Siemens PTI Report Number:

Supplemental Integrated Resource Plan

Draft for the Review of the Puerto Rico Energy Commission

Prepared for

Puerto Rico Electric Power Authority (PREPA)

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Revision History

Date	Rev.	Description
March 28, 2016		Draft for the Review of the Puerto Rico Energy Commission (PREC)
April 1, 2016		Second Draft including sensitivities for demand response and full RPS compliance and revised Future 2 scenarios results.
April 19, 2016		Draft including Portfolio Runs with the reduced fuel forecasts provided on March 21, 2016 as ordered by PREC on April 12, 2016.
April 25, 2016		Draft including P3MF1M_S4 and P3MF1M_S5 portfolio runs with reduced fuel forecasts provided on March 21, 2016 as ordered by PREC on April 12, 2016.

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Section

1

Executive Summary

This proceeding involves integrated resource planning (IRP) for the Puerto Rico Electric Power Authority (PREPA), a public power electric utility. PREPA filed the original draft of its proposed Integrated Resource Plan (Base IRP) in five Volumes in July 2015. The Commission issued a notice of Deficiencies in IRP Filing on August 3, 2015. PREPA, to comply with that notice, filed four revised Volumes (I to IV) on August 17, 2015, and the final revised version of Volume V on September 30, 2015.

The Puerto Rico Energy Commission (PREC or the Commission) issued an Order on IRP Compliance and Intervenors Comments on December 4, 2015 (the Order). The Order directed that PREPA submit three interim explanatory memoranda on certain specified aspects of the IRP followed by an amendment / supplementation of the IRP (Supplemental IRP) that reflected those interim items and a number of other directives. The Commission subsequently engaged in an open process with PREPA to clarify certain aspects of the Order. The Commission later issued two orders (on January 15th and February 9th, 2016) that extended the due dates somewhat, and in the February 9th order clarified further the scope of the work required by the Order and temporarily relieved PREPA from compliance with its directives relating to energy storage.[1]

1.1 Factors Considered in the Supplemental IRP

In collaboration with PREPA, Siemens Power Technologies International (PTI) constructed a combination of Portfolios, Futures, and Sensitivities (PFS) to address the Order requirements in the Supplemental IRP by analyzing the use of emerging technologies that could lead to utility scale solutions and opportunities for Puerto Rico to move to a more carbon neutral sustainable energy system in a feasible and economic manner. The modified Portfolios, Futures, and Sensitivities were formulated with the implementation of the following new or revised factors.

1. Beginning in 2017, Demand Side Management (DSM) Energy Efficiency (EE) achieves a reduction on the modeled load starting from 0.2 percent rate of reduction and incrementing by 0.2 percent per annum through 2024, and from 2025 and thereafter the reduction on the modeled load stabilizes at 1.5 percent

[1] The Order (the December 4th order), on page 5, in Section I, item 7, issued certain storage evaluation directives to PREPA. The Order did not contain any other specific directives on the subject of storage, although on page 6, in Section II, the three interim reports were addressed and the third one referred to transmission and storage without further detail.

per year. The EE framework assumes a cost of 4.5 cents per kWh[2] and assumes that the load shape for EE is identical to the overall aggregate load requirement for PREPA.

2. For utility scale solar PV projects, excluding projects with valid contracts (that include renegotiated contracts), Siemens PTI employs a levelized cost ranging from \$130/MWh to \$110/MWh depending on the installation year to reflect the capital costs and fixed operating costs as detailed in Section 6 of this report. These costs were formulated by applying the expected reduction in capital cost for PV projects that PREPA is likely to capture (at least partially) via competitive bidding in the later years of the IRP horizon for generic solar PV projects included in the model.

3. The level of utility scale renewable generation projects were reevaluated based on the lower demand from EE to allow for (1) a revised RPS target of 12 percent by 2025 and full RPS compliance of 20 percent by 2035, and (2) full RPS compliance of 15 percent by 2020 and 20 percent by 2035 as a sensitivity case. RPS target levels in the Supplemental IRP exceed those in the Base IRP that were 10 percent and 15 percent in 2020 and 2035, respectively.

4. Siemens PTI evaluated the demand response necessary to achieve low or zero curtailment[3] with full RPS compliance. The required demand response could be managed through shifting demand from the day-peak to the mid-day to increase the ability to integrate renewables. This analysis helps to quantify the amount of demand response needed.

5. Sensitivities of AOGP, AES (expiration by December 31, 2027) and EcoEléctrica (expiration by December 31, 2022[4]) were evaluated under the conditions of the revised Futures and Portfolios.

6. As discussed in the transmission report, the transmission studies confirmed that only one SCC-800 combined cycle plant at Palo Seco is required in the north for those cases where gas is only available in the south of the island.

7. Sensitivities of reduced fuel forecasts provided on March 21, 2016 are evaluated in Section 9 as ordered by PREC on April 12, 2016.

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[2] In 2014 US dollars.

[3] Renewable generation curtailment happens when a portion of the renewable generation cannot be accepted due to technical requirements of the conventional generating fleet, and the renewable plant must lower its production although the solar or wind generation is available. Curtailment has a financial impact to PREPA as per the existing contractual conditions if energy production capability is available given the meteorological conditions and PREPA cannot take it. In these instances, PREPA has to pay for the estimated amount of energy that could have been produced at the contractual prices. A target of 2 percent curtailment has generally been agreed with PREPA.

[4] PPOA expiration dates are November 28, 2027 for AES and March 20, 2022 for EcoEléctrica, but to simplify the analysis they were assumed to expire on December 31 of 2027 and 2022, respectively.

All other important factors remain identical to the Base IRP, including the IRP planning horizon of fiscal year (FY) 2016 to 2035 (July 1, 2015 – June 30, 2035); the objective to identify the plan that best provides for PREPA's long-term electricity needs in a reliable, flexible and cost effective manner under a variety of market, regulatory and economic conditions; existing and new generation resources characteristics; and Portfolio evaluation metrics.

Consistent with the Base IRP, all dollar amounts presented in the Supplemental IRP are in real 2015 dollars unless otherwise noted.

All dates unless otherwise noted in the Supplemental IRP are kept consistent with the Base IRP and will be updated once the IRP is approved and its conditions known.

1.2 Supplemental IRP PFS Construction Approach

Based on the Commission's requirement, the Supplemental IRP provides an assessment of a modified Portfolio 3 based on a modified Future 1 (base case with AOGP coming on line by July 1, 2017) and Future 2 (a pessimistic case assuming that AOGP does not happen). The primary modification of the two Futures includes lower demand from EE and higher RPS target levels. Portfolio 3 includes the addition of generating capacity from renewable resources as well as new and efficient fossil fuel resources to replace existing aged and inflexible generation units in order to improve system efficiency and better integrate increasing renewable resources. The primary modification of Portfolio 3 includes lower levels of new generation resources corresponding to the lower demand and expedited schedules due to higher requirement of renewable integration.

The Supplemental IRP Portfolios are constructed based on the important findings of the Base IRP, which confirmed the reserve levels necessary to maintain an acceptable amount of Loss of Load Hours (LOLH). Specifically, the reduction in demand that EE is indicated to achieve and the reserve levels required for acceptable LOLHs are used to formulate modified Portfolios.

The availability of capital, practical permitting and EPC (engineering, procurement, and construction) development time and strategies dictate the sequencing and timing of projects. In addition, system reliability aspects should be considered. In order to implement a system-wide generation replacement and integration plan, an optimized strategy heavily dependent on the critical system components' stabilization periods is required.

The Base IRP has validated that the replacement of PREPA's fleet was economically justified, i.e. the fuel savings introduced by the new generation more than compensate the capital investments. After it was determined how many new units would be required in the long-term given the load reduction referenced above, we put them in service as soon as practically possible, with consideration to the capital, system, and schedule restrictions.

The amount of new renewable resources is dictated by RPS goals (at either reduced or full compliance levels) and the reduced demand due to EE referenced above. The amount of new conventional generation resources is determined by the amount of fast ramping conventional resources needed for renewable integration and the need to maintain reserve margin.

During the process of constructing the modified Portfolios, we repeatedly tested decreasing amounts of new fossil fueled generation resources from the proposed Portfolios as described in subsequent sections, and observed that the reserve margin drops to unacceptable levels in the long-term. These tests validated the optimal amount of new fossil fueled generation resources and associated schedules during the portfolio construction stage.

Finally, to prevent the low utilization or idling of new fossil fueled generation resources in the long-term given the declining demand from EE referenced above, we intentionally kept the most efficient existing units in service until the load reduction allowed their retirement without causing system reserve margin to reach unacceptable levels, i.e. those that are expected to result in a number of LOLHs under PREPA's planning criteria of four hours per year. The actual date of retirement of this efficient existing generation depends on the physical condition of the units and their capability to maintain efficient operation. That is if a unit can be kept in service longer than indicted in this report, it will probably be as it gives flexibility to the dispatch and this normally results in lower costs, unless as indicted above the conditions are deteriorating and the increasing fixed and variable cost and do not justify maintaining the unit in service any longer.

The transmission studies carried out for the implementation of the recommendations of this supplementary IRP are presented in a separate report named "PREPA Integrated Resource Plan Supplementary Evaluation: Transmission Analysis"

The next section presents the selected portfolios to optimally respond to the modified Futures and Sensitivities.

1.3 Summary of Supplemental IRP PFS

The modified Portfolios, Futures, and Sensitivities included in the Supplemental IRP are presented in Table 1-1. They are based on Portfolio 3 which was found to be superior to Portfolio 2 in the Base IRP. In addition to these eight portfolios, an assessment of all in costs comparison between the new H Class CC unit and the old Aguirre and Costa Sur steam units will be provided to demonstrate optimality of the new generation resources.

Table 1-1: Supplemental IRP Portfolio, Future and Sensitivity Summary

	Portfolios, Futures, and Sensitivities (PFS)	AOGP	AES	EcoEléctrica
1	P3MF1M	yes	yes	yes
1*	P3MF1M_RE Recips at Palo Seco	yes	yes	yes
2	P3MF2M_No AOGP	no	yes	yes
3	P3MF1M_S1 No AES	yes	no	yes
4	P3MF2M_S1 No AOGP No AES	no	no	yes
5	P3MF2M_S2 No AOGP No EcoEléctrica	no	yes	no
6	P3MF2M_S3 No AOGP No AES No EcoEléctrica	no	no	no
7	P3MF1M_S4 Demand Response	yes	yes	yes
8	P3MF1M_S5 Full RPS by 2020	yes	yes	yes

Source: Siemens PTI, Pace Global

Given the myriad of considerations and tradeoffs to be evaluated from the basis of generation, system operation, capital costs, fuel and operation costs, and environmental compliance, Siemens PTI believes that a systematic approach to evaluating all PFS will help establish clarity for the planning approaches with quantifiable metrics to identify the Portfolios that meet PREPA's objective of providing for its long-term electricity needs in a reliable, cost competitive, and flexible manner under a wide variety of market, regulatory, and economic conditions.

1.4 PFS Performance Evaluation Results

Consistent with the Base IRP, the PFS in the Supplemental IRP are evaluated against several important criteria, including costs, operation and environmental metrics.

1.4.1 Cost Metrics

Cost metrics include capital costs and present value of system costs. Capital costs associated with construction of new generation, fuel infrastructure, transmission upgrades and improvements are evaluated. The system costs include amortized capital costs, cost of power plant demolition, fuel costs, variable and fixed generation operating costs, purchased power costs from AES and EcoEléctrica and renewable purchased power costs. The system costs are not intended to capture all costs but only costs that have an impact on the portfolios on an incremental basis.

Table 1-2 and Table 1-3 provide a summary of the capital costs and system costs for the modified Portfolio 3 under the two modified Futures evaluated as well as the sensitivity cases. Table 1-4 presents the system costs summary for the seven portfolios evaluated under fuel sensitivity.

Table 1-2: PFS Capital Costs Summary

Capital Costs	Unit	Future 1					
		P3F1	P3MF1M	P3MF1M_S1	P3MF1M_S4	P3MF1M_S5	P3MF1M RE
FY 2016 - 2025 Total Capital Costs	*$ million*	3,329	3,153	3,153	3,153	4,473	3,122
FY 2026 - 2035 Total Capital Costs	*$ million*	1,923	1,461	1,914	1,461	54	1,461
FY 2016 - 2035 Total Capital Costs	*$ million*	5,252	4,614	5,067	4,614	4,527	4,584

Capital Costs	Unit	Future 1					
		P3F1	P3MF1M	P3MF1M_S1	P3MF1M_S4	P3MF1M_S5	P3MF1M_RE
Generation	*$ million*	2,887	2,157	2,609	2,157	2,069	2,126
Fuel Infrastructure	*$ million*	385	385	385	385	385	385
Transmission	*$ million*	1,981	2,073	2,073	2,073	2,073	2,073
Total	*$ million*	5,252	4,614	5,067	4,614	4,527	4,584

Capital Costs	Unit	Future 2				
		P3F2	P3MF2M	P3MF2M_S1	P3MF2M_S2	P3MF2M_S3
FY 2016 - 2025 Total Capital Costs	*$ million*	3,715	3,745	3,745	4,175	4,175
FY 2026 - 2035 Total Capital Costs	*$ million*	959	50	502	50	502
FY 2016 - 2035 Total Capital Costs	*$ million*	4,674	3,794	4,247	4,225	4,677

Capital Costs	Unit	Future 2				
		P3F2	P3MF2M	P3MF2M_S1	P3MF2M_S2	P3MF2M_S3
Generation	*$ million*	2,693	1,814	2,266	2,244	2,697
Fuel Infrastructure	*$ million*	0	0	0	0	0
Transmission	*$ million*	1,981	1,981	1,981	1,981	1,981
Total	*$ million*	4,674	3,794	4,247	4,225	4,677

Source: Siemens PTI, Pace Global

Table 1-3: PFS System Costs Summary

System Costs	Unit	Future 1					
		P3F1	P3MF1M	P3MF1M_S1	P3MF1M_S4	P3MF1M_S5	P3MF1M_RE
Total Present Value of System Costs	*$ million*	26,842	25,836	25,846	26,060	26,087	25,869
Average Annual System Costs	*$ million*	2,415	2,292	2,293	2,312	2,309	2,295
Present Value of System Costs Difference with P3MF1M	*$ million*	1,006	0	10	224	251	34

System Costs	Unit	Future 2				
		P3F2	P3MF2M	P3MF2M_S1	P3MF2M_S2	P3MF2M_S3
Total Present Value of System Costs	*$ million*	29,301	28,825	29,083	28,611	28,801
Average Annual System Costs	*$ million*	2,663	2,603	2,641	2,581	2,609
Present Value of System Costs Difference with P3MF2M	*$ million*	476	0	258	-214	-25

Source: Siemens PTI, Pace Global

Table 1-4: Fuel Sensitivity System Costs Summary

System Costs	Unit	Future 1			
		P3F1Fuel	P3MF1MFuel	P3MF1M_S4Fuel	P3MF1M_S5 Fuel
Total Present Value of System Costs	*$ million*	23,503	22,701	23,382	23,468
Average Annual System Costs	*$ million*	2,167	2,056	2,121	2,126

System Costs	Unit	Future 2		
		P3F2Fuel	P3MF2MFuel	P3MF2M_S2Fuel
Total Present Value of System Costs	*$ million*	23,680	22,920	22,541
Average Annual System Costs	*$ million*	2,212	2,112	2,068

Source: Siemens PTI, Pace Global

1.4.2 Environmental and Compliance Metrics

Environmental and compliance metrics focus on system wide emission reduction, CO_2 emissions, MATS compliance status, and RPS and renewable penetration. Table 1-5 presents a summary of the environmental metrics for the modified Portfolio 3 under the two modified Futures evaluated as well as the sensitivity cases.

Table 1-5: PFS Environmental Metrics Summary

Emission Metrics	Unit	Future 1					
		P3F1	P3MF1M	P3MF1M_S1	P3MF1M_S4	P3MF1M_S5	P3MF1M_RE
Average Annual CO_2 Emission	million lbs.	22,603	20,947	19,340	20,133	19,852	20,964
CO_2 Emission Reduction (2035 vs. 2016)	%	36%	77%	60%	43%	43%	44%
Average Annual FPM Emission	million lbs.	25	25	16	24	24	25
FPM Emission Reduction (2035 vs. 2016)	%	12%	15%	99%	12%	12%	14%
Average Annual NO_x Emission	million lbs.	41	38	35	36	33	39
NO_x Emission Reduction (2035 vs. 2016)	%	63%	62%	78%	63%	63%	62%
Average Annual SO_x Emission	million lbs.	19	19	15	18	18	19
SO_x Emission Reduction Rate (2035 vs. 2016)	%	76%	77%	100%	77%	76%	77%

Emission Metrics	Unit	Future 2				
		P3F2	P3MF2M	P3MF2M_S1	P3MF2M_S2	P3MF2M_S3
Average Annual CO_2 Emission	million lbs.	23,469	20,947	19,302	20,996	19,279
CO_2 Emission Reduction (2035 vs. 2016)	%	33%	46%	61%	46%	61%
Average Annual FPM Emission	million lbs.	27	26	17	27	17
FPM Emission Reduction (2035 vs. 2016)	%	11%	16%	98%	11%	97%
Average Annual NO_x Emission	million lbs.	37	36	32	31	27
NO_x Emission Reduction (2035 vs. 2016)	%	59%	55%	73%	69%	89%
Average Annual SO_x Emission	million lbs.	26	25	21	26	21
SO_x Emission Reduction Rate (2035 vs. 2016)	%	75%	77%	98%	76%	97%

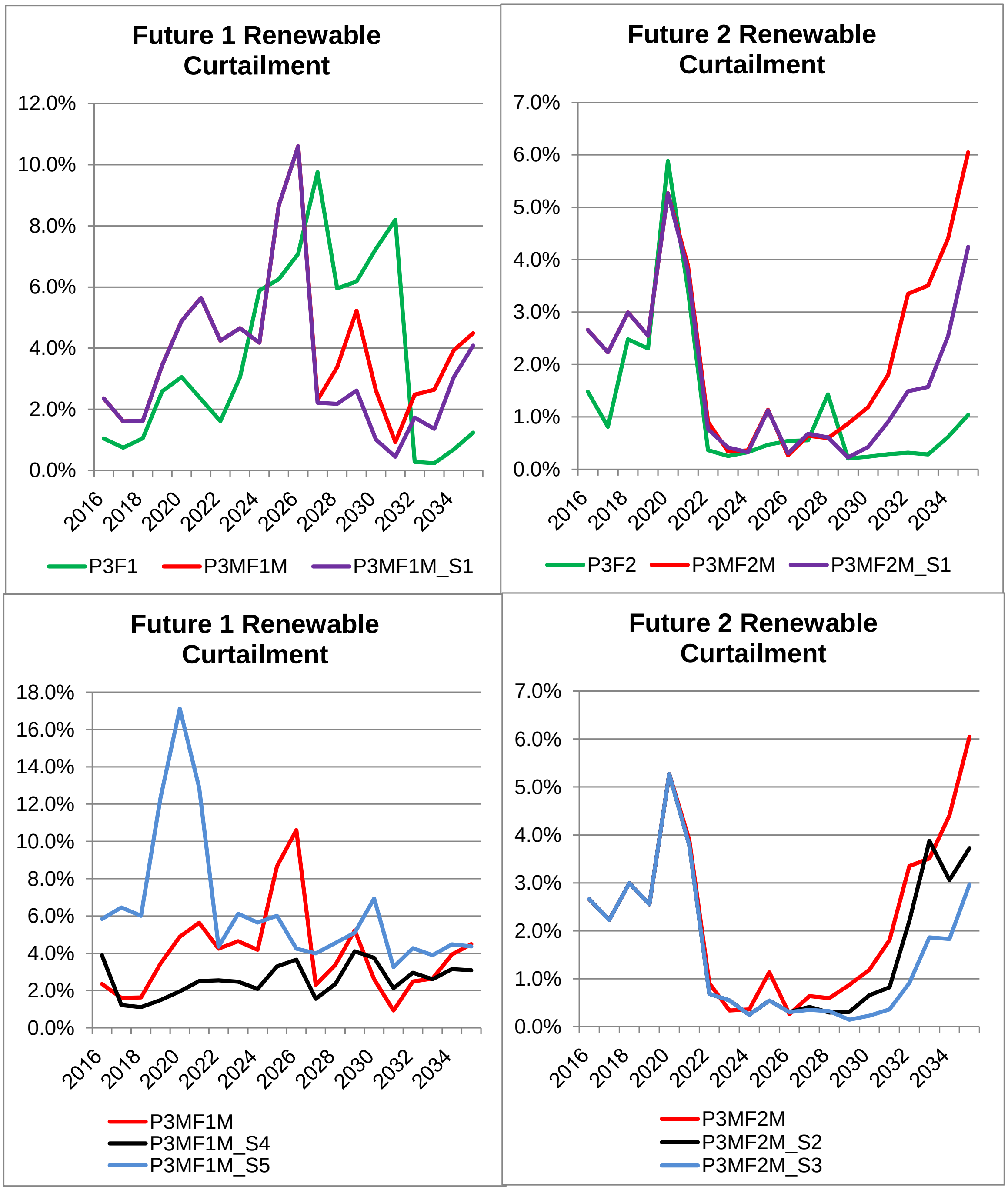
Source: Siemens PTI, Pace Global

1.4.3 Operation Metrics

Operation metrics are monitored to assess reliability, efficiency, adequacy and security. For example, renewable curtailment assesses the portfolio's performance in accommodating renewable generation without excessive curtailment. Renewable generation curtailment happens when a portion of renewable generation cannot be accepted in the system due to certain technical requirements of the conventional generating fleet and the renewable plant must lower its production although sun irradiation or wind is available. Curtailment could have a financial impact to PREPA as per the existing contractual conditions if energy production capability is available given the meteorological conditions and PREPA cannot take it. In these instances, PREPA has to pay for the estimated amount of energy that could have been produced at the contractual prices. LOLH and reserve margin provide an indication of the ability of the generating fleet to meet the load.

Table 1-6 and Figure 1-1 present a summary of the operation metrics and curtailment levels for the modified Portfolio 3 under the two modified Futures evaluated as well as the sensitivity cases.

Figure 1-1: PFS Curtailments Summary



Source: Siemens PTI, Pace Global

Table 1-6: PFS Operation Metrics Summary

Operation Metrics	Unit	Future 1					
		P3F1	P3MF1M	P3MF1M_S1	P3MF1M_S4	P3MF1M_S5	P3MF1M_RE
Max LOLH	Hours	4	4	4	0	5	2
Average Annual Renewable Curtailment Cost	$ million	13	11	10	9	23	12
Average Annual Renewable Curtailment Percentage	%	4%	4%	4%	3%	6%	4%
System Heat Rate Improvement 2035 vs. 2016 (Total Generation)	%	26%	24%	31%	22%	22%	24%
System Heat Rate Improvement 2035 vs. 2016 (Thermal Generation)	%	15%	12%	20%	13%	13%	12%

Operation Metrics	Unit	Future 2				
		P3F2	P3MF2M	P3MF2M_S1	P3MF2M_S2	P3MF2M_S3
Max LOLH	Hours	4	4	4	4	4
Average Annual Renewable Curtailment Cost	$ million	3	7	5	5	4
Average Annual Renewable Curtailment Percentage	%	1%	2%	2%	2%	2%
System Heat Rate Improvement 2035 vs. 2016 (Total Generation)	%	28%	25%	31%	26%	33%
System Heat Rate Improvement 2035 vs. 2016 (Thermal Generation)	%	17%	13%	20%	14%	22%

Source: Siemens PTI, Pace Global

We noted that for the case with full RPS compliance (P3MF1_S5) there are five hours of LOLH. These hours occur in 2020 before the new flexible H Class units are added to the system and during the period that the Aguirre Combined Cycle units are being repowered. Under these conditions the system is trying to balance renewable curtailment that favors minimizing the number of steam units online while maintaining reliability. The observed LOLH and the curtailment (17 percent for that year) are indicative of the difficulty of achieving this balance if 15 percent RPS compliance is to be achieved this year. See Appendix C for more details on the values above.

Section

2

Conclusions and Recommendations

Based on the assumption of an aggressive EE plan that causes a significant reduction in demand, the key findings of the Supplemental IRP include the following.

1. Compared with P3F1 results in the Base IRP, P3MF1M demonstrates the benefits of lower capital costs due to a lower demand as a result of EE, smaller new generation at Palo Seco, lower overall system costs, and improved levels of renewable penetration to achieve 20 percent by 2035. It has adequate performance from an operational and environmental point of view, provided that the dispatch of the repowered Aguirre CC 1&2 are adjusted for compliance with the greenhouse gas (GHG) New Source Standard.

2. The investments in the recommended Portfolio 3 can be modified to adapt to the reduced demand. The only change recommended based on this study is not to consider the use of an F Class combined cycle in the north but rather a smaller SCC-800 or similar unit; as proposed in Portfolio 2. This will give the flexibility required for adapting to the reduced demand.

3. Assuming the generic solar PV PPOA pricing for 17 projects that come on line after 2020 as presented in Table 6-2 leads to savings of $130 million for the present value of system costs and $18 million average annual system costs for the IRP period of 2016-2035. Table 2-1 shows the summary based on P3MF1M results. ***All system costs for the portfolios in the Supplemental IRP are presented using the generic levelized cost of energy (LCOE) price assumption.***

Table 2-1: Generic Solar PV Project Savings

(in 2015$ million)	Generic LCOE	Contract Price	Savings
Present Value of System Costs (2016-2035)	25,786	25,916	130
Average Annual System Costs (2016-2035)	2,286	2,304	18

Source: Siemens PTI, Pace Global

4. Compared with P3F2 results in the Base IRP, P3MF2M demonstrates the benefits of lower capital costs, lower overall system costs (due to high efficiency units being expedited at three sites), and improved levels of renewable penetration to achieve 20 percent by 2035. This is due to the assumption of a lower demand achieved by EE plan. It has adequate performance from an operational and environmental point of view. However, despite of all the special considerations in the portfolio construction in

P3MF2M, it still incurs approximately $3 billion higher present value of system costs than P3MF1M due to higher fuel costs without AOGP.

5. The non-renewal of AES contract can be handled by the modified Portfolio 3 under both Future 1 and 2 from a system operation perspective, if the capital is available to replace AES with new generation. The sensitivity case assumed investing in H Class 1X1 CC to replace AES, and incurs higher capital costs and system costs. Therefore, an extension of the AES contract is recommended because AES is typically the lowest cost resource in PREPA's fleet.

6. The non-renewal of EcoEléctrica contract can be handled by the modified Portfolio 3 under the tested Future 2 from a system operation perspective if the capital is available to replace EcoEléctrica with new generation. The sensitivity case assumed investing in H Class 1X1 CC to replace EcoEléctrica, and incurs higher capital costs. Due to the improved efficiency of the new H Class 1X1 CC and reduced fixed and capital costs, overall system costs are lowered. However, an extension of the EcoEléctrica contract (preferably with renegotiated terms in particular with respect of the capacity payments and fuel prices) is recommended since this will free up valuable capital resources for the modernization of the balance of PREPA's fleet.

7. Using demand response to achieve reduced curtailment with RPS compliance resulted in much higher system costs than P3MF1M. This is primarily due to two reasons: (1) the cheaper conventional generation is reduced at night while higher prices for PV generation is paid at the day time; and (2) the estimated cost of the control systems to shift from the night peak to the mid-day.

8. Full RPS compliance sensitivity requires three new H Class 1X1 CCs to be built on an accelerated schedule in parallel, but still resulted in $251 million higher present value of system costs than P3MF1M.

9. The fuel forecast sensitivity assessment of Future 1 with AOGP indicates that even though the savings in fuel approximately equal the cost in capital for the initial replacement of Aguirre, the replacement of Aguirre and Costa Sur units is required to control the curtailment and achieve the reduced RPS targets.

10. The fuel forecast sensitivity assessment of Future 2 without AOGP indicates that the investment in the AOGP is justified even with reduced fuel prices.

All findings with respect of the reduced number of new units additions should be considered by PREPA in the decision making following the approval of the IRP. For this, PREPA while advancing all studies and permitting procedures considering that the demand will be maintained or may increase, should maintain its options open. At the time of making construction decisions, the actual path of the demand should be revised and only the required units should be constructed; e.g., only one SCC-800 (or similar) in the north instead of three as in the original Portfolio 2.

Section
3

Energy Efficiency

Beginning in 2017, Demand Side Management (DSM) Energy Efficiency (EE) achieves a reduction on the modeled load starting from 0.2 percent rate of reduction and incrementing by 0.2 percent each year through 2024, and from 2025 and thereafter the rate of reduction stabilizes at 1.5 percent per year. The energy efficiency are assumed at a cost of 4.5 cents per kWh for EE, using the dollar value for 2014 and assume that the load shape of EE is identical to the overall aggregate load requirement for PREPA. The EE cost is applied to the EE MWhs and added to the overall system costs. Table 3-1 and Table 3-2 show the modified demand and sales with the above mentioned EE included.

Table 3-1: Modified Demand Forecast with Energy Efficiency

			Peak Demand			Energy (GWh) - Generation		
FY Year	Yearly Reduction	Factor	Original	New	Delta	Original	New	Delta
2016	0	100%	2,969	2,969	0	20,492	20,492	0
2017	0.20%	100%	2,967	2,961	6	20,483	20,442	41
2018	0.40%	99%	2,964	2,946	18	20,464	20,341	123
2019	0.60%	99%	2,968	2,932	35	20,488	20,243	245
2020	0.80%	98%	2,932	2,874	58	20,209	19,808	401
2021	1.00%	97%	2,920	2,833	87	20,120	19,523	597
2022	1.20%	96%	2,907	2,787	120	20,030	19,203	827
2023	1.40%	95%	2,909	2,749	159	20,042	18,945	1,097
2024	1.50%	93%	2,910	2,710	201	20,053	18,672	1,382
2025	1.50%	92%	2,912	2,671	241	20,065	18,402	1,663
2026	1.50%	90%	2,913	2,632	282	20,076	18,136	1,940
2027	1.50%	89%	2,915	2,594	321	20,087	17,874	2,213
2028	1.50%	88%	2,917	2,556	360	20,097	17,615	2,483
2029	1.50%	86%	2,918	2,519	399	20,108	17,359	2,748
2030	1.50%	85%	2,920	2,483	437	20,118	17,108	3,010
2031	1.50%	84%	2,921	2,447	474	20,128	16,859	3,268
2032	1.50%	83%	2,922	2,411	511	20,138	16,615	3,523
2033	1.50%	81%	2,924	2,376	548	20,147	16,373	3,774
2034	1.50%	80%	2,925	2,342	584	20,156	16,135	4,021
2035	1.50%	79%	2,927	2,308	619	20,166	15,900	4,265

Source: Siemens PTI

Table 3-2: Modified Sales Forecast with Energy Efficiency

	Energy (GWh) - Sales			
FY Year	**Original**	**Factor**	**New**	**Delta**
2016	16,853	0.82	16,853	0
2017	16,846	0.82	16,812	34
2018	16,829	0.82	16,728	101
2019	16,850	0.82	16,648	201
2020	16,772	0.83	16,439	333
2021	16,695	0.83	16,200	495
2022	16,618	0.83	15,931	686
2023	16,628	0.83	15,718	910
2024	16,638	0.83	15,491	1,146
2025	16,648	0.83	15,268	1,380
2026	16,657	0.83	15,048	1,610
2027	16,667	0.83	14,830	1,836
2028	16,676	0.83	14,616	2,060
2029	16,685	0.83	14,404	2,280
2030	16,693	0.83	14,196	2,498
2031	16,702	0.83	13,990	2,712
2032	16,710	0.83	13,787	2,923
2033	16,718	0.83	13,587	3,132
2034	16,726	0.83	13,389	3,337
2035	16,734	0.83	13,195	3,540

Source: Siemens PTI

Section

4

Distributed Generation

Distributed Generation (DG), *i.e.* customer installed generation is modeled in the same way as in the Base IRP, as equivalent generators located in selected substations in PREPA's network. The substations for modeling of the equivalent DG were selected based on the current location of DG in the island and the customer base that is likely to install this type of generation. As can be observed in the table below, the bulk of the DG is in the north of the island, which is expected as this is also the location of a significant percentage of the load.

Table 4-1: DG Capacity by Area (MW)[5]

Totals	Percent	MW	Note
North	71 percent	43	S. Juan, Bayamón, Carolina, Caguas & Arecibo
South	14 percent	9	Ponce
West	14 percent	9	Mayagüez
Total	100 percent	61	

The total amount of DG generation modeled was derived from PREPA's projection of DG to be added to the network starting from an initial value of 61 MW by 2015 growing to 322 MW by 2035.

Table 4-2 shows the total amounts of distributed generation modeled, the substation where the various equivalents were located, and their size.

[5] DG Capacity by Area (MW) included in Integrated Resource Plan Volume I: Supply Portfolios and Futures Analysis, dated August 17, 2015 (p 4-7).

Table 4-2: Base DG Forecast (MW) for Selected Dates and Allocations by Substation[6]

Area Num	Proposed Bus	2/1/2015	7/1/2015	7/1/2020	7/1/2025	7/1/2035
1	88- SJSP	12.5	13.9	28.3	40.7	66.1
2	45 -Bayamón 115	10.3	11.5	23.3	33.6	54.5
3	85 - S. Llana	5.1	5.7	11.6	16.7	27.1
4	21 - Caguas	9.9	11.0	22.4	32.2	52.3
5 - 6	8 - Jobos	8.8	9.7	19.8	28.5	46.4
7	38 - Dos Bocas	5.6	6.3	12.7	18.3	29.8
8	277 Mayagüez TC	8.7	9.6	19.6	28.2	45.8
	Total Base	**60.9**	**67.6**	**137.7**	**198.3**	**322.1**

All DG was assumed to be photovoltaic (PV) and the production by each of the seven locations above was derived based on the expected irradiance at the sites in a similar way that the production for utility scale PV was modeled. In summary, DG is modeled by seven equivalent PV generators across the island and increasing in size.

[6] Base DG Production Forecast for Selected Dates and Allocation by Substation, dated August 17, 2015 (p 4–8).

Section

5

Renewable Generation

Given the assumed levels of EE and the corresponding reduction in demand, there is an important reduction in the required levels of renewable generation to achieve RPS compliance, making this more feasible, particularly after the bulk of PREPA's fleet is replaced by 2025 under the IRP.

Given the above, the Base Case RPS compliance path will be modeled with reduced targets until the end of FY 2025 and, after that year, when the new flexible combined cycle plants in the south are expected to be in service, we will switch to the original intended path so that by 2035 there is 20 percent of renewable penetration. Table 5-1 below shows path used in the study.

Table 5-1: RPS Targets Modeled

Year	RPS Target	Note
2016	*8.00%*	Reduced Target
2017	*8.50%*	Reduced Target
2018	*9.00%*	Reduced Target
2019	*9.50%*	Reduced Target
2020	*10.00%*	Reduced Target
2021	*10.40%*	Reduced Target
2022	*10.80%*	Reduced Target
2023	*11.20%*	Reduced Target
2024	*11.60%*	Reduced Target
2025	*12.00%*	Reduced Target
2026	*12.30%*	Reduced Target
2027	*12.60%*	Reduced Target
2028	*12.90%*	Reduced Target
2029	*13.20%*	Reduced Target
2030	*13.50%*	Reduced Target
2031	*14.80%*	Original Target
2032	*16.10%*	Original Target
2033	*17.40%*	Original Target
2034	*18.70%*	Original Target
2035	*20.00%*	Original Target

Given that the required amounts of renewable generation are a function of the sales, Table 3-2 shows the assumed generation and sales projection as affected by EE. Based on this and the conservative assumption that DG does not count for RPS compliance we present in the tables below (Table 5-2 to Table 5-5)[7] the amounts of renewable generation to be modeled.

Table 5-2: Renewable Generation in 2020 for 10 Percent Penetration

Peak Generation Total (MW)	2,833
Energy Sales + Net Metering (MWh)	16,199,673
Energy DG (138 MW) @ 21 % Capacity Factor	253,325
Net Sales (MWh)	15,946,348
Target Penetration	**10%**
Target PPOA Energy (MWh)	1,594,635
Capacity in PPOA PV + Wind (MW) in Projects	744
Add PV @ 21% for required penetration (MW)	-
Total PPOA (MW)	**744**
Average Capacity Factor	*24%*
DG in the system (MW)	138
Total Renewable Generation (MW)	**882**
Total % Energy from Renewable	***11%***
% Renewable as function of peak	*31%*

[7] The information shown in these tables is given according to the RPS requirement that is established for calendar year. The peak demand and energy (generation and sales) shown in Section 3 tables are provided for fiscal year.

Table 5-3: Renewable Generation in 2025 for 12 Percent Penetration

Peak Generation Total (MW)	2,632
Energy Sales + Net Metering (MWh)	15,047,639
Energy DG (198 MW) @ 21 % Capacity Factor	364,755
Net Sales (MWh)	14,682,884
Target Penetration	**12%**
Target PPOA Energy (MWh)	1,761,946
Capacity in PPOA PV + Wind (MW) in Projects	856
Add PV @ 21% for required penetration (MW)	-
Total PPOA (MW)	**856**
Average Capacity Factor	*23%*
DG in the system (MW)	198
Total Renewable Generation (MW)	**1,055**
Total % Energy from Renewable	***14%***
% Renewable as function of peak	*40%*

Table 5-4: Renewable Generation in 2035 for 20 Percent Penetration

Peak Generation Total (MW)	2,308
Energy Sales + Net Metering (MWh)	13,194,680
Energy DG (322 MW) @ 21 % Capacity Factor	592,566
Net Sales (MWh)	12,602,115
Target Penetration	**20%**
Target PPOA Energy (MWh)	2,520,423
Capacity in PPOA PV + Wind (MW) in Projects	1,056
Add PV @ 21% for required penetration (MW)	215
Total PPOA (MW)	**1,271**
Average Capacity Factor	*23%*
DG in the system (MW)	322
Total Renewable Generation (MW)	**1,593**
Total % Energy from Renewable	***24%***
% Renewable as function of peak	*69%*

For the sensitivity case in which 15 percent penetration is required in 2020, it will be necessary to add flexibility to PREPA's fleet. However, there are practical limitations on how fast this can be achieved, even if capital availability was not a factor. In this sense this case is similar to Future 2 where there is no AOGP and the Aguirre units need to be replaced in an accelerated manner due to MATS compliance. Therefore this case will be studied using the same replacement plan for Future 2, which subject to the feasibility review to be conducted during the analysis, should have two H Class units available by beginnings of 2022 approximately.

The amounts of renewable generation will be modeled are as shown below for 2020. Note that the total PPOA renewable generation required (1,201 MW) for 15 percent penetration, is very similar to the value that would achieve 20 percent penetration by 2035 (1,271 MW), thus increases on PPOA from this moment onwards should be small and the RPS goals achieved by the reduction in load that Energy Efficiency is expected to produce.

Table 5-5: Renewable Generation in 2020 for 15 percent penetration

Peak Generation Total (MW)	2,833
Energy Sales + Net Metering (MWh)	16,199,673
Energy DG (138 MW) @ 21 % Capacity Factor	253,325
Net Sales (MWh)	15,946,348
Target Penetration	**15%**
Target PPOA Energy (MWh)	2,391,952
Capacity in PPOA PV + Wind (MW) in Projects	1,056
Add PV @ 21% for required penetration (MW)	145
Total PPOA (MW)	**1,201**
Average Capacity Factor	*23%*
DG in the system (MW)	138
Total Renewable Generation (MW)	**1,339**
Total % Energy from Renewable	***16%***
% Renewable as function of peak	*47%*

The renewable generation projects will be represented using the same models employed for the Base IRP, turning on / or off particular projects to achieve the targets levels of penetration above.

In particular for the maximum penetration of 20 percent renewable generation, all individual projects selected for the IRP (1,056 MW) will be required[8], plus 215 MW of generic PV. It is

[8] See, IRP Volume I dated August 17, 2015, Table 4-2: PPOA Projects Considered in this Study (p. 4-3).

important to note that the 1,056.4 MW in renewable energy is derived from currently active power purchase operating agreements (PPOA), Master Agreements, and/or contracts that were signed by PREPA.

We have included as a reference Table 5-6, for the explicit renewable projects considered in the Supplemental IRP, which details the contract numbers. The projects in Table 5-6 were modeled explicitly in the Supplemental IRP as we had appropriate information on them, but this is not intended to give the impression that these are the only active contracts.

As of March 28, 2016, in addition to the renewable projects included in Table 5-6, PREPA has 9 contracts with a total capacity of 261.9 MW in wind power, 2 contracts with 3.5 MW of Landfill Gas, 5 contracts with a total of 150 MW of solar power, and 2 contracts with 89 MW of Waste to Energy, and 8 Master Agreements with total availability of 600 MW, for a grand total of renewable energy in existing contracts, PPOAs, and Master Agreements of 2,160.1 MW. All projects with existing contracts (operational and new) have high prices, and these prices are not likely to drop significantly if the developers actually go forward with the new projects. In order for PREPA to be able to solicit any new renewable generation projects with new lower updated prices, it would require new projects with existing contracts, PPOAs, and Master Agreements not to go forward. Please refer to PREPA's website[9] to see copies of the existing contracts, PPOAs, and Master Agreements and their respective amendments.

In order to manage the significant uncertainty on the number of renewable generation contracts that may not go forward, we will provide the results in two ways: a) considering that most of the renewable projects go forward and there is not a significant reduction in price; and b) assuming that some of the renewable projects that do not have renegotiated PPOA contracts do not materialize and can be replaced by new contracts based on updated capital and O&M costs determined considering the current status of the technology and projections made by experts in the area (e.g., publications by NREL and Energy Department as well as Siemens experience in the area).

[9] http://www.aeepr.com/Documentos/Ley57/CONTRATOS/EnergiaRenovable1.htm
http://www.aeepr.com/Documentos/Ley57/ENMIENDAS/EnergiaRenovableEnmiendas1.htm

Table 5-6: Explicit Renewable Projects Considered

No.	Name	Technology	Capacity (MW)	Capacity Factor (percent)	Cumulative RPS Level (percent)	Price ($/MWh)	Contract Number
1	AES Ilumina, LLC	PV	20	21	0.2	194	2010-P00050
31	Pattern Santa Isabel, LLC	Wind	95	38	2.2	157	2010-P00047
32	Punta Lima (Go Green PR)	Wind	26	28	2.6	156	2010-AI0001
46	San Fermín Solar Farm, LLC (Coquí Power, LLC)	PV	20	21	2.8	185	2011-P00050
60	Windmar Renewable Energy , Inc. (Cantera Martinó)	PV	2.1	21	2.8	197	2012-P00015
18	Horizon Energy, Inc. (Salinas Solar Farm)	PV	10	21	2.9	178	2011-P00034
24	Landfill Gas Technologies of Fajardo, LLC	Landfill Gas	4	80	3.1	100	2013-P00044
25	Landfill Gas Technologies of Fajardo, LLC (Toa Baja)	Landfill Gas	4	80	3.3	100	2013-P00073
3	PV Project # 3	PV	20	21	3.5	163	2012-P00037
4	PV Project # 4	PV	57	21	4.2	172	2011-P00043
5	PV Project # 5	PV	20	21	4.4	160	2013-P00070
7	PV Project # 7	PV	40	20	4.8	175	2012-P00031
15	PV Project # 15	PV	20	21	5.1	165	2013-P00042
16	PV Project # 16	PV	17.8	21	5.3	171	2011-P00042
21	PV Project # 21	PV	33.5	20	5.6	167	2012-P00053
30	PV Project # 30	PV	50	20	6.2	180	2011-P00048
36	PV Project # 36	PV	20	21	6.4	185	2012-P00045
39	PV Project # 39	PV	20	21	6.6	170	2012-P00061
42	PV Project # 42	PV	20	21	6.9	170	2013-P00003
43	PV Project # 43	PV	20	21	7.1	158	2013-P00041
47	PV Project # 47	PV	25	19	7.4	163	2012-P00146
48	PV Project # 48	PV	20	21	7.6	158	2013-P00052
57	PV Project # 57	PV	20	21	7.8	165	2012-P00080
62	PV Project # 62	PV	10	21	7.9	185	2012-P00052
63	PV Project # 63	PV	20	20	8.1	185	2013-P00049
8	PV Project # 8	PV	10	21	8.3	185	2013-P00046
9	PV Project # 9	PV	30	21	8.6	185	2013-P00045
10	PV Project # 10	PV	15	21	8.8	185	2013-P00048
11	PV Project # 11	PV	30	21	9.1	185	2013-P00047
12	PV Project # 12	PV	15	21	9.3	185	2013-P00050
17	PV Project # 17	PV	30	21	9.6	185	2013-P00074
22	PV Project # 22	PV	40	21	10.1	185	2012-P00140
23	PV Project # 23	PV	20	21	10.3	185	2012-P00138
27	PV Project # 27	PV	52	21	10.9	185	2012-P00141
28	PV Project # 28	PV	20	21	11.1	185	2013-P00068
34	PV Project # 34	PV	20	21	11.4	185	2013-P00076
35	PV Project # 35	PV	20	21	11.6	185	2013-P00075
41	PV Project # 41	PV	20	21	11.8	185	2013-P00069
44	PV Project # 44	PV	20	20	12.0	185	2013-P00004
45	PV Project # 45	PV	20	21	12.3	185	2013-P00072
53	PV Project # 53	PV	30	21	12.6	185	2012-P00139
54	PV Project # 54	PV	30	21	12.9	185	2011-P00090
56	PV Project # 56	PV	20	21	13.2	185	2012-P00079
		TOTAL	**1,056**				

Section

6

Utility Scale Solar PV Costs

For utility scale solar PV projects assumed besides those that have valid contracts (including renegotiated contracts), Siemens PTI estimated a levelized cost of energy, which reflects the capital costs, tax credits, and fixed operating costs. The estimated levelized cost presented in Table 6-1 takes into consideration the significant reduction in capital cost for PV projects and that PREPA is likely to capture (at least partially) via competitive bidding after 2020. This generic utility scale solar PV levelized cost of energy (LCOE) for fixed axis projects are applied to PRPEA's generic renewable projects that come on line after 2020. Table 6-2 lists the projects that assumed generic LCOE in the Supplemental IRP.

Table 6-1: Levelized Cost of Energy (LCOE) for Generic Solar PV Projects

Year	All-In Capital Cost (2015$/kW)		LCOE (2015$/MWh)	
	Fixed Axis	Single Axis Tilt	Fixed Axis	Single Axis Tilt
2021	**2,406**	2,704	**130**	131
2022	**2,329**	2,617	**130**	131
2023	**2,255**	2,534	**138**	139
2024	**2,184**	2,454	**134**	135
2025	**2,114**	2,376	**130**	131
2026	**2,048**	2,301	**126**	127
2027	**1,983**	2,229	**123**	124
2028	**1,921**	2,159	**119**	120
2029	**1,861**	2,092	**116**	117
2030	**1,803**	2,026	**113**	113
2031	**1,776**	1,996	**111**	112
2032	**1,750**	1,966	**110**	110
2033	**1,723**	1,937	**108**	109
2034	**1,697**	1,907	**107**	107
2035	**1,672**	1,879	**105**	106

Source: Pace Global

Table 6-2: Levelized Utility Scale Solar PV Project Costs

New Renewable PPOAs	Nameplate Capacity (MW)	Commercial Online Date	Base IRP Contract Price ($/MWh)	Supplement IRP LCOE ($/MWh)
PV Project # 22	40	2021	185	130
PV Project # 23	20	2022	185	130
PV Project # 27	52	2025	185	130
PV Project # 28	20	2026	185	126
PV Project # 34	20	2029	185	116
PV Project # 35	20	2031	185	111
PV Project # 41	20	2031	185	111
PV Project # 44	20	2031	185	111
PV Project # 45	20	2031	185	111
PV Project # 53	30	2032	185	110
PV Project # 54	30	2032	185	110
PV Project # 56	20	2032	185	110
PV Project # 95	51	2032	185	110
PV Project # 96	38	2032	185	110
PV Project # 97	25	2032	185	110
PV Project # 98	76	2032	185	110
PV Project # 99	63	2032	185	110

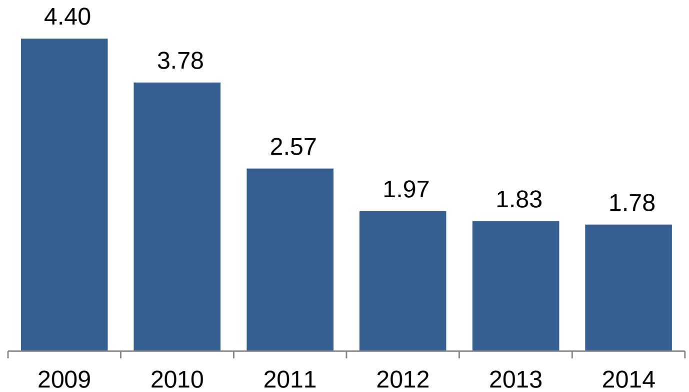
Source: Pace Global

6.1 Utility Scale Solar PV Capital Costs

In arriving at technology cost estimates, Siemens PTI Pace Global reviews public reputable studies, available IRPs, and our client's confidential experience. We generally do not employ data from press releases as determining the basis of the estimated costs is usually not feasible. This helps ensure analysis is considered on an "apples-to-apples" basis. As a result, our estimates are derived from no single source.

In the case of solar PV, the National Renewable Energy Lab (NREL) provides a rich data set from which to explain current costs and trends. According to NREL, utility scale solar PV pricing continued to decline in Q1 of 2015 with fixed-tilt 100 MW solar PV overnight costs now reaching $1.78/Wdc as shown in Figure 6-1 below. At the same time, NREL reports the average cost for a single axis 100 MW solar PV system is $1.91/Wdc. However, for utility scale systems that must integrate with existing AC grid systems, project performance and cost must be considered on an AC power basis. The Department of Energy's (DOE) Sunshot program regularly reports on solar developments and in its Photovoltaic System Pricing Trends, 2015 Edition the AC to DC Utility scale solar PV conversion factor for fixed tilt systems were 1.27 and for single axis tracking system the conversion was 1.33. As a result, NREL's Q1 2015 U.S. National Average utility scale fixed tilt and signal axis system costs are $2.26/Wac and $2.54/Wac respectively. However, these are in fact 2014 values reported in 2015. To adjust these 2014 figures to current year, the GDP deflator series was applied. Therefore the estimated 2015 U.S. National Average utility scale fixed tilt and signal axis system costs are $2.29/Wac and $2.58/Wac, respectively.

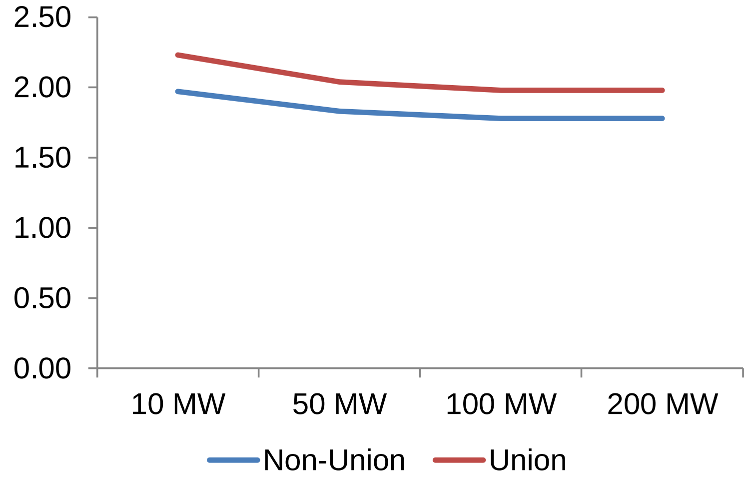
Figure 6-1: 100 MW Fixed Tilt U.S. National Average (2015$/Wdc)



Source: NREL

NREL's costs, while instructive, do not represent the complete cost of a 20-50 MW solar PV system for PREPA. First, NREL's costs do not include financing costs, which would add approximately 7.2 percent to the cost given the expected construction cycle. Second, for smaller systems such as those considered for PREPA, there are diseconomies of scale, which increase unit prices as evidenced in Figure 6-2 below. As a result, the unit costs of a 20 - 50 MW capacity system are generally about 10 percent higher than for the 100 MW systems in NREL's estimates. Finally, in general construction costs on Puerto Rico are higher than the U.S. national average. According to standard Department of Defense (DoD) cost factors used to evaluate global construction costs, construction costs are about 16 percent higher in Puerto Rico. Therefore, the 2015 all in cost to build a 20 MW utility scale fixed tilt and signal axis system on Puerto Rico are estimated at \$3.12/Wac and \$3.51/Wac, respectively.

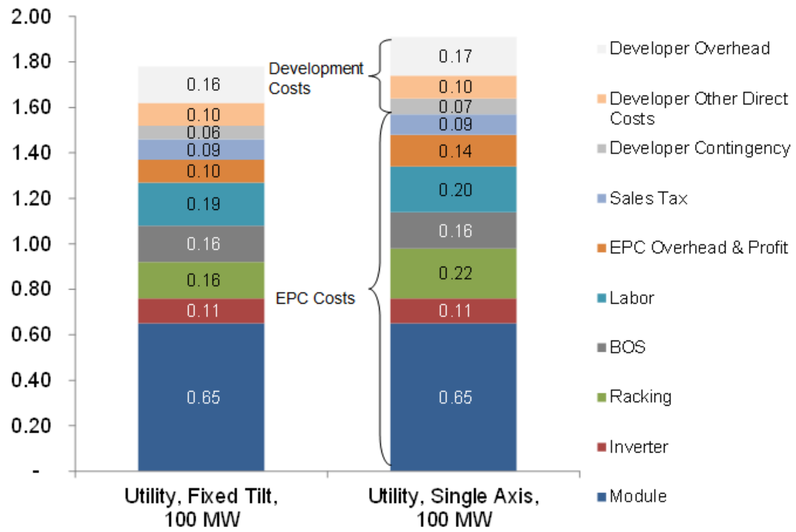
Figure 6-2: Solar PV Economies of Scale by Labor Type for Fixed Tilt (2015$/Wdc)



Source: U.S. Photovoltaic Prices and Cost Breakdowns: Q1 2015 Benchmarks for Residential, Commercial, and Utility-Scale Systems; NREL, September 2015

Importantly, while costs declined as the NREL study indicates, the rate of decline has slowed significantly in the past 2-3 years as production scale and global competition has driven equipment pricing down. Though some continued improvement in equipment cost is expected, NREL and other experts now expect most cost reductions will come from solar PV project soft costs. Soft costs generally include cost items such as Installation Labor, EPC Overhead & Profit, Developer Contingency, Developer Other Direct Costs, and Developer Overhead. As displayed in Figure 6-3 below, for the fixed tilt and single axis systems, soft costs comprise $0.60/Wdc and $0.68/Wdc, respectively.

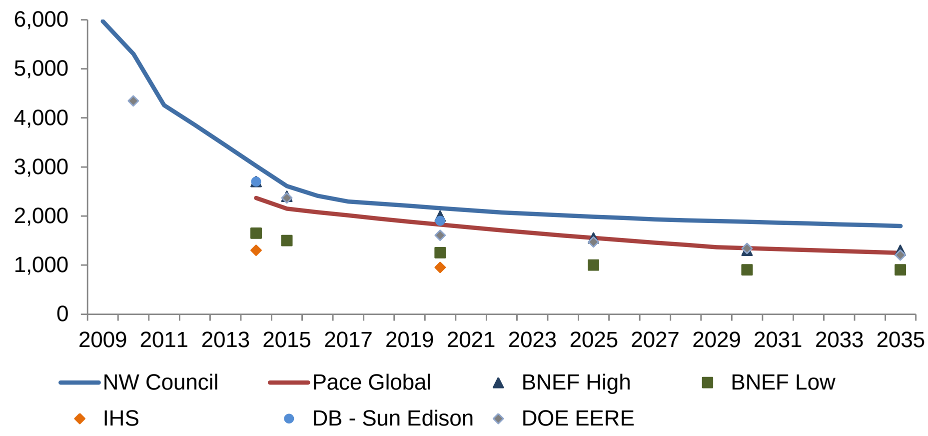
Figure 6-3: 100 MW U.S. National Average Solar PV Cost Breakdown, (2015$/Wdc)



Source: U.S. Photovoltaic Prices and Cost Breakdowns: Q1 2015 Benchmarks for Residential, Commercial, and Utility-Scale Systems; NREL, September 2015

To forecast capital cost for solar power generation technology, Siemens PTI Pace Global reviewed numerous public sources regarding industry issues, trends, and predictions. Equipment, material, labor, and developer costs were considered to derive the rate of cost change. This estimate was then compared with independent forecasts to ensure consistency. As a result, Pace Global expects solar capital costs to decline at a compound annual growth rate of 2.7 percent p.a. through 2035, which is in-line with other expert forecasts presented in Figure 6-4 below.

Figure 6-4: U.S National Average Overnight Solar PV Capital Costs (2015$/kW)



Source: DOE, Pace Global, NW Council, BNEF, IHS, DB – Sun Edison

By combining the 2015 Puerto Rico capital cost estimate with the anticipated decline rate in solar power generation technology costs, a specific forecast for solar PV cost on Puerto Rico were derived as shown in Table 6-1.

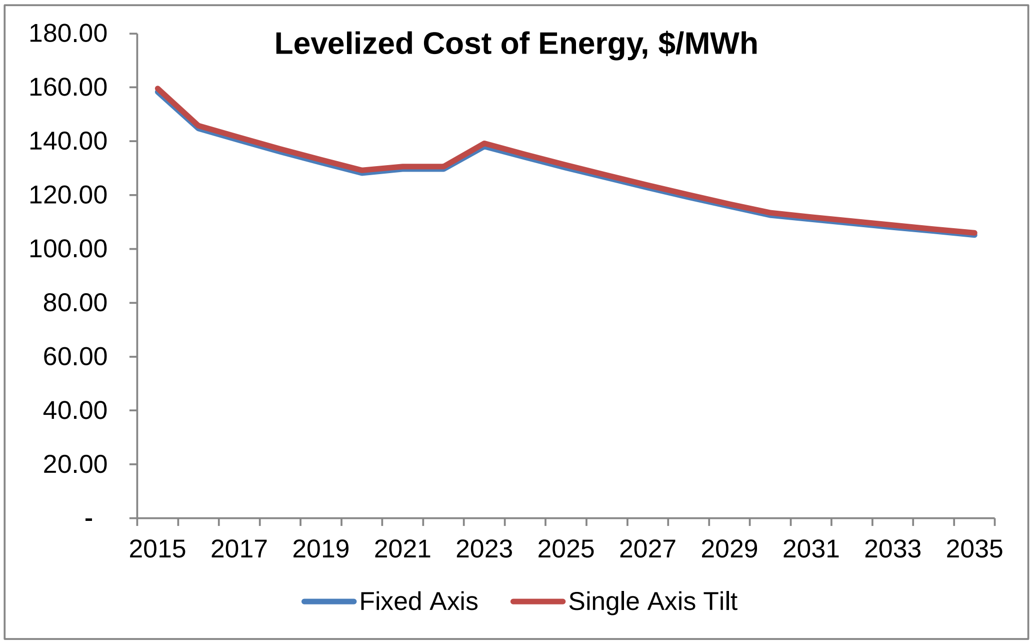
6.2 Fixed Operating Costs

To determine the operations and maintenance expenditure that might be expected for a solar power generator, Pace Global compared the estimates of other reputable industry studies and recent utility integrated resource plans available in the public domain. Estimates for fixed panel systems varied from $10.00/kW-yr. to $33.50/kW-yr. with an average of $19.58/kW-yr., while single axis tilt systems are expected to require annual operations and maintenance expenditures of $21.75/kW-yr.

6.3 Levelized Cost of Solar

The graphic below shows the levelized cost of solar for the fixed axes and single axes tracking systems over time. In the 2016-2020 period, levelized costs decrease due to declining capital costs. However, in the 2021-2023 period, levelized costs increase despite decreasing capital costs due to a step down in the investment tax credit. Post 2023, the capital costs again decrease due to the declining capital costs while the investment tax credit remains the same through the end of the forecast period.

Figure 6-5: Levelized Cost of Energy (2015$/MWh)



Source: Pace Global

The levelized cost is a function of capital cost, fixed operating and maintenance costs, capital recovery factor, and capacity factors associated with each solar technology. Pace Global used capacity factor of 21 percent for fixed axis and 23.4 percent for single axis tilt for Puerto Rico. The capital recovery factor is an annual stream of payments required to make the project whole over the useful life of the technology. In determining the capital recovery factor, a number of different parameters are considered. These include the useful life, MACRS depreciation schedule, financing parameters (cost of equity, cost of debt, capital structure), and federal renewable tax credits. Table 6-3 summarizes the components of the capital recovery factor. The federal renewable tax credits for solar include a 30 percent tax credit for solar installations between 2015 and 2020, 26 percent in 2021, 22 percent in 2022, and 10 percent from 2023 onwards.

Table 6-3: Assumptions of Capital Recovery Factor

Useful life	20 years
MACRS Depreciation Schedule	5 years
Cost of Equity	15.3 percent
Cost of debt	9 percent (nominal)
Capital Structure Debt to Equity	60:40
Income Taxes	8 percent
Inflation Rate	2 percent

Source: Pace Global

6.4 Renewable Energy Certificates (RECs)

Pace Global projects the price of renewable energy certificates to meet Puerto Rico RPS goals based on the fundamental drivers of the value of these instruments. RECs represent the cost premium of renewable energy qualified to meet the RPS over the average cost of energy from traditional sources. Pace Global assumes that the majority of PREPA's uncontracted RPS requirements will be supplied by solar PV generating facilities as it is the most cost competitive qualified renewable technology in Puerto Rico and the technology for which PREPA has secured most of its forward purchases to meet RPS requirements. Solar module costs have declined notably in recent years resulting in a lower all in cost. Pace Global expects further reductions in project installation and "soft" costs in the coming years to further reduce solar' s levelized cost of energy between 2016 and 2030. The projected REC price curve reflects this decline while also accounting for the outlook of the average cost of energy from traditional sources. Pace Global projects REC prices at or above $30/MWh before 2020 and after this time, prices declining to the $5/MWh level by 2030. This decline is largely driven by the expected reduction in the all in cost of solar PV during this time period. The forecasted levelized cost of PV solar power includes the REC costs.

Section

7

Demand Response

Demand response (DR), *i.e.*, the shift of demand from the night peak to the mid-day to increase the capability to incorporate renewables, was assessed. For this purpose, we determined the demand response necessary to achieve a maximum of 2 percent curtailment with RPS compliance. Two percent curtailment is seen as a practical high limit by PREPA.

If the cost of PV drops as expected, then greater levels of renewable integration could be achieved by providing incentives to customers to install time-based control systems in their homes, commercial establishments or industries to shift this demand from the night peak to the day-peak and mid-day hours where the cost of generation would be lower than the long run marginal cost of new generation at night. The control systems will prevent some loads (such as appliances, HVAC, industrial processes) from operating during the night peak and instead make them run pre-cooling and/or other processes during the day time hours. If the current PPOA prices hold, there would be practically no economic incentive for the implementation and the funding of demand response in order to increase renewables integration.

The demand response used in the study was designed so that the curtailment was limited to two percent and it was optimized each year to reflect the increasing capability of PREPA's fleet to accommodate renewable generation. Thus the levels of demand response that PREPA will need to acquire vary by year. This assumption may be optimistic and the actual demand response may likely deviate, but this analysis provides a view of the maximum benefits that can be expected.

Table 7-1 below shows the levels of renewable considered and the curtailment that is expected under the base scenario (P3MF1M) for full RPS compliance and daytime hours[10]. Note that as the fleet modernizes the level of curtailment drops. This is followed in the table by the required ***average level*** of demand response by year. This is a selected value so that when multiplied by the shape of the demand response (see below) the curtailment is limited to a design value of 2 percent[11]. Note that this required average DR Level increases to 2025

[10] There can be night time curtailment due to conventional generation limitations but this can only be handled using the minimum non-regulating limits of the generators. This is not feasible during daytime with PV generation online as regulation is a paramount consideration for the safe operation of the system.

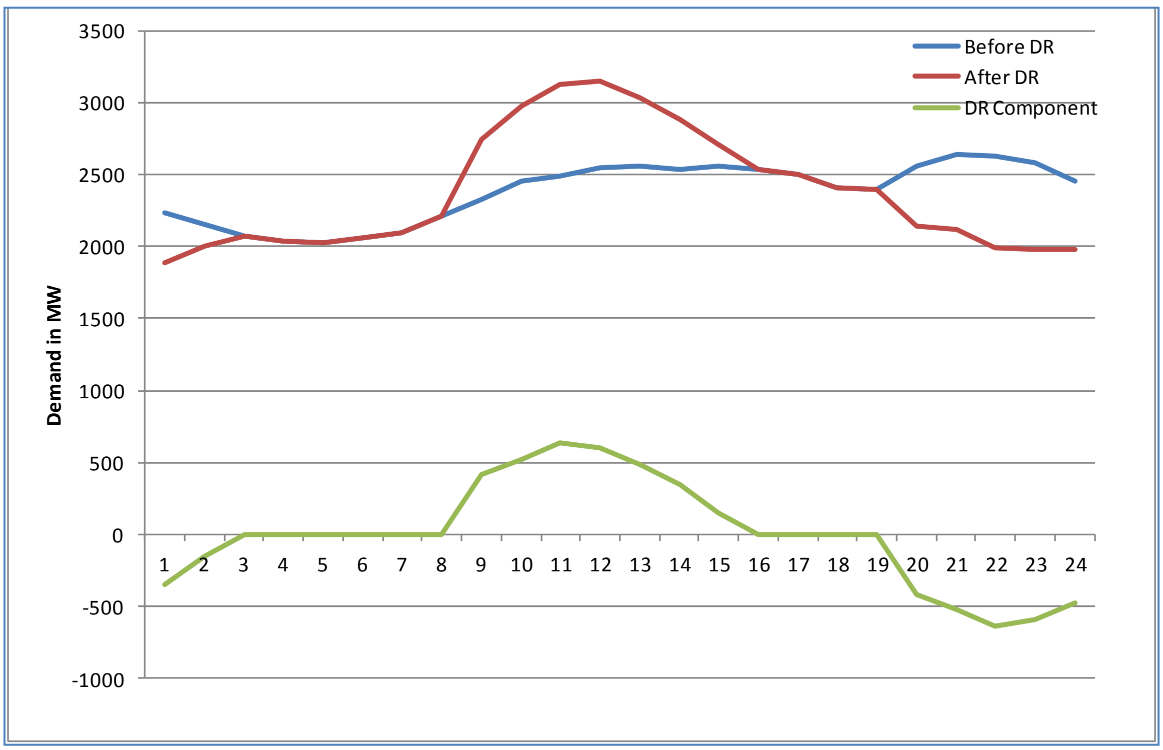
[11] The actual obtained curtailment was higher than this target, possibly due to additional restrictions on regulating reserve that necessitated having more thermal units online than

to a value of 450 MW, after which drops to a minimum of 70 MW by 2035. The last column of the table shows the estimated curtailment with the demand response in place. This last value is an approximation used for the design. Actual values will come from the simulations and presented later in this report.

To complement the average DR level, its shape was determined so that the response approximately matched the shape of the curtailment and the demand response contribution was maximum close to noon time and reduces towards the hours of the morning and evening.

The average DR level times the shape produces the DR for each year as indicated above. The figures below show as a reference the demand before and after the modeled response for year 2025 and various day types (maximum, average and minimum demand days). The actual demand response is also provided.

Figure 7-1: Maximum Demand Day



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those considered in the design. This finding is further supported by the fact that the “night” or thermal curtailment increased significantly; i.e. the need to bring thermal units to their emergency lower limits due to low demand.

Figure 7-2: Average Demand Day

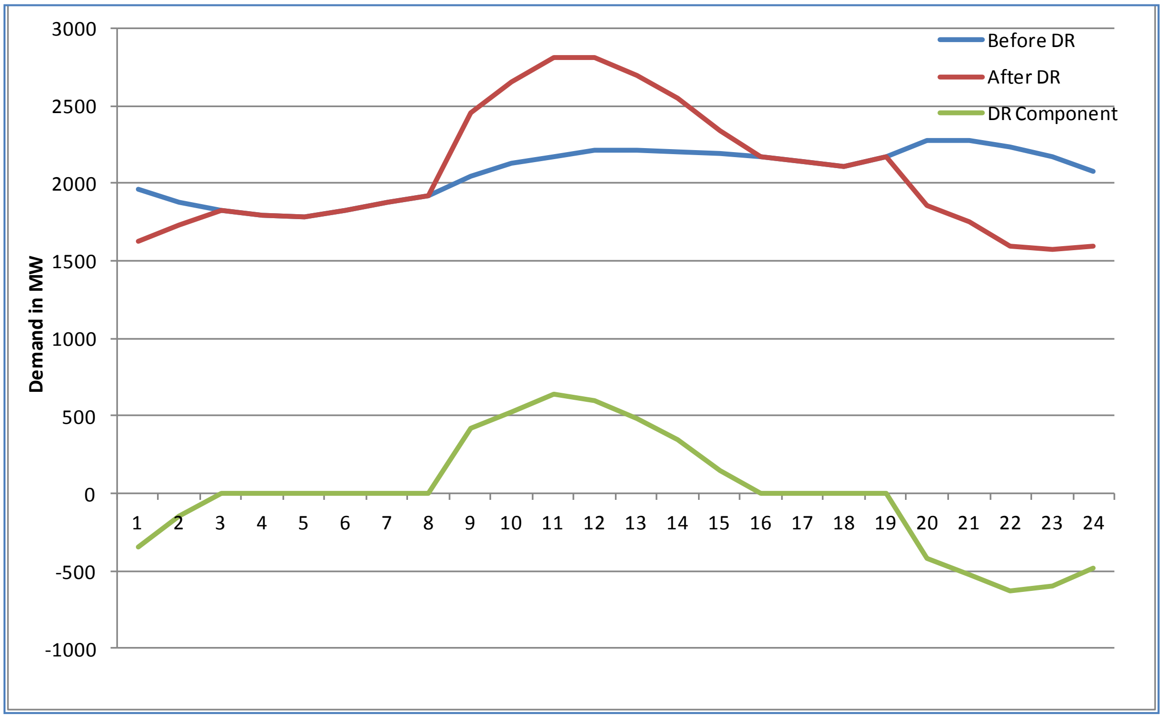
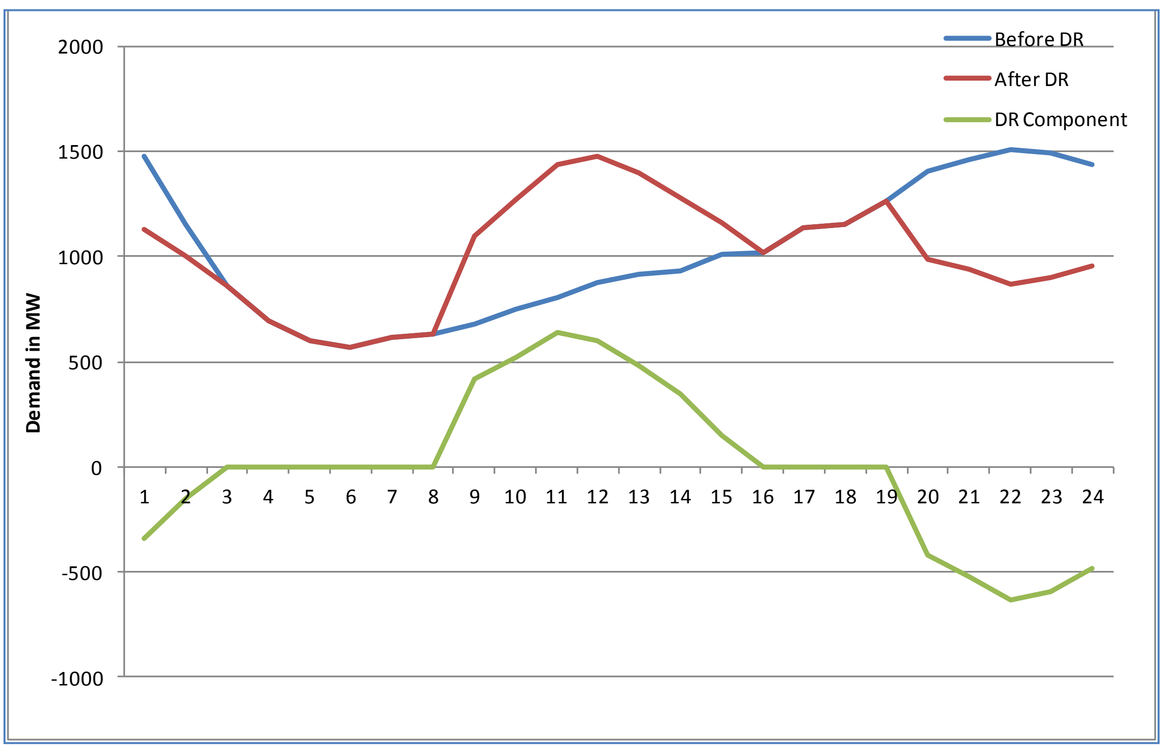


Figure 7-3: Minimum Demand Day



Clearly a well-designed demand response program will increase the capability to incorporate more renewable PV generation (an almost 1-for-1 relationship in MWh), and this is what we designed our model to represent. The analysis will provide not only the impact in renewable penetration increases, but also supply costs reductions as shown later in this report.

Comparing the cost of the additional PV generation during the day with the savings from reduced conventional generation in the evening, the economic justifications for the implementation of the demand response program can be assessed. This will be demonstrated by comparing the cost of the base P3MF1M case with reduced targets, with the costs of this demand response case.

Note however that from the outset we do not expect demand response to be economic, even assumed that it has zero cost and considering the absolute minimum cost for PV generation presented in the previous section at $110/MWh - $130/MWh, which is significantly higher than the cost of conventional generation on a H Class combined cycle unit (average variable cost of $67/MWh and all in costs – including fixed costs and amortized capital costs – of $93/MWh).

In case PREPA decides to advance a demand response program, studies need to be conducted including: (1) the market assessment and energy audits for identification of opportunities; (2) determine the target markets (i.e., commercial clients, industrial, residential); (3) design the incentive programs based on the resources that will become available to PREPA as a result of the load shift and/or government incentives; and (4) roll out and monitor.

Table 7-1: Demand Response Level

Calendar Year	Renewable Generation MWh	Total Curtailment MWh	Daytime Curtailment MWh (1)	Main Curtailment MWh (2)	Peak Average Curtailment MW*	Day Curtailment %	Demand Response Level MW (3)	New Day Curtailment MWh	New Daytime Curtailment %
2015	1,277,838	85,475	67,106	47,689	32.2	5.3%	0.0	67,106	5%
2016	2,145,958	150,026	142,993	110,642	82.0	6.7%	200.0	37,033	2%
2017	2,343,167	148,441	140,624	108,523	80.3	6.0%	200.0	36,245	2%
2018	2,538,426	245,743	231,179	175,502	120.4	9.1%	300.0	55,410	2%
2019	2,666,256	310,372	301,381	237,852	165.6	11.3%	400.0	43,821	2%
2020	2,732,648	596,532	575,445	437,856	288.9	21.1%	560.0	63,928	2%
2021	2,757,378	284,097	275,130	218,805	159.1	10.0%	300.0	47,340	2%
2022	2,784,227	393,152	382,904	298,887	211.8	13.8%	350.0	67,396	2%
2023	2,811,879	369,626	358,184	283,625	201.8	12.7%	350.0	53,060	2%
2024	2,841,530	362,197	348,217	272,206	188.2	12.3%	350.0	58,988	2%
2025	2,861,781	526,500	511,620	393,872	269.9	17.9%	450.0	62,547	2%
2026	2,886,360	405,167	395,140	307,203	214.6	13.7%	400.0	66,444	2%
2027	2,910,860	216,540	211,265	175,356	130.5	7.3%	200.0	56,365	2%
2028	2,938,468	248,283	243,297	203,204	147.3	8.3%	200.0	60,336	2%
2029	2,956,707	259,341	254,168	210,228	152.0	8.6%	200.0	56,844	2%
2030	2,979,686	146,968	144,712	119,580	95.4	4.9%	90.0	61,975	2%
2031	3,001,905	112,315	111,200	93,091	75.0	3.7%	70.0	47,886	2%
2032	3,029,550	114,817	113,354	94,117	74.8	3.7%	50.0	57,907	2%
2033	3,047,586	134,387	132,488	110,653	88.3	4.3%	50.0	73,068	2%
2034	3,070,209	146,785	143,617	117,480	92.5	4.7%	70.0	64,285	2%
2035	3,091,803	143,646	140,927	112,554	91.0	4.6%	70.0	59,438	2%

Notes

(1) Day Time Curtailment = Curtailment from 7 AM to 7 PM

(2) Main Curtailment = Curtailment from 9 AM to 3 PM used to provide a first indication on when DR should occur.

(3) Demand Response Level = the average value of the required demand response. This value x Demand Response Shape = Demand Response in MW.

Section

8

Supplemental IRP PFS Details and Results

This section provides detailed PSF construction, schedule, reserve margin, cost, environmental and operation metrics for each of the eight PSF combinations required by the Commission and presented in Table 1-1.

8.1 Portfolio 3 Modified Future 1 Modified (P3MF1M)

8.1.1 Schedules and New Generation Resources

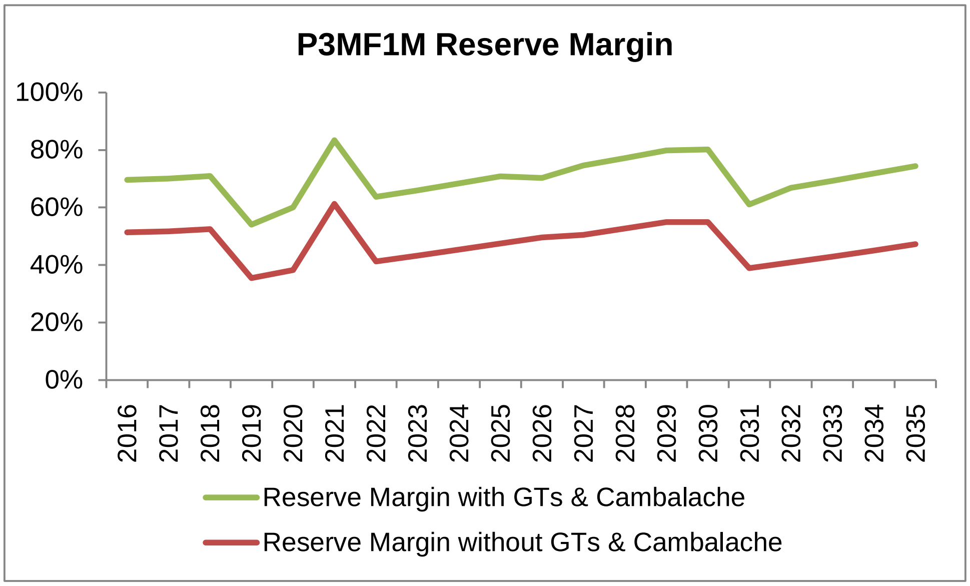
In P3MF1M, the new generation resources are selected and sequenced to best serve the assumed lower demand due to ramping EE penetration and the modified RPS targets discussed in Section 5 of this report. In addition to advancing the repowering of the Aguirre CC units to July 1, 2020, four new generation resources are added in P3MF1M to achieve an acceptable reserve margin as shown in Figure 8-1. Detailed key decisions are presented in Figure 8-2, and a timeline indicating key portfolio retirement, fuel switching, and new build schedules is presented in Figure 8-3. As a result, P3MF1M incurs total capital costs of $4,614 million during 2016-2035, much lower than P3F1 capital costs of $5,252 million in the Base IRP. The new fossil fueled generation resources include:

- SCC-800 1X1 CC with diesel as primary fuel at Palo Seco by July 1, 2020;
- H Class 1X1 CC with natural gas as primary fuel at Costa Sur by July 1, 2026;
- H Class 1X1 CC with natural gas as primary fuel at Aguirre by July 1, 2026; and
- H Class 1X1 CC with natural gas as primary fuel at Aguirre by July 1, 2029.

Costa Sur 5&6 steam units will be retired by July 1, 2026, while Aguirre 1&2 steam units will be retired by July 1, 2029 and July 1, 2030, respectively.

Recall that the retirement of the existing generation was done as soon as it could be achieved without compromising system reliability, however in practice these units add flexibility to the dispatch and their retirement will be a function of balancing actual operating costs as affected by practical impacts of aging and impacts on integration of renewable generation with the savings introduced in the economic dispatch.

Figure 8-1: P3MF1M Reserve Margin



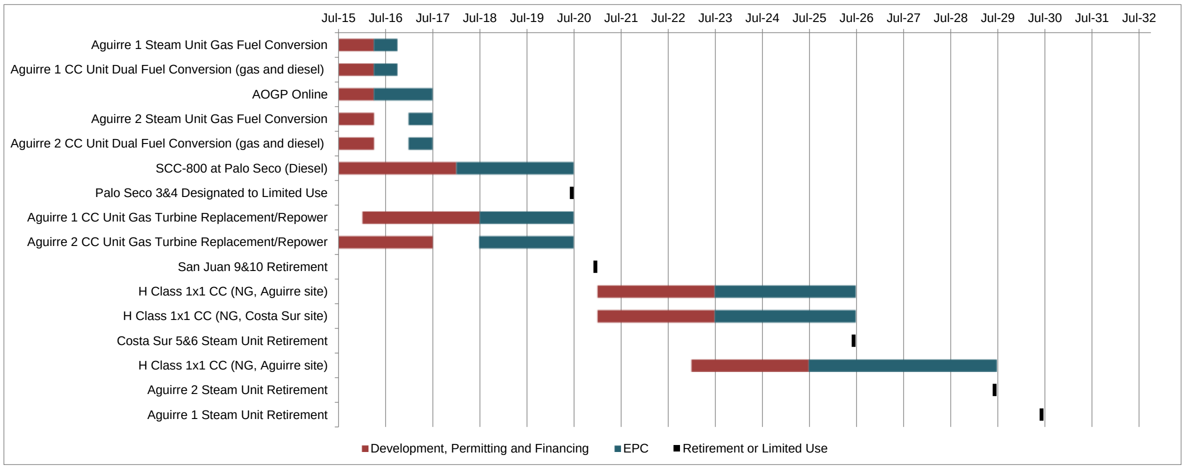
Source: Siemens PTI, Pace Global

Figure 8-2: P3MF1M Key Decisions

Portfolio Decisions that Differ from P3F1	Date	Capacity Impact (MW)
SCC-800 at Palo Seco (Diesel)	7/1/2020	70
Aguirre 1 CC Unit Gas Turbine Replacement/Repower	7/1/2020	4
Aguirre 2 CC Unit Gas Turbine Replacement/Repower	7/1/2020	4
H Class 1X1 CC (NG, Costa Sur site)	7/1/2026	393
H Class 1X1 CC (NG, Aguirre site)	7/1/2026	393
Costa Sur 6 Steam Unit Retirement	7/1/2026	(410)
Costa Sur 5 Steam Unit Retirement	7/1/2026	(410)
H Class 1X1 CC (NG, Aguirre site)	7/1/2029	393
Aguirre 2 Steam Unit Retirement	7/1/2029	(450)
Aguirre 1 Steam Unit Retirement	7/1/2030	(450)

Source: Siemens PTI, Pace Global

Figure 8-3: P3MF1M Schedules



Note: San Juan steam units 9&10 and Palo Seco steam units 3&4 will be retired or designated as limited use.

Source: Siemens PTI, Pace Global

8.1.2 Cost Summary

The portfolio capital cost requirements are close to $4.61 billion during 2016-2035, with $3.15 billion during 2016-2025 and $1.46 billion during 2026-2035. System costs average $2.29 billion per year over the forecast period. The present value of system costs aggregates to $25.84 billion over the 2016-2035 forecast period. The annual portfolio or system costs slightly decrease over the forecast horizon by 0.60 percent per year on a real basis. The system efficiency improves significantly, with system thermal generation heat rate declining from 9,450 Btu/kWh in 2016 to 8,278 Btu/kWh in 2035. The annual fuel costs decrease by an average 4.92 percent per year over the study period.

8.1.3 Environmental Compliance Summary

The portfolio results indicate compliance with the proposed Clean Power Plan requirements, but not in compliance with the GHG New Source Standard when individual units are considered, in particular the issue was observed with the Aguirre CC 1&2, low dispatch levels and this could be addressed by adjusting the dispatch by for example including this limitation as a restriction in the operating cost optimization procedure.

The emission rate declines over time as the generation mix changes from oil fired generation capacity to new, more efficient natural gas fired generation capacity and greater renewable capacity. Total CO_2 emissions are expected to decline by 77 percent by 2035 from 2016 levels.

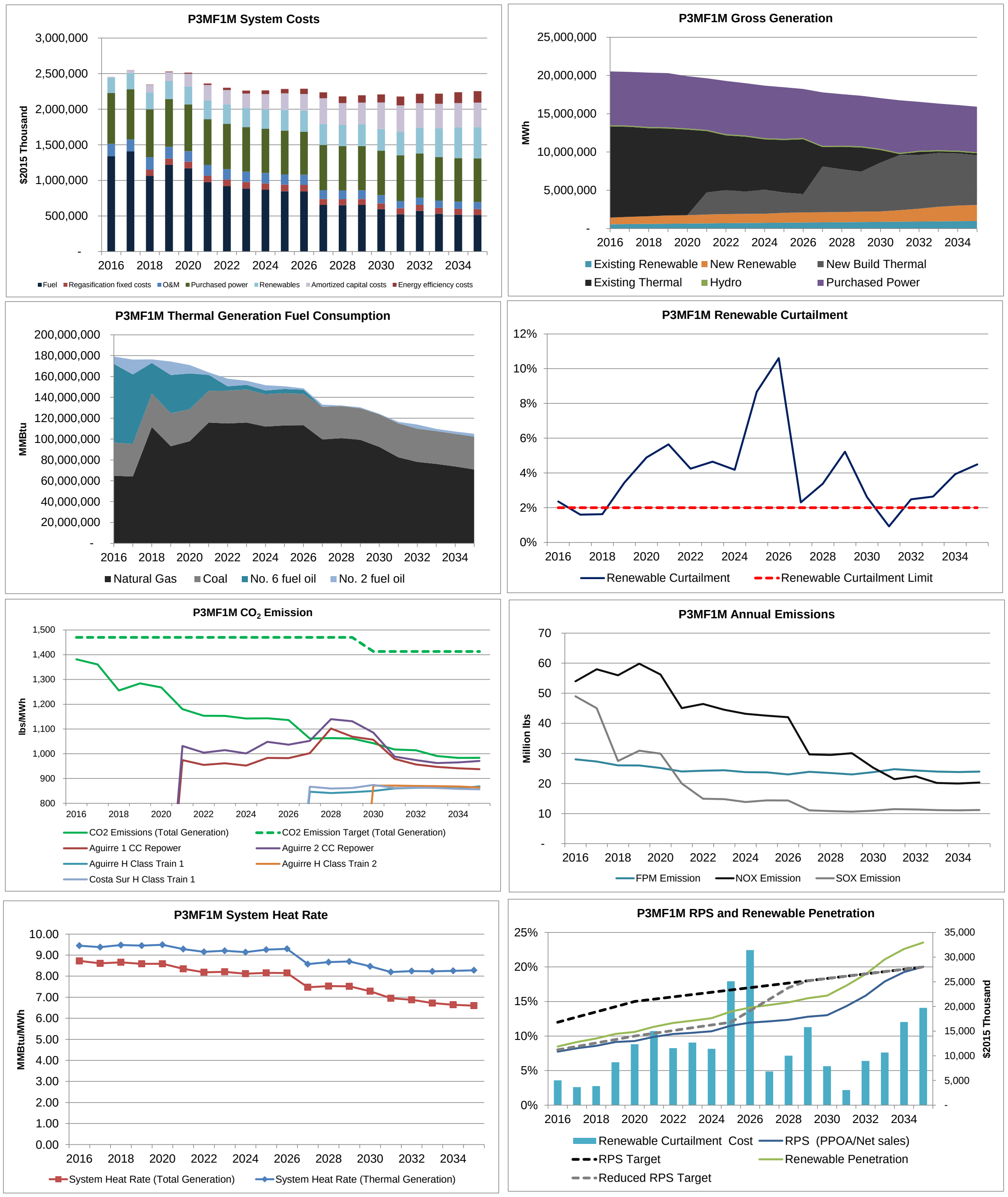
In terms of RPS goals, the portfolio is below (by less than 1 percent) a reduced RPS goal of 10 percent renewable generation of energy sales by 2020 and 12 percent by 2025, but slightly exceeds the 20 percent RPS goal by 2035. Renewable penetration levels are expected to reach 23.53 percent in 2035, while the RPS is expected at 20.04 percent in 2035. Renewable energy comes in the form of utility scale solar resources and distributed solar.

8.1.4 Operational Performance Summary

As expected, the day-time renewable curtailments are higher than P3F1 due to increased RPS. The portfolio performs well in terms of reliability with zero loss of load hours in most years and always at or below the threshold of 4 hours. The operating reserves are healthy for all years with the portfolio maintaining adequate spinning reserves to respond to generation and transmission contingencies. P3MF1M total gas consumption at Aguirre is well within the permit limit of AOGP during the IRP horizon. There is one year that the total gas consumption is within 1 percent of the limit, and this is considered within the margin of error of the POMOD simulations.

P3MF1M portfolio metrics are presented in Figure 8-4, and more results are presented in Appendix C.

Figure 8-4: P3MF1M Portfolio Metrics

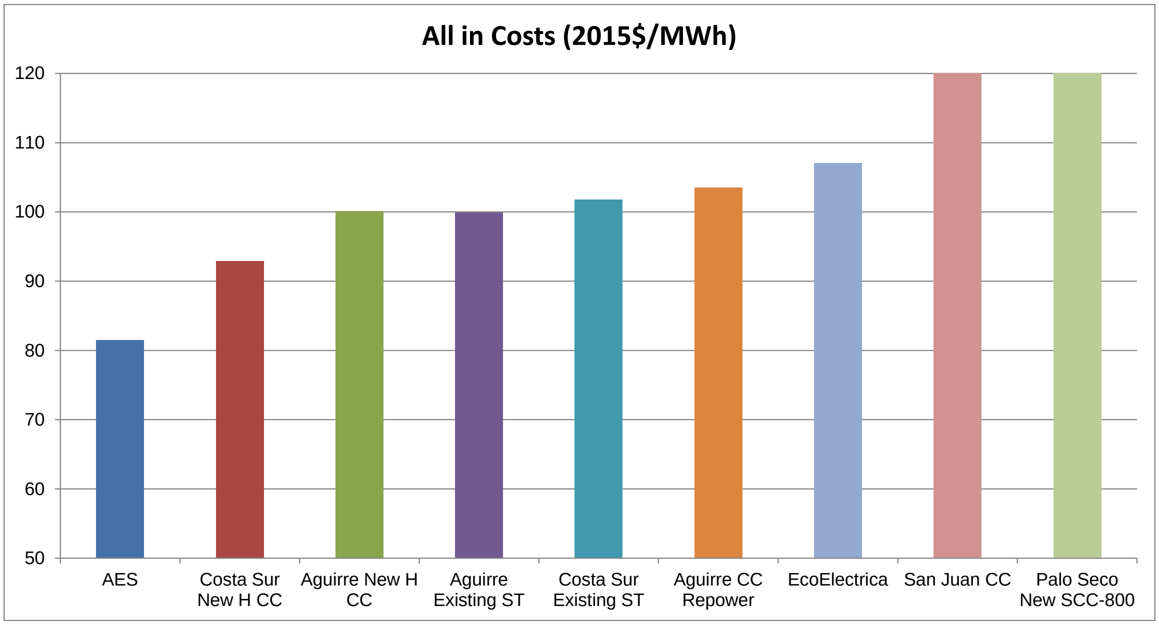


Source: Siemens PTI, Pace Global

8.1.5 Optimality

An assessment of all in costs comparison between the new H Class CC unit and the old Aguirre and Costa Sur steam units as shown in Figure 8-5 confirms the optimality of the new generation resources.

Figure 8-5: P3MF1M All In Costs by Generation Resources



Source: Siemens PTI, Pace Global

In addition, Siemens PTI examined the relative performance of four trains of reciprocating engines at Palo Seco (P3MF1M_RE) instead of the one SCC-800 1X1 CC (P3MF1M). Table 8-1 shows the costs metrics and Figure 8-6 shows the curtailment metrics. While the curtailment levels are similar, the overall system costs are higher for the P3MF1M_RE.

Table 8-1: P3MF1M_RE Cost Metrics

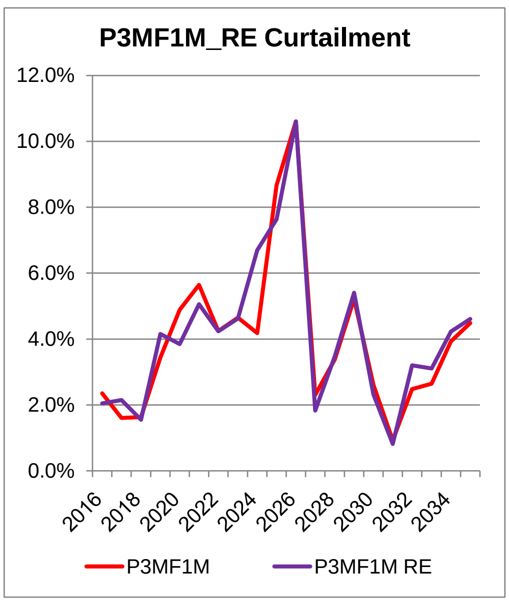
Capital Costs	Unit	Future 1	
		P3MF1M	P3MF1M_RE
FY 2016 - 2025 Total Capital Costs	*$ million*	3,153	3,122
FY 2026 - 2035 Total Capital Costs	*$ million*	1,461	1,461
FY 2016 - 2035 Total Capital Costs	*$ million*	4,614	4,584

Capital Costs	Unit	Future 1	
		P3MF1M	P3MF1M_RE
Generation	*$ million*	2,157	2,126
Fuel Infrastructure	*$ million*	385	385
Transmission	*$ million*	2,073	2,073
Total	*$ million*	4,614	4,584

System Costs	Unit	Future 1	
		P3MF1M	P3MF1M_RE
Total Present Value of System Costs	*$ million*	25,836	25,869
Average Annual System Costs	*$ million*	2,292	2,295

Source: Siemens PTI, Pace Global

Figure 8-6: P3MF1M_RE Curtailment Comparaison



Source: Siemens PTI, Pace Global

8.2 Portfolio 3 Modified Future 2 Modified (P3MF2M)

8.2.1 Schedules and New Generation Resources

In P3MF2M, the AOGP is not built. In this case, the new generation resources are selected and sequenced in consideration of five primary factors: (1) there is no gas at Aguirre and Aguirre 1&2 must be retired (or designated limited use) due to MATS compliance; (2) the assumed lower demand due to ramping EE penetration; (3) the modified RPS targets; (4) replacement of existing units with new highly efficient resources to save fuel costs; and (5) expedited new builds to upgrade the fleet and lower overall system costs.

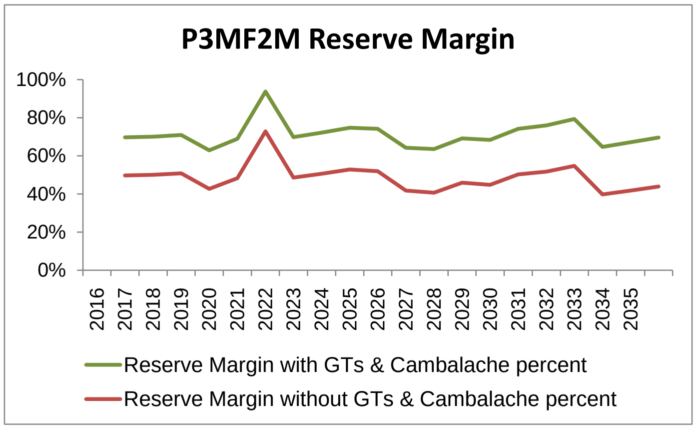
The Aguirre 1&2 CC units repowering remains the same schedule as in P3F2, i.e., by December 31, 2019 and 2020 respectively. Three new generation resources are added to achieve an acceptable reserve margin as shown in Figure 8-7. Detailed key decisions are presented in Figure 8-8, and a timeline indicating key portfolio retirement, fuel switching, and new build schedules is presented in Figure 8-9. As a result, P3MF2M incurs total capital costs of $3,794 million during 2016-2035, much lower than P3F2 capital costs of $4,674 million in the Base IRP. The new resources include:

- H Class 1X1 CC with diesel as primary fuel at Palo Seco by December 31, 2020;
- H Class 1X1 CC with diesel as primary fuel at Aguirre by December 31, 2020; and
- H Class 1X1 CC with natural gas as primary fuel at Costa Sur by December 31, 2021.

Aguirre 1&2 steam units will be retired by December 31, 2021, while Costa Sur 5&6 steam units can be retired by July 1, 2025 and July 1, 2032, respectively.

It is very important to note that from a generation point of view it would have been preferred to install two H Class combined cycle plants by December 31st 2020 at Costa Sur instead of only one. However, it is not feasible from a transmission point of view to have this generation in place together with Costa Sur units 5&6 and EcoEléctrica due to severe contingency overloads that would occur, as was demonstrated in a separate report named “PREPA Integrated Resource Plan Supplementary Evaluation: Transmission Analysis”.

Figure 8-7: P3MF2M Reserve Margin



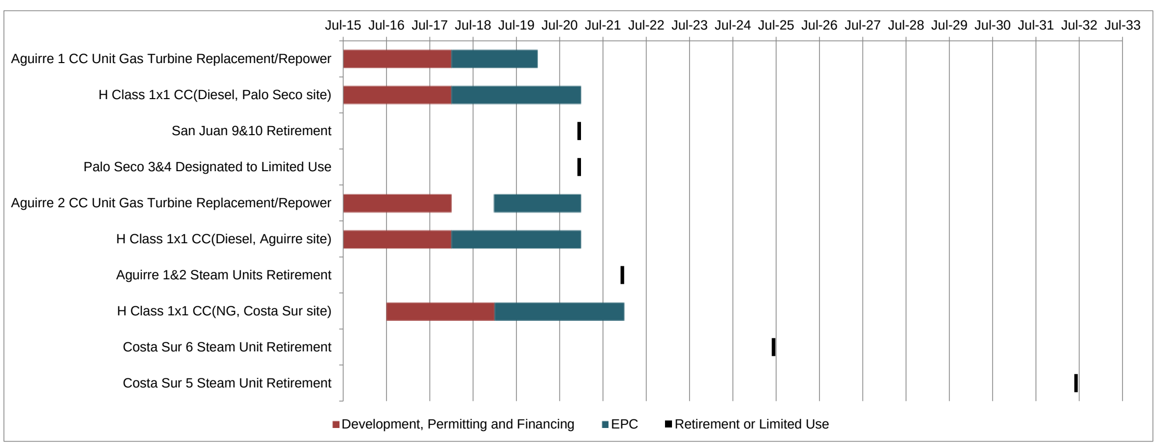
Source: Siemens PTI, Pace Global

Figure 8-8: P3MF2M Key Decisions

Portfolio Decisions that Differ from P3F2	Date	Capacity Impact (MW)
H Class 1x1 CC(Diesel, Palo Seco site)	12/31/2020	382
H Class 1x1 CC (Diesel, Aguirre site)	12/31/2020	382
H Class 1x1 CC (NG, Costa Sur Site)	12/31/2021	393
Aguirre 2 Steam Unit Retirement	12/31/2021	(450)
Aguirre 1 Steam Unit Retirement	12/31/2021	(450)
Costa Sur 6 Steam Unit Retirement	7/1/2025	(410)
Costa Sur 5 Steam Unit Retirement	7/1/2032	(410)

Source: Siemens PTI, Pace Global

Figure 8-9: P3MF2M Schedules



Note: San Juan steam units 9&10 and Palo Seco steam units 3&4 will be retired or designated as limited use.

Source: Siemens PTI, Pace Global

8.2.2 Cost Summary

The portfolio capital cost requirements are close to $3.8 billion during 2016-2035, with $3.75 billion during 2016-2025 and $0.05 billion during 2026-2035. System costs average $2.6 billion per year over the forecast period. The present value of system costs aggregates to $28.83 billion over the 2016-2035 forecast period. The annual portfolio or system costs slightly increase over the forecast horizon by 0.2 percent per year on a real basis. The system efficiency improves significantly, with system thermal generation heat rate declining from 9,457 Btu/kWh in 2016 to 8,239 Btu/kWh in 2035. The annual fuel costs decrease by an average 1.7 percent per year over the study period.

8.2.3 Environmental Compliance Summary

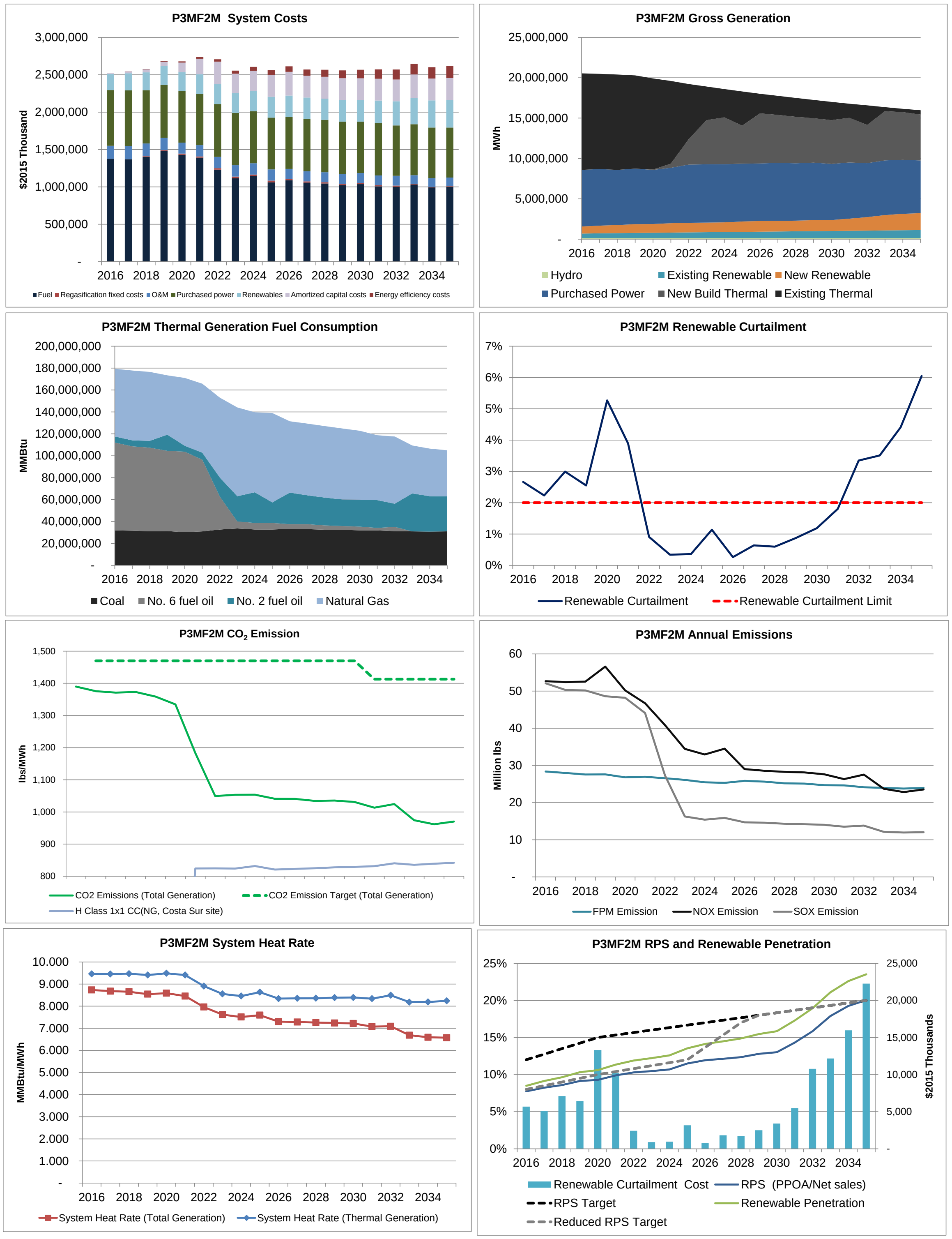
The portfolio results indicate compliance with the Clean Power Plan requirements and the GHG New Source Standard. The NOx, SOx, CO_2 and FPM emissions decline over time. Total CO_2 emissions are expected to decline by 46 percent by 2035 from 2016 levels.

In terms of RPS goals, the portfolio is below (by less than 1 percent) a reduced RPS goal of 10 percent renewable generation of energy sales by 2020 and 12 percent by 2025, but slightly exceeds the 20 percent RPS goal by 2035. Renewable penetration levels are expected to reach 23.53 percent in 2035, while the RPS is expected at 20.04 percent in 2035. Renewable energy comes in the form of utility scale solar resources and distributed solar.

8.2.4 Operational Performance Summary

The day-time renewable curtailments in the tail years are similar to P3F2 levels. The portfolio performs well in terms of reliability with zero loss of load hours in most years and always at or below the threshold of 4 hours. The operating reserves are healthy for all years with the portfolio maintaining adequate spinning reserves to respond to generation and transmission contingencies. P3MF2M portfolio metrics are presented in Figure 8-10, and more results are presented in Appendix C.

Figure 8-10: P3MF2M Portfolio Metrics



Source: Siemens PTI, Pace Global

8.3 Portfolio 3 Modified Future 1 Modified Sensitivity 1 (P3MF1M_S1)

8.3.1 Schedules and New Generation Resources

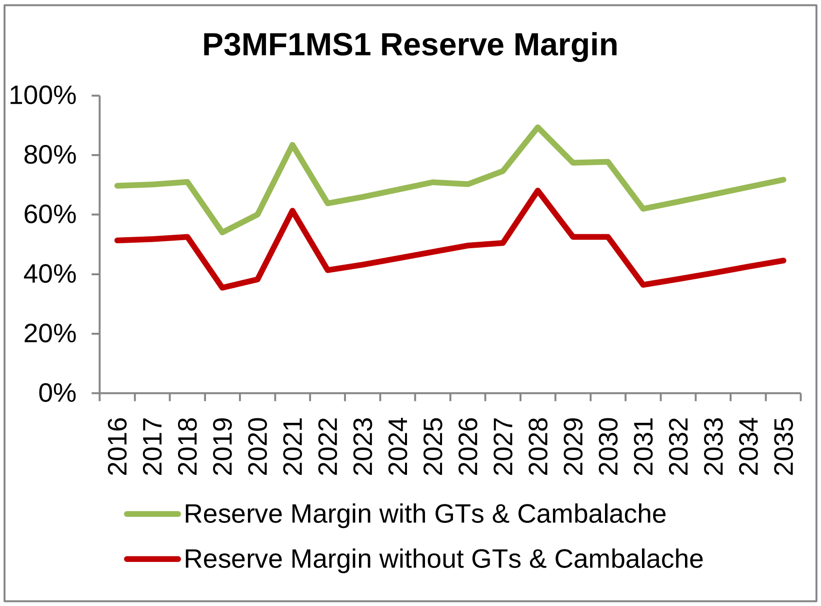
In P3MF1M_S1, which is a No AES case, the new generation resources are adjusted in consideration of these primary factors: (1) AES expires by December 31, 2027; (2) the assumed lower demand due to ramping EE penetration; and (3) the modified RPS targets.

In addition to advancing the repowering of Aguirre CC units to July 1, 2020, five new generation resources are added in P3MF1M_S1 to achieve an acceptable reserve margin as shown in Figure 8-11. Detailed key decisions are presented in Figure 8-12, and a timeline indicating key portfolio retirement, fuel switching, and new build schedules are presented in Figure 8-13. As a result, P3MF1M_S1 incurs total capital costs of $5,067 million during 2016-2035, lower than P3F1 capital costs of $5,252 million in the Base IRP. The new fossil fueled generation resources include:

- SCC-800 1X1 CC with diesel as primary fuel at Palo Seco by July 1, 2020;
- H Class 1X1 CC with natural gas as primary fuel at Costa Sur by July 1, 2026;
- H Class 1X1 CC with natural gas as primary fuel at Aguirre by July 1, 2026;
- H Class 1X1 CC with natural gas as primary fuel at Aguirre by July 1, 2027; and
- H Class 1X1 CC with natural gas as primary fuel at Costa Sur by July 1, 2029.

Costa Sur 5&6 steam units will be retired by July 1, 2026, while Aguirre 1&2 steam units can be retired by July 1, 2029 and July 1, 2030, respectively. The actual retirement date (beyond these dates) will be a function of the conditions of the units.

Figure 8-11: P3MF1M_S1 Reserve Margin



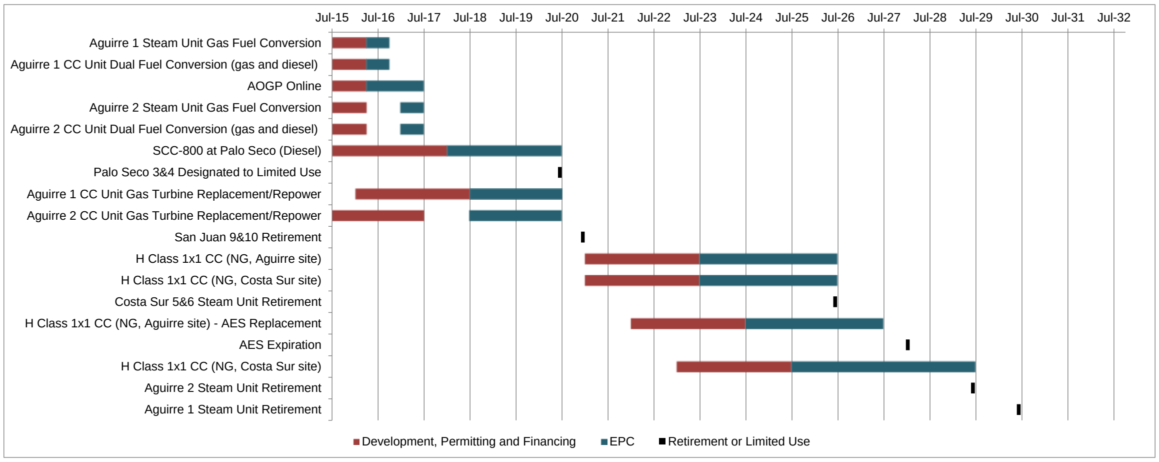
Source: Siemens PTI, Pace Global

Figure 8-12: P3MF1M_S1 Key Decisions

Portfolio Decisions that Differ from P3F1	Date	Capacity Impact (MW)
SCC-800 at Palo Seco (Diesel)	7/1/2020	70
Aguirre 1 CC Unit Gas Turbine Replacement/Repower	7/1/2020	4
Aguirre 2 CC Unit Gas Turbine Replacement/Repower	7/1/2020	4
Costa Sur 6 Steam Unit Retirement	7/1/2026	(410)
Costa Sur 5 Steam Unit Retirement	7/1/2026	(410)
H Class 1X1 CC (NG, Aguirre site)	7/1/2026	393
H Class 1X1 CC (NG, Costa Sur site)	7/1/2026	393
H Class 1x1 CC (NG, Aguirre Site, AES Replacement)	7/1/2027	393
AES Expiration	12/31/2027	(454)
H Class 1X1 CC (NG, Costa Sur site)	7/1/2029	393
Aguirre 2 Steam Unit Retirement	7/1/2029	(450)
Aguirre 1 Steam Unit Retirement	7/1/2030	(450)

Source: Siemens PTI, Pace Global

Figure 8-13: P3MF1M_S1 Schedules



Note: San Juan steam units 9&10 and Palo Seco steam units 3&4 will be retired or designated as limited use.

Source: Siemens PTI, Pace Global

8.3.2 Sensitivity Results Comments

P3MF1M_S1 evaluates the impact of not extending the AES contract after its termination as expected in 2027. Because AES plant is currently PREPA's least expensive resource, its retirement increases the system costs and incurs higher capital costs as shown in Table 8-2. Curtailment is improved as shown in Figure 8-14. Additional P3MF1M_S1 results are presented in Appendix C.

This sensitivity shows that the non-renewal of AES contract could be handled by the modified Portfolio 3 under Future 1 from a system operation perspective. However, it incurs higher capital costs and system costs. An extension of the AES contract is recommended because AES is the lowest cost resource in PREPA's fleet, and this can free up valuable capital resources for the modernization of the balance of PREPA's fleet.

Table 8-2: P3MF1M_S1 Cost Metrics

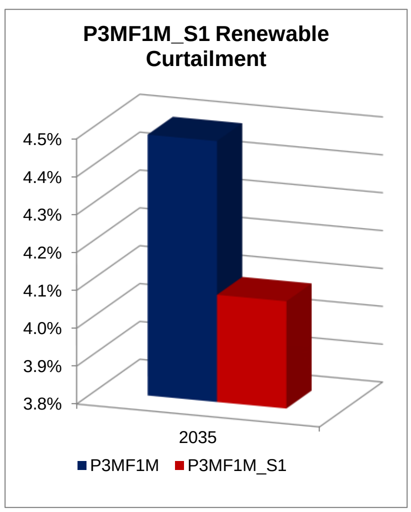
Capital Costs	Unit	Future 1	
		P3MF1M	P3MF1M_S1
FY 2016 - 2025 Total Capital Costs	*$ million*	3,153	3,153
FY 2026 - 2035 Total Capital Costs	*$ million*	1,461	1,914
FY 2016 - 2035 Total Capital Costs	*$ million*	4,614	5,067

Capital Costs	Unit	Future 1	
		P3MF1M	P3MF1M_S1
Generation	*$ million*	2,157	2,609
Fuel Infrastructure	*$ million*	385	385
Transmission	*$ million*	2,073	2,073
Total	*$ million*	4,614	5,067

System Costs	Unit	Future 1	
		P3MF1M	P3MF1M_S1
Total Present Value of System Costs	*$ million*	25,836	25,846
Average Annual System Costs	*$ million*	2,292	2,293
Present Value of System Costs Difference with P3MF1M	*$ million*		10

Source: Siemens PTI, Pace Global

Figure 8-14: P3MF1M_S1 Curtailment Comparison



Source: Siemens PTI, Pace Global

8.4 Portfolio 3 Modified Future 2 Modified Sensitivity 1 (P3MF2M_S1)

8.4.1 Schedules and New Generation Resources

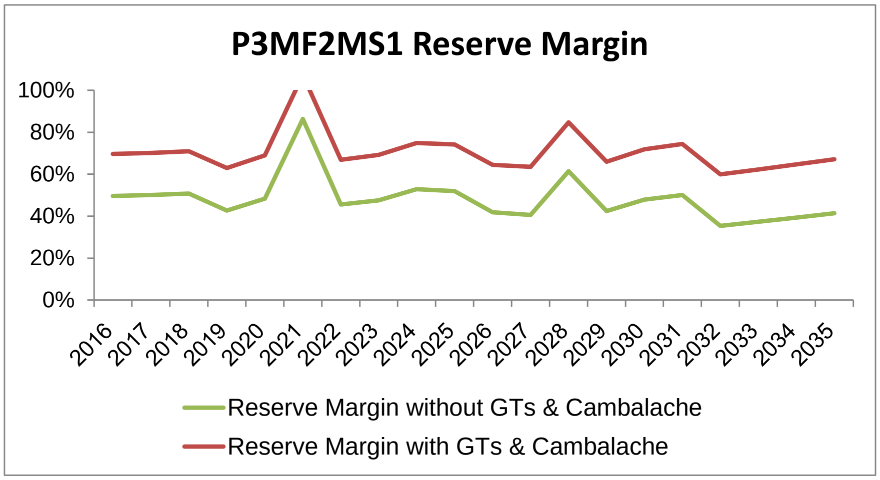
In P3MF2M_S1, which is a No AOGP and No AES case, the new generation resources are adjusted in consideration of six primary factors: (1) There is no gas at Aguirre and Aguirre 1&2 must be retired (or designated limited use) due to MATS compliance; (2) AES expires by December 31, 2027; (3) the assumed lower demand due to ramping EE penetration; (4) the modified RPS targets; (5) replacement of existing units with new highly efficient resources to save fuel costs; and (6) expedited new builds to upgrade the fleet and lower overall system costs.

The Aguirre 1&2 CC units repowering remains the same schedule as in P3F2, i.e., by December 31, 2019 and 2020 respectively. Four new generation resources are added to achieve an acceptable reserve margin as shown in Figure 8-15. Detailed key decisions are presented in Figure 8-16, and a timeline indicating key portfolio retirement, fuel switching, and new build schedules is presented in Figure 8-17. As a result, P3MF2M_S1 incurs total capital costs of $4,247 million during 2016-2035, lower than P3F2 capital costs of $4,674 million in the Base IRP. The new resources include:

- H Class 1X1 CC with diesel as primary fuel at Palo Seco by December 31, 2020;
- H Class 1X1 CC with diesel as primary fuel at Aguirre by December 31, 2020;
- H Class 1X1 CC with natural gas as primary fuel at Costa Sur by December 31, 2021;
- H Class 1X1 CC with natural gas as primary fuel at Costa Sur by July 1, 2027.

Aguirre 1&2 steam units to be retired by December 31, 2021, while Costa Sur 5&6 steam units can be retired by July 1, 2025 and July 1, 2031, respectively. As before these dates are earliest limits and actual later dates are possible.

Figure 8-15: P3MF2M_S1 Reserve Margin



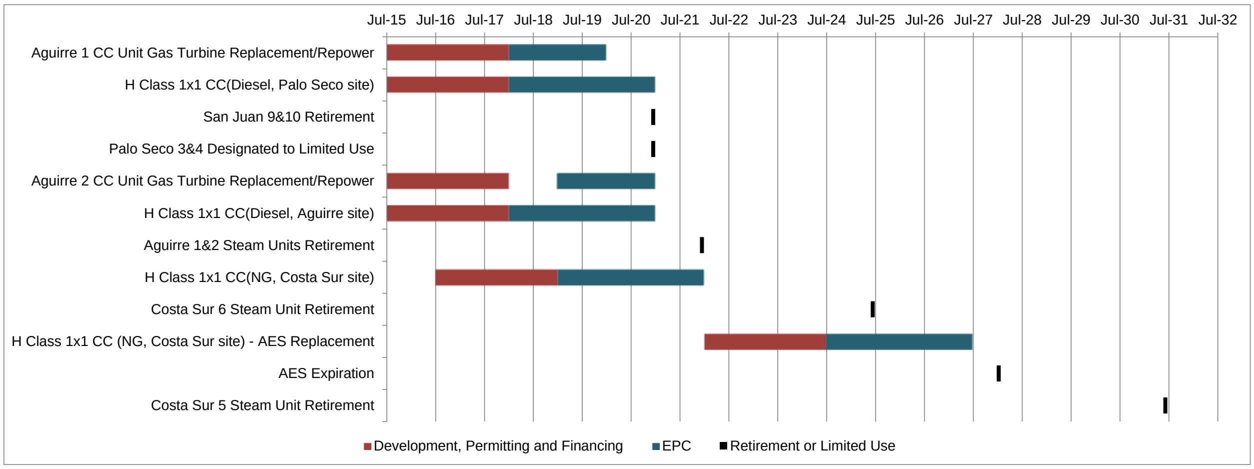
Source: Siemens PTI, Pace Global

Figure 8-16: P3MF2M_S1 Key Decisions

Portfolio Decisions that Differ from P3F2	Date	Capacity Impact (MW)
H Class 1x1 CC(Diesel, Palo Seco site)	12/31/2020	382
H Class 1x1 CC (Diesel, Aguirre site)	12/31/2020	382
H Class 1x1 CC (NG, Costa Sur Site)	12/31/2021	393
Aguirre 2 Steam Unit Retirement	12/31/2021	(450)
Aguirre 1 Steam Unit Retirement	12/31/2021	(450)
Costa Sur 6 Steam Unit Retirement	7/1/2025	(410)
AES Expiration	12/31/2027	(454)
H Class 1x1 CC (NG, Costa Sur Site, AES Replacement)	7/1/2027	393
Costa Sur 5 Steam Unit Retirement	7/1/2031	(410)

Source: Siemens PTI, Pace Global

Figure 8-17: P3MF2M_S1 Schedules



Note: San Juan steam units 9&10 and Palo Seco steam units 3&4 will be retired or designated as limited use.

Source: Siemens PTI, Pace Global

8.4.2 Sensitivity Results Comments

P3MF2M_S1 evaluates the impacts of not building AOGP and not extending the AES contract after its termination as expected in 2027. Because AES plant is currently PREPA's least expensive resource, its retirement incurs higher capital costs and system costs as shown in Table 8-3. Curtailment is improved as shown in Figure 8-18. Additional P3MF2M_S1 results are presented in Appendix C.

This sensitivity shows that the non-renewal of AES contract could be handled by the modified Portfolio 3 under Future 2 from a system operation perspective. However, because there is no AOGP and the higher gas prices in Future 2, it is more expensive to replace AES in Future 2 than in Future 1. Therefore, an extension of the AES contract is especially recommended in Future 2, because AES is the lowest cost resource in PREPA's fleet and this can free up valuable capital resources for the modernization of the balance of PREPA's fleet.

Table 8-3: P3MF2M_S1 Cost Metrics

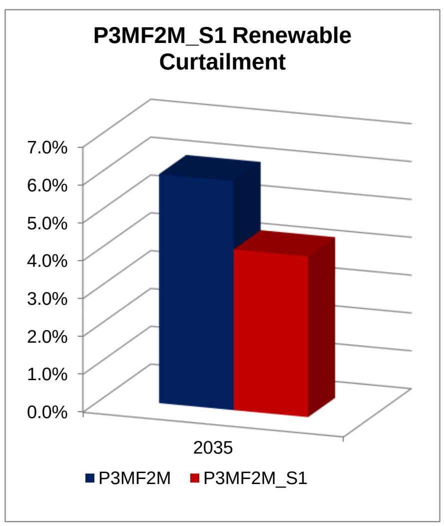
Capital Costs	Unit	Future 2	
		P3MF2M	P3MF2M_S1
FY 2016 - 2025 Total Capital Costs	*$ million*	3,745	3,745
FY 2026 - 2035 Total Capital Costs	*$ million*	50	502
FY 2016 - 2035 Total Capital Costs	*$ million*	3,794	4,247

Capital Costs	Unit	Future 2	
		P3MF2M	P3MF2M_S1
Generation	*$ million*	1,814	2,266
Fuel Infrastructure	*$ million*	0	0
Transmission	*$ million*	1,981	1,981
Total	*$ million*	3,794	4,247

System Costs	Unit	Future 2	
		P3MF2M	P3MF2M_S1
Total Present Value of System Costs	*$ million*	28,825	29,083
Average Annual System Costs	*$ million*	2,603	2,641
Present Value of System Costs Difference with P3MF2M	*$ million*		258

Source: Siemens PTI, Pace Global

Figure 8-18: P3MF2M_S1 Curtailment Comparison



Source: Siemens PTI, Pace Global

8.5 Portfolio 3 Modified Future 2 Modified Sensitivity 2 (P3MF2M_S2)

8.5.1 Schedules and New Generation Resources

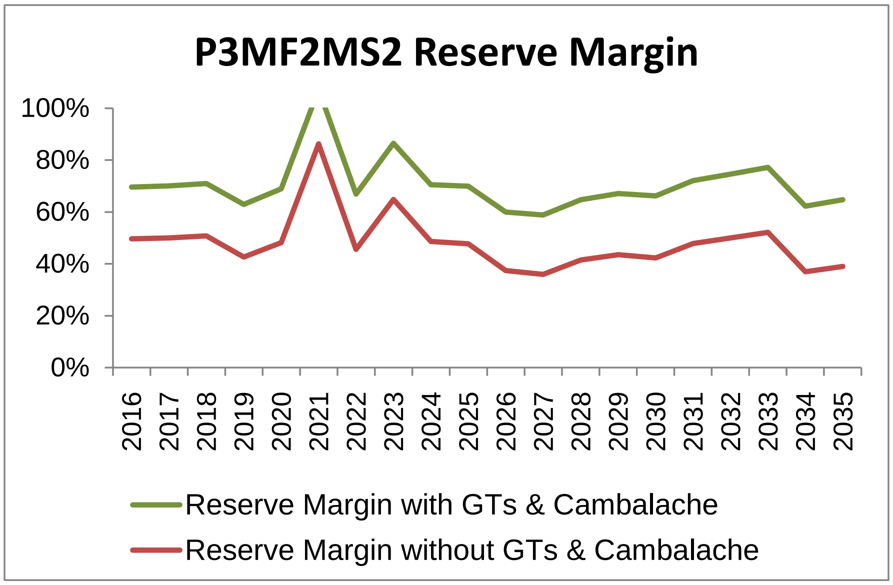
In P3MF2M_S2, which is a No AOGP and No EcoEléctrica case, the new generation resources are selected and sequenced in consideration of six primary factors: (1) There is no gas at Aguirre and Aguirre 1&2 must be retired (or designated limited use) due to MATS compliance; (2) EcoEléctrica expires by December 31, 2022; (3) the assumed lower demand due to ramping EE penetration; (4) the modified RPS targets; (5) replacement of existing units with new highly efficient resources to save fuel costs; and (6) expedited new builds to upgrade the fleet and to lower overall system costs.

The Aguirre 1&2 CC units repowering remains the same schedule as in P3F2, i.e., by December 31, 2019 and 2020 respectively. Four new generation resources are added to achieve an acceptable reserve margin as shown in Figure 8-19. Detailed key decisions are presented in Figure 8-20, and a timeline indicating key portfolio retirement, fuel switching, and new build schedules is presented in Figure 8-21. As a result, P3MF2M_S2 incurs total capital costs of $4,225 million during 2016-2035, lower than P3F2 capital costs of $4,674 million in the Base IRP. The new resources include:

- H Class 1X1 CC with diesel as primary fuel at Palo Seco by December 31, 2020;
- H Class 1X1 CC with diesel as primary fuel at Aguirre by December 31, 2020;
- H Class 1X1 CC with natural gas as primary fuel at Costa Sur by December 31, 2021;
- H Class 1X1 CC with natural gas as primary fuel at Costa Sur by July 1, 2022.

Aguirre 1&2 steam units will be retired by December 31, 2021, while Costa Sur 5&6 steam units can be retired by July 1, 2025 and July 1, 2033, respectively. Later dates for the retirements of Costa Sur 5&6 steam are possible.

Figure 8-19: P3MF2M_S2 Reserve Margin



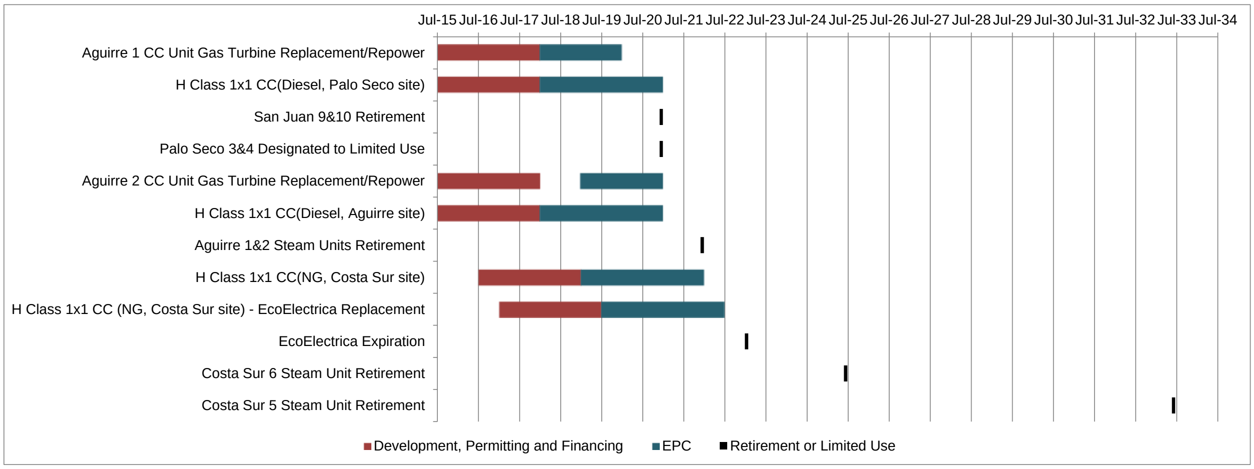
Source: Siemens PTI, Pace Global

Figure 8-20: P3MF2M_S2 Key Decisions

Portfolio Decisions that Differ from P3F2	Date	Capacity Impact (MW)
H Class 1x1 CC(Diesel, Palo Seco site)	12/31/2020	382
H Class 1x1 CC (Diesel, Aguirre site)	12/31/2020	382
H Class 1x1 CC (NG, Costa Sur Site)	12/31/2021	393
Aguirre 2 Steam Unit Retirement	12/31/2021	(450)
Aguirre 1 Steam Unit Retirement	12/31/2021	(450)
H Class 1x1 CC (NG, Costa Sur Site, EcoElectrica Replacement)	7/1/2022	393
EcoElectrica Expiration	12/31/2022	(507)
Costa Sur 6 Steam Unit Retirement	7/1/2025	(410)
Costa Sur 5 Steam Unit Retirement	7/1/2033	(410)

Source: Siemens PTI, Pace Global

Figure 8-21: P3MF2M_S2 Schedules



Note: San Juan steam units 9&10 and Palo Seco steam units 3&4 will be retired or designated as limited use.

Source: Siemens PTI, Pace Global

8.5.2 Sensitivity Results Comments

P3MF2M_S2 evaluates the impacts of not building AOGP and not extending the EcoEléctrica contract after its termination as expected in 2022. EcoEléctrica plant (507 MW with heat rate of 7.50 MMBtu/MWh) is replaced with more efficient new H Class 1X1 CC (393 MW with heat rate of 6.88 MMBtu/MWh), lowering the overall system costs. However, this sensitivity case requires expedited new builds that represents total capital costs of $2.1 billion by FY 2023 (including four H Class 1X1 CC new builds and Aguirre CC gas turbines replacement) and parallel projects execution. Table 8-4 shows the capital costs and system costs and Figure 8-22 shows the curtailment impact. Additional P3MF2M_S2 results are presented in Appendix C.

The non-renewal of EcoEléctrica contract could be handled by the modified Portfolio 3 under the Future 2 from a system operation perspective and lowers the overall system costs. However, it incurs higher capital costs and requires bringing multiple parallel new builds on line during 2020-2022. An extension and negotiation of improved terms (in particular with respect of the capacity payments and spot fuel prices) of the EcoEléctrica contract is recommended because this will free up valuable capital resources for the modernization of the balance of PREPA's fleet.

Table 8-4: P3MF2M_S2 Cost Metrics

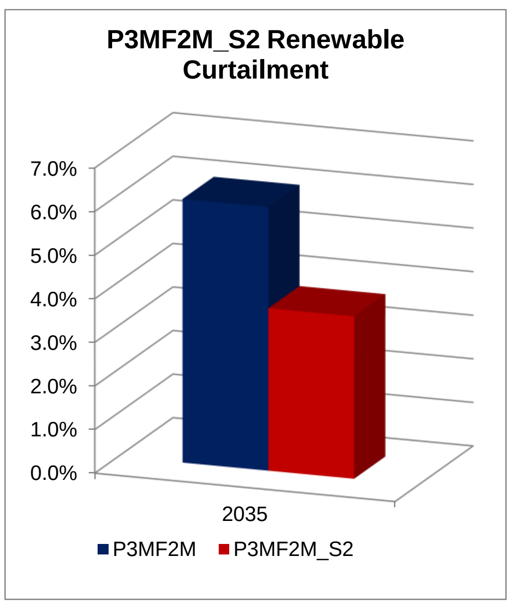
Capital Costs	Unit	Future 2	
		P3MF2M	P3MF2M_S2
FY 2016 - 2025 Total Capital Costs	*$ million*	3,745	4,175
FY 2026 - 2035 Total Capital Costs	*$ million*	50	50
FY 2016 - 2035 Total Capital Costs	*$ million*	3,794	4,225

Capital Costs	Unit	Future 2	
		P3MF2M	P3MF2M_S2
Generation	*$ million*	1,814	2,244
Fuel Infrastructure	*$ million*	0	0
Transmission	*$ million*	1,981	1,981
Total	*$ million*	3,794	4,225

System Costs	Unit	Future 2	
		P3MF2M	P3MF2M_S2
Total Present Value of System Costs	*$ million*	28,825	28,611
Average Annual System Costs	*$ million*	2,603	2,581
Present Value of System Costs Difference with P3MF2M	*$ million*		-214

Source: Siemens PTI, Pace Global

Figure 8-22: P3MF2M_S2 Curtailment Comparison



Source: Siemens PTI, Pace Global

8.6 Portfolio 3 Modified Future 2 Modified Sensitivity 3 (P3MF2M_S3)

8.6.1 Schedules and New Generation Resources

In P3MF2M_S3, which is a No AOGP, No EcoEléctrica and No AES case, the new generation resources are selected and sequenced in consideration of seven primary factors: (1) there is no gas at Aguirre and Aguirre 1&2 must be retired (or designated limited use) due to MATS compliance; (2) EcoEléctrica expires by December 31, 2022; (3) AES expires by December 31, 2027; (4) the assumed lower demand due to ramping EE penetration; (5) the modified RPS targets; (6) replacement of existing units with new highly efficient resources to save fuel costs; and (7) expedited new builds to upgrade the fleet and to lower overall system costs.

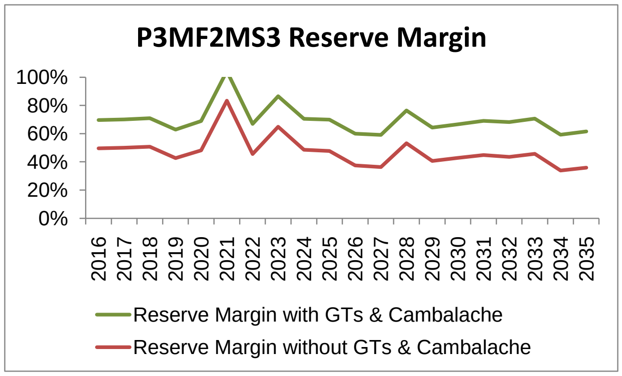
The Aguirre 1&2 CC units repowering remains the same schedule as in P3F2, i.e., by December 31, 2019 and 2020 respectively. Five new generation resources are added to achieve an acceptable reserve margin as shown in Figure 8-23. Detailed key decisions are presented in Figure 8-24, and a timeline indicating key portfolio retirement, fuel switching, and new build schedules is presented in Figure 8-25. As a result, P3MF2M_S3 incurs total capital costs of $4,677 million during 2016-2035, slightly higher than P3F2 capital costs of $4,674 million in the Base IRP. The new resources include:

- H Class 1X1 CC with diesel as primary fuel at Palo Seco by December 31, 2020;
- H Class 1X1 CC with diesel as primary fuel at Aguirre by December 31, 2020;
- H Class 1X1 CC with natural gas as primary fuel at Costa Sur by December 31, 2021;
- H Class 1X1 CC with natural gas as primary fuel at Costa Sur by July 1, 2022; and
- H Class 1X1 CC with natural gas as primary fuel at Costa Sur by July 1, 2027.

Aguirre 1&2 steam units will be retired by December 31, 2021, while Costa Sur 5&6 steam units can be retired by July 1, 2025 and July 1, 2033, respectively.

Costa Sur, the only location with gas, will have 3 H Class 1X1 CC by in the long term. This is feasible due to the retirement of EcoEléctrica and one unit at Costa Sur.

Figure 8-23: P3MF2M_S3 Reserve Margin



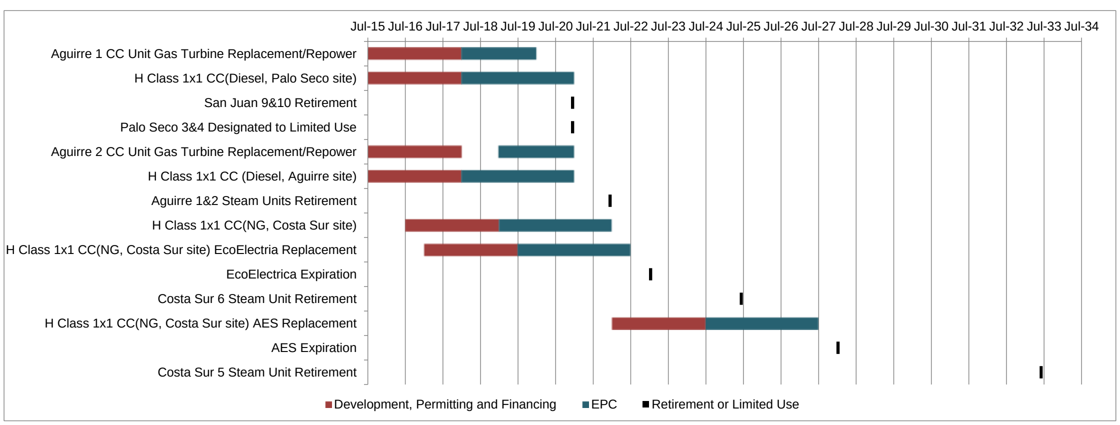
Source: Siemens PTI, Pace Global

Figure 8-24: P3MF2M_S3 Key Decisions

Portfolio Decisions that Differ from P3F2	Date	Capacity Impact (MW)
H Class 1x1 CC(Diesel, Palo Seco site)	12/31/2020	382
H Class 1x1 CC (Diesel, Aguirre site)	12/31/2020	382
H Class 1x1 CC (NG, Costa Sur Site)	12/31/2021	393
Aguirre 2 Steam Unit Retirement	12/31/2021	(450)
Aguirre 1 Steam Unit Retirement	12/31/2021	(450)
H Class 1x1 CC (NG, Costa Sur Site, EcoElectrica Replacement)	7/1/2022	393
EcoElectrica Expiration	12/31/2022	(507)
Costa Sur 6 Steam Unit Retirement	7/1/2025	(410)
H Class 1x1 CC (NG, Costa Sur Site, AES Replacement)	7/1/2027	393
AES Expiration	12/31/2027	(454)
Costa Sur 5 Steam Unit Retirement	7/1/2033	(410)

Source: Siemens PTI, Pace Global

Figure 8-25: P3MF2M_S3 Schedules



Note: San Juan steam units 9&10 and Palo Seco steam units 3&4 will be retired or designated as limited use.

Source: Siemens PTI, Pace Global

8.6.2 Sensitivity Results Comments

P3MF2M_S3 evaluates the impacts of not building AOGP, not extending the EcoEléctrica contract after its termination in 2022, and not extending the AES contract after its termination in 2027.

This sensitivity case requires total capital costs of $4.68 billion over the IRP time horizon and requires expedited new builds and parallel projects execution. Table 8-5 shows the capital costs and system costs and Figure 8-26 shows the curtailment impact. Additional P3MF2M_S3 results are presented in Appendix C.

The non-renewal of EcoEléctrica and AES contract could be handled by the modified Portfolio 3 under the Future 2 from a system operation perspective, if the capital is available to replace both contracts with new generation resources and if it is feasible for PREPA to handle multiple new builds. However, an extension of both contracts is recommended because this will free up valuable capital resources for the modernization of the balance of PREPA's fleet.

Table 8-5: P3MF2M_S3 Cost Metrics

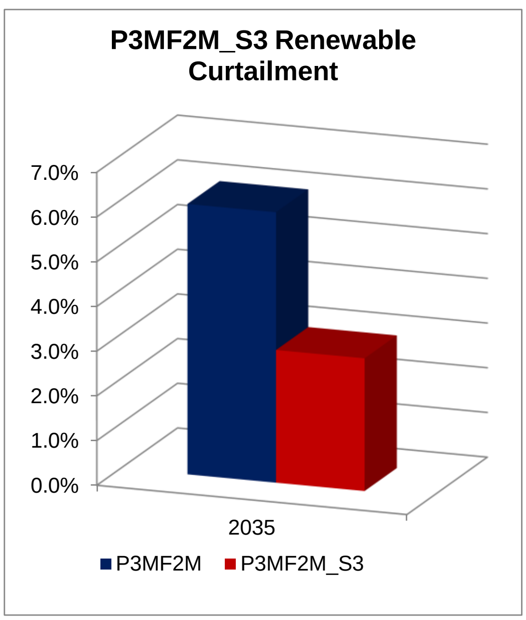
Capital Costs	Unit	Future 2	
		P3MF2M	P3MF2M_S3
FY 2016 - 2025 Total Capital Costs	*$ million*	3,745	4,175
FY 2026 - 2035 Total Capital Costs	*$ million*	50	502
FY 2016 - 2035 Total Capital Costs	*$ million*	3,794	4,677

Capital Costs	Unit	Future 2	
		P3MF2M	P3MF2M_S3
Generation	*$ million*	1,814	2,697
Fuel Infrastructure	*$ million*	0	0
Transmission	*$ million*	1,981	1,981
Total	*$ million*	3,794	4,677

System Costs	Unit	Future 2	
		P3MF2M	P3MF2M_S3
Total Present Value of System Costs	*$ million*	28,825	28,801
Average Annual System Costs	*$ million*	2,603	2,609
Present Value of System Costs Difference with P3MF2M	*$ million*		-25

Source: Siemens PTI, Pace Global

Figure 8-26: P3MF2M_S3 Curtailment Comparaison



Source: Siemens PTI, Pace Global

8.7 Portfolio 3 Modified Future 1 Modified Sensitivity 4 (P3MF1M_S4)

In P3MF1M_S4, which is a demand response sensitivity with full RPS compliance, the fossil fuel new resource decisions are the same as P3MF1M, but with increased renewable generation to achieve full RPS compliance by 2020. This inevitably would cause increased curtailment, unless demand response is in place.

8.7.1 Sensitivity Results Comments

P3MF1M_S4 resulted in much higher system costs than P3MF1M. This is primarily due to two reasons: (1) the cheaper conventional generation is reduced at night while higher prices for PV generation is paid at the day time; and (2) an estimated cost of 2 cents per kWh for the control systems to shift from the night peak to the mid-day. Section 7 provides more details on the design of demand response.

It should be noted that while a curtailment of 2 percent was used in the design of the demand response, the actual curtailment was slightly higher in the PROMOD simulations probably due to the need of having more thermal generating units online for regulation, than those considered in the design. This observation is based on the fact that the “night” or thermal curtailment increased significantly and in 2025 and 2026 (that also have the highest renewable curtailment) up to 35 percent of the total curtailment was at night. Note that thermal curtailment is handled in practice by lowering the thermal units to their emergency lower limits where the capability to regulate is lost and can be operationally challenging.

Table 8-6: P3MF1M_S4 Cost Metrics

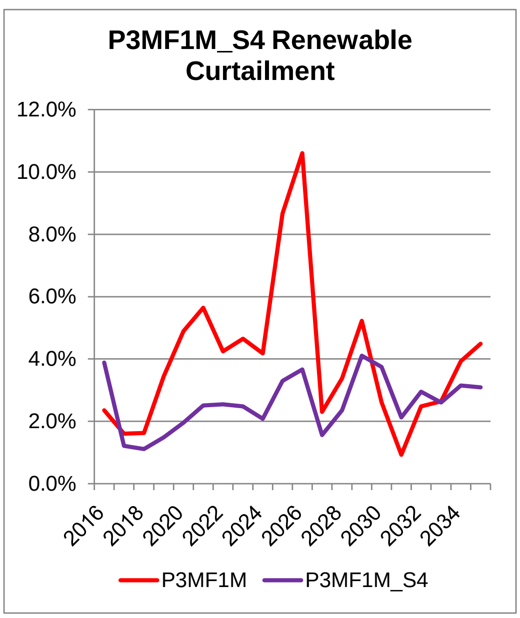
Capital Costs	Unit	Future 1	
		P3MF1M	P3MF1M_S4
FY 2016 - 2025 Total Capital Costs	*$ million*	3,153	3,153
FY 2026 - 2035 Total Capital Costs	*$ million*	1,461	1,461
FY 2016 - 2035 Total Capital Costs	*$ million*	4,614	4,614

Capital Costs	Unit	Future 1	
		P3MF1M	P3MF1M_S4
Generation	*$ million*	2,157	2,157
Fuel Infrastructure	*$ million*	385	385
Transmission	*$ million*	2,073	2,073
Total	*$ million*	4,614	4,614

System Costs	Unit	Future 1	
		P3MF1M	P3MF1M_S4
Total Present Value of System Costs	*$ million*	25,836	26,060
Average Annual System Costs	*$ million*	2,292	2,312
Present Value of System Costs Difference with P3MF1M	*$ million*		224

Source: Siemens PTI, Pace Global

Figure 8-27: P3MF1M_S4 Curtailment Comparison



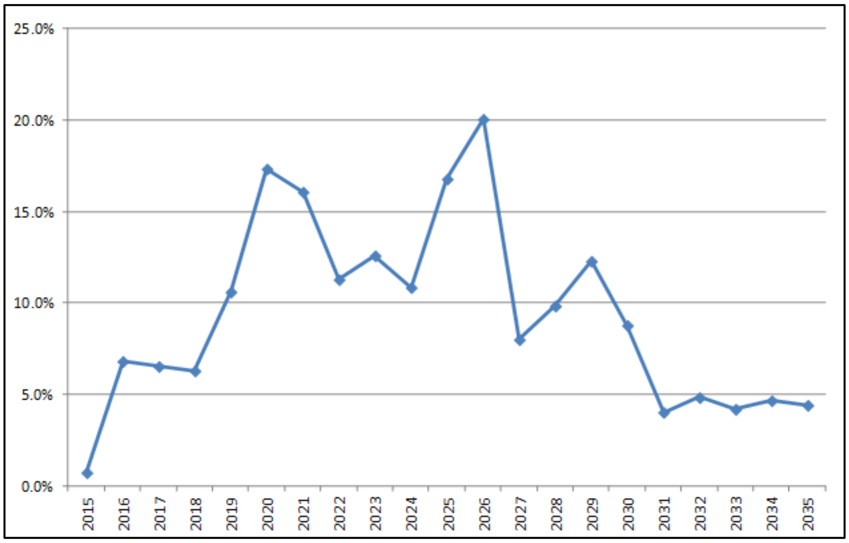
Source: Siemens PTI, Pace Global

8.8 Portfolio 3 Modified Future 1 Modified Sensitivity 5 (P3MF1M_S5)

8.8.1 Schedules and New Generation Resources

Siemens PTI run a case for P3MF1M with full RPS compliance and found the curtailment rises to unacceptable levels as shown in Figure 8-29.

Figure 8-28: P3MF1M Full RPS Compliance Case Curtailment



Source: Siemens PTI, Pace Global

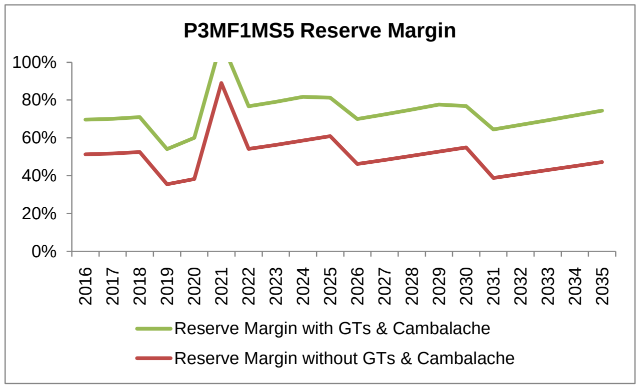
Subsequently, Siemens PTI designed P3MF1M_S5, which is full RPS compliance case. In this case, the new generation resources are selected and sequenced in consideration of four primary factors: (1) full RPS compliance by 2020; (2) the assumed lower demand due to ramping EE penetration; (3) expedited new builds to upgrade the fleet to support the integration of renewable generation; and (4) replacement of existing units with new highly efficient resources to save fuel costs.

In addition to advancing the repowering of the Aguirre 1&2 CC units to July 1, 2020, the required new generation resources are added with an accelerated timeline to add flexibility to the system and minimize curtailment. Figure 8-29 shows the entry dates and reserve margin. Detailed key decisions are presented in Figure 8-30, and a timeline indicating key portfolio retirement, fuel switching, and new build schedules is presented in Figure 8-31. As a result, P3MF1M_S5 incurs total capital costs of $4,527 million during 2016-2035, significantly lower than P3F1 capital costs of $5,252 million in the Base IRP. The new resources include:

- SCC-800 1X1 CC wit diesel as primary fuel at Palo Seco by July 1, 2020;
- H Class 1X1 CC with gas as primary fuel at Costa Sur by December 31, 2020;
- H Class 1X1 CC with gas as primary fuel at Aguirre by December 31, 2020; and
- H Class 1X1 CC with natural gas as primary fuel at Aguirre Site by December 31, 2021.

Costa Sur 5&6 steam units will be retired by December 31, 2020, while Aguirre 1&2 steam units will be retired by July 1, 2025 and July 1, 2030, respectively.

Figure 8-29: P3MF1M_S5 Reserve Margin



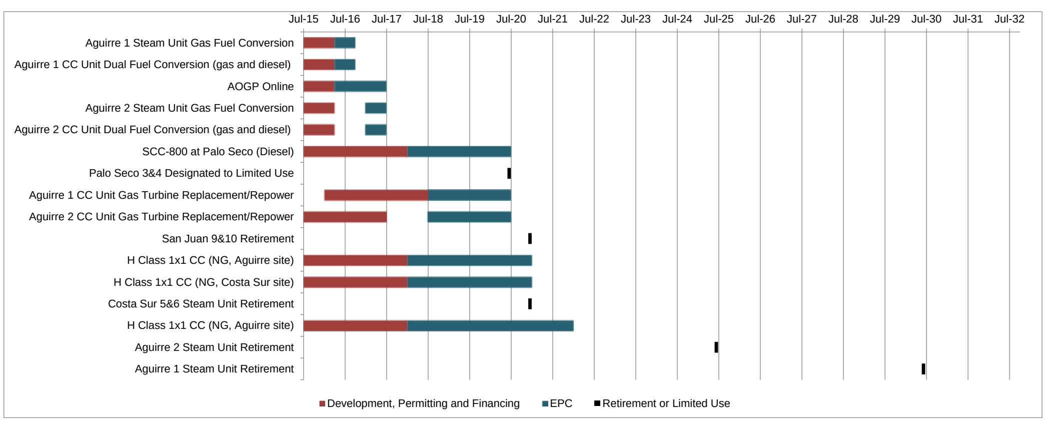
Source: Siemens PTI, Pace Global

Figure 8-30: P3MF1M_S5 Key Decisions

Portfolio Decisions that Differ from P3F1	Date	Capacity Impact (MW)
SCC-800 at Palo Seco (Diesel)	7/1/2020	70
Aguirre 1 CC Unit Gas Turbine Replacement/Repower	7/1/2020	4
Aguirre 2 CC Unit Gas Turbine Replacement/Repower	7/1/2020	4
H Class 1X1 CC (NG, Costa Sur site)	12/31/2020	393
H Class 1X1 CC (NG, Aguirre site)	12/31/2020	393
Costa Sur 6 Steam Unit Retirement	12/31/2020	(410)
Costa Sur 5 Steam Unit Retirement	12/31/2020	(410)
H Class 1X1 CC (NG, Aguirre site)	12/31/2021	393
Aguirre 2 Steam Unit Retirement	7/1/2025	(450)
Aguirre 1 Steam Unit Retirement	7/1/2030	(450)

Source: Siemens PTI, Pace Global

Figure 8-31: P3MF1M_S5 Schedules



Note: San Juan steam units 9&10 and Palo Seco steam units 3&4 will be retired or designated as limited use.

Source: Siemens PTI, Pace Global

8.8.2 Sensitivity Results Comments

P3MF1M_S5 evaluates the impacts of a full RPS compliance. In order to improve the ability of the PREPA fleet to integrate increased renewable generation, the three H Class 1X1 CC new builds are all put on accelerated schedule, which requires significant upfront capital and resources to execute the new builds at Palo Seco, Aguirre and Costa Sur sites simultaneously. This sensitivity case requires total capital costs of $4.53 billion over the IRP time horizon. Table 8-7 shows the capital costs and system costs, Figure 8-32 shows the curtailment impact, and Figure 8-33 shows the RPS and renewable penetration levels. Additional P3MF1M_S5 results are presented in Appendix C.

Table 8-7: P3MF1M_S5 Cost Metrics

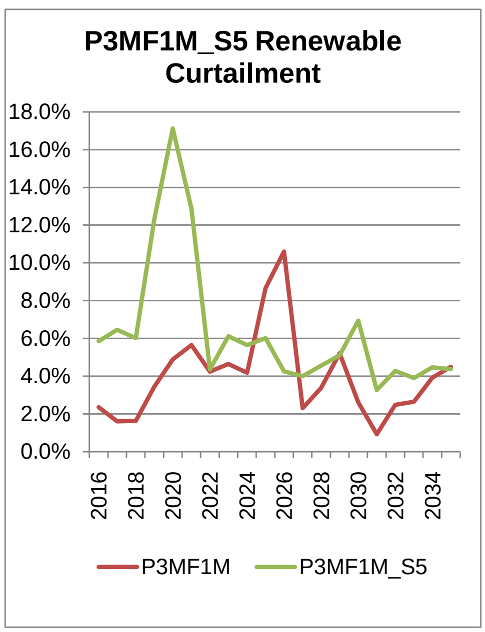
Capital Costs	Unit	Future 1	
		P3MF1M	P3MF1M_S5
FY 2016 - 2025 Total Capital Costs	*$ million*	3,153	4,473
FY 2026 - 2035 Total Capital Costs	*$ million*	1,461	54
FY 2016 - 2035 Total Capital Costs	*$ million*	4,614	4,527

Capital Costs	Unit	Future 1	
		P3MF1M	P3MF1M_S1
Generation	*$ million*	2,157	2,069
Fuel Infrastructure	*$ million*	385	385
Transmission	*$ million*	2,073	2,073
Total	*$ million*	4,614	4,527

System Costs	Unit	Future 1	
		P3MF1M	P3MF1M_S1
Total Present Value of System Costs	*$ million*	25,836	26,087
Average Annual System Costs	*$ million*	2,292	2,309
Present Value of System Costs Difference with P3MF1M	*$ million*		251

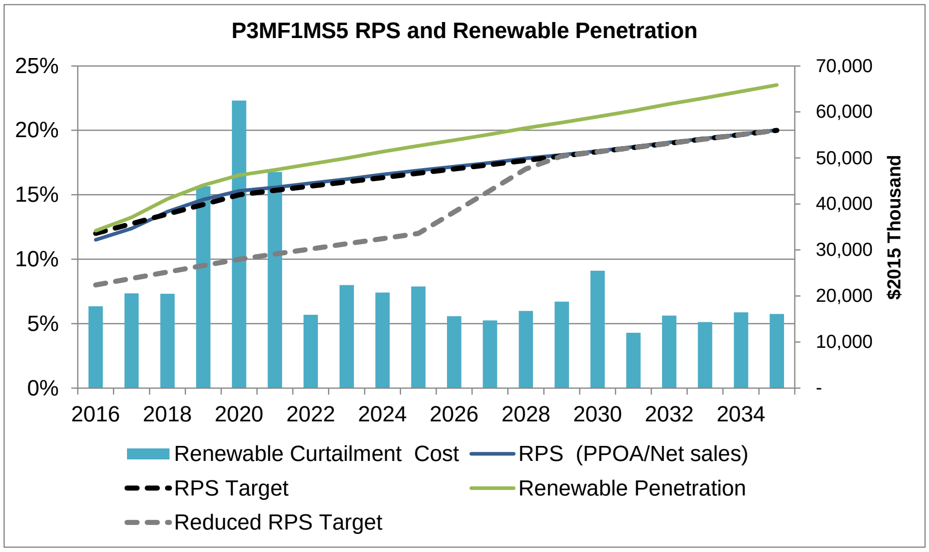
Source: Siemens PTI, Pace Global

Figure 8-32: P3MF1M_S5 Curtailment Comparison



Source: Siemens PTI, Pace Global

Figure 8-33: P3MF1M_S5 RPS and Renewable Penetration Levels



Source: Siemens PTI, Pace Global

Section

9

Fuel Sensitivity Analysis

At the request of the Commission on April 12, 2016 Order, PREPA and Siemens conducted an assessment of the impact of a reduced fuel forecast on the decisions and recommendation made with respect of PREPA IRP. The fuel forecast sensitivity includes a total of seven PFS combinations as presented in Table 1-1, using the reduced fuel forecasts provided to the Commission on March 21, 2016. The reduced fuel forecasts are presented in Appendix 0.

Table 9-1: Fuel Sensitivity Case Summary

	Portfolios, Futures, and Sensitivities (PFS)	AOGP	EcoEléctrica
1	P3F1 Fuel Sensitivity Case	yes	yes
2	P3F2 Fuel Sensitivity Case	no	yes
3	P3MF1M Fuel Sensitivity Case	yes	yes
4	P3MF2M Fuel Sensitivity Case	no	yes
5	P3MF2M_S2 Fuel Sensitivity Case (No AOGP No EcoEléctrica)	no	no
6	P3MF1M_S4 Fuel Sensitivity Case (Demand Response)	yes	yes
7	P3MF1M_S5 Fuel Sensitivity Case (Full RPS by 2020)	yes	yes

Source: Siemens PTI, Pace Global

The present value of system costs of Portfolio 3 with Reduced Fuel Forecast is reduced by approximately $3 billion in Future 1 and approximately $6 billion in Future 2. Summary of the system costs of the seven PFS with reduced fuel forecasts are presented in Table 9-2.

Table 9-2: Fuel Sensitivity System Costs Summary

System Costs	Unit	Future 1			
		P3F1Fuel	P3MF1MFuel	P3MF1M_S4Fuel	P3MF1M_S5 Fuel
Total Present Value of System Costs	*$ million*	23,503	22,701	23,382	23,468
Average Annual System Costs	*$ million*	2,167	2,056	2,121	2,126

System Costs	Unit	Future 2		
		P3F2Fuel	P3MF2MFuel	P3MF2M_S2Fuel
Total Present Value of System Costs	*$ million*	23,680	22,920	22,541
Average Annual System Costs	*$ million*	2,212	2,112	2,068

Source: Siemens PTI, Pace Global

The main decisions with respect of MATS compliance; i.e. the retirement or designation of limited use of the units in the north, or the need to modernize the fleet by the incorporation of new flexible efficient units for the integration of renewables, are not affected by the change in fuel prices. However, the level in which the fuel savings compensate for the capital investments is affected and this is assessed in this report in addition to the detailed sensitivity results presented in Appendix C.

Finally, it should be mentioned that given the fact that Portfolio 2 has higher capital costs than Portfolio 3, it should have even less favorable results than Portfolio 3 under the reduced fuel price scenario than with the base fuel prices, thus Portfolio 3 would still be the favored. Similarly, the inability of Portfolio 1 to incorporate the expected levels of renewable is still present, making Portfolio 1 infeasible in the long term.

We present below the results of the fuel prices sensitivity analysis and compare with the case with the base fuel prices.

9.1 P3F1 Fuel Sensitivity Analysis

As a reference we present below, the main results of P3F1 with the base fuel forecast and this will be followed by the changes that the reduced fuel forecast introduces.

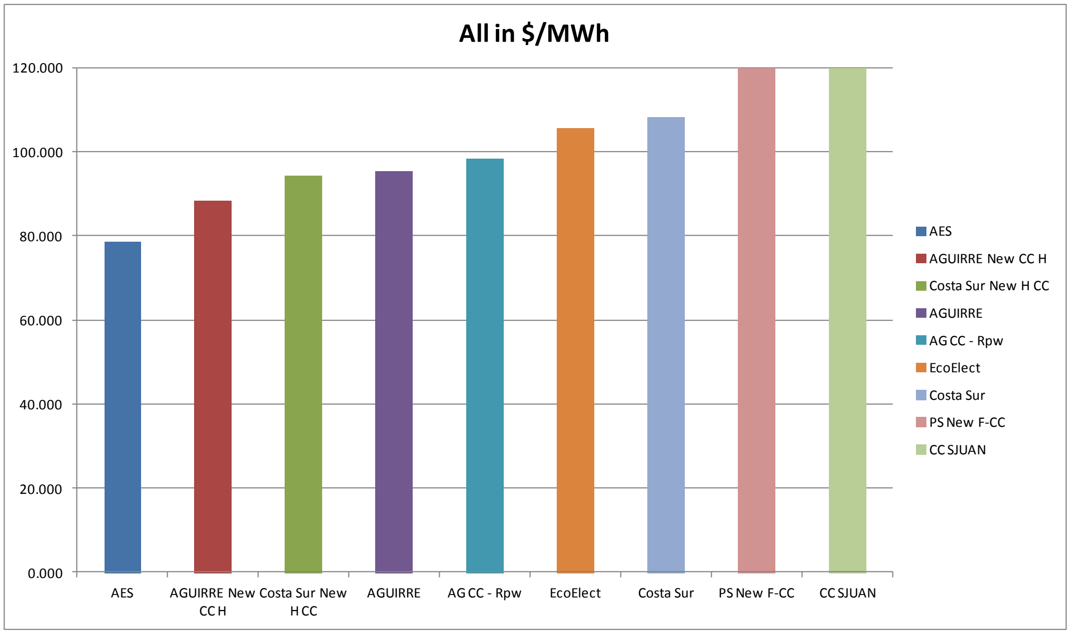
P3F1 fuel sensitivity case resulted in a present value of system costs of $23.5 billion, which is approximately $3 billion lower than the P3F1 with base fuel forecast, driven by the substantially lower fuel forecast assumed in the fuel sensitivity analysis.

9.1.1 P3F1 with Base Fuel Forecast

As can be observed below, considering the base fuel forecast, the average all in price, including fuel, fixed and variable operating as well as capital amortization results in reduced costs for the new H Class units at Aguirre and Costa Sur than the steam units that are being replaced, clearly justifying its replacement as soon as practicable, which in this case, besides time requirements for permitting and EPC (engineering, procurement, and construction) development, is limited by capital availability in Future 1.

The average prices are considered from 2020 onwards to take into consideration only the period after MATS compliance is achieved.

Figure 9-1: P3F1 All In Costs with Base Fuel Forecast

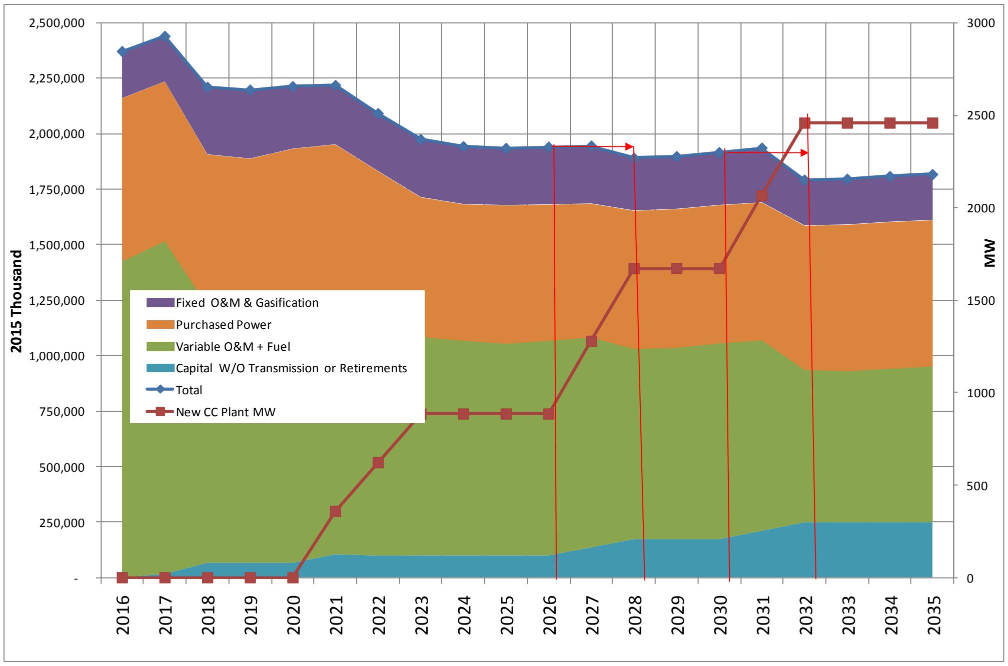


Source: Siemens PTI

This is further illustrated in the figure below that shows on the left axis the total thermal generation costs including the capital invested in the new units and on the right hand axis the total new generation added to the system.

We note in this figure that in spite of the fuel prices going up in real terms over the period of analysis, the yearly costs go down when the Aguirre units are replaced in 2026 and this reduction is more pronounced when the Costa Sur units are retired and the Portfolio is fully implemented. This confirms the observations above with respect of the Aguirre and Costa Sur units.

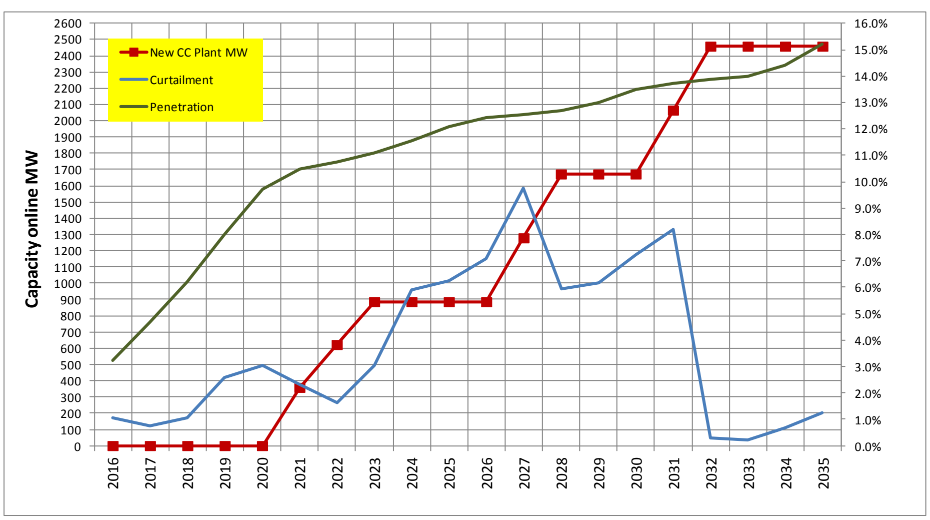
Figure 9-2: P3F1 Thermal Generation Costs with Base Fuel Forecast



Source: Siemens PTI

Finally, we observe below that the replacement of the Aguirre and Costa Sur units is required to control the curtailment and achieve the reduced RPS targets considered in Future 1. Note that the curtailment goes down as soon as new capacity is added to the system.

Figure 9-3: P3F1 Curtailment Costs with Base Fuel Forecast



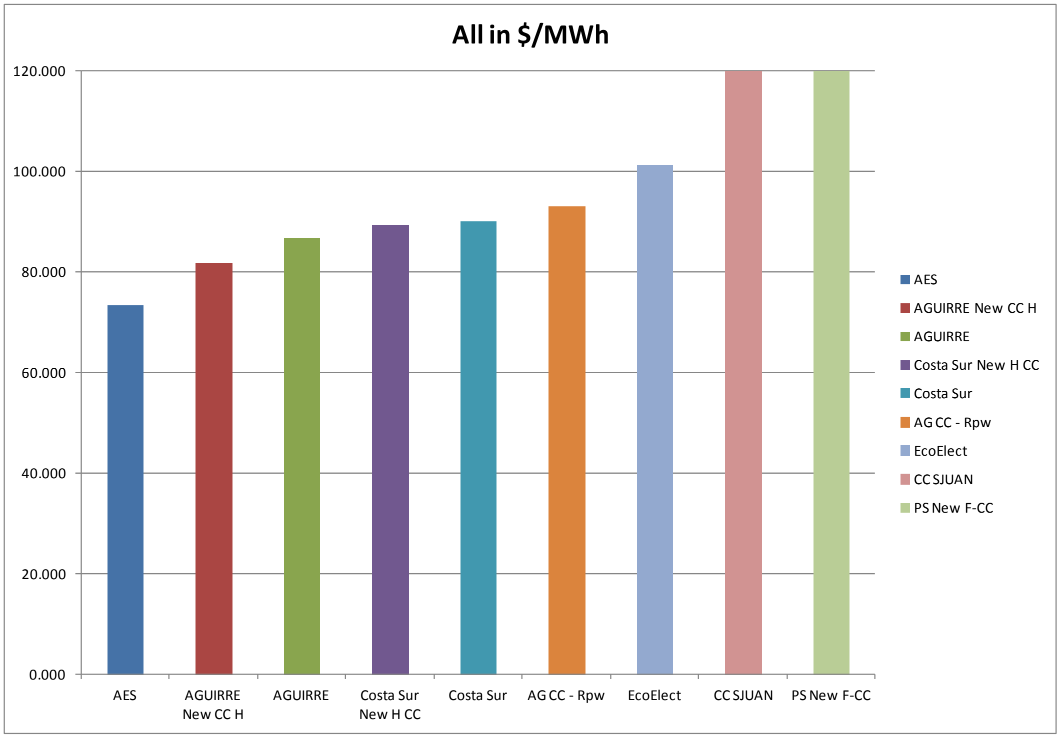
Source: Siemens PTI

9.1.2 P3F1 with Reduced Fuel Forecast

We present below the main results of P3F1 with the reduced fuel forecast.

Considering the reduced fuel forecast the average all in price for the new H Class units at Aguirre and Costa Sur are still smaller than the corresponding units being replaced. We note however that the optimization is resulting in higher dispatch of the new H Class units at Aguirre and hence reduced costs.

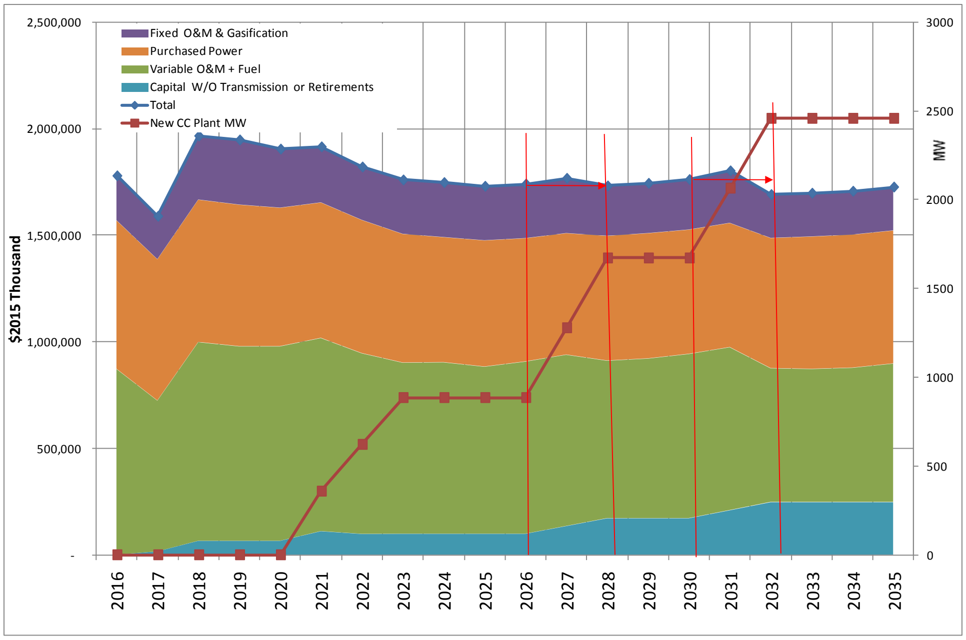
Figure 9-4: P3F1 All In Costs with Reduced Fuel Forecast



Source: Siemens PTI

As before, the figure below shows on the left axis the total thermal generation costs, including the capital invested in the new units, and on the right hand axis the total new generation added to the system, with the reduced fuel forecast. We note that in this case when only the Aguirre units are replaced the total generation costs remain about the same, but when the entire Portfolio 3 is fully deployed by the replacement of the Costa Sur units there is still an important reduction in costs. This is indicative of the convenience of this Portfolio even in the presence of reduced fuel costs.

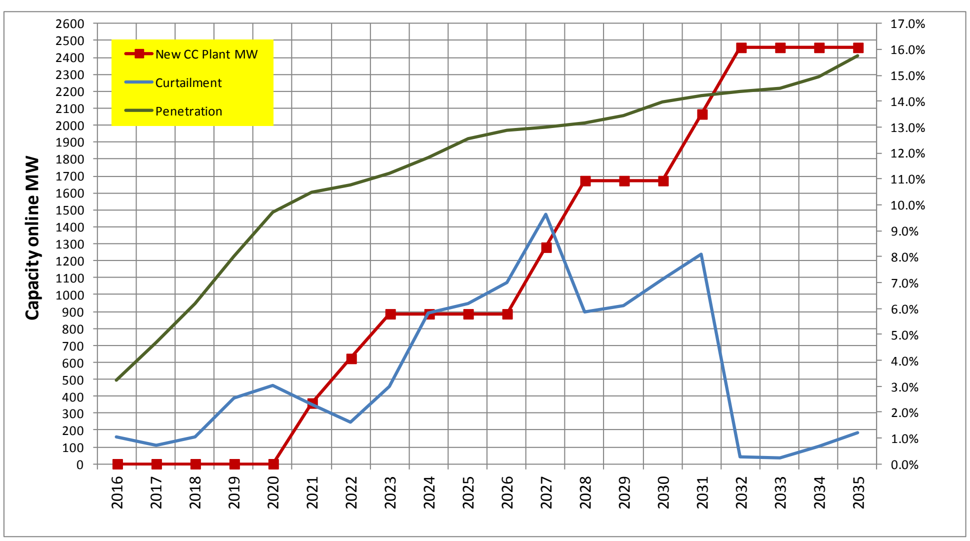
Figure 9-5: P3F1 Thermal Generation Costs with Reduced Fuel Forecast



Source: Siemens PTI

Finally we observe below that the replacement of the Aguirre and Costa Sur Units is required to control the curtailment and achieve the reduced RPS targets. Therefore, although from a thermal cost perspective the savings in fuel approximately equal the cost in capital for the initial replacement of Aguirre, this replacement is necessary to manage curtailment.

Figure 9-6: P3F1 Curtailment Costs with Reduced Fuel Forecast



Source: Siemens PTI

9.2 P3F2 Fuel Sensitivity Analysis

Future 2 considers that the AOGP is not built and hence the Aguirre units need to be replaced. The key question to be answered in this case is whether with the reduced fuel forecast the AOGP would still be a desirable investment.

P3F2 fuel sensitivity case resulted in a present value of system costs of $23.7 billion, which is approximately $5.6 billion lower than the P3F2 with base fuel forecast, driven by the substantially lower fuel forecast assumed in the fuel sensitivity analysis.

By comparing the present value of the system costs for Portfolio 3 with the reduced fuel forecast and without AOGP at $23.7 billion with the corresponding value of $23.5 billion with AOGP, we observe more than a $177 million dollar difference thus justifying the investment in the AOGP even in the case of low fuel prices.

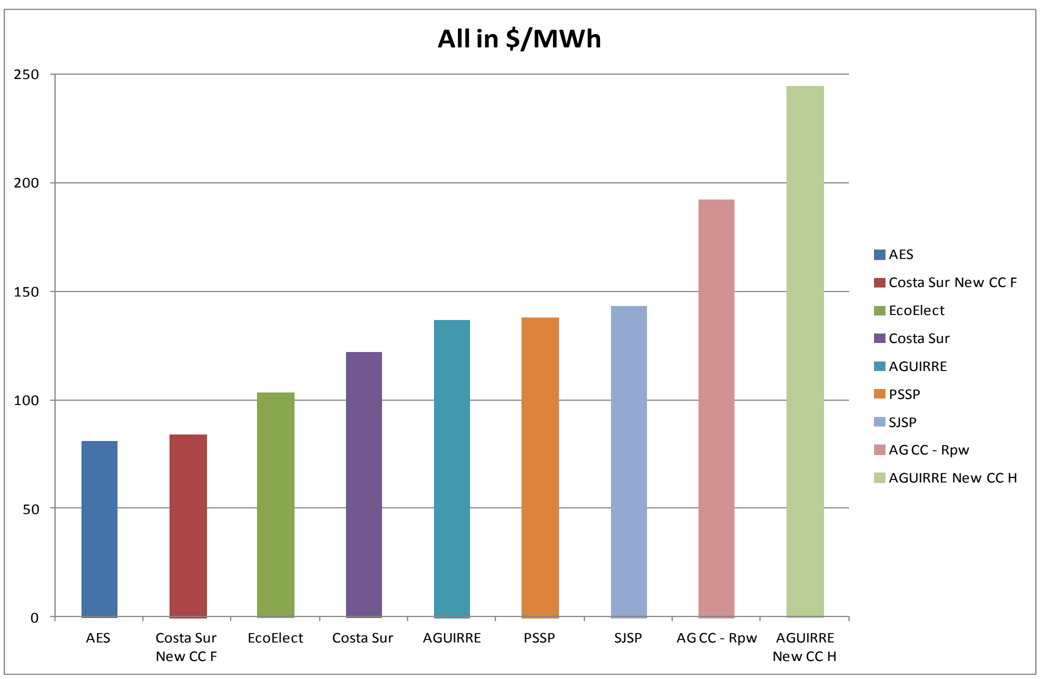
9.2.1 P3F2 with Base Fuel Forecast

As before, we present below the main results of P3F2 with the base fuel forecast and this is followed by the changes that the reduced fuel forecast introduces.

The main observation is that with the base fuel forecast there are important benefits of replacing the Costa Sur units by the H Class in FY 2028 and 2029.

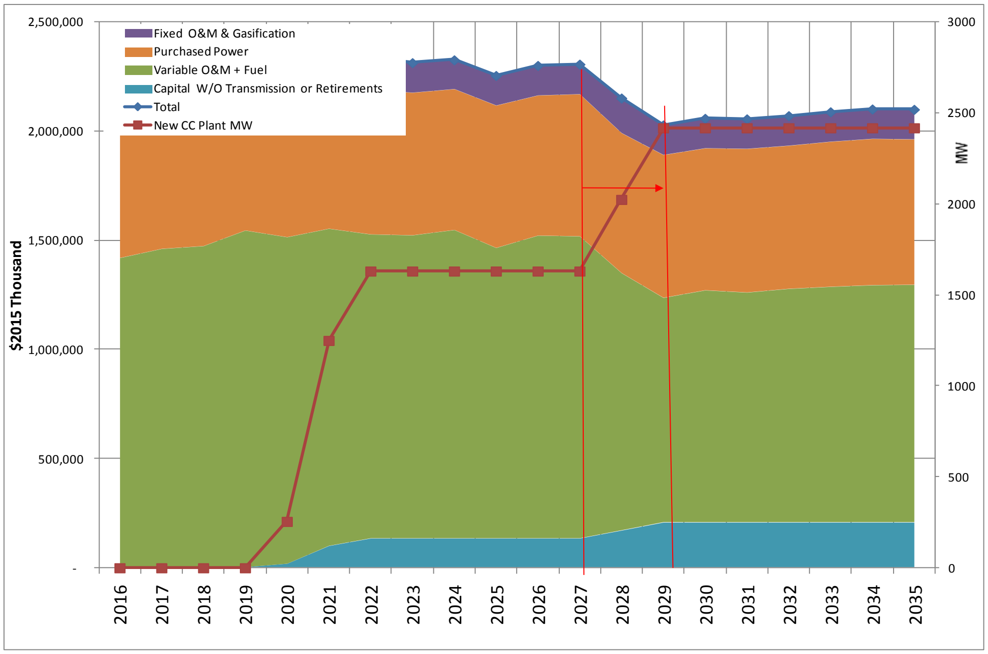
This is in reality the only optional replacement as the H Class replacement of Aguirre 1&2 and the replacement of the units in the north is required for MATS compliance.

Figure 9-7: P3F2 All In Costs with Base Fuel Forecast



Source: Siemens PTI

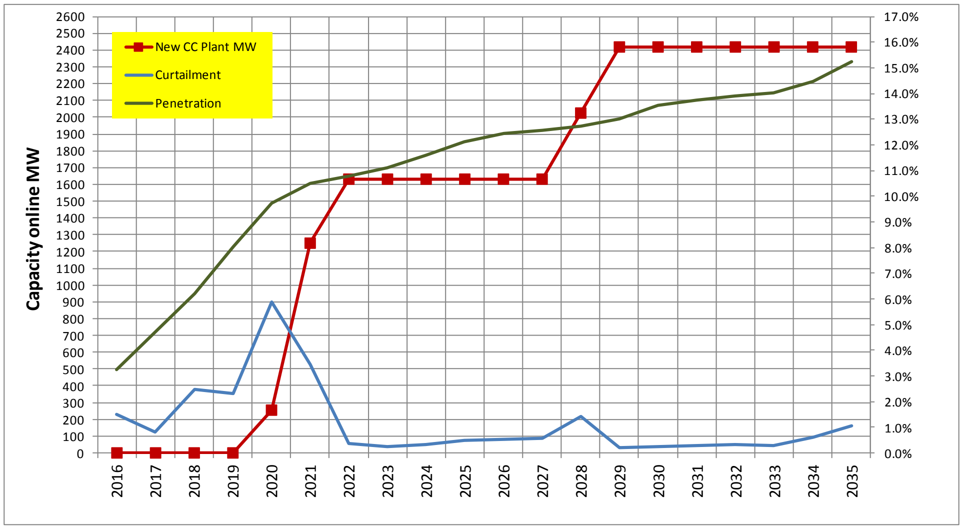
Figure 9-8: P3F2 Thermal Generation Costs with Base Fuel Forecast



Source: Siemens PTI

Finally, we observe that the curtailment in this case is fairly low and the addition of the generation at Costa Sur prevents it from increasing.

Figure 9-9: P3F2 Curtailment Costs with Base Fuel Forecast



Source: Siemens PTI

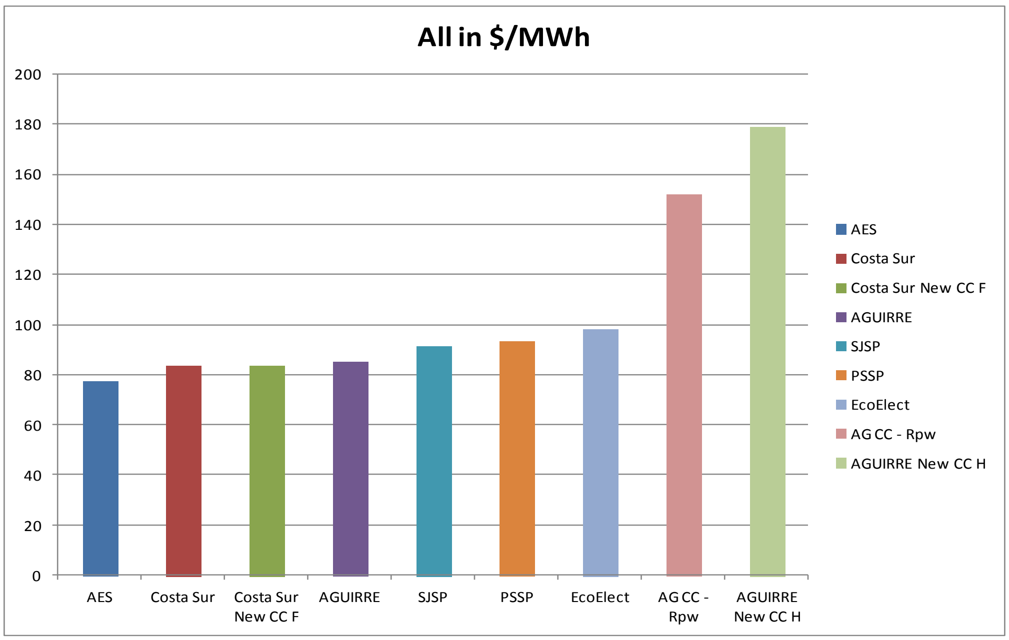
9.2.2 P3F2 with Reduced Fuel Forecast

We present below the main results of P3F2 with the reduced fuel forecast. In this case we note that due to the drop in fuel prices, the replacement of the Costa Sur units by the new H Class basically results in compensation of the capital investments.

Also we note that the curtailment is fairly contained by the time of replacement of the Costa Sur units and it could be possible to delay this investment without significantly affecting the curtailment.

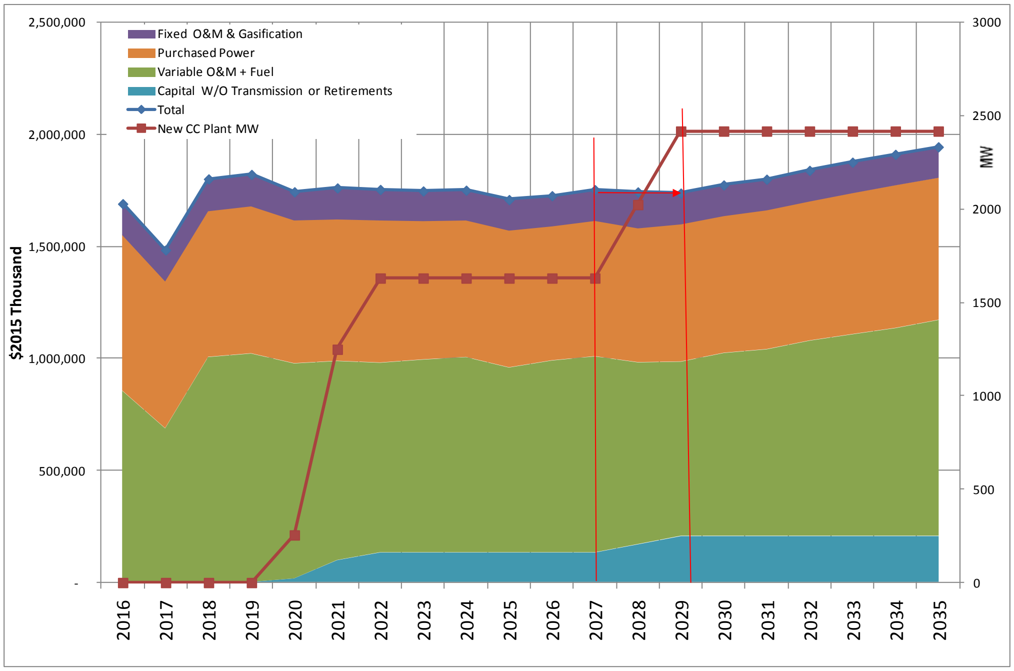
Base on the above, we conclude that in case that the AOGP is not developed and the drop fuel prices are maintained, then it could be possible to delay the replacement of the Costa Sur units.

Figure 9-10: P3F2 All In Costs with Reduced Fuel Forecast



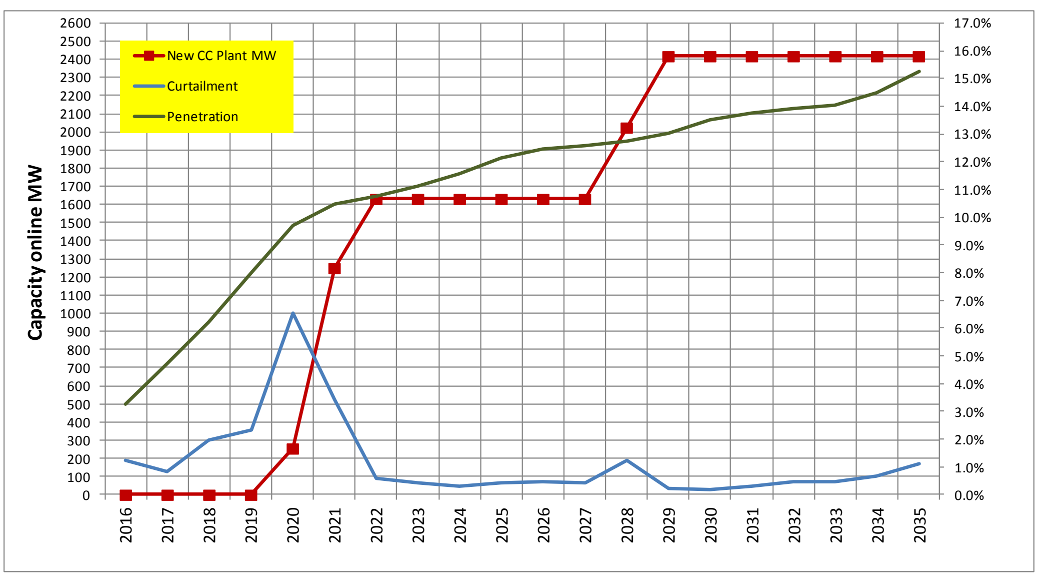
Source: Siemens PTI

Figure 9-11: P3F2 Thermal Generation Costs with Reduced Fuel Forecast



Source: Siemens PTI

Figure 9-12: P3F2 Curtailment Costs with Reduced Fuel Forecast



Source: Siemens PTI

9.3 P3MF1M Fuel Sensitivity Analysis

We present below the results of the Portfolio 3 modified as presented earlier in this report, for Future 1 with the assumed demand reduction due to energy efficiency and reduced fuel prices.

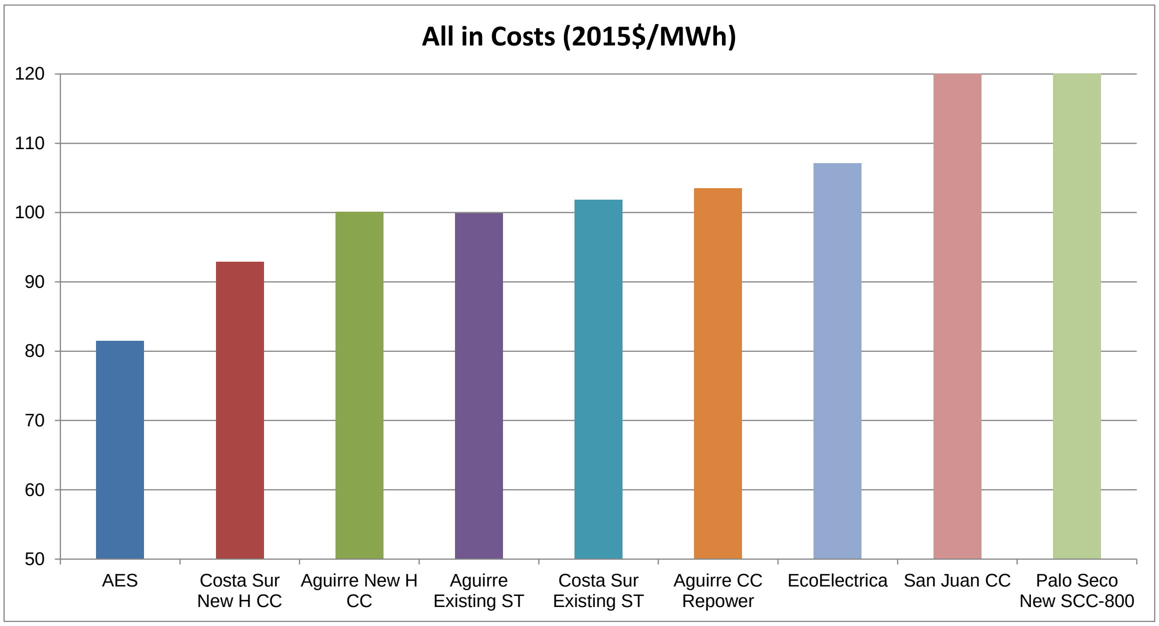
P3MF1M fuel sensitivity case resulted in a present value of system costs of $22.7 billion, which is approximately $3 billion lower than the P3MF1M with base fuel forecast, driven by the substantially lower fuel forecast assumed in the fuel sensitivity analysis.

9.3.1 P3MF1M with Base Fuel Forecast

As was done above, we first present the main results of P3MF1M with the base fuel forecast, followed by the changes that the reduced fuel forecast introduces.

As can be observed below, considering the base fuel price forecast, the average all in costs for the new H Class units at Aguirre and Costa Sur are lower than those of the units being replaced, justifying its replacement as soon as practicable, which in this case is limited by capital availability and the time required for permitting and EPC (engineering, procurement, and construction) development.

Figure 9-13: P3MF1M All In Cost with Base Fuel Forecast

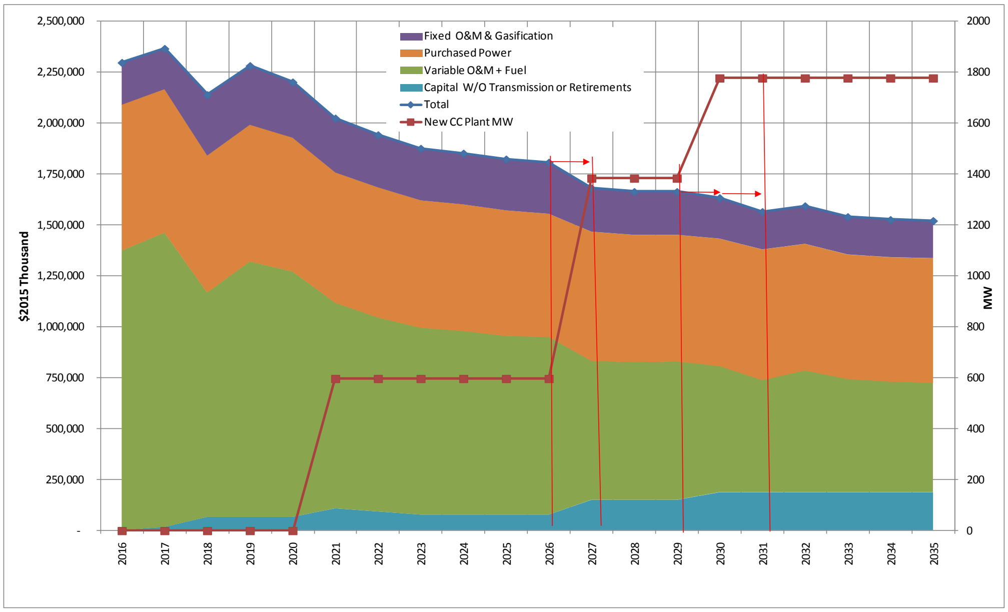


Source: Siemens PTI

This is further illustrated in the figure below that shows the total thermal generation costs including the capital invested in the new units on the left hand axis and on the right hand axis the total new generation added to the system.

We note in this figure that the yearly costs go down when Costa Sur 5&6 are retired and replaced by one H Class unit the Aguirre site and another at the Costa Sur site in FY 2027. Also we note that there is a positive, albeit lesser impact when the Aguirre 1&2 units are retired in 2030 and 2031 and replaced by a new H Class unit at Aguirre in FY 2030.

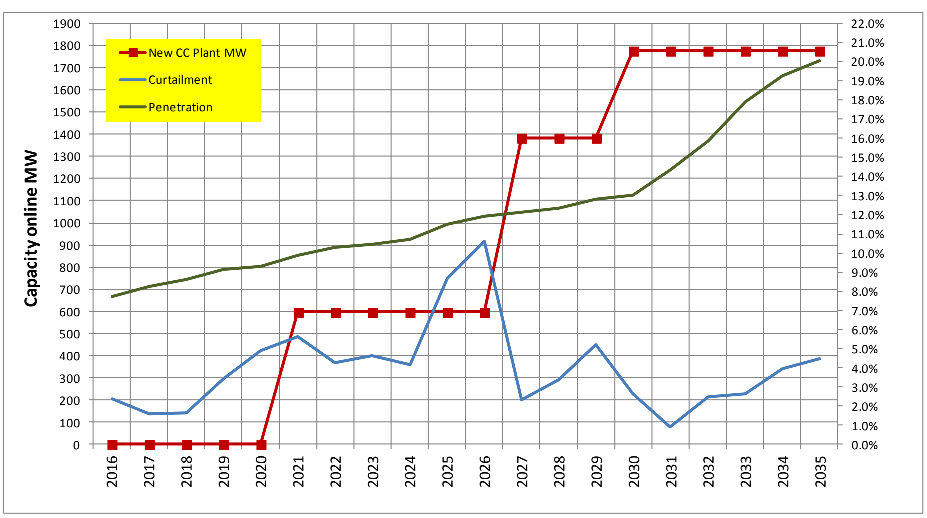
Figure 9-14: P3MF1M Thermal Generation Costs with Base Fuel Forecast



Source: Siemens PTI

Finally, we observe below that the replacement of the Aguirre and Costa Sur units is required to control the curtailment and achieve the evaluated RPS targets. Note that the curtailment goes down as soon as new capacity is added to the system.

Figure 9-15: P3MF1M Curtailment Costs with Base Fuel Forecast



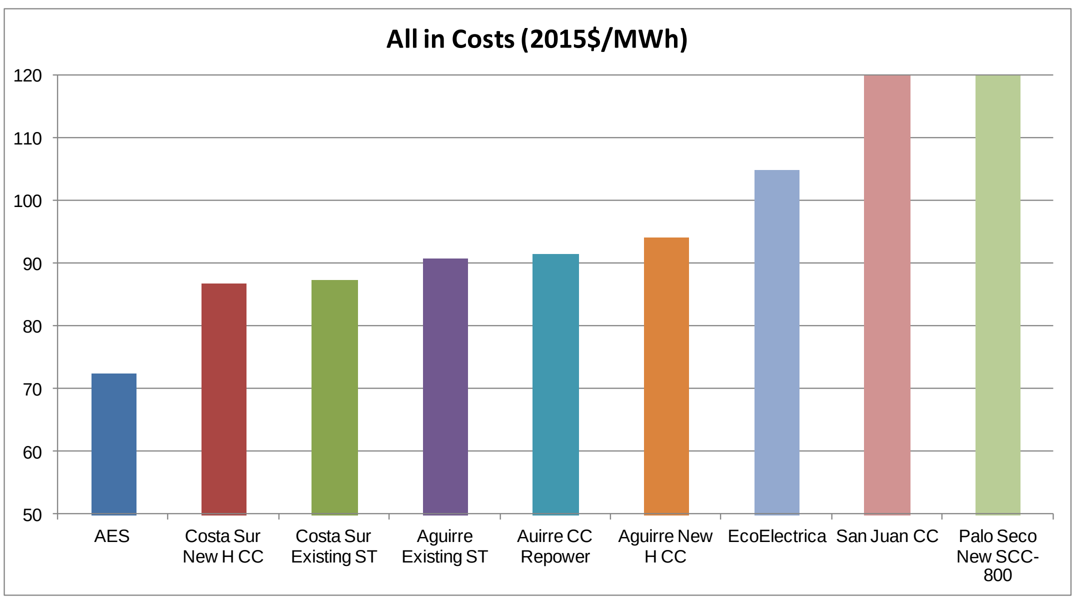
Source: Siemens PTI

9.3.2 P3MF1M with Reduced Fuel Forecast

We present below the main results of P3MF1M with the reduced cost fuel forecast.

Considering the reduced cost fuel forecast the average all in costs for the new H Class units at Costa Sur are still smaller than the corresponding units being replaced. In this case however the all in costs of the Aguirre H Class units is higher than the steam units. Note that while we can state that the replacement is convenient when the new flexible units have lower all in costs than the steam electric units being replaced, the contrary is not necessarily true and further evaluations are required. The reason for this is that the more flexible units also take the role of providing regulating reserves and enabling renewable generation integration, thus their dispatch is lower than would otherwise result producing a higher all in cost. This can be further confirmed by noting that while the units at Aguirre and Costa Sur have the same fuel prices and same efficiency, the Aguirre units have higher price showing that they are providing the reserves.

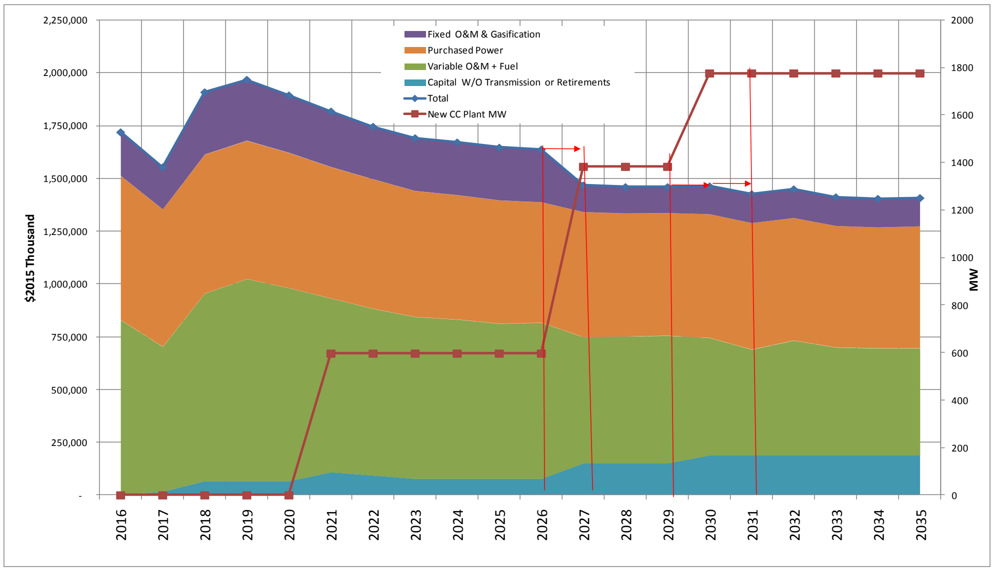
Figure 9-16: P3MF1M All In Costs with Reduced Fuel Forecast



Source: Siemens PTI

The figure below shows on the left axis the total thermal generation costs, including the capital invested in the new units, and on the right hand axis the total new generation added to the system. As before, we note that the yearly costs go down when Costa Sur 5&6 are retired and replaced by one H Class unit at the Aguirre site and another at the Costa Sur site in FY 2027. Also we note that there is a small but positive impact when the Aguirre 1&2 units are retired in 2030 and 2031 and replaced by a new H Class unit at Aguirre in FY 2030. This last replacement could be postponed if it were not for the negative impact that it would have on the curtailment of renewable generation as shown in Figure 9-18.

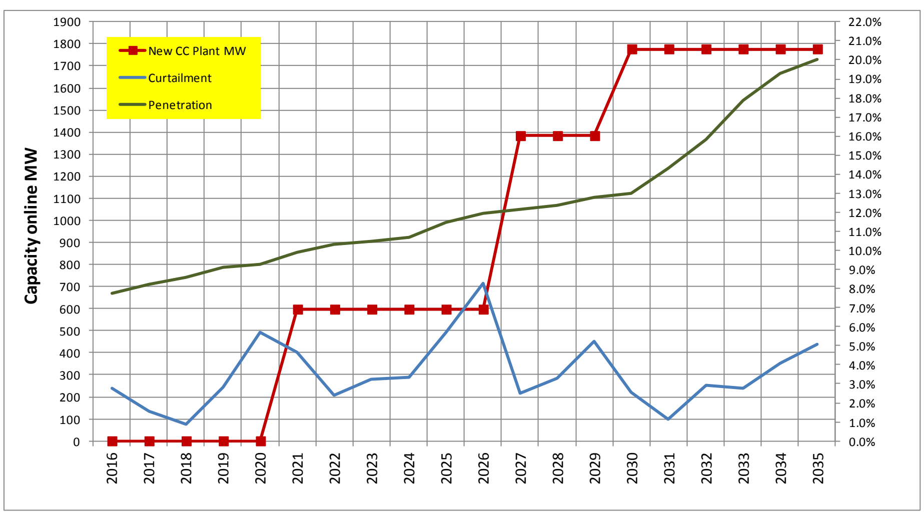
Figure 9-17: P3MF1M Thermal Generation Costs with Reduced Fuel Forecast



Source: Siemens PTI

Finally, we observe below that as was the situation with the base fuel forecast, the replacement of the Aguirre and Costa Sur units is required to control the curtailment and achieve the reduced RPS targets and both Costa Sur 5&6 and Aguirre 1&2 should be retired to reach full RPS compliance.

Figure 9-18: P3MF1M Curtailment Costs with Reduced Fuel Forecast



Source: Siemens PTI

9.4 P3MF2M Fuel Sensitivity Analysis

This case considers that the AOGP is not built and there is the energy efficiency demand reduction. In this case, all replacement decisions are made for MATS compliance and comprises of the retirement of the Aguirre 1&2 steam units and its replacement by two H Class combined cycle units, one at Aguirre and the other at Costa Sur, as well as the retirement or designation of limited use of the steam units in the north (San Juan 9&10 and Palo Seco 3&4) and the installation of an H Class combined cycle at Palo Seco site.

Therefore in this case the reduction in fuel prices has no impact on the decisions as these are not based on economics.

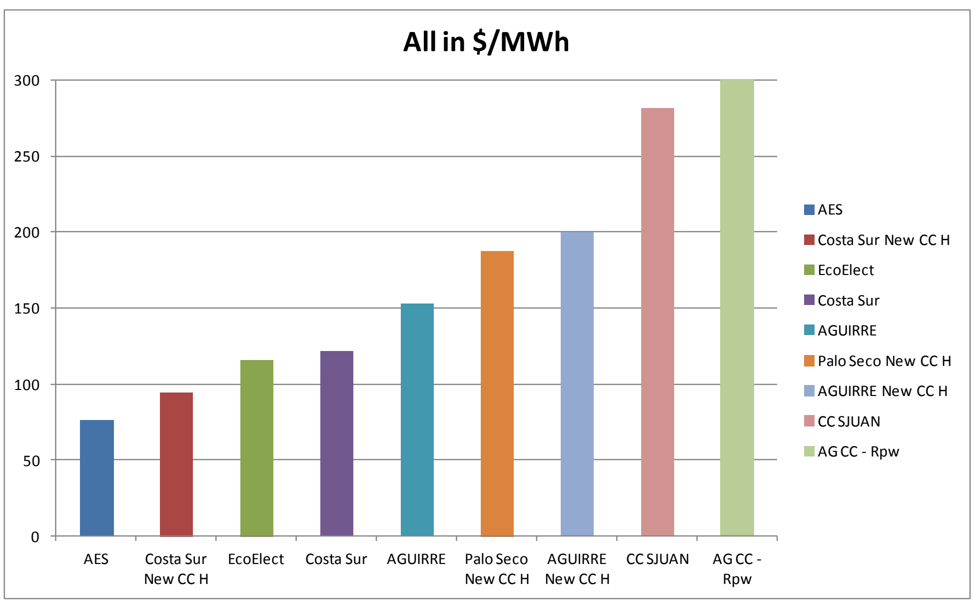
P3MF2M fuel sensitivity case resulted in a present value of system costs of $22.9 billion, which is approximately $5.9 billion lower than the P3MF2M with base fuel forecast, driven by the substantially lower fuel forecast assumed in the fuel sensitivity analysis.

As before, the key finding in this case (P3MF2M fuel sensitivity case) is that the present value of the system costs of $22.9 billion is about $219 million higher than the corresponding value for the case that the AOGP is built (P3MF1M fuel sensitivity case with a present value of system costs of $22.7 billion), thus demonstrating again the convenience of the AOGP project.

9.4.1 P3MF2M with Base Fuel Forecast

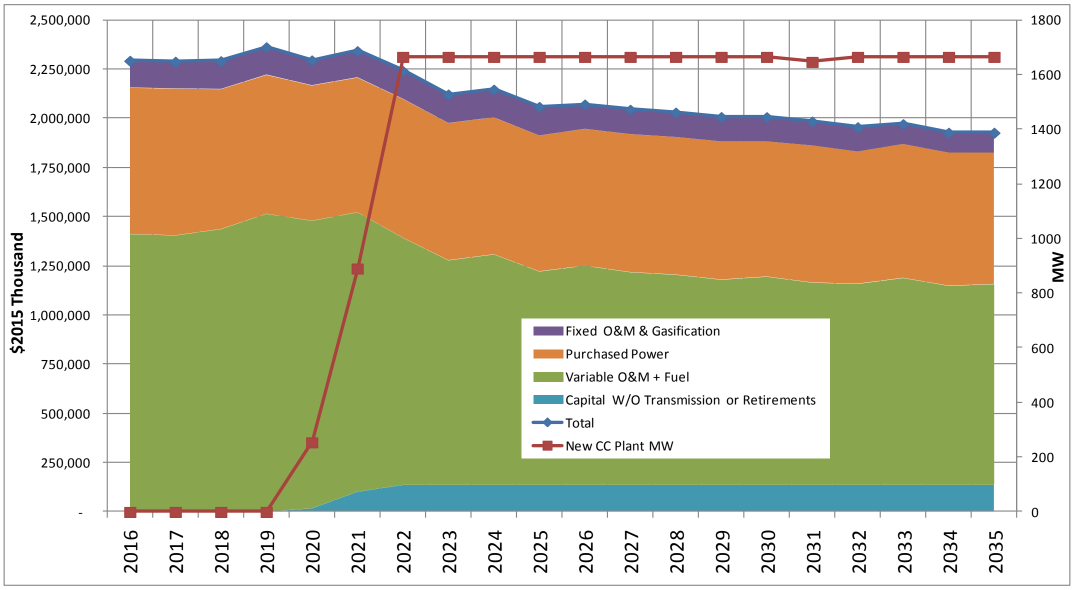
We present below the same results as above for the case with original and reduced fuel prices. Here it can be observed that the trends are fundamentally the same, with a downward displacement for the case of reduced fuel prices.

Figure 9-19: P3MF2M All In Costs with Base Fuel Forecast



Source: Siemens PTI

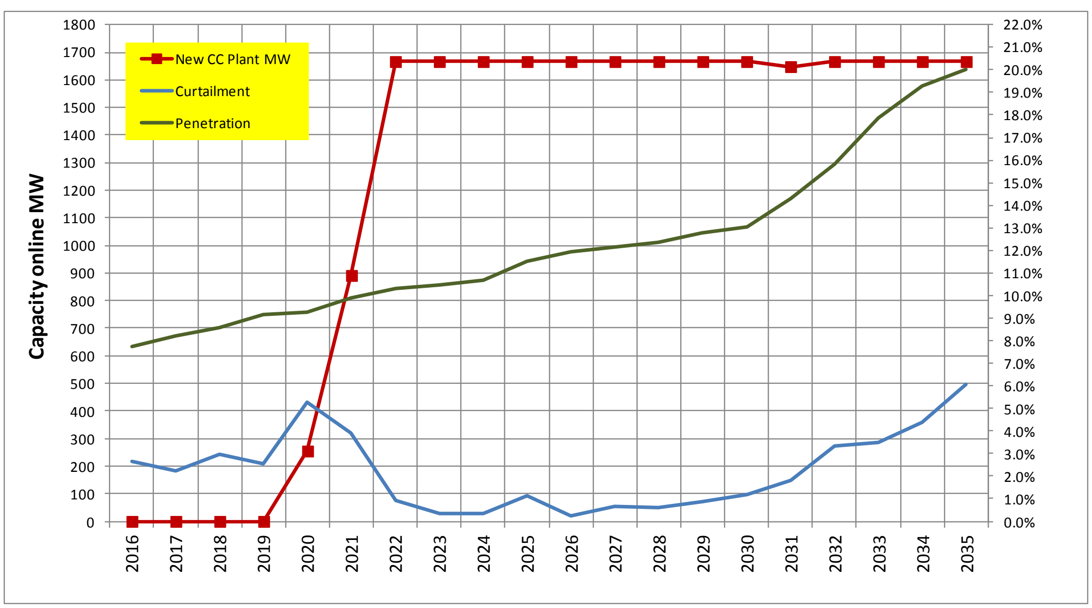
Figure 9-20: P3MF2M Thermal Generation Costs with Base Fuel Forecast



Source: Siemens PTI

As before the curtailment increases towards the end of the period when we seek to achieve full RPS compliance.

Figure 9-21: P3MF2M Curtailment Costs with Base Fuel Forecast

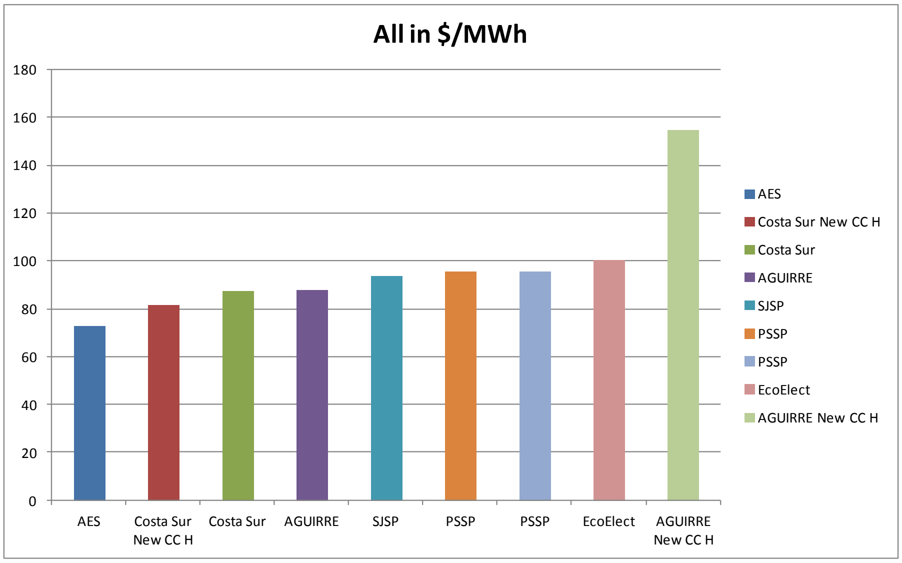


Source: Siemens PTI

9.4.2 P3MF2M with Reduced Fuel Forecast

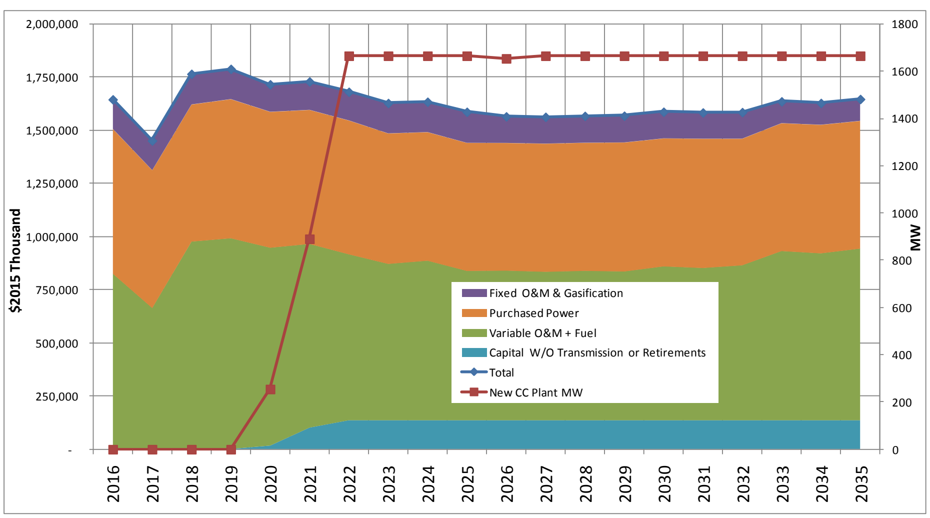
We present below the main results of P3MF2M with the reduced fuel forecast. In this case we note that the trends are basically the same in terms of just an initial capital investment and the following energy production as a reflection of demand and fuel prices. We also note in this last case that as the fuel prices recover towards the end of the period, the reduction in generating cost due to demand drop is off-set by the increase in fuel prices.

Figure 9-22: P3MF2M All In Costs with Reduced Fuel Forecast



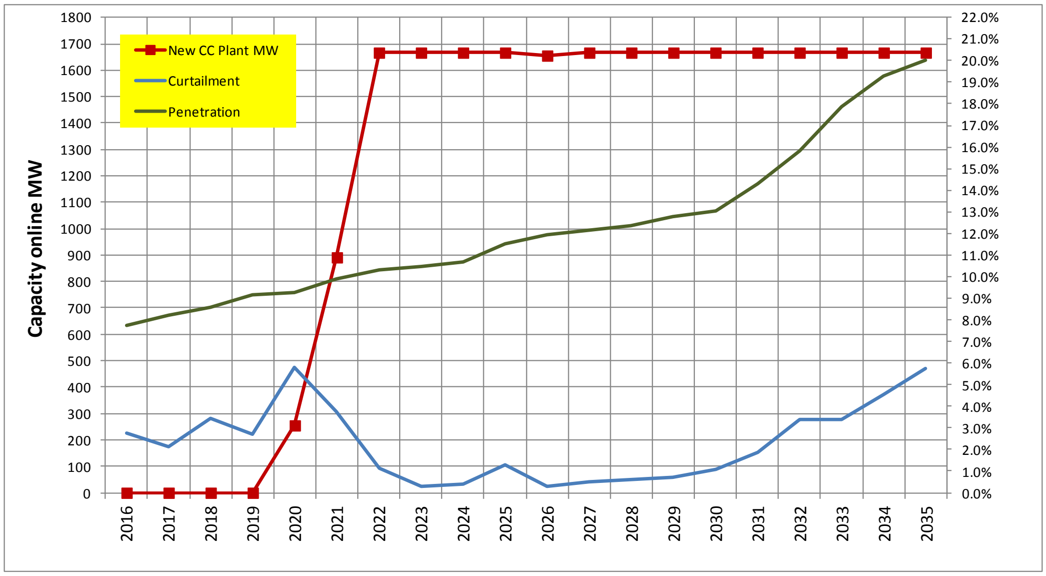
Source: Siemens PTI

Figure 9-23: P3MF2M Thermal Generation Costs with Reduced Fuel Forecast



Source: Siemens PTI

Figure 9-24: P3MF2M Curtailment Costs with Reduced Fuel Forecast



Source: Siemens PTI

9.5 P3MF2M_S2 No EcoEléctrica Fuel Sensitivity Analysis

This sensitivity shows the impact of the reduced fuel prices in the case the EcoEléctrica contract is not extended in 2022.

This case has the same result as the case with the base fuel prices; if the EcoEléctrica contract were to remain with the its current terms, it would be more economic to replace it with a new H Class combined cycle at Costa Sur.

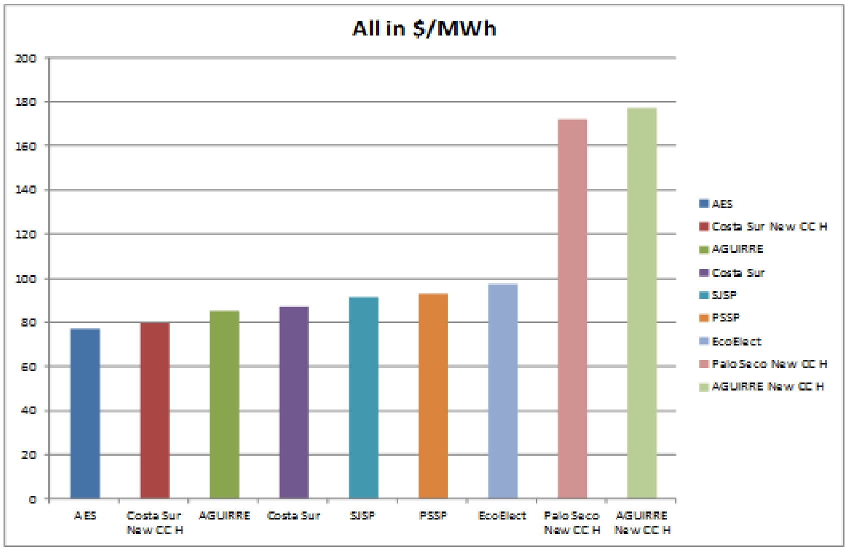
This can be observed in the figures below. In the first figure we observe that the all in cost for EcoEléctrica is higher than its replacement (the H Class at Costa Sur).

In the second figure we note that the thermal production costs with the extension of the EcoEléctrica contract (dashed line) are greater than the resulting costs in this sensitivity. This can be further explained by noting that the savings in purchased power by not extending the EcoEléctrica contract are higher than the capital investments on the H Class unit at Costa Sur and the associated increase in fuel costs.

Finally, we observe that the curtailment is about the same in this case as with the base fuel prices and better than the case with EcoEléctrica extended (four percent towards the end instead of six percent).

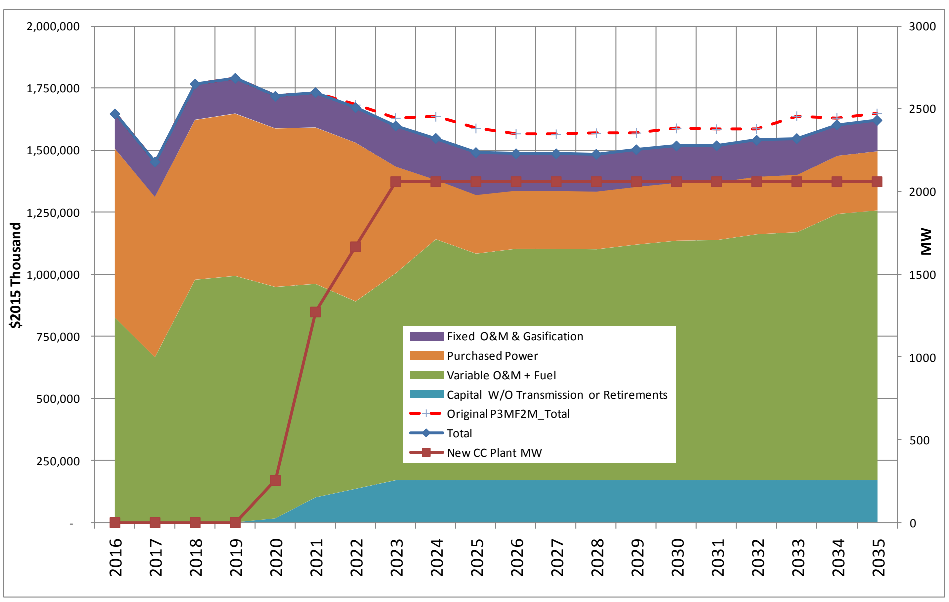
P3MF2M_S2 fuel sensitivity case resulted in a present value of system costs of $22.5 billion, which is approximately $6 billion lower than the P3MF2M_S2 with base fuel forecast, driven by the substantially lower fuel forecast assumed in the fuel sensitivity analysis.

Figure 9-25: P3MF2M_S2 All In Cost with Reduced Fuel Forecast



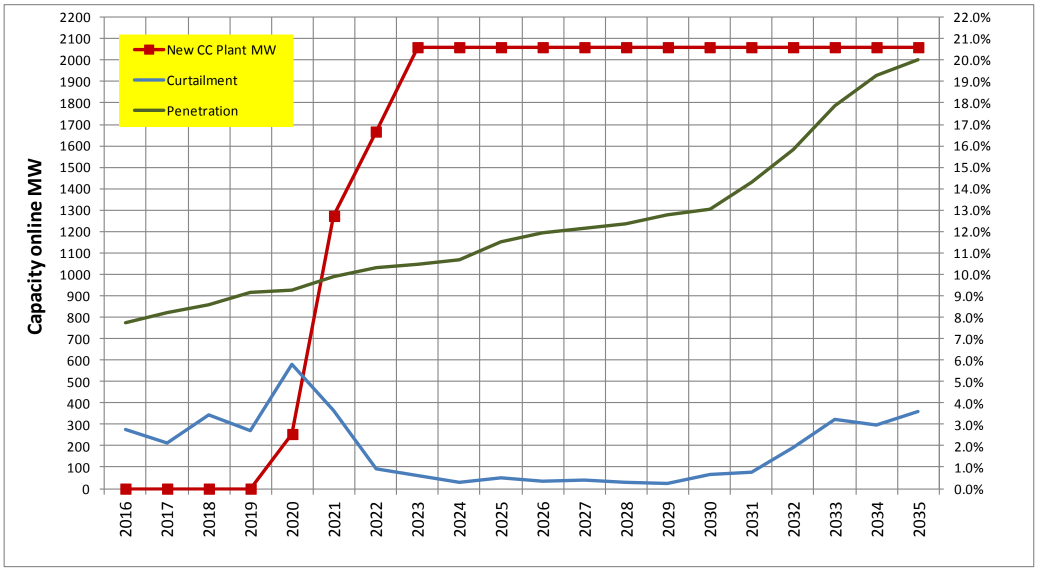
Source: Siemens PTI

Figure 9-26: P3MF2M_S2 Thermal Generation Costs with Reduced Fuel Forecast



Source: Siemens PTI

Figure 9-27: P3MF2M_S2 Curtailment Costs with Reduced Fuel Forecast



Source: Siemens PTI

9.6 P3MF1M_S4 Demand Response Fuel Sensitivity Analysis

We present below the results of the Portfolio 3 modified as presented earlier in this report, for Future 1 with the assumed demand reduction due to energy efficiency, reduced fuel prices and Demand Response in place to achieve full RPS Compliance.

P3MF1M_S4 fuel sensitivity case resulted in a present value of system costs of $23.4 billion, which is approximately $2.7 billion lower than the P3MF1M_S4 with base fuel forecast, driven by the substantially lower fuel forecast assumed in the fuel sensitivity analysis.

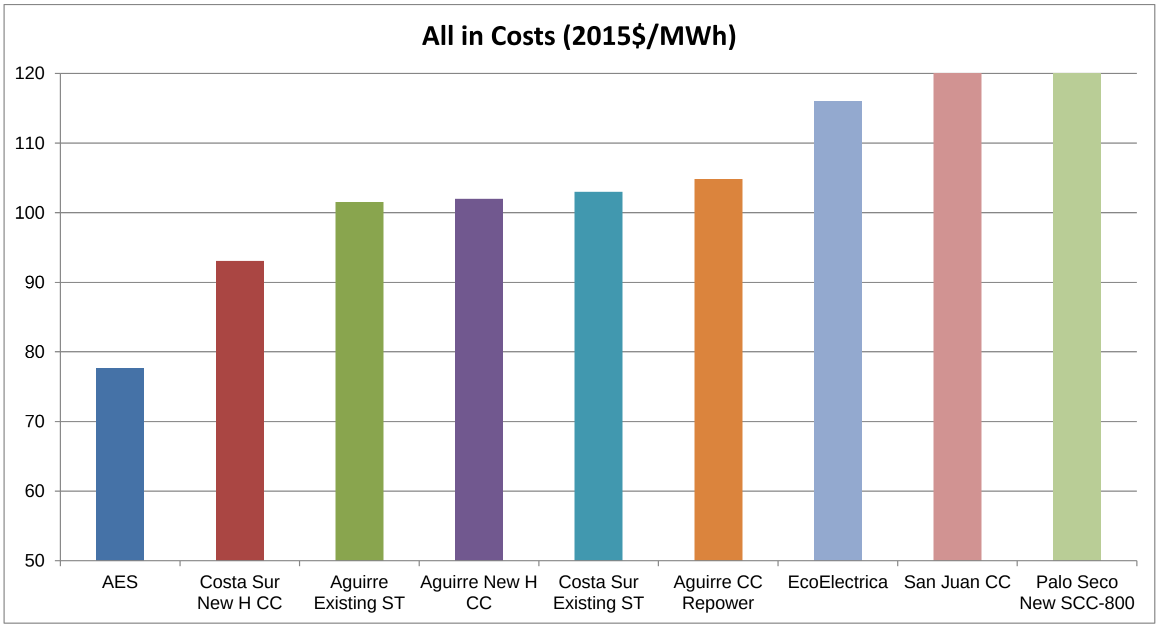
As demand response is basically geared to achieve full RPS compliance, the impact of reduced fuel prices are substantially the same as the results presented above for P3MF1M.

9.6.1 P3MF1M_S4 with Base Fuel Forecast

As was done above, we first present the main results of P3MF1M_S4 with the base fuel forecast, followed by the changes that the reduced fuel forecast introduces.

As can be observed below, considering the base fuel price forecast, the average all in costs for the new H Class units at Costa Sur are lower than those of the units being replaced, justifying its replacement as soon as practicable, which in this case, besides time requirements for permitting and EPC (engineering, procurement, and construction) development, is limited by capital availability. We note that the all in costs for the new H Class units at Aguirre are about the same as those for the Costa Sur and Aguirre units. As indicated earlier, the reason for this is that the more flexible units also take the role of providing regulating reserves and enabling renewable generation integration, thus their dispatch is lower than would otherwise result producing a higher all in cost (note that while the units at Aguirre and Costa Sur have the same fuel prices and same efficiency, the Aguirre units have higher price showing that they are providing the reserves).

Figure 9-28: P3MF1M_S4 All In Costs with Base Fuel Forecast

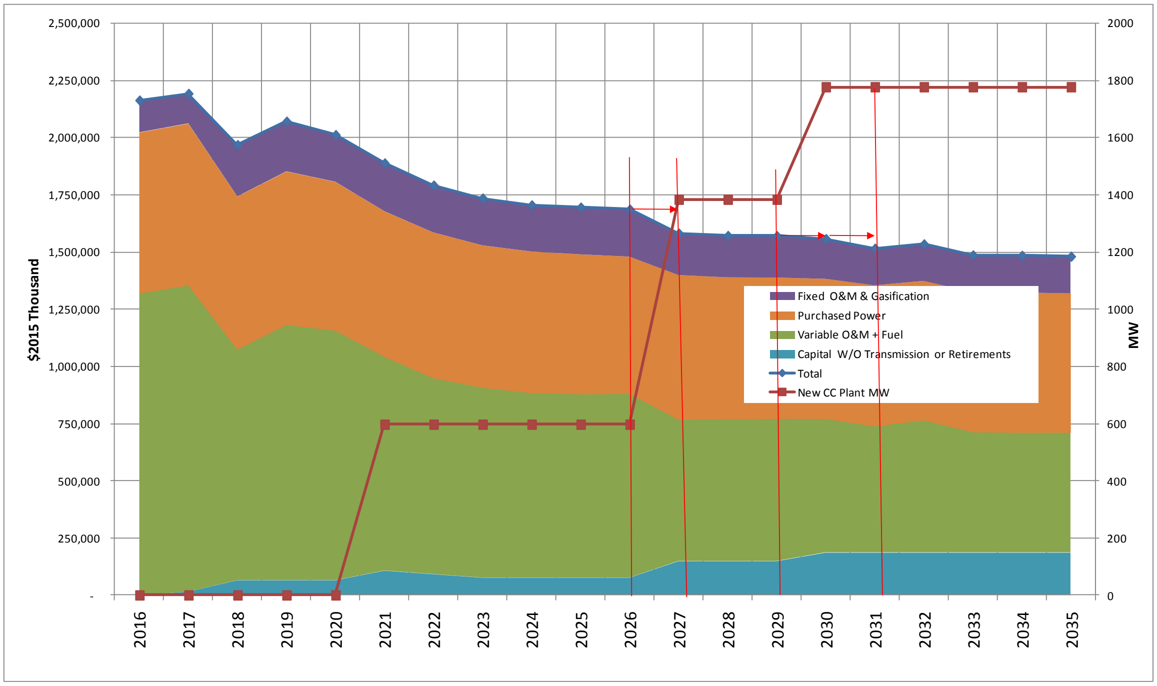


Source: Siemens PTI

This is further illustrated in the figure below that shows on the left axis the total thermal generation costs including the capital invested in the new units and on the right axis the total new generation added to the system.

We note in this figure that the yearly costs go down when Costa Sur 5&6 are retired and replaced by one H Class unit at the Aguirre site and another at the Costa Sur site in FY 2027. Also we note that there is a reduced impact when the Aguirre 1&2 units are retired in 2030 and 2031 and replaced by a new H Class unit at Aguirre in FY 2030. This last replacement could possibly be postponed depending on the conditions of Aguirre and if the curtailment can be controlled via other means as discussed below.

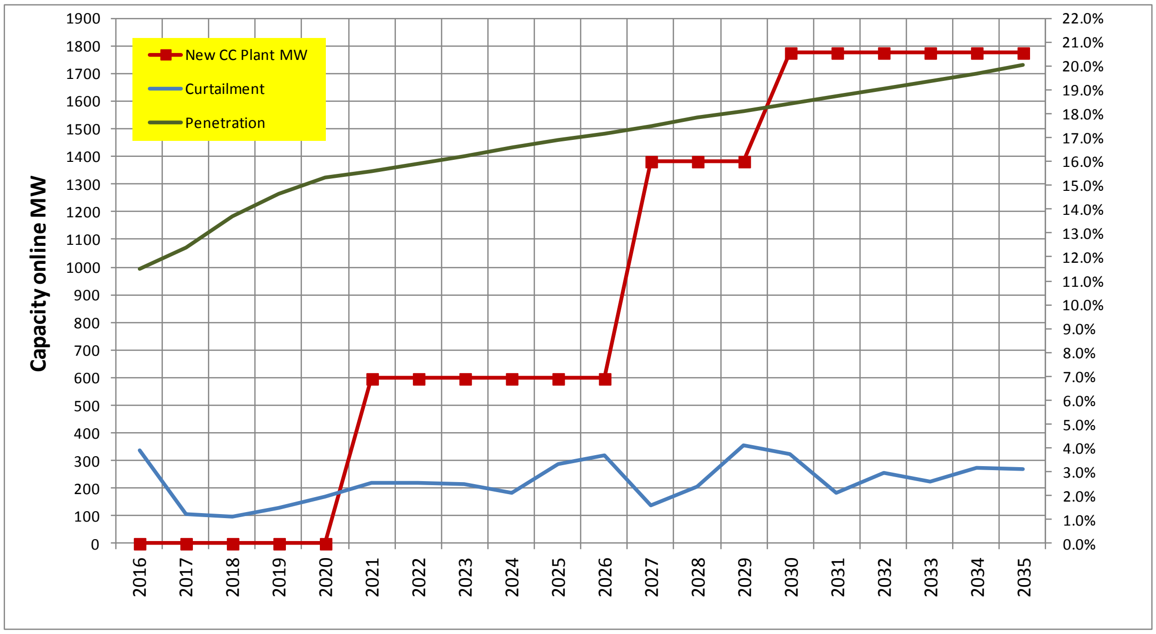
Figure 9-29: P3MF1M_S4 Thermal Generation Costs with Base Fuel Forecast



Source: Siemens PTI

We observe in the figure below that, in spite of the demand response, the curtailment starts drifting up and then goes down as soon as new capacity is added to the system. Thus in addition to the demand response (which is substantial), the replacement of the steam units at Costa Sur initially and then at Aguirre is required.

Figure 9-30: P3MF1M_S4 Curtailment Costs with Base Fuel Forecast



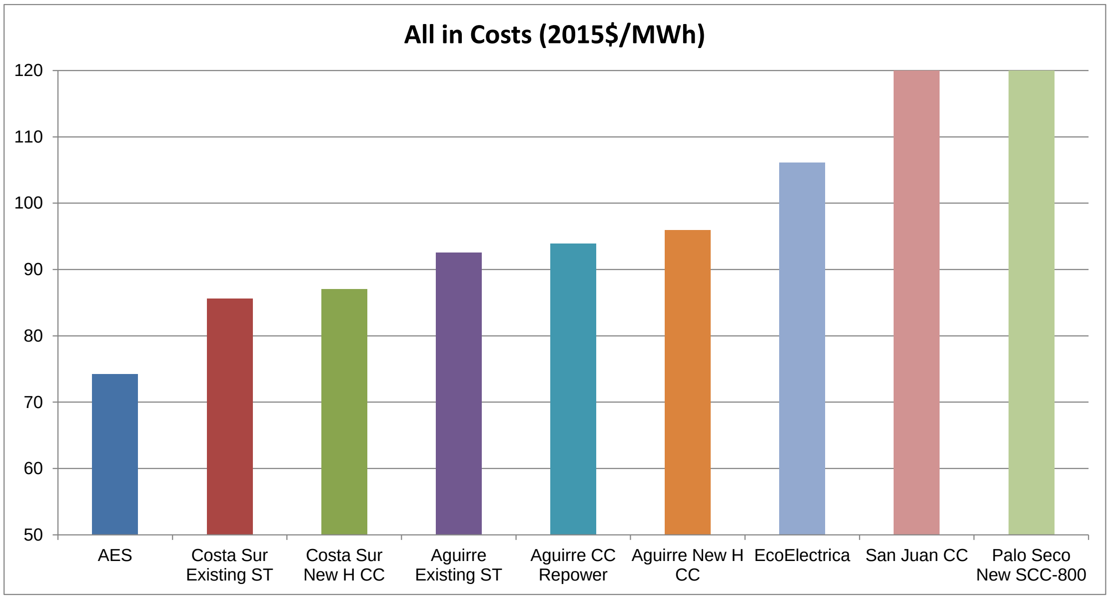
Source: Siemens PTI

9.6.2 P3MF1M_S4 with Reduced Fuel Forecast

We present below the main results of P3MF1M_S4 Demand Response, with the reduced cost fuel forecast.

Considering the reduced cost fuel forecast, the average all in costs for the new H Class units at Costa Sur are similar to those of Costa Sur 5&6 and smaller than Aguirre 1&2. The all in costs of the Aguirre H Class units are higher than the steam units. As before, the reason for this is that the more flexible units are providing regulating reserves and enabling renewable generation integration and their dispatch is lower than would otherwise be.

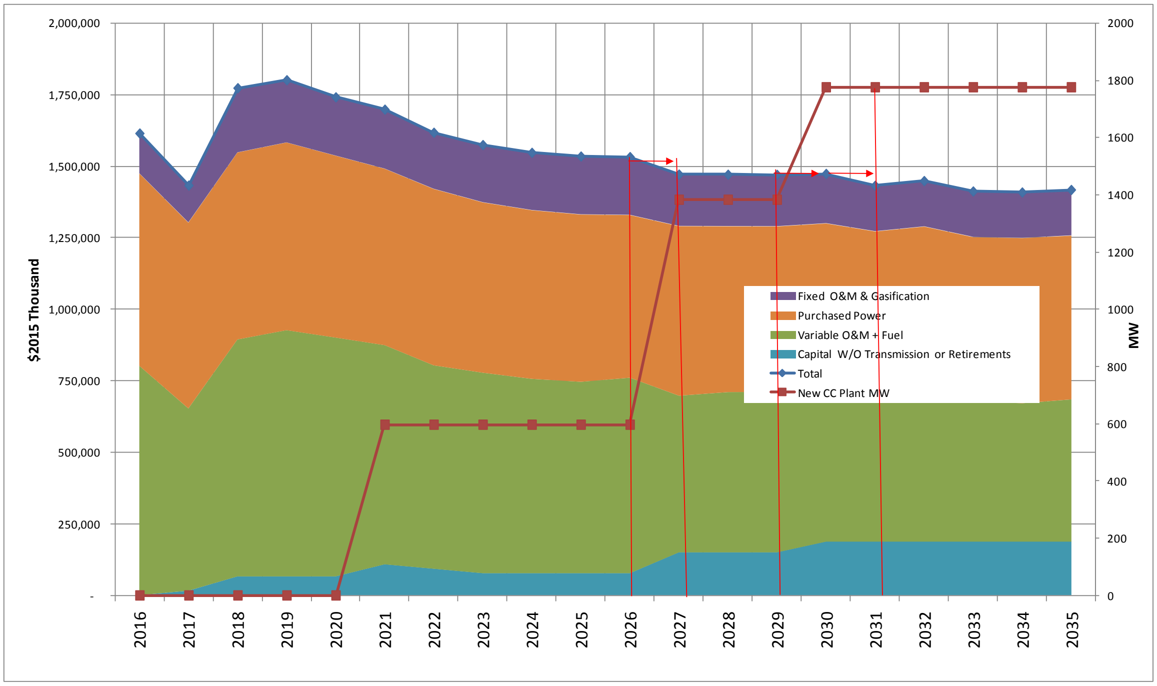
Figure 9-31: P3MF1M_S4 All In Costs with Reduced Fuel Forecast



Source: Siemens PTI

As was shown the yearly costs do go down when Costa Sur 5&6 are retired and replaced by one H Class unit at the Aguirre site and another at the Costa Sur site by FY 2027. Also we note that there is a much smaller, but positive impact when the Aguirre 1&2 units are retired in 2030 and 2031 and replaced by a new H Class unit at Aguirre in FY 2030. This last replacement could be postponed if the curtailment could be managed as discussed below.

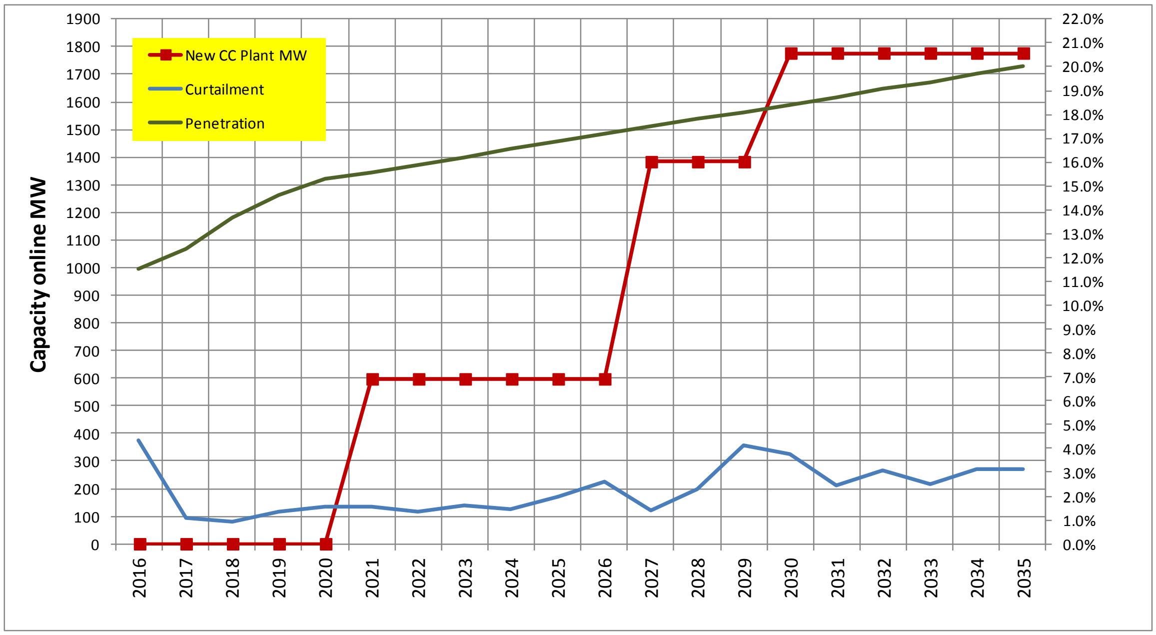
Figure 9-32: P3MF1M_S4 Thermal Generation Costs with Reduced Fuel Forecast



Source: Siemens PTI

Finally, we observe below that as was the situation with the base fuel forecast, the addition of flexible generation and replacement of the Costa Sur units helps control the curtailment in addition to the demand response. The retirement of the Aguirre units and the addition of the second H class unit at Aguirre could possibly be postponed, but note that the curtailment with this replacement is hovering around 3 percent.

Figure 9-33: P3MF1M_S4 Curtailment Costs with Reduced Fuel Forecast



Source: Siemens PTI

9.7 P3MF1M_S5 Full RPS Compliance Fuel Sensitivity Analysis

This case considers that the AOGP is built, there is the energy efficiency demand reduction and Full RPS Compliance is required by 2020. In this case, all replacement decisions are made for MATS or full RPS compliance and all flexible units are added as soon as possible (between FY 2021 and 2022), Costa Sur 5&6 are retired and the Aguirre units stay in service until the reduction in demand allows its retirement as well.

Therefore in this case the reduction in fuel prices has no impact on the decisions as these are not based on economics.

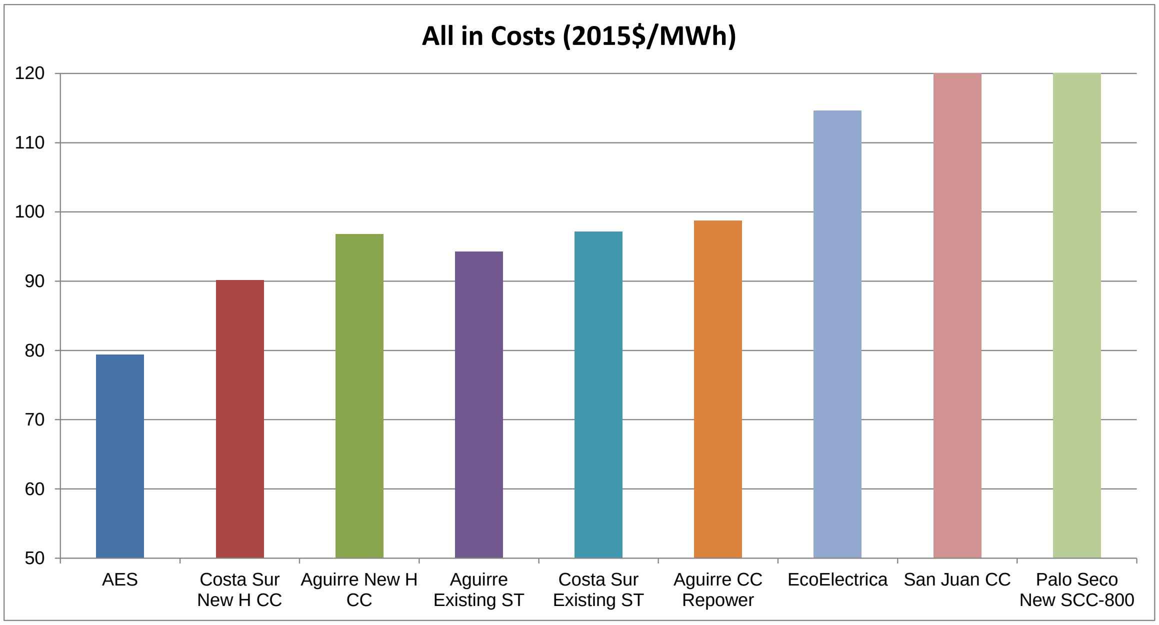
P3MF1M_S5 fuel sensitivity case resulted in a present value of system costs of $23.5 billion, which is approximately $2.6 billion lower than the P3MF1M_S5 with base fuel forecast, driven by the substantially lower fuel forecast assumed in the fuel sensitivity analysis.

9.7.1 P3MF1M_S5 with Base Fuel Forecast

We present below the same results as above for the case with original and reduced fuel prices. Here it can be observed that the trends are fundamentally the same, with a downward displacement for the case of reduced fuel prices.

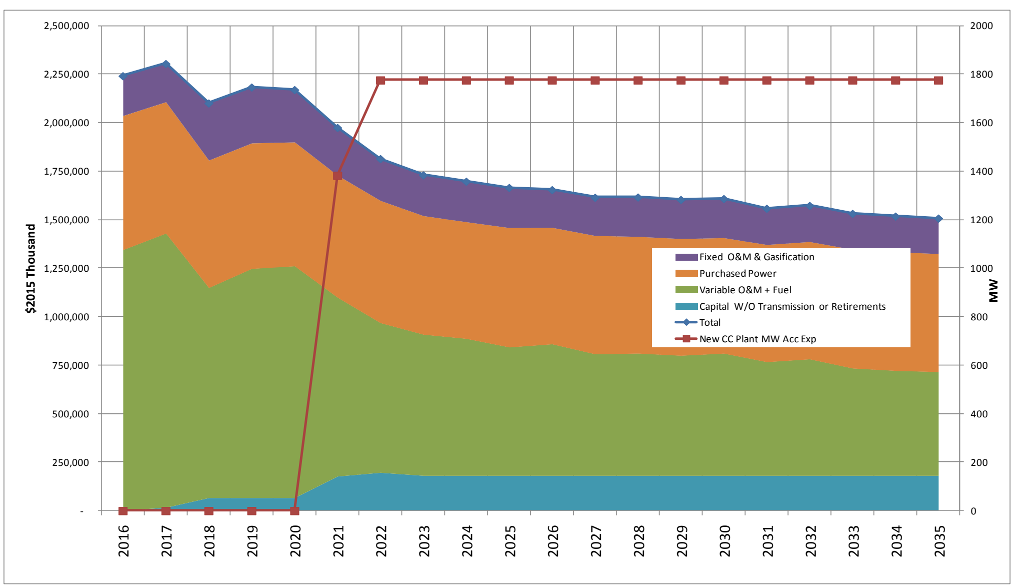
With the base fuel prices the new H Class units have significantly lower costs than the units being replaced.

Figure 9-34: P3MF1M_S5 All In Costs with Base Fuel Forecast



Source: Siemens PTI

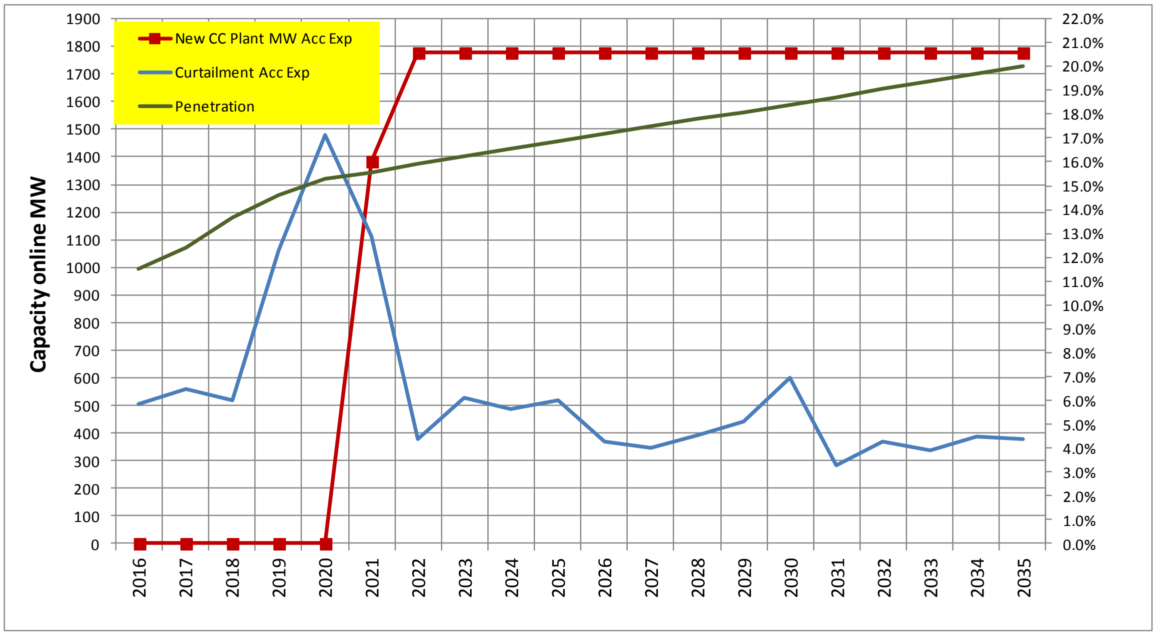
Figure 9-35: P3MF1M_S5 Thermal Generation Costs with Base Fuel Forecast



Source: Siemens PTI

As before we note that there is an important increase in the curtailment by 2020 as the new units are not yet in place and full RPS compliance is sought.

Figure 9-36: P3MF1M_S5 Curtailment Costs with Base Fuel Forecast



Source: Siemens PTI

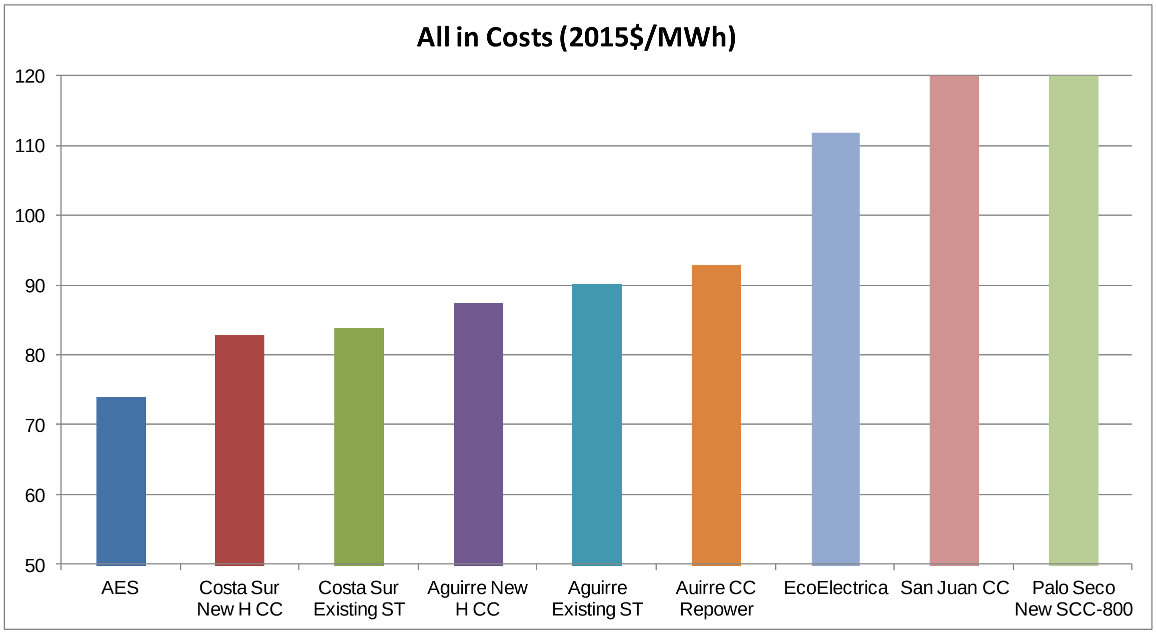
9.7.2 P3MF1M_S5 with Reduced Fuel Forecast

We present below the main results of P3MF1M_S5 which is designed for full RPS compliance with the reduced fuel forecast. We note that the trends are basically the same as with the base fuel forecast, showing an initial capital investment and the following energy production as a reflection of demand and fuel prices.

We note below that with the reduced fuel prices, the order is reversed with respect of the new Aguirre H Class units that have higher all in costs than the replaced Costa Sur steam units 5&6, however, this is due to the reduced dispatch to accommodate the renewable and its incorporation to the system is mandated by this fact.

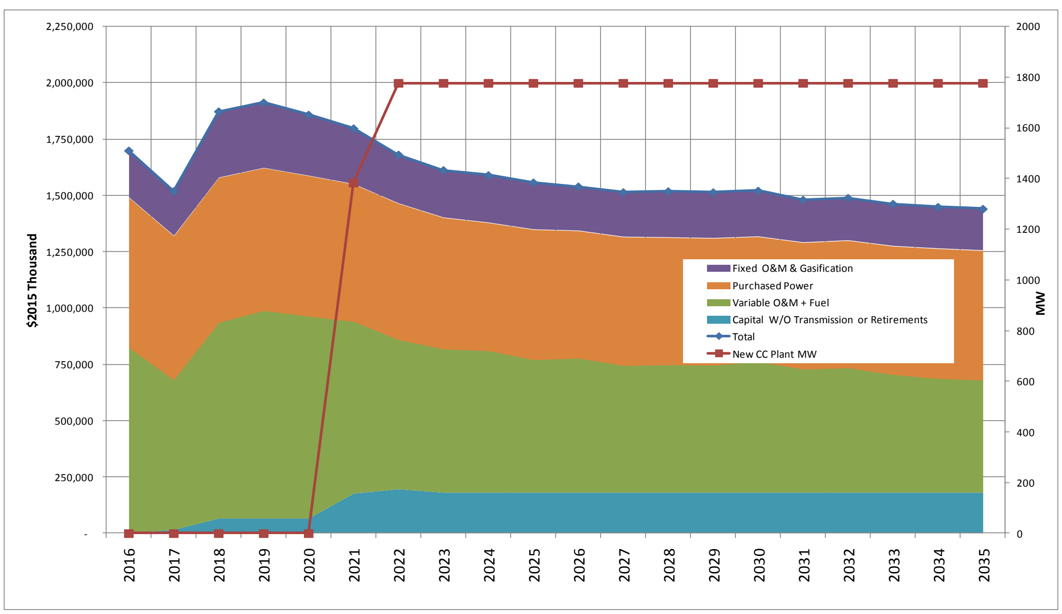
We note the same trend as before on the thermal system costs and very similar curtailment profile.

Figure 9-37: P3MF1M_S5 All In Costs with Reduced Fuel Forecast



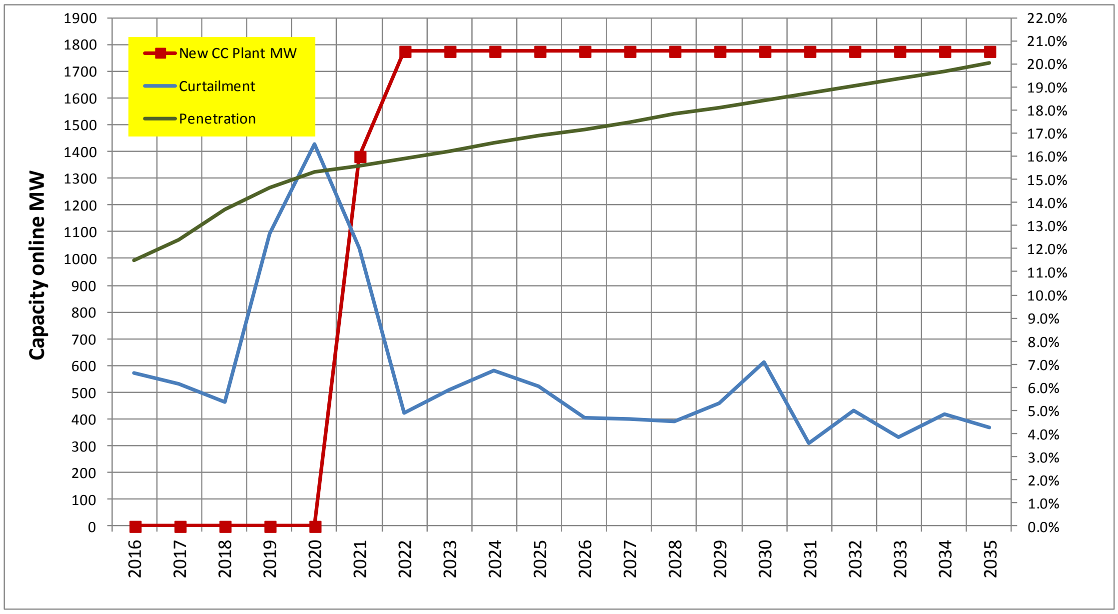
Source: Siemens PTI

Figure 9-38: P3MF1M_S5 Thermal Generation Costs with Reduced Fuel Forecast



Source: Siemens PTI

Figure 9-39: P3MF1M_S5 Curtailment Costs with Reduced Fuel Forecast



Source: Siemens PTI

Section

10

Action Plan

This section addresses the actions PREPA plans to take in the near term as a result of its analysis, and as requested by Section 8 of the Order. This section addresses five requested items in the Order. The transmission information requested is presented in a separate document named "Sections 6 & 8: Transmission".

10.1 Estimated Near Term Major Generation and AOGP Capital Expenditures

The Preferred Resource Plan, which is P3F1 as established in the Base IRP, is expected to incur an estimated capital expenditure of $1.15 billion during FY2016-2021 for generation and AOGP as presented in Table 10-1 below. This includes AOGP capital costs, fuel conversion, repowering, retirements and new F Class 1X1 CC at Palo Seco. It should be noted that the capital costs for representative future generation resources are derived using the PEACE capital cost estimating module associated with the GT Pro plan design software. Competitive bidding will be possible at the time a project is implemented.

In addition, the all in costs are reflected in the fiscal year that the projects become commercial on line, while in more detailed near term planning, the capital expenditures will follow a tailored spending curve for each type of project.

All dates unless otherwise noted in the Supplemental IRP are kept consistent with the Base IRP that is all process for near term projects are started in July 2015. These dates will be updated once the IRP is approved and its conditions known.

Table 10-1: P3F1 (Base IRP) Near Term Capital Expenditures

P3F1 5-Year Projects Summary	2016	2017	2018	2019	2020	2021
AOGP	-	-	384,938	-	-	-
Aguirre 1 Steam Unit Gas Fuel Conversion	-	39,209	-	-	-	-
Aguirre 2 Steam Unit Gas Fuel Conversion	-	-	39,209	-	-	-
Aguirre 1 CC Unit Dual Fuel Conversion (gas and diesel)	-	24,632	-	-	-	-
Aguirre 2 CC Unit Dual Fuel Conversion (gas and diesel)	-	-	24,632	-	-	-
New Generation at Palo Seco (F Class)	-	-	-	-	-	392,101
Aguirre 1 CC Unit Gas Turbine Replacement/Repower	-	-	-	-	-	196,629
Costa Sur 3 Unit Retirement	-	-	-	-	5,700	-
Costa Sur 4 Unit Retirement	-	-	-	-	5,700	-
Palo Seco 1 Unit Retirement	-	-	-	-	5,700	-
Palo Seco 2 Unit Retirement	-	-	-	-	5,700	-
San Juan 7 Unit Retirement	-	-	-	-	6,450	-
San Juan 8 Unit Retirement	-	-	-	-	6,450	-
San Juan 9 Steam Unit Retirement or Limited Use	-	-	-	-	-	6,375
San Juan 10 Steam Unit Retirement or Limited Use	-	-	-	-	-	6,375
Total	**-**	**63,841**	**448,779**	**-**	**35,700**	**601,480**

5-Year Total Capex (Generation and AOGP)
1,149,799

Note:

(1) Above schedules are based on fiscal year.

(2) San Juan steam units 9&10 and Palo Seco steam units 3&4 will be retired or designated as limited use. For planning purposes, we included retirement costs for San Juan steam units 9&10.

(3) This table does not include transmission capex which is presented in the “PREPA Integrated Resource Plan Supplementary Evaluation: Transmission Analysis”.

Source: PREPA, Siemens PTI, Pace Global

Alternatively, planning on three SCC-800 1X1 CCs instead of one F Class 1X1 CC at Palo Seco will add some flexibility if the EE materializes and PREPA decides that only one SCC-800 will be needed at Palo Seco, in which case, additional transmission upgrades will be needed as discussed in the “PREPA Integrated Resource Plan Supplementary Evaluation: Transmission Analysis”. Table 10-2 presents the total capital costs with three SCC-800 1X1 CCs at Palo Seco.

Table 10-2: P3MF1 (Base IRP Modified) Near Term Capital Expenditures

P3MF1 5-Year Projects Summary	2016	2017	2018	2019	2020	2021
AOGP	-	-	384,938	-	-	-
Aguirre 1 Steam Unit Gas Fuel Conversion	-	39,209	-	-	-	-
Aguirre 2 Steam Unit Gas Fuel Conversion	-	-	39,209	-	-	-
Aguirre 1 CC Unit Dual Fuel Conversion (gas and diesel)	-	24,632	-	-	-	-
Aguirre 2 CC Unit Dual Fuel Conversion (gas and diesel)	-	-	24,632	-	-	-
SCC-800 at Palo Seco (train 1)					124,726	-
SCC-800 at Palo Seco (train 2)					-	126,003
SCC-800 at Palo Seco (train 3)					-	126,003
Aguirre 1 CC Unit Gas Turbine Replacement/Repower	-	-	-	-	-	196,629
Costa Sur 3 Unit Retirement	-	-	-	-	5,700	-
Costa Sur 4 Unit Retirement	-	-	-	-	5,700	-
Palo Seco 1 Unit Retirement	-	-	-	-	5,700	-
Palo Seco 2 Unit Retirement	-	-	-	-	5,700	-
San Juan 7 Unit Retirement	-	-	-	-	6,450	-
San Juan 8 Unit Retirement	-	-	-	-	6,450	-
San Juan 9 Steam Unit Retirement or Limited Use	-	-	-	-	-	6,375
San Juan 10 Steam Unit Retirement or Limited Use	-	-	-	-	-	6,375
Total	**-**	**63,841**	**448,779**	**-**	**160,426**	**461,384**

5-Year Total Capex (Generation and AOGP)
1,134,431

Note:

(1) Above schedules are based on fiscal year.

(2) San Juan steam units 9&10 and Palo Seco steam units 3&4 will be retired or designated as limited use. For planning purposes, we included retirement costs for San Juan steam units 9&10.

(3) This table does not include transmission capex which is presented in the “PREPA Integrated Resource Plan Supplementary Evaluation: Transmission Analysis”.

Source: PREPA, Siemens PTI, Pace Global

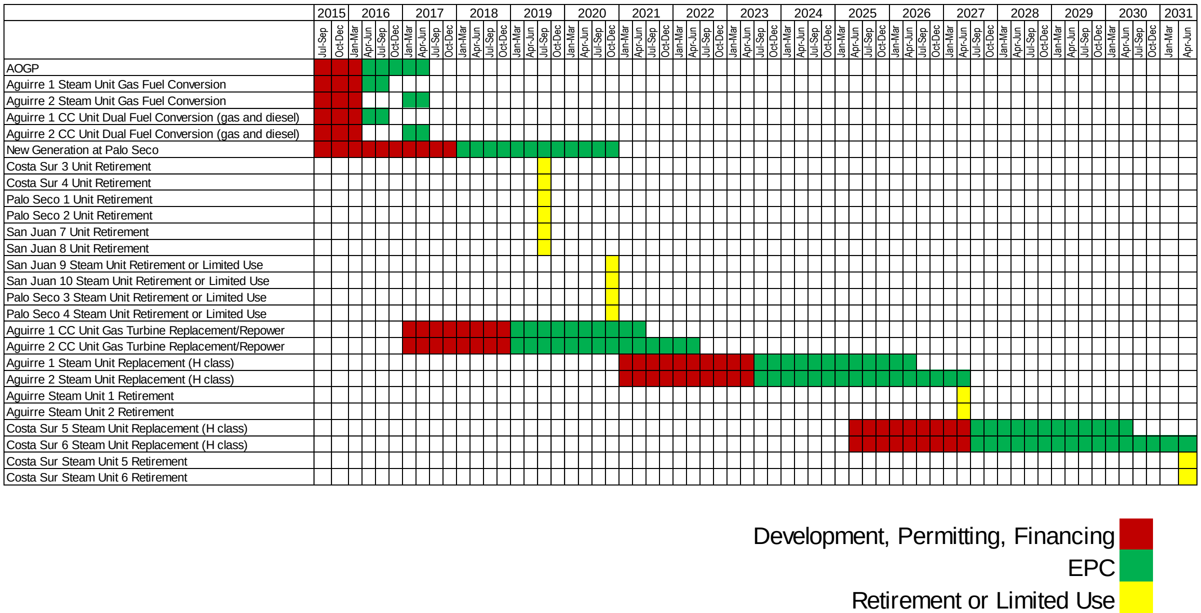
10.2 Requests for Proposals (RFPs)

PREPA expects to issue the following RFPs related to generation during the first five years should include the following projects.

1. New generation at Palo Seco
2. Aguirre CC gas turbine replacement
3. New Generation at Aguirre

Detailed action plans are presented in Table 10-3 below. It should be noted that the dates in the action plan are based on Base IRP filed in 2015. These dates will be updated once the IRP is approved and its conditions known.

Table 10-3: Action Plan Based on P3F1 in Base IRP



Source: PREPA, Siemens PTI, Pace Global

10.3 MATS Strategies

The IRP requires the approval of the Puerto Rico Energy Commission as mandated by Act 57 of 2014. As proposed, the IRP includes the steps necessary for PREPA to meet its Mercury and Air Toxics Standards (MATS) obligations. The alternatives analysis contained herein, and the selection of a preferred alternative, is subject to the Puerto Rico Energy Commission's approval. PREPA will be able to commit to the development of a plan and a timeline for MATS compliance upon the Puerto Rico Energy Commission's approval of the Integrated Resources Plan.

Consequently, any timelines considered herein should be considered proposals, which could be subject to further change. The proposed schedules are based on an assessment of the standard time periods for projects of a similar nature and scope assuming full funding. Thus, the proposed plan included herein should only be used for discussion purposes, since it is based on assumptions.

10.4 MATS Compliance

All of PREPA's existing 14 steam units (approximately 2,900 MW of total capacity) are subject to MATS. Costa Sur 5&6 steam units are in compliance with MATS as they are currently burning natural gas and No. 6 fuel oil in a dual-fuel firing mode.

Compliance with MATS at Aguirre 1&2 steam units depends on the availability of natural gas to be supplied by the AOGP. Future 2 assumes that, without AOGP, Aguirre 1&2 steam units will be included in a settlement with the federal government in a manner to allow for their continued operation until their retirement as they are critical to electrical system safety and reliability. Under such a circumstance, Aguirre 1&2 would continue to burn No. 6 fuel oil due to the unavailability of natural gas.

For MATS purposes, Costa Sur 3&4, Palo Seco 1&2, San Juan 7&8 have been designated as limited use[12] units and will operate in that mode until such time as they are retired, which is currently projected for December 31, 2020.

Any settlement negotiation with federal and state regulatory authorities, regarding Palo Seco 3&4 and San Juan 9&10 units will materially impact near term power supply costs. In the Base IRP, continued operation of Palo Seco 3&4 and San Juan 9&10 is assumed through December 31, 2020, during which time those units would burn No. 6 fuel oil. Thereafter, Palo Seco 3&4 and San Juan 9&10 will either be retired or designated as limited use.

10.5 AES and EcoEléctrica PPOAs

To supplement its capacity, PREPA purchases power from two generators under the terms and conditions of PPOAs,[13] including 507 MW of gas-fired capacity from EcoEléctrica, L.P. and 454 MW of coal-fired capacity from AES for a total capacity of 961 MW. Purchased power costs from AES and EcoEléctrica plants are relatively constant over the forecast horizon as these units are base-loaded units with the lowest production costs, and new unit additions and system improvements do not materially alter the dispatch profile of these facilities.

AES plant is typically the least expensive resource, and its retirement impacts the system costs and incurs higher capital costs. The non-renewal of AES contracts could be handled by the modified Portfolio 3 in Future 1 and 2, but incurs high capital costs and system costs. Therefore, an extension of the AES contract is recommended because AES is typically the lowest cost resource in the fleet.

EcoEléctrica is the only combined cycle facility that currently operates with natural gas and has been operating a LNG terminal since 2000. The non-renewal of EcoEléctrica contract could be handled by the modified Portfolio 3 under the tested Future 2 from a system operation perspective. However, it requires expedited new builds, parallel projects execution, and higher capital costs. Therefore, an extension of the EcoEléctrica contract is recommended (preferably with renegotiated terms in particular with respect of the capacity payments and fuel prices) since this will free up valuable capital resources for the modernization of the balance of PREPA's fleet.

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[12] Limited use units will have an annual heat input capacity factor of less than 8 percent over 24 month periods.

[13] Please refer to PREPA's website to see copies of the existing contracts and their respective amendments.
http://www.aeepr.com/Documentos/Ley57/AES/Contratos%20AES1.htm
http://www.aeepr.com/Documentos/Ley57/EcoElectrica/EcoElectrica1.htm

Appendix

A

Glossary of Terms

Aguirre Offshore GasPort (AOGP): A floating offshore liquefied natural gas regasification facility off the southern coast of Puerto Rico. It will consist of three main components: an offshore berthing platform; an offshore marine LNG receiving facility consisting of an FSRU moored at the offshore berthing platform; and a subsea pipeline connecting the platform to the Aguirre Power Complex, which will run across the Jobos Bay.

Air Cooled Condensers (ACCs): Air Cooled Condenser is a direct dry cooling system where the steam is condensed inside air-cooled finned tubes.

Amortized capital Costs: Capital investment spread over time, typically following a fixed repayment schedule, often associated with the repayment of debt issued to finance such capital investment.

British Thermal Unit (Btu): A unit of energy measure that indicates the amount of heat required to raise the temperature of one pound of water by 1oF at a constant atmospheric pressure.

Combined Cycle (CC): A form of power generation that captures exhaust heat often from a CT (or multiple CTs) to create additional electric power beyond that created by the simple CT and enhance the overall efficiency of the unit by producing more output for the same level of input.

Combustion Turbine (CT): A form of power generation that forces air into a chamber heated through the combustion of a type of fuel (often diesel or natural gas) which causes the heated air to expand and power the circulation of a turbine that spins an electric generator to produce electricity.

Capital Cost: The cost of various sources of funds used in a financing an entity’s operations.

Curtailment or Renewable Generation Curtailment: Curtailment happens when due to technical requirements of the conventional generating fleet a portion of the renewable generation cannot be accepted in the system and the renewable plant must back down its production although sun irradiation or wind is available. Curtailment also can have a financial impact to PREPA as per the existing contractual conditions if energy production capability is available given the meteorological conditions and PREPA cannot take it, then it has to be paid at the contractual prices and on an estimate of the energy that could have been produced.

Debt service: The amount of capital required to repay principal and/or interest on issued debt over a given period of time. Such repayment typically follows a predetermined schedule.

Discount rate: The age at which future cash flows are discounted based on the risk and uncertainty of the receipt of such cash flows over time. The greater the uncertainty of future cash flows, the more such cash flows will be discounted (assigned a higher discount rate) in determining the value of that stream of cash flows.

Distributed generation (DG): Electrical generation that is located on the distribution system (rather than the transmission system), often located at a customer's site on either the customer's or the utility's side of the electric meter.

Duct fire: Duct firing is firing of supplemental fuel in the gas turbine exhaust gas to raise its temperature entering the Heat Recovery Steam Generator, resulting in higher steam and power production.

Energy efficiency (EE): Any number of technologies employed to reduce energy consumption. Examples include more efficient lighting, refrigeration, heating, etc.

Engineering, Procurement and Construction (EPC): EPC is a prominent form of contracting agreement in the construction industry. The engineering and construction contractor will carry out the detailed engineering design of the project, procure all the equipment and materials necessary, and then construct to deliver a functioning facility or asset to their clients.

Federal Energy Regulatory Commission (FERC): FERC is the United States federal agency with jurisdiction over interstate electricity sales, wholesale electric rates, hydroelectric licensing, natural gas pricing, and oil pipeline rates. FERC also reviews and authorizes liquefied natural gas (LNG) terminals, interstate natural gas pipelines and non-federal hydropower projects.

Fixed operations and maintenance expenses (FOM): Expenses incurred as a result of operations and maintenance that do not vary with operations.

Floating Storage and Regasification Unit (FSRU): A Floating Storage Regasification Unit (FSRU) is the vital component required while transiting and transferring Liquefied Natural Gas (LNG) through the oceanic channels.

Fossil fuel: A fuel source that is derived from the decomposition of plant and animal matter under the ground. Typically, coal, oil, and natural gas fall under the definition of fossil fuels.

Future: A Future is defined as a set of internally consistent assumptions that describe the future external environment in which PREPA might be expected to operate its Supply Portfolios.

Gas combustion turbine (GT): A form of power generation that forces air into a chamber heated through the combustion of a type of fuel (often diesel or natural gas) which causes the heated air to expand and power the circulation of a turbine that spins an electric generator to produce electricity.

Heat rate: The efficiency at which a generator converts input fuel to electric output, typically measured in Btu/kWh.

Heat Recovery Steam Generator (HRSG): HRSG is an energy recovery heat exchanger that recovers heat from a hot gas stream. It produces steam that can be used in a process (cogeneration) or used to drive a steam turbine (combined cycle).

Heavy Fuel Oil (HFO, No. 6 fuel oil or Bunker C): is a high-viscosity residual oil requiring preheating to 220 – 260 °F (104 – 127 °C).

Higher Heating Value (HHV): The higher heating value (also known gross calorific value or gross energy) of a fuel is defined as the amount of heat released by a specified quantity (initially at 25°C) once it is combusted and the products have returned to a temperature of 25°C, which takes into account the latent heat of vaporization of water in the combustion products.

Hydroelectric generation: Electrical generation that converts the kinetic energy of moving water to electricity by turning a turbine.

Integrated Resource Plan (IRP): The process of projecting future energy demand, and analyzing current and future energy, transmission, and distribution resources to plan to meet such future demand at minimized cost to the system owner/operator and its stakeholder.

Interest during Construction (IDC): IDC is any interest that is paid during the construction phase of a building or other tangible property.

Kilowatt (kW): One thousand watts.

Kilowatt-hour (kWh): One thousand watts produced for one hour of time.

Liquefied natural gas (LNG): Natural gas that has been converted to liquid form for ease of transport and/or storage.

Load forecast: A forecast of expected future energy demand based on an analysis of underlying economic indicators and past correlation between energy consumption and such economic conditions.

Loss of Load Hours (LOLH): LOLH is a metrics that considers all hours during a year which there may be a risk of insufficient generation.

Lower Heating Value (LVH): The lower heating value (also known as net calorific value) of a fuel is defined as the amount of heat released by combusting a specified quantity (initially at 25°C) and returning the temperature of the combustion products to 150°C, which assumes the latent heat of vaporization of water in the reaction products is not recovered.

Mercury and Air Toxics Standards (MATS): MATS is an environmental regulation proposed by the US Environmental Protection Agency (EPA) in 2011 to reduce the emissions of hazardous air pollutants, such as mercury and acid gases, from coal-and-oil fired power plants.

Maximum capacity: The highest amount of electricity an electric generator or group of generators may produce within the design specifications of the generator.

Megawatt (MW): One million watts or 1,000 kilowatts.

Megawatt-hour (MWh): One million watts (or 1,000 kilowatts) produced for one hour of time.

Minimum capacity: The lowest amount of electricity an electric generator or group of generators may produce within the design specifications of the generator.

Minimum Down time: The period of time a generator needs to remain shut down before it can be started again.

Minimum Up time: The period of time a generator needs to remain operating after start up before it can be shut down again.

MMBtu: One million Btus.

MMcf: Million cubic feet

MMscf/d: One million standard cubic feet per day.

National Environmental Policy Act (NEPA): NEPA is a United States environmental law that established a U.S. national policy promoting the enhancement of the environment. NEPA's most significant accomplishment was setting up procedural requirements for all federal government agencies to prepare environmental assessments (EAs) and environmental impact statements (EISs).

Net Present Value (NPV): A method of calculating the current value of a series of cash flows, which considers the time value of money, and discounts future cash flows based on a determined discount rate or cost of capital.

Operating reserves: Operating reserve is a portion of generating capacity available to the operator of a power system that may be increased or decreased in order to match short-term fluctuations in energy demand on the system.

Power Purchase and Operating Agreement (PPOA): A contract by which energy is bought and sold at prices and over time periods specified by the contractual terms.

Purchased power: Power purchased from a third party used to meet retail or wholesale electric demand.

Ramp rates or ramping speed: The speed at which a generating unit may increase and/or decrease output, typically measured in MW per minute.

Reciprocating engine: A generating unit type that utilizes the movement of pistons to convert pressure into a rotating motion, which can be used to turn an electric generator and produce electricity.

Regulation: An ancillary service product that provides extremely short term (intra-minute) upward and/or downward generation flexibility to meet fluctuations in load.

Renewable generation: Electric generation produced by a source that is considered to be readily renewable, including power generated by the wind, the sun (through photovoltaic processes or solar thermal processes), water (hydroelectric generation), biomass, etc.

Renewable Portfolio Standard (RPS): An energy policy which specifies the proportion of the energy mix that must come from renewable resources for an electricity provider. Typically, an RPS will require a certain age of renewables be used (on a capacity or energy basis) by a certain year in the future. Such policies will typically specify interim age targets in addition to final goals for renewable generation.

Reserve margin: A measure of available capacity over and above the capacity needed to meet normal peak demand levels.

Return on equity: The age rate of net return derived from an equity investment, or the annual or total net cash in-flow divided by the equity investment.

Photovoltaics (PV): is the name of a method of converting solar energy into direct current electricity using semiconducting materials that exhibit the photovoltaic effect, a phenomenon commonly studied in physics, photochemistry and electrochemistry**.**

Spinning reserves: An ancillary services product that provides available capacity to a power system operator over short- to medium-term time intervals, typically within ten minutes.

Steam Turbine Generator (STG): Generation that produces power through the process of boiling water to produce steam, which turns an electrical generator.

Supply Portfolio: A Supply Portfolio is the set of generation resources that PREPA can deploy to meet customer demand, environmental compliance, and system reliability requirements.

Thermal generation: Power generation created through the creation of heat, as contrasted against many renewable generation technologies (biomass and biogas excepted), which do not rely on heat to produce electricity.

Transmission system: The series of towers and wires that transmit electricity from generation sources to the distribution system at higher voltages than the distribution system to minimize technical losses of transmitted electricity.

The United States Environmental Protection Agency (EPA): EPA is an agency of the U.S. federal government which was created for the purpose of protecting human health and the environment by writing and enforcing regulations based on laws passed by Congress.

Ultra-low sulfur diesel (ULSD): ULSD is a cleaner-burning diesel fuel that contains 97 less sulfur than low-sulfur diesel (LSD).

Variable operations and maintenance expenses (VOM): Operations and maintenance expenses that vary as a function of the amount of energy that is being produced.

Weighted Average Cost of Capital (WACC): A calculation of a firm's cost of capital in which each category of capital is proportionately weighted. All capital sources - common stock, preferred stock, bonds and any other long-term debt - are included in a WACC calculation.

Appendix

B

Model Assumptions

Appendix B-1: Aguirre CC and ST Units Parameters

Parameters	Unit	Aguirre CC		Aguirre ST	
		Unit 1	Unit 2	Unit 1	Unit 2
Fuel	Type	Diesel	Diesel	No. 6 fuel oil	No. 6 fuel oil
Maximum Capacity	MW	260	260	450	450
Minimum Capacity	MW	49	49	230	230
Fixed O&M Expense	2015 $/kW-year	21.60	21.60	30.57	30.57
Variable O&M Expense	2015 $/MWh	6.48	6.48	2.15	2.15
Heat Rate at Maximum Capacity	MMBtu/MWh	11.14	11.14	9.60	9.70
Heat Rate at Minimum Capacity	MMBtu/MWh	11.42	11.42	9.86	10.05
Forced Outage		20	20	4	4
Minimum Downtime	Hours	0	0	48	48
Minimum Runtime	Hours	2	2	720	720
Ramp Up Rate	MW/minute	5	5	5	5
Ramp Down Rate	MW/minute	5	5	5	5

Note: Aguirre CC units are later converted to dual fuel of natural gas and diesel and the same parameters are used. Aguirre ST units are later converted to natural gas and the same parameters are used.

Appendix B-2: Costa Sur ST Parameters

Parameters	Unit	Costa Sur ST	
		Unit 5	Unit 6
Fuel	Type	Natural gas No. 6 fuel oil	Natural gas No. 6 fuel oil
Maximum Capacity	MW	410	410
Minimum Capacity	MW	250	250
Fixed O&M Expense	2015 $/kW-year	34.31	34.31
Variable O&M Expense	2015 $/MWh	2.60	2.60
Heat Rate at Maximum Capacity	MMBtu/MWh	9.75	9.97
Heat Rate at Minimum Capacity	MMBtu/MWh	9.84	10.02
Forced Outage		2	3
Minimum Downtime	Hours	48	48
Minimum Runtime	Hours	720	720
Ramp Up Rate	MW/minute	5	5
Ramp Down Rate	MW/minute	5	5

Appendix B-3: Palo Seco ST Parameters

Parameters	Unit	Palo Seco ST	
		Unit 3	Unit 4
Fuel	Type	No. 6 fuel oil	No. 6 fuel oil
Maximum Capacity	MW	216	216
Minimum Capacity	MW	130	130
Fixed O&M Expense	2015 $/kW-year	44.34	44.34
Variable O&M Expense	2015 $/MWh	4.72	4.72
Heat Rate at Maximum Capacity	MMBtu/MWh	9.73	9.73
Heat Rate at Minimum Capacity	MMBtu/MWh	10.35	10.35
Forced Outage		9	3
Minimum Downtime	Hours	48	48
Minimum Runtime	Hours	720	720
Ramp Up Rate	MW/minute	3	3
Ramp Down Rate	MW/minute	3	3

Appendix B-4: San Juan CC and ST Parameters

Parameters	Unit	San Juan CC		San Juan ST	
		Unit 5	Unit 6	Unit 9	Unit 10
Fuel	Type	Diesel	Diesel	No. 6 fuel oil	No. 6 fuel oil
Maximum Capacity	MW	200	200	100	100
Minimum Capacity	MW	155	155	70	70
Fixed O&M Expense	2015 $/kW-year	26.15	26.15	46.78	46.78
Variable O&M Expense	2015 $/MWh	2.12	2.12	2.69	2.69
Heat Rate at Maximum Capacity	MMBtu/MWh	7.63	7.85	10.28	10.26
Heat Rate at Minimum Capacity	MMBtu/MWh	8.46	8.86	10.35	10.50
Forced Outage		21	10	10	9
Minimum Downtime	Hours	48	48	48	48
Minimum Runtime	Hours	120	120	720	720
Ramp Up Rate	MW/minute	3	3	3	3
Ramp Down Rate	MW/minute	3	3	3	3

Appendix B-5: EcoEléctrica CC Parameters

Parameters	Unit	EcoEléctrica CC
		Unit 1
Fuel	Type	Natural Gas
Maximum Capacity	MW	507
Minimum Capacity	MW	275
Fixed O&M Expense	2015 $/kW-year	181
Variable O&M Expense	2015 $/MWh	0.00
Heat Rate at Maximum Capacity	MMBtu/MWh	7.50
Heat Rate at Minimum Capacity	MMBtu/MWh	8.31
Forced Outage		2
Minimum Downtime	Hours	8
Minimum Runtime	Hours	168
Ramp Up Rate	MW/minute	10
Ramp Down Rate	MW/minute	10

Appendix B-6: AES Coal Plant Parameters

Parameters	Unit	AES Coal Plant	
		Unit 1	Unit 2
Fuel	Type	Coal	Coal
Maximum Capacity	MW	227	227
Minimum Capacity	MW	166	166
Fixed O&M Expense	2015 $/kW-year	75.97	75.97
Variable O&M Expense	2015 $/MWh	6.91	6.91
Heat Rate at Maximum Capacity	MMBtu/MWh	9.79	9.79
Heat Rate at Minimum Capacity	MMBtu/MWh	9.93	9.93
Forced Outage		3	3
Minimum Downtime	Hours	48	48
Minimum Runtime	Hours	720	720
Ramp Up Rate	MW/minute	0	0
Ramp Down Rate	MW/minute	0	0

Appendix B-7: Cambalache CT Parameters

Parameters	Unit	Cambalache CT		
		Unit 1	Unit 2	Unit 3
Fuel	Type	Diesel	Diesel	Diesel
Maximum Capacity	MW	83	83	83
Minimum Capacity	MW	50	50	50
Fixed O&M Expense	2015 $/kW-year	23.32	23.32	23.32
Variable O&M Expense	2015 $/MWh	5.27	5.27	5.27
Heat Rate at Maximum Capacity	MMBtu/MWh	11.55	11.55	11.55
Heat Rate at Minimum Capacity	MMBtu/MWh	11.55	11.55	11.55
Forced Outage		10	10	10
Minimum Downtime	Hours	7	7	7
Minimum Runtime	Hours	7	7	7
Ramp Up Rate	MW/minute	2	2	2
Ramp Down Rate	MW/minute	2	2	2

Appendix B-8: Mayagüez CT Parameters

Parameters	Unit	Mayaguüez CT			
		Unit 1	Unit 2	Unit 3	Unit 4
Fuel	Type	Diesel	Diesel	Diesel	Diesel
Maximum Capacity	MW	50	50	50	50
Minimum Capacity	MW	25	25	25	25
Fixed O&M Expense	2015 $/kW-year	10.15	10.15	10.15	10.15
Variable O&M Expense	2015 $/MWh	6.11	6.11	6.11	6.11
Heat Rate at Maximum Capacity	MMBtu/MWh	9.32	9.32	9.32	9.32
Heat Rate at Minimum Capacity	MMBtu/MWh	11.20	11.20	11.20	11.20
Forced Outage		9	9	9	9
Minimum Downtime	Hours	0	0	0	0
Minimum Runtime	Hours	0	0	0	0
Ramp Up Rate	MW/minute	6	6	6	6
Ramp Down Rate	MW/minute	6	6	6	6

Appendix B-9: GT Units Parameters

Parameters	Unit	GT Units
		Each Unit
Fuel	Type	Diesel
Maximum Capacity	MW	21
Minimum Capacity	MW	21
Fixed O&M Expense	2015 $/kW-year	25.33
Variable O&M Expense	2015 $/MWh	19.27
Heat Rate at Maximum Capacity	MMBtu/MWh	14.40
Heat Rate at Minimum Capacity	MMBtu/MWh	14.40
Forced Outage		15
Minimum Downtime	Hours	0
Minimum Runtime	Hours	0
Ramp Up Rate	MW/minute	2
Ramp Down Rate	MW/minute	2

Appendix B-10: H Class Parameters

Generation Unit Type	Unit	Siemens SCC6-8000H	Generic H Class
		Natural Gas	Diesel
Max. Unit Capacity w/o Duct Fire	MW	368	357
Max. Unit Capacity with Duct Fire	MW	393	381
Min. Unit Capacity	MW	184	178
Fixed O&M Expense	2015 $/kW-year	16.65	16.65
Variable O&M Expense	2015 $/MWh	2.80	2.80
Capital Costs	2015 $/kW	1,011	1,163
Heat Rate at 100% Rated Capacity (Unfired)	MMBtu/MWh	6.88	6.67
Heat Rate at Full Duct Fire Capacity	MMBtu/MWh	6.98	6.77
Unit Capacity Degradation	%	2.5%	2.5%
Unit Heat Rate Degradation	%	1.5%	1.5%
Annual Required Maintenance Time	Hours per Year	360	360
Unit Forced Outage Rate	%	2%	2%
Unit Forced Outage Duration	Hours	40	40
Minimum Downtime	Hours	2	2
Minimum Runtime	Hours	2	2
Ramp Up Rate	MW/minute	50	50
Ramp Down Rate	MW/minute	50	50
Regulation Minimum Range	MW	184	178
Regulation Maximum Range	MW	368	357
Regulation Ramp Rate	MW/minute	50	50

Appendix B-11: SCC-800 Parameters

Generation Unit Type	Unit	Siemens SCC-800	
		Natural Gas	Diesel
Max. Unit Capacity w/o Duct Fire	MW	59	57
Max. Unit Capacity with Duct Fire	MW	72	70
Min. Unit Capacity	MW	24	23
Fixed O&M Expense	2015 $/kW-year	23.00	23.00
Variable O&M Expense	2015 $/MWh	3.00	3.00
Capital Costs	2015 $/kW	1,648	1,800
Heat Rate at 100% Rated Capacity (Unfired)	MMBtu/MWh	7.7	7.47
Heat Rate at Full Duct Fire Capacity	MMBtu/MWh	8.03	7.76
Unit Capacity Degradation	%	2.5%	2.5%
Unit Heat Rate Degradation	%	1.5%	1.5%
Annual Required Maintenance Time	Hours per Year	360	360
Unit Forced Outage Rate	%	2%	2%
Unit Forced Outage Duration	Hours	40	40
Minimum Downtime	Hours	2	2
Minimum Runtime	Hours	2	2
Ramp Up Rate	MW/minute	14	14
Ramp Down Rate	MW/minute	14	14
Regulation Minimum Range	MW	24	23
Regulation Maximum Range	MW	72	70
Regulation Ramp Rate	MW/minute	14	14

Appendix B-12: Reciprocating Engine Parameters

Generation Unit Type	Unit	Reciprocating Engine
		Diesel
Max. Unit Capacity	MW	17
Min. Unit Capacity	MW	5
Fixed O&M Expense	2015 $/kW-year	22.52
Variable O&M Expense	2015 $/MWh	8.01
Capital Costs	2015 $/kW	1,304
Heat Rate at 100% Rated Capacity	MMBtu/MWh	8.44
Unit Capacity Degradation	%	2.5%
Unit Heat Rate Degradation	%	1.5%
Annual Required Maintenance Time	Hours per Year	360
Unit Forced Outage Rate	%	2%
Unit Forced Outage Duration	Hours	40
Minimum Downtime	Hours	2
Minimum Runtime	Hours	2
Ramp Up Rate	MW/minute	2.5
Ramp Down Rate	MW/minute	2.5
Regulation Minimum Range	MW	5
Regulation Maximum Range	MW	17
Regulation Ramp Rate	MW/minute	2.5

Appendix

C

Model Results

Appendix C-1: P3MF1M Results

Puerto Rico Electric Power Authority
Portfolio 3M; Future 1M
Supplemental IRP Metrics Analysis

		Fiscal Year	2016	2017	2018	2019	2020	2025	2030	2035
COST	**Unit**	**Total / Average**								
Present Value of System Costs	*$000*	*25,835,668*	2,374,830	2,309,324	1,987,828	2,004,796	1,864,262	1,214,469	840,164	600,327
System Costs	*$000*	*2,291,554*	2,454,967	2,551,081	2,346,630	2,529,078	2,513,191	2,281,584	2,199,611	2,190,287
Capital Costs (FY 2016 - 2025)	*$ million*	3,153	134	240	615	239	239	248	489	-
Capital Costs (FY 2026 - 2035)	*$ million*	1,461								
Capital Costs (FY 2016 - 2035)	*$ million*	4,614								
ENVIRONMENTAL COMPLIANCE										
CO_2 Emissions (Total Generation)	*lbs/MWh*		*1,381*	*1,361*	*1,255*	*1,284*	*1,268*	*1,143*	*1,043*	*984*
CO_2 Emission Target (Total Generation)	*lbs/MWh*		*1,470*	*1,470*	*1,470*	*1,470*	*1,470*	*1,470*	*1,413*	*1,413*
Aguirre 1 CC Repower	*lbs/MWh*		-	-	-	-	-	*983*	*1,057*	*938*
Aguirre 2 CC Repower	*lbs/MWh*		-	-	-	-	-	*1,048*	*1,085*	*971*
Aguirre H Class Train 1	*lbs/MWh*		-	-	-	-	-	-	*850*	*868*
Aguirre H Class Train 2	*lbs/MWh*		-	-	-	-	-	-	*872*	*864*
Costa Sur H Class Train 1	*lbs/MWh*		-	-	-	-	-	-	*874*	*857*
RPS (PPOA/Net sales)	*percent*		*7.74%*	*8.23%*	*8.59%*	*9.14%*	*9.28%*	*11.50%*	*13.02%*	*20.04%*
RPS Target	*percent*		*12.00%*	*12.75%*	*13.50%*	*14.25%*	*15.00%*	*16.67%*	*18.33%*	*20%*
Reduced RPS Target	*percent*		*8.00%*	*8.50%*	*9.00%*	*9.50%*	*10.00%*	*12.00%*	*18.33%*	*20.00%*
Renewable Penetration	*percent*		*8.48%*	*9.14%*	*9.65%*	*10.32%*	*10.60%*	*13.54%*	*15.86%*	*23.53%*
OPERATIONS										
Renewable Curtailment	*percent*		*2.4%*	*1.6%*	*1.6%*	*3.4%*	*4.9%*	*8.7%*	*2.6%*	*4.5%*
Renewable Curtailment Limit	*percent*		*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*
Renewable Curtailed Energy	*MWh*		33,673	24,596	26,275	59,105	85,217	177,936	58,282	138,379
Renewable Curtailment Cost	$000		5,033	3,651	3,864	8,681	12,357	24,141	7,490	16,528
LOLH	*hours*		*0.00*	*0.00*	*0.00*	*4.00*	*0.00*	*0.00*	*0.00*	*0.00*
Reserve Margin with GTs & Cambalache	*percent*		*70%*	*70%*	*71%*	*54%*	*60%*	*71%*	*80%*	*74%*
Reserve Margin without GTs & Cambalache	*percent*		*51%*	*52%*	*52%*	*35%*	*38%*	*47%*	*55%*	*47%*
System Costs Summary	**Unit**	**Fiscal Year**	**2016**	**2017**	**2018**	**2019**	**2020**	**2025**	**2030**	**2035**
Fuel	$000		1,338,917	1,410,080	1,064,359	1,217,210	1,170,019	847,171	594,590	513,308
Regasification fixed costs	$000		-	-	85,126	89,223	92,766	92,032	82,745	83,041
O&M	$000		173,763	165,027	177,126	164,990	146,434	143,104	115,144	100,696
Purchased power	$000		716,729	705,392	672,197	671,847	657,516	616,259	625,410	611,503
Renewables	$000		214,891	229,180	238,464	253,456	253,882	279,684	288,328	369,367
Amortized capital costs	$000		10,667	39,864	104,755	123,155	177,368	240,349	379,366	350,780
Energy efficiency costs	$000		-	1,538	4,604	9,197	15,207	62,984	114,027	161,592
Total System Costs	**$000**		2,454,967	2,551,081	2,346,630	2,529,078	2,513,191	2,281,584	2,199,611	2,190,287

Appendix C-2: P3MF1M_RE Results

Puerto Rico Electric Power Authority
Portfolio 3M; Future 1M; RE
Supplemental IRP Metrics Analysis

		Fiscal Year	2016	2017	2018	2019	2020	2025	2030	2035
COST	**Unit**	**Total / Average**								
Present Value of System Costs	*$000*	*25,869,329*	2,381,140	2,310,098	2,005,917	1,971,887	1,882,914	1,224,975	838,920	602,177
System Costs	*$000*	*2,294,555*	2,461,490	2,551,937	2,367,984	2,487,563	2,538,335	2,301,322	2,196,355	2,197,039
Capital Costs (FY 2016 - 2025)	*$ million*	3,122	134	240	615	239	334	248	489	-
Capital Costs (FY 2026 - 2035)	*$ million*	1,461								
Capital Costs (FY 2016 - 2035)	*$ million*	4,584								
ENVIRONMENTAL COMPLIANCE										
CO_2 Emissions (Total Generation)	*lbs/MWh*		*1,377*	*1,362*	*1,263*	*1,273*	*1,275*	*1,145*	*1,041*	*987*
CO_2 Emission Target (Total Generation)	*lbs/MWh*		*1,470*	*1,470*	*1,470*	*1,470*	*1,470*	*1,470*	*1,413*	*1,413*
Aguirre 1 CC Repower	*lbs/MWh*		-	-	-	-	-	*978*	*1,064*	*941*
Aguirre 2 CC Repower	*lbs/MWh*		-	-	-	-	-	*1,036*	*1,100*	*972*
Aguirre H Class Train 1	*lbs/MWh*		-	-	-	-	-	-	*847*	*868*
Aguirre H Class Train 2	*lbs/MWh*		-	-	-	-	-	-	*868*	*866*
Costa Sur H Class Train 1	*lbs/MWh*		-	-	-	-	-	-	*874*	*859*
RPS (PPOA/Net sales)	*percent*		*7.74%*	*8.23%*	*8.59%*	*9.14%*	*9.28%*	*11.50%*	*13.02%*	*20.04%*
RPS Target	*percent*		*12.00%*	*12.75%*	*13.50%*	*14.25%*	*15.00%*	*16.67%*	*18.33%*	*20%*
Reduced RPS Target	*percent*		*8.00%*	*8.50%*	*9.00%*	*9.50%*	*10.00%*	*12.00%*	*18.33%*	*20.00%*
Renewable Penetration	*percent*		*8.48%*	*9.14%*	*9.65%*	*10.32%*	*10.60%*	*13.54%*	*15.86%*	*23.53%*
OPERATIONS										
Renewable Curtailment	*percent*		*2.0%*	*2.1%*	*1.5%*	*4.2%*	*3.8%*	*7.6%*	*2.3%*	*4.6%*
Renewable Curtailment Limit	*percent*		*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*
Renewable Curtailed Energy	*MWh*		29,247	33,011	24,956	71,326	67,083	156,772	51,855	142,118
Renewable Curtailment Cost	$000		4,372	4,900	3,670	10,476	9,728	21,270	6,664	16,974
LOLH	*hours*		*0.00*	*0.00*	*0.00*	*0.00*	*2.00*	*0.00*	*0.00*	*0.00*
Reserve Margin with GTs & Cambalache	*percent*		*70%*	*70%*	*71%*	*54%*	*60%*	*71%*	*80%*	*74%*
Reserve Margin without GTs & Cambalache	*percent*		*51%*	*52%*	*52%*	*35%*	*38%*	*47%*	*55%*	*47%*

System Costs Summary	**Unit**	**Fiscal Year**	**2016**	**2017**	**2018**	**2019**	**2020**	**2025**	**2030**	**2035**
Fuel	$000		1,344,462	1,412,573	1,082,495	1,177,230	1,184,750	867,689	593,739	522,689
Regasification fixed costs	$000		-	-	84,145	92,906	90,759	90,095	82,732	83,095
O&M	$000		173,667	165,041	178,079	164,246	146,967	143,592	114,682	100,517
Purchased power	$000		717,803	703,740	675,442	667,373	661,657	619,428	625,979	611,499
Renewables	$000		214,891	229,180	238,464	253,456	253,882	279,684	288,328	369,367
Amortized capital costs	$000		10,667	39,864	104,755	123,155	185,113	237,850	376,867	348,281
Energy efficiency costs	$000		-	1,538	4,604	9,197	15,207	62,984	114,027	161,592
Total System Costs	**$000**		2,461,490	2,551,937	2,367,984	2,487,563	2,538,335	2,301,322	2,196,355	2,197,039

Appendix C-3: P3MF2M Results (No AOGP)

Puerto Rico Electric Power Authority
Portfolio 3M; Future 2M
Supplemental IRP Metrics Analysis

		Fiscal Year	2016	2017	2018	2019	2020	2025	2030	2035
COST	**Unit**	**Total / Average**								
Present Value of System Costs	*$000*	*28,825,259*	2,438,501	2,304,521	2,181,731	2,127,915	1,986,712	1,362,481	980,549	717,178
System Costs	*$000*	*2,602,501*	2,520,787	2,545,776	2,575,533	2,684,395	2,678,264	2,559,649	2,567,149	2,616,617
Capital Costs (FY 2016 - 2025)	*$ million*	3,745	134	176	167	239	433	248	-	-
Capital Costs (FY 2026 - 2035)	*$ million*	50								
Capital Costs (FY 2016 - 2035)	*$ million*	3,794								
ENVIRONMENTAL COMPLIANCE										
CO_2 Emissions (Total Generation)	*lbs./MWh*		*1,390*	*1,376*	*1,371*	*1,373*	*1,359*	*1,054*	*1,031*	*970*
CO_2 Emission Target (Total Generation)	*lbs./MWh*		*1,470*	*1,470*	*1,470*	*1,470*	*1,470*	*1,470*	*1,413*	*1,413*
H Class 1x1 CC(NG, Costa Sur site)	*lbs/MWh*		-	-	-	-	-	*832*	*829*	*842*
RPS (PPOA/Net sales)	*percent*		*7.74%*	*8.23%*	*8.59%*	*9.14%*	*9.28%*	*11.50%*	*13.02%*	*20.04%*
RPS Target	*percent*		*12.00%*	*12.75%*	*13.50%*	*14.25%*	*15.00%*	*16.67%*	*18.33%*	*20.00%*
Reduced RPS Target	*percent*		*8.00%*	*8.50%*	*9.00%*	*9.50%*	*10.00%*	*12.00%*	*18.33%*	*20.00%*
Renewable Penetration	*percent*		*8.48%*	*9.14%*	*9.65%*	*10.32%*	*10.60%*	*13.54%*	*15.86%*	*23.53%*
OPERATIONS										
Renewable Curtailment	*percent*		*2.7%*	*2.2%*	*3.0%*	*2.6%*	*5.3%*	*1.1%*	*1.2%*	*6.0%*
Renewable Curtailment Limit	*percent*		*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*
Renewable Curtailed Energy	*MWh*		38,073	34,258	48,300	43,804	91,807	23,329	26,499	186,440
Renewable Curtailment Cost	$000		5,691	5,085	7,103	6,434	13,313	3,165	3,405	22,268
LOLH	*hours*		*0.00*	*0.00*	*0.00*	*4.00*	*0.00*	*0.00*	*0.00*	*0.00*
Reserve Margin with GTs & Cambalache	*percent*		*70%*	*70%*	*71%*	*63%*	*69%*	*74%*	*74%*	*70%*
Reserve Margin without GTs & Cambalache	*percent*		*50%*	*50%*	*51%*	*43%*	*48%*	*52%*	*50%*	*44%*

System Costs Summary	**Unit**	**Fiscal Year**	**2016**	**2017**	**2018**	**2019**	**2020**	**2025**	**2030**	**2035**
Fuel	$000		1,376,319	1,370,277	1,402,010	1,479,109	1,429,217	1,060,318	1,036,066	1,000,607
Regasification fixed costs	$000		-	-	7,944	11,789	15,591	23,810	15,792	7,414
O&M	$000		174,002	173,449	170,960	165,854	147,873	149,220	132,828	116,159
Purchased power	$000		744,908	746,980	712,228	707,266	688,733	692,082	688,558	669,928
Renewables	$000		214,891	229,180	238,464	253,456	253,882	279,684	288,328	369,367
Amortized capital costs	$000		10,667	24,351	39,323	57,723	127,761	291,550	291,550	291,550
Energy efficiency costs	$000		-	1,538	4,604	9,197	15,207	62,984	114,027	161,592
Total System Costs	**$000**		2,520,787	2,545,776	2,575,533	2,684,395	2,678,264	2,559,649	2,567,149	2,616,617

Appendix C-4: P3MF1M_S1 Results (No AES)

Puerto Rico Electric Power Authority

Portfolio 3M; Future 1M; Sensitivity 1_No AES

Supplemental IRP Metrics Analysis

		Fiscal Year	2016	2017	2018	2019	2020	2025	2030	2035
COST	**Unit**	**Total / Average**								
Present Value of System Costs	*$000*	*25,845,989*	2,374,830	2,309,324	1,987,828	2,004,796	1,864,262	1,214,469	841,236	604,733
System Costs	*$000*	*2,293,191*	2,454,967	2,551,081	2,346,630	2,529,078	2,513,191	2,281,584	2,202,417	2,206,364
Capital Costs (FY 2016 - 2025)	*$ million*	3,153	134	240	615	239	239	248	489	-
Capital Costs (FY 2026 - 2035)	*$ million*	1,914								
Capital Costs (FY 2016 - 2035)	*$ million*	5,067								
ENVIRONMENTAL COMPLIANCE										
CO_2 Emissions (Total Generation)	*lbs/MWh*		*1,381*	*1,361*	*1,255*	*1,284*	*1,268*	*1,143*	*791*	*719*
CO_2 Emission Target (Total Generation)	*lbs/MWh*		*1,470*	*1,470*	*1,470*	*1,470*	*1,470*	*1,470*	*1,413*	*1,413*
Aguirre 1 CC Repower	*lbs/MWh*		-	-	-	-	-	*983*	*1,038*	*919*
Aguirre 2 CC Repower	*lbs/MWh*		-	-	-	-	-	*1,048*	*1,075*	*943*
Aguirre H Class Train 1	*lbs/MWh*		-	-	-	-	-	-	*823*	*846*
Aguirre H Class Train 2	*lbs/MWh*		-	-	-	-	-	-	*840*	*854*
Costa Sur H Class Train 1	*lbs/MWh*		-	-	-	-	-	-	*868*	*859*
Costa Sur H Class Train 2	*lbs/MWh*		-	-	-	-	-	-	*876*	*862*
RPS (PPOA/Net sales)	*percent*		*7.74%*	*8.23%*	*8.59%*	*9.14%*	*9.28%*	*11.50%*	*13.02%*	*20.04%*
RPS Target	*percent*		*12.00%*	*12.75%*	*13.50%*	*14.25%*	*15.00%*	*16.67%*	*18.33%*	*20.00%*
Reduced RPS Target	*percent*		*8.00%*	*8.50%*	*9.00%*	*9.50%*	*10.00%*	*12.00%*	*18.33%*	*20.00%*
Renewable Penetration	*percent*		*16.16%*	*17.29%*	*18.14%*	*19.34%*	*19.75%*	*24.77%*	*28.45%*	*42.70%*
OPERATIONS										
Renewable Curtailment	*percent*		*2.4%*	*1.6%*	*1.6%*	*3.4%*	*4.9%*	*8.7%*	*1.0%*	*4.1%*
Renewable Curtailment Limit	*percent*		*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*
Renewable Curtailed Energy	*MWh*		33,657	24,582	26,282	59,084	85,201	177,954	22,467	125,873
Renewable Curtailment Cost	$000		5,031	3,649	3,865	8,678	12,355	24,144	2,887	15,034
LOLH	*hours*		*0.00*	*0.00*	*0.00*	*4.00*	*0.00*	*0.00*	*0.00*	*0.00*
Reserve Margin with GTs & Cambalache	*percent*		*70%*	*70%*	*71%*	*54%*	*60%*	*71%*	*78%*	*72%*
Reserve Margin without GTs & Cambalache	*percent*		*51%*	*52%*	*52%*	*35%*	*38%*	*47%*	*53%*	*45%*

System Costs Summary	**Unit**	**Fiscal Year**	**2016**	**2017**	**2018**	**2019**	**2020**	**2025**	**2030**	**2035**
Fuel	$000		1,338,917	1,410,080	1,064,359	1,217,210	1,170,019	847,171	777,190	709,264
Regasification fixed costs	$000		-	-	85,126	89,223	92,766	92,032	88,626	88,228
O&M	$000		173,763	165,027	177,126	164,990	146,434	143,104	130,287	115,225
Purchased power	$000		716,729	705,392	672,197	671,847	657,516	616,259	387,803	375,119
Renewables	$000		214,891	229,180	238,464	253,456	253,882	279,684	288,328	369,367
Amortized capital costs	$000		10,667	39,864	104,755	123,155	177,368	240,349	416,156	387,570
Energy efficiency costs	$000		-	1,538	4,604	9,197	15,207	62,984	114,027	161,592
Total System Costs	**$000**		2,454,967	2,551,081	2,346,630	2,529,078	2,513,191	2,281,584	2,202,417	2,206,364

Appendix C-5: P3MF2M_S1 Results (No AOGP, No AES)

Puerto Rico Electric Power Authority

Portfolio 3M; Future 2M; Sensitivity 1 No AOGP No AES

Supplemental IRP Metrics Analysis

		Fiscal Year	2016	2017	2018	2019	2020	2025	2030	2035
COST	**Unit**	**Total / Average**								
Present Value of System Costs	*$000*	*29,082,870*	2,438,501	2,304,521	2,181,731	2,127,915	1,986,712	1,362,373	1,021,342	749,105
System Costs	*$000*	*2,641,084*	2,520,787	2,545,776	2,575,533	2,684,395	2,678,264	2,559,448	2,673,947	2,733,102
Capital Costs (FY 2016 - 2025)	*$ million*	3,745	134	176	167	239	433	248	-	-
Capital Costs (FY 2026 - 2035)	*$ million*	502								
Capital Costs (FY 2016 - 2035)	*$ million*	4,247								
ENVIRONMENTAL COMPLIANCE										
CO_2 Emissions (Total Generation)	*lbs./MWh*		*1,390*	*1,376*	*1,371*	*1,373*	*1,359*	*1,051*	*781*	*706*
CO_2 Emission Target (Total Generation)	*lbs./MWh*		*1,470*	*1,470*	*1,470*	*1,470*	*1,470*	*1,470*	*1,413*	*1,413*
Costa Sur H Class Train 1	*lbs/MWh*		-	-	-	-	-	*832*	*812*	*824*
Costa Sur H Class Train 2	*lbs/MWh*		-	-	-	-	-	-	*825*	*835*
RPS (PPOA/Net sales)	*percent*		*7.74%*	*8.23%*	*8.59%*	*9.14%*	*9.28%*	*11.50%*	*13.02%*	*20.04%*
RPS Target	*percent*		*12.00%*	*12.75%*	*13.50%*	*14.25%*	*15.00%*	*16.67%*	*18.33%*	*20.00%*
Reduced RPS Target	*percent*		*8.00%*	*8.50%*	*9.00%*	*9.50%*	*10.00%*	*12.00%*	*18.33%*	*20.00%*
Renewable Penetration	*percent*		*8.48%*	*9.14%*	*9.65%*	*10.32%*	*10.60%*	*13.54%*	*15.86%*	*23.53%*
OPERATIONS										
Renewable Curtailment	*percent*		*2.7%*	*2.2%*	*3.0%*	*2.6%*	*5.3%*	*1.1%*	*0.4%*	*4.2%*
Renewable Curtailment Limit	*percent*		*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*
Renewable Curtailed Energy	*MWh*		38,073	34,258	48,300	43,804	91,807	23,089	9,472	130,871
Renewable Curtailment Cost	$000		5,691	5,085	7,103	6,434	13,313	3,133	1,217	15,631
LOLH	*hours*		*0.00*	*0.00*	*0.00*	*4.00*	*0.00*	*0.00*	*0.00*	*0.00*
Reserve Margin with GTs & Cambalache	*percent*		*70%*	*70%*	*71%*	*63%*	*69%*	*74%*	*72%*	*67%*
Reserve Margin without GTs & Cambalache	*percent*		*50%*	*50%*	*51%*	*43%*	*48%*	*52%*	*48%*	*41%*

System Costs Summary	**Unit**	**Fiscal Year**	**2016**	**2017**	**2018**	**2019**	**2020**	**2025**	**2030**	**2035**
Fuel	$000		1,376,319	1,370,277	1,402,010	1,479,109	1,429,217	1,060,242	1,315,357	1,289,463
Regasification fixed costs	$000		-	-	7,944	11,789	15,591	23,796	25,153	16,240
O&M	$000		174,002	173,449	170,960	165,854	147,873	149,157	155,056	137,229
Purchased power	$000		744,908	746,980	712,228	707,266	688,733	692,033	447,685	430,871
Renewables	$000		214,891	229,180	238,464	253,456	253,882	279,684	288,328	369,367
Amortized capital costs	$000		10,667	24,351	39,323	57,723	127,761	291,550	328,340	328,340
Energy efficiency costs	$000		-	1,538	4,604	9,197	15,207	62,984	114,027	161,592
Total System Costs	**$000**		2,520,787	2,545,776	2,575,533	2,684,395	2,678,264	2,559,448	2,673,947	2,733,102

Appendix C-6: P3MF2M_S2 Results (No AOGP, No EcoEléctrica)

Puerto Rico Electric Power Authority

Portfolio 3M; Future 2M; Sensitivity 2 No AOGP No EcoElectrica

Supplemental IRP Metrics Analysis

		Fiscal Year	2016	2017	2018	2019	2020	2025	2030	2035
COST	**Unit**	**Total / Average**								
Present Value of System Costs	*$000*	*28,610,799*	2,438,501	2,304,521	2,181,731	2,127,915	1,986,712	1,325,140	966,785	720,655
System Costs	*$000*	*2,580,583*	2,520,787	2,545,776	2,575,533	2,684,395	2,678,264	2,489,498	2,531,113	2,629,303
Capital Costs (FY 2016 - 2025)	*$ million*	4,175	134	176	167	239	433	248	-	-
Capital Costs (FY 2026 - 2035)	*$ million*	50								
Capital Costs (FY 2016 - 2035)	*$ million*	4,225								
ENVIRONMENTAL COMPLIANCE										
CO_2 Emissions (Total Generation)	*lbs./MWh*		*1,390*	*1,376*	*1,371*	*1,373*	*1,359*	*1,067*	*1,043*	*973*
CO_2 Emission Target (Total Generation)	*lbs./MWh*		*1,470*	*1,470*	*1,470*	*1,470*	*1,470*	*1,470*	*1,413*	*1,413*
Costa Sur H Class Train 1	*lbs/MWh*		-	-	-	-	-	*811*	*813*	*829*
Costa Sur H Class Train 2	*lbs/MWh*		-	-	-	-	-	*822*	*825*	*835*
RPS (PPOA/Net sales)	*percent*		*7.74%*	*8.23%*	*8.59%*	*9.14%*	*9.28%*	*11.50%*	*13.02%*	*20.04%*
RPS Target	*percent*		*12.00%*	*12.75%*	*13.50%*	*14.25%*	*15.00%*	*16.67%*	*18.33%*	*20.00%*
Reduced RPS Target	*percent*		*8.00%*	*8.50%*	*9.00%*	*9.50%*	*10.00%*	*12.00%*	*18.33%*	*20.00%*
Renewable Penetration	*percent*		*8.48%*	*9.14%*	*9.65%*	*10.32%*	*10.60%*	*13.54%*	*15.86%*	*23.53%*
OPERATIONS										
Renewable Curtailment	*percent*		*2.7%*	*2.2%*	*3.0%*	*2.6%*	*5.3%*	*0.5%*	*0.7%*	*3.7%*
Renewable Curtailment Limit	*percent*		*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*
Renewable Curtailed Energy	*MWh*		38,073	34,258	48,300	43,804	91,807	11,134	14,723	114,865
Renewable Curtailment Cost	$000		5,691	5,085	7,103	6,434	13,313	1,511	1,892	13,719
LOLH	*hours*		*0.00*	*0.00*	*0.00*	*4.00*	*0.00*	*0.00*	*0.00*	*0.00*
Reserve Margin with GTs & Cambalache	*percent*		*70%*	*70%*	*71%*	*63%*	*69%*	*70%*	*66%*	*65%*
Reserve Margin without GTs & Cambalache	*percent*		*50%*	*50%*	*51%*	*43%*	*48%*	*48%*	*42%*	*39%*

System Costs Summary	**Unit**	**Fiscal Year**	**2016**	**2017**	**2018**	**2019**	**2020**	**2025**	**2030**	**2035**
Fuel	$000		1,376,319	1,370,277	1,402,010	1,479,109	1,429,217	1,357,342	1,361,246	1,353,364
Regasification fixed costs	$000		-	-	7,944	11,789	15,591	34,005	25,229	15,599
O&M	$000		174,002	173,449	170,960	165,854	147,873	172,899	156,005	139,830
Purchased power	$000		744,908	746,980	712,228	707,266	688,733	256,013	259,708	262,982
Renewables	$000		214,891	229,180	238,464	253,456	253,882	279,684	288,328	369,367
Amortized capital costs	$000		10,667	24,351	39,323	57,723	127,761	326,570	326,570	326,570
Energy efficiency costs	$000		-	1,538	4,604	9,197	15,207	62,984	114,027	161,592
Total System Costs	**$000**		2,520,787	2,545,776	2,575,533	2,684,395	2,678,264	2,489,498	2,531,113	2,629,303

Appendix C-7: P3MF2M_S3 Results (No AOGP, No AES, No EcoEléctrica)

Puerto Rico Electric Power Authority

Portfolio 3M; Future 2M; Sensitivity 3 No AOGP No EcoElectrica No AES

Supplemental IRP Metrics Analysis

		Fiscal Year	**2016**	**2017**	**2018**	**2019**	**2020**	**2025**	**2030**	**2035**
COST	**Unit**	**Total / Average**								
Present Value of System Costs	*$000*	*28,800,716*	2,438,501	2,304,521	2,181,731	2,127,915	1,986,712	1,325,140	1,009,114	747,439
System Costs	*$000*	*2,609,174*	2,520,787	2,545,776	2,575,533	2,684,395	2,678,264	2,489,498	2,641,935	2,727,023
Capital Costs (FY 2016 - 2025)	*$ million*	4,175	134	176	167	239	433	248	-	-
Capital Costs (FY 2026 - 2035)	*$ million*	502								
Capital Costs (FY 2016 - 2035)	*$ million*	4,677								
ENVIRONMENTAL COMPLIANCE										
CO_2 Emissions (Total Generation)	*lbs./MWh*		*1,390*	*1,376*	*1,371*	*1,373*	*1,359*	*1,067*	*771*	*693*
CO_2 Emission Target (Total Generation)	*lbs./MWh*		*1,470*	*1,470*	*1,470*	*1,470*	*1,470*	*1,470*	*1,413*	*1,413*
Costa Sur H Class Train 1	*lbs/MWh*		-	-	-	-	-	*811*	*807*	*815*
Costa Sur H Class Train 2	*lbs/MWh*		-	-	-	-	-	*822*	*812*	*822*
Costa Sur H Class Train 3	*lbs/MWh*		-	-	-	-	-	-	*822*	*829*
RPS (PPOA/Net sales)	*percent*		*7.74%*	*8.23%*	*8.59%*	*9.14%*	*9.28%*	*11.50%*	*13.02%*	*20.04%*
RPS Target	*percent*		*12.00%*	*12.75%*	*13.50%*	*14.25%*	*15.00%*	*16.67%*	*18.33%*	*20%*
Reduced RPS Target	*percent*		*8.00%*	*8.50%*	*9.00%*	*9.50%*	*10.00%*	*12.00%*	*18.33%*	*20%*
Renewable Penetration	*percent*		*8.48%*	*9.14%*	*9.65%*	*10.32%*	*10.60%*	*13.54%*	*15.86%*	*23.53%*
OPERATIONS										
Renewable Curtailment	*percent*		*2.7%*	*2.2%*	*3.0%*	*2.6%*	*5.3%*	*0.5%*	*0.2%*	*3.0%*
Renewable Curtailment Limit	*percent*		*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*
Renewable Curtailed Energy	*MWh*		38,073	34,258	48,300	43,804	91,807	11,134	5,171	91,500
Renewable Curtailment Cost	$000		5,691	5,085	7,103	6,434	13,313	1,511	664	10,928
LOLH	*hours*		*0.00*	*0.00*	*0.00*	*4.00*	*0.00*	*0.00*	*0.00*	*0.00*
Reserve Margin with GTs & Cambalache	*percent*		*70%*	*70%*	*71%*	*63%*	*69%*	*70%*	*67%*	*62%*
Reserve Margin without GTs & Cambalache	*percent*		*50%*	*50%*	*51%*	*43%*	*48%*	*48%*	*43%*	*36%*

System Costs Summary	**Unit**	**Fiscal Year**	**2016**	**2017**	**2018**	**2019**	**2020**	**2025**	**2030**	**2035**
Fuel	$000		1,376,319	1,370,277	1,402,010	1,479,109	1,429,217	1,357,342	1,670,097	1,653,788
Regasification fixed costs	$000		-	-	7,944	11,789	15,591	34,005	26,836	17,636
O&M	$000		174,002	173,449	170,960	165,854	147,873	172,899	179,287	161,282
Purchased power	$000		744,908	746,980	712,228	707,266	688,733	256,013	-	-
Renewables	$000		214,891	229,180	238,464	253,456	253,882	279,684	288,328	369,367
Amortized capital costs	$000		10,667	24,351	39,323	57,723	127,761	326,570	363,359	363,359
Energy efficiency costs	$000		-	1,538	4,604	9,197	15,207	62,984	114,027	161,592
Total System Costs	**$000**		2,520,787	2,545,776	2,575,533	2,684,395	2,678,264	2,489,498	2,641,935	2,727,023

Appendix C-8: P3MF1M_S4 Results (Demand Response)

Puerto Rico Electric Power Authority

Portfolio 3M; Future 1M; Sensitivity 4; Demand Response

Supplemental IRP Metrics Analysis

		Fiscal Year	2016	2017	2018	2019	2020	2025	2030	2035
COST	**Unit**	**Total / Average**								
Present Value of System Costs	*$000*	*26,059,825*	2,402,622	2,306,892	2,005,080	1,992,132	1,876,646	1,230,000	855,816	597,120
System Costs	*$000*	*2,311,923*	2,483,697	2,548,395	2,366,996	2,513,103	2,529,886	2,310,762	2,240,590	2,178,587
Capital Costs (FY 2016 - 2025)	*$ million*	3,153	134	240	615	239	239	248	489	-
Capital Costs (FY 2026 - 2035)	*$ million*	1,461								
Capital Costs (FY 2016 - 2035)	*$ million*	4,614								
ENVIRONMENTAL COMPLIANCE										
CO_2 Emissions (Total Generation)	*lbs/MWh*		*1,339*	*1,310*	*1,195*	*1,217*	*1,195*	*1,092*	*1,000*	*984*
CO_2 Emission Target (Total Generation)	*lbs/MWh*		*1,470*	*1,470*	*1,470*	*1,470*	*1,470*	*1,470*	*1,413*	*1,413*
Aguirre 1 CC Repower	*lbs/MWh*		-	-	-	-	-	*1,027*	*1,030*	*934*
Aguirre 2 CC Repower	*lbs/MWh*		-	-	-	-	-	*1,119*	*1,055*	*966*
Aguirre H Class Train 1	*lbs/MWh*		-	-	-	-	-	-	*859*	*871*
Aguirre H Class Train 2	*lbs/MWh*		-	-	-	-	-	-	*877*	*872*
Costa Sur H Class Train 1	*lbs/MWh*		-	-	-	-	-	-	*870*	*854*
RPS (PPOA/Net sales)	*percent*		*11.50%*	*12.39%*	*13.68%*	*14.63%*	*15.31%*	*16.89%*	*18.41%*	*20.03%*
RPS Target	*percent*		*12.00%*	*12.75%*	*13.50%*	*14.25%*	*15.00%*	*16.67%*	*18.33%*	*20%*
Reduced RPS Target	*percent*		*8.00%*	*8.50%*	*9.00%*	*9.50%*	*10.00%*	*12.00%*	*18.33%*	*20.00%*
Renewable Penetration	*percent*		*12.22%*	*13.25%*	*14.68%*	*15.74%*	*16.54%*	*18.81%*	*21.07%*	*23.52%*
OPERATIONS										
Renewable Curtailment	*percent*		*3.9%*	*1.2%*	*1.1%*	*1.5%*	*2.0%*	*3.3%*	*3.7%*	*3.1%*
Renewable Curtailment Limit	*percent*		*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*
Renewable Curtailed Energy	*MWh*		79,947	27,043	27,326	38,992	53,135	94,091	111,265	95,191
Renewable Curtailment Cost	$000		11,793	3,870	3,793	5,305	7,134	12,117	13,791	11,368
LOLH	*hours*		*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*
Reserve Margin with GTs & Cambalache	*percent*		*70%*	*70%*	*71%*	*54%*	*60%*	*71%*	*77%*	*74%*
Reserve Margin without GTs & Cambalache	*percent*		*51%*	*52%*	*52%*	*35%*	*38%*	*47%*	*55%*	*47%*

System Costs Summary	**Unit**	**Fiscal Year**	**2016**	**2017**	**2018**	**2019**	**2020**	**2025**	**2030**	**2035**
Fuel	$000		1,286,537	1,306,079	975,080	1,083,692	1,060,045	775,209	561,124	499,899
Regasification fixed costs	$000		-	-	85,083	89,229	92,769	91,797	83,083	83,289
O&M	$000		172,526	162,750	173,490	161,364	143,229	139,885	113,886	100,851
Purchased power	$000		703,931	707,930	669,189	670,981	650,585	611,755	612,441	609,405
Renewables	$000		304,940	320,014	342,041	357,621	366,109	368,363	369,229	369,194
Amortized capital costs	$000		10,667	39,864	104,755	123,155	177,368	240,349	379,366	350,780
Energy efficiency costs	$000		-	1,538	4,604	9,197	15,207	62,984	114,027	161,592
Demand response costs	$000		5,096	10,220	12,754	17,864	24,573	20,419	7,433	3,577
Total System Costs	**$000**		2,483,697	2,548,395	2,366,996	2,513,103	2,529,886	2,310,762	2,240,590	2,178,587

Appendix C-9: P3MF1M_S5 Results (Full RPS Compliance)

Puerto Rico Electric Power Authority
Portfolio 3M; Future 1M; Sensitivity 5; Full RPS
Supplemental IRP Metrics Analysis

		Fiscal Year	2016	2017	2018	2019	2020	2025	2030	2035
COST	**Unit**	**Total / Average**								
Present Value of System Costs	*$000*	*26,086,731*	2,409,270	2,337,415	2,046,177	2,013,371	1,925,606	1,189,154	850,419	596,966
System Costs	*$000*	*2,309,473*	2,490,569	2,582,113	2,415,511	2,539,896	2,595,887	2,234,026	2,226,460	2,178,024
Capital Costs (FY 2016 - 2025)	*$ million*	4,473	134	240	615	239	239	248	-	-
Capital Costs (FY 2026 - 2035)	*$ million*	54								
Capital Costs (FY 2016 - 2035)	*$ million*	4,527								
ENVIRONMENTAL COMPLIANCE										
CO_2 Emissions (Total Generation)	*lbs/MWh*		*1,338*	*1,325*	*1,215*	*1,214*	*1,212*	*1,013*	*1,004*	*982*
CO_2 Emission Target (Total Generation)	*lbs/MWh*		*1,470*	*1,470*	*1,470*	*1,470*	*1,470*	*1,470*	*1,413*	*1,413*
Aguirre 1 CC Repower	*lbs/MWh*		-	-	-	-	-	*1,037*	*956*	*932*
Aguirre 2 CC Repower	*lbs/MWh*		-	-	-	-	-	*1,065*	*990*	*966*
Aguirre H Class Train 1	*lbs/MWh*		-	-	-	-	-	*857*	*860*	*868*
Aguirre H Class Train 2	*lbs/MWh*		-	-	-	-	-	*868*	*867*	*865*
Costa Sur H Class Train 1	*lbs/MWh*		-	-	-	-	-	*856*	*861*	*859*
RPS (PPOA/Net sales)	*percent*		*11.50%*	*12.39%*	*13.68%*	*14.63%*	*15.30%*	*16.88%*	*18.40%*	*20.03%*
RPS Target	*percent*		*12.00%*	*12.75%*	*13.50%*	*14.25%*	*15.00%*	*16.67%*	*18.33%*	*20.00%*
Reduced RPS Target	*percent*		*8.00%*	*8.50%*	*9.00%*	*9.50%*	*10.00%*	*12.00%*	*18.33%*	*20.00%*
Renewable Penetration	*percent*		*12.22%*	*13.25%*	*14.68%*	*15.73%*	*16.53%*	*18.80%*	*21.06%*	*23.52%*
OPERATIONS										
Renewable Curtailment	*percent*		*5.8%*	*6.5%*	*6.0%*	*12.3%*	*17.1%*	*6.0%*	*6.9%*	*4.4%*
Renewable Curtailment Limit	*percent*		*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*
Renewable Curtailed Energy	*MWh*		120,362	143,939	147,666	322,271	465,443	171,349	205,832	134,668
Renewable Curtailment Cost	$000		17,755	20,599	20,499	43,847	62,493	22,069	25,507	16,082
LOLH	*hours*		*0.00*	*0.00*	*0.00*	*0.00*	*5.00*	*0.00*	*0.00*	*0.00*
Reserve Margin with GTs & Cambalache	*percent*		*70%*	*70%*	*71%*	*54%*	*60%*	*81%*	*77%*	*74%*
Reserve Margin without GTs & Cambalache	*percent*		*51%*	*52%*	*52%*	*35%*	*38%*	*61%*	*55%*	*47%*

System Costs Summary	**Unit**	**Fiscal Year**	**2016**	**2017**	**2018**	**2019**	**2020**	**2025**	**2030**	**2035**
Fuel	$000		1,309,835	1,378,502	1,046,773	1,147,058	1,160,500	640,164	604,891	511,348
Regasification fixed costs	$000		-	-	84,154	92,790	91,591	83,370	83,070	82,995
O&M	$000		173,808	164,955	176,205	163,093	146,285	120,059	116,085	100,845
Purchased power	$000		691,319	677,239	656,983	647,053	638,885	615,569	595,726	608,462
Renewables	$000		304,940	320,014	342,039	357,550	366,051	368,211	368,992	369,112
Amortized capital costs	$000		10,667	39,864	104,755	123,155	177,368	343,669	343,669	343,669
Energy efficiency costs	$000		-	1,538	4,604	9,197	15,207	62,984	114,027	161,592
Total System Costs	**$000**		2,490,569	2,582,113	2,415,511	2,539,896	2,595,887	2,234,026	2,226,460	2,178,024

Appendix C-10: P3F1 Fuel Sensitivity Results

Puerto Rico Electric Power Authority

Portfolio 3; Future 1; Reduced Fuel Forecast

IRP Metrics Analysis

		Fiscal Year	2016	2017	2018	2019	2020	2025	2030	2035
COST	**Unit**	**Total / Average**								
Present Value of System Costs	*$000*	*23,502,526*	1,750,163	1,513,434	1,781,304	1,709,842	1,645,852	1,159,043	861,917	625,960
System Costs	*$000*	*2,166,577*	1,809,221	1,671,872	2,102,829	2,156,990	2,218,754	2,177,457	2,256,561	2,283,810
Capital Costs (FY 2016 - 2025)	*$ million*	3,333	134	240	615	239	239	248	-	-
Capital Costs (FY 2026 - 2035)	*$ million*	1,942								
Capital Costs (FY 2016 - 2035)	*$ million*	5,275								
ENVIRONMENTAL COMPLIANCE										
CO_2 Emissions (Total Generation)	*lbs/MWh*		*1,478*	*1,483*	*1,295*	*1,267*	*1,262*	*1,125*	*1,044*	*961*
CO_2 Emission Target (Total Generation)	*lbs/MWh*		*1,470*	*1,470*	*1,470*	*1,470*	*1,470*	*1,470*	*1,413*	*1,413*
Aguirre 1 CC Repower	*lbs/MWh*		-	-	-	-	-	*946*	*988*	*988*
Aguirre 2 CC Repower	*lbs/MWh*		-	-	-	-	-	*995*	*1,044*	*983*
Aguirre H Class Train 1	*lbs/MWh*		-	-	-	-	-	-	*842*	*831*
Aguirre H Class Train 2	*lbs/MWh*		-	-	-	-	-	-	*857*	*846*
Costa Sur H Class Train 1	*lbs/MWh*		-	-	-	-	-	-	-	*857*
Costa Sur H Class Train 2	*lbs/MWh*		-	-	-	-	-	-	-	*858*
RPS (PPOA/Net sales)	*percent*		*3.24%*	*4.70%*	*6.20%*	*8.02%*	*9.72%*	*12.54%*	*13.99%*	*15.77%*
RPS Target	*percent*		*12.00%*	*12.75%*	*13.50%*	*14.25%*	*15.00%*	*16.67%*	*18.33%*	*20%*
Reduced RPS Target	*percent*		*8.00%*	*8.50%*	*9.00%*	*9.50%*	*10.00%*	*12.00%*	*13.50%*	*15%*
Renewable Penetration	*percent*		*7.24%*	*10.29%*	*13.42%*	*17.11%*	*20.59%*	*26.70%*	*30.04%*	*33.96%*
OPERATIONS										
Renewable Curtailment	*percent*		*1.0%*	*0.7%*	*1.0%*	*2.6%*	*3.0%*	*6.2%*	*7.1%*	*1.2%*
Renewable Curtailment Limit	*percent*		*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*
Renewable Curtailed Energy	*MWh*		6,944	6,958	12,707	39,617	55,819	143,635	189,700	36,901
Renewable Curtailment Cost	$000		912	956	1,790	5,716	8,217	21,001	27,192	5,231
LOLH	*hours*		*0.00*	*0.00*	*0.00*	*0.00*	*2.00*	*0.00*	*0.00*	*0.00*
Reserve Margin with GTs & Cambalache	*percent*		*70%*	*70%*	*70%*	*70%*	*63%*	*68%*	*64%*	*62%*
Reserve Margin (without GTs & Cambalache)	*percent*		*51%*	*51%*	*52%*	*51%*	*44%*	*49%*	*45%*	*43%*

System Costs Summary	**Unit**	**Fiscal Year**	**2016**	**2017**	**2018**	**2019**	**2020**	**2025**	**2030**	**2035**
Fuel	$000		836,922	671,726	894,592	876,568	877,826	751,253	737,271	619,401
Regasification fixed costs	$000		-	-	84,253	92,686	90,771	90,291	92,517	89,240
O&M	$000		175,162	166,691	178,108	176,345	150,973	148,269	134,351	115,881
Purchased power	$000		696,281	662,018	667,328	663,510	648,947	591,382	582,140	623,154
Renewables	$000		90,189	131,573	173,793	224,725	272,869	341,099	381,888	431,492
Amortized capital costs	$000		10,667	39,864	104,755	123,155	177,368	255,163	328,394	404,643
Total System Costs	**$000**		1,809,221	1,671,872	2,102,829	2,156,990	2,218,754	2,177,457	2,256,561	2,283,810

Appendix C-11: P3F1 Base IRP Results (Revised)

Puerto Rico Electric Power Authority
Portfolio 3; Future 1; Revised
IRP Metrics Analysis

		Fiscal Year	2016	2017	2018	2019	2020	2025	2030	2035
COST	**Unit**	**Total / Average**								
Present Value of System Costs	*$000*	*26,759,377*	2,324,415	2,284,681	1,986,538	1,905,851	1,873,112	1,268,034	920,902	650,902
System Costs	*$000*	*2,407,015*	2,402,851	2,523,859	2,345,107	2,404,259	2,525,121	2,382,215	2,410,988	2,374,812
Capital Costs (FY 2016 - 2025)	*$ million*	3,333	134	240	615	239	239	248	-	-
Capital Costs (FY 2026 - 2035)	*$ million*	1,942								
Capital Costs (FY 2016 - 2035)	*$ million*	5,275								
ENVIRONMENTAL COMPLIANCE										
CO_2 Emissions (Total Generation)	*lbs/MWh*		*1,425*	*1,407*	*1,290*	*1,262*	*1,262*	*1,123*	*1,044*	*962*
CO_2 Emission Target (Total Generation)	*lbs/MWh*		*1,470*	*1,470*	*1,470*	*1,470*	*1,470*	*1,470*	*1,413*	*1,413*
Aguirre 1 CC Repower	*lbs/MWh*		-	-	-	-	-	*949*	*961*	*974*
Aguirre 2 CC Repower	*lbs/MWh*		-	-	-	-	-	*996*	*1,005*	*983*
Aguirre H Class Train 1	*lbs/MWh*		-	-	-	-	-	-	*852*	*830*
Aguirre H Class Train 2	*lbs/MWh*		-	-	-	-	-	-	*872*	*844*
Costa Sur H Class Train 1	*lbs/MWh*		-	-	-	-	-	-	-	*855*
Costa Sur H Class Train 2	*lbs/MWh*		-	-	-	-	-	-	-	*858*
RPS (PPOA/Net sales)	*percent*		*3.24%*	*4.69%*	*6.20%*	*8.01%*	*9.71%*	*12.51%*	*13.96%*	*15.73%*
RPS Target	*percent*		*12.00%*	*12.75%*	*13.50%*	*14.25%*	*15.00%*	*16.67%*	*18.33%*	*20%*
Reduced RPS Target	*percent*		*8.00%*	*8.50%*	*9.00%*	*9.50%*	*10.00%*	*12.00%*	*13.50%*	*15%*
Renewable Penetration	*percent*		*7.17%*	*10.20%*	*13.32%*	*17.00%*	*20.47%*	*26.52%*	*29.80%*	*33.67%*
OPERATIONS										
Renewable Curtailment	*percent*		*1.0%*	*0.7%*	*1.1%*	*2.6%*	*3.1%*	*6.3%*	*7.2%*	*1.2%*
Renewable Curtailment Limit	*percent*		*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*
Renewable Curtailed Energy	*MWh*		6,944	6,958	12,707	39,617	55,819	143,635	189,700	36,901
Renewable Curtailment Cost	$000		927	970	1,813	5,782	8,306	21,264	27,583	5,312
LOLH	*hours*		*0.00*	*0.00*	*0.00*	*0.00*	*2.00*	*0.00*	*0.00*	*0.00*
Number of Plants that could Trigger Load Shedding	*number*		*5*	*5*	*5*	*5*	*5*	*6*	*6*	*6*
Size of Load Shed (if 300 MW spinning)	*MW*		*150*	*150*	*150*	*150*	*150*	*150*	*110*	*93.28*
Number of Starts	*number*									
Total Starts Steam Existing and New per unit	*number*		14	17	13	13	15	10	10	8
Total Starts Existing CC per unit	*number*		91	87	94	169	179	0	0	0
Total Starts EcoEléctrica	*number*		7	7	5	5	7	3	7	8
Total Starts New CC per unit	*number*		0	0	0	0	0	117	85	142
Total Starts GT per unit	*number*		45	65	75	44	93	46	10	13
Reserve Margin with GTs & Cambalache	*percent*		*70%*	*70%*	*70%*	*70%*	*63%*	*68%*	*64%*	*62%*
Reserve Margin without GTs & Cambalache	*percent*		*51%*	*51%*	*52%*	*51%*	*44%*	*49%*	*45%*	*43%*

System Costs Summary	**Unit**	**Fiscal Year**	**2016**	**2017**	**2018**	**2019**	**2020**	**2025**	**2030**	**2035**
Fuel	$000		1,390,916	1,464,670	1,119,658	1,110,153	1,164,497	922,022	849,919	672,967
Regasification fixed costs	$000		-	-	84,194	92,638	90,919	90,672	92,460	89,338
O&M	$000		174,853	166,298	179,279	177,976	152,337	148,665	134,810	116,077
Purchased power	$000		735,761	720,987	682,963	675,136	666,665	624,128	623,039	659,827
Renewables	$000		90,654	132,039	174,259	225,201	273,334	341,566	382,365	431,959
Amortized capital costs	$000		10,667	39,864	104,755	123,155	177,368	255,163	328,394	404,643
Total System Costs	**$000**		2,402,851	2,523,859	2,345,107	2,404,259	2,525,121	2,382,215	2,410,988	2,374,812

Note: Revision is made regarding fiscal year in which the generation capital costs occur in the model.

Appendix C-12: P3F2 Fuel Sensitivity Results

Puerto Rico Electric Power Authority
Portfolio 3; Future 2; Reduced Fuel Forecast
IRP Metrics Analysis

		Fiscal Year	2016	2017	2018	2019	2020	2025	2030	2035
COST	**Unit**	**Total / Average**								
Present Value of System Costs	*$000*	*23,679,816*	1,733,945	1,485,543	1,707,274	1,668,401	1,579,723	1,175,025	883,667	694,426
System Costs	*$000*	*2,211,588*	1,792,456	1,641,061	2,015,436	2,104,711	2,129,607	2,207,481	2,313,506	2,533,606
Capital Costs (FY 2016 - 2025)	*$ million*	3,715	134	176	167	239	433	248	-	-
Capital Costs (FY 2026 - 2035)	*$ million*	959								
Capital Costs (FY 2016 - 2035)	*$ million*	4,674								
ENVIRONMENTAL COMPLIANCE										
RPS (PPOA/Net sales)	*percent*		*3.24%*	*4.70%*	*6.20%*	*8.02%*	*9.72%*	*12.12%*	*13.53%*	*15.25%*
RPS Target	*percent*		*12.00%*	*12.75%*	*13.50%*	*14.25%*	*15.00%*	*16.67%*	*18.33%*	*20%*
Reduced RPS Target	*percent*		*8.00%*	*8.50%*	*9.00%*	*9.50%*	*10.00%*	*12.00%*	*13.50%*	*15%*
Renewable Penetration	*percent*		*4.02%*	*5.64%*	*7.28%*	*9.20%*	*11.00%*	*13.97%*	*15.91%*	*18.14%*
OPERATIONS										
Renewable Curtailment	*percent*		*1.2%*	*0.8%*	*2.0%*	*2.3%*	*6.5%*	*0.4%*	*0.2%*	*1.1%*
Renewable Curtailment Limit	*percent*		*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*
Renewable Curtailed Energy	*MWh*		8,385	7,624	23,960	35,736	120,661	10,115	4,736	33,424
Renewable Curtailment Cost	$000		1,101	1,047	3,375	5,156	17,763	1,479	679	4,738
LOLH	*hours*		*0.00*	*0.00*	*3.00*	*0.00*	*4.00*	*0.00*	*0.00*	*0.00*
Reserve Margin with GTs & Cambalache	*percent*		*70%*	*70%*	*70%*	*61%*	*63%*	*63%*	*61%*	*61%*
Reserve Margin without GTs & Cambalache	*percent*		*50%*	*50%*	*50%*	*41%*	*42%*	*42%*	*40%*	*40%*

System Costs Summary	Unit	Fiscal Year	2016	2017	2018	2019	2020	2025	2030	2035
Fuel	$000		819,483	651,406	971,095	986,142	926,842	794,755	785,236	934,381
Regasification fixed costs	$000		-	-	7,889	11,829	15,432	14,707	16,641	16,651
O&M	$000		175,197	174,988	171,195	166,337	146,825	154,929	154,343	152,947
Purchased power	$000		696,920	658,744	652,141	657,955	639,877	612,886	612,335	635,072
Renewables	$000		90,189	131,573	173,793	224,725	272,869	341,099	381,888	431,492
Amortized capital costs	$000		10,667	24,351	39,323	57,723	127,761	289,105	363,063	363,063
Total System Costs	**$000**		1,792,456	1,641,061	2,015,436	2,104,711	2,129,607	2,207,481	2,313,506	2,533,606

Appendix C-13: P3MF1M Fuel Sensitivity Results

Puerto Rico Electric Power Authority

Portfolio 3M; Future 1M; Reduced Fuel Forecast

Supplemental IRP Metrics Analysis

		Fiscal Year	2016	2017	2018	2019	2020	2025	2030	2035
COST	**Unit**	**Total / Average**								
Present Value of System Costs	*$000*	*22,700,545*	1,816,170	1,573,835	1,796,542	1,757,411	1,637,225	1,121,179	778,341	570,336
System Costs	*$000*	*2,055,882*	1,877,456	1,738,596	2,120,817	2,216,998	2,207,125	2,106,323	2,037,752	2,080,868
Capital Costs (FY 2016 - 2025)	*$ million*	3,153	134	240	615	239	239	248	489	-
Capital Costs (FY 2026 - 2035)	*$ million*	1,461								
Capital Costs (FY 2016 - 2035)	*$ million*	4,614								
ENVIRONMENTAL COMPLIANCE										
CO_2 Emissions (Total Generation)	*lbs/MWh*		*1,433*	*1,434*	*1,260*	*1,285*	*1,268*	*1,151*	*1,043*	*989*
CO_2 Emission Target (Total Generation)	*lbs/MWh*		*1,470*	*1,470*	*1,470*	*1,470*	*1,470*	*1,470*	*1,413*	*1,413*
Aguirre 1 CC Repower	*lbs/MWh*		-	-	-	-	-	*976*	*1,067*	*940*
Aguirre 2 CC Repower	*lbs/MWh*		-	-	-	-	-	*1,042*	*1,102*	*975*
Aguirre H Class Train 1	*lbs/MWh*		-	-	-	-	-	-	*848*	*871*
Aguirre H Class Train 2	*lbs/MWh*		-	-	-	-	-	-	*870*	*864*
Costa Sur H Class Train 1	*lbs/MWh*		-	-	-	-	-	-	*872*	*858*
RPS (PPOA/Net sales)	*percent*		*7.74%*	*8.23%*	*8.59%*	*9.14%*	*9.28%*	*11.50%*	*13.02%*	*20.04%*
RPS Target	*percent*		*12.00%*	*12.75%*	*13.50%*	*14.25%*	*15.00%*	*16.67%*	*18.33%*	*20%*
Reduced RPS Target	*percent*		*8.00%*	*8.50%*	*9.00%*	*9.50%*	*10.00%*	*12.00%*	*18.33%*	*20.00%*
Renewable Penetration	*percent*		*8.48%*	*9.14%*	*9.65%*	*10.32%*	*10.60%*	*13.54%*	*15.86%*	*23.53%*
OPERATIONS										
Renewable Curtailment	*percent*		*2.7%*	*1.5%*	*0.9%*	*2.8%*	*5.7%*	*5.7%*	*2.5%*	*5.1%*
Renewable Curtailment Limit	*percent*		*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*
Renewable Curtailed Energy	*MWh*		39,283	23,716	14,465	48,795	99,377	116,806	56,562	155,979
Renewable Curtailment Cost	$000		5,872	3,520	2,127	7,167	14,411	15,848	7,269	18,630
LOLH	*hours*		*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*
Reserve Margin with GTs & Cambalache	*percent*		*70%*	*70%*	*71%*	*54%*	*60%*	*71%*	*80%*	*74%*
Reserve Margin without GTs & Cambalache	*percent*		*51%*	*52%*	*52%*	*35%*	*38%*	*47%*	*55%*	*47%*

System Costs Summary	**Unit**	**Fiscal Year**	**2016**	**2017**	**2018**	**2019**	**2020**	**2025**	**2030**	**2035**
Fuel	$000		794,730	651,485	853,702	921,691	880,668	705,399	536,369	486,207
Regasification fixed costs	$000		-	-	85,144	89,243	92,806	90,938	82,750	82,982
O&M	$000		173,836	165,355	175,381	164,550	146,143	142,435	50,509	51,900
Purchased power	$000		683,332	651,172	658,766	655,707	641,051	584,533	586,403	578,041
Renewables	$000		214,891	229,180	238,464	253,456	253,882	279,684	288,328	369,367
Amortized capital costs	$000		10,667	39,864	104,755	123,155	177,368	240,349	379,366	350,780
Energy efficiency costs	$000		-	1,538	4,604	9,197	15,207	62,984	114,027	161,592
Total System Costs	**$000**		1,877,456	1,738,596	2,120,817	2,216,998	2,207,125	2,106,323	2,037,752	2,080,868

Appendix C-14: P3MF2M Fuel Sensitivity Results

Puerto Rico Electric Power Authority
Portfolio 3M; Future 2M; Reduced Fuel Forecast
Supplemental IRP Metrics Analysis

		Fiscal Year	2016	2017	2018	2019	2020	2025	2030	2035
COST	**Unit**	**Total / Average**								
Present Value of System Costs	*$000*	*22,919,603*	1,811,157	1,546,130	1,735,903	1,673,045	1,556,668	1,110,986	820,113	640,168
System Costs	*$000*	*2,111,604*	1,872,273	1,707,991	2,049,233	2,110,570	2,098,527	2,087,174	2,147,115	2,335,647
Capital Costs (FY 2016 - 2025)	*$ million*	3,745	134	176	167	239	433	248	-	-
Capital Costs (FY 2026 - 2035)	*$ million*	50								
Capital Costs (FY 2016 - 2035)	*$ million*	3,794								
ENVIRONMENTAL COMPLIANCE										
CO_2 Emissions (Total Generation)	*lbs./MWh*		*1,435*	*1,448*	*1,370*	*1,370*	*1,357*	*1,064*	*1,036*	*970*
CO_2 Emission Target (Total Generation)	*lbs./MWh*		*1,470*	*1,470*	*1,470*	*1,470*	*1,470*	*1,470*	*1,413*	*1,413*
H Class 1x1 CC(NG, Costa Sur site)	*lbs/MWh*		-	-	-	-	-	*834*	*832*	*843*
RPS (PPOA/Net sales)	*percent*		*7.74%*	*8.23%*	*8.59%*	*9.14%*	*9.28%*	*11.50%*	*13.02%*	*20.04%*
RPS Target	*percent*		*12.00%*	*12.75%*	*13.50%*	*14.25%*	*15.00%*	*16.67%*	*18.33%*	*20.00%*
Reduced RPS Target	*percent*		*8.00%*	*8.50%*	*9.00%*	*9.50%*	*10.00%*	*12.00%*	*18.33%*	*20.00%*
Renewable Penetration	*percent*		*8.48%*	*9.14%*	*9.65%*	*10.32%*	*10.60%*	*13.54%*	*15.86%*	*23.53%*
OPERATIONS										
Renewable Curtailment	*percent*		*2.8%*	*2.1%*	*3.5%*	*2.7%*	*5.8%*	*1.3%*	*1.1%*	*5.7%*
Renewable Curtailment Limit	*percent*		*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*
Renewable Curtailed Energy	*MWh*		39,383	32,768	55,910	46,894	101,287	26,159	23,839	177,000
Renewable Curtailment Cost	$000		5,887	4,864	8,222	6,888	14,688	3,549	3,063	21,140
LOLH	*hours*		*0.00*	*0.00*	*0.00*	*4.00*	*0.00*	*0.00*	*0.00*	*0.00*
Reserve Margin with GTs & Cambalache	*percent*		*70%*	*70%*	*71%*	*63%*	*69%*	*74%*	*74%*	*70%*
Reserve Margin without GTs & Cambalache	*percent*		*50%*	*50%*	*51%*	*43%*	*48%*	*52%*	*50%*	*44%*

System Costs Summary	**Unit**	**Fiscal Year**	**2016**	**2017**	**2018**	**2019**	**2020**	**2025**	**2030**	**2035**
Fuel	$000		791,583	630,770	943,782	958,917	899,566	679,680	703,286	789,121
Regasification fixed costs	$000		-	-	7,902	11,791	15,408	22,266	15,530	7,359
O&M	$000		174,183	174,004	170,777	165,506	147,831	148,983	132,632	116,408
Purchased power	$000		680,950	648,147	644,380	653,980	638,871	602,025	601,762	600,250
Renewables	$000		214,891	229,180	238,464	253,456	253,882	279,684	288,328	369,367
Amortized capital costs	$000		10,667	24,351	39,323	57,723	127,761	291,550	291,550	291,550
Energy efficiency costs	$000		-	1,538	4,604	9,197	15,207	62,984	114,027	161,592
Total System Costs	**$000**		1,872,273	1,707,991	2,049,233	2,110,570	2,098,527	2,087,174	2,147,115	2,335,647

Appendix C-15: P3MF2M_S2 Fuel Sensitivity Results

Puerto Rico Electric Power Authority

Portfolio 3M; Future 2M; Sensitivity 2; Reduced Fuel Forecast

Supplemental IRP Metrics Analysis

		Fiscal Year	2016	2017	2018	2019	2020	2025	2030	2035
COST	**Unit**	**Total / Average**								
Present Value of System Costs	*$000*	*22,541,261*	1,811,157	1,546,130	1,735,903	1,673,045	1,556,668	1,059,192	793,065	632,579
System Costs	*$000*	*2,068,336*	1,872,273	1,707,991	2,049,233	2,110,570	2,098,527	1,989,870	2,076,302	2,307,958
Capital Costs (FY 2016 - 2025)	*$ million*	4,175	134	176	167	239	433	248	-	-
Capital Costs (FY 2026 - 2035)	*$ million*	50								
Capital Costs (FY 2016 - 2035)	*$ million*	4,225								
ENVIRONMENTAL COMPLIANCE										
RPS (PPOA/Net sales)	*percent*		*7.74%*	*8.23%*	*8.59%*	*9.14%*	*9.28%*	*11.50%*	*13.02%*	*20.04%*
RPS Target	*percent*		*12.00%*	*12.75%*	*13.50%*	*14.25%*	*15.00%*	*16.67%*	*18.33%*	*20.00%*
Reduced RPS Target	*percent*		*8.00%*	*8.50%*	*9.00%*	*9.50%*	*10.00%*	*12.00%*	*18.33%*	*20.00%*
Renewable Penetration	*percent*		*8.48%*	*9.14%*	*9.65%*	*10.32%*	*10.60%*	*13.54%*	*15.86%*	*23.53%*
OPERATIONS										
Renewable Curtailment	*percent*		*2.8%*	*2.1%*	*3.5%*	*2.7%*	*5.8%*	*0.5%*	*0.7%*	*3.6%*
Renewable Curtailment Limit	*percent*		*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*
Renewable Curtailed Energy	*MWh*		39,383	32,768	55,910	46,894	101,287	10,564	14,573	111,165
Renewable Curtailment Cost	$000		5,887	4,864	8,222	6,888	14,688	1,433	1,873	13,277
LOLH	*hours*		*0.00*	*0.00*	*0.00*	*4.00*	*0.00*	*0.00*	*0.00*	*0.00*
Reserve Margin with GTs & Cambalache	*percent*		*70%*	*70%*	*71%*	*63%*	*69%*	*70%*	*66%*	*65%*
Reserve Margin without GTs & Cambalache	*percent*		*50%*	*50%*	*51%*	*43%*	*48%*	*48%*	*42%*	*39%*

System Costs Summary	**Unit**	**Fiscal Year**	**2016**	**2017**	**2018**	**2019**	**2020**	**2025**	**2030**	**2035**
Fuel	$000		791,583	630,770	943,782	958,917	899,566	877,671	932,624	1,056,372
Regasification fixed costs	$000		-	-	7,902	11,791	15,408	32,728	24,931	15,282
O&M	$000		174,183	174,004	170,777	165,506	147,831	172,790	156,044	140,184
Purchased power	$000		680,950	648,147	644,380	653,980	638,871	237,443	233,778	238,592
Renewables	$000		214,891	229,180	238,464	253,456	253,882	279,684	288,328	369,367
Amortized capital costs	$000		10,667	24,351	39,323	57,723	127,761	326,570	326,570	326,570
Energy efficiency costs	$000		-	1,538	4,604	9,197	15,207	62,984	114,027	161,592
Total System Costs	**$000**		1,872,273	1,707,991	2,049,233	2,110,570	2,098,527	1,989,870	2,076,302	2,307,958

Appendix C-16: P3MF1M_S4 Fuel Sensitivity Results

Puerto Rico Electric Power Authority

Portfolio 3M; Future 1M; Sensitivity 4; Demand Response; Reduced Fuel Forecast

Supplemental IRP Metrics Analysis

		Fiscal Year	2016	2017	2018	2019	2020	2025	2030	2035
COST	**Unit**	**Total / Average**								
Present Value of System Costs	*$000*	*23,381,890*	1,872,625	1,619,701	1,840,169	1,778,640	1,676,052	1,144,519	823,845	579,922
System Costs	*$000*	*2,121,379*	1,935,816	1,789,264	2,172,319	2,243,780	2,259,467	2,150,171	2,156,887	2,115,841
Capital Costs (FY 2016 - 2025)	*$ million*	3,153	134	240	615	239	239	248	489	-
Capital Costs (FY 2026 - 2035)	*$ million*	1,461								
Capital Costs (FY 2016 - 2035)	*$ million*	4,614								
ENVIRONMENTAL COMPLIANCE										
CO_2 Emissions (Total Generation)	*lbs/MWh*		*1,388*	*1,384*	*1,202*	*1,219*	*1,198*	*1,101*	*1,003*	*987*
CO_2 Emission Target (Total Generation)	*lbs/MWh*		*1,470*	*1,470*	*1,470*	*1,470*	*1,470*	*1,470*	*1,413*	*1,413*
Aguirre 1 CC Repower	*lbs/MWh*		-	-	-	-	-	*1,008*	*1,032*	*937*
Aguirre 2 CC Repower	*lbs/MWh*		-	-	-	-	-	*1,106*	*1,069*	*969*
Aguirre H Class Train 1	*lbs/MWh*		-	-	-	-	-	-	*859*	*872*
Aguirre H Class Train 2	*lbs/MWh*		-	-	-	-	-	-	*877*	*872*
Costa Sur H Class Train 1	*lbs/MWh*		-	-	-	-	-	-	*869*	*854*
RPS (PPOA/Net sales)	*percent*		*11.50%*	*12.39%*	*13.68%*	*14.63%*	*15.31%*	*16.89%*	*18.41%*	*20.03%*
RPS Target	*percent*		*12.00%*	*12.75%*	*13.50%*	*14.25%*	*15.00%*	*16.67%*	*18.33%*	*20%*
Reduced RPS Target	*percent*		*8.00%*	*8.50%*	*9.00%*	*9.50%*	*10.00%*	*12.00%*	*18.33%*	*20.00%*
Renewable Penetration	*percent*		*12.22%*	*13.25%*	*14.68%*	*15.74%*	*16.54%*	*18.81%*	*21.07%*	*23.52%*
OPERATIONS										
Renewable Curtailment	*percent*		*4.3%*	*1.1%*	*0.9%*	*1.3%*	*1.6%*	*2.0%*	*3.7%*	*3.1%*
Renewable Curtailment Limit	*percent*		*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*
Renewable Curtailed Energy	*MWh*		89,048	24,517	22,704	35,278	42,963	56,144	111,265	96,121
Renewable Curtailment Cost	$000		13,136	3,508	3,152	4,799	5,768	7,230	13,791	11,479
LOLH	*hours*		*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*
Reserve Margin with GTs & Cambalache	*percent*		*70%*	*70%*	*71%*	*54%*	*60%*	*71%*	*77%*	*74%*
Reserve Margin without GTs & Cambalache	*percent*		*51%*	*52%*	*52%*	*35%*	*38%*	*47%*	*55%*	*47%*

System Costs Summary	**Unit**	**Fiscal Year**	**2016**	**2017**	**2018**	**2019**	**2020**	**2025**	**2030**	**2035**
Fuel	$000		769,307	604,339	796,382	828,546	804,211	643,546	518,338	473,214
Regasification fixed costs	$000		-	-	85,107	89,233	92,366	90,466	83,077	83,356
O&M	$000		172,660	163,207	172,221	161,267	143,100	138,786	114,217	101,175
Purchased power	$000		673,146	650,080	654,455	656,897	636,533	585,257	571,199	572,953
Renewables	$000		304,940	320,014	342,041	357,621	366,109	368,363	369,229	369,194
Amortized capital costs	$000		10,667	39,864	104,755	123,155	177,368	240,349	379,366	350,780
Energy efficiency costs	$000		-	1,538	4,604	9,197	15,207	62,984	114,027	161,592
Demand response costs	$000		5,096	10,220	12,754	17,864	24,573	20,419	7,433	3,577
Total System Costs	**$000**		1,935,816	1,789,264	2,172,319	2,243,780	2,259,467	2,150,171	2,156,887	2,115,841

Appendix C-17: P3MF1M_S5 Fuel Sensitivity Results

Puerto Rico Electric Power Authority

Portfolio 3M; Future 1M; Sensitivity 5; Full RPS; Reduced Fuel Forecast

Supplemental IRP Metrics Analysis

		Fiscal Year	2016	2017	2018	2019	2020	2025	2030	2035
COST	**Unit**	**Total / Average**								
Present Value of System Costs	*$000*	*23,468,407*	1,882,721	1,625,889	1,854,389	1,797,805	1,694,185	1,130,888	816,423	578,169
System Costs	*$000*	*2,126,311*	1,946,253	1,796,099	2,189,106	2,267,956	2,283,912	2,124,563	2,137,454	2,109,444
Capital Costs (FY 2016 - 2025)	*$ million*	4,473	134	240	615	239	239	248	-	-
Capital Costs (FY 2026 - 2035)	*$ million*	54								
Capital Costs (FY 2016 - 2035)	*$ million*	4,527								
ENVIRONMENTAL COMPLIANCE										
CO_2 Emissions (Total Generation)	*lbs/MWh*		*1,389*	*1,395*	*1,218*	*1,216*	*1,212*	*1,014*	*1,007*	*984*
CO_2 Emission Target (Total Generation)	*lbs/MWh*		*1,470*	*1,470*	*1,470*	*1,470*	*1,470*	*1,470*	*1,413*	*1,413*
Aguirre 1 CC Repower	*lbs/MWh*		-	-	-	-	-	*1,025*	*958*	*938*
Aguirre 2 CC Repower	*lbs/MWh*		-	-	-	-	-	*1,054*	*993*	*967*
Aguirre H Class Train 1	*lbs/MWh*		-	-	-	-	-	*857*	*858*	*868*
Aguirre H Class Train 2	*lbs/MWh*		-	-	-	-	-	*868*	*864*	*865*
Costa Sur H Class Train 1	*lbs/MWh*		-	-	-	-	-	*854*	*858*	*858*
RPS (PPOA/Net sales)	*percent*		*11.50%*	*12.39%*	*13.68%*	*14.63%*	*15.30%*	*16.88%*	*18.40%*	*20.03%*
RPS Target	*percent*		*12.00%*	*12.75%*	*13.50%*	*14.25%*	*15.00%*	*16.67%*	*18.33%*	*20%*
Reduced RPS Target	*percent*		*8.00%*	*8.50%*	*9.00%*	*9.50%*	*10.00%*	*12.00%*	*18.33%*	*20.00%*
Renewable Penetration	*percent*		*12.22%*	*13.25%*	*14.68%*	*15.73%*	*16.53%*	*18.80%*	*21.06%*	*23.52%*
OPERATIONS										
Renewable Curtailment	*percent*		*6.6%*	*6.1%*	*5.4%*	*12.6%*	*16.5%*	*6.0%*	*7.1%*	*4.2%*
Renewable Curtailment Limit	*percent*		*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*
Renewable Curtailed Energy	*MWh*		136,402	136,999	131,466	331,161	449,683	171,569	210,822	130,768
Renewable Curtailment Cost	$000		20,121	19,606	18,250	45,056	60,377	22,097	26,125	15,616
LOLH	*hours*		*0.00*	*0.00*	*0.00*	*0.00*	*17.00*	*0.00*	*0.00*	*0.00*
Reserve Margin with GTs & Cambalache	*percent*		*70%*	*70%*	*71%*	*54%*	*60%*	*81%*	*80%*	*74%*
Reserve Margin without GTs & Cambalache	*percent*		*51%*	*52%*	*52%*	*35%*	*38%*	*61%*	*55%*	*47%*
System Costs Summary	**Unit**	**Fiscal Year**	**2016**	**2017**	**2018**	**2019**	**2020**	**2025**	**2030**	**2035**
Fuel	$000		789,986	631,289	835,357	888,622	864,087	568,042	556,058	475,939
Regasification fixed costs	$000		-	-	84,200	92,824	91,560	83,474	83,112	83,033
O&M	$000		174,153	164,845	174,861	163,045	145,843	120,366	116,323	100,955
Purchased power	$000		666,507	638,548	643,290	633,563	623,795	577,817	555,273	575,144
Renewables	$000		304,940	320,014	342,039	357,550	366,051	368,211	368,992	369,112
Amortized capital costs	$000		10,667	39,864	104,755	123,155	177,368	343,669	343,669	343,669
Energy efficiency costs	$000		-	1,538	4,604	9,197	15,207	62,984	114,027	161,592
Total System Costs	**$000**		1,946,253	1,796,099	2,189,106	2,267,956	2,283,912	2,124,563	2,137,454	2,109,444

Appendix

D

Reduced Fuel Forecast (March 21, 2016)

Appendix D-1: Reduced Fuel Forecast (March 21, 2016)

Month	Monthly Average Price (US$/MMBTU)						Adders (US$/MMBTU)									Final Price (US$/MMBTU)															EcoEléctrica				
							No. 6			No. 2				Natural Gas @ HH		No. 6				No. 2							Nat Gas Aguirre	Nat Gas CS 5&6		Base Fuel	Energy Charge	Energy Charge	Future 1,3 & 4 Spot Fuel Price	Future 2 Spot Fuel Price
	WTI	No. 6	No. 2	Natural Gas Indexed to No. 6	Natural Gas @ Henry Hub	Coal CAPP	San Juan / Palo Seco	Aguirre	Souco	Aguirre / San Juan CC	Mayagüez / Arecibo	Trucks	Natural Gas Indexed to No. 6	Capacity charge and others	Shipping Cost Adder	Aguirre	Costa Sur	San Juan	Palo Seco	Aguirre CC	San Juan CC	Mayaguez	Arecibo	Natural Gas Indexed to No. 6	Natural Gas Indexed to HH	Coal AES	Future 1,3,&4	Nat Gas Futures 1,3,&4	Nat Gas Future 2	US$/MMBTU	US$/kWh	US$/MMBTU	US$/MMBTU	US$/MMBTU
Apr-15	9.3401	8.7317	13.7858	8.9303	2.6090	1.9883	1.3095	1.4683	1.4683	1.3330	1.3330	1.3753	1.5000	1.0000	3.5000	10.1999	10.1999	10.0412	10.0412	15.1188	15.1188	15.1188	15.1188	9.5542	7.1090	4.0631		9.5542	9.5542	4.3931	0.0430	5.7360	15.1188	15.1188
May-15	10.1655	9.0231	14.7808	9.1899	2.8500	1.8558	1.3095	1.4683	1.4683	1.3330	1.3330	1.3753	1.5000	1.0000	3.5000	10.4913	10.4913	10.3326	10.3326	16.1137	16.1137	16.1137	16.1137	9.5542	7.3500	4.0564		9.5542	9.5542	4.3931	0.0430	5.7360	16.1137	16.1137
Jun-15	10.2606	8.7850	14.0422	8.9101	2.7836	1.6996	1.3095	1.4683	1.4683	1.3330	1.3330	1.3753	1.5000	1.0000	3.5000	10.2533	10.2533	10.0946	10.0946	15.3752	15.3752	15.3752	15.3752	9.5542	7.2836	4.0497		9.5542	9.5542	4.3931	0.0430	5.7360	15.3752	15.3752
Jul-15	8.7758	7.6874	12.6326	7.7719	2.8396	1.6113	1.3095	1.4683	1.4683	1.3330	1.3330	1.3753	1.5000	1.0000	3.5000	9.1557	9.1557	8.9970	8.9970	13.9656	13.9656	13.9656	13.9656	8.4839	7.3396	4.0430		8.4839	8.4839	4.3931	0.0430	5.7360	13.9656	13.9656
Aug-15	7.3529	6.3537	11.3564	6.4882	2.7738	1.7197	1.3095	1.4683	1.4683	1.3330	1.3330	1.3753	1.5000	1.0000	3.5000	7.8220	7.8220	7.6633	7.6633	12.6894	12.6894	12.6894	12.6894	8.4839	7.2738	4.0364		8.4839	8.4839	4.3931	0.0430	5.7360	12.6894	12.6894
Sep-15	7.8052	6.2368	11.3585	6.3377	2.6609	1.6277	1.3095	1.4683	1.4683	1.3330	1.3330	1.3753	1.5000	1.0000	3.5000	7.7050	7.7050	7.5463	7.5463	12.6915	12.6915	12.6915	12.6915	8.4839	7.1609	4.0297		8.4839	8.4839	4.3931	0.0430	5.7360	12.6915	12.6915
Oct-15	7.9286	6.6646	11.1064	6.7488	2.3409	1.6838	1.3095	1.4683	1.4683	1.3330	1.3330	1.3753	1.1250	1.0000	3.5000	8.1328	8.1328	7.9741	7.9741	12.4394	12.4394	12.4394	12.4394	8.1934	6.8409	4.0231		8.1934	8.1934	4.3931	0.0430	5.7360	12.4394	12.4394
Nov-15	7.2702	6.3746	10.5980	6.4330	2.0924	1.6878	1.3095	1.4683	1.4683	1.3330	1.3330	1.3753	1.1250	1.0000	3.5000	7.8428	7.8428	7.6841	7.6841	11.9309	11.9309	11.9309	11.9309	8.0094	6.5924	4.0164		8.0094	8.0094	4.3931	0.0430	5.7360	11.9309	11.9309
Dec-15	6.3819	4.8643	8.6267	4.9256	1.9296	1.7287	1.3095	1.4683	1.4683	1.3330	1.3330	1.3753	1.1250	1.0000	3.5000	6.3325	6.3325	6.1738	6.1738	9.9597	9.9597	9.9597	9.9597	7.8656	6.4296	4.0098		7.8656	7.8656	4.3931	0.0430	5.7360	9.9597	9.9597
Jan-16	5.4812	4.1236	7.5324	4.1419	2.2875	1.7337	1.3095	1.4683	1.4683	1.3330	1.3330	1.3753	1.1250	1.0000	3.5000	5.5919	5.5919	5.4331	5.4331	8.8654	8.8654	8.8654	8.8654	7.1869	6.7875	4.1598		7.1869	7.1869	2.6322	0.0344	4.5869	8.8654	8.8654
Feb-16	4.9556	3.7696	7.4029	3.7201	2.2032	1.6411	1.3095	1.4683	1.4683	1.3330	1.3330	1.3753	1.1250	1.0000	3.5000	5.2378	5.2378	5.0791	5.0791	8.7359	8.7359	8.7359	8.7359	7.3939	6.7032	4.1529		7.3939	7.3939	2.6322	0.0344	4.5869	8.7359	8.7359
Mar-16	4.6818	3.5324	7.0381	3.4729	2.1556	1.6072	1.3095	1.4683	1.4683	1.3330	1.3330	1.3753	1.1250	1.0000	3.5000	5.0007	5.0007	4.8420	4.8420	8.3710	8.3710	8.3710	8.3710	7.3422	6.6556	4.1461		7.3422	7.3422	2.6322	0.0344	4.5869	8.3710	8.3710
Apr-16	4.4676	3.3485	6.7509	3.3225	2.1027	1.5797	1.3095	1.4683	1.4683	1.3330	1.3330	1.3753	1.1250	1.0000	3.5000	4.8168	4.8168	4.6580	4.6580	8.0838	8.0838	8.0838	8.0838	6.7128	6.6027	4.1393		6.7128	6.7128	2.6322	0.0344	4.5869	8.0838	8.0838
May-16	4.3176	3.2207	6.5485	3.2116	2.0567	1.5549	1.3095	1.4683	1.4683	1.3330	1.3330	1.3753	1.1250	1.0000	3.5000	4.6889	4.6889	4.5302	4.5302	7.8815	7.8815	7.8815	7.8815	6.6783	6.5567	4.1324		6.6783	6.6783	2.6322	0.0344	4.5869	7.8815	7.8815
Jun-16	4.2469	3.1610	6.4522	3.1333	2.0236	1.5338	1.3095	1.4683	1.4683	1.3330	1.3330	1.3753	1.1250	1.0000	3.5000	4.6293	4.6293	4.4706	4.4706	7.7852	7.7852	7.7852	7.7852	6.6553	6.5236	4.1256		6.6553	6.6553	2.6322	0.0344	4.5869	7.7852	7.7852
Jul-16	4.2715	3.1828	6.4840	3.0947	2.0073	1.5174	1.3095	1.4683	1.4683	1.3330	1.3330	1.3753	1.1250	1.0000	3.5000	4.6510	4.6510	4.4923	4.4923	7.8170	7.8170	7.8170	7.8170	6.0771	6.5073	4.1188		6.0771	6.0771	2.6322	0.0344	4.5869	7.8170	7.8170
Aug-16	4.3321	3.2355	6.5643	3.0912	2.0005	1.5073	1.3095	1.4683	1.4683	1.3330	1.3330	1.3753	1.1250	1.0000	3.5000	4.7037	4.7037	4.5450	4.5450	7.8973	7.8973	7.8973	7.8973	6.0714	6.5005	4.1120		6.0714	6.0714	2.6322	0.0344	4.5869	7.8973	7.8973
Sep-16	4.3925	3.2880	6.6440	3.1097	2.0009	1.4996	1.3095	1.4683	1.4683	1.3330	1.3330	1.3753	1.1250	1.0000	3.5000	4.7563	4.7563	4.5975	4.5975	7.9769	7.9769	7.9769	7.9769	6.0656	6.5009	4.1052		6.0656	6.0656	2.6322	0.0344	4.5869	7.9769	7.9769
Oct-16	4.3421	3.2456	6.5752	3.1155	2.0048	1.4920	1.3095	1.4683	1.4683	1.3330	1.3330	1.3753	1.1250	1.0000	3.5000	4.7139	4.7139	4.5551	4.5551	7.9082	7.9082	7.9082	7.9082	5.9318	6.5048	4.0985		5.9318	5.9318	2.6322	0.0344	4.5869	7.9082	7.9082
Nov-16	4.2395	3.1585	6.4361	3.0935	2.0095	1.4779	1.3095	1.4683	1.4683	1.3330	1.3330	1.3753	1.1250	1.0000	3.5000	4.6268	4.6268	4.4680	4.4680	7.7691	7.7691	7.7691	7.7691	5.9318	6.5095	4.0917		5.9318	5.9318	2.6322	0.0344	4.5869	7.7691	7.7691
Dec-16	3.9792	2.9378	6.0837	3.0160	2.0091	1.4606	1.3095	1.4683	1.4683	1.3330	1.3330	1.3753	1.1250	1.0000	3.5000	4.4060	4.4060	4.2473	4.2473	7.4167	7.4167	7.4167	7.4167	5.9375	6.5091	4.0850		5.9375	5.9375	2.6322	0.0344	4.5869	7.4167	7.4167
Jan-17	4.2191	3.1426	6.4063	2.9904	2.0144	1.4331	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	4.3926	4.3926	4.0926	4.0926	7.6563	7.6563	7.6563	7.6563	5.9099	6.5144	4.0782		5.9099	5.9099	2.0718	0.0317	4.2212	7.6563	7.6563
Feb-17	4.8351	3.6752	7.2268	3.0803	2.0327	1.4370	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	4.9252	4.9252	4.6252	4.6252	8.4768	8.4768	8.4768	8.4768	5.9099	6.5327	4.0715		5.9099	5.9099	2.0718	0.0317	4.2212	8.4768	8.4768
Mar-17	5.5481	4.3045	8.1617	3.3260	2.0644	1.4619	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	5.5545	5.5545	5.2545	5.2545	9.4117	9.4117	9.4117	9.4117	5.9214	6.5644	4.0648		5.9214	5.9214	2.0718	0.0317	4.2212	9.4117	9.4117
Apr-17	6.2248	4.9131	9.0358	3.6405	2.1104	1.4890	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	6.1631	6.1631	5.8631	5.8631	10.2858	10.2858	10.2858	10.2858	5.9426	6.6104	4.0581		5.9426	5.9426	2.0718	0.0317	4.2212	10.2858	10.2858
May-17	6.8277	5.4641	9.8051	3.9462	2.1700	1.5117	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	6.7141	6.7141	6.4141	6.4141	11.0551	11.0551	11.0551	11.0551	5.9714	6.6700	4.0514		5.9714	5.9714	2.0718	0.0317	4.2212	11.0551	11.0551
Jun-17	7.3743	5.9702	10.4952	4.2196	2.2471	1.5297	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	7.2202	7.2202	6.9202	6.9202	11.7452	11.7452	11.7452	11.7452	6.0059	6.7471	4.0447		6.0059	6.0059	2.0718	0.0317	4.2212	11.7452	11.7452
Jul-17	7.9153	6.4768	11.1723	4.4678	2.3282	1.5445	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	7.7268	7.7268	7.4268	7.4268	12.4223	12.4223	12.4223	12.4223	6.2212	6.8282	4.0381	6.8282	6.8282	6.2212	2.0718	0.0317	4.2212	6.8282	12.4223
Aug-17	8.3827	6.9190	11.7525	4.6936	2.4024	1.5585	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	8.1690	8.1690	7.8690	7.8690	13.0025	13.0025	13.0025	13.0025	6.2672	6.9024	4.0314	6.9024	6.9024	6.2672	2.0718	0.0317	4.2212	6.9024	13.0025
Sep-17	8.7360	7.2564	12.1879	4.8911	2.4668	1.5696	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	8.5064	8.5064	8.2064	8.2064	13.4379	13.4379	13.4379	13.4379	6.3074	6.9668	4.0247	6.9668	6.9668	6.3074	2.0718	0.0317	4.2212	6.9668	13.4379
Oct-17	8.7940	7.3134	12.2572	5.0215	2.5188	1.5767	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	8.5634	8.5634	8.2634	8.2634	13.5072	13.5072	13.5072	13.5072	6.6548	7.0188	4.0181	7.0188	7.0188	6.6548	2.0718	0.0317	4.2212	7.0188	13.5072
Nov-17	8.6844	7.2107	12.1195	5.0720	2.5580	1.5744	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	8.4607	8.4607	8.1607	8.1607	13.3695	13.3695	13.3695	13.3695	6.6836	7.0580	4.0115	7.0580	7.0580	6.6836	2.0718	0.0317	4.2212	7.0580	13.3695
Dec-17	8.2289	6.7802	11.5526	5.0097	2.5803	1.5668	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	8.0302	8.0302	7.7302	7.7302	12.8026	12.8026	12.8026	12.8026	6.7066	7.0803	4.0049	7.0803	7.0803	6.7066	2.0718	0.0317	4.2212	7.0803	12.8026
Jan-18	8.0461	6.6094	11.3229	4.9146	2.5902	1.5475	0.9500	1.2500	1.2500	1.2500	1.0800	1.3753	1.1250	1.0000	3.5000	7.8594	7.8594	7.5594	7.5594	12.5729	12.5729	12.5729	12.5729	6.9346	7.0902	4.0656	7.0902	7.0902	6.9346	2.2911	0.0327	4.3643	7.0902	12.5729
Feb-18	8.1973	6.7536	11.5089	4.8575	2.5953	1.5366	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	8.0036	8.0036	7.7036	7.7036	12.7589	12.7589	12.7589	12.7589	6.9404	7.0953	4.0656	7.0953	7.0953	6.9404	2.2911	0.0327	4.3643	7.0953	12.7589
Mar-18	8.3198	6.8712	11.6590	4.8782	2.5970	1.5370	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	8.1212	8.1212	7.8212	7.8212	12.9090	12.9090	12.9090	12.9090	6.9461	7.0970	4.0656	7.0970	7.0970	6.9461	2.2911	0.0327	4.3643	7.0970	12.9090
Apr-18	8.3524	6.9038	11.6972	4.9287	2.5983	1.5366	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	8.1538	8.1538	7.8538	7.8538	12.9472	12.9472	12.9472	12.9472	6.9855	7.0983	4.0656	7.0983	7.0983	6.9855	2.2911	0.0327	4.3643	7.0983	12.9472
May-18	8.3517	6.9048	11.6941	4.9581	2.6012	1.5333	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	8.1548	8.1548	7.8548	7.8548	12.9441	12.9441	12.9441	12.9441	6.9855	7.1012	4.0656	7.1012	7.1012	6.9855	2.2911	0.0327	4.3643	7.1012	12.9441
Jun-18	8.3900	6.9428	11.7395	4.9761	2.6117	1.5290	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	8.1928	8.1928	7.8928	7.8928	12.9895	12.9895	12.9895	12.9895	6.9855	7.1117	4.0656	7.1117	7.1117	6.9855	2.2911	0.0327	4.3643	7.1117	12.9895

Appendix D-2: Reduced Fuel Forecast (March 21, 2016)

	Monthly Average Price (US$/MMBTU)						Adders (US$/MMBTU)									Final Price (US$/MMBTU)														EcoEléctrica				
							No. 6			No. 2				Natural Gas @ HH		No. 6				No. 2							Nat Gas Aguirre	Nat Gas CS 5&6		Base Fuel	Energy Charge	Energy Charge	Future 1,3 & 4 Spot Fuel Price	Future 2 Spot Fuel Price
Month	WTI	No. 6	No. 2	Natural Gas Indexed to No. 6	Natural Gas @ Henry Hub	Coal CAPP	San Juan / Palo Seco	Aguirre	Souco	Aguirre / San Juan CC	Mayagüez / Arecibo	Trucks	Natural Gas Indexed to No. 6	Capacity charge and others	Shipping Cost Adder	Aguirre	Costa Sur	San Juan	Palo Seco	Aguirre CC	San Juan CC	Mayaguez	Arecibo	Natural Gas Indexed to No. 6	Natural Gas Indexed to HH	Coal AES	Future 1,3,&4	Nat Gas Futures 1,3,&4	Nat Gas Future 2	US$/MMBTU	US$/kWh	US$/MMBTU	US$/MMBTU	US$/MMBTU
Jul-18	8.5331	7.0805	11.9144	5.0098	2.6274	1.5260	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	8.3305	8.3305	8.0305	8.0305	13.1644	13.1644	13.1644	13.1644	6.9755	7.1274	4.0656	7.1274	7.1274	6.9755	2.2911	0.0327	4.3643	7.1274	13.1644
Aug-18	8.6976	7.2391	12.1153	5.0667	2.6433	1.5265	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	8.4891	8.4891	8.1891	8.1891	13.3653	13.3653	13.3653	13.3653	6.9870	7.1433	4.0656	7.1433	7.1433	6.9870	2.2911	0.0327	4.3643	7.1433	13.3653
Sep-18	8.8320	7.3693	12.2786	5.1372	2.6593	1.5278	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	8.6193	8.6193	8.3193	8.3193	13.5286	13.5286	13.5286	13.5286	6.9928	7.1593	4.0656	7.1593	7.1593	6.9928	2.2911	0.0327	4.3643	7.1593	13.5286
Oct-18	8.7433	7.2862	12.1670	5.1756	2.6734	1.5282	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	8.5362	8.5362	8.2362	8.2362	13.4170	13.4170	13.4170	13.4170	7.0397	7.1734	4.0656	7.1734	7.1734	7.0397	2.2911	0.0327	4.3643	7.1734	13.4170
Nov-18	8.5476	7.1012	11.9233	5.1633	2.6842	1.5218	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	8.3512	8.3512	8.0512	8.0512	13.1733	13.1733	13.1733	13.1733	7.0454	7.1842	4.0656	7.1842	7.1842	7.0454	2.2911	0.0327	4.3643	7.1842	13.1733
Dec-18	8.0543	6.6347	11.3095	5.0607	2.6860	1.5120	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	7.8847	7.8847	7.5847	7.5847	12.5595	12.5595	12.5595	12.5595	7.0512	7.1860	4.0656	7.1860	7.1860	7.0512	2.2911	0.0327	4.3643	7.1860	12.5595
Jan-19	7.8546	6.4479	11.0587	4.9426	2.6819	1.4920	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	7.6979	7.6979	7.3979	7.3979	12.3087	12.3087	12.3087	12.3087	7.0924	7.1819	3.9207	7.1819	7.1819	7.0924	2.6306	0.0344	4.5858	7.1819	12.3087
Feb-19	7.9953	6.5823	11.2320	4.8738	2.6778	1.4809	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	7.8323	7.8323	7.5323	7.5323	12.4820	12.4820	12.4820	12.4820	7.0866	7.1778	3.9207	7.1778	7.1778	7.0866	2.6306	0.0344	4.5858	7.1778	12.4820
Mar-19	8.1162	6.6981	11.3801	4.8898	2.6737	1.4812	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	7.9481	7.9481	7.6481	7.6481	12.6301	12.6301	12.6301	12.6301	7.0866	7.1737	3.9207	7.1737	7.1737	7.0866	2.6306	0.0344	4.5858	7.1737	12.6301
Apr-19	8.1533	6.7349	11.4240	4.9394	2.6717	1.4809	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	7.9849	7.9849	7.6849	7.6849	12.6740	12.6740	12.6740	12.6740	7.0494	7.1717	3.9207	7.1717	7.1717	7.0494	2.6306	0.0344	4.5858	7.1717	12.6740
May-19	8.1594	6.7423	11.4294	4.9697	2.6727	1.4780	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	7.9923	7.9923	7.6923	7.6923	12.6794	12.6794	12.6794	12.6794	7.0494	7.1727	3.9207	7.1727	7.1727	7.0494	2.6306	0.0344	4.5858	7.1727	12.6794
Jun-19	8.2036	6.7859	11.4821	4.9894	2.6825	1.4742	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	8.0359	8.0359	7.7359	7.7359	12.7321	12.7321	12.7321	12.7321	7.0494	7.1825	3.9207	7.1825	7.1825	7.0494	2.6306	0.0344	4.5858	7.1825	12.7321
Jul-19	8.3495	6.9262	11.6606	5.0250	2.6981	1.4716	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	8.1762	8.1762	7.8762	7.8762	12.9106	12.9106	12.9106	12.9106	7.0197	7.1981	3.9207	7.1981	7.1981	7.0197	2.6306	0.0344	4.5858	7.1981	12.9106
Aug-19	8.5155	7.0861	11.8635	5.0836	2.7140	1.4724	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	8.3361	8.3361	8.0361	8.0361	13.1135	13.1135	13.1135	13.1135	7.0312	7.2140	3.9207	7.2140	7.2140	7.0312	2.6306	0.0344	4.5858	7.2140	13.1135
Sep-19	8.6510	7.2174	12.0283	5.1555	2.7301	1.4739	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	8.4674	8.4674	8.1674	8.1674	13.2783	13.2783	13.2783	13.2783	7.0369	7.2301	3.9207	7.2301	7.2301	7.0369	2.6306	0.0344	4.5858	7.2301	13.2783
Oct-19	8.5670	7.1387	11.9225	5.1947	2.7442	1.4746	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	8.3887	8.3887	8.0887	8.0887	13.1725	13.1725	13.1725	13.1725	7.0878	7.2442	3.9207	7.2442	7.2442	7.0878	2.6306	0.0344	4.5858	7.2442	13.1725
Nov-19	8.3772	6.9593	11.6861	5.1827	2.7548	1.4686	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	8.2093	8.2093	7.9093	7.9093	12.9361	12.9361	12.9361	12.9361	7.0936	7.2548	3.9207	7.2548	7.2548	7.0936	2.6306	0.0344	4.5858	7.2548	12.9361
Dec-19	7.8950	6.5033	11.0861	5.0797	2.7561	1.4593	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	7.7533	7.7533	7.4533	7.4533	12.3361	12.3361	12.3361	12.3361	7.0993	7.2561	3.9207	7.2561	7.2561	7.0993	2.6306	0.0344	4.5858	7.2561	12.3361
Jan-20	7.7000	6.3210	10.8412	4.9608	2.7512	1.4402	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	7.5710	7.5710	7.2710	7.2710	12.0912	12.0912	12.0912	12.0912	7.1405	7.2512	3.7866	7.2512	7.2512	7.1405	2.7048	0.0348	4.6342	7.2512	12.0912
Feb-20	7.8385	6.4531	11.0116	4.8912	2.7463	1.4297	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	7.7031	7.7031	7.4031	7.4031	12.2616	12.2616	12.2616	12.2616	7.1348	7.2463	3.7866	7.2463	7.2463	7.1348	2.7048	0.0348	4.6342	7.2463	12.2616
Mar-20	7.9572	6.5669	11.1571	4.9066	2.7414	1.4301	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	7.8169	7.8169	7.5169	7.5169	12.4071	12.4071	12.4071	12.4071	7.1348	7.2414	3.7866	7.2414	7.2414	7.1348	2.7048	0.0348	4.6342	7.2414	12.4071
Apr-20	7.9937	6.6031	11.2003	4.9556	2.7385	1.4300	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	7.8531	7.8531	7.5531	7.5531	12.4503	12.4503	12.4503	12.4503	7.0975	7.2385	3.7866	7.2385	7.2385	7.0975	2.7048	0.0348	4.6342	7.2385	12.4503
May-20	7.9997	6.6104	11.2057	4.9853	2.7388	1.4273	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	7.8604	7.8604	7.5604	7.5604	12.4557	12.4557	12.4557	12.4557	7.0975	7.2388	3.7866	7.2388	7.2388	7.0975	2.7048	0.0348	4.6342	7.2388	12.4557
Jun-20	8.0430	6.6531	11.2573	5.0042	2.7480	1.4237	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	7.9031	7.9031	7.6031	7.6031	12.5073	12.5073	12.5073	12.5073	7.0975	7.2480	3.7866	7.2480	7.2480	7.0975	2.7048	0.0348	4.6342	7.2480	12.5073
Jul-20	8.1861	6.7906	11.4323	5.0390	2.7631	1.4213	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	8.0406	8.0406	7.7406	7.7406	12.6823	12.6823	12.6823	12.6823	7.0678	7.2631	3.7866	7.2631	7.2631	7.0678	2.7048	0.0348	4.6342	7.2631	12.6823
Aug-20	8.3487	6.9473	11.6311	5.0969	2.7786	1.4222	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	8.1973	8.1973	7.8973	7.8973	12.8811	12.8811	12.8811	12.8811	7.0736	7.2786	3.7866	7.2786	7.2786	7.0736	2.7048	0.0348	4.6342	7.2786	12.8811
Sep-20	8.4816	7.0760	11.7926	5.1681	2.7942	1.4238	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	8.3260	8.3260	8.0260	8.0260	13.0426	13.0426	13.0426	13.0426	7.0851	7.2942	3.7866	7.2942	7.2942	7.0851	2.7048	0.0348	4.6342	7.2942	13.0426
Oct-20	8.3991	6.9989	11.6888	5.2066	2.8077	1.4246	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	8.2489	8.2489	7.9489	7.9489	12.9388	12.9388	12.9388	12.9388	7.1263	7.3077	3.7866	7.3077	7.3077	7.1263	2.7048	0.0348	4.6342	7.3077	12.9388
Nov-20	8.2131	6.8230	11.4570	5.1936	2.8178	1.4190	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	8.0730	8.0730	7.7730	7.7730	12.7070	12.7070	12.7070	12.7070	7.1378	7.3178	3.7866	7.3178	7.3178	7.1378	2.7048	0.0348	4.6342	7.3178	12.7070
Dec-20	7.7402	6.3759	10.8688	5.0895	2.8182	1.4101	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	7.6259	7.6259	7.3259	7.3259	12.1188	12.1188	12.1188	12.1188	7.1435	7.3182	3.7866	7.3182	7.3182	7.1435	2.7048	0.0348	4.6342	7.3182	12.1188
Jan-21	7.5490	6.1971	10.6287	4.9696	2.8124	1.3917	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	7.4471	7.4471	7.1471	7.1471	11.8787	11.8787	11.8787	11.8787	7.1789	7.3124	3.6607	7.3124	7.3124	7.1789	2.7703	0.0351	4.6770	7.3124	11.8787
Feb-21	7.6848	6.3266	10.7957	4.8991	2.8066	1.3816	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	7.5766	7.5766	7.2766	7.2766	12.0457	12.0457	12.0457	12.0457	7.1732	7.3066	3.6607	7.3066	7.3066	7.1732	2.7703	0.0351	4.6770	7.3066	12.0457
Mar-21	7.8012	6.4382	10.9384	4.9137	2.8007	1.3822	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	7.6882	7.6882	7.3882	7.3882	12.1884	12.1884	12.1884	12.1884	7.1732	7.3007	3.6607	7.3007	7.3007	7.1732	2.7703	0.0351	4.6770	7.3007	12.1884
Apr-21	7.8369	6.4736	10.9807	4.9620	2.7970	1.3821	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	7.7236	7.7236	7.4236	7.4236	12.2307	12.2307	12.2307	12.2307	7.1359	7.2970	3.6607	7.2970	7.2970	7.1359	2.7703	0.0351	4.6770	7.2970	12.2307
May-21	7.8428	6.4808	10.9859	4.9909	2.7965	1.3797	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	7.7308	7.7308	7.4308	7.4308	12.2359	12.2359	12.2359	12.2359	7.1359	7.2965	3.6607	7.2965	7.2965	7.1359	2.7703	0.0351	4.6770	7.2965	12.2359
Jun-21	7.8853	6.5226	11.0365	5.0091	2.8050	1.3763	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	7.7726	7.7726	7.4726	7.4726	12.2865	12.2865	12.2865	12.2865	7.1359	7.3050	3.6607	7.3050	7.3050	7.1359	2.7703	0.0351	4.6770	7.3050	12.2865
Jul-21	8.0255	6.6575	11.2081	5.0431	2.8197	1.3742	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	7.9075	7.9075	7.6075	7.6075	12.4581	12.4581	12.4581	12.4581	7.1063	7.3197	3.6607	7.3197	7.3197	7.1063	2.7703	0.0351	4.6770	7.3197	12.4581
Aug-21	8.1850	6.8111	11.4030	5.1002	2.8346	1.3751	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	8.0611	8.0611	7.7611	7.7611	12.6530	12.6530	12.6530	12.6530	7.1120	7.3346	3.6607	7.3346	7.3346	7.1120	2.7703	0.0351	4.6770	7.3346	12.6530
Sep-21	8.3153	6.9372	11.5614	5.1707	2.8498	1.3768	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	8.1872	8.1872	7.8872	7.8872	12.8114	12.8114	12.8114	12.8114	7.1178	7.3498	3.6607	7.3498	7.3498	7.1178	2.7703	0.0351	4.6770	7.3498	12.8114
Oct-21	8.2344	6.8616	11.4596	5.2084	2.8628	1.3776	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	8.1116	8.1116	7.8116	7.8116	12.7096	12.7096	12.7096	12.7096	7.1647	7.3628	3.6607	7.3628	7.3628	7.1647	2.7703	0.0351	4.6770	7.3628	12.7096
Nov-21	8.0520	6.6892	11.2324	5.1947	2.8722	1.3723	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	7.9392	7.9392	7.6392	7.6392	12.4824	12.4824	12.4824	12.4824	7.1704	7.3722	3.6607	7.3722	7.3722	7.1704	2.7703	0.0351	4.6770	7.3722	12.4824

Appendix D-3: Reduced Fuel Forecast (March 21, 2016)

Month	Monthly Average Price (US$/MMBTU)						Adders (US$/MMBTU)									Final Price (US$/MMBTU)														EcoEléctrica				
							No. 6			No. 2				Natural Gas @ HH		No. 6				No. 2							Nat Gas Aguirre	Nat Gas CS 5&6		Base Fuel	Energy Charge	Energy Charge	Future 1,3 & 4 Spot Fuel Price	Future 2 Spot Fuel Price
	WTI	No. 6	No. 2	Natural Gas Indexed to No. 6	Natural Gas @ Henry Hub	Coal CAPP	San Juan / Palo Seco	Aguirre	Souco	Aguirre / San Juan CC	Mayagüez / Arecibo	Trucks	Natural Gas Indexed to No. 6	Capacity charge and others	Shipping Cost Adder	Aguirre	Costa Sur	San Juan	Palo Seco	Aguirre CC	San Juan CC	Mayaguez	Arecibo	Natural Gas Indexed to No. 6	Natural Gas Indexed to HH	Coal AES	Future 1,3,&4	Nat Gas Futures 1,3,&4	Nat Gas Future 2	US$/MMBTU	US$/kWh	US$/MMBTU	US$/MMBTU	US$/MMBTU
Dec-21	7.5885	6.2508	10.6557	5.0898	2.8719	1.3638	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	7.5008	7.5008	7.2008	7.2008	11.9057	11.9057	11.9057	11.9057	7.1762	7.3719	3.6607	7.3719	7.3719	7.1762	2.7703	0.0351	4.6770	7.3719	11.9057
Jan-22	7.4010	6.0755	10.4203	4.9691	2.8652	1.3461	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	7.3255	7.3255	7.0255	7.0255	11.6703	11.6703	11.6703	11.6703	7.2077	7.3652	3.5424	7.3652	7.3652	7.2077	2.8274	0.0354	4.7143	7.3652	11.6703
Feb-22	7.5341	6.2025	10.5840	4.8980	2.8585	1.3365	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	7.4525	7.4525	7.1525	7.1525	11.8340	11.8340	11.8340	11.8340	7.2077	7.3585	3.5424	7.3585	7.3585	7.2077	2.8274	0.0354	4.7143	7.3585	11.8340
Mar-22	7.6482	6.3120	10.7239	4.9119	2.8518	1.3371	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	7.5620	7.5620	7.2620	7.2620	11.9739	11.9739	11.9739	11.9739	7.2019	7.3518	3.5424	7.3518	7.3518	7.2019	2.8274	0.0354	4.7143	7.3518	11.9739
Apr-22	7.6833	6.3467	10.7654	4.9594	2.8472	1.3372	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	7.5967	7.5967	7.2967	7.2967	12.0154	12.0154	12.0154	12.0154	7.1647	7.3472	3.5424	7.3472	7.3472	7.1647	2.8274	0.0354	4.7143	7.3472	12.0154
May-22	7.6890	6.3537	10.7705	4.9876	2.8459	1.3349	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	7.6037	7.6037	7.3037	7.3037	12.0205	12.0205	12.0205	12.0205	7.1647	7.3459	3.5424	7.3459	7.3459	7.1647	2.8274	0.0354	4.7143	7.3459	12.0205
Jun-22	7.7307	6.3947	10.8201	5.0050	2.8539	1.3318	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	7.6447	7.6447	7.3447	7.3447	12.0701	12.0701	12.0701	12.0701	7.1647	7.3539	3.5424	7.3539	7.3539	7.1647	2.8274	0.0354	4.7143	7.3539	12.0701
Jul-22	7.8682	6.5269	10.9884	5.0383	2.8680	1.3298	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	7.7769	7.7769	7.4769	7.4769	12.2384	12.2384	12.2384	12.2384	7.1293	7.3680	3.5424	7.3680	7.3680	7.1293	2.8274	0.0354	4.7143	7.3680	12.2384
Aug-22	8.0245	6.6776	11.1794	5.0946	2.8825	1.3308	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	7.9276	7.9276	7.6276	7.6276	12.4294	12.4294	12.4294	12.4294	7.1408	7.3825	3.5424	7.3825	7.3825	7.1408	2.8274	0.0354	4.7143	7.3825	12.4294
Sep-22	8.1522	6.8012	11.3347	5.1643	2.8972	1.3325	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	8.0512	8.0512	7.7512	7.7512	12.5847	12.5847	12.5847	12.5847	7.1465	7.3972	3.5424	7.3972	7.3972	7.1465	2.8274	0.0354	4.7143	7.3972	12.5847
Oct-22	8.0730	6.7271	11.2349	5.2013	2.9096	1.3335	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	7.9771	7.9771	7.6771	7.6771	12.4849	12.4849	12.4849	12.4849	7.1895	7.4096	3.5424	7.4096	7.4096	7.1895	2.8274	0.0354	4.7143	7.4096	12.4849
Nov-22	7.8941	6.5580	11.0121	5.1868	2.9185	1.3284	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	7.8080	7.8080	7.5080	7.5080	12.2621	12.2621	12.2621	12.2621	7.1953	7.4185	3.5424	7.4185	7.4185	7.1953	2.8274	0.0354	4.7143	7.4185	12.2621
Dec-22	7.4397	6.1283	10.4467	5.0814	2.9174	1.3203	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	7.3783	7.3783	7.0783	7.0783	11.6967	11.6967	11.6967	11.6967	7.2010	7.4174	3.5424	7.4174	7.4174	7.2010	2.8274	0.0354	4.7143	7.4174	11.6967
Jan-23	7.3267	6.0231	10.3042	4.9718	2.9114	1.3033	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	7.2731	7.2731	6.9731	6.9731	11.5542	11.5542	11.5542	11.5542	7.2364	7.4114	3.4688	7.4114	7.4114	7.2364	2.8763	0.0356	4.7462	7.4114	11.5542
Feb-23	7.5583	6.2435	10.5901	4.9269	2.9073	1.2963	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	7.4935	7.4935	7.1935	7.1935	11.8401	11.8401	11.8401	11.8401	7.2307	7.4073	3.4688	7.4073	7.4073	7.2307	2.8763	0.0356	4.7462	7.4073	11.8401
Mar-23	7.7795	6.4551	10.8621	4.9836	2.9053	1.3002	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	7.7051	7.7051	7.4051	7.4051	12.1121	12.1121	12.1121	12.1121	7.2307	7.4053	3.4688	7.4053	7.4053	7.2307	2.8763	0.0356	4.7462	7.4053	12.1121
Apr-23	7.9138	6.5848	11.0261	5.0790	2.9074	1.3038	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	7.8348	7.8348	7.5348	7.5348	12.2761	12.2761	12.2761	12.2761	7.2031	7.4074	3.4688	7.4074	7.4074	7.2031	2.8763	0.0356	4.7462	7.4074	12.2761
May-23	8.0030	6.6715	11.1339	5.1526	2.9144	1.3050	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	7.9215	7.9215	7.6215	7.6215	12.3839	12.3839	12.3839	12.3839	7.2031	7.4144	3.4688	7.4144	7.4144	7.2031	2.8763	0.0356	4.7462	7.4144	12.3839
Jun-23	8.1118	6.7774	11.2658	5.2092	2.9321	1.3048	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	8.0274	8.0274	7.7274	7.7274	12.5158	12.5158	12.5158	12.5158	7.2031	7.4321	3.4688	7.4321	7.4321	7.2031	2.8763	0.0356	4.7462	7.4321	12.5158
Jul-23	8.3049	6.9644	11.5008	5.2750	2.9557	1.3054	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	8.2144	8.2144	7.9144	7.9144	12.7508	12.7508	12.7508	12.7508	7.2107	7.4557	3.4688	7.4557	7.4557	7.2107	2.8763	0.0356	4.7462	7.4557	12.7508
Aug-23	8.5047	7.1587	11.7433	5.3579	2.9783	1.3084	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	8.4087	8.4087	8.1087	8.1087	12.9933	12.9933	12.9933	12.9933	7.2279	7.4783	3.4688	7.4783	7.4783	7.2279	2.8763	0.0356	4.7462	7.4783	12.9933
Sep-23	8.6637	7.3142	11.9354	5.4488	2.9995	1.3118	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	8.5642	8.5642	8.2642	8.2642	13.1854	13.1854	13.1854	13.1854	7.2394	7.4995	3.4688	7.4995	7.4995	7.2394	2.8763	0.0356	4.7462	7.4995	13.1854
Oct-23	8.5963	7.2507	11.8508	5.5006	3.0169	1.3141	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	8.5007	8.5007	8.2007	8.2007	13.1008	13.1008	13.1008	13.1008	7.3297	7.5169	3.4688	7.5169	7.5169	7.3297	2.8763	0.0356	4.7462	7.5169	13.1008
Nov-23	8.4171	7.0793	11.6296	5.4947	3.0292	1.3103	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	8.3293	8.3293	8.0293	8.0293	12.8796	12.8796	12.8796	12.8796	7.3412	7.5292	3.4688	7.5292	7.5292	7.3412	2.8763	0.0356	4.7462	7.5292	12.8796
Dec-23	7.9420	6.6245	11.0442	5.3902	3.0301	1.3033	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	7.8745	7.8745	7.5745	7.5745	12.2942	12.2942	12.2942	12.2942	7.3469	7.5301	3.4688	7.5301	7.5301	7.3469	2.8763	0.0356	4.7462	7.5301	12.2942
Jan-24	7.7686	6.4604	10.8283	5.2701	3.0240	1.2875	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	7.7104	7.7104	7.4104	7.4104	12.0783	12.0783	12.0783	12.0783	7.4099	7.5240	3.4092	7.5240	7.5240	7.4099	2.9573	0.0360	4.7990	7.5240	12.0783
Feb-24	7.9335	6.6196	11.0295	5.2045	3.0176	1.2799	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	7.8696	7.8696	7.5696	7.5696	12.2795	12.2795	12.2795	12.2795	7.4042	7.5176	3.4092	7.5176	7.5176	7.4042	2.9573	0.0360	4.7990	7.5176	12.2795
Mar-24	8.0797	6.7614	11.2073	5.2318	3.0113	1.2820	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	8.0114	8.0114	7.7114	7.7114	12.4573	12.4573	12.4573	12.4573	7.4042	7.5113	3.4092	7.5113	7.5113	7.4042	2.9573	0.0360	4.7990	7.5113	12.4573
Apr-24	8.1409	6.8218	11.2803	5.2951	3.0075	1.2837	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	8.0718	8.0718	7.7718	7.7718	12.5303	12.5303	12.5303	12.5303	7.3748	7.5075	3.4092	7.5075	7.5075	7.3748	2.9573	0.0360	4.7990	7.5075	12.5303
May-24	8.1671	6.8487	11.3104	5.3372	3.0073	1.2831	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	8.0987	8.0987	7.7987	7.7987	12.5604	12.5604	12.5604	12.5604	7.3748	7.5073	3.4092	7.5073	7.5073	7.3748	2.9573	0.0360	4.7990	7.5073	12.5604
Jun-24	8.2265	6.9075	11.3810	5.3663	3.0170	1.2816	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	8.1575	8.1575	7.8575	7.8575	12.6310	12.6310	12.6310	12.6310	7.3748	7.5170	3.4092	7.5170	7.5170	7.3748	2.9573	0.0360	4.7990	7.5170	12.6310
Jul-24	8.3827	7.0599	11.5701	5.4102	3.0330	1.2810	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	8.3099	8.3099	8.0099	8.0099	12.8201	12.8201	12.8201	12.8201	7.3530	7.5330	3.4092	7.5330	7.5330	7.3530	2.9573	0.0360	4.7990	7.5330	12.8201
Aug-24	8.5556	7.2289	11.7789	5.4769	3.0490	1.2833	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	8.4789	8.4789	8.1789	8.1789	13.0289	13.0289	13.0289	13.0289	7.3588	7.5490	3.4092	7.5490	7.5490	7.3588	2.9573	0.0360	4.7990	7.5490	13.0289
Sep-24	8.6957	7.3666	11.9473	5.5563	3.0647	1.2860	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	8.6166	8.6166	8.3166	8.3166	13.1973	13.1973	13.1973	13.1973	7.3703	7.5647	3.4092	7.5647	7.5647	7.3703	2.9573	0.0360	4.7990	7.5647	13.1973
Oct-24	8.6157	7.2907	11.8477	5.5998	3.0778	1.2880	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	8.5407	8.5407	8.2407	8.2407	13.0977	13.0977	13.0977	13.0977	7.4272	7.5778	3.4092	7.5778	7.5778	7.4272	2.9573	0.0360	4.7990	7.5778	13.0977
Nov-24	8.4291	7.1116	11.6180	5.5876	3.0867	1.2841	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	8.3616	8.3616	8.0616	8.0616	12.8680	12.8680	12.8680	12.8680	7.4387	7.5867	3.4092	7.5867	7.5867	7.4387	2.9573	0.0360	4.7990	7.5867	12.8680
Dec-24	7.9507	6.6521	11.0298	5.4779	3.0850	1.2773	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	7.9021	7.9021	7.6021	7.6021	12.2798	12.2798	12.2798	12.2798	7.4444	7.5850	3.4092	7.5850	7.5850	7.4444	2.9573	0.0360	4.7990	7.5850	12.2798
Jan-25	7.7756	6.4860	10.8125	5.3539	3.0767	1.2620	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	7.7360	7.7360	7.4360	7.4360	12.0625	12.0625	12.0625	12.0625	7.4820	7.5767	3.3442	7.5767	7.5767	7.4820	3.0401	0.0364	4.8530	7.5767	12.0625
Feb-25	7.9397	6.6448	11.0122	5.2862	3.0688	1.2546	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	7.8948	7.8948	7.5948	7.5948	12.2622	12.2622	12.2622	12.2622	7.4820	7.5688	3.3442	7.5688	7.5688	7.4820	3.0401	0.0364	4.8530	7.5688	12.2622
Mar-25	8.0857	6.7869	11.1893	5.3132	3.0614	1.2569	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	8.0369	8.0369	7.7369	7.7369	12.4393	12.4393	12.4393	12.4393	7.4763	7.5614	3.3442	7.5614	7.5614	7.4763	3.0401	0.0364	4.8530	7.5614	12.4393
Apr-25	8.1472	6.8477	11.2625	5.3771	3.0566	1.2588	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	8.0977	8.0977	7.7977	7.7977	12.5125	12.5125	12.5125	12.5125	7.4390	7.5566	3.3442	7.5566	7.5566	7.4390	3.0401	0.0364	4.8530	7.5566	12.5125

Appendix D-4: Reduced Fuel Forecast (March 21, 2016)

Month	Monthly Average Price (US$/MMBTU) WTI	No. 6	No. 2	Natural Gas Indexed to No. 6	Natural Gas @ Henry Hub	Coal CAPP	Adders (US$/MMBTU) No. 6 San Juan / Palo Seco	No. 6 Aguirre	No. 6 Souco	No. 2 Aguirre / San Juan CC	No. 2 Mayagüez / Arecibo	No. 2 Trucks	Natural Gas Indexed to No. 6	Natural Gas @ HH Capacity charge and others	Natural Gas @ HH Shipping Cost Adder	Final Price (US$/MMBTU) No. 6 Aguirre	No. 6 Costa Sur	No. 6 San Juan	No. 6 Palo Seco	No. 2 Aguirre CC	No. 2 San Juan CC	No. 2 Mayaguez	No. 2 Arecibo	Natural Gas Indexed to No. 6	Natural Gas Indexed to HH	Coal AES	Nat Gas Aguirre Future 1,3,&4	Nat Gas CS 5&6 Nat Gas Futures 1,3,&4	Nat Gas CS 5&6 Nat Gas Future 2	EcoEléctrica Base Fuel US$/MMBTU	Energy Charge US$/kWh	Energy Charge US$/MMBTU	Future 1,3 & 4 Spot Fuel Price US$/MMBTU	Future 2 Spot Fuel Price US$/MMBTU
May-25	8.1739	6.8752	11.2931	5.4197	3.0557	1.2584	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	8.1252	8.1252	7.8252	7.8252	12.5431	12.5431	12.5431	12.5431	7.4390	7.5557	3.3442	7.5557	7.5557	7.4390	3.0401	0.0364	4.8530	7.5557	12.5431
Jun-25	8.2338	6.9346	11.3641	5.4491	3.0649	1.2571	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	8.1846	8.1846	7.8846	7.8846	12.6141	12.6141	12.6141	12.6141	7.4390	7.5649	3.3442	7.5649	7.5649	7.4390	3.0401	0.0364	4.8530	7.5649	12.6141
Jul-25	8.3902	7.0877	11.5530	5.4937	3.0805	1.2567	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	8.3377	8.3377	8.0377	8.0377	12.8030	12.8030	12.8030	12.8030	7.4114	7.5805	3.3442	7.5805	7.5805	7.4114	3.0401	0.0364	4.8530	7.5805	12.8030
Aug-25	8.5632	7.2573	11.7615	5.5613	3.0962	1.2591	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	8.5073	8.5073	8.2073	8.2073	13.0115	13.0115	13.0115	13.0115	7.4229	7.5962	3.3442	7.5962	7.5962	7.4229	3.0401	0.0364	4.8530	7.5962	13.0115
Sep-25	8.7033	7.3955	11.9296	5.6416	3.1116	1.2620	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	8.6455	8.6455	8.3455	8.3455	13.1796	13.1796	13.1796	13.1796	7.4344	7.6116	3.3442	7.6116	7.6116	7.4344	3.0401	0.0364	4.8530	7.6116	13.1796
Oct-25	8.6237	7.3197	11.8306	5.6855	3.1243	1.2641	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	8.5697	8.5697	8.2697	8.2697	13.0806	13.0806	13.0806	13.0806	7.4874	7.6243	3.3442	7.6243	7.6243	7.4874	3.0401	0.0364	4.8530	7.6243	13.0806
Nov-25	8.4375	7.1405	11.6020	5.6731	3.1328	1.2605	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	8.3905	8.3905	8.0905	8.0905	12.8520	12.8520	12.8520	12.8520	7.4932	7.6328	3.3442	7.6328	7.6328	7.4932	3.0401	0.0364	4.8530	7.6328	12.8520
Dec-25	7.9598	6.6804	11.0162	5.5618	3.1305	1.2540	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	7.9304	7.9304	7.6304	7.6304	12.2662	12.2662	12.2662	12.2662	7.4989	7.6305	3.3442	7.6305	7.6305	7.4989	3.0401	0.0364	4.8530	7.6305	12.2662
Jan-26	7.8411	6.5678	10.8685	5.4454	3.1228	1.2392	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	7.8178	7.8178	7.5178	7.5178	12.1185	12.1185	12.1185	12.1185	7.5423	7.6228	3.3131	7.6228	7.6228	7.5423	3.0883	0.0366	4.8845	7.6228	12.1185
Feb-26	8.0852	6.8045	11.1654	5.3984	3.1169	1.2338	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	8.0545	8.0545	7.7545	7.7545	12.4154	12.4154	12.4154	12.4154	7.5365	7.6169	3.3131	7.6169	7.6169	7.5365	3.0883	0.0366	4.8845	7.6169	12.4154
Mar-26	8.3179	7.0314	11.4475	5.4609	3.1133	1.2384	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	8.2814	8.2814	7.9814	7.9814	12.6975	12.6975	12.6975	12.6975	7.5365	7.6133	3.3131	7.6133	7.6133	7.5365	3.0883	0.0366	4.8845	7.6133	12.6975
Apr-26	8.4591	7.1701	11.6172	5.5650	3.1138	1.2428	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	8.4201	8.4201	8.1201	8.1201	12.8672	12.8672	12.8672	12.8672	7.5071	7.6138	3.3131	7.6138	7.6138	7.5071	3.0883	0.0366	4.8845	7.6138	12.8672
May-26	8.5525	7.2628	11.7286	5.6455	3.1195	1.2449	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	8.5128	8.5128	8.2128	8.2128	12.9786	12.9786	12.9786	12.9786	7.5071	7.6195	3.3131	7.6195	7.6195	7.5071	3.0883	0.0366	4.8845	7.6195	12.9786
Jun-26	8.6667	7.3759	11.8650	5.7077	3.1364	1.2458	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	8.6259	8.6259	8.3259	8.3259	13.1150	13.1150	13.1150	13.1150	7.5129	7.6364	3.3131	7.6364	7.6364	7.5129	3.0883	0.0366	4.8845	7.6364	13.1150
Jul-26	8.8694	7.5760	12.1081	5.7798	3.1594	1.2474	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	8.8260	8.8260	8.5260	8.5260	13.3581	13.3581	13.3581	13.3581	7.5244	7.6594	3.3131	7.6594	7.6594	7.5244	3.0883	0.0366	4.8845	7.6594	13.3581
Aug-26	9.0792	7.7838	12.3591	5.8704	3.1815	1.2512	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	9.0338	9.0338	8.7338	8.7338	13.6091	13.6091	13.6091	13.6091	7.5359	7.6815	3.3131	7.6815	7.6815	7.5359	3.0883	0.0366	4.8845	7.6815	13.6091
Sep-26	9.2461	7.9501	12.5578	5.9696	3.2021	1.2554	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	9.2001	9.2001	8.9001	8.9001	13.8078	13.8078	13.8078	13.8078	7.5474	7.7021	3.3131	7.7021	7.7021	7.5474	3.0883	0.0366	4.8845	7.7021	13.8078
Oct-26	9.1749	7.8818	12.4698	6.0267	3.2186	1.2585	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	9.1318	9.1318	8.8318	8.8318	13.7198	13.7198	13.7198	13.7198	7.6455	7.7186	3.3131	7.7186	7.7186	7.6455	3.0883	0.0366	4.8845	7.7186	13.7198
Nov-26	8.9862	7.6980	12.2400	6.0214	3.2298	1.2559	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	8.9480	8.9480	8.6480	8.6480	13.4900	13.4900	13.4900	13.4900	7.6570	7.7298	3.3131	7.7298	7.7298	7.6570	3.0883	0.0366	4.8845	7.7298	13.4900
Dec-26	8.4861	7.2104	11.6325	5.9098	3.2291	1.2503	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	8.4604	8.4604	8.1604	8.1604	12.8825	12.8825	12.8825	12.8825	7.6628	7.7291	3.3131	7.7291	7.7291	7.6628	3.0883	0.0366	4.8845	7.7291	12.8825
Jan-27	8.3625	7.0918	11.4802	5.7910	3.2221	1.2364	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	8.3418	8.3418	8.0418	8.0418	12.7302	12.7302	12.7302	12.7302	7.7297	7.7221	3.3144	7.7221	7.7221	7.7297	3.1619	0.0370	4.9326	7.7221	12.7302
Feb-27	8.6205	7.3451	11.7912	5.7441	3.2165	1.2317	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	8.5951	8.5951	8.2951	8.2951	13.0412	13.0412	13.0412	13.0412	7.7239	7.7165	3.3144	7.7165	7.7165	7.7239	3.1619	0.0370	4.9326	7.7165	13.0412
Mar-27	8.8659	7.5873	12.0857	5.8119	3.2128	1.2369	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	8.8373	8.8373	8.5373	8.5373	13.3357	13.3357	13.3357	13.3357	7.7239	7.7128	3.3144	7.7128	7.7128	7.7239	3.1619	0.0370	4.9326	7.7128	13.3357
Apr-27	9.0142	7.7349	12.2622	5.9231	3.2131	1.2419	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	8.9849	8.9849	8.6849	8.6849	13.5122	13.5122	13.5122	13.5122	7.6985	7.7131	3.3144	7.7131	7.7131	7.6985	3.1619	0.0370	4.9326	7.7131	13.5122
May-27	9.1119	7.8331	12.3776	6.0094	3.2186	1.2446	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	9.0831	9.0831	8.7831	8.7831	13.6276	13.6276	13.6276	13.6276	7.6985	7.7186	3.3144	7.7186	7.7186	7.6985	3.1619	0.0370	4.9326	7.7186	13.6276
Jun-27	9.2316	7.9531	12.5191	6.0763	3.2354	1.2460	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	9.2031	9.2031	8.9031	8.9031	13.7691	13.7691	13.7691	13.7691	7.7043	7.7354	3.3144	7.7354	7.7354	7.7043	3.1619	0.0370	4.9326	7.7354	13.7691
Jul-27	9.4446	8.1660	12.7722	6.1537	3.2585	1.2481	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	9.4160	9.4160	9.1160	9.1160	14.0222	14.0222	14.0222	14.0222	7.7197	7.7585	3.3144	7.7585	7.7585	7.7197	3.1619	0.0370	4.9326	7.7585	14.0222
Aug-27	9.6651	8.3870	13.0335	6.2505	3.2805	1.2525	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	9.6370	9.6370	9.3370	9.3370	14.2835	14.2835	14.2835	14.2835	7.7312	7.7805	3.3144	7.7805	7.7805	7.7312	3.1619	0.0370	4.9326	7.7805	14.2835
Sep-27	9.8404	8.5639	13.2402	6.3565	3.3010	1.2572	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	9.8139	9.8139	9.5139	9.5139	14.4902	14.4902	14.4902	14.4902	7.7427	7.8010	3.3144	7.8010	7.8010	7.7427	3.1619	0.0370	4.9326	7.8010	14.4902
Oct-27	9.7650	8.4907	13.1478	6.4182	3.3174	1.2609	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	9.7407	9.7407	9.4407	9.4407	14.3978	14.3978	14.3978	14.3978	7.8487	7.8174	3.3144	7.8174	7.8174	7.8487	3.1619	0.0370	4.9326	7.8174	14.3978
Nov-27	9.5658	8.2943	12.9075	6.4142	3.3283	1.2590	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	9.5443	9.5443	9.2443	9.2443	14.1575	14.1575	14.1575	14.1575	7.8602	7.8283	3.3144	7.8283	7.8283	7.8602	3.1619	0.0370	4.9326	7.8283	14.1575
Dec-27	9.0383	7.7738	12.2728	6.2980	3.3271	1.2540	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	9.0238	9.0238	8.7238	8.7238	13.5228	13.5228	13.5228	13.5228	7.8659	7.8271	3.3144	7.8271	7.8271	7.8659	3.1619	0.0370	4.9326	7.8271	13.5228
Jan-28	8.9078	7.6469	12.1133	6.1741	3.3195	1.2407	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	8.8969	8.8969	8.5969	8.5969	13.3633	13.3633	13.3633	13.3633	7.9408	7.8195	3.3339	7.8195	7.8195	7.9408	3.2609	0.0375	4.9972	7.8195	13.3633
Feb-28	9.1797	7.9172	12.4379	6.1261	3.3134	1.2366	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	9.1672	9.1672	8.8672	8.8672	13.6879	13.6879	13.6879	13.6879	7.9350	7.8134	3.3339	7.8134	7.8134	7.9350	3.2609	0.0375	4.9972	7.8134	13.6879
Mar-28	9.4381	8.1754	12.7452	6.1991	3.3091	1.2424	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	9.4254	9.4254	9.1254	9.1254	13.9952	13.9952	13.9952	13.9952	7.9293	7.8091	3.3339	7.8091	7.8091	7.9293	3.2609	0.0375	4.9972	7.8091	13.9952
Apr-28	9.5942	8.3327	12.9293	6.3182	3.3090	1.2479	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	9.5827	9.5827	9.2827	9.2827	14.1793	14.1793	14.1793	14.1793	7.9096	7.8090	3.3339	7.8090	7.8090	7.9096	3.2609	0.0375	4.9972	7.8090	14.1793
May-28	9.6970	8.4373	13.0495	6.4109	3.3141	1.2511	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	9.6873	9.6873	9.3873	9.3873	14.2995	14.2995	14.2995	14.2995	7.9096	7.8141	3.3339	7.8141	7.8141	7.9096	3.2609	0.0375	4.9972	7.8141	14.2995
Jun-28	9.8229	8.5651	13.1970	6.4831	3.3309	1.2531	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	9.8151	9.8151	9.5151	9.5151	14.4470	14.4470	14.4470	14.4470	7.9096	7.8309	3.3339	7.8309	7.8309	7.9096	3.2609	0.0375	4.9972	7.8309	14.4470
Jul-28	10.0471	8.7919	13.4609	6.5664	3.3540	1.2558	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	10.0419	10.0419	9.7419	9.7419	14.7109	14.7109	14.7109	14.7109	7.9289	7.8540	3.3339	7.8540	7.8540	7.9289	3.2609	0.0375	4.9972	7.8540	14.7109
Aug-28	10.2791	9.0273	13.7332	6.6702	3.3760	1.2607	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	10.2773	10.2773	9.9773	9.9773	14.9832	14.9832	14.9832	14.9832	7.9404	7.8760	3.3339	7.8760	7.8760	7.9404	3.2609	0.0375	4.9972	7.8760	14.9832
Sep-28	10.4635	9.2156	13.9486	6.7839	3.3965	1.2659	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	10.4656	10.4656	10.1656	10.1656	15.1986	15.1986	15.1986	15.1986	7.9577	7.8965	3.3339	7.8965	7.8965	7.9577	3.2609	0.0375	4.9972	7.8965	15.1986

Appendix D-5: Reduced Fuel Forecast (March 21, 2016)

Month	Monthly Average Price (US$/MMBTU)						Adders (US$/MMBTU)									Final Price (US$/MMBTU)														EcoEléctrica				
							No. 6			No. 2				Natural Gas @ HH		No. 6				No. 2							Nat Gas Aguirre	Nat Gas CS 5&6		Base Fuel	Energy Charge	Energy Charge	Future 1,3 & 4 Spot Fuel Price	Future 2 Spot Fuel Price
	WTI	No. 6	No. 2	Natural Gas Indexed to No. 6	Natural Gas @ Henry Hub	Coal CAPP	San Juan / Palo Seco	Aguirre	Souco	Aguirre / San Juan CC	Mayagüez / Arecibo	Trucks	Natural Gas Indexed to No. 6	Capacity charge and others	Shipping Cost Adder	Aguirre	Costa Sur	San Juan	Palo Seco	Aguirre CC	San Juan CC	Mayaguez	Arecibo	Natural Gas Indexed to No. 6	Natural Gas Indexed to HH	Coal AES	Future 1,3,&4	Nat Gas Futures 1,3,&4	Nat Gas Future 2	US$/MMBTU	US$/kWh	US$/MMBTU	US$/MMBTU	US$/MMBTU
Oct-28	10.3840	9.1375	13.8520	6.8506	3.4127	1.2702	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	10.3875	10.3875	10.0875	10.0875	15.1020	15.1020	15.1020	15.1020	8.0676	7.9127	3.3339	7.9127	7.9127	8.0676	3.2609	0.0375	4.9972	7.9127	15.1020
Nov-28	10.1741	8.9281	13.6011	6.8480	3.4234	1.2688	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	10.1781	10.1781	9.8781	9.8781	14.8511	14.8511	14.8511	14.8511	8.0734	7.9234	3.3339	7.9234	7.9234	8.0734	3.2609	0.0375	4.9972	7.9234	14.8511
Dec-28	9.6184	8.3731	12.9387	6.7267	3.4217	1.2643	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	9.6231	9.6231	9.3231	9.3231	14.1887	14.1887	14.1887	14.1887	8.0791	7.9217	3.3339	7.9217	7.9217	8.0791	3.2609	0.0375	4.9972	7.9217	14.1887
Jan-29	9.4807	8.2377	12.7720	6.5972	3.4136	1.2517	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	9.4877	9.4877	9.1877	9.1877	14.0220	14.0220	14.0220	14.0220	8.1579	7.9136	3.3707	7.9136	7.9136	8.1579	3.3567	0.0379	5.0596	7.9136	14.0220
Feb-29	9.7670	8.5257	13.1105	6.5479	3.4069	1.2481	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	9.7757	9.7757	9.4757	9.4757	14.3605	14.3605	14.3605	14.3605	8.1521	7.9069	3.3707	7.9069	7.9069	8.1521	3.3567	0.0379	5.0596	7.9069	14.3605
Mar-29	10.0390	8.8008	13.4310	6.6267	3.4022	1.2544	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	10.0508	10.0508	9.7508	9.7508	14.6810	14.6810	14.6810	14.6810	8.1521	7.9022	3.3707	7.9022	7.9022	8.1521	3.3567	0.0379	5.0596	7.9022	14.6810
Apr-29	10.2032	8.9683	13.6228	6.7542	3.4016	1.2604	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	10.2183	10.2183	9.9183	9.9183	14.8728	14.8728	14.8728	14.8728	8.1306	7.9016	3.3707	7.9016	7.9016	8.1306	3.3567	0.0379	5.0596	7.9016	14.8728
May-29	10.3113	9.0795	13.7479	6.8538	3.4065	1.2641	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	10.3295	10.3295	10.0295	10.0295	14.9979	14.9979	14.9979	14.9979	8.1306	7.9065	3.3707	7.9065	7.9065	8.1306	3.3567	0.0379	5.0596	7.9065	14.9979
Jun-29	10.4436	9.2156	13.9015	6.9317	3.4231	1.2667	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	10.4656	10.4656	10.1656	10.1656	15.1515	15.1515	15.1515	15.1515	8.1364	7.9231	3.3707	7.9231	7.9231	8.1364	3.3567	0.0379	5.0596	7.9231	15.1515
Jul-29	10.6794	9.4569	14.1764	7.0214	3.4462	1.2699	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	10.7069	10.7069	10.4069	10.4069	15.4264	15.4264	15.4264	15.4264	8.1500	7.9462	3.3707	7.9462	7.9462	8.1500	3.3567	0.0379	5.0596	7.9462	15.4264
Aug-29	10.9233	9.7075	14.4601	7.1330	3.4682	1.2753	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	10.9575	10.9575	10.6575	10.6575	15.7101	15.7101	15.7101	15.7101	8.1673	7.9682	3.3707	7.9682	7.9682	8.1673	3.3567	0.0379	5.0596	7.9682	15.7101
Sep-29	11.1171	9.9077	14.6844	7.2548	3.4886	1.2811	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	11.1577	11.1577	10.8577	10.8577	15.9344	15.9344	15.9344	15.9344	8.1788	7.9886	3.3707	7.9886	7.9886	8.1788	3.3567	0.0379	5.0596	7.9886	15.9344
Oct-29	11.0332	9.8244	14.5835	7.3270	3.5047	1.2859	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	11.0744	11.0744	10.7744	10.7744	15.8335	15.8335	15.8335	15.8335	8.2966	8.0047	3.3707	8.0047	8.0047	8.2966	3.3567	0.0379	5.0596	8.0047	15.8335
Nov-29	10.8123	9.6013	14.3217	7.3258	3.5152	1.2850	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	10.8513	10.8513	10.5513	10.5513	15.5717	15.5717	15.5717	15.5717	8.3023	8.0152	3.3707	8.0152	8.0152	8.3023	3.3567	0.0379	5.0596	8.0152	15.5717
Dec-29	10.2273	9.0101	13.6307	7.1988	3.5130	1.2810	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	10.2601	10.2601	9.9601	9.9601	14.8807	14.8807	14.8807	14.8807	8.3138	8.0130	3.3707	8.0130	8.0130	8.3138	3.3567	0.0379	5.0596	8.0130	14.8807
Jan-30	10.0821	8.8657	13.4567	7.0631	3.5044	1.2688	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	10.1157	10.1157	9.8157	9.8157	14.7067	14.7067	14.7067	14.7067	8.3947	8.0044	3.4238	8.0044	8.0044	8.3947	3.4491	0.0384	5.1200	8.0044	14.7067
Feb-30	10.3833	9.1724	13.8095	7.0123	3.4972	1.2657	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	10.4224	10.4224	10.1224	10.1224	15.0595	15.0595	15.0595	15.0595	8.3889	7.9972	3.4238	7.9972	7.9972	8.3889	3.4491	0.0384	5.1200	7.9972	15.0595
Mar-30	10.6694	9.4652	14.1434	7.0973	3.4920	1.2725	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	10.7152	10.7152	10.4152	10.4152	15.3934	15.3934	15.3934	15.3934	8.3889	7.9920	3.4238	7.9920	7.9920	8.3889	3.4491	0.0384	5.1200	7.9920	15.3934
Apr-30	10.8420	9.6433	14.3431	7.2339	3.4911	1.2791	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	10.8933	10.8933	10.5933	10.5933	15.5931	15.5931	15.5931	15.5931	8.3674	7.9911	3.4238	7.9911	7.9911	8.3674	3.4491	0.0384	5.1200	7.9911	15.5931
May-30	10.9555	9.7616	14.4733	7.3410	3.4956	1.2833	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	11.0116	11.0116	10.7116	10.7116	15.7233	15.7233	15.7233	15.7233	8.3674	7.9956	3.4238	7.9956	7.9956	8.3674	3.4491	0.0384	5.1200	7.9956	15.7233
Jun-30	11.0945	9.9062	14.6331	7.4251	3.5121	1.2864	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	11.1562	11.1562	10.8562	10.8562	15.8831	15.8831	15.8831	15.8831	8.3732	8.0121	3.4238	8.0121	8.0121	8.3732	3.4491	0.0384	5.1200	8.0121	15.8831
Jul-30	11.3423	10.1628	14.9193	7.5217	3.5351	1.2901	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	11.4128	11.4128	11.1128	11.1128	16.1693	16.1693	16.1693	16.1693	8.3908	8.0351	3.4238	8.0351	8.0351	8.3908	3.4491	0.0384	5.1200	8.0351	16.1693
Aug-30	11.5985	10.4292	15.2147	7.6415	3.5571	1.2961	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	11.6792	11.6792	11.3792	11.3792	16.4647	16.4647	16.4647	16.4647	8.4080	8.0571	3.4238	8.0571	8.0571	8.4080	3.4491	0.0384	5.1200	8.0571	16.4647
Sep-30	11.8021	10.6420	15.4480	7.7722	3.5774	1.3024	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	11.8920	11.8920	11.5920	11.5920	16.6980	16.6980	16.6980	16.6980	8.4195	8.0774	3.4238	8.0774	8.0774	8.4195	3.4491	0.0384	5.1200	8.0774	16.6980
Oct-30	11.7137	10.5532	15.3426	7.8503	3.5934	1.3077	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	11.8032	11.8032	11.5032	11.5032	16.5926	16.5926	16.5926	16.5926	8.5452	8.0934	3.4238	8.0934	8.0934	8.5452	3.4491	0.0384	5.1200	8.0934	16.5926
Nov-30	11.4812	10.3158	15.0697	7.8505	3.6036	1.3073	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	11.5658	11.5658	11.2658	11.2658	16.3197	16.3197	16.3197	16.3197	8.5509	8.1036	3.4238	8.1036	8.1036	8.5509	3.4491	0.0384	5.1200	8.1036	16.3197
Dec-30	10.8659	9.6865	14.3495	7.7173	3.6011	1.3038	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	10.9365	10.9365	10.6365	10.6365	15.5995	15.5995	15.5995	15.5995	8.5567	8.1011	3.4238	8.1011	8.1011	8.5567	3.4491	0.0384	5.1200	8.1011	15.5995
Jan-31	10.7131	9.5327	14.1679	7.5747	3.5919	1.2920	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	10.7827	10.7827	10.4827	10.4827	15.4179	15.4179	15.4179	15.4179	8.6512	8.0919	3.4927	8.0919	8.0919	8.6512	3.5383	0.0388	5.1782	8.0919	15.4179
Feb-31	11.0297	9.8589	14.5354	7.5222	3.5843	1.2893	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	11.1089	11.1089	10.8089	10.8089	15.7854	15.7854	15.7854	15.7854	8.6454	8.0843	3.4927	8.0843	8.0843	8.6454	3.5383	0.0388	5.1782	8.0843	15.7854
Mar-31	11.3303	10.1703	14.8829	7.6138	3.5786	1.2967	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	11.4203	11.4203	11.1203	11.1203	16.1329	16.1329	16.1329	16.1329	8.6397	8.0786	3.4927	8.0786	8.0786	8.6397	3.5383	0.0388	5.1782	8.0786	16.1329
Apr-31	11.5115	10.3596	15.0907	7.7604	3.5773	1.3038	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	11.6096	11.6096	11.3096	11.3096	16.3407	16.3407	16.3407	16.3407	8.6239	8.0773	3.4927	8.0773	8.0773	8.6239	3.5383	0.0388	5.1782	8.0773	16.3407
May-31	11.6307	10.4852	15.2261	7.8755	3.5815	1.3085	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	11.7352	11.7352	11.4352	11.4352	16.4761	16.4761	16.4761	16.4761	8.6239	8.0815	3.4927	8.0815	8.0815	8.6239	3.5383	0.0388	5.1782	8.0815	16.4761
Jun-31	11.7766	10.6388	15.3923	7.9663	3.5978	1.3121	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	11.8888	11.8888	11.5888	11.5888	16.6423	16.6423	16.6423	16.6423	8.6239	8.0978	3.4927	8.0978	8.0978	8.6239	3.5383	0.0388	5.1782	8.0978	16.6423
Jul-31	12.0367	10.9114	15.6901	8.0704	3.6209	1.3163	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	12.1614	12.1614	11.8614	11.8614	16.9401	16.9401	16.9401	16.9401	8.6473	8.1209	3.4927	8.1209	8.1209	8.6473	3.5383	0.0388	5.1782	8.1209	16.9401
Aug-31	12.3057	11.1943	15.9972	8.1990	3.6428	1.3228	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	12.4443	12.4443	12.1443	12.1443	17.2472	17.2472	17.2472	17.2472	8.6588	8.1428	3.4927	8.1428	8.1428	8.6588	3.5383	0.0388	5.1782	8.1428	17.2472
Sep-31	12.5192	11.4202	16.2398	8.3394	3.6630	1.3296	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	12.6702	12.6702	12.3702	12.3702	17.4898	17.4898	17.4898	17.4898	8.6703	8.1630	3.4927	8.1630	8.1630	8.6703	3.5383	0.0388	5.1782	8.1630	17.4898
Oct-31	12.4262	11.3257	16.1299	8.4238	3.6788	1.3355	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	12.5757	12.5757	12.2757	12.2757	17.3799	17.3799	17.3799	17.3799	8.8078	8.1788	3.4927	8.1788	8.1788	8.8078	3.5383	0.0388	5.1782	8.1788	17.3799
Nov-31	12.1818	11.0732	15.8456	8.4255	3.6888	1.3355	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	12.3232	12.3232	12.0232	12.0232	17.0956	17.0956	17.0956	17.0956	8.8193	8.1888	3.4927	8.1888	8.1888	8.8193	3.5383	0.0388	5.1782	8.1888	17.0956
Dec-31	11.5352	10.4042	15.0954	8.2854	3.6859	1.3325	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	11.6542	11.6542	11.3542	11.3542	16.3454	16.3454	16.3454	16.3454	8.8250	8.1859	3.4927	8.1859	8.1859	8.8250	3.5383	0.0388	5.1782	8.1859	16.3454
Jan-32	11.3743	10.2404	14.9060	8.1352	3.6762	1.3209	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	11.4904	11.4904	11.1904	11.1904	16.1560	16.1560	16.1560	16.1560	8.9234	8.1762	3.5770	8.1762	8.1762	8.9234	3.6243	0.0393	5.2343	8.1762	16.1560
Feb-32	11.7068	10.5871	15.2885	8.0807	3.6681	1.3187	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	11.8371	11.8371	11.5371	11.5371	16.5385	16.5385	16.5385	16.5385	8.9177	8.1681	3.5770	8.1681	8.1681	8.9177	3.6243	0.0393	5.2343	8.1681	16.5385

Appendix D-6: Reduced Fuel Forecast (March 21, 2016)

Month	Monthly Average Price (US$/MMBTU)						Adders (US$/MMBTU)									Final Price (US$/MMBTU)														EcoEléctrica				
							No. 6			No. 2				Natural Gas @ HH		No. 6				No. 2							Nat Gas Aguirre	Nat Gas CS 5&6		Base Fuel	Energy Charge	Energy Charge	Future 1,3 & 4 Spot Fuel Price	Future 2 Spot Fuel Price
	WTI	No. 6	No. 2	Natural Gas Indexed to No. 6	Natural Gas @ Henry Hub	Coal CAPP	San Juan / Palo Seco	Aguirre	Souco	Aguirre / San Juan CC	Mayagüez / Arecibo	Trucks	Natural Gas Indexed to No. 6	Capacity charge and others	Shipping Cost Adder	Aguirre	Costa Sur	San Juan	Palo Seco	Aguirre CC	San Juan CC	Mayaguez	Arecibo	Natural Gas Indexed to No. 6	Natural Gas Indexed to HH	Coal AES	Future 1,3,&4	Nat Gas Futures 1,3,&4	Nat Gas Future 2	US$/MMBTU	US$/kWh	US$/MMBTU	US$/MMBTU	US$/MMBTU
Mar-32	12.0225	10.9179	15.6501	8.1795	3.6620	1.3266	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	12.1679	12.1679	11.8679	11.8679	16.9001	16.9001	16.9001	16.9001	8.9119	8.1620	3.5770	8.1620	8.1620	8.9119	3.6243	0.0393	5.2343	8.1620	16.9001
Apr-32	12.2127	11.1189	15.8661	8.3367	3.6603	1.3343	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	12.3689	12.3689	12.0689	12.0689	17.1161	17.1161	17.1161	17.1161	8.8904	8.1603	3.5770	8.1603	8.1603	8.8904	3.6243	0.0393	5.2343	8.1603	17.1161
May-32	12.3376	11.2522	16.0068	8.4606	3.6642	1.3395	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	12.5022	12.5022	12.2022	12.2022	17.2568	17.2568	17.2568	17.2568	8.8904	8.1642	3.5770	8.1642	8.1642	8.8904	3.6243	0.0393	5.2343	8.1642	17.2568
Jun-32	12.4906	11.4151	16.1794	8.5586	3.6805	1.3436	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	12.6651	12.6651	12.3651	12.3651	17.4294	17.4294	17.4294	17.4294	8.8904	8.1805	3.5770	8.1805	8.1805	8.8904	3.6243	0.0393	5.2343	8.1805	17.4294
Jul-32	12.7635	11.7045	16.4890	8.6706	3.7034	1.3483	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	12.9545	12.9545	12.6545	12.6545	17.7390	17.7390	17.7390	17.7390	8.9177	8.2034	3.5770	8.2034	8.2034	8.9177	3.6243	0.0393	5.2343	8.2034	17.7390
Aug-32	13.0456	12.0047	16.8083	8.8089	3.7252	1.3554	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	13.2547	13.2547	12.9547	12.9547	18.0583	18.0583	18.0583	18.0583	8.9292	8.2252	3.5770	8.2252	8.2252	8.9292	3.6243	0.0393	5.2343	8.2252	18.0583
Sep-32	13.2695	12.2443	17.0603	8.9596	3.7454	1.3627	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	13.4943	13.4943	13.1943	13.1943	18.3103	18.3103	18.3103	18.3103	8.9464	8.2454	3.5770	8.2454	8.2454	8.9464	3.6243	0.0393	5.2343	8.2454	18.3103
Oct-32	13.1717	12.1437	16.9457	9.0508	3.7610	1.3691	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	13.3937	13.3937	13.0937	13.0937	18.1957	18.1957	18.1957	18.1957	9.0918	8.2610	3.5770	8.2610	8.2610	9.0918	3.6243	0.0393	5.2343	8.2610	18.1957
Nov-32	12.9150	11.8756	16.6497	9.0541	3.7708	1.3696	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	13.1256	13.1256	12.8256	12.8256	17.8997	17.8997	17.8997	17.8997	9.0976	8.2708	3.5770	8.2708	8.2708	9.0976	3.6243	0.0393	5.2343	8.2708	17.8997
Dec-32	12.2359	11.1648	15.8689	8.9064	3.7675	1.3669	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	12.4148	12.4148	12.1148	12.1148	17.1189	17.1189	17.1189	17.1189	9.1033	8.2675	3.5770	8.2675	8.2675	9.1033	3.6243	0.0393	5.2343	8.2675	17.1189
Jan-33	12.0667	10.9906	15.6715	8.7479	3.7573	1.3556	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	12.2406	12.2406	11.9406	11.9406	16.9215	16.9215	16.9215	16.9215	9.2136	8.2573	3.6766	8.2573	8.2573	9.2136	3.7071	0.0397	5.2883	8.2573	16.9215
Feb-33	12.4157	11.3588	16.0693	8.6912	3.7488	1.3538	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	12.6088	12.6088	12.3088	12.3088	17.3193	17.3193	17.3193	17.3193	9.2078	8.2488	3.6766	8.2488	8.2488	9.2078	3.7071	0.0397	5.2883	8.2488	17.3193
Mar-33	12.7469	11.7098	16.4453	8.7978	3.7423	1.3623	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	12.9598	12.9598	12.6598	12.6598	17.6953	17.6953	17.6953	17.6953	9.2021	8.2423	3.6766	8.2423	8.2423	9.2021	3.7071	0.0397	5.2883	8.2423	17.6953
Apr-33	12.9463	11.9230	16.6697	8.9666	3.7403	1.3705	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	13.1730	13.1730	12.8730	12.8730	17.9197	17.9197	17.9197	17.9197	9.1806	8.2403	3.6766	8.2403	8.2403	9.1806	3.7071	0.0397	5.2883	8.2403	17.9197
May-33	13.0772	12.0643	16.8157	9.0998	3.7439	1.3762	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	13.3143	13.3143	13.0143	13.0143	18.0657	18.0657	18.0657	18.0657	9.1806	8.2439	3.6766	8.2439	8.2439	9.1806	3.7071	0.0397	5.2883	8.2439	18.0657
Jun-33	13.2375	12.2371	16.9950	9.2055	3.7599	1.3808	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	13.4871	13.4871	13.1871	13.1871	18.2450	18.2450	18.2450	18.2450	9.1806	8.2599	3.6766	8.2599	8.2599	9.1806	3.7071	0.0397	5.2883	8.2599	18.2450
Jul-33	13.5235	12.5440	17.3166	9.3262	3.7828	1.3860	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	13.7940	13.7940	13.4940	13.4940	18.5666	18.5666	18.5666	18.5666	9.2118	8.2828	3.6766	8.2828	8.2828	9.2118	3.7071	0.0397	5.2883	8.2828	18.5666
Aug-33	13.8192	12.8622	17.6483	9.4748	3.8045	1.3936	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	14.1122	14.1122	13.8122	13.8122	18.8983	18.8983	18.8983	18.8983	9.2233	8.3045	3.6766	8.3045	8.3045	9.2233	3.7071	0.0397	5.2883	8.3045	18.8983
Sep-33	14.0538	13.1161	17.9099	9.6366	3.8245	1.4016	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	14.3661	14.3661	14.0661	14.0661	19.1599	19.1599	19.1599	19.1599	9.2348	8.3245	3.6766	8.3245	8.3245	9.2348	3.7071	0.0397	5.2883	8.3245	19.1599
Oct-33	13.9510	13.0093	17.7905	9.7352	3.8400	1.4085	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	14.2593	14.2593	13.9593	13.9593	19.0405	19.0405	19.0405	19.0405	9.3880	8.3400	3.6766	8.3400	8.3400	9.3880	3.7071	0.0397	5.2883	8.3400	19.0405
Nov-33	13.6816	12.7246	17.4826	9.7400	3.8496	1.4094	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	13.9746	13.9746	13.6746	13.6746	18.7326	18.7326	18.7326	18.7326	9.3995	8.3496	3.6766	8.3496	8.3496	9.3995	3.7071	0.0397	5.2883	8.3496	18.7326
Dec-33	12.9689	11.9702	16.6704	9.5840	3.8459	1.4071	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	13.2202	13.2202	12.9202	12.9202	17.9204	17.9204	17.9204	17.9204	9.4053	8.3459	3.6766	8.3459	8.3459	9.4053	3.7071	0.0397	5.2883	8.3459	17.9204
Jan-34	12.7912	11.7851	16.4648	9.4165	3.8353	1.3960	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	13.0351	13.0351	12.7351	12.7351	17.7148	17.7148	17.7148	17.7148	9.5234	8.3353	3.7915	8.3353	8.3353	9.5234	3.7867	0.0401	5.3402	8.3353	17.7148
Feb-34	13.1572	12.1757	16.8782	9.3574	3.8264	1.3946	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	13.4257	13.4257	13.1257	13.1257	18.1282	18.1282	18.1282	18.1282	9.5176	8.3264	3.7915	8.3264	8.3264	9.5176	3.7867	0.0401	5.3402	8.3264	18.1282
Mar-34	13.5044	12.5479	17.2689	9.4723	3.8195	1.4036	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	13.7979	13.7979	13.4979	13.4979	18.5189	18.5189	18.5189	18.5189	9.5119	8.3195	3.7915	8.3195	8.3195	9.5119	3.7867	0.0401	5.3402	8.3195	18.5189
Apr-34	13.7132	12.7739	17.5019	9.6535	3.8171	1.4124	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	14.0239	14.0239	13.7239	13.7239	18.7519	18.7519	18.7519	18.7519	9.4943	8.3171	3.7915	8.3171	8.3171	9.4943	3.7867	0.0401	5.3402	8.3171	18.7519
May-34	13.8503	12.9235	17.6534	9.7968	3.8204	1.4187	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	14.1735	14.1735	13.8735	13.8735	18.9034	18.9034	18.9034	18.9034	9.4943	8.3204	3.7915	8.3204	8.3204	9.4943	3.7867	0.0401	5.3402	8.3204	18.9034
Jun-34	14.0181	13.1065	17.8394	9.9108	3.8363	1.4238	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	14.3565	14.3565	14.0565	14.0565	19.0894	19.0894	19.0894	19.0894	9.4943	8.3363	3.7915	8.3363	8.3363	9.4943	3.7867	0.0401	5.3402	8.3363	19.0894
Jul-34	14.3177	13.4316	18.1733	10.0408	3.8591	1.4295	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	14.6816	14.6816	14.3816	14.3816	19.4233	19.4233	19.4233	19.4233	9.5255	8.3591	3.7915	8.3591	8.3591	9.5255	3.7867	0.0401	5.3402	8.3591	19.4233
Aug-34	14.6274	13.7687	18.5175	10.2005	3.8807	1.4377	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	15.0187	15.0187	14.7187	14.7187	19.7675	19.7675	19.7675	19.7675	9.5370	8.3807	3.7915	8.3807	8.3807	9.5370	3.7867	0.0401	5.3402	8.3807	19.7675
Sep-34	14.8729	14.0375	18.7890	10.3744	3.9006	1.4462	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	15.2875	15.2875	14.9875	14.9875	20.0390	20.0390	20.0390	20.0390	9.5485	8.4006	3.7915	8.4006	8.4006	9.5485	3.7867	0.0401	5.3402	8.4006	20.0390
Oct-34	14.7650	13.9241	18.6646	10.4807	3.9160	1.4537	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	15.1741	15.1741	14.8741	14.8741	19.9146	19.9146	19.9146	19.9146	9.7175	8.4160	3.7915	8.4160	8.4160	9.7175	3.7867	0.0401	5.3402	8.4160	19.9146
Nov-34	14.4824	13.6222	18.3445	10.4872	3.9253	1.4550	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	14.8722	14.8722	14.5722	14.5722	19.5945	19.5945	19.5945	19.5945	9.7290	8.4253	3.7915	8.4253	8.4253	9.7290	3.7867	0.0401	5.3402	8.4253	19.5945
Dec-34	13.7352	12.8222	17.5003	10.3223	3.9212	1.4531	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	14.0722	14.0722	13.7722	13.7722	18.7503	18.7503	18.7503	18.7503	9.7348	8.4212	3.7915	8.4212	8.4212	9.7348	3.7867	0.0401	5.3402	8.4212	18.7503
Jan-35	13.5486	12.6257	17.2863	10.1449	3.9102	1.4422	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	13.8757	13.8757	13.5757	13.5757	18.5363	18.5363	18.5363	18.5363	9.8550	8.4102	3.9217	8.4102	8.4102	9.8550	3.8632	0.0404	5.3902	8.4102	18.5363
Feb-35	13.9321	13.0397	17.7157	10.0832	3.9009	1.4410	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	14.2897	14.2897	13.9897	13.9897	18.9657	18.9657	18.9657	18.9657	9.8493	8.4009	3.9217	8.4009	8.4009	9.8493	3.8632	0.0404	5.3902	8.4009	18.9657
Mar-35	14.2958	13.4341	18.1213	10.2070	3.8936	1.4507	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	14.6841	14.6841	14.3841	14.3841	19.3713	19.3713	19.3713	19.3713	9.8435	8.3936	3.9217	8.3936	8.3936	9.8435	3.8632	0.0404	5.3902	8.3936	19.3713
Apr-35	14.5144	13.6733	18.3630	10.4016	3.8909	1.4601	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	14.9233	14.9233	14.6233	14.6233	19.6130	19.6130	19.6130	19.6130	9.8259	8.3909	3.9217	8.3909	8.3909	9.8259	3.8632	0.0404	5.3902	8.3909	19.6130
May-35	14.6577	13.8317	18.5201	10.5558	3.8940	1.4669	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	15.0817	15.0817	14.7817	14.7817	19.7701	19.7701	19.7701	19.7701	9.8259	8.3940	3.9217	8.3940	8.3940	9.8259	3.8632	0.0404	5.3902	8.3940	19.7701
Jun-35	14.8334	14.0253	18.7129	10.6786	3.9097	1.4725	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	15.2753	15.2753	14.9753	14.9753	19.9629	19.9629	19.9629	19.9629	9.8259	8.4097	3.9217	8.4097	8.4097	9.8259	3.8632	0.0404	5.3902	8.4097	19.9629
Jul-35	15.1469	14.3695	19.0593	10.8186	3.9324	1.4788	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	15.6195	15.6195	15.3195	15.3195	20.3093	20.3093	20.3093	20.3093	9.8611	8.4324	3.9217	8.4324	8.4324	9.8611	3.8632	0.0404	5.3902	8.4324	20.3093

Appendix D-7: Reduced Fuel Forecast (March 21, 2016)

Month	Monthly Average Price (US$/MMBTU)						Adders (US$/MMBTU)									Final Price (US$/MMBTU)														EcoEléctrica				
							No. 6			No. 2				Natural Gas @ HH		No. 6				No. 2							Nat Gas Aguirre	Nat Gas CS 5&6		Base Fuel	Energy Charge	Energy Charge	Future 1,3 & 4 Spot Fuel Price	Future 2 Spot Fuel Price
	WTI	No. 6	No. 2	Natural Gas Indexed to No. 6	Natural Gas @ Henry Hub	Coal CAPP	San Juan / Palo Seco	Aguirre	Souco	Aguirre / San Juan CC	Mayagüez / Arecibo	Trucks	Natural Gas Indexed to No. 6	Capacity charge and others	Shipping Cost Adder	Aguirre	Costa Sur	San Juan	Palo Seco	Aguirre CC	San Juan CC	Mayaguez	Arecibo	Natural Gas Indexed to No. 6	Natural Gas Indexed to HH	Coal AES	Future 1,3,&4	Nat Gas Futures 1,3,&4	Nat Gas Future 2	US$/MMBTU	US$/kWh	US$/MMBTU	US$/MMBTU	US$/MMBTU
Aug-35	15.4710	14.7262	19.4164	10.9903	3.9539	1.4875	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	15.9762	15.9762	15.6762	15.6762	20.6664	20.6664	20.6664	20.6664	9.8726	8.4539	3.9217	8.4539	8.4539	9.8726	3.8632	0.0404	5.3902	8.4539	20.6664
Sep-35	15.7278	15.0106	19.6978	11.1770	3.9737	1.4966	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	16.2606	16.2606	15.9606	15.9606	20.9478	20.9478	20.9478	20.9478	9.8841	8.4737	3.9217	8.4737	8.4737	9.8841	3.8632	0.0404	5.3902	8.4737	20.9478
Oct-35	15.6145	14.8902	19.5684	11.2918	3.9888	1.5047	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	16.1402	16.1402	15.8402	15.8402	20.8184	20.8184	20.8184	20.8184	10.0609	8.4888	3.9217	8.4888	8.4888	10.0609	3.8632	0.0404	5.3902	8.4888	20.8184
Nov-35	15.3184	14.5703	19.2358	11.3000	3.9979	1.5065	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	15.8203	15.8203	15.5203	15.5203	20.4858	20.4858	20.4858	20.4858	10.0724	8.4979	3.9217	8.4979	8.4979	10.0724	3.8632	0.0404	5.3902	8.4979	20.4858
Dec-35	14.5355	13.7227	18.3590	11.1254	3.9935	1.5049	0.9500	1.2500	1.2500	1.2500	1.2500	1.3753	1.1250	1.0000	3.5000	14.9727	14.9727	14.6727	14.6727	19.6090	19.6090	19.6090	19.6090	10.0782	8.4935	3.9217	8.4935	8.4935	10.0782	3.8632	0.0404	5.3902	8.4935	19.6090

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PREC Order Section 6. Transmission

Hereby PREPA provides the requested responses on Transmission required to maintain a reliable system under the recommended portfolio 3.

As rightly indicated by the Commission the transmission analysis under Volume II of the Base IRP (i.e. the IRP filed on August 2015), was based on using 3 SCC-800 at the Palo Seco site instead of the Portfolio 3 recommended F-Class combined cycle.

This was done in this way for the following reasons; the first one is that from a transmission point of view both Portfolios were very similar; the key driver of the transmission investments is the generation in the north, being the three SCC-800 at Palo Seco considered in Portfolio 2 somewhat a more conservative solution than the F-Class considered in Portfolio 3; both provide voltage support at Palo Seco and their maximum power output was similar (210 MW vs 279 MW). As shown in Table 1-1 of Volume II of the Base IRP report, the study of the Portfolio 2 results in a slightly more stressed system and the solutions indentified will work for both Portfolios. Moreover the uncertainty with respect of the demand in the north would more than make for the differences in active power output.

The second reason is that the smaller SCC-800 or similar small combined cycle technology solution was deemed to be more flexible and the probability that the Portfolio 3 would be modified to include these units was seen likely at the time and this cemented our decision.

This last issue turned out to be right, as a result of the review of the demand forecast mandated by the Commission to incorporate the impacts of EE, we evidenced the opportunity of minimizing further the generation in the north and this can be most effectively be achieved by adopting the SCC-800 solution, reciprocating engines or similar technology[1]. Thus if the demand drops as indicated by the Commission only one SCC-800 is built, however if it does not due to many reasons including economic recovery and growth, then the solution

[1] The results of the supplemental IRP evaluation with reduced demand still support the small combined cycle technology (SSC-800 or similar) as the preferred option.

adding additional small combined cycles like the SCC-800 is implemented. The solution with one F-Class unit does not have this flexibility.

Section 6.a.

The list of major planned transmission projects required under Portfolio 3 is similar to the list provided in Volume II (Tables 11-1 and 11-2). The following list of projects is prioritized based on different categories that address system stability and reliability issues from different perspectives in the context of power systems analyses and simulation results complemented with field evaluations and inspections. It is important to emphasize that the strategic integration of the transmission projects included in each category is critical, independently of its assigned priority, to permit compliance with the system reliability requirements.

Priority 1 Projects – main projects critical to voltage stability and voltage regulation, voltage collapse situations might result if no reactive power sources, reliable transmission lines and transmission centers are strategically integrated to compensate for the generation reduction at the North. If these investments are not in place there would be immediate and uncontrollable system collapse.

- Dynamic Reactive Compensation STATCOM 100 MVARS Monacillo
- Dynamic Reactive Compensation STATCOM 100 MVARS at SJSP
- Line 50900 Aguirre – Aguas Buenas
- Line 51000 Aguirre – Aguas Buenas

This category also includes main 230 kV projects critical to manage severe and multiple system overloads. These overloads can be so severe that it is possible that they result in the uncontrolled tripping of the affected elements and cascading outages that could result in partial or total system blackouts. The absence of these investments would result in unacceptable operating conditions.

- New 230/115 kV Transformer Bayamón TC
- New 115 kV Underground Cable Sabana Llana TC – Berwind TC

- Yabucoa – Humacao Corridor (41000 & 36300 Reinforcement and Relocation
- Line 51000 Aguirre – Aguas Buenas
- Line 50900 Aguirre – Aguas Buenas
- Line 50900 Aguas Buenas – Bayamón TC
- Line 51000 Aguas Buenas – Sabana Llana TC
- Line 50200 Costa Sur – Manatí TC
- Line 50200 Manatí TC – Bayamón TC
- Line 50100 Cambalache TC – Manatí TC

Priority 2 Projects – this includes projects related with 115 kV transmission lines that mitigate the propagation of cascaded outages by providing backup circuits and high power transfer capability toward major load centers. These projects also mitigate transmission congestion and the need to turn on expensive generation in the north during certain transmission outages.

- Line 37800 Cayey TC – Caguas TC & Caguas TC – Monacillo TC
- Line 41400 Humacao TC – Juncos TC
- Line 37400 Cambalache TC – Barceloneta TC
- Line 36200 Monacillo TC – Quebrada Negrito
- Line 36100 Bayamón TC – Ciales
- Line 38900 Hato Rey TC – Martin Peña GIS

Priority 3 Projects – main projects related with serious switchyard reliability and operational problems, system protection coordination problems and mitigation of major system faults and outages need to be addressed by the integration and replacement of critical switchyard equipment and elements

- San Juan new 38 kV GIS and 115 kV GIS Bus Extension.
- Control and Protection Metropolitan Area TC (Monacillo TC and Viaducto TC)
- Bus Reconstruction of Monacillo TC and Viaducto TC
- Venezuela TC

Section 6.b.

In response to the request for providing a table elaborating the cost and timing of each major transmission project; we provide below in Table 1 the projects identified in the Base IRP, all of which are necessary, and their required commercial dates. Note that these dates while updated to represent a reviewed sequencing of projects, are based on the same starting dates of the Base IRP (start Jun 2015) for comparison reasons and requires that all investments must be in place by the time the steam units in the north are retired (December 2020 as per the Base IRP). These dates will have to be updated by the time the IRP is approved taking into consideration the conditions and timing of such approval and may include shifts mandated by operating and reliability constraints .

The table above is followed by Table 2 that provides the costs and timings of the additional investments identified to reduce the required generation in the north if the demand were to drop according to the Energy Efficiency assumptions in the supplemental IRP evaluations.

Table 1: Base IRP Projects

Main Transmission Projects Capital Costs Summary	Commercial on line date	All-in Capital Costs ($2015 thousands)
Dynamic Reactive Compensation STATCOM 100 MVAR Monacillo	10/1/2018	17,300
Dynamic Reactive Compensation STATCOM 100 MVAR at SJSP	4/1/2019	18,900
New 230/115 kV Transformer Bayamón	1/1/2020	24,100
West Area Capacitor Bank	1/1/2019	526
San Juan GIS 38 & 115 kV extension for new underground circuits and second 115/38 kV transformer	7/1/2020	9,075
Control and Protection Metropolitan Area TC	7/1/2018	7,680
Bus Reconstruction Area TC	7/1/2017	2,300
Venezuela Transmission Center	1/1/2020	9,901
Yabucoa - Humacao Corridor(41000 &36300) Reinforcement and Relocation (New 115 kV underground cable)	1/1/2019	12,625
Line 50900 Aguirre - Aguas Buenas	10/1/2017	16,383
Line 51000 Aguirre - Aguas Buenas	10/1/2017	16,383
Line 50900 Aguas Buenas - Bayamón TC	10/1/2018	8,331
Line 51000 Aguas Buenas - Sabana Llana TC	1/1/2019	11,252
Line 50200 Costa Sur - Manatí TC	7/1/2020	23,984
Line 50200 Manatí TC - Bayamón TC	4/1/2020	20,068
Line 50100 Cambalache TC - Manatí TC	4/1/2019	16,536
Line 37400 Manatí TC – Vega Baja TC – Dorado TC	4/1/2017	11,696
Line 36100 Bayamón TC – Ciales	12/1/2017	2,028
Line 37800 Cayey - Caguas & Caguas TC - Monacillo TC	7/1/2019	33,192
Line 37400 Cambalache TC - Barceloneta TC- Manatí TC	4/1/2017	6,310
Line 38900 Hato Rey TC – Martin Peña GIS	10/1/2019	2,044
Line 36200 Monacillo TC- Quebrada Negrito	7/1/2020	11,390
Line 41400 Humacao TC-Juncos TC	12/31/2020	8,067
New 115 kV Underground Cable Sabana Llana TC – Berwind TC	7/1/2018	16,304
Total Main Transmission Projects Base IRP		306,375

Table 2: Supplemental IRP Required Projects

Main Transmission Projects Capital Costs Summary	Commercial on line date	All-in Capital Costs ($2015 thousands)
New Underground Transmission Line Berwind TC - Martin Peña GIS	7/1/2020	34,600
Reconstruction and reconductoring of Line 37900 Sabana Llana TC - Monacillo TC	12/1/2020	8,040
Construction of a new 115 kV San Juan GIS to replace the existing switchyard	12/1/2020	42,400
Total Supplementary IRP Transmission Projects Base IRP		**85,040**

Section 6.c.

Please refer to the Siemens Report titled "PREPA Integrated Resource Plan Supplementary Evaluation: Transmission Analysis" for the evaluations conducted to evaluate the transmission requirements for the revised scenarios and that result in the investments presented in Table 2 above.

Section 8.a.

Transmission Action Plan: Major Capital Expenditures

The tables below provide the implementation detail for the transmission projects separated in those that are related to the Base IRP and those corresponding to the additional investments required for the supplemental IRP. Some of the projects that require line reconstruction no engineering / procurement are provided as these are already in place or it follows standardized procedures. Also for the San Juan GIS, engineering and construction of the 38 kV GIS bus are advancing in parallel.

Figure 1 Action Plan For Base IRP Projects

Main Transmission Projects Facility	2015		2016				2017				2018				2019				2020				Cost [000$]
	Jul-Sept	Oct-Dec	Jan-Mar	April-Jun	Jul-Sept	Oct-Dec	Jan-Mar	April-Jun	Jul-Sept	Oct-Dec	Jan-Mar	April-Jun	Jul-Sept	Oct-Dec	Jan-Mar	April-Jun	Jul-Sept	Oct-Dec	Jan-Mar	April-Jun	Jul-Sept	Oct-Dec	
San Juan GIS 38 kV & 115 kV Bus extension to integrate 115 kV underground circuits and transformer #2 115/38 kV																							9,075.00
Control and Protection Metropolitan Area TC																							7,680.00
Bus Reconstruction Metropolitan Area TC																							2,300.00
Line 37800 Jobos - Caguas & Caguas TC - Monacillo TC																							33,192.00
Line 50100 Cambalache TC - Manati TC																							16,536.00
Line 36100 Bayamón TC – Ciales																							2,028.00
Line 37400 Cambalache TC - Barceloneta -Manati TC																							6,310.00
Line 37400 Manati TC-Vega Baja TC- Dorado TC																							11,696.00
Line 36200 Monacillo TC- Quebrada Negrito																							11,390.00
Line 41400 Humacao TC-Juncos TC																							8,067.00
New 115 kV Underground Cable Sabana Llana TC – Berwind TC																							16,304.00
Line 50200 Manati TC - Bayamon TC																							20,068.00
Line 38900 Hato Rey TC – Martin Peña GIS																							2,044.00
Dynamic Reactive Compensation STATCOM 100 MVAR MTC																							17,300.00
New 230/115 kV Transformer Bayamon, switchyard extension and bus reconfiguration																							24,100.00
West Area Capacitor Bank																							526.00
Line 50200 Costa Sur - Manati TC																							23,984.00
Venezuela TC																							9,901.00
Yabucoa - Humacao Corridor(41000 &36300) Reinforcement and																							12,625.00
Line 51000 Aguas Buenas - Sabana Llana TC																							11,252.00
Dynamic Reactive Compensation STATCOM 100 MVAR BTC																							18,900.00
Line 50900 Aguas Buenas - Bayamón TC																							8,331.00
Line 50900 Aguirre - Aguas Buenas																							16,383.00
Line 51000 Aguirre - Aguas Buenas																							16,383.00
																							$ 306,375.00

Legend	
Switchyards protection, coordination and control systems replacement	
Transmission centers and switchyards increase capacity, reconstruction and major improvements projects	
230 kV lines reconstruction	
115 kV lines reconstruction	
New 115 kV lines	
New 115/38 kV switchyard	
New STATCOM and Reactive Sources	
Engineering Design and Procurement (EDP)	
EDP/Construction	

Figure 2 Action Plan For Additional IRP Projects

Main Transmission Projects Facility	2015 Jul-Sept	2015 Oct-Dec	2016 Jan-Mar	2016 April-Jun	2016 Jul-Sept	2016 Oct-Dec	2017 Jan-Mar	2017 April-Jun	2017 Jul-Sept	2017 Oct-Dec	2018 Jan-Mar	2018 April-Jun	2018 Jul-Sept	2018 Oct-Dec	2019 Jan-Mar	2019 April-Jun	2019 Jul-Sept	2019 Oct-Dec	2020 Jan-Mar	2020 April-Jun	2020 Jul-Sept	2020 Oct-Dec	Cost [000$]
New San Juan 115 kV GIS																							42,400.00
Line 37900 Monacillos TC-Sabana Llana TC																							8,040.00
New 115 kV Underground Cable Martin Peña GIS – Berwind TC																							34,600.00
																							85,040.00

Legend	
New 115 kV switchyard	
115 kV lines reconstruction	
New 115 kV lines	
Engineering Design and Procurement (EDP)	

The transmission action plans shown above are very aggressive and tightly scheduled and its successful realization depends closely on various precedent processes and conditions, which are detailed below:

- PREPA's restructuring process outcome and results.
- IRP approval process.
- Availability of the necessary funds for these projects.
- Continuous availability of PREPA's specialized helicopters for the transmission lines construction works.
- Full availability of the necessary highly specialized technical and engineering human resources for completing these projects.
- Capacity to hire adequate human resources and technical and engineering services as required for the projects.
- Timely award of construction permits by the Office of Permits Management (OGPe).
- The purchase of major equipment, materials and services is done on time and without delays caused by bid protests or other complaints.
- The projects construction schedule is not delayed by third parties complaints or law suits against PREPA regarding the construction works.
- The projects sites, specially the new underground lines, are free from archaeological findings, contamination or similar conditions, which could require remedies or mitigation actions
- No force majeure events such as storms and hurricanes affecting the project construction.
- The coordination of programmed outages is done in a timely manner, without risking the reliability and security of the power system for which is considered a minimum of

contingencies on the generation and transmission systems. This coordination can be fully achieved only if there are no additional contingencies to those already planned for. The coordination of programmed outages is particularly critical for the reconstruction of the transmission lines, some of which share the same easement.

The projects' action plans and work schedule could be significantly delayed by any of the above processes and conditions, and evidently, as shown in the transmission analyses, as consequence the ability of the system to operate reliably without the steam turbine generation in the North of the island would be impossible.

Siemens PTI Report Number:

PREPA Integrated Resource Plan Supplementary Evaluation: Transmission Analysis

REDACTED - Draft for the Review of the Puerto Rico Energy Commission.

Prepared for

Puerto Rico Electric Power Authority

Submitted by:
Siemens Industry

April 1, 2016

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Revision History

Date	Rev.	Description
March 28, 2016		Draft for the review of the Puerto Rico Energy Commission.
April 1, 2016		Second Draft including Additional Section 1.3.7 entitled “Cable Sabana Llana TC to Berwind TC”

Contents

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Section

1

Introduction

The transmission study has as one of its main objectives to evaluate the transmission requirements for revised scenarios, as well as to perform the corresponding system analyses to identify which elements of the planned transmission upgrades and projects are still needed.

As could be appreciated, the assumed reduction in demand opened the opportunity for reduction of conventional generation additions and in particular the generation in the north, which is one of the most expensive under most Futures, where the gas availability is limited to the south of the island.

This minimization of north of the island generation, while optimal from the point of view of load supply, results in a heavier use of transmission beyond what was considered in the Base IRP (August 2015 filed IRP). Another way of seeing this is that the optimal use of the reduction in load is rather than postponing transmission additions is to delay or eliminate the addition of new expensive generation in the north.

The transmission plan formulated, however, requires PREPA to rely more on its transmission system that will need to be refurbished, as indicated in the Base IRP and strengthened with the same investments identified in the same study and to which PREPA will need to add some additional transmission investments identified in this supplemental IRP assessment. A very important disadvantage related with this transmission topology is that it increases the grid's vulnerability to atmospheric disturbances, natural disasters, sabotage attacks and multiple contingency system events with the potential of electrically separating the major load centers located in the North from the generation facilities of the South. These situations could result in system blackouts and outages, as well as prolonged service interruptions to thousands of industrial, commercial and residential clients throughout the north and east of Puerto Rico.

1.1 Scenarios

The present study was based on the analysis of six base cases that were created considering a reduced demand forecast as per the Puerto Rico Energy Commission's December 4, 2015 Order, as clarified and amended. A short term scenario, the fiscal year 2021 (Calendar 2020) with a total demand of 2833 MW and a long term scenario at the 2035 with a total demand of 2308 MW were studied.

For both conditions, the following was considered:

- SCC-800 combined cycle trains

- Reciprocating engines
- No generation in the north

This totalizes the six scenarios that were studied. In the study one of the two San Juan combined cycle train (San Juan 5&6 or the San Juan Repowering) was considered unavailable due to maintenance and the other train was considered available.

The previous study considered that three SCC-800 combined cycle units with duct firing were necessary in the north to supply a night peak load of 3030 MW. This conclusion was based on the assumption that the demand was not reduced by the 2020 and the peak load during night was similar to the 2015. Figure 1-1 shows the comparison of the previous load forecast with the one that is considered in this study. It can be observed that the load reduction by 2020 can is small, but by the 2035 the difference is of 600 MW.

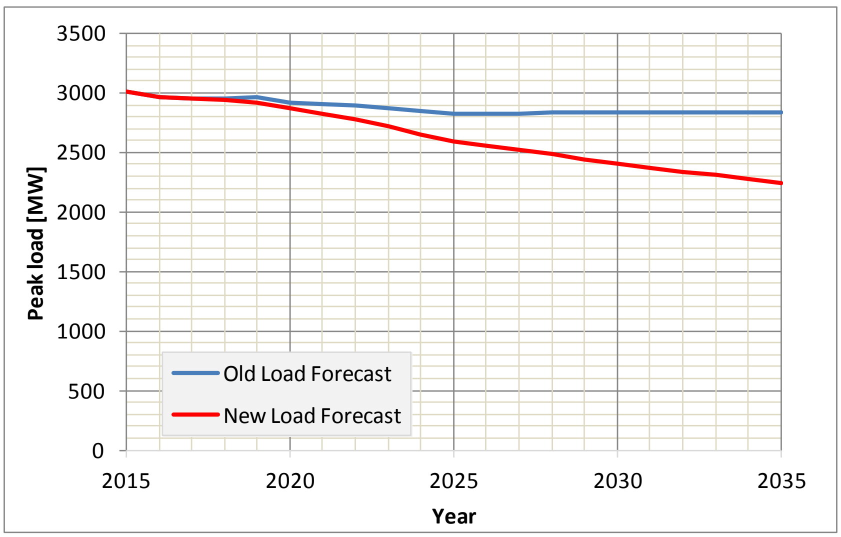

Figure 1-1. New and old night peak load forecast for Puerto Rico.

1.2 Dispatch Conditions

The analysis was conducted for the nigh peak as this is the time the heaviest use of transmission occurs, due to the absence of renewable generation.

The base dispatch conditions were obtained from the PROMOD runs at 21 hrs August 11 of 2022 and were adjusted to match the north generation scenarios.

1.2.1 SCC-800 combined cycle at Palo Seco

The base case considers that there is only one combined cycle SCC-800 running without duct firing. Duct firing increases the net output of the unit in 13 MW. The total generation available at Palo Seco transmission center is of 70 MW.

The total conventional generation available at the north of the 2020 case is 270 MW; one San Juan Repowering (200 MW) + the SCC 800 at Palo Seco (70 MW).

The total generation at the 2021 night peak case was of 2,833 MW, with a total spinning reserve of 460 MW (%16) and is detailed in the table below;

Table 1-1. FY2021 – Night peak case.

Unit	Dispatch [MW]
805 C.S.5 23.000	290
806 C.S.6 23.000	287
809 AG.1 24.000	350
810 AG.2 23.000	350
811 SJREPST1 13.800	44.7
856 SJREPG1 13.800	155.3
858 ECOGT1 17.100	162.7
859 ECOGT2 17.100	162.7
860 ECOSTEAM 17.100	181.5
871 AES 1 21.000	227.0
872 AES 2 21.000	227.0
Palo Seco (1 x SCC800)	57
10601 AG_REPCC-1 15.000	263.5
10602 AG_REPCC-2 15.000	0
TOTAL	**2833**
Total thermal	**2757**
Total hydro	**59**
Total renewable	**16**

[redacted] shows the voltages and flows in the main facilities on the Puerto Rico system.

1.2.2 Reciprocating engines at Palo Seco

The base case considers four reciprocating units of 17.3 MW each at Palos Seco. The total conventional generation available at the north of the 2020 case is 269 MW; one San Juan Repowering (200 MW) + 4 x 17.3 MW reciprocating engines at Palo Seco (69.2 MW).

The total generation at the 2021 night peak case was of 2,833 MW, with a total spinning reserve of 443 MW (%16) and is detailed in the table below;

Table 1-2. FY2021 – Night peak case.

Unit	Dispatch [MW]
805 C.S.5 23.000	290
806 C.S.6 23.000	283
809 AG.1 24.000	350
810 AG.2 23.000	350
811 SJREPST1 13.800	44.7
856 SJREPG1 13.800	155.3
858 ECOGT1 17.100	162.7
859 ECOGT2 17.100	162.7
860 ECOSTEAM 17.100	181.5
871 AES 1 21.000	227.0
872 AES 2 21.000	227.0
Palo Seco (4 x 17.3)	69.2
10601 AG_REPCC-1 15.000	263.5
10602 AG_REPCC-2 15.000	0
TOTAL	**2833**
Total thermal	**2757**
Total hydro	**59**
Total renewable	**16**

This case presented a voltage profile similar to the one that considers SCC-800 combined cycle units. STATCOM devices also presented a similar reactive power generation.

[redacted] shows the voltages and flows in the main facilities on the Puerto Rico system.

1.2.3 Case with no generation at Palo Seco

This case considers that there is no new generation available by the 2020 at Palo Seco. The total conventional generation available in the north of the island (after MATS compliance retirements) in the 2020 case is 200 MW (one S.J. Repowering combined cycle).

This case presented voltage profiles similar as the previous, but both STATCOM devices increased it loading to %20% and %27, respectively (20 MVAr and 27 MVAr).

[redacted] shows the voltages and flows in the main facilities of the Puerto Rico system.

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1.3 Transmission reinforcements

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Section

2

Contingency Analysis

2.1 Contingency Selection (Confidential)

The following contingencies were simulated through the AC contingency solution (ACCC) activity:

- All single contingencies at 115 kV and 230 kV voltage levels (N-1).
- Generation contingencies (G-1).
- [redacted]
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2.2 Planning Criteria

All facilities under normal or contingency conditions must be below their normal rating (Rate A – current expressed as MVA). If the loading results greater than 85%, it will be reported, as some of current PREPA' transmission lines are limited to this power transfer level.

Bus voltages under normal and contingency conditions should be within the 0.95 to 1.05 pu range. From previous studies PREPA has indicated that the normal operation of 115 kV buses within San Juan metro area is in the order of 1.03 pu and under contingencies they expect that it should not go further than 0.97 pu.

It will be reported as abnormal bus voltage any deviation further than 0.90 pu.

2.3 Contingency analysis FY 2021 – with generation at Palo Seco

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2.3.1 Conclusions (Confidential)

It is possible to conclude that in order to address all the situations above and allow the operation of the system with only one SCC 800 or four large reciprocating engines in Palo Seco after retiring or designation of limited use to the steam units in the north, the following investments are necessary:

- The construction of a new underground cable of 231 MVA capacity between Berwind TC and Martin Peña GIS.
- The reconstruction of the San Juan Repowering units 5 & 6 115 kV switchyard to increase the reliability of these units.
- The reconstruction of the corridor Sabana Llana – Encantada – Conquistador – Monacillos and at the same time change the conductor to a 1192.5 kcmil ACSR (231 MVA)

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2.3.2 Conclusions

It can be concluded that t is not possible to safely operate the system with no generation in Palo Seco after retiring or designation of limited use of the steam units in the north.

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Section

3

Voltage Stability (Confidential)

This section presents the study methodology, assumptions and results of the voltage stability assessment.

The main objective of the Voltage Stability assessment is to determine the margin of security for the scenarios with and without generation at Palo Seco site.

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Section

4

Scenario P3MF2M (Confidential)

In P3MF2M, which is a No AOGP case, the new generation resources are adjusted in consideration of six primary factors: (1) There is no gas at Aguirre and Aguirre 1&2 must be retired (or designated limited use) due to MATS compliance; (2) the assumed lower demand due to ramping EE penetration; (3) the modified RPS targets; (4) replacement of existing units with new highly efficient resources to save fuel costs; and (5) expedited new builds to upgrade the fleet and lower overall system costs. The base case is shown at Figure 4-1.

The Aguirre 1&2 CC units repowering remains the same schedule as in P3F2, i.e., by December 31, 2019 and 2020 respectively. The new resources include:

- H Class 1X1 CC with diesel as primary fuel at Palo Seco by December 31, 2020;
- H Class 1X1 CC with diesel as primary fuel at Aguirre by December 31, 2020;
- H Class 1X1 CC with natural gas as primary fuel at Costa Sur by December 31, 2021.

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Section

5

Dynamic stability assessment

This section presents the study methodology, assumptions and results of the dynamic stability simulations performed by Siemens PTI to assess PREPA's system performance under the FY2021 scenario.

The main objective was to identify if the power system presents an unstable behavior for the scenarios with reduced generation in the north.

The starting points of the stability study are the load flows used at the contingency evaluation. The dynamic data (.dyr) used is the same as the Reliability Study (2014), without the dynamic models of the future renewable projects and the addition of the STATCOM models (Bayamón TC and Monacillos).

The dynamic models of the small generators (Toro Negro, Rio Blanco, Yauco, Dos Bocas, Culebra, and Caonillas & Garza) were not considered as their total output corresponding to each case were replaced by a negative load by the activity GNET. Their impact on the dynamics is considered negligible

The following assumptions were considered for the analysis:

1. The dynamic simulations are performed with PSS®E Revision 32.2.5.
2. A simulation time step of 0.002 seconds has been used in all simulations.
3. A total simulation time of 30 seconds with the first 100 ms undisturbed.
4. The following channels are selected for monitoring the dynamic performance of the system:
    a. Conventional Units – Rotor Angles, Rotor Speed Deviations, Mechanical Power, Electrical Power (Active and Reactive) and Terminal Voltage.
    b. Voltage for all buses in the 115 kV – 230 kV range.
    c. Frequency at Monacillos.
5. The rotor angles were measured related to Aguirre unit 1 (809)

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5.2 Primary reserve assessment

The maximum and minimum limits of the governors for the units that participate in frequency control were updated. The python script (SETGOV.py) was used for a correctly setting up of the limits of the IEESGO and GGOV1 governor models of Costa Sur, Aguirre, San Juan and EcoElectrica generating units and the USGT8H dynamic model used for the SCC-800 unit at Palo Seco. This way it was guarantee that they would not exceed their short term primary regulation limits.

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Section

6

Conclusions

PREPA's power system was evaluated against the scenarios of reduced demand proposed by the Energy Commission. For this, various alternatives were contemplated as regards the thermal generation in the North.

It can be concluded that it is not possible to safely operate the system with no generation in Palo Seco after retiring or designation of limited use of the steam units in the north. It was verified the possibility of the operation of the power system with reduced generation at Palo Seco. Such generation can be composed by an SCC-800 with duct firing, or as well as by a combination of reciprocating engines with similar size to the power provided by the SCC-800.

To achieve this, new reinforcements must be considered in addition to the ones determined at the previous IRP filed study. The reinforcements are essentially necessary due to the increase in the load flow to the metro area due to the reduction of the generation.

A new link between Berwind TC to Martin Peña GIS through the construction of a new underground cable was found to be necessary. Once this cable is in service the existing line will be opened and eventually reconstructed if feasible.

The reconstruction of the San Juan Repowering units 5 & 6 115 kV switchyard to increase the reliability of these units is also required.

The reconstruction of the corridor Sabana Llana - Encantada - Conquistador - Monacillos is necessary due to its current condition and its importance in the flows to the north. It is recommended that its capacity be increased at this time to add flexibility and eventually allow economic operation with the units in the north off line.

Additional investments are recommended to make the gas turbines from Daguao TC and Vega Baja TC more reliable in terms of their availability for remote fast start-ups.

In addition to the lines that require reconstruction and reconductoring, the following transmission lines should be evaluated by PREPA to verify the physical condition and confirm the ampacity:

Line 39000 Aguas Buenas – Monacillo TC

Line 39000 Aguas Buenas – San José – Caguas TC

Line 37800 Jobos TC – Cayey TC

Line 36200 Rio Blanco – Daguao TC

Line 50800 Yabucoa TC – S. Llana TC

It is also very important to emphasize that the transmission plan and topology formulated in this supplemental IRP assessment increases the grid's vulnerability to atmospheric disturbances, natural disasters, sabotage attacks and multiple contingency system events with the potential of electrically separating the major load centers located in the North from the generation facilities of the South. These situations could result in system blackouts and outages, as well as prolonged service interruptions to thousands of industrial, commercial and residential clients and critical loads throughout the north and east of Puerto Rico.

In order to address national electric system security, PREPA's main generating facilities and transmission line corridors have been strategically designed and geographically distributed throughout the Island, and its reliability becomes an aspect of paramount importance. The geographical location of current PREPA's generating units, especially the ones that are located at the metro zone, have been critical in maintaining the stability of the system during multiple contingency events that have separated the system into electrical islands. The capability to maintain the system stable during these types of situations and circumstances through the geographically strategic locations of the generating facilities is one of Puerto Rico's system strengths and fundamental design principles.

It is critical for PREPA's grid reliability and the Island's economic and financial stability, to avoid the catastrophic consequences that under extreme but common events to Caribbean electric isolated systems the generation reduction plan in the North might cause. This relevant aspect of national system security needs to be seriously addressed to complement the formulated transmission plan.

PREPA needs to evaluate the implementation of a Network Security Plan that will define generating solutions beyond those identified via economic studies. This plan will likely include the incorporation of stand-by generation that is not expected to dispatch but just be available to supply the north during a prolonged separation north-south As highlighted in the Base IRP, PREPA will need to evaluate the installation of new stand-by generation at strategic locations on the network and define which units should be maintained in stand-by in the north to confront this type of emergencies. Continuation of the designation of limited use of some of the steam units (SJ 9 &10 PS 3 & 4) could be an alternative, but the selected units must be maintained and frequently started to guarantee availability and performance.

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