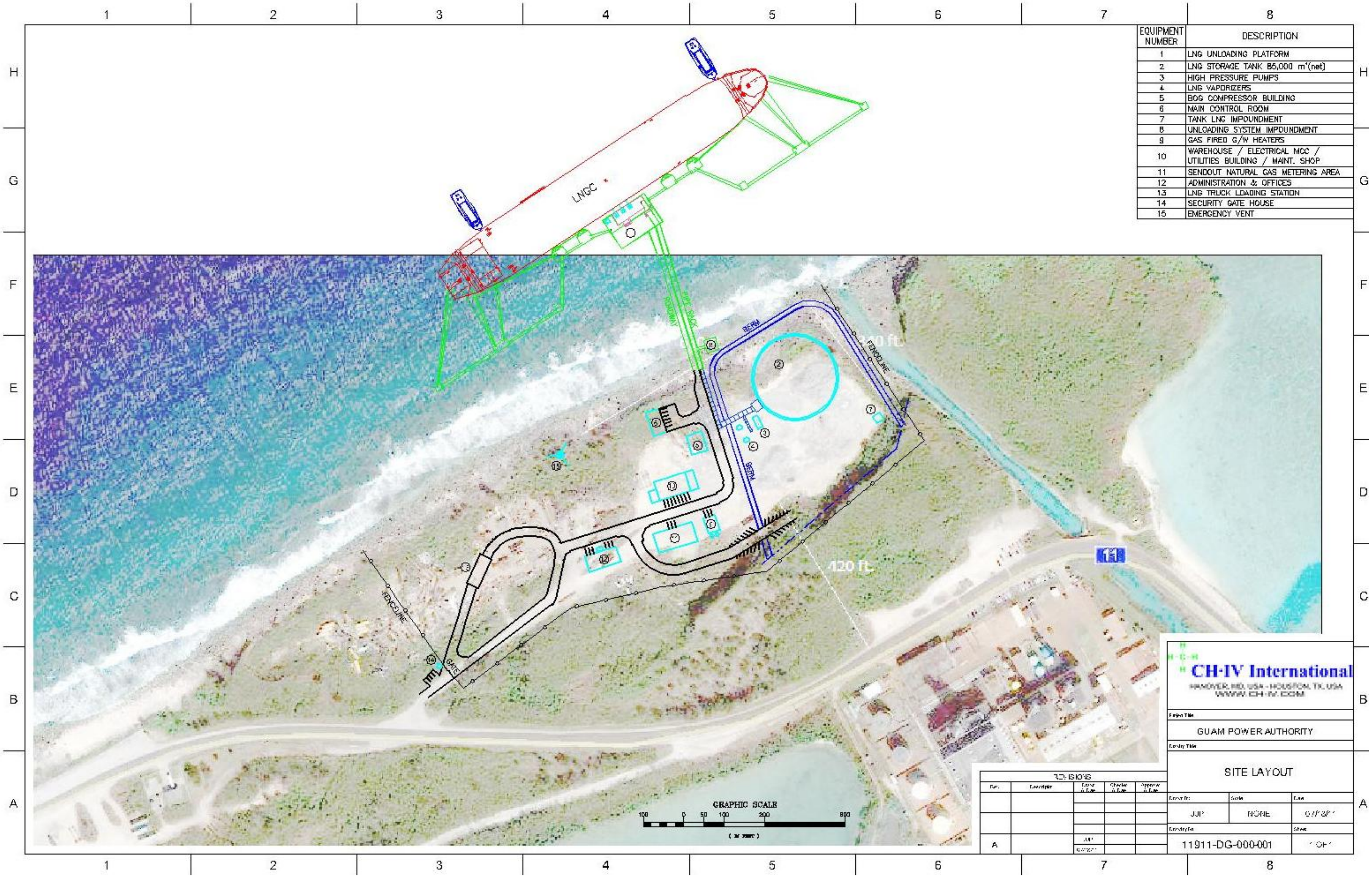
12.1.2 Hazard Mitigation

Fire water and, where appropriate, deluge systems shall be provided to protect personnel, equipment and facilities.

Hazards from potential LNG spills and vapor ignition shall be mitigated by a combination of fire and vapor suppression systems, which may include:

- Dry chemical systems
- Dedicated fire water system
- Dedicated water deluge and sprinkler applications
- High expansion foam systems.

Appendix A – Proposed Site Layout for Land-Based LNG Import Terminal Adjacent to Cabras/Piti Power Station



Appendix B: Units

Quantity (Base Units)	From Metric	To English	Multiply By
Electric Current	Ampere (A)	Ampere (A)	1.0
Length	meter (m)	feet (ft)	3.2808
Mass	kilograms (kg)	pound mass (lb_m)	2.2046
Temperature	degrees Celsius (°C)	degrees Fahrenheit (°F)	(°C x 1.8) +32
	degrees Kelvin (°K) =°C plus 273.15	degrees Rankine (°R) = °F plus 459.67	°K x 1.8
Time	second (s)	second (s)	1.0
Amount of Substance	mole (mol)	mole (mol)	1.0
Area	square meter (m^2)	square feet (ft^2)	10.764
Density	kilograms per cubic meter (kg/m^3)	pounds per cubic foot (lb/ft^3)	0.062428
Dynamic Viscosity	centipoises (μ)	pounds mass per foot-second (lb_m/ft-s)	0.00067222
Electric Resistance	Ohm (Ω)	Ohm (Ω)	1.0
Electromotive Force	Volt (V)	Volt (V)	1.0
Energy, Work, Quantity of Heat	Joule (J)	British thermal unit (Btu)	0.0009478
Enthalpy	Joule (J)	British thermal unit (Btu)	0.0009478
Entropy	Joule per degree Celsius (J/°C)	British thermal unit per degree Fahrenheit (Btu/°F)	0.000526
Feed Composition	mole percent (Mole%)	mole percent (Mole%)	1.0
Force	Newton (N)	pound force (lb)	0.2248
Frequency	Hertz (Hz)	Hertz (Hz)	1.0
Fluid Flow Rate (Volumetric)	cubic meters per hour (m^3/h) or kiloliters per hour (kl/h)	U. S. gallons per minute (gpm)	4.4028
Gas Flow Rate (Volumetric)	normal cubic meters per hour (Nm^3/hr)	standard cubic feet per day (scfd) (approx.)	895.92
Linear Acceleration	meters per second squared (m/s^2)	feet per second squared (ft/s^2)	3.2808
Linear Velocity	meters per second (m/s)	feet per second (ft/s)	3.2808
LNG Trade	metric tons	standard cubic feet (scf) (approx.)	46,865

Appendix B: Units

Quantity (Base Units)	From Metric	To English	Multiply By
Mass Flow Rate	kilograms per hour (kg/h)	pounds mass per hour (lb_m/h)	2.2046
Moment of Force	Newton meter (N-m)	foot-pound (ft-lb)	0.73756
Power	Watts (W)	British thermal unit per hour (Btu/h)	3.4134
	Watts (W)	horsepower (hp)	0.0013405
Pressure	Pascals (Pa) or Newtons per square meter (N/m^2)	pounds per square inch – gage or absolute (psi)	0.0001450
	bar	pounds per square inch	14.5038
Quantity of Electricity	Coulomb	Coulomb	1.0
Rotational Velocity	revolutions per minute (rpm)	revolutions per minute (rpm)	1.0
Specific Enthalpy	Joule per kilogram (J/kg)	British thermal unit per pound mass (Btu/lb_m)	0.00042992
Specific Entropy	Joule per kilogram degree Kelvin (J/kg-°K)	British thermal unit per pound mass degree Rankine (Btu/lb_m-°R)	0.00023885
Stress	Newtons per square meter (N/m^2)	pounds per square inch (psi)	0.00014504
Thermal Conductivity	Watt per meter degree Celsius (W/m^2-°C)	British thermal unit inch per hour foot squared degree Fahrenheit (Btu-in/hr-ft^2-°F)	6.9335
Time	Minute (min)	minute (min)	1.0
	hour (h)	hour (h)	1.0
Volume	cubic meters (m^3)	cubic feet (ft^3)	35.314
Volume (Liquid)	liters	U. S. gallons	0.2642
Weight	Metric tons	pounds (lbs)	2204.62

Appendix C: Glossary of Terms and Conditions

Term / Abbreviation	Definition
°C	Degree Celsius
100 Year Event	Something that based on historical data would not occur more than once in 100 years.
ACI	American Concrete Institute
API	American Petroleum Institute
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
Bar, bara	Bar absolute
Barg	Bar gauge
Bathymetric	Relating to the measurement of depths of water in oceans, seas, and lakes.
Battery Limit	The exterior limit of the terminal equipment or land, beyond which the terminal has no immediate responsibility.
BBL (bbl)	barrel, 42 U.S. gallons
Berth	The location where a ship is moored for loading.
BOG	Boil Off Gas
BOP	Balance Of Plant (Scope of this document)
C1	Methane
C2	Ethane
C3	Propane
Cathodic Protection	A means of protecting metals against corrosion by supplying a small electric charge (negative) to the surface, preventing the accumulation of corrosive ions.
Centrifugal Pump	A pump in which the fluid flows axially through an inlet into an impeller and is accelerated by a rotating element, increasing the velocity and as a result, the pressure.
Cryogenic	Temperatures colder than -75°C [-100°F].
DB	Design Basis
DBA	decibel relative to human ear response to sound
DCS	Distributed Control System
Deluge	A system used to cover or spray essential equipment with water in the event of a fire.
Dolphin	A buoy or cluster of closely driven piles used as a fender for a dock, berth or as a mooring or guide for boats.
Dry Gas Seals	Seals on compressors that use dry gas as the sealing medium as opposed to liquids such as oil.
Ed	Edition
ESD	Emergency Shut Down
ESDV	Valve closed only in the event of ESD

Appendix C: Glossary of Terms and Conditions

Term / Abbreviation	Definition
ERS	Emergency Release System (on Loading and Vapor Arms)
FEED	Front End Engineering and Design
Frost Heave	A condition that occurs when the moisture in soil expands when frozen. This can develop very high upward forces when constrained under foundations such as those supporting LNG tanks.
Full Containment (FCT)	An LNG storage tank design in which concrete surrounds a two wall tank such that in the event of an inner tank containment failure, the LNG liquid and vapor will be fully contained within the concrete wall boundary.
Gross Heating Value	The total heat obtained from the combustion of a specified amount of fuel which is at 60°F when combustion starts, and the combustion products of which are cooled to 60°F before the quantity of heat released is measured.
Head	The pressure differential that causes a fluid in a pipeline or system to flow. Usually measured in terms of the height of liquid in a column.
Heat Leak	A general term used to describe heat added to the process fluid from the surroundings at any location in the terminal.
HP	High Pressure
HTF	Heat Transfer Fluid
iC4	iso Butane
iC5	iso Pentane
Impoundment	An area defined through the use of dikes or site topography for the purpose of containing any accidental spill of LNG or flammable refrigerants.
kW	kilowatt
LN2 or LIN	Liquid nitrogen
LNG	Liquefied Natural Gas
LNGC	Liquefied Natural Gas Carrier
LTS	LNG Transfer System
MCR	Main Control Room
MLLW	Mean Low Low Water
mmscfd	Million Standard Cubic Feet per Day
MTPA	Million Metric Tons Per Annum
nC4	normal Butane
nC5	normal Pentane
NFPA	National Fire Protection Association
P&ID	Piping and Instrumentation Diagram
PCR	Unloading Platform Control Room
PLC	Programmable Logic Controller
ppb	Parts per billion
ppm	Parts per million
PCMS	Process Control and monitoring System

Appendix C: Glossary of Terms and Conditions

Term / Abbreviation	Definition
Radiograph	A picture produced on a sensitive film surface by a form of radiation other than light, such as X-ray or Gamma ray. A means for inspection of welds.
Relief Valve	A valve that opens at a designated pressure and bleeds a system in order to prevent a build-up of excessive pressure that might damage the system.
RTD	Resistance Temperature Detector
Saturation Pressure	The pressure at which a vapor confined above a liquid will be in stable equilibrium with it. Below saturation pressure, some of the liquid will change to vapor, and above saturation pressure, some of the vapor will condense to liquid.
Seismic Zone	The site-specific seismic conditions that determine the level of design required for the components in the terminal such that they can withstand a probabilistic maximum considered earthquake.
SIGGTO	Society of International Gas Ships and Terminal Operators
Slug Cooldown	To introduce LNG into piping or equipment without requiring prior gradual cooldown.
SMLS	Storage and Marine Loading System
Stages	Higher pressure increases in a centrifugal pump or compressor can be achieved by using multiple “stages” in which two or more impellers are mounted in series on a common shaft. The velocity and pressure of the fluid increases as it is accelerated through each stage.
Submerged Electric Motor	A motor used to power cryogenic pumps in which the motor components and bearings are submerged in the process fluid, helping to keep the device lubricated and cooled.
TBD	To Be Determined
te	tonne or metric ton
TEMA	Tubular Exchanger Manufacturers Association
UPS	Uninterruptible Power Supply
UTM	Universal Transverse Mercator
UV/IR	Ultraviolet/Infrared as a method for flame detection
Vacuum	A pressure below atmospheric pressure
Vapor Handling System	A pressure controlled system used to guarantee a prioritized distribution of boiloff gas to the appropriate components within the terminal.
Vaporizer	A device used to convert LNG to natural gas by adding heat.
VJ	Vacuum Jacketed insulation system
w.c.	Water Column as a method of measuring pressure (see “Head” above)

EXHIBIT E

Pipe Routes


TANGUISSON PT
YIGO
DEDEDO
MACHECHE
RTE 16 BRANCH
CABRAS
PITI BRANCH
TENJO VISTA
Image © 2011 GeoEye
Data LDEO-Columbia, NSF, NOAA
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
©2010 Google
Imagery Date: 2/17/2011
13°28'36.45" N 144°46'58.66" E elev 171 ft
Eye alt 14.54 mi
N

EXHIBIT F

Downtime Analysis

COAST & HARBOR ENGINEERING

Date: July 19, 2011

To: Tony Petroccitto, Winzler & Kelly

From: Scott W. Fenical, PE

Subject: DRAFT Feasibility-Level Downtime Analysis
Guam Power Authority LNG Terminal

Tony,

The following technical letter was developed by Coast & Harbor Engineering (CHE) to provide Winzler & Kelly (W&K) with a feasibility-level evaluation of potential mooring and operational downtime at a proposed LNG marine terminal located outside Apra Harbor, Guam. The downtime data were developed to provide a feasibility-level insight into the impacts of coastal conditions (winds and waves) on operations and mooring. As such, they incorporate a significant measure of conservatism and the analysis should be revised with additional detail prior to any design efforts. The project site location outside Apra Harbor, Guam is shown below in Figure 1.

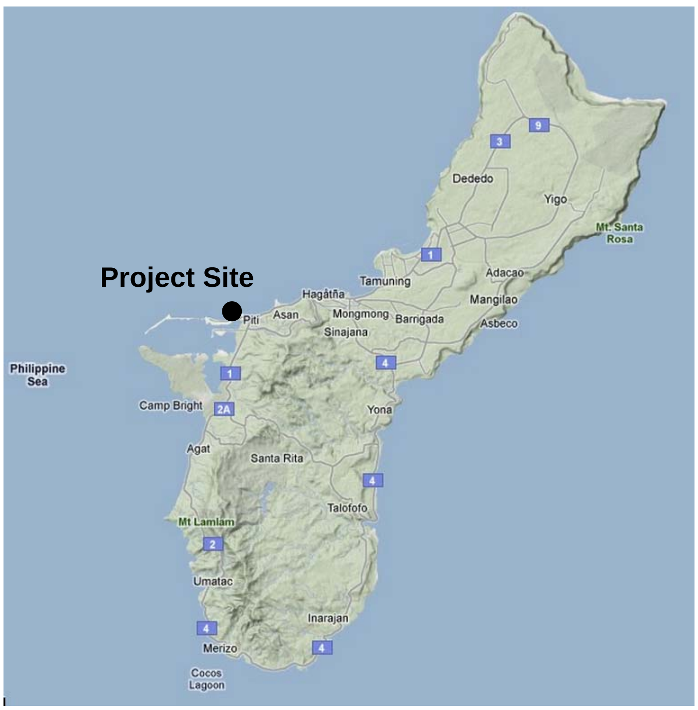


Figure 1. Project site location (Google Maps)

To determine potential downtime from winds and waves, CHE performed analysis using the following two datasets:

- Local wind data collected by Guam Power Authority, 2006-2010 (5 years). These wind data were collected at the Meteorological Tower of Cabras, Piti (Guam) at 60m elevation using 10-minute averages. The data were provided to CHE by W&K and are available on the web at http://guampowerauthority.com/special/renew1.php.
- Global wave conditions generated by NOAA using numerical modeling tools with measured data assimilation. These data consisted of approximately 10 years of offshore wave conditions at 3-hour intervals.

Downtime Criteria

Downtime is defined in this analysis as time in which operations must cease based on either berthed vessel motions or mooring system impacts which would cause the vessel to depart the terminal. Since the terminal and mooring system have not yet been designed and no mooring analysis has been performed, wind-induced downtimes are provided for a range of threshold wind speeds for informational purposes.

Wave-induced downtime values are based on allowable vessel motions. Criteria for allowable motions for berthed LNG vessels were taken from PIANC (1995) and consisted of 2-meter peak-to-peak motions in surge, sway and heave (heave limit assumed), as well as 2-degree peak-to-peak motions in pitch, roll and yaw. If the motion limits in any one or several of the 6 degrees of freedom were exceeded, it was assumed that downtime was incurred during that 3-hr time interval.

Design Vessels

Particulars for the two design moored vessels that were used in the analysis are provided below in Table 1. The vessel *Belanak* was intended to represent a common vessel, while *Celestine River* was intended to represent an upper bound on vessel size at the terminal. *Belanak* and *Celestine River* are shown in Figure 2.

Table 1. Design Vessel Particulars

Particular	*Belanak*	*Celestine River*
Length Overall (m)	257.0	289.7
Breadth (m)	34.0	49.0
Maximum Draft (m)	9.0	11.5
Dead Weight (mt)	51,579	77,163
Cargo Tank Type	Membrane	Moss Spherical
Cargo Tank Capacity (m^3)	75,000	145,000

Figure 2. ***Belanak (left) and Celestine River (right)***

Wave-Induced Downtime

The global wave model data were first filtered to remove waves originating from land, as the original model data does not possess sufficient resolution to evaluate nearshore effects. It should be noted that no wave transformation was performed; only the nearby deepwater data were used. Response Amplitude Operators (RAOs), or 6 degree-of-freedom vessel motion coefficients based on wave height and period, were generated for *Belanak* and *Celestine River* using CHE's seakeeping database. The data were generated using accurate vessel dimensions, with hull form data taken from a prototype tanker. The assumptions used in generation of the RAOs are expected to result in conservative downtime estimates appropriate for this feasibility-level effort. Mooring stiffness was ignored.

The 10-year wave database was analyzed and wave-induced vessel response in all 6 degrees of freedom was predicted at 3-hour intervals. The predicted motions were then compared with PIANC limits. The average annual wave-induced downtime based on the vessel motion criteria from PIANC is approximately 33% for *Belanak* and approximately 9% for *Celestine River*; however, the downtime for each vessel is significantly higher in December and January. Figure 3 shows the downtime by month for both vessels, and Table 2 provides the downtime estimates in tabular format.

Wind-Induced Downtime

Wind data were processed and converted to 10m elevation and 30-second duration appropriate for evaluation of mooring impacts. Since no mooring system has been designed, the average annual downtime and downtime by month are presented in Table 3 based on a range of wind speeds between 10 and 60 knots. For example, wind speeds greater than 30 knots occur only approximately 0.6% of the time, on an annual average basis. This can be interpreted to mean that the annual average operational/mooring downtime for a wind speed threshold of 30 knots is approximately 0.6%.

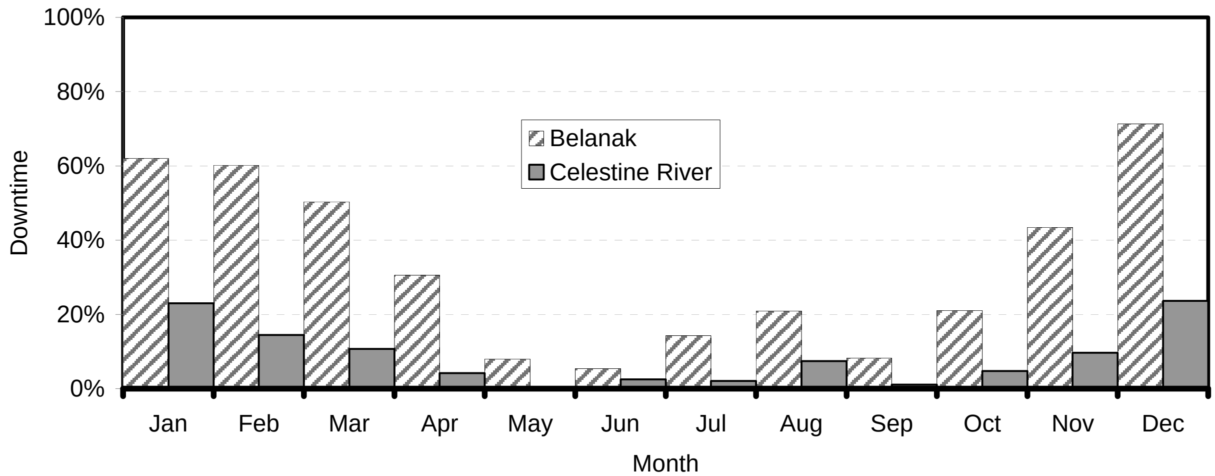


Figure 3. Wave-induced downtime by month for *Belanak* and *Celestine River*

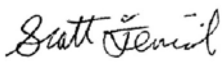
Summary

Mooring/operational downtime was estimated on a feasibility level using existing local wind and global wave model data. Based on the predicted wave and wind climate at the site, and the calculated LNG vessel response to the wave conditions, the annual average downtime for mooring and operations are up to approximately 34% for *Belanak*, and up to approximately 9% for *Celestine River*. However, seasonal analysis indicates that downtime will vary significantly throughout the year; downtime is likely to be less than 5% during certain summer months, but may be up to approximately 72% and 25% during certain winter months for *Belanak* and *Celestine River*, respectively. Since wave-induced downtimes dominate over wind-induced downtime, reductions in design vessel size will tend to increase downtime, while an increase in design vessel size will tend to reduce downtime.

Determination of whether the estimated downtime is acceptable for successful operation of the terminal is dependent on factors outside this analysis. Vessel motion limits for operations and mooring are specific to loading equipment and the terminal design, and should be evaluated in greater detail during conceptual design. Conceptual design efforts should also include local wave transformation and mooring analysis to more accurately define the potential terminal downtime. It is likely that with more refined wave and vessel motion analysis, conservatism can be removed and the projected downtime will be reduced.

Thank you for the opportunity to participate in this project. Please do not hesitate to contact me at (415) 773-2164 with any questions or comments.

Regards,



Scott W. Fenical, PE
Principal

References

Permanent International Association of Navigation Congresses (PIANC). 1995. *Criteria for Movement of Moored Ships in Harbours: A Practical Guide*. Working Group 24, Supplement to Bulletin #88. PIANC 1995

Table 2. Wave-Induced Downtime

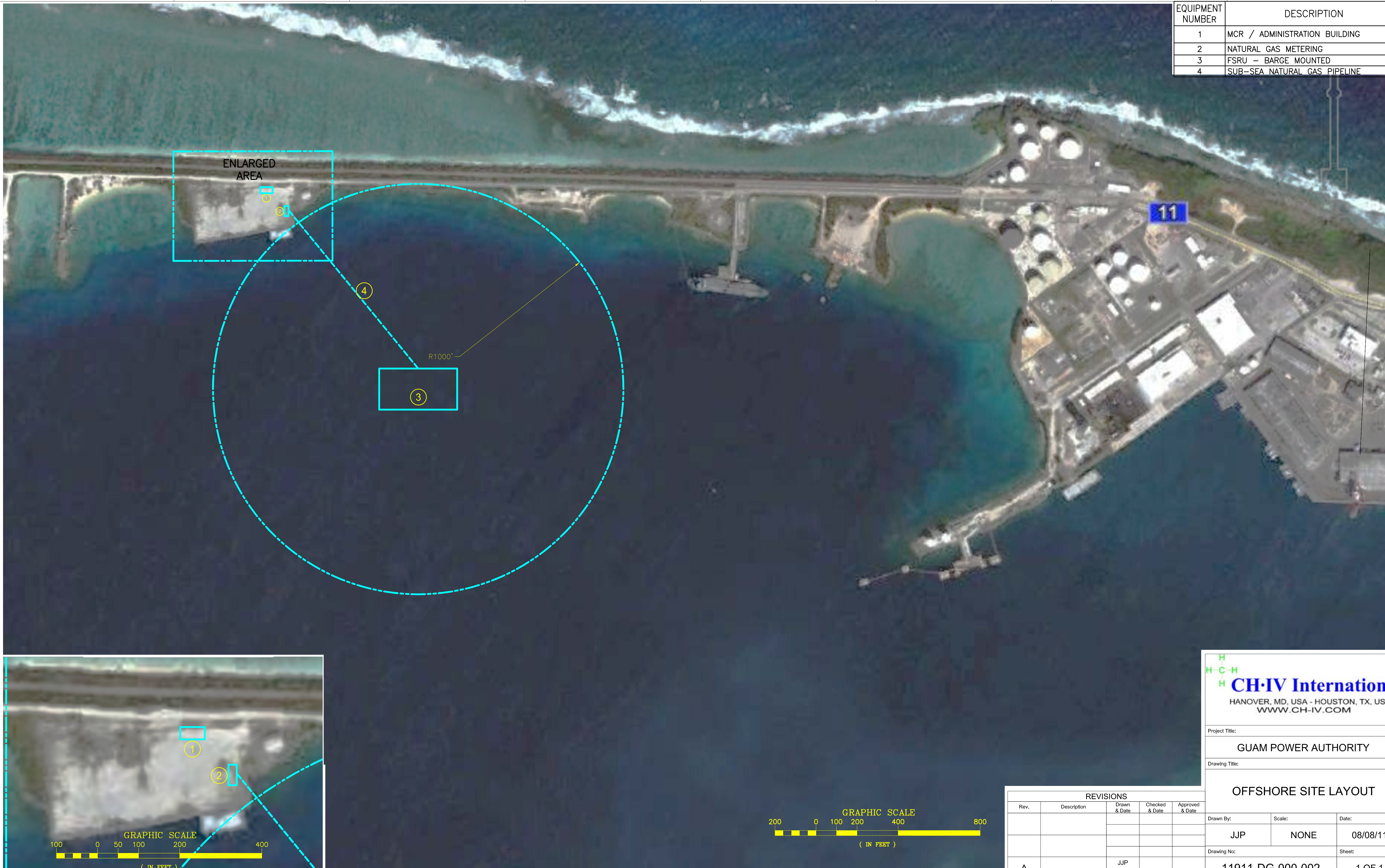
Vessel	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	AVERAGE ANNUAL
Belanak	62.1%	60.2%	50.3%	30.6%	8.0%	5.4%	14.3%	21.0%	8.3%	21.0%	43.4%	71.3%	33.0%
Celestine River	23.0%	14.5%	10.7%	4.2%	0.1%	2.5%	2.1%	7.5%	1.1%	4.8%	9.7%	23.7%	8.7%

Table 3. Wind-Induced Downtime

Downtime Threshold Wind Speed (knots)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	AVERAGE ANNUAL
10	62.5%	57.3%	54.1%	49.9%	33.7%	30.7%	23.4%	21.1%	20.5%	28.2%	49.1%	47.8%	39.8%
20	5.4%	2.3%	3.9%	0.3%	0.2%	0.4%	1.2%	2.6%	1.1%	2.0%	2.6%	1.7%	2.0%
30	0.7%	0.2%	0.1%	0.1%	0.1%	0.3%	0.3%	1.7%	0.4%	0.8%	1.7%	0.9%	0.6%
40	0.3%	0.1%	0.1%	0.1%	0.1%	0.3%	0.3%	1.3%	0.3%	0.6%	1.6%	0.8%	0.5%
50	0.3%	0.1%	0.1%	0.0%	0.1%	0.2%	0.2%	0.9%	0.1%	0.4%	1.6%	0.8%	0.4%
60	0.2%	0.1%	0.0%	0.0%	0.0%	0.2%	0.2%	0.7%	0.1%	0.3%	1.4%	0.7%	0.3%

EXHIBIT G

Offshore Site Layout



EQUIPMENT NUMBER	DESCRIPTION
1	MCR / ADMINISTRATION BUILDING
2	NATURAL GAS METERING
3	FSRU – BARGE MOUNTED
4	SUB–SEA NATURAL GAS PIPELINE

REVISIONS

Rev.	Description	Drawn & Date	Checked & Date	Approved & Date
A		JJP 08/08/11		

CH·IV International
HANOVER, MD, USA - HOUSTON, TX, USA
WWW.CH-IV.COM

Project Title: GUAM POWER AUTHORITY

Drawing Title: OFFSHORE SITE LAYOUT

Drawn By:	Scale:	Date:
JJP	NONE	08/08/11

Drawing No:	Sheet:
11911-DG-000-002	1 OF 1

W:\Projects – Import\Guam – RW Beck – 11911\Drawings\11911-DG-000-002 OffShore Site Layout Rev A.dwg, 8/15/2011 3:40:47 PM

EXHIBIT H

Conversion Data

Plant and Emission Data for LNG Feasibility Model

Plant Operating Characteristics

	Unit	Plant Type	Maximum Capacity (MW)		Full Load Heat Rate (Btu/kWh)		Minimum Capacity (MW)		Heat Rate at Min (Btu/kWh)		Planned Maintenance Rate (% time per year)		Equivalent Forced Outage Rate (% time per year)		Fuel Types Burned and Ratios (Name of Fuel and % of time per year)		Plant Variable O&M (all non-fuel variable) (2011 $/MWh)		Plant Fixed O&M (2011 $/KW-year)	
			Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
1	Cabras 1	ST	61.0	60.0	12,500	12,875	12.0	12.0	15,000	15,450	6.0	6.0	6.0	6.0	RFO No 6	LNG	5.00	4.75	56.00	53.20
2	Cabras 2	ST	60.3	60.0	11,300	11,639	12.1	12.0	15,150	15,605	6.0	6.0	6.0	6.0	RFO No 6	LNG	5.00	4.75	56.00	53.20
3	Cabras 3	SSD	38.4	37.9	8,230	8,339	22.0	21.0	9,100	9,220	8.0	8.0	2.5	2.5	RFO No 6	LNG	5.00	5.00	40.00	40.00
4	Cabras 4	SSD	38.4	37.9	8,230	8,339	22.0	21.0	9,100	9,220	8.0	8.0	2.5	2.5	RFO No 6	LNG	5.00	5.00	40.00	40.00
5	TEMES (Piti 7)	GE Fr 6B	40.0	40.0	11,500	11,500	20.0	20.0	14,750	14,750	6.0	6.0	3.0	3.0	RFO No 6	LNG	6.00	6.00	98.00	98.00
6	MEC (Piti 8)	SSD	44.2	43.7	8,300	8,395	28.0	28.0	9,175	9,280	5.0	5.0	2.0	2.0	RFO No 6	LNG	5.00	5.00	100.00	100.00
7	MEC (Piti 9)	SSD	44.2	43.7	8,300	8,395	28.0	28.0	9,175	9,280	5.0	5.0	2.0	2.0	RFO No 6	LNG	5.00	5.00	100.00	100.00
8	PRUVIENT (Tanguisson 1)	ST	24.8	24.0	13,400	13,802	6.4	6.4	16,550	17,047	8.0	8.0	4.0	4.0	RFO No 6	LNG	5.00	5.00	52.00	52.00
9	PRUVIENT (Tanguisson 2)	ST	24.8	24.0	13,400	13,802	6.4	6.4	16,550	17,047	8.0	8.0	4.0	4.0	RFO No 6	LNG	5.00	5.00	52.00	52.00
10	Tenjo 1	MSD	4.4	3.1	8,640	9,072	2.2	1.6	9,150	9,608	4.0	4.0	2.5	2.5	No 2	LNG	8.00	7.60	55.00	52.25
11	Tenjo 2	MSD	4.4	3.1	8,640	9,072	2.2	1.6	9,150	9,608	4.0	4.0	2.5	2.5	No 2	LNG	8.00	7.60	55.00	52.25
12	Tenjo 3	MSD	4.4	3.1	8,640	9,072	2.2	1.6	9,150	9,608	4.0	4.0	2.5	2.5	No 2	LNG	8.00	7.60	55.00	52.25
13	Tenjo 4	MSD	4.4	3.1	8,640	9,072	2.2	1.6	9,150	9,608	4.0	4.0	2.5	2.5	No 2	LNG	8.00	7.60	55.00	52.25
14	Tenjo 5	MSD	4.4	3.1	8,640	9,072	2.2	1.6	9,150	9,608	4.0	4.0	2.5	2.5	No 2	LNG	8.00	7.60	55.00	52.25
15	Tenjo 6	MSD	4.4	3.1	8,640	9,072	2.2	1.6	9,150	9,608	4.0	4.0	2.5	2.5	No 2	LNG	8.00	7.60	55.00	52.25
16	Yigo	LM2500	21.0	21.0	9,800	9,800	12.6	12.6	11,800	11,800	5.0	5.0	3.0	3.0	No 2	LNG	6.00	5.70	13.00	12.35
17	Macheche	LM2500	21.0	21.0	9,800	9,800	12.6	12.6	11,800	11,800	5.0	5.0	3.0	3.0	No 2	LNG	6.00	5.70	13.00	12.35
18	Dededo CT 1	GE Fr 5	22.0	22.0	13,280	13,280	17.6	17.6	17,100	17,100	6.0	6.0	3.0	3.0	No 2	LNG	6.00	5.70	12.50	11.88
19	Dededo CT 2	GE Fr 5	22.0	22.0	13,280	13,280	17.6	17.6	17,100	17,100	6.0	6.0	3.0		No 2	LNG	6.00	5.70	12.50	11.88
20	Dededo MSD 1	MSD	2.0		13,250		0.4		13,900		4.0		17.0		No 2					
21	Dededo MSD 2	MSD	2.0		13,250		0.4		13,900		4.0		17.0		No 2					
22	Dededo MSD 3	MSD	2.0		13,250		0.4		13,900		4.0		17.0		No 2					
23	Dededo MSD 4	MSD	2.0		13,250		0.4		13,900		4.0		17.0		No 2					
24	Talofofo 1	MSD	4.7		9,150		1.3		9,150		4.0		8.5		No 2					
25	Talofofo 2	MSD	4.7		1,950		1.3		8,150		4.0		8.5		No 2					
26	Paluntat 1	MSD	4.4		8,640		2.2		9,150		4.0		2.5		No 2					
27	Paluntat 2	MSD	4.4		8,640		2.2		9,150		4.0		2.5		No 2					

Plant and Emission Data for LNG Feasibility Model

	Unit	Plant Type	Plant Operating Characteristics (cont.) Upfront engineering Duration	Upfront engineering Spending ($ M)	Permitting Duration	Permitting Spending ($ M)	Procurement and Planning Duration	Procurement and Planning Spending ($ M)	Outage for conversion Duration	Outage for conversion Spending ($ M)	Emissions Rates Full load NOX (water injected on CTs) (lbs/MMBtu) Pre	Full load NOX Post	Full Load CO (lbs/MMBtu) Pre	Full Load CO Post	Full Load SO2 (lbs/MMBtu) Pre	Full Load SO2 Post	Full Load VOC (lbs/hr) Pre	Full Load VOC Post	Full Load Particulate Matter (lbs/hr) Pre	Full Load Particulate Matter Post
1	Cabras 1	ST	1-6	0.750	7-30	0.750	24-42	5.000	43-48	5.500	0.3236	0.2000	0.0344	0.0600	2.1620	0.0100	3.79	4.19	84.80	1.49
2	Cabras 2	ST	1-6	0.750	7-30	0.750	24-42	5.000	43-48	5.500	0.3236	0.2000	0.0344	0.0600	2.1620	0.0100	3.38	3.75	75.70	1.33
3	Cabras 3	SSD	1-6	0.750	7-30	0.750	27-36	6.000	37-39	6.000	2.2040	3.1700	0.1551	0.3860	1.5442	0.0100	12.82	12.82	57.90	0.01
4	Cabras 4	SSD	1-6	0.750	7-30	0.750	27-36	6.000	37-39	6.000	2.4296	3.1700	0.1055	0.3860	1.4805	0.0100	10.83	10.83	65.80	0.01
5	TEMES (Piti 7)	GE Fr 6B	1-6	0.400	7-30	0.400	27-39	0.600	40-41	0.600	0.0925	0.0900	0.0134	0.1100	0.3485	0.0100	3.20	0.97	14.40	0.87
6	MEC (Piti 8)	SSD	1-6	0.750	7-30	0.750	27-36	6.000	37-39	6.000	3.2999	3.1700	0.1777	0.3860	1.9387	0.0100	16.60	73.37	97.68	0.01
7	MEC (Piti 9)	SSD	1-6	0.750	7-30	0.750	27-36	6.000	37-39	6.000	3.3407	3.1700	0.1607	0.3860	1.8148	0.0100	16.40	73.37	93.56	0.01
8	PRUVIENT (Tanguisson 1)	ST	1-6	0.750	7-30	0.750	24-42	2.600	43-48	2.500	0.4435	0.2000	0.0014	0.0600	1.7220	0.0100	n/a	1.83	14.90	0.65
9	PRUVIENT (Tanguisson 2)	ST	1-6	0.750	7-30	0.750	24-42	2.600	43-48	2.500	0.3520	0.2000	0.0023	0.0600	1.9275	0.0100	n/a	1.83	18.60	0.65
10	Tenjo 1	MSD	1-6	0.125	7-30	0.125	27-36	0.400	37-39	0.400	1.6303	0.4000	0.3509	0.3500	0.0881	0.0100	2.28	2.28	2.28	0.01
11	Tenjo 2	MSD	1-6	0.125	7-30	0.125	27-36	0.400	37-39	0.400	2.0026	0.4000	0.4728	0.3500	0.0926	0.0100	1.59	1.59	2.42	0.01
12	Tenjo 3	MSD	1-6	0.125	7-30	0.125	27-36	0.400	37-39	0.400	1.8485	0.4000	0.3402	0.3500	0.0941	0.0100	1.61	1.61	2.42	0.01
13	Tenjo 4	MSD	1-6	0.125	7-30	0.125	27-36	0.400	37-39	0.400	1.8164	0.4000	0.3380	0.3500	0.0899	0.0100	2.36	2.36	1.65	0.01
14	Tenjo 5	MSD	1-6	0.125	7-30	0.125	27-36	0.400	37-39	0.400	1.8036	0.4000	0.3616	0.3500	0.0952	0.0100	2.34	2.34	1.91	0.01
15	Tenjo 6	MSD	1-6	0.125	7-30	0.125	27-36	0.400	37-39	0.400	1.6538	0.4000	0.3402	0.3500	0.0700	0.0100	1.76	1.76	2.10	0.01
16	Yigo	LM2500	1-6	0.150	7-30	0.150	27-39	0.750	40-41	0.750	0.1058	0.0900	0.0626	0.1100	0.3808	0.0100	0.04	0.43	9.77	0.39
17	Macheche	LM2500	1-6	0.150	7-30	0.150	27-39	0.750	40-41	0.750	0.1089	0.0900	0.0732	0.1100	0.2993	0.0100	0.03	0.43	10.00	0.39
18	Dededo CT 1	GE Fr 5	1-6	0.100	7-30	0.100	27-39	0.400	40-41	0.400	0.2028	0.0900	0.0323	0.1100	0.4149	0.0100	0.06	0.61	15.80	0.56
19	Dededo CT 2	GE Fr 5	1-6	0.100	7-30	0.100	27-39	0.400	40-41	0.400	0.2028	0.0900	0.0323	0.1100	0.4149	0.0100	0.06	0.61	15.80	0.56
20	Dededo MSD 1	MSD																		
21	Dededo MSD 2	MSD																		
22	Dededo MSD 3	MSD																		
23	Dededo MSD 4	MSD																		
24	Talofofo 1	MSD																		
25	Talofofo 2	MSD																		
26	Paluntat 1	MSD																		
27	Paluntat 2	MSD																		

Appendix F: COST ASSUMPTIONS

Fixed costs are in $/month, and includes labor cost and fixed management fees (for units under Performance Management Contract) or fixed O&M fees (for the Piti 8&9 ECA Extension).

Unit	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Cab 1	198,520	204,476	210,610	216,929	200,311	137,608	142,425	147,409	152,569	157,909	163,436	169,156	175,076	181,204	187,546	194,110	200,904	207,936	215,213	222,746
Cab 2	198,520	204,476	210,610	216,929	200,311	137,608	142,425	147,409	152,569	157,909	163,436	169,156	175,076	181,204	187,546	194,110	200,904	207,936	215,213	222,746
Piti 8	198,175	198,175	198,175	198,175	203,724	209,429	215,293	221,321	227,518	233,888	240,437	247,169	254,090	261,205	268,518	276,037	283,766	291,711	299,879	308,276
Piti 9	198,175	198,175	198,175	198,175	203,724	209,429	215,293	221,321	227,518	233,888	240,437	247,169	254,090	261,205	268,518	276,037	283,766	291,711	299,879	308,276
Piti 7	54,203	55,829	57,504	59,229	61,006	63,141	65,351	67,638	70,006	72,456	74,992	77,617	80,333	83,145	86,055	89,067	92,184	95,411	98,750	102,206
DCT 1	18,323	19,193	19,769	20,362	20,893	21,472	21,810	22,480	23,170	23,882	24,616	25,372	26,152	26,956	27,784	28,638	29,519	30,426	31,362	32,326
DCT 2	18,323	19,193	19,769	20,362	20,893	21,472	21,810	21,919	22,032	22,149	22,270	22,395	22,524	22,658	22,797	22,941	23,089	23,243	23,402	23,567
MCT	69,000	71,390	73,532	75,738	77,931	110,502	113,956	117,291	120,741	124,313	128,010	131,836	135,796	139,894	144,136	148,527	153,071	157,774	162,642	167,680
YCT	64,582	66,840	68,846	70,911	72,959	75,360	77,584	79,645	81,779	83,986	86,272	88,637	91,085	93,618	96,241	98,955	101,764	104,671	107,681	110,795
MDI 1	3,054	3,146	3,240	3,337	3,437	3,558	3,682	3,811	3,945	4,083	4,225	4,373	4,526	4,685	4,849	5,019	5,194	5,376	5,564	5,759
MDI 2	3,054	3,146	3,240	3,337	3,437	3,558	3,682	3,811	3,945	4,083	4,225	4,373	4,526	4,685	4,849	5,019	5,194	5,376	5,564	5,759
Tal 1	3,325	3,425	3,528	3,634	3,743	3,874	4,009	4,150	4,295	4,445	4,601	4,762	4,928	5,101	5,279	5,464	5,656	5,853	6,058	6,270
Tal 2	3,325	3,425	3,528	3,634	3,743	3,874	4,009	4,150	4,295	4,445	4,601	4,762	4,928	5,101	5,279	5,464	5,656	5,853	6,058	6,270
Ten 1	15,033	15,484	15,948	16,427	16,920	17,512	18,125	18,759	19,416	20,095	20,798	21,526	22,280	23,060	23,867	24,702	25,567	26,461	27,388	28,346
Ten 2	15,033	15,484	15,948	16,427	16,920	17,512	18,125	18,759	19,416	20,095	20,798	21,526	22,280	23,060	23,867	24,702	25,567	26,461	27,388	28,346
Ten 3	15,033	15,484	15,948	16,427	16,920	17,512	18,125	18,759	19,416	20,095	20,798	21,526	22,280	23,060	23,867	24,702	25,567	26,461	27,388	28,346
Ten 4	15,033	15,484	15,948	16,427	16,920	17,512	18,125	18,759	19,416	20,095	20,798	21,526	22,280	23,060	23,867	24,702	25,567	26,461	27,388	28,346
Ten 5	15,033	15,484	15,948	16,427	16,920	17,512	18,125	18,759	19,416	20,095	20,798	21,526	22,280	23,060	23,867	24,702	25,567	26,461	27,388	28,346
Ten 6	15,033	15,484	15,948	16,427	16,920	17,512	18,125	18,759	19,416	20,095	20,798	21,526	22,280	23,060	23,867	24,702	25,567	26,461	27,388	28,346
Yigo Diesel Generators	27,960	253,799	261,413	269,256	277,333	202,242	208,472	214,894	221,516	228,342	235,379	242,634	250,113	257,823	265,772	273,968	282,416	291,127	300,106	309,364

Table F-1. Fixed Cost

Variable costs are in $/MWH

Unit	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Cab 1	5.45	5.59	5.73	5.87	6.02	6.17	6.32	6.48	6.64	6.81	6.98	7.15	7.33	7.52	7.70	7.90	8.10	8.30	8.50	8.72
Cab 2	5.45	5.59	5.73	5.87	6.02	6.17	6.32	6.48	6.64	6.81	6.98	7.15	7.33	7.52	7.70	7.90	8.10	8.30	8.50	8.72
Piti 8	2.62	2.69	2.76	2.83	2.90	2.97	3.04	3.12	3.20	3.28	3.36	3.44	3.53	3.62	3.71	3.80	3.90	3.99	4.09	4.19
Piti 9	2.62	2.69	2.76	2.83	2.90	2.97	3.04	3.12	3.20	3.28	3.36	3.44	3.53	3.62	3.71	3.80	3.90	3.99	4.09	4.19
Piti 7	12.86	13.19	13.51	13.85	14.20	14.55	14.92	15.29	15.67	16.07	16.47	16.88	17.30	17.73	18.18	18.63	19.10	19.57	20.06	20.56
DCT 1	16.33	16.74	17.15	17.58	18.02	18.47	18.94	19.41	19.89	20.39	20.90	21.42	21.96	22.51	23.07	23.65	24.24	24.85	25.47	26.10
DCT 2	16.33	16.74	17.15	17.58	18.02	18.47	18.94	19.41	19.89	20.39	20.90	21.42	21.96	22.51	23.07	23.65	24.24	24.85	25.47	26.10
MCT	11.26	11.55	11.84	12.13	12.43	12.75	13.06	13.39	13.73	14.07	14.42	14.78	15.15	15.53	15.92	16.31	16.72	17.14	17.57	18.01
YCT	12.86	13.19	13.51	13.85	14.20	14.55	14.92	15.29	15.67	16.07	16.47	16.88	17.30	17.73	18.18	18.63	19.10	19.57	20.06	20.56
MDI 1	17.46	17.89	18.34	18.80	19.27	19.75	20.24	20.75	21.27	21.80	22.34	22.90	23.48	24.06	24.66	25.28	25.91	26.56	27.23	27.91
MDI 2	17.46	17.89	18.34	18.80	19.27	19.75	20.24	20.75	21.27	21.80	22.34	22.90	23.48	24.06	24.66	25.28	25.91	26.56	27.23	27.91
Tal 1	17.46	17.89	18.34	18.80	19.27	19.75	20.24	20.75	21.27	21.80	22.34	22.90	23.48	24.06	24.66	25.28	25.91	26.56	27.23	27.91
Tal 2	17.46	17.89	18.34	18.80	19.27	19.75	20.24	20.75	21.27	21.80	22.34	22.90	23.48	24.06	24.66	25.28	25.91	26.56	27.23	27.91
Ten 1	17.46	17.89	18.34	18.80	19.27	19.75	20.24	20.75	21.27	21.80	22.34	22.90	23.48	24.06	24.66	25.28	25.91	26.56	27.23	27.91
Ten 2	17.46	17.89	18.34	18.80	19.27	19.75	20.24	20.75	21.27	21.80	22.34	22.90	23.48	24.06	24.66	25.28	25.91	26.56	27.23	27.91
Ten 3	17.46	17.89	18.34	18.80	19.27	19.75	20.24	20.75	21.27	21.80	22.34	22.90	23.48	24.06	24.66	25.28	25.91	26.56	27.23	27.91
Ten 4	17.46	17.89	18.34	18.80	19.27	19.75	20.24	20.75	21.27	21.80	22.34	22.90	23.48	24.06	24.66	25.28	25.91	26.56	27.23	27.91
Ten 5	17.46	17.89	18.34	18.80	19.27	19.75	20.24	20.75	21.27	21.80	22.34	22.90	23.48	24.06	24.66	25.28	25.91	26.56	27.23	27.91
Ten 6	17.46	17.89	18.34	18.80	19.27	19.75	20.24	20.75	21.27	21.80	22.34	22.90	23.48	24.06	24.66	25.28	25.91	26.56	27.23	27.91
Yigo Diesel Generators	22.69	23.26	23.84	24.44	25.05	25.68	26.32	26.98	27.65	28.34	29.05	29.78	30.52	31.28	32.07	32.87	33.69	34.53	35.39	36.28

Table F-2. Variable Cost

$ per year; Capital Improvement Costs and Annual CIP/Major O&M Costs for all units except Ukudu

Unit	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Cab 1	1,191,734	1,225,102	1,259,405	1,294,669	1,330,919	1,368,185	1,406,494	1,445,876	1,486,361	1,527,979	1,570,762	1,614,743	1,659,956	1,706,435	1,754,215	1,803,333	1,853,826	1,905,734	1,959,094	2,013,949
Cab 2	1,191,734	1,225,102	1,259,405	1,294,669	1,330,919	1,368,185	1,406,494	1,445,876	1,486,361	1,527,979	1,570,762	1,614,743	1,659,956	1,706,435	1,754,215	1,803,333	1,853,826	1,905,734	1,959,094	2,013,949
Piti 8	5,366,851	5,366,851	1,831,590	746,022	665,460	684,092	703,247	722,938	743,180	763,989	785,381	807,372	829,978	853,217	877,108	901,667	926,913	952,867	979,547	1,006,974
Piti 9	5,366,851	5,366,851	1,831,590	746,022	665,460	684,092	703,247	722,938	743,180	763,989	785,381	807,372	829,978	853,217	877,108	901,667	926,913	952,867	979,547	1,006,974
Piti 7	238,347	245,020	251,881	258,934	3,194,206	273,637	281,299	289,175	297,272	305,596	314,152	322,949	331,991	341,287	350,843	360,667	370,765	381,147	391,819	402,790
DCT 1	238,347	245,020	251,881	258,934	266,184	3,694,099	281,299	289,175	297,272	305,596	314,152	322,949	331,991	341,287	350,843	360,667	370,765	381,147	391,819	402,790
DCT 2	238,347	245,020	251,881	258,934	266,184	273,637	3,797,534	289,175	297,272	305,596	314,152	322,949	331,991	341,287	350,843	360,667	370,765	381,147	391,819	402,790
MCT	238,347	245,020	251,881	258,934	5,722,953	6,316,068	281,299	289,175	297,272	305,596	314,152	322,949	331,991	341,287	350,843	360,667	370,765	381,147	391,819	402,790
YCT	4,238,347	245,020	251,881	11,263,616	266,184	273,637	281,299	289,175	297,272	305,596	314,152	322,949	331,991	341,287	350,843	360,667	370,765	381,147	391,819	402,790
MDI 1	119,173	122,510	125,941	129,467	133,092	136,818	140,649	144,588	148,636	152,798	157,076	161,474	165,996	170,643	175,422	180,333	185,383	190,573	195,909	201,395
MDI 2	119,173	122,510	125,941	129,467	133,092	136,818	140,649	144,588	148,636	152,798	157,076	161,474	165,996	170,643	175,422	180,333	185,383	190,573	195,909	201,395
Tal 1	119,173	122,510	125,941	129,467	133,092	136,818	140,649	144,588	148,636	152,798	157,076	161,474	165,996	170,643	175,422	180,333	185,383	190,573	195,909	201,395
Tal 2	119,173	122,510	125,941	129,467	133,092	136,818	140,649	144,588	148,636	152,798	157,076	161,474	165,996	170,643	175,422	180,333	185,383	190,573	195,909	201,395
Ten 1	119,173	122,510	125,941	129,467	133,092	136,818	140,649	144,588	148,636	152,798	157,076	161,474	165,996	170,643	175,422	180,333	185,383	190,573	195,909	201,395
Ten 2	119,173	122,510	125,941	129,467	133,092	136,818	140,649	144,588	148,636	152,798	157,076	161,474	165,996	170,643	175,422	180,333	185,383	190,573	195,909	201,395
Ten 3	119,173	122,510	125,941	129,467	133,092	136,818	140,649	144,588	148,636	152,798	157,076	161,474	165,996	170,643	175,422	180,333	185,383	190,573	195,909	201,395
Ten 4	119,173	122,510	125,941	129,467	133,092	136,818	140,649	144,588	148,636	152,798	157,076	161,474	165,996	170,643	175,422	180,333	185,383	190,573	195,909	201,395
Ten 5	119,173	122,510	125,941	129,467	133,092	136,818	140,649	144,588	148,636	152,798	157,076	161,474	165,996	170,643	175,422	180,333	185,383	190,573	195,909	201,395
Ten 6	119,173	122,510	125,941	129,467	133,092	136,818	140,649	144,588	148,636	152,798	157,076	161,474	165,996	170,643	175,422	180,333	185,383	190,573	195,909	201,395
Yigo Diesel Generators	1,000,000	1,028,000	1,089,680	1,155,061	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table F-3. Annual Fixed Costs

Appendix G: IRP Analysis Results

Base Case Scenario

LEGEND:

- + Phase III RRA
- + Phase IV RRA
- + Phase V RRA
- + Phase VI RRA
- + Phase VII RRA

	Scenario	Fuel	NPV Cost (MM)	Savings from BASE (MM)	Lowest RM after 2024 (%)	Units Built: 2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
A	Base	Base	$ 4,528.61		94.45																	
B	Base+Ph3	Base	$ 4,475.71	$ 52.90	94.45																	
C	Base+Ph345	Base	$ 4,225.83	$ 302.78	133.28																	
D	Base+Ph345-Piti892030	Base	$ 4,185.96	$ 342.66	106.28																	
E	Base+Ph345-Piti72024	Base	$ 4,212.18	$ 316.43	121.00																	
F	DC	Base	$ 4,771.71	$ (243.09)	83.01																	
G	DC+Ph3	Base	$ 4,709.54	$ (180.93)	83.01																	
H	DC+Ph345	Base	$ 4,476.18	$ 52.43	119.56																	
I	Base+Ph3456	Base	$ 4,130.53	$ 398.08	137.44																	
J	Base+Ph34567	Base	$ 4,107.56	$ 421.05	137.44																	

NOTES:

Negative values indicate additional cost compared to baseline scenario (Scenario A).

Net Present Value (NPV) and Savings costs are in millions.

All scenarios use Baseline Fuel Forecast.

Base Case Load Forecast modified from Base to High Load Forecast (“DC”) in scenarios F, G and H.

Liquefied Natural Gas (LNG) Scenario

LEGEND:

- + Phase III RRA
- + Phase IV RRA
- + Phase V RRA
- + Phase VI RRA
- + Phase VII RRA

NOTES:

Negative values indicate additional cost compared to baseline scenario (Scenario A).

Net Present Value (NPV) and Savings costs are in millions.

30-year Amortization of CAPEX

	Scenario	Fuel	NPV Cost (MM)	Savings from BASE (MM)	Lowest RM after 2024 (%)	Units Built: 2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
LNG-1	Base+LNG	Base	$ 4,179.63	$ 348.98	94.45																	
	MMBTU study period:	MMBTU from Ukudu Units:	142,332,700	per day:	27,853.76	*RW Beck assumption is 34,000 BTU per day*																
LNG-2	Base+LNG+ProposedUnits	Base	$ 4,179.61	$ 349.00	94.54																	4- FuelCell
	MMBTU study period:	MMBTU from Ukudu Units:	142,261,590	per day:	27,839.84	*RW Beck assumption is 34,000 BTU per day*																

22-year Amortization of CAPEX

	Scenario	Fuel	NPV Cost (MM)	Savings from BASE (MM)	Lowest RM after 2024 (%)	Units Built: 2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
LNG-3	Base+LNG	Base	$ 4,517.17	$ 11.44	94.45																	
	MMBTU study period:	(Ukudu)	142,332,700	per day:	27,853.76	*RW Beck assumption is 34,000 BTU per day*																
LNG-4	Base+LNG+ProposedUnits	Base	$ 4,517.17	$ 11.44	94.45																	
	MMBTU study period:	(Ukudu)	142,332,700	per day:	27,853.76	*RW Beck assumption is 34,000 BTU per day*																
LNG-5	Base+Ph345+LNG	Base	$ 4,197.04	$ 331.57	133.28																	
	MMBTU study period:	(Ukudu)	109,019,148	per day:	21,334.47	*RW Beck assumption is 34,000 BTU per day*																

Robustness Analysis; Fuel Price from 2030 onwards is fixed.

	Scenario	Fuel	NPV Cost (MM)	Savings from BASE (MM)	Lowest RM after 2024 (%)	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
LNG-6	DC+LNG	2030	$ 4,618.34	$ (89.72)	83.01																	
	MMBTU study period:	(Ukudu)	146,534,970	per day:	28,676.12	*RW Beck assumption is 34,000 BTU per day*																
LNG-7	DC+Ph345+LNG	2030	$ 4,380.31	$ 148.30	119.56																	
	MMBTU study period:	(Ukudu)	121,605,866	per day:	23,797.63	*RW Beck assumption is 34,000 BTU per day*																

Reliability Study

These scenarios were completed to match the Scenarios completed in Volume I of this IRP, and supplement the results of the Reliability Analysis.

LEGEND:

- + Phase III RRA
- + Phase IV RRA
- + Phase V RRA
- + Phase VI RRA
- + Phase VII RRA

NOTES:

Negative values indicate additional cost compared to baseline scenario (Scenario A).

Net Present Value (NPV) and Savings costs are in millions.

Reliability Study Scenarios

Taken from GPA IRP Vol 1 Reliability Study; all retirements scheduled 2024

									Units Built:													
	Scenario	**Fuel**	**NPV Cost (MM)**	**Savings from BASE (MM)**	**Lowest RM after 2024 (%)**	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
R-1	Base Case No ES BESS	Base	$ 4,528.61		94.45																	
R-2	Base + Phase III	Base	$ 4,475.71	$ 52.90	94.45																	
R-3	Base + III + IV - MacYigo	Base	$ 4,278.66	$ 249.96	109.76																	
R-4	Base + III + IV - Piti7	Base	$ 4,312.34	$ 216.28	110.29																	
R-5	Base + Phase III + IV - Ded CT	Base	$ 4,309.86	$ 218.75	108.51																	
R-6	Base + III + IV - Piti 8&9	Base	$ 4,265.78	$ 262.83	95.58																	
R-7	Base+III+IV+V-Piti8&9	Base	$ 4,160.98	$ 367.63	106.28																	
R-8	Base+PhaseIII+IV+V+VI-Piti8&9	Base	$ 4,065.53	$ 463.08	108.98																	
R-9	Base+PhaseIII+IV+V+VI+VII-Piti8&9	Base	$ 4,042.56	$ 486.05	108.98																	

Retirement Scenarios

The results below show the impact of retiring each unit, between the years of 2024-2031. First set of analysis was done with baseline scenario, and the 2nd set was assuming that Phase III, IV and V are already in place.

LEGEND:

- + Phase III RRA
- + Phase IV RRA
- + Phase V RRA
- + Phase VI RRA
- + Phase VII RRA

NOTES:

Negative values indicate additional cost compared to baseline scenario (Scenario A).

Net Present Value (NPV) and Savings costs are in millions.

Retirements

Piti 8&9

							Units Built:														
Scenario	**Fuel**	**NPV Cost (MM)**	**Savings from BASE (MM)**	**Lowest RM after 2024 (%)**	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Base-Piti89_2024	Base	$ 4,599.63	$ (71.02)	75.87										1- DslRcp							
Base-Piti89_2025	Base	$ 4,602.37	$ (73.75)	75.87										1- DslRcp							
Base-Piti89_2026	Base	$ 4,596.60	$ (67.99)	75.87										1- DslRcp							
Base-Piti89_2027	Base	$ 4,593.94	$ (65.32)	75.87										1- DslRcp							
Base-Piti89_2028	Base	$ 4,591.29	$ (62.67)	75.87										1- DslRcp							
Base-Piti89_2029	Base	$ 4,591.16	$ (62.55)	75.87										1- DslRcp	1- DslRcp						
Base-Piti89_2030	Base	$ 4,584.27	$ (55.65)	75.87										1- DslRcp							
Base-Piti89_2031	Base	$ 4,580.38	$ (51.77)	75.87										1- DslRcp							

Base+III+IV+V-Piti8&9_2024	Base	$ 4,160.98	$ 367.63	106.28																	
Base+III+IV+V-Piti8&9_2025	Base	$ 4,163.49	$ 365.12	106.28																	
Base+III+IV+V-Piti8&9_2026	Base	$ 4,168.30	$ 360.31	106.28																	
Base+III+IV+V-Piti8&9_2027	Base	$ 4,172.97	$ 355.65	106.28																	
Base+III+IV+V-Piti8&9_2028	Base	$ 4,177.47	$ 351.14	106.28																	
Base+III+IV+V-Piti8&9_2029	Base	$ 4,181.80	$ 346.82	106.28																	
Base+III+IV+V-Piti8&9_2030	Base	$ 4,185.96	$ 342.66	106.28																	
Base+III+IV+V-Piti8&9_2031	Base	$ 4,190.18	$ 338.43	106.28																	

Retirements

Piti 7

Scenario	Fuel	NPV Cost (MM)	Savings from BASE (MM)	Lowest RM after 2024 (%)	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
							Units Built:														
Base-Piti7_2024	Base	$ 4,514.97	$ 13.65	82.17																	
Base-Piti7_2025	Base	$ 4,515.78	$ 12.83	82.17																	
Base-Piti7_2026	Base	$ 4,518.89	$ 9.72	82.17																	
Base-Piti7_2027	Base	$ 4,519.66	$ 8.95	82.17																	
Base-Piti7_2028	Base	$ 4,520.41	$ 8.20	82.17																	
Base-Piti7_2029	Base	$ 4,521.15	$ 7.47	82.17																	
Base-Piti7_2030	Base	$ 4,521.86	$ 6.75	82.17																	
Base-Piti7_2031	Base	$ 4,522.56	$ 6.06	82.17																	

Base+III+IV+V-Piti7_2024	Base	$ 4,212.18	$ 316.43	121.00																	
Base+III+IV+V-Piti7_2025	Base	$ 4,213.00	$ 315.62	121.00																	
Base+III+IV+V-Piti7_2026	Base	$ 4,216.11	$ 312.51	121.00																	
Base+III+IV+V-Piti7_2027	Base	$ 4,216.88	$ 311.73	121.00																	
Base+III+IV+V-Piti7_2028	Base	$ 4,217.63	$ 310.98	121.00																	
Base+III+IV+V-Piti7_2029	Base	$ 4,218.36	$ 310.25	121.00																	
Base+III+IV+V-Piti7_2030	Base	$ 4,219.08	$ 309.54	121.00																	
Base+III+IV+V-Piti7_2031	Base	$ 4,219.77	$ 308.84	121.00																	

Retirements

Tenjo

Scenario	Fuel	NPV Cost (MM)	Savings from BASE (MM)	Lowest RM after 2024 (%)	Units Built: 2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Base-Tenjo_2024	Base	$ 4,506.03	$ 22.58	86.20																	
Base-Tenjo_2025	Base	$ 4,507.68	$ 20.94	86.20																	
Base-Tenjo_2026	Base	$ 4,509.27	$ 19.34	86.20																	
Base-Tenjo_2027	Base	$ 4,510.83	$ 17.78	86.20																	
Base-Tenjo_2028	Base	$ 4,512.34	$ 16.27	86.20																	
Base-Tenjo_2029	Base	$ 4,513.82	$ 14.80	86.20																	
Base-Tenjo_2030	Base	$ 4,515.25	$ 13.36	86.20																	
Base-Tenjo_2031	Base	$ 4,516.65	$ 11.96	86.20																	

Retirements

Yigo CT

Scenario	Fuel	NPV Cost (MM)	Savings from BASE (MM)	Lowest RM after 2024 (%)	Units Built: 2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Base-YCT_2024	Base	$ 4,506.81	$ 21.81	88.51																	
Base-YCT_2025	Base	$ 4,516.98	$ 11.63	88.51																	
Base-YCT_2026	Base	$ 4,517.88	$ 10.73	88.51																	
Base-YCT_2027	Base	$ 4,518.76	$ 9.85	88.51																	
Base-YCT_2028	Base	$ 4,519.62	$ 9.00	88.51																	
Base-YCT_2029	Base	$ 4,520.45	$ 8.17	88.51																	
Base-YCT_2030	Base	$ 4,521.25	$ 7.37	88.51																	
Base-YCT_2031	Base	$ 4,522.03	$ 6.59	88.51																	

Robustness Analysis: Fuel Price

LEGEND:

- + Phase III RRA
- + Phase IV RRA
- + Phase V RRA
- + Phase VI RRA
- + Phase VII RRA

NOTES:

Negative values indicate additional cost compared to baseline scenario (Scenario A).

Net Present Value (NPV) and Savings costs are in millions.

								Units Built:														
Scenario		**Fuel**	**NPV Cost (MM)**	**Savings from BASE (MM)**	**Lowest RM after 2024 (%)**	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
F-1	BaseLoad_LowFuel	Base	4,070.02	$ 458.59	94.45																	
F-2	BaseLoad_HiFuel	Base	4,838.55	$ (309.94)	94.45																	

								Units Built:														
Scenario		**Fuel**	**NPV Cost (MM)**	**Savings from BASE (MM)**	**Lowest RM after 2024 (%)**	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Fuel Price Forecast for ULSD set to 2030 price for the rest of study period; no escalation.																						
RA2-A	Base	2030	$ 4,285.27	$ 243.34	94.45																	
RA2-B	Base+345	2030	$ 4,078.91	$ 449.71	133.28																	
RA2-C	Base+34567	2030	$ 4,024.32	$ 504.30	137.44																	
RA2-D	Base+345-Piti89	2030	$ 4,034.85	$ 493.76	106.28																	
RA2-E	DC	2030	$ 4,506.31	$ 22.30	83.01																	
RA2-F	DC+345	2030	$ 4,310.44	$ 218.18	119.56																	
RA2-G	DC+34567	2030	$ 4,269.25	$ 259.36	122.88																	

Robustness Analysis: Unit Retirements

LEGEND:

- + Phase III RRA
- + Phase IV RRA
- + Phase V RRA
- + Phase VI RRA
- + Phase VII RRA

NOTES:

Net Present Value (NPV) and Savings costs are in millions.

						Units Built:																
Scenario		**Fuel**	**NPV Cost (MM)**	**Savings from BASE (MM)**	**Lowest RM after 2024 (%)**	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
RA-1	Base-Piti7DCT_2024	Base	$ 4,502.82	$ 25.80	75.31											1-DslRcp						
RA-2	Base-Piti7YCT_2024	Base	$ 4,493.16	$ 35.45	76.23																	
RA-3	Base-Piti7-MDI_2024	Base	$ 4,511.22	$ 17.39	78.92																	
RA-4	Base-Piti7-MCT-YCT_2024	Base	$ 4,472.33	$ 56.28	77.86										1-DslRcp							
RA-5	Base+Ph345-Piti7_2024	Base	$ 4,212.18	$ 316.43	121.00																	
RA-6	Base+Ph345-Piti7-MCT-YCT_2024	Base	$ 4,164.86	$ 363.76	108.18																	
RA-7	Base+Ph345-Piti7-DCT_2024	Base	$ 4,196.07	$ 332.55	106.93																	
Fuel Price Forecast for ULSD set to 2030 price for the rest of study period; no escalation. Piti 8&9 retires on 1/1/2029, all others retire on 1/1/2024.																						
RA2-H	DC+345-Piti89	2030	$ 4,268.07	$ 260.54	94.14																	
RA2-I	DC+34567-Piti89	2030	$ 4,226.11	$ 302.51	95.96																	
RA2-H_R1	DC+345-Piti89Piti7	2030	$ 4,254.42	$ 274.19	82.59																	
RA2-H_R2	DC+345-Piti89Tenjo	2030	$ 4,245.47	$ 283.15	86.38																	
RA2-H_R3	DC+345-Piti89TenjoMDI	2030	$ 4,241.76	$ 286.85	83.32																	
RA2-H_R4	DC+345-Piti89TenjoYCT	2030	$ 4,223.66	$ 304.95	80.79																	
RA2-H_R5	DC+345-Piti89TenjoMDIYCT	2030	$ 4,219.96	$ 308.66	77.73																	
RA2-H_R6	DC+345-Piti89Piti7Tenjo	2030	$ 4,233.72	$ 294.90	74.99																1-DslRcp	1-DslRcp
RA2-H_R7	DC+345-Piti89Piti7TenjoMDI	2030	$ 4,236.34	$ 292.27	80.00						1-DslRcp											

Appendix H: SECTIONS FROM THE POWER PURCHASE AGREEMENT WITH KEPCO

Schedule 4 Amend – Signed (March 2021).pdf

SCHEDULE 4

DETERMINATION OF TARIFF

1 Introduction and Definitions

1 This Schedule 4 shall be read in conjunction with, and is subject to, the provisions of the ECA of which this Schedule 4 is a part. To the extent that any provision of this Schedule 4 is inconsistent with any provision of the ECA, the provision of the ECA shall prevail. References to Articles and Sections are to Articles and Sections of this Schedule 4 unless indicated otherwise. References to Tables and Annexes are to the Tables and Annexes to this Schedule 4.

2 Payments to be made under the ECA shall be calculated in accordance with this Schedule 4 and adjusted as provided herein.

3 The procedures for the presentation and payment of invoices as set out in Article 13 of the ECA shall apply to all invoices referred to in this Schedule 4.

1.1 Definitions -

Capitalized terms used and not defined herein shall have the meaning set forth in the ECA. Without prejudice to the generality of Section 1.1, for the purposes of this Schedule 4 the following words and phrases shall bear the meanings ascribed thereto:

"Capacity Charge" has the meaning set forth in Section 3 below.

"Energy Charge" has the meaning set forth in Section 4 below.

"**Fixed Capacity Charge**" means the charge in respect of the Facility calculated in accordance with paragraph 3.1 of Section 3 below

"**Fixed Operations and Maintenance Charge**" means the charge in respect of the Facility described in Section 3.2 below.

"**Fixed Operations and Maintenance Charge Reserve Facility**" means the charge in respect of the Reserve Facility calculated in accordance with Section 3.3 below.

"**Fuel Charge**" means the charge calculated in accordance with paragraph 4.2 of Section 4 below.

"**Variable Operations and Maintenance Charge**" means the charge calculated in accordance with paragraph 4.1 of Section 4 below.

"**Variable Operations and Maintenance Charge Reserve Facility**" means the charge in respect of the Reserve Facility calculated in accordance with Section 4.1 below.

"**Supplemental Charge**" has the meaning set forth in Section 5 below.

"Index" means the US Bureau of Labor Statistics, Current Employment Statistics, transportation and public utilities, average hourly wages of production workers, CES4422000008. The index to be used for preparing invoices in accordance with Article 13 of the ECA in any Contract Year shall be the index published closest to the date preceding third month.

"**Index on Reference Date**" means 36.84.

"Reference Date" – is the Bid Date which is April 2nd 2019.

SS

2 Tariff components

The Tariff charges in respect of the Facility consist of three components:

a) Capacity Charge, which is comprised of the Fixed Capacity Charge (FCC) plus the Fixed Operations and Maintenance Charge (FOMC) as set out in Section 3;

b) Energy Charge, which is comprised of the Fuel Charge (FC) plus the Variable Operation and Maintenance Charge (VOMC) as set out in Section 4; and

c) Supplemental Charge (SC), which includes the charges set forth in Section 5 that are not included in the Capacity Charge or the Energy Charge.

The Tariff charges in respect of the Reserve Facility consist of three components:

a) the Fixed Operations and Maintenance Charge Reserve Facility as set out in Section 3;

b) Energy Charge, which is comprised of the Fuel Charge (FC) plus the Variable Operation and Maintenance Charge Reserve Facility as set out in Section 4; and

c) Supplemental Charge (SC), which includes the charges set forth in Section 5 that are not included in the Capacity Charge or the Energy Charge.

3 Capacity Charge

The Capacity Charge component of the Tariff in respect of the Facility is composed of two parts: (1) the Fixed Capacity Charge and (2) the Fixed Operations and Maintenance Charge, in each case for each kW of Dependable Capacity. The Capacity Charge in respect of the Facility will commence on the Commercial Operation Date and shall be payable by GPA (pursuant to the terms and conditions set forth in the ECA) on a monthly basis until the end of the Term.

The Capacity Charge component of the Tariff in respect of the Reserve Facility only has the Fixed Operations and Maintenance Charge Reserve Facility, which will commence on the Commercial Operation Date Reserve Facility and shall be payable by GPA (pursuant to the terms and conditions set forth in the ECA) on a monthly basis until the end of the Term.

3.1 Fixed Capacity Charge

The Fixed Capacity Charge (FCC) is stated for each period in USD/kW/month Table A.3.

Equation 3.1 sets forth the application of the FCC as applied to the Dependable Capacity of the Facility. In the event that a switch to Natural Gas takes place at a date later than the beginning of Contact Year 4, , the Dependable Capacity shall be corrected as set forth in Schedule 11, Section 2.

Equation 3.1: Fixed Capacity Charge

Fixed Capacity Charge (US$) = $FCC_n \times DC_n \times DCCF_n$

Where:

FCC_n =	The FCC (US$/kW/month) for the n-th period of payment proposed at Bid Date
DC_n =	Dependable Capacity (kW) in n-th period provided that, if different levels of Dependable Capacity are applicable during such period, DC_n shall be the weighted average of such levels reflecting the time periods (in hours) during which each level shall have applied during the n-th period.
$DCCF_n$ =	Dependable Capacity Correction Factor for the n-th period as set out in Clause 2 of Schedule 11 to compensate additional capacity degradation for prolonged ULSD operation of the Facility in the event that the switch to Natural Gas takes place at a date later than the date falling on the Day following the date of the third anniversary from the Day upon which the Facility is Commissioned.

3.2 Fixed Operations and Maintenance Charge

The Fixed Operations and Maintenance Charge (FOMC) in USD/kW/month is set forth in Table A.4.

FOMC, as specified in Table A.4 shall be adjusted monthly for inflation by comparing the Index on the Reference Date to the Index at the time that the adjustments are being made. In the event that the switch to Natural Gas takes place at a date later than the beginning of Contact Year 4, the FOMC values specified in Table A.4 will also be corrected for certain high load operation as described in Schedule 11, Section 4. Thus, the Fixed Operations and Maintenance Charge will be calculated as follows:

Equation 3.2: FOMC

FOMC (US$) = $FOMC_n$ x CFL_n x DC_n x $DCCF_n$

Where:

$FOMC_n$ = Where,

Where,

DC_n	=	Dependable Capacity (kW) in the n-th period.
$FOMC_n$	=	FOMC component defined above for the n-th period of payment (US$/kW/Month)
$FOMC_o$	=	FOMC as of the Reference date (US$/kW/Month)
I_n, I_0	=	Index prevailing at the n-th period of payment and on Reference Date, respectively.
$DCCF_n$	=	Dependable Capacity Correction Factor for the n-th period as set out in Clause 2 of Schedule 11 to compensate additional capacity degradation for prolonged ULSD operation of the Facility In the event that the switch to Natural Gas takes place at a date later than the date falling on the Day following the date of the third anniversary from the Day upon which the Facility is Commissioned
CFL_n	=	Correction Factor Load for Fixed O&M component for the n-th period as set out in Clause 4 of Schedule 11 to compensate additional O&M cost for prolonged ULSD operation of the Facility in the event that the switch to Natural Gas takes place at a date later than the date falling on the Day following the date of the third anniversary from the Day upon which the Facility is Commissioned.

3.3 Fixed Operations and Maintenance Charge Reserve Facility

The Fixed Operations and Maintenance Charge Reserve Facility in USD/kW/month is set forth in Table A.5 and shall be adjusted monthly for inflation by comparing the Index on the Reference Date to the Index at the time that the adjustments are being made. The Fixed Operations and Maintenance Charge Reserve Facility will be calculated as follows:

Equation 3.3: Fixed Operations and Maintenance Charge Reserve Facility

Fixed Operations and Maintenance Charge Reserve Facility (US$)		
FOMCRF (US$) = FOMCRFn x DCRFn/CCRF		
$FOMCRF_n$	=	Where, $\left(\frac{I_n}{I_o} \times \boldsymbol{FOMCRF_o}\right)$
Where,		
$DCRF_n$	=	Dependable Capacity in respect of the Reserve Facility for the n-th period of payment, kW
CCRF	=	Contracted Capacity in respect of the Reserve Facility, kW
$FOMCRF_n$	=	Fixed Operation and Maintenance Charge Reserve Facility component defined above for the n-th period of payment, USD
$FOMCRF_o$	=	as of the Reference Date (US$/Month)
I_n, I_0	=	Index prevailing at the n-th period of payment and on Reference Date, respectively.

4 Energy Charge

The Energy Charge component of the Tariff in respect of the Facility is composed of two parts and charged for each kWh of Net Energy Output: (1) the Variable Operation and Maintenance Charge, and (2) the Fuel Charge (if any). The Energy Charge in respect of the Facility will commence on the Commercial Operation Date and shall be payable by GPA (pursuant to the terms and conditions set forth in the ECA) on a monthly basis until the end of the Term.

The Energy Charge component of the Tariff in respect of the Reserve Facility is composed of two parts and charged for each kWh of Net Energy Output: (1) the Variable Operation and Maintenance Charge Reserve Facility, and (2) the Fuel Charge (if any). The Energy Charge in respect of the Reserve Facility will commence on the Commercial Operation Date Reserve Facility and shall be payable by GPA (pursuant to the terms and conditions set forth in the ECA) on a monthly basis until the end of the Term.

4.1 Variable Operation and Maintenance Charge

The Variable Operation and Maintenance Charge (VOMC) and the Variable Operation and Maintenance Charge Reserve Facility is stated for each period in Table A.6.

The VOMC shall be adjusted annually for inflation by comparing the Index on the Reference Date to the Index at the time that the adjustments are being made.

The calculation for the VOMC and Variable Operation and Maintenance Charge Reserve Facility will be as follows:

Equation 4.1: VOMC

VOMC (US$) = VOMCn x En

Where:

VOMCn =

Where:

E_n	=	Net Energy Output (kWh) in the n-th period.
$VOMC_n$	=	VOMC component defined above for the n-th period of payment (US$/kWh)
$VOMC_o$	=	Escalatable VOMC component as of the Reference Date (US$/kWh)
I_n, I_0	=	Index, prevailing at n-th period of payment and on Reference Date respectively.

Equation 4.2: Variable Operation and Maintenance Charge Reserve Facility

VOMCRF (US$) = VOMCRFn x REOn

Where:

VOMCRFn = Where: $$\left(\frac{I_n}{I_o} \times VOMC \right)$$

Where:

REO_n	=	Reserve Energy Output (kWh) in the n-th period.
$VOMCRF_n$	=	VOMC in respect of the Reserve Facility component defined above for the n-th period of payment (US$/kWh)
$VOMCRF_o$	=	Escalatable VOMC in respect of the Reserve Facility component as of the Reference Date (US$/kWh)
I_n, I_0	=	Index, prevailing at n-th period of payment and on Reference Date respectively.

4.2 Fuel Charge

The fuel charge adjusts the consumption of fuel at the Guaranteed Heat Rate (GHR) at Site Reference Conditions (SRC) and various loads (percentages of the Facility Dependable Capacity) using ULSD and Natural Gas and the heat rate correction curves to account for changes in ambient dry bulb temperature, ambient pressure, ambient humidity, average power factor, average carbon to hydrogen (C/H) ratio of Fuel and wet bulb temperature. The need for correction for changes in the wet bulb temperature will be confirmed at the detailed design stage and during the process of GPA's review and approval of Facility Performance Test procedure. In the event that it is determined that correction for changes in relative humidity also accounts for changes in wet bulb temperature, this Schedule 4 will be amended by deleting the wet bulb correction factors Kwt_m from Equations 4.2 and 4.3 below and deleting the wet bulb correction curves from this Schedule 4. The Guaranteed Heat Rate shall not be corrected for degradation at any time during the ECA Term. However, in the event that a switch to Natural Gas takes place at a date later than beginning of Contact Year 4, Guaranteed Heat Rate shall be corrected to reflect the potential for additional degradation due to prolonged ULSD operation as set forth in Schedule 11, Section 3.

All the costs of startups and shutdowns will be borne by the Project Company regardless of whether startups or shutdowns were requested by GPA or initiated by the Project Company. The Project Company shall be responsible for the quantity of Fuel (expressed in MMBtu) used for start-ups, shut downs, load limitations and/or Guaranteed Heat Rate compliance.

The Fuel Charge for ULSD and Natural Gas will be calculated as follows:

Equation 4.3: ULSD Fuel Charge

$FC_n = PCFR_n \times FP_n$

Where:

$PCFR_n = TFC_n - GPAF_n - REF_n - GPAF_{Tn}$

Where:

$GPAF_n \text{ (in MMBtu)} = \sum_{m=1}^{M} [GHR_m \times GHRCF_n \times E_m \times Kdt_m \times Kbp_m \times Krh_m \times Kpf_m \times KC/HRatio_m \times Kwt_m)] \times [MMBtu / 10^6 Btu]$

$REF_n \text{ (in MMBtu)} = REGHR \times REO_n \times [MMBtu / 10^6 Btu]$ Where:

FC_n	=	Fuel Charge in n-th billing period
n	=	Monthly billing period
$GPAF_n$	=	GPA Fuel consumption in n-th billing period by Combined Cycle Units
$GPAF_{on}$	=	GPA other Fuel consumption in n-th billing period
REF_n	=	Fuel consumption to generate Reserve Energy Output during the n-th period (kWh)
$GPAT_{Tn}$	=	Quantity of Fuel Removed by GPA from the on-Site ULSD storage by Trucks expressed in MMBtu
$PCFR_n$	=	Project Company Fuel Responsibility in n-th billing period
TFC_n	=	Total Fuel consumed at the Facility in n-th billing period expressed in MMBtu
FP_n	=	Fuel Price in n-th billing period (US$/MMBtu)
m	=	Dispatch metering interval (30 minutes)
M	=	Total number of intervals (m) during a billing period (n), which will vary from month to month depending on the actual dispatch that period.
GHRm	=	Guaranteed Heat Rate (Btu/kWh) for the applicable Facility in Simple Cycle or Combined Cycle mode, as the case may be, when operating on ULSD, corrected for actual load conditions existing during interval (m) that are due to GPA's Dispatch Instructions as shown in Table A.7 and Table A.9. For load conditions that are less than per GPA's Dispatch Instructions due to inability of Facility to meet GPA load requirements up to Dependable Capacity after the Facility has exceeded its Allowable Total Outages Energy for the applicable Contract Year pursuant to ECA Article 3.5, GHR_m shall be the Guaranteed Heat Rate for the load per the Dispatch Instructions.
$GHRCF_n$	=	Guaranteed Heat Rate Correction Factor during n-th billing period as set out in Clause 3 of Schedule 11 to compensate additional heat rate degradation for prolonged ULSD operation of the Facility in the event that the switch to Natural Gas takes place at a date later than the third anniversary of the Day upon which the Facility is Commissioned.
E_m	=	Net Energy Output during the m-th interval (kWh)
Kdt_m	=	GHR Correction factor of each operation mode for average ambient dry bulb temperature during the m-th interval (based on Figure A.1 or Figure A.7)
Krh_m	=	GHR Correction factor of each operation mode for average relative humidity during the m-th interval (based on Figure A.8)
Kpf_m	=	GHR Correction factor of each operation mode for average power factor during the m-th interval (based on Figure A.2 or Figure A.9)
$KC/H\ Ratio_m$	=	GHR Correction factor for average ULSD C/H ratio during the m-th interval (based on Figure A.3 or Figure A.10)
Kwt_m	=	GHR Correction factor for cooling tower performance of each operation mode for average wet bulb temperature during the m-th interval (based on Figure A.11)
REGHR	=	Guaranteed Heat Rate for Reserve Facility (Btu/kWh) as shown in Table A.11
REO_n	=	Reserve Energy Output (kWh) in the n-th period during n-th period in MMBtu

The Fuel Charge will be calculated and payable on an annual basis. When the sum of the monthly Fuel Charges calculated in accordance with Equation 4.2 above results in a positive number for a Contract Year, such amount will be deducted from the amount otherwise payable by GPA in the first invoice that is due for payment in the next Contract Year.

Equation 4.4: Natural Gas Fuel Charge in respect of the Facility

$$FC_n = PCFR_n \times FP_n$$

Where:

$$PCFR_n = TFC_n - GPAF_n$$

Where:

$$GPAF_n \text{ (in MMBtu)} = \sum_{m=1}^{M} [GHR_m \times GHRCF_n \times E_m \times (Kdt_m \times Krh_m \times Kpf_m \times KC/HRatio_m \times Kwt_m)] \times [MMBtu / 10^6 Btu];$$

FC_n	=	Fuel Charge in n-th billing period
n	=	Monthly billing period
$GPAF_n$	=	GPA Fuel consumption in n-th billing period by Combined Cycle Units
$PCFR_n$	=	Project Company Fuel Responsibility in n-th billing period
TFC_n	=	Total Fuel consumed at the Facility in n-th billing period expressed in MMBtu
FP_n	=	Fuel Price in n-th billing period (US$/MMBtu)
m	=	Dispatch metering interval (30 minutes)
M	=	Total number of intervals (m) during a billing period (n), which will vary from month to month depending on the actual dispatch that period.
GHRm	=	Guaranteed Heat Rate (Btu/kWh) for the Facility of each operation mode when operating on Natural Gas, corrected for actual load conditions existing during interval (m) that are due to GPA's Dispatch Instructions as shown in Table A.8 and Table A.10. For load conditions that are less than per GPA's Dispatch Instructions due to inability of Facility to meet GPA load requirements up to Dependable Capacity after the Facility has exceeded its Allowable Total Outages Energy for the applicable Contract Year pursuant to ECA Article 3.5, GHR_m shall be the Guaranteed Heat Rate for the load per the Dispatch Instructions.
$GHRCF_n$	=	Guaranteed Heat Rate Correction Factor during n-th billing period as set out in Clause 3 of Schedule 11 to compensate additional heat rate degradation for prolonged ULSD operation of the Facility in the event that the switch to Natural Gas takes place at a date later than the date following the Day of the third anniversary from the Day upon which the Facility is commissioned.
E_m	=	Net Energy Output during the m-th interval (kWh)
Kdt_m	=	GHR Correction factor of each operation mode for average ambient dry bulb temperature during the m-th interval (based on Figure A.4 or Figure A.12)
Krh_m	=	GHR Correction factor of each operation mode for average relative humidity during the m-th interval (based on Figure A.13)
Kpf_m	=	GHR Correction factor of each operation mode for average power factor during the m-th interval (based on Figure A.5 or Figure A.14)
$KC/H\ Ratio_m$	=	GHR Correction factor of each operation mode for average Natural Gas C/H ratio during the m-th interval (based on Figure A.6 or Figure A.15)
Kwt_m	=	GHR Correction factor for cooling tower performance of each operation mode for average wet bulb temperature during the m-th interval (based on Figure A.16)

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The Fuel Charge will be calculated and payable on an annual basis. When the sum of the monthly Fuel Charges calculated in accordance with Equation 4.3 above results in a positive number for a Contract Year, such amount will be deducted from the amount otherwise payable by GPA in the first invoice that is due for payment in the next Contract Year.

5 Supplemental Charges

Supplemental Charges include any costs due under Article 16 of the ECA.

Appendix A Annual Availability, Tariffs and Guaranteed Heat Rates

Annual Availability of the Facility (Guarantee)

Table A.1: Annual Availability of the Facility (Guarantee) Table -

Agreement Period	Annual Availability (%)	Guaranteed Maximum Forced Outage Hours	Guaranteed Maximum Total Outage Hours (h)
Contract Year 1	96.61	175.2	296.95
Contract Year 2	92.50	175.2	656.95
Contract Year 3	96.61	175.2	296.95
Contract Year 4	97.98	175.2	176.95
Contract Year 5	91.68	175.2	728.95
Contract Year 6	97.98	175.2	176.95
Contract Year 7	97.16	175.2	248.95
Contract Year 8	97.98	175.2	176.95
Contract Year 9	93.05	175.2	608.95
Contract Year 10	97.16	175.2	248.95
Contract Year 11	97.98	175.2	176.95
Contract Year 12	91.68	175.2	728.95
Contract Year 13	97.98	175.2	176.95
Contract Year 14	97.16	175.2	248.95
Contract Year 15	93.05	175.2	608.95
Contract Year 16	97.98	175.2	176.95
Contract Year 17	97.16	175.2	248.95
Contract Year 18	97.98	175.2	176.95
Contract Year 19	91.68	175.2	728.95
Contract Year 20	97.98	175.2	176.95
Contract Year 21	97.16	175.2	248.95
Contract Year 22	93.05	175.2	608.95
Contract Year 23	97.98	175.2	176.95
Contract Year 24	97.16	175.2	248.95
Contract Year 25	97.98	175.2	176.95
Average	96.11	175.2	341.11

* Note: This Table A.1 above for years with the steam turbine major overhaul is calculated based on the shutdown for maintenance of all gas turbines and steam turbines at the same time. If the maintenance scheme is changed at the request of GPA, the availability guarantee for a year with steam turbine maintenance shall be decreased by 0.67% if one 1 gas turbine is operated in simple cycle during steam

turbine major overhaul and by 1.34% if two gas turbines are operated in simple cycle during the steam turbine major overhaul.

A.1.1 Annual capacity factor

Notwithstanding Article 9.2(b) of the ECA, GPA's right to issue Dispatch Instructions is subject to compliance with environmental Laws and any applicable environmental Government Authorizations, including air permits (collectively "**Emission Limits**"). The annual capacity factor for the Facility shall be limited to the extent restricted by the Emission Limits:

- 85% on both ULSD and NG operation for Contract Years without steam turbine maintenance

- From 58% through 64% on ULSD, 83% on NG for Contract Years with steam turbine maintenance depending on the number of startups/shutdowns and other operation conditions affecting emissions from the Facility, which is subject to GEPA's approval at the time of the application for relevant Emission Limits.

For avoidance of doubt, the unavailability of Dependable Capacity in whole or in part due to such Emission Limits shall not be considered as Outage Hours.

Table A.2: Annual Availability of the Reserve Facility (Guarantee) Table

Agreement Period	Annual Availability (%)	Guaranteed Maximum Total Outage Hours (h)
Contract Year 1	95.03	435.35
Contract Year 2	94.24	504.35
Contract Year 3	94.13	514.35
Contract Year 4	94.30	499.35
Contract Year 5	93.85	538.35
Contract Year 6	92.90	622.35
Contract Year 7	93.99	526.35
Contract Year 8	94.16	511.35
Contract Year 9	94.71	463.35
Contract Year 10	93.80	543.35
Contract Year 11	93.23	593.35
Contract Year 12	93.44	574.35
Contract Year 13	94.57	475.35
Contract Year 14	93.93	531.35
Contract Year 15	94.57	475.35
Contract Year 16	94.16	511.35
Contract Year 17	92.51	656.35
Contract Year 18	94.38	492.35

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Agreement Period	Annual Availability (%)	Guaranteed Maximum Total Outage Hours (h)
Contract Year 19	94.27	502.35
Contract Year 20	94.03	523.35
Contract Year 21	93.85	538.35
Contract Year 22	93.17	598.35
Contract Year 23	94.44	487.35
Contract Year 24	93.40	578.35
Contract Year 25	95.03	435.35
Average	94.00	525.27

* Note: This Table A.2 above is calculated based on the diesel engine unit of the Reserve Facility operating for 2,600 hours per year. If the annual operating hours are increased, a formula for the impact of the availability due to the increase in operating hour shall be developed in consultation with GPA and adjusted accordingly according to the maintenance intervals and periods recommended by the manufacturer.

The unavailability of Dependable Capacity in respect of the Reserve Facility in whole or in part due to compliance with Emission Limits shall not be considered as Outage Hours.

A.1 Capacity Charge

A.1.1 Fixed Capacity Charge

Table A.3: Fixed Capacity Charge

Agreement Period	Fixed Capacity Charge (USD/kW/month)
Contract Year 1	16.7550
Contract Year 2	16.7550
Contract Year 3	16.7550
Contract Year 4	16.7550
Contract Year 5	16.7550
Contract Year 6	16.7550
Contract Year 7	16.7550
Contract Year 8	16.7550
Contract Year 9	17.1659
Contract Year 10	18.8825
Contract Year 11	20.7707
Contract Year 12	22.8478
Contract Year 13	25.1325
Contract Year 14	25.1325

Agreement Period	Fixed Capacity Charge (USD/kW/month)
Contract Year 15	25.1325
Contract Year 16	25.1325
Contract Year 17	25.1325
Contract Year 18	25.1325
Contract Year 19	25.1325
Contract Year 20	25.1325
Contract Year 21	25.1325
Contract Year 22	25.1325
Contract Year 23	25.1325
Contract Year 24	25.1325
Contract Year 25	25.1325

A.1.2 Fixed Operation and Maintenance Charge

Table A.4: Fixed Operation and Maintenance Charge

Agreement Period	FOMC on ULSD (USD/kW/Month)	FOMC on Natural Gas (USD/kW/Month)
Commercial Operation Date through end of the Term (Facility)	11.5246	7.5735

Table A.5: Fixed Operation and Maintenance Charge Reserve Facility

Agreement Period	FOMC on ULSD (USD/Month)	FOMC on Natural Gas (USD/Month)
Commercial Operation Date through end of the Term	166,667	N/A

A.2 Energy Charge

A.2.1 Variable Operation and Maintenance Charge

Table A.6: Variable Operation and Maintenance Charge and Variable Operation and Maintenance Charge Reserve Facility

Agreement Period	VOMC on ULSD (USD/kWh)	VOMC on Natural Gas (USD/kWh)

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Commercial Operation Date through end of the Term (Facility)(VOMC)	0.0016	0.0015
Commercial Operation Date Reserve Facility through end of the Term (Reserve Facility)(Variable Operation and Maintenance Charge Reserve Facility)	0.025	N/A

A.2.2 Fuel Charge for Simple Cycle Operation Mode

A.2.2.1 Guaranteed Heat Rates for Simple Cycle Operation on USLD

Table A.7: Guaranteed Heat Rate for Simple Cycle Operation on ULSD at Site Reference Conditions

Percent of Dependable Capacity	Guaranteed Heat Rate (HHV) (Btu/kWh)
100%	9,836
95%	9,928
90%	10,063
85%	10,246
80%	10,452
75%	10,718
70%	11,011
65%	9,947
60%	10,112
55%	10,405
50%	10,762
45%	11,230
40%	11,768
35%	13,052
30%	10,668
25%	11,348
20%	12,406
15%	14,389
10%	18,009
Minimum Load	18,009 [at 10% of Dependable Capacity]

A.2.2.2 Guaranteed Heat Rates for Simple Cycle Operation on Natural Gas

Table A.8: Guaranteed Heat Rate for Simple Cycle Operation on Natural Gas at Site Reference Conditions

Percent of Dependable Capacity	Guaranteed Heat Rate (HHV) (Btu/kWh)
100%	10,651
95%	10,747
90%	10,903
85%	11,104
80%	11,338
75%	11,619
70%	11,919
65%	10,797
60%	11,008
55%	11,302
50%	11,701
45%	12,203
40%	12,775
35%	13,620
30%	11,276
25%	11,993
20%	13,073
15%	15,175
10%	19,090
Minimum Load	19,090 [at 10% of Dependable Capacity]

* Use Linear Interpolation when the load values fall between the stated percentages

A.2.3 Fuel Charge for Combined Cycle Operation Mode

A.2.3.1 Guaranteed Heat Rates for Combined Cycle Operation on USLD

Table A.9: Guaranteed Heat Rate for Combined Cycle Operation on ULSD at Site Reference Conditions

Percent of Dependable Capacity	Guaranteed Heat Rate (HHV) (Btu/kWh)
100%	6,648
95%	6,657
90%	6,684
85%	6,750
80%	6,790
75%	6,877
70%	6,985
65%	6,694
60%	6,727
55%	6,811
50%	6,949
45%	7,149
40%	7,449
35%	8,041
30%	7,434
25%	7,754
20%	8,313
15%	9,367
10%	11,352
Minimum Load	11,352

* Use Linear Interpolation when the load values fall between the stated percentages

A.2.3.2 Guaranteed Heat Rates for Combined Cycle Operation on Natural Gas

Table A.10: Guaranteed Heat Rate for Combined Cycle Operation on Natural Gas at Site Reference Conditions

Percent of Dependable Capacity	Guaranteed Heat Rate (HHV) (Btu/kWh)
100%	6,771
95%	6,810
90%	6,840
85%	6,902
80%	6,962
75%	7,058
70%	6,776
65%	6,836
60%	6,881
55%	6,988
50%	7,137
45%	7,348
40%	7,644
35%	8,240
30%	7,600
25%	7,945
20%	8,529
15%	9,593
10%	11,647
Minimum Load	11,647

* Use Linear Interpolation when the load values fall between the stated percentages

A.2.4 Fuel Charge for Reserve Facility

Table A.11: Guaranteed Heat Rate for Reserve Facility

Agreement Period	Guaranteed Heat Rate, (HHV) (Btu/kWh)
Commercial Operation Date through end of the Term	10,556

[All the correction curves below might be modified before submission of Performance Test Procedure based on detail design from OEM]

A.2.5 Heat Rate Correction for Simple Cycle Operation Mode

A.2.5.1 Correction Curve for Simple Cycle (SC) Operation on USLD

Figure A.1: ULSD SC Kdt Correction Factor

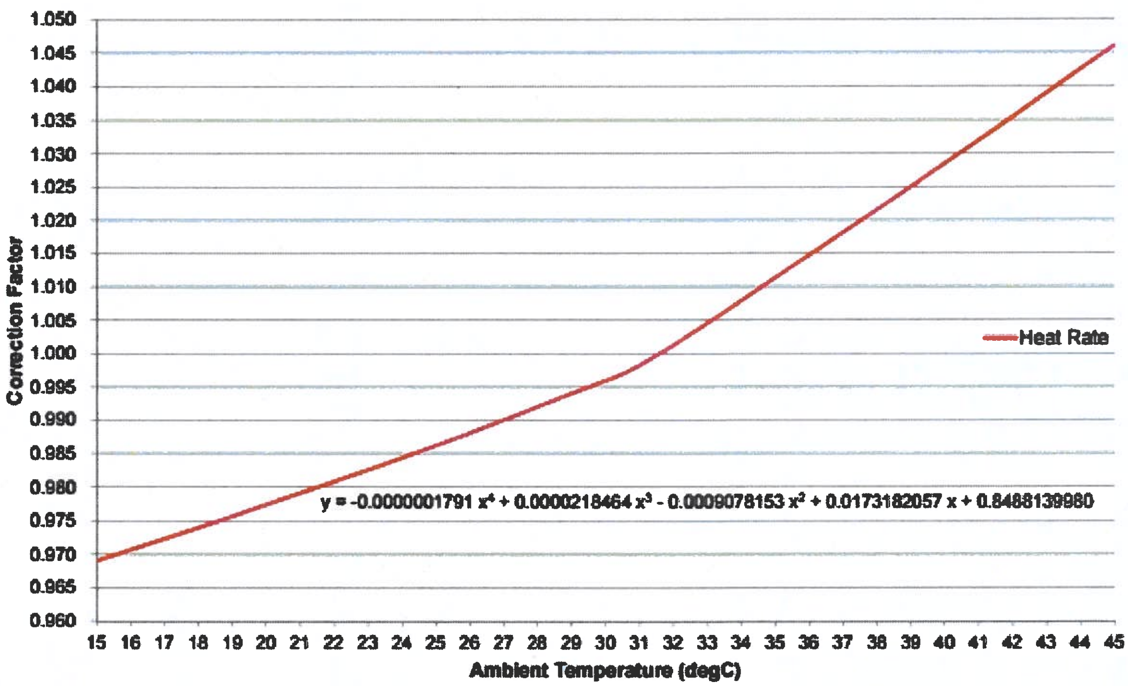


Figure A.2: ULSD SC Kpf Correction Factor

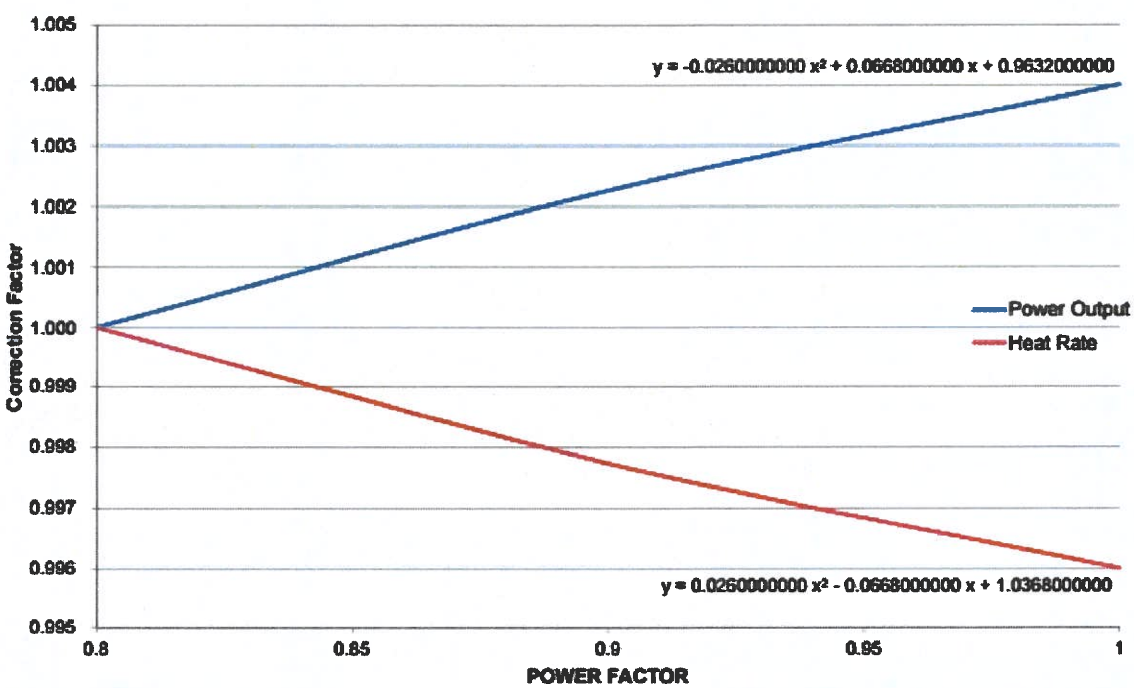
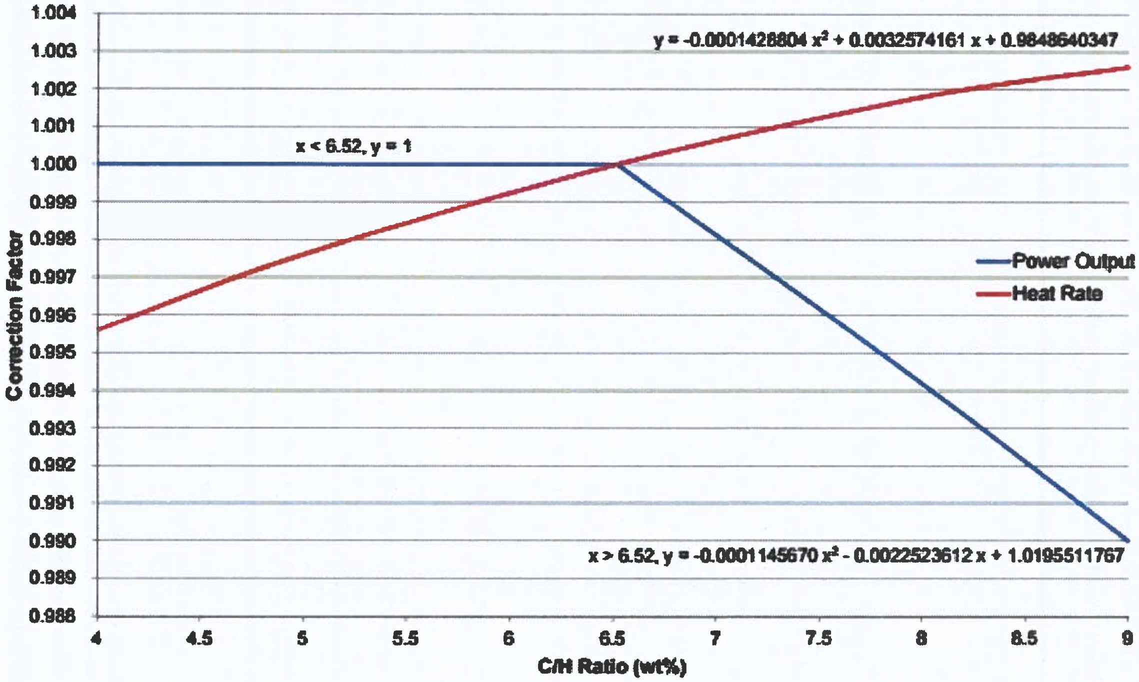


Figure A.3: ULSD SC $K_{C/H\ Ratio}$ Correction Factor



A.2.5.2 Correction Curve for Simple Cycle (SC) Operation on Natural Gas

Figure A.4: Natural Gas SC Kdt Correction Factor

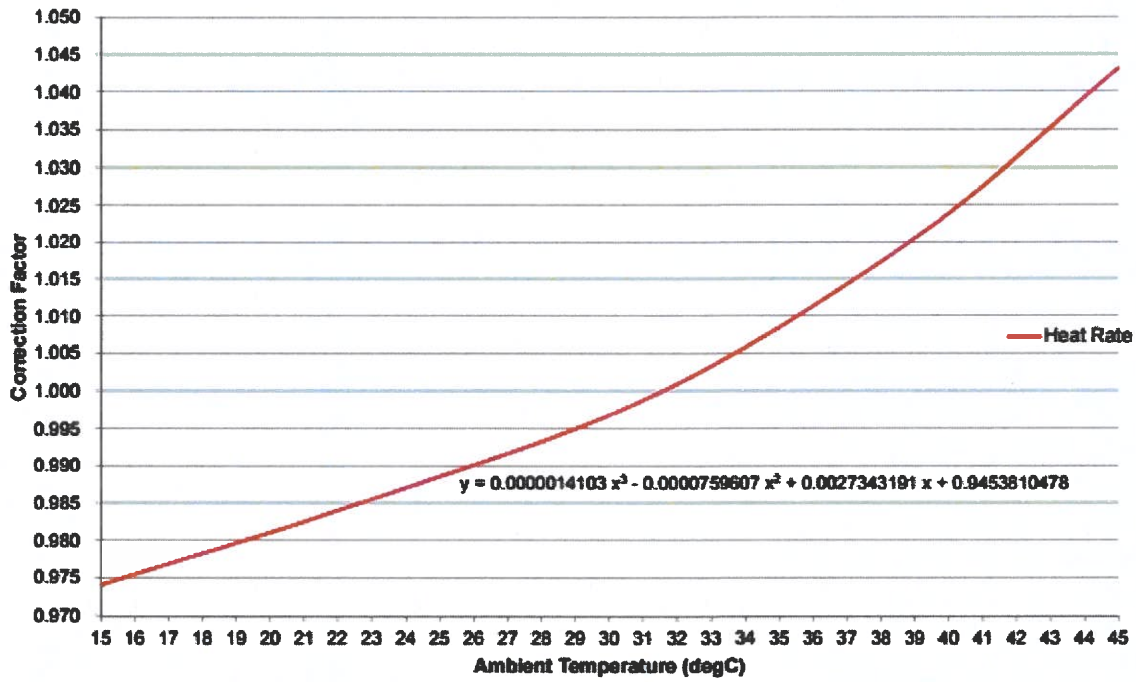


Figure A.5: Natural Gas SC Kpf Correction Factor

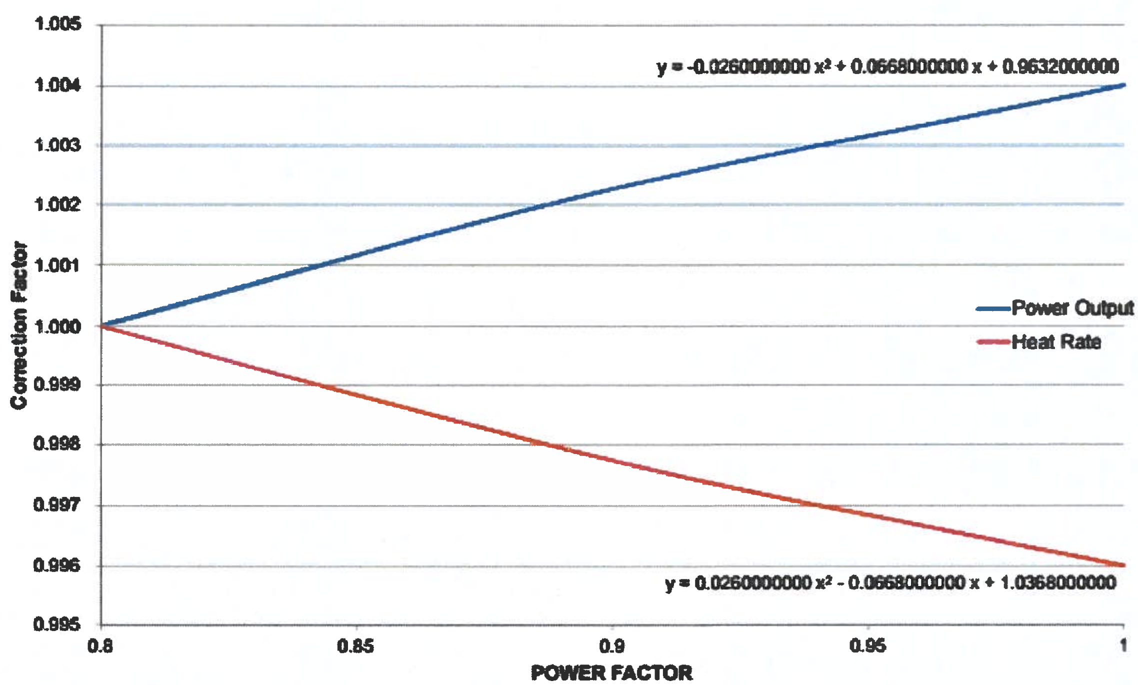
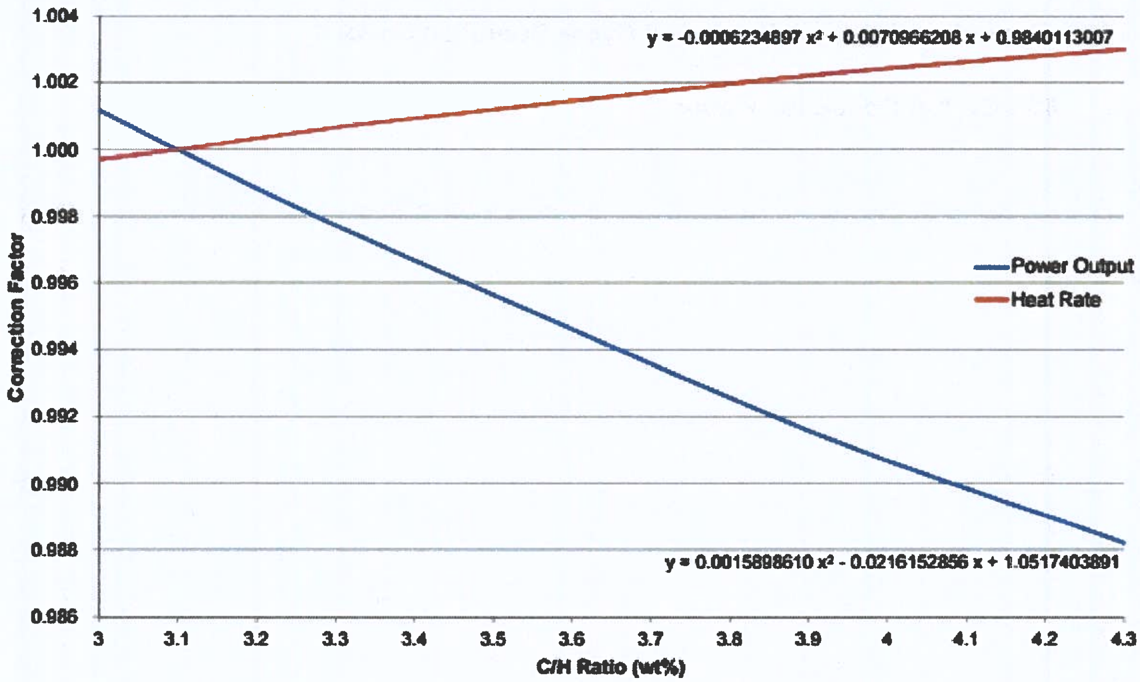


Figure A.6: Natural Gas SC KC/H Ratio Correction Factor



A.2.6 Heat Rate Correction for Combined Cycle (CC) Operation Mode

A.2.6.1 Correction Curve for Combined Cycle Operation on USLD

Figure A.7: ULSD CC Kdt Correction Factor

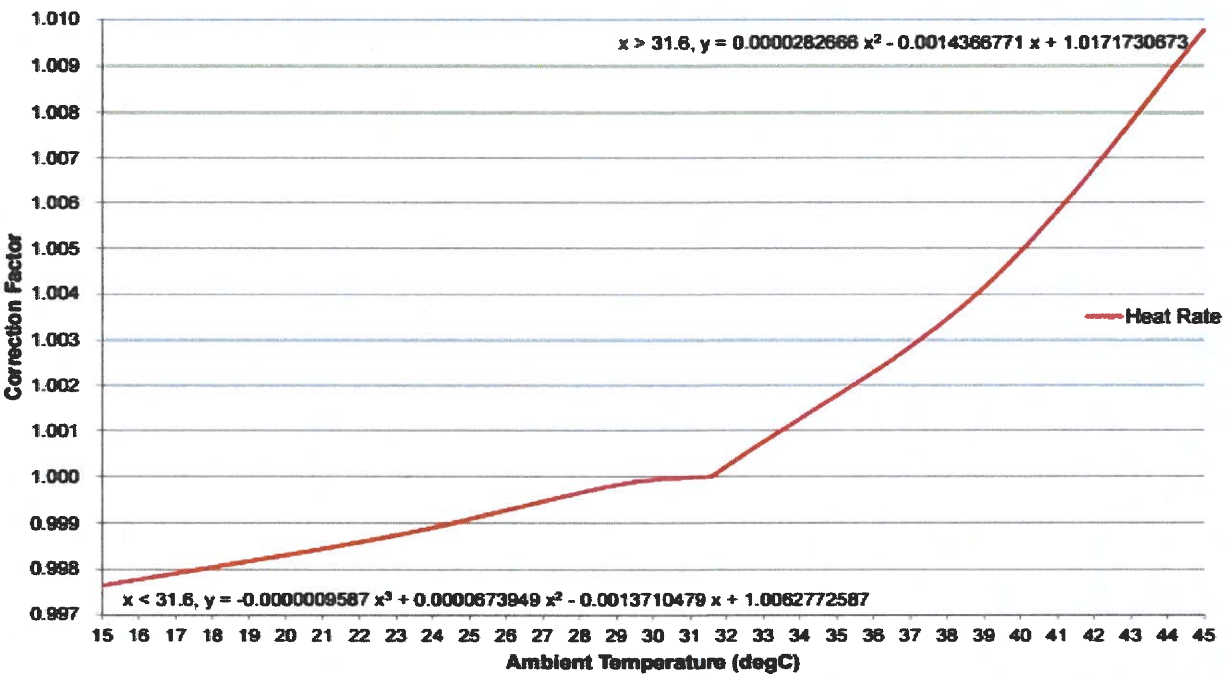


Figure A.8: ULSD CC Krh Correction Factor

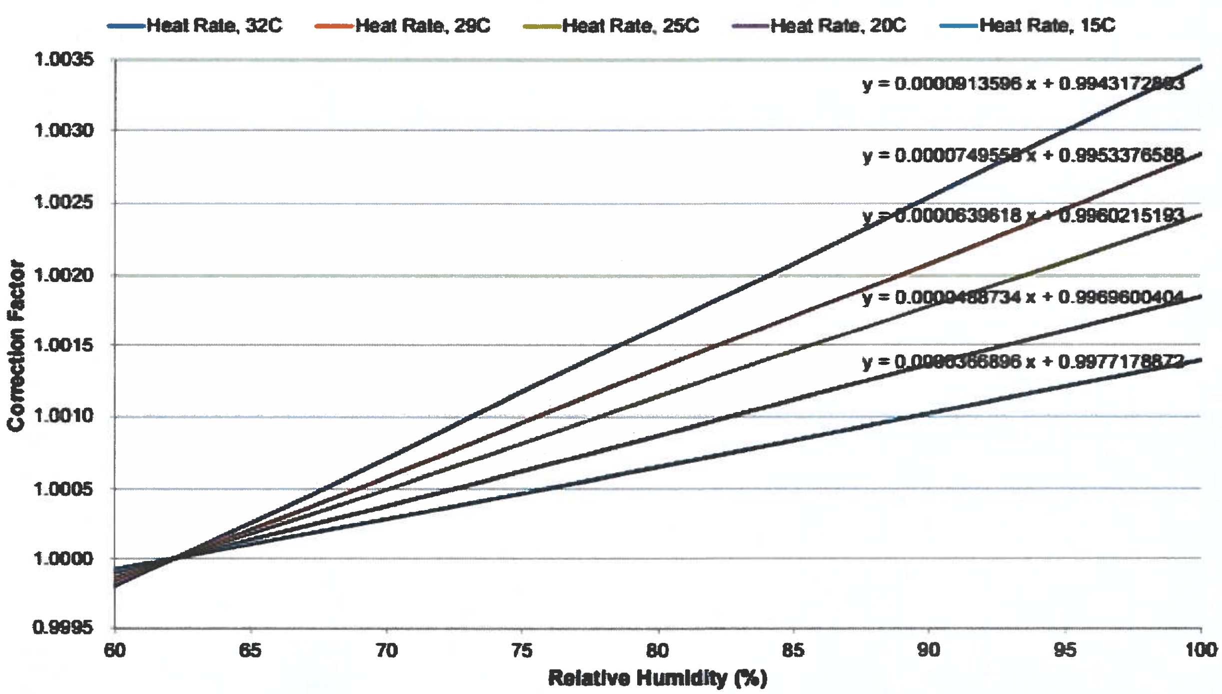


Figure A.9: ULSD CC Kpf Correction Factor

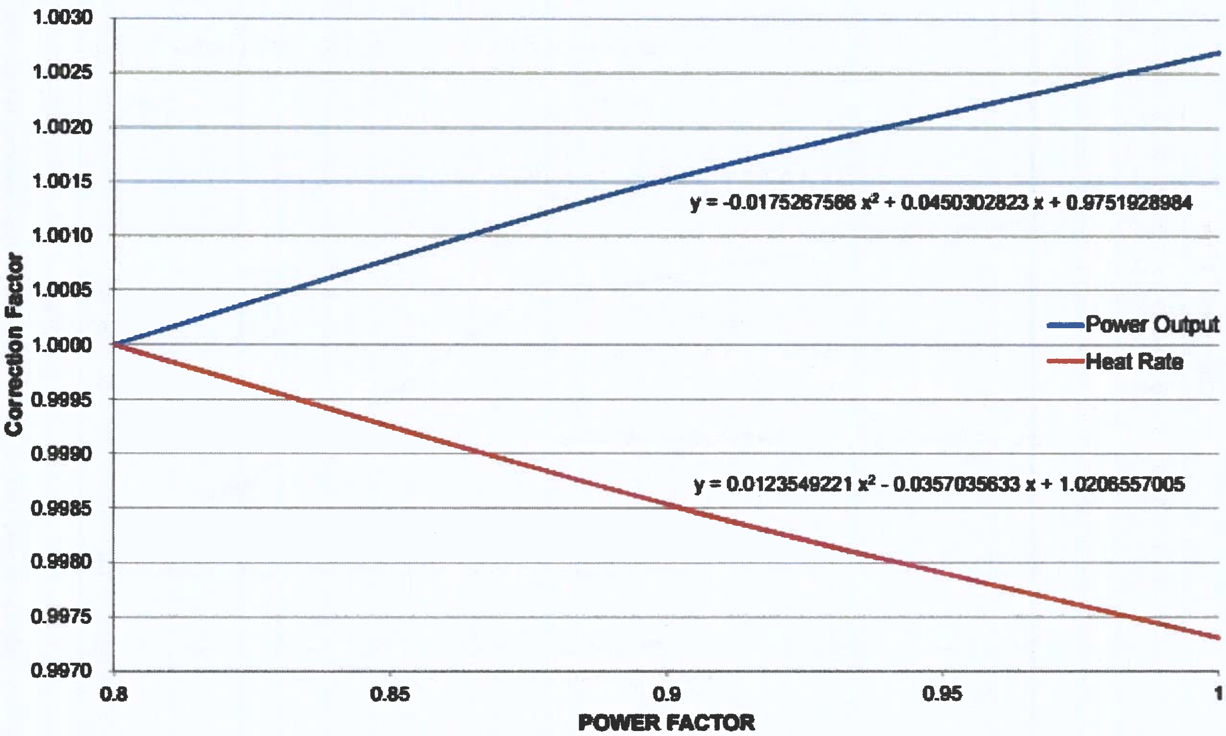


Figure A.10: ULSD CC KC/H Ratio Correction Factor

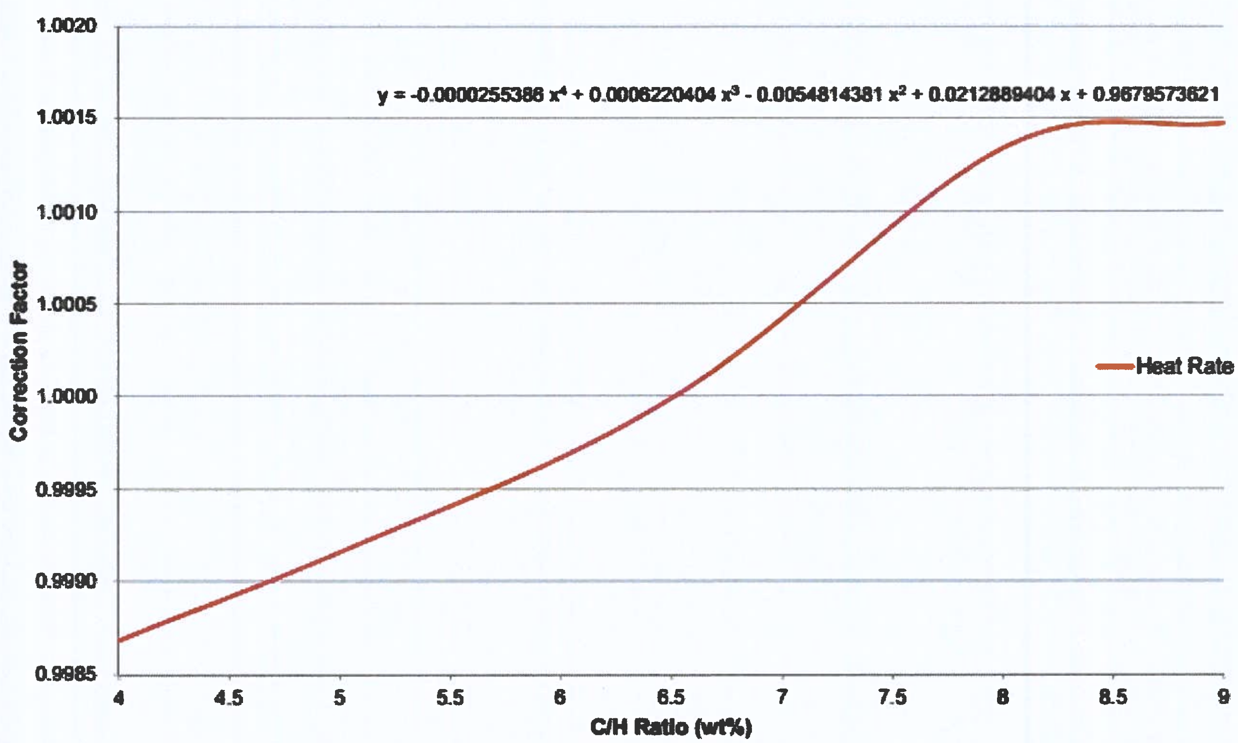
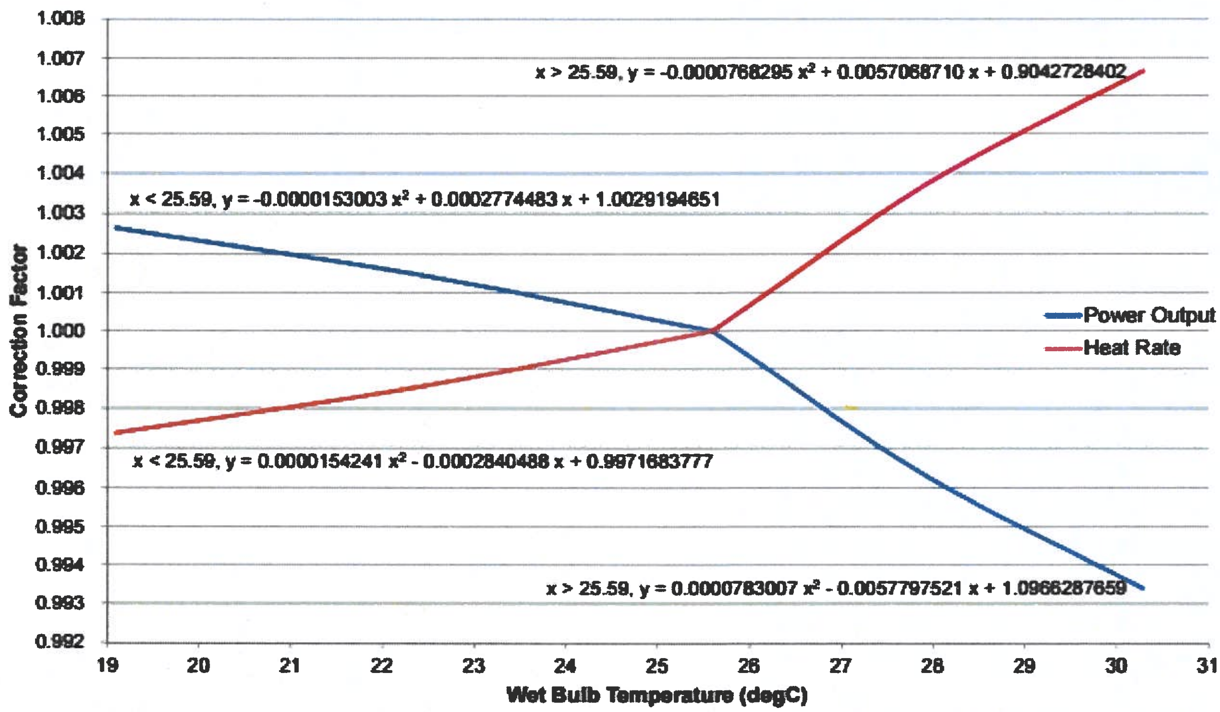


Figure A.11: ULSD CC Kwt Ratio Correction Factor



A.2.6.2 Correction Curve for Combined Cycle Operation on Natural Gas

Figure A.12: Natural Gas CC Kdt Correction Factor

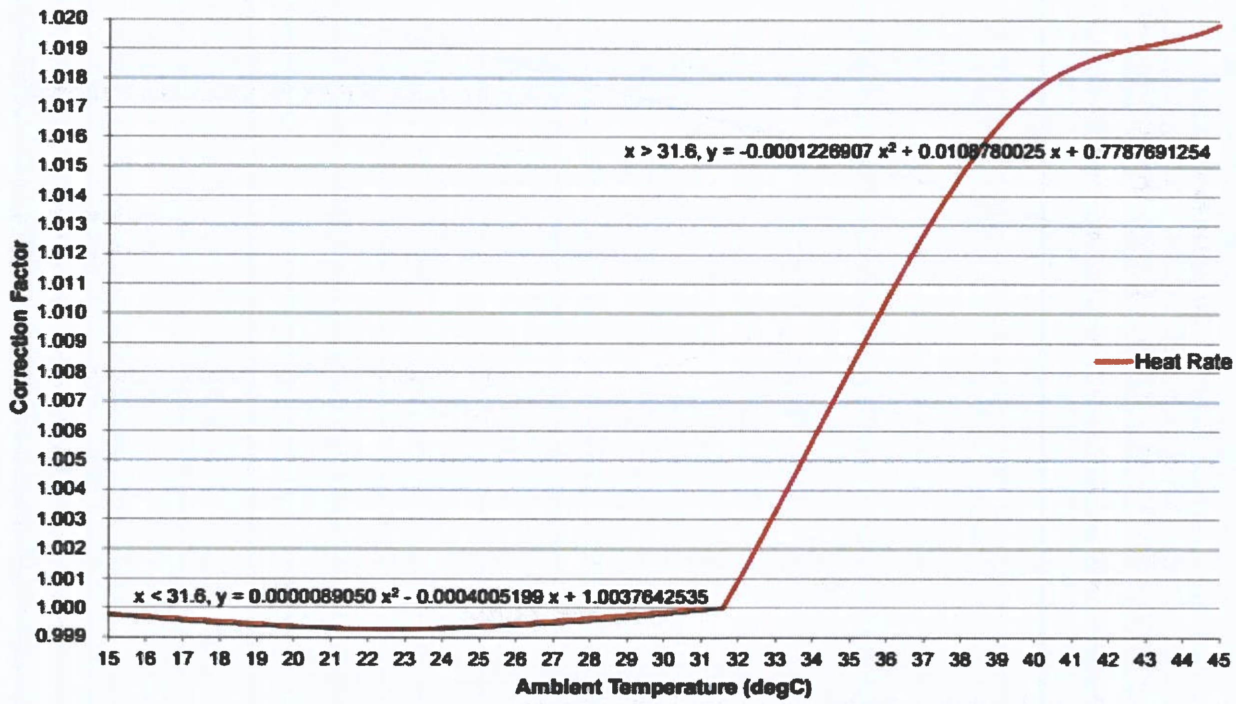


Figure A.13: Natural Gas CC Krh Correction Factor

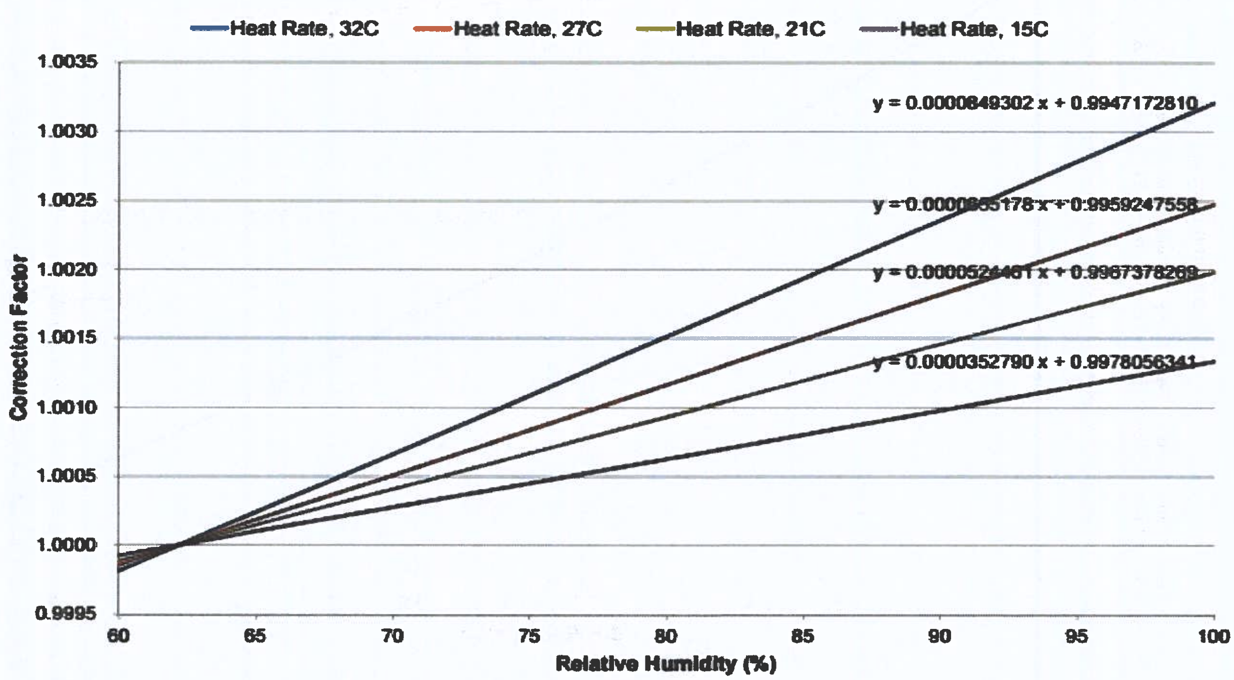


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Figure A.14: Natural Gas CC Kpf Correction Factor

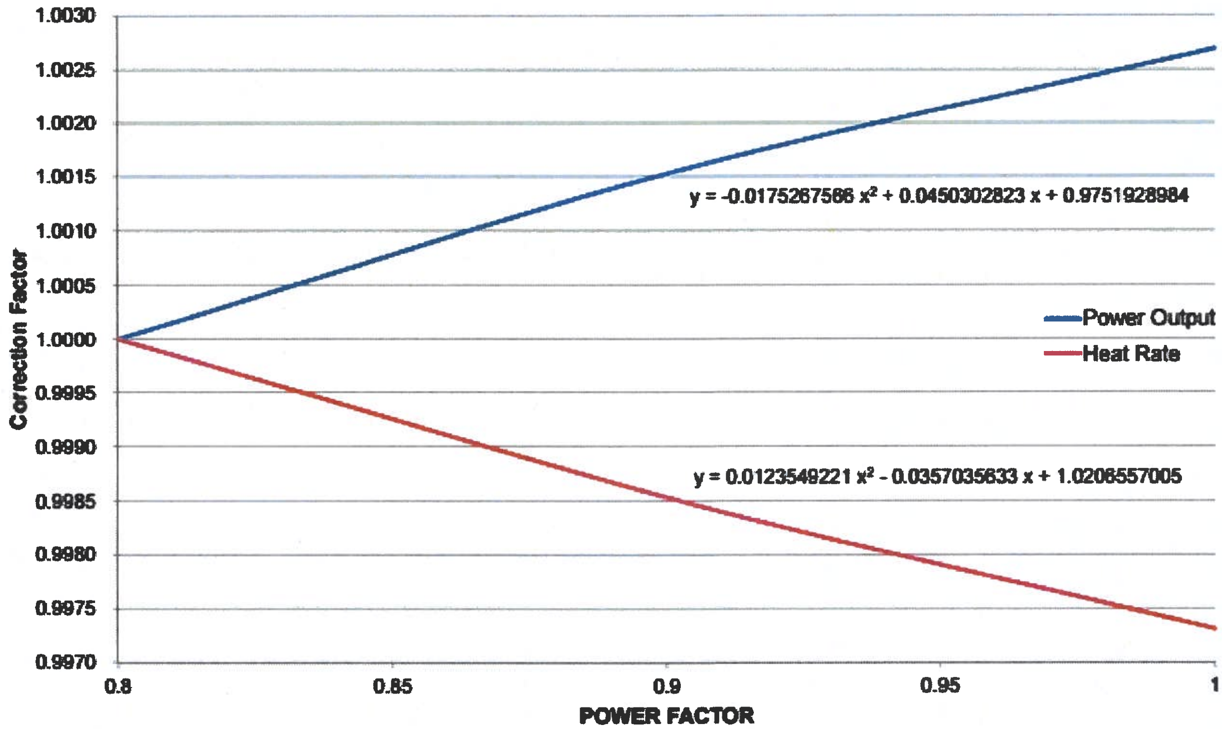


Figure A.15: Natural Gas CC KC/H Ratio Correction Factor

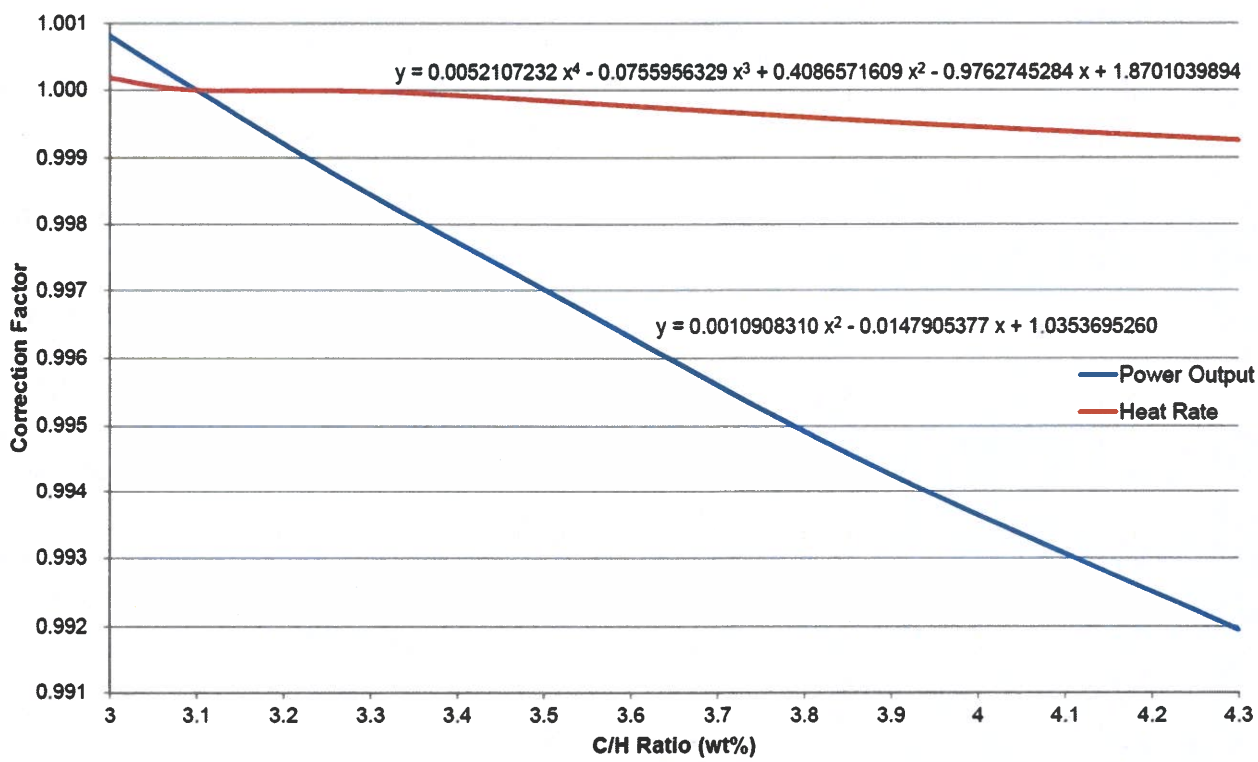
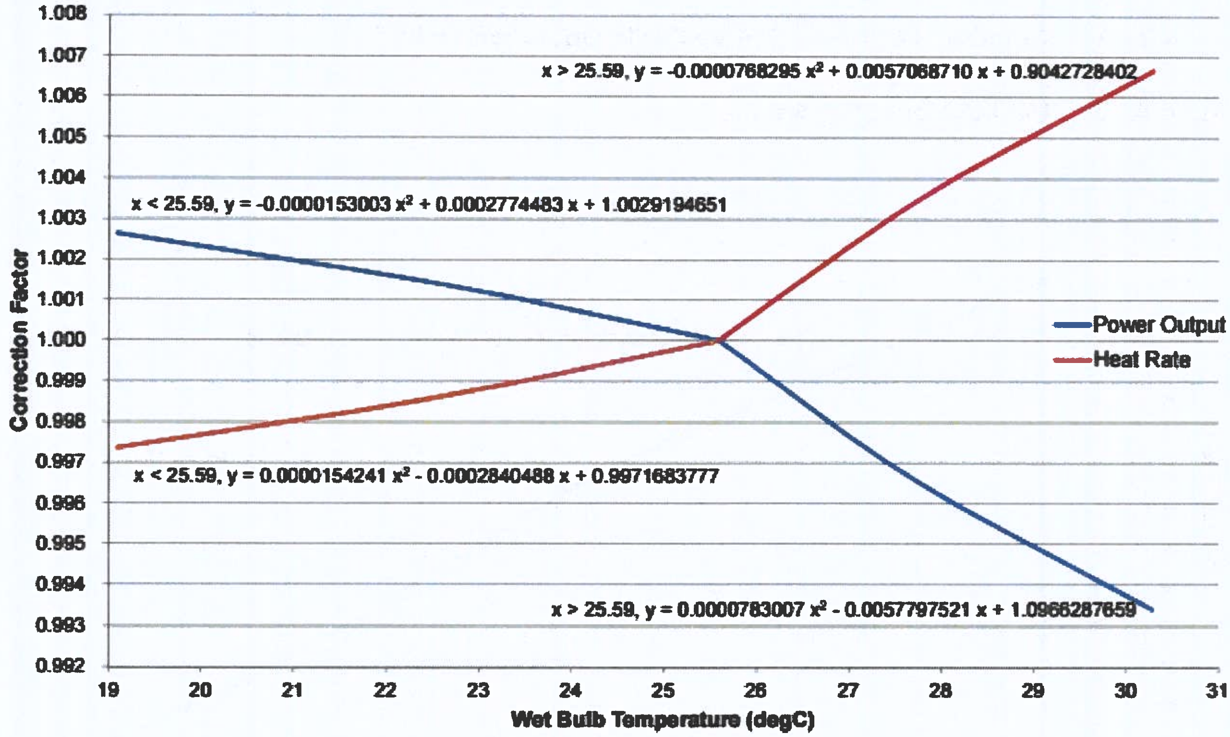


Figure A.16: Natural Gas CC Kwt Correction Factor



A.2.7 Power Output Correction for Simple Cycle Operation Mode

A.2.7.1 Correction Curve for Simple Cycle Operation on USLD

Figure A.17: ULSD Kdt Correction Factor

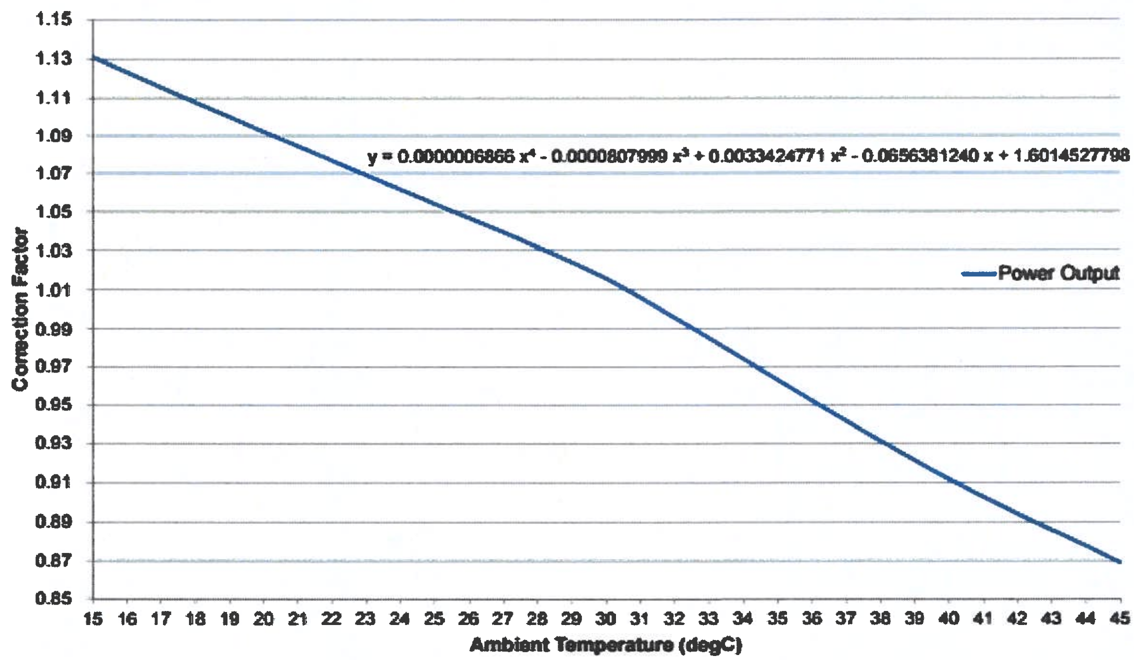


Figure A.18: ULSD Kbp Correction Factor

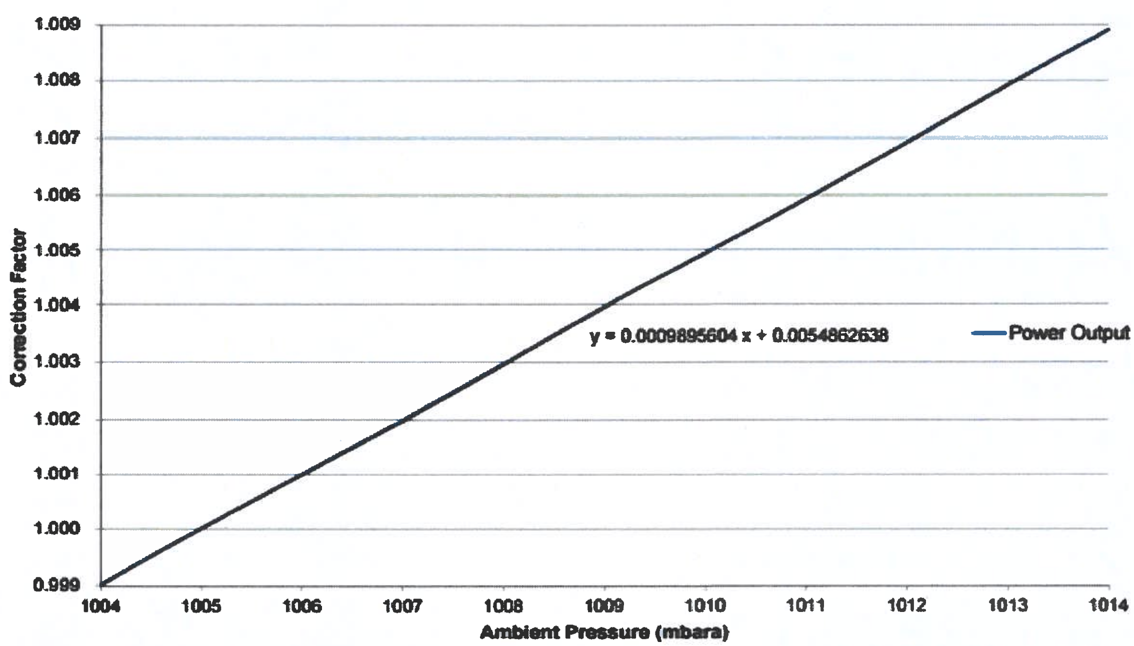


Figure A.19: ULSD Krh Correction Factor

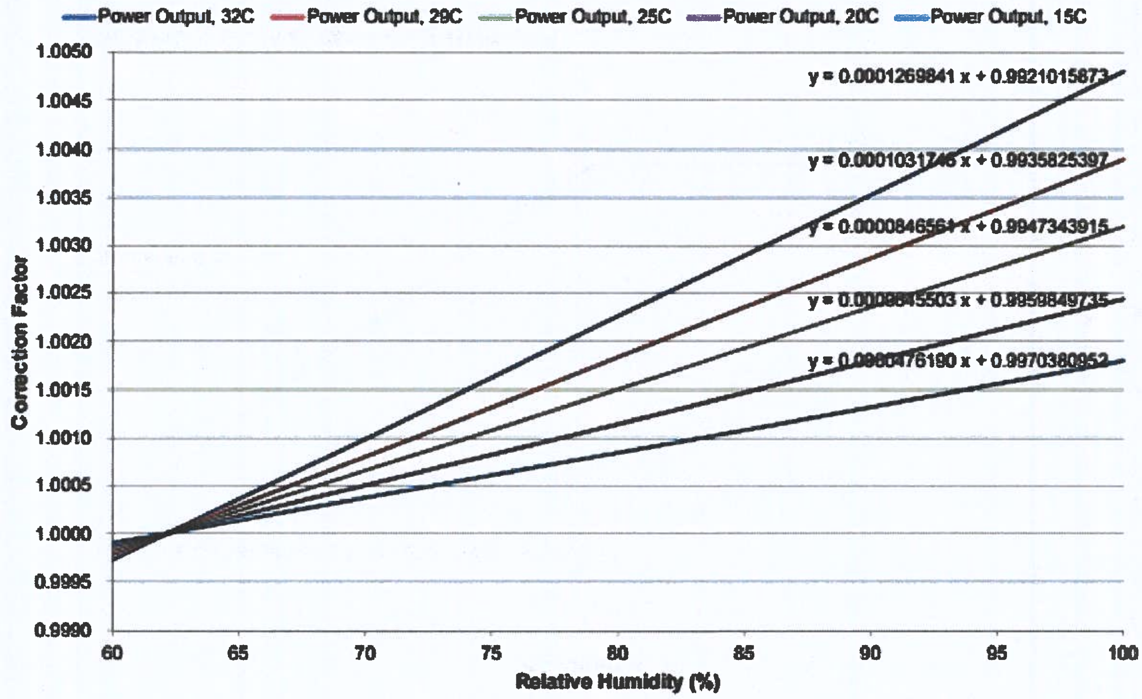


Figure A.20: ULSD Kpf Correction Factor

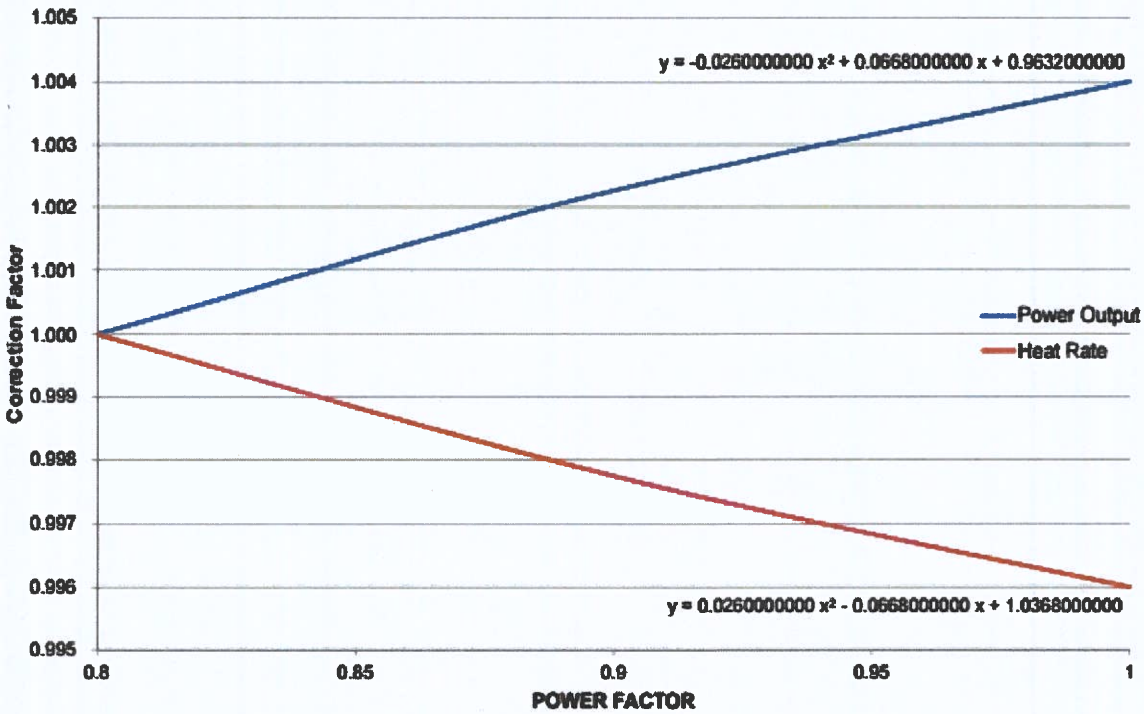
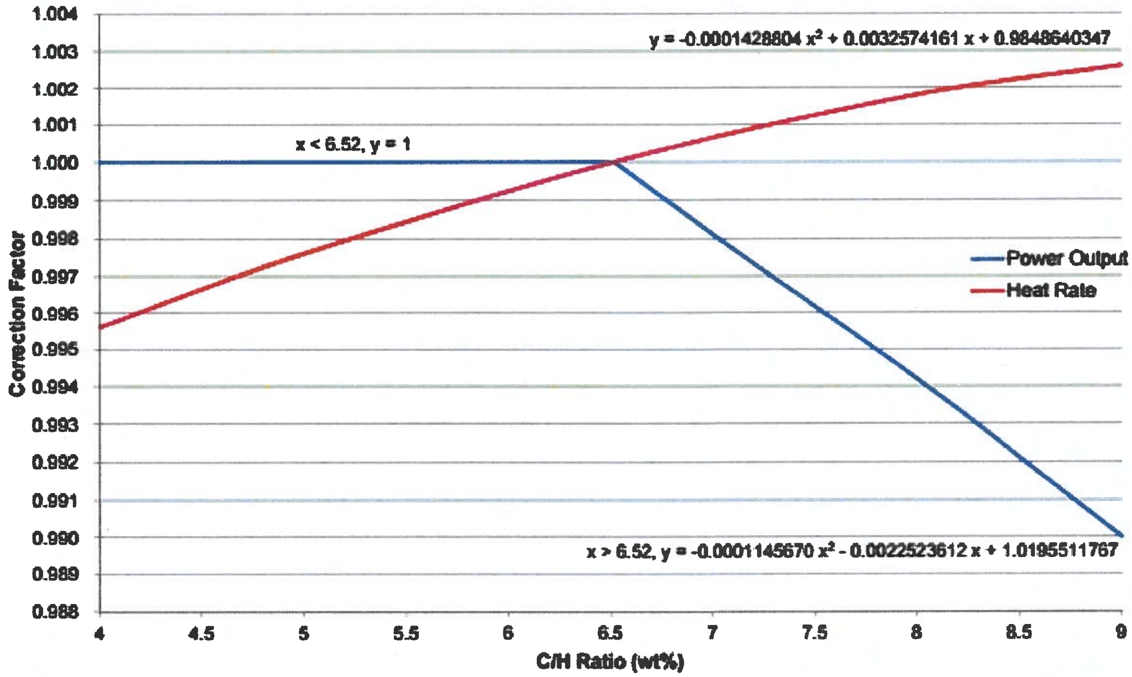


Figure A.21: ULSD $K_{C/H\ Ratio}$ Correction Factor



A.2.7.2 Correction Curve for Simple Cycle Operation on Natural Gas

Figure A.22: Natural Gas Kdt Correction Factor

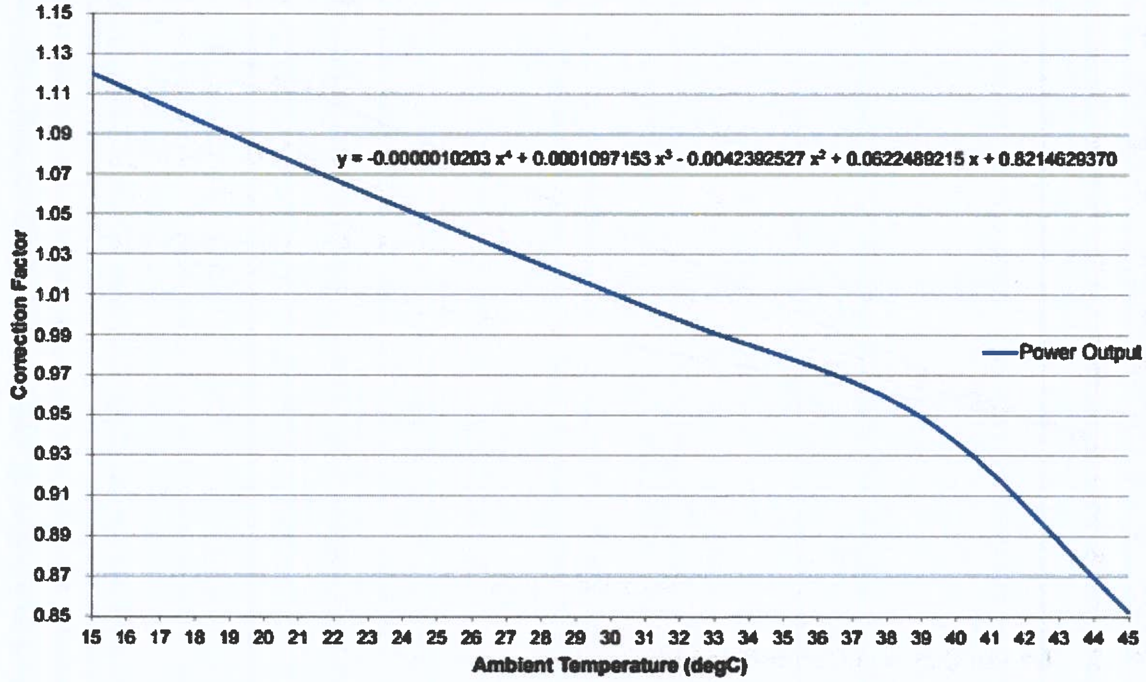


Figure A.23: Natural Gas Kbp Correction Factor

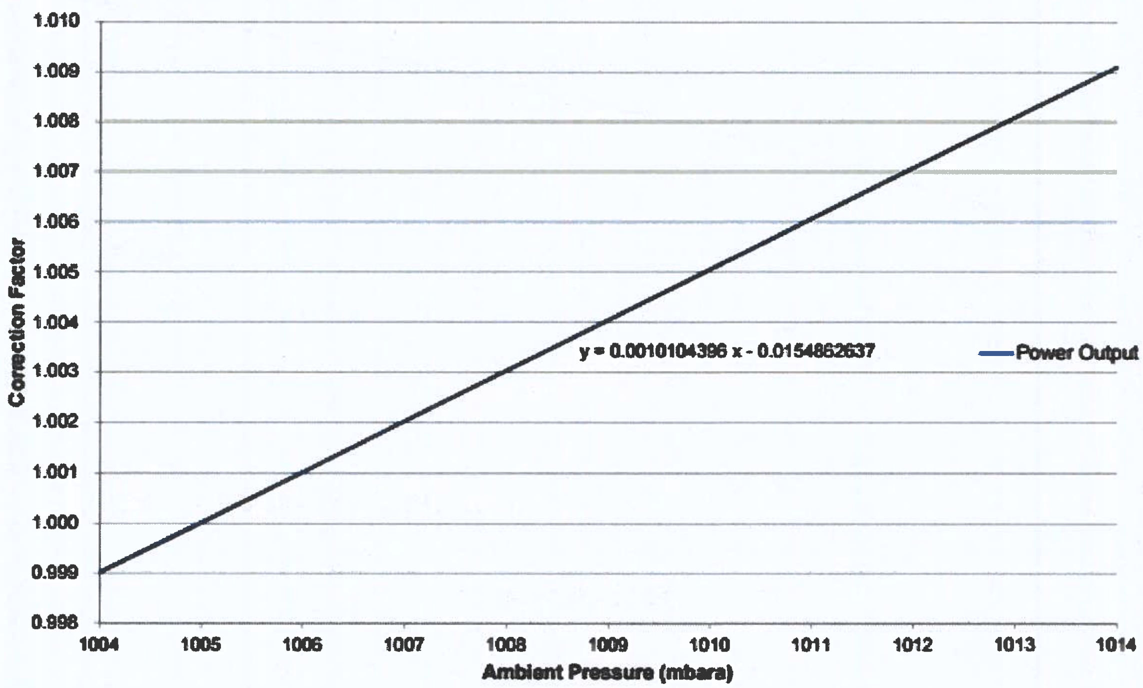


Figure A.24: Natural Gas Krh Correction Factor

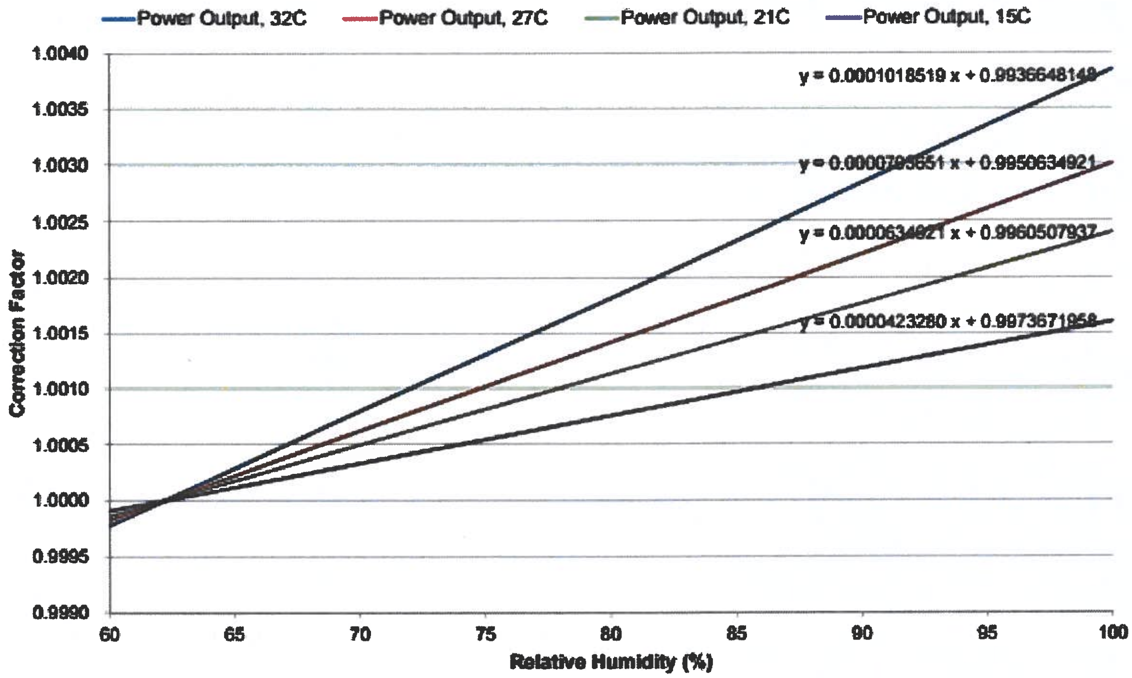


Figure A.25: Natural Gas Kpf Correction Factor

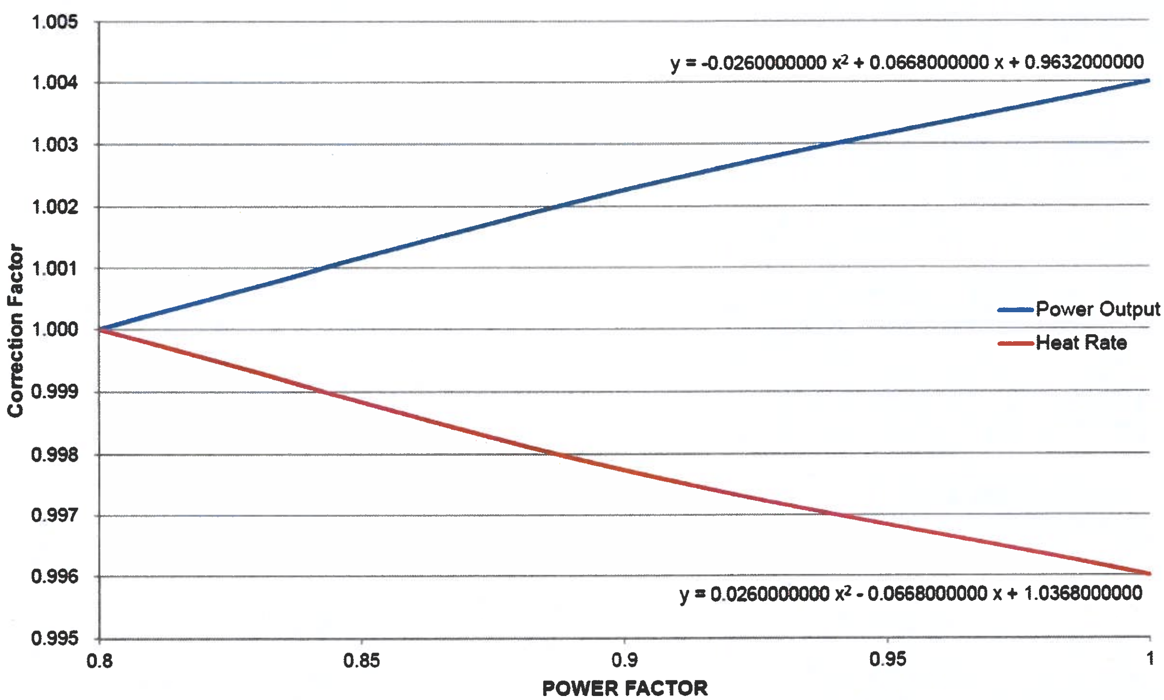
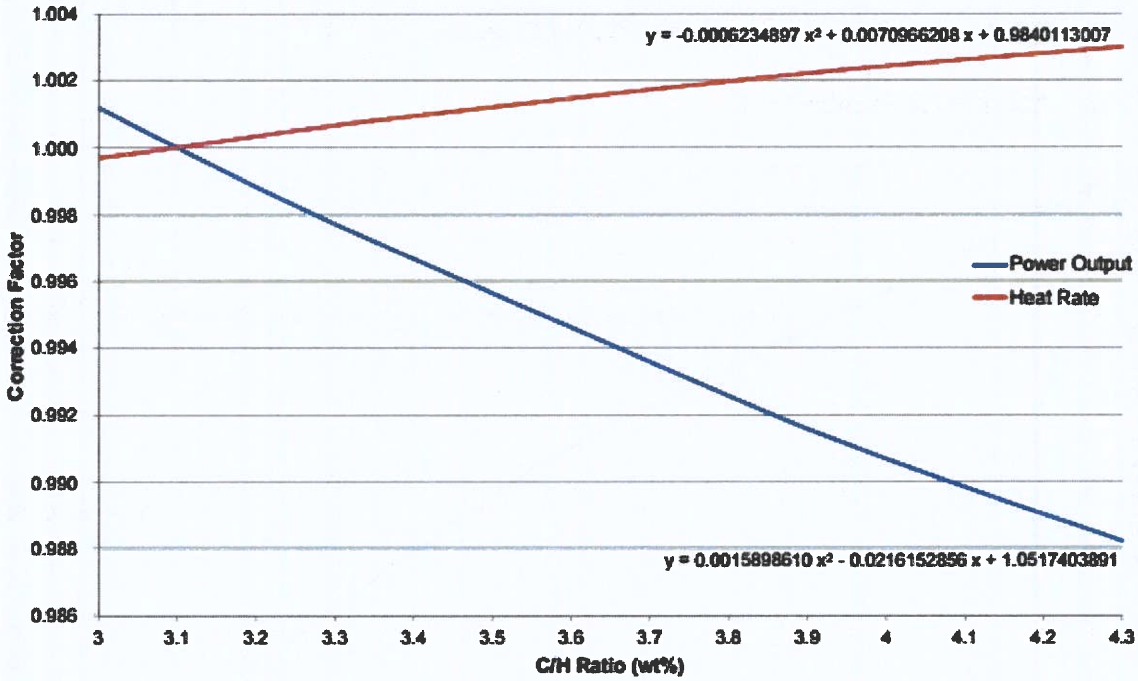


Figure A.26: Natural Gas $K_{C/H\ Ratio}$ Correction Factor



A.2.8 Power Output Correction for Combined Cycle Operation Mode

A.2.8.1 Correction Curve for Combined Cycle Operation on USLD

Figure A.27: ULSD Kdt Correction Factor

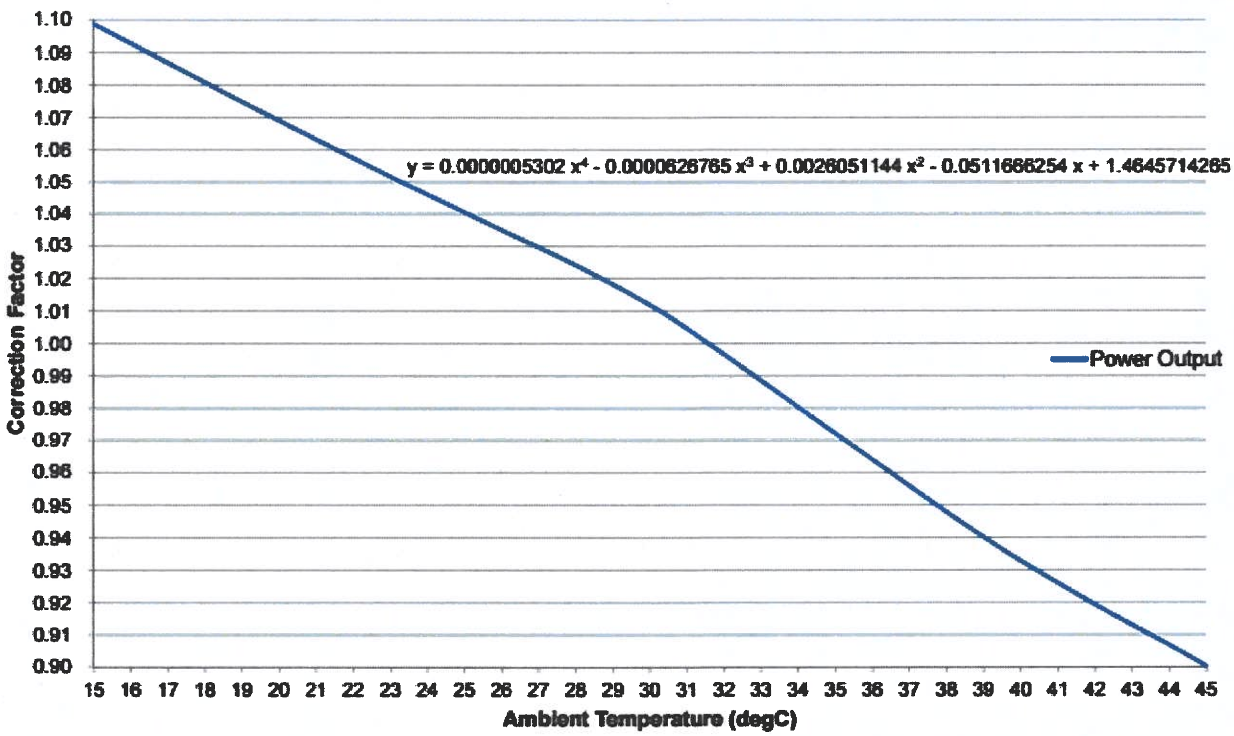


Figure A.28: ULSD Kbp Correction Factor

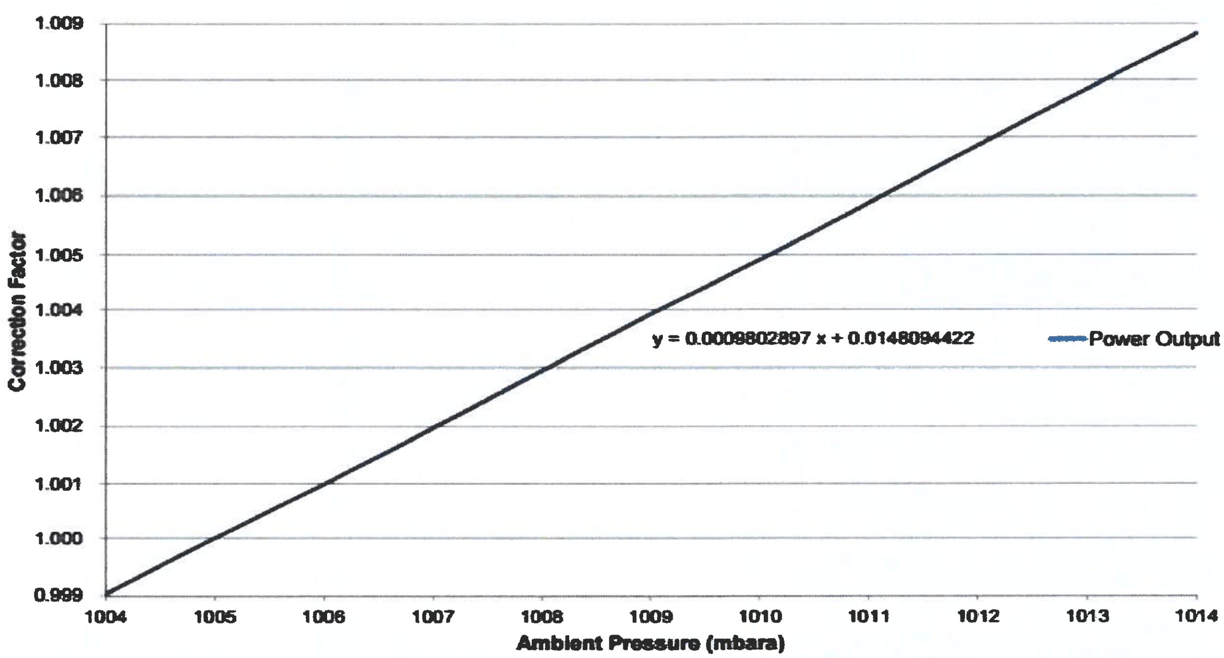


Figure A.29: ULSD Krh Correction Factor

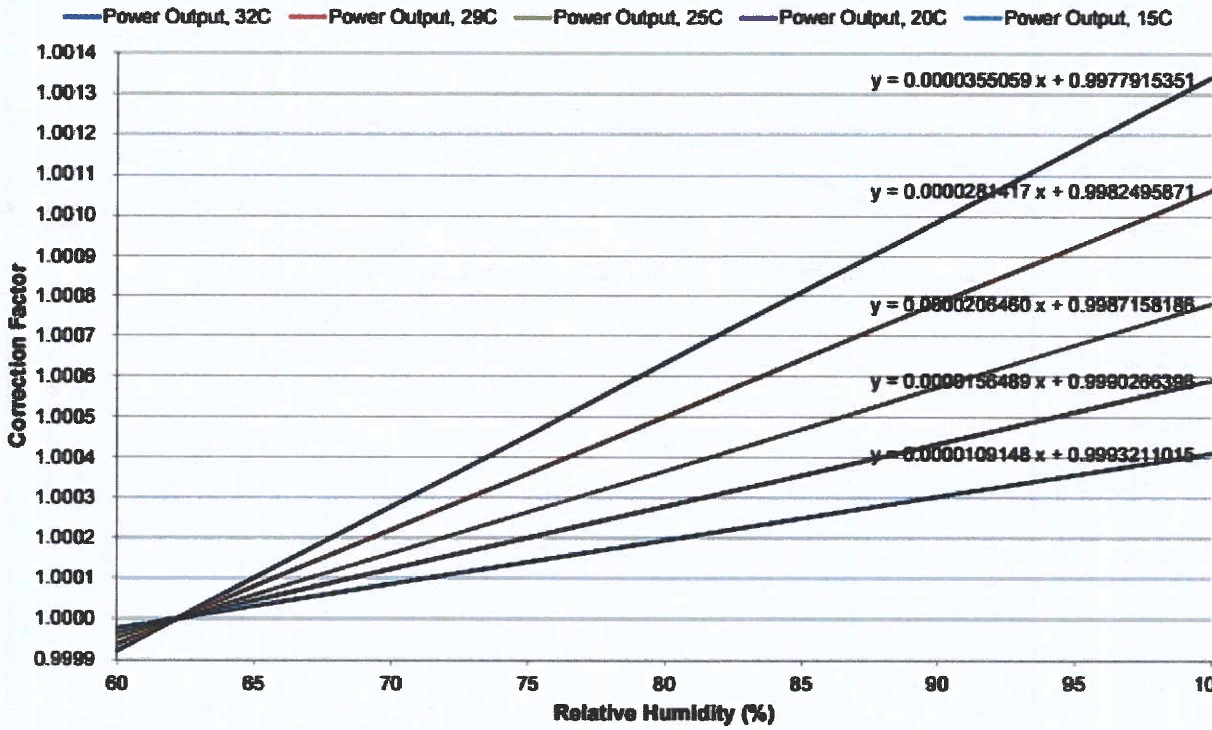


Figure A.30: ULSD Kpf Correction Factor

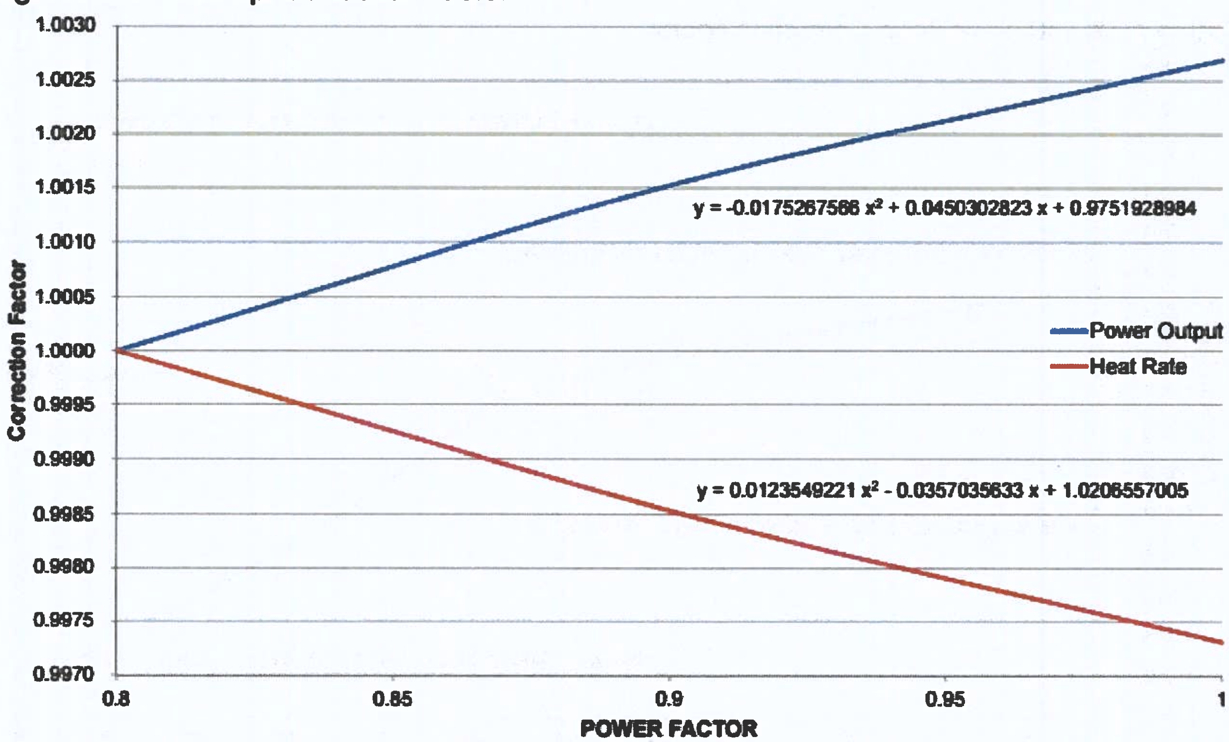


Figure A.31: ULSD KC/H Ratio Correction Factor

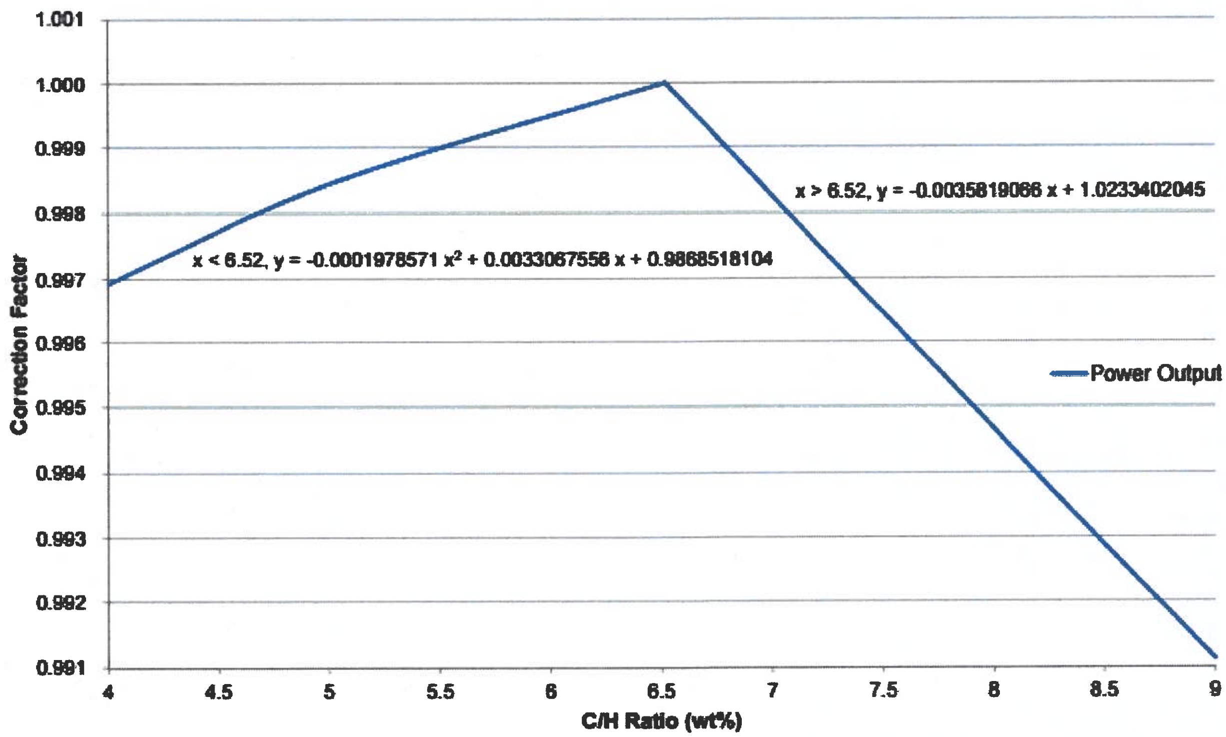
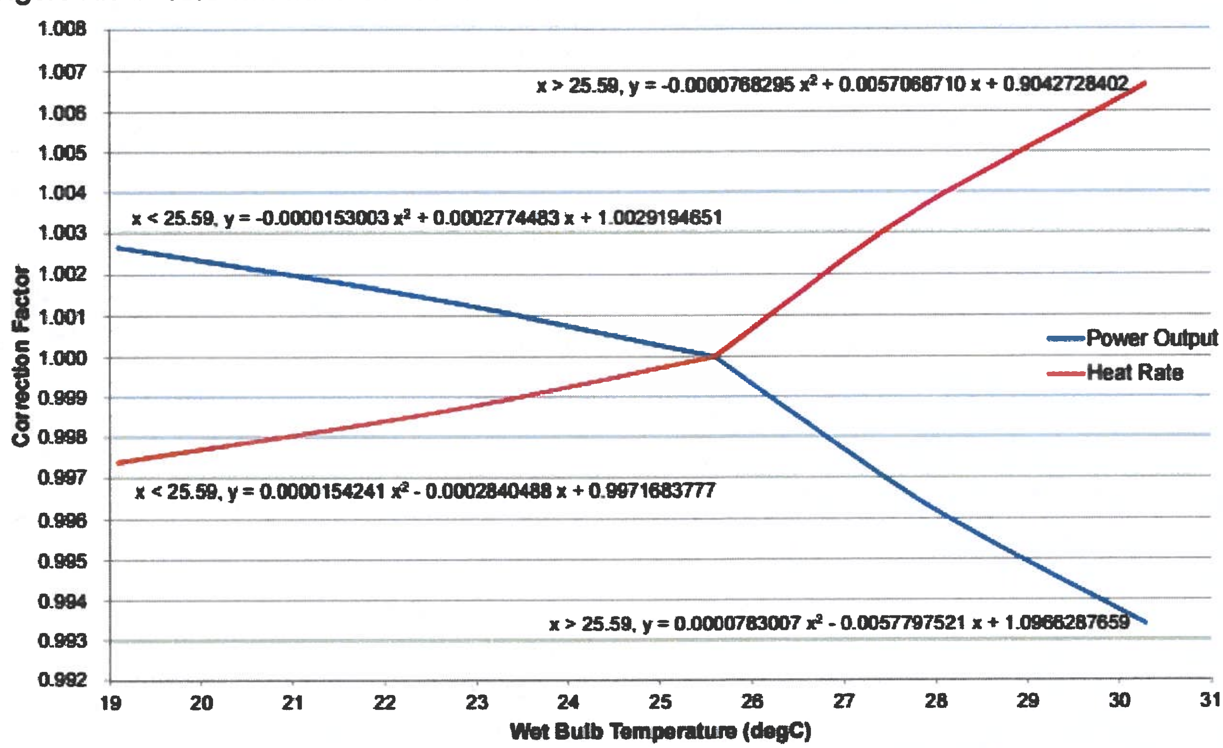


Figure A.32: ULSD Kwt Ratio Correction Factor



A.2.8.1 Correction Curve for Combined Cycle Operation on Natural Gas

Figure A.33: Natural Gas Kdt Correction Factor

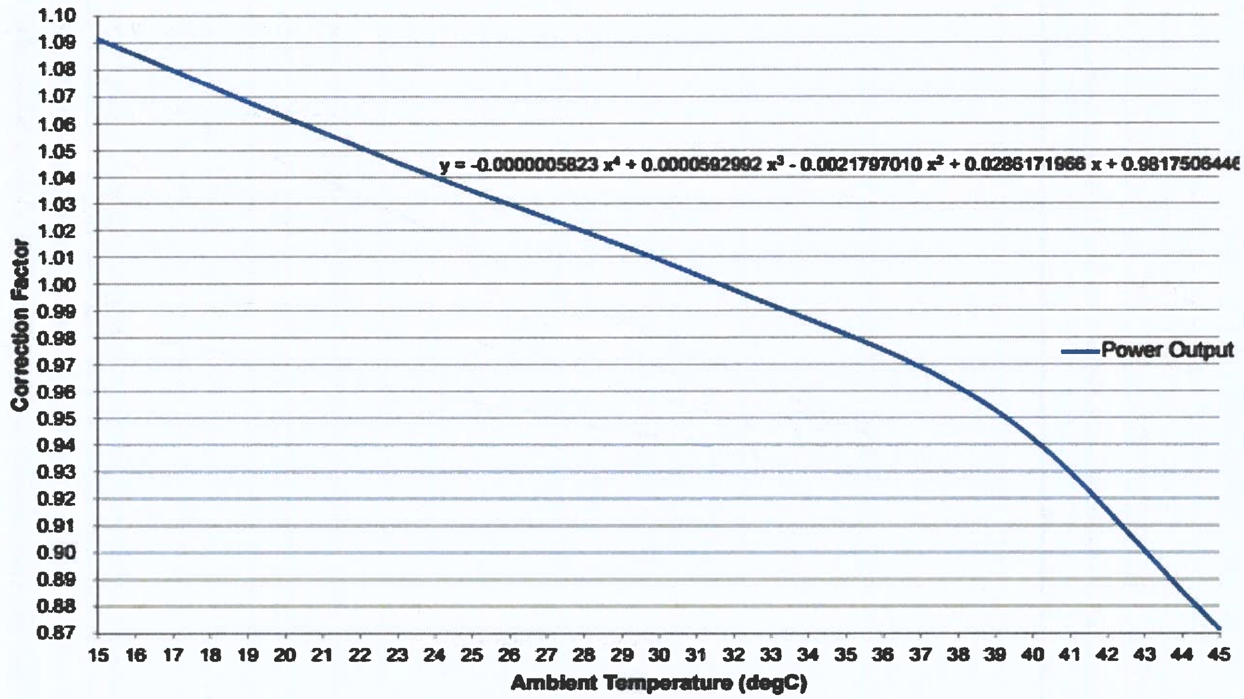


Figure A.34: Natural Gas Kbp Correction Factor

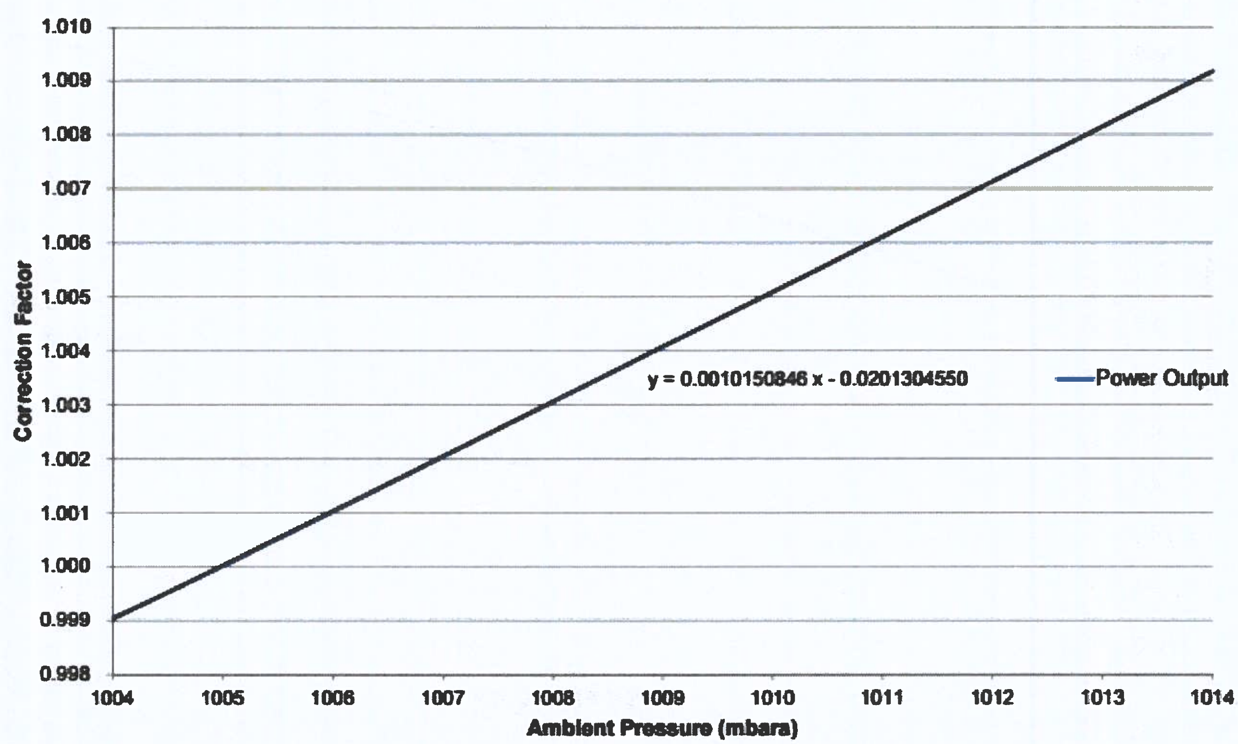


Figure A.35: Natural Gas Krh Correction Factor

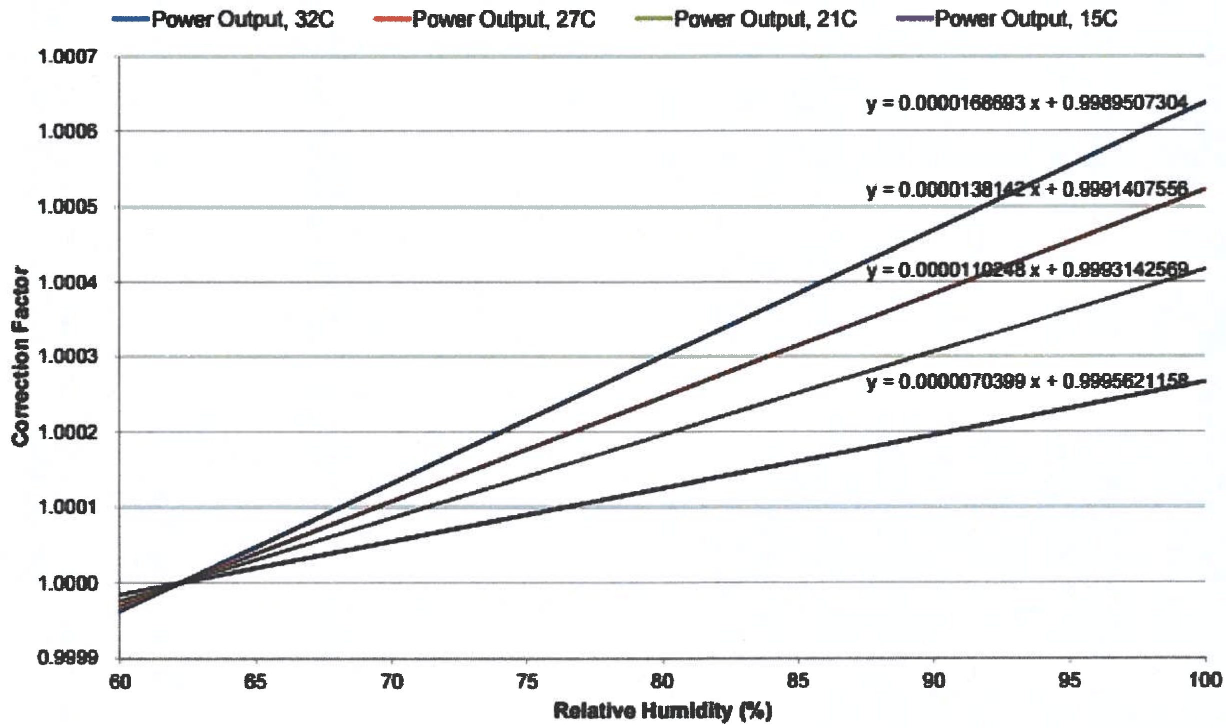


Figure A.36: Natural Gas Kpf Correction Factor

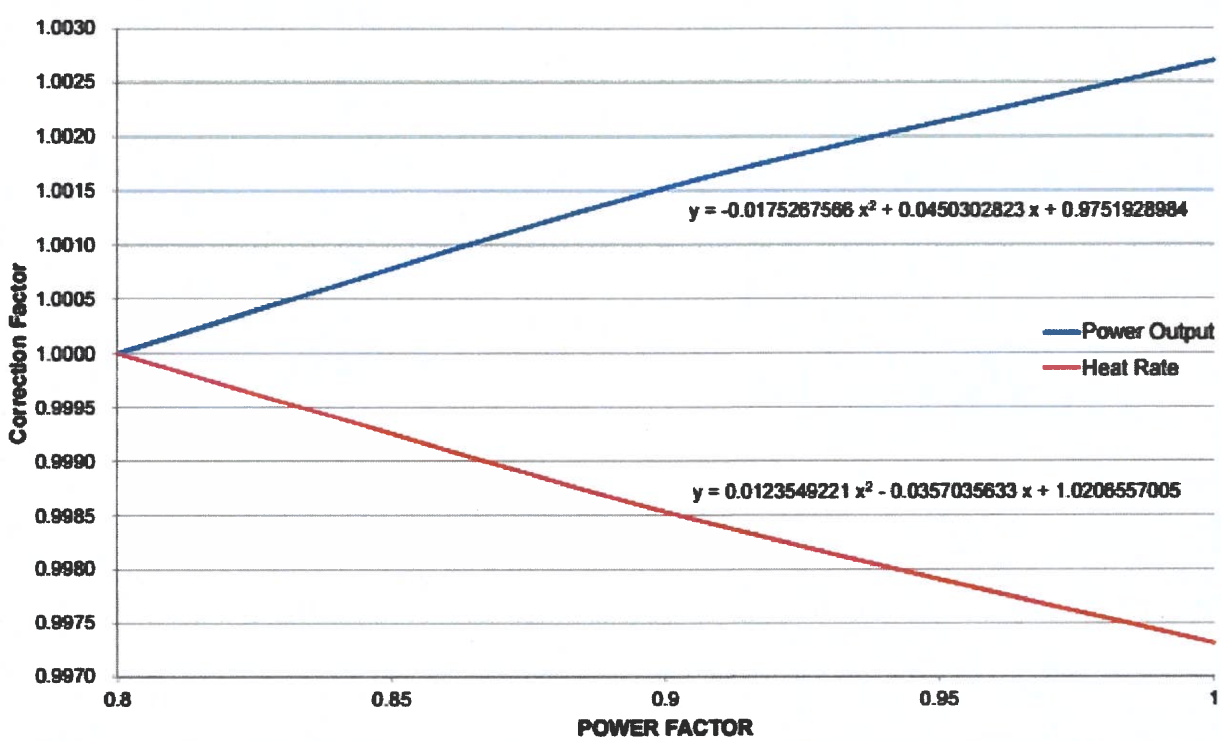


Figure A.37: Natural Gas KC/H Ratio Correction Factor

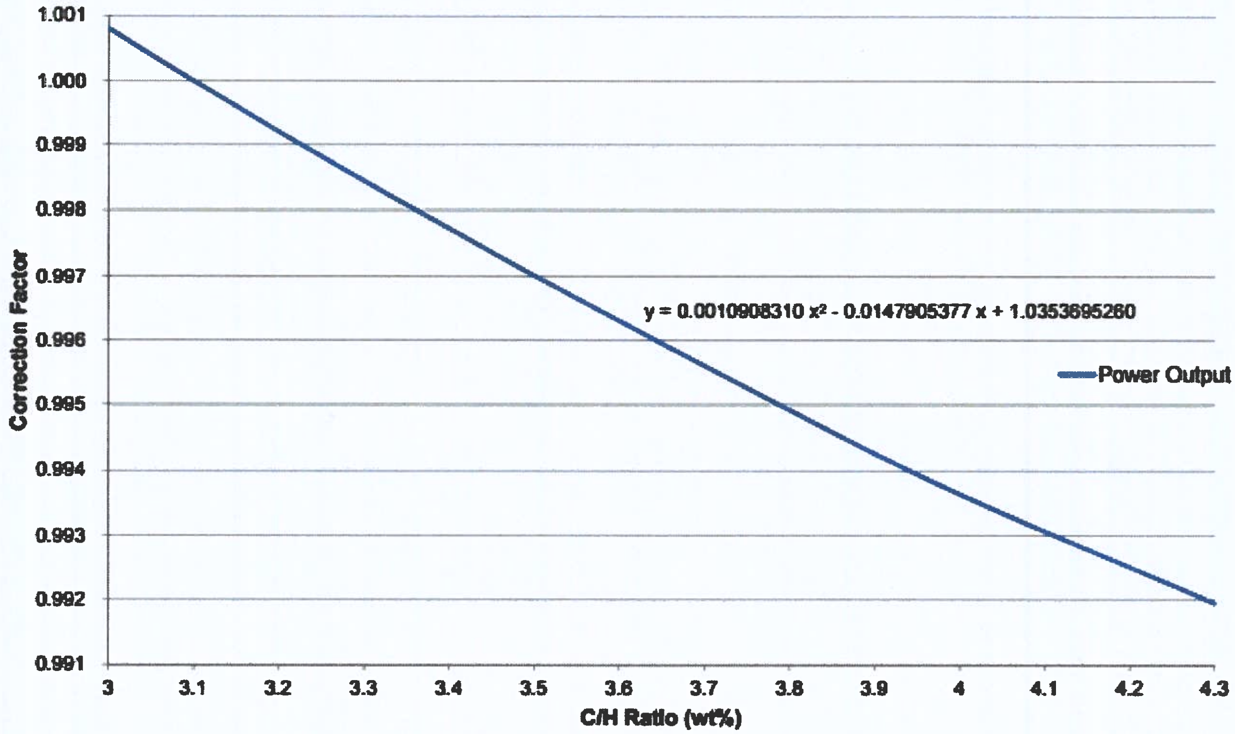
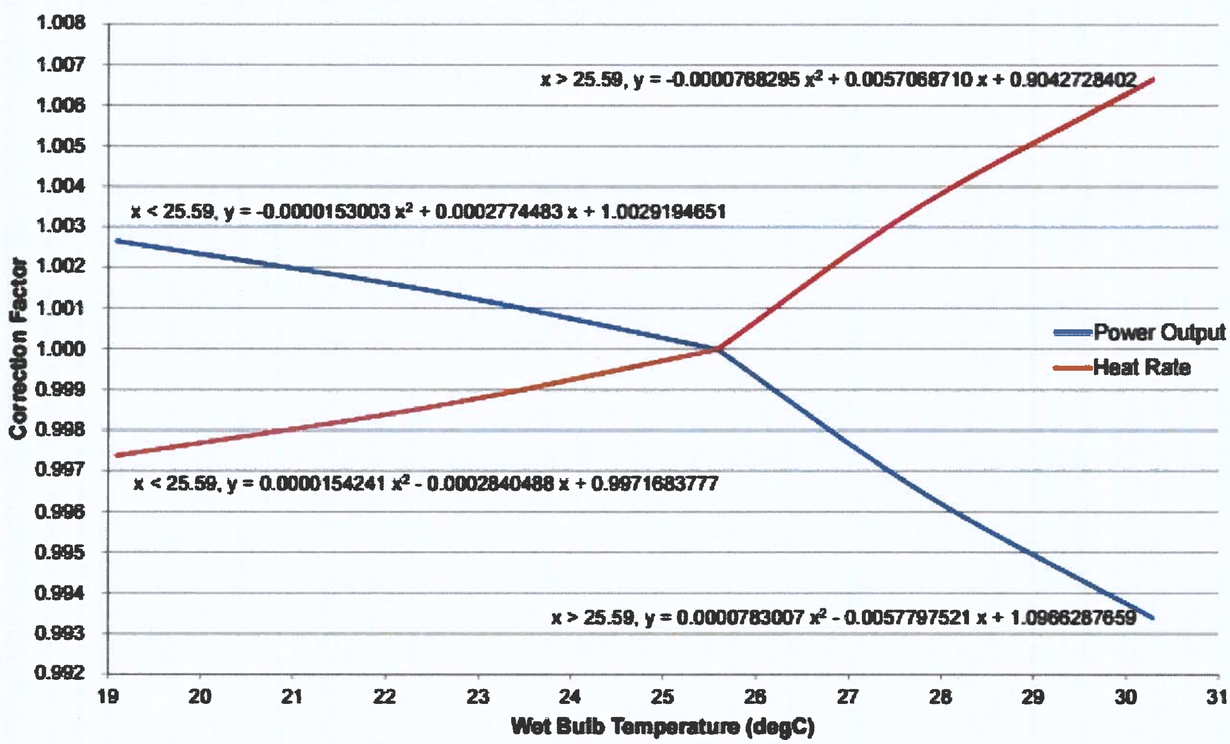


Figure A.38: Natural Gas Kwt Ratio Correction Factor



SCHEDULE 8
Transfer Price

Part A of Schedule 8 – Transfer Price

Reason for Termination Price to be Paid by GPA	Transfer Price
Project Company Event of Default	**Project Company Default Transfer Price** will be equal to the Outstanding Debt.
GPA Event of Default	**GPA Default Transfer Price** will be calculated as the present value of (i) future Fixed Capacity Charge payments and (ii) eighty percent (80%) of the future Fixed Operation and Maintenance Charge Reserve Facility payments from the date of termination of the Agreement until the end of the Term of the Agreement, calculated at a discount rate of five percent (5%) per year, plus Termination Payments, provided that in no event shall such amount be less than the Outstanding Debt plus Termination Payments.
Termination by GPA for convenience	**Early Transfer Price** will be calculated as the present value of (i) future Fixed Capacity Charge payments and (ii) eighty percent (80%) of the future Fixed Operation and Maintenance Charge Reserve Facility payments from the date of termination of the Agreement until the end of the Term of the Agreement, calculated at a discount rate of five percent (5%) per year, plus Termination Payments, provided that in no event shall such amount be less than the Outstanding Debt plus Termination Payments.
Termination due to Prolonged Force Majeure	**Force Majeure Transfer Price** will be equal to the Outstanding Debt plus 50% of the projected equity investment determined as of Financial Close.

In this Schedule:

"**Outstanding Debt**" means, as of the date of termination:

(a) the lesser of (x) the aggregate principal amount of the Project Company's outstanding debt (including accrued interest and the Project Company's liability to a Lender in respect of any amounts drawn under a letter of credit for debt service reserve, up to an amount, for such amounts drawn under such a letter of credit, not exceeding thirty million Dollars (US$30,000,000) issued by or on behalf of the Project Company and excluding all amounts drawn under an Equity Bridge Loan), (y) after the Commercial Operation Date, the then applicable Outstanding Debt Cap, and (z) the principal amount of the Project loan/s committed by Lenders pursuant to the Financing Documents as of Financial Close, excluding all amounts drawn under an Equity Bridge Loan (the "**Initial Debt Amount**"); plus

(b) applicable swap breakage cost under the Financing Documents; plus

(c) accrued commitment fees and prepayment and make-whole premiums and penalties (including interest period breakage costs) payable under the Financing Documents.

"**Outstanding Debt Cap**" means for any period, the amount set forth next to such period in Part B of this Schedule 8, provided that such amount shall be increased by the amount of any actual delayed payment or actual non-payment of debt or increased amount of debt arising from a GPA Event of Default or the occurrence of an event of Force Majeure or an Excusable Event or a GPA Delay Event.

"**Termination Payments**" means:

(a) all income, receipts, sales, value added, transfer, property or other taxes and any other costs imposed on the Project Company by any Government Authority as a result of termination of the Agreement or the transfer of the Project Facilities to GPA or payment of the purchase price therefor;

(b) all reasonable and documented amounts payable by the Project Company with respect to each of the Contractors' termination costs for the termination of subcontracts entered into by a Contractor for the engineering, procurement and construction, or the operation and maintenance of the Project Facilities (including, for the avoidance of doubt, the provision of technical services or any other long-term programme or service for the Project Facilities);

(c) all reasonable and documented amounts outstanding and payable by the Project Company to a Contractor upon termination of the Construction Contract or an O&M Contract with respect to work completed or performed by each of the Contractors and not yet paid for by the Project Company and for which no amount of principal of debt or drawing of equity has been incurred; and

(d) all costs and expenses (including any redundancy or severance payments) payable by the Project Company or a Contractor arising from the termination, retrenchment or retirement of their respective employees or contractors in connection with the termination of the Agreement.

Notwithstanding the above, the following costs shall be excluded from the definition of Termination Payments:

(i) costs applicable to the early termination of the LTPA with the LTP Contractor that are in excess of the amounts set forth in the table below. Defined terms in the table below have the meanings given to them in the LTPA with the LTP Contractor:

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Milestone	Cancellation Amount per Combustion Turbine
Prior to the first scheduled Level C Inspection	$9,113,466
After the first Level C Inspection and prior to the second scheduled Level C Inspection	$6,126,153
After the second Level C Inspection and prior to the third scheduled Level C Inspection	$3,912,073
After the third Level C Inspection	$1,737,993

(it being acknowledged that GPA shall not be obliged to pay termination costs in respect of the termination of the LTPA to the extent that GPA elects to assume the LTPA pursuant to Article 4.5(h)(iii) of the ECA);

(ii) costs applicable to the early termination of the Construction Contract that are in excess of the Discretionary Termination Payment (as such term is defined in the Construction Contract) (it being acknowledged that GPA shall not be obliged to pay termination costs in respect of the termination of the Construction Contract to the extent that GPA elects to assume the Construction Contract pursuant to Article 4.5(h)(iii) of the ECA); and

(iii) costs applicable to the early termination of any other LTPA unless such costs have been previously approved by GPA (it being acknowledged that GPA shall not be obliged to pay termination costs in respect of the termination of such other LTPA to the extent that GPA elects to assume such other LTPA pursuant to Article 4.5(h)(iii) of the ECA).

JC

Part B of Schedule 8 - Outstanding Debt Cap

Period	Outstanding Debt Cap (% of Initial Debt Amount)
1	100
2	100
3	100
4	99.4
5	98.3
6	97.3
7	96.1
8	94.9
9	92.6
10	90.1
11	86.6
12	82.7
13	78.4
14	72.6
15	66.6
16	60.3
17	54.0
18	47.8
19	42.3
20	36.7
21	30.7
22	24.5
23	18.0
24	9.3
25	0

JC

SCHEDULE 9
Form of Performance Bond and Transfer Security

JC

SCHEDULE 10
ULSD and NG Metering System and Settlement

JC

JC

2022 Integrated Resource Plan Volume III:

Addendum to the

2018 Environmental Strategic Plan

ROGER PABUNAN ENGINEERING SUPERVISOR PLANNING & REGULATORY DIVISION	10-22-2021 DATE
SYLVIA IPANAG MANAGER PLANNING & REGULATORY DIVISION	10/22/2021 DATE
JOHN J. CRUZ JR., PE ASSISTANT GENERAL MANAGER ENGINEERING & TECHNICAL SERVICES	10/22/2021 DATE
JOHN M. BENAVENTE, PE GENERAL MANAGER	11/1/2021 DATE

Table of Contents

1 Introduction

The 2022 Integrated Resource Plan Volume III: Environmental Strategic Plan is written as an Addendum to the 2018 Environmental Strategic Plan instead of rewriting the whole 2018 ESP.

2 Background

The Environmental Strategic Plan (ESP) was established in December of 2012 to consolidate recommendations and decisions affected by current and upcoming environmental regulations. It began as a living document regarding the re-designation of the Cabras-Piti area, and an update of GPA's environmental policy. It was developed alongside the Ambient Air Quality Monitoring Plan. Later, it expanded to include impact of other regulations (EGU MACT, RICE MACT, NAAQS, etc.)

The ESP was updated in December 2018 to include new regulations and the development of GPA's future resources and energy portfolio. A quick summary of key actions related to Environmental Regulations are as follows:

- GPA has supported GEPA in the re-designation work and in the preparation of the Draft State Implementation Plan (SIP) and Emissions Inventory. Ambient Air Quality Monitoring Plan drafts were first sent to US EPA in May 2012. Revisions to the Plan were sent to US EPA with the final version completed and filed with USEPA & Guam EPA at the end of 2013. Around June 2016, Guam EPA discontinued review of AAQM Plan in favor of modeling to show compliance.
- RICE MACT
  - Installed Oxidation Catalysts at Tenjo, MDI and Talofofo (5.2014)
  - Conversion of Piti 8&9 to ULSD and installing Oxidation Catalysts. This is also a requirement of the Consent Decree and State Implementation Plan
- EGU MACT
  - Deactivated Tanguisson Power Plant (2.2015)

  - Retirement of Cabras 1&2 after Commissioning of New Power Plant (Consent Decree)
- Designation for the 2010 1-hr SO2 received December 2017
  - Non-Attainment for for a 6.074-km radius centered on the Piti-Cabras Facilities
  - Unclassifiable/Attainment for the rest of the Island
- Continue work on decreasing hazardous emissions, such as expansion of Demand-Side Management Program
  - DSM program expanded to Residential Customers (2015)
  - Renewable Resource Contracts, 26.5 MW (2015), 120 MW (in progress)
  - GPA expects to award additional renewable energy purchase contracts for approximately 60MW of installed PV on leased Navy properties in a current bid. GPA is finalizing procurement documents for an additional renewable energy contract from approximately 60MW installed renewable facility.
  - Pilot program for use of Electric Vehicles

3 Updates to the 2018 Environmental Strategic Plan

The 2021 Generation Expansion Plan included key recommendations from the State Implementation Plan and the Consent Decree.

The following are updates to the 2018 Environmental Strategic Plan and a summary of requirements from the State Implementation Plan and Consent Decree.

3.1 Progress on Redesignation and State Implementation Plan

Since 2017, GPA has been assisting Guam EPA in the completion of the State Implementation Plan, which was originally due July 2019. The Final State Implementation Plan Control Strategy was completed by GPA and TRC, and submitted to Guam EPA and USEPA in February 2020 by GPA's P&R Division. The deadline for Guam EPA to submit to USEPA Was October 19, 2020. Major requirements for the SIP are:

- Removal of Units #3 and #4 from Cabras Power Plant Title V Permit. After the explosion, GPA has notified Guam EPA and USEPA that Cabras 3 and 4 are no longer operable.
- Updating Fuel Requirements for Piti CT Unit #7. During the time, the CT was allowed to use Diesel Fuel with 0.5% sulfur. However, now a Guam law is implemented where all Power Plants with the exception of Cabras Power Plant can only use ULSD as fuel.
- Piti #8 and #9 change in fuel to ULSD or LNG. The original consent decree deadline was December 31, 2021 under Consent Decree Section VI.B.22.2, and the new date which is still under negotiation is July 31, 2022.
- Transition Cabras Units #1 and #2 to lower-sulfur RFO. In order to comply with the 10hour SO2 NAAQS, GPA proposed to switch to the use of residual fuel oil with 0.2%Sulfur content. The original consent decree date was dependent on the Tank Refurbishment date under Consent Decree section VI.D.29, and the new date which is still under negotiation is December 31, 2022.
- Retirement of Cabras Units #1 and #2. The original consent decree date was October 31, 2022, under Consent Decree Section VI.D.32, and the new date which is still under negotiation is April 30,2024.

3.2 Progress on Compliance with Environmental Regulations

Since 2012, GPA and its consultant, TRC, has been proactively coordinating *with USEPA* Region IX and Guam EPA with support of environmental consultant, for updates to current and upcoming regulations and to support continued compliance to existing environmental requirements for GPA's existing Power Plants. GPA & USEPA entered into a Consent Decree in April 2020. Major Requirement are:

1. Retirement of Cabras 1 and 2
    - GPA will retire these units once the new power plant is in operation, which will eliminate the use of Residual Fuel Oil in all of GPA's power plants
2. Conversion of Piti 8 & 9 to ULSD with installation of Oxidation-Catalyst

- GPA committed to the fuel conversion of Piti 8&9 units to ULSD by July 2022 to comply with the State Implementation Plan and Consent Decree requirement

3. Construction of a new power plant that will run on ULSD
    - GPA entered into a IPP contract with KEPCO to build a ULSD/LNG dual fuel plant which would serve as GPA's primary baseload plant. GPA also committed to the fuel conversion of Piti 8&9 units to ULSD which would completely remove the heavy fuel oil use in GPA
    - Resulting from 2012 IRP recommendations, were the potential retirement of Cabras 1&2 Power Plant and conversion of Piti 8&9 to ULSD, with the additional loss of Cabras 3&4
4. Construction of at least 100 MW of solar power
5. Completion of 40 MW Energy Storage System
6. Construction of New ULSD Pipeline

APPENDIX A: 2018 ENVIRONMENTAL STRATEGIC PLAN

Environmental Strategic Plan (ESP)

DECEMBER 2018

Environmental Strategic Plan (ESP)

DECEMBER 2018

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JOHN M. BENAVENTE, P.E.
GENERAL MANAGER

ENVIRONMENTAL STRATEGIC PLAN TEAM

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TABLE OF CONTENTS

1. BACKGROUND

In December 2012, the Guam Power Authority (GPA) adopted an Environmental Strategic Plan (ESP) as a guide for achieving environmental compliance over the next five years especially in light of proposed U.S. EPA regulations.

The document set out a road map for the next five years to provide context for individual compliance decisions. Among the initiatives recommended were:

1. Inclusion of Environmental Compliance in GPA's Integrated Resource Plan
2. Communicating key environmental compliance requirements with internal and external stakeholders
3. Establishment of a process for ensuring each major activity undergoes review for compliance with environmental requirements stated in the ESP
4. As recommended by TRC, the filing or request of a consent decree to exempt GPA from various regulations; and a recommendation from Guam EPA for 325 Waiver for various sections of the Clean Air Act
5. Continued actions decreasing hazardous air emissions from the utility and the Guam community:
    a. Transition to ULSD
    b. Acquisition of a Renewable Energy Supply Contracts
    c. Establishment of a demand-side management program

GPA acted on these recommendations as follows:

Recommendation #1 – The Integrated Resource Plan included a section specifically for Environmental Compliance. Resource options investigated during the study included associated expenses and activities necessary to ensure compliance with applicable regulatory requirements.

Recommendation #2 – GPA presented the 2012 Environmental Strategic Plan, to:

- Internal stakeholders such as the Generation Division;
- External stakeholders, such as the Independent Power Producers; and,
- Key customers such as the Department of Navy (Naval Base Guam Command)

GPA, also, put into place a process for constant collaboration with key partners such as the IPPs to better coordinate and consolidate efforts for complying with US EPA and Guam EPA requirements, such as the RICE MACT and Boiler MACT.

Recommendation #3 – Most major activities concerning Generation already undergo compliance review. GPA's Planning and Regulatory Division have stepped up its communication and coordination with both US EPA and Guam EPA to ensure professional trust based on absolute transparency and candor. Recent activities include GPA's active communication and coordination with USEPA and Guam EPA during the repair and recommissioning of Dededo CT Plant, and in the solicitation for a contract for Temporary Power.

Recommendation #4 – GPA's Legal Counsel and Environmental Manager regularly communicate with USEPA and Guam EPA regarding environmental compliance matters including but not limited to a Consent Decree and waiver or considerations. Examples of these are the one-year extension granted to GPA for the installation of control equipment to ensure the fast-track diesel units comply with RICE MACT. The parties have also been discussing a potential Consent Decree.

Recommendation #5 -GPA has transitioned to ULSD for all its ULSD-fired units. A 20-year contract for 25 MW of renewable energy is in place, as well as a Demand-side Management Program. GPA has also awarded 120 MW of Renewable Energy Supply Contracts.

2. PURPOSE OF THE PLAN

2.1 PURPOSE

GPA's intention is to meet the regulations under each of the Environmental Acts of the United States. GPA intends to do this in a way that maximizes the environmental benefits, preserving or enhancing Guam's environment.

This ESP first reviews the known objectives and requirements of the environmental agencies and then presents the GPA plan for meeting those objectives and requirements. The ESP is a living document changing and adapting as new environmental requirements and regulations are introduced, or as current environmental requirements and regulations are updated.

2.2 HISTORY

The ESP was first published in 2012 and considered the compliance issues faced by GPA at that time. Regulations had just been promulgated by the United States Environmental protection Agency (USEPA) requiring control of emissions from most generation units. Cabras 1&2 and Tanguisson 1&2 were required to reduce emissions of particulate matter including hazardous metals. Cabras 3&4 as well as MEC 8&9 were required to reduce carbon monoxide (CO) emissions to control organic compound emissions. The smaller diesel engines at Dededo, Tenjo, Manenggon, and Talofofo all needed similar CO controls. The combustion turbines (TEMES, Macheche, Marbo, Yigo and Dededo) were not under regulation for emission reductions. The Dededo and Marbo combustion turbines were, however, in various states of disrepair and the requirements to restart them were in doubt.

In 2012 the most serious issue facing GPA was control of Sulfur Dioxide (SO_2) emissions from the burning of residual oil at the major generation units. USEPA had promulgated significant more stringent National Ambient Air Quality Standards (NAAQS) for both Sulfur Dioxide and Nitrogen Dioxide (NO_2) in 2010 and the Cabras/Piti and Tanguisson areas could not meet those new limits. Various mechanisms to meet those NAAQS were discussed in detail in the 2012 ESP. Additionally, USEPA was preparing to limit emission of Carbon Dioxide (CO_2) from power plants to meet Climate Change goals and GPA needed to prepare for those initiatives. USEPA was also preparing new rules for discharge of cooling waters to the ocean which could require extensive revisions to the Cabras and Tanguisson outfalls.

The background for this revised ESP is decidedly different. GPA undertook and accomplished the retrofitting of the Tenjo, Manenggon, and Talofofo diesel engines with catalyst control devices which meet the regulatory requirements. The closure of the Tanguisson power plant and the removal of the Dededo diesels has eliminated the need for air pollution controls on those units and refurbishing of the Tanguisson outfall. The loss of Cabras units 3&4 has lowered the cost associated with adding pollution controls to those units. The USEPA has not moved forward with controls on power plants for CO_2 and thus that potential set of requirements is not in this current plan.

The other issues remain and this revised ESP will outline the requirements that are still to be met and the options for attaining compliance, in addition to a discussion of the tasks already completed. The ESP shall also provide guidance on upcoming regulations and challenges that may impact GPA, such as new technologies or alternate solutions to on-going issues.

3. US EPA STRATEGIC PLAN

The US EPA published its Strategic Plan in April of 2018 ("FY 2018-2022 EPA Strategic Plan", February 12, 2018). The plan outlines a wide range of objectives, some of which apply to Guam and others which do not. The following is a summary of the objectives and potential issues for Guam and GPA.

3.1 PROVIDE REAL RESULTS ON CLEAN AIR, LAND WATER

US EPA's plan is to work to attain the standards for clean air, land and water that are already in place.

3.1.1 Improving Air Quality

The strategy is to prioritize the effort to reduce the number of areas around the country that are non-attainment. US EPA has already taken several actions to strengthen the compliance planning for the National Ambient Air Quality Standards (NAAQS) and contemplates further actions. These have significant effects for air quality on Guam and for GPA. By pollutant, these are the changes:

1. **Sulfur Dioxide (SO_2)**: EPA added a new 1-hour average NAAQS which, for the Cabras/Piti power plants, is 4 times more restrictive than the old NAAQS, i.e. requiring at least four times greater reduction in emissions to meet the NAAQS. This adds to the current problem that the Cabras/Piti area is non-attainment for the old NAAQS. Additionally, EPA required that non-attainment with the NAAQS would be determined by modeling alone. This NAAQS is a significant challenge for GPA and will be discussed in more detail later. On January 9, 2018 the US EPA declared that a circle 6.074 kilometers in diameter centered on the Cabras power plant is "nonattainment" for SO2. The remainder of the island was designated as "unclassified/attainment". "Unclassified/attainment" means that "available information does not indicate that the NAAQS is exceeded." The Guam EPA is required by the rule to submit to US EPA a compliance plan by October 9, 2019 after EPA declared a new non-attainment area for the new NAAQS. Compliance with the NAAQS is required by April 9, 2023.

2. **Nitrogen Dioxide (NO_2)**: EPA has added a new 1-hour average NAAQS which is more than seven times more restrictive than the old NAAQS. NO_2 concentrations have never previously been addressed on Guam. It is expected that the Cabras-Piti plants and Tenjo will have trouble complying with this new NAAQS. On February 17, 2012 EPA designated Guam as "unclassified/attainment" as it did for the entire country. EPA's definition of "unclassifiable/attainment" is that "available information does not indicate that the NAAQS is exceeded." In general this means that the area is in attainment until some measured or modeled data is used to change the classification. EPA required major cities

to monitor NO_2 air quality near major roadways. To date, no such monitoring has revealed a violation of the NAAQS. It is not clear what further steps the agency expects to take to require compliance with this NAAQS. Should a compliance requirement arise, Cabras/Piti and Tenjo may need to address this NAAQS.

3. **Particulate Matter**: EPA has promulgated a new NAAQS for particulate matter less than 2.5 microns in size. There are both stringent annual average and 24 hour average NAAQS. There have never been $PM_{2.5}$ measurements taken on Guam. There were some PM_{10} measurements taken in 1996 and again in 1999-2000 at Apra Heights which were relatively low but were unlikely to have measured the impact of the power plants. Because of fugitive dust sources and the presence of significant sea salt in the air, the situation may be important. EPA promulgated a further reduction to the annual average NAAQS to 12 $\mu g/m^3$.

   US EPA has a goal of studying and promulgating regulations directed at the emissions of black carbon (California has already done so). Since the emissions of residual oil firing contain black carbon, GPA's plants may be subject to such a rule. Rulemaking schedule has not yet been set. Control of particulate emissions would be expected.

   Should EPA take further actions on the $PM_{2.5}$ NAAQS, residual fuel oil firing would need to be reviewed for compliance. Ultra-Low Sulfur Diesel (ULSD) fuel would not interfere with compliance with the NAAQS.

4. There are also NAAQS for ***Carbon Monoxide, Ozone and Lead***. Keeping in mind that RICE MACT required reduction in carbon monoxide for reciprocal internal combustion engines, the CO NAAQS is not expected to be attainment issue on Guam. The constant winds of Guam do not allow for the formation of ozone. The relatively small content of lead in residual fuel oil and ULSD mean that exceeding the lead NAAQS is unlikely.

5. The US EPA strategy de-emphasizes control of ***Greenhouse Gas (GHG) emissions***. Current regulations require GPA to provide an annual report on its GHG emissions from its two largest stations; these are public and can be found on the EPA website (https://ghgdata.epa.gov/ghgp). GPA is complying with the reporting provisions having submitted its first report in March of 2011 and each successive March.

   The EPA data base shows that in 2016 1,053,548 Metric Tonnes (MT) of Carbon Dioxide Equivalent (CO2e) were reported for power plants on Guam. These include Cabras, Piti, Macheche, Dededo, and Yigo. The other power plants are not required to report because their emissions are below the reporting threshold, 25,000 tonnes CO2e.

   The Tanguisson emissions have ended. The Marinas Energy Company also reports independently but will be reported by GPA starting in 2019. GPA is complying with the reporting requirements and needs to ensure that each year these are complete and calculated correctly. Fines are possible for misreporting. No emission limits flow from this reporting rule.

The EPA proposed the Affordable Clean Energy (ACE) plan in August of 2018. This plan would reduce GHG emissions by requiring energy efficiency improvements at subject power plans. The proposal would include Cabras 1 & 2. Example energy improvement projects are listed in the proposal. The proposal also proposes to eliminate the need for a New Source Review or Prevention of Significant Deterioration permit for such projects.

6. Construction of new power plants and modifications to the existing major power plants would trigger New Source Review (significant increases in emissions) or new fossil fuel major power plants may require Best Available Control Technology (BACT) determinations for GHG emissions. In general, BACT has been confined to use of the most energy efficient practices which harmonize energy goals and GHG goals. So far, the requirements do not specify a change in fuel, i.e. if the proposed project is for oil firing, the BACT process does not require consideration of natural gas, but that may change. Every effort to increase fuel efficiency (reducing CO_2 emissions) should be taken in these projects so that permitting can go smoothly. GPA current plans are to construct only minor sources and not be subject to these rules. The modifications planned for MEC 8 & 9, however, may trigger these rules.

7. US EPA has promulgated a New Source Performance Standard (NSPS) for electric generation sources specifically for GHG emissions reductions which would apply to new power plant construction. The final rule was promulgated in October of 2015. The limit is 1000 lbs of CO_2 per Megawatt hour for combustion turbines greater than 250 Million BTU per Hour and 1,100 lbs/ MWhr for smaller combustion turbines. The rule, however, exempts combustion turbines which do not have natural gas available. Thus no Guam power plants would be subject to the rule unless natural gas is imported. This rule is currently under court review and GPA should follow this litigation closely.

8. US EPA has also promulgated a separate NSPS for modified or reconstructed fossil fuel steam electric plants. Units subject to this rule would include the steam units at Cabras. If these units were to be modified or reconstructed the proposal would require heat rate efficiency improvements of at least 2% and an emissions limit of no less than 2100 lbs CO_2 per MWh. Modifications of the steam electric units at Cabras #1 and #2.. This rule is currently in litigation and GPA should follow this litigation closely.

9. US EPA promulgated (March 5, 2004) and then stayed (August 18, 2004) the National Emissions Standards for Hazardous Air Pollutant Emissions (NESHAP or MACT Standards) for combustion turbines. That rule would have controlled Hazardous Air pollutant (HAP) emissions from a facility that would emit more than 25 tons per year of HAPs. Currently, none of GPA's existing CTs exceed 25 tons per year of HAPs and would not be subject to the rule. For facilities that are subject to the rule it would have required that formaldehyde emissions be limited to 91 parts per billion. That generally would have

required an oxidation catalyst be installed. US EPA is currently working on this rule and may lift the stay in the near future. In order to be a minor source of HAPs, the new power station would install oxidation catalysts.

10. US EPA proposed an Existing Source Performance Standard (ESPS) for carbon dioxide emissions on June 18, 2014. This is generally called the Clean Power Plan (CPP). The proposed rule was supplemented on November 4, 2014 with specific targets for Guam. This proposed regulation would have required the Guam EPA to develop a plan to reduce carbon dioxide emissions from Cabras #1 and #2 on a schedule stretching until 2030. Those targets were to reduce emissions from the four steam electric units from 1948 pounds of CO_2/MW Hour (2012 baseline) to 1733 pounds of CO_2/MW Hour during the period from 2020 to 2029 and reach a final goal of 1586 pounds of CO_2/MW Hour in 2030. The plan that Guam EPA devises could include increase in energy efficiencies or changes to lower emitting fuels at the steam units. Alternatively the plan could be to reduce the use of these steam plants by replacement of their power with solar power, wind power or demand side management. EPA noted in its proposal that renewable energy goals had been set by the Guam legislature. Final promulgation was in June 2015. The final rule did not require any reductions on Guam. The Supreme Court has stayed the implementation of this rule and it seems likely that the current administration will not go forward with the rule. The CPP has been replaced by a new proposal, ACE (see above).

11. US EPA's goals include assisting communities in making adaptations to potential global warming effects. The potential effects on Guam would primarily be increased sea surface temperature. This would lead to increased atmospheric temperature on Guam and air conditioning load. Whether increase in sea surface temperature would lead to more frequent typhoons is a matter of scientific debate, but it is possible. The other potential global warming effect on Guam is an increased sea surface height. There are significant consequences for the Cabras/Piti power plants themselves if there are significant sea level rises, but there are also consequences for the entire island. There is presently no timeline on this EPA effort.

3.1.2 Water Quality Goals

The goal for EPA is timely completion of NPDES permits. Cabras has a recently issued NPDES permit. None of the other plants need one (Tanguisson had one that has been terminated). The Cabras new permit conditions are those flowing from Section 316(B) of the regulations which cover the diminished effect of cooling water withdrawals from the ocean. Cabras/Piti still withdraw cooling water from the ocean although at reduced quantities with the loss of Cabras 3&4. GPA completed required studies to determine the effects of the withdrawals on sea life. GPA and Guam EPA have agreed to an alternate compliance schedule which anticipates the closure of Cabras 1 & 2 by 2022. A revised NPDES permit application has been submitted to that effect.

3.1.3 General Goals

The broad goal of "Cooperative federalism" is to return more power to make decisions on environmental goals and methods to the various states and territories. This means that rather than imposing methods and guidance on the Guam EPA, there is more opportunity for the Guam EPA to decide how to meet environmental objectives.

3.2 GUAM ENVIRONMENTAL PROTECTION AGENCY

The Guam EPA seeks to enforce the US Environmental laws and provide a safe, clean environment for Guam.

4. GPA'S ENVIRONMENTAL STRATEGIC PLAN

This ESP illustrates GPA's progress in complying with current and upcoming regulatory requirements. It includes GPA's plans to address or mitigate the potential issues from and impacts of these regulatory requirements.

4.1 AIR QUALITY COMPLIANCE

4.1.1 National Ambient Air Quality Standards (NAAQS)

4.1.1.1 Regulatory Requirements

Compliance with the goal of meeting the NAAQS is primarily accomplished by reductions of emissions from each generating station as required by the air quality permits issued by the Guam EPA. Appendix C lists all the activities undertaken by GPA to meet these emission limitations.

The following descriptions of air pollutants being measured under NAAQS is from the U.S. Environmental Protection Agency website.

Sulfur Dioxide
SO_2 is one of a group of highly reactive gasses known as "oxides of sulfur." The largest sources of SO_2 emissions are from fossil fuel combustion at power plants and other industrial facilities. Smaller sources of SO_2 emissions include industrial processes such as extracting metal from ore, and the burning of high sulfur containing fuels by locomotives, large ships, and non-road equipment. SO_2 is linked with a number of adverse effects on the respiratory system.[1]

Nitrogen Dioxide
NO_2 is one of a group of highly reactive gasses known as "oxides of nitrogen," or "nitrogen oxides (NOx)." Other nitrogen oxides include nitrous oxide and nitric oxide. While EPA's National Ambient Air Quality Standard covers this entire group of NO_x, NO_2 is the component of greatest interest and the indicator for the larger group of nitrogen oxides. NO_2 forms quickly from emissions from cars, trucks and buses, power plants, and off-road equipment. In addition to contributing to the formation of ground-level ozone, and fine particle pollution, NO_2 is linked with a number of adverse effects on the respiratory system.[2]

Particulate Matter
"Particulate matter," also known as particle pollution or PM, is a complex mixture of extremely small particles and liquid droplets. Particle pollution is made up of a number of components, including acids (such as nitrates and sulfates), organic chemicals, metals, and soil or dust particles. The size of particles is directly linked to their potential for causing health problems. EPA is concerned about particles that are

[1] http://www.epa.gov/airquality/sulfurdioxide/

[2] http://www.epa.gov/air/nitrogenoxides/

10 micrometers in diameter or smaller because those are the particles that generally pass through the throat and nose and enter the lungs. Once inhaled, these particles can affect the heart and lungs and cause serious health effects. EPA groups particle pollution into two categories:

- "Inhalable coarse particles," such as those found near roadways and dusty industries, are larger than 2.5 micrometers and smaller than 10 micrometers in diameter.
- "Fine particles," such as those found in smoke and haze, are 2.5 micrometers in diameter and smaller. These particles can be directly emitted from sources such as forest fires, or they can form when gases emitted from power plants, industries and automobiles react in the air.[3]

Table 4.1: NATIONAL AMBIENT AIR QUALITY STANDARDS APPLICABLE TO GUAM

POLLUTANT	AVERAGING TIME	CONCENTRATION	ATTAINMENT STATUS	STATE IMPLEMENTATION PLAN EFFECTIVE DATE	COMPLIANCE DEADLINE
Sulfur Dioxide (SO2)	1 Hour	75 ppb	Cabras/Piti= Nonattainment	19-Oct-19	9-Apr-23
			Remainder of Island = Unclassifiable / Attainment		
	3 Hour	500 ppb	Cabras/Piti= Non-Attainment		
			Remainder of Island = Unclassifiable / Attainment		
Nitrogen Dioxide (NO2)	1 Hour	100 ppb	Unclassified / Attainment	EPA has not required Guam EPA to develop a SIP for attainment or maintenance of the NO_2	
	1 Year	53 ppb			
Particulate Matter (PM 2.5)	1 year	12 µg/m3	Unclassified / Attainment	EPA has not required Guam EPA to develop a SIP for attainment or maintenance of the PM	
	24 Hours	35 µg/m3			

[3] http://www.epa.gov/airquality/particlepollution/

4.1.1.2 Status and Progress

Nitrogen Dioxide

EPA first set standards for NO_2 in 1971, setting both a primary standard (to protect health) and a secondary standard (to protect the public welfare) at 0.053 parts per million (53 ppb), averaged annually. All areas in the U.S. meet the current (1971) NO_2 1 Year average standards.

On January 22, 2010, EPA strengthened the health-based NO_2 NAAQS by setting a new 1-hour NO_2 standard at the level of 100 parts per billion (ppb). This level defines the maximum allowable concentration anywhere in an area. It will protect against adverse health effects associated with short-term exposure to NO_2.[4] This new standard is expected to be much stricter than the annual standard and it is likely that many major sources of NO_2 emissions will find it difficult to demonstrate compliance through dispersion modeling procedures. Considering the potential need to support an attainment demonstration, it seems prudent to include monitoring of NO_2 in any proposed monitoring plan. GPA should wait for guidance from USEPA to Guam EPA before proceeding with strategies to control NO2 emissions. Depending on the status of generation in the Cabras/Piti area. It is possible that the NAAQS is exceeded on Nimitz Hill. Additionally a few inland diesel engine sites with nearby higher terrain may have difficulty meeting the NAAQS.

The deadline for compliance with the NAAQS is 5 years from promulgation or in this case 2015. EPA has not required Guam EPA to develop a SIP for attainment or maintenance of the NO_2 1 Hour NAAQS and will not do so until it has evidence that the NAAQS is being exceeded. GPA should be sure to watch developments on the NO_2 NAAQS compliance plans.

Particulate Matter

Based on its review of the air quality criteria and NAAQS for particulate matter, EPA promulgated revisions to the primary and secondary NAAQS for PM on October 16, 2006. With regard to primary standards for fine particles, EPA revised the level of the 24-hour $PM_{2.5}$ standard to 35 micrograms per cubic meter ($\mu g/m^3$) and (in 2013) revised the level of the annual $PM_{2.5}$ standard at 12 $\mu g/m^3$. With regard to primary standards for particles generally less than or equal to 10 µm in diameter (PM_{10}), EPA retained the 24-hour PM_{10} and revoked the annual PM_{10} standard. With regard to secondary PM standards, EPA made them identical in all respects to the primary PM standards, as revised.[5] It is expected that residual fuel oil fired facilities would have difficulty meeting this NAAQS if EPA began to actively pursue it. ULSD fueled facilities will not have any difficulty meeting NAAQS.

EPA declared Guam unclassified/attainment for the PM NAAQS. The deadline for compliance with the NAAQS is 5 years from promulgation or in this case 2017. EPA has not required Guam EPA to develop a

[4] http://www.epa.gov/air/nitrogenoxides/pdfs/20100122fs.pdf

[5] http://www.gpo.gov/fdsys/pkg/FR-2006-10-17/html/06-8477.htm

SIP for attainment or maintenance of the PM NAAQS and will not do so until it has evidence that the NAAQS is being exceeded. GPA should be sure to watch developments on the PM NAAQS compliance plans,

Sulfur Dioxide

In March of 1999, GPA, the US EPA and the Guam EPA signed a consent agreement which establishes that compliance with the NAAQS for SO2 be maintained by a system which allows use of 2% sulfur residual oil fuel when the winds are blowing the emissions out to sea and the use of 1.19% sulfur residual oil when the winds are blowing toward the land.

The portions of Guam that are located within a 3.5 kilometer radius of the Cabras-Piti and Tanguisson power generating facilities were designated as non-attainment areas for the 3-hour and 24-hour average SO_2 NAAQS. That determination was made in the 1980's. GPA pursued having EPA declare the area around the shuttered Tanguisson Station as attainment.

GPA has provided ambient air quality monitoring of SO_2 between 1995 and 2001. Much of this monitoring preceded the changes in emissions resulting from the Consent decree. The maximum concentrations measured at several locations during these various monitoring programs are as follows:

Table 4.2 Maximum Concentrations Based on AAQM Data 1995-2001

LOCATION	MAXIMUM CONCENTRATION
Nimitz Hill (3 hour)	270 ppb (707 $\mu g/m^3$)
Apra Heights (3 hour)	189 ppb (495 $\mu g/m^3$)
Piti mayor's Office (3 hour)	171 ppb (448 $\mu g/m^3$)
Dededo (1 hour)	160 ppb (419 $\mu g/m^3$)

These results show compliance with the 3 Hour average NAAQS. The results are, however, in excess of the new one-hour average NAAQS.

In 2017, GPA performed air quality dispersion modeling in preparation for the submittal under the Data Requirements Rule (DDR) as required by US EPA region 9. A complete modeling protocol was approved by both USEPA and Guam EPA. This modeling was performed with the model AERMOD at actual emission rates for 2011-2013 for island power plants SO_2 sources. The results of the modeling are shown on Table 4.3.

These model results estimate the difficulty in meeting the NAAQS for SO_2 on Nimitz Hill. Even without the Cabras units 3 & 4, the results are more than twice the NAAQS. Included in the modeling were ship emissions from the harbor which have no effect on Nimitz Hill. The background concentration derived in the report is 29 $\mu g/m^3$.

Table 4.3 Culpability Analysis of GPA Applicable Sources' Modeled H4H Result; No Background Added

Source	H4H (2011-2013)								COMPLIANCE COMPARISON			
	2011		2012		2013		3-yr Average		Modeled + Background (29 µg/m3)		NAAQS	
	µg/m^3	ppb	µg/m^3	ppb	µg/m^3	ppb	µg/m^3	ppb	µg/m^3	ppb	µg/m^3	ppb
GPA	478	182	571	218	619	236	556	212	585	223	196	75
Cabras 1	164	63	321	122	298	114	261	100				
Cabras 2	162	62	204	78	180	69	182	70				
Cabras 3&4	132	50	37	14	81	31	83	32				
Piti 8&9	20	8	9	3	60	23	29	11				
Piti 7	0	0	0	0	0	0	0	0				

On June 29, 2017 the Guam EPA requested designation of an area nearby Cabras/Piti as non-attainment for the 1 Hour SO_2 NAAQS. The area is a circle of 6.074 kilometers (~3.4 miles) from the center of the SO_2 sources at the power plants. On August 22, 2017 US EPA agreed with the Guam EPA suggested designation and added that all other areas of Guam would be designated unclassified/attainment. On January 9, 2018 US EPA published in the Federal Register (FR 83, No. 6, page 1171) those results for designations for Guam. That final rule was effective April 9, 2018. The designation requires Guam EPA to develop a State Implementation Plan (SIP) for the Cabras/Piti area and establish rules and regulations to safeguard the NAAQS on the rest of the Island.

By virtue of the January 9, 2018 Federal register notice, the fact of the Tanguisson power plant shut down has been accepted by EPA and no separate SIP for the Tanguisson area is needed. The old 3.5 kilometer non-attainment area around Tanguisson has been replaced by the designation of "unclassified/attainment".

4.1.1.3 Future Compliance Considerations

Guam EPA is required to develop and submit by October 9, 2019 to US EPA a State Implementation Plan (SIP) to attain the SO_2 NAAQS. The SIP must present a plan to reduce emissions in the non-attainment area and demonstrate that the NAAQS will be attained and maintained. The deadline for completing the plan and coming into attainment is five years after approval of the plan by USEPA or as early as October 9, 2024. The required SIP deals only with SO_2. Compliance issues with the NO_2 and $PM_{2.5}$ NAAQS await EPA action.

Should USEPA and Guam EPA act on compliance requirements for NO_2 and $PM_{2.5}$, GPA should ensure the following:

- For the Tenjo Power Plant, NO_2 and $PM_{2.5}$ emissions would not meet NAAQS. Stack height should be increased or operating parameters changed.

- For the Piti 8 & 9 Power Plant, GPA should consider installation of Oxidation Catalyst and Selective Catalytic Reduction (SCR) that would address both CO emissions and NO_2 emissions. Use of ULSD would comply with PM standards.
- For the Piti 7 Power Plant alone, no changes needed to meet NO_2 or $PM_{2.5}$ NAAQS. If Piti 8&9 are not revised to comply Piti 7 does not add sufficient NO_2 or PM to change the situation and no controls on Piti 7 would be needed.
- For GPA's northern CT Plants, no revisions necessary.
- For GPA's Manenggon and Talofofo fast-track diesel plants, no revisions are necessary.
  For the new power plant to be located at the Harmon area, use of ULSD will be incompliance with the SO_2 and $PM_{2.5}$ NAAQS and use of SCR will allow compliance with the NO_2 NAAQS.
- For the 40-MW temporary power station located beside the Yigo Combustion Turbine Power Plant, installation of Oxidation Catalyst for compliance with CO emissions are needed to ensure compliance. Alternatively, the thirty-nine (30) individual engines could be split between Yigo site and other sites to attain compliance.

4.1.1.4 Proposed Actions and Economic Impact

State Implementation Planning

GPA will assist Guam EPA in the development of the SO_2 SIP. Air pollution emission control options include the following:

1. Close Cabras Units 1 and 2, leaving only Piti 7, 8 & 9 in the Cabras/Piti complex. Switch major generation to new power plant. Residual Fuel sulfur content at MEC 8 & 9 would also have to be reduced at least below 1.7 %. Switching to 1.19% sulfur residual oil (already on hand and regularly purchased) would meet the requirements as would ULSD. TEMES permit should be changed to firing ULSD which it already does.
2. Reduce the sulfur content of all the fuels sufficiently to meet the NAAQS. Under this option the cost of fuel goes up. The current consent decree allows the use of lower sulfur fuel only on days with winds toward Nimitz Hill.
3. The other power plants such located in northern Guam and southern Guam, including GPA's Temporary Power Station located beside Yigo CT Power plant, outside of the Cabras/Piti area will not be included in the SIP. Any changes made to these unit should ensure compliance with NAAQS.

Without further action by EPA, GPA does not need to address compliance with the NO_2 or $PM_{2.5}$ NAAQS in the near future. If EPA requires further action, then the compliance considerations outlined in the previous section should be considered.

The deadline for compliance with the one hour SO_2 NAAQS is five years after the effective date of the area designation or April 9, 2023.

4.1.2 Green House Gas (GHG) Reporting

4.1.2.1 Regulatory Requirements

GPA is required to provide an annual report on its GHG emissions that will be made public. GPA has been complying with the reporting provisions since March of 2011. GPA needs to ensure that these are complete and calculated correctly.

4.1.2.2 Status and Progress

Given the current regulatory agenda, there is nothing in addition to reporting GHG emissions that is required of GPA, unless a new power generation unit is constructed or significant changes are made to existing generation units such as Dededo. In either case, GPA may be required to reduce GHG emissions by either increasing energy efficiency at existing stations or consider only natural gas as a fuel for new generation units (Guam is currently exempt from that proposed requirement).

4.1.2.3 Future Compliance Considerations

The current manpower requirements for reporting GHG emissions on a yearly basis will continue for the foreseeable future. No additional cost for GHG regulatory efforts would be needed unless a triggering change is made at an existing generation unit. If, so, a major capital cost may be incurred to build any required energy efficiency project, but that cost may be offset by the energy efficiency savings. If GPA changes fuel, the reporting requirements would remain the same.

From 2011 onward, modifications which require new source review permits and have increases in emissions of GHG greater than 75,000 tons per year of CO_2 equivalent emissions at any existing power plant facility will trigger permitting requirements for GHG emissions. This permit activity will include Best Available Control technology determinations for GHG emissions and force, at a minimum, fuel efficiency requirements and at most, changes in fuels to those which emit less GHG, i.e. LNG.

4.1.2.4 Proposed Actions & Economic Impact

There are no current limits on GHG emissions for the existing generation fleet. Any energy efficiency projects undertaken now by GPA can be used as credits against future GHG requirements. There is no significant cost in reporting GHG emissions. No additional manpower or budget is required to support his requirement.

4.1.3 Maximum Achievable Control Technology

4.1.3.1 Regulatory Requirements

There are three promulgated MACT standards which apply to GPA power units on Guam. These are:

- **Steam Electric Generation**: On December 16, 2011 EPA promulgated MACT standards for steam electric generation units (also referred to as the Mercury Air Toxics Rule (MATS)). Cabras 1 and 2 are subject to this rule. The standards require a significant reduction of metals emissions from these units. The compliance date was March 2014. The rule is currently stayed, but EPA is considering reinstituting the rule. GPA will have to control metals emissions based on a recent CAA Information Collection Request ICR test at Cabras 1. Options for emissions controls are discussed further later in this plan. Further information is in Appendix C.

- **Diesel Engines**: EPA's MACT standard for diesel engines applies to all the diesel engines of GPA. It requires that Carbon Monoxide (CO) emissions be controlled by 70%. The compliance date was May 2013 with the possibility of an extension to May 2014. By May 2014, all GPA fast track diesels (Tenjo, Talafofo and Manenggon) were outfitted with the appropriate control devices and meet the MACT standard. Cabras 3# and #4 and MEC #8 and #9 (slow diesels) cannot meet the MACT with the current fuel. Cabras 3 and 4 are now closed and MEC 8 & 9 are being researched for a change to ULSD which would allow the use of oxidation catalyst to meet the Standard.

  The MACT standard does not apply to the diesel engines used for temporary Power at Yigo. These engines are less than 500 horsepower and are thus not subject to the rule. The permit limits NO_2 and CO emissions to less than 250 tons per year. Difficulties in meeting this limit will need to be addressed. SCRs are currently installed in the units to meet NO_2 limits. If operation will continue to be the same as it is as of August 2018, installation of oxidation catalyst need to be considered.

- **Combustion Turbines**: EPA has not finalized its rule for combustion turbines. As proposed, EPA's MACT standard for combustion turbines (CT) would not apply directly to the current GPA combustion turbines because none are located at major sources for Hazardous Air Pollutants (HAP). The existing combustion turbines at Dededo might become subject to the rule if it is finalized and GPA seeks to increase the operating frequency of the units beyond the current permit limits. Because that would be a major modification it would trigger New Source review. Under New Source Review, it is probable that CO emissions would be limited to reduce HAP emissions. Any new combustion turbines built by GPA would have to comply with the CT MACT if finalized, but otherwise would employ the technology to reduce emissions below New Source Review and HAP emission triggers.

4.1.3.2 Status and Progress

Steam Electric Generation

Based on ICR testing results, GPA is currently not complying with Non-Continental US Standards for Steam Electric Generation. TRC has provided options for GPA to consider in complying with this standard. One of the options is to close the units and switch major generation to a new power plant. For Tanguisson 1 and 2, GPA has decided to de-activate the power plant due to operational requirements at that time (2016). For Cabras 1&2, GPA has decided to keep the plant operating until a new power plant operating on cleaner fuel is online, by which time Cabras 1&2 can be retired.

GPA has filed a notice of applicability for the EGU MACT. The units subject to the rule are Cabras 1 & 2 and Tanguisson 1&2. Compliance requirements using the current fuel include the installation of Electrostatic Precipitators (ESP) on each unit. However, the NAAQS compliance requirements would require simultaneous installation of scrubbers that would also address compliance issues with the EGU MACT. The installation of the ESP only would only delay the additional equipment to address the SO_2 and other air quality standards five years later, however the scrubbers could address both but would require an earlier installation at much higher costs. The initial compliance date for the Boiler MACT was April 2015; the only other option left is to retire the units. In 2014, GPA decided to de-activate Tanguisson 1&2. In 2016, the solicitation for a new power plant was finally approved and in 2017 GPA issued a solicitation for a new power plant or plants up to 180 MW capacity. Once in operation, the plan is to retire Cabras 1&2, eliminating the need to install controls that would allow compliance with EGU MACT and NAAQS standards.

Diesel Engine

GPA is also subject to the RICE MACT for all fast track (medium speed) diesel units and the Cabras 3&4 and MEC 8&9 slow speed diesel units, but not for the 39 1.1-MW temporary power generation units. GPA has complied with the MACT for the fast track diesels by installing oxidation catalysts. These control devices will need to be maintained and the reporting and recordkeeping conditions complied with. The slow diesels cannot meet this MACT standard with the current fuel and discussions with US EPA are ongoing. Cabras 3&4 had a major catastrophic failure in August 2015 and will not be returning online.

In August 2012 GPA filed a request for a one year extension from the RICE MACT for all the units burning Ultra Low Sulfur Diesel Fuel because there was not enough time to comply. Compliance was achieved by the end of the one year extension. In this same filing, GPA has requested an exemption for the slow diesel units (Cabras 3 & 4 and Piti 8 &9) firing residual fuel oil because compliance requires the changing of fuel or several hundred million dollars for compliance equipment. The extension for the fast speed diesels was granted and the controls were installed before the deadline. The exemption for the slow speed diesels request was denied.

GPA is in discussions with EPA over the compliance path for the slow speed diesels.

4.1.3.3 Future Compliance Considerations

Appendices B and C illustrate GPA's options for complying with the Steam Electric Generation MACT rule and the RICE MACT.

4.1.3.4 Proposed Actions & Economic Impact

The EGU MACT (also called the Mercury Air Toxics Rule) will cost approximately $48,400,000 for ESP installations at Cabras Units #1 and #2. As indicated earlier, GPA could remove this cost entirely by advancing the installation of the NAAQS compliance equipment, scrubbers. The cost for the scrubbers is estimated at $220,000,000 for wet scrubbers or $362,000,000 for dry scrubbers. In addition, quarterly testing is estimated to cost $200,000 per year for all four steam units. Another method is reducing mercury and other metals in the purchased fuel. That method is expected to be extremely expensive although it has not been costed. Another option is to close Units 1 & 2 and switch major generation to a new power plant site.

The RICE MACT compliance cost was $3,464, 000 in capital costs and additional O&M costs per year for compliance at the Ultra-Low Sulfur Diesel Units. At the slow speed diesels however, the cost would be $3.5 to 4 million capital costs for control. There would also be additional costs for fuel due to transition from RFO to ULSD, and annual O&M costs of about $212,000 for maintenance and replacement of the oxidation catalyst. Another option is to close MEC 8 & 9 and switch major generation to a new power plant site.

4.1.4 Community Right to Know Act

4.1.4.1 Regulatory Requirements

GPA is required to file a Tier 2 and a Toxic Release Inventory annually for the previous year's emissions. The Toxic Release Inventory is submitted normally by July 1st, while the Tier 2 deadline is every March 1st.

4.1.4.2 On-going Compliance Activities

Annual development of the emissions inventory and submission of the forms is required.

4.1.4.3 Future Compliance Considerations

There are no foreseen changes in the Community Right to know Act requirements expected at this time.

4.1.4.4 Proposed Actions & Economic Impact

Emission inventory and submission costs are included in the annual Planning and Regulatory Division Budget. There are no additional economic impacts expected in complying with the regulatory requirements.

4.2 WATER QUALITY COMPLIANCE

4.2.1 Regulatory Requirements

GPA is required to maintain and comply with a National Pollutant Discharge and Elimination System (NPDES) permit for Cabras because of the use of seawater in cooling and the discharge of heated water back to the ocean. Cabras has recently received its NPDES permit. Renewal of the permit includes the requirements to meet the proposed changes to cooling water intake structures.

4.2.2 On-going Compliance Activities

Protecting America's Waters

GPA has federal NPDES permit for its uses of water at Cabras. EPA proposed in March, 2011 to add to the requirements for steam electric utilities the elimination of once through cooling systems. Since Cabras uses ocean water gathered offshore and returned at higher temperature to the ocean environment, these proposed rules could require a major shift in water intake structures or the selection of a closed cycle cooling system (cooling towers). The Final 316(b) Phase II and Phase III Entrainment and impingement rule was promulgated in June of 2013. Currently available evaluations of impingement of fish on the cooling water intakes suggest that GPA does not have to revise its cooling water intake system to meet the requirements of this final rule. Compliance would need to be determined within the facility NPDES permit.

The Spill Prevention Control and Countermeasures (SPCC) program is a significant point of emphasis with EPA and GPA is working to strengthen its SPCC plans.

4.2.3 Future Compliance Considerations

A detailed survey of the impacts of the cooling water intake system to the environment should be completed. The following details regarding extent of damage done to the environment should be included, such as:

- How many species and what quantity of species are taken into the system;
- The status and effectiveness of the current systems to avoid such intakes;
- Design recommendations to solve issues and adverse impacts; and
- Any exceedance of the limits set in the proposed rule were included in the Final rule.

4.2.4 Proposed Actions & Economic Impact

GPA Water Resources

GPA has completed the 316(b) studies and filed for and obtained an Alternate Compliance Schedule. If Cabras 1 & 2 are closed by the end of 2022 GPA will no longer need to submit 316(b) characterization data.

GPA has completed the 316(b) studies and filed for and obtained an Alternate Compliance Schedule.

Information required under part122.21 including the following were submitted:

- 122.21(r) (2) Source water physical data;
- 122.21(r) (3) Cooling water intake structure data;
- 122.21(r) (4) Source water baseline biological characterization data;
- 122.21(r) (5) Cooling water system data;
- 122.21(r) (7) Performance studies; and

- 122.21(r) (8) Operational status.

Impingement Report was submitted in October 2015.

Jamie Marincola of USEPA is waiving the requirements for the following:

- 122.21(r) (9) Entrainment Characterization Study;
- 122.21(r) (10) Comprehensive Technical Feasibility and Cost Evaluation Study;
- 122.21(r) (11) Benefits Valuation Study;
- 122.21(r) (12) Non-Water Quality Environmental and Other Impacts Study;
- 122.21(r) (13) Peer Review

If Cabras 1 & 2 are closed by the end of 2022 GPA will no longer need to submit 316(b) characterization data.

GPA did submit an application for permit renewal on July 15, 2017.

4.3 MAJOR MODIFICATIONS OR UPGRADES

4.3.1 *Regulatory Requirements*

Whenever GPA decides to modify existing units, a determination should be made by GPA of the need for a federal New Source Review (NSR) permit. In an attainment area the NSR permit is often called a Prevention of Significant Deterioration (PSD) permit.

An NSR permit requires that Best Available Control Technology (BACT) be used to control emissions. Emissions subject to such controls include SO2, NOx, Particulate Matter, CO, hydrocarbons, metals and chlorine and fluorine. Most importantly, the BACT requirements now extend to GHG emissions. BACT is almost always more stringent than the New Source Performance Standards (NSPS) for the subject source.

Currently, any SO2 emissions from Cabras-Piti would be subject to additional requirements including off setting any new SO2 emissions. These requirements must be strictly adhered to because many utilities across the US have been sued by US EPA for non-compliance with these rules.

4.3.2 *Future Compliance Considerations*

Most modifications at existing power plants which are major sources (greater than 250 tons per year of any pollutant) would be subject to these rules. Routine maintenance and repair is one category of changes that are exempt. So too are increases in emissions allowed by the permit which are not accomplished through a capital project. The definition of a modification is highly complex but in general any modification which is a capital project which results in a change to the equipment and increases emissions is a modification. In addition, restarting a unit after virtual non-use for more than 5 years require an NSR/PSD permit and a BACT evaluation. When considering changes outside of the permit allowable, the agency should be consulted.

4.3.3 *Proposed Actions & Economic Impact*

GPA should ensure that all modifications for existing power generation and other air pollutant emitting units are evaluated by the Planning and Regulatory Division.

If applicable, GPA should request an "applicability determination" from US EPA. Such determinations can take on the order of 60-90 days. If GPA is pressed for time, a NSR application can be prepared under the assumption that an NSR permit is needed. Most straight forward NSR applications take 60-90 days to prepare and 6-9 months for US EPA to review and issue. The key point of the analysis is the BACT requirements for each pollutant and the modeling to demonstrate attainment.

The Planning and Regulatory Division will establish standard operating procedures and process maps to guide various GPA divisions in this process.

4.4 INSTALLATION OF NEW RESOURCES OR INFRASTRUCTURE

4.4.1 *Regulatory Requirements*

Whenever GPA decides to build a new unit, a determination should be made by GPA of the need for a federal New Source Review (NSR) permit. An NSR permit requires that Best Available Control technology (BACT) be used to control emissions. Emissions subject to such controls include SO2, NOx, Particulate Matter, CO, hydrocarbons, metals and chlorine and fluorine. Most importantly, the BACT requirements now extend to GHG emissions. BACT is almost always more stringent than the New Source Performance Standards (NSPS) for the subject source. Currently, any SO2 emissions from Cabras-Piti or Tanguisson would be subject to additional requirements including off setting any new SO2 emissions. These requirements must be strictly adhered to because many utilities across the US have been sued by US EPA for non-compliance with these rules.

4.4.2 *Situation Analysis*

New units, at existing sites or new sites, are subject to permitting and control technology rules dependent on the emission increases from the proposed units.

GPA is proposing a new power plant in the northern area of Guam near the site of the old Tanguisson plant. It would be north and west of Dededo near the current GWA waterworks and would use the waterworks outflow for cooling. As proposed such a plant would have three nominal 60 MW combustion turbines. These could be single cycle or combined cycle units. Combined cycle units re-burn the first pass exhaust to create more power. They would be fueled by ULSD. If outfitted with Selective Catalytic Reduction (SCR) and oxidation catalysts, emissions of nitrogen dioxide and carbon monoxide would be low enough to make the plant a minor source of air emissions. This would avoid the need for an analysis of BACT, MACT, GHG and NSR requirements. A discussion of environmental impacts of such a facility are provided in Appendix F.

4.4.3 *Proposed Actions & Economic Impact*

GPA should ensure that all new generation units and other air pollutant-emitting units, including fuel facilities (new or expansion of existing), are analyzed to determine if a permit is needed. If there are questions about applicability GPA should request an “applicability determination” from US EPA. Such determinations can take on the order of 60-90 days. A NSR application can be prepared under the assumption that an NSR permit is needed. Most straight forward NSR applications take 60-90 days to prepare and 6-9 months for US EPA to review and issue. The key point of the analysis is the BACT requirements for each pollutant and the modeling to demonstrate attainment. The cost of preparing a NSR permit application ranges from $50,000- $200,000 depending on the complexity of the project and the complexity of the modeling required by US EPA. The currently proposed NSPS for new electric generating units would impose the use of natural gas, however “non-continental” sources are currently exempted. Changes in fuel pipelines and fuel storage facilities are subject to SPCC plans and construction requirements that vary with the nature and size of the operation or tank.

The Planning and Regulatory Division will establish standard operating procedures and process maps to guide various GPA divisions in this process.

4.5 RENEWABLE RESOURCES

There are currently no Federal environmental mandates or requirements for the use of renewable resources. GPA has installed 26.5 MW of solar power and plans to install another 120 MW. There are no EPA regulations that apply to these units.

4.6 ALTERNATIVE ENERGY RESOURCES

4.6.1 *Energy Storage Systems*

Storage systems such as batteries and flywheels as well as pumped hydropower storage systems may be needed as the reliance on solar power increases. Battery systems and flywheels would not require air permitting, but permitting of new transmission lines would be needed. Hydropower storage systems would require permitting of a new dam.

4.6.2 *Alternative Fuels – Biodiesel*

The substitution of biological oils in fuels that are called bio-diesel does not fall under the federal rules. On Guam, the only requirement of such a fuel would be that it contain less than 15 ppm of sulfur and that it be shown as an alternative fuel in the permit for any facility using such fuel. It is not expected that any off-island bio-diesel source could be competitive with ULSD. An on-island source might well be competitive. The plant to produce such a fuel would be subject to environmental permits.

4.6.3 *Alternative Fuels – Reprocessed Waste Oil*

The reprocessing of waste oils for use as a fuel is covered by 40 CFR Part 63, Subpart DD. The primary emission controls on such processes are control of VOC emissions from tankage and process equipment such as pipelines, flanges, pumps etc. The rule requires leak detect and repair programs to insure control of fugitive emissions of VOCs. Again, use in engines would be as an alternate fuel in the facilities permit and sulfur content below 15 ppm. GPA currently follows 40 CFR 279.11 for accepting waste oil to burn.

4.6.4 *Waste-to-Energy Facilities*

Because various wastes (waste oil and sewage sludge for example) need to be disposed of on island and landfill space is limited, the potential to produce power from burning these wastes exists. Such combustion facilities are covered by NSPS and MACT standards and are highly regulated.
The primary regulations which deal with the burning of wastewater treatment sludge Is 40 CFR Part 60 Subpart LLLL and 40 CFR Part 62 Subpart LLL. These regulations require a health risk assessment be conducted before construction of such a facility. There is a long list of emission limits for both criteria and Hazardous Air Pollutants which must be met. The list includes SO_2, NO_2, CO, Particulate Matter, lead, mercury, cadmium and dioxins. The addition of oil waste may or may not allow compliance with these emission limits. Significant operator training and certification is also required.
The primary regulations which deal with the burning of municipal solid waste are covered by three sets of regulations:

- > 250 tons/day – 40 CFR part 60, Cb, Ea, Eb and FFF
- 35-350 tons/day – 40 CFR part 60, AAAA, BBBB and JJJ
- Other Solid Waste Incinerators are covered by 40 CFR Part 60, EEEE and FFFF

4.6.5 *Carbon Capture Technology*

GPA is not required under any current rule to reduce emissions of GHG, especially carbon dioxide (CO_2). Because there is no requirement to reduce Carbon Dioxide (CO_2) emissions, any technology would be an unnecessary expense. Carbon capture technology removes CO2 from the exhaust stream generally through the use of amines. To start with, an exhaust stream from a power plant (boiler, diesel or CT) must be cleansed of all criteria and Hazardous Air Pollutants before being introduced to currently available carbon capture systems. Therefore, carbon capture technology does not help GPA in meeting the real and pressing NAAQS compliance issues that it faces. There is also an issue of what to do with the CO_2 once it is captured. Some systems collect CO_2 for a buyer. There is no such buyer on Guam. Even if an export buyer could be found the CO_2 would have to be cryogenically liquefied and put on special ships (none built yet) for export. Otherwise, the CO_2 would have to be sent down a well and put in an underground reservoir.

4.7 CLEAN AIR OPERATING PERMITS

Operating Permits are issued for 5 years by the Guam EPA. The operating permits for GPA sources were due to be renewed in September 2014. Applications for these renewal permits were prepared by GPA and submitted in September of 2013. To date, these permits have not been renewed by Guam EPA. GPA continues to comply with the old permits and is in complete compliance with the Clean Air Act by doing so.

However, GPA should ensure that continuous and timely tracking of emissions are completed diligently, given the operational challenges GPA faces today, and will face for the next few years until the new power plants are online. Failure to comply with permit limits will require GPA to apply for PSD permit from Guam EPA/USEPA, and the installation of best available control technology. As of August 2018, some of the plants that have reached or are nearing the permit limits are GPA's Talofofo Diesel Units and GPA's Temporary Power Station (Aggreko Units).

4.8 OIL POLLUTION ACT OF 1990

4.8.1 *Regulatory Requirements*

Any oil pipeline including those in the Cabras oil storage area, pipelines from the storage area to the power plants and the pipeline to Tanguisson are subject to the requirement to have and maintain both a Facility Response Plan (FRP) for the actions to be taken in the event of an oil spill into waters of the US and a Spill Prevention and Control Plan (SPCC). The requirements for the contents of these documents change from time to time and GPA must keep up with the latest requirements and keep the documents up to date. Any new pipeline would have to have a FRP and SPCC.

For the closure or deactivation of GPA power plants, such as Tanguisson and the lack of further need for that fuel oil pipeline triggers the need to investigate the line to see if remediation is necessary.

4.8.2 *Situation Analysis*

Currently GPA has the FRP and SPCC plans that are required.

4.9 GPA ENERGY RESOURCES

4.9.1 *Fuels and Air Quality*

About 95% of GPA's Installed Capacity are fossil fuel generation units, with 67% using RFO and the rest fueled by ULSD. An objective of this plan is to make headway toward a wider option of fuels for electric power generation.

The most logical environmental alternative is natural gas which would have to be imported as liquefied natural gas (LNG). LNG would have several environment advantages:

- No sulfur in the fuel and therefore a complete resolution of the SO_2 non-attainment issue.
- Lower NO_2 emissions because there is no nitrogen in the fuel (there would still be NOx emissions from the nitrogen involved in combustion of air).
- Lower Green House Gas (GHG) emissions because of more efficient use of the carbon in the fuel.
- Near elimination of particulate matter emissions, including metals.
- Replacement of oil pipelines with natural gas pipelines to the various plants, reducing the potential environmental impact of the pipelines.

Another option is to convert to Ultra-Low Sulfur Diesel. ULSD Conversion would have several environmental advantages:

- Lower sulfur content that will allow compliance with NAAQS requirements, resolving non-attainment issue.
- Compliance with RICE MACT for Piti #8 and #9, if Oxidation Catalyst and Selective Catalytic Reduction Equipment are installed.

Continued reliance on oil will force several key environmental compliance decisions:

Compliance with the SO_2 NAAQS will require reductions in SO_2 emissions. This can be done in three ways:

A. Reduce sulfur content of oil to ppm ranges at significant cost to show attainment with current EPA modeling requirements. Can be done two ways, by reducing sulfur content of RFO, or transitioning to Ultra Low Sulfur Diesel for all plants.
B. Adopt emissions controls on SO_2 emissions (scrubbers) to reduce emissions.
C. Close Cabras/Piti facilities and move ULSD generation elsewhere.

The selection of one of these three options must be made prior to Guam EPA's submission of a control plan the meet the SO_2 NAAQS to EPA. GPA's SPORD and P&R Divisions are actively coordinating with Guam EPA with regards to significant dates and requirements regarding the NAAQS.

GPA must make decisions on meeting the MACT standards which have earlier deadlines than the SO_2 compliance. Work on compliance with the MACT for fast track diesel engines was completed by the compliance date of May 2014. Oxidation catalyst control devices were installed. The status of the slow speed diesels is the subject of consent decree discussions with the US EPA. Compliance with the steam electric MACT (if it ever becomes final) at Cabras using the current fuel requires a scrubber or electrostatic precipitator to remove metals. Discussions are underway with US EPA to resolve these issues.

The need to address the air quality issues at specific plants can arise at any point in time if modifications to a specific plant are proposed which trigger New Source Performance Standards (NSPS), MACT and/or New Source Review (NSR). When these programs are triggered, the specific plant must come into compliance with all of the air quality regulations before the modifications can be implemented. For instance, the potential for refurbishing the combustion turbines at Dededo and bringing them back on line may require NSR and would thus require MACT and modeling analysis showing that it meets all the NAAQS. This would be a significant burden on the project and could lead to delays of 6 to 9 months while the permit was obtained. Such projects could trigger changes in fuel or controls before the overall strategy is set.

Renewable Energy. The appropriate environmental strategy is to support, encourage and participate in any new generation from alternative sources of energy. GPA will continue its current Renewable Acquisition plan, with Phase I completed and already in effect, and Phase II awarded and scheduled for completion in 2020. Guam has significant wind resources on the eastern side of the island and efforts to tap this source of energy will be pursued. However, biomass and waste to energy technologies may offer firm power which is more desirable.

GPA will watch advances in wave power, solar power and nuclear power for advances which would make them viable options for Guam. The development of new modular (less than 60 MW) nuclear plants has the potential to make construction easier and cheaper and provide for much lower generation costs.

Energy Use Reduction. GPA has already invested in energy use reduction programs and will continue to invest in these programs in order to reduce the demand and growth of demand. GPA's program includes: Demand-Side Management Energy Appliance Rebate Program, Utility Energy Services Contracting (UESC) Program for Navy and Large Customers; and the Bringing Energy Savings to Schools (BEST) Program, promoting energy efficiency and water conservation. GPA also has a net metering program, and filed for modifications of the program with the Guam Public Utilities Commission.

4.10 INFRASTRUCTURE AND ASSET MANAGEMENT

4.10.1 *Fuel Facility Management*

The Planning and Regulatory Division is responsible for ensuring that the Clean Water Act Spill Prevention, Control and Countermeasures (SPCC) plans for the fuel supply operation are up to date and accurate. Additionally, the Oil Pollution Act requires a Facility Response Plan (FRP) because of the proximity to the ocean of the facility. GPA recognizes the responsibility to ensure that oil is not spilled and is appropriately contained. Proper maintenance of the facility and its pipelines and constant vigilance for leaks or spills is essential to this compliance.

4.10.2 *GPA Pipeline Management*

The Planning and Regulatory Division completed yearly pipeline assessments for GPA's Fuel Supply System. The Central Maintenance Division is responsible for daily/continuous maintenance and inspections.

GPA recognizes the need for a more aggressive approach to the maintenance and operation of its fuel pipelines, in preparation for potential compliance requirements from federal agencies such as EPA or

Department of Transportation. This depends on the future use of the pipeline system given the closure of Tanguisson Power Plant.

GPA intends to initiate a program for continuous improvement of its oil pipeline system. Activities may include pipeline assessment, smart pigging, integrity testing, and other activities related to improving pipeline condition, making it safer and less prone to leakage.

4.10.3 *GPA Automotive Fleet Management*

GPA will manage its automotive fleet to take advantage of new opportunities for energy use and emission reduction. In 2010 and 2011, GPA actively supported the transition to Ultra-Low Sulfur Diesel. The use of electric vehicles is another effort GPA could adopt in support of energy use and emission reduction for its automotive fleet.

4.10.4 *Retirement and Deactivation of Power Plants*

4.10.4.1 Tanguisson

GPA has retired the Tanguisson power plant and has continuing obligations to handle environmental problems at the plant. The issues include the requirements for removing and disposing of asbestos from the plant interior, cleanup and removal of the oil pipeline from the port, piping in the facility and tankage. Because there is underground oil in the area of the facility and an ongoing monitoring and removal system, GPA must conclude these activities in a manner that meets Guam EPA requirements. There are also minor hazardous waste issues in the building and storage areas which must be addressed.

4.10.4.2 Dededo Diesels

GPA has removed the Dededo diesel engines from their building. An investigation is needed to ensure that oil has not seeped below the cement pad on which the diesels sat and provide any cleanup that is needed. The tanks and pipelines that served the diesel engines must be cleaned up in the appropriate way.

4.10.4.3 Marbo

GPA has not used the Marbo diesels in many years. The site should be cleaned by removal of the equipment including engine, tanks and pipelines. An investigation into any spills should be conducted and remediation completed as necessary. An asbestos survey would also need to be conducted. Any minor hazardous waste should be removed from the site and disposed of correctly.

4.10.4.4 Cabras 3 and 4

These two units have been declared out of service. The site should be cleaned by removal of the equipment including engine, tanks and pipelines. An investigation into any spills should be conducted and remediation completed as necessary. An asbestos survey would also need to be conducted. Any minor hazardous waste should be removed from the site and disposed of correctly.

4.10.4.5 Cabras Units 1 & 2
GPA is contemplating the potential closure of Unit 1 and 2 at Cabras. The site should be cleaned by removal of the equipment including boilers, tanks and pipelines. An investigation into any spills should be conducted and remediation completed as necessary. An asbestos survey would also need to be conducted. Any minor hazardous waste should be removed from the site and disposed of correctly.

4.10.5 *Good housekeeping*

The Planning and Regulatory Division ensures Good Housekeeping through regular inspection of the various GPA facilities, the purpose of which is to ensure that pollutants are not making their way into storm water runoff from GPA sites.

4.11 CLEAN POWER PLAN

US EPA proposed an Existing Source Performance Standard (ESPS) for carbon dioxide emissions on June 18, 2014. This is generally called the Clean Power Plan (CPP). The proposed rule was supplemented on November 4, 2014 with specific GHG reduction targets for Guam. This proposed regulation would have required the Guam EPA to develop a plan to reduce carbon dioxide emissions from Cabras #1 and #2 on a schedule stretching until 2030. Those targets were to reduce emissions from the four (Cabras and Tanguisson) steam electric units from 1948 pounds of CO_2/MW Hour (2012 baseline) to 1733 pounds of CO_2/MW Hour during the period from 2020 to 2029 and reach a final goal of 1586 pounds of CO_2/MW Hour in 2030. The plan that Guam EPA needed to devise could include increase in energy efficiencies or changes to lower emitting fuels at the steam units. Alternatively the plan could be to reduce the use of these steam plants by replacement of their power with solar power, wind power or demand side management. EPA noted in its proposal that renewable energy goals had been set by the Guam legislature. Final promulgation was in June 2015. The final rule did not require any reductions on Guam.
The Supreme Court has stayed the implementation of this rule and the current administration has proposed not to go forward with the rule.

4.12 AFFORDABLE CLEAN ENERGY (ACE) PLAN

US EPA proposed on August 21, 2018 that the CPP be replaced by a new rule called the Affordable Clean Energy (ACE) plan. ACE would require that Guam EPA chose from a number of options to increase the efficiency of power production from Cabras 1 & 2. That is, reduce GHG emissions by creating more electricity with the same amount of fuel. The proposal does not exempt Guam or oil-fired power plants. The proposal does, however, include exemption from the New Source Review permitting process for such energy efficiency projects. This was an issue that stymied prior efforts by GPA to upgrade Cabras 1 & 2. The proposal requires Guam EPA to prepare a State Implementation Plan (SIP) within three years of promulgation, roughly 2021 and compliance by 2023.

4.13 COMMUNITY INVOLVEMENT

4.13.1 *GPA Waste and Recycling Programs*

GPA has been working toward complete recycling of its power plant and office wastes and will continue adding to it as opportunities for recycling become available and cost effective.

4.13.2 *Cleaning up Communities and Advancing Sustainability*

Clean up means remediation or reuse of contaminated properties in environmentally sound ways and land preservation. EPA's goals with respect to electric utility wastes are directed at fossil fuel combustion wastes. GPA currently has no combustion wastes but may acquire such wastes as a result of using control devices for air emissions control. Such wastes are generally treated by Federal rule as exempt from the solid waste requirements. Should GPA begin producing such wastes, every effort should be made to either reuse the material or find acceptable ways to store or dispose of the material.

4.13.3 *Ensuring Chemical Safety and Preventing Pollution*

This EPA goal is focused on product chemical safety and not related to GPA activities. Pollution prevention, however, would be focused on the integrity and safety of GPA's oil pipelines. These programs also cover each generation location, the offices and any other operational property of GPA. GPA currently provides Toxic Release Inventory (TRI) reporting for the cleaning materials it uses.

5. ENFORCEMENT OF ENVIRONMENTAL LAWS

EPA enforcement can be avoided by always complying with environmental laws and seeking constantly to keep the environment clean. GPA is involved in the community and the environment of Guam in a way that preserves and protects the people and environment so that no EPA enforcement is necessary. It is important to GPA to keep the lines of communication open and active.

Region 9 of US EPA is the regional office in San Francisco which covers activities of the agency through the Pacific Islands Program office. Region 9 has been supportive and appreciative of the GPA efforts to import low sulfur diesel fuel to Guam. The Office also is taking a keen interest in SO_2 non-attainment situation, which it would like to resolve. GPA's Strategic Planning and Operations Research Division supported the resolution of this non-attainment situation by working with Guam EPA, Sen. Telo Taitague and representatives from US EPA Region 9 in the conversion of the combustion turbine and fast-track diesel power plants from Regular Diesel to Ultra-Low Sulfur Diesel. GPA's Strategic Planning and Operations Research Division together with the Planning and Regulatory Division actively collaborated with US EPA and Guam EPA in the re-designation of the Cabras-Piti Area; the divisions continue to support Guam EPA in drafting the State Implementation Plan for submission in 2019.

Region 9 is a significant supporter of Green House Gas emission reductions, pollution prevention and sustainability initiatives. Expect support for any GPA initiatives in these areas.

6. INITIATIVES AND RECOMMENDATIONS

GPA's Environmental Strategic Planning Team, composed of representatives from GPA's Strategic Planning & Operations Research Division, and Planning & Regulatory Division, have the following initiatives and recommendations to be able to provide safe, reliable, and responsive energy services in an environmentally sensitive and responsible manner:

Initiative 1: Expanded Aggressive Compliance Program. Compliance with current and upcoming Environmental Regulations should continue to be included in planning for GPA's generation, transmission and distribution resources, as well as energy services. This initiative has commenced and is ongoing with the inclusion of Environmental Compliance in GPA's Integrated Resource Plan. Future Compliance Considerations and Proposed Actions recommended in this plan should be considered and actively updated by the Environmental Strategic Planning Team. Timely, responsible and diligent tracking should also be done to ensure compliance with all permit requirements particularly those that immediately impacts operations, such as the permit requirements, emission limits and running hours

Initiative 2: Continuous Communication. Key Environmental Compliance Requirements shall be communicated regularly to internal partners (other GPA Divisions), and externally through meetings or discussions with stakeholders. This initiative has commenced and is ongoing through two internal Environmental Strategic Plan Presentations and conference calls with GPA's Environmental Consultant, and with a Stakeholder Meeting with representatives from the US Navy, Guam EPA and the Governor's Office. Continuous communication shall also be practiced on a daily, operational level, to ensure that operation is completed while maintaining regulatory compliance.

Initiative 3: Review Process. GPA should establish a process that ensures each major activity (CIP or Major O&M) undergoes review for compliance with environmental requirements stated in this Strategic Plan (such as PSD Applicability Determination). In complying with the various regulatory requirements, GPA shall consider the installation of control devices, the use of a different fuel type, and others such as to request exemption from USEPA. Process maps and SOPs will be created by the Planning and Regulatory Division to support various GPA divisions in this activity.

Initiative 4: Inclusion of Fuel Supply System in GPA Continuing Obligations. GPA should ensure that the fuel supply system is included in the continuing obligations and day-to-day O&M activities related to ensuring compliance with Environmental Regulations.

Initiative 5: Compliance Review for Temporary Power Generation. GPA should investigate and find solution(s) for the compliance issues currently affecting the temporary power generation units. In developing the plan for these units post contract period, GPA must consider the current issues and environmental compliance requirements.

Initiative 6: Asset Retirement or De-activation. GPA should plan for the proper retirement or de-activation of various assets that are not in use, and to establish processes to ensure that the retirement or de-activation requirements are completed as required, including the recommendations illustrated in this ESP. The Assistant General Manager for Engineering & Technical Services (AGMETS) initiated this process through the establishment of Decommissioning Plan Guidelines.

Initiative 7: GPA shall continue working on actions decreasing hazardous air emissions from the utility and the Guam Community. Some of the actions completed between 2010 and today were the transition from 0.5% Sulfur Diesel to Ultra-Low Sulfur Diesel (15ppm or less) for GPA's inland diesel-fired units, and the acquisition of 26.5 MW of Renewable Energy Contracts. GPA's leadership and facilitation of the effort to transition to ultra-low sulfur diesel decreased sulfur dioxide emissions in the Guam Transportation, Construction, Power Generation and other economic sectors. Furthermore, GPA has undertaken a Demand-side Management Program for residential customers, and large customers. These programs have created a virtual power plant of energy savings and hazardous air emission reductions.

Initiative 8: Skills Upgrade for Environmental Team. The AGMETS outlined skills upgrade activities for the Environmental Strategic Team, to reduce reliance on environmental consultants and service contracts. GPA shall build up its professional competency on Environmental Air Quality Modeling, Environmental Engineering Studies & Analysis including technical report writing, Environmental Law and managing Stakeholder Engagement.

Initiative 9: Investigation on the Use of Electric Vehicles (Utility-scale and Island-Wide) for reduction of Emissions. GPA shall investigate the impact of conversion of diesel-fueled and gasoline-fueled vehicles to electric vehicles, and its impact on emissions and GPA operations.

Initiative 10: Investigation on Proper Disposal of Solar PV Panels and Lithium-Ion Batteries. In 2019, GPA is scheduled to start operating its Energy Storage System to help mitigate the impacts of intermittency from renewable energy resources and the impacts of under-frequency load shedding. Additionally, GPA awarded a contract for renewable energy supply of 120 MW. In line with these efforts, GPA shall look into the process for proper disposal of lithium-ion batteries and solar PV panels (including metals, chemicals and batteries) as part of the process for managing these assets.

The GPA Environmental Strategic Plan also recommends:

RECOMMENDATION 1: Regulatory Compliance and Solicitation for New Generation. Between 2016 through 2018, GPA and its environmental consultant, TRC, completed various studies regarding regulatory compliance for the new power plant, as well as the impact to the Guam environment. These studies were completed to support GPA's effort in getting approval and issuing a solicitation for New Generation to be located in the northern part of the island. Appendix G of the ESP summarizes the studies completed.

RECOMMENDATION 2: Continue tracking/monitoring developments for:

- Compliance requirements for NOx and PM emissions
- EGU MACT
- Clean Power Plan
- Affordable Clean Energy Plan

APPENDIX A

GUAM POWER AUTHORITY ENVIRONMENTAL POLICY

Guam Power Authority
Environmental Policy

Guam Power Authority values highly a clean, healthy environment. GPA considers environmental issues as part of its core business planning and decision making. GPA shall provide safe, reliable, and responsive utility service in an environmentally sensitive and responsible manner.

Guam Power Authority's policy is to:

- Comply with relevant government environmental regulations, corporate policies and other applicable requirements.
- Implement standard environmental management system to prevent pollution and minimize environmental impacts and strive to continually improve the system.
- Implement Demand-Side Management Programs where cost effective to promote energy efficiency and conservation
- Develop quality management programs (QMP) to document, implement and maintain processes associated with improved environmental stewardship.
- Promote a workplace culture emphasizing proper employee training, personal responsibility and compliance with respect to environmental requirements, goals and program implementation.
- Ensure adequate resources are allocated for the implementation of this policy.

GPA shall hold all employees responsible and accountable for implementing this environmental policy.

____________________ General Manager

________________ Date

Guam Power Authority
Environmental Commitment

1. We will integrate environmental factors throughout our decision-making process.

2. We accept accountability for our environmental performance and through our actions, will demonstrate high social integrity.

3. We recognize that every employee has a responsibility toward meeting our environmental commitment, and we will ensure that the necessary training and resources are available to employees.

4. We will openly communicate our environmental values, actions and performance, and will provide opportunities for feedback.

5. We will practice responsible environmental stewardship of all GPA-owned properties under our management.

6. We will ensure compliance with applicable environmental requirements at our operations and will monitor, assess, and continuously improve our environmental performance.

7. We will foster a corporate culture that protects the environment and promotes pollution prevention and long-term energy and natural resource efficiency

8. We will commit human and financial resources necessary to support and implement our environmental commitment and will continually review our performance for consistency with these principles.

APPENDIX B

LISTING OF CONTINUING OBLIGATIONS

1. AIR Act
    a. Annual Emission Testing
    b. Continuous Emission Monitoring and Relative Accuracy Test Audits
    c. Annual Emission Inventory and Fees
    d. New Source Performance Standards reporting
    e. Intermittent Control Strategy, Cabras-Piti Area, Fuel Switching and Reporting Requirements
    f. Title V permit reporting requirements
2. Water Act
    a. Section 316(b) Phase I and Phase II requirements
    b. Effluent Discharge Monitoring
    c. Discharge Monitoring Reports
    d. Toxicity Testing
    e. Best Management Practice Plan
    f. Annual Chemical Usage Report
    g. Spill Prevention Control and Countermeasures Plan
    h. Oil Pollution Prevention Response Plan

3. Resource Conservation and Recovery Act
    a. Solid/Hazardous Waste Management Plan
    b. Used Oil Recycling Plan

4. Toxic Substance Control Act
    a. PCB Management Program
    b. Asbestos Operation and Management Plan

5. Environmental Planning and Community Right to Know
    a. Annual Toxic Release Inventory Report
    b. Oil Spill Emergency Response and Facility Response Plan

APPENDIX C

CURRENT ENVIRONMENTAL COMPLIANCE FEES

Annual Emissions

Annual Emission Fees	
2013	$73,405
2014	$80,164
2015	$71,430
2016	$53,144
2017	$58,892

** Cabras 3&4 offline on Aug. 31st (2015)

8 Power Plants + 125 Water System Diesel Facilities
Not yet inclusive of MEC 8 & 9 (rough estimate about $30K)

Title V Air Permit Renewal (every 5 years)

$	1,000	per facility
	9	Facilities
$	9,000	Total

1 Yigo CT
2 Dededo CT
3 Macheche CT
4 Cabras Power Plant
5 Piti 8 & 9
6 Piti 7 CT
7 Tenjo
8 Manenggon
9 Talofofo

APPENDIX D

OFFICIAL COMMUNICATION – REDESIGNATION AND AAQM

- Ambient Air Quality Monitoring Plan
- Redesignation
  - Data Requirements Rule
  - Request for Redesignation of Tanguisson

GUAM POWER AUTHORITY
ATURIDÅT ILEKTRESEDÅT GUAHAN
P.O.BOX 2977 • AGANA, GUAM U.S.A. 96932-2977

May 29, 2012

Michael Mann
USEPA REGION 9 /Pacific Region
75 Hawthorne Street
Mail Code: CED-6
San Francisco, CA 94105
Office Phone 415-972-3505

SUBJECT: Guam Ambient Air Monitoring Plan

Dear Mr. Mann:

Please see the attached "Guam Ambient Air Monitoring Plan" for USEPA review. Also included are three copies of the soft files on CD.

Should you have any questions please contact me via phone at (671) 648-3217 or via email at sipanag@gpagwa.com .

Sincerely,

Sylvia L. Ipanag
Engineer Supervisor

Attachments: As Stated

Cc: Administrator, GEPA

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION 9

75 Hawthorne Street
San Francisco, CA 94105-3901

June 6, 2013

Ms. Sylvia L. Ipanag
Engineer Supervisor
Guam Power Authority
P.O. Box 2977
Agana, Guam 96932-2977

SUBJECT: Quality Assurance Project Plan (QAPjP) contained within Guam Ambient Air Monitoring Plan, Guam Power Authority
[QA Office Document Control Number AIRP0272Q2]

Thank you for submitting the QAPjP for Guam Power Authority, dated March 13, 2013. The plan is not approved. The majority of comments were partially addressed. Most notably, the QA Manager's position, a contractor to TRC (monitoring organization), is not sufficiently independent; the objective for monitoring needs clarification (i.e., whether monitoring is to satisfy National Ambient Air Quality Standards (NAAQS) or Prevention of Significant Deterioration (PSD); the roles and responsibilities need further definition and clarity; particulate monitoring laboratory conditions to be met were not identified; and Standard Operating Procedures should be included in the plan for review.

Previously provided comments appear in boldface type with the evaluation of the response to comment (RTC) in normal type. Please provide response to comments by July 31, 2013.

If you have any questions regarding the preparation of this QAPjP, please contact Roseanne Sakamoto, USEPA Region 9 QA Office at (415) 972-3813.

We appreciate your agency's efforts in preparing this plan. We look forward to continuing to work with you as this program progresses.

Sincerely,

Eugenia McNaughton, Ph.D.
Manager, Quality Assurance Office (MTS-3)
Management and Technical Support Division

Enclosure

Guam Power Authority

CONCERNS
1. Section A3. Distribution List
The list is incomplete. Please complete.

This comment has been addressed.

2. Section A4.1. Roles and Responsibilities
This section should discuss how independence of the QA manager's position is maintained, when they report directly to Guam Power Authority (i.e., the parties responsible for preparing the QAPP).

This comment has been partially addressed. The RTC indicates that the QA manager reports to the TRC Environmental Project and Monitoring manager. However, TRC is under contract to Guam Power Authority (GPA), the responsible monitoring organization. The QA manager reporting to TRC management does not establish independence and still remains a conflict of interest as GPA controls the contract.

One way to work around this issue might be to have the QA manager provide Guam EPA and US EPA with copies of any corrective action reports and to invite Guam EPA and US EPA to participate on any internal audits conducted. It is further recommended that GPA participate in the National Performance Audit Program (NPAP), National Performance Evaluation Program (NPEP), and that technical system audits (TSAs) be conducted by Guam EPA or US EPA as provided in 40 CFR Part 58, Appendix A, Section 2.4 and 2.5, respectively.

Information on Table A.1 and Figure A.4.1 should be made consistent, i.e., all positions are accounted for, including those of contractors.

Table A.1 does not have a provision for a data reviewer. Please identify position responsible for performing data review.

Note that Section C.1.1(2) discusses the use of a contract manager. It is not clear what position manages contracts or what their responsibilities are. Please clarify.

These comments have been partially addressed. The specific responsibilities and activities of the individual positions identified on A3 should be described in more detail. For example, in Table A.1 no one is listed as being responsible for any corrective action activities. The specific responsibilities for each position should be provided in a bulleted list.

It is not sufficient for Guam EPA to review and approve the QAPjP, since there is no independent oversight of the project (see Comment 2). It is recommended that Guam EPA, Air Pollution Control Program Manager perform TSAs as specified in QA Handbook for Air Pollution Measurement Systems, Volume II, Ambient Air Quality Monitoring Program, EPA-454/B-08-003, December, 2008.

Additionally, AMSTECH is introduced in C1.1, Performance Audits for the first time. It is a subcontractor to TRC. AMSTECH should be identified in the organizational chart and its role and responsibilities discussed. In C1.2, Technical System Audits, a TRC Field Sampling Coordinator is included, but is not mentioned in A3 or A4. The roles and responsibilities of all involved in this project should be included and discussed in A3 and A4.

3. Section A.5.1(2), Ambient Monitoring Purpose and objectives.
Please clarify what the third column in the tables provided in this sections represent.

This comment has been satisfactorily addressed.

4. Section A6.1, Project Overview, Meteorological Monitoring.
Please cite the date of the guidance documents referenced, and also include Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements, Version 2.0 (Final), March, 2008, EPA-454/B-08-002.

This comment has been satisfactorily addressed with appropriate and updated references.

5. Section A.6.2, Project Schedule
Table A.5, please clarify why monitoring will cease in 2015.

This comment has been partially addressed. The following RTC statement should be included in Section A5.1.(2), Ambient Monitoring - Purpose and Objectives: "The schedule is based on a monitoring program duration of 3 years, the monitoring length required for a non-attainment redesignation request and the minimum time required to show compliance with NAAQS."

6. Section B4, Analytical Methods Requirements
Sections covering PM10 and PM2.5 should also discuss the parties conducting filter conditioning, along with laboratory conditioning specifications (i.e., QA Handbook for Air Pollution Measurement Systems, Volume II, Ambient Air Quality Monitoring Program, EPA454/B-08-003, December 2008, Appendix D, Measurement Quality Objectives and Validation Templates).

This comment has been partially addressed. The RTC states the laboratory has not been selected. It is recommended that the plan include a statement regarding the measures to be taken to ensure the laboratory selected is compliant with 40 CFR Part 50, Appendix J (PM10) and L (PM2.5) and QA Guidance Documents 2.12 (PM2.5) and 2.11 or 2.10 (PM10). Please specify the guidance method to be used for PM10 monitoring. For example, a request for proposal may be submitted that identifies the elements the laboratory must meet.

The plan should also specify whether Federal Reference or Equivalent Methods (along with FRM/FEM number) will be used for monitoring in Section A6.1 or on Table B.1, Methodology.

7. Section B7, Instrument Calibration and Frequency

Please provide the cited Table B.6. Note that not all the QC checks identified in QA Handbook for Air Pollution Measurement Systems, Volume II, Ambient Air Quality Monitoring Program, EPA454/B-08-003, December 2008, Appendix D, Measurement Quality Objectives and Validation Templates are covered in the Tables that are provided. It is recommended the missing Table B.6 cover this information.

This comment has been partially addressed. The RTC stated: "Table B.4 was incorrectly addressed as Table B.6 in this section. Table B.4 has this information as well as other tables in the Appendices." It is recommended that the tables referred to in the response be cited in the plan.

Note that Table A.7, Meteorological Data Measurement Quality Objectives and Table C.1, PSD Calibration and Accuracy Criteria – Meteorological Measurements reference criteria for Prevention of Significant Deterioration (PSD) for meteorology determination. It is not clear whether the plan objectives are to meet National Ambient Air Quality Standards (NAAQS) or PSD. Please clarify this in Section A5.1, Problem Statement and Background, as it currently appears that the purpose is to meet NAAQS criteria. If both NAAQS and PSD are to be met, there should be an explanation as to why both are necessary.

If the purpose is to monitor to meet NAAQS criteria, it is recommended that criteria from Table 0-5 and 0-6 for SLAMS/SPMs from Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV, Meteorological Measurements, Version 2.0 (Final), EPA-454/B-08-002, March 2008 be referenced instead.

Data Management SOPs should similarly be updated to reflect information from Tables 0-5 and 0-6.

8. Section B10, Data Management.
Please clarify the frequency at which the USB memory device is uploaded to TRC's Raleigh, NC office, and how the system at NC differs from the TRCAir.com. A copy of what is submitted to the central server (TRCAir.com) should always be accessible.

The data security system of TRCAir.com should also be briefly described (i.e., passwords, protected fields, etc.).

These comments were partially addressed. It is recommended the information contained in the RTC be incorporated into the plan.

9. Section C, Assessment and Response
For all audits noted in this section i.e., performance, technical, field and data quality systems 1audits, identify the parties conducting the audit, the frequencies at which they will be conducted

Note that Table A.1 states that performance audits will be conducted by the QA manager, while this section states that an "independent audit team" will perform

this function. Please make consistent. If an independent audit team is used, they should be included in Section A4.1. If they are contractors, the measures taken to ensure they are proficient in performing audits should be discussed.

These comments have been partially addressed. In Section C1.2, Technical System Audits (TSA) it is stated that a system audit may be conducted. It is recommended that this be changed to: "will be conducted." The frequency at which the TSAs are to be conducted should be specified.

Additionally, the TRC audit team is mentioned for the first time in C1.1, but is not mentioned in A1.4. A TRC Field Sampling Coordinator is also introduced in C1.2, but is not mentioned in A1.4. Please include the TRC Audit Team and Field Sampling Coordinators in A1.4 and discuss their role and responsibilities.

Please also specify the parties performing the Data Quality Systems Audits and Regulatory Audits and the frequency at which they will be conducted.

10. Section C.1.1(1), Meteorological Sensors and Section D1, Data Review, Verification and Validation.
Acceptance limits for accuracy of meteorological sensors should be from Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements, Version 2.0 (Final), March , 2008, EPA-454/B-08-002, Table 0-09, Modeling Application Measurement Quality Objectives, and 0-10, Modeling Application Calibration and Accuracy Criteria.

This comment has been partially addressed. Please see Comment 7. It is recommended that criteria from Table 0-5 and 0-6 for SLAMS/SPMs from Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV, Meteorological Measurements, Version 2.0 (Final), EPA-454/B-08-002, March 2008 be referenced instead.

11. Section C1.1.(2), Data Quality Systems Audits
Please clarify the difference between data quality systems audits from performance audits.

This comment has been partially addressed. The respective portions of the field and data quality RTC should be incorporated into the plan where these activities are discussed. Additionally, data quality audits should review QC checks, audits, calibrations performed on the monitoring instruments. The plan should include a discussion as to how the data will be flagged and corrective actions taken documented if they found not to be acceptable,.

12. Section D2.1, Data Validation Process
Please state the position responsible for performing this function. Please see related Concern 1.

This comment has been partially addressed. Section D2.1, Data Validation process introduces a data technician position, which is not listed in A3 and A4 (but is included in

Table A1). Please make all related sections and tables regarding project organization, roles and responsibilities consistent (i.e., A3, A4 and Table A1).

13. Table A.7, Meteorological Data Measurement Quality Objectives and Table C.1, PSD Calibration and Accuracy Criteria - Meteorological Measurements
Please clarify the source of the information provided on this table. Alternatively use Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements, Version 2.0 (Final), March, 2008, EPA-454/B-08-002, Table 0-09, Modeling Application Measurement Quality Objectives, and 0-10, Modeling Application Calibration and Accuracy Criteria.

This comment has been partially addressed. Table A.7, Meteorological Data Measurement Quality Objectives information is for Prevention of Significant Deterioration (PSD) when it should be for NAAQS. It is recommended that criteria from Table 0-5 and 0-6 for SLAMS/SPMs from Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV, Meteorological Measurements, Version 2.0 (Final), EPA-454/B-08-002, March 2008 be referenced instead.

14. Table C3, Accuracy Limits and Validation Criteria for Pollutant Measurements
The frequency checks for the first three PM10/PM2.5 QC checks, e.g., single point flow rate, single point temperature and pressure checks, should be completed monthly rather than quarterly (please see Appendix D, QA Handbook, Volume II).

This comment has been satisfactorily addressed and frequencies are identified as monthly rather than quarterly.

15. Table C.4, SO_2 and Nox Audit Levels
It is not clear whether the audit levels identified on this table are representative of concentrations determined at the site. Please clarify as audit levels are dependent on site concentrations.

This comment has been partially addressed. It is recommended that the concentrations identified in Table C.4 be discussed in the plan as to whether they are the usual concentrations encountered in Guam (suggest A5.1(1) and Table C.4).

16. Standard Operating Procedures (SOPs
All SOPs submitted should specify the QC criteria that needs to be satisfied for the QC checks performed and identified in QA Handbook for Air Pollution Measurement Systems, Volume II, Ambient Air Quality Monitoring Program, EPA454/B-08-003, December 2008, Appendix D, Measurement Quality Objectives and Validation Templates (e.g., one point QC checks, zero/span checks, calibrations, etc.).

This comment has been partially addressed. The RTC states: "TRC is in the process of updating all SOPs and field data sheets to include the QC criteria as specified in the QA Handbook for each parameter."

All SOPs and field data sheets must be submitted for review prior to plan approval. This is inclusive of Appendices C, D, E and Section B10, Data Management (discussion on TRC SOPs related to data management.

17. New Comments

A) Table B1, Methodology

Please include an additional column to list the federal reference or equivalent method number.

B) B3.1(1) Field Sample Custody

This version of the plan is missing a bullet from the previously submitted plan. Please be sure to include the second bullet: Filters will be recovered by the filed sampler within 7 days and 9 hours from the sample end date.

Bullet 13. Please be sure to place custody seals on all boxes or coolers.

C) B5, Quality Control Requirements

Please replace Appendix E with Appendix F in the following statement: Detailed MQOs as well as corresponding accuracy goals are presented in the tables included in Appendix F.

GUAM POWE[R AUTHORITY]
ATURIDÅT ILEKT[RESEDÅT GUÅHAN]
P.O.BOX 2977 • AGAN[A]

U.S. Postal Service™
CERTIFIED MAIL™ RECEIPT
(Domestic Mail Only; No Insurance Coverage Provided)
For delivery information visit our website at www.usps.com®
SAN FRANCISCO CA 94105
OFFICIAL USE

Postage	$ 6.85 $3.32	0101
Certified Fee	3.10 $3.10	16
Return Receipt Fee (Endorsement Required)	2.55 $2.55	Postmark Here
Restricted Delivery Fee (Endorsement Required)	$0.00	
Total Postage & Fees	$ 12.50 $8.97	11/13/2013

Sent To EUGENIA MCNAUGTON, USEPA
Street, Apt. No.; or PO Box No. 75 Hawthorne ST
City, State, ZIP+4 SF CA 94105
PS Form 3800, August 2006 See Reverse for Instructions

7008 3230 0001 7957 0770

USPS BARRIGADA UMPO 13 NOV 2013

November 8, 2013

Eugenia McNaughton, Ph.D.
Manager, Quality Assurance Office (MTS-3)
Management and Technical Support Division
USEPA REGION 9 /Pacific Region
75 Hawthorne Street
San Francisco, CA 94105

SUBJECT: Quality Assurance Project Plan (QAPjP) contained within Guam Ambient Air Monitoring Plan, Guam Power Authority

Dear Ms McNaughton:

In reference to your letter dated June 6, 2013, please see attached responses and updated Quality Assurance Project Plan (QAPjP)

Should you have any questions please contact me via phone at (671) 648-3217 or via email at sipanag@gpagwa.com .

Sincerely,

Sylvia L. Ipanag CM, CESCO
Environmental Manager

RECEIVED
NOV 18 2013
Guam Environmental Protection Agency

Attachments: As Stated

Cc: Administrator, GEPA
Michael Mann, USEPA Region 9/ Pacific Region
Gwen Yoshumura, USEPA Region 9
Kerry Drake, USEPA Region 9
John Kelly, USEPA Region 9

GUAM POWER AUTHORITY
ATURIDÅT ILEKTRESEDÅT GUAHAN
P.O.BOX 2977 • AGANA, GUAM U.S.A. 96932-2977

November 8, 2013

Eugenia McNaughton, Ph.D.
Manager, Quality Assurance Office (MTS-3)
Management and Technical Support Division
USEPA REGION 9 /Pacific Region
75 Hawthorne Street
San Francisco, CA 94105

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In reference to your letter dated June 6, 2013, please see attached responses and updated Quality Assurance Project Plan (QAPjP)

Should you have any questions please contact me via phone at (671) 648-3217 or via email at sipanag@gpagwa.com .

Sincerely,

Sylvia L. Ipanag CM, CESCO
Environmental Manager

Attachments: As Stated

Cc: Administrator, GEPA
Michael Mann, USEPA Region 9/ Pacific Region
Gwen Yoshumura, USEPA Region 9
Kerry Drake, USEPA Region 9
John Kelly, USEPA Region 9

Quality Assurance Project Plan (QAPP) contained within Guam Ambient Air Monitoring Plan, Guam Power Authority [QA Office Document Control Number AIRP0272Q2]

Responses to USEPA Comments dated June 6, 2013

Comment 2. **Section A4.1. Roles and Responsibilities**

In Section A4.1 TRC states that the QA Manager report to GPA Environmental Manager. The Org chart has been modified. Reference to the National Air Quality Management Director has been removed from Section A4.1

Guam EPA and USEPA will be given results from all internal audits that will be conducted. Guam EPA and/or USEPA can conduct TSAs at their discretion.

Data Technician = Data Reviewer. TRC has made this title consistent throughout

This statement has been added to Section A.4.1.(1):

> Guam, EPA, Air Pollution Control Program Manager performs TSAs as specified in QA Handbook for Air Pollution Measurement Systems, Volume II, Ambient Air Quality Monitoring Program, EPA-454/B-08-003, December, 2008.

AMSTECH has is identified in the Org Chart. Their responsibilities are now highlighted in Section A.4.1.(4); a new section

Field Sampling Coordinator = Field Operations Manager. TRC has made this title consistent throughout.

A bulleted list for all roles individual responsibilities has been added in Table A.1

All Positions identified in Table A.1 are now summarized in Section A.4.1(3) TRC

Comment 5. **Section A.6.2, Project Schedule**

The following statement has been added to Section A.6.2) Project Schedule:

> The schedule is based on a monitoring program duration of three (3) years, the monitoring length required for non-attainment redesignation request and the minimum time required to show compliance with NAAQS.

Comment 6. **Section B4, Analytical Methods Requirements**

TRC has added a statement to Section B.4) Analytical Method Requirements indicating that TRC will review the candidate Laboratory's SOPs and QAPP to ensure compliance with 40 CFR Part 50, Appendix J (PM10) and Appendix L (PM2.5) as well as QA Guidance Documents 2.11 for both PM10 and PM2.5 as it contains the more stringent requirements.

FRM designation numbers are presented in Section B.2. These numbers have been added in a new column of Table B.1.

Comment 7. **Section B7, Instrument Calibration and Frequency**

QC Checks, to be performed monthly, has been added to Table A.5

PSD MQOs were chosen for this program. The following has been added to Section: A.5(2) to clarify why:

> The secondary objective of this AAQM is to collect data of sufficient quality to meet permit requirements for PSD permitting. Therefore PSD monitoring guidelines will be followed.

Comment 8. **Section B10, Data Management**

TRC has added a statement to Section B.10) Data Management that explains that updates to the data logging software will send continuous data directly to a local server in Raleigh, NC.

Comment 9. **Section C, Assessment and Response**

The first sentence in Section C.1.2) Technical Systems Audit, has been changed to read:

> A system audit of field activities including sampling and field measurements will be conducted and documented by the TRC Project QA Officer (or designee) at the start of sampling.

Field Sampling Coordinator = Field Operations Manager. TRC has made this title consistent throughout.

There will be no TRC Field Audit Team; performance audits will be conducted by AMSTECH. All reference to a TRC Audit Team has been removed from the QAPP

Also added to this section is a statement identifying the frequency of audits: Data Quality System Audits will be conducted annually by AMSTECH. Regulatory audits will be conducted as-needed (as specified in QAPP) and will be coordinated by Guam EPA

Comment 10. **Section C1.1(1) Meteorological Sensors and Section D1, Data Review, Verification and Validation**

(same as comment 7)

PSD MQOs were chosen for this program. The following has been added to Section: A.5(2) to clarify why:

> The secondary objective of this AAQM is to collect data of sufficient quality to meet permit requirements for PSD permitting. Therefore PSD monitoring guidelines will be followed.

Comment 11. **Section Cl.1.(2), Data Quality Systems Audits**

The following list of field documentation has been added to the review of data quality systems audits: QC Checks, audits, calibrations performed on the monitoring instruments.

This section now also includes the handling of any findings from the audit. All audit findings will be reviewed by the Data Manager to determine impact on data validity. Data will be flagged as valid or invalid during this review. The Data Manager will notify the Project Manager and the Air Quality Project Manager of any necessary corrective actions.

Comment 12. **Section D2.1, Data Validation Process**

All Positions identified in Table A.1 are now summarized in Section A.4.1(3) TRC

Comment 13. **Table A.7, Meteorological Data Measurement Quality Objectives and Table C.l, PSD Calibration and Accuracy Criteria - Meteorological Measurements**

(same as comment 7)

PSD MQOs were chosen for this program. The following has been added to Section: A.5(2) to clarify why:

> The secondary objective of this AAQM is to collect data of sufficient quality to meet permit requirements for PSD permitting. Therefore PSD monitoring guidelines will be followed.

Comment 15. **Table C.4, SO2 and NOx Audit Levels**
The following statement has been added to section A5.1

> Audit levels will be based on expected concentrations in Guam. Audit levels will be determined during the first audit to ensure these levels are inclusive of actual concentrations.

Comment 16. **Standard Operating Procedures (SOPs)**
SOPs are needed for approval of this QAPP. SOPs needed to complete:

- Laboratory Analysis
- Sulfur Dioxide Analyzers – operation and maintenance
- NOx Analyzers – operations and maintenance
- BAM 1020s – operations and maintenance
- BAMs 1020s - calibration
- BGI PQ200s – operation and maintenance
- BG PQ200s – calibration
- Met Sensors/Tower – operation and maintenance
- Met Sensors – calibration
- Data Validation

Comment 17. **New Comments**
17a.
FRM designation numbers are presented in Section B.2. These numbers have been be added in a new column of Table B.1.
17b.
This bulleted statement has been added back into the QAPP in Section B3.1.(1):

> Filters will be recovered by the field sampler within 7 days and 9 hours from the sample end date.

The use of custody seals is addressed in the bullet beginning with "Samples will be properly packaged…"
17c.
Appendix E has been replaced with Appendix F in the following Statement in Section B.5) Quality Control Requirements.

> Detailed MQOs as well as corresponding accuracy goals are presented in the tables included in Appendix F.

Other Revisions:
A) PROJECT MANAGEMENT ELEMENTS - Vince Pereira has been appointed as Guam EPA Air Pollution Control Program Manager following Pete Cruz's passing.
A3) Distribution List – Same comment as above

GUAM POWER AUTHORITY
AIR QUALITY MONITORING NETWORK

QUALITY ASSURANCE PROJECT PLAN (QAPP)

Ambient Air Quality Monitoring Network

Sulfur Dioxide (SO_2), Particulate Matter ($PM_{10}/PM_{2.5}$), Oxides of Nitrogen (NO_x) and Meteorology

Prepared for

Guam Power Authority

Prepared by

TRC Environmental Corporation
Gainesville, FL and Littleton, CO

January, 2013

A2) TABLE OF CONTENTS

TABLES

FIGURES

APPENDICES

A4) PROJECT ORGANIZATION

A4.1) Roles and Responsibilities

The Guam Environmental Protection Agency (Guam EPA), Guam Power Authority (GPA) and TRC Environmental Corporation (TRC) will all play vital roles in the implementation of this project. The role of each entity is summarized below and described in Table A.1. A project flow chart is provided as Figure A4.1.

A4.1.(1) Guam EPA

Guam EPA is responsible for assisting in the site selection process and approving and evaluating the measurements to be conducted at each monitoring station. Guam EPA will also be responsible for reviewing and approving this QAPP. Guam EPA and/or the USEPA can conduct Technical System Audits at their discretion. If such an audit is requested by either agency, it will be accommodated. Guam, EPA, Air Pollution Control Program Manager performs TSAs as specified in QA Handbook for Air Pollution Measurement Systems, Volume II, Ambient Air Quality Monitoring Program, EPA-454/B-08-003, December, 2008.

A4.1.(2) GPA

GPA will be responsible for assisting in the selection of sites, securing use of the site locations, installing monitoring shelters, site security and installation of utilities. GPA will review data reports prior to submittal to Guam EPA.

A4.1.(3) TRC

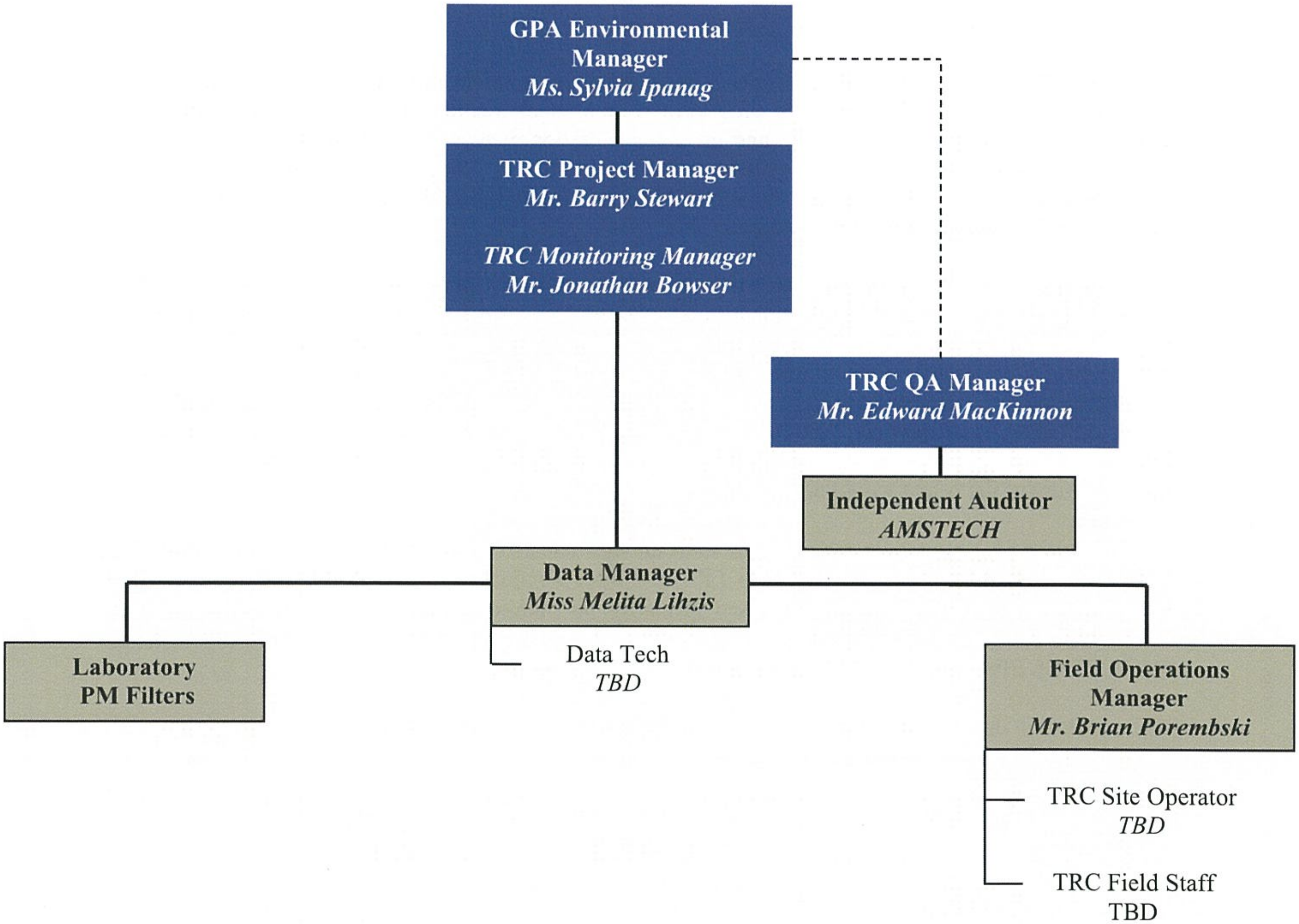
TRC has been contracted by GPA and will be responsible for instrumentation installation, calibration, operation and maintenance; data collection and reporting. TRC will assist in the selection of sites and provide the equipment, instrumentation and personnel necessary to ensure that the data is of sufficient quantity and quality to meet the objectives of the program, as described in this QAPP. TRC will ensure that quality control (QC) and standard operating procedures (SOPs) are followed in accordance with U.S. EPA and Guam EPA requirements, as applicable, such that the quality assurance (QA) objectives of this plan are met.

TRC's Quality Assurance Manager is responsible for overall implementation of practices and procedures within the QAPP. The QA Manager reports directly to Guam Power Authority's Environmental Manager. The Quality Assurance Manager ensures performance audits and data quality assessments are conducted in accordance with QAPP requirements, and will report findings of quality control activities to the Project and Monitoring Managers. The results from all internal audits of the network to be conducted during this program will be summarized and reported to Guam EPA.

TRC's Project Manager is responsible for ensuring successful outcomes and managing all aspects of the project. All contract personnel report to the Project Manager.

The Monitoring Program Manager is responsible for ensuring that all monitoring activities and data validation and reporting procedures are in compliance with Federal Regulations and the project QAPP. The Monitoring Program Manager reports to the Project Manager

Figure A4.1. Project Organizational Chart



A5.1.(2) Ambient Monitoring- Purpose and Objectives

The primary reason for an AAQM program is that the modeling is predicting concentrations that are substantially higher than are expected, given the meteorological conditions of maximum concentrations. The maximum modeled concentrations on land occur during rare nighttime events when winds blow from the west, northwest. Evaluations of the measured data from the on-site meteorological tower at Cabras show that there are no more than 15 hours in a year when winds blow in any 10 degree sector toward the land and that these events are rarely more than a few hours in duration and all occur at night. The AERMOD/AERMET modeling system characterizes these conditions as very stable events with pencil thin plumes (very little dispersion) headed toward elevated terrain obstacles. It is probable that the actual dispersion is substantially greater because the winds are off the ocean and the ocean/land interface generates considerably more turbulence during these time periods, and thus dispersion is greater than a land surface. There is a method of preparing the meteorological data (AERMOD-COARE) to account for the difference in dispersion of winds coming off the water as opposed to the land. By measuring the appropriate meteorological variables and the ambient concentrations simultaneously, the AAQM program will be able to show that the reason that monitored concentrations on Guam are not consistent with the modeling is because of the dispersion characteristics of the on shore wind flow. The AERMOD-COARE method has been approved for use in the arctic by Region 10, US EPA and this program seeks to develop the information necessary for such approval for Guam.

The modeling results from AERMOD without the COARE methodology are summarized below and explained in detail in Appendix A.

At Nimitz Hill east of the Cabras-Piti power plant complex the model (following the Draft SO_2 Guidance[5]) is predicting SO_2 concentrations as follows:

Period	Predicted Concentration ($\mu g/m^3$)	National Ambient Air Quality Standard ($\mu g/m^3$)
1-HR	6516.90	196
3-HR	5447.60	1300
24-HR	2767.41	365
Annual	135.86	80

On the elevated terrain above the Tanguisson Power plant the model is predicting SO_2 concentrations as follows:

Period	Predicted Concentration ($\mu g/m^3$)	National Ambient Air Quality Standard ($\mu g/m^3$)
1-HR	2072.00	196
3-HR	2955.17	1300
24-HR	931.54	365
Annual	99.54	80

These concentrations are nearly 5 times higher than the 1996 model predictions and per se 5 times further from the measured concentrations. Without accurate and carefully crafted meteorological and ambient

[5] "Guidance for 1-Hour SO2 NAAQS SIP Submissions, Public Review Draft 9/22/2011

A6) PROJECT DESCRIPTION

A6.1) Project Overview

The proposed monitoring program for Guam Power Authority includes continuous monitoring of both air quality and meteorological variables at select locations or sites that are necessary to meet the objectives of the project described in Section 1.0 of the AMP. Monitoring of the meteorological parameters will be useful in the analyses of temporal and spatial variability of observed pollutant concentrations and will also be necessary as input to drive the dispersion modeling analyses that may be used to assess current and future potential impacts from specific sources of emissions on the Island. Dispersion models require meteorological data as input to characterize prevailing atmospheric conditions which are subsequently used to calculate potential atmospheric transport and dilution of emitted air pollutants of interest. The meteorological variables proposed to be monitored are specifically aimed at satisfying regulatory modeling requirements in general and those of the AERMOD/AERMET modeling system in particular. Consideration has also been given to currently non-regulatory versions of the AERMOD/AERMET modeling system which may be useful in the marine/tropical climate experienced on Guam. A discussion of the proposed meteorological monitoring network and of the existing meteorological data resources on the Island is provided in the following subsection.

This monitoring plan also proposes to establish six (6) air quality monitoring stations at strategic locations on the Island as identified in Table A.3 . These stations are intended to monitor Sulfur Dioxide (SO_2) at all stations as well as Oxides of Nitrogen (NO_X) and Particulate Matter at three (3) of the six stations. A discussion of the proposed air quality monitoring program is provided in the following sections. A summary of all monitoring parameters to be measured at each monitoring location is presented in Table A.4.

AIR QUALITY MONITORING

Purpose of Air Quality Monitoring

The portions of Guam that are located within a 3.5 kilometer radius of the Piti-Cabras and Tanguisson power generating facilities are currently designated as non-attainment areas for the 24-hour average SO_2 NAAQS, (http://www.epa.gov/airquality/greenbook/snp.html#66Pit). That NAAQS and those non-attainment area designations will remain in effect until U.S. EPA approves a SIP that demonstrates attainment and maintenance of the new and more stringent 1-hour average SO_2 NAAQS.

Also, a number of new U.S. EPA regulations have been promulgated, such as the short term 1-hour average SO_2 and NO_2 and the $PM_{2.5}$ NAAQS that require States and U.S. Territories to reevaluate their SIPs to see if further action is necessary to ensure that the new NAAQS are met.

While dispersion modeling may be used to demonstrate compliance with the NAAQSs, it has become increasingly difficult to demonstrate compliance with the much stricter NAAQSs and the conservative nature of the available models. Therefore it is prudent, especially for areas that are already designated as non-attainment, to consider monitoring of actual conditions. Ambient air quality data, although by itself cannot be used to demonstrate attainment of the new 1-hour SO_2 NAAQS, it can be indispensable in assessing the accuracy and applicability of the required regulatory modeling analyses. Thus this monitoring plan includes a proposal to monitor the three newest and most important regulated pollutants with the strictest NAAQS requirements, SO_2, NO_2 and particulate matter, including PM10 and $PM_{2.5}$.

- "Inhalable coarse particles," such as those found near roadways and dusty industries, are larger than 2.5 micrometers and smaller than 10 micrometers in aerodynamic diameter.

- "Fine particles," such as those found in smoke and haze, are 2.5 micrometers in aerodynamic diameter and smaller. These particles can be directly emitted from sources such as forest fires, or they can form when gases emitted from power plants, industries and automobiles react in the air.

Based on its review of the air quality criteria and NAAQS for particulate matter, on October 16, 2006, EPA promulgated revisions to the primary and secondary NAAQS for PM to provide increased protection of public health and welfare, respectively. With regard to primary standards for fine particles, EPA revised the level of the 24-hour $PM_{2.5}$ standard to 35 $\mu g/m^3$ and retaining the level of the annual $PM_{2.5}$ standard at 15 $\mu g/m^3$. With regard to primary standards for PM_{10}, EPA retained the 24-hour PM_{10} and revoked the annual PM_{10} standard. With regard to secondary PM standards, EPA made them identical in all respects to the primary PM standards, as revised.

The proposed monitoring program includes monitoring of both $PM_{2.5}$ and PM_{10} at three locations on the Island to characterize the current conditions of ambient concentration of PM that can be used to support demonstrations of compliance with the NAAQSs.

METEOROLOGICAL MONITORING

Purpose of Meteorological Monitoring

The purpose of the meteorological monitoring effort is to develop a high quality, comprehensive meteorological data base that can be relied upon to support the following efforts as they may arise:

- Spatial and temporal evaluation of observed ambient concentrations of pollutants of interest at the various air quality monitoring stations,
- Use as input to dispersion models to assess potential impacts of pollutants emitted from specific sources,
- Use as input to dispersion models to assess compliance with applicable ambient air quality standards due to impacts from individual or multiple sources on the Island,
- Use to support permitting efforts for new sources of emission,
- Support re-designation efforts of the current SO_2 non-attainment areas on the Island.

This monitoring plan proposes to install minimal new monitoring equipment at a strategic location that will allow development of a comprehensive data base through the continued use of existing and available sources of meteorological data. The strategic plan is to rely on the existing meteorological tower located at the Piti site to obtain wind data from the 60 meter height and the National Weather Service site at the Guam Airport (GUM) to provide surface observations, and install a new meteorological observing station at the Nimitz Hill site with a 10 meter tower to enhance the available meteorological data from the existing stations. The new site will include state of the art monitoring equipment to continuously monitor and record wind speed, wind direction, temperature, humidity, solar radiation, pressure and precipitation. Each of these variables is further discussed below.

In addition, a major objective of the this program is to develop a comprehensive meteorological data base that will satisfy the regulatory requirements for use in regulatory approved dispersion models such as AERMOD/AERMET modeling system or alternate models such as AERMOD-COARE and CALPUFF. The monitoring methodology, equipment used, Quality Control and Quality Assurance procedures and

Precipitation

This monitoring plan includes monitoring of precipitation at the Nimitz Hill site. Precipitation data is important in determining potential pollutant wet deposition affects and in evaluating consistency of observed ambient conditions and other meteorological variable. A rain gage will be used to monitor and record rainfall.

Solar Radiation

Solar and/or net radiation data are used to determine atmospheric stability, for calculating various surface-layer parameters used in dispersion modeling, for estimating convective (daytime) mixing heights, and for modeling photochemical reactions.[1]

Solar radiation refers to the electromagnetic energy in the solar spectrum (0.10 to 4.0 µm wavelength); the latter is commonly classified as ultraviolet (0.10 to 0.40 µm), visible light (0.40 to 0.73 µm), and near-infrared (0.73 to 4.0 µm) radiation. Net radiation includes both solar radiation (also referred to as short-wave radiation) and terrestrial or long-wave radiation; the sign of the net radiation indicates the direction of the flux (a negative value indicates a net upward flux of energy).

A Pyranometer and net radiometer will be installed at the Nimitz Hill site.

A6.2) Project Schedule

The tentative project implementation schedule is outlined in Table A.5. Project activities ranging from installation of the monitoring network to demobilization are identified. The schedule is based on monitoring program duration of three (3) years, the monitoring length required for non-attainment redesignation request and the minimum time required to show compliance with NAAQS.

A6.3) Scheduled Field Activities

Federal regulation provides for the implementation of a number of qualitative and quantitative checks to ensure that data will meet the Data Quality Objectives (DQOs) for the project. Each of the checks attempts to evaluate phases of measurement uncertainty.

TRC will have primary responsibility for implementation of all monitoring program QC measures. The following is a summary of QC activities that will be implemented to ensure that measurement uncertainty is maintained within established acceptance criteria for the attainment of the program DQOs. QC activities will include, but not be limited to, the following:

- SO_2 an NO_X
  - Quarterly multipoint calibrations,
  - Weekly automated calibration checks (zero/span and a precision point in the range of 70-80 ppb),
  - Daily review of instrument measurements and diagnostics,
  - Weekly operational checks by site operator,
  - Routine maintenance as specified in TRC's Standard Operating Procedures (SOP), and
  - Quarterly independent performance audit.

- $PM_{10/2.5}$

A7) QUALITY OBJECTIVES AND CRITERIA FOR MEASUREMENT DATA

A7.1) Data Quality Objectives (DQOs)

A7.1.(1) DQO Process

The Data Quality Objectives (DQOs) of this project are to provide valid data that satisfy the regulating authority's requirements. Monitoring is performed in accordance with TRC Standard Operating Procedures (SOPs) and EPA regulations and guidance documents.

The GPA Ambient Air Monitoring Program is designed to achieve program DQOs and meet or exceed the minimum standard requirements for field monitoring and analytical methods. The overall QA objective is to develop and implement procedures for continuous air quality and meteorological monitoring, data validation and reporting which will provide results that are scientifically valid, and the levels of which are sufficient to meet program DQOs.

A7.1.(2) Measurement Quality Objectives (MQOs)

Measurement Quality Objectives (MQOs) are designed to evaluate and control various phases (sampling, preparation, analysis) of the measurement process to ensure that total measurement uncertainty is within the range prescribed by the DQOs. MQOs can be defined (as in the Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II, Ambient Air Quality Monitoring Program) in terms of the following data quality indicators:

- *Precision* – a measure of mutual agreement among individual measurements of the same property usually under prescribed similar conditions. This is the random component of error.
- *Bias* – the systematic or persistent distortion of a measurement process which causes error in one direction.
- *Accuracy* – a measure of the overall agreement of a measurement to a known value; includes a combination of random error (precision) and systematic error (bias) components of both sampling and analytical operations.
- *Representativeness* – a qualitative term that expresses "the degree to which data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition."
- *Completeness* – a measure of the amount of valid data needed to be obtained from a measurement system.
- *Comparability* – a qualitative term that expresses the measure of confidence that one data set can be compared to another and can be combined for the decision(s) to be made.
- *Detectability* – the determination of the low range critical value of a characteristic that a method specific procedure can reliably discern.

Tables A.6 and A.7 summarize the MQOs for the pollutant monitors and the meteorological station, respectively.

A7.2) Data Quality Assessment

Methods for calculating precision, accuracy and bias are conducted following the procedures specified in Appendix A of 40 CFR Part 58 and guidance provided in Quality Assurance Handbook for Air Pollutions

A8) SPECIAL TRAINING REQUIREMENT/CERTIFICATION

Appropriate training will be provided to employees supporting the GPA Ambient Air Quality Monitoring Program, commensurate with their duties. No special training or certifications are required for this monitoring project. Field technicians and scientists, data analysts and the QA manager are all either meteorologists or environmental scientists with expertise in operation of monitoring instrumentation, data management and data QC procedures as they apply to meteorological and ambient air quality monitoring programs.

On-site personnel will receive training on station and instrumentation operation, maintenance and QC procedures. Additional training will be provided, as appropriate, throughout the entire term of the project as deemed necessary by the TRC project manager.

Documents relevant to adhering to this QAPP will be made available to all site personnel and located in the field office for accessibility. Such documents include, but are not limited to:

- GPA Air Monitoring Plan
- TRC SOPs
- GPA Quality Assurance Project Plan
- Instrument operation and maintenance manuals

Most of the on-site activities described in this QAPP constitute routine sampling and analyses for which no special training requirements or certifications are needed. However, all TRC staff working on-site will comply with the GPA Health and Safety Plan in effect at the time. All health and safety training records are maintained in the TRC files. Prior to the start of the on-site work, all field personnel will be given instruction specific to the project, covering the following areas:

- Organization and lines of communication and authority,
- Overview of the QAPP, including sample collection, handling, and labeling procedures,
- QA/QC requirements,
- Documentation requirements, and
- Health and safety requirements.

Instructions will be provided by the TRC Field Operations Manager and TRC Project QA Officer.

B) MEASUREMENT AND DATA ACQUISITION

B1) SAMPLING PROCESS DESIGN

Refer to Section A6 for the monitoring design of this project. This section discusses the areas being sampled, what is being tested, and how often. Table B.1 summarizes the measurement methodologies that will be employed during this monitoring program. Table B.2 is a list of the equipment manufacturers along with their physical address, web address and phone number.

B2) SAMPLING METHODS AND REQUIREMENTS

B2.1) Ambient Air Quality Monitoring

Continuous monitoring of SO_2 concentrations will be conducted using Teledyne-Advanced Pollution Instrumentation (TAPI) model T100 UV Fluorescent SO_2 Analyzers. The T100 is designated as a Federal Equivalent Method (FEM), designation EQSA-0495-100.

At the Dededo, Nimitz and Apra sites, $NO/NO_2/NO_X$ will be measured using TAPI model T200 Chemiluminescence Analyzers. The T200 is designated as an Automated Reference Method for the measurement of NO_2, designation number RFNA-1194-099.

The T100 and T200 analyzers will be calibrated with TAPI Model T700 dynamic dilution calibrators coupled with Model 701 zero air systems. National Institute of Standards and Technology (NIST) traceable gas standards will be used for generation of calibration gases. At stations monitoring $NO/NO_2/NO_x$, the T700s will be equipped with ultraviolet (UV) ozone (O_3) generators and photometers for production of NO_2 calibration gas by gas phase titration of NO with O_3. The 701 zero air systems produce clean, dry air using oil-free compressors and scrubbers for the removal of SO_2, NO, NO_2 and O_3.

Instruments will be installed in temperature controlled concrete shelters provided by GPA. The shelters will be certified to withstand sustained winds up to 150 miles per hour (mph) if properly installed. The shelters will be equipped with a 12,000 Btu industrial heating and air conditioning system capable of maintaining an internal temperature within ± 2 °C of the set point. For introduction of ambient air to the analyzers, the shelters will be fitted with borosilicate glass sample inlets and manifolds.

Continuous measurement data will be recorded on a PC-based data acquisition system with local backup. Data will be transmitted to a cloud server and to a server located in Raleigh, NC on a 5-minute basis. Five minute and hourly averaged concentrations will be calculated for comparison to the NAAQS and to comply with reporting requirements established for SO_2.

PM_{10} and $PM_{2.5}$ concentrations will be monitored continuously on a "real-time" basis using beta-attenuation monitors manufactured by Met One Instruments, Inc. (Met One). Met One BAM -1020s will be configured to meet FEM requirements for measurement of PM_{10} and $PM_{2.5}$ mass concentrations as described in Federal Register designations EQPM-0798-122 and EQPM-0308-170. As with gas analyzer measurements, particulate matter mass concentration data will be recorded on a PC-based data acquisition system and transmitted to a cloud server and a backup server located in Raleigh, NC on an hourly basis. Twenty-four (24) hour average concentrations of PM_{10} and $PM_{2.5}$ will be calculated and reported for comparison to the NAAQS established for those parameters. Additionally, BGI PQ-200 units configured to meet FRM requirements will be co-located with the BAM-1020s at the Dededo site for determination of measurement precision.

B3) SAMPLE HANDLING AND CUSTODY REQUIREMENTS

Particulate samples collected using the BGI PQ-200 units will be transported to the laboratory for gravimetric analysis. TRC, or a laboratory contracted by TRC or GPA will perform the gravimetric analysis of these samples. This section describes the sample handling and custody requirements for the PM_{10} and $PM_{2.5}$ samples collected following the EPA FRM.

Summaries of sample media, required sample volumes, preservation, and holding time requirements for all samples are presented in Table B.3.

B3.1) Sample Custody

Sample custody is addressed in two parts: field sample collection and laboratory analysis.

A sample is considered to be under a person's custody if

- the item is in the actual possession of a person;
- the item is in the view of the person after being in actual possession of the person;
- the item was in the actual physical possession of the person but is locked up to prevent tampering; and,
- the item is in a designated and identified secure area.

B3.1.(1) Field Sample Custody

Sample handling is an important part of the field investigation program since samples that are incorrectly handled can affect the quality of data. Sample handling begins at the collection of the samples and continues until the sample has been analyzed. An over-riding consideration essential for the validation of environmental measurement data is the necessity to demonstrate that samples have been obtained from the locations stated and that they have reached the laboratory without alteration. Evidence of sample tracking from collection to shipment, laboratory receipt, and laboratory custody (until proper sample disposal and the introduction of field investigation results as evidence in legal proceedings when pertinent) must be documented.

Sample chain-of-custody and packaging procedures are summarized below. These procedures will ensure that the samples will arrive at the laboratory, with the chain-of-custody, intact. The TRC Field Operations Manager (or designee) is responsible for overseeing and supervising the implementation of proper sample custody procedures in the field and up until the samples have been transferred to a courier. The chain-of-custody procedures are initiated in the field immediately following sample collection. The procedures consist of: (1) preparing and attaching a unique sample label to each sample collected, (2) completing the chain-of-custody form, and (3) preparing and packing the samples for shipment.

- The field sampler is personally responsible for the care and custody of the samples until they are transferred or dispatched properly. Field procedures have been designed such that as few people as possible will handle the samples.

- Filters will be recovered by the field sampler within seven (7) days and nine (9) hours from the sample end date.

Samples will be received and logged in by a designated sample custodian or his/her designee. Upon sample receipt, the sample custodian will

- Examine the shipping containers to verify that the custody tape is intact,
- Examine all sample containers for damage,
- Compare samples received against those listed on the chain-of-custody,
- Examine all shipping records for accuracy and completeness,
- Sign and date the chain-of-custody immediately (if shipment is accepted) and attach the air bill,
- Note any problems associated with the coolers and/or samples on the receipt form and notify the Laboratory Project Manager, who will be responsible for contacting the TRC Project QA Officer,
- Attach laboratory sample container labels with unique laboratory identification and test, and
- Place the samples in the proper laboratory storage.

Following receipt, samples will be logged in according to the following procedure:

- The samples will be entered into the laboratory tracking system. At a minimum, the following information will be entered: project name or identification, unique sample numbers (both client and internal laboratory), type of sample, required tests, date and time of laboratory receipt of samples, and field identification provided by field personnel.
- The Laboratory Project Manager will be notified of sample arrival.
- The completed chain-of-custody, air bills, and any additional documentation will be placed in the final file.

Figure B.2. **Chain-of-Custody (EXAMPLE)**

Company Name		
Contact		Phone
E-Mail Address		Fax
Report Address		
City	State	Zip
Billing Address		
City	State	Zip
PO #	Project	

CHESTER LabNet
12242 SW Garden Place
Tigard, OR 97223
(503) 624-2183
Fax (503) 624-2653
cln@chesterlab.net

CHAIN-OF-CUSTODY RECORD

Page___ of___

Turn Around Time
☐ Standard
☐ Rush ____________ (Specify)

LabNet ID	Field Sample ID	Site	Sample Date	Volume (m^3)	Particle Size	Analysis Requested										Remarks

Relinquished By: (Signature) Date/Time	Received By: (Signature) Date/Time	Notes:
Relinquished By: (Signature) Date/Time	Received By: (Signature) Date/Time	

B4) ANALYTICAL METHODS REQUIREMENTS

TRC, or a contracted laboratory in Guam will be performing the gravimetric analysis required for this air monitoring program. The lab will perform the analysis in accordance with their SOPs (see Appendix D of this document) as well as with 40 CFR Part 50, Appendices J and L. The laboratory selected will also be responsible for conducting filter conditioning, in accordance with the conditioning specifications outlined in Quality Assurance guidance documents (i.e., QA Handbook for Air Pollution Measurement Systems, Volume II, Ambient Air Quality Monitoring Program, EPA 454/B-08-003, December 2008, Appendix D, Measurement Quality Objectives and Validation Templates). TRC will review the candidate Laboratory's SOPs and QAPP to ensure compliance with 40 CFR Part 50, Appendix J (PM10) and Appendix L (PM2.5) as well as QA Guidance Documents 2.11 for both PM10 and PM2.5 as it contains the more stringent requirements.

B4.1) PM_{10} – 40 CFR Part 50, Appendix J

This method provides for the measurement of the mass concentration of particulate matter with an aerodynamic diameter less than or equal to 10 micrometers (PM_{10}) in ambient air over a 24-hour period. Concentrations of PM_{10} will be compared to National Ambient Air Quality Standards as specified in Section A5.1. The measurement process is nondestructive, and the PM_{10} sample can be subjected to subsequent physical or chemical analyses. Quality assurance procedures and guidance are provided in 40 CFR Part 58, Appendices A and B.

Each filter is weighed (after moisture equilibration) before and after use to determine the net weight (mass) gain due to collected PM_{10}. The total volume of air sampled, corrected to EPA reference conditions (298 °K, 760 mmHg), is determined from the measured flow rate and the sampling time. The mass concentration of PM_{10} in the ambient air is computed as the total mass of collected particles in the PM_{10} size range divided by the volume of air sampled, and is expressed in micrograms per standard cubic meter ($\mu g/m^3$).

The analytical balance must be suitable for weighing the type and size of filters required by the sampler. The range and sensitivity required will depend on the filter tare weights and mass loadings. Typically, an analytical balance with a sensitivity of 0.1 µg is required for low-volume samplers (~1 m^3 /hr).

B4.2) $PM_{2.5}$ – 40 CFR Part 50, Appendix L

This method provides for the measurement of the mass concentration of fine particulate matter having an aerodynamic diameter less than or equal to 2.5 micrometers ($PM_{2.5}$) in ambient air over a 24-hour period. Concentrations of $PM_{2.5}$ will be compared to National Ambient Air Quality Standards as specified in Section A5.1. The measurement process is considered to be nondestructive, and the $PM_{2.5}$ sample obtained can be subjected to subsequent physical or chemical analyses. Quality assessment procedures are provided in 40 CFR Part 58, Appendix A.

Each filter is weighed (after moisture and temperature conditioning) before and after sample collection to determine the net gain due to collected $PM_{2.5}$. The total volume of air sampled is determined by the sampler from the measured flow rate at actual ambient temperature and pressure and the sampling time. The mass concentration of $PM_{2.5}$ in the ambient air is computed as the total mass of collected particles in the $PM_{2.5}$ size range divided by the actual volume of air sampled, and is expressed in micrograms per cubic meter of air ($\mu g/m^3$).

B5) QUALITY CONTROL REQUIREMENTS

QC, as it applies to an air quality monitoring program, is the overall system of technical activities and procedures developed to measure the attributes and performance of the sampling program against defined standards to verify that they meet the stated requirements established by the program. Quality control includes:

- Establishing specifications or acceptance criteria for each quality characteristic of the monitoring/analytical process,
- Assessing proceduresusedinthemonitoring/analyticalprocesstodetermineconformancetothesespecifications, and
- Taking any necessary corrective actions to bring them into conformance.

The overall goal of QC is to minimize loss of data through invalidation by establishing a reasonable level of checking at various stages of the data collection process. QC procedures determine if field and lab procedures are producing acceptable data and are used to initiate appropriate corrective actions; therefore QC is both proactive and corrective.

TRC will have primary responsibility for implementation of all monitoring program QC measures. The following is a summary of QC activities that will be implemented to ensure that measurement uncertainty is maintained within established acceptance criteria for the attainment of the program DQOs. QC activities will include, but not be limited to, the following:

- SO_2 and NO_x
  - Quarterly multipoint calibration checks,
  - Weekly automated calibration checks (zero/span and a precision point in the range of 70-80 ppb),
  - Daily review of instrument measurements and diagnostics,
  - Weekly operational checks by site operator, and
  - Routine maintenance as specified in TRC's Standard Operating Procedure (SOP).
  - Quarterly independent performance audit.

- $PM_{10/2.5}$
  - Daily review of instrument measurements and diagnostics,
  - Monthly flow checks,
  - Routine maintenance as specified in TRC's SOP, and
  - Quarterly performance audit

- Meteorological Measurements
  - Quarterly calibrations,
  - Weekly reasonableness checks by site operator
    - Verification that wind sensors are operational and show no sign of damage,
    - Wind speed, wind direction and temperature measurements represent actual conditions, and
  - Semi-annual performance audits.

Detailed MQOs as well as corresponding accuracy goals are presented in the tables included in Appendix F. These tables were directly reproduced from Appendix D of the Quality Assurance Handbook, Volume II.

B6) INSTRUMENT/EQUIPMENT TESTING, INSPECTION, AND MAINTENANCE REQUIREMENTS

All monitoring equipment will be tested during the pre-operational phase of the program. All instruments and sensors will receive a cursory calibration check to verify operation prior to deployment. All calibration standards will be inspected for current calibrations and traceability to NIST or the appropriate authority. For this monitoring program, TRC has purchased new gas monitors, gas calibrators, meteorological instruments and continuous PM monitors. In addition, data acquisition PCs and hardware have also been purchased new. Manufacturer's warranties will be in place for the majority of the program.

The following is a summary of activities and procedures TRC will follow to ensure all instrumentation and equipment will operate at acceptable performance levels throughout the duration of the program.

- SO_2 and NO_x
  - Daily review of instrument measurements and diagnostics,
  - Weekly operational checks by site operator, and
  - Routine maintenance as specified in TRC's Standard Operating Procedure (SOP).
  - Quarterly independent performance audit.

- $PM_{10/2.5}$
  - Daily review of instrument measurements and diagnostics,
  - Monthly flow checks,
  - Routine maintenance as specified in TRC's SOP, and
  - Quarterly performance audit

- Meteorological Measurements
  - Weekly reasonableness checks by site operator
    - Verification that wind sensors are operational and show no sign of damage,
    - Wind speed, wind direction and temperature measurements represent actual conditions, and
  - Semi-annual performance audits.
  - Routine maintenance as specified in TRC SOPs.

Documentation of all site activities will be provided through the use of multiple forms including the site log books, site visit check sheets, maintenance and repair activities as well as calibration records. Inventory of spare parts and a schedule of routine activities will be maintained at each station. Copies of these forms are included in the appropriate TRC SOP. Table B.4 summarizes the scheduled field activities

Table B.5 presents an inventory of spare parts and expendable items that will be maintained on site for the duration of this monitoring program.

B8) INSPECTION/ACCEPTANCE REQUIREMENTS FOR SUPPLIES

TRC and/or GPA have purchased new equipment for this project to minimize the potential for instrument failure and data loss. In addition, consumables and spare parts for a minimum of 13 months have been purchased for all monitoring locations. These parts and consumables were obtained from the original equipment manufacturer and will be located at the background site. TRC's field scientists and site operator will be responsible for maintaining an inventory of these items. In the event additional parts or supplies are needed, they will be procured from the instrument manufacturer through TRC's Guam Office where they will be inspected prior to deployment in GUAM. On a weekly basis, the local site operator will communicate to the project manager the status of all spare parts and consumable items. The Project Manager will be responsible for ordering all parts, supplies and materials, as required, to meet the requirements of this program. The Project Manager will also be responsible for ensuring that these parts and supplies meet the specifications of the instrument manufacturer allowing all instrumentation to be operated in compliance with this QAPP.

B10) DATA MANAGEMENT

Data management involves the collection, storage, transmittal, validation, reporting and archiving of measurements taken from continuous and time integrated samplers, sensors and instruments. The primary data collection systems will be comprised of on-site PCs running software developed to acquire data digitally from the instrumentation operating at the monitoring station. All continuous measurement instrumentation has built in data averaging and storage capabilities, as well as the ability to transmit those data digitally (e.g. USB, RS-485 or LAN interface). The DAS software requests data from the instruments and populates a locally stored database containing multiple averaging intervals of each parameter. This database is the primary source of data.

For this monitoring program, the local (site) database will be comprised of 5 minute and hourly tables. Meteorological parameters, SO_2 and NOx concentrations (along with instrument QC checks) will be stored in 5-minute and hourly tables. Continuous PM parameters (concentrations and QC) will be stored hourly.

At 5-minute intervals, data are transferred via TCP/IP to a central server hosted by TRCAir.com. This server maintains TRC's central air monitoring database and hosts a limited access/secure website to allow for data display, review and editing. A user account and password are required to access the website. A second level password will be required for access to the database management system. TRC's web based system is under development and security measures will be implemented, as necessary, to protect the integrity of data.

Software running on the central server performs a diagnostic check on incoming data and generates error reports based on screening criteria. These reports are emailed to project personnel. For QC purposes, data will also be stored on a local USB memory device and transferred to a server located in TRC's Raleigh, NC office on a monthly basis to preserve raw data as recorded at each station. Updates to the data logging software will send continuous data directly to a local server at the Raleigh, NC office location.

Data analysts will review measurement data on a daily basis as a first level of validation. If any data are determined to be missing, the DAS software will attempt to retrieve these data from the instruments and place them in the local database. These values will be transferred to and populated in the central server. In the event data are not retrieved automatically, the data analyst can connect to the instrument directly, retrieve data manually and load those data in to the central database.

The central database is structured with duplicate tables. The original data tables are protected, so they cannot be altered. A duplicate set of tables are identified as 'edited.' All data validation activities are stored in the edited tables.

Review and validation activities will be documented to ensure integrity and traceability of the measurement data. Edits will be independently verified by a second analyst, the project manager or other project staff. Status codes will be entered into the database indicating the action taken and validity of the datum.

Hard copy data (station logs, sample chain of custody forms, QC checks sheets, etc.) will be sent to the Raleigh office on a monthly basis. Site documentation will be reviewed as part of the data validation process and data from manual samplers will be loaded into the central database.

All data management activities will be performed in a manner consistent with TRC SOPs, as applicable.

At each level, d_i must be less than or equal to 15% to achieve the MQO as summarized in Table C.3 (refer also to the SO_2 and NO_x Validation Templates in Appendix E). All data used for the assessment of measurement accuracy will be submitted quarterly as specified in 40 CFR 58, Appendix A section 5.2.

Particulate Matter Instrumentation

Audits will be performed of the BAM 1020 and BGI PQ-200 units in conformance with the manufacturer recommendations as well as 40 CFR 50 Appendix L. Audits will consist of checks of all instrument parameters listed below, also summarized in Table C.3:

- Flow rate
- Leak check
- Verify temperature and pressure

The percent difference between the actual parameter value reported by the independent audit standard and the value indicated by the particulate monitoring instrument will be used to assess data accuracy. The digital output of the instrument will be compared to the known value using the validation criteria in Table C.3. Accuracy data compiled from the audit results will be submitted as part of the quarterly report.

C1.2) Technical System Audits

A system audit of field activities including sampling and field measurements will be conducted and documented by the TRC Project QA Officer (or designee) at the start of sampling. The purpose of this audit is to verify that all established procedures are being followed as planned and documented and to allow for timely corrective action, reducing the impact of any nonconformance. The audit will ensure that all personnel have read the QAPP. The audit will cover field sampling records, field measurement results, field instrument operation and calibration records, sample collection, preservation, handling, and packaging procedures, adherence to QA procedures, personnel training, sampling procedures, review of sampling design versus the sampling plan, corrective action procedures, and chain-of-custody, etc. Follow-up surveillance will be conducted by the TRC Field Operations Manager to verify that QA procedures are maintained throughout the investigation.

Prior to performing the audit, the auditor will review the QAPP and assure that the audit equipment is certified and is up to date with calibrations.

Upon completion of the audit, the TRC Project QA Officer will prepare a written audit report, which summarizes the audit findings, identifies deficiencies and recommends corrective actions. In addition, a verbal debriefing will also be given to the TRC Field Operations Manager and TRC Project Manager at the time of the audit. The written report will be submitted to the TRC Project Manager, who will be responsible for ensuring that corrective measures are implemented.

Field Systems Audit

The following tasks will be performed during the audit:

Station Locations:

- Instrument shelter and surrounding area inspections
- Inventory of air monitoring equipment

need for corrective action. The TRC Field Sampling Operations Manager will approve the corrective action and notify the TRC Project Manager and TRC QA Officer. The TRC Project Manager, in consultation with GPA, if necessary, will approve the corrective action. The TRC Field Operations Manager will ensure that the corrective action is implemented by the field team. Corrective actions will be implemented and documented in the field logbook. Documentation will include:

- A description of the circumstances that initiated the corrective action,
- The action taken in response,
- The final resolution, and
- Any necessary approvals.

No staff member will initiate corrective action without prior communication of findings through the proper channels as described above. All corrective actions will take into account the possible effect on the data. If necessary, a problem resolution audit will be conducted.

C2) REPORTS TO MANAGEMENT

C2.1) Performance and Technical Systems Audit Reports

Within 45 days of the independent audits the auditor will prepare and submit audit report(s) to the Project Manager and Quality Assurance Manager. Performance and Technical Systems Audits will be conducted on a semi-annual basis.

C2.2) Quarterly Data Reports

The Project Manager is routinely kept informed of project oversight and assessment activities and findings via meetings with monitoring managers. Additionally, the Project Manager receives the quarterly report, which contains the following elements: quarterly data summary including any violation of standards, completeness achieved, explanation of any missing or invalidated data, hourly pollutant and calibration and audit forms. The Data Manager is responsible for compiling the quarterly report. Quarterly electronic data submittals will include pollutant concentrations along with measurement quality checks (as specified in section 1.3 of 40 CFR 58, App. A) in Air Quality System (AQS) format.
Each quarterly report will be comprised of the following:

- Executive Summary;
- Hourly values for SO_2, NO_x, WS, WD, temperature, delta temperature, relative humidity and net solar radiation;
- Highest 5-minute SO_2 concentration in each hour;
- 24-hour values for PM_{10} and $PM_{2.5}$;
- Summary of highest concentrations recorded;
- Results of instrument QC checks;
- QA/QC and equipment maintenance documentation;
- Results of performance audits;
- Quarterly and cumulative data capture statistics by parameter;
- Precision and bias estimates, including calculations;
- Statement of Compliance relative to NAAQS;

D) DATA VALIDATION AND USABILITY

D1) DATA REVIEW, VERIFICATION AND VALIDATION

Data review, validation and verification procedures are used to accept, reject or qualify air quality and meteorological measurement data in an objective and consistent manner. Criteria used to review and validate measurement data are defined in this section. The degree to which data comply with the quality requirements addressed in Section B of this QAPP is determined by these criteria. Ambient air quality data will be validated, invalidated or qualified by comparing measurements with criteria established in the Data Validation Tables as presented in EPA QA Handbook Volume II, Appendix D. These tables are reproduced and presented in Appendix E of this document. These tables establish three levels of criteria where each table has a different degree of implication about the quality of the data. Criteria that are deemed **critical** to maintaining the integrity data are shown in the first section of the tables. Observations that do not meet all criterion on the Critical Criteria Table should be invalidated unless there are compelling reason and justification otherwise. Criteria that are important for maintaining and evaluating data quality are included in the second section of the table. Violation of an **Operational** criterion or a number of operational criteria may be cause for invalidation. Detailed review of quality control results and operational information may or may not indicate data are acceptable for the parameter being evaluated. If one or more of these criteria are not met data are considered suspect unless other quality control information demonstrates otherwise. **Systematic** criteria which are important for the correct interpretation of the data but may not impact the validity are shown in the third section of the Tables.

Meteorological data will be evaluated based on criteria presented in Table C.1.

Overall, in order for data to be considered valid, each data point must be identifiable in terms of parameter, date, time and units. Instruments and sensors must be calibrated and operated according to applicable TRC SOPs and must be bracketed by acceptable calibrations, QC checks and audits to support determination of validity. All documentation, including site logs, check lists and maintenance records must be sufficient to support validity of the data.

D3) RECONCILIATION WITH USER REQUIREMENTS

The objectives of this monitoring program are described in Section A.5. TRC and GPA have established this air monitoring program to measure the levels of gaseous and particulate PM pollution as required by GUAM EPA. Gaseous, PM and meteorological monitoring systems are installed to provide scientifically defensible air quality data to characterize the extent, frequency of occurrence, and magnitude of pollutant concentrations in the region. Data are expected to provide a true representation of air quality in the vicinity of the GPA facilities and surrounding communities.

TRC will conduct quarterly and annual review of the monitoring program to ensure all data considered valid meet the defined network acceptance criteria and monitoring objectives by verifying that quality assurance procedures and documentation are reviewed and evaluated in the data validation process. Performance audits, calibrations, automated and manual precision and accuracy tests, technical systems audits, as well as all other methods used to ensure data quality are considered as part of this review. If, at any time, the review process indicates objectives of the monitoring program are not being met, the project and QA managers will reassess this QAPP.

Table A.1 Program Responsibilities	
Position	**Role**
Guam EPA	• Assist in site selection • QAPP review • Data review • Technical System Audit
Guam Power Authority Environmental Manager	• Overall program management and coordination. • Reviews data prepared by TRC and submits the information to GUAM EPA. • Responsible for site acquisition and response to SO_2, PM_{10} and $PM_{2.5}$ action levels.
TRC Project Manager	• Ensures successful outcomes and managing all aspects of the project. • All contract personnel report to the Project Manager.
TRC Monitoring Program Manager	• Ensures that all monitoring activities and data validation and reporting procedures are in compliance with Federal Regulations and the project QAPP. • The Monitoring Program Manager reports to the Project Manager
TRC QA Manager	• Overall implementation of practices and procedures within the QAPP. • Ensures performance audits and data quality assessments are conducted in accordance with QAPP requirements.
TRC Field Operations Manager (FOM)	• Overall responsibility of field operations, field activities, and the operation of the monitoring sites. • Reports to the Monitoring Program Manager.
TRC Field Scientist(s)	• Site set-up, deploying monitoring equipment. • Quality control checks. • Retrieves data from the monitoring sites. • Reports to the Field Operations Manager.
TRC Data Manager	• Database management. • Final data validation. • Preparation of periodic reports. • Reports to the Monitoring Program Manager.
Data Technician	• Daily data review for completeness and reasonableness. • Reports discrepancies or suspect data to the Data Manager. • Reviews QC activities for determining data validity status.
Independent Auditor	• Performs Quality Assurance Audits as directed by the TRC QA Manager. • Reports to Guam Power Authority Environmental Manager

Table A.4 Summary of Monitoring Program Parameters			
Parameter	**Measurement Units**	**Reporting Interval**	**Site Locations**
SO_2	Parts per billion (ppb)	Hourly (highest 5-min)	All
NO_2	ppb	Hourly	Dededo, Nimitz Hill and Apra Heights
PM_{10}	Micrograms per cubic meter ($\mu g/m^{3}$)	Daily (24 hour)	Dededo, Nimitz Hill and Apra Heights
$PM_{2.5}$	$\mu g/m^3$	Daily (24 hour)	Dededo, Nimitz Hill and Apra Heights
WS	Meters per second (m/s)	Hourly	Nimitz Hill
WD	Directional degrees (°)	Hourly	Nimitz Hill
$\sigma\theta$	°	Hourly	Nimitz Hill
W	m/s	Hourly	Nimitz Hill
σw	Radians	Hourly	Nimitz Hill
T/ΔT	Degrees Celsius (°C)	Hourly	Nimitz Hill
RH	Percent (%)	Hourly	Nimitz Hill
SR	Watts per square meter (w/m^2)	Hourly	Nimitz Hill

Table A.5 Project Schedule – Based on a 3-Year Monitoring Program.		
Activity	**Frequency**	**Date Due**
Installation	Once	Start
Calibrations	Quarterly or as required	1 month after Installation, Quarterly Thereafter.
Station/Equipment Checks	Weekly	n/a
Quality Control Checks	Monthly	n/a
Audits	Quarterly/Semi-Annual	Based on Initiation Date
Reports	Quarterly	Draft 30 Days After Quarter End. Final Due 45 Days After Quarter End.
Final Calibration	Once	3 years & 2 months after Installation
Demobilization	Once	3 years & 2 months after Installation

Table A.7 Meteorological Data Measurement Quality Objectives[1]

Measurement	Method	Reporting Units	Operating Range	Resolution	Averaging Interval	Accuracy	Raw Data Collection Frequency	Completeness
Ambient Temperature	Pt RTD	°C	-50 – 50	0.1	Hourly	± 0.5	1 second	90%
Delta Temperature	Pt RTD	°C	-5 - 5	0.01	Hourly	± 0.1	1 second	90%
Relative Humidity	Capacitive Sensor	%	0 - 100	0.1	Hourly	± 7%	1 second	90%
Horizontal Wind Speed	Propeller Anemometer	m/sec	0.5 – 50.0	0.1	Hourly	±0.2 m/s	1 second	90%
Wind Direction	Vane anemometer	Degrees	0 – 360	1	Hourly	± 5 Deg	1 second	90%
Vertical Wind Speed	Propeller Anemometer	m/sec	-25 – 25 m/s	0.1	Hourly	± 0.2 m/s	1 second	90%
Solar Radiation	Pyranometer	Watts/m2	0 – 1,396	1	Hourly	± 5%	1 second	90%

1. Values reported above replicated from QA Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements, Version 2.0. EPA-454/B-08-002, March 2008. Tables 0-07 and 0-08 PSD Measurement Quality Objectives and Calibration and Accuracy Criteria.

Table B.1 Methodology					
Parameter	**Method**	**Manufacturer**	**Model**	**Reference**	**Federal Register #**
SO_2	Pulsed UV Fluorescence	Teledyne-API	T-100	FEM	EQSA-0495-100
NOx	Chemiluminescence	Teledyne-API	T-200	FRM	RFNA-1194-099
PM_{10}	Beta Attenuation	Met One Inst.	BAM-1020	FEM	EQPM-0798-122
$PM_{2.5}$	Beta Attenuation	Met One Inst.	BAM-1020	FEM	EQPM-0308-170
PM_{10}	Filter	BGI	PQ-200	FRM	RFPS-1298-125
$PM_{2.5}$	Filter	BGI	PQ-200	FRM	RFPS-0498-116
WS	Prop/AC Pulses	R.M. Young	05305	Meets EPA PSD	N/A
WD	Vane/Potentiometer	R.M. Young	05305	Meets EPA PSD	N/A
W	Prop/AC Pulses	R.M. Young	27106	N/A	N/A
T/ΔT	Pt RTD/Aspirated Shield	R.M. Young	41342	N/A	N/A
RH	Capacitive	Young/Rotronic	41382	N/A	N/A
R_s, R_n	Thermopile	Kipp and Zonen	CNR-4	N/A	N/A

Table B.4 Scheduled Field Activities							
Field Activity	**Every Visit**	**Weekly**	**Bi-weekly**	**Monthly**	**Quarterly**	**Semi-Annually**	**Annually**
Communication with Project Manager	X	X					
Change SO_2/NO_x inlet filter			X				
Verify Instrument/Sensor Readings	X	X					
Inspect/Clean sample manifold	X	X					
Inspect/Clean PM sampling system inlets (VSCC & PM_{10} Impactor)				X			
PM Filter Blanks (10%)				Bi-Monthly			
PM Flow Verifications/Leak Checks				X			
Visually Inspect Meteorological sensors/cables	X	X					
Site operator checks/inspections, logbook entries	X	X					
$PM_{10/2.5}$ FRM Samples (1/6 days)		X					
Zero/Spam checks (auto)			X				
Perform& record analyzer calibrations.					X		
Perform & record meteorological calibrations.						X	
Pollutant Instrument Calibrations					X		
Filter Shipments			X				
Audit pollutant analyzers (independent)					X		
Met systems Audit (independent)						X	
Certify SO2tank standards							
Certify SO2dilution calibrator							X
Ship Documentation to TRC			X				

Table C.1 PSD Calibration and Accuracy Criteria – Meteorological Measurements

Measurement	Calibration			Accuracy		
	Type	Acceptance Criteria	Frequency	Type	Acceptance Criteria	Frequency
Ambient Temperature	3 pt. Water Bath with NIST traceable RTD or thermometer	± 0.5 °C	Quarterly	3 pt. Water Bath with NIST traceable RTD or thermometer	± 0.5 °C	Within 60 days of startup and 6 month intervals
Relative Humidity	NIST-traceable Psychrometer, chamber or standard solutions	±7% RH	Quarterly	NIST-traceable Psychrometer, chamber or standard solutions	±7% RH	Within 60 days of Startup and 6 month intervals
Horizontal Wind Speed	NIST-traceable Synchronous Motor	±0.2 m/s < 5 m/s, ±5%. 5 m/s	Quarterly	NIST-traceable Synchronous Motor	±0.2 m/s	Within 60 days of Startup and 6 month intervals
Wind Direction	Magnetic Compass or GPS	±5 degrees Including orientation error	Quarterly	Magnetic Compass or GPS	±5 degrees including orientation error	Within 60 days of Startup and 6 months thereafter
Solar Radiation	NIST-traceable Pyranometer	5% of mean Observed interval[1]	Quarterly	NIST-traceable Pyranometer	5% of mean Observed interval[1]	Within 60 days of Startup and 6 month intervals
Vertical Wind Speed	NIST-traceable Synchronous Motor	±0.2 m/s	Quarterly	NIST-traceable Synchronous Motor	±0.2 m/s	Within 60 days of Startup and 6 month intervals

1. Values reported above replicated from QA Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements, Version 2.0. EPA-454/B-08-002, March 2008. Table 0-08 PSD Calibration and Accuracy Criteria.

Table C.3 Accuracy Limits and Validation Criteria for Pollutant Measurements

Parameter	Criteria	Samples Evaluated	Acceptable Range	Frequencyof Evaluation	Reference
PM_{10} /$PM_{2.5}$ Continuous and FRM	Flow Rate Accuracy	Single point flow rate check	± 4% of reference flow standard and ±5% of nominal flow of 1 m^3/hr	Monthly	Method 2.12 Section 10.2 BAM Operation Manual Sec. 5.1
PM_{10} /$PM_{2.5}$ Continuous and FRM	Ambient temperature	Single point check	± 2 °C of actual	Monthly	40 CFR 50 App. L, Sec. 7.4.8($PM_{2.5}$) Same for PM_{10}
PM_{10} /$PM_{2.5}$ Continuous and FRM	Ambient pressure	Single point check	± 10 mm Hg of actual	Monthly	40 CFR 50 App. L, Sec. 7.4.8($PM_{2.5}$) Same for PM_{10}
PM_{10} /$PM_{2.5}$ Continuous and FRM	Filter temperature	Single point calibration check	± 1 °C of actual	Quarterly	BAM Operation Manual Sec. 7.18
PM_{10} /$PM_{2.5}$ Continuous	Filter relative humidity	Single point check	± 4% of actual	Quarterly	BAM Operation Manual Sec. 7.19
SO_2/NO_x	3 consecutive audit levels	Test atmosphere generated from Certified Standard	≤ 15% difference for each audit level	Quarterly	40 CFR 58 App. A Section 3.2.2.1

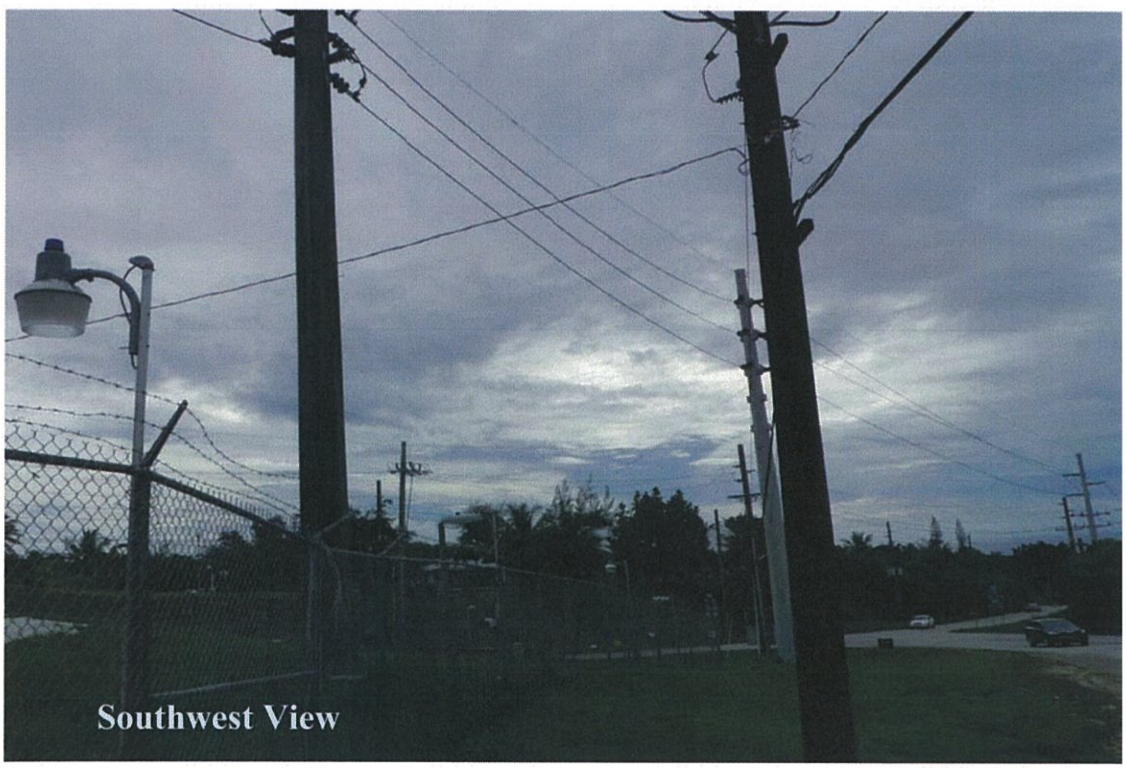
APPENDIX A

GPA Air Monitoring Plan

Apra Site Location

Apra Site Location (continued)

South View



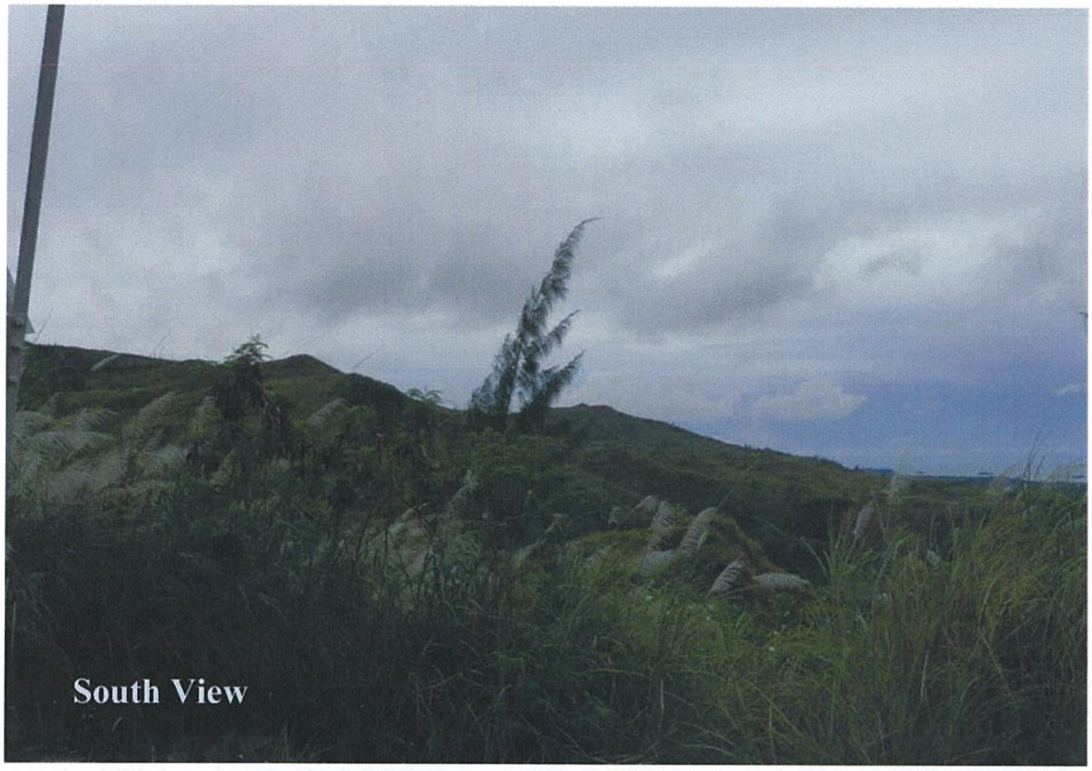
Southwest View

Dedede Site Location

Dededo Site Location (continued)

Nimitz Hill Site Location

Nimitz Hill Site Location (continued)



South View

Southwest View

Piti Site Location

Piti Site Location (continued)

Port Site Location

Port Site Location (continued)

Tanguisson Site Location

Tanguisson Site Location (continued)

APPENDIX C

TRC Standard Operating Procedures (SOPs) and Project Forms

APPENDIX E

AMSTECH External Quality Assurance Audit Standard Operating Procedures

SO_2 Validation Template

Requirement	Frequency	AcceptanceCriteria	Information /Action
CRITICAL CRITERIA- SO_2			
OnePointQC Check Singleanalyzer	1/ 2 weeks	<u><</u>+10%(percentdifference)	0.01-0.10ppm Relative toroutineconcentrations 40 CFR Part 58App A Sec 3.2
Zero/span check	1/2 weeks	Zerodrift#"3% offullscale Span drift #"10 %	
OPERATIONAL CRITERIA- SO_2			
ShelterTemperature			
Temperaturerange	**Daily** (hourly values)	20to30EC. (Hourlyave) or permanufacturersspecificationsifdesignated to a wider temperature range	Generallythe20-30 ECrangewillapplybut the mostrestrictiveoperablerange ofthe instrumentsin theshelter may also beusedasguidance
TemperatureControl	Daily(hourlyvalues)	#"2EC SD over 24 hours	
Temperature Device Check	2/year	"2ECofstandard	
Precision (using 1-point QC checks)	Calculated annually andas appropriate fordesignvalue estimates	90%CLCV≤10%	90% Confidence Limit ofcoefficient of variation40 CFR Part 58 App A sec 4.1.2
Bias (using 1-point QC checks)	Calculated annually andas appropriate fordesignvalue estimates	95%CL≤ + 10%	95% Confidence Limit ofabsolute bias estimate 40 CFR Part 58 App A sec 4.1.3
Annual Performance Evaluation			
Single analyzer	Everysite 1/year 25%ofsitesquarterly	Percent differenceofeach auditlevel≤15%	3consecutiveauditconcentrations notincluding zero 40CFR Part58 AppA sec 3.2.2
PrimaryQA Organization (PQAO)	annually	95%ofauditpercentdifferencesfallwithinthe onepointQCcheck95%probability intervals atPQAO levelof aggregation	40 CFR Part 58App A sec 4.1.4
FederalAudits(NPAP)	1/yearat selected sites 20% of sites audited	Meanabsolute difference#15%	40 CFR Part 58App A sec 2.4
Stateaudits	1/year	State requirements	
Verification/Calibration	Upon receipt/adjustment/repair/ installation/moving 1/6monthsifmanualzero/span performed biweekly 1/yearifcontinuouszero/span performed daily	Allpoints within"2% offull scale of best-fit straight line	Multi-point calibration (0and4upscalepoints)
ZeroAir		Concentrationsbelow LDL	
Gaseous Standards		NISTTraceable (e.g.,EPA Protocol Gas)	VendormustparticipateinEPAProtocolGas VerificationProgram 40 CFR Part 58App A sec 2.6.1

$PM_{2.5}$ Filter Based Local Conditions Validation Template

Criteria	Frequency	Acceptable Range	Information (CFR or Method 2.12)
CRITICALCRITERIA-$PM_{2.5}$Filter Based Local Conditions			
FilterHoldingTimes			
SampleRecovery	all filters	#7 days9 hoursfrom sampleend date	Part50AppLSec10.10
Post-sampling Weighing	all filters	#10 daysfrom sample enddate ifshippedat ambient temp, or #30daysifshippedbelow ave ambient(or4EC orbelowfor avesampling temps<4EC)fromsampleenddate	Part50AppLSec 8..3.6
Sampling Period (including multiplepowerfailures)	all filters	1380-1500minutes,or value if < 1380and exceedance ofNAAQS[1/] midnighttomidnight	Part50AppLSec 3.3 Part50,App.LSec7.4.15
Sampling Instrument			
Average Flow Rate	every24hoursofop	averagewithin5% of16.67liters/minute	Part50AppLSec7.4
Variability in Flow Rate	every24hoursofop	CV #2%	Part50,App.LSec7.4.3.2
Filter			
VisualDefectCheck(unexposed)	all filters	seereference	Part50,App.LSec10.2
FilterConditioningEnvironment			
Equilibration	all filters	24 hours minimum	Part50,App.LSec8.2
Temp.Range	all filters	24-hrmean20-23EC	Part50,App.LSec8.2
Temp.Control	all filters	"2EC SD* over24hr	Part50,App.LSec8.2
HumidityRange	all filters	24-hrmean30%-40%RHor #5% samplingRH but > 20%RH	Part50,App.LSec8.2
HumidityControl	all filters	"5% SD* over24hr.	Part50,App.LSec8.2
Pre/post Sampling RH	all filters	differencein24-hrmeans #"5% RH	Part50,App.LSec8.3.3
Balance	all filters	located infilter conditioningenvironment	Part50,App.LSec8.3.2
Verification/Calibration			
One-pointFlowRateVerification	1/4 weeks	"4%oftransferstandard	Part50,App.L,Sec9.2.5 Part 58, Appendix ASec 3.2.3 &3.3.2
OPERATIONAL EVALUATIONS TABLE $PM_{2.5}$ Filter BasedLocal Conditions			
FilterChecks			
Lot Blanks	9filtersperlot	lessthan15 Fgchangebetweenweighings	Method2.12Sec.7.7
ExposureLotBlanks	3filtersperlot	lessthan15 Fgchangebetweenweighings	Method2.12Sec.7.7
FilterIntegrity (exposed)	eachfilter	novisualdefects	Method2.12Sec.8.2
Filter Holding Times			
Pre-sampling	all filters	<30daysbeforesampling	Part50,App.LSec8.3
Lab QC Checks			
FieldFilterBlank	10% or 1perweighing session	"30 Fgchange betweenweighings	Part50,App.LSec8.3
LabFilterBlank	10% or 1perweighing session	"15 Fgchange betweenweighings	Part50,App.LSec8.3
BalanceCheck	beginning,10thsample,end	#3Fg	MethodSec.7.9
DuplicateFilterWeighing	1perweighingsession	"15 Fgchange betweenweighings	Method Sec 7.11
Sampling Instrument			

$PM_{2.5}$ Filter Based Local Conditions Validation Template (Continued)

Criteria	Frequency	Acceptable Range	Information (CFR or Method 2.12)
LeakCheck[@]		see *Verification/Calibration*	
Circulating Fan FilterCleaning	1/4 weeks	cleaned/changed	Method Sec 9.3
Manufacturer-Recommended Maintenance	per manufacturers' SOP	per manufacturers' SOP	
SYSTEMATIC CRITERIA -$PM_{2.5}$ Filter Based Local Conditions			
Data Completeness	quarterly	$\geq$75%	Part50,App.N,Sec.4.1(b)4.2(a)
Reporting Units	all filters	Fg/m^3 at ambienttemp/pressure(PM)	Part50.3
Rounding Convention			
Annual3-yraverage	quarterly	nearest 0.1Fg/m^3($\geq$0.05 roundup)	Part50,App.NSec2.3
24-hour,3-yearaverage	quarterly	nearest 1Fg/m^3($\geq$0.5roundup)	Part50,App.NSec2.3
Detection Limit			
Lower DL	all filters	#2 Fg/m^3	Part50,App.LSec3.1
Upper Conc. Limit	all filters	$200 Fg/m^3	Part50,App.LSec3.2
Verification/Calibration Standards Recertifications –Allstandards should havemulti-point certifications againstNIST Traceable standards			
Flow Rate TransferStd.	1/yr	"2%ofNIST-traceableStd.	Part50,App.LSec9.1&9.2
Field Thermometer	1/yr	"0.1ECresolution, "0.5EC accuracy	Method Sec 4.2.2
Field Barometer	1/yr	"1 mm Hg resolution,"5 mm Hg accuracy	Method Sec 4.2.2
PrimaryMass Stds.(compareto NIST-traceablestandards)	1/yr	0.025 mg	Method Sec 4.3.7
Microbalance			
Readability	atpurchase	1 Fg	Part50,App.LSec8.1
Repeatability	1/yr	1Fg	
Calibration &Check Standards			
Flow Rate TransferStd.	1/yr	"2%ofNIST-traceableStd.	Part 50, APP L,Sec 9.1& 9.2
Verification/Calibration			
Clock/timer Verification	1/4 weeks	1 min/mo	Part50,App.L,Sec7.4
Precision			
Single analyzer	1/3mo.	Coefficientofvariation(CV)$\leq$10%	
Single analyzer	1/yr	CV $\leq$ 10%	
PrimaryQualityAssuranceOrg.	Annualand3yearestimates	90%CLofCV$\leq$ 10%	Part 58, App A,Sec 4.3.1
Bias			
PerformanceEvaluation Program (PEP)	5 audits for PQAOs with $\leq$5 sites 8 audits for PQAOs with > 5 sites	"10%	Part58,AppA,Sec3.2.7,4.3.2

1/ value must be flagged *SD= standard deviation CV= coefficientofvariation[@] = Scheduled tooccur immediatelyafter impactor cleaned/changed.

Continuous PM2.5 Local ConditionsValidation Template (Continued)

Criteria	Frequency	AcceptableRange	Information (CFR orMethod2.12)
Accuracy			
TemperatureAudit	2/yr	"2EC	Method2.12Sec.10.2
PressureAudit	2/yr	"10 mm Hg	Method2.12Sec.10.2
SemiAnnualFlowRateAudit	2/yr	"4%ofauditstandard "5%ofdesign flowrate	Method2.12Sec.10.2
Calibration &Check Standards (working standards)			Part 58, App A,Sec 3.3.3
Field Thermometer	1/yr	"0.1ECresolution, "0.5EC accuracy	Method2.12Sec4.2&6.4
Field Barometer	1/yr	"1 mm Hg resolution,"5mm Hg accuracy	Method2.12Sec4.2&6.5
ShelterTemperature			
Temperaturerange	**Daily** (hourly values)	20to30EC. (Hourlyave) or permanufacturersspecificationsifdesignatedto awider temperaturerange	Generallythe20-30 ECrangewillapplybut themostrestrictiveoperablerangeofthe instrumentsin theshelter mayalsobeusedas guidance
TemperatureControl	Daily(hourlyvalues)	#"2EC SD over 24 hours	
Temperature Device Check	2/year	"2EC	
Monitor Maintenance			
Virtual Impactor VerySharpCut Cyclone	Every30days	cleaned/changed	Method 2.12Sec 9.2
Inlet Cleaning	Every30days	cleaned	Method 2.12Sec 9.3
FilterChamberCleaning	1/4 weeks	cleaned	Method 2.12Sec 9.3
Circulating Fan FilterCleaning	1/4 weeks	cleaned/changed	Method 2.12Sec 9.3
Manufacturer-Recommended Maintenance	per manufacturers' SOP	per manufacturers' SOP	
SYSTEMATICCRITERIA- $PM_{2.5}$ Continuous, Local Conditions			
Data Completeness	quarterly	$\geq$75%	Part50,App.N,Sec.4.1(b)4.2(a)
Reporting Units		Fg/m^3 at ambienttemp/pressure($PM_{2.5}$)	Part50.3
Rounding Convention			
Annual3-yraverage	quarterly	nearest 0.1Fg/m^3($\geq$0.05 roundup)	Part50,App.NSec2.3
24-hour,3-yearaverage	quarterly	nearest 1Fg/m^3($\geq$0.5roundup)	Part50,App.NSec2.3
Detection Limit			
Lower DL	all filters	#2 Fg/m^3	Part50,App.LSec3.1
Upper Conc. Limit	all filters	$200 Fg/m^3	Part50,App.LSec3.2
Verification/Calibration Standards Recertifications - Allstandards should havemulti-pointcertifications against NIST Traceablestandards			

PM_{10} Filter Based High Volume (HV) STP Conditions Validation Template

Criteria	Frequency	Acceptable Range	Information (CFR or Method 2.11)
CRITICALCRITERIA-PM_{10}Filter Based Hi-Vol			
FilterHoldingTimes			
SampleRecovery	all filters	ASAP	Part 50 AppJ sec 9.16
SamplingPeriod	all filters	1440 minutes ±60minutes midnighttomidnight	Part 50 App J sec 7.1.5
Sampling Instrument			
Average Flow Rate	every24hoursofop	~1.13m^3/min(varieswithinstrument)	Method2.11
Filter			
VisualDefectCheck(unexposed)	all filters	seereference	Method 2.10sec 4.2
Collectionefficiency	all filters	99 %	Part 50, App J sec 7.2.2
Integrity	all filters	"5 : g/m^3	Part 50, App J sec 7.2.3
Alkalinity	all filters	<25.0microequivalents/gram	Part 50, App J sec 7.2.4
FilterConditioningEnvironment			
Equilibration	all filters	24 hours minimum	Part 50, App.J sec 9.3
Temp.Range	all filters	15-30EC	Part 50, App.J sec 7.4.1
Temp.Control	all filters	"3EC SD* over24hr	Part 50, App.J sec 7.4.2
HumidityRange	all filters	20% - 45%RH	Part 50, App.J sec 7.4.3
HumidityControl	all filters	"5% SD* over24hr	Part 50, App.J sec 7.4.4
Pre/post Sampling RH	all filters	differencein24-hrmeans #"5% RH	recommendation
Balance	all filters	located infilter conditioningenvironment	recommendation
Verification/Calibration			
One-pointFlowRateVerification	1/3 mo	"7% oftransferstandardand 10% from design	Method 2.10sec Table 3-1
OPERATIONAL EVALUATIONS TABLE PM_{10}Filter BasedHi-Vol			
Lab QC Checks			
BalanceCheck	beginning,10thsample,end	±0.5 mg oftruezeroand± 0.5mg 1-5gcheckweight	Method2.11sec4.5
"Routine"duplicateweighing	5-7perweighing session	"2.8 mg change from original value	Method 2.11sec4.5.3 From routinefilterset
Verification/Calibration			
System LeakCheck	Duringprecalibrationcheck	Auditoryinspectionwithfaceplateblocked	Method 2.11sec 2.3.2
FR Multi-point Verification/Calibration	1/yr	3of4calpoints within± 10%ofdesign	Method 2.11sec 2.3.2

PM_{10}Filter Based High Volume (HV)STPConditions Validation Template (Continued)

Criteria	Frequency	Acceptable Range	Information (CFR or Method 2.11)
Flow Rate TransferStd.	1/yr	"2%ofNIST-traceableStd.	Method 2.10sec 9
Verification/Calibration			
Clock/timer Verification	4/year	5 min/mo	recommendation
Precision			
Single analyzer	1/3mo.	Coefficientofvariation(CV)≤10%	recommendation
Single analyzer	1/yr	CV ≤ 10%	recommendation
PrimaryQualityAssuranceOrg.	Annualand3yearestimates	90%CLofCV≤ 10%	Part 58, App A,sec 4.3.1

SD= standard deviation
CV= coefficientofvariation

Continuous PM10 STP Conditions Validation Template (Continued)

Criteria	Frequency	Acceptable Range	Information (CFR or Method 2.11)
24-hour,3-yearaverage	quarterly	nearest 10 Fg/m^3(≥5roundup)	Part 50 AppK sec 1
Verification/Calibration Standards and Recertifications - Allstandards should have multi-point certifications against NIST Traceablestandards			
Flow Rate TransferStd.	1/yr	"2%ofNIST-traceableStd.	Part 50, App.J sec 7.3
Field Thermometer	1/yr	"0.1ECresolution, "0.5EC accuracy	recommendation
Field Barometer	1/yr	"1 mm Hg resolution,"5 mm Hg accuracy	recommendation
Calibration &Check Standards			
Flow Rate TransferStd.	1/yr	"2%ofNIST-traceableStd.	Method 2.10sec 9
Verification/Calibration			
Clock/timer Verification	4/year	5 min/mo	recommendation

SD= standard deviation CV = coefficient of variation

APPENDIX E

OFFICIAL COMMUNICATION – REGULATORY COMPLIANCE REQUIREMENTS

- EGU MACT Notice of Applicability
- RICE MACT Notice of Applicability and Compliance Deadline Extension
- PSD Permit Request, Dededo CT

GUAM POWER AUTHORITY
ATURIDÅT ILEKTRESEDÅT GUAHAN
P.O. BOX 2977, HÅGATÑA, GUAM 96932-2977

July 5, 2012

Doug McDaniel
Chief Enforcement Officer
Air Division, U.S. EPA Region IX
75 Hawthorne Street, San Francisco, CA 94105

Re: Initial Notification of Applicability - Guam Power Authority

National Emission Standards for Hazardous Air Pollutants (NESHAP) for Fossil-Fuel-Fired Electric Utility, Industrial-Commercial-Institutional, and Small Industrial-Commercial-Institutional Steam generating Units (40 CFR Part 63, Subpart UUUUU)

Dear Mr. McDaniel:

In accordance with 40 CFR §63.9(b)(2)(i) through (iv), the Guam Power Authority of 1911 Route 16, Harmon, Guam 96911 USA hereby submits this notification of applicability for subject emission units.

Unit Location	Power Output (MW)	Unit Type	(Fuel)
Cabras Unit 1	66	Steam Boiler	Residual Fuel Oil
Cabras Unit 2	66	Steam Boiler	Residual Fuel Oil
Tanguisson Unit 1	26.5	Steam Boiler	Residual Fuel Oil
Tanguisson Unit 2	26.5	Steam Boiler	Residual Fuel Oil

These units operated by Guam Power Authority are sources of hazardous air pollutants. The subject emission units emit metals, chlorides and fluorides.

Because these units use the same fuel oil from the same provider, Guam Power Authority requests that EPA allow the testing of only one (1) unit during the compliance emission testing phase. The ICR testing provided for Cabras Unit 1 shows significantly lower results than the emission limits which provide a level of assurance that differences among the units would not affect overall compliance.

Respectfully,

JOAQUIN C. FLORES, P.E.
General Manager

Cc: Michael Mann, USEPA Region IX (Guam Program Manager)
Kerry Drake, USEPA Region IX
Roger Kohn, USEPA Region IX
Eric Palacios, Guam EPA
File: P&R, SPORDS

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Street, Apt. No.; or PO Box No. 75 Hawthorne Street

City, State, ZIP+4 San Francisco, CA 94105

PS Form 3800, February 2000 — See Reverse for Instructions

GUAM POWER AUTHORITY
ATURIDÅT ILEKTRESEDÅT GUAHAN
P.O. BOX 2977, HÅGATÑA, GUAM 96932-2977

COPY

July 5, 2012

Doug McDaniel
Chief Enforcement Officer
Air Division, U.S. EPA Region IX
75 Hawthorne Street, San Francisco, CA 94105

Re: Initial Notification of Applicability - Guam Power Authority

National Emission Standards for Hazardous Air Pollutants (NESHAP) for Fossil-Fuel-Fired Electric Utility, Industrial-Commercial-Institutional, and Small Industrial-Commercial-Institutional Steam generating Units (40 CFR Part 63, Subpart UUUUU)

Dear Mr. McDaniel:

In accordance with 40 CFR §63.9(b)(2)(i) through (iv), the Guam Power Authority of 1911 Route 16, Harmon, Guam 96911 USA hereby submits this notification of applicability for subject emission units.

Unit Location	Power Output (MW)	Unit Type	(Fuel)
Cabras Unit 1	66	Steam Boiler	Residual Fuel Oil
Cabras Unit 2	66	Steam Boiler	Residual Fuel Oil
Tanguisson Unit 1	26.5	Steam Boiler	Residual Fuel Oil
Tanguisson Unit 2	26.5	Steam Boiler	Residual Fuel Oil

These units operated by Guam Power Authority are sources of hazardous air pollutants. The subject emission units emit metals, chlorides and fluorides.

Because these units use the same fuel oil from the same provider, Guam Power Authority requests that EPA allow the testing of only one (1) unit during the compliance emission testing phase. The ICR testing provided for Cabras Unit 1 shows significantly lower results than the emission limits which provide a level of assurance that differences among the units would not affect overall compliance.

Respectfully,

JOAQUIN C. FLORES, P.E.
General Manager

RECEIVED
JUL 11 2012
Guam Environmental Protection Agency

Cc: Michael Mann, USEPA Region IX (Guam Program Manager)
Kerry Drake, USEPA Region IX
Roger Kohn, USEPA Region IX
Eric Palacios, Guam EPA
File: P&R, SPORDS
Pete Cruz, Guam EPA

GUAM POWER AUTHORITY
ATURIDÅT ILEKTRESEDÅT GUAHAN
P.O. BOX 2977, HÅGATÑA, GUAM 96932-2977

October 10, 2012

Doug McDaniel
Chief Enforcement Officer
Air Division, U.S. EPA Region IX
75 Hawthorne Street, San Francisco, CA 94105

Re: Request for Extension - Guam Power Authority
National Emission Standards for Hazardous Air Pollutants (NESHAP) for Coal/Oil-Fired Electric Utility, Industrial-Commercial-Institutional, and Small Industrial-Commercial-Institutional Steam Generating Units (40 CFR Part 63, Subpart UUUUU)

Dear Mr. McDaniel:

In accordance with 40 CFR §63.6(i)(4) through (7), the Guam Power Authority of 1911 Route 16, Harmon, Guam 96911 USA hereby submits this request for an extension of the compliance date until May 2016. The following units are included in this request:

Unit Location (No. of units)	Power Output (MW)	Unit Type	Fuel
Cabras Power Plant Unit No. 1	66	Steam Boiler	Residual Fuel Oil
Cabras Power Plant Unit No. 2	66	Steam Boiler	Residual Fuel Oil

This request is only for the two Cabras units since we are considering derating the Tanguisson units to below 25 megawatts. Our previous notification listed all four units as being subject to the rule.

This request for a one year extension is based primarily on difficulties in deciding if control is needed and what type of control equipment to install. The ICR tests show filterable particulate matter is only marginally above the standard. It is possible that the changes in burners and control systems that we have proposed would allow these units to be incompliance with the MATS limit. We have yet to hear from Region 9 about our request for an applicability determination on this project.

Additionally, if compliance with the MATS did require a control device it is difficult to decide which control device to install. If the MATS were the only goal then an Electrostatic Precipitator would be appropriate. However, the nearly simultaneous imposition of meeting the sulfur dioxide one hour NAAQS would require a scrubber that would also meet the MATS requirements. We have yet to learn with clarity what the NAAQS requirements are going to be and whether a scrubber will be needed. Region 9 has yet to approve our monitoring plan and thus we are stymied in knowing what route to take.

In addition, GPA is in quandary sourcing equipment, technical expertise and fuel required for compliance due to Guam's geographical location.

We wish to inform EPA that it is likely that GPA will also apply for the one year reliability extension. Aside from the steam engine units covered under MATS, GPA is currently working on compliance with other newly promulgated regulations that affect several diesel engine units (RICE MACT). Given the limited period for compliance with all regulations, installation of control devices and testing of affected units would have to be done concurrently, requiring downtimes which adversely affect availability and reliability of the island's power supply. Such condition would be detrimental to national security, as in the case of U.S. Department of Defense (DOD), one of GPA's largest and most critical customers on island.

Guam Power Authority is supportive of EPA's effort to reduce harmful emissions but respectfully ask the Agency to consider this request for extension.

Respectfully,

JOAQUIN C. FLORES, P.E.
General Manager

Cc: Michael Mann, USEPA Region IX (Guam Program Manager)
Kerry Drake, USEPA Region IX
Roger Kohn, USEPA Region IX
Eric Palacios, Guam EPA
Peter Cruz, Guam EPA
File: P&R, SPORD

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City, State, ZIP+4: SF CA 94105

PS Form 3800, August 2006 See Reverse for Instructions

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX
75 Hawthorne Street
San Francisco, CA 94105

December 6, 2012

Joaquin C. Flores, P.E.
General Manager
Guam Power Authority
P.O. Box 2977
Agana, Guam U.S.A. 96932-2977

Subject: Extension Request for Cabras 1 & 2

Dear Mr. Flores:

The U.S. Environmental Protection Agency (EPA) has reviewed your request, dated October 10, 2012, for one year compliance date extension for Cabras Power Plant Units 1 and 2 for the National Emission Standards for Hazardous Air Pollutants for Fossil-Fuel-Fired Electric Utility, Industrial-Commercial-Institutional Steam Generating Units (40 CFR Part 63, Subpart UUUUU) .

We recognize that you are waiting for a Prevention of Significant Deterioration (PSD) applicability determination from the Region 9 Air Permits Office regarding your burner and control system changes. This determination will have a direct bearing on the need for installation of controls at the Units. If controls are required, you may become eligible for the compliance date extension as specified in 40 CFR Part 63.6(i)(4). Please resubmit your request once you have determined that the additional time is needed for installation of controls.

If you have any questions, please contact John Brock of my staff at 415-972-3999 or email at brock.john@epa.gov.

Sincerely,

Douglas K. McDaniel
Chief, Air Enforcement Office

cc: Eric Palacois, Guam EPA
Peter Cruz, Guam EPA

GUAM POWER AUTHORITY
ATURIDÅT ILEKTRESEDÅT GUAHAN
P.O.BOX 2977 • AGANA, GUAM U.S.A. 96932-2977

March 30, 2012

Michael Mann
USEPA REGION 9 /Pacific Region
75 Hawthorne Street
Mail Code: CED-6
San Francisco, CA 94105
Office Phone 415-972-3505

SUBJECT: Initial Notification Of Applicability

Dear Mr. Mann:

Attached is the Guam Power Authority's Initial Notification of Applicability under 40 CFR Part 63 Subpart ZZZZ.

Should you have any questions please contact Sylvia Ipanag at (671) 648-3217.

Sincerely,

Joaquin C. Flores, P.E.
General Manager

Attachments: As Stated

Cc: Administrator, GEPA
Air Program Manager, GEPA
Manager of Generation
P&R File

Initial Notification of Applicability[b]

National Emission Standards for Hazardous Air Pollutants:

Stationary Reciprocating Internal Combustion Engines

40 CFR Part 63 Subpart ZZZZ

☒ Yes, I am subject to 40 CFR Part 63 subpart ZZZZ National Emission Standards for Hazardous Air Pollutants for Stationary Reciprocating Internal Combustion Engines

NAICS code(s): 221112

Compliance Date: ☒ Existing source: May 3, 2013 ☐ New/reconstructed source: upon initial startup

Note: The May 3, 2013 compliance date for existing sources applies to the following engine types:

- Existing non-emergency compression ignition (CI) stationary RICE with a site rating of more than 500 brake HP located at a major source of HAP emissions
- Existing stationary CI RICE with a site rating of less than or equal to 500 brake HP located at a major source of HAP emissions
- Existing stationary CI RICE located at an area source of HAP emissions

Company name: GUAM POWER AUTHORITY

Facility name (if different): CABRAS 3 & 4 DIESEL POWER PLANT

Facility (physical location) address: Route 11, Cabras Island, Piti, Guam

My facility is a (please choose one): ☐ Major source ☒ Area source

Owner name/title: Joaquin C. Flores, P.E.- General Manager

Owner/company address: PO Box 2977 Hagatña Guam 96932

Owner telephone number: (671) 648-3202

Owner email address (if available): jflores@gpagwa.com

If the Operator information is different from the Owner, please provide the following:

Operator name/title: Chang Yol Lee – Plant General Manager Korea East West Power

Operator telephone number: (671) 475-5284

Operator email address (if available): powerlee@ewp.co.kr

Brief description of the stationary RICE at the facility, including number of engines and the site-rated HP of each engine:

Unit ID	Description	Site Rated HP	Manufacturer	Model	Serial No
DEG 3	40 MW Low Speed Diesel Engine	53,619	Bobcock & Wilcox	12K80MC-S	B93247
DEG 4	40 MW Low Speed Diesel Engine	53,619	Bobcock & Wilcox	12K80MC-S	B94309

I hereby certify that the information presented herein is correct to the best of my knowledge.

(Signature) 3/30/12 (Date)

Joaquin C. Flores, P.E
General Manager

(671) 648-3202
Telephone no.

Initial Notification of Applicability[b]

National Emission Standards for Hazardous Air Pollutants:

Stationary Reciprocating Internal Combustion Engines

40 CFR Part 63 Subpart ZZZZ

☒ Yes, I am subject to 40 CFR Part 63 subpart ZZZZ National Emission Standards for Hazardous Air Pollutants for Stationary Reciprocating Internal Combustion Engines

NAICS code(s): 221112

Compliance Date: ☒ Existing source: May 3, 2013 ☐ New/reconstructed source: upon initial startup

Note: The May 3, 2013 compliance date for existing sources applies to the following engine types:

- Existing non-emergency compression ignition (CI) stationary RICE with a site rating of more than 500 brake HP located at a major source of HAP emissions
- Existing stationary CI RICE with a site rating of less than or equal to 500 brake HP located at a major source of HAP emissions
- Existing stationary CI RICE located at an area source of HAP emissions

Company name: GUAM POWER AUTHORITY

Facility name (if different): TENJO DIESEL POWER PLANT

Facility (physical location) address: Lot No. 19 Tract 2411, off Route 2 A, Tenjo Vista, Guam

My facility is a (please choose one): ☐ Major source ☒ Area source

Owner name/title: Joaquin C. Flores, P.E.- General Manager

Owner/company address: PO Box 2977 Hagatña Guam 96932

Owner telephone number: (671) 648-3202

Owner email address (if available): jflores@gpagwa.com

If the Operator information is different from the Owner, please provide the following:

Operator name/title: ______________________________

Operator telephone number: ______________________________

Operator email address (if available): ______________________________

Brief description of the stationary RICE at the facility, including number of engines and the site-rated HP of each engine:

Unit ID	Description	Site Rated HP	Manufacturer	Model	Serial No
DEG 1	4.88 MW Diesel Engine	6,169	Caterpillar	3616	01PD00069
DEG 2	4.88 MW Diesel Engine	6,169	Caterpillar	3616	01PD00051
DEG 3	4.88 MW Diesel Engine	6,169	Caterpillar	3616	01PD00072
DEG 4	4.88 MW Diesel Engine	6,169	Caterpillar	3616	01PD00068
DEG 5	4.88 MW Diesel Engine	6,169	Caterpillar	3616	01PD00067
DEG 6	4.88 MW Diesel Engine	6,169	Caterpillar	3616	01PD00071

I hereby certify that the information presented herein is correct to the best of my knowledge.

[signature] (Signature) 3/30/12 (Date)

Joaquin C. Flores, P.E
General Manager

(671) 648-3202
Telephone no.

Initial Notification of Applicability[b]

National Emission Standards for Hazardous Air Pollutants:

Stationary Reciprocating Internal Combustion Engines

40 CFR Part 63 Subpart ZZZZ

☒ Yes, I am subject to 40 CFR Part 63 subpart ZZZZ National Emission Standards for Hazardous Air Pollutants for Stationary Reciprocating Internal Combustion Engines

NAICS code(s): 221112

Compliance Date: ☒ Existing source: May 3, 2013 ☐ New/reconstructed source: upon initial startup

Note: The May 3, 2013 compliance date for existing sources applies to the following engine types:

- Existing non-emergency compression ignition (CI) stationary RICE with a site rating of more than 500 brake HP located at a major source of HAP emissions
- Existing stationary CI RICE with a site rating of less than or equal to 500 brake HP located at a major source of HAP emissions
- Existing stationary CI RICE located at an area source of HAP emissions

Company name: GUAM POWER AUTHORITY

Facility name (if different): DEDEDO DIESEL POWER PLANT

Facility (physical location) address: Marine Corp Drive Dededo Guam

My facility is a (please choose one): ☐ Major source ☒ Area source

Owner name/title: Joaquin C. Flores, P.E. – General Manager

Owner/company address: PO Box 2977 Hagatña Guam 96932

Owner telephone number: (671) 648-3202

Owner email address (if available): jflores@gpagwa.com

Initial Notification of Applicability[b]

National Emission Standards for Hazardous Air Pollutants:

Stationary Reciprocating Internal Combustion Engines

40 CFR Part 63 Subpart ZZZZ

☒ Yes, I am subject to 40 CFR Part 63 subpart ZZZZ National Emission Standards for Hazardous Air Pollutants for Stationary Reciprocating Internal Combustion Engines

NAICS code(s): 221112

Compliance Date: ☒ Existing source: May 3, 2013 ☐ New/reconstructed source: upon initial startup

Note: The May 3, 2013 compliance date for existing sources applies to the following engine types:

- Existing non-emergency compression ignition (CI) stationary RICE with a site rating of more than 500 brake HP located at a major source of HAP emissions
- Existing stationary CI RICE with a site rating of less than or equal to 500 brake HP located at a major source of HAP emissions
- Existing stationary CI RICE located at an area source of HAP emissions

Company name: GUAM POWER AUTHORITY

Facility name (if different): MANENGGON DIESEL POWER PLANT

Facility (physical location) address: Manenggon Hills Yona Guam

My facility is a (please choose one): ☐ Major source ☒ Area source

Owner name/title: Joaquin C. Flores, P.E.- General Manager

Owner/company address: PO Box 2977 Hagatña Guam 96932

Owner telephone number: (671) 648-3202

Owner email address (if available): jflores@gpagwa.com

If the Operator information is different from the Owner, please provide the following:

Operator name/title: ______________________________

Operator telephone number: ______________________________

Operator email address (if available): ______________________________

Brief description of the stationary RICE at the facility, including number of engines and the site-rated HP of each engine:

Unit ID	Description	Site Rated HP	Manufacturer	Model	Serial No
DEG 1	5.3 MW Medium Speed Diesel Engine Generator	7,775	Wartsila	16V32	5999
DEG 2	5.3 MW Medium Speed Diesel Engine Generator	7,775	Wartsila	16V32	5998

I hereby certify that the information presented herein is correct to the best of my knowledge.

(Signature)

3/30/12
(Date)

Joaquin C. Flores, P.E
General Manager

(671) 648-3202
Telephone no.

Initial Notification of Applicability[b]

National Emission Standards for Hazardous Air Pollutants:

Stationary Reciprocating Internal Combustion Engines

40 CFR Part 63 Subpart ZZZZ

☒ Yes, I am subject to 40 CFR Part 63 subpart ZZZZ National Emission Standards for Hazardous Air Pollutants for Stationary Reciprocating Internal Combustion Engines

NAICS code(s): 221112

Compliance Date: ☒ Existing source: May 3, 2013 ☐ New/reconstructed source: upon initial startup

Note: The May 3, 2013 compliance date for existing sources applies to the following engine types:

- Existing non-emergency compression ignition (CI) stationary RICE with a site rating of more than 500 brake HP located at a major source of HAP emissions
- Existing stationary CI RICE with a site rating of less than or equal to 500 brake HP located at a major source of HAP emissions
- Existing stationary CI RICE located at an area source of HAP emissions

Company name: GUAM POWER AUTHORITY

Facility name (if different): TALOFOFO DIESEL POWER PLANT

Facility (physical location) address: Route 4 A, Talofofo, Guam

My facility is a (please choose one): ☐ Major source ☒ Area source

Owner name/title: Joaquin C. Flores, P.E.- General Manager

Owner/company address: PO Box 2977 Hagatña Guam 96932

Owner telephone number: (671) 648-3202

Owner email address (if available): jflores@gpagwa.com

If the Operator information is different from the Owner, please provide the following:

Operator name/title: ______________________________

Operator telephone number: ______________________________

Operator email address (if available): ______________________________

Brief description of the stationary RICE at the facility, including number of engines and the site-rated HP of each engine:

Unit ID	Description	Site Rated HP	Manufacturer	Model	Serial No
DEG 1	4.88 MW Diesel Engine	6,169	Caterpillar	3616	1PD00059
DEG 2	4.88 MW Diesel Engine	6,169	Caterpillar	3616	1PD00070

I hereby certify that the information presented herein is correct to the best of my knowledge.

(Signature) 3/30/12 (Date)

Joaquin C. Flores, P.E
General Manager

(671) 648-3202
Telephone no.

GUAM POWER AUTHORITY
ATURIDÅT ILEKTRESEDÅT GUAHAN
P.O. BOX 2977, HÅGATÑA, GUAM 96932-2977

August 6, 2012

Doug McDaniel
Chief Enforcement Officer
Air Division, U.S. EPA Region IX
75 Hawthorne Street, San Francisco, CA 94105

Re: Request for Extension and Exemption - Guam Power Authority
National Emission Standards for Hazardous Air Pollutants (NESHAP) for Reciprocating Internal Combustion Engines at area sources (40 CFR Part 63, Subpart ZZZZ)

Dear Mr. McDaniel:

In accordance with 40 CFR §63.6(i)(4) through (7), the Guam Power Authority of 1911 Route 16, Harmon, Guam 96911 USA hereby submits this request for an extension of the compliance date until May 3, 2014. The following units are included in this request:

Unit Location	Horsepower (HP)	Unit Type	Fuel Type
Tenjo Units # 1-6	6095	Diesel	Ultra Low Sulfur
Dededo Diesel # 1-4	3600	Diesel	Ultra Low Sulfur
Manenggon Units # 1&2	7400	Diesel	Ultra Low Sulfur
Talofofo Units # 1&2	6095	Diesel	Ultra Low Sulfur

GPA further requests an exemption from the Diesel MACT for the following units:

Unit Location	Horsepower (HP)	Unit Type	Fuel Type
Cabras Units 3 & 4	52,680	Diesel	RFO #6
MEC Units 8 & 9	59,249	Diesel	RFO #6

The request for an exemption is made for the following reasons:

a. The rule states that Guam is exempt from the requirement in the MACT to change fuels. These units are currently fired with residual oil, either 2% sulfur content or 1.19% sulfur content. The rule and the regulatory Impact Analysis, do not contemplate that compliance will be achieved using this fuel. As a result, there is no EPA guidance on how to achieve 23 ppm CO emissions and no guidance on the control device to use. Oxidation catalyst systems are precluded from use on exhaust streams of greater than 500-600 ppm of sulfur dioxide because the catalyst will become contaminated in a relatively short amount of time and the effect of oxidation of the sulfur dioxide will create copious amounts of H_2SO_4 (sulfuric acid) which would have to be exhausted or controlled. Additionally, vendors will not guarantee performance for exhaust streams above 500 ppm sulfur dioxide.

b. In order to use an oxidation catalyst, GPA would have to purchase and use a lower sulfur fuel oil, in direct contradiction of the exemption. In order to get the sulfur dioxide content to the 500-600 ppm range, a low sulfur residual oil would have to be purchased for these four diesel engines. The logistical problem of constructing new tankage to store this new fuel grade will be difficult due to lack of space. Additionally, the cost differential for this fuel is on the order of $73,000,000 per year for the four units.
c. Even if it were reasonable to acquire the reduced sulfur fuel, the cost of the oxidation catalyst systems would be about $6,500,000 with annual maintenance costs of $1,170,000. The total burden to the Guam rate payers would be substantial.
d. The cost differential of the fuel could be reduced if a dry scrubber system and baghouse were installed to reduce the exhaust sulfur dioxide to 500-600 ppm. Such a system would involve significant capital costs of about $410,000,000 and annual operating costs of $64,000,000. The total burden to the Guam rate payers would be substantial.
e. Because the current CO emissions from these units are measured at 65 ppm, they are not significant producers of the Hazardous Air Pollutants for which the rule seeks reduced emissions. These generation units are slow speed diesels. Slow Speed Diesels are highly efficient at producing power.

The Guam Power Authority is supportive of EPA's efforts to reduce harmful emissions but respectfully requests EPA to consider the substantial burden that will be passed on to our customers.

Respectfully,

JOAQUIN C. FLORES, P.E.
General Manager

Cc: Michael Mann, USEPA Region IX (Guam Program Manager)
Kerry Drake, USEPA Region IX
Roger Kohn, USEPA Region IX
Eric Palacios, Guam EPA
Pete Cruz, Guam EPA
File: P&R, SPORD
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City, State, ZIP+4 SF CA 94105

PS Form 3800, August 2006 — See Reverse for Instructions

Senator Thomas C. Ada
CHAIRMAN - Committee on Utilities, Transportation, Public Works, and Veterans Affairs
31st Guam Legislature • I Mina'trentai Unu Na Liheslaturan Guåhan

August 8, 2012

Doug McDaniel
Chief Enforcement Officer
Air Division, U.S. EPA Region IX
75 Hawthorne Street, San Francisco, CA 94105

Re: Support of Guam Power Authority's Request for Extension and Exemption
National Emission Standards for Hazardous Air Pollutants (NESHAP) for Reciprocating Internal Combustion Engines at area sources (40 CFR Part 63, Subpart ZZZZ)

Dear Mr. McDaniel:

As Chairman of the Committee on Utilities of the 31st Guam Legislature, I am writing to express my support for GPA's requests to your office for extensions and exemptions related to complying with 40 CFR §63.6(i)(4) through (7).

I fully support Guam Power Authority's request for an extension because Guam Power Authority is unable to obtain financing prior to July 1, 2013. Upon securing financing, construction will commence by August 15, 2013 and completed by December 15, 2013. Guam Power Authority expects achieving compliance at its medium speed diesel facilities by May 3, 2014.

Furthermore, I fully support Guam Power Authority's request for an exemption for its slow speed diesel facilities. Over 22% of Guam households are below the poverty line. If the United States Environmental Protection Agency does not grant an exemption, Guam Power Authority would have to pass on approximately 30% or greater annual fuel cost increase to customers as well as increases for capital and operations maintenance costs. This presupposes that the required change in fuel sulfur content is available to the Guam market.

I am supportive of EPA's efforts to reduce harmful emissions but respectfully request EPA to consider Guam Power Authority's requests.

Respectfully,

Thomas C. Ada
Chairman

Cc: Michael Mann, USEPA Region IX (Guam Program Manager)
Kerry Drake, USEPA Region IX
Roger Kohn, USEPA Region IX
Eric Palacios, Guam EPA
Pete Cruz, Guam EPA
Joaquin C. Flores, P.E., GPA

Ada Plaza Center, Ste. 207 • 173 Aspinall Avenue • Hagåtña, Guam 96910
Phone: (671) 473-3301 • Fax: (671) 473-3303 • Email: Tom@SenatorAda.org • www.SenatorAda.org

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX
75 Hawthorne Street
San Francisco, CA 94105

January 16, 2013

Joaquin C. Flores, P.E.
General Manager
Guam Power Authority
P.O. Box 2977
Agana, Guam U.S.A. 96932-2977

Subject: Extension and Exemption Request from the National Emission Standards for Hazardous Air Pollutants (NESHAP) for Reciprocating Internal Combustion Engines (RICE) - (40 CFR Part 63, Subpart ZZZZ)

Dear Mr. Flores:

The U.S. Environmental Protection Agency (EPA) has reviewed your one year extension request dated August 6, 2012 for RICE at Tenjo, Dededo, Manenggon and Talofofo. According to the provisions under 40 CFR 63.6(i), a reason must be given for the extension request. No such reason was given in your August 6, 2012 letter. Please resubmit your extension request and include the reason for the extension.

Regarding the exemption request for Cabras 3 & 4 and MEC Units 8 & 9, we cannot grant your request because to do so would be in violation of the Clean Air Act (CAA). If you believe EPA has authority under the CAA to grant such a request, please let us know.

If you have any questions, please contact John Brock of my staff at 415-972-3999 or email at brock.john@epa.gov.

Sincerely,

Calvin Ho for Douglas McDaniel

Douglas K. McDaniel
Chief, Air Enforcement Office

cc: Eric Palacois, Guam EPA
Peter Cruz, Guam EPA

GUAM POWER AUTHORITY
ATURIDÅT ILEKTRESEDÅT GUAHAN
P.O. BOX 2977, HÅGATÑA, GUAM 96932-2977

February 8, 2013

COPY

Doug McDaniel
Chief Enforcement Officer
Air Division, U.S. EPA Region IX
75 Hawthorne Street, San Francisco, CA 94105

Re: Request for Extension - Guam Power Authority
National Emission Standards for Hazardous Air Pollutants (NESHAP) for Reciprocating Internal Combustion Engines at area sources (40 CFR Part 63, Subpart ZZZZ)

Dear Mr. McDaniel:

On August 6, 2012 the Guam Power Authority (GPA) sent you a letter requesting an extension for diesel units burning Ultra Low Sulfur Diesel fuel and requesting an exemption for diesel units burning residual fuel oil. At this time GPA would like to request that these two issues be bifurcated. On January 16, 2013 you responded that GPA needed to provide a reason as spelled out in §63.3 for the extension. GPA is responding as follows:

Ultra Low Sulfur Diesels

In accordance with 40 CFR §63.6(i)(4) through (7), the Guam Power Authority of 1911 Route 16, Harmon, Guam 96911 USA hereby supplements its request for an extension of the compliance date until May 3, 2014. The following units are included in this request:

UNIT LOCATION	HORSEPOWER (HP)	UNIT TYPE	FUEL TYPE
Tenjo Units #1-6	6095 each	Diesel	Ultra Low Sulfir
Manenggon Units #1 and #2	7400 each	Diesel	Ultra Low Sulfir
Talofofo Units #1 and #2	6095 each	Diesel	Ultra Low Sulfir

(The diesel engines at Dededo have been removed from the list due to their imminent retirement.)

GPA is unable to get a commitment from the manufacturers of oxidation catalyst systems for installation in time to meet the compliance date of May 3, 2013. GPA is following a path toward compliance which is outlined on the attached chart. It projects compliance testing to occur after April 14, 2014 and before May 2, 2014.

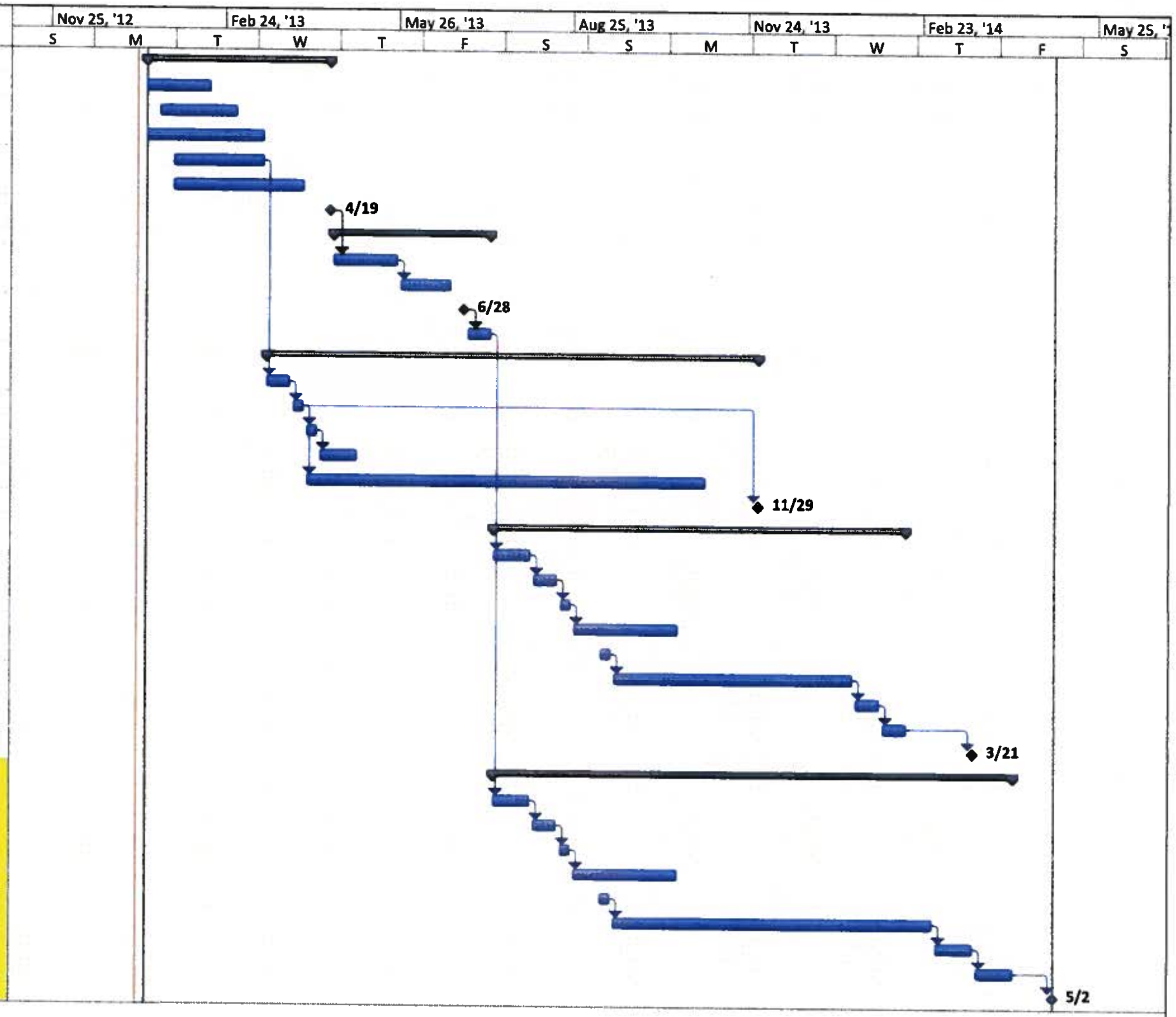
GPA hopes that this outline of the compliance plans provides sufficient detail to meet the need of EPA's request for further details of the reason why these units cannot meet the May 3, 3013 date.

Respectfully,

JOAQUIN C. FLORES, P.E.
General Manager

Cc: Michael Mann, USEPA Region IX (Guam Program Manager)
Kerry Drake, USEPA Region IX
Roger Kohn, USEPA Region IX
Eric Palacios, Guam EPA
Peter Cruz, Guam EPA
File: P&R, SPORD

ID	Task Name	Duration	Start	Finish
1	**Preliminary Design**	**70 days**	**Mon 1/14/13**	**Fri 4/19/13**
2	Data Gathering and Site Visit	25 days	Mon 1/14/13	Fri 2/15/13
3	Process Design Analysis and Equipment Sizing	30 days	Mon 1/21/13	Fri 3/1/13
4	Regulatory Assistance and Stack Modeling	45 days	Mon 1/14/13	Fri 3/15/13
5	Prepare Major Equipment Specifications	35 days	Mon 1/28/13	Fri 3/15/13
6	Prepare Preliminary Design Deliverables	50 days	Mon 1/28/13	Fri 4/5/13
7	Review Preliminary Design	5 days	Mon 4/15/13	Fri 4/19/13
9	**Detailed Design**	**60 days**	**Mon 4/22/13**	**Fri 7/12/13**
10	60% Design Deliverable Package	25 days	Mon 4/22/13	Fri 5/24/13
11	90% Design Deliverable Package	20 days	Mon 5/27/13	Fri 6/21/13
12	Design Review	5 days	Mon 6/24/13	Fri 6/28/13
13	Final Design Deliverable Package	10 days	Mon 7/1/13	Fri 7/12/13
15	**Procure Major Equipment**	**185 days**	**Mon 3/18/13**	**Fri 11/29/13**
16	Solicit Vendor Bids	10 days	Mon 3/18/13	Fri 3/29/13
17	Review Vendor Bids	5 days	Mon 4/1/13	Fri 4/5/13
18	Issue Purchase Order(s)	5 days	Mon 4/8/13	Fri 4/12/13
19	Receive Vendor Submittal	15 days	Mon 4/15/13	Fri 5/3/13
20	Fabrication	150 days	Mon 4/8/13	Fri 11/1/13
21	Delivery	170 days	Mon 4/8/13	Fri 11/29/13
23	**Construction (with no incumberances)**	**155 days**	**Mon 7/15/13**	**Fri 2/14/14**
24	Contractor Bidding	15 days	Mon 7/15/13	Fri 8/2/13
25	Bid Review	10 days	Mon 8/5/13	Fri 8/16/13
26	Issue Contracts	5 days	Mon 8/19/13	Fri 8/23/13
27	Procure Materials	40 days	Mon 8/26/13	Fri 10/18/13
28	Mobilize	5 days	Mon 9/9/13	Fri 9/13/13
29	Field Construct & Install Equipment	90 days	Mon 9/16/13	Fri 1/17/14
30	Control Integration	10 days	Mon 1/20/14	Fri 1/31/14
31	Startup & Commissioning	10 days	Mon 2/3/14	Fri 2/14/14
33	**Compliance Testing**	15 days	Mon 3/3/14	Fri 3/21/14
35	**Construction (with engines in operation)**	**195 days**	**Mon 7/15/13**	**Fri 4/11/14**
36	Contractor Bidding	15 days	Mon 7/15/13	Fri 8/2/13
37	Bid Review	10 days	Mon 8/5/13	Fri 8/16/13
38	Issue Contracts	5 days	Mon 8/19/13	Fri 8/23/13
39	Procure Materials	40 days	Mon 8/26/13	Fri 10/18/13
40	Mobilize	5 days	Mon 9/9/13	Fri 9/13/13
41	Field Construct & Install Equipment	120 days	Mon 9/16/13	Fri 2/28/14
42	Control Integration	15 days	Mon 3/3/14	Fri 3/21/14
43	Startup & Commissioning	15 days	Mon 3/24/14	Fri 4/11/14
44	**Compliance Testing**	**15 days**	**Mon 4/14/14**	**Fri 5/2/14**



Project: GPA Diesel Engine Cataly
Date: Wed 1/9/13

Task	Project Summary	Inactive Milestone	Manual Summary Rollup	Deadline			
Split	External Tasks	Inactive Summary	Manual Summary	Progress			
Milestone	External Milestone	Manual Task	Start-only				
Summary	Inactive Task	Duration-only	Finish-only				

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX
75 Hawthorne Street
San Francisco, CA 94105

March 20, 2013

Joaquin C. Flores, P.E.
General Manager
Guam Power Authority
P.O. Box 2977
Agana, Guam U.S.A. 96932-2977

Subject: Extension and Exemption Request from the National Emission Standards for Hazardous Air Pollutants (NESHAP) for Reciprocating Internal Combustion Engines (RICE) - (40 CFR Part 63, Subpart ZZZZ)

Dear Mr. Flores:

The U.S. Environmental Protection Agency (EPA) has reviewed your one year extension request dated February 8, 2013 for RICE at Tenjo, Manenggon and Talofofo. The reason given for the extension request is for the purpose of installing controls. According to the provisions under 40 CFR 63.6(i), EPA grants your request for an extension until May 3, 2014.

If you have any questions, please contact John Brock of my staff at 415-972-3999 or email at brock.john@epa.gov.

Sincerely,

Douglas K. McDaniel
Manager, Air Section
Enforcement Division

cc: Eric Palacois, Guam EPA
Peter Cruz, Guam EPA

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX
75 Hawthorne Street
San Francisco, CA 94105-3901

December 20, 2012

Joaquin C. Flores, P.E.
General Manager
Guam Power Authority
P.O. Box 2977
Agana, Guam 96932-2977

Re: Prevention of Significant Deterioration (PSD) Applicability Determinations for Cabras and Dededo Plants

Dear Mr. Flores:

We are writing in response to your letters dated April 27, 2012 and June 18, 2012, in which you described projects that Guam Power Authority (GPA) is planning at your Cabras and Dededo power plants. The Cabras project will consist of maintenance of the boiler feed pumps, condensate pumps, and forced air fans, as well as replacement of portions of the boiler control systems. These upgrades are designed to reduce parasitic load by increasing energy efficiency. The Dededo project will consist of repair and replacement of components in generators used in conjunction with two existing combustion turbines. You requested that EPA concur with your conclusion that neither project is a "major modification" as defined in the PSD regulations at 40 CFR 52.21.

The PSD applicability analysis you submitted for Cabras does not adhere to the required 40 CFR 52.21 (a)(2) - *applicability procedures* for determining if a project will result in a major modification because it did not specify a 24-month period for Baseline Actual Emissions (BAE), subtract BAE from either Potential to Emit (PTE) or Projected Actual Emissions (PAE), and compare the resulting emission changes with the PSD significant emission increase thresholds. Based on the data provided with your submittal, we were only able to determine that the proposed project would result in a significant emissions increase (the Step 1 test), based on the use of a BAE to PTE applicability test. GPA did not provide sufficient data for us to determine if the project would result in significant net emissions increase using a BAE to PTE test (the Step 2 test), nor was there sufficient data or justification to perform a BAE to PAE test. (For your convenience, we have attached EPA Region 9's Guidance on PSD Applicability Determinations, which explains the two step process for determining PSD applicability for modifications to existing PSD major stationary sources.)

The GPA Cabras plant is a PSD major source because its potential to emit NO_x, SO_x, PM, PM10, PM2.5, and greenhouse gases exceeds the major source thresholds in the PSD regulations. EPA performed a Step 1 BAE to PTE applicability test on the Cabras Steam Units No. 1 and 2 to determine if a significant emission increase will occur. Based on this first step of the required analysis, which considers only whether the project will result in a significant emissions increase,

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the Cabras project would result in significant increases of NO_x, SO_x, PM, and greenhouse gases. As shown below in Table 1, the proposed project exceeds the applicable PSD significance levels for these pollutants, and therefore would be a major modification under the PSD regulations, unless the project does not also result in a significant net emissions increase. (See 40 CFR 52.21(b)(23) and (b)(2)(i).)

Table 1 - Emission Changes from Cabras Boiler Energy Efficiency Project

	NO_x (tpy)	CO (tpy)	VOC (tpy)	PM (tpy)	SO_x (tpy)	GHG
Potential to Emit	2560.00	176.95	2.12	740.02	7750.00	865,649
Baseline Actual Emissions	1,630.00	113.22	0.77	473.47	4945.00	553,854
Emission Increase	930.00	63.73	1.35	266.55	2805.00	311,795
PSD Significance Level (40 CFR 52.21(b)(23))	40	100	40	25	40	75,000
Significant Emission Increase?	**Yes**	**No**	**No**	**Yes**	**Yes**	**Yes**

Step 2 of the emissions analysis is used to determine whether a significant net emissions increase will occur at a major stationary source. Your submittal does not provide any data on any other increases or decreases in actual emissions at Cabras that are contemporaneous and creditable, as those terms are defined in the PSD regulations. Thus in the absence of additional data from GPA, we are unable to determine whether the project would be able to "net out" of PSD applicability by showing that the project does not result in any significant net emissions increases under Step 2.

As GPA is aware, the PSD regulations also allow PSD applicability to be determined using a BAE to PAE emission increase test. To perform a BAE to PAE applicability test (which appears to have been GPA's intent), the analysis must provide a basis for the post-project projected actual emissions consistent with the requirements of 52.21(b)(41)(ii)(a). The PSD regulations state that the calculation of PAE must "consider all relevant information, including but not limited to, historical operational data, the company's own representations, the company's expected business activity and the company's highest projections of business activity, the company's filings with the State or Federal regulatory authorities, and compliance plans under the approved State Implementation Plan" (40 CFR 52.21 (b)(41)(ii)(a)). Although your April 27, 2012 letter did include PAE data, GPA did not substantiate or document the basis for concluding that the Cabras plant will not increase its annual operating hours after the project is completed, and does not provide any basis or justification for the PAE you submitted. As a result of the repairs you are proposing to make at the Cabras plant, we expect the facility to have increased utilization, which has been our experience with other facilities. Instead, your letter claims that utilization will not increase without further discussion or rationale for such a conclusion. If you choose to make a new submittal for our review, GPA must justify the PAE it selects and demonstrate that any capacity the boilers may gain from the project will not result in a significant emissions increase or a significant net emission increase.

In addition we note that for particulate matter we only reviewed PSD applicability for PM, because this is the only particulate matter emission data that GPA provided. The submitted data does not address PM10 or PM2.5 emissions. While the PM, PM10 and PM2.5 emission rates for natural gas combustion devices can typically be considered the same, this is not true for combustion devices fired on various types of fuel oil. In addition, the PSD major modification thresholds for PM10 and PM2.5, 15 and 10 tons per year respectively, are lower than the PM threshold (25 tons per year). GPA must evaluate all three forms of PM for emission increases; or at a minimum, GPA's evaluation must discuss any assumptions used to evaluate the three PM standards as a group.

For the Dededo plant, the repair and replacement of components in the generators operated in conjunction with the two combustion turbines will occur in the non-emitting equipment downstream of the turbines. This project does not appear to be a modification under the PSD regulations. However, for EPA to make a final PSD applicability determination for the Dededo project, GPA must first document that the project does not involve debottlenecking. Specifically, GPA should address the question of whether the generators' current state of disrepair is limiting turbine operation, and if the repairs will cause emission increases by allowing the facility to operate for more hours or at higher loads than it currently does. If the repairs will allow these types of emission increases, then they must be evaluated to determine whether they will result in both a significant emissions increase and a significant net emissions increase before an applicability determination can be made.

If you have any questions regarding this matter, please contact Roger Kohn of the EPA's Region 9 Permits Office at (415) 972-3973 or kohn.roger@epa.gov.

Sincerely,

Gerardo C. Rios
Chief, Permits Office
Air Division

Enclosure

cc: Peter Cruz, Guam EPA

EPA Region 9 Guidance on PSD Applicability Determinations

PSD Applicability

The PSD regulations (40 CFR 52.21) define a "major source" as any source type belonging to a list of 28 source categories which emits or has the potential to emit 100 tons per year (tpy) or more of any regulated NSR pollutants, or any other source type which emits or has the potential to emit such pollutants in amounts equal to or greater than 250 tpy. A major modification is defined as a project at an existing major source that will result in a 'significant'[1] and a 'significant net' – emissions increase above specified emission thresholds for pollutant subject to regulation. Therefore, to determine PSD applicability, the emission increases of all regulated NSR pollutants[2] due to the project must be determined and compared to the applicable emission thresholds. By definition, GHG are only considered a regulated NSR pollutant, if the emissions are above specified thresholds. This document does not address the additional GHG evaluation criteria.

PSD Applicability Questions:

1. For new stationary sources: Will the project emit any pollutants above the applicable major source thresholds? (100 or 250 tons per year depending on source category)
2. For modifications at an existing PSD major source: Will the project emit any regulated NSR pollutants (excluding non-attainment pollutants) above their significance thresholds? (i.e. PM, fluorides, sulfuric acid mist, hydrogen sulfide, reduced sulfur, GHG...See (b)(23)(i))[3]

The following information and documentation is needed to make an applicability determination. This information should be gathered before starting the emission calculations.

Project Description and Information

1. Is the source an existing PSD major source?
   - Evaluate based on current PTE emissions, not whether the source has an existing PSD permit.
2. Provide a description of the project, which includes at a minimum, the equipment type, size, fuel(s) to be used, and operating hours, including any limitations on these parameters.
3. Is the project a modification of an existing unit, addition of a new unit or hybrid of both?
4. Where is the projected to be located?
5. What are the non-attainment pollutants for the project area?
6. Is the project located within 10, 100 or 300 km of a Class I area? If yes, provide a list of each Class I area and the distance from the project.

Emission Data Needed

1) Which NSR regulated pollutants will be emitted? (See 52.21(b)(50))
2) Identify the 24-month period to be used to calculate BAE for each pollutant and EU.
3) Provide the emission data for each pollutant, each EU for each 24 month period.
4) Provide any emission data need for corrections during the selected 24 month period.
5) Are the emission limits currently in effect for each EU the same as during the baseline period? If not, provide both current and historical emission limit data for each 24-month period and each EU.

[1] See 52.21 (b)(23) for 'significant' emission threshold levels
[2] See 52.21 (b)(50) and (b)(23)(i) for definition.
[3] See regulation for municipal waste combustors and solid waste landfills.

PSD Applicability Calculations for Modifications to Existing PSD Major Stationary Sources (Excluding Electric Utility Steam Generating Units – EUSGU)

Step 1: Calculate Emission Increases Due to the Proposed Project[4]
(Note: Perform a separate calculation for each emission unit (EU) affected by the project.)

Part 1: Chose Option 1 or 2 as Post-Project Calculation Method

Option 1: Calculate Projected Actual Emissions (PAE) for each EU

1. What is the highest annual (12 month) PAE rate for each pollutant…
   a. during the next 5 years?
   b. during the next 10 years? (if capacity or PTE will be increased)
2. Provide all emission calculations, including emission factors, hours of operation and other data used in determining the PAE. Emissions from start-ups, shutdowns and malfunctions must be included. If one of 28 listed source categories, also include fugitives.[5]
3. Provide a summary of all relevant information, including historical operational data, expected business activity and highest projection of such activity, filings with relevant regulatory authorities and compliance plans to support basis of projection. If this information is not provided in the application, then the Permit Authority must use the PTE test, see Option 2.

Option 2: Calculate Potential to Emit (PTE) for each EU

1. What is the PTE rate for each pollutant? May consider practically and legally enforceable physical or operational limits to be included in the permit.
2. Provide all emission calculations, including emission factors, hours of operation and other data used in determining the PTE. If one of 28 listed source categories, also include fugitives.[5]

Part 2: Calculate Adjusted Baseline Actual Emissions for each (BAE) EU involved in project

- **New Units:** By definition, the BAE equals zero for newly constructed units and equals the PTE for a unit in operation less than 2 years.

- **Existing Units**: The BAE may be selected from any consecutive 24-month period during the 10-year period prior to the application submittal date, if sufficient data is available to verify actual emissions. The following information must be provided and the Adjusted BAE calculated for each EU in the project.

1. Specify what consecutive 24-month period is to be used for each pollutant.[6]
2. Provide verifiable/supportable emission data for this period, including the source of the data.[7]

---

4 No netting is allowed under Step 1.
5 This requirement does not currently apply due to a stay EPA issued on the rulemaking that imposed this requirement.
6 A separate 24-month period may be used for each pollutant, but if multiple units are involved, the selected 24-month period for each individual pollutant must be the same for all emission units.
7 For example, fuel usage, CEM data, emission factors…

3. Based on this data, calculate the BAE for each pollutant that were emitted from each EU in the project.
4. Provide information regarding any emission data from the selected 24-month period that need to be corrected (added or subtracted), including:
   a. Start-up, Shut down and Maintenance (SSM) emissions. (Add)
   b. If one of 28 listed source categories, also include fugitive emissions. (Add)
   c. Excess emissions due to violations. (Subtract)
   d. New applicable regulations requiring an adjustment in allowable emissions. (Subtract)
5. Calculate the Adjusted BAE for each pollutant (Subtract or Add any emissions as required).

Part 3: Calculate and Sum the Projects Emission Increases

1. For each EU, calculate the emission increase for each pollutant emitted as follows:
   a. PAE (Part 1, Option 1) – Adjusted BAE (Part 2), or
   b. PTE (Part 1, Option 2) – Adjusted BAE (Part 2)

2. For each pollutant, sum the emission increases from all emission units included in the project to calculate the Emission Increases for the project.

Part 4: Evaluate PSD applicability under Step 1 –
Is the sum of the Emission Increases from the project above the significant threshold for any listed pollutant?

a. **If no, and the project is not within 10 km of a Class I area, then stop.** PSD requirements do not apply based on the projects calculated emission increases and proximity to a Class I area.
b. **If no, and the project is within 10 km of a Class I area, then more evaluation is needed.** PSD requirements do not apply based on the projects calculated emission increases, but may still apply based on impacts to Class I areas. See Class I area analysis for more details.[8]
c. **If yes, continue to Step 2** and calculate the net emission increases and decreases, for each pollutant, for both the project AND the facility.

Step 2: Calculate Net Emission Increases (NEI) for the Project and new & modified EU's in last 5 yrs (Note: These calculations must be performed not only for the EU's affected by the project, but for all EU's that were new or modified within 5 yrs prior to date of the pending application.)

Part 1: Calculate Emission Increases from new or modified EU's in the last 5 years
Repeat Step 1, Part 1, Option 2 instructions for all EUs modified within 5 yrs prior to the application under review, if 1) such EU was not subject to Major NSR/PSD requirements or 2) ERC's were not generated. If the project was subject to Major NSR/PSD or ERCs were generated, then the emission increases/decreases associated with the project are not creditable and therefore are not part of this calculation. Note that PAE (Step 1, Part 1, Option 1) cannot be used for Step 2 calculations.

[8] Regardless of emission increase calculations, if the project would increase the 24-hr average concentration of any regulated pollutant in that area by 1 $\mu g/m^3$ or greater, then the project is also considered a "significant" emissions increase, and thus triggers PSD permit requirements for that pollutant.

Part 2: Calculate Adjusted Baseline Actual Emissions for each EU modified in the last 5 years
Repeat the Step 1, Part 2 instructions for all EUs covered by Step 2, Part 1 above. Note that the 5 yr look-back period for each EU is the date construction of that EU started or the current application submittal date, whichever is earlier.

Part 3: Calculate and Sum Facilities Creditable Emission Increases and Decreases

1. For each EU modified in the last 5 years, calculate the emission increase/decrease for each pollutant emitted as follows: PTE (Step 2, Part 1) – Adjusted BAE (Step 2, Part 2)

2. For each pollutant, sum the emission increases and decreases from all emission units included in Step 1 (the project) and Step 2 (new or modified in the last five years) to calculate the Net Emission Increases (NEI) for the project.

Part 4: Evaluate PSD applicability under Step 2 –
Is the NEI calculated in Part 3, above the significant threshold for any listed pollutant?

1. **If no, and the project is not within 10 km of a Class I area, then stop.** PSD requirements do not apply based on the projects calculated emission increases and proximity to a Class I area.
2. **If no, and the project is within 10 km of a Class I area, then more evaluation is needed.** PSD requirements do not apply based on the projects calculated emission increases, but may still apply based on impacts to Class I areas. See Class I area analysis for more details.[8]
3. **If yes, the project is subject to PSD permit requirements,** unless:
   a. the pollutant above the significant level is a non-attainment pollutant. (Note that NA precursors, such as NO_x, stand on their own as attainment pollutants, such as NO_2. The same is true for PM_{10} and $PM_{2.5}$ precursors.) or
   b. the applicant chooses to proceed to Step 3, which requires operational and emission data related to the emissions an existing unit could have accommodated during the 24 month period used to determine the BAE.

Step 3: Additional Post-Project Adjustments
(Only applicable if source can provide specific emission and operational data for existing emission units involved in the project)

1. Are any of these emissions attributable to existing capacity of the emission unit?
   If yes, provide explanation and calculations.[9]
2. Are any of these emissions attributable to demand growth?
   If yes, provide explanation and calculations.

[9] Allowable capacity currently not being utilized multiplied by post project emission factors.

Baseline Actual Emissions (BAE) Example:

A gas fired boiler had 340 tons of NOx emissions for the 24-month period of Jan. 1, 2007 thru Dec. 31, 2008. The company supplied their approved annual emission inventory for documentation. During the 24-month period, there was one breakdown that resulted in excess emissions of 2 tons of NO_x. These excess emissions did not qualify as 'malfunction' emissions under the Districts rules. In 2009, the local agency adopted a new regulation requiring all existing boilers to reduce NO_x emissions, based on size. For this boiler, the new limit was 10 ppm, whereas the old limit had been 20 ppm, though the source had average emissions of 15 ppm during the 24-month period.

Baseline Actual Emissions Worksheet

The following information should be collected before starting emission calculations:

- What are the Baseline Actual Emissions (BAE) for each pollutant that is not non-attainment?
- What 24-month period is being used for each pollutant?
- How are the emissions being determined? (e.g. fuel usage, CEM data, emission factors...)
- Is there verifiable/supportable emission data for this period?*
- Are there any emissions from this time period that need to be added/subtracted? *
  - Excess emissions due to violations, not including (SSM) emissions?
  - New regulations requiring an emissions adjustment?

Calculate the adjusted Baseline Actual Emissions for each pollutant by subtracting any excess emissions or new regulation reductions from the BAE for the 24-month period.

Pollutant	24 mo period	Type of data?	Verifi-able?	BAE	-- Excess Emissions	-- New Regs Reductions	= Adjusted BAE
NOx	1/1/07 - 12/31/09	EI from CEM	Yes	340	2	112.7	225.3
VOC							
SOx							
CO							
PM_{10}							

All emissions are reported in Tons per Year (tpy).

* Attach documentation and calculations.

Example calculations:

In this case, two adjustments must be made to the original 24-month emission data. The excess emissions and the reductions due to the new regulations must be subtracted from the baseline before it is averaged into an annual rate. Subtracting the 2 tons of excess emissions is simple, calculating the emission reductions from the new regulations is more difficult. If real time CEM data is available, then a real time reduction can be calculated for the 24-month period. If only annual emissions data is provided, as in this example, then it is permissible to use average emission data to make the necessary corrections. In this case, the source emitted a total of 340 tons of NO_x, which represents an average of 15 ppm during this time period. The new standard is 10 ppm, which is 2/3 of their past emissions. Thus the 340 ton value must be corrected by subtracting the 2 tons of excess emissions and reducing the remaining value by 1/3, resulting in 225.3 tons, divided by 2 to determine an annual average rate, gives 112.6 tons of NO_x per year.

APPENDIX F

COMPLIANCE CHART

<table>
<tr><th>REGULATION</th><th colspan="2">National Ambient Air Quality Standards (NAAQS)</th></tr>
<tr><td rowspan="9">REQUIREMENTS</td><td colspan="2">New Short-term NAAQS:
Sulfur Dioxide (2010) - 1 Hour Average (3,24 and Annual)
Nitrogen Dioxide (2010) - 1 Hour Average (Annual)

Other New NAAQS:
Ozone (2008) - Reduced 8 Hour Average -Proposed (2014) Further Reduction
Lead (2008) - Reduced Quarterly Average (1/10)
PM2.5 (2006) - Reduced 24 Hour Average (1/2)
(2013)- Reduced annual average (12)
Carbon Monoxide - No change</td></tr>
<tr><td>FOR:</td><td>LIMITS</td></tr>
<tr><td>SO2</td><td>75 ppb (New 1-hour standard)</td></tr>
<tr><td>NO2</td><td>100 ppb (New 1-hour standard)</td></tr>
<tr><td rowspan="2">PM 2.5</td><td>35 µg/m^3 (New 24-hour standard)</td></tr>
<tr><td>12 µg/m3 (New annual Standard)</td></tr>
<tr><td>PM 10</td><td>150 µg/m3 (24 Hour Standard)</td></tr>
<tr><td rowspan="2">CO</td><td>9 ppm (8 Hour Average)</td></tr>
<tr><td>35 ppm (1 Hour Average)</td></tr>
<tr><td>GPA Subject to Regulatory Requirements?</td><td colspan="2">YES, all units</td></tr>
<tr><td>Applicable Penalties</td><td colspan="2">$44,881 per unit for each day of non-compliance</td></tr>
<tr><td>Additional Information / Remarks</td><td colspan="2">2011/2012 Modeling results show difficulty meeting NAAQS for the following:
• Cabras – Piti Area</td></tr>
<tr><td rowspan="4">DEADLINES / MILESTONES / EFFECTIVE DATES</td><td colspan="2">Control devices should be installed or fuel switch effected by April 9, 2023. See below for specific milestones for each standard.</td></tr>
<tr><td>Standard</td><td>Deadlines/Milestones</td></tr>
<tr><td>1-HR SO2</td><td>Final Rule: June 22, 2010
Initial Designation: June 22, 2011 (Guam requested “unclassified, no response from EPA)
Final Designation: December 31, 2017. Cabras-Piti area designated as “Non-Attainment”. The rest of Guam “Unclassified/Attainment”.
Designation released: April 9, 2018
State Implementation Plan due to USEPA/Guam EPA: Oct. 9, 2019
Compliance Deadline: April 9, 2023</td></tr>
<tr><td>1-HR NO2</td><td>Final Rule: Feb. 9, 2010
Effective Date of Rule: Feb. 29, 2011</td></tr>
</table>

		The EPA has designated Guam as a single "Unclassifiable/Attainment" area at this time, meaning that there is no adequate information to indicate that the air quality in these areas exceed the 2010 NO2 NAAQS.
	24-HR PM2.5	*EPA's 2006 24-hr PM2.5 standard and 2013 annual average standard designates Guam as "Unclassifiable/Attainment" area. New NAAQS will affect permitting of new units.*
IMPACT	These combined make existing and new sources subject to reduction in operations, penalties, etc. Compliance requires addition of expensive control devices or change in fuel.	
	UNIT	**IMPACT**
	Cabras 1&2	Will not meet SO2, NO2 requirements.
	Piti 8&9	Will not meet SO2, NO2 requirements.
	Piti 7	Will not meet SO2, NO2 requirements.
	Dededo CT, Macheche CT, Yigo CT	Meet all NAAQS requirements.
	MDI, Talofofo, Tenjo Diesel Units	Tenjo and Manenggon will have difficulty meeting requirements.
	Temporary Power Station (Aggreko)	Controls installed to address NO2 requirements; SO2 requirements met because of ULSD utilization.
	New CCT Power Plant	Will meet all NAAQS requirements
	**Dededo Diesel Units retirement/deactivation on September 3, 2013. **Cabras 3&4 explosion in Aug. 31, 2015. **Tanguisson 1&2 retirement/deactivation effective February 1, 2015.	
GPA COMPLIANCE REQUIREMENTS	Reduction of emissions through installation of control devices, such as scrubbers or converting to cleaner fuel.	
	UNIT	**COMPLIANCE REQUIREMENT**
	Cabras 1&2	FOR SO2: Installation of control devices such as scrubbers, or convert to cleaner fuel. FOR NO2: Installation of Selective Catalytic Reduction Controls. FOR PM: (addressed w/ SO2 emission control)
	Piti 8&9	FOR SO2: Installation of control devices such as scrubbers, or convert to cleaner fuel. FOR NO2: Installation of Selective Catalytic Reduction Controls. FOR PM: (addressed w/ SO2 emission control)
	Piti 7	Change permit to ULSD

	Dededo CT, Macheche CT, Yigo CT	No NAAQS compliance requirements
	MDI, Talofofo, Tenjo Diesel Units	Tenjo and Manenggon will have difficulty meeting requirements. SCR likely to be needed. Talafofo and MDI have no NAAQS compliance requirements.
	New CCT Power Plant	Modeling will demonstrate no NAAQS compliance requirements when SCR and oxidation catalyst are used.
	1-HR SO2	**99th Percentile** **< 75 ppb**
	UNIT	**COMPLIANCE REQUIREMENT**
GPA Options for COMPLIANCE	Cabras 1&2	**OPTION 1:** Installation of Control Devices – Dry or Wet Scrubbers. Control devices will also allow Cabras 1&2 to meet MATS requirements. *CAPITAL COST* • Wet FGD System = $86M per unit • Lime Spray Drying System = $136.5M per unit *O&M COST* • Wet FGD System = $10M per year • Dry Scrubbers = $4M per year
		OPTION 2: Convert to ULSD *CAPITAL COST* • Cost for converting unit to ULSD-firing *O&M COST* • Increase in Fuel Cost
		OPTION 3: Convert to LNG *CAPITAL COST:* • Cost for converting unit to LNG-firing *O&M COST* • Increase in Fuel Cost
		OPTION 4: Retire Units. • Cost for unit retirement – *Capacity Issues!*
	Piti 8&9	OPTION 1: Installation of Control Devices – Dry or Wet Scrubbers. Control devices will not address RICE MACT compliance. *CAPITAL COST* • Wet FGD System = $65M per unit • Lime Spray Drying System = $106M per unit *O&M COST* • Wet FGD System = $10M per year • Dry Scrubbers = $4M per year
		OPTION 2: Convert to ULSD *CAPITAL COST* • Cost for converting unit to ULSD-firing *O&M COST* • Increase in Fuel Cost
		OPTION 3: Convert to LNG *CAPITAL COST* • Cost for converting unit to LNG *O&M COST* • Increase in Fuel Cost
		OPTION 4: Retire Units.

	• Cost for unit retirement – *Capacity Issues!*
MDI, Talofofo and Tenjo	No SO2 compliance issues burning ULSD
Piti # 7	
Dededo, Macheche and Yigo	No SO2 compliance issues burning ULSD
New Units	No SO2 compliance issues burning ULSD
1-HR NO2	**98th Percentile < 100 ppb**
Cabras 1&2	Applicable to all units as they are built or modified. All new units or modifications of existing units will need Selective Catalytic Reduction controls to comply. No action currently needed by GPA.
Piti 8&9	Applicable to all units as they are built or modified. All new units or modifications of existing units will need Selective Catalytic Reduction controls to comply. No action currently needed by GPA.
MDI, Talofofo and Tenjo Units	Applicable to all units as they are built or modified. All new units or modifications of existing units will need Selective Catalytic Reduction controls to comply. No action currently needed by GPA.
Piti # 7	Applicable to all units as they are built or modified. All new units or modifications of existing units will need Selective Catalytic Reduction controls to comply. No action currently needed by GPA.
Dededo, Macheche and CT Units	Applicable to all units as they are built or modified. All new units or modifications of existing units will need Selective Catalytic Reduction controls to comply. No action currently needed by GPA.
NEW UNITS	Must demonstrate compliance for permit. Purchase with SCR.
24-HR PM2.5	**98th Percentile and Annual Mean < 35 µg/m³ and < 12ug/m3**
Cabras 1&2	Compliance with MATS or SO2 requirements.
Piti 8&9	Compliance with RICE MACT or SO2 requirements.

	MDI, Talofofo and Tenjo Units	Compliance with RICE MACT or SO2 requirements.
	Piti #7	
	Dededo, Macheche and CT Units	Compliance with SO2 requirements.
	NEW UNITS	Compliance with SO2 requirements.

<table>
<tr><th>REGULATION</th><th colspan="2">EGU MACT</th></tr>
<tr><td rowspan="5">REQUIREMENT</td><td colspan="2">Requires all Steam Electric Generating Units (EGU) to meet very low air emission rates of 11 toxic metals, including Mercury and emissions of chlorides and fluorides (surrogates for dioxins and furans) Status of rule in doubt after June 2015 Supreme Court ruling. Cabras Units 1 & 2 would be subject to the rule.</td></tr>
<tr><td>FOR:</td><td>LIMITS</td></tr>
<tr><td>PM</td><td>Filterable PM < 0.03 lb./MMBtu (surrogate for metal HAP)</td></tr>
<tr><td>Metals</td><td>Total non-mercury metals < 0.0006 lbs./MMBtu</td></tr>
<tr><td>Halides</td><td>Hydrogen Chloride 2.0E-4 lb/MMBtu

Hydrogen Fluoride 6.0E-5 lb/MMBtu</td></tr>
<tr><td>GPA Subject to Regulatory Requirements?</td><td colspan="2">YES if promulgated, for Cabras 1&2.</td></tr>
<tr><td>Applicable Penalties</td><td colspan="2">$44,881 per unit for each day of non-compliance</td></tr>
<tr><td>Additional Information / Remarks</td><td colspan="2">Testing Fees in 2014:
• Cabras 1&2: $100,000 each
*Start-ups, Shutdown and tune-up requirements must be considered.
**CEM for PM not recommended by TRC due to unreliability of available monitors.
Halides below limits from chemical testing.</td></tr>
<tr><td>DEADLINES / MILESTONES / EFFECTIVE DATES</td><td colspan="2">Initial Notification sent: 7/6/2012
Compliance Deadline: 4/16/2015</td></tr>
<tr><td>IMPACT</td><td colspan="2">Rule would be applicable to Cabras 1&2, and plant is currently not meeting emission limits. May require change in fuel or reduction in operations, penalties, etc. Compliance requires addition of expensive control devices or change in fuel.
**Tanguisson 1&2 retirement/deactivation effective February 1, 2015.</td></tr>
<tr><td>GPA COMPLIANCE REQUIREMENTS</td><td colspan="2">Meet emission limits through control devices or cleaner fuel.</td></tr>
<tr><td rowspan="2">GPA Options for COMPLIANCE</td><td colspan="2">OPTION 1: Continue using RFO but reduce metal content to meet standard. Reduction of metals in current RFO may lead to significant increase in fuel costs.
CAPITAL COST
• Expenses for reconfiguration that may be needed for new metal specifications.
O&M COST
• Additional fuel costs for reduction in metal content.</td></tr>
<tr><td colspan="2">OPTION 2: Installation of Control Devices such as Electrostatic Precipitators. Baghouses are not recommended for RFO fuel. This control device will not allow unit to meet NAAQS.
CAPITAL COST
• $17.4M per unit</td></tr>
</table>

	O&M COST • $11M annually
	OPTION 3: Convert to ULSD *CAPITAL COST* • [undetermined] *O&M COST* • Differential Cost of Fuel
	OPTION 4: Convert to LNG *CAPITAL COST* • [undetermined] *O&M COST* • Differential Cost of Fuel
	OPTION 5: Retire units. • Cost for unit retirement – *Capacity Issues!*
	TESTING COSTS: Quarterly Stack Testing for Metals: $200,000 per year for both units

<table>
<tr><th>REGULATION</th><th colspan="2">RICE MACT</th></tr>
<tr><td rowspan="3">REQUIREMENT</td><td colspan="2">Requires all Diesel Engines greater than 500 HP to emit less than 23 ppm Carbon Monoxide.
If emissions > 23 ppm, reduce emission to <23 ppm or 70% control.</td></tr>
<tr><td>FOR:</td><td>LIMITS</td></tr>
<tr><td>CO</td><td>< 23 ppmv @15% O_2</td></tr>
<tr><td>GPA Subject to Regulatory Requirements?</td><td colspan="2">YES, for Piti 8&9, and MDI, Talofofo and Tenjo Units</td></tr>
<tr><td>Applicable Penalties</td><td colspan="2">$44,881 per unit for each day of non-compliance</td></tr>
<tr><td>Additional Information / Remarks</td><td colspan="2">Does not require fuel switching</td></tr>
<tr><td>DEADLINES / MILESTONES / EFFECTIVE DATES</td><td colspan="2">• Final Rule: Aug 20, 2010
• Initial Notification Deadline: Feb 11, 2011 (completed April 2012, late filing)
• Extension request for fast track diesels, July 2012
• Exemption request for slow speed diesels, July 2012 (denied)
• Compliance Date May 3, 2013
• One-year Extension Compliance Date (fast track): May 3, 2014 (request approved)
• Oxidation catalysts were installed on all fast track diesels by compliance date. Performance tests to demonstrate compliance were performed by compliance date (December 16, 2014)
• Slow Speed Diesels not yet in compliance</td></tr>
<tr><td>IMPACT</td><td colspan="2">Rule is applicable to Slow Speed Diesel Units (Piti 8&9) and Fast Track Diesel Units.
**Cabras 3&4 Slow Speed Diesel Units catastrophic failure on Aug. 31, 2015.</td></tr>
<tr><td>GPA COMPLIANCE REQUIREMENTS</td><td colspan="2">Meet emission limits through Oxidation Catalysts.</td></tr>
<tr><td rowspan="3">GPA COMPLIANCE ACTIVITIES</td><td colspan="2">MDI, Talofofo and Tenjo Units</td></tr>
<tr><td colspan="2">CAPITAL COSTS
• Tenjo $641,000
• Dededo retired
• Manenggon 1&2 $313,000
• Talofofo 1 and 2 $240,000
TOTAL Equipment COST = $1,194,000
• Engineering and Construction COST = $2,815,000</td></tr>
<tr><td colspan="2">ANNUAL O&M COSTS
• Tenjo $183,000
• Dededo $72,000
• Manenggon 1&2 $74,000
• Talofofo 1 and 2 $61,000
TOTAL COST = $390,000</td></tr>
</table>

GPA Options for COMPLIANCE	**Piti 8 & 9**
	OPTION 1: Stay on RFO, install oxidation catalysts. ***ISSUES:*** ***(1) Unable to find oxidation catalyst that can handle RFO.*** ***(2)*** *Sending exhaust gases directly to catalyst will oxidize SO2, creating sulfuric acid – need to reduce Sulfur content. Oxidation can be up to 40% SO2; more fuel would be needed to heat exhaust gases to temperature high enough to convert to CO (very expensive)* ***(3)*** *Will not address NAAQS issues*
	OPTION 2: Convert to ULSD and install oxidation catalysts. Also addresses NAAQS issues. *CAPITAL COST* • $3.441M for oxidation catalyst installation • Additional cost for converting power plant to ULSD firing *O&M COST* • Differential cost of fuel • O&M cost for catalyst
	OPTION 3: Convert to LNG --- **Not subject to rule, and also addresses NAAQS issues** *CAPITAL COST* • $3.441M for oxidation catalyst installation • Additional cost for converting power plant to ULSD firing *O&M COST* • Differential cost of fuel • O&M cost for catalyst *if converted to LNG, start-up will need ULSD, therefore catalyst would still need to be installed

REGULATION	NEW SOURCE REVIEW – MAJOR MODIFICATION FOR CT PLANTS	
REQUIREMENT	New Source Review (Prevention of Significant Deterioration / PSD) permit from EPA needed if units are modified in such a way as to trigger a PSD permit. For Dededo CT, NSR was not required due to critical requirement for units to be online as soon as possible, following catastrophic failure of Cabras 3&4. This section outlines what the requirements would be if CT plants are modified in such a way as to trigger PSD permit. PSD permit will require BACT analysis to control emissions specified below.	
	FOR:	**LIMITS**
	SO_2	< 40 TPY
	NO_2	9 ppmvd
	PM	<25 TPY
	CO	<100 TPY
	VOC	<40 TPY
	Formaldehyde	91 ppmvd@15% Oxygen
GPA Subject to Regulatory Requirements?	**YES, for new or modified units**	
Applicable Penalties	$44,881 per unit for each day of non-compliance	
Additional Information / Remarks	Modified Unit emissions more than above limits would require PSD permit from US EPA	
DEADLINES / MILESTONES / EFFECTIVE DATES		
IMPACT	Causes costs of modifications to rise.	
GPA COMPLIANCE REQUIREMENTS	PSD Permit Application = $65,000 Applicability Determination = $15,000	
GPA Options for COMPLIANCE	**Formaldehyde (Oxidation Catalyst)**	
	CAPITAL COSTS = $1,989,439 per turbine	
	ANNUAL O&M COSTS= $627,000 per turbine	
	NOx Control (SCR)	
	CAPITAL COSTS $4,573,000 per unit	
	ANNUAL O&M COSTS • $1,542,000 per unit (relatively high due to short catalyst life)	

REGULATION	GREENHOUSE GAS REQUIREMENTS	
REQUIREMENT	o New Source or Major Modification Permitting Rules: Requires Best Available Control Technology at permitting. Generally requires energy efficiency. • New Source Performance Standards: Current proposal does not apply to oil fired non-continental sources. • Each Title V facility must apply to add GHG to Title V permit by July 1, 2012	
	FOR:	LIMITS
	CO2	>75,000 TPY requires BACT
GPA Subject to Regulatory Requirements?	**YES, all units as they are built or modified. For existing units, will need to modify Title V Permit.**	
Applicable Penalties	$44,881 per unit for each day of non-compliance	
Additional Information / Remarks		
DEADLINES / MILESTONES / EFFECTIVE DATE	• New Source or Major Modification Permitting Rules: Jun 3, 2010 • New Source Performance Standards: Do not apply to oil firing • Existing units need TitleV permit modifications.	
IMPACT	None	
GPA COMPLIANCE REQUIREMENTS	Controls for emissions of CO2, such as Carbon Capture and Sequestration (CCS), are not required. There is no market for CO2 on Guam or within reasonable shipping distance (special ships would have to be built or bought). Drilling wells and pumping CO2 below ground on Guam would be a dangerous and expensive sequestration method.	
GPA Options for COMPLIANCE		

REGULATION	CLEAN WATER ACT Section 316B Requirements **Based on inputs from Planning & Regulatory Division and Clean Water Act Consultant*	
REQUIREMENT	• New Source or Major Modification Permitting Rules: Requires Best Technology Available (BTA) at permitting or permit revision. •Existing Facilities: Requires extensive operational changes to the existing cooling water intakes.	
	FOR:	LIMITS
	Cabras 1 & 2	Minimal fish impingement
GPA Subject to Regulatory Requirements?	Cabras 1&2 are subject to the rule.	
Applicable Penalties	(not provided)	
Additional Information / Remarks		
DEADLINES / MILESTONES / EFFECTIVE DATES	• Final Rule promulgated in Fall of 2014 • Compliance required at NPDES permit renewal. Cabras received NPDES permit with 316(b) requirements written in. Requirement for study and mitigation in new permit. .	
IMPACT		
GPA COMPLIANCE REQUIREMENTS	3 Options: • Option1: Demonstrate minimal fish impingement. • Option 2: reduce inflow to 0.5 feet per second. • Option 3: Close Units 1 & 2	
GPA Options for COMPLIANCE		

<table>
<tr><th>FOR</th><th colspan="2">NEW POWER PLANT: COMBUSTION TURBINES</th></tr>
<tr><td rowspan="9">REQUIREMENT</td><td colspan="2">New combustion turbines would require full Prevention of Significant Determination (PSD) Permitting, including modeling and Best Available Control Technology (BACT) Determination, unless the use of Oxidation Catalyst and Selective Catalytic Reduction controls decrease facility emissions below 250 tons per year.

If PSD permit is needed, it must address GHG Emissions and may require the use of Heat Recovery Supplemental Generation (HRSGs, after burners). Because USEPA is the permitting authority, the permit will require endangered species and cultural resources consultations as well as environmental justice evaluation. BACT analysis to control emissions required illustrated below:</td></tr>
<tr><td>FOR:</td><td>LIMITS to Avoid PSD Permit</td></tr>
<tr><td>SO_2</td><td>< 250 TPY, ULSD</td></tr>
<tr><td>NO_2</td><td>9 ppmvd</td></tr>
<tr><td>PM</td><td>< 250 TPY, ULSD</td></tr>
<tr><td>CO</td><td><250 TPY, oxidation catalyst</td></tr>
<tr><td>CO_2</td><td>No limit</td></tr>
<tr><td>VOC</td><td><250 TPY</td></tr>
<tr><td>Formaldehyde</td><td>91 ppmvd@15% Oxygen</td></tr>
<tr><td>DEADLINES / MILESTONES / EFFECTIVE DATES</td><td colspan="2">PSD Permit needs to be filed no less than 9 months before the estimated operational date for the turbines.</td></tr>
<tr><td>GPA COMPLIANCE REQUIREMENTS</td><td colspan="2">Reduce emissions below 250 tons per year to avoid the need to obtain PSD permit.</td></tr>
<tr><td rowspan="6">GPA Options for COMPLIANCE GPA Options for COMPLIANCE *Based on TRC Environmental estimates</td><td colspan="2">Formaldehyde (Oxidation Catalyst)</td></tr>
<tr><td colspan="2">CAPITAL COSTS
• $1,989,439 per turbine</td></tr>
<tr><td colspan="2">ANNUAL O&M COSTS
• $627,000 per turbine</td></tr>
<tr><td colspan="2">NOx Control (SCR)</td></tr>
<tr><td colspan="2">CAPITAL COSTS
$4,573,000 per unit</td></tr>
<tr><td colspan="2">ANNUAL O&M COSTS
• $1,542,000 per unit (relatively high due to short catalyst life)</td></tr>
</table>

FOR	NEW POWER PLANT: WASTE-TO-ENERGY FACILITY	
REQUIREMENT	Propose to build a new power plant to use the waste energy available in waste oils being collected on island and sludge generated by the wastewater treatment plant. Sewage sludge incinerator emissions are currently regulated under 40 CFR Part 60, Subpart LLLL and Part 62—Subpart LLL	
	FOR:	**LIMITS**
	SO2	15 ppm
	NO2	150 ppm
	PM	18 milligrams/m3
	CO	64 ppm
	CO2	none
	Dioxins/Furans	1.2 Nanograms/m3
	Mercury	0.037 milligrams/m3
	Cadmium	0.0016 milligrams/m3
	Lead	0.0074 milligrams/m3
DEADLINES / MILESTONES / EFFECTIVE DATES	Siting Analysis (equivalent to a Risk Assessment) must be completed before construction and Operator licensing must be completed before operation.	
GPA COMPLIANCE REQUIREMENTS	Costing for compliance has not yet occurred	
GPA Options for COMPLIANCE	CAPITAL COSTS • $	
	ANNUAL O&M COSTS • $	

FOR	Use of Bio-Diesel as Primary Fuel (mixed with ULSD)	
REQUIREMENT	Because bio-diesel is a new fuel it would have to appear in the permit for any facility which uses it or mixes it with ULSD. Guam EPA of 15 ppm of Sulfur would still apply. No other regulatory requirements.	
	FOR:	**LIMITS**
	SO2	15 ppm sulfur in fuel Guam requirement.
	NO2	None.
	PM	None
	CO	<23 ppm for diesels
	CO2	None
	VOC	None
	Formaldehyde	Only if required for CT
DEADLINES / MILESTONES / EFFECTIVE DATES	Permit in place before use.	
GPA COMPLIANCE REQUIREMENTS	Follow permit monitoring and recordkeeping requirements	
GPA Options for COMPLIANCE *Based pm cost estimates provided by TRC Environmental	CAPITAL COSTS • $300,000 for alternate tankage at power site	
	ANNUAL O&M COSTS • $ 50,000 for tankage upkeep and monitoring	

FOR	RE-PROCESSING WASTE OIL	
REQUIREMENT	Oil reprocessing facilities are regulated under 40 CFR Part 63, Subpart DD	
	FOR:	**LIMITS**
	VOC	Tank construction and leak limits, leak detection and repair for processing piping.
DEADLINES / MILESTONES / EFFECTIVE DATES	Construction requirements. Permit if required.	
GPA COMPLIANCE REQUIREMENTS	Ongoing monitoring and leak detection plus reporting requirements.	
GPA Options for COMPLIANCE		
	CAPITAL COSTS • $ Not yet costed.	
	ANNUAL O&M COSTS • $ Not yet costed.	
GPA Options for COMPLIANCE		
	CAPITAL COSTS • $ Not yet costed.	
	ANNUAL O&M COSTS • $ Not yet costed.	

APPENDIX G

STUDIES COMPLETED FOR THE PROPOSED NORTHERN POWER PLANT

ATTACHMENT A: DRAFT HARMON MODELING, 04-15-16

Preliminary Air Quality Modeling for Proposed Harmon Location for the Guam Power Authority

(TRC Project 182207.0000.0000)
April 15, 2016

Prepared for

Guam Power Authority

Prepared by

TRC Companies, Inc.

April 15, 2016

Preliminary Air Quality Modeling for Proposed Harmon Location

Introduction:

The Guam Power Authority (GPA) is considering the establishment of a new power production facility in the Harmon Area. Conceptually, there could be up to three 60 MW combined cycle combustion turbines (CCCT) located at this facility. TRC Environmental Corporation (TRC) was requested to provide a preliminary strategic evaluation of the air quality permitting modeling issues which may arise. Specifically, TRC was asked to address the air quality modeling analyses which might be required in a permit application to understand the issues and opportunities which might be encountered.

Model Input Considerations:

Emissions:

Newly purchased CCCT's are subject to the New Source Performance Standards (NSPS) which currently require that these units be equipped with Selective Catalytic Reduction (SCR) to reduce their emissions of Nitrogen Oxides. It is unlikely that Oxidation Catalysts (to reduce Carbon Monoxide emissions as a surrogate for hydrocarbons and hazardous air pollutant emissions) will be required. Additionally, GPA plans to burn Ultra Low Sulfur Diesel (ULSD) fuel in these units. TRC has obtained data for GE LM6000 units which in CCCT configuration produce about 60 MW burning diesel fuel in order to estimate the emissions for this modeling exercise. TRC was unable to find emissions data for the new GE models burning ULSD. The exact units purchased will come with a manufacturers guaranteed emissions profile and that would supersede the data TRC has used here. That data is shown for one unit on Table 1.

Table 1: Emissions (grams/second) Per Each 60 MW Unit

% of Load	NO_X		SO_2		CO	PM_{10} / $PM_{2.5}$	
	1-hour	Annual	1-,3- and 24-hour	Annual	1- and 8-hour	24-hour	Annual
100	0.932	0.932	0.088	0.088	0.822	0.745	0.745
75	0.75	0.75	0.071	0.071	6.6	0.597	0.597
50	0.568	0.568	0.053	0.053	5.01	0.454	0.454
25	0.392	0.392	0.037	0.037	3.46	0.314	0.314

Building and Location:

The potential plant locations on the property outline that TRC was provided and which were modeled are shown in Figure 1.

FIGURE 1: Evaluated Site Locations

In each case the modeled maximum concentrations occurred in the same general locations to the west of the property line impacting either terrain features to the southwest or northwest or impacting the ground before the steep drop-off to the western coast. This leads us to the conclusion that it does not matter from a modeling point of view where the plant will be located on the property. It should be remembered that winds are predominantly from the east and only rarely from the west.

TRC chose a building height of 40 feet and would advise that the stack be built to 2.5 times the building height, which is 100 feet. TRC also modeled stack heights of 150 feet and 60 feet. The 60 foot height will increase ground level concentrations because of building downwash being accounted for in the model.

Stack Exit parameters

The stack exit parameters were taken from GE data and assumptions about the preferred exit velocity at the stack top. The velocity was chosen to avoid stack tip downwash. TRC assumed a stack design of three separate flues in one stack. For the purpose of this modeling analysis only one unit operating at 100 percent load was modeled assuming the stack exit parameters shown in Table 2:

Table 2: Stack Parameters

% of Load	Height meters	Temperature °Kelvin	Velocity meters/second	Diameter meters
100	30.48	373.15	20.2	3.046
75	30.48	373.15	17.02	3.046
50	30.48	373.15	14.65	3.046
25	30.48	373.15	11.62	3.046

Model Results

The modeled concentrations of each pollutant for one 60 MW unit operating at 100 percent load are presented in Table 3. These results are for the 100 foot stack height case.

TABLE 3: Modeling Results (100 foot stack)

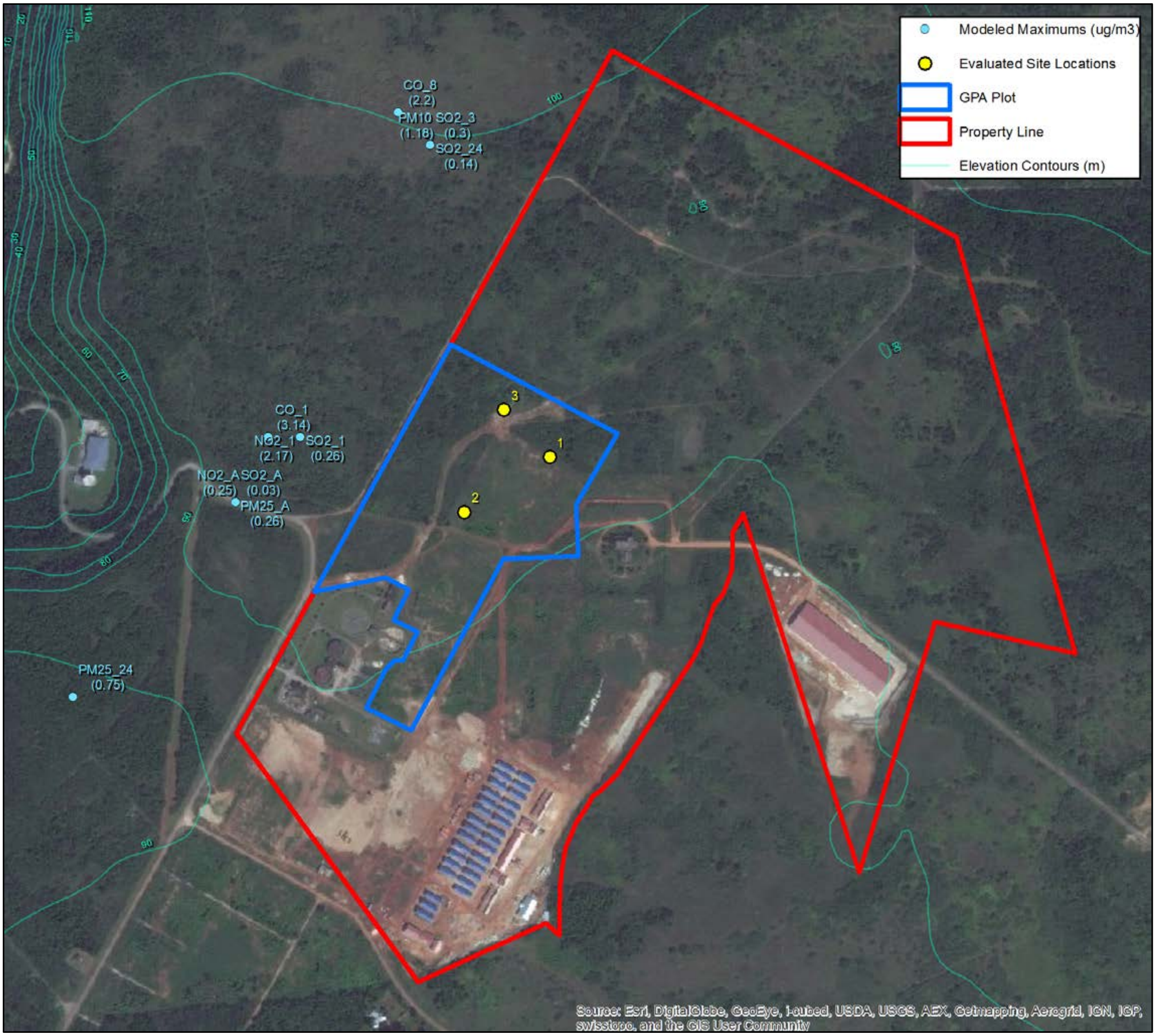
Pollutant	NO_2[1]		SO_2				CO		PM_{10}	$PM_{2.5}$	
Averaging Period	1-hour	Annual	1-hour	3-hour	24-hour	Annual	1-hour	8-hour	24-hour	24-hour	Annual
Statistic	H1H	H1H	H1H	H1H	H1H	H1H	H1H	H1H	H1H	H1H	H1H
Modeling Period	ug/m3	ug/m3	ug/m3	ug/m3	ug/m3	ug/m3	ug/m3	ug/m3	ug/m3	ug/m3	ug/m3
2006	-	0.31	-	-	-	0.03	-	-	-	-	0.25
2007	-	0.28	-	-	-	0.03	-	-	-	-	0.23
2008	-	0.31	-	-	-	0.03	-	-	-	-	0.25
2009	-	0.27	-	-	-	0.03	-	-	-	-	0.21
2010	-	0.33	-	-	-	0.03	-	-	-	-	0.26
5-Year MET or MAX of Above	2.17	0.33	0.26	0.30	0.14	0.03	31.4	22.0	1.18	0.75	0.26
SIL (ug/m3)	7.5	1	7.8	25	5	1	2000	500	5	1.2	0.3
NAAQS (ug/m3)	188	100	196	1309	365	80	40000	10000	150	35	12
Pass?	Below SIL	Below SIL	Below SIL	Below SIL	Below SIL	Below SIL	Below SIL	Below SIL	Below SIL	Below SIL	Below SIL
Pass at 3X?	Below SIL	Below SIL	Below SIL	Below SIL	Below SIL	Below SIL	Below SIL	Below SIL	Below SIL	Below NAAQS	Below NAAQS

[1]: 80% ARM factor applied to 1-hour values. 75% ARM factor applied to annual values.

The modeling results indicate that the impacts of one unit operating at full load will be below all applicable modeling Significant Impact Levels (SILs). Extrapolating these results up to three 60 MW units operating at 100 percent load will not exceed any of the NAAQS or the SILs, except for $PM_{2.5}$. Meeting the SIL is important because for pollutants with impacts below that concentration no further modeling is required. Results above the SIL for $PM_{2.5}$ would mean that the modeling for a PSD permit will require modeling of all other PM $_{2.5}$ sources on the island. While there is no particular reason that the modeling results with other sources would be above the NAASQ, all source modeling would require further EPA review and increase the time for their approval of the permit. If all the results are below the SIL, EPA review would proceed more quickly.

Figure 2 shows the maximum impact locations for the various pollutants in the one unit 100% load case:

FIGURE 2: Model Results One Unit 100% Load (at Location 1)



The other load conditions do not create any additional increase in concentrations over the 100% load case. As with the 100% load case they are less than the SIL with the exception of the 2 or 3 unit operating case exceeding the SIL for $PM_{2.5}$. Raising the stack height to 150 feet does not resolve the issue of the 2 or 3 unit operating case going above the SIL. Lowering the stack height to 60 feet also does not exceed the NAAQS but does create SIL issues for NO_2 and PM_{10} in the 2 and 3 unit operating cases.

SUMMARY

Preliminary modeling for one 60 MW combined cycle combustion turbine operating in the Harmon area shows that such a facility will meet the NAAQS, with a minimum of modeling effort being required for a PSD permit. When modeled maximum concentrations for a particular pollutant are modeled to be below its respective SIL no further modeling is generally required and the proposed facility or project is deemed an insignificant source for air quality impact purposes. An insignificant source cannot contribute or cause an NAAQS violation, therefore no additional modeling or air quality analyses are required. This result can streamline and expedite both the permitting process and permit issuance schedule.

The modeled results for one 60 MW unit were mathematically extrapolated to calculate potential impacts from three 60 MW units operating simultaneously. For two or three units operating simultaneously, the maximum concentrations of $PM_{2.5}$ is predicted to be above the SILs and thus the project would be considered to have a significant air quality impact of $PM_{2.5}$ requiring additional air quality modeling analyses. The additional modeling analyses must include all permitted sources of $PM_{2.5}$ on the island plus a background concentration to account for all other sources. The nearest power plant that might affect or contribute to the Harmon predicted impacts is Dededo. These analyses will require additional effort and time and will likely extend the application review and permit issuance time frame. Although the EPA is required to process an application in one year after they have received a "complete" application, complication of the modeling analyses could result in delays due to additional review time and data requests to confirm compliance with the NAAQS.

The modeling analyses performed also show that the physical plant may be placed at any location on the property outlined without significantly affecting the modeling results. To achieve the modeled results discussed above, TRC recommends a design stack height of 2.5 times the building height planned for the project, estimated here as 100 feet. Stack heights lower than the good engineering heights suggested here are not advisable.

The above discussion and analyses are based on the project locating in an area designated as attainment of all NAAQS. The proposed Harmon project area is currently designated as non-attainment for the SO_2 NAAQS. Therefore the ease of permitting is also dependent upon the US EPA declaring the area as attainment for the SO_2 NAAQS. Guam EPA must make this request of US EPA. Without this declaration, even the small amount of SO_2 emissions from the proposed project will have to be offset against the reduction in emissions at Tanguisson and/or Dededo. In either case, this complication will drag out the permitting time.

ATTACHMENT B: PRELIMINARY AIR QUALITY IMPACT ANALYSIS – PROPOSED NORTHERN POWER PLANT

INTRODUCTION

GPA has proposed that a nominal 180 MW power plant be built consisting of three 60 MW combustion turbines. These are currently expected to be single cycle combustion turbines. The likely location is shown in Figure 1.

Figure 1: Proposed Site for New Power Plant in the Harmon Area.

The new plant would burn Ultra Low Sulfur Diesel (ULSD) fuel. The units would have the capability to burn natural gas, should gas become available. The new plant would be built with two add on control devices, presumably on each unit. The control devices would be Selective Catalytic Reduction (SCR) to remove nitrogen dioxide emissions and oxidation catalysts to remove carbon monoxide emissions.

These add on control devices will accomplish several objectives:

a. Reduction of emissions of nitrogen dioxide (NO_2) and carbon monoxide (CO) both of which are criteria pollutants and have NAAQS which must be met in order to protect the public.
b. Reduction of emissions of volatile organic compounds, especially formaldehyde, which are products of combustion of oil. Some reduction of particulate matter emissions would also occur.
c. The reduced emissions would qualify the entire plant to be a "minor" source which means less than 250 tons per year of any one pollutant. The permitting of a minor source is easier, quicker and can be done by the Guam EPA. It avoids the New Source Review requirements for Best Available Control Technology (BACT), Maximum Achievable Control Technology (MACT) for major sources and detailed modeling analysis.

EMISSIONS

Emissions were estimated using data for GE LM6000 combustion turbines for data were on file. These data are for the criteria pollutants from oil firing assuming SCR and oxidation catalysts are being used. Emissions for natural gas firing would be lower.

Table 1: Estimated Emissions Using GE LM6000 Combustion Turbine Data Provided by GPA

Load	100% VFR Scaling Factor	Volume Flow Rate	Stack Diameter	Stack Velocity	Stack Temp	NO_X	CO	SO_2	$PM_{10}/PM_{2.5}$
%		ACFM	ft	m/s	ºF	lb/hr	lb/hr	lb/hr	lb/hr
100	-	312,304	10	20.1999998	212	7.4	6.52	0.7	5.91
75	0.84	263,132	10	17.02	212	5.95	5.24	0.56	4.74
50	0.73	226,477	10	14.65	212	4.51	3.98	0.42	3.6
25	0.58	179,704	10	11.62	212	3.11	2.75	0.29	2.49

Data for Hazardous Air Pollutants were determined using US EPA's emission factor documents. Again, emissions for natural gas would be far lower or non-existent. They are as follows:

Table 2: Estimated HAPs Using GE LM6000 Combustion Turbine Data Provided by GPA

Hazardous Air Pollutant	Pounds/1000 gallons	Pounds/Hour
Benzene	0.000214	0.00020152
Formaldehyde	0.033	0.0310761
Naphthalene	0.00113	0.00106412
111 Trichloroethylene	0.000236	0.00022224
Toluene	0.00062	0.00058385

Table 3: Estimated Metal Emissions Using GE LM6000 Combustion Turbine Data Provided by GPA

Metals	Pounds per trillion BTU	Pounds/Hour
Arsenic	4	0.00522
Beryllium	3	0.003915
Cadmium	3	0.003915
Chromium	2	0.00261
Lead	9	0.011745
Mercury	3	0.003915
Nickel	3	0.003915
Selenium	15	0.019575

Modeling of these emissions was accomplished by the standard methods following the Guideline on Air Quality models and the methods in the modeling for the DRR which were approved by Guam EPA and USEPA region 9. Meteorological data from the Guam Airport was used. The modeling results for the criteria pollutants can be summarized as follows:

Table 4: Modeling Results for Criteria Pollutants, GPA Proposed Power Plant Using GPA data for GE LM6000 Combustion Turbine

Pollutants	Cabras 1&2 (RFO-Fired) µg/m³	Proposed Power Plant, Notional Emissions (ULSD-Fired) µg/m³	NAAQS (1-HOUR) µG/M³	Emissions Improvement over NAAQS %	Emissions Improvement over Cabras 1&2 %
Sulfur Dioxide (SO_2)	443	0.78	196	99.60%	99.82%
Nitrogen Oxides (NO_x)	80.8	6.51	188	96.54%	91.94%
Carbon Monoxide (CO)	8.6	9.42	40,000	99.98%	-9.53%
Particulate Matter	26.9	3.54	35	89.89%	86.84%

The table contains a comparison to the modeling results for Cabras 1& 2 on Refinery fuel Oil. Note that the maximum air quality impacts from the new plant are substantially below the NAAQS for each pollutant and that there would be a substantial air quality improvement over the impact of Cabras 1 & 2. CO emissions are much lower than NAAQS requirements, however, there is a slight increase in CO emissions for Combustion Turbine compared to Steam Turbine units.

Modeling for the Hazardous Air Pollutants was done in the same manner. The results are compared to the USEPA Region 9 residential Risk Concentration despite there being no residences in the area.

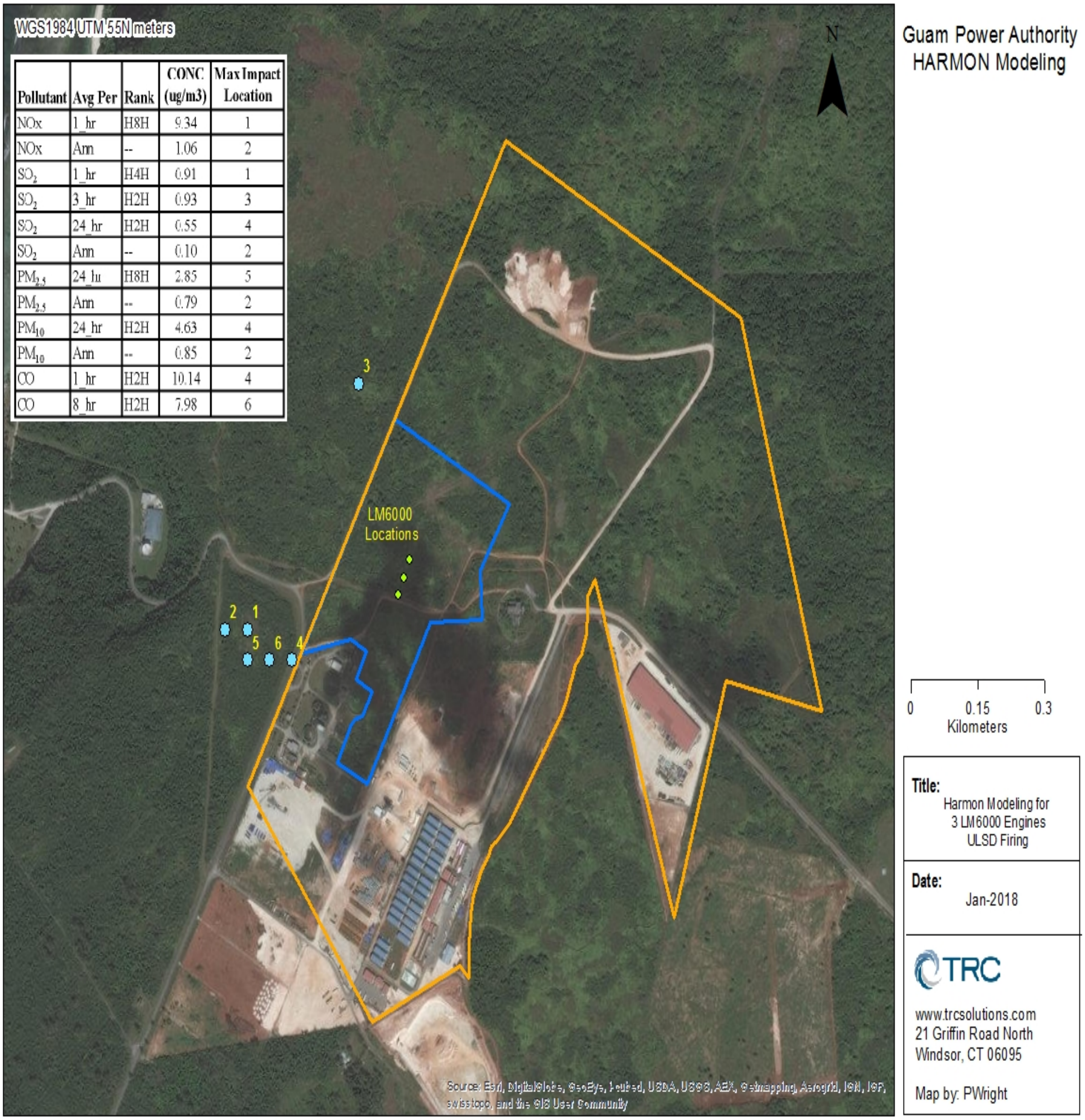
Table 5 and 6: Modeling Results vs. USEPA Region 9 Residential Risk Concentration; Comparison to Toxic Endpoints

Volatile Organic Compounds (VOCs)	Predicted Concentration µg/m³	EPA Regional Residential Risk Concentration µg/m³	Times lower than the Risk Concentration
Benzene	1.40E-05	0.36	25,713
Formaldehyde	0.002159	0.22	101
Naphthalene	7.39E-05	0.082	1,109
Trichloroethylene	1.54E-05	0.048	3,116
Toluene	4.06E-05	5200	128,078,817

METALS	Predicted Concentration µg/m³	EPA Regional Residential Risk Concentration µg/m³	Times lower than the Risk Concentration
Arsenic	0.000363	0.00065	2
Beryllium	0.000272	0.0012	4
Cadmium	0.000272	0.0016	6
Lead	0.000816	0.15	184
Mercury	0.000272	0.0031	11
Nickel	0.000272	0.011	40
Selenium	0.00136	21	15439

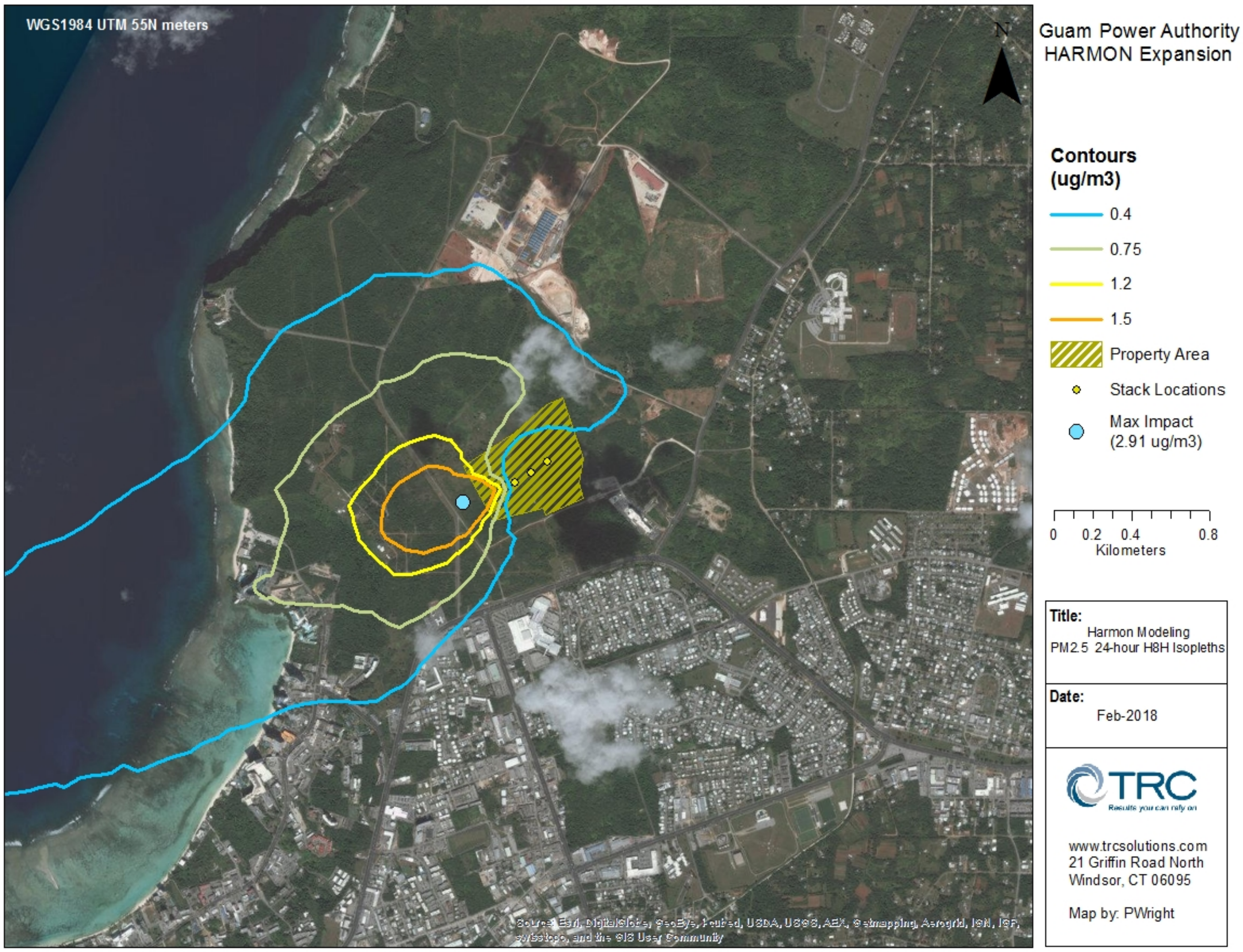
Figures showing the isopleths of concentration for some of the pollutants modeled are show below.

Figure 2: Harmon Modeling for Three (3) LM6000 Engines, ULSD Firing



Pollutant	Avg Per	Rank	CONC (ug/m3)	Max Impact Location
NOx	1_hr	H8H	9.34	1
NOx	Ann	--	1.06	2
SO_2	1_hr	H4H	0.91	1
SO_2	3_hr	H2H	0.93	3
SO_2	24_hr	H2H	0.55	4
SO_2	Ann	--	0.10	2
$PM_{2.5}$	24_hr	H8H	2.85	5
$PM_{2.5}$	Ann	--	0.79	2
PM_{10}	24_hr	H2H	4.63	4
PM_{10}	Ann	--	0.85	2
CO	1_hr	H2H	10.14	4
CO	8_hr	H2H	7.98	6

Figure 3: Harmon Modeling PM2.5 24-Hour HBH Isopleths



CONCLUSION

The new power plant burning ULSD and with controls will have little to no impact on air quality and be well below any regulatory standards that apply. If natural gas becomes available, even less impact can be expected.

2022 Integrated Resource Plan Volume IV:

Demand-Side Management Plan

10/27/2021

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Table of Contents

1 Executive Summary

GPA developed its DSM program in 2015, and rolled out with three (3) programs for the residential customers. The programs were for Air Conditionings, Washers and Dryers. The roll-out started out slow in the first year but gradually improved toward the end of the year. This is due to lack of customers' familiarity and low expectancy of the program. As of August of 2021, GPA has received and processed over 22,000 rebates as shown in Figure 1 and paid out about $6.8M. GPA anticipates that these amounts to significantly increase with the roll-out of the Commercial programs for Air Conditioning Units.

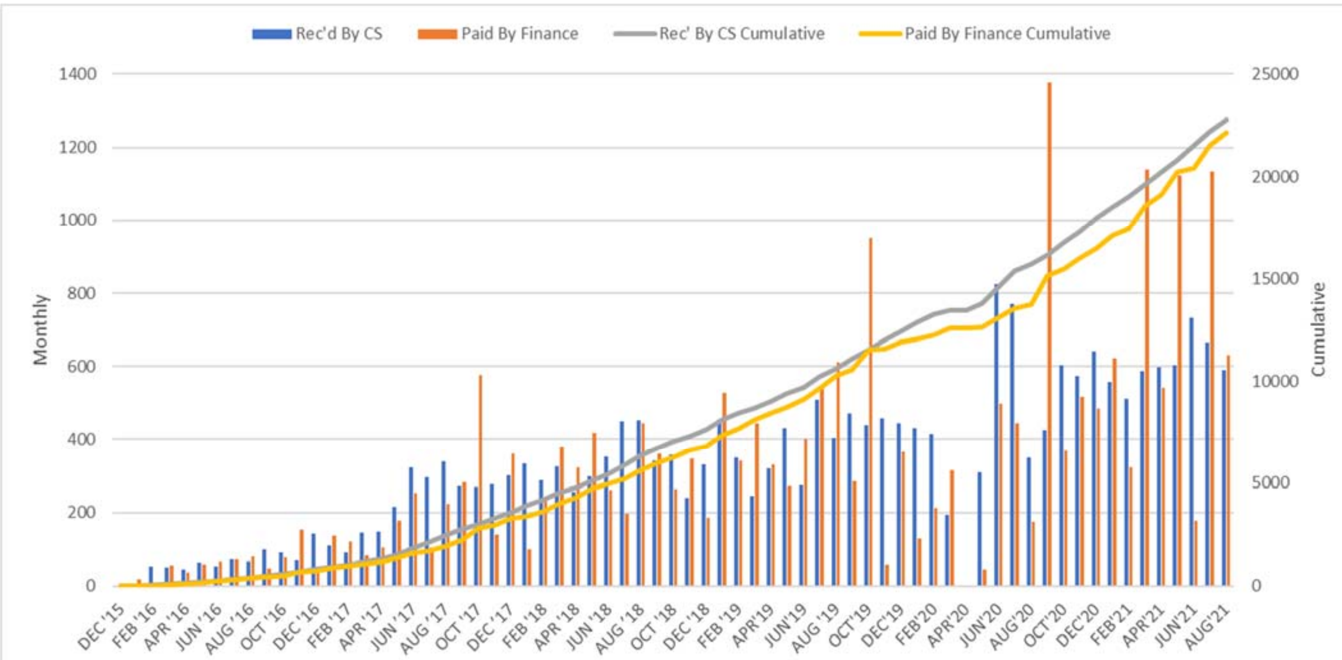


Figure 1. Number of Rebates Received and Paid

2 Demand-Side Management (DSM) Program

The Guam Power Authority (GPA) Demand-Side Management (DSM) Program is much more than just an appliance rebate program. DSM consists of the following major activities:

- Energy Sense Appliance Rebate Program;
- Energy Sense Appliance Residential & Small Non-Residential Energy Audit Program;
- Marketing;

- Metering & Verification (M&V);
- Utility Energy Services Contracting (UESC) Program;
- Bringing Energy Savings To (BEST) Schools Program;
- Grant Funded Projects;
- Pilot Projects;
- Organizational Infrastructure;
- New DSM Section Staffing;
- Demand-Response Programs (Future).

3 DSM Program Update

This section provides the background, purpose, and summary of activities to date on GPA's DSM Program activities.

3.1 Energy Sense Rebate Program

The PUC order docket 13-14 mandated that GPA proactively create and implement effective Demand-Side Management (DSM) programs as part of GPA's Integrated Resource Plan. It ordered that the ALJ work collaboratively with GPA, GPA's consultants and Lummus Consultants (PUC consultants) to develop a GPA Demand-Side Management (DSM) and Energy Efficiency (EE) program.

GPA contracted Leidos to help in developing and implementing the DSM and EE program. The working team completed development of the DSM and EE programs in 2015. GPA submitted a report to the PUC detailing an initial suite of DSM rebate programs for immediate execution. Out of the recommendations from this report, the working team chose an initial slate of residential rebate programs. GPA rolled out the initial slate of rebate programs in December 2015. The inaugural rebate programs included Residential Air Conditioning (A/C), Residential Washer, and Residential Dryer Programs. The Residential A/C program consisted of split A/C, central A/C, and Window A/C rebates.

In 2016, GPA submitted an additional DSM Study under the title, Energy Sense Program Plan, to the PUC recommending expansion of the DSM rebate program. GPA branded all energy efficient rebate activities under the Energy Sense brand. The ALJ, GPA, Lummus, and Leidos again collaboratively worked on this report. The ALJ and GPA chose ten additional programs to expand the DSM rebate program and provide other energy efficiency and energy technology services.

The PUC Order in GPA Docket 13-14 dated May 25, 2017 set forth the following ten (10) new initiatives:

A. Customer Energy Audits
B. Commercial A/C: High Efficiency Packaged Rooftop Unit and Solar Thermal Assisted AC per collector (no more than four collectors per customer)
C. Commercial A/C: High Efficiency Split, Ducted A/C System and Solar Thermal Assisted A/C per collector (no more than two collectors per customer)
D. Commercial Building Energy Management System
E. Residential A/C: Variable Refrigerant Flow A/C
F. Commercial A/C: Variable Refrigerant Flow A/C
G. Commercial Indoor and Outdoor Lighting
H. Water Heating
I. 100 Residential and Commercial Customer ESS Pilot Program
J. Smart Inverter Upgrade Rebates.

In May 2021, GPA contracted Sheffield Scientific, LLC, and their partners at Utility Financial Solutions (UFS), to review and identify current Energy Sense rebate programs and identify potential modifications to the program. This process identifies each programs ability to reduce future capital expenditures on generation, transmission, distribution, and variable production costs. Several programs have been immediately identified for this study:

A. Residential Air Conditioning Reset
B. Residential Clothes Washers & Dryers Reset
C. Commercial Air Conditioning: Variable Refrigerant Flow
D. Commercial Air Conditioning: Central Ducted
E. Commercial Air Conditioning: Packaged Rooftop

F. Commercial Lighting

3.2 Expanded DSM Rebate Program Implementation

The growth of the initial DSM residential rebate programs for air conditioning, washers, and dryers grew exponentially. GPA did not have sufficient funding to accommodate the growing initial program and roll out the expanded DSM rebate program. However, GPA used federal grants to fund projects for customers using the technologies and services among the ten new initiatives. GPA can support a claim to have somewhat met the PUC mandate for encouraging the use of these technologies and services through its UESC, BEST Schools, and federal grant programs. GPA took the above steps to implement the expansion rebate program if somewhat obliquely.

Direct Implementation Steps for executing the expanded DSM Rebate Program include:

- Trade Ally Certification;
- Mapping out the Rebate Process for New Elements of the Expanded Program;
- Marketing the New Services and Technologies Eligible for Rebates;
- Setting up Metering & Verification Processes.

Based on the findings of Sheffield Scientific's study, GPA executed a soft-rollout of Commercial Split and Central Air Conditioning rebate programs in June 2021 for commercial customers with rate schedules G and J. GPA is currently preparing for a September 2021 rollout of the following commercial rebate programs:

A. Variable Refrigerant Flow Air Conditioning
B. Large Central Air Conditioning – Over 5 Tons
C. Rooftop Package Air Conditioning

The study also set the rebate level for the commercial rebate programs as given in Table 3-1.

Table 3-1. Commercial Rebate Programs Rebate Levels

Commercial Program Description	Rebate ($ Per Ton)
Ductless Split Air Conditioning Units	
≥ 18 SEER and < 21 SEER	105
≥ 21 SEER and < 25 SEER	135
≥ 25 SEER	155
Ducted Central Air Conditioning Units	
< 5 Ton	
≥ 17 SEER and < 21 SEER	230
≥ 21 SEER and < 25 SEER	300
≥ 25 SEER	350
≥ 5 Ton	
≥ 16 IEER and < 18 IEER or (≥ 11 EER and < 12 EER Expire in 2024)	175
≥ 18 IEER and < 20 IEER or (≥ 12 EER and < 13 EER Expire in 2024)	230
≥ 20 IEER or (≥ 13 EER Expire in 2024)	320
Variable Refrigerant Flow Units	
< 5 Ton	
≥ 17 SEER and < 21 SEER	230
≥ 21 SEER and < 25 SEER	300
≥ 25 SEER	350
≥ 5 Ton	
≥ 16 IEER and < 18 IEER or (≥ 11 EER and < 12 EER Expire in 2024)	175
≥ 18 IEER and < 20 IEER or (≥ 12 EER and < 13 EER Expire in 2024)	230
≥ 20 IEER or (≥ 13 EER Expire in 2024)	320
Package Rooftop Units	
< 5 Ton	
≥ 17 SEER and < 21 SEER	230
≥ 21 SEER and < 25 SEER	300
≥ 25 SEER	350
≥ 5 Ton	
≥ 16 IEER and < 18 IEER or (≥ 11 EER and < 12 EER Expire in 2024)	175
≥ 18 IEER and < 20 IEER or (≥ 12 EER and < 13 EER Expire in 2024)	230
≥ 20 IEER or (≥ 13 EER Expire in 2024)	320

3.2.1 Establishment and Certification of Trade Allies

GPA has already certified potential trade allies for the expanded DSM Rebate Program. Furthermore, GPA has used products from these potential trade allies in projects conducted under its UESC and BEST Schools Programs.

Table 3-2 illustrates the trade ally certification checklist for implementing the expanded DSM Rebate Program. Chief on GPA's things-to-do list is updating the Energy Sense Website.

Table 3-2. Trade Ally Certification Checklist

Trade Ally Certification Checklist	Check if Completed
Contact Potential Suppliers	X
Create List of Potential Supplier Products and Prices	X
Create Certification Criteria and Process for Supplier Products	X
Certify Products and Trade Allies	X
Update Energy Sense Website	
Create Relationship with Guam Stakeholders	
Guam Energy Office (GEO)	X
Guam Department of Education (GDOE)	X
Guam Housing & Urban Renewal Authority (GHURA)	
Guam Association Realtors (GAR)	
Department of the Navy (DON)	X
Naval Facilities Engineering Command Marianas (NAVFAC MAR)	X
Naval Facilities Engineering Command Pacific (NAVFAC PAC)	X
Resilient Energy Power Office (REPO)	X
Andersen Air Force Base (AAFB)	X
Industry	X

3.2.2 The DSM Rebate Process

Table 3-3 shows the rebate Process checklist and work status for implementation of the expanded program(s):

- Commercial Building Energy Management System;
- Commercial A/C: High Efficiency Split, Ducted A/C Systems and Solar Thermal Assisted AC;
- Residential A/C: Variable Refrigerant Flow A/C;
- Commercial A/C: Variable Refrigerant Flow A/C;
- Commercial Indoor and Outdoor Lighting;
- Water Heating.

GPA must modify this existing process for other technology and service elements in the expanded program.

Table 3-3. Rebate Process Checklist: Expanded DSM Rebate Program Implementation

Rebate Process Checkllst	Check if Completed
Create Rebate Forms	X
Create Rebate Process	X
Create Processes and Swim Lane Maps	Ongoing
Create Rebate Processing Training/Certification for HR to Administer and Deliver	Ongoing
Update Energy Sense Website	Ongoing
Disseminate Rebate Forms	Ongoing

GPA must take additional time developing the processes for:

- 100 Customer ESS pilot residential and commercial programs;
- Smart Inverter Upgrade Rebates.

The underlying technologies have progressed significantly since 2017. GPA will bid out the ESS pilot program. GPA will contract the program design and implementation. GPA will contract out the design and implementation of the Smart Inverter Upgrade Program.

Figure 3-1 illustrates the swim lane map of the existing DSM rebate process. The following expanded program technology categories can use the same exact process with little modification:

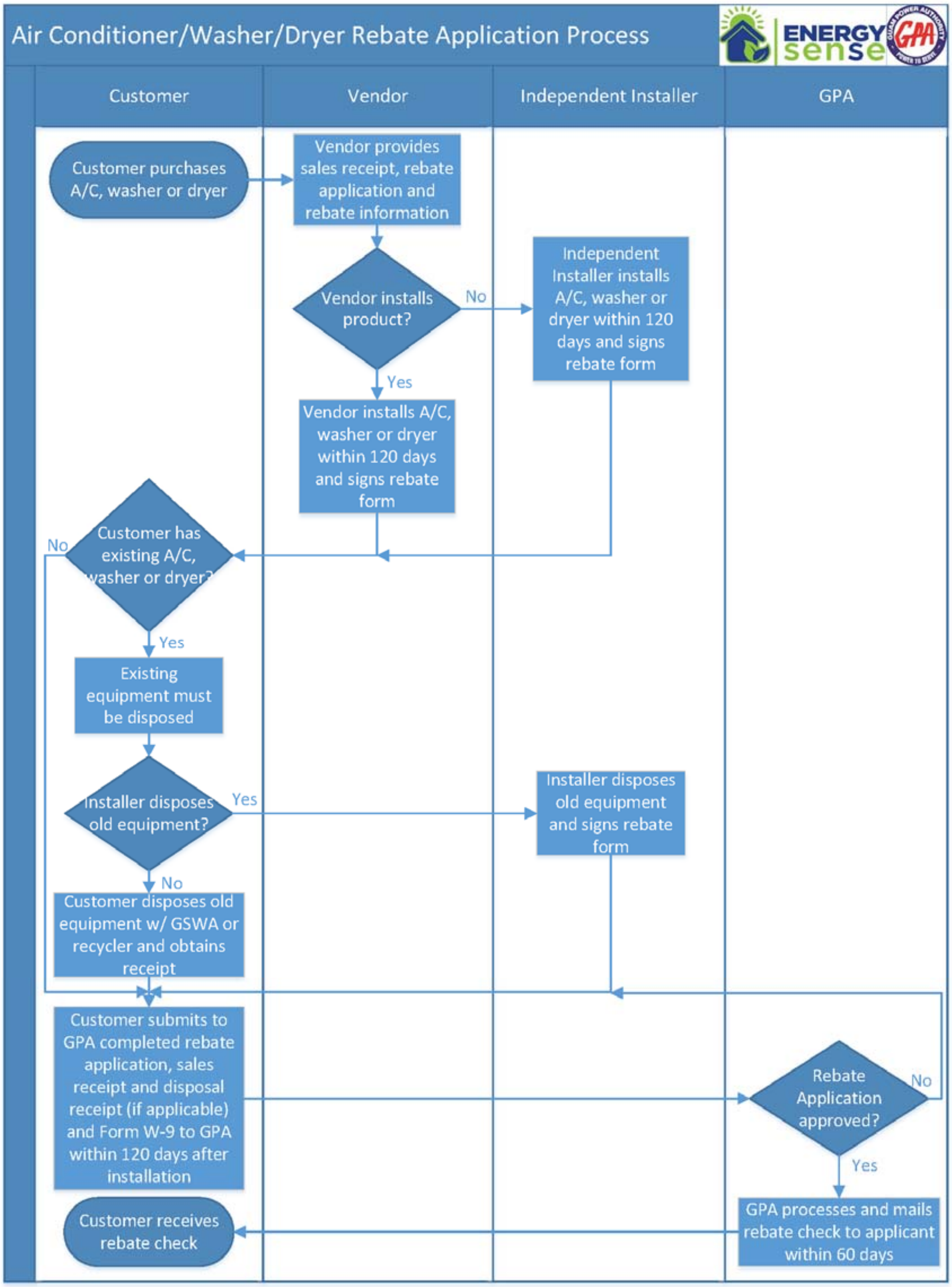


Figure 3-1. DSM Rebate Process Swim Lane Map

3.2.3 The Energy Sense Rebate Application Process Digital Transformation

The Energy Sense Rebate Program (ESRP) expenditures and application counts continue to increase year-over-year. Since FY 2017 the program has seen an average growth of about twenty-four percent annually. The number of submitted applications has increased from approximately 2,000 to over 7,000 in the past five years as demonstrated in Figure 3-2 below. The recent addition of the Commercial Rebate Programs will also add to these figures.

The growth of the original rebate program as well as the roll-out of several new programs heightens the need for digital transformation of the current manual processing of applications and the management of trade ally information.

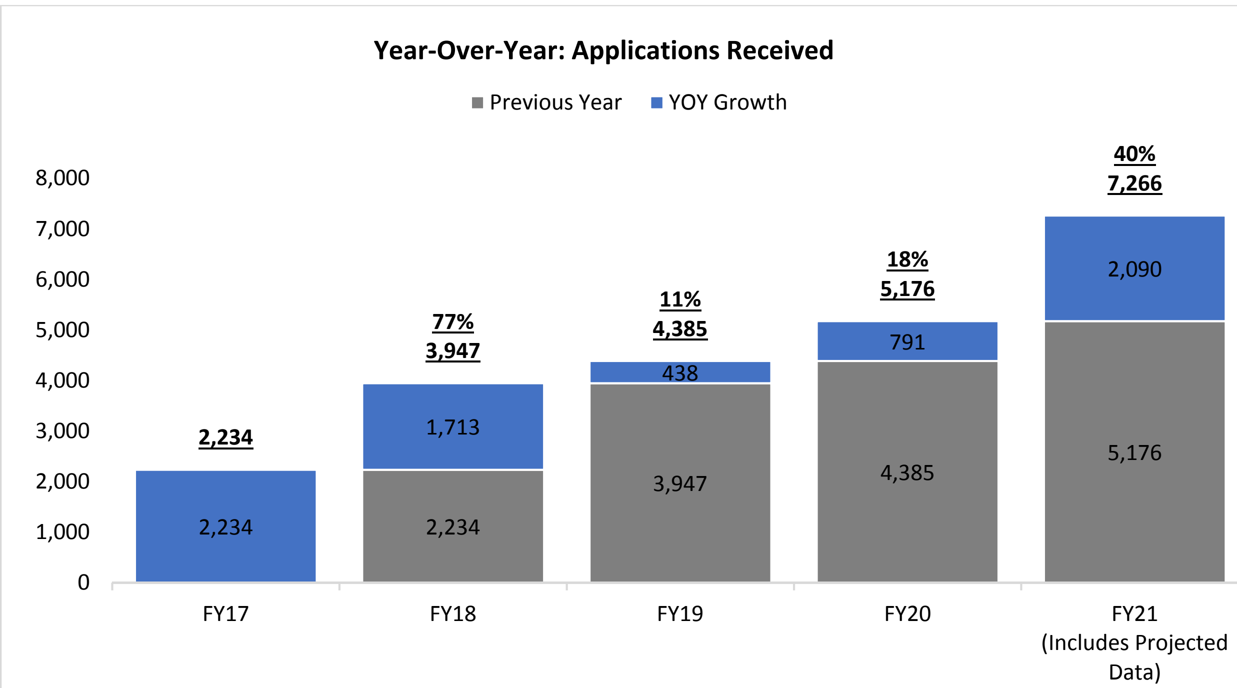


Figure 3-2. Growth of Total Applications Received

Although this increase in volume is a positive factor for the Demand Side Management (DSM) objective, it poses a couple of challenges for GPA:

- Sustain increasing workload
- Utilize available resources (staffing and business tools)
- Maintain quality of work

GPA staffing involved in the program has mainly remained stagnant as demonstrated in Table 3-4. At most, only about four employees work fulltime on the Energy Sense Rebate Programs. This includes reviewing, processing, overseeing, managing, and expanding each program. The majority of the other employees operate in a partial or temporary supporting capacity since the rebate program is not their primary assignment.

Table 3-4. Energy Sense Rebate Program Workforce

GPA Energy Sense Support Staff

Division	Classification	Primary Role	FY19	FY20	FY21
Customer Service	Staff	No	9	10	10
Customer Service	Supervisor	No	3	2	2
SPORD	Staff	Yes	2	3	3
SPORD	Supervisor	Yes	1	1	1
Budget	Staff	No	1	1	1
Budget	Supervisor	No	1	1	1
Accounting	Staff	No	3	3	3
Accounting	Supervisor	No	1	1	1
		Total	**21**	**22**	**22**

In FY 2020 the DSM Program was also greatly impacted by the COVID-19 pandemic resulting in a 59-calendar day shutdown or limitation of GPA operations. This temporary limitation caused a backlog of approximately 1,700 rebate applications. To prevent additional backlogs and keep up with the continual growth in rebate processing GPA conducted an internal review of its current processes and resources.

Based on the internal review GPA identified four primary objectives:

(1) Increase efficiency
(2) Reduce errors
(3) Consolidate business tools
(4) Record and extract data for analysis and reporting

GPA has done some inter-department staff augmentation to help improve some of these areas. This allocated staffing from other departments to assist more with the Energy Sense Rebate process. While this helps the program additional measures still need to be implemented to better manage the increasing workload. Digitizing the DSM application process has been identified as one such measure which directly impacts the four areas identified above and supports future program growth.

DIGITAL TRANSFORMATION

Xtendly LLC is GPA's current web-based and mobile application developer for the DSM Digitization and PayGPA portals. In August 2020 GPA had signed an existing contract change order and Scope of Work (SOW) agreement between GPA and Xtendly LLC to help address the four primary objectives:

(1) Creating a digital application to increase data flow efficiencies by removing repetitive data entry tasks and reduce delays by automating internal processes;
(2) Creating digital forms with good data validation rules to decrease remedial tasks associated with error correction;
(3) Creating a web-based application or User-Interface (UI) to consolidate onto one technology platform replacing the current state of using multiple business tools such as Microsoft Office products, CC&B, JDE/E1 and other programs or software; and,
(4) Creating a single managed Data source recorded and shared via an established database server.

The digital transformation of the Energy Sense Rebate Program started with converting the current paper application form (Figure 3-4) to a digital format as shown in Figure 3-5. This transition creates an easier form to fill using features such as drop downs, check boxes, and auto-fill aides as some examples. This segment is internally referred to as the "Front-End". This is the user-interface and experience the GPA customer will interact with when submitting applications.

ENERGY sense

Air Conditioning Rebate Program for Ductless Systems
Rebate Application for GPA Residential Customers

GPA

Please read the information on the reverse side before completing the rebate application.

Applicant Information:

APPLICANT NAME (First, Middle Initial, Last): ______________________ TELEPHONE: (___) ___-____

INSTALLATION ADDRESS (NUMBER, STREET, UNIT): ______________________

CITY: ______________, Guam ZIP: ____________ EMAIL: ______________________

GPA ELECTRIC ACCOUNT NUMBER: ______________ NAME ON GPA ACCOUNT: ______________

Applicant must be either the GPA account holder or the property owner to claim a rebate. Is Applicant the owner of the residential property? ❑ YES ❑ NO

Exceptions may be made if the tenant or property owner represenative provides an authorization letter with a copy of photo I.D.. Residential customers with Commercial Accounts must provide proof of residency in order to participate in this rebate program. Condominium or property managers may apply for tenants.

MAILING ADDRESS (if different than above): ______________________

CITY: ______________, Guam ZIP: ____________

HOME SIZE (approx. sq. ft.): ____________ HOME AGE (approx. year built): ____________ NEW CONSTRUCTION? ❑ YES ❑ NO

HOME TYPE (check one): ❑ SINGLE FAMILY ❑ APARTMENT ❑ CONDO ❑ MOBILE HOME ❑ OTHER

Installer Information:

TECHNICIAN NAME: ______________________ WORK TELEPHONE: (___) ___-____

COMPANY NAME: ______________________ ADDRESS: ______________________

CITY: ______________ ZIP: ______________ EMAIL: ______________________

INSTALLER SIGNATURE: ______________________ DATE OF FINAL INSTALLATION: ______________

New Equipment Information:

If Qty more than 1, provide data for all units installed. Provide Model #s for both indoor and outdoor units.

System Type	Rebate	Description	Qty	Tons	Manufacturer	System Model # or Indoor & Outdoor Model #s	SEER[1]	Install Date
Ductless Air Conditioning System < 1 Ton	$100	≥ 18 SEER and < 21 SEER						
	$200	≥ 21 SEER and < 23 SEER						
	$250	≥ 23 SEER						
Ductless Air Conditioning System ≥ 1 Ton	$200	≥ 16 SEER and < 21 SEER						
	$300	≥ 21 SEER and < 22 SEER						
	$325	≥ 22 SEER and < 25 SEER						
	$350	≥ 25 SEER and < 28 SEER						
	$600	≥ 28 SEER						

Existing/Old Equipment Information:

Check if there is no existing/old equipment being replaced ❑ NO EXISTING EQUIPMENT

Existing/old air conditioning (AC) equipment must be removed and properly disposed. Old equipment must be disposed of by either the Installer or the Applicant with Guam Solid Waste Authority (GSWA) or a Guam Environmental Protection Agency (GEPA) listed recycler. If Applicant is disposing, there must be a receipt of disposal from GSWA or the recycler attached to this rebate form.

System Type	Size (tons)	Age (Years)	Equipment Condition Prior to Removal	SEER[1]	Disposal Party
❑ Split System ❑ Central Unit			❑ Operational ❑ Failed		❑ Customer ❑ Installer
❑ Split System ❑ Central Unit			❑ Operational ❑ Failed		❑ Customer ❑ Installer

1 Seasonal Energy Efficiency Ratio

INSTALLER SIGNATURE FOR DISPOSAL (must be same as above): ______________________ DATE: ____________

Installer certifies equipment will be properly disposed with a GEPA listed recycler or GSWA.

Acceptance of Terms and Conditions:

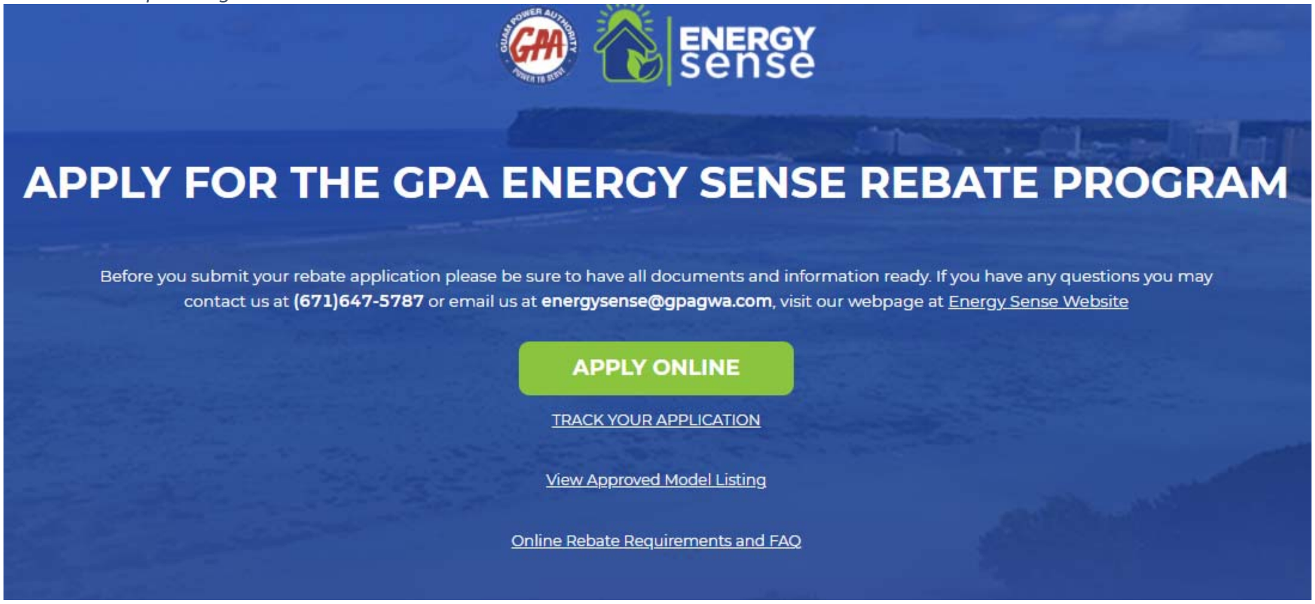
I hereby certify that I am the GPA electric account owner and/or the owner of the residential property at which the service/installation occurred, that I have purchased the equipment described on this Rebate Application, and that it has been installed at the indicated installation address. I have read the Terms and Conditions on the reverse side of this form and acknowledge that GPA may verify the information provided. **I acknowledge a copy of the itemized sales receipt with the date of purchase must accompany this form. If an Installer is not disposing of the equipment, a disposal receipt must accompany this form.**

APPLICANT SIGNATURE: ______________________ DATE: ____________

Rev. 3.0, 05/11/2021

Figure 3-4. GPA Ductless Split AC Application Form

Front-End Sample Image 1



Front-End Sample Image 2

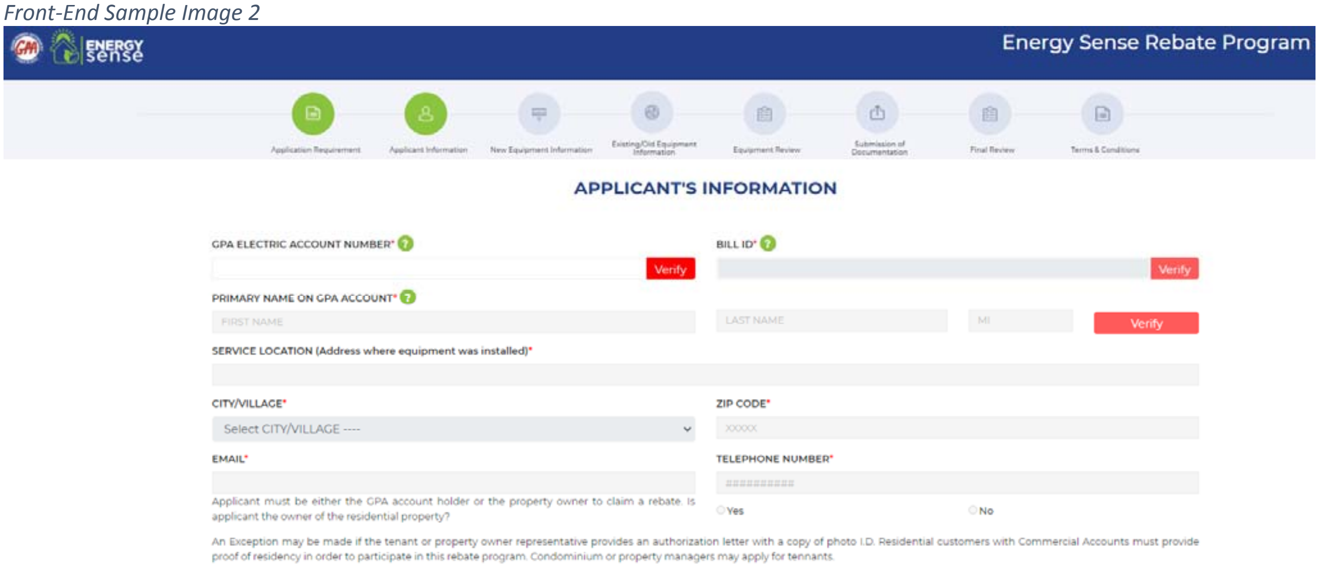
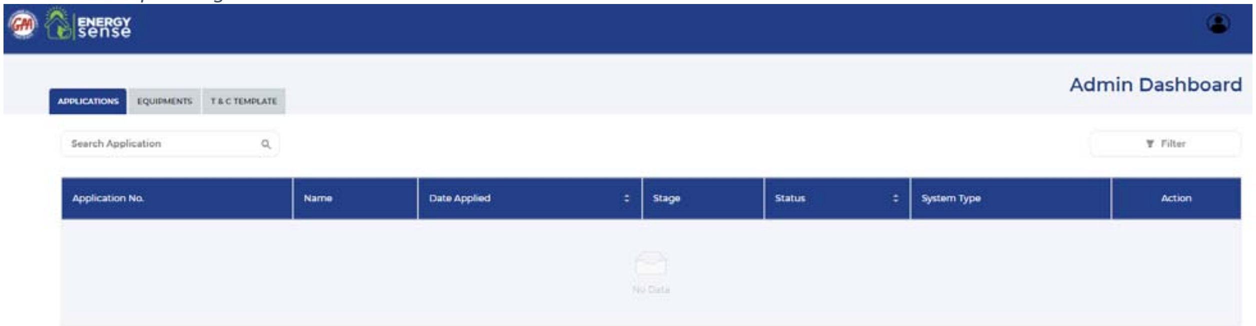


Figure 3-5. Front-End Sample Image

While the Front-End was being developed GPA also needed another user interface to review and process submitted applications. This UI is referred to as the “Back-End” illustrated in Figure 3-6 below.

Back-End Sample Image 1



Back-End Sample Image 2

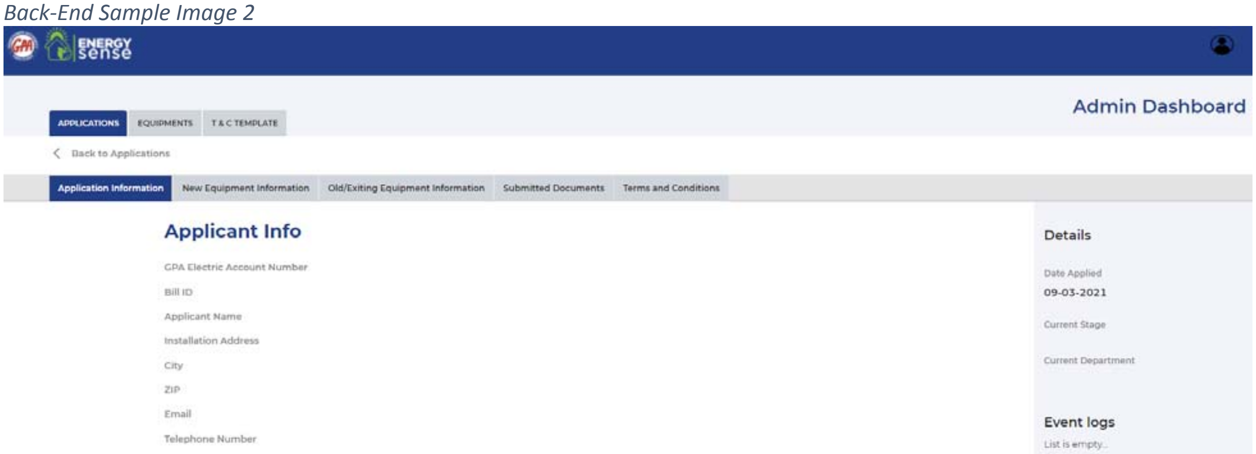


Figure 3-6. Back-end Sample Image

With both the Front-End and Back-End portals under development the rest of the digital transformation involves GPA's overall rebate process. This includes application submission, review, processing, approvals, and lastly check-issuance. Figure 3-7 illustrates the most recent digital process flow.

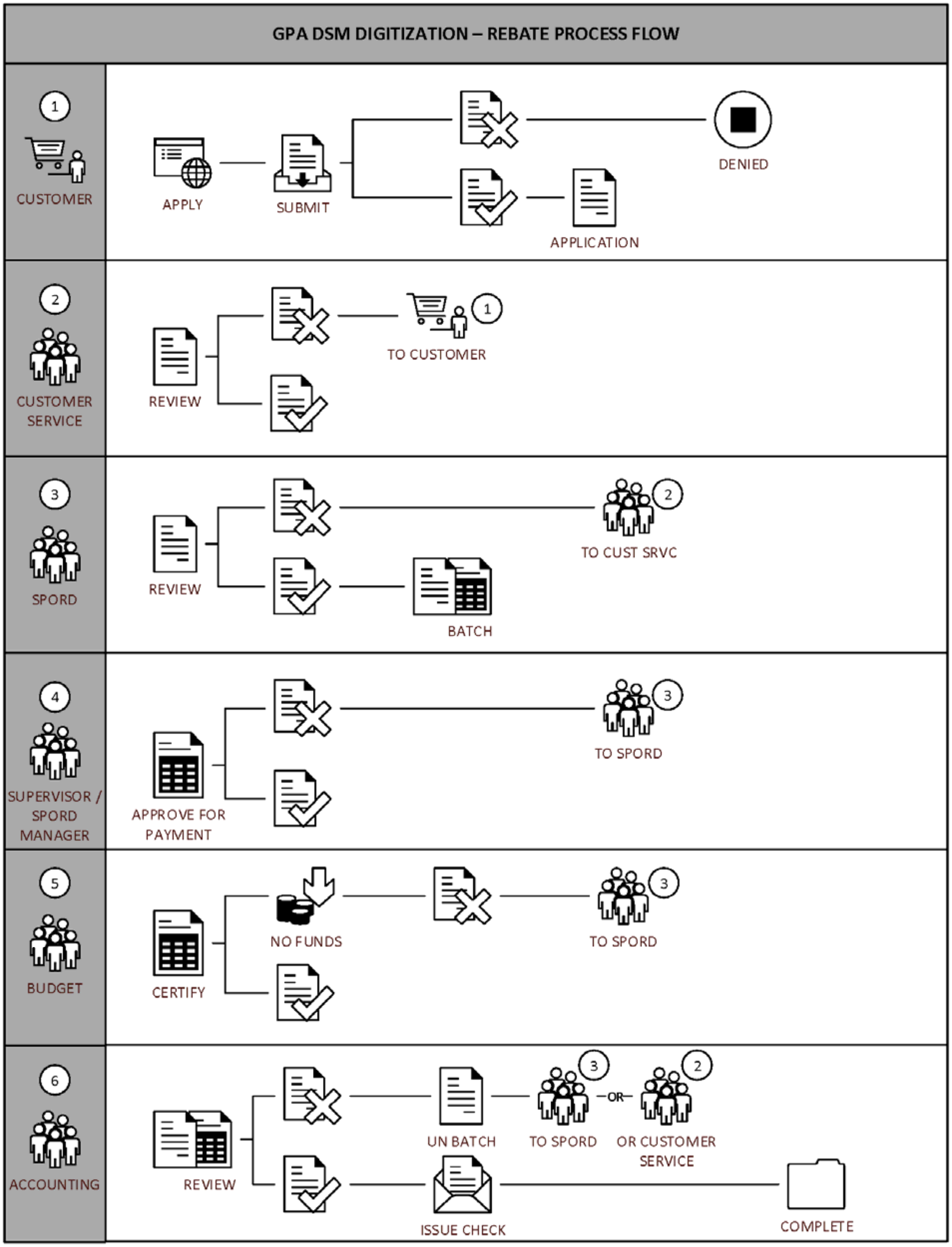


Figure 3-7. GPA DSM Digitalization Transformation - Digital Process Flow Diagram

On May 2020, GPA established an on-premise database server to interact with Xtendly's database. Having the server "on premise" allows for GPA to directly control the security, infrastructure, and data. This structure creates a better network topology to allow for custom reporting, future-proofing, and potential integration with other GPA systems. As the project stands, it is nearing the latter part of the build, testing, and deployment phases. Figure 3-8 below illustrates the DSM digitization development process.

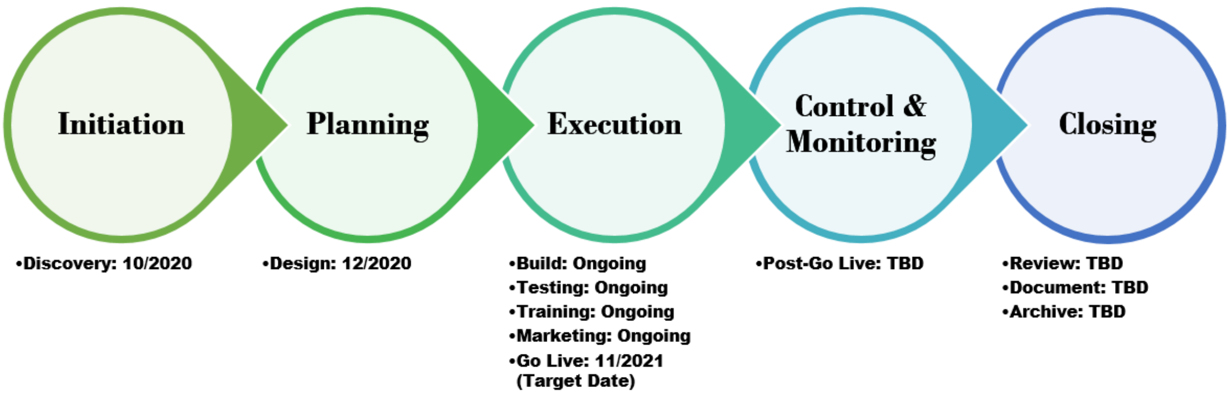


Figure 3-8. DSM Digitization Development Flow

DIGITAL CHALLENGES AND THREATS

While going digital has its benefits it also has its own unique challenges and potential threats. Throughout the digital transformation, GPA has remained cognitive of balancing a customer focused approach along with ensuring system security.

Challenges:

- Ease-of-Use versus system security
- Creating to a digital mindset for all stakeholders

Threats:

- Cyber security
- Fraudulent applications or users

Most recent digital applications and programs deployed locally in Guam, particularly those involving financial assistance for the COVID-19 pandemic, have experienced some of these issues. This demonstrates some important lessons that GPA needs to remain cognitive of as it deploys this newly developed digital program, application, and process.

3.2.4 DSM Marketing Plan Execution

Initial DSM Rebate Program marketing activities included setting up the DSM Rebate Program Website and rebate forms. GPA developed a website for its rebate program called Energy Sense - http://guampowerauthority.com/gpa_authority/EnergySense/es-home.html. GPA also created the rebate programs and conducted trade ally training.

The expanded DSM Rebate Program is fully explicated in the presentation "PUC Report - DSM"[1] referenced in the PUC RFI as "the September 1, 2017 report." This report is reproduced in Appendix B.

GPA executed the DSM Marketing Plan in FY 2016 through 2018. These advertising and outreach activities greatly accelerated the program growth. However, GPA significantly decreased DSM marketing activities in FY 2019 and FY 2020. Table 3-5 illustrates the Marketing Checklist for implementing the DSM Rebate Program. The rationale behind this decision included:

- Funding should be focused and prioritized on paying out rebates;
- Marketing activities generated more interest in the program and thus increased the number rebates paid out straining available budgets;
- Trade ally marketing activities generated interest in the program resulting in program growth;
- SPORD staff in charge of the DSM program oversee other critical projects including the New Power Plant, Phase II and Phase III Renewable Acquisition projects, Mobile Workforce Management System Deployment, managing GPA's fuel supply chain, etc.

[1] Cruz, John J. Jr. (2017). Energy Sense Program: Setting a Sustainable DSM Program. Guam Power Authority

Table 3-5 – Expanded DSM Rebate Program Marketing Checklist

Marketing Checklist	Check if Completed
Create Point-of-Sales Signage Kits	**Ongoing**
Create Opportunities for Trade Ally Cooperative Advertising	**X**
GPWA Green Home Expo Event	
Market Research	**Ongoing**
Participant Focus Groups & Surveys	**Ongoing**
Trade Ally Feedback	**X**
GPWA Rebate Processor Feedback	**Continuous**
Customer Feedback	**X**
Customer Surveys	**X**
Outreach	**Ongoing**
Reach Out to UOG on Participating in their Energy Model Home Display	**X**
Smart Home with L+G Meters/Home Area Network	
GHURA	
GDOE	**X**

3.2.4.1 Media Advertising

SPORD solicited and contracted Adztech to support the team with DSM marketing. GPA's Public Information Office (PIO) and Adztech developed print, television, and radio advertisements. In August 2021, GPA entered into a 5-year contract with Adztech for Energy Sense Rebate Program Marketing Services (GPA-RFP-21-004). Contract scope is as follows:

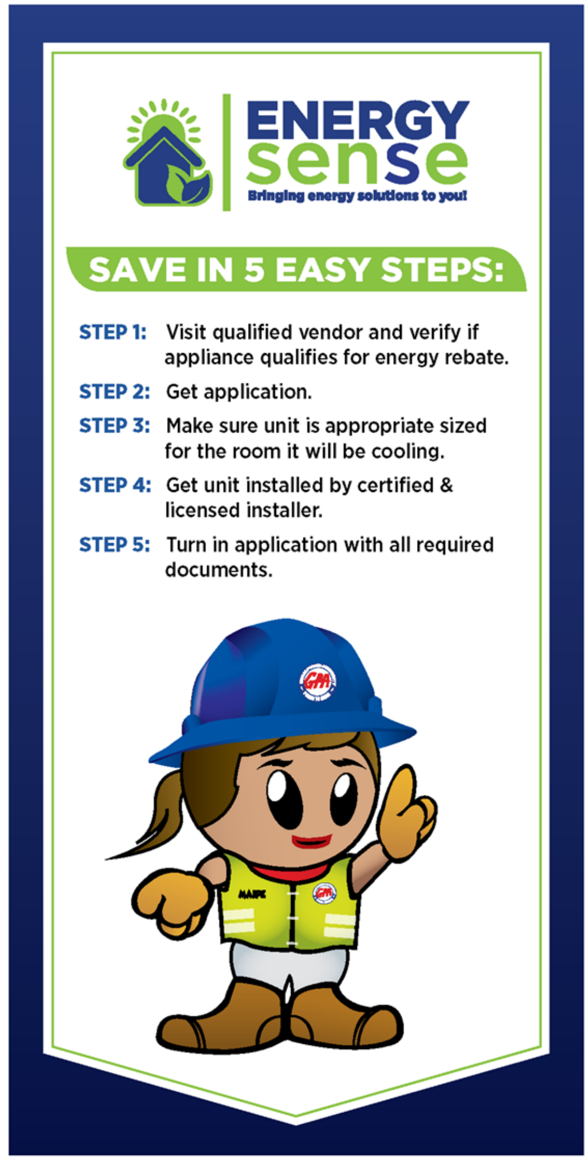
- Design and execute marketing programs for Energy Sense Rebate Programs;
- Design and provide point-of-sales advertising banners, posters, and other materials for each specific rebate technology class such as residential and commercial air conditioning, commercial lighting, etc. for use by trade allies;
- Design and provide print, television, radio, social media, and other media advertising;
- Design and provide a K-12 curriculum for energy efficiency and island sustainability for use by public and private schools as part of their STEM programs;
- Create videos and other marketing materials for GPA to us at its facilities to inform customers about the program;
- Design and provide a traveling marketing kit for GPA to use at trade shows, village meetings, and other public events to educate customers about GPA's Energy Sense Green Island activities;

- Perform statistically valid surveys and conduct focus groups to provide meaningful and actionable information for strategic and operational decisions;
- Develop and provide a marketing program for Electrification of Guam transportation;
- Create videos for YouTube educating customers about energy efficiency, the GPA Energy Sense Program, DIY energy audits, energy saving tips;
- Marketing consultations or educational tutorials as required;
- Any other marketing or advertising services for the GPA Energy Sense Rebate Program and other DSM pilots and programs approved or ordered by the Guam Public Utilities Commission.

3.2.4.2 Point-of-Sales Kits

The PIO and marketing contractor developed an eleven-piece point-of-sale kit distributed to trade allies. These kits standardized the presentation of equipment eligible for rebates as well as helped the DSM Rebate Program stand out among other elements in trade ally showrooms. Figures 3-9 through 3-12 show examples from the sales kit.

3ft x 5ft RETRACTABLE SIGN 1



3ft x 5ft RETRACTABLE SIGN 2

Figure 3-9 – Trade Ally Point-of-Sale Kit: Retractable Signs

8.5in x 11in DSM Register Sign

Figure 3-10 – Trade Ally Point-of-Sale Kit: DSM Register Sign

6in x 4in Shelf Talker 1

Figure 3-11 – Trade Ally Point-of-Sale Kit: Shelf Talker 1

6in x 4in Shelf Talker 2

Figure 3-12. Trade Ally Point-of-Sale Kit: Shelf Talker 2

Going forward with the implementation of the expanded program, most of the sales kit is re-useable and applies to most of the new technology streams. GPA will develop additional point-of-sales material for Solar Thermal Assisted AC products and Commercial Building Energy Management System.

3.2.4.3 Opportunity Marketing

GPA continues to participate in the UOG Center for Island Sustainability (CIS) conferences and other venues allowing opportunities to showcase GPA's DSM rebate program. GPA participates in interviews from local media about the DSM program.

3.2.4.4 Customer Surveys and Market Research

Customer surveys are pure market research and should be conducted at least annually. Figure 3-13 shows GPA survey results throughout the decade. In 2014, residential customer satisfaction ticked up by almost 10% due to Smart Grid activities. In 2018, residential customer satisfaction ballooned upwards by 15% from 2014.

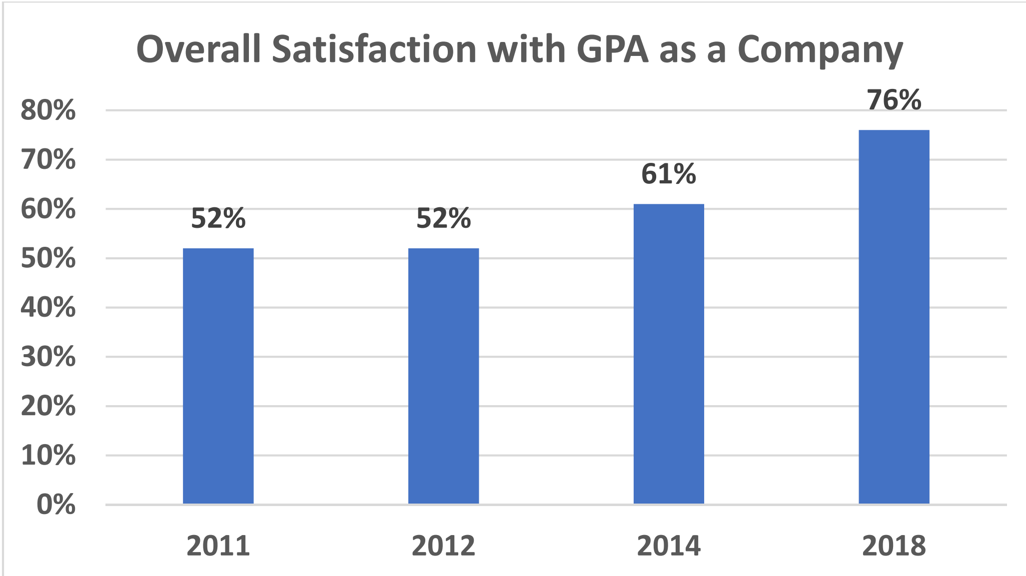


Figure 3-13 – Residential Customer Satisfaction Survey Results throughout the Decade

The analysis of the FY 2018 survey concluded that customers participating in the DSM rebate program or who had knowledge of the program were strongly likely to have positive opinions about GPA as a company. Participation and awareness of GPA's DSM Rebate Program are the strongest measures associated with customer satisfaction. The analysis indicated:

> "The strongest measure of association was found among rate payers who participated in the Energy Sense Program (ESP). 82% of ratepayers who participated were satisfied with GPA compared to 76% of all rate payers regardless of their participation. Perhaps more interesting was that none of the rate payers who participated in the ESP indicated they were dissatisfied with GPA."[2]

As of May 2020, The DSM rebate program including DSM marketing and outreach activities, DSM planning and studies, and rebate payments have been funded by the LEAC (Guam PUC Order - GPA Docket 20-05).

[2] Merrill, Jay. (2018). "Possible Drivers of Satisfaction with GPA." Merrill & Associates. Slide 6.

3.2.4.5 Outreach

Recommendations from the expanded DSM Plan and discussions of that plan include participation and development of community outreach wherein energy efficiency and renewable energy are discussed and demonstrated. This outreach may include but not be limited to:

- Regular Village Workshops;
- Meetings with Guam Housing & Urban Renewal Authority (GHURA), Guam Association Realtors (GAR), Guam Department of Education (GDOE), Department of Navy (DON), Andersen Air Force Base (AAFB), and other large customers;Participation in Home Expo, Trade Show, and Sustainability Type Events;
- Development of a K-12 Curriculum and Demonstrations;
- Participation and speaking at Professional Organization Events such as the Rotary Club, Guam Association of Realtors, Guam Hotel & Restaurant Association, Society of American Military Engineers, etc.;
- Creation and Annual Hosting of a GPA DSM event showcasing energy efficiency, renewable energy, energy contracting, trade allies, and GPA's DSM Program offerings.

GPA participates in the annual UOG Center for Island Sustainability (CIS) Conference as a sponsor, panel members, and speakers.

3.2.4.6 Branding

GPA must invest in creating an Energy Sense Brand and complete a Voice of the Customer Quality Functional Deployment (VOC QFD). The VOC QFD aligns customer requirements with each element of how each unique service is delivered. "QFD is a methodology by which Voice of Customer (VOC) is converted to design parameters (or CTQ) for developing a new process or product."[3] GPA has yet to complete this set of tasks.

[3] Suvo. (2015). Quality Function Deployment in Voice of the Customer. URL: https://www.brighthubpm.com/six-sigma/34740-quality-function-deployment-in-voice-of-the-customer/ (Last Visited February 17, 2020)

3.2.5 Metering & Verification (M&V)

A metering & verification program is an expensive and complex proposition. Performing an M&V process on every rebate application is not feasible.

GPA subscribes to four major measurement and verification (M&V) activities including:

- Determining baselines and estimated savings;
- Developing the different M&V plans for rebate programs, UESC and Large Customers;
- Developing the post-installation M&V report, a part of conducting post-installation M&V activities
- Performing periodic M&V to determine whether the savings persist.

GPA incorporates M&V activities in its UESC, BEST Schools Program, and pilot programs. The results of these activities are strongly indicative of incorporating energy efficiency into homes and businesses. GPA continuously refines the M&V processes used in the above programs. Table 3-6 refers to the Metering & Verification Checklist staus for implementing the expanded DSM program. GPA will use DSM funding to purchase the necessary equipment and training to perform these M&V activities.

An example of an excellent M&V application is GPA's partnership with the University of Guam Center for Island Sustainability. This report discusses this partnership under Section 2.6 Pilot Projects.

Table 3-6. Metering & Verification Checklist: Expanded DSM Rebate Program Implementation

Metering & Verification Checklist	UESC	BEST Schools	Pilots	Residnetial Rebate Programs	Commercial Rebate Programs
Create M&V Process	X	X	X	X	X
Create M&V Performance Dashboards	X	X	X		
Execute & Refine Process	X	X	X		

3.3 Utility Energy Services Contracting (UESC) Program

GPA's Utility Energy Services Contracting (UESC) Program is patterned after the federal government program under the same name. The Federal Energy Management Program (FEMP) recognizes GPA as a utility partner under the FEMP Utility Partnership Program.[4]

Authorized by the Energy Policy Act of 1992, P.L. 102-486 (codified as 42 U.S.C. 8256), the federal Utility Energy Service Contract (UESC) is a limited-source contract between a federal agency and its serving utility for:

- Energy-efficiency improvements;
- Water-efficiency and conservation improvements;
- Demand-reduction services including renewable energy supply.

"A UESC between a customer federal agency and a franchised serving utility can be put in place for the utility to provide energy management services such as:

- Assessing project potential;
- Designing solutions;
- Providing project financing;
- Installing the measures;
- Providing performance assurance."[5]

GPA's UESC Program is open to federal agencies and large customers. In addition to the federal UESC program, GPA's UESC Program may provide:

- Energy Efficiency Project Development and Execution;
- Renewable Energy Project Development and Execution;
- Resiliency Project Development and Execution for Department of the Defense Customers;
    - Back-Up Power;

[4] Federal Energy Management Program. (2021). Utility Program Utility Partners. URL: https://www.energy.gov/eere/femp/utility-program-utility-partners.
[5] Utility Energy Service Contracts for Federal. Agencies. URL: https://www.energy.gov/eere/femp/utility-energy-service-contracts-federal-agencies (Last visited February 17, 2020)

- Specialized Power Quality;
- Microgrids;
- “Behind the Fence” Projects Enhancing Energy and Power Quality Resiliency.

GPA partners with world class Energy Services Companies (ESCO) to deliver UESC services. GPA acquires these partnerships through a competitive RFP process. GPA partnered with Johnson Controls, Inc. (JCI) and Science Applications International Corporation (SAIC) from 2009 through 2016. GPA has currently partnered with Siemens Industry, Inc. under its Smart Infrastructure, Energy Performance & Services unit.

Between 2009 through 2016, GPA performed audits at several Guam commercial businesses including but not limited to KenCorp hotels. GPA also conducted audits for the Department of the Navy, the Federal Aviation Administration, and other federal agencies. GPA also facilitated GIAA’s energy efficiency contract with JCI helping manage the contract including managing third-party metering & verification (M&V). GPA’s UESC team partnered with the Guam Energy Office to execute approximately $20 MM of energy efficiency federal grants. This ensured that Guam would not lose these grants. GPA also performed residential audits on behalf of GEO.

After the contracts with JCI and SAIC expired, GPA suspended the UESC program until it completed procurement for another ESCO partner. In the interim, GPA secured a Basic Order Agreement (BOA) from the Department of the Navy to facilitate Navy’s procurement of projects performed under GPA’s UESC Program.

The Guam Power Authority and Siemens Engineering Team completed site evaluations at Naval Base Guam (NBG) and Andersen Air Force Base (AAFB) in November 2019. As a result of these evaluations, Siemens has prepared several site-specific Energy Conservation Measures (ECMs) for each facility. These ECMs will be used as viable building blocks for a preliminary assessment request in order to further develop projects on energy efficiency, reliability, and resiliency.

UESC funding comes from customers and grants. GPA’s ESCO partner provides the initial preliminary audits at their risk and at no cost to GPA or customers. Customers may choose to move towards a detailed investment grade audit (IGA). The IGA provides a more detailed audit and engineering analysis sufficient to bring to UESC financiers if third-party financing is desired. The IGA is not for free. Customers have the option of paying for the IGA if they choose not to go forward with recommended projects, or proceeding to projects based on the IGA. The ESCO partner may provide guarantees of the estimated savings should the customer want it.

3.4 Bringing Energy Savings To (BEST) Schools Program

GPA BEST Schools program is a derivative of GPA's UESC Program specifically targeted towards Guam Public Schools. The Consolidated Commission on Utilities approved the BEST Schools Program and allocated $500,000 of seed funding from the savings garnered from GPA's refinancing of revenue bonds. GPA allocated these funds towards:

- A preliminary feasibility assessment for Guam Department of Education (GDOE);
- A pilot project for installing energy efficiency retrofits at a pilot school.

Guam Power Authority contracted with Siemens Industry, Inc. (Siemens) in April, 2018 to perform a preliminary feasibility assessment for Guam Department of Education (GDOE) as part of the Bringing Energy Savings to (BEST) Schools Program. The preliminary assessment was designed to help GDOE achieve the legislative mandate to decrease overall energy consumption by 10% and explore renewable energy systems. GPA and Siemens designed the preliminary feasibility to help GDOE achieve their legislative mandate to reduce their overall energy consumption by 10% and to deploy renewable energy systems. Additionally, GDOE could use this study to help prioritize and plan how to reduce their operational expenditures, while modernizing their infrastructure and extending the life of their equipment.

GDOE's facilities include 27 elementary schools, 8 middle schools, and 6 high schools and their combined area approaches 4,000,000 ft^2. Siemens and GPA conducted site walk-through audits at GDOE locations from June 11, 2018 through June 22, 2018 and again from July 9, 2018 through July 10, 2018. Based on these level one audits and other existing documents and information, the study explored the financial viability of the following targeted Facility Improvements Measures (FIMs):

- Heating Ventilation & Air-Conditioning (HVAC) Systems;

- Water/Wastewater Systems;
- Energy Management Systems (EMS);
- Lighting Systems;
- Operations & Maintenance (O&M) Efficiencies.

GPA and Siemens completed the study, “Bringing Energy Savings to (BEST) Schools Program – Preliminary Feasibility Assessment,” in October 2018. GPA and Siemens jointly presented the results of this study to GDOE management in 2018.

The preliminary study included a utility cost and savings analysis and a summary of the existing conditions of the systems targeted for improvements by school. Siemens’ Facility Improvement Measure (FIM) recommendations are prioritized and ranked based on preliminary estimates of project implementation costs and expected savings. For additional details, please refer to the study.

GPA and GDOE selected B. P. Carbullido Elementary School as the school to receive the pilot energy efficiency retrofits. GPA and Siemens completed the pilot project by August 2019.

Going forward, until such time that GDOE is able to fund the recommendations made by GPA and Siemens, for fiscal years 2019 and 2020, GPA has applied for federal grants on behalf of GDOE to keep the program moving. In FY 2019, GPA obtained two grants for a total of $1.25 MM from the Department of Interior’s Office of Insular Affairs Energizing Insular Communities Program. These two grants funded LED lighting retrofits for Southern High School and George Washington High School. GPA and Siemens completed these grant project by August 2019 starting construction work on these projects in the summer months. In FY 2020, GPA obtained two grants totaling $ 1,109,387 for LED retrofits at Agueda I. Johnston Middle School and Maria A. Ulloa Elementary School. GPA and Siemens will complete these retrofits by August 2020.

GPA’s BEST Schools Projects have or will have provided GDOE free of charge the following technologies from the list of technologies approved for GPA’s expanded DSM Rebate Program:

- B.P. Carbullido Elementary School;
    - Customer Energy Audits;

    - Commercial A/C: High Efficiency Split, Ducted A/C System and Solar Thermal Assisted AC Collectors;
    - Commercial Building Energy Management System;
    - Commercial Indoor and Outdoor Lighting;
- Southern High School and George Washington High School;
    - Customer Energy Efficient Lighting Audits;
    - Commercial Indoor and Outdoor Lighting;
- Agueda I. Johnston Middle School and Maria A. Ulloa Elementary School (by August 2020);
    - Customer Energy Efficient Lighting Audits;
    - Commercial Indoor and Outdoor Lighting.

GPA can make the case that prior to executing the expanded rebate program it has provided $2,859,387 to a large customer for energy efficiency audits and approved DSM equipment fulfilling a portion of the PUC's DSM mandate.

3.5 Grant Funded Projects

Guam Power Authority has a history of success for augmenting its funding for renewable energy, energy efficiency, T&D undergrounding, and Smart Grid projects through federal grants. Grants are a significant part of GPA's DSM funding strategy. In particular, GPA has received several grants from the Department of Interior's (DOI) Office of Insular Affairs (OIA) Energizing Insular Communities (EIC) Program helping the Authority fulfill the PUC's DSM mandate to promote energy efficiency among its residential and non-residential customers.

3.5.1 Grant Funded Projects Associated with the BEST Schools Program

GPA and GDOE collaborated on a grant opportunity for energy efficiency projects under the Department of Interior's (DOI) Energizing Insular Communities grant program. GPA was awarded grant funding for LED lighting retrofit at George Washington High School & Southern High School. Construction was completed in Summer, 2019.

In October, 2019 GPA received notice from the Office of Insular Affairs' Energizing Insular Communities (EIC) of new grant award in the amount of $1.1M for BEST Schools LED Lighting Retrofit Projects at Agueda I. Johnston Middle School and Maria A. Ulloa Elementary School. Construction is expected to begin Summer, 2020.

The aforementioned grants, affected school, and grant amount include:

- FY 2019 EIC Grants Awarded to GPA
  - $954,685 to fund the Bringing Energy Savings To (BEST) schools program for an LED lighting retrofit at Southern High School;
  - $295,315 to fund the Bringing Energy Savings To (BEST) schools program for an LED lighting retrofit at George Washington High School;
- FY 2020 EIC Grants Awarded to GPA
  - $586,771 to fund the Bringing Energy Savings To (BEST) schools program for an LED lighting retrofit at the Agueda I. Johnston Middle School;
  - $522,616 to fund a BEST schools program LED lighting retrofit at the Maria A. Ulloa Elementary School.

These four EIC grants fulfill the PUC's mandate for:

- Providing Customer Energy Efficient Lighting Audits;
- Incentivizing Commercial Indoor and Outdoor Lighting.

GPA plans to submit additional LED lighting retrofit grant proposals on behalf of GDOE schools for FY 2021.

3.5.2 Grant Partnerships with the Guam Energy Office

GPA has once again renewed its successful partnership with the Guam Energy Office (GEO). GPA fully supports the GEO mandate and as in the past will continue to provide GEO with technical and project management support on their grants.

The U.S. Department of Energy has awarded a competitive grant to Guam Energy Office. The $75,000 grant will go toward developing an EnergySmart Schools Program establishing energy management practices for up to four Guam K-12 facilities.

According to GEO's press release in the Guam Post, the funding supports[6]:

- In-depth energy audits at participating (private) schools;
- The development of site-specific recommendations for building upgrades;
- The development of K-12 curriculum and student-engagement services;
- An EnergySmart conference at the project conclusion; and
- Training activities for attendees of the EnergySmart conference.

The EnergySmart Schools Program audits, site specific recommendations, and curriculum development were completed in the 2nd Quarter of 2021. The EnergySmart conference is planned for November 2021. This grant will help fund the DSM Final Report's recommendation to help establish a K-12 STEM Program curriculum for Guam. This will allow GPA to complete the DSM Program requirement to develop a K-12 STEM curriculum.

3.6 Pilot Projects

Pilot projects are projects used as learning experiences. Examples of pilot projects that GPA has completed include:

- Cotal Wind Turbine Generator;
- UOG Energy Efficient Model House;
- B.P. Carbullido Elementary School Energy Efficiency Retrofit.

[6] Daily Post Staff. (2019). Guam Energy Office receives $75K for schools program. URL: https://www.postguam.com/business/local/guam-energy-office-receives-k-for-schools-program/article_5baf9d20-3fb7-11e9-91e9-93b625882301.html (Last visited February 17, 2020).

The expanded DSM Program calls for a 100 Residential and Commercial Customer ESS Pilot Program. The pilot programs GPA will perform under this requirement include:

- Demand Reduction Pilot for San Vitores Large Customers with coincident demands greater than 500 KW;
- ESS for legacy NEM customers for frequency and voltage control.

3.6.1 Cotal Wind Turbine Generator Projects

GPA received a $2.1 MM EIC grant from the DOI/OIA to install a 275 KW Vergnet Wind Turbine Generator (WTG) at Cotal. The project was a complete success. Robi Robichaud then of NREL wrote that the insular areas should use the Guam project as the standard for all future wind projects.[7] GPA completed the installation of the WTG in 2016. Subsequent enquiries of Vergnet indicate that three or four additional WTGS could be installed at Cotal producing electric power at about 9.5 cents per kWH.

GPA partnered with the University of Guam (UOG) Center for Island Sustainability (CIS) to retrofit its office building in Dean Circle with energy efficient appliances and practices. The UOG CIS building is surrounded with buildings with exactly the same design, construction, and use. GPA and Siemens developed a metering & verification process in order to capture the energy, demand, and monetary savings. The surrounding similar buildings were part of the M&V process. The purpose of this model office was to showcase the benefits of demand side management.

In March, 2018, the Guam Power Authority provided energy efficient appliances to be used in the newly renovated SEA Grant office in UOG Dean's Circle. Appliances provided include four (4) high-SEER air conditioners, one (1) energy efficient water heater, seven (7) LED lighting fixtures with occupancy sensors, and one (1) ENERGY STAR® refrigerator.

The Energy Efficient Model Office pilot achieved between 50% to 75% energy, demand, and monetary savings over energy use performance of the similar buildings around it. The savings are equivalent to having installed a 9.5 cent per kWH solar power purchase agreement.

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[7] Robichaud, Robi. (2016). Cotal Wind Turbine Project. National Renewable Energy Laboratories. Boulder, Colorado.

GPA and Siemens completed the B.P. Carbullido Elementary School Energy Efficiency Retrofit Project and is currently monitoring the project energy performance.

The DSM Expanded program requirement for GPA to conduct a 100 Residential and Commercial Customer ESS Pilot Program is a demand reduction and demand-response pilot program. Should the pilot prove successful in demonstrating sufficient benefit for GPA and Customers, GPA will include another activity under its DSM Program: Demand-Response. GPA plans to bid this pilot program out and fund the program out of DSM LEAC funding. GPA would either reduce the amount of rebates from both residential and commercial programs to fund this pilot over a five-year period, scale the pilot back, execute the project in smaller phases, or request additional funding.

4 Establishment of a New DSM Section

The CCU has approved a new Demand-Side Management and Green Programs (DSM&GP) Section under the Strategic Planning & Operations Division (SPORD). DSM&GP manages GPA's DSM Rebate, UESC, Demand Response and Interruptible Load, Renewable Energy, BEST Schools, and other Green Energy Customer Programs.

GPA has approved a six-staff Demand-Side Management and Green Programs (DSM&GP) Section. For FY 2020, GPA budgeted for a four-staff. GPA promoted Francis J. Iriarte, PE into the Supervisor position. Mr. Iriarte holds Professional Engineering Licensure for Guam, and the Certified Energy Auditor and Certified Energy Manager certification from the Association of Energy Engineers. He has over ten years' experience working on energy efficiency and renewable energy projects. He is currently supported by a Management Analyst (Harvey J. Camacho) and an Engineer II (Victor A. Torres). GPA has recently recruited an Engineer III (Josepher Fernando) to support the section and will recruit for an additional DSM section engineer.

With the expansion of the DSM Rebate Program, GPA should expand the DSM&GP to its full complement of six full-time employees. GPA should contract some administrative work out as the volume of rebates expands.

5 DSM Organizational Infrastructure

This section discusses the following topics under the umbrella of organizational infrastructure:

- DSM Planning and Establishment of Rebate Levels;
- Creation of a Consolidated DSM Program Handbook;
- Continuing Research on New Energy Efficiency Technologies.

5.1 DSM Planning and Establishment of Rebate Levels;

GPA performed a significant amount of DSM planning in FY 2021 re-determining appropriate rebate levels for the existing and new rebate programs as part of the FY 2022 Integrated Resource Planning Process. GPA contracted with Sheffield Scientific LLC and Utility Financial Solutions LLC to complete this work. Part of the consulting work scope is to train GPA Energy Sense Staff to perform these analysis going forward.

5.2 Creation of a Consolidated DSM Program Handbook

Creation of a Consolidated DSM Handbook flows from completion of the following activities:

- Rebate Process Swim Lane Mapping;
- Trade Ally Certification Process Mapping;
- Eligible Equipment Certification Process Mapping;
- DSM Marketing Process Mapping;
- DSM Message Map;
- Metering & Verification Process Mapping;
- UESC Program Process Mapping;
- BEST Schools Program Process Mapping;
- Grant Program Process Mapping;

- Pilot Project Program Process Mapping;
- Job, Task, and Responsibility Mapping of the DSM Section Staff;
- Identification of Education, Certification, and Training Required for each DSM Staff Position.

5.3 DSM, Continuing Research, and the Learning Organization

The DSM Section is a continuous learning organization. The learning and education of DSM staff never ends. The core knowledge areas within DSM include:

- Energy Efficiency;
- Renewable Energy;
- Energy Contracting;
- Demand-Response;
- Metrology and sensors;
- Power Quality;
- Building Controls and Energy Management Systems;
- Co-generation and Tri-generation.

Obtaining competence and later excellence in these knowledge areas requires training, certification, professional registration, networking among peer professionals, and an extensive grounding on trade ally technology, products, and services. It requires continuous research in the state-of-the-art in multiple disciplines.

Each DSM staff member must work closely with trade allies becoming experts on their products. As engineer engineering professionals, the DSM Supervisor and engineering staff must earn the essential professional certifications for the job.

The DSM Supervisor must earn the following minimum set of Association of Energy Engineers certifications:

- Certified Energy Auditor (CEA);
- Certified Energy Manager (CEM);

- Certified Measurement & Verification Professional (CMVP);
- Renewable Energy Professional (REP).

DSM engineers must earn the following minimum set of Association of Energy Engineers certifications:

- Certified Energy Auditor (CEA) on promotion to Engineer II;
- Certified Energy Manager (CEM) on promotion to Engineer III;
- Renewable Energy Professional (REP) within five years of date of hire into the DSM section.

DSM Management Analysts must earn one of the following Association of Energy Engineers certifications:

- Energy Efficiency Practitioner;
- Certified Residential Energy Auditor;
- Performance Contracting and Funding Professional.

Maintaining the above certifications requires annual training, education and practice in the discipline. GPA must subscribe to a membership in the Association of Energy Engineers as well as their engineering discipline: IEEE, ASME, ASHRAE.

Members of the DSM section must attend the following professional events at least once every three years and at least one member attending one of these events every year:

- Association of Energy Engineers (AEE) Energy Conference & Expo (East, West, or World);
- Association of Energy Services Professionals (AESP) National Conference & Expo;
- Smart Electric Power Alliance (SEPA) Utility Conference.

The Association of Energy Engineers (AEE) Energy Conference & Expo brings together energy professionals from commercial, industrial, institutional, and governmental sectors to learn about the latest energy-saving strategies, products, services, and technologies. There are three conferences AEE East, AEEE West, and AEE World held at different times and locations in the United States and internationally. The event provides multiple opportunities for networking, or meeting with potential vendors and business partners.

The Association of Energy Services Professionals (AESP) National Conference & Expo is a premier energy industry event for top program managers, implementers, marketers, evaluators, policy makers, consultants, and manufacturers in Demand-side Management and Energy Efficiency. The conference features more than 40 sessions covering tools and technology, demand response, implementation, and more, in addition to top-notch educational sessions, pre-conference workshops, and networking events.

The Smart Electric Power Alliance (SEPA) Utility Conference is not simply a trade show; rather, it is the place where utilities share how they solve issues related to renewable energy, transportation electrification, energy storage, and energy efficiency in a confidential, intimate setting. Topics cover everything from speeding up solar interconnection queues to best practices for determining the locational value of your DER assets. Celebrate grid modernization and distributed energy achievements, learn about projects and innovations, and be prepared to share takeaways with your peers.

DSM Section members must have full understanding and proficiency of the California Standard Practice Manual Economic Analysis of Demand-Side Programs and Projects. They must have full understanding and proficiency of the "Methods of Demand Site Management and Demand Response."[8] GPA will complete this manual by the end of FY 2022.

6 DSM Rebate Program Growth

Figure 5-1 illustrates the growth of rebate payouts for the existing DSM Rebate Program. Fiscal years 2016 through 2020 are historical. FY 2021 uses historical data along with projected data for the remaining months. Table 6-1 shows the categories of expenses. The first three years of the program experienced exponential growth. However, program growth seems to have slowed down considerably in FY 2019 through FY 2021 compared to previous years. However,

[8] 6. Saad, Muhammad. (2016). Methods of Demand Site Management and Demand Response. Research & Reviews: Journal of Engineering and Technology. Volume 5, Issue 3. ISSN:2319-9873.

GPA program advertising was negligible in both those years and may be the reason why program growth plateaued. Performing a regression analysis on the first three fiscal years historical growth and marketing expenses yields an R-Squared of 0.904. Investing in marketing/advertising explains about 90.4% of the growth in the program. More marketing/advertising strongly indicates higher growth.

Initial first full year funding requirements for the DSM Commercial Rebate is likely to be on the order of one million dollars as per discussions with Lynn Scott from GESI. Mr. Scott believes that there is substantial market demand for the products for which GPA will provide rebates for in the expanded program.

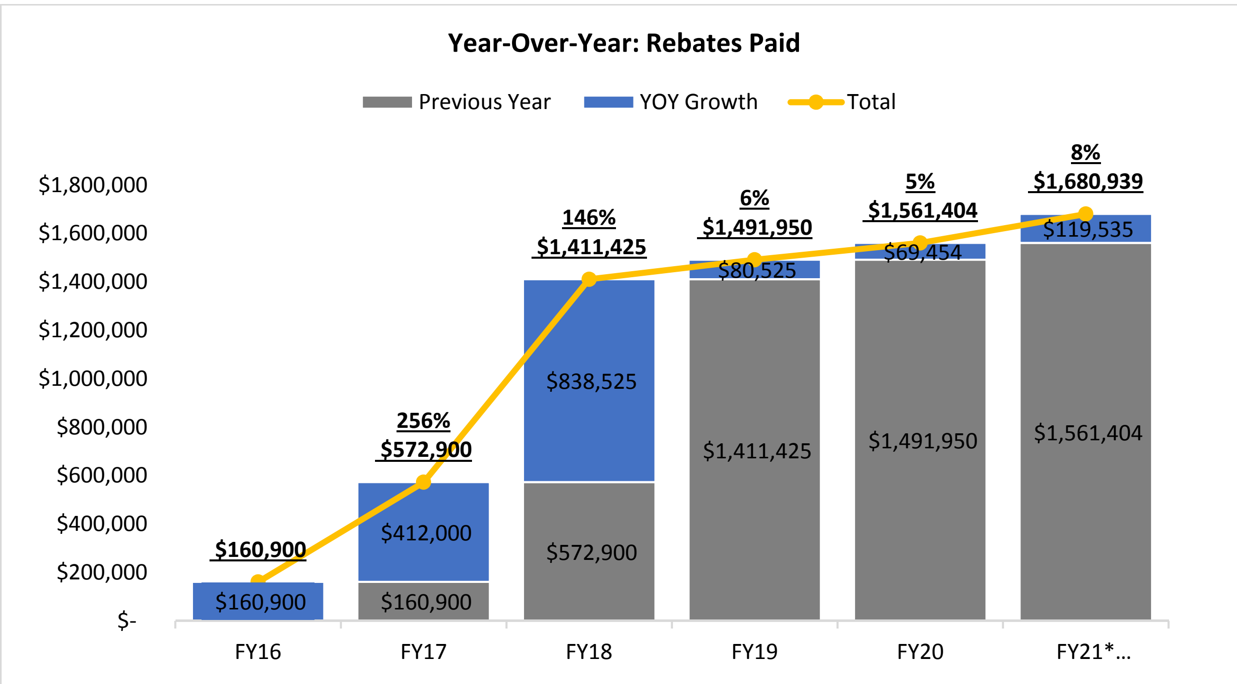

Figure 6-1. DSM Rebate Program Growth

Table 6-1 – DSM Rebate Program Expenses

Annual Expenses

Fiscal Year	**FY16**	**FY17**	**FY18**	**FY19**	**FY20**	**FY21***
Rebates-Split A/Cs	$ 154,700	$ 557,275	$ 1,349,825	$ 1,374,650	$ 1,468,001	$ 1,454,425
Rebates-Central A/Cs	$ 3,400	$ 8,200	$ 4,400	$ 6,500	$ 2,400	$ 2,300
Rebates-Washer/Dryer	$ 2,800	$ 7,425	$ 57,200	$ 110,800	$ 91,003	$ 94,097
Remaining FY21 Projections*						$ 130,117.00
Total Paid Rebates	**$ 160,900**	**$ 572,900**	**$ 1,411,425**	**$ 1,491,950**	**$ 1,561,404**	**$ 1,680,939**
Non-Rebate Expenses (Marketing & Collateral)	**$ 39,627**	**$ 107,806**	**$ 143,099**	**$ 62,740**	**$ 47,402**	**$ 83,932**
Total Expenses	**$ 200,527**	**$ 680,706**	**$ 1,554,524**	**$ 1,554,690**	**$ 1,608,806**	**$ 1,764,871**

Program Gorwth Based on Expenses

Fiscal Year	FY16	FY17	FY18	FY19	FY20	FY21
Previous Year's Rebates Paid	$ -	$ 160,900	$ 572,900	$ 1,411,425	$ 1,491,950	$ 1,561,404
Growth form Previous Year	$ 160,900	$ 412,000	$ 838,525	$ 80,525	$ 69,454	$ 119,535
Growth per Year (%)	100%	256%	146%	6%	5%	8%
Total Paid Rebates	**$ 160,901**	**$ 572,903**	**$ 1,411,426**	**$ 1,491,950**	**$ 1,561,404**	**$ 1,680,939**

**Data is as of 8/31/2021*

7 Energy Sense Program Funding

Under the May 28, 2020 Guam PUC Order (GPA Docket 20-05), the Guam PUC approved funding for the Energy Sense Program under the Levelized Energy Adjustment Clause (LEAC) consistent with past Guam PUC precedents funding GPA's Renewable Power Purchase contracts under LEAC. The PUC ordered that the LEAC rate nominally include funding for $1,500,000 per LEAC period beginning June 1, 2020. The funding amount allocated for Energy Sense will be trued up every six-months with each LEAC going forward. The first true-up will occur in the December 2020 GPA submittals for the February to July LEAC period.

LEAC funding allows GPA to expand the Energy Sense Rebate program to include additional eligible appliances for residential customers and rebates for eligible equipment for non-residential customers.

8 Energy Sense Rebate Program Incentive Levels Reset

GPA conducted an investigation into current and planned Energy Sense appliance rebate incentive levels. It has been over four years since these incentive levels have been evaluated. Table 8-1 shows the results of this investigation.

Table 8-1. Energy Sense Rebate Program Incentive Levels

Programs	Current Rebate ($)	Reset Rebate ($ Per Ton)
Ductless Split Air Conditioning Units		
< 1 Ton		
≥ 18 SEER and < 21 SEER	100	79
≥ 21 SEER and < 23 SEER	200	131
≥ 23 SEER	250	131
≥ 25 SEER		158
≥ 1 Ton		
≥ 16 SEER and < 21 SEER	200	105
≥ 21 SEER and < 22 SEER	300	175
≥ 22 SEER and < 25 SEER	325	175
≥ 25 SEER and < 28 SEER	350	210
≥ 28 SEER	600	210
Ducted Central Air Conditioning Units		
≥ 3 Ton and < 4 Ton		
≥ 16 SEER and < 21 SEER	500	140
≥ 4 Ton		
≥ 18 SEER	800	140

Programs	Current Rebate	Reset Rebate
Washer Units	$ 200 per Unit	$ 20 per Unit
Dryer Units	$ 200 per Unit	$ 40 per Unit

Appendix A: Bibliography

1. CCU Resolution No. 2019-18, Authorizing Management of the Guam Power Authority to File Recommendations for Placing the Demand-Side Management (DSM) Program Expenses under LEAC, adopted November 26, 2019, at pgs. 1-2.
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3. Daily Post Staff. (2019). Guam Energy Office receives $75K for schools program. URL: https://www.postguam.com/business/local/guam-energy-office-receives-k-for-schools-program/article_5baf9d20-3fb7-11e9-91e9-93b625882301.html (Last visited February 17, 2020).
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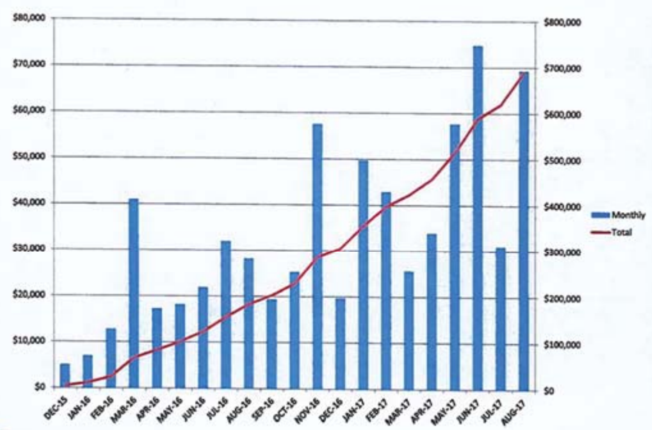
Appendix B: September 1, 2017 Report

PUC Report– DSM

As of SEPTEMBER 1ST, 2017



2

DSM Rebate Program Expansion Implementation Plan

All Expenses – Fiscal Year

Description	FY16	FY17 SEP	Total to Date
Regular Pay	$11,169.02	$18,730.40	$ 29,899.42
Other Contractual	$28,278.50	$38,850.10	$67,128.60
Paid Rebates-Split AC	$154,700.00	$474,150.00	$ 628,850.00
Paid Rebates- Central AC	$3,400.00	$7,700.00	$11,100.00
Paid Rebates-Washer/Dryers	$2,800.00	$ 7,025.00	$ 9,825.00
Total Expenses	$200,527.30	$546,455.50	$746,982.80

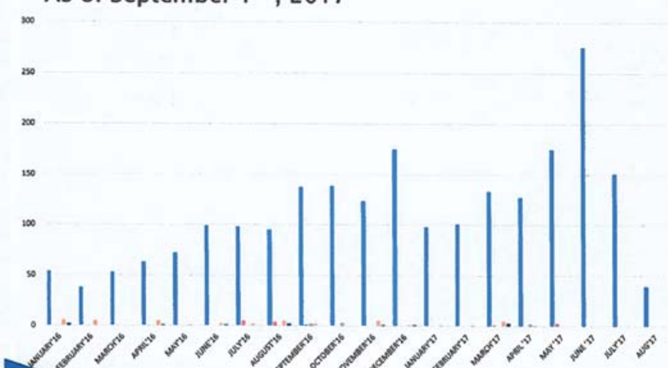
3

FY 2017– Rebate Amount Paid Monthly

Month	Total	Split A/C Units	Central A/C Units	Washers/ Dryers
OCTOBER'16	$25,250.00	$23,450.00	$800.00	$1,000.00
NOVEMBER'16	$57,525.00	$55,625.00	$1,600.00	$300.00
DECEMBER'16	$19,625.00	$18,225.00	$800.00	$600.00
JANUARY'17	$49,650.00	$48,050.00	–	$1,600.00
FEBRUARY'17	$42,850.00	$42,850.00	$325.00	–
MARCH'17	$25,550.00	$25,550.00	–	–
APRIL '17	$33,875.00	$30,950.00	$800.00	$2,125.00
MAY'17	$57,675.00	$54,275.00	$2,400.00	$1,000.00
JUNE'17	$74,675.00	$74,675.00	$1,300.00	$200.00
JUL'17	$30,975.00	$30,975.00	–	–
AUG'17	$69,400.00	$69,200.00	–	$200.00
TOTALS	$488,875.00	$474,150.00	$7,700.00	$7,025.00

4

Number of Equipment Based on Application Received– As of September 1st, 2017



5

Number of Equipment Based on Application Received– December 2015 to AUGUST 15, 2017

Month	Split A/C Units	Central A/C Units	Window Units	Washer	Dryer
JANUARY'16	54	0	0	6	2
FEBRUARY'16	38	0	0	5	0
MARCH'16	53	0	0	0	0
APRIL'16	63	0	0	5	1
MAY'16	72	0	0	1	0
JUNE'16	99	0	0	2	1
JULY'16	98	5	0	2	0
AUGUST'16	95	4	0	5	2
SEPTEMBER'16	137	1	2	2	0
OCTOBER'16	138	0	3	0	0
NOVEMBER'16	123	0	0	5	1
DECEMBER'16	175	0	0	1	1
JANUARY'17	98	0	0	1	0
FEBRUARY'17	101	0	0	1	0
MARCH'17	133	1	0	5	3
APRIL '17	127	0	2	1	0
MAY '17	175	3	0	0	0
JUNE '17	276	0	0	0	0
JULY'17	151	0	0	0	0
AUG'17	40	0	0	0	0
TOTAL	2245	14	8	43	10

6

PUC Approved DSM Program Expansion

Program Item		Program Description
A.		Energy Audits (through GPA Customer Services (Residential), GPA E&TS (Commercial, Government, Industrial), Online Energy Audits, or Third-Party Hired by GPA)
B.		Commercial A/C: High Efficiency Packaged Rooftop Unit (20 Ton Minimum, 15 EER or better); Solar Thermal Assisted AC per Collector (No More than Two Collectors)
C.		Commercial Building Energy Management System
D.		Commercial A/C: High Efficiency Split, Ducted A/C System (10 ton assumed, 18 SEER or better); Solar Thermal Assisted AC per Collector (No More than Two Collectors)
E.		Residential A/C: Variable Refrigerant Flow A/C
F.		Commercial A/C: Variable Refrigerant Flow A/C
G.		Commercial Lighting
	1	Internal Lighting- Tube LED Lamp, T-5 Lamp, and Low Wattage -T-8 Lamp
	2	Outdoor Lighting-LED Floodlights and LED Parking Lot Streetlights
H.		Water Heating: Low Flow Showerheads; Energy Star Electric Water Heaters (Conventional & Heat Pump); Tankless Water Heaters
I.		100 Customer (Minimum) ESS Pilot Program Residential, Commercial/Industrial
J.		Smart Inverter New System and Upgrade Rebates

8

What progress made 2017 to present?

DSM Expansion Rebate Program:
Direct Implementation Steps

1. Certify Trade Allies
2. Rebate Process
3. Marketing
4. Metering & Verification

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DSM Expansion Rebate Program:
Direct Implementation Steps

1. Certify Trade Allies
    a. Contact Potential Suppliers
    b. Create List of Potential Supplier Products and Prices
    c. Create Certification Criteria and Process for Supplier Products
    d. Certify Products and Trade Allies
    e. Update Energy Sense Website
    f. Create Trade Ally Relationship with Guam Stakeholders
        - Guam Energy Office (GEO)
        - Guam Energy Task Force (GETF)
        - Guam Department of Education (GDOE)
        - Guam Housing & Urban Renewal Authority (GHURA)
        - Guam Association Realtors (GAR)
        - Department of the Navy (DON)
            - NAVFAC PAC & NAVFAC MAR
            - REPO
        - Andersen Air Force Base
        - Industry

10

DSM Expansion Rebate Program:

Direct Implementation Steps

2. Rebate Process
   a. Create Rebate Forms
   b. Create Rebate Processing
      a. Create Processes and Swim Lane Maps
      b. Create Rebate Processing Training/Certification for HR to Administer and Deliver
      c. Provide Rebate Processing Training/Certification for:
         - GPA/GWA Customer Services
         - Trade Allies
         - Guam Energy Office
         - Customers
      d. Update Energy Sense Website
   c. Disseminate Rebate Forms

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DSM Expansion Rebate Program:

Direct Implementation Steps

3. Marketing
   a. Create Point-of-Sales Signage Kits
   b. Create Opportunities for Trade Ally Cooperative Advertising
   c. GPWA Green Home Expo Event
   d. Market Research
      - Participant Focus Groups & Surveys
        - Trade Ally Feedback
        - GPWA Rebate Processor Feedback
        - Customer Feedback
      - Customer Surveys
   e. Outreach
      - Reach Out to UOG on Participating in their Energy Model Home Display
      - Smart Home with L+G Meters/Home Area Network
      - GHURA
      - GDOE

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DSM Expansion Rebate Program:
Direct Implementation Steps

4. Metering & Verification
   a. Create M&V Process
   b. Create M&V Performance Dashboards
   c. Execute & Refine Process

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Parallel Tasks

1. Execute DSM Marketing Plan
2. Establish Rebate Levels:
   a. >= 20 Ton, Solar Thermal Assisted AC
   b. 10 Ton to 20 Ton , Solar Thermal Assisted AC
   c. Outdoor Lighting-LED Floodlights and LED Parking Lot Streetlights
   d. Energy Star Electric Water Heaters (Conventional & Heat Pump)
   e. Tankless Water Heaters
   f. 100 Customer (Minimum) ESS Pilot Program Residential, Commercial/Industrial
   g. Smart Inverter New System and Upgrade Rebates
3. * Create a Consolidated DSM Program Handbook
4. Continue to Research New Energy Efficiency Technologies
5. Establish New DSM Section
6. DSM Planning
   a. Adopt & Modify California DSM Evaluation Methodology
   b. Revaluate Rebate Levels & Technologies Each Year
   c. Issue Annual DSM Program Addendum Report

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Implementation Plan Progress

Certify Trade Allies

1. Contact Potential Suppliers of New Products
   - Assigned Tasks to Engineer II Detailed from Engineering
2. Create List of Potential Supplier Products and Prices
   - Using List of Current Air Conditioning Trade Allies
   - Following up with Firms who have already contacted GPA
3. Create Certification Criteria and Process for Supplier Products
   - Adopting Original Certification Process (Swim Lane Map)
4. Certify Products and Trade Allies
   - Assigned Tasks to Engineer II Detailed from Engineering
5. Update Energy Sense Website
   - Contracted to AdzTech
6. Create Trade Ally Relationship with Guam Stakeholders
   - Contacted UOG for GPA-UOG Partnership on Energy Efficiency Demonstration Project
     - Model Homes
       - Legacy Appliances
       - Energy Efficient Appliances Eligible for Rebates
     - Discussing UESC options with Siemens

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Rebate Process

- Contracted to AdzTech
  - Brochures
  - Rebate Forms
  - Web Site

17

Marketing

- AdzTech Awarded DSM Marketing Services Contract
  - Task Based Contract
- 60-90 Days
  - Point-of-Sales Kits
  - Fact Sheets
  - Trade Ally Manual
  - Social Media Campaign
  - Advertising
- 3 - 4 Months
  - Middle School Energy Sense Kit
    - Teaming up with a Teacher who has used My Energy Portal as a teaching aide
- 4 - 6 Months
  - Village Workshop Outreach Kits
  - Residential Energy Audit Program

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Energy Solutions K-12 STEM Program

- Partner: Siemens
  - Siemens' Sustainability Education Program includes:
    - K-12 or Higher Ed energy & STEM programs
    - Energy Efficiency Workshops
    - Energy & Renewable Workforce Training
    - PR/marketing support
  - Siemens could offer these resources once they have a couple projects in Guam completed.

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Completed or Substantially Complete

- 60-90 Days
  - Point-of-Sales Kits ✓
  - Fact Sheets ✓
  - Trade Ally Manual ✓
  - Social Media Campaign ✓
  - Advertising ✓

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Metering & Verification

- Rebate Program: Work is still very preliminary
- GIAA M&V
  - GPA has performed M&V for GIAA each year on their $11.4 MM Energy Efficiency Project facilitated by GPA.

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Parallel Tasks

1. Execute DSM Marketing Plan (Being Done)
2. Establish Rebate Levels:

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Comm	A/C	High EE Packaged Rooftop Unit (20 ton assumed, 15 EER or better)	Standard eff. System (11 EER at 20 tons)	A/C Unit	$1,000
Comm	A/C	Solar thermal assisted AC (20 ton)	Solar thermal assisted AC per collector (no more than four collectors) per location/customer premises	A/C Unit per collector	$300
Comm	Building	Building Energy Mgmt System	No Mgmt System	Customer / Site	$1,200
Comm	A/C	High EE Split, Ducted A/C System (18 SEER or better; 10 ton assumed)	Standard EE System (14 SEER/11.2 EER at 10 tons)	A/C Unit	$500
Comm	A/C	Solar thermal assisted AC (10 ton)	Solar thermal assisted AC per collector (no more than two collectors) per location/customer premises	A/C Unit per collector	$300
Comm	A/C	Variable Refrigerant Flow AC	Standard technology	A/C Unit	$100
Comm	Lighting	Internal Lighting-Tube LED Lamp	Standard (32 W T-8) Fluorescent Lamp	Lamp	$5.00
Comm	Lighting	Internal Lighting-T-5 Lamp	Standard (high output T-12) Fluorescent Lamp	Lamp	$4.00
Comm	Lighting	Internal Lighting-Low wattage T-8 Lamp	Standard (32 W T-8) Fluorescent Lamp	Lamp	$4.00
Comm	Lighting	Outdoor LED Flood Lights	LED Outdoor Flood Lights	per Lamp/Single Fixture	$10.00
Comm	Lighting	Outdoor LED Parking Streetlights	Outdoor LED Parking Streetlights	Lamp/Luminaire/Single Fixture	$35.00
Res	A/C	Variable Refrigerant Flow AC	Standard eff. Room or Central A/C	A/C Unit	$100
Res	Water Heating	Energy Star Heat Pump Electric Water Heaters	Standard water heater	Water heater	$500
Res	Water Heating	Tankless Water Heaters	Standard water heater	Water heater	$50
Res	Water Heating	Low Flow Showerheads	Standard fixture	Fixture	$15.00
Res	Lighting	Internal Lighting-LED Bulbs	CFL / Incandescent (assumed at 50/50)	2 Lamp Unit	$10.00

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New DSM Section

- Added One Engineer Detailed to New DSM Program Roll-Out.

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Utility Energy Services Contract (UESC)

- Awarded to Siemens
- Kick-off Meetings Held Week of September 11 to 15, 2017
- Scope of Work
  - Perform Large Customer Level I Energy Audits
    - GPA and Siemens will Prescreen Customers for potential follow-up projects
    - Siemens will perform Level I energy audits for large customers prequalified by GPA and Siemens at no cost
  - Develop Energy Efficiency, Water Conservation, and Renewable Energy Projects with Customers
  - Energy Efficiency, FEMP, and Renewable Energy Training
  - Co-Brand Joint GPA-Siemens Activities

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UESC Activities

- Customer Meetings (Sep 11-15, 2017)
  - Navy
  - REPO
  - UOG CIS
    - Austin Shelton
  - UOG Facilities Group
    - Sonny Perez
  - Guam Energy Office (GEO)
  - GWA

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UESC Potential Project Development Activities

- GWA Water Loss Reduction
  - Production Well Metering
  - Leak Detection
  - Energy Efficiency Projects
  - Renewable Energy Projects
- Energy Smart Home with UOG
- Community Solar Project
- EV Charging Infrastructure
- Data Center Power Quality and Energy Efficiency
- ESS Pilot Project

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UESC Follow-Up Activities

- Customer Meetings
  - GCC
  - GHURA
  - GIAA
  - GDOE
  - Charter Schools
  - Guam Mass Transit
  - Docomo/GTA/Communication Carriers
  - Private Commercial Customers

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UESC Follow-Up Activities

- Data Analysis on Top Consuming Customers (GPA)
- Co-Branding Marketing (GPA-SIEMENS)
- Financing Business Models (GPA-SIEMENS)
- Training Schedules
- Action Items Follow Up on GPA-UOG Activities

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Appendix C: Acknowledgements

Principal Authors

John J. Cruz Jr., PE, CEA, CEM / Assistant General Manager, Engineering & Technical Services (AGMETS)

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Daniel Rueckert, PE, CISM/ Sheffield Scientific LLC

Michael Johnson/ Utility Financial Solutions, LLC.

Commercial Market Information Reference

Lynn Scott / Chief Operations Officer / Green Energy Solutions, Inc.

Appendix D: Commercial Market Information Reference

Re: Approved Initiatives.

DELETE REPLY REPLY ALL FORWARD •••

Lynn <lynn@gesiworld.com>
Wed 2/26/2020 2:26 PM

Mark as unread

To: John J Cruz, Jr.;

Yes

Sent from my iPhone

On Feb 26, 2020, at 1:32 PM, John J Cruz, Jr. <jcruz@gpagwa.com> wrote:

Lynn,

May I use this email in my report.

Get [Outlook for iOS]

From: Lynn Scott <lynn@gesiworld.com>
Sent: Wednesday, February 26, 2020 1:06 PM
To: 'John J Cruz, Jr.'
Subject: RE: Approved Initiatives.

Hi John,
Per our discussion yesterday, depending on the amount of rebate associated with each approved product, I believe the demand will exceed the requested budget for the commercial DSM rebates.
Over the past year GESI has assessed more than 50 commercials buildings.
The most common products that we find during these assessments are as follows:
lighting:
T-8, 4 ft tube lights
6" & 8" Recessed Can Lights
250W Parking / Street lights
150-250W Flood Lights
250W – 450W High Bay Lights (Warehouse/Gym)

Air Conditioners:

3-5 Ton Ducted Split	most common
4-5 Ton Rooftop Package units	#2
7.5 Ton Rooftop Package units	#3
10 – 20 ton both Package & Ducted Split	#4
50 Ton Ducted Split	#5

The reasons that kept GPA customers from purchasing energy conservation products.

Appendix E: DSM Program Plan Timelines

Table E-1 - FY 2020 DSM Rebate Program Roll Out Task Schedule

DSM Program Task Breakdown	FY 2020									
	Residential	**Commercial/Non-Residential AC**			**Commercial/ Non-Residential**			**Residential A/C:**	**Residential**	
	Existing Four Programs	**Rooftop & STA Collectors**	**Split, Ducted & STA Collectors**	**Variable Refrigerant Flow A/C**	**Building EMS**	**Indoor and Outdoor Lighting**	**Energy Audits**	**Variable Refrigerant Flow A/C**	**Water Heating**	**Energy Audits**
Trade Allies										
Trade Ally Requirements	Completed	Completed	Completed			Completed	Completed	Completed		
Trade Ally Certification	Completed	Completed	Completed			Completed	Completed	Completed		
Trade Ally Management	Completed	Completed	Completed			Completed	Completed	Completed		
Rebate Processing										
Create Rebate Forms	Completed	Completed	Completed			Jun'20	Jun'20	Jun'20		
Create Rebate Process	Completed	Jun'20	Jun'20			Jun'20	Jun'20	Jun'20		
Create Processes and Swim Lane Maps	Completed	Jun'20	Jun'20			Jun'20	Jun'20	Jun'20		
Create Rebate Processing Training/Certification for HR to Administer and Deliver	Dec'20									
Provide Rebate Processing Training/Certification for:										
GPA/GWA Customer Services Rebate Claim Training	Completed	Jun'20	Jun'20			Jun'20	Jun'20	Jun'20		
Trade Allies	Completed	Jun'20	Jun'20			Jun'20	Jun'20	Jun'20		
Customers (YouTube Videos)	Sep'20									
Disseminate Rebate Forms	Completed	Jun'20	Jun'20			Aug'20	Jun'20	Jun'20		
Update DSM Website	Completed	Jun'20	Jun'20			Aug'20	Jun'20	Jun'20		
Process Rebates	Ongoing	Jun'20	Jun'20			Aug'20	Jun'20	Jun'20		
Program Roll-Out	Completed	Jul'20	Jul'20			Aug'20	Jul'20	Jul'20		
Rebate Level Review/Modification	Jun'20	Jun'20	Jun'20			Jun'20	Jun'20	Jun'20		

Table E-2 - FY 2021 DSM Rebate Program Roll Out Task Schedule

DSM Program Task Breakdown	Existing Four Programs	Rooftop & STA Collectors	Split, Ducted & STA Collectors	Variable Refrigerant Flow A/C	Building EMS	Indoor and Outdoor Lighting	Energy Audits	Variable Refrigerant Flow A/C	Water Heating	Energy Audits
Trade Allies										
Trade Ally Requirements	Ongoing	Ongoing	Ongoing	Ongoing		Ongoing	Ongoing	Ongoing		Oct'20
Trade Ally Certification	Ongoing	Ongoing	Ongoing	Ongoing		Ongoing	Ongoing	Ongoing		Oct'20
Trade Ally Management	Ongoing	Ongoing	Ongoing	Ongoing		Ongoing	Ongoing	Ongoing		Oct'20
Rebate Processing										
Create Rebate Forms	Completed	Completed	Completed	Completed		Completed	Completed	Completed		Oct'20
Create Rebate Process										
Create Processes and Swim Lane Maps	Completed	Completed	Completed	Completed		Completed	Completed	Completed		Oct'20
Create Rebate Processing Training/Certification for HR to Administer and Deliver	Completed	Completed	Completed	Completed		Completed	Completed	Completed		Oct'20
Provide Rebate Processing Training/Certification for:										
GPA/GWA Customer Services Rebate Claim Training	Completed	Completed	Completed	Completed		Completed	Completed	Completed		Oct'20
Trade Allies	Completed	Completed	Completed	Completed		Completed	Completed	Completed		Oct'20
Customers (YouTube Videos)	Completed	Completed	Completed	Completed		Completed	Completed	Completed		Oct'20
Disseminate Rebate Forms	Completed	Completed	Completed	Completed		Completed	Completed	Completed		Dec'20
Update DSM Website	Completed	Completed	Completed	Completed		Completed	Completed	Completed		Nov'20
Process Rebates	Ongoing	Ongoing	Ongoing	Ongoing		Ongoing	Ongoing	Ongoing		
Program Roll-Out	Completed	Completed	Completed	Completed		Completed	Completed	Completed		Jan'21
Rebate Level Review/Modification	Completed									

Table E-3 - FY 2022 DSM Rebate Program Roll Out Task Schedule

FY 2022										
DSM Program Task Breakdown	Residential	Commercial AC			Commercial			Residential A/C:	Residential	
	Existing Four Programs	Rooftop & STA Collectors	Split, Ducted & STA Collectors	Variable Refrigerant Flow A/C	Building EMS	Indoor and Outdoor Lighting	Energy Audits	Variable Refrigerant Flow A/C	Water Heating	Energy Audits
Trade Allies										
Trade Ally Requirements	Ongoing	Ongoing	Ongoing	Ongoing		Ongoing	Ongoing	Ongoing	Oct'22	Ongoing
Trade Ally Certification	Ongoing	Ongoing	Ongoing	Ongoing		Ongoing	Ongoing	Ongoing	Oct'22	Ongoing
Trade Ally Management	Ongoing	Ongoing	Ongoing	Ongoing		Ongoing	Ongoing	Ongoing	Oct'22	Ongoing
Rebate Processing										
Create Rebate Forms	Completed	Completed	Completed	Completed		Completed	Completed	Completed	Nov'22	Completed
Create Rebate Process									Nov'22	
Create Processes and Swim Lane Maps	Completed	Completed	Completed	Completed		Completed	Completed	Completed	Nov'22	Completed
Create Rebate Processing Training/Certification for HR to Administer and Deliver	Completed	Completed	Completed	Completed		Completed	Completed	Completed	Nov'22	Completed
Provide Rebate Processing Training/Certification for:									Nov'22	
GPA/GWA Customer Services Rebate Claim Training	Completed	Completed	Completed	Completed		Completed	Completed	Completed	Nov'22	Completed
Trade Allies	Completed	Completed	Completed	Completed		Completed	Completed	Completed	Nov'22	Completed
Customers (YouTube Videos)	Completed	Completed	Completed	Completed		Completed	Completed	Completed		Completed
Disseminate Rebate Forms	Completed	Completed	Completed	Completed		Completed	Completed	Completed		Completed
Update DSM Website	Completed	Completed	Completed	Completed		Completed	Completed	Completed	Nov'22	Completed
Process Rebates	Ongoing	Ongoing	Ongoing	Ongoing		Ongoing	Ongoing	Ongoing		Ongoing
Program Roll-Out	Completed	Completed	Completed	Completed		Completed	Completed	Completed	Jan'23	Completed
Rebate Level Review/Modification									Dec'22	

Table E-4 - FY 2023 DSM Rebate Program Roll Out Task Schedule

FY 2023										
	Residential	**Commercial AC**			**Commercial**			**Residential A/C:**	**Residential**	
DSM Program Task Breakdown	**Existing Four Programs**	**Rooftop & STA Collectors**	**Split, Ducted & STA Collectors**	**Variable Refrigerant Flow A/C**	**Building EMS**	**Indoor and Outdoor Lighting**	**Energy Audits**	**Variable Refrigerant Flow A/C**	**Water Heating**	**Energy Audits**
Trade Allies										
Trade Ally Requirements	Ongoing	Ongoing	Ongoing	Ongoing	Oct'22	Ongoing	Ongoing	Ongoing	Ongoing	Ongoing
Trade Ally Certification	Ongoing	Ongoing	Ongoing	Ongoing	Oct'22	Ongoing	Ongoing	Ongoing	Ongoing	Ongoing
Trade Ally Management	Ongoing	Ongoing	Ongoing	Ongoing	Oct'22	Ongoing	Ongoing	Ongoing	Ongoing	Ongoing
Rebate Processing										
Create Rebate Forms	Completed	Completed	Completed	Completed	Nov'22	Completed	Completed	Completed	Completed	Completed
Create Rebate Process					Nov'22					
Create Processes and Swim Lane Maps	Completed	Completed	Completed	Completed	Nov'22	Completed	Completed	Completed	Completed	Completed
Create Rebate Processing Training/Certification for HR to Administer and Deliver	Completed	Completed	Completed	Completed	Nov'22	Completed	Completed	Completed	Completed	Completed
Provide Rebate Processing Training/Certification for:					Nov'22					
GPA/GWA Customer Services Rebate Claim Training	Completed	Completed	Completed	Completed	Nov'22	Completed	Completed	Completed	Completed	Completed
Trade Allies	Completed	Completed	Completed	Completed	Nov'22	Completed	Completed	Completed	Completed	Completed
Customers (YouTube Videos)	Completed	Completed	Completed	Completed		Completed	Completed	Completed	Completed	Completed
Disseminate Rebate Forms	Completed	Completed	Completed	Completed	Nov'22	Completed	Completed	Completed	Completed	Completed
Update DSM Website	Completed	Completed	Completed	Completed		Completed	Completed	Completed	Completed	Completed
Process Rebates	Ongoing	Ongoing	Ongoing	Ongoing	Nov'22	Ongoing	Ongoing	Ongoing	Ongoing	Ongoing
Program Roll-Out	Completed	Completed	Completed	Completed	Jan'23	Completed	Completed	Completed	Completed	Completed
Rebate Level Review/Modification					Dec'22					

Table E-5 – DSM Program Marketing Task Schedule

DSM Program Marketing Task Breakdown	FY 2020	FY 2021	FY 2022	FY 2023
Marketing				
Advertising				
Create Point-of-Sales Signage Kits	Sept'20	Maintain	Maintain	Maintain
Create Opportunities for Trade Ally Cooperative Advertising	Sept'20	Maintain	Maintain	Maintain
Create Mulit-media Advertising Campaigns	Sept'20	Maintain	Maintain	Maintain
Market Research				
Participant Focus Groups & Surveys		Nov'20		
Trade Ally Feedback		Dec'20		
GPWA Rebate Processor Feedback		Jan'21		
Customer Feedback		Feb'21		
Customer Surveys		Mar'21		
Outreach				
Village Workshops	Sept'20	Expand	Expand	Maintain
GHURA		Sept'21	Ongoing	Ongoing
GDOE	Ongoing	Ongoing	Ongoing	Ongoing
K-12 Curriculum and Demonstrations	Nov'20			
Participation in Home Expo, Trade Show, and Sustainability Type Events	Ongoing	Ongoing	Ongoing	Ongoing
Participation and speaking at Professional Organization Events such as the Rotary Club, GAR, GHRA, SAME, etc.	Ongoing	Ongoing	Ongoing	Ongoing
Create & Hold GPWA Green Home Expo Event		May'21	Ongoing	Ongoing
Opportunity Marketing				
Reach Out to UOG on Participating in their Energy Model Home Display	Completed	Ongoing	Ongoing	Ongoing
Smart Home with L+G Meters/Home Area Network - Pilot & Market			May'22	Ongoing
Participate in the UOG CIS Conference	Mar'20	Mar'21	Mar'22	Mar'23
Work with Local Media on DSM Program Stories	Ongoing	Ongoing	Ongoing	Ongoing
Branding				
Complete a VOC QFD	Start	Sep'21		
Define the Energy Sense Brand	Start	Continue	Oct'21	

Table E-6 – DSM Program M&V Task Schedule

DSM Program Task Breakdown	Building EMS	Indoor and Outdoor Lighting	Smart Inverter Upgrade [1]	ESS Pilot Program [2]	ESS Pilot Program [2]	Smart Inverter Upgrade [1]
Setting up Metering & Verification Processes						
Choose Which Rebates to Perform M&V (Start & Continue)	Feb'23	Sep'20				
Create M&V Process						
Determine baselines and estimated savings	Dec'22	Aug'20	Dec'20	Mar'21	Mar'21	Dec'20
Develop the M&V plan	Dec'22	Aug'20	Dec'20	Mar'21	Mar'21	Dec'20
Develop the post-installation M&V activities and reporting	Dec'22	Aug'20	Dec'20	Mar'21	Mar'21	Dec'20
Create M&V Performance Dashboards	Dec'22	Aug'20	Dec'20	Mar'21	Mar'21	Dec'20
Execute M&V Process (Start)	Mar'23	Oct'20	Aug'22	Aug'22	Aug'22	Aug'22
Perform periodic M&V to determine whether the savings persist	Periodically	Periodically	Periodically	Periodically	Periodically	Periodically
Refine the M&V Process	As Necessary	As Necessary	As Necessary	As Necessary	As Necessary	As Necessary

1 - Assumes the following:
- Studies completed December 2020
- Rebate Program starts January 2021
- Residential ESS Pilot Equipment and Systems installed by August 2022

2 - Assumes the following:
- Task Order for Pilot Project Development is issued by August 2020
- Studies and Project Development Plan completed March 2021
- Equipment and Systems installed by August 2022

Table E-7 – DSM Program UESC & BEST Schools Program Task Schedule

DSM Program Task Breakdown	FY 2020	FY 2021	FY 2022	FY 2023
Utility Energy Services Contracting (UESC)				
Energy Efficiency Project Development				
Develop Projects - Level I Audits	Ongoing	Ongoing	Ongoing	Ongoing
Execute Projects	TBD	TBD	TBD	TBD
Renewable Energy Project Development				
Phase III Renewable Energy Acquisition	Protested			
Develop Projects - Level I Audits	Ongoing	Ongoing	Ongoing	Ongoing
Execute Projects	TBD	TBD	TBD	TBD
DoD Resiliency Project Development				
Back-Up Power	Ongoing	Ongoing	Ongoing	Ongoing
Specialized Power Quality	Ongoing	Ongoing	Ongoing	Ongoing
Microgrids;	Ongoing	Ongoing	Ongoing	Ongoing
"Behind the Fence" & "Outside the Fence" Projects Enhancing Energy and Power Quality Resiliency	Ongoing	Ongoing	Ongoing	Ongoing
Execute Projects	TBD	TBD	TBD	TBD
BEST Schools program				
"Bringing Energy Savings to (BEST) Schools Program – Preliminary Feasibility Assessment," Completion	Completed			
Funding "Preliminary Feasibility Assessment Projects"				
B. P. Carbullido Elementary School Retrofit Project	Completed Summer '19			
EIC Grant - LED Lighting Retrofits for Southern High School	Completed Summer '20			
EIC Grant - LED Lighting Retrofits for George Washington High School	Completed Summer '21			
EIC Grant - LED Lighting Retrofits for Agueda I. Johnston Middle School		Construction Summer '20		
EIC Grant - LED Lighting Retrofits for Maria A. Ulloa Elementary School		Construction Summer '20		
Explore Funding Models		Ongoing	Ongoing	Ongoing
Project M&V				
EIC Grant - LED Lighting Retrofit Prjects	Ongoing	Ongoing	Ongoing	Ongoing
B. P. Carbullido Elementary School Retrofit Project	Ongoing	Ongoing	Ongoing	Ongoing

Table E-8 – DSM Program Grant Partnerships Task Schedule

Grants	Grantor	Description	Grant Execution or Submittal			
			FY 2020	FY 2021	FY 2022	FY 2023
Energizing Insular Communities (EIC) Grant Program	Department of Interior (DOI)/Office of Insular Affairs (OIA)	Grant funding for energy strategies that reduce the cost of electricity and reduce dependence on foreign fuels. OIA uses the following criteria in evaluating proposals: • the size of reduction in a territory's dependence on off-island fuels; • the size of reduction in cost of electricity in the territory; and • the degree to which the proposal is identified and supported in the territory's Strategic Energy Plan and/or Energy Action Plan	Agueda Johnston Maria Ulloa Construction Summer '20	Submit May'20	Submit May'21	Submit May'22
Technical Assistance Program (TAP)	Department of Interior (DOI)/Office of Insular Affairs (OIA)	TAP grants are intended for short-term, non-capital projects. TAP priorities include, but are not limited to projects which foster development of the insular areas in the following areas specific to GPA: energy production and capacity building.		Submit	Submit	Submit
EnergySmart Schools	Department of Energy	State Energy Program. Via Guam Energy Office (GEO)	Start	Completion November '20		
Federal Emergency Management Agency (FEMA)	Department of Homeland Security (DHS)	The program provides financial assistance for state and local governments to implement measures that will "harden" structures and infrastructure. Schools are eligible to receive funding if they serve as local shelters in the event of a disaster. Energy efficiency and renewable energy are important parts of this hardening process, improving electrical systems so that they can endure significant periods of time without being connected to a larger grid.			Submit Jan'21	Submit Jan'22
Rural Development Community Facilities Grant Program	United States Department of Agriculture (USDA)	Community Programs administers programs designed to develop essential community facilities for public use in rural areas.	Working on Eligibility		Submit	Submit
Not-For-Profit Organizations that Provide Energy-Efficiency Grants	Doris Duke Charitable Foundation	https://www.ddcf.org/	Ongoing	Ongoing	Ongoing	Ongoing
	the Pew Charitable Trusts	https://www.pewtrusts.org/en/				
	Bullitt Foundation	https://www.bullitt.org/				
	Kendall Foundation	https://www.kendall.org/				
	Clinton Climate Initiative	https://www.clintonfoundation.org/our-work/clinton-climate-initiative				
	Bill & Melinda Gates Foundation	https://www.gatesfoundation.org/				
	Kresge Foundation	https://kresge.org/				

Table E-9 – DSM Program Pilot Task Schedule

DSM Program Task Breakdown	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025
Residential Customer ESS Pilot Program						
ESS for legacy NEM customers for frequency and voltage control						
Issue Task Order for Pilot Project RFP Development	Aug'20					
Develop Bid Specifications		Mar'21				
Execute Procurement		Jun'21				
Award Contract			Dec'21			
Execute Project			Dec'21		Ongoing	Ongoing
Execute M&V Plan				Aug'22	Ongoing	Ongoing
Project Reporting			Dec'21	Ongoing	Ongoing	Ongoing
Complete Pilot Feasibility Report						Jul'25
Decide Whether to Expand Pilot into a DSM/Femand Response Program						Aug'25
Smart Inverter Upgrade Rebates						
Complete studies	Aug'20	Ongoing	Ongoing	Ongoing	Ongoing	Ongoing
Certify Trade Allies	Aug'20	Ongoing	Ongoing	Ongoing	Ongoing	Ongoing
Commercial Customer ESS Pilot Program						
Demand Reduction Pilot for San Vitores Large Customers with coincident demands greater than 500 KW						
Issue Task Order for Pilot Project RFP Development	Aug'20					
Develop Bid Specifications		Mar'21				
Execute Procurement		Jun'21				
Award Contract			Dec'21			
Execute Project			Dec'21		Ongoing	Ongoing
Execute M&V Plan				Aug'22	Ongoing	Ongoing
Project Reporting			Dec'21	Ongoing	Ongoing	Ongoing
Complete Pilot Feasibility Report						Jul'25
Decide Whether to Expand Pilot into a DSM/Femand Response Program						Aug'25
Smart Inverter Upgrade Rebates						
Complete studies	Aug'20	Ongoing	Ongoing	Ongoing	Ongoing	Ongoing
Certify Trade Allies	Aug'20	Ongoing	Ongoing	Ongoing	Ongoing	Ongoing

Table E-10 –New DSM Section Staffing

DSM Staff Positions	Position Filled			
	FY 2020	FY 2021	FY 2022	FY 2023
DSM Supervisor	Completed			
Engineer II	Completed			
Management Analyst	Completed			
Engineer I	Recruiting	Completed		
Engineer I		Recruiting	Completed	
Clerk		Recruiting	Completed	

Table E-11–New DSM Section Staffing

DSM Program Task Breakdown	FY 2020	FY 2021	FY 2022	FY 2023
DSM Planning and Establishment of Rebate Levels				
Issue Task Order to LEIDOS	Completed			
Creation of a Consolidated DSM Program Handbook				
Rebate Process Swim Lane Mapping	Completed			
Trade Ally Certification Process Mapping	Completed			
Eligible Equipment Certification Process Mapping	Completed			
DSM Marketing Process Mapping	Sep'20			
DSM Message Map	Sep'20			
Metering & Verification Process Mapping	Sep'20			
UESC Program Process Mapping	Sep'20			
BEST Schools Program Process Mapping	Sep'20			
Grant Program Process Mapping	Sep'20			
Pilot Project Program Process Mapping	Sep'20			
Job, Task, and Responsibility Mapping of the DSM Section Staff	Sep'20			
Identification of Education, Certification, and Training Required for each DSM Staff Position	Sep'20			
Continuing Research on New Energy Efficiency Technologies				
State of the Art Smart Inverters	Ongoing	Ongoing	Ongoing	Ongoing
Home Area Networks for Energy Efficiency Controls/Monitoring	Ongoing	Ongoing	Ongoing	Ongoing
Energy Efficiency	Ongoing	Ongoing	Ongoing	Ongoing
Renewable Energy	Ongoing	Ongoing	Ongoing	Ongoing
Energy Contracting	Ongoing	Ongoing	Ongoing	Ongoing
Demand-Response	Ongoing	Ongoing	Ongoing	Ongoing
Metrology and sensors	Ongoing	Ongoing	Ongoing	Ongoing
Power Quality	Ongoing	Ongoing	Ongoing	Ongoing
Building Controls and Energy Management Systems	Ongoing	Ongoing	Ongoing	Ongoing
Co-generation and Tri-generation	Ongoing	Ongoing	Ongoing	Ongoing
Professional Certifications (Number of Staff)				
Professional Engineer License	1		2	
Certified Energy Auditor (CEA) Certified Energy Manager (CEM) Certified Measurement & Verification Professional (CMVP) Renewable Energy Professional (REP) Energy Efficiency Practitioner (EEP) Certified Residential Energy Auditor (CREA) Performance Contracting and Funding Professional (RCFP)	1	2	3	4
Conference Atendance (Staff Attendees)				
Association of Energy Engineers (AEE) Energy Conference & Expo (East, West, or World)	1			1
Association of Energy Services Professionals (AESP) National Conference & Expo		1		
Smart Electric Power Alliance (SEPA) Utility Conference			1	

2022 Integrated Resource Plan Volume VI:

Information/Operation Technology Plan

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DATE

Table of Contents

1 Introduction

The 2022 Integrated Resource Plan Volume VI: Information/Operational Technology Plan is about Digital Transformation. This cover document is an introduction to the Sheffield Scientific report: Information Technology (IT)/Operations Technology Integration Study & Plan.

Digital transformation refers to the process of using digital technologies to create new—or enhance existing—business processes, culture and customer experiences to meet changing business and market requirements. A digital utility gets the right information to the right people or systems to take the right action immediately. A digital utility uses real-time information to make better strategic and operational decisions based on accurate, timely information. This applies to both the Guam Power Authority and Guam Waterworks Authority.

Digital Transformation is characterized by innovation, inclusion, market and customer orientation, and resilience.

Innovation is using new technology or processes to improve decision making. Inclusion means reaching out to customers, stakeholders, and the community for ideas to improve GPA/GWA services. This inclusion is interactive and iterative. It is transparent and honest. Using quality functional deployment, the digital utility translates and transforms the voice of the customer into engineering or service characteristics that will delight the customer.

Having a market and customer orientation, the digital utility operates like a firm in a highly competitive market. The digital utility transforms rate payers into valued customers.

The digital utility is resilient. It has the capabilities to anticipate and ride-through disruptions whether natural disasters, extreme price volatility or risks in the supply chain, competition, technological change, and regulatory disruption. Underlying all of this is information: the right information, at the right time, to the right people or systems to make the best decisions and to anticipate and moderate risks.

2 Situation Analysis

Simply put, GPA and GWA IT Divisions perform the same tasks for two IT systems within largely the same building. Both organizations share network and communications architecture and use the same or similar software applications. Both GPA and GWA serve a largely overlapping customer base. And, both IT organizations compete for the same pool of talent to fill similar or the same functional positions. It did not make sense continuing this situation.

In recognition of the above, the GPA AGMETS and GWA AGMA have had many discussions over several years about consolidating functions, responsibilities, and resources across both GPA and GWA IT can improve the functioning of both organizations while reducing costs and improving performance. GPA and GWA hired Sheffield Scientific LLC to organize these discussions and develop a plan and business case for consolidating the two IT/OT organizations.

3 Scope of Work

Digital business is a reality and GPWA Should Move Forward with the implementation of an GPA/GWA Information Technology (IT) Shared Services Model to increase the operational efficiency and effectiveness of the IT organization for creating a governance, people, process, and technology infrastructure that delivers core IT services across both power and water divisions.

Strategic

- Align with merged business unit strategy and goals;
- Decisive and committed leadership;
- Effective up-front planning;
- Develop of a clear set of guiding principles;
- Creating performance milestones.

Tactical

- Quick mobilization projects;
- A focus on details for each project and tasks;
- Common analysis and decision-making framework;
- Clear priorities (e.g., standardized vs. consolidate vs. reengineer);
- Customer focus outcomes;
- Practical expectations.

Human

- Comprehensive communication plan with employees and customers;
- A disciplined team structures;
- Project management organization;
- Mechanisms to address change;
- Mechanisms for knowledge management.

4 Conclusions and Recommendations

GPA & GWA Current state Disparate and Unconnected IT Organizations providing differentiated services, standards & technology Competing Resources the following recommendation will provide GPWA IT with a future state with a connected and integrated efficient IT Shared Service Model providing consistent services, standards, and technology through a common IT roadmap. A concise set of 38 recommendations exist for the following areas:

- Network Infrastructure
- Security Policies and Procedures
- Applications and Software
- Operational Analysis and Network Future Design

5 IT/OT Capital Plan

The Capital plan is a blueprint for future spending, on its capital plan that involve the following set of key priorities over the next 3 years. Table 5-1 shows the capital budget.

- Organizing a new department, and structure for the IT/OT parties involved to determine who will be involved in the planning process and to establish their respective responsibilities.
- Inventorying of all IT and OT Assets along with the assessing the condition of capital assets already owned, controlled, or maintained by the governing IT/OT business units.
- Establishing priority ranking criteria for each of the 38 recommendations that will be used as a guideline for prioritizing project funding.

- Preparing financial forecasts for cost benefits analysis for recommendations to determine the level of capital expenditures which the governing body can make over the period covered by the capital plan.
- Preparing project requests for each recommendation along with sequenced time initiatives to request capital funding for the repair, renovation, upgrading or replacement of assets identified through the inventory process.
- Prioritizing and ranking of projects recommendations for setting timing goals and sets forth funding options.

6 IT/OT O&M Budget

GPA has a $6 million annual IT/OT budget set aside for it for planed processes and technology upgrades and improvements. GWA currently allocates $200K per year for IT improvements but most of this allocation for FY2020 & FY2021 is consumed by the JDE E1 upgrade project. A $37 million budget for SCADA has been secured and is outlined in the GWA Master Plan. Table 6-1 shows the O&M budget.

Table 5-1. Capital Budget

GPWA Integration Study & Plan
Business Case Data

Costs

	Work Breakdown By Recommendation Project				Cost Category	Total Cost
	ID	Project Recommendation #	Recommendations Summary Section	Description		
Capital					Capital Expenditure:	$ 2,710,280
	4.4	Recommendation 4	Network Infrastructure	Move towards a shared Internet edge utilizing next generation firewalls	Capital	$ 132,400
	4.5	Recommendation 5	Network Infrastructure	Share network infrastructure & Segmentation	Capital	$ 91,500
	4.6	Recommendation 6	Network Infrastructure	Configure GWA SSIDs on Headquarters Wireless Infrastructure	Capital	$ 40,000
	4.7	Recommendation 7	Network Infrastructure	Expand GPA's SolarWinds Orion installation and Splunk SIEM	Capital	$ 88,920
	4.8	Recommendation 8	Network Infrastructure	Complete Northern Fiber Ring Project	Capital	$ 37,500
	4.9	Recommendation 9	Network Infrastructure	Complete Buildout of Disaster Recovery Site	Capital	$ 325,800
	4.10	Recommendation 10	Network Infrastructure	Implement Multi-Factor Authentication for Remote Access	Capital	$ 46,600
	5.4	Recommendation 4	Security Policies & Procedures	Develop Governance Policies	Capital	$ 74,000
	5.5	Recommendation 5	Security Policies & Procedures	Develop Supporting Governance Documentation	Capital	$ 16,000
	6.1	Recommendation 1	Application Review	Complete the shared SCADA system deployment	Capital	$ 200,000
	6.2	Recommendation 2	Application Review	Renew support for GIS Solution for GWA	Capital	$ 25,000
	6.3	Recommendation 3	Application Review	Configure and Use ChangeGear for Change Management	Capital	$ 37,960
	6.4	Recommendation 4	Application Review	Use Ticketing System	Capital	**$ 45,280**
	6.5	Recommendation 5	Application Review	Implement a shared services document management solution	Capital	$ 478,000
	6.6	Recommendation 6	Application Review	Continue to Implement a Joint Mobile Workforce Management (MMW) system that includes a robust network and set of devices.	Capital	$ 35,800
	6.7	Recommendation 7	Application Review	Implement Customer Care & Billing (CC&B) Application Management Centeralized Administration	Capital	$ 45,400
	6.8	Recommendation 8	Application Review	Customer Service Web Applications Development, Support and Maintenance	Capital	$ 96,000
	6.9	Recommendation 9	Application Review	Shared ERP environment with JD Edwards	Capital	$ 200,000
	8.2	Recommendation 2	Network Future Design	Deploy a Shared Services Ticketing and Change Management System	Capital	$ 78,280
	8.3	Recommendation 3	Network Future Design	Share disaster recovery capabilities and move backups to a remote data center	Capital	$ 75,000
	8.4	Recommendation 4	Network Future Design	Deploy a Shared Services Email Solution for GWA and GPA	Capital	$ 44,000
	8.5	Recommendation 5	Network Future Design	Consolidate to a shared virtual environment	Capital	$ 45,280
	8.6	Recommendation 6	Network Future Design	Implement asset and inventory management tool	Capital	$ 115,560
	8.7	Recommendation 7	Network Future Design	Deploy AMI Solution for GWA	Capital	$ 100,000
	8.8	Recommendation 8	Network Future Design	Merge customer records databases	Capital	$ 118,000
	8.9	Recommendation 9	Network Future Design	Electronic Reporting and Invoicing	Capital	$ 118,000

Table 6-1. O&M Budget

O&M					O&M Expenditure:	$ 4,445,080
	4.1	Recommendation 1	Network Infrastructure	**Update and maintain a set of infrastructure and data flow diagrams**	O&M	$ 42,000
	4.2	Recommendation 2	Network Infrastructure	**Budget for and replace end-of-life assets and expiring maintenance and service contracts**	O&M	$ 12,500
	4.3	Recommendation 3	Network Infrastructure	**Maintain hypervisor, server, and storage solution**	O&M	$ 40,000
	5.1	Recommendation 1	Security Policies & Procedures	**Develop governance program**	O&M	$ 50,000
	5.2	Recommendation 2	Security Policies & Procedures	**Review and approve baseline control set**	O&M	$ 24,000
	5.3	Recommendation 3	Security Policies & Procedures	**Perform a risk assessment**	O&M	$ 112,000
	5.6	Recommendation 6	Security Policies & Procedures	**Enforce Change Control and Configuration Management Processes**	O&M	$ 16,000
	5.7	Recommendation 7	Security Policies & Procedures	**Manage Unified Control Framework, Technical Controls Gap Assessment Workbook, and Operational Calendar**	O&M	$ 24,000
	7.1	Recommendation 1	Organizational Analysis	**Establish an Updated Governance for IT Management Duties and Operations**	O&M	$ 303,000
	7.2	Recommendation 2	Organizational Analysis	**Establish Program / Project and Organizational Change Methodologies supporting IT Projects**	O&M	$ 462,000
	7.3	Recommendation 3	Organizational Analysis	**Develop and approve a combined GPWA IT Shared Services Organizational Structure**	O&M	$ 3,314,300
	8.1	Recommendation 1	Network Future Design	**Shared Network Infrastructure Vendors**	O&M	$ 45,280

ACKNOWLEDGEMENTS

Consultants: Sheffield Scientific

Dan Rueckert, P.E., CISM, OGC / itSMF / Vice President – Strategy

George D. Gamble, PMP, Six Sigma Black Belt / Senior Director/ Cyber Security Services

GPA & GWA IT Staff Heavily Participated in this Effort

IT Leadership

Melvyn K. Kwek, CICSP, CISA / GPA / Chief Information Technology Officer (CITO)

Manny Apuron, / GWA / Information Technology Manager

Executive Sponsorship

John J. Cruz Jr., P.E, CEA, CEM /GPA / Assistant General Manager, Engineering & Technical Services

Christopher M. Budasi / GWA / Assistant General Manager of Administration and Support

Senior Executive Interviews

John M. Benavente, P.E. / GPA / General Manager

John J. E. Kim, CPA / Chief Financial Officer (CFO)

Tricee P. Limtiaco / GPA / Assistant General Manager, Administration (AGMA)

Melinda C. Mafnas, P.E. / GPA / Assistant General Manager, Operations (AGMO)

D. Graham Botha, Esquire / GPA / Legal Counsel

Miguel C. Bordallo, P.E. / GWA / General Manager

Taling M. Taitano, CPA, CGFM / GWA / Chief Financial Officer (CFO)

Gilda M. Mafnas, Assistant Chief Financial Officer (ACFO)

Information Technology

Eileen Bihag / GPA / Database Administrator

Cody Farnum / GPA / Database Administrator

Rey Gataongay / GPA / Programmer Analyst II

Matthew C.W. Ho / GPA / Network Systems Administrator

Jonathan K. Chargualaf / GPA / Network Systems Administrator

Mar Vic G. Escabillas / GPA / Network Systems Administrator

Lourdes C. Palomo / GWA / Systems & Programming Administrator

Elly T. Torres Jr. / GWA / Network Administrator

Anthony N. Cedeno / GWA / Programmer Analyst II

GPA SPORD

Jennifer Sablan, P.E., CEA, CEM / SPORD Manager

Roel Cahinhinan, P.E., CEA, CEM / Engineering Supervisor, System and Smart Grid Planning (SPASG)

Francis J. Iriarte, P.E., CEA, CEM / Engineering Supervisor, Demand Side Management & Green Programs (DSM&GP)

Lorraine O. Shinohara, P.E., CEA, CEM, BA / Engineering Supervisor, Strategic Planning & Energy Contracting (SPEC)

Harvey J. Camacho / Management Analyst I (DSM&GP)

Engineering

Joven Acosta, P.E. / GPA / Engineering Manager

Vincent J. Sablan, P.E. / GPA / Engineer Supervisor, Distribution

Josi B. Aguon / GPA / Engineer Supervisor, Customer Services

Antonio S. Gumataotao / GPA / Real Estate

Rights of Way Supervisor

Manuel M. Minas / GPA / Engineer Supervisor, Project Management

Barbara C. Cruz, P.E. /GWA / Senior Engineer Supervisor, P.E.

Brett Railey, P.E. / GWA / Senior Engineer Supervisor, P.E.

GPA Planning & Regulatory (Environmental Compliance)

Roger Pabunan / Engineer Supervisor (Environmental), Air, TSCA

Norbert Madrazo / Engineer Supervisor (Environmental), Water, SPCC, RCRA

GPA Public Information Office

Artemio S. Perez, Communication Manager (retired)

GWA Management

"Geigy" Ma. Teogenesa Q. Salayon / Utility Services Administrator

"Lisa" Elizabeth M. San Augustin / Utility Services Administrator

Sandra J. Santos / Controller

Yvonne M. Cruz / Chief Budget Officer

Appendix A: Report Interview List

#	Organizatio	Interview	Date	Time	Topic
1	GPA	Eileen Behag Meeting Minutes Merged	08/12/20	9:00 AM ?	IT Interview Questions Discussion
2	GPA	Rey Gatongay Meeting Minutes	08/12/20	10:00 AM ?	IT Interview Questions Discussion
3	GPA	Jonathon Chargualaf Meeting Minutes	08/13/20	10:00 AM ?	IT Interview Questions Discussion
4	GPA	Cody Farnum Meeting Minutes	08/14/20	10:00 AM ?	IT Interview Questions Discussion
5	GPA	Mar Vic Escabillas Meeting Minutes	08/14/20	9:00 AM ?	IT Interview Questions Discussion
6	GPA	Matthew Ho Meeting Minutes	08/14/20	9:00 AM ?	IT Interview Questions Discussion
7	GWA	Manny Apuron Meeting Minutes	08/20/20		IT Interview Questions Discussion
8	GWA	Ely Torres Meeting Minutes	08/24/20		IT Interview Questions Discussion
9	GWA	Anthony Cedeno Meeting Minutes	08/24/20		IT Interview Questions Discussion
10	GWA	Manny Apuron Meeting Minutes	08/28/20	10:00 AM CHsT	IT Interview Questions Discussion-Questionnaire
11	GPA	Melvin Kwek	08/28/20	[illegible]:00 AM CHsT	IT Interview Questionnaire-Completed 8/31/20
12	GPA	Melvin Kwek Meeting Minutes	09/01/20		Governance Meeting Minutes
13	GWA	GPWA Senior Management Finance Questionnaire - 090820 v2 D3	09/08/20		Executive Governance
14	GWA	Lou Palomo Meeting Minutes	09/09/20		Governance Meeting Minutes
15	GWA	Geigy Salayon	09/10/20	2:30 PM CHsT	Senior Management Questionnaire-Asset Management-Operations
16	GWA	Lisa San Agustin	09/10/20	2:00 PM CHsT	GPWA Senior Management CIS Questionnaire - 091020 v1 - D3
17	GWA	Miguel Bordallo	09/11/20	8:00 AM CHsT	GPWA Senior Management GM Questionnaire - 091120 v1 - D3
18		Barbara Cruz, Bret Railey	09/11/20	2:00 PM CHsT	GPWA Senior Management Engr Questionnaire - 091120 v1 - D3
19	GWA	Manny Apuron	09/17/20		Assessment Findings
20	GPA	John Cruz	09/18/20	6:30 AM CHsT	AGM-Engineering and Technical Services
21	GPA	Beatrice Limtiaco	09/24/20	11:00 AM CHsT	AGM-Administrative discussion
22	GPA	Artemio Perez	09/24/20	9:00 AM CHsT	Communications
23	GPA	Roger Pabunan, Norbert Madrazo	09/25/20	10:00 AM CHsT	Senior Management Questionnaire-Planning and Regulatory
24	GPA	Joven Costa, Vince Sablan, Antonio Gumatoatoa	09/25/20	9:00 AM CHsT	Engineering discussion
25	GPA	John Kim Meeting Minutes	09/25/20	2:00 PM CHsT	Executive Governance CFO Interview Deck
26	GPA	Jennifer Sablan, Roel Cahinhinan, Francis Iriarte, Lorraine Shinohara, Harvey Comacho, Josi Aguon, Antonio Gumataotoa, Manuel Minas	09/29/20	9:00 AM CHsT	E&TS Team
27	GPA	Melinda Mafnas	09/30/20	1:00 PM CHsT	AGM-Operations
28	GPA	Graham Botha	10/01/20	10:30 AM CHsT	Staff Attorney-Legal
29	GPA	John Benevente	10/06/20	7:00 AM CHsT	Senior Management Questionnaire- General Manager
30	GPA	Norbet Madrazo, Roger Pubunan	09/25/20	10:00 AM CHsT	Enviornmental

Information Technology (IT) Integration Study & Plan

Final Report – Volume 1

Prepared by:

Sheffield Scientific

Your partner for a brighter energy future

August 16, 2021

1. Executive Summary

Digital transformation technologies (hardware, software, and services) and cyber security are transforming every part of the modern-day utility Information Technology (IT) and Operational Technology architecture and budgets. The digital transformation shift is happening and involves fundamental redesign of business models and processes for a future where the organization uses information and insight through analytics and vision at the heart of business operations. Today's digital world is becoming hyper-modular, software-controlled, connected and data-rich, and used at all levels of the decision-making process. The successful future organization must strongly commit to a digital transformation plan and understand the significance of digital disruption and why the continued use of complex legacy technology and lack of skilled people are two of the biggest barriers to digital transformation.

A digital transformation plan is a strategic, long-term plan focusing on integrated digital media channels, implementation of new technologies, and smart, digital ways of working. It includes digital technology and the use of data to target customers and stakeholders more precisely with personalized messages. Digital technologies and cyber security are two of the key drivers for digital transformation in reshaping how an organization establish and maintain customer relationships, business strategy, governance, people, processes, and technology around digital opportunities and establish new capabilities, culture, and skills to realize the full impact and utilization.

Digital transformation has become an ambiguous, catchall term that encompasses a whole host of technology and business initiatives—from modernization, to cloud migrations, to digital platforms, digital transformation is seemingly everywhere. In the big picture, for this report digital transformation refers to the process of using digital technologies to create new—or enhance existing—business processes, culture and customer experiences to meet changing business and market requirements.

Digital Transformation and delivery are causing utility organizations to reshape its Information Technology (IT) mission, vision, goals, and core values for the required digital future and impacts and defines the organization's strategy and requires continual evolution so that the organization can stay on track.

Do not underestimate the cultural implications of digital transformation, which require a shift in mindsets and ways of working. Implementing the technology is just part of the journey; leaders find sustained success by focusing on shifting culture and mindset. Investing in a digital transformation now will provide long-term benefits. A culture conducive to digital transformation is a hallmark of maturing organization.

It is easy to become enamored by new technology. That is why it is so important for the organization to have a digital transformation strategy supported by Business Change Management (BCM). As new technology emerges, the organization can avoid the pitfalls of embracing those advancements too quickly, rolling them out in a way that could cause too much disruption (or even too little), and not properly tracking the changes within the organization.

The basic idea with a digital transformation strategy is to analyze your organizations needs and your culture, to set business objectives and understand and document the risks, to run frequent pilots and tests, to ask internal employees for feedback about those rollouts, to proceed with the new technologies, and then to continue analyzing their effectiveness.

Successful digital transformation requires investments in technologies, people and processes that drive business value. This includes funding for critical initiatives that support the digital enterprise, including cloud, cybersecurity and customer experience. Success also requires effective governance of cloud-based assets and clear visibility into the cost of cloud resources. A digital transformation strategy helps leaders answer the following questions for their business:

- Where are you now in our journey?
- Where do you want to be in 1, 3 and 5 years from now?
- Is our organization's strategy working and if not, how are we going to get there?

The following steps can help you develop a digital transformation strategy in a way that helps you make the changes required for your organization in the most effective ways.

1. Identify people, process, and technology pain points to create a vision from the business assessment
2. Assess your current As-Is and To-Be state to define and prioritize digital initiatives
3. Document your digital transformation strategy (vision, plan & action) create a delivery plan, review goals, current situation and talking decks of how to move forward on the transformational journey
4. Connect technology, platforms and data in function and interfaces in the digital transformation strategy
5. Get clear leadership buy-in and create a budget plan and promote communication
6. Define and measure success through setting digital transformation goals and KPIs to deliver analytics to drive decision making
7. Develop a digital transformation roadmap to cast vision with a focus on the long term with intermediate goals
8. Analyze the culture and develop key messaging of the digital strategy to prepare for the culture changes and continuous improvement culture to embrace change
9. Align strategic documentation for a establishing a digital strategy and set business goals
10. Document the risks through a departmental scenario-based risk assessment
11. Create a resource plan and Identify the skills matrix for its department need for the digital transformation launch training, qualification upgrades or hire new employees
12. Map out technology implementation and start to adjust and prepare the infrastructure
13. Run Pilot tests as you change and break business processes and scale and transformation
14. Gather feedback and refine as needed from stakeholders
15. Roll out the new technologies
16. Keep analyzing the impact and risk management

Information technology exists to *support* the mission of the organization as defined by GPA and GWA leadership. Information technology is the underlying foundational infrastructure for engendering GPA and GWA strategic visions. Investments in information technology are driven principally by the desire to improve the way work is done; to improve the customer experience; to improve decision making; to adhere to various laws, regulations, and policies; and to help the organization manage its risks. The themes uncovered and recommendations in this document serve as the foundation for strategically investing in IT resources and technology through a shared services organization for strategy, governance, people, processes, and technology to facilitate the work of the IT Organization. Information technology is an enabler for operational excellence: getting the right information to the right people at the right time so they can make the right decisions and actions without the need to get management approvals.

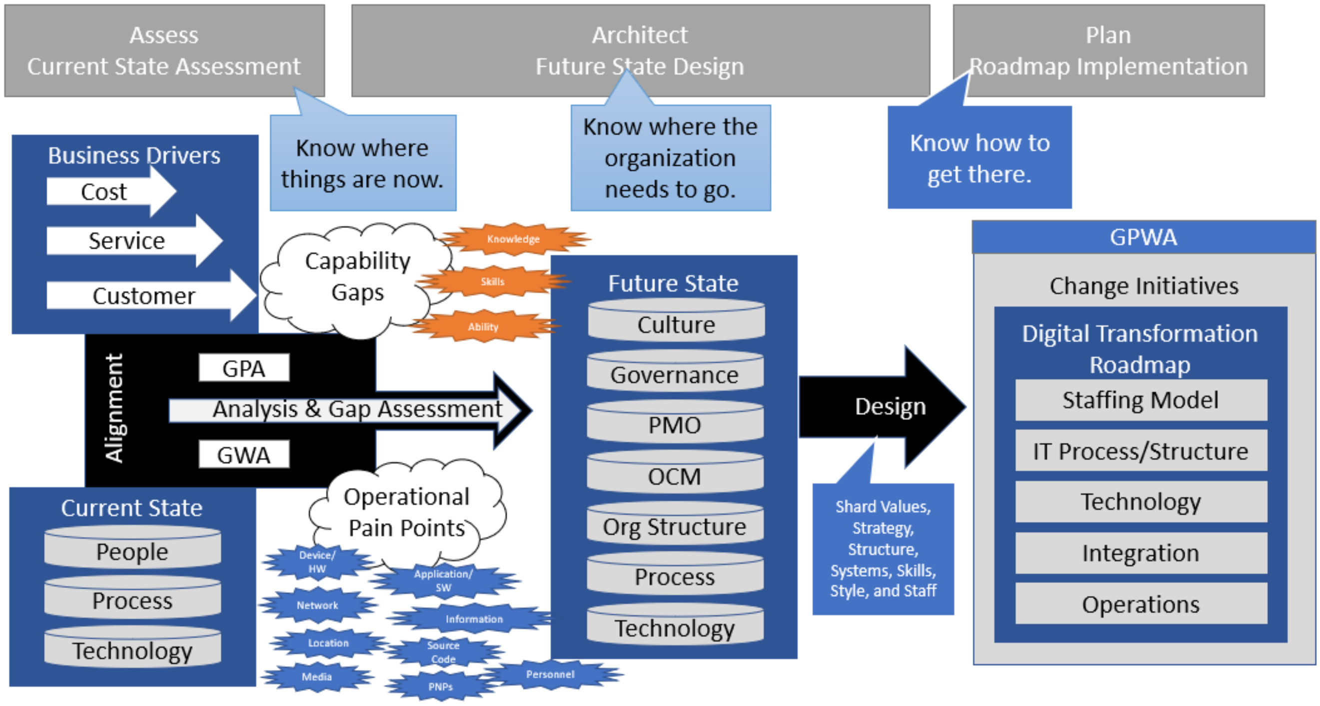
To date, GPA and GWA have taken the initial steps to digitalize their business front ends to provide a deeper level of seamless customer service. By taking the next step of digitalizing backend operations through digital shared services, they can expand efficiently, achieve significant time savings, and avoid outsourcing.

The concept of sharing services across multiple functional units is relatively straightforward. Essentially, individual divisions carry out several corporate support functions, which, when analyzed across multiple divisions, may exhibit duplication, overlap, and redundancy. Furthermore, the fragmented nature of services often prevents efficiencies and expertise from being built up in individual organizations, leading to higher costs and potentially lower service levels. Information technology is an enabler for Porter's strategic aim of finding synergies or fit within the organization's work processes to become more effective. Being effective is doing the right things efficiently.

Shared service structures aim to address these gaps and inefficiencies by bringing together resources, functions, processes, and skills from dispersed organizational units. These arrangements thus create economies of scale, increase standardization, pool skill sets, and often generate critical mass required to yield a positive return on new investments (i.e., information technology, process reengineering, automation, etc.). As a result, due to sharing of services, organizations can experience lower process costs, improved productivity, better quality of outputs, and ultimately enhanced internal customer satisfaction levels.

However, it is important to recognize that, the nature, structure, and scope of shared service arrangements can vary dramatically, depending on several factors. These include the maturity of existing organizations, business objectives of each unit, uniqueness of in-scope functions, readiness and capacity for change, and other organizational, technological, cultural, and financial considerations. Consequently, exploration and development of shared service models need to consider these often overly complex factors to arrive at a solution that creates value for all parties involved. Thus, from a practical perspective, creation of mutually beneficial structures for sharing of services is neither simple, nor straightforward. It requires significant analytical rigor, proofs of concept from prior cases, extensive stakeholder engagement, multiple validation stages, and thoughtful implementation planning.

This report represents the basis and plan for transforming GPA and GWA IT into a GPWA centric organization that incorporates people, process and technology aspects into a common delivery model.



1.1. Results

In accordance with the sponsorship of GWA and GPA Sheffield Scientific has completed a comprehensive IT Information Technology (IT) Integration Study & Plan. The results of the Sheffield Scientific IT Integration Study and Plan project completed for the Guam CCU and respective GPA and GWA Management teams, recommends that:

Digital business is a reality and GPWA Should Move Forward with the implementation of an GPA/GWA Information Technology (IT) Shared Services Model to increase the operational efficiency and effectiveness of the IT organization.

The proposed model is to create a governance, people, process, and technology infrastructure that delivers core IT services across both power and water divisions. The primary focus of the new IT shared service arrangement is to provide data center, infrastructure management, and storage services. All GPA and GWA IT divisions are in-scope for the proposed model. The proposed shared service model is based on the following three key requirements:

1. The Unit is staffed by consolidating impacted IT resources from GPA and GWA IT divisions. The proposed model is based on the premise that the current service delivery model can be optimized by creating a common resource pool. This common resource pool will help enable leveraging of resources across GPWA divisions to maximize IT operational effectiveness.

2. All physical IT data center and infrastructure assets that will be managed are to be consolidated and housed as a single organization. In order to meet the current and future capacity requirements for consolidated computing facilities, GPWA has built a new data center and has plans for the build a co-location disaster recover data center facility.
3. The new organization will operate under the Shared Services Division with functional reporting to a body comprised of representatives from participating organizations. Fair representation of all participating organizations is a critical success factor to help determine if requirements are accounted for in service level agreement mechanisms and project resources are available to meet demand. A well-defined governance model with a transparent mandate and clearly defined roles and responsibilities is required to manage the quality and effectiveness of service delivery.

While service delivery will be provisioned by groups in the IT Unit, participating organizations in GPA and GWA will own the service management relationship. This local service management layer will interact with a relationship management layer and other governance processes at all levels of the IT Unit.

A shared services model would consolidate provision of standardized services for Information Technology for GPA and GWA. Standardizing these functions into a shared service model would deliver cost efficiencies and improve the quality of outcomes. A shared services model could potentially include strategic and advisory services such as quality management and project management. Removing responsibility for execution of these core activities from individual departments will also allow them to focus on core strategic IT/OT activities.

A shared services department is the establishment of a service by one part of an organization or group that was once performed by two or more parts of the organization or group. Thus, the funding and resourcing of the service is shared and the providing department effectively becomes an internal service provider.

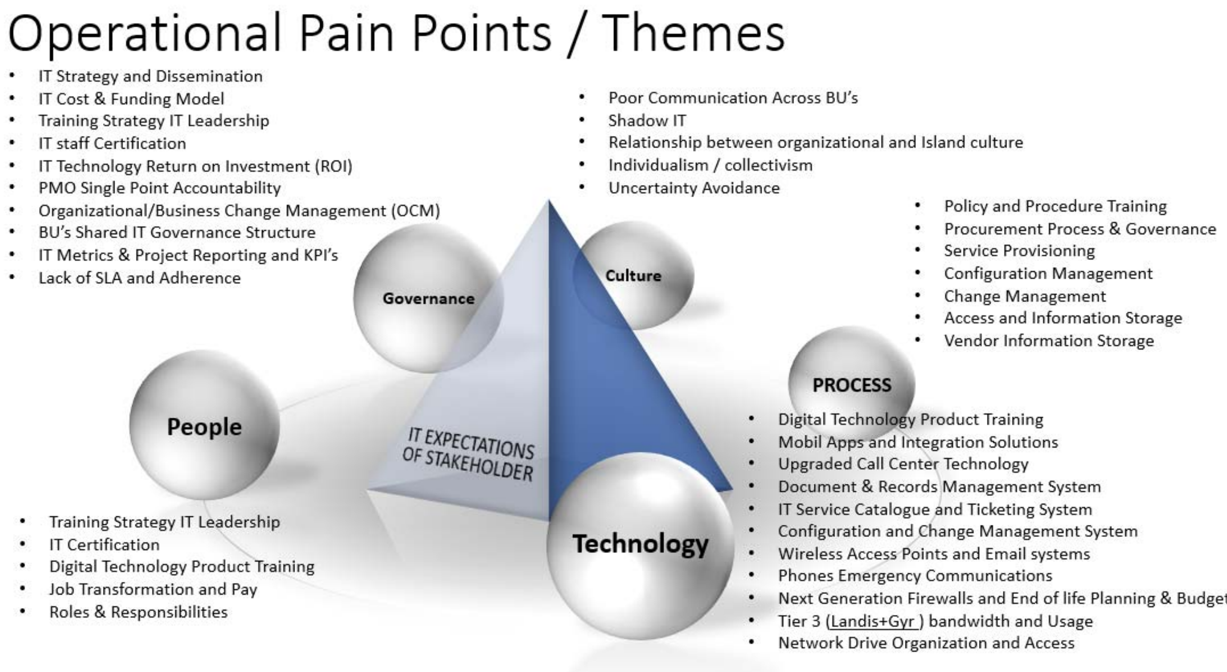
Guam has been on a journey to address the integration of the GWA/GPA IT departments for several years and has made progress in a number of areas, including Oracle Customer Care & Billing (CC&B), JD Edwards – Enterprise One, disaster recovery, physical security, and various organizational tools and processes. Many of these services and systems have been on a transformational journey toward a shared service arrangement but have never been formalized to realize and track through metrics to their full benefit.

1.2. Operational Pain Point / Themes

Throughout the analysis and study execution activities, Sheffield observed behaviors by senior management and staff that significantly improve the customer service to internal and external stakeholders provided by the IT organization:

- Encouragement by management for IT staff to actively participate in all phases of the review
- Involvement of many stakeholders; representatives from all departments and all levels from senior management to front line staff
- Transparency of discussions and sharing of information among stakeholders, including the CCU
- Executive sponsorship by the GPA AGM-ETS and GWA AGM-A.

As a result, the following major project themes were identified after analyzing input from GPA and GWA IT staff, Senior Leaders, and influencers across the organizations regarding IT opportunities for improvement:



1.3. Approach to Implementation

Although shared service is a common strategy for optimizing service delivery of common IT infrastructure services, it is important to realize that shared service is a journey that requires vision, commitment, and strong leadership. Establishing a well-defined shared service unit for the proposed services will require time, effort, budget, and commitment across the different stakeholders (GPA and GWA).

Prior to implementation, a detailed analysis of the current cost drivers and future infrastructure needs is required to build a detailed business case. This detailed business case is needed to demonstrate the specific financial savings, expected improvements in service delivery and associated costs at a more granular level. The detailed business case should reevaluate:

- Implementation and 'roll-out' of the new Shared Service Unit that will take approximately three years based on the proposed roadmap. The timeline assumes a phased implementation approach starting with consolidation of GPA and GWA core IT infrastructure to within the current facility and a re-organization of the FTE resources to staff the proposed Unit. The proposed timing incorporates requirements for detailed design of the target operating model and addressing complex labor relations and HR issues as described in Section 6.
- The key elements of this project effort have been placed in an actionable roadmap to accomplish all supporting recommendations, which address the areas of risk relating to:
    1. Perform review & analysis of the network infrastructure of GPA & GWA (IT/OT)
    2. Perform review & analysis of security policies, programs, plans, processes, and procedures of GWA & GPA

3. Review of infrastructure and application portfolio for GPA/GWA
4. Perform detailed organizational analysis of GPA & GWA IT integrated into a combined GPWA
5. Create and integrate network IT policies and operations design (Technical)
6. Develop & deliver roadmap and final report for GPA/GWA IT consolidation

1.4. Costs Benefit Analysis

The execution of the projects and organizational restructure coming out of the IT Integration Plan Roadmap, including the formation of the IT Shared Services team will driver key benefits for the GWA and GPA. This will be accomplished through technology innovation projects identified in the roadmap combined with process effectiveness and efficiencies estimated at 15% in IT through best practices and methodologies as part of the deployment. The cost benefit analysis provides individual analysis per recommendation the key benefits are provided in the following areas.

Example Benefits

Efficiency	Within one year, 20% reduction in overall payroll costs. Consolidation of services into a single efficient organization reduces duplication of overhead functions
Harmonization	Within one year, all staff using the same Information Technology process
Customer Focus	Within six months, IT staff spend 50% less time on administrative duties
Capabilities	Within 18 months, able to apply advanced analytics across all customer service transactions
Service Quality	10% fewer customer complaints. Cross-cutting infrastructure, such as Customer Service website, Document Imaging, and Service Recovery Plan, adds structure and consistency to service delivery
Standardization	Consistent interpretation and application of policy ensures equity, and standardization makes it easier to improve processes, fix problems, infuse technology, and use of ITIL Best Practices
Better Use of Technology	High volume makes it easier to identify and prioritize system changes; consolidating work and standardizing processes make it easier to architect and implement technology solutions

The execution of the projects and organizational restructure coming out of the IT Integration Plan Roadmap reflect a positive benefits stream versus cost projection across GPA and GWA approximately 32 months from project execution. The stand-up phase will be driven through the completion of the detailed position studies and management decisions. (Refer to Section 9 for further cost benefit details) and calculated benefits are classified into two categories: 1) Cost Avoidance and 2) Process Efficiency & Effectiveness. Improvements through the consolidation of infrastructure and organizational responsibilities provide the basis of the cumulative cost versus savings curve presented in Figure 1-1. Reconciliation against existing capital projects needs to be performed to confirm expenditure estimates.

	2021	2022	2023	2024	2025
Total Costs	**$37,500**	**$3,317,080**	**$1,535,380**	**$1,350,700**	**$914,700**
Capital Costs:	$ 37,500	$ 1,616,100	$ 620,680	$ 436,000	$ -
O&M Costs:	$0	$1,700,980	$914,700	$914,700	$914,700
Total Savings	**$81,120**	**$1,178,324**	**$2,346,584**	**$2,126,444**	**$2,311,304**
Capital Savings:	$ 81,120	$ 698,880	$ 1,469,060	$ 1,340,040	$ 1,529,900
O&M Savings:	$0	$479,444	$877,524	$786,404	$781,404
Cummulative Costs:	$37,500	$3,354,580	$4,889,960	$6,240,660	$7,155,360
Cummulative Savings:	$81,120	$1,259,444	$3,606,028	$5,732,472	$8,043,776
Costs vs. Savings:	**$43,620**	**-$2,095,136**	**-$1,283,932**	**-$508,188**	**$888,416**

* Savings are currently based on an average between conservative and aggressive savings for a GPWA IT organization

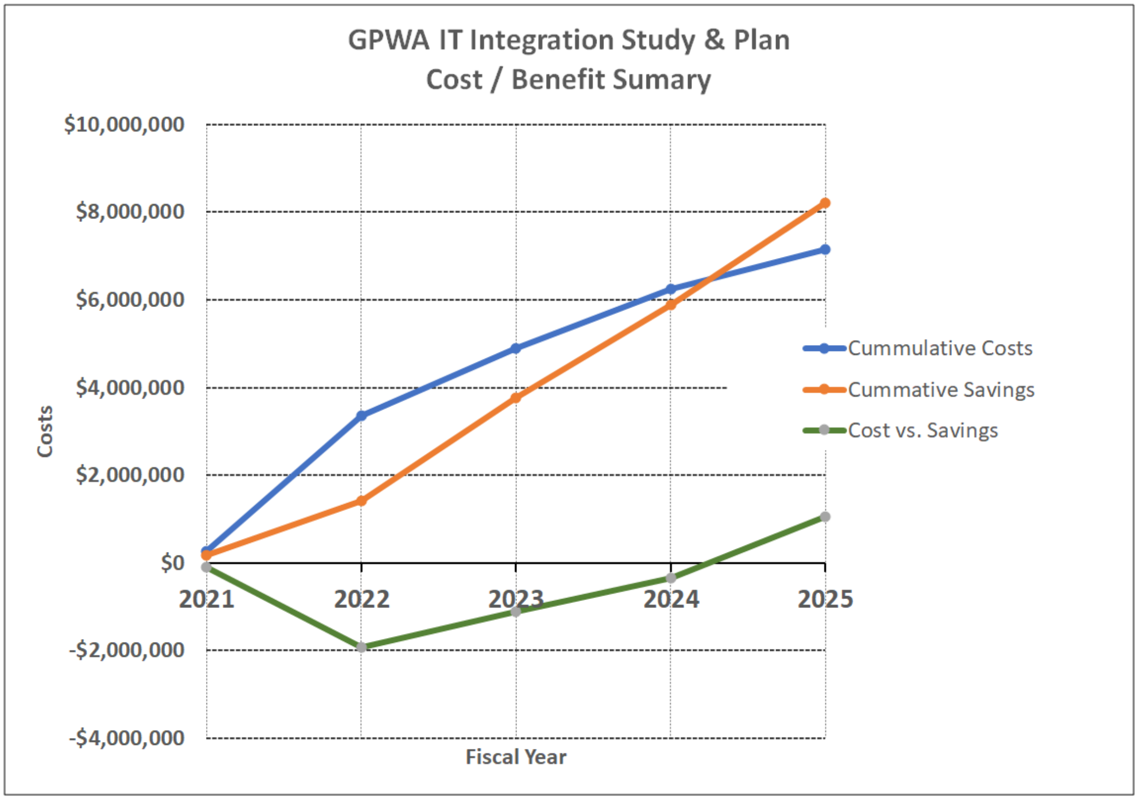


Figure 1-1: Cost versus Savings for IT Integration Projects and Organization Restructure

Key Assumptions for the cost benefit include:

1. Number of work hours per year assumes 52 weeks in a year, 5 days in a week, and 8 hours in a day (2080 hours per year). Vacation and training days are not subtracted since this will be used with loaded rates.
2. Standard Hourly billing rate for savings is $39 hour based on GWA and GPA average burdened rates for IT.
3. FY2021 dollar basis with no escalation used in analysis
4. Fiscal Year (FY) - October 1 - September 30, 20XX
5. Use $39 USD per hour burden rate for GPWA in cost and savings
6. All capital projects to be completed by FY2024.
7. Recommendation 8.7 for the GWA AMI Project is represented with $4.5 mil in cost and savings in FY2023. Further detailed analysis is underway by Brown & Caldwell related to cost of service.
8. Alignment with FY2022 IT budgets still needs to be completed with GWA and GPA. Minimal progress was accomplished in FY2021 due to the JD Edwards – Enterprise One projects in GWA and GPA.

Implementation and 'roll-out' of the Shared Services Unit is forecasted to take approximately 3 years if funding is approved. The timeline assumes a phased implementation approach starting with consolidation of GPA & GWA IT divisions and IT physical infrastructure to a co-location facility area and reorganizing resources. Shared service delivery of IT infrastructure is expected to deliver positive financial benefits and qualitative benefits within approximately 32 months after project start.

1.5. Critical Success Factors for Shared Services

Strategic	Tactical	Human
• Align with merged business unit strategy and goals • Decisive and committed leadership • Effective up-front planning • Develop of a clear set of guiding principles • Creating performance milestones	• Quick mobilization • A focus on details • Common analysis and decision-making framework • Clear priorities (e.g., standardized vs. consolidate vs. reengineer) • Customer focus • Practical expectations	• Comprehensive communication with employees and customers • A disciplined team structures • Project management organization • Mechanisms to address change • Mechanisms for knowledge management

1.6. Alignment

The recommendations and roadmap for this Information Technology (IT) Integration Study & Plan align closely with and support the implementation of the:

- GPA Strategic Plan
- GWA Strategic Plan and Master Water Plan
- Past Study and Agreements

1.7. Recommendation Summary

This set of 38 recommendations includes the conclusions drawn from the analysis that contributes towards fulfilling the purpose of this project.

Section 4 Network Infrastructure	Section 5 Security Policies & Procedures	Section 6 Application Review	Section 7 Organizational Analysis	Section 8 Network Future Design
4.1 Robust set of infrastructure and data flow diagrams	**5.1 IT Governance Program**	**6.1 Shared SCADA system**	**7.1 Governance for IT Management Duties and Operations**	**8.1 Shared Network Infrastructure Vendors**
4.2 Budget for end-of-life equipment & service contracts	**5.2 Baseline Cyber Security Controls**	**6.2 Renew GIS Solution for GWA**	**7.2 Program / Project and Organizational Change Methodologies**	**8.2 Shared Services Ticketing and Change Management System**
4.3 Maintain virtual servers, and storage solution to end of life	**5.3 Risk Assessment and confirm inventory of assets and impact rating**	**6.3 Standardize Change Management solution**	**7.3 Shared Services Organizational Structure**	**8.3 Share Disaster Recovery solutions**
4.4 Shared set of Boundary Firewalls	**5.4 IT Cybersecurity Governance Policies**	**6.4 Help Desk Ticketing System**		**8.4 Shared Email Solution**
4.5 Share network infrastructure & Segmentation	**5.5 IT Governance Process & SOP Documentation**	**6.5 Shared Document Management System**		**8.5 Consolidate to single virtual environment**
4.6 Configure Wireless Access	**5.6 Change Control and Configuration Management**	**6.6 Mobile Workforce Management (MMW) system**		**8.6 Asset and inventory management tool**
4.7 Expand IT Operations Management and Security Intelligence Applications	**5.7 Unified Compliance Framework**	**6.7 Customer Care & Billing (CC&B) Centerlized Administration**		**8.7 AMI Solution for GWA**
4.8 Complete Northern Fiber Ring Project		**6.8 Web Applications Development, Support and Maintenance**		**8.8 Merge customer records databases**
4.9 Buildout of Disaster Recovery Sites		**6.9 Shared ERP environment with JD Edwards**		**8.9 Electronic Reporting and Invoicing**
4.10 Secure access control through multiple credentials				

1.8. GPWA Organizational Structure

The results of the organizational analysis supported by the other study workstreams (Network / Infrastructure, Security, Applications and IT Service Management) results have revealed opportunities for improvements that can be incorporated into the restructuring of the IT organizations for GPA and GWA.

The recommendations provide the business needs along with the supporting preliminary cost benefit evaluation that points to the primary objective of the IT Integration Study & Plan which is:

1. Establish an Updated Governance for IT Management Duties and Operations
2. Establish Program / Project and Organizational Change Methodologies supporting IT Projects
3. Develop and approve a combined GPWA IT Shared Services Organizational Structure
    - Organization and Staffing Model
    - IT Process / Structure
    - Technology and Application Integration
    - Operations
    - Applications and Tools

The reason a shared service organization can be a benefit of an IT consolidation of functions and resource management due to barriers as:

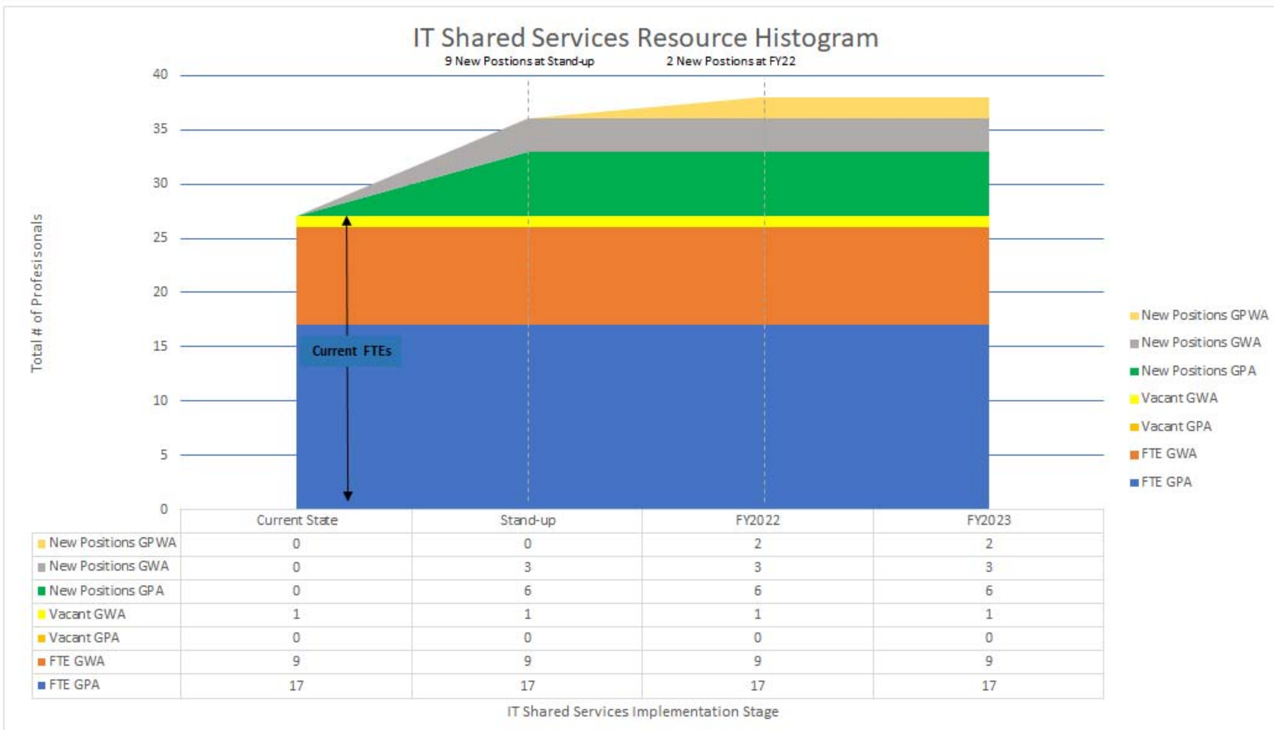
- Limited skill sets on island and an aging workforce that can benefit with joint collaboration and management oversight that exemplifies "The needs of the many outweigh the needs of the few". GPA and GWA are currently competing in the same limited labor pool.
- Increased formalization of roles and duties in alignment with GPA and GWA business objectives
- Consolidation of fragmented business processes aligned and organized to industry best practice methodologies and standards to gain business efficiencies.
- Metrics and reporting to an oversight organization for performance and behavior reinforcement.

The results of the analysis have created a preliminary organizational structure that incorporates the following guiding principles and assumptions into its model.

- The model supports business alignment for increased internal and external GWA and GPA customer service.
- Current and proposed IT organizational structures from GPA and GWA have been shared and analyzed as part of the proposed shared services organizational structure.
- Fully maximize governance, best practices, and organizational effectiveness within IT
- Creates an IT Oversight Committee made up of to be named GPA, GWA and CCU members in providing business guidance and approval of policies governing IT for the business.
- Organizational categories or teams have been created but greater evaluation of individual skill sets needs to be completed to confirm updates capabilities and determine job descriptions, salary structure and a management reporting structure.
- Preliminary position assignment within the IT Shared Services model is based on limited input obtained by Sheffield Scientific team members and will be validated with GPA and GWA IT

Integration Sponsors. Vacant and new positions need to be reviewed on skill sets needed moving forward along with employee development plans for existing employees.

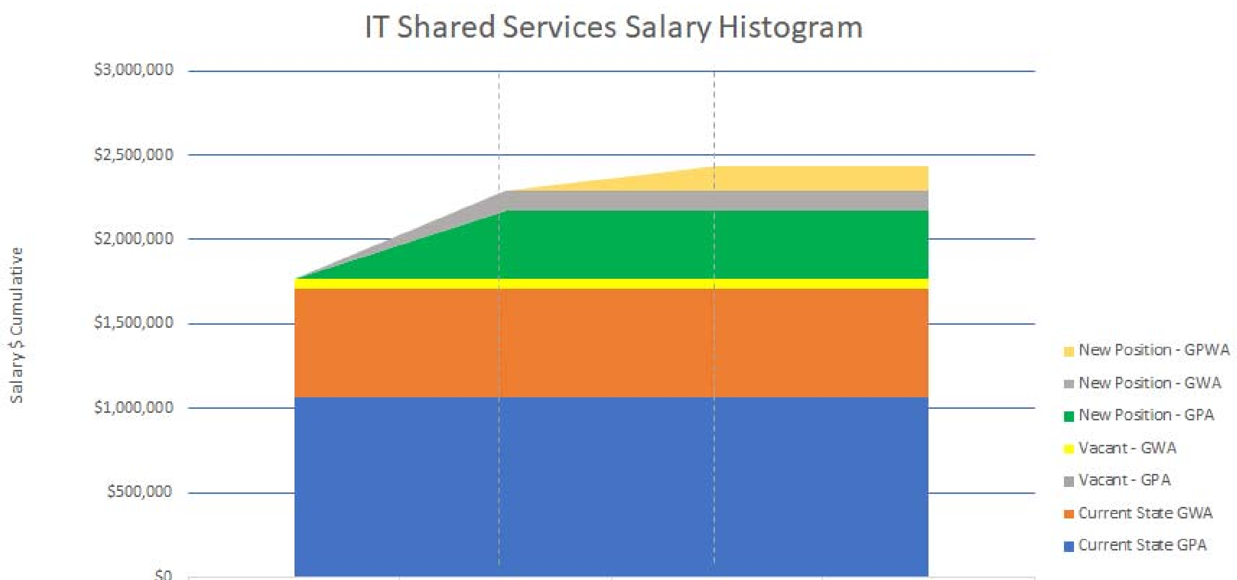
- The use of outside Implementation Support Specialists will be determined to fulfill possible identified roles on a short-term basis while formal hiring practices are executed within the organization. They will also be needed to support implementation tasks.
- Definition of the budget funding process, approval limits and governance supporting the GPWA IT Shared Services organization need to be confirmed with the CFOs of GPA and GWA.
- Review of job positions with GPA and GWA Human Resources personnel needs to be conducted for policy and labor agreement compliance assurance.
- Cost benefit analysis for the organizational analysis will be presented as part of the Section 0 – Cost Benefit Analysis.
-



	Current State	Stand-up	FY2022	FY2023
New Positions GPWA	0	0	2	2
New Positions GWA	0	3	3	3
New Positions GPA	0	6	6	6
Vacant GWA	1	1	1	1
Vacant GPA	0	0	0	0
FTE GWA	9	9	9	9
FTE GPA	17	17	17	17

The following resource histogram provides by key time periods the anticipated size of the organization. Current existing Full Time Equivalents (FTE), Vacant positions not currently filled and pending New Positions based on existing IT organizations and the Integration Study are presented in the current diagram.

The resulting salary profile as discussed in the cost benefit analysis is reflected at the major milestones of the GPWA IT lifecycle.



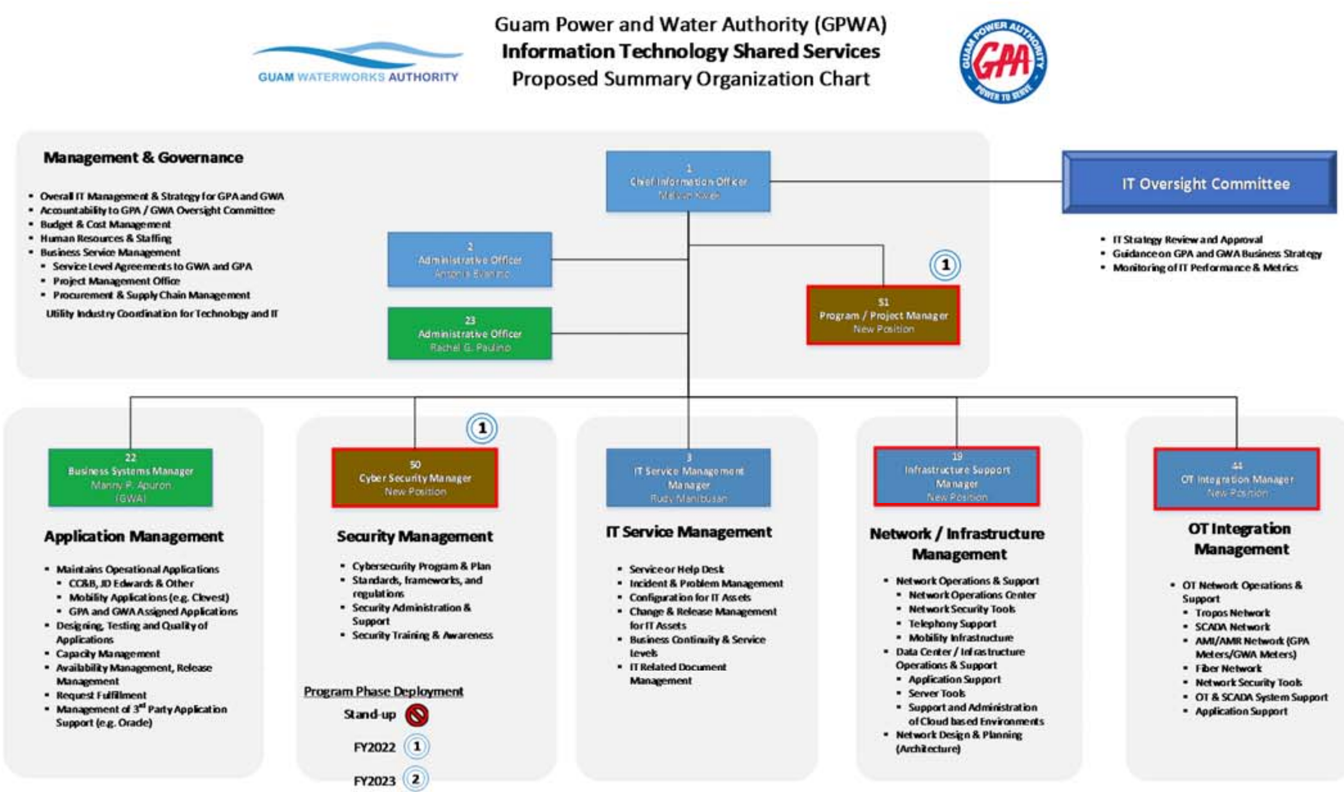
	Current State	Stand-Up Cost	FY2022	FY2023
New Position - GPWA	$0	$0	$150,000	$150,000
New Position - GWA	$0	$120,000	$120,000	$120,000
New Position - GPA	$0	$400,000	$400,000	$400,000
Vacant - GWA	$58,556	$58,556	$58,556	$58,556
Vacant - GPA	$0	$0	$0	$0
Current State GWA	$639,636	$639,636	$639,636	$639,636
Current State GPA	$1,071,129	$1,071,129	$1,071,129	$1,071,129

IT Shared Services Implementation Stage

Note: FY21 Salary Information by employee

Position Type / Organization	Current State	Stand-Up Cost	FY2022	FY2023	
Current State GPA	$1,071,129	$1,071,129	$1,071,129	$1,071,129	FY2020 (Q1 Burden Salary)
Current State GWA	$639,636	$639,636	$639,636	$639,636	FY2020 (Q1 Burden Salary)
Vacant - GPA	$0	$0	$0	$0	FY2020 (Q1 Burden Salary)
Vacant - GWA	$58,556	$58,556	$58,556	$58,556	FY2020 (Q1 Burden Salary)
New Position - GPA	$0	$400,000	$400,000	$400,000	
New Position - GWA	$0	$120,000	$120,000	$120,000	
New Position - GPWA	$0	$0	$150,000	$150,000	
Total:	$1,769,321	$2,289,321	$2,439,321	$2,439,321	
Existing FTE Annual Salary (GPA & GWA):	$1,769,321	$1,769,321	$1,769,321	$1,769,321	
New Postions Estimated Salary Annual:		$520,000	$670,000	$670,000	
Burden (31%)		$161,200	$207,700	$207,700	
New Postions Estimated Burden Salary Annual:		**$681,200**	**$877,700**	**$877,700**	

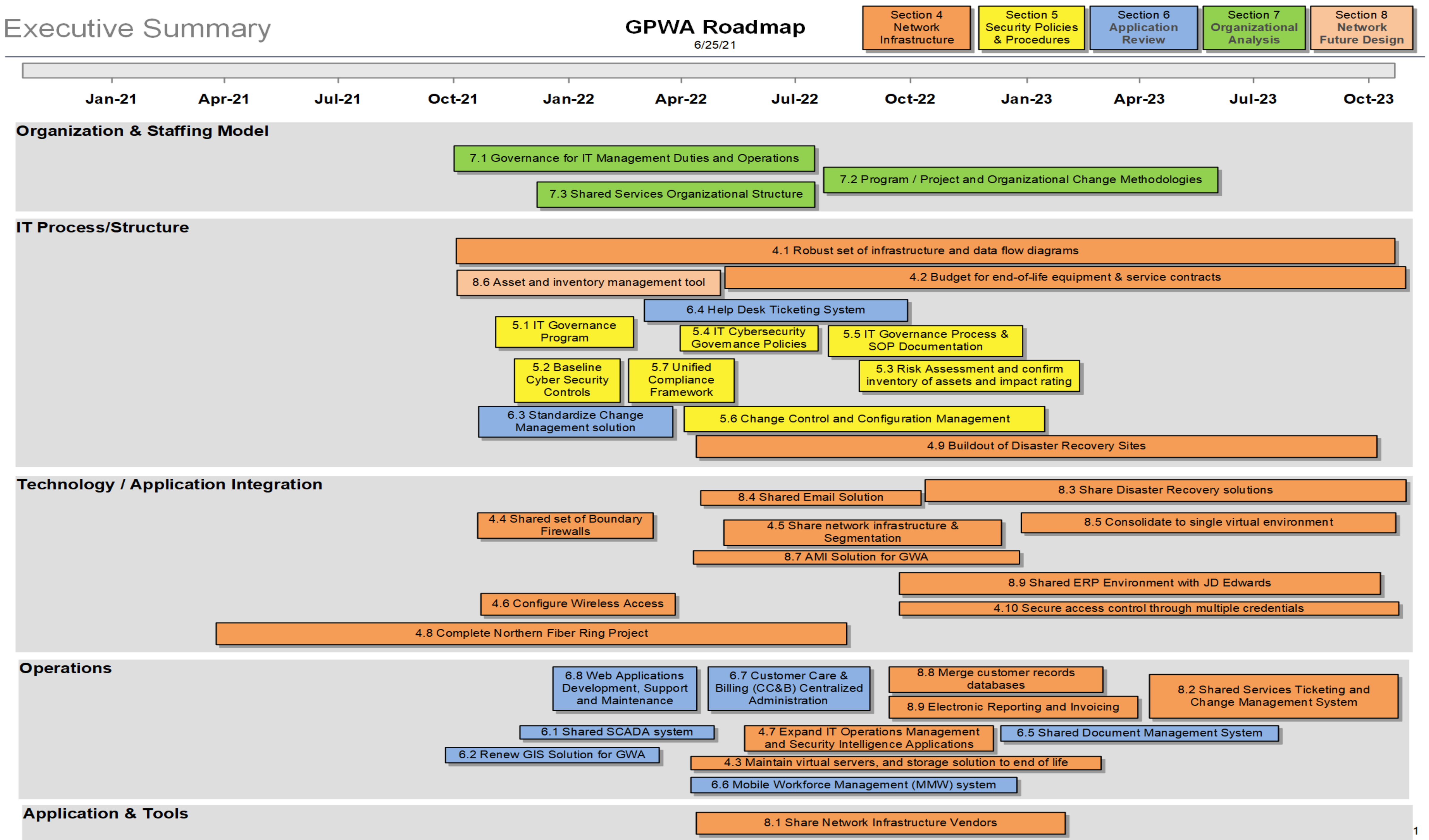
Note: Organizational alignment is forecast to be performed in early FY2022 which accelerates Stand-up and FY2022 costs.



GUAM WATERWORKS AUTHORITY
Guam Power and Water Authority (GPWA)
Information Technology Shared Services
Proposed Summary Organization Chart
Management & Governance
Overall IT Management & Strategy for GPA and GWA
Accountability to GPA / GWA Oversight Committee
Budget & Cost Management
Human Resources & Staffing
Business Service Management
Service Level Agreements to GWA and GPA
Project Management Office
Procurement & Supply Chain Management
Utility Industry Coordination for Technology and IT
1
Chief Information Officer
IT Oversight Committee
IT Strategy Review and Approval
Guidance on GPA and GWA Business Strategy
Monitoring of IT Performance & Metrics
2
Administrative Officer
23
Administrative Officer
Rachel G. Paulino
1
51
Program / Project Manager
New Position
22
Business Systems Manager
Manny P. Apuron
(GWA)
Application Management
Maintains Operational Applications
CC&B, JD Edwards & Other
Mobility Applications (e.g. Clevest)
GPA and GWA Assigned Applications
Designing, Testing and Quality of Applications
Capacity Management
Availability Management, Release Management
Request Fulfillment
Management of 3rd Party Application Support (e.g. Oracle)
1
50
Cyber Security Manager
New Position
Security Management
Cybersecurity Program & Plan
Standards, frameworks, and regulations
Security Administration & Support
Security Training & Awareness
Program Phase Deployment
Stand-up
FY2022 1
FY2023 2
3
IT Service Management Manager
Rudy Manibusan
IT Service Management
Service or Help Desk
Incident & Problem Management
Configuration for IT Assets
Change & Release Management for IT Assets
Business Continuity & Service levels
IT Related Document Management
19
Infrastructure Support Manager
New Position
Network / Infrastructure Management
Network Operations & Support
Network Operations Center
Network Security Tools
Telephony Support
Mobility Infrastructure
Data Center / Infrastructure Operations & Support
Application Support
Server Tools
Support and Administration of Cloud based Environments
Network Design & Planning (Architecture)
44
OT Integration Manager
New Position
OT Integration Management
OT Network Operations & Support
Tropos Network
SCADA Network
AMI/AMR Network (GPA Meters/GWA Meters)
Fiber Network
Network Security Tools
OT & SCADA System Support
Application Support

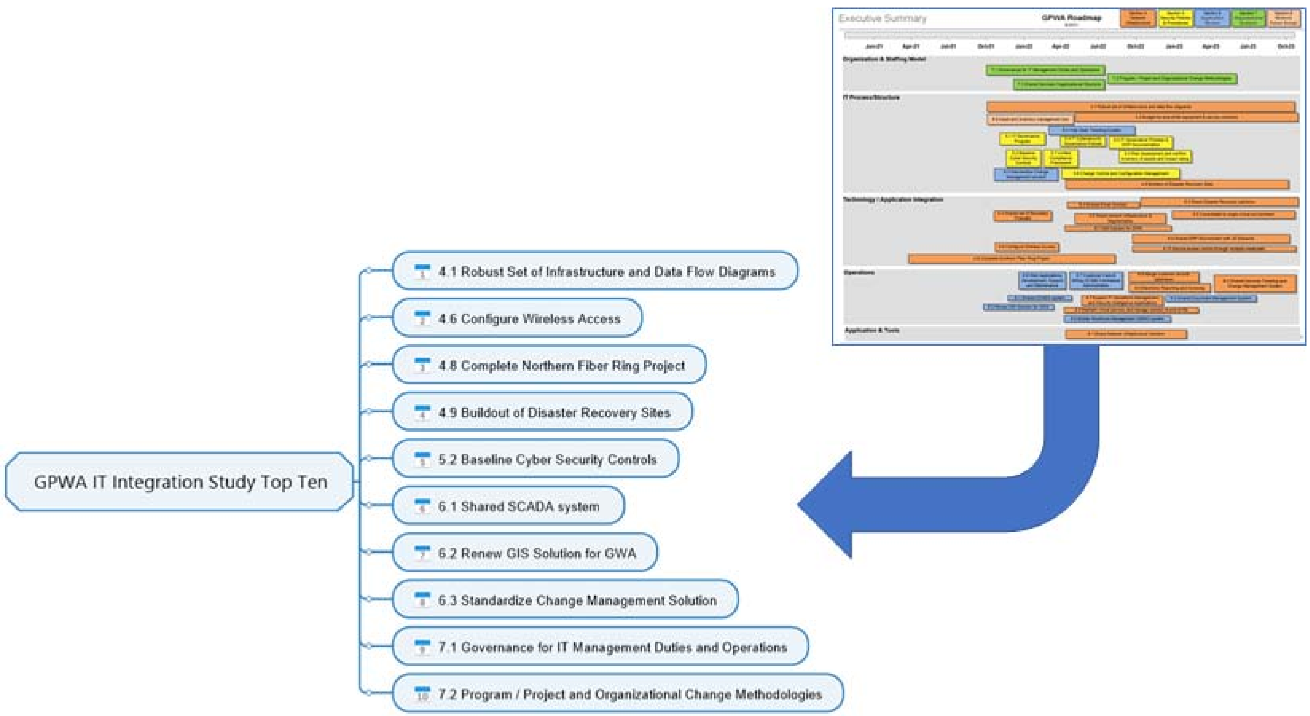
1.9. Roadmap

The master roadmap is essential for organizational change. It is a statement of intent and direction that helps ensure that transformational processes are successful by providing the vision and focus necessary to ensure that changes in the business ecosystems of governance, people, process, and technology do not divert attention from their primary goals and objectives. The chart below presents provides the consolidation, logic, and timing execution of all recommendations and actions into a single graphical representation.



1.9.1. Top Ten Short-term Recommendations & Playbook

The IT Integration Study and supporting roadmap has presented analysis and recommendations in which GPWA management will review, internalize, validate and prioritize in the individual interests of each organization. We realize that the largest most impactful recommendation is 7.3 Shared Services Organizational Structure which merges the GPA and GWA IT groups into a single organizational entity. This recommendation will take multiple management working sessions and CCU meetings to bring to a decision. With that said, it is important to note that other recommendations can move forward ahead and independent of this major decision to which will contribute to improved business processes, joint working conditions and increased efficiencies for GWA and GPA.



We have extracted the "Top Ten" recommendations that were planned for immediate or short-term execution within the next 9-12 months of the proposed overall roadmap. In efforts to "jumpstart" efforts of the plan and begin execution of the roadmap with a "playbook" with 6 scenarios which utilizes all or some that intent of the Top Ten recommendations in producing observable results to GPA and GWA for various projects.   These projects can start immediately with appropriate funding and accountability to the Sponsoring AGM's in GPA and GWA.

Scenario 1: Shared SCADA System

Scenario 2: Configure Wireless Access

Scenario 3: Complete Northern Fiber Ring Project

Scenario 4: Buildout of Disaster Recovery Sites

Scenario 5: Baseline Cyber Security Controls

Scenario 6: Renew GIS Solution for GWA

In reviewing the playbook, we could forecast that Scenarios 1 and 6 could be supported in parallel by a single third-party Project Manager / Specialist or possibly dedicated internal resources. Scenarios 2,3, and 4 could be supported in parallel by a single third-party Network Specialist. Scenario 5 would require a dedicated cyber security specialist working with GPA and GWA IT security personnel. As mentioned before, these scenarios with their supporting recommendation could start immediately for GPA and GWA.

1.10. Conclusion

The IT Shared Services journey starts with the organizational transition, charter development, job description reviews and updates while supporting daily business operations. As part of this journey and a key for cultural change we presented the Business Change Management as a vehicle that aspires to trigger and guide the journey. The Business Change Management will be used as a model for guiding the Guam GPWA IT merged businesses units so that every member will "work" together for greater success.

Business Change Management refers to the actions in which a company or business unit alters a major component of its organization, such as its culture, structure, the underlying technologies or infrastructure it uses to operate, or its internal processes. Business change management is the method of leveraging change to bring about a successful resolution, and it typically includes three major phases: Preparation, implementation, and follow-through.

The Business Change Management Model provides a set of solutions to difficult challenges the businesses IT leaders and employees alike will face and details how to bridge the gap and "work" together. By definition, a team must share a common mission and vision, established operating practices, and have excellent communication skills. Great IT leaders must have both strong people skills as well as organization skills to ensure their teams succeed. The role of the leader is to “keep everyone on track” to achieve collective success. We recommend the use of a qualified third-party to navigate this journey which will allow parallel project efforts to progress forward for GPWA.

An IT shared services model will consolidate the provisioning of standardized services for Information Technology for GPA and GWA. Standardizing these functions into a shared service model would deliver cost efficiencies and improve the quality of outcomes with accountability. A shared services model could potentially include strategic and advisory services such as quality management and project management. Removing responsibility for execution of these core activities from individual departments will also allow them to focus on core strategic activities.

1.11. GPWA IT Integration Study & Roadmap Report Structure

The GPWA Information Technology (IT) Integration Study & Plan provides the results, analysis, and recommendations of the work performed over approximately 18 weeks of working with all GPA and GWA business units and multiple months of review and refinement in a collaborative enterprise approach. It represents the collection and analysis of information from all business units or key organizational entities related to Information and Operational Technology from previous studies, assessments, audits or reports, interviews, and working sessions. Due to the information obtained and materials the report is divided the following volumes:

Volume 1:

1. Executive Summary
2. Table of Contents
3. Introduction and Basis of Study
4. GPA/GWA Network Infrastructure Assessment
5. GPA/GWA Security Policies and Procedures Assessment
6. GPA/GWA Applications Assessment
7. GPA/GWA Organizational Analysis
8. Network Future Design
9. Cost Benefit Analysis
10. Roadmap

11 – 18 Appendices A - H

Appendix H contains electronic versions:

Volume 2: Cost Benefit Workbook (Electronic) with project and benefit details.
Volume 3: Organizational Maturity Analysis (Electronic)
Volume 4: Cyber Security Unified Controls Framework Workbook (Electronic)
Volume 5: GPWA Technical Controls Gap Assessment Workbook (Electronic)
Volume 6: Skills Matrix (Electronic) with supporting Histograms
Volume 7: Skills Matrix Combined Level 2 Analysis (Electronic)

2. Table of Contents

Change Made By	Date Change Made	Details of Change	Reviewed/ Approved By
Sheffield Scientific	10/19/20	Version 0.96 (DRAFT)	Gamble / Rueckert
Sheffield Scientific	11/09/20	Version 0.98 (DRAFT) Incorporated feedback from GPA and GWA AGM reviews	Gamble / Rueckert
Sheffield Scientific	11/29/20	Version 0.99 (DRAFT) Updated skills maturity to Level 2 analysis (Appendix H – Volume 7), incorporated detailed feedback from GPA AGM and updates from GWA AGM.	Gamble / Rueckert
Sheffield Scientific	1/4/21	Version 1.01 (DRAFT) Added Executive Section 1.9.1 and Report Section 10.4.1 for Top Ten and Playbook Scenarios with supporting Executive Summary section.	Gamble / Rueckert
Sheffield Scientific	1/17/21	Version 1.02 (DRAFT) Per GPWA meeting of 1/14/21 added Draft updates to support GM and AGM briefings and Volume 2 – Cost Benefit and Volume 6 – Skills Maturity	Gamble / Rueckert
Sheffield Scientific	2/17/21	Version 1.05 (DRAFT) Per GPWA meeting of 2/16/21 updated Top Ten diagram and GM / AGM briefings.	Gamble / Rueckert
Sheffield Scientific	3/9/21	Version 2.02 (DRAFT) Per GPWA meetings of 2/18/21 and 2/19/21 for CFO briefings the organization (Section 7) and cost benefit (Section 9) were updated to clarify all structure and costs. The Executive Summary was also updated to reflect the refined analysis.	Gamble / Rueckert
Sheffield Scientific	6/25/21	Version 3.01 (DRAFT) Per GPWA meeting of 6/15/21 recommended to move almost all projects and supporting cost / benefit to start in FY2022 due to Enterprise One budget impacts in FY2021. The Sakman Theory was updated with an industry business change management approach. Organizational models remained the same in the plan in accelerating FY2022.	Gamble / Rueckert
Sheffield Scientific	8/16/221	Version 3.02 (DRAFT) Per GPWA meeting of 7/14/21 adjusted projects except for Northern Ring Fiber to FY2022 and supporting cost / benefit to start in FY2022. Updated graphics to reflect changes to Roadmap and Cost / Benefit. Appendix H – Volume 2 Cost Work Book updated.	Gamble / Rueckert

3. Introduction & Basis of Study

3.1. Introduction / Background

Guam Power Authority (GPA) and Guam Water Authority (GWA), collectively GPA and GWA will be denoted hereafter as GPWA, have continued to enhance their technology and network infrastructure through the addition and replacement of various resource types that include: Device/Hardware, Application/Software, Network, Information, Location, Source Code, Media, Personnel, Policies and Procedures due to Water Utility Management, Smart Grid projects, SCADA, Advanced Metering, a Customer Information System (CIS) Replacement and an Office / Data Center Relocation. Because of these dynamic technology and infrastructure changes, there is an opportunity to analyze and provide increased efficiencies and reliability through of merger of management, operational, technical and governance control attributes of the greater GPWA. The results presented in this study and plan for the IT Integration Study & Plan supported with IT Strategic Plan with logical and cost justification supported by an executable Roadmap will advance GPWA to the next level of IT effectiveness for the company and its customers.

Figure 3-1: IT / Business Transformation

3.2. Guiding Principles for the Study & Plan Project

- Upgrade “orphaned” and “legacy” systems
- Streamline, then automate business processes
- Leverage mobile technologies to increase efficiency and connectivity of the workforce

- Expand use of online technologies to better serve and engage various stakeholders (customers, staff, vendors, community, etc.)
- Improve information transparency and accuracy for customers
- Mitigate system performance risks
- Develop integrated technology solutions that cut across functional units
- Enhance two-way information flows by expanding the use of real-time technologies
- Harness the power of information with business intelligence and predictive analytics
- Optimize existing systems, end-to-end
- Fully maximize governance and organizational effectiveness within IT
- Continue to transition from a legacy environment to modern, distributed architectures
- Provide actionable alternatives and recommendations for initiatives and projects supported by a prioritized roadmap

3.3. Approach

The IT Network Integration Study is broken down into a logical flow (Refer to Figure 3-2) and a seven-step execution plan which spanned the effort as outlined in the graphic below. Sheffield documented the Assessment Approach, Procedures Performed, Results and Observations, Supporting Analysis Materials, recommendations and Roadmap with supporting Appendix materials and graphics for each section in the GPWA IT Integration Study & Plan scope of work.

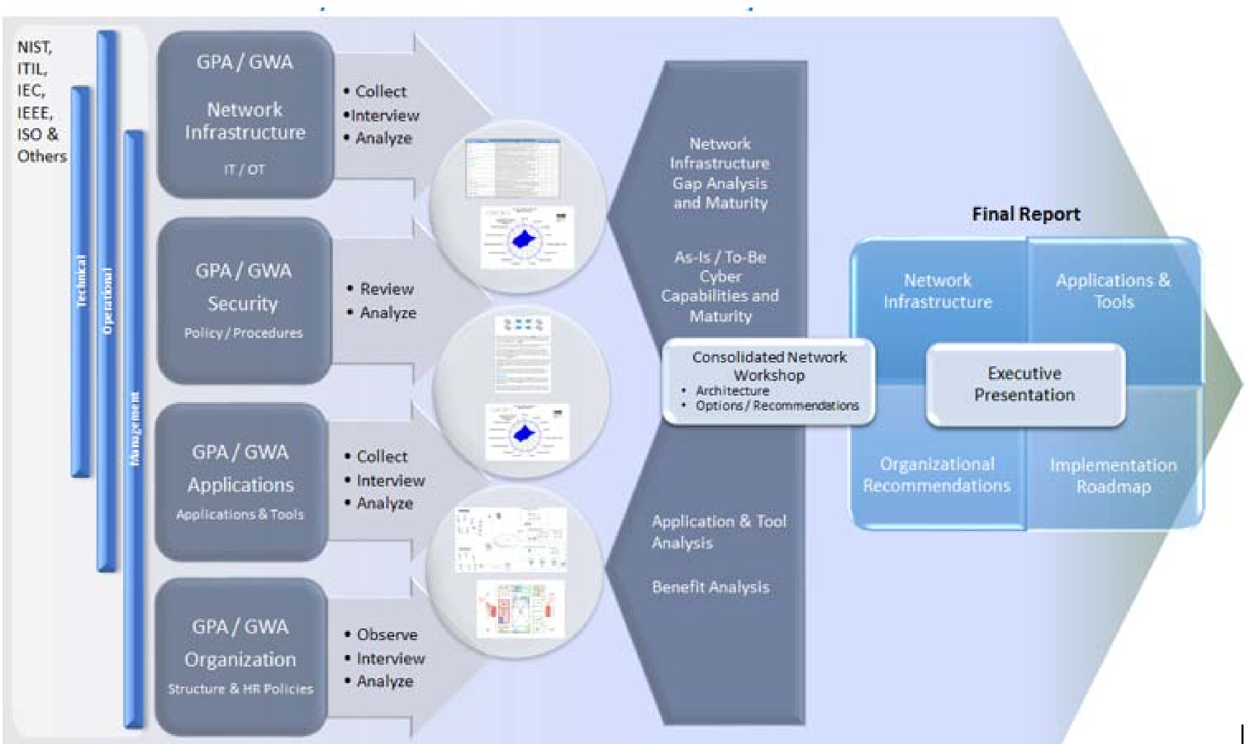


Figure 3-2 GPA / GWA IT integration Study & Plan Logic

Interviews were conducted in a confidential discussion which aided in open, transparent, and candid interaction. Only where appropriate have individual participants been identified within the report.

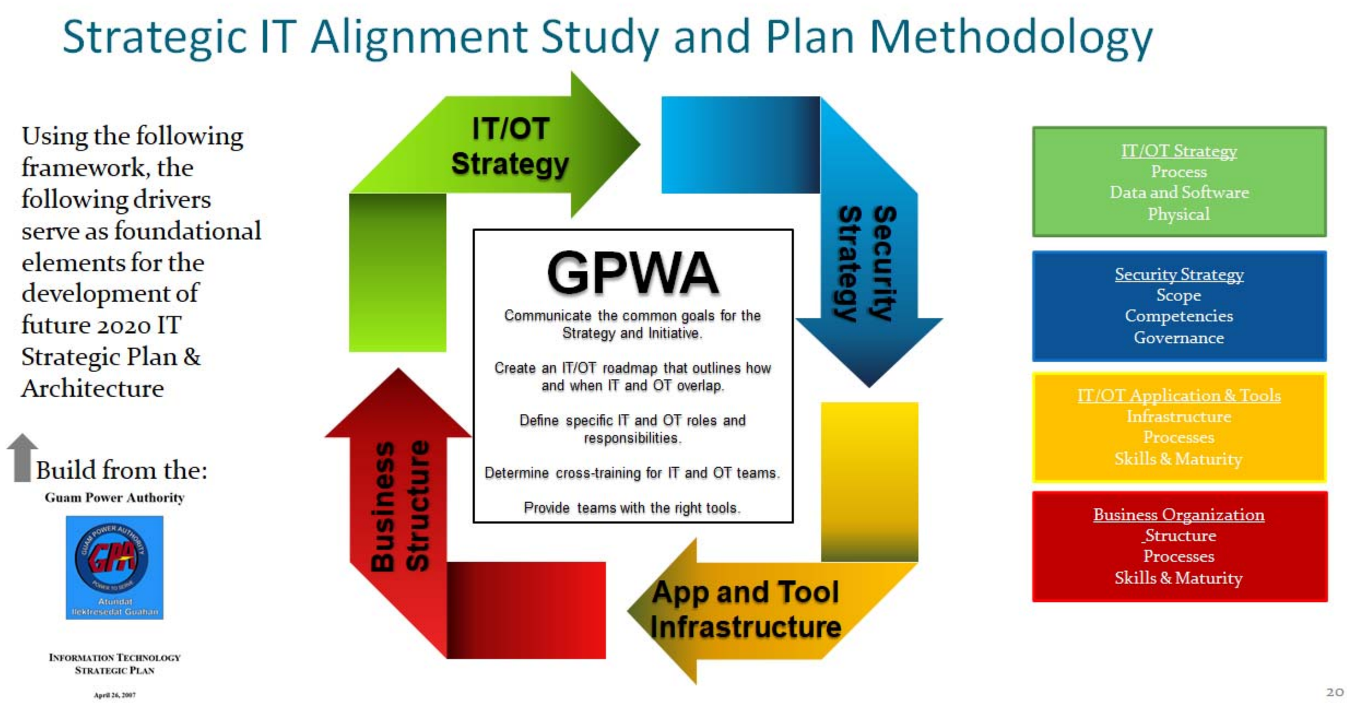


Figure 3-3: Strategic IT Alignment Study and Plan Methodology

Study and Plan at GPWA with key scope areas listed below:

1. Performed Review & Analysis of the network Infrastructure of GPA & GWA (IT/OT)
   a) Analyzed current network topology, supporting technologies and processes for GPA
   b) Analyzed current network topology, supporting technologies, policies, programs, plans and processes for GWA
   c) Determined the required modernizing of an IT Enterprise Level Architecture interface needs for the two organizations
   d) Documented all IT GPA & GWA External providers
   e) Determined maturity levels, gap analysis, and define areas of opportunity for network Integration
2. Performed Review & Analysis of Security Policies, programs, Plans Processes, and Procedures of GWA & GPA
   a) Performed As-Is / To-Be cyber security operational controls capabilities and maturity (Gap Analysis) for GPA
   b) Performed As-Is / To-Be cyber security capabilities and maturity (Gap Analysis) for GWA
7. Reviewed Infrastructure and Application Portfolio for GPA/GWA
   a) Analyzed tool & application inventory, governance, and support for GPA and GWA
   b) Prepared opportunities and recommendations for application and tool Integration for GPWA
8. Performed Organizational Analysis of GPA & GWA IT Integration into GPWA

a) Reviewed organizational structure and HR policies for GPA and GWA
b) Performed Business / IT Alignment Prioritization for GPWA

9. Created integrated Network IT policies and Operations Design (Technical)

   a) Prepared preliminary consolidated network infrastructure architecture for GPA / GWA
   b) Conducted workshop to GPA / GWA on consolidated architecture for technology & operations processes
   c) Prepared recommended consolidated network infrastructure architecture for GPA / GWA

10. Developed & Deliver Roadmap and Final Report for GPA/GWA IT Consolidation

   a) Developed Benefit Analysis Report for GPWA
   b) Developed Draft Version of Roadmap and Final Report
   c) Reviewed & Socialized Final Report with Sponsors and Key Stakeholders in GPA and GWA
   d) Conducted Final Presentation to CCU

3.4. Mission Statement for the IT Integration Study & Plan

Mission

The mission of the GPA / GWA IT Integration Study & Plan for Information Technology is to build a quality and customer-centric focused technology infrastructure, establish and maintain an effective operational environment, and deliver quality, prompt, cost effective, and reliable technology services that align with the mission in delivering cost effective service, as well as compliment the organization's economic goals.

In support of this mission, we will:

Partner with the internal and external customers to understand their information technology needs and provide leadership and planning for the effective and strategic use of emerging technologies. Strategic IT planning must be an integral part of an organization's strategic planning and enterprise governance. The strategic IT plan should reflect the relevance of technology to each of the organization's strategic business goals and changes the organization will need to make to its information and communications infrastructure. The organization's technology environment must be aligned with its long-term strategic plan, goals, and objectives. The organization's management and governance board must recognize the critical role of technology and its cost and benefits in laying the foundation for and enabling its strategic direction and operational goals for digital transformation journey.

Demonstrate technical and operational excellence through a commitment to professionalism and continuous improvement. A vision, mission, or values are of little importance if employees are unaware of them.

IT Shared Services Organization Mission:

To provide timely, accurate, high-quality, cost-effective, and customer-focused support for GPWA business and technical services.

"To Get the Right Information, At the Right Time, To the Right People to Make the Right Decisions!"

3.5. Vision Statement

Vision for the IT Organization

Recognized national leader in Information Technology services in support of electrical and water services, and to be the preferred workspace for quality technology personnel and customer services. GPWA will achieve operational excellence: getting the right information to the right people at the right time so they can make excellent strategic, tactical, and operational decisions immediately.

Information Technology Services will be recognized as a high-performance cross functional team providing technology excellence that advances information sharing in alignment with Guam's mission and goals.

3.6. Core Values for the IT Organization

In order to fulfill the mission, business value will be created by allowing IT service management to properly leverage governance, people, process, and technology in support of customer needs. Both Divisions of Information Technology are committed to the following core cultural values:

- Accountability
- Clarity of Vision
- Employee Fulfillment
- Exceptional Customer Service
- Teamwork

3.7. Key Values for the IT Organization

Reliable IT Infrastructure and Facilities

- Evaluate and uphold reliability standards for adopted technologies
- Adopt innovative technologies and solutions in accordance with institutional needs, initiatives, financial priorities, and regulatory compliance

Efficient and Effective Access to Information and Technology Resources

- Foster knowledge related to efficiency, effectiveness, and timely access to information
- Enabling user-friendly innovative technology solutions that consistently support the learning needs and process
- Promote and ensure quality, accuracy, and access of information and data

Quality and Reliable Technology Support

- Emphasize the importance of technology usage and support to users
- Prioritize the resolution of technology issues as needed
- Monitor constituency satisfaction

Minimal IT Risks

- Reduce risk by enabling user participation in training and sense of ownership
- Implement technical and behavioral controls to protect institutional and user data

- Implement technical best practices to ensure business continuity and disaster recovery
- Prioritize identifying and addressing security vulnerabilities

A Dedicated and Professionally Talented Workforce

- Foster a working environment that encourages staff satisfaction, engagement, and development
- Enhance knowledge of effective recruitment and retention strategies
- Encourage personal and professional growth through collaboration and continuing education

Institution-Wide Awareness of Learning Technologies

- Enhance learning management and knowledge management technologies content and delivery for the organization. These technologies would include the Learning Management System (LMS) and IT knowledge base in the Help Desk.
- Collaborate and evaluate and disseminate information regarding learning technologies

Refreshed IT Strategic Plan on an Annual Basis

- Set a schedule for refreshing the plan
- Involve key stakeholders in the review of the plan

3.8. Key IT Goals

- Exemplary Customer Service: Provide the highest quality of customer service to our internal stakeholders and customers, recognizing that we are here to advance the organizations mission in providing timely, accurate, high-quality, cost-effective, and customer-focused support for all business and technical services "To Get the Right Information, At the Right Time, To the Right People to Make the Right Decisions!"
- Pervasive Partnership: To partner with the organization's management and administrative groups in the use of information technology to develop cost-effective, innovative, and comprehensive solutions and services to advance the organizations mission.
- Transformation/Engagement/Communications: To be an engine for transformational change at the organization through best practices in the use of information technologies, next-generation infrastructure, and new ways of communicating with and engaging our customers and stakeholders, recognizing the growing role of technology with the organization.
- IT/OT Innovation: To be an innovator in the use of advanced information and operational technology to solve problems in new ways and at new scales, serving both customers and administrative goals, as well as enhancing the reputation of the IT/OT organization.
- Effective IT Governance: To provide a clear framework for IT governance that enhances IT service across the organization and ensures successful IT deployments, information security, interoperable systems, and clear guidance on risk and compliance matters.

4. GPA / GWA Network Infrastructure

4.1. Assessment Approach

The network infrastructure review was done in three phases: Discovery, Analysis, and Recommendations. Existing AS-IS documents and diagrams were reviewed. GPA and GWA staff interviews were conducted as well as a site inspection of the data center, selected field locations, and main administration building.

To-Be documents and diagrams were created as part of the project. The as-is state of a process is the "now" state. It's how the process operates before you make any changes or improvements. The to-be process, on the other hand, is the future state. These improvements needed are captured in the roadmap.

4.2. Network Infrastructure Procedures Performed

- Gathered documents and diagrams
- Interviewed GPA and GWA Staff
- Reviewed documents and network infrastructure diagrams provided by GWA and GPA
- Conducted a physical inspection of the data center
- Analyzed collected information
- Developed roadmap and recommendations

4.3. Network Infrastructure Results and Observations

GWA has limited staff that has to fill multiple roles. While they do conduct cross-training, this limits their ability to send personnel for training and creates the risk of roles being unfulfilled due to illness, vacations, or employee attrition.

Network diagrams and data flow diagrams were out of date or missing which led to confusion as to the "source of truth" when making changes to the network. The document management system for both organizations lacked strong security controls and was not managed or maintained on a regular schedule which exacerbated the issue.

Key security equipment was end of life and no clear process was implemented to secure and/or manage budgets for end-of-life equipment to ensure it is replaced before going out of support with the vendor. GWA currently has a SonicWALL firewall solution that is not yet end of life and has current support. However, these firewalls do not support next gen firewall functionality which increases security risks. GPA's firewalls are end of life and need to be replaced. Having two different solutions does not allow personnel to provide support across the organizational boundaries due to knowledge and skill sets.

GPA and GWA share data center space yet have disparate solutions for hypervisor, servers, and storage preventing them from being able to share resources during disasters, maintenance outages, and general maintenance activities. This also prevents them from sharing licensing and maintenance costs. GWA recently installed a VxRail solution from Dell to host their VM environment. GPA is in the process of upgrading their

Cisco UCS blade server solution as well as their EMX storage. A shared system would lead to reduced costs for licensing and training and allow for sharing resources since two different skill sets would not be necessary.

GPA and GWA do not share an internet edge which reduces visibility of potential malicious activity. It also requires a web proxy server which introduces a single point of failure into the environment.

GWA and GPA share a physical headquarters building and data center. GWA and GPA maintain separate network infrastructure within the building. GPA and GWA have each standardized on a different vendor for network infrastructure leading to the maintenance and administration of two separate sets of network infrastructure. This results in higher maintenance, support, training, and licensing costs than if infrastructure were shared. Having two different solutions does not allow personnel to provide support across the organizational boundaries due to knowledge and skill sets required and does not support an integrated environment. GPA has standardized on Cisco switches and routers. GWA has a mix of Netgear and Cisco switches.

GWA does not currently have a wireless solution available in the headquarters building. GPA has wireless access installed in the building, but coverage is spotty in areas leading to complaints from various business units. GPA uses Tropos access points for their indoor wireless solution which supports large scale implementation, but the deployment of the networking equipment should be re-evaluated for better coverage or a more robust solution. Wireless solution will need to be extended for GWA campus in Upper Tumon which includes four buildings and a warehouse. A fifth building may be built in the future and will need to be included in the project plan and budgeting.

Neither utility has an effective solution for monitoring devices, servers, applications, and networks. Some logs are being kept and minimum alerting capabilities are available leading to manual log reviews conducted on an ad-hoc basis (only if something is suspected of taking place, such as a breach). Fiber technology is being deployed and needs to be completed to fully operationalize the monitoring and alerting. Fiber line between Fadian and Upper Tumon was planned for implementation last fiscal year but was set aside by GPA Engineering due to the covid-19 pandemic. This project needs to be placed back into the planning cycle and be completed in an expeditious manner. Neither entity has the resources available to provide 24/7 monitoring preventing them from quickly identifying and responding to breaches or having consistent audit materials for forensic analysis. GWA has no monitoring and if a network device or service fails, they rely on end users to alert them that there is an issue. GPA has deployed the SolarWinds Orion suite for network monitoring and alerting, however there is limited personnel capacity so only the most urgent alerts are generated, and logs are reviewed on an ad-hoc basis.

Network coverage is not available and/or not sufficient to support the GPA mobile workforce. Fiber connections were in the process of being deployed at the time of this study to key GPA and GWA locations (Northern Fiber Ring Project). The current GWA SCADA Master Plan outlines the ability to support mobile workforce applications and GWA SCADA RTU traffic. The organization should confirm technically the GWA SCADA Master Plans assumptions can support the required bandwidth requirements are sufficient for both entities, which includes bandwidth needs for projects planned and inflight. ISP carrier coverage and SLA should also be assessed as users reported ongoing issues with coverage and outages.

The backup data center for all critical systems of both entities is located geographically near the primary data center. This lack of geographic diversity does not meet best practice and puts information at risk. Current plans exist to have DR located in a renovated Customer Service Center server room and then in co-location building at GWA Upper Tumon campus that houses all DR and backup System Control Centers. GWA will be purchasing data services for a mobile workforce solution. Analysis might include the capability of the GPA network to deliver data from field workers to JD Edwards (JDE) Enterprise One (E1) in the cloud. GPA has secured a facility co-located at the Docomo Pacific data center to use for disaster recovery which does not meet the geographical best practice. GWA is configuring an instance of JDE in Oracle Cloud. JDE E1 productions servers will reside in Oracle Cloud Data Center in Phoenix Arizona.

Both organizations lack formal change control processes resulting in inaccurate asset inventories, out of date network diagrams, poor control over baseline configurations, lack of communication of changes to impacted personnel, and no method to capture lessons learned or metrics. Both organizations have a system which could be upgraded or better utilized to support change and configuration control processes. Neither organization is using the full system capabilities and lacks the knowledge, skills, and/or training to use the change and configuration functionalities.

Neither organization has a full asset inventory or inventory tracking system. The lack of asset inventories resulted in the use of non-standardized products with no documented baselines, and the use of two or more competing products.

4.4. Network Infrastructure Recommendations

4.4.1. Continue to update and maintain a set of infrastructure and data flow diagrams

GPA	X
GWA	X

GPA/GWA Network Infrastructure

Recommendation 4.1 – Continue to update and maintain a set of infrastructure and data flow diagrams

Introduction

Audience: IT Senior Management Team

Situation: The lack of document control has led to an inaccurate and incomplete set of infrastructure and data flow diagrams. This is exacerbated by the lack of skilled personnel to support the maintenance objectives.

Complication: While the infrastructure diagrams are being updated as part of this project, the data flow diagrams will continue to be out of date until a skilled resource is identified for their maintenance and change control processes are put in place to ensure they are continually updated as hardware and software are updated or changed.

Question: *What can be done to ensure all infrastructure diagrams and data flows are documented and maintained?*

Next Steps:

- Review and update per changes in the network / infrastructure configuration.
- Document a change control process for network diagrams and data flows

Governing thought

Accurate network diagrams and data flow documentation establish the foundation of the network infrastructure and helps support management and improvement on the network. By understanding the network, administrators are better able to support network users by more readily identifying bottlenecks, security concerns, compliance issues, make better decisions to improve and update network capabilities, and standardize processes.

Arguments

Supporting Concepts

Identify network infrastructure

- Suboptimal control of network traffic and bandwidth requirements to maintain performance
- Higher risk of network breach

Document baseline configurations and data flow requirements

- Inability to quickly troubleshoot misconfigured devices
- Inability to quickly identify evidence of configuration changes, incompatible processes, or tampering

Update network diagrams and data flow diagrams

- Inability to quickly troubleshoot recurring help desk or maintenance themes
- Greater spending due to lack of standardization and competing processes or resource requirements
- Supports vendors on project implementation
- Support training of personnel

Manage and maintain infrastructure and data flow diagrams through formal change control processes

- Lack of process to identify and document changes
- Lack of accountability for changes
- Ongoing maintenance and support issues
- Extended resolution times for end-user support

4.4.2. Budget for and replace end-of-life assets and expiring maintenance and service contracts

GPA has a $6 million annual IT/OT budget set aside for it for planed processes and technology upgrades and improvements. GWA currently allocates $200K per year for IT improvements but most of this allocation for FY2020 & FY2021 is consumed by the JDE E1 upgrade project. A $37 million budget for SCADA has been sucured and is oultlined in the GWA Master Plan.

GPA	X
GWA	X

GPA/GWA Network Infrastructure

Recommendation 4.2 – Budget for and replace end-of-life assets and expiring maintenance and service contracts

Introduction

Audience: IT Senior Management Team

Situation: GPA/GWA IT does not have funds allocated to replace end-of-life and end-of-support hardware and software and maintenance contracts are expiring before being renewed.

Complication: When hardware, software, and maintenance contracts become end-of-life, end-of-support, or expire it increases the organization's risk of security breaches and may increase the cost of renewal due to new licensing structures. It also increases the efforts of the procurement department to initiate a new contract and/or negotiate new terms.

Question: What can be done to manage hardware, software, and maintenance schedules and costs?

Next Steps:

- Review quarterly, obtain quotes for equipment that is end of life or soon to be end of life. Procure equipment

Governing thought

When applications and devices are no longer supported by the vendor, they introduce an increased security risk to the organization since no patches or updates are available. While vendors may provide some level of support it is generally at a higher cost and is not indefinite. Additionally, as hardware and software goes out of date it often becomes incompatible with newer applications and hardware causing some systems to fail or necessitate the need for a work around which requires addition technical support to manage the environment.

Arguments

Supporting Concepts

Identify assets and systems to be included in the tracking process and tool

- Lack of accurate asset and system inventories
- Increased risk of loss of assets
- Difficulty of baseline configuration management
- Detection of technology gaps
- Identification of training gaps
- Maintenance tracking & End of Life tracking

Identify and document life expectancy and maintenance cycles for critical assets and systems (Operational Calendar)

- Out of date Hardware, software & firmware
- Incompatibility issues
- Lack of support
- Increased security issues
- Out of date training

Budget for the replacements and renewals of end-of-life equipment

- Need for emergency replacements
- Management of redundant hardware, software, and services
- Planning for capital
- Third-party support cost management
- Control of personnel training cycles and content updates

4.4.3. Maintain existing hypervisor, server, and storage solution until end-of-life

GPA	X
GWA	X

GPA/GWA Network Infrastructure

Recommendation 4.3 – Maintain installed hypervisor, server, and storage solution to end of life then move to Shared Solution

Introduction

Audience: IT Senior Management Team

Situation: GPA (Cisco) and GWA (Dell) have differing solutions for hypervisor, servers, and storage. These hypervisor and storage solutions have been recently installed or upgraded.

Complication: While the goal is to move to a single shared services solution, both organizations have an investment in the current solutions.

Question: What can be done to reduce costs associated with hypervisor, server, and storage solutions?

Next Steps:

- Identify standard solution for hypervisor, server, and storage
- Review end of life and develop a strategy and timeline to move to shared service model

Governing thought

GPWA's migration to a single shared hypervisor and storage services platform needs to be accomplished in stages in order to manage the cost of the transition. GPWA should wait until their current infrastructure components reach end of life before replacing them.

Arguments

Supporting Concepts

Cross train shared services IT personnel on both systems

- Multiple solutions from diverse vendors create higher training costs.
- Multiple procedures to track and manage
- Multiple training modules required to support system admins and users

Consider trunking GWA VLANs into the GPA hypervisors and GPA VLANs into the GWA hypervisors to make best use of system capacity and licensing.

- Separate hypervisors require additional OS licenses and service contracts.
- Consistency of security and configuration management.

Use micro segmentation and VLANs to isolate VMs in the shared environment.

- VMware NSX allows the use of micro segmentation for securing individual applications in a virtual environment.
- Where micro segmentation is not practical, use VLANs and firewalls to segment systems from each other.

4.4.4. Move towards a shared Internet edge utilizing next generation firewalls

GPA	X
GWA	X

GPA/GWA Network Infrastructure

Recommendation 4.4 – Move towards a shared Internet edge utilizing next generation firewalls

Introduction

Audience: IT Senior Management Team

Situation: Both organizations have limited visibility into potential malicious network activity which has led to reduced response times to identified threats. Possibly Palo Alto or Fortigate solutions can work for this solution based on budget.

Complication: Both organizations are using different brands of firewall solutions and both solutions lack next gen functions and auditability of layer 7 protocols. This is resulting in the need for proxy servers and increased maintenance and support personnel to support redundant and less secure devices.

Question: *What can be done to reduce costs and risks associated with network activity and provide additional functionality and auditability of layer 7 protocols and security?*

Next Steps:

- Identify and standardize on a next-gen firewall solution

Governing thought

The use of next-generation firewalls improves security control and provides network traffic visibility. Management is simplified because they can incorporate the functionality of anti-virus, anti-malware, and other security applications into one device. Next-gen firewalls are also better equipped to address advanced persistent threats, modern malware attacks, and application layer attacks.

Arguments

Supporting Concepts

Identify organizational security requirements

- Multiple solutions which fail to meet security needs
- Incompatible systems and solutions increase the need for bridging technology
- Duplicate systems require additional support and training time

Identify skills needed to support the system and system users

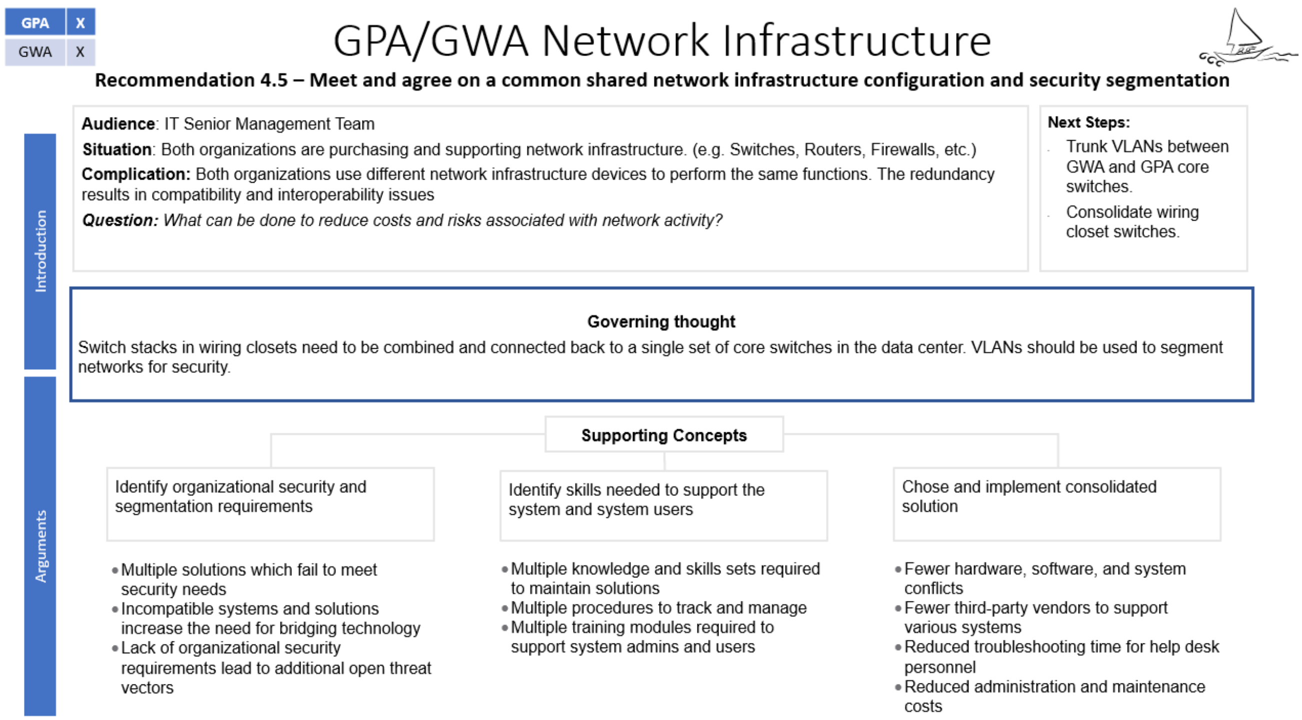
- Multiple knowledge and skills sets required to maintain different solutions
- Develop and maintain multiple procedures to track and manage both solutions
- Multiple training modules required to support system admins and users

Chose and implement consolidated solution

- Fewer hardware, software, and system conflicts
- Fewer third-party vendors to support various systems
- Reduced troubleshooting time for help desk personnel
- Reduced administration, operation and maintenance costs

4.4.5. Meet and agree on a common Shared Network Infrastructure, Configuration and Security Segmentation

GWA is ready to upgrade all Fadian switches. A proposal was submitted for CIP funding last year and is on hold until a GPA & GWA effort is agreed upon and implemented. Training will need to be developed and executed as part of the OCM activity critical to achieve the successful outcome of the project. An integrated project plan and project management for the organization's multiple team members with KSAs to manage switches, routers and firewalls installation and tracking is rquired.



4.4.6. Configure GWA SSIDs on Headquarters Wireless Infrastructure

Currently only GPA has an implemented wireless solution for its employees. Implementing and sharing the costs of a Wi-Fi solution will allow for a reduction in overall costs to GPA and enhanced capabilities for GWA personnel. Tropos access points are optimized for outdoor mesh deployments. An enterprise wireless solution offering Wireless Intrusion Prevention System (IPS) and central management and monitoring of wireless infrastructure and clients should be deployed. A policy on usage with training will need to be completed. This will improve the security posture of GPA, reduce maintenance costs, and allow GWA to have mobile network access within the building.

GPA	X
GWA	X

GPA/GWA Network Infrastructure

Recommendation 4.6 – Configure GWA SSIDs on Headquarters building Wireless Infrastructure

Introduction

Audience: IT Senior Management Team

Situation: Only GPA has wireless networking capabilities

Complication: GWA personnel have no mobile access capabilities allowing them to work independently in the headquarters building. The introduction of a second wireless system within the same building would be problematic from a maintenance perspective as there is the likelihood of radio frequency interference, issues with overlapping channels, and device placement in addition to the costs of redundant devices, services, and support personnel.

Question: *What can be done to provide GWA with wireless networking capabilities without doubling equipment and maintenance costs?*

Next Steps:
- Identify wireless bandwidth requirements
- Enforce policy and proper usage of internet services to manage bandwidth

Governing thought

The use of wireless capabilities by GWA personnel will increase productivity by allowing them to access information during meetings and while otherwise away from their desk. Since GPA already has wireless networking capabilities which could be scaled, GWA would not have to duplicate wireless infrastructure resulting in a cost savings when the combined cost of services is considered.

Arguments

Supporting Concepts

Connect GWA Office VLANs into GPA switches and APs
- GPA and GWA network infrastructure must be merged in order to share network resources including wireless.

Scale wireless networking capabilities to allow for use by GWA
- There are gaps in wireless coverage in the headquarters building. Additional APs may be required to cover GWA areas of the building.

Communicate changes, and train personnel, update policies and procedures
- Reduce security risks associated with wireless usage
- Set expectations for usage

4.4.7. Expand GPA's SolarWinds Orion installation and Splunk SIEM to monitor GWA network devices, servers, and applications

GWA Team needs implemented tools and training to have a disciplined approach in monitoring the network and to allow a real time view of security threats and network degradation and application failures.

GPA	X
GWA	X

GPA/GWA Network Infrastructure

Recommendation 4.7 – Expand GPA's SolarWinds Orion installation and Splunk SIEM to GWA to monitor its infrastructure

Introduction

Audience: IT Senior Management Team

Situation: GWA has no capability to monitor network devices

Complication: GWA relies on ad-hoc log reviews to identify potential security concerns which leaves them at a greater risk for security breaches.

Question: *What can be done to enhance the security of GWA networks, systems, and devices?*

Next Steps:
- Identify security requirements and investigate licensing

Governing thought

Organizations who implement monitoring save money in network performance, employee productivity, and infrastructure costs. Network monitoring allows organizations to identify and resolve a variety of network issues by providing visibility and control of hardware and software assets allowing administrators to optimize network functions and provide faster response times to outages. An optimized network has fewer performance issues and less down time which equates to better employee productivity and provides an audit trail for forensic analysis in the event of a security incident. Configuration of GPA devices to monitor GWA traffic and systems will prevent the need for redundant systems and personnel necessary to improve GWA's security posture.

Arguments

Supporting Concepts

Analyze and document security requirements
- Alignment of security objectives
- Enhances metrics capabilities

Update licensing
- Continuous security updates to monitoring software
- Prevent fees associated with licensing discrepancies

Configure appliances and systems
- Allows traffic to pass from GWA to GPA appliances
- Eliminates need for a redundant security solution at GWA
- Reduces personnel necessary to support redundant systems

Send logs and alerts
- Reduces manual log review efforts
- Increases identification of potential security issues or breaches
- Reduces response time to potential security issues or breaches

4.4.8. Complete northern fiber ring project

GPA and GWA SCADA priorities should follow their currently documented SCADA Master Plans.

GPA	X
GWA	X

GPA/GWA Network Infrastructure

Recommendation 4.8 – Complete Northern Fiber Ring Project

Introduction

Audience: IT Senior Management Team

Situation: Poor connectivity between substations and other facilities on the northern end of the island.

Complication: GPA has been negotiating with on-island carriers for fiber swaps to complete the ring. This effort should continue to ensure the ring connects back to the data center and provides redundant connectivity to all locations.

Question: *What can be done to network reliability and performance between critical locations for both GWA and GPA?*

Next Steps:

- Monitor progress on current project. Assess service area and bandwidth requirements
- Look toward carriers to provide coverage to some areas

Governing thought

The completion of the northern fiber ring will expand high speed resilient connectivity between the data center and critical GPA and GWA locations on Guam.

Arguments

Supporting Concepts

Assess bandwidth requirements and ISP coverage and costs
- Ensure bandwidth needs are met for both water and power
- Reduce redundant or overlapping services

Assign project management and enable metrics collection
- Address slow project implementation progress
- Capture project metrics

Complete fiber ring infrastructure project
- Eliminates need for redundant infrastructure or wireless services
- Ensure timely transmission of metering and outage data
- Water treatment plant access

Complete fiber swap agreements with carriers.
- Provide fiber connectivity to locations where GPA has not been able to run their own fiber.
- Improves outage response times

GPWA will need to allocate performing resources and budget to complete a more expanded scope than the last mile of the Norther Fiber Ring Swap. What needs to be completed in the expanded scope for Roadmapping should include:

- GPWA fiber to each substation, water treatment plant, wastewater treatment plant, each GPA and GWA campus.
- GPWA fiber to each AMI collector expand number of collectors.
- fiber to in-span pole top router gateways to shorten hops back to headend

These long-range 3-to-5-year Roadmapping projects will be completed through:

- construction projects
- fiber swap projects
- temporary carrier contracts.
- Solar PV projects
- New fuel pipeline project.

4.4.9. Share disaster recovery capabilities and move backups to a remote data center

GPA	X
GWA	X

GPA/GWA Network Infrastructure

Recommendation 4.9 – Complete buildout of Disaster Recovery Site for both divisions to co-locate

Introduction

Audience: IT Senior Management Team

Situation: Neither GPA or GWA have disaster recovery capabilities. GPA has leased rack space at the Docomo data center on the island to build a DR site.

Complication: The new DR site needs to be scaled to include GWA applications as well as GPA applications.

***Question:** What can be done to reduce the risk associated with a disaster?*

Next Steps:

- Assess storage and security requirements

Governing thought

As an interim solution to moving disaster recovery capabilities to an off-island facility or cloud solution, GPWA should complete the build out of the Docomo data center. It should be scaled to include GWA applications as well as GPA applications.

Arguments

Supporting Concepts

Assess storage, access, and security requirements. Identify applications requiring DR capabilities and restoration time requirements for those applications.

- Storage, access, and security requirements may vary by organization and data type
- GWA is using Oracle cloud for JDE Disaster Recovery.

Identify DR and backup storage location and provider and conduct skills assessment

- Ability to share resources
- Reduction in redundant infrastructure costs
- Reduction in maintenance vs. two discrete solutions
- Verification of personnel with skills and training to manage remote storage

Migrate DR and backups to identified provider

- Reduced risk of data loss
- Enhanced data retention and recovery capabilities
- Shared storage costs
- Shared management resources

4.4.10. Implement Multi-factor Authentication for remote Access to the network for GPA and GWA

GPA needs to implemt a solution for multi factor athentication for the enviornment. GWA is currently implementing Multi-Factor Authentication with Oracle Identity Cloud Services and will go live with JD Edwards EnterpriseOne in 2021. Other applications will need to have multi factor authentication in order to remotly access the network.

GPA	X
GWA	X

GPA/GWA Network Infrastructure

Recommendation 4.10 – Implement Multi-Factor Authentication for Remote Access to the network for GPA and GWA

Introduction

Audience: IT Senior Management Team

Situation: Both organizations allow remote access to their networks through VPN (virtual private networking). However, these systems are not current on best practices for cyber security. Neither organization is using multi-factor authentication for VPN.

Complication: Both organizations are using different firewall solutions and both solutions lack a multi-factor authentication mechanism for positively identifying the remote user.

***Question:** What can be done to security for remote access?*

Next Steps:

- Identify and standardize on a next-gen firewall solution

Governing thought

The use of multi-factor authentication prevents credentials from being easily stolen or shared. Implementation of MFA for remote access is considered a best practice for cyber security and is almost always noted in security audits.

Arguments

Supporting Concepts

Identify cyber security controls requiring MFA

- The current solution does not comply with GPA's and GWA's documented policies and procedures.

Identify an MFA solution. Ideally, the same solution can be deployed for both GPA and GWA.

- Multiple knowledge and skills sets required to maintain solutions
- Multiple procedures to track and manage
- Multiple training modules required to support system admins and users

Choose and implement consolidated solution

- Fewer hardware, software, and system conflicts
- Fewer third-party vendors to support various systems
- Reduced troubleshooting time for help desk personnel
- Reduced administration and maintenance costs

5. GPA/GWA Security Policies and Procedures

Sheffield was tasked with performing a Review & Analysis of Information Technology (IT), Operational Technology (OT) Cyber Security Policies, Programs, Plans Processes, and Standard Operating Procedures (SOPs) for the GWA & GPA IT organizations. This analysis was conducted as two distinct and separate tasks.

1. Task A represents the GPA analysis
    - Perform As-Is / To-Be cyber security capabilities and maturity (Gap Analysis) for GPA
2. Task B represents the GWA- analysis.
    - Perform As-Is / To-Be cyber security capabilities and maturity (Gap Analysis) for GWA

An organization's IT / OT Cyber Security Policies make up the overall strategy for how the organization will implement information security principles and technology. Common IT /OT Cyber Security Policy implementation challenges include:

- The process of getting an IT / OT Cyber Security Policy implemented is difficult, time-consuming, and expensive
- The IT / OT Cyber Security Policies must be clear and consistent
- IT / OT Cyber Security Policy should fit into your existing business structure and not mandate a complete, ground-up change, to how your business operates

Once the IT / OT Cyber Security Policy has been created, perhaps the hardest part of the process is deployment throughout the organization.

- Make sure the policies are supported by the organization's senior management team
- Make sure that the policies are officially adopted as company policy
- Review each policy and think about how it will be applied within the organization
- Make sure that the necessary tools are in place to conform to the policy
- Create a plan to make appropriate changes to either the network or the policy
- Work with the necessary departments within the organization (legal, IT, HR, etc.) to establish procedures to support your policies
- Provide basic awareness and objectives training to the users

5.1. Security Policies and Procedures Assessment Approach

Sheffield submitted a documentation request for all Policies, Programs, Plans, Processes, and Procedures in each of the NIST 18 areas as outlined in the organizations' governing Cyber Security Plans. An analysis was conducted which included:

- Evaluation of GPA and GWA's IT/OT cybersecurity program documentation for design effectiveness. This evaluation supported the identification of areas where NIST 800-53 Rev 4 best practice documentation for grant funding compliance was missing or inadequate.
- Evaluation of GWA's cybersecurity program documentation for inclusion of AWWA best practices for G430-09 Security Practices for Operation and Management.

GPA and GWA IT organizations, upon a structured documentation request, provided Sheffield with documentation in support of their IT, OT, and cybersecurity policies, programs, plans, processes, and SOPs. Only a portion of the supporting documentation received was formally approved and operationalized by the senior management team of each organization and in use at the time of this study plan analysis.

Sheffield inventoried and mapped all received documents and results of the structured interview questionnaires to the newly created Guam project Gap Assessment Workbooks for each respective organization for NIST 800-53 Rev 4 low baseline and American Water Works Association (AWWA) recommended controls.

An in-depth analysis was completed for each organization and a set of workbooks was created for each organization to determine the overall % of completeness against the Unified Control Framework (UCF). A UCF is a table of standards and regulations used to identify common controls between multiple standards or regulating bodies. The UCF and subsequently selected controls were then used by Sheffield, along with the defined and agreed upon Capability Maturity Model Integration (CMMI) rating scale, to determine the Maturity Levels for the organizations and to identify GPA and GWA's progress towards a level 3.5 maturity:

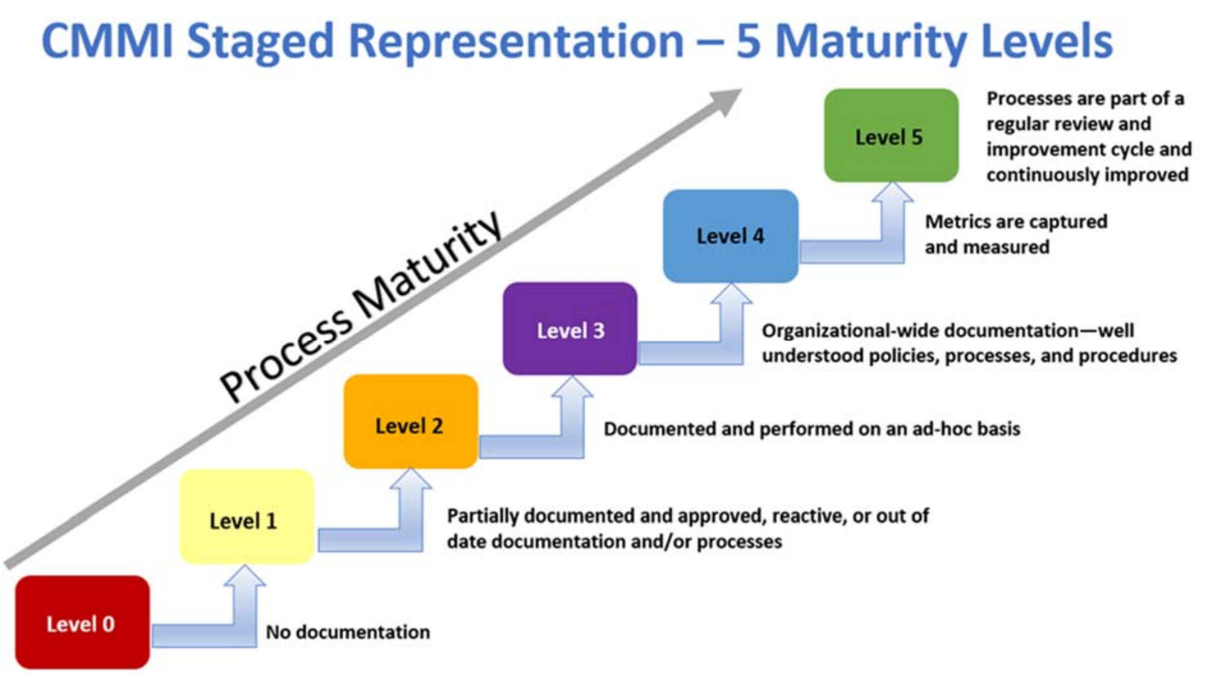


Figure 5-1: CMMI Maturity Levels

5.2. Security Policies and Procedures Performed

To complete an effective and up to date analysis for the organizations, Sheffield developed a current Unified Control Framework (UCF) to use as the baseline for conducting a gap assessment against the IT, OT, and cyber security environments. The UCF includes the following regulations and standards inputs to help support Guam when applying for grant funding by adopting industry best practices:

- NIST SP-800-53 Rev 4 - The SP 800-53 guidelines were created to heighten the security of the information systems used within the federal government. The guidelines themselves apply to any component of an information system that stores, processes, or transmits federal information
- Cybersecurity Guidance from the American Water Works Association (AWWA). This guidance is for security against top threats facing the water sector. Provides guidance on vulnerabilities and the development of a cybersecurity risk management program.

Sheffield collected and performed a review of the current set of implemented policies, programs, plans, processes, and SOP documentation developed on or after 2011 against the newly adopted and created UCF, completed a structured in-depth review of the documentation's structure and content, and compared the content with the current NIST SP 800-53 Rev 4 and AWWA recommended controls. Sheffield also conducted interviews for other areas of the projects. Time was taken to review the results of stakeholder and subject matter expert (SME) interviews for items relating to policy, plans, SOPs, and framework.

CMMI scores were mapped using the Gap Assessment Workbook and approved by the respective organization's IT managers. Graphics were developed to show the completeness of the documentation both by type and classification.

The results of CMMI report were confirmed with the managers of the respective organization before socialization with senior management teams.

The following tools, documentation, and evidence of the project section execution were performed during the completion of Tasks A and B

- Development, execution, and documentation of a current UCF to perform gap assessment against relative set of regulations
- Development, execution, and documentation of a spreadsheet that detailed the controls necessary for compliance against the documentation for analysis
- Development, execution, and documentation of a questionnaire to identify which controls documented in the cybersecurity policy were fully implemented and formally approved
- Development, execution, and documentation of the CMMI level based on the controls Gap Assessment data to provide the maturity level for the current documentation and design effectiveness results for each organization

5.3. Security Policies and Procedures Results and Observations

Our results and observations for both GPA and GWA work tasks are outlined based on the three common implementation classifications of technical, management, and operational areas:

- Technical controls use technology
- Management controls use administrative or management methods
- Operational controls are implemented by people in day-to-day operations

Note: Technical controls were assessed based on information provided in documentation and through structured interviews. A more detailed assessment of technical controls and capabilities will be provided in

Sections 4- GPA / GWA Network Infrastructure, Section 6 - GPA/GWA Application Review, and Section 8- Network Future Design.

Neither organization has approved a complete and holistic set of IT/OT and risk-based enterprise cyber security policies, plans, processes, and standard operating procedures required for protecting their information and operational technology systems, devices, and networks and a current UCF was not provided with their documentation.

Both GPA and GWA drafted an initial set of IT, OT, and Cyber Security documentation in 2011 and 2017, respectively, most of which were not formally authorized. Some supporting standard operating procedures (SOPs) were mapped to these drafted policy directives but did not fully meet the requirements of the initially drafted Cyber Security Plan and overarching Cybersecurity Policy to support the 17 Policy Directives identified in the overarching Cybersecurity Policy. Significant documentation work is still needed to ensure the IT/OT cyber security policies and SOPs are complete, relevant, and accepted at the enterprise level. A key consideration is the need for a Management Model for documentation management.

The establishment of a risk-based documentation framework has been slow in development and adoption within both organizations. Greater management oversight and governance is necessary to effectively establish the needed focus of IT/OT and cyber security efforts. A lack of documented processes and procedures with a management model lifecycle approach for the enterprise is severely impacting the organization's security posture as well. Failure to document and enforce standardized policies and procedures leaves both GPA and GWA at risk and limits their ability to comply with federal grant application and funding requirements.

There are disparate attempts across both business units to address IT/OT cybersecurity with ad-hoc and embedded IT/OT business and security processes and frameworks rather than a holistic, unified, and prioritized approach for the enterprise.

Documentation of technical safeguards, including system architectures, reference architecture, engineering disciplines, security software, and related hardware, software, and firmware are crucial component to ensure critical and sensitive data are adequately protected. This documentation is lacking in many cases for Information Technology (IT) and Operational Technology (OT) systems (i.e., Business Unit systems). This documentation is a key component that must be present to ensure systems work together to secure critical and sensitive data, information, and IT/OT system functions.

Both GPA and GWA are at a CMMI maturity level 1 based on the following Sheffield developed scale and AS-IS analysis. Remember that security controls are classified as technical (implemented with technology), management (using administrative methods), and operational (for day-to-day operations).

Document management systems were lacking in both organizations. Personnel indicated the inability to find and/or share critical documents resulted in the use of measures to circumvent security controls.

Change control processes were missing in both organizations. This included management, technical, and operational change control. The lack of management change controls processes is contributing to issues related to missing and out of date governance documentation. Technical change control discrepancies have resulted in redundant assets and systems, conflicting software, missing baseline controls, and inability to capture metrics. The operational change control discrepancies have led to the failure to replace hardware and software before going out of support or reaching end of life.

Procurement processes were convoluted and resulted in issues, including delays, allowing assets to go out of support or exceed end-of-life limits.

5.3.1. Task A: Guam Power Authority (GPA) Gap Analysis

In 2011 an effort was undertaken to develop and approve a Cyber Security Plan, overarching Cyber Security Policy and 17 Policy Directives necessary to meet NIST 800-53-4 Low Baseline. Of the 18 documents only the overarching cybersecurity policy was formally approved. The policy identified the need for the creation of the remaining 17 policies and several, plans, programs, processes, and procedures. While the 17 remaining policies were drafted, they did not receive final approval and the program was never fully implemented.

GPA Governance Gaps

To complete an effective and up to date analysis for the organization, Sheffield reviewed and created a current Unified Control Framework (UCF) to use as the baseline for conducting a gap assessment against the control documentation set for IT, OT, and cyber security environments.

Governance gaps are areas where documentation, i.e., program governance, either fails to exist or is not documented in a means that would meet an audit of the controls for which it is intended to support.

The documentation is broken into two distinct sections for the purposes of this assessment. These two areas include:

- Program documentation including policies, plans, processes, and procedures
- Artifacts including forms and reports

Of the 226 overall documents identified the Unified Control Framework as necessary in to support the cybersecurity program less than 1% are adequately documented and approximately 68% remain undocumented. Of the 226 documents, 75 represent program documentation and 151 are artifacts generated by robust program documentation.

The program assessment revealed that currently only three (3) procedures are deemed to be implemented at an organizational level with well understood objectives).

- Personnel screening procedure
- Media and information sanitization procedure
- Physical control access procedures

Artifacts are generated when following documented policies, programs, plans, processes, and procedures. For the sake of this effort fully documented procedures were assumed to generate an artifact. Therefore, artifacts are estimated at 70% undocumented with less than 1% adequately documented.

Only seven (7) of the identified 151 artifacts were deemed to implemented at an organizational level or above:

- Evidence of third-party screening process

- Evidence of system integrity scans
- Acquisition contracts
- System user and administrator security documentation
- Proof of access request and approval
- Logs of physical access
- Maintenance of audit records (where records are being captured)

Based on this analysis the GPA IT, OT, and cybersecurity program maturity level are estimated at level one (1) since a majority of the program remains undocumented or partially documented, and documented processes and procedures are only performed on an ad-hoc basis. A level 3.5 would be obtained through properly documenting all the policy, standards and processes and procedures. Artifacts would need to be collected to provide and audit trail of analysis to demonstratable demonstrate a managed and optimizing state within the organization. Of the 226 UCF Documents to meet the NIST low baseline cybersecurity controls no program documentation and only three (3) artifacts have reached a level four (4) or five (5) maturity level.

- Proof of access requests and approvals
- Logs of physical access
- Maintenance of audit records (where records are being captured)

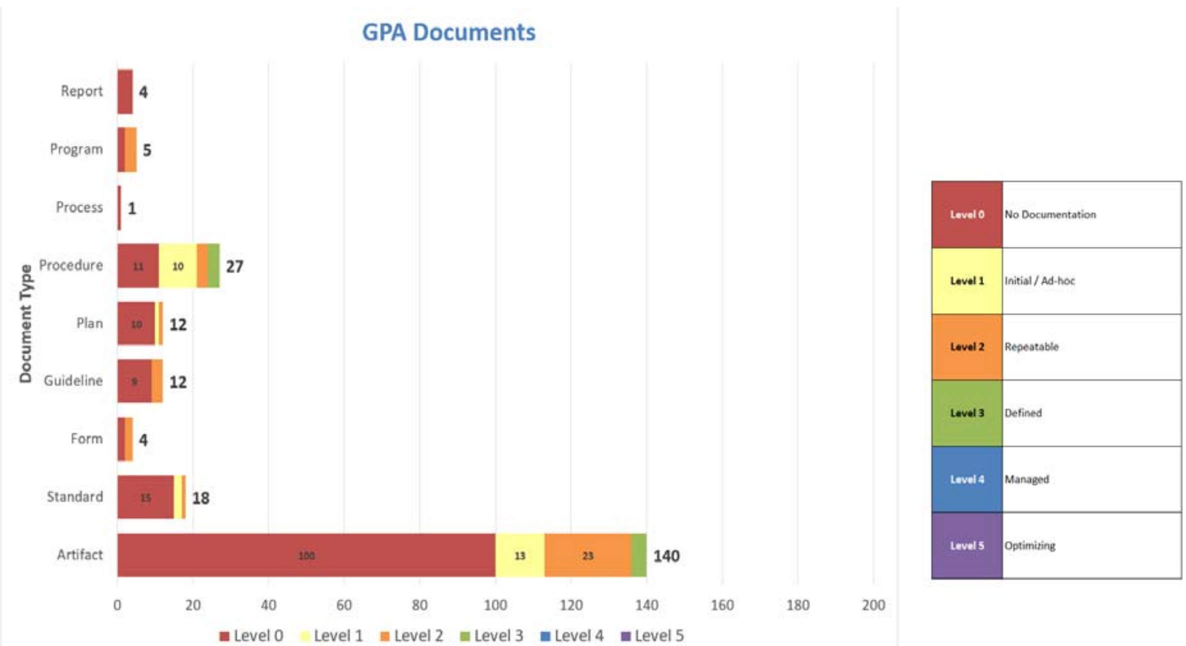


Figure 5-2: GPA UCF Documentation Gaps

GPA Technical Controls Gaps

The technical controls as well as non-technical vulnerabilities gap assessment was completed by developing the GPWA Technical Controls Gap Assessment Workbook containing all NIST 800-53 Rev 4 security controls and comparing it against GPA approved documentation.

The analysis identified multiple areas where technical controls could be implemented to achieve improvement.

- Red represents controls which have not been implemented according to the provided documentation
- Yellow represents controls which have been partially implemented or are not fully documented
- Orange represents controls that are implemented and documented

Security Gap Assessment Summary Report - GPA

Identifier	Family	Family Description	Current Assessment	Target
1	AC	Access Control	1.02	3.50
2	AT	Awareness and Training	0.00	3.50
3	AU	Audit Accountability	1.25	3.50
4	CA	Security Assessment Authorization	0.67	3.50
5	CM	Configuration Management	0.92	3.50
6	CP	Contingency Planning	0.69	3.50
7	IA	Identification Authentication	1.32	3.50
8	IR	Incident Response	0.55	3.50
9	MA	Maintenance	0.63	3.50
10	MP	Media Protection	0.83	3.50
11	PE	Physical Environmental	1.43	3.50
12	PL	Planning	0.00	3.50
13	PS	Personnel Security	0.85	3.50
14	RA	Risk Assessment	0.40	3.50
15	SA	System Services Acquisition	0.64	3.50
16	SC	System Communications	0.88	3.50
17	SI	System Information	1.10	3.50
18	PM	Program Management	0.42	3.50

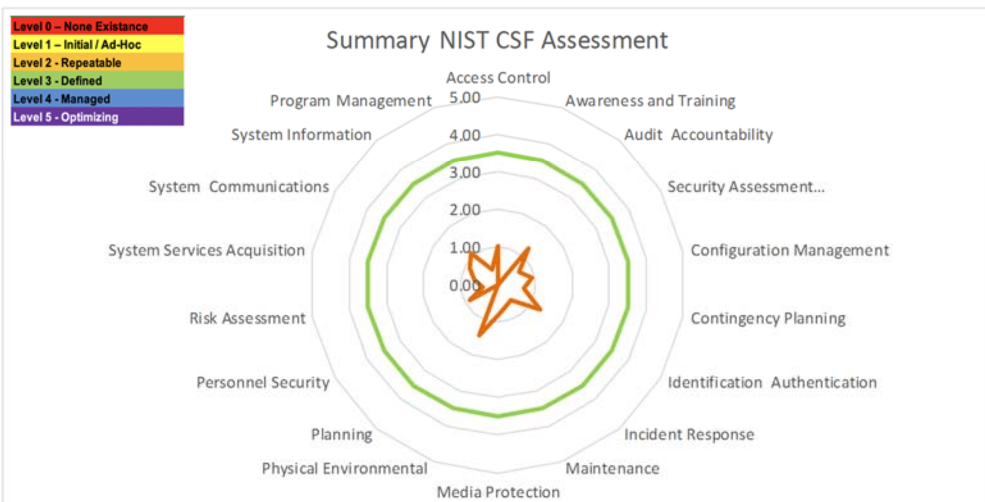


Figure 5-3: Security Gap Assessment Summary Report

The GPA cybersecurity program maturity level is estimated at level one (1) based on the summary report of technical control implementation. Of the 286 UCF controls necessary to meet the NIST low baseline only 7 are deemed repeatable.

These 7 controls include:

1. Locking out users after a defined number of unsuccessful logon attempts
2. Enforcing a waiting period before users may attempt to logon after the defined number of logon attempts
3. Authorizing remote access prior to allowing connections

4. Enforcing physical access controls such as badging form employees and logging of visitors to areas where information systems reside
5. Verifying visitors prior to access to the facility (This is done at locations where badged access is supported.)
6. Physical controls are in place where badged access is not available
7. Visitors are escorted and monitored

GPA Maturity Level by Documentation Classification

The maturity levels of documentation based on the three common implementation classifications of technical, management, and operational, as identified in the UCF, are provided to allow focus to be directed to the appropriate organizations for implementation. This assessment showed that operational and technical controls demonstrated a greater level of maturity than management controls which proved true in each of the 3 assessment strategies.

Management:

Management controls are aimed at achieving goals by providing clear guidance. Guidance should be formally documented in the form of policies, processes, plans, programs, guidelines, and procedures. Management controls define how organizational goals will be accomplished and measured in addition to providing guidance on remediating defects within the control set.

Management controls represent the greatest risk to the organization. Of the 76 management controls 82% remain undocumented with only two (2) documents assessed at a level three (3) maturity level, based on information provided in interviews, as indicated below:

1. Acquisition contracts
2. System user and administrator security documentation

Operational:

Operational controls are aimed at supporting normal business operations. This includes how normal business processes, such as maintenance activities, are executed.

Forty-six percent of operational controls had some level of documentation with seven (7) evidencing a level three (3) maturity level or above.

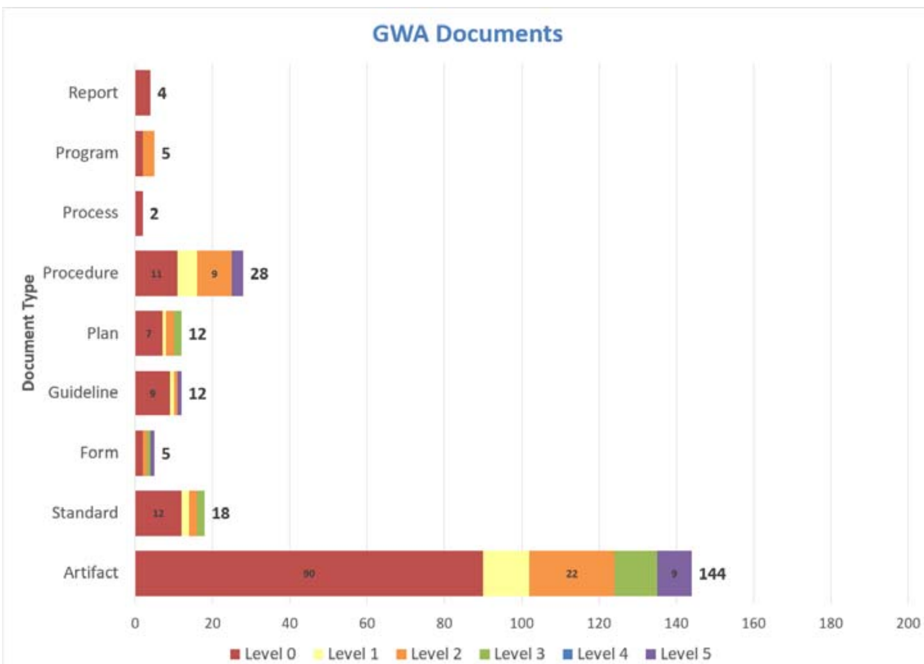
1. Personnel screening procedure
2. Proof of third-party screening process artifact
3. Media and information sanitization procedure
4. Physical access control procedure
5. System and information integrity scans evidence artifact
6. Proof of access requests and approvals
7. Logs of physical access

Technical:

Technical controls are measures intended to meet the protection requirements of a system and support management and operational functions. These measures or safeguards are primarily implemented and executed through hardware, software, or firmware.

This section identifies gaps in the documentation of technical controls and does not identify whether the technical controls have been implemented in their respective environments. For information about technical controls implementation refer to the following Sections 4- GPA / GWA Network Infrastructure, Section 6 - GPA/GWA Application Review, and Section 8- Network Future Design.

Technical controls represent the second largest gap. Of the 58 control documents necessary for compliance only 17 show some level of documentation with two (2) artifacts assessed to meet a level three (3) maturity level or above. While interviews revealed processes were in place to meet several of the technical controls, the processes and procedures were primarily undocumented or only partially documented and performed on an ad-hoc basis, and not understood at an organizational level or supported by a formally authorized policy, process, procedure, or standard operating procedure.



Level 0	No Documentation
Level 1	Initial / Ad-hoc
Level 2	Repeatable
Level 3	Defined
Level 4	Managed
Level 5	Optimizing

Figure 5-4: GPA Maturity Level of Documentation by Classification

5.3.2. Task B: Guam Waterworks Authority (GWA) Gap Analysis

In 2017 GWA revised and adopted a Cybersecurity Policy based on the 2011 GPA Cybersecurity Policy. This policy is supported by a handful of SOPs, but the remaining documentation required as part of this policy was never developed. In addition to the NIST 800-53 Rev 4 low controls GWA is responsible for meeting the AWWA G430-09 Security Practices for Operation and Management requirements. All but ten (10) of these requirements cleanly fit into the NIST framework. These ten (10) controls are related to the monitoring, testing, surveillance, and communications of contaminants. It was assumed for the sake of this gap assessment that GWA has the following controls in place to meet these requirements and no documentation was requested or provided as it is out of scope for IT.

The assumptions are:

1. GWA has implemented water contamination detection, monitoring, and surveillance program
2. GWA keeps logs or records of monitoring or surveillance of indicators of contamination
3. GWA keeps logs or records of laboratory testing for contaminants
4. GWA has established communications methods with customers, health authorities, and adjacent utilities for sharing contamination information
5. GWA keeps records of communications
6. GWA has established and maintains and uninterruptible power supplies for critical IT, ICS, and SCADA systems and has the means of providing backup generators or backup power supplies for critical facilities and has records documenting compliance with this requirement
7. GWA has established threat level-based protocols for monitoring security threats to the water supply and has processes and procedures in place for monitoring threats and escalating security in response to threats
8. GWA has a contamination response procedure
9. GWA has established and maintains a procedure for analyzing and communicating security issues with employees, response agencies such as police and fire, the public, and regulatory agencies
10. GWA has a process for identifying and establishing partnerships with agencies essential to emergency response and recovery

GWA Governance Gaps

To complete an effective and up to date analysis for the organization, Sheffield reviewed and created a current Unified Control Framework (UCF) (Appendix H – Volume 4) to use as the baseline for conducting a gap assessment against the control documentation set for IT, OT, and cyber security environments.

Governance gaps are areas where documentation, i.e., program governance, either fails to exist or is not documented in a means that would meet an audit of the controls for which it is intended to support. The documentation is broken into two distinct sections for the purposes of this assessment. These two areas include:

- Program documentation including policies, plans, processes, and procedures
- Artifacts including forms and reports

Of the 230 overall documents identified the Unified control Framework as necessary in to support the GWA cybersecurity program approximately 13% are adequately documented and approximately 60% remain undocumented. Of the 230 documents, 86 represent program documentation and 144 are artifacts generated by robust program documentation.

Currently only eight (8) program documents have been deemed to be implemented at an organizational level (3) or higher:

- Risk assessment standard (identified via interview)
- Security awareness and training standard (identified via interview)
- Security awareness and training program (identified via interview)
- Access securitization procedure

- Physical security plan (identified via interview)
- Physical access control procedures
- Visible identification procedure (AWWA requirement)
- Wireless access guideline (assessed at level 5 due to organizational restriction)

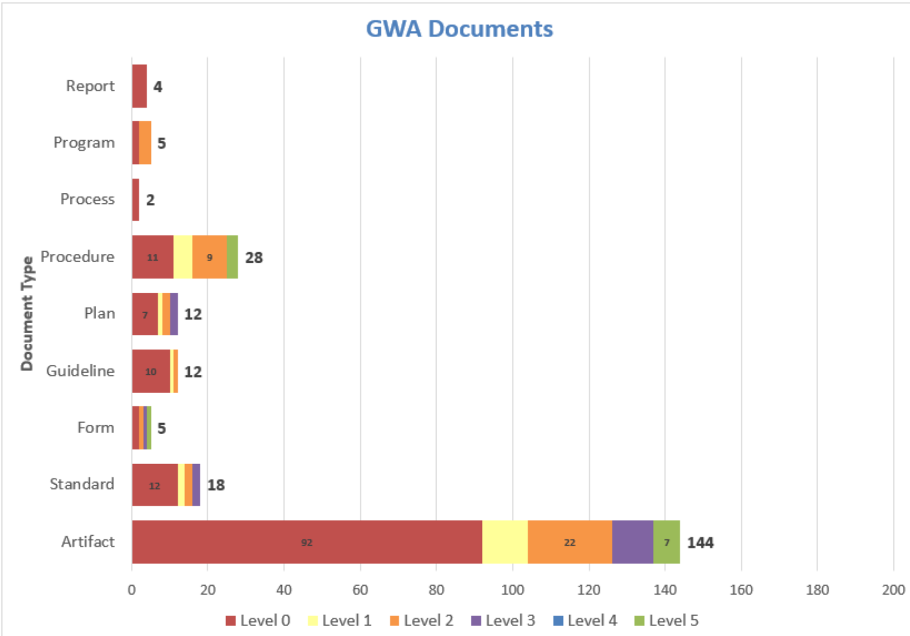
Artifacts are generated when following documented processes and procedures. For the sake of this effort fully documented procedures were assumed to generate an artifact. Therefore, artifacts are estimated at 63% undocumented with less than 14% adequately documented.

Only 22 of the 153 identified artifacts are deemed to be implemented at an organizational level or higher, four of which were assessed at a level five (5) and part of a regular review and improvement cycle.

- Authorization of wireless access connections (assessed at level 5 due to organizational restriction)
- Wireless connection agreements (assessed at level 5 due to organizational restriction)
- List of personnel with authorized physical access
- Review and approval of list of personnel with authorized physical access

Based on this analysis the GWA cybersecurity program maturity level is estimated at level one (1) since much of the program remains undocumented or partially documented. Of the 230 UCF Documents to meet the NIST low baseline and AWWA cybersecurity controls only 14 have reached a level four (4) or five (5) maturity. Nine (9) of which are artifacts. Note that due to organizational restrictions against use of wireless access, all wireless access controls were assessed at a level five (5).

1. Procedure secure access
2. Wireless access guideline
3. Authorization of wireless access connections
4. Wireless connection agreements
5. Physical access control procedures
6. List of personnel with authorized physical access
7. Review and approval of list of personnel with authorized physical access
8. Proof of physical access requests and approvals
9. Authorization for delivery/removal of system components
10. Logs of physical access
11. Personnel rules of behavior for information systems
12. Signed acknowledgement of receipt of rules of behavior
13. Records of access requests to protected storage and protected digital media
14. Physical access control procedures which include display of visible identification



Level 0	No Documentation
Level 1	Initial / Ad-hoc
Level 2	Repeatable
Level 3	Defined
Level 4	Managed
Level 5	Optimizing

Figure 5-5: GWA UCF Documentation Gaps

GWA Technical Controls Gaps

The technical controls gap assessment was completed by developing the GPWA Technical Controls Gap Assessment Workbook containing all NIST 800-53 Rev 4 security controls and AWWA G430-09 security practice recommendations and comparing them against GPA approved documentation.

This section identifies gaps in the documentation of technical controls and does not identify whether the technical controls have been implemented in their respective environments. For information about technical controls implementation refer to the following Sections 4- GPA / GWA Network Infrastructure, Section 6 - GPA/GWA Application Review, and Section 8- Network Future Design.

The analysis identified multiple areas where technical controls could be implemented to achieve improvement

- Red represents controls which have not been implemented
- Yellow represents controls which have been partially implemented or are not fully documented
- Orange represents controls that are implemented and documented

Security Gap Assessment Summary Report - GWA

Identifier	Family	Family Description	Current Assessment	Target
1	AC	Access Control	0.72	3.50
2	AT	Awareness and Training	0.90	3.50
3	AU	Audit Accountability	0.08	3.50
4	CA	Security Assessment Authorization	0.67	3.50
5	CM	Configuration Management	0.58	3.50
6	CP	Contingency Planning	0.44	3.50
7	IA	Identification Authentication	1.16	3.50
8	IR	Incident Response	0.30	3.50
9	MA	Maintenance	1.00	3.50
10	MP	Media Protection	1.00	3.50
11	PE	Physical Environmental	1.65	3.50
12	PL	Planning	0.75	3.50
13	PS	Personnel Security	0.60	3.50
14	RA	Risk Assessment	0.30	3.50
15	SA	System Services Acquisition	0.55	3.50
16	SC	System Communications	0.81	3.50
17	SI	System Information	0.45	3.50
18	PM	Program Management	0.33	3.50
19	AWWA	American Water Works Association	1.75	3.50

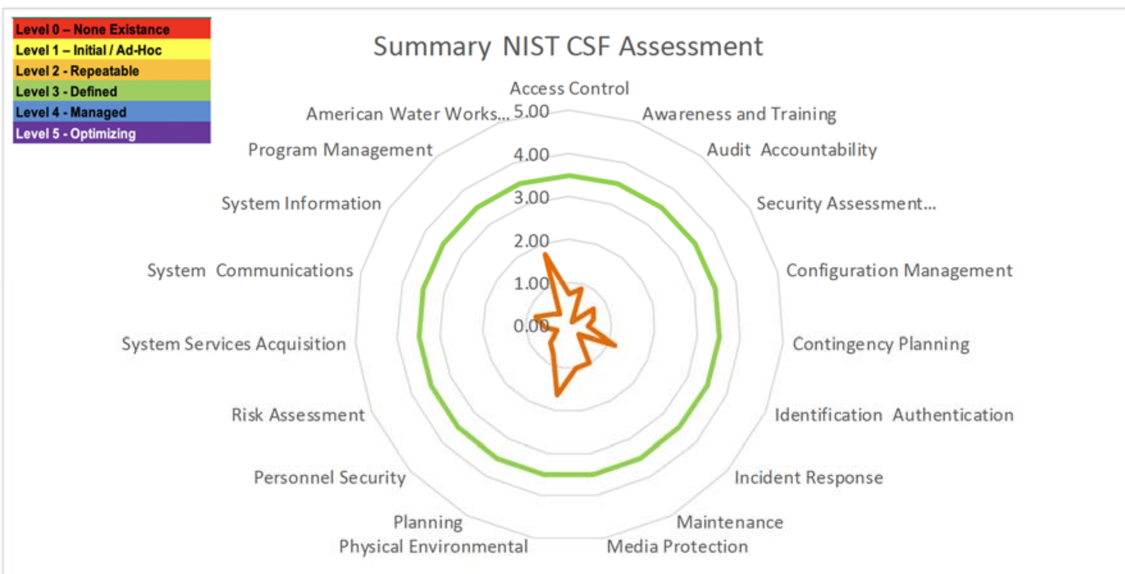


Figure 5-6: GWA Technical Controls Gap Report

GWA Maturity Level by Documentation Classification

The maturity levels of documentation are based on the three common implementation classifications of technical, management, and operational, as identified in the UCF, are provided to allow focus to be directed to the appropriate organizations for implementation. This assessment showed that operational and technical controls demonstrated a greater level of maturity than management controls which proved true in each of the 3 assessment strategies.

Management:

Management controls are aimed at achieving goals by providing clear guidance. Guidance should be formally documented in the form of policies, processes, plans, programs, guidelines, and procedures. Management controls define how organizational goals will be accomplished and measured in addition to providing guidance on remediating defects within the control set.

Management controls represent the greatest risk to the organization. Of the 77 controls 82% remain undocumented with only four (4) documents assessed at a level three (3) maturity level, based on information provided in interviews and documentation reviews, as indicated below:

1. Risk Assessment Standard
2. Security Awareness and Training Standard
3. Personnel Rules of Behavior for Information Systems
4. Signed Acknowledgement of Receipt of Rules of Behavior

Operational:

Operational controls are aimed at supporting normal business operations. This includes how normal business processes, such as maintenance activities, are executed.

Fifty percent of operational controls had some level of documentation with eight (8) evidencing a level five (5) maturity level. Most of which are in the physical security realm.

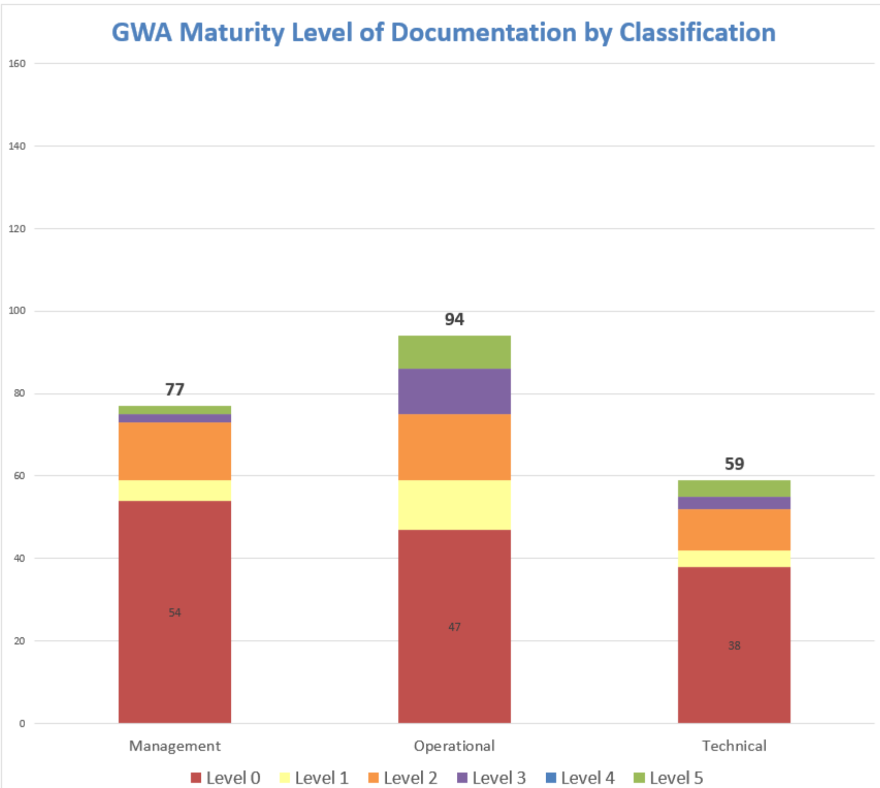
1. Physical access control procedures
2. List of personnel with authorized physical access
3. Evidence of reviews and approvals of list of personnel with physical access authorization
4. Proof of access requests and approvals
5. Logs of physical access
6. Record of requests to access protected storage and protected digital media
7. Proof of authorization for the delivery/removal of system components
8. Procedure requiring visible identification

Technical:

Technical controls are measures intended to meet the protection requirements of a system and support management and operational functions. These measures or safeguards are primarily implemented and executed through hardware, software, or firmware.

Technical controls represent the second largest gap. Of the 59 control documents necessary for compliance only 18 show some level of documentation, fourteen (14) of which are artifacts, and only four (4) of which meet a level three (3) maturity level or above. While interviews revealed processes were in place to meet several of the technical controls, the processes and procedures were primarily undocumented or only partially documented and not understood at an organizational level or supported by a formally authorized policy. Note that three (3) of the four (4) level three (3) or above controls are artifacts

1. Proof of password requirements conformity
2. Access securitization procedure
3. Authorization of remote access connections
4. Audit records



Level 0	No Documentation
Level 1	Partially documented and approved, reactive, or out of date documentation and/or processes
Level 2	Documented and performed on an ad-hoc basis
Level 3	Organizational-wide documentation — well understood policies, processes, and procedures
Level 4	Quantitatively managed
Level 5	Continuously Improved

Figure 5-7: GWA Documentation by Classification

5.4. Security Policies and Procedures Supporting Analysis Materials

The following materials were established and developed by Sheffield to support the analysis for both Tasks A and B:

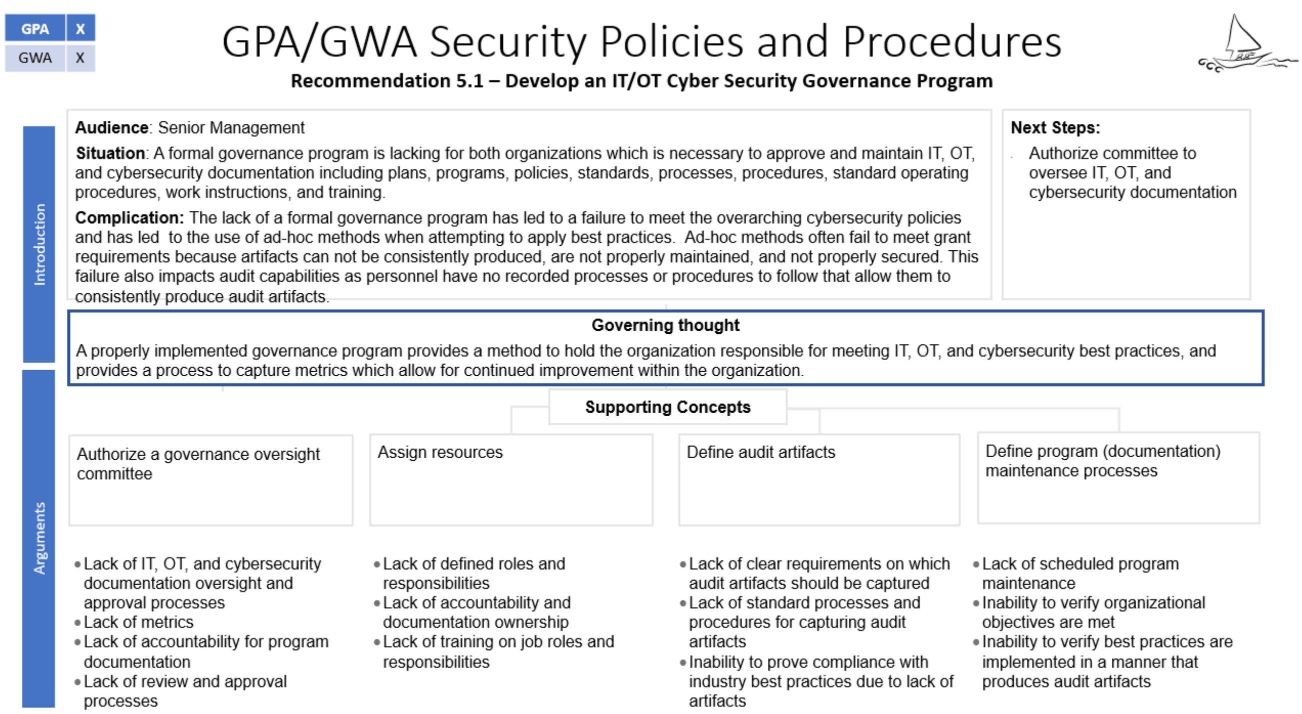
- Documentation Request
- Drop Box Inventory
- Working Spreadsheet of Controls Assessment against Documentation
- IT Interview Questionnaires
- Unified Control Framework (UCF).XLS
- Output of the Gap Assessment workbook
- CMMI Maturity Level graphic and descriptions

5.5. Security Policies and Procedures Recommendations

For this section of the report, Sheffield has identified five (5) recommendations for GPWA with a supporting roadmap timeline and detailed implementation task for execution:

5.5.1. Develop an IT/OT Cyber Security Governance Program

- Both GPA and GWA lack a formal governance program. Policies, processes, and procedures are developed on an ad-hoc basis when a need arises. The ad-hoc documents are not well communicated or distributed and leaves Guam at risk for cyber incidents and fails to meet the minimum level of best practice controls implementation necessary to apply for and secure infrastructure grant funding. The formal approval and maintenance of a governance documentation is the underpinning of a successful program.
- Resources must be allocated not only for the development of the program, but also for ongoing maintenance, training, and support of governance activities. Once roles and responsibilities are assigned and understood, personnel will be better able to support the technical processes and procedures necessary to secure the GPWA infrastructure.
- A Governance Program Development Process Flow has been developed to assist Guam in this effort.



5.5.2. Review and Approve Baseline Set of Common and Unique security Controls

There are 274 baseline controls for NIST 800-53 R4 low, 21 optional controls which should be implemented for the management of the cybersecurity program, four (4) AWWA controls, and six (6) optional controls which are included as best practice. These controls should be documented as part of the governance program and included in the 18 policies or directives, approximately 27 procedures, 11 guidelines, and 17 plans and programs, in addition to the supporting forms and templates necessary to support the generation of compliance artifacts.

GPA and GWA are at different levels of maturity in their management, operational, and technical classifications. In areas where both organizations have the same objectives, the formally approved and adopted documentation of each utility may be leveraged and refined to support a unified GPWA.

GPA	X
GWA	X

GPA/GWA Security Policies and Procedures

Recommendation 5.2 – Review and approve cyber security baseline control set of best practice for both organizations

Introduction

Audience: Senior Management

Situation: Neither organization has formally approved a baseline control set identifying what security practices will be implemented and maintained within their organization.

Complication: Guam is dependent on federal grants to support security objectives. Grant authoring agencies require evidence of security practices which are implemented and maintained within the organization prior to approving funding. Without an approved baseline control set Guam has no method for providing consistent evidence of security practices that are implemented and maintained.

Question: *What can be done to ensure all IT, OT, and cybersecurity baseline security controls are properly documented?*

Next Steps:

- Identify security practices and controls which must be implemented within the organization

Governing thought

A baseline security control set establishes direction and focus for IT, OT, physical security, and cybersecurity within an organization. This controls set helps identify what has already been implemented within the organization, what must be implemented for the desired level of security, and what security controls can not be implemented due to technical or resource restrictions.

Arguments

Supporting Concepts

Identify desired security controls

- Lack of security requirements
- Lack of consistency in the application of implemented security controls
- Lack of approval or management of implemented security controls

Identify required documentation and training

- Lack of documentation to support application of security controls
- Lack of knowledge and skills necessary to apply security controls
- Lack of training on how, when, why, or who should apply the security controls

Define security controls maintenance processes

- Lack of scheduled review and maintenance of security baselines
- Inability to verify security controls are consistently applied
- Inability to capture metrics on controls implementation
- Inability to identify areas for security program improvement

5.5.3. Perform Risk Assessment of Information and Operational Technology Systems

A risk assessment will help identify which assets, systems, and information is critical to the organization or must be protected under law and which have less stringent protection requirements.

An insider threat is a malicious threat to an organization that comes from people within the organization, such as employees, former employees, contractors or business associates, who have inside information concerning the organization's security practices, data and computer systems.

Top Concerns for GPWA should be around identifying and stopping insider threats by employees, contractors, and privileged users with continuous security monitoring, behavioral analytics, and powerful alerts.

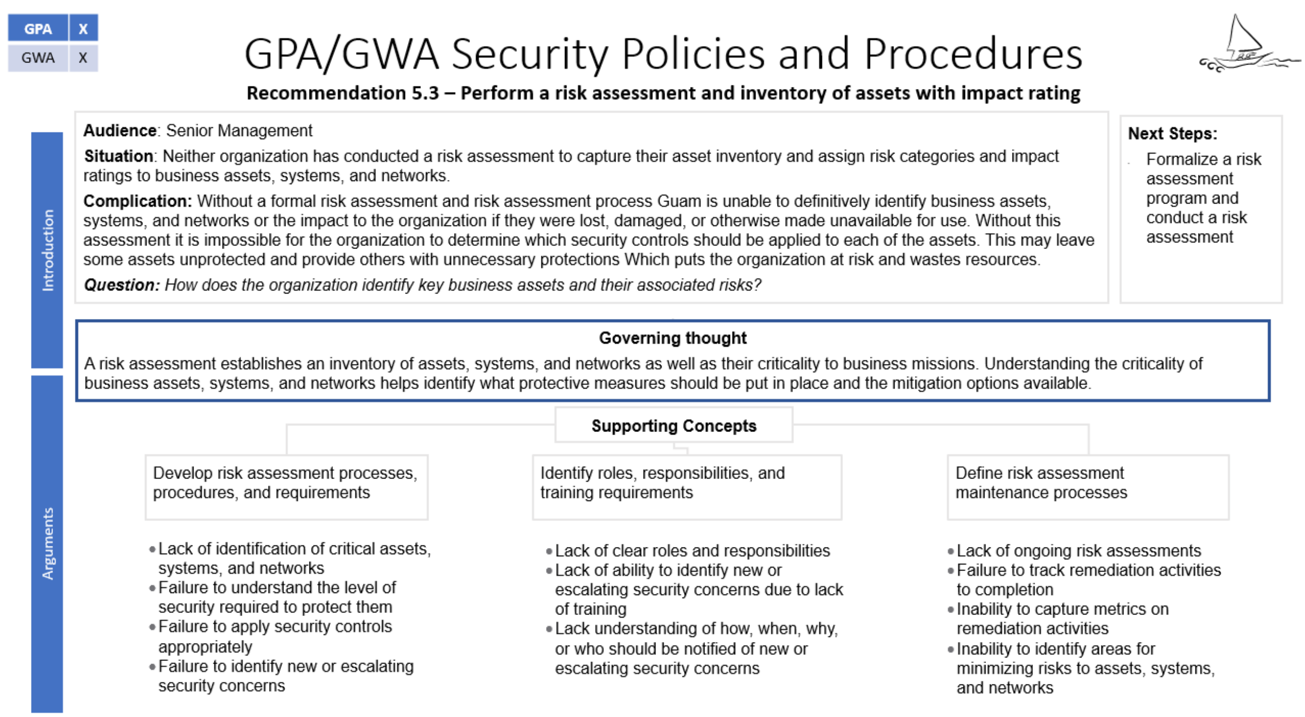
Insider Threats include:

- Malicious cyber attacks
- Social engineering
- Downloading malicious internet content
- Information leakage

- Illegal activities

Administer disciplinary action for chronic carelessness or an intentional breach of cyber security policy. If the breach was accidental, it should be treated as an opportunity for more cyber security awareness training. But whenever chronic carelessness or an intentional breach occurs, disciplinary action should be considered. Remember that some punishments are external. In recent years, responsibility for cyber security breaches has shifted to supervisors, managers, executives, and even the board of directors if there is evidence of a pervasive culture of noncompliance to cyber security policies and regulations.

Making proper assignments has the potential to reduce workload by ensuring controls are only applied where necessary and no time is wasted producing artifacts for non-critical assets, systems, or information. The risk assessment will also help identify any technology gaps or other areas of concern which may need to be addressed with manual processes. It is critical that this information is fed back into the program documentation and any necessary changes or updates are made to processes, procedures, or other work instructions to ensure the continued enforceability of the overarching policy in accordance with the governance program.



5.5.4. Develop IT Management Model for Information and Operational Technology System Documentation

Once the governance program has been formally sanctioned, the risk assessment is completed, and the control set has been approved, responsible personnel may begin documenting the policies, plans, programs, processes, procedures, and standard operating procedures necessary to fulfil the controls identified to meet the best practices. As a starting point GWA SOP-1000-GM-001 should be normalized and used as the bases for the preparation and Revision of Policies and Procedures. This could be used as a joint process used for approving Policies and procedures for GPWA

GPA	X
GWA	X

GPA/GWA Security Policies and Procedures

Recommendation 5.4 – Develop IT Management Model for Information and Operational Technology System Documentation

Introduction

Audience: Senior Management

Situation: Formally approved IT, OT, physical security, and cybersecurity documentation is lacking throughout both organizations.

Complication: The lack of formally approved policies and standards and current lack of oversight has led to a variety of ad-hoc security practices which fail to meet minimum security objectives identified by Guam in existing documentation. These ad-hoc practices are inconsistently applied leaving the organization open to physical and logical security breaches. Additionally, the lack of supporting documentation to prove adherence to the overarching policy leads to contradictory practices which in turn leads to audit failure and increased risk of security breaches.

Question: *What can be done to ensure all IT, OT, and cybersecurity policies and standards are created, formally approved, and implemented at an organizational level?*

Next Steps:

- Create governance documentation to support all approved baseline security controls

Governing thought

Formally approved policies and standards are the foundation for the successful governance of security practices. Properly documented and approved policies, plans, processes, and procedures help ensure that security controls are implemented consistently across the organization, allow for the capture of program metrics, and generate repeatable results and artifacts. They also confirm to the organization that executive leadership is concerned with security practices.

Arguments

Supporting Concepts

Develop or update existing policies and standards to support approved baseline security controls

- Documented security policies are not being enforced
- Lack of documentation to support existing security policy controls
- Existing documentation is inconsistent and fails to meet security policy requirements

Assign roles and responsibilities

- Lack of defined roles and responsibilities
- Lack of accountability and documentation ownership
- Lack of formal approvers
- Lack of understanding regarding how baseline security controls should be met among responsible parties

Document approval process

- Lack of formal approval processes
- Lack of top-down management and support
- Lack of documentation requirements and objectives

Define documentation maintenance processes

- Lack of scheduled documentation maintenance including reviews, updates, and approvals
- Lack of compliance calendar identifying what audit activities must be completed and when
- Failure to capture changes to policies and standards and their associated processes and procedures

5.5.5. Develop supporting IT cyber security governance processes and SOP BU's Level documentation

GPA	X
GWA	X

GPA/GWA Security Policies and Procedures

Recommendation 5.5 – Develop Supporting IT cyber security governance process and SOP BU's level documentation

Introduction

Audience: Senior Management

Situation: Formally approved IT, OT, physical security, and cybersecurity documentation is lacking throughout both organizations.

Complication: The lack of a formally approved documents in support of policies and standards such as plans, programs, processes, and procedures has led to a variety of ad-hoc security practices which fail to meet minimum security objectives identified in the few approved cybersecurity policies and standards. These ad-hoc processes and procedures are inconsistently applied leaving the organization open to physical and logical security breaches. Additionally, the lack of supporting documentation to prove adherence to the overarching policies and standards leads to contradictory practices which in turn leads to audit failure and increased risk of security breaches.

Question: *What can be done to ensure all IT, OT, and cybersecurity documents are created, formally approved, and implemented at an organizational level?*

Next Steps:

- Create supporting governance documentation to support all approved policies and standards

Governing thought

Formally approved documentation is the foundation for the successful governance of security practices. Properly documented and approved plans, processes, and procedures help ensure that security controls are implemented consistently across the organization, allow for the capture of program metrics, and generate repeatable results and artifacts. They also confirm to the organization that executive leadership is concerned with security practices.

Arguments

Supporting Concepts

Develop documentation to support approved policies and standards

- Documented plans, processes, and procedures are not being enforced
- Lack of supporting documentation for to support existing security policy controls
- Existing documentation is inconsistent and fails to meet security policy requirements

Assign roles and responsibilities

- Lack of defined roles and responsibilities
- Lack of accountability and documentation ownership
- Lack of formal approvers
- Lack of understanding regarding how baseline security controls should be met among responsible parties

Document approval process

- Lack of formal approval processes
- Lack of top-down management and support
- Lack of documentation requirements and objectives

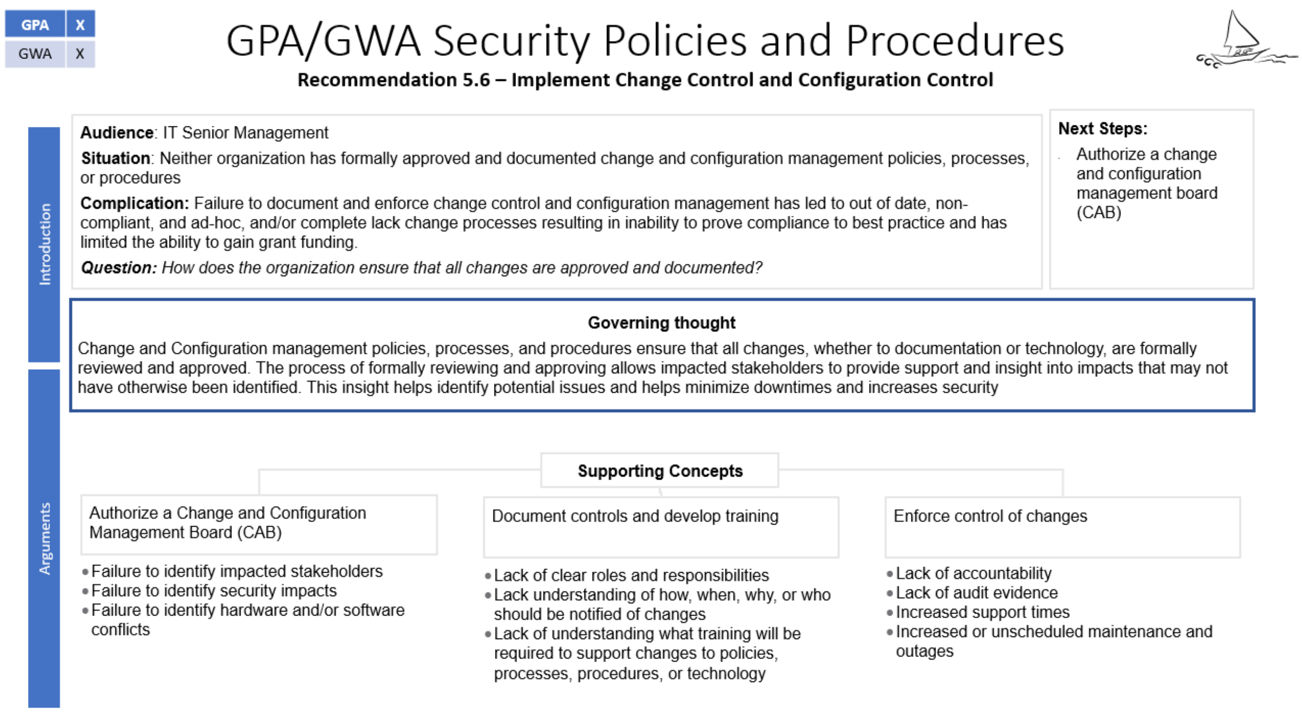
Define documentation maintenance processes

- Lack of scheduled documentation maintenance including reviews, updates, and approvals
- Lack of compliance calendar identifying what audit activities must be completed and when
- Failure to capture changes to processes and procedures

5.5.6. Implement change and configuration control

A change and configuration control system will help support a variety of activities necessary to control costs and resource usage including:

- Supporting comprehensive asset inventories
- Managing baseline configurations and ensuring consistency across the environment
- Supporting implementation of security controls
- Providing metrics
- Reducing outage times
- Reducing errors related to changes
- Reducing staffing and repair costs



5.5.7. Manage a Unified Control Framework and Remediate the Technical Controls Gap Assessment Findings

Both the Unified Control Framework and the Technical Controls Gap Assessment Workbook should be managed to identify areas where improvements are made to provide an updated view of their current status. The maintenance of this document will help identify areas where additional support is necessary and help align both organizations in their progress towards a unified entity.

Recommendation 5.7 – Manage Unified Control Framework, Technical Controls Gap Assessment Findings

Introduction

Audience: Senior Management

Situation: Neither organization has a documented Unified Control Framework (UCF) identifying required security documentation to meet best practice controls, a technical controls workbook identifying best practice low baseline security controls, or an operational calendar identifying review cycles and compliance artifact generation cycles.

Complication: Without an understanding of best practices which should be implemented to manage a minimum level of security and how and where to document those practices, the organization cannot properly implement a security program with some level of assurance that security objectives are being met. If the UCF and technical controls gap assessment workbook, created for this project, fail to be maintained Guam has no method to ensure program documentation is meeting the security objectives as outlined in the security controls workbook. Additionally, the lack of a compliance calendar has resulted in the failure to maintain organizational governance documentation, and failure to create audit documents based on the audit schedule requirements.

Question: *How does the organization ensure that approved security controls are adequately documented and updated when necessary?*

Next Steps: Develop a review process and cycle and assign responsible parties

Arguments

Governing thought

A Unified Control Framework is the mapping of security controls to documentation which allows an organization to quickly identify parallel security controls and requirements across multiple governing agencies and standards organizations. This mapping alleviates the tendency to create new documentation when regulations or requirements are released and supports the revision process for existing documentation to accommodate new, changed, or removed regulations or requirements.

Supporting Concepts

Develop a review process

- No formal list of standards, regulations, requirements, and best practices which the organization intends to meet
  - Current cross-mappings only include NIST 800-53 Rev 4 and AWWA G430-09
- Lack current list of documentation the organization intends to produce
- Inability to identify missing audit evidence

Identify roles, responsibilities, and training requirements

- Lack of clear roles and responsibilities
- Lack of ability to identify new and or changing regulations
- Lack understanding of how, when, why, or who should be notified of new or changing regulations
- Lack of understanding what training will be required to support new or changing regulations

Assign governing committee

- Lack of agreement on what security controls will be implemented across each organization or business unit
- Lack of agreement on what should be documented, where, and when
- Lack of agreement authority levels necessary for approval of the addition or removal of security controls

6. GPA/GWA Application Review

6.1. Application Review Assessment Approach

The application and system reviews were done in three phases: Discovery, Analysis, and Recommendations. Existing documents and diagrams were reviewed. GPA and GWA staff interviews were conducted as well as a site inspection of the data center and main administration building.

6.2. Application Review Procedures Performed

- Gathered documents and diagrams
- Interviews with GPA and GWA Staff
- Reviewed documents, network infrastructure, and data flow diagrams by GWA and GPA
- Conducted a physical inspection of the data center
- Analyzed collected information
- Developed roadmap and recommendations

6.3. Application Review Results and Observations

A Guam shared SCADA system has been in the deployment phase for two years. GPA has been putting assets on the system, but GWA only has only deployed it to one location creating gaps in the visibility and control of critical infrastructure systems.

Guam is heavily dependent on truck rolls to investigate outages and power quality issues. While GPA has deployed a SmartGrid network, including a Landis & Gyr AMI system with coverage to almost all of their customers, GWA does not currently have a working smart meter system (AMI).

Two different email systems are in use which creates additional overhead and potential security issues. Personnel are currently unable to send large files within the organization and employ “work arounds” to circumvent applied security controls for sharing the files. GWA has an older POP3 email system and GPA has an on-premise Microsoft Exchange email system integrated with their Active Directory authentication directory. Neither organization has the resources to provide a more secure solution.

Neither organization has implemented a formal software change management system, with associated governance, leading to gaps in asset inventories, inaccurate metrics, inadequate or poorly managed resources, failure to meet SLAs, and ad-hoc change practices. While GPA uses the ChangeGear ticketing system for network and application problems and incidents and has installed the ChangeGear change management system, which supports tickets being opened via email, many times customers request support informally when techs are in the field and these support incidents may not be recorded in the system. GWA uses the SolarWinds ticketing system and has an automated process to open tickets using email. However, neither organization follows a process to update and close tickets as the work is performed so no audit trail is available for reference when troubleshooting problems which often leads to redundant efforts to troubleshoot issues. Failure to use the full capabilities of a change management system has also led to a lack of notifications to affected users when changes are being made to networks and applications.

Basic diagrams of business application integration relationships were reviewed and through interviews they were defined as shown in the tables for GWA and GPA.

Guam Power Authority Business Application Interfaces													
Systems	UC4 (Oracle)	Shoretel IVR	POS System	PAYGPA Site	OMS	MDMS	L&G AGA system	JD Edwards	GPWA Mobile Apps	GIS	Exchange Server	CC&B	AMI CC
AMI CC													
CC&B													
Exchange Server													
GIS													
GPWA Mobile Apps													
JDE													
L&G AGA system													
MDMS													
OMS													
PAYGPA Site													
POS System													
Shoretel IVR													
UC4 (Oracle)													

Guam Water Authority Business Application Interfaces										
Systems	Lucity	Shortel	PayGWA.com	Orion Read System	MTI Automated IVR Payment System	JD Edwards	GWA POS	GPWA Mobil Application	CC&B	ArcGIS
ArcGIS										
CC&B										
GPWA Mobil Application										
GWA POS										
JD Edwards										
MTI Automated IVR Payment System										
Orion Read System										
PayGWA.com										
Shortel										
Lucity										

Figure 6-1: GPA and GWA Application Interface Touch Points

Even though GWA and GPA share a CIS and billing system, Oracle CC&B, they each maintain separate customer records and billing leading to duplication of personnel resource efforts and redundant data which has to be managed, stored, secured, and backed up.

Both GWA and GPA use the ESRI ArcGIS solution for GIS mapping of assets. However, they maintain separate systems and licenses. GWA's support contract on the system has lapsed leading to higher costs for renewals.

Neither GWA or GPA have an electronic IT asset management solution for tracking critical assets in the organizations which has led to gaps in the identification of and criticality assessment of those assets to the critical infrastructure. Failure to properly document and manage the assets impacts maintenance and operational calendars leading to failure to renew licenses, obtain support, maintain equipment, troubleshoot issues, and manage budgets efficiently.

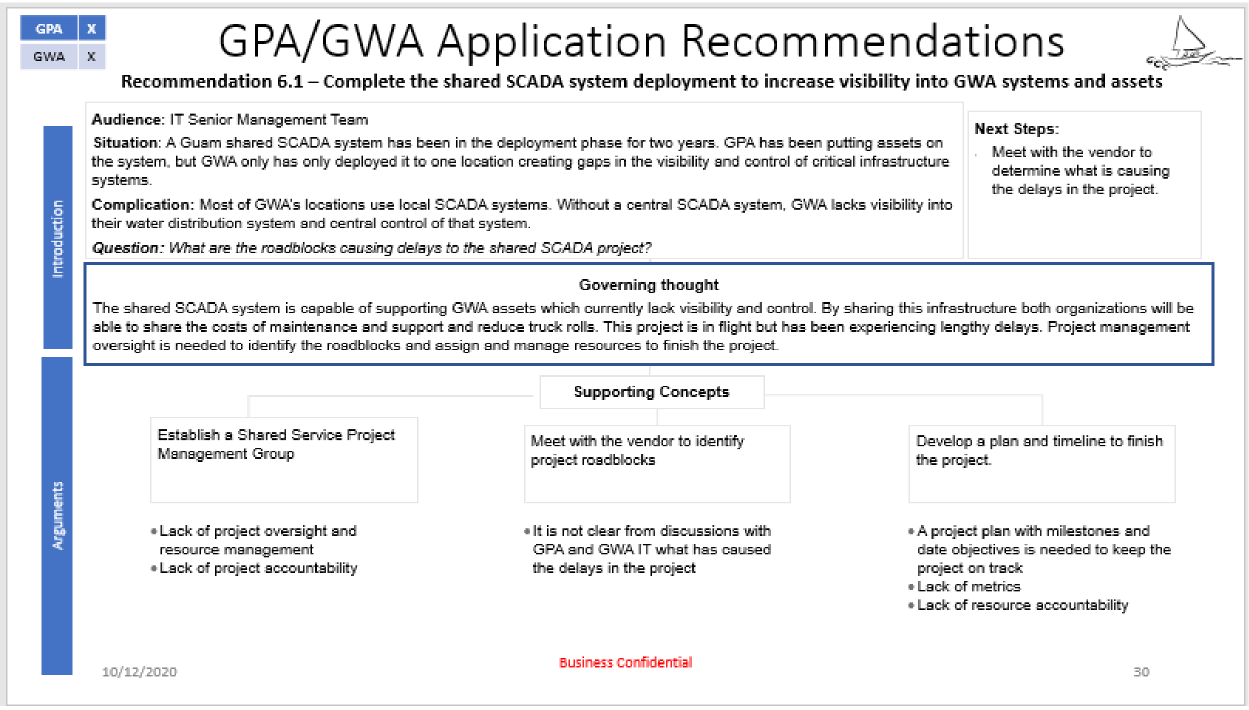
Neither GWA or GPA have a document management system to securely control access to documents and maintain version control. This has led to confusion about which document is relevant and circumventing security controls intended to ensure that only authorized personnel have access to sensitive documents.

6.4. Application Review Recommendations

6.4.1. Complete the shared SCADA deployment for GWA and GPA

The shared SCADA system is capable of supporting GWA assets which currently lack visibility and control. By sharing this infrastructure both organizations will be able to share the costs of maintenance and support and reduce truck rolls. This project is in flight but has been experiencing lengthy delays. Project management oversight is needed to identify the roadblocks and assign and manage resources to finish the project.

Recommend deployment of GPA's Tier 1 and Tier 2 networks to improve visibility into and control of critical infrastructure systems in Guam.



6.4.2. Renew GIS solution for GWA

While he ESRI GIS licensing model is per user and sharing a solution does not represent a cost savings in that area, there are potential savings to maintenance and support contracts and opportunities to share internal support personnel which should be considered. Establish a statement of work to initiate a procurement for a ESRI ArcSuite Maintenance and Support Contract.

GPA	
GWA	X

GPA/GWA Application Review

Recommendation 6.2 – Renew support for GIS Solution for GWA (Short Term)

Introduction

Audience: IT Senior Management Team

Situation: GWA IT has noted that the support for the ESRI application has lapsed.

Complication: GWA IT's attempts to resolve the issue through the engineering department have been unsuccessful

Question: *What is the best way to mitigate the risk of a critical application that has lapsed support?*

Next Steps:

- Identify GIS solution requirements

Governing thought

A working GIS application is critical to GWA's business. Priority attention from senior management is required to renew the support contract. GWA currently has the main instance of the ESRI GIS on a lap top due to network bandwidth issue. Backup and Protection of this information is questionable..

Arguments

Supporting Concepts

Manage and Identify funds to pay for the support renewal.	Create a PO for the purchase
• The Engineering Department has been unresponsive to IT requests.	• Escalation to executive management may be required to resolve the issue with Engineering.

6.4.3. Standardize on Common Change Management Solution for both Organizations

GPA	X
GWA	X

GPA/GWA Application Review

Recommendation 6.3 – Standardize on common Change Management solution for both Organizations

Introduction

Audience: IT Senior Management Team

Situation: GPA has purchased the ChangeGear ITIL based Service Desk solution. However, they are currently only using it for ticketing and not change management. Need to determine if Solarwinds could be used for solution for common platform..

Complication: Without a change management application to automate workflows, change management policies and procedures are not being followed and no metrics are being captured.

Question: *What is the least expensive and quickest way to implement Change Management for GPWA?*

Next Steps:

- Configure workflows in ChangeGear software
- Procure licenses for GWA personnel

Governing thought

Change Management is critical to metric improvement, business unit communication, and the creation of an audit trail of changes for troubleshooting issues.

Arguments

Supporting Concepts

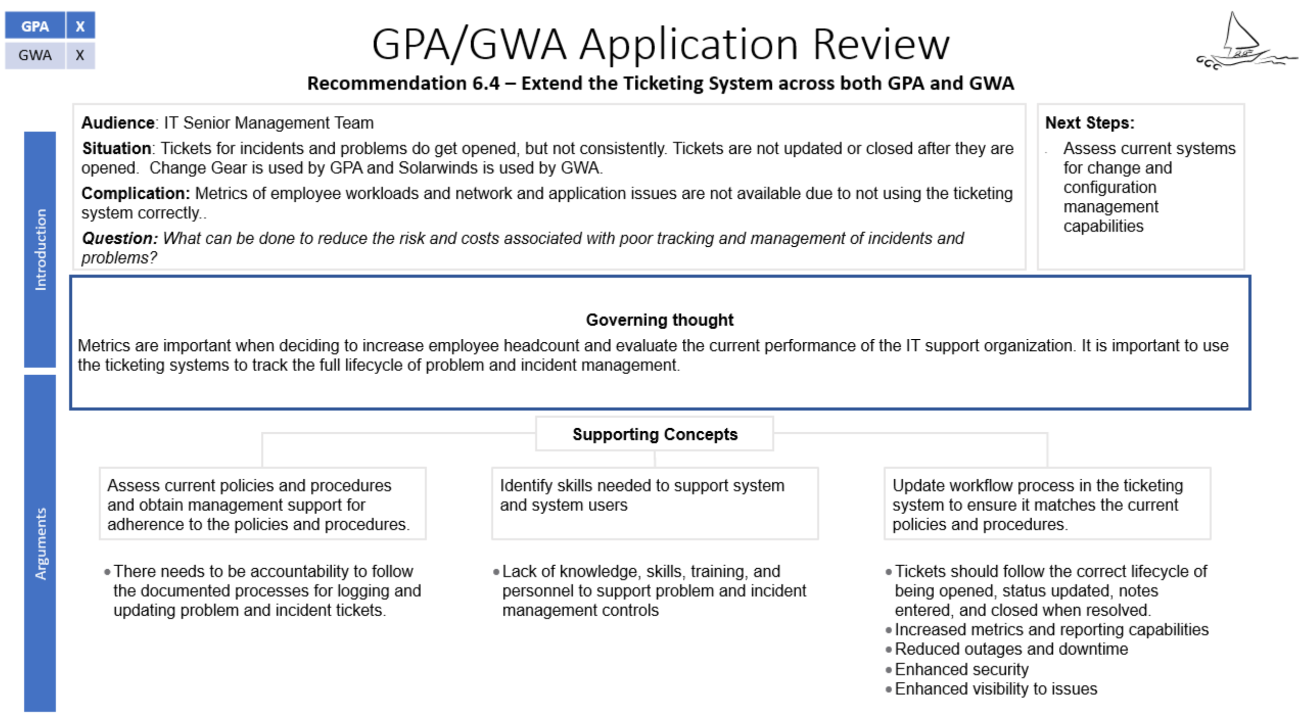
Add GWA to GPA's ChangeGear application. Standardizing on a single application will pave the way to move to a shared services organization.	Update policies and procedures so that both organizations follow the same processes.	Configure workflows in ChangeGear. Workflows ensure that the proper approvals are obtained before changes are executed.	Train personnel on the new policies and procedures for change management. Employees should understand the processes that they are expected to follow.
• Neither GWA nor GPA follow a change management process • System capabilities are not fully utilized resulting in wasted costs/efforts	• Ensure that both organizations follow the same procedures until a shared services organization can be formed • Lack of clear responsibilities for changes and communications	• Failure to utilize ChangeGear application functionalities to automatically send approval requests to the proper approvers • Failure to capture metrics	• Lack of support, enforcement, and adoption of change management processes • Lack of accountability • Unapproved changes

6.4.4. Extend the Ticketing System across both GPA and GWA

A shared ticketing system and change management system would allow both utilities to find synergies in deployment, and communication of changes.

A properly implemented ticketing and change management system allows organizations to capture metrics on network availability, employee workloads, and problem resolution times which in turn helps support budget allocations for hardware, software, and resources. GPA will need to have a documented and implemented SOP for help desk with Time Standards/SLA for responding to tickets.

A change management system also provides notification to affected users of impending changes to the network and applications and an audit trail of changes made for reference when troubleshooting problems which is crucial to reducing resolution times and meeting organizational SLAs.



6.4.5. Implement a shared services document management solution

A properly deployed document management system will help ensure the confidentiality, integrity, and availability (CIA) of organizational documentation. Both organizations expressed concerns in each of these areas and sharing the solution would enhance CIA by:

- Providing access to only approved personnel and reduce the sharing of documentation out of normal and approved channels
- Support version control and document management processes
- Provide one storage location (source of truth) across both organizations and thus eliminate redundant copies and the maintenance of two systems and sets of data.

GPA	X
GWA	X

GPA/GWA Application Review

Recommendation 6.5 – Implement a shared services document management solution

Introduction

Audience: IT Senior Management Team

Situation: Shared Drive is a mess and vendor information is stored all over the organization. A shared backed up document management systems is needed for the organization.

Complication: ***Question:*** *Records are lost and no indexing to finding vendor information supplied at sign-off of a project. Files are too large to email, so data is on media devices without proper security employed. GWA is implementing Oracle CEC*

Question: *What can be done to enforce media and information protection and storage ability across the organization?*

Next Steps:

- Inventory information according to an Information Protection Program
- Analysis of the proper solution for information indexing and storage

Governing thought

A properly deployed document management system will help ensure the confidentiality, integrity, and availability (CIA) of organizational documentation. Both organizations expressed concerns in each of these areas and sharing the solution would enhance CIA

Arguments

Supporting Concepts

x
Indexing of documentation and vendor information

- Inability to find and share information due to no indexing
- Multiple copies of information is stored across staff member devices and computer
- No documentation of record being maintained

Media protection and access of information must be protected and placed under version control

- Records are being stored anywhere around the organization with adhoc repositories
- Aging workforce with information storage of manuals and required data to maintain systems and network
- Security Issues with Mobil devices in use

Information and classification must be done along with records management.

- Lack of classification and storage of information
- Documentation is not under records management so large amount of data is being stored

6.4.6. Continue to Implement a joint Mobile Workforce Management (MMW) system

GPA	X
GWA	X

GPA/GWA Application Review

Recommendation 6.6 – Continue to Implement a joint Mobile Workforce Management (MMW) System

Introduction

Audience: IT Senior Management Team

Situation: Mobile Workforce Management is needed to connects dispatchers with field technicians to coordinate field services for both GPWA utilities

Complication: GPWA is seeing an increased focus on mobility and digitization and the proliferation of consumer-grade devices like tablets and smartphones are facilitating a shift around the hardware and software used to coordinate mobile workforces. GPA is moving forward with the Clevest and GWA is implementing a separate solution.

Question: *How is GPWA going to be able to take advantage of a MWM solutions that allow both utilities to bring real-time information to technicians in the field, managers, and executives to help improve worker safety and the overall customer experience?*

Next Steps:

Analyzes MWM software and hardware, including systems (license fees, services, maintenance, and software as a service [SaaS]) and devices (laptops, tablets, and handhelds/smartphones).

Governing thought

Will GPWA be able to take full advantage and value of mobilizing a workforce technology (MWMT) that includes devices, services, and applications through and established back-haul network. To take full advantage of common functionalities of MWMT service that includes dispatch, routing, dissemination of technical information to the field force, worker and asset monitoring, and reporting that will provide improved operational efficiencies and cost reductions. Provide end-to-end control of business operations, from scheduling tasks as per customer requests to measuring and optimizing field-resource performance

Arguments

Supporting Concepts

Increase in workforce Productivity

- High volumes of paper-based activities
- No workflow automation
- Limited on-site documentation
- Workforce availability
- Workforce Optimization
- Smarter Worker
- Enhanced Customer Support

Improvement in Asset reliability

- Inaccurate asset information to achieve better resource allocation and shorter outage resolution
- Proactive asset maintenance
- Better situational awareness

Reduction in Total Maintenance Costs

- Reactive asset maintenance due to lack of real-time data status
- Limited collaboration between field workers and coordination teams
- Improve first time issue resolution
- Faster Response to outages

6.4.7. Implement Customer Care & Billing (CC&B) Application Management Centralized Administration

GPA	X
GWA	X

GPA/GWA Application Review

Recommendation 6.7 – Implement Customer Care & Billing (CC&B) Application Management Centralized Administration

Introduction

Audience: IT Senior Management Team

Situation: Lack of a centralized organization with the governing decision-making powers, CC&B personnel receive commands from the two it organizations on the administration and schema changes for the solution.

Complication: Lack of how to-do system administration in determining which services to centralize or share?

Question: *Does GPWA need a centralized framework to manage key components of its architecture in operate multiple instances of CC&B solution to reduce total cost of operations?*

Next Steps:

- Prepare preliminary design and discuss with Customer Services. A Customer One related activity.

Governing thought

A unified customer service management platform is need in the organization. Every service department and service operator can obtain and share standardized information regarding customer service operations. Need to break down business barriers and information silos, providing more efficient cooperation, shorter feedback times and lower costs. This system is a large IT maintenance Issue and must include a centralized management platform.

Arguments

Supporting Concepts

Maintaining Security by Implementing, Managing, and Troubleshooting Service Packs and Security Updates

- Using Group Policy to Install a Service Pac
- Using SMS for Service Pack Installation
- Using Custom Scripts
- Create and maintain a patch baseline for installing Service Packs

Deploying Inbound WebServices (IWS)

- Supporting its customer-oriented business processes through the removal of information barriers between business departments
- Maintaining and sharing standardized and extensible customer information across the company to enhance customer experience levels

Upgrading the Application Database Component

- Connecting its new IT with internal platforms and external entities—including its call center, banks, the WeChat messaging service and others—to reduce service costs

6.4.8. Customer Service Web Applications Development, Support and Maintenance

GPA	X
GWA	X

GPA/GWA Application Review

Recommendation 6.8 – Customer Service Web Applications Development, Support and Maintenance

Introduction

Audience: IT Senior Management Team

Situation: Web applications require maintenance just like any other type of software, but as an organization it is not positioned to architect and if not manage correctly the organization could expose it customer data to risks.

Complication: *Question:* *A l*ack of skilled application support and maintenance staff that are assigned to promptly deal with real time problems that web based applications may encounter while running day to day operations.

Question: *How ill GPWA web development, web application being focus on as a key customer experience tool and how is maintenance focusing on upgrading application to ensure it remains productive and/or cost effective?*

Next Steps:

- Technology and Platform Changes
- Customer Services input and requirements
- Reporting on downtime, server updates or development work completed

Governing thought

With growing customer experience initiatives and Customer One program for GPWA, it is highly important to give customers an enchanting experience so that they feel comfortable coming back to your website. Technical support team will need ensures systems are operation with limited down time and security considerations and functionality is in place with our cost-effective web application support plans.

Arguments

Supporting Concepts

Pro-active Troubleshooting and Web App Maintenance

- Optimization for New Browser Versions
- Technical Documentation
- Testing and Debugging of Software

Constant Monitoring

- Maintenance of web applications and ongoing development.
- Testing and Debugging of Software

Technical and Functional Enhancements

- Customer Expectations through GPWA Customer Services
- Updating and Maintaining Security Protocols
- Database Maintenance and Purging
- 3rd Party Integrations

6.4.9. Shared ERP environment with JD Edwards

GPA	X
GWA	X

GPA/GWA Application Review

Recommendation 6.9 – Shared ERP environment with JD Edwards

Introduction

Audience: IT Senior Management Team

Situation: Oracle wants to move all JD Edwards customers to EnterpriseOne 9.2, but upgrades are expensive and disruptive to the business.

Complication: *Question*: *Oracle JD Edwards EnterpriseOne is an integrated ERP software suite. JDE is unique in that organizations running their business processes through the software have choice of database and deployment options. JD Edwards can be deployed on-premise or on the cloud (private, public, or hybrid cloud).*

Question: *On the Oracle Cloud, JD Edwards can integrate with Oracle's platform and infrastructure technologies in addition to on-premises systems for both organizations*

Next Steps:

- Leverage existing investments in hardware, databases, and software so that they can be integrated with legacy and third-party products.

Governing thought

Since Oracle acquired JD Edwards, the ERP solution, it has evolved and refined it along with the other offerings in its ERP portfolio. Branding the solution as JD Edwards EnterpriseOne, Oracle emphasizes the product's capabilities for supporting continuous innovation, enhanced by industry solutions. With JDE organizations can integrate different aspects of their business in one system.

Arguments

Supporting Concepts

Major application or tools upgrade?

- Who will support major upgrades and tools
- Product has become known for its reliability and stability.
- Flexibility and options as far as platform, database and hardware options

Who supports the system reporting

- Enhanced interface
- Ability to use more software functionality, without developer skills
- Streamlined and modern user experience

Architecture

- System possesses built-in modules for reporting tools, database systems and other third-party and web server applications.
- This connectivity makes the integration of business processes faster and easier

7. GPA/GWA Organizational Analysis

7.1. Organizational Analysis Assessment Approach

Sheffield conducted a review and analysis of the IT organizational structures for both GWA and GPA to gain an understanding of the current state related in four specific areas.

1. Organizational Structure
2. Skill Sets, Certifications & Training
3. Job Descriptions & Roles
4. Governance & Salary Structure

Analysis captured through a documentation review and interviews allowed us to define the organization and provide a gap analysis against IT Best Practice / Baseline Organization categories to understand the needs that have to be acted upon as part of a proposed future state organization and roadmap activities.

The IT Best Practice / Baseline Organization consists of these 5 major categories:

1. Management & Governance (Business Perspective)
2. IT Service Management
3. Network / Infrastructure Management
4. Security Management
5. Application Management

Establishment of a basis and expectations for the IT organization was important to understand the core responsibilities that align people, business processes, and technology to support GPA and GWA customers goals. Figure 7-1 provides a tailored, high-level dependency flow for core areas in IT based on industry best practices, IT Infrastructure Library (ITIL) Version 3, and the Microsoft Operating Framework (MOF). The diagram represents the high-level core business process categories, integrations, and dependencies of an IT organization. ITIL provides the alignment of IT services for the business with technology and allows us to create a maturity baseline by which we can measure progress within the organization over time. As a reference example, a previous study performed by IDC of companies who implemented ITIL solutions saw:

- 50% decrease in system & network downtime
- 30% improvement in IT staff productivity and
- 25% improvement in bringing new services online

ITIL Version 3 was used to focus on core IT capabilities with future growth towards Versions 4 and 5 based on maturity over years of use.

In the context of the gap analysis for GPA and GWA we reviewed against the five main areas and their primary attributes:

1. Management & Governance (Business Perspective) performs the core alignment with customer business strategies through the management and execution of IT organization, its related programs, and projects. This area is primarily focused on the project management through planning and execution of PMI based methodologies over IT projects, relationships with 3rd party technology and

software companies utilizing best supply chain processes though GPA and GWA, and communications and training for internal and external customers through the solutions deployed.

2. IT Service Management - are the activities that are performed by an organization to design, plan, deliver, operate, and control information technology (IT) services offered to internal and external customers. They contain services as a Service or Help Desk, Incident & Problem Management, Configuration, Change & Release Management for IT Assets, Business Continuity & Service Levels, Differing from more technology-oriented IT management approaches like network management and IT systems management, IT service management is characterized by adopting a process approach towards management, focusing on customer needs and IT services for customers rather than IT systems, and stressing continual improvement.
3. Network / Infrastructure Management – is to use proven, repeatable processes to provide a stable operating network (e.g., Tropos, Corporate, Other) and infrastructure (e.g., GPA / GWA Data Center, Cloud based Environments) environment for everyone using the technology for their business tools and applications.
4. Security Management – focuses on the structured fitting through a defined program into the organization all aspects of security based on standards, frameworks, and regulations. The program provides requirements for establishing, implementing, operating, monitoring, reviewing, maintaining, and improving a documented Information Security Management System within the context of the organization's overall business risks. It specifies requirements for the implementation of security controls customized to the needs of individual organizations.
5. Application Management – focuses on a set of best practices required to manage and improve applications and web services through their life cycle. This function supports and maintains operational applications and as well as helps in the designing, testing, and improving the quality of applications. There are close relationships with IT Service Management related to Incident Management processes, but it connects with Catalogue Management, Capacity Management, Availability Management, Release Management, Service Validation & Testing, Configuration Management, Request Fulfillment, and Continual Service Improvement.

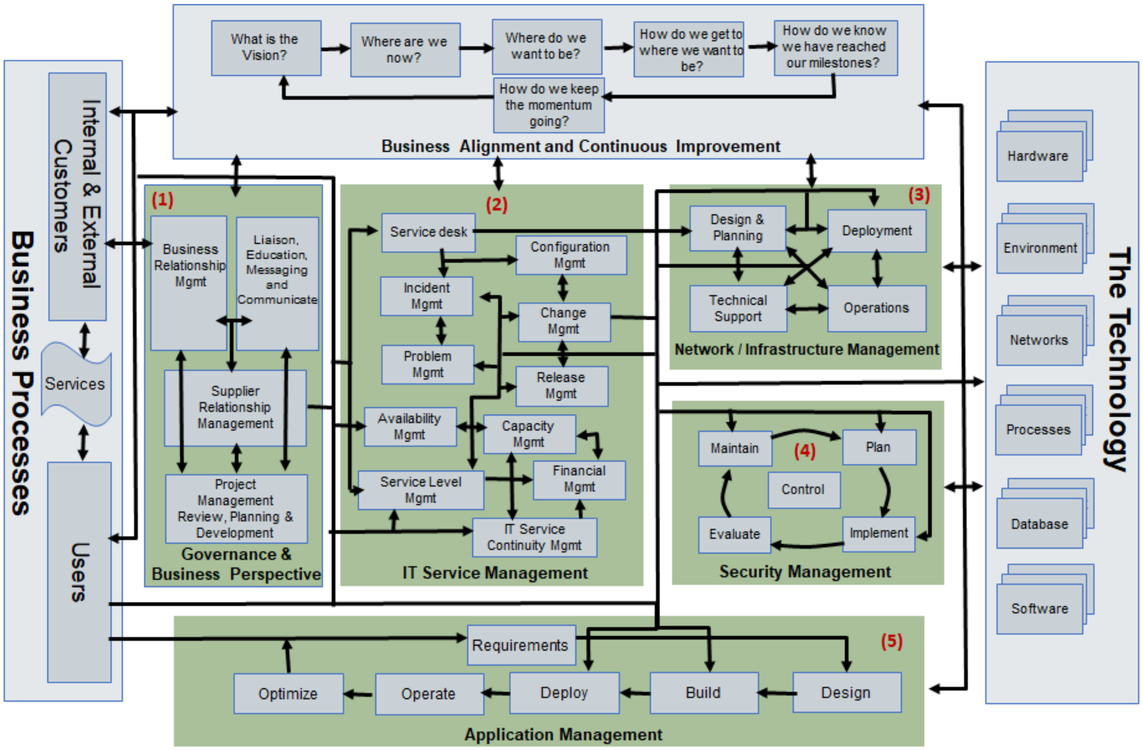


Figure 7-1: ITIL based core business categories and Business / Technology Basis

In reviewing the organizational roles and responsibilities it is important that sufficient skills and expertise is provided in the categories of the model through internal or external supplied resources to achieve service levels for GPA and GWA.

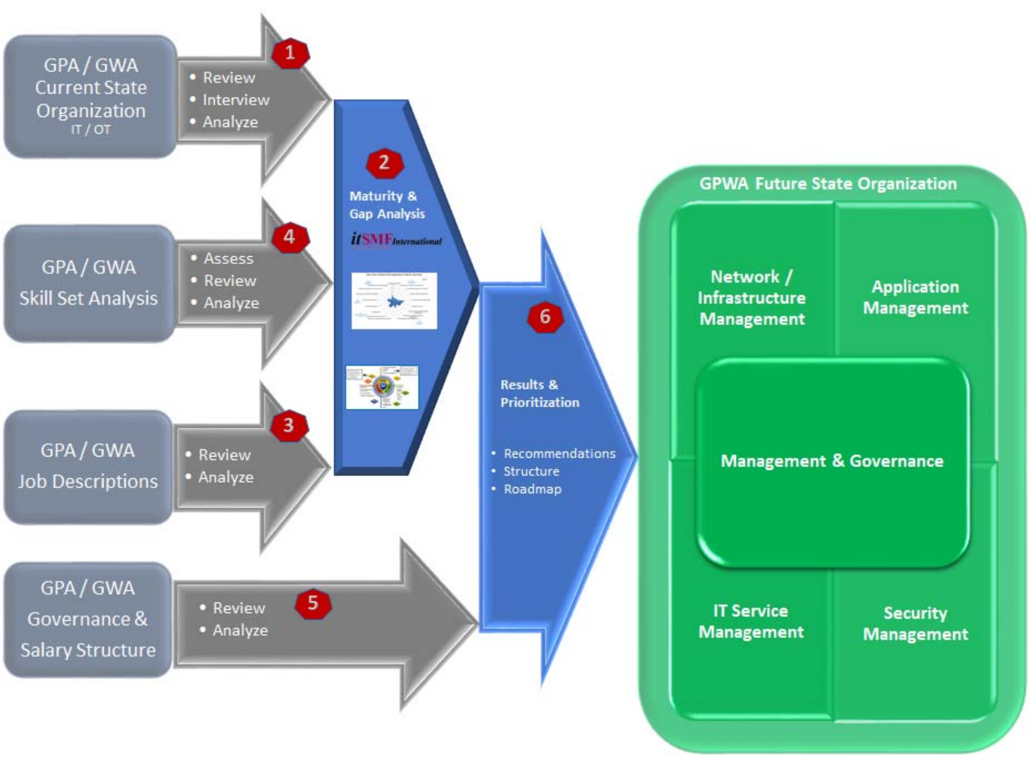


Figure 7-2: Organizational Analysis Approach

Figure 7-2 provides the logic for the organizational analysis conducted through the document review, interviews, maturity gap analysis, and skills for the Current State IT Organizations. The maturity analysis combined with the skills assessment allowed us to understand technical expertise of the GPA and GWA IT organizations along with their strengths, weaknesses, opportunities, and threats.

The resulting gap analysis and maturity assessment provides the input to put forth the recommendations, proposed structure, and roadmap tasks for the Future State organization(s).

7.2. Organizational Analysis Procedures Performed

To understand and analyze the current state of the GPA and GWA IT organizations the work was broken down into six major tasks:

1. **Reviewed organizational structure and HR policies for GPA and GWA** and analyzed existing business charters, previous studies, organizational structures for the GPA and GWA IT organizations and OT areas as applicable to the analysis work. Job descriptions, human resource policies, labor agreements, salary structures, skills and responsibilities were reviewed and categorized into common attributes for analysis.
2. **Reviewed for ITIL based Best Practices and other standards** as part of the analysis. Areas of opportunity with maturity ratings were defined and mapped to support the overall roadmap development for the organization.
3. **Reviewed organizational roles and job descriptions.** Review of the job duties and roles were accomplished through review of existing job descriptions and interviews performed with IT team members from GWA and GPA to determine capabilities gaps.
4. **Conducted skills assessment** to determine if the job descriptions and job information provided in interviews related to the job descriptions were sufficient to meet the skill sets required by each IT department and a combined GPWA IT organization. Sheffield is using the combined skills assessment as a basis for analysis of the current state and justification of recommended changes.
5. **Reviewed salaries and departmental compensation between GPA and GWA IT** personnel with similar job descriptions and identified discrepancies based on knowledge, skills, and abilities for each IT department.
6. **Performed Organizational / IT Alignment Prioritization for GPWA** using the results of the GPA / GWA IT Organizational Analysis along with the results of the GPA / GWA Application & Tools Inventory Opportunity Report, Cybersecurity Gap Analysis and Maturity Report for GWA & GPA and GPWA Network Infrastructure Design Report to develop the prioritization of a consolidated GPWA IT organization.

7.3. Organizational Analysis Results and Observations

Guam Power Authority (GPA) and Guam Water Authority (GWA) have continued to enhance their technology and network infrastructure starting in 1980's through the addition and replacement of various hardware, networks, and applications due to Smart Grid projects, SCADA development & deployment, Advanced

Metering Infrastructure, Mobile Workforce Management, a Customer Information System (CIS) replacement, and an office / data center relocation. Because of these dynamic technology, business and infrastructure changes the supporting IT organizations have been challenged in establishing and maintaining pace with the skills and expertise needed to support it, managing to the service levels that are necessary for business users, and capturing measurements and metrics for providing continuous improvement of services.

7.3.1. Organizational Maturity Analysis versus ITIL Categories

Based on the review of the IT organizations through interviews, document reviews, and on-site field verification activities we compared observed capabilities against ITIL categories tailored to GPA and GWA (Refer to Figure 7-4 ITIL Category Definitions)

The analysis was measured by using CMMI maturity levels against the ITIL Categories.

Maturity Level Defintions:					
0 - Nonexistent	**1 - Informal / Initial**	**2 – Defined / Developing**	**3 - Managed / Defined**	**4 - Measured**	**5 - Optimized**
Characteristics					
■ Little or no process maturity exists. ■ Tasks are performed informally and are uncoordinated. ■ Processes are undefined, and staff changes cause failures.	■ Processes are ad hoc, disconnected and disorganized. ■ A few individual advocates exist, but no formal program is in place, and/or there is limited awareness or acceptance across the organization.	■ The vision is outlined, and management buy-in is secured. ■ Requirements are assessed, responsibilities are assigned and an implementation plan is in place. ■ Gaps are identified. ■ Communications and education programs roll out across the organization. ■ Stand-alone supporting technology systems and tools	■ Goals, practices and performance metrics are fully defined. ■ Processes are standardized, integrated, documented and implemented. ■ A formal governance and compliance model is in place. ■ Partial integration of supporting technology and tools.	■ Process is part of the culture and is an integral, inseparable part of ongoing operations and decision making. ■ Performance is measured and highly predictable. ■ Fully integrated supporting technologies and tools	■ Processes are fully mature. ■ All investments and decisions are linked. ■ Feedback from stakeholders is used to adjust and continually improve processes as people, technology and business requirements change and opportunities arise. ■ Refined and tailored supporting systems and tools provided proactive actions.

Figure 7-3: CMMI Maturity Level Definitions

Item	Category	Definition
1	Management & Governance	
1a	Governance & Project Management	Projects and project management operate in an environment broader than that of the project itself. The understanding of broader context involves the understanding Project Phases and the Project Life Cycle, Regulatory Compliance, Project Sponsors & Stakeholders, Organizational Understanding & Influences, General Management Skills, Security Management Best Practices and possible Social - Economic Influences. A methodology is identified and trained upon for the IT organization.
1b	Education, Training & Communications	Development, Management and Execution of an education curriculum, training, and internal customer communication. Awareness training, call trees, escalation paths, application training, network / infrastructure training to maintain relevant knowledge in the respective area. Websites, external links to application and technical training, reference materials and classroom training would be content managed within this area.
1c	Supplier Relationship & Procurement	Interaction and management of procurement tasks along with supplier management for service contracts, license and maintenance agreements and managed services
1d	Documentation Management	Documentation is defined for the IT business including all supporting policies, procedures, manuals, and diagrams supporting the IT business.
1e	Internal Business Relationship	Definition and performance of service levels with internal customers in Network / Infrastructure and application Management
1f	Human Resources	Management of job descriptions, skills / capabilities, salary structure and policies for the IT organization
2	IT Service Management	

Item	Category	Definition
2a	Service Desk (Incident & Problem Management)	The Service desk logs and categorizes incidents for action and remediation. Incidents are response to services levels for an unplanned interruption to an IT service or reduction in quality to an IT services. A failure of a configuration item(s) would also be considered an incident. Incident management forms part of the overall process of dealing with problems in the organization. Defined processes and supporting tools provide management of the daily incidents within the company related to IT.
2b	Change, Configuration & Release Management	Changes related to assets supporting network, infrastructure, and applications through the use of a configuration management system that contains all IT assets and resource types.
2c	Availability & Capacity Management	Management of job descriptions, skills / capabilities, salary structure and policies for the IT organization within Guam Power Authority and Guam Water Authority
2d	Business Continuity & Disaster Recovery	Processes, tools, and infrastructure to support defined service levels to the GPA and GWA business groups in the event on man-made and natural events.
3	Network / Infrastructure Management	
3a	Design & Planning (Architecture)	Understanding of network and infrastructure concepts and architectures to aid in the definition of the applicable tools for capacity, bandwidth, processing power to support defined business operations.
3b	Operations	Day to day management and actions for network policies and tools used within the business to applicable service levels.
3c	Technical Expertise	Understanding of technical (hardware and software) components used within the IT area and keeping current with manufacturer releases and capabilities. Certifications in Oracle, Microsoft, CISCO would contribute to this level of understanding in the business.
4	Security Management	
4a	Security Administration	Day to day management and actions for security policies and tools used within the business. Adjusting user profiles based on organizational changes are part of this area.
4b	Frameworks, Standards & Regulations	Understanding of relevant cybersecurity frameworks (NIST, ISO, NERC, AWWA, DHS, Other) and the use within GPA and GWA. Industry certifications such as CISSP, CISM, CISA and others would contribute to this understanding in supporting the business.
5	Application Management	
5a	Business Requirements & Documentation	Understanding of business rules for applications that are supported by process flows, user manuals and other documentation.
5b	Application Lifecycle Management	Manages applications through their lifecycle that support GPWA business processes and information. Custodian of expertise for Applications.

Figure 7-4: ITIL Category Definitions

The analysis revealed GPA and GWA exhibit levels of 0) Nonexistent to 2) Defined / Developing levels of deviations in their maturity levels against the ITIL categories but were recognized by business organizations in having Managed / Defined levels for their working relationships.

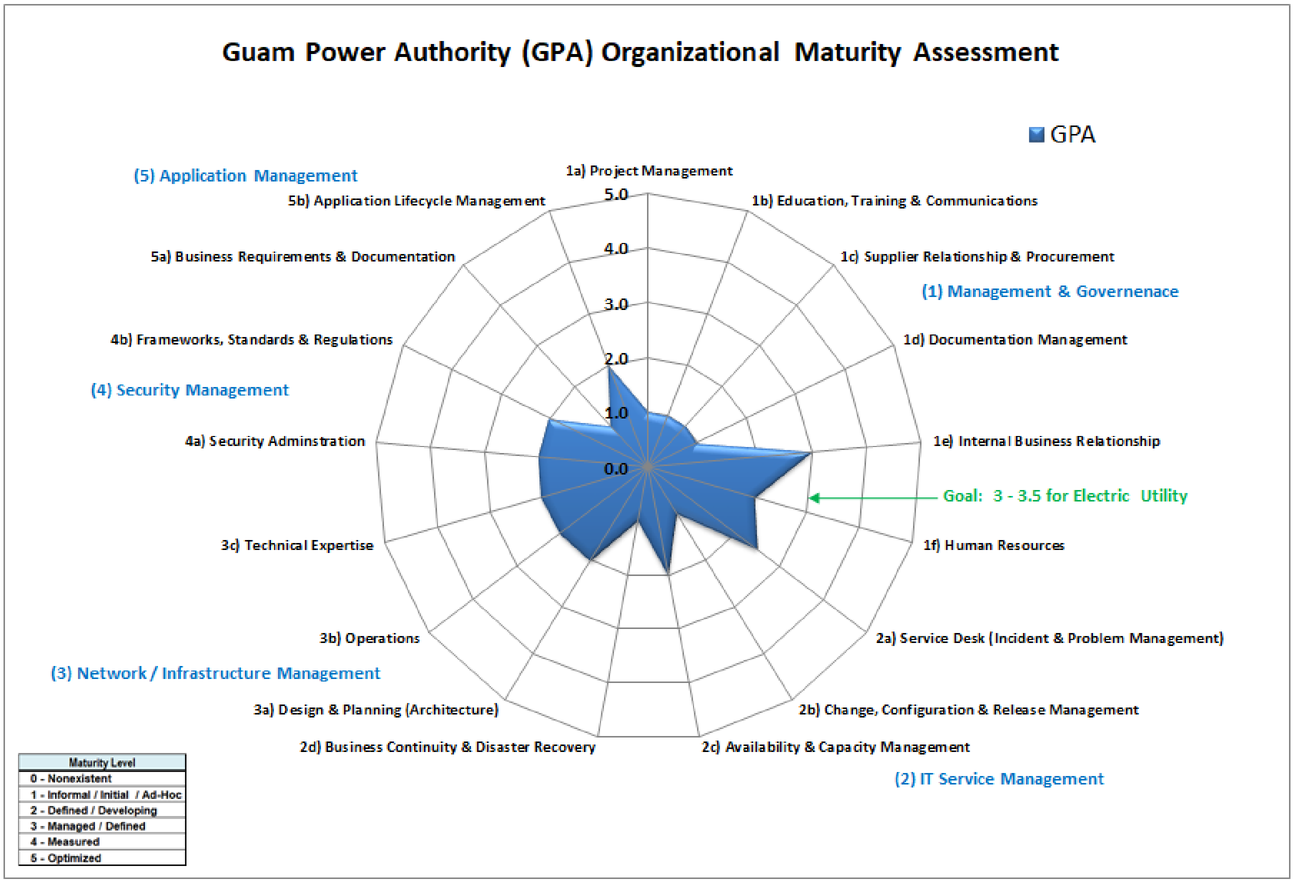


Figure 7-5: GPA Organizational Maturity

Observations:

1) Management & Governance

- No documented or observable project management methodologies
- Minimal education and training methodologies. Primary turnover from previous projects.
- Basic management of suppliers but an ad-hoc for licensing and hardware procurement
- Supporting documentation varies on project. Organization is dispersed with no observed document management methodology or systems.
- No defined service levels with internal business customers but particularly good and respected communications with Sponsors and Key Stakeholders.
- Evolving organizational strategy for jobs, roles and demands. No supporting metrics observed on workloads but everyone busy.
- Dated and evolving job descriptions that do not reflect current tools and processes

2) IT Service Management

- Help Desk tool and functions in place but service request metrics for incident management not shared.
- Informal and incomplete asset management databases and integration diagrams.
- Informal patch management process with no Change Advisory Board or similar function.

- Applications and network availability that was observed to be satisfactory with business users, but no metrics shared with analysis team.
- Current development on disaster recovery plans and supporting infrastructure with Oracle. No business impact analysis reviewed as supporting criteria.
- Too reactive – more time spent firefighting than enabling business innovation or new business models

3) Network / Infrastructure Management

- Support of network and servers maintaining reliability and up-time criteria.
- No network architect expertise on staff so as needed support from 3rd party sources being used.
- End of life equipment being replaced with pending no support deadlines
- Some Networking (CCNA), Oracle-DB and MS-SQL certifications within current staff
- No formalized support for mobility

4) Security Management

- Basic security administration duties being fulfilled with existing staff
- General knowledge of cybersecurity standards and frameworks demonstrated but no deep expertise
- No certifications
- A cybersecurity plan exists but not being utilized as written
- Basic cybersecurity policies and procedures are in place to support the business
- Annual internal audit reviews for privacy being conducted. Penetration test performed two years ago.

5) Application Management

- Oracle CC&B expertise on staff and maintain current levels of training
- Documentation is from project implementations on applications
- No formal service level agreements observed for internal business customers
- Limited application support knowledge so dependence on Application Vendors for Level 2 & 3
- No application management strategy or plan observed in analysis
- JD Edwards "Enterprise One" project underway for upgrading legacy application to updated architecture and functionality.

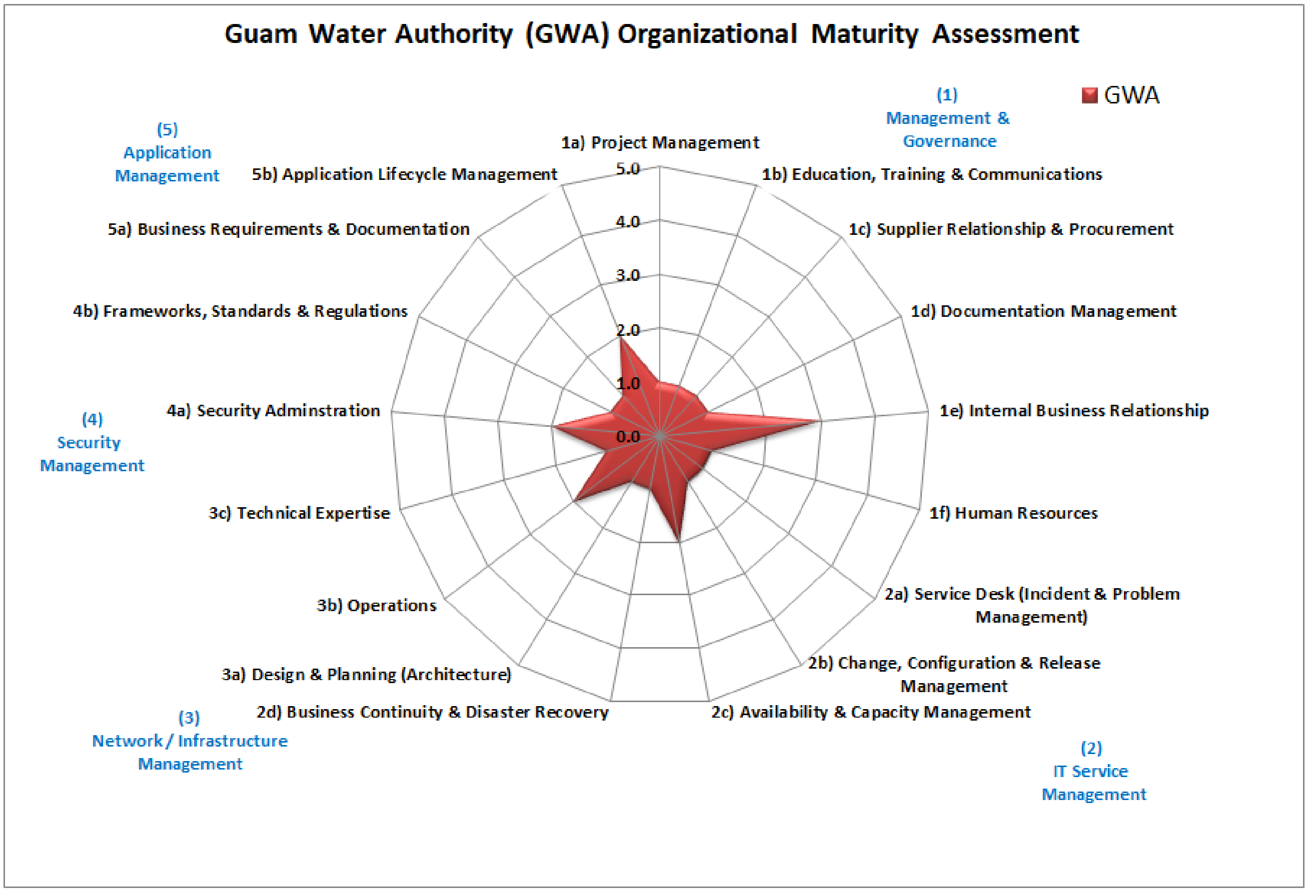


Figure 7-6: GWA Organizational Maturity

<u>Observations:</u>

1) Management & Governance

- No documented or observable project management methodologies
- Limited education and training methodologies
- Basic management of suppliers but an ad-hoc for licensing and hardware procurement
- Recognition of document management deficiencies with a proposed staff role.
- Organization is dispersed with no observed document management methodology or systems.
- No defined service levels with internal business customers but all staff members are exceptionally good with Sponsors and Key Stakeholders.
- Evolving organizational strategy for jobs, roles and demands. No supporting metrics observed on workloads but everyone busy.
- Staff is cross trained on many different duties which limits deep involvement on technical subjects.
- Dated and evolving job descriptions that do not reflect current tools and processes

2) IT Service Management

- Help Desk tool in place but "after the fact" reporting and close-out. No service request metrics for incident management were shared.
- Informal and incomplete asset management databases and integration diagrams.
- Informal patch management process with no Change Advisory Board or similar function.
- Applications and network availability that was observed to be satisfactory with business users, but no metrics shared with analysis team.
- Current development on disaster recovery plans and supporting infrastructure with Oracle and coordination with GPA. No business impact analysis reviewed as supporting criteria.
- Too reactive – more time spent firefighting than enabling business innovation or new business models

3) Network / Infrastructure Management

- Support of network and servers maintaining reliability and up-time criteria.
- No network architect expertise on staff so as needed support from 3rd party sources being used.
- No networking or database certifications within the current staff

4) Security Management

- Basic security administration duties being fulfilled with existing staff
- General knowledge of cybersecurity standards and frameworks demonstrated but no deep expertise at the IT Manager level
- A cybersecurity plan exists but not being utilized as written
- Basic cybersecurity policies and procedures are in place to support the business
- Annual internal audit reviews for privacy being conducted. Penetration test performed two years ago
- No certifications

5) Application Management

- Oracle CC&B expertise on staff and maintain current levels of training
- Documentation is from project implementations on applications
- No formal service level agreements observed for internal business customers
- Limited application support knowledge so dependence on Application Vendors for Level 2 & 3
- No application management strategy or plan observed in analysis
- JD Edwards "Enterprise One" project underway for upgrading legacy application to updated architecture and functionality. Migration of Lucity CMMS planned as part of the JD Edwards project.

7.3.2. Skills Review by Job Role

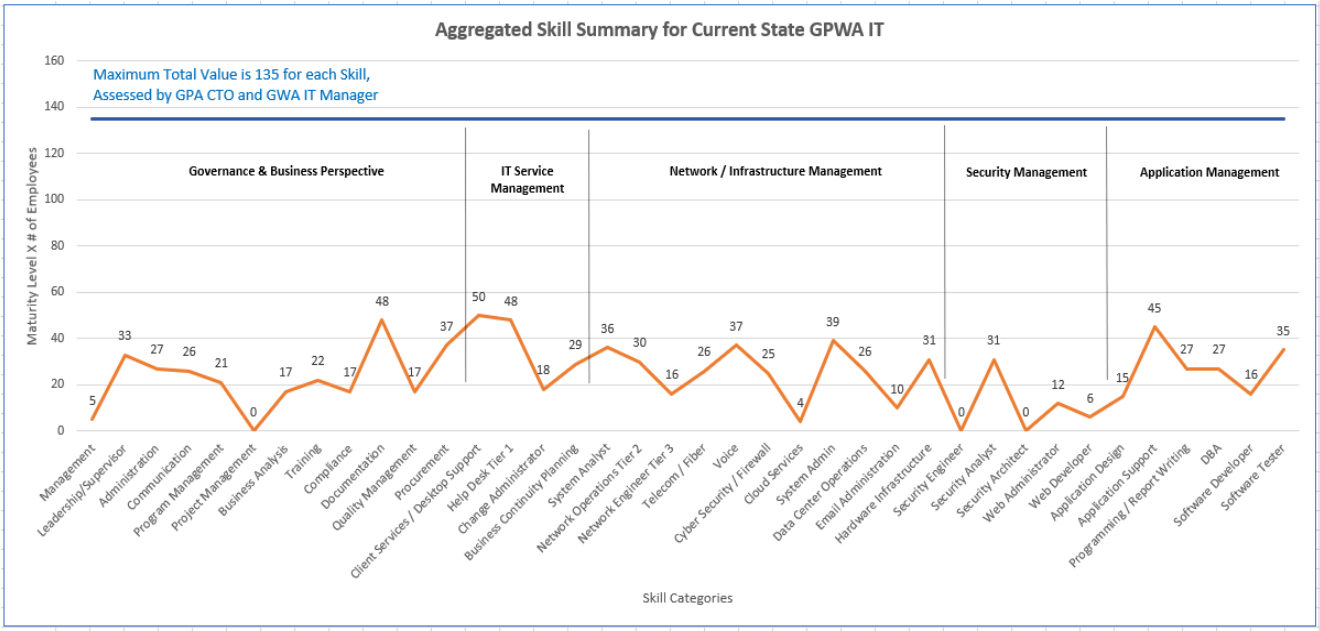
The following skills analysis of the organizational structures for each IT department revealed some similarities, but both organizations were missing key roles and skill sets for the successful management of their IT departments. In cases where there were similarities, there was a tendency to duplicate roles and responsibilities between the organizations.

Figure 7-7 provides an aggregated summary view of a self-assessed evaluation of skills performed by each IT Manager for their respective IT organization. These incorporate current positions and were graded on a 1 (Awareness) – 5 (Expert) levels and aggregated by the total of GWA and GPA employees which is 27 FTE. The maximum level amount for any single skill would be 135. This logic allows to assess the knowledge and skill for a joint organization. The skills evaluations have also been normalized against key attributes within ITIL categories for and evidence of skills gaps between similar job titles and associated roles and responsibilities. Sheffield used this information combined with interview results to determine a demonstrated skill level which will be used for recommendations in the future state organization and road mapping tasks. Results on the skills assessment revealed that GWA has many personnel and are exposed to many different business processes and areas.

Key results identified:

- Deficiencies within Governance and Business Perspective specifically in Management and Project Management. Increased levels in improvements in Compliance, Training, and Quality Management.
- IT Service Management needs increased skill focus in Change Management (Network / Applications) supported by a Change Advisory Board (CAB) to manage the on-going patch and releases provided by all GPWA vendors.
- Network / Infrastructure Management is supported with a basic level of Systems Administration, but Senior Level Network support is heavily dependent on 3rd parties.
- Security Management is providing basic network and application security administration, but senior level security engineering and architect skills are needed to support on-going operations to support dynamically changing system security plans.
- Application Management needs increased application content and development expertise as basic administration is being handled especially for CC&B and upcoming JD Edwards - Enterprise One

As part of the recommendations, a detailed review of job descriptions by a qualified third-party need to be conducted for all IT personnel in GWA and GPA for proper alignment of skills and salaries within the CCU and Guam organizational structures.



Legend:
1=Awareness
2=Basic (trained; no on-the-job experience)
3=Intermediate (some on-the-job experience)
4=Advanced (intensive on-the-job experience)
5=Expert (drives strategy; visible on the market as senior expert)

Figure 7-7: GPA / GWA Skills Assessment

Figure 7 – 8 provides the assessed skill level by professional in GPA and GWA as completed by their respective manager.

GWPA — IT Employee Skills Matrix

Legend:
1=Awareness
2=Basic (trained; no on-the-job experience)
3=Intermediate (some on-the-job experience)
4=Advanced (intensive on-the-job experience)
5=Expert (drives strategy; visible on the market as senior expert)

						Governance & Business Perspective												IT Service Management				Network / Infrastructure Management											Security Management					Application Management					
						1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	4	4	4	4	4	5	5	5	5	5	5
ID	Employee	Organization	Job Description	Certifications	Job Description Reviewed (Y / N)	Management	Leadership/Supervisor	Administration	Communication	Program Management	Project Management	Business Analysis	Training	Compliance	Documentation	Quality Management	Procurement	Client Services / Desktop Support	Help Desk Tier 1	Change Administrator	Business Continuity Planning	System Analyst	Network Operations Tier 2	Network Engineer Tier 3	Telecom / Fiber	Voice	Cyber Security / Firewall	Cloud Services	System Admin	Data Center Operations	Email Administration	Hardware Infrastructure	Security Engineer	Security Analyst	Security Architect	Web Administrator	Web Developer	Application Design	Application Support	Programming / Report Writing	DBA	Software Developer	Software Tester
1	Melvyn Kwek	GPA	Chief Information Technology Officer		Y	3		3	3					3	3		4												3					4									3
2	Antonia Evaristo	GPA	Administrative Officer		Y			3	2						2		3																										
3	Rudy Manibusan	GPA	PC Support Supervisor		N		3										3	3	4		2				4	3																	
4	Rick Peredo	GPA	Computer Technician II		Y													4	4						4	4																	
5	Vien Anastacio	GPA	Computer Technician I		Y													4	4						3	4																	
6	Mar Vic Escabillas	GPA	Network Administrator	Networking (CCNA)	Y										3					3	3	3	4		3	4	3		4		4	4		4									
7	Jonathon Chargualaf	GPA	Network Administrator	Networking (CCNA)	Y		3								3		3				3	3	4		4	4	4		4	4		4		3									
8	Matthew Ho	GPA	Network Administrator	Networking (CCNA)	Y										3						3	3	4		4	4	4		4	4		4		4									
9	Eileen Bihag	GPA	Database Administrator	Oracle-DB	Y							2			3																								4	4	4		4
10	Cody Farnum	GPA	Database Administrator	Oracle-DB	Y										3																								4	4	4		4
11	Ray Gatongay	GPA	Computer Systems Analyst II	MS-SQL	N							3			3																								4	4	4		4
12	James Duenas	GPA	Computer Operations Supervisor		N		3						2				4	4	4	3		3							3	3		3							4				
13	Christopher Untalan	GPA	Computer Operator III		Y													4	4			3							3	3		3											
14	Michelle Castro	GPA	Information Security Administrator	Security+	Y								3	2	3				4		3						4							4									
15	Jacob Barnes	GPA	Help Desk Supervisor		Y		2		2				2		2			3	4																								
16	Blaine Dydasco	GPA	Help Desk Technician		Y		2		3						3			4	4																								
17	Vladimir Navasca	GPA	Help Desk Technician (Temp)		Y				2						2			4	4																								
22	Manny Apuron	GWA	IT Manager	DB2, SQL	Y	1	4	4		3		3	4	3		4	3	4		3	3	4		2			2	1	3			3		3				3	3	3	3	4	4
23	Rachel Paulino	GWA	Administrative Officer		N		4		4				4		3	3	4	3	1						1	2																	
24	Ely Torres	GWA	Network Administrator		Y		3	3		3				3	2		3	3		3	3	4	4	3	1	2	3	1				3		3									
25	Lou Palomo	GWA	Systems & Programming Administrator	DB2, SQL, MySQL, Oracle	Y	1	3	4		3		3	4	3	2	4	4	3		3	3	4		2			1		3	3	3			3		3		4	4	4	4	4	4
26	Cecille Cesa (Vacant)	GWA	Cyber Security Administrator		Y		3	3	3	3			3	3	2	3	3	3		3	3	3	3	3	1	2	3	1	3		3	4		3		3			4				
27	Anthony Cedeno	GWA	Programmer Analyst	SQL, MySQL, Oracle	Y			2		3		3			2	3						3	2	2			1	1	3							3	3	4	4	4	4	4	4
28	Julius Sy	GWA	Programmer Analyst	SQL, MySQL, Oracle	Y			2		3		3			2							3	2	2		2			3							3	3	4	4	4	4	4	4
29	Chris Portin	GWA	Computer Operator III		Y		3	3	3	3					2		3	4	4		3		3	2	1	2			3	3		3							4				4
30	John Dixon	GWA	Computer Operator II		Y				2										4				2			2				3									3				
31	Allen McDonald	GWA	Computer Operator II		Y				2										4				2			2				3									3				
	TOTAL SCORE					5	33	27	26	21	0	17	22	17	48	17	37	50	48	18	29	36	30	16	26	37	25	4	39	26	10	31	0	31	0	12	6	15	45	27	27	16	35
	GAP					130	102	108	109	114	135	118	113	118	87	118	98	85	87	117	106	99	105	119	109	98	110	131	96	109	125	104	135	104	135	123	129	120	90	108	108	119	100

In some instances a value was assigned based on previous work products or projects.

Figure 7-8: GPA / GWA Skills Assessment by Employee

7.3.3. IT Job Descriptions & Salary Structure

Documented job descriptions were obtained through a formal request but only revealed approximately 70% of the defined roles existing or proposed in IT. Furthermore, the reviewed job descriptions date as far back as 1980 for Computer Operators for GPA and GWA which reflect technologies and duties that have been retired in the current environment.

The analysis revealed that some personnel have a large variety of responsibilities to the organization which leads to a lack of focus due to unclear priorities and objectives.

Business alignment between IT department and existing compensation plans are different for each employee groups and management team. Although compensation plans are not always seen as a strategic business initiative, their huge impact on a company's bottom line, recruiting, retaining, and motivating people has led to compensation design efforts which must be considered as an important element to achieving success.

Guam faces several challenges related to identifying and retaining personnel. In a recent publication by the Pacific Island Times there are over 50 thousand working age residents who do not want to work or are not looking for work as opposed to the 3,100 who are actively seeking jobs. The 51,660 working age residents not seeking work is nearly the same number of individuals employed in Guam (64,790). At the same time island businesses are demanding more qualified personnel to fill the job openings since there is a clear shortage of skilled labor on the island.

Interviews with management personnel revealed their concerns about identifying and retaining personnel which included lack of applying individuals with the necessary skill sets, inability to pay competitive wages, concerns with certifications, lack of incentives, and advancement necessary to retain personnel who have increased their knowledge and or skill sets and abilities (KSA's).

7.4. Organizational Analysis Recommendations

The results of the organizational analysis have dictated three major recommendations for action as a part of the IT Integration Study & Plan for GWA and GPA. These recommendations provide short and longer-term benefits to both IT organizations. These recommendations are presented in detail with supporting arguments and decision criteria supporting each one.

- Recommendation 1 – Establish an Updated Governance for IT Management Duties and Operations
- Recommendation 2 – Establish Program / Project and Organizational Change Methodologies supporting IT Projects
- Recommendation 3 – Develop and approve a combined GPWA IT Shared Services Organizational Structure

Recommendation 3 which involves the merger and transformation of the GWA and GPA IT organizations into a shared services organization will be discussed in Section 7.6 - Organizational Analysis Conclusion. All recommendations have actionable tasks which are contained in Section 9.0 – Roadmap.

7.4.1. Establish an Updated Governance for IT Management Duties and Operations

GPA	X
GWA	X

GPA / GWA Organizational Analysis

Recommendation 7.1 – Establish an Updated Governance for IT Management Duties and Operations

Introduction

Audience: GPA and GWA Senior Management

Situation: The lack of a governing body over the GWA and GPA IT organizations has left both GWA and GPA in the challenging position of trying to make physical, logical, and organizational changes to improve IT, OT, physical security, and cyber security without the authority to enforce them. This lack of definition and governance has led to the many ad-hoc work practices observed with no accountable metrics.

Complication: The ability to manage, operate, and make decisions for IT is perceived as not accountable to the business. Many IT projects fail to deliver expectations and cost benefit to the business. This lack of governance also contributes to IT having misaligned and/or insufficient resources, infrastructure, and competencies to support business objectives.

Question: *What is the financial impact to GPA and GWA in managing IT without transparency of business processes and supporting metrics for financial and technological accountability?*

Next Steps:

Work on GPA and GWA management consensus to proceed forward with the charter and establish governance committee.

Governing thought

A defined structure supported by validated metrics is needed to make good decisions for the business. A governing body with the use of IT best practices, standards, and frameworks provide the basis for managing the IT organization and supporting processes efficiently and effectively.

Arguments

Supporting Concepts

IT Governance is currently focused on GPA and GWA individually not both.

- Decisions are based on addressing one unit or the other not the entire utility function.
- Many systems are being purchased twice which increases the cost.
- System updates and patches must be done for both GPA & GWA.

Redundant IT functions create variance in operations and no focus on best practice adoption and operation is apparent.

- Lack of results based KPIs and Metrics which prevents early detection of issues.
- Many practices are dated due to old practices and systems.
- Customer facing personnel must perform redundant entry of customer account actions.
- Separate systems provide additional challenges to portray a cohesive utility operation.

Duplicate support functions creates standardization issues/increased cost that a single governance model could eliminate.

- Streamlined systems free up personnel to focus on quality of operation.
- IT Hardware and systems purchased for both reduce supporting infrastructure and personnel requirements.

7.4.2. Establish Program / Project and Organizational Change Methodologies Supporting IT Projects

GPA	X
GWA	X

GPA / GWA Organizational Analysis

Recommendation 7.2 – Establish Program / Project and Organizational Change Methodologies Supporting IT Projects

Introduction

Audience: GPA and GWA Senior Management

Situation: The need for repeatable and effective project execution of IT projects is needed to enable business process improvements to GWA and GPA. No defined GPA or GWA project execution or organizational change methodology exists today leaving IT larging dependent on the technology vendor or systems integrator to provide this service to GPA or GWA. Basic methods can be established using PMI, Kotter, Prosci, and other industry practices to provide guidance to IT projects.

Complication: Neither organization is effectively tracking or managing projects to delays, project overruns, and failure to meet project objectives; which erodes confidence in the ability to delivery in a reliable and timely fashion.

Question: *How important is it to GWA and GPA that projects are delivered on time within budgets and implemented to return on investment expectations?*

Next Steps:

Work on GPA and GWA management consensus to proceed forward in coordination of the IT Oversight Committee.

Governing thought

IT project management is the process of planning, organizing and delineating responsibility for the completion of an organizations' specific IT goals. Projects need formalized discipline that enables an organization to transform from where it is today to where it wants to be in the future with minimal disruption.

Arguments

Supporting Concepts

Projects are GWA /GPA IT centric and do not employ project management best practices such as PMI

- Lack of a standard project management methodology makes control more difficult
- Project business cases are inconsistent when done
- Many skills for project and change management do not exist or are too limited to enable consistent use
- Utility personnel skill make up should increase PMM/OCM Skills.

Organizational Change Management (OCM) Methodology for GWA / GPA Projects do not exist

- Current IT organization structure lacks coverage of key functions which creates incomplete organizational consideration
- Lack of organizational context for projects impedes achievement of organization's business objectives
- Lack or routine and purpose for a project engenders distrust and other acceptance barriers

Lack of OCM and supporting operational measurements makes objective assessment of progress difficult

- Progress is difficult to track and access
- Redundancy of systems creates double information capture when engaged with GPA & GWA which erodes confidence
- Lack of metrics makes oversight difficult
- Lack of project organizational context hinders effective organizational engagement

7.4.3. Develop and Approve a combined GPWA IT Shared Service Organizational Structure

GPA	X
GWA	X

GPA / GWA Organizational Analysis

Recommendation 7.3 – Develop and approve a combined GPWA IT Shared Services Organizational Structure

Introduction

Audience: GPA and GWA Senior Management

Situation: GPA and GWA provide IT services to their respective business organizations by supplying infrastructure, network, and applications in an independent manner. CC&B, SCADA, GIS, and JDE are common applications along with network infrastructure that can be leveraged across both organizations. An IT Shared Service organization supported by ITIL Best Practices can offer improved efficiencies, lower costs, and result in greater overall effectiveness for the water and power utilities.

Complication: Lack of critical skill sets and an aging workforce increase business risk due to the impending loss of skilled resources. The discrepancy in salaries between mainland jobs with the same skillset requirements makes it increasingly difficult to find and retain local talent.

Question: *How can GPA and GWA IT leverage the right skills in the right place at the right cost?*

Next Steps:
Work on GPA and GWA management consensus to proceed forward in organizational establishment

Governing thought

Shared Services can only be achieved through joint ownership of outcomes and collaboration between the GWA and GPA. A shared services organization promotes accountability, stakeholder participation, and defined integration points for decision-making with the business. The use of a hybrid approach enables more effective use of internal resources complimented with external service providers expertise. There are many opportunities between GPA and GWA to share IT expertise and infrastructure. A shared services model is designed to aggregate transactional and common activities into a consolidated, integrated, business services entity resulting in cost reduction, process optimization, and sustainable value creation.

Arguments

Supporting Concepts

The current organization structure is incomplete in addition to having needless redundancies

- No CIO role exists
- CTO focus does not provide coverage of organization information needs
- Lack of CISO role leaves security functions as a secondary issue which enhances risk

The current structure encourages personnel to focus on power or water functions which distracts from a sound utility operation focus

- The current organization structure lacks key specialty roles and is division rather then utility focused
- Some specialties are in limited supply or not available in Guam
- Utility-wide Information Technology focus is limited due to historic structure

Current operations and standards are based on GPA and GWA vs. a utility wide basis

- Service level focuses are GPA and GWA based instead of Utility Services focus
- Many functions lack metrics which when in place are GPA/GWA centric
- Operations tend not to be monitored by results-based metrics which makes early detection of issues less likely

7.5. Organizational Analysis Conclusion

The results of the organizational analysis supported by the other study workstreams (Network / Infrastructure, Security, Applications and IT Service Management) results have revealed opportunities for improvements that can be incorporated into the restructuring of the IT organizations for GPA and GWA.

The recommendations that are presented in Section 7.4 provide the business needs along with the supporting preliminary cost benefit evaluation that points to the primary objective of the IT Integration Study & Plan which is;

- Establish an Updated Governance for IT Management Duties and Operations
- Establish Program / Project and Organizational Change Methodologies supporting IT Projects
- Develop and approve a combined GPWA IT Shared Services Organizational Structure

An IT shared services model would consolidate the provisioning of standardized services for Information Technology for GPA and GWA. Standardizing these functions into a shared service model would deliver cost efficiencies and improve the quality of outcomes. A shared services model could potentially include strategic and advisory services such as quality management, project management. Removing responsibility for execution of these core activities from individual departments, will also allow them to focus on core strategic activities.

A shared services department is the establishment of a service by one part of an organization or group that was once performed by two or more parts of the organization or group. Thus, the funding and resourcing of the service is shared and the providing department effectively becomes an internal service provider. Is a combined IT Shared Services in the best business interests for GPA and GWA?

The answer to the question is if IT can benefit from the consolidation of functions and resource management due to barriers as:

- Limited skill sets on island and an aging workforce that can benefit with collaboration and management oversight that exemplifies "The needs of the many outweigh the needs of the few".
- Increased formalization of roles and duties in alignment with GPA and GWA business objectives
- Consolidation of fragmented business processes aligned and organized to industry best practice methodologies and standards to gain business efficiencies.
- Metrics and reporting to an oversight organization for performance and behavior reinforcement

The results of the analysis have created a preliminary organizational structure that incorporates the following guiding principles and assumptions into its model.

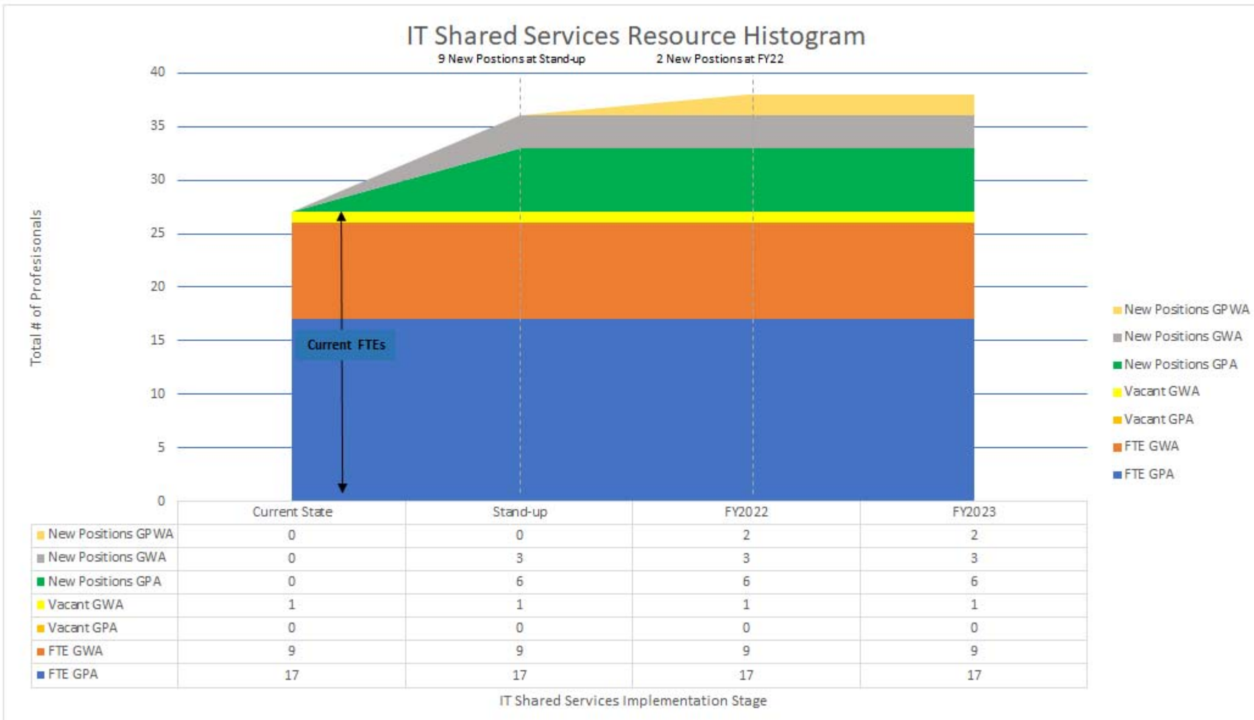
- The model supports business alignment for increased internal and external GWA and GPA customer service
- Current and proposed IT organizational structures from GPA and GWA have been shared and analyzed as part of the proposed shared services organizational structure.
- Fully maximize governance, best practices, and organizational effectiveness within IT
- Creates an IT Oversight Committee made up of to be named GPA, GWA and CCU members in providing business guidance and approval of policies governing IT for the business.
- Organizational categories or teams have been created but greater evaluation of individual skill sets needs to be completed to confirm updates capabilities and determine job descriptions, salary structure and a management reporting structure.
- Preliminary position assignment within the IT Shared Services model is based on limited input obtained by Sheffield Scientific team members and will be validated with GPA and GWA IT Integration Study Sponsors.
- The use of outside Implementation Support Specialists will be determined to fulfill possible identified roles on a short-term basis while formal hiring practices are executed within the organization. They will also be needed to support implementation tasks.
- Definition of the budget funding process, approval limits and governance supporting the GPWA IT Shared Services organization need to be confirmed with the CFOs of GPA and GWA.
- Review of job positions with GPA and GWA Human Resources personnel needs to be conducted for compliance assurance.
- Cost benefit analysis for the organizational analysis will be presented as part of the Section 0 – Cost Benefit Analysis.

The IT Shared Services organization is going to be presented in two versions.

- Version 1 – Presents the IT Shared Services organization structure with all current and proposed new employees and contractor roles identified from IT structures obtained from GPA and GWA.
- Version 2 – Presents the IT Shared Services organization structure that has the proposed positions removed due to a combined benefit of the consolidation of the organizations. This consolidation would be identified as cost avoidance benefit. We are recommending the positions that need to be

filled be done in a three-stage approach which are at 1) Stand up of the IT Shared Services organization, 2) Positions filled during FY2022 and 3) If required, remaining positions filled in FY2023.

The Version 2 organizational model is also presented in a histogram based on positions. The following resource histogram provides, by key time periods, the anticipated size of the organization. Current existing Full Time Equivalents (FTE), Vacant positions not currently filled and pending New Positions based on existing IT organizations and the Integration Study are presented in the current diagram.



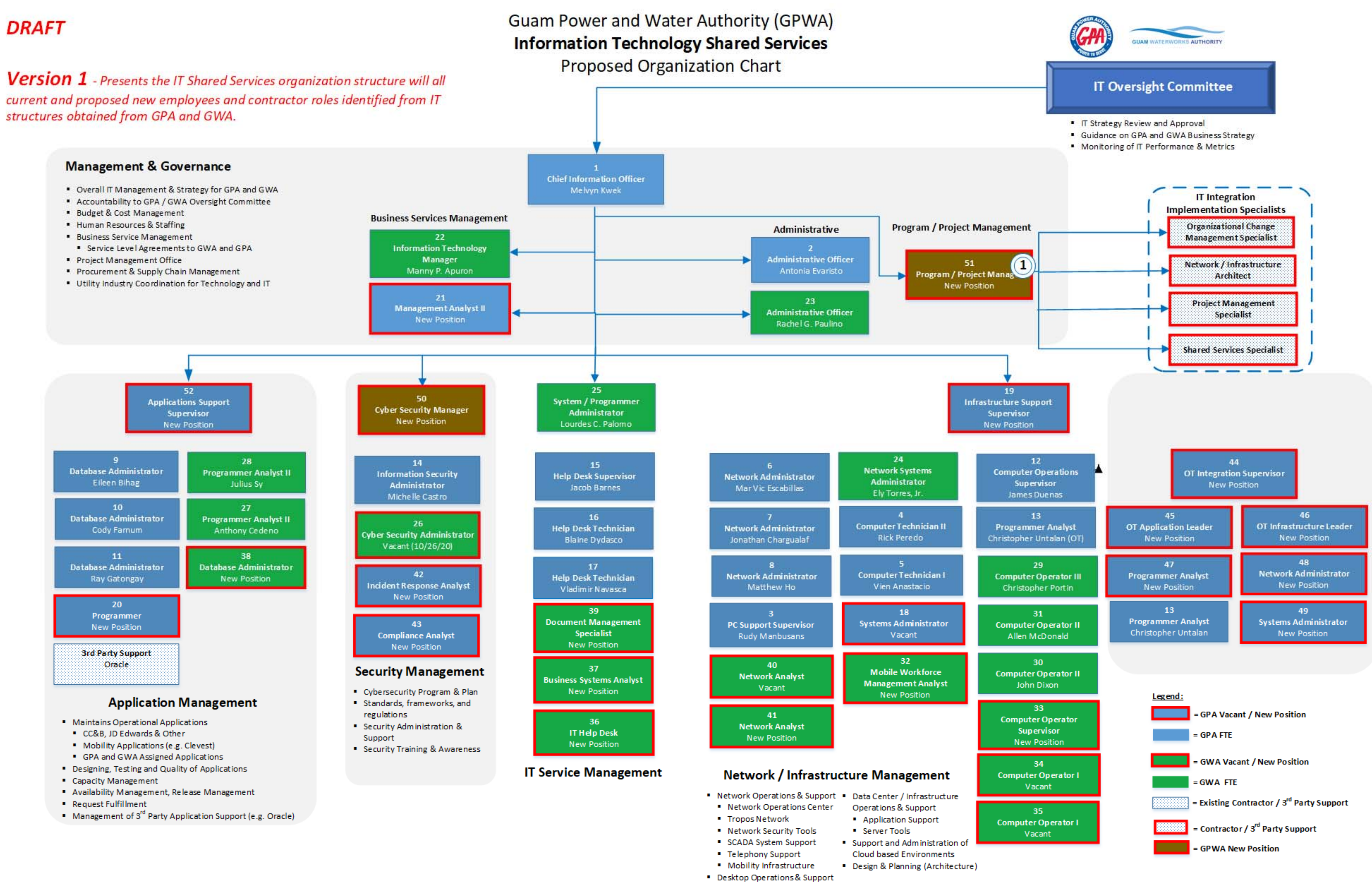
	Current State	Stand-up	FY2022	FY2023
New Positions GPWA	0	0	2	2
New Positions GWA	0	3	3	3
New Positions GPA	0	6	6	6
Vacant GWA	1	1	1	1
Vacant GPA	0	0	0	0
FTE GWA	9	9	9	9
FTE GPA	17	17	17	17

Major highlights in the GPWA IT Shared Services organizational structure:

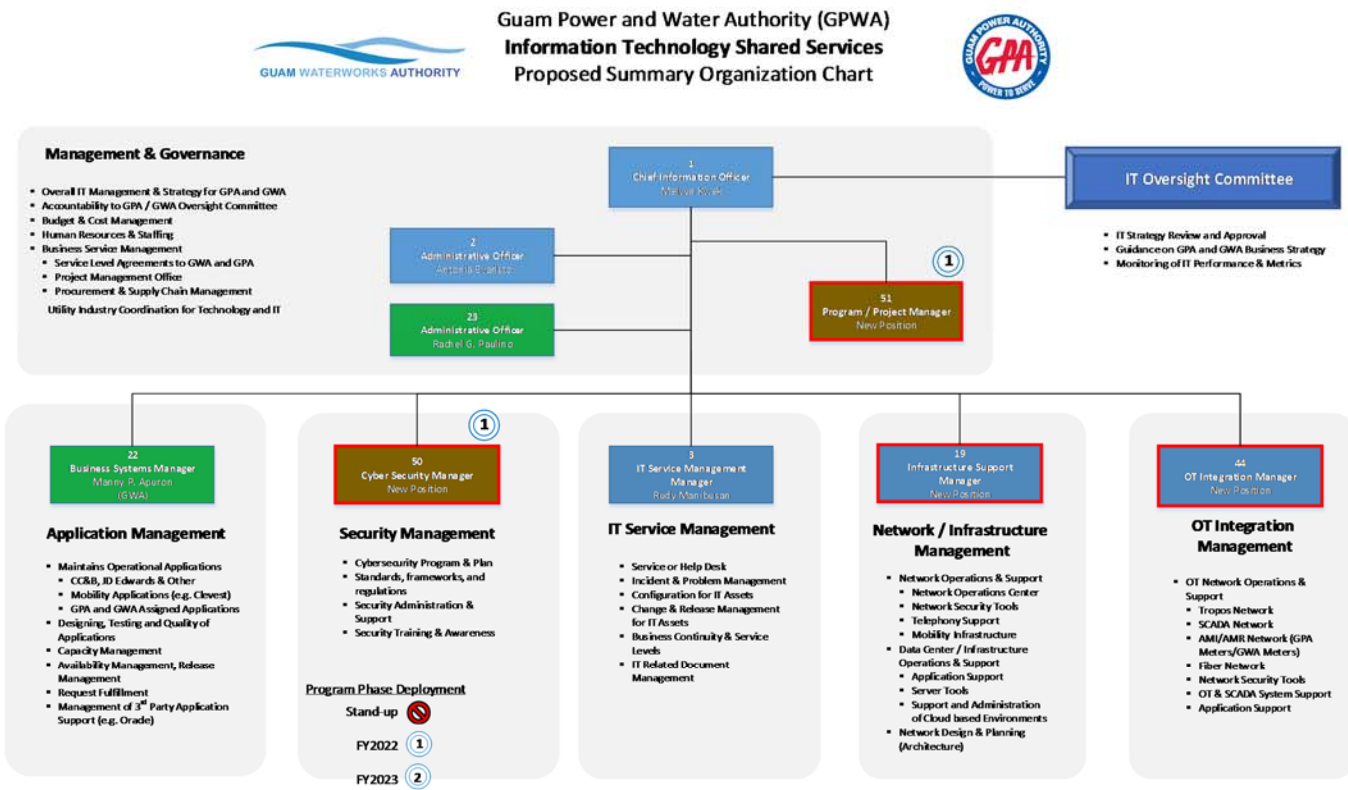
- An IT Oversight Committee made up of to be named GPA, GWA, and CCU members in providing business guidance and approval of policies governing IT for the business.
- The GPWA IT Shared Services organization is structured into 5 primary areas:
    1. Management & Governance
    2. IT Service Management
    3. Network / Infrastructure Management
    4. Security Management
    5. Application Management
- The formalization of a Chief Information Officer (CIO) position over the GPWA IT Shared Services
- The establishment of a Cyber Security Manager to oversee the plan, policies, standards, and frameworks supporting cyber security in the critical infrastructure areas of water and power.

- The establishment of a Program / Project Manager position to manage and oversee project management methodologies and the oversight of projects within the IT domain. A logic and process will be defined for individual projects through this position.

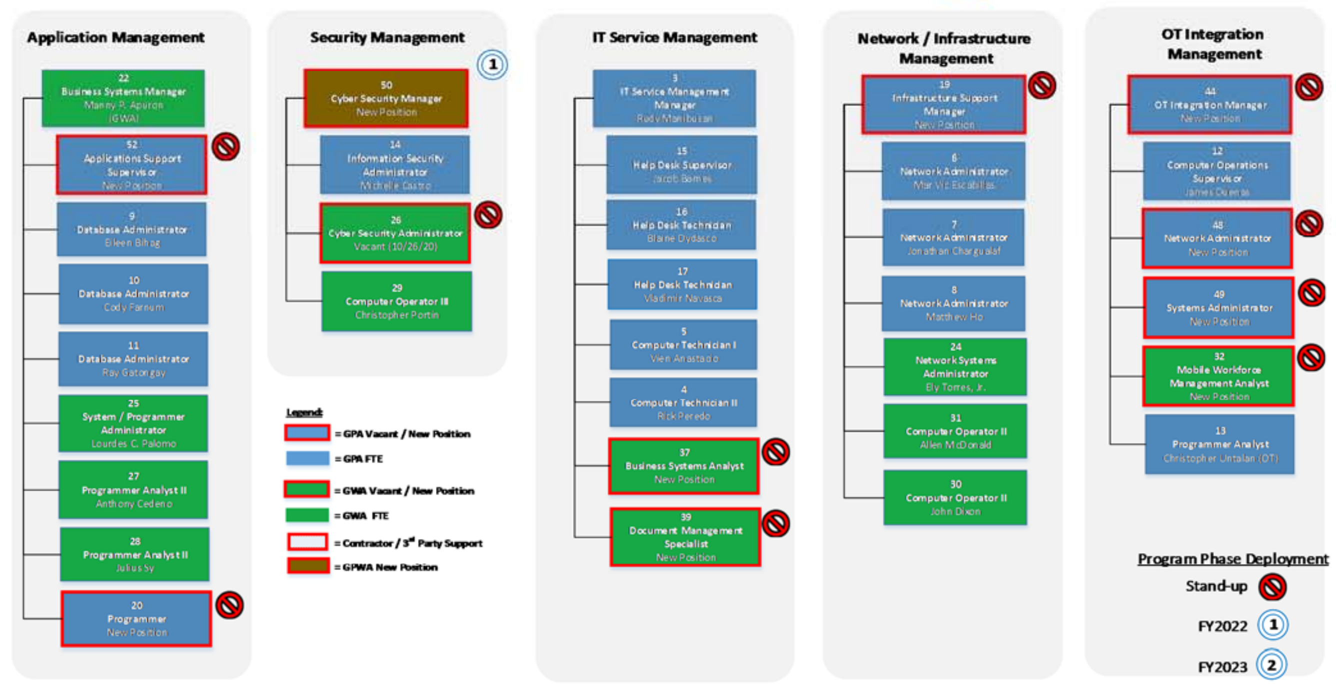
7.5.1. GPWA IT Shared Services Model (Version 1)



7.5.2. GPWA IT Shared Services Model (Version 2)



Guam Power and Water Authority (GPWA)
Information Technology Shared Services
Proposed Detailed Organization Chart



8. Network Future Design

8.1. Network Future Design Assessment Approach

The results of the network infrastructure and application discoveries and analysis were reviewed. GPA and GWA employees and management were interviewed. Industry trends and best practices were included where possible.

8.2. Network Future Design Procedures Performed

- Gathered documents and diagrams
- Interviewed GPA and GWA Staff
- Reviewed documents, network infrastructure, and data flow diagrams provided by GWA and GPA
- Conducted a physical inspection of the data center
- Analyzed collected information
- Developed roadmap and recommendations

8.3. Network Future Design Results and Observations

GPA and GWA share a headquarters building, but maintain separate network and server infrastructure, including separate Internet circuits. GPA has deployed a wireless network in the headquarters building, but GWA does not have any wireless capabilities.

GPA has a network monitoring and alerting system as well as a SIEM for logging and log analysis, but GWA does not have any of these capabilities.

GPA has begun the process of securing a disaster recovery site on the island. GWA production servers will reside in the cloud and its backup instance of JDE will reside on the island, a new colocation facility is in the works at an existing site at upper Tumon for its DR capabilities.

Neither GPA nor GWA follow a formal change control process. Both have ticketing systems, but tickets are not always opened and those that are, are not updated or closed.

Both GPA and GWA are using older firewalls that do not support next generation features such as application inspection and decryption. Because of this, various network security technologies have been developed to protect organizational data and infrastructures. One of the most effective of these modern technologies is the data diode. A data diode is a unidirectional network communication device that enables the safe, one-way transfer of data between segmented networks. Data diode design maintains physical and electrical separation of source and destination networks, establishing a non-routable, completely closed one-way data transfer between networks. Data diodes effectively eliminate external points of entry to the sending system, preventing intruders and contagious elements from infiltrating the network.

GPA has invested millions of dollars in deploying fiber and wireless networks throughout the island. GWA does not have such infrastructure and relies on third party carriers to provide their WAN backbone.

GWA and GPA maintain separate email systems. GPA uses an on-premise Microsoft Exchange system with integrated calendaring and GWA has an older POP3 email system.

GWA and GPA have been deploying a shared SCADA system for the past two years, but the project has stalled on the GWA location deployments.

Neither GWA nor GPA have a central document management system.

GPA and GWA maintain separate customer records in CC&B. This duplicates the effort for data entry and customer service.

Both GWA and GPA use the ESRI GIS system, but they maintain separate servers and licenses for these systems.

Neither organization has an asset management system for tracking critical IT assets.

8.4. Network Future Design Recommendations

Create a Shared Services IT organization including departments to support System Administration, Storage, and Email, Network Operations and Engineering, Change, Problem, and Incident Management, Client Services and Helpdesk, Cyber Security, and Project Management.

Converge the GPA and GWA networks and standardize on a single router and switch vendor. The firewalls do not have to be from the same vendor. There are some integration advantages to using the same vendor for wireless as the switches, but the wireless solution can be from a different vendor. Use VLANs and next generation firewalls to segment the network and maintain best practices for cyber security. Use separate firewalls for the Internet edge and the OT networks following the Purdue security model for layered security.

Expand GPA's network monitoring, alerting, configuration management, and logging system to include GWA and move system to the Shared Services infrastructure.

Implement a Shared Services Service Desk solution including problem, incident, and change management. Develop a workflow for submitting and approving changes as well as creating, updating, and closing problem and incident tickets.

Build out disaster recovery capabilities for both GPA and GWA. Consider moving to an off-island colocation or cloud-based solution as the lease with the Docomo data center nears the end of its term.

Converge the GPA and GWA server and storage infrastructure and standardize on a single vendor. GPWA may need less on-premises capacity if they move towards a cloud-based or hybrid on-premise / cloud model.

Converge GPA and GWA's email systems. Consider moving to a cloud-based solution such as Office 365 that will reduce maintenance costs and offer additional functionality such as a document management system.

Leverage GPA's OT and Smart Grid networks to deploy automated metering and SCADA solutions for GWA.

Merge GPA and GWA customer records in CC&B and form a Shared Service Customer Service department. This will eliminate duplicated data entry and allow for a more streamlined customer service experience for GPA and GWA customers.

While ESRI is licensed on a per user basis, evaluate if moving to a shared GIS system would reduce server licensing, maintenance, and hardware costs.

Implement a shared services asset tracking database. Evaluate systems that can be integrated with the service desk system to better track the impact of changes and incidents to IT assets.

8.4.1. Migrate to a shared Network Infrastructure based Product Lifecycle

GPA	X
GWA	X

GPA/GWA Network Future Design

Recommendation 8.1 – Migrate to a Shared Network Infrastructure based on Product Lifecycle

Introduction

Audience: IT Senior Management Team

Situation: Both organizations are purchasing and supporting network infrastructure.

Complication: Both organizations are using different network infrastructure devices to perform the same functions. The redundancy results in compatibility and interoperability issues

Question: *What can be done to reduce costs and risks associated with network activity?*

Note: Dependence on GPA/GWA Network Infrastructure – Recommendation 5

Next Steps:

- Identify and standardize on a next-gen firewall solution

Governing thought

Converge the GPA and GWA networks and standardize on a single router and switch vendor. The firewalls do not have to be from the same vendor. There are some integration advantages to using the same vendor for wireless as the switches, but the wireless solution can be from a different vendor.

Arguments

Supporting Concepts

Identify organizational network requirements

- Multiple solutions which fail to meet business needs
- Incompatible systems and solutions increase the need for bridging technology

Identify skills needed to support the system and system users

- Multiple knowledge and skills sets required to maintain solutions
- Multiple procedures to track and manage
- Multiple training modules required to support system admins and users

Choose and implement consolidated solution

- Fewer hardware, software, and system conflicts
- Fewer third-party vendors to support various systems
- Reduced troubleshooting time for help desk personnel
- Reduced administration and maintenance costs

8.4.2. Deploy a Shared Service Ticketing and Change Management System

GPA	X
GWA	X

GPA/GWA Network Future Design

Recommendation 8.2 – Deploy a Shared Services Ticketing and Change Management System

Introduction

Audience: IT Senior Management Team

Situation: Neither GPA or GWA follow a formal Change Management process.

Complication: Neither organization has implemented a formal change management system, with associated governance, which has led to gaps in asset inventories, inaccurate metrics, inadequate or poorly managed resources, failure to meet SLAs, and ad-hoc change practices. Applicable solutions could be ServiceNow or stay with a Solarwinds

Question: *What can GPA and GWA do to improve communications with the business units, provide better metrics on systems and network availability, manage assets, and better metrics on employee workloads?*

Next Steps:

- Identify technical, operational, governance, security, and regulatory requirements and artifacts needed for audit compliance

Governing thought

Improve communications, provide an audit trail of changes made for troubleshooting outages, and improve metrics on systems and network availability and employee workloads.

Arguments

Supporting Concepts

Authorize formal project and identify technical, operational, security, and regulatory requirements and artifacts needed for audit compliance

- Lack of governance
- Lack of understanding of requirements
- Lack of visibility to compliance and audit artifacts

Assess current applications, knowledge, and skills for available resources and tools

- Lack of understanding of current tool capabilities
- Lack of understanding on configuring and using current tool capabilities

Configure tools to support ticketing and change management

- Inability to track efforts and costs associated with support efforts
- Reduced troubleshooting capabilities
- Increase issue remediation times
- Limited ability to support security incident investigations

Develop a ticketing and change management workflow and establish governance

- Lack of governance for change and configuration management
- Lack of accountability for change
- Inability to provide compliance and audit artifacts

8.4.3. Share disaster recovery capabilities and move backups to a remote data center

Both entities store their backups locally which poses a threat in the event of disaster. Moving backups to a remote (geographically diverse-off island) data center or to the cloud will help ensure that backups are secure and available when needed. This will reduce facility, connectivity, and maintenance costs.

Considerations for your disaster recovery capabilities local versus cloud:

Implications of having your backup and disaster recovery efforts locally hosted include:

- Dedicated infrastructure with protected access, with more agility to make the right choices in terms of access, compliance, and physical protection.
- Usage fees can be substantial depending on the services required.
- Ensure securely store and transfer information comply with all applicable regulations.
- Dedicated infrastructure you can perform personalized management functions that your business requires.

The emergence of cloud technology is changing the data preservation landscape. Reasons to have your backup and disaster recovery efforts housed on the cloud include:

- Cloud backup reduces cost
- Flexibility and reduced downtime
- Simplification and efficiency
- Cost-effectiveness
- Cloud computing can reduce the odds of security breaches, equipment failures
- Cloud technology enhances scalability
- Cloud environments reduce the burden of IT and OT staff
- Cloud backup offers better accessibility
- Cloud delivers faster disaster recovery times

GPA	X
GWA	X

GPA/GWA Network Future Design

Recommendation 8.3 – Share disaster recovery capabilities and move to a remote data center or cloud to meet geographical diversity requirements

Introduction

Audience: IT Senior Management Team

Situation: Disaster recovery and backup capabilities are stored on island

Complication: Both utilities use an on-island data center for backup and recovery which puts them at an increased risk of losing back up and recovery capabilities in the event of a disaster. GWA is moving JD Edwards to cloud based solution.

Question: *What can be done to reduce the risk associated with a disaster?*

Next Steps:

- Assess storage and security requirements

Governing thought

Storing backup and recovery data within a 100-mile radius increases the risk of loss due to fires, hurricanes, typhoons, floods, and other natural disasters. When data backup and storage is within a 60 to 100-mile radius of the primary backup and storage disasters have the increased potential to impact both the primary storage and backups. In situations where geographic diversity is not available, best practice methods of storing backup and recovery data to the cloud should be considered.

Arguments

Supporting Concepts

A cloud-based solution would allow complete remote administration of applications and meet geographic diversity requirements.

- Cloud based solutions are subscription based and require a recurring budget to pay for.

Not all applications require DR. Identifying which applications are required in the event of a disaster and what the restoration time requirements are is important.

- Application tiers by priority are typically used: Tier 1 most critical, Tier 2, Tier 3, etc.

Failover testing should occur regularly to train personnel on the procedures and ensure applications will work as expected.

- Reduced risk of data loss
- Enhanced data retention and recovery capabilities
- Shared storage costs
- Shared management resources

8.4.4. Implement a shared email system

Sharing an email system will reduce overhead and maintenance costs by standardizing on one solution. Consideration should be given to a cloud service to further reduce maintenance overhead and enhance security. Many options are available such as Microsoft Office 365 or Google G Suite. These systems also include document management solutions such as MS SharePoint and Google AODocs.

For GWA this is an urgent request to be resolved as there is no archiving of email assets. The email assets are simply lost forever when mail storage is exceeded, and users delete email to allow for new email activity. When employees separate from GWA, no archiving is taking place unless someone prompts IT to back up the email for the user. The greatest impact comes from vendor information on project roll off is often email to the internal resources and this includes drawing and required engineering information.

GPA	X
GWA	X

GPA/GWA Network Future Design

Recommendation 8.4 – Deploy a Shared Services Email Solution for GWA and GPA

Introduction

Audience: IT Senior Management Team

Situation: Two different email systems are in use which creates additional overhead and potential security issues.

Complication: GWA has an older POP3 email system and GPA has an on-premise Microsoft Exchange email system integrated with their Active Directory authentication directory. Neither organization has the resources to provide a more secure solution.

Question: *Would a cloud-based email solution such as Microsoft Office 365 to reduce maintenance costs, improve availability, and enable additional functionality such as document management?*

Next Steps:

- Conduct an analysis of requirements

Governing thought

Cloud-based email systems may reduce the cost of ownership, improve high availability, improve security, and improve the functionality of GWA's and GPA's email systems by reducing or eliminating the need for internal management and support of two systems. Additionally, enhanced functionality such as SharePoint for document management becomes an option.

Arguments

Supporting Concepts

Authorize a formal project, establish a Shared Services Email and Systems Administration Department, and identify technical, operational, security, and regulatory requirements

- Lack of efficient use of resources
- Lack of formal project sponsorship, resource allocation, assigned tasks, and approved scope, schedule, and budget
- Lack of defined requirements

Evaluate on-premise and cloud-based email options and choose a solution

- Lack of understanding of costs vs benefits
- Lack of understanding of which vendors can meet requirements
- Lack of consideration for time/effort required to patch and maintain systems, and HW lifecycle, licensing, etc.

Identify governance, skills, and training gaps

- Lack of resource knowledge and skills to manage and maintain AMI solution
- Lack of processes and procedures
- Lack of training materials
- Inability to share resources across organizations, if appropriate

Consider how cloud-based solutions might reduce hardware and software maintenance as well as provide additional functionality.

- Email systems require a lot of time intensive maintenance: patch management, hardware lifecycle replacement, licensing, backups and recovery.

8.4.5. Consolidate to a shared hypervisor, server, and storage solution

The lack of standardization has led to diverse solutions which must be managed and maintained resulting in higher overhead and licensing costs.

GPA	X
GWA	X

GPA/GWA Network Future Design

Recommendation 8.5 – Consolidate to a shared hypervisor, server, and storage solution

Introduction

Audience: IT Senior Management Team

Situation: IT does not have a standard solution for hypervisor, servers, and storage solutions

Complication: The lack of standardization between organizations has led to the use of multiple solutions. Each solution requires specially trained personnel for the management and maintenance of the system. Where internal support personnel don't have the required skills, engage third-parties for the maintenance and support of the system.

Question: *What can be done to reduce costs associated with hypervisor, server, and storage solutions?*

Next Steps:

- Identify standard solution for hypervisor, server, and storage

Governing thought

The use of standardized equipment and solutions organizations can reduce efforts for setup, troubleshooting, and recovery by focusing their efforts and training on a single product. Because the product is used more often personnel can become experts which reduces the need for third-party service and support over time. Additionally, it allows the organization to take advantage of volume discounts to further reduce costs.

Arguments

Supporting Concepts

Identify technical (functional) and operational (user) requirements

- Multiple solutions which fail to meet organizational needs
- Incompatible systems and solutions

Identify skills needed to support the system and system users

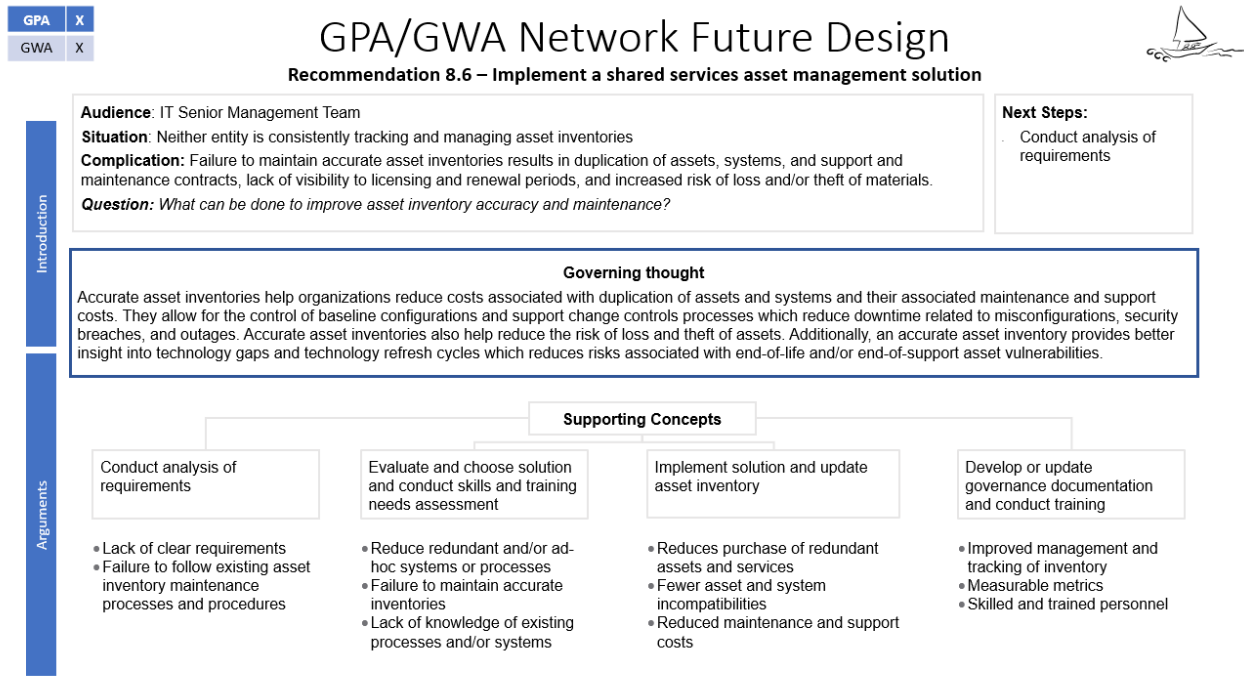
- Multiple knowledge and skills sets required to maintain solutions
- Multiple procedures to track and manage
- Multiple training modules required to support system admins and users

Chose and implement consolidated solution

- Fewer hardware, software, and system conflicts
- Fewer third-party vendors to support various systems
- Reduced troubleshooting time for help desk personnel
- Reduced administration and maintenance costs

8.4.6. Implement a shared services asset management solution

Currently neither organization does a sufficient job of managing their asset inventories. Sharing a management solution would allow both organizations to provide better tracking of their critical assets and support contracts while simplifying lifecycle management and budgeting processes for shared assets. This will also allow for integration with incident, problem, and change managements systems and enhance the tracking of systems affected by incidents and changes.

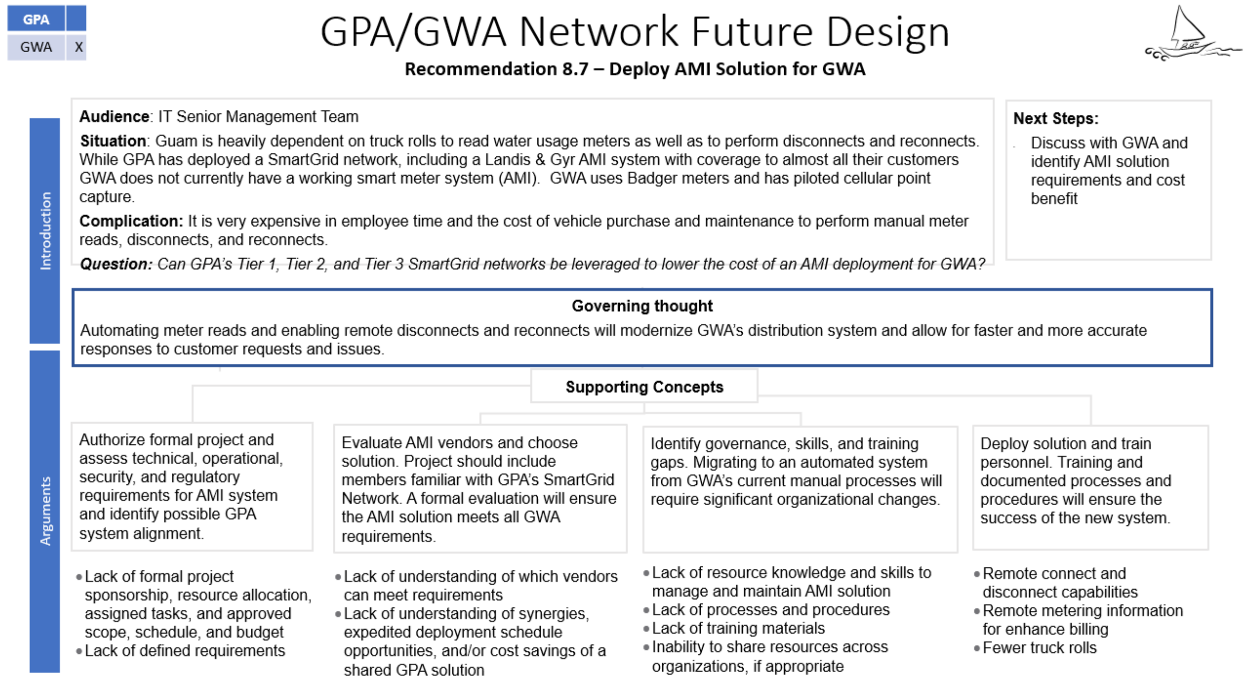


8.4.7. Deploy AMI solution for GWA

The shared services entity should consider leveraging GPA's Tier 3 Smart Grid network by deploying Landis & Gyr compatible water meters. Standardizing on one product will reduce maintenance and support costs and provide visibility into the system that is not currently supported by GWA's metering system.

Leverage of GPA's Tier 1 and Tier 2 networks will:

- Reduce the need for truck rolls
- Reduce operating costs



8.4.8. Merge customer records databases

GPA and GWA share the same customer database. Having two customer records increases the costs to maintain and manage data and necessitates the engagement of two service representatives to support one customer. Merging the databases would allow for a streamlined customer service experience by allowing customers to manage all their utility concerns at one window. This will eliminate redundant data entry efforts and reduce costs.

Consolidated billing has the following benefits:

- Enhanced Customer Service - With advanced customer notifications based on up-to-date work history, communicate issues with customers.
- One bill – You get one bill for multiple accounts.
- Generates more revenue – generate more revenue by completing more work in the same amount of time.
- Capitalized on administrative savings - Save time and money on administratively burdensome tasks: move in/move out coordination's, meter re-readings, and shut on/shut-offs.
- Easy tracking – You can track the charges across multiple accounts and download the combined cost and usage data.
- No extra fee – Identify dual accounts that are not paying - Identify which accounts are not paying so you do not lose money in the process. This also gets you to follow-up on those accounts quicker and prioritize your work where it is most valued.

GPA	X
GWA	X

GPA/GWA Network Future Design

Recommendation 8.8 – Merge customer records databases

Introduction

Audience: IT Senior Management team
Situation: GPA and GWA serve the same customer base and maintain separate records
Complication: Use of two customer records increases the costs to maintain and manage data and necessitates the engagement of two service representatives or double entry to support one customer
Question: *What advantages would be provided by creating and maintaining one set of customer records?*

Next Steps:
Initiate project to analyze the merging customer records

Governing thought

Maintenance of two records databases increases storage capacity requirements, hardware requirements, and associated personnel to manage and support two records databases, hardware, and software. Having two records also negatively impacts customer experience by the need for them to wait in two separate queues or provide the same information twice to address payments and billing issues.

Supporting Concepts

Arguments

Initiate project to merge customer records. Support by senior management will ensure the project's success. Customer One Initiative	A shared services customer service department will allow the customers to resolve both power and water issues with one point of contact. This saves both customer and GPA/GWA time.	Reduces duplicate data entry.	Update governance documents and training materials. Both GWA and GPA should be operating from the same governance documentation.
• Lack of formal project sponsorship, resource allocation, assigned tasks, and approved scope, schedule, and budget	• Currently customers have to visit separate customer representatives for GWA and GPA.	• Enter or update customer information in the database only once for both GWA and GPA.	• Duplicate procedures • Duplicate training materials

8.4.9. Merge customer records databases

GPA	X
GWA	X

GPA/GWA Network Future Design

Recommendation 8.9 – Electronic Reporting and Invoicing

Introduction

Audience: IT Senior Management team
Situation: GPA and GWA lack an electronic reporting and invoicing system
Complication: A way to save money by creating a process to digitize invoices and provider OnDemand customer information
Question: *is it important to for a utility to convert traditional billing and payment customers to a paperless, automated with in-depth reporting solution.*

Next Steps:
Consider the customer first when deploying the system.
Consider fully-outsourced and hosted solutions to simplify PCI Compliance

Governing thought

it is important for utility companies to get on board with (and convert their customers to) paperless billing and electronic payments. Utility companies can no longer follow the status quo. At the very least, you must start planning for this conversion now. If done thoughtfully, the benefits will surely outweigh any assumed risks such as cost or the seemingly insurmountable task of implementing it. Those who delay will face an uphill battle.

Supporting Concepts

Arguments

Printing and Postage rates increasing, the U.S. Postal Service considering massive reductions in service, and more and more customers turning to web and mobile apps to conduct business	Automated Statement Printing and Mailing Services	Provide a useful electronic bill-pay-communication solution run the potential of losing money and harming customer relationships	Time and manpower to produce manual billing and reporting
• Cost-efficiency • Improved customer service • Inform customers about rebates and incentives • Communicate resource-saving technologies and practices • Drive customers to your website for more information or online bill pay	• Gives you better control over the statement document processing thanks to real-time notifications and constant updates. • Tracks consumer response to critical documents thanks to the integration with customer analytics tools.	• Make the move to paperless easy and offer more features. • Apprehension that no longer receiving a paper bill could increase the likelihood that they'll inadvertently miss a bill and/or payment • Announce regulated initiatives, mandates or rate changes	• Ability to focus on your business • Regulatory compliance • A monthly billing statement can become more than just a boring transactional document. • Encourage participation in new efficiency programs

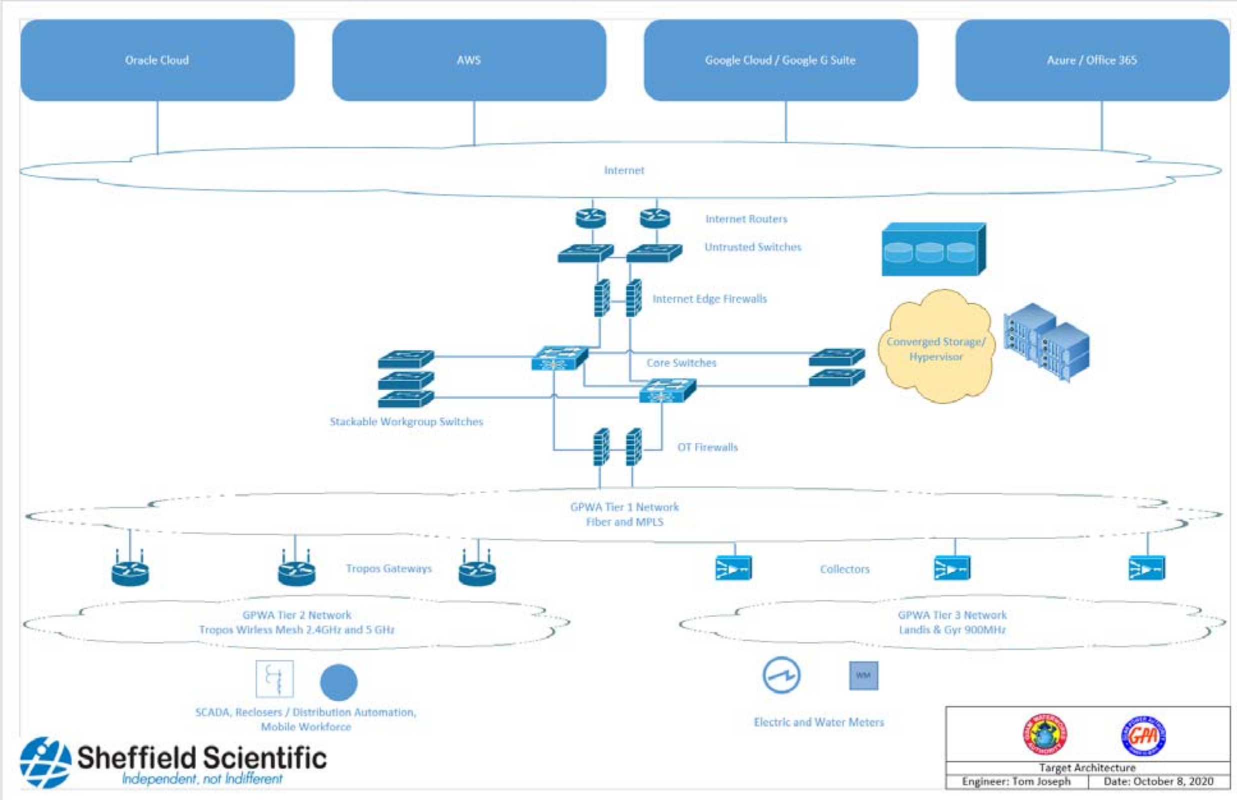


Figure 7-1: Target Network Architecture

9. Cost Benefit Analysis

9.1. Analysis Approach

The recommendations produced from the IT Integration Study analysis have evolved into the creation of projects or initiatives that will produce costs and benefits related to a shared services IT organization or the joint use of technology within GPA and GWA. This cost benefit has been prepared using the information collected to provide at least a solid understanding of the financial impacts and benefits for Fiscal Years 2021 to 2025. This analysis has been segregated into cost categories of Capital and Operations & Maintenance (O&M) but will need to validate with accounting principles from each authority.

9.2. Cost Benefit Analysis (CBA) Summary

A CBA it is a method for decision-making that is based on comparing a detailed analysis of costs to a detailed analysis of expected benefits and adjusting for the future value of the money spent and any variables that might occur along the way. In other words, it is an educated guess.

The execution of the projects coming out of the IT Integration Study & Plan Roadmap which includes the formation of the IT Shared Services Team reflect a positive benefit versus cost projection across GPA and GWA. The cost-benefit analysis tool was developed was used to analyze CBA decisions. The process was used to sum the benefit of a situation or action and then subtracts the costs associated with taking that action. The cost-benefit analysis is an exercise to compare the costs and benefits of a given decision, where both are expressed in monetary units.

Inputs included:

- Costs including those of implementing and maintaining an intervention.
- Benefits including those resulting from an intervention, such as Information Technology (IT) and Operational Technology (OT) costs averted, productivity gains, and the monetized value of shared service organization improvements.

The Benefits are classified into two categories:
1) Cost Avoidance and
2) Process Efficiency & Effectiveness.

Shared Services Organization are attractive because they hold the potential for:

- Digitization and new business models have a positive influence on the service organization
- Process automation are optimized through a shared service operation
- Faster decision making, more informed policy making, more effective workforce management and improved resource alignment with company’s mission goals
- Improved servicing ration/response times, reduced cycle times and improved automated reporting
- Reduced duplicative software/hardware/operations/labor resources
- Increased interactivity with constituents including improved communication and responsiveness
- Enhanced quality, timeliness, accuracy, and consistency

The execution of the projects and organizational restructure coming out of the IT Integration Plan Roadmap, including the formation of the IT Shared Services team will driver key benefits for the GWA and GPA. This will be accomplished through technology innovation projects identified in the roadmap combined with process effectiveness and efficiencies (15%) in IT through best practices and methodologies as part of the deployment.

The cost-benefit analysis finds, quantifies, and adds all the positive factors for improvements through the consolidation of infrastructure and organizational responsibilities and provides the basis of the cumulative cost versus savings curve presented in Figure 9-1.

	2021	2022	2023	2024	2025
Total Costs	**$37,500**	**$3,317,080**	**$1,535,380**	**$1,350,700**	**$914,700**
Capital Costs:	$ 37,500	$ 1,616,100	$ 620,680	$ 436,000	$ -
O&M Costs:	$0	$1,700,980	$914,700	$914,700	$914,700
Total Savings	**$81,120**	**$1,178,324**	**$2,346,584**	**$2,126,444**	**$2,311,304**
Capital Savings:	$ 81,120	$ 698,880	$ 1,469,060	$ 1,340,040	$ 1,529,900
O&M Savings:	$0	$479,444	$877,524	$786,404	$781,404
Cummulative Costs:	$37,500	$3,354,580	$4,889,960	$6,240,660	$7,155,360
Cummulative Savings:	$81,120	$1,259,444	$3,606,028	$5,732,472	$8,043,776
Costs vs. Savings:	**$43,620**	**-$2,095,136**	**-$1,283,932**	**-$508,188**	**$888,416**

* Savings are currently based on an average between conservative and aggressive savings for a GPWA IT organization

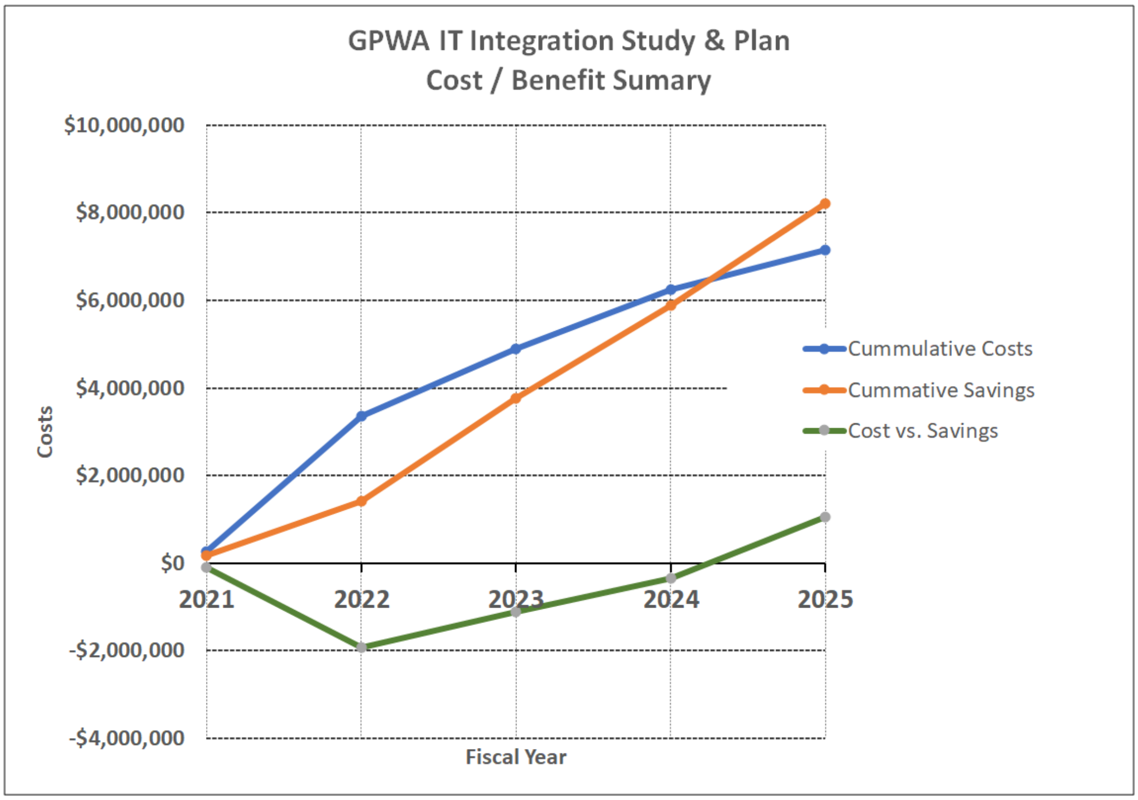


Figure 9-1: Cost versus Saving

Key Assumptions for the cost benefit include:

1. Number of work hours per year assumes 52 weeks in a year, 5 days in a week, and 8 hours in a day (2080 hours per year). Vacation and training days are not subtracted since this will be used with loaded rates.
2. Standard Hourly billing rate for savings was $39 hour based on GWA and GPA average burdened rates for IT.
3. FY2021 dollar basis with no escalation used in analysis
4. Fiscal Year (FY) - October 1 - September 30, 20XX
5. Use $39 USD per hour burden rate for GPWA in cost and savings
6. All capital projects to be completed by FY2023

7. Recommendation 8.7 for the GWA AMI Project is represented with $4.5 mil in cost and savings in FY2023. Further detailed analysis is underway by Brown & Caldwell related to cost of service.
8. Alignment with FY2022 IT budgets still needs to be completed with GWA and GPA. Minimal progress was accomplished in FY2021 due to the JD Edwards – Enterprise One projects in GWA and GPA.

Implementation and ‘roll-out’ of the Shared Services Unit is forecasted to take approximately 3 years if funding is approved. The timeline assumes a phased implementation approach starting with consolidation of GPA & GWA IT divisions and IT physical infrastructure to a co-location facility area and reorganizing resources. Shared service delivery of IT infrastructure is expected to deliver positive financial benefits and qualitative benefits within approximately 32 months of project start.

9.3. Cost Summary

The cost summary table (Figure 9-2) provides the individual recommended project estimated costs based on analysis. Some projects need additional information to confirm total costs for the project. Details of the cost summary can be referenced in Appendix H.

GPWA Integration Study & Plan
Business Case Data
Costs

	Work Breakdown By Recommendation Project		Cost	Fiscal Year					Total Cost
	ID	Description	Category	2021	2022	2023	2024	2025	
Capital			Capital Expenditure:	$ 37,500	$ 1,616,100	$ 620,680	$ 436,000	$ -	$ 2,710,280
	4.4	Recommendation 4 – Move towards a shared Internet edge utilizing next generation firewalls	Capital	$ -	$ 60,000	$ 72,400	$ -	$ -	$ 132,400
	4.5	Recommendation 5 – Share network infrastructure	Capital	$ -	$ 91,500	$ -	$ -	$ -	$ 91,500
	4.6	Recommendation 6 – Configure GWA SSIDs on Headquarters Wireless Infrastructure	Capital	$ -	$ 40,000	$ -	$ -	$ -	$ 40,000
	4.7	Recommendation 7 – Expand GPA's SolarWinds Orion installation and Splunk SIEM	Capital	$ -	$ 88,920	$ -	$ -	$ -	$ 88,920
	4.8	Recommendation 8 – Complete Northern Fiber Ring Project	Capital	$ 37,500	$ -	$ -	$ -	$ -	$ 37,500
	4.9	Recommendation 9 – Complete Buildout of Disaster Recovery Site	Capital	$ -	$ 100,000	$ 225,800	$ -	$ -	$ 325,800
	4.10	Recommendation 10 – Implement Multi-Factor Authentication for Remote Access	Capital	$ -	$ 46,600	$ -	$ -	$ -	$ 46,600
	5.4	Recommendation 4 – Develop Governance Policies	Capital	$ -	$ 74,000	$ -	$ -	$ -	$ 74,000
	5.5	Recommendation 5 – Develop Supporting Governance Documentation	Capital	$ -	$ 16,000	$ -	$ -	$ -	$ 16,000
	6.1	Recommendation 1 – Complete the shared SCADA system deployment	Capital	$ -	$ 200,000	$ -	$ -	$ -	$ 200,000
	6.2	Recommendation 2 – Renew support for GIS Solution for GWA	Capital	$ -	$ 25,000	$ -	$ -	$ -	$ 25,000
	6.3	Recommendation 3 – Configure and Use ChangeGear for Change Management	Capital	$ -	$ 37,960	$ -	$ -	$ -	$ 37,960
	6.4	Recommendation 4 – Use Ticketing System	Capital	$ -	$ 45,280	$ -	$ -	**$ -**	**$ 45,280**
	6.5	Recommendation 5 – Implement a shared services document management solution	Capital	$ -	$ 478,000	$ -	$ -	$ -	$ 478,000
	6.6	Recommendation 6 – Continue to Implement a Joint Mobile Workforce Management (MMW) system that includes a robust network and set of devices.	Capital	$ -	$ -	$ 35,800	$ -	$ -	$ 35,800
	6.7	Recommendation 7 – Implement Customer Care & Billing (CC&B) Application Management Centeralized Administration	Capital	$ -	$ -	$ 45,400	$ -	$ -	$ 45,400
	6.8	Recommendation 8 – Customer Service Web Applications Development, Support and Maintenance	Capital	$ -	$ -	$ 96,000	$ -	$ -	$ 96,000
	6.9	Recommendation 9 – Shared ERP environment with JD Edwards	Capital	$ -	$ -	$ -	$ 200,000	$ -	$ 200,000
	8.2	Recommendation 2 – Deploy a Shared Services Ticketing and Change Management System	Capital	$ -	$ 78,280	$ -	$ -	$ -	$ 78,280
	8.3	Recommendation 3 – Share disaster recovery capabilities and move backups to a remote data center	Capital	$ -	$ 75,000	$ -	$ -	$ -	$ 75,000
	8.4	Recommendation 4 – Deploy a Shared Services Email Solution for GWA and GPA	Capital	$ -	$ 44,000	$ -	$ -	$ -	$ 44,000
	8.5	Recommendation 5 – Consolidate to a shared virtual environment	Capital	$ -	$ -	$ 45,280	$ -	$ -	$ 45,280
	8.6	Recommendation 6 – Implement asset and inventory management tool	Capital	$ -	$ 115,560	$ -	$ -	$ -	$ 115,560
	8.7	Recommendation 7 – Deploy AMI Solution for GWA	Capital	$ -	$ -	$ 100,000	$ -	$ -	$ 100,000
	8.8	Recommendation 8 – Merge customer records databases	Capital	$ -	$ -	$ -	$ 118,000	$ -	$ 118,000
	8.9	Recommendation 9 – Electronic Reporting and Invoicing	Capital	**$ -**	**$ -**	$ -	$ 118,000	$ -	$ 118,000
O&M			O&M Expenditure:	$ -	$ 1,700,980	$ 914,700	$ 914,700	$ 914,700	$ 4,445,080
	4.1	Recommendation 1 – Update and maintain a set of infrastructure and data flow diagrams	O&M	$ -	$ 24,000	$ 6,000	$ 6,000	$ 6,000	$ 42,000
	4.2	Recommendation 2 – Budget for and replace end-of-life assets and expiring maintenance and service contracts	O&M	$ -	$ 12,500	$ -	$ -	$ -	$ 12,500
	4.3	Recommendation 3 – Maintain hypervisor, server, and storage solution	O&M	$ -	$ 25,000	$ 5,000	$ 5,000	$ 5,000	$ 40,000
	5.1	Recommendation 1 – Develop governance program	O&M	$ -	$ 50,000	$ -	$ -	$ -	$ 50,000
	5.2	Recommendation 2 – Review and approve baseline control set	O&M	$ -	$ 24,000	$ -	$ -	$ -	$ 24,000
	5.3	Recommendation 3 – Perform a risk assessment	O&M	$ -	$ 34,000	$ 26,000	$ 26,000	$ 26,000	$ 112,000
	5.6	Recommendation 6 – Enforce Change Control and Configuration Management Processes	O&M	$ -	$ 16,000	$ -	$ -	$ -	$ 16,000
	5.7	Recommendation 7 – Manage Unified Control Framework, Technical Controls Gap Assessment Workbook, and Operational Calendar	O&M	$ -	$ 24,000	$ -	$ -	$ -	$ 24,000
	7.1	Recommendation 1 – Establish an Updated Governance for IT Management Duties and Operations	O&M	$ -	$ 303,000	$ -	$ -	$ -	$ 303,000
	7.2	Recommendation 2 - Establish Program / Project and Organizational Change Methodologies supporting IT Projects	O&M	$ -	$ 462,000	$ -	$ -	$ -	$ 462,000
	7.3	Recommendation 3 – Develop and approve a combined GPWA IT Shared Services Organizational Structure	O&M	$ -	$ 681,200	$ 877,700	$ 877,700	$ 877,700	$ 3,314,300
	8.1	Recommendation 1 – Shared Network Infrastructure Vendors	O&M	$ -	$ 45,280	$ -	$ -	$ -	$ 45,280

Figure 9-2: Cost Summary for Recommended Projects

9.4. Savings / Benefits Summary

The benefit summary table (Figure 9-3) provides by individual recommended projects the logic and estimated benefits in either cost avoidance or Process Efficiency & Effectiveness costs based on the analysis. For some projects additional information is needed to confirm total benefit logic and costs with GPA and GWA. Details of the benefits summary are referenced in Appendix H.

GPWA Integration Study & Plan
Business Case Data
Benefits

	Work Breakdown By Recommendation Project		Cost	Savings Category	Fiscal Year					Total Cost Savings
	ID	Description	Category		2021	2022	2023	2024	2025	
Capital					$ 81,120	$ 698,880	$ 1,469,060	$ 1,340,040	$ 1,529,900	$ 5,119,000
Capital	4.4	Recommendation 4 – Move towards a shared Internet edge utilizing next generation firewalls	Capital	Cost Avoidance	$ -	$ 20,280	$ 40,560	$ 10,140	$ -	$ 70,980
Capital	4.5	Recommendation 5 – Share network infrastructure	Capital	Cost Avoidance	$ -	$ 60,840	$ 121,680	$ 121,680	$ 121,680	$ 425,880
Capital	4.6	Recommendation 6 – Configure GWA SSIDs on Headquarters Wireless Infrastructure	Capital	Process Efficiency & Effectiveness	$ -	$ 20,280	$ 40,560	$ 40,560	$ 40,560	$ 141,960
Capital	4.7	Recommendation 7 – Expand GPA's SolarWinds Orion installation and Splunk SIEM	Capital	Process Efficiency & Effectiveness	$ -	$ 20,280	$ 40,560	$ 40,560	$ 40,560	$ 141,960
Capital	4.8	Recommendation 8 – Complete Northern Fiber Ring Project	Capital	Process Efficiency & Effectiveness	$ 81,120	$ 162,240	$ 40,560	$ 40,560	$ 40,560	$ 365,040
Capital	4.9	Recommendation 9 – Complete Buildout of Disaster Recovery Site	Capital	Cost Avoidance	$ -	$ 187,200	$ 187,200	$ 187,200	$ 187,200	$ 748,800
Capital	4.10	Recommendation 10 – Implement Multi-Factor Authentication for Remote Access	Capital	Cost Avoidance	$ -	$ 93,600	$ 93,600	$ 93,600	$ 93,600	$ 374,400
Capital	5.4	Recommendation 4 – Develop Governance Policies	Capital	Process Efficiency & Effectiveness	$ -	$ 10,140	$ 10,140	$ 10,140	$ 10,140	$ 40,560
Capital	5.5	Recommendation 5 – Develop Supporting Governance Documentation	Capital	Process Efficiency & Effectiveness	$ -	$ 10,140	$ 10,140	$ 10,140	$ 10,140	$ 40,560
Capital	6.1	Recommendation 1 – Complete the shared SCADA system deployment	Capital	Process Efficiency & Effectiveness	$ -	$ 81,120	$ 162,240	$ 162,240	$ 162,240	$ 567,840
Capital	6.2	Recommendation 2 – Renew support for GIS Solution for GWA	Capital	Process Efficiency & Effectiveness	$ -	$ 2,340	$ 2,340	$ 2,340	$ 2,340	$ 9,360
Capital	6.3	Recommendation 3 – Configure and Use ChangeGear for Change Management	Capital	Process Efficiency & Effectiveness	$ -	$ 10,140	$ 20,280	$ 20,280	$ 20,280	$ 70,980
Capital	6.4	Recommendation 4 – Use Ticketing System	Capital	Process Efficiency & Effectiveness	$ -	$ 10,140	$ 20,280	$ 20,280	$ 20,280	$ 70,980
Capital	6.5	Recommendation 5 – Implement a shared services document management solution	Capital	Process Efficiency & Effectiveness	$ -	$ -	$ 81,120	$ 162,240	$ 162,240	$ 405,600
Capital	6.6	Recommendation 6 – Continue to Implement a Joint Mobile Workforce Management (MMW) system that includes a robust network and set of devices.	Capital	Process Efficiency & Effectiveness	$ -	$ 10,140	$ 20,280	$ 20,280	$ 20,280	$ 70,980
Capital	6.7	Recommendation 7 – Implement Customer Care & Billing (CC&B) Application Management Centeralized Administration	Capital	Process Efficiency & Effectiveness	$ -	$ -	$ 10,140	$ 20,280	$ 20,280	$ 50,700
Capital	6.8	Recommendation 8 – Customer Service Web Applications Development, Support and Maintenance	Capital	Process Efficiency & Effectiveness	$ -	$ -	$ 10,140	$ 20,280	$ 20,280	$ 50,700
Capital	6.9	Recommendation 9 – Shared ERP environment with JD Edwards	Capital	Process Efficiency & Effectiveness	$ -	$ -	$ 200,000	$ -	$ 200,000	$ 400,000
Capital	8.2	Recommendation 2 – Deploy a Shared Services Ticketing and Change Management System	Capital	Process Efficiency & Effectiveness	$ -	$ -	$ 40,560	$ 40,560	$ 40,560	$ 121,680
Capital	8.3	Recommendation 3 – Share disaster recovery capabilities and move backups to a remote data center	Capital	Cost Avoidance	$ -	$ -	$ 93,600	$ 93,600	$ 93,600	$ 280,800
Capital	8.4	Recommendation 4 – Deploy a Shared Services Email Solution for GWA and GPA	Capital	Process Efficiency & Effectiveness	$ -	$ -	$ 60,840	$ 60,840	$ 60,840	$ 182,520
Capital	8.5	Recommendation 5 – Consolidate to a shared virtual environment	Capital	Process Efficiency & Effectiveness	$ -	$ -	$ 20,280	$ 20,280	$ 20,280	$ 60,840
Capital	8.6	Recommendation 6 – Implement asset and inventory management tool	Capital	Process Efficiency & Effectiveness	$ -	$ -	$ 20,280	$ 20,280	$ 20,280	$ 60,840
Capital	8.7	Recommendation 7 – Deploy AMI Solution for GWA	Capital	Process Efficiency & Effectiveness	$ -	$ -	$ -	$ -	$ -	$ -
Capital	8.8	Recommendation 8 – Merge customer records databases	Capital	Process Efficiency & Effectiveness	$ -	$ -	$ 60,840	$ 60,840	$ 60,840	$ 182,520
Capital	8.9	Recommendation 9 – Electronic Reporting and Invoicing	Capital	Process Efficiency & Effectiveness	$ -	$ -	$ 60,840	$ 60,840	$ 60,840	$ 182,520
O&M				O&M Cost Savings:	$ -	$ 479,444	$ 877,524	$ 786,404	$ 781,404	$ 2,924,776
O&M	4.1	Recommendation 1 – Update and maintain a set of infrastructure and data flow diagrams	O&M	Process Efficiency & Effectiveness	$ -	$ 20,280	$ 40,560	$ 20,280	$ 20,280	$ 101,400
O&M	4.2	Recommendation 2 – Budget for and replace end-of-life assets and expiring maintenance and service contracts	O&M	Cost Avoidance	$ -	$ 35,000	$ 15,000	$ 5,000	$ -	$ 55,000
O&M	4.3	Recommendation 3 – Maintain hypervisor, server, and storage solution	O&M	Cost Avoidance	$ -	$ 40,560	$ 81,120	$ 20,280	$ 20,280	$ 162,240
O&M	5.1	Recommendation 1 – Develop governance program	O&M	Process Efficiency & Effectiveness	$ -	$ 20,280	$ 20,280	$ 20,280	$ 20,280	$ 81,120
O&M	5.2	Recommendation 2 – Review and approve baseline control set	O&M	Process Efficiency & Effectiveness	$ -	$ 20,280	$ 20,280	$ 20,280	$ 20,280	$ 81,120
O&M	5.3	Recommendation 3 – Perform a risk assessment	O&M	Cost Avoidance	$ -	$ 20,280	$ 20,280	$ 20,280	$ 20,280	$ 81,120
O&M	5.6	Recommendation 6 – Enforce Change Control and Configuration Management Processes	O&M	Process Efficiency & Effectiveness	$ -	$ 93,600	$ 187,200	$ 187,200	$ 187,200	$ 655,200
O&M	5.7	Recommendation 7 – Manage Unified Control Framework, Technical Controls Gap Assessment Workbook, and Operational Calendar	O&M	Process Efficiency & Effectiveness	$ -	$ 10,140	$ 10,140	$ 10,140	$ 10,140	$ 40,560
O&M	7.1	Recommendation 1 – Establish an Updated Governance for IT Management Duties and Operations	O&M							$ -
O&M	7.2	Recommendation 2 - Establish Program / Project and Organizational Change Methodologies supporting IT Projects	O&M							$ -
O&M	7.3	Recommendation 3 – Develop and approve a combined GPWA IT Shared Services Organizational Structure	O&M	Process Efficiency & Effectiveness	$ -	$ 219,024	$ 462,384	$ 462,384	$ 462,384	$ 1,606,176
O&M	8.1	Recommendation 1 – Shared Network Infrastructure Vendors	O&M	Process Efficiency & Effectiveness	$ -	$ -	$ 20,280	$ 20,280	$ 20,280	$ 60,840

Figure 9-3: Benefits Summary for Recommended Projects

9.5. IT Shared Services Organization Cost and Benefits Discussion

The creation of the IT Shared Services organization is identified in Recommendations 7.1 – 7.3 as part of the study. The formation of this group will encompass the merger of the GPA and GWA IT groups into a common entity that will utilize best practices in providing IT services to GPA and GWA. Key tasks as they related to costs and benefits are reflected as:

- The formation of new job roles in the Chief Information Officer (CIO), Program / Project Manager and the Cyber Security Manager. All three roles are deficiencies in the current organization and will contribute to the overall success of the IT Shared Service organization. The CIO and Business Service Manager can be filled with the reclassification of a current IT positions. The Program / Project Manager and the Cyber Security Manager will have to be defined and filled with either internal or external placement.

- Other roles from the current organization have either identified New Positions or have Vacant positions to be filled but are on hold for placement. The merger of the IT groups provides an opportunity for his will be accomplished through technology innovation projects identified in the roadmap combined with process effectiveness and efficiencies (15%) in IT through best practices and methodologies as part of the deployment. We are proposing that jobs be filled in phased approach based on the budget process and human resource policy but there should be a sense of immediacy to achieve the immediate stand-up formation at the beginning of Q1 / FY2022.

Position Number Summary

Postion Type	Org	Current State	Stand-up	FY2022	FY2023
FTE					
	GPA	17	17	17	17
	GWA	9	9	9	9
Vacant					
	GPA	0	0	0	0
	GWA	1	1	1	1
New Positions					
	GPA	0	6	6	6
	GWA	0	3	3	3
	GPWA	0	0	2	2
Total Headcount:		**27**	**36**	**38**	**38**

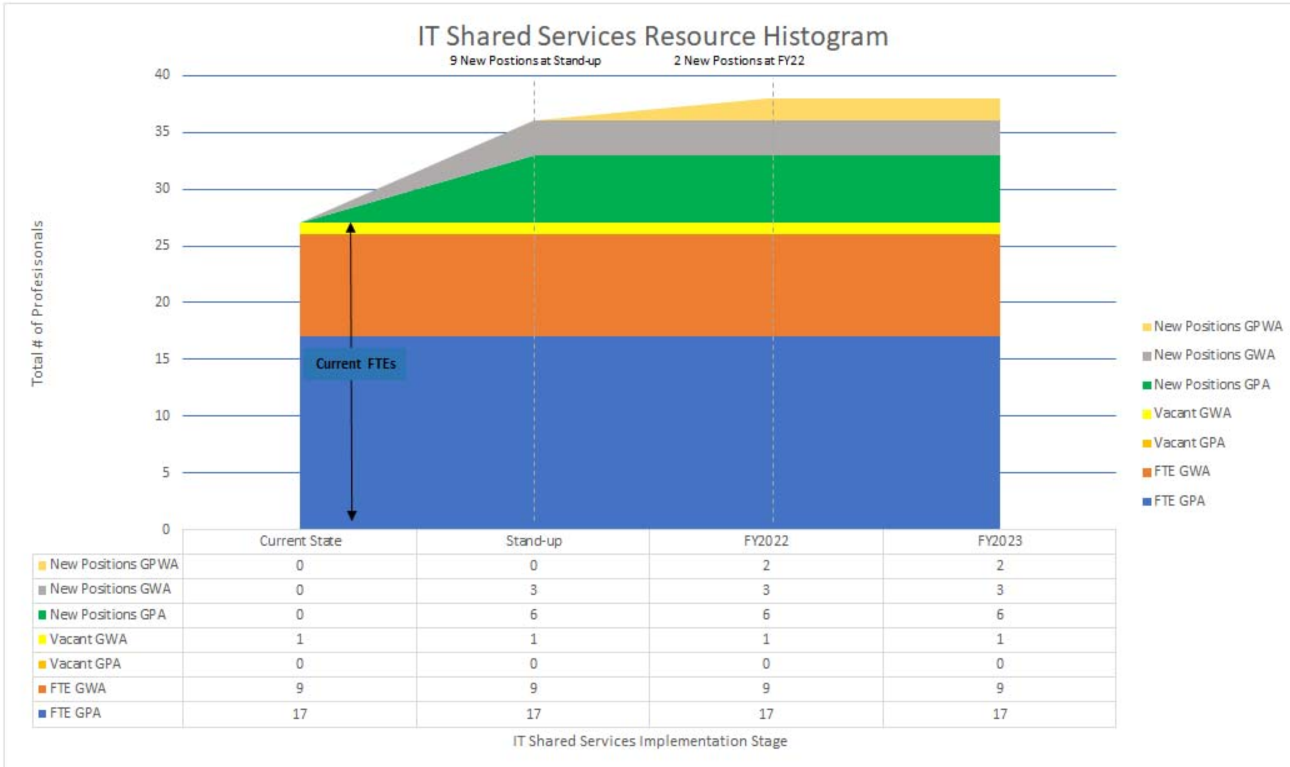
New Positons:

GPA: Infrastructure Support Supervisor
Programmer
OT Integration Supervisor
Network Adminstrator
Systems Administrator
Application Support Supervior

GWA: Mobile Workforce Management Analyst
Business Systems Analyst
Document Management Specialist

GPWA: Cyber Security Manager (FY22)
Program / Project Manager (FY22)

Figure 9-4: Position by Time Event



	Current State	Stand-up	FY2022	FY2023
New Positions GPWA	0	0	2	2
New Positions GWA	0	3	3	3
New Positions GPA	0	6	6	6
Vacant GWA	1	1	1	1
Vacant GPA	0	0	0	0
FTE GWA	9	9	9	9
FTE GPA	17	17	17	17

Figure 9-5: Position for IT Shared Services Salary Estimates by Time Event

10. Master Roadmap

A master roadmap is essential for organizational change. It is a statement of intent and direction that helps ensure that transformational processes are successful by providing the vision and focus necessary to ensure that changes in the business ecosystems of people, process, and technology do not divert attention from their primary goals and objectives.

10.1. Understanding the Roadmap

The following road mapping process model identifies the progression of phases which are necessary for successful business transformation and organizational change. The GPA / GWA IT Integration Study & Plan project supported the objectives of the preliminary Phase of assessment and diagnosis of organizational needs and roadblocks to the successful implementation of a combined IT/OT shared services organization.

The information gathered during this project is the foundation for the master roadmap developed by Sheffield Scientific to support Guam's endeavors to complete the road mapping process and final implementation of the shared services organization. The master roadmap provides the "actionable tasks" with details necessary to ensure the successful completion of the development and follow-up phases of the process which are identified in Figure 9 – 1.

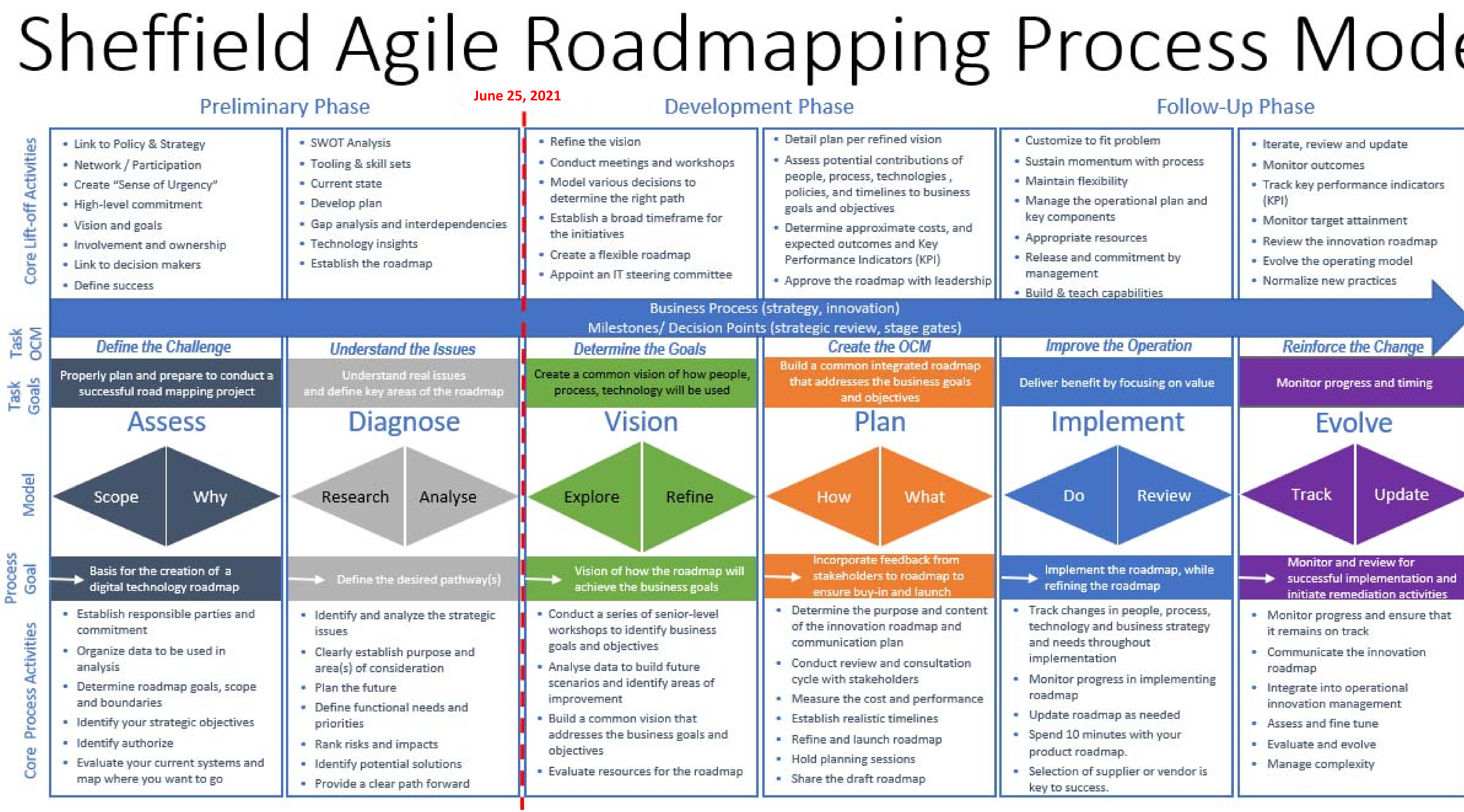


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Figure 9 – 1: Roadmap Lifecycle Methodology

10.2. Master Roadmap Plan

This actionable Master Roadmap Plan provides guidance for the preparation and implementation of a Shared Services Organization Project Master Roadmap Plan (PMRP) and the level of actionable detail required to develop the Integration Master Schedule (IMS). The PMRP and IMS are fundamental management tools that are critical to performing effective planning, scheduling, and execution of work efforts. The PMRP and IMS are to document planning assumptions and decisions, facilitate communication among project stakeholders, and document approved scope, cost, and schedule baselines. This is used to achieve Operational Excellence by guiding and providing the right information to the right people at the right time to make the right decisions at the right level without having to get directions from management.

- Master Roadmap Plan (MRP) is event-based roadmap plan, contractual document, and relatively top level mapped to all recommendations as presented in the Executive Summary of this report.
- Integration Master Schedule (IMS) is a task and calendar-based schedule, not contractually binding, that includes the level of detail necessary for day-to-day execution.

Phase #	Phase Name	Roadmap Key Activities	1. Project Management	2. OCM	3. People	4. Process	5. Technology
Phase 1	Vision	· Develop IT Vision, Mission and Values • Determine What Success Looks Like • Determine Why the Organization needs to Change • Establish Executive Sponsorship	• Determine activity sets and timing based on mission, success criteria and organizational change items	• Define success • Identify Key Senior Stakeholders and affected operational groups	• Establish Executive Sponsorship • Clarify Displaced personnel options	• Develop your IT Vision, Mission, and Values • Identify Process categories to be analyzed.	• Identify technology consideration/topics for analysis
Phase 2	Analyze	· Identify processes to be incorporated to Shared Services · Define the technology to be used · Assess the location of the Shared Services Organization · Agree upon most appropriate solutions • Determine Go No-Go decision criteria • Assess business risk • Identify Baseline Costs • Determine Measures of Success • Develop Organizational Change Management Strategy • Assess Business Risk • Determine Measure of Success	• Assess the location of the Shared Services Organization • Determine Go No-Go decision criteria • Assess business risk • Identify baseline costs	• Agree upon most appropriate solutions • Assign a champion • Determine Measures of Success • Organizational Benefit Analysis • Identification of Organizational Change Key Messages • Create Awareness of the Changes to Come (What & Why)	• Identification & Engagement of Stakeholders • Employee Impact analysis • Assign a Champion	• Identify Potential Shared Services process evaluation criteria • Apply criteria to candidate processes • Develop future state policy	• Identify the technology evaluation criteria to be used • Determine Technology Baseline
Phase 3	Design	· Build a detailed picture and integrated Project Plan: o What the future processes will be o What will be done by whom o Where it will be done o How it will be done · Detailed Technology Design o Capability requirements o Software selection o Hardware selection o Infrastructure design	• Build a detailed picture and Integration Study Project Plan • Determine Resource Requirements o People o Equipment o Facilities o Timing	• Clarify relationships with internal business unit customers, stakeholders, and IT departments • Create a sense of urgency to change • Key Messages by Organizational Area	• Staffing Requirements • Roles/Qualifications • Design Personnel Performance Measurements • Develop career paths for the organization	• What the future processes will be • What will be done by whom • Where it will be done • How it will be done • Develop Policy Framework • Determine and define work controls	• Detailed Technology Design o Capability requirements o Software selection o Hardware selection o Infrastructure design

Phase #	Phase Name	Roadmap Key Activities	1. Project Management	2. OCM	3. People	4. Process	5. Technology
		o Security requirements • Clarify relationships with internal business unit customers, stakeholders, and IT departments	• Integration of Process Design	• Engagement of Thought Leaders • Training Plan • Personnel Impact Mitigation • Create Desire for Change (How it will help) • Define Measures of Organizational Success • Assess Effectiveness of Communications • Monitor and address concerns/objections	• Develop recruiting strategies and staffing approaches • Develop Detailed Job Descriptions		o Security requirements • Design Technology Performance Measurements • Develop and address Service Level Agreements
Phase 4	Build & Test	• Close Integration of Process Design • Technology Tools Installation • Training of key current users on support of Shared Services processes & Tools • Creation of policy and procedure documentation • Creation of User Guides & Training Materials • Implementation of New Job Descriptions • Training of new employees on processes and technology	• Detailed Build and Test Plan • Establish and Maintain monitoring of project activities • Conduct tests and adjust per test results • Create Implementation Task Plan	• Create an understanding of how work will be done • Create confidence and anticipation for the new model • Promote the changes	• Begin transition training • Develop new work skills • Test new processes and perfect for roll out • Develop operational procedures within process framework • Test and adjust as needed • Review and revise job descriptions per test results	• Begin policy and controls transition with controls testing • Monitor policy testing and make refinements per control test results • Conduct process testing	• Perform System Testing • Perform User Acceptance Testing • Perform Performance Testing • Adjust per test results • Create & Update Technical Documentation
Phase 5	Implement & Roll Out	• Confirm process and technology solutions function as intended • Confirm Business is in a ready state to transition • Migration is managed and controlled • Phased Implementation • Knowledge transfer to the new shared services organization • Allocation of performing resources	• Execute Implementation Workplan • Monitor results and adjust as needed • Document Lessons Learned • Create and manage enhancement requests	• Activate the change (execute the new methods) • Provide coaching as needed to make the changes work • Encourage feedback • Identify refinements	• Transition personnel to new roles • Provide support to create success • Monitor and respond to operational feedback	• Monitor controls and address results • Provide clarification and adjust as operating results warrant	• Monitor HW & SW performance • Perform Tuning • Manage SLAs

Phase #	Phase Name	Roadmap Key Activities	1. Project Management	2. OCM	3. People	4. Process	5. Technology
		• Monitor Results based KPIs (Key Performance Indicators)		• Acknowledge and celebrate success			
Phase 6	Optimize	• Optimize working practices • Stabilize shared services organization • Build strong relationship between the shared services organization and business partner relationships • Embed a culture of continuous improvement • Reevaluate roles and responsibilities and adjust as necessary	• Upgrade systems as necessary for continued support of the shared services organization • Share Improvements	• Make the changes stick • Make the new way the new normal • Reward New Behaviors • Encourage New Ideas	• Manage and adjust workload as warranted	• Monitor Vision realization • Identify additional opportunities to expand the new model	• Monitor new technology to enhance and improve solution vibrancy • Identify and create improvement to SLAs

Figure 9-2: Project Plan Roadmap with Functions

10.3. Roadmap Recommendation Project Transformation Sheets

The process of identifying the recommendations is a key part of the IT Integration Study & Plan but transforming the recommendations into actionable tasks or projects is critical in making the study “real” for GWA and GWA. This section provides the individual work sheets, per recommendation, of the scope, objectives, work plan, risks, and benefit discussion for each recommendation. Supporting details are also connected in the Executive Summary Roadmap Chart and in Section 8 – Cost Benefit.

GPA/GWA Network Infrastructure

Roadmap Recommendation 4.1 – Continue to update and maintain a set of infrastructure and data flow diagrams

A. Recommendation Scope and Objective

Objectives in Order of Impact:
- Establish network change control processes
- Update network and data flow diagrams upon and add, change or remove

Recommendation Scope:
- GPA and GWA networking equipment
- GPA and GWA critical applications

B. Approach/Work Plan

- Work with governance team to document and implement change control processes
- Agreed upon Design Template and Diagram Guide
- Training on Template and Diagram Guide
- Document and/or verify requirements
- Document and/or verify baseline configurations
- Create and/or update infrastructure diagrams and data flows

C. Risks and Dependencies

- Personnel with an understanding of network topology and data flows must be hired
- Change control processes and procedures must be implemented and driven from the top down to ensure compliance
- Configuration requirements and baselines must be established
- Docutainment Management and Storage System
- Asset inventory Tool

D. Benefits

- Enhanced network security
- Reduced troubleshooting and maintenance efforts
- Reduction in incompatible equipment and applications
- Up to date diagrams that matches the asset inventory at any point in time

F. Deliverables

- Network diagrams
- Data flow diagrams
- Documented change management procedure

G. Estimated Timeframe

- **12 + Weeks**

H. Estimated Cost

- **< $50K**

GPA/GWA Network Infrastructure

Roadmap Recommendation 4.2 – Budget for and replace end-of-life assets and expiring maintenance and service contracts

A. Recommendation Scope and Objective

Objectives in Order of Impact:
- Reserved budget
- Operational calendar

Recommendation Scope:
- IT network hardware and software
- IT maintenance contracts
- IT service contracts

B. Approach/Work Plan

- Identify and document hardware, software, maintenance contracts and service contracts
- Updated Governance for the T Procurement Process and transparency
- Identify replacement costs, licensing costs, and renewal costs
- Determine replacement/renewal priorities
- Allocate 20% of budget over a five-year period for replacements and renewals

C. Risks and Dependencies

- Accurate asset inventory and defined asset management process
- Hardware, software, and contract life expectancy
- Backlog of inventory due or overdue for replacement or renewal may require larger initial costs while operational calendar and budgeting process is being implemented

D. Benefits

- Reduction in late payments and fees
- Reduction in tracking and management efforts
- Reduction in duplicate, redundant, or overlapping maintenance and service contracts
- Enhanced visibility of budget for long-term planning

F. Deliverables

- Updated asset inventory
- Updated IT Procurement Process and reporting
- Operational calendar
- 5-yr budget allocations

G. Estimated Timeframe

- **4 - 8 Weeks**

H. Estimated Cost

- **< $50K**

GPA/GWA Network Infrastructure

Roadmap Recommendation 4.3 – Maintain installed hypervisor, server, and storage solution to end of life then move to Shared Solution

A. Recommendation Scope and Objective

Objectives in Order of Impact:

- Cross train shared services IT personnel on both hypervisor, server, and storage solutions.

Recommendation Scope:

- IT network hardware and software
- IT maintenance contracts
- IT service contracts

B. Approach/Work Plan

- Identify IT personnel skillsets
- Identify training solution options
- Choose a solution
- Develop training plan
- Implement solution
- Update policies and procedures

C. Risks and Dependencies

- Accurate asset inventory and defined asset management process
- Failure to identify all technical and operational requirements
- Network architecture and data flow diagrams
- Skilled personnel or support contracts

D. Benefits

- A larger pool of trained personnel to support both environments
- More efficient use of capacity and licensing of the server and storage solutions.

F. Deliverables

- Procedures
- Training materials

G. Estimated Timeframe

- 4 - 8 Weeks

H. Estimated Cost

- < $50K

GPA/GWA Network Infrastructure

Roadmap Recommendation 4.4 – Move towards a shared Internet edge utilizing next generation firewalls

A. Recommendation Scope and Objective

Objectives in Order of Impact:

- Standardize on a next-generation firewall solution

Recommendation Scope:

- IT network firewall and proxy server
- IT maintenance contracts
- IT service contracts

B. Approach/Work Plan

- Identify security requirements
- Identify solution options
- Identify training and skills necessary to support options
- Choose a solution
- Develop training plan
- Implement solution
- Develop procedures and training and train personnel

C. Risks and Dependencies

- Accurate asset inventory and defined asset management process
- Failure to identify all security requirements
- Network architecture and data flow diagrams
- Skilled personnel or support contracts

D. Benefits

- Reduction in time to identify and resolve security concerns
- Reduction in supporting documentation requirements such as multiple procedures
- Reduction in training materials development and training hours
- Reduction in maintenance and support costs
- Improved visibility into malicious behavior on the network.

F. Deliverables

- Single consolidated solution for firewalls
- Procedures
- Training materials

G. Estimated Timeframe

- 4 - 8 Weeks

H. Estimated Cost

- **> $100K**

GPA/GWA Network Infrastructure

Roadmap Recommendation 4.5 – Meet and agree on a common shared network infrastructure configuration and security segmentation

A. Recommendation Scope and Objective

Objectives in Order of Impact:

- Standardize on a shared network infrastructure

Recommendation Scope:

- IT network equipment
- IT network maintenance contracts
- IT service contracts

B. Approach/Work Plan

- Identify security requirements
- Identify solution options
- Identify training and skills necessary to support options
- Choose a solution
- Develop training plan
- Implement solution
- Develop procedures and training and train personnel

C. Risks and Dependencies

- Accurate asset inventory and defined asset management process
- Failure to identify all security requirements
- Network architecture and data flow diagrams
- Skilled personnel or support contracts

D. Benefits

- Reduction in time to identify and resolve security concerns
- Reduction in supporting documentation requirements such as multiple procedures
- Reduction in training materials development and training hours
- Reduction in maintenance and support costs

F. Deliverables

- Single shared solution for network devices
- Procedures
- Training materials

G. Estimated Timeframe

- **12 + Weeks**

H. Estimated Cost

- **> $100K**

GPA/GWA Network Infrastructure

Roadmap Recommendation 4.6 – Configure GWA SSIDs on Headquarters building Wireless Infrastructure

A. Recommendation Scope and Objective

Objectives in Order of Impact:

- Scale GPA wireless network to allow for usage by GWA

Recommendation Scope:

- GPWA Headquarters Building

B. Approach/Work Plan

- Conduct wireless coverage assessment of the headquarters building.
- Identify any additional training and skills necessary to support expanded wireless environment
- Purchase equipment/services necessary to support the addition of GWA users
- Develop training and communications plan
- Implement solution
- Update procedures and training and train personnel

C. Risks and Dependencies

- Current and future state bandwidth needs assessment
- Security requirements
- Network architecture – wireless subnets
- Skilled personnel or support contracts

D. Benefits

- Ability to scale known solution
- Increase in GWA personnel productivity
- Reduction in supporting documentation requirements such as multiple procedures
- Reduction in training materials development and training hours
- Reduction in maintenance and support costs

F. Deliverables

- Single consolidated solution for both organizations
- Updated network architecture diagrams
- Updated procedures and training materials
- Communications plan

G. Estimated Timeframe

- **4 - 8 Weeks**

H. Estimated Cost

- **< $50K**

GPA/GWA Network Infrastructure

Roadmap Recommendation 4.7 – Expand GPA's SolarWinds Orion installation and Splunk SIEM to GWA to monitor its infrastructure

A. Recommendation Scope and Objective

Objectives in Order of Impact:
- Expand GPA's monitoring and alerting capabilities to cover GWA assets, systems, and networks

Recommendation Scope:
- IT networking equipment
- IT managed applications and systems

B. Approach/Work Plan

- Analyze GWA security requirements
- Update licensing
- Conduct skills gap assessment and identify training requirements
- Configure GWA firewalls to allow access to monitoring and alerting hardware and software
- Configure monitoring and alerting hardware and software
- Update procedures and develop training for GWA personnel
- Train GWA personnel

C. Risks and Dependencies

- Divergent security requirements
- Personnel with skills and training to review logs and alerts and respond appropriately
- Network architecture and data flow diagrams

D. Benefits

- Ability to scale existing solution vs. purchase new/redundant systems
- Increased ability to recognize and respond to potential security incidents
- Reduction in documentation such as multiple procedures for multiple systems
- Reduction in training materials development and training hours
- Reduction in maintenance and support costs

F. Deliverables

- Single consolidated solution for both organizations
- Updated network architecture diagrams
- Updated procedures and training materials

G. Estimated Timeframe

- **8 – 12 Weeks**

H. Estimated Cost

- **$50K – 75K**

GPA/GWA Network Infrastructure

Roadmap Recommendation 4.8 – Complete Northern Fiber Ring Project

A. Recommendation Scope and Objective

Objectives in Order of Impact:
- Complete Current build out of the Northern Fiber Ring to New Facility

Recommendation Scope:
- Expand the Northern Fiber Ring to include GWA sites
- Northern Fiber Ring is an Island wide ongoing project

B. Approach/Work Plan

- Assess combined GPA GWA bandwidth requirements for metering and outage data on the northern ring
- Assess ISP carrier coverage and costs
- Implement project management and identify project metrics
- Complete the fiber ring
- Configure metering and outage systems to capture and transmit data

C. Risks and Dependencies

- Bandwidth requirements
- Network architecture
- Inflight and planned projects requiring bandwidth

D. Benefits

- Ability to share capital infrastructure
- Increased visibility to identify and troubleshoot outages
- Accurate billing information
- Fewer truck rolls

F. Deliverables

- Northern fiber ring buildout phases
- Updated network architecture
- Project metrics
- Bandwidth assessment

G. Estimated Timeframe

- **12 + Weeks Current**
- **1-3 years ongoing Phases**

H. Estimated Cost

- **> $100K**
- **> $100K**

GPA/GWA Network Infrastructure

Roadmap Recommendation 4.9 – Complete buildout of Disaster Recovery Site for both divisions to co-locate

A. Recommendation Scope and Objective

Objectives in Order of Impact:

- Move backups to a remote data center
- Share disaster recovery capability
- Upper Tumon planned site

Recommendation Scope:

- Disaster recovery and data storage capabilities

B. Approach/Work Plan

- Identify DR and backup data storage, access, and security requirements
- Assess costs and capabilities for off-island or cloud storage
- Choose a solution
- Conduct a skills and training assessment
- Migrate data to chosen storage location
- Update policies, processes, procedures, work instructions, and training modules
- Train personnel on new or changed policies, processes, procedures, and work instructions

C. Risks and Dependencies

- Data storage, access, and security requirements
- Data classifications
- Remote (off-island) storage providers and capabilities
- Personnel knowledge, skills, and training

D. Benefits

- Ability to share infrastructure and/or services
- Reduced risk of loss to critical data
- Shared support and maintenance

F. Deliverables

- Shared data storage environment
- Skills and training assessment
- Updated governance documentation

G. Estimated Timeframe

- **4 - 8 Weeks**

H. Estimated Cost

- **< $50K**

Roadmap Recommendation 4.10 – Implement Multi-Factor Authentication for Remote Access to the network for GPA and GWA

A. Recommendation Scope and Objective

Objectives in Order of Impact:

- Standardize on an MFA solution

Recommendation Scope:

- IT network firewall and VPN solution
- IT maintenance contracts
- IT service contracts

B. Approach/Work Plan

- Identify security requirements
- Identify solution options
- Identify training and skills necessary to support options
- Choose a solution
- Develop training plan
- Implement solution
- Develop procedures and training and train personnel

C. Risks and Dependencies

- Accurate asset inventory and defined asset management process
- Failure to identify all security requirements
- Network architecture and data flow diagrams
- Skilled personnel or support contracts

D. Benefits

- Improved security posture for remote access
- Compliance with cyber security policies and procedures
- Reduction in training materials development and training hours
- Reduction in maintenance and support costs

F. Deliverables

- Single consolidated solution for MFA
- Procedures
- Training materials

G. Estimated Timeframe

- **4 - 8 Weeks**

H. Estimated Cost

- **< $50K**

GPA/GWA Security Policies and Procedures

Roadmap Recommendation 5.1 – Develop an IT/OT Cyber Security Governance Program

A. Recommendation Scope and Objective

Objectives in Order of Impact:

- Develop governance program

Recommendation Scope:

- GPA and GWA IT organizations

B. Approach/Work Plan

- Assign senior individual or committee with authority to set IT program policy
- Identify requirements and metrics
- Assign roles and responsibilities
- Determine program maintenance processes
- Document program

C. Risks and Dependencies

- Governance oversight committee or leader with authority to approve organizational policy

D. Benefits

- Accountability for program documentation
- Accountability for compliance with policies, plans, programs, processes, and procedures
- Measurable metrics

F. Deliverables

- Governance program
- Requirements matrix
- Metrics
- List of roles and responsibilities
- Program maintenance process

G. Estimated Timeframe

- **12 + Weeks**

H. Estimated Cost

- **< $50K**

GPA/GWA Security Policies and Procedures

Roadmap Recommendation 5.2 – Review and approve cyber security baseline control set of best practice for both organizations

A. Recommendation Scope and Objective

Objectives in Order of Impact:

- Review baseline control set
- Approve baseline control set

Recommendation Scope:

- GPA and GWA IT organizations

B. Approach/Work Plan

- Identify security requirements
- Review technical gap assessment completed as part of this project and identify which baseline controls will be implemented to meet security requirements
- Approve baseline control set
- Determine how baseline controls will be met
- Develop processes, procedures, work instructions, and training to support controls

C. Risks and Dependencies

- Governance oversight committee or leader with authority to approve organizational documentation
- Technical gap assessment workbook
- Knowledge or skills complete baseline control gap assessment
- Lack of technical capabilities or knowledge and skills to implement baseline controls

D. Benefits

- Defined security objectives
- Compliance with grant application requirements
- Measurable metrics
- Standardized security practices
- Visibility into technology and security control gaps

F. Deliverables

- Baseline security controls
- Updated technical controls gap assessment

G. Estimated Timeframe

- **4 - 8 Weeks**

H. Estimated Cost

- **< $50K**

Roadmap Recommendation 5.3 – Perform a risk assessment and inventory of assets with impact rating

A. Recommendation Scope and Objective

Objectives in Order of Impact:
- Perform risk assessment

Recommendation Scope:
- GPA and GWA IT organizations

B. Approach/Work Plan

- Define and establish system categories
- Conduct risk assessment, characterizing systems, identifying threats and vulnerabilities, and control measures
- Determine likelihood and impact
- Document results and assign categories
- Document corrective actions and track progress

C. Risks and Dependencies

- Risk assessment procedure
- Formal approval
- Knowledge or skills to complete risk assessment
- Understanding of appropriate mitigation and corrective actions
- Plan of Actions and Milestones workbook for tracking mitigation and corrective actions to completion

D. Benefits

- Clearly identified risk categories
- Understanding of current threats and vulnerabilities
- Identification of technology and skills gaps
- Justification for security projects and/or personnel

F. Deliverables

- Risk assessment report
- Plan of action and milestones

G. Estimated Timeframe

- **Less than 4 weeks**

H. Estimated Cost

- **$50K – 75K**

GPA/GWA Security Polices and Procedures

Roadmap Recommendation 5.4 – Develop IT Management Model for IT/OT System Documentation

A. Recommendation Scope and Objective

Objectives in Order of Impact:
- Develop governance documentation

Recommendation Scope:
- GPA and GWA IT organizations

B. Approach/Work Plan

- Identify approved baseline security controls
- Identify roles and responsibilities
- Review and update existing policies and standards to reflect approved baseline security controls
- Create new policies and standards for any identified gaps to meet approved baseline security controls
- Submit for approval
- Develop training materials to support documentation
- Identify and train impacted personnel
- Develop documentation maintenance processes and procedures
- Develop operational calendar

C. Risks and Dependencies

- Approved baseline security controls
- Understanding of how controls will be met
- Approval authority
- List of regulatory, compliance, and organizational artifacts with generation timelines (Unified Control Framework (UCF) and operational calendar)

D. Benefits

- Consistent implementation of security controls
- Organizational alignment on policies and standards
- Consistent audit artifacts
- Enhanced security
- Reduction in efforts to complete routine tasks

F. Deliverables

- Policies and standards for approved security controls
- Roles and responsibilities matrix
- Operational calendar
- Updated UCF
- Training materials
- Documentation maintenance and approval process

G. Estimated Timeframe

- **8 – 12 Weeks**

H. Estimated Cost

- **> $100K**

GPA/GWA Security Policies and Procedures

Roadmap Recommendation 5.5 – Develop Supporting IT Cyber security governance process and SOP BU's level documentation

A. Recommendation Scope and Objective

Objectives in Order of Impact:

- Develop governance documentation

Recommendation Scope:

- GPA and GWA IT organizations

B. Approach/Work Plan

- Review approved policies, standards and UCF to identify necessary associated governance documentation
- Identify roles and responsibilities
- Develop documentation to support each of the controls such as programs, plans, processes, procedures, and work instructions
- Submit for approval
- Develop training materials to support documentation
- Identify and train impacted personnel
- Develop documentation maintenance processes and procedures
- Develop operational calendar

C. Risks and Dependencies

- Approved policies and standards
- Understanding of how controls will be met
- Approval authority
- List of regulatory, compliance, and organizational artifacts with generation timelines (Unified Control Framework (UCF) and operational calendar)

D. Benefits

- Consistent application of processes, procedures, and work instructions
- Consistent audit artifacts
- Enhanced security
- Reduction in efforts to complete routine tasks

F. Deliverables

- Governance documentation for approved security controls
- Roles and responsibilities matrix
- Operational calendar
- Updated UCF
- Training materials
- Documentation maintenance and approval process

G. Estimated Timeframe

- **8 – 12 Weeks**

H. Estimated Cost

- **> $100K**

GPA/GWA Security Policies and Procedures

Roadmap Recommendation 5.6 – Implement Change Control and Configuration Control

A. Recommendation Scope and Objective

Objectives in Order of Impact:
- Enforce Change Control and Configuration Management processes

Recommendation Scope:
- GPA and GWA IT organizations

B. Approach/Work Plan

- Authorize a change and configuration management board (CAB)
- Document roles and responsibilities
- Develop and or update processes to review and approve changes
- Document training requirements for impacted personnel
- Communicate change and configuration management responsibilities
- Conduct periodic audits to ensure processes are being enforced

C. Risks and Dependencies

- Approved change and configuration management policies and procedures
- Change and configuration management board (CAB)
- Tools or technology to document and manage changes

D. Benefits

- Enhanced security
- Measurable metrics
- Audit and compliance evidence
- Reduction in outages and maintenance times
- Enhanced ability to support end-users

F. Deliverables

- CAB
- Roles and responsibilities matrix
- Formal change processes and updated policies and procedures
- Training plan and materials

G. Estimated Timeframe

- **8 – 12 Weeks**

H. Estimated Cost

- **< $50K**

GPA/GWA Security Policies and Procedures

Roadmap Recommendation 5.7 – Manage Unified Control Framework, Technical Controls Gap Assessment Findings

A. Recommendation Scope and Objective

Objectives in Order of Impact:

- Develop process for the ongoing management and maintenance of the Unified Control Framework (UCF), Technical Controls Gap Assessment workbook, and Operational Calendar

Recommendation Scope:

- GPA and GWA IT organizations

B. Approach/Work Plan

- Document review processes
- Identify changes in regulatory, compliance, and organizational requirements or best practice and associated artifacts
- Update UCF
- Identify changes in security controls to be implemented based on regulatory, compliance, or organizational needs or requirements
- Update technical controls gap assessment workbook
- Identify changes to schedule of artifact generation
- Update operational calendar

C. Risks and Dependencies

- Approved Unified Control Framework (UCF)
- Updated Technical Controls Gap Assessment Workbook
- Operational calendar

D. Benefits

- Ability to consistently generate relevant audit artifacts
- Visibility into technical controls gaps
- Measurable metrics for determining program health

F. Deliverables

- Updated UCF
- Updated technical controls gap assessment workbook
- Updated operational calendar

G. Estimated Timeframe

- **Less than 4 weeks**

H. Estimated Cost

- **< $50K**

10.3.3. GPA/GWA Application Review

GPA/GWA Application Recommendations

Roadmap Recommendation 6.1 – Complete the shared SCADA system deployment to increase visibility into GWA systems and assets

A. Recommendation Scope and Objective

Objectives in Order of Impact:
- Complete shared SCADA deployment

Recommendation Scope:
- GPA and GWA SCADA systems

B. Approach/Work Plan

- Assign project manager with authority to oversee project and assign work to GPA and GWA resources
- Review and update project plan and identify changes to scope, schedule, budget, requirements, resources, stakeholders, milestones, risks, issues, constraints, and metrics
- Assign project resources
- Track and manage project scope, schedule, and budget to completion
- Add GPA and GWA assets to the system

C. Risks and Dependencies

- Governance oversight committee or leader with authority to approve organizational policy

D. Benefits

- Accountability for program documentation
- Accountability for compliance with policies, plans, programs, processes, and procedures
- Measurable metrics

F. Deliverables

- Updated project plan
- Resource allocations
- Project metrics and reports
- Updated Risks and Issues register

G. Estimated Timeframe

- **12 + Weeks**

H. Estimated Cost

- **75K – 100K**

GPA/GWA Application Recommendations

Roadmap Recommendation 6.2 – Renew support for GIS Solution for GWA (Short Term)

A. Recommendation Scope and Objective

Objectives in Order of Impact:

- Renew support contract for the ESRI application

Recommendation Scope:

- GWA GIS system

B. Approach/Work Plan

- Escalate issue to executive management
- Identify funds to renew the support contract.
- Procure support contract
- Identify governance, skills, and training gaps
- Document associated policies, processes, procedures, and develop and deploy training.

C. Risks and Dependencies

- Technical, operational, security, and regulatory requirements for GIS systems
- Formal purchase authorization

D. Benefits

- Vendor support for a critical GWA application

F. Deliverables

- Purchase Order
- ESRI support contract

G. Estimated Timeframe

- **Less than 4 weeks**

H. Estimated Cost

- **< $50K**

GPA/GWA Application Recommendations

Roadmap Recommendation 6.3 – Standardize on common Change Management solution for both Organizations

A. Recommendation Scope and Objective

Objectives in Order of Impact:

- A change management process that is followed and adheres to GPA's and GWA's policies and procedures

Recommendation Scope:

- ChangeGear system

B. Approach/Work Plan

- Procure and add additional licenses for GWA personnel
- Update policies and procedures
- Configure workflows in ChangeGear application
- Train personnel on the new policies and procedures

C. Risks and Dependencies

- Senior management support of the new change management process
- Employee support of the new change management process
- Formation of a change advisory board and weekly CAB meeting to review and approve critical changes

D. Benefits

- Improved communication with business units on impactful changes to systems and the network
- Audit trail of changes for use when troubleshooting issues
- Improved availability of the network and critical applications
- Improved metrics on employee workloads and changes to the network

F. Deliverables

- Updated policies and procedures
- Training materials
- Configured workflows in ChangeGear.

G. Estimated Timeframe

- **4 - 8 Weeks**

H. Estimated Cost

- **< $50K**

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GPA/GWA Application Recommendations

Roadmap Recommendation 6.4 – Extend the Ticketing System across both GPA and GWA

A. Recommendation Scope and Objective

Objectives in Order of Impact:

- Use the ticketing system for problem and incident management throughout the entire process of identifying and resolving the issue.

Recommendation Scope:

- IT and business critical assets, systems, and networks

B. Approach/Work Plan

- Assess current systems to make sure workflows match the documented process.
- Conduct skills and training assessment
- Update governance documentation
- Communicate changes and train personnel

C. Risks and Dependencies

- Management needs to support the use of the documented policies and procedures for problem and incident management.
- Governance policies and processes
- Governance board and/or authorized representative
- Skilled and trained support personnel

D. Benefits

- Improved metrics for employee workload
- Improved metrics for network and application outages and issues
- Reduction in troubleshooting and remediation of problems
- Enhanced auditing capabilities

F. Deliverables

- Training materials on the use of the ticketing systems.
- Updated workflows in the ticketing systems
- Updated governance documentation

G. Estimated Timeframe

- **8 – 12 Weeks**

H. Estimated Cost

- **< $50K**

GPA/GWA Application Recommendations

Roadmap Recommendation 6.5 – Implement a shared services document management solution

A. Recommendation Scope and Objective

Objectives in Order of Impact:

- Use a document management system is a system to receive, track, manage and must be capable of storing documents and reduce paper.
- Must be capable of keeping a record of the various versions created and modified by different users.

Recommendation Scope:

- Must be able to support IT , customer service and engineering

B. Approach/Work Plan

- Determine Who Will Take Charge of the DMS
- Assess the Current Filing System and Determine Strategy Requirements
- Taking inventory and determine document size and types for inclusion
- Establish Procedures and Requirements and then document
- Preparing the DMS Strategy Processes and implementation
- Purge Unnecessary Documents
- Organize Documents and Maintain the Process and DMS

C. Risks and Dependencies

- Loss of data in the event of a disaster.
- Time and cost overruns.
- Missing the opportunity to delight customers.
- Failing to comply with legal requirements
- Information Protection Program (IPP)
- Change in Culture from Paper to Electronic Storage

D. Benefits

- Improves access to information
- Reduces operating costs
- Diminishes litigation risk
- Protects critical information

F. Deliverables

- Electronic Document Management System (EDMS)
- Optimized internal workflows
- Backup and storage of Documents and sole source
- Role based access and tracking

G. Estimated Timeframe

- **8 – 12 Weeks**

H. Estimated Cost

- **< $500K**

GPA/GWA Application Recommendations

Roadmap Recommendation 6.6 – Continue to Implement a joint Mobile Workforce Management (MMW) System

A. Recommendation Scope and Objective

Objectives in Order of Impact:

- Develop a Mobil workforce architecture
- Implement a mobile workforce solution

Recommendation Scope:

- Mobile workforce management system. Both GPA and GWA have implemented systems

B. Approach/Work Plan

- Use Existing Phones/Devices and systems
- Simple Integration
- Phone vs Tablet vs Laptop
- Develop Forms
- Report Generation
- Asset Management
- Native App vs Online
- License Model

C. Risks and Dependencies

- Cyber Security Implications of Mobile Workforce
- Physical access to devices
- Communication Interception

D. Benefits

- Faster Decision-making
- Deeper Insights Into Workers Behavior
- Reduced Operational Complexity
- Improved Client Service

F. Deliverables

- Functional and Modular Architecture
- Mobile Business Platform

G. Estimated Timeframe

- **8 – 12 Weeks**

H. Estimated Cost

- **< $900K**

GPA/GWA Application Recommendations

Roadmap Recommendation 6.7 – Implement Customer Care & Billing (CC&B) Application Management Centralized Administration

A. Recommendation Scope and Objective

Objectives in Order of Impact:

- Lower your hardware expenses. You can reduce hardware costs by keeping all servers and networking equipment in one place
- Improve productivity for IT staff.
- Increase your purchasing power.
- Improve the flow of information

Recommendation Scope:

- Implement a CC&B Centralized Administration Model

B. Approach/Work Plan

- Evaluation and communication of the Strategic Plan.
- Development of an implementation structure.
- Development of implementation-support policies and programs.
- Budgeting and allocation of resources.
- Discharge of functions and activities.

C. Risks and Dependencies

- Centralized governance involves the entire enterprise in the development and implementation of risk management and cyber security strategies.
- Centralized governance involves the entire enterprise in the development and implementation of risk management and cyber security strategies.

D. Benefits

- Administration User Id and Group
- Database Connection Monitoring
- Centralized resources approach is easy to administer
- All the systems at the its administrators' fingertips
- All the systems are geographically close to one another
- Automation tools also make an administrator's job easier and facilitate controlling remote systems from a central location.

F. Deliverables

- Centralized administration model
- A core administrative group controls all of the IT assets at one central location
- Centralized resource staff

G. Estimated Timeframe

- **8 – 12 Weeks**

H. Estimated Cost

- **< $450K**

GPA/GWA Application Recommendations

Roadmap Recommendation 6.8 – Customer Service Web Applications Development, Support and Maintenance

A. Recommendation Scope and Objective

Objectives in Order of Impact:

- 24/7 monitoring and surveillance services to provide highly available systems
- 24/7 service desk to provide continuous customer care services
- Ability to apply critical updates, maintenance or upgrades to application services
- Objective is to create an internal website development and maintenance process to support the business with future website development projects

Recommendation Scope:

- Customer facing Web site administration and development

B. Approach/Work Plan

- Business Problem and objective analysis
- Current State Analysis
- Project management
- Architecture and design
- Content
- Programming
- Design the Process
- Continuous Integration

C. Risks and Dependencies

- Communications and IT are supporting the business units in the beginning of the process
- The organization lacks in resources and therefore there are semi qualified people to take responsibility of the site
- The documentations included very little supportive guidelines for maintenance or development

D. Benefits

- Reliable application services aimed at the highest availability to end users
- Key understanding of system performance and tuning services are provided to keep the applications running as efficiently as possible for a better user experience.
- Periodic vulnerability scans, remediation and audits

F. Deliverables

- In-house maintenance in a centralized model to maintain and provide onsite resources and skills for performing technical support work
- Service Level Agreements detailing projected hours and cost

G. Estimated Timeframe

- **8 – 12 Weeks**

H. Estimated Cost

- **< $150K**

GPA/GWA Application Recommendations

Roadmap Recommendation 6.9 – Shared ERP environment with JD Edwards

A. Recommendation Scope and Objective

Objectives in Order of Impact:

- Modernize and integrate business processes and systems.

Recommendation Scope:

- Integrated suite of modules that are comprehensively devised to digitally sequence and streamline the business functions

B. Approach/Work Plan

- Identify the problems / Set the objective(s)
- Define scope/team
- Brainstorm/evaluate the options
- Data migration
- Check infrastructure
- Customization
- Change management
- Technology & Knowledge Transfer
- Project management and Testing
- Final touch (go live) & on-going support

C. Risks and Dependencies

- Failure to Redesign Business Processes to Fit the Software
- Lack of Senior Management Support
- Insufficient Training and Reskilling of End-Users
- Lack of Ability to Recruit and Retain Qualified Systems, Developers
- Inability to Obtain Full-Time Commitment of Employee to Project Management and Project Activities
- Lack of Integration
- Lack of Change Management
- Poor Technology Planning
- Less than Awesome Project Management

D. Benefits

- More efficient at lower cost
- Make Better Decisions With a Unified Management System
- Enhanced Business Reporting:
- Better reporting tools with real-time information.
- Better customer service: Better access to customer information.

F. Deliverables

- Project Charter and Scope Statement
- Target Budget and Schedule
- Organizational Structure and Staff Requirements
- Business Process Mapping
- Systems Testing
- Recruitment and retention of IT/ERP Subject Matter Expert professionals
- Training and reskilling

G. Estimated Timeframe

- **32 – 46 Weeks**

H. Estimated Cost

- **< $350K**

10.3.1. GPA/GWA Organizational Analysis

GPA / GWA Organizational Analysis

Roadmap Recommendation 7.1 – Establish an Updated Governance for IT Management Duties and Operations

A. Recommendation Scope and Objective

Objectives in Order of Impact:

- Develop and approve a Charter between GPA and GWA that defines the duties of an IT Oversight Committee
- Investigate, analyze, and define the most effective approach for ITIL Best Practice standards to establish a basis for common processes in IT
- Update or develop policies and procedures supporting IT projects, management, and operations capabilities to reinforce IT Oversight Committee Objectives and ITIL Best Practices

B. Approach/Work Plan

- Workstream 1:
  - Develop draft charter for IT Oversight Committee with processes, frequency, and decision criteria
  - Review and approve charter with GWA and GPA Senior Management
  - Conduct IT Oversight Committee meetings with 3rd party facilitation to establish required results
- Workstream 2:
  - Perform ITIL gap analysis against existing documentation and work practices to map appropriate level of maturity
  - Develop and approve implementation plan for ITIL Best Practices
- Workstream 3:
  - Based on results of ITIL gap analysis and implementation plan, develop prioritized listing of updates or new documentation needed for IT

C. Risks and Dependencies

- Do nothing continues to make business decisions in a fragmented approach resulting in increased costs and process inefficiencies
- Adopt a "commonsense" approach for leveraging ITIL Best Practices. A detailed complete implementation of ITIL is not needed for GWA and GPA and would not be cost effective. ITIL along with other standards can be the reference as maturity and automation levels increase in the organization.

D. Benefits

- Joint decisions for GWA and GPA for IT resulting in reducing costs in hardware, manpower and licensing costs.
- Standardized processes and procedures coupled with local knowledge to provide repeatable results and metrics.
- Knowledgebase to support aging workforce and transfer to new employees

F. Deliverables

- IT Oversight Committee Charter
- ITIL Implementation Plan
- Updated and / or new policies and procedures supporting IT business functions

G. Estimated Timeframe

- 12 + Weeks

H. Estimated Cost

- > $100K

GPA / GWA Organizational Analysis

Roadmap Recommendation 7.2 - Establish Program / Project and Organizational Change Methodologies Supporting IT Projects

A. Recommendation Scope and Objective

Objectives in Order of Impact:

- Assess IT Project Management methodologies and make selection for GPA and GWA
- Assess IT Organizational Change Management methodologies and make selection for GPA and GWA. OCM includes education and training aspects of projects
- Develop and implement metrics for projects in GWA and GPA

C. Risks and Dependencies

- A tailored approach is needed to leverage major benefits from the PMM and OCM without going into too much detail which could paralyze the IT organization.
- Determine internal and external service providers for PMM and OCM to implement and maintain knowledgebase for GWA and GPA.
- Do nothing continues to reinforce poor project performance and user acceptance.

F. Deliverables

- Document library of PMM tools, templates, and instructions
- Document library of OCM tools, templates, and instructions.
- Dashboard and report supporting good project execution and management

B. Approach/Work Plan

- Workstream 1 – Project Management Methodology:
  - Assess industry methodologies (e.g. PMI, Agile, Waterfall, etc.) and determine a good fit for GWA and GPA
  - Develop a tailored approach of the selected PMM for GWA and GPA
  - Determine internal and external service providers for PM
  - Train GPA / GWA internal users on PMM
- Workstream 2 – Organizational Change Management Methodology:
  - Assess industry methodologies (e.g. Prosci, Kotter, Other) and determine a good fit for GWA and GPA
  - Develop a tailored approach of the selected OCM for GWA and GPA
  - Determine internal and external service providers for OCM
  - Train GPA / GWA internal users on OCM
- Workstream 3 – Metrics and Governance for PMM and OCM:
  - Confirm metrics and milestones for PMM and OCM for IT projects
  - Create and distribute status dashboard for Sponsors and Stakeholder review for IT projects
  - Report back to the IT Oversight Committee on project performance

D. Benefits

- Increase the probabilities that the project will achieve all of its objectives and surpass its expected ROI
- 80^{+} % that of being completed at a lower cost than was initially budgeted

G. Estimated Timeframe

- 12 + Weeks

H. Estimated Cost

- > $100K

GPA / GWA Organizational Analysis

Roadmap Recommendation 7.3 – Develop and approve a combined GPWA IT Shared Services Organizational Structure

A. Recommendation Scope and Objective

Objectives in Order of Impact:

- Establish GPWA shared services organizational structure with supporting business objectives
- Identify and fill roles for IT personnel to align with the Shared Services model
- Define and monitor metrics for shared services performance that is accountable through the IT Oversight Committee

C. Risks and Dependencies

- Resistance to organizational change will require 3rd party assistance to ensure a smooth transition to the new IT Shared Services group
- New accountability rules for the shared services organization needs to be reinforced by GPA and GWA Senior Management
- Aging workforce could accelerate key resource retirements within IT

F. Deliverables

- GPWA Organizational Structure with role definition and salary structure
- GPA and GWA IT service levels and supporting metrics
- Organizational transition plan
- Performance metrics dashboard
- Certified OCM

B. Approach/Work Plan

- Workstream 1 – Define GPWA Shared Service Organizational Structure:
  - Conduct a skills set maturity assessment
  - Confirm services for GWA and GPA with identified levels and expectations
  - Develop and approve an organizational structure with GPA and GWA Senior management
- Workstream 2 – Confirm roles and salary structure for IT Shared Services model:
  - Update or develop new job descriptions with a supporting salary structure
  - Develop organizational transition plan for GPA and GWA IT organizations
  - Approve and fill roles with the new GPWA IT organization
- Workstream 3 – Define metrics and monitor shared services performance:
  - Confirm service levels for GWA and GPA. Develop status dashboard for the IT Oversight Committee
  - Monitor metrics on a monthly basis for organization effectiveness and cost performance

D. Benefits

- Align and right size resources, enable greater economies of scale, and decrease duplication of effort with process efficiencies
- Align business and IT expertise in supporting solutions through a common view for the GPA and GWA "Customer One" initiative

G. Estimated Timeframe

- 12 + Weeks

H. Estimated Cost

- > $100K

10.3.2. Network Future Design

GPA/GWA Network Future Design

Roadmap Recommendation 8.1 – Migrate to a Shared Network Infrastructure based on Product Lifecycle

A. Recommendation Scope and Objective

Objectives in Order of Impact:

- Standardize on a shared network infrastructure

Recommendation Scope:

- IT network equipment
- IT network maintenance contracts
- IT service contracts

B. Approach/Work Plan

- Identify security requirements
- Identify solution options
- Identify training and skills necessary to support options
- Choose a solution
- Develop training plan
- Implement solution
- Develop procedures and training and train personnel

C. Risks and Dependencies

- Accurate asset inventory and defined asset management process
- Failure to identify all security requirements
- Network architecture and data flow diagrams
- Skilled personnel or support contracts

D. Benefits

- Reduction in time to identify and resolve security concerns
- Reduction in supporting documentation requirements such as multiple procedures
- Reduction in training materials development and training hours
- Reduction in maintenance and support costs

F. Deliverables

- Single shared solution for network devices
- Procedures
- Training materials

G. Estimated Timeframe

- **12 + Weeks**

H. Estimated Cost

- **> $100K**

GPA/GWA Network Future Design

Roadmap Recommendation 8.2 – Deploy a Shared Services Ticketing and Change Management System

A. Recommendation Scope and Objective

Objectives in Order of Impact:

- Deploy a ticketing and change management system

Recommendation Scope:

- GPA and GWA IT systems

B. Approach/Work Plan

- Assign project manager with authority to oversee project and assign work to GPA and GWA resources
- Assess technical, operational, security, and regulatory requirements
- Evaluate and choose a solution
- Identify governance, skills, and training gaps
- Deploy solution
- Document associated policies, processes, procedures, and develop and deploy training

C. Risks and Dependencies

- Lack of formal change management governance and accountability
- Technical, operational, security, and regulatory requirements
- Formal project authorization
- Resources with the knowledge and skills to support the ticketing and change management system

D. Benefits

- Ability to capture reliable metrics such as network availability, employee workloads, and problem resolution times
- Faster issue resolution times
- Enhanced communications of system outages
- Audit trail for use in troubleshooting and potential breach investigations

F. Deliverables

- Shared ticketing and change management system
- Project plan
- Governance documentation
- Training documentation

G. Estimated Timeframe

- **12 + Weeks**

H. Estimated Cost

- **> $100K**

GPA/GWA Network Future Design

Roadmap Recommendation 8.3 – Share disaster recovery capabilities and move to a remote data center or cloud to meet geographical diversity requirements

A. Recommendation Scope and Objective

Objectives in Order of Impact:

- Move backups to a remote data center
- Share disaster recovery capability

Recommendation Scope:

- Disaster recovery and data storage capabilities

B. Approach/Work Plan

- Identify DR and backup data storage, access, and security requirements
- Assess costs and capabilities for off-island or cloud storage
- Choose a solution
- Conduct a skills and training assessment
- Migrate data to chosen storage location
- Update policies, processes, procedures, work instructions, and training modules
- Train personnel on new or changed policies, processes, procedures, and work instructions

C. Risks and Dependencies

- Data storage, access, and security requirements
- Data classifications
- Remote (off-island) storage providers and capabilities
- Personnel knowledge, skills, and training

D. Benefits

- Ability to share infrastructure and/or services
- Reduced risk of loss to critical data
- Shared support and maintenance

F. Deliverables

- Shared data storage environment
- Skills and training assessment
- Updated governance documentation

G. Estimated Timeframe

- **4 - 8 Weeks**

H. Estimated Cost

- **< $50K**

GPA/GWA Network Future Design

Roadmap Recommendation 8.4 – Deploy a Shared Services Email Solution for GWA and GPA

A. Recommendation Scope and Objective

Objectives in Order of Impact:

- Deploy a shared services email solution

Recommendation Scope:

- GPA and GWA email systems

B. Approach/Work Plan

- Project Plan
- Plan & Build Project Scope
- Plan Project Team & Structure
- Plan Target Infrastructure & Platforms
- Plan How You Will Design, Build, Test & Manage Your Gold Image
- Plan Dependencies, Storage & Network Issues
- Plan T(minus) Timeline
- Plan Scheduling Methodology
- Plan End-User Engagement
- Plan Which Software Tools Will Best Support Your Migration Efforts
- Plan Deployment Logistics.

C. Risks and Dependencies

- Technical, operational, security, and regulatory requirements for email systems
- Formal project authorization
- Resources with the knowledge and skills to support a shared services on-premise or cloud-based email system

D. Benefits

- Increased security
- Controlled method for sharing files and information
- Reduced local maintenance for software upgrades and patches
- Reduction in HW costs (lifecycle replacement if cloud-based)
- Simplified backup and storage (if cloud-based)
- Less susceptibility to disaster (if cloud-based)

F. Deliverables

- Shared email solution
- Project plan
- Governance documentation
- Training documentation

G. Estimated Timeframe

- **12 + Weeks**

H. Estimated Cost

- **$50K – 75K**

GPA/GWA Network Future Design

Roadmap Recommendation 8.5 – Consolidate to a shared hypervisor, server, and storage solution

A. Recommendation Scope and Objective

Objectives in Order of Impact:

- Consolidate to a shared hypervisor, server, and storage solution

Recommendation Scope:

- IT network hardware and software
- IT maintenance contracts
- IT service contracts

B. Approach/Work Plan

- Build a Virtualization Center of Excellence (2 to 4 weeks)
- Phase 1: Conduct Operational Assessment (2 to 6 weeks)
  - Step 1. Determine operational readiness
  - Step 2. Assess how well the IT infrastructure environment is understood and documented
  - Step 3. Review current/planned projects to assess impact and identify candidate projects for collaboration
  - Step 4. Document current application portfolio and fit with virtualization
- Phase 2: Plan/Design (2 to 6 months)
- Phase 3: Build (4 to 8 weeks)
- Phase 4: Manage (ongoing)

C. Risks and Dependencies

- Accurate asset inventory and defined asset management process
- Failure to identify all technical and operational requirements
- Network architecture and data flow diagrams
- Skilled personnel or support contracts

D. Benefits

- Reduce Server Costs with Desktop and Server Virtualization
- Centralize Management of Your Virtual Data Center
- An automated virtual solution can simplify management while simultaneously delivering performance
- Cut Hardware and Operating Costs with Server Consolidation minimize downtime

F. Deliverables

- Single consolidated solution for hypervisor, servers, and storage
- Procedures
- Training materials

G. Estimated Timeframe

- **12 + Weeks**

H. Estimated Cost

- **> $100K**

GPA/GWA Network Future Design

Roadmap Recommendation 8.6 – Implement a shared services asset management solution

A. Recommendation Scope and Objective

Objectives in Order of Impact:

- Implement change and configuration control capabilities

Recommendation Scope:

- IT and business critical assets, systems, and networks

B. Approach/Work Plan

- Review the organization's structure.
- Conduct an asset management self-assessment.
- Identify the asset management policies and goals to be achieved.
- Prepare and implement an asset management action plan.
- Review and monitor progress.
- Solicit feedback from stakeholders
- Monitoring, reviewing and updating the system

C. Risks and Dependencies

- Accurate asset inventory
- Baseline configurations
- Governance policies and processes
- Governance board and/or authorized representative
- Skilled and trained support personnel

D. Benefits

- Centralizing asset repository
- Efficient tracking and record keeping
- Reduce the labor requirement for AIM
- Tracking assets throughout their lifecycle
- Discovering any possibility for threats or changes to the assets in advance

F. Deliverables

- Asset and inventory control system
- Updated asset inventory
- Updated governance documentation

G. Estimated Timeframe

- **8 – 12 Weeks**

H. Estimated Cost

- **< $50K**

GPA/GWA Application Network Future Design

Roadmap Recommendation 8.7 – Deploy AMI Solution for GWA

A. Recommendation Scope and Objective

Objectives in Order of Impact:

- Deploy AMI solution for GWA

Recommendation Scope:

- GPA and GWA SCADA systems

B. Approach/Work Plan

- Develop the business case for your large-scale technology projects
- Navigate the procurement and vendor contract negotiation process
- Deploy smart grid/advanced metering infrastructure (AMI) programs
- Integrate new systems into your existing technology landscape
- Adapt to and realize the full benefits of new technologies through change management
- Design and execute public awareness and education campaigns
- Implement a comprehensive benefits verification program
- Maximize the use and value of new data streams
- Augment your staff to support your new technologies

C. Risks and Dependencies

- Technical, operational, security, and regulatory requirements for AMI systems
- Understanding of GPA AMI system capabilities
- Formal project authorization
- Resources with the knowledge and skills to support an AMI system

D. Benefits

- Remote customer connect and disconnects
- Fewer truck rolls
- Enhanced customer billing and support capabilities
- Reduction in operating costs

F. Deliverables

- AMI solution
- Project plan
- Governance documentation
- Training documentation

G. Estimated Timeframe

- **12 + Weeks**

H. Estimated Cost

- **> $100K**

Refer to Cost Benefit section for addiitonal cost logic.

GPA/GWA Network Future Design

Roadmap Recommendation 8.8 – Merge customer records databases

A. Recommendation Scope and Objective

Objectives in Order of Impact:

- Merge customer records databases

Recommendation Scope:

- GPA and GWA customer records

B. Approach/Work Plan

- Assign project manager with authority to oversee project and assign work to GPA and GWA resources
- Standardize the data
- Check for duplicates
- Fill in missing data
- Create a data map
- Merge and automate

C. Risks and Dependencies

- Accurate customer records databases
- Customer records management system
- Skilled DBA resources for data convergence and migration to unified storage location

D. Benefits

- Reduced data entry costs
- Streamlined customer service experience for GWA and GPA customers
- Enables consolidation of collections
- Reduced payment transactions due to both water and power being on one account

F. Deliverables

- Shared ticketing and change management system
- Project plan
- Governance documentation
- Training documentation

G. Estimated Timeframe

- **12 + Weeks**

H. Estimated Cost

- **> $100K**

GPA/GWA Network Future Design

Roadmap Recommendation 8.9 – Electronic Reporting and Invoicing

A. Recommendation Scope and Objective

Objectives in Order of Impact:

- Billing automation systems for public utilities (e.g. electricity, gas and water) have been widely implemented

Recommendation Scope:

- E-billing and reporting through and electronic billing process for paying and receiving bills online

B. Approach/Work Plan

- Prepare the infrastructure
- Coordinate with the organizations involved in implementation
- Implement training
- Install the production solution
- Convert the data
- Perform final verification in production
- Implement new processes and procedures
- Monitor the solution

C. Risks and Dependencies

- Fears of system hacks and network failure that create uneasiness and uncertainty in the minds of customers and regulators
- Security and stability of the financial system
- Operational risks, solvency/liquidity risks and risks associated with more advanced financial services

D. Benefits

- There are many ways that organizations can save money by creating a process to digitize invoices.
- Digitizing of services to optimize the transfer and treatment of invoices
- Simplified billing and reporting
- Electronic and automated invoice processes can result in savings of 60-80% compared to traditional paper-based processing

F. Deliverables

- Payment and reporting solutions to support digitization

G. Estimated Timeframe

- **12 + Weeks**

H. Estimated Cost

- **> $300K**

10.4. Roadmap Conclusion and Top Ten

The goal of this Roadmap is to continue progress by creating a formal framework for GPWA for funding decisions beginning with the FY2022 budget.

Because it is considered a living document, we intend to refine and expand the Roadmap as needed to reflect present and future GPWA questions, needs, and priorities. We believe that successful implementation of the Roadmap, including partnerships, will allow GPWA to answer key questions about new technologies and fulfill its Information Technology mission to provide the right information at the right time to the right people to make the right decisions. The Roadmap should be especially useful to stakeholders internal and external to GPWA as they seek support to form a shared service organization. Detailed rough order of magnitude (ROM) cost estimates can be found for the recommendations in Section 9 – Cost Benefit.

The journey starts with the organizational transition, charter development, job description reviews and updates while supporting daily business operations. The use of a qualified third-party should be considered that will allow project parallel efforts to progress forward for GPWA.

10.4.1. Top Ten Short-term Recommendations & Playbook

The IT Integration Study and supporting roadmap has presented analysis and recommendations in which GPWA management will review, internalize, validate and prioritize in the individual interests of each organization. We realize that the largest most impactful recommendation is 7.3 Shared Services Organizational Structure which merges the GPA and GWA IT groups into a single organizational entity. This recommendation will take multiple management working sessions and CCU meetings to bring to a decision. With that said, it is important to note that other recommendations can move forward ahead and independent of this major decision to which will contribute to improved business processes, joint working conditions and increased efficiencies for GWA and GPA.

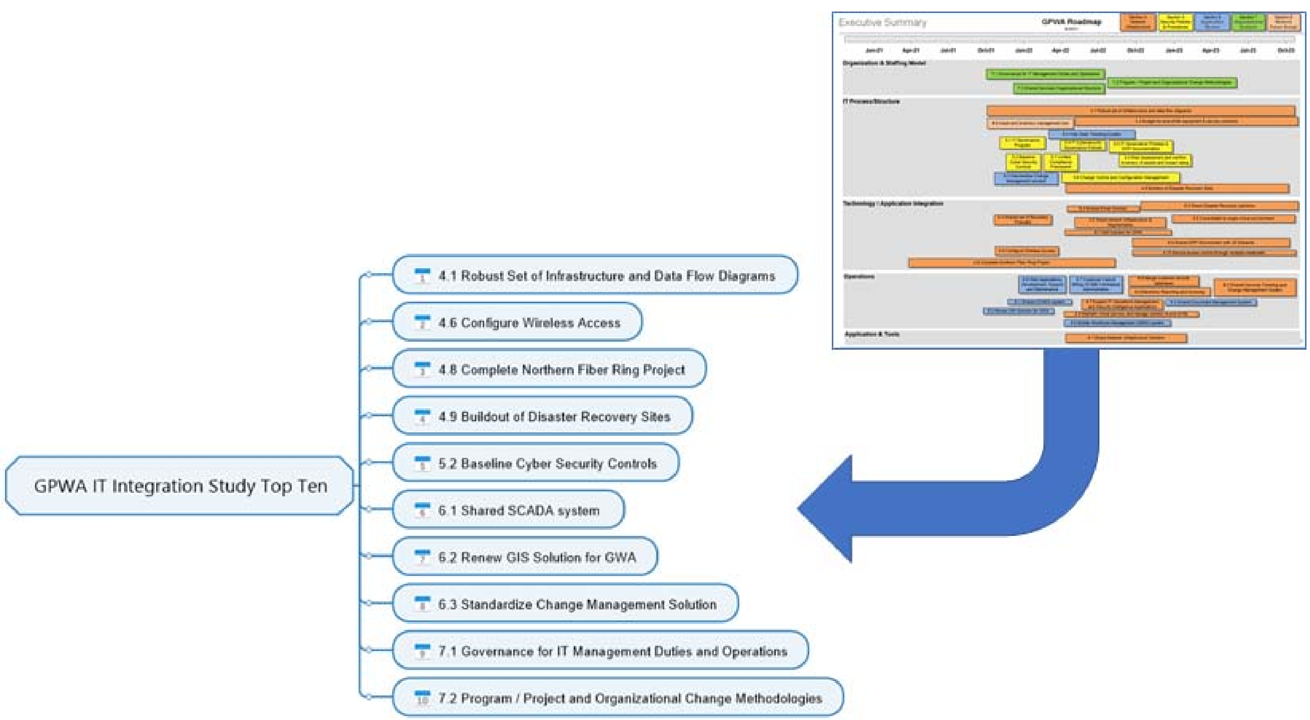


Figure 9-3: IT Integration Study "Top Ten" Short Term Recommendations

We have extracted the "Top Ten" recommendations (Refer to Figure 9.3) that were planned for immediate or short-term execution within the next 9 -12 months of the proposed overall roadmap. In efforts to "jumpstart" efforts of the plan and begin execution of the roadmap with a "playbook" with 6 scenarios which utilizes all or some that intent of the Top Ten recommendations in producing observable results to GPA and GWA for various projects. These projects can start immediately with appropriate funding and accountability to the Sponsoring AGM's in GPA and GWA.

Scenario 1: Shared SCADA System

Primary Recommendation:

- 6 — 6.1 Shared SCADA system

Supporting Recommendations:

- 1 — 4.1 Robust Set of Infrastructure and Data Flow Diagrams
- 10 — 7.2 Program / Project and Organizational Change Methodologies
- 8 — 6.3 Standardize Change Management Solution

<u>Work Description:</u>
Provide a third-party Project Manager / Specialist to manage scope and tasks for the focus on the Siemens SCADA system completion within GWA. As part of this work, they would develop drawings (Infrastructure and Data Flow) to a defined standard for GPWA. All project management (scope, schedule, cost) and change management (communications, training) tasks would reflect the anticipated standard for the new GPWA IT organization. Coordination with GPA would be accomplished for developing templates and standards for HMI and other SCADA attributes.

Scenario 2: Configure Wireless Access

Primary Recommendation:

- 2 — 4.6 Configure Wireless Access

Supporting Recommendations:

- 1 — 4.1 Robust Set of Infrastructure and Data Flow Diagrams
- 10 — 7.2 Program / Project and Organizational Change Methodologies
- 8 — 6.3 Standardize Change Management Solution
- 9 — 7.1 Governance for IT Management Duties and Operations

<u>Work Description:</u>
Provide a third-party Network Specialist to manage scope and tasks for build-out completion of the wireless for the GPWA Main Offices. As part of this work, they would develop drawings (Infrastructure and Data Flow) to a defined standard for GPWA. All project management (scope, schedule, cost) and change management (communications, training) tasks would reflect the anticipated standard for the new GPWA IT organization. Development of operational standards would contribute to the definition of IT Management Duties and Operation of the wireless network for both GWA and GPA.

Scenario 3: Complete Northern Fiber Ring Project

Primary Recommendation: 4.8 Complete Northern Fiber Ring Project

Supporting Recommendations:

- 4.1 Robust Set of Infrastructure and Data Flow Diagrams
- 7.2 Program / Project and Organizational Change Methodologies
- 6.3 Standardize Change Management Solution
- 7.1 Governance for IT Management Duties and Operations

Work Description:

Provide a third-party Network Specialist to manage scope and tasks for build-out completion of the Northern Ring Fiber Project. Provide expertise and management on the needed fiber swaps to support project objectives for GWA and GPA. As part of this work, they would develop drawings (Infrastructure and Data Flow) to a defined standard for GPWA. All project management (scope, schedule, cost) and change management (communications, training) tasks would reflect the anticipated standard for the new GPWA IT organization. Development of operational standards would contribute to the definition of IT Management Duties and Operation of the fiber network for both GWA and GPA.

Scenario 4: Buildout of Disaster Recovery Sites

Primary Recommendation: 4.9 Buildout of Disaster Recovery Sites

Supporting Recommendations:

- 4.1 Robust Set of Infrastructure and Data Flow Diagrams
- 7.2 Program / Project and Organizational Change Methodologies
- 6.3 Standardize Change Management Solution
- 7.1 Governance for IT Management Duties and Operations

Work Description:

Provide a third-party Network Specialist to manage scope and tasks for build-out completion of the Disaster Recovery sites working with GPA and GWA. Provide expertise and management on the infrastructure and management of third-party service providers to support project objectives for GWA and GPA. As part of this work, they would develop drawings (Infrastructure and Data Flow) to a defined standard for GPWA. All project management (scope, schedule, cost) and change management (communications, training) tasks would reflect the anticipated standard for the new GPWA IT organization. Development of operational standards would contribute to the definition of IT Management Duties and Operation of the disaster recovery sites for both GWA and GPA.

Scenario 5: Baseline Cyber Security Controls

5.2 Baseline Cyber Security Controls

Primary Recommendation:

Supporting Recommendations:

- 10 7.2 Program / Project and Organizational Change Methodologies
- 8 6.3 Standardize Change Management Solution
- 9 7.1 Governance for IT Management Duties and Operations

<u>Work Description:</u>

Provide a third-party Cyber Security Specialist to develop updates to policies and procedures in collaboration with GPA and GWA IT Security personnel on implementation of joint cyber security controls. All project management (scope, schedule, cost) and change management (communications, training) tasks would reflect the anticipated standard for the new GPWA IT organization. Development of templates, operational standards and other documentation would contribute to the definition of IT Management Duties and Operation for cyber security for both GWA and GPA.

Scenario 6: Renew GIS Solution for GWA

Primary Recommendatior

- 7 6.2 Renew GIS Solution for GWA

Supporting Recommendations:

- 10 7.2 Program / Project and Organizational Change Methodologies
- 9 7.1 Governance for IT Management Duties and Operations

<u>Work Description:</u>

Provide a third-party Project Manager / Specialist to manage scope and tasks for renewal of the GIS license for GWA while also reviewing the GPA terms and conditions of their agreement. All project management (scope, schedule, cost) and change management (communications, training) tasks would reflect the anticipated standard for the new GPWA IT organization. Coordination with GPA would be accomplished for developing a common GIS agreement with ESRI with goals of a future joint architecture between GPA and GWA.

In reviewing the playbook, we could forecast that Scenarios 1 and 6 could be supported in parallel by a single third-party Project Manager / Specialist. Scenarios 2,3, and 4 could be supported in parallel by a single third-party Network Specialist. Scenario 5 would require a dedicated cyber security specialist working with GPA and GWA IT security personnel.

As mentioned before, these scenarios with their supporting recommendation could start immediately for GPA and GWA.

11. Appendix A – Scope of Work

Scope of Work

The IT Integration Study & Plan was broken down into a logical flow seven step execution plan that spanned the effort. Sheffield, GPA and GWA worked together in a collaborative manner to obtain desired results with the information that was available.

Step 1 - Initiate Project & Document Requests

Sheffield requested existing documentation supporting the GPA and GWA technology. Organizational diagrams, job descriptions, 5-year plans with capital project lists, network diagrams, policies and procedures, application & tool inventory, cybersecurity plans, data center configuration and support processes, business continuity & disaster recovery plans were included in this data request. The documents were reviewed, analyzed, and categorized into a document library for use during the study.

Deliverable(s):

- GPA / GWA IT Network Integration Study Document Inventory

Step 2 - Performed Review & Analysis of the Network Infrastructure of GPA & GWA (IT / OT)

Analyzed current network topology, supporting technologies, and processes for GPA and GWA

Sheffield conducted a review of the data center with elements (links, nodes, etc.) of the GPA communication network supporting business (IT) and operational systems (OT) including SCADA within GPA. Wired (Fiber, coax, twisted pair and other) and Wireless (Microwave, Cellular, Satellite and other) were analyzed for applicability and utilization. The results were defined in a workbook for use in future analysis supporting merger and integration opportunities for the network.

Deliverable(s):

- Network Analysis Workbook for GPA
- Network Analysis Workbook for GWA

Determined the required modernization of the IT Enterprise Level Architecture interface needs for the two organizations

Sheffield reviewed the current technology and infrastructure to see if the business model remained relevant. As part of the review Sheffield looked at the operational and IT department people, process, technology, and governance silos. Additionally, they conducted an in-depth analysis of core business processes, technology stacks, and administration to understand the current managed eco-system.

Deliverable(s):

- Report on IT Department Modernizing Areas of boundary and interface

IT GPA & GWA external providers

Sheffield looked at the federated IT infrastructure and the level of current and required centralized IT departments and the decentral IT Department and redundancies of people, process, technology, and governance with a focus on low costs of overhead with a focus on merger of external providers of IT services and related third party vendor risks and workflows.

Deliverable(s):

- List of all External IT Providers

Determined maturity levels, conducted gap analysis, and defined areas of opportunity for network integration

As a result of the analysis, appropriate maturity levels were assessed against IT Service Management (ITSM) Best Practice areas for data center operations. The network topology was gapped against the Purdue network model for efficiency and effectiveness. Business continuity and Disaster Recovery requirements were incorporated into the analysis. This task was completed for GPA, GWA and a combined GPWA network scenario.

Deliverable(s):

- GPA Gap Analysis with Maturity Levels Report
- GWA Gap Analysis with Maturity Levels Report
- GPWA recommended data center and network future state network architecture

Step 3 - Performed Review & Analysis of Security Policies, Programs, Plans, Processes, and Procedures of GWA & GPA

Performed As-Is / To-Be IT and cyber security operational controls capabilities and maturity (Gap Analysis)

Sheffield conducted a review of existing cyber security policies, standards organizational responsibilities, and cybersecurity plan for GPA and GWA and analyzed As-Is and To-Be cyber security capabilities and maturity (Gap Analysis). Additionally, the current Implementation of NIST Cyber Security Framework using the NIST 800-53 Controls along with applicable industry regulations (DHS, NERC, Other) and review current Security education and awareness for GPA and GWA were assessed.

Deliverable(s):

- Cybersecurity Gap Analysis and Maturity Report for GPA
- Cybersecurity Gap Analysis and Maturity Report for GWA

Step 4 - Review of infrastructure and Applications Portfolio for GPA & GWA

Analyzed tool & application inventory, governance, and support for GPA and GWA

Sheffield confirmed the tools and application inventory and its related support for network, business, and operational systems (e.g. Oracle CC&B, Financials, JD Edwards, Siemens, CISCO, Netgear, SPLUNK, SolarWinds, Human Resource & Payroll, Email (Exchange Server for GPA and Hosted Environment for GWA), Microsoft Office & Network tools, GIS / ESRI, Bentley, Landis & Gyr, Mobility platforms and others) for on-premise and third-party hosted systems. The applications and tools were mapped to their business functions for comparison between the GPA and GWA. A review of supporting license agreements, on-going certification & training for the tools and applications was conducted to understand economic impacts and integrated opportunities. Identification of support personnel and data owners was documented to understand the footprint for the application or tool.

Deliverable(s):

- GPA / GWA Application & Tools Inventory and Analysis

Prepared opportunities and recommendations for application and IT tool integration for GPWA

Based on the review and analysis of the GPA / GWA application and tool inventory, Sheffield performed an analysis to identify areas of overlap and gaps to the tools and applications utilized by GPA and GWA. The analysis utilized findings from the analysis of the network topology and cybersecurity areas to determine opportunities and recommendations for integration between GPA and GWA systems.

Deliverable(s):

- GPA / GWA Application & Tools Inventory Opportunity Report

Step 5 – Perform Organizational Analysis of GPA & GWA IT integration into GPWA

Reviewed organizational structure and HR policies for GPA and GWA

Sheffield reviewed and analyzed existing business charters and organizational structures for the GPA and GWA IT organizations and OT, areas as applicable, to conduct the analysis work. Job descriptions, human resource policies, labor agreements, salary structures, skills, and responsibilities were reviewed and categorized into common attributes for analysis.

Deliverable(s):

- GPA / GWA IT Organizational Analysis

Performed Organizational / IT Alignment Prioritization for GPWA

The results of the GPA / GWA IT Organizational Analysis were used with the results of the GPA / GWA Application & Tools Inventory Opportunity Report, Cybersecurity Gap Analysis and Maturity Report for GWA & GPA and GPWA Network Infrastructure Design Report to develop the prioritization of a consolidated GPWA IT organization. Reviews for ITIL based Best Practices and other standards were incorporated into the analysis. Areas of opportunity with maturity ratings were defined and mapped to support the overall roadmap development for the organization.

Deliverable(s):

- GPWA IT Organizational Alignment & Prioritization Analysis

Step 6 - Create Consolidated Network, IT Policies and Operations Design (Technical)

Prepared preliminary consolidated network infrastructure architecture for GPA / GWA

The review and analysis of the network infrastructure, applications, tools, and cybersecurity areas provided input to the preliminary design of the future state architecture for a combined GPA and GWA infrastructure. Sheffield developed a recommended draft report for the technical aspects of a unified infrastructure supporting GPWA. The analysis provided a listing of recommended projects and an implementation logic.

Deliverable(s):

- GPA / GWA Preliminary Network Infrastructure Design and Project Sequence

Conducted workshop to GPA / GWA on consolidated architecture for technology & operational processes

The results of the Preliminary Network Infrastructure Design were socialized with GPA and GWA IT stakeholders and then a workshop was facilitated by Sheffield to confirm assumptions and vetting of the technical design for a GPWA network as a common goal for both organizations.

Deliverable(s):

- GPA / GWA Workshop Meeting Results

Prepared recommended consolidated network infrastructure architecture for GPA / GWA

The results of the Network Infrastructure Design workshop were reviewed and incorporated into a final version of the GPWA Network Infrastructure Design for use in the road mapping and cost benefit areas of the study and plan.

Deliverable(s):

- GPWA IT Network Integration Study Infrastructure Design Report

Step 7 - Developed & Delivered Roadmap and Final Report for GPA & GWA IT Integration

a) Developed Benefit Analysis Report for GPWA

Sheffield prepared a benefit analysis based on the information captured related to technical, process, people, and financial aspects of the IT area. The analysis included a review of aging critical network infrastructure and information technology, the application of a risk-based management and prioritization of capital costs, including a pro-active/pre-emptive approach to increasing standards and regulations, key automation and mobility initiatives and labor efficiencies were attributes of the benefit analysis. The benefit analysis contributed to the roadmap project efforts within the final report.

Deliverable(s):

- GPWA IT Network Integration Study & Plan Benefit Analysis

Developed Draft Version of IT Network Integration Study & Plan Roadmap and Final Report

Sheffield merged all aspects of the study deliverables which includes:

- GPWA recommended data center and network future state network architecture
- GPA / GWA Preliminary Network Infrastructure Design and Project Sequence
- Cybersecurity Gap Analysis and Maturity Report for GPA and GWA
- GPA / GWA Application & Tools Inventory Opportunity Report
- GPWA IT Alignment Prioritization Analysis
- GPWA Benefit Analysis

The roadmap consists of a multi-workstream project layout with supporting descriptions for people, process, and technology projects based on a business prioritization and cost basis. The executive summary precedes the main body of the report for the highlighting of study results, risks, assumptions, benefits and resulting actions for the IT area.

Deliverable(s):

- GPWA IT Network Integration Study & Plan Roadmap and Final Report (DRAFT)

Reviewed & Socialized Final Report with Key Stakeholders in GPA and GWA

The GPWA Roadmap and Final Report were socialized with Sponsors and key stakeholders within GPA and GWA. This effort supported the understanding of the content, recommendations, and actions resulting from the study.

Deliverable(s):

- GPWA Roadmap and Final Report (DRAFT Updates)

Conducted Final Presentation to CCU

Sheffield prepared an Executive presentation of the GPWA Roadmap and Final Report and presented it to the CCU in Guam for action. Upon completion of the CCU Executive Presentation, the GPWA Roadmap and Final Report were packaged and issued to GPA and GWA Sponsors.

Deliverable(s):

- GPWA Roadmap and Final Report – Executive Presentation
- GPWA Roadmap and Final Report (FINAL)

12. Appendix B – Security Policies and Procedures

12.1.1. Governance Program Development Process Flow

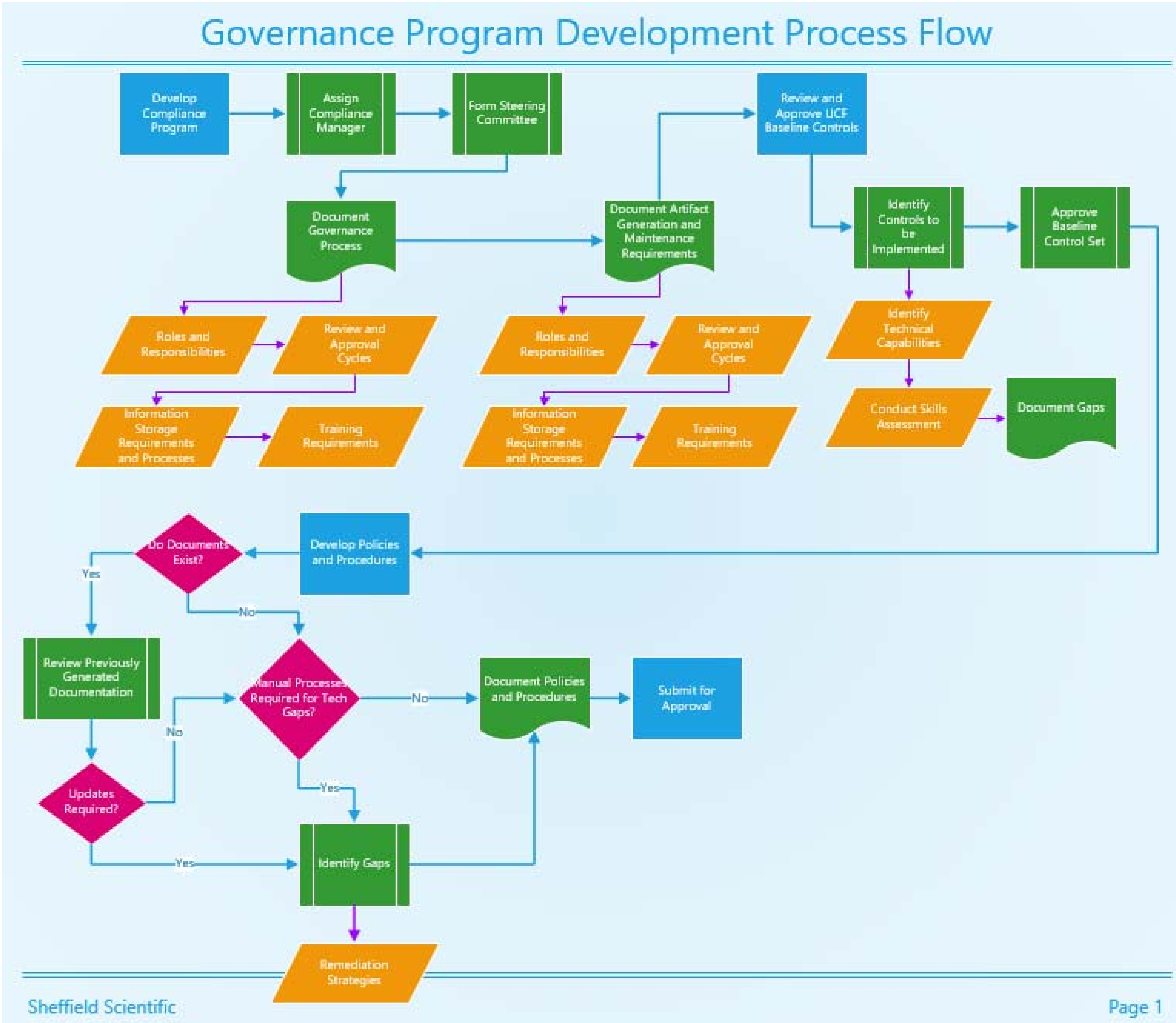


Figure B-1: Governance Program Development Process Flow

13. Appendix C – Document Inventory

The following is the list of documents captured from GWA and GPA in supporting the IT Integration Study & Plan.

Guam Power Authority (GPA)						
Item #	Type	File Name	Number	Revision / Version	Date	Description
1	Worksheet	GPA-CISCO-inventory_2018-03-14_rev1.2.xlsx	None	1.2	08/04/20	None
2	Plan	Guam Power Authority Cyber Security Plan - BV.pdf	None	1.06	10/03/11	Document has not been reviewed or updated since 2011. Corresponding policies and procedures require development.
3	Policy	GPA Policy Directive on Cyber Security Policy_Final_9_28_2011.docx	CS Policy-Utilities-1	1	09/23/11	Document has not been reviewed or updated since 2011. Corresponding policies and procedures require development. Policy is not enforced.
4	Policy	GPA Policy Governance Final 8_8_2011 1.docx	GOV-Utilities-1	1	09/19/11	Document has not been reviewed or updated since 2011. Policy is not enforced.
5	Policy	GPA Policy Directive on Risk Assessment 9_23_2011 (2).docx	RA-Utilities-1	1	10/12/11	Document has not been reviewed or updated since 2011. Policy is not enforced.
6	Policy	GPA Utilities Policy Directive on Media Protection 08052011 (3).docx	SA-UTILITIES-1	1	10/01/11	Document has not been reviewed or updated since 2011. Policy is not enforced.
7	Policy	GPA System and Service Acquisition Directive 09232011 (1).docx	IPP-UTILITIES-1	1	10/01/11	Document has not been reviewed or updated since 2011. Policy is not enforced.
8	Procedure	GPA Procedure on SDLC (1).docx	SYSTEM DEVELOPMENT LIFE CYCLE (SDLC) - Utilities-1	1	08/12/11	Document is draft and has not been reviewed or updated since 2011. Procedure not in use.
9	Policy	GPA Policy Directive on Personnel Security 8_8_2011 (2) (3) - JLQ comments (2).docx	PS-Utilities-1	1	10/03/11	Document has not been reviewed or updated since 2011. Policy is not enforced.

Guam Power Authority (GPA)						
Item #	Type	File Name	Number	Revision / Version	Date	Description
10	Policy	GPA Configuration Management Policy Directive draft v.99.1ver3.docx	CC-Utilities-1	1.3	10/14/11	Document has not been reviewed or updated since 2011. Policy is not enforced.
11	Form	ChangeControlForm.doc	Support Services Change Control Request & Implementation Plan	None	10/10/11	Not actively used.
12	Policy	FINAL DRAFT Data BackUp POLICY_2.1.2020 (1).docx	None	None	02/01/20	Document is in draft and not in effect.
13	Procedure	FINAL Draft SOP108 End User Access Controls 2.17.20 (1)	SOP-108	None	02/17/20	Document is in draft and not in effect. Provides partial accounting of supporting documentation needed for access control.
14	Procedure	FINAL DRAFT Data Center Security SOP 2.04.2020	None	None	02/04/20	Document is in draft and not in effect.
15	Procedure	SOP-099 Information Technology Asset Procurement Guidelines and Disposal	SOP-099	None	08/28/19	Missing key elements of NIST SA including security requirements and documentation requirements.
16	Procedure	SOP-142 Information Data Classification, Impacts and Responsibilities	SOP-142	None	08/28/19	Covers information protection area of RA at a high level. Could be more comprehensive.
17	Procedure	SOP-150 Network and Data System Access	SOP-150	None	01/02/19	High level network access policy. Needs to be supported by procedures.
18	Procedure	SOP-163 Password Creation and Protection Policy	SOP-163	None	05/07/18	Covers user level password policies such as length, special characters, use of common names/words.
19	Procedure	SOP-166 Portable and Removable Media Guidelines	SOP-166	None	02/10/20	High-level policy for removable media use on GPA assets.

Guam Power Authority (GPA)						
Item #	Type	File Name	Number	Revision / Version	Date	Description
20	Procedure	SOP-167 Laptop and Mobile Devices	SOP-167	None	02/13/20	High-level procedure for mobile device issuance, security standards for mobile devices, and software policy.
22	Report	GPA FY20Q3Quarterlystaffingpattern	None	None	07/22/20	Staffing report -3rd quarter FY2020. Required by law.
23	Job Description	Application Support Supervisor	None	None	11/12/18	(in progress of getting created)
24	Job Description	Infrastructure Support Supervisor	None	None	05/12/97	(in progress of getting created)
25	Job Description	Information Security Administrator	None	None	06/01/07	(Existing)

Figure C-1: GPA Documentation List

Guam Water Authority						
Item #	Type	File Name	Number	Revision / Version	Date	Description
1	Form	Operations-Service-Request-Form-Fillable.pdf	None	None	None	Covers basic user setup and removal
2	Form	User-Access-Request-Form-Rev-Fillable.pdf	None	None	None	Covers new badging and some systems.
3	Form	Software Installation Request.pdf	None	None	None	No list of approved software included.
4	Form	GWA-Confidentiality-and-Non-Disclosure-Agreement Fill.pdf	None	None	None	None

Guam Water Authority						
Item #	Type	File Name	Number	Revision / Version	Date	Description
5	Form	Networking-Service-Request-Form-Fillable.pdf	None	None	None	Includes maintenance, installation, services, and vpn access. Should have some means to categorize by type of request.
6	Form	Lucity User Access Request - REVISED_Fillable.pdf	None	None	None	None
7	Worksheet	Business Process Owners.xlsx	None	None	None	None
8	Worksheet	Password Settings.xlsx	None	None	None	Polices for CC&B, Oracle JDE, Orion, and Lucity
9	Procedure	SOP-1200-IT-002, Network & Data System Access.pdf	SOP-1200-IT-002	A	12/10/19	Policy does not cover all areas of access control
10	Procedure	SOP-1200-IT-001, Password Creation & Protection.pdf	SOP-1200-1T-001	A	12/10/19	Policy is well documented.
11	Worksheet	Information Technology Personnel Contact.xlsx	None	None	None	None
12	Report	GWA 2018-Annual-Report-v4_FINAL.pdf	None	None	3/27/19	None

Guam Water Authority						
Item #	Type	File Name	Number	Revision / Version	Date	Description
13	Policy	Cyber Security Policy.pdf	1	1.00	7/28/17	2017 cybersecurity policy reflects that in in combination with associated policies, procedures and artifacts will constitute the plan, however not all supporting documentation was provided.
14	Procedure	SOP-1200-IT-003, Information Technology & Data Center Security.pdf	SOP-1200-IT-003	A	12/10/10	Covers media sanitization at a high level. Needs additional information and supporting controls
15	Procedure	SOP-1200-IT-004, Acceptable Use of Information Technology.pdf	SOP-1200-IT-004	A	12/10/19	Should be updated to include more details
16	Guideline	USB Storage Device Exception.pdf	None	None	None	None
17	Job Description	Programmer Analyst.pdf	2.641	None	3/1/91	None
18	Job Description	Systems and Programming Administrator.pdf	2.675	None	9/1/11	None
19	Policy	SOP#GM120 Physical Security and Access Control System.pdf	SOP-GM-120	None	4/19/16	Policy does not fully cover NIST PE-3 controls. Last reviewed and updated 2016

Guam Water Authority						
Item #	Type	File Name	Number	Revision / Version	Date	Description
20	Job Description	Network Systems Administrator.pdf	None	None	3/1/08	None
21	Job Description	Information Technology Manager.pdf	None	None	3/1/08	None
22	Job Description	Computer Operator II.pdf	0.515	None	7/1/80	None
23	Job Description	Information Security Administrator.pdf	2.671	None	1/8/13	None
24	Job Description	Computer Operator III.pdf	0.518	None	7/1/80	None
25	Diagram	GWA Backbone 2020 with no IP.pdf	None	None	8/11/20	None
26	Diagram	IT Organizational Chart.pdf	None	None	8/13/20	None
27	Report	GWA-Citizen-Centric-Report-2019.pdf	None	None	8/1/20	None
28	Worksheet	Guam Interviews sheet from GWA 08052020 MPA.xlsx	None	None	8/14/20	None
29	Worksheet	Copy of Copy of Balances with	None	None	8/20/20	None

Guam Water Authority						
Item #	Type	File Name	Number	Revision / Version	Date	Description
		Budgets_FY 19 five year 08202020 (3).xlsx				
30	Table / Picture	GWA Application Support System.JPG	None	None	44063	None
32	Report	GWA FY2020-Q2-Q3-Transmittal-Staffing-Report-to-Guam-Legislature-mcb-signed	None	None	44043	Covid 19 staffing report
33	Plan	GWRMPU_Vol1OverviewandFundamentals_FINAL_201808	None	Volume 1	43313	Water Resources Master Plan-Prepared by Brown and Caldwell
34	Report	2020-2-27-GWA-Docket-19-08-Rate-Decision	None	None	43888	Rate case 2020
1	Form	Operations-Service-Request-Form-Fillable.pdf	None	None	None	Covers basic user setup and removal

Figure C-2: GWA Documentation List

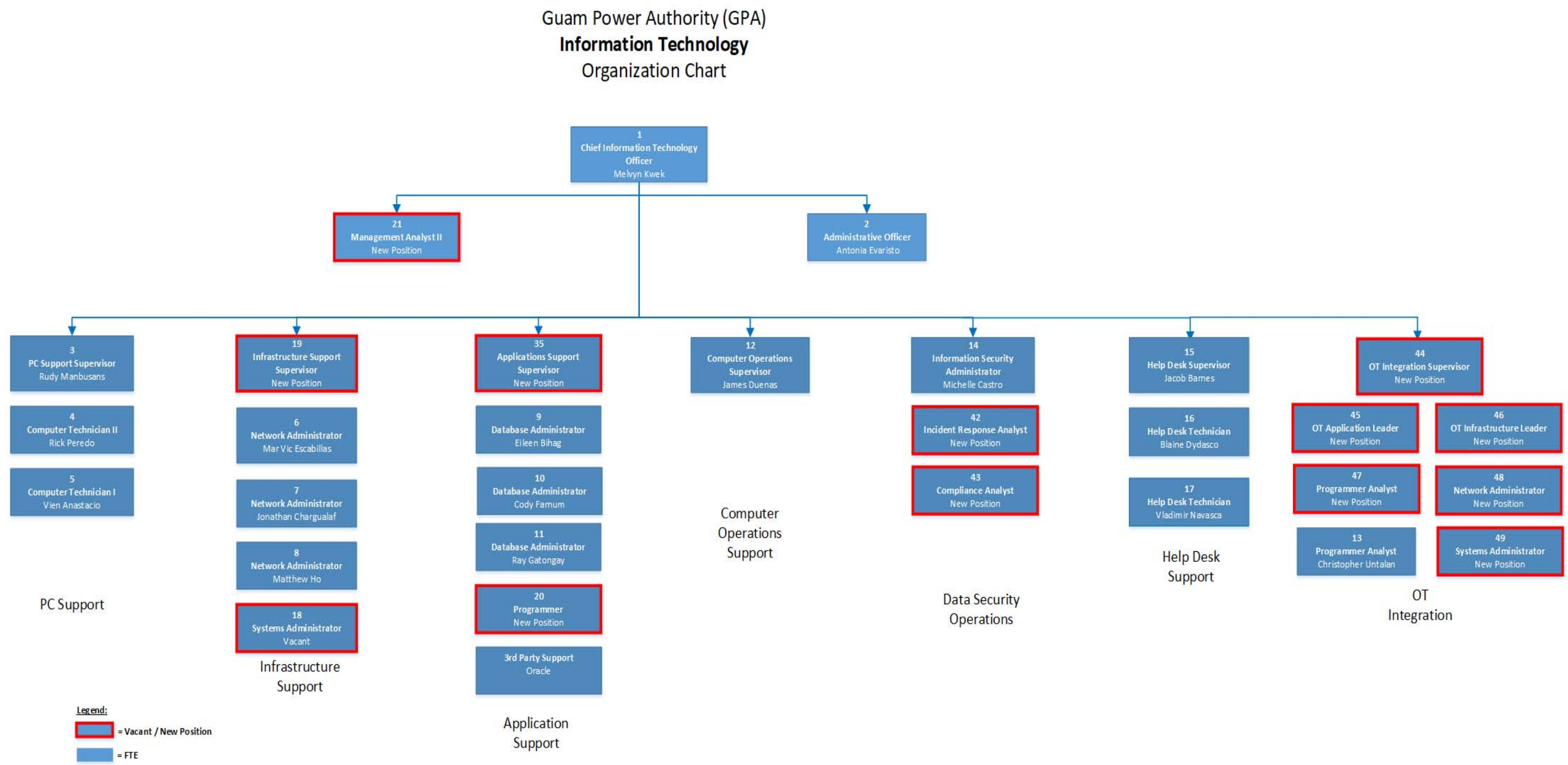
14. Appendix D – Interview List

The following is the interview listing from GWA and GPA in supporting the IT Integration Study & Plan.

#	Organizatio	Interview	Date	Time	Topic
1	GPA	Eileen Behag Meeting Minutes Merged	08/12/20	9:00 AM ?	IT Interview Questions Discussion
2	GPA	Rey Gatongay Meeting Minutes	08/12/20	10:00 AM ?	IT Interview Questions Discussion
3	GPA	Jonathon Chargualaf Meeting Minutes	08/13/20	10:00 AM ?	IT Interview Questions Discussion
4	GPA	Cody Farnum Meeting Minutes	08/14/20	10:00 AM ?	IT Interview Questions Discussion
5	GPA	Mar Vic Escabillas Meeting Minutes	08/14/20	9:00 AM ?	IT Interview Questions Discussion
6	GPA	Matthew Ho Meeting Minutes	08/14/20	9:00 AM ?	IT Interview Questions Discussion
7	GWA	Manny Apuron Meeting Minutes	08/20/20		IT Interview Questions Discussion
8	GWA	Ely Torres Meeting Minutes	08/24/20		IT Interview Questions Discussion
9	GWA	Anthony Cedeno Meeting Minutes	08/24/20		IT Interview Questions Discussion
10	GWA	Manny Apuron Meeting Minutes	08/28/20	10:00 AM CHsT	IT Interview Questions Discussion-Questionnaire
11	GPA	Melvin Kwek	08/28/20	[illegible]:00 AM CHsT	IT Interview Questionnaire-Completed 8/31/20
12	GPA	Melvin Kwek Meeting Minutes	09/01/20		Governance Meeting Minutes
13	GWA	GPWA Senior Management Finance Questionnaire - 090820 v2 D3	09/08/20		Executive Governance
14	GWA	Lou Palomo Meeting Minutes	09/09/20		Governance Meeting Minutes
15	GWA	Geigy Salayon	09/10/20	2:30 PM CHsT	Senior Management Questionnaire-Asset Management-Operations
16	GWA	Lisa San Agustin	09/10/20	2:00 PM CHsT	GPWA Senior Management CIS Questionnaire - 091020 v1 - D3
17	GWA	Miguel Bordallo	09/11/20	8:00 AM CHsT	GPWA Senior Management GM Questionnaire - 091120 v1 - D3
18		Barbara Cruz, Bret Railey	09/11/20	2:00 PM CHsT	GPWA Senior Management Engr Questionnaire - 091120 v1 - D3
19	GWA	Manny Apuron	09/17/20		Assessment Findings
20	GPA	John Cruz	09/18/20	6:30 AM CHsT	AGM-Engineering and Technical Services
21	GPA	Beatrice Limtiaco	09/24/20	11:00 AM CHsT	AGM-Administrative discussion
22	GPA	Artemio Perez	09/24/20	9:00 AM CHsT	Communications
23	GPA	Roger Pabunan, Norbert Madrazo	09/25/20	10:00 AM CHsT	Senior Management Questionnaire-Planning and Regulatory
24	GPA	Joven Costa, Vince Sablan, Antonio Gumatoatoa	09/25/20	9:00 AM CHsT	Engineering discussion
25	GPA	John Kim Meeting Minutes	09/25/20	2:00 PM CHsT	Executive Governance CFO Interview Deck
26	GPA	Jennifer Sablan, Roel Cahinhinan, Francis Iriarte, Lorraine Shinohara, Harvey Comacho, Josi Aguon, Antonio Gumataotoa, Manuel Minas	09/29/20	9:00 AM CHsT	E&TS Team
27	GPA	Melinda Mafnas	09/30/20	1:00 PM CHsT	AGM-Operations
28	GPA	Graham Botha	10/01/20	10:30 AM CHsT	Staff Attorney-Legal
29	GPA	John Benevente	10/06/20	7:00 AM CHsT	Senior Management Questionnaire- General Manager
30	GPA	Norbet Madrazo, Roger Pubunan	09/25/20	10:00 AM CHsT	Enviornmental

Figure D-1: GPA / GWA Interview List

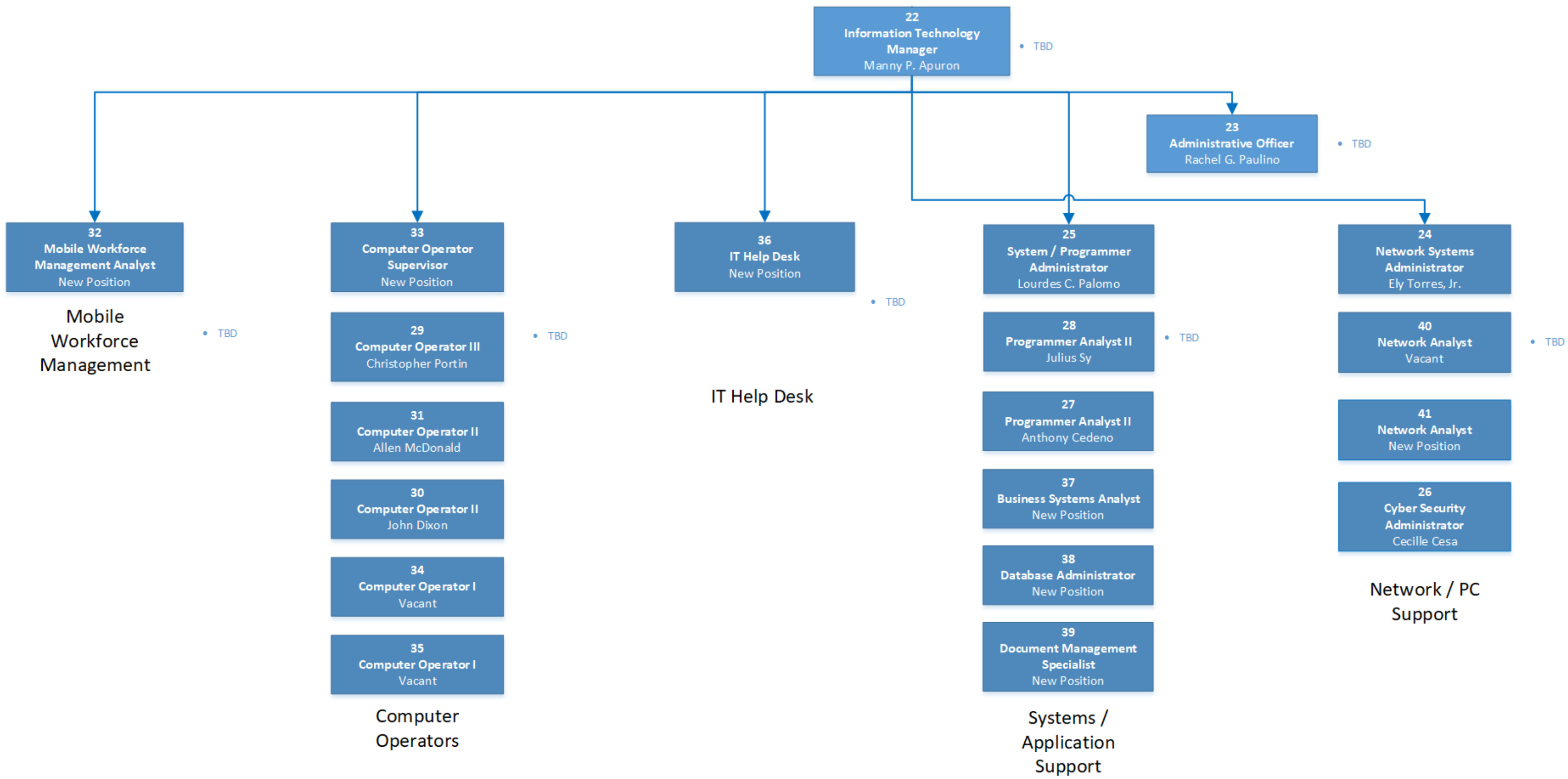
15. Appendix E - Current State Organizational Charts



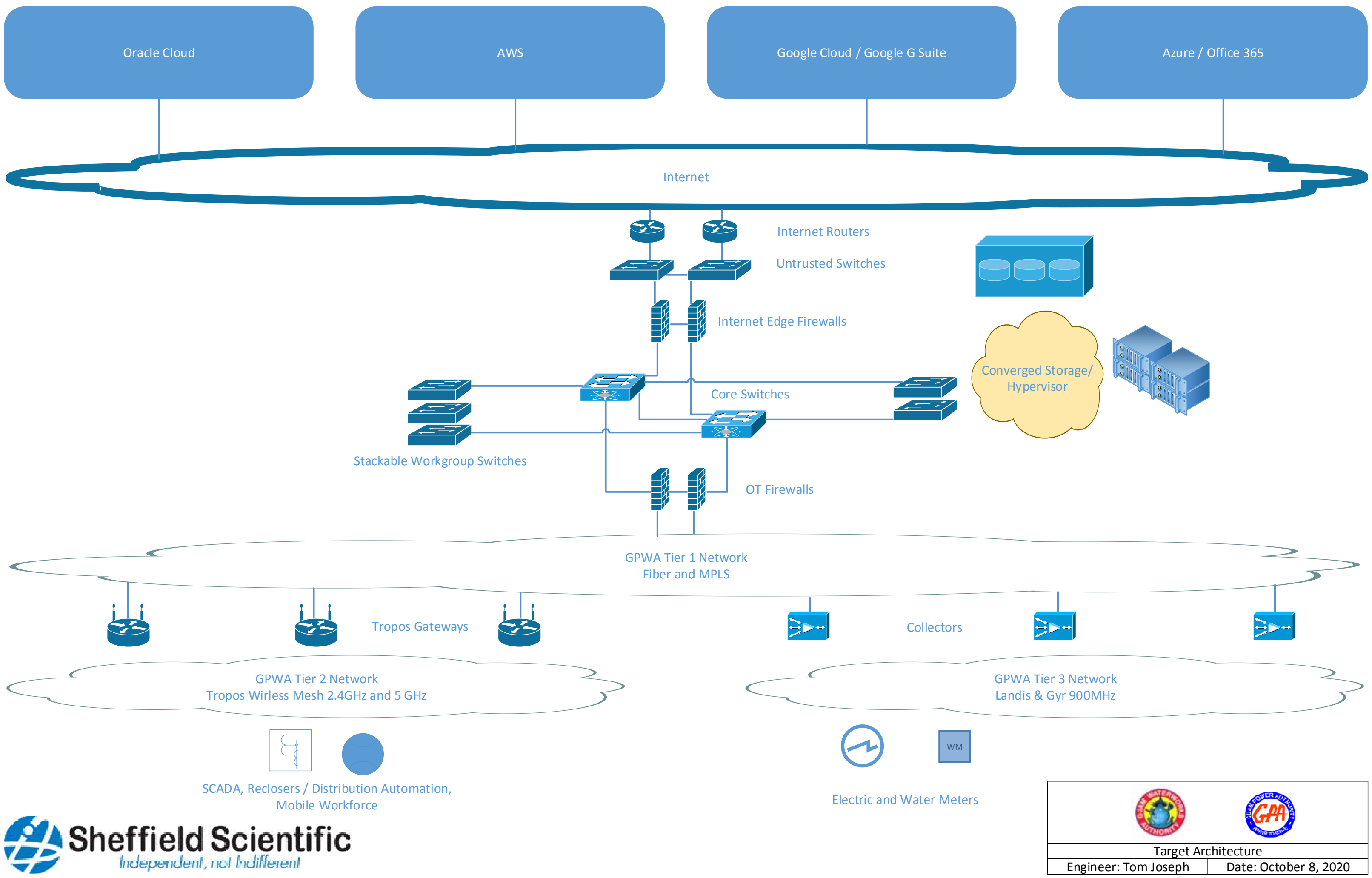
Guam Water Authority (GWA)

Information Technology

Organization Chart



16. Appendix F - Future State Network Diagram



17. Appendix G - Acronyms & Glossary

Acronyms

Term	Description
AWWA	American Water Works Association
BCP	Business Continuity Plan
CC&B	Customer Care and Billing (Oracle)
CCU	Consolidated Commission on Utilities
CIO	Chief Information Officer
CIS	Customer Information System
CITO	Chief Information Technology Officer
CMDB	Change and Configuration Management Database
CMMI	Capability Maturity Model Integration
GPA	Guam Power Authority
GPWA	Guam Power and Water Association
GWA	Guam Water Authority
HR	Human Resources
IP	Internet protocol
IT	Information Technology
ITIL	Information Technology Infrastructure Library
ITM	Information Technology Management
ITSM	IT Service Management
JDE	JD Edwards
MAC	Media Access Control
NERC	North American Electric Reliability Corporation
NIST	National Institute of Standards and Technology
OT	Operation Technology
POA&M	Plan of Actions and Milestones
RA	Risk Assessment
SCADA	Supervisory Control and Data Acquisition
SGSN	Smart Grid Systems and Networks
SME	Subject Matter Expert
SOP	Standard Operating Procedures
UCF	Unified Control Framework
VA	Vulnerability Assessment
VPN	Virtual Private Network

Glossary of Terms

Term	Description
American Water Works Association	International non-profit, scientific and educational association founded to improve water quality and supply
Business Continuity Plan	Defines how a business will operate during an interruption.
Customer Care and Billing	Application supporting customer information-service connections such as meter reads, rating, and billing
Change and Configuration Management Database	Stores information about hardware and software assets and their applied configurations
Capability Maturity Model Integration	Process level improvement training and appraisal program
Denial of Service	Type of attack on a service that disrupts its normal function and prevents other users from accessing it.
Internet protocol	The principal communications protocol in the Internet protocol suite for relaying datagrams across network boundaries
Information Technology Infrastructure Library	A set of detailed practices for IT service management that focuses on aligning IT services with the needs of business
IT Service Management	Activities performed by an organization to design, plan, deliver, operate, and control information technology services offered to customers
JDE	Enterprise Resource Planning Software
Media access control	Network data transfer policy that determines how data is transmitted between two computer terminals through a network cable
North American Electric Reliability Corporation	Agency tasked with ensuring the reliability of the North American electrical grid
Plan of action and milestones	Risk tracking and mitigation monitoring document
Risk Assessment	A process to identify hazards and risks, and analyze the risk associated with the hazard or risk
Supervisory Control and Data Acquisition	A control system architecture comprising computers, networked data communications and graphical user interfaces (GUI) for high-level process supervisory management, while also comprising other peripheral devices like programmable logic controllers (PLC) and

Term	Description
	discrete proportional-integral-derivative (PID) controllers to interface with process plant or machinery
Unified Control Framework	A way to identify common controls between multiple standards or regulating bodies
Vulnerability Assessment	The process of identifying, quantifying, and prioritizing the vulnerabilities in a system
Virtual Private Network	Extends a private network across a public network and enables users to send and receive data across shared or public networks as if their computing devices were directly connected to the private network

18. Appendix H – Support Information (Volumes 2 – 7)

Volume 2 - Cost Benefit Business Case

Volume 2: Cost Benefit Workbook (Electronic) with project and benefit details.

Volume 3 - GPWA
ITSM Org Maturity M

Volume 3: Organizational Maturity Analysis (Electronic)

Volume 4 - GWA-GPA
Unified Control Frame

Volume 4: Cyber Security Unified Controls Framework Workbook (Electronic)

Volume 5 - Guam
Gap Assessment Wor

Volume 5: GPWA Technical Controls Gap Assessment Workbook (Electronic)

Volume 6 - Guam
SkillsMatrix Combin

Volume 6: Skills Matrix with Cost Basis (Electronic) with Histograms

Volume 7 - Skills
Matrix Combined Le

Volume 7: Skills Matrix Combined Level 2 Analysis

2022 Integrated Resource Plan Volume VII:

Strategic Plan

10/27/2021

LORRAINE O. SHINOHARA, P.E. DATE

ENGINEERING SUPERVISOR

STRATEGIC PLANNING & ENERGY CONTRACTING

10/28/21

JENNIFER G. SABLAN, P.E. DATE

STRATEGIC PLANNING & OPERATIONS RESEARCH MANAGER

10/28/2021

JOHN J. CRUZ JR., P.E. DATE

ASSISTANT GENERAL MANAGER

ENGINEERING & TECHNICAL SERVICES

11/1/2021

JOHN M. BENAVENTE, P.E. DATE

GENERAL MANAGER

GUAM POWER AUTHORITY

Table of Contents

1 Introduction

The 2021 Strategic Plan is a living document. It also has a historical context building upon prior work and understanding. This body of work includes work performed with Virchow Krause and later Baker Tilly from 2007 to 2012, internally led Strategic Planning sessions from 2015 through 2018, and insights garnered through critical observation and research.

Strategic planning is "a mechanism for stimulating disciplined thought"[1] and gaining understanding. And, from that understanding come to "an iterative series of decisions that add up over time."[2] These iterative series of decisions that add up over time create meaningful and purposeful direction. It is really about the process of planning and less the plans generated from the process. A list of projects is not a strategic plan.

Strategic planning is the basis for other planning. In the 2022 Integrated Resource Plan consists of nine volumes investigating various technical aspects of GPA. All of these investigations carried out in these volumes have their roots in the Strategic Plan.

2 Strategic Planning Approach

The 2021 Strategic Plan works on the GPA mission and vision statements and the ever-present SWOT analysis. However, it also folds in strategic planning concepts and methods from Jim Collins (*Good to Great*) and Michael Porter (*What is Strategy?*). It also uses "Theory of Change" and "Zap the Gaps" concepts to help define how we get from the "right now" to our desired outcomes. Rick Davies defines a theory of change as: "The description of a sequence of events that is expected to lead to a particular desired outcome"[3]

This provides a rich analytical framework to understand GPA and the environment it competes in.

3 Where Are We Going and How Do We Get There?

At the end of the next 10 years, GPA will:

- Eliminate Underfrequency Load Shedding and Non-Major Storm Power Outages

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[1] Jim Collins.(2017). The Role of Strategic Planning as a Mechanism for Disciplined Thought. URL: https://www.jimcollins.com/media_topics/TheRoleOfStrategicPlanning.html (Last accessed October 12, 2021 12:05 am)

[2] Ibid.

[3] Rick Davies, April 2012: Blog post on the criteria for assessing the evaluability of a theory of change http://mandenews.blogspot.co.uk/2012/04/criteria-for-assessing-evaluablity-of.html

- Deliver Excellent Power Quality Always
- Ensure Customers Achieve the Highest Economic Levels of Efficiency while Maintaining a High Quality of Life for Themselves
- Delight Customers
- Provide Customers Greater than 50% of their Electric Energy from Renewable Sources
- Operate and Maintain a Highly Resilient Power System
- Achieve Emissions Reductions Below EPA Compliance Requirements
- Reduce GPA Greenhouse Gas Emissions per KWH by over 50% from FY 2012
- Lower Customer Overall Bills by more than 15%
- Minimize the Volatility of LEAC Charges Caused by Fossil Fuels
- Achieve Operational Effectiveness Across All GPA Activities
- Achieve Better than 95% Customer Satisfaction Ratings For GPA as a Company and For GPA Services
- Achieve Better than BBB+ Bond Rating
- Create and Maintain Synergistic Partnerships with GWA, the CCU, PUC, EPA, Customers, and Stakeholders to make Guam a better Place to Live and Work

GPA will achieve the above through:

- Grid Transformation
- Customer Experience Transformation
- Affordability Transformation
- Digital Transformation
- Investments in Foundational Infrastructure.

The following five panels illustrate how GPA will achieve these transformations.

GPA GRID TRANSFORMATION

SOLUTIONS TOWARD A HIGHLY RESILIENT, RELIABLE, AFFORDABLE AND HIGH RENEWABLE ENERGY PRODUCTION GRID

Charge/Discharge-Anytime Battery Energy Storage Systems (BESS) - Provides spinning reserve and frequency regulation. Greatly improves grid response to FIDVR, duck curve ramp ups, and excess solar PV production events. Provides other grid services.

Flexible Efficient Generation - Better follows the changes in demand and available generation online especially when large intermittent sources of power are on the grid. Reduces power rates.

Energy Shifting Battery Energy Storage Systems (ES BESS) - Decreases Excess Solar PV Production Events by storing 100% of energy for nighttime use; Replaces expensive production from peaking generation.

Demand Response (DR) - Adjusts customer demand up or down however needed by the grid.

Synchronous Condensers (SC) - Provides Short-Circuit MVA to power system to keep the grid stable, prevents grid-tied inverter cessation, improves fault response and voltage, and allows GPA grid to operate with 100% renewable energy.

Smart Grid (SG) - Advanced technology for getting the right information to the right people or systems at the right time to make the right strategic and operational decisions.

Energy Efficiency - Energy efficiency has a much higher rate of return than just simply installing solar PV. Putting energy efficiency first lowers energy costs for everyone.

Time-of-Use (TOU) Rates - Provides incentives for customers to change their electricity-use behavior to match the needs of the grid.

Daytime Charging Electric Vehicles (EV) - Prevents curtailment of synchronous generation and solar PV during excessive solar PV production events when solar PV production is high and daytime loads are low. Slows growth of system peak deferring expensive investments for new capacity.

Micrograms - Using synchronous generators and Solar PV + energy-shifting battery energy storage systems with grid forming capability to provide power after natural disasters such as typhoons especially in southern Guam.

Grid Controller - Optimizes all resources to provide the most benefit at the least cost. Improves system stability and system economics.

Solar Irradiance Sensor Network - Provide real-time estimates of solar PV power production. Forecast solar PV power production. Track cloud cover.

System Protection - Improve System Protection to operate in an environment with less synchronous generation and more inverter based resources.

Improving Generator Reliability - Improving GPA generator availability results in serving more load using less generation. It also significantly lowers energy costs.

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GPA CUSTOMER EXPERIENCE TRANSFORMATION SOLUTIONS

Guam Transportation Electrification - As customers switch to electric vehicles, their relationship with GPA becomes more critical. Designing the charging experience to delight customers will improve GPA customer experience.

Energy Efficiency - Energy efficiency has a much higher rate of return than just simply installing solar PV. Customers who get rebates or who have better knowledge of the Energy Sense Appliance Rebate Program do not rate GPA as a company unsatisfactory. Getting rebates is a highly positive customer experience.

Energy Shifting Battery Energy Storage Systems (ES BESS) - Using BESS to provide spinning reserve and frequency regulation improves power quality and reduces customer outages improving the GPA customer experience. GPA addition of renewable energy improves customer satisfaction with GPA as a company.

Smart Grid (SG) - Smart Grid systems can reduce the number of customer outages improving the GPA customer experience.

Conservation Voltage Reduction (CVR) - Reduces distribution system line losses lowering LEAC rates. Reduces customer energy consumption.

Conversion of Manual Customer-Facing Processes to Digital Ones - Customer expectations for service are being driven by the telecom, virtual commerce, and entertainment industries. Going digital improves the GPA customer experience. Going digital includes online payment portals, mobile apps, and Energy Sense online rebate application processing, and more.

Customer Outreach - Customers want to be informed about GPA outages, rates, and other GPA matters. Building this outreach improves GPA's relationships with its customers. It also defuses disinformation.

Energy Sense Program Outreach - Customers want to be informed about energy efficiency, renewable energy, and ways to lower their power bills. Building this outreach improves GPA's relationships with its customers.

GPWA Information/Operations Technology (IT/OT) Consolidation - Reduces IT/OT capital and operating costs for GPA and GWA. Reduces costs passed onto customers.

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GPA AFFORDABILITY TRANSFORMATION SOLUTIONS

Guam Transportation Electrification - Electric vehicles charging from the grid will increase GPA revenues allowing GPA to reduce rates for everyone. Reduces GPA fleet expenses for fuel and maintenance.

Energy Efficiency - Energy efficiency has a much higher rate of return than just simply installing solar PV. Putting energy efficiency first lowers energy costs for everyone.

Improving Generator Reliability - Improving GPA generator availability results in serving more load using less generation. It also significantly lowers energy costs.

Flexible Efficient Generation - Better follows the changes in demand especially when large intermittent sources of power are on the grid. Reduces LEAC rates especially when using natural gas.

Daytime Charging Electric Vehicles (EV) - Slows growth of system peak deferring expensive investments for new capacity resulting in lower future energy costs.

Smart Grid (SG) - Smart Grid systems such as Mobile Workforce Management, Advanced Grid Analytics, Distribution Automation increase work productivity reducing energy costs passed onto customers.

Energy Shifting Battery Energy Storage Systems (ES BESS) - Decreases Excess Solar PV Production Events by storing 100% of energy for nighttime use; Replaces expensive production from peaking generation. Lowers and stabilizes LEAC rates.

GPWA Information/Operations Technology (IT/OT) Consolidation - Reduces IT/OT capital and operating costs for GPA and GWA. Reduces costs passed onto customers.

Conservation Voltage Reduction (CVR) - Reduces distribution system line losses lowering LEAC rates. Reduces customer energy consumption.

LNG Infrastructure and Supply - Greatly reduces fuel costs. Significantly lower greenhouse gas emissions. Enables Guam to bunker large gas-fueled ships. Enables Guam to be a regional natural gas hub. Increases GPA revenue streams that can be used to reduce base rates.

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GPA DIGITAL TRANSFORMATION SOLUTIONS

GPWA Information/Operations Technology (IT/OT) Consolidation - A secure, reliable, and responsive IT/OT infrastructure supported by a skilled and capable staff is critical for supporting GPA's Strategic Transformation.

Smart Grid (SG) - The technology enabler for driving operational improvements and efficiencies. The Smart Grid makes possible the transition of GPA manual processes into information-based, digitally enhanced automated processes. Use of smart controls and sensors improves reliability, resiliency, and affordability.

Creating Organizational Alignment & Fit - Creating a more skilled, resilient, streamlined, and effective organization through process mapping & re-engineering leveraging information and operational technology is the end goal for digital transformation.

Energy Sense Program Outreach - Customer expectations are driven by the customer connection capabilities of the telecom, streaming entertainment, and virtual shopping industries. Building this outreach through relevant content improves GPA's relationships with its customers. The conversion of the manual Energy Sense Rebate Application process to a digital platform supports the objective of digital transformation.

Business Analytics - The Smart Grid, Energy Sense Web-sites, Internet of Things (IOT) and Third-party content providers are creating more data and information that any individual(s) can analyze the business value for GPA. The use of artificial intelligence engines with defined logic provides GPA the ability to respond in a proactive manner to grid conditions to determine the best resolution for customers.

Simulation and the Digital Twin - In response to extreme natural events, the ability to work remotely along with utilize real-time simulation through a Digital Twin of an energy system allows for continuous learning to GPA engineers and operators.

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GPA FOUNDATIONAL INFRASTRUCTURE SOLUTIONS

Human Resource Rebalancing - GPA will soon retire several power plants beginning with Cabras 1&2. GPA must plan to rebalance its workforce considering the displacement of these employees. This must be well in advance of the actual plant retirements.

Grid Transformation Solutions - Without completion of Grid Transformation Projects, the grid will not be stable, reliable, resilient, and affordable.

GPWA Information/Operations Technology (IT/OT) Consolidation - A secure, reliable, and responsive IT/OT organization and infrastructure is critical for supporting GPA's Strategic Transformation.

Creating Organizational Alignment & Fit - Creating a more resilient, streamlined, and effective organization through process mapping & re-engineering. Incorporating and leveraging information technology into business processes creates the digital transformation shift.

Cyber and Physical Security (CAPS) - Secure GPA's cyber resources. Secure GPA substations, power plants, and other critical infrastructure facilities.

Succession Planning - With over 50% of its workforce eligible to retire within five years, GPA must hire and train new employees to take over. GPA must update its job descriptions and eligibility requirements moving these jobs into the 21st century. Many jobs will have changed because of digital transformation and technology.

Smart Grid (SG) - Smart Grid is the grid's information superhighway driving operational improvements and efficiencies.

Aging T&D Infrastructure Replacement - Like all other U.S. power utilities, GPA must plan for replacing its aging infrastructure. GPA should invest in an Asset Management ERP capability to guide and manage the replacement process.

Improving Generator Reliability - Achieving 95% GPA generator availability is a cornerstone for grid resiliency, reliability, and affordability.

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2021 Strategic Plan

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Guam Power Authority Strategic Plan

Vision

VISION

- Core Values
- Vivid Description
- Context Analysis
  - SWOT
  - Porter's Five Forces

- Core Purpose

- Big Hairy Audacious Goals

- Theory of Change
- Zap the Gaps

- Critical Success Factors
- Key Performance Indicators

- Budgeting
- Project Development/Execution

- Process Mapping
- Workflow and Accountability Analysis
- Building Fit

Vision Statement

GPA will be the best utility providing outstanding energy solutions to our island community.

Core Values

- Integrity
- Passion

Core Values Ramifications

- Because We Value Integrity We Conduct Ourselves With:
  - Transparency
  - Accountability
  - Safety
  - Quality
- Our Passion for Customers, GPA, and Guam Fuels Our Advocacy For:
  - Delivering High Quality Services and Product
  - Working Safely
  - Making Power More Affordable

Vivid Description

- We will:
  - Change the landscape of how power is produced and delivered!
  - Overwhelmingly overturn customers' negative perceptions of GPA and delight them!
  - Dramatically reduce pollution on our island!
  - Eliminate power outages and power quality problems!
  - Provide excellent, reliable power service throughout typhoons!
  - Achieve excellent operational effectiveness throughout all GPA activities!
  - Maintain Synergistic Partnerships with GWA, the CCU, PUC, EPA, Customers and Stakeholders to achieve Common Goals and Dramatically Improve the Quality of Life on Guam!
  - Do the right things in the best way by achieving and maintaining strategic focus and clarity on what we provide and do not provide!
  - Earn our Customers' Loyalty

Mission

MISSION

- Core Values
- Vivid Description
- Context Analysis
  - SWOT
  - Porter's Five Forces

- Core Purpose

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- Key Performance Indicators

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- Workflow and Accountability Analysis
- Building Fit

MISSION

Mission Statement

- GPA SHALL provide:
  - R eliable
  - E3 fficient, Effective, Environmentally Sound
  - A2 ffordable, Accountable
  - L eading Energy Solutions

Core Purpose

- GPA's Core Purpose is to enhance customer quality of life by providing affordable, reliable, clean, effective electric service and valuable energy solutions while being completely transparent and accountable to Customers and others who depend on us.

Strategic Objectives

STRATEGIC OBJECTIVES

Big Hairy Audacious Goals

- Over the next 10 years GPA will:
  - Eliminate Underfrequency Load Shedding and Non-Major Storm Power Outages
  - Deliver Excellent Power Quality Always
  - Ensure Customers Achieve the Highest Economic Levels of Efficiency while Maintaining a High Quality of Life for Themselves
  - Delight Customers
  - Provide Customers Greater than 50% of their Electric Energy from Renewable Sources
  - Operate and Maintain a Highly Resilient Power System
  - Achieve Emissions Reductions Below EPA Compliance Requirements
  - Reduce GPA Greenhouse Gas Emissions per KWH by over 50% from FY 2012
  - Lower Customer Overall Bills by more than 15%
  - Minimize the Volatility of LEAC Charges Caused by Fossil Fuels
  - Achieve Operational Effectiveness Across All GPA Activities
  - Achieve Better than 95% Customer Satisfaction Ratings
    - For GPA as a Company
    - For GPA Services
  - Achieve Better than BBB+ Bond Rating
  - Create and Maintain Synergistic Partnerships with GWA, the CCU, PUC, EPA, Customers, and Stakeholders to make Guam a better Place to Live and Work

Strategic Issues

- Throughout GPA's Strategic Planning since 2006 and especially the 2015 Core Planning Team's work, the following Strategic Issues dominate:

1. GPA must measurably improve its customer service.
2. GPA must create, model, and reinforce a corporate culture that supports its Mission and Vision.
3. GPA must provide measurably better product quality and reliability.

Strategic Objectives

- All the Strategic Objectives in past Strategic Planning may be distilled into five general objectives:
  - Grid Transformation
  - Customer Experience Transformation
  - Sustained Energy Affordability Transformation
  - Digital Transformation
  - Foundational Infrastructure

Grid Transformation	Customer Experience Transformation	Affordability Transformation
Digital Transformation		
Foundational Infrastructure		

Color Associations

RED
Red is associated with:
Passion, Youth, Danger, Demand, Excitement.

ORANGE
Orange is associated with:
Energy, Warmth, Cheer, Confidence, Desire.

YELLOW
Yellow is associated with:
Abundance, Clarity, Hope, Optimisim, Friendship.

GREEN
Green is associated with:
Calm, Ressurance, Health, Peace, Money.

BLUE
Blue is associated with:
Business, Reliability, Creation, Trust, Strength.

PINK
Pink is associated with:
Compassion, Loyalty, Beauty, Sensitivity, Charisma.

PURPLE
Purple is associated with:
Protection, Thought, Luxury, Dignity, Imagination.

GREY
Grey is associated with:
Security, Authority, Maturity, Character, Balance.

BLACK
Black is associated with:
Sophistication, Power, Formality, Mystery, Depth.

https://www.clipartlogo.com/istock/smart-goal-setting-chart-with-keywords-and-icons-sketch-1517217.html

Grid Transformation

- Long-Term 10-year goal
  - Continuously Reduce Power Outages, Equipment Failures and Dirty Power
- Key Performance Indicators
  - Reduce the annual UFLS SAIDI contribution to less than 5 minutes by 2030
  - Reduce the annual Equipment Failure SAIDI contribution to less than 5 minutes by 2030
  - Reduce the annual Vegetation Management SAIDI contribution to less than 5 minutes by 2030
  - 50% Renewable Energy by 2030
- Theory of Change Preconditions to Meet Objective
  - New Ukudu Power Plant Online
  - Renewable Integration Study (RIS) Project Recommendations Completed
  - Fiber Optic Network Completed to Support RIS Projects
  - Optimize Smart Grid Infrastructure
  - Distribution Study Completed
    - Distribution Study Recommendations Completed
  - Culture Change

Customer Experience Transformation

- Long-Term 5-year goal
  - Power of “No”
    - No Customers Dissatisfied with their Customer Experience
  - Digital Utility
    - Pay Anywhere/Whenever
    - Get Account Information Anywhere/Whenever
    - Service Application Anywhere/Whenever
    - Provide Customers with a High Quality, 24/7 Customer Service Interaction
  - All GPA Employees are Customer Representatives
- Long-Term KPIs
  - Less than 5% of Customers rate GPA Unsatisfactory by 2025
    - As a Company
    - GPA Service
  - 95% Customer Satisfaction or better by 2025
    - As a Company
    - GPA Service
  - 50% or More Customers Using Non-Face Payment and Service Transactions by 2025

- Theory of Change Preconditions to Meet Objective
  - Marketing Program
    - Voice of the Customer Quality Functional Deployment
    - Branding
    - Information Outreach to Customers
      - How to Save on their Power Bills
      - Mobile Services
  - Mobile Applications
    - Customer and Employee Training to Support Applications
    - Customer Information Kiosks
    - Payment Kiosks
    - Mobile Apps
    - Web site Applications
    - Queue Management
  - Culture Change
  - Back Office Resources
  - Grid Transformation
  - Affordability Transformation
  - Foundational Infrastructure

Delighting Customers

1. Invite New Customers into a Relationship
2. Offer Personalized Recommendations
3. Look For Areas Where You Can Make Life Easier For Your Customers

K.C. Boyce. (2018). Three Things Utilities Can Do to Delight Their Customers. URL: https://escalent.co/blog/three-things-utilities-can-do-to-delight-their-customers/

Invite New Customers into a Relationship

The top three onboarding activities that improve customer relationships and provide moments of delight:

1. Provide bill payment options
2. Connect your customers
3. Emphasize reliability—but prepare your customers for outages

- Don't make the mistake of sending all of this information at once.
- Spread out onboarding messaging over time, making each touch focused on a specific thing and—importantly—fun and engaging for your new customers to read.
- Effective onboarding can provide a significant boost to brand trust levels and increase the likelihood for customers to make positive comments

Offer Personalized Recommendations

- Utilities like Duke Energy and Georgia Power are building predictive analytics capabilities for “next best offer” programs—and it shows: two-thirds of customers who received a recommendation from these utilities found it highly relevant and three-quarters followed the recommendation.
- The impact on customer scoring of this is substantial
- Remember that customers are contacting you because of a problem and your offerings are also solving customer problems—so product and service recommendations aren’t unwelcome if they help address customers’ issues

STRATEGIC OBJECTIVES

Look For Areas Where You Can Make Life Easier For Your Customers

- Energy Efficiency Programs
  - Energy Sense Rebate Program
  - BEST Schools Program
  - Utility Energy Services Contracting Program
  - Grants
- Payments
  - Prepaid
  - PayGPA
  - Telephone Pay
  - Mobile Apps
  - Payment Plans
- Non-Utility Scale Solar PV
  - Solar Farms
  - Grants (USDA)
- Being there when customers look to engage with new energy-related offerings—whether customers ultimately buy from the utility—helps delight them.

Improve Customers' Perception of GPA Value

1. Demonstrate strong community engagement.
2. Show How GPA Is An Environmental Steward
3. Consistently Deliver on Operational Excellence.
4. Guard GPA's reputation (By doing it right)
   a. Every interaction matters in showing customers that we care about them.
   b. Be unfailingly ethical and trustworthy.
   c. Keep Our Commitments.
5. Go Beyond—Well Beyond—The Commodity.
   a. Customers respond strongly to utility offerings that help them control their energy use and cost, but also value offerings that improve convenience and reduce their environmental impact.

K.C. Boyce. (2018). Five Right Ways—and One Very Wrong Way—to Improve Value Perceptions among Utility Customers. URL: https://escalent.co/blog/five-right-ways-and-one-very-wrong-way-to-improve-value-perceptions-among-utility-customers/

Affordability Transformation

- Long-Term 5-year goal
  - Reduce Energy Bills by 15% or greater
- Key Performance Indicators
  - 120 Days Cash on Hand by 2025
  - Generating Free Cash Flows by 2025
  - 15% Average Energy Bill (from FY 2018) Reduction by 2025
- Theory of Change Preconditions to Meet Objective
  - Right Size Labor Force
  - Long Range CIP and O&M Plan
  - Stabilize LEAC
  - Create New Revenue Sources
    - Natural Gas Franchise and Sales
    - Electric Vehicle Infrastructure
- O&M and CIP Discipline
- Generate Sufficient Free Cash Flows to Fully Fund Future O&M and CIP Requirements and Retire Debt Early
- Take Advantage of Productivity Enhancers
  - Productivity Applications
  - Create Organizational Fit
  - Automation
- Grid Transformation
- Foundational Infrastructure

Foundational Infrastructure

- Five-Year Goal
  - Complete the Infrastructure for Achieving Operational Excellence
  - Operational Excellence is Getting the Right Information to the Right People at the Right Time to Take the Right Actions Immediately
- Key Performance Indicators
  - 40% increase in employee productivity by 2025 (MWFM)
  - Generation EAF greater than or equal to 95% for GPA legacy generation by 2025
  - 50% of Aging Bulk Power Transformer Assets over 30 years old replaced by 2030
  - 50% of Aging Breaker Assets over 30 years old replaced by 2030

- Theory of Change Preconditions to Meet Objective
  - Cybersecurity
  - IT/OT Network Refresh
  - Marketing Plan and Execution
  - Expanded Communications Resources
  - Complete Mobile Workforce Roll Out for Every Field Process and Inventory Management
  - Complete ERP Upgrade
  - Enterprise Asset Management
  - Rigorous Training Program
  - Continuous Measurable Improvement Program
  - Culture Change

Strategy

STRATEGY

- Core Values
- Vivid Description
- Context Analysis
  - SWOT
  - Porter's Five Forces

- Core Purpose

- Big Hairy Audacious Goals

- Theory of Change
- Zap the Gaps

- Critical Success Factors
- Key Performance Indicators

- Budgeting
- Project Development/Execution

- Process Mapping
- Workflow and Accountability Analysis
- Building Fit

Strategies

- Systems
  - Ride the Technical Capability Up and the Price Curve Down
  - Adopt Processes and Technologies that Significantly Boost Productivity
  - Build Power System and Organizational Resiliency
  - Improve O&M
    - Fix It Before It Breaks
- Customers
  - Find the Voice of the Customer and Build our Customer Experiences Around It
  - Deliver On-Demand Services
  - Develop Loyal Customers
- Affordability and Financial Stability
  - Make CIP Investments Based on Technical Information-Based Studies
  - Increase Sources of Revenues While Reducing Expenses
  - Decrease Cross-Subsidization
- Culture
  - Achieve Operational Excellence
  - Develop a Culture Passionate About Customers

Balanced Scorecard

Balanced Scorecard

- Balanced Scorecard tool provides a high level window into how the organization is performing.
- The Balanced Scorecard was created by Norton and Kaplan
- Windows into Organizational Performance
  - Critical Success Factors
  - Key Performance Indicators
  - Performance Indicators

BALANCED SCORECARD

BALANCED SCORECARD

Critical Success Factor (CSF)	Key Performance Indicators (KPI)	Metrics
CSF#1 – Achieve Excellent Customer Service	2	5
CSF#2 – Provide Affordable and Value products	4	7
CSF#3 – Develop Sustainable Workforce and Leadership	4	6
CSF#4 – Achieve High System Reliability	1	4
CSF#5 – Effectively Use Technology	3	3
Totals: 5	**14**	**25**

BALANCED SCORECARD

Critical Success Factor (CSF)	*Key Performance Indicator (KPI)*	**Metric (M)**		**Metric Owner**	**Reporting Frequency**
CSF#1 – Achieve Excellent Customer Service	***KPI#1 – Sustained Improvements of Customer Satisfaction***	M#1 – Increase Overall Satisfaction with Customer Service Experience (Annual Survey)	P1	Communication Manager	Annually
	KPI#2 - Improve Customer Experience	M#1 – Improve Average Wait Time	P2	AGMA	Monthly
	KPI#2 - Improve Customer Experience	M#2 – Decrease Call or Visit Abandonment (Call Center Effectiveness)	P3	AGMA	Monthly
	KPI#2 - Improve Customer Experience	M#3 – Reduce Service Center Traffic	P4	AGMA	Monthly
	KPI#2 - Improve Customer Experience	M#4 – Increase Web, Pay by Phone, and Prepay Payments	P5	Communication Manager	Monthly

BALANCED SCORECARD

Critical Success Factor (CSF)	*Key Performance Indicator (KPI)*	**Metric (M)**		**Metric Owner**	**Reporting Frequency**
CSF#2 – Provide Affordable and Value products	***KPI#1 – Minimize Energy Production Cost***	M#1 – Meet PUC System Heat Rate Standard (9600 BTU/kWh)	P1	AGMO	Monthly
	KPI#1 – Minimize Energy Production Cost	M#2 – Economically Dispatch Generation Resources	P2	AGMO	Monthly
	KPI#2 – Reduce Line and Unaccounted for Energy Losses	M#1 – Reduce Station Service Use	P3	AGMO	Monthly
	KPI#2 – Reduce Line and Unaccounted for Energy Losses	M#2 – Reduce Line and Unaccounted for Losses	P4	AGMETS	Monthly
	KPI#3 – Achieve Energy Diversity at Affordable Cost	M#1 – Provide Technical and Economic Alternatives thru Integrated Resource Plan	P5	AGMETS	Semi-Annually
	KPI#4 – Improve Credit Raing	M#1 – Achieve 1.75x Debt Service Coverage Target	P6	CFO	Monthly
	KPI#4 – Improve Credit Raing	M#2 – Achieve 120 Days Unrestricted Cash	P7	CFO	Monthly

BALANCED SCORECARD

Critical Success Factor (CSF)	*Key Performance Indicator (KPI)*	**Metric (M)**		**Metric Owner**	**Reporting Frequency**
CSF#3 – Develop Sustainable Workforce and Leadership	***KPI#1 – Implement a Succession Planning Program***	M#1 – Develop Succession Planning Program	P1	AGMA	Annually
	KPI#2 – Implement Structured Leadership and Workforce Training	M#1 – Implement Leadership Training Program	P2	AGMA	Quarterly
	KPI#2 – Implement Structured Leadership and Workforce Training	M#2 –Develop Workforce Annual Training Needs	P3	AGMA	Annually
	KPI#2 – Implement Structured Leadership and Workforce Training	M#3 – Implement Skilled Cross Training Program	P4	AGMA	Quarterly
	KPI#3– Achieved Increased Safety Awareness & Enhanced Safety Practices	M#1 – Reduce Safety Incidents Thru Awareness and Training	P5	AGMA	Monthly
	KPI#4 – Enhance Employee Satisfaction	M#1 – Conduct Employee Satisfaction Survey	P6	Communication Manager	Annually

BALANCED SCORECARD

Critical Success Factor (CSF)	*Key Performance Indicator (KPI)*	**Metric (M)**		**Metric Owner**	**Reporting Frequency**
CSF#4 – Achieve High System Reliability	***KPI#1 – Reduce Customer Outages***	M#1 – Improve System Reliability Indices (SAIDI, SAIFI, CAIFI, CEMI-5)	P1	AGMETS/AGMO	Monthly
	KPI#1 – Reduce Customer Outages	M#2 – Meet Equivalent Availability and Forced Outage Performance Target (Baseload Units)	P2	AGMO	Monthly
	KPI#1 – Reduce Customer Outages	M#3 – Meet Equivalent Availability and Forced Outage Performance Target (Diesel Units)	P3	AGMO	Monthly
	KPI#1 – Reduce Customer Outages	M#3 – Capacity Reserve No Less than Largest Unit During Any Period	P3	AGMO	Monthly

Critical Success Factor (CSF)	*Key Performance Indicator (KPI)*	Metric (M)		Metric Owner	Reporting Frequency
CSF#5 – Effectively Use Technology	***KPI#1 – Implement Excellent Cyber Security Program***	M#1 – Implement state of the Art Cyber Security Systems to protect critical Infrastructure and Customer Information	P1	AGMETS/CITO	Semi-Annually
	KPI#2 – Implement Excellent Physical Security Program	M#1 – Implement state of the Physical Security Systems to protect Infrastructure	P2	AGMETS/CITO	Quarterly
	KPI#3 – Improve Productivity Through the Use of Technology & Automation	M#1 –Implement Effective Technological Improvements which improve efficiency, provides improved services and reduces cost	P2	AGMETS/CITO	Quarterly

BALANCED SCORECARD

- Create New KPI Dashboard
  - Accessible by All
  - Updated Often

Tactics

TACTICS


VISION
• Core Values
• Vivid Description
• Context Analysis
• SWOT
• Porter's Five Forces
MISSION
• Core Purpose
STRATEGIC OBJECTIVES
• Big Hairy Audacious Goals
STRATEGY
• Theory of Change
• Zap the Gaps
BALANCED SCORECARD
• Critical Success Factors
• Key Performance Indicators
TACTICS
• Budgeting
• Project Development/Execution
ORGANIZATIONAL ALIGNMENT & FIT
• Process Mapping
• Workflow and Accountability Analysis
• Building Fit

Strategies

- Systems
  - Ride the Technical Capability Up and the Price Curve Down
  - Adopt Processes and Technologies that Significantly Boost Productivity
  - Build Power System and Organizational Resiliency
  - Improve O&M
    - Fix It Before It Breaks
- Customers
  - Find the Voice of the Customer and Build our Customer Experiences Around It
  - Deliver On-Demand Services
  - Develop Loyal Customers
- Affordability and Financial Stability
  - Make CIP Investments Based on Technical Information-Based Studies
  - Increase Sources of Revenues While Reducing Expenses
  - Decrease Cross-Subsidization
- Culture
  - Achieve Operational Excellence
  - Develop a Culture Passionate About Customers

Systems

Strategy 1 Ride the Technical Capability Up and the Price Curve Down

- Tactic 1 Develop and Execute Bids for Renewable Energy and Energy Storage in Phases
- Tactic 2 Implement Grid Automation in Phases

Systems

Strategy 2 Adopt Processes and Technologies that Significantly Boost Productivity

Tactic 1 Boost Operational Productivity

- Execute Mobile Workforce Management System Project for each Field, Inventory Management, and Other Processes (Increase Productivity by 40 to 60%)
- Implement Distribution Automation via Streetlight Controllers and Existing Grid Stream Network

Tactic 2 Boost Enterprise Productivity

- Upgrade Enterprise Asset Management (EAM) as a CMMS Replacement
- Upgrade Enterprise Resource Planning (ERP) (E1) as a JDE Replacement

Tactic 3 Develop Operational Excellence throughout GPA

Operational Excellence is getting the right information to the right people at the right time so they can take the right action immediately

Systems

Strategy 3 Build Power System and Organizational Resiliency

Tactic 1 System Planning

- Develop Renewable Integration Study for Transmission System and Execute its Recommendations
- Develop Distribution System Medium Range Plan and Execute its Recommendations
- Develop and Execute Underground Infrastructure Program

Tactic 2 Develop and Execute Succession Planning System

Tactic 3 Develop Additional Apprenticeship Programs for Future Skillsets While Eliminating Programs for Declining Skillsets

Systems

Strategy 4 Improve O&M: Fix It Before IT Breaks

Tactic 1 Develop and Execute Predictive Maintenance Processes and Projects

- Infrared
- Radio Frequency Investigation & Television Interference

Tactic 2 Develop and Execute Analytics Based Planning and O&M Processes

- Advanced Grid Analytics'

Customers

Strategy 1 Find the Voice of the Customer and Build our Customer Experiences Around It

Tactic 1 Voice of the Customer (VOC) Quality Functional Deployment (QFD)

- Perform Primary Market Research to Determine How Customers Want Services to be Delivered
- Design and Tailor Details of the Customer Experience to these Insights

Tactic 2 Develop Public Outreach Programs and Frequently Engage and Inform Customers Especially About Opportunities to Save on their Energy Bill

Customers

Strategy 2 Deliver On-Demand Services

Tactic 1	Develop, Launch, and Improve Multiple Channels for Making Payments 24/7
Tactic 2	Develop, Launch, and Improve Multiple Channels for Making and Delivering Non-Face2Face Service Requests, Account Applications, and Notifications
Tactic 3	Market Program to Build Utilization of these Channels

Customers

Strategy 3 Develop Loyal Customers

Tactic 1	Improve First Call Resolution
Tactic 2	Anticipate and Exceed Customers' Expectations
Tactic 3	Engage with Customers About Opportunities to Save on their Energy Bill

TACTICS

Strategies

- O&M
  - Fix It Before It Breaks
- Affordability and Financial Stability
  - Make CIP Investments Based on Technical Information-Based Studies
  - Increase Sources of Revenues While Reducing Expenses
- Culture
  - Achieve Operational Excellence

Affordability and Financial Stability

Strategy 1 Make CIP Investments Based on Technical Information-Based Studies

Tactic 1 Complete Integrated Resource Planning Cycle

- Integrated Resource Plan
  - Generation System Capacity and Energy Expansion Plan
  - Renewable Integration Plan
  - Long-Range Transmission Plan
  - Medium Range Distribution Plan
  - System Protection Plan
  - Relay Coordination Study
  - IT/OT Strategi Plan

Tactic 2 Optimize Budget Process

Affordability and Financial Stability

Strategy 2 Increase Sources of Revenues While Reducing Expenses

Tactic 1 Investigate and Secure New Sources of Revenues

- Transportation Electrification
- Franchising
  - Fuel Storage, Pipeline, and Tanker Truck Fueling Rental
  - Natural Gas Export Franchising
  - Natural Gas On-Island Sales to Navy and Large Customers
- Back Up Power Services
- Co-Generation
- Parking Lot Lighting Services
- Data Centers

Tactic 2 Right-Sizing Staff and Assets

Tactic 3 Optimize Rates and Cost Recovery

Culture

Strategy 1 Achieve Operational Excellence

Tactic 1 Deploy and Optimize the Necessary Information and Communication Systems to Support Operational Excellence

- Mobile Workforce Management
- Distribution Automation
- Substation Automation
- SCADA
- Outage Management System
- Tier 1, 2, 3 Networks

Tactic 2 Develop the Organizational Infrastructure and Work Processes Supporting Operational Excellence

- Change Management

Tactic 3 Deploy and Optimize the Necessary Training Programs to Support Operational Excellence

Culture

Strategy 2 Develop a Culture Passionate About Customers

Tactic 1 Instill the Perception that Every GPA Employee is a Customer Service Representative

Tactic 2 Engage with the Community

- High School Career Day
- Science Fair
- Rotary Club
- Lions Club
- Local Conferences
- Others

Grid Transformation Solutions

Charge/Discharge-Anytime Battery Energy Storage Systems (BESS) - Provides spinning reserve and frequency regulation. Greatly improves grid response to FIDVR, duck curve ramp ups, and excess solar PV production events. Provides other grid services.

Flexible Efficient Generation - Better follows the changes in demand and available generation online especially when large intermittent sources of power are on the grid. Reduces power rates.

Energy Shifting Battery Energy Storage Systems (ES BESS) - Decreases Excess Solar PV Production Events by storing 100% of energy for nighttime use; Replaces expensive production from peaking generation.

Demand Response (DR) - Adjusts customer demand up or down however needed by the grid.

Synchronous Condensers (SC) - Provides Short-Circuit MVA to power system to keep the grid stable, prevents grid-tied inverter cessation, improves fault response and voltage, and allows GPA grid to operate with 100% renewable energy.

Smart Grid (SG) - Advanced technology for getting the right information to the right people or systems at the right time to make the right strategic and operational decisions.

Energy Efficiency - Energy efficiency has a much higher rate of return than just simply installing solar PV. Putting energy efficiency first lowers energy costs for everyone.

Time-of-Use (TOU) Rates - Provides incentives for customers to change their electricity-use behavior to match the needs of the grid.

Daytime Charging Electric Vehicles (EV) - Prevents curtailment of synchronous generation and solar PV during excessive solar PV production events when solar PV production is high and daytime loads are low. Slows growth of system peak deferring expensive investments for new capacity.

Microgrids - Using synchronous generators and Solar PV + energy-shifting battery energy storage systems with grid forming capability to provide power after natural disasters such as typhoons especially in southern Guam.

Grid Controller - Optimizes all resources to provide the most benefit at the least cost. Improves system stability and system economics.

Solar Irradiance Sensor Network - Provide real-time estimates of solar PV power production. Forecast solar PV power production. Track cloud cover.

System Protection - Improve System Protection to operate in an environment with less synchronous generation and more inverter based resources.

Improving Generator Reliability - Improving GPA generator availability results in serving more load using less generation. It also significantly lowers energy costs.

Customer Experience Transformation Solutions

Guam Transportation Electrification - As customers switch to electric vehicles, their relationship with GPA becomes more critical. Designing the charging experience to delight customers will improve GPA customer experience.

Energy Efficiency - Energy efficiency has a much higher rate of return than just simply installing solar PV. Customers who get rebates or who have better knowledge of the Energy Sense Appliance Rebate Program do not rate GPA as a company unsatisfactory. Getting rebates is a highly positive customer experience.

Energy Shifting Battery Energy Storage Systems (ES BESS) - Using BESS to provide spinning reserve and frequency regulation improves power quality and reduces customer outages improving the GPA customer experience. GPA addition of renewable energy improves customer satisfaction with GPA as a company.

Smart Grid (SG) - Smart Grid systems can reduce the number of customer outages improving the GPA customer experience.

Conservation Voltage Reduction (CVR) - Reduces distribution system line losses lowering LEAC rates. Reduces customer energy consumption.

Conversion of Manual Customer-Facing Processes to Digital Ones - Customer expectations for service are being driven by the telecom, virtual commerce, and entertainment industries. Going digital improves the GPA customer experience. Going digital includes online payment portals, mobile apps, and Energy Sense online rebate application processing, and more.

Customer Outreach - Customers want to be informed about GPA outages, rates, and other GPA matters. Building this outreach improves GPA's relationships with its customers. It also defuses disinformation.

Energy Sense Program Outreach - Customers want to be informed about energy efficiency, renewable energy, and ways to lower their power bills. Building this outreach improves GPA's relationships with its customers.

GPWA Information/Operations Technology (IT/OT) Consolidation - Reduces IT/OT capital and operating costs for GPA and GWA. Reduces costs passed onto customers.

Affordability Transformation Solutions

Guam Transportation Electrification - Electric vehicles charging from the grid will increase GPA revenues allowing GPA to reduce rates for everyone. Reduces GPA fleet expenses for fuel and maintenance.

Improving Generator Reliability - Improving GPA generator availability results in serving more load using less generation. It also significantly lowers energy costs.

Daytime Charging Electric Vehicles (EV) - Slows growth of system peak deferring expensive investments for new capacity resulting in lower future energy costs.

Energy Shifting Battery Energy Storage Systems (ES BESS) - Decreases Excess Solar PV Production Events by storing 100% of energy for nighttime use; Replaces expensive production from peaking generation. Lowers and stabilizes LEAC rates.

Conservation Voltage Reduction (CVR) - Reduces distribution system line losses lowering LEAC rates. Reduces customer energy consumption.

Energy Efficiency - Energy efficiency has a much higher rate of return than just simply installing solar PV. Putting energy efficiency first lowers energy costs for everyone.

Flexible Efficient Generation - Better follows the changes in demand especially when large intermittent sources of power are on the grid. Reduces LEAC rates especially when using natural gas.

Smart Grid (SG) - Smart Grid systems such as Mobile Workforce Management, Advanced Grid Analytics, Distribution Automation increase work productivity reducing energy costs passed onto customers.

GPWA Information/Operations Technology (IT/OT) Consolidation - Reduces IT/OT capital and operating costs for GPA and GWA. Reduces costs passed onto customers.

Digital Transformation Solutions

GPWA Information/Operations Technology (IT/OT) Consolidation - A secure, reliable, and responsive IT/OT infrastructure supported by a skilled and capable staff is critical for supporting GPA's Strategic Transformation.

Smart Grid (SG) - The technology enabler for driving operational improvements and efficiencies. The Smart Grid makes possible the transition of GPA manual processes into information-based, digitally enhanced automated processes. Use of smart controls and sensors improves reliability, resiliency, and affordability.

Creating Organizational Alignment & Fit - Creating a more skilled, resilient, streamlined, and effective organization through process mapping & re-engineering leveraging information and operational technology is the end goal for digital transformation.

Energy Sense Program Outreach - Customer expectations are driven by the customer connection capabilities of the telecom, streaming entertainment, and virtual shopping industries. Building this outreach through relevant content improves GPA's relationships with its customers. The conversion of the manual Energy Sense Rebate Application process to a digital platform supports the objective of digital transformation.

Business Analytics - The Smart Grid, Energy Sense Web-sites, Internet of Things (IOT) and Third-party content providers are creating more data and information that any individual(s) can analyze the business value for GPA. The use of artificial intelligence engines with defined logic provides GPA the ability to respond in a proactive manner to grid conditions to determine the best resolution for customers.

Simulation and the Digital Twin - In response to extreme natural events, the ability to work remotely along with utilize real-time simulation through a Digital Twin of an energy system allows for continuous learning to GPA engineers and operators.

Foundational Infrastructure Solutions

Human Resource Rebalancing - GPA will soon retire several power plants beginning with Cabras 1&2. GPA must plan to rebalance its workforce considering the displacement of these employees. This must be well in advance of the actual plant retirements.

Succession Planning - With over 50% of its workforce eligible to retire within five years, GPA must hire and train new employees to take over. GPA must update its job descriptions and eligibility requirements moving these jobs into the 21st century. Many jobs will have changed because of digital transformation and technology.

Grid Transformation Solutions - Without completion of Grid Transformation Projects, the grid will not be stable, reliable, resilient, and affordable.

Smart Grid (SG) - Smart Grid is the grid's information superhighway driving operational improvements and efficiencies.

GPWA Information/Operations Technology (IT/OT) Consolidation - A secure, reliable, and responsive IT/OT organization and infrastructure is critical for supporting GPA's Strategic Transformation.

Aging T&D Infrastructure Replacement - Like all other U.S. power utilities, GPA must plan for replacing its aging infrastructure. GPA should invest in an Asset Management ERP capability to guide and manage the replacement process.

Creating Organizational Alignment & Fit - Creating a more resilient, streamlined, and effective organization through process mapping & re-engineering. Incorporating and leveraging information technology into business processes creates the digital transformation shift.

Improving Generator Reliability - Achieving 95% GPA generator availability is a cornerstone for grid resiliency, reliability, and affordability.

Organizational Alignment & Fit

ORGANIZATIONAL ALIGNMENT & FIT

- Core Values
- Vivid Description
- Context Analysis
  - SWOT
  - Porter's Five Forces

- Core Purpose

- Big Hairy Audacious Goals

- Theory of Change
- Zap the Gaps

- Critical Success Factors
- Key Performance Indicators

- Budgeting
- Project Development/Execution

- Process Mapping
- Workflow and Accountability Analysis
- Building Fit


ORGANIZATIONAL ALIGNMENT
Strategic Plan
Organizational Priorities
Executive Team puts these ahead of departmental priorities.
Departmental Priorities
Departmental priorities must support organizational priorities.
Team Member Priorities
Individual team member priorities are derived from departmental priorities.

Breaking Down Silos: Fit

- Fit means that the value or cost of one activity is affected by the way other activities are performed
- Good Strategies depend on the connection among many things especially on making interdependent choices: Fit.
- Activities within the Value Chain must fit together and create synergies.

Creating Fit

- Mapping out GPA work processes
- Mapping out the interdependencies between Business Unit activities
- Making the processes more efficient and effective.
- Creating Synergies between work processes, external and internal organizations.

- GPA should contract this work with the goal of increasing productivity by 40% by 2025.

2021 Strategic Planning Session

Porter’s Five Forces Analysis

Agenda

- Competition: The Right Mind-Set
- Porter's Five Forces
- Value Chain
- Competitive Advantage
- Porter's Three Competitive Strategies

Competition: The Right Mind-Set

Strategic Competition means choosing a path different from that of others.

Competition: Looking Forward

- The Core Question: Performance in the face of Competition.
  - What value will GPA create and for whom?
  - How will we capture some of that value for GPA and its employees?
- Competition focuses more on meeting customer needs than on demolishing rivals.
  - In business, multiple winners can thrive and coexist
  - There are many needs to serve, and many ways to win.

Ten Practical Implications

1. Vying to be the best is an intuitive but self-destructive approach to competition. Better to be unique.
2. Competition is about profits, not market share
3. Competitive advantage is not about beating rivals. It is about creating unique value for customers. If you have a competitive advantage, it will show up in your profit and loss (P&L),
4. A distinctive value proposition is essential for strategy. But strategy I more than just marketing. If your value proposition does not require a specifically tailored value chain to deliver it, it will have no strategic relevance.
5. Do not feel you have to “delight” every customer. The sign of a good strategy is that it deliberately makes some customers unhappy.
6. No strategy is meaningful unless it makes clear what the organizations will not do. Making trade-offs is the linchpin that makes competitive advantage possible and sustainable.
7. Do not overestimate or underestimate the importance of good execution. It is unlikely to be a source of sustainable advantage, but without it even the most brilliant strategy will fail to produce superior performance.
8. Good strategies depend on many choices, not one, and on the connections between them. A core competence alone will rarely produce a sustainable competitive advantage.
9. Flexibility in the face of uncertainty may sound like a good idea, but it means your organization will never stand for anything or become good at anything. Too much change can be as disastrous for strategy as too little.
10. Committing to strategy does not require heroic predictions about the future. Making that commitment actually improves your ability to innovate and to adapt to turbulence.

The Right Mind-Set

BE THE BEST	GUAM POWER AUTHORITY	BE UNIQUE
Be Number 1		Earn Higher Returns
Focus on Market Share		Focus on Profits
Serve "Best" Customer with "Best" Product		Meet Diverse Needs of Target Customers
Compete by Imitation		Compete by Innovation
ZERO-SUM A Race No One Can Win A Race to the Bottom		POSITIVE SUM Multiple Winners, Many Events

- Porter relates that the real point of competition is not to beat your rivals. It is to earn profits.
- But, GPA is a non-profit!
- Reword the statement for GPA:
    - The real point of competition is to generate sufficient money to sustainably reinvest to provide value to customers and employees.
    - Generate free cash flows

(Magretta, 2012)

COMPETITION

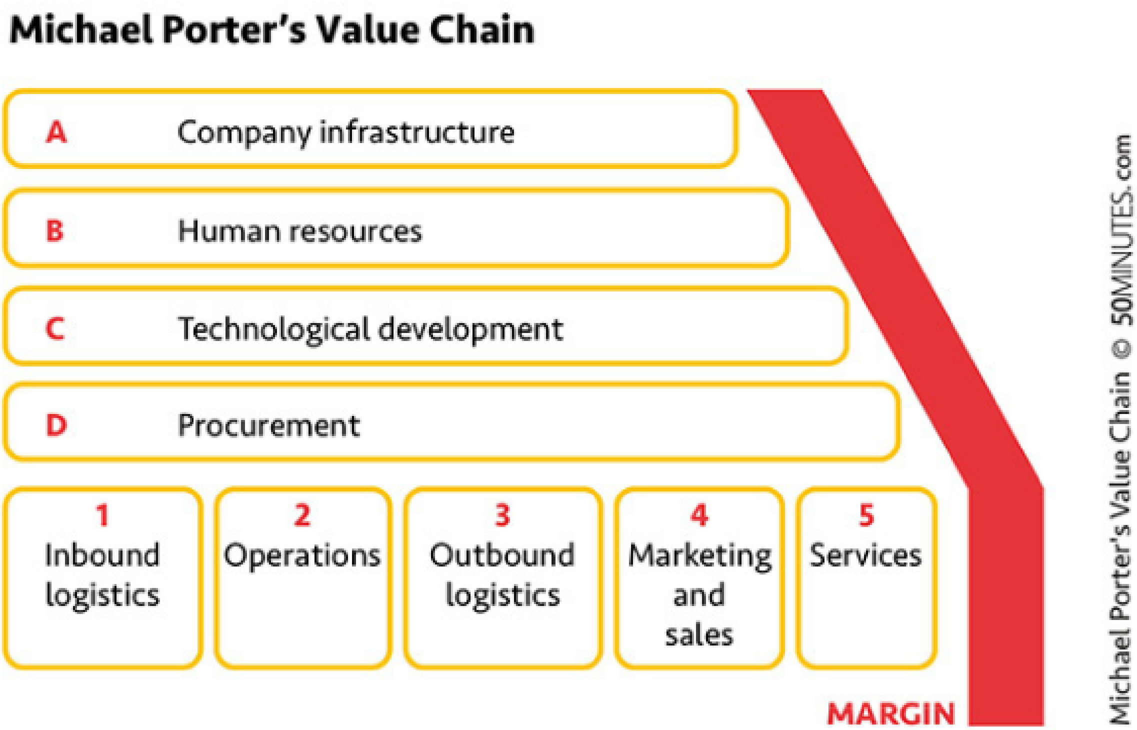
A company's performance has two sources:

	INDUSTRY STRUCTURE	RELATIVE POSITION
Porter's framework	Five forces	Value chain
The analysis focuses on	Drivers of industry profitability	Differences in activities
The analysis explains	Industry average price and cost	Relative price and cost

Porter's Five-Forces
Help us Evaluate
Industry Structure

If a company has a COMPETITIVE ADVANTAGE, it can sustain higher relative prices and/or lower relative costs than its rivals in an industry.

Michael Porter's Value Chain



What does GPA's Value Chain Look Like?

Value is the capacity of a good, work or service to meet a particular want

- Supply Chain refers to the integration of all activities involved in the process of sourcing, procurement, conversion and logistics.
- Value Chain implies the series of business operations in which utility is added to the goods and services offered by the firm so as to enhance customer value.

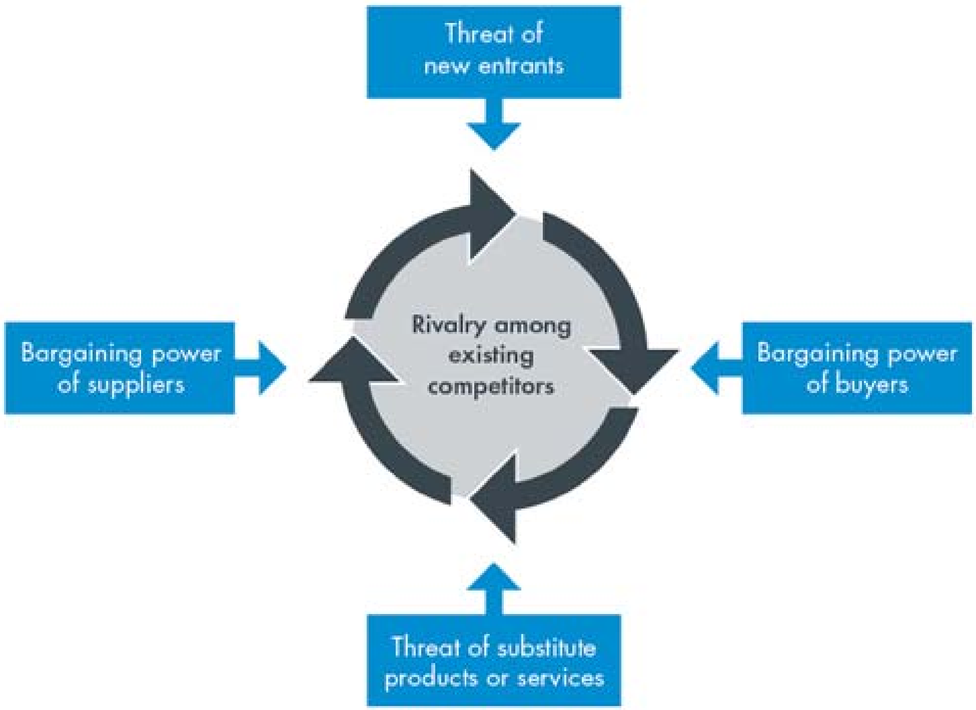
Porter's Five Forces

Porter's Five Forces of Competitive Position Analysis

- Developed in 1979 by Michael E Porter of Harvard Business School as a simple framework for assessing and evaluating the competitive strength and position of a business organization.
- Based on the concept that there are five forces that determine the competitive intensity and attractiveness of a market.
- Porter's five forces help to identify where power lies in a business situation. This is useful both in understanding the strength of an organization's current competitive position, and the strength of a position that an organization may look to move into.
- Strategic analysts often use Porter's five forces to understand whether new products or services are potentially profitable. By understanding where power lies, the theory can also be used to identify areas of strength, to improve weaknesses and to avoid mistakes.

PORTERS FIVE FORCES

Porter’s Five Forces
Competitive Position Analysis



Porter’s Five-Forces - Competition

- Horizontal Competition
  - Threat of Substitute Products or Services
  - Threat of Established Rivals
  - Threat of New Entrants
- Vertical Competition
  - Bargaining Power of Suppliers
  - Bargaining Power of Customers

Horizontal Competition Forces

- Threat of substitution
  - Assessment of how tightly bound customers are to our product/service
  - Close substitute products in a market increases the likelihood of customers switching to alternatives in response to price increases
- Competitive rivalry
  - Assessment of how competitive the market is
  - Main driver is the number and capability of competitors in the market
  - Many competitors, offering undifferentiated products and services, will reduce market attractiveness
- Threat of new entry
  - Assessment of how easy it is to enter the market
  - Profitable markets attract new entrants eroding profitability
  - Unless incumbents have strong and durable barriers to entry then profitability will decline to a competitive rate
    - Economies of scale
    - Capital requirements
    - Government policies

Vertical Competition Forces

- Supplier power
  - An assessment of how easy it is for suppliers to drive up prices
  - Drivers include:
    - Number of large suppliers of each essential input
    - Uniqueness of their product or service
    - Relative size and strength of the supplier
    - GPA cost of switching from one supplier to another.
- Buyer power
  - An assessment of how easy it is for buyers to drive prices down
  - Drivers include:
    - Number of (large) buyers in the market
    - Importance of each individual buyer to the organization
    - Buyer Cost of switching from GPA to another

Balance of Power

The Force	Impact	Why	
IF Threat of Entry ↑	Profitability ↓	Prices ↓	Costs ↑
IF Supplier Power ↑		Costs ↑	
IF Buyer Power ↑		Prices ↓	Costs ↑
IF Substitutes ↑		Prices ↓	Costs ↑
IF Rivalry ↑		Prices ↓	Costs ↑

Substitutes

- Distributed Generation
  - Solar PV
  - Wind Turbine Generators
  - Fuel Cells
  - Co-Generation/Tri-Generation
- Energy Efficiency
- Energy Storage
- How easy is it for customers to replace what GPA provides?

Full Retail Rate NEM

- Currently, GPA pays owners of grid-connected solar PV and wind energy systems at the full retail rate
  - Non-NEM customers subsidize NEM customers
- Collectively, full-retail NEM and generous Federal ITC and PTC subsidies provide an enormous opportunity for profit for solar PV installers especially zero-down PPAs

Hidden NEM Subsidies by Non-NEM Customers

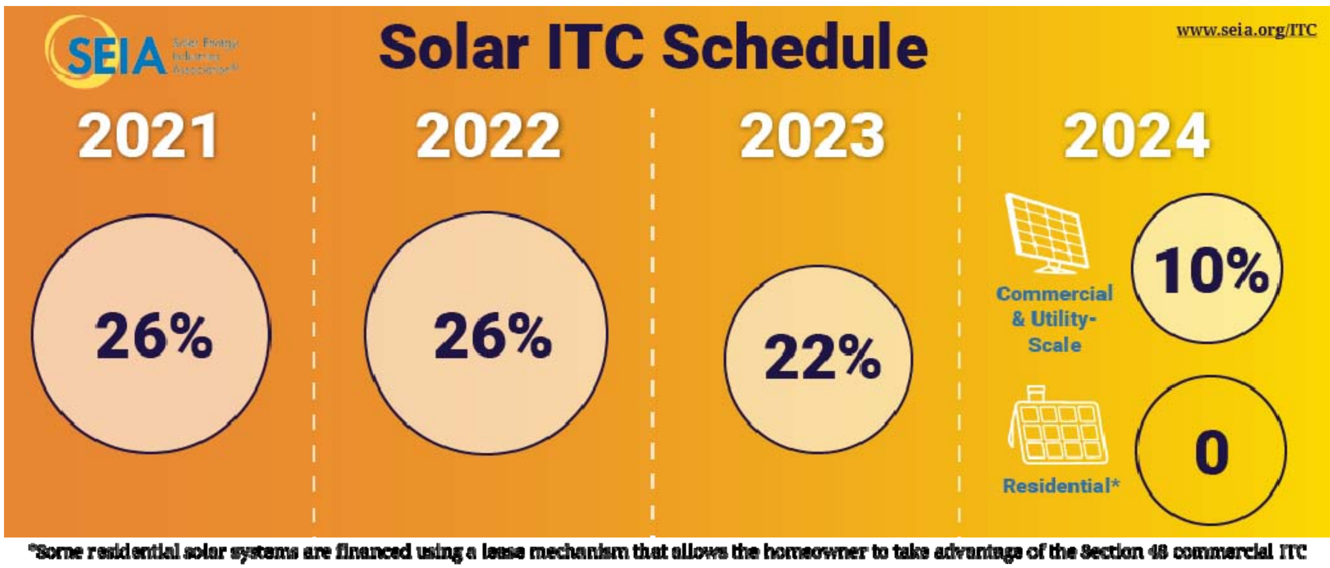
- NEM customer systems are intermittent and impose a spinning reserve and ramping cost on the GPA grid
- NEM customer solar PV systems produce power during daylight hours when GPA production costs are less expensive and in exchange receive a higher rate than the value of that energy
  - Energy Production at Peak is the most expensive for GPA

Federal Tax Credits Subsidize Substitutes

- Solar Energy Investment Tax Credit (ITC)
- Congress established a 30% ITC for any offshore wind project that begins construction by December 31, 2025
- Guam Market is not a Significant Wind Energy Market

Solar Energy Investment Tax Credit (ITC)

- Congress passed a two-year delay of the ITC phasedown in 2020



- 26 percent for projects that begin construction in 2021 and 2022
- 22 percent for projects that begin construction in 2023
- After 2023, the residential credit drops to zero while the commercial credit drops to a permanent 10 percent
- Commercial and utility-scale projects which have commenced construction before December 31, 2023 may still qualify for the 26 or 22 percent ITC if they are placed in service before January 1, 2026

Technical Targets[a]: 100 kW–3 MW Combined Heat and Power and Distributed Generation Fuel Cell Systems Operating on Natural Gas[b]

Characteristic	Units	2015 Status[c]	2020 Target
Electrical efficiency at rated power[d]	% (LHV)	42–47	>50%[e]
CHP energy efficiency[f]	% (LHV)	70–90	90%
Equipment cost, natural gas	$/kW	1,200[g]–4,500[g]	$1,000/kW[g]
Installed cost, natural gas	$/kW	2,400[g]–5,500[g]	$1,500/kW[g]
Equipment cost, biogas	$/kW	3,200–6,500	$1,400/kW[g]
Installed cost, biogas	$/kW	4,900–8,000	$2,100/kW[g]
Number of planned/forced outages over lifetime	–	50	40
Operating lifetime[h]	h	40,000–80,000	80,000
System availability[i]	%	95	99%

a Includes fuel processor,power electronics, stack, and ancillaries: complete system.

b Pipeline natural gas delivered at typical residential distribution line pressures.

c Status varies by technology.

d Ratio of regulated AC net output energy to the lower heating value (LHV) of the input fuel.

e Higher electrical efficiencies (e.g., 60% using Solid oxide fuel cells (SOFC)) are preferred for non-CHP applications.

f Ratio of regulated AC net output energy plus recovered thermal energy to the LHV of the input fuel. For inclusion in CHP energy-efficiency calculation, heat must be available at a temperature sufficiently high to be useful in space and water heating applications. Provision of heat at 80°C or higher is recommended.

g Includes projected cost advantage of high-volume production (100 MW per year).

h Time until >10% net power degradation.

i Percentage of time the system is available for operation under realistic operating conditions and load profile. Unavailable time includes time for scheduled maintenance.

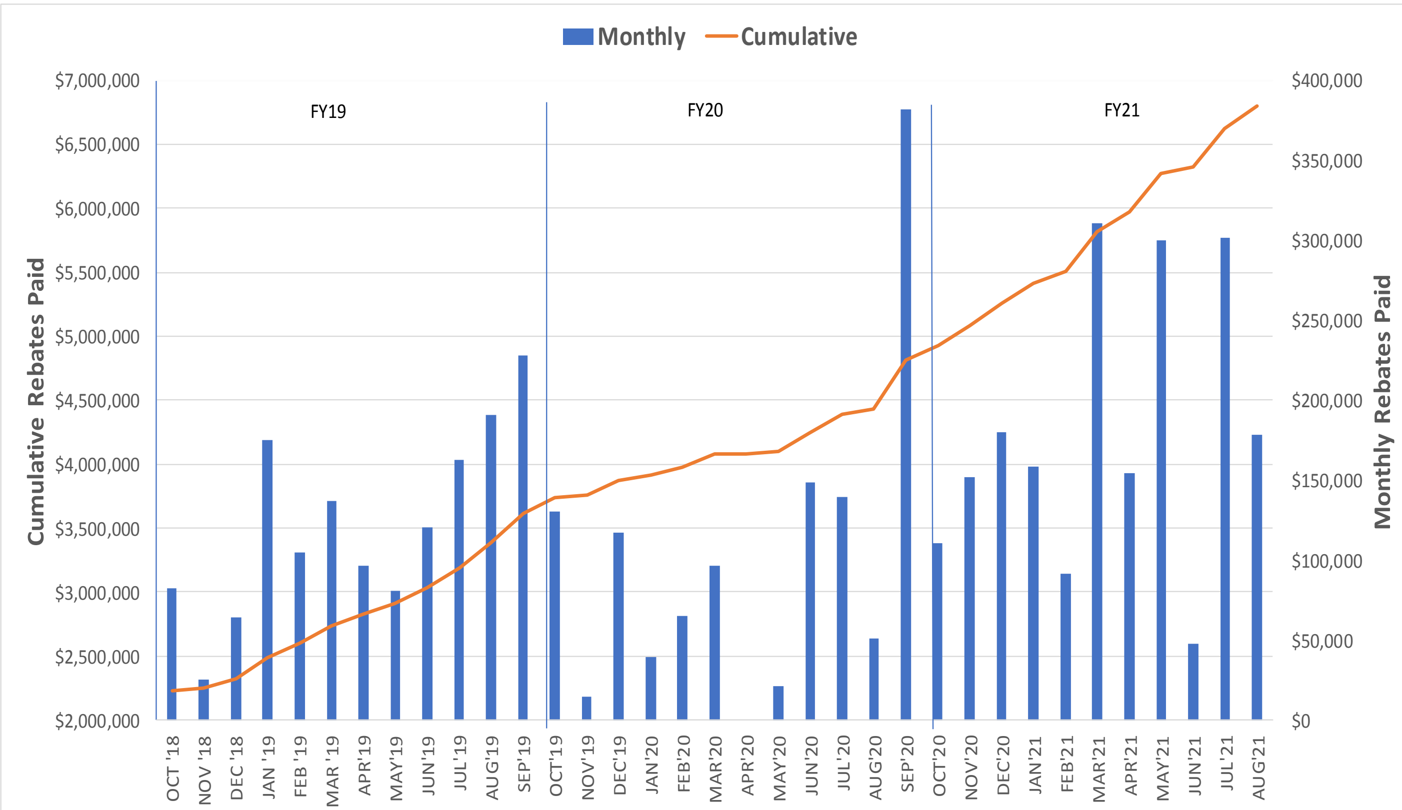
- Natural gas CHP fuel cell systems likely will be competitive with GPA grid-supply by 2020
- Does GPA enter this market?
- Does GPA provide – through its partners – IPP CHP providers?
- What Organizational Infrastructure must GPA create to support this program if we decide to do it?

Hotel Customers & Backup Power Systems

- Largest Block of Hotels requested that GPA consider providing, operating, and maintaining backup Power Systems for the Hotels
  - Suggested these GPA supplied backup systems could be used as part of an interruptible load program
  - This block of hotels is planning for replacement of its backup generation
    - Should GPA try to get on the ground floor with Customer's planning efforts?
  - This Customer Rebuffed Zero-Down Offer
- Natural Gas Fuel Cell Systems would be a great fit and opportunity for increasing GPA revenue
- By supplying these customers with backup power, steam/hot water, and air conditioning, these customers may likely have a much greater dependency on GPA
  - Lowers Risk of Customer Defection

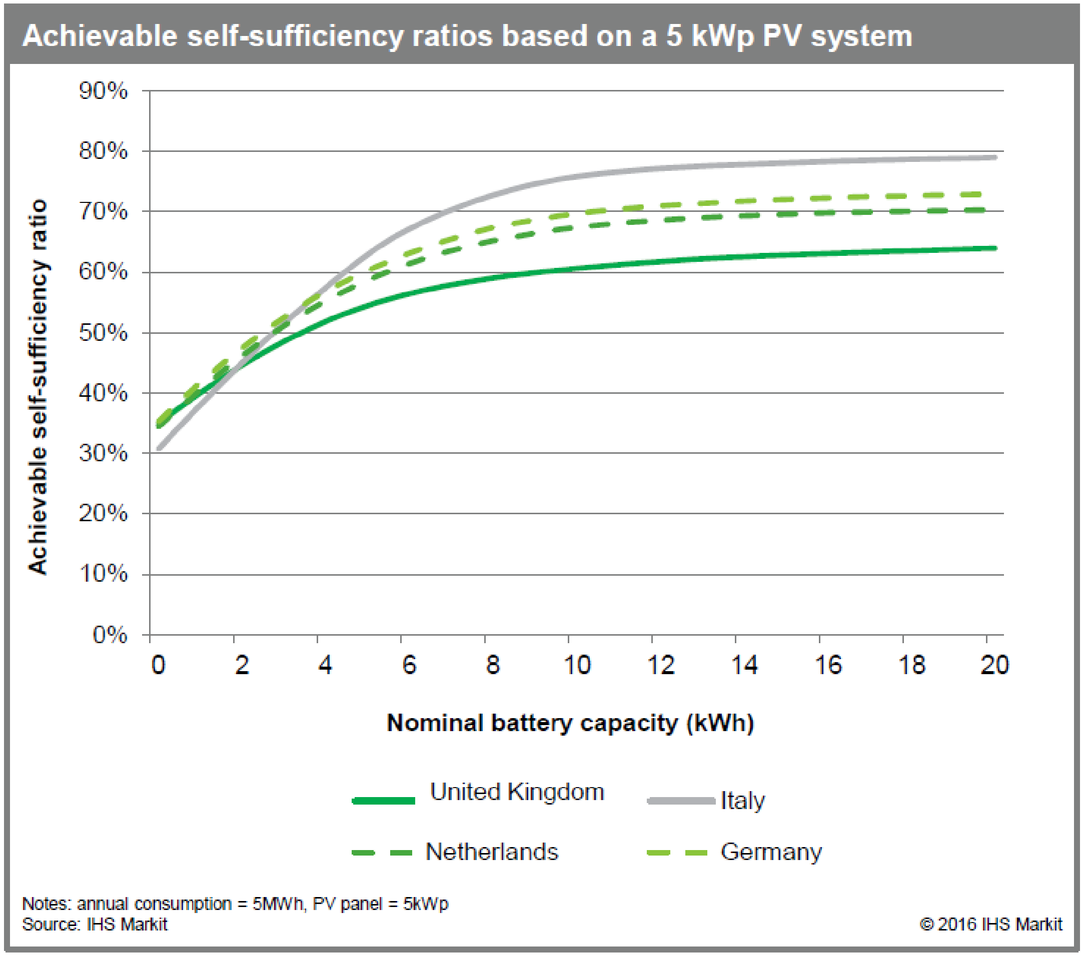
US Navy Seeking LNG and Backup Power

- GPA SPORD and AGMETS met with US Navy on their Master Planning
- They would like GPA to consider:
  - Selling natural gas to DoD to fuel 100% baseload capable generation on Marine Bases
  - Generation For Resiliency and not Main Energy Supply
  - GPA countered with, GPA should supply both and for DoD to consider Co-generation from GPA



DSM Rebates Paid Out FY2019 to Present

- Should GPA Cap Annual Rebate Program Amounts?



ENERGY STORAGE

- ESS Sweet Spot is 5 to 8 kWh
- Complete disconnection from the grid will not become economically attractive until at least 2025
- US Penetration of BESS is 1/6 that of Europe
- Full disconnection is unlikely.

- PV sizing in concert with Energy Storage Sizing

- The point of this slide is to note that although distributed ESS is not currently a big impact on Guam, it may find some traction in the future.
- The counterpoint to this is that the rainy season precludes depending totally on PV+ESS

Bunkering

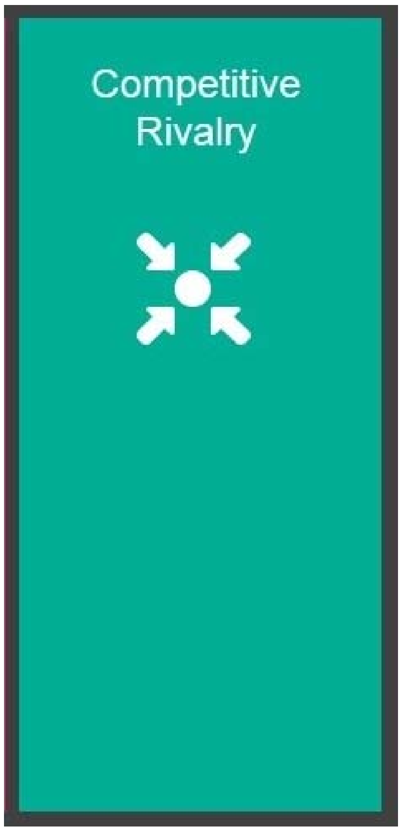
- GPA has a monopoly on RFO supply on Guam
- Substitute Fuel on Guam is ULSD at a considerably higher cost
- Under Annex VI of IMO's pollution prevention treaty (MARPOL), the International Maritime Organization has adopted
  - Regulations to address the emission of air pollutants from ships
  - Mandatory energy-efficiency measures to reduce emissions of greenhouse gases from international shipping
  - Targets to cut the shipping sector's overall CO_2 output by 50 percent by 2050
- GPA has an opportunity to franchise natural gas bunkering for ships

Competitive Tactics

1. Reduce NEM Credits from Full-Retail to GPA VOS
2. Charge NEM Customers Grid Integration Fee
3. Set Up GPA Zero-Down Program
   - Qualify Trade Allies
   - GPA VOS+
   - Shorter PPAs
   - Purchase Option at End of PPA Term
   - GPA Shares Tax Credit with Private Installer/O&M Partner/Trade Ally
     - Partner Monetizes Tax Credit
       - GPA receives share banks it for program expenses.
       - Partner share buys-down solar PV system cost and provides added profit
       - GPA may align with Finance Partner other then installers to monetize tax credit
   - Option: Include Storage
4. Enter into partnerships to provide natural gas-fired CHP fuel cells
5. GPA Community Solar
6. Develop greater large customer dependency on GPA
7. Provide ESS to customers through rebates or Leases
   - Large Customers Benefit from Demand Charge Reduction Strategy
     - GPA's Demand rates are too low.
   - GPA Benefits through reduced reserve and generation capacity requirements

PORTERS FIVE FORCES

Competitive Rivalry

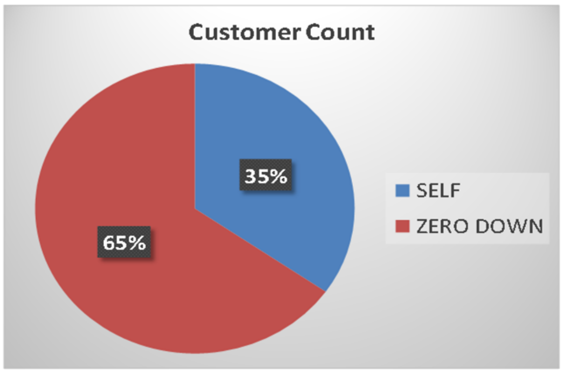


- NEM is still rowing
- NEM systems add to spinning reserve and frequency & power regulation costs
- How painful would it be to lose customers to a rival?
- Rivals are pushing Community Solar with Guam PUC, Legislature, and Executive Branch

NEM – PV Statistics

September 2021

Net Metering Customer Summary

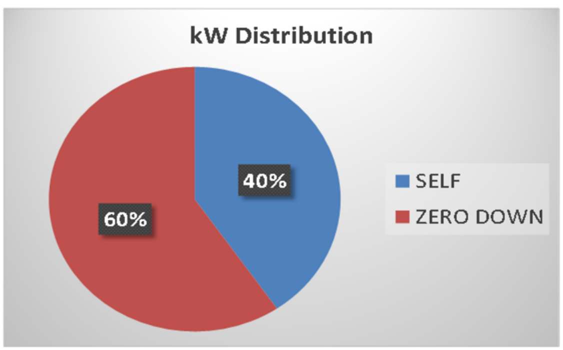


Customer Count

Description	Number of Customers
SELF	782
ZERO DOWN	1,470
Grand Total	**2,252**

Rate Class and Technology

Technology	Schedule	Customer Count	Total kW
Solar Energy	R - Residential	2,090	19,891.89
	J - Gen Service Dmd	63	3,940.05
	K - Small Gov Dmd	11	358.10
	L - Large Government	2	122.80
	P - Large Power	12	1,140.70
	G - Gen Serv Non-Dmd	59	1,667.62
	S - Sm Gov Non-Dmd	7	78.80
Wind Turbine	R - Residential	2	3.60
Grand Total		2,246	27,203.56



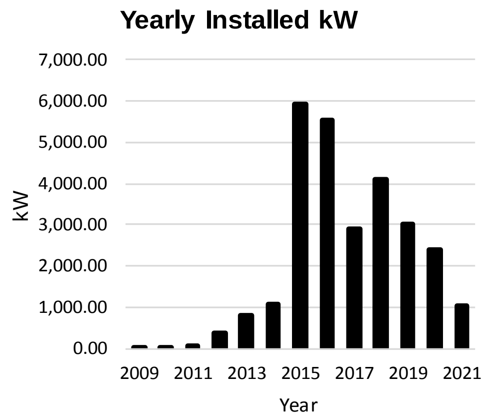
kW Distribution

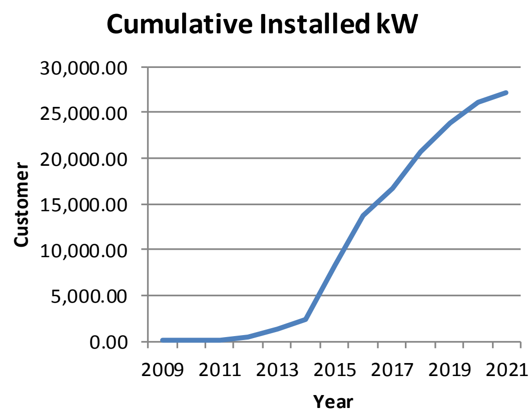
Description	kW
SELF	11,042
ZERO DOWN	16,241
Grand Total	**27,283**

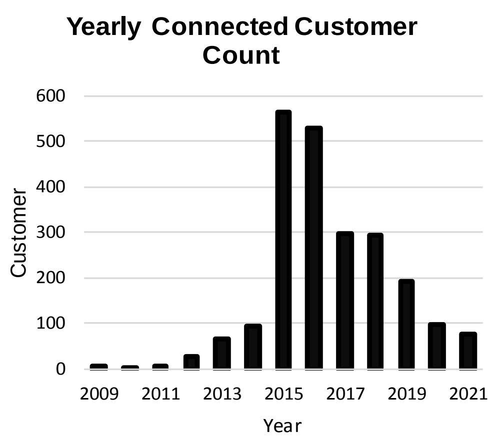
Projection Date Ending 12/31/2021

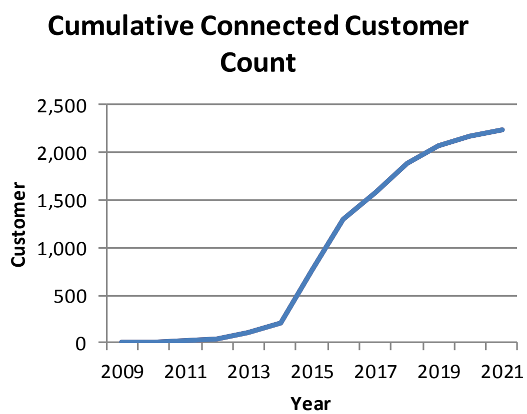
Customer Rate Class	Renewable Energy Capacity (kW)	*Annual Projected kWh Generated	Non-Fuel Yield $/kWh	Estimated Annual Revenue Loss
R	19,895.49	31,979,356	0.000000	$ 2,796,446.85
J	3,940.05	5,462,024	0.000000	$ 675,762.58
K	358.10	567,352	0.133883	$ 75,958.81
L	122.80	202,126	0.129809	$ 26,237.83
P	1,140.70	1,386,230	0.000000	$ 152,416.00
G	1,667.62	2,602,310	0.145397	$ 378,368.20
S	78.80	124,251	0.147902	$ 18,377.01
Grand Total	27,203.56	42,323,650		$ 4,123,567.27

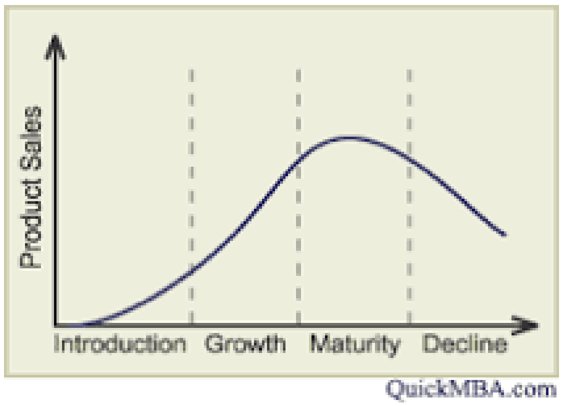
*Estimated number of hours from NREL for Guam (13.4 degrees North and 144 degrees East).


Yearly Installed kW
7,000.00
6,000.00
5,000.00
4,000.00
3,000.00
2,000.00
1,000.00
0.00
kW
2009 2011 2013 2015 2017 2019 2021
Year


Cumulative Installed kW
30,000.00
25,000.00
20,000.00
15,000.00
10,000.00
5,000.00
0.00
Customer
2009 2011 2013 2015 2017 2019 2021
Year


Yearly Connected Customer Count
600
500
400
300
200
100
0
Customer
2009 2011 2013 2015 2017 2019 2021
Year


Cumulative Connected Customer Count
2,500
2,000
1,500
1,000
500
0
Customer
2009 2011 2013 2015 2017 2019 2021
Year


Product Sales
Introduction
Growth
Maturity
Decline
QuickMBA.com

Third-Party Community Solar

- Back door to Open Retail Access
- Once Open Retail Access is Established, GPA Revenues likely to Decline Rapidly
- GPA opposed Open Retail Access Push Attempted through Two Bills in the Guam Legislature in 2009
  - GPA Brought in Ken Rose, one of the Chief Architects of Open Retail Access and U.S. Electric Industry Deregulation
  - Rose showed that Open Retail Access /Deregulation Failed to reduce Electricity Prices. It did the Opposite.
  - In 2009, the effects of the Industry Restructuring began to Manifest itself in increases of Wholesale Electricity Prices as much as 80% in some jurisdictions.

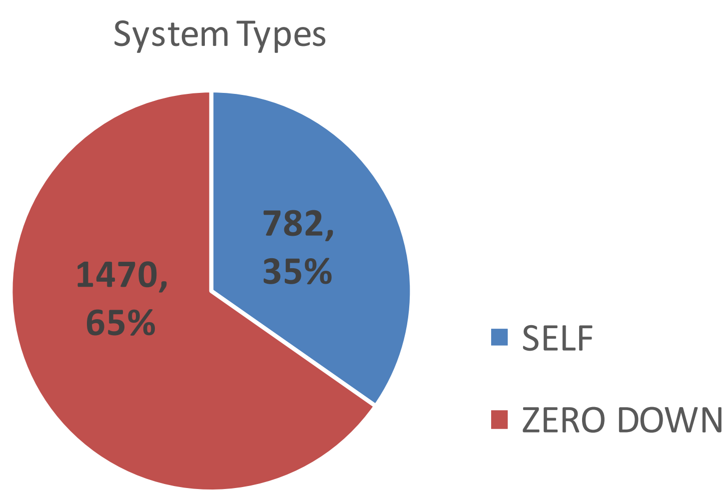
Where is GPA in the Product Lifecycle?

Good Question.

PORTERS FIVE FORCES

Company	System Count	Capacity (kW)	% of Installed Systems
Company I	1,115	12,834	47.04%
Company N	287	4,447	16.30%
Company E	347	3,255	11.93%
Company Q	237	2,519	9.23%
Company J	154	2,513	9.21%
Company L	38	584	2.14%
Company F	26	454	1.66%
Company R	5	288	1.06%
Company B	13	100	0.37%
Company A	6	80	0.29%
Company D	6	50	0.18%
Company G	3	38	0.14%
Company K	3	37	0.13%
Company O	4	26	0.10%
Company C	3	17	0.06%
Company H	2	15	0.05%
Company P	2	14	0.05%
Company M	1	12	0.04%
Grand Total	**2,252**	**27,283**	**100.00%**

Market Share of Competitors



NEM Growth: TBD MW/Year

Zero-Down Caveats[1]

- Consumers are increasingly at risk of being duped by rooftop solar leasing companies that promise easy terms, including no money down (Forbes, 2015)
- These contracts lack transparency when it comes to the true terms and economic benefits of such long-term leases (Scientific American, 2014).
- Aggressive solar companies rope consumers into lease agreements by offering zero down and initial low payments that escalate over time (Forbes, 2015)
- They project inflated savings for the consumer based on false assumptions that electricity costs from the grid will rise at a rate higher than the escalation rate of the lease. But the estimated savings almost never materialize (The Fool, 2014).

1. https://www.forbes.com/sites/jamesconca/2015/01/17/rooftop-solar-shines-light-on-bad-business-practices/#33f4a837a88d
2. https://www.fool.com/investing/general/2014/04/30/will-the-solar-lease-live-forever-or-flameout.aspx

Zero-Down: General Terms

- Contract Term
  - Guam: 25-year terms
  - U.S. Mainland: usually 15 or 20-year terms
- PPA Expiration
  - Guam: Removal or lease extension
  - U.S. Mainland: Ownership of the panels transfers for a nominal payment
- Fixed Escalator Plan
  - Payment rises at a predetermined rate, typically between 2% – 5%
  - Annual Escalation Rate (Guam)
- Fixed Price Plan
  - Constant price throughout the term of the PPA
- Project owner typically, though not always, receives all of the direct benefits associated with:[1]
  - **Net metering credits**
  - Federal tax incentives
  - Construction incentives
  - Renewable energy certificates (RECs)
- PPA must transfer to new owner if Lessee sells house
- Solar PV System does not work if grid is down (from Guam Lease)

- One source indicates GPA Customer keeps credits

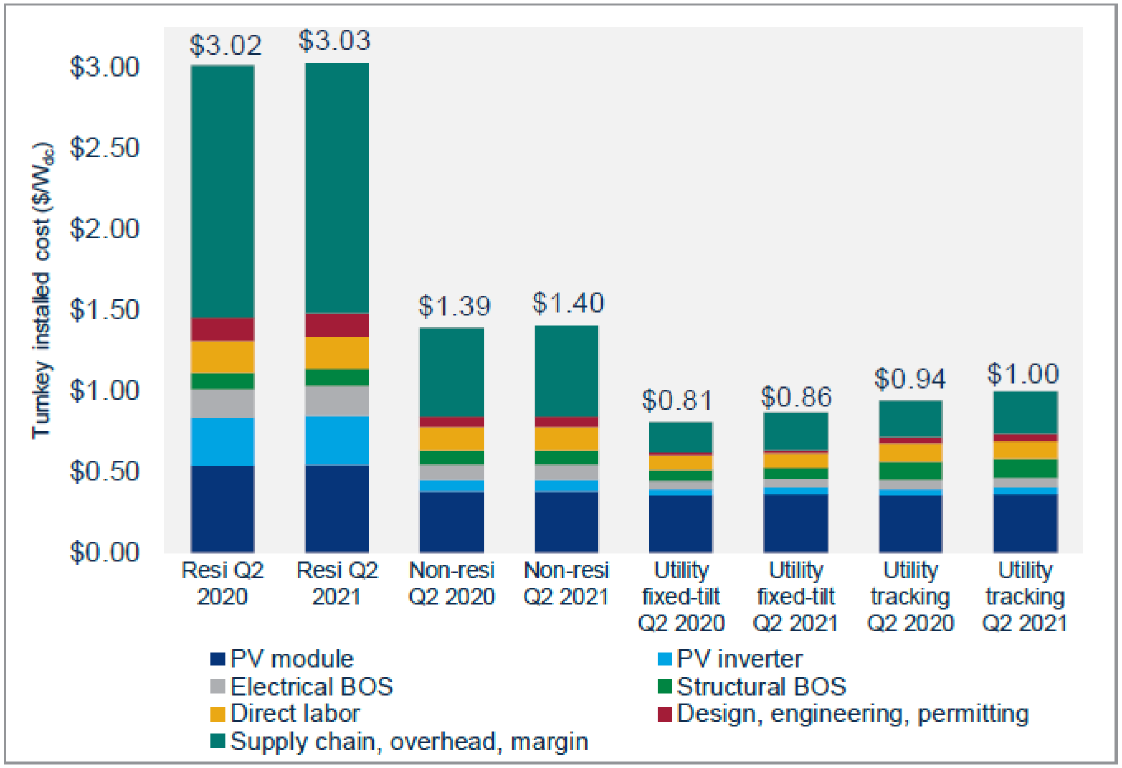
1. Leading by Example Program. *Renewable Energy Power Purchase and Net Metering Credit Purchase Agreement Guidance for State Entities.* Massachusetts Department of Energy Resources. December 2013. URL: http://www.mass.gov/eea/docs/eea/lbe/ppa-and-nma-guidance.pdf

U.S. Mainland Trend

- Zero-down lease and PPA agreements are starting to lose market share for three reasons:[1]
  - Solar panels are becoming cheaper to buy;
  - People don't want to sign long term contracts, particularly when these contracts can make it more difficult to sell a house (if the new owner does not want to take over the lease);
  - With a PPA or lease the solar company and its financiers get the benefits of all the incentives including the investment tax credit (ITC); and
  - To put it simply, you save tens of thousands of dollars more over the life of the solar system if you buy it with cash or with a loan than what you do entering into a lease or PPA agreement.

1. https://www.solar-estimate.org/solar-financing/ppa-solar

Modeled US national average system prices by market segment, Q2 2020 and Q2 2021



Source: Wood Mackenzie

Utility-Scale Versus Roof Top Solar

- GPA subsidizes NEM
- GPA is NEM system s' battery
- NEM causing operational problems that are expensive to fix
- NEM not paying their share of costs.

Is GPA Losing the Customer Engagement War?

Evolving Behavior of Consumers & Business Customers

- Customers increasingly
  - Check prices at a keystroke
  - Selective about which brands share their lives
  - Form impressions from every encounter and post withering online reviews
- These changes present significant organizational challenges, as well as opportunities.
- The biggest challenge is that all of us have become marketers
  - The critical moments of interaction, or touch points, between companies and customers are increasingly spread across different parts of the organization
  - Customer engagement is now everyone’s responsibility

McKinsie Recommendations

1. Hold a customer-engagement summit
2. Create a customer-engagement council
3. Appoint a ‘chief content officer’
4. Create a ‘listening center’
5. Challenge your total customer-engagement budget

Transforming the Customer Experience and Engagement

- CCU directives driving customer experience and engagement
  - Mobile App
  - Social Media
  - Outage Notification
- Smart Grid Tools
  - MyEnergy/E-Portal
  - BizConnect
  - Outage Management System (OMS)

TelCom Digital Engagement

- GPA’s 2018 Customer Satisfaction Survey has characterized that customers’ GPA service expectations are for a large part driven by customer engagement by the local Telcom and Fuel Station industry
- At the core of these engagements is Gamification

Gamification

- Involves an understanding of:
  - What motivates people
  - How people want to be rewarded
  - What will make people stay loyal.
- Engages the basic principles of human psychology
  - At its core, gamification has a human centered design; optimized for feelings, motivation, insecurities and engagement.
  - Gaming creates positive emotion, drives social relationships and fosters feelings of accomplishment.
- How can GPA use gamification to create loyal customers? Should we?

10 Amazingly Successful Examples of Gamification

1. The Samsung Nation
2. The US Army
3. Jillian Michaels Fitness Program
4. Starbucks
5. Nike+ Run Club
6. Progress Wars
7. Nissan Carwings
8. Beat The GMAT
9. AccorHotels
10. Stride Rite

Antoine Leclercq. (2015). 10 Amazingly Successful Examples of Gamification. https://potion.social/en/blog/10-amazingly-successful-examples-of-gamification

Utility Digital Transformation

- Digital transformation in a true sense involves leveraging Cloud, Big Data, mobility and social media technologies to transform how companies do business.
- Gamification

GPA Must Adapt its Rate Structure

- Mainland Utility Responses to Distributed Energy
  - Moving customer charges to recover appropriate amount of fixed costs through the customer charge
  - Moving to customer charges based on panel size of customers or AMP's
  - Charges based on kVA of Transformer Capacity
  - Implementing demand charges for residential customers
  - Residential Time of Use Rates
  - Implementing customer charges and minimum bills
  - Changing Rate Designs to properly align with Fixed and Variable Costs
  - Develop a new rate class for customers with Roof Top Solar
  - Keep Rate Structure and develop a surcharge for Roof Top Solar
  - Charge to recover stranded cost at time of solar installation
  - Buy-All Sell-All Rates

Buy-All Sell-All

- Called a VOST (Value of Solar Tariff) where all electricity used by customer is billed at retail rates. All energy produced by solar array is credited at the VOST
- Customer's charged for all energy consumed and credited at avoided cost for energy generated by solar unit
- Requires two meters

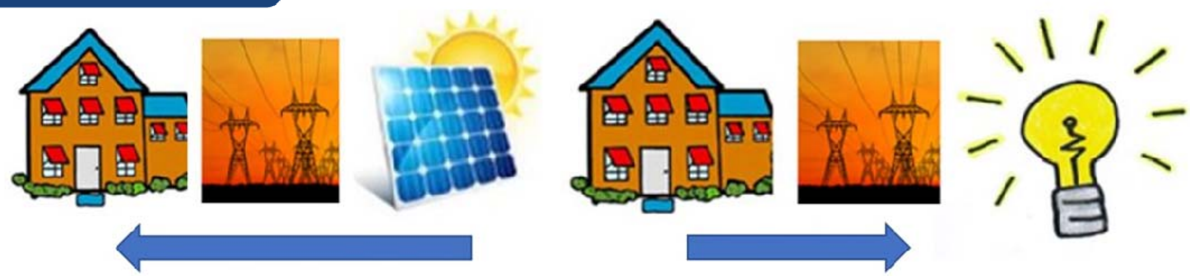
Customer is charged for all energy used even if produced by solar array. Customer is credited at the Avoided Cost Value of Solar (VOST).

Metering & Billing Method

Customer billed on total electric usage by adding energy taken from GRID and energy produced by solar array less energy provided by the solar array back to the GRID

Customer receives a credit for all energy produced by solar array

Metering required:
- Meter on solar unit
- Meter on facility



600 kWh + 800 kWh − 500 kWh = 900 kWh − 800 kWh

600 kWh	800 kWh	500 kWh	900 kWh	800 kWh
Customer's use from Electric grid at Retail Rates	Total Generation from Solar Panel at Retail Rates	Customer gives back to Electric Grid at Retail Rates	Billed at Retail Rates	Credit at Avoided Cost

Competitive Tactics

1. Move into the solar industry, both in the utility-scale and rooftop markets
2. Reduce NEM Credits from Full-Retail to GPA VOS
   - Allow for sustainable NEM program
   - GPA does not object to NEM, just full-retail NEM.
3. Charge NEM Customers Grid Integration Fee
4. Integrate Renewables + Energy Efficiency
5. Set Up GPA Zero-Down Program
   - Qualify Trade Allies
   - GPA VOS+
   - Shorter PPAs
   - Purchase Option at End of PPA Term
   - GPA Shares Tax Credit with Private Installer/O&M Partner/Trade Ally
     - Partner Monetizes Tax Credit
       - GPA receives share banks it for program expenses.
       - Partner share buys-down solar PV system cost and provides added profit
     - GPA may align with Finance Partner other then installers to monetize tax credit
   - Option: Include PV behind Energy Storage
     - Note: Having separate inverters for PV and ESS exacerbates issues with Short Current Ratio
6. Enter Community Solar Market
7. Adapt its rates to send appropriate price signals
8. Buy-All Sell-All
9. Market DSM as a substitute for alternate supply
10. Focus on creating the best customer experience (CX) possible

Potential New Entrants

- Barriers to Entry
  - No Open Retail Access
    - GPA Owns Grid
    - IPP and PPA Contracts Turn Over Substations and Transmission Line Interconnection Facilities
  - GPA Contends It is Not Subject to FERC PURPA
- Off-Island U.S. & International Firms May Challenge PURPA Applicability to Guam
- Threat of Legislature or PUC Establishing Open Retail Access
- How easy is it for someone to enter our market?

Bunkering

- GPA is a monopoly for RFO supply on Guam
- Matson has stopped Bunkering with GPA since the IMO requirements went into effect

Competitive Tactics

1. Emphasize One-Guam Approach with Navy and their DoD Customers
   - Actively engage NAVFAC, REPO, and Congressional Representation for Common Ground, Win-Win Projects
   - Get Behind the Fence
   - Improve Power Quality
   - Improve Resilience
2. Research Legal Basis for PURPA Non-Applicability to Guam
   - Develop strong basis for future legal challenges
   - Engage Legislature and PUC to build barriers against adopting PURPA
3. Engage Legislature and PUC to build strong barriers against Open Retail Access
4. Improve Power Quality, Affordability, Service, and Customer Satisfaction
5. Focus on creating the best customer experience (CX) possible

PORTERS FIVE FORCES

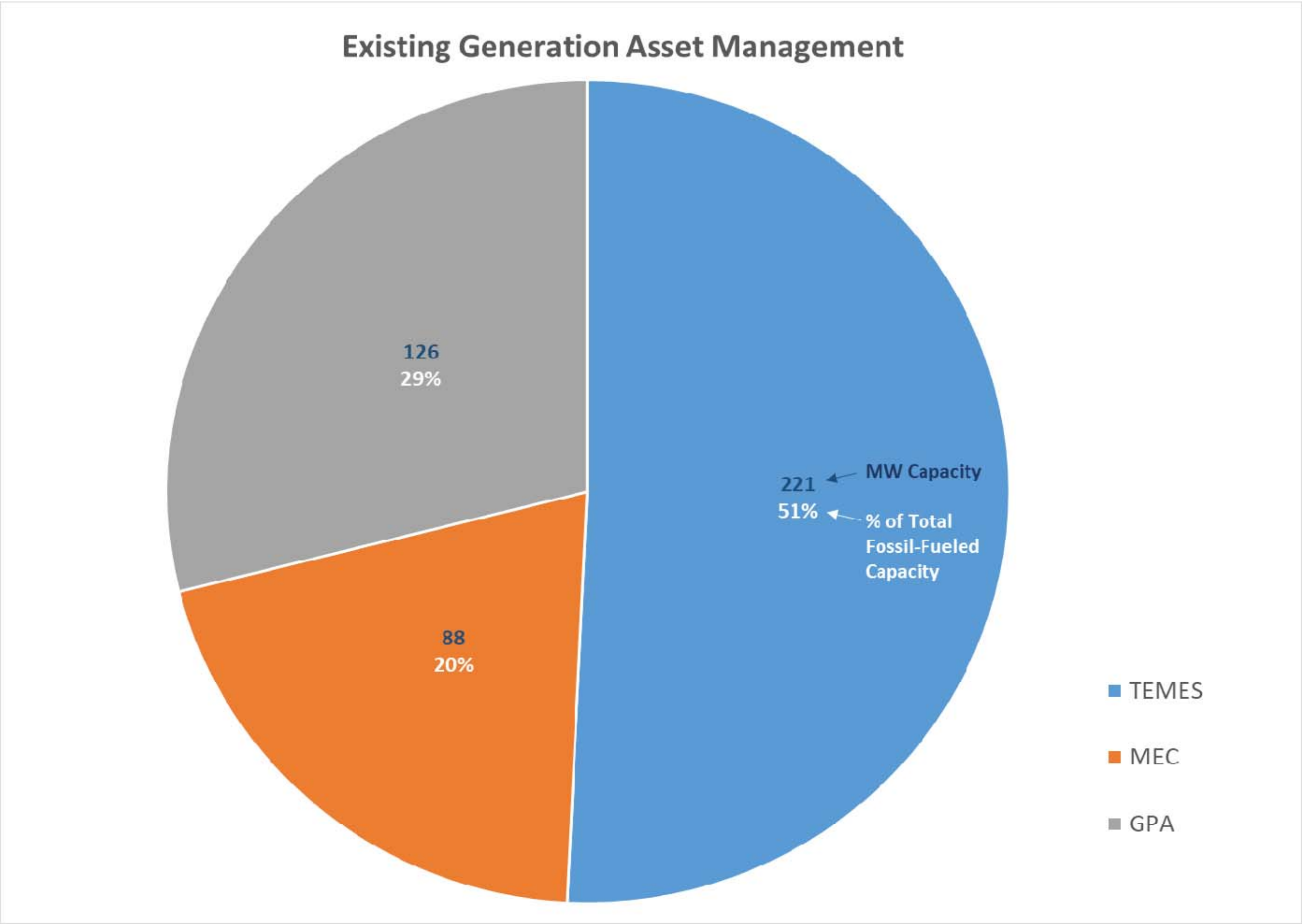
Suppliers

- ULSD Fuel Supply has been Problematic
- Energy Generation Supply
- Fuel Diversification
  - Renewables
  - LNG
  - ULSD
- Renewables + Energy Storage
- Construction Workforce
- Aging Workforce (Labor Pool)
- How painful is it to lose a supplier?

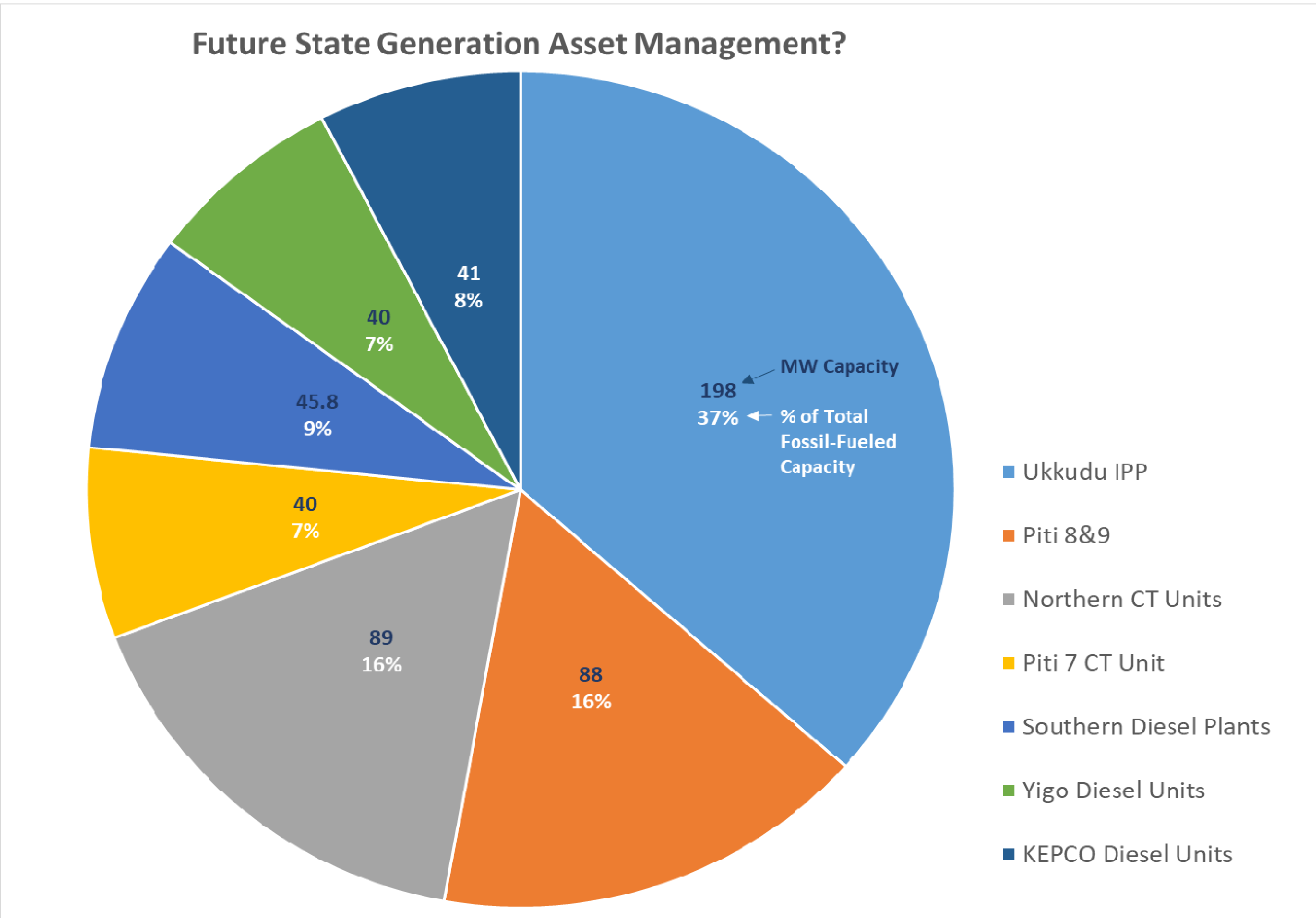
Large/Key Suppliers

- IPPs & PMCs
- Fuel Supply
- Construction Services
- GPA Human Resources
- IT/OT Infrastructure

PORTERS FIVE FORCES



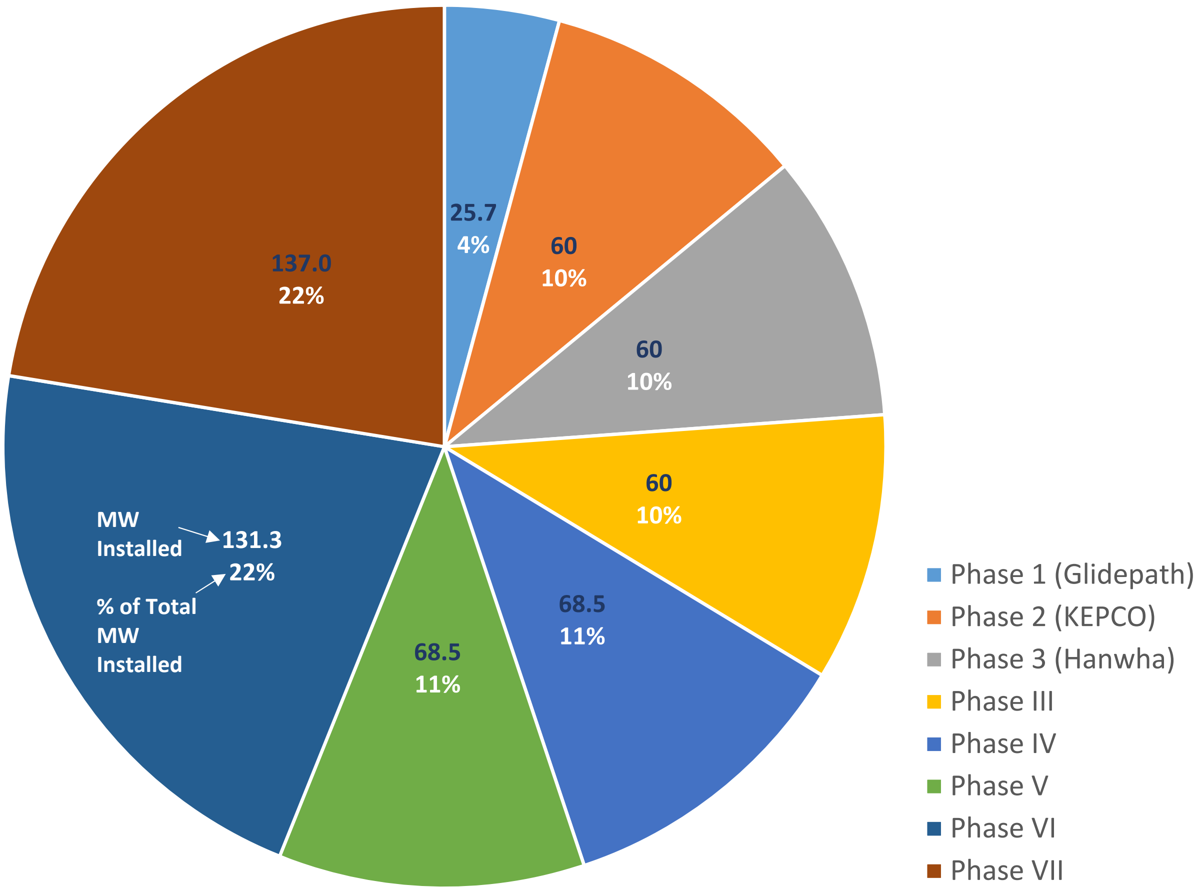
- 100% of Existing Generating Assets owned by GPA
- 51% of Generation Assets under TEMES, Guam Inc. Management
- 20% of Generation Assets managed and staffed by MEC
- Significant operational reliability challenges with TEMES Management of Cabras 1&2
  - About 30% of Generation
- Diversification of Suppliers is a good tactic but avoid overdiversification to simplify contract management
  - What is the optimal number of contracts that dilutes the power of generation supply versus simplifies the management of these contracts?



- We are getting out of the Generation business
- What does this mean?

Does the Graphic Reflect the Future Structure of Generation Plant Ownership and Management?

Future State Renewable Energy Supply?



Renewable Resource	Owner	MW Installed	Est. MWH/Yr	Est. Hrs Online
Phase 1 (Glidepath)	Glidepath	25.7		
Phase 2 (KEPCO)	KEPCO	60		
Phase 3 (Hanwha)	Hanwha	60		
Phase III	*solicitation in progress*	60		
Phase IV	*planned*	68.5	300,000	12
Phase V	*planned*	68.5	300,000	12
Phase VI	*planned*	131.3	575,000	12
Phase VII	*planned*	137.0	600,000	12

- Phase III awarded to one bidder, but currently under protest and awaiting decision
- Phase IV
  - Should we limit the size of each Bid Proposal?
    - Limit project size to reduce load shedding potential?
    - Limit maximum power to the grid?
      - Renewable Capacity Greater than Maximum Power to the Grid
  - Should we eliminate Talofofo/Dandan/Apra as an interconnecting site?
    - Large simultaneous power injection from southern renewables increases system losses
- Should we create microgrids around regional ESS, Renewables, and Generation?

Fuel Supply

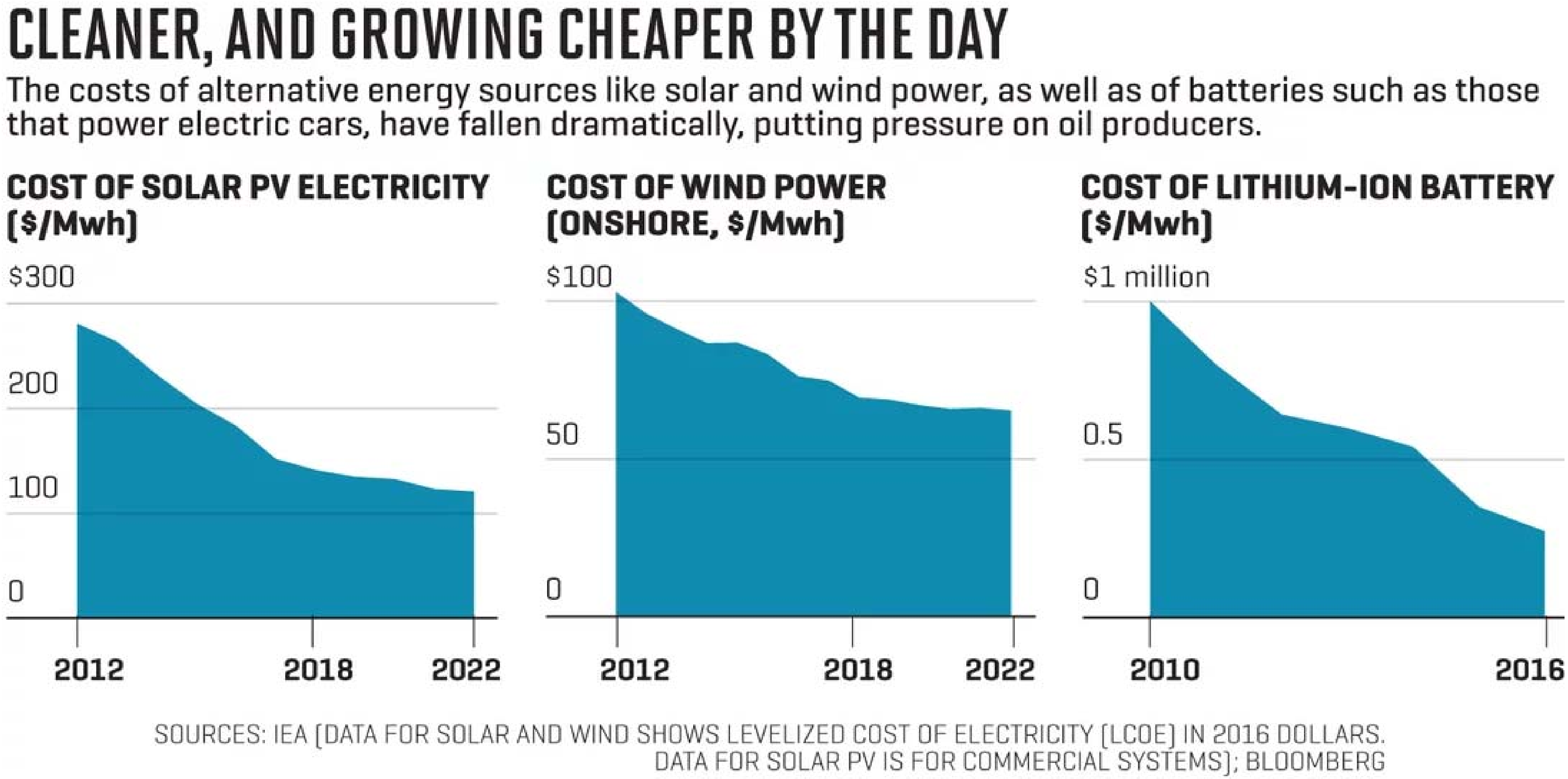
- Residual Fuel Oil (RFO)
  - GPA has a single RFO supplier
  - Receiving infrastructure is tolled from Tristar
  - GPA owns two bulk storage tanks
  - GPA rents two RFO tanks from Tristar
  - GPA moving off RFO
- Ultra Low Sulfur Diesel (ULSD)
  - Receiving infrastructure is tolled from Tristar
  - GPA rents one ULSD tank from Tristar (190 KBBL)
  - Mobil & IP&E have insufficient storage infrastructure
  - GPA depends on Mobile & IP&E for tanker truck deliveries
  - Mobile has COSTSI contractually locked up for all remaining tanker truck capacity
- Bunkering
  - Bunkering Infrastructure through Tristar
  - GPA draws from own inventory

Fuel Supply

- GPA has issues with ULSD supply whenever several baseloads are simultaneously on outage
  - Delivery requirements to CTs and Diesel Power Plants outstrip the individual Mobile and IP&E capacity to provide tanker trucks and drivers
  - Over the past three years, GPA has required a second source
  - Competing interests between Mobile and IP&E allows one or the other to dictate operational terms to GPA
  - This situation is untenable in the long-term
  - GPA has to maintain its own storage reserves but relies on Mobil and IP&E for delivery.

Future State Fuel Business Models

- Diversification
  - LNG/NG
  - ULSD
  - Renewable Energy (PPAs)
- ULSD Business Model
  - GPA-Owned Storage
  - Contracted Supply and Delivery
  - Pipeline Delivery to Tenjo Vista, Piti 7, and Piti 8&9
  - Ukkudo Tanker Truck Fuel Gantry for Northern CTs and Aggreko Units
- LNG Business Model
  - FSRU LNG Storage
  - Ukkudo CNG Storage?
  - Land-Based LNG Storage?
- Franchised LNG Business Model
  - Off-Island Isotainer Sales
  - Land Transportation & Heavy Equipment
  - Ship Bunkering
  - CHP Fuel Cell System Supply
  - Conventional CHP System Supply


CLEANER, AND GROWING CHEAPER BY THE DAY
The costs of alternative energy sources like solar and wind power, as well as of batteries such as those that power electric cars, have fallen dramatically, putting pressure on oil producers.
COST OF SOLAR PV ELECTRICITY ($/Mwh)
$300
200
100
0
2012
2018
2022
COST OF WIND POWER (ONSHORE, $/Mwh)
$100
50
0
2012
2018
2022
COST OF LITHIUM-ION BATTERY ($/Mwh)
$1 million
0.5
0
2010
2016
SOURCES: IEA [DATA FOR SOLAR AND WIND SHOWS LEVELIZED COST OF ELECTRICITY [LCOE] IN 2016 DOLLARS. DATA FOR SOLAR PV IS FOR COMMERCIAL SYSTEMS]; BLOOMBERG

If Solar And Wind Are So Cheap, Why Are They Making Electricity So Expensive?

Michael Shellenberger, CONTRIBUTOR
I write about energy and the environment FULL BIO

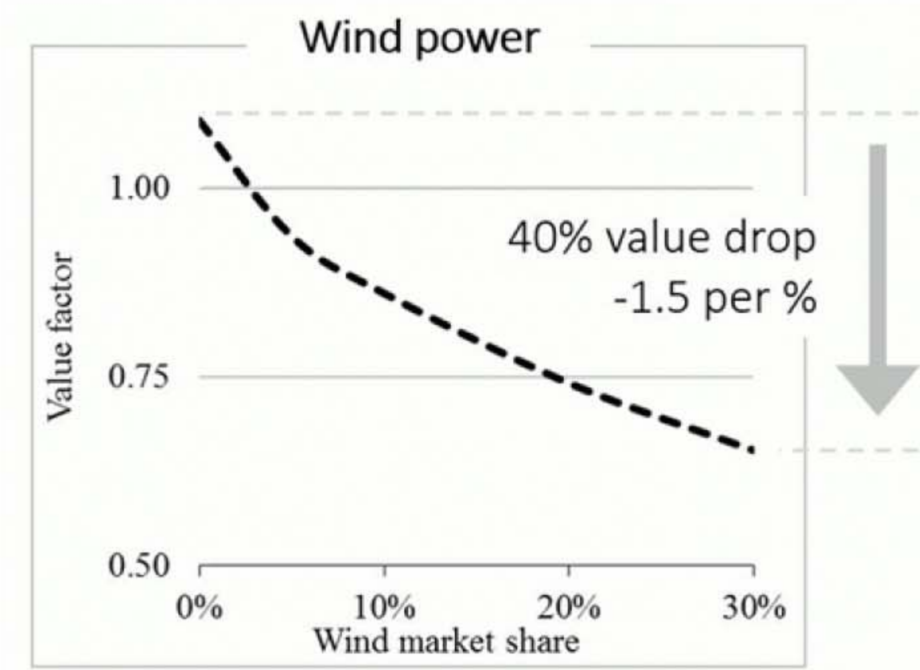
Opinions expressed by Forbes Contributors are their own.

- Electricity prices increased by:
  - 51 percent in Germany during its expansion of solar and wind energy from
  - 2006 to 2016;
  - 24 percent in California during its solar energy build-out from 2011 to 2017;
  - over 100 percent in Denmark since 1995 when it began deploying renewables
  - (mostly wind) in earnest.

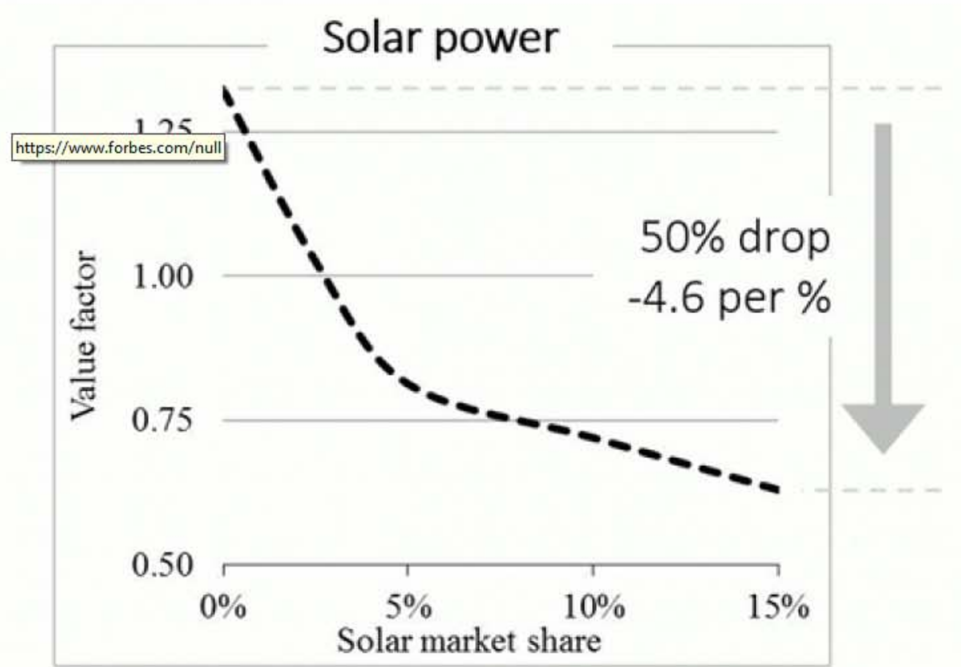
- What gives? If solar panels and wind turbines became so much cheaper, why did the price of electricity rise instead of decline?

The Reason

- In a paper for Energy Policy, Leon Hirth estimated that the economic value of wind and solar would decline significantly as they become a larger part of electricity supply.
  - The reason? Their fundamentally unreliable nature. Both solar and wind produce too much energy when societies don’t need it, and not enough when they do.
  - Solar and wind thus require that natural gas plants, hydro-electric dams, batteries or some other form of reliable power be ready at a moment’s notice to start churning out electricity when the wind stops blowing and the sun stops shining.
  - And unreliability requires solar- and/or wind-heavy places like Germany, California and Denmark to pay neighboring nations or states to take their solar and wind energy when they are producing too much of it.



Source: updated from Hirth (2013): Market value



Source: updated from Hirth (2015): Market value of solar

The value factor of wind power decreases from ~1.1 at low penetration to ~0.65 at 30% market share (1.5 points per point market share).

The value factor of solar power decreases from ~ 1.3 at low penetration to ~ 0.6 at 15% market share: (4.6 points per point market share).

EP

Hirth predicted that the economic value of wind would decline 40% once it reached 30% of electricity, and that the value

Guam is Different

- No Inexpensive Gas or Nuclear Generation
- Not allowing the intermittent nature of Renewable PPAs to dominate
- Existing Grid Issues:
  - Numerous UFLS Outages
  - Weak Voltage and Frequency Regulation
  - Oil-based Generation
  - Inefficient Existing Generation System
  - Spinning Reserve is Expensive and Really Does not Work Effectively on GPA System with Existing Generation and Controls
  - Cabras-Agana 115 KV Lines an O&M Liability
  - Fault Clearing a Big Issue for Maintaining Grid Stability
- Environmental Compliance Driving Generation and Fuel Changes
- GPA Leadership Got Out in Front of the Problem before it Became a Substantial Problem Unlike Hawaii, Germany, Denmark, and California.

Construction Workforce

- GPA and GWA are embarking on several large infrastructure construction projects. ($2 billion)
- Similarly, DoD is embarking on its military buildup construction projects. ($8.7 billion)
- Is there sufficient construction capacity?
- How does the GPA cope?

Military Buildup Acceleration

- Defense Secretary James Mattis
  - *"In light of the serious situation we face, we are accelerating implementation of the 2015 Guidelines for the U.S.-Japan Defense Cooperation and continuing to realign U.S. forces in Japan and Guam."* -- The Guam Daily Post Aug 21, 2017
- Potential tightening of Construction Contractor availability
- Counterpoint: Recent Awards going to off-island USA-Japan Consortiums potentially bringing in their own workforce.
  - $165 million contract has been awarded to Granite-Obayashi, a joint venture between two subsidiaries of construction business giants.
    - Granite Construction Inc. is a multibillion-dollar U.S. company involved in construction and mining.
    - Obayashi Corp. is one of Japan's leading publicly listed construction firms with projects worldwide, and which built the Tokyo Skytree landmark in Japan.
    - The Guam Daily Post Aug 21, 2017

Visa Holdups

- Kevin Penton. (2018). "Guam Businesses Secure Class Cert. In H-2B Visa Suit." URL: https://www.law360.com/articles/1028869/guam-businesses-secure-class-cert-in-h-2b-visa-suit
  - Law360 (April 2, 2018, 5:51 PM EDT) -- A Guam federal judge on Saturday certified a class of businesses in the U.S. territory that allege the federal government unfairly denied their H-2B temporary worker visa petitions, rejecting arguments by the government that the employers lacked standing because the time to get relief had passed.

GPA Demographics: Retirement

Retirement Plan Distribution

RETIREMENT PLAN	EXEC		CFO		AGMA		AGMETS		AGMO		TOTAL	
	Count	Percent	Count	Percent	Count	Percent	Count	Percent	Count	Percent	Count	Percent
DB	4	44.4%	6	15.0%	6	8.7%	17	22.4%	45	19.0%	78	18.1%
DB1.75	4	44.4%	15	37.5%	30	43.5%	41	53.9%	90	38.0%	180	41.8%
DC	0	0.0%	19	47.5%	33	47.8%	18	23.7%	99	41.8%	169	39.2%
LTD	0	0.0%	0	0.0%	0	0.0%	0	0.0%	2	0.8%	2	0.5%
SSN	1	11.1%	0	0.0%	0	0.0%	0	0.0%	1	0.4%	2	0.5%
TOTAL	9	100.0%	40	100.0%	69	100.0%	76	100.0%	237	100.0%	431	100.0%

"As we started gathering data, we found not only in the electric utility, but in the other utilities, the statistics were similar," he said. "The aging workforce, in some cases **25 percent to 35 percent of the workforce, is age 55 and above and on the precipice of retirement.**" – Jon O'Connell, The Times-Tribune, January 29, 2017

Defined Benefit Plan Employees are incentivized to retire. GPA employees often have very marketable skills in short supply on Guam. Working after they retire may considerably increase their incomes.

PORTERS FIVE FORCES

EXEC Retirement Plan Distribution

RETIREMENT PLAN	Count	Percent	Min	Max	Avg	Median
DB	4	44.4%	24.33	33.33	31.06	33.29
DB1.75	4	44.4%	16.92	28.50	22.58	22.46
DC	0	0.0%	-	-	-	-
LTD	0	0.0%	-	-	-	-
SSN	1	11.1%	46.67	46.67	46.67	46.67
TOTAL	9	100.0%				

CFO Retirement Plan Distribution

RETIREMENT PLAN	Count	Percent	Min	Max	Avg	Median
DB	6	15.0%	26.42	39.58	31.06	30.21
DB1.75	15	37.5%	4.75	27.67	16.77	17.75
DC	19	47.5%	0.00	28.75	5.21	4.08
LTD	0	0.0%	-	-	-	-
SSN	0	0.0%	-	-	-	-
TOTAL	40	100.0%				

AGMA Retirement Plan Distribution

RETIREMENT PLAN	Count	Percent	Min	Max	Avg	Median
DB	6	8.7%	26.58	29.92	28.57	29.13
DB1.75	30	43.5%	4.00	34.75	15.60	13.71
DC	33	47.8%	0.42	29.08	9.50	7.00
LTD	0	0.0%	-	-	-	-
SSN	0	0.0%	-	-	-	-
TOTAL	69	100.0%				

AGMETS Retirement Plan Distribution

RETIREMENT PLAN	Count	Percent	Min	Max	Avg	Median
DB	17	22.4%	21.08	42.42	29.28	28.17
DB1.75	41	53.9%	3.67	32.25	16.90	17.25
DC	18	23.7%	0.33	29.00	9.22	4.13
LTD	0	0.0%	-	-	-	-
SSN	0	0.0%	-	-	-	-
TOTAL	76	100.0%				

AGMO Retirement Plan Distribution

RETIREMENT PLAN	Count	Percent	Min	Max	Avg	Median
DB	45	19.0%	12.00	40.08	28.69	28.08
DB1.75	90	38.0%	3.83	34.08	17.85	16.67
DC	99	41.8%	0.75	35.33	14.29	13.00
LTD	2	0.8%	10.92	23.25	17.08	17.08
SSN	1	0.4%	17.50	17.50	17.50	17.50
TOTAL	237	100.0%				

IT/OT Infrastructure

- Schweitzer Engineering Laboratories
- Landis + Gyr
- TropOs/ABB
- Cisco
- Dell
- Oracle
- General Electric
- Itron
- Harris Smartworks
- Symantec
- Siemens
- Schneider Electric

Schweitzer Engineering Laboratories (SEL)

- Relays
- Communication Gateways
- Software Defined Network (SDN) Systems
- Fiber Optic Communication Multiplexing Systems
- Substation/Generation Meters
- Navy Revenue Meters
- SEL RTUs: RTACs?

Landis + Gyr

- Advanced Metering Infrastructure (AMI)
- Command Center
- Tier3 Communications (GridStream)
- Revenue Meters (Non-Navy)
- Potential GWA Meters & Meter Communication Modules
- Advanced Grid Analytics
  - Technology Roadmap
    - Real-Time Monitoring and Control of Distribution Assets

TropOs/ABB

- Tier2 Communications
  - Meter Backhaul
  - GPWA SCADA
  - Mobile Workforce Management System
  - Field VOIP Support

Cisco

- Network Routers
- Network Switches
- Network Firewalls
- Intrusion Detection System (IDS)
- Intrusion Prevention System (IPS)
- Email Security Appliance (ESA)
- Security

Dell Federal Government Solutions

- Standalone Servers
- Blade Server Systems
- Workstations
- Dell Federal Government Solutions
  - Computing Equipment Supply Chain Management
  - Directives like the Federal Information Technology Acquisition Reform Act (FITARA) provide a framework for moving ahead, but only Dell has the tools to help agencies build a new architecture and make the transition seamlessly.
- VMware, Inc (Dell Subsidiary)
  - Server

Oracle

- Customer Care & Billing (CC&B)
- Business Intelligence Tool
- SCADA Historian (Database)

General Electric

- D20/D200 RTUs
  - Substitutes under consideration
    - SEL RTAC
    - OSI Inc OSIRIS RTU
- DAPmini Servers
- Substation Automation Systems

Itron

- MV90 System
  - Polls Navy, Substation, and Generator Meters
  - Data Collection
  - Data Verification

Suppliers

- Harris Smartworks
  - Meter Data Management System (MDMS)
  - BizConnect
  - MyEnergy Portal
- Symantec
  - Web Proxy
  - Anti-Virus/Anti-Malware Application
- Siemens
  - GPWA SCADA
- Schneider Electric
  - SCADPack RTUs (GWA)

Energy Storage Systems

- LG CNS Batteries and Energy Storage Systems
  - Phase I ESS
  - Phase II Renewable Energy Acquisition
- Is there a need for diversity of supply?

Project	Site	ESS Inverter Output (MW)	Guaranteed (MWh)	Installed (MWh)
ESS Phase I	Agana	24	6	13
	Talofofo	16	16	23
Phase II	KEPCO_LGCNS	32	32	
	Hanwha	40	65	
Phase III	Naval Base Guam	20	120	
	South Finegayan	20	120	
Total		**152**	**359**	

Energy Storage Systems

How does GPA Compare?

Project	Site	ESS Max Inverter Output (MW)	Guaranteed (MWh)
GPA Aggregate	Guam	152	359
TESLA	South Australia	100	129
Southern California Edison (Tesla)	Mira Loma Battery Storage	20	80
San Diego Gas & Electric (SDG&E) (AES)	Escondido, California	30	120
Alta Gas (Greensmith)	Pomona, California	20	80

Competitive Tactics

1. Diversify Suppliers
2. Negotiate Long-Term Discount Contracts as Preferred Buyer

Buyers

- Navy is GPA's Largest Customer
  - Dynamic between One-Guam. Mission Resiliency, and Energy Cost Reduction
- Hotels are a Large Block of Customers
- Government of Guam Customers
  - Guam Waterworks Authority (GWA)
  - Guam Department of Education (GDOE)
  - Guam Department of Public Works (GDPW)
- How painful is it to lose a customer?

Customers are Buyers

- In general, the longer a customer stays with a company, the more that customer is worth
  - Long-term customers buy more, take less of a company’s time, are less sensitive to price, and bring in new customers
  - Best of all, they have no acquisition or start-up cost
- What keeps customers loyal is the value they receive.

Customer Value

- Epictetus: “What concerns me is not the way things are, but rather the way people think things are.“
- Service/quality, like beauty, is in the eye of the beholder. (Clemmer, 2018)
- Without Knowing and Appreciating What Customers Value is a Prescription for Failing to Meet Customers’ Expectations and a Broad Avenue for Wasting Money.

Navy

- “One Guam” Approach
- What does “One Guam” this mean?
- How Committed is the Federal Government to “One Guam?”
- Pain Points
  - Massachusetts Institute of Technology, Lincoln Laboratory Report
- Using their Leverage on GPA
  - Phase III Experience

One Guam Commitment

- Former NAVFAC Marianas Commanding Officer Capt. Stephanie Jones
  - "We are striving to achieve reliable and resilient power and water systems for Guam. This is best accomplished through our continued work with GPA and GWA to find creative solutions to resolve critical utility issues facing the island."
- Desiree Masterson, former regional energy program manager for NAVFAC Marianas
  - "We had a huge push in the past two years from the Secretary of the Navy to install renewable energy projects worldwide. We coordinated with GPA and this partnership has resulted in Guam now being a part of the Navy renewable program."
  - With the number of energy projects on island the Secretary of the Navy looked at Guam specifically and said, 'I want to do this energy plan here first as a model for the rest of the Navy,' according to Masterson. "The plan being formulated is to establish a plan of action to meet energy goals through 2035. In addition to sustainability, the plans address resiliency, security, renewable energy projects and efficiency."
- Frank Whitman. (2017) URL: http://www.navy.mil/submit/display.asp?story_id=100185

Navy/DoD Concerns Regarding GPA Supply

- MIT Lincoln Lab Report
- Points of Concern
  - UFLS Outages
  - Power Quality (includes outages)
  - Spares
  - Base Power Infrastructure O&M

Massachusetts Institute of Technology, Lincoln Laboratory Report

- Deficiency
    - Military installations see longer, more frequent outage events, with critical loads not being served, and outage information not sufficiently recorded or reported.
    - The increased need for emergency backup generation, in combination with generator wet stacking from vastly oversized generation assets, results in higher maintenance costs and increased failures.
    - The Guam Power Authority (GPA) supplies power to the entire island of Guam, including all naval sites. The **power reliability is less robust** than U.S. mainland installations, with frequent under-frequency trips and power outages from equipment failure, animals, and humans (from both GPA supply and within the fence line).
    - Conversations with site personnel indicate a **widespread belief that power quality and outage problems are caused by GPA**, and especially from its existing 20 MW Solar PV installation. This belief has not been verified, but GPA is currently conducting a study to analyze the effect of solar penetration on grid stability.

Massachusetts Institute of Technology, Lincoln Laboratory Report

- Military installations on Guam should **leverage commonalities between the electrical systems and share stockpiles of common components**. This will reduce shipping lead times and increase the resilience of all installations. (Opportunity)
- Sufficient resources should be allocated to **enable a power system analysis to help determine power quality causes and solutions** (Opportunity)
- AAFB/NSAA should coordinate with GPA to test the **Dededo CT plant** to AAFB/NSAA interconnection, and verify that the system provides sufficient backup power. (Opportunity)

Massachusetts Institute of Technology, Lincoln Laboratory Report

- **Backup generation for MCBG** should be centralized with the ability to add generation in 1-2 MW units as the site is built out. Common components for the backup power expansion efforts should be required. (Opportunity)
- **Critical loads (including black start requirements) to be powered by the Orote power plant** should be identified to enable emergency operation planning for feeder switching requirements and power plant expansion if needed. (Opportunity)

Massachusetts Institute of Technology, Lincoln Laboratory Report

- Costs (Opportunity)
  - The annual electrical distribution O&M costs include maintenance to critical sections of each site's electrical distribution system, calculated as $/kW-y from NAVFAC accounting information and scaled by the ratio of critical load to non-critical load at the site as determined for each base.
  - Distribution system O&M cost was estimated to be $98/MWh for all sites in NAVFACMAR, **and includes costs of labor, liquid fuel, BOS Contracts, equipment, materials and supplies, sustainment, restoration and modernization, controls and integration engineering and other support, and taxes.**

PORTERS FIVE FORCES

Massachusetts Institute of Technology, Lincoln Laboratory Report

- Cyber and Physical Security is a Major Concern
- There is no Cyber Security without Physical Security

Electric Grid and Outages (MIT LL Report)

Grid MTTF (h)	1564.29
Grid MTTR (h)	1.23
Distribution MTTF (h)	4512.73
Distribution MTTR (h)	8.22
Number of Substations	3
Number of Feeders	34
Years of Data input	2.5

Table 2. Electrical Grid Outage Data for NBG

LEGEND

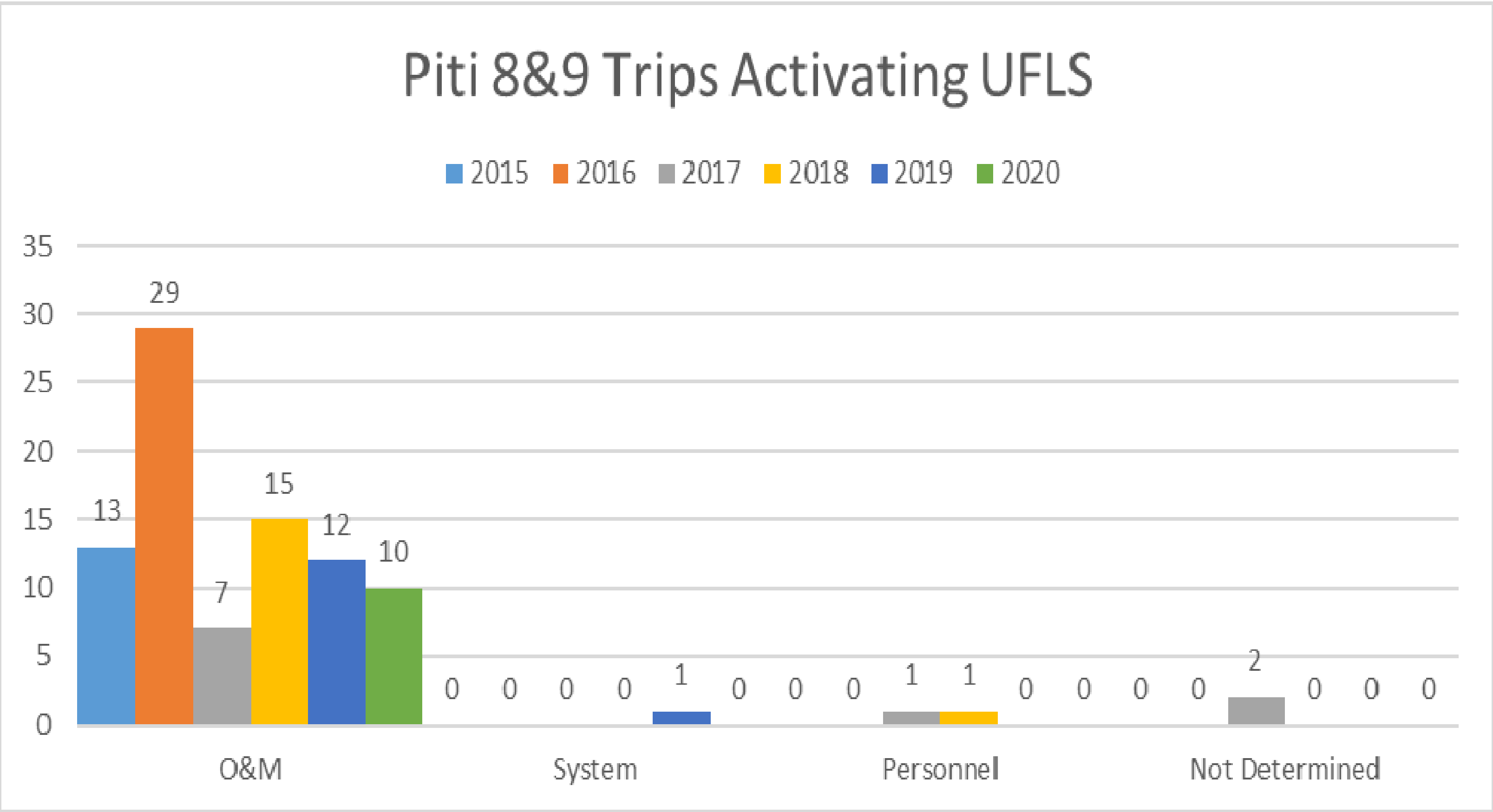
MTTF Mean Time to Failure
MTTR Mean Time to Repair

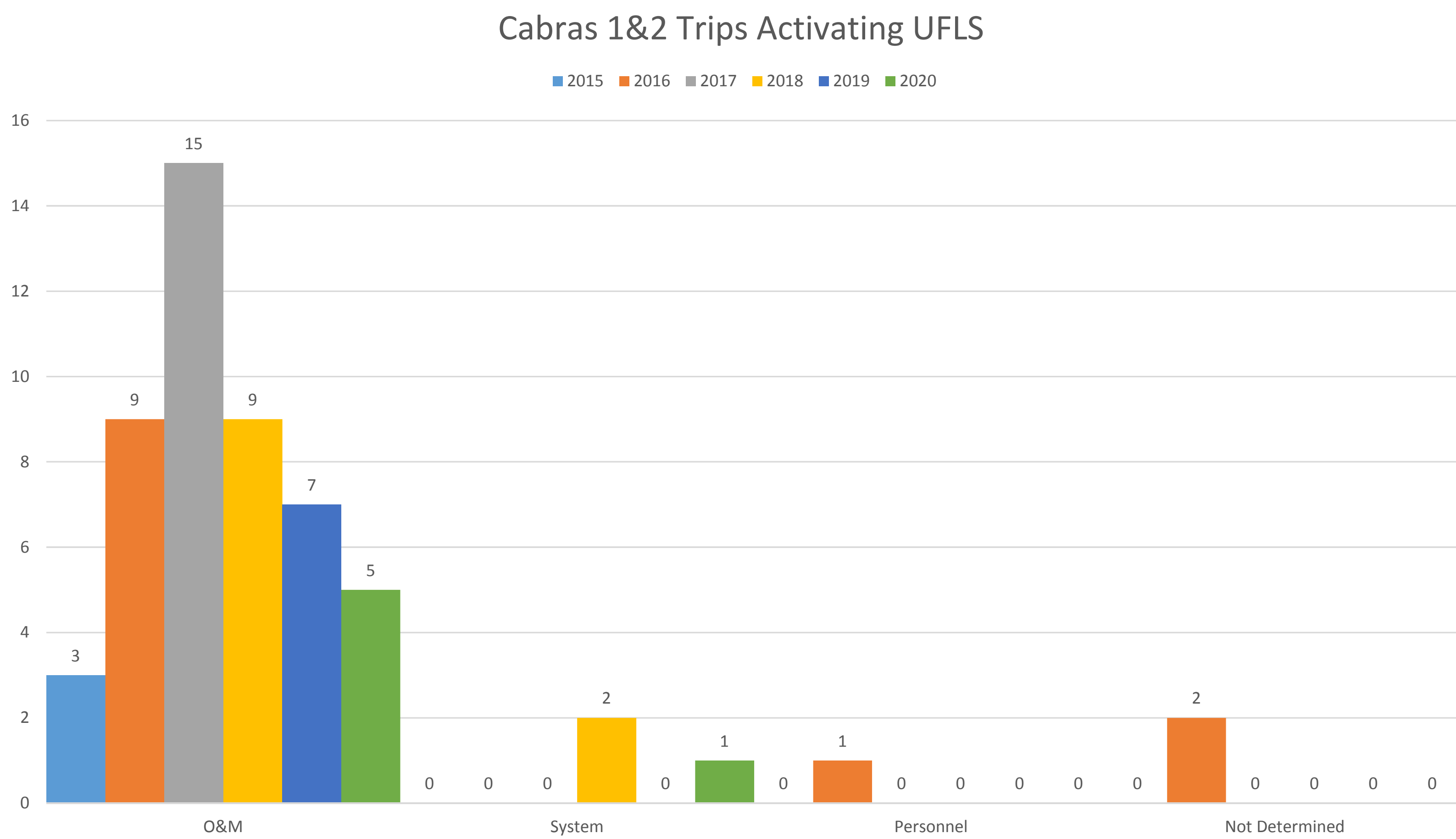
Grid MTTR is about 2.142 months

Reducing UFLS Outages

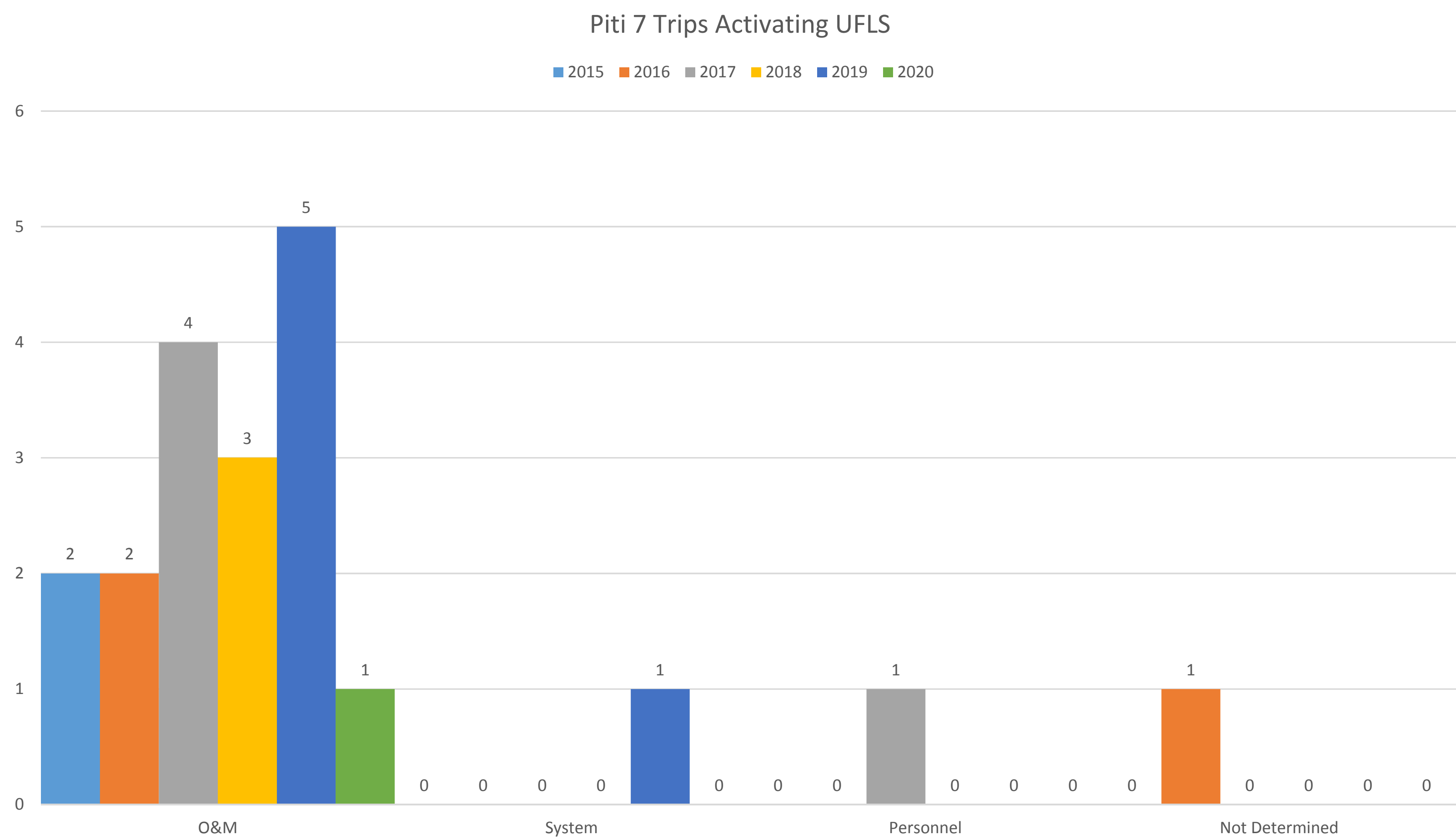
- Build in System Resiliency Capabilities
  - Flexible Generation ✓
  - Contingency/Spinning Reserve ESS ✓
  - Synchronous Condensers ✓
- Mitigate the effects of System Faults and Transients
  - Strengthen Voltage Support ✓
  - Clear Faults Quickly ✓
- Reduce Generator Trips
  - Better Preventive Maintenance
  - Better Operator Training
  - Better Equipment & Auxiliary Systems
  - Better Operation of the Power Plant
- The above is not a comprehensive list.
- ✓ Renewable Integration Study Recommendations

PORTERS FIVE FORCES




Cabras 1&2 Trips Activating UFLS
2015
2016
2017
2018
2019
2020
16
14
12
10
8
6
4
2
0
15
9
9
7
5
3
0
0
0
2
0
1
0
1
0
0
0
0
0
2
0
0
0
0
O&M
System
Personnel
Not Determined

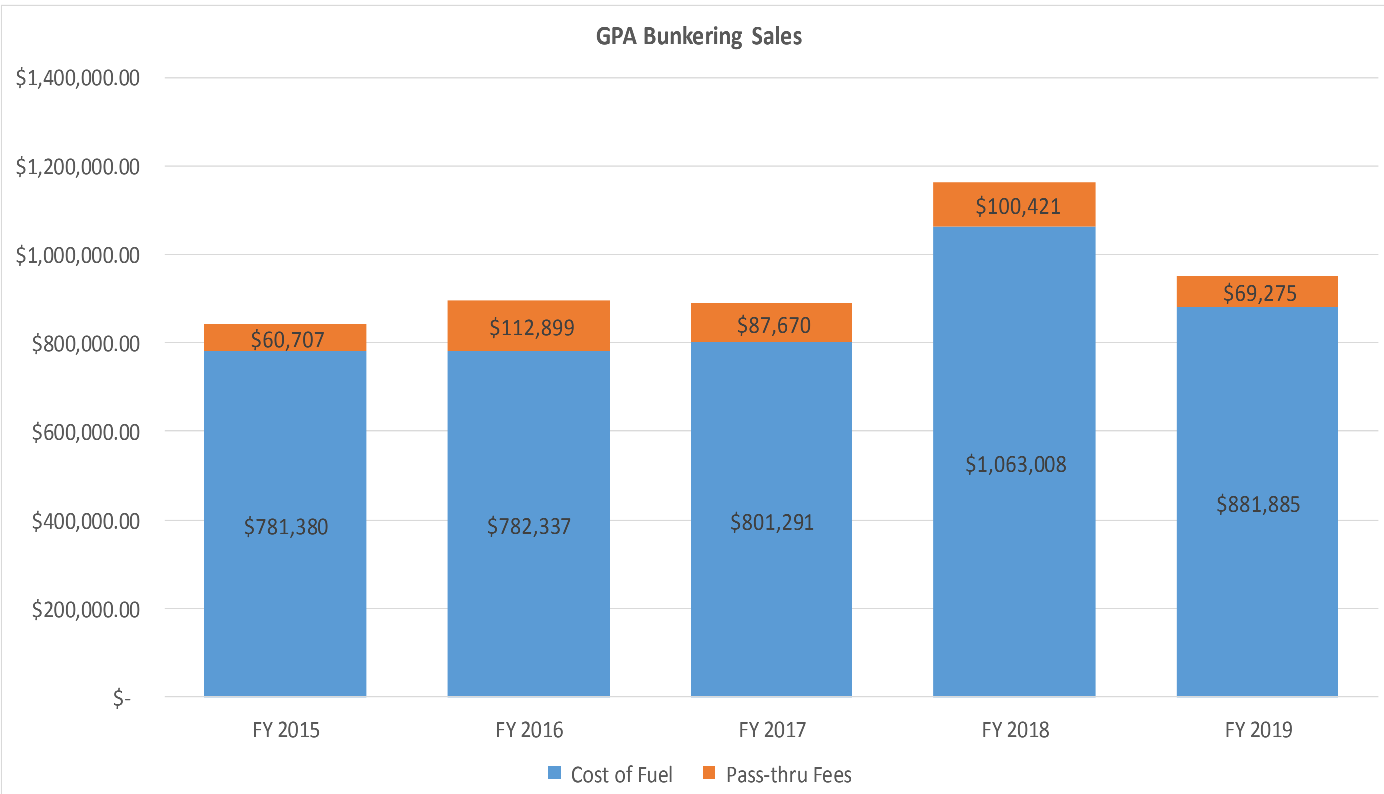
PORTERS FIVE FORCES



PORTERS FIVE FORCES

UFLS Instigator	Date	Root Cause	CLASSIFICATION
Cabras 1	2/5/2020	Fuel valve actuator problems	O&M
	3/30/2020	Outside disturbance	System
	12/10/2020	Activation of boiler drum high level alarms	O&M
	12/12/2020	Activation of boiler drum high level alarms	O&M
Cabras 2	5/7/2020	Loss of burner pressure	O&M
	12/27/2020	Failure on fuel oil discharger pressure transmitter	O&M
MEC 8	2/1/2020	Fuel oil leak on cylinder #3 fuel pump head	O&M
	3/21/2020	Loss of power to fuel booster pump #2	O&M
	4/10/2020	Engine turbocharger overspeed	O&M
	6/11/2020	Fuel injector leak on cylinder #1	O&M
	11/9/2020	Engine overspeed	O&M
	11/11/2020	Engine turbocharger overspeed	O&M
MEC 9	1/9/2020	Replacement of cylinder #7 fuel injection valve	O&M
	2/18/2020	Damaged fuel injector on cylinder #7	O&M
	5/5/2020	Low F.O. pressure / broken exhaust pipe bolts	O&M
	5/27/2020	Turbocharger #2 overspeed	O&M
PITI 7 CT	6/12/2020	High temperature gear enclosure	O&M
Macheche CT	2/6/2020	Activation of fuel pump low pressure switch	O&M
	6/22/2020	Activation of generator trip alarm	O&M
	9/8/2020	Loss of field windings	O&M
	11/20/2020	Activation of exhaust gas thermocouple prove failed alarm	O&M
	12/11/2020	Open circuit of the emergency stop button	O&M
Yigo CT	6/18/2020	Loss of station power	O&M
Dededo CT1	2/24/2020	Leak on hydraulic torque convertor	O&M
Aggreko	6/21/2020	High voltage and unbalanced current	O&M
	10/14/2020	Activation of high voltage and high frequency alarms	O&M
	11/24/2020	Activation of high voltage and high frequency alarms	O&M
GlidePath Solar	3/30/2020	Sudden drop of solar from 15MW to 5MW	Solar Drop
	4/6/2020	Sudden drop of solar from 24MW to 7MW	Solar Drop
	4/11/2020	Sudden drop of solar from 24MW to 7MW	Solar Drop
	4/24/2020	Sudden drop of solar from 22Mw to 10MW	Solar Drop
	4/27/2020	Sudden drop of solar from 22MW to 6MW	Solar Drop
	5/24/2020	Sudden drop of solar	Solar Drop
	6/10/2020	Sudden drop of solar from 24MW to 7MW	Solar Drop
	7/19/2020	Sudden drop of solar	Solar Drop
	9/14/2020	Sudden drop of solar from 20MW to 3MW	Solar Drop
	11/1/2020	Sudden drop of solar from 20MW to 5MW	Solar Drop
	11/28/2020	Sudden drop of solar from 18MW to 4MW	Solar Drop

Bunkering



- Matson is our only customer
- Clipper and others want to become a customer
- Small Revenues and Decreasing
- With LNG, GPA may have an opportunity to refuel ships.
- The UN's International Maritime Organization (IMO) called on shipping companies to reduce GHG emissions by the year 2050 to 50 percent of their 2008 level

LNG Ship Re-Fueling

- After years of contentious talks, the International Maritime Organization (IMO) finally agreed this week to reign in [GHG] emissions from shipping. After a tense two weeks of negotiations that went down to the wire, 170 countries agreed on Friday to halve shipping emissions by 2050, compared to 2008.
- https://www.forbes.com/sites/davekeating/2018/04/15/for-the-first-time-maritime-shipping-has-a-climate-target/#6a3a235768e7

Desalinization

- The following are the highlights of a discussion between the GPA AGMETS and GWA Senior Engineer Supervisor, P.E., Brett Railey, on the paper: "Hydrologic Resources of Guam."[1]
- Guam's aquifer consists of freshwater floating on top of seawater. Over pumping will cause saltwater to infiltrate into this layer of freshwater. GWA monitors water wells for chlorides and other indicators so that this does not happen.
- Guam's water resources are finite. It is estimated that withdrawing water at 40% capacity of the aquifer is the maximum resource limit. GWA believes it is operating at 20% of the aquifer capacity. Monitoring will indicate the true limits.
- GWA is not optimizing the production of the aquifer(s) because it would be too expensive. GWA builds wells where there are existing infrastructure such as roads and electricity. This means that GWA may reach a maximum water resource limit sooner than 40%.
- Railey suspects it is unlikely GWA will reach the aquifer limit - for many decades if ever. Based on best science GWA is producing at currently less than 50% sustainable production. GWA has some significant gains to be made with reducing non-revenue water (loss). As wells reach the end of useful life they can be relocated to more optimal locations. While desal is one possible solution, waste water reuse and other technologies will likely be a better solution.

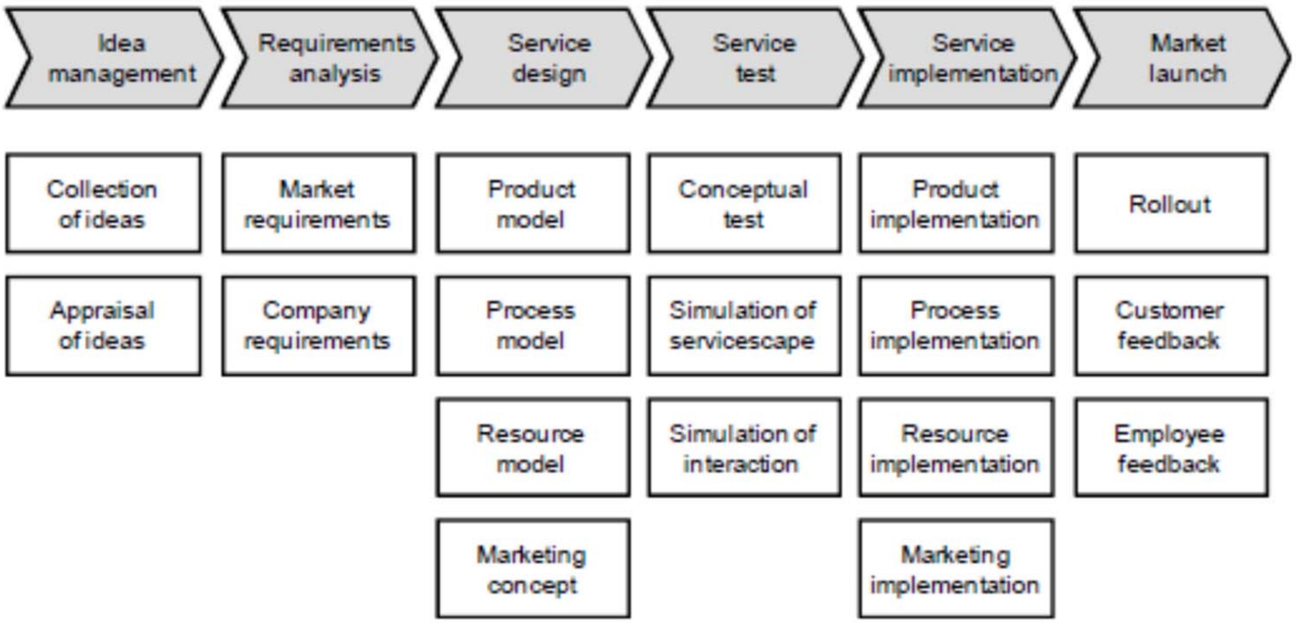
Note 1: Stephen B. Gingerich. (2003). Hydrologic Resources of Guam, U.S. Geological Survey Water-Resources Investigations Report 03-4126.

Stretch Goals: Consider The Power of No

In an Ideal World, this is what we want to achieve.

- Reliability
  - No Customer Outages
  - No Customer Power Quality Issues
  - No Transmission System Equipment Failures
  - No Distribution Circuit Element Failures
  - No Cyber or Physical Security Compromises
- Safety
  - No Employees or Customers Hurt by T&D System
- Work Force Development
  - No T&D Employee will lack the equipment, knowledge, experience, and training necessary for the employee to perform excellently
- System Improvement
  - No Excuses for Not Planning in Depth and Breadth

New Service Development Model



Optimizing the Customer Experience

New service development model, developed at Fraunhofer IAO (Burger, Kim, Meiren, 2010)

Competitive Tactics

- Achieving Operational Excellence
- Achieving Operational Effectiveness
- Reducing Price Volatility
- Eliminating Outages
- Achieving Appropriate Power Quality
- Partnering with Customers
- Market Segmentation: Find Out what Clusters of Customers Value
  - Not all Customers are the Same and will Differ with respect to:
    - Needs
    - Perceived Value
    - Ability and Willingness to Pay
  - Target Key Customers requiring Higher Value
    - Value is a subjective experience dependent on context

Value Chain

What is Value?

- The Clemmer Group - The Three Rings of Perceived Value: An Integrated Customer Focus
  - Fundamental to delivering high service/quality levels is starting with the customer's perceptions of value.
    - The outside-in view of weighting what's most important must drive the integration of the technical, processes/systems, and people interaction components that combine to create the customer's overall experience.
    - Looks Like Hines: Customer perception of Value must pull that GPA activities towards meeting that expectation
  - What is high (or low) service/quality?
    - Whatever the customer says it is.
  - **Customer's perceptions of the value they are receiving must become the common yardstick against which all activities of every operating and support department and team throughout the entire organization are measured.**

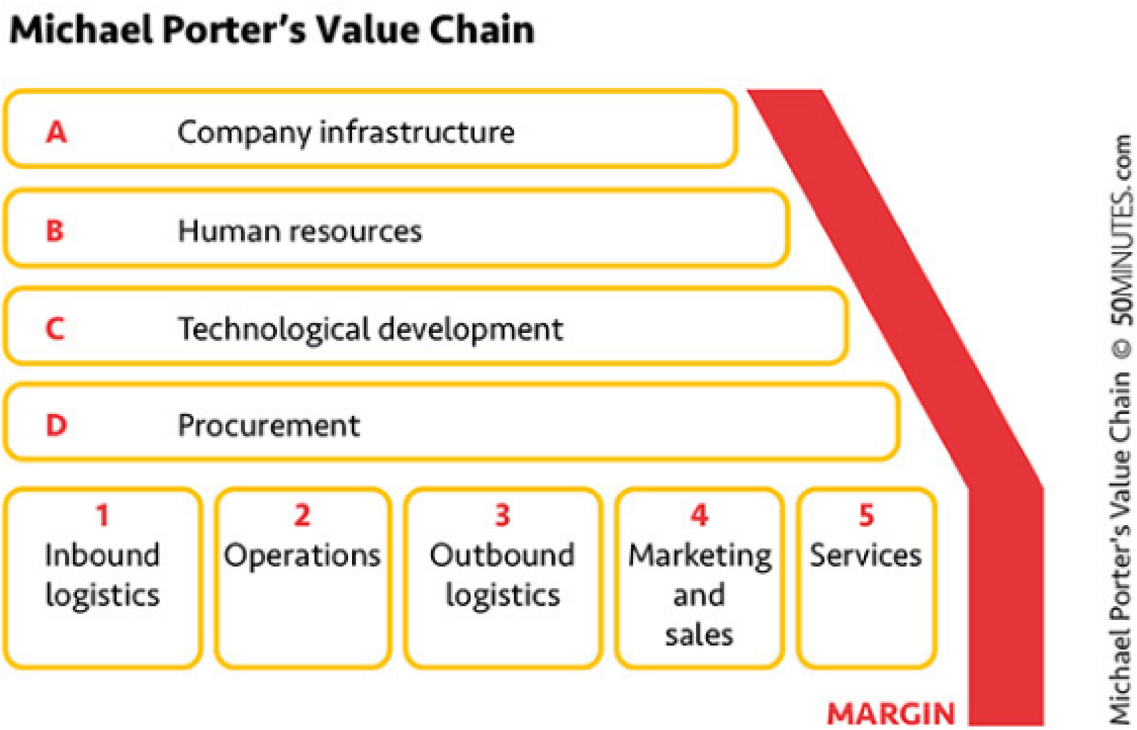
VALUE CHAIN

Integrated Customer Focus Drill-Down	First Ring *Basic Product or Service*	Second Ring *Support*	Third Ring ***Enhanced Service***
Focus	Requirements/Specs Met	Satisfaction	Delight
Customer Concern	Does the product/service meet my needs/standards/ expectations?	Is the product/service convenient/efficient/easy to access or use?	How do they make me feel?
Key Elements	Technology/Technical expertise	Systems, processes, policies, and structure	Leadership and Culture
Controlled by	Technical specialists	Management	Front line performers
Abilities Needed	Industry/Field/Trade/ Clinical Knowledge or Skills	Intellect and Reasoning (IQ)	Emotional Intelligence (EQ)
Result	**Indifferent Customer**	**Satisfied Customer**	**Loyal Customer**
Potential for Defection	**Highly Vulnerable**	**Vulnerable**	**None**

Note: Loyal Customers are willing to pay more.

Source: Clemmer Modified

Michael Porter's Value Chain

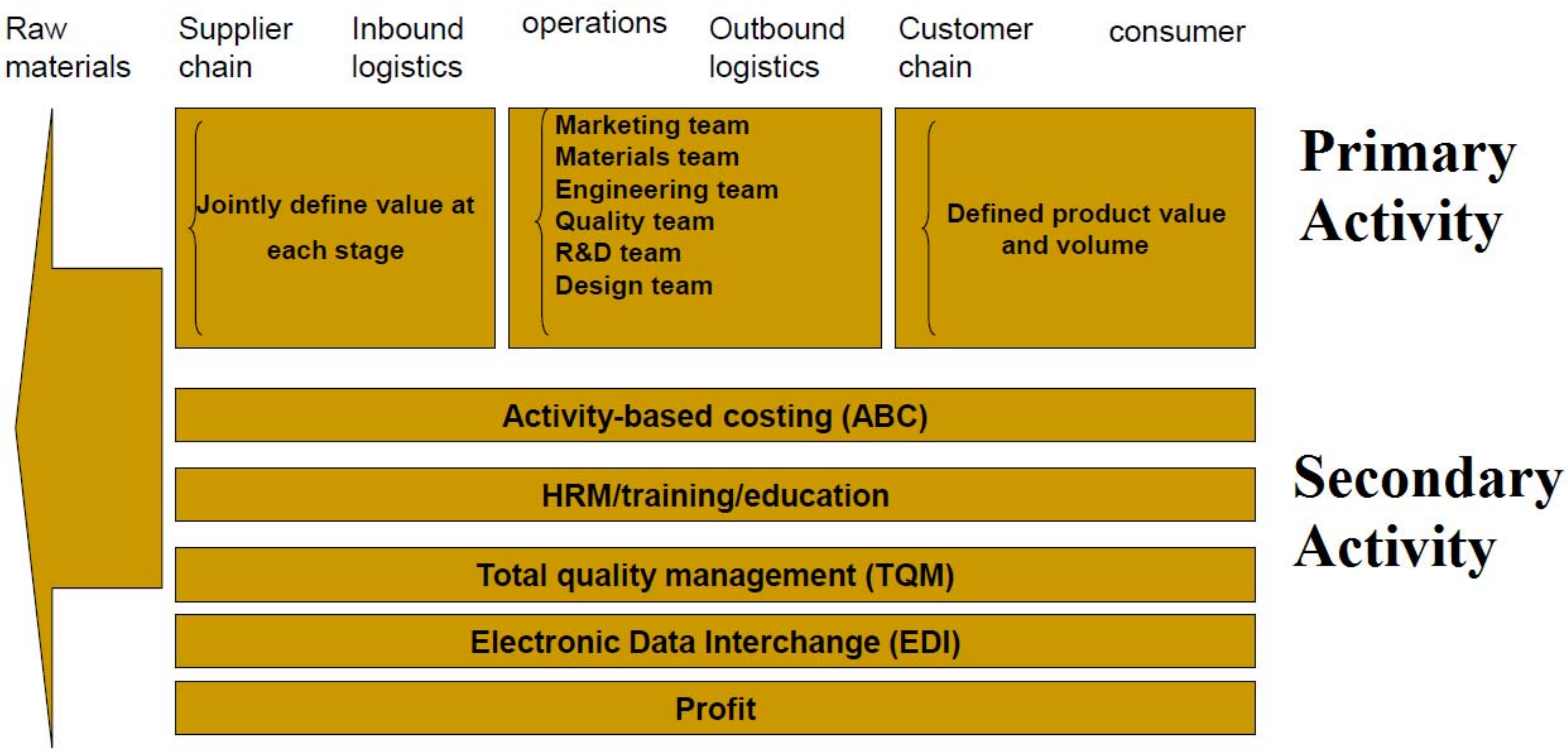


What does GPA's Value Chain Look Like?

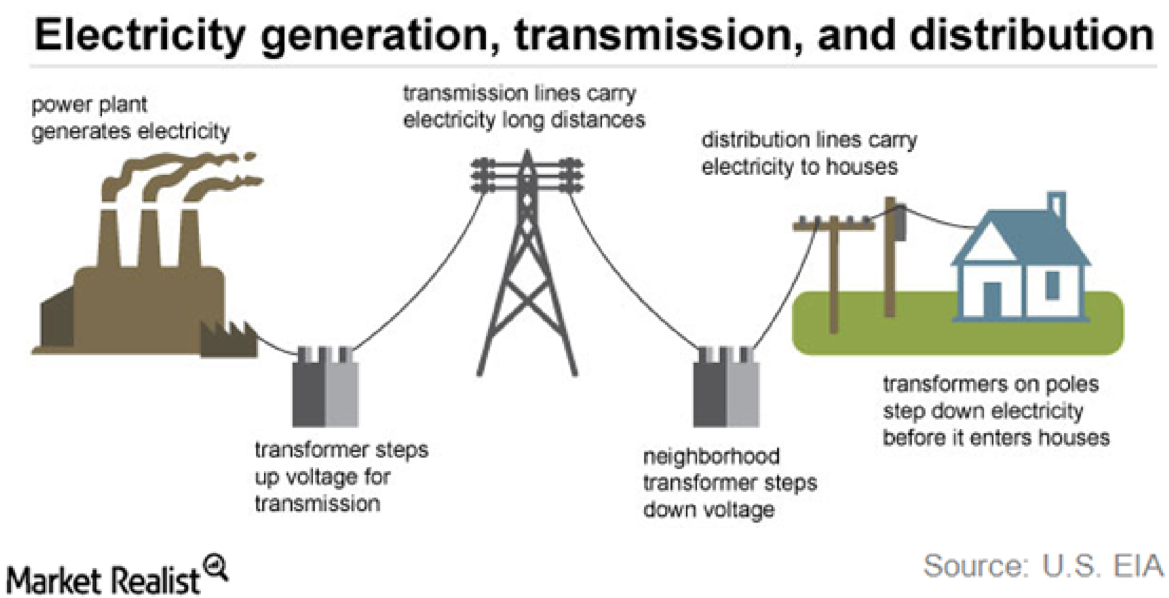
Value is the capacity of a good, work or service to meet a particular want

- Supply Chain refers to the integration of all activities involved in the process of sourcing, procurement, conversion and logistics.
- Value Chain implies the series of business operations in which utility is added to the goods and services offered by the firm so as to enhance customer value.

Peter Hines' Value Chain

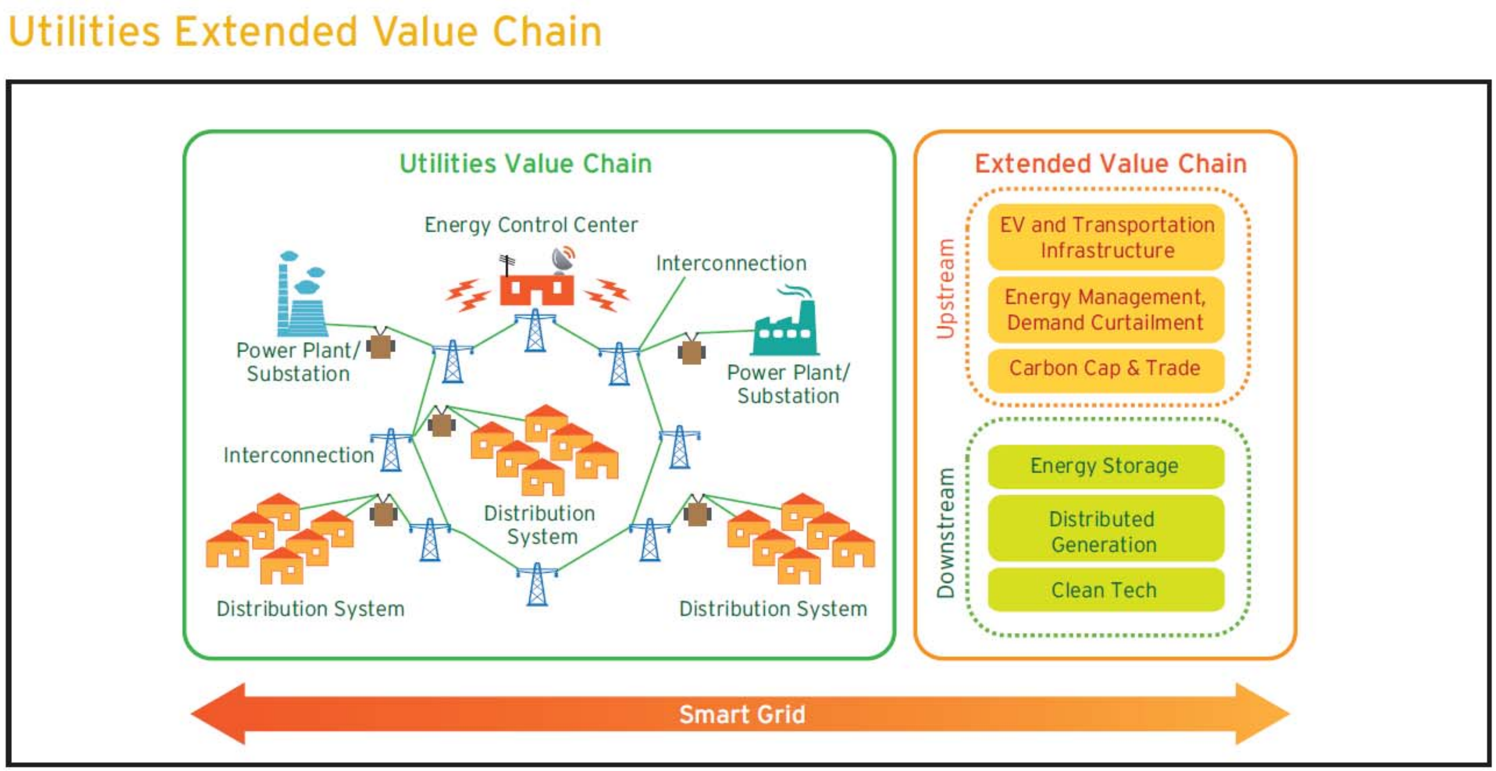


Traditional Electric utility Value Chain



- Missing
  - Real-Time Information and Analytics (Smart Grid)
  - Grid Control
  - DSM
  - Renewable Energy
  - Marketing
  - Customer Relationships
  - Billing
  - Communications & Networks

Cognizant Extended Value Chain



Clean Tech
Lobby

Revolution on the Road to Digital Transformation

- Digital transformation requires:
  - Deploying dramatic new technology.
  - Turning work flows on their heads.
  - Blowing up old business models.
- Leveraging Real-Time, Actionable Information and Instant Connections to Achieve Operational Excellence and Effectiveness
  - Right-Information to the Right-People to perform the Right-Actions
    - Real Time Information on the State of the System for those Responsible for its Operation & Maintenance
    - Instant Assessment if the System is Normal or Abnormal
    - If the System is Abnormal, Instant Assessment on whether to take action or not without the need to ask Management for approval
- Leveraging Real-Time, Actionable Information and Instant Connections to help Customers engage us when and how they want to manage their use of our services.

Activity Mapping

- Start from Customer Value Proposition and work backwards in the Value Chain
- Create "Fit" and interdependencies between internal organizations to create synergies and efficiencies.

Competitive Advantage

What is GPA’s Competitive Advantage?

What is it?

- If you have a real competitive advantage, it means that compared with rivals, you operate at lower cost, command a premium price, or both. (Magretta, 2012)
- Competitive advantage is about superior performance.
- For non-profits, Competitive Advantage means:
  - Producing more value for customers for every dollar spent, or
  - Producing the same value using fewer resources
- Michael Porter, founder of the modern business strategy field and one of the world's most influential thinkers on management and competitiveness, emphasizes that a true competitive advantage is one that is sustainable against rivals and "can establish a difference that it [a business] can preserve".
- Difficult to imitate
- Derives from Activities in the Value Chain

Basic Units of Competitive Advantage

- The Overall Value Chain in which the company's activities are embedded form the basic units of competitive advantage
- A company's Value Chain is the collection of all its value-creating and cost-generating activities
- Competitive Advantage can be described as:
    - Something, that the competing firms are not able to do, or
    - Something GPA owns that the rivals firms wish to have

Competitive Advantage Best Measurement

- The goal of Strategy is to earn superior returns on the resources you deploy
- Best measured by return on capital
  - Customer Satisfaction Generated versus Invested Capital?
  - Free Cash Flows Generated versus Invested Capital?

What it is not?

- Simply Improving Operational Effectiveness is not a Strategy
  - Rarely Sustainable
  - May be Copied
  - Aka Best Practices, Operational Excellence
  - But, should not be ignored as a tactic
- Best Practices

How to Describe It?

- A competitive advantage is what makes you better than the competition in your customers' minds.[1]
- Three Determinants in Describing/Recognizing Competitive Advantage
  1. Benefit
     - GPA must be clear on the benefit we provide customers
     - GPA must generate interest in this value
     - Benefit must be something that our Customers truly need and that offers real value
  2. Target Market
     - Who are our customers?
     - GPA must know exactly who buys from us, and how we can make their life better.
  3. Competition
     1. More than just similar companies or products
     2. Includes anything else our customers could do to meet the need GPA can fulfill.

1. https://www.thebalance.com/what-is-competitive-advantage-3-strategies-that-work-3305828

COMPETITIVE ADVANTAGE

Competitive advantage arises from the activities in a company's value chain

ACTIVITIES	Perform SAME activities as rivals, execute better	Perform DIFFERENT activities from rivals
VALUE CREATED	Meet same needs at lower cost	Meet different needs and/or same needs at lower cost
ADVANTAGE	Cost advantage, but hard to sustain	Sustainably higher prices and/or lower costs
COMPETITION	Be the BEST, compete on EXECUTION	Be UNIQUE, compete on STRATEGY

The value chain: Configuring activities to create customer value

- How far upstream or downstream do the industry's activities extend?
- What are the key value-creating activities at each step in the chain?
- Compare the value chains of rivals in an industry to understand differences in prices and costs

Brainstorm Session

Consider

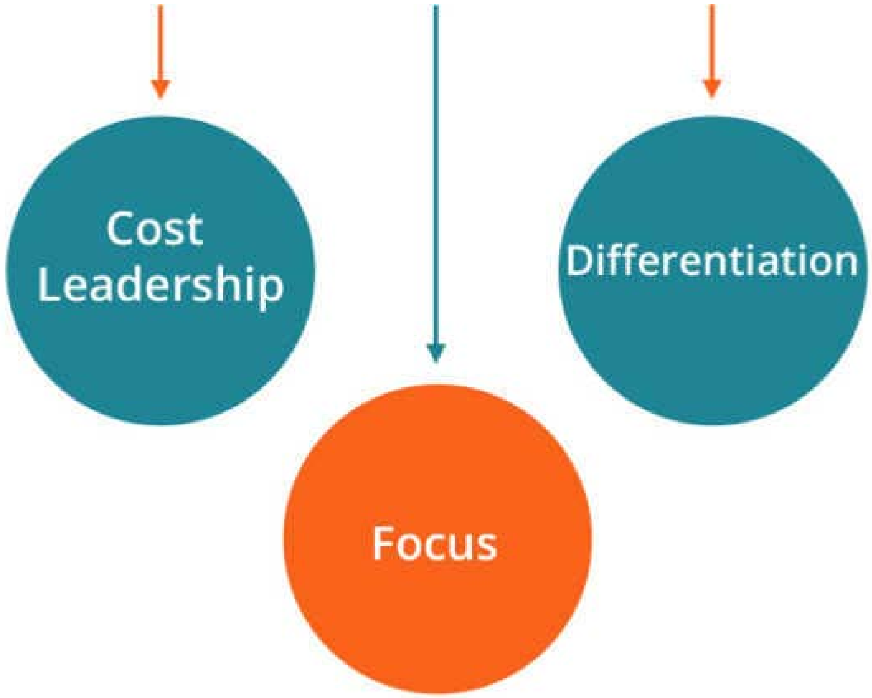
- GPA's competitive advantage is its power system infrastructure. GPA must maintain control over its distribution and transmission system. GPA must plan and execute improvements to this infrastructure as well as adopt a least-cost plan for upgrading and replacing legacy equipment. Additionally, GPA is rightsizing its operations to improve operational excellence and affordability.
  - John M. Benavente, PE, FY 2016 GPA Citizen-Centric Report

GPA Competitive Advantage

- What is GPA's Competitive Advantage?
  - GPA's Transmission & Distribution System
  - GPA's Monopoly Status
  - Access to Municipal Financing
- Defending the Castle
  1. GPA must maintain control over access to its transmission & distribution systems
  2. GPA must maintain its monopoly status
  3. GPA must maintain access to Municipal Financing

Porter’s Three Generic Competitive Strategies

Porter's Three Generic Competitive Strategies



Porter's Generic Strategies

- Following broad characterizations capture the fundamental dimensions of strategic choice
  - ***Focus*** refers to the breadth or narrowness of the customers and customer needs the company has chosen to serve
  - ***Differentiation*** allows a company to command a premium price
  - ***Cost Leadership*** allows a company to compete by offering a low relative price

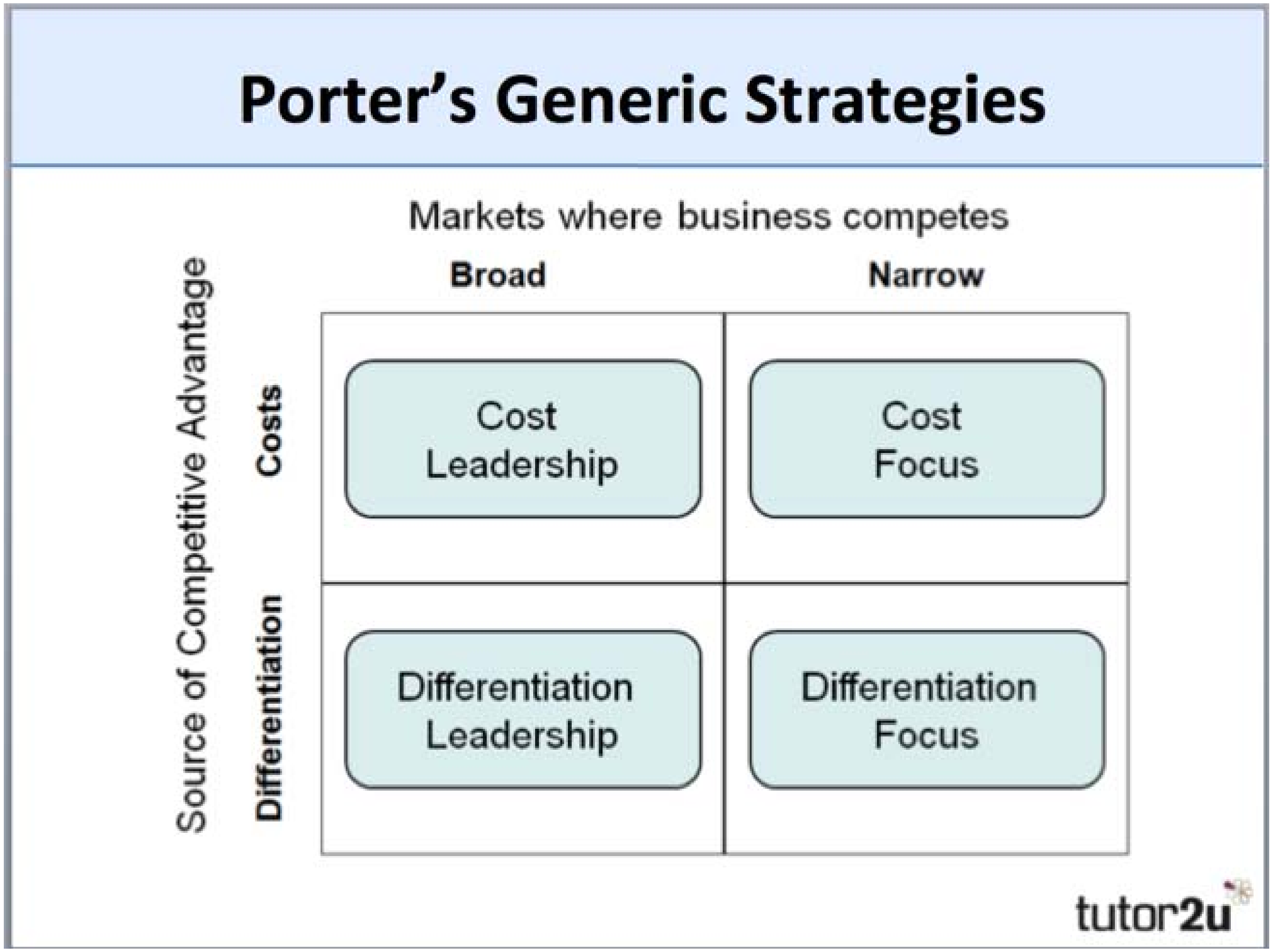
Porter's Caveat

- Do not get stuck in the middle!
- Happens when a customer tries to be all things to all customers.
- Stuck in the middle between:
  - Cost Leaders meeting "just enough" of customer needs
  - Differentiators who do a better job satisfying customers who want more

Strategy is Complex and Multidimensional

- When a Company makes choices about which customers and needs its serves, and tailors its value chain to those choices, it is possible to be differentiated and low cost and focused at the same time (i.e., Enterprise) or more convenient and lower cost (i.e., Southwest Airlines).
- The essence of Strategy is choosing what not to do.

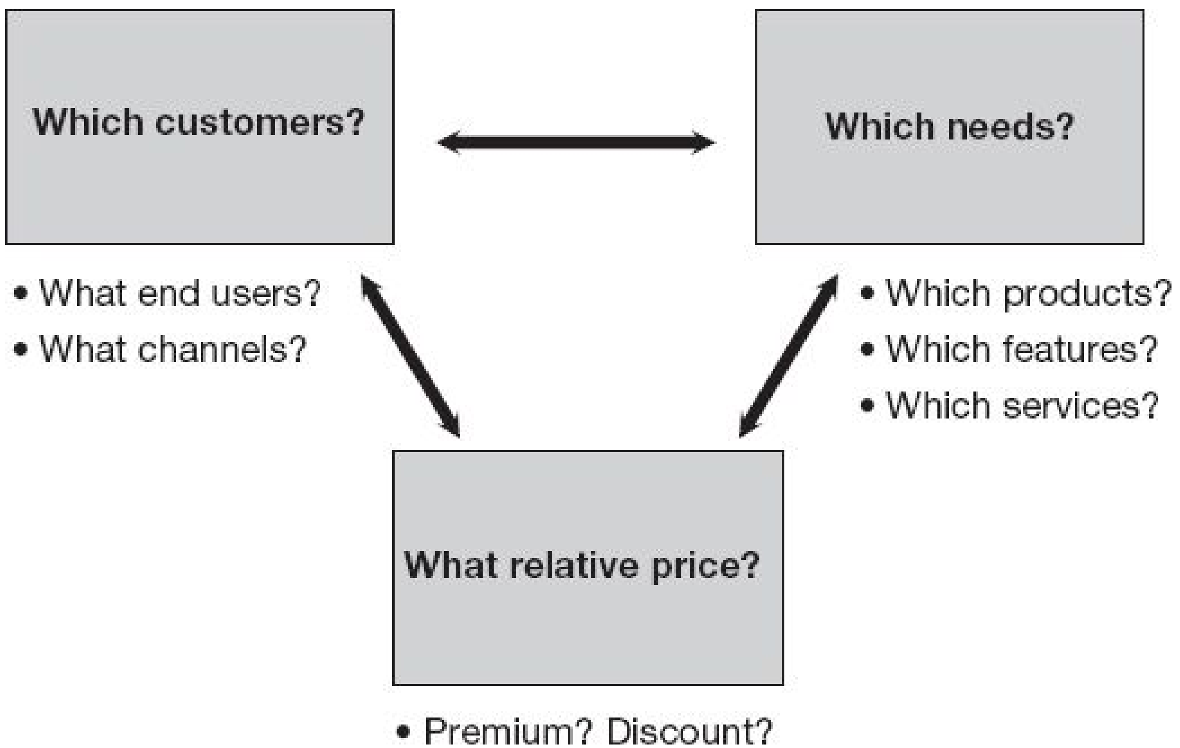
PORTER'S THREE COMPETITIVE STRATEGIES



- All about Creating Value

PORTER'S THREE COMPETITIVE STRATEGIES

The value proposition answers three questions



First Test of a Strategy:
A Distinctive Value Proposition

- Is our Value Proposition different from our rivals?
- If we are trying to serve the same customers and meet the same needs and sell at the same relative price, then by Porter's definition, we do not have a Strategy

The Second Test: A Tailored Value Chain

- A distinctive value proposition will not translate into a meaningful strategy unless the best set of activities to deliver value is different from the activities performed by rivals
- The essence of strategy and competitive advantage lies in the *activities*, in choosing to *perform activities differently* or to *perform different activities* from rivals

The Third Test: Trade-Offs

- Strategy's Linchpin
- Hold a strategy together and contribute to both creating and sustaining competitive advantage
- Misconceptions
    1. Managers tend to believe that "more is always better" that you can have it all do everything. Making trade-offs is a sign of weakness.
    2. Sustaining a competitive advantage is not possible and is largely short and temporary.

Where Trade-Offs are Made

- Incompatible product features
  - A product that best meets one set of needs performs poorly in addressing others
- Trade-offs in activities comprising the value chain
  - The configuration of one set of activities that best delivers one kind of value cannot equally well deliver another
  - If an activity is overdesigned for its use, value will be destroyed.
- Inconsistencies in image or reputation
- Maintaining and steepening trade-offs, making them even sharper is essential to sustaining strategy

Beware of False Trade-Offs

- In general, false trade-offs arise when organizations fall behind in operational effectiveness – that is, when they lag in how well they perform basic activities that are generic, and not strategy specific.
  - For example
    - Water quality in steam power plants
    - Vegetation management in electric distribution systems
    - Infrared inspections in transmission, distribution, and substation O&M

Consider

- When you try to offer something for everyone, you tend to relax the trade-offs that underpin your competitive advantage.
- The irony is that unless firms make trade-offs and deliberately choose not to serve all customers and needs, then these firms are unlikely to do a good job serving any customers and needs.
- Building and sustaining competitive advantage requires discipline about saying no to a host of initiatives that would blur our uniqueness.
- The notion that the customer is always right is one of the half-truths leading to mediocre performance.
- Trade-offs explain why it is not true that you should give every customer what they want. Some are not your customer. Send them away.

The Fourth Test: Fit

- Fit means that the value or cost of one activity is affected by the way other activities are performed
- Fit
  - An amplifier for raising the power of trade-offs creating greater value and making our strategy more difficult to imitate
  - Makes a more sustainable strategy by raising barriers to imitation
  - Incorporates but is greater than alignment

Breaking Down Silos: Fit

- Good Strategies depend on the connection among many things especially on making interdependent choices: Fit.
- Activities within the Value Chain must fit together and create synergies.

The Fifth Test: Continuity

- This aspect of Strategy is fundamentally about people and their capacity to absorb and process change.
- Continuity
  - Reinforces a company's identity by building a company's brand, its reputation, and its customer relationships.
  - Helps suppliers, channels, and other outside long-term partners to contribute to a company's competitive advantage.
  - Allows an organization to build unique capabilities and skills tailored to its strategy improving in individual activities and fit across activities
  - Increase the odds that people throughout the organization will understand the company's strategy and how they can contribute to it.

Consider

- Continuity of strategy does not mean that an organization should stand still. As long as there is stability in the core value proposition, there can, and should, be enormous innovation in how it is delivered.
- Great strategies are rarely, if ever, built on a particularly detailed or concrete prediction of the future.

Strategy and Change

1. Good strategies have staying power, but keep eye on how customers' needs change versus the company's core value proposition.
2. Keep an eye on innovation of all sorts that can serve to invalidate the essential trade-offs on which a strategy relies.
3. Keep an eye on technological or managerial breakthroughs that can trump a company's value proposition. (rare)

- Consider
  - Determine whether a technology is truly disruptive by considering whether it can be integrated into the company's existing value chain or customized in a way that enhances existing activities.

Flexibility versus Strategy

- Substituting flexibility for strategy, your organization never stands for anything or becomes good at anything.
- Flexibility without strategy guarantees mediocrity.

Consider

- Strategy should be 100% thought out and analyzed – Not True
  - Porter argues that good analysis is essential, but it is a mistake to think a strategy should be fully defined in its entirety before it is adopted and implemented. There are too many variables and too much uncertainty to anticipate everything.
- GPA should experiment and see what strategy emerges – No.
  - An organization cannot simply stumble its way into a good strategy by encouraging unconnected experimentation in all its units.
  - Strategy is about the whole , not the parts.
  - There must be stable core to begin with, or at least a grounded hypothesis about how the company is going to create and capture value.

What must change at GPA?

1. **GPA must achieve operational effectiveness** otherwise strategy will not matter and we are doomed. GPA must continuously assimilate best practices that do not conflict with our strategy or the trade-offs essential to it. Failure to do this will result in cost penalties that will swamp out our other advantages.
2. GPA must change whenever there are ways to extend our value proposition or better ways to deliver it.
   - GPA must deepen its commitment to smart grid enabled value production
   - GPA must engage its customers in the ways they are willing to be engaged.

Performance Linking

- Firms should be able to link the performance of strategy directly to their Profit and Loss (P&L)
- Should GPA work with the PUC to move away from merely cost based rates and recognize value as well as costs?

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SWOT Analysis

SWOT Analysis

- **S**trengths and **W**eaknesses are often internal to your organization, while **O**pportunities and **T**hreats generally relate to external factors
- For this reason, SWOT is sometimes called Internal-External Analysis and the SWOT Matrix is sometimes called an IE Matrix.

Strengths

- What advantages does GPA have?
- What does GPA do better than anyone else?
- What unique or lowest-cost resources can you draw upon that others can't?
- What do people in GPA’s market see as its strengths?
- What factors mean that GPA "gets the sale"?
- What is GPA's Unique Selling Proposition (USP)?
- Consider GPA’s strengths from both an internal perspective, and from the point of view of customers and people in our market.

Weaknesses

- What could GPA improve?
- What should GPA avoid?
- What are people in our market likely to see as weaknesses?
- What factors lose GPA sales?
- Consider this from an internal and external basis:
    - Do other people seem to perceive weaknesses that GPA doesn't see?
    - Are our competitors doing any better than us?

Opportunities

- What good opportunities can GPA spot?
- What interesting trends are GPA aware of?
- Useful opportunities can come from such things as:
  - Changes in technology and markets on both a broad and narrow scale.
  - Changes in government policy related to your field.
  - Changes in social patterns, population profiles, lifestyle changes, and so on.
  - Local events.

Threats

- What obstacles does GPA face?
- What are our competitors doing?
- Are quality standards or specifications for our job, products or services changing?
- Is changing technology threatening our position?
- Does GPA have bad debt or cash-flow problems?
- Could any of your weaknesses seriously threaten GPA’s business?

2018 GPA Energy Sense Program Market Research

Energy Sense Program
Market Research

Prepared by Market Research & Development, Inc. | October 2018

Project Overview

- The Guam Power Authority (GPA) contracted Market Research & Development, Inc. (MR&D) to conduct research to identify GPA rate payer's attitudes toward renewable energy, electric vehicles, and specifically, the GPA Energy Sense Program. In addition, GPA wanted to find out how satisfied rate payers are with their products and services.
- This study was two fold:
  1. Initial focus groups were conducted with both residential and commercial Energy Sense program participants and non-Energy Sense Program participants.
  2. From the information ascertained from the focus groups, a questionnaire was formulated and MR&D conducted a quantitative study among GPA rate payers.

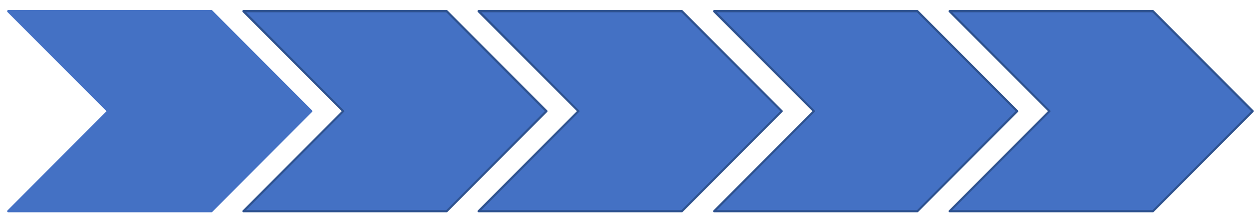
Focus Group Methods

- Four focus groups were conducted:
  - Focus Group 1: Residents who did not participate in the GPA Energy Sense Program
  - Focus Group 2: Residents who participated in the GPA Energy Sense Program
  - Focus Group 3: Business representatives who did not participate in the GPA Energy Sense Program
  - Focus Group 4: Business representatives who participated in the GPA Energy Sense Program
- A focus group is a discussion facilitated by a trained researcher to illicit detailed responses to meet specific information objectives.

Focus Group Information Objectives

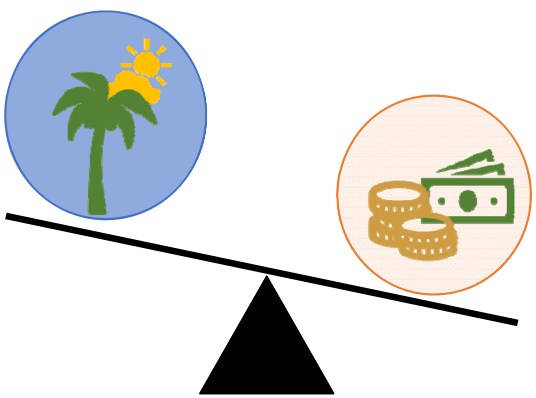
- The discussion for the three groups concentrated on the following topics:
  - What residents and business representatives think about renewable energy
  - What residents and business representatives understand about renewable energy
  - How aware residents and business representatives are of the technical aspects of renewable energy
  - What residents and business representatives think about the GPA Energy Sense Program
  - How satisfied residents and business representatives are with the services provided by GPA

FOCUS
GROUPS



Residential Focus Group Key Take-Aways

- Participants believed that renewable energy was important. However, the cost and uncertainty of the benefits are barriers to embracing renewable energy products and programs.
- Participants were willing to pay more for renewable energy if it led to savings in the near to medium future. The government was the preferred provider of renewable energy programs.



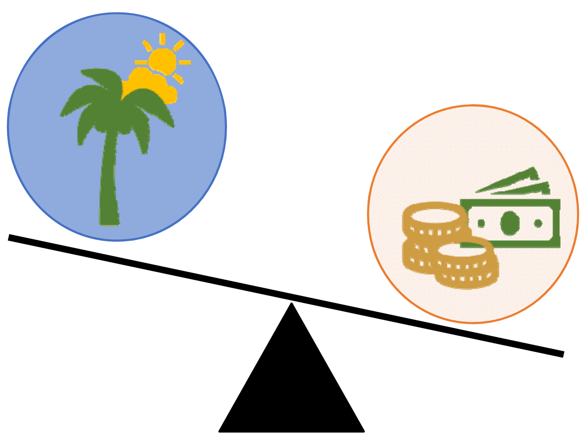
Private	Public
• Creates healthy competition	• Quality control • Stability • Consistency

Residential Focus Group Key Take-Aways

- Most participants knew what a SEER rating was and thought it was important in selecting appliances. Participants also approved of GPA converting its fleet to electric vehicles so long as it does not cost rate-payers more money.
- Participants were receptive to the Energy Sense Program but want more appliances covered and information more widely distributed.
- Participants were satisfied with GPA but believed that the Authority is tired and out of touch with rate-payers. Communication methods are insufficient. More social media and community outreach are preferred.

Business Focus Group Key Take-Aways

- Overall perception of renewable energy is positive, but there are concerns about its viability for business customers
- Business representatives are not convinced that public ownership of renewable energy is best.
- There is more interest in saving money than in saving the environment.

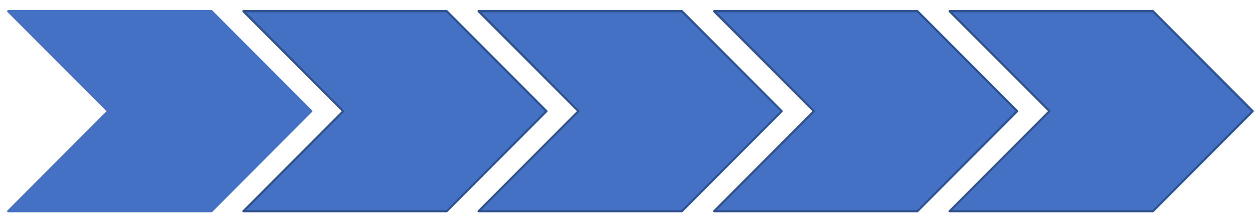


Private	Public
• More trustworthy • More efficient • More flexible • Private firms come and go.	• More stable

Business Focus Group Key Take-Aways

- The Energy Sense Program is unknown for businesses. Respondents were interested in a program tailored toward business customers.
- Respondents were satisfied with GPA overall. However, there were concerns over the phone customer service and long wait times at locations.

QUANTITATIVE RESEARCH



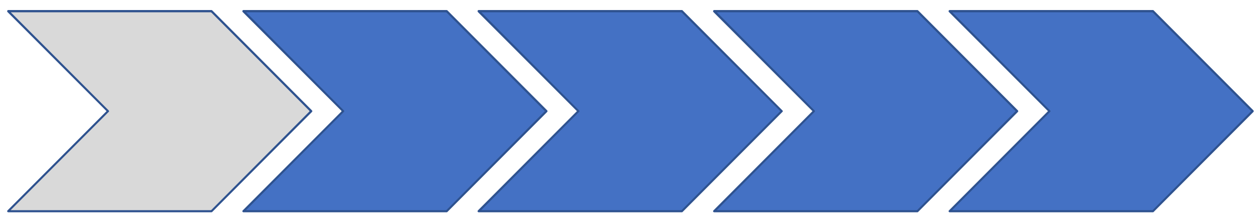
Quantitative Research Methods

- MR&D conducted Computer Assisted Telephone Interviews (CATI) with residents of Guam who were primarily responsible for paying their power bill.
- Between August 22 and August 31, 2018, there were 403 completed interviews.
  - Respondents were selected based on random sampling from published telephone numbers on Guam, and interviews were collected daily between 10 AM and 8 PM
  - All respondents were individuals responsible for paying their GPA power bill.
- The sample size is accurate to +/-4.5% at the 95% confidence interval. That means that if the survey were to be replicated 100 times, 95 times out of 100 the results would have the same level of accuracy.

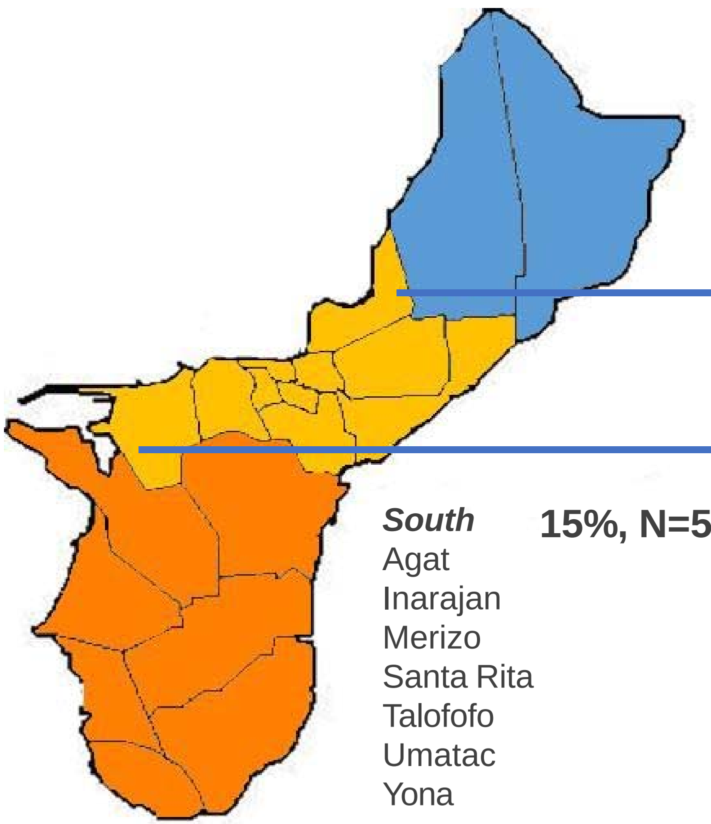
Quantitative Research Information Objectives

- GPA was interested in ascertaining the following objectives during the quantitative research:
  1. Overall demographic profile of primary rate-payers
  2. Rate payer perceptions of renewable energy, and renewable energy providers on Guam
  3. Perceptions of GPA's proposed electric fleet
  4. Awareness of and affinity for GPA's Energy Sense Program
  5. Overall perceptions and satisfaction with GPA

DEMOGRAPHICS



Demographics



North
Dededo
Yigo

41%, N=164

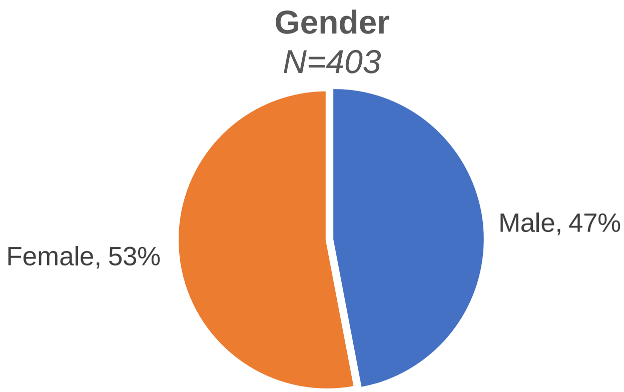
Central
Agana Heights
Agana/Hagåtña
Asan-Maina
Barrigada
Chalan Pago
Mangilao
Mongmong-Toto-Maite
Ordot
Piti
Sinajana
Tamuning
Tumon

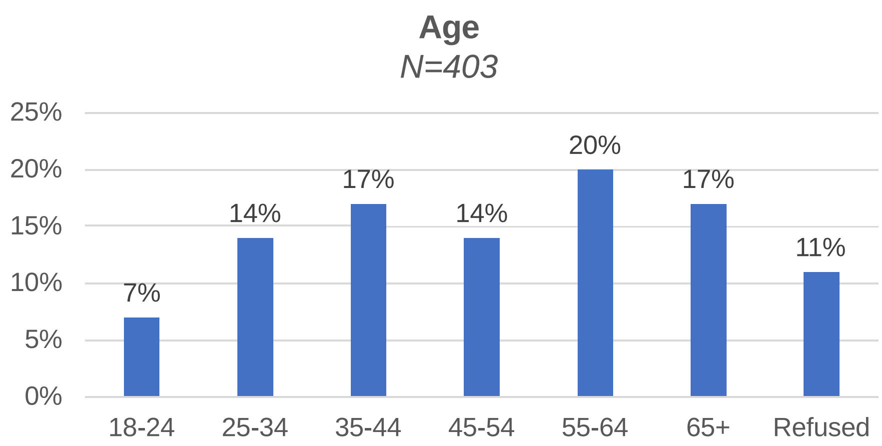
39%, N=157

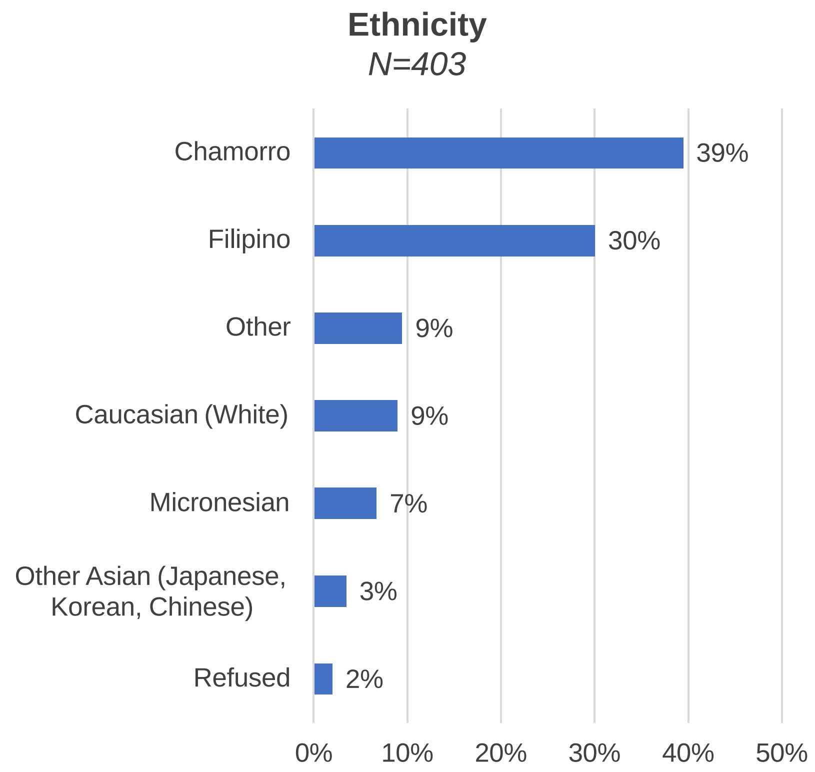
South
Agat
Inarajan
Merizo
Santa Rita
Talofofo
Umatac
Yona

15%, N=59

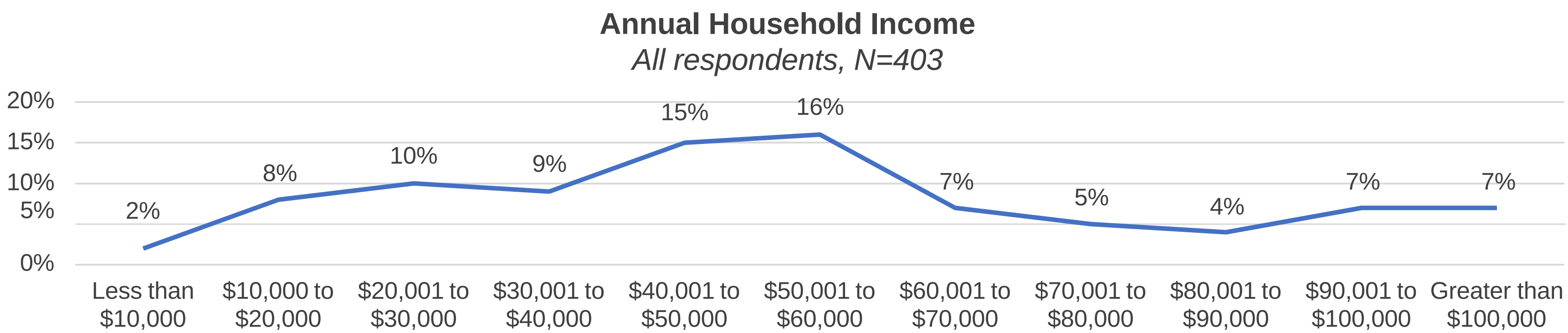
Demographics

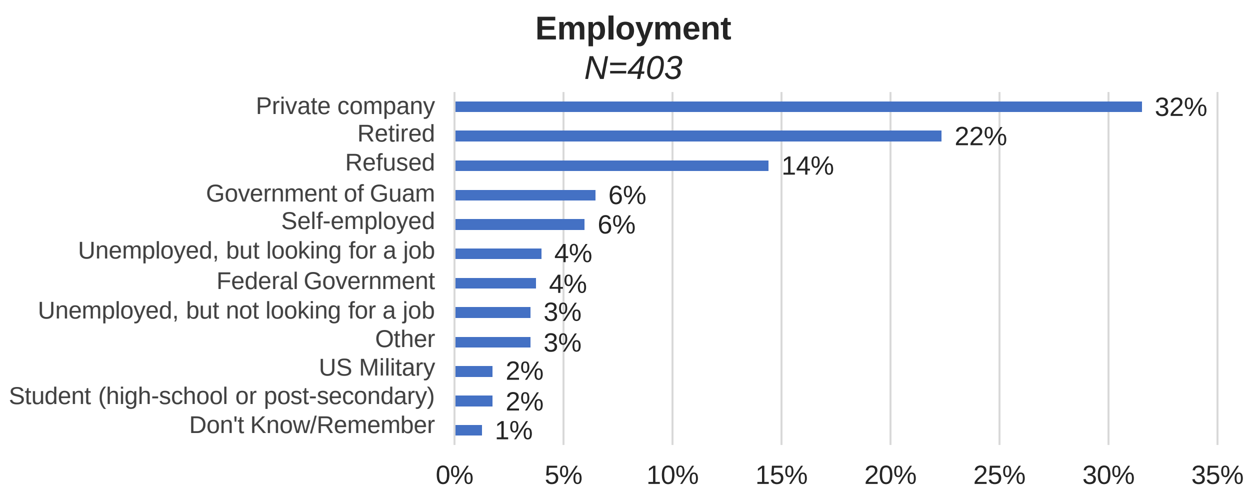




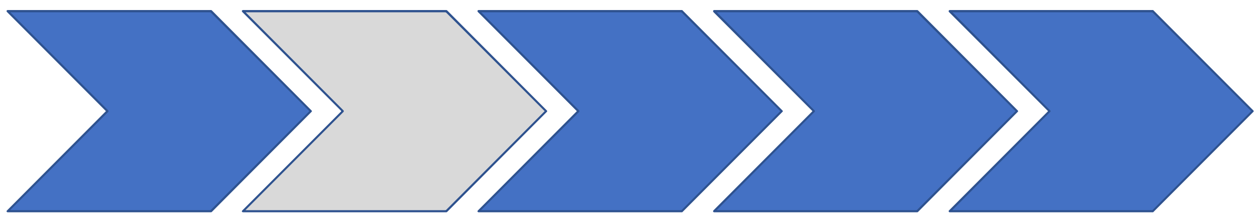


Demographics



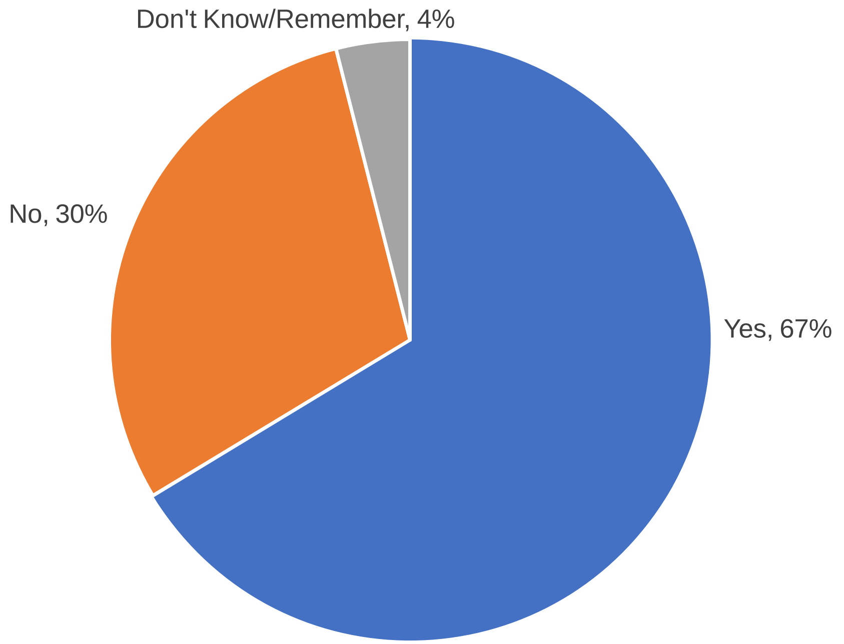


I. RENEWABLE ENERGY PERCEPTIONS

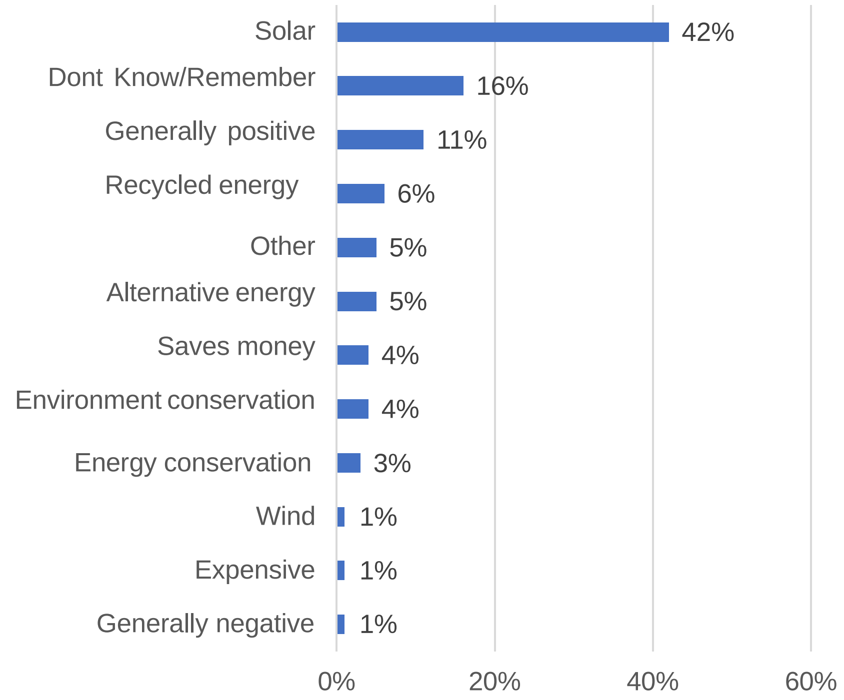


Renewable Energy Awareness

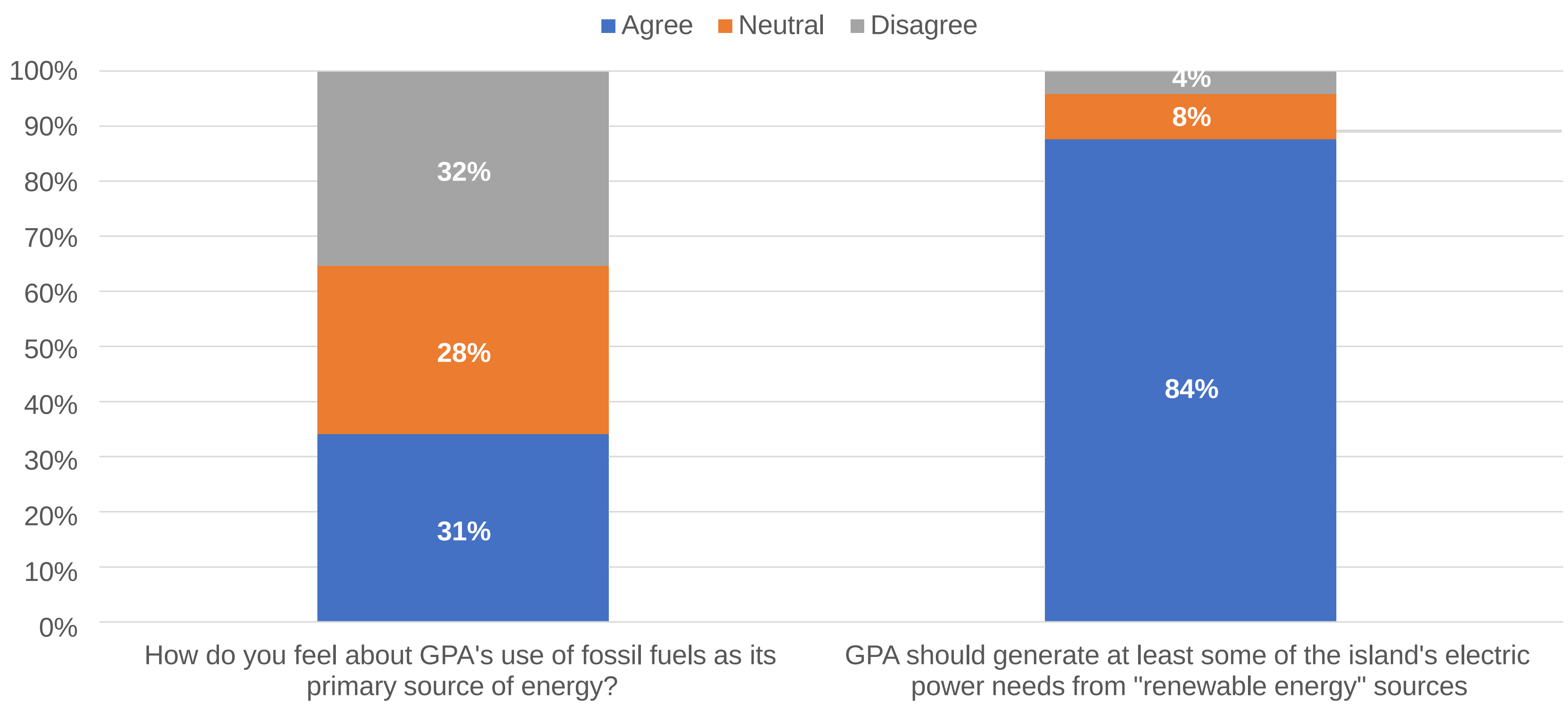
Are you aware of the concept of renewable energy?
N=403



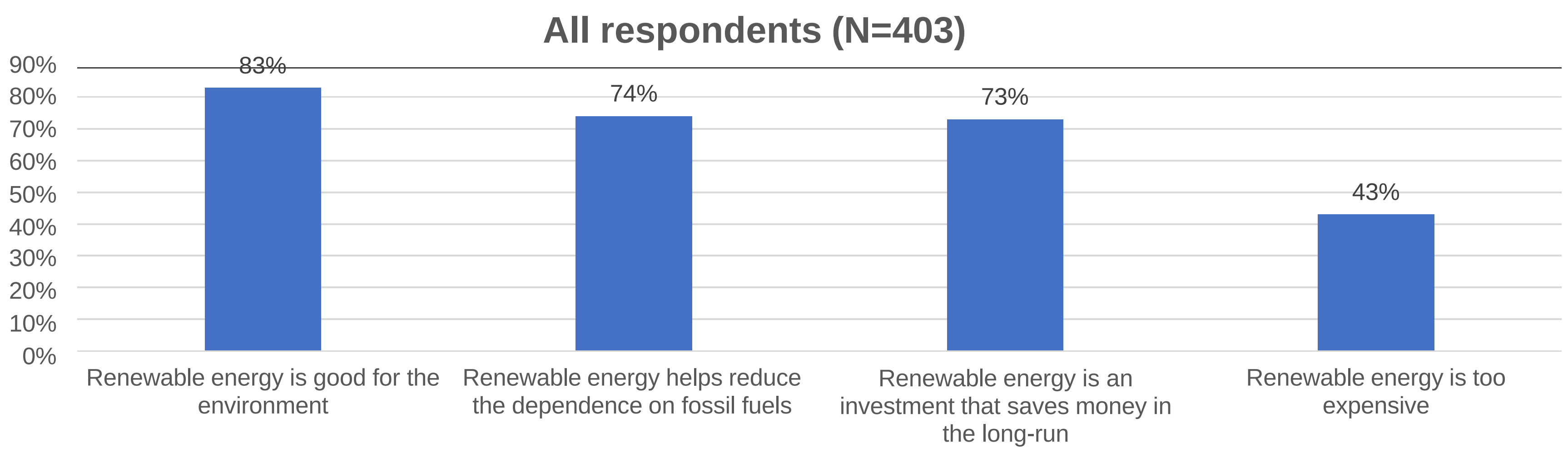
What word first comes to mind when you hear the term "renewable energy"?
N=403

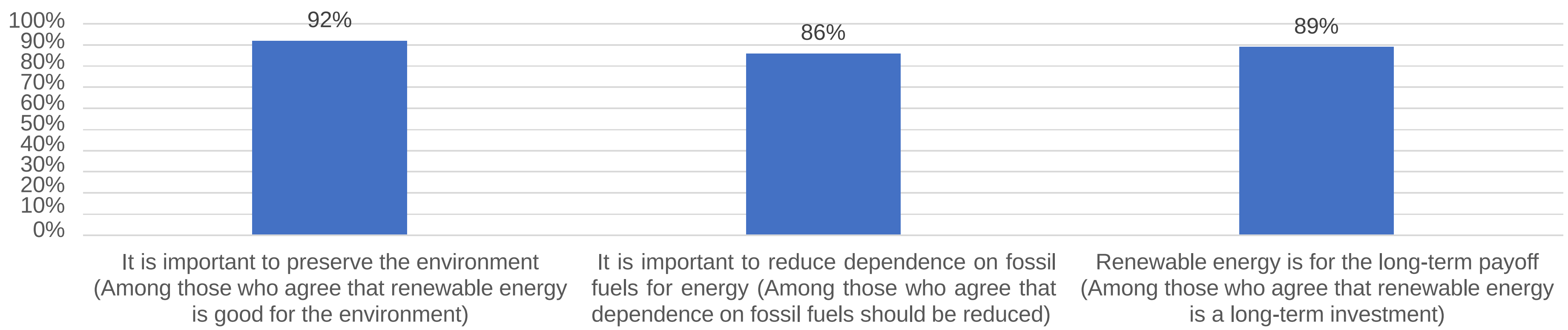


Perceptions on Renewable Energy



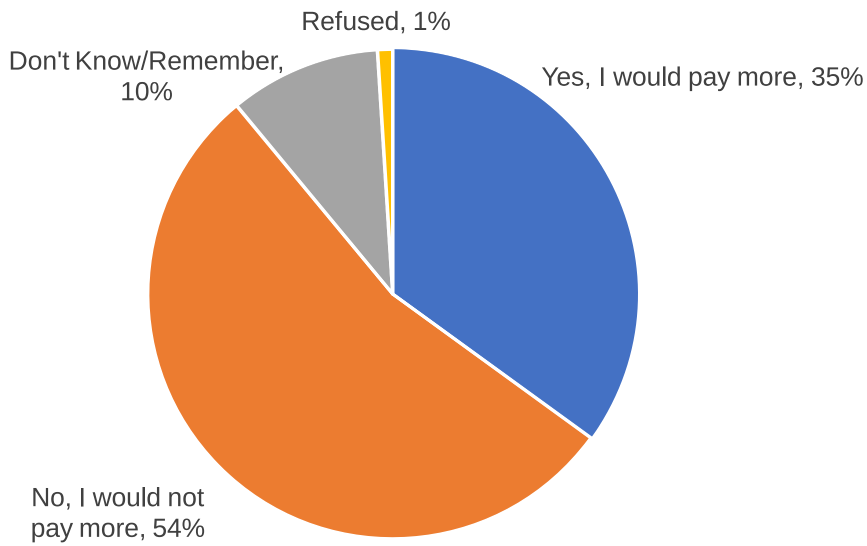
Perceptions on Renewable Energy



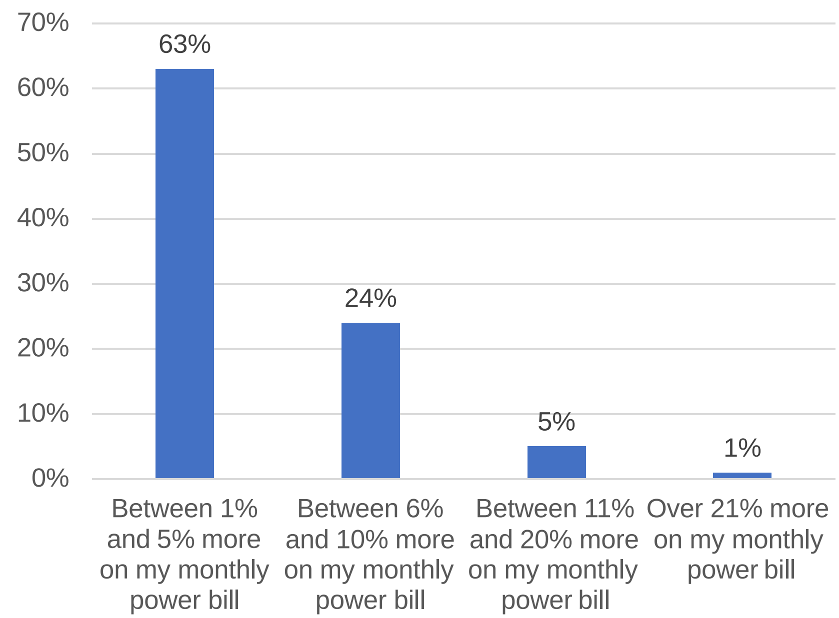


Willingness to Pay More for Renewable Energy

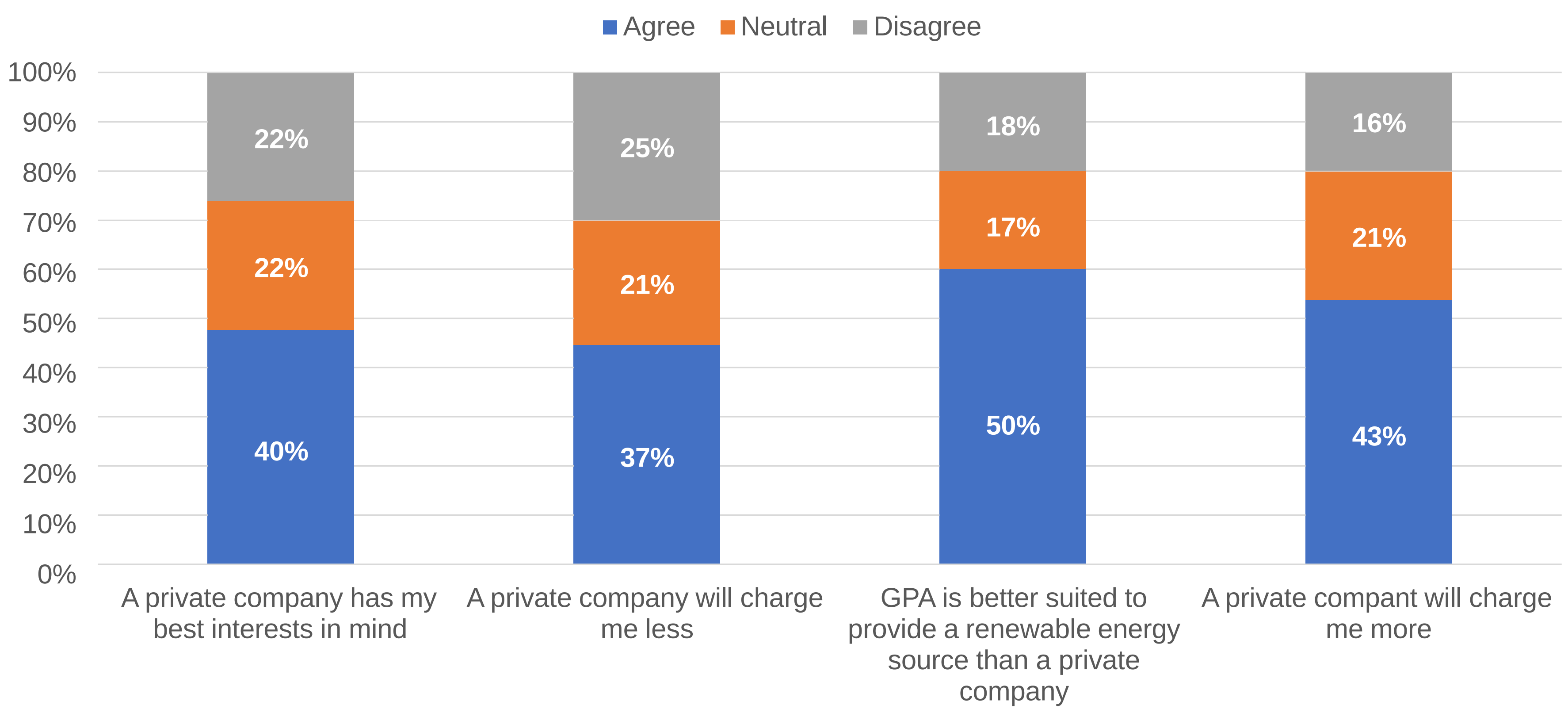
Would you be willing to pay a premium every month on top of your power bill for the next 5 years if GPA guaranteed that your bill would be lower or not raise for those 5 years?
All respondents, N=403



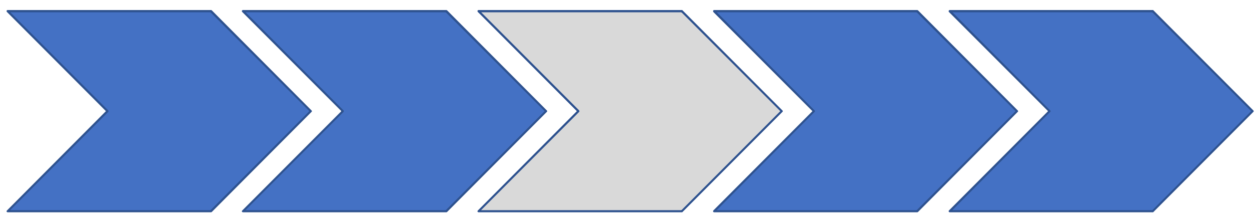
How much would you be willing to pay more?
Among those willing to pay more, n=120



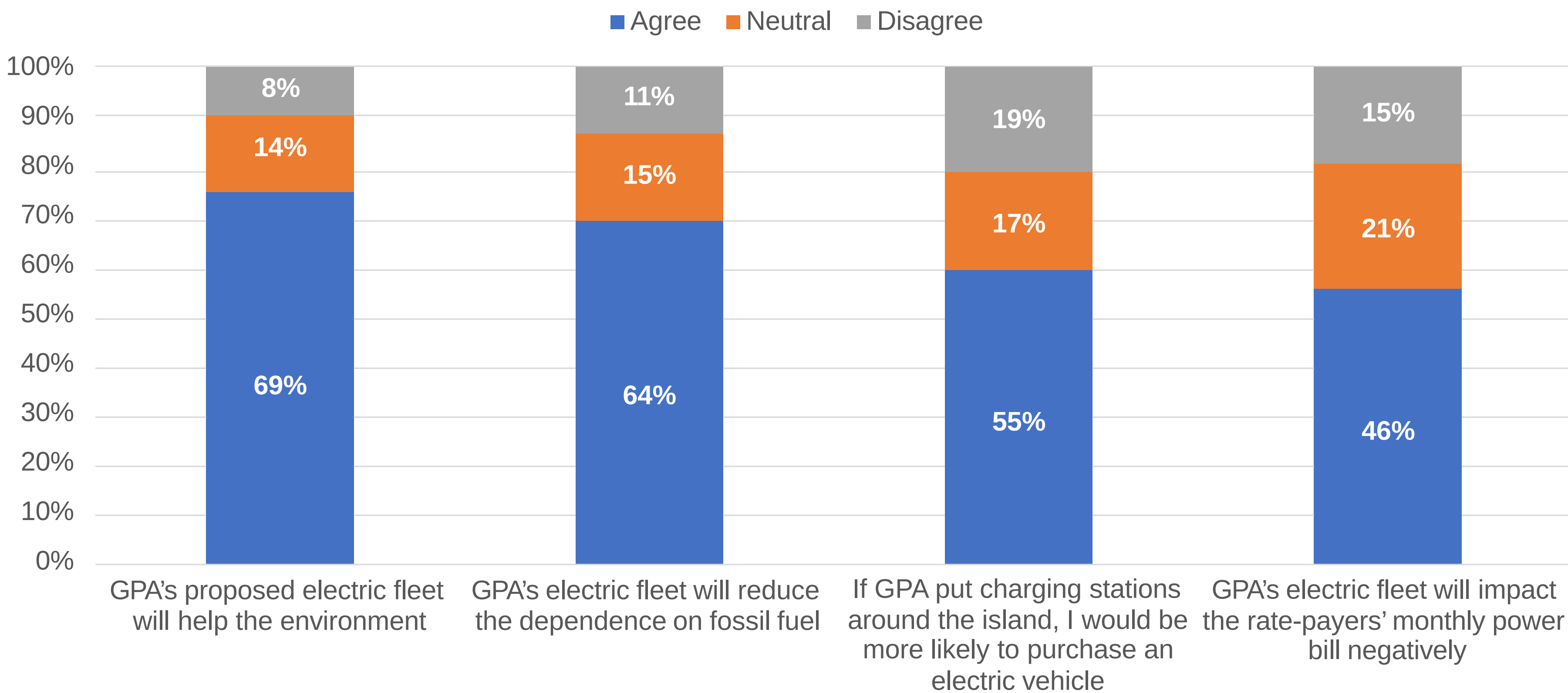
Renewable Energy Providers



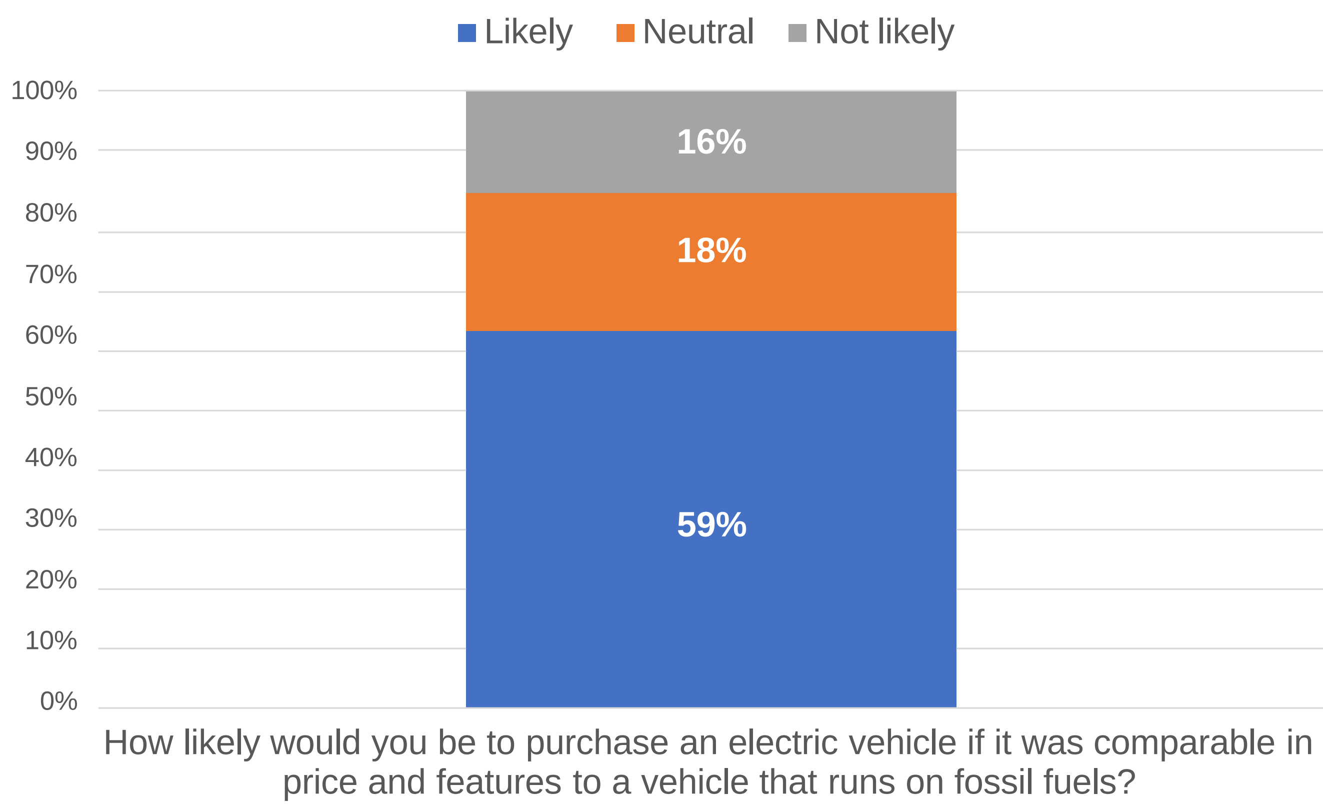
II. PERCEPTIONS OF GPA’S ELECTRIC FLEET



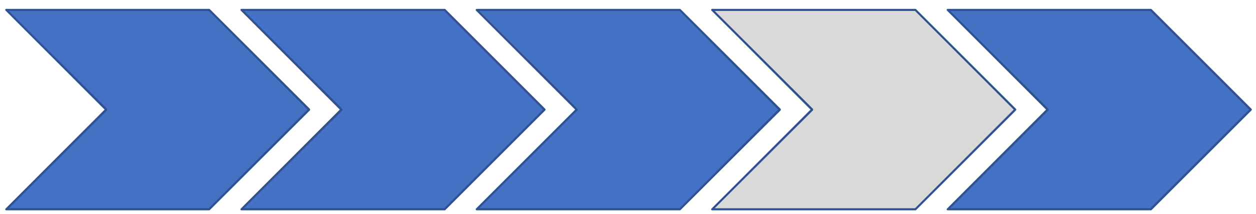
Perceptions of GPA's Electric Fleet



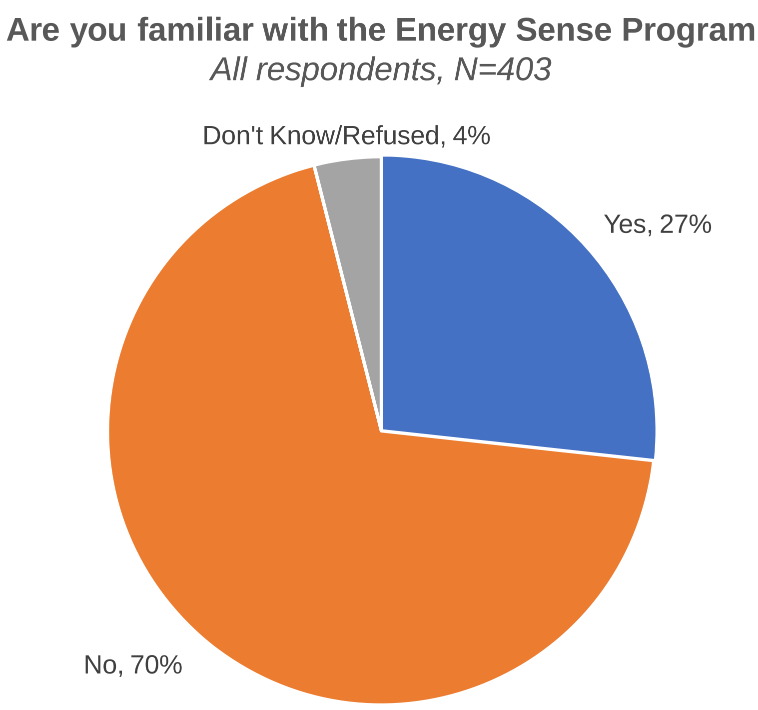
Likeliness to Purchase an Electric Vehicle

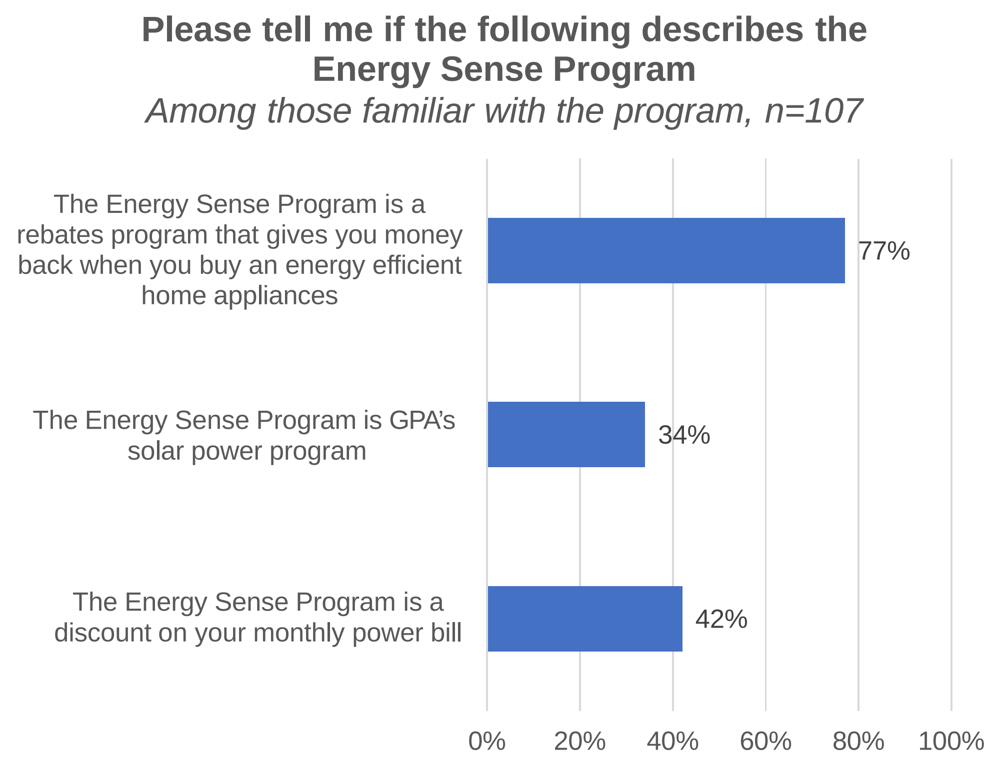


III. GPA'S ENERGY SENSE PROGRAM



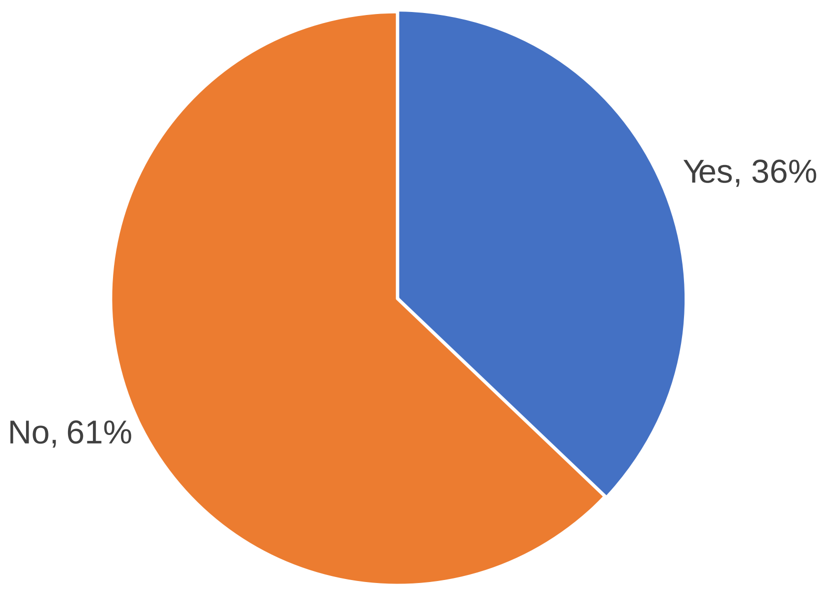
Awareness of the Energy Sense Program



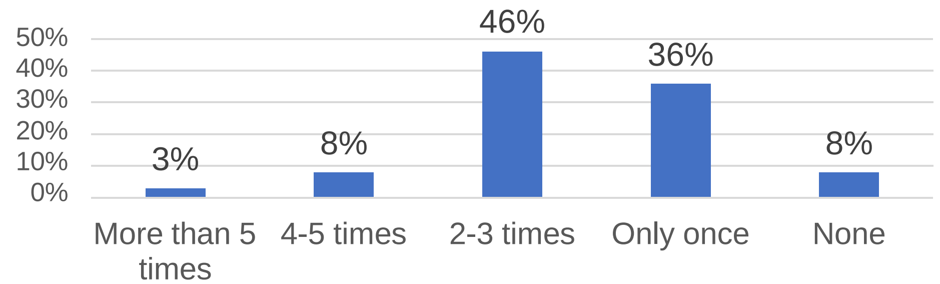


Previous Participation in the Energy Sense Program

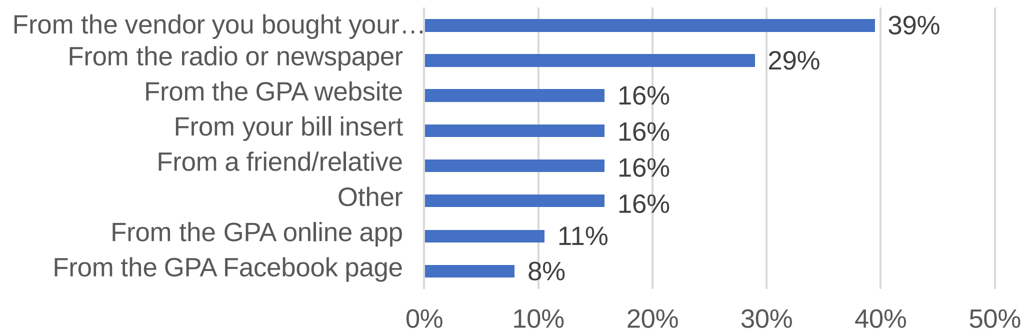
Have you participated in the Energy Sense Program previously?
Among those familiar with the program, n=107



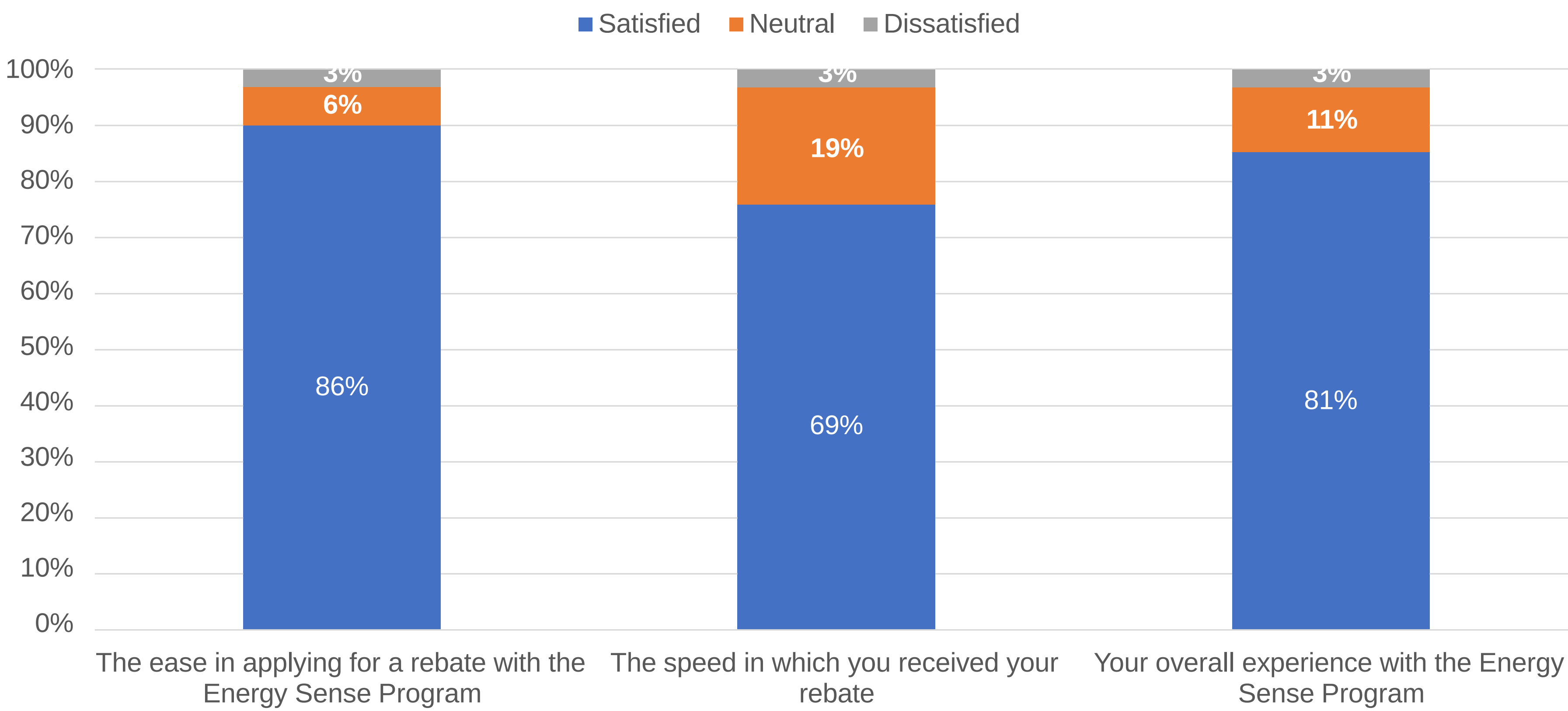
How many times in the past two years have you used the Energy Sense Program?
Among those who participated previously, n=38



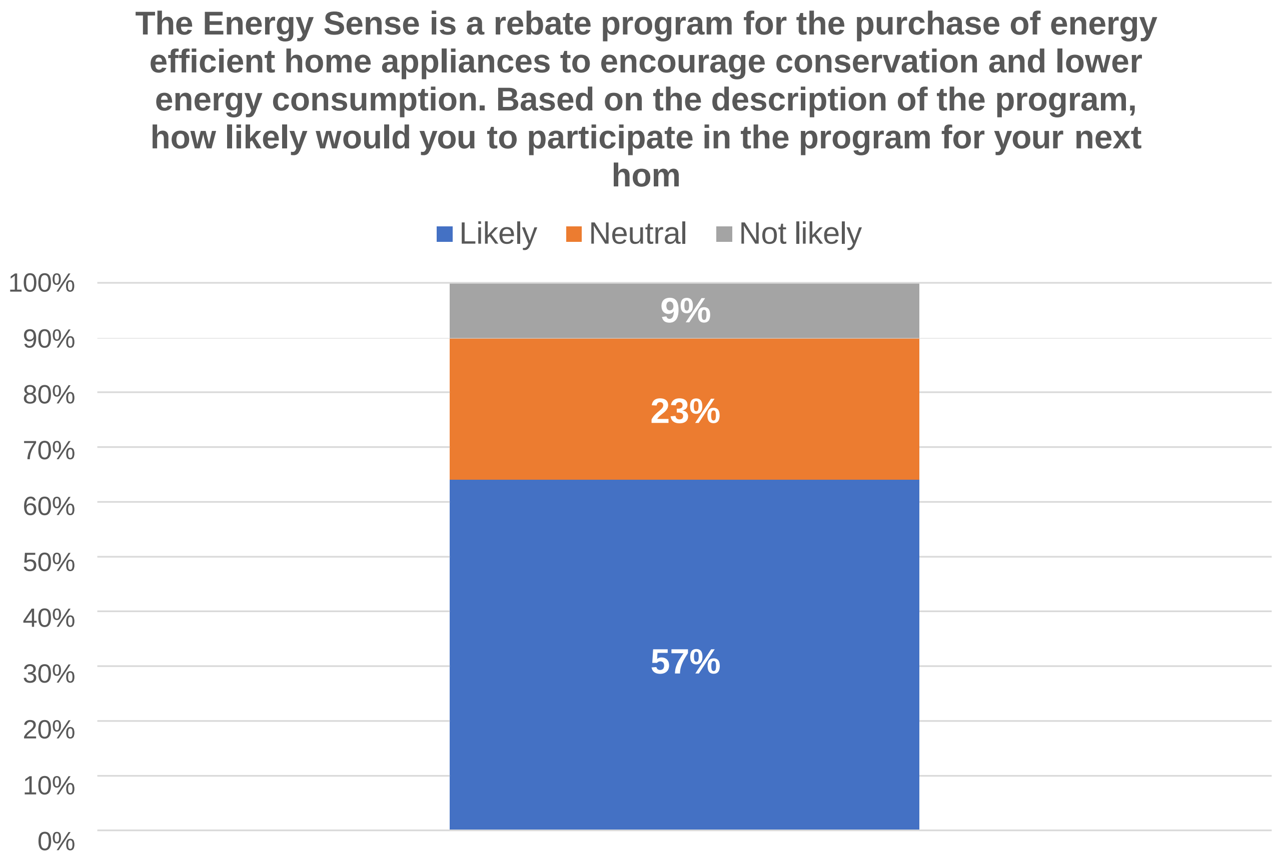
How did you find out about the Energy Sense Program?
Among those who participated in the program previously, n=38



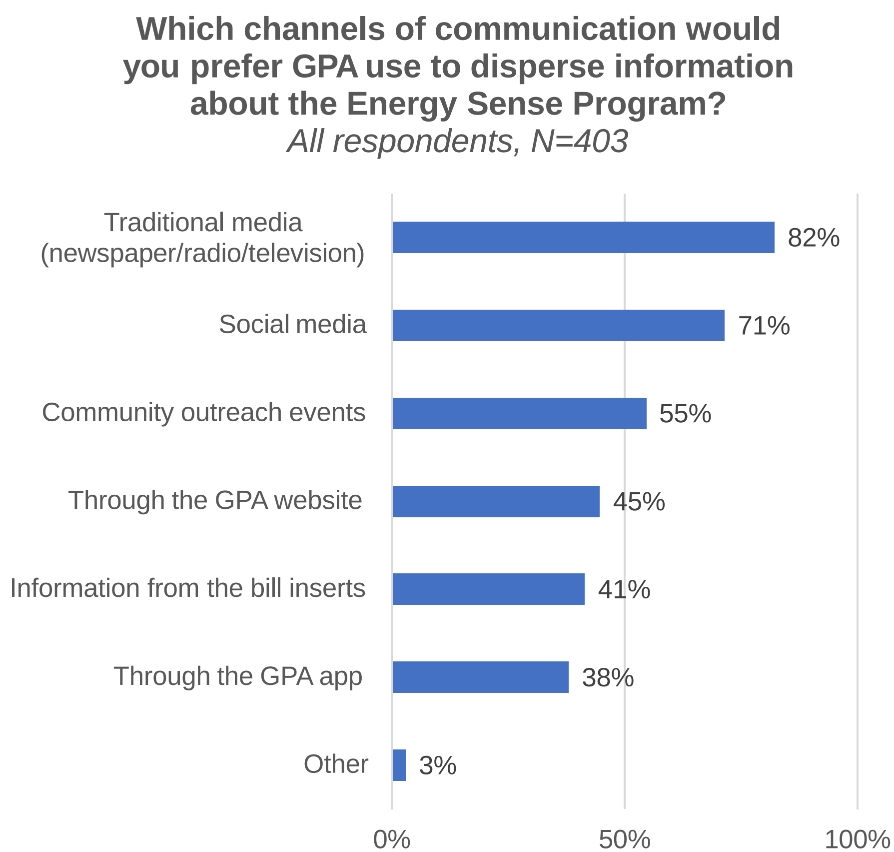
Energy Sense Participant Satisfaction

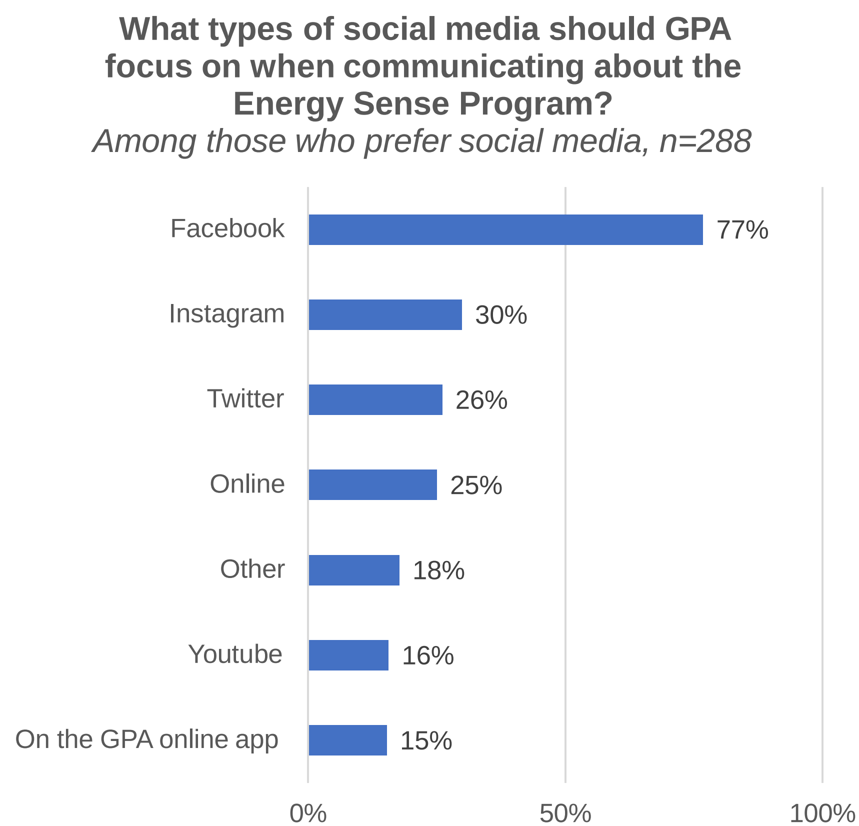


Interest in the Energy Sense Program



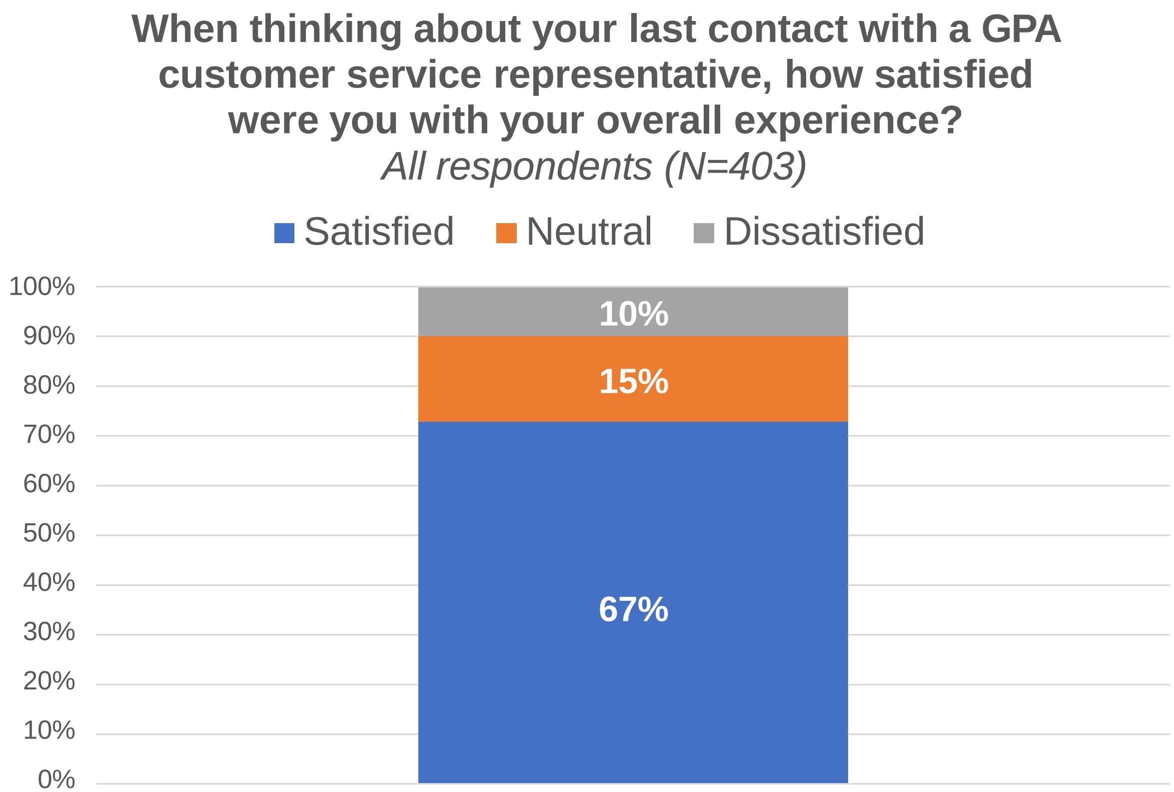
Communication Channels for the ESP



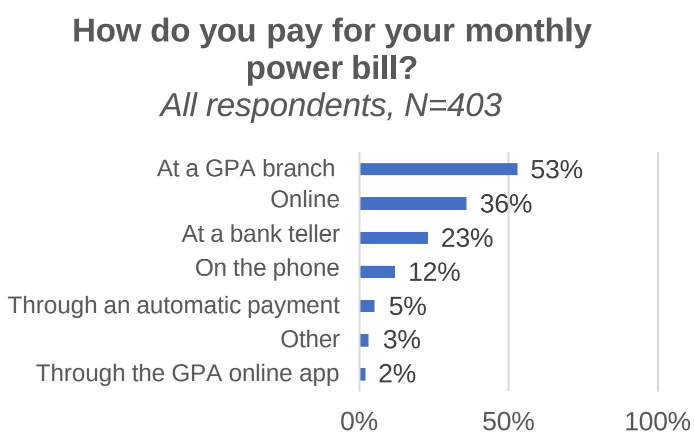


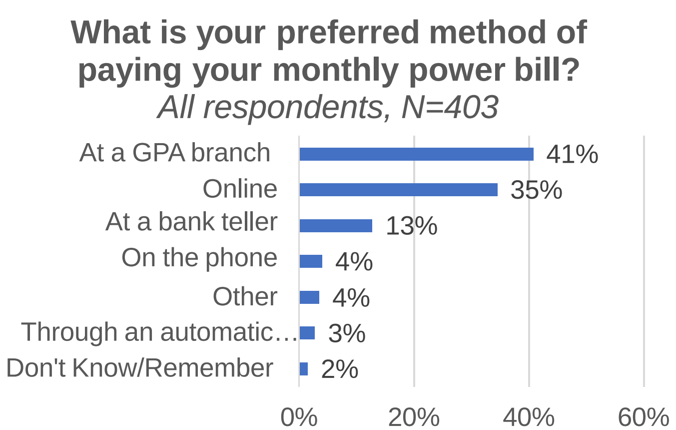
IV. OVERALL PERCEPTIONS & SATISFACTION WITH GPA

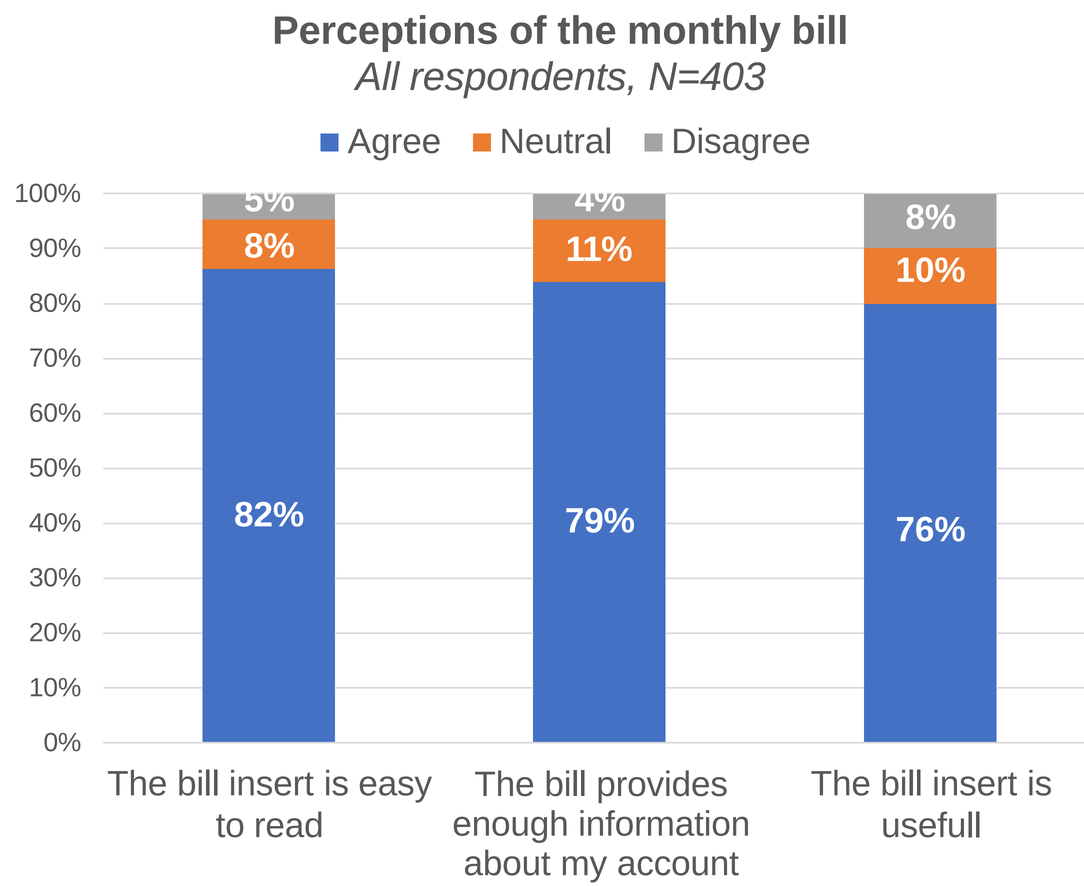
Customer Service Overall Satisfaction



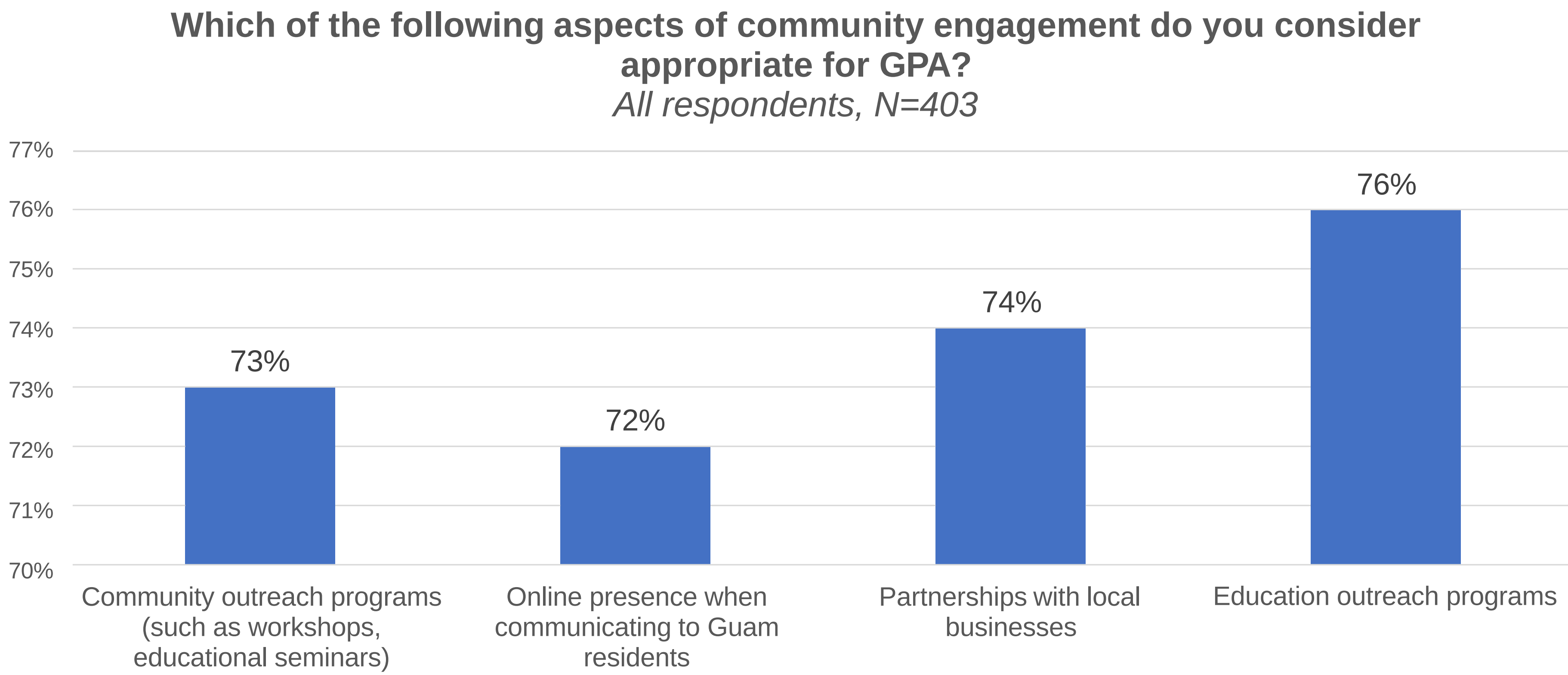
Methods of Monthly Bill Payments



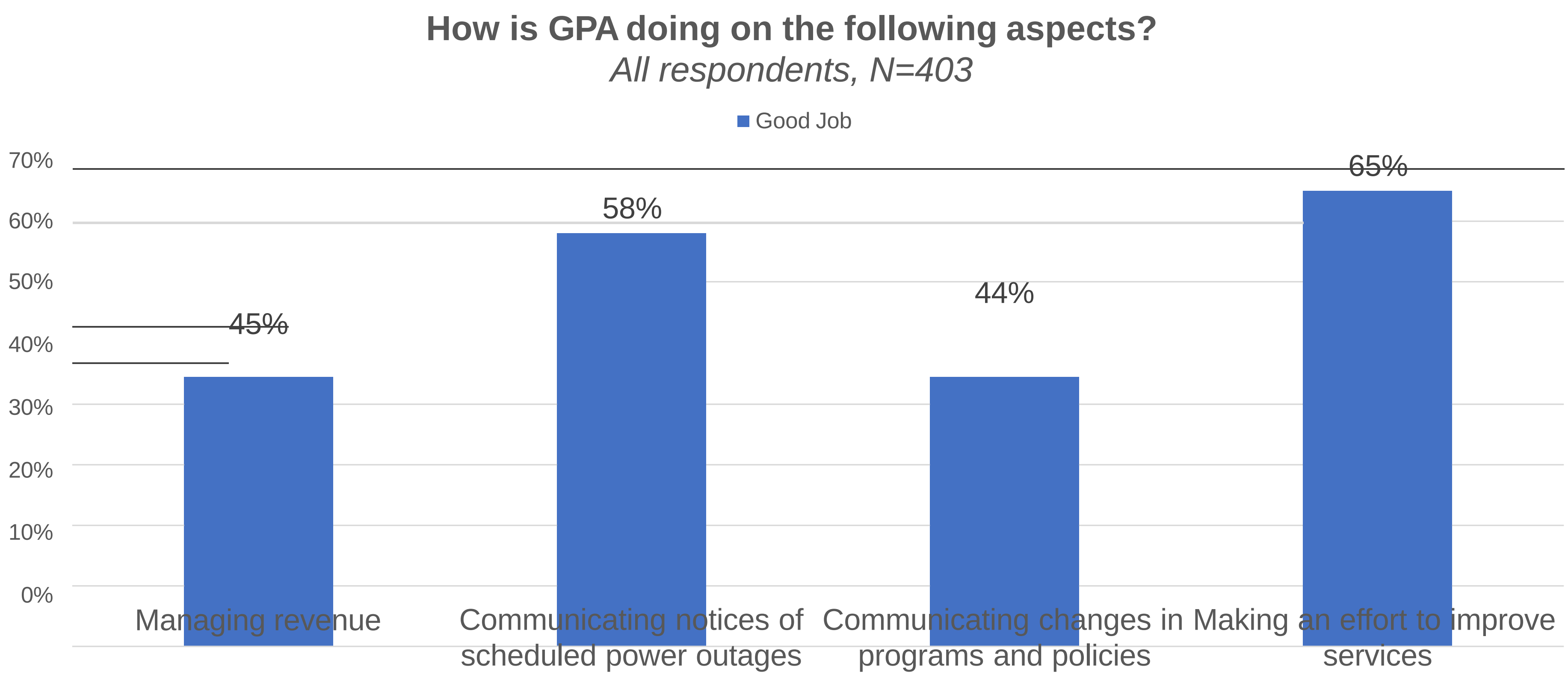




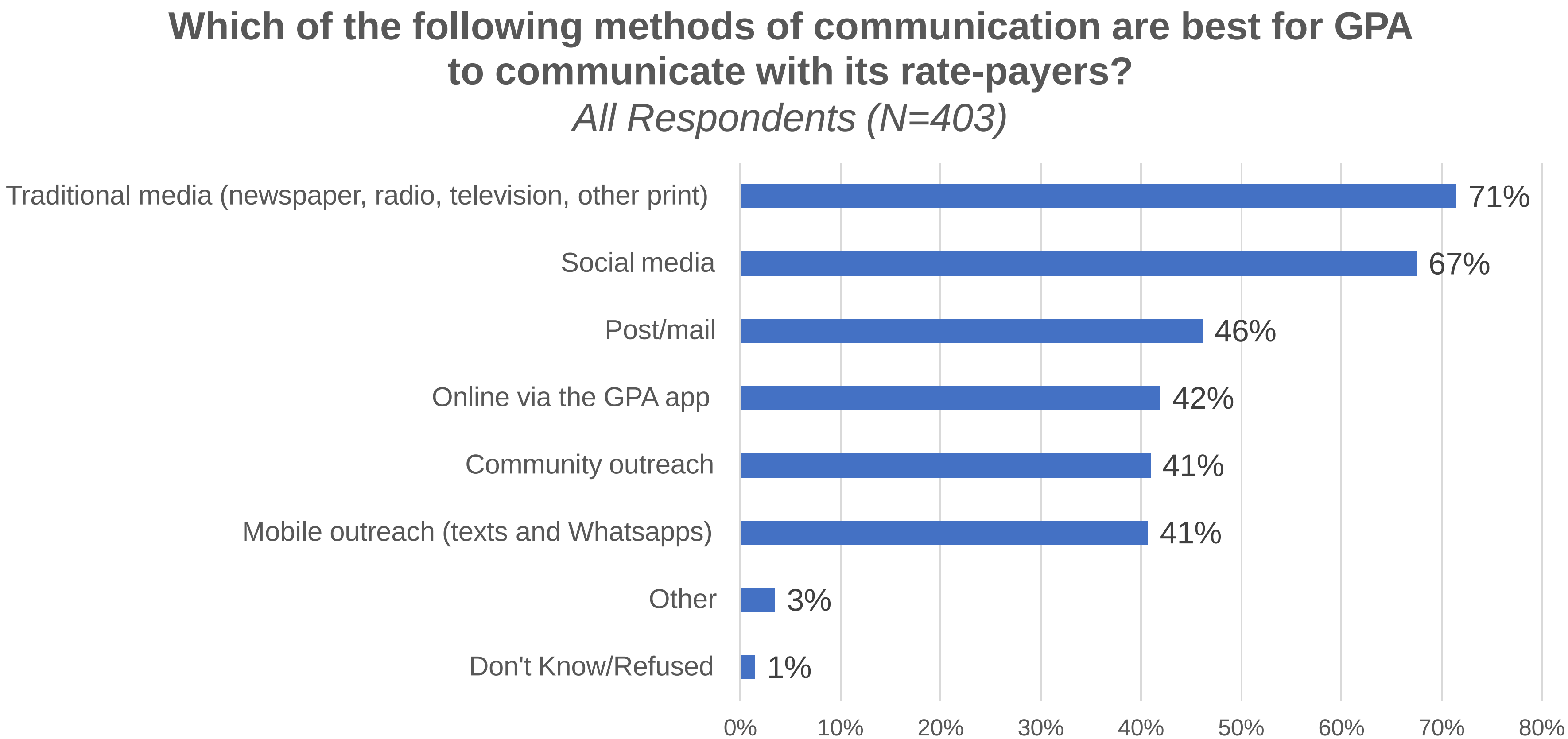
Community Engagement Perceptions for GPA



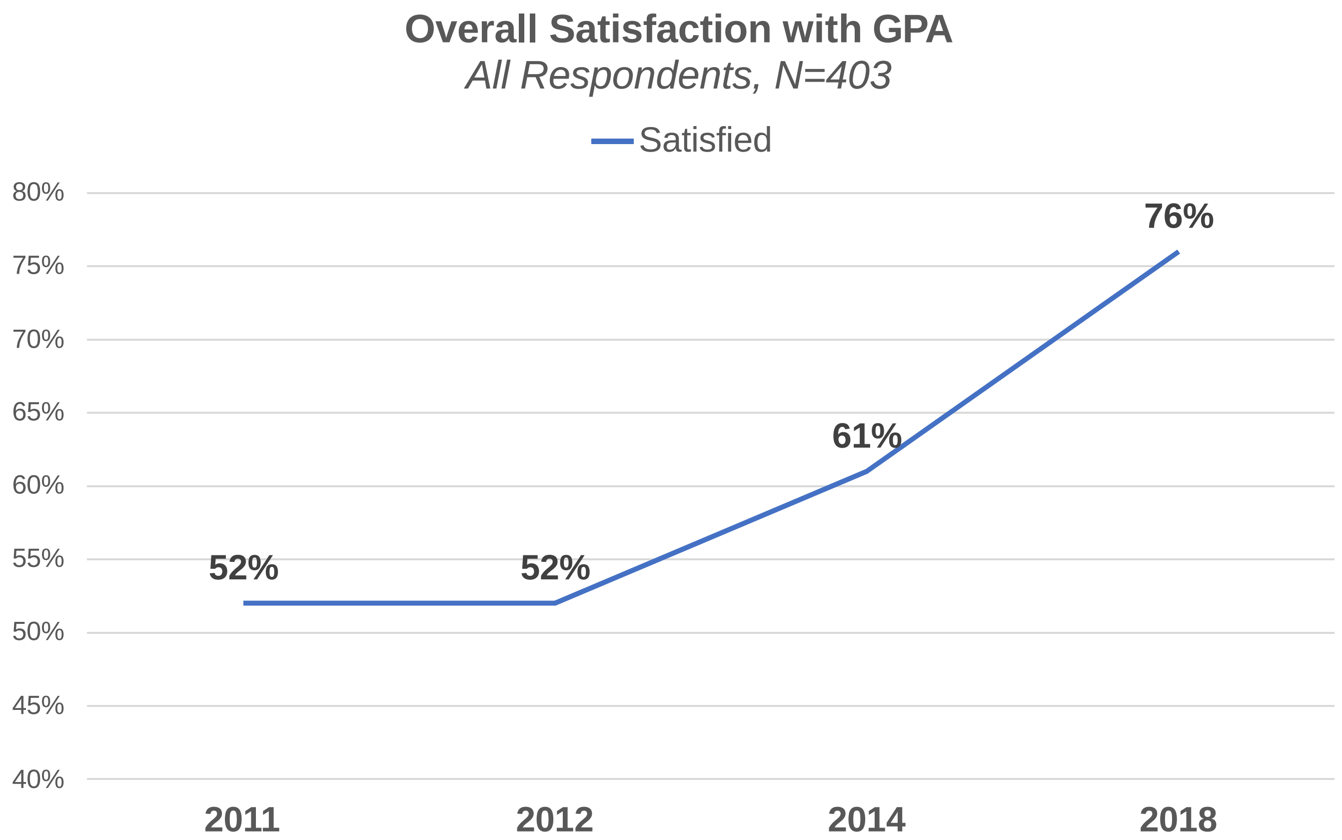
Perceptions of GPA's Performance



Preferred Methods of Communication from GPA

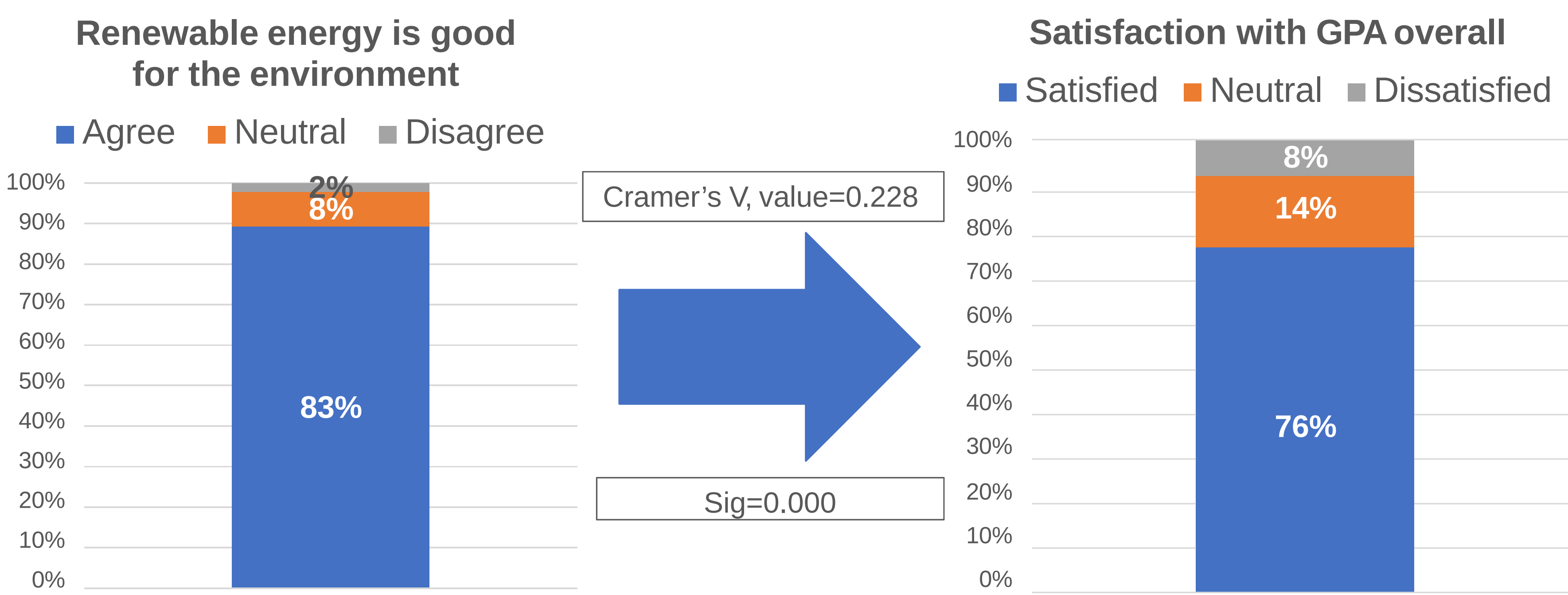


Overall Satisfaction with GPA



Satisfaction Association

There is a strong association between perceptions of renewable energy as being good for the environment and satisfaction with GPA overall.



Guam Power Authority: Energy Sense Program

Residential Focus Groups

ENERGY sense
Bringing energy solutions to you!

GUAM POWER AUTHORITY
GPA
POWER TO SERVE

MR&D
Market Research & Development, Inc.

Prepared by Market Research & Development, Inc. | May 2018

PURPOSE

- Market Research & Development, Inc. was contracted to conduct research to identify Guam residents' attitudes regarding renewable energy, electric vehicles and specifically, the GPA Energy Sense Program. In addition, GPA wanted to find out how satisfied rate payers are with their products and services.

METHOD

- The information will be collected utilizing both qualitative focus groups and quantitative survey methods.
- This report provides the key findings of the first phase of the project, two focus groups conducted among Guam residents.
  - Focus Group 1: Residents that did not participate in the GPA Energy Sense Program
  - Focus Group 2: Residents that participated in the GPA Energy Sense Program
- A focus group is a discussion facilitated by a trained researcher to illicit detailed responses to meet specific information objectives.

METHOD

- The discussion for the two groups focused on the following topics:
  - What people think about renewable energy
  - What people understand about renewable energy
  - How aware people are of the technical aspects of renewable energy
  - What people think about the GPA Energy Sense Program
  - How satisfied people are with the services provided by GPA

METHOD

Non-Energy Sense Program Participants

- The first focus group was conducted on Saturday, March 17, 2018 between 9 AM and 11 AM.
- The participants' ages ranged between 27 and 60.
- There were 7 females and 1 male.

Energy Sense Program Participants

- The second focus group was conducted on Tuesday, March 21, 2018, between 6 PM and 8 PM.
- There were 5 females and 1 male.

The focus groups were conducted at MR&D's focus group facility in Harmon.

GENERAL PERCEPTIONS OF RENEWABLE ENERGY

GENERAL PERCEPTIONS OF RENEWABLE ENERGY

- Participants were asked to state the first things that come to mind when thinking about renewable energy. Participants identified different types of renewable energy such as solar, wind, and hydro electric power.

Positive

- Solar power
  - Good investment and inexpensive in the long-run
- Pollution reduction

Neutral

- Wind power
  - Unfamiliar with benefits and effectiveness
- Hydro power
  - Unfamiliar with benefits and effectiveness
  - Relevant to other locations other than Guam

Negative

- Solar power
  - Expensive initial investment
- By-products of renewable energy
- Unpredictable weather might damage appliances

- *"I would put solar power as positive because it uses natural sunlight to generate power…"*
- *"… I would invest, but what are the options? Is it all or nothing or are there finance options?"*
- *"I think one thing negative would be the expenses for the solar power. I mean, solar power is good, but you need this much money to get it installed… the initial investment can be very expensive."*

GENERAL PERCEPTIONS OF RENEWABLE ENERGY

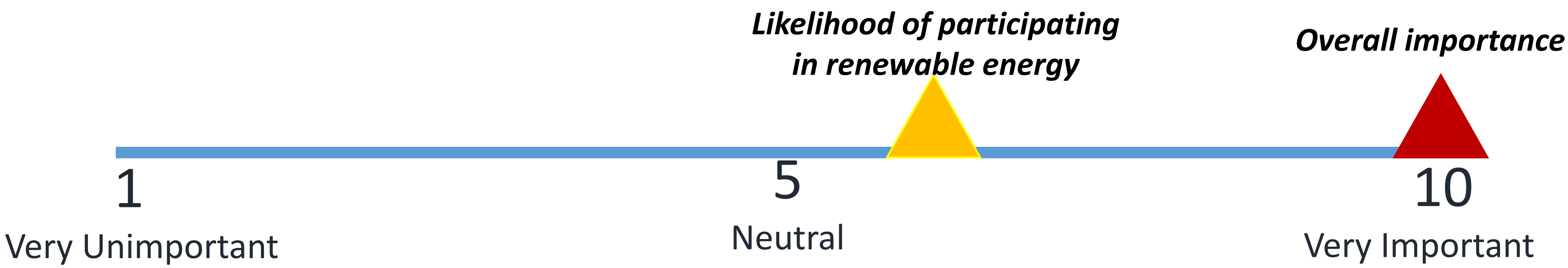
- The overall perception of alternative energy sources was positive.
  - Saves the environment
  - Potentially reduces energy costs

- Most voiced concerns about the viability of solar and wind power.
  - Difficulty and expense in maintaining such systems.
  - Effectiveness in withstanding natural disasters (like typhoons).
  - The cost of installation and acquisition

- *"You know, I would be willing to save the environment, but at the same time, I'm also concerned about my savings. Like how much am I going to save? You know, I need to protect my wallet as well."*
- *"It goes to the maintenance too. You know, are we also going to be paying for the maintain the panels or what would be the process for that."*

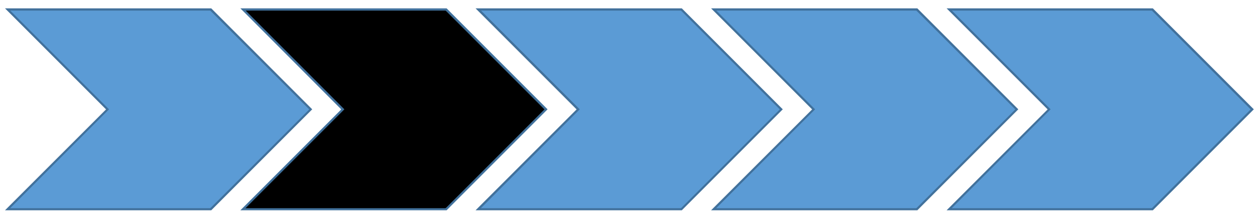
GENERAL PERCEPTIONS OF RENEWABLE ENERGY

- Most participants viewed renewable energy as very important because of their concerns about the environment.
- When asked if they personally would purchase renewable energy systems, most indicated that they were interested but were hesitant because such systems were viewed as too expensive.



- *"I would rate it as a 10 because you know, it helps the environment and conserves our energy."*
- *"I would also rate it as a 7 or 8 because although it is really important to conserve energy and save the environment, it also hurts the pocket to invest in renewable energy."*

GENERAL KNOWLEDGE OF RENEWABLE ENERGY

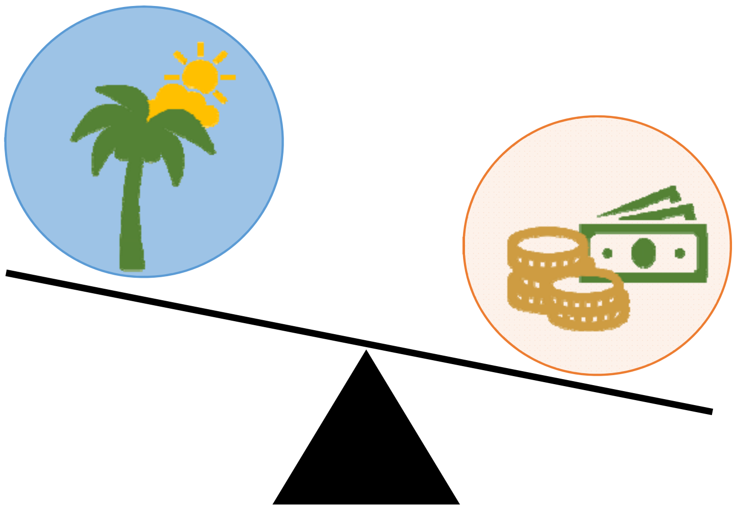


GENERAL KNOWLEDGE OF RENEWABLE ENERGY

- Solar power was most frequently mentioned type of renewable energy available on Guam.
- When participants were asked their familiarity with other renewable energy sources other than GPA, they mentioned Micronesia Renewable Energy (MRE), and Sunnova.

- *"Oh, I know about Micronesia Renewable Energy. Yeah, we have that one and the windmills at Cross Island Road."*
- *"I know another company, I think it's called Sunnova."*

GENERAL KNOWLEDGE OF RENEWABLE ENERGY



ENVIRONMENT vs PERSONAL

- *"I think, for me, personal and environment benefits go hand in hand, you know, you have to think about yourself first before being able to afford all of this."*

- When asked about the balance between personal/financial or environmental effects, participants were more concerned about the financial aspect of investing in renewable energy.
- When asked how much they would pay for renewable energy systems, the group agreed that they would pay as much as $40-$150 a month above their current power bill for solar energy.
  - The expenditure lasts for no more than four years
  - Total cost must include installation, maintenance and insurance

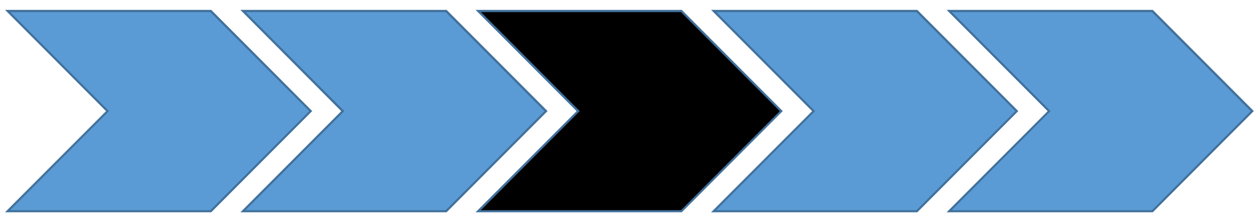
GENERAL KNOWLEDGE OF RENEWABLE ENERGY

- Participants were asked if renewable energy should be provided by the government or private companies. Most participants agreed that the government should provide renewable energy.

Private	Public
• Creates healthy competition	• Quality control • Stability • Consistency

- *"I think it'll create healthy competition for one because if you only have one primary source, then it'll be like a monopoly. Then where else are we going to get it? You know, they can jack up the prices and we wouldn't have any say."*
- *"When I think about government, it's there to set a baseline of services… if GPA were to offer this, everyone on island can access it, not just those people with money. It's better for the people."*

GENERAL PERCEPTIONS OF TECHNICAL ASPECTS



GENERAL PERCEPTIONS OF TECHNICAL ASPECTS

- SEER RATING
  - Most participants understood that a SEER rating is a measurement of energy efficiency.
  - Half of the group mentioned seeing rebate ads in the paper associated with appliances that had high SEER ratings.
  - Half of the participants believed that a higher SEER rating was important in their choice for purchasing an appliance.

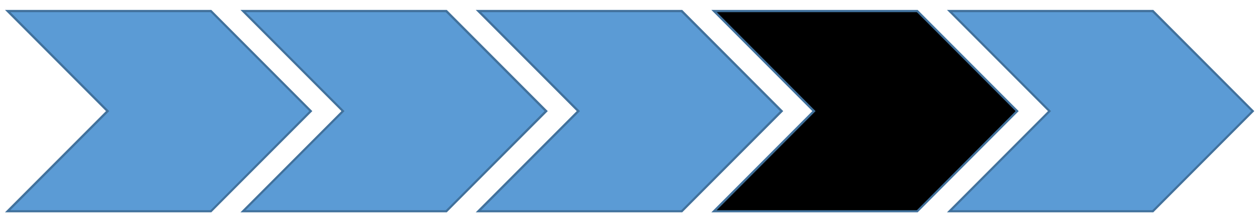
- *"The higher the number, the better it is, AND the higher the rebate." (ESP participant)*
- *"I think of that as an investment. You know, I mean, yeah, it's costly but in the long run, that's going to pay off." (ESP participant)*
- *"I've heard about it but I don't know much about it… I mean, it's advertised in the newspaper." (Non participant)*

GENERAL PERCEPTIONS OF TECHNICAL ASPECTS

- When participants were asked about their awareness of GPA's plan to create an electric fleet, no participants were aware of the GPA's plan.
- Although participants were generally in favor of GPA's transition to an electric fleet, they were concerned about the costs coming out of rate-payer pockets.
- Overall, the groups emphasized the importance of educating the public on the technical aspects of electric cars—specifically, charging station availability, charging capabilities, battery replacement, hidden fees, and electric car qualifications for the rebate program.

- *"You know, it's good for GPA to implement electric vehicles. They can be a role model for the public and show the public that they're making that effort to save the environment."*
- *"I wouldn't mind them going electric but don't pass the cost on to consumers."*

GENERAL PERCEPTIONS OF THE ENERGY SENSE PROGRAM



GENERAL PERCEPTIONS OF THE ENERGY SENSE PROGRAM

- *"You know, I would like more information on the program. You know, do more marketing and educate the public more about this program."*
- *"The process was really painless. I bought a new aircon and there was a form that the vendor gave me. I brought that to GPA… and I got my rebate in the mail."*

- Less than half of the non-energy sense program group had heard of the program. Those who were aware indicated it was associated with GPA and that they had seen or heard of it from inserts in their power bill.
- After the ESP was explained, the non-participants were receptive to the program, but were concerned about the efficiency and speed of the rebate process.
- Both groups suggested that GPA should conduct community outreach to educate the public about the program.
- ESP participants were satisfied with their experiences, claiming the rebate process was quicker than they had expected, and simple.

GENERAL PERCEPTIONS OF THE ENERGY SENSE PROGRAM

- When asked about their impressions of the Energy Sense Program Brochure, their first thoughts were:
  - The program catered to AC users
  - The brochure was modern and easy to read
  - Participants suggested that there should be more appliances that qualify under the rebate program. Some examples include:
    - Electric cars
    - Energy efficient lightbulbs
    - Solar panels
    - Electric Stoves
    - Washers/Dryers

- *"It's specific to air conditioning."*
- *"I like the fact that it's straight to the point. It's very modern and simple to read."*
- *"I think this brochure is very informative. You know, it's showing me step by step the entire process for the rebate program."*

OVERALL PERCEPTIONS AND SATISFACTION WITH GPA

OVERALL PERCEPTIONS AND SATISFACTION WITH GPA

- Participants were asked to describe their perception of GPA as a person. This exercise is used to help respondents articulate their perception of GPA.
- Insights from this exercise include:
  - GPA is an old 40 – 60 year old man
  - GPA is accepted in the community
  - GPA might be out of touch
  - GPA works "for the people"
- The groups identified the following as GPA's weaknesses:
  - Poor decision making
  - Budget overrun
  - Poor communication

- *"I see him more like a politician, like he's down for the people, but he'll get up there if he has to."*
- *"He's somewhat outdated"*
- *"Along those lines, he needs to expand his resources and network more with other people you know, with other islands or jurisdictions similar to Guam."*

OVERALL PERCEPTIONS AND SATISFACTION WITH GPA

- Although overall perception of GPA was positive, participants indicated a negative view of GPA's customer service, particularly with the wait time at their locations and over the phones.
- It was stated that the long wait was not a reflection of the customer service representatives as there were no negative encounters with the representatives themselves.

- *"Right now, the customer service is slow. You know, one way to improve it is to hire more workers."*
- *"The wait is long. I remember waiting almost two hours just to get information. But you know, the customer one-on-one is very good."*
- *"The organization structure needs to be improved."*

OVERALL PERCEPTIONS AND SATISFACTION WITH GPA

- More than half of the participants indicated a general satisfaction with the decrease in power outages this past year compared to two years prior.
- Regarding previous load-shedding schedules, participants indicated GPA's communication was reliable about upcoming outages.
- Participants indicated that the new bill was informative, but raised concerns of paper-waste. Participants suggested adding the

- *"You know, the power outages are not as frequent as before. It's only once in awhile compared to when I was younger."*
- *"And you know, when they're going to do some work on the power poles, it's good because they inform the public of when they're going to be doing the work."*
- *"I think the old bill was less paper. You know, there was no envelope, no extra pages, it was just the one sheet."*
- *"I love the insert every month (for the new bill). I like looking at the recipes every month."*
- *"I want to see like a hybrid of the bill. You know, less paper but still have those tips."*

OVERALL PERCEPTIONS OF GPA

- Suggestions on how to improve communications:
  - Community Outreach in Village Community Centers
    - Education Workshops
      - Energy Saving Tips
      - Information about GPA Programs
  - Social Media Participation (Facebook and Instagram)
    - Information on scheduled power outages
    - Energy Saving Tips (FAQs)
    - Energy Sense Program Information
  - Traditional Media (Radio, Television, Print)
    - Information on scheduled power outages
    - Energy Saving Tips (FAQs)
    - Energy Sense Program Information

- *"They should do more community outreach. You know, get on social media and educate the public about the program."*
- *"I think it really comes down to community outreach. Advertisements are one thing, but you need to show the people what it is you're talking about."*
- *"I think the top 3 is radio, television, and newspaper."*
- *"I think what can help is to bring educational outreach to the community centers and let the people in those villages know about GPA energy saving products and programs.*

KEY TAKE-AWAYS

- Participants believed that renewable energy was important. However, the cost and uncertainty of the benefits are barriers to embracing renewable energy products and programs.
- Participants were willing to pay more for renewable energy if it led to savings in the near to medium future. The government was the preferred provider of renewable energy programs.
- Most participants knew what a SEER rating was and thought it was important in selecting appliances. Participants also approved of GPA converting its fleet to electric vehicles so long as it does not cost rate-payers more money.
- Participants were receptive to the Energy Sense Program but want more appliances covered and information more widely distributed.
- Participants were satisfied with GPA but believed that the Authority is tired and out of touch with rate-payers. Communication methods are insufficient. More social media and community outreach are preferred.

Possible Drivers of Satisfaction with GPA

November 2018

In July 2018 GPA conducted a ratepayer survey in support of its Energy Sense Program. The purpose was to identify affinity, recognition, and usage of the program among all GPA rate payers.

The survey was conducted between August 22 and August 31, 2018 and collected approximately 400 randomly selected interviews.

The survey was accurate to +/-4.5% at the 95% confidence interval. That means that if the survey were to be replicated 100 times, 95 times out of 100 the results would have the same results within the margin of error.

There were several interesting findings from the research.

- Ratepayers who participated in the Energy Sense Program were more likely to be satisfied with GPA than those who did not.
- Customers that had a positive "last experience" with a GPA representative were much more likely to be satisfied with GPA overall.
- Overall satisfaction with GPA has increased significantly over the last five years.

These findings stimulated interest in attempting to determine if the relationship between participation and awareness of the Energy Sense Program and satisfaction with GPA was statistically significant or coincidental.

Further Investigation

- MR&D was requested to conduct further analysis of the survey information to ascertain if there were measurable levels of association between these variables as well as others.
- In all, there were 10 variables discovered to have significant measures of association with overall GPA satisfaction.

Variables Measured
Awareness of the Energy Sense Program
Participation in the Energy Sense Program
Village region
Customer service experience
Community outreach programs appropriate for GPA
Ease of reading for the monthly bill
Information on the monthly bill
Awareness of renewable energy
Perception of renewable energy being good for the environment
The usefulness of the monthly bill insert

Significant Measures of Association

- The measures fell into three separate levels of strength:
  - Participation and awareness of GPA's Energy Sense Program and where visitors lived on Guam exhibited the strongest levels of association, meaning that the relationships found were statistically significant.
  - The next strongest group of variables were those that were related to the customer service experience, perceptions about GPA's new bill and public outreach initiatives.
  - The final group of variables with weaker measures of association involved general attitudes about renewable energy, whether the bill insert provided by GPA was useful and, finally, ethnicity.

ASSOCIATION MEASURES WITH CUSTOMER SATISFACTION

Independent Variable	Cramer' V	Significance	Strength
Participation in Energy Sense Program	0.372	0.007	Very Strong
Awareness of Energy Sense Program	0.365	0.000	Very Strong
Village Region	0.363	0.000	Very Strong
Customer Service Experience	0.278	0.000	Moderately Strong
Community Outreach Programs are Appropriate for GPA	0.272	0.000	Moderately strong
Ease of Reading for Monthly Bill	0.270	0.000	Moderately Strong
Information on Monthly Bill	0.266	0.000	Moderately Strong
Awareness of Renewable Energy	0.241	0.002	Moderate
Renewable energy is good for the environment	0.228	0.000	Moderate
Bill Insert is Usefull	0.218	0.000	Moderate
Ethnicity	0.195	0.018	Weak

Participation in the Energy Sense Program

		HAVE YOU PARTICIPATED IN THE ENERGY SENSE PROGRAM PREVIOUSLY?					
		Yes		No		Total	
		%	N	%	N	%	N
Satisfaction with GPA Overall	Satisfied	82%	32	76%	49	77%	82
	Neutral	18%	7	15%	10	17%	18
	Dissatisfied	0%	0	10%	6	7%	7
	Total	100%	39	100%	65	100%	107

- The strongest measure of association was found among rate payers who participated in the Energy Sense Program (ESP). 82% of ratepayers who participated were satisfied with GPA compared to 76% of all rate payers regardless of there participation. Perhaps more interesting was that none of the rate payers who participated in the ESP indicated they were dissatisfied with GPA. Some 10% of those who did not participate indicated they were dissatisfied with GPA.

Awareness of the Energy Sense Program

		Have you heard of the Energy Sense Program offered by Guam Power Authority?					
		Yes		No		Total	
		%	N	%	N	%	N
Satisfaction with GPA Overall	Satisfied	77%	82	78%	218	76%	306
	Neutral	17%	18	13%	36	14%	57
	Dissatisfied	7%	7	9%	24	8%	33
	Total	*100%*	*107*	*100%*	*281*	*100%*	*403*

- Although the association found between awareness of ESP and GPA satisfaction was strong, it did not vary from overall measures of satisfaction with GPA.
- Promoting awareness of the program is less impactful in enhancing satisfaction with GPA than engaging customers in the program.

Customer Service & Overall Satisfaction

		When thinking of the last contact you had with a GPA customer service representative, how satisfied were you with your overall experience?							
		Satisfied		Neutral		Dissatisfied		Total	
		%	N	%	N	%	N	%	N
Satisfaction with GPA Overall	Satisfied	85%	227	55%	33	54%	21	76%	281
	Neutral	10%	28	30%	18	18%	7	14%	53
	Dissatisfied	4%	11	15%	9	26%	10	8%	30
	Total	***100%***	***268***	***100%***	***60***	***54%***	***39***	***100%***	***367***

- There is also a strong relationship between the last contact a ratepayer had with a customer service representative and their overall rating of GPA. Some 26% of those customers that were dissatisfied with the last contact with a GPA customer service representative were also dissatisfied with GPA. For those satisfied with their last contact only 4% expressed dissatisfaction with GPA.
- Similarly only 54% of those customers expressing dissatisfaction with their last customer service visit were satisfied with GPA overall.

Village and Overall Satisfaction

		North		Central		South		Total	
		%	N	%	N	%	N	%	N
Satisfaction with GPA Overall	Satisfied	75%	124	76%	118	82%	48	77%	290
	Neutral	15%	24	15%	24	12%	7	14%	55
	Dissatisfied	8%	14	9%	13	7%	4	8%	31
	Total	100%	164	100%	157	100%	59	100%	380

- Interestingly, ratepayers in southern Guam are more likely to be satisfied with GPA overall than ratepayers in the north or central regions of the islands. Some 82% of southern ratepayers indicated they were satisfied with GPA compared to 75% of rate payers in the North and 76% of ratepayers that reside in the central part of the island.

Rate payers were asked if GPA should provide outreach to the community and ratepayers. Four types were measured:

- Community (workshops, seminars in community centers)
- Educational (school visits, educational materials about energy)
- Business Partnerships (teaming with local businesses to inform the public about energy issues)
- Online (more robust social and digital media campaigns)

All four exhibited moderately strong measures of association with overall satisfaction with GPA. More than three quarters of those asked indicated that all of these forms of outreach were appropriate. Likewise, more than 75% of those who felt that more outreach was appropriate were satisfied with GPA.

GPA's New Bill Format and Overall Satisfaction

		The bill is easy to read							
		Agree		Neutral		Disagree		Total	
		%	N	%	N	%	N	%	N
Overall Satisfaction with GPA	Satisfied	81%	268	48%	16	47%	9	76%	293
	Neutral	12%	41	38%	13	16%	3	14%	57
	Dissatisfied	6%	20	12%	4	32%	6	8%	30
	Total	*100%*	*329*	*100%*	*34*	*100%*	*19*	*100%*	*382*

- Customers were asked to rate how satisfied they were with the new bill.
- All three measures were moderately strongly associated with overall satisfaction. Over 80% of those ratepayers that felt the bill changes were useful were satisfied with GPA.

GPA's Bill Format and Overall Satisfaction

		The bill provides enough information about my account							
		Agree		Neutral		Dissagree		Total	
		%	N	%	N	%	N	%	N
Overall Satisfaction with GPA	Satisfied	81%	257	61%	27	33%	6	76%	296
	Neutral	13%	41	27%	12	22%	4	14%	61
	Dissatisfied	6%	19	11%	5	39%	7	8%	38
	Total	*100%*	*319*	*100%*	*44*	*100%*	*18*	*100%*	*399*

GPA's Bill Format and Overall Satisfaction

		The bill insert is useful							
		Agree		Neutral		Disagree		Total	
		%	N	%	N	%	N	%	N
Overall Satisfaction with GPA	Satisfied	82%	252	49%	19	55%	17	76%	288
	Neutral	11%	34	35%	14	23%	7	14%	55
	Dissatisfied	6%	19	19%	7	19%	6	8%	32
	Total	*100%*	*307*	*100%*	*40*	*100%*	*31*	*100%*	*375*

Attitudes About Renewable Energy and Overall Satisfaction with GPA

		Are you aware of the concept of renewable energy?					
		Yes		No		Total	
		%	N	%	N	%	N
Satisfaction with GPA Overall	Satisfied	75%	200	81%	96	76%	296
	Neutral	16%	42	11%	13	14%	55
	Dissatisfied	9%	23	9%	9	8%	32
	Total	100%	268	100%	120	100%	383

- Ninety percent of those that are aware of renewable energy believe it is beneficial to for the island.

Attitudes About Renewable Energy and Overall Satisfaction with GPA

		Renewable energy is good for the environment							
		Agree		Neutral		Disagree		Total	
		%	N	%	N	%	N	%	N
Overall Satisfaction with GPA	Satisfied	77%	258	76%	26	40%	4	76%	288
	Neutral	14%	47	15%	5	40%	4	14%	56
	Dissatisfied	8%	27	6%	2	20%	2	8%	31
	Total	*100%*	*334*	*100%*	*34*	*100%*	*10*	*100%*	*375*

- At the same time almost a third (31%) of rate payers indicated that they are not aware what renewable energy is all about.
- The measures of association for both variables were moderate in strength but statistically significant. The more respondents are aware of renewable energy and the more they believe it is good for Guam the greater the likelihood that they are satisfied with GPA overall.

Key Observations

- The results of the analysis were based upon measures of association between single variables and overall satisfaction with GPA. The observations offer an insight but should not be viewed as conclusive but offer the potential platform for understanding how to drive improved customer satisfaction with GPA. The key takeaways are:
  - Programs that engage ratepayers with ways of learning more about GPA and how to save energy costs are one of the most powerful means (of those measured) to increase satisfaction with GPA overall. Unfortunately, only 27% of ratepayers are aware that the ESP program exists.
  - Outreach and improved communication with customers is appreciated by ratepayers and positively impacts how they perceive the Authority.
  - GPA's positive overall rating is only as good as the last interaction that customers experience with the company. If that last interaction was positive then ratings improve, if the last interaction was negative, overall ratings are negatively affected.
  - Perceptions regarding renewable energy or its impact on the environment are significantly less impactful on GPA ratings than actions that GPA takes to save ratepayers money or provides practical information about saving power.
  - Ratepayers will be receptive and consumer ratings for GPA improve through proactive initiatives that demonstrate and educate how consumers can conserve power.

Recommendations

More research is warranted to expand GPA's understanding of the relationship between customer satisfaction and revenue related issues such as customer migration from the grid, or views regarding capital expenditures, LEAC and rate increases to determine if improving satisfaction with GPA and its services is related to maintaining or increasing revenues for GPA.

The key performance indicators for GPA's renewable energy strategy should be developed. These measures should be measurable and identified as part of the strategy. If a formal written renewable energy strategic plan does not exist it is important that it be developed.

Additional research should be initiated to identify an expanded list of variables that drive customer satisfaction and how in combination they explain how ratepayers feel about the GPA brand and the service it provides. Consumer attitudes regarding GPA should be modeled to provide a means of understanding the impact of policy decisions on overall customer satisfaction.

Rate payers were asked if GPA should provide outreach to the community and ratepayers. Four types were measured:

- Community (workshops, seminars in community centers)
- Educational (school visits, educational materials about energy)
- Business Partnerships (teaming with local businesses to inform the public about energy issues)
- Online (more robust social and digital media campaigns)

More than 75% of all rate payers believe that all of the forms of outreach identified were appropriate. All four exhibited moderately strong measures of association with overall satisfaction with GPA. More than three quarters of those asked indicated that all of these forms of outreach were appropriate. Likewise, more than 75% of those who felt that more outreach was appropriate were satisfied with GPA.

Which of the following aspects of community engagement do you consider appropriate for GPA?

		Community outreach programs (such as workshops, educational seminars)							
		Agree		Neutral		Disagree		Total	
		%	N	%	N	%	N	%	N
GPA Satisfaction	Satisfied	78%	229	78%	44	70%	19	76%	292
	Neutral	15%	43	14%	8	11%	3	14%	54
	Dissatisfied	7%	21	7%	4	19%	5	8%	30
	Total	*100%*	*293*	*100%*	*57*	*100%*	*27*	*100%*	*377*

- Some 78% of ratepayers surveyed (293 of 377) believe that community outreach programs are appropriate for GPA to consider.
- About the same proportion 78% also indicate they are satisfied with GPA.

Which of the following aspects of community engagement do you consider appropriate for GPA?

		Education outreach programs							
		Agree		Neutral		Disagree		Total	
		%	N	%	N	%	N	%	N
GPA Satisfaction	Satisfied	78%	241	80%	40	62%	16	76%	297
	Neutral	13%	41	16%	8	19%	5	14%	54
	Dissatisfied	8%	24	4%	2	19%	5	8%	31
	Total	*100%*	*308*	*100%*	*50*	*100%*	*26*	*100%*	*384*

- Similarly some 80% (308 of 384) of rate payers believe that education related community engagement is appropriate for GPA.
- Also, 78% of those that agree also indicate they are satisfied with GPA.

Which of the following aspects of community engagement do you consider appropriate for GPA?

		Partnerships with local businesses							
		Agree		Neutral		Disagree		Total	
		%	N	%	N	%	N	%	N
GPA Satisfaction	Satisfied	78%	234	71%	41	78%	14	76%	289
	Neutral	13%	40	18%	10	17%	3	14%	53
	Dissatisfied	8%	23	12%	6	6%	1	8%	30
	Total	*100%*	*299*	*100%*	*57*	*100%*	*18*	*100%*	*374*

- Also about 80% (299 of 374) believe that partnerships with local businesses is an appropriate form of outreach for GPA to pursue.
- Of those that agree partnerships are appropriate, 78% are satisfied with GPA.

Which of the following aspects of community engagement do you consider appropriate for GPA?

		Online presence when communicating to Guam residents							
		Agree		Neutral		Disagree		Total	
		%	N	%	N	%	N	%	N
GPA Satisfaction	Satisfied	79%	227	84%	50	57%	16	76%	293
	Neutral	13%	39	12%	7	21%	6	14%	52
	Dissatisfied	8%	22	4%	2	21%	6	8%	30
	Total	*100%*	*289*	*100%*	*59*	*100%*	*28*	*100%*	*376*

- Finally, about 77% (289 of 376) believed that online outreach measures are appropriate.
- Of those that approve of online outreach techniques 79% indicated they are satisfied with GPA.

Customer Service Focus Group Report

GUAM AUTOMOBILE DEALERSHIP PERSPECTIVES ON ELECTRIC VEHICLES SURVEY

2022 Integrated Resource Plan Volume VIII:

Electric Vehicle Roadmap

10/26/2021

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Table of Contents

1 Introduction

The Guam Power Authority (GPA) supports the electrification of the Guam Transportation industry. It has invested in three Nissan Leafs. It is the only Government of Guam Agency that has made this investment.

GPA is also vested in developing awareness of electric vehicles in the Guam Community. Recently, GPA signed a two-year Memorandum of Agreement (MOA) for Demand Side Management Electric Vehicle Lease with the University of Guam. "GPA shall maintain ownership of the vehicle throughout the lease period, which may be renewed annually by GPA. The electric vehicle shall be used for public outreach, educational, and professional business use only."[1]

GPA is not just exploring transportation electrification of passenger vehicles. It is engaged in the electrification of heavy-duty trucks, bucket trucks, school and commercial buses, and other heavy-duty equipment. GPA has been selected for the United States Environmental Protection Agency (US EPA) first ever FY21 DERA Insular Areas grant program. GPA's winning concept is replacing a conventional bucket truck with a new bucket truck equipped with an electric power take off system (ePTO).

"Historically, the PTO output shaft has been part of the internal combustion engine or transmission, which requires the engine to be idling during use. An idling engine can produce up to twice as much exhaust emissions as an engine while driving."[2] Replacing the PTO with an ePTO "makes the vehicle environmentally friendly and is the first step towards hybrid and all-electric powertrains."[3]

GPA is not alone in electrifying its heavy-duty vehicle fleet. GPA and Guam Regional Transit Authority have set strategic goals to electrify their heavy-duty vehicle fleets. The private sector may eventually follow their lead. Nadel and Huether (2021) state that electric charging

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[1] Gerry Partido. (2021). GPA promotes wider use of electric vehicles on Guam. Pacific Daily News. URL: https://www.pncguam.com/gpa-promotes-wider-use-of-electric-vehicles-on-guam/

[2] Bruno Jouffrey. (2021). How to Take Advantage of an Electric Power Take-Off. Parker Hannifin Corporation. URL: http://blog.parker.com/how-to-take-advantage-of-an-electric-power-take-off

[3] Ibid.

infrastructure for fleets and truck stops is a critical issue.[4] Nadel and Huether (2021) report: "The fact that charging stations suitable for heavy-duty vehicles are virtually nonexistent today is one of the largest obstacles to heavy-duty EV adoption. We must prioritize utility rate design and promotion of managed charging if we want to make EV operating costs attractive while being fair to all ratepayers "[5] Therefore GPA must take an active role early to engender its strategic goal for electrification of Guam's transportation industry while finding solutions to the technical issues imposed by EV penetration.

The use of huge industrial chargers will not be long-time coming. Cel Baubata, Executive Manager of the Guam Regional Transit Authority (GRTA), is a man of action. But, he also has the insight that planning is essential and prudent to any visionary action and helps ensure successful execution. Babauta's vision is to transform GRTA and perhaps the Guam transportation industry to electric vehicles. This is a vision shared by GPA. Having secured federal grants, Babauta will break ground within a year and half to bring several all-electric buses for use by GRTA to serve the Guam community. He has reached out to Guam Power Authority for support. Support that GPA feels honored to provide.

2 Document Organization

This volume of the IRP consists of this document, the Demand Side Management (DSM) Electric Vehicle Program: Implementation & Communications Logic report by Sheffield Scientific, and the Guam Automobile Dealership Perspectives on Electric Vehicles Survey by AdzTech. The remaining sections of this document are organized as follows:

- Section 3 introduces the GPA Electric Vehicle Roadmap;
- Section 4 discusses the potential ramifications of large-scale growth of electric vehicles on the GPA system;
- Section 5 discusses Managed Electric Vehicle Charging as a Service Partnership;

[4] Nadel, S., and P. Huether. 2021. Electrifying Trucks: From Delivery Vans to Buses to 18-Wheelers. Washington, DC: American Council for an Energy-Efficient Economy. www.aceee.org/research-report/t2102. P. iv
[5] Ibid.

- Section 6 discusses customer education on electric vehicles especially regarding making the best and most efficient use of the technology.

3 Electric Vehicle Roadmap

Guam Power Authority (GPA) hired Sheffield Scientific and subcontractor Utility Financial Solutions to develop a GPA Electric Vehicle Roadmap. This included developing rates for GPA installed public electric vehicle chargers.

A major driver for this roadmap is the arrival of new lines of electric vehicles across all major vehicle manufacturers. Figure 3-1 shows a US Electric Vehicle Sales Forecast. Over 100 additional Electric Vehicle models will become available by 2024. Additionally, Figure 3-2 shows that potential EV customers are concerned about access to EV charging stations or limited EV range. Limited range should not be a concern for Guam. However, access to charging stations may very well be. GPA finds that this is a concern with Guam automobile dealerships already selling electric vehicles and those that will soon be introducing and selling EVs. GPA, EV dealerships, and customers must work together to create an environment and infrastructure that supports high penetration of electric vehicles while ensuring that electric vehicles do not pose problems for the grid and become part of the solution for a more resilient, affordable grid.

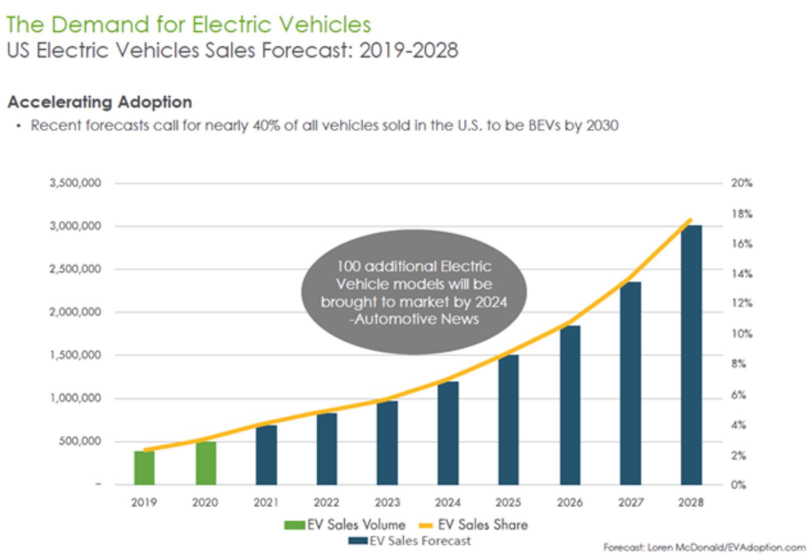

Figure 3-1 US Electric Vehicles Sales Forecast

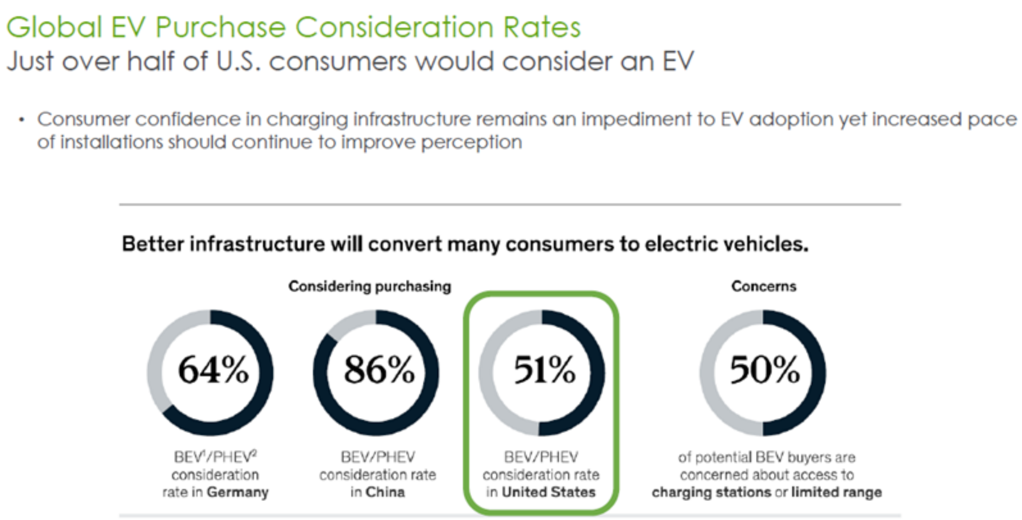

Figure 3-2. Global EV Purchase Consideration Rates

Figure 3-3 shows the Electric Vehicle Roadmap report from the Sheffield report.

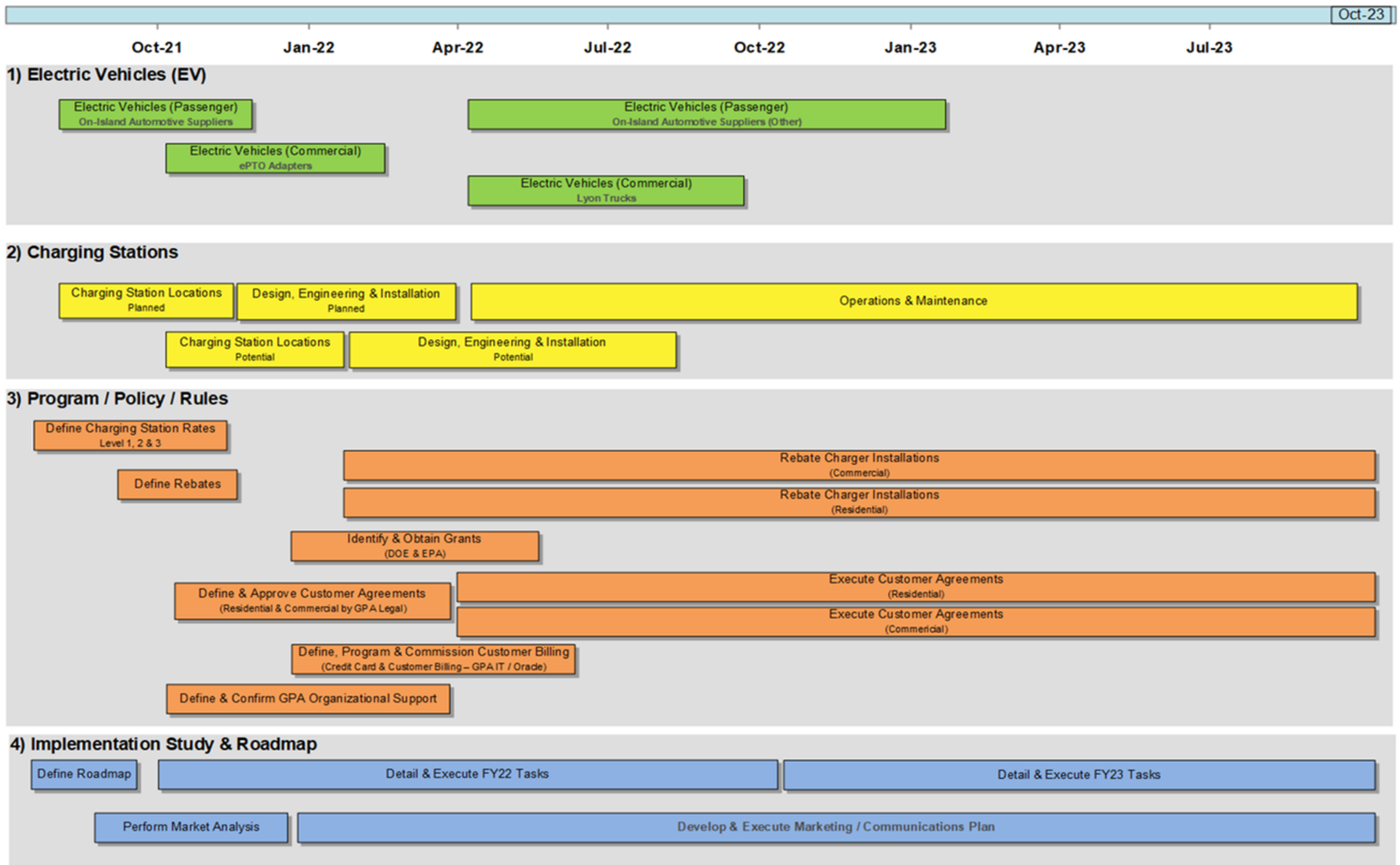

Figure 3-3. GPA Electric Vehicle Roadmap.

4 Caveats on Uncontrolled Electric Vehicle Penetration

Part of building a reliable, stable, and resilient system is being able to fund the necessary capex and O&M expenses required. Electrification of Guam's transportation is a considerable future revenue source to provide this funding while reducing rates for all GPA customers. However, the penetration of EV chargers throughout the GPA distribution system is not without hazard. For example, DC fast chargers several to a location or clustered closely on a feeder will impose harmonics issues on the distribution system. Uncontrolled EV penetration without GPA EV charging management will result in greater needs for generation capacity.

4.1 Managing Electric Vehicle Charging on Guam

This section discusses how GPA must manage EV charging to improve generation system reliability and resiliency rather than degrade it. Deb et al. (2018) state:

> "The detrimental impact of EV charging station loads on the electricity distribution network cannot be neglected. The high charging loads of the fast charging stations results in increased peak load demand, reduced reserve margins, voltage instability, and reliability problems. Further, the penalty paid by the utility for the degrading performance of the power system cannot be neglected"[6].

There are three potential negative issues with mass EV penetration into the grid: charging demand, harmonics, and phase voltage unbalance. A fourth issue: EV charging power sourcing is both an opportunity and a potential problem.

4.1.1 Uncontrolled Electric Vehicle Charging Can Lead to Generation Capacity Additions

If GPA does not have control over EV charging, EV charging can build up a considerable increase in system peak demand. This would require GPA to build more capacity and potentially increase rates. Assuming a negligible EV sales in today's market, for EV sales to reach 50% of new light duty vehicle sales by 2033, the sales growth rate must be about 3.44%/year. Assuming the light duty vehicle new car market is 8,000 per year results in 9,473 electric vehicles added within the first five years assuming these vehicles remain operable. Assume that each EV

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[6] Sanchari Deb, Kari Tammi, Karuna Kalita, and Pinakeshwar Mahanta (2018). Impact of Electric Vehicle Charging Station Load on Distribution Network. Energies 2018, 11, 178; doi:10.3390/en11010178. URL: file:///C:/Users/jcruz/Downloads/energies-11-00178.pdf

requires charging at 4.4 kW and that they all charge coincident with GPA system peak. This will increase GPA's system peak demand by 41.68 MW.

4.1.2 Uncontrolled Electric Vehicle Charging Can Lead to Problems with System Harmonics

GPA must investigate Level I and II chargers as higher penetration levels evolve. "One of the challenges associated with EV battery charging comes from the potentially high harmonic currents associated with the conversion of ac power system voltages to dc EV battery voltages. Harmonic currents lead to increased losses in distribution circuits and reduced life expectancy of such power distribution components as capacitors and transformers. Harmonic current injections also cause harmonic voltages on power distribution networks. These distorted voltages can affect power system loads.[7]

However, GPA may have more immediate issues with DC fast chargers especially where several are installed in the same location or clustered closely together on a feeder. Large chargers for buses or industrial heavy machinery may also be a concern. "If there are many electric vehicles in fast charging at the same time, the voltage distortion should exceed the admissible limit. Using photovoltaic (PV) to charge electric vehicles is a good solution to charge EVs.[8] GPA should explore the use of localized Solar PV resources with Battery Energy Storage as part of a solution for industrial fast charging. GPA envisions that these PV systems be non-net metering and not connected to the GPA grid.

Canvassing through the technical literature on EV Chargers and their impact on the distribution system reveals several guideline rules of thumb. Rodrigo et al. (2018) paper[9] concludes with the following rules of thumb:

- For feeders having a random distribution of EV chargers along it, "up to 30% of EV charger penetration at nominal load and up to 40% of EV charger penetration can be absorbed to the distribution feeder without violating IEEE 519 prescribed limits."[10]

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[7] Staats, P. T., "The harmonic impact of electric vehicle battery charging", PhDT, 1997.
[8] V. Nguyen, T. Tran-Quoc and S. Bacha, "Harmonic distortion mitigation for electric vehicle fast charging systems," 2013 IEEE Grenoble Conference, 2013, pp. 1-6, doi: 10.1109/PTC.2013.6652435.
[9] A. S. Rodrigo and V. G. C. Priyanka, "Impact of High Penetration of EV Charging on Harmonics in Distribution Networks," 2018 Moratuwa Engineering Research Conference (MERCon), 2018, pp. 340-344, doi: 10.1109/MERCon.2018.8421990.
[10] Ibid.

- "If the EV chargers are clustered together 20% of EV penetration can be absorbed considering harmonic profile at source as well as PCC [point-of-common-coupling]."[11]

"Different techniques can be used for reduction harmonic current. The most common are line filters (using passive components: inductors and capacitors) and active electronic circuitry."[12] GPA should require distribution engineers and SPORD planners to train on modeling of harmonic equipment such as EV chargers and in determining harmonic mitigation strategies in the distribution system. Minimally, GPA should perform measurements and analysis on GPA should perform harmonic analysis on proposed clusters of EV chargers whenever it can verify such clusters in advance. Working closely with charger companies and EV dealerships will be key too this and enforcing standards and rules regarding EV charging on the GPA system.

4.1.3 Electric Vehicle Battery Charging and 3-Phase Power Supply Unbalance

High penetrations of residential Level 1 and Level II chargers will impose voltage problems on GPA's distribution system. "Increased EV penetration may result in sustained secondary service under-voltage conditions, violation of under-voltage limits, and three-phase power supply unbalance, which would deteriorate the service."[13] "ANSI C84.1-2011 [61] provides the national standard for voltage regulation. As per the standard, typically, the service voltage should range within ±5% of the nominal voltage rating and the three-phase voltage unbalance should not exceed 3%."[14] Note that GWA facilities with motor pump loads require three-phase voltage unbalance within 1%. Uncontrolled installation of these chargers may require reconfigurations of feeders to correct the unbalance. GPA should plan ahead and work with EV dealerships, charger providers, and customers to ensure that these problems are anticipated and mitigated from the very beginning.

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[11] Ibid.
[12] A. Bosak, A. Bosak, L. Kulakovskyi and T. Oboronov, "Impact of EV Chargers on Total Harmonic Distortion in the Distribution System Network," 2019 IEEE 6th International Conference on Energy Smart Systems (ESS), 2019, pp. 329-333, doi: 10.1109/ESS.2019.8764244.
[13] Anamika Dubey and Surya Santoso (2015). Electric Vehicle Charging on Residential Distribution Systems: Impacts and Mitigations. IEEE. URL: https://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=7264982
[14] Ibid.

4.2 Electric Vehicle Battery Charging Sourcing

Solar PV energy production is stochastic depending on the weather. Installing these types of resources to serve these new loads at minimum solar PV production periods may result in curtailing the resource during high production days. Curtailments may require GPA to pay for energy not taken increasing customer energy costs. A better solution may be to charge EVs by increasing the dispatch of GPA synchronous generation as needed in conjunction with the already planned developments of utility-scaled solar PV.

Solar PV systems are at risk for damage from typhoon high winds. Good design and installation execution for high winds can certainly be done to prevent damages from PV panel uplift. However, one also must consider what may be carried by high winds and smashes into solar PV panels. The planning team has observed that Guam's Pacific Solar has an excellent racking system for high wind loading. Pacific Solar lost three systems during a recently typhoon in the CNMI while its competitors lost about a quarter of their systems. Pacific Solar's three systems were damaged by flying debris not wind uplift.

GPA must take conservative views and strategies with respect to typhoons and other natural disasters, especially since the Guam transportation system will become highly dependent on GPA as EV penetration increases.

Some of the vehicle charging load could also be supplied by large commercial rooftop systems as well. These would not be net metering systems. They would be installed for electric vehicle charging and not connected to GPA's grid. There will be room for both GPA and Private PV systems for EV Charging. Other EV vehicle charging sources can come from energy storage systems that would charge at off-grid periods and then discharge while charging electric vehicles.

5 Managed Electric Vehicle (EV) Charging as A Service Partnership

The Smart Electric Power Alliance Energy Services Interface Task Force states:

"One of the most direct means to minimize the challenges of rapid EV adoption while simultaneously enhancing energy reliability and resiliency is to support interactive communication and coordination between grid operators, EVSEs and charging stations, and

EV drivers. This interactive capability is known as managed charging, which refers to "central or customer control of EV charging to provide vehicle grid integration (VGI) offerings, including wholesale market services." (SEPA 2019b). An energy service contract promises to provide a standard mechanism to exchange actionable information across the value chain."[15]

GPA currently uses an Energy Services Contractor to manage, develop, and execute energy efficiency and renewable projects for large customers. GPA can do the similarly with Managed EV Charging.

SPORD will run the procurement and manage the program. Engineering will run the operations side of the contract with the Managed EV Charging Contractor such as EV site planning, Distribution System Sourcing Requirements, Design reviews, etc.

Collectively, the Contractor, Engineering, SPORD and EV dealer stakeholders will plan out for the location, size, and technology of EV chargers. All EV chargers will be under the control of GPA/Contractor. The Managed EV Charging Contractor will enable EV charge control for GPA as part of equipment installations. GPA Smart Grid Communication Network Infrastructure will provide the communication backhaul.

6 Electric Vehicles for Guam

The long-awaited EV explosion is coming soon. Bloomberg Technology reported that: "Consultant Ernst & Young LLP now sees EV sales outpacing fossil fuel-burners in 12 years in Europe, China and the U.S. -- the world's largest auto markets. And by 2045, non-EV sales are seen plummeting to less than 1% of the global car market, EY forecast using an AI-powered prediction tool."[16]

Guam has two things going for it when it comes to EV adoption:

- High fuel prices;
- Shorter daily driving distances reducing range anxiety.

[15] SEPA Energy Services Interface Task Force. (2021). An EV Managed Charging Framework: Simplifying Managed Charging with Energy Service Contracts. Smart Electric Power Alliance. page 6.

[16] Brett Haensel and Keith Naughton. (2021). Electric Vehicles Seen Reaching Sales Supremacy by 2033, Faster Than Expected. Bloomberg Technology. URL: https://www.bloomberg.com/news/articles/2021-06-22/shift-to-electric-cars-coming-faster-than-expected-study-shows

What Guam has not had a lot is EV support from dealerships. For many years, Nissan was the only dealership to sell plug-in, all-electric vehicles: the Nissan Leaf. Within the last four years, Cars Plus began selling the Kona all electric vehicle. In August 2021, GPA met with Triple J and others regarding supporting Triple J's soon to be launched all-electric vehicle sales.

A strong market for electric vehicles is both a major benefit for GPA as well as a source for potential problems if GPA does not get involved in a major launch of EVs on Guam.

The following subsection discuss:

- Customer education points to pave the way to greater adoption of electric vehicles;
- EV charging control strategies to mitigate issues with mass EV charging and using them to improve the reliability and resiliency of GPA's grids.

GPA must educate customers to support greater adoption of electric vehicles on Guam. This educational outreach should include:

- Smart Electric Vehicle Charging Strategy;
- Electric Vehicle Battery Life and How to Extend It;
- Providing Opportunities for Potential Customers to Drive an EV.

6.1.1 Smart Electric Vehicle Charging Strategy

Many detractors of electric vehicle point at the long charging times to maintain full battery charge. However, topping off the battery every day is not an efficient charging strategy and adds time to charging. It also quickens battery degradation and leads to a sooner end of life.[17] The most efficient and least destructive charging strategy is to keep the EV battery state-of-charge (SoC) between 20% to 80% of charge. Table 6-1 compares the average autonomy rate per hour of charging for different charge regimens. Charging EVs by keeping the battery state-of-charge between 20% to 80% provides the most value.

[17] Emmanouil D. Kostopoulos, George C. Spyropoulos, John K. Kaldellis. (2020). Real-world study for the optimal charging of electric vehicles. Energy Reports, Volume 6, 2020. Pages 418-426. ISSN 2352-4847, https://doi.org/10.1016/j.egyr.2019.12.008. (https://www.sciencedirect.com/science/article/pii/S2352484719310911)

Table 6-1. Average Autonomy Rate (range/hour of charging)[18]

Charging (% SOC)	km per charging hour	miles per charging hour
20- 100	60.50	37.81
80 - 100	42.00	26.25
20 - 80	71.00	44.38

6.1.2 Extending Electric Vehicle Battery Life Strategy

Kong et al. (2018) state in their paper, "State of Health [SOH] Estimation for Lithium-Ion Batteries," that:

> "Many studies have suggested that temperature and discharge/charge current rate are the primary factors causing battery aging."[19]

The takeaway from the Kong et al. (2018) paper is that "SOH is a complex issue for which temperature and discharge/charge current rate are primary factors"[20] that users of EVs have some control over. This leads us to Andrew Ryan's (2021) article, "Make your electric vehicle battery last longer."[21] This article cites three strategies for keeping EV batteries heathier and lasting longer:

- Manage the state of battery charge;
- Avoid extreme heat.;
- Limit the amount of rapid charge sessions.[22]

Manage the state of battery charge by keeping it within the 20% to 80% range. This is the charging sweet spot.

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[18] Ibid.
[19] XiangRong Kong, Arman Bonakdarpour, Brian T. Wetton, David P. Wilkinson, Bhushan Gopaluni, (2018). State of Health Estimation for Lithium-Ion Batteries, IFAC-PapersOnLine, Volume 51, Issue 18, 2018, Pages 667-671, ISSN 2405-8963, https://doi.org/10.1016/j.ifacol.2018.09.347. (https://www.sciencedirect.com/science/article/pii/S2405896318320329)
[20] Ibid.
[21] Andrew Ryan. (2021). Make your electric vehicle battery last longer. Fleet News. URL: https://www.fleetnews.co.uk/electric-fleet/charging-and-infrastructure/make-your-electric-vehicle-battery-last-longer
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The use of DC rapid chargers in conjunction with hot climates presents issues for vehicle lithium-ion batteries. A high temperature climate region is one having temperatures higher than 80.6 degrees Fahrenheit more than five days a year. This definition certainly applies to Guam.

Enel X reports:

> "However, the combination of frequent DC rapid-charging in hot ambient temperature settings can accelerate the battery's loss of capacity. You should try to only use DC rapid-charge stations when you need to, and use slow charging stations for daily recharging at home."[23]

Although "EVs feature systems to cool the batteries when they rise in temperature, … Enel X recommends drivers take steps to protect the battery if they are used in areas where temperatures frequently exceed"[24] 80.6°F. These steps include:

- "Not … [leaving] the car parked in direct sunlight for long periods of the day when the temperatures are very high;
- "Not … [leaving] a fully-charged EV sitting unprotected for prolonged periods in extreme heat;"
- Not needlessly charge an electric vehicle past 80% on high heat days.[25]

[23] Ibid.
[24] Ibid.
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Demand Side Management (DSM)

Electric Vehicle Program

Implementation & Communications Logic

Prepared by:

Sheffield Scientific

Your partner for a brighter energy future

September 23, 2021

Table of Contents

Introduction & Purpose

This document provides the attributes for the development & implementation, supporting descriptions and logic of the Electric Vehicle (EV) program at the Guam Power Authority (GPA). Figure A presents a holistic decomposed graphical view of the EV Program which is broken down into 4 main areas:

1) Electric Vehicles: Defines types of EVs for passenger and commercial use. Automotive suppliers currently on-island and potential suppliers based on market opportunity.

2) Charging Stations: Defines categories of Chargers (Level 1 – 3) and available charger connections to vehicles. Charging station short-term and potential longer-term locations. Design and Engineering for Charging Stations along with Operations and Maintenance support for Charging Stations.

3) Program / Policy / Rules: Provides description and discussion for Charging Station Rate Structures, Customer Rebates, Customer Agreements for EVs, Customer Billing Rules and Supporting Grants (DOE, EPA).

4) Implementation Study & Roadmap: Sets project expectations and implementation logic for EV program execution.

Further details will be refreshed as key deliverables are completed for rate structures, rebates and a market analysis which will further influence requirements for the EV Program.

Electric Vehicle Program Vision

Guam Power Authority (GPA) continues modernization of its electric grid infrastructure through digitization and deployment of Smart Grid technologies combined with a Demand Side Management (DSM) Program to support the strategic delivery of energy saving services to their customers.

Based on the maturity of electric vehicles (EV) and needs of GPA's customers, the effective deployment of EV's in Guam will provide cost and environmental benefits to the island. GPA desires to **provide leadership and commercial ownership** on the EV Program which is an integral part of GPA's Integrated Resource Plan.

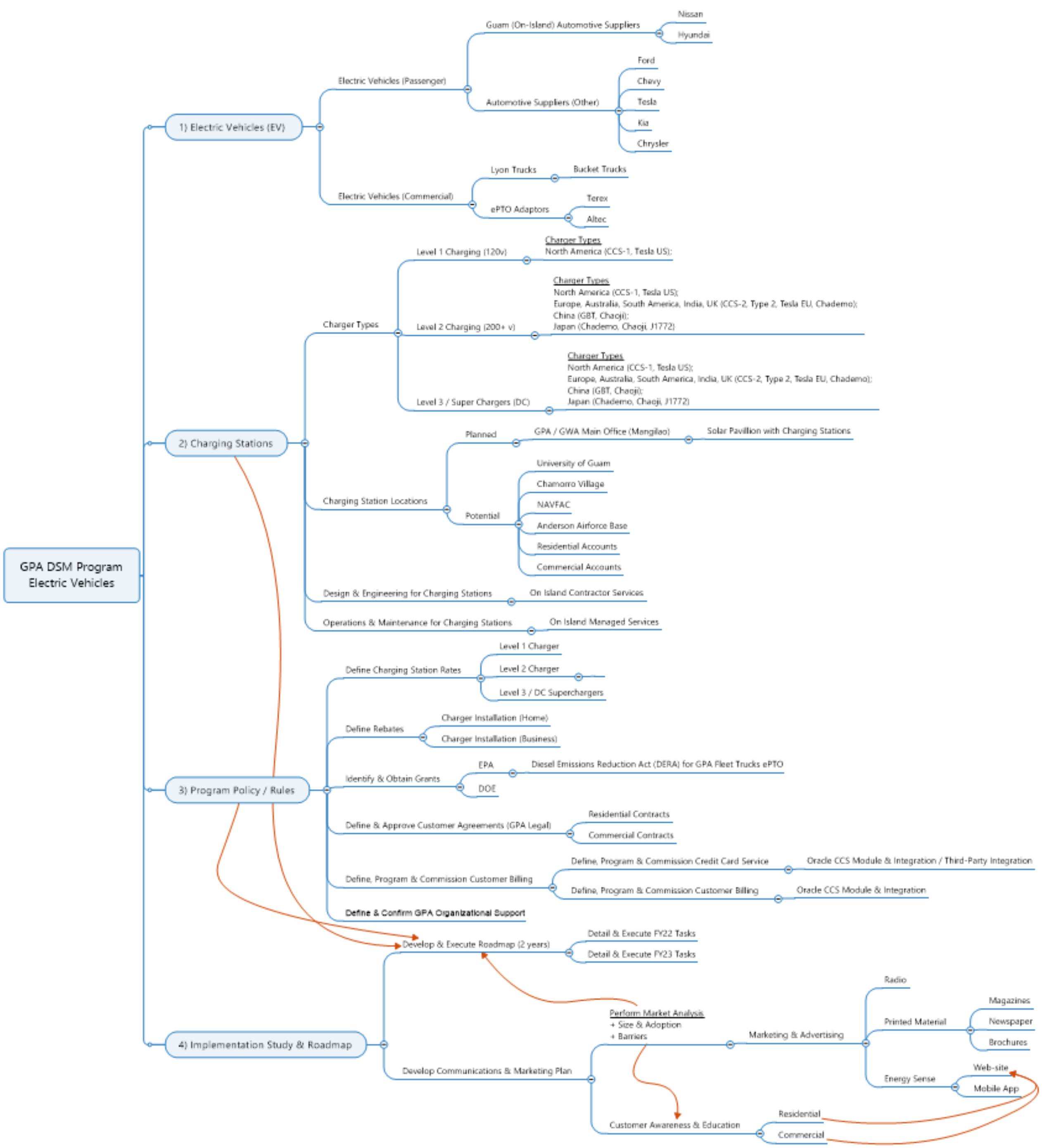


Figure A – Electric Vehicle Planning Map

Current State – Summary

Guam has two major automotive suppliers of electric vehicles (EV) through Nissan (Leaf) and Hyundai (Kona). Current totals have a total of 19 EVs on the island including the GPA Fleet with 3 vehicles. Recently, it was discovered that there are 7 Tesla's on the island raising the total to 26 vehicles. Other EV models from both suppliers are anticipated for island use as demand increases as a result of an accepted GPA EV Program.

Background / Previous Commitments / Events by GPA related to the EV Program:

- August 2017 – GPA commitment to electric vehicles for service fleet with the purchase of 2 Nissan Leaf's
- April 2021 - Memorandum of Agreement (MOA) for DSM EV Lease for the University of Guam
- July 2021 – Development of DSM EV Charging Rates, Supporting Implementation Logic & Communications Plan and an EPA DERA Grant Project for emission reductions via EV promotion (ePTO)

1) Electric Vehicles

Passenger Options

Passenger category vehicles from current On Island Automotive Suppliers include:

- Nissan (Nissan, Acura - Models: Leaf - Charging Type(s): CHAdeMO, J1772)
- Hyundai (Models: Kona - Charging Type(s): CCS-2, Type 2)

Passenger category vehicles from potential Automotive Suppliers include:

- Tesla (Models: Various)
- General Motors (Chevrolet, Buick, Cadillac – Models: Various)
- Ford Motor (Ford, Lincoln - Models: Various)
- Toyota (Toyota, Lexus - Models: Various)
- Kia (Models: Various)
- Chrysler (Jeep, Dodge, Chrysler - Models: Various)

GPA DSM staff have had discussions with Nissan and Hyundai dealers on their EV sales expectations. These discussions will continue with the execution of the detailed marketing analysis and understanding of the supplier strategy for Guam. An electric vehicle market demand survey conducted in 2019 provided the following forecast for the USA.

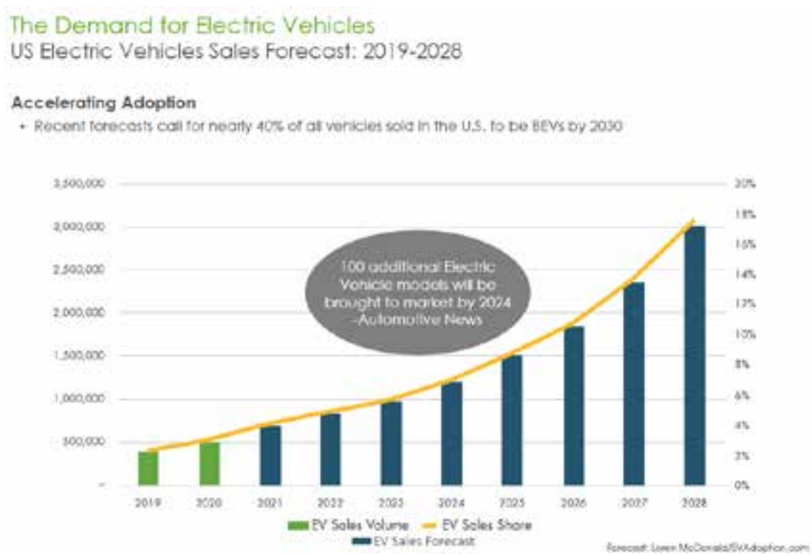


Figure B – Electric Vehicle Sales Forecast (USA)

Triple J Enterprises, LLC which is a large conglomerate in Guam with automotive dealerships, real estate and restaurants has been investigating innovative electric vehicle programs that would accommodate residents and tourists to Guam. A market survey for the USA provided feedback on if charging infrastructure was available and reliable would drive adoption to electric vehicles.

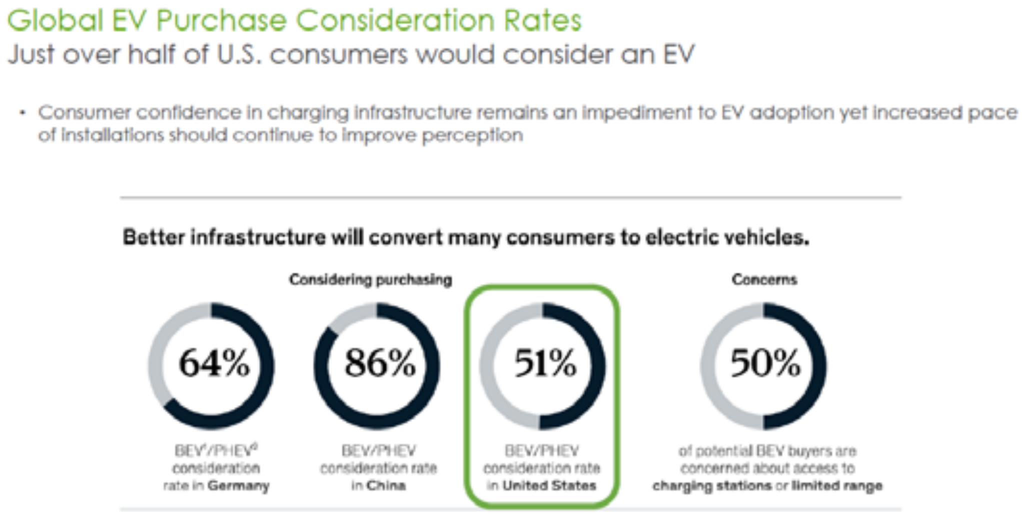


Figure C – Electric Vehicle Consumer Adoption Forecast

Commercial Options

Commercial category vehicles at this point can be broken into two types: 1) Commercial Class 6 & 8 Trucks (All Electric) and Electric Power Takeoff (ePTO) for existing truck retrofits within the Guam Fleet.

For commercial, all electric Bucket Truck development it has been led by the Canadian manufacturer, Lion, with a Model 8 vehicle that has an estimated cost $300 – 400K per truck. This price is an estimate, but we are requesting further pricing details from Lion. The Lion truck is highly configurable and a pilot project by Consolidated Edison is starting currently for industry observation.

The GPA DSM staff is also reviewing and analyzing for a potential future Fleet replacement strategy and possible support through a grant funded project.

The other commercial option is the Electric Power Takeoff (ePTO) Technology which has been led by two manufacturers: 1) Terex and 2) Altec. The ePTO powers a truck's onboard equipment – such as aerial platforms and digger derricks – without the need to run the engine. GPA Planning & Regulatory staff currently have an EPA – DERA grant application for approval supporting an ePTO pilot for some existing GPA Fleet trucks.

2) Charging Stations

The results of the pending EV market analysis will dictate further definition and requirements for the EV Program Charging stations, types and locations.

Currently there are 3 Charger Types that have been developed from a geographic and manufacturer perspective.

Level 1: Utilizes 120-volt power and takes all day (and night) for an EV charging.

- North America (CCS-1, Tesla US)

Level 2: Utilizes uses 240 volts and recharges an EV in an hour or to predetermined level (e.g., 80%) in a faster method.

- North America (CCS-1, Tesla US);
- Europe, Australia, South America, India, UK (CCS-2, Type 2, Tesla EU, CHAdeMO);
- Japan (CHAdeMO, Chaoji, J1772)

Level 3: Utilizes DC Fast Charging or Tesla Supercharging that completes a charge in under an hour at public charging stations.

- North America (CCS-1, Tesla US);
- Europe, Australia, South America, India, UK (CCS-2, Type 2, Tesla EU, CHAdeMO);
- Japan (CHAdeMO, Chaoji, J1772)

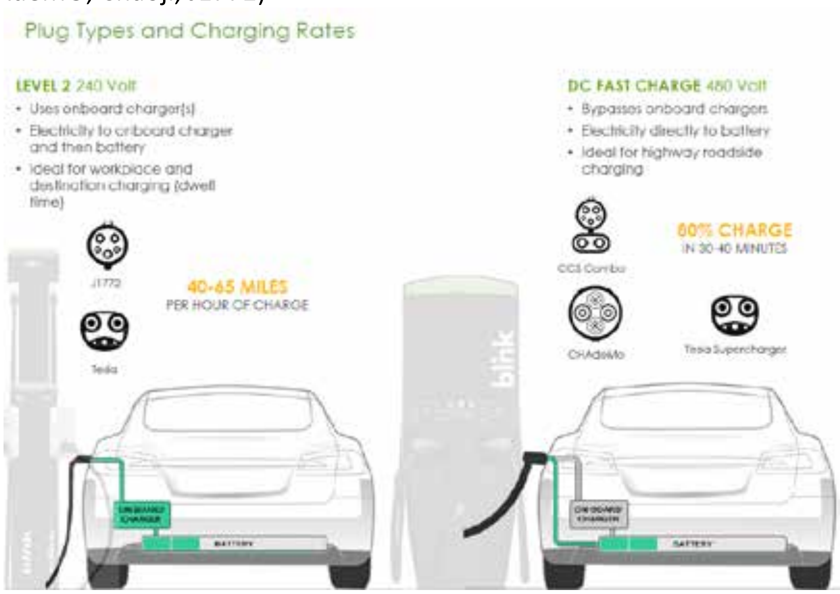


Figure D – Electric Vehicle Plug Types and Charging Rates for Level 2 & 3 Chargers

The installation of an individual charging station would involve a 3-phase process involving Site Planning, Installation and Activation by service providers, GPA and manufacturers (e.g., Blink) as displayed in the following example.

Some common Installation considerations and criteria to anticipate for EV chargers include:

- Power available –Amperage output always 80% of input*
- Power source proximity –Less distance = less cost
- Trenching –Can it be avoided? Grass vs. asphalt?
- Conduit size –Set up for future expansion?

- Mounting options –Wall mount? Pedestal? Pole?
- Cellular / Wi-Fi access –Is there Signal? Is a booster needed?
- Permitting –Check local requirements
- ADA (Americans with Disabilities Act) –Check local requirements
- Protective equipment –Check local requirements
- Local Load Management –Link up to 20 chargers to one circuit
- Flexibility of amperage input –15 to 100 input amps
- Modular units with mounting flexibility –Pedestal, wall or pole mounts with available cable management systems.
- Deployment configurations –Single units, dual units, or multiple kiosk controlled chargers.
- Geographically separated secondary backup systems

For the GPA service territory there are planned and potential charging stations that include:
Planned

- GPA / GWA Main Office (Mangilao) - Solar Pavilion with Charging Station(s)

Potential (Listed by Priority)

- University of Guam in cooperation with the EV Lease Program)
- Chamorro Village
- NAVFAC Base
- Anderson Airforce Base
- Commercial Accounts
- Residential Accounts

The vision of GPA is to have a close working and commercial arrangement with their customers in the deployment, operations and maintenance of EV charging stations in Guam. The deployment sequence and expansion of EVs could have potential impact to grid operations introduced by harmonics affecting power quality on the island. The harmonic effect will be analyzed with GPA Grid Operations and Engineering. The Design & Engineering for Charging Stations for will be accomplished a close partnership between GPA, manufacturers and On-Island Contractor Services. Specific GPA specifications will be defined for:

- Qualified / Certified Distributors for Charging Stations
- Level 1, 2 & 3 charging station installation
- Network connectivity via WAN / Fiber for billing and diagnostics back to GPA
- Supporting Physical Security protection (e.g., cameras, alarms and sensors)

On-going Operations & Maintenance for Charging Stations will mature with in-house services or partnering for On-Island Managed Services which will involve:

- GPA Specifications (Commercial and/or Passenger type vehicles):
- Condition and Preventative Inspections
- Corrective / Break – Fix Services for the Charging Stations
- Diagnostics for predictive maintenance (e.g., adapters, cables, etc.)

3) Program / Policy / Rules

The definition of Charging Station Rate Structures as defined in the DSM Refresh Project will contribute to the revenue and cost benefit analysis for the EV Program. Each level of charger type is defining an appropriate customer billing rate. A Level 1 Charger for residential use will probably utilize TOU rate in which a meter will be installed to supporting charging and with the potential of a first year of operations of free electricity as a rebate incentive. Level 2 and Level 3 charging rates are defined based on demand and the amount of convenience in the charging time. Table A provides the initial charging rate structure with a recommended kWh rate of $ 0.48 along with the economic analysis for a charging station over a 10-year life.

Load Factor	Hourly Energy	Hourly Capital	Admin Charge	Taxes and Processing	Hourly Rate	kWh Rate
5%	$ 4.15	$ 8.59	$ 1.27	$ 1.82	$ 15.82	$ 1.44
10%	$ 3.22	$ 4.29	$ 0.80	$ 1.15	**$ 9.47**	$ 0.86
15%	$ 2.91	$ 2.86	$ 0.65	$ 0.93	**$ 7.35**	$ 0.67
20%	$ 2.75	$ 2.15	$ 0.57	$ 0.82	**$ 6.29**	$ 0.57
25%	$ 2.66	$ 1.72	$ 0.53	$ 0.76	**$ 5.66**	$ 0.51
30%	**$ 2.60**	**$ 1.43**	**$ 0.50**	**$ 0.71**	**$ 5.24**	$ 0.48
35%	$ 2.55	$ 1.23	$ 0.47	$ 0.68	**$ 4.93**	$ 0.45
40%	$ 2.52	$ 1.07	$ 0.46	$ 0.66	**$ 4.71**	$ 0.43
45%	$ 2.49	$ 0.95	$ 0.45	$ 0.64	**$ 4.53**	$ 0.41
50%	$ 2.47	$ 0.86	$ 0.43	$ 0.62	$ 4.39	$ 0.40
Recommended					**$ 5.24**	**$ 0.48**

Station Costs Assumptions

Site Costs	
Station Cost	$ 13,000
Life	10
Depreciation	$ 1,300
Maintenance	1,300
Facilities Charge	759
Return	403
Annual Costs	**$ 3,762**

Table A - Proposed Electric Vehicle Charging Rates (9/15/21 Forecast for DSM Refresh)

In working with GPA customers, it is important to understand the comparison of electric versus gasoline powered vehicles in which Table 2 provides an analysis of equivalent gallon of gasoline and cost values.

Battery Charging Efficiency		**90.0%**
Miles per Gallon		30
Electric Equvalent Factor		1.00
Average kWh per Mile at 30 mpg		0.25
Adjusted MPG equivalent		0.25
Average		
kWh per hour		9.9
kWh/Mile		0.250
Miles per hour of Charge		**39.6**
Equivalent Gallons of Charge		1.32
Price per Gallon	**$**	**4.40**
Gasoline Cost Equivalent	**$**	**5.81**

Table B - Proposed Electric Vehicle Charging Rates (9/15/21 Forecast for DSM Refresh)

The pending market analysis will be also investigating rebates for home residential or business commercial installations with incentives for based on GPA specifications and grid operations time of use (TOU) scheduling.

Existing work by the Strategic Planning and Operations Research Division (SPORD) and the Planning & Regulatory Divisions within GPA are also investigating and securing grants with the Dept. of Energy (DOE), the Dept. of Interior (DOI)/OIA and Environmental Protection Agency (EPA) through their Diesel Emissions Reduction Act (DERA) for projects like the ePTO conversion for fleet trucks.

As the market is finalized it will dictate further requirements for the EV supporting infrastructure that will drive the definition of policies and Customer Agreements developed in cooperation with GPA Legal for Residential and Commercial Customers. The policies will also be supported and leveraged by existing GPA technology investments for:

- Customer Account / Billing
- Credit Card Payment Services
- Oracle CCS Module & Integration / Third-Party Integration
- Landis+Gyr Metering integration
- Customer Information Services through Oracle CCS Module & Integration

Organizational Responsibilities

GPA organizational responsibilities are planned to mature based on program growth which will transfer from Engineering & Technical Services – SPORD to Engineering and then to Distribution Operations. Figure B provides high level expectations that would encompass the following GPA organizational roles during its project lifecycle.

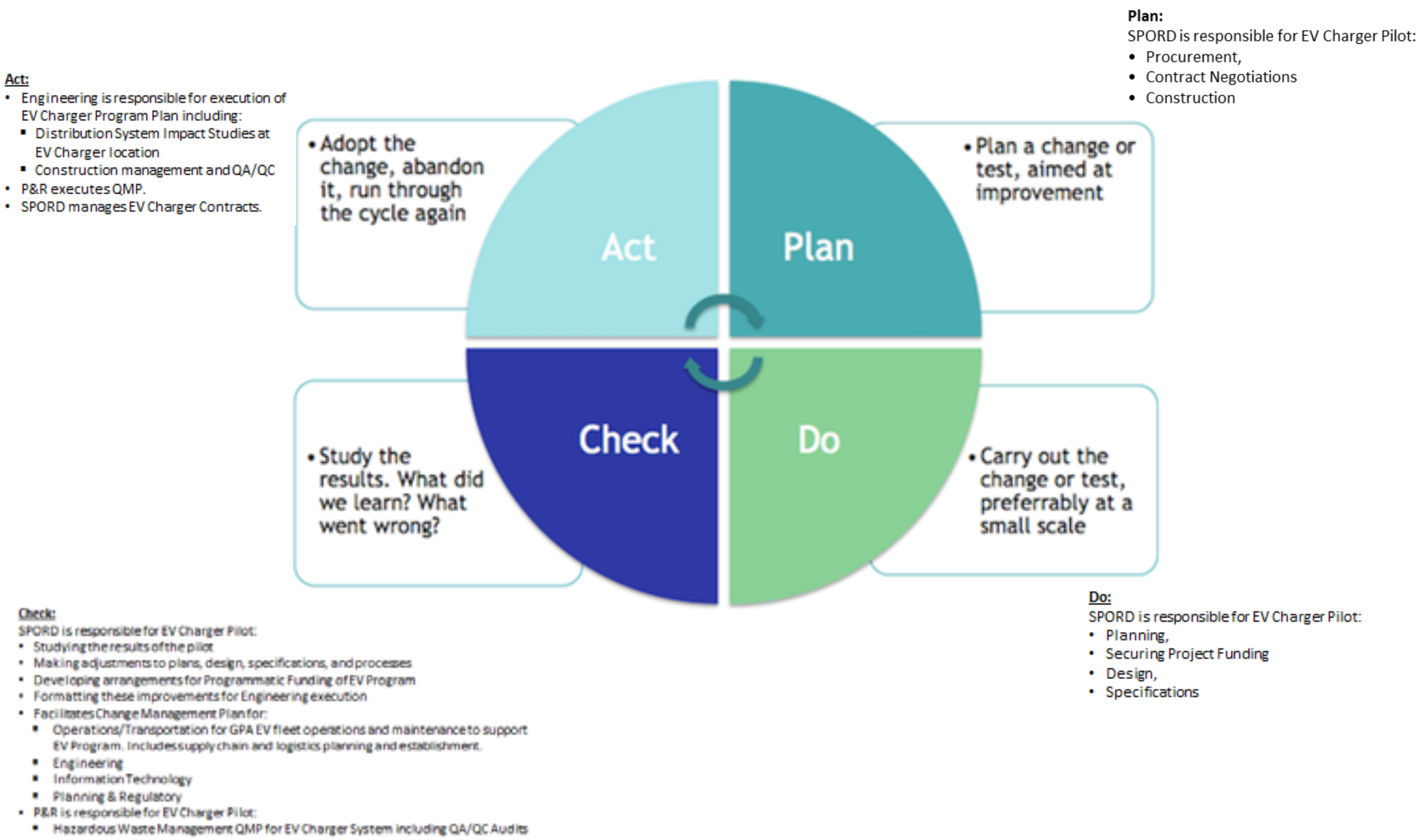


Figure B – PDCA Logic for GPA

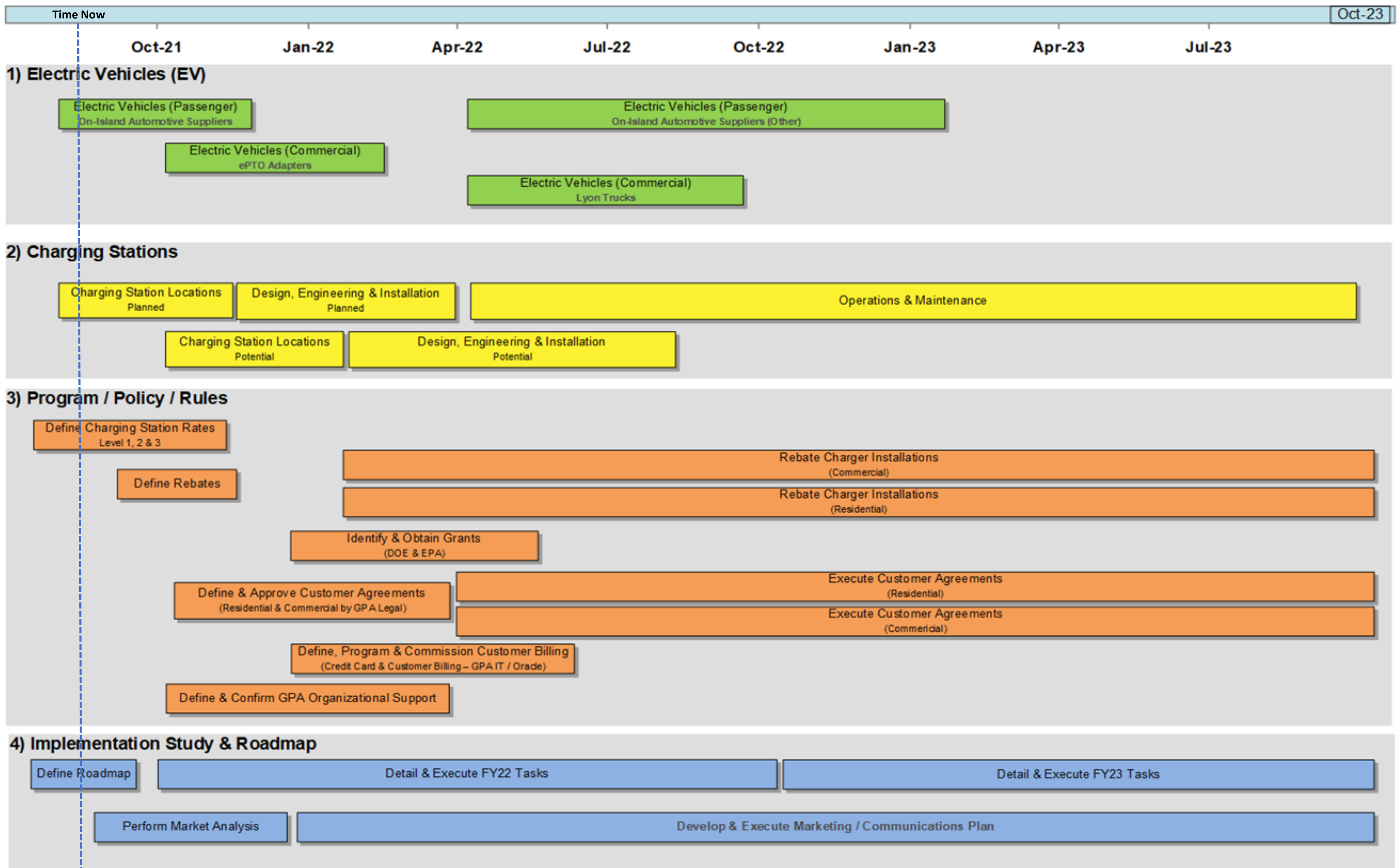
The timing of organizational change will be defined based on input from the marketing analysis and the EV Program business plan.

4) Implementation Study & Roadmap

The execution of a Market Analysis (GPA Procurement in progress for 3rd party study under SPORD) will analyze automotive suppliers, market size for Guam and anticipated adoption rate by residential and commercial customers. Barriers for success will include automotive dealer acceptance and commitment. Use cases for Single Family, Multi-family and Commercial will be analyzed within the market analysis to dictate requirements for the program and a supporting Marketing & Communications Plan (M&CP).   The M&CP will define a Marketing & Advertising strategy that involves Radio, Printed Material, Magazines, Newspapers (e.g., Guam Pacific Daily News), Brochures and updates to GPA Website (Energy Sense).   The definition of mobile applications will also be analyzed to engage customer based demographics within the service territory.   The MC&P results will also define Awareness & Education for Residential (Single Family / Multi-family) and Commercial Customers.

Develop & Execute Roadmap

Based on the EV Program work to date, the following presents a preliminary logic (Figure C) for tasks to be executed in FY22 and FY23. The roadmap will be refined with additional details as studies are completed that contribute requirements to the EV Program.



Perceptions on Electric Vehicles of Major Guam Dealerships

Survey Executed by

ADZTECH

Dealership Perceptions & Plans on Electric Vehicles Survey

- At the Time Sheffield completed the EV Roadmap Report, GPA tasked AdzTech to execute a survey of Dealership Perceptions & Plans on Electric Vehicles.

- GPA and AdzTech developed the survey questions.

- AdzTech solicited the following Dealerships to respond to the survey:
  - AK
  - CarsPlus
  - Nissan
  - Triple J
  - Prestige
  - AutoSpot

- All but AutoSpot responded

Gauging Dealership Interest in EV Sales

Question	AK	CarsPlus	Nissan	Triple J	Prestige
Is your company/dealership interested in selling Electric Vehicles?	Yes	Yes we already do	Yes we already do	Yes	Yes
When do you anticipate the start of selling Electric Vehicles?	January-22	early 2020	2013	Q1 2022	2023
When did you start selling EVs?	Chevrolet Bolt EV and EUV by January 2022; BMW i4 ad iX by January 2023.	2020	2013	Will Not Begin Until Q1 2022	N/A
Types of vehicles sold: make and model?	Chevrolet Bolt EV and EUV by January 2022; BMW i4 ad iX by January 2023.	Hyundai Kona EV	Nissan Leaf Hatchback	To Be Determined	N/A
How many of each model have you sold?	We anticipate 2 units per year as a start	25 units	32	N/A	N/A
What makes and models would you sell?	Chevrolet Bolt EV and BMW i4 and iX.	Hyundai Kona EV	Currently the Leaf Hatchback with 220 mile range and soon an SUV called the Ariya with over 300 miles range	Ford, Kia, Volvo, Honda (Tbd) And Commercial Vehicles	Subaru Solterra SUV
When will your EV Models be available on the island?	Chevrolet Bolt EV and EUV by January 2022; BMW i4 and iX by January	Currently on island since early 2020	Leaf available now and Ariya sometime in the 1st quarter of 2022.	Q1 2022	Estimated by 2023
Is there an option to Special Order?	Yes.	Yes	Always	Yes there will be	Yes
Would a government tax break or subsidy incentivize your company?	A government tax break or subsidy will incentivize dealers and consumers	There is currently a tax break for EV purchases: a $7500 federal tax credit and $3000 local Guam Energy Office incentive.	Absolutely	Yes	Absolutely

Who is Out or In with EVs

If your company is not interested in selling Electric Vehicles:					
Question	AK	CarsPlus	Nissan	Triple J	Prestige
What is the reason for not selling EV?	We are interested in selling all EV including BEV, HEV, and PHEV models.	Already sell Evs	Already sell Evs	Will sell Evs	Will sell Evs

EV Charging

Question	AK	CarsPlus	Nissan	Triple J	Prestige
What types of charger levels (level 1, level 2, level 3 (DC fast/rapid/ chargers or Tesla Superchargers)) have been included with the vehicles?	We will follow our OEM brand partners specifications	Level 1 chargers come with the vehicle. We currently sell Level 2 chargers.	All vehicles include a Level I charger. The previous model Leaf (before 2018) required a wall mount 240v charger (Level II) to be installed at homeowner's residence at their expense. The new model now comes with a EVSE Charge Cord that can only be used at a residence that supplies a consistent 220+ volts, single pole line. Most condominiums, townhouses or commercial locations use a 3-phase system that only produces 208 volts and requires a wall charger to be installed at the residence. Unfortunately, not all condominiums/townhouses have a place to install the Level II wall chargers. And if you're a renter, it's extremely difficult to get the association to allow them to install a wall mount Level II charger. We installed a Level III charger at our store in 2013 offered to our customers in cases of emergency.	Level 1 & 2 (Typically The Vehicles Come With Level 1 Chargers).	N/A
What charger connector standard is used (SAE J1772, CHAdeMO, Combined Charging System (CCS), Tesla Supercharger)?	We will follow our OEM brand partners specifications		The Leaf uses a CHAdeMO connector. However, the Ariya will use the CCS1 connector	Sae J1772	N/A
Will the dealership host an EV charger?	Yes, for both our customers and for our service departments	Yes, in the future	We installed a Level III charger at our store in 2013 offered to our customers in cases of emergency.	Yes, it plans to	Yes
Type of charging infrastructure do you anticipate may be needed to accelerate EV adoption?	Public charging stations at high traffic areas e.g., shopping malls, banks, and hotels	Covered parking area for fast charge Level 3 systems	This is a loaded question. Actually, the beauty of this island is it's geography. It's 31 miles long and 8 miles wide. Most drivers wouldn't need to recharge their vehicle more than 2 or 3 times a week unless they're a pizza hut delivery driver. And they would be able to charge their vehicle at home while they're sleeping. In the states, they have off peak hours in the evenings where the kWh rate is a little lower than the daytime peak demand. That's when most people charge their vehicles. However, the question is, how much demand would there be from customers who do not have access to a charger at their residence. This requires a deeper conversation than what could be supplied here, but definitely access points around the island would be needed to accommodate the growing penetration of electric vehicles.	High traffic areas such as restaurants, Malls, Government Agencies, Schools & Universities	adequate location charge station either private or government operates.

Dealer Perceptions on Partnering up with GPA

Question	AK	CarsPlus	Nissan	Triple J	Prestige
Are you receptive to partnering with GPA and other dealerships to build out public knowledge and outreach on electric vehicle charging stations?	Yes, depending on the costs?	Yes		Yes	Yes. will consider
Will you consider charging incentive rates?	No. Complimentary for customers	Yes	I don't understand the question	Yes. If The Dealership Also Gets Incentive	No
Would your company dedicate part of your advertising budget to promote?	Absolutely	Yes	To promote what, specifically? We already promote the product	Yes It will	
Would your company commit to a public-private partnership and cross-promote EV sales?	Yes.	Yes	You would have to give us more detail on the specifics	Yes	
Are you receptive to GPA controlling and managing EV charging?	Yes. However, it should not be exclusive since private sector companies could make it cost competitive		If you are talking about GPA assuming all costs for infrastructure and charging for the use of their charging stations, that could be considered. It would have to be practical for the end user	Yes, If Required	

Dealership EV Marketing

Question	AK	CarsPlus	Nissan	Triple J	Prestige
Does your Marketing Plan include Electric Vehicles?	Not at this time. But it will be included at the time of launch	Yes		N/A But, once we have EV's on Inventory; we will include this as part of our Overall Marketing Plan	Not at this time
Which Advantages of Plug-In Vehicles (PEV) are you including in your EV Marketing Plan?	See below	Yes	Yes	Yes	
Lower operating cost	Yes, including maintenance and fuel.	Yes		Yes	
Smoother operation	Yes, quiet cabin interior	Yes		Yes	
Better acceleration	Yes, no lag time in acceleration	Yes	Yes	Yes	
Ability to fuel up at home	Yes, if charging stations are installed at home	Yes	Yes	Yes	

GPA's Role for Incentivizing EVs

Question	AK	CarsPlus	Nissan	Triple J	Prestige
What do you think GPA should do to accelerate adoption of electric vehicles?					Communicate EV benefit to the consumers & incentives by Government for EV purchase, GPA rates incentives
Deploy publicly available charging infrastructure	Yes	Yes	Yes	Yes	
Educate employees, customers, and auto dealers	Yes	Yes	Yes	Yes	
Electrify its own fleet and report its experience to the public	Yes. Other GovGuam fleets could follow GPA's example	Yes	Yes	Yes	
Evaluate charging rate design and payment options	Yes	Yes	Yes	Yes	
Pilot vehicle-to-grid (V2G) integration technologies	Yes, the public needs to understand how this works and the cost of entry	Yes	Yes	Yes	
Provide incentives	Yes	Yes	Yes	Yes	
Project EV adoption and grid impact for the community	Yes	Yes	Yes	Yes	

Dealership Perception of EVs

Question	AK	CarsPlus	Nissan	Triple J	Prestige
How do you feel personally about EV?	Connected, Autonomous, Shared, and Electric (CASE) are the future of mobility.	We absolutely love electric vehicles and have personally seen the benefits of owning and driving one. You further your savings and sustainability by having solar panels on your home because when you charge your EV at home, you're utilizing energy from your solar panels. Win / Win.			

Dealer View of Customer Perception on EVs

Question	AK	CarsPlus	Nissan	Triple J	Prestige
How do your customers perceive Electric Vehicles?				We believe customers have many doubts and likely don't trust Electric Vehicles, and like any new technology, adoption is slow. Most customers simply do not think EVs can ever replace gas cars and just aren't ready to transition. There are the obvious reasons, such as upfront costs, lack of availability, and range anxiety. Over time, aith more electric vehicles available, increased charging infrastructure deployment, and reduced production and battery costs, the EV segment should begin to prosper.	power cost vs. gasoline cost, lack of Goverment incentives
Vehicle Cost?	High cost of entry to consider	While vehicles do cost more initially, this is more than made up through the savings in fuel and maintenance. EVs not only are gas-free, but they also do not require regular oil changes as traditional vehicles do.	When you consider the Federal Tax Credits and the local rebates, the Electric Leaf is a very affordable vehicle.	Yes	Yes. EV is higher price than gasoline models
Battery Charging time?	Unknown at this time	Level 1 œ5 miles per hour. Level 2 œ30 miles per hour.	Most models offer vehicles with varying ranges. We currently off the Leaf in two battery configurations. The 1st is a 40kWh battery that offers a range of up to 150 miles. The + model offers a 62kWh battery that offers a range of approximately 220 miles.	Yes	yes. limited information by car maker
Uncertainty of battery life?	Concern for replacement down time	The battery has a 10 year warranty	The warranty for the batteries are 8 years or 100,000 miles, whichever occurs first.	Yes	yes. unclear
Need for charging infrastructure?	How do I charge my vehicle if I live in an apartment?	EVs are suited for regular 110 outlets and 220 outlets with the level 2 charger therefore with Guam's size we really don't need charging infrastructures all over the island. Owners can charge up at home overnight and have battery life to last almost a week on Guam. Apartments and Condos will need to install chargers in their parking lot for their residences.	Electric Vehicles are the vehicles of the future. But it's still quite a ways off. Some of the smaller manufacturers are setting deadlines when they expect to build electric vehicles only. The larger manufacturers have set tentative deadlines, but most of them are a moving target. It all depends on the development of the batteries and how fast they can develop fast charging systems and increase the capacities. And then they have to consider how to dispose of them responsibly.	Yes	
Will GPA set a specific rate or tariff for EVs?	How much will it cost?		This would be a question for GPA.	Yes	
Tax savings incentives?	Need incentives to consider a BEV or ICE (internal combustion engine) drive train	Federal tax credit is $7500	As mentioned previously, there is still a Federal Tax Credit of $7,500 for the Nissan Leaf and as far as I know, the Guam Energy Commission is still offering a rebate of up to $3,000.00.	Yes	yes. no plans up to date

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2022 Integrated Resource Plan Volume IX:

Impacts of Customer Installed Solar and Batteries

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IMPACTS OF CUSTOMER INSTALLED SOLAR AND BATTERIES

Guam Power Authority - GPA

UFS UTILITY FINANCIAL SOLUTIONS, LLC

Mark Beauchamp, President
November 13, 2021

Table of Contents

Executive Summary

Purpose of Study

The main objective of this study is to review and recommend appropriate penetration levels of customer installed solar. Previous solar policy allowed for 1,000 customer solar installations, this number was exceeded in June of 2016 and an interim policy was subsequently approved in in 2017 limiting customer solar installations to 10% of the August 2017 peak of 261 mW or 26 mW, current solar installation is approximately 25.5 mW. In October, 2018 GPA filed a request to move to a Value of Solar tariff rate to replace the current Net Metering rider and establish an Energy Storage Rate. The PUC denied the request and directed GPA to complete a planned distribution system impact study to identify how distributed generation impacts the distribution system. The PUC directed GPA to complete an independent study to determine the cost of the grid and other services used by NEM customers and detail the value of those services to the NEM customers. The PUC directed GPA to establish a clear cost causation of NEM customers impacting grid reliability.

The purpose of this study is to address the specific requests of the PUC and a summary of the recommendations is listed below. The report of Landis and Gear reviewing the solar impacts on GPA distribution system was not completed at the time of this report. A summary of the recommendations included in this report is listed below.

1) Penetration of Solar Recommendation

For GPA, its current NEM installed solar represents approximately 10% of its system peak demand. However, in review of solar installations on each GPA substation feeder, the average feeders with rooftop solar has a minimum daytime feeder loading of 24.7%. Over half of the feeders with solar have greater than 50% penetration rates with several above 90%. From an operational perspective, loadings based on the minimum daytime loadings is a more accurate indicator of distribution feeder performance in terms of forced outages, voltage and frequency control. Numerous engineering studies discussed later in this report have found that penetration rates approaching 30% results in the operational benefits associated with distributed generation diminishing, and over 30% they, in fact, acerbate system reliability and outage management.

It is therefore recommended that solar penetration be allowed up to 30% of the minimum respective feeder daytime load. Otherwise, for new solar installations customers should be required to install "smart" inverters and adequate battery storage capacity.

This means that there should NOT be any additional solar added to overhalf of the existing GPA feeders without adequate battery installations.

2) Battery (Storage) Recommendation

This study shows a connection between solar intermittency (without batteries) with Under Frequency Load Shedding (UFLS) which can cause a variety of power quality issues and outage events. It is recommended that battery storage be added at NEM solar and / or at strategic feeder locations. In both scenarios these costs should be passed on to NEM customers that do not have properly sized and configured batteries. New solar should be required to add properly sized and configured storage.

When storage is configured to assist with frequency response or power quality, batteries complement the intermittency of the solar production and dynamically smooths delivered output to match the variable customer load. It is possible that higher penetrations of solar can be achieved once storage is properly integrated into the current feeders to support existing solar.

GPA should consider pre-qualifying customer to ensure the solar and batteries are correctly sized. Please see the supplemental section on "Right Sizing".

3) Value of Solar and LEAC Findings

There is a cost shift (subsidy) from non-NEM Customers to NEM Customers. Prior value of solar (VOS) study results as well as this updated study confirm these financial findings. Under the current GPA "full retail" value being given to NEM solar, there is a growing and large annual recurring financial under recovery to GPA. Solar customers should be credited at the utility's avoided cost value of solar (also detailed in this report). One of the main components used to identify the avoided cost value for GPA is the LEAC. GPA should consider modifying its current Levelized Energy Adjustment Costs (LEAC) from the current 6-month true up to a rolling 12 month average calculation to the proper LEAC is credited to solar customers.

4) Metering and Billing Recommendation

The most common change in the electric industry is the evolution away from NEM (traditional net metering at full retail credit) and crediting solar using either a net billing or a buy-all, sell-all metering and billing method. It is recommended GPA initially move to one of these two methodologies. Please see section on metering and billing.

5) Grandfathering Existing NEM customers

It is common practice to grandfather current NEM customers to limit or minimize customer financial impacts. The recommendations in this report should be applied only to new solar installations. Existing NEM customers should be grandfathered using GPA's current NEM policy for a period of 10 years. After that time the customers would move to the current GPA NEM tariff. As a result of this recommendation, the current solar subsidy of approximately $4.0 million per year would continue for the next 10 years.

GPA Customer Solar Installations

GPA current net energy metered customers exceed 2,100 with installed capacity as of June 2021 of 25.5 MW(ac). The table below shows the total NEM installs by rate class.

Current NEM Installs by Rate Class Installs and kW

Rate Class	NEM Installs	% Installs	NEM KW	% KW	Avg KW per Install
EGEND-J	62	3%	3,731	15%	60.2
ERES-R	1,995	93%	18,705	73%	9.4
EGEN-G	64	3%	1,596	6%	24.9
ESGSD-K	13	1%	475	2%	36.6
ELPS-P	9	0%	841	3%	93.4
ESGS-S	5	0%	45	0%	9.0
ELGS-L	2	0%	123	0%	61.4
Total	2,150	100%	25,517	100%	11.9

Current Utility Installed Solar

GPA currently has an estimated 30 MW(ac) solar installation. This is through a purchase power agreement (PPA) for the DANDAN facility. DANDAN and currently installed NEM solar represent 20% of the annual GPA peak load and produces 5% of GPA's total annual kWh energy requirements. There are two additional utility installed solar generation projects planned over the next few years. These two facilities KEPCO and HANWHA have an estimated capacity of 115 MW(ac). Once these units are operational the total utility owned solar generation would exceed 145 MW(ac), representing 50% of GPA's peak load and 12% of the annual energy requirements for GPA.

NEM Ownership

There are a number of NEM ownership[i] approaches. The most common for GPA are:

- Self – DER owned by customer
- Zero – DER owned by 3rd party with payment terms and rights negotiated between homeowner and 3rd party.

Sixty-four percent of the current NEM solar installs are 3rd party ownership and not directly owned by the homeowner. These customers are under contract with the 3rd party for a specified period of time.

The terms of the agreements can be of concern if they assume the customer will be credited at full retail value. If the utility moves away from net metering at full retail value, the customer could be locked into an agreement that no longer makes economic sense.

In addition, terms of 3rd party agreements may lead to utility impacts by creating community pressure to maintain current net metering rate structures. This may increase the strain on the utility distribution system and shift costs to non-NEM customers. The table below shows the 3rd party installs (Zero) represent 61% of the solar installation capacity.

NEM Ownership Installs and kW

	NEM Installs	% Installs	NEM KW	% KW	Avg KW per Install
CUST	714	33%	9,588	38%	13.4
UNKWN	61	3%	437	2%	7.2
ZERO	1,375	64%	15,492	61%	11.3
Total	2,150	100%	25,517	100%	11.9

The table below identifies the 3rd party owners located in Guam. The largest installer is MRE representing 79% of the 3rd party owner's solar capacity.

ZERO Installs and kW

ZERO	NEM Installs	% Installs	NEM KW	% KW	Avg KW per Install
ENABLE	72	5%	778	5%	10.8
MRE	1,071	78%	12,172	79%	11.4
MRE WITH BATTERY	3	0%	26	0%	8.5
O3	1	0%	100	1%	100.0
PRES	1	0%	6	0%	5.5
SUNSOLAR	227	17%	2,411	16%	10.6
Total	1,375	100%	15,492	100%	11.3

Power Quality and Frequency Response

Overview of Power Quality and Frequency Response

High penetrations of solar without battery storage can cause power quality and frequency response issues, or "under frequency load shedding" (UFLS) events. The purpose of Under Frequency Load Shedding (UFLS) is to balance generation and load when an event causes a significant drop in frequency such as solar production declining due to cloud cover. Under Frequency Load Shedding is a mechanism designed to protect the system from further damage or a widespread outage.

Solar is viewed as a generation resource at the distribution feeder level. This means that the utility is supplying less power to the feeder through dispatchable generation. When customers require energy and solar production declines the dispatchable generators cannot immediately vary production to make the difference. This causes the need for GPA to shed load to protect the system against larger outages. High penetration of solar relative to the minimum daytime feeder loading presents a problem because it has the highest chance of under frequency load shedding or power quality issues.

For example, if a minimum daytime feeder loading is 100 kW with a 90 kW solar array (representing 90% solar penetration relative to the minimum daytime feeder loading), the utility is supplying 10 kW through dispatchable generation. In the event of intermittent cloud coverage, the solar production will drop off, requiring the generator to fill the load gap. In many cases, the generator is not designed to ramp up quickly enough to fill the load gap. As a result, the system views an under frequency and will stop servicing the load often resulting in a brown-out or power outage.

The most common solution is to pair solar with appropriately sized and configured batteries (storage). In the event of intermittency, solar and batteries are viewed by the system as one resource. When the solar production drops off, the battery will instantaneously provide discharging power to fill the gap, avoiding an under frequency event.

GPA's Engineering Concerns of Higher Solar Penetration

GPA engineers have outlined concerns related to the impacts of rising DER penetration at the distribution feeder level. These concerns include:

- **Loading** – GPA is monitoring net metering installations to ensure lines are not overloaded.
- **Voltage** – Feeders with higher solar penetration tend to increase peak voltage during the day, while nighttime voltage stays the same or decreases with load. As more net metering installations are installed, system voltage will require dynamic voltage control to maintain acceptable voltage levels.

- **Metering** – GPA meters installed at the substation feeders cannot handle the return kWh reads for excess customer solar generation.

- **Protection** – GPA is concerned that insufficient breaker protection exists to ensure proper line protection.

Utility engineers have observed that as the concentration of distributed residential and commercial rooftop solar systems increases, electric systems have begun to experience operational impacts that have affected the performance of its generation, transmission, and distribution systems at the expense of system reliability.

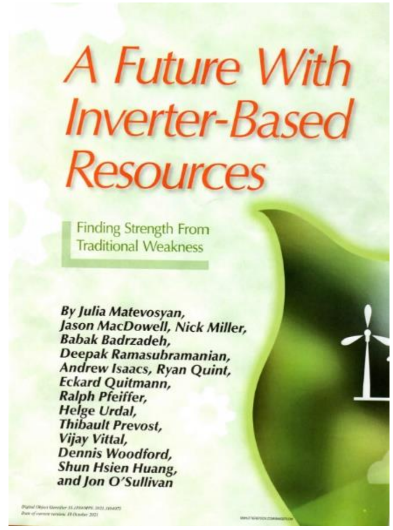
The following represent the range of impacts that distributed solar systems have been observed to have on electric systems. At low levels of solar penetration these impacts tend to be negligible; however, as that rate rises the number of, and their impact become both observable and can diminish system efficiency and reliability.

Range of Voltage Levels	Harmonic Distortions	Flicker Severity	Voltage Imbalance
• Over Voltage: Injection into utility distribution feeder during low load conditions • Under Voltage: Low or no solar electric production during high load conditions	• Causing Heating of equipment • Overloading Neutral Line • Errant tripping of circuit breaker	• Voltage fluctuations due to variant cloud cover	• Large differences in voltage levels among a three-phase circuit serving single phase feeders

<u>Reports on Articles on VRE Penetration</u>

The level of R&C Rooftop Solar penetration clearly affects utility operations. Since 2015 over 3,000 IEEE papers reported on these impacts. Since 2018, the number of annual studies increased from 300 to 600 coinciding with rising penetration rates. The higher the penetration, the more prevalent and pervasive the impact on both feeder specific and system wide performance.

High penetrations of solar without battery storage can cause power quality and frequency response issues, or "under frequency load shedding" (UFLS) events. The purpose of Under Frequency Load Shedding (UFLS) is to balance generation and load when an event causes a significant drop in frequency such as solar production declining due to cloud cover. Under Frequency Load Shedding is a mechanism designed to protect the system from further damage or a widespread outage.



IEEE Power & Energy magazine, Volume 19, Number 6, November/December 2021 is dedicated to addressing "The Future Balancing Act – High VRE Penetration and Energy System Integration". One article, A Future with Inverter-Based Resources, addresses a number of small island issues.

Below are excepts from this paper that address the impacts of high IBR penetration on "small islands":

System Characteristics and Impacts of High IBR Penetration

The industry is currently learning from small and medium island systems with high penetrations of IBRs. These networks present their challenges but also serve to inform design decisions for large systems that represent most of the world's power consumption. The following sections discuss four types of systems with high ***IBR*** *penetration, where stability issues manifest themselves differently depending on specific characteristics. A summary of stability risks for six power systems illustrative of different characteristics is provided in Table 1.*

Small Islands

Some small, permanently islanded systems (up to about 1 GW), such as Hawaii, are rapidly approaching 100% IBR penetration levels. Detailed electromagnetic transient (EMT) studies are reinforcing predictions of island-wide instability with the high penetration of GFL IBRs and are demonstrating the potential for GFM batteries, which may be "low-hanging fruit" compared to GFM wind and solar photovoltaics, to contribute to grid stabilization.

Since an islanded system needs to source all stability requirements by itself and cannot rely on neighboring grids for support, technical challenges related to stability include the following:

- ✓ *The frequency sensitivity due to lower inertia and the large size of a contingency relative to the system size can easily lead to inadvertent* ***GFL IBR*** *tripping. The same can happen due to voltage stability issues since older distributed IBRs are particularly sensitive to voltage events. At high penetrations, this can cause rapid changes in available generation, making frequency control difficult and preventing effective load* *shedding. Enforcing ride-through standards on distributed IBRs (for example, adopting the IEEE 1547-2018 standard) may help address these issues.*

- ✓ *Control-driven stability issues can widely propagate through a small island system, with devastating effects.*
- ✓ *Protection coordination and sufficient short circuit current may also be challenging unless addressed with modern protection technologies that are smarter than simple overcurrent protection.*

Recent work evaluating the potential benefit of GFM control in batteries is showing a strong stabilizing influence on frequency. However, there are pitfalls since the inverter response is entirely dictated by controls. There may be unexpected behaviors that can trigger interactions. The ability of GFM devices to respond effectively to disturbances and provide a stabilizing influence is limited by equipment capability and grid constraints.

Table 1

table 1. Stability risks in various power systems.

Frequency Stability Risks

Occasional	Acute	Chronic
• Under intact conditions, a system is relatively immune to fast and severe frequency events. • Challenges tend to be weighted toward congestion management.	• Frequency control concerns can limit operation. • Periods of poor frequency containment occur during credible events. • Control of frequency following possible or planned system splits is difficult.	• A system often has a risk of substantial frequency control problems and a high RoCoF.

Voltage and Angle Stability Risks

Local	Regional	Systemwide
• Electrical distances are limited. • Interface collapse and system separations are remote concerns. • Local voltage support issues are possible.	• Significant power imports and exports with dynamic constraints are an occasional factor. • Separation tends to be a high-impact, low-frequency event.	• A system has high power transfers across ac transmission interfaces, for which voltage instability and angular separation are a primary concern and often impose operating constraints.

Control Stability Risks

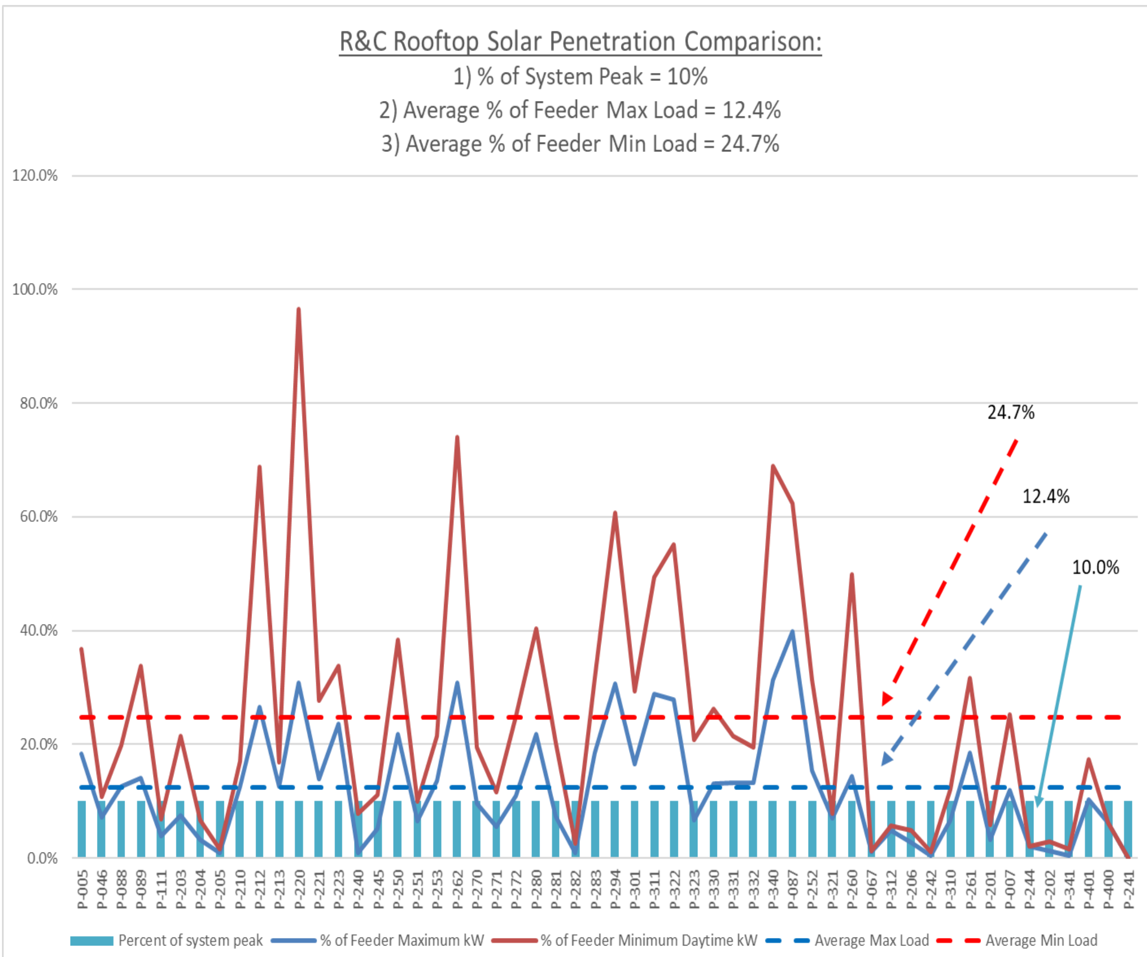
Local	Regional	Systemwide
• There are some locations (e.g., individual nodes and small areas) with low system strength and a risk of control interactions.	• There are entire regions of very high IBR penetration and little or no synchronous generation with ac transmission to other stronger areas.	• An entire system has extended periods of very low or even zero synchronous short circuit contribution.

CE: Central Europe; TX: Texas; GB: Great Britain; AU: Australia; IR: Ireland; HI: Hawaii.

GPA Feeders with Solar

GPA has 54 distribution feeders with one or more rooftop solar installations. The graph below compares the installed solar relative to the minimum daytime loading. Of these 54 feeders the average percent of solar output per feeder during low load conditions is 24.7%.

The red peak and valley line in the R&C Rooftop Solar Penetration Comparison shows the level of installed solar relative to the minimum daytime loading. For example, Feeder P-220 shows greater than 90% installed solar relative to the minimum daytime feeder loading.



When measuring solar penetration, Solar Capacity as a % of System Peak, while a standard benchmark for setting renewable portfolio standards, does not provide an accurate reflection of distributed solar impact on utility operations. A more appropriate measure is feeder specific solar capacity as a % of minimum feeder load. This latter ratio is used by distribution engineers to screen feeders for emerging reliability issues to proactively mitigate forced outages as well as over and under voltage conditions that can damage both utility equipment and consumer appliances.

As noted earlier on page 6, the higher the penetration, the more prevalent and pervasive the impact on both feeder specific and system wide performance. Since 2015 over 3,000 IEEE papers reported on these impacts. Since 2018, the number of annual studies increased from 300 to 600 coinciding with rising penetration rates. Based on a review of these engineering studies and feeder loading standards, between 15% - 30% of solar penetration at minimum loading, system disturbances began to occur and worsen as that percentage exceeds 30%. It is reiterated that GPA's average percent of feeder specific solar penetration averages 24.7% with many feeders over 30% solar penetration.

GPA Power Outages

The data in this section illustrates the connection between solar intermittency (without batteries) with Under Frequency Load Shedding (UFLS) which can cause a variety of power quality issues and outage events. In 2019, 67% of GPA outages were due to Under Frequency Load Shedding (UFLS) events and solar accounted for 149 events or 23% of the total UFLS generation outages.

Solar UFLS outages increase in frequency (of solar production) at the beginning of the day, mid-day and at the end of the day (hours ending 9, 11, 13 and 16) – When solar production is:

  - Ramping up for the day
  - At max daily production
  - Ramping down for the day

The highest number of outages caused by solar was during the month of March when solar is at the peak monthly production for the year.

- Preliminary (existing Net Metering) data suggests that UFLS events increase with:
  - Large single solar array installed on feeder (big install)
  - Large total solar kW installed on feeder from multiple installs (many small installs)
  - Feeder has high solar installations in relation to feeder maximum demand
  - Feeder has high solar installations in relation to feeder minimum daytime demand

GPA Outage Detail

GPA provided outages data log for calendar year 2019, the information tracked the type and number of outages. In 2019, GPA experienced 1,087 outages, (average of three outages per day) 67% of the outages were caused by Under Frequency Load Shedding events (UFLS). UFLS occurs due to a sudden drop in frequency when there is an in-balances between electricity generated and customers electric needs. These outages can occur due to events at the distribution level such as a sudden increase in electricity needed, at the transmission level and at the generation level when power supply occurs intermittently causing the in-balance between power supplied and power needed by customers.

The following table shows that 91% of the UFLS outages occurred due to generation.

UFLS by Root Level Type

Years	2019		
UFLS	TRUE		
RootLevelName	**UFLSInstigatorName**	**Count of UFLS**	**Count of UFLS2**
Distribution		11	2%
Generation		662	91%
Transmission		56	8%
Grand Total		**729**	**100%**

Of the 662 UFLS events at the generation level, NRG solar caused the largest number of UFLS events of 149 or 23%.

UFLS for Generation

Years	2019		
UFLS	TRUE		
RootLevelName	**UFLSInstigatorName**	**Count of UFLS**	**Count of UFLS2**
Generation		1	0%
	AGGREKO	24	4%
	Cabras 1	76	11%
	Cabras 2	45	7%
	Machche CT	46	7%
	NRG SOLAR	149	23%
	Piti 7 CT (TEM)	67	10%
	Piti 8 (MEC)	108	16%
	Piti 9 (MEC)	135	20%
	Yigo CT	11	2%
Generation Total		**662**	**100%**
Grand Total		**662**	**100%**

NRG outages most frequently occur during months with the highest solar production. Thirty Three percent (33%) of the UFLS events occurred during the month of March when solar production is highest. The tables below confirm the correlation between UFLS outages and solar production.

support1 – UFLS solar events by Month

TripMonthNumber	Count of DomainLevel2
1	9
2	9
3	49
4	22
5	16
6	12
7	12
8	16
10	4
Grand Total	**149**

**Months 9, 11, 12 had no solar events*

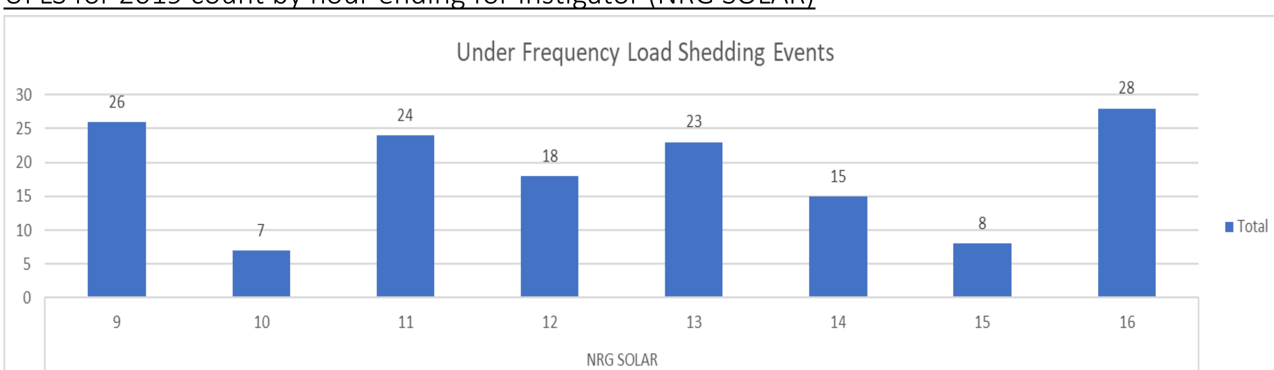
support2 – Solar production by Month

Dandan Solar Facility Monthly Production	
Month	Percent of Annual
Jan	7.7%
Feb	8.3%
Mar	10.0%
Apr	9.8%
May	9.1%
Jun	9.1%
Jul	8.9%
Aug	6.2%
Sep	7.6%
Oct	7.6%
Nov	7.7%
Dec	8.0%
	100.0%

The outages most frequently occur at the beginning of the day, mid-day and at the end of the day (hours ending 9, 11, 13 and 16) – When solar production is:

- Ramping up for the day
- At max daily production
- Ramping down for the day

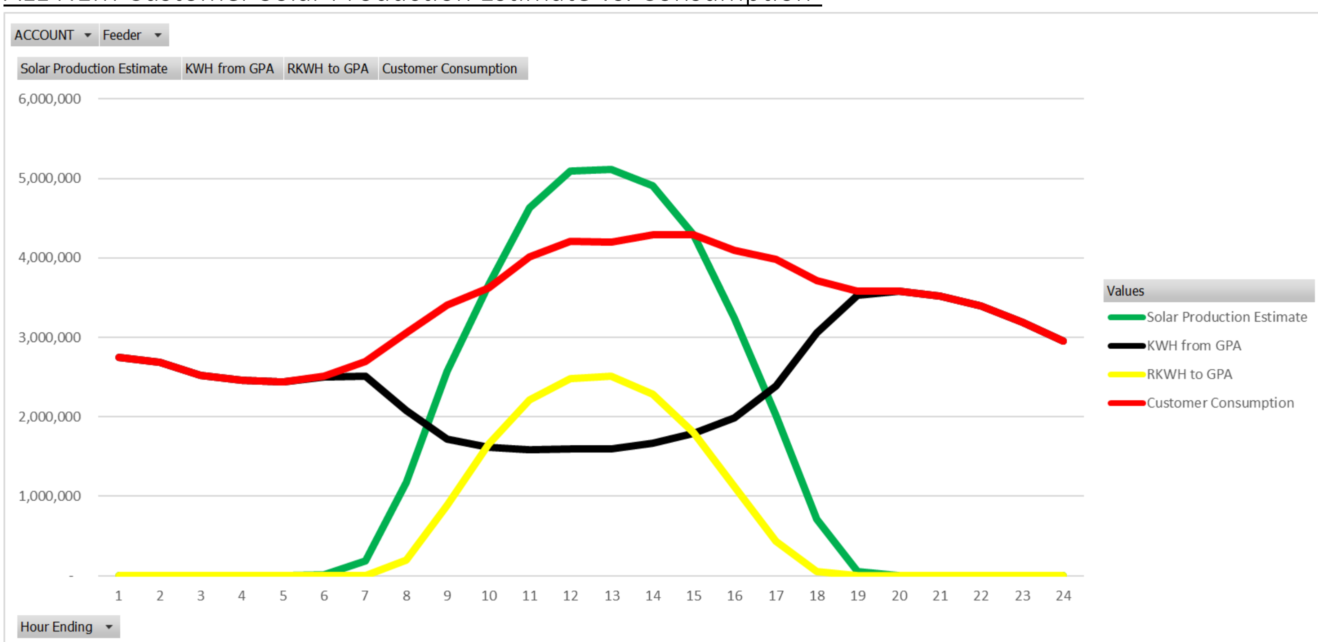
UFLS for 2019 count by hour ending for Instigator (NRG SOLAR)



A review of all of the feeders with solar was conducted to predict the NEM Customer solar production estimate vs. their consumption.

The following graph shows the NEM Customer solar production estimate vs. their consumption. The green curve estimates the average hourly production of all of the NEM Customer production. The red curve represents the calculated NEM Customer hourly total consumption. Since the NEM solar systems are not metered, the production and relative consumption had to be estimated using the NREL predicted solar production used in the value of solar sections of this study. You will see by having the green solar production curve peak higher than the calculated total NEM consumption, that NEM customers are likely producing more energy than they need during middle of the average day. This excess energy is hopefully able to be utilized by surrounding neighbors without solar. However, if this is not the case, it may be possible that GPA utility scale solar may need to be curtailed and / or stored in batteries. This will likely lead to the need for additional storage within the distribution system. It will likely be accomplished with a combination of NEM customer owned storage and strategically placed GPA owned storage. Both come at a cost and will need to be paid by the NEM customers over time to avoid subsidy pressure for non-NEM Customers.

ALL NEM Customer Solar Production Estimate vs. Consumption[ii]



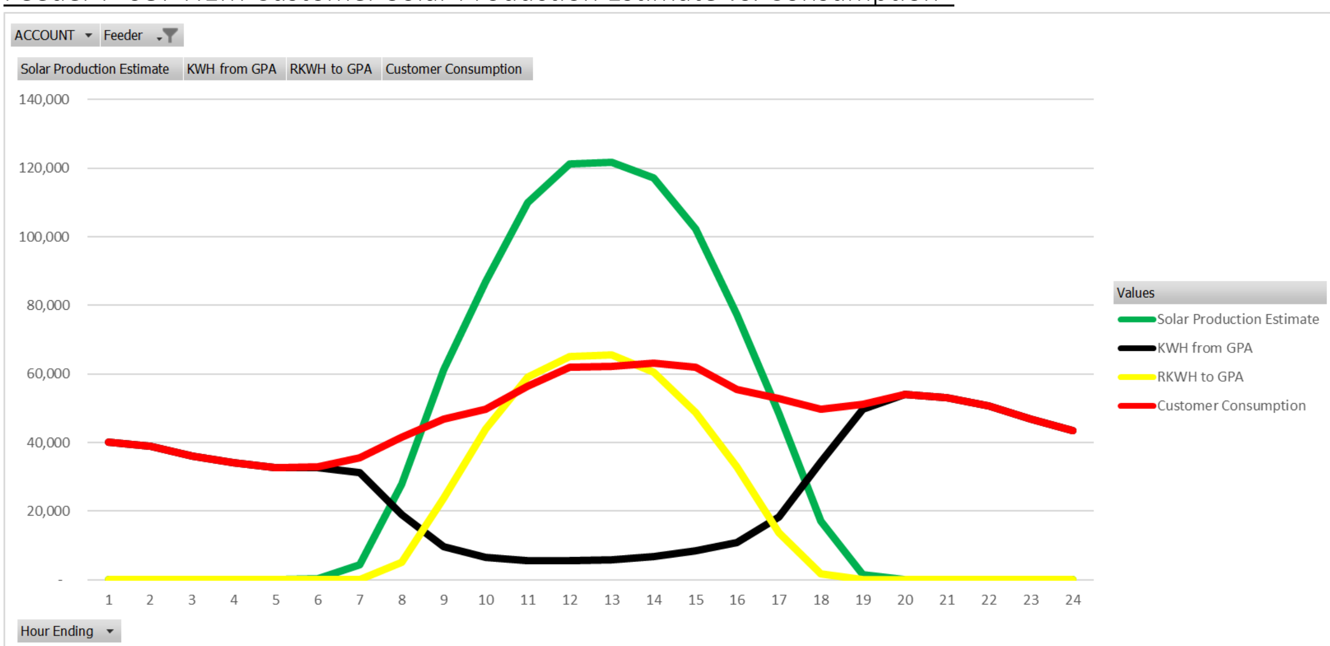
The next table data is a summary of specific feeders that were analyzed for NEM Customer solar production estimate vs. their consumption. The feeder data was summarized from the GPA maintained and provided Net Metering report[iii].

UFS also calculated the NEM Customer solar production estimate vs. their consumption for each of the following four identified feeders:

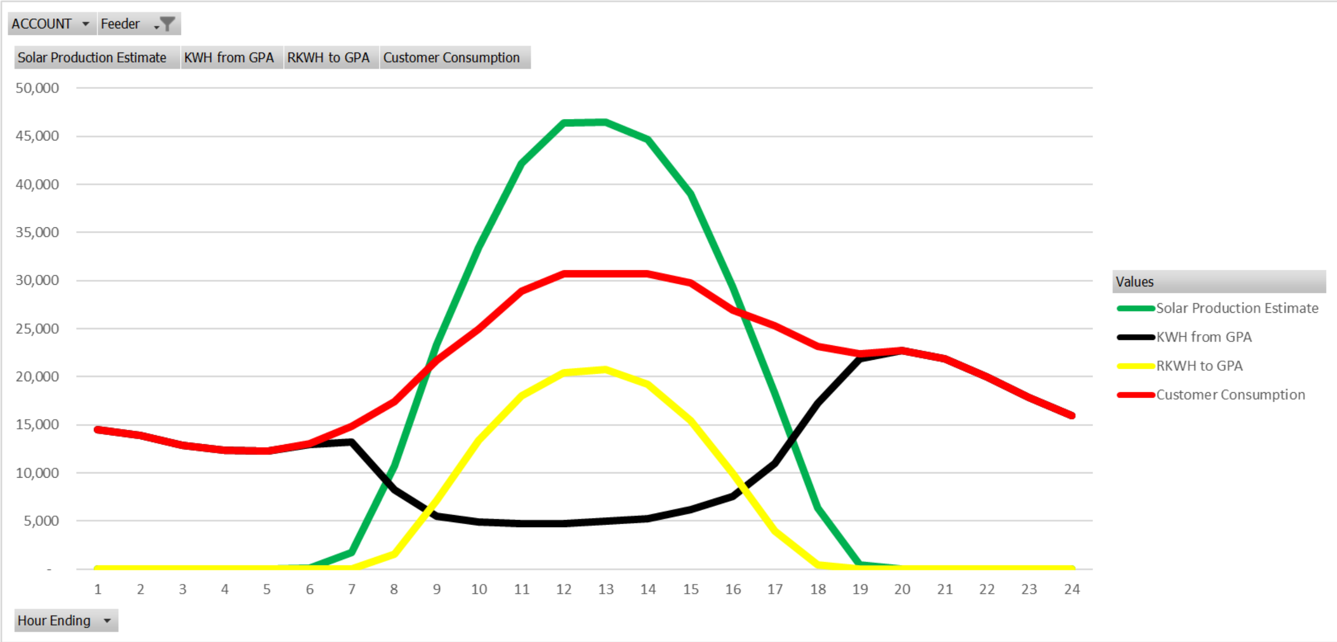
]Specific Feeders – Solar Production vs. Consumption

UFS Recommendations on Engineering Feeder Study	
Feeder	UFS Notes
P-087	Has larger array installed, has higher total solar
P-220	Has high total solar (small max feeder)
P-322	Has larger array installed, has highest penetration of solar total kW installed
P-401	Has highest average sized solar installed (multiple 100 kW?)

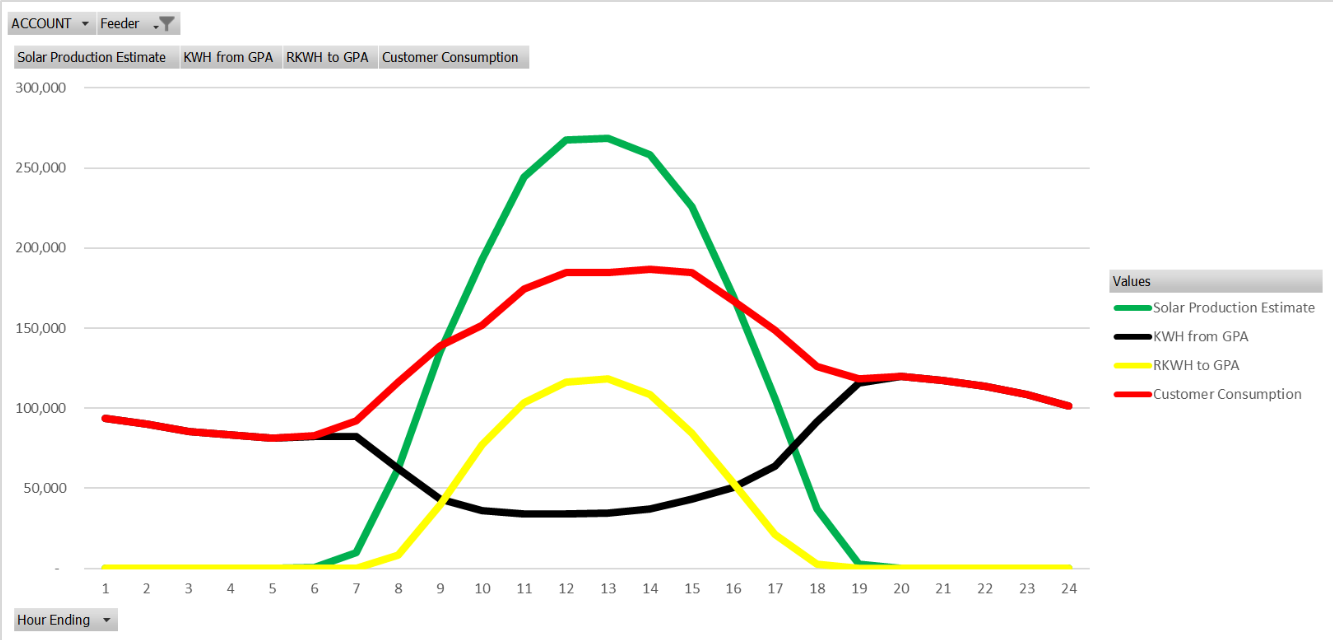
Feeder P-087 NEM Customer Solar Production Estimate vs. Consumption[iv]



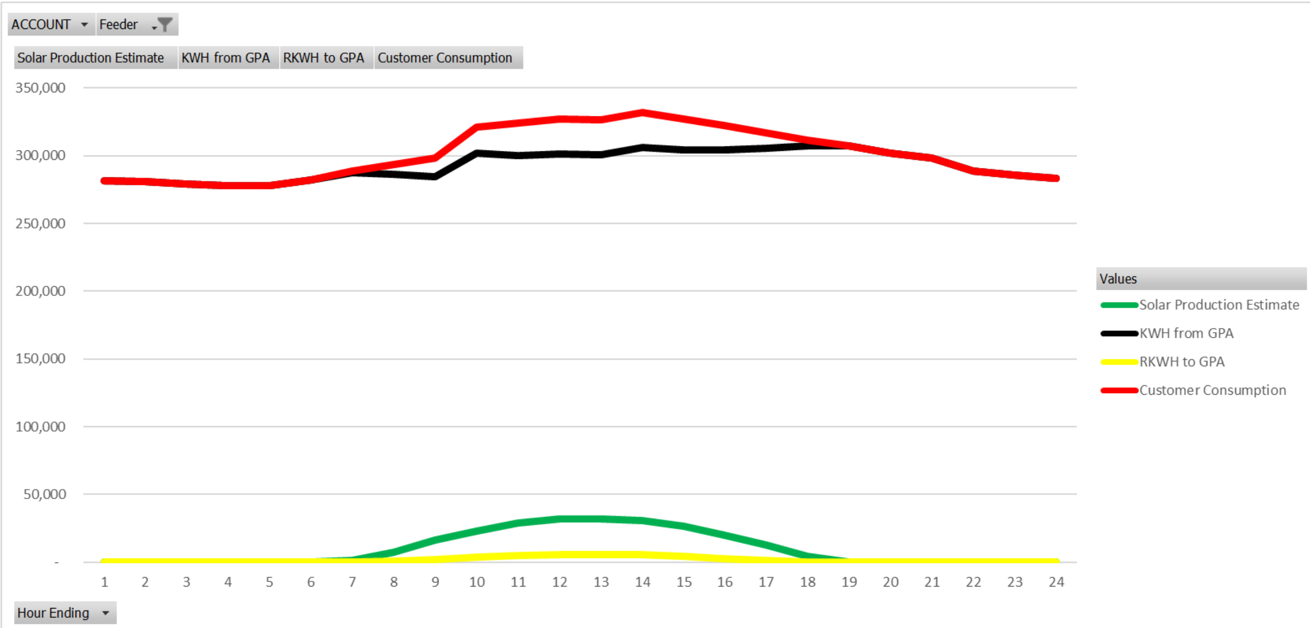
Feeder P-220 NEM Customer Solar Production Estimate vs. Consumption[v]



Feeder P-322 NEM Customer Solar Production Estimate vs. Consumption[vi]



Feeder P-401 NEM Customer Solar Production Estimate vs. Consumption[vii]



The data suggests:

- The feeder P-401 with fewer but larger solar arrays installed may potentially support more solar (big install)
- Large total solar kW installed on feeder from multiple installs (many small installs) may be vulnerable to UFLS events
- Feeder has high solar installations in relation to feeder maximum demand may be vulnerable to UFLS events
- Feeders with high solar installations in relation to feeder minimum daytime demand experience higher rates of UFLS events

Current solar install statistics for specific four feeders

Row Labels	Min of Size (kW)3	Average of Size (kW)3	Max of Size (kW)3	Sum of Size (kW)	Count of Size (kW)3	Sum of % of Maximum kW	Sum of % of Minimum Daytime kW
P-087	3	10	100	1,563	153	40%	62%
P-220	3	9	25	187	21	31%	97%
P-322	1	18	100	2,107	117	28%	55%
P-401	17	59	100	117	2	10%	17%

Feeders with Solar Outages

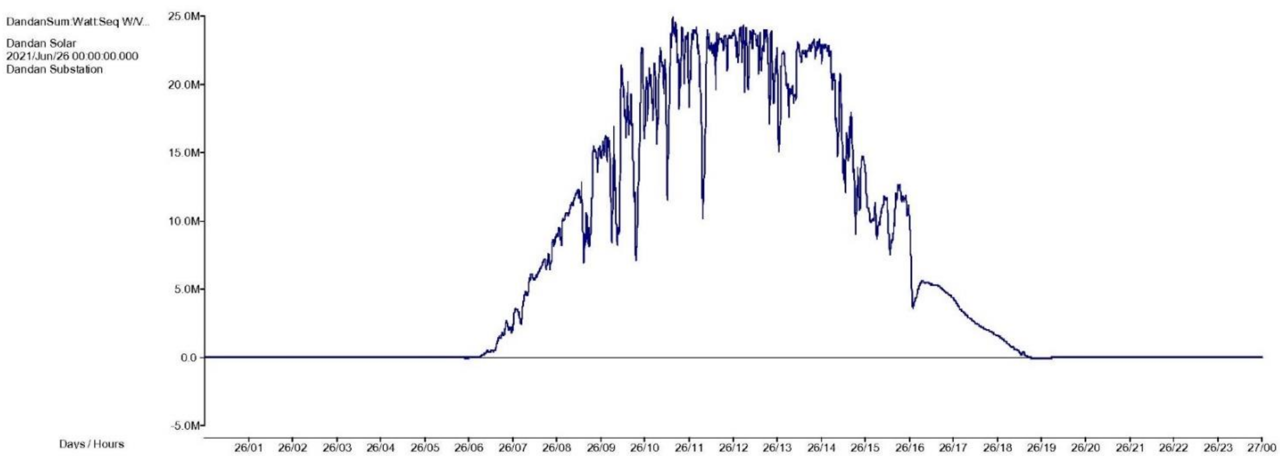
UFLSInstigatorName	Facility	Count of DomainLevel2
NRG SOLAR	P005	1
	P007	1
	P088	5
	P111	1
	P202	1
	P204	6
	P205	5
	P210	4
	P211	7
	P212	7
	P213	4
	P220	7
	P221	6
	P223	5
	P240	4
	P244	1
	P245	1
	P246	1
	P251	1
	P260	4
	P270	1
	P271	1
	P272	8
	P281	5
	P282	5
	P283	7
	P301	6
	P311	4
	P312	9
	P323	1
	P331	5
	P340	7
	P341	8
	P400	10
NRG SOLAR Total		**149**

Solar production is often depicted as a reliable and consistent production resource with production increasing consistently during the day and then decreasing in the early evening with no production during the night. The actual production on a daily basis or real-time basis varies substantially often due to cloud cover. The DANDAN charts[viii] below show two sample individual days of hourly production. The steep peaks and valleys show the variations in solar production occurring when the panels are obstructed from sunlight caused from variable clouds.

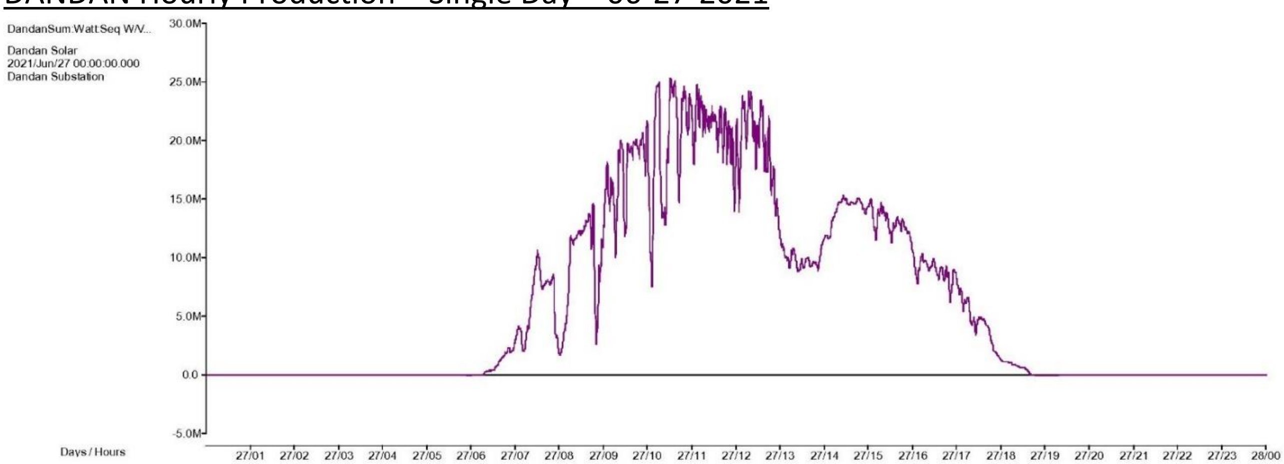
DANDAN has been recently remedied the variability of production with the installation of utility scale batteries downstream from the solar production. When storage is configured to assist with frequency response or power quality, batteries complement the intermittency of the solar production and dynamically smooths delivered output to match the variable customer load.

GPA has recently required battery installation for new solar installations. UFS is recommending this requirement remains in place and battery installations are appropriately sized and configured.

DANDAN Hourly Production – Single Day – 06-26-2021



DANDAN Hourly Production – Single Day – 06-27-2021



Value of Solar

The data in this section calculates the value of solar (VOS). The VOS is the recommended credit to pay NEM customers for their excess rkWh (customer energy returned to GPA).

The summary results are:

- Annual calculated dollar under recovery due to current installed solar is $3.9 million
- There were 2,150 customers with behind the meter solar at as of June 2020
- There is a total of 25.5 MW of installed solar
- The current value of solar (VOS) is calculated to be 12 cents per kWh (rounded to nearest penny)
- **The main cost driver in the VOS calculation is the LEAC. It is recommended that GPA implement and change to a 12 month rolling average LEAC. The LEAC value should change monthly based on the rolling 12 month average and also feed into the monthly VOS that is credited under a net billing approach.**

Assumptions used for this updated VOS:

- Fiscal year end 12/31/2021
- Annual compound degradation of 0.8 of one percent
- Value of LEAC of 11 cents per kWh
- Value of Distribution system loss $ per kWh of 1.178 cents
- Average kWh emissions of 0.0051 cents
- Assumed average annual solar production from NREL of 1,421 kWh per kW DC of installed solar
- Assumed typical NREL DC to AC ratio of 1.2
- NREL DC production * DC to AC ratio = 1,705 kWh average annual production per kW AC of installed solar – note GPA tracks NEM Customer install by kW AC

To calculate the annual subsidy:

- (Base Rate by Class + LEAC) – VOS = under recovery by class * Annual Solar Generation by class

To calculate the value of solar (VOS):

- VOS = LEAC + Distribution System Loss $ per kWh + Average kWh emissions

The following table shows the calculated annual under recovery by rate class. For example, the rate schedule ERES-R shows the largest annual dollar under recovery (subsidy). Each NEM customer production estimate is adjusted based on the age of their system by an annual degradation percentage.

Value of Solar: **Value of Solar under these assumptions and NEM stats is 12.1826 cents per rkWh**

Summary of NEM annual under recovery by rate schedule

Projection ending date: 12/31/2021									
Schedule	**Average of Base Rate**	**Average of LEAC**	**Average of Average kWh emissions**	**Average of Distribution System Loss $ per kWh**	**Average of VOS**	**Average of under recovery (subsidy) / kWh**	**Sum of Projected Annual kWh Generated**	**Sum of Estimated Annual Subsidy**	
EGEND-J	0.131121	0.110000	0.000051	0.011775707	0.121826	0.119295	6,195,093	$	739,042
EGEN-G	0.150836	0.110000	0.000051	0.011775707	0.121826	0.139010	2,656,238	$	369,243
ELGS-L	0.135248	0.110000	0.000051	0.011775707	0.121826	0.123422	204,265	$	25,211
ELPS-P	0.115389	0.110000	0.000051	0.011775707	0.121826	0.103563	1,400,812	$	145,072
ERES-R	0.092931	0.110000	0.000051	0.011775707	0.121826	0.081105	30,958,527	$	2,510,882
ESGSD-K	0.139322	0.110000	0.000051	0.011775707	0.121826	0.127496	777,952	$	99,186
ESGS-S	0.153341	0.110000	0.000051	0.011775707	0.121826	0.141515	74,650	$	10,564
Grand Total	**0.096310**	**0.110000**	**0.000051**	**0.011775707**	**0.121826**	**0.084484**	**42,267,537**	**$**	**3,899,199**

Metering and Billing Methods (all assumed to be right sized)

Many utilities are evolving their metering and billing methods. This allows the NEM customer to continue to be compensated for their solar and storage. This also allows the utility to minimize financial subsidies that may be shifted to non-NEM customers. There is also a shift in terminology away from the traditional "NEM" terminology to "DG" or "DER". "NEM" – net energy metered has implied that customers will be net metered and receive full retail credit for their excess rkWh (return kWh to grid). Recently, the more generic "DG" – distributed generation or "DER" – distributed energy resources terminology is being used. However, the most common change in the electric industry is the evolution away from NEM (traditional net metering at full retail credit) and evolve to crediting at the calculated value of solar under either:

Net Billing

- Only requires one, dual register revenue meter.
- All utility delivered kWh billed at retail, all utility received rkWh from customer excess credited at calculated value of solar as updated.
- Differing values are often credited for customer production based on having solar only or solar with batteries

Buy-All, Sell-All

- Requires two, dual register meters – one on customer premise, one on DER.
- All customer consumption billed at retail; all customer production credited at calculated value of solar as updated.
- Differing values are often credited for customer production based on having solar only or solar with batteries

Many utilities are also defining metering and billing methods based on the right sized install.

Category 1

Net Billing (right sized up to utility specified policy – example: 25 kW)

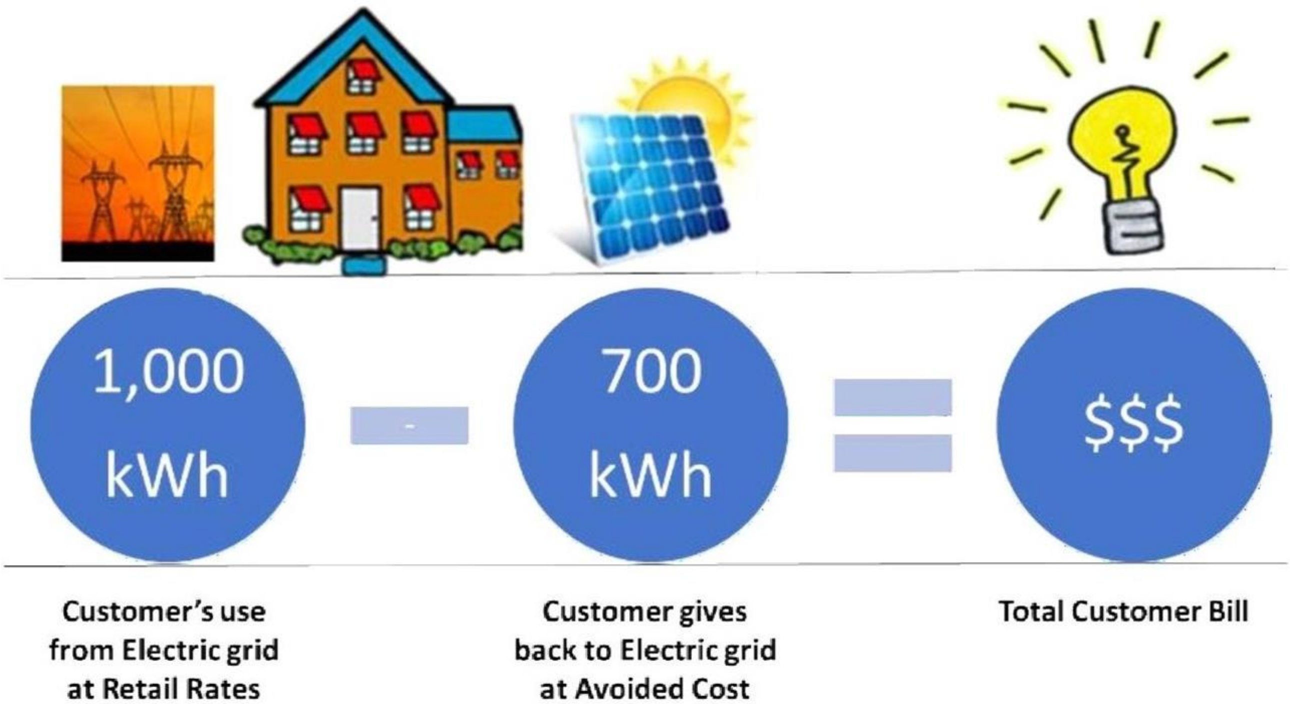
- Only requires one, dual register revenue meter.
- All utility delivered kWh at retail; all utility received from customer excess credited at calculated value.
- Storage required per utility spec. May consider grace period or exception for existing solar installs. Grandfathered customers may be compensated at the solar only credit rate if they do not have proper batteries.

Category 2

Buy-All, Sell-All (right sized up to utility specified policy - example: >25 up to 100 kW)

- Requires two, dual register meters – one on customer premise, one on DER.
- All consumption at retail, all production credited at calculated value.
- Storage required per utility spec. May consider grace period or exception for existing solar installs. Grandfathered customers may be compensated at the solar only credit rate if they do not have proper batteries.

Net Billing Graphical Example



Buy-All, Sell-All Graphical Example

The following is a sample of a utility bill for a residential net billing customer with solar and batteries. This utility also enforces a monthly minimum bill – the respective monthly customer or meter charge plus applicable taxes.

Net Billing Actual Bill Example – Solar with Battery

Sample Utility
Address Line One
City State, Zip

Utility Logo Here

Phone 999-999-9999
Fax 999-999-9999

Customer Name
Customer Address
City State, Zip

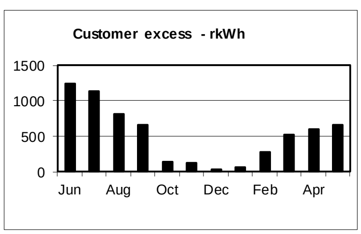
Customer Number: ####

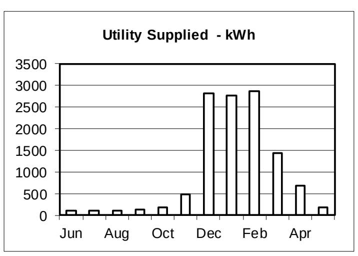
Billing Period From:	7/1/2021
Billing Period To:	7/31/2021
	31 Days
Statement Date:	8/1/2021
Date Due:	**9/1/2021**
Amount Due:	**$ 9.45**

Elec-110-Residential NET BILLING with MIN MONTHLY

	Meter:	Previous Reading	Current Reading	Meter Multiplier	Electric Supplied / Excess	Register Type
Utility Supplied kWh	18541291	15665	15837	1	172	kWh
Customer Excess rkWh	18541291	7337	8002	1	665	rkWh - SB

Energy Charge:
All kWh's @$0.1275 Summer
All kWh's @$0.1100 NonSummer
Customer excess energy credit:
Energy exported to grid by the customer-owned generator will be credited at the current avoided cost during the billing period. Monthly customer excess energy credit shall be forefitted in excess of the required Electric Customer Charge & taxes for a given billing period. In no case shall credits for excess energy be carried forward.
Current credits for rkWh:
Solar with battery = 5.47 cents / rkWh
Solar only = 2.195 cents / rkWh





Electric Usage (kWh):			
Utility Supplied (kWh)	172	0.12750	**$ 21.93**
Customer Excess Energy Credit			
Solar with Battery (rkWh - SB)	**665**	0.05470	**$ (36.38)**
Solar only (rkWh - S)	**0**	0.02195	**$ -**
Energy Charge:			**$ (14.45)**
Power Cost Adjustment:			
Electric Usage (kWh)	**172**		
PCA Rate	**$ 0.00854**		
SubTotal:			**$ 1.47**
Electric Customer Charge Monthly Minimum			**$ 9.00**
Total Before Taxes:			**$ 9.00**
State Utility Tax:			**$ 0.45**
Electric Penalty:			
Past due balances are subject to 1.5% penalty			
Total Current Charges:			**$ 9.45**
Previous Balance:			**$ 18.01**
Payment(s) Received:			**$ (18.01)**
Adjustments:			**$ -**
TOTAL AMOUNT DUE:			**$ 9.45**

The following is a sample of a utility bill for a residential net billing customer with solar only – no battery. This utility also enforces a monthly minimum bill – the respective monthly customer or meter charge plus applicable taxes.

Net Billing Actual Bill Example – Solar Only – No Battery

Sample Utility
Address Line One
City State, Zip

Utility Logo Here

Phone 999-999-9999
Fax 999-999-9999

Customer Name
Customer Address
City State, Zip

Customer Number: ####

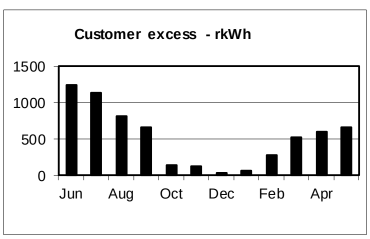
Billing Period From: 7/1/2021
Billing Period To: 7/31/2021
31 Days
Statement Date: 8/1/2021
Date Due: 9/1/2021

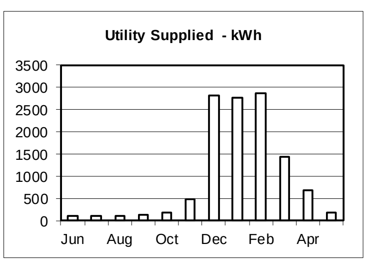
Amount Due: $ 18.35

Elec-110-Residential NET BILLING with MIN MONTHLY

	Meter:	Previous Reading	Current Reading	Meter Multiplier	Electric Supplied / Excess	Register Type
Utility Supplied kWh	18541291	15665	15837	1	172	kWh
Customer Excess rkWh	18541291	7337	8002	1	665	rkWh - S

Energy Charge:
All kWh's @$0.1275 Summer
All kWh's @$0.1100 NonSummer
Customer excess energy credit:
Energy exported to grid by the customer-owned generator will be credited at the current avoided cost during the billing period. Monthly customer excess energy credit shall be forefitted in excess of the required Electric Customer Charge & taxes for a given billing period. In no case shall credits for excess energy be carried forward.
Current credits for rkWh:
Solar with battery = 5.47 cents / rkWh
Solar only = 2.195 cents / rkWh





Electric Usage (kWh):			
Utility Supplied (kWh)	172	0.12750	**$ 21.93**
Customer Excess Energy Credit			
Solar with Battery (rkWh - SB)	0	0.05470	$ -
Solar only (rkWh - S)	665	0.02195	$ (14.60)
Energy Charge:			$ 7.33
Power Cost Adjustment:			
Electric Usage (kWh)	172		
PCA Rate	$ 0.00854		
SubTotal:			$ 1.47
Electric Customer Charge Monthly Minimum			$ 9.00
Total Before Taxes:			$ 17.80
State Utility Tax:			$ 0.55
Electric Penalty:			
Past due balances are subject to 1.5% penalty			
Total Current Charges:			$ 18.35
Previous Balance:			$ 18.01
Payment(s) Received:			$ (18.01)
Adjustments:			$ -
TOTAL AMOUNT DUE:			$ 18.35

The following is a sample of a utility bill for a "Large Power Service" buy-all, sell-all customer with solar only – no battery. This example customer has two revenue meters served by the utility. This example customer has three behind the meter solar arrays – individually metered. The retail kWh rate on all consumption shown on this bill is 5.73 cents per kWh. The value of solar credit on all production shown on this bill is 3.51 cents per kWh. The PCA (LEAC) on all consumption kWh shown on this bill is a negative 0.18 cents per kWh. The demand for total consumed demand shown on this bill is $13.77 per kW for the month.

Buy-all, Sell-all Actual Bill Example – Solar Only – No Battery

Utility Logo and Address

[redacted]

Customer Name
Account # [redacted]

Billing Date:	08/10/2021
Current Bill Due Date:	08/24/2021

Important Messages

WARNING: Service subject to disconnect if not paid seven (7) days after due date. Balance forward subject to immediate disconnect. If disconnected, service will not be reconnected until the entire outstanding balance on the account is paid. Reconnect fees must be paid prior to reconnect of service. Reconnect Fee $25, After Hours Reconnect Fee $50.

Total Amount Due

$224,263.93

Due Date: 08/24/2021

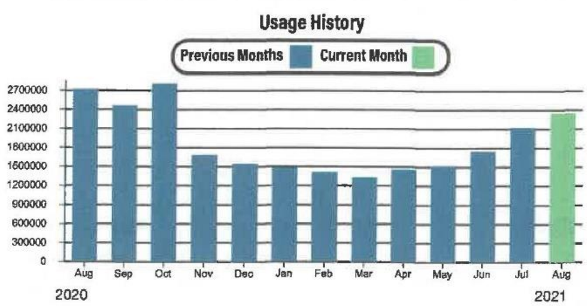
Previous Balance	$203,028.71
Payment Received	-$203,028.71
Balance Forward	$0.00
Current Charges	$224,263.93
Total Amount Due 08/24/2021	**$224,263.93**
Amount Due After 08/24/2021	**$235,624.69**

Disconnect Date 08/31/2021
Disconnect notices are no longer issued.

Service Address: [redacted]

All Reading Dates From / To @ From 7/1/2021 To 07/31/2021

Description	Meter No.	Reading Dates From	Reading Dates To	Readings Previous	Readings Present	Multiplier	kWh Usage
VAR-C Large Power Service	90290029	[redacted]		11356	11763	2800	1128204
VAR-C Large Power Service	90290030			12901	13315	2800	1159200
VAR-C LPS VALUE OF SOLAR	90290024			0	1138	40	45520
VAR-C LPS VALUE OF SOLAR	90290032			0	125	20	2500
VAR-C LPS VALUE OF SOLAR	90290036			0	457	20	9140



Current Service Detail

Balance Forward			$0.00
Usage Charge	2,344,564 KWH	@ 0.05730	$134,343.52
PCA	2,344,564 KWH	@ -0.00180	-$4,220.22
Solar Generation Credit	57,160 KWH	@ -0.03510	-$2,006.31
Demand Charge	6917.192 KW	@ 13.77000	$95,249.74
Customer Charge			$897.20
Total Electric Charges			**$224,263.93**
Total Current Charges			$224,263.93
Total Amount Due 08/24/2021			**$224,263.93**
If Paid After 08/24/2021			$235,624.69

Disconnect Date 08/31/2021

Right Sizing NEM Solar and Storage

Some utilities are considering "Right sizing" each NEM install. This allows the NEM customer to install up to their entire year of energy needs. This also allows the utility to minimize the excess solar being pushed to the grid in excess of the NEM customer power needs. The excess power is generally pushed back to the grid when the NEM customer energy needs does not align with the solar production timing. The storage right sizing is intended to compliment the solar install for frequency response or power quality during daylight hours. Remaining energy stored in the battery system could then be used as the NEM customer chooses after daylight hours.

- Pre-Qualify each customer before install
- Example allows up to "Net zero"
- Solar sizing fixed array vs. 1-axis tracking array

Solar Right Sizing Calculator Example

UFS Solar Right Sizing Calculator Example			
Confirm all areas in green below are correct to Utility policy			
To be filled in for right sizing prior to each install			
Right sized KW DC allowed up to and metering / billing method			
	100%	Up to % for annual kWh before solar	
	100%	Up to % for peak KW before solar	
	1.2	DC to AC Ratio	
		PVWATTS solar production per year per KW DC of solar adjusted for snow loss if applicable	
	Fixed	1,600	kWh
	1-Axis	1,850	kWh
	customer monthly kWh before solar	1,100	monthly kWh
	should equal customer annual kWh before solar	13,200	confirm customer annual kWh total correct from monthly average above
		Enter peak KW before solar to be filled in for specific customer requesting solar below	
	customer peak KW before solar	9	peak KW AC
		11.00	Fixed KW DC allowed for KW
		11.00	1-Axis KW DC allowed for KW
Choose Min or Max allowed based on Utility Policy			
Min	Min of annual kWh or peak KW before solar	**8.00**	Fixed KW DC up to allowed final
		7.00	1-Axis KW DC up to allowed final

Storage Right Sizing Calculator Example

UFS Storage Right Sizing Calculator Example		
Confirm all areas in green below are correct to Utility policy		
	Enter Utility policy number of storage hours required	
	1	(number of continuous battery discharge hours @ peak solar ac in frequency response / power quality mode)
	100%	Utility policy percent of solar ac peak for battery to support continuous
	7.00	Min KW AC battery suggested for up to 8 KW DC Fixed solar @ 1 continous hour
	6.00	Min KW AC battery suggested for up to 7 KW DC 1-Axis solar @ 1 continous hour

Predicting Solar Production

It is possible to have different solar production based on geographical differences. However, these geographical differences are not usually material as long as they are in the same general area. Guam specifically would be considered by most to be the same general area as far as estimating solar production. There may be some real-time differences in cloud coverage. The general assumption is that the clouds will move across Guam and not have a material overall difference on solar production in total from varying locations. However, it is more common to see material differences in solar production based on the solar array type. Some utilities are calculating solar production based on the array type by general common area. It is also more common to differentiate estimated solar production based on the age of the specific solar install. All of the referenced subsidy calculations in this study utilize and recognize each customer's age of system. The most common solar array types [ix] are:

- Fixed (open rack) – similar to roof mount and not as common
- Fixed (roof mount) – common for GPA, common value of solar
- 1-Axis Tracking – common upgrade if fixed array not installed, common secondary value of solar
- 1-Axis Backtracking – similar to 1-Axis tracking and not as common
- 2-Axis Tracking – not common

The main reason that a utility will invest in quantifying actual solar production is usually only when a customer is on a Buy-All, Sell-All metering and billing method as described in the study above. If a customer is on a traditional net metering or more recent net billing metering and billing method, the actual solar production does not need to be tracked for billing purposes. Many studies do estimate total solar production regardless of metering and billing methods. This is the case for the past and current studies for Guam in order to estimate the annual subsidy being caused by the current NEM Customers. This is for benchmarking and comparison purposes only and does not currently flow through to any financial impact to NEM Customers.

There is growing industry interest related to the importance and accuracy of knowing each DER production. This generally comes down to a financial decision related to the additional cost of gaining this data vs. cheaper alternative methods. The most complete but not the most cost-effective method is to require all solar systems (new and existing, with or without storage) customers to install an additional meter on their DER production. Another method would be to install meters on strategic customer solar systems and apply those results to like customer installs. A third method would be to install irradiance sensors strategically around the service territory and apply those results to local solar systems. A fourth method could be to have GPA install strategic, single panel solar arrays with meters around the island. The following summary lists the main solar system production estimates:

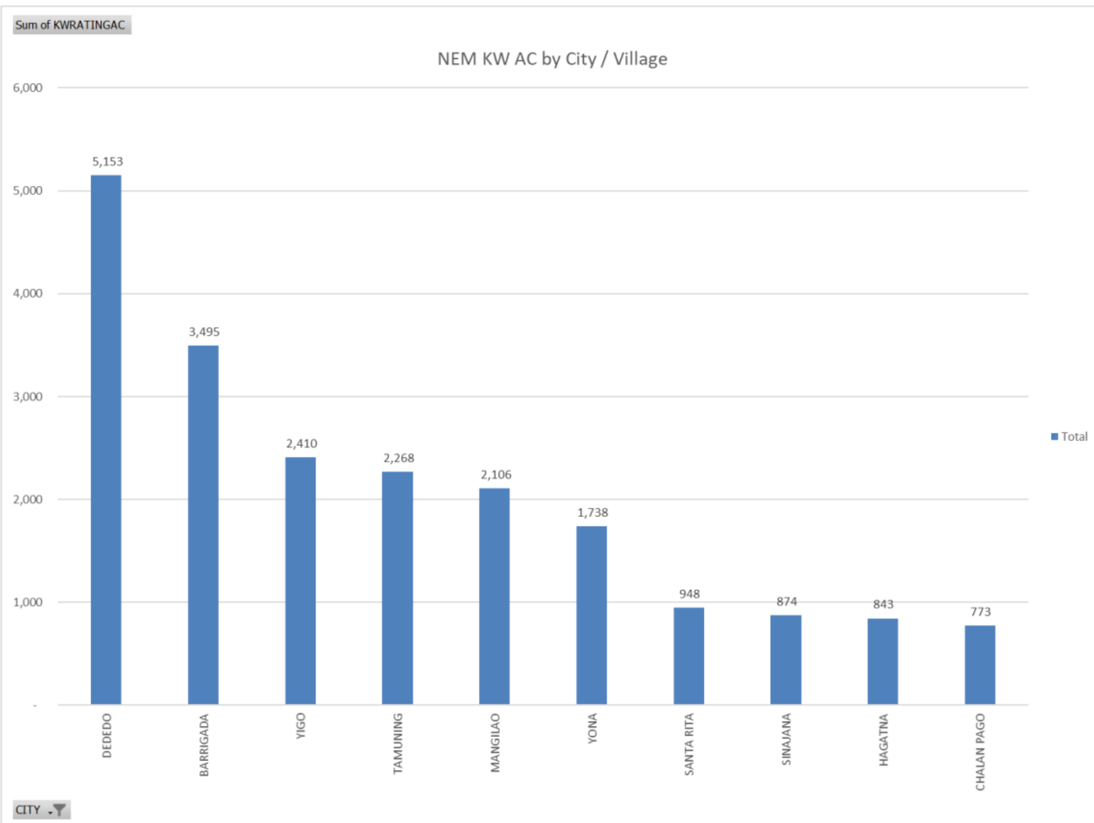
Alternatives to Quantify and Validate Solar Production

- Install a second production meter on all new solar systems.
- Potentially require and/or opt-in installing second production meter on existing solar systems.
- Install irradiance sensors in strategic locations.
- Install single panel arrays with meters in strategic locations.

The following data could guide GPA staff as to strategic locations that may provide optimal selective metering.

Top 10 Cities / Villages for Solar Penetration[x]

CITY	Sum of KWRATINGAC
DEDEDO	5,153
BARRIGADA	3,495
YIGO	2,410
TAMUNING	2,268
MANGILAO	2,106
YONA	1,738
SANTA RITA	948
SINAJANA	874
HAGATNA	843
CHALAN PAGO	773
Grand Total	**20,607**



Survey of Select State Legislation

Five states generated over 14% of its electric needs with solar in the first half of 2020. These states were California, Massachusetts, Vermont, Nevada, and Hawaii, the US solar production represented 2.9% of electric production.

GPA Comparison

Comparing Guam's solar with other states, GPA has the fourth highest solar production only exceeded by California, Massachusetts and Hawaii. Guam is projecting the highest solar growth rates over the next five years expecting to more the double its current solar production. Percentages in the table below have been updated as of Q4 2020.[xi]

Location	Percent of Energy Generation from Solar	Installed Solar Capacity (MW)	Projected Solar Growth over next 5 years (MW)	Projected Solar Growth over next 5 years (%)
California	23.6%	31,873	21,637	68%
Massachusetts	18.5%	3,263	1,851	57%
Hawaii	17.0%	1,427	1,403	98%
Guam	15.6%	51	120	236%
Nevada	15.3%	3,904	4,297	110%
Vermont	14.5%	381.7	256	67%

Further, the table below summarizes the current system and aggregate capacity limits in place to assist in minimizing negative impacts on electric infrastructure. GPA has exceeded the limits highlighted in the table below.[xii]

Location	System Capacity Limits: Residential	System Capacity Limits: Commercial	Aggregate Capacity Limits
California	100% Customer's annual load		None
Massachusetts	60 kW	1-10 MW	8% municipal utility peak load
Hawaii	100 kW / 50 kW		Utility Dependent
Guam	25 kW	100 kW	1,000 customers
Nevada	Lesser of 1 MW or Customer's annual requirements		80 MW
Vermont	2.2 MW military systems / 20 kW micro-CHP		None

The following section summarizes the currently available net metering rules and regulations for the five states referenced above. This data was compiled using the DSIRE Programs website. [xii]

California Rules and Regulations

- California Solar Mandate: Requires all homes built after 12/31/2019 to have rooftop solar systems (customer installed)[xiii]
    - Homes where sun is shaded are exempt
- The state has a goal of 50% clean energy production by 2030
- CPUC called for a successor tariff (NEM 3.0, AB 327) by the end of 2021
    - Framework focuses on "advanced TOU rate designs"

System Capacity Limit:	100% of customer's annual load 5 MW for systems operating under the bill credit transfer program authorized by Public Utilities Code 2830. System must be owned by, operated by, or on property under the control of, a local government or university.
Aggregate Capacity Limit:	N/A
Net Excess Generation:	Credited to customer's next bill at retail rate. After 12-month cycle, customer may opt to roll over credit indefinitely or to receive payment for credit at a rate equal to the 12-month average spot market price for the hours of 7 am to 5 pm for the year in which the surplus power was generated. (If customer makes no affirmative decision, credit is granted to utility with no compensation for customer.)
Ownership of Renewable Energy Credits:	Customer owns RECs. If customer receives payment for net excess generation at the end of a 12-month cycle, utility owns RECs associated with those electricity credits.
Meter Aggregation:	Virtual net metering allowed for multi-tenant properties. Meter aggregation allowed for local governments if all participating accounts receive a time-of-use rate. Pending determination from the CPUC and ratemaking authorities of other utilities, meter aggregation may be allowed for all customers with multiple meters on parcels of land contiguous to the location of the renewable energy system. See below for more explanation.

Massachusetts Rules and Regulations

- MA Dept of Energy Resources, St. 2016, c. 75, §11, MGL c. 25A, §6: "The purpose of 225 CMR 20.00 is to establish a statewide solar incentive program to encourage the continued use and development of generating units that use solar PV technology by residential, commercial, governmental, and industrial electricity customers throughout the Commonwealth."
- MA Bill S. 2995 passed in the house and senate Jan 2021 but was not passed by the governor.[xiv] Bill Specifics:
  - Energy efficiency standards for 17 common appliances
  - Increase state's renewable portfolio by 3% annually 2025 – 2029
  - Exempt businesses who generate rooftop solar from the state's net metering cap
  - Clarifies tax treatment of solar projects
  - Adoption benchmarks for electric vehicles and charging stations

Eligible Renewable/Other Technologies:	Geothermal Electric, Solar Thermal Electric, Solar Photovoltaics, Wind (All), Biomass, Hydroelectric, Municipal Solid Waste, Combined Heat & Power, Fuel Cells using Non-Renewable Fuels, Wind (Small), Hydroelectric (Small), Anaerobic Digestion, Fuel Cells using Renewable Fuels, Other Distributed Generation Technologies
Eligible Storage Technologies:	Lithium-ion
Applicable Sectors:	Commercial, Industrial, Local Government, Nonprofit, Residential, Schools, State Government, Federal Government, Agricultural, Institutional
Applicable Utilities:	Investor-owned utilities
System Capacity Limit:	10 MW for net metering by a municipality or other governmental entity; 2 MW for all other "Class III" systems; 1 MW for all other "Class II" systems; 60 kW for all other "Class I" systems
Aggregate Capacity Limit:	7% of utility's peak load for private entities; 8% of utility's peak load for municipalities or governmental entities. Systems 10 kW and under on a single-phase circuit and systems 25 kW and under on a three-phase circuit are exempt from the private aggregate capacity limit.
Net Excess Generation:	Varies by system type and customer class
Ownership of Renewable Energy Credits:	Customer owns RECs
Meter Aggregation:	Neighborhood net metering allowed

Vermont Rules and Regulations

- 30 V.S.A. § 8010: Self Generation and Net Metering
    - Establishes that the NEM customer shall pay the same rates and fees as other customers in the same rate class
    - To the extent possible, net metering should not shift costs between NEM customers and other customers
    - Utilities must include provisions that govern if there is a limit on the cumulative plant capacity of net metering systems to be installed over time
- 30 V.S.A. § 8005: RES Categories (Renewable Energy Programs)
    - 55% of each retail electricity provider's annual sales must be renewable energy, beginning 1/1/2017 and increasing by 4% each year until reaching 75% on and after 1/1/2032
        - Municipal providers may petition the required amount if they serve under 6,000 customers for a period of up to 3 years. One period approval per provider.

Eligible Renewable/Other Technologies:	Solar Thermal Electric, Solar Photovoltaics, Wind (All), Biomass, Hydroelectric, Combined Heat & Power, Landfill Gas, Wind (Small), Hydroelectric (Small), Anaerobic Digestion, Fuel Cells using Renewable Fuels
Applicable Sectors:	Commercial, Local Government, Nonprofit, Residential, Schools, State Government, Federal Government, Agricultural, Institutional
Applicable Utilities:	All utilities
System Capacity Limit:	2.2 MW for military systems; 20 kW for micro-CHP
Aggregate Capacity Limit:	None
Net Excess Generation:	Credited to customer's next bill at the blended residential rate; excess credits not used within 12 months of generation granted to utility
Ownership of Renewable Energy Credits:	Utility owns RECs unless the customer elects to retain ownership. Customers granting RECs to the utility receive a positive 2 cent/kWh credit adjustor applicable to all system production for 10 years. Customers electing to retain ownership of their RECs receive a negative 3 cent/kWh credit adjustor in perpetuity.
Meter Aggregation:	Group net metering allowed

Nevada Rules and Regulations

Assembly Bill 405 (AB 405), sections 23 – 25, "Energy Bill of Rights"

- Every Nevada resident has a right to:
  - Generate, consume, and export renewable energy
  - Use storage technology
  - Be allowed to connect to the electric grid and be provided a meter by the electric utility
  - Provided a fair credit for energy exported
  - Be charged under their existing rate class absent a net metering system

Eligible Renewable/Other Technologies:	Geothermal Electric, Solar Thermal Electric, Solar Photovoltaics, Wind (All), Biomass, Hydroelectric, Wind (Small), Hydroelectric (Small)
Applicable Sectors:	Commercial, Industrial, Residential
Applicable Utilities:	Investor-owned utilities
System Capacity Limit:	The lesser of 1 MW or 100% of the customer's annual requirements for electricity
Aggregate Capacity Limit:	80 MW for AB 405 net metering
Net Excess Generation:	Systems up to 25 kW: monthly net excess generation credited at a rate equal to 75% of retail rate Systems larger than 25 kW and up to 1 MW: Monthly netting at the retail rate. Any credits that exceed the customer's monthly bill will be carried over to the next billing period indefinitely.
Ownership of Renewable Energy Credits:	Customer owns RECs (unless utility subsidizes system)
Meter Aggregation:	Not addressed for most technologies. Meter aggregation allowed for hydro installations across contiguous properties owned by the customer generator. Meter aggregation allowed for very specific wind projects. See below.

Hawaii Rules and Regulations

- PUC Goal of 100% renewable energy portfolio by 2045
- PUC approved[xv]:
  - Phase 1: 8 Utility scale solar projects totaling 274.5 MW capacity plus 1,098 MWh storage
  - Phase 2: 10 Utility scale solar projects totaling 434 MW capacity plus 1,863 MWh storage (phase 2)
    - Phase 2 standalone storage = additional 737 MWh
  - 18 of the approved projects will be built and owned by private developers and Hawaiian Electric will build and own the two storage projects
  - All projects estimated completion by end of 2023
- Customer Grid Supply – Hawaiian Electric offers a program with the following limitations for roof top solar[xvi]
  - Bill credit set through 2022
  - Capacity limit for unit that varies by utility
  - Ability to disconnect customer system from grid when needed

Eligible Renewable/Other Technologies:	Solar Photovoltaics, Wind (All), Biomass, Hydroelectric, Wind (Small), Hydroelectric (Small)
Applicable Sectors:	Commercial, Local Government, Residential, State Government, Federal Government
Applicable Utilities:	All utilities
System Capacity Limit:	100 kW for HECO, MECO, HELCO customers; 50 kW for KIUC customers
Aggregate Capacity Limit:	Separate limits exist for each island and each of the two tariffs
Net Excess Generation:	Credited to customer's next bill at a specified rate, which varies by utility and tariff
Ownership of Renewable Energy Credits:	Not addressed
Meter Aggregation:	Community-Based Renewable Energy authorized

Endnotes

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[i] GPA supplied MDMS export "GPA_NetMeterAcctsList_20210629_v6.csv"

[ii] GPA supplied MDMS database summarized in "summary results ALL.xlsx"

[iii] GPA maintained and suppled "Net Metering" file dated November 2020

[iv] GPA supplied MDMS database summarized in "summary results ALL.xlsx"

[v] GPA supplied MDMS database summarized in "summary results ALL.xlsx"

[vi] GPA supplied MDMS database summarized in "summary results ALL.xlsx"

[vii] GPA supplied MDMS database summarized in "summary results ALL.xlsx"

[viii] GPA supplied DANDAN charts from Tesla Graph data

[ix] https://pvwatts.nrel.gov/pvwatts.php

[x] GPA supplied MDMS database listing of NEM Customers

[xi] SEIA: Solar State by State, https://www.seia.org/states-map

[xii] "Programs." DSIRE, NC State University, programs.dsireusa.org/system/program.

[xiii] Chuong, Annie. "The California Solar Mandate: Everything You Need to Know." *Solar.com*, 5 Jan. 2021, www.solar.com/learn/california-solar-mandate/.

[xiv] Walton, Robert. "Massachusetts Gov. Baker Vetoes Climate Legislation, Citing Unsupported Mandates." *Utility Dive*, 15 Jan. 2021, www.utilitydive.com/news/massachusetts-gov-baker-vetoes-climate-legislation-citing-unsupported-man/592881/

[xv] https://energy.hawaii.gov/hawaiian-electric-phase2

[xvi] https://www.hawaiianelectric.com/products-and-services/customer-renewable-programs/private-rooftop-solar/customer-grid-supply-plus