Puerto Rico Avoided Cost Study: Avoided Capacity Costs

Puerto Rico Energy Bureau – Technical Conference

Presentation for Discussion

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June 22, 2022

Agenda

1. Synopsis of responses to LUMA questions and comments on Avoided Energy Costs
   - The previous avoided cost technical conference (February 8, 2022) focused on avoided energy costs.
   - LUMA provided a series of questions and comments (March 7, 2022) based on the technical conference presentation.
   - Responses to LUMA questions and comments (June 6, 2022) included written responses (Appendix A), an Excel file with more detailed data (Appendix B), and an updated slide deck (Appendix C)
2. New Avoided Capacity Cost methodology and draft results
3. Brief touch base on the value of avoided greenhouse gas (GHG) emissions from EE
4. Discussion questions

Section 1 – Synopsis of Responses to LUMA Questions and Comments

Responses to LUMA Questions and Comments

LUMA’s feedback was helpful and informed updates to the avoided energy cost modeling, including:

- The timing of plant retirements
- The load and peak demand forecast
- The energy efficiency savings forecast
- The natural gas and oil price projections
- The renewable portfolio standard targets

As recommended by LUMA, the avoided energy cost modeling now reflects the best available data.

Section 2 – Avoided Capacity Costs

Purpose and Methodology

Purpose: Estimating Avoided Capacity Costs from EE for use in EE benefit/cost studies

- Not intended as a detailed operational representation
- Planning exercise to capture key changes to capacity and production trajectories under two different load trajectories

Methodology: EnCompass capacity expansion and production cost model used to develop 18-year cost streams (2021-2038) for each of “No EE” and “Full EE” cases

- Aligned with IRP results, but updated including procurement delays and load forecast
- Includes LUMA suggested changes
- Re-run of EnCompass reflects essence of IRP results for “No EE” and “Full EE” conditions, but details diverge from exact outcome of the Siemens 2018 runs

Detailed Methodology

Context:

1) Differential between the “No EE” and “Full EE” case
2) Did not directly consider single, “No EE” case to estimate avoided capacity. Capacity considerations in isolation are more complex than energy, since battery capacity used in direct support of meeting RPS, in addition to meeting night peak.

Differential case, “No EE” vs. “Full EE” load level and resource builds. Use hard-coded input assumptions for some resources, allow optimization for others

- Run capacity expansion and production cost modeling case for two scenarios:
  - “No EE” case (basis of avoided energy cost information thus far)
  - “Full EE” case – premised on S3S2B run from IRP
- Compute stream of energy and capacity costs for each. Comprised of fuel, variable O&M, fixed costs, and new build costs (amortized)
- Compare cases

Results Summary

Lower nightly peak load from EE reduces capacity need, but incremental battery capacity is still required to store daytime solar energy, especially in later years with high solar PV levels.

- Unlike fossil peaking capacity, battery capacity has an every-day role in energy system regardless of the level of peak load.

Modeling capacity costs (based on scenarios with and without EE):

- Optimal capacity expansion results include primarily new solar PV and battery storage, at different paces / levels depending on energy and peak load projection.
- In IRP and this exercise, "fixed" decisions on future coal, gas (EcoElectrica) retirement; and some GTs. Model allowed to retire oil and gas steam/CC resources if not needed.
- While technically "sub-optimal" to fix/hard code resource paths, it is still reasonable to estimate savings, or avoided capacity and energy costs, from model results.

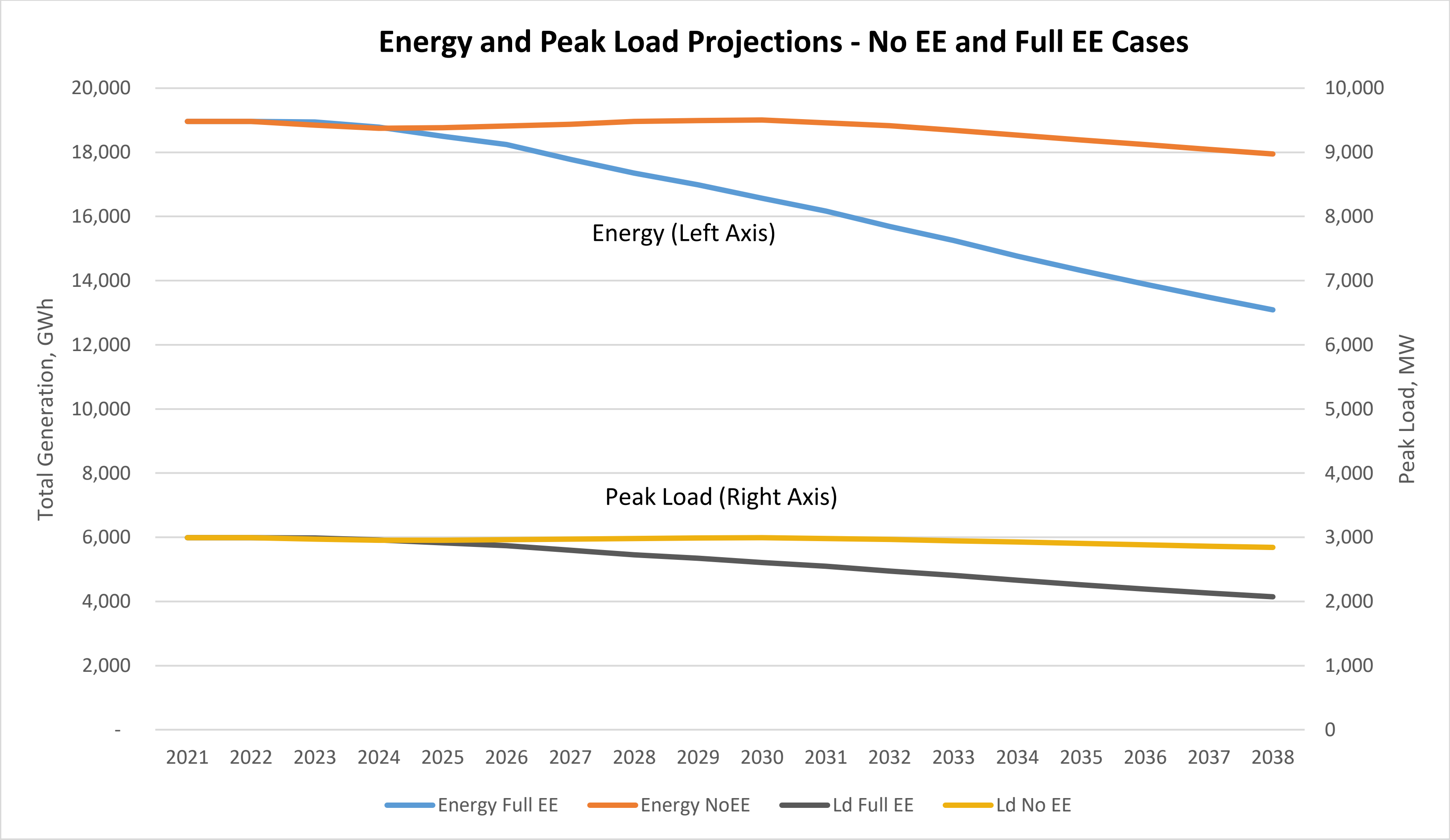
Results Summary (cont’d)

On the margin, lower peak load and reduced total energy (from EE effects) causes an incremental reduction in later year battery requirements to serve nightly peaks.

- This is the primary form of capacity value savings from EE.

Energy and Peak Trajectories - No EE, Full EE

- No EE case assumes roughly flat peak and energy trajectory.
- Full EE case illustrates declining energy, peak requirements.



Capacity Resource Retirement and Expansion

- These units hard coded or pace-constrained input – retirement and new build
  - Retire: Coal end of 2027, Eco Electrica end of 2032
  - Constraints on pace of solar PV and battery builds
- These units (retire or build) come out of capacity expansion optimization
  - Oil steam – can retire early, must retire by 2025
  - Costa Sur – no fixed retirement date
  - San Juan 5 &6 – no fixed retirement date
  - Solar PV and battery builds
  - New CC, CT, RICE builds – can occur if needed
- Next slide: capacity resource retirement results

Endogenous/Economic Retirement vs Fixed Retirement

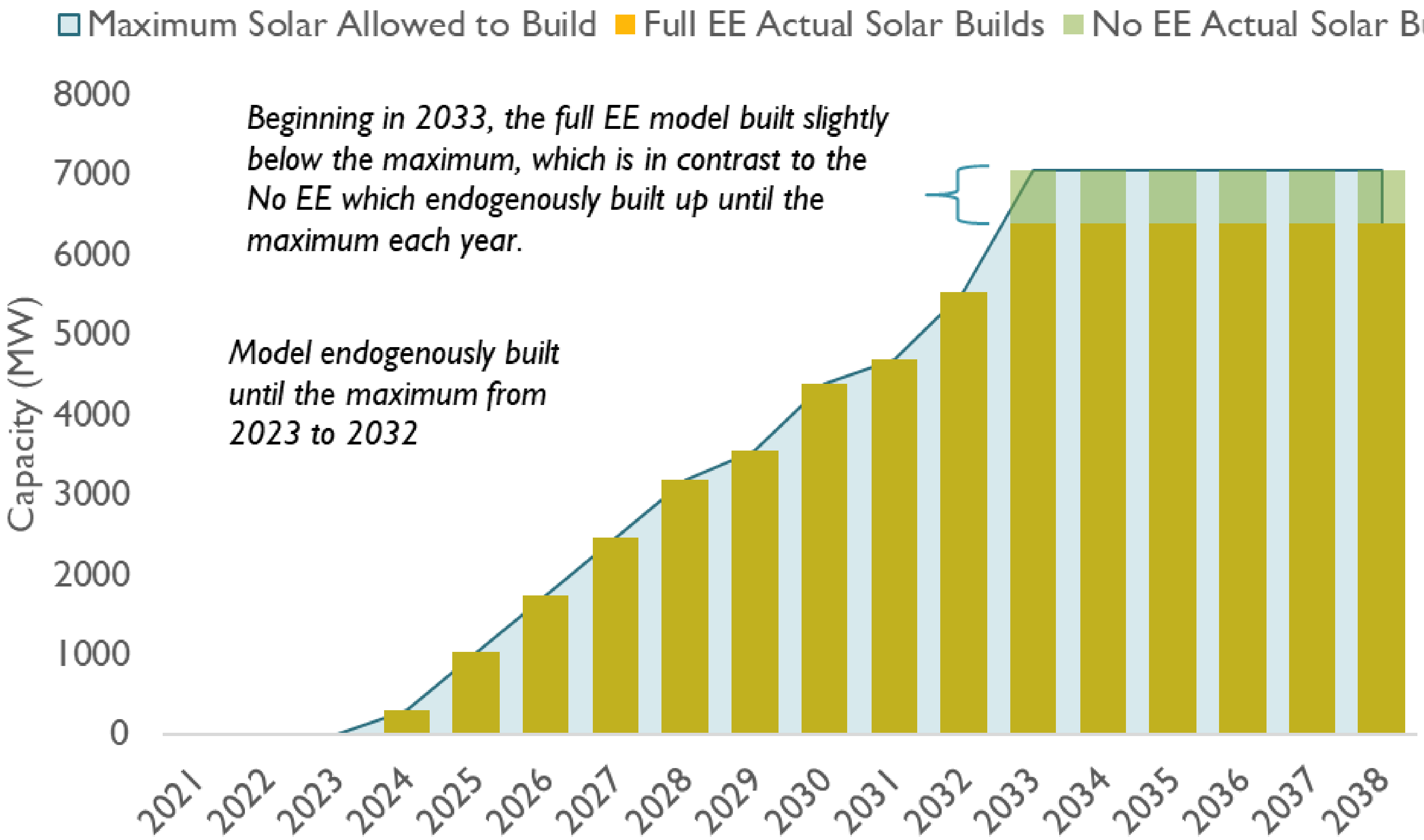
- Lower peak load (Full EE) leads to earlier retirement for some resources.

Resource	Can Endogenously Retire after 2023?	Did Retire Endogenously?	Must Retire By:	Actual Retirement Date in No EE Scenario	Actual Retirement Date in Full EE Scenario	Retired Early in Full EE Relative to No EE?
Aguirre 1 CC	Yes	No	2025	2025	2025	No
Aguirre 2 CC	Yes	No	2025	2025	2025	No
Aguirre GT21 & GT22	Yes	Yes	*	2027	2025	Yes
Aguirre Steam 1	Yes	Yes	2025	2025	2024	Yes
Aguirre Steam 2	Yes	No	2025	2025	2025	No
Cambalache CT 2	No	No	2038	2038	2038	No
Cambalache CT 3	No	No	2038	2038	2038	No
Costa Sur 5	Yes	Yes	2040	2028	2026	Yes
Costa Sur 6	Yes	Yes	2040	2038	2027	Yes
Costa Sur GT11 & GT12	Yes	Yes	2038	2026	2025	Yes
DAGUAO GT11 & GT12	Yes	Yes	2038	2026	2025	Yes
EcoElectrica	No	No	2032	2032	2032	No
Jobos GT11 & GT12	Yes	Yes	2038	2026	2025	Yes
Mayaguez GT 1	No	No	2040	2040	2040	No
Mayaguez GT 2	No	No	2040	2040	2040	No
Mayaguez GT 3	No	No	2040	2040	2040	No
Mayaguez GT 4	No	No	2040	2040	2040	No
Palo Seco 3	Yes	Yes	2025	2023	2023	No
Palo Seco 4	Yes	Yes	2025	2023	2023	No
Palo Seco CT 11	Yes	No	2025	2025	2025	No
Palo Seco CT 12	Yes	No	2025	2027	2027	No
SAN JUAN 07	Yes	Yes	2025	2023	2023	No
SAN JUAN 08	Yes	Yes	2025	2023	2023	No
SAN JUAN 5 CC_Conversion	Yes	Yes	2040	2038	2030	Yes
SAN JUAN 6 CC_Conversion	Yes	Yes	2040	2038	2031	Yes
Vega Baja GT11 & GT12	Yes	Yes	*	2026	2024	Yes
YABUCOA GT11 & GT12	Yes	Yes	*	2026	2024	Yes

** Resource assumed to be online throughout modeling period*

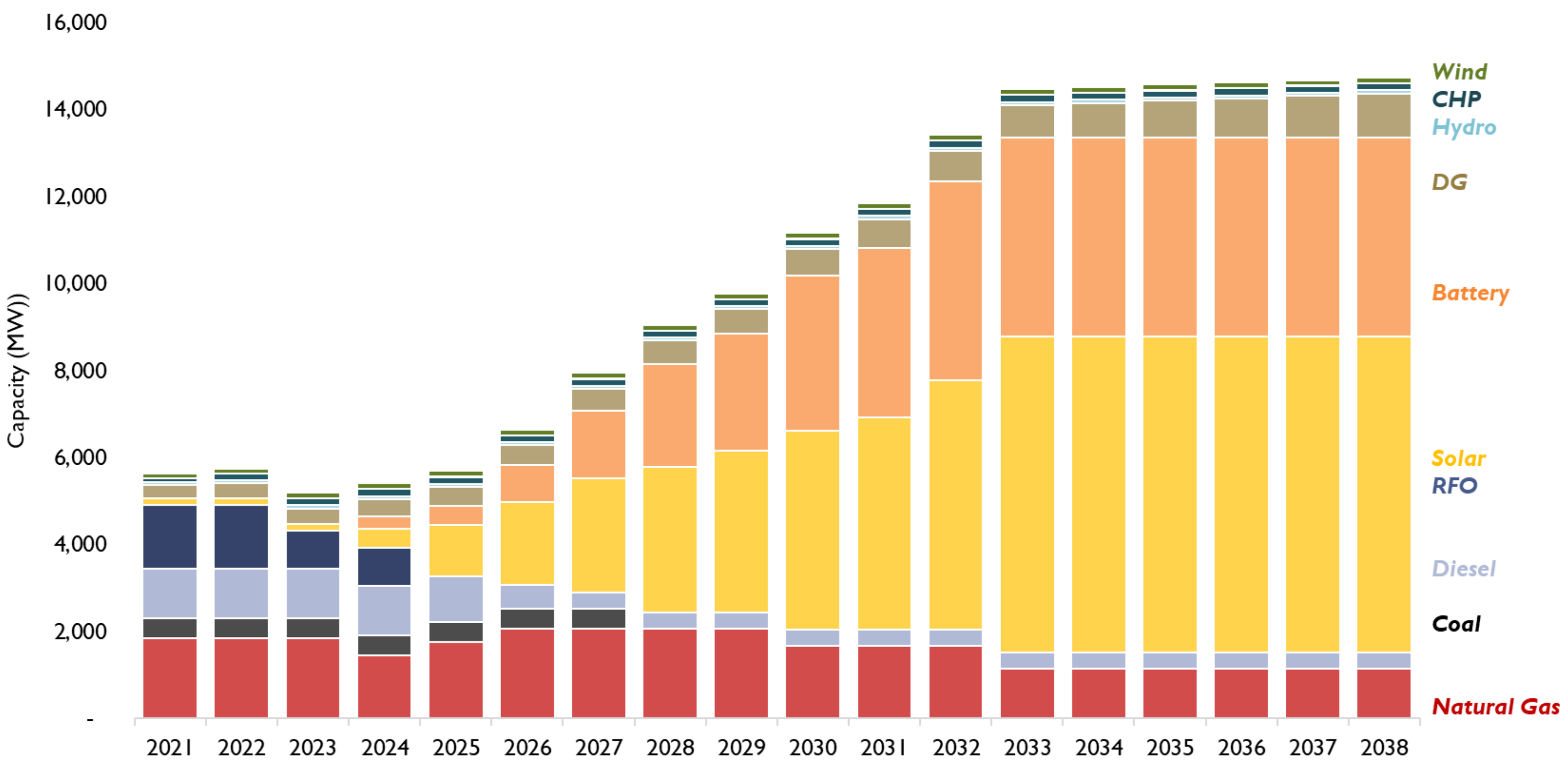
Endogenous/Economic Builds vs Fixed Builds

- Applied the same maximum constraints on solar builds for the No EE and the Full EE case, and let the model select the optimal amount of solar.



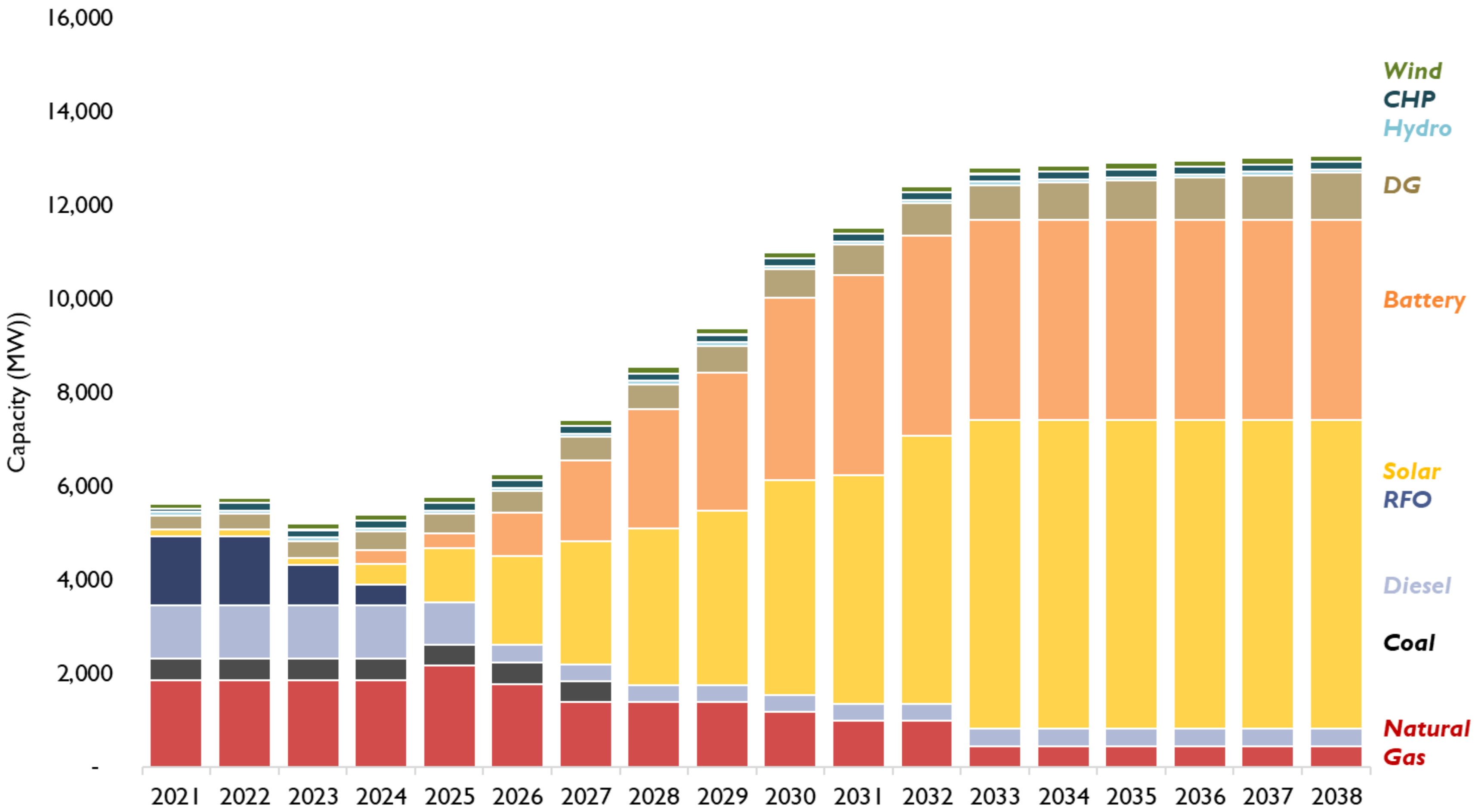
Existing No EE Case Capacity Trajectory

- Model builds to meet RPS and peak load needs



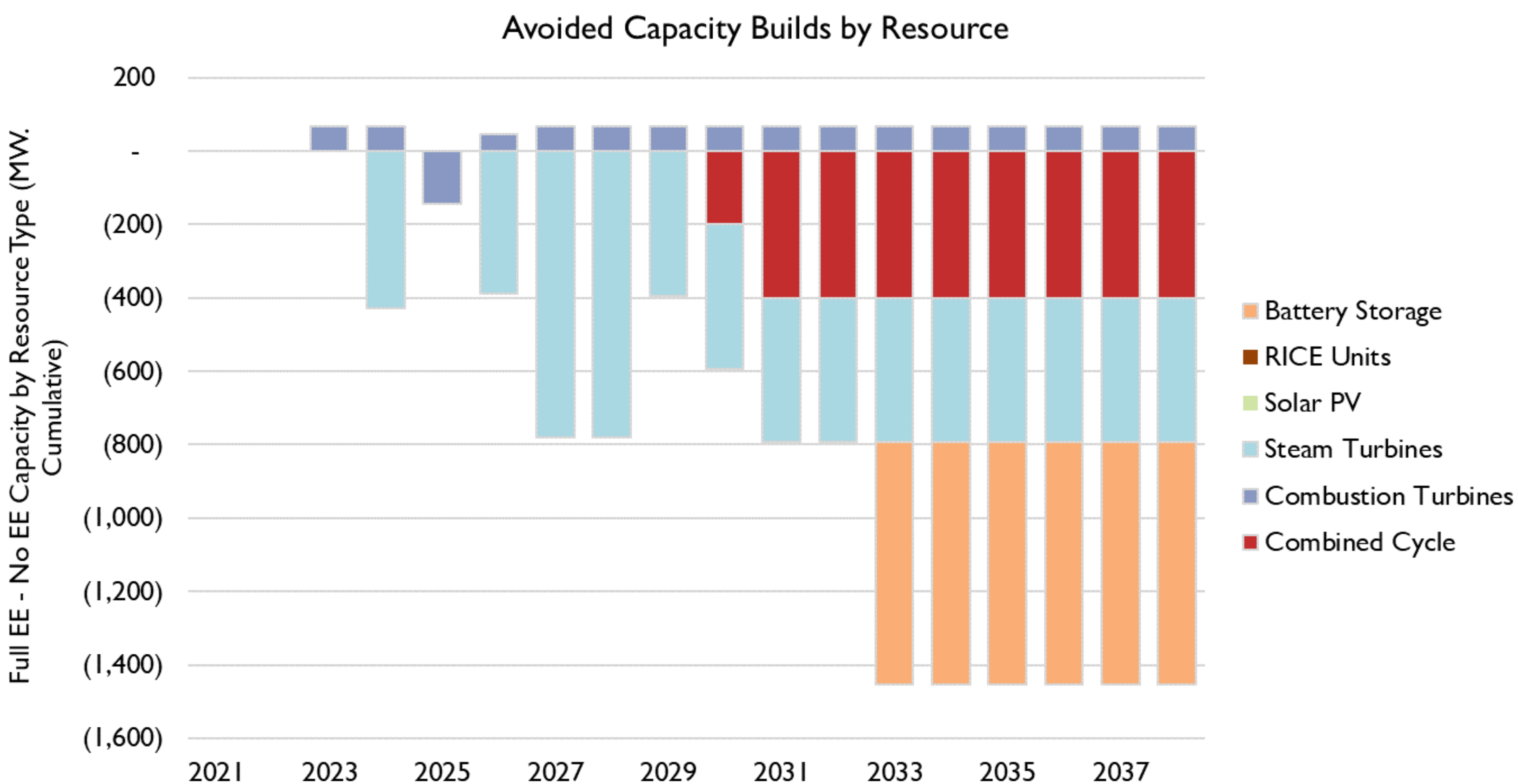
Full EE Case Capacity Trajectory

- Same pattern as No EE Case, with lower levels of battery and solar PV



No and Full EE Case Capacity Difference

- No EE case builds/holds more capacity over time than Full EE Case, to meet higher loads
- Kept one unit at Costa Sur and the converted San Juan CC. More batteries/PV.
- Full EE case has more CTs, earlier battery installation pace.

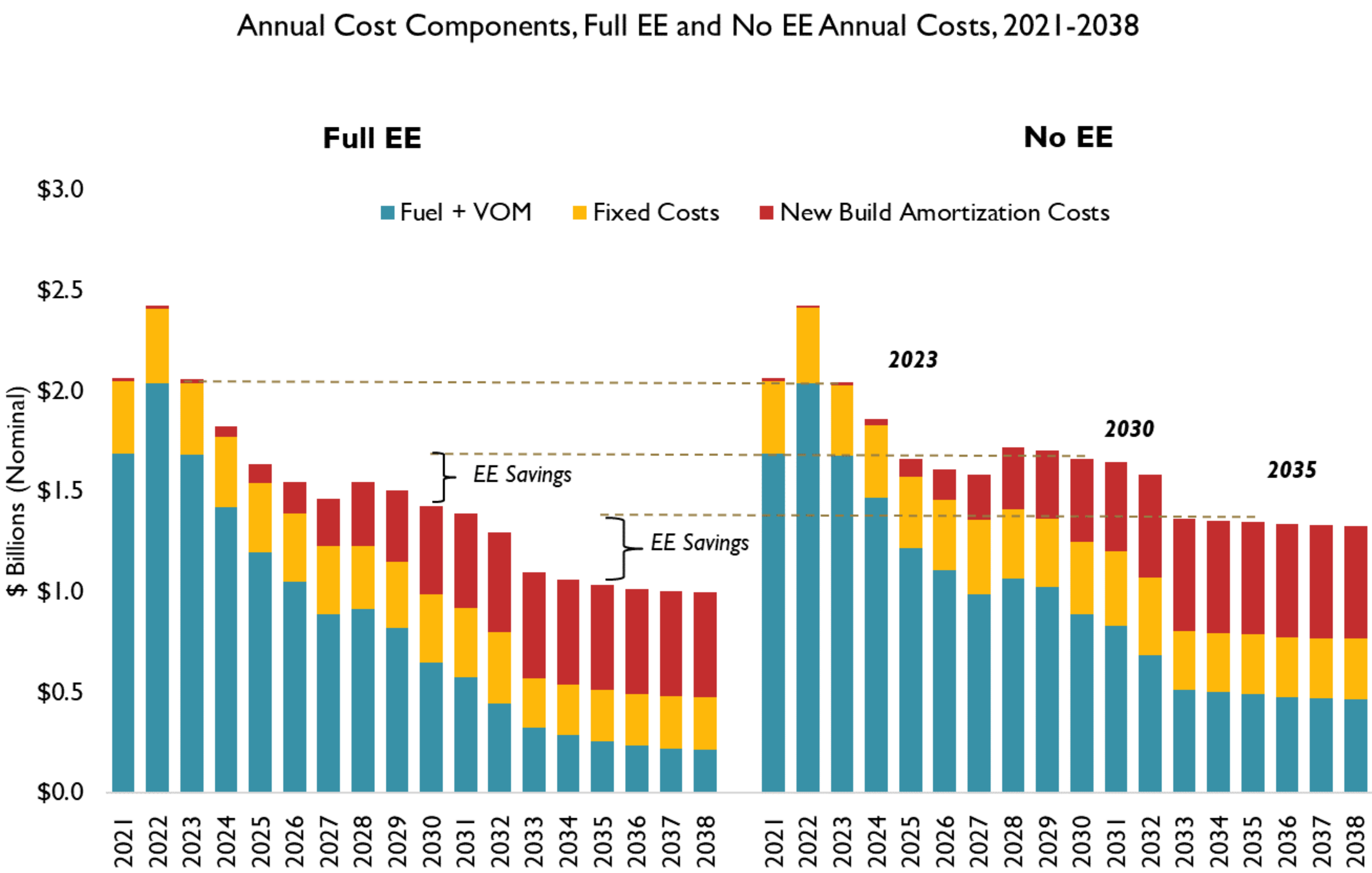


Total Energy and Capacity Costs

- No EE and Full EE case modeling – computation of total operational costs plus annual/amortization cost for new builds.
  - In each case, considered as annual "revenue requirements" to cover all production and new resource costs.
  - Analysis excludes end effects beyond 2038.
- Energy portion: fuel plus non-fuel variable O&M.
- Capacity portion: all else
  - Fixed operational costs, plus annual/amortization costs for new resources.
- Production costs (fuel + variable O&M), fixed costs, and annual/amortized costs for new resources are all greater in the No EE case, since more resources required to meet higher load.

Total Energy and Capacity Costs – No EE vs. Full EE

- No EE case – higher annual costs (excludes EE costs)



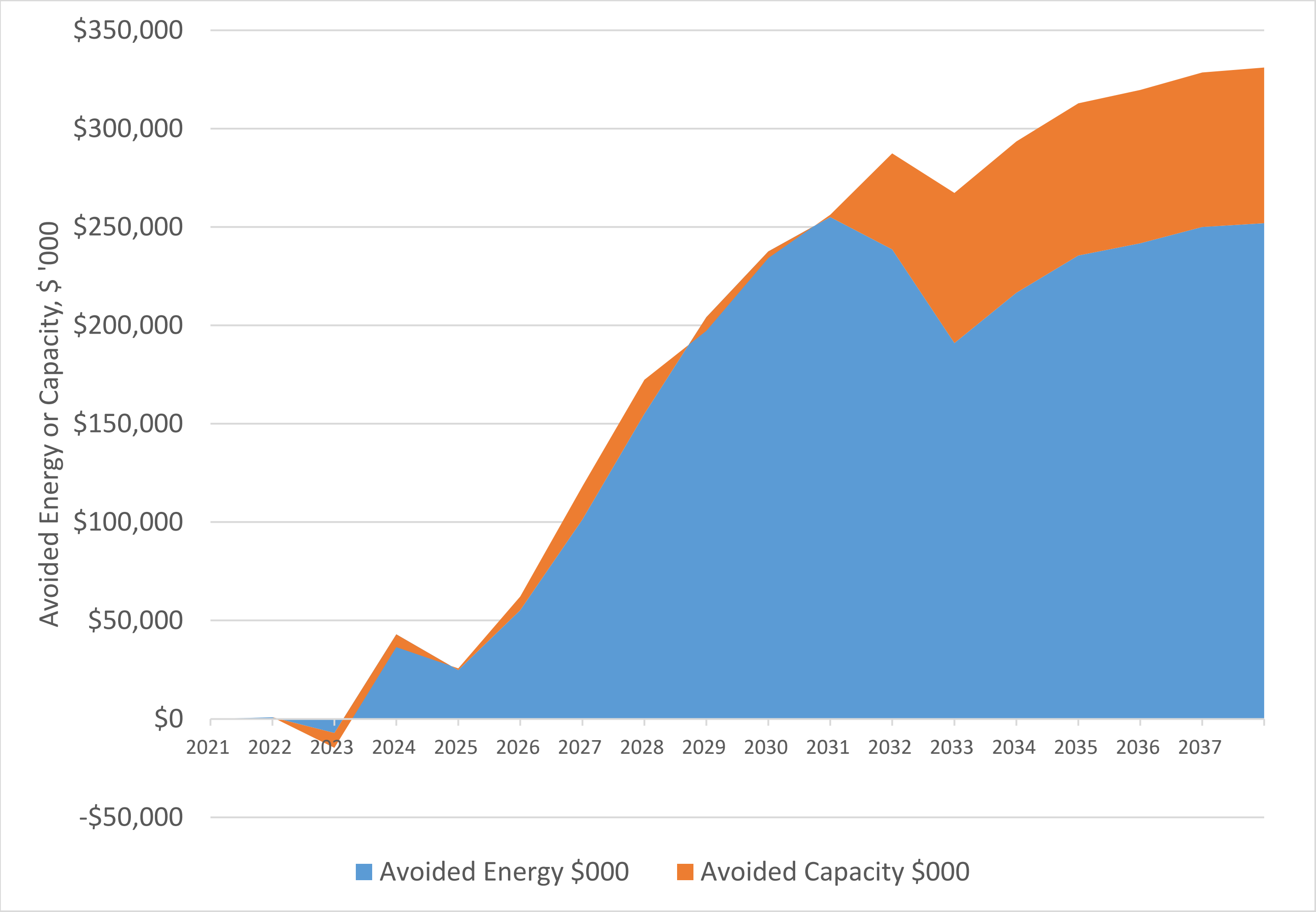
Difference in Total Energy and Capacity Costs: No EE vs. Full EE

- Avoided energy and capacity combined = $1.32 billion NPV ($2021)

Year	Avoided Energy $000	Avoided Capacity $000	Total Avoided E + C, $000
2021	(53)	0	(53)
2022	872	0	872
2023	(7,113)	(7,602)	(14,715)
2024	42,925	(6,406)	36,519
2025	24,829	808	25,637
2026	55,199	7,022	62,221
2027	101,437	16,767	118,204
2028	155,022	17,411	172,432
2029	204,156	(6,961)	197,194
2030	237,585	(3,418)	234,167
2031	255,083	1,112	256,196
2032	238,670	48,705	287,376
2033	190,999	76,363	267,362
2034	216,674	76,880	293,554
2035	235,461	77,430	312,891
2036	241,707	77,988	319,695
2037	249,984	78,509	328,493
2038	251,911	79,107	331,018
Nominal Sum	$2,695,349	$533,714	$3,229,063
18-yr. NPV ($2021) Sum, 8%	$1,141,523	$184,265	$1,325,788

Total Avoided Energy and Capacity Costs

- Avoided energy dominates early year value, avoided capacity value increases in the later years.



Total Avoided Energy and Capacity Costs – Per Unit

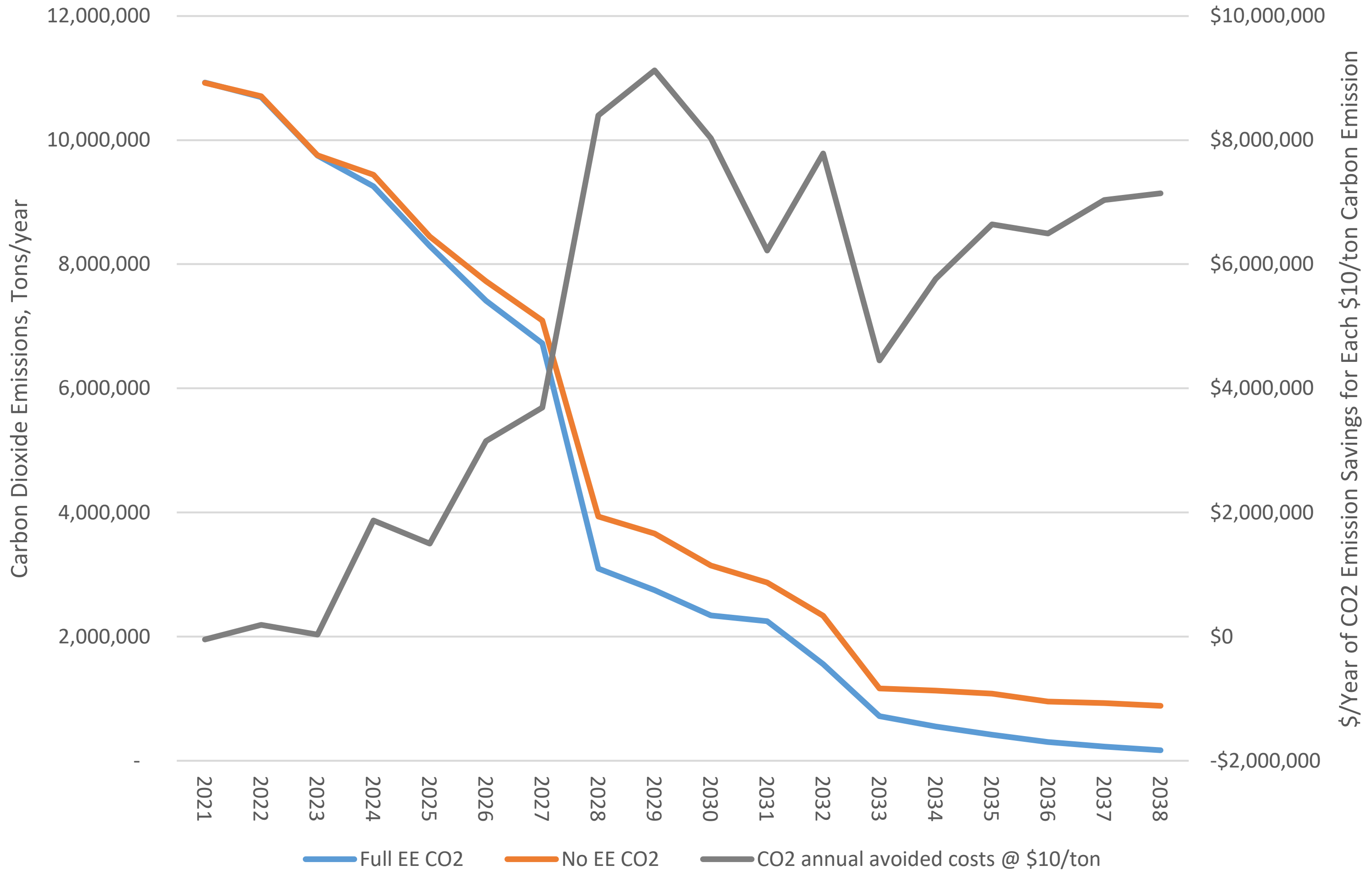
- Avoided energy value higher in early years, lower as more PV on system over time; avoided capacity lower in early years and increases in the later years.

				Delta Energy and Peak by Year			
				No EE - Full EE	No EE - Full EE	Avoided Capacity $/kW-year	Avoided Energy $/MWh per year
Year	Avoided Energy $000	Avoided Capacity $000	Total Avoided E + C, $000	Energy Delta, GWh	Peak Load Delta, MW		
2021	(53)	0	(53)	-	-		
2022	872	0	872	-	-		
2023	(7,113)	(7,602)	(14,715)	(100)	(16)	475	71
2024	42,925	(6,406)	36,519	(30)	(5)	1,281	(1,429)
2025	24,829	808	25,637	270	42	19	92
2026	55,199	7,022	62,221	579	91	77	95
2027	101,437	16,767	118,204	1,093	172	97	93
2028	155,022	17,411	172,432	1,614	254	69	96
2029	204,156	(6,961)	197,194	2,008	316	(22)	102
2030	237,585	(3,418)	234,167	2,437	384	(9)	97
2031	255,083	1,112	256,196	2,749	433	3	93
2032	238,670	48,705	287,376	3,142	496	98	76
2033	190,999	76,363	267,362	3,434	542	141	56
2034	216,674	76,880	293,554	3,769	595	129	57
2035	235,461	77,430	312,891	4,066	642	121	58
2036	241,707	77,988	319,695	4,347	687	114	56
2037	249,984	78,509	328,493	4,608	728	108	54
2038	251,911	79,107	331,018	4,857	770	103	52
Nominal Sum	$2,695,349	$533,714	$3,229,063				
18-yr. NPV ($2021) Sum, 8%	$1,141,523	$184,265	$1,325,788				

Section 3 – Avoided Greenhouse Gas Emissions Costs

Avoided Greenhouse Gas Emissions Costs

- Model provides total CO_2 emissions for each case – avoided emissions is difference between "No EE" and "Full EE" case.
- Value of avoided carbon dioxide emissions approaches $8 million annually in the later years using a value of $10/ton.



Section 4 – Discussion Questions

Discussion Questions

1. Lower peak load and lower energy needs leads to lower overall resource requirement and fuel consumption. Different capacity trajectory analyses could be considered, but all would give rise to roughly similar patterns as seen here. Is there value in continuing to "sensitivity test" capacity trajectories, given the purpose of this exercise?

2. The year over year values fluctuate significantly. Should we consider average values when computing actual benefits?
   - Use "no EE" case marginal energy costs / prices for avoided energy metric, applied on an annual basis
   - Use differential case assessment for the avoided capacity metric, but apply an average over the planning horizon

3. There is no explicit carbon price for greenhouse gas emissions cost savings in Puerto Rico. What is the best way to estimate the carbon savings benefit of EE implementation?

Additional Slides – Technical Detail

Capacity Data

Sum of Capacity (MW)	Column											
Row Labels	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2035	2038
⊟ Full EE Dispatch	**5,625**	**5,744**	**5,267**	**5,467**	**5,845**	**6,332**	**7,481**	**8,613**	**9,438**	**11,068**	**12,973**	**13,139**
Coal:Conventional	454	454	454	454	454	454	454					
Demand:Distributed Generation	382	501	530	559	590	623	658	695	732	773	1,010	1,176
Gas/Oil:Combined Cycle	1,436	1,436	1,436	1,436	1,739	1,232	1,232	1,232	1,232	1,032	302	302
Gas/Oil:Combustion Turbine	785	785	851	851	599	599	578	578	578	578	578	578
Gas/Oil:Steam Turbine	2,245	2,245	1,643	1,214	782	393						
Hydro:Hydroelectric	70	70	70	70	70	70	70	70	70	70	70	70
Renewable:Landfill	5	5	5	5	5	5	5	5	5	5	5	5
Renewable:Solar PV	147	147	147	447	1,167	1,887	2,607	3,327	3,687	4,527	6,537	6,537
RICE Units					9	17	26	34	43	51	60	60
Renewable:Wind	101	101	131	131	131	131	131	131	131	131	131	131
Storage:Battery				300	300	920	1,720	2,540	2,960	3,900	4,280	4,280
⊟ No EE Dispatch	**5,625**	**5,744**	**5,201**	**5,610**	**6,029**	**6,615**	**8,077**	**9,208**	**9,545**	**11,335**	**14,689**	**14,855**
Coal:Conventional	454	454	454	454	454	454	454					
Demand:Distributed Generation	382	501	530	559	590	623	658	695	732	773	1,010	1,176
Gas/Oil:Combined Cycle	1,436	1,436	1,436	1,436	1,739	1,232	1,232	1,232	1,232	1,232	702	702
Gas/Oil:Combustion Turbine	785	785	785	785	743	554	512	512	512	512	512	512
Gas/Oil:Steam Turbine	2,245	2,245	1,643	1,643	782	782	782	782	393	393	393	393
Hydro:Hydroelectric	70	70	70	70	70	70	70	70	70	70	70	70
Renewable:Landfill	5	5	5	5	5	5	5	5	5	5	5	5
Renewable:Solar PV	147	147	147	447	1,167	1,887	2,607	3,327	3,687	4,527	7,197	7,197
RICE Units					9	17	26	34	43	51	69	69
Renewable:Wind	101	101	131	131	131	131	131	131	131	131	131	131
Storage:Battery				80	340	860	1,600	2,420	2,740	3,640	4,600	4,600