26-27 Transmission Planning Process RESOLVE Modeling Results

R.25-06-019 Integrated Resource Planning

Attachment to Administrative Law Judge's Ruling

Energy Division Staff
September 30, 2025

California Public Utilities Commission

Contents

Overview of 26-27 TPP Proposed Portfolios Analysis

Overview of the CAISO's Transmission Planning Process

- Every year Commission staff develop a recommended set of 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 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, 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 project 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 can typically analyze 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
- The Commission adopted the 25-26 TPP portfolio in Decision (D.) 25-02-026. 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 achieves a 25 million metric ton (MMT) greenhouse gas (GHG) emissions target in 2035, including 4.5 gigawatts (GW) of offshore wind from CPUC jurisdictional LSEs' IRPs submitted in November 2022
  - The sensitivity portfolio was a potential long lead-time resource deployment future reflective of the upper bound of the CPUC's need determination that was adopted in D.24-08-064, pursuant to Assembly Bill 1373

Overview of 26-27 TPP Analysis

- Staff has conducted analysis to support the development of portfolios for consideration for study in CAISO's 26-27 TPP
  - The analysis builds off the 25-26 TPP portfolio that the Commission adopted in D.25-02-026
- This deck includes analysis for two TPP portfolio classifications:
  - A proposed 26-27 TPP Base Case
  - A proposed 26-27 TPP Sensitivity
- This deck also includes analysis for three additional portfolios not being recommended for TPP transmittal:
  - Least-cost Comparison Portfolio
  - Diablo Canyon Power Plant Retention Portfolio
  - GHG Reductions to 25 MMT
- The Commission will transmit a single base case portfolio and can consider transmitting an additional sensitivity portfolio to the CAISO for their TPP
- Comments are sought on the Administrative Law Judge's Ruling Seeking Comment on 26-27 TPP and Near-Term Procurement
  - Opening comments on are due on October 22, 2025
  - Reply comments are due on October 31, 2025

Upcoming Milestones for 26-27 TPP Portfolios

Milestone	Key dates
ALJ Ruling on 26-27 TPP and Near-Term Procurement	September 29, 2025
Party comments on ALJ Ruling	Opening comments: October 22, 2025 Reply comments: October 31, 2025
Staff workshop on busbar mapping	Early November
Proposed Decision	December 2025 – January 2026
Decision adopted by Commission	January-February 2026

26-27 TPP Case Matrix: Overview of Cases

A high-level summary of differences between the cases follows below. Key details of each case, including the input assumptions, are provided later in the deck.

Proposed Base Case: Partial AB1373 (Extended OSW Online Dates)
Proposed Sensitivity Case: Limited Wind

Case Name	Forced-in Procurement	Onshore Wind Availability	Offshore Wind Availability	Diablo Canyon Availability	New Gas Candidates	GHG Target	Load Forecast
Least-Cost Comparison Case	None	Base Potential	Base Potential	Retires in 2025, per SB 846	None	25 MMT by 2035 & 8 MMT by 2045	2024 IEPR Planning Scenario
Proposed Base Case	Half of maximum procurement amounts considered in D.24-08-064, per AB1373	Base Potential	Extends online dates	Retires in 2025, per SB 846	None	25 MMT by 2035 & 8 MMT by 2045	2024 IEPR Planning Scenario
Proposed Sensitivity Case	None	Reduced Potential	None	Retires in 2025, per SB 846	None	25 MMT by 2035 & 8 MMT by 2045	2024 IEPR Planning Scenario
GHG Reductions to 25 MMT	None	Base Potential	Base Potential	Retires in 2025, per SB 846	Allowed	25 MMT by 2035, held constant through 2045	2024 IEPR Planning Scenario
DCPP Extension	None	Base Potential	Base Potential	Extended through 2045	None	25 MMT by 2035 & 8 MMT by 2045	2024 IEPR Planning Scenario

Summary of Input Updates for 26-27 TPP Modeling

Status of Final 2025 I&A Document for the 2024-2026 IRP Cycle

- The Draft 2025 I&A document was released by Staff in February 2025 and laid out key data elements and sources of inputs and assumptions for the 2024-2026 IRP Cycle[1]
- The Final 2025 I&A document will be released by Staff following the forthcoming IRP Filing Requirements Ruling and Filing Requirements Base Portfolio
- Key updates to the Draft 2025 I&A used for modeling the TPP Portfolios are described in the following slides

1. Available at: https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/electric-power-procurement/long-term-procurement-planning/2024-26-irp-cycle-events-and-materials

Summary of RESOLVE Updates Since 25-26 TPP (1)

Further detail can be found in the 2025 Draft Inputs & Assumptions[1]

Data	Change
Zonal Topology (Disaggregation of CAISO)	CAISO RESOLVE zone disaggregated into PG&E, SCE, and SDGE, with associated data updates PG&E<>SCE transmission path expansion candidate(s) added to RESOLVE optimization Remote generator representation added to align with SERVM
Default Candidate Resources	Enhanced Geothermal (EGS) and Generic Long Duration Storage (LDES) added as default candidates Pumped Hydro (PHS) and Adiabatic Compressed Air Storage (A-CAES) combined into a single "Location-Constrained Storage" category
Candidate Regions	Updated to align with CAISO study areas used in transmission planning
Resource Cost	Updated to 2024 NREL ATB New capital cost assumptions for solar, onshore wind, and Li-ion battery New financing costs
Resource Potential	Updates to solar potential using 2024 BLM Western Solar Plan Additional location-constrained storage potential projects included
Minimum Builds	Near-term minimum build constraints added to RESOLVE to reflect recent LSE contracts incremental to the baseline resources (June 2025 IRP Procurement Compliance data)

1 https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/integrated-resource-plan-and-long-term-procurement-plan-irp-ltpp/2024-2026-irp-cycle-events-and-materials/2025_draft_inputs_and_assumptions_public_slides.pdf

Summary of RESOLVE Updates Since 25-26 TPP (2)

Data	Change
Baseline Resources	Updated to latest available data from CAISO, WECC, and LSE filings
Planned External (Non-CAISO) Builds	Updated to reflect most recent IRP Procurement Compliance data
Load Forecast & Profiles	Updated to 2024 IEPR Historical baseline profile updated to include 2021 & 2022
Generation Profiles	Updates to wind model used by staff to develop profiles 2021 and 2002 weather years included New hourly profiles for EGS to represent thermal ambient derates
Day Sampling	Updated 36 RESOLVE sample days incorporating latest load and generation profiles
PRM and ELCC Inputs	Updated target PRM % and resource ELCCs informed by SERVM runs 3D solar-storage surface with dimensions for solar, 4-hr battery, and 8-hr battery (multipliers for longer duration storage relative to 8-hr dimension)
GHG Target	Near-term trajectory updated to reflect historical GHG data up to 2022 Long-term trajectory updated to reflect higher CAISO load share for statewide GHG target
Dollar Year	Costs inflated to 2024 dollar year from 2022 dollar year
Inter-Day Sharing	Functionality in RESOLVE to track long duration storage state of charge over a chronological 8760 hours to enable energy sharing over multi-day and/or seasonal periods

Summary of RESOLVE Updates Since 2025 Draft I&A

Data	Change
Resource Regions	Designated candidate wind and geothermal areas in the portion of northeastern CA served by NVE as new Northeast CA region
Resource Potential and Land Use	• Updated to latest available CEC Protected Areas Layer and Core Land-Use Screen, including corrections to the incorporation of the 2024 BLM Western Solar Plan • Incorporated Global Wind Atlas wind speed data into wind resource potential analysis • Clarified treatment of in-state, non-CAISO wind and geothermal potential within IID and NVE service territories • Revised assumptions for estimating the near-field EGS resource potential
Resource Availability	Extended the first available year of Idaho Wind to 2031 due to recent federal policies
Transmission	EGS-resources fully modeled on the CAISO transmission system to study locational dependencies
Resource Cost	Incorporated latest federal policy impacts, including July 2025 Budget Reconciliation Bill and tariffs
Gas Retention Costs	Updated to increase over time to the cost of repowering. More information available in the appendix.

Baseline and Contracted Resources

26-27 TPP Proposed Base Case

Baseline Resources

- The IRP Baseline represents online and in-development resources, as of the 2025 Draft I&A
  - Online: from CAISO Master Generating Capability List (MGC), as of Spring 2024
  - In-Development: additional contracts found in the December 2023 LSE Filings (incremental contracts from later LSE filings are forced-in to RESOLVE as minimum builds

Resource Type (cumulative GW)	2026	2028	2031	2036	2041	2045
Natural Gas	26.4	26.4	26.4	26.4	26.4	26.4
CHP	2.4	2.4	2.4	1.9	-	-
Nuclear	0.6	0.6	0.6	0.6	0.6	0.6
Geothermal	1.8	2.1	2.1	2.1	2.1	2.1
Biomass	0.5	0.5	0.5	0.5	0.5	0.5
Biogas	0.3	0.3	0.3	0.3	0.3	0.3
Hydro	9.1	9.1	9.1	9.1	9.1	9.1
In-State Wind	6.5	6.5	6.5	6.5	6.5	6.5
Out-of-State Wind	1.5	3.1	3.1	3.1	3.1	3.1
Utility-Scale Solar	23.3	23.4	23.4	23.4	23.4	23.4
Customer (BTM) Solar	20.8	22.6	25.6	28.5	30.0	31.3
Li-ion Battery (4-hr)	14.2	14.5	14.5	14.5	14.5	14.5
Li-ion Battery (8-hr)	0.3	0.3	0.3	0.3	0.3	0.3
Location-Constrained Storage	1.6	1.6	1.6	1.6	1.6	1.6
Shed DR	3.4	3.4	3.4	3.4	3.4	3.4

Minimum Builds: LSE Contracted Resources

- Contracts incremental to the baseline found in the June 2025 IRP Compliance Filings are forced-in to RESOLVE as minimum builds

PG&E Minimum Builds

Technology	2026	2028	2031
Geothermal	67	68	68
In-State Wind	72	72	72
Out-of-State Wind	-	-	-
Solar	460	1,045	1,155
Battery Storage (4-hr)	852	1,411	1,521
Battery Storage (8-hr)	112	147	160

SCE Minimum Builds (MW)

Technology	2026	2028	2031
Geothermal	42	60	100
In-State Wind	-	-	-
Out-of-State Wind	535	535	535
Solar	2,126	3,829	3,829
Battery Storage (4-hr)	2,396	4,541	4,541
Battery Storage (8-hr)	41	876	876

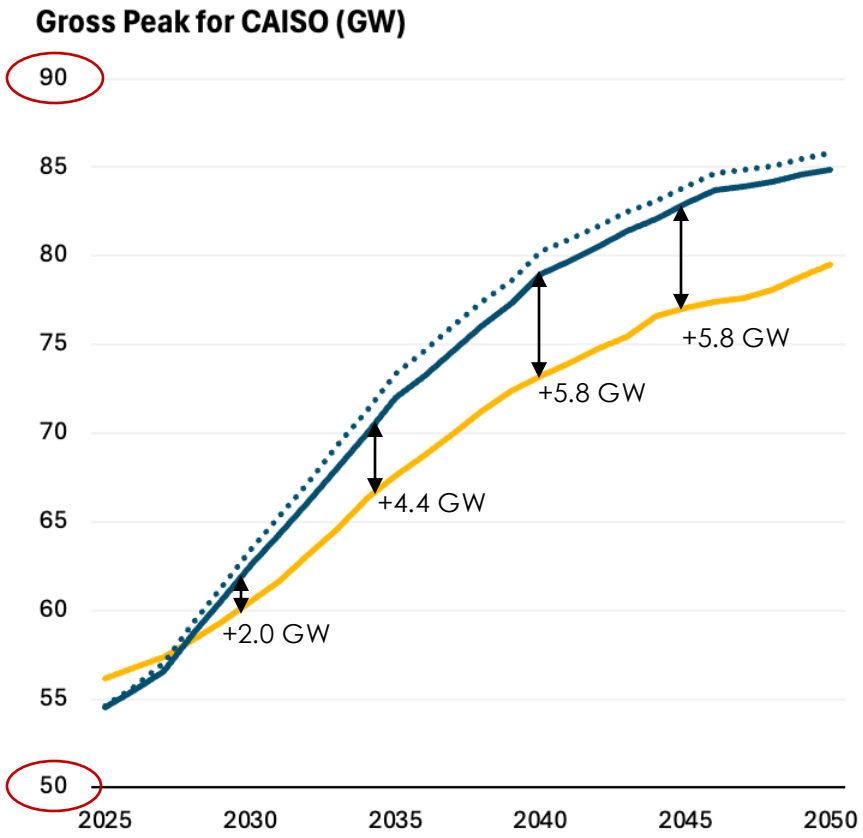
SDGE Minimum Builds (MW)

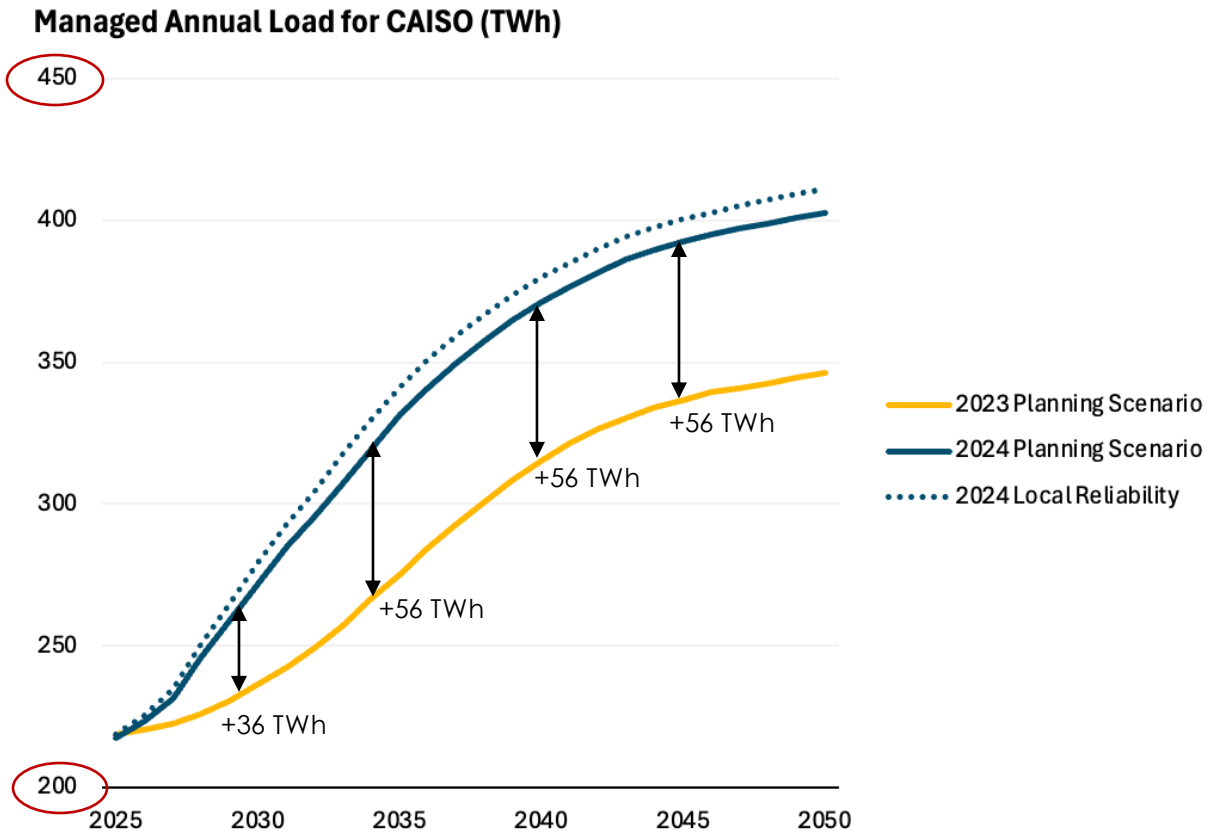
Technology	2026	2028	2031
Geothermal	-	-	-
In-State Wind	-	-	-
Out-of-State Wind	-	-	-
Solar	175	275	275
Battery Storage (4-hr)	660	760	760
Battery Storage (8-hr)	25	25	25

2024 IEPR Load Forecast

The 2024 IEPR Forecast Drives Additional Resource Needs

- Forecasts for both system peak and annual energy grow significantly in the 2024 IEPR, compared to the 2023 IEPR, driving increased capacity and GHG-free energy needs

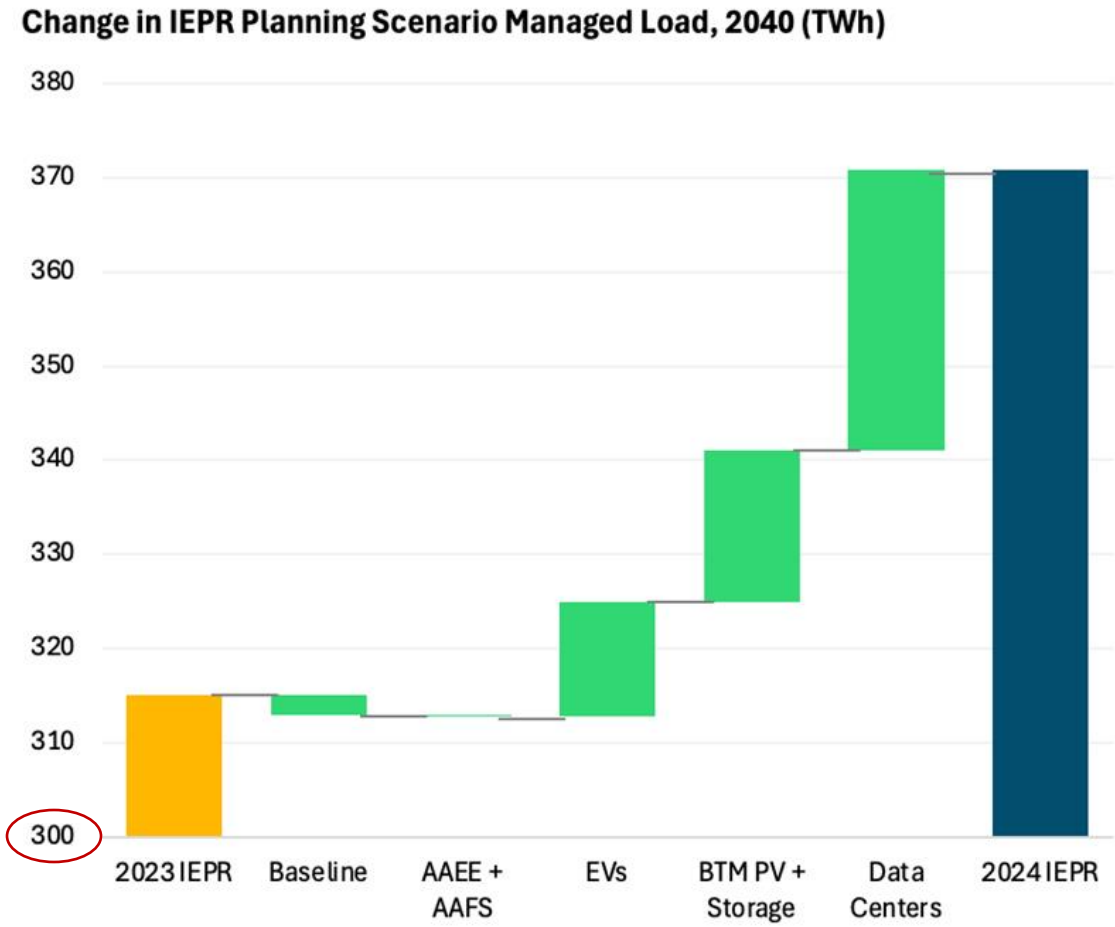




Gross Peak is Managed Peak (sales & losses) + BTM PV. In RESOLVE, Gross Peak and Energy includes the effects of AAEE, AAFS, EV charging, climate change, data centers, and BTM storage. In SERVM, "consumption" peak and energy is modeled, separate from all the above load modifiers including BTM PV. All figures here assume no BTM CHP retirement. which is implemented as a change to baseline consumption in RESOLVE

2024 IEPR vs. 2023 IEPR: Managed Load Waterfall

- Increases in load are primarily driven by:
  - The introduction of significant data center loads in the 2024 IEPR by 2040
  - Less adoption and lower capacity factors for BTM Solar and Storage
  - Updates to electric vehicles, including higher vehicle miles travelled (VMT)
- Changes to the baseline, energy efficiency (AAEE), and building electrification (AAFS) are relatively small
  - In the 2030s, AAFS demand is higher in the 2024 IEPR, but is similar by 2040



Managed load = sales + losses

2024 IEPR Total Load by Component

- Baseline consumption remains the bulk of total load by 2040, but most growth is driven by electrification and data centers
  - Managed load grows by 157 TWh from 2024 to 2040; ~80% of this is driven by EVs, building electrification (AAFS), and data centers
  - BTM PV and energy efficiency (AAEE), which reduce load, grow more slowly
- By 2040, EVs grow to 23% of <u>total</u> managed load, followed by building electrification (10%) and data centers (8%)

Load Component	2024 Load	2040 Load
Baseline	241 TWh	271 TWh
Climate Impacts	~0	2 TWh
Building Electrification (AAFS)	~0	37 TWh
Baseline LDVs	1 TWh	37 TWh
Baseline MHDVs	~0	9 TWh
Policy-Driven (AATE) LDVs	~0	33 TWh
Policy-Driven (AATE) MHDVs	~0	7 TWh
Data Centers	1 TWh	30 TWh
BTM Storage Losses	~0	<1 TWh
BTM PV	-28 TWh	-45 TWh
Energy Efficiency (AAEE)	-2 TWh	-11 TWh
Total Managed Load	**214 TWh**	**371 TWh**

EVs

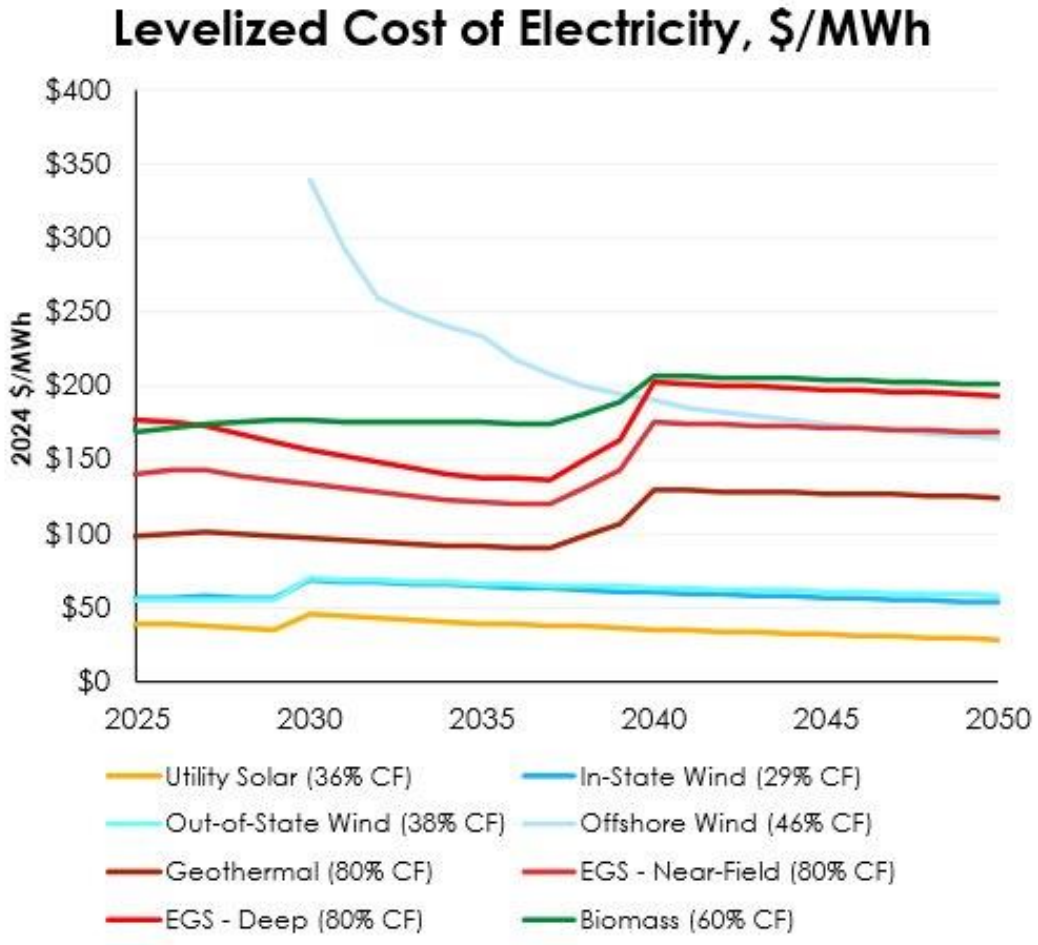
Managed load = sales + losses; loads less than 0.2 TWh in 2024 are listed as ~0 (approximately zero)

Resource Cost Updates

Changes from 2025 Draft Inputs & Assumptions

Summary of Resource Cost Updates

- Policy trajectories shifted materially in Q2 2025, leading to the following updates:
  - Impacts of the OBBBA are reflected via revised tax credit assumptions for renewables, energy storage, and other clean firm technologies
  - Wide-ranging tariffs were announced and applied across U.S. trading partners, impacting every technology but which are especially impactful for technologies dependent upon imports from China and Southeast Asia
- Additional policy drivers of near-term resource costs, including Anti-Dumping and Countervailing Duties (AD/CVD) and Foreign Entities of Concern (FEOC) regulations, are being monitored for additional Treasury guidance but are not reflected in these updates



Tax Credit Assumption Updates

- The OBBBA has ended tax credits for wind and solar projects that fail to commence construction by July 3, 2026
- Energy storage and clean-firm technologies retain tax full eligibility through 2032, as well as safe-harboring provisions and the three-year phase-out established in the IRA

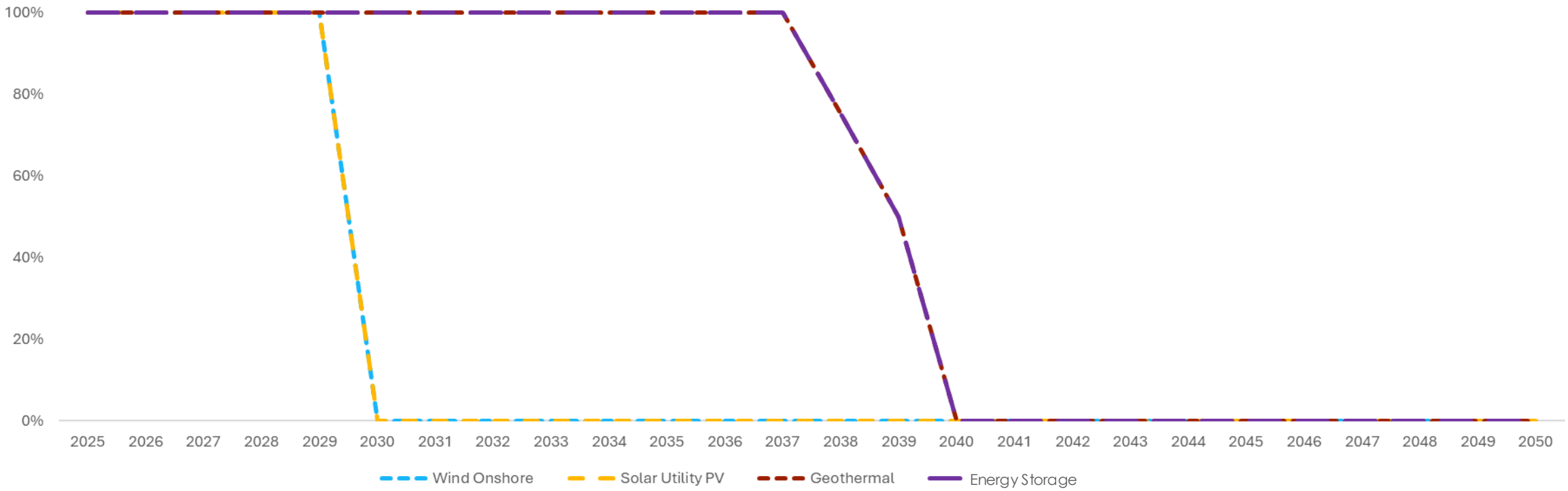


Figure adapted from E3 RECOST (2025 Q3), https://www.ethree.com/tools/recost-model/

Tariff Assumptions for Key Technologies

- Current tariff and tax policy (post-OBBBA) is assumed to last through 2029, reflecting precedent in federal trade policy
- U.S. trade policy impacts by technology are estimated by assessing the supply chains of imported components by country, and applying the latest tariff rates (as of mid-July 2025) to the proportions of project CAPEX attributable to those imports
- Tariff impacts are largest for solar and Li-ion battery storage, which source most of their components from China and Southeast Asia
- These results assume that solar developers will be able to adapt their supply chains to avoid AD/CVD penalties
- The BESS supply chain is uniquely dependent on imports from China, which is subject to some of the highest tariffs applied under current U.S. policy

Tariff Impacts for Key Technologies

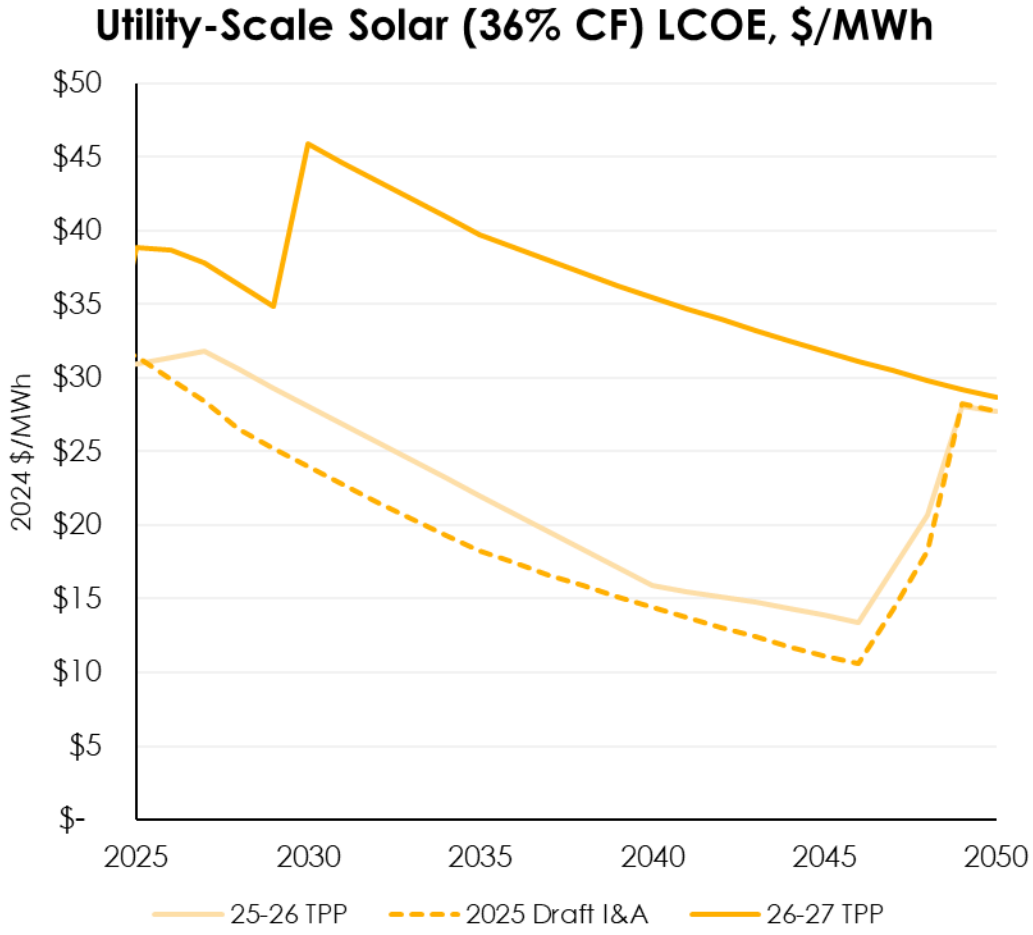
Technology	Key Imports (Countries)	Capex at Risk (% Total)	Weighted Average Tariff (% Rate Applied to Capex at Risk)
Wind (Onshore)	Nacelle, rotors, towers (Mexico, Germany)	55%	29%
Solar (Utility PV)	Module and BOS (Vietnam, China)	44%	70%
BESS (Standalone, Li-ion)	Cabinets and BOS (China)	73%	121%

Figure adapted from E3 RECOST (2025 Q3), https://www.ethree.com/tools/recost-model/

RESOLVE Updates

Utility-Scale Solar Cost Updates

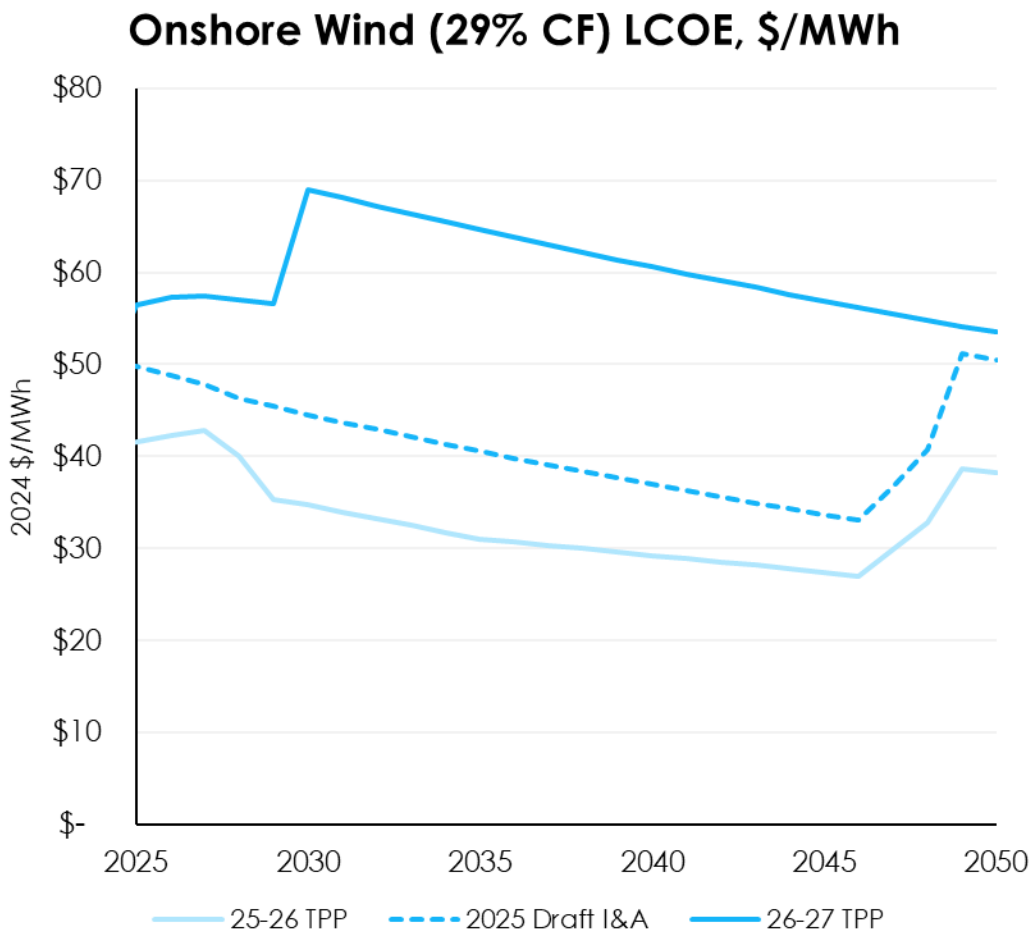
- Under the base tariff rates, utility-scale solar LCOE is estimated to increase by ~25% in the near-term, with additional impacts once the supply of safe-harbored modules is exhausted by 2030
- Additional impacts due to AD/CVD and FEOC regulations are not captured here; the tariff exposure risk for projects unable to adjust their material suppliers is extremely high



Note: LCOE is not used as an input in IRP modeling and is reported as reference only.

Onshore Wind Cost Updates

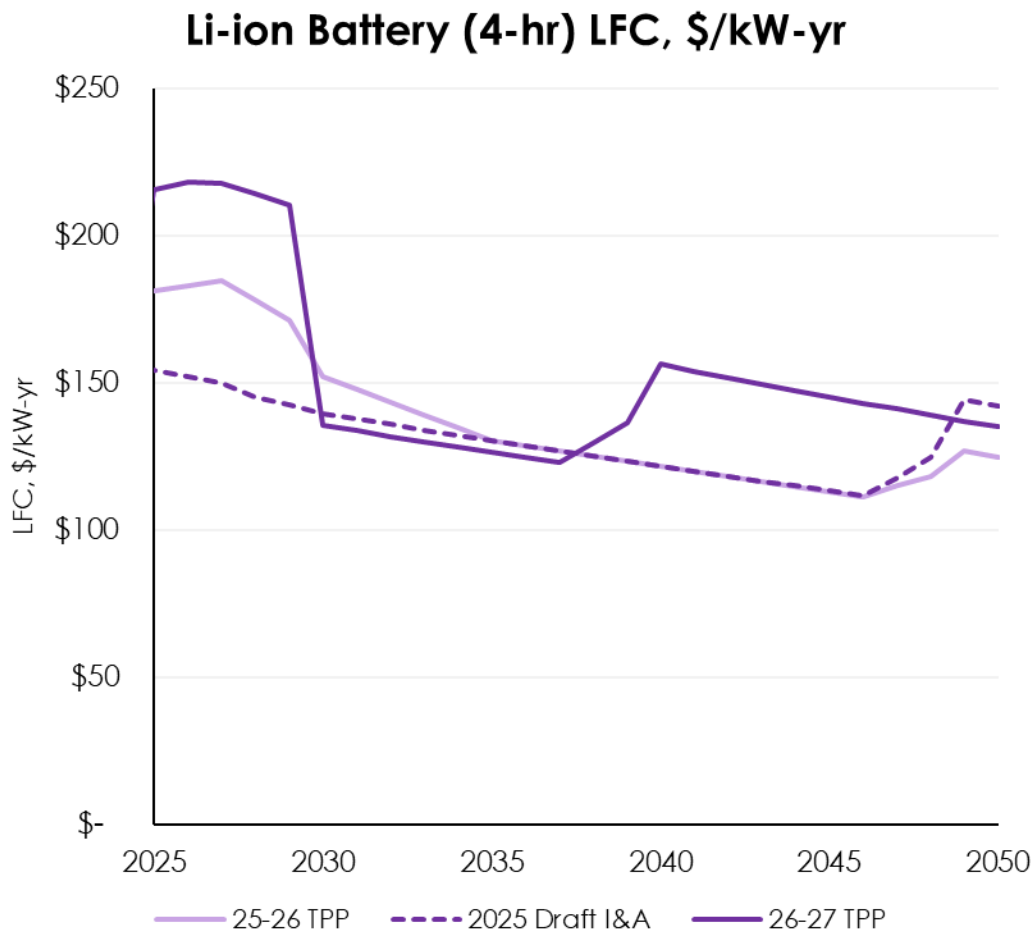
- The supply chain for wind turbines is less impacted by tariff policy
- Onshore wind projects face additional pressures from recent federal policies delaying or canceling projects sited on federal land or seeking federal permits
  - These near-term pressures are not assumed to impact resource procurements in the timeline of the TPP (2036-2041)



Note: LCOE is not used as an input in IRP modeling and is reported as reference only.

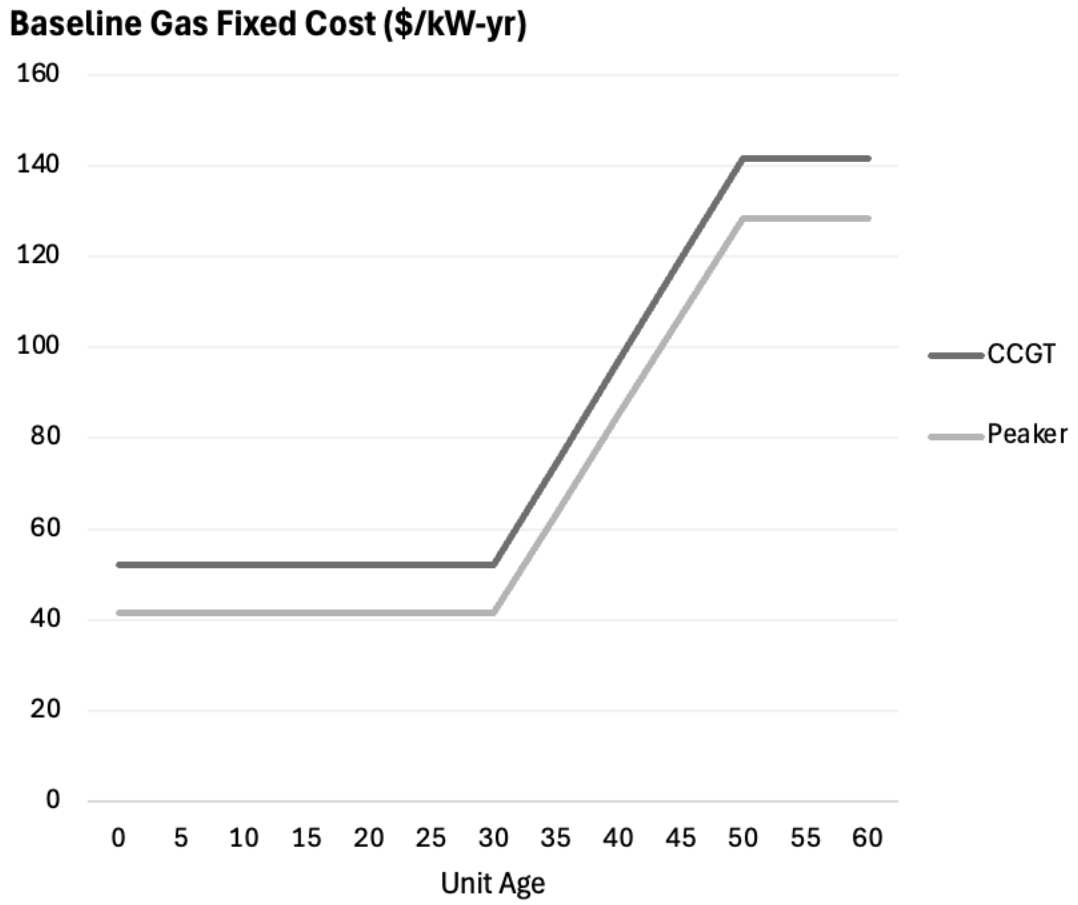
Li-ion Battery Storage Cost Updates

- The supply chain for battery storage components is highly dependent on suppliers in China, which has been flagged as a Foreign Entity of Concern (FEOC) by the DOE
- Under preliminary federal guidance, BESS project developers will need to demonstrate that the majority of CAPEX is not sourced from Chinese suppliers, or else risk forfeiture of federal tax credits
- Battery costs in RESOLVE include tariff impacts on Li-ion battery storage costs assuming pre-OBBBA resource supply chains, but does not consider FEOC restrictions on tax credit eligibility



RESOLVE Gas Retention Costs

- First 30 years of life use the gas fixed O&M costs from previous cycles, derived from the CEC[1]
- From the age of 50 years, baseline gas unit costs are equal to the cost of repowering (brownfield costs, as a % of greenfield (new) costs), plus the Fixed O&M of a new unit
  - CCGT: Brownfield costs 90% of greenfield
  - Peaker: Brownfield costs 86% of greenfield
- Linear increase from age 30 to 50

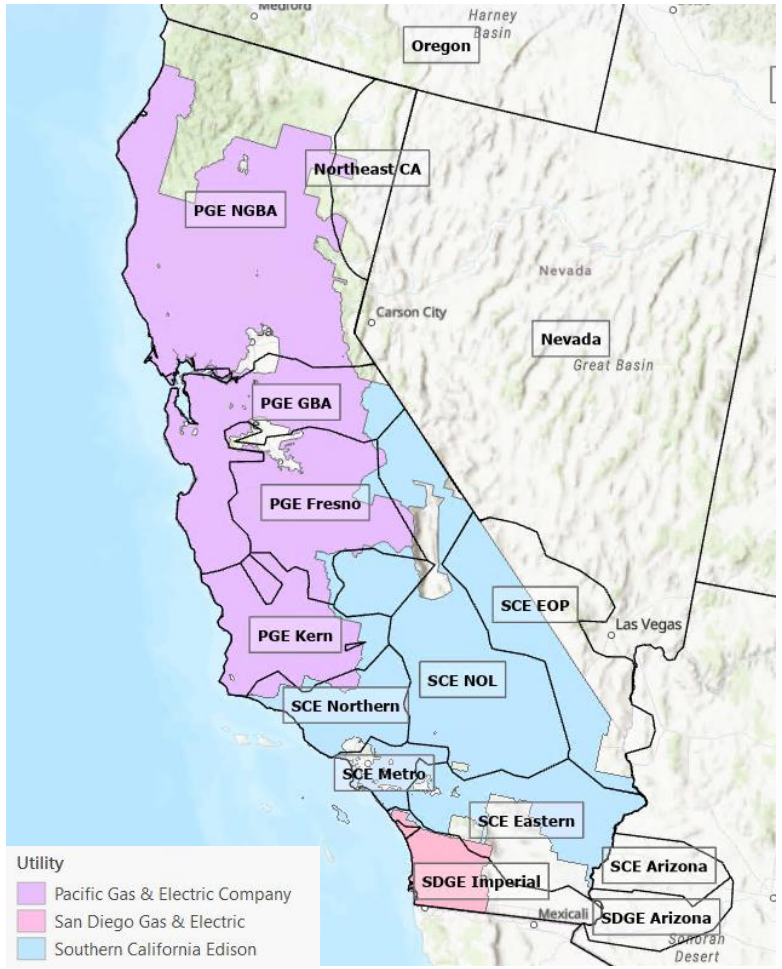


1 CEC Cost of New Generation Report: https://www.energy.ca.gov/sites/default/files/2021-06/CEC-200-2019-005.pdf; costs in real 2022$

Resource Potential and Transmission Updates

Changes from 2025 Draft Inputs & Assumptions

New Candidate Resource Regions using CAISO Study Areas



- The resource potential regions used in RESOLVE have been updated to align with the CAISO Study Areas used in transmission planning
  - Resource potential is assigned to substations, which are assigned to Study Areas in the CAISO White Paper[1]
- Assignments to RESOLVE zones are as follows:
  - PG&E: North of Greater Bay Area (NGBA), Greater Bay Area (GBA), Fresno, Kern
  - SCE: Northern, Metro, North of Lugo (NOL), Eastern, East of Pisgah (EOP), Arizona
  - SDGE: Imperial, Arizona
- Arizona substations owned by the CAISO are divided between SCE and SDGE
- The GLW/VEA systems modeled as part East of Pisgah
- **Candidate wind and geothermal resources near NVE-owned transmission lines in northeastern California are represented as a separate region**

1 https://www.caiso.com/library/transmission-capability-estimate-inputs-for-cpuc-integrated-resource-plan-aug-29-2024

Solar Resource Potential

- In the 2023 I&A and 25-26 TPP, the in-state solar resource potentials were calculated using the 2023 CEC Core Land-Use Screens
  - Additional 80% discounts were applied to account for overall feasibility to develop (not reflected in 1st column at right)
- After incorporating updated CEC datasets[1] and evaluating the BLM 2024 Western Solar Plan (WSP) exclusions, an additional 50% reduction is recommended for regions that are not significantly impacted by the BLM 2024 WSP and fall outside the DRECP:
  - All PG&E areas
  - SCE Northern
  - SCE Metro

Resource Regions	2023 I&A (MW)	BLM WSP (MW)	Reduction (%)[1]	26-27 TPP (MW)[2]	Overall Adjustment (%)
PG&E NGBA	124,146	111,219	10%	55,768	55%
PG&E GBA	38,741	40,123	-4%	19,903	49%
PG&E Fresno	90,708	87,979	3%	44,113	51%
PG&E Kern	53,678	55,663	-4%	27,708	48%
SCE Northern	44,467	46,267	-4%	22,959	51%
SCE Metro	1,017	859	16%	429	58%
SCE NOL	21,512	21,696	-1%	21,696	-1%
SCE Eastern	18,606	36,394	-96%	36,394	-96%
SCE EOP	72,653	29,530	59%	29,704	59%
SCE Arizona	91,812	42,194	54%	42,194	54%
SDGE Imperial	13,147	13,382	-2%	13,382	-2%
SDGE Arizona	68,813	44,402	35%	44,402	35%
Total	**639,301**	**445,857**		**358,653**	

[1] Negative reductions caused by updates to the CEC Core Land Use Screen, primarily fixes to the GAP analysis in SCE Eastern as part of an updated Base Exclusions layer, that were not reflected in the 2023 I&A

[2] Final values for 26-27 TPP reflect additional reassignments of resource clusters due to transmission topology

In-State Wind Resource Potential Updates

- The in-state wind resource potential in RESOLVE has been updated to incorporate one new data layer, and updates to two CEC land-use screens:
  - Global Wind Atlas (GWA) Mean Annual Wind Speed[1] (replacing NREL supply curve)
  - CEC Protected Areas Layer[2]
  - CEC Core Land-Use Screen[3]
- GWA publishes mean annual wind speeds at 100-m hub height and 250-m lateral resolution; a minimum annual average wind speed of 6.5 m/s was set as the cut-off value for commercial viability
- The techno-economic screen[4] and updated PAL and environmental screens are subtracted from the high-wind-speed areas to yield the net acreage suitable for development
- For RESOLVE, available land area is divided using a 4-km grid into candidate project areas; each area is screened for a minimum suitable project area of 0.5 km^2 (~1 turbine) and maximum distance of 30 miles from an electrical substation
- MW potentials for RESOLVE are estimated using a 40 acre/MW density factor

[1] https://globalwindatlas.info/en/
[2] *To be discussed in a later section. This layer includes data for CAISO-controlled portions of southern Nevada and western Arizona*
[3] *To be discussed in a later section. This layer only applies to California; out-of-state regions use the WECC Environmental Risk Class dataset*
[4] https://cecgis-caenergy.opendata.arcgis.com/datasets/b99eaaf368c54953844b578a92b0cd63_0/explore

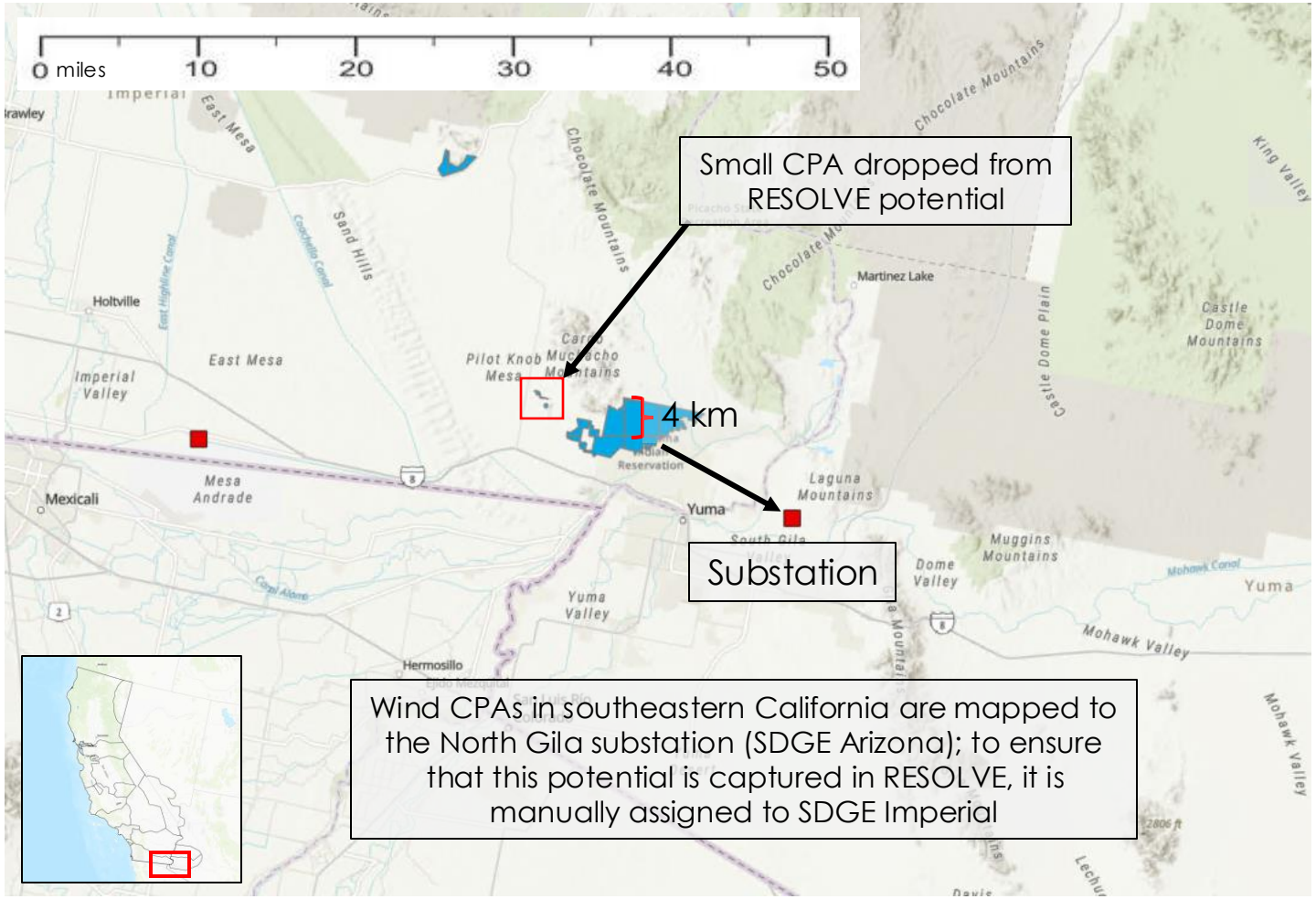
Wind Potential Totals by Study Area (MW)

Study Area	2025 Draft I&A	26-27 TPP	Delta
Northeast CA	N/A	584	+584
PG&E NGBA	2,872	1,894	-978
PG&E GBA	231	245	+14
PG&E Fresno	2,228	-	-2,228
PG&E Kern	91	245	+154
SCE Northern	1,701	2,447	+746
SCE Metro	-	-	-
SCE NOL	948	1,243	+295
SCE Eastern	165	819	+654
SCE EOP	1,399 (1)	241	-1,158
SDGE Imperial	251	971 (2)	+415
Baja California	2,473	1,654 (3)	-819
Total	**12,359**	**10,344**	**-2,015**

[1] The SCE EOP total from the Draft I&A assumes a 50% haircut to the total potential; no additional haircut is applied to the updated 26-27 TPP result
[2] Includes 305 MW of wind in southeastern CA interconnecting to the North Gila substation in AZ
[3] The Baja California potential was revised based on review of projects in the CAISO interconnection queue

Converting Land Area to Resource Potential in RESOLVE

- Land area is partitioned using a 4-km fishnet
- Each 4-km square becomes a "candidate project area" (CPA)
- MW totals are calculated using density factors:
  - Solar: 8.24 acre/MW (DC)
  - Wind: 40 acre/MW
- CPAs are assigned to substations using a nearest-neighbor algorithm
- All CPAs are screened for a maximum distance to nearest substation of 30 miles
- Wind CPAs are additionally filtered for a minimum viable project size of 3.3 MW[1]
- The resource potential is first summed to produce totals by substation; then, the potentials for RESOLVE are calculated by summing across the substations within each Study Area



[1] *Represents the T3 turbine rating from NREL 2024 ATB: https://atb.nrel.gov/electricity/2024/land-based_wind.*

In-State Geothermal Resource Potential

- The in-state geothermal resource potential comes from the latest CEC geospatial data layer containing footprints of known geothermal fields[1]
- After accounting for existing projects, planned development, and protected area exclusions, a total of 33 geothermal fields are identified and grouped by region
- Geothermal fields in IID service territory area (reported here under SCE Eastern and SDGE Imperial) are assumed to be available for procurement, with tie-in locations at Mirage and Imperial Valley
  - **Northeast CA Geothermal and SCE Eastern Geothermal (delivered to Mirage) will incur additional transmission costs**

Resource Regions	Conventional Geothermal Potential, MW
Northeast CA	178
PG&E NGBA	668 [2]
SCE NOL	142
SCE Eastern	1,883 [3]
SDGE Imperial	529
Total	**3,399**

[1] Geothermal Resource Potential by Field, CEC 2024
[2] Excludes 18 MW at the Geysers reported as "In Development" in the CPUC Generator Baseline.
[3] Excludes 44 MW near the Salton Sea reported as "In Development" in the CPUC Generator Baseline.

Near-Field EGS Resource Potential

- Near-Field EGS resources are assumed to represent next-generation geothermal projects under consideration in California and neighboring states
- The in-state near-field EGS resource potential, following NREL[1], is assumed to be equal to the hydrothermal resource potential
  - **Northeast CA EGS and SCE Eastern EGS (delivered to Mirage) will incur additional transmission costs**
- The out-of-state near-field EGS potential is assumed to match the "Mean" Undiscovered Resources as reported in USGS Fact Sheet 2008-3082[2]

Region	Hydrothermal Potential (MW)	Near-Field EGS Potential (MW)
Northeast CA	178	178
PG&E NGBA	668 [3]	668
SCE NOL	142	142
SCE Eastern	1,883 [4]	1,883
SDGE Imperial	529	529
Nevada	1,451	4,364
Utah	184	1,464
Oregon	520	1,893
Idaho	-	1,872
Total	**5,554**	**12,992**

[1] *Augustine, C. et. al. NREL, 2023.* https://www.nrel.gov/docs/fy23osti/84822.pdf.
[2] *Williams, C. et. al. USGS, 2008.* https://pubs.usgs.gov/fs/2008/3082/pdf/fs2008-3082.pdf.
[3] *Excludes 18 MW at the Geysers reported as "In Development" in the CPUC Generator Baseline.*
[4] *Excludes 44 MW near the Salton Sea reported as "In Development" in the CPUC Generator Baseline*

Enhanced Geothermal Resource Potential Totals

- EGS is assumed to be available for procurement in California, Oregon, Nevada, Idaho, and Utah
- For deep EGS, only the in-CAISO (including IID) 3-km potential will be used in IRP modeling; all out-of-state deep EGS (including Northeast CA) will be excluded
- The representation of deep EGS on transmission is expanded to represent the full locational dependency of the resource potential on the transmission system
- All non-CAISO EGS will incur additional transmission costs to deliver to the CAISO system

Resource Region	Near-Field EGS (MW)	Deep EGS (3 km) [1,2]
PG&E	668	15,461
SCE	2,025	1,115
SDGE	529	438
CAISO Total	3,224	17,016
Northeast CA[3]	178	4,264
Nevada[3]	4,364	Not modeled
Oregon[3]	1,893	Not modeled
Idaho[3]	1,872	Not modeled
Utah[3]	1,464	Not modeled

[1] In-state totals reflect amounts within 30 miles of electrical substation. Out-of-state totals reflect total potential.

[2] Based on the amount of Deep EGS potential at 3-km depth, and the incremental drilling costs to access EGS at deeper depths, only the Deep EGS potential at 3-km will be modeled in RESOLVE

[3] Transmission pathways for non-CAISO EGS are assumed to be identical to those for hydrothermal resources

Annual Resource Build Limits

Note: This is a modeling build limit and has no direct impact on actual build rate.

- In the 2025 Draft I&A MAG webinar, Staff updated the near-term solar build limit to 4,000 MW/year through 2028, based on annual procurement rates from LBNL Tracking the Sun[1] and the CAISO Master Generating Capability List (MGC)[2]
  - For the 26-27 TPP, the limits have been revised to reflect the system need required to meet GHG policy in 2028
- For the 26-27 TPP, Staff introduced near-term build limits for in-state wind and geothermal, reflecting commercial interest, procurement challenges, and project deployment timelines
  - Wind: 250 MW/year through 2030, 1,000 MW/year from 2031 through 2035
  - Geothermal: 200 MW/year through 2032
- The full resource potential, subject to resource-level near-term build limits and transmission deliverability constraints, will continue to restrict capacity additions after these constraints are relaxed

Technology (Cumulative MW)	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036+
Utility-Scale Solar	4,000	9,000	15,000	Full potential							
In-State Wind	250	500	750	1,000	1,250	2,250	3,250	4,250	5,250	6,250	Full
In-State Geothermal	200	400	600	800	1,000	1,200	Full potential				

1 https://emp.lbl.gov/utility-scale-solar; 2 http://oasis.caiso.com/mrioasis/logon.do

Near-Term Wind Resource Build Limits by Study Area

- Additional restrictions for wind resources were identified by reviewing the CAISO interconnection queue, Cluster 15 project queue, and queues from neighboring jurisdictions; these limits restrict wind procurements up until 2035

Resource (Cumulative MW)	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035+
Northeast CA Wind	300	300	300	300	300	300	1,015	1,015	1,015	Full Potential
PG&E NGBA Wind	0	206	206	206	206	206	206	206	206	
PG&E GBA Wind	266	266	990	990	1,399	1,399	1,399	1,399	1,399	
PG&E Fresno Wind	80	80	80	80	80	80	292	292	292	
SCE Northern Wind	0	0	100	206	206	206	206	206	206	
SCE NOL Wind	0	213	213	316	316	316	316	316	316	
SCE Eastern Wind	0	0	0	0	676	676	676	676	676	
SCE EOP Wind	1,050	3,618	3,618	3,719	3,719	3,719	3,719	3,719	3,719	
SDGE Imperial Wind	0	0	194	194	194	700	1,701	1,701	1,701	
SDGE Baja California Wind	353	353	353	353	353	353	653	653	653	

Near-Term Geothermal Resource Build Limits by Study Area

- Additional restrictions for geothermal resources were identified by reviewing the CAISO interconnection queue, Cluster 15 project queue, and queues from neighboring jurisdictions; these limits restrict geothermal procurements up until 2035

Resource (Cumulative MW)	2026	2027	2028	2029	2030	2031	2032+
Northeast CA Geothermal	0	0	0	0	Full potential		Full Potential
PG&E NGBA Geothermal	0	0	0	0	Full potential		
SCE NOL Geothermal	0	0	0	0	Full potential		
SCE Eastern Geothermal	83	140	357	671	Full potential		
SDGE Imperial Geothermal	0	83	83	83	Full potential		
PG&E Oregon Geothermal	0	0	0	0	Full potential		
PG&E Nevada Geothermal	0	0	0	0	Full potential		
SCE Nevada Geothermal	288	387	411	411	411	411	
SCE Utah Geothermal	0	40	40	80	Full potential		

26-27 TPP Proposed Base Case Portfolio

Proposed 26-27 TPP Base Case Overview

- Proposed base case designed to be similar to the 25-26 TPP base case with similar policy assumptions
  - Incorporates the 25 MMT GHG target by 2035 (same as 25-26 TPP and 24-25 TPP)
  - Same amount of offshore wind forced in (i.e. half of D.24-08-064 potential, the decision pursuant to AB 1373), but extends the online dates
  - Updated to the 2024 IEPR Planning Scenario (25-26 TPP base case used the 2023 IEPR planning scenario)
    - General increase in selected capacity for 26-27 TPP (when compared to 25-26 TPP base case) due to increased load in the 2024 IEPR; peaks in the 2030s at ~30 GW
- For the proposed Base Case Portfolio staff studied a case that reflects a partial buildout of the maximum procurement volumes considered in the Commission's need determination analysis pursuant to D.24-08-064, related to Assembly Bill (AB) 1373. Staff also included a Least-Cost comparison case.
  - Refer to Appendix for 26-27 TPP Least Cost comparison Portfolio
- CAISO's study of these portfolios focuses on model years that are 10 and 15 years in the future:
  - 2036 — 10-year projection
  - 2041 — 15-year projection

Input from D.24-08-064 Procurement, per AB 1373

- AB1373 (Garcia, 2023) authorizes centralized procurement of specified Long Lead-Time (LLT) resources[1], including geothermal, offshore wind, and long duration storage (LDES) with different durations
- For the 26-27 TPP, the proposed base case requires RESOLVE to select **half of the maximum procurement amounts** specified by the CPUC need determination (D.24-08-064), to come online from 2031-37[2]
- Offshore wind online dates are assumed to be extended from dates used in previous TPP portfolios
  - Morro Bay online in 2036
  - Humboldt online in 2041

AB1373 Minimum Builds

Procurement Type	Minimum Build	Note
Offshore Wind - Morro Bay	2.9 GW	Online 2036
Offshore Wind - Humboldt	1.6 GW	Online 2041
Geothermal	0.5 GW	
Long Duration Storage (12+hr)	0.5 GW	
Long Duration Storage (Multi-Day)	0.5 GW	

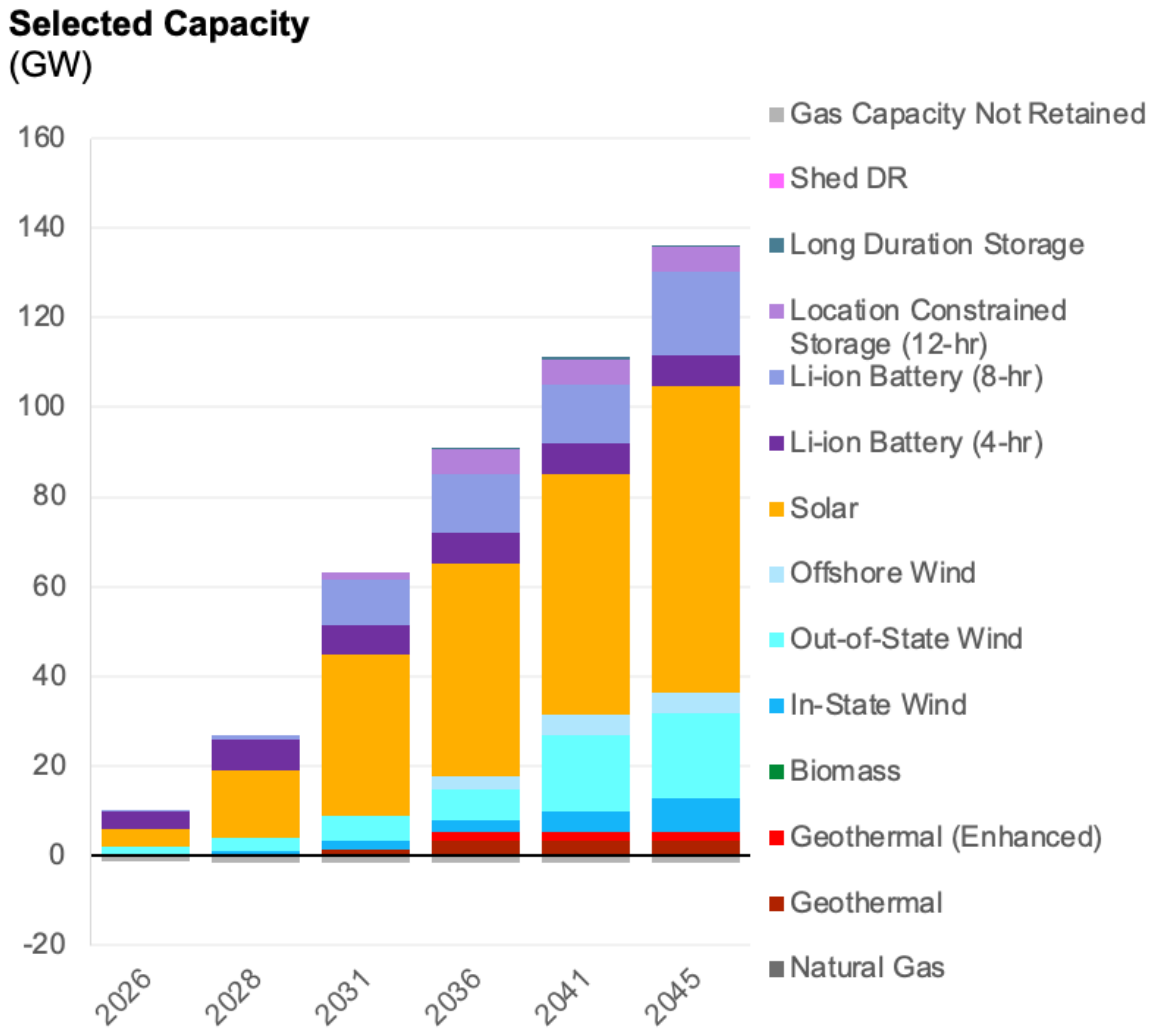
1 Centralized procurement activity would be carried out by the California Department of Water Resources (DWR), when requested by the CPUC

2 https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M539/K202/539202613.PDF

RESOLVE Modeling Results: 26-27 TPP Proposed Base Case Portfolio

26-27 TPP Proposed Base Case

Selected Builds



Geothermal is selected for reliability needs due to its high ELCC and high capacity-factor, GHG-free energy; most of the conventional geothermal potential is built out by 2036, and EGS is also built in that year (prior to the expiration of tax credits)

Almost all available out-of-state wind is selected; near-term in-state wind build limits bind through 2028, and the loss of tax credits slows adoption until the 2040s

Solar and storage are resources that scale to meet growing GHG-free energy demand

Small amounts of gas with high fixed O&M are non-retained early on

The partial amounts of the maximum procurement volumes of offshore wind and multi-day storage as considered in AB1373, are forced in; RESOLVE selects above partial AB1373 procurement forced-in amounts for geothermal and location-constrained LDES

26-27 TPP Proposed Base Case

Selected Builds

Note: Generating portfolios is Step #1 as part of the Busbar Mapping Process. See Assumptions for the 2026-2027 TPP for the latest Busbar Mapping Methodology document

- New resources (nameplate GW), both LSE planned and RESOLVE selected, above the IRP-RESOLVE modeling resource baseline (See Slide 14)

Resource Type (cumulative GW)	2026	2028	2031	2036	2041	2045
Natural Gas	-	-	-	-	-	-
Geothermal	0.1	0.3	1.2	3.4	3.4	3.4
Geothermal (Enhanced)	-	-	-	1.7	1.7	1.7
Biomass	-	-	-	-	-	-
In-State Wind	0.3	0.8	2.0	2.6	4.8	7.7
Out-of-State Wind	1.4	2.9	5.5	7.0	17.0	19.0
Offshore Wind	-	-	-	2.9	4.5	4.5
Solar	4.0	15.0	35.9	47.5	53.7	68.5
Li-ion Battery (4-hr)	3.9	6.7	6.8	6.8	6.8	6.8
Li-ion Battery (8-hr)	0.2	1.0	10.0	13.2	13.2	18.6
Location Constrained Storage (12-hr)	-	-	1.6	5.4	5.4	5.4
Generic Long Duration Storage (12-hr)	-	-	-	-	-	-
Generic Long Duration Storage (24-hr)	-	-	-	0.5	0.5	0.5
Generic Long Duration Storage (100-hr)	-	-	-	-	-	-
Shed DR	-	-	-	-	-	-
Gas Capacity Not Retained	(1.3)	(1.7)	(1.7)	(1.7)	(1.7)	(1.7)

Selected Builds – Forced-in vs. RESOLVE-Selected

- Significant amounts of conventional geothermal and location-constrained storage are selected beyond AB1373 forced-in amounts
- RESOLVE does not select offshore wind or multi-day storage beyond the forced-in amounts, though the latter is selected a year earlier than required, likely to capture tax credits before expiration

	2036			2041			2045		
Resource/Input	**AB1373**	**RESOLVE-Selected**	**Total**	**AB1373**	**RESOLVE-Selected**	**Total**	**AB1373**	**RESOLVE-Selected**	**Total**
Conventional Geothermal	-	3.4 GW	3.4 GW	0.5 GW	4.6 GW	3.4 GW	0.5 GW	4.6 GW	3.4 GW
Enhanced Geothermal (EGS)	-	1.7 GW	1.7 GW			1.7 GW			1.7 GW
Offshore Wind	2.9 GW	-	2.9 GW	4.5 GW	-	4.5 GW	4.5 GW	-	4.5 GW
Location-Constrained Storage (12-hr)	-	5.4 GW	5.4 GW	0.5 GW	4.9 GW	5.4 GW	0.5 GW	4.9 GW	5.4 GW
Generic LDES (12-hr)	-	-	-		-	-		-	-
Generic LDES (24-hr)	-	0.5 GW	0.5 GW	0.5 GW	-	0.5 GW	0.5 GW	-	0.5 GW
Generic LDES (100-hr)	-	-	-		-	-		-	-

Totals rounded to the nearest 0.1 GW

26-27 TPP Proposed Base Case

Selected Builds by CAISO Study Area (2036)

Region	In-State Wind	Out-of-State Wind	OSW	Solar	Li-ion Battery (4-hr)	Li-ion Battery (8-hr)	Location-Constrained Storage (12-hr)	In-State Geothermal	Out-of-State Geothermal	EGS - Near Field	EGS - Deep
PG&E_Fresno	-	-	-	3,256	226	2,396	-	-	-	-	269
PG&E_GBA	247	582	-	684	612	45	149	-	-	-	87
PG&E_Kern	-	-	2,924	9,675	369	1,182	818	-	-	-	-
PG&E_NGBA	599	-	1,607	2,454	314	-	-	668	808	45	-
PG&E_Northeast_CA	-	-	-	-	-	-	-	178	-	-	-
SCE_Arizona	-	2,936	-	4,940	904	156	-	-	-	-	-
SCE_Eastern	372	-	-	4,646	470	-	1,800	7	-	-	-
SCE_EOP	255	4,100	-	690	638	748	500	-	1,069	-	-
SCE_Metro	-	-	-	5	1,365	6,874	-	-	-	-	-
SCE_NOL	-	-	-	543	542	6	386	142	-	-	-
SCE_Northern	-	-	-	6,082	623	969	1,280	-	-	-	-
SDGE_Arizona	-	-	-	14,207	85	1,198	-	-	-	-	-
SDGE_Baja_California	353	-	-	-	-	-	-	-	-	-	-
SDGE_Imperial	700	-	-	190	675	137	-	529	-	-	-

+ 500 MW Generic Long Duration Storage sited in SCE

SDGE Baja California interconnects at SDGE Imperial

26-27 TPP Proposed Base Case

Selected Builds by CAISO Study Area (2041)

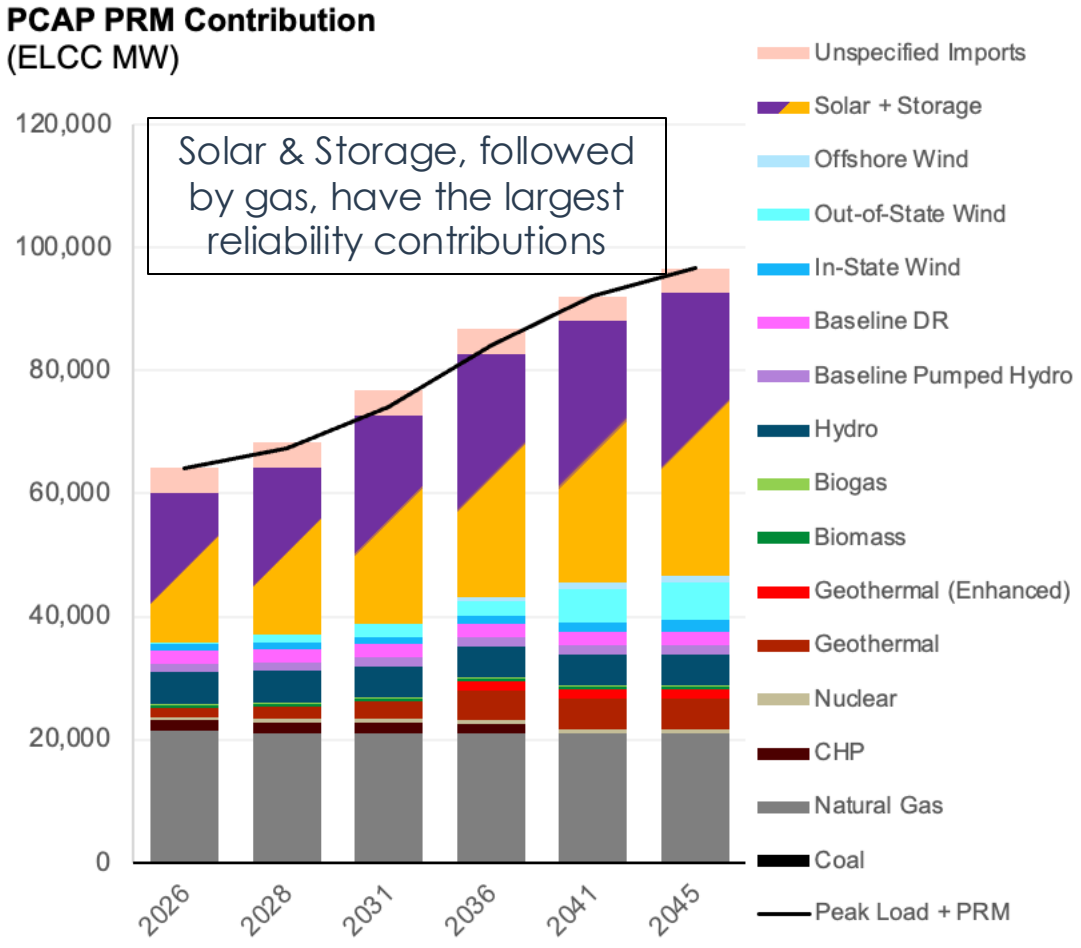
Region	In-State Wind	Out-of-State Wind	Offshore Wind	Solar	Li-ion Battery (4-hr)	Li-ion Battery (8-hr)	Location-Constrained Storage (12-hr)	In-State Geothermal	Out-of-State Geothermal	EGS - Near Field	EGS - Deep
PG&E_Fresno	-	-	-	6,034	226	2,396	-	-	-	-	269
PG&E_GBA	247	4,000	-	1,084	612	45	149	-	-	-	87
PG&E_Kern	-	-	2,924	9,675	369	1,182	818	-	-	-	-
PG&E_NGBA	1,867	-	1,607	2,466	314	-	-	668	808	45	-
PG&E_Northeast_CA	-	-	-	-	-	-	-	178	-	-	-
SCE_Arizona	-	8,936	-	4,940	904	156	-	-	-	-	-
SCE_Eastern	372	-	-	7,386	470	-	1,800	7	-	-	-
SCE_EOP	255	5,957	-	690	638	748	500	-	1,069	-	-
SCE_Metro	-	-	-	387	1,365	6,874	-	-	-	-	-
SCE_NOL	-	-	-	697	542	6	386	142	-	-	-
SCE_Northern	-	-	-	7,409	623	969	1,280	-	-	-	-
SDGE_Arizona	-	-	-	14,207	85	1,198	-	-	-	-	-
SDGE_Baja_California	1,654	-	-	-	-	-	-	-	-	-	-
SDGE_Imperial	700	-	-	190	675	137	-	529	-	-	-

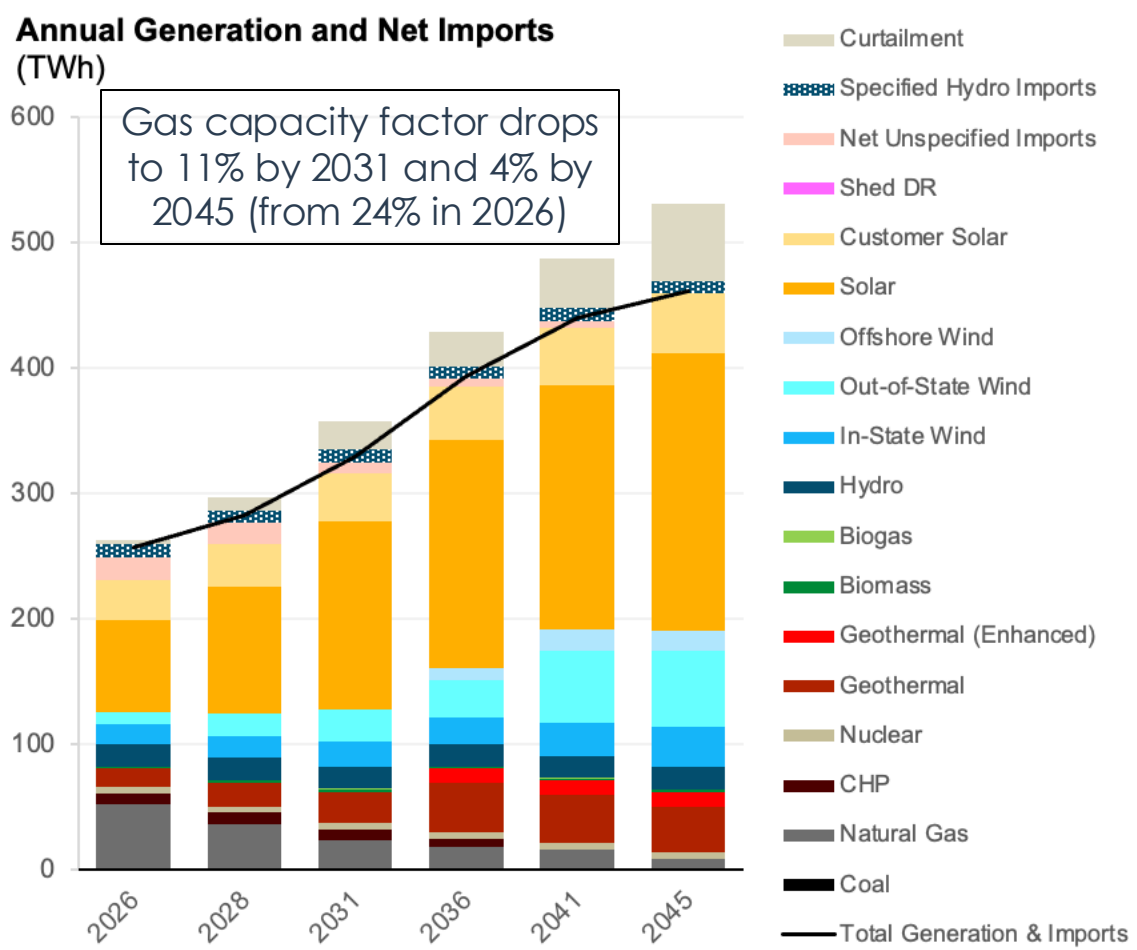
+ 500 MW Generic Long Duration Storage sited in SCE

SDGE Baja California interconnects at SDGE Imperial

26-27 TPP Proposed Base Case

Reliability and Energy Mix

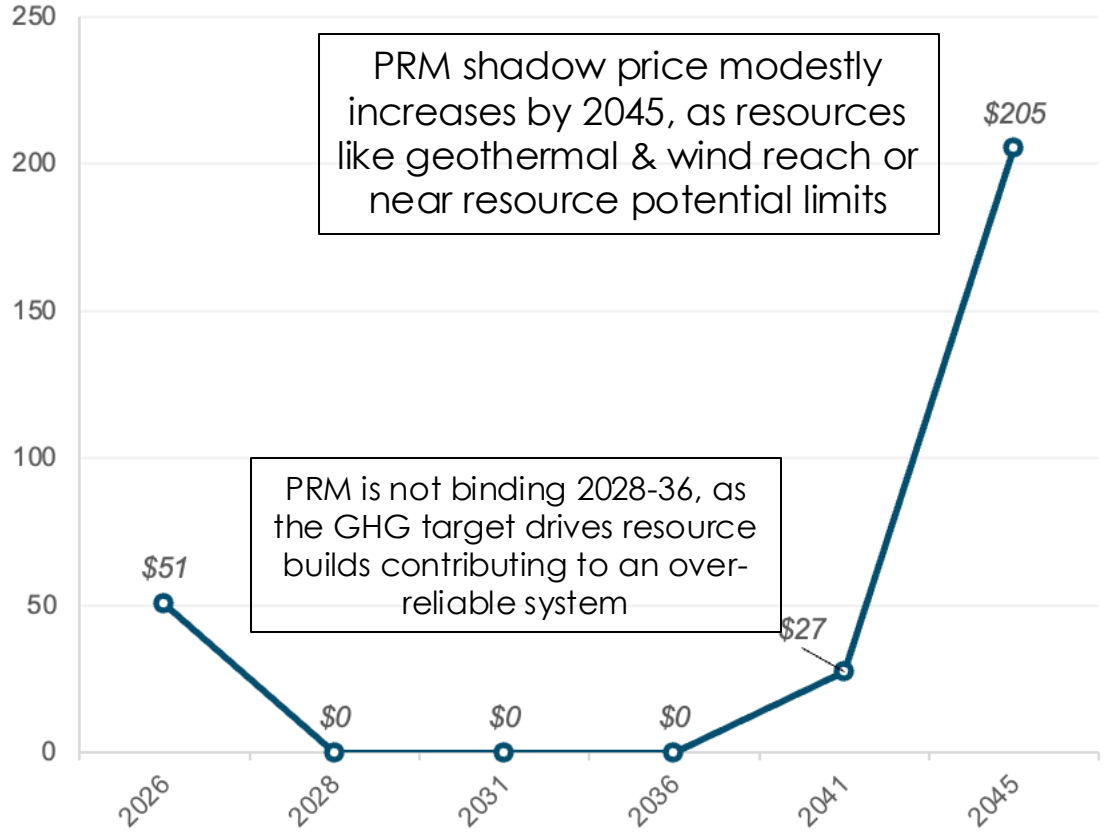




Planning Reserve Margin (PRM) and GHG Constraints

- Shadow prices represent the cost of meeting a constraint, i.e. the cost of the last kW of firm capacity or the last ton of GHG emissions reduction

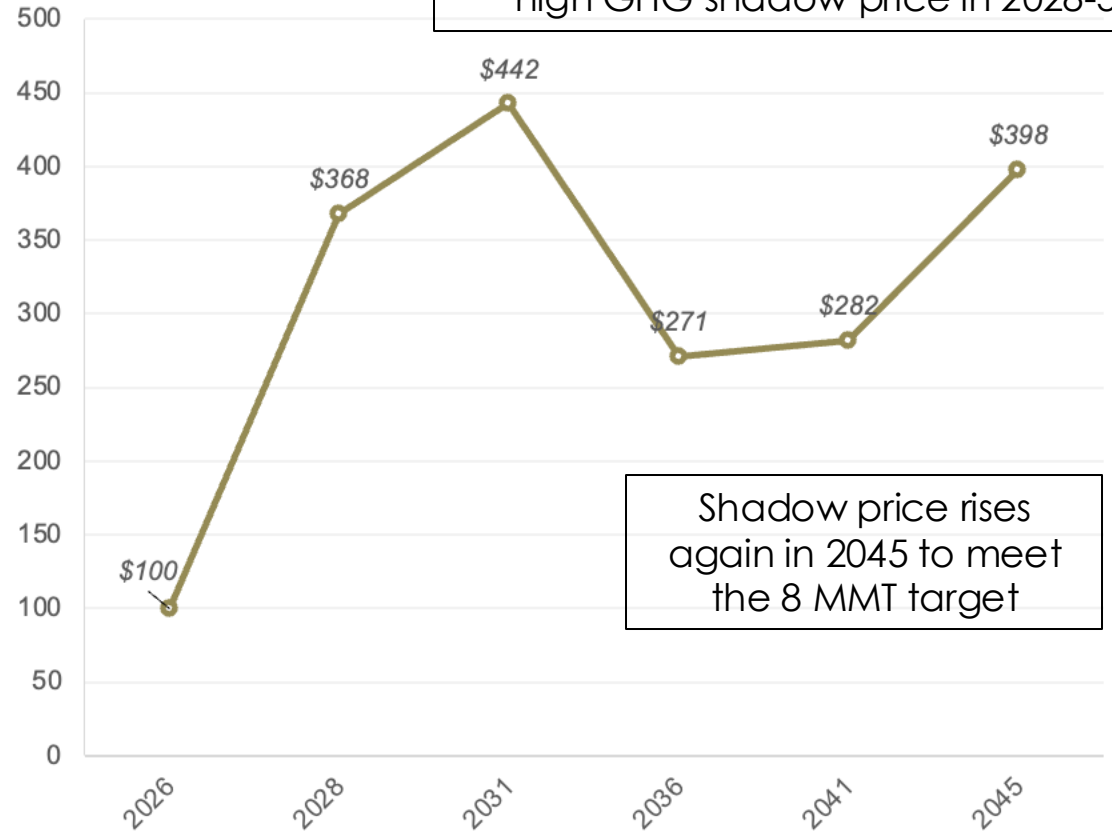
PRM Shadow Prices
($/kW-year)



PRM shadow price modestly increases by 2045, as resources like geothermal & wind reach or near resource potential limits

PRM is not binding 2028-36, as the GHG target drives resource builds contributing to an over-reliable system

GHG Target Shadow Price
($/ton CO_2)



Near-term build limits for wind and geothermal, along with tariffs, drive a high GHG shadow price in 2028-31

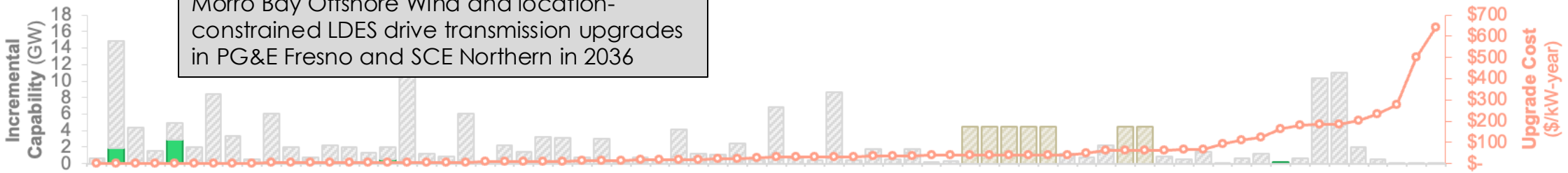
Shadow price rises again in 2045 to meet the 8 MMT target

Note: Officially selected transmission upgrades are determined by the CAISO Transmission Plan

RESOLVE-Selected Transmission Upgrades

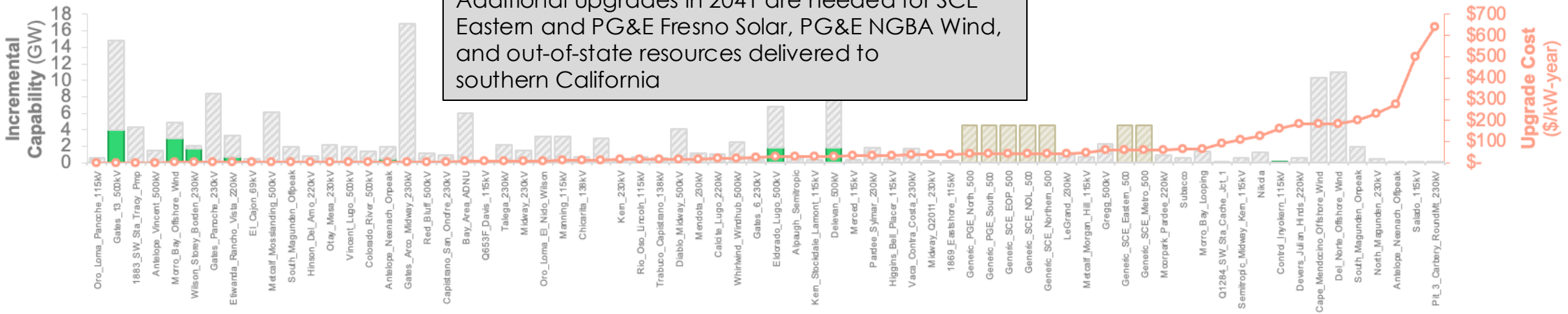
Selected Transmission Upgrades by Cost, 2036
(GW)

Morro Bay Offshore Wind and location-constrained LDES drive transmission upgrades in PG&E Fresno and SCE Northern in 2036



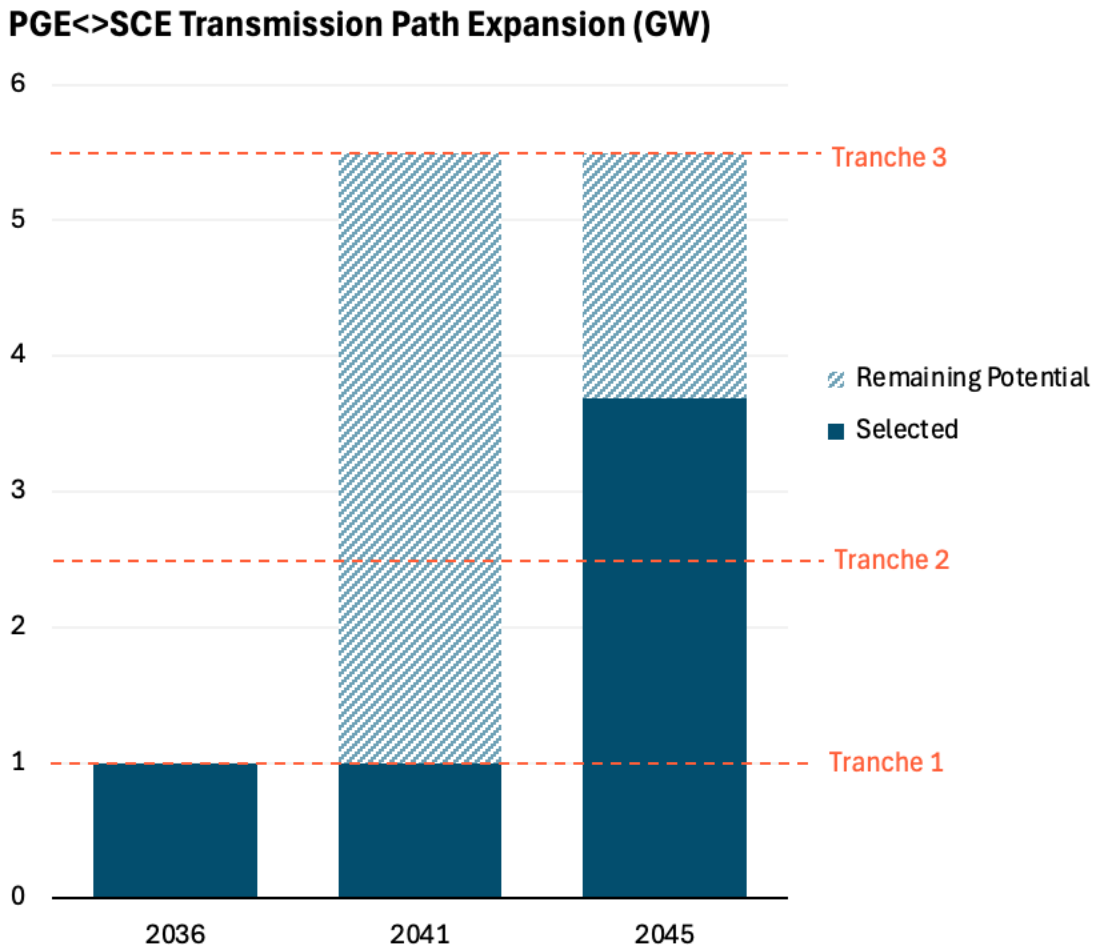
Selected Transmission Upgrades by Cost, 2041
(GW)

Additional upgrades in 2041 are needed for SCE Eastern and PG&E Fresno Solar, PG&E NGBA Wind, and out-of-state resources delivered to southern California



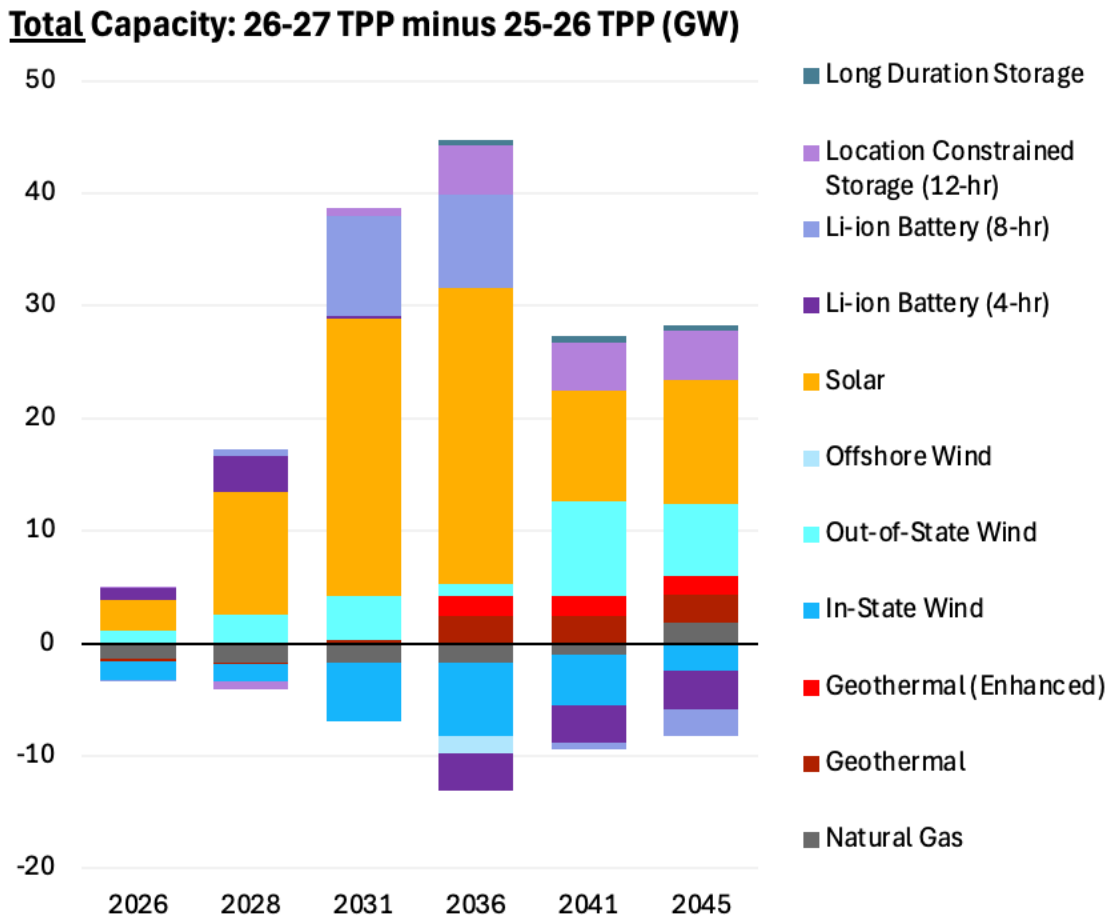
PG&E<>SCE Transmission Expansion

- Path 26/Path 15 expansion(s) are selected primarily to increase import capacity into PG&E
- The first tranche (1 GW) is optimally selected in the first available year (2036)
- An additional ~2.5 GW expansion, including all of tranche 2, is optimally selected in 2045



Total Capacity Comparison with the Adopted 25-26 TPP Base Case

- Note: both the previous and the upcoming TPP base case had some amount of resources forced-in, though quantities and resource types differ. Notably, the model never optimally selects offshore wind.
- General increase in selected capacity for 26-27 TPP due to increased load in the 2024 IEPR forecast
  - 25-26 TPP used the 2023 IEPR forecast; capacity differences peak at ~30 GW in the 2030s
- Most incremental capacity is solar, storage, and geothermal (the latter starting in the mid-2030s)
- Shifts from in-state to out-of-state wind, in part because of changing resource potential assumptions
- Extension of offshore wind online dates from 2032-35 to 2036-41
- Shifts from shorter- to longer-duration storage, in part because of significant amounts of 4-hr battery forced-in for 25-26 TPP
- Gas is not retained earlier in the 26-27 TPP, but more gas is retained by 2045



25-26 TPP results for 2031, 2036, and 2041 interpolated between model years

Total Capacity Comparison with the Adopted 25-26 TPP Base Case

Resource Type	2026	2028	2031	2036	2041	2045
Natural Gas	-	-	-	-	-	-
Geothermal	(0.2)	(0.2)	0.3	2.5	2.5	2.5
Geothermal (Enhanced)	-	-	-	1.7	1.7	1.7
Biomass	-	-	-	-	-	-
In-State Wind	(1.7)	(1.6)	(5.3)	(6.5)	(4.5)	(2.5)
Out-of-State Wind	1.1	2.6	3.9	1.1	8.4	6.4
Offshore Wind	-	-	-	(1.6)	-	-
Solar	2.8	10.9	24.6	26.3	9.8	11.0
Li-ion Battery (4-hr)	1.1	3.2	0.2	(3.3)	(3.3)	(3.3)
Li-ion Battery (8-hr)	(0.2)	0.6	8.8	8.3	(0.6)	(2.5)
Location Constrained Storage (12-hr)	0.1	(0.6)	0.8	4.3	4.3	4.3
Generic Long Duration Storage (12-hr)	-	-	-	-	-	-
Generic Long Duration Storage (24-hr)	-	-	-	0.5	0.5	0.5
Generic Long Duration Storage (100-hr)	-	-	-	-	-	-
Shed DR	-	-	-	-	-	-
Gas Capacity Not Retained (positive value = more capacity retained)	(1.3)	(1.7)	(1.7)	(1.7)	(1.0)	1.8

25-26 TPP results for 2031, 2036, and 2041 interpolated between model year

Baseline Capacity Comparison with the Adopted 25-26 TPP Base Case

- Staff updated the IRP baseline resources ahead of the 26-27 TPP to incorporate additional online and in-development resources[1]

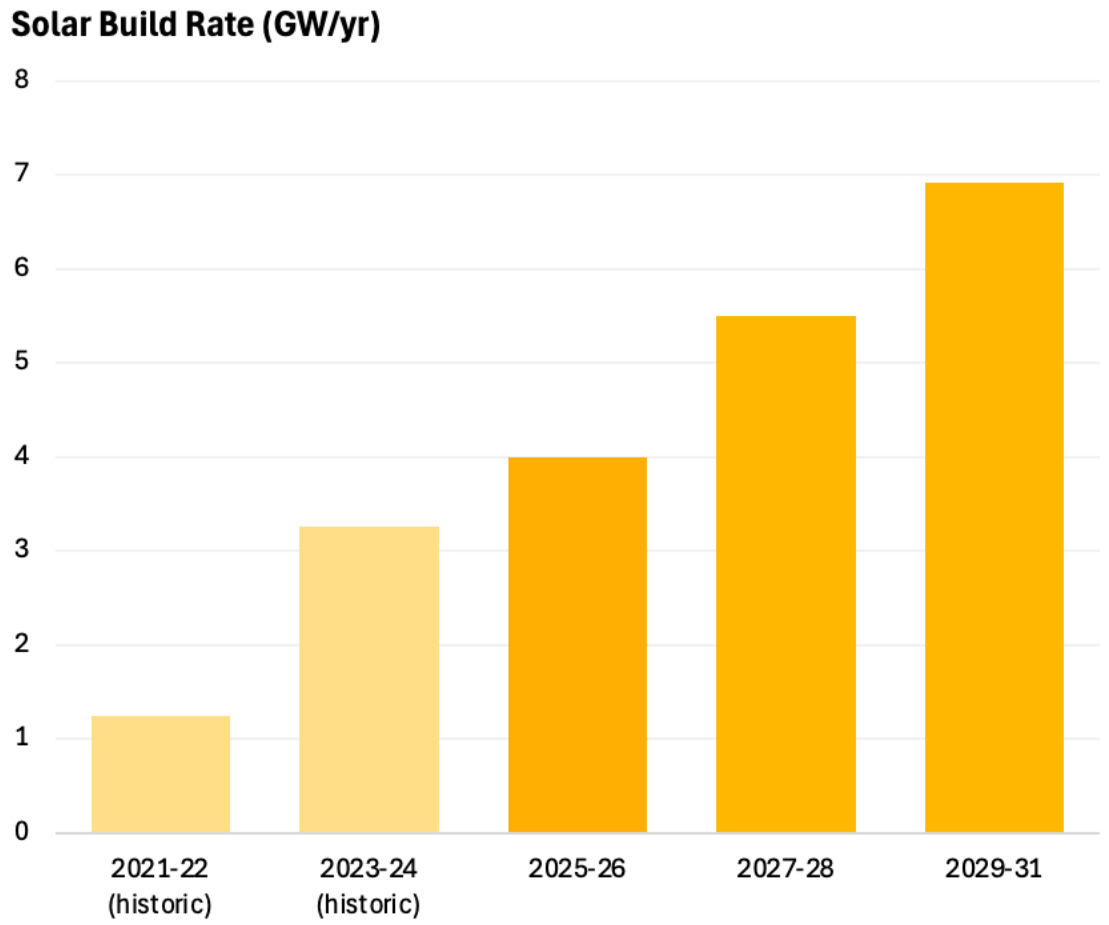
Resource Type	2026	2028	2031	2036	2041	2045
Natural Gas	-	-	-	-	-	-
Geothermal	-	0.3	0.3	0.3	0.3	0.3
Geothermal (Enhanced)	-	-	-	-	-	-
Biomass	-	-	-	-	-	-
In-State Wind	-	-	-	-	-	-
Out-of-State Wind	0.2	1.8	1.8	1.8	1.8	1.8
Offshore Wind	-	-	-	-	-	-
Solar	4.3	4.4	4.4	4.4	4.4	4.4
Li-ion Battery (4-hr)	5.2	5.5	5.5	5.5	5.5	5.5
Li-ion Battery (8-hr)	0.1	0.1	0.1	0.1	0.1	0.1
Location Constrained Storage (12-hr)	0.2	0.2	0.2	0.2	0.2	0.2
Generic Long Duration Storage (12-hr)	-	-	-	-	-	-
Generic Long Duration Storage (24-hr)	-	-	-	-	-	-
Generic Long Duration Storage (100-hr)	-	-	-	-	-	-
Shed DR	-	-	-	-	-	-

Accounting changes (e.g. NQC vs. nameplate reporting) excluded

1 https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/integrated-resource-plan-and-long-term-procurement-plan-irp-ltpp/2024-2026-irp-cycle-events-and-materials/2025_draft_inputs_and_assumptions_public_slides.pdf

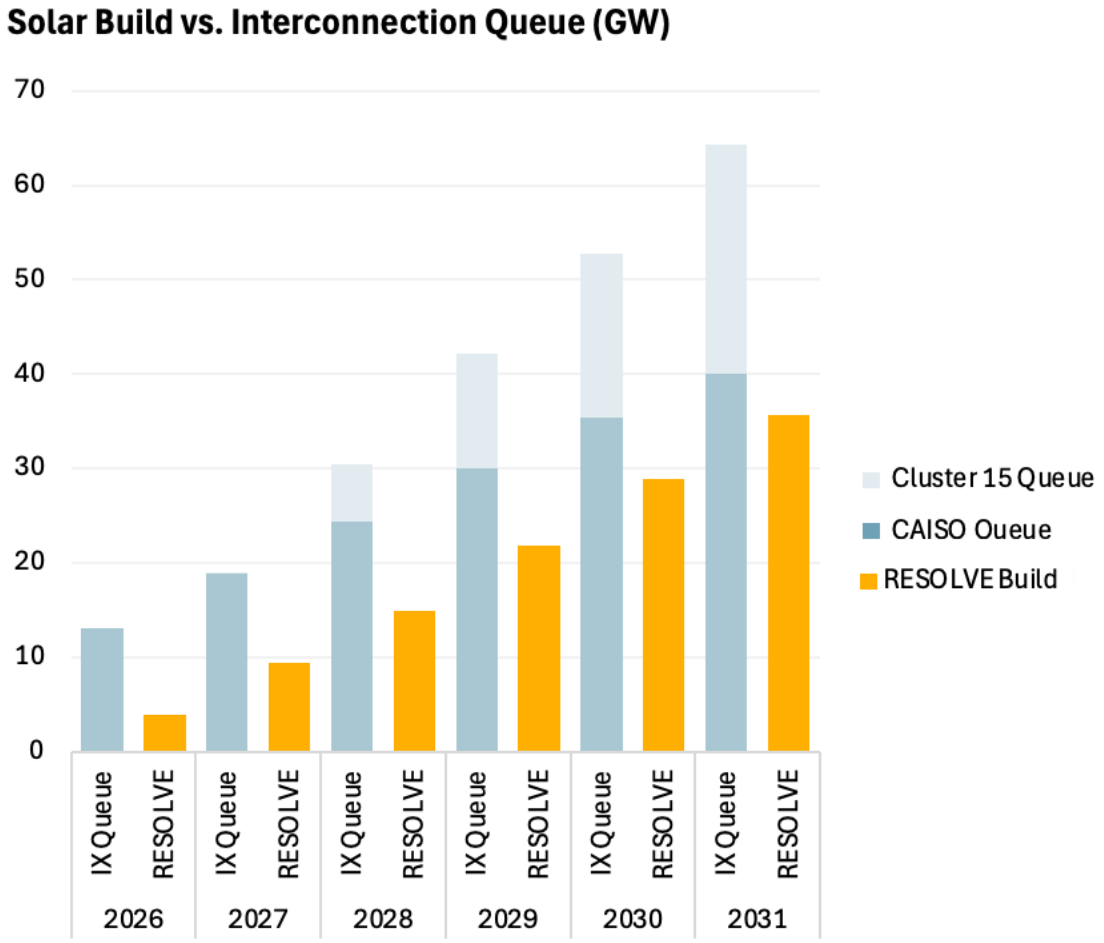
Solar Build Rates Through 2031

- Solar is the scalable energy resource due to near-term wind and geothermal limits, and significant builds are needed to meet the 2030 GHG target
- Build rate accelerates from ~3-4 GW/yr (recent historical) to ~7 GW/yr by 2030



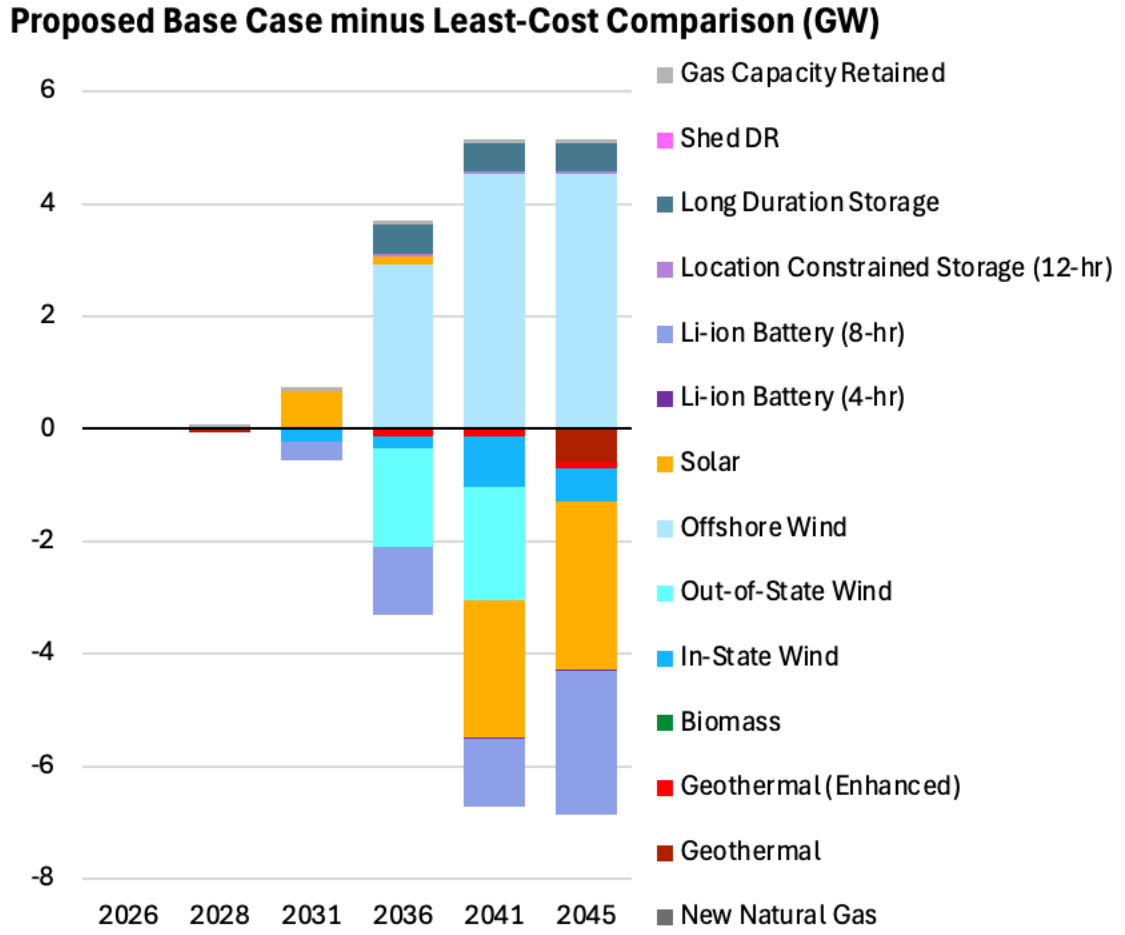
Solar Build: RESOLVE vs. Interconnection Queue

- By 2030, RESOLVE is selecting nearly the full amount of solar in the CAISO interconnection queue
- Cluster 15 queue would add some (potentially) available projects, but RESOLVE still selects well over half by 2030 to meet the GHG target



Selected Builds Comparison with Least-Cost Comparison Case

- Offshore wind and multi-day storage are forced-in to the proposed base case
  - AB1373 amounts of geothermal and 12-hr+ storage (full, not just partial) are already exceeded in least-cost comparison case
- Forced-in offshore wind and multi-day storage primarily displace solar and battery, and a small amount of in-state wind
  - ~2 GW out-of-state wind extended from 2035 to 2045
  - Small amount of geothermal (above AB1373 amounts) avoided in 2045



System Cost Comparison with Least-Cost Comparison Case

RESOLVE-Optimized Costs ($MM in 2024$)

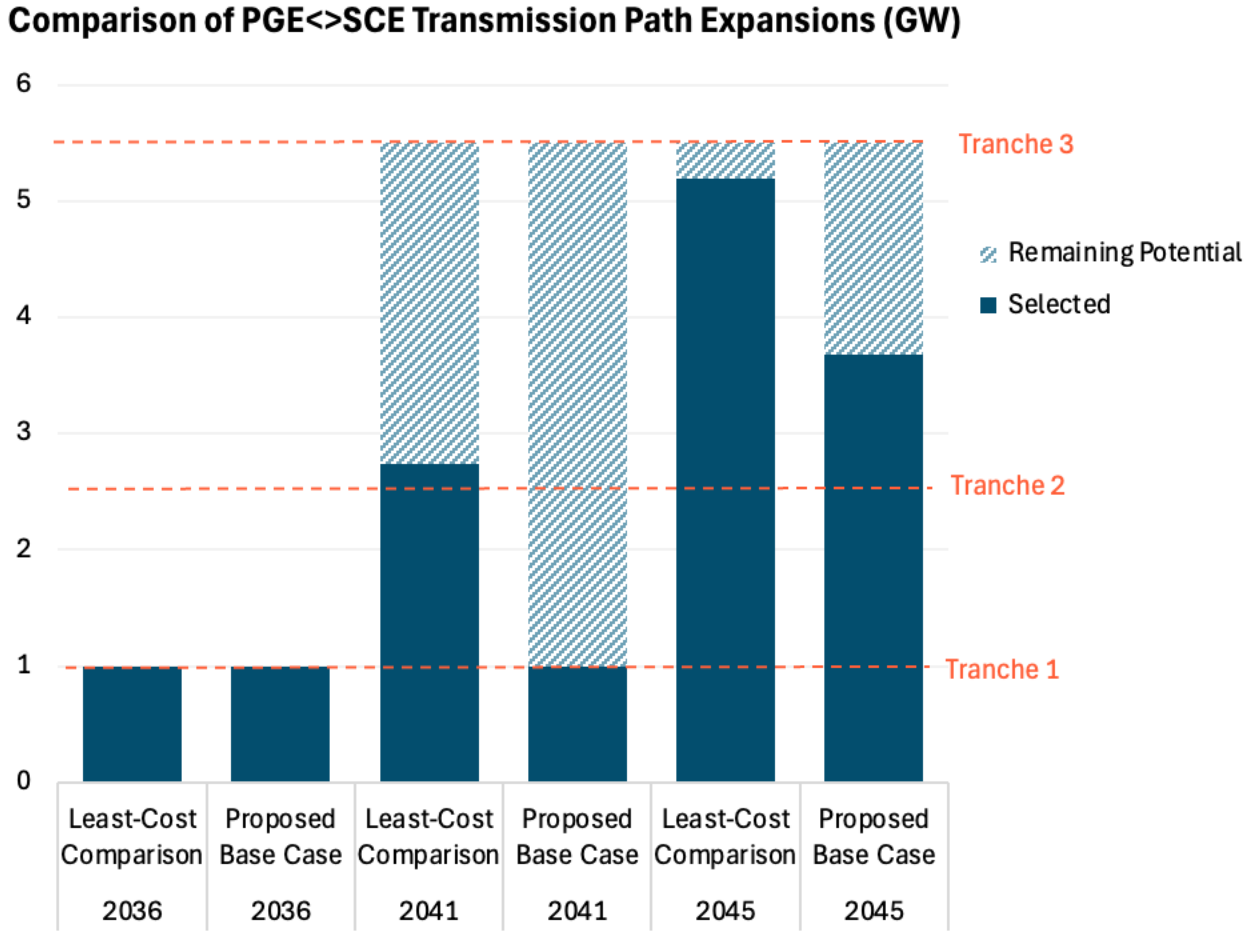
Case	2026	2028	2031	2036	2041	2045	NPV
Least-Cost Comparison Case	$8,758	$11,983	$18,094	$24,231	$28,392	$34,865	$394,735
Proposed Base Case	$8,758	$11,995 +$12 (0.1%)	$18,066 -$28 (0.2%)	$26,174 +$1,943 (8.0%)	$30,730 +$2,338 (8.2%)	$37,317 +$2,452 (7.0%)	$417,749 +$23,014 (5.8%)

- Partial AB1373 procurement volumes for offshore wind and multi-day storage increase costs by ~$1.9-2.5 Billion
  - Minimal differences before AB1373 procurement (2031 and earlier)

RESOLVE-optimized costs account for ~15-30% of total system costs (increasing over time); non-optimized baseline generation, transmission, and distribution make up the rest of the revenue requirement

PG&E<>SCE Transmission Comparison with Least-Cost Comparison Case

- Both cases select the first tranche in the first available year
- In later years and tranches, the least-cost comparison case selects ~1.5 GW additional expansion than the proposed base case



Summary & Conclusions

Summary & Conclusions

- Compared to the **2023 IEPR**, the **revised 2024 IEPR has higher demand and peak load,** driving an **increase in resource buildout**
  - 25-26 TPP used the 2023 IEPR forecast; load growth in the 2024 IEPR (which is being used for the current 26-27 TPP) drives additional resource builds, up to ~30 GW above the 25-26 TPP
  - Shifts from in-state to out-of-state wind, in part because of changing resource potential assumptions
- **GHG target leads to an over-reliable system in some years**; Planning Reserve Margin is not binding from 2028-2036
- Aggressive near-term **solar build rate accelerates** from ~3-4 GW/yr to ~7 GW/yr by 2030 to meet GHG goals due to near-term wind and geothermal limits, in excess of reliability build need
- PG&E<>SCE transmission path expansion candidate(s) added to RESOLVE optimization, and Path 26/Path 15 expansion(s) are selected primarily to **increase zonal import capacity into PG&E TAC area,** but expansion benefit reduces post-offshore wind addition
- RESOLVE **selects above partial AB1373 procurement forced-in amounts for geothermal and location-constrained LDES;** RESOLVE does not currently select any offshore wind due to resource's high cost under current cost assumptions

26-27 TPP Proposed Sensitivity Portfolio

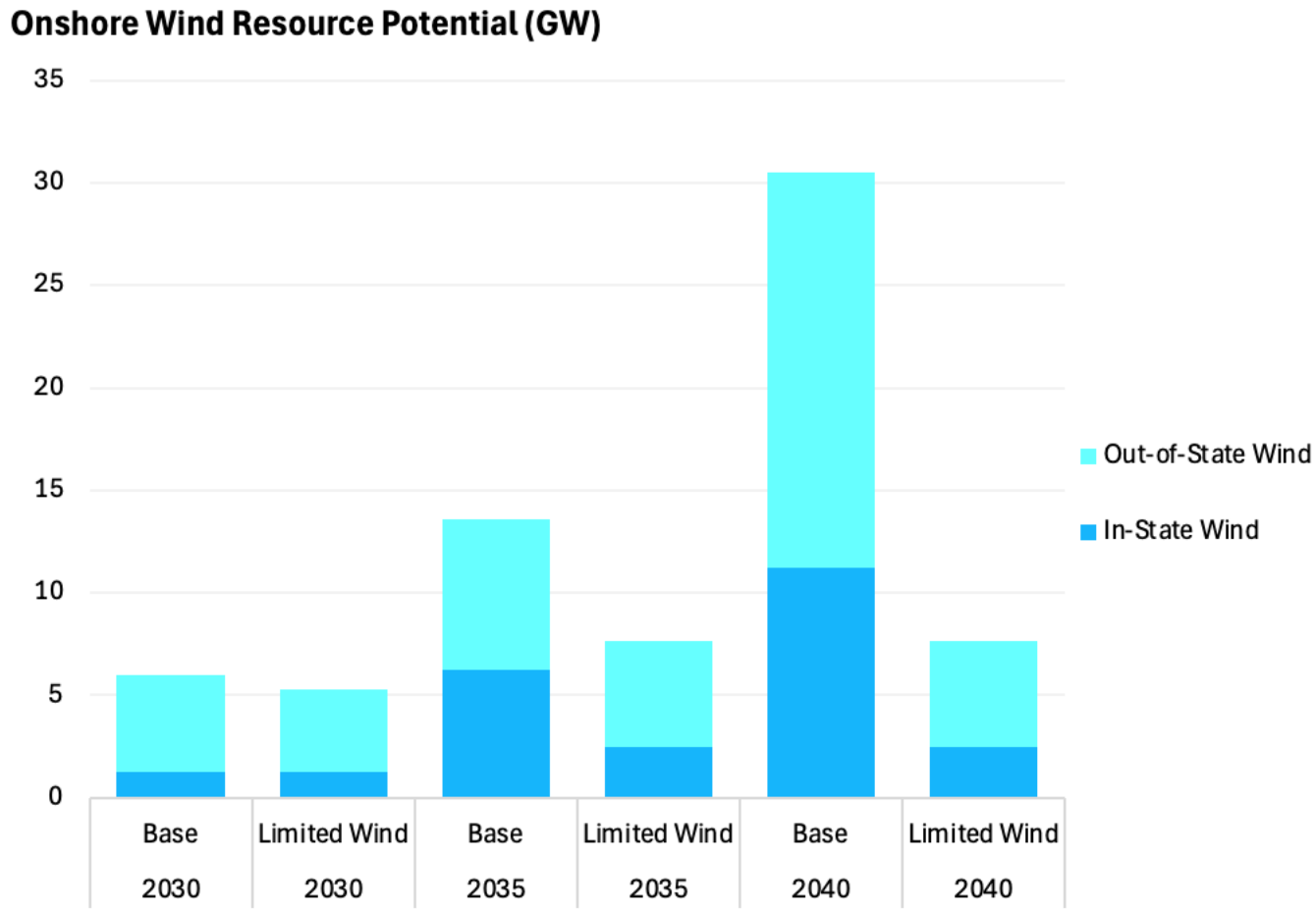
Background – Purpose of Sensitivity

- In addition to the Proposed 26-27 TPP Base Case portfolio, Staff is proposing to transmit one sensitivity portfolio to the CAISO focused on a limited wind deployment future
- The sensitivity would represent a future with reduced in-state and out-of-state wind procurement, and without offshore wind
  - Reflects the recent lack of wind development in California, the increased difficulty of permitting wind in California, and the current changes in federal policy toward wind projects
  - Designed to serve as a plausible alternative scenario associated with the proposed base case (as opposed to a TPP sensitivity that gathers additional transmission information to support future portfolio development and explore incremental optionality or risk)
  - Would provide insights into transmission implications and resources that would be needed to replace wind in the recommended base case portfolio and recently adopted TPP portfolios if its development were significantly limited

RESOLVE Modeling Results: Proposed 26-27 TPP Sensitivity Portfolio

Limited Wind Sensitivity – Resource Potential Inputs

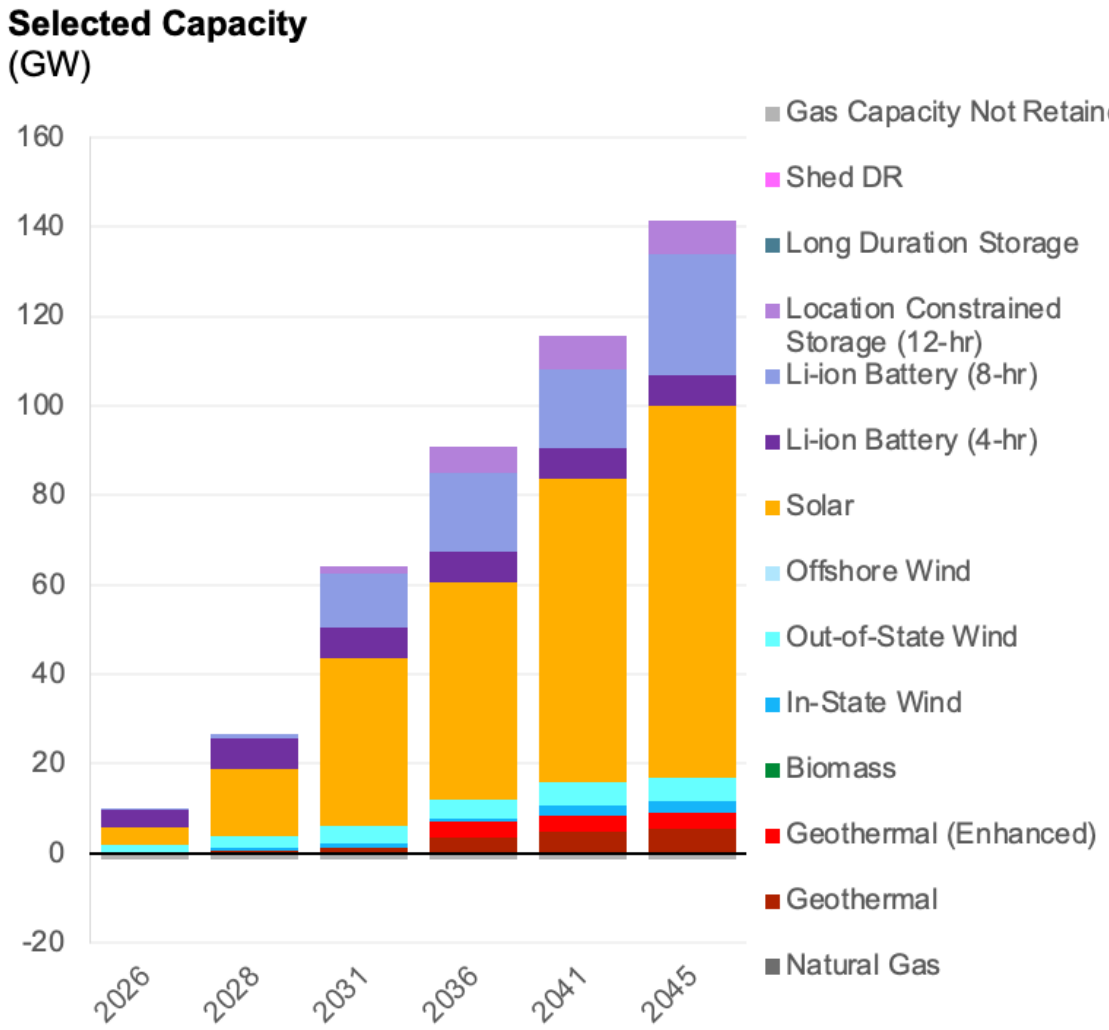
- The limited wind potential sensitivity explores significant reductions to resource potential (as shown in the graphic to the right)
  - Maximum 2.5 GW In-State Wind
  - Out-of-State Wind limited to existing transmission rights (SunZia, SWIP-North, TransWest), plus 2 GW of additional SunZia potential
  - No Offshore Wind



On graph, In-State Wind potential for "Base" includes build limits through 2035

26-27 TPP Proposed Sensitivity Case: Limited Wind

Selected Builds



Geothermal is selected for reliability needs due to its high ELCC (contribution to reliability) and high capacity- factor, GHG-free energy; the entire conventional geothermal potential is built out to fill need otherwise met by wind; significant amounts of EGS is also built in 2036 (prior to the expiration of tax credits)

Limits to wind potential bind in most years, with the exception of in-state wind in the 2030s (shortly after the loss of tax credits)

Solar and storage are resources that scale to meet growing GHG-free energy demand and fill some of the need otherwise met by wind

Small amounts of gas with high fixed O&M are non-retained early on

Actual buildout will depend on procurement options, therefore, geothermal selection in model could be considered a proxy for other resources with similar attributes, e.g. high ELCC

26-27 TPP Proposed Sensitivity Case: Limited Wind

Selected Builds

Note: Generating portfolios is Step #1 as part of the Busbar Mapping Process. See Assumptions for the 2026-2027 TPP for the latest Busbar Mapping Methodology document

Resource Type	2026	2028	2031	2036	2041	2045
Natural Gas	-	-	-	-	-	-
Geothermal	0.1	0.6	1.2	3.4	4.7	5.6
Geothermal (Enhanced)	-	-	-	3.6	3.6	3.6
Biomass	-	-	-	-	-	-
In-State Wind	0.3	0.8	0.9	0.9	2.5	2.5
Out-of-State Wind	1.4	2.5	4.0	4.0	5.1	5.1
Offshore Wind	-	-	-	-	-	-
Solar	4.0	15.0	37.5	48.6	67.6	83.2
Li-ion Battery (4-hr)	3.9	6.7	6.8	6.8	6.8	6.8
Li-ion Battery (8-hr)	0.2	1.0	12.1	17.7	17.7	26.9
Location Constrained Storage (12-hr)	-	-	1.6	5.7	7.5	7.5
Generic Long Duration Storage (12-hr)	-	-	-	-	-	-
Generic Long Duration Storage (24-hr)	-	-	-	-	-	-
Generic Long Duration Storage (100-hr)	-	-	-	-	-	-
Shed DR	-	-	-	-	-	-
Gas Capacity Not Retained	(1.2)	(1.2)	(1.2)	(1.2)	(1.2)	(1.2)

26-27 TPP Proposed Sensitivity Case: Limited Wind

Selected Builds by CAISO Study Area (2036)

Region	In-State Wind	Out-of-State Wind	Offshore Wind	Solar	Li-ion Battery (4-hr)	Li-ion Battery (8-hr)	Location-Constrained Storage (12-hr)	In-State Geothermal	Out-of-State Geothermal	EGS - Near Field	EGS - Deep
PG&E_Fresno	-	-	-	3,666	226	4,943	-	-	-	-	286
PG&E_GBA	247	-	-	1,154	612	45	400	-	-	-	616
PG&E_Kern	-	-	-	9,754	369	-	876	-	-	-	5
PG&E_NGBA	206	-	-	2,452	314	-	-	652	808	1,426	-
PG&E_Northeast_CA	-	-	-	-	-	-	-	178	-	-	-
SCE_Arizona	-	2,546	-	6,726	904	1,370	-	-	-	-	-
SCE_Eastern	-	-	-	4,176	470	-	1,800	7	-	7	-
SCE_EOP	255	1,500	-	1,076	638	1,471	500	-	1,069	741	-
SCE_Metro	-	-	-	5	1,365	7,604	-	-	-	-	-
SCE_NOL	-	-	-	326	542	6	386	142	-	-	-
SCE_Northern	-	-	-	6,549	623	635	1,280	-	-	-	-
SDGE_Arizona	-	-	-	12,509	85	1,459	-	-	-	-	-
SDGE_Baja_California	-	-	-	-	-	-	-	-	-	-	-
SDGE_Imperial	194	-	-	190	675	137	-	529	-	529	-

SDGE Baja California interconnects at SDGE Imperial

26-27 TPP Proposed Sensitivity Case: Limited Wind

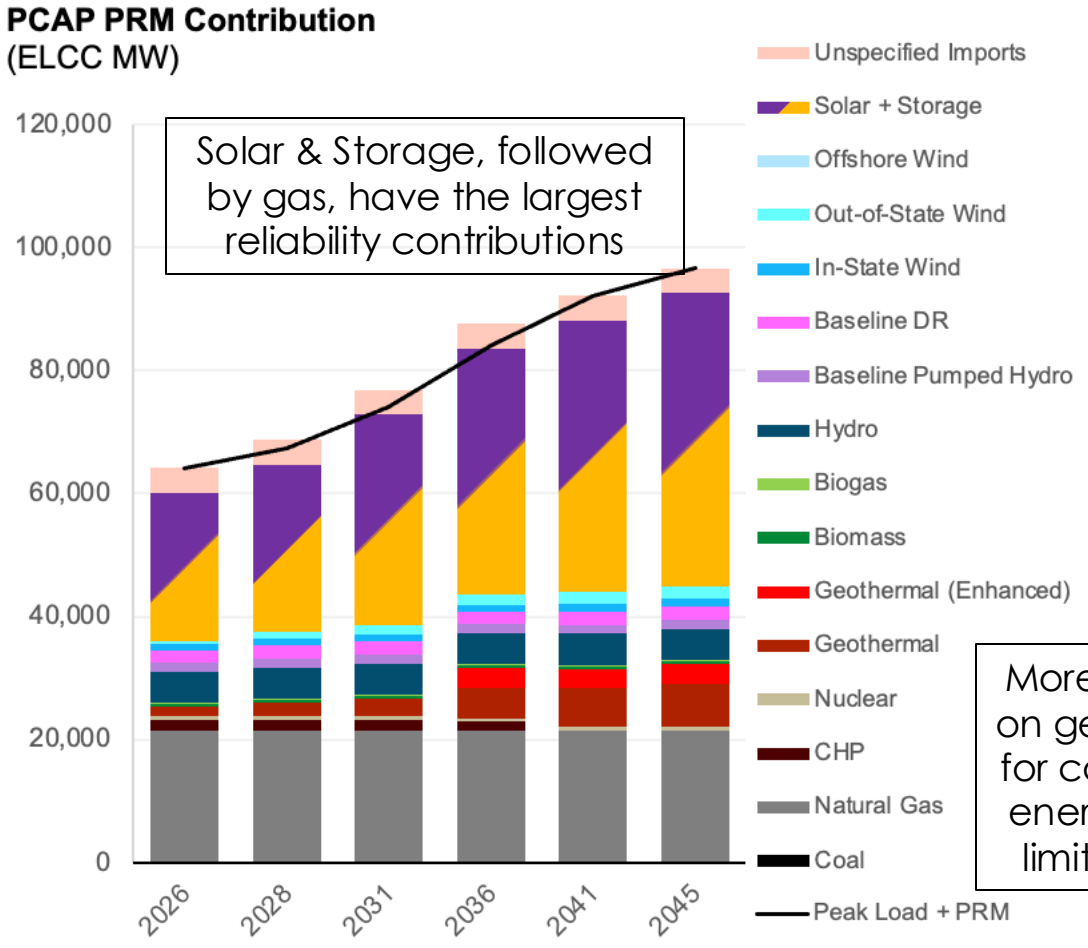
Selected Builds by CAISO Study Area (2041)

Region	In-State Wind	Out-of-State Wind	Offshore Wind	Solar	Li-ion Battery (4-hr)	Li-ion Battery (8-hr)	Location-Constrained Storage (12-hr)	In-State Geothermal	Out-of-State Geothermal	EGS - Near Field	EGS - Deep
PG&E_Fresno	-	-	-	7,326	226	4,943	-	-	-	-	286
PG&E_GBA	247	-	-	2,751	612	45	400	-	-	-	616
PG&E_Kern	-	-	-	9,775	369	-	876	-	-	-	5
PG&E_NGBA	1,805	-	-	3,053	314	-	-	652	808	1,426	-
PG&E_Northeast_CA	-	-	-	-	-	-	-	178	-	-	-
PG&E (Generic)	-	-	-	-	-	-	-	16	-	-	-
SCE_Arizona	-	2,546	-	6,726	904	1,370	-	-	-	-	-
SCE_Eastern	-	-	-	9,111	470	-	1,800	7	-	7	-
SCE_EOP	255	2,600	-	1,076	638	1,471	500	-	1,069	741	-
SCE_Metro	-	-	-	387	1,365	7,604	-	-	-	-	-
SCE_NOL	-	-	-	1,039	542	6	386	142	-	-	-
SCE_Northern	-	-	-	9,532	623	635	3,080	-	-	-	-
SCE (Generic)	-	-	-	-	-	-	-	1,301	-	-	-
SDGE_Arizona	-	-	-	16,456	85	1,459	-	-	-	-	-
SDGE_Baja_California	-	-	-	-	-	-	-	-	-	-	-
SDGE_Imperial	194	-	-	395	675	137	-	529	-	529	-

SDGE Baja California interconnects at SDGE Imperial

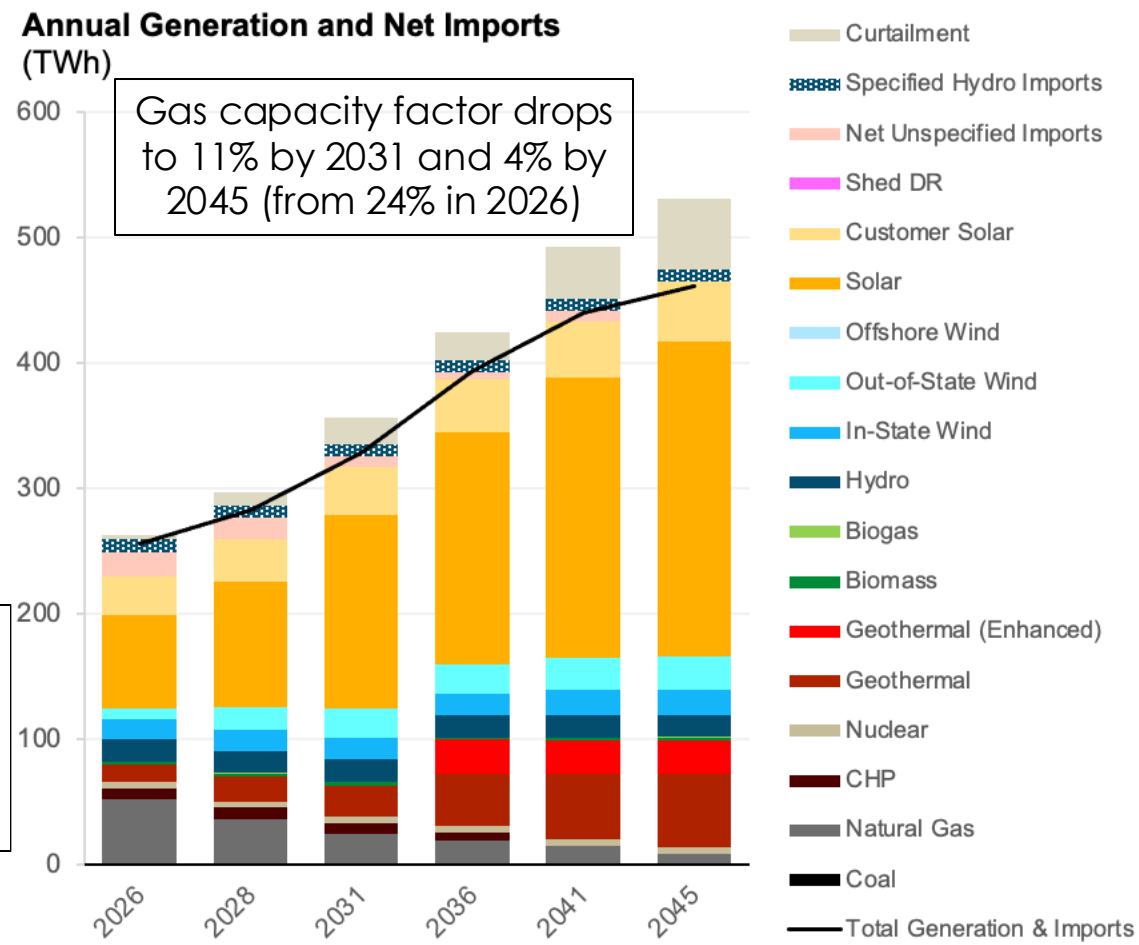
26-27 TPP Proposed Sensitivity Case: Limited Wind

Reliability and Energy Mix



Solar & Storage, followed by gas, have the largest reliability contributions

More reliance on geothermal for capacity & energy under limited wind

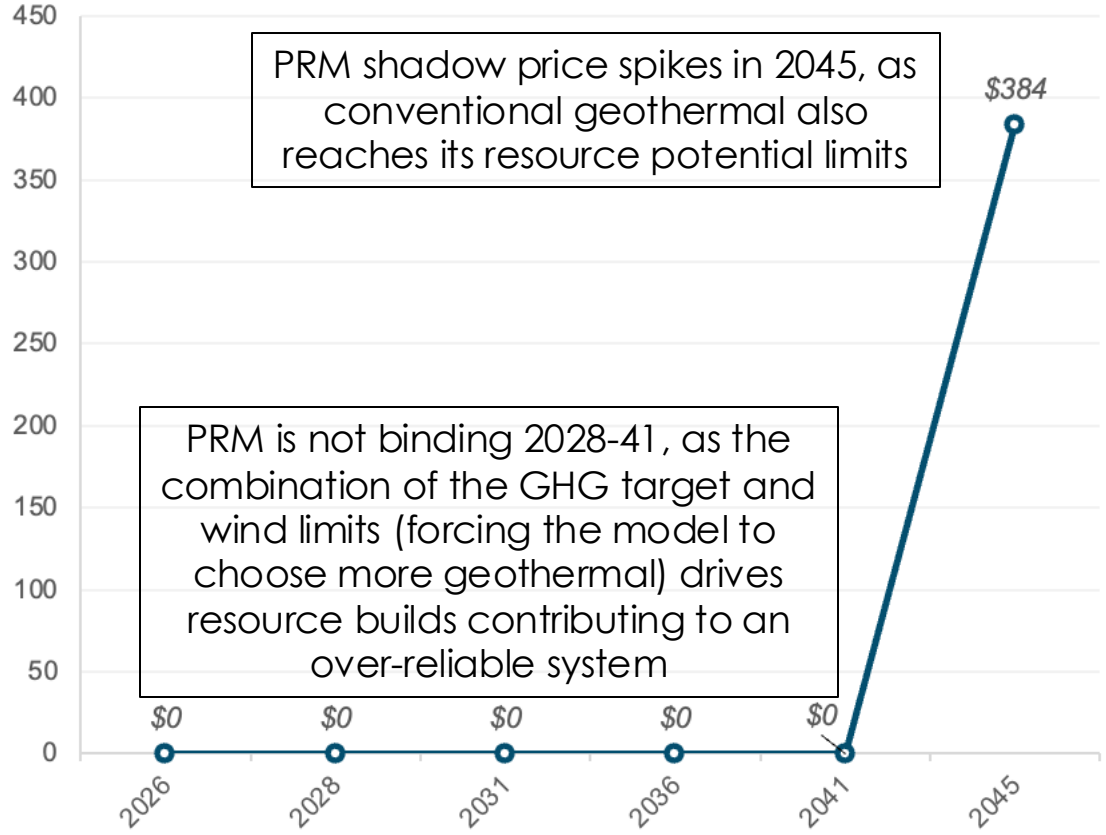


Gas capacity factor drops to 11% by 2031 and 4% by 2045 (from 24% in 2026)

PRM and GHG Constraints

- Shadow prices represent the cost of meeting a constraint, i.e. the cost of the last kW of firm capacity or the last ton of GHG emissions reduction

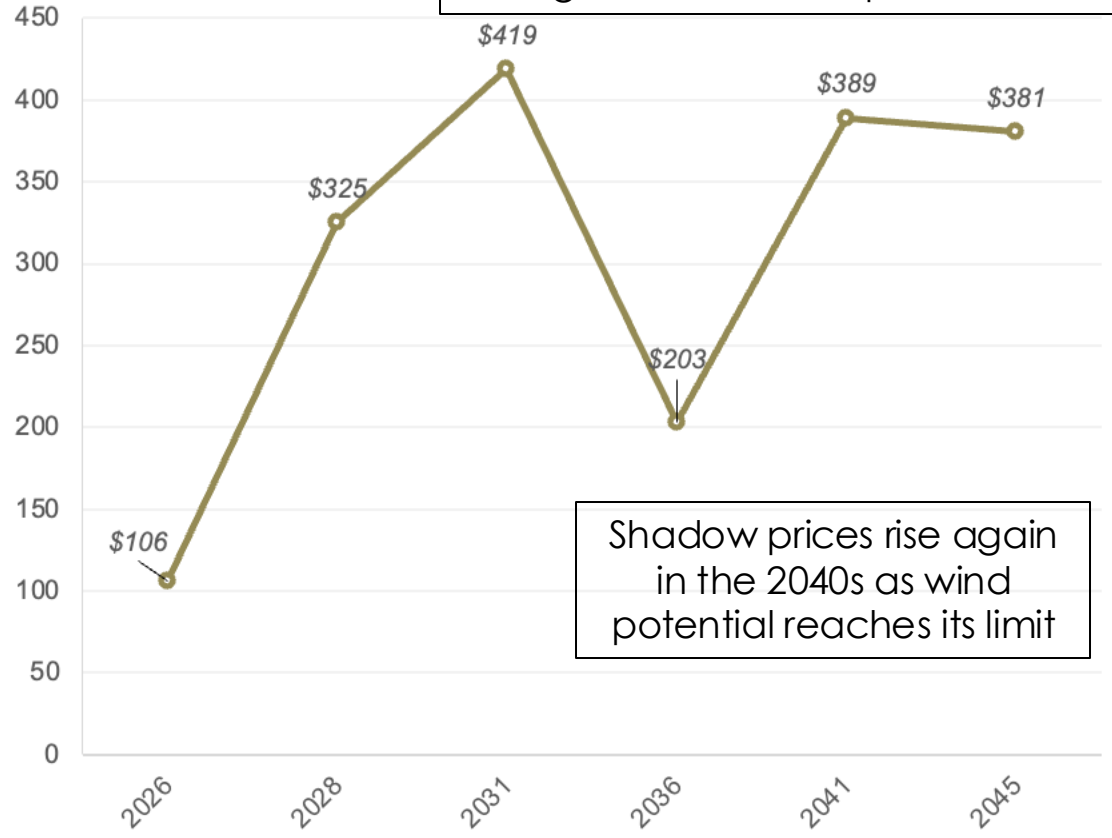
PRM Shadow Prices
($/kW-year)



PRM shadow price spikes in 2045, as conventional geothermal also reaches its resource potential limits

PRM is not binding 2028-41, as the combination of the GHG target and wind limits (forcing the model to choose more geothermal) drives resource builds contributing to an over-reliable system

GHG Target Shadow Price
($/ton CO_2)

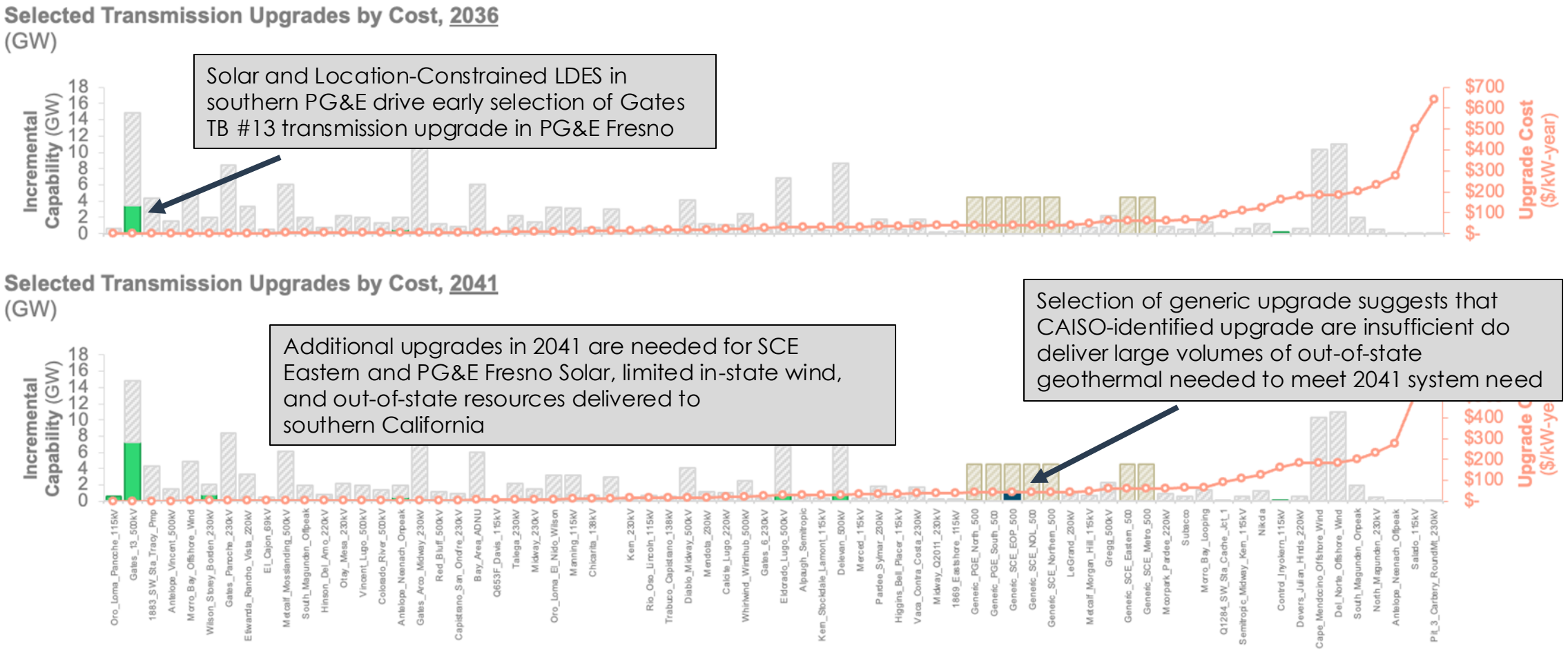


Near-term build limits for wind and geothermal, along with tariffs, drive a high GHG shadow price in 2028-31

Shadow prices rise again in the 2040s as wind potential reaches its limit

Note: Officially selected transmission upgrades are determined by the CAISO Transmission Plan

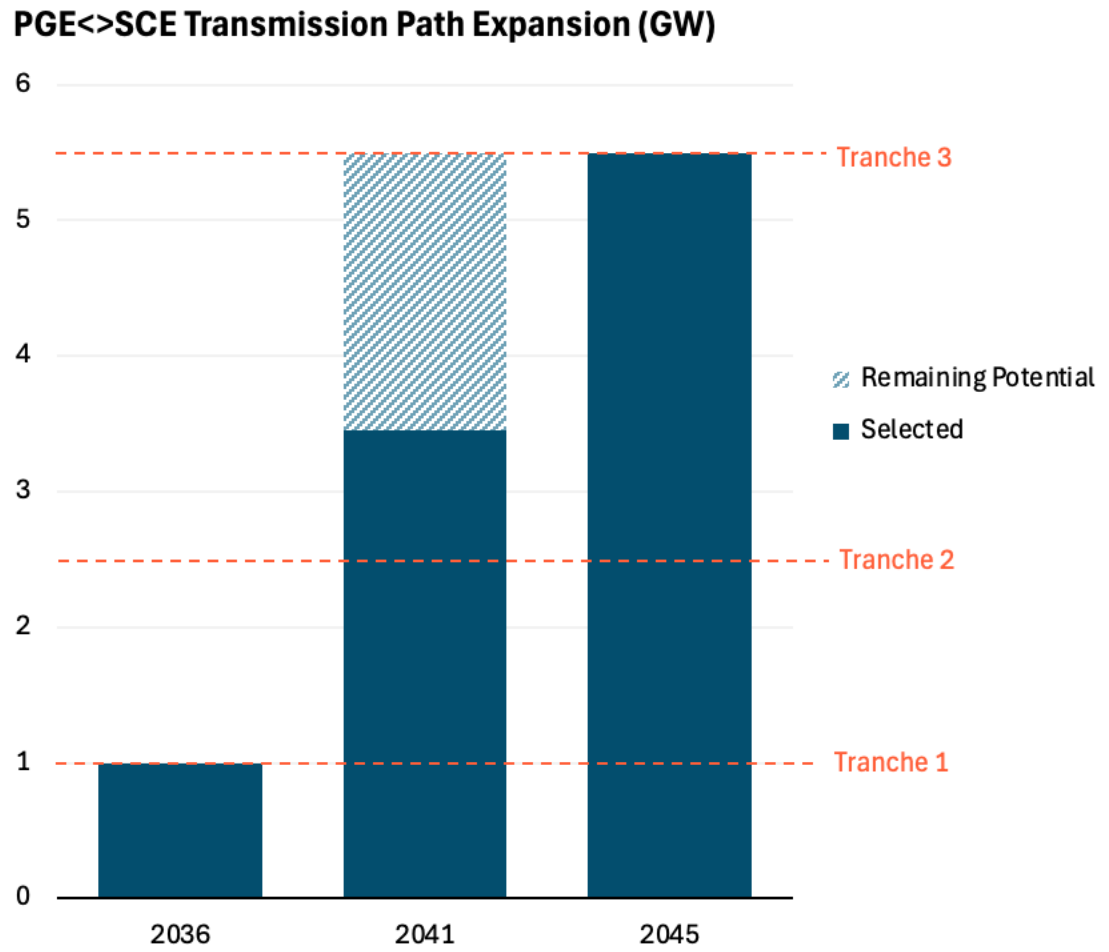
RESOLVE-Selected Transmission Upgrades



26-27 TPP Proposed Sensitivity Case: Limited Wind

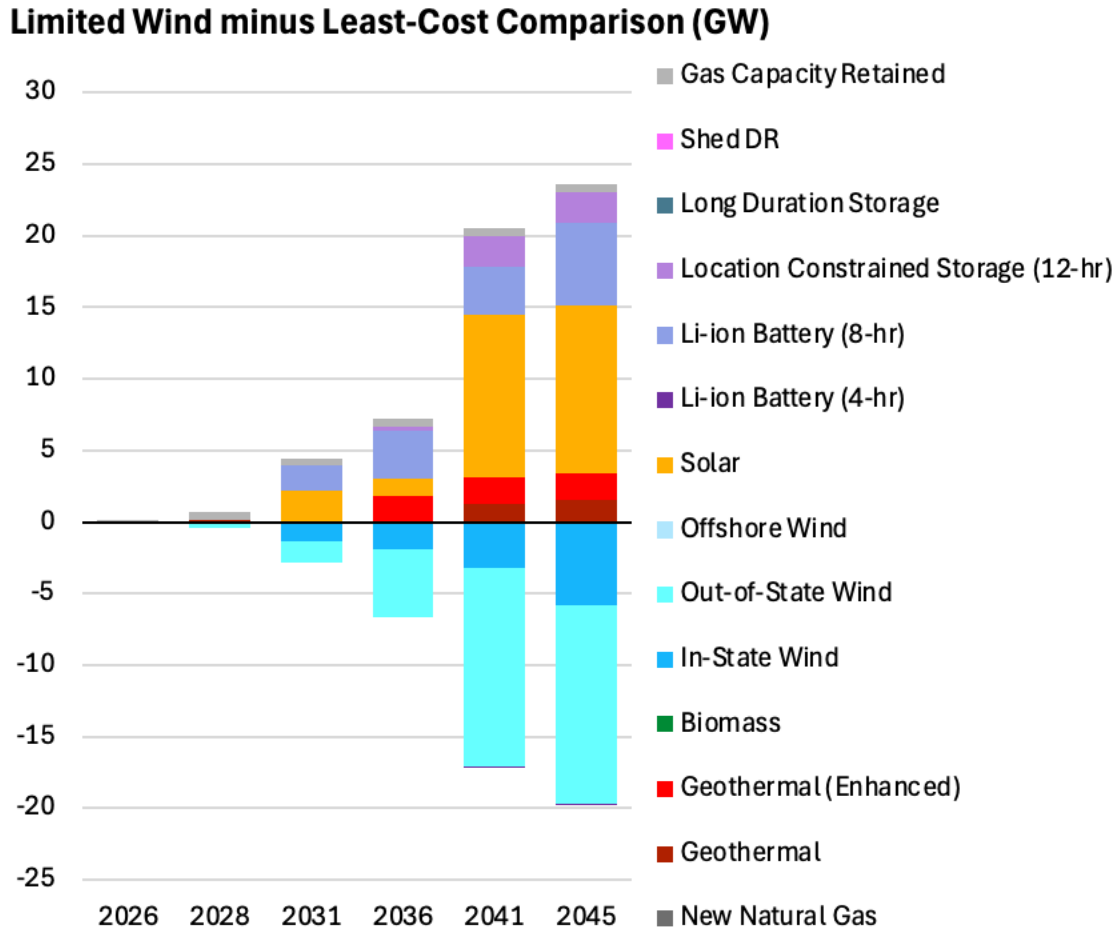
PG&E<>SCE Transmission Expansion

- Path 26/Path 15 expansion(s) are selected primarily to increase import capacity into PG&E
- The first tranche (1 GW) is selected in the first available year
- Significant expansion is selected by 2041, with the whole 5.5 GW potential built out by 2045



Selected Builds Comparison with Least-Cost Comparison Case

- Most differences arise starting in 2036, when most onshore wind potential is available in the least-cost comparison case
- The Limited Wind case primarily replaces wind with additional solar and storage, plus ~3 GW of geothermal (conventional and enhanced)



System Cost Comparison with Least-Cost Comparison Case

RESOLVE-Optimized Costs($ MM in 2024$)

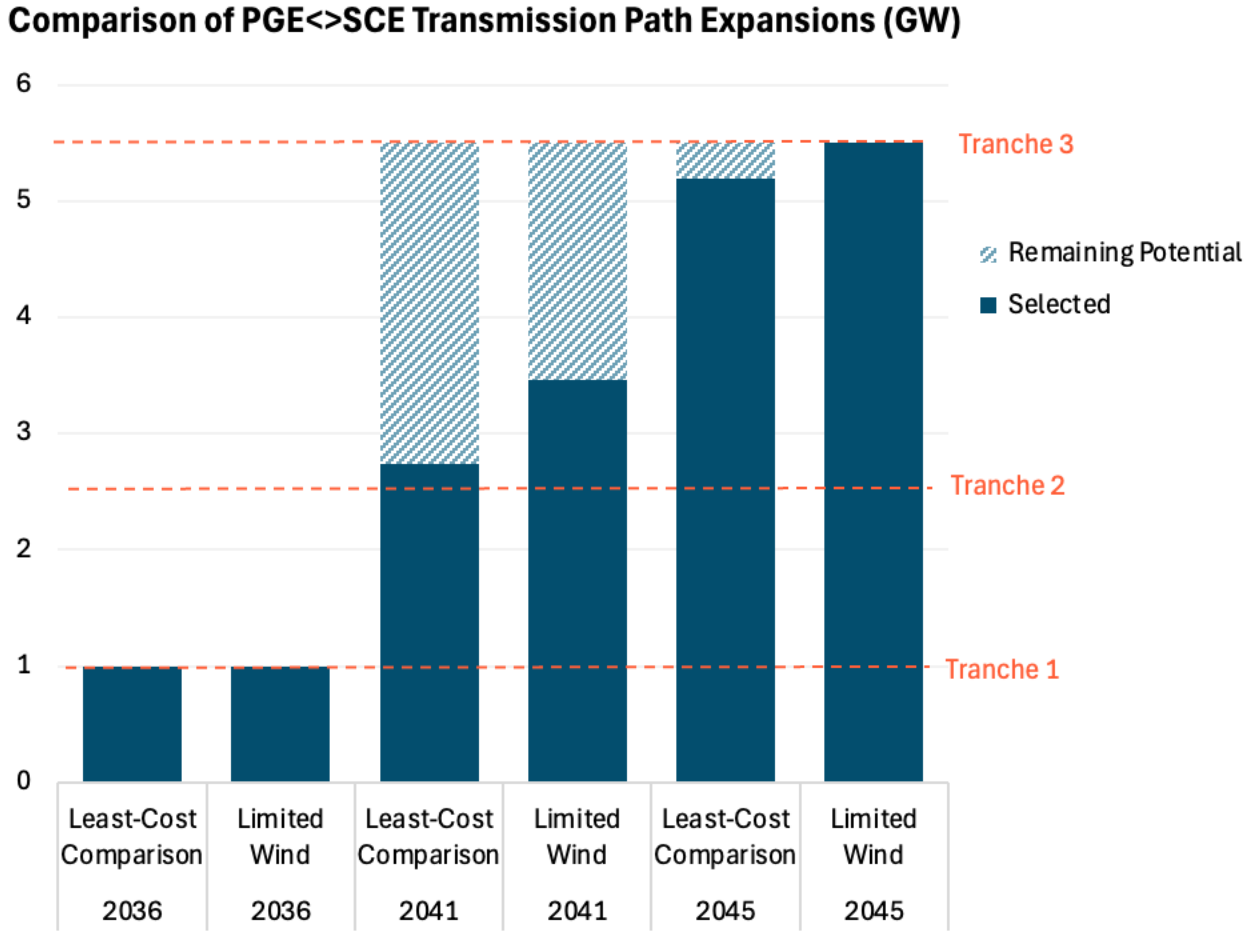
Case	2026	2028	2031	2036	2041	2045	NPV
Least-Cost Comparison Case	$8,758	$11,983	$18,094	$24,231	$28,392	$34,865	*$394,735*
Limited Wind Potential	$8,759 +$1 (<0.1%)	$12,001 +$18 (0.1%)	$18,104 +$10 (0.1%)	$24,816 +$585 (2.4%)	$29,720 +$1,328 (4.7%)	$36,071 +$1,206 (3.5%)	*$405,466* *+$10,731* *(2.7%)*

- Cost differences with the least-cost comparison case are relatively small until 2041, when wind build in least-cost increases significantly; limiting the wind potential increases costs by ~$1.2-1.3 Billion in those years

RESOLVE-optimized costs account for ~15-30% of total system costs (increasing over time); non-optimized baseline generation, transmission, and distribution make up the rest of the revenue requirement

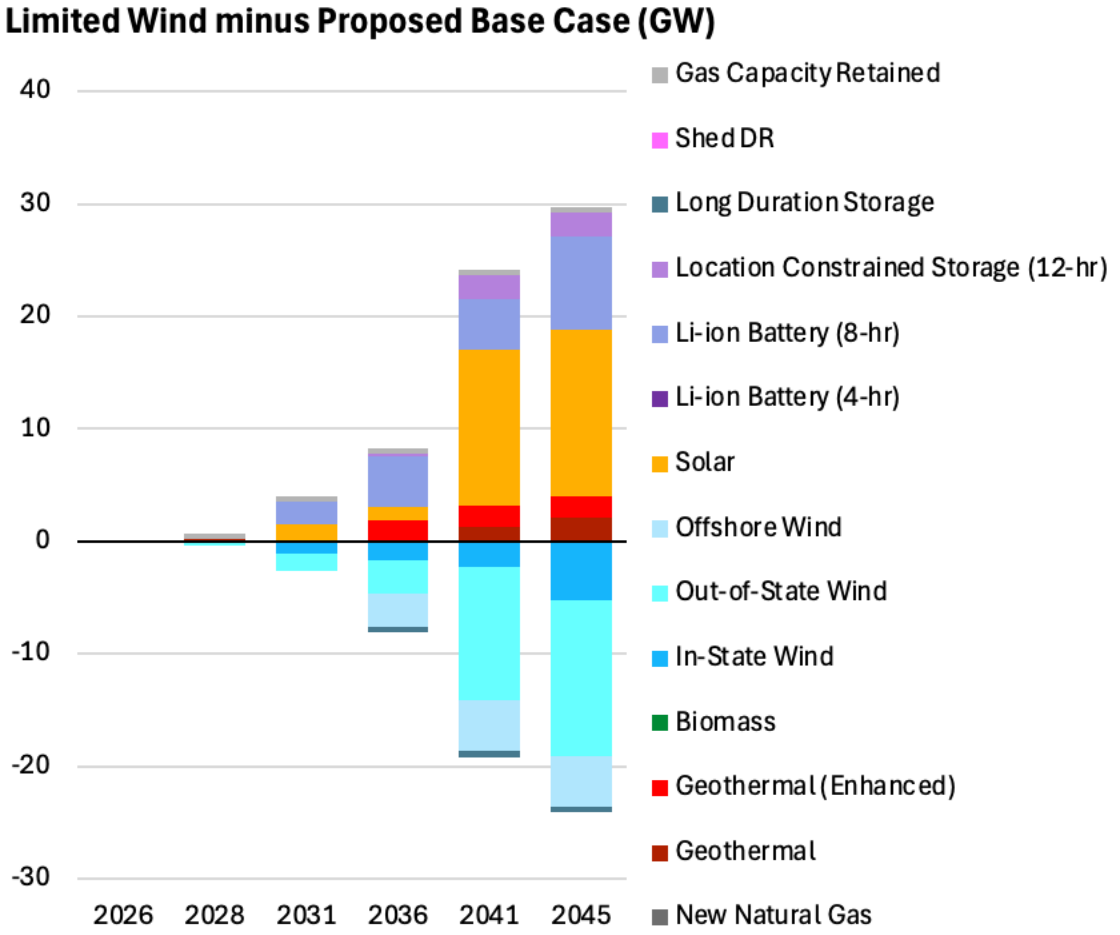
PG&E<>SCE Transmission Comparison with Least-Cost Comparison Case

- Both cases select the first tranche in the first available year
- In later years and tranches, the limited wind case selects ~0.3-1.3 GW additional expansion than the least-cost comparison case
  - Much of the additional geothermal selected in the Limited Wind case is located in SCE, increasing the opportunity/need for path expansion



Selected Builds Comparison with Base Case

- Most differences arise starting in 2036, when most onshore wind potential is available in the base case, along with offshore wind forced-in for the base case
- The Limited Wind case primarily replaces wind (onshore and offshore) with additional solar and storage, plus ~4 GW of geothermal (conventional and enhanced)



26-27 TPP Proposed Sensitivity Case: Limited Wind

System Cost Comparison with Base Case

RESOLVE-Optimized Costs ($MM in 2024$)

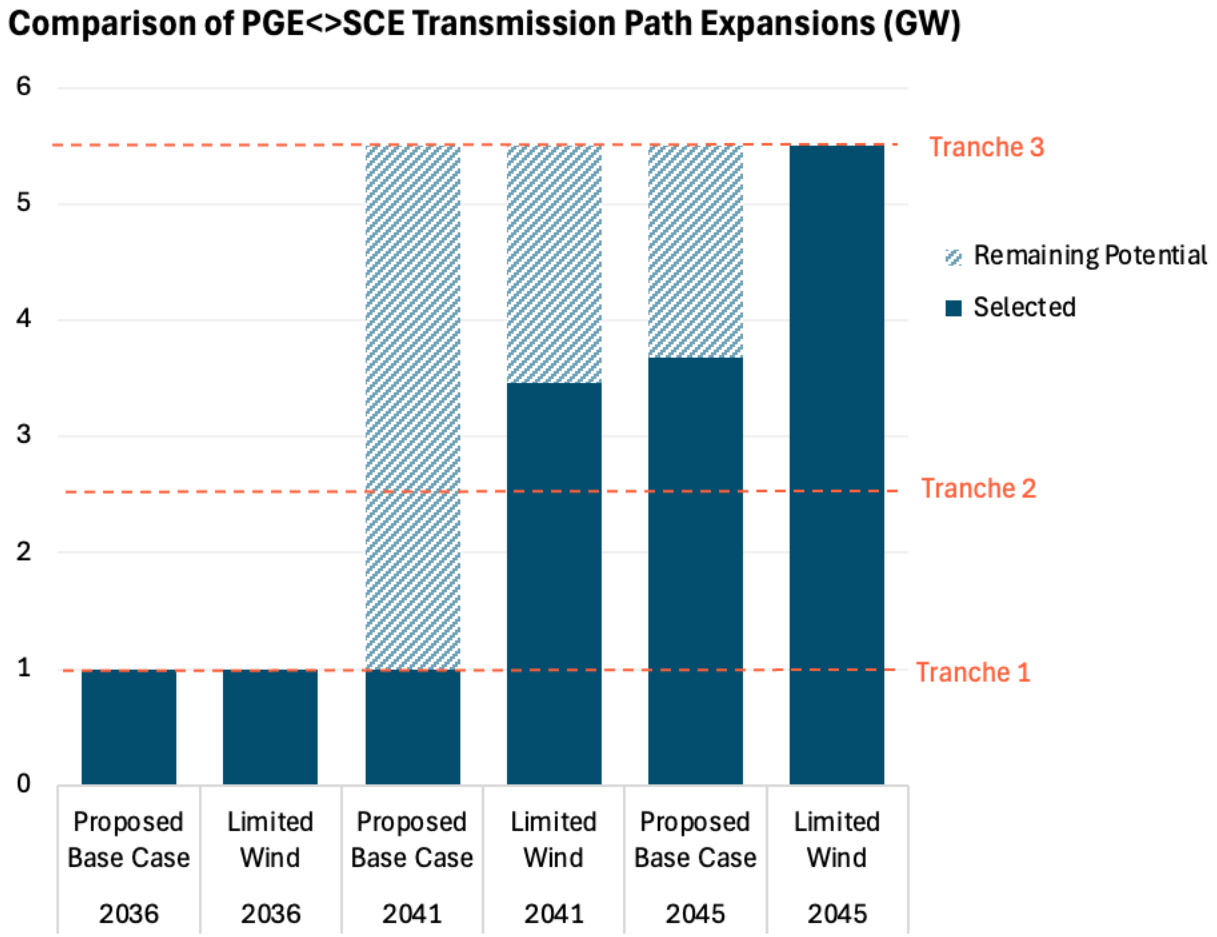
Case	2026	2028	2031	2036	2041	2045	NPV
Proposed Base Case	$8,758	$11,995	$18,066	$26,174	$30,730	$37,317	*$417,749*
Limited Wind Potential	$61,000 +$1 (<0.1%)	$68,538 +$6 (<0.1%)	$79,801 +$39 (<0.1%)	$94,317 -$1,448 (1.5%)	$107,210 -$1,330 (1.2%)	$119,314 -$1,566 (1.3%)	*$1,549,513* *-$14,613* *(0.9%)*

- Despite the limits to onshore wind potential, the Limited Wind case has lower costs in 2036 and beyond, due to relatively expensive offshore wind and multi-day storage forced-in for partial AB1373 procurement volumes in the base case
  - Forcing in offshore wind (including associated transmission) is more expensive than limiting onshore wind
  - Minimal differences before 2036 (first model year with AB1373 procurement)

RESOLVE-optimized costs account for ~15-30% of total system costs (increasing over time); non-optimized baseline generation, transmission, and distribution make up the rest of the revenue requirement

PG&E<>SCE Transmission Comparison with Base Case

- Both cases select the first tranche in the first available year
- In later years and tranches, the limited wind case selects ~1.5-2.5 GW additional expansion than the base case
  - Offshore wind mapped to PG&E in the base case (partial AB1373) reduces the need for imports from SCE
  - Much of the additional geothermal selected in the Limited Wind case is located in SCE, increasing the opportunity/need for path expansion



Summary & Conclusions

Summary & Conclusions

- Primarily replaces wind with **additional solar and storage**, plus ~3 GW of **geothermal** (conventional and enhanced)
  - More reliance on geothermal for capacity & energy with limited wind
- Forcing in offshore wind is **more expensive** than limiting onshore wind
- Limits to wind potential bind in most years, with the exception of in-state wind in the 2030s (shortly after the loss of tax credits)
- **Additional expansion of the Path 26/Path 15 expansion** compared to the Proposed Base Case is required to meet PG&E load

Appendix

RESOLVE Modeling Results
26-27 TPP Least Cost Comparison Portfolio

Least Cost Comparison Portfolio

- Shows the least-cost resource mix for meeting state goals (including statewide electric sector emissions of 25 MMT by 2035 and 8 MMT by 2045) over the planning horizon to serve as a reference point
- This portfolio does not force in any of the AB 1373 resource procurements as minimum builds
- This case reflects all updates from the 25-26 TPP and 2025 Draft I&A made to the Proposed Base Case, including load data from the 2024 IEPR

26-27 TPP: Least Cost Comparison

Selected Builds

Resource Type	2026	2028	2031	2036	2041	2045
Natural Gas	-	-	-	-	-	-
Geothermal	0.1	0.4	1.2	3.4	3.4	4.0
Geothermal (Enhanced)	-	-	-	1.8	1.8	1.8
Biomass	-	-	-	-	-	-
In-State Wind	0.3	0.8	2.3	2.8	5.7	8.3
Out-of-State Wind	1.4	2.9	5.5	8.8	19.0	19.0
Offshore Wind	-	-	-	-	-	-
Solar	4.0	15.0	35.2	47.3	56.2	71.5
Li-ion Battery (4-hr)	3.9	6.7	6.8	6.8	6.8	6.8
Li-ion Battery (8-hr)	0.2	1.0	10.4	14.4	14.4	21.1
Location Constrained Storage (12-hr)	-	-	1.6	5.4	5.4	5.4
Generic Long Duration Storage (12-hr)	-	-	-	-	-	-
Generic Long Duration Storage (24-hr)	-	-	-	-	-	-
Generic Long Duration Storage (100-hr)	-	-	-	-	-	-
Shed DR	-	-	-	-	-	-
Gas Capacity Not Retained	(1.3)	(1.8)	(1.8)	(1.8)	(1.8)	(1.8)

Small amounts of gas with high fixed O&M are non-retained early on

Geothermal is selected for reliability needs due to its high ELCC and high capacity- factor, GHG-free energy; most of the conventional geothermal potential is built out by 2036, and EGS is also built in that year (prior to the expiration of tax credits)

Almost all available out-of-state wind is selected; near-term in-state wind build limits bind through 2028, and the loss of tax credits slows adoption until the 2040s

Solar and storage are resources that scale to meet growing GHG-free energy demand

26-27 TPP: Least Cost Comparison

Selected Builds by CAISO Study Area (2036)

Region	In-State Wind	Out-of-State Wind	Offshore Wind	Solar	Li-ion Battery (4-hr)	Li-ion Battery (8-hr)	Location-Constrained Storage (12-hr)	In-State Geothermal	Out-of-State Geothermal	EGS - Near Field	EGS - Deep
PG&E_Fresno	-	-	-	3,860	226	4,218	-	-	-	-	269
PG&E_GBA	247	1,749	-	989	612	45	114	-	-	-	146
PG&E_Kern	-	-	-	9,675	369	-	818	-	-	-	3
PG&E_NGBA	762	-	-	2,000	314	-	-	668	808	1,411	-
PG&E_Northeast_CA	-	-	-	-	-	-	-	178	-	-	-
SCE_Arizona	-	2,936	-	4,940	904	156	-	-	-	-	-
SCE_Eastern	676	-	-	4,020	470	-	1,800	7	-	-	-
SCE_EOP	255	4,100	-	690	638	1,157	500	-	1,069	-	-
SCE_Metro	-	-	-	5	1,365	6,659	-	-	-	-	-
SCE_NOL	-	-	-	278	542	6	386	142	-	-	-
SCE_Northern	-	-	-	6,492	623	760	1,280	-	-	-	-
SDGE_Arizona	-	-	-	14,169	85	1,247	-	-	-	-	-
SDGE_Baja_California	353	-	-	-	-	-	-	-	-	-	-
SDGE_Imperial	514	-	-	190	675	137	-	529	-	-	-

SDGE Baja California interconnects at SDGE Imperial

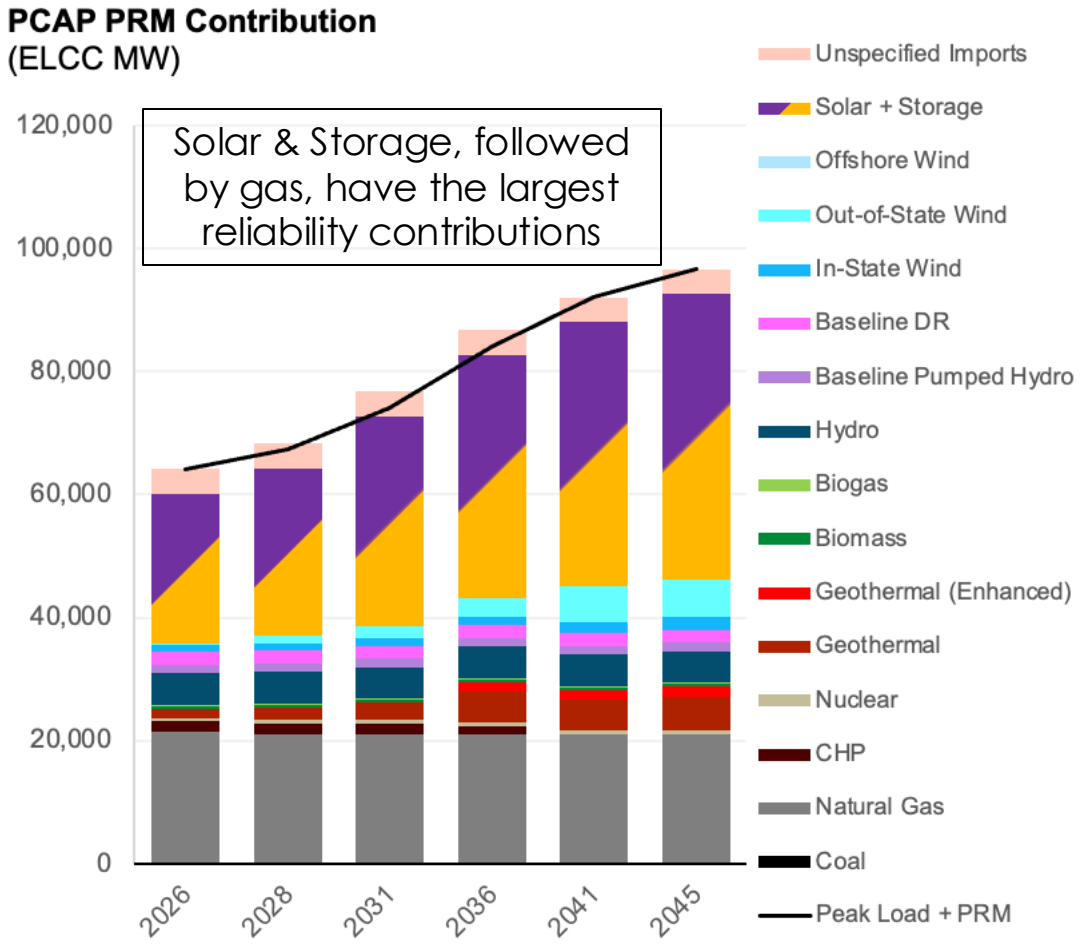
26-27 TPP: Least Cost Comparison

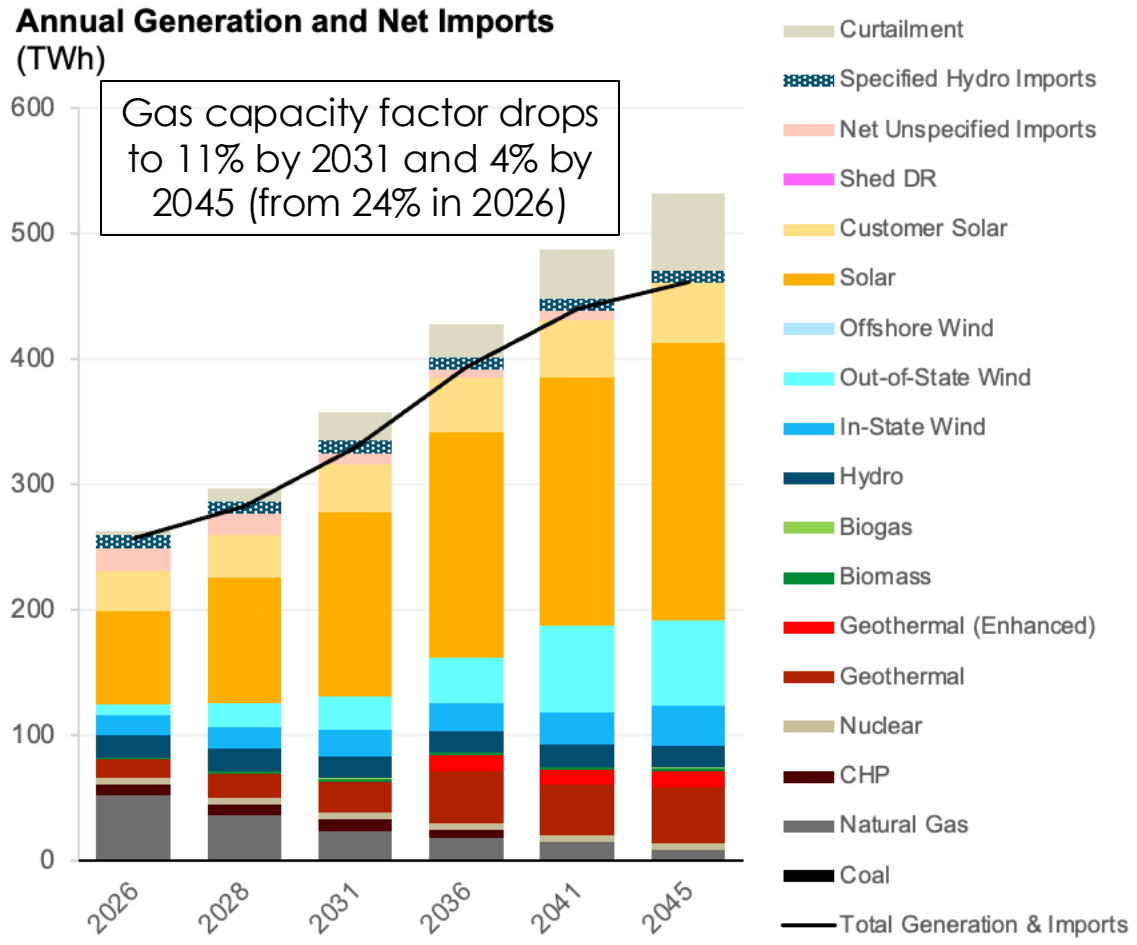
Selected Builds by CAISO Study Area (2041)

Region	In-State Wind	Out-of-State Wind	Offshore Wind	Solar	Li-ion Battery (4-hr)	Li-ion Battery (8-hr)	Location-Constrained Storage (12-hr)	In-State Geothermal	Out-of-State Geothermal	EGS - Near Field	EGS - Deep
PG&E_Fresno	-	-	-	7,588	226	4,218	-	-	-	-	269
PG&E_GBA	247	4,000	-	1,094	612	45	114	-	-	-	146
PG&E_Kern	3	-	-	9,675	369	-	818	-	-	-	3
PG&E_NGBA	1,893	-	-	2,000	314	-	-	668	808	1,411	-
PG&E_Northeast_CA	-	-	-	-	-	-	-	178	-	-	-
SCE_Arizona	-	8,936	-	4,940	904	156	-	-	-	-	-
SCE_Eastern	676	-	-	7,386	470	-	1,800	7	-	-	-
SCE_EOP	255	6,100	-	690	638	1,157	500	-	1,069	-	-
SCE_Metro	-	-	-	387	1,365	6,659	-	-	-	-	-
SCE_NOL	-	-	-	543	542	6	386	142	-	-	-
SCE_Northern	-	-	-	7,425	623	760	1,280	-	-	-	-
SDGE_Arizona	-	-	-	14,169	85	1,247	-	-	-	-	-
SDGE_Baja_California	1,654	-	-	-	-	-	-	-	-	-	-
SDGE_Imperial	943	-	-	294	675	137	-	529	-	-	-

SDGE Baja California interconnects at SDGE Imperial

Reliability and Energy Mix

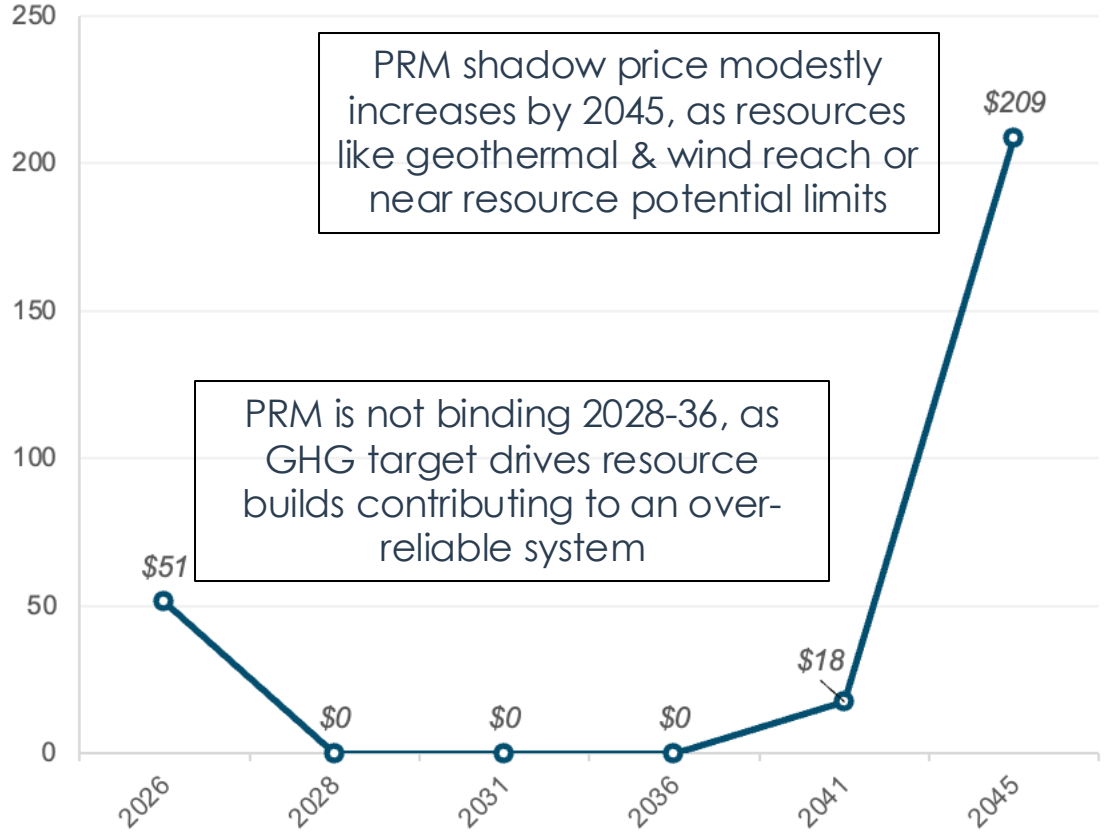




PRM and GHG Constraints

- Shadow prices represent the cost of meeting a constraint, i.e. the cost of the last kW of firm capacity or the last ton of GHG emissions reduction

PRM Shadow Prices
($/kW-year)



PRM shadow price modestly increases by 2045, as resources like geothermal & wind reach or near resource potential limits

PRM is not binding 2028-36, as GHG target drives resource builds contributing to an over-reliable system

GHG Target Shadow Price
($/ton CO_2)

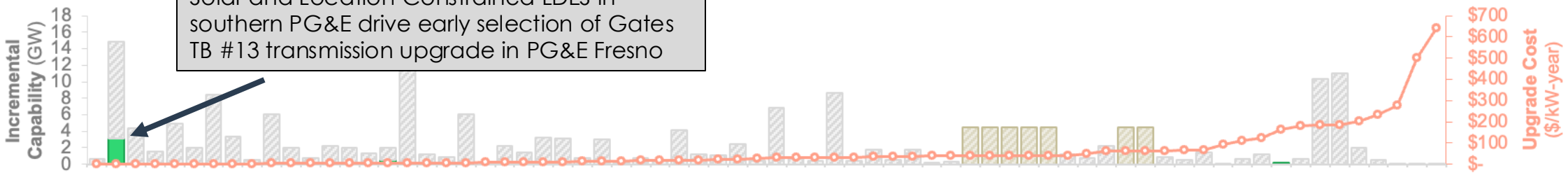
Near-term build limits for wind and geothermal, along with tariffs, drive a high GHG shadow price in 2028-31

Shadow price rises again in 2045 to meet the 8 MMT target

Note: Officially selected transmission upgrades are determined by the CAISO Transmission Plan

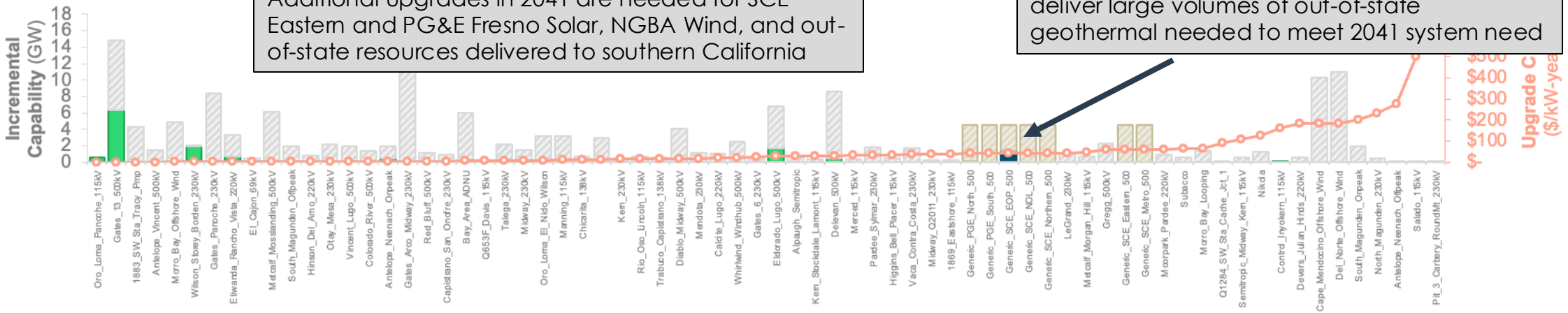
RESOLVE-Selected Transmission Upgrades

Selected Transmission Upgrades by Cost, 2036
(GW)



Solar and Location-Constrained LDES in southern PG&E drive early selection of Gates TB #13 transmission upgrade in PG&E Fresno

Selected Transmission Upgrades by Cost, 2041
(GW)

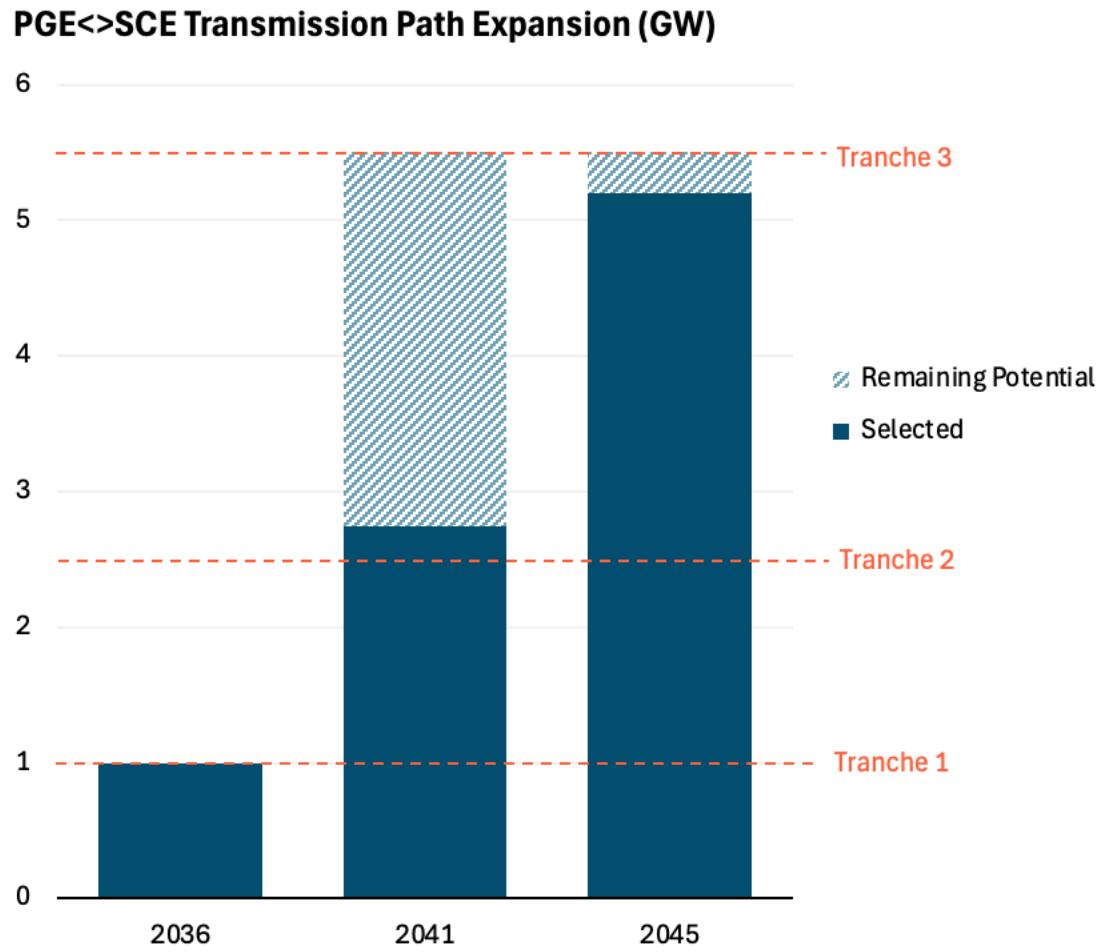


Additional upgrades in 2041 are needed for SCE Eastern and PG&E Fresno Solar, NGBA Wind, and out-of-state resources delivered to southern California

Selection of generic upgrade suggests that CAISO-identified upgrades are insufficient do deliver large volumes of out-of-state geothermal needed to meet 2041 system need

PG&E<>SCE Transmission Expansion

- Path 26/Path 15 expansion(s) are selected primarily to increase import capacity into PG&E
- The first tranche (1 GW) is selected in the first available year
- Significant expansion is selected by 2041, with the nearly the entire 5.5 GW potential built out by 2045



RESOLVE Modeling Results: DCPP Extension Portfolio

DCPP Sensitivity Inputs

- Diablo Canyon Power Plant (DCPP) is the only nuclear-fueled generator within California, and its largest generator at 2.3 GW
- DCPP was originally scheduled to retire by 2025
  - Unit 1 on November 2, 2024; Unit 2 on August 26, 2025[1]
- SB846, passed in September 2022, directs the state to pursue of 5-year extension of DCPP's lifetime
  - Unit 1 on October 31, 2029; Unit 2 on October 31, 2030[2]
- SB846 also **required IRP base assumptions to maintain the 2025 retirement date** for planning purposes
- In PG&E's application to the Nuclear Regulatory Commission (NRC) for a renewed operating license, it requested a 20-year license to operate through 2045[3]; **sensitivity assumes that 20-year extension occurs**
  - The NRC staff recommendation in the supplemental EIR (June 2025)[4] stated that the adverse environmental impacts of license renewal for Diablo Canyon are not so great that preserving the option of license renewal for energy-planning decision-makers would be unreasonable
- Staff developed a Fixed O&M **cost for DCPP**, approximately $450/kW-yr (2024$), totaling **approximately $1 Billion/year** for the whole power plant, based on PG&E testimony on the costs of extending and operating DCPP through 2030
  - Assume same rate of costs 2031-45; staff believe all costs included are not "one-time" extension costs and reflect continued costs through the extended lifetime
  - Fuel costs not included in this total as it is endogenously modeled in RESOLVE at $0.71/MMBtu

1 https://www.energy.ca.gov/sites/default/files/2020-03/Nuclear_Power_Reactors_in_California_ada.pdf;
2 https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=202120220SB846
3 https://www.regulations.gov/document/NRC-2023-0192-0001
4 https://www.nrc.gov/docs/ML2515/ML25156A357.pdf

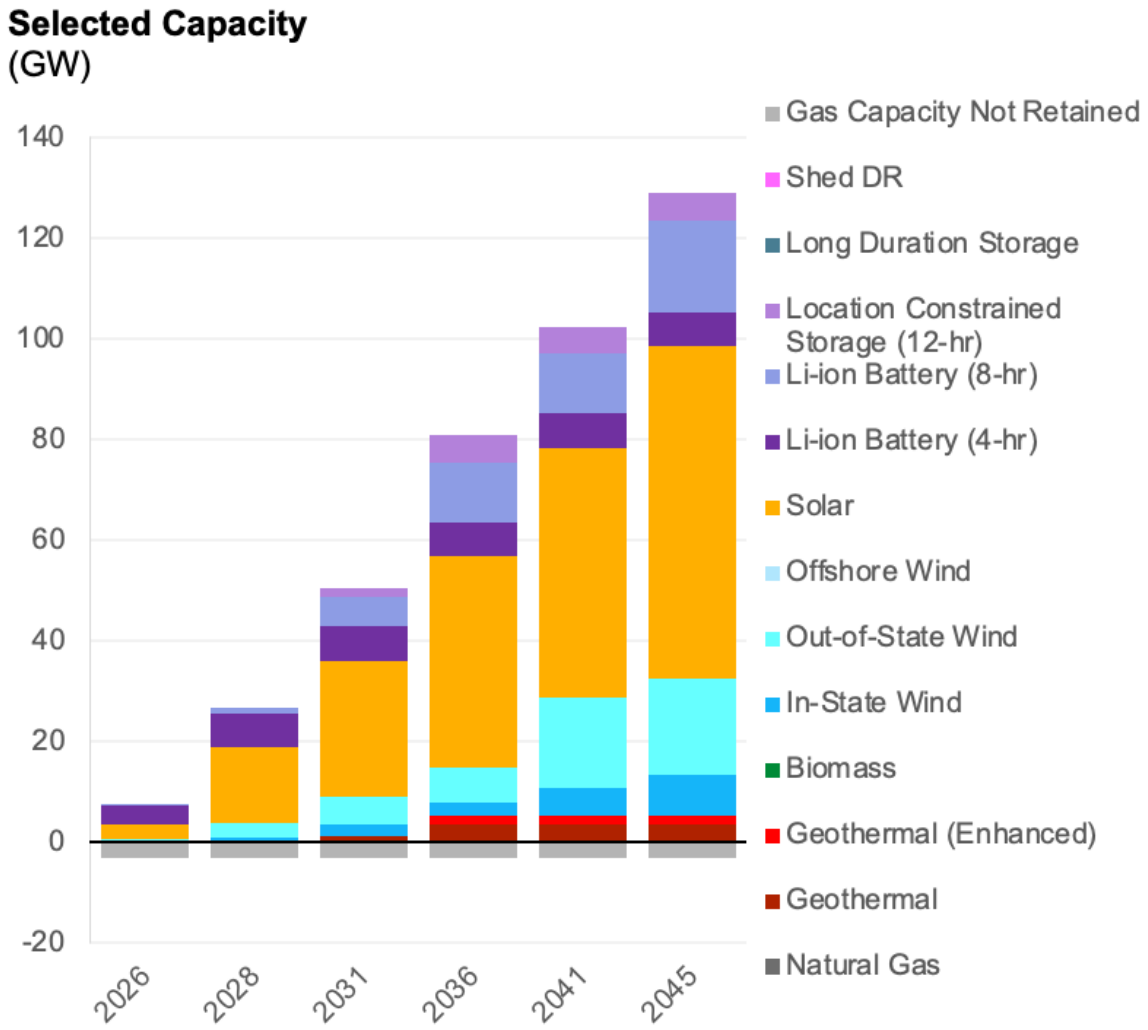
Motivation for Study

- Staff is not presenting this case as a sensitivity for the CAISO to study in its TPP process.
  - Commission is statutorily required to plan as if DCPP is offline beginning in 2024/2025[1]
  - Additionally, it is unlikely that studying this case would provide insight into future transmission needs as DCPP is already online
- Rather, this study creates an opportunity to compare the mix of resource attributes that would be selected with extended inclusion of this clean, firm, existing resource
- Study of DCPP Extension is informational only and would allow for updated analysis that would take into account the latest NRC staff recommendation, and the scenario of a possible future renewed license.

[1] *See* SB 846 (Stats. 2022, Ch. 239), which added Public Utilities Code Section 712.8(q)

26-27 TPP: DCPP Extension

Selected Builds



Geothermal is selected for reliability needs due to its high ELCC and high capacity- factor, GHG-free energy; most of the conventional geothermal potential is built out by 2036; EGS is also built in 2036 (prior to the expiration of tax credits)

Almost all available out-of-state wind is selected; near-term in-state wind build limits bind through 2028, and the loss of tax credits slows adoption until the 2040s

Solar and storage are resources that scale to meet growing GHG-free energy demand; the solar build limit is met in 2028 to capture tax credits

Gas with high fixed O&M is non-retained early on

26-27 TPP: DCPP Extension

Selected Builds

Resource Type	2026	2028	2031	2036	2041	2045
Natural Gas	-	-	-	-	-	-
Geothermal	0.1	0.1	1.2	3.4	3.4	3.4
Geothermal (Enhanced)	-	-	-	1.8	1.8	1.8
Biomass	-	-	-	-	-	-
In-State Wind	0.1	0.8	2.3	2.7	5.6	8.3
Out-of-State Wind	0.5	2.9	5.5	7.0	18.0	19.0
Offshore Wind	-	-	-	-	-	-
Solar	2.8	15.0	27.1	41.8	49.5	65.9
Li-ion Battery (4-hr)	3.9	6.7	6.8	6.8	6.8	6.8
Li-ion Battery (8-hr)	0.2	1.0	5.9	11.8	11.8	18.3
Location Constrained Storage (12-hr)	-	-	1.6	5.4	5.4	5.4
Generic Long Duration Storage (12-hr)	-	-	-	-	-	-
Generic Long Duration Storage (24-hr)	-	-	-	-	-	-
Generic Long Duration Storage (100-hr)	-	-	-	-	-	-
Shed DR	-	-	-	-	-	-
Gas Capacity Not Retained	(3.1)	(3.1)	(3.1)	(3.1)	(3.1)	(3.1)

26-27 TPP: DCPP Extension

Selected Builds

Resource Type	2026	2028	2031	2036	2041	2045
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Geothermal (Enhanced)	-	-	-	1.8	1.8	1.8
Biomass	-	-	-	-	-	-
In-State Wind	0.1	0.8	2.3	2.7	5.6	8.3
Out-of-State Wind	0.5	2.9	5.5	7.0	18.0	19.0
Offshore Wind	-	-	-	-	-	-
Solar	2.8	15.0	27.1	41.8	49.5	65.9
Li-ion Battery (4-hr)	3.9	6.7	6.8	6.8	6.8	6.8
Li-ion Battery (8-hr)	0.2	1.0	5.9	11.8	11.8	18.3
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Generic Long Duration Storage (12-hr)	-	-	-	-	-	-
Generic Long Duration Storage (24-hr)	-	-	-	-	-	-
Generic Long Duration Storage (100-hr)	-	-	-	-	-	-
Shed DR	-	-	-	-	-	-
Gas Capacity Not Retained	(3.1)	(3.1)	(3.1)	(3.1)	(3.1)	(3.1)

Gas with high fixed O&M is non-retained early on

Geothermal is selected for reliability needs due to its high ELCC and high capacity- factor, GHG-free energy; most of the conventional geothermal potential is built out by 2036; EGS is also built in 2036 (prior to the expiration of tax credits)

Almost all available out-of-state wind is selected; near-term in-state wind build limits bind through 2028, and the loss of tax credits slows adoption until the 2040s

Solar and storage are resources that scale to meet growing GHG-free energy demand; the solar build limit is met in 2028 to capture tax credits

Selected Builds by CAISO Study Area (2036)

Region	In-State Wind	Out-of-State Wind	OSW	Solar	Li-ion Battery (4-hr)	Li-ion Battery (8-hr)	Location-Constrained Storage (12-hr)	In-State Geothermal	Out-of-State Geothermal	EGS - Near Field	EGS - Deep
PG&E_Fresno	-	-	-	1,247	226	2,279	-	-	-	-	269
PG&E_GBA	247	-	-	130	612	45	123	-	-	-	70
PG&E_Kern	-	-	-	9,675	369	-	818	-	-	-	3
PG&E_NGBA	684	-	-	619	314	-	-	668	808	1,411	-
PG&E_Northeast_CA	-	-	-	-	-	-	-	178	-	-	-
SCE_Arizona	-	2,936	-	4,940	904	156	-	-	-	-	-
SCE_Eastern	676	-	-	1,808	470	-	1,800	7	-	-	-
SCE_EOP	255	4,100	-	690	638	1,217	500	-	1,069	-	-
SCE_Metro	-	-	-	5	1,365	6,093	-	-	-	-	-
SCE_NOL	-	-	-	328	542	6	386	142	-	-	-
SCE_Northern	-	-	-	7,905	623	635	1,280	-	-	-	-
SDGE_Arizona	-	-	-	14,229	85	1,248	-	-	-	-	-
SDGE_Baja_California	353	-	-	-	-	-	-	-	-	-	-
SDGE_Imperial	514	-	-	190	675	137	-	529	-	-	-

SDGE Baja California interconnects at SDGE Imperial

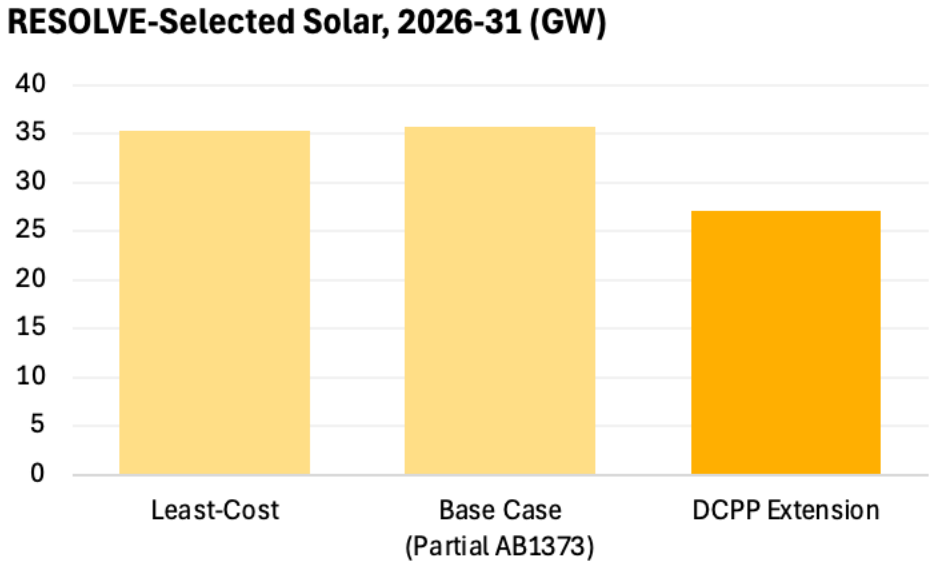
Selected Builds by CAISO Study Area (2041)

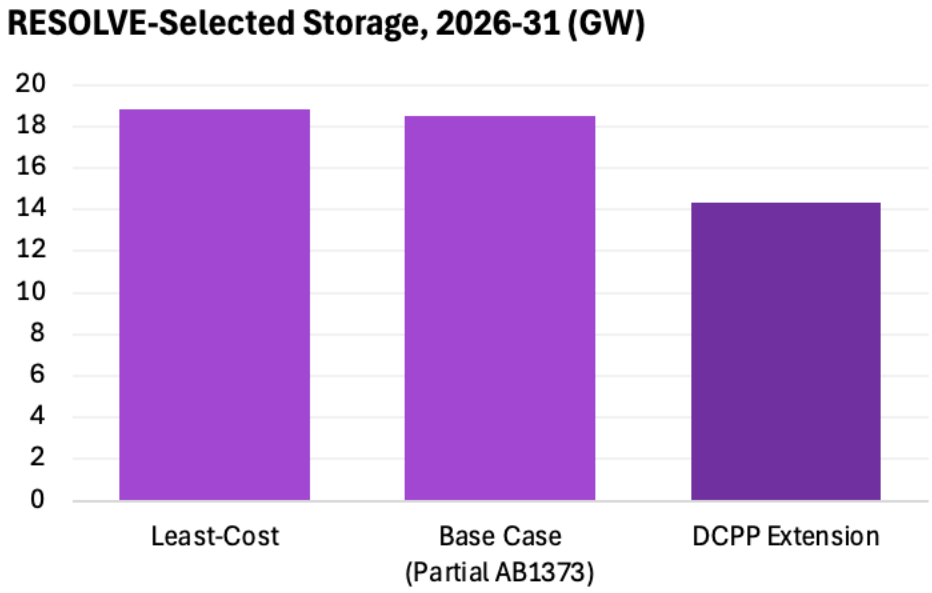
Region	In-State Wind	Out-of-State Wind	OSW	Solar	Li-ion Battery (4-hr)	Li-ion Battery (8-hr)	Location-Constrained Storage (12-hr)	In-State Geothermal	Out-of-State Geothermal	EGS - Near Field	EGS - Deep
PG&E_Fresno	-	-	-	4,832	226	2,279	-	-	-	-	269
PG&E_GBA	247	4,000	-	531	612	45	123	-	-	-	70
PG&E_Kern	3	-	-	9,675	369	-	818	-	-	-	3
PG&E_NGBA	1,867	-	-	648	314	-	-	668	808	1,411	-
PG&E_Northeast_CA	-	-	-	-	-	-	-	178	-	-	-
SCE_Arizona	-	8,936	-	4,940	904	156	-	-	-	-	-
SCE_Eastern	676	-	-	5,168	470	-	1,800	7	-	-	-
SCE_EOP	255	5,073	-	690	638	1,217	500	-	1,069	-	-
SCE_Metro	-	-	-	387	1,365	6,093	-	-	-	-	-
SCE_NOL	-	-	-	328	542	6	386	142	-	-	-
SCE_Northern	-	-	-	7,905	623	635	1,280	-	-	-	-
SDGE_Arizona	-	-	-	14,229	85	1,248	-	-	-	-	-
SDGE_Baja_California	1,654	-	-	-	-	-	-	-	-	-	-
SDGE_Imperial	943	-	-	190	675	137	-	529	-	-	-

SDGE Baja California interconnects at SDGE Imperial

Near-Term Builds (2026-31)

- Extension of DCPP would reduce the near-term (2026-31) solar and storage build rates necessary to meet the GHG target, relative to the least-cost comparison and base cases
  - Solar: 4.5 GW/yr instead of 6 GW/yr
  - Storage: 2.4 GW/yr instead of 3 GW/yr
  - Small decreases in wind and geothermal builds
- Solar and storage build rates after 2031 are similar to the least-cost comparison and base cases, as incremental GHG and reliability needs are the same with DCPP remaining online





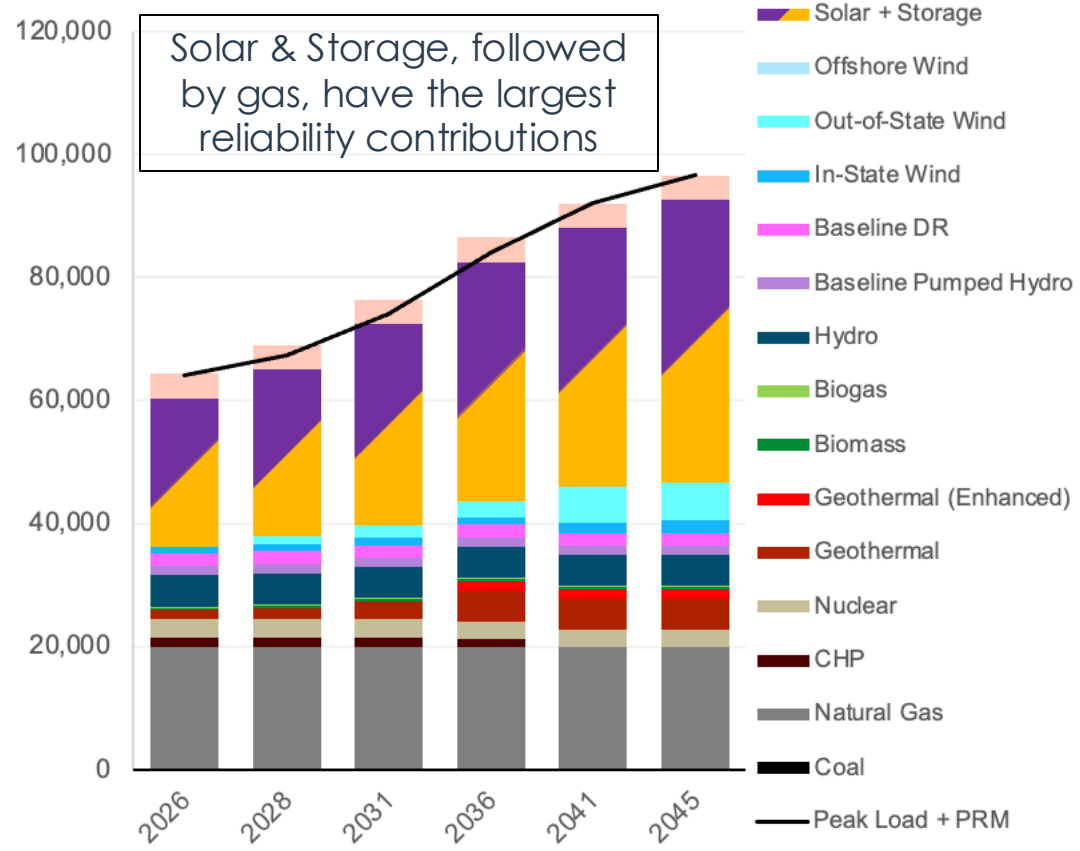
26-27 TPP: DCPP Extension

Reliability and Energy Mix

With DCPP Extension, nuclear provides a noticeable amount of firm capacity & energy through 2045

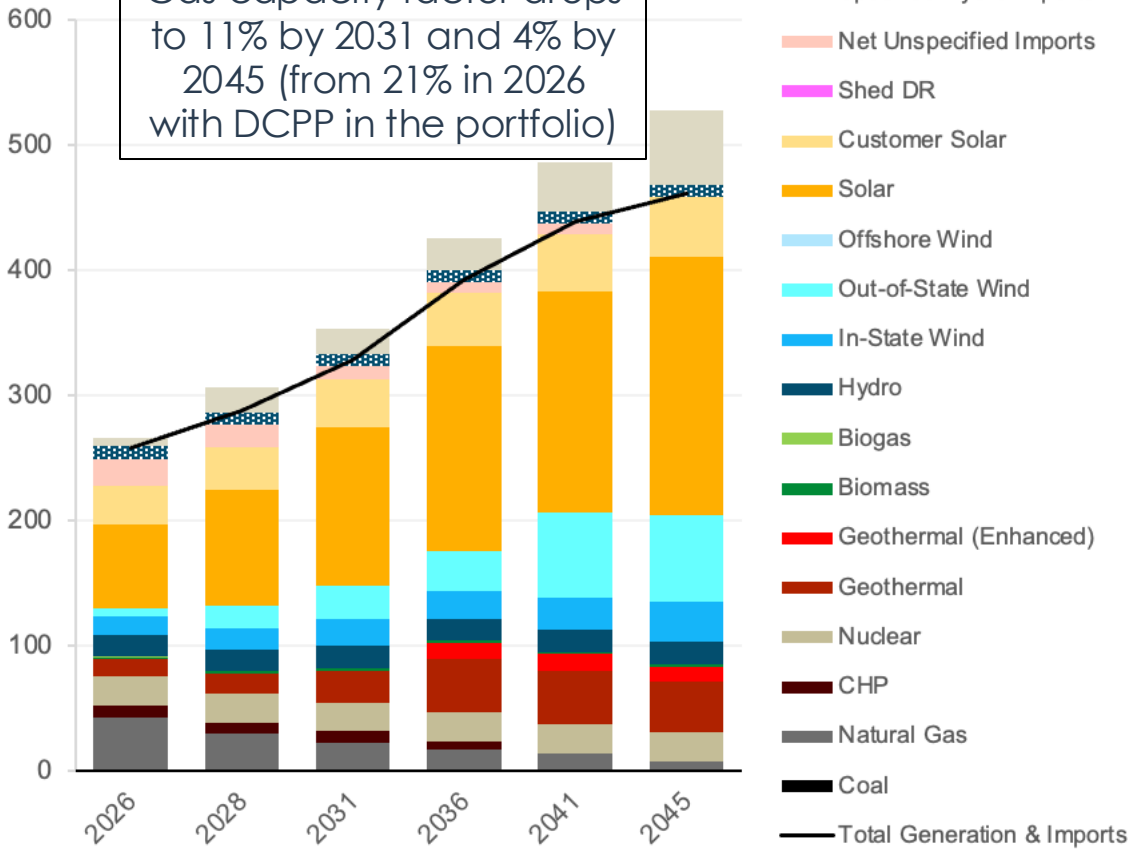
PCAP PRM Contribution
(ELCC MW)

Solar & Storage, followed by gas, have the largest reliability contributions



Annual Generation and Net Imports
(TWh)

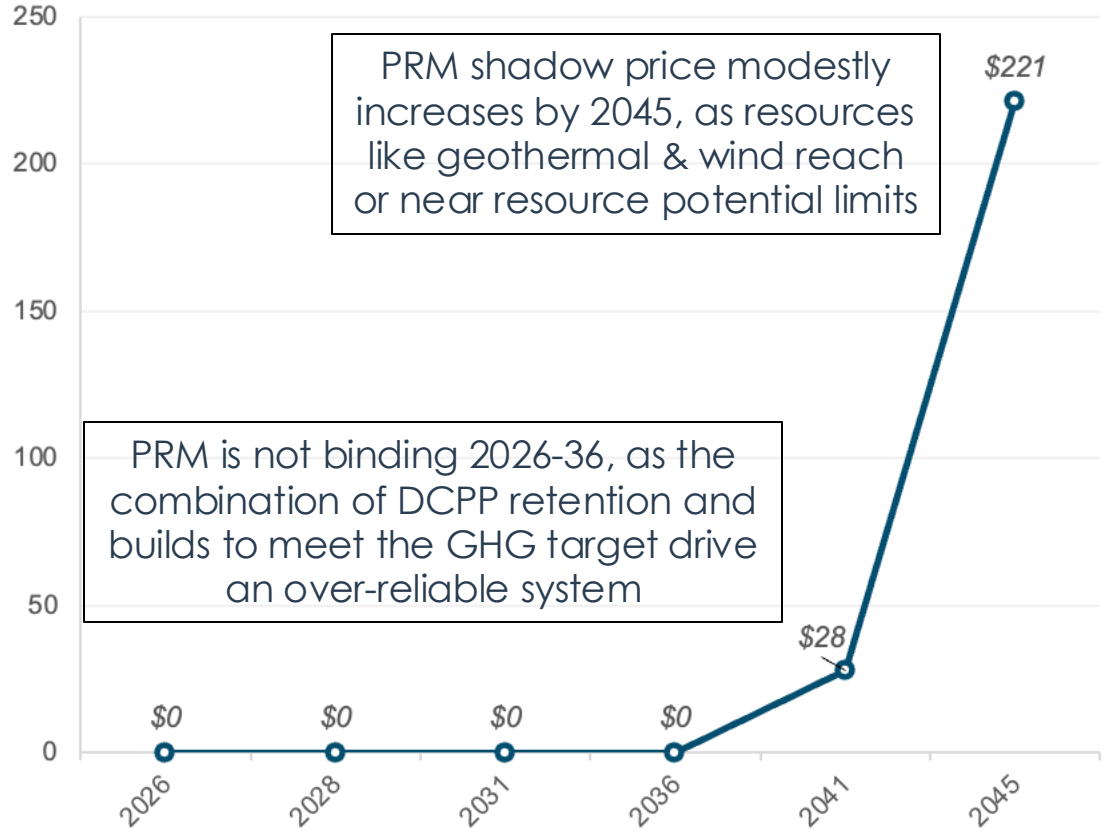
Gas capacity factor drops to 11% by 2031 and 4% by 2045 (from 21% in 2026 with DCPP in the portfolio)



PRM and GHG Constraints

- Shadow prices represent the cost of meeting a constraint, i.e. the cost of the last kW of firm capacity or the last ton of GHG emissions reduction

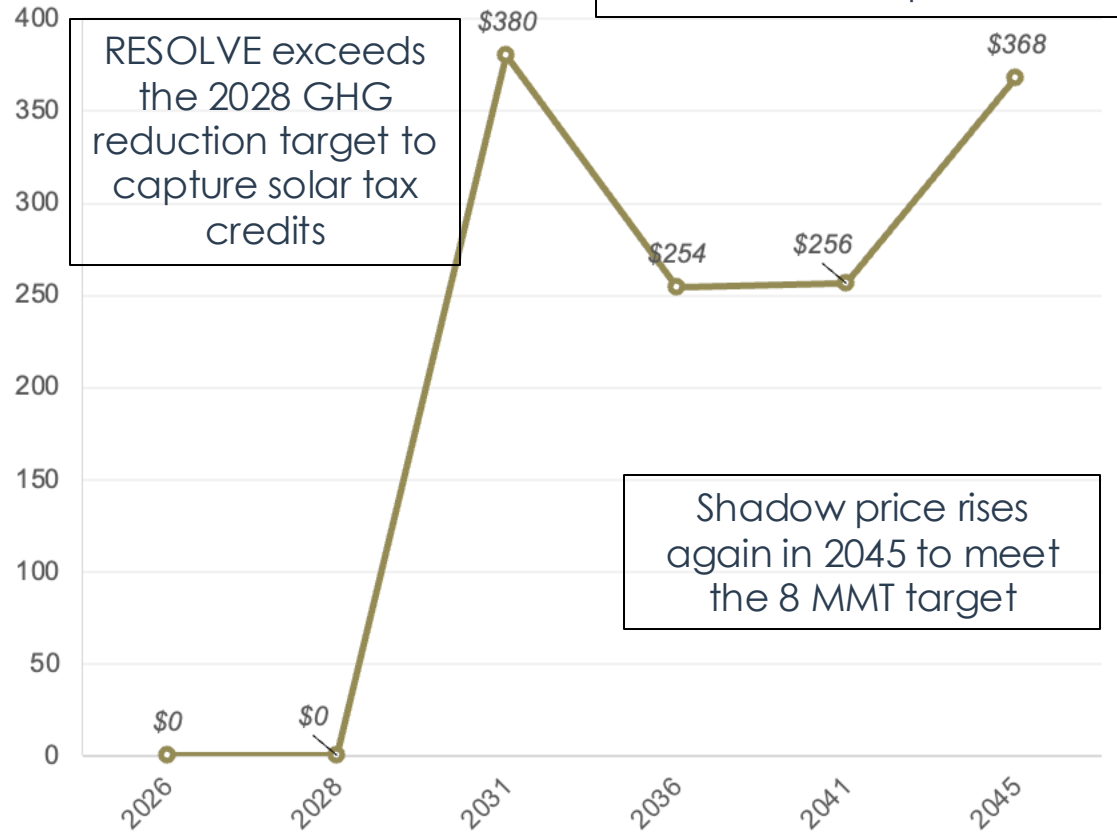
PRM Shadow Prices
($/kW-year)



PRM shadow price modestly increases by 2045, as resources like geothermal & wind reach or near resource potential limits

PRM is not binding 2026-36, as the combination of DCPP retention and builds to meet the GHG target drive an over-reliable system

GHG Target Shadow Price
($/ton CO_2)



Near-term build limits for wind and geothermal, drive a high GHG shadow price in 2031

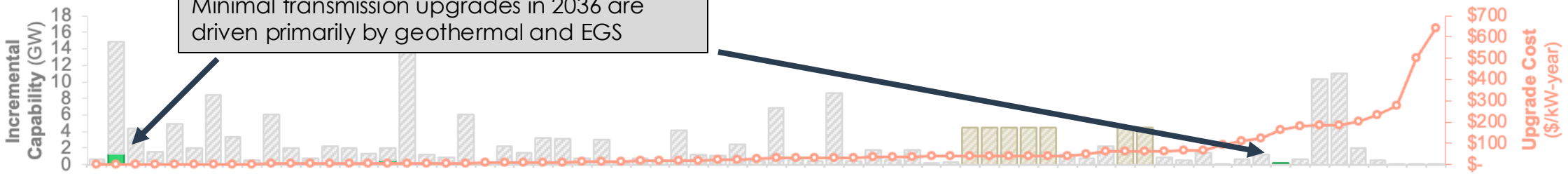
RESOLVE exceeds the 2028 GHG reduction target to capture solar tax credits

Shadow price rises again in 2045 to meet the 8 MMT target

Note: Officially selected transmission upgrades are determined by the CAISO Transmission Plan

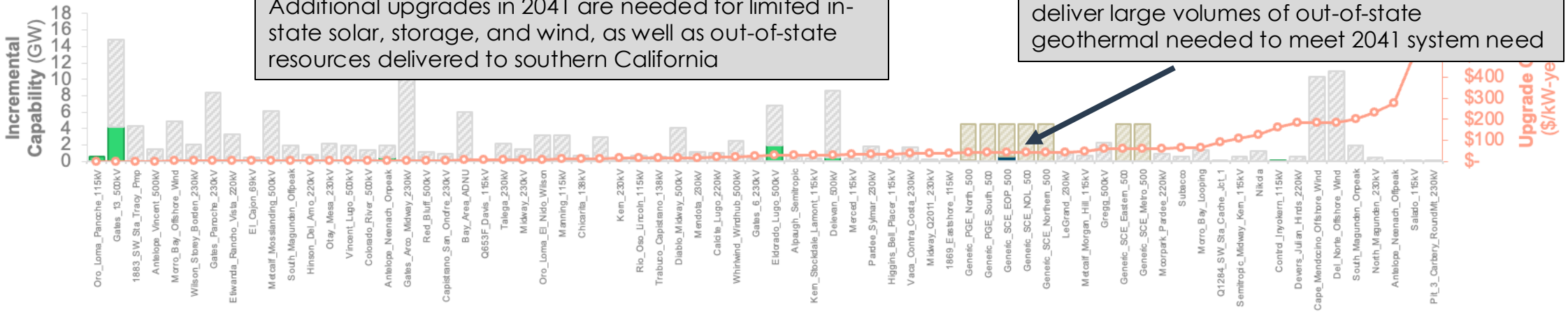
RESOLVE-Selected Transmission Upgrades

Selected Transmission Upgrades by Cost, 2036
(GW)



Minimal transmission upgrades in 2036 are driven primarily by geothermal and EGS

Selected Transmission Upgrades by Cost, 2041
(GW)

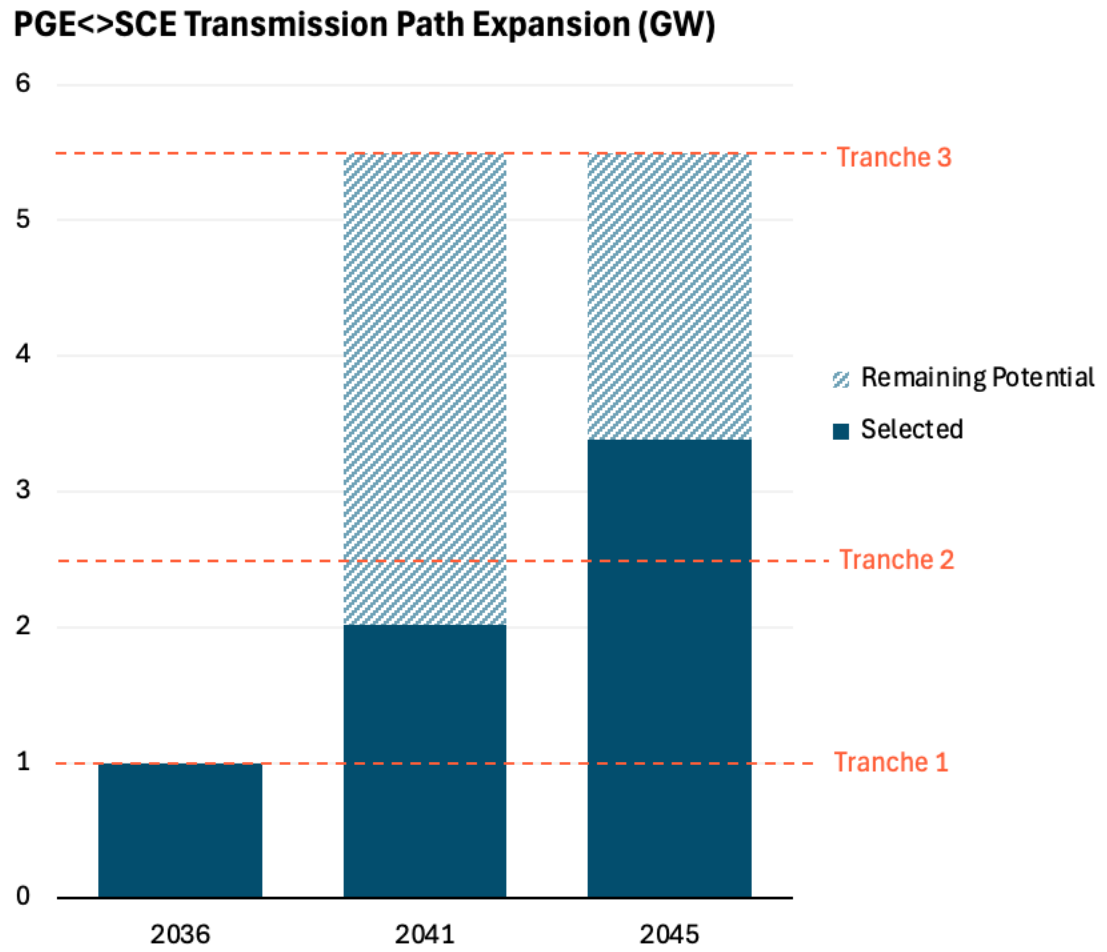


Additional upgrades in 2041 are needed for limited in-state solar, storage, and wind, as well as out-of-state resources delivered to southern California

Selection of generic upgrade suggests that CAISO-identified upgrade are insufficient do deliver large volumes of out-of-state geothermal needed to meet 2041 system need

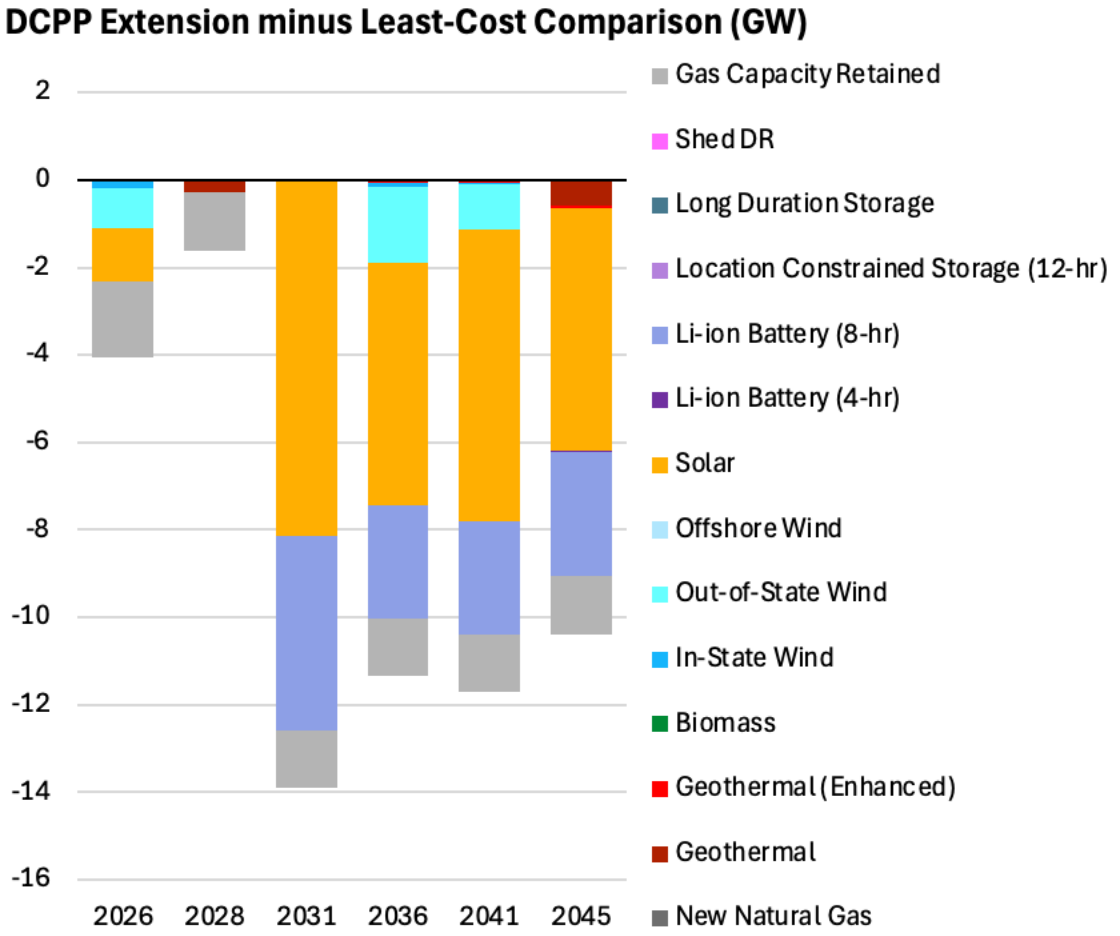
PG&E<>SCE Transmission Expansion

- Path 26/Path 15 expansion(s) are selected primarily to increase import capacity into PG&E
- The first tranche (1 GW) is selected in the first available year
- Approximately ~2.5 GW additional upgrade is selected by 2045; DCPP Extension reduces the need for additional import capacity into PG&E



Selected Builds Comparison with Least-Cost Comparison Case

- DCPP Extension primarily displaces solar and batteries (~8-12 GW) starting in the 2030s
  - No solar is displaced in 2028, as RESOLVE builds up to the limit to capture tax credits
- An additional ~1.5 GW of gas capacity is not retained for reliability needs
- Small decrease in geothermal build in 2045; 2028 geothermal build is extended to 2031
- Out-of-state wind builds in 2036-41 are extended to 2045 due to lowered need for new GHG-free energy in the 2030s.



System Cost Comparison with Least-Cost Comparison Case

RESOLVE-Optimized Costs ($MM in 2024$)

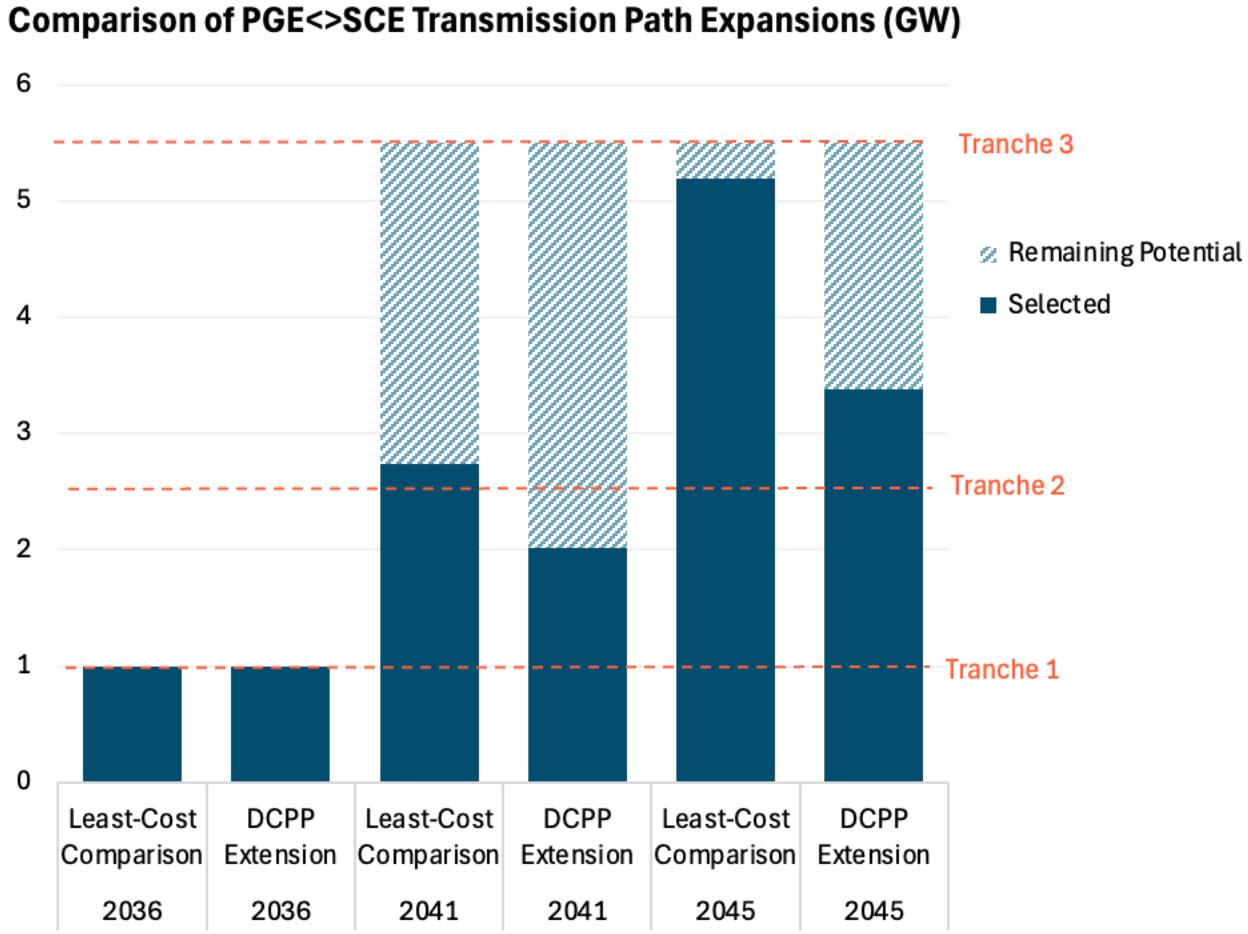
Case	2026	2028	2031	2036	2041	2045	NPV
Least-Cost Comparison Case	$8,758	$11,983	$18,094	$24,231	$28,392	$34,865	*$394,735*
DCPP Extension	$8,871 +$323 (3.7%)	$11,364 -$619 (5.2%)	$17,178 -$916 (5.1%)	$23,339 -$892 (3.7%)	$27,323 -$1,069 (3.8%)	$33,620 -$1,245 (3.6%)	*$379,890* *-$14,845* *(3.8%)*

- Extending DCPP saves approximately $600 Million to $1.2 Billion each year, except for 2026
  - ~$1.6-2.2 Billion avoided costs (mostly new renewables & storage not built), minus~$1 Billion DCPP costs
  - Avoided costs in 2026 is lower than DCPP Extension costs
  - 2036 cost difference is smaller because RESOLVE builds geothermal in that year to capture tax credits, regardless of DCPP being online, reducing avoided costs

RESOLVE-optimized costs account for ~15-30% of total system costs (increasing over time); non-optimized baseline generation, transmission, and distribution make up the rest of the revenue requirement

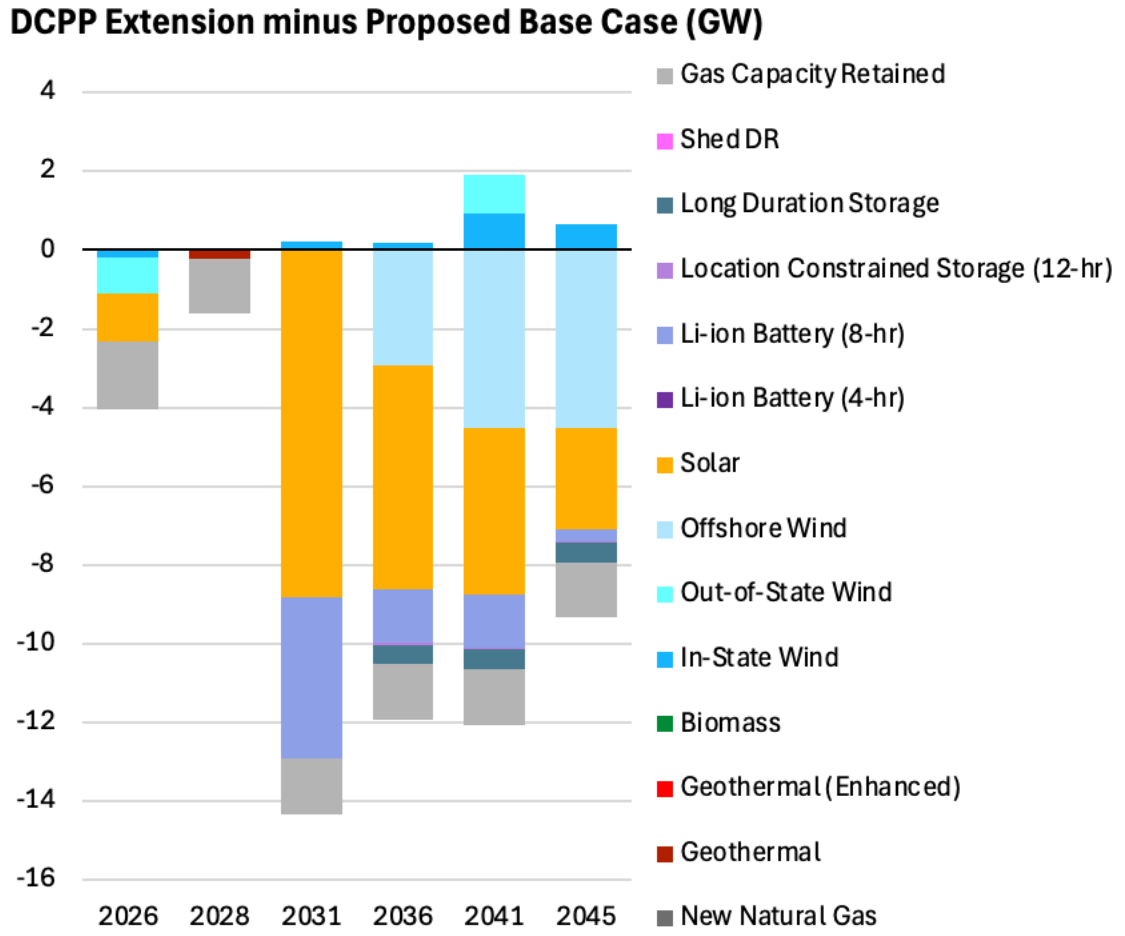
PG&E<>SCE Transmission Comparison with Least-Cost Comparison Case

- Both cases select the first tranche in the first available year
- By 2045, the DCPP Extension avoids ~1.8 GW additional upgrade, relative to least-cost Comparison
  - DCPP provides firm, clean energy directly to PG&E, reducing the need for imports from SCE



Selected Builds Comparison with Base Case

- DCPP Extension primarily displaces solar and batteries starting in the 2030s
  - No solar is displaced in 2028, as RESOLVE builds up to the limit to capture tax credits
- An additional ~1.5 GW of gas capacity is not retained for reliability needs
- Offshore wind and multi-day storage forced-in to the base case for partial AB1373 procurement volumes are also not in the sensitivity portfolio
  - Small amounts of additional onshore wind in the 2040s, relative to the base case; DCPP also helps replace forced-in AB1373 resources



System Cost Comparison with Base Case

RESOLVE-Optimized Costs ($MM in 2024$)

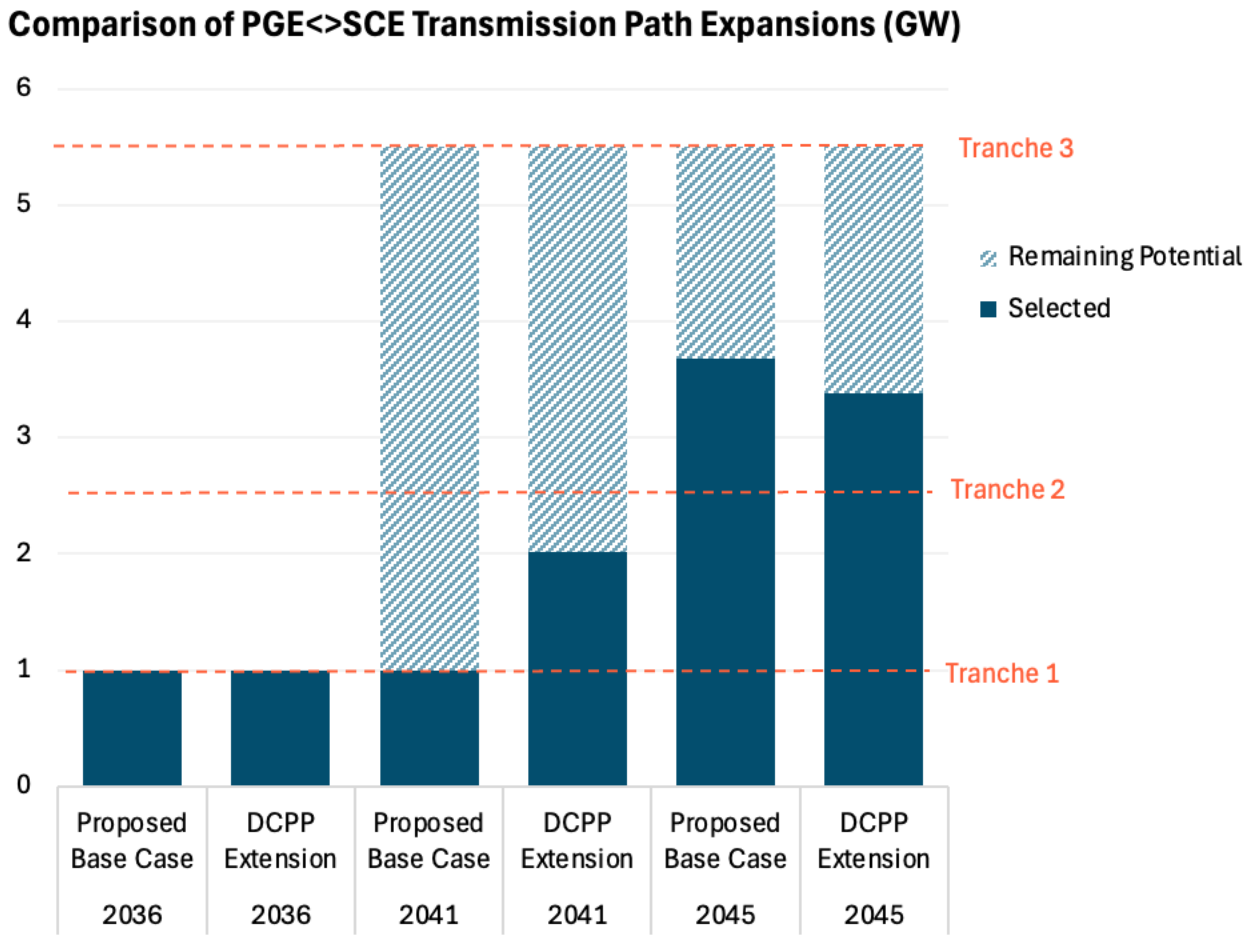
Case	2026	2028	2031	2036	2041	2045	NPV
Proposed Base Case	$60,999	$68,532	$79,762	$95,765	$108,540	$120,880	*$1,564,126*
DCPP Extension	$61,321 -$322 (0.5%)	$68,111 -$421 (0.6%)	$79,083 -$679 (0.9%)	$93,048 -$2,717 (2.8%)	$105,022 -$3,518 (3.2%)	$117,071 -$3,709 (3.1%)	*$1,527,324* *-$36,802* *(2.4%)*

- The combination of retention of DCPP, and excluding relatively expensive AB1373 resources (offshore wind and multi-day storage) saves $2.7-3.7 Billion per year
  - $3.7-4.7 Billion avoided costs, minus ~$1 Billion DCPP costs

RESOLVE-optimized costs account for ~15-30% of total system costs (increasing over time); non-optimized baseline generation, transmission, and distribution make up the rest of the revenue requirement

PG&E<>SCE Transmission Comparison with Base Case

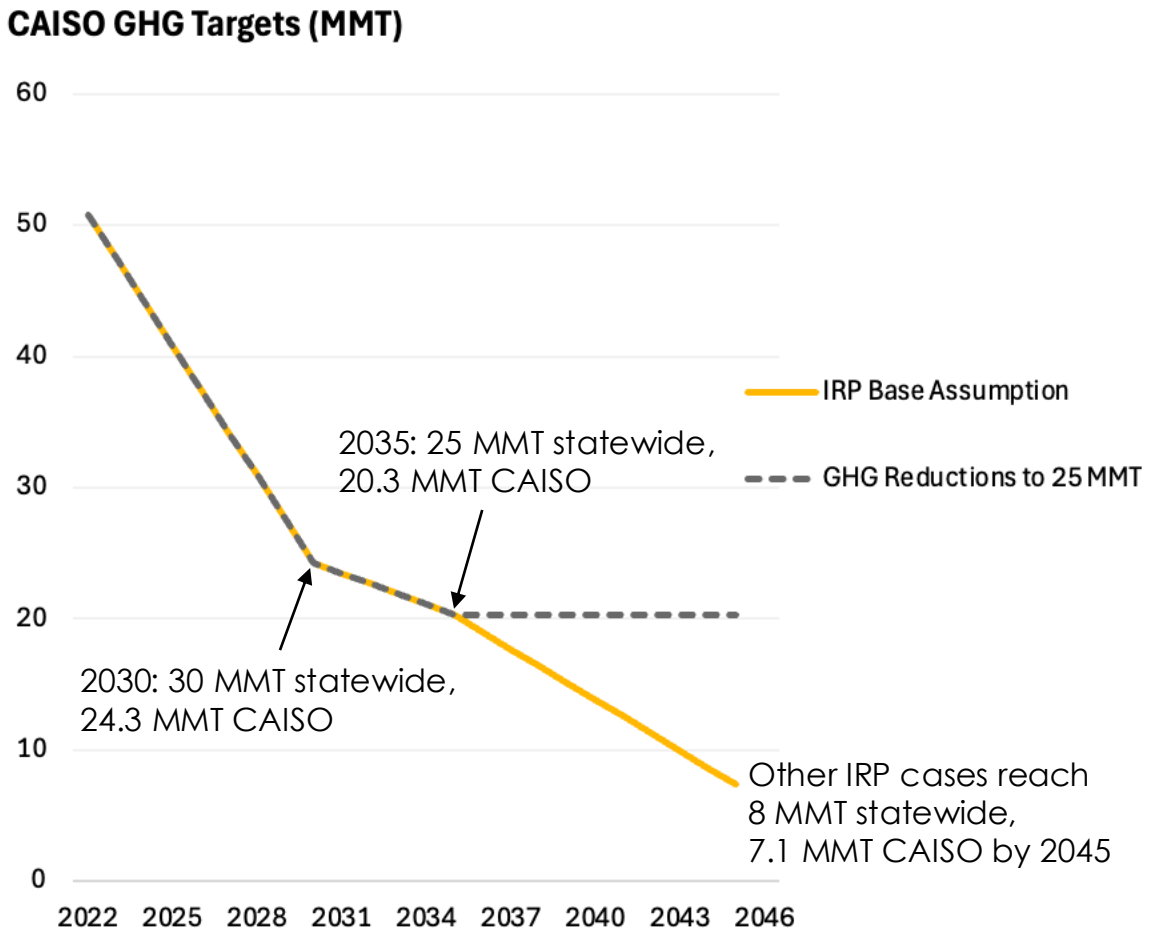
- Both cases select the first tranche in the first available year
- By 2045, both cases select ~3.5 GW total upgrade
  - Both offshore wind and DCPP provide energy directly to PG&E, reducing the need for imports from SCE



RESOLVE Modeling Results: Compliance with GHG Reductions to 25 MMT

GHG Reductions to 25 MMT Sensitivity Inputs

- The GHG Reductions to 25 MMT sensitivity maintains the adopted GHG emissions targets through 2035, but **holds the GHG target constant from 2035-45**
  - IRP base assumption is to achieve the 2022 CARB scoping plan emissions budget in 2045
  - After 2035, legislative RPS & CES targets (SB100, SB1020) may drive builds, if they exceed GHG requirements
- In this sensitivity, **new natural gas generators are allowed** for selection by RESOLVE
  - Primarily selected for reliability needs

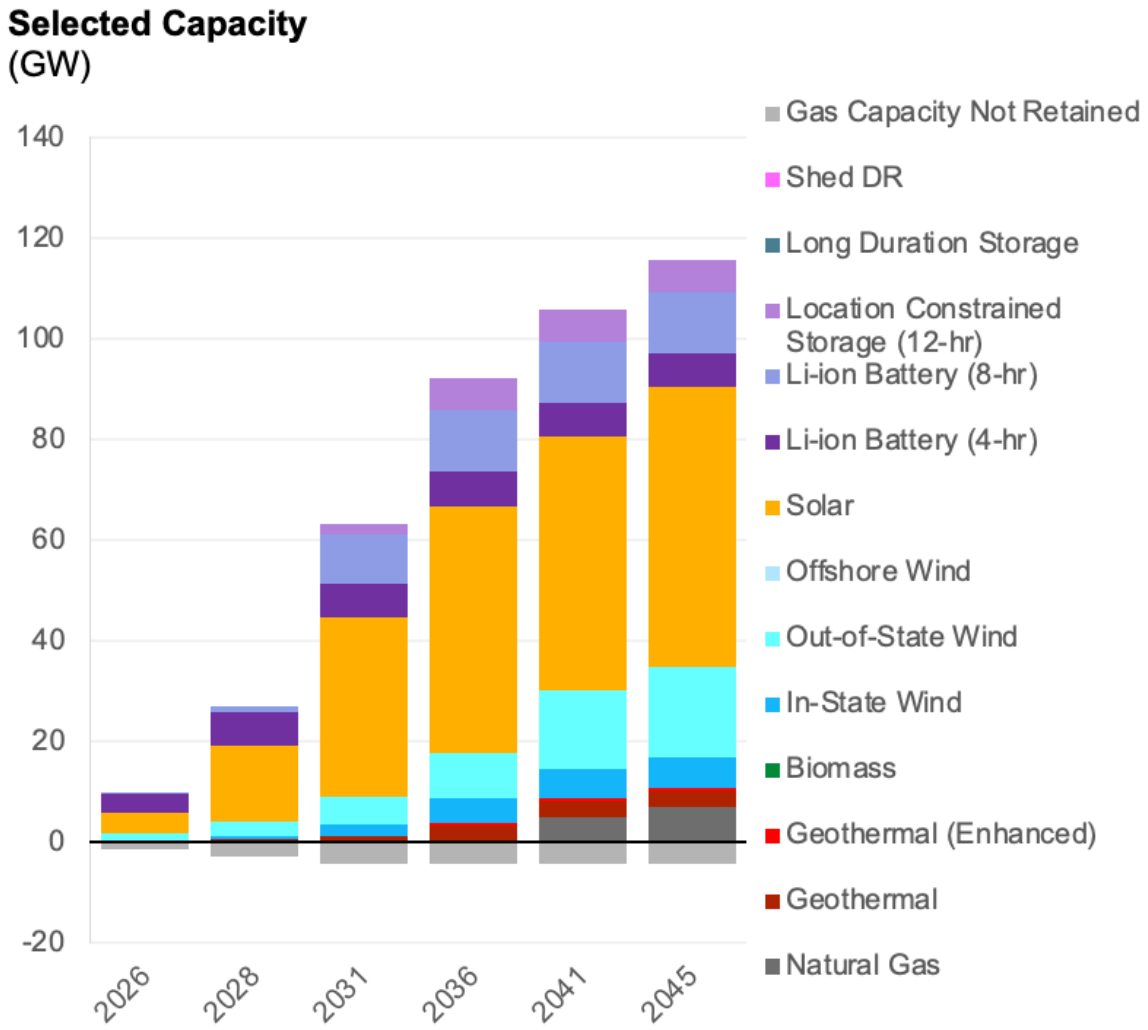


26-27 TPP: GHG Reductions to 25 MMT

Motivation for Study

- Staff is not presenting this case as a sensitivity for the CAISO to study in its TPP process
- In the previous two TPP cycles, the Commission adopted portfolios to meet an 8 MMT by 2045 target, consistent with the CARB Scoping Plan update
  - Studying this portfolio is unlikely to provide insight into future and incremental transmission needs because it is smaller than those adopted portfolios
- Rather, studying a case that does not include a GHG target after 2035 provides an opportunity to identify the resources that are not selected in this case compared to the 8 MMT by 2045 portfolios
- This sensitivity analysis provides insights into the types of resources that can most effectively reduce GHGs to achieve California's 2045 climate goals

Selected Builds



Geothermal is selected for reliability needs due to its high ELCC and high capacity- factor, GHG-free energy; most of the conventional geothermal potential is built out by 2036; small amounts of EGS are also built in 2036 (prior to the expiration of tax credits)

Almost all available out-of-state wind is selected; near-term in-state wind build limits bind through 2028, and the loss of tax credits slows adoption until the 2040s

Solar and storage are resources that scale to meet growing GHG-free energy demand

Gas with high fixed O&M is non-retained early on; highly-efficient new gas is built for reliability needs in the 2040s, resulting in a net increase in the size of the gas fleet by 2.7 GW

26-27 TPP: GHG Reductions to 25 MMT

Selected Builds

Resource Type	2026	2028	2031	2036	2041	2045
Natural Gas	-	-	-	-	4.9	7.0
Geothermal	0.1	0.5	1.2	3.2	3.2	3.2
Geothermal (Enhanced)	-	-	-	0.6	0.6	0.6
Biomass	-	-	-	-	-	-
In-State Wind	0.3	0.8	2.3	4.8	5.7	6.1
Out-of-State Wind	1.4	2.9	5.5	9.0	15.6	17.8
Offshore Wind	-	-	-	-	-	-
Solar	4.0	15.0	35.6	49.1	50.4	55.5
Li-ion Battery (4-hr)	3.9	6.7	6.8	6.8	6.8	6.8
Li-ion Battery (8-hr)	0.2	1.0	9.8	12.1	12.1	12.1
Location Constrained Storage (12-hr)	-	-	2.1	6.3	6.3	6.3
Generic Long Duration Storage (12-hr)	-	-	-	-	-	-
Generic Long Duration Storage (24-hr)	-	-	-	-	-	-
Generic Long Duration Storage (100-hr)	-	-	-	-	-	-
Shed DR	-	-	-	-	-	-
Gas Capacity Not Retained	(1.3)	(2.9)	(4.3)	(4.3)	(4.3)	(4.3)

Selected Builds by CAISO Study Area (2036)

Region	In-State Wind	Out-of-State Wind	OSW	Solar	Li-ion Battery (4-hr)	Li-ion Battery (8-hr)	Location-Constrained Storage (12-hr)	In-State Geothermal	Out-of-State Geothermal	EGS - Near Field	EGS - Deep
PG&E_Fresno	-	-	-	6,375	226	3,749	-	-	-	-	-
PG&E_GBA	247	2,000	-	1,022	612	45	400	-	-	-	-
PG&E_Kern	13	-	-	9,767	369	-	887	-	-	-	-
PG&E_NGBA	1,641	-	-	2,000	314	-	460	668	808	616	-
PG&E_Northeast_CA	-	-	-	-	-	-	-	178	-	-	-
SCE_Arizona	-	2,936	-	4,636	904	461	-	-	-	-	-
SCE_Eastern	676	-	-	6,083	470	-	1,800	7	-	-	-
SCE_EOP	255	4,100	-	1,351	638	220	500	-	908	-	-
SCE_Metro	-	-	-	387	1,365	5,160	-	-	-	-	-
SCE_NOL	-	-	-	828	542	6	500	142	-	-	-
SCE_Northern	-	-	-	6,010	623	635	1,280	-	-	-	-
SDGE_Arizona	-	-	-	10,450	85	1,683	-	-	-	-	-
SDGE_Baja_California	1,427	-	-	-	-	-	-	-	-	-	-
SDGE_Imperial	514	-	-	190	675	137	-	529	-	-	-

SDGE Baja California interconnects at SDGE Imperial

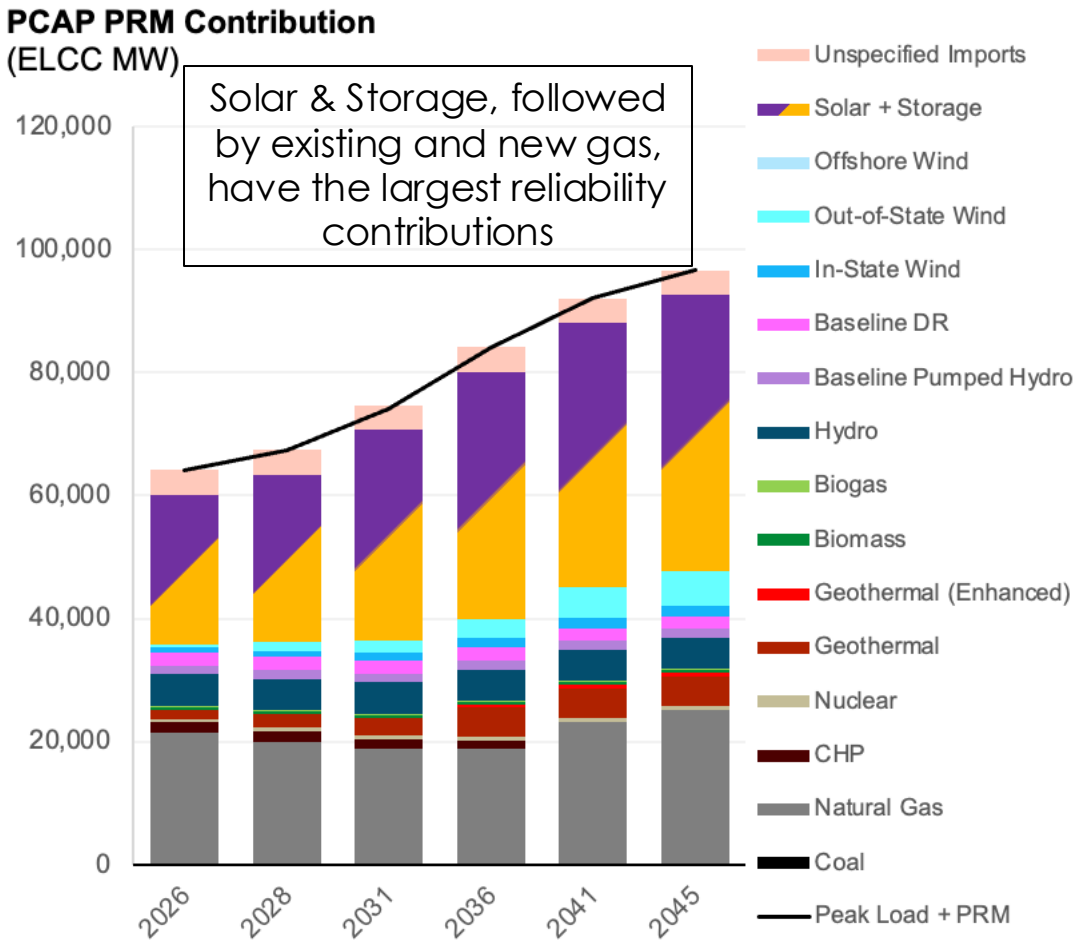
26-27 TPP: GHG Reductions to 25 MMT

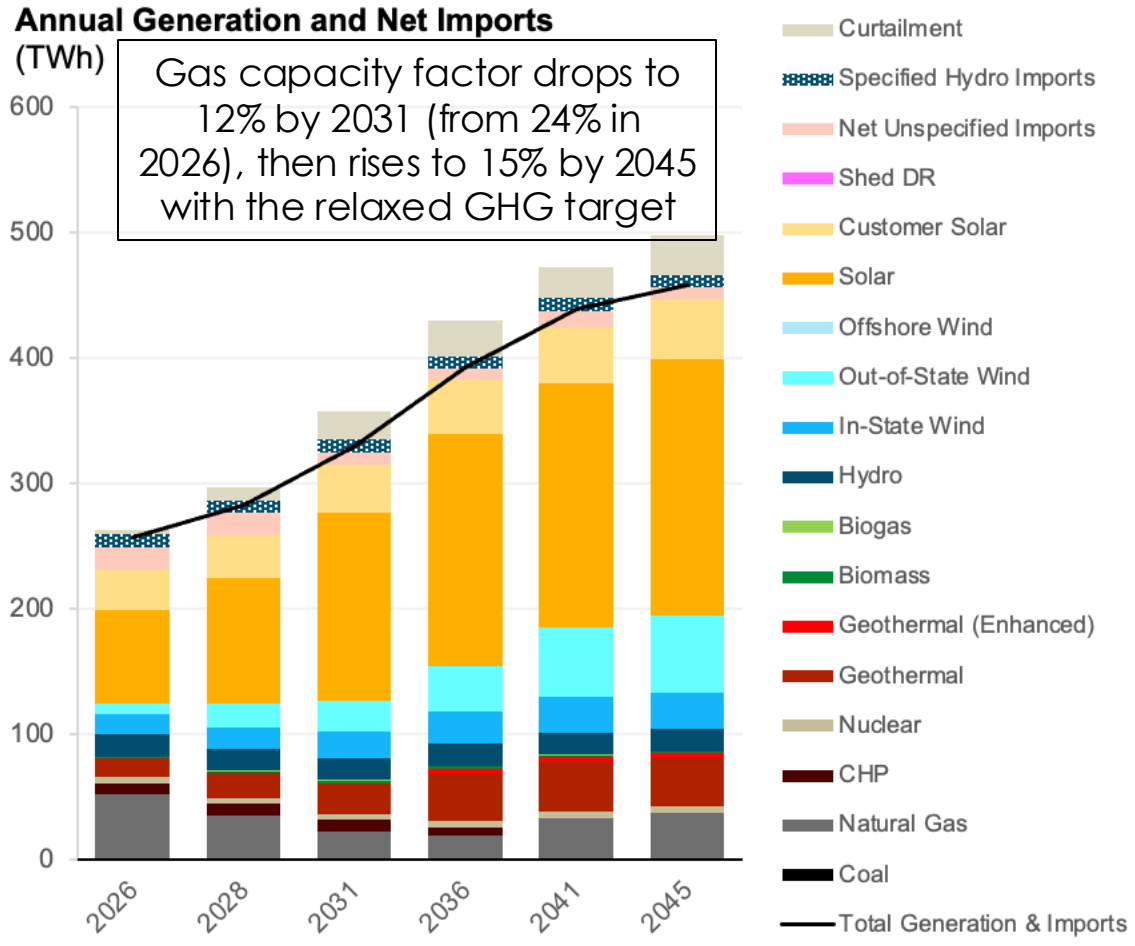
Selected Builds by CAISO Study Area (2041)

Region	In-State Wind	Out-of-State Wind	OSW	Solar	Li-ion Battery (4-hr)	Li-ion Battery (8-hr)	Location-Constrained Storage (12-hr)	In-State Geothermal	Out-of-State Geothermal	EGS - Near Field	EGS - Deep	Natural Gas
PG&E_Fresno	-	-	-	7,409	226	3,749	-	-	-	-	-	-
PG&E_GBA	247	3,951	-	1,108	612	45	400	-	-	-	-	-
PG&E_Kern	13	-	-	9,767	369	-	887	-	-	-	-	-
PG&E_NGBA	1,893	-	-	2,000	314	-	460	668	808	616	-	-
PG&E_Northeast_CA	-	-	-	-	-	-	-	178	-	-	-	-
PG&E (Generic)	-	-	-	-	-	-	-	-	-	-	-	4,915
SCE_Arizona	-	7,570	-	4,636	904	461	-	-	-	-	-	-
SCE_Eastern	676	-	-	6,083	470	-	1,800	7	-	-	-	-
SCE_EOP	255	4,100	-	1,351	638	220	500	-	908	-	-	-
SCE_Metro	-	-	-	387	1,365	5,160	-	-	-	-	-	-
SCE_NOL	-	-	-	828	542	6	500	142	-	-	-	-
SCE_Northern	-	-	-	6,155	623	635	1,280	-	-	-	-	-
SDGE_Arizona	-	-	-	10,450	85	1,683	-	-	-	-	-	-
SDGE_Baja_California	1,654	-	-	-	-	-	-	-	-	-	-	-
SDGE_Imperial	943	-	-	190	675	137	-	529	-	-	-	-

SDGE Baja California interconnects at SDGE Imperial

Reliability and Energy Mix

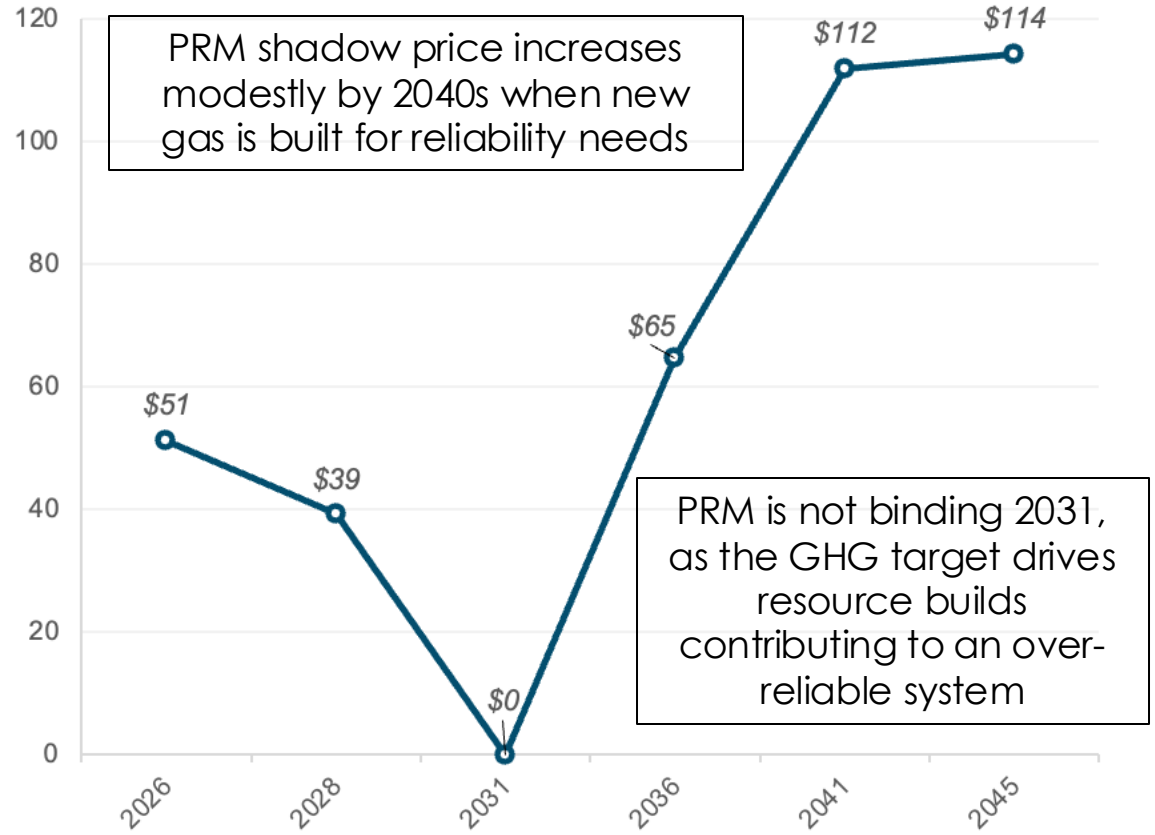




PRM and GHG Constraints

- Shadow prices represent the cost of meeting a constraint, i.e. the cost of the last kW of firm capacity or the last ton of GHG emissions reduction

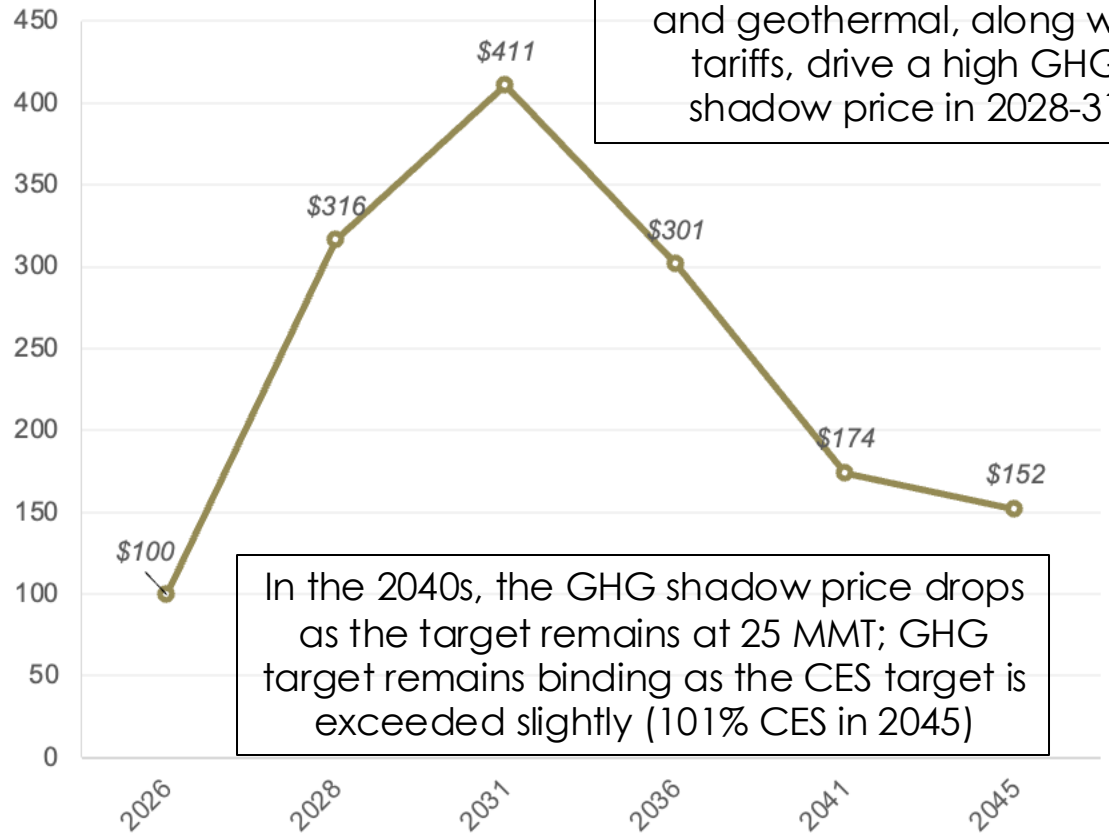
PRM Shadow Prices
($/kW-year)



PRM shadow price increases modestly by 2040s when new gas is built for reliability needs

PRM is not binding 2031, as the GHG target drives resource builds contributing to an over-reliable system

GHG Target Shadow Price
($/ton CO_2)



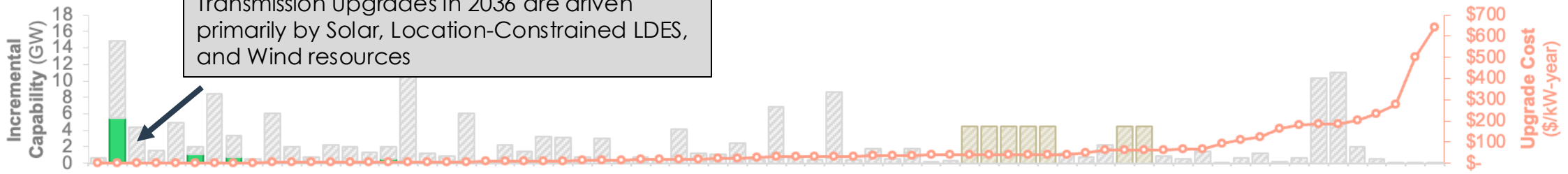
Near-term build limits for wind and geothermal, along with tariffs, drive a high GHG shadow price in 2028-31

In the 2040s, the GHG shadow price drops as the target remains at 25 MMT; GHG target remains binding as the CES target is exceeded slightly (101% CES in 2045)

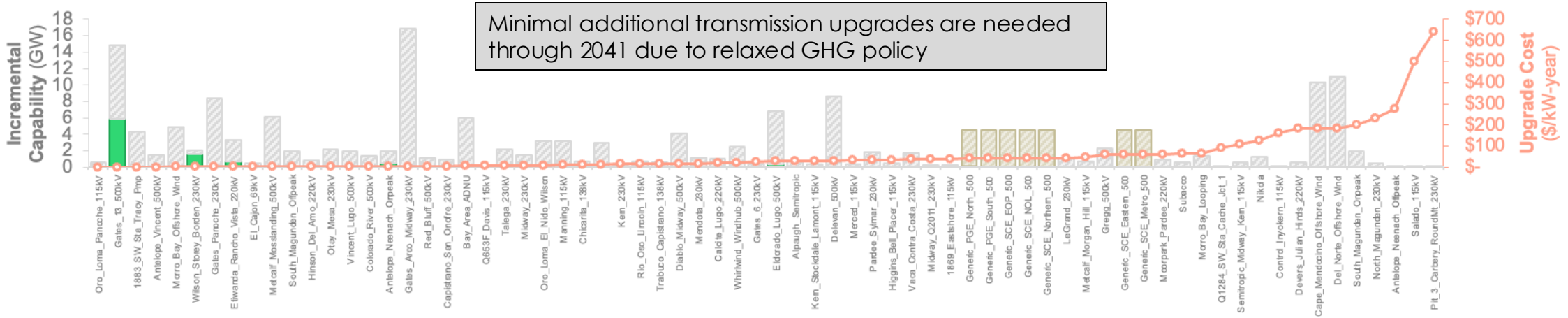
Note: Officially selected transmission upgrades are determined by the CAISO Transmission Plan

RESOLVE-Selected Transmission Upgrades

Selected Transmission Upgrades by Cost, 2036
(GW)

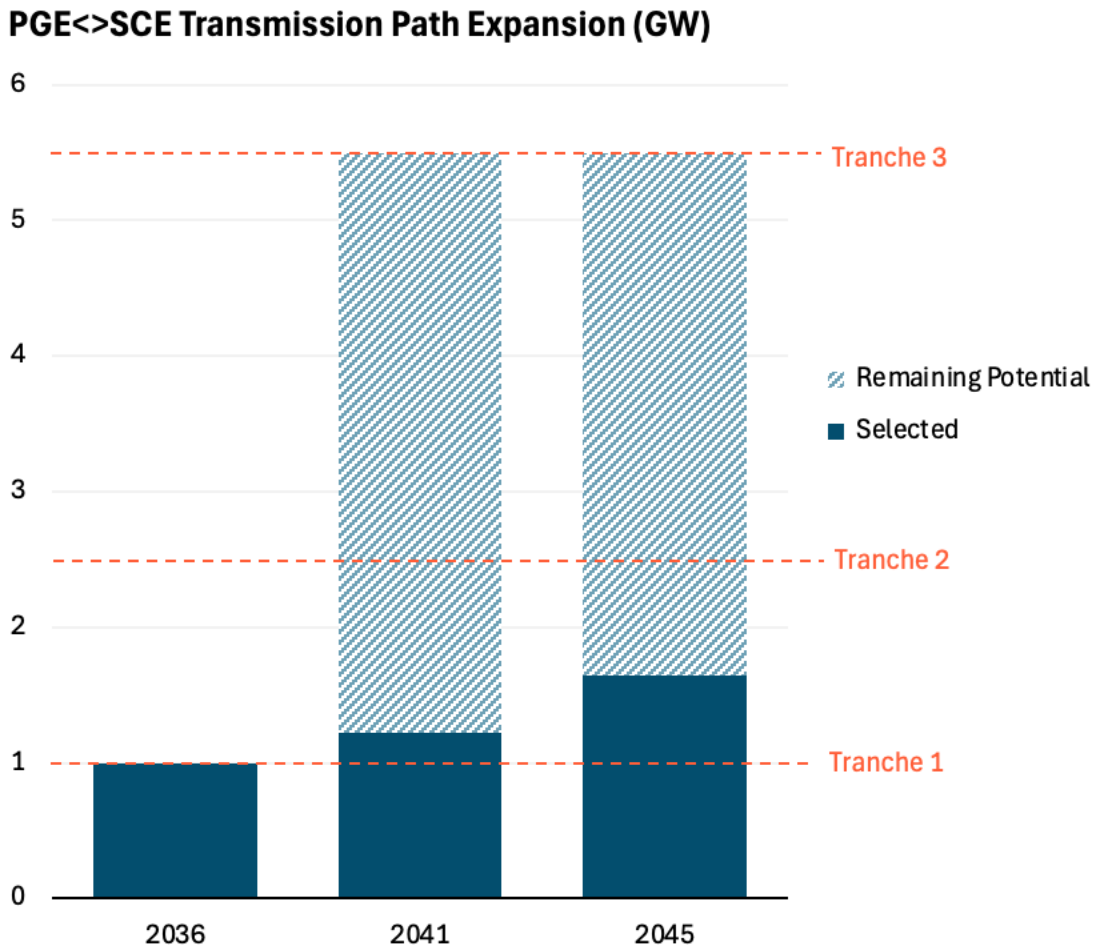


Selected Transmission Upgrades by Cost, 2041
(GW)



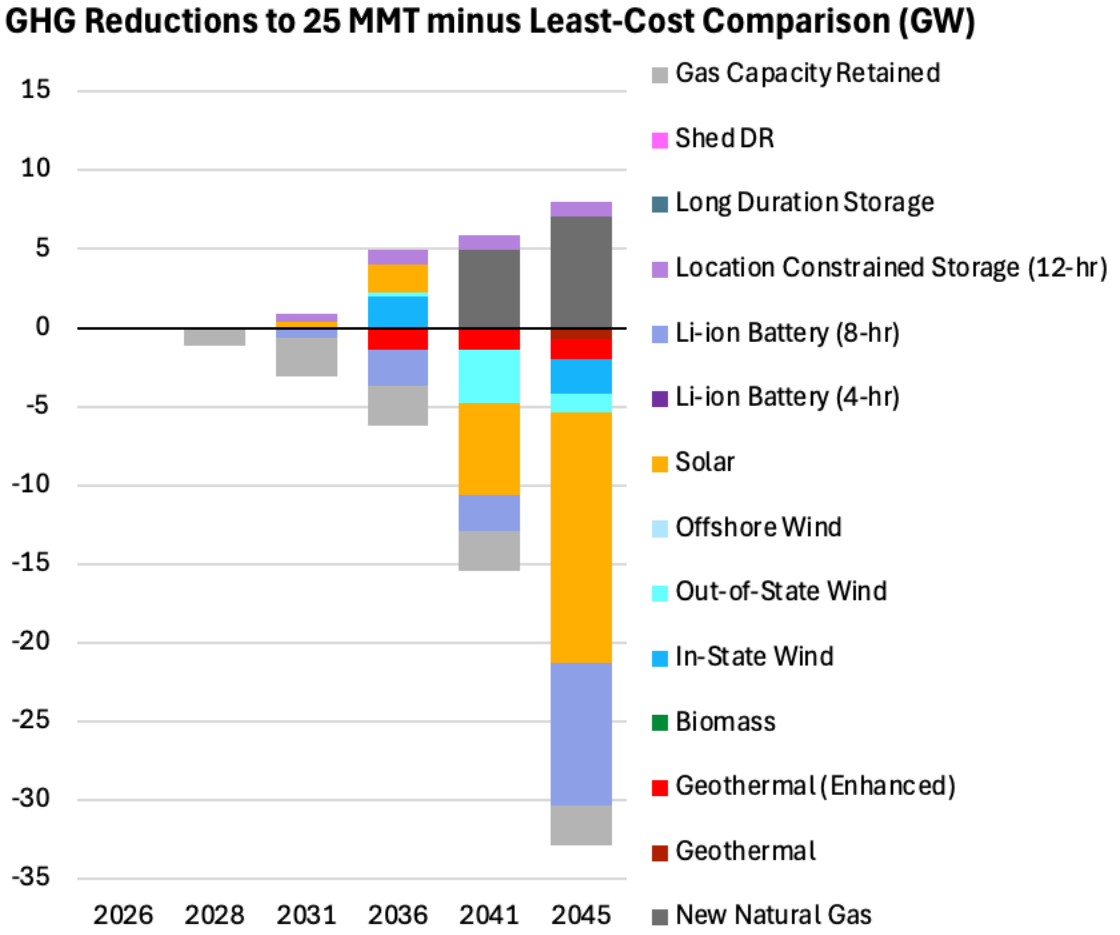
PG&E<>SCE Transmission Expansion

- Path 26/Path 15 expansion(s) are selected primarily to increase import capacity into PG&E
- The first tranche (1 GW) is selected in the first available year
- Only part of tranche 2 (+1.5 GW) is selected by 2045, as the higher GHG target reduces the need for clean energy import into PG&E



Selected Builds Comparison with Least-Cost Comparison Case

- Few changes up 2031, when the reliability target is not binding, and GHG target is unchanged
  - Additional gas not retained in these earlier years, which is "replaced" by new gas in the 2040s
- By 2045, new natural gas displaces a mix of geothermal (conventional and EGS), solar, storage, along with small amounts of wind
  - EGS displaced in 2036 is replaced by a a temporary increase in solar and storage builds, before gas replaces its reliability contribution in the 2040s
  - Location-constrained storage also replaces EGS as a firm resource in 2036



System Cost Comparison with Least-Cost Comparison Case

RESOLVE-Optimized Costs ($MM in 2024$)

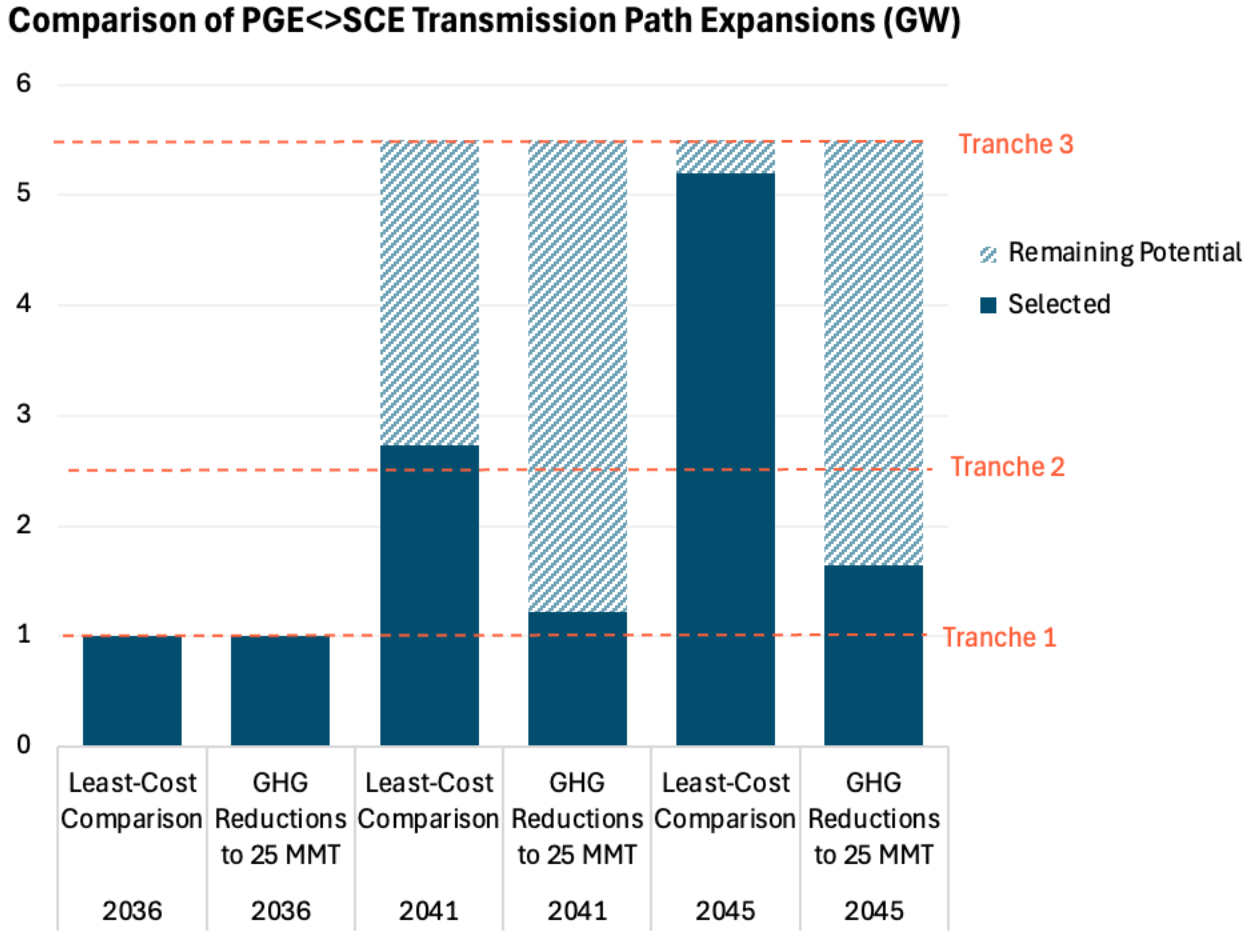
Case	2026	2028	2031	2036	2041	2045	NPV
Least-Cost Comparison Case	$8,758	$11,983	$18,094	$24,231	$28,392	$34,865	*$394,735*
GHG Reductions to 25 MMT	$8,759 +$1 (<0.1%)	$11,965 -$18 (0.1%)	$18,154 +$60 (0.3%)	$23,873 -$358 (1.5%)	$25,989 -$2,403 (8.5%)	$30,802 -$4,063 (11.7%)	*$367,590* *-$27,145* *(6.9%)*

- Approximately $2-4 Billion annual savings in the 2040s with GHG Reductions to 25 MMT Sensitivity
  - Minimal differences up to 2036, as the GHG target remains the same until that year

RESOLVE-optimized costs account for ~15-30% of total system costs (increasing over time); non-optimized baseline generation, transmission, and distribution make up the rest of the revenue requirement

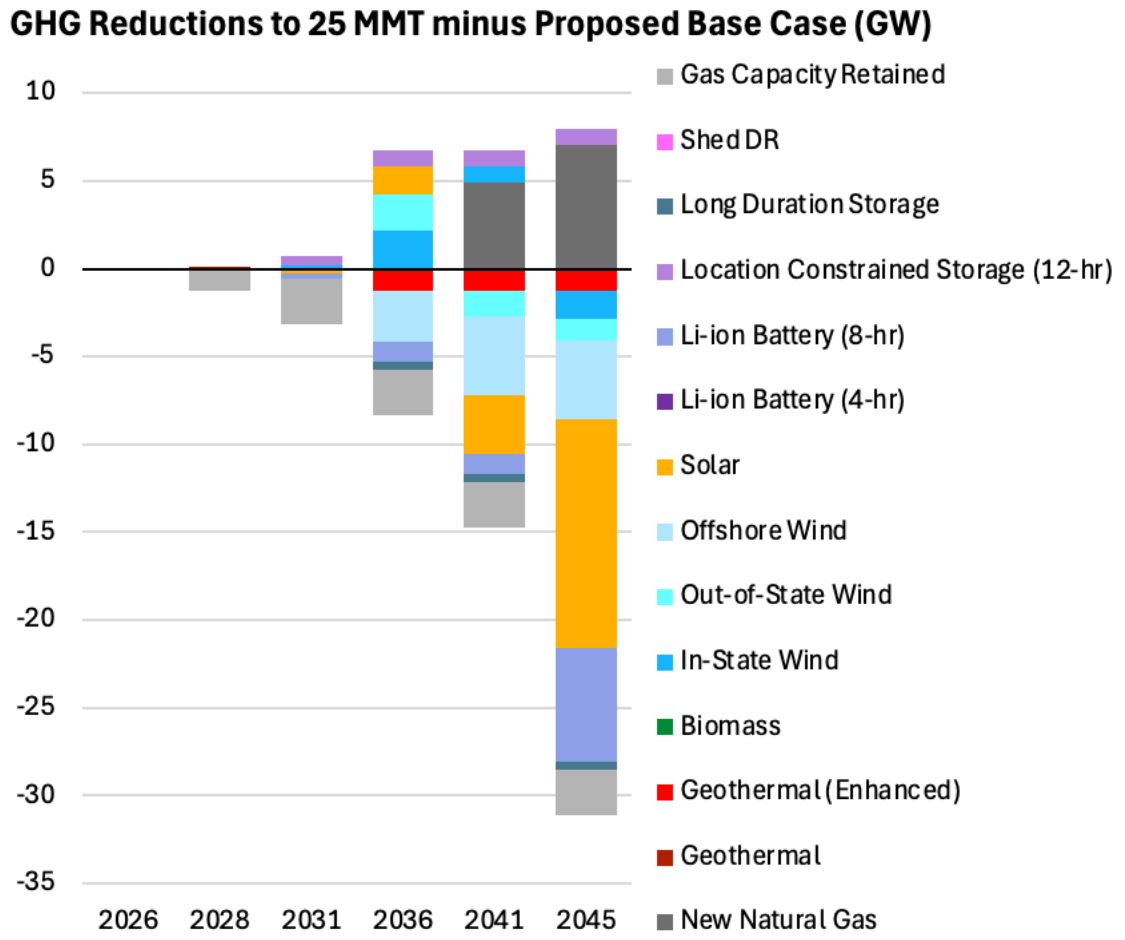
PG&E<>SCE Transmission Comparison with Least-Cost Comparison Case

- Both cases select the first tranche in the first available year
- Allowing gas capacity (as well as raising the GHG target) lowers the need for path expansion
  - Reduces the need for clean energy import into PG&E (including firm geothermal resources)
  - Avoids ~4 GW by 2045



Selected Builds Comparison with Base Case

- Few changes up 2031, when the reliability target is not binding, and GHG target is unchanged
  - Additional gas not retained in these earlier years, which is "replaced" by new gas in the 2040s
- By 2045, new natural gas displaces a mix of geothermal, offshore wind (forced-in for partial AB1373 procurement volumes in base case), solar and storage, along with a small amount of onshore wind
  - Location-constrained storage replaces some geothermal as a firm resource in 2036
- Minor shifts in solar and onshore wind before 2045



System Cost Comparison with Base Case

RESOLVE-Optimized Costs ($MM in 2024$)

Case	2026	2028	2031	2036	2041	2045	NPV
Proposed Base Case	$60,999	$68,532	$79,762	$95,765	$108,540	$120,880	*$1,564,126*
GHG Reductions to 25 MMT	$60.999	$68,502 -$30 (<0.1%)	$79,850 +$88 (0.1%)	$93,374 -$2,391 (2.5%)	$103,479 -$4,741 (4.4%)	$114,045 -$6,515 (5.4%)	*$1,511,638* *-$52,488* *(3.4%)*

- Approximately $2-6 Billion annual savings in the starting in 2036, due to a combination of GHG Reductions to 25 MMT Sensitivity, and removal of partial AB1373 procurement offshore wind and multi-day storage volumes forced-in for the base case
  - Minimal differences before 2036, as the GHG target remains the same until that year

RESOLVE-optimized costs account for ~15-30% of total system costs (increasing over time); non-optimized baseline generation, transmission, and distribution make up the rest of the revenue requirement

PG&E<>SCE Transmission Comparison with Base Case

- Both cases select the first tranche in the first available year
- In 2041, neither case selects significant path expansion beyond tranche 1
  - Base case: driven by offshore wind mapped to PG&E
  - GHG Reductions to 25 MMT Sensitivity: driven by gas as a capacity resource and higher GHG target, reducing need for clean energy flow to PG&E
- In 2045, only the base case selects beyond tranche 2