DRAFT

PREPA IRP 2019 Technical Conference

August 13, 2019

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Introduction

- Siemens PTI, working with PREPA, developed the 2019 IRP designed with the overarching goal of producing an economic, environmentally sustainable, reliable and resilient system for Puerto Rico.
- The 2019 IRP is not a classical IRP designed to identify the least cost approach to address the expected gap between future load growth and resources while maintaining a desired Planning Reserve Margin (PRM). Rather, this plan must satisfy the five pillars below for <u>a system with declining load</u>.

  - ***Customer-Centric****:* Costumer participation via customer side energy resources, energy efficiency and demand response plays a predominant role in the supply and consumption matrix of Puerto Rico.
  - ***Financial Viability:*** The plan minimizes the cost of supply and drastically reduces the dependence on imported fuels and the associated volatility; thus, supporting affordable rates.
  - ***Reliable and Resilient:*** The IRP is centered on the concept of MiniGrids, defined as zones of resiliency into which the system can be segregated during and after a major event.
  - ***Model of Sustainability:*** The IRP's implementation will transition the Puerto Rico electric system from one centered on fossil fuels to one in which renewable resources play a central, if not, the predominant role, drastically reducing emissions and achieve compliance with all current regulations.
  - ***Economic Growth Engine:*** The new generation resources that will have to be developed and the overall reduction in the system cost are expected to result in employment opportunities and economic growth for Puerto Rico.

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Introduction

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- In this presentation we will go over the analysis process and assumptions that drive the results of the capacity expansion plan and the recommended Action Plan.
- In a separate presentation we will cover the transmission assessment and the investments for resiliency that support and get to the load the generation resources selected by the plans discussed next.
- The presentation covers:
  - ***Formulation of Scenarios, Strategies and Sensitivities***
  - ***Load Forecasts, Energy Efficiency and Customer Resources***
  - ***Existing Resources Considered***
  - ***New Resources Definition and Cost Projection (Thermal, Storage, Renewables)***
  - ***Fuel Forecast***
  - ***Resource Plan Development***
  - ***Caveats and Limitations***
  - ***Action Plan (to be introduced by Mr. Ortiz)***

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Strategies, Scenarios & Sensitivities (LTCE runs)

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Strategies

- Strategies are aspects that PREPA can control in the formulation of the least cost Long Term Capacity Expansion (LTCE) Plan. These strategies were thoroughly discussed during the stakeholder process and are summarized below

- ***Strategy 1*** is fully centralized and there are no local resource requirements. It was used to assess the impact of resiliency requirements.
- ***Strategy 2*** is focused on resiliency and requires that there are local resources installed so they cover at least 80% of the peak demand.
- ***Strategy 3*** drops this requirement to 50%.
- Given the high levels of renewable and storage that the plans are building, in general Strategy 2 results in plans that are similar or better than Strategy 3.

Strategy 1 — A traditional, centralized energy program; *Reliable & Economic*

Strategy 2 — A distributed system of flexible generation, and micro or mini-grids and hardening of existing infrastructure around the island; *Resilient / Closer to Customer*

Strategy 3 — A mixture of the first two strategies that embodies a combination of the benefits of each strategy

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Scenarios Considered

- ***Scenarios*** are a combination of assumptions with respect of infrastructure (e.g. fuel), generation costs and availability as well as other factors that influence the choice and timing of resources serving the load. They were designed to provide information on impact of courses of action and help identifying the best Action Plan.
- Five Scenarios were considered for the LTCE formulation as shown below.
  - **Scenario 1:** was designed to assess the impact of no new gas terminals in the Island, beyond San Juan 5&6 conversion
  - **Scenario 2 and 4:** were designed to assess the impact of LNG and new gas terminals (4 and 2 became equivalent)
  - **Scenario 3:** was designed to assess the way the system would be developed assuming a very low cost of renewables
  - **Scenario 5:** was designed to assess how the system would be developed without any restrictions on thermal
  - **ESM:** Designed based on results of other scenarios to account for expert opinion and uncertainties not factored in by the IRP

Scenario	New Gas				Renewable & Storage	
	AOGP	Land-based LNG at San Juan	Ship-based LNG at Yabucoa	Ship-based LNG at Mayagüez	Costs	Availability
1	No	No	No	No	Reference	Reference
2	No	Yes	No	No	Reference	Reference
3	No	Yes	Yes	Yes	Low	High
4	No	Yes	Yes	Yes	Reference	Reference
5	Yes	Yes	Yes	Yes	Reference	Reference
ESM	No	Yes	Yes	Yes	Reference	Reference

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Cases and Sensitives

- ***Cases:*** The impact of load was accounted for by Cases: Base Load Forecast, High Load Forecast and Low Load Forecast.

- ***Sensitivities:*** Selected to evaluate the change on certain important assumptions. Sensitivities additional to the ones shown below were assessed during the execution of the IRP, but not included in the final evaluation (e.g. Sensitivity 2 lower levels of EE, or Sensitivity 3 economic retirement of AES), due to changes in the law (Act 17-2019)

Sensitivity	Solar/BESS	Gas	Gas	Solar/BESS	Gas	Solar/BESS	PPOA
	Low Cost	Only Ship-based LNG at San Juan	High Gas Prices	High Cost	No Ship-Based LNG at SJ	Base Cost	EcoEléctrica Stays Online
1	◆						
4		◆					
5			◆				
6				◆			
7					◆		
8						◆	
9							◆

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Portfolio Cases

- Portfolio cases are unique combinations of Scenarios and Strategies.
- There were 35 final portfolio cases assessed and an LTCE produced. The portfolio cases are named under the convention of “Scenario ID + Strategy ID + Sensitivity ID + Load Forecast (High, Base or Low)”.
- Scenarios 1 to 4 are assessed under Strategies 1 to 3 and the Base Load Forecast. Scenario 5 is designed not to have any restrictions and only the Strategy 1 is used.
- Scenarios 1 to 4 are assessed under High and Low Growth for the Strategy that resulted in least cost above (Strategy 2 in most cases) as well as the sensitivities.
- Regarding the 35 portfolio cases and associated model treatment, the LTCE is run in all core scenarios and those sensitivities that change the availability of gas (Sensitivity 4 and 7). Other sensitivities to capital costs or fuel prices are carried out maintaining the expansion plan identified in the core run and for the strategy that resulted in least cost

Count	Case ID	Scenario	Strategy	Sensitivity	Load	AURORA LTCE
1	S1S2B	1	2		Base	Yes
2	S1S2H	1	2		High	Yes
3	S1S2L	1	2		Low	Yes
4	S1S3B	1	3		Base	Yes
5	S1S2S1B	1	2	1	Base	No
6	S1S2S5B	1	2	5	Base	No
7	S1S2S6B	1	2	6	Base	No
8	S1S2S7B	1	2	7	Base	Yes
9	S1S1B	1	1		Base	Yes
10	S3S2B	3	2		Base	Yes
11	S3S2H	3	2		High	Yes
12	S3S2L	3	2		Low	Yes
13	S3S3B	3	3		Base	Yes
14	S3S2S5B	3	2	5	Base	No
15	S3S2S8B	3	2	8	Base	No
16	S4S2B	4	2		Base	Yes
17	S4S2H	4	2		High	Yes
18	S4S2L	4	2		Low	Yes
19	S4S2S9B	4	2	9	Base	No
20	S4S3B	4	3		Base	Yes
21	S4S2S1B	4	2	1	Base	No
22	S4S2S4B	4	2	4	Base	Yes
23	S4S2S5B	4	2	5	Base	No
24	S4S2S6B	4	2	6	Base	No
25	S4S1B	4	1		Base	Yes
26	S5S1B	5	1		Base	Yes
27	S5S1S5B	5	1	5	Base	No
28	S5S1S1B	5	1	1	Base	No
29	S5S1S6B	5	1	6	Base	No
30	ESM				Base	Yes
31	ESM High				High	Yes
32	ESM Low				Low	Yes
33	ESMS1B			1	Base	No
34	ESMS6B			6	Base	No
35	ESMS5B			5	Base	No

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Load Forecast, EE & Customer Resources

Load Forecast & Energy Efficiency

- An econometric model was developed for the load forecast for the three largest customer classes: residential, commercial and industrial, using a Classical Linear Regression Model (CLRM) in which the dependent variable, energy sales, is expressed as a linear equation combining the independent variables. For Puerto Rico, 15 variables were used including:
  - *weather variable (cooling degree days or CDD)*
  - *two economic variables (population and GNP)*
  - *12 month specific dummy variables (one for each month of the year) to capture the seasonality of energy demand on a monthly basis*
- For other smaller categories we used historical extrapolations

Residential	Commercial	Industrial
▪ CDD ▪ GNP ▪ Population ▪ 12 months variable	▪ CDD ▪ GNP ▪ 12 months variable	▪ CDD ▪ GNP ▪ Manufacturing employment ▪ 12 months variable

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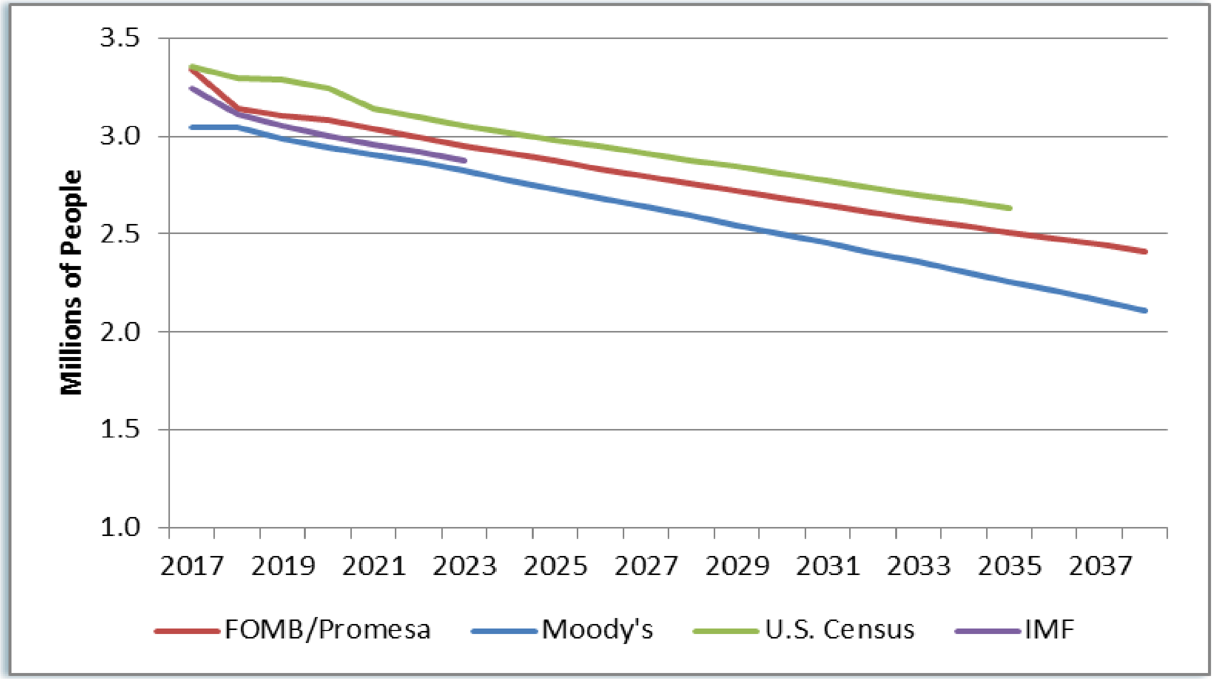
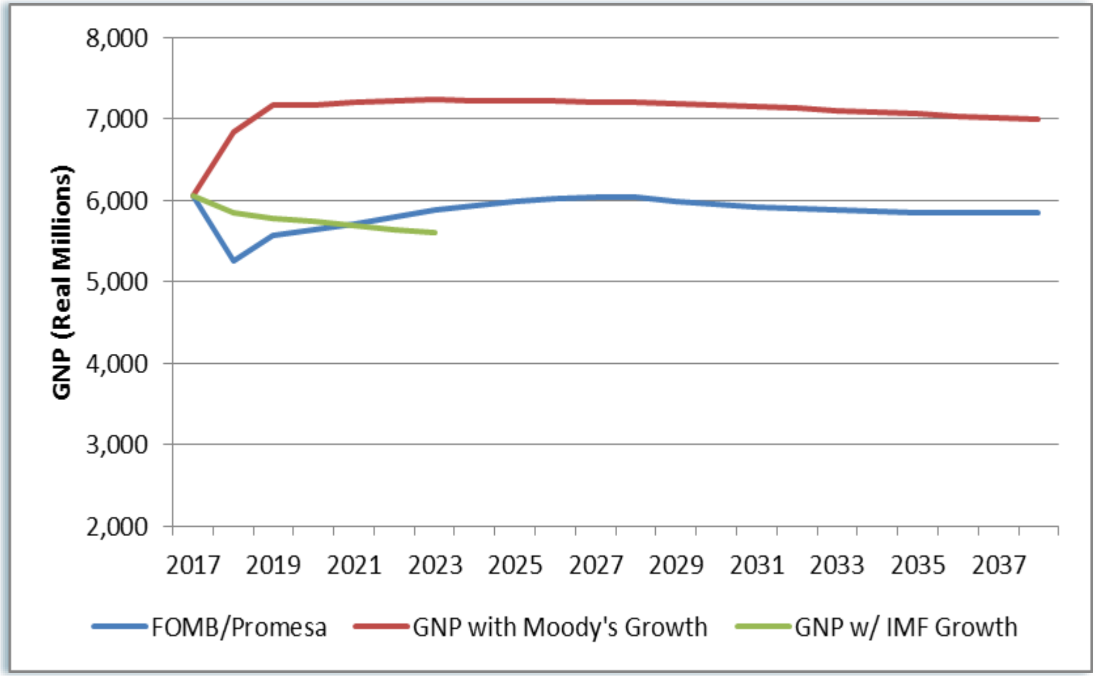
Load Forecast & Energy Efficiency

- Population decline and flat to declining GNP are behind the reductions in the energy forecast.
- FOMB population and GNP forecasts were used in our analysis





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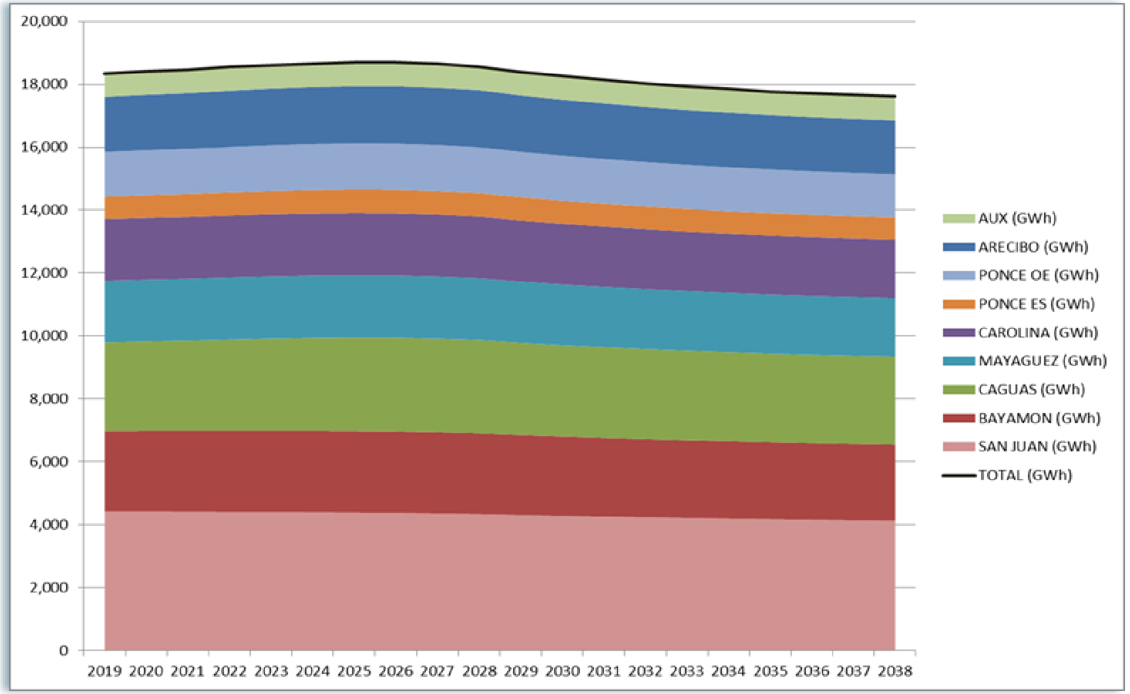
Load Forecast & Energy Efficiency

- The load forecast by customer class was adjusted by including the technical and non-technical losses and PREPA's own consumption creating a forecast of demand for generation.
- This forecast was produced for each of the 10 areas into which the system was separated for modeling.



Fiscal Year	Gross Energy Sales (GWh)	Technical Losses (GWh)	Non-Technical Losses (GWh)	Auxiliary (GWh)	PREPA Own Use (GWh)	Total Energy Demand (GWh)
2019	15,301	1,438	827	751	34	18,351
2020	15,357	1,444	830	751	34	18,415
2021	15,403	1,448	832	751	34	18,469
2022	15,470	1,454	836	751	34	18,545
2023	15,530	1,460	839	751	34	18,613
2024	15,574	1,464	841	751	34	18,665
2025	15,595	1,466	842	751	34	18,689
2026	15,596	1,466	843	751	34	18,690
2027	15,554	1,462	840	751	34	18,642
2028	15,487	1,456	837	751	34	18,565
2029	15,341	1,442	829	751	34	18,397
2030	15,223	1,431	822	751	34	18,261
2031	15,120	1,421	817	751	34	18,144
2032	15,025	1,412	812	751	34	18,034
2033	14,939	1,404	807	751	34	17,935
2034	14,862	1,397	803	751	34	17,848
2035	14,796	1,391	799	751	34	17,772
2036	14,741	1,386	796	751	34	17,708
2037	14,694	1,381	794	751	34	17,654
2038	14,654	1,377	792	751	34	17,608
CAGR	**-0.23%**	**-0.23%**	**-0.23%**	**0.00%**	**0.00%**	**-0.22%**

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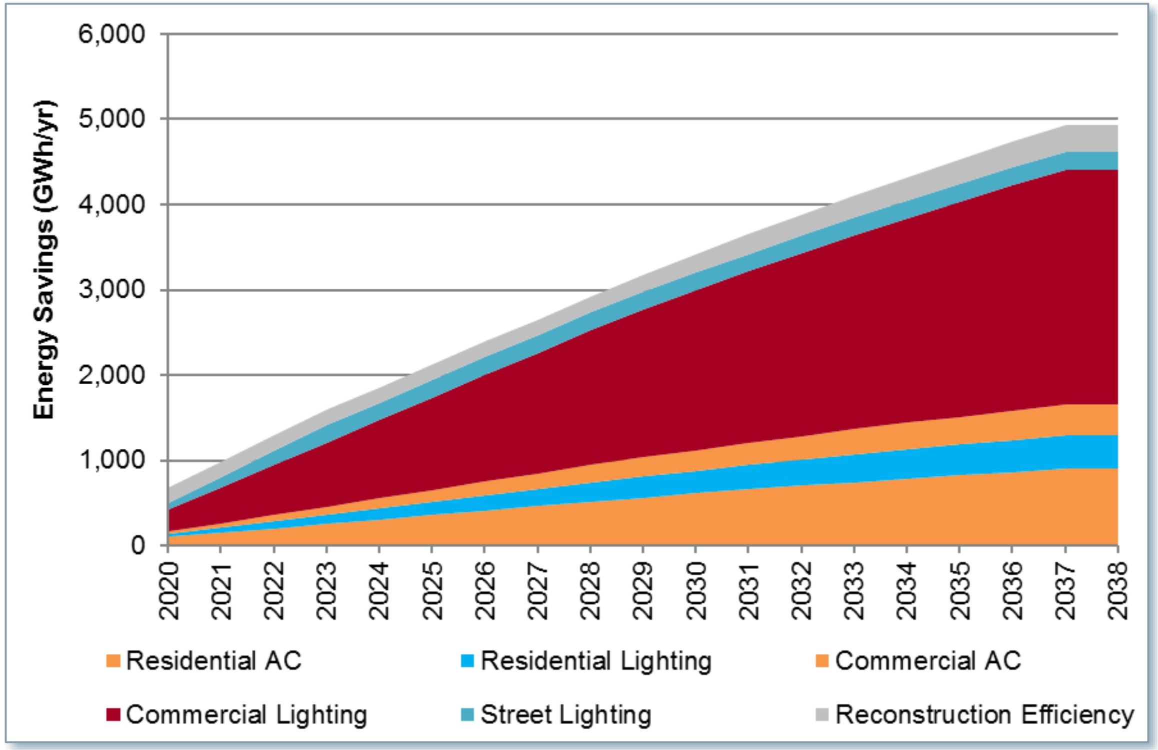
Load Forecast & Energy Efficiency

- Energy Efficiency gains of approximately 2% per year from 2020 until 2037 are included in the forecast.
- Six main categories of energy efficiency were identified and used in the projection, which assumed high levels of success.
- The cost of the EE programs was also identified.



EE Program	Program Description	Rationale	Key Assumptions	Est. Cost Effectiveness Range (TRC[1])
Residential A/C	Incentivizes higher efficiency A/C units in existing homes	Residential consumption represented ~36% of PREPA's total energy load in 2017, and space cooling is a major component of this consumption. This measure provides rebates for the installation of higher efficiency 12 EER A/C units.	Participation rates, energy savings, and program costs are based on comparable programs with adjustments made for Puerto Rico to account for the prevalence of window and split A/C units in homes. Expected useful life is assumed at 10 years and savings are retired as the technology stock turns over.	3 - 5
Residential Lighting	Provides free LEDs to residential customers	This measure provides LED bulbs to residential customers with 5 per customer and 60W equivalent bulbs. This measure offers an option for the nearly 1/3 of customers who rent their residence. Similar lighting projects have also been used in Barbados and Jamaica (Pilot).	Participation rates average 10% annually where participants are using incandescent lamps as a baseline	3 - 5
Commercial A/C	Incentivizes higher efficiency A/C systems in existing commercial buildings	This measure provides an incentive for the installation of more efficient (17 SEER) 5-ton A/C systems in commercial buildings. A prescriptive 5-ton unit size was used to model this measure to simplify the initial program design. Comparable programs are offered by mainland U.S. utilities in Florida and in many other states.	This program model had to assume typical commercial building A/C sizes. Industry calculators were used to estimate the resulting savings from the higher efficiency A/C unit.	1 - 2
Commercial Lighting	Incentivizes installation of high efficiency lighting in commercial buildings	This measure provides commercial customers with a rebate for efficient lighting retrofits which is based on a $ / kW reduction in lighting demand resulting from the retrofit and considers different lighting technologies. Comparable programs are offered by mainland U.S. utilities in Florida and in many other states.	A significant assumption is the annual kWh savings per participant, which was based on a review of comparable lighting programs. This estimate could be better informed by more granular data on commercial building loads in Puerto Rico should this data become available.	2 - 3
Public Street Lighting	Funded full conversion of public street lighting to LED lamps	Street lighting historically accounted for around 2 percent of PREPA's total load. New and more efficient technologies exist and are cost competitive. A full conversion of Puerto Rico's public street lighting, from conventional incandescent lamps to LED, phased in over 5 years.	A key assumption to this measure is that public funding for this project is available.	n/a
Residential Rebuilding Efficiency	Rebuilding Hurricane homes with higher standards for efficiency cooling, appliances and lighting	Additional efficiency is assumed as the remaining homes are rebuilt and restored.	Efficiency savings based on aligned with FOMB Financial Plan and built to current codes and standards.	n/a

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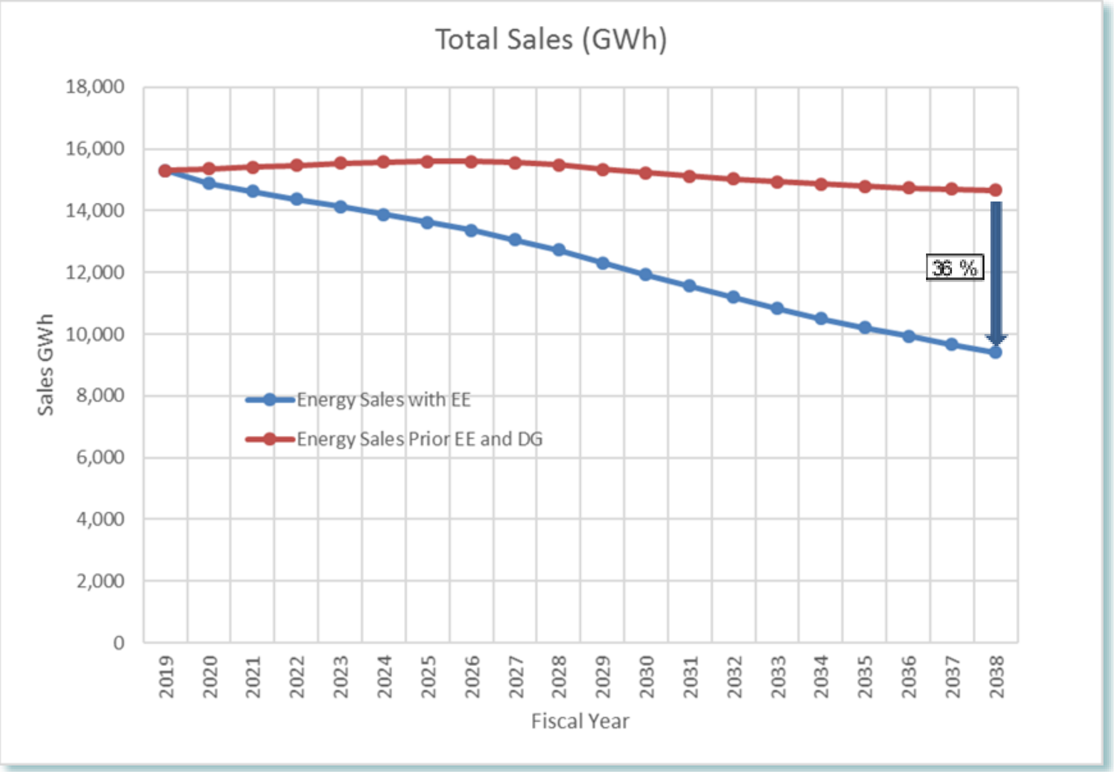
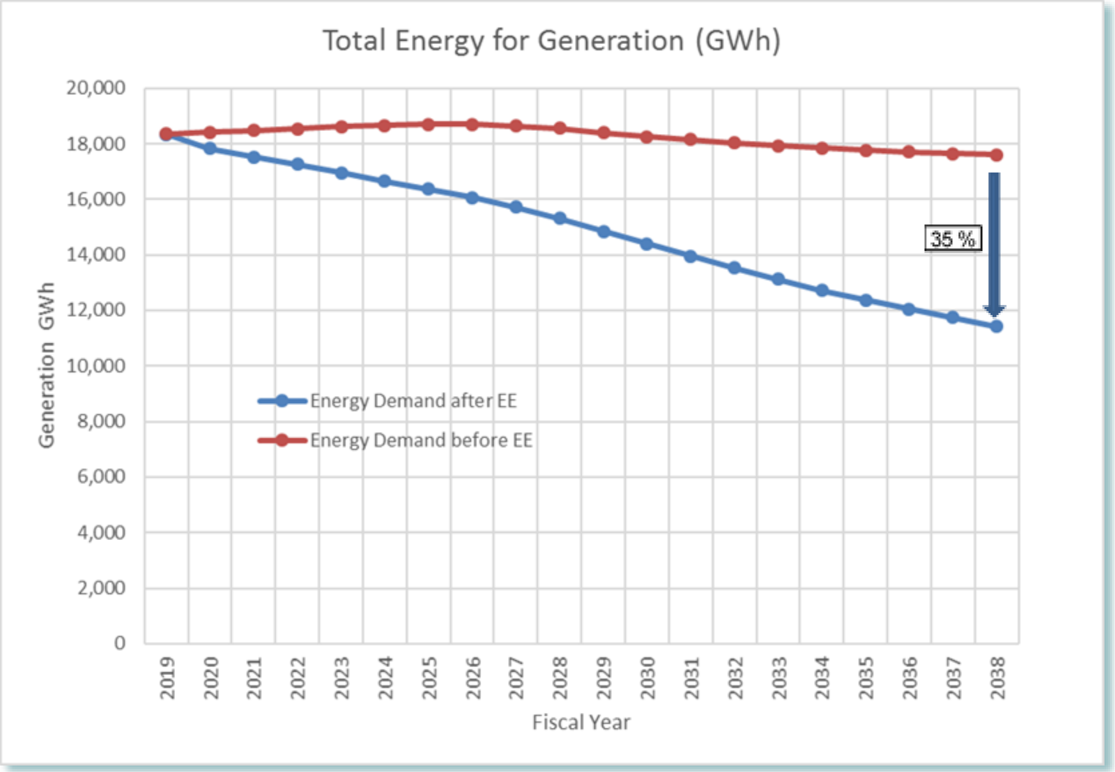
Load Forecast & Energy Efficiency

- The net effect of Energy Efficiency improvements was to reduce the total sales and the demand for generation by 36% and 35%, respectively, by the end of the period.





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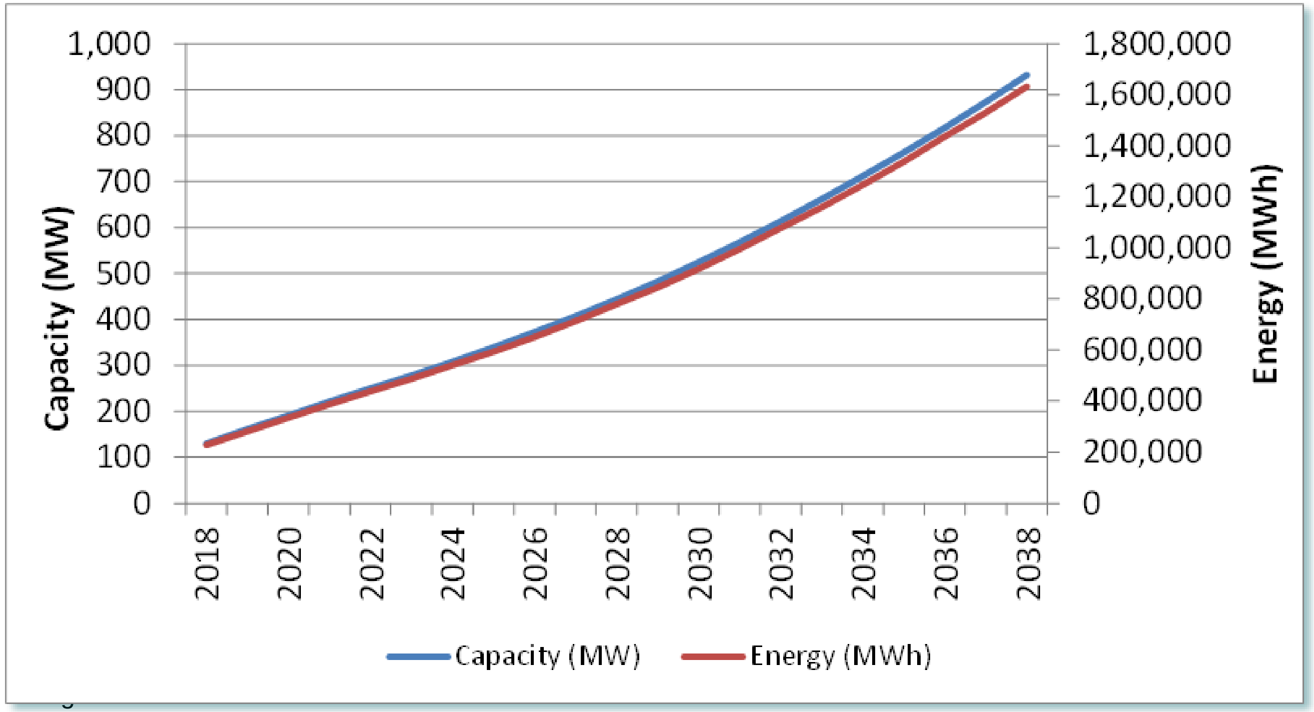
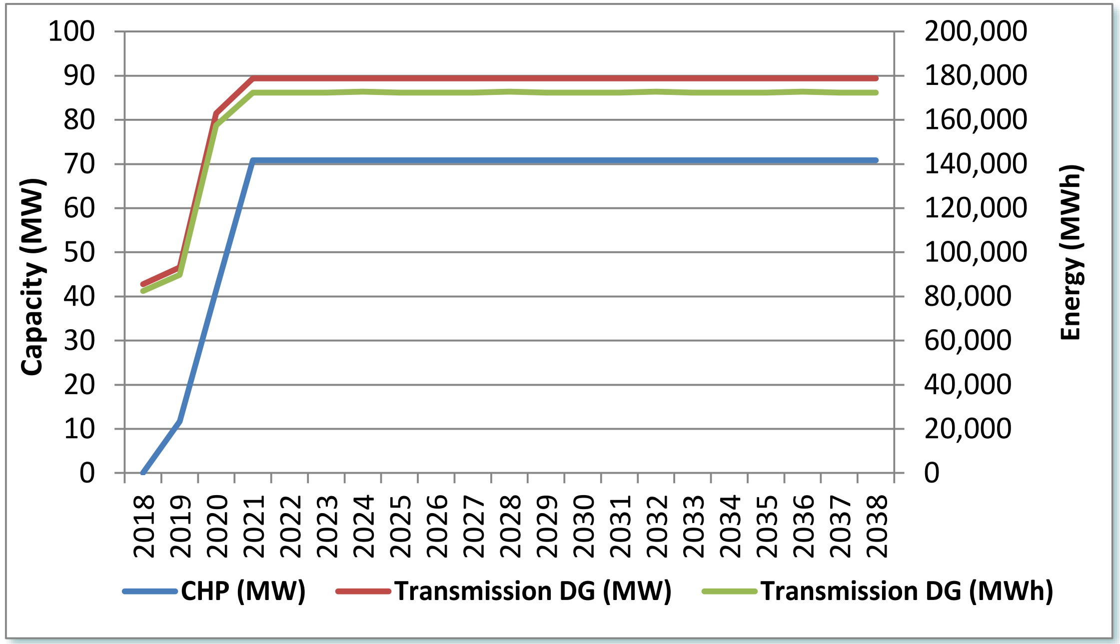
Customer Owned Generation

- Customer owned generation, DG connected at distribution level, DG connected at transmission level and CHP were modeled independently of the load to account for its profile, but they have an important impact on utility served load.
- Distribution level DG was forecasted using an econometric model using the Energy Information Administration (EIA) Annual Energy Outlook (AEO) for Residential Sector Equipment Stock and Efficiency, and Distributed Generation-Solar Photovoltaic Capacity as the exogenous variable for the projection and the historical installation in Puerto Rico.
- For CHP we considered the projects in the interconnection queue and then added to the model this CHP as an available option for selection on the LTCE. A similar approach was done for Transmission Level DG and beyond the interconnection projects in the queue it was modeled as integrated in the utility scale DG.





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Load Forecast + Energy Efficiency + Customer Owned Generation

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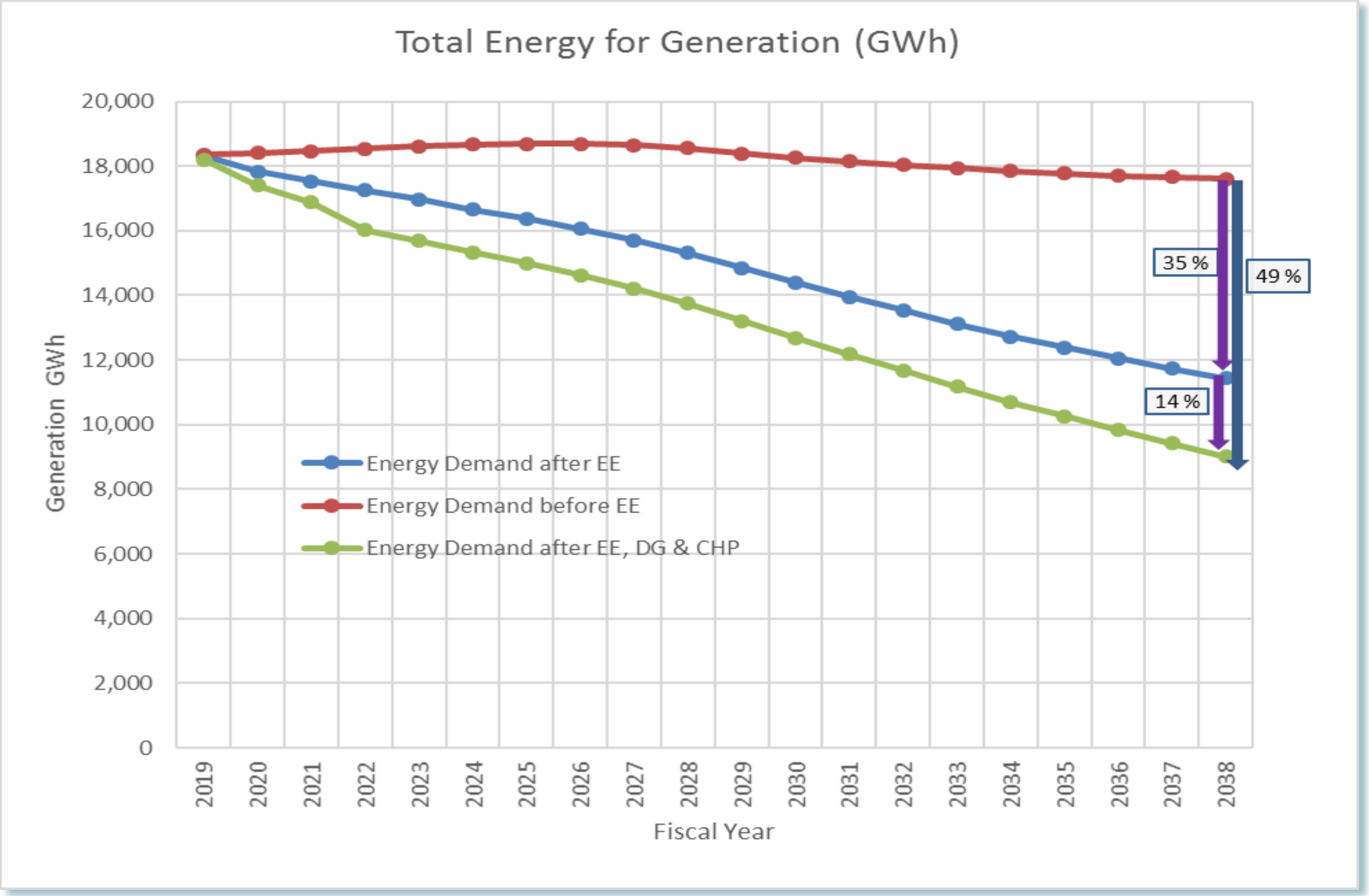
- Once the flat to declining load is combined with the impacts of energy efficiency gains and the effects of customer owned generation, we observe that during the planning period the demand will **Decline** by almost 50%.
- This makes challenging the selection of new resources as their value to the system declines over time as a result of declining energy delivered to the load (i.e., lower Capacity Factors) and reduced need for reserves.
- With declining loads there is a risk of stranding assets.



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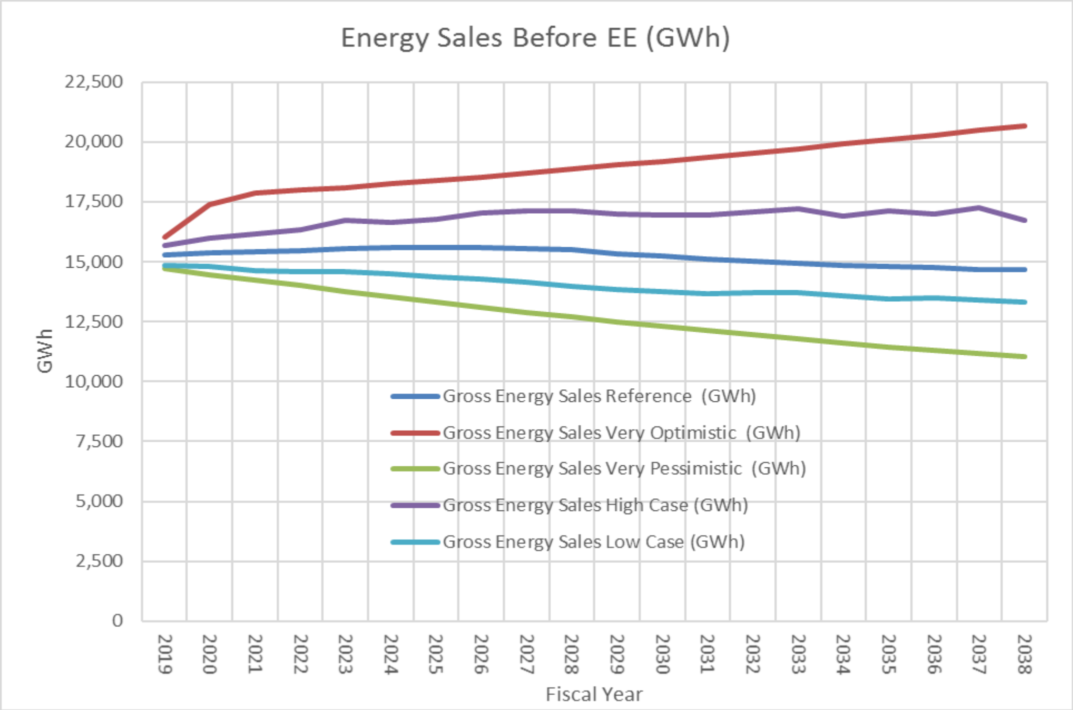
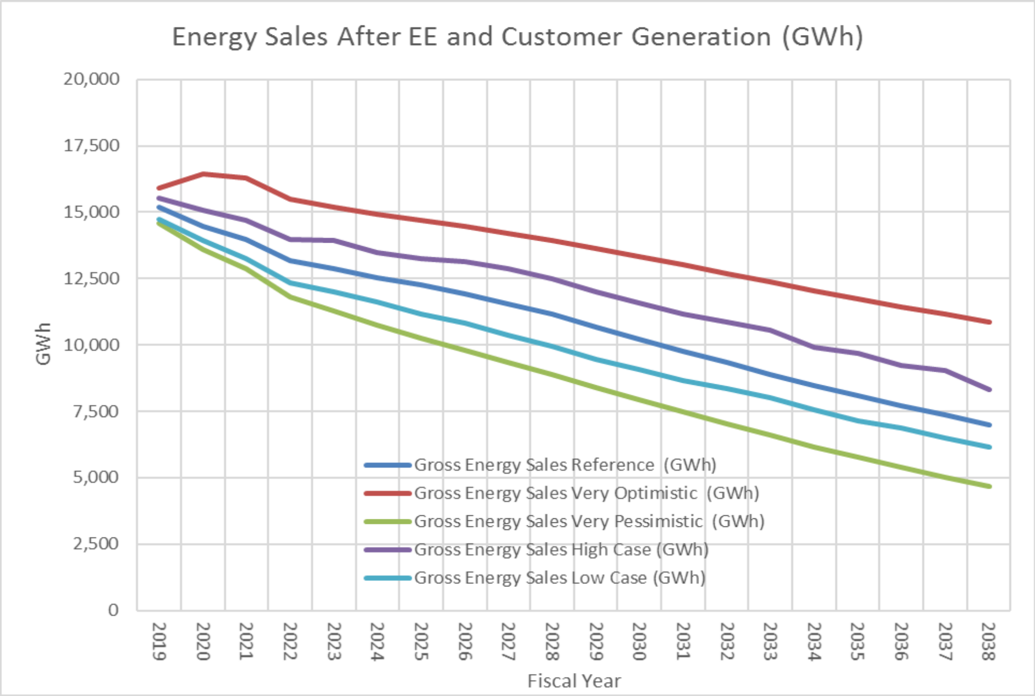
High & Low cases

- Siemens produced a number of forecasts including the high and low cases as well as one very optimistic and one very pessimistic based on changes in the population forecast and GNP forecasts.
- Additionally and stochastic distribution of gross sales was produced.





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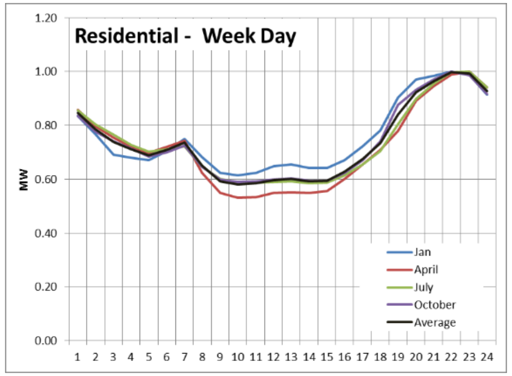
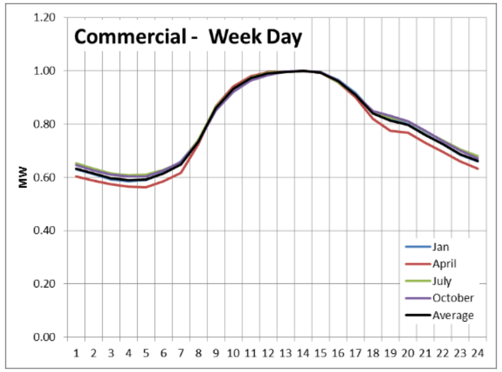
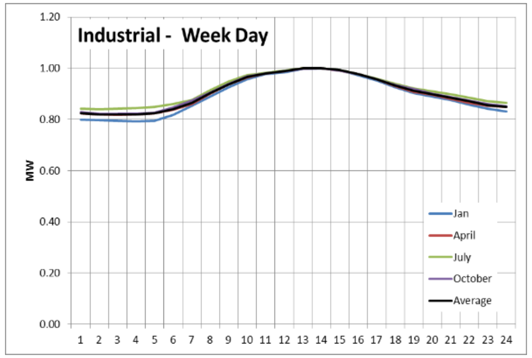
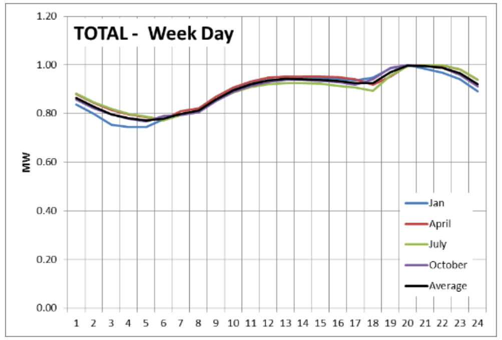
Load Profiles

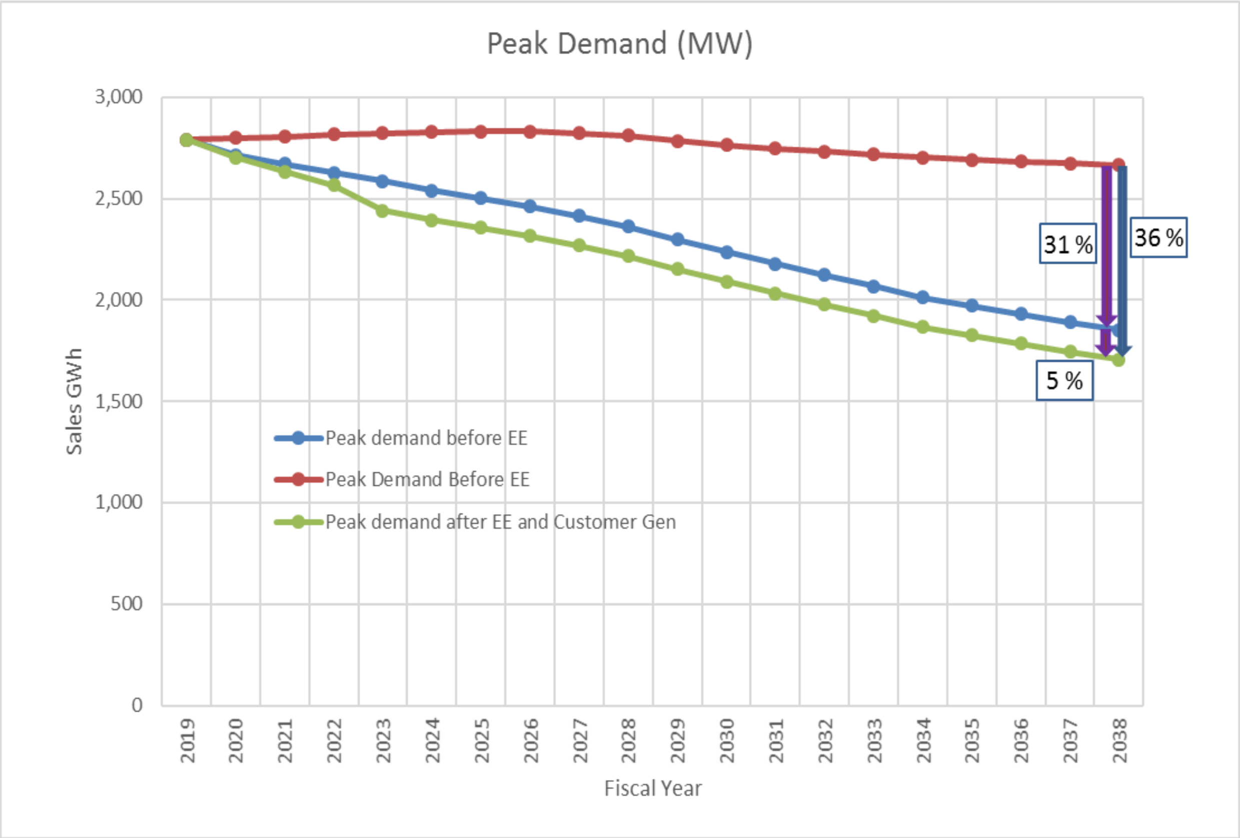
- The energy forecast was converted into an hourly forecast considering the load profiles for residential, commercial and industrial customers.
- The figure to the right shows the forecasted annual peak load based on consideration of these profiles.











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Existing Resources

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Existing Resources

- The IRP considered the existing thermal resources, both PREPA owned and IPP owned.
- PREPA's thermal resources are subject to economic retirement by the LTCE model and some of them have a limit due to MATS compliance beyond which have to be retired (end of 2024).
- The AES PPOA has a termination date of 2027, by which it must be retired under all cases.
- The table to the left shows the main units considered as available resources at the start of the analysis in the IRP.

	Generation Units	Maximum Modeled Capacity (MW)	Fuel	Heat Rate at Max. Capacity (BTU/kWh)	FOM (2018 $/kW-year)	VOM (2018 $/MWh)
MATS Affected Units	Aguirre 1 ST	450	No. 6 fuel oil	9,600	32.04	2.25
	Aguirre 2 ST	450	No. 6 fuel oil	9,700	32.04	2.25
	Costa Sur 5 ST	410	Natural gas	9,747	35.96	2.72
	Costa Sur 6 ST	410	Natural gas	9,747	35.96	2.72
	Palo Seco 3 ST	216	No. 6 fuel oil	9,725	46.47	4.95
	Palo Seco 4 ST	216	No. 6 fuel oil	9,725	46.47	4.95
	San Juan 7 ST	100	No. 6 fuel oil	10,497	49.02	2.93
	San Juan 8 ST	100	No. 6 fuel oil	10,445	49.02	2.93
Combined Cycle	Aguirre 1 CC	260	Diesel	11,140	22.64	6.79
	Aguirre 2 CC	260	Diesel	11,140	22.64	6.79
	San Juan 5 CC	200	Diesel	7,625	27.40	2.22
	San Juan 6 CC	200	Diesel	7,853	27.40	2.22
Gas Turbine	Cambalache 2 GT	83	Diesel	11,549	24.44	5.52
	Cambalache 3 GT	83	Diesel	11,549	24.44	5.52
	Mayagüez 1 GT	50	Diesel	9,320	10.64	6.40
	Mayagüez 2 GT	50	Diesel	9,320	10.64	6.40
	Mayagüez 3 GT	50	Diesel	9,320	10.64	6.40
	Mayagüez 4 GT	50	Diesel	9,320	10.64	6.40
	Daguao 2 GTs	42	Diesel	14,400	26.54	20.19
	Palo Seco GT11 & GT12	42	Diesel	14,400	26.54	20.19
	Palo Seco GT21 & GT 22	42	Diesel	14,400	26.54	20.19
	Palo Seco GT31 & GT32	42	Diesel	14,400	26.54	20.19
	Aguirre GT21 & GT22	42	Diesel	14,400	26.54	20.19
	Costa Sur GT11 & GT12	42	Diesel	14,400	26.54	20.19
	Jobos GT11 & GT12	42	Diesel	14,400	26.54	20.19
	Yabucoa GT11 & GT12	42	Diesel	14,400	26.54	20.19
	Vega Baja GT11 & GT12	42	Diesel	14,400	26.54	20.19
Hydro	Hydro	34	Water	N/A	N/A	N/A
IPP Units	AES Coal 2 Units	454	Coal	9,791	79.46	7.23
	EcoEléctrica Plant	507	Natural gas	7,497	189.34	0.00
	Total	**5,010**				

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Existing Resources: PREPA

- The large steam units at Aguirre are candidates for early retirement due to their relative inflexibility and at maximum could run until the new CCGT enters service (2025) when they must retire due to MATS compliance.
- Palo Seco Steam 3 & 4 as well as San Juan 7 & 8 are well located in the north of the island, but can only run until the new CCGT enters service (2025). They retire at this time or more commonly earlier.
- Costa Sur 5&6 in principle could run for the entire planning period as they burn natural gas but due to the reduction in demand and the units' relative inflexibility are retired early (before 2025)

Parameters	Unit	Aguirre ST		Costa Sur ST	
		Unit 1	Unit 2	Unit 5	Unit 6
Fuel	Type	No. 6 fuel oil	No. 6 fuel oil	Natural Gas	Natural Gas
Maximum Capacity	MW	450	450	410	410
Minimum Capacity	MW	200	200	180	180
Fixed O&M Expense	2018 $/kW-year	32.04	32.04	35.96	35.96
Variable O&M Expense	2018 $/MWh	2.25	2.25	2.72	2.72
Heat Rate at Maximum Capacity	MMBtu/MWh	9.60	9.70	9.75	9.75
Heat Rate at Minimum Capacity	MMBtu/MWh	9.94	10.16	9.93	10.07
Forced Outage	%	20	20	2	4
Minimum Downtime	Hours	48	48	48	48
Minimum Runtime	Hours	720	720	720	720
Ramp Up Rate	MW/minute	5	5	5	5
Ramp Down Rate	MW/minute	5	5	5	5

Parameters	Unit	Palo Seco ST		San Juan ST	
		Unit 3	Unit 4	Unit 7	Unit 8
Fuel	Type	No. 6 fuel oil	No. 6 fuel oil	No. 6 fuel oil	No. 6 fuel oil
Maximum Capacity	MW	216	216	100	100
Minimum Capacity	MW	130	130	70	70
Fixed O&M Expense	2018 $/kW-year	46.47	46.47	49.02	49.02
Variable O&M Expense	2018 $/MWh	4.95	4.95	2.93	2.93
Heat Rate at Maximum Capacity	MMBtu/MWh	9.73	9.73	10.50	10.45
Heat Rate at Minimum Capacity	MMBtu/MWh	10.35	10.35	10.50	10.50
Forced Outage	%	42	42	15	15
Minimum Downtime	Hours	48	48	48	48
Minimum Runtime	Hours	720	720	720	720
Ramp Up Rate	MW/minute	3	3	3	3
Ramp Down Rate	MW/minute	3	3	3	3

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Existing Resources : PREPA

- The combined cycle units at Aguirre are maintained and in general provide peaking service and support for the Ponce MiniGrid.
- The combined cycle units at San Juan are converted to natural gas (LNG) under all scenarios.
- The peaking units at Cambalache and Mayaguez are maintained for peaking service (or conversion to gas for the second). The small GTs are retired early.
- The hydro units are assumed to be repowered, increasing their capacity and the capacity factor as shown below:

Year	2019	2020	2021	2022	2023
Capacity (MW)	34	50	70	70	70
Availability Factor	20%	40%	60%	80%	90%
Capacity Factor	15%	25%	28%	28%	28%
Annual Generation GWh	44,676	109,500	171,696	171,696	171,696

Parameters	Unit	Aguirre CC		San Juan CC	
		Unit 1	Unit 2	Unit 5	Unit 6
Fuel	Type	Diesel	Diesel	Diesel	Diesel
Maximum Capacity	MW	260	260	200	200
Minimum Capacity	MW	46	46	155	155
Fixed O&M Expense	2018 $/kW-year	22.64	22.64	27.40	27.40
Variable O&M Expense	2018 $/MWh	6.79	6.79	2.22	2.22
Heat Rate at Maximum Capacity	MMBtu/MWh	11.14	11.14	7.63	7.85
Heat Rate at Minimum Capacity	MMBtu/MWh	11.42	11.42	8.46	8.86
Forced Outage	%	20	20	18	18
Minimum Downtime	Hours	0	0	48	48
Minimum Runtime	Hours	2	2	120	120
Ramp Up Rate	MW/minute	5	5	3	3
Ramp Down Rate	MW/minute	5	5	3	3

Parameters	Unit	Cambalache CT		GT Units
		Unit 2	Unit 3	Each Unit
Fuel	Type	Diesel	Diesel	Diesel
Maximum Capacity	MW	83	83	21
Minimum Capacity	MW	50	50	21
Fixed O&M Expense	2018 $/kW-year	24.44	24.44	26.54
Variable O&M Expense	2018 $/MWh	5.52	5.52	20.19
Heat Rate at Maximum Capacity	MMBtu/MWh	11.55	11.55	14.40
Heat Rate at Minimum Capacity	MMBtu/MWh	11.55	11.55	14.40
Forced Outage	%	10.0	10.0	15
Minimum Downtime	Hours	7	7	0
Minimum Runtime	Hours	7	7	0
Ramp Up Rate	MW/minute	2	2	2
Ramp Down Rate	MW/minute	2	2	2

Parameters	Unit	Mayagüez 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	2018 $/kW-year	10.64	10.64	10.64	10.64
Variable O&M Expense	2018 $/MWh	6.40	6.40	6.40	6.40
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

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Existing Resources : EcoEléctrica.

- EcoEléctrica is an efficient combined cycle plant in the south of the island fueled with natural gas.
- After expiration of the current contract, we found that if the existing capacity payments are maintained it would be more economical to replace EcoEléctrica with a new combined cycle facility.
- The table to the left shows the modeled estimated reduction for breakeven with the CCGT.
- The reduction was for testing purposes and the actual value required on one hand depends on the forecasted capacity factors (higher → lower reduction) and does not consider other aspects that could enter in the actual negotiation.

Parameters	Unit	EcoEléctrica CC Unit 1
Fuel	Type	Natural Gas
Maximum Capacity	MW	507
Minimum Capacity	MW	275
Fixed O&M Expense	2018 $/kW-year	162.05
Variable O&M Expense	2018 $/MWh	0.00
Capital Costs	2018 $(000)	124,226
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

	Original			Modeled based on Eq CCGT NPV analysis.			
Calendar Year	Fixed O&M Costs (Nominal 000$)	Capital Costs (Nominal $000)	Total Fixed Costs (Nominal $000)	Fixed O&M Costs (Nominal 000$)	Capital Costs (Nominal $000)	Total Fixed Costs (Nominal $000)	Reduction
2019	84,594	109,923	194,517	84,594	109,923	194,517	0%
2020	87,092	121,628	208,720	87,092	121,628	208,720	0%
2021	98,772	141,377	240,149	98,772	141,377	240,149	0%
2022	101,143	144,184	245,327	47,537	67,767	115,304	53%
2023	103,570	147,092	250,662	48,678	69,133	117,811	53%
2024	106,348	150,464	256,813	49,984	70,718	120,702	53%
2025	108,601	153,014	261,615	51,042	71,917	122,959	53%
2026	111,207	156,081	267,288	52,268	73,358	125,625	53%
2027	113,878	159,200	273,078	53,522	74,824	128,347	53%
2028	116,931	162,817	279,748	54,957	76,524	131,482	53%
2029	119,408	165,651	285,059	56,122	77,856	133,978	53%
2030	122,274	168,982	291,255	57,469	79,421	136,890	53%
2031	125,211	172,313	297,523	58,849	80,987	139,836	53%
2032	128,565	176,284	304,849	60,426	82,853	143,279	53%
2033	131,291	179,292	310,583	61,707	84,267	145,974	53%
2034	134,442	182,887	317,330	63,188	85,957	149,145	53%
2035	137,670	186,535	324,206	64,705	87,672	152,377	53%
2036	141,358	190,811	332,169	66,438	89,681	156,120	53%
2037	144,356	194,096	338,452	67,847	91,225	159,073	53%
2038	144,356	194,096	338,452	67,847	91,225	159,073	53%
						Average	53%

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Existing Resources : AES

- AES's coal-fired steam electric cogeneration station began commercial operation in November 2002.
- The owners of the facility have entered into a PPOA with the PREPA to provide 454 MW of power for a period of 25 years.
- IRP will not assume a renewal of the AES PPOA, in line with the provision of Act 17-2019 that precludes the use of Coal Fired generation after January 1st 2028.
- This unit has the lowest cost per MWh produced in the Island.

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	2018 $/kW-year	77.96	77.96
Variable O&M Expense	2018 $/MWh	7.09	7.09
Capital Costs	2018 $(000)	121,499	121,499
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

Year	AES Coal Plant		
	Fixed O&M Costs (Nominal $/kW)	Variable O&M Costs (Nominal $/MWh)	Capital Costs (Nominal $000)
2018	77.96	7.09	121,499
2019	79.83	7.26	122,916
2020	81.75	7.43	122,991
2021	83.71	7.61	108,311
2022	85.72	7.79	94,026
2023	87.78	7.98	83,779
2024	89.88	8.17	74,127
2025	92.04	8.37	74,865
2026	94.25	8.57	75,627
2027	96.51	8.78	76,390
2028	98.83	8.99	77,159
2029	101.20	9.20	77,934
2030	103.63	9.42	78,714
2031	106.11	9.65	79,502
2032	108.66	9.88	80,298
2033	111.27	10.12	81,103
2034	113.94	10.36	81,915
2035	116.67	10.61	82,735
2036	119.47	10.86	83,564
2037	122.34	11.12	84,400
2038	122.34	11.12	84,400

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Existing Resources : Renewable

- As of December 2018, 11 PPOAs are in either commercial operation or in pre-operation (energized, under testing, and selling energy and renewable energy credits to PREPA).
- These projects represent 272.9 MW of capacity, including 147.1 MW PV, 121 MW of wind, and 4.8 MW of landfill gas.
- The PPOAs under renegotiation were included as candidates for the LTCE but at the new competitive prices, as will be discussed on the next section, with the exception of Energy Answers WTE.

Ref. Number	Name	Status	Contract Number	Technology	Capacity MW
1	AES Ilumina	Operation	2010-P00050	Solar	20
18	Horizon Energy	Operation	2011-P00034	Solar	10
46	San Fermin Solar (Coqui Power)	Operation	2011-P00050	Solar	20
60	Windmar (Cantera Martino)	Operation	2010-P00052	Solar	2.1
30	Yarotek (Oriana)	Operation	2011-P00048	Solar	45
32	Go Green (Punta Lima)	Operation	2010-AI0001	Wind	26
31	Pattern (Pattern Santa Isabel)	Operation	2010-P00047	Wind	75
24	Fajardo Landfill Tech (Landfill Gas Technologies of Fajardo)	Operation	2013-P00046	Landfill G	2.4
		Total Capacity			**200.5**

Ref. Number	Name	Status	Contract Number	Technology	Capacity MW
7	Fonroche Energy (Humacao Solar Project)	Pre-Operation	2012-P00031	Solar	40.0
62	Windmar (Vista Alegre/Coto Laurel)	Pre-Operation	2012-P00052	Solar	10.0
25	Toa Baja Landfill Tech (Landfill Gas Technologies of Fajar	Pre-Operation	2013-P00073	Landfill G	2.4
		Total Capacity			**52.4**

Ref. Number	Name	Status	Contract Number	Technology	Capacity MW
5	Atenas Solar Farm (Desarrollos del Norte)	Re-negotiation	2013-P00070	Solar	20
3	Blue Beetle III	Re-negotiation	2012-P00037	Solar	20
4	Ciro Group (Ciro One Salinas)	Re-negotiation	2011-P00043	Solar	57
15	Grupotec USA Inc (Xzerta-Tec)	Re-negotiation	2013-P00042	Solar	20
16	Guayama Solar Farm (Guayama Solar Energy)	Re-negotiation	2011-P00042	Solar	17.8
21	Irradia Energy USA (Morovis Solar Farm)	Re-negotiation	2012-P00053	Solar	33.5
42	Moca Solar Farm	Re-negotiation	2013-P00003	Solar	20
43	North Coast Solar	Re-negotiation	2013-P00041	Solar	20
36	Renewable Energy Authority (Vega Serena)	Re-negotiation	2012-P00045	Solar	20
39	Resun (Barceloneta)	Re-negotiation	2012-P00061	Solar	20
47	Solaner	Re-negotiation	2012-P00146	Solar	25
48	Solar Blue (Solar Blue Bemoga)	Re-negotiation	2013-P00052	Solar	20
57	WindMar (Santa Rosa)	Re-negotiation	2012-P00080	Solar	20
63	YFN Yabucoa Solar (Justin Orozco)	Re-negotiation	2013-P00049	Solar	20
6	Energy Answers Arecibo	Re-negotiation	2010-AI0018	WTE	79
		Total Capacity			**412.3**

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Existing Resources : Renewable

- Similarly, the sites of not renegotiated projects were considered as site candidates for new PV or Wind projects.

Ref. Number	Name	Status	Contract Number	Technology	Capacity MW
41	Cabo Solar	Not Renegotiated	2013-P00069	Solar	20
44	Caracol Solar (Roma Solar) LLC	Not Renegotiated	2013-P00004	Solar	20
52	Carolina Solar (Trina)	Not Renegotiated	2013-P00067	Solar	20
10	Fonroche Energy (Humacao Solar Project)	Not Renegotiated	2013-P00048	Solar	15
9	Fonroche Energy (Solar Project Ponce)	Not Renegotiated	2013-P00045	Solar	30
12	Fonroche Energy (Vega Baja Solar Project)	Not Renegotiated	2013-P00050	Solar	15
8	Fonroche Energy (Lajas Solar Project)	Not Renegotiated	2013-P00046	Solar	10
11	Fonroche Energy (South Solar 2)	Not Renegotiated	2013-P00047	Solar	30
13	GG Alternative Energy Corp.	Not Renegotiated	2013-P00077	Solar	20
17	Hatillo Solar (Pattern)	Not Renegotiated	2013-P00074	Solar	30
19	HSEA PR Isla Solar I	Not Renegotiated	2013-P00057	Solar	40
22	Jonas Solar Farm (Jonas Solar Energy)	Not Renegotiated	2012-P000140	Solar	40
23	Juncos Solar Energy	Not Renegotiated	2012-P00138	Solar	20
26	M Solar (M Solar Generating)	Not Renegotiated	2012-P00142	Solar	50
34	REA Ceiba (REA Energy Ceiba Solar Plant)	Not Renegotiated	2013-P00076	Solar	20
33	REA Energy (Luquillo Solar Plant)	Not Renegotiated	2013-P00051	Solar	20
35	REA Hatillo (REA Energy Hatillo Solar Plant)	Not Renegotiated	2013-P00075	Solar	20
45	Sierra Solar (Roma Solar)	Not Renegotiated	2013-P00072	Solar	20
53	Vega Baja Solar Energy	Not Renegotiated	2012-P00139	Solar	30
54	Western Wind (Yabucoa Solar)	Not Renegotiated	2011-P00090	Solar	30
56	WindMar (Dorado-Toa Baja)	Not Renegotiated	2012-P00079	Solar	20
2	Aspenall Energy	Not Renegotiated	2012-P00089	Wind	10
14	GG Alternative Energy Corp.	Not Renegotiated	2013-P00071	Wind	10
50	Tradewind Energy (Tradewinds Energy Barceloneta)	Not Renegotiated	2012-P00030	Wind	75
51	Tradewind Energy (Tradewinds Energy Vega Baja)	Not Renegotiated	2012-P00028	Wind	50
55	Wind to Energy	Not Renegotiated	2011-P00101	Wind	20
58	WindMar (Dorado-Toa Baja)	Not Renegotiated	2012-P00095	Wind	44
61	Windmar (Punta Ventana)	Not Renegotiated	2008-AI0066C	Wind	18.4
59	Windmar (Punta Verraco)	Not Renegotiated	2012-P00049	Wind	34.5
49	Sunbeam	Not Renegotiated	2010-AI0031	WTE	10
37	Renewable Power Group	Not Renegotiated	2012-P00010	Landfill G	2
38	Renewable Power Group	Not Renegotiated	2012-P0009	Landfill G	1.5
		Total Capacity			**795.4**

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Environmental Regulations

- The regulations that have the most effect on the IRP decisions are the MATS (mentioned earlier) and the RPS.
- The LTCEs are run with a restriction to meet Act 17-2019 which sets minimum targets of renewable and alternative energy and puts the island on a path to 100% renewable generation by 2050. The targets set by the Act are a minimum of:
  - 40% on or before 2025
  - 60% on or before 2040
  - 100% on or before 2050
- The IRP did not consider a price for carbon, but all new fossil units are low emission gas fired combined cycles using air cooled condensers, and thus have small environmental footprints.

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New Resources

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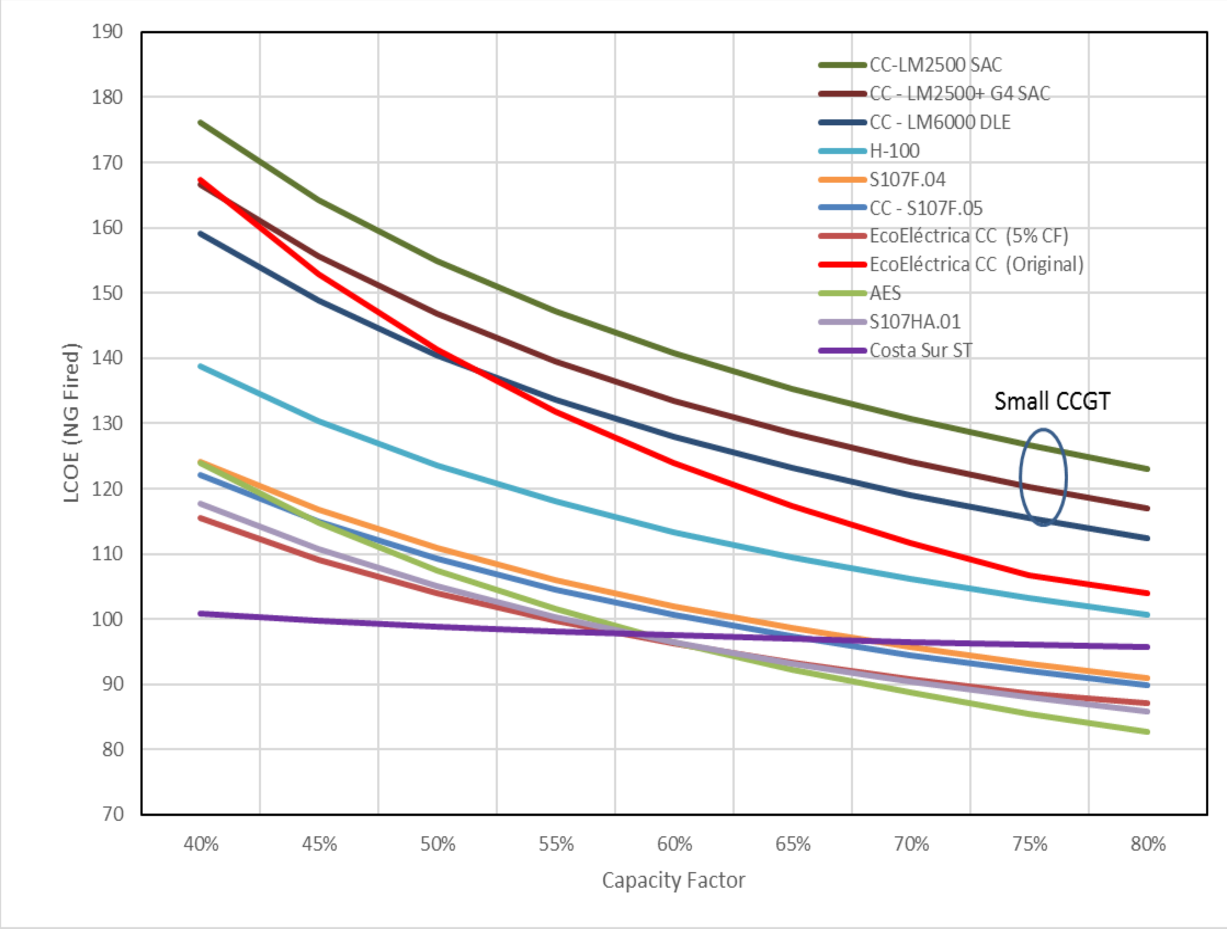
Thermal Resources

- The LTCE process was offered a large number of thermal resources with different technologies (CCGT, GT and RICE) and sizes.
- F Class units were the most commonly selected by the LTCE. H Class units were considered too large and only under Scenario 5 were selected.
- The small CCGTs were not found to be competitive (see LCOE to the right). RICE and Peakers were selected by the plans but in relatively small amounts (typically 2 units).

Representative New Resource Candidates	Capacity (MW)	Development Duration (Years)	EPC Duration (Years)
H Class CCGT (GE S107HA.01) (Duct Fired)	449	2.5	3.0
F-Class CCGT (GE S107F.04) (Duct Fired)	302	2.5	3.0
F-Class CCGT (GE S107F.05) (Duct Fired)	369	2.5	3.0
Medium CCGT (Hitachi H-100) (Duct Fired)	144	2.5	2.5
Small CCGT (GE LM6000 DLE) (Duct Fired)	66	2.0	2.0
Small CCGT (GE LM2500+ G4 SAC) (Duct Fired)	47.7	2.0	2.0
Small CCGT (GE LM2500 SAC) (Duct Fired)	35	2.0	2.0
Aero/Small GT Peaker (GE LM6000 DLE)	41	1.5	1.5
Aero/Small GT Peaker (GE LM2500 SAC)	22	1.5	1.5
Small CHP (Solar Turbines Mars 100)	9	1.5	1.5
RICE (Wartsila 18V50DF)	16	1.5	1.5



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Thermal Resources

- The table to the right shows the main parameters for the F-Class CCGT selected by the LTCE.
- The thermal resources as well as renewable resources are assumed to be financed by third parties (WACC 8.5%) and recovered over the life of the assets.
- The tables below provide the CapEx and the estimated Capital Recovery Factor as a function of life.

Generation Unit Type	Unit	F Class CC - Smaller (GE S107F.04)	
		Natural Gas	Diesel
Max. Unit Capacity w/o Duct Fire	MW	251	245
Max. Unit Capacity with Duct Fire	MW	302	296
Min. Unit Capacity	MW	144	141
Min. Unit Capacity (% of Duct Fired Capacity	%	48%	48%
Fixed O&M Expense	2018 $/kW-year	22.09	22.09
Variable O&M Expense	2018 $/MWh	1.75	1.75
Heat Rate at 100% Rated Capacity (Unfired)	MMBtu/MWh	7.27	7.09
Heat Rate at Full Duct Fire Capacity	MMBtu/MWh	7.55	7.34
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	30	30
Ramp Down Rate	MW/minute	30	30
Regulation Minimum Range	MW	144	141
Regulation Maximum Range	MW	251	245
Regulation Ramp Rate	MW/minute	30	30

Representative New Resource Candidates	Natural Gas Fired		Diesel Fired	
	Capacity (MW)	Capital Costs (2018$/KW)	Capacity (MW)	Capital Costs (2018$/KW)
F-Class CCGT (GE S107F.04) (Duct Fired)	302	$994	296	$1,017
F-Class CCGT (GE S107F.05) (Duct Fired)	369	$927	361	$948
Aero/Small GT Peaker (GE LM6000 DLE)	41	$1,375	39	$1,444
Aero/Small GT Peaker (GE LM2500 SAC)	22	$1,627	21	$1,689
RICE (Wartsila 18V50DF)	16	$1,612	16	$1,612

Asset Class	Capital Recovery Period (Years)	CCR
Combined Cycle Plant	28	9.5%
Small Combined Cycle	20	10.6%
Existing Unit Fuel Conversion / Switching (San Juan)	21	10.4%
Solar PV /Wind	25	9.8%
Battery Storage	20	10.6%
LNG Terminal	22	9.8%

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Thermal Resources; Mobile 23.8 MW units

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- For the replacement of the 21 MW Frame 5 units, Siemens considered using the mobile units (FT8 MOBILEPAC 25 DLN).
- These units have a name plate capacity of 23.8 MW when burning natural gas and 22.6 MW when burning LFO with a heat rate (HHV) of 11,129 BTU/kWh and 10,964 BTU/kWh, respectively.
- The capital cost differs depending on whether a new unit is replacing an existing unit or is being added on site. This is presented below.
- The units are modeled assuming they can burn containerized LNG.

Name	Existing Units	Zone	Capex ($/kW) Existing	Capex ($/kW) Additional
Daguao	2	Carolina	900	1000
Yabucoa	2	Caguas	900	1000
Palo Seco	6	Bayamon	900	1000
Costa Sur	2	Ponce Oe	900	1000
Aguirre	2	Ponce ES	900	1000
Vega Baja	2	Bayamon	900	1000
Jobos	2		900	1000

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Solar Photovoltaic (PV) Projects.

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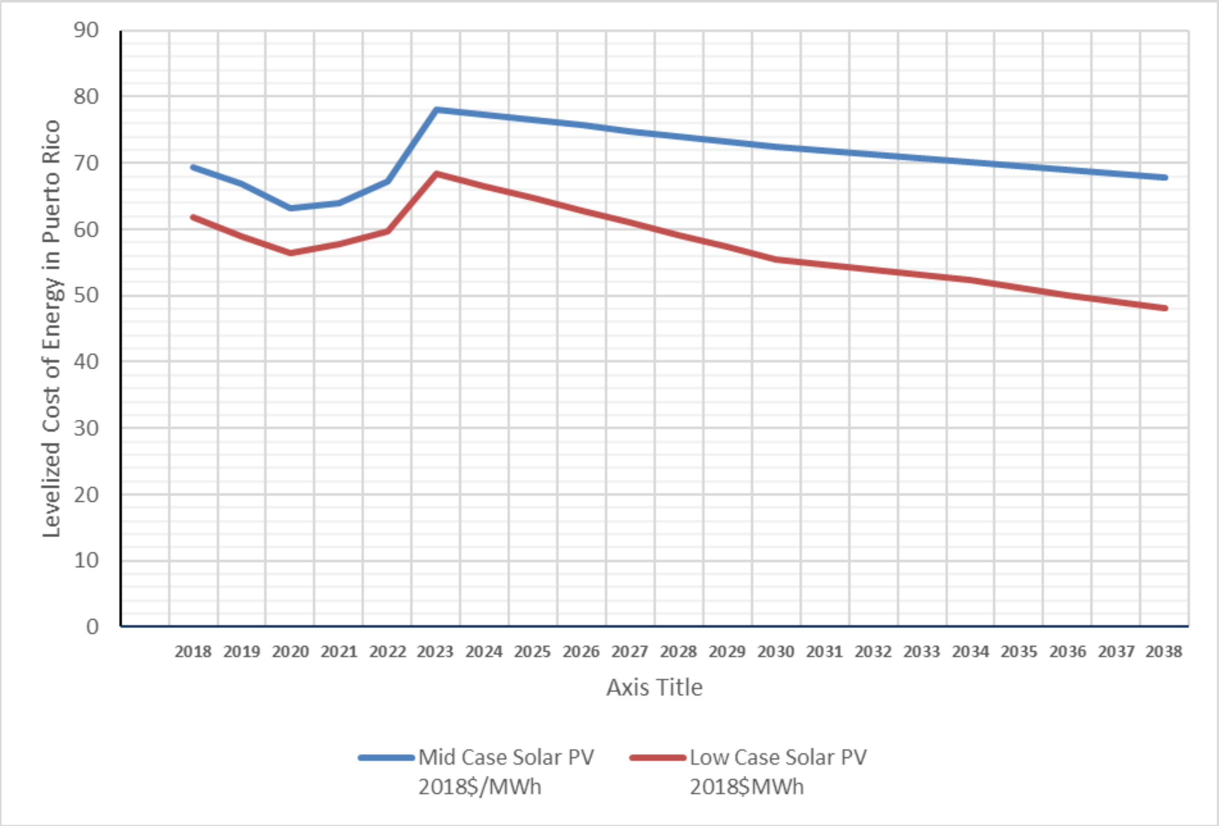
- The IRP assumes utility scale solar for new builds of renewable resources.
- The cost estimates for utility scale solar PV projects were developed through the following steps:

1. Establish baseline solar PV operating and overnight capital costs estimate, using the 2018 Annual Technology Baseline (ATB) by National Renewable Energy Laboratory (NREL)
2. Evaluate interconnection and land costs specific to Puerto Rico, based on PREPA's projects and costs
3. Assess construction and financing costs reflecting Puerto Rico specific assumptions:16% Puerto Rico Cost Adder, Finance Factors 101.5%, ITC considered, 8.5% WACC
4. 30 years economic life
5. Select a capacity factor (22%) and
6. Calculate Levelized Cost of Energy (LCOE) for solar PV in Puerto Rico.



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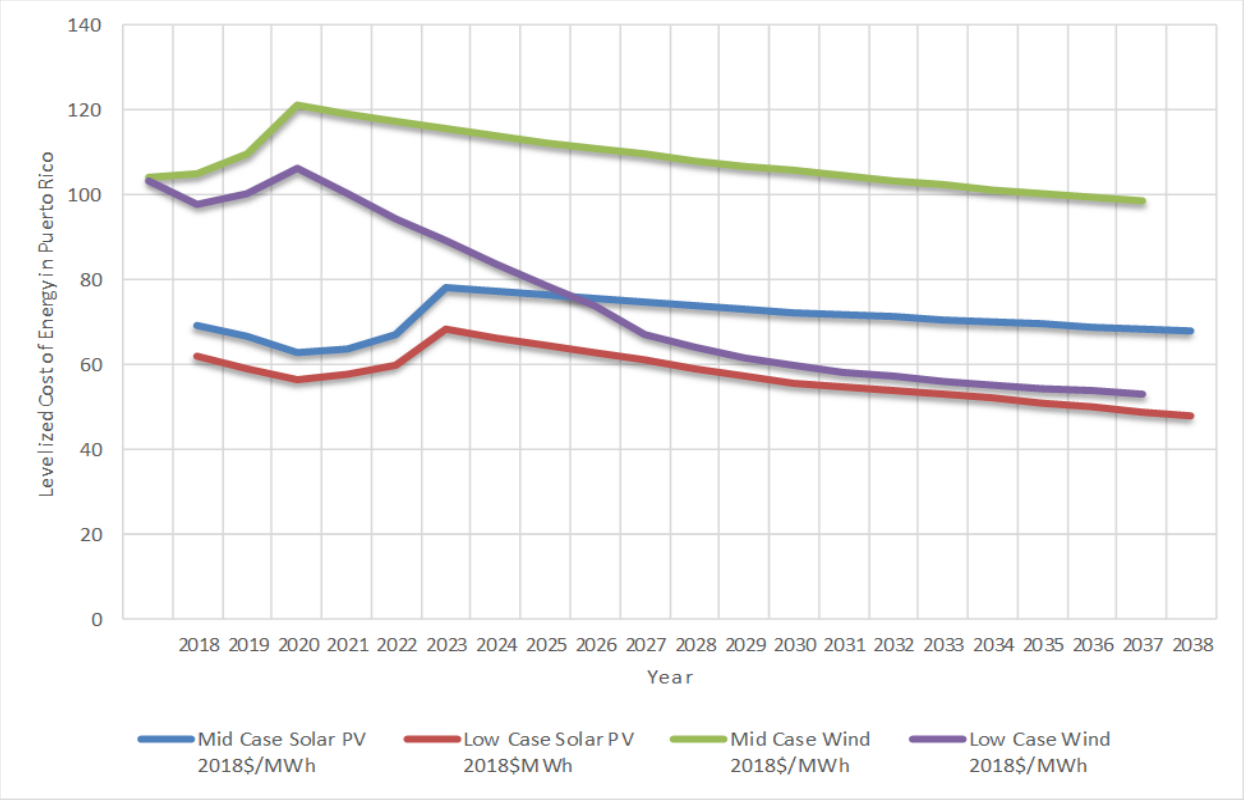
Wind Turbine Generation Projects.

- The IRP also assumes utility scale wind turbine generation (WTG) projects for renewable resources.
- The cost estimates for utility WTG projects were developed in a way similar to the approach taken with PV, but an improvement in capacity factors was assumed in line with NREL's projections (TRG-8). ITC availability and 30 years economic life were assumed
- As can be observed, Wind Generation is expected to be competitive with PV only in the low cases.



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Storage.

- Storage costs include the following elements:
  - **Capital costs:** The capital costs are for the entirety of the Battery Energy Storage System (BESS), which comprises the battery cell, the Power Conversion System (PCS) costs, and the related EPC costs. The battery energy storage system costs include the storage module (SM) and the balance of system (BOS) costs.
  - **Augmentation costs:** Augmentation costs represent the additional BESS equipment needed to maintain the usable energy capability to cycle the unit according to the usage profile in the particular use case, for the life of the system. The time-series of varying costs is converted into a level charge over the life of the system to provide greater clarity.
  - **Operating costs:** These include the O&M costs, charging costs, and costs of extended warranties for the major equipment.
  - **Other costs:** These include financing costs (debt service payments), taxes paid, costs of meeting local and regional regulatory requirements, and warranty costs.
  - In spite of the incurrence of augmentation costs, the economic life was limited to 20 years.

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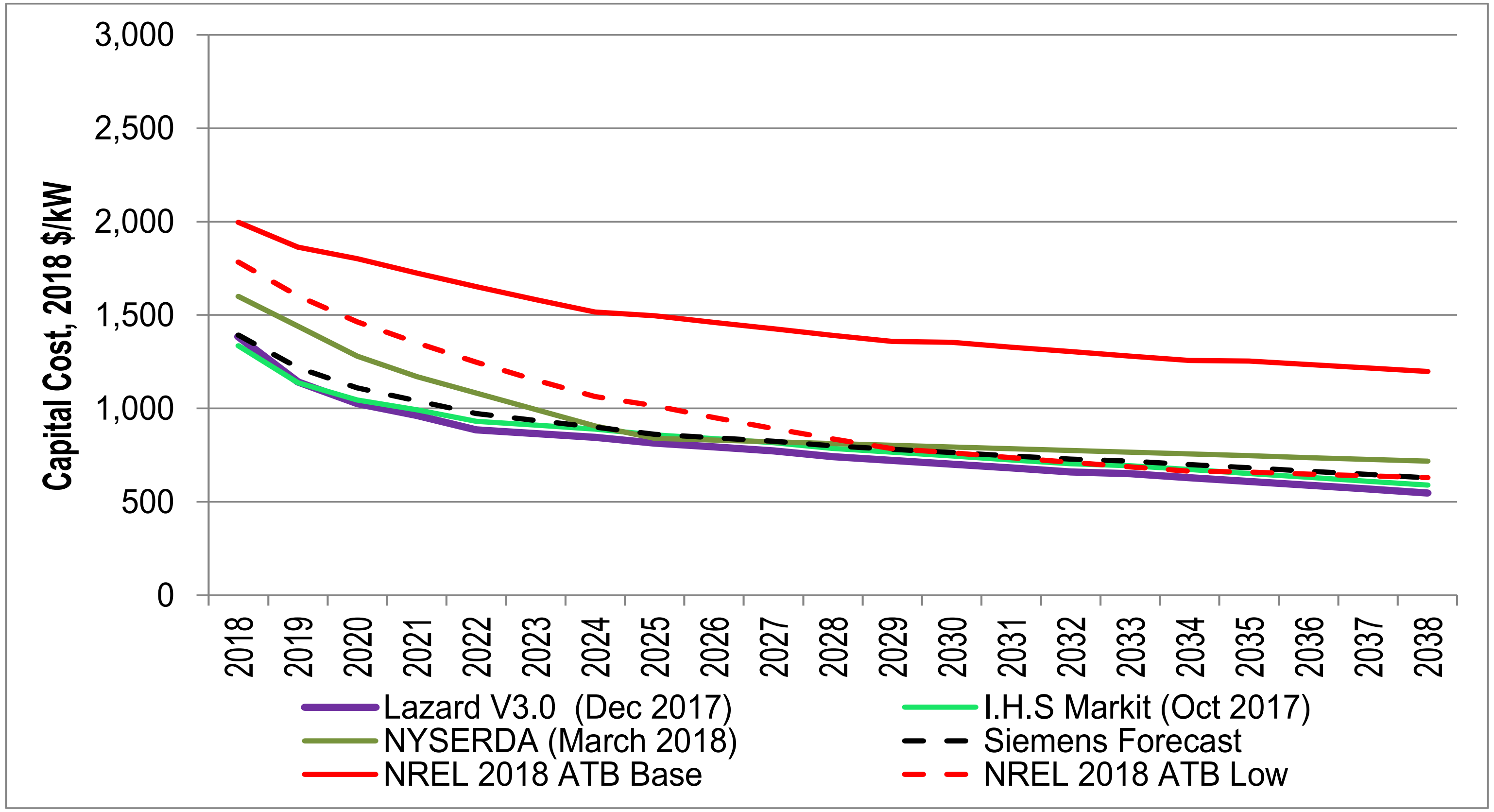
Storage.

- Cost decline are forecasted by different sources.

4-hour Li-ion Battery System Capital Cost Forecasts



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Storage.

- Siemens used in the IRP a base cost and a low cost as shown in the tables below.

Li-Ion Battery System Capital Cost and Operating Cost Assumptions – Base Case.

Construction Year	All-in Capital Costs			Operating Costs	
	4-hour Li-ion Battery Storage 2018$/KW	2-hour Li-ion Battery Storage 2018$/KW	6-hour Li-ion Battery Storage 2018$/KW	Fixed Operating Costs 2018$/kW-year	Variable Operating Costs 2018$/MWh
2018	1,392	832	1,953	9.09	2.67
2019	1,218	734	1,703	8.96	2.60
2020	1,110	674	1,546	8.95	2.58
2021	1,041	635	1,447	8.81	2.51
2022	972	596	1,349	8.67	2.43
2023	936	576	1,296	8.54	2.36
2024	899	556	1,243	8.41	2.29
2025	861	534	1,188	8.40	2.28
2026	843	523	1,163	8.26	2.20
2027	825	512	1,138	8.12	2.13
2028	800	496	1,104	7.99	2.06
2029	782	485	1,079	7.86	1.99
2030	764	474	1,054	7.85	1.97
2031	746	462	1,031	7.71	1.90
2032	728	450	1,007	7.57	1.82
2033	717	443	992	7.44	1.75
2034	700	431	969	7.31	1.69
2035	682	419	945	7.30	1.67
2036	664	407	922	7.19	1.64
2037	647	395	898	7.08	1.62
2038	629	383	875	6.97	1.59

Li-Ion Battery System Capital Cost and Operating Cost Assumptions – Low Case.

Construction Year	All-in Capital Costs			Operating Costs	
	4-hour Li-ion Battery Storage 2018$/KW	2-hour Li-ion Battery Storage 2018$/KW	6-hour Li-ion Battery Storage 2018$/KW	Fixed Operating Costs 2018$/kW-year	Variable Operating Costs 2018$/MWh
2018	1,236	756	1,716	8.52	2.55
2019	1,047	651	1,443	8.22	2.45
2020	931	588	1,275	8.15	2.42
2021	857	549	1,165	7.81	2.31
2022	779	506	1,053	7.49	2.19
2023	743	488	997	7.18	2.09
2024	701	467	935	6.88	1.99
2025	664	448	880	6.80	1.95
2026	643	438	848	6.46	1.84
2027	623	428	818	6.14	1.73
2028	594	411	777	5.84	1.62
2029	573	400	746	5.55	1.53
2030	553	389	717	5.45	1.49
2031	536	375	696	5.11	1.37
2032	513	358	668	4.80	1.26
2033	497	345	650	4.50	1.16
2034	483	334	633	4.22	1.07
2035	465	319	610	4.10	1.02
2036	450	307	593	4.04	1.00
2037	437	296	578	3.98	0.99
2038	418	280	555	3.92	0.97

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Fuel Forecast

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Infrastructure

- The table below summarizes the infrastructure considered and costs.

Infrastructure Option	CAPEX ($MM) (2018$)	Annual OPEX ($MM) (2018$)	Max Daily Gas Volume (MMcf/d)	Max Capacity (MW)	Annualized CAPEX ($/kW) (2018$)	Annual OPEX ($/kW) (2018$)	CAPEX + Annual OPEX ($/kW)
Land-based LNG at San Juan Port with pipeline to Palo Seco	$492	$25.60	93.6	650	$77	$39	$117
Land-Based San Juan Low CAPEX Estimate	$408	$21.20	93.6	650	$64	$33	$97
Land-Based San Juan High CAPEX Estimate	$590	$30.70	93.6	650	$93	$47	$140
Ship-based LNG at Mayagüez (west)	$185	$9.60	43.2	300	$63	$32	$95
Ship-based LNG at Yabucoa (east)	$185	$9.60	43.2	300	$63	$32	$95
Ship-based Mayagüez-Yabucoa Low CAPEX Estimate	$167	$8.70	43.2	300	$57	$29	$85
Ship-based Mayagüez-Yabucoa High CAPEX Estimate	$222	$11.50	43.2	300	$75	$38	$114
Ship-based LNG (FSRU) at San Juan Port (supply to San Juan only)	$185	$9.60	50.4	350	$54	$27	$81
Ship-based San Juan Low CAPEX Estimate	$167	$8.70	50.4	350	$48	$25	$73
Ship-based San Juan High CAPEX Estimate	$222	$11.50	50.4	350	$65	$33	$98

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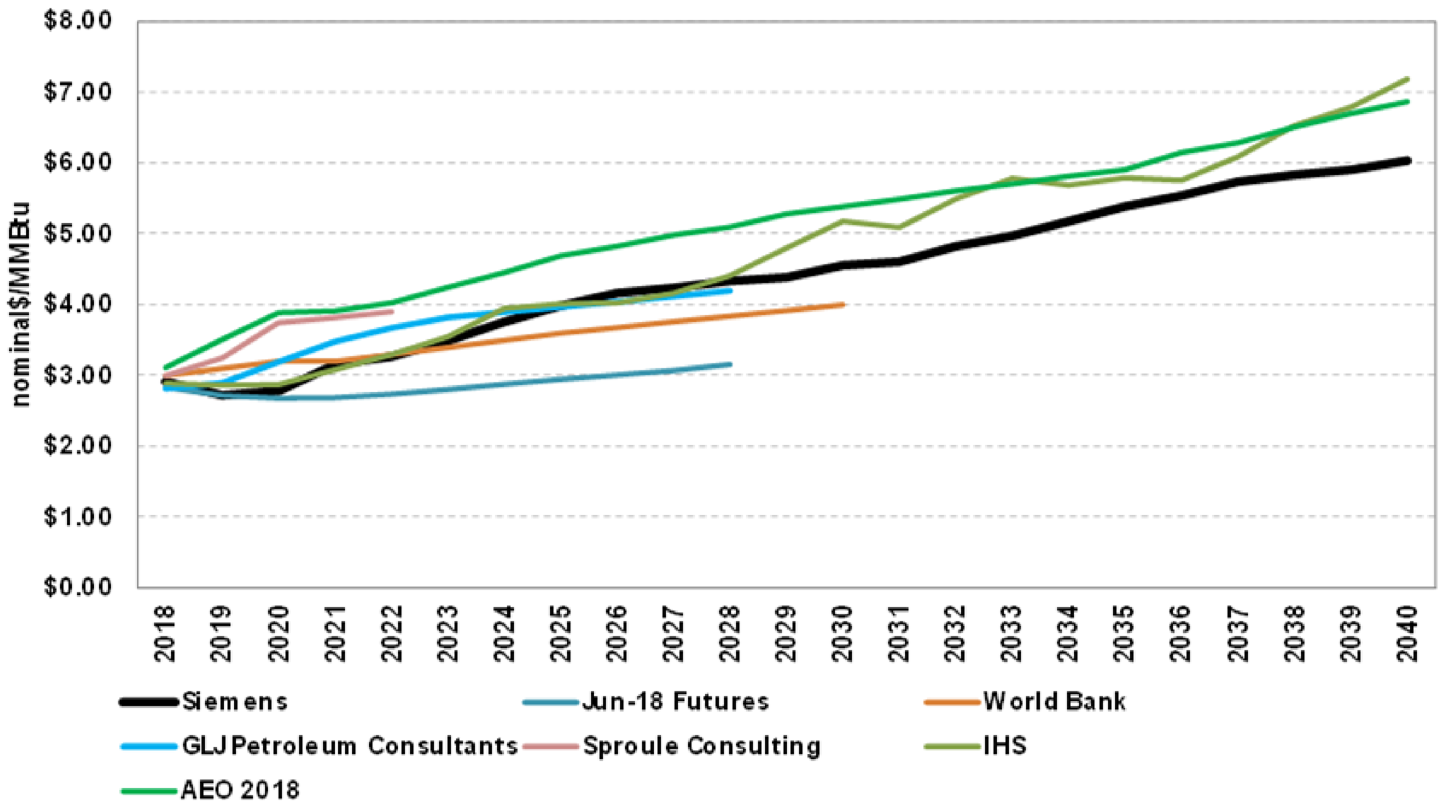
Natural Gas Forecast

- Natural Gas was forecasted on the basis of Henry Hub pricing, which can be considered a proxy for other markets in the region.
- The figure below shows the forecast:



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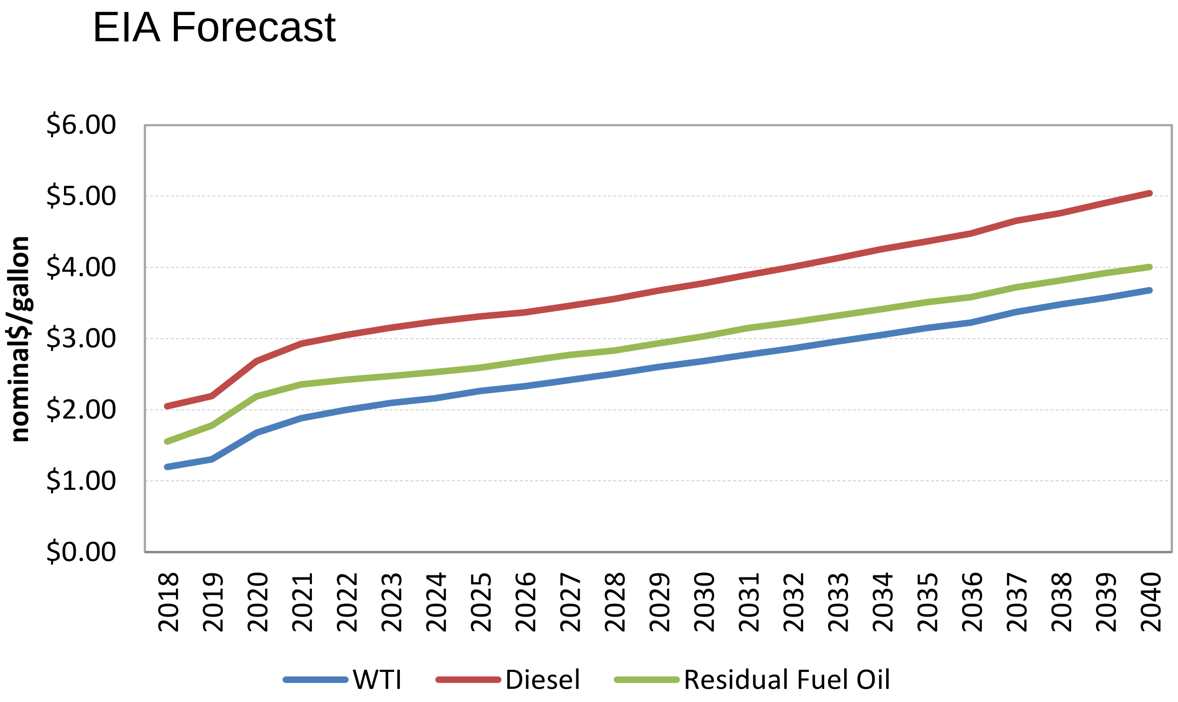
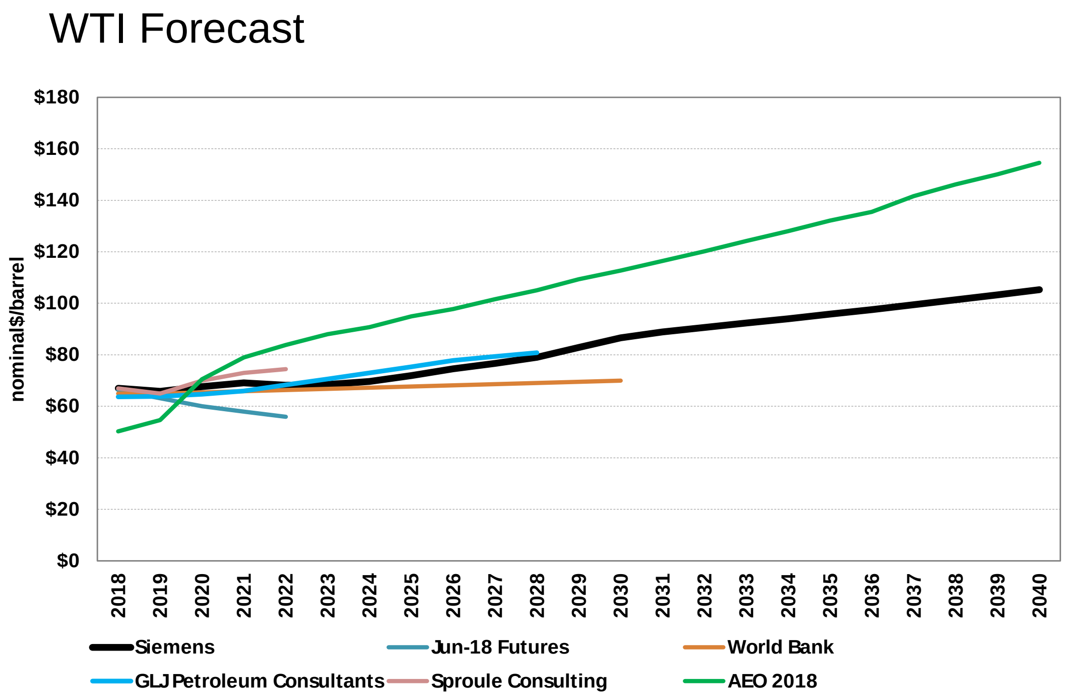
Crude Oil (WTI), Diesel (LFO) and Residual Fuel Oil (RFO or HFO)

- The figure below show the forecasted prices for liquid fuels:





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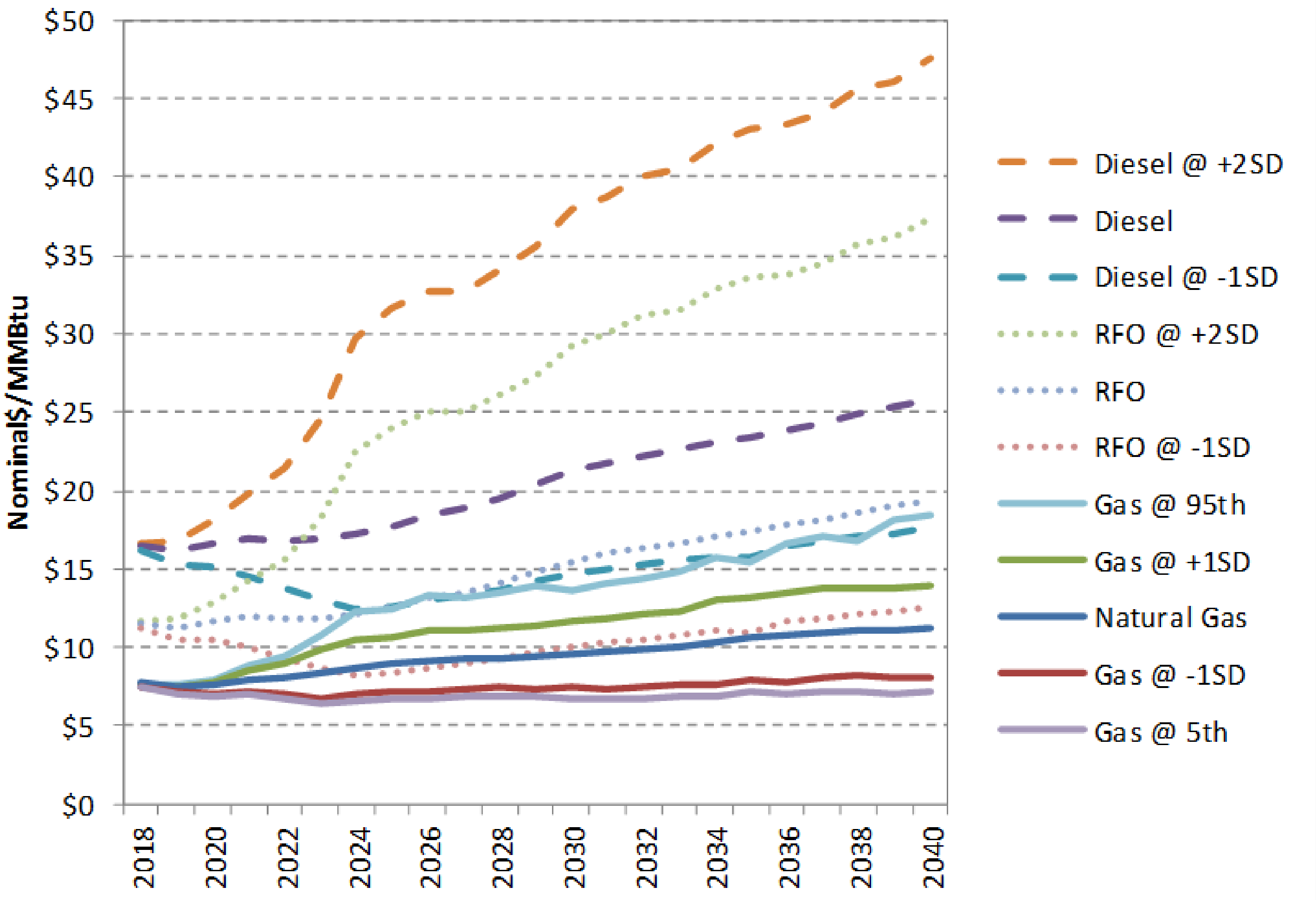
Forecasted Delivered Fuel to Plants

- The figure shows the forecast for fuel delivery at Aguirre (Gas does not include the regasification facility):



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Forecasted Delivered Fuel to Plants

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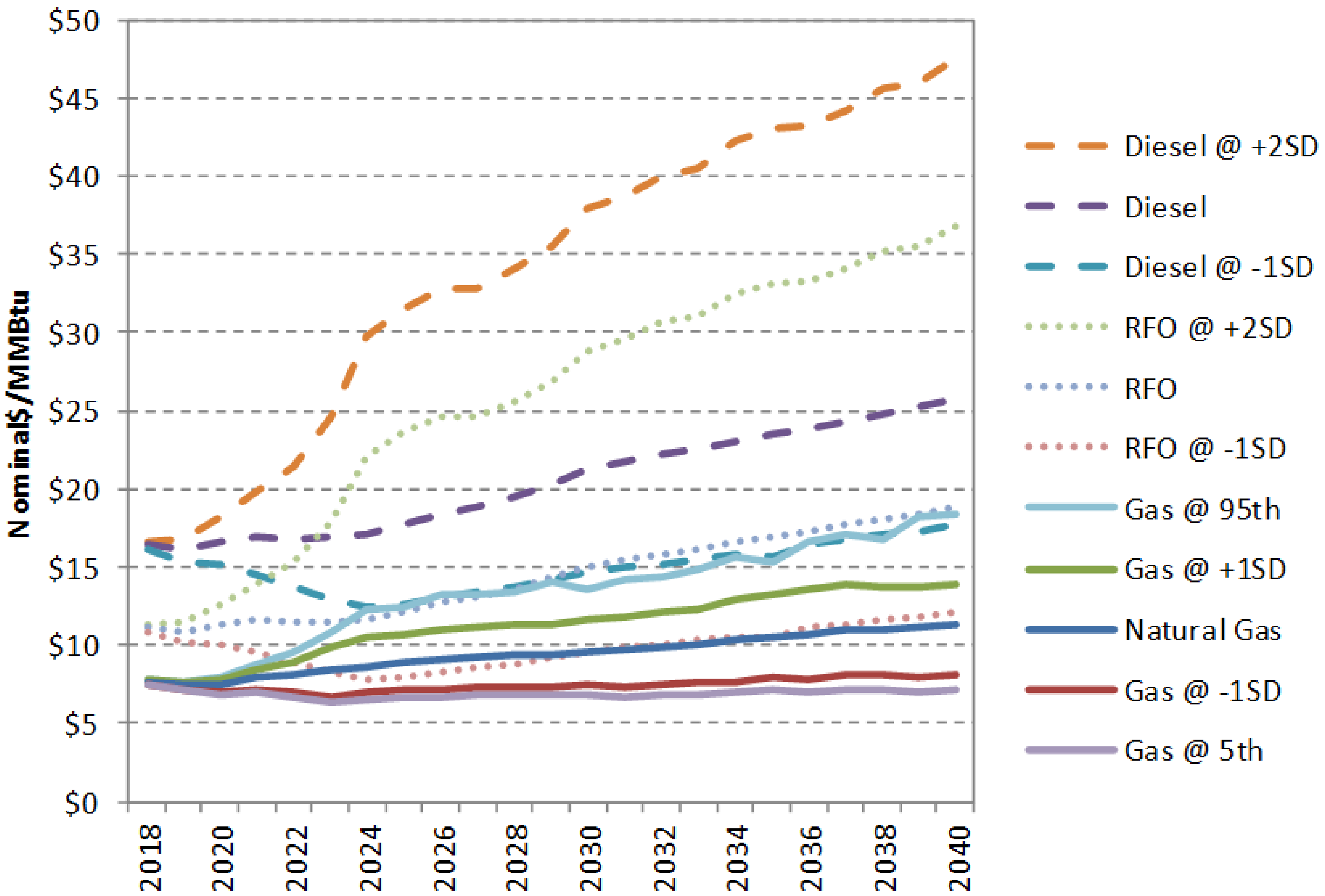
- The figure shows the forecast cost for fuel delivery at San Juan and Palo Seco:



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Forecasted Delivered Fuel to Plants

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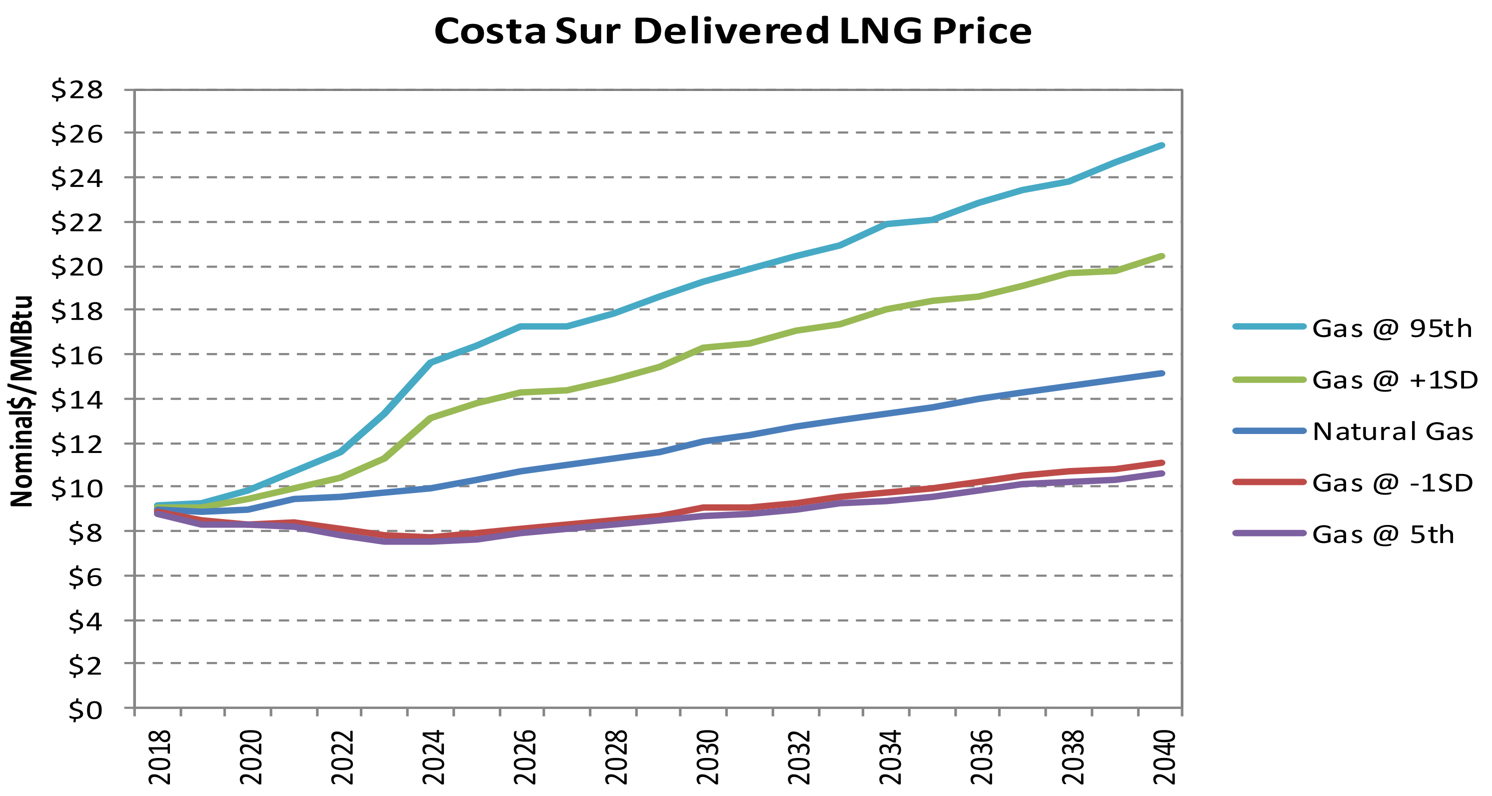
- The figure shows the forecast cost for fuel delivery at Costa Sur:



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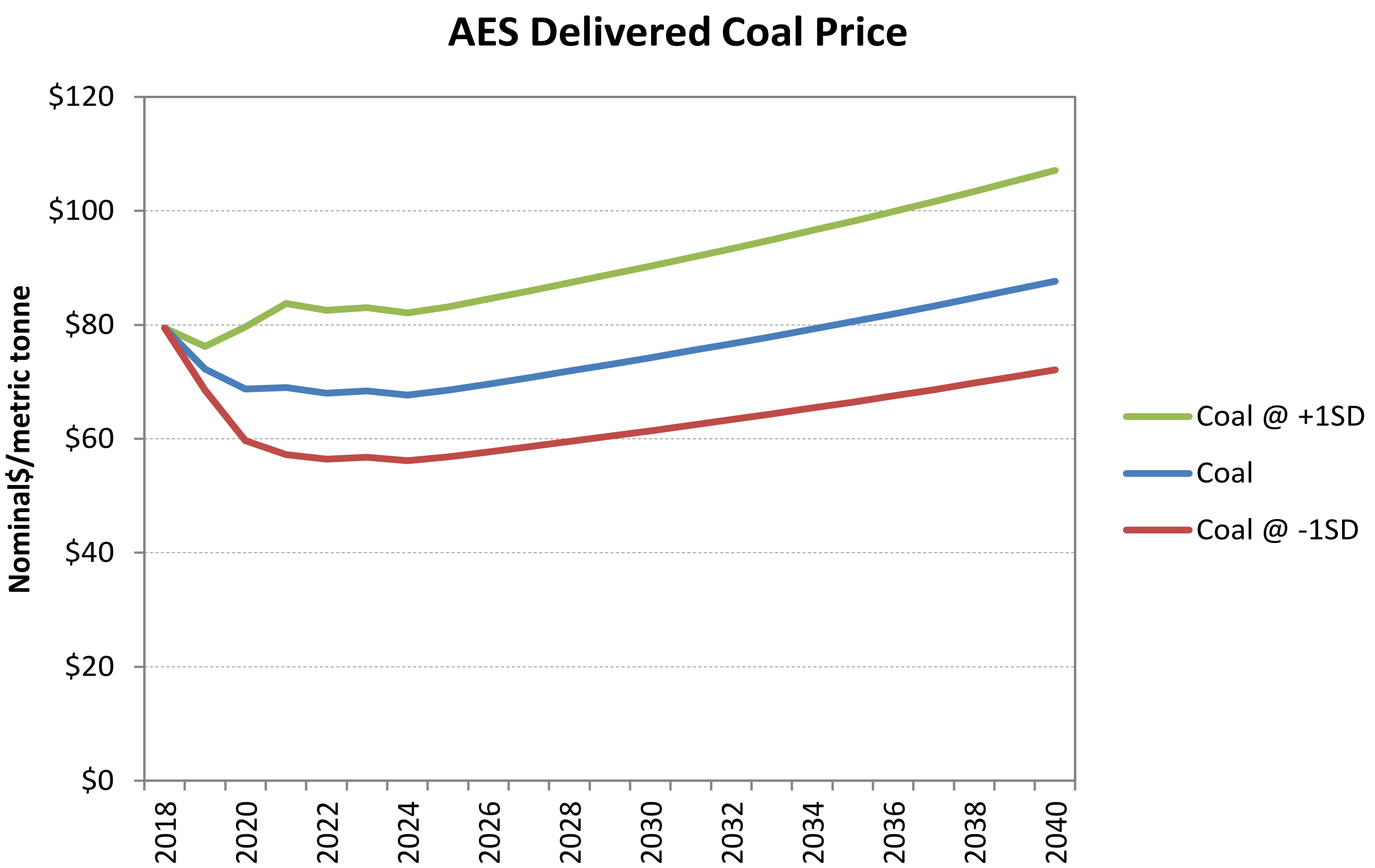
Forecasted Delivered Fuel to Plants

- The figure shows the forecast cost for coal delivery to AES:



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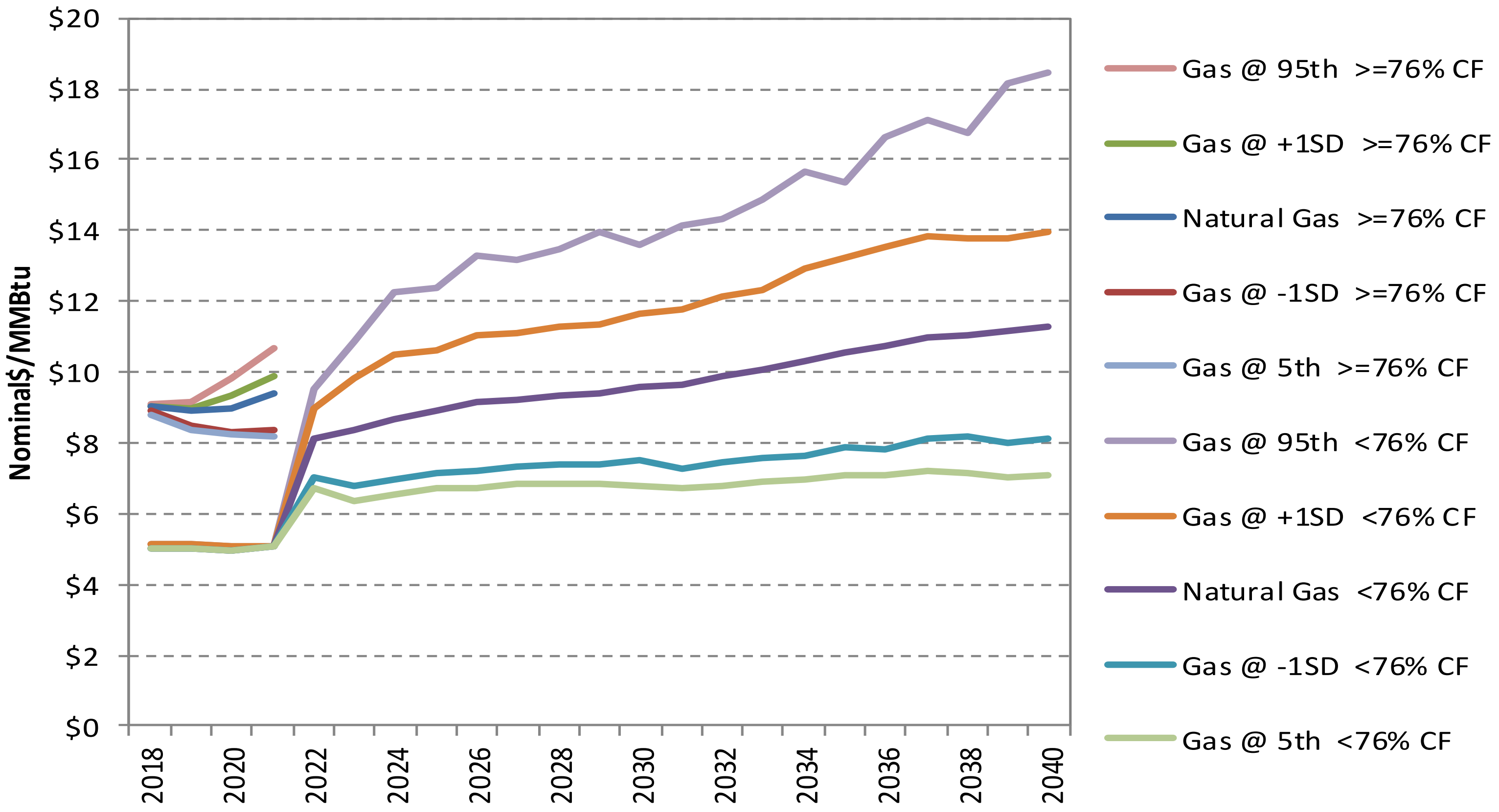
Forecasted Delivered Fuel to Plants

- The figure shows the forecast for coal delivery to EcoEléctrica (note change after contract termination) .



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Resource Plan Development

Introduction

- The 35 Portfolio Cases were assessed to identify the recommended resource plan and identify the common no regret / minimum regret elements across the plans.
- Scenario 2 is not included in the final 35 Cases as S4S2 and S4S3 resulted in the same resources that would be built under the constraints of Scenario 2.
- The main metrics used for assessment include:
  - ***NPV of the generation revenue requirements:*** Includes the return on capital, fuel cost, fixed and variable O&M and regasification (LNG).
  - ***The average cost of generation:*** All in cost for the period 2019 to 2028 in $/MWh.
  - **Total Capital Investments**: Sum of all investments in the LTCE plan to be made by the developers.
  - **RPS Compliance;** 2038 value but there is compliance every year.
  - **NPV of Deemed Energy Not Served**: energy that would be lost in case that the system had to revert to MiniGrid isolated operations for 1 month every 5 years; it is a relative metric for comparison.
  - **Reserve margin**
  - **Emission Reductions**
  - **Technology Risk:** a ratio of photovoltaic generation added to the system to the peak load; there are potential challenges to manage generation whose output can be much higher than the peak load.

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Resource additions overview

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- In this section of the presentation we present first an overview of the performance of each plan followed by the details.
- To provide an overview of the characteristics of the plans, the table below provides an overview of the resource additions under Base Load Forecast. Note the consistency on renewable and BESS. Thermal resources, however are located according to strategy and gas availability.

	Large & Medium CCGTs and Peakers							Renewable and Storage				
Case ID	F - Class Palo Seco 2025	F - Class Costa Sur 2025	San Juan 5&6 Conversion	F-Class Yabucoa 2025	Mayaguez Peker Conversion	Other	Peakers 2025 (MW)	New Solar 2025 (MW)	BESS 2025 (MW)	New Solar 2038 (MW)	BESS 2038 (MW)	Customer Owned Generation 2038 (MW)
S1S2B	–	EcoEléctrica Instead	✓	–	–	–	559.2	2,580	1,280	2,700	1,720	1,176
S1S3B	–	EcoEléctrica Instead	✓	–	–	–	513	2,580	1,280	2,580	1,840	1,176
S1S1B	–	✓	✓	X	X	Costa Sur 5&6 to 2037 & 2031	301.6	2,520	1,240	2,520	2,080	1,176
S3S2B	–	✓	✓	–	–	–	348	2,820	1,320	4,140	3,040	1,176
S3S3B	–	✓	✓	–	–	–	371	2,820	1,280	4,140	2,280	1,176
S4S2B	✓	✓	✓	–	–	–	371	2,220	1,320	2,820	1,640	1,176
S4S3B	2027	✓	✓	–	–	–	394	2,580	1,320	2,820	1,320	1,176
S4S1B	–	–	✓	2028	–	F-Class at Mayguez 2025	348	2,700	1,240	2,700	1,640	1,176
S5S1B	–	369 MW (2025&2028)	✓	–	–	–	371	2,580	1,200	2,580	1,480	1,176
ESM	✓	EcoEléctrica Instead	✓	✓	✓	–	421	2,400	920	2,580	1,640	1,176

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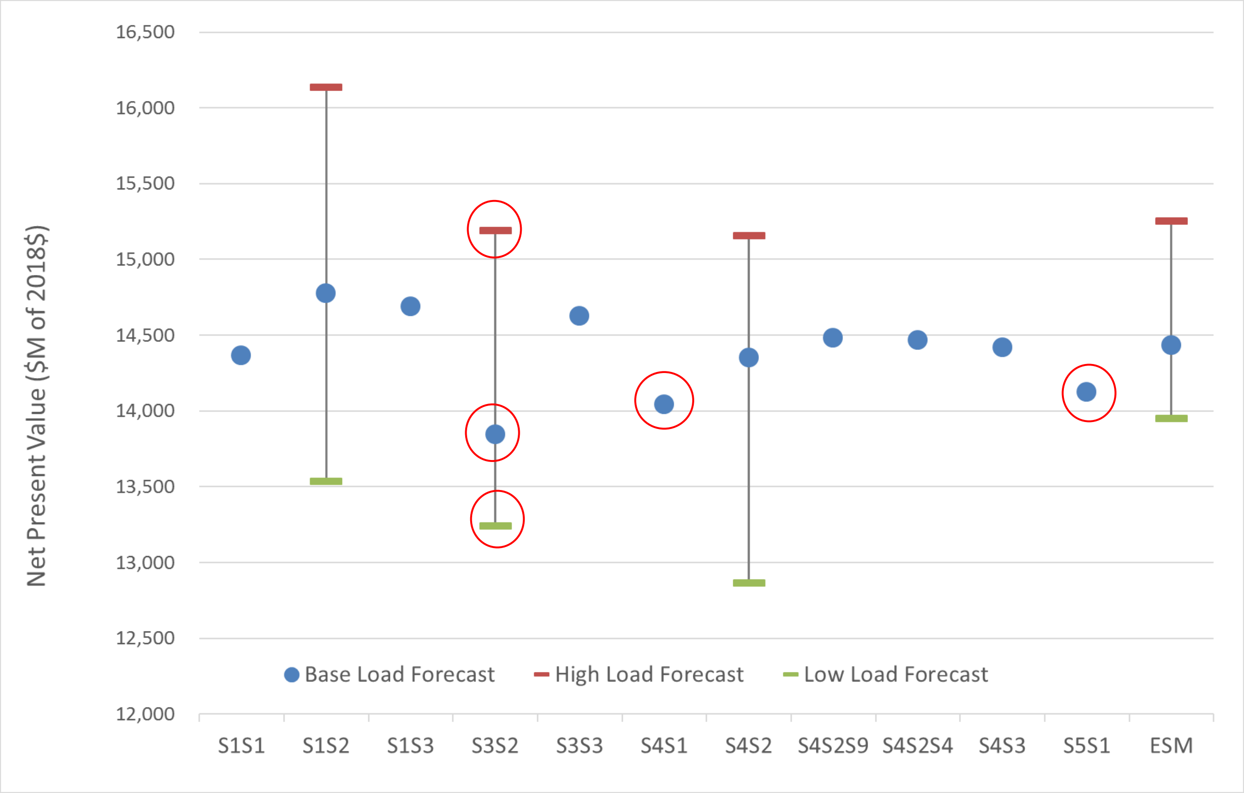
Performance Overview: NPV of revenue requirements

- The NPV of the revenue requirements is one of the most important metrics.
- Scenario 3 Strategy 2 (S3S2) has the lowest NPV ($13.8) for base load forecast but has higher costs than Scenario 4 Strategy 2 for the low load forecast and about the same as S4S2 and the ESM for the high load forecast.
- This plan depends on a deeper drop in costs of renewable and has levels of PV that can more that double the system load.
- S4S1 and S5S1 have the second and third lowest NPV results ($14.0B and $14.3B) for the base load forecast. The use of a centralized strategy results in the location of thermal resources away from the load and higher expected energy not served during major events.



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Performance Overview: NPV of revenue requirements

- S1S1 NPV is similar to S4S2 and the ESM, but as it extends Costa Sur 5&6 and EcoEléctrica until well after 2030, and maintains a concentration of generation in the south that creates/perpetuates resiliency issues. This case also has high levels of curtailment in the medium and long term.
- S4S2 and S4S3 have very similar NPVs, but Strategy 2 has better performance with respect to resiliency.
- ESM's NPV ($14.43B) is very similar to S4S2's ($14.35). We note that the ESM and S4S2 NPVs are also very similar for the possible high demand case *and only deviate from each other under low demand* conditions.

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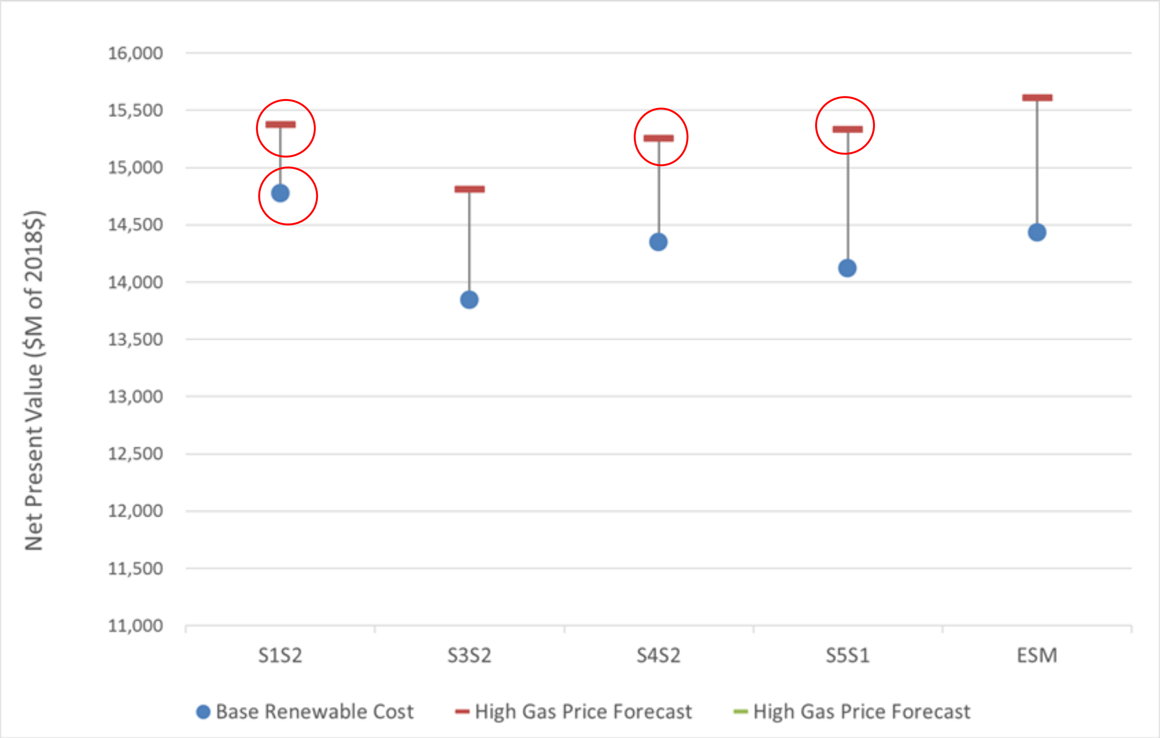
Performance Overview: Gas Price Sensitivity

- Gas price increases affect all plans similarly with the exception of S1S2B that is affected the least, and S5S1 that sees the greatest impact.
- Both plans NPVs are higher than S4S2B's.



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Performance Overview: Score Card Base Load Forecast

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- To further facilitate the comparison between the portfolios, we use a “balanced score card” where the key metrics were normalized so that green is the best outcome and red is the worst.
- We observe that the S4S2B and the ESM have the most consistent performance across all metrics.
- Other plans either have high costs (S1S2, S1S3, S3S3), worse performance with respect to resiliency (S1S1, S4S1 and S5S1) or have higher technology risks (S3S2).

	S1S1B	S1S2B	S1S3B	S3S2B	S3S3B	S4S1B	S4S2B	S4S3B	S5S1B	ESM
NPV @ 9% 2019-2038 k$	96	94	94	100	95	97	96	96	98	96
Average 2019-2028 2018$/MWh	98	94	95	100	97	97	97	96	98	97
Capital Investment Costs ($ Millions)	100	95	100	65	66	89	84	90	89	100
NPV Deemed Energy Not Served	18	95	42	99	100	23	82	73	34	76
RPS 2038	78	61	61	100	78	78	78	61	77	77
Emissions Reductions	99	99	100	100	94	87	89	85	90	91
Technology Risk (PV / Max Demand)	100	93	98	61	61	93	89	89	98	98
High Fuel Price Sensitivity on NPV		100		97			98		94	96
High Renewable Cost Sensitivity on NPV		100		50	50		100		99	100
Overall	79	89	73	83	80	70	87	83	82	88

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Performance Overview: Score Card Base Load Forecast

- For high load growth, S4S2 has the best overall outcomes, closely followed by the ESM. Scenario 1 and Scenario 3 have worse outcomes due to high NPVs and higher energy not served and particularly for the second, greater technology risk.

High Load Forecast	S1S2H	S3S2H	S4S2H	ESM high
NPV @ 9% 2019-2038 k$	94	100	100	97
Average 2019-2028 2018$/MWh	95	99	100	98
Capital Investment Costs ($ Millions)	96	65	100	98
NPV Deemed Energy Not Served	81	67	100	81
RPS 2038	100	100	88	78
Emissions Reductions	100	98	86	97
Technology Risk (PV / Max Demand)	77	54	98	100
Overall	85	78	93	89

- For low load both the ESM and S4S2 have the best overall results, but the ESM has higher NPV than any of the cases, compensated by lower capital costs results.
- The sensitivity to further load declines makes it important to keep options open with this plan to commit if necessary to the large generation investments that differ from the S4S2.

Low Load Forecast	S1S2L	S3S2L	S4S2L	ESM Low
NPV @ 9% 2019-2038 k$	95	97	100	92
Average 2019-2028 2018$/MWh	95	97	100	92
Capital Investment Costs ($ Millions)	100	60	88	98
NPV Deemed Energy Not Served	75	65	100	98
RPS 2038	88	88	100	70
Emissions Reductions	100	97	90	93
Technology Risk (PV / Max Demand)	85	49	79	100
Overall	85	74	89	89

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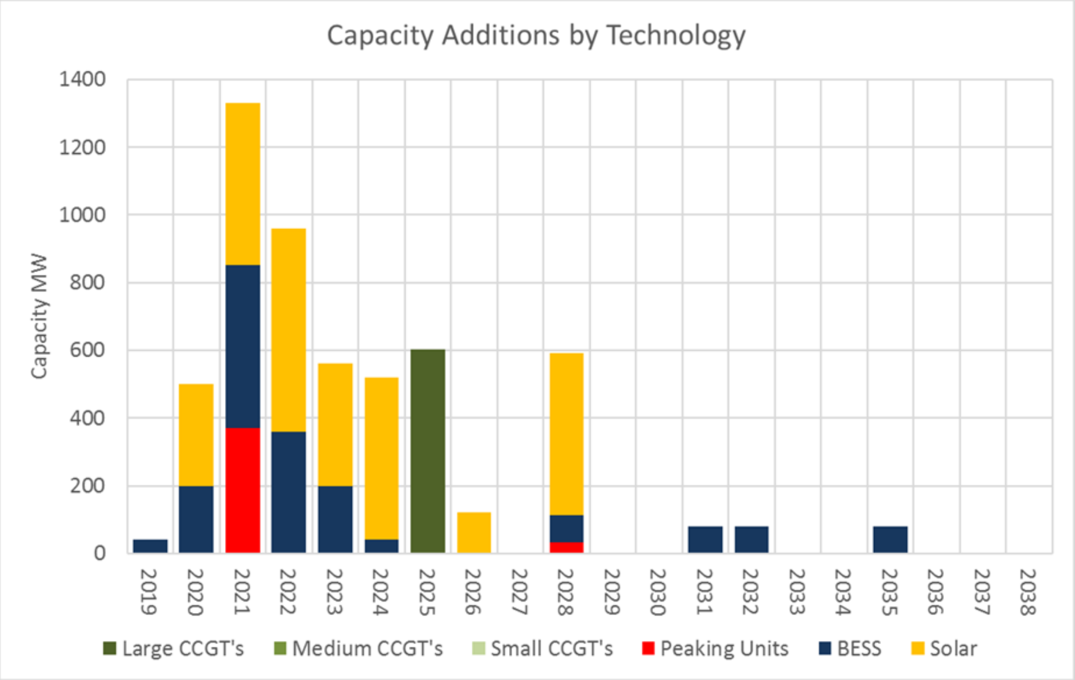
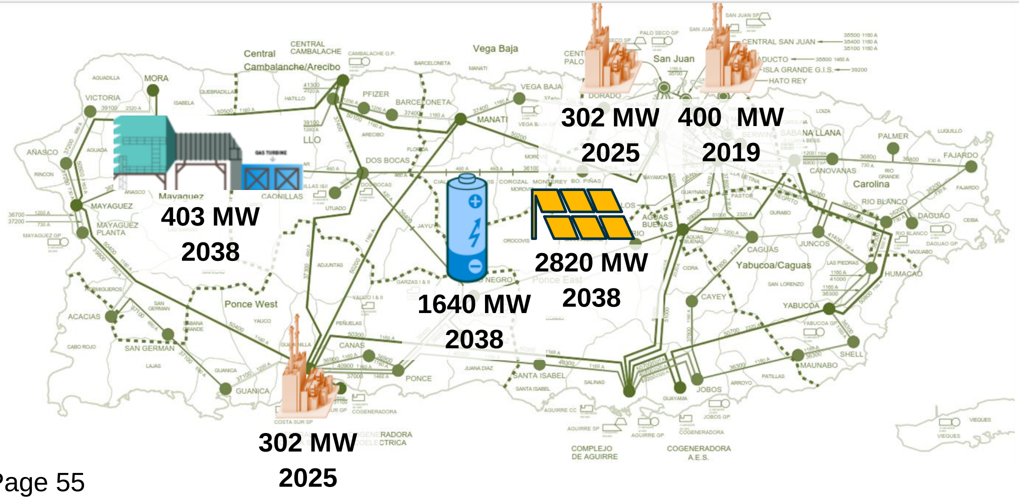
Scenario 4 Results

Scenario 4 Strategy 2 with Base Load Forecast Generation Additions





Total LTCE Additions over the planning period

- 2,820 MW of utility scale PV are added starting in 2020 with a 300 MW and 2,220 MW by 2025. This value is met or exceeded across the cases.
- Note a large block of PV by 2028 when AES retires.
- 1,640 MW of battery energy storage are added with a combination of 2, 4 and 6 hours discharge times. 1,320 MW are installed by 2025 (about 80% of the total).
- All plans have 920 MW of storage or more, hence about 1,000 MW is robust provided that the PV is also installed.
- Two large CCGTs are installed, one F-Class in Palo Seco and one F-Class in Costa Sur in 2025.
- The Costa Sur CCGT decision can be reversed if agreement on a renegotiated contract is reached with EcoEléctrica.
- SJ 5 & 6 are converted to gas in 2019. One unit is retired economically by 2034.
- 371 MW of peaking generation are distributed throughout the island by 2021. A small addition of 32 MW is made by 2028.

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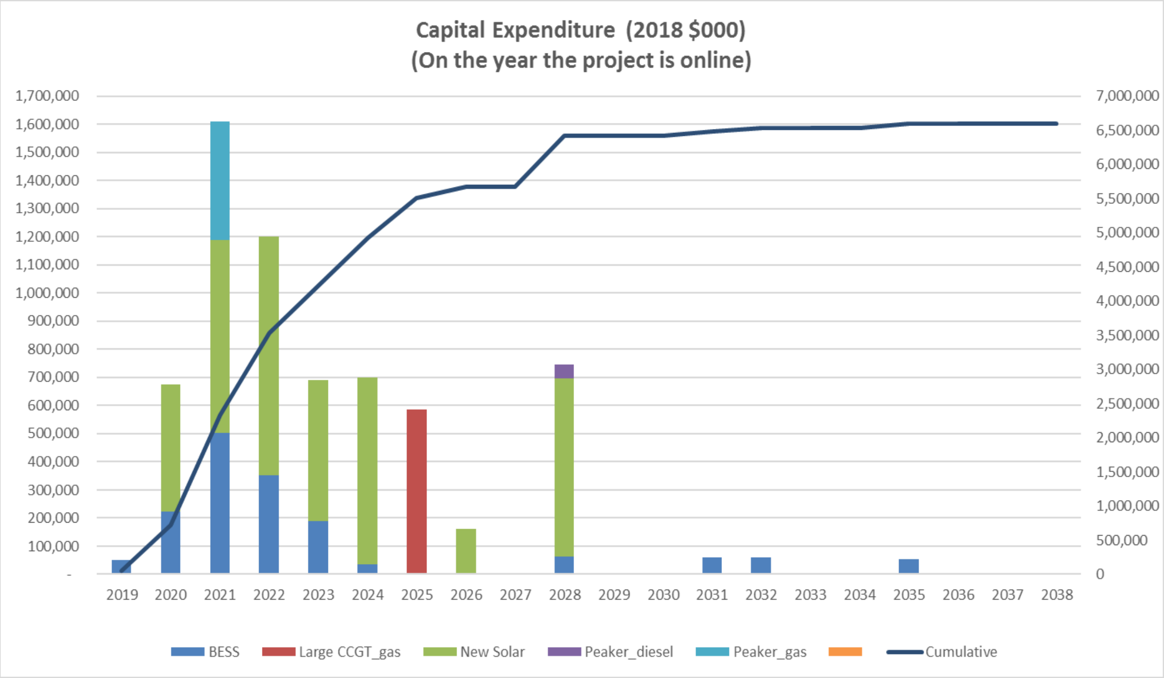
Scenario 4 Strategy 2 Capital Expenditures



LTCE Economic Retirements

- Capital expenditures are assumed to be made by developers and covered in a fixed charge calculated using the WACC and the economic life.
- However, the overnight capital expenditures required for the S4S2 Portfolio under the Base Load forecast are shown to the left where we observe that most will happen by 2025.
- The largest investment is required for the generation assets expected to be in service in 2021 ($1.6 billion), for new solar, peaking generation and storage.
- Total capital investments reach $ 6.6 billion (US$ 2018) by 2038.

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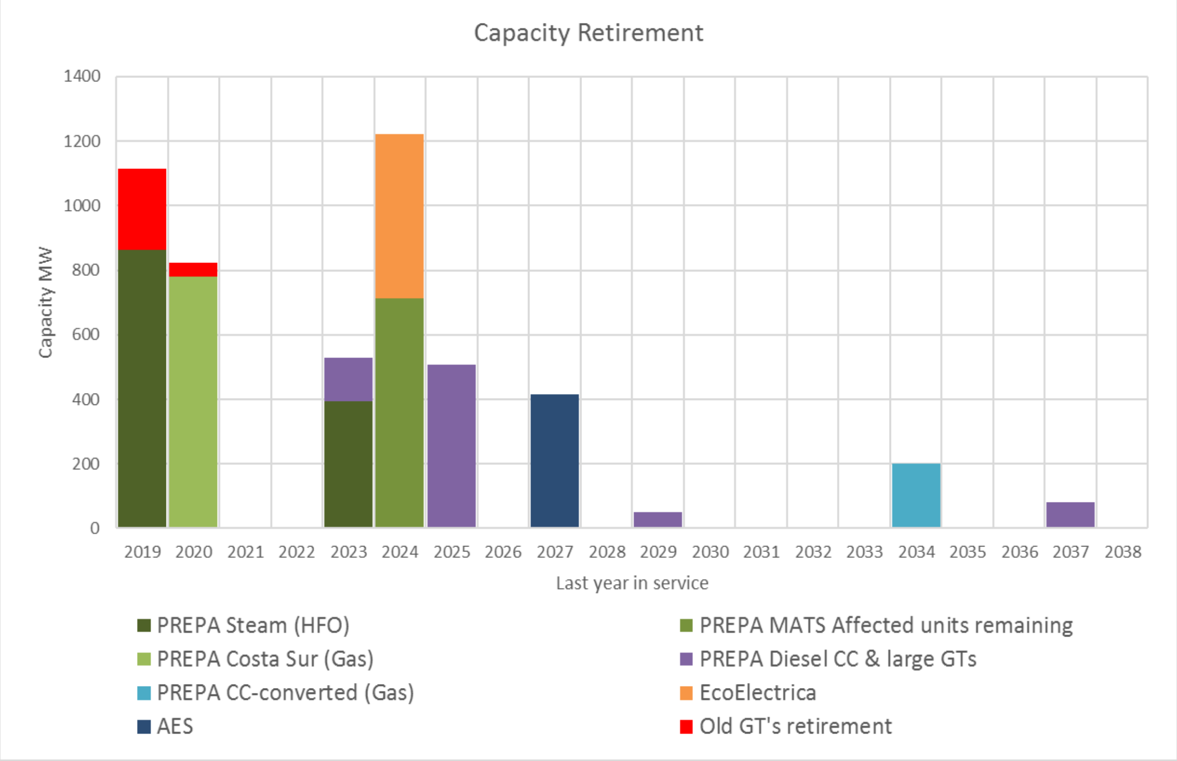
Scenario 4 Strategy 2 with Base Load Forecast Generation Retirements



LTCE Economic Retirements

- The assumed installation of the PV and Storage in 2020 allows for the economic retirement of Aguirre ST 1 and 2 (end of 2019), Palo Seco ST 3 and 4 (end of 2024) and San Juan ST 7 & 8 end of 2023.
- EcoEléctrica is economically retired by the end of 2024, when the new CCGT is assumed to be in service.
- Costa Sur 5 & 6 last year in service is 2020 as they could not compete with EcoEléctrica, under the base load and low load forecast. Under the high load case, one of the units stays online until the end of 2029.
- AES is retired by 2028, not economically but by model input as per law.
- The Aguirre CC 1 and 2 are retired by 2025. Cambalache 2 & 3 retire in 2023 and 2037 and two Aero Mayagüez peakers are retired in 2023 and 2029.
- The NG converted SJ 6 units are retired by 2034.

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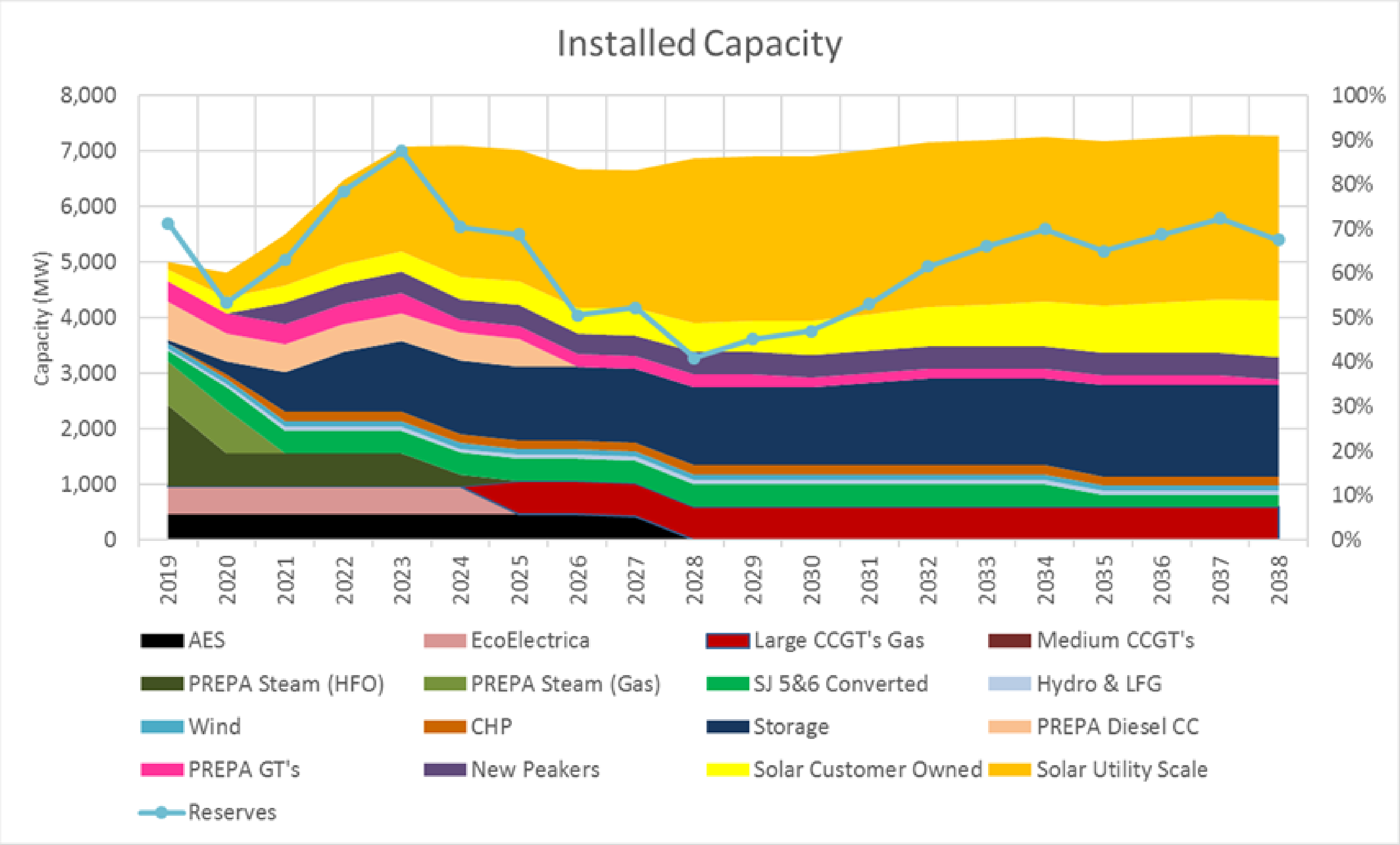
Scenario 4 Strategy 2 with Base Load Forecast Capacity & Reserves



Installed Capacity & Reserves

- As can be observed with this LTCE plan, the system transitions to one based on renewables. This can be observed considering that by 2038, 79% of the installed capacity in the system consists of renewable generation or facilities in place for its integration (storage and peakers).
- As PREPA's units and the thermal PPOAs are phased out, the operating reserves are reduced reaching a minimum of 41% in 2028.
- The Planning Reserve Margin of 30% appears not to have been a binding constraint on the LTCE plan formulation.

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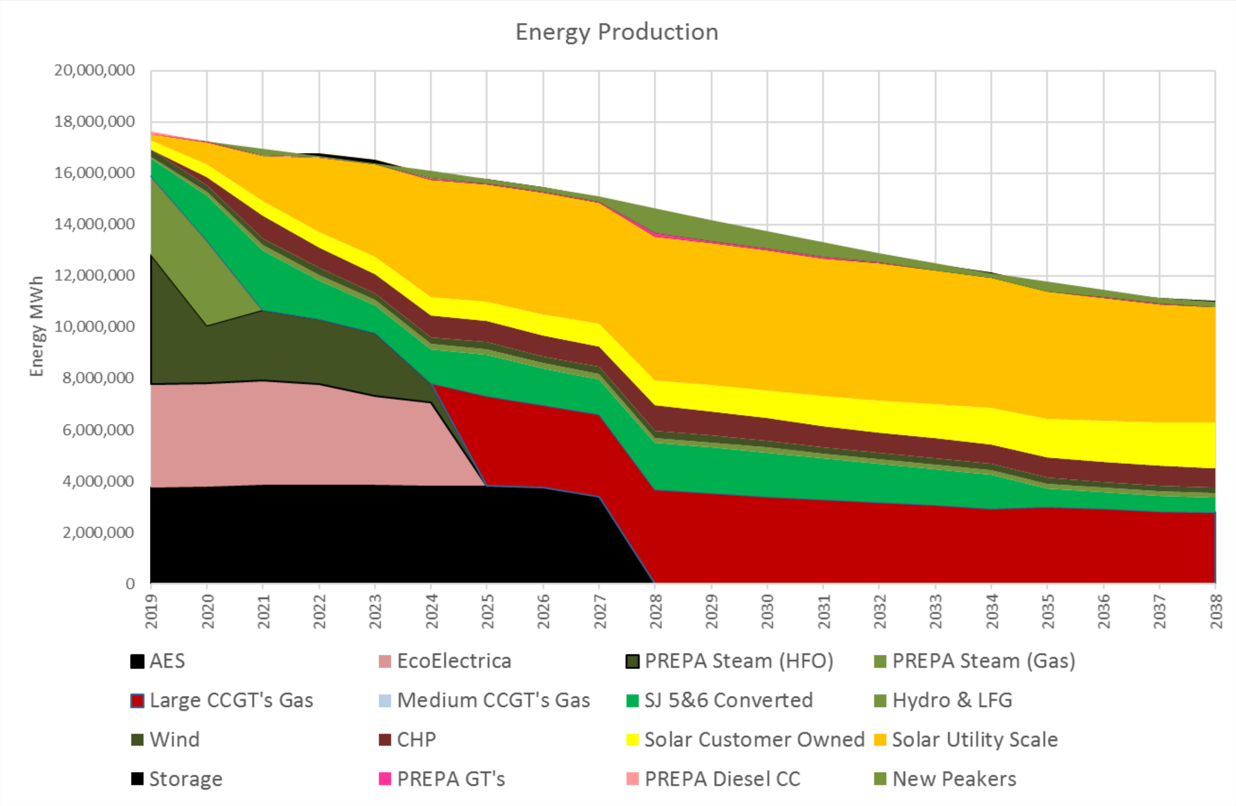
Scenario 4 Strategy 2 with Base Load Forecast Energy Mix



Installed Capacity & Reserves

- Total renewable generation accounts for 63% of the total energy produced by 2038, with gas generation accounting for 30% of the total.
- Most of the gas generation comes from the two new large CCGTs and San Juan conversions. As such, the development of the land based LNG terminal at San Juan is critical for this Scenario.

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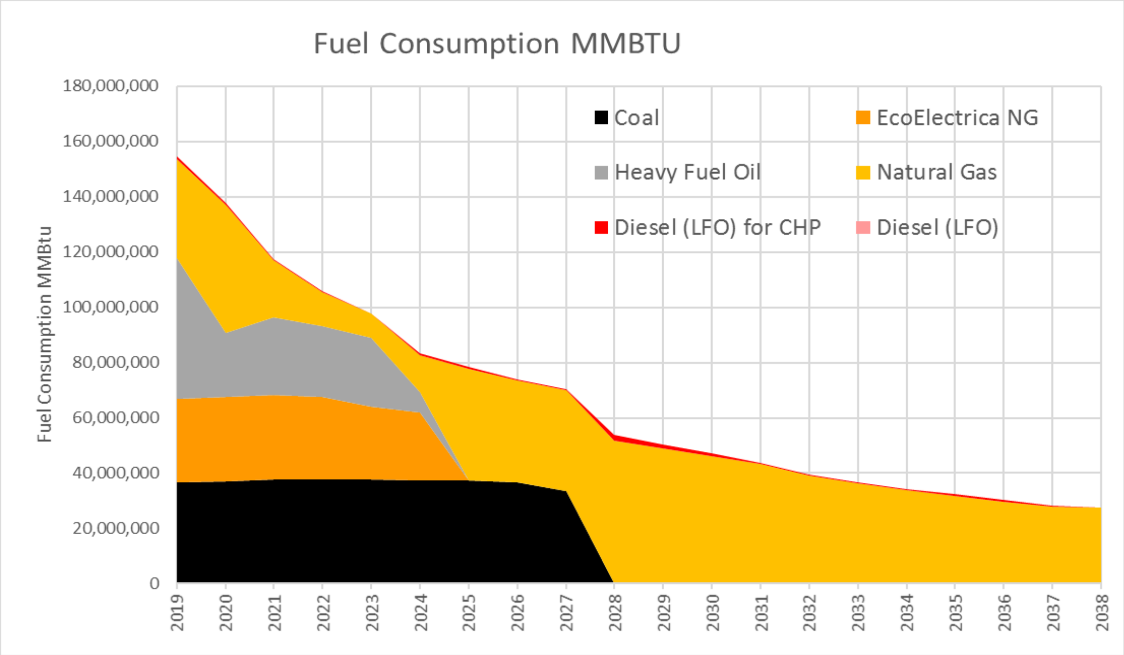
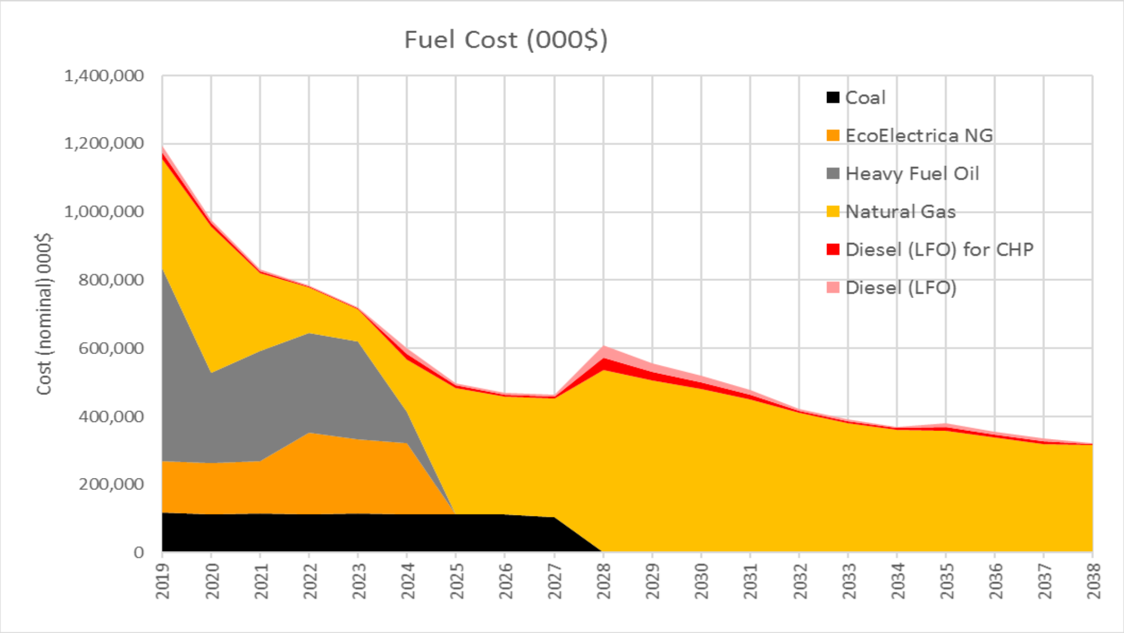
Scenario 4 Strategy 2 with Base Load Forecast
Fuel Diversity





Fuel Consumption

- In line with the change in the energy supply matrix, there is a sharp drop in fuel consumption and associated costs with the implementation of the plan. Total fuel consumption drops 82% by 2038, with natural gas dominating.
- Fuel costs decline 73% through the study period in line with the decline in fuel consumption to $319 million by 2038.

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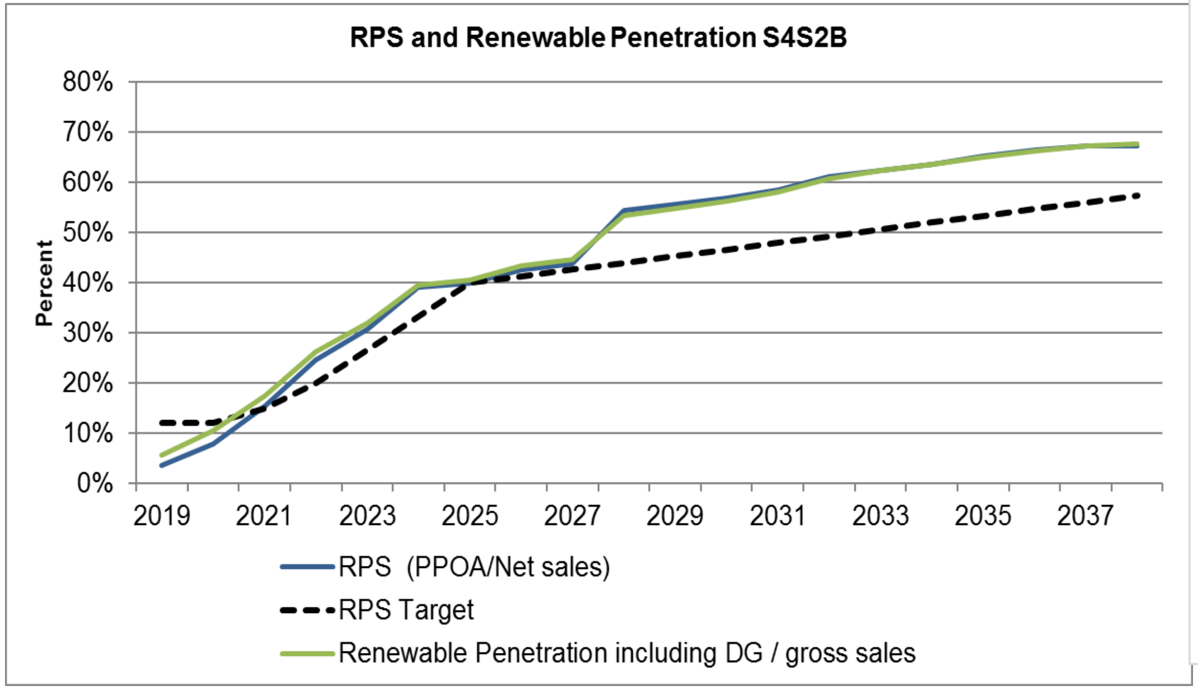
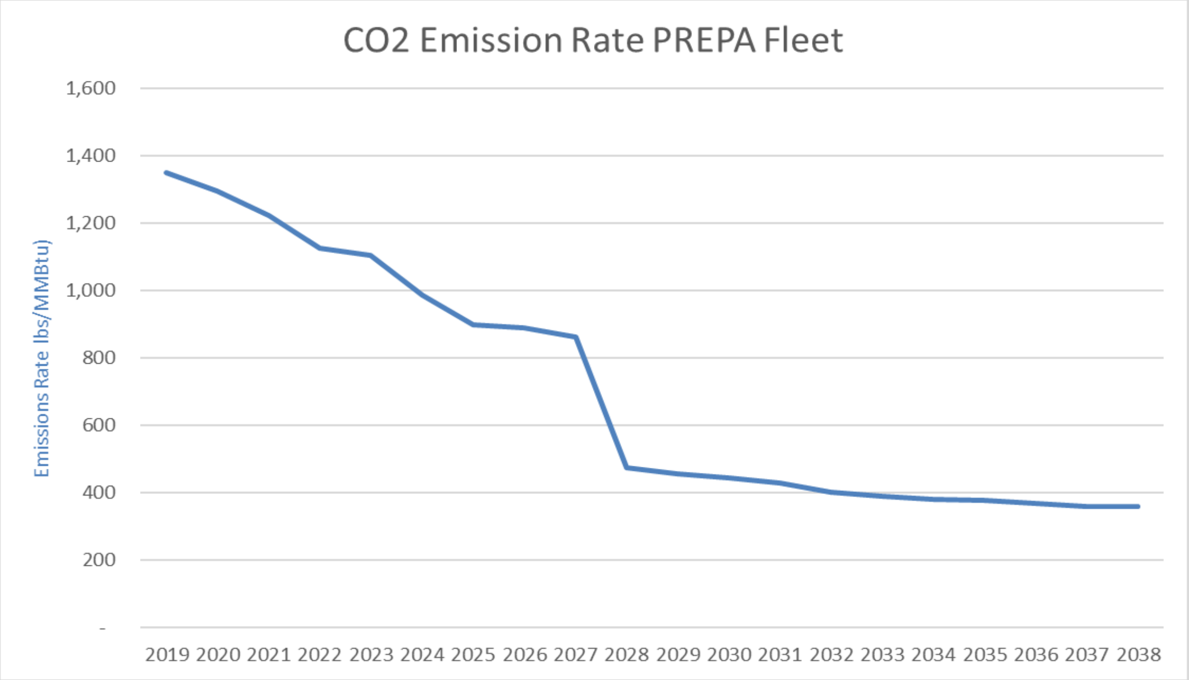
Scenario 4 Strategy 2 with Base Load Forecast RPS Compliance and Emissions





RPS Compliance

- The Scenario 4 plan is MATS compliant after 2024 and achieves 68% RPS compliance by 2038 under the base case load forecast (60% under high load and 77% under low load growth).
- CO_2 emissions for PREPA's fleet fall in the first ten years of the forecast driven by the retirement of the older fuel oil, diesel and gas units along with increased penetration of solar generation. Emissions fall 42% by 2027 and 61% by 2028 with AES coal retirement.

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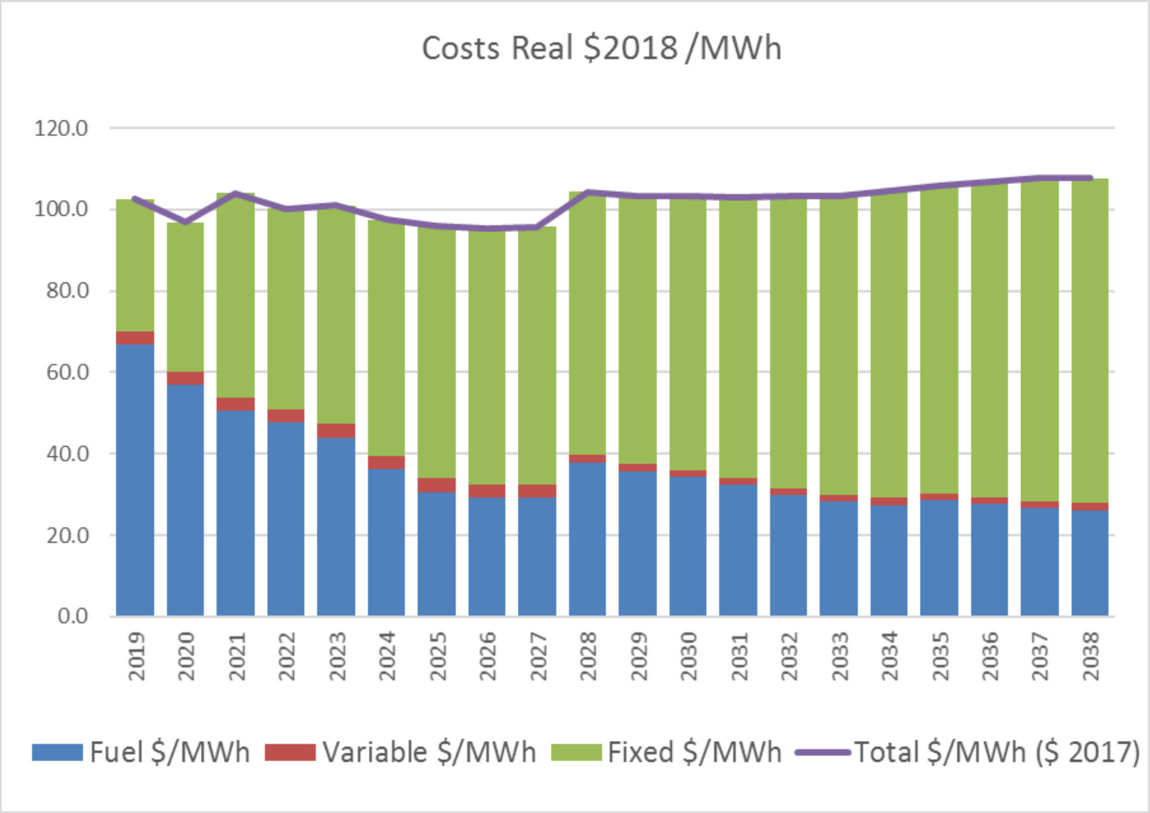
Scenario 2 Strategy 2 with Base Load Forecast Total Cost of Supply



Total Cost of Supply

- The total cost of supply in real dollars, including annualized capital costs, fuel costs, and fixed and variable O&M, is projected to decline with the implementation of the plan from $102.5/MWh in 2019 to $96.6/MWh by 2027 (real $2018).
- The costs increase in 2028, with AES retirement, and continue a gradual increase to reach $107.7/MWh by 2038 driven by new installations of battery storage and declining demand. Customer rates are expected to decline through 2027 under this plan.
- The net present value of the revenue requirement costs is $14.35 billion (nominal @ 9% rate).

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Scenario 4 Changes with strategies and load forecasts

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Resource impacts

- Only under the low load scenario is the Palo Seco CCGT not developed for Strategy 2. Strategy 3 locates the new CCGTs at Mayaguez and Yabucoa, possibly as a consequence of centralized strategy, and is less resilient.
- There is reduced need for storage in the high load case due to the reduced need to manage curtailment and in the low case due to a combination of reduced PV and reduced thermal generation.
- Retirements are largely consistent, with the exception of CS 5 under high load that retires by 2029.

Additions

Case ID	F - Class Palo Seco 2025	F - Class Costa Sur 2025	San Juan 5&6 Conversion	F-Class Yabucoa 2025	Mayaguez Peker Conversion	Other	Peakers 2025 (MW)	New Solar 2025 (MW)	BESS 2025 (MW)	New Solar 2038 (MW)	BESS 2038 (MW)	Customer Owned Generation 2038 (MW)
S4S2B	✓	✓	✓	–	–	–	371	2,220	1,320	2,820	1,640	1,176
S4S2H	✓	✓	✓	–	–	–	394	2,460	940	2,520	980	1,176
S4S2L	–	✓	✓	–	–	–	434	2,100	960	2,520	1,020	1,176
S4S3B	2027	✓	✓	–	–	–	394	2,580	1,320	2,820	1,320	1,176
S4S1B	–	–	✓	2028	–	F-Class at Mayguez 2025	348	2,700	1,240	2,700	1,640	1,176

Retirements

Case ID	AES 1 & 2	Aguirre Steam 1 & 2	Aguirre CC 1 & 2	Costa Sur 5 & 6	EcoElectrica	Palo Seco 3 & 4	San Juan 5 & 6	San Juan 5 & 6 Conv	San Juan 7 & 8
S4S2B	1 - 2027 2 - 2027	1 - 2019 2 - 2019	1 - 2025 2 - 2025	5 - 2020 6 - 2020	2024	3 - 2025 4 - 2023	5 - 2019 6 - 2019	6 - 2034	7 - 2023 8 - 2023
S4S2H	1 - 2027 2 - 2027	1 - 2020 2 - 2019	1 - 2025	5 - 2029 6 - 2020	2024	3 - 2025 4 - 2025	5 - 2019 6 - 2019	6 - 2034	7 - 2023 8 - 2023
S4S2L	1 - 2027 2 - 2027	1 - 2020 2 - 2019	1 - 2025 2 - 2032	5 - 2019 6 - 2020	2024	3 - 2021 4 - 2023	5 - 2019 6 - 2019	6 - 2034	7 - 2023 8 - 2023
S4S3B	1 - 2027 2 - 2027	1 - 2019 2 - 2019	1 - 2025 2 - 2029	5 - 2020 6 - 2020	2024	3 - 2022 4 - 2023	5 - 2019 6 - 2019	5 - 2036 6 - 2032	7 - 2021 8 - 2023
S4S1B	1 - 2027 2 - 2027	1 - 2020 2 - 2019	1 - 2032 2 - 2025	5 - 2022 6 - 2020	2024	3 - 2019 4 - 2019	5 - 2019 6 - 2019	5 - 2035 6 - 2030	7 - 2019 8 - 2019

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Scenario 2 Changes with strategies and load forecasts

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Resource impacts

- Only under the low load scenario is the Palo Seco CCGT not developed for Strategy 2. Strategy 1 locates the new CCGTs at Mayaguez and Yabucoa, as a consequence of the centralized strategy, but it is less resilient.
- There is reduced need for storage in the high load case due to the reduced need to manage curtailment and in the low case due to a combination of reduced PV and reduced thermal generation.
- Retirements are largely consistent with the exception of CS 5 under high load that retires by 2029.

Additions

Case ID	F - Class Palo Seco 2025	F - Class Costa Sur 2025	San Juan 5&6 Conversion	F-Class Yabucoa 2025	Mayaguez Peker Conversion	Other	Peakers 2025 (MW)	New Solar 2025 (MW)	BESS 2025 (MW)	New Solar 2038 (MW)	BESS 2038 (MW)	Customer Owned Generation 2038 (MW)
S4S2B	✓	✓	✓	–	–	–	371	2,220	1,320	2,820	1,640	1,176
S4S2H	✓	✓	✓	–	–	–	394	2,460	940	2,520	980	1,176
S4S2L	–	✓	✓	–	–	–	434	2,100	960	2,520	1,020	1,176
S4S3B	2027	✓	✓	–	–	–	394	2,580	1,320	2,820	1,320	1,176
S4S1B	–	–	✓	2028	–	F-Class at Mayguez 2025	348	2,700	1,240	2,700	1,640	1,176

Retirements

Case ID	AES 1 & 2	Aguirre Steam 1 & 2	Aguirre CC 1 & 2	Costa Sur 5 & 6	EcoElectrica	Palo Seco 3 & 4	San Juan 5 & 6	San Juan 5 & 6 Conv	San Juan 7 & 8
S4S2B	1 - 2027 2 - 2027	1 - 2019 2 - 2019	1 - 2025 2 - 2025	5 - 2020 6 - 2020	2024	3 - 2025 4 - 2023	5 - 2019 6 - 2019	6 - 2034	7 - 2023 8 - 2023
S4S2H	1 - 2027 2 - 2027	1 - 2020 2 - 2019	1 - 2025	5 - 2029 6 - 2020	2024	3 - 2025 4 - 2025	5 - 2019 6 - 2019	6 - 2034	7 - 2023 8 - 2023
S4S2L	1 - 2027 2 - 2027	1 - 2020 2 - 2019	1 - 2025 2 - 2032	5 - 2019 6 - 2020	2024	3 - 2021 4 - 2023	5 - 2019 6 - 2019	6 - 2034	7 - 2023 8 - 2023
S4S3B	1 - 2027 2 - 2027	1 - 2019 2 - 2019	1 - 2025 2 - 2029	5 - 2020 6 - 2020	2024	3 - 2022 4 - 2023	5 - 2019 6 - 2019	5 - 2036 6 - 2032	7 - 2021 8 - 2023
S4S1B	1 - 2027 2 - 2027	1 - 2020 2 - 2019	1 - 2032 2 - 2025	5 - 2022 6 - 2020	2024	3 - 2019 4 - 2019	5 - 2019 6 - 2019	5 - 2035 6 - 2030	7 - 2019 8 - 2019

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Scenario 4 Sensitivities

No Retirement of EcoEléctrica (Sensitivity 9)

- If EcoEléctrica is retained, the new CCGT at Costa Sur is not installed and there is an slight increase in the NPV.
- With at reduction of 60% in the EcoEléctrica capacity payments, the NPVs are the same.

Case ID	Scenario	Strategy	Sensitivity	Load	NPV @ 9% 2019-2038 k$	Average 2019-2028 2018$/MWh	RPS 2038	NPV Deemed Energy Not Served k$ (1)
S4S2B	4	2		Base	14,350,195	99.3	68%	247,445
S4S2S9B	4	2	9	Base	14,480,364	99.6	68%	267,841
			Increase:		0.9%	0.2%		

No Land Based LNG at San Juan (Sensitivity 4)

- Only one new CCGT is installed at Costa Sur in 2020. Solar installations are higher with 3,060 MW, compared to 2,820 MW in the base case. Storage installations are the same, with 1,640 MW.
- Overall portfolio costs are about $116 million higher under this sensitivity.

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Scenario 4 Sensitivities

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Other Sensitivities (S1 Low cost of renewables, S5 high gas prices, S6 high cost of renewables)

- These sensitivities did not affect the LTCE, hence result in minor changes of the variable costs and hence the NPV.

Case ID	Scenario	Strategy	Sensitivity	Load	AURORA LTCE	NPV @ 9% 2019-2038 k$	Average 2019-2028 2018$/MWh	NPV Deemed Energy Not Served k$ (1)	NPV + ENS k$	Capital Investment Costs ($ Millions)
S4S2B	4	2		Base	Yes	14,350,195	99.3	247,445	14,597,640	6,595
S4S2S9B	4	2	9	Base	No	14,480,364	99.6	267,841	14,748,205	6,265
S4S2S1B	4	2	1	Base	No	14,012,096	97.4	247,445	14,259,541	5,961
S4S2S4B	4	2	4	Base	Yes	14,466,325	100.9	345,809	14,812,134	6,552
S4S2S5B	4	2	5	Base	No	15,255,494	104.8	247,445	15,502,939	6,595
S4S2S6B	4	2	6	Base	No	15,565,108	106.7	247,445	15,812,553	8,756

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ESM Plan

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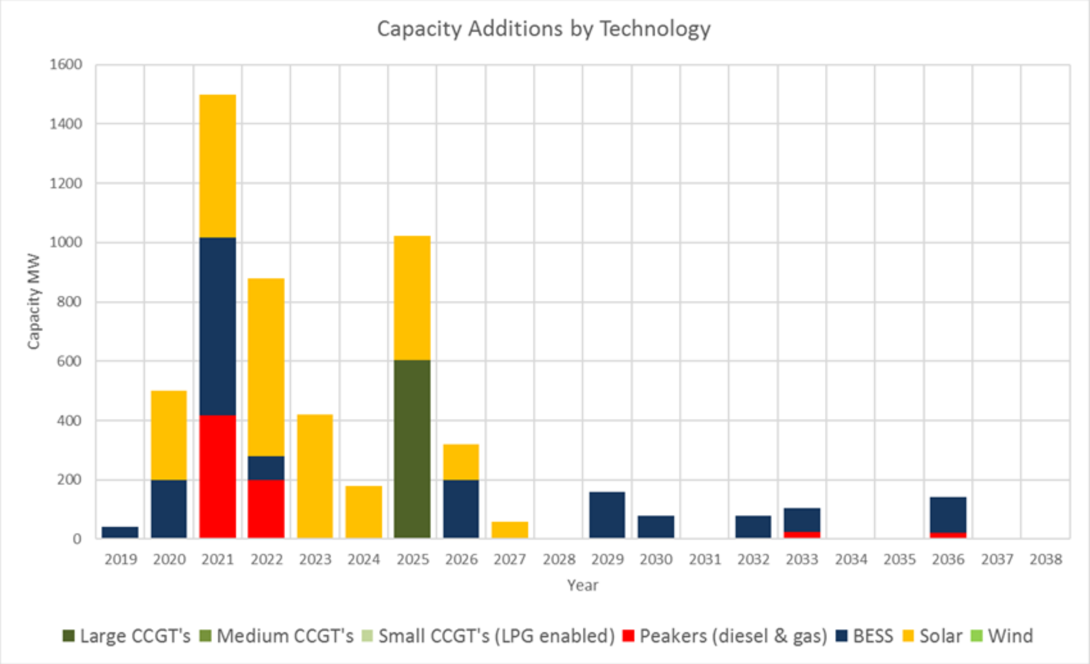
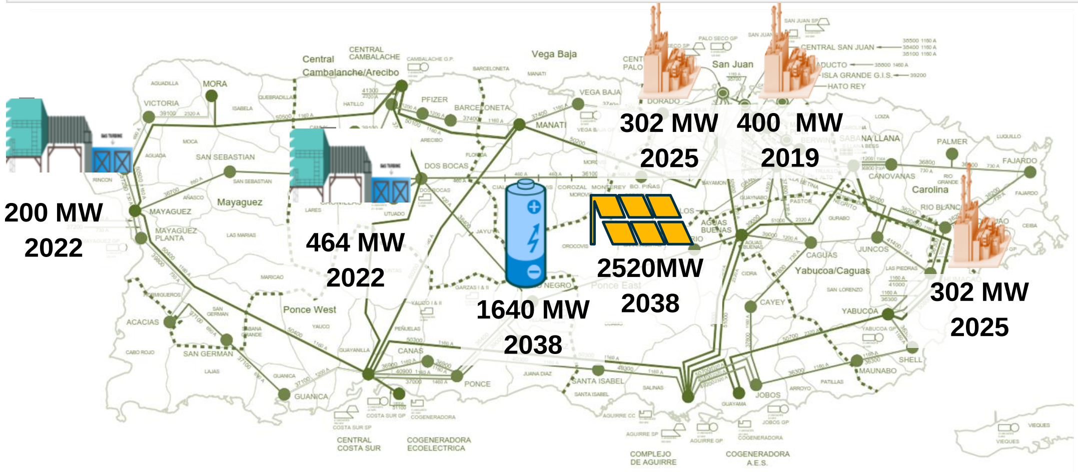
ESM Plan with Base Load Forecast Generation Additions





Total LTCE Additions over the planning period

- 2,520 MW of utility scale PV are added starting in 2020 and 2,400 MW by 2025, in line with most scenarios, and 180 MW more than the S4S2B. Almost all of the PV is added by this case in 2025.
- 1,640 MW of battery energy storage are added with a combination of 2, 4 and 6 hours discharge times, identical to the S4S2. 920 MW are installed by 2025 (400 MW less than S4S2).
- Two large CCGTs are installed, one F-Class in Palo Seco and one F-Class in Yabucoa by 2025, in line with the plan.
- EcoEléctrica is maintained by the plan; this may account for about 1% of additional NPV with an straight comparison with S4S2. In fact S2S4S9B's NPV, at $14.48 B, is almost identical to the ESM's $14.43 B.
- SJ 5 & 6 are converted to gas in 2019. One unit is retired economically by 2034.
- At Mayaguez 200 MW are converted to gas by 2022.
- 418 MW of peaking generation is added by 2021, distributed throughout the island. Two additional peakers of 23 MW each are added after 2030.

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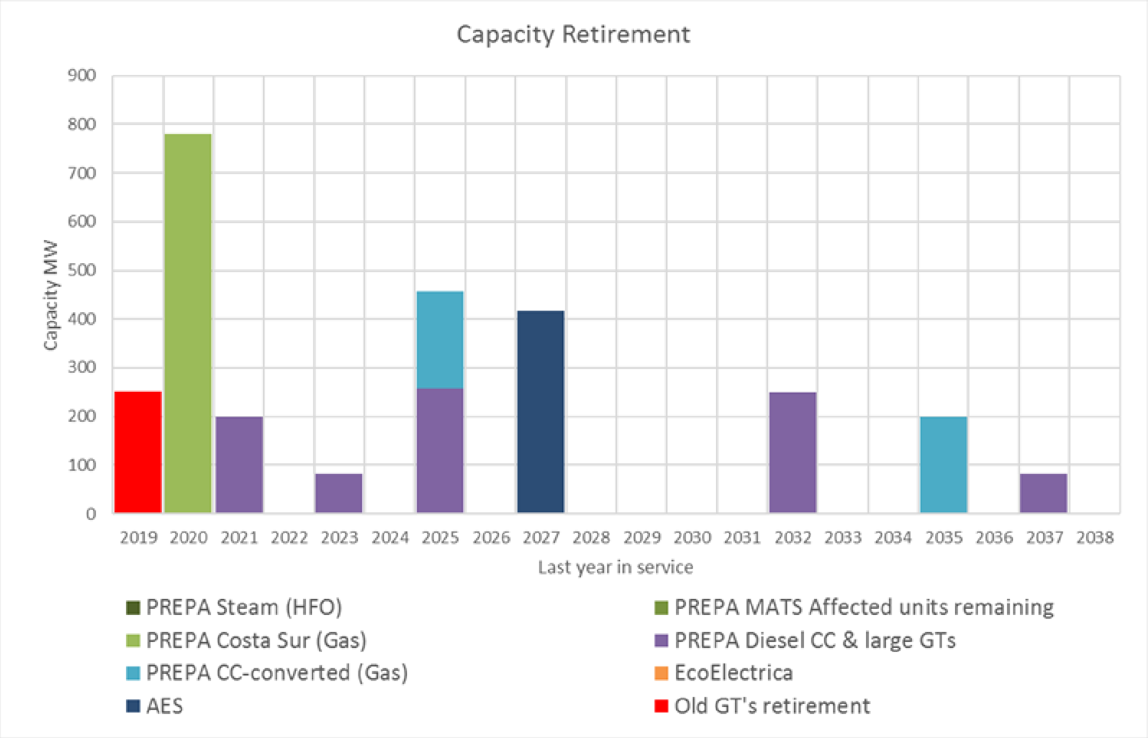
ESM with Base Load Forecast Generation Retirements



LTCE Economic Retirements

- The assumed installation of the PV and Storage in 2020 allows for the economic retirement of Aguirre ST 1 and 2 (end of 2019), Palo Seco ST 3 and 4 (end of 2024) and San Juan ST 7 & 8 by end of 2021 and 2023.
- Costa Sur 5 & 6 last year in service is 2020 as they could not compete with EcoEléctrica, under the base load and low load forecast. Under the high load case, one of the units stays online slightly longer, to 2021.
- AES is retired by 2028, not economically but by model input.
- The Aguirre CC 1 is retired by 2025 and CC 2 by 2032. Cambalache 2 & 3 are retired by the model in 2023 and 2037, however they should be kept available for MiniGrid Operations.
- The NG converted SJ 6 is retired by 2035.

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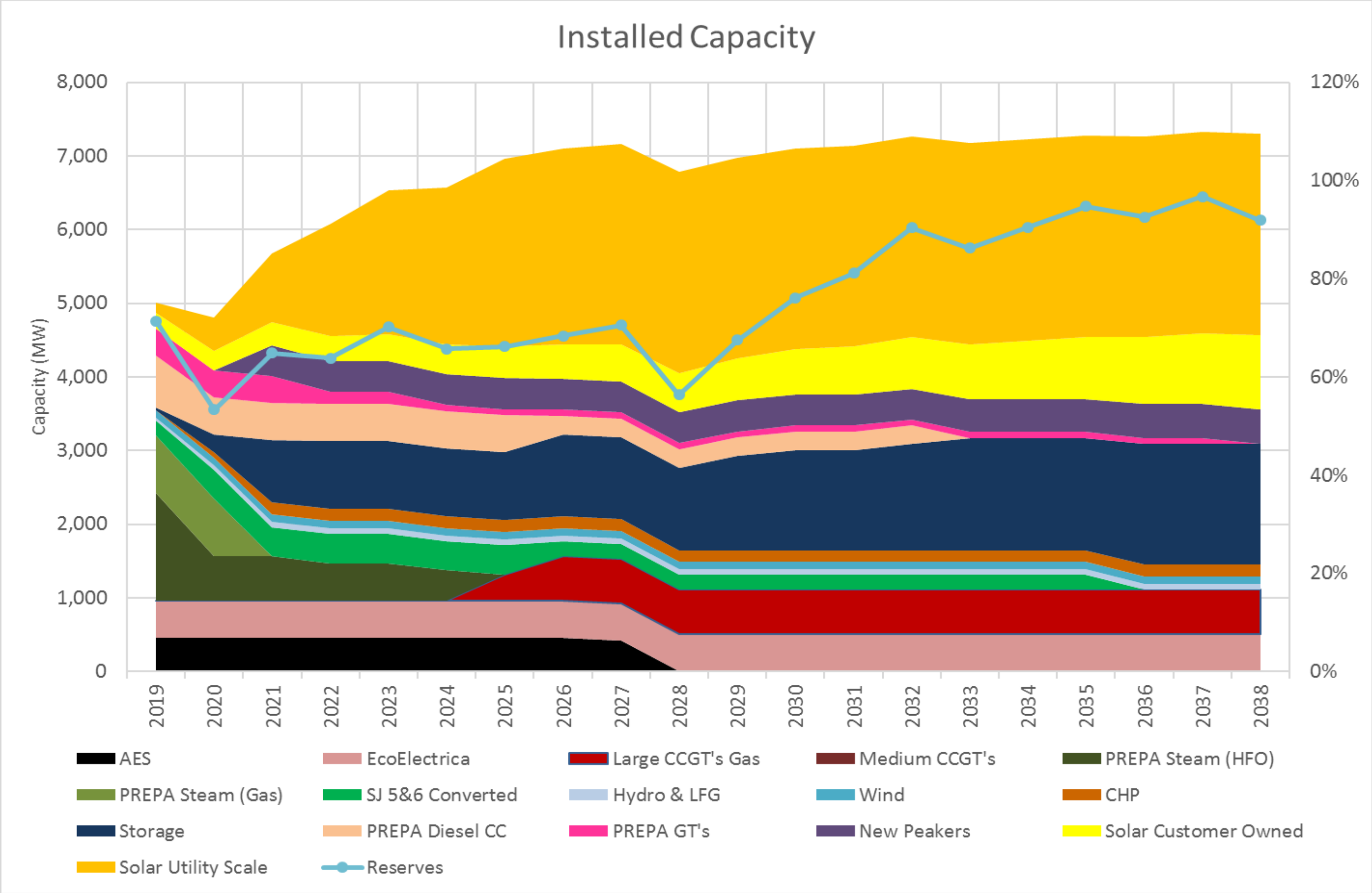
ESM with Base Load Forecast Capacity & Reserves



Installed Capacity & Reserves

- The system moves away primarily from coal and oil to natural gas, renewables and energy storage. By 2038, 62% of the installed capacity in the system consists of renewable generation or facilities in place for its integration (battery storage)
- As PREPA’s units and the thermal PPOAs are phased out the operating reserves are reduced reaching a minimum of 56% by 2028.
- The Planning Reserve Margin was not found to be binding at any time on the LTCE decisions.

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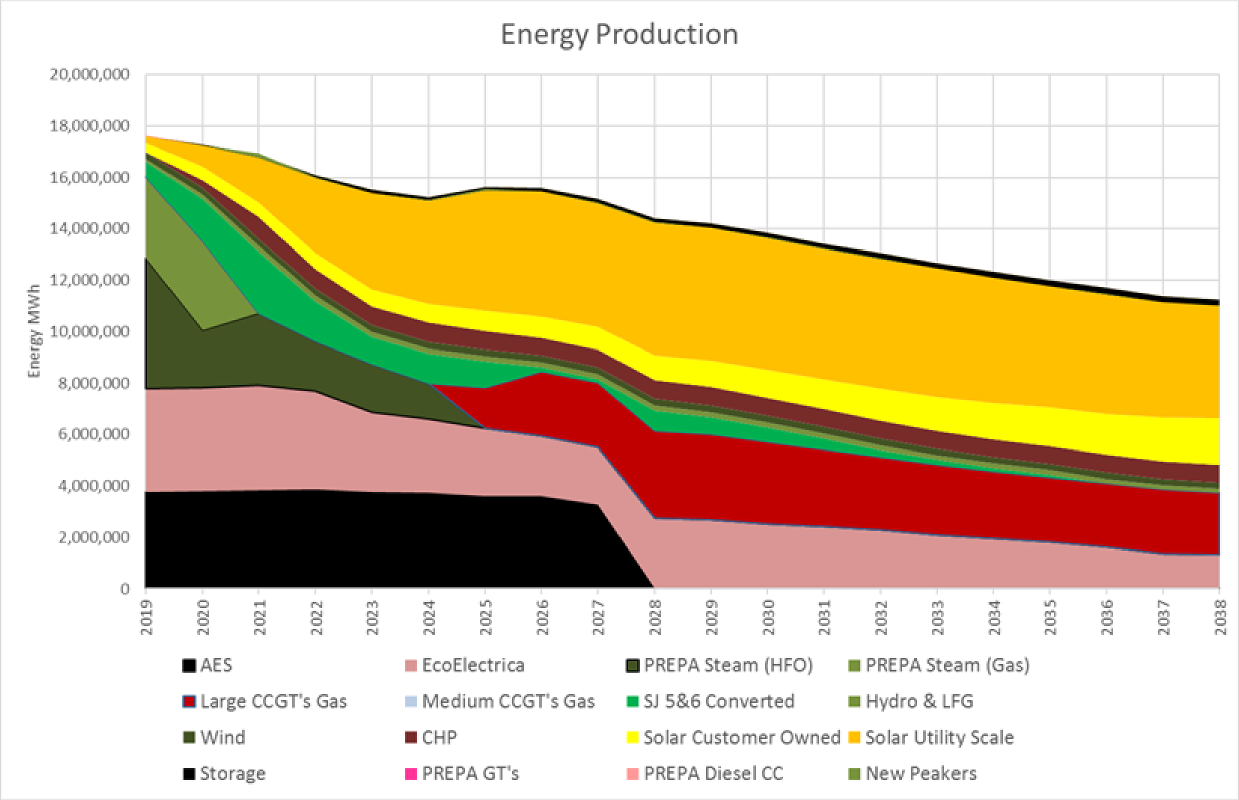
ESM with Base Load Forecast Energy Mix



Installed Capacity & Reserves

- Total renewable generation accounts for 62% of the total energy produced by 2038, which is slightly lower than the 63% in the S4S2 plan.
- Most of the gas generation comes from the two new large CCGTs and EcoEléctrica.
- The development of the San Juan LNG and the Yabucoa LNG is critical for the feasibility of these units.

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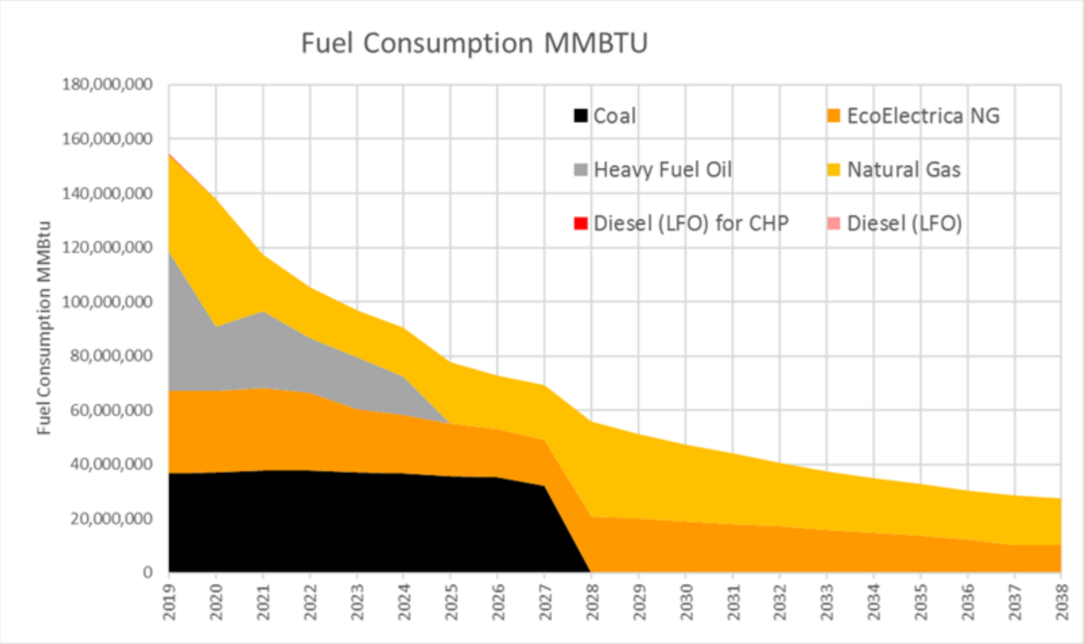
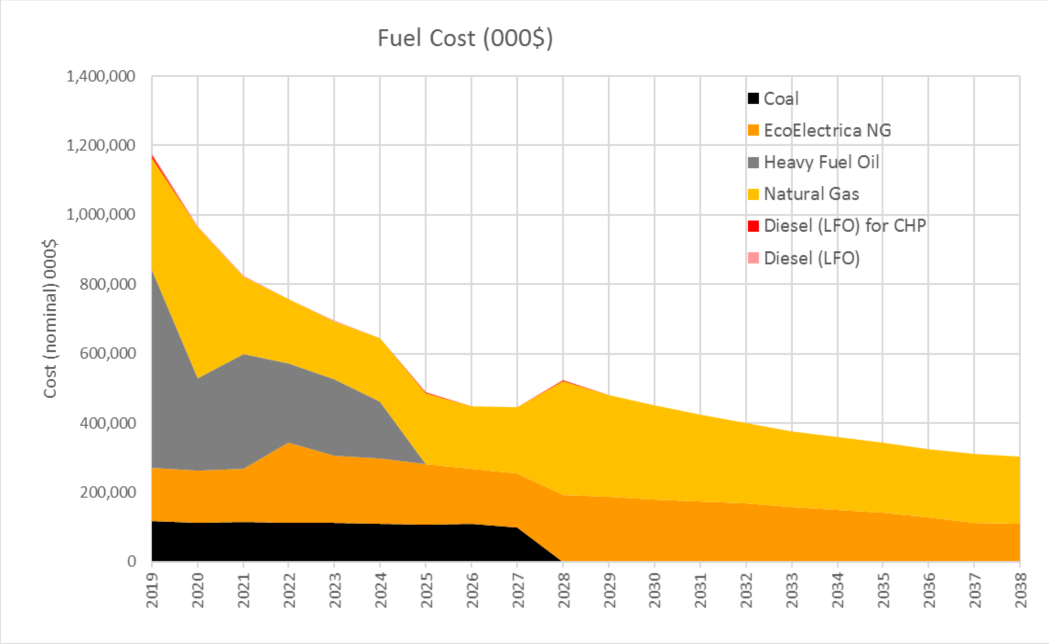
ESM with Base Load Forecast
Fuel Diversity





Fuel Consumption

- In line with the change in the energy supply matrix, there is a sharp drop in fuel consumption and associated costs with the implementation of the plan. Total fuel consumption drops 82% by 2038 with natural gas dominating, very similar to the S4S2 Case.
- Fuel costs decline 74% through the study period in line with the decline in fuel consumption to $304 million by 2038. Again very similar to the S4S2 ($319 million).

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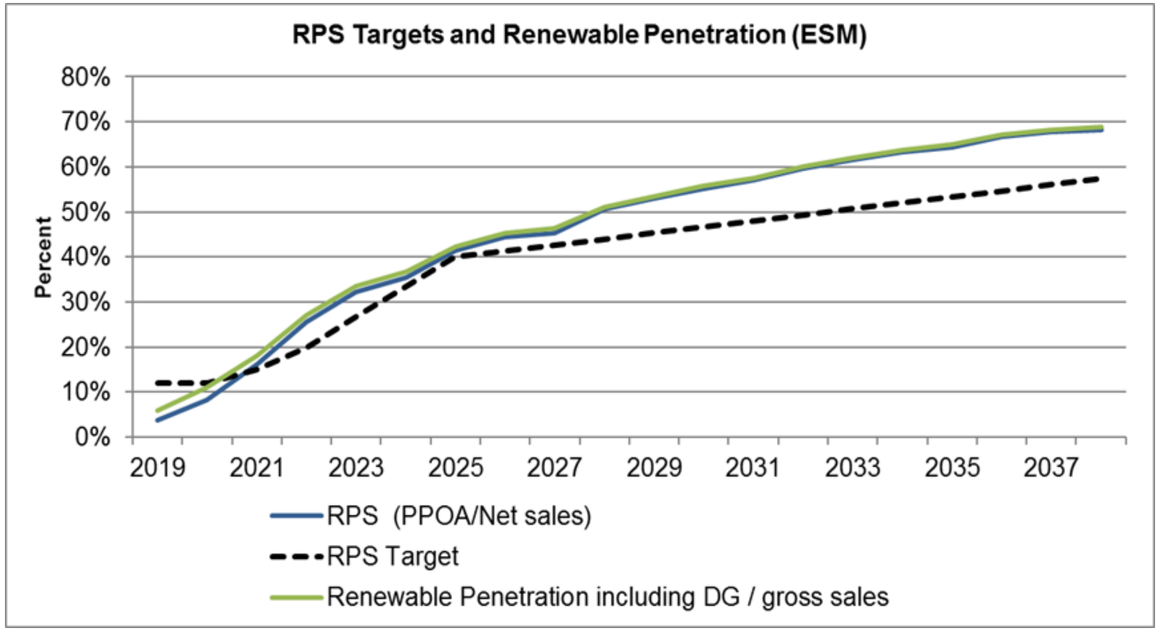
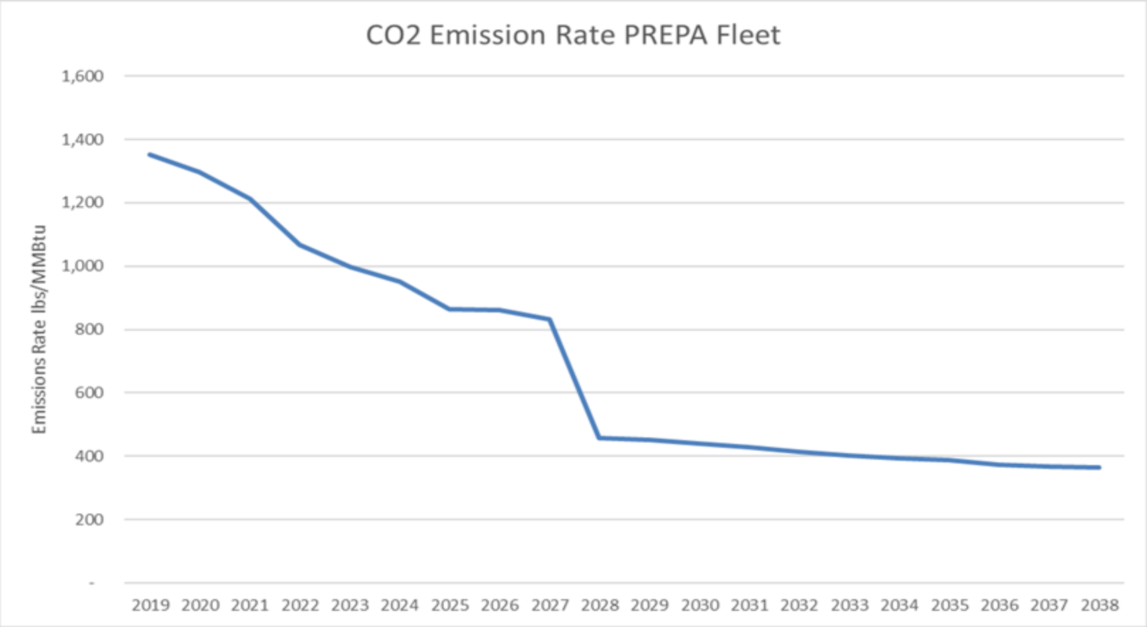
ESM with Base Load Forecast
RPS Compliance and Emissions





RPS Compliance

- The Scenario 4 plan is MATS compliant after 2024 and achieves 67% RPS compliance by 2038 under the base case load forecast (53% under high load and 54% under low load growth).
- CO_2 emissions for PREPA's fleet fall in the first ten years of the forecast driven by the retirement of the older fuel oil, diesel and gas units along with increased penetration of solar generation. Emissions fall 52% by 2027 and 75% by 2028 with AES coal retirement. Emissions reach an 87% reduction by 2038.

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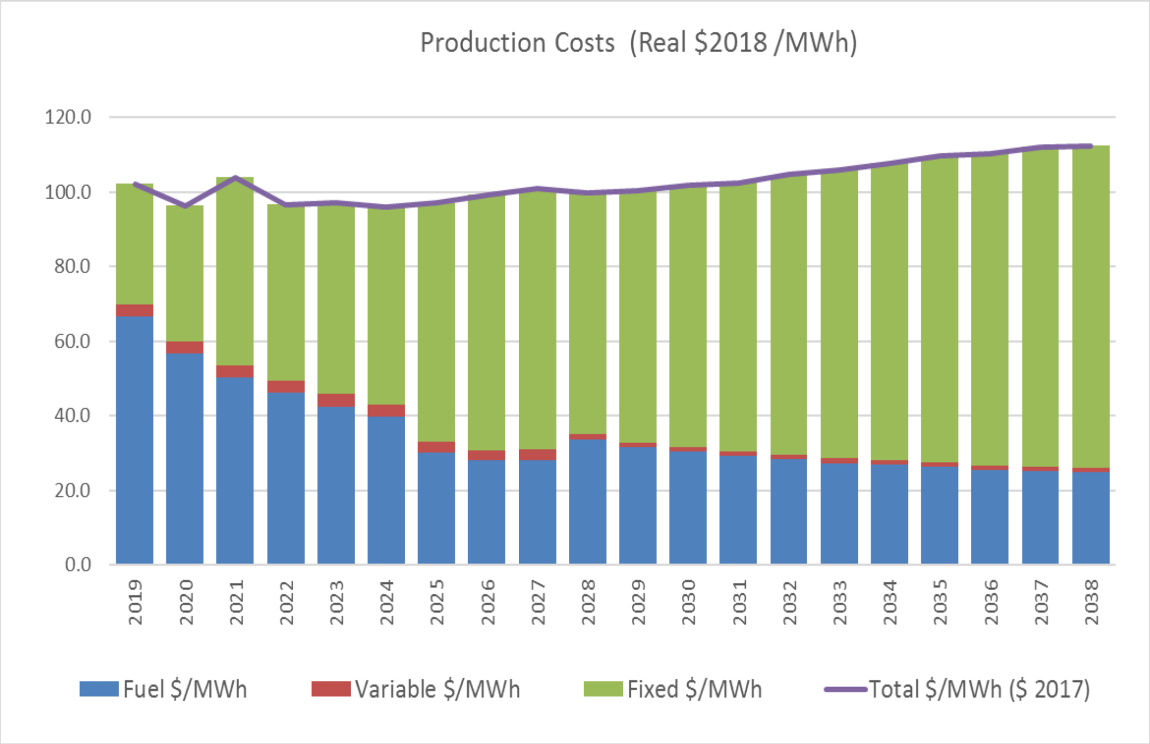
Preliminary results subject to revision

ESM with Base Load Forecast
Total Cost of Supply



Total Cost of Supply

- The total cost of supply in real dollars, including annualized capital costs, fuel costs, and fixed and variable O&M, is projected to decline with the implementation of the plan from $102.5/MWh in 2019 to $ 97.0/MWh by 2027 (slightly higher than the S4S2B's $96.6/MWh).
- Production costs average $98.9/MWh for the first 10 years of the plan, 0.3% lower than S4S2. In the last ten years of the plan, production costs average $106.8/MWh, 1.9% higher than S4S2.
- The net present value of the revenue requirement costs reaches $ 14.43 billion (nominal @ 9% rate), $81 million higher than S4S2 ($14.35 billion).

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ESM Changes with load forecast

Resource impacts

- The only changes that load has on the ESM plan is the amount of PV and Storage.
- As with the S2S2 cases, there is reduced need for storage in the high load case due to the reduced need to manage curtailment and in the low case due significantly reduced PV.
- Retirements are largely consistent with smaller difference between the cases.

Additions

Case ID	F - Class Palo Seco 2025	F - Class Costa Sur 2025	San Juan 5&6 Conversion	F-Class Yabucoa 2025	Mayaguez Peker Conversion	Other	Peakers 2025 (MW)	New Solar 2025 (MW)	BESS 2025 (MW)	New Solar 2038 (MW)	BESS 2038 (MW)	Customer Owned Generation 2038 (MW)
ESM	✓	EcoEléctrica Instead	✓	✓	✓	–	421	2,400	920	2,580	1,640	1,176
ESM High	✓	EcoEléctrica Instead	✓	✓	✓	–	421	2,340	1,040	2,460	1,040	1,176
ESM Low	✓	EcoEléctrica Instead	✓	✓	✓	–	421	1,920	1,040	1,980	1,040	1,176

Retirements

Case ID	AES 1 & 2	Aguirre Steam 1 & 2	Aguirre CC 1 & 2	Costa Sur 5 & 6	EcoElectrica	Palo Seco 3 & 4	San Juan 5 & 6	San Juan 5 & 6 Conv	San Juan 7 & 8
ESM	1 - 2027 2 - 2027	1 - 2019 2 - 2019	1 - 2025 2 - 2032	5 - 2020 6 - 2020	Not Retired	3 - 2025 4 - 2025	5 - 2019 6 - 2019	5 - 2035 6 - 2025	7 - 2023 8 - 2021
ESM High	1 - 2027 2 - 2027	1 - 2022 2 - 2019	1 - 2025 2 - 2025	5 - 2021 6 - 2020	Not Retired	3 - 2025 4 - 2021	5 - 2019 6 - 2019	5 - 2036 6 - 2025	7 - 2025 8 - 2022
ESM Low	1 - 2027 2 - 2027	1 - 2022 2 - 2019	1 - 2025 2 - 2028	5 - 2020 6 - 2020	Not Retired	3 - 2022 4 - 2025	5 - 2019 6 - 2019	5 - 2033 6 - 2025	7 - 2021 8 - 2025

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Scenario 1, 3 & 5

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Preliminary results subject to revision

Scenario 1

LTCE Plan

- Scenario 1 cannot develop new LNG terminals, but instead maintains EcoEléctrica and adds a larger number of peakers that have relatively high dispatch (as high as 19% in some years). Maintaining Costa Sur 5&6 would minimize the addition of peakers at the cost of resiliency.

	Large & Medium CCGTs and Peakers							Renewable and Storage				
Case ID	F - Class Palo Seco 2025	F - Class Costa Sur 2025	San Juan 5&6 Conversion	F-Class Yabucoa 2025	Mayaguez Peker Conversion	Other	Peakers 2025 (MW)	New Solar 2025 (MW)	BESS 2025 (MW)	New Solar 2038 (MW)	BESS 2038 (MW)	Customer Owned Generation 2038 (MW)
S1S2B	–	EcoEléctrica Instead	✓	–	–	–	559.2	2,580	1,280	2,700	1,720	1,176
S1S3B	–	EcoEléctrica Instead	✓	–	–	–	513	2,580	1,280	2,580	1,840	1,176
S1S1B	–	EcoEléctrica Instead	✓	–	–	Costa Sur 5&6 to 2037 & 2031	301.6	2,520	1,240	2,520	2,080	1,176
S4S2B	✓	✓	✓	–	–	–	371	2,220	1,320	2,820	1,640	1,176
ESM	✓	EcoEléctrica Instead	✓	✓	✓	–	421	2,400	920	2,580	1,640	1,176

Costs

- Scenario 1 has in consequence consistently higher costs than the ESM and Scenario 4.
- It does have greater emissions reductions

	Central Metrics							
Case ID	**NPV @ 9% 2019-2038 k$**	**Average 2019-2028 2018$/MWh**	**RPS 2038**	**NPV Deemed Energy Not Served k$ (1)**	**NPV + ENS k$**	**Lowest Reserve Margin**	**Emissions Reductions**	**Capital Investment Costs ($ Millions)**
S1S2B	14,773,629	102.2	69%	214,355	14,987,984	38%	97%	5,840
S1S3B	14,687,535	101.8	68%	485,666	15,173,201	33%	97%	5,560
S1S1B	14,366,811	98.4	68%	1,150,508	15,517,319	35%	96%	5,546
S4S2B	14,350,195	99.3	68%	247,445	14,597,640	42%	86%	6,595
ESM	14,431,214	99.0	67%	266,947	14,698,161	53%	88%	5,556

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Scenario 3

LTCE Plan

- Scenario 3, which assumes much lower costs of renewables, does not develop the CCGT at Palo Seco but instead installs 4,140 MW of PV (47% more than S4S2) and 3,040 MW of storage. These values are both higher than the modeled 233% and 171% times the long term peak demand (1,800 MW), which is unprecedented and highlights important technological risk, much higher than other cases.

	Large & Medium CCGTs and Peakers						Renewable and Storage					
Case ID	F - Class Palo Seco 2025	F - Class Costa Sur 2025	San Juan 5&6 Conversion	F-Class Yabucoa 2025	Mayaguez Peker Conversion	Peakers 2025 (MW)	New Solar 2025 (MW)	BESS 2025 (MW)	New Solar 2038 (MW)	BESS 2038 (MW)	Customer Owned Generation 2038 (MW)	PV / Max Demand
S3S2B	–	✓	✓	–	–	348	2,820	1,320	4,140	3,040	1,176	233%
S4S2B	✓	✓	✓	–	–	371	2,220	1,320	2,820	1,640	1,176	159%
ESM	✓	EcoEléctrica Instead	✓	✓	✓	421	2,400	920	2,580	1,640	1,176	145%

Costs

- Scenario 3 has an NPV that is 96.4% of the S4S2's and lower emissions.
- The Capital expenditure is higher.
- Indicates a possible path forward but a) the system will be more difficult to operate and b) even lower reduction of PV costs would need to be achieved.

	Central Metrics							
Case ID	**NPV @ 9% 2019-2038 k$**	**Average 2019-2028 2018$/MWh**	**RPS 2038**	**NPV Deemed Energy Not Served k$ (1)**	**NPV + ENS k$**	**Lowest Reserve Margin**	**Emissions Reductions**	**Capital Investment Costs ($ Millions)**
S3S2B	13,843,500	96.4	87%	205,871	14,049,371	48%	97%	8,474
S4S2B	14,350,195	99.3	68%	247,445	14,597,640	42%	86%	6,595
ESM	14,431,214	99.0	67%	266,947	14,698,161	53%	88%	5,556

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Scenario 5

LTCE Plan

- Scenario 5 does not develop the Palo Seco CCGT, but instead develops two larger F Class units at Costa Sur. The levels of PV and Storage are similar to those of S4S2.

	Large & Medium CCGTs and Peakers						Renewable and Storage				
Case ID	F - Class Palo Seco 2025	F - Class Costa Sur 2025	San Juan 5&6 Conversion	F-Class Yabucoa 2025	Mayaguez Peker Conversion	Peakers 2025 (MW)	New Solar 2025 (MW)	BESS 2025 (MW)	New Solar 2038 (MW)	BESS 2038 (MW)	Customer Owned Generation 2038 (MW)
S4S2B	✓	✓	✓	–	–	371	2,220	1,320	2,820	1,640	1,176
S5S1B	–	369 MW (2025&2028)	✓	–	–	371	2,580	1,200	2,580	1,480	1,176
ESM	✓	EcoEléctrica Instead	✓	✓	✓	421	2,400	920	2,580	1,640	1,176

Costs

- Scenario 5 has an NPV that is 98% of the S4S2's but about double the deemed energy not served.
- It continues the reliance in generation located in the south of the island.

Case ID	NPV @ 9% 2019-2038 k$	Average 2019-2028 2018$/MWh	RPS 2038	NPV Deemed Energy Not Served k$ (1)	NPV + ENS k$	Lowest Reserve Margin	Emissions Reductions	Capital Investment Costs ($ Millions)
S4S2B	14,350,195	99.3	68%	247,445	14,597,640	42%	86%	6,595
S5S1B	14,122,690	98.4	67%	593,173	14,715,863	32%	87%	6,201
ESM	14,431,214	99.0	67%	266,947	14,698,161	53%	88%	5,556

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ESM & Scenario 4

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ESM & Scenario 4

- ***Cost*** – Scenario 4 and the ESM have substantially the same cost (NPV) under the base case load forecast and the high load forecast. Important differences only appear under the low load forecast in which case the decisions on Scenario 4 are better.

	S4S2	ESM	Difference	Difference
Base	$14,350	$14,431	($81)	-0.6%
High	$15,155	$15,255	($99)	-0.7%
Low	$12,866	$13,952	($1,086)	-8.4%

- One of the reasons for the difference in the base case is that EcoEléctrica is not renewed in Scenario 4 but not on the ESM. If EcoEléctrica continues in Scenario 4 (or had lower cost in the ESM) the differences are much smaller.

	S4S2S9	ESM	Difference	Difference
Base	$14,480	$14,431	$49	0.3%

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ESM & Scenario 4

- ***RPS*** – Scenario 4 and the ESM both are in compliance with the current RPS and on the Base Case they are substantially the same.

	S4S2	ESM	Difference
Base	68%	67%	1%
High	60%	53%	7%
Low	77%	54%	23%

- ***Resiliency*** – The plans are also very similar on the metric of “Deemed Energy Not Served”.

	S4S2	ESM	S4S2S9	Difference
Base	$247	$267	$268	$1
High	$319	$392		
Low	$198	$202		

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ESM & Scenario 4

- ***Decisions*** – Scenario 4 and the ESM both develop significant amounts of PV and Storage, in fact to levels that will change dramatically the way the system is operated.
  - On the thermal additions they also share important components as the ESM reflects the lessons derived from the evaluation of Scenario 4. The ESM maintains the flexibility to develop the Yabucoa LNG terminal and the Mayaguez LNG terminal, however, resulting in a solution that does not rely on a single new LNG project and maintains the optionality that comes from adding generation close to the load centers in the east and west of the island.

	S4S2	S4S2S9	ESM
302 MW CCGT at Costa Sur 2025	Added assuming EcoEléctrica cannot be renegotiated	Assumes EcoEléctrica is renegotiated in lieu of CCGT addition	Assumes EcoEléctrica is renegotiated in lieu of CCGT addition
302 MW CCGT at Yabucoa 2025 with ship-based LNG delivery infrastructure	Not Added	Not Added	Added
200 MW Mayagüez Peaker Conversion with ship-based LNG delivery infrastructure	Not Converted	Not Converted	Converted
23 MW Mobile Peaking Units	16 units added	16 units added	18 units added

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Caveats & Limitations

Caveats & Limitations

- The IRP is subject a number of caveats and limitations presented in the Main Report, however we would like to highlight the following:

  a. The load is expected to significantly decline over the IRP's planning horizon and a drastic change in load assumptions could affect the IRP results and require significant changes. Hence, it is important to review the IRP plan in three years and maintain the flexibility to adapt as in the recommended plan.

  b. The location of the peaking generation is a function of the needs for local support, which depend on assumptions on available generation and load. PREPA should have the flexibility to adjust and redeploy these units to react to changes.

  c. The IRP considers that all new renewable generation will have market prices adjusted to Puerto Rico conditions.

  d. The IRP assumes an accelerated timeline for solar and storage projects, including permitting, development and interconnection.

  e. Storage and PV levels as recommended are unprecedented and are result of ongoing changes in the industry. There will be a learning curve that should be considered as the system integrates increasing amounts of PV and storage.

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Caveats & Limitations

f. For maintaining the reliability of the system the interconnection of renewable generation must be done together with the required levels of storage and comply with the MTRs related to frequency and voltage response.

g. The IRP recommends the retirement of the existing steam generating fleet at different times, including the Aguirre 1 & 2 units by the end of 2019. However, these recommendations are based on the forecasted reduction in load, assumed levels of reliability of the existing fleet at the time of retirement, and the commissioning of the new generation resources on a timely basis. Dates are likely to slip and the retirements should be only implemented after all the prerequisites have been met.

h. The IRP is based on assumptions with respect of expected technical performance and capital cost estimates for generation resources, including thermal resources and LNG terminal, that while considered reasonable, could have an important impact on implementation if material deviations occur.

i. The installation dates for equipment are a function of multiple assumptions including permitting, engineering and construction times. For those cases that the equipment is committed by the earliest assumed entry, the dates should be read as the reported date or earlier

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