Puerto Rico Avoided Cost Study: Appendix C - Updated Modeling Results

Puerto Rico Energy Bureau

May 23, 2022

Background

On March 7th 2022, LUMA Energy ServCo,LLC (LUMA) submitted its comments on Attachments A and B to the Resolution and Order of February 7, 2022, and the Avoided Cost Modeling Presentation.

LUMA included 17 comments and questions in its submission. Synapse identified 4 comments/recommendations that necessitated re-running the model with updated inputs and parameters including:

- #3 pertaining to the availability of peaker units
- #5 and #6 pertaining to the system load and peak demand.
- #7 and #8 pertaining to the natural gas and oil price forecast

The purpose of this updated slide deck is to illustrate the impact of these recommendations on overall model results and provided additional information as requested in the comments.

No EE Model Updates: Inputs

Given these previously outlined recommendations, Synapse has modified the following inputs:

- Load
 - Synapse updated the load forecast to use the PREPA's more recent load forecast based on the 2021 Fiscal plan.
 - Impact: Load is higher across all periods in the modeling horizon.
- Peaker Unit Availability
 - Synapse made 42 MW of Diesel capacity available in 2021 in response to PREPA's comments about certain Diesel Peakers we assumed to be retired (as ordered in the IRP).
 - Impact: Diesel capacity is fractionally higher in the earlier years of the modeling horizon
- Fuel Prices
 - Synapse updated the fuel prices in 2 meaningful ways:
 - Updated our data sources (AEO 2022, and latest futures prices).
 - Calibrated against 11 months of 2021 fuel receipts vs 5 months. Scaled up prices.
 - Impact: Fuel prices are higher in the earlier years due to higher futures price that likely reflect the high degree of uncertainty in oil and gas markets.

No EE Model Updates: Modeling Framework

In addition to the input changes, Synapse has also slightly modified its modeling framework for the No EE case.

- The prior results featured fixed builds of solar and batteries, broadly consistent with the buildout results from the Siemens No EE Case in the 2018 IRP.
- In the latest set of results, Synapse observed that using the same approach for solar and battery builds was an infeasible option given the incorporation of the updated, higher load forecast into the model.
- Therefore, Synapse modified its approach to solar and battery builds by:
 - allowing the model to optimize the buildout of solar and batteries up to levels deemed feasible given procurement timelines.
 - removing 2-hour batteries as an option for better comparability against the Siemens No EE Case

EnCompass Data Input Updates



PREPA System Peak Demand – No EE Load Update

Period	No EE Peak Load (MW) 1/26/22	No EE Peak Load (MW) 4/7/22
2021	2,861	2,994
2022	2,858	2,994
2023	2,864	2,973
2024	2,867	2,955
2025	2,867	2,956
2026	2,860	2,962
2027	2,848	2,970
2028	2,826	2,982
2029	2,803	2,989
2030	2,784	2,993
2031	2,767	2,981
2032	2,750	2,969
2033	2,736	2,947
2034	2,723	2,925
2035	2,712	2,903
2036	2,703	2,881
2037	2,695	2,859
2038	2,696	2,842



Source: https://oversightboard.pr.gov/fiscal-plans-2/

PREPA System Load – No EE Energy Update, and Effect of Full EE Scenario on Load Trajectory

Period	No EE Annual Energy (GWh) 1/26/22	No EE Annual Energy (GWh) 4/7/22
2021	18,033	18,965
2022	18,101	18,965
2023	18,157	18,846
2024	18,190	18,750
2025	18,197	18,766
2026	18,169	18,818
2027	18,100	18,870
2028	17,972	18,963
2029	17,812	18,991
2030	17,678	19,005
2031	17,557	18,918
2032	17,445	18,830
2033	17,344	18,682
2034	17,255	18,534
2035	17,175	18,386
2036	17,107	18,237
2037	17,049	18,088
2038	17,027	17,944





Updated load data Source: https://oversightboard.pr.gov/fiscal-plans-2/

No EE Henry Hub Gas Price Update

Period	HH Gas Price (\$/MMBTU) 1/26/22	HH Gas Price (\$/MMBTU) 4/7/22
2021	3.71	3.71
2022	4.15	5.17
2023	3.70	4.20
2024	3.56	3.45
2025	3.20	3.19
2026	3.40	3.40
2027	3.54	3.54
2028	3.78	3.78
2029	4.00	4.00
2030	4.16	4.16
2031	4.27	4.27
2032	4.44	4.44
2033	4.63	4.63
2034	4.77	4.77
2035	4.90	4.90
2036	5.01	5.01
2037	5.11	5.11
2038	5.25	5.25



Note: Synapse updated the base henry hub natural gas price using the latest NYMEX forwards from March 2022 and the 2022 AEO. The forecast was also calibrated against 10 months of 2021.

No EE WT Crude Oil Price Update

Period	WT Crude Oil Price (\$) 1/26/22	WT Crude Oil Price (\$) 4/7/22
2021	67.99	67.99
2022	71.38	100.99
2023	63.50	85.00
2024	61.59	68.19
2025	66.12	70.64
2026	69.86	73.78
2027	74.25	77.80
2028	78.97	81.36
2029	82.87	84.57
2030	87.71	87.87
2031	91.60	91.78
2032	95.84	95.32
2033	99.34	98.47
2034	102.90	101.22
2035	106.42	104.44
2036	110.69	108.46
2037	115.15	112.13
2038	120.09	116.15



Note: Synapse updated the base WTI crude oil forecast with the latest values from EIA's STEO and the 2022 AEO. The forecast was also calibrated against 10 months of 2021.

Peaker Unit Updates

- 42 MW of peaker units made available in 2021 based on LUMA's comments
 - Does not align with PREB orders, but minimal impact on broad modeling outcomes for both energy and capacity over the planning horizon.

Updated Results

Updated No EE Modeling Results: Capacity

The updated model results show that cumulative capacity buildout trends are largely unchanged. The model still features:

(i) a rapid buildout of solar and battery capacity beginning in 2025,

- (ii) residual fuel oil and diesel capacity mostly retire by 2026,
- (ii) gas capacity remaining mostly unchanged until EcoElectrica retirement by 2032



Updated No EE Modeling Results: Generation

Similarly, generation results are broadly unchanged. The key themes continue to be:

- (i) the accelerated reduction of RFO generation between 2021 and 2025.
- (ii) solar and battery generation replacing the coal generation with the expiration of AES Coal
- (iii) solar and battery generation replacing the load previously met by EcoElectrica



Updated No EE Modeling Results: Capacity & Generation

A comparison of the latest results and the (1/26) results show that the system capacity and generation trends differ only slightly.

- System capacity is overall higher in the latest model run driven by the model choosing to build more solar in response to the, updated, higher load forecast.
- Total natural gas capacity in the long-term is mostly unchanged with the exception of the following:
 - Costa Sur 5 remains online through 2028 instead of retiring in 2025, leading the 2025 capacity to be higher than in the previous results.
 - Only 1 302 MW gas CC plant is built in 2025, the model previously built another in 2033.
- Battery builds decrease slightly with the exclusion of 2hr batteries as an option.
- Diesel capacity is overall lower in the long-term.

	2021	2025	2030	2035	2038
Coal	-	-	-	-	-
Diesel	42	506	(231)	(231)	(294)
Natural Gas	-	696	393	91	91
RFO	-	-	-	-	-
Solar	-	-	-	1,410	1,353
Hydro	-	-	-	-	(28)
СНР	-	-	-	-	-
DG	-	-	-	-	-
LFG	-	-	-	-	(2)
Wind	-	-	-	-	-
Battery	(60)	(700)	(80)	(200)	(200)
Peak Load	133	89	209	191	146

Den	a Gene	ration (Gvvn)	4/25 -	1/26)
	2021	2025	2030	2035	2038
Coal	(1)	(54)	-	-	-
Diesel	4	(54)	(5)	-	-
Natural Gas	941	641	1,269	(650)	(764)
RFO	(13)	-	-	-	-
Solar	(0)	(2)	41	2,307	2,109
Hydro	(0)	(0)	I	0	(68)
СНР	-	-	-	-	-
DG	(0)	(30)	34	(310)	(419)
LFG	-	-	-	-	(21)
Wind	(0)	(1)	I	(9)	(10)
Battery	(0)	(860)	154	1,483	1,371
Load	932	569	1,327	1,211	917

Delta Capacity (MW) (4/25 – 1/26)

Updated No EE Modeling Results: Marginal Energy Prices

- The latest modeling results show off-peak and on-peak energy prices rise in the short term (2021-2025) due to higher fuel costs stemming from the update.
- In the longer term, energy prices are lower overall when compared to the (1/26) results as a result of greater solar and battery adoption.



- On-peak period: Hours of 9:00 a.m. to 10:00 p.m. during weekdays (Monday-Friday), excluding certain holidays.
- Off-peak period: Hours of 10:00 p.m. to 9:00 a.m. during the weekdays (Monday-Friday), all weekend hours, and all hours during certain holidays.
- Synapse notes that the off-peak and on-peak definitions are subject to change and may shift over time.

Source: Tariff Book - Electric Service Rates and Riders, Puerto Rico Electric Power Authority.

Updated No EE Modeling Results: 2025 Heat Map

Heat maps of Puerto Rico avoided energy costs can be used to identify the month/hour combinations associated with high/low energy costs for purposes of determining peak/off-peak hours and TOU rates.

2025 Load	l We	ighte	ed Pri	ce (20	20 \$/M	Wh)																		
												Hou	r End	ing										
Month	I	2	3	4	5	6	7	8	9	10		12	13	14	15	16	17	18	19	20	21	22	23	24
January	90	89	79	78	78	79	79	77	61	61	51	38	51	61	63	76	100	85	83	Ш	92	92	83	84
February	81	79	79	78	78	79	79	72	54	49	31	17	26	48	57	75	80	84	93	86	85	103	93	92
March	83	81	79	78	78	80	78	68	49	38	23	26	43	48	60	77	85	85	104	126	107	95	85	85
April	93	80	79	80	79	79	77	64	54	45	30	31	43	55	66	82	94	86	105	99	98	104	105	104
May	86	84	82	82	82	82	79	72	70	66	58	58	68	70	77	95	106	87	89	116	150	107	96	89
June	85	85	85	85	85	84	76	73	72	71	67	67	72	72	75	115	97	104	86	102	101	95	90	106
July	86	85	85	85	85	84	77	73	70	67	62	62	69	70	74	102	86	95	115	101	105	96	98	86
August	98	87	88	86	86	87	79	75	72	70	61	58	68	72	74	94	108	90	124	120	121	101	105	100
September	116	87	86	86	86	86	83	75	74	74	67	67	68	74	77	105	136	100	142	119	132	140	119	101
October	89	89	88	88	88	88	86	78	76	75	66	65	67	76	77	84	99	109	113	121	117	103	99	106
November	92	91	89	86	86	89	87	82	79	79	77	70	68	74	80	82	103	104	101	112	103	131	112	112
December	89	85	84	82	82	85	85	81	77	77	76	75	74	75	77	79	89	109	100	120	101	99	91	89

Updated No EE Modeling Results: 2030 Heat Map

By 2030, hourly load weighted prices largely fall in comparison to 2025 prices, particularly in the off-peak hours, reflecting the impact of batteries that have resulted in a reduction in annual diesel peaker generation.

2030 Load Weighted Price (2020 \$/MWh)

												Hou	r Endi	ing										
Month	Ι	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
January	84	84	84	84	84	84	84	76	75	75	75	75	75	75	75	76	83	83	83	83	83	83	83	83
February	76	76	76	76	76	76	76	69	68	68	68	68	68	68	68	69	75	75	75	75	75	75	75	75
March	77	77	77	77	77	77	76	64	64	64	62	60	64	64	64	68	76	76	76	76	76	76	76	76
April	76	76	76	76	76	76	74	65	65	65	61	60	65	65	66	74	76	76	76	76	76	76	76	75
May	84	84	84	84	84	84	79	75	75	75	75	74	74	75	75	83	83	83	83	83	83	83	83	83
June	82	82	82	82	82	82	77	73	73	73	73	73	73	73	74	81	82	82	82	82	82	82	82	82
July	80	80	80	80	80	80	76	72	72	72	71	71	71	72	72	79	80	80	80	80	80	80	80	80
August	83	83	83	83	83	83	79	73	73	74	74	74	74	74	74	82	83	83	83	83	83	83	83	83
September	105	105	105	105	105	105	102	86	86	86	86	86	86	86	87	91	97	97	97	96	97	97	97	97
October	99	99	99	99	99	99	99	83	82	82	82	82	82	82	82	94	99	99	99	99	99	99	99	99
November	94	94	94	94	94	94	94	85	84	84	84	84	84	84	84	84	93	93	93	93	93	93	93	93
December	87	87	87	87	87	87	87	80	78	78	78	78	78	78	78	78	87	87	87	87	87	87	87	87

Updated No EE Modeling Results: 2038 Heat Map

By 2038, mid-day load weighted prices have fallen substantially, reflecting the abundance of solar to meet load. Off-peak hours also decline, albeit at a more muted pace, reflecting greater battery buildouts.

2038 Loa	d W	'eigh	nted	Pric	:e (2	020	\$/ M `	Wh))															
	1											11												
												Hou	r Ena	ng										
Month	I	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
January	73	73	73	73	73	73	73	28	27	27	27	23	25	27	27	28	71	71	71	71	70	70	70	70
February	81	81	81	81	81	81	81	27	22	22	20	22	22	22	22	30	69	69	69	69	68	68	68	68
March	68	68	68	68	68	68	66	25	25	17	19	21	23	21	25	30	68	68	68	68	68	68	68	68
April	42	42	42	42	42	42	34	16	16	12	10	9	16	16	19	30	38	37	37	37	37	37	37	37
May	59	59	59	59	59	59	45	37	37	37	26	30	35	37	38	58	59	59	59	59	59	59	59	59
June	80	80	80	80	80	80	47	18	18	18	14	14	18	18	19	79	79	79	79	79	79	79	79	79
July	75	74	74	74	74	74	52	22	22	22	15	9	20	22	22	74	74	74	74	74	74	74	74	74
August	91	91	90	90	91	91	84	14	14	14	12	12	14	14	14	69	97	97	97	97	97	97	96	96
September	88	88	88	88	88	88	80	31	28	28	17	19	23	28	28	48	82	81	81	82	82	82	82	81
October	93	93	93	93	93	93	94	32	27	27	25	18	18	22	27	37	93	93	93	93	93	93	93	93
November	82	82	82	82	82	82	82	56	53	53	53	50	45	48	53	53	81	81	81	81	81	81	80	80
December	81	81	81	81	81	81	81	74	73	73	73	73	73	73	73	73	82	82	82	82	82	82	82	82

Updated No EE Modeling Results: Peak Day in 2025



Updated No EE Modeling Results: Peak Day in 2030



Updated No EE Modeling Results: Peak Day in 2038



Modeling Results: Marginal Hours

 Battery storage is primarily on the margin. For marginal energy price calculation, the model knows the cost of the power that was used to charge the battery, and accounts for battery round-trip efficiency losses.



Marginal hours: number of hours that a resource will be used to generate the next additional kW of power that is required. Some factors that determine whether a resource is on the margin are unit heat rates, fixed and variable O&M costs, technical constraints, and environmental regulations.





Note: Figure is based on the peak day of 2025, using data for mid-day, figure meant to be illustrative only and excludes batteries to prevent double counting of generation from solar



Note: Figure is based on the peak day of 2030, using data for mid-day, figure meant to be illustrative only and excludes batteries to prevent double counting of generation from solar



Note: Figure is based on the peak day of 2030, using data for mid-day, figure meant to be illustrative only and excludes batteries to prevent double counting of generation from solar