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COMISION DE ENERGIA DE
PUERTO RICO
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ESTADO LIBRE ASOCIADO DE PUERTO RICO
NEGOCIADO DE ENERGÍA DE PUERTO RICO

IN RE: REVISION DEL PLAN INTEGRADO DE RECURSOS DE LA AUTORIDAD DE ENERGÍA ELÉCTRICA DE PUERTO RICO	**NÚN. CEPR-AP-2018-0001;** **SOBRE: MOCION PARA INFORMAR REUNION CON STAKEHOLDERS**

MOCIÓN PARA INFORMAR

AL HONORABLE NEGOCIADO DE ENERGIA DE PUERTO RICO:

Comparece la Autoridad de Energía Eléctrica (Autoridad), mediante la representación legal que suscribe y muy respetuosamente **EXPONE Y SOLICITA:**

1. El pasado 12 de marzo de 2019, la Autoridad llevó a cabo una presentación del Plan Integrado de Recursos (PIR) objeto del presente caso.
2. La Autoridad tuvo la oportunidad de presentar el PIR a las partes interesadas (stakeholders). Además, discutió los resultados principales del mismo, así como, el plan de acción propuesto.
3. La presentación tuvo una sesión en inglés durante la mañana y otra en español durante la tarde.
4. Acompañamos en este trámite copia de la presentación y copia de las hojas de asistencia para su conocimiento.
5. Informamos también, que la presentación se encuentra disponible en los enlaces electrónicos de la Autoridad.

DE LO ANTERIOR, solicitamos muy respetuosamente a este Honorable Negociado tome conocimiento.

RESPETUOSAMENTE SOMETIDO

En San Juan, Puerto Rico, hoy 14 de marzo de 2019.

CERTIFICO haber presentado este escrito en el día de hoy ante la Secretaría del Negociado de Energía de Puerto Rico. .

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PREPA

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Integrated Resources Plan Stakeholders Meeting
March 12, 2019, Morning Session

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Autoridad de Energía Eléctrica

Reunión de Partes Interesadas Plan Integrado de Recursos
12 de marzo de 2019, Sesión de la Tarde

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PREPA 2018-2019 IRP Stakeholder Meeting

MARCH 2019

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AGENDA

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- Objectives
- Design Concepts
- Scenarios / Sensitivities
- Results of the Long Term Capacity Expansion Plans
- Resource Action Plan
- Questions & Answers

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Objectives

PRIMARY STRATEGIC OBJECTIVES

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From the stakeholder process and Board Vision the following central objectives were considered: Economic Growth Engine:

- ***Resiliency:*** The IRP has to result in a resilient system that is able to prepare, manage and timely recovery from extreme weather events like hurricane Maria.
- ***Financially Viable:*** the plan has to minimize the cost of supply and drastically reduce the dependence on imported fuels and the associated volatility
- ***Sustainable:*** The Puerto Rico electric system has to transition from one centered on fossil fuels to one in which renewable resources play a central, if not, the predominant role.
- ***Customer-Centric:*** Costumer participation via energy efficiency, customer side energy resources (distributed generation) and demand response have a predominant role in the supply and consumption matrix of Puerto Rico. Customers are empowered to participate and take ownership on their energy security and affordability
- ***Economic Growth Engine:*** promote and support the economy of Puerto Rico.

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TACTICAL OBJECTIVES

A good and implementable IRP also needs:

- ***To be Flexible:*** The IRP is not and strict prescription of actions over its timeframe, but rather a road map with short term actions and off-ramps to deal with an uncertain future.

The short term actions have actual projects which are always the best option, called **no-regret projects** in our discussion, and preparatory actions that will ensure that we create and maintain the alternatives necessary for allow adapting to an uncertain future.

The medium and long term actions have directional value, they show were we should go it's a compass

***In the long run IRP has to have the flexibility of sails and not rails*.**

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TACTICAL OBJECTIVES

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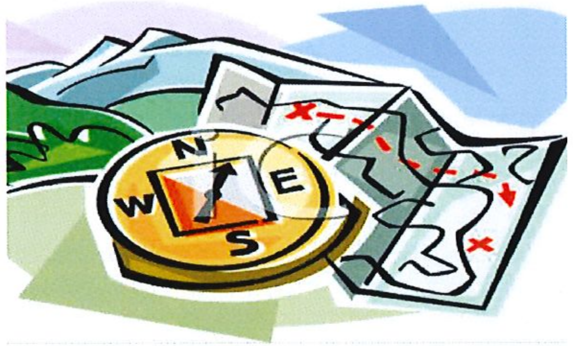
A good and implementable IRP also needs:

- ***To be Practical:*** the plan must be implementable and account for physical limitations on number of projects that can be carried out in parallel, without compromising the reliability of the system and the ability to manage them
- ***To be Pragmatic:*** While forward looking and based on the use of new technologies as storage, the technical risks must be managed and the adoption measured, particularly as we are moving towards drastic departure from the way the system is being operated.

The IRP will change the system but it must be done prudently.



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Design Concepts

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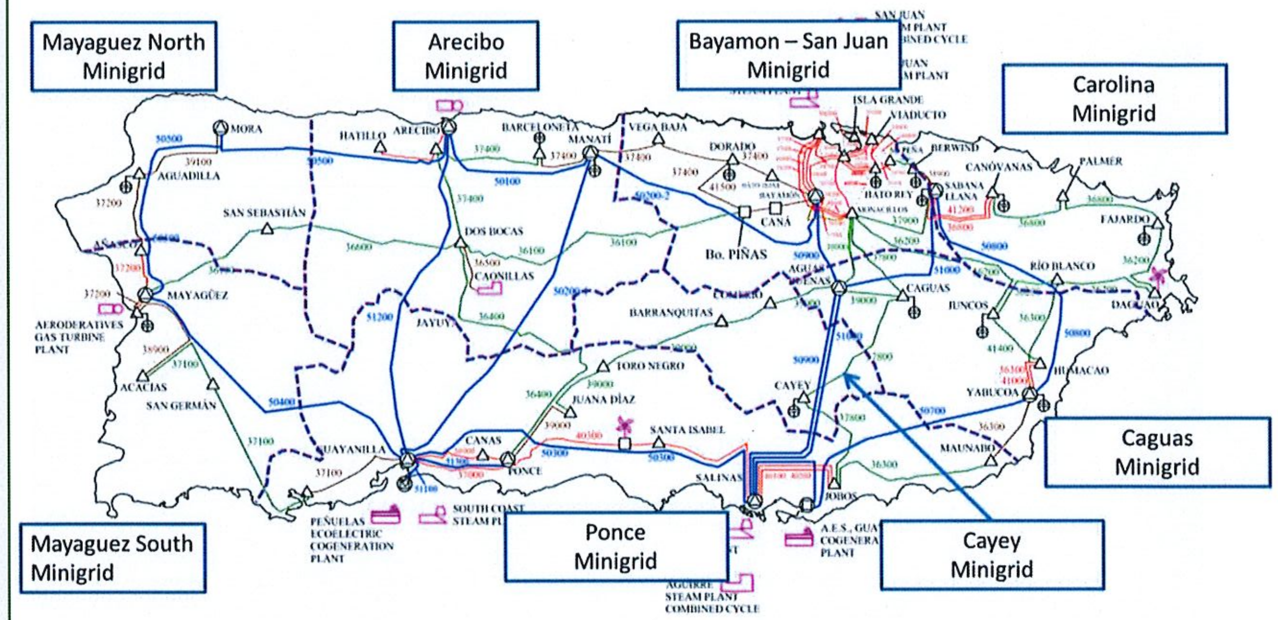
Design Concepts
The MiniGrids

- *Resiliency is central* to the IRP is and from the onset we centered on defining how the plan would allow managing major events and minimize the dependence on vulnerable transmission lines.
- The PREPA-Siemens team separated the system into 8 electrical islands called *MiniGrids* for short, considering geography and the vulnerability of various overhead lines.
- Following (or even in preparation for) a major event the system is **segregated into autonomous areas** that can operate separately from each other for extended periods of time including months.



Complementing MiniGrids, microgrids are defined for areas where there is difficulty of access and it would be impractical to harden the system to integrate them to the MiniGrid in the short term

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Design Concept
The MiniGrids

The MiniGrids (and microgrids) are designed with a dual approach:

Generation Resource Selection:

- ***Critical loads*** be served by thermal resources only; full coverage right after the event.
- ***Priority loads*** to be served by a combination of thermal resources and PV + Storage as assigned by the IRP.
- ***Balance of loads*** to be served by a combination of thermal resources and PV + Storage and on grid isolated mode some level of load shed is accepted, but should be minimized.

The IRP Resource Plan must be focused on distributed resources

Transmission / Distribution design:

- Hardening / new underground facilities to create a MiniGrid backbone to which the generation is connected and loads are served from.
- Building underground facilities for interconnection of critical loads
- New underground reliable facilities for the Interconnection of MiniGrids and faster consolidation '
- Hardening of the existing infrastructure as complementary to the above.

Transmission & Distribution Investments are critical for the relation of the plan benefits

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Design Concepts
Customer Initiatives

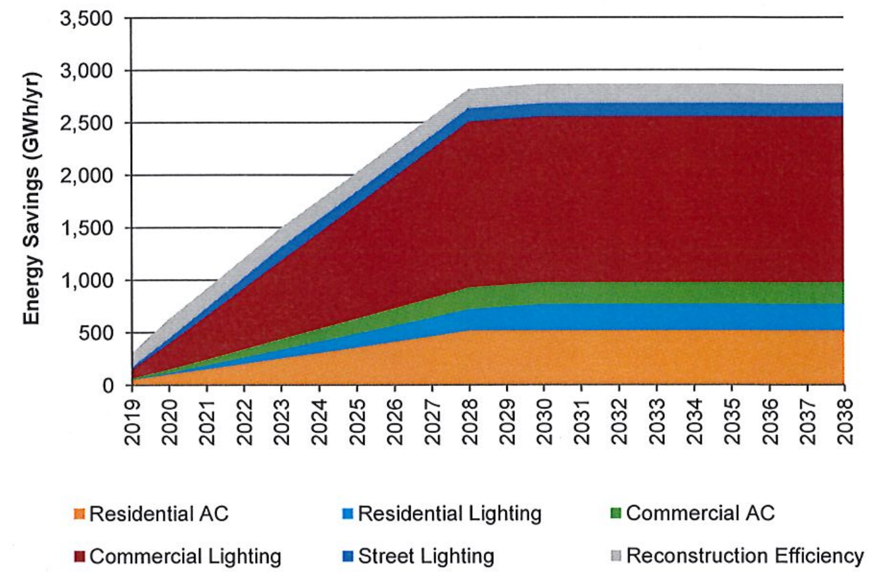
The IRP includes a number of customers initiatives :

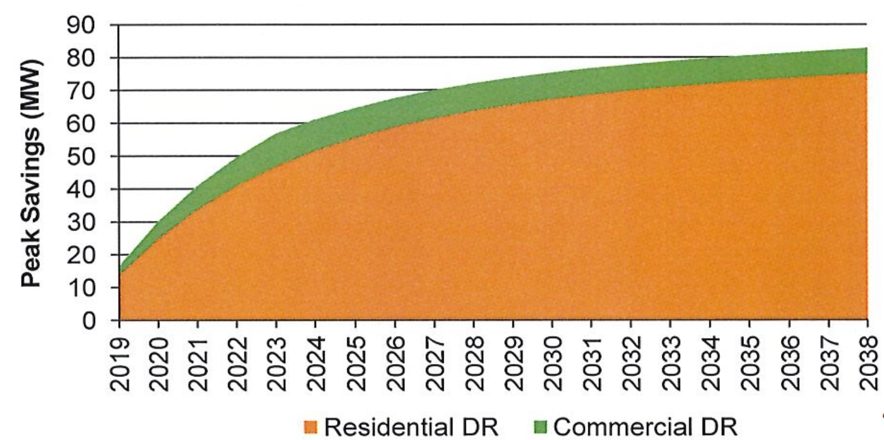
Energy Efficiency:

- This is one of the most sustainable and high return alternatives to supply; maintain the comfort and services but consume less.
- 2% Year on Year gains for 10 years considered and initiatives identified
- Detailed implementation studies need to be carried out anchored on Puerto Rico customer base reality

Demand Response :

- Load can help provide reserves reducing the need to dispatch and even build expensive peaking generation.
- The impact on loads is minimal as they are called upon only during emergencies.
- Over 3% of the peak demand (10% of the planning reserve margin) can be supplied from this source.





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Design Concepts
Customer Initiatives

The IRP includes a number of customers initiatives :

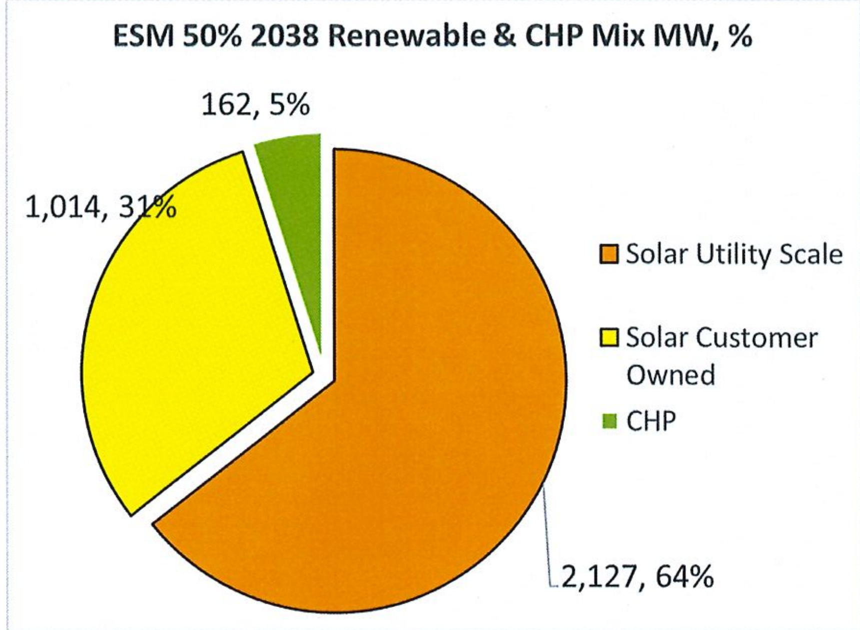
Rooftop Solar & CHP:

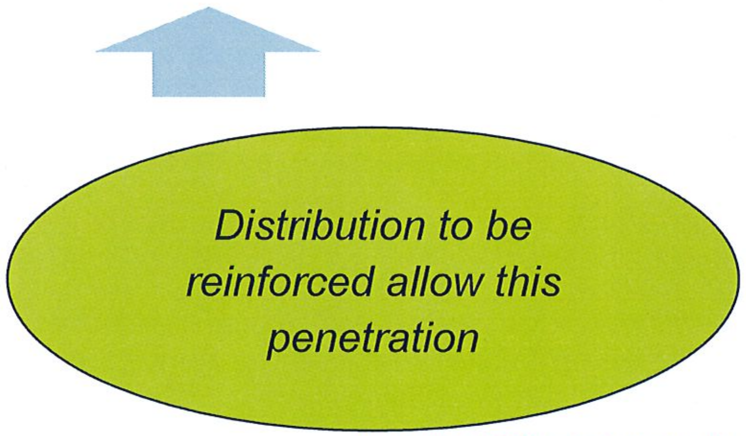
- Customer owned rooftop solar is an important element of he IRP resources.
- The IRP is NOT prescriptive in the actual amounts to be integrated, if more than forecasted are connected then less will be required from the utility scale PV. Virtual power plants composed of rooftop solar operated in an integrated manner could replace an equivalent utility scale plant
- Customer owned Storage can also support the integration on PV, and as before if customer installs, then the less will be required at the utility scale

Combined Heat and Power (CHP):

- CHP is efficient way to provide cooling / steam and electric energy, but requires capital investments from industrial / commercial customers, thus conservative assumptions on integration were made. However as before if more is installed then less thermal generation is required.

Now resources are not fringe and must be properly implemented and be able to support the grid (IEEE 1547).





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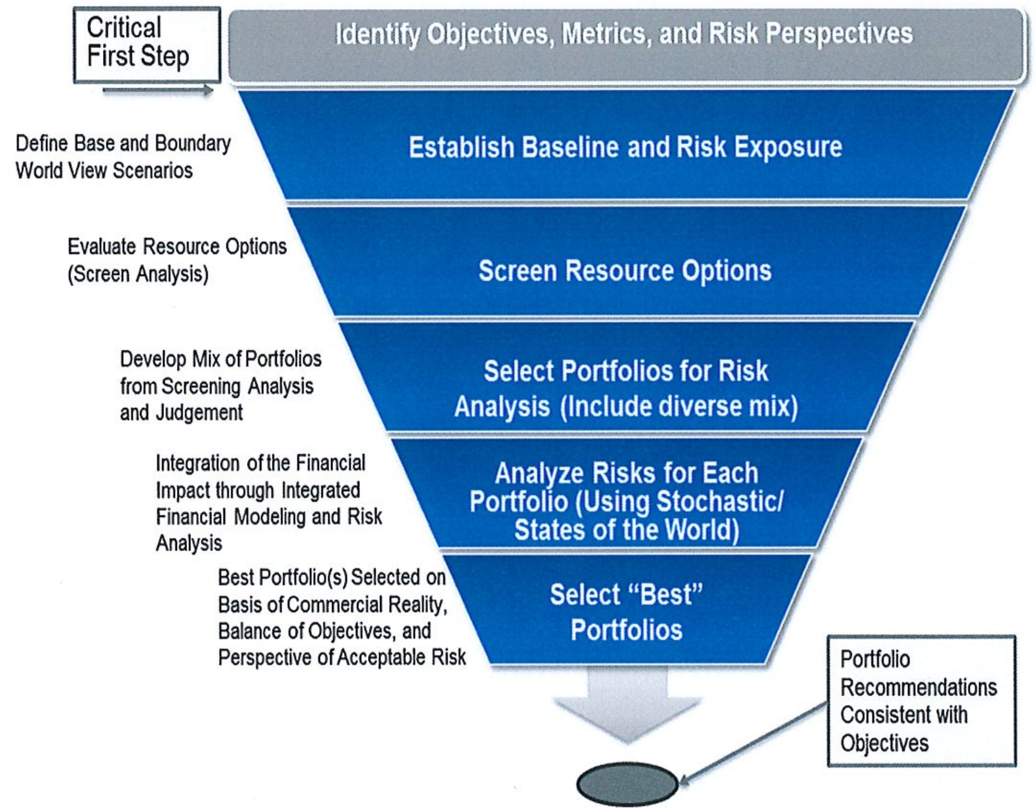
Design Concepts
Long Term Capacity Expansion Plan

- To replace PREPA's ageing generating fleet, complement the customer owned generation and provide a supply side resources to the MiniGrids and Puerto Rico in general a Long Term Capacity Expansion Plans (LTCEs) are produced.
- These LTCE's provide the information necessary to design our "road map" to achieve the overarching goal of creating an economic, reliable and resilient power system for Puerto Rico, complete with short term decisions and the off-ramps to deal with uncertainties.
- Next we will focus on this aspect of the IRP starting with ***strategies and scenarios*** moving to results and the action plan.



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Long Term Capacity Expansion Plans (LTCE's)

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STRATEGIES

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Designed to identify the best way to provide distributed resources to the MiniGrid and asses the implied cost.

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

- **Strategy 1** is fully centralized and there are no local resource requirements.
- **Strategy 2:** resources selected with a requirement that at least 80% of the peak demand must be covered locally.
- **Strategy 3** drops the requirement above to 50%.

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SCENARIOS

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The scenarios designed to assess the impact of uncertainties over which we have limited control and shed light on the least cost course of action if they materialize.

Scenario	New Gas				Renewable & Storage	
	AOGP	Land-based LNG at San Juan	Ship-based LNG at Yabucoa	Ship-based LNG at Mayaguez	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	Small	Reference	Conservative

- ***Scenario 1:*** Provides information on impact of no new gas facilities in the island.
- ***Scenario 2:*** Rolled into 4 below
- ***Scenario 4:*** New gas terminals competing with renewable at forecasted prices and expected interconnection capabilities
- ***Scenario 3:*** New gas terminals competing with renewable with lower prices and higher interconnection capability
- ***Scenario 5:*** Same as 4, but with the AOGP and large combined cycle units accepted.
- ***ESM:*** Considers pre-defined investments decisions based on RFP processes, described next

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SCENARIOS
ESM

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- ***ESM:*** Considers pre-defined investments decisions based on RFP processes.
  - Land based LNG terminal at San Juan and a new 302 MW CCGT by 2025 (or as early as possible);
  - Conversion of San Juan 5&6 to gas, supported by ship-based LNG (also in all other scenarios except 1).
  - At Yabucoa a Ship-Based LNG terminal to be developed and 302 MW CCGT is installed by 2025 (or as early as possible).
  - At Mayagüez, a Ship-Based LNG terminal is developed and Aero units to be able to burn natural gas.
  - The ESM also includes an additional smaller plant of approximately 100 MW in the north (small CCGT) that can burn both natural gas and LPG (liquefied petroleum gas).
  - 18x23 MW GTs installed throughout the island.

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SENSITIVITIES

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Designed to provide further information on impact of key variables on Scenario 1, Scenario 4 and 5

Sensitivity	Solar/BESS		Energy Efficiency	PPOAs	Gas	
	Low Cost	High Cost	Low EE	Economic Retirement of AES and EcoEléctrica	Ship-based LNG at San Juan	High Gas Prices
1	◆					
2			◆			
3				◆		
4					◆	
5						◆
6		◆				

- ***Load Forecast is Critical****; All Scenarios / Strategies were run with Base, High and Low load forecast.*
- *34 LTCE's final runs were made.*

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34 LTCE'S

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The 34 final LTCE's are shown below

Count	Case ID	Scenario	Strategy	Sensitivity	Load
1	S1S2B	1	2		Base
2	S1S2H	1	2		High
3	S1S2L	1	2		Low
4	S1S3B	1	3		Base
5	S1S3H	1	3		High
6	S1S3L	1	3		Low
7	S1S2S1B	1	2	1	Base
8	S1S2S2B	1	2	2	Base
9	S1S2S3B	1	2	3	Base
10	S1S1B	1	1		Base
11	S3S2B	3	2		Base
12	S3S2H	3	2		High
13	S3S2L	3	2		Low
14	S3S3B	3	3		Base
15	S3S3H	3	3		High
16	S3S3L	3	3		Low

Count	Case ID	Scenario	Strategy	Sensitivity	Load
17	S4S2B	4	2		Base
18	S4S2B-M	4	2		Base
19	S4S2H	4	2		High
20	S4S2L	4	2		Low
21	S4S3B	4	3		Base
22	S4S3H	4	3		High
23	S4S3L	4	3		Low
24	S4S2S3B	4	2	3	Base
25	S4S2S4B	4	2	4	Base
26	S4S2S5B	4	2	5	Base
27	S4S2S6B	4	2	6	Base
28	S4S1B	4	1		Base
29	S5S1B	5	1		Base
30	S5S1S5B	5	1	5	Base
31	ESM Plan	4	2		Base
32	ESM high	4	2		High
33	ESM low	4	2		Low
34	ESM 50% RPS	4	2		Low

LTCE's are named as SxSySx

where

x= Scenario,

y=Strategy and

z= Sensitivity

B = Base Load Forecast

L = Low load forecast and

H = High load forecast.

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Scenario ESM

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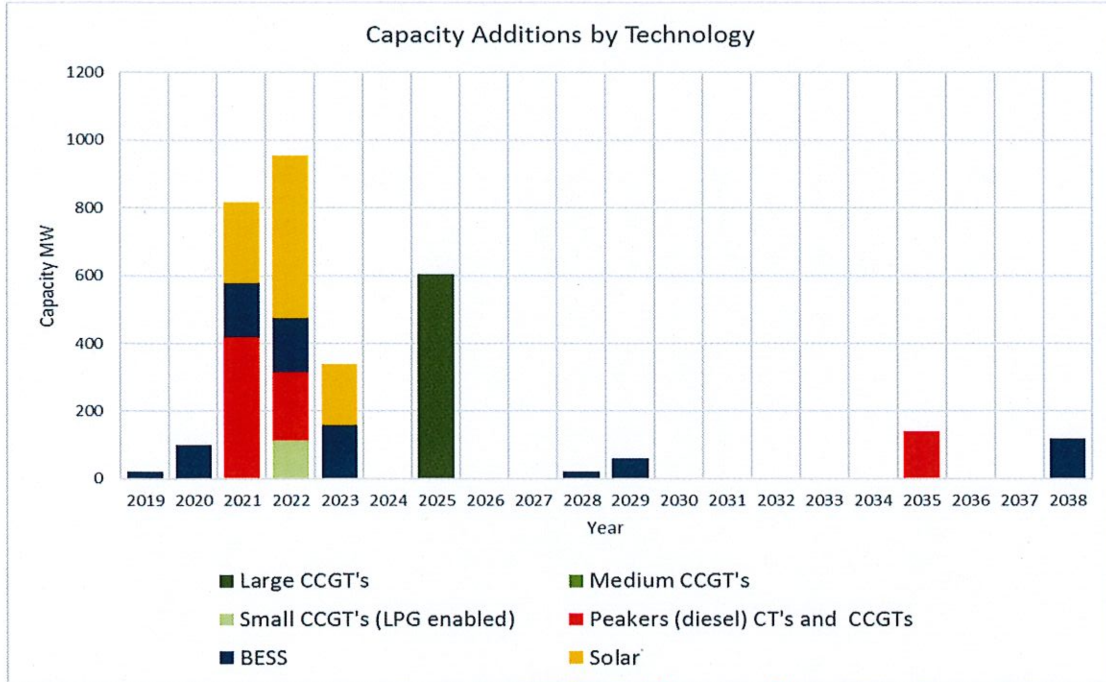
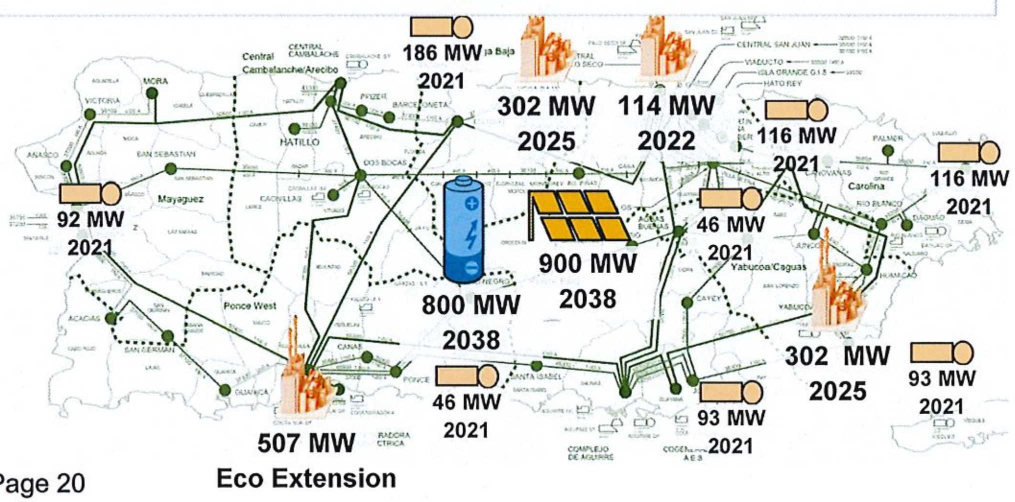
Scenario ESM with Base Load Forecast Generation Additions





LTCE Additions

- 900 MW of utility scale PV are added starting with 240 MW in 2021. All of the capacity is installed by 2023.
- 800 MW of battery energy storage, mostly 4 hour batteries. More than half of the total is installed by 2022. Ratio of battery to solar is 0.88 MW/1 MW.
- Two large CCGTs are installed, one F Class in Palo Seco and one F-Class in Yabucoa, both in 2025. A 114 MW unit (LPG enable) is also installed at San Juan.
- SJ 5 & 6 converted to gas in 2019. One unit retired later economically by 2027.
- 759 MW of peaking generation added, some of it to provide MiniGrid resiliency (in particular at Carolina, Caguas, Cayey, Ponce (Jobos) and Mayaguez North.).

Observations

- Thermal additions are largely the ones identified as input to the plan, except for a diesel CCGT (141 MW) in Ponce east by 2035.
- After retirement of AES in 2027 a small block of storage is added
- The plan does not develop a new CCGT at Costa Sur, due to EcoEléctrica's continuous operation (by design).

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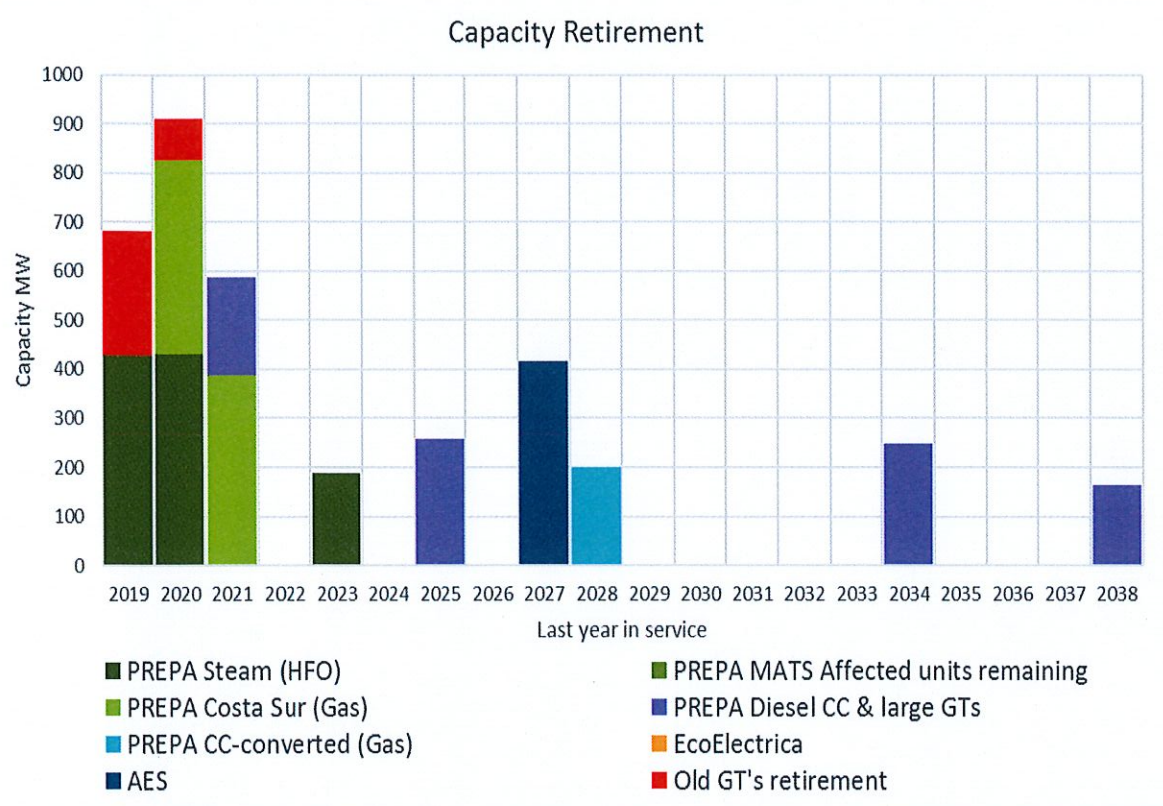
Scenario ESM with Base Load Forecast Generation Retirements



LTCE Economic Retirements

- The installation of the solar PV and Storage in 2020 allows for the economic retirement of Aguirre ST 1 and 2 (2019 and 2020), Palo Seco ST 3 & 4 in 2024 and San Juan ST 7 & 8 in 2023.
- EcoEléctrica is modelled to stay in service. The fixed payments are reduced to about 40% of current values.
- Costa Sur 5 & 6 last year in service are 2021 and 2020, respectively.
- AES is retired at the end of 2027, not economically but by model input.
- The Aguirre CC unit 1 is retired in 2025 and unit 2 in 2034. The Cambalache units stay online for reserves and MiniGrid support.
- The four units of Aero Mayaguez are converted to gas by 2022 and stay online through the planning period. San Juan 5 stays online through the planning period, while San Juan 6 is retired in 2028.

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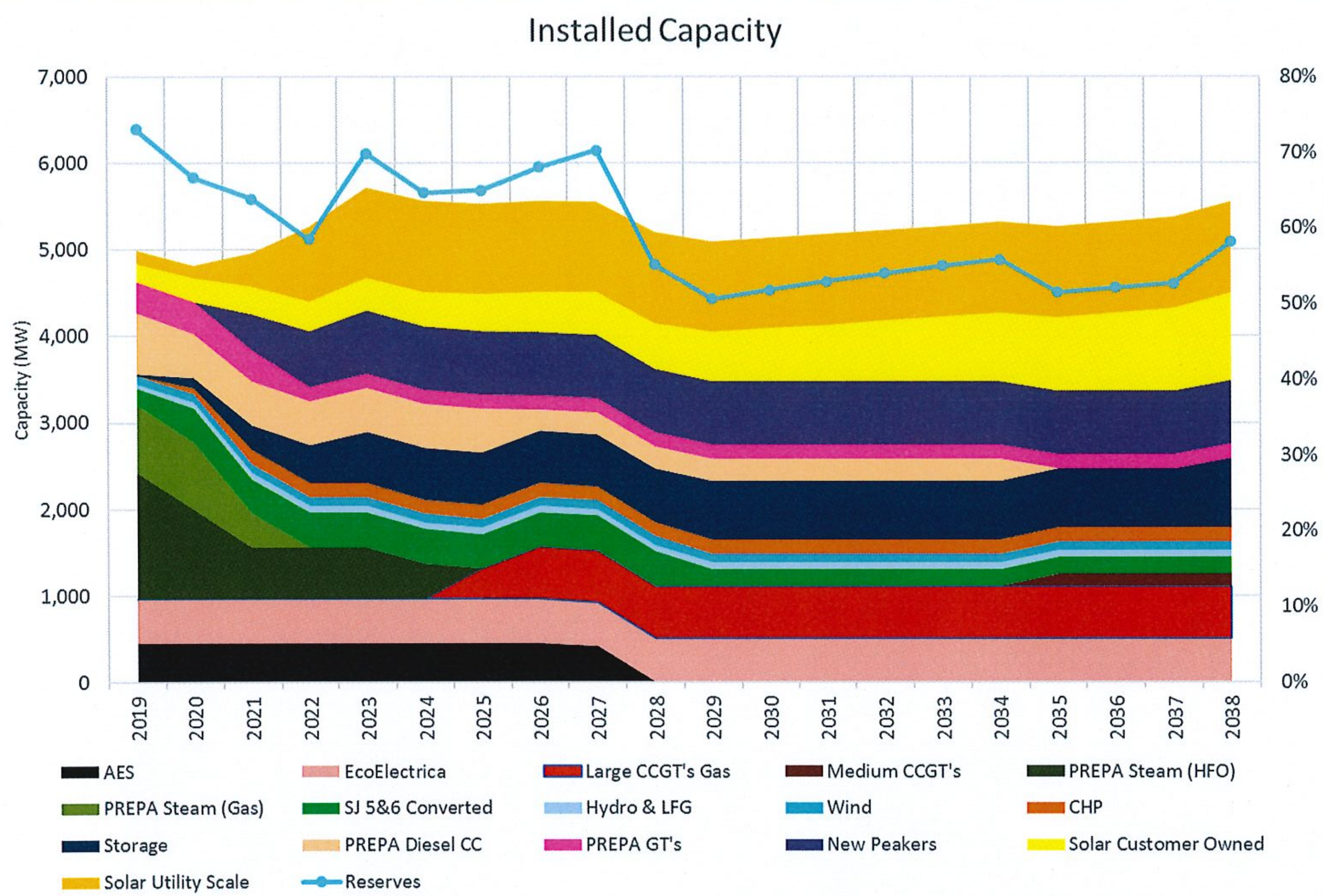
Scenario ESM with Base Load Forecast Capacity & Reserves



Installed Capacity & Reserves

- Under the ESM portfolio, the system moves away primarily from coal and oil to natural gas and renewables. By 2038, 53% 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 PPOA's are phased out, the operating reserves decline from 73% in 2019 to a low of 51% by 2029 with the retirement of AES coal. Operating reserves rise gradually afterwards driven by the decline in load and the medium diesel CCGT.
- The Planning Reserve Margin of 30% is not a binding constraint on the LTCE plan formulation.

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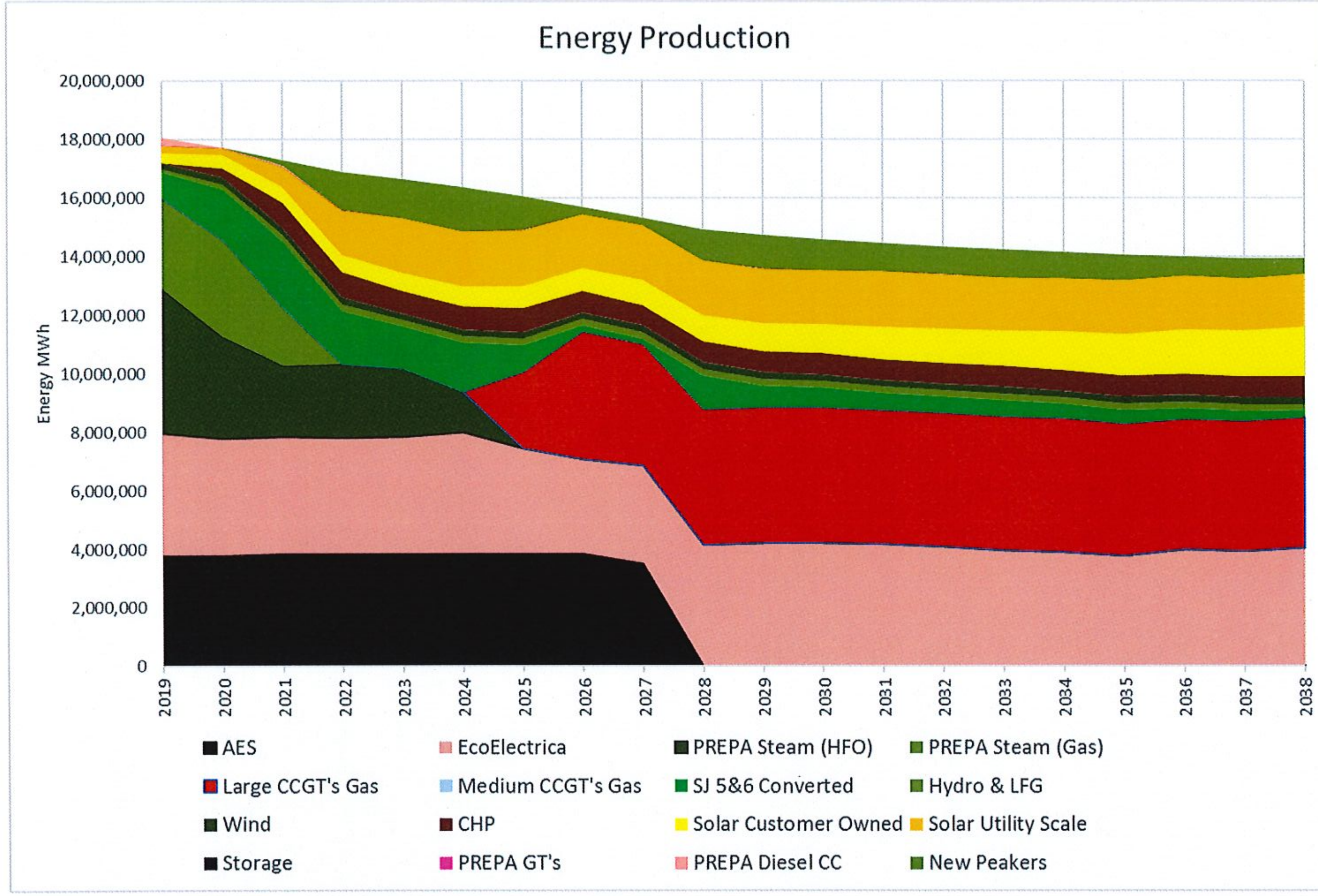
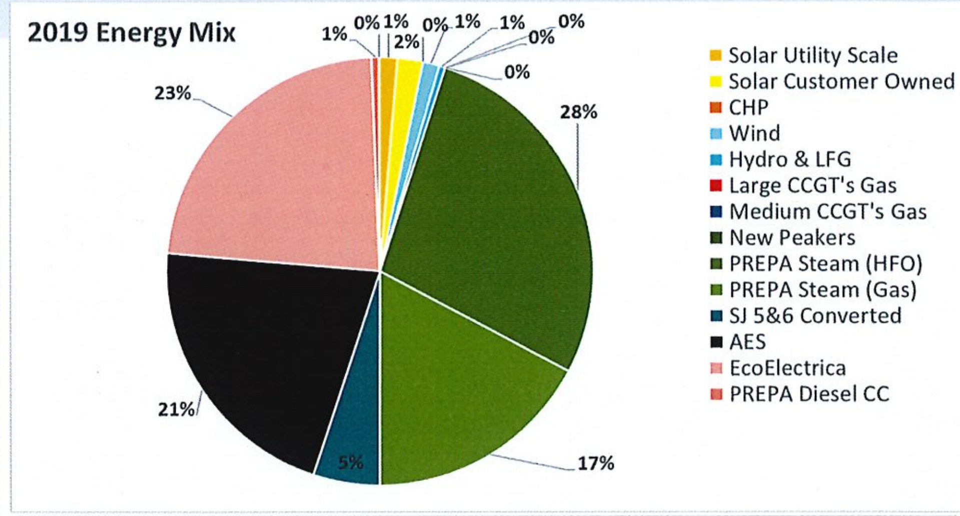
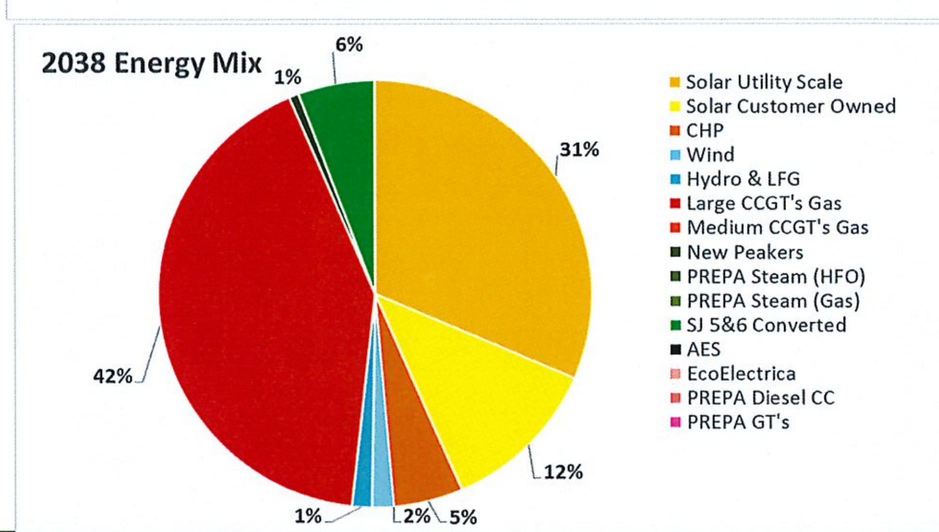
Scenario ESM Strategy 2 with Base Load Forecast Energy Mix







- As can be observed the energy mix changes significantly over the life of the plan. By 2038, 29% of the energy comes renewable generation and 34% from natural gas.

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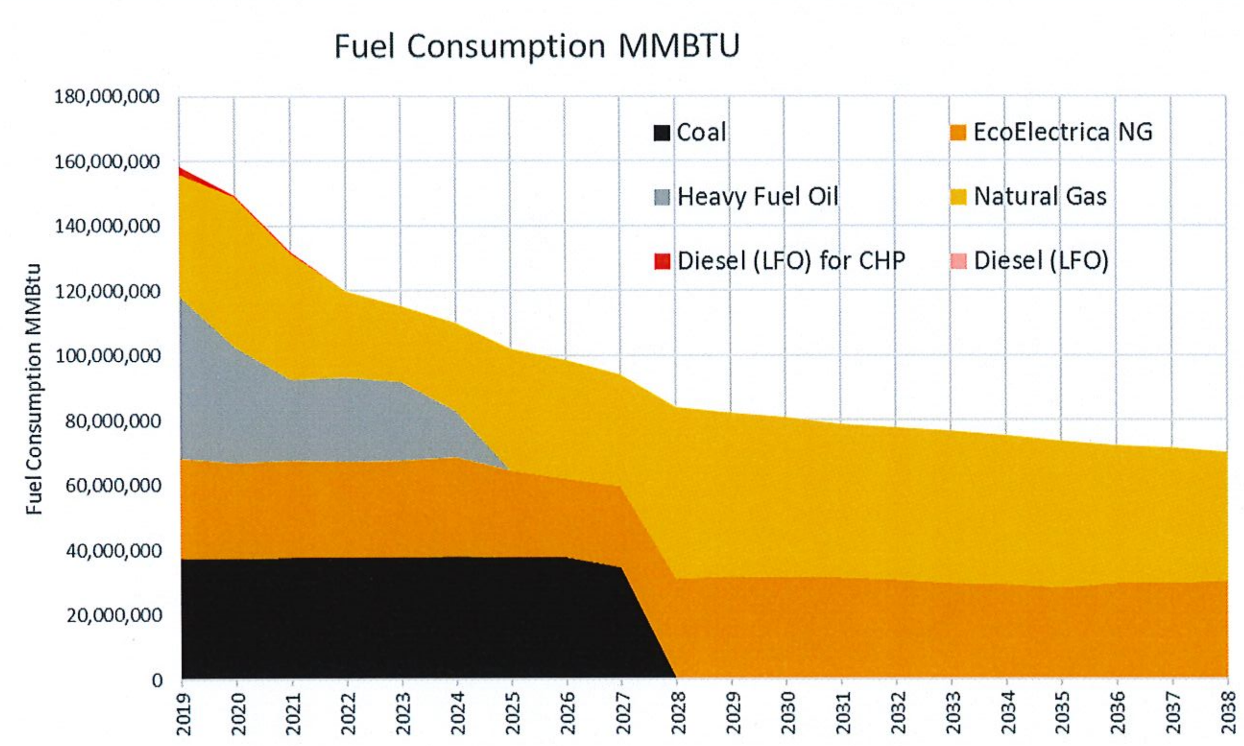
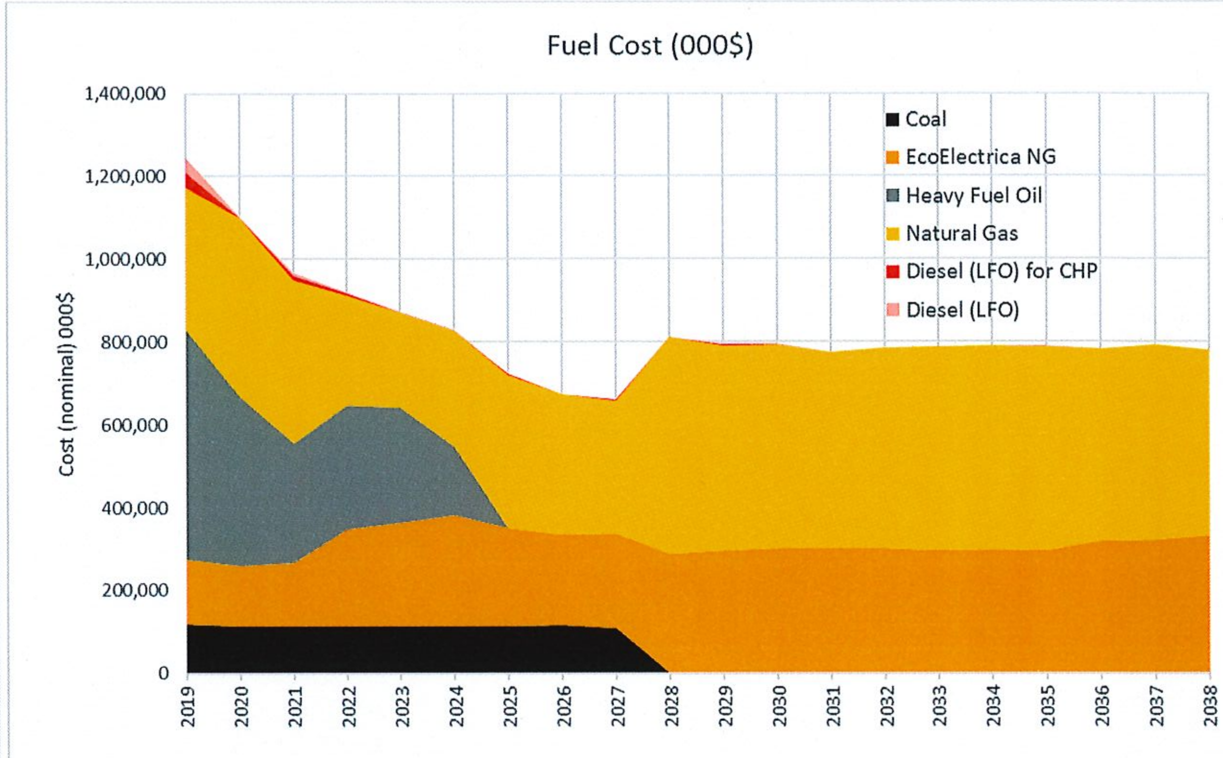
Scenario ESM Strategy 2 with Base Load Forecast
Fuel Consumption





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. Fuel consumption declines 44% by 2038 and fuel costs by 36%.
- Fuel consumption under the ESM plan is 95% higher compared to the least cost plan under Scenario 4

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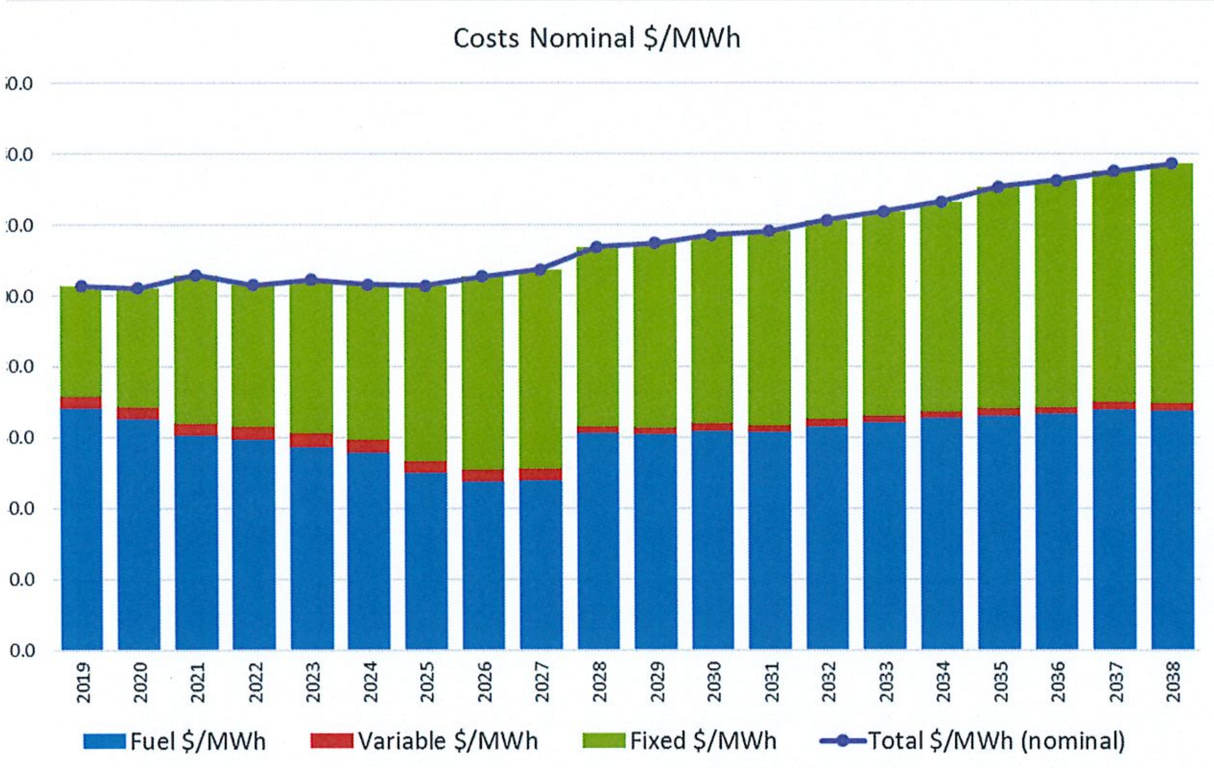
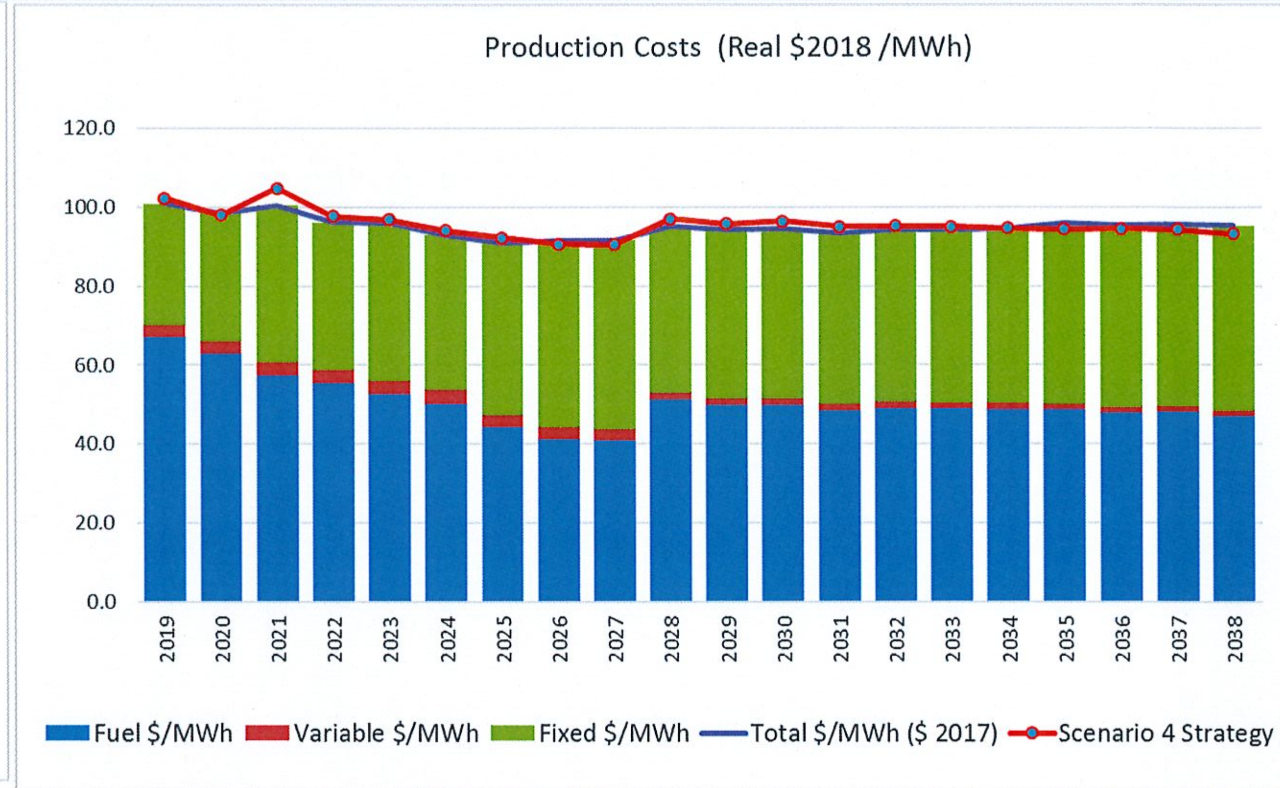
Scenario ESM Strategy 2 with Base Load Forecast
Total Cost of Supply





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 expected to decline with the implementation of the plan in 2022 onwards from 100.4/MWh in 2021 (real $2017) to $91.5/MWh by 2027, prior to AES Coal retirement in 2028. The costs increased in 2028 with AES retirement and remains largely flat near $95/MWh in the long-term.

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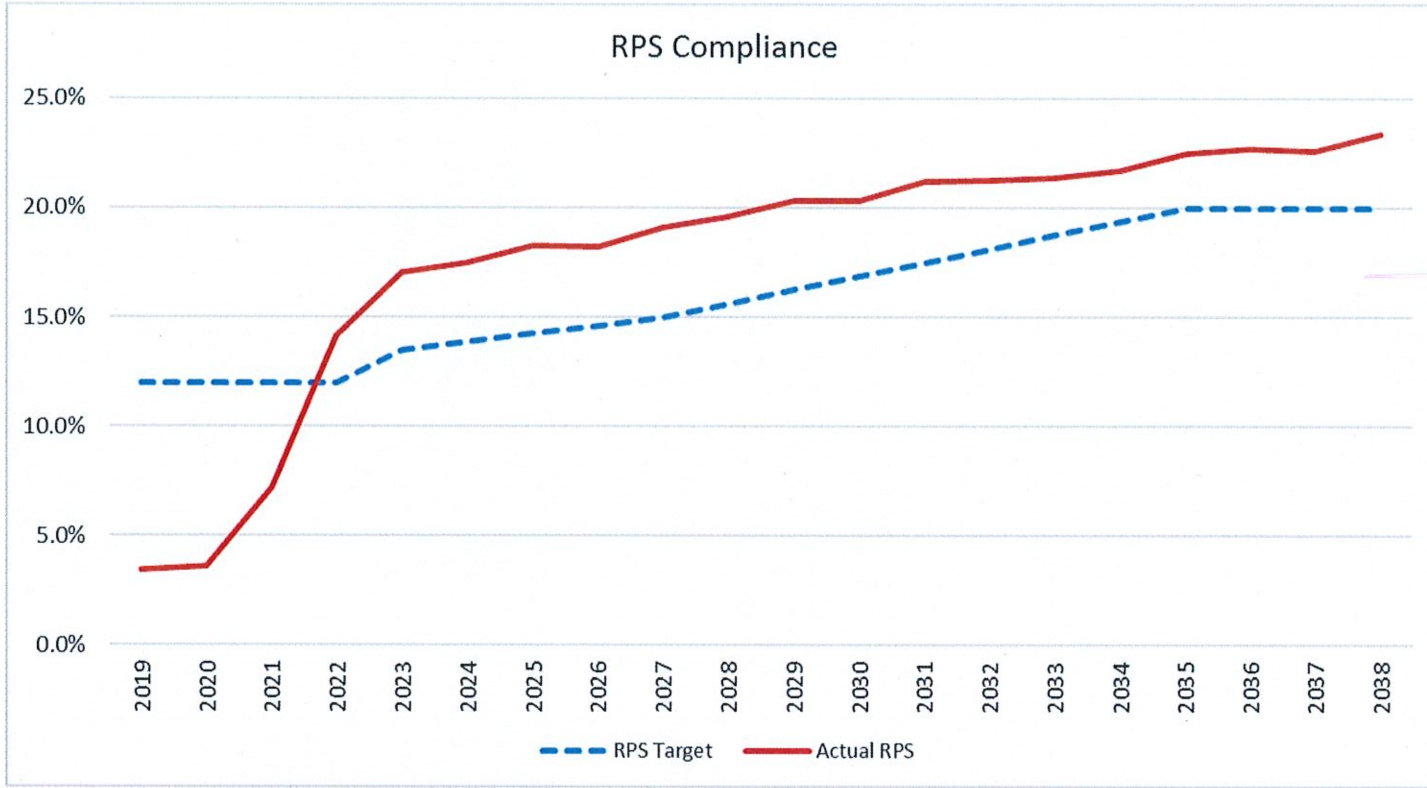
ESM Plan RPS Compliance (Under the Current Law)



RPS Compliance

- By 2023, the RPS compliance is achieved with the 900 MW of solar PV installed by that year.
- Renewable penetration under the Plan reaches 23.4% by 2038, in line with existing targets but short of the proposed 50% penetration by 2040.

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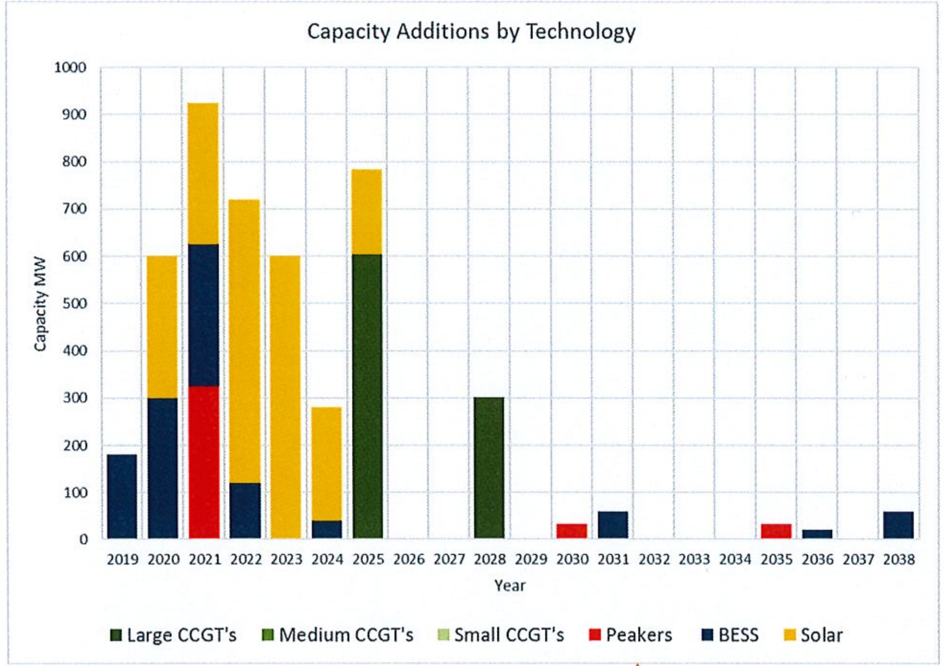
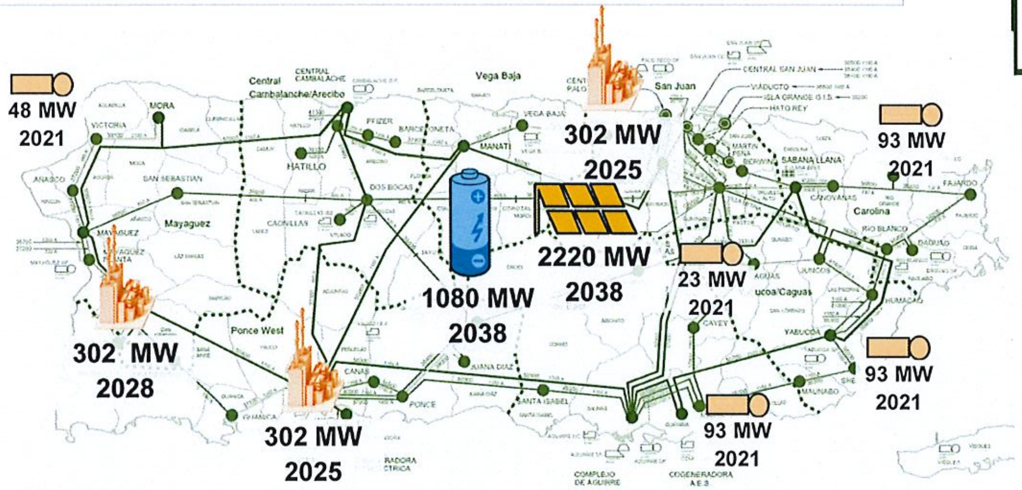
Scenario 4 Strategy 2 Under Base Load

Scenario 4 Least Cost Plan - Base Load Forecast Generation Additions





LTCE Additions

- 2,220 MW of utility scale PV are added starting in 2020 with 300 MW. By 2022, 1,200 MW are installed (max. allowed) with all 2,000 MW online by 2025.
- 1,080 MW of battery energy storage with a combination of 2 and 4 hour durations. Most of the capacity (900 MW) are installed by 2022.
- Three large CCGTs are installed using F class technologies, one in Bayamon (Palo Seco) another one in Ponce (Costa Sur), both in 2025. An additional F-Class is installed in Mayaguez South in 2028 (with AES retirement).
- SJ 5 & 6 converted to gas in 2019. SJ 6 retires economically later in 2035.
- 451 MW of peaking generation distributed throughout the island (80 MW diesel and 371 MW gas)

Observations

- The plan combined with the retirements discussed next allows for incorporation large amounts of renewable generation with very small curtailment.
- Earlier installation of renewable taking advantage of ITC.
- Plan is MATS compliant and reduces exposure to fuel volatility.

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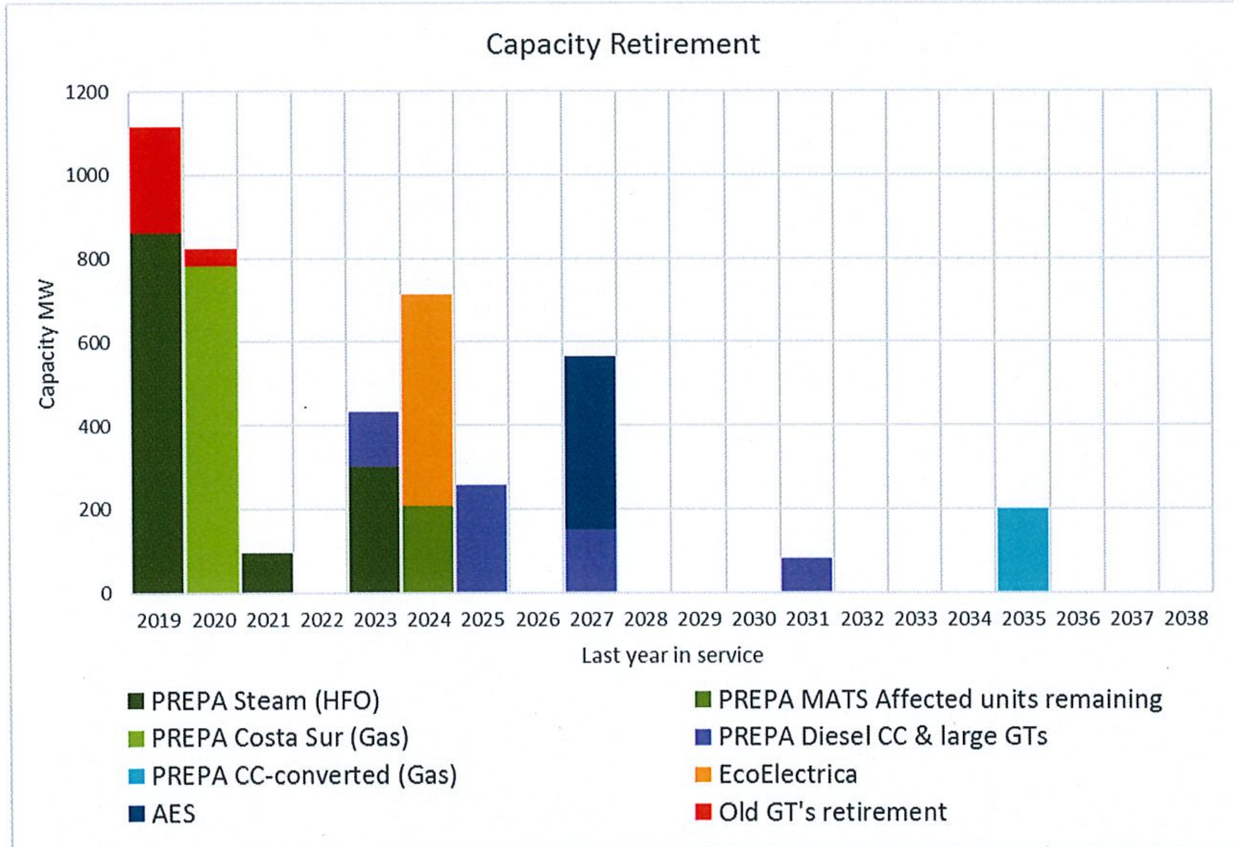
Scenario 4 Strategy 2 with Base Load Forecast Generation Retirements



LTCE Economic Retirements

- The installation of the PV and Storage in 2020 allows for the economic retirement of Aguirre ST 1 and 2 (2019), Palo Seco ST 3 (2023) and San Juan ST 7 & 8 (2023 & 2021 correspondingly)
- EcoEléctrica is economically retired in 2024, even though there was a reduction of payments of 45% and the unit could cycle every week.
- Costa Sur 5 & 6 last year in service is 2020 as could not compete with EcoEléctrica.
- AES is retired by 2027, not economically but by model input
- The Aguirre CC 1 is retired in 2025, but Aguirre 2 stays online providing reserves. The Cambalache 2 & 3 retire in 2031 and 2023, respectively. And Aero Mayaguez are all retired by 2027.
- The NG converted SJ 6 is retired by 2035. SJ5 stays online.

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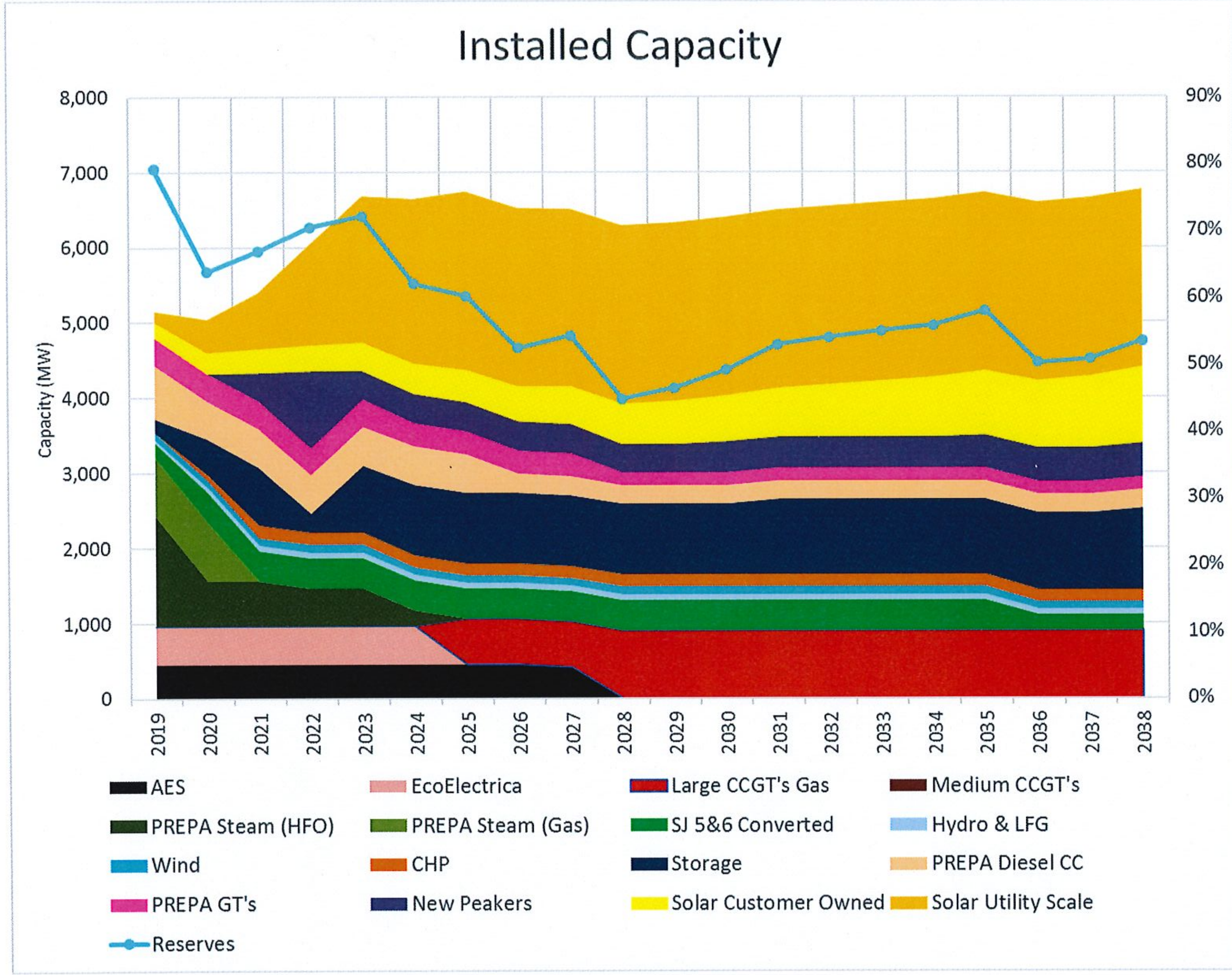
Scenario 4 Strategy 2 with Base Load Forecast Capacity & Reserves



Installed Capacity & Reserves

- With the least Cost Plan, the system transitions to one based on renewables. This can be observed considering that by 2038, 77% of the installed capacity in system consists of renewable generation or facilities in place for its integration (storage and peaking units).
- As PREPA's units and the thermal PPOA's are phased out the operating reserves are reduced reaching a minimum of 45 % in 2028.
- The Planning Reserve Margin of 30% appears not to have been binding constraint on the LTCE plan formulation.

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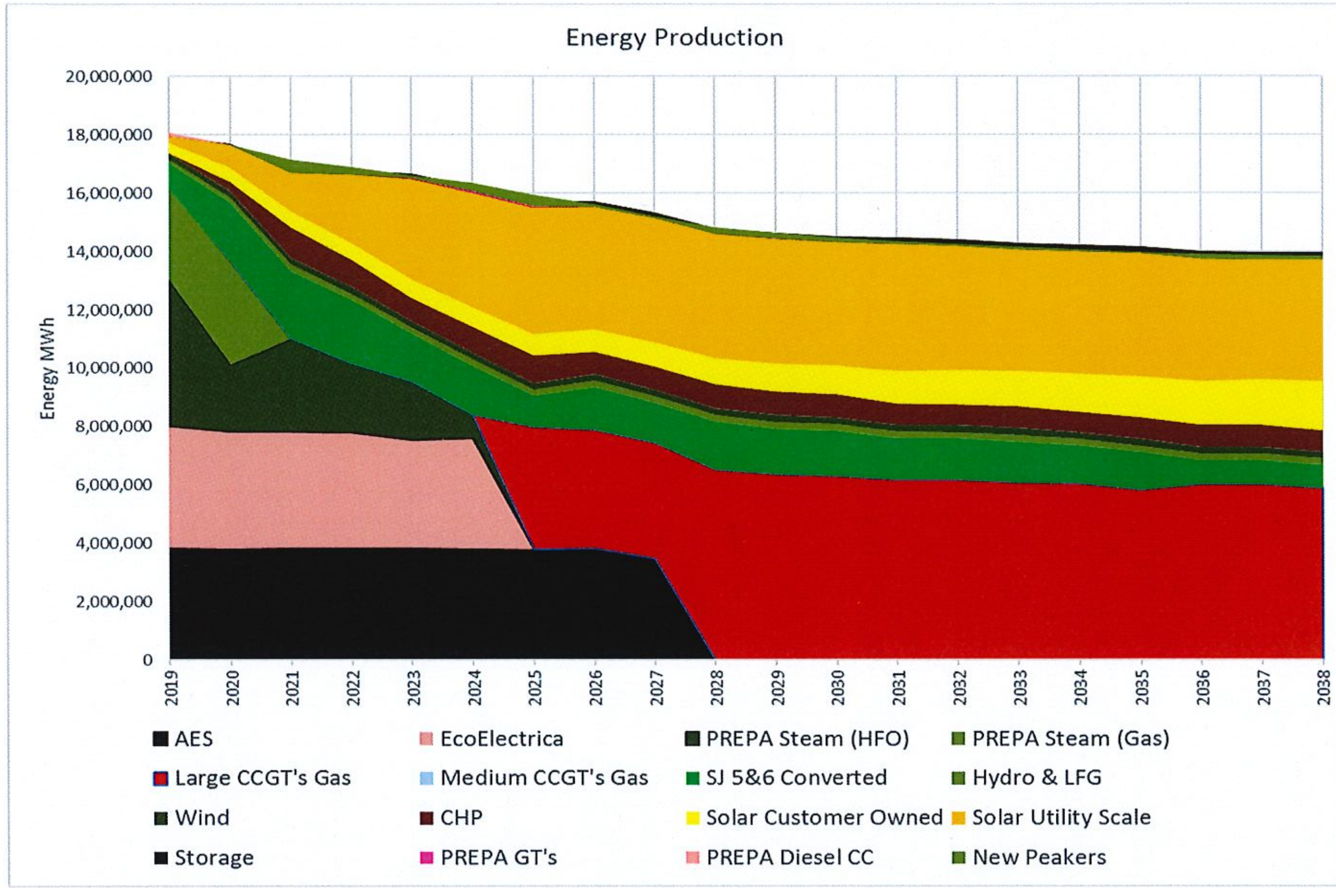
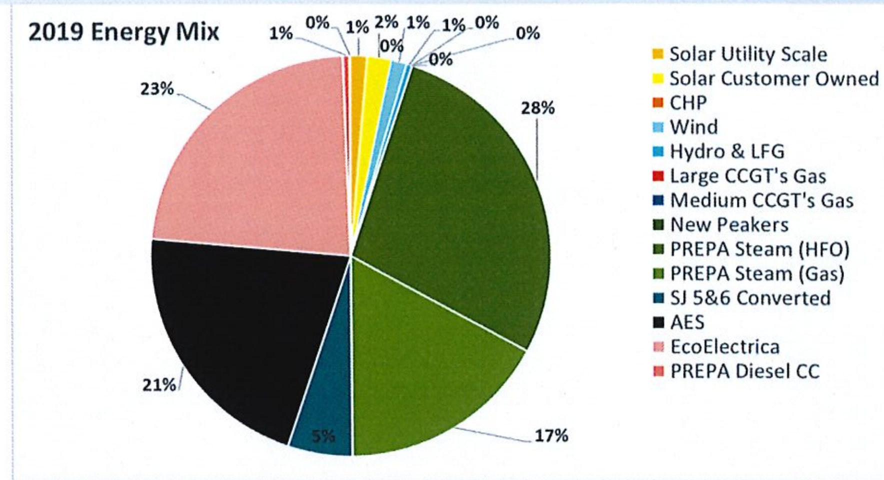
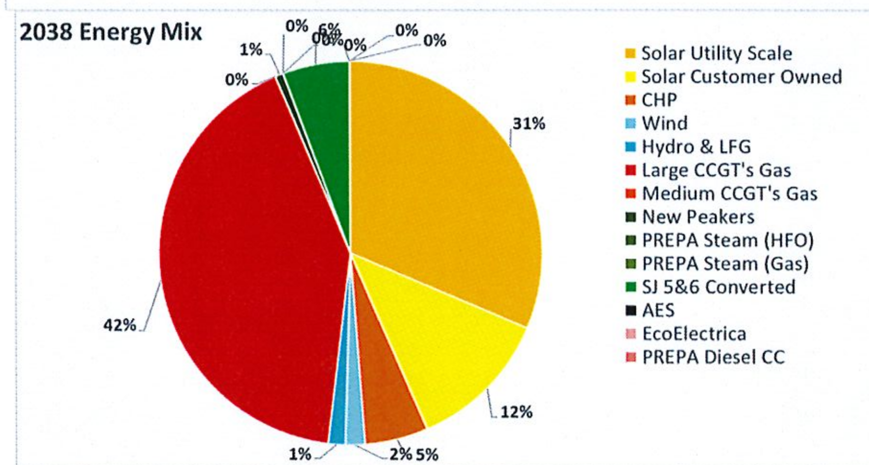
Scenario 4 Strategy 2 with Base Load Forecast Energy Mix







- As can be observed the energy mix changes significantly over the life of the plan and by 2038 47% of the energy is from renewable generation, 48% from natural gas and 5% from CHP applications

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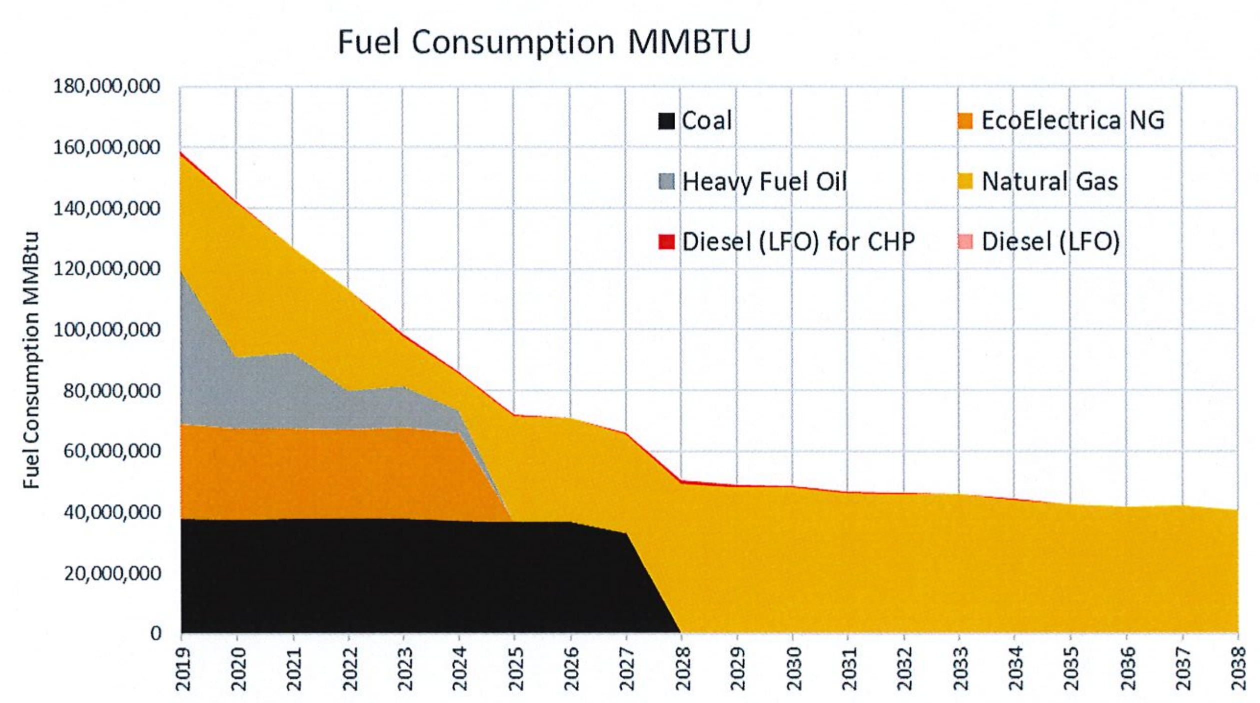
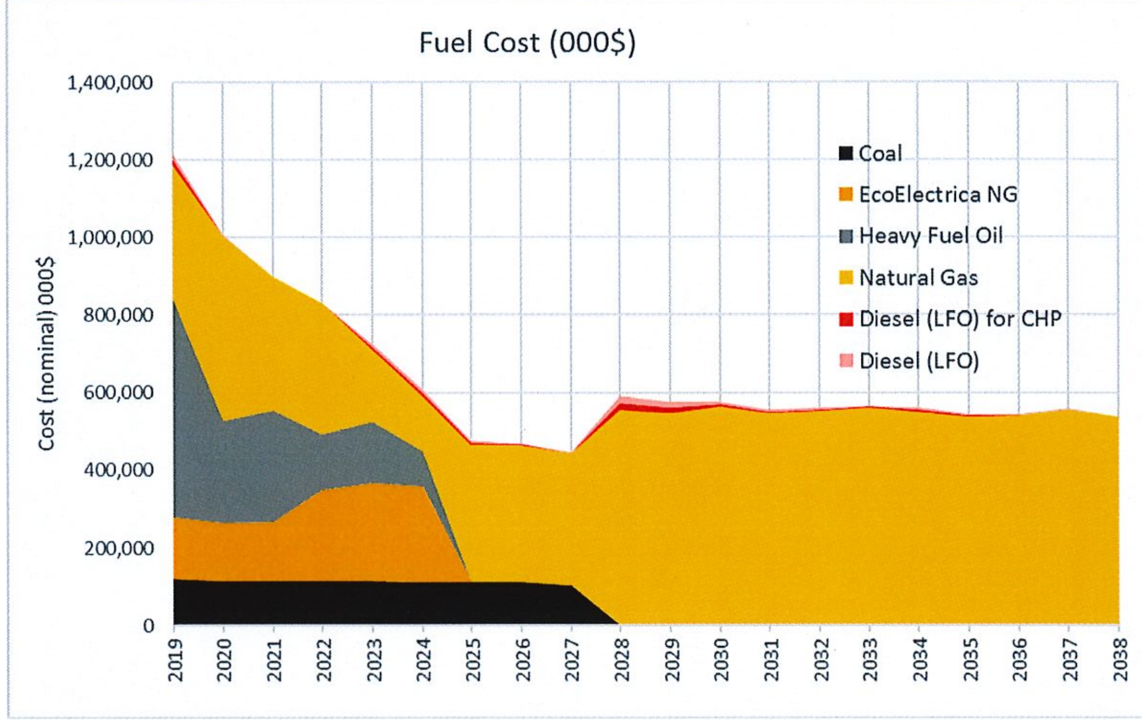
Scenario 4 Strategy 2 with Base Load Forecast
Fuel Consumption





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. The fuel consumption falls 68% by 2038 and fuel costs are 47% lower.

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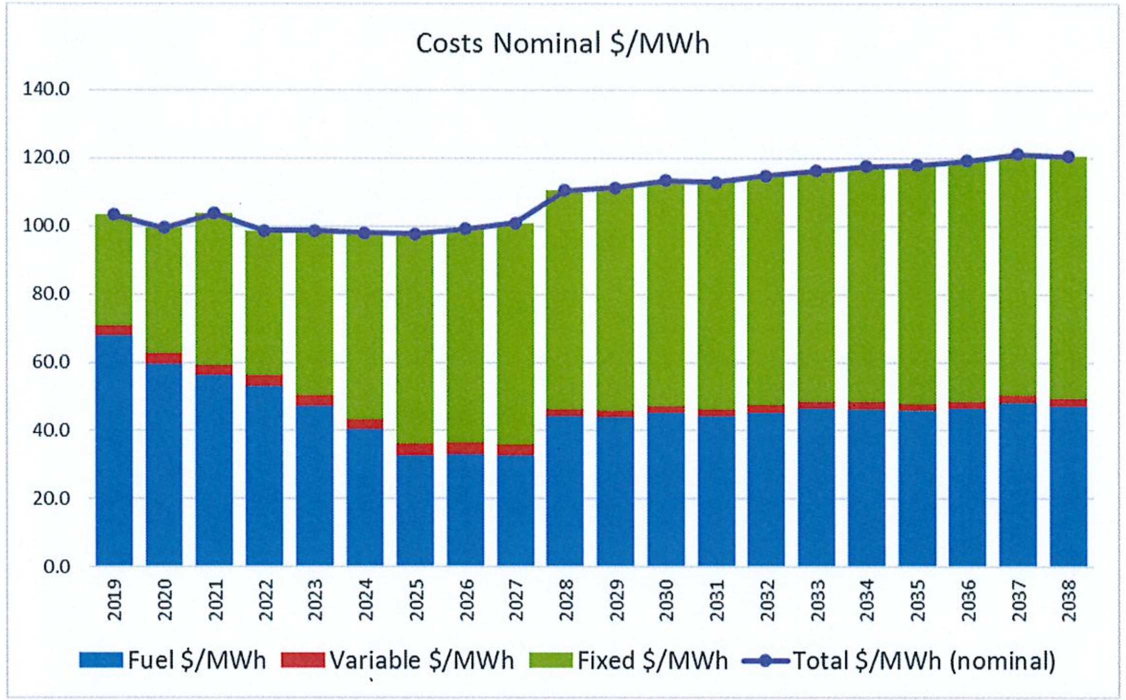
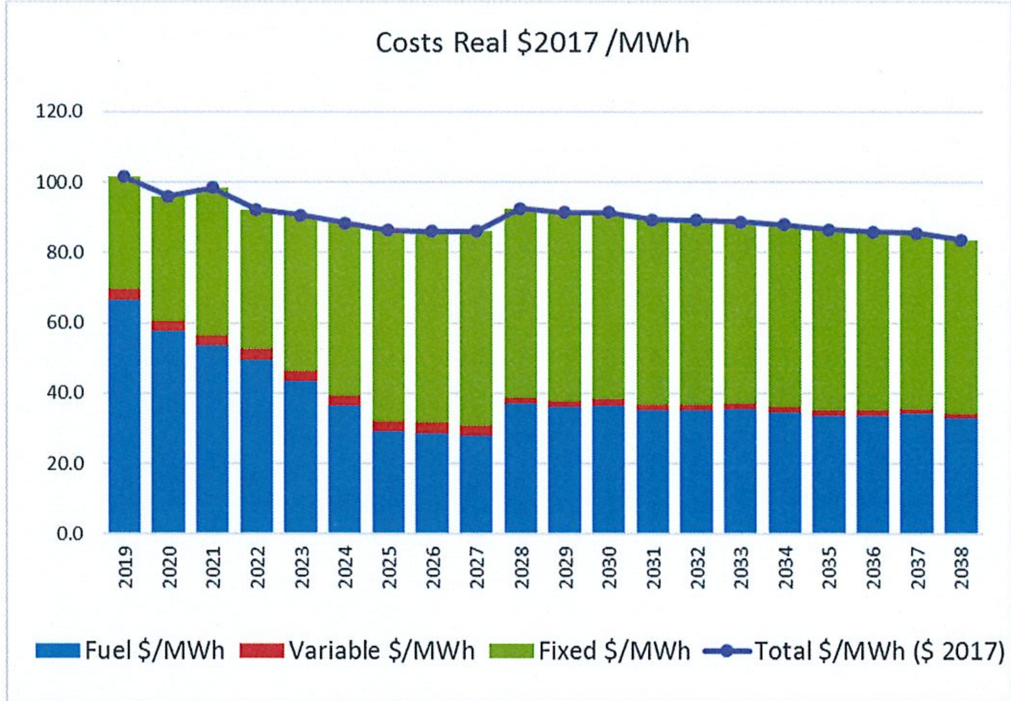
Scenario 4 Strategy 2 with Base Load Forecast
Total Cost of Supply





Total Cost of Supply

- The total cost of supply in real dollars including annualized capital costs, fuel costs, fixed and variable O&M is expected to decline with the implementation of the plan starting in 2022 from $102/MWh in 2019 (real $2017) to $90/MWh by 2027, prior to AES Coal retirement by 2028. Total costs rise again with AES retirement in 2028 but fall in the long-term to reaching $93/MWh by 2038.

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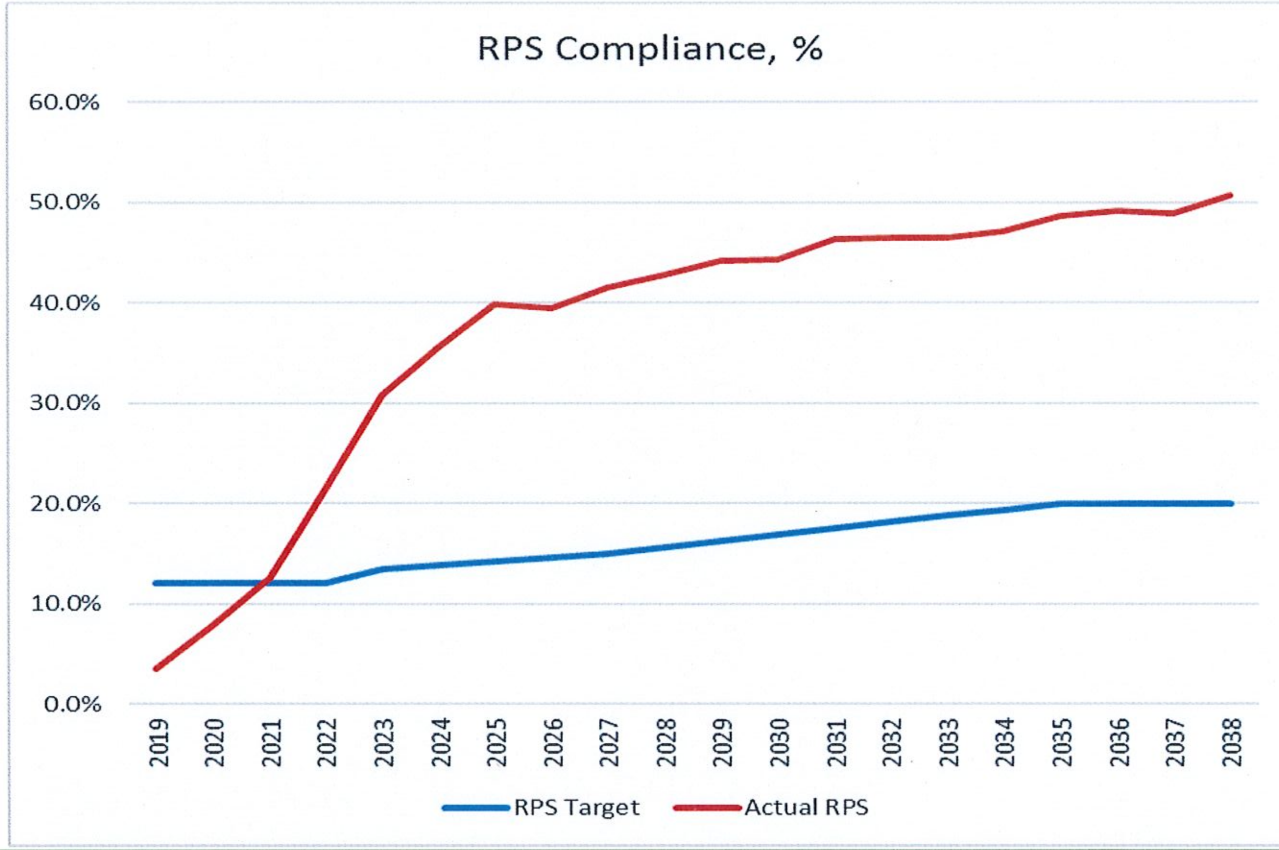
Scenario 4 Strategy 2 with Base Load Forecast RPS Compliance (Under Current Law)



RPS Compliance

- By 2021 RPS compliance is achieved with 600 MW of solar PV installed through that year.
- The RPS targets are almost tripled by the end of the forecast period with 51% renewable penetration, meeting the proposed targets.

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34 LTCE's Recommendations

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34 FINAL LTCE RUN RESULTS
Overview of all recommendations

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Scenario	Count	Case ID	F - Class Palo Seco 2025	F - Class Costa Sur 2025	F-Class Mayague z 2028	F-Class Yabucoa 2025	Small CCGT (LPG/NG) North	F - Class San Juan 2029	Medium CCGT Yabucoa 2024	Peakers (small CC) 2019-2022	New Solar 2019 - 2022	BESS 2019 - 2022	New Solar 2023 - 2028	BESS 2023 - 2028	New Solar Total	BESS Total
No New Gas	1	S1S2B	X	✓ (2025, 2028)	X	X	X	X	X	396	1200	1200	2520	380	3720	2140
No New Gas	2	S1S2H	X	✓ (2025 x 2, 2033)	X	X	X	X	Palo Seco 20	472	1200	1240	3060	120	4320	1880
No New Gas	3	S1S2L	X	✓ (2025, 2028)	X	X	X	X	X	303	1200	1160	2100	180	3300	1800
No New Gas	4	S1S3B	✓	✓ (2025, 2028)	X	X	X	X	X	343	1200	1120	2520	160	3720	1640
No New Gas	5	S1S3H	✓ (141 MW)	✓ (2025, 2028)	X	X	X	X	Palo Seco 20	476	1200	940	3060	120	4260	2500
No New Gas	6	S1S3L	X	✓ (2025, 2028)	X	X	X	X	X	303	1200	1120	2040	20	3240	1900
No New Gas	7	S1S2S1B	✓ (141 MW)	✓ (2025, 2028)	X	X	X	X	X	345	1200	1120	2640	500	3840	2700
No New Gas	8	S1S2S2B	X	✓ (2025 x 2, 2028)	X	X	X	X	X	444	1200	1140	2820	80	4020	1800
No New Gas	9	S1S2S3B	✓ (S. Juan LFO)	✓ (2025)	X	X	X	X	✓ (LFO)	350	1200	1140	1140	0	2640	1560
No New Gas	10	S1S1B	X	✓ (2025, 2028)	X	X	X	X	X	297	1200	1160	2520	0	3720	2220
Scenario 3	11	S3S2B	✓	✓	X	X	X	X	X	303	1500	980	2520	200	4020	2380
Scenario 3	12	S3S2H	✓	✓	X	X	X	X	X	303	1500	1180	4560	200	4560	3260
Scenario 3	13	S3S2L	✓ 2027	✓	X	X	X	X	X	303	1500	940	1980	240	3480	1980
Scenario 3	14	S3S3B	✓	✓	X	X	X	X	X	303	1500	1020	2460	260	3960	3960
Scenario 3	15	S3S3H	✓ 2027	✓	X	X	✓ (76MW)	X	✓	303	1500	1100	2880	100	4560	2220
Scenario 3	16	S3S3L	✓ 2027	✓	X	X	X	X	X	303	1500	960	1860	260	3420	2440
Scenario 4	17	S4S2B	✓	✓	✓	X	X	X	X	372	1200	900	1020	40	2220	1080
Scenario 4	18	S4S2B-M	✓	✓	✓	X	X	X	X	387	1200	900	1020	40	2220	1080
Scenario 4	19	S4S2H	✓	✓	✓	X	X	✓	✓	479	1200	800	1380	0	2580	960
Scenario 4	20	S4S2L	✓	✓	X	X	X	X	X	280	1200	1100	900	60	2100	1160
Scenario 4	21	S4S3B	✓	✓	✓	X	X	X	X	388	1200	900	1140	160	2340	1540
Scenario 4	22	S4S3H	✓	✓	✓	✓	X	X	X	440	1200	1000	1380	0	2580	1420
Scenario 4	23	S4S3L	✓	✓	X	✓ (2028)	X	X	X	280	1200	1080	720	0	1920	1080
Scenario 4	24	S4S2S3B	✓	✓	X	X	X	X	X	303	1200	920	960	20	2160	1020
Scenario 4	25	S4S2S4B	✓	✓ 2027	X	✓	X	X	X	327	1200	1160	1140	0	2340	1220
Scenario 4	26	S4S2S5B	✓	✓	X	X	X	X	✓	591	1200	580	1140	80	2340	960
Scenario 4	27	S4S2S6B	✓	✓	✓ (2025)	X	X	✓ (2028)	✓	204	720	620	0	0	780	620
Scenario 4	28	S4S1B	✓	✓	✓	X	X	X	X	324	1200	900	1140	0	2340	1460
S5	29	S5S1B	✓	302 + 369	X	X	X	X	X	71	1200	1020	960	0	2160	1020
S5	30	S5S1S5B	✓	✓	X	X	X	X	X	60	1200	1060	1140	643	2340	1400
ESM	31	ESM Plan	✓	Eco Instead	X	✓	✓	X	X	418	720	440	180	140	900	800
ESM	32	ESM high	✓	Eco Instead	X	✓	✓	X	X	477	720	440	960	160	1680	780
ESM	33	ESM low	✓	Eco Instead	X	✓	✓	X	X	418	720	440	0	140	720	640
ESM	34	ESM 50% RPS	✓	Eco Instead	X	✓	✓	X	X	618	720	440	420	260	1980	820

Dark green	Strong no regret with no varation among cases that support decision being made
Light green	Decission common to multiple cases / little variation between scenarios that allow the decission to be taken
Yellow	Decission common to few scenarios that allow the decission to be taken
Orange	Decission common to one scenario, PV / BESS: outlier or close follow up required.

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COMMON ELEMENTS OF 34 LTCE RUNS –
No Regret / Minimum Regret Decisions

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The LTCE's had a number of no-regret / minimum regret decisions as identified by commonalities of outcomes and these are:

1. ***Maximize the rate of installation of solar photovoltaic (PV) generation for the first four years (2019 to 2022) of the plan.***
   - Early installation benefit from the Investment Tax Credit
   - Declining demand favors early installations to maximize the life benefit
   - ***The LTCE always hit the allowable practical limits of interconnection***
2. ***Install between 440 MW to 900 MW of Battery Energy Storage in the first four years of the plan.***
   - Early installation support the integration of PV and provides reserves
   - Declining demand favors early installation to supply greater initial load
   - ***Differences as basically driven by the assumed practical limits of interconnection***

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COMMON ELEMENTS OF 34 LTCE RUNS – No Regret / Minimum Regret Decisions

3. ***Convert San Juan 5&6 Combined Cycle (CC) to burn natural gas***
   - Whenever offered it was chosen by the LTCE
   - Since it became a committed project it was built in the IRP for all scenarios but Scenario1

4. ***Develop a land-based LNG terminal in San Juan to supply a new 302 MW CCGT at Palo Seco and the existing San Juan 5&6 CCGT***
   - Whenever offered it was chosen by the LTCE
   - The land-based LNG allow developing flexible and economic resources close to the loads
5. ***A new 300 MW CCGT at Costa Sur or extend a renegotiated contract with EcoEléctrica***
   - A new 303 MW CCGT always displaces EcoEléctrica if the current contract fixed payments are maintained.
   - It is possible to adjust the fixed payments for EcoEléctrica so that there is a breakeven costs compared to a new CCGT.

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COMMON ELEMENTS OF 34 LTCE RUNS –
No Regret / Minimum Regret Decisions

6. ***Add smaller Gas Turbines (GTs) capable of burning containerized natural gas (18 GTs x 23 MW).***

   - Provide the required minimal thermal supply to the MiniGrids in the short term.
   - Together with storage to manage the integration of solar PV

7. ***Ship-Based LNG terminal at Mayagüez to supply the 4x50 MW Aeros and possibly a new 300 MW CCGT.***

   - Together with the CCGT at Yabucoa provides a least cost solution
   - If the Yabucoa CCGT cannot be developed, it's the next best alternative to that CCGT.
   - Under a high load growth case, developing a CCGT here together with Yabucoa is a least cost option
   - Plans should be made for this terminal as a minimum regret strategy

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COMMON ELEMENTS OF 34 LTCE RUNS –
No Regret / Minimum Regret Decisions

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8. ***Develop a Ship-Based LNG terminal at Yabucoa with a new 300 MW CCGT***
   - Together with the conversion of the GTs at Mayaguez is a least cost solution
   - It is also a least cost solution under; a) high load growth, together with a CCGT at Mayaguez or b) the land based LNG terminal at San Juan cannot be developed
   - Plans should be made for this terminal as a minimum regret strategy
9. ***Monitor Renewable (PV) and storage prices as well as integration technologies***
   - With low renewable prices and high adoption, lower costs of supply can be achieved.
   - Volumes are very high and may stretch the ability to operate the system, but technology is improving fast, this may become partical in the future.
   - This is one case that we need to keep flexibility and be able to change our course.

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34 LTCE's Metrics and Results

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34 FINAL LTCE RUN RESULTS
Metrics

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LTCE's were assessed according to a number of metrics

1. ***NPV of total generation costs (CapEx, O&M, Fuel) at a discount rate applicable to PREPA as a public utility; 9% (6.86% on a real dollar basis)***
2. ***Average cost of generation (all in) for the period 2019 to 2028 in $/MWh ($ 2018)***
3. ***Capital Costs***
4. ***Resiliency: Present value of energy that would be lost in case that the system had to revert to MiniGrid isolated operations for 1 month every 5 years***
5. ***RPS compliance achieved by 2038***
6. ***Reduction in CO2 emissions***
7. ***Technology risk; ratio of photovoltaic generation to the system to the peak load***
8. ***Other: minimum reserve margin observed and year***

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34 FINAL LTCE RUN RESULTS
Details

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Count	Case ID	Scenario	Strategy	Sensitivity	Load	NPV @ 9% 2019-2038 $000	Average 2019-2028 2018$/MWh	RPS 2038	NPV Deemed Energy Not Served MiniGrid Ops $000 (1)	Lowest Reserve Margin	PV / Max Demand	Emissions Reductions	Capital Investment Costs ($ Millions)
1	S1S2B	1	2		Base	16,216,702	101.1	81%	235,982	44% (2025)	175%	86%	6,579
2	S1S2H	1	2		High	17,903,791	101.7	89%	199,201	49% (2028)	178%	81%	7,694
3	S1S2L	1	2		Low	14,748,153	99.7	71%	185,656	49%(2025)	170%	87%	5,790
4	S1S3B	1	3		Base	16,076,200	100.4	76%	250,482	41%(2024)	175%	84%	6,645
5	S1S3H	1	3		High	17,835,218	101.3	93%	410,097	30% (2032)	175%	83%	7,287
6	S1S3L	1	3		Low	14,680,008	99.1	71%	265,850	39% (2028)	167%	87%	5,668
7	S1S2S1B	1	2	1	Base	15,434,453	97.1	84%	273,910	41%(2025)	180%	87%	6,718
8	S1S2S2B	1	2	2	Base	17,315,412	100.1	84%	338,854	51%(2033)	189%	81%	7,115
9	S1S2S3B	1	2	3	Base	15,858,601	100.3	59%	126,327	45%(2028)	124%	91%	5,275
10	S1S1B	1	1		Base	15,395,763	100.5	81%	594,235	50%(2025)	175%	86%	6,308
11	S3S2B	3	2		Base	14,714,793	93	87%	80,098	41% (2024)	189%	53%	7,247
12	S3S2H	3	2		High	16,141,041	94	99%	95,517	29%(2028)	188%	84%	7,931
13	S3S2L	3	2		Low	13,596,756	92.8	76%	54,035	32%(2025)	180%	88%	6,281
14	S3S3B	3	3		Base	14,749,058	93.3	87%	164,509	32%(2024)	186%	87%	7,059
15	S3S3H	3	3		High	16,181,429	93.9	96%	136,258	33%(2025)	188%	84%	8,065
16	S3S3L	3	3		Low	13,566,244	91.8	96%	173,547	33% (2025)	177%	88%	6,137
17	S4S2B	4	2		Base	15,195,166	96.3	49%	228,285	42% (2028)	104%	76%	6,131
18	S4S2B-M	4	2		Base	15,143,289	96.0	49%	226,360	42% (2028)	104%	76%	6,132
19	S4S2H	4	2		High	17,046,702	99.0	57%	169,249	38% (2034)	106%	72%	7,536
20	S4S2L	4	2		Low	14,094,994	96.6	48%	247,228	44% (2030)	108%	80%	5,468
21	S4S3B	4	3		Base	15,290,245	96.4	54%	343,059	30% (2030)	110%	77%	6,610
22	S4S3H	4	3		High	16,646,410	96.7	59%	452,412	32% (2028)	106%	72%	7,454
23	S4S3L	4	3		Low	14,013,227	95.8	45%	332,614	42% (2029)	99%	78%	5,656
24	S4S2S3B	4	2	3	Base	14,919,759	95.1	47%	262,528	37% (2026)	101%	54%	5,523
25	S4S2S4B	4	2	4	Base	15,288,253	96.4	53%	482,855	35% (2037)	110%	77%	6,509
26	S4S2S5B	4	2	5	Base	16,266,967	101.8	52%	195,783	47% (2037)	110%	75%	6,264
27	S4S2S6B	4	2	6	Base	16,203,306	101.7	22%	166,167	42% (2028)	37%	72%	5,821
28	S4S1B	4	1		Base	15,352,066	97.3	51%	476,701	29% (2034)	110%	74%	6,717
29	S5S1B	5	1		Base	14,769,222	92.7	49%	1,142,452	30% (2026)	101%	77%	5,468
30	S5S1S5B	5	1	5	Base	15,417,661	95.7	54%	1,027,570	32% (2030)	110%	76%	5,987
31	ESM Plan	4	2		Base	15,186,419	95.4	24%	319,291	45% (2028)	42%	66%	4,098
32	ESM high	4	2		High	16,589,582	95.8	40%	484,235	40% (2034)	69%	69%	4,954
33	ESM low	4	2		Low	14,111,364	95.7	20%	330,499	49% (2029)	37%	71%	3,355
34	ESM 50% RPS	4	2		Low	15,216,945	95.7	44%	306,724	47% (2028)	102%	75%	5,131

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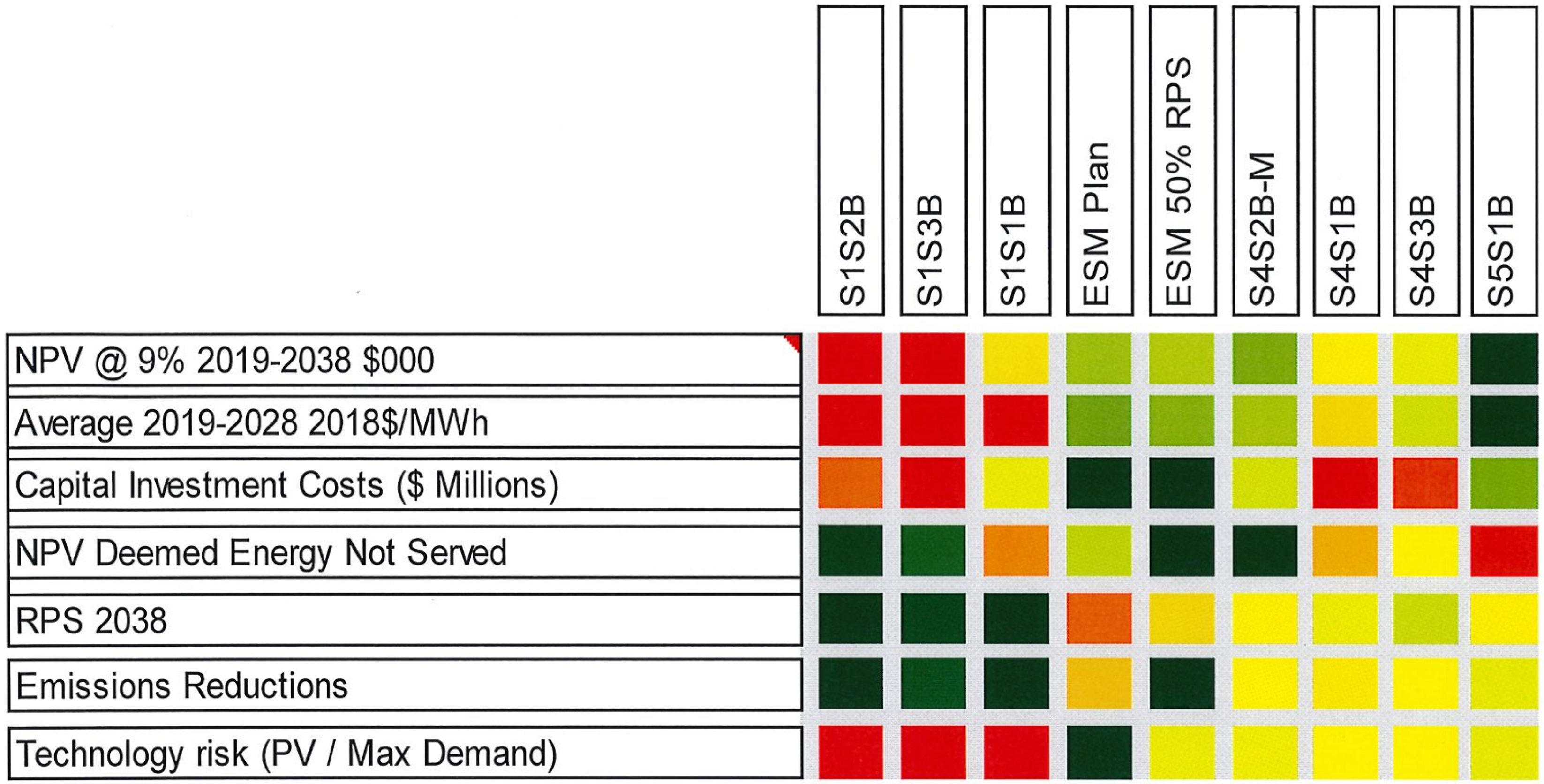
34 FINAL LTCE RUN RESULTS
Base Load Growth Case Score Card Green Best / Red Worst



- Scenario 1 worst on costs and technology risk
- ESM with 50% by 2040 and S4S2-M are very similar in most metrics.
- S5S1 has the lowest costs but the worst outcome in resiliency as it is centralized.

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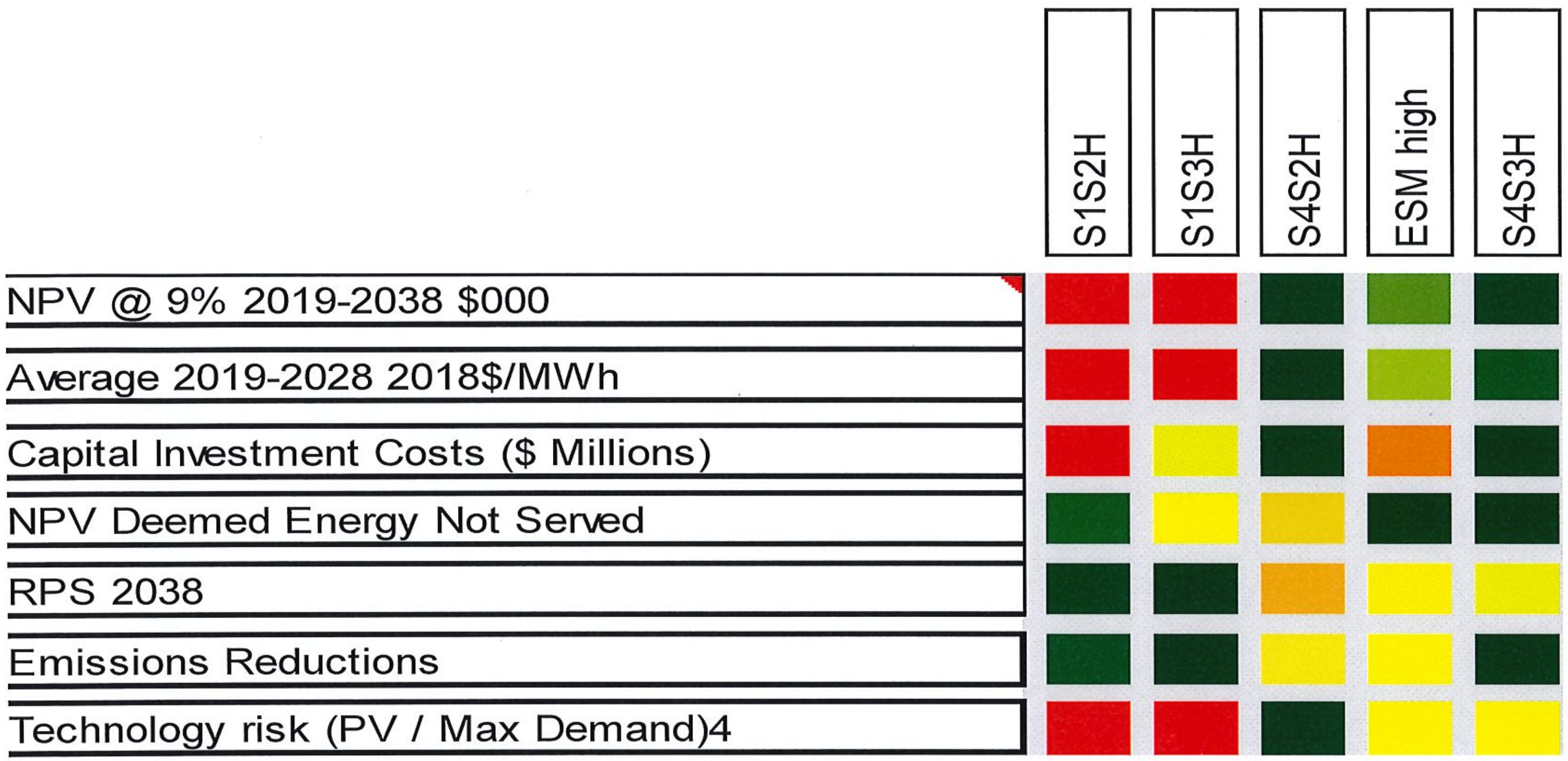
34 FINAL LTCE RUN RESULTS
High Load Growth Case Score Card Green Best / Red Worst



- Scenario 1 worst on costs and technology risk
- ESM-H and S4S2H are similar in most metrics.
- S4S3H has the best outcomes and it has CCGTs at Palo Seco Mayaguez & Yabucoa, same PV as Base Load.
- ESM-H has higher capex as the add growth is attended by PV (capital intensive)

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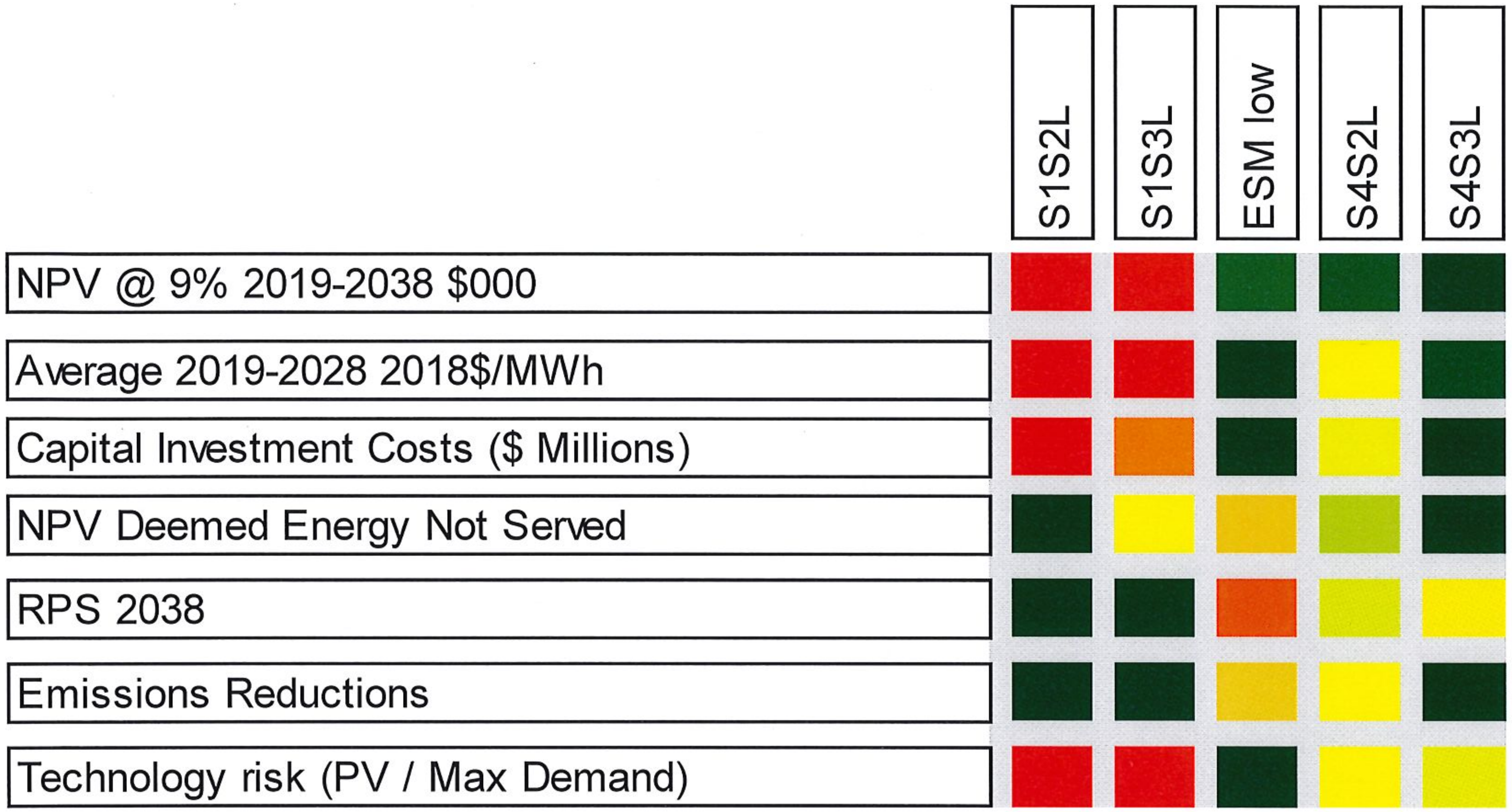
34 FINAL LTCE RUN RESULTS
Low Load Growth Case Score Card Green Best / Red Worst



- Scenario 1 worst on costs and technology risk
- ESM-L and S4S3L are similar in most metrics.
- Main difference with S4S2L is an F-Class at Yabucoa in S4S3L by 2028
- ESM-L is worst on RPS as it was not required to get to 50% by 2040

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34 FINAL LTCE RUN RESULTS
NPV view

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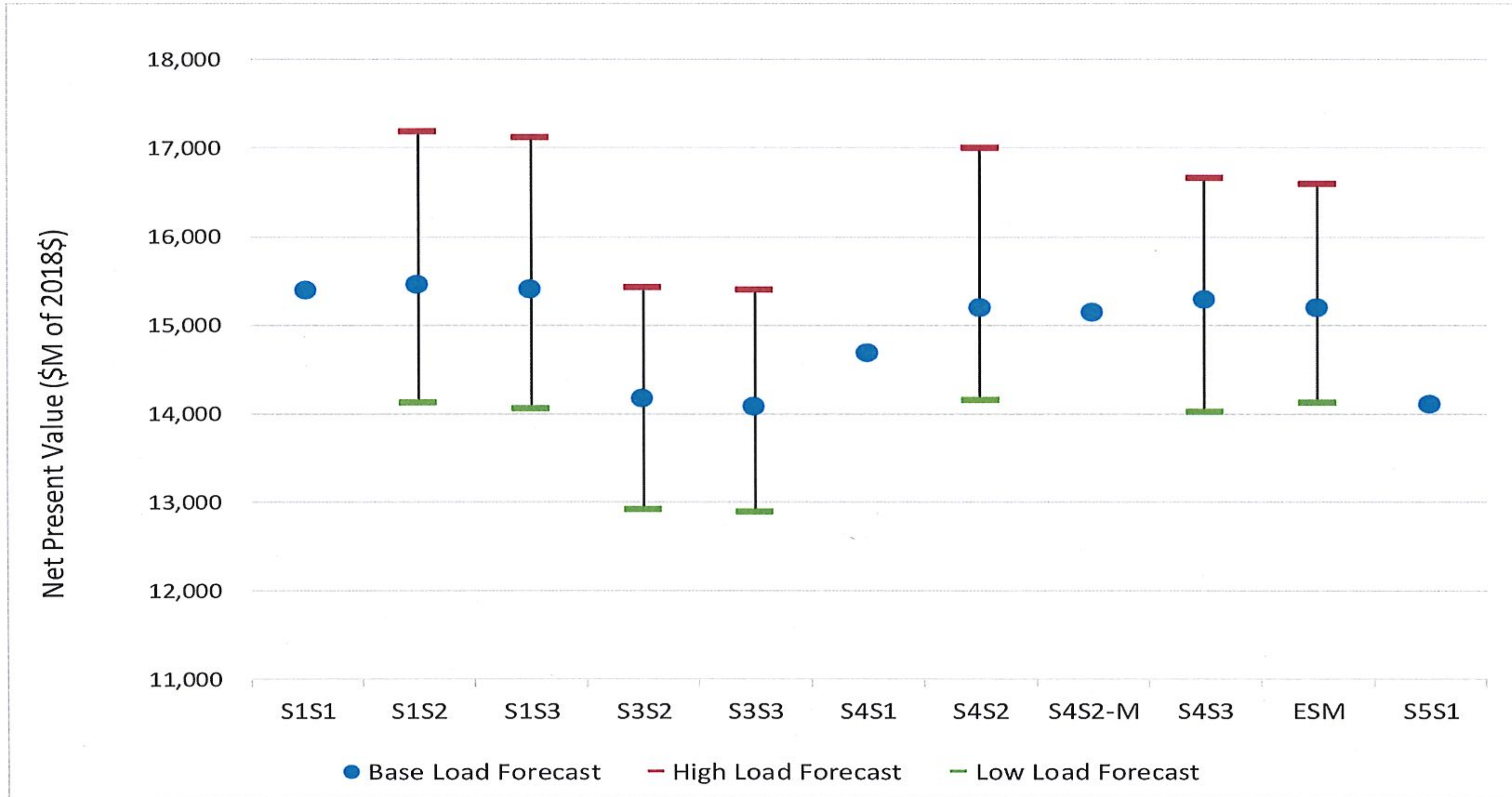

- Scenario 3 has the lowest NPV but assumes high rate of interconnection of renewable and deeper drop in costs. It highlights an opportunity to be aware if the underlying assumptions materialize.
- Scenario 5 has the lowest NPV but as indicated earlier is the least resilient. Same observation with Scenario 4 Strategy 1.
- .

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Action Plan 5 years

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ACTION PLAN

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- **Solar Photovoltaics (install 900 MW to 1800 MW) ESM & S4S2**

ESM	2019	2020	2021	2022	2023
Solar PV Additions (MW)	0	0	240	480	180
Cumulative Additions (MW)	0	0	240	720	900
Capital Expenditures ($M)	-	-	$343	$678	$251

S4S2B	2019	2020	2021	2022	2023
Solar PV Additions (MW)	0	300	300	600	600
Cumulative Additions (MW)	0	300	600	1200	1800
Capital Expenditures ($M)	-	$452	$428	$848	$837

- **Battery Energy Storage (install 600 MW to 900 MW) ESM & S4S2**

ESM	2019	2020	2021	2022	2023
BESS Additions (MW)	20	100	160	160	160
Cumulative Additions (MW)	20	120	280	440	600
Capital Expenditures ($M)	$24	$109	$163	$153	$147

S4S2B	2019	2020	2021	2022	2023
BESS Additions (MW)	180	300	300	120	0
Cumulative Additions (MW)	180	480	780	900	900
Capital Expenditures ($M)	$216	$328	$308	$115	-

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ACTION PLAN; NEXT 5 YEARS

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- **San Juan 5&6 Combined Cycle (CC) Conversion to Natural Gas (2x200MW) by 2019**
- **Mayagüez 1, 2, 3, 4 Peaker Conversion to LNG Natural Gas (4x50MW) by 2022 *supported by a Ship-Based LNG***
- ***EcoEléctrica Contract Renegotiation and Extension with a CCGT as the basis***
- ***San Juan Generator Conversions to Synchronous Condensers for PV integration***
- ***Palo Seco CCGT (302 MW F-Class) by 2025 supported by a Land-Based LNG***
- ***Costa Sur CCGT (302 MW F-Class) by 2025 if contract negotiation unsuccessful***
- ***Yabucoa CCGT (302 MW F-Class) by 2025 supported by a Ship-Based LNG***
- ***Mayagüez CCGT (302 MW F-Class) if Yabucoa is not built supported by a Ship-Based LNG***
- ***San Juan Small CCGT – LPG/NG (3x38MW) as an option against delays / early failure of units, supported by a Ship-Based LNG and with LPG as an option.***

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ACTION PLAN

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- **Mobile Gas Turbine Peaking Units (18x23 MW) for resiliency.**

Location	Number of Units
Jobos	2
Mayagüez North	4
Carolina (Daguao)	5
Caguas (Yabucoa)	5
Cayey	2
Total	18

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ACTION PLAN

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- **Retirements of Existing units are based on:**
  - The realization of forecasted load reductions
  - The real implementation and effectiveness of Energy Efficiency and Demand Response Programs
  - The installation and commissioning of the large scale solar and battery storage resources
  - The installation and commissioning of the new conventional generation units.
  - Effective maintenance and availability of PREPA's remaining units
  - Actual zero dispatch experience of the units to be shut down

Unit	Last Year in Service
Frame 5 Peakers	2019 to 2021
Aguirre ST 1	2019
Aguirre ST 2	2020
Costa Sur 6	2020
Costa Sur 5	2021
San Juan 7&8	2023

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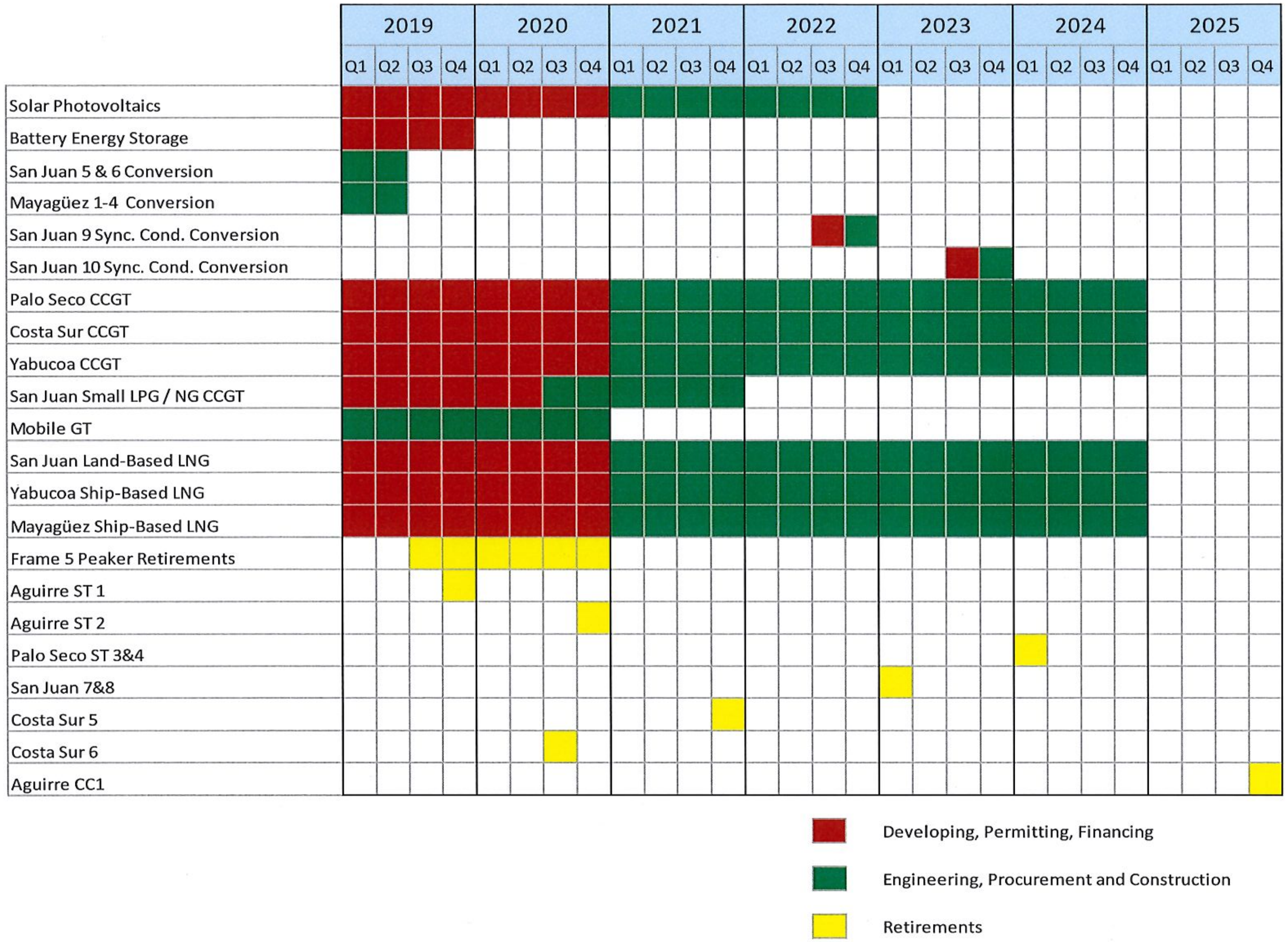
ACTION PLAN
High Level Timeline



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REFERENCES

- **The IRP full documents can be found at.**
  - https://aeepr.com/es-pr/QuienesSomos/Paginas/ley57/Plan-Integrado-de-Recursos.aspx

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