Value of LDES in CPUC IRP

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Modeling Methodology & Assumptions

Methodology

As a starting point, Resilient Transition used the 2026-2027 Transmission Planning Process RESOLVE Package, posted on the CPUC website on 10/6/2025. For this study we ran two RESOLVE cases:

- **Reference Case: TPP Proposed Base Case**
  As a benchmarking exercise, we reran the TPP Proposed Base Case ("TPP_AB1373_Delayed_OSW") to confirm that we can replicate the results presented by CPUC Staff. This provides a "reference case" from which to compare our sensitivity case.

- **Sensitivity Case: No Incremental LDES**
  As a benchmarking exercise, we reran the TPP Proposed Base Case

In both cases, we ran RESOLVE for the same planning years (2026, 2028, 2031, 2036, 2041, 2045) and using the same Gurobi solver as CPUC Staff to ensure comparability.

Modeling Assumptions & Key Metrics

Reference Case: TPP Proposed Base Case

MTR LLT LDES Procurement Order Requirement

By default, the TPP Proposed Base Case models the MTR LLT LDES procurement order, which requires 1 GW of LLT LDES[1], of which the model assumes 446 MW is met with baseline resources. Resources that count toward the MTR and Supplemental MTR procurement orders use vintage-based ELCC accounting based on CPUC Staff memos[2].

Based on the Resource Data Templates submitted by LSEs, the TPP Proposed Base Case assumes just over 1 GW of incremental LDES capacity by 2031, as shown in Table 1. In other words, the TPP Proposed Base Case assumes that the MTR LLT LDES requirement is met with baseline & pipeline resources.

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[1] The MTR LLT LDES excludes 4-hr Li-ion batteries from counting toward the procurement need, even at a derated capacity. LDES resources are assigned vintage-based ELCC values, as described on Slide 42 of https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/integrated-resource-plan-and-long-term-procurement-plan-irp-ltpp/2025_09_need-determination-analysis.pdf

[2] https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/integrated-resource-plan-and-long-term-procurement-plan-irp-ltpp/2023-07-irpstaff_mtr_nqc_validation_tool_oh.pdf

Table 1. Assumed incremental minimum new build LDES capacity in TPP Proposed Base Case (MW).

	2024	2025	2026	2027	2028	2029
PG&E	112	147	147	147	160	160
SCE	41	51	876	876	876	876
SDG&E	25	25	25	25	25	25
Total	**178**	**223**	**1,048**	**1,048**	**1,061**	**1,061**

Given these assumptions, the Reference Case does not see the MTR procurement order or the LDES carve-out provision as binding constraints that drive RESOLVE candidate resource selections.

System RA Planning Reserve Margin Storage ELCC Assumptions

Separate from the MTR procurement accounting, RESOLVE still models a PRM using a solar-storage ELCC surface derived from CPUC Staff SERVM runs. To capture resource contributions toward meeting the PRM, RESOLVE models several declining ELCC curves/surfaces for different resource technology categories:

- Solar + storage
- In-state wind
- Out-of-state wind
- Offshore wind

For the solar + storage surface specifically, CPUC Staff extrapolate multipliers relative to 4-hr storage resources for each LDES duration rather than studying to full interactive nature of these different technologies. For the purposes of this study, we did not change the storage ELCC multipliers, since we did not have access to the CPUC's SERVM model; however, we note that the CPUC assumes only modest increases in ELCC for longer-duration storage resources, as shown in Table 2.

Table 2. Assumed storage ELCC multipliers by duration (100% = relative to 4-hr storage)

Storage Duration	2026	2028	2031	2036	2041	2045
8-hr	100%	100%	100%	100%	100%	100%
12-hr	100%	100%	**107%**	**137%**	**146%**	**153%**
24-hr	100%	100%	**110%**	**150%**	**156%**	**161%**
100-hr	100%	100%	**115%**	**177%**	**194%**	**206%**

Another assumption inherent in the CPUC modeling is that these independent ELCC curves/surfaces can be added arithmetically to meet the PRM; however, this assumption means that RESOLVE does not fully capture interactive effects. In other words, it is possible that—if the portfolio selected by RESOLVE differs too greatly from the assumptions used for the various

SERVM runs to generate the original ELCC assumptions—that a portfolio reliability check would reveal that the selected portfolio is over-/under-reliable.

GHG Planning Target

In the Reference case, the GHG planning target is binding in all years, indicating that RESOLVE resource selection is being driven by its need for GHG-free resources.

Total LDES Selected by RESOLVE in TPP Proposed Base Case

The TPP Proposed Base Case procures **9 GW of LDES by 2031** and just over **24 GW of LDES by 2045**.

Table 3. Planned & RESOLVE-selected LDES capacity in TPP Proposed Base Case (GW).

Storage Duration	2026	2028	2031	2036	2041	2045
8-hr	0.2	1.0	7.6	12.1	12.1	18.6
12-hr			1.6	5.4	5.4	5.4
24-hr				0.5	0.5	0.5
100-hr						
Total	**0.2**	**1.0**	**9.2**	**18.0**	**18.0**	**24.5**

Sensitivity: No Incremental LDES Case

For the purposes of this sensitivity, we made three changes to the TPP Proposed Base Case:

1. Removed the minimum build constraints in the TPP Proposed Base Case described in Table 1.
2. Removed all 8-, 12-, 24-, and 100-hr LDES candidate resource options.
3. Relaxed the modeled MTR LLT LDES requirement (since we removed all candidate resources that the model could use to meet the requirement).

This sensitivity represents a “worst-case” scenario where no additional LDES resources are successfully contracted, and the remaining 554 MW MTR LLT LDES procurement requirement is not met.

Modeling Results

Total Resource Cost Implications & LDES System Value

The sensitivity case shows that removal of LDES candidates from the RESOLVE portfolio results in (a) upwards of **$400 million/year in incremental TRC** starting by 2031 and (b) **NPV TRC increase of $9.6 billion** (in 2024 $) over the TPP Proposed Base Case (+0.6% over the Reference Case).

Table 4. CAISO System Total Resource Cost (2024 $ billions)

Storage Duration	2026	2028	2031	2036	2041	2045	NPV
Reference	65.6	73.7	85.7	102.3	115.6	128.3	1,669.0
No Incremental LDES	65.5	73.6	86.2	103.1	116.3	129.2	1,678.5
Change in TRC	**-0.1**	**-0.1**	**+0.4**	**+0.8**	**+0.7**	**+1.0**	**+9.6**

Calculating the change in TRC (excluding LDES investment cost) between the Reference Case and the Sensitivity case also allows us to estimate the system value that RESOLVE sees for LDES candidates (taken as a whole). Another way of interpreting this is that this represents the levelized portfolio cost savings (investment + operations) that are achieved by including LDES in the Reference Case.

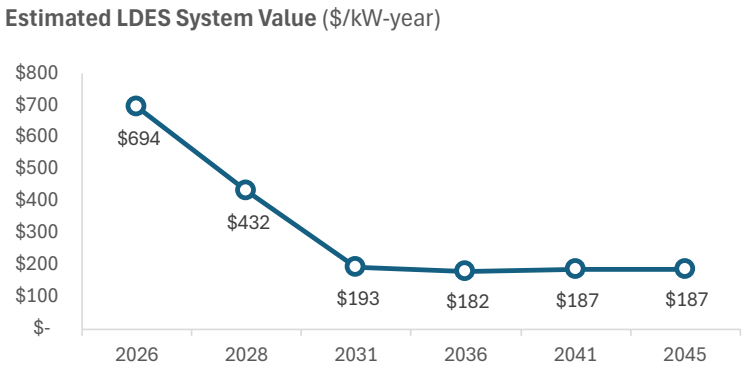

Figure 1. Estimated system value of LDES selected in TPP Proposed Base Case.

As shown in Figure 1, the value to the system of LDES starts initially high—consistent with mid-term resource availability constraints and reliability needs—and then settles at about $187/kW-year over the full planning horizon. This gives us a benchmark for a “breakeven cost of LDES” in each planning year.

Selected Portfolio Changes

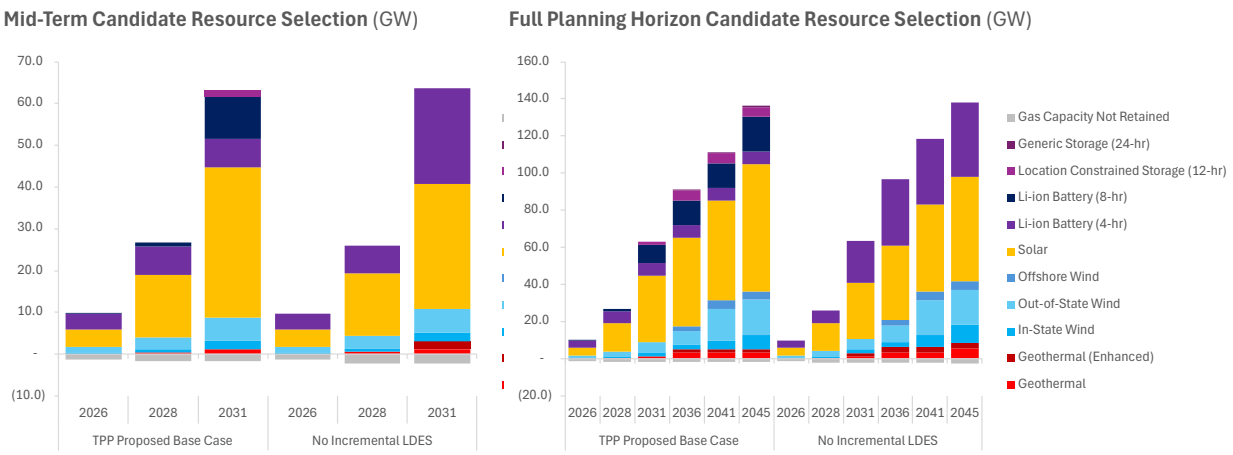

Figure 2. Comparison RESOLVE-selected portfolios in Reference vs. No Incremental LDES sensitivity cases

As shown in Figure 2 (left), mid-term resource selection shifts completely to 4-hr Li-ion batteries, replacing 9 GW of LDES selected by 2031 with an additional **16 GW of 4-hr Li-ion batteries**. Figure 2 (right), shows that over the full planning horizon, the shift toward 4-hr Li-ion also correlates with a 12 GW reduction in total solar capacity selected, with RESOLVE relying on a greater mix of geothermal & wind for GHG-free energy (see Table 5 for tabular results).

ELCC Results

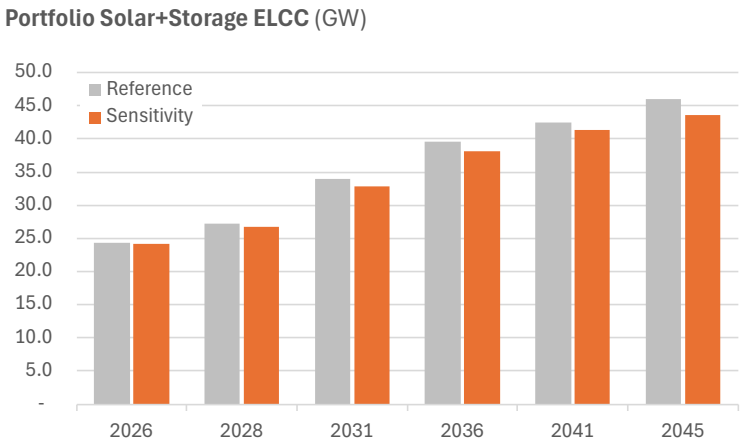

Figure 3. Comparison achieved solar + storage ELCC for Reference vs. Sensitivity case.

Despite adding 16 GW more 4-hr Li-ion batteries, the Sensitivity Case gets less total ELCC from the solar + storage portfolio, as shown in Figure 3. Given the interactive solar + storage ELCC surface, it's not possible with the results we have available from RESOLVE to disaggregate the

ELCC contributions of storage resources; however, from the RESOLVE results, we can see the marginal storage ELCC by type in each year, as shown in Figure 4.

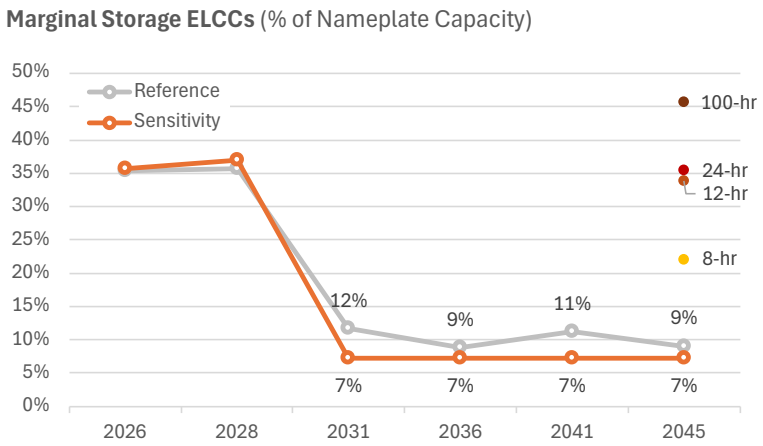

Figure 4. Comparison storage marginal ELCCs in Reference vs. Sensitivity cases. Achieved marginal ELCCs are a function of total capacity selected by RESOLVE.

The marginal ELCC is a function how much of a resource type RESOLVE selects, with greater selection leading to lower marginal ELCCs. Figure 4 shows the rapid buildout of solar and storage resources in both the Reference and Sensitivity Cases leads to sharp declines in marginal ELCC; however, the Sensitivity Case hits a lower marginal ELCC due to its greater buildout of storage resources (as discussed in Figure 2). Figure 4 also shows how much higher the marginal ELCC of various LDES archetypes would be in 2045 compared to the 7% marginal ELCC for 4-hr storage.

Appendix. Tabular Results

Table 5. Change in RESOLVE-selected capacity (GW) in No Incremental LDES sensitivity case.

Resource Type	2026	2028	2031	2036	2041	2045
Geothermal		+0.3				+2.2
Geothermal (Enhanced)			+1.8	+1.1	+1.1	+1.1
In-State Wind			+0.2	+0.2	+1.7	+2.1
Out-of-State Wind				+2.0	+2.0	
Solar			-6.0	-7.3	-7.0	-12.1
Li-ion Battery (4-hr)			+16.2	+28.7	+28.7	+33.2
Li-ion Battery (8-hr)	-0.2	-1.0	-7.6	-12.1	-12.1	-18.6
Location Constrained Storage (12-hr)			-1.6	-5.4	-5.4	-5.4
Generic Storage (24-hr)				-0.5	-0.5	-0.5
Gas Capacity Not Retained	+0.1	-0.6	-0.6	-0.6	-0.6	-0.8