2025-2026 Transmission Planning Process (TPP) Proposed Decision

Modeling & Analysis

Energy Division Staff

January 10, 2025

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Overview of 25-26 TPP Proposed Portfolio Analysis

Overview of the CAISO's Transmission Planning Process

- Every year Commission staff develop a recommended set of resource mix portfolios for the California Independent System Operator (CAISO) to use in its annual Transmission Planning Process (TPP).
- Generally, in each TPP cycle, the CAISO evaluates a reliability and/or policy-driven base case resource mix portfolio.
  - Under the CAISO tariff adopted by the Federal Energy Regulatory Commission (FERC), if the results of the base case analysis show the need for additional transmission development to accommodate the expected future resource mix, the transmission projects are brought to the CAISO Board for approval in the spring of the second year of the TPP.
  - If approved by the CAISO Board, under the FERC tariff, the new transmission project(s) would receive cost recovery through the Transmission Access Charge.
- Along with the base case analysis that generally leads directly to transmission project approval, in each TPP cycle the CAISO typically analyzes one or more sensitivity portfolios.
  - The purpose of the sensitivity portfolio analysis is not to lead directly to transmission development immediately, but rather to assist in future planning by identifying relevant transmission needs and potential costs if an alternative resource mix is required.
- The Commission adopted the 2024-25 TPP portfolio in Decision (D.)24-02-047. This Decision included both a base case and a sensitivity portfolio that the CAISO is in the process of analyzing for the current TPP cycle.
  - The base case portfolio was based on the scenario that, per CPUC modeling, can support the achievement of a 25 million metric ton (MMT) greenhouse gas (GHG) emissions target in 2035, including 4.5 gigawatts (GW) of offshore wind.
  - The sensitivity portfolio was a High Natural Gas Retirement scenario, designed to assist in planning for the potential future retirement of fossil-fueled resources as their economics decline.

Overview of 25-26 TPP Analysis

- On September 12, 2024, the Commission issued an Administrative Law Judge Ruling Seeking Comment on Electricity Resource Portfolios for 2025-2026 Transmission Planning Process.
  - CPUC staff released supplementary analysis alongside that Ruling: 2025-2026 Transmission Planning Process RESOLVE Analysis.
- That Ruling and the supplemental analysis Staff released supported the development of portfolios for consideration for study in the California Independent System Operator's (CAISO) 25-26 Transmission Planning Process (TPP).
- This deck includes portions of the analysis released in that deck related to the proposed 25-26 TPP Base Case and to a proposed 25-26 TPP sensitivity portfolio.
  - This deck includes additional analysis on the proposed 25-26 TPP base case, including production cost modeling results.
  - Analysis released with the September 12, 2024, Ruling related to the "Alternate" sensitivity portfolio is largely omitted from this deck. Stakeholders should refer to the Ruling's supplemental analysis deck for that information.
- The PD proposes transmitting a single Base Case portfolio and recommends a single sensitivity portfolio to the CAISO for their TPP.
- Staff is seeking stakeholder comments on the Decision Transmitting Electricity Resource Portfolios to the California Independent System Operator for 2025 2026 Transmission Planning Process:
  - Opening comments are due on January 30, 2025
  - Reply comments are due on February 4, 2025

Modeling Steps Leading to the Proposed 25-26 TPP Portfolios

- Staff used RESOLVE to produce the Proposed TPP portfolio:
  - Baseline resources, inclusive of LSEs' planned resource as they submitted in November 2022, plus RESOLVE selecting additional resources and/or gas retention to meet policy and reliability constraints.
- The RESOLVE portfolio was translated into SERVM inputs and simulated in SERVM to determine loss of load expectation (LOLE) and GHG emissions. SERVM results for the following are included in this deck:
  - Pre-busbar mapped portfolios for 2026, 2030, 2035, and 2040.
  - Busbar mapped portfolios for 2035 and 2040.

Input Updates for 25-26 TPP Modeling

RESOLVE and SERVM updates

Summary of RESOLVE-specific Input Updates for 25-26 TPP

- IRP periodically updates its modeling inputs and assumptions to reflect new data, better modeling functionality, and other changes as needed
- Updates for the 25-26 TPP modeling are compared to what was used in the 24-25 TPP portfolios adopted in D.24-02-047

Changes in Transmission and Interconnection Representation	• Added new resource interconnection limits in RESOLVE on each transmission constraint cluster based on number and voltage of buses in the cluster
Load Inputs	• Switched from 2022 IEPR to 2023 IEPR • Higher annual load and peak forecast, especially in 2035+
Geothermal Resource Cost	• Binary technology represented instead of Flash • 30% cost increase to align with binary geothermal costs from the 2023 NREL ATB
Arizona Solar Profiles	• Corrected Arizona Solar candidate resource profile to reflect daylight savings time adjustment

Changes in Transmission and Interconnection Representation in the 25-26 TPP

- For the 24-25 TPP, RESOLVE selected multiple GWs of resources at transmission clusters that are comprised of only a few individual substations.
  - Since those substations cannot accept such large capacity additions, many resources had to be relocated during Busbar Mapping.
- For the 25-26 TPP, additional constraints were added to the RESOLVE model to represent feasible limits on resource interconnection at the substation level.

- Substations are assigned a default interconnection capacity according to voltage, and limits are set for each cluster by summing across all substations.
- Individual substation expansions are not represented, but RESOLVE can choose to build generic transmission upgrades to interconnect highly economic resources.
- Actual mapping to individual substations or to a new substation, if warranted, is still performed in the Busbar Mapping process.

Substation Voltage (kV)	Default Interconnection Capacity (MW)
115	100
138	200
161	200
230	1,500
500	3,000

Integrated Energy Policy Report (IEPR) Updates

- RESOLVE's load inputs were updated from CEC's 2022 IEPR CED to the 2023 IEPR CED (revised version). Updates include:
  - Annual energy
  - Gross peak
  - BTM resources
  - Hourly profiles
  - Associated changes in total reliability need and clean energy generation requirements for RPS, SB100 and SB1020
- The CEC produced the 2023 IEPR forecast for 2023-2040 while the TPP modeling horizon is 2024-2045, necessitating extrapolation of the CEC's load forecast.
  - Post-2040 extrapolation methods differ from methods used for the 24-25 TPP for the 2022 IEPR.
    - Supplemental data for 2041-50 was available to derive a growth rate for BTM resources
    - The baseline was extrapolated using the growth rate for the last five years of data (2035-40); whereas the 2022 IEPR was extrapolated using the 2021 ATE forecast

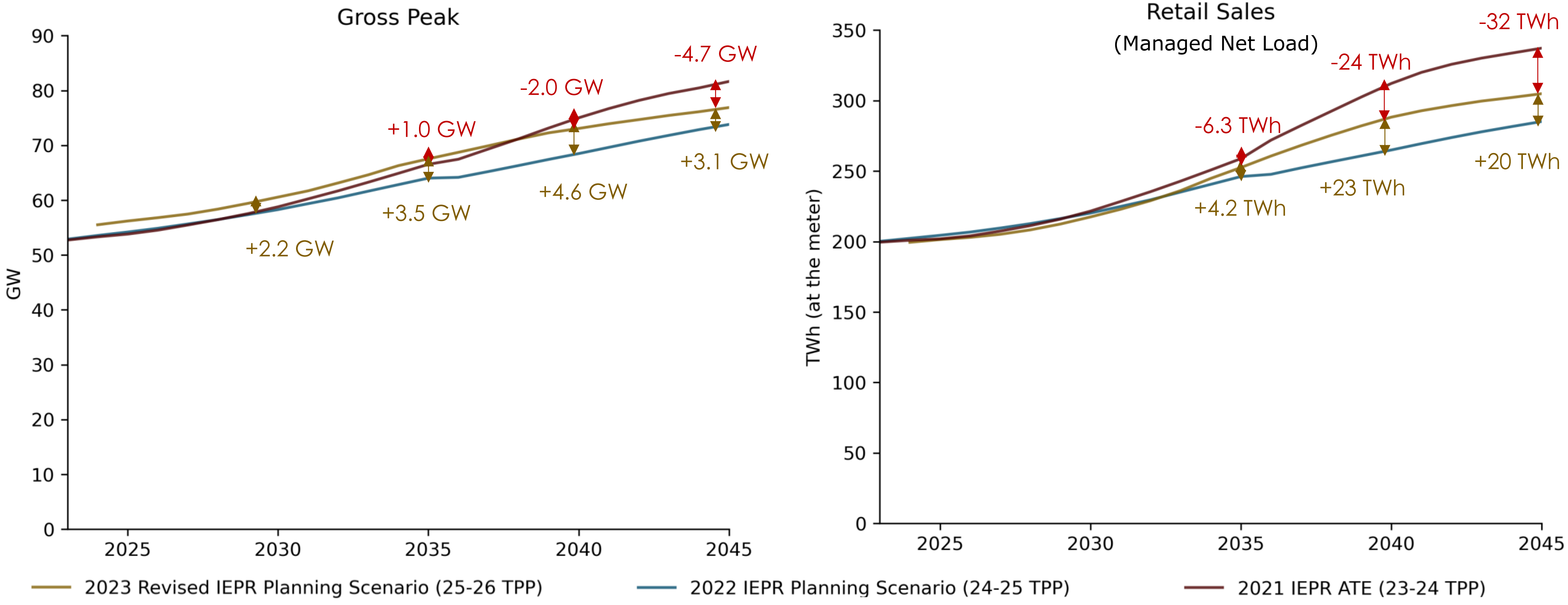
The GHG Allowance Price was also updated to CED 2023 for the carbon price floor but had a negligible difference from the CED 2022 GHG Allowance Price

Summary of Changes in 2023 IEPR from 2022 IEPR

- The 2023 IEPR Planning Scenario shows higher retail sales and gross peak than the 2022 IEPR
  - The gross peak[1] in 2035 is 3.5 GW higher, and in 2045 is 3.1 GW higher in the 2023 IEPR forecast compared to the 2022 Forecast, an increase of 5% and 4%, respectively
  - Annual retail sales increase by 6.4 TWh in 2035, or 3%, and 20 TWh in 2045, or 7%
  - In the long-term, annual load grows faster than peak due to high rates of space heating electrification
- Higher retail sales and gross peak in the 2023 IEPR are driven by increased building electrification (AAFS) and lower energy efficiency (AAEE) impacts compared to 2022 IEPR.
- Managed net peak load shifts to winter in early 2040s due to building electrification
  - Building electrification loads are 4-5x higher in the 2023 IEPR than the 2022 vintage after 2035

1. Gross peak is managed net load + BTM PV.

Gross System Peak and Total Managed Retail Sales



Note: Gross peak is Managed Net Load + BTM PV

Note: Assumes no CHP retirement

Note: the 2023 IEPR shows a higher near-term gross peak than the 2022 IEPR, but a lower near-term managed peak (after BTM PV production). This is due to changes to the IEPR baseline consumption shapes between IEPR vintages. IRP uses the gross peak for planning (showing increased reliability need) whereas RA uses the managed peak for planning (showing decreased reliability need).

Resource Cost Update

- The 24-25 TPP used flash geothermal costs from the 2023 NREL ATB
- The 25-26 TPP uses binary geothermal costs from the 2023 NREL ATB as a more realistic technology for future geothermal build

Technology	Cases Used For	All-in fixed Cost (2022$/kW-yr)
Geothermal – Flash	24-25 TPP	$520/kW-yr
Geothermal – Binary	25-26 TPP	$660/kW-yr

~30% increase

25-26 TPP Portfolio SERVM Baseline Adjustment (1/3)

- The RESOLVE results for the 25-26 TPP were run using the 2023-vintage baseline (same as the 24-25 TPP/2023 PSP); subsequently, the SERVM database used for production cost and reliability modeling was updated to the newest, 2024-vintage baseline, available here.
- To align the RESOLVE results with the new baseline, any new capacity in the 2024 baseline was subtracted from the 25-26 TPP RESOLVE builds, using the following steps for each technology:
    - Identify new units in the 2024 baseline, relative to the 2023 baseline
    - Map new units to the analogous RESOLVE candidate resource, and subtract those units' capacity from the RESOLVE candidate build
    - For cases where the new units' capacity exceeds the RESOLVE candidate build, subtract the difference from the RESOLVE candidate resource(s) with the most build
        - e.g. 333 MW of new units were mapped to Greater_LA_Solar, but RESOLVE did not build this candidate until 2039, so the 333 MW was subtracted from Southern_NV_ElDorado_Solar, which had >9 GW of RESOLVE build by 2030, instead
    - Minor adjustments were made as needed to ensure the cumulative adjusted RESOLVE builds for each candidate do not decrease year-over-year.
- A workbook with this methodology is available on the "Assumptions for the 2025-2026 TPP" website.

SERVM-Specific Modeling Updates since Commission Adopted 2023 PSP (2/3)

- Key SERVM updates are summarized below
  - More detailed documentation of updates is available in the “Methodology and Inputs Overview” section of this July 2024 report published in CPUC’s Resource Adequacy (RA) Proceeding (R.23-10-011): Loss of Load Expectation Study for 2026 Including Slice of Day Tool Analysis.
- Updated the model's range of historical weather and hydro from 1998-2020 to 2000-2022
  - Used to model historical-based distribution of hourly electric demand, renewables production, and hydro profiles
  - Modeled weather variability increases due to inclusion of extreme hot weather conditions from 2022
- Revised the weather-normalization model for creating weather year-based hourly electric demand profiles for SERVM
- Updated to use 2023 IEPR demand forecast
  - Annual peak and energy forecast magnitude
  - Annual forecast penetration of demand-side resources
- Revised wind models for on-shore and off-shore wind

SERVM-Specific Modeling Updates since Commission Adopted 2023 PSP (3/3)

- Updated generating and storage unit forced outage rates and maintenance rates
- Incorporated thermal unit output derating based on weather
- Updated Baseline of existing and in-development generating and storage units. The baseline was updated with the following:
    - CAISO Master Generating Capability List, Jan 2024
    - Load-serving entities (LSE) Filings submitted for IRP compliance on December 1, 2023
    - WECC 2032 Anchor Data Set, Dec 2023
    - Unit operating parameters and constraints derived from the CAISO Masterfile, May 2024
- Updated load and resource projections for Non-CAISO regions
    - Non-CAISO IRPs
    - Extrapolation from FERC 714 and EIA 861 data used to fill in gaps
- Key SERVM input data summarized above are posted here: System Reliability Modeling Datasets 2024.

25-26 TPP Proposed Base Case Portfolio

Proposed 25-26 TPP Base Case Overview

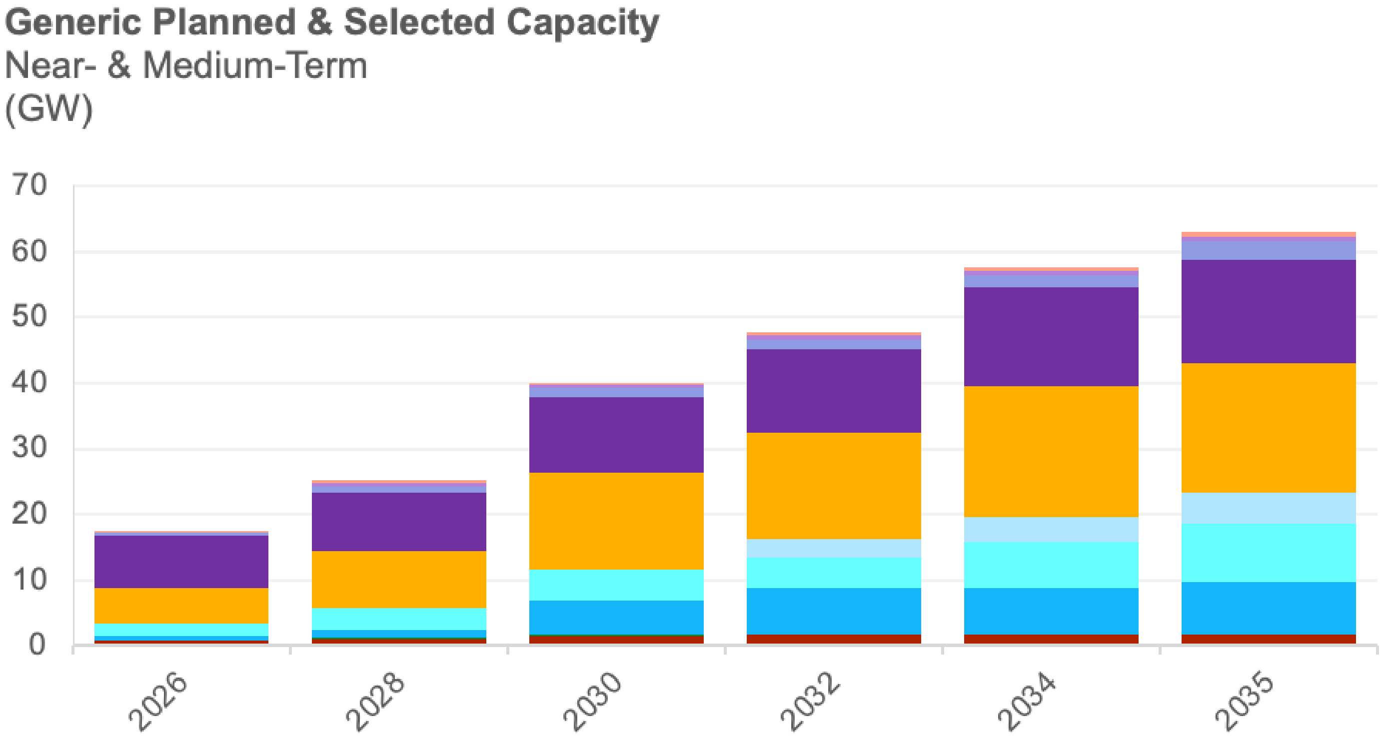
- Proposed base case designed to be similar to the 2024-25 TPP base case with same policy assumptions
  - Incorporates the 25 MMT GHG target by 2035 (same as for the 24-25 TPP)
  - Includes LSE plans submitted in their November 2022 IRP filings (same as for the 24-25 TPP)
  - RESOLVE uses the same modeling resource baseline as the 2024-25 TPP, with new additions netted out to align with SERVM's updated modeling baseline (see slide 14)
  - RESOLVE relies on the same Inputs & Assumptions (I&A) used in the 2024-25 TPP outside of the changes noted earlier, while SERVM's I&A are documented in slides 15 and 16 and in the following document: Loss of Load Expectation Study for 2026 Including Slice of Day Tool Analysis
    - Aligning the two models I&A is a key effort for the CPUC and will be a part of Q1 2025's stakeholder I&A process
  - Updated to the 2023 IEPR Planning Scenario (24-25 TPP base case used the 2022 IEPR Planning Scenario)
- Key model years for busbar mapping and transmittal to CAISO
  - 2035 — 10-year projection
  - 2040 — 15-year projection

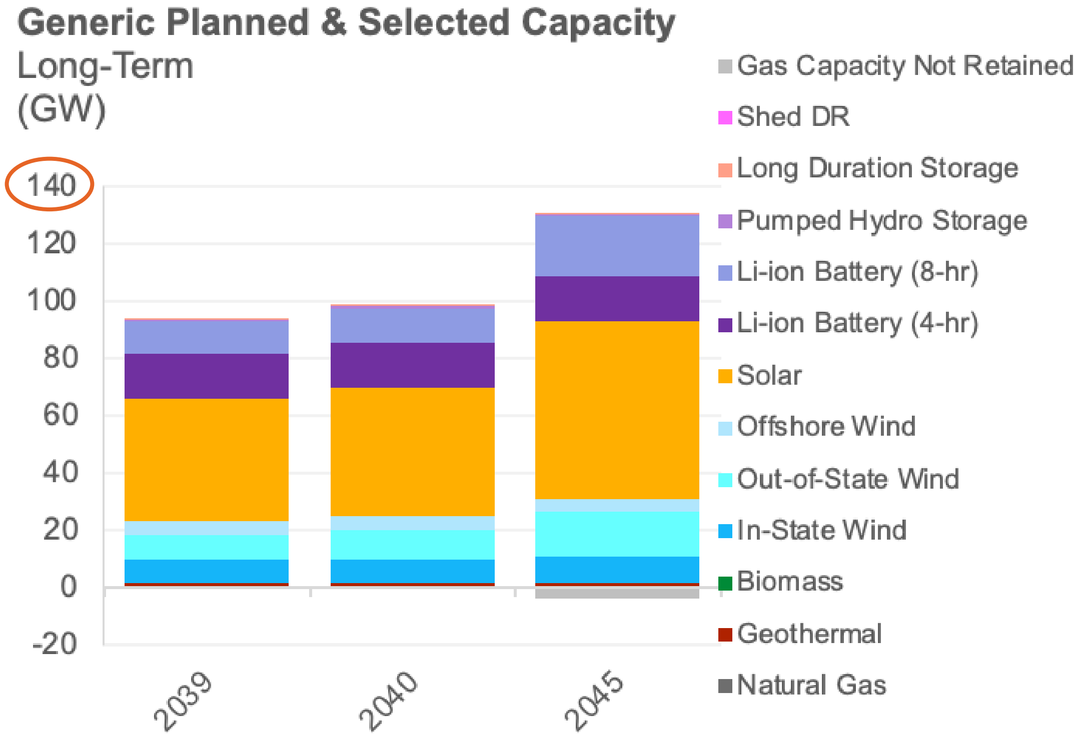
RESOLVE Modeling Results: 25-26 TPP Proposed Base Case Portfolio

25-26 TPP Proposed Base Case

Planned & Selected Capacity (GW)

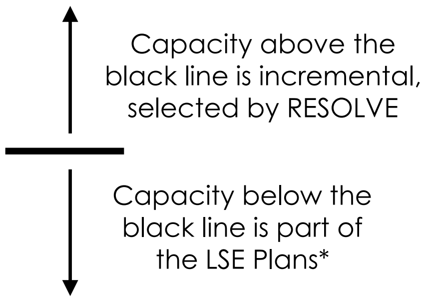
- New resources (nameplate GW), both LSE planned and RESOLVE selected, above the IRP-RESOLVE modeling resource baseline

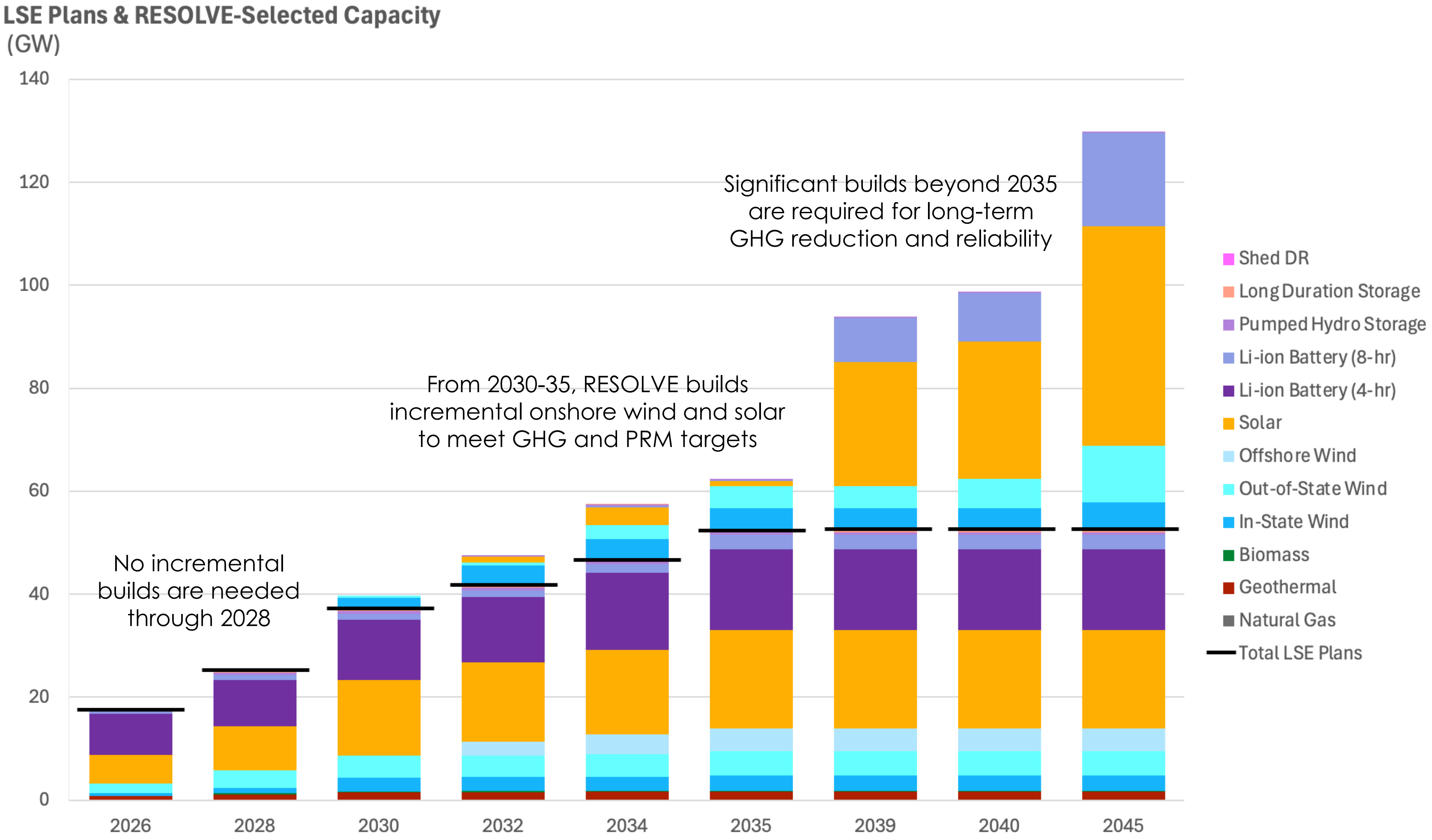




25-26 TPP Proposed Base Case

LSE Planned Builds vs. RESOLVE-Selected Builds (GW)





* LSE plans only go out to 2035

Note: A portion of LSE Planned wind is generic (not specified as in-state or out-of-state) and can be sited optimally by RESOLVE. For the purposes of this graph, any generic wind in the LSE plans is allocated based on the share of RESOLVE-selected wind in 2035 (approximately 50% each in-state and out-of-state).
Note: All Capacity is incremental to the 2023 Baseline (https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/integrated-resource-plan-and-long-term-procurement-plan-irp-ltpp/2023-irp-cycle-events-and-materials/aggregated-lse-plans-and-baseline-resources-2023-psp_v2.xlsx)

25-26 TPP Proposed Base Case

Planned & Selected Capacity (GW)

- New resources (nameplate GW), both LSE planned and RESOLVE selected, above the IRP-RESOLVE modeling resource baseline

Resource Category	2026	2028	2030	2032	2034	2035	2039	2040	2045
Natural Gas	-	-	-	-	-	-	-	-	-
Geothermal	0.8	1.1	1.5	1.6	1.6	1.6	1.6	1.6	1.6
Biomass	-	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
In-State Wind	0.7	1.0	5.2	7.0	7.0	7.9	7.9	7.9	9.0
Out-of-State Wind	1.8	3.4	4.7	4.7	7.0	9.0	9.1	10.7	15.7
Offshore Wind	-	-	-	2.7	3.9	4.5	4.5	4.5	4.5
Solar	5.5	8.5	14.8	16.3	19.8	19.8	42.6	44.9	61.8
Li-ion Battery (4-hr)	8.0	9.0	11.6	12.7	15.0	15.7	15.7	15.7	15.7
Li-ion Battery (8-hr)	0.4	1.0	1.2	1.4	1.9	2.8	11.2	12.0	21.1
Pumped Hydro Storage (12-hr)	-	0.5	0.5	0.8	0.8	0.8	0.8	0.8	0.8
Long Duration Storage (8-24 hr)*	0.1	0.3	0.3	0.4	0.5	0.5	0.5	0.5	0.5
Shed DR	-	-	-	-	-	-	-	-	-
Gas Capacity Not Retained	-	-	-	-	-	-	-	-	(3.5)
Total	**17.3**	**25.1**	**40.0**	**47.7**	**57.7**	**62.9**	**94.1**	**98.8**	**127.4**

*Long Duration Storage technologies include Flow Battery (8-hr) and A-CAES (24-hr)

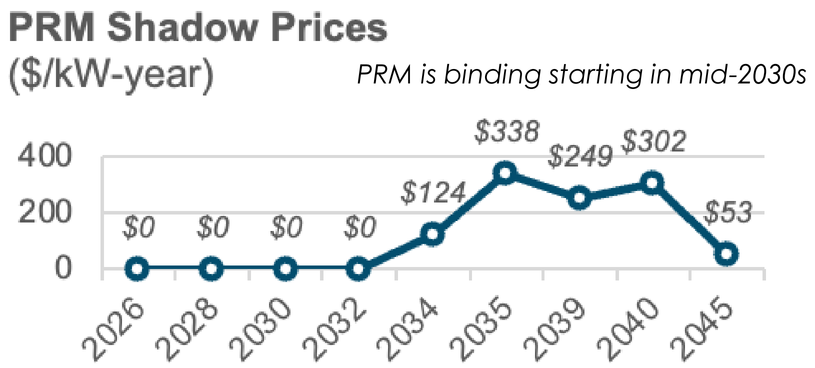
25-26 TPP Proposed Base Case

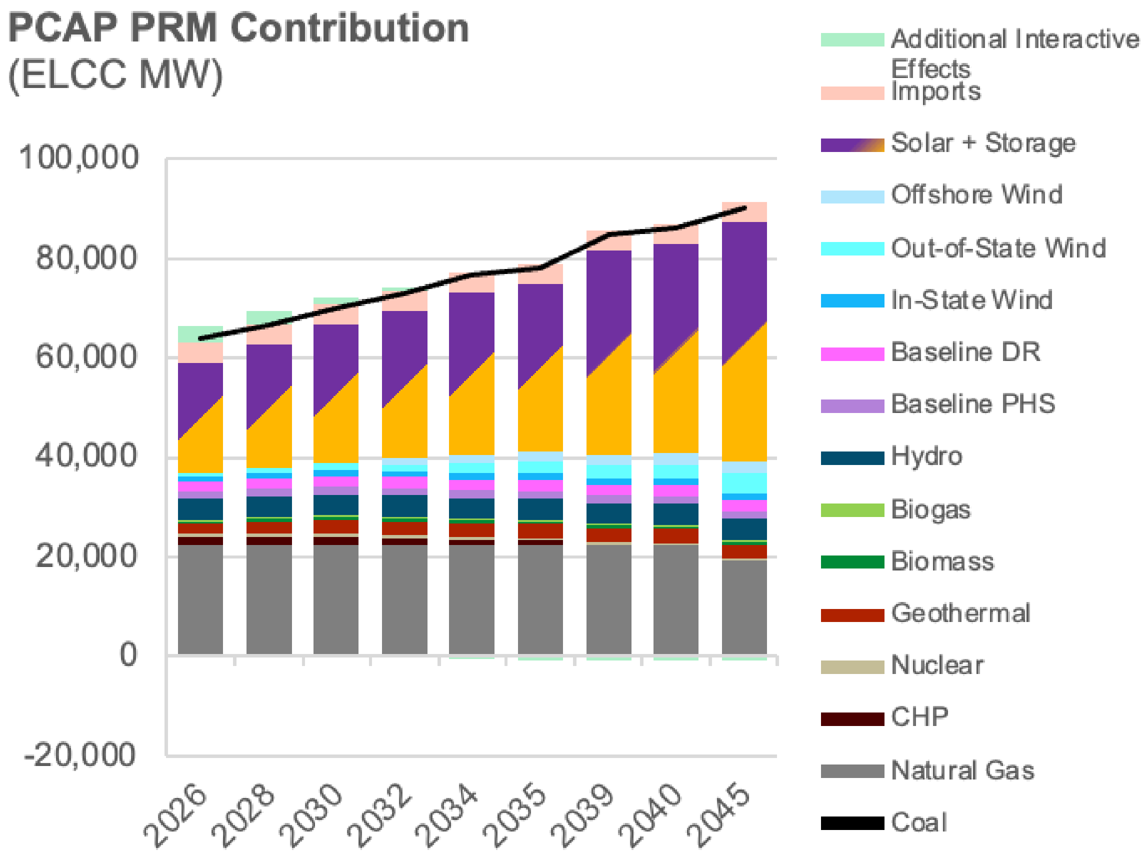
PRM Constraints

- RESOLVE modeling results

Additional resources above those in the LSE plans are only required to meet reliability requirements from mid 2030s; earlier than the 24-25 TPP due to increased system peak in the 2023 IEPR forecast

Natural gas resources provide ~20 GW of capacity throughout the study horizon





Most incremental capacity needs are met with solar and storage. Geothermal and wind also provide incremental resource adequacy.

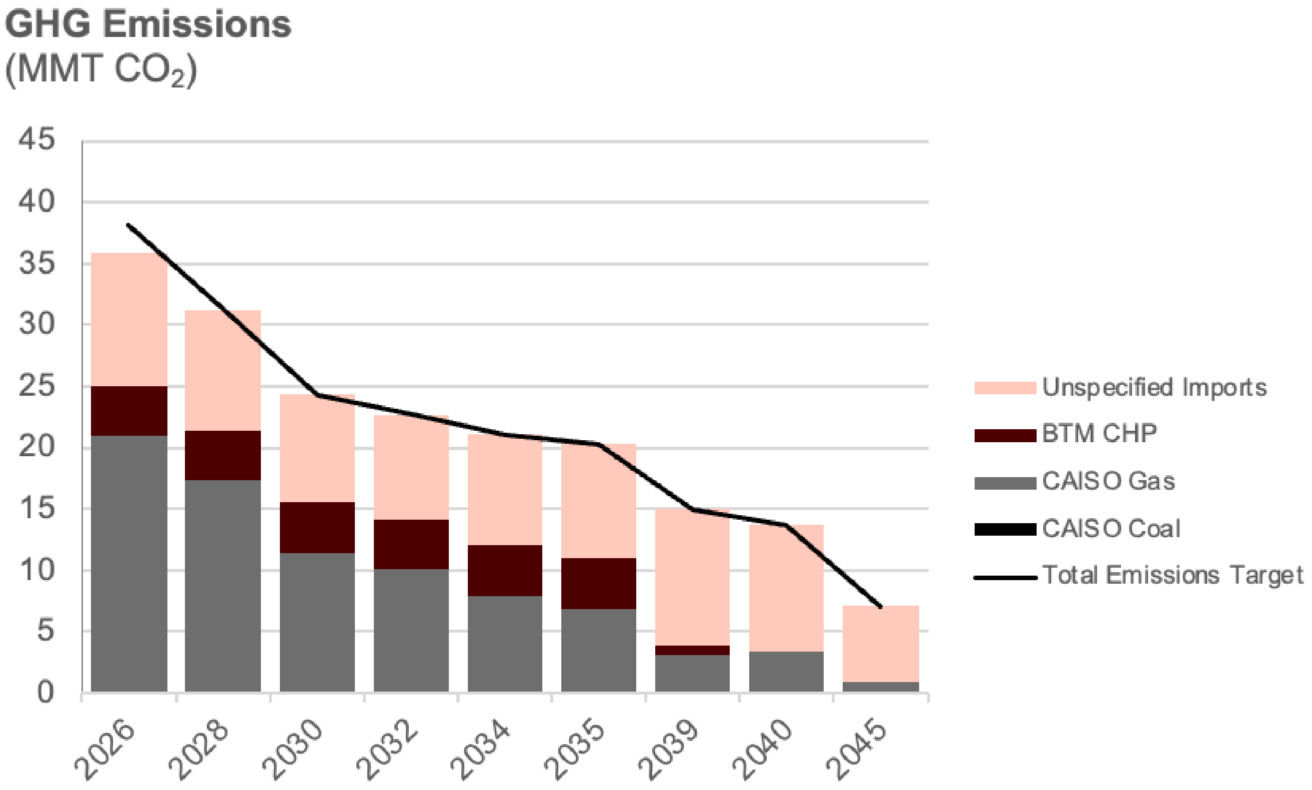
25-26 TPP Proposed Base Case

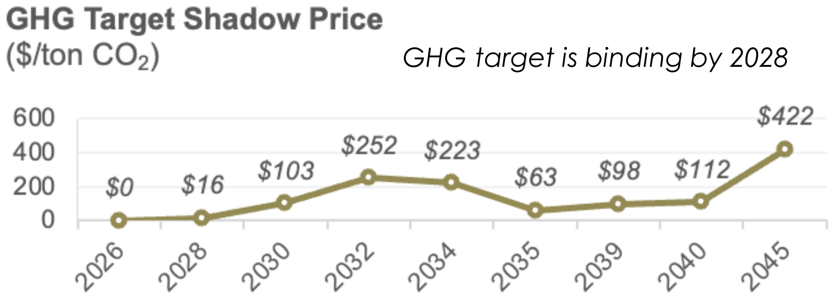
GHG Constraints

- RESOLVE modeling results

New clean resources are added to help meet GHG emissions target in all modeled years, except 2026 when GHG emissions of the portfolio is below the target

BTM CHP, and associated GHG emissions, assumed to phase out between 2035 and 2040.





In the terminal year of 2045, the cost rises steeply to meet the stringent 2045 GHG target.

Base Case Comparison to 24-25 TPP and 23-24 TPP Base Cases

25-26 TPP Proposed Base Case vs. 24-25 TPP vs. 23-24 TPP

	25-26 TPP Proposed Base Case	24-25 TPP	23-24 TPP
IEPR Vintage	2023	2022	2021 ATE
2035			
Peak load (GW)	67.5	64.0	66.5
Annual energy demand (TWh)	332	322	336
Total resources selected (GW)	62.9	56.8	73.0
Gas selected (GW)	-	-	0.1
Gas not retained (Negative = not retained)	-	- 2.7	-
2040			
Peak load (GW)	74.4	70.0	74.9
Annual energy demand (TWh)	386	364	404
Total resources selected (GW)	98.8	81.0	106.6
Gas selected (GW)	-	-	4.8
Gas not retained (Negative = not retained)	-	- 2.7	-
Annual Costs Net Present Value (NPV)			
Est. Annual Costs ($MM)*	$228,677	$222,515	$263,099

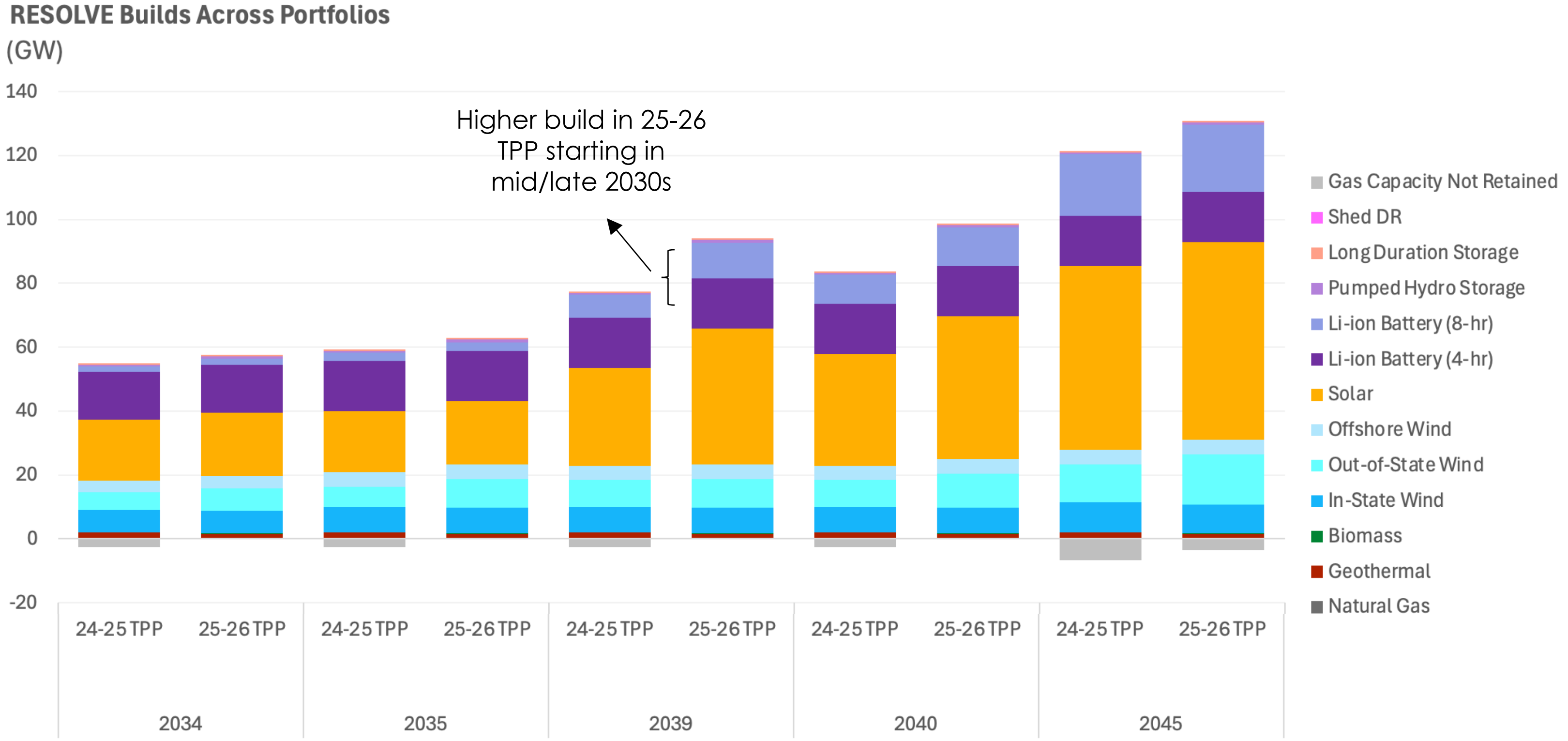
Note: 2023 builds in 23-24 TPP are removed in results shown to enable more consistent comparison; costs for 23-24 TPP converted from 2019$ to 2022$

All loads are for CAISO
*Excludes non-optimized costs, which represent ~75-80% of system costs

25-26 TPP Proposed Base Case vs. 24-25 TPP Base Case

Comparison of Planned & Selected Capacity (GW)

- Additional resource buildout is driven by a higher peak in 2023 IEPR (used in 25-26 TPP) than in 2022 IEPR (used in 24-25 TPP)
- The 24-25 TPP vs. 25-26 TPP **difference in resource buildout is largest in 2039**, consistent with when the 2022 vs. 2023 IEPR peak load difference is largest
- In 2039, **12.4 GW more solar** is built, partially to serve increased energy needs and partially for capacity
- In 2045, an additional 3.0 GW gas is retained in the 25-26 TPP, and **all gas is retained prior to 2045**
- Due to increased winter loads, builds in 25-26 TPP **shift from in-state to out-of-state wind**, as out-of-state wind has higher winter capacity factors
- Additional **8-hr batteries**, and **pumped hydro** are selected; less **geothermal**



NPV of optimized costs* ($MM in 2022 Dollar Year, 2024-2065)	
25-26 TPP (Revised IEPR)	$228,677 (+$6,162 MM or +3%)
24-25 TPP**	$222,515

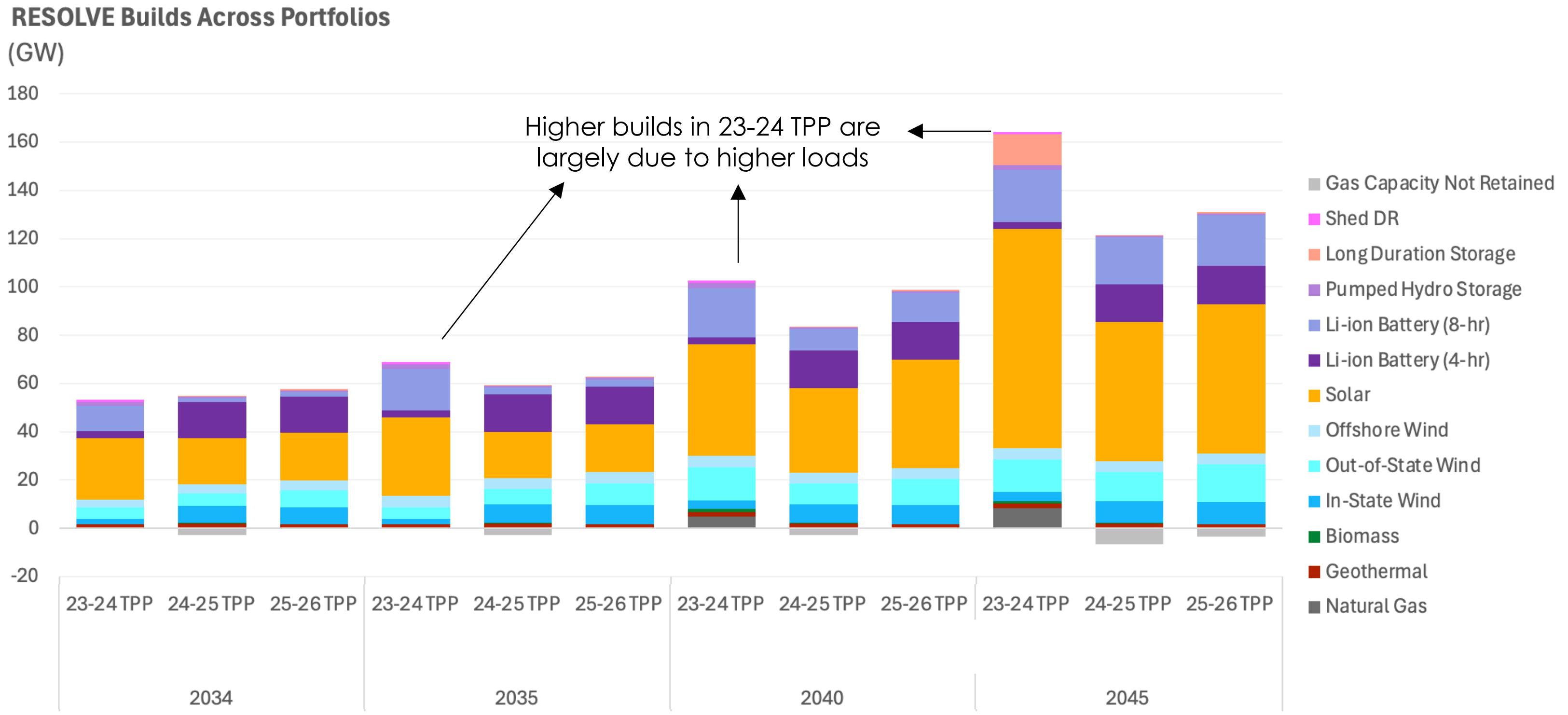
Annual Optimized Costs ($MM)	**2034**	**2035**	**2039**	**2040**	**2045**
25-26 TPP (Revised IEPR)	14,473 (+$144M)	14,764 (+$721M)	17,391 (+$2,281M)	18,137 (+$2,531M)	19,842 (+$2,328M)
24-25 TPP	13,929	14,045	15,110	15,606	17,514

* Excludes non-optimized costs, which represent ~~75-80% of system costs
**Minor correction to CHP cost made since results were originally released

Comparison of 23-24 TPP, 24-25 TPP, 25-26 TPP Proposed Case

Comparison of Planned & Selected Capacity (GW)

- Differences in resource buildout are driven by differences in **load**, **resource economics**, and **GHG targets**
- The 23-24 TPP used the 2022 NREL ATB, which did not reflect IRA incentives or significant increases for battery cost in recent years as a result
- The 2021 IEPR (used in 23-24 TPP) has significantly higher (8-12%) annual loads by 2045, which combined with different resource economics modeled, results in **significantly larger amounts of solar and long duration storage in 23-24 TPP***
- The **23-24 TPP** has a less stringent GHG target by 2045 (15 MMT vs. 8 MMT), allowing for **new gas build**
- All three TPP portfolios have **similar amounts** of **geothermal, out-of-state wind, and offshore wind** build
    - 23-24 TPP was modeled with lower in-state wind potential, which led to lower amounts of in-state wind build



Note: 23-24 TPP modeled 4-hr and 8-hr batteries in aggregate; these are separated for the purpose of this analysis based on the average battery duration of the 23-24 TPP portfolio
Note: 2023 builds and other baseline differences in 23-24 TPP are removed in results shown to enable more consistent comparison
**Long Duration Storage in the 23-24 TPP are 8-hour Flow Batteries, which were not subject to transmission constraints. Biomass was also not subject to transmission constraints in the 23-24 TPP*
***2045 is not used in the TPP planning portfolio*

Planned & Selected Capacity (GW) – Delta from 24-25 TPP

Increase in out-of-state wind driven by increased winter loads (driven by 4-5x more building electrification) and transmission constraints***

Increased geothermal costs contributed to slightly reduced geothermal build

Resource Category	2026	2028	2030	2032	2034	2035	2039	2040	2045
Natural Gas	-	-	-	-	-	-	-	-	-
Geothermal	-	-	-	(0.2)	(0.3)	(0.3)	(0.3)	(0.3)	(0.3)
Biomass	-	-	-	-	-	-	-	-	-
In-State Wind	(0.2)	(0.0)	(0.8)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.3)
Out-of-State Wind	0.2	0.0	0.2	0.2	1.7	2.7	0.8	2.4	3.8
Offshore Wind	-	-	-	-	0.0	-	-	-	-
Solar	(1.3)	(1.4)	-	0.6	0.8	0.8	11.9	9.9	4.4
Li-ion Battery (4-hr)	-	-	-	-	-	-	-	-	-
Li-ion Battery (8-hr)	-	-	-	-	0.2	-	4.0	3.0	1.6
Pumped Hydro Storage (12-hr)	-	-	-	0.3	0.3	0.3	0.3	0.3	0.3
Long Duration Storage (8-24 hr)*	-	-	-	-	0.1	-	-	-	-
Shed DR	-	-	-	-	-	-	-	-	-
Gas Capacity Not Retained**	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	3.1
Total	**1.3**	**1.3**	**2.1**	**3.5**	**5.4**	**6.1**	**19.2**	**17.8**	**12.5**

More gas retained to serve higher reliability need

Significantly more solar buildout in 2039 and 2040 due to higher GHG-free energy needs to meet IEPR's higher peak load

*Long Duration Storage technologies include Flow Battery (8-hr) and A-CAES (24-hr); **Positive Value = More Gas Retained
***Out-of-state wind provides higher CF than in-state wind, offshore wind, or solar resources, which is valuable for serving winter building electrification load

Planned & Selected Capacity (GW) – Delta from 23-24 TPP

23-24 TPP built new gas from 2035 onward due to higher loads and a less stringent emissions target

Resource Category	2026	2028	2030	2032	2034	2035	2040	2045
Natural Gas	-	-	-	-	-	(0.1)	(4.8)	(8.2)
Geothermal	(0.0)	0.3	0.7	0.8	0.1	0.1	(0.4)	(0.4)
Biomass	(0.0)	0.1	0.1	0.1	0.1	0.1	(0.9)	(0.9)
In-State Wind	(1.5)	(1.1)	3.0	4.8	4.8	5.7	4.3	5.4
Out-of-State Wind	1.5	(1.4)	(0.1)	(0.1)	2.2	4.2	(3.0)	2.1
Offshore Wind	(0.1)	(0.2)	(3.1)	(0.5)	0.6	(0.2)	(0.2)	(0.2)
Solar	1.1	2.6	(0.0)	(6.7)	(5.6)	(12.7)	(1.5)	(28.9)
Li-ion Battery (4-hr)	5.3	6.1	8.7	9.8	12.1	12.8	12.8	12.8
Li-ion Battery (8-hr)	0.4	1.0	(1.0)	(6.6)	(8.5)	(14.2)	(8.4)	(0.5)
Pumped Hydro Storage (12-hr)	(0.2)	(0.5)	(0.5)	(0.2)	(0.8)	(1.2)	(1.2)	(1.2)
Long Duration Storage (8-24 hr)*	0.1	0.3	0.3	0.4	0.5	0.5	0.5	(12.1)
Shed DR	(1.0)	(1.0)	(1.0)	(1.0)	(1.0)	(1.0)	(1.0)	(1.0)
Gas Capacity Not Retained**	-	-	-	-	-	-	-	(3.5)
Total	**5.5**	**6.1**	**7.0**	**0.7**	**4.4**	**(6.1)**	**(3.8)**	**(36.7)**

Note: 2039 is excluded from comparison since 2039 was not modeled in the 23-24 TPP
Note: 23-24 TPP modeled 4-hr and 8-hr batteries in aggregate; these are separated for the purpose this analysis based on the average battery duration of the 23-24 TPP portfolio
Note: 2023 builds in 23-24 TPP are removed in results shown to enable more consistent comparison

25-26 TPP has higher wind builds

23-24 TPP has significantly more solar and 8-hr battery build starting in 2035

23-24 TPP has significantly more long duration storage build in 2045

*Long Duration Storage technologies include Flow Battery (8-hr) and A-CAES (24-hr); **Positive Value = More Gas Retained

Conclusions from RESOLVE modeling

- Compared to the **2022 IEPR**, the **revised 2023 IEPR has higher demand and peak load,** driving an **increase in resource buildout** in the RESOLVE portfolios
  - By 2040, the **25-26 TPP** has **10.6 GW more solar, 3.2 GW more 8-hr battery storage,** and **2.7 GW more gas retained** than the 24-25 TPP
  - The revised 2023 IEPR also has **higher winter loads,** which drives a shift from in-state wind and solar to out-of-state wind
- The transmission constraint updates have also contributed to a **shift in location** of some resource buildout and geothermal cost updates have **slightly reduced the geothermal selected** by RESOLVE

Reliability & Emissions Results: 25-26 TPP Proposed Base Case Portfolio

SERVM Analysis

Reliability and GHG Results – 25-26 TPP Proposed Base Case – pre-busbar mapped portfolios

25 MMT CORE	2026		2030		2035		2040		
Category\Model	RESOLVE	SERVM	RESOLVE	SERVM	RESOLVE	SERVM	RESOLVE	SERVM	Units
LOLE		0.00232		0.000		0.0207		1.56	days/year
CAISO emitting generation	53,239	71,234	28,991	50,415	17,629	43,877	8,503	48,325	GWh
CAISO generator emissions	20.93	30.63	11.40	22.38	6.91	19.05	3.32	20.15	MMT CO2
Unspecified imports	25,358	4,984	20,598	9,434	21,698	13,855	24,244	19,325	GWh
Unspecified imports emissions	10.85	2.13	8.82	4.04	9.29	5.93	10.38	8.27	MMT CO2
CAISO BTM CHP emissions	4.08	4.08	4.08	4.08	4.08	4.08	-	-	MMT CO2
Total CAISO emissions	35.87	36.85	24.30	30.50	20.28	29.07	13.70	28.42	MMT CO2
Difference in GHG emissions		0.98		6.20		8.78		14.72	MMT CO2

- Some difference in emissions is expected due to model differences:
  - SERVM models individual unit dispatch for the full 8760 hours of a year with more detailed constraints and random outages
  - SERVM used updated lower capacity factor OOS wind profiles; RESOLVE used prior higher capacity factor OOS wind profiles
- Additionally, the RESOLVE model used for the 2025-2026 TPP modeling was not configured to model intra-CAISO flow constraints and therefore may not have located new build optimally within CAISO. This contributes to less efficient dispatch in SERVM, resulting in higher LOLE, more curtailment, and higher use of thermal units, ultimately adding to any baseline difference in emissions between the models.

Reliability and GHG Results – 25-26 TPP Proposed Base Case – busbar mapped portfolio

25 MMT CORE	2035		2040		
Category\Model	RESOLVE	SERVM	RESOLVE	SERVM	Units
LOLE		0.00785		0.0863	days/year
CAISO emitting generation	17,629	41,455	8,503	41,496	GWh
CAISO generator emissions	6.91	17.99	3.32	17.10	MMT CO2
Unspecified imports	21,698	10,538	24,244	13,240	GWh
Unspecified imports emissions	9.29	4.51	10.38	5.67	MMT CO2
CAISO BTM CHP emissions	4.08	4.08	-	-	MMT CO2
Total CAISO emissions	20.28	26.59	13.70	22.77	MMT CO2
Difference in GHG emissions		6.30		9.07	MMT CO2

- Busbar mapping considers transmission and interconnection constraints in more detail than RESOLVE and incorporates changes to siting of new resources between SERVM zones compared to the raw RESOLVE results.
- The PG&E subregion had much higher LOLE and GHG emissions relative to SCE before mapping so the mapping results shown here maximize placement of new build in PG&E rather than SCE.
- The more optimal placement of busbar-mapped new build within CAISO resulted in lower LOLE, curtailment, and thermal generation, ultimately reducing the difference in emissions between the models (reduction of 2.48 MMT in 2035 and 5.65 MMT in 2040).

Reliability Results – 25-26 TPP Proposed Base Case – summary and conclusions

- Loss of Load Expectation (LOLE) results for 2026 and 2030 are all well below the reliability target (0.1) at 0.002 and 0.000, respectively.
  - No busbar mapping was done as many of the selected new resources represent projects already planned and these years are not key years for studying transmission upgrade/expansion in the 25-26 TPP.
- After busbar mapping, the LOLE results for 2035 and 2040 are 0.008 and 0.086, respectively, both below the reliability target (0.1).
  - Busbar mapping maximizing locations in PG&E was essential to reducing LOLE in 2040 because PG&E had an outsize share of load growth and LOLE events in winter months relative to SCE and SDG&E.

GHG Results – 25-26 TPP Proposed Base Case – summary and conclusions

- SERVM CAISO GHG results are higher than RESOLVE results, ranging from 0.98 to 14.72 MMT per annum between 2026 and 2040 (without busbar mapping) - some difference was expected due to SERVM model differences from RESOLVE:
  - SERVM models individual unit dispatch for the full 8760 hours of a year with more detailed constraints and random outages
  - SERVM used updated lower capacity factor OOS wind profiles; RESOLVE used prior higher capacity factor OOS wind profiles
  - SERVM models individual TAC areas including intra-CAISO flow constraints. Placement of RESOLVE-selected new build that does not consider these factors would contribute to less efficient dispatch in SERVM, resulting in higher LOLE, more curtailment, higher use of thermal units, and ultimately higher emissions.
- After busbar mapping, the GHG difference from RESOLVE reduced from 8.78 to 6.30 MMT in 2035 and from 14.72 to 9.07 MMT in 2040
  - Similarly to the LOLE impact, busbar mapping maximizing locations in PG&E was essential to help reduce the GHG gap with RESOLVE
  - SERVM model results show that by 2040 just over half of CAISO GHG emissions occur in PG&E, and for all TAC areas a large share of GHG emissions occur in winter months, due in part to less available clean energy in winter and strong winter load growth that must then be met with higher usage of thermal units and imports
  - Staff confirmed that load growth especially in winter months was relatively greater in PG&E than the SCE and SDG&E TAC areas, largely driven by growth in fuel substitution (primarily building electrification) and to a lesser extent overnight electric vehicle charging growth. These demand pattern changes (and effects on modeling results) were first observed in the prior 2022 IEPR demand forecast (with SERVM modeling 2039) and observed again here with the 2023 IEPR demand forecast (and SERVM modeling 2040).
- Staff will further investigate the remaining GHG difference from RESOLVE during model calibration work planned for Q1 of 2025
  - About 2 MMT of the remaining GHG difference is already accounted for due to the known OOS wind capacity factor difference between the models
  - Model calibration work will consider tighter model alignment with respect to unit operating constraints, GHG pricing, and representation of individual TAC areas within CAISO and flow constraints between them, as well as ways to better model and plan for the strong winter load growth projected to occur by 2040

Staff Recommended 25-26 TPP Sensitivity Portfolio

Background – Purpose of Sensitivity

- In addition to the Proposed 25-26 TPP Base Case, Staff are proposing to pass one sensitivity portfolio to the CAISO focused a higher Long Lead-Time (LLT) resource deployment future.
  - For the 2025-26 TPP cycle, Staff considered two options for the sensitivity portfolio: the Staff Recommended and the Alternate sensitivity portfolios.
  - Based on stakeholder comments received on the 25-26 TPP Ruling, the Commission is proposing to adopt the Staff Recommended sensitivity portfolio for the 25-26 TPP cycle.
  - Some of the analysis for the Alternate portfolios is included as a point of reference, and additional information specific to the Alternate portfolio is available here.
- The recently adopted AB 1373 related Decision (D.) 24-08-064 contained a need determination for specific LLT resources for potential procurement by the Dept. Of Water Resources.
  - Identified a need for up to 7.6 GW of offshore wind (OSW), 2 GW of long duration energy storage (LDES), and 1 GW of geothermal in addition to existing procurement orders.
  - The amounts of OSW and LDES have not previously been studied in any TPP base case or in a sensitivity case that reflected a reasonable alternate scenario to the TPP base case.*
- The Staff Recommended sensitivity portfolio depicts a potential LLT resource deployment future reflective of the upper bound of the AB 1373 Decision need determination.
  - Designed to serve as reasonable alternative scenario to the proposed base case.
  - Provide insights into transmission implications and resources that are displaced from more LLTs being in the portfolio.

*While the 23-24 TPP OSW Sensitivity included 13.4 GW of OSW and the 24-25 TPP High Gas Retirement Sensitivity included 3.7 GW of LDES both portfolios were designed to gather long-term transmission information to inform future scenarios and do not reflect a likely or realistic deployment of the specific resources over the timeframe of the TPP studies.

Background – LLT Resource Amounts

- The Staff recommended sensitivity portfolio differs from the proposed base case assumptions by having **additional Long Lead-Time (LLT) resources forced-in,** specifically geothermal, long duration energy storage (LDES), and offshore wind (OSW)) by 2035.*
  - Both options Staff considered had the same total amount of OSW, geothermal, and LDES resources (see table below).
  - The OSW, geothermal, and LDES resource amounts reflects the upper bound of the potential LLT resources indicated for central procurement in the AB 1373 Decision (D.24-08-064).
  - Total amounts also account for the clean firm and long duration storage procurement requirements per the Mid-Term Reliability (MTR) Decision (D.21-06-035) adjusted for such resources already contracted and included in baseline.[1]
  - Amounts assume little to no additional procurement by LSEs beyond MTR and AB 1373 Decision amounts for specified LLT resources (e.g., the 7.6 GW of OSW is the total amount modeled, including LSE plans)
  - LDES resources are represented as A-CAES and Pumped Hydro (the two 12+ hr duration storage resource options modeled in RESOLVE).
  - Only complete results from the "Recommended" case are included in this deck.

Case Name	Portfolio Name	Year LLTs forced-in*	Geothermal Build (MW)	A-CAES Build (MW)	Pumped Hydro Build (MW)	Offshore Wind Build (MW)	LSE Plan Configuration
	25-26 TPP Base Case	-	*1,639*	*200*	*756*	*4,531*	*Full LSE plans*
Alternate	LLT (2035 LSE Plans)	2035	2,139	900	1,777	7,555	Full LSE plans
Recommended	LLT (2030 LSE Plans)	2035	2,139	900	1,777	7,555	LSE plans through 2030

*Forced-in Geothermal, A-CAES, and Pumped Hydro may be selected by the model any time 2031-2035

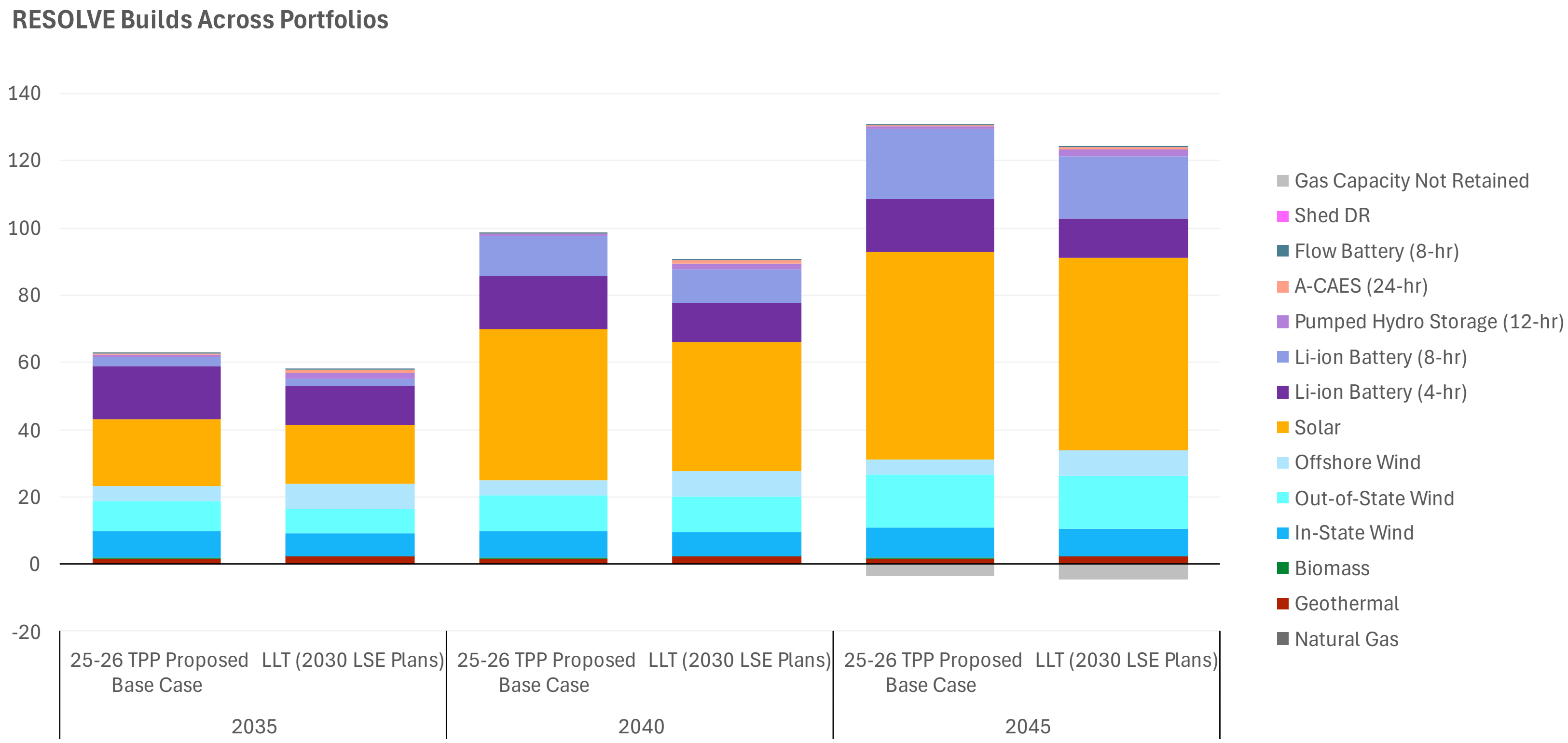
[1] The modeling baseline for this analysis is available here: https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/integrated-resource-plan-and-long-term-procurement-plan-irp-ltpp/2023-irp-cycle-events-and-materials/aggregated-lse-plans-and-baseline-resources-2023-psp_v2.xlsx

Sensitivity Portfolio Results: Recommended – LLT (2030 LSE Plans)

Recommended – LLT (2030 LSE Plans) Sensitivity vs. 25-26 TPP Proposed Base Case

Comparison of Planned & Selected Capacity (GW)

- The additional **5.5 GW of LLT resources** added in 2035 **displaces ~13 GW of other resource builds** by 2040
- Compared to the 25-26 TPP, **starting in 2035, about ~1 GW less solar and battery is built annually** when additional, high-capacity factor LLT resources are added to the system
- **2 GW out-of-state wind is delayed** from 2035 to 2040
- By 2040, the LLT case has **similar amounts of onshore wind** (<1 GW differences)
- **All gas is retained until 2045**. In 2045, gas not retained totals 3.5 GW in the 25-26 TPP and ~4.4 GW in the LLT case
- Forcing-in additional LLT resources **increases total NPV costs by ~$3 Billion**



NPV of optimized costs* ($MM in 2022 Dollar Year, 2024-2065)	
LLT (2030 LSE Plans)	$231,930 (+$3,253 MM or +1.4%)
25-26 TPP Proposed Base Case	$228,677

Annual Optimized Costs ($MM)	**2035**	**2040**	**2045**
LLT (2030 LSE Plans)	15,232 (+$468M)	18,449 (+$312M)	20,232 (+$390M)
25-26 TPP Proposed Base Case	14,764	18,137	19,842

* Excludes non-optimized costs, which represent ~~75-80% of system costs

Recommended – LLT (2030 LSE Plans)

Planned & Selected Capacity (GW) – Incremental to 25-26 TPP Proposed Base Case

Forced-in LLTs

Additional Geothermal, A-CAES, and Pumped Hydro are gradually built over 2032-35 (not allowed for Offshore Wind)

Significant amounts of solar and storage displaced after 2035

Resource Category	2026	2028	2030	2032	2034	2035	2039	2040	2045
Natural Gas	-	-	-	-	-	-	-	-	-
Geothermal	-	-	-	0.1	0.5	0.5	0.5	0.5	0.5
Biomass	-	-	-	-	-	-	-	-	-
In-State Wind	-	-	0.0	(0.1)	(0.1)	(1.0)	(0.7)	(0.7)	(0.7)
Out-of-State Wind	-	-	(0.0)	(0.0)	-	(2.0)	(0.1)	(0.2)	-
Offshore Wind	-	-	-	-	(0.0)	3.0	3.0	3.0	3.0
Solar	-	-	-	(0.5)	(2.2)	(2.2)	(6.6)	(6.5)	(4.6)
Li-ion Battery (4-hr)	-	-	-	(1.1)	(3.4)	(4.1)	(4.1)	(4.1)	(4.1)
Li-ion Battery (8-hr)	-	-	-	(0.1)	0.2	(0.7)	(1.9)	(1.8)	(2.4)
Pumped Hydro Storage (12-hr)	-	-	-	0.8	1.0	1.0	1.0	1.0	1.0
A-CAES (24-hr)	-	-	-	-	0.3	0.7	0.7	0.7	0.7
Flow Battery (8-hr)	-	-	-	(0.1)	(0.2)	(0.2)	(0.2)	(0.2)	(0.2)
Shed DR	-	-	-	-	-	-	-	-	-
Gas Capacity Not Retained*	-	-	-	-	-	-	-	-	(0.9)
Total	**-**	**-**	**0.0**	**(1.0)**	**(3.8)**	**(4.9)**	**(8.3)**	**(8.2)**	**(7.6)**

With LSE Plans only forced-in up to 2030, a mix of onshore wind, solar, and storage is displaced in 2035. RESOLVE begins selecting 8-hr batteries in lieu of 4-hr starting in 2034.

Additional gas not retained in 2045

*Positive Value = More Gas Retained

Appendices

Appendix I: Input Updates Across Recent TPP cycles

Scope of Input Updates across TPP cycles

23-24 TPP	24-25 TPP	25-26 TPP (all cases)
• Resource costs • Load inputs (2021 IEPR ATE) • Modeling resource Baseline • Updated NQC values • Transmission deliverability-resource mappings, existing transmission deliverability capacity, and transmission upgrade costs from CAISO 21-22 TPP and CAISO 20-year Study • Secondary system need (SSN) transmission utilization values, per CAISO	• Modeling resource Baseline • Resource cost (2023 NREL) • Load inputs • Resource potential PRM accounting & resource accreditation • Sampling from SERVM's 23-weather year dataset for loads and generation profiles • Resource-transmission representation & deliverability upgrades based on CAISO data • Resource builds in non-CAISO external zones • Modeling and data updates for modeling load shift resources • Emerging technologies as candidate resources	• New Transmission Cluster Constraints • Load Inputs (2023 IEPR) • Geothermal Resource Cost • Arizona Solar Profiles

Appendix II: Additional RESOLVE modeling results

25-26 TPP Proposed Base Case

Planned & Selected Capacity (GW)

Resource Category	2026	2028	2030	2032	2034	2035	2039	2040	2045
Natural Gas	-	-	-	-	-	-	-	-	-
Geothermal	0.8	1.1	1.5	1.6	1.6	1.6	1.6	1.6	1.6
Biomass	-	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
In-State Wind	0.7	1.0	5.2	7.0	7.0	7.9	7.9	7.9	9.0
Out-of-State Wind	1.8	3.4	4.7	4.7	7.0	9.0	9.1	10.7	15.7
Offshore Wind	-	-	-	2.7	3.9	4.5	4.5	4.5	4.5
Solar	5.5	8.5	14.8	16.3	19.8	19.8	42.6	44.9	61.8
Li-ion Battery (4-hr)	8.0	9.0	11.6	12.7	15.0	15.7	15.7	15.7	15.7
Li-ion Battery (8-hr)	0.4	1.0	1.2	1.4	1.9	2.8	11.2	12.0	21.1
Pumped Hydro Storage (12-hr)	-	0.5	0.5	0.8	0.8	0.8	0.8	0.8	0.8
A-CAES (24-hr)	-	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Flow Battery (8-hr)	0.1	0.1	0.1	0.2	0.3	0.3	0.3	0.3	0.3
Shed DR	-	-	-	-	-	-	-	-	-
Gas Capacity Not Retained	-	-	-	-	-	-	-	-	(3.5)
Total	**17.3**	**25.1**	**40.0**	**47.7**	**57.7**	**62.9**	**94.1**	**98.8**	**127.4**

25-26 TPP Proposed Base Case

LSE Planned Builds (GW)

Resource Category	2026	2028	2030	2032	2034	2035	2039	2040	2045
Natural Gas	-	-	-	-	-	-	-	-	-
Geothermal	0.8	1.1	1.5	1.6	1.6	1.6	1.6	1.6	1.6
Biomass	-	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
In-State Wind	0.7	1.0	2.8	2.8	2.8	3.1	3.1	3.1	3.1
Out-of-State Wind	1.8	3.4	4.1	4.1	4.3	4.6	4.6	4.6	4.6
Offshore Wind	-	-	-	2.7	3.9	4.5	4.5	4.5	4.5
Solar	5.5	8.5	14.8	15.3	16.4	19.0	19.0	19.0	19.0
Li-ion Battery (4-hr)	8.0	9.0	11.6	12.7	15.0	15.7	15.7	15.7	15.7
Li-ion Battery (8-hr)	0.4	1.0	1.2	1.4	1.7	2.8	2.8	2.8	2.8
Pumped Hydro Storage (12-hr)	-	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Long Duration Storage (8-24 hr)	0.1	0.3	0.3	0.4	0.5	0.5	0.5	0.5	0.5
Shed DR	-	-	-	-	-	-	-	-	-
Gas Capacity Not Retained	-	-	-	-	-	-	-	-	-
Total	17.3	25.1	37.0	41.6	46.8	52.5	52.5	52.5	52.5

Note: A portion of LSE Planned wind is generic (not specified as in-state or out-of-state) and can be sited optimally by RESOLVE. For the purposes of this table, any generic wind in the LSE plans is allocated based on the share of RESOLVE-selected wind in 2035 (approximately 50% each in-state and out-of-state).

25-26 TPP Proposed Base Case

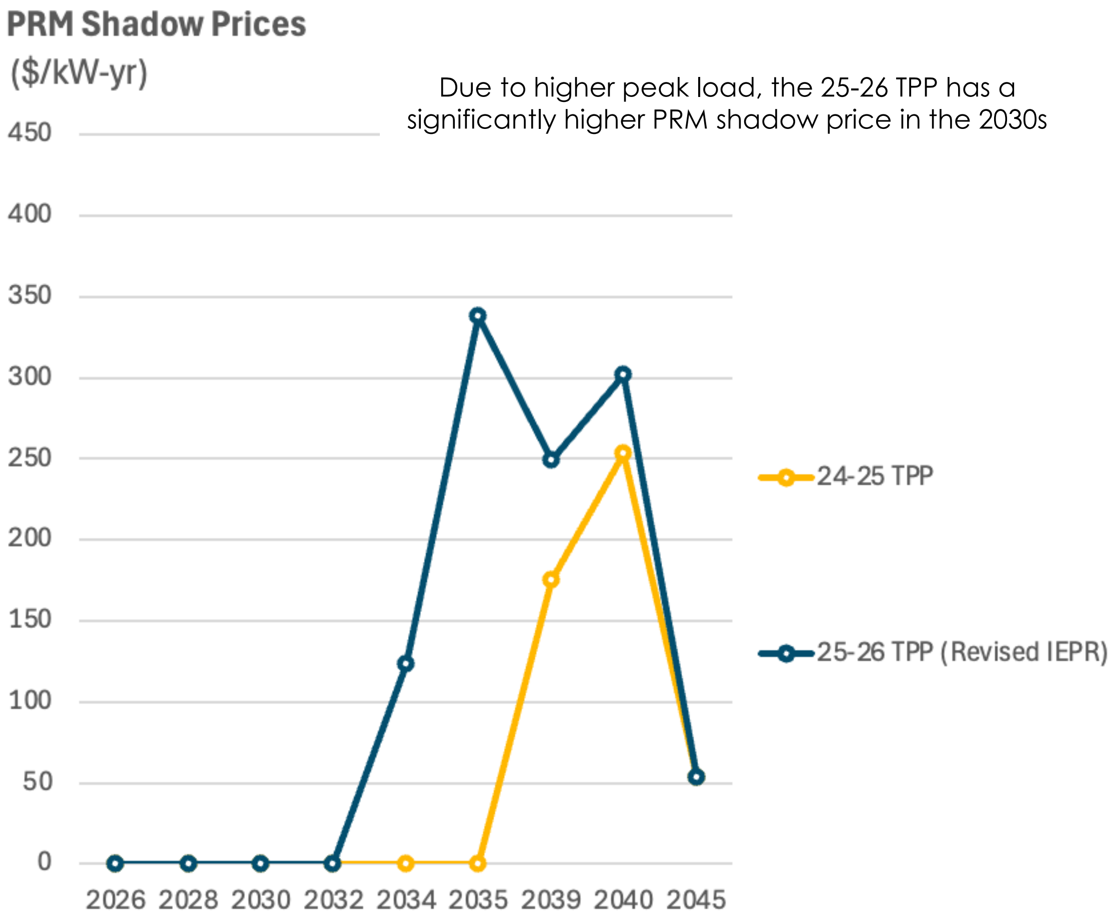
RESOLVE-Selected Builds (GW)

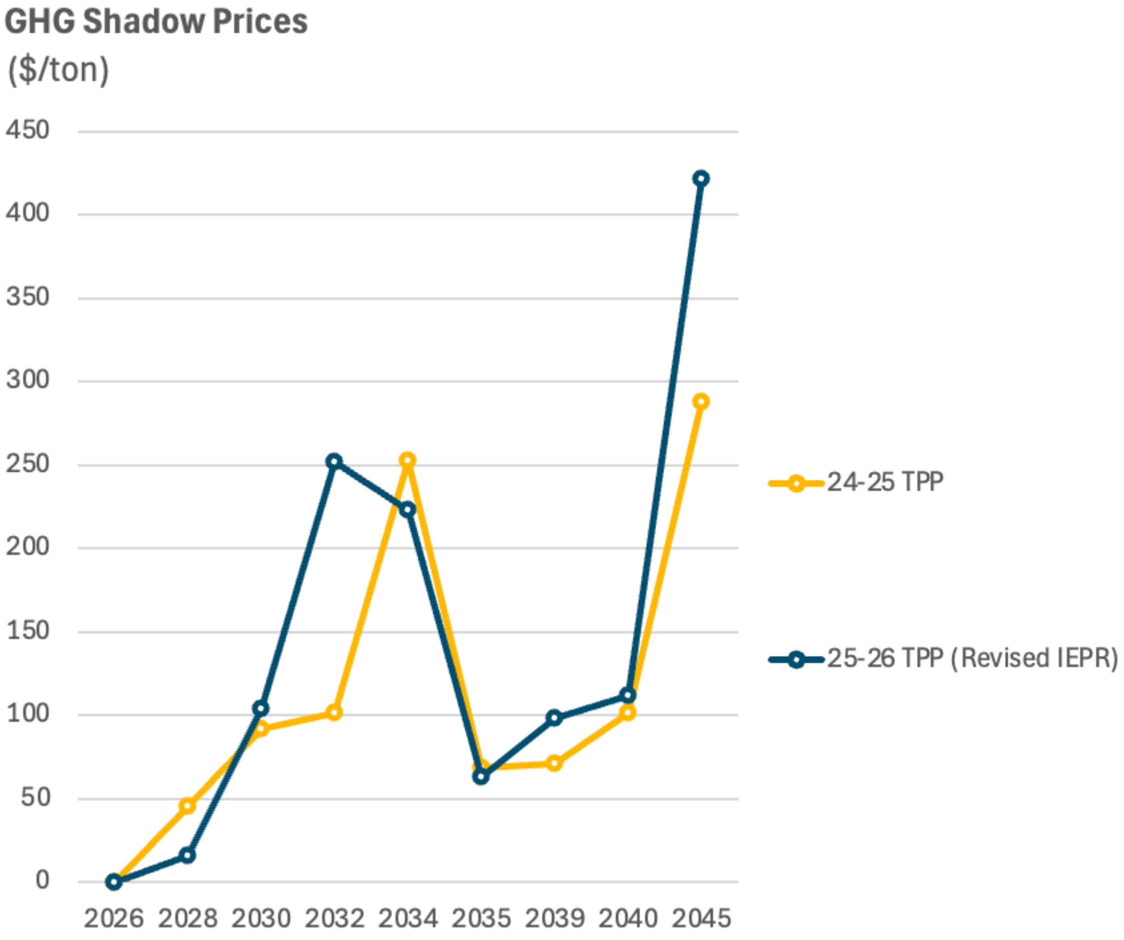
Resource Category	2026	2028	2030	2032	2034	2035	2039	2040	2045
Natural Gas	-	-	-	-	-	-	-	-	-
Geothermal	-	-	-	0.0	0.0	-	-	-	-
Biomass	-	-	-	-	-	-	-	-	-
In-State Wind	-	-	2.4	4.2	4.2	4.8	4.8	4.8	5.9
Out-of-State Wind	-	-	0.6	0.6	2.7	4.4	4.5	6.1	11.2
Offshore Wind	-	-	-	-	0.0	-	-	-	-
Solar	-	-	-	1.0	3.4	0.8	23.6	25.9	42.8
Li-ion Battery (4-hr)	-	-	-	-	-	-	-	-	-
Li-ion Battery (8-hr)	-	-	-	-	0.2	-	8.3	9.2	18.3
Pumped Hydro Storage (12-hr)	-	-	-	0.3	0.3	0.3	0.3	0.3	0.3
Long Duration Storage (8-24 hr)	-	-	-	-	0.1	-	-	-	-
Shed DR	-	-	-	-	-	-	-	-	-
Gas Capacity Not Retained	-	-	-	-	-	-	-	-	(3.5)
Total	**-**	**-**	**2.8**	**6.0**	**10.7**	**9.8**	**41.4**	**46.2**	**77.3**

25-26 TPP Proposed Base Case comparison to 24-25 TPP Base Case

PRM and GHG Shadow Prices Comparison

Due to higher peak load, the 25-26 TPP has a significantly higher PRM shadow price in the 2030s





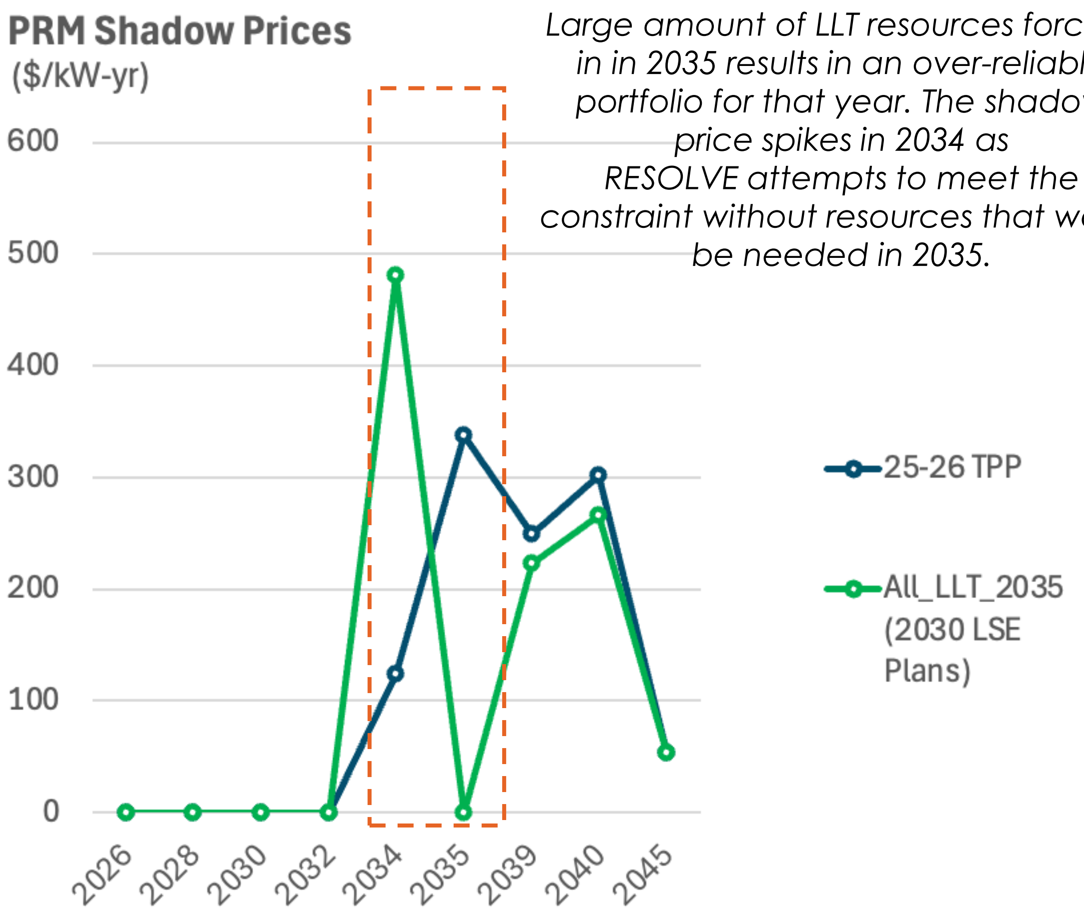
Recommended – LLT (2030 LSE Plans)

Planned & Selected Capacity (GW)

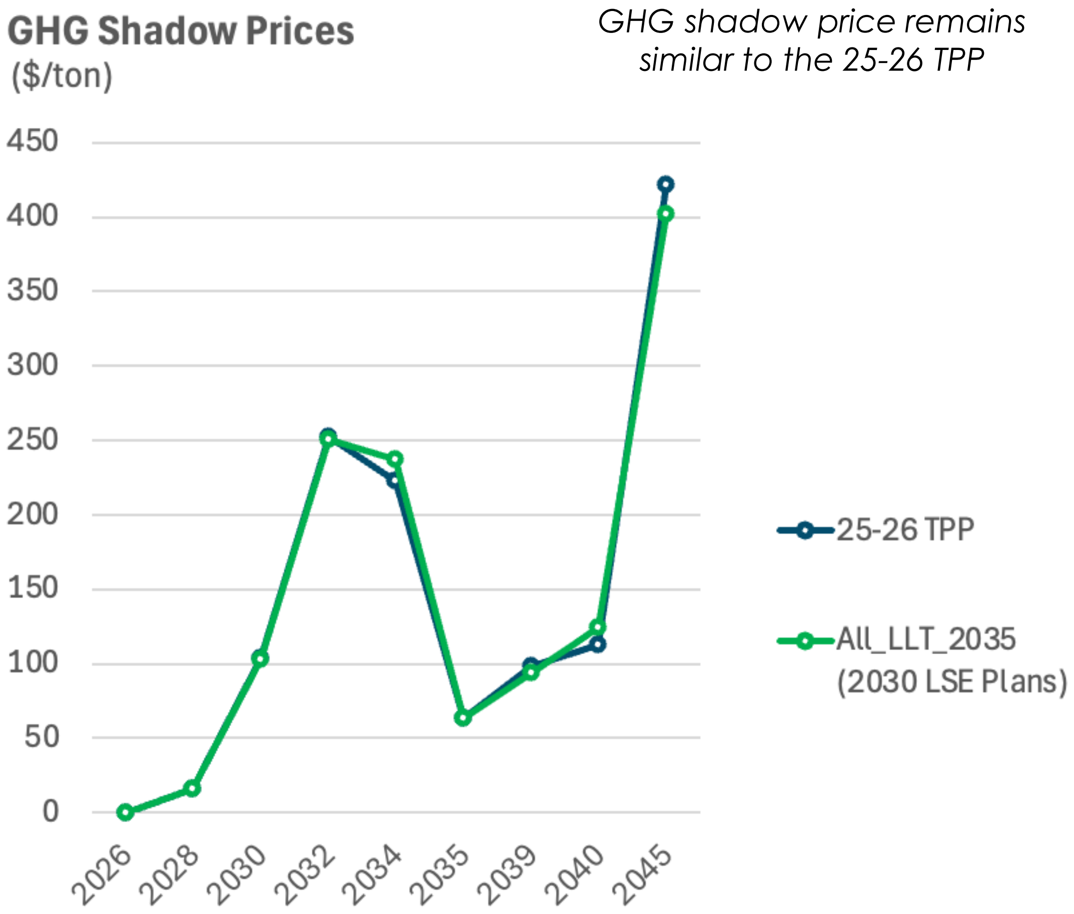
Resource Category	2026	2028	2030	2032	2034	2035	2039	2040	2045
Natural Gas	-	-	-	-	-	-	-	-	-
Geothermal	0.8	1.1	1.5	1.7	2.1	2.1	2.1	2.1	2.1
Biomass	-	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
In-State Wind	0.7	1.0	5.2	6.9	6.9	6.9	7.2	7.2	8.3
Out-of-State Wind	1.8	3.4	4.7	4.7	7.0	7.0	9.0	10.5	15.7
Offshore Wind	-	-	-	2.7	3.9	7.6	7.6	7.6	7.6
Solar	5.5	8.5	14.8	15.8	17.7	17.7	36.0	38.4	57.3
Li-ion Battery (4-hr)	8.0	9.0	11.6	11.6	11.6	11.6	11.6	11.6	11.6
Li-ion Battery (8-hr)	0.4	1.0	1.2	1.2	2.1	2.1	9.3	10.2	18.7
Pumped Hydro Storage (12-hr)	-	0.5	0.5	1.5	1.8	1.8	1.8	1.8	1.8
A-CAES (24-hr)	-	0.2	0.2	0.2	0.5	0.9	0.9	0.9	0.9
Flow Battery (8-hr)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Shed DR	-	-	-	-	-	-	-	-	-
Gas Capacity Not Retained	-	-	-	-	-	-	-	-	(4.4)
Total	**17.3**	**25.1**	**40.0**	**46.7**	**53.9**	**58.0**	**85.7**	**90.6**	**119.8**

Recommended – LLT (2030 LSE Plans)

PRM and GHG Constraints



Large amount of LLT resources forced-in in 2035 results in an over-reliable portfolio for that year. The shadow price spikes in 2034 as RESOLVE attempts to meet the constraint without resources that won't be needed in 2035.



GHG shadow price remains similar to the 25-26 TPP

24-25 TPP Base Case

Planned & Selected Capacity (GW)

Resource Category	2026	2028	2030	2032	2034	2035	2039	2040	2045
Natural Gas	-	-	-	-	-	-	-	-	-
Geothermal	0.8	1.1	1.5	1.8	2.0	2.0	2.0	2.0	2.0
Biomass	-	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
In-State Wind	0.8	1.1	5.9	7.0	7.0	7.9	7.9	7.9	9.2
Out-of-State Wind	1.7	3.4	4.5	4.5	5.3	6.3	8.3	8.3	12.0
Offshore Wind	-	-	-	2.7	3.9	4.5	4.5	4.5	4.5
Solar	6.9	9.9	14.8	15.7	19.0	19.0	30.7	35.0	57.5
Li-ion Battery (4-hr)	8.0	9.0	11.6	12.7	15.0	15.7	15.7	15.7	15.7
Li-ion Battery (8-hr)	0.4	1.0	1.2	1.4	1.7	2.8	7.2	9.0	19.5
Pumped Hydro Storage (12-hr)	-	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Long Duration Storage (8-24 hr)*	0.1	0.3	0.3	0.4	0.5	0.5	0.5	0.5	0.5
Shed DR	-	-	-	-	-	-	-	-	-
Gas Capacity Not Retained	(2.7)	(2.7)	(2.7)	(2.7)	(2.7)	(2.7)	(2.7)	(2.7)	(6.6)
Total	**16.0**	**23.8**	**37.9**	**44.2**	**52.3**	**56.8**	**74.8**	**81.0**	**115.0**

*Long Duration Storage technologies include Flow Battery (8-hr) and A-CAES (24-hr)

Appendix III: Transmission Information for TPP analyses

Resource Level Summary: Delta from 24-25 TPP Base Case (2040)

Solar & Wind Resources (MW)

Likely to serve energy

Resource	Year	25-26 TPP	24-25 TPP	Delta
Riverside_Solar	2040	8,688	2,868	5,820
Greater_Imperial_Solar	2040	5,171	39	5,132
Southern_NV_Eldorado_Solar	2040	12,576	7,702	4,874
New_Mexico_Wind	2040	6,000	2,028	3,972
Southern_PGAE_Solar	2040	2,854	1,226	1,628
Humboldt_Bay_Offshore_Wind	2040	1,607	-	1,607
Greater_LA_Solar	2040	375	-	375
Northern_California_Wind	2040	2,288	2,259	30
Solano_Wind	2040	405	375	30
Central_Valley_North_Los_Banos_Wind	2040	153	241	(88)
Greater_Kramer_Solar	2040	4,052	4,438	(386)
Wyoming_Wind	2040	4,407	6,000	(1,593)
Morro_Bay_Offshore_Wind	2040	2,924	4,531	(1,607)
Arizona_Solar	2040	4,117	7,811	(3,694)
Tehachapi_Solar	2040	6,934	10,796	(3,862)

Storage, Geothermal, & Gas Resources (MW)

Likely to serve capacity

Resource	Year	25-26 TPP	24-25 TPP	Delta
CAISO_Li_Battery_8hr_Dispatch	2040	12,011	9,036	2,975
CAISO_New_Pumped_Storage_12hr	2040	756	477	279
Pacific_Northwest_Geothermal	2040	60	33	27
Greater_Imperial_Geothermal	2040	1,217	1,345	(127)
Northern_California_Geothermal	2040	314	544	(230)

- The updated transmission constraints caused a shift in location for solar, wind, and geothermal resources
  - Shift in wind buildout from Wyoming to New Mexico
  - Shift in solar from Tehachapi and Arizona to Southern NV, Riverside, Greater Imperial, and Greater LA
  - Shift in geothermal from Northern CA and Greater Imperial to Pacific Northwest
- Offshore wind shift from Morro Bay to Humboldt reflects the locational change applied to the resource portfolio transmitted to CAISO not reflected in E3's 24-25 TPP results

Shifts from Largest 24-25 TPP Base Case Clusters, 2040

Cluster	24-25 TPP Builds (MWs)	25-26 TPP IX Limit (MWs)	25-26 TPP Builds (MWs)	Notable Resources
19	6,300	3,000	4,707*	WY, ID, UT Wind Southern Nevada Solar + Storage
48	5,882	200	54	Arizona Solar + Storage
66	5,780	3,000	3,000	Tehachapi Solar + Storage
4	4,950	33,000	6,021	Greater LA Storage
15	4,604	2,100	2,100	Southern Nevada Solar + Storage Southern Nevada Wind (60 MW)
13	4,393	3,000	3,000	Tehachapi Solar Tehachapi Wind (1,200 MW)
32	4,320	3,000	3,000	Tehachapi Solar Tehachapi Wind (250 MW)
9	3,562	16,500	7,376	Riverside Solar + Storage
16	3,368	400	400	Southern Nevada Solar + Storage Southern Nevada Wind (300 MW)

- Top build clusters (capacity additions > 3 GW) from the **24-25 TPP**
- Resource builds are moving **out of** these regions due to interconnection limits:
  - Wyoming Wind
  - Tehachapi Solar/Storage
  - Arizona Solar/Storage

* 1.4 GW of Wyoming Wind is built that triggers non-CAISO “generic” transmission and interconnection upgrades in SCE Eastern

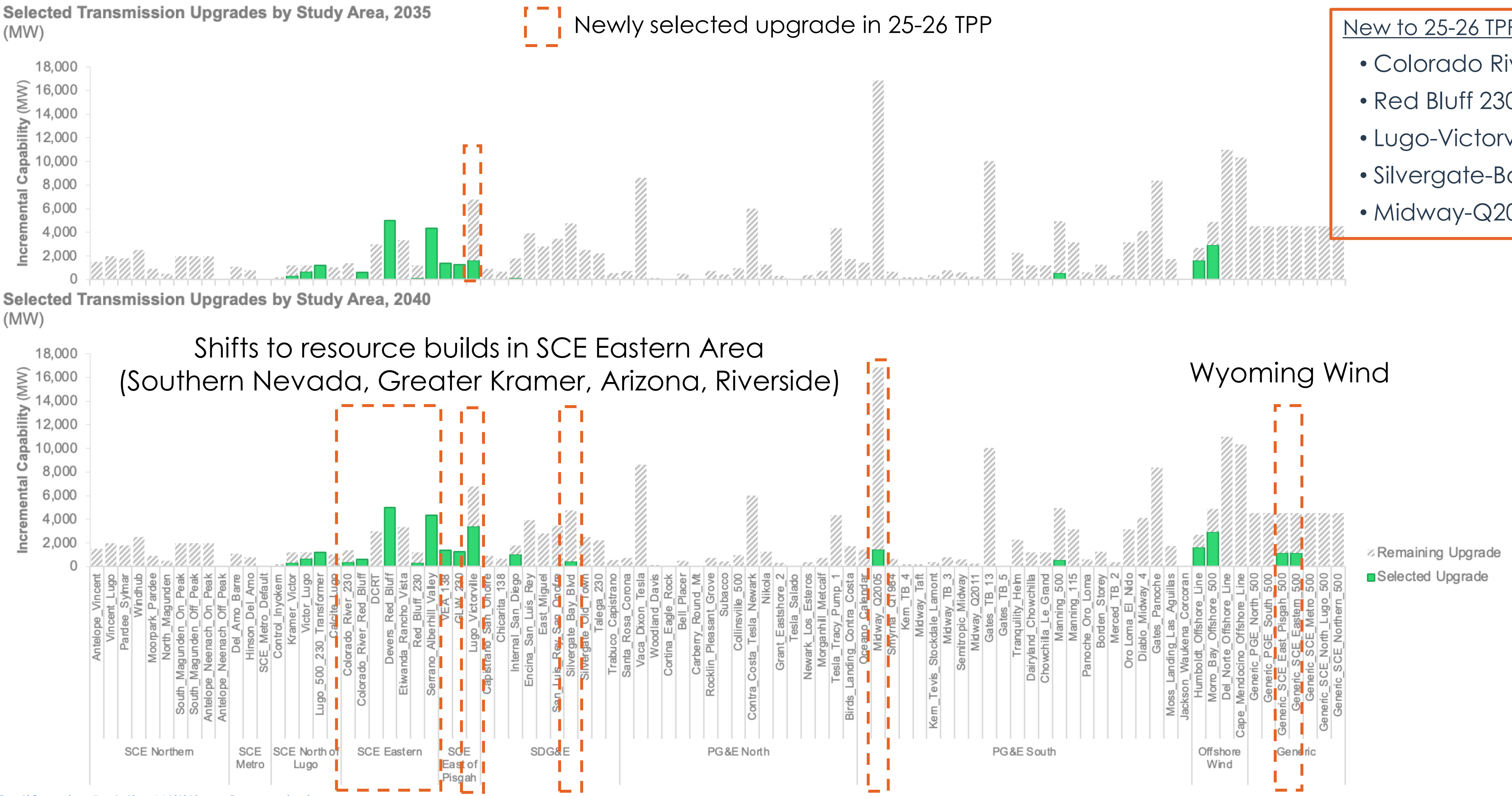
Shifts to Largest 25-26 TPP Proposed Base Case Clusters, 2040

Cluster	24-25 TPP Builds (MWs)	25-26 TPP IX Limit (MWs)	25-26 TPP Builds (MWs)	Notable Resources
2	2,940	18,000	13,086	Southern Nevada Solar + Storage Southern Nevada Wind (300 MW)
9	3,562	16,500	7,376	Riverside Solar + Storage
4	4,950	33,000	6,021	Greater LA Storage
55	2,028	6,000	6,000	New Mexico Wind
19	6,300	3,000	4,707*	WY, ID, UT Wind Southern Nevada Solar + Storage
13	4,393	3,000	3,000	Tehachapi Solar Tehachapi Wind (1,200 MW)
32	4,320	3,000	3,000	Tehachapi Solar Tehachapi Wind (250 MW)
66	5,780	3,000	3,000	Tehachapi Solar + Storage
62	0	3,000	1,987	Arizona Solar + Storage

* 1.4 GW of Wyoming Wind is built that triggers non-CAISO "generic" transmission and interconnection upgrades in SCE Eastern

- Top build clusters (capacity additions > 3 GW) from the **25-26 TPP**
- Resource builds are moving **into** these regions due to interconnection availability:
  - Greater LA Storage
  - Riverside Solar/Storage
  - Southern Nevada Solar/Storage
  - New Mexico Wind

RESOLVE-Selected Transmission Upgrades, Base Case



New to 25-26 TPP:

- Colorado River 230 kV
- Red Bluff 230 kV
- Lugo-Victorville
- Silvergate-Bay Boulevard 230 kV
- Midway-Q2005 230 kV

25-26 TPP Proposed Base Case

Resource FCDS and EODS, 2035 in MWs

Solar and Wind Resources	FCDS	EODS	Total
Arizona_Solar	3,707	-	3,707
Baja_California_Wind	900	1,573	2,473
Cape_Mendocino_Offshore_Wind	-	-	-
Central_Valley_North_Los_Banos_Wind	-	153	153
Del_Norte_Offshore_Wind	-	-	-
Greater_Imperial_Solar	39	-	39
Greater_Imperial_Wind	133	-	133
Greater_Kramer_Solar	1,012	-	1,012
Greater_LA_Solar	-	-	-
Humboldt_Bay_Offshore_Wind	1,607	-	1,607
Idaho_Wind	300	-	300
Morro_Bay_Offshore_Wind	2,924	-	2,924
New_Mexico_Wind	6,000	-	6,000
Northern_California_Solar	26	100	126
Northern_California_Wind	334	1,954	2,288
Riverside_Solar	659	-	659
Solano_Wind	220	185	405
Southern_NV_Eldorado_Solar	9,111	330	9,441
Southern_NV_Eldorado_Wind	711	(0)	711
Southern_PGAE_Solar	247	-	247
Tehachapi_Solar	4,602	0	4,602
Tehachapi_Wind	1,732	-	1,732
Utah_Wind	-	-	-
Wyoming_Wind	2,700	-	2,700

Capacity Resources	FCDS	EODS	Total
CAISO_Adiabatic_CAES_24hr	200	-	200
CAISO_Flow_Battery_8hr_Dispatch	308	-	308
CAISO_Li_Battery_4hr_Dispatch	15,707	0	15,707
CAISO_Li_Battery_8hr_Dispatch	2,834	-	2,834
CAISO_New_Pumped_Storage_12hr	756	-	756
Central_Nevada_Geothermal	40	-	40
Greater_Imperial_Geothermal	1,217	-	1,217
InState_Biomass	-	171	171
Inyokern_North_Kramer_Geothermal	7	-	7
Northern_California_Geothermal	314	-	314
Northern_Nevada_Geothermal	-	-	-
Pacific_Northwest_Geothermal	60	-	60
Utah_Geothermal	-	-	-

All units in MWs

25-26 TPP Proposed Base Case

Resource FCDS and EODS, 2040 in MWs

Solar and Wind Resources	FCDS	EODS	Total
Arizona_Solar	4,117	-	4,117
Baja_California_Wind	900	1,573	2,473
Cape_Mendocino_Offshore_Wind	-	-	-
Central_Valley_North_Los_Banos_Wind	-	153	153
Del_Norte_Offshore_Wind	-	-	-
Greater_Imperial_Solar	5,171	-	5,171
Greater_Imperial_Wind	133	-	133
Greater_Kramer_Solar	4,052	-	4,052
Greater_LA_Solar	375	-	375
Humboldt_Bay_Offshore_Wind	1,607	-	1,607
Idaho_Wind	300	-	300
Morro_Bay_Offshore_Wind	2,924	-	2,924
New_Mexico_Wind	6,000	-	6,000
Northern_California_Solar	26	100	126
Northern_California_Wind	334	1,954	2,288
Riverside_Solar	8,688	-	8,688
Solano_Wind	220	185	405
Southern_NV_Eldorado_Solar	12,246	330	12,576
Southern_NV_Eldorado_Wind	711	(0)	711
Southern_PGAE_Solar	2,854	-	2,854
Tehachapi_Solar	6,934	0	6,934
Tehachapi_Wind	1,732	-	1,732
Utah_Wind	-	-	-
Wyoming_Wind	4,407	-	4,407

Capacity Resources	FCDS	EODS	Total
CAISO_Adiabatic_CAES_24hr	200	-	200
CAISO_Flow_Battery_8hr_Dispatch	308	-	308
CAISO_Li_Battery_4hr_Dispatch	15,707	0	15,707
CAISO_Li_Battery_8hr_Dispatch	12,011	-	12,011
CAISO_New_Pumped_Storage_12hr	756	-	756
Central_Nevada_Geothermal	40	-	40
Greater_Imperial_Geothermal	1,217	-	1,217
InState_Biomass	-	171	171
Inyokern_North_Kramer_Geothermal	7	-	7
Northern_California_Geothermal	314	-	314
Northern_Nevada_Geothermal	-	-	-
Pacific_Northwest_Geothermal	60	-	60
Utah_Geothermal	-	-	-

All units in MWs

Recommended – LLT (2030 LSE Plans)

Resource Level Summary: Incremental to 25-26 TPP Proposed Base Case (2035)

Solar & Wind Resources (MWs)

Likely to serve energy

Resource	Year	Recommended – LLT (2030 LSE Plans)	25-26 TPP	Delta
Morro_Bay_Offshore_Wind	2035	4,875	2,924	1,951
Humboldt_Bay_Offshore_Wind	2035	2,680	1,607	1,073
Southern_NV_Eldorado_Solar	2035	9,508	9,441	67
Solano_Wind	2035	454	405	49
Northern_California_Solar	2035	121	126	(5)
Central_Valley_North_Los_Banos_Wind	2035	32	153	(121)
Tehachapi_Solar	2035	4,027	4,602	(575)
Baja_California_Wind	2035	1,573	2,473	(900)
Arizona_Solar	2035	2,064	3,707	(1,643)
New_Mexico_Wind	2035	4,000	6,000	(2,000)

- Forced-in geothermal and pumped hydro builds are spread between multiple locations
  - Forced-in offshore wind fills the full potential of Morro Bay & Humboldt Bay; full A-CAES potential built
- LLT resources primarily displace New Mexico and Baja California wind; Solar is displaced in both Arizona and Tehachapi
- Battery builds are shifted to differ from the 2035 Full LSE Plans case, with builds either displaced or shifting to both Greater LA and Arizona

Storage, Geothermal, & Gas Resources (MWs)

Likely to serve capacity

Resource	Year	Recommended – LLT (2030 LSE Plans)	25-26 TPP	Delta
Arizona_Li_Battery_8hr	2035	906	-	906
Riverside_East_Pumped_Storage	2035	1,277	477	800
Greater_Imperial_Geothermal	2035	1,717	1,217	500
Southern_PGAE_Adiabatic_CAES	2035	400	-	400
Greater_LA_Li_Battery_8hr	2035	333	-	333
Tehachapi_Adiabatic_CAES	2035	500	200	300
Riverside_West_Pumped_Storage	2035	500	279	221
Greater_Kramer_Li_Battery_8hr	2035	231	100	131
Southern_PGAE_Flow_Battery	2035	54	-	54
Greater_Imperial_Li_Battery_8hr	2035	21	-	21
Greater_Kramer_Li_Battery_4hr	2035	665	664	1
Southern_NV_Eldorado_Li_Battery_4hr	2035	3,591	3,602	(11)
Riverside_Li_Battery_4hr	2035	445	520	(75)
Southern_PGAE_Li_Battery_4hr	2035	2,233	2,395	(162)
Northern_California_Flow_Battery	2035	54	308	(254)
Riverside_Li_Battery_8hr	2035	-	485	(485)
Northern_California_Li_Battery_8hr	2035	645	1,191	(546)
Greater_Imperial_Li_Battery_4hr	2035	-	571	(571)
Arizona_Li_Battery_4hr	2035	-	870	(870)
Greater_LA_Li_Battery_4hr	2035	1,193	2,078	(885)
Southern_PGAE_Li_Battery_8hr	2035	-	1,058	(1,058)
Northern_California_Li_Battery_4hr	2035	2,198	3,751	(1,553)

Recommended – LLT (2030 LSE Plans)

Resource Level Summary: Incremental to 25-26 TPP Proposed Base Case (2045)

Solar & Wind Resources (MWs)

Likely to serve energy

Resource	Year	Recommended – LLT (2030 LSE Plans)	25-26 TPP	Delta
Morro_Bay_Offshore_Wind	2045	4,875	2,924	1,951
Humboldt_Bay_Offshore_Wind	2045	2,680	1,607	1,073
Arizona_Solar	2045	5,265	4,317	948
Solano_Wind	2045	454	405	49
Central_Valley_North_Los_Banos_Wind	2045	32	153	(121)
Northern_California_Solar	2045	121	366	(245)
Greater_Kramer_Solar	2045	4,438	4,867	(429)
Baja_California_Wind	2045	1,889	2,473	(584)
Tehachapi_Solar	2045	7,093	7,780	(688)
Southern_NV_Eldorado_Solar	2045	17,560	18,610	(1,050)
Southern_PGAE_Solar	2045	6,281	7,725	(1,443)
Greater_Imperial_Solar	2045	4,632	6,278	(1,646)

- LLT resources displace >1 GW of solar and batteries at Northern California, Southern PG&E, Southern Nevada – El Dorado, and Greater Imperial
- Baja California wind continues to be displaced, by not New Mexico Wind
- Similar to the 2035 Full LSE Plans case, battery builds are displaced or shift to Northern CA by 2045

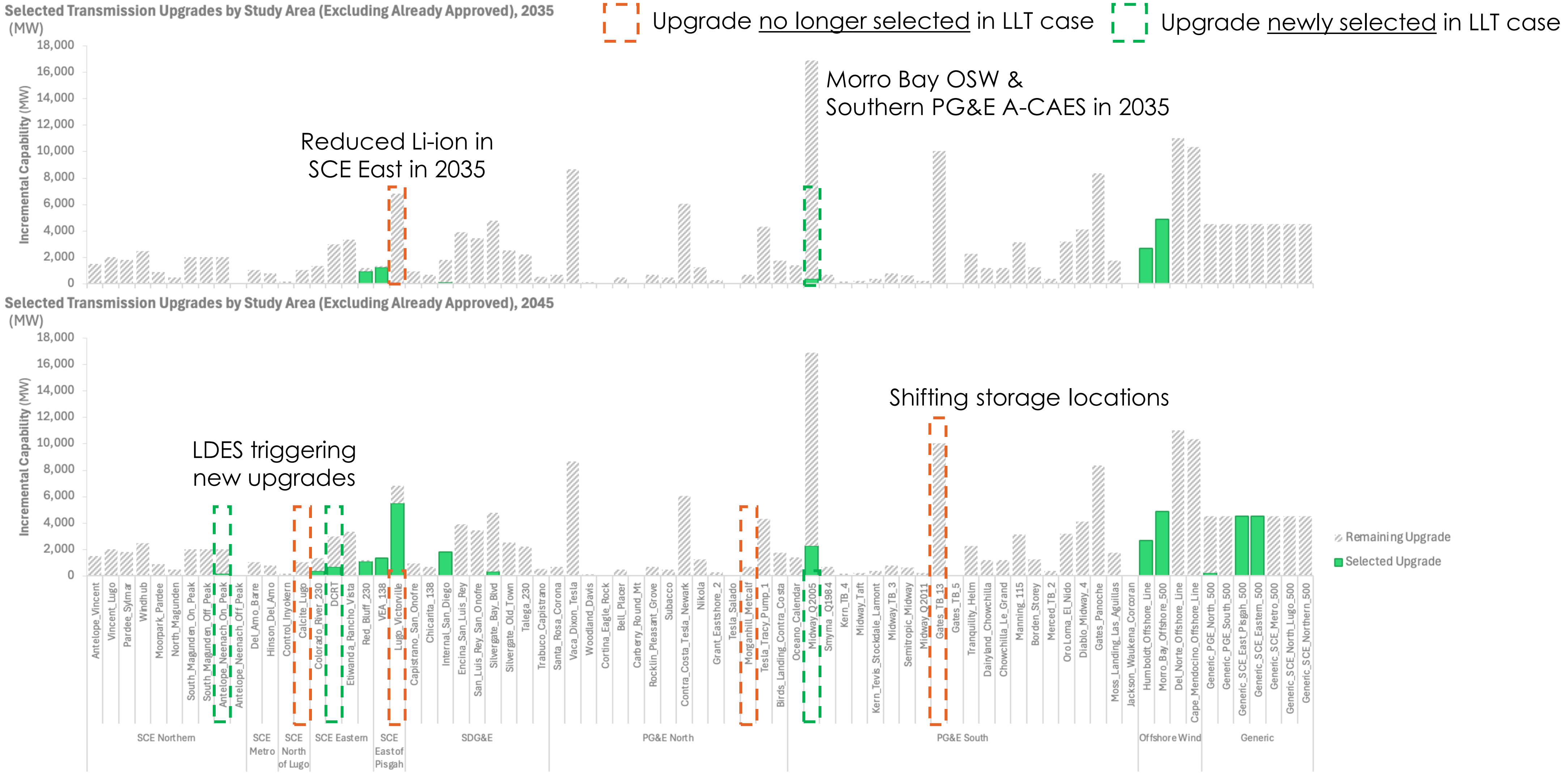
Storage, Geothermal, & Gas Resources (MWs)

Likely to serve capacity

Resource	Year	Recommended – LLT (2030 LSE Plans)	25-26 TPP	Delta
Arizona_Li_Battery_8hr	2045	935	-	935
Riverside_East_Pumped_Storage	2045	1,277	477	800
Greater_Imperial_Geothermal	2045	1,717	1,217	500
Southern_PGAE_Adiabatic_CAES	2045	400	-	400
Greater_LA_Li_Battery_8hr	2045	10,316	9,916	400
Greater_Imperial_Li_Battery_8hr	2045	948	637	311
Tehachapi_Adiabatic_CAES	2045	500	200	300
Riverside_West_Pumped_Storage	2045	500	279	221
Southern_PGAE_Flow_Battery	2045	54	-	54
Greater_Kramer_Li_Battery_4hr	2045	665	664	1
Southern_NV_Eldorado_Li_Battery_4hr	2045	3,591	3,602	(11)
Riverside_Li_Battery_4hr	2045	445	520	(75)
Southern_PGAE_Li_Battery_4hr	2045	2,233	2,395	(162)
Northern_California_Flow_Battery	2045	54	308	(254)
Southern_NV_Eldorado_Li_Battery_8hr	2045	3,212	3,504	(293)
Greater_Kramer_Li_Battery_8hr	2045	231	563	(331)
Riverside_Li_Battery_8hr	2045	-	485	(485)
Greater_Imperial_Li_Battery_4hr	2045	-	571	(571)
Arizona_Li_Battery_4hr	2045	-	870	(870)
Greater_LA_Li_Battery_4hr	2045	1,193	2,078	(885)
Northern_California_Li_Battery_8hr	2045	883	2,123	(1,240)
Northern_California_Li_Battery_4hr	2045	2,198	3,751	(1,553)
Southern_PGAE_Li_Battery_8hr	2045	2,184	3,871	(1,687)

Recommended – LLT (2030 LSE Plans)

RESOLVE-Selected Transmission Upgrades



Excludes upgrades already approved by CAISO and modeled as zero-cost in RESOLVE