Integrated Resource Planning (IRP) Proposed Portfolios for the 24-25 Transmission Planning Process (TPP) and Preliminary Busbar Mapping

Workshop

Energy Division Staff

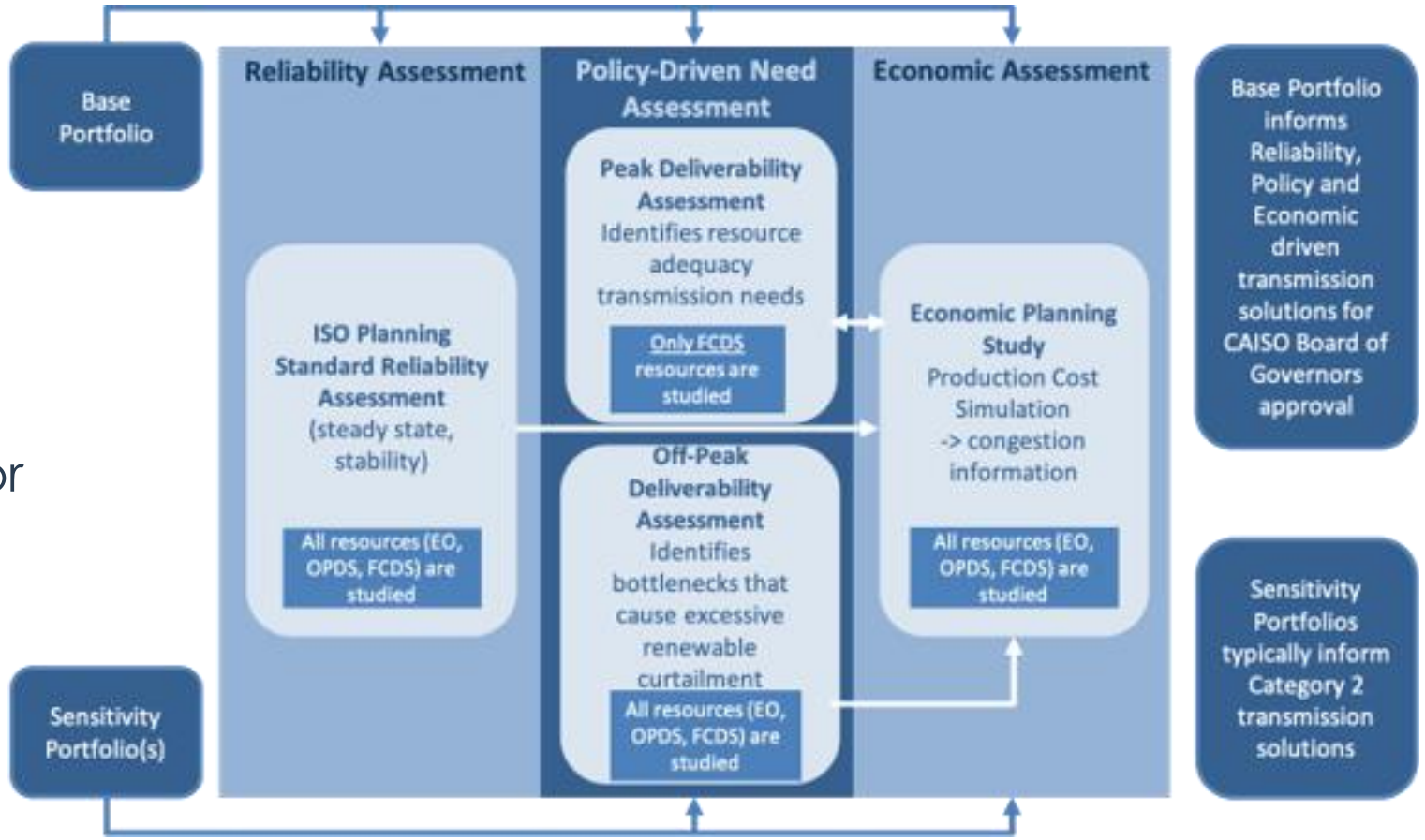
October 20, 2023

California Public
Utilities Commission

IRP's role in the CAISO's TPP

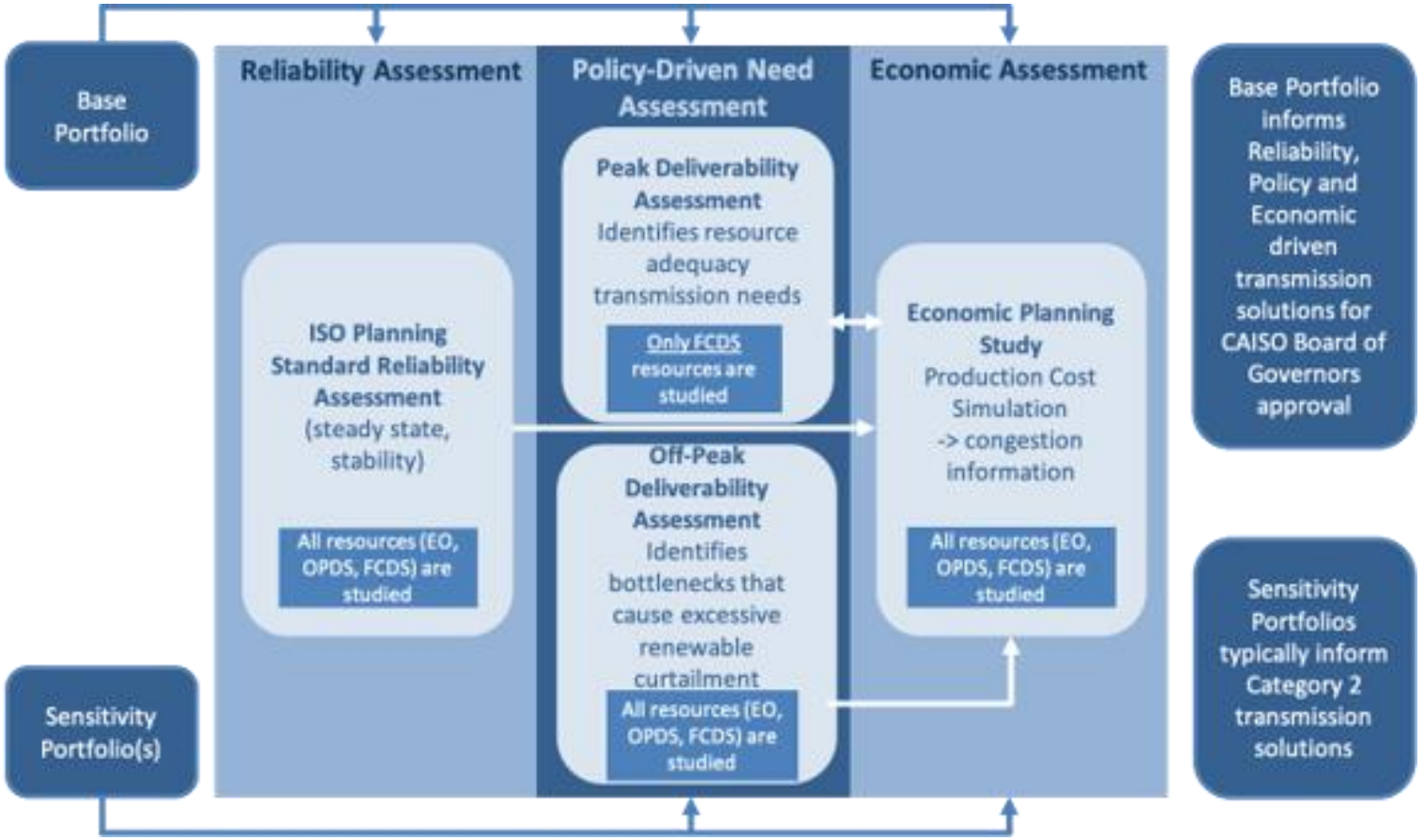
IRP Role in the CAISO's Transmission Planning Process

- The CAISO's TPP is an annual comprehensive evaluation of the CAISO's transmission grid to:
  1. Address grid reliability requirements,
  2. Identify upgrades needed to successfully meet California's policy goals, and
  3. Explore projects that can bring economic benefits to consumers.
- CPUC develops resource portfolios and CEC develops load scenarios for use by CAISO in the TPP.
  - In accordance with new CPUC-CEC-CAISO Memorandum of Understanding agreed to in Dec. 2022.
  - Replaced and expanded on the May 2010 MOU between the CAISO and the CPUC.



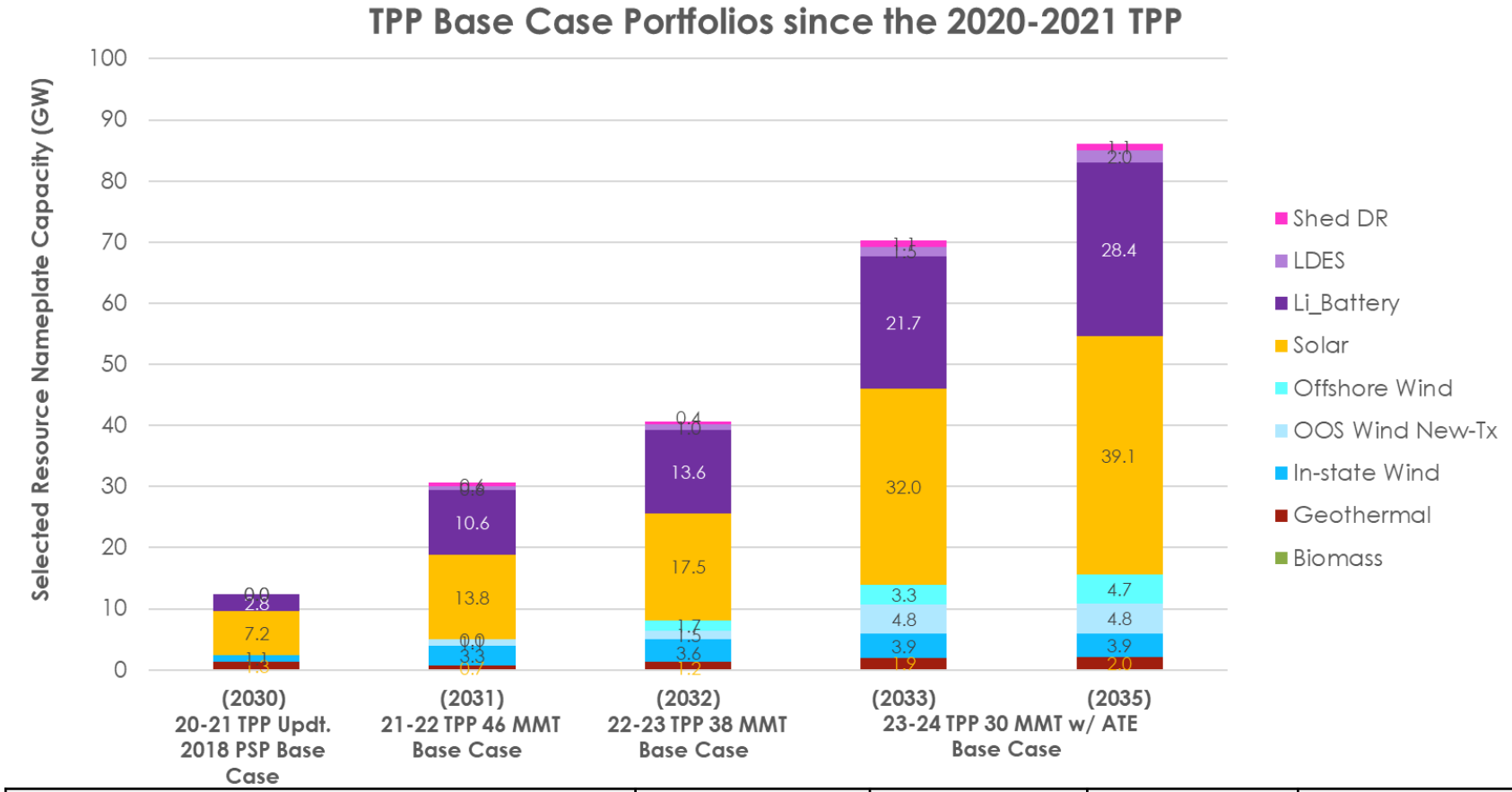
IRP Role in the CAISO's Transmission Planning Process

- The CPUC typically transmits multiple distinct portfolios developed in the IRP process:
  - Reliability and Policy-Driven Base Case portfolio
  - Policy-Driven Sensitivity portfolio(s)
- Historically has focused on grid needs up to 10-years into the future.
- Shifting to transmitting portfolios that model further out into the future:
  - Per Public Utilities Code § 454.57 (SB 887, 2022), portfolios passed to the CAISO will model out at least 15 years.
  - For 24-25 TPP, proposed portfolios will include mapped results for 2034 (10-years out) and 2039 (15-years out)



Past Base Case Portfolios since the 2020-2021 TPP

- Recently, CPUC has transmitted portfolios with more resources and longer planning horizons.
- For the 22-23 TPP, CPUC and CEC in a joint letter requested the CAISO :
  - Use a higher load scenario, the 2021 IEPR Additional Transportation Electrification in the TPP studies, and
  - Study a higher electrification sensitivity portfolio modeling out to 2035.
- Transmitted a higher electrification portfolio as the 23-24 TPP base case, modeling out to 2035.



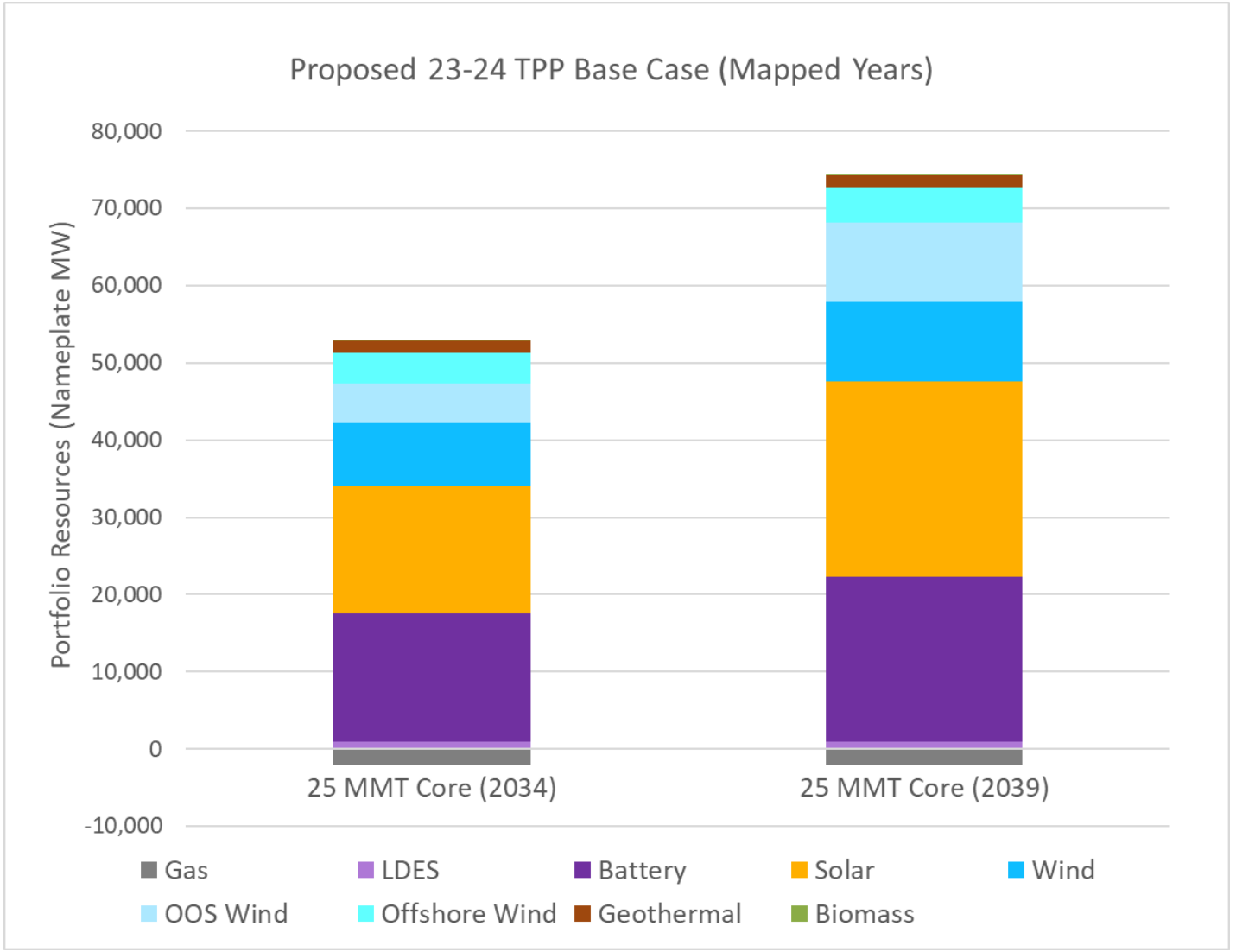
Upgrades Approved in TPP		20-21 TPP	21-22 TPP	22-23 TPP	23-24 TPP
Reliability Driven Upgrades	No. of Upgrades	3	16	24	Ongoing
	Est. Cost ($billions)	$ 0.02 – 0.04	$ 0.9 – 1.4	$ 1.69	
Policy Driven Upgrades	No. of Upgrades	None	7	21	Ongoing
	Est. Cost ($billions)	0	$1.2 – 1.6	$ 5.2	

Proposed 24-25 TPP Base Case Portfolio

Proposed 2024-2025 TPP Base Case Portfolio

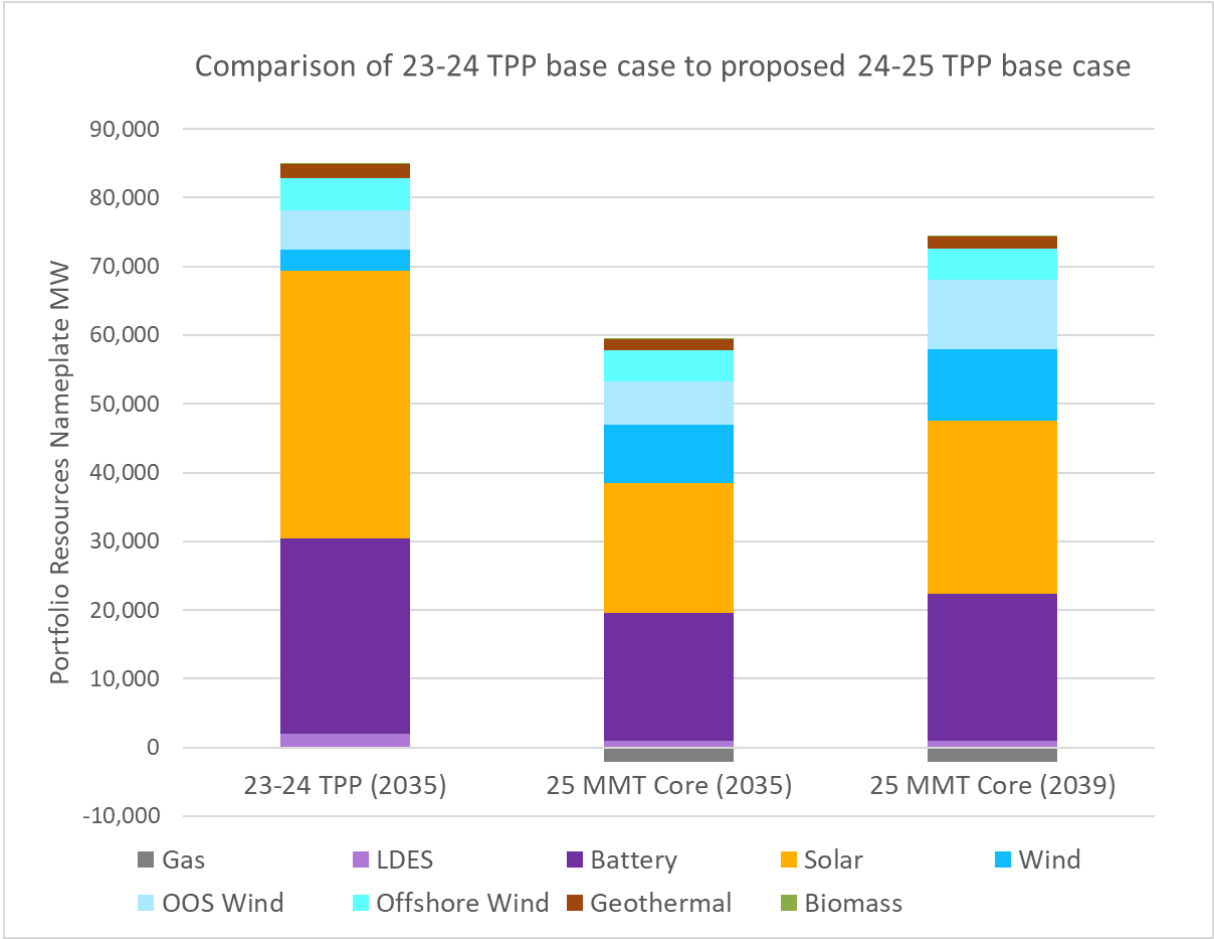
- The Proposed PSP Portfolio – the 25 MMT by 2035 Core Portfolio – is also the proposed 24-25 TPP Base Case.
- Will be mapping model years 2034 (10-year projection) and 2039 (15-year projection).

RESOLVE Resource Type	2034 – Selected MWs	2039 – Selected MWs
LDES	935	985
Li_Battery	16,671	21,364
Solar	16,395	25,200
Wind	8,129	10,362
OOS Wind	5,268	10,204
Offshore Wind	3,855	4,531
Geothermal	1,613	1,731
Biomass	171	171
Total New Res:	**53,037**	**74,548**
Gas	*(2,128)*	*(2,128)*



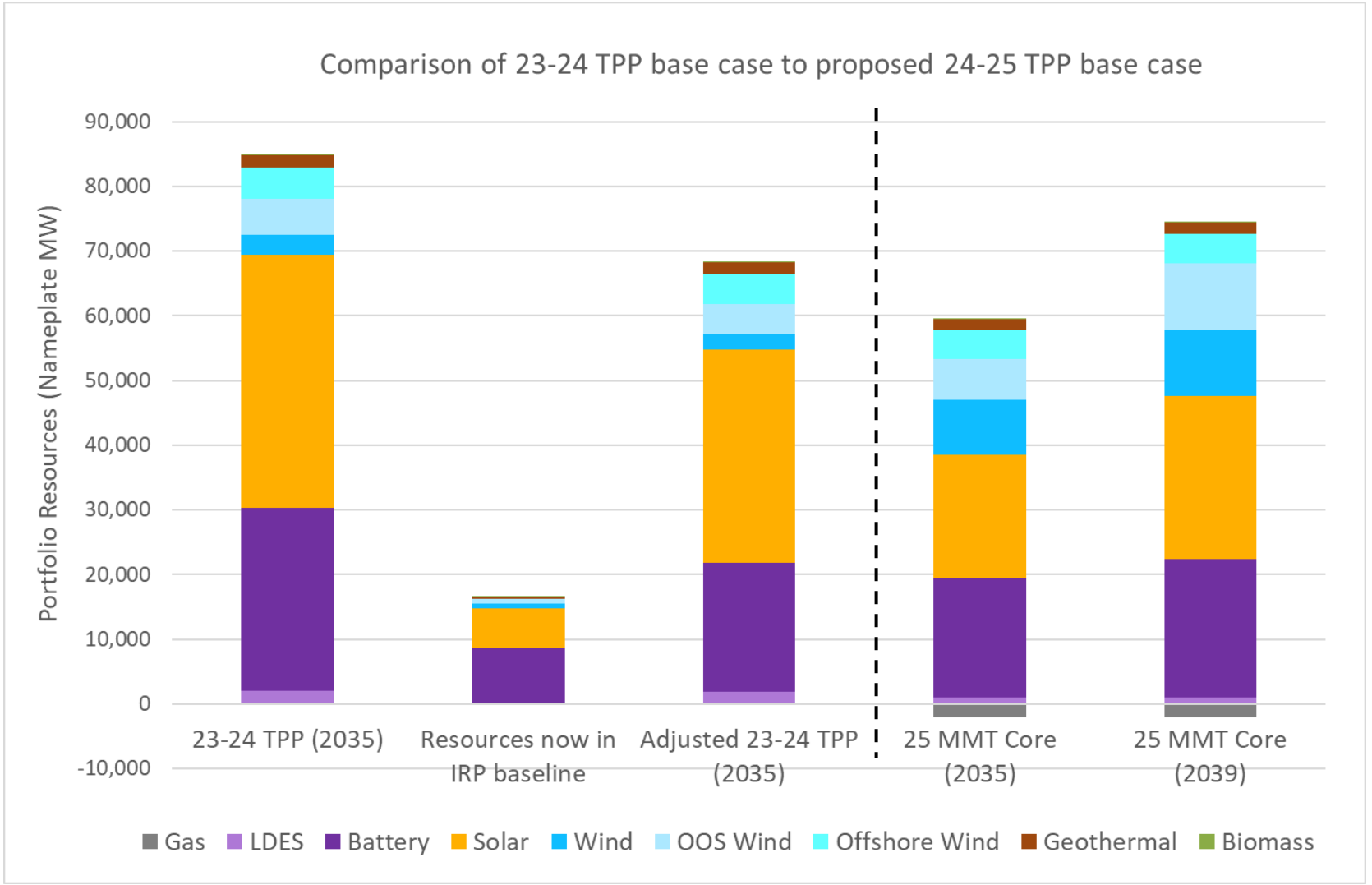
2024-25 TPP Base Case Portfolio vs 23-24 TPP Base Case

- The proposed 24-25 TPP base case appears to have (~25 GW) fewer nameplate resources by 2035 when compared to the 23-24 TPP base case.
- The key driver of this difference is the updated RESOLVE baseline.
  - Additional resources in the baseline now mean less needs to be built.
  - Contains ~16 GW of new and contracted resources not include in the previous TPP baseline.
- Actual difference is thus smaller than appears (~9 GW) and is driven by additional changes in the RESOLVE assumptions:
  1. Different resource mix selected by RESOLVE (More wind selected, which has higher capacity value and thus leads to less nameplate MWs)
  2. Updated ELCC surfaces, particularly changes to solar-storage curve (Less solar and storage needed)
  3. Reduced load projections in 2022 IEPR scenarios used compared to 2021 IEPR ATE scenario used for previous TPP portfolios.



Accounting for new resources in updated baseline

- Previous 23-24 TPP base case used older resource baseline to align with previous Transmission White Paper.
- Portfolio included about ~16.6 GW of resources identified that are now included in the RESOLVE baseline.
- Accounting for these resources reduces nameplate difference to ~9 GW.
  - Remaining difference can be attributed to the other three main changes.



2023 I&A On-Shore Wind Resource Potentials

- New 2023 Inputs and Assumptions for RESOLVE include significantly higher on-shore wind resource potentials.
- Several changes resulted in the resource potentials for onshore, in-CAISO wind:
  - Higher hub-height (110 m)
  - Increased resource density assumption to 40 acres/MW
  - Shift from locations specific analysis to state-wide analysis
  - Potentials based on land-use analysis rather than estimated commercial interest (Northern California and Southern Nevada)
  - Increase in commercial interest (Baja California, MX)
- CEC Land-use screens applied for in- California, WECC land-use screen applied for Southern Nevada.
- Approved Tx upgrades enable more wind to be selected in key areas.

In-CAISO Wind Area	2019 I&A Old Potentials (MW)	New Potentials (MW)	Locations RESOLVE Selected, 2039 (MW)	Percent of Available Selected
Southern Nevada (NV)	442	5,010	5,010	100.00%
Baja California (MX)	600	2,473	2,473	100.00%
Carrizo	287	-	-	0.00%
Central Valley Los Banos	173	2,810	32	1.14%
Greater Imperial	-	133	133	100.00%
Greater Kramer	-	-	-	0.00%
Humboldt	34	-	-	0.00%
Kern Greater Carrizo	60	-	-	0.00%
Northern California	866	2,330	849	36.44%
Riverside	-	-	-	0.00%
Solano	560	500	375	75.00%
Tehachapi	275	1,730	1,489	86.07%
Total:	**3,297**	**14,986**	**10,361**	**69.14%**

Proposed 2024-2025 TPP Base Case Portfolio: RESOLVE Selected Renewable Resources

- Summary of RESOLVE selected renewable generation resources for 2034 and 2035 by resource type and RESOLVE modeling location.

RESOLVE Resource Name	Resource Type	Selected Resources - 2034 (MW)	Selected Resources - 2039 (MW)
InState Biomass	Biomass/Biogas	**171.0**	**171.0**
Central_Nevada_Geothermal	Geothermal	**40.0**	**40.0**
Greater_Imperial_Geothermal	Geothermal	**1,238.6**	**1,356.1**
Inyokern_North_Kramer_Geothermal	Geothermal	**7.1**	**7.1**
Northern_California_Geothermal	Geothermal	**314.3**	**314.3**
Northern_Nevada_Geothermal	Geothermal	-	-
Pacific_Northwest_Geothermal	Geothermal	**13.0**	**13.0**
Utah_Geothermal	Geothermal	-	-
Distributed Solar	Solar	-	-
Arizona_Solar	Solar	**3,243.3**	**3,243.3**
Greater_Imperial_Solar	Solar	**39.0**	**39.0**
Greater_Kramer_Solar	Solar	**1,012.3**	**4,065.8**
Greater_LA_Solar	Solar	-	-
Northern_California_Solar	Solar	**126.0**	**126.0**
Riverside_Solar	Solar	**659.0**	**659.0**
Southern_NV_Eldorado_Solar	Solar	**4,665.3**	**4,665.3**
Southern_PGAE_Solar	Solar	**1,586.3**	**1,586.3**
Tehachapi_Solar	Solar	**5,063.7**	**10,796.1**
Solar and Geo. Resource Total		**18,179.0**	**27,082.4**

RESOLVE Resource Name	Resource Type	Selected Resources - 2034 (MW)	Selected Resources - 2039 (MW)
Baja_California_Wind	Wind	**1,572.8**	**2,472.8**
Central_Valley_North_Los_Banos_Wind	Wind	**32.0**	**32.0**
Greater_Imperial_Wind	Wind	**133.2**	**133.2**
Greater_Kramer_Wind	Wind		
Humboldt_Wind	Wind		
Kern_Greater_Carrizo_Wind	Wind		
Northern_California_Wind	Wind	**849.0**	**849.0**
Riverside_Palm_Springs_Wind	Wind		
Solano_Wind	Wind	**375.0**	**375.0**
Southern_NV_Eldorado_Wind	Wind	**5,011.2**	**5,011.2**
Tehachapi_Wind	Wind	**156.0**	**1,488.8**
Idaho_Wind	OOS Wind	**300.0**	**300.0**
New_Mexico_Wind	OOS Wind	**1,968.0**	**1,968.0**
Wyoming_Wind	OOS Wind	**3,000.0**	**7,936.1**
Cape_Mendocino_Offshore_Wind	Offshore Wind	-	-
Del_Norte_Offshore_Wind	Offshore Wind	-	-
Humboldt_Bay_Offshore_Wind	Offshore Wind	-	-
Morro_Bay_Offshore_Wind	Offshore Wind	**3,855.0**	**4,531.0**
Wind Resource Total		**17,252.2**	**25,097.1**

Proposed 2024-2025 TPP Base Case Portfolio: RESOLVE Selected Storage Resources

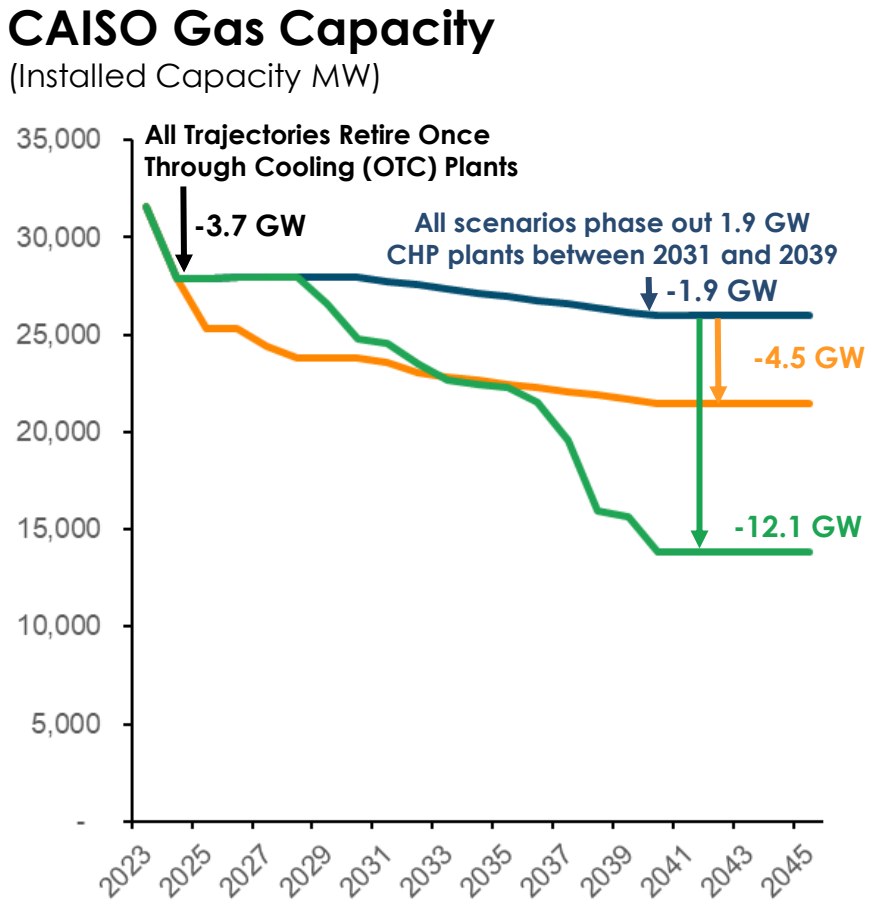
- Summary of RESOLVE selected storage resources for 2034 and 2035 by resource type and RESOLVE modeling location.

RESOLVE Resource Name	Resource Type	Selected Resources - 2034 (MW)	Selected Resources - 2039 (MW)
Arizona_Li_Battery_4hr	Li_Battery	**972.4**	**972.4**
Arizona_Li_Battery_8hr	Li_Battery	**189.9**	**189.9**
Greater_Imperial_Li_Battery_4hr	Li_Battery	-	-
Greater_Imperial_Li_Battery_8hr	Li_Battery	-	-
Greater_Kramer_Li_Battery_4hr	Li_Battery	**445.3**	**445.3**
Greater_Kramer_Li_Battery_8hr	Li_Battery	**164.9**	**164.9**
Greater_LA_Li_Battery_4hr	Li_Battery	**3,471.0**	**4,020.4**
Greater_LA_Li_Battery_8hr	Li_Battery	**587.2**	**587.2**
Northern_California_Li_Battery_4hr	Li_Battery	**875.4**	**875.4**
Northern_California_Li_Battery_8hr	Li_Battery	-	**2,697.0**
Riverside_Li_Battery_4hr	Li_Battery	**707.8**	**707.8**
Riverside_Li_Battery_8hr	Li_Battery	-	-
Southern_NV_Eldorado_Li_Battery_4hr	Li_Battery	**1,145.5**	**1,145.5**
Southern_NV_Eldorado_Li_Battery_8hr	Li_Battery	**439.4**	**439.4**
Southern_PGAE_Li_Battery_4hr	Li_Battery	**5,637.7**	**5,837.3**
Southern_PGAE_Li_Battery_8hr	Li_Battery	**331.5**	**815.3**
Tehachapi_Li_Battery_4hr	Li_Battery	**1,702.9**	**1,702.9**
Tehachapi_Li_Battery_8hr	Li_Battery	-	**762.8**
LI_Battery Total		**16,671.0**	**21,363.5**

RESOLVE Resource Name	Resource Type	Selected Resources - 2034 (MW)	Selected Resources - 2039 (MW)
Northern_California_Pumped_Storage	LDES	-	-
Riverside_East_Pumped_Storage	LDES	**298.6**	**298.6**
Riverside_West_Pumped_Storage	LDES	-	-
San_Diego_Pumped_Storage	LDES	-	-
Tehachapi_Pumped_Storage	LDES	**178.4**	**178.4**
Southern_PGAE_Adiabatic_CAES	LDES	-	-
Tehachapi_Adiabatic_CAES	LDES	**200.0**	**200.0**
Arizona_Flow_Battery	Flow_Battery	-	-
Greater_Imperial_Flow_Battery	Flow_Battery	**29.4**	**29.4**
Greater_Kramer_Flow_Battery	Flow_Battery	-	-
Greater_LA_Flow_Battery	Flow_Battery	**50.0**	**50.0**
Northern_California_Flow_Battery	Flow_Battery	**70.6**	**70.6**
Riverside_Flow_Battery	Flow_Battery	-	-
Southern_NV_Eldorado_Flow_Battery	Flow_Battery	-	-
Southern_PGAE_Flow_Battery	Flow_Battery	**108.0**	**158.0**
Tehachapi_Flow_Battery	Flow_Battery	-	-
Other Storage Total		**935.0**	**985.0**

Proposed 24-25 TPP Sensitivity Portfolio — Gas Retirement Scenario

RESOLVE Sensitivity Portfolios — Gas Retirement Trajectories



Base

No gas forced to retire after OTC retirements, except for CHP phase out in the 2030s

Moderate Gas Retirement

Trajectory includes LSE plans' un-contracted CC and CT gas plants, shows accelerated retirements in the near-term but available gas capacity is relatively constant beyond 2030

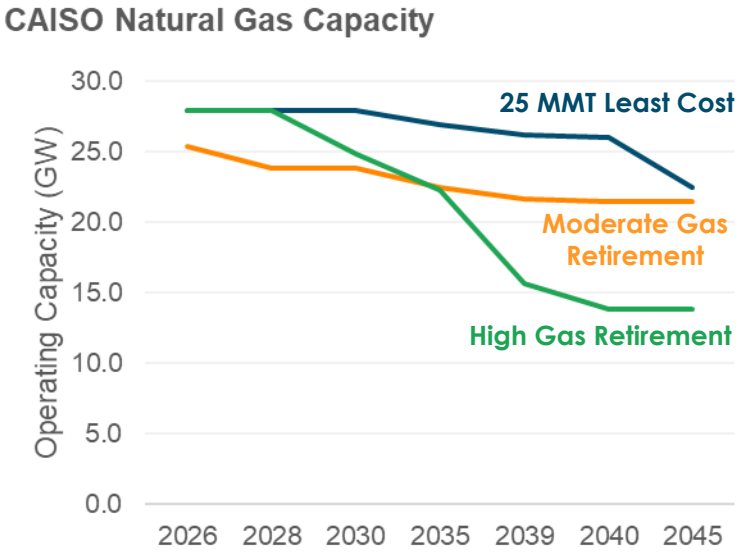
High Gas Retirement

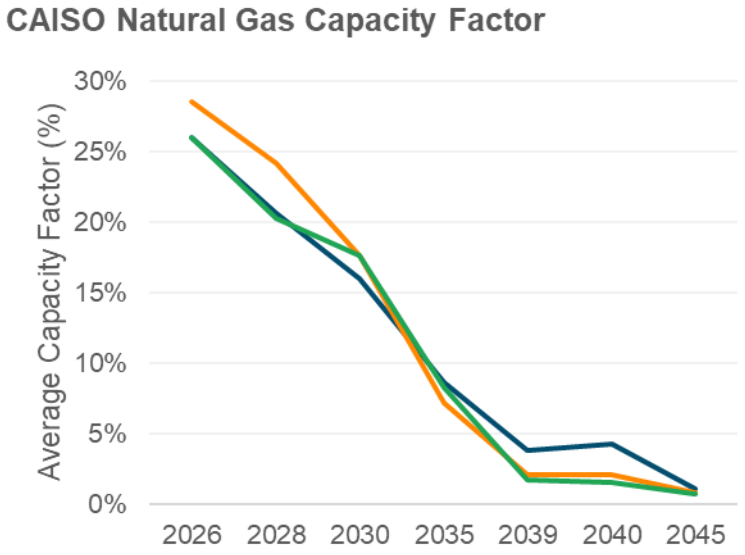
Delays retirements in near-term but ramps to meet LSEs un-contracted CC and CT gas capacity by 2035; continues to reduce gas capacity through 2040 using a 35-year age-based criteria

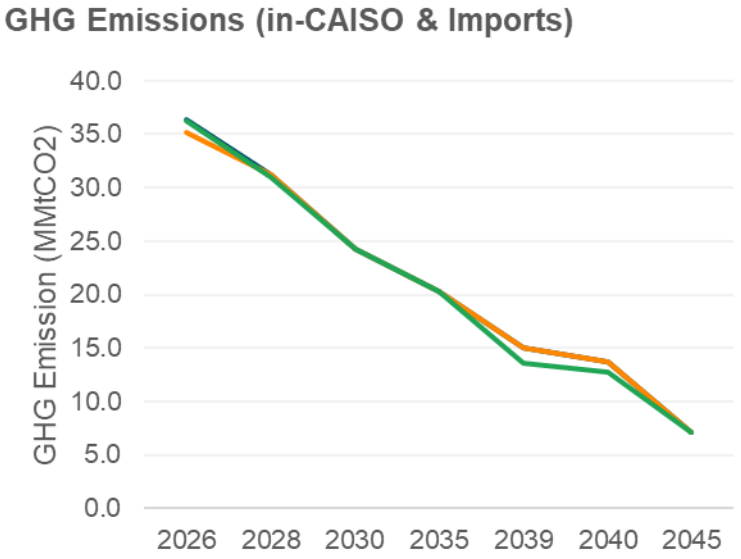
In all scenarios and sensitivities, RESOLVE can choose to not retain additional gas capacity; the plot represents the maximum existing CAISO gas capacity available

Thermal Fleet Utilization in Gas Retirement Sensitivities

- Reflecting the deployment of clean energy from greenhouse gas emissions limits, natural gas fleet utilization declines to <5% by ~2035 regardless of whether gas plants are retired
- ***Gas retirements provide little to no GHG emissions reductions benefits***
  - While in-state gas generation goes down, it is replaced with imports (frequently gas plants in neighboring regions)
    - This change in in-state gas generation represents a significant decrease relative to previously adopted IRP portfolios, though RESOLVE's decision to choose imports instead could represent a "knife edge" effect in its decision making between those two resource types
    - In the late 2030s and beyond, the least-cost case shows higher *in-CAISO* gas generation than either gas retirement trajectory, but total GHG emissions are similar across all three cases because of higher levels of unspecified imports

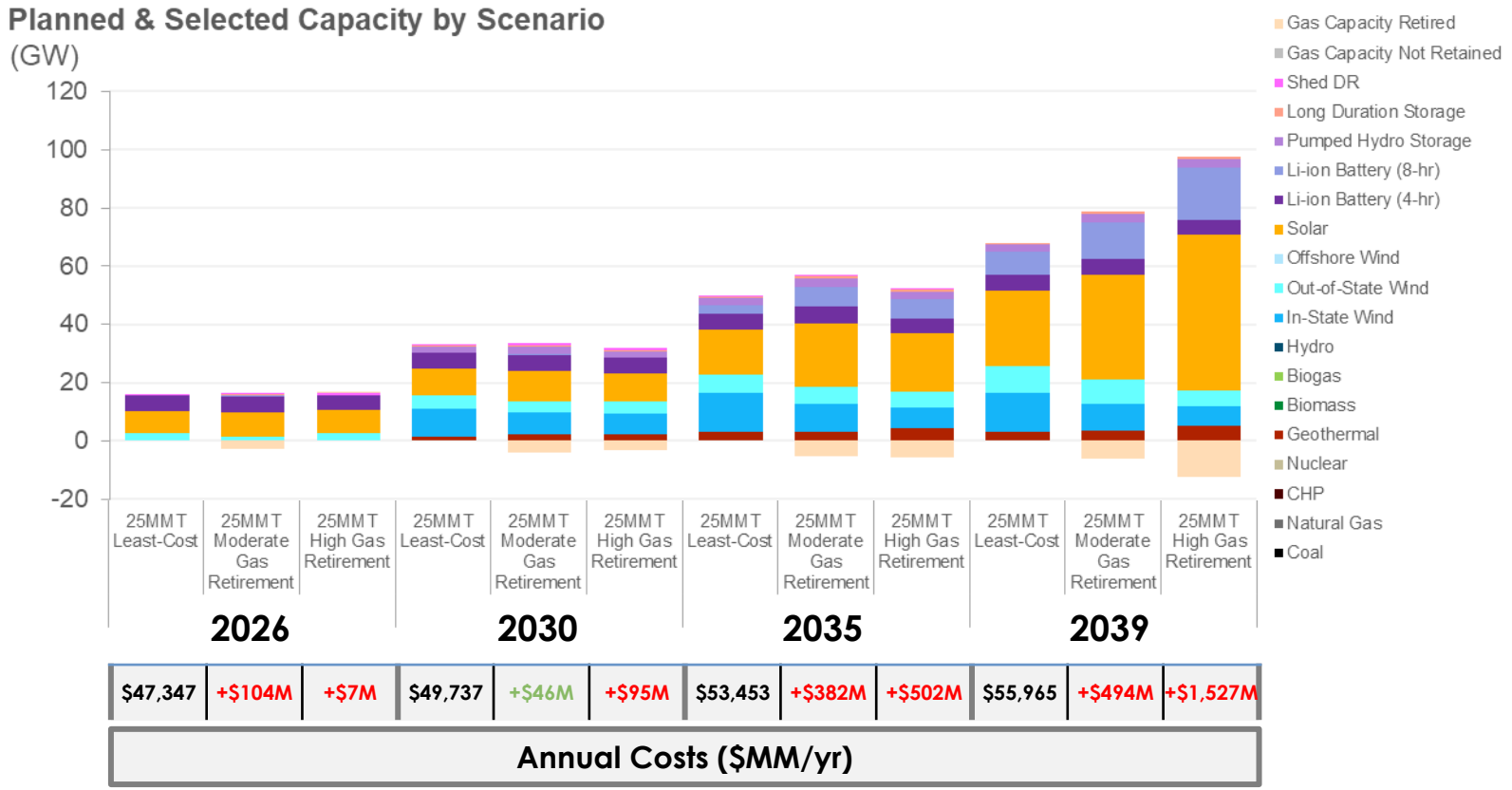






25 MMT Least Cost vs Gas Retirement Sensitivities

- Gas retirement scenarios increase system costs the more gas is forced to retire
  - Annual cost impact = ~$7-$1,500M/yr
- Gas plants are replaced largely with solar and long-duration storage resources
  - This in turn displaces lower cost and likely more valuable land-based wind resources
  - This does not result in substantive net-new clean generation (or GHG emission reduction) as resource selection is still driven by the GHG emissions trajectory

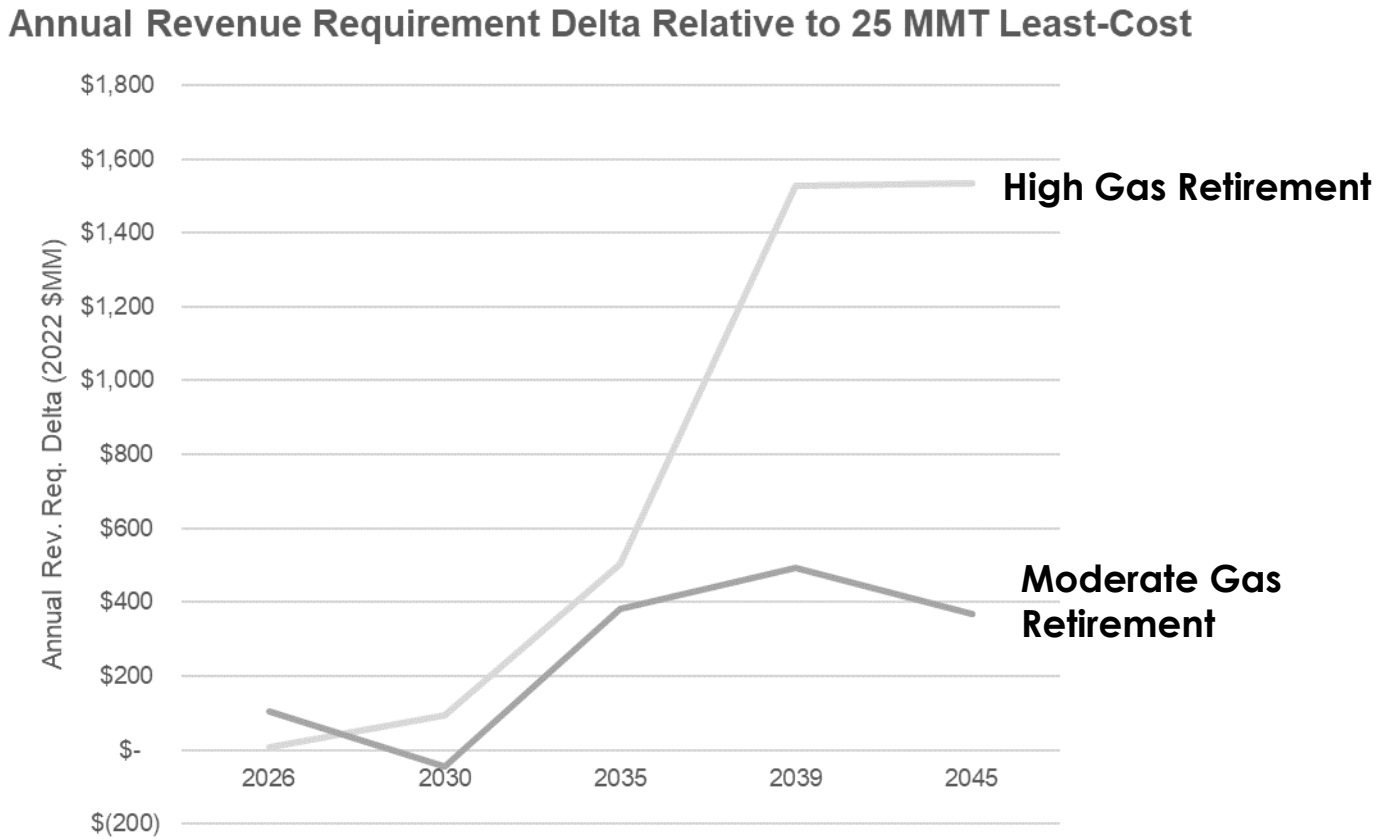


NPV of Revenue Requirement
($MM in 2022 Dollar Year, 2024-2065)

25 MMT Least-Cost	$896,300
25 MMT Moderate Gas Retirement	$900,042 (+$3,742MM)
25 MMT High Gas Retirement	$909,338 (+$13,038MM)

Gas Retirement Cost Impacts

- Gas retirements increase costs despite not having a material reduction in GHG emissions
- Sensitivities were not analyzed to see if they would meet the local reliability requirements in LCR areas where gas generators are retired
  - Replacing firm capacity in local areas may be a challenge for the high gas retirements scenario
  - Long-duration storage may be able to replace some of the local capacity need



Cost impacts are limited near- to mid-term as new renewables and storage for GHG-reduction provide new reliability value

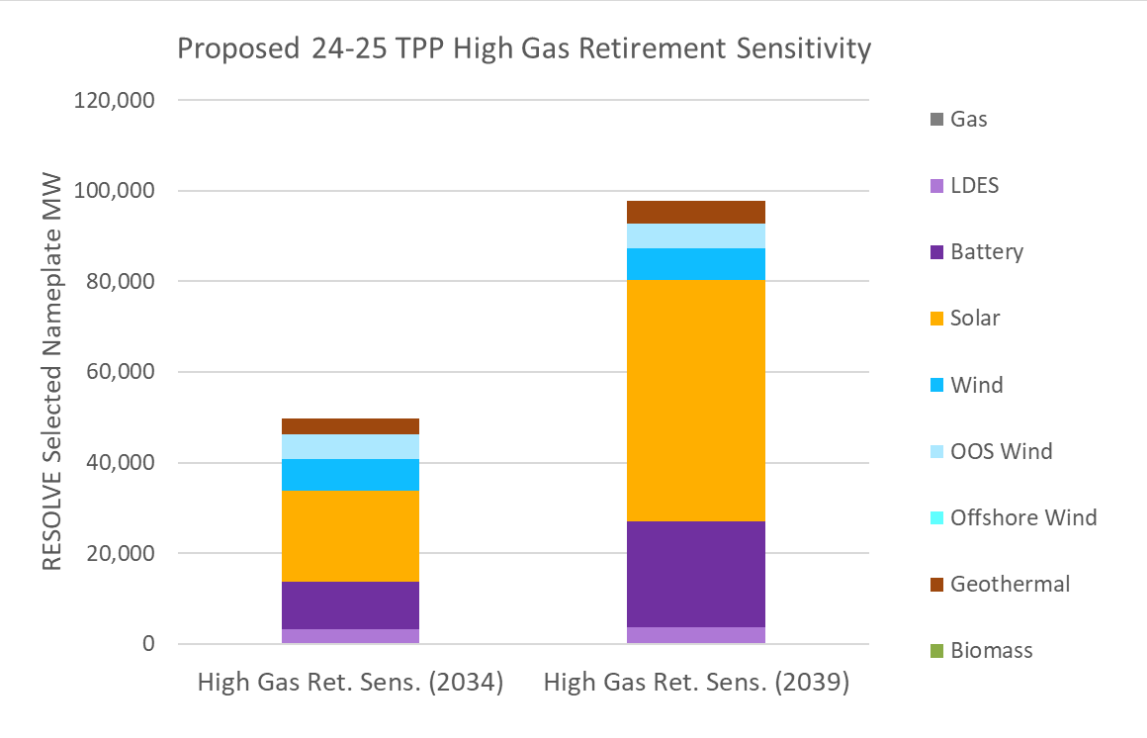
However, ***long-term the cost impacts become significant*** (and under higher retirement levels) as renewable and storage capacity value saturates, limiting their ability to offset firm capacity

Proposed 24-25 TPP Sensitivity – High Gas Retirement Portfolio

- Ruling proposed using the High Gas Retirement Sensitivity as the one policy-driven sensitivity portfolio to transmit to CAISO for the 2024-25 TPP.
  - Total gas retirements as RESOLVE input, in 2034 and 2039 mapping years (OTC and CHP amounts also assumed in proposed base case):

Res Type	GWs Retired (2034)	GWs Retired (2039)
OTC	(3.7)	(3.7)
CHP	(0.76)	(1.73)
Additional Gas	(4.67)	(10.5)

  - Sensitivity does not include the LSE planned resources and instead allows RESOLVE to optimize for least-cost.
- Portfolio does not have specific units or locations for gas retirements, only reflects system wide amounts and impacts.



RESOLVE Resource Type	2034 – Selected MWs	2039 – Selected MWs
LDES	3,300	3,700
Li_Battery	10,500	23,400
Solar	20,000	53,300
Wind	7,000	7,000
OOS Wind	5,400	5,400
Offshore Wind	-	-
Geothermal	3,500	5,000
Biomass	-	-
Total New Res:	**53,037**	**74,548**

Busbar Mapping

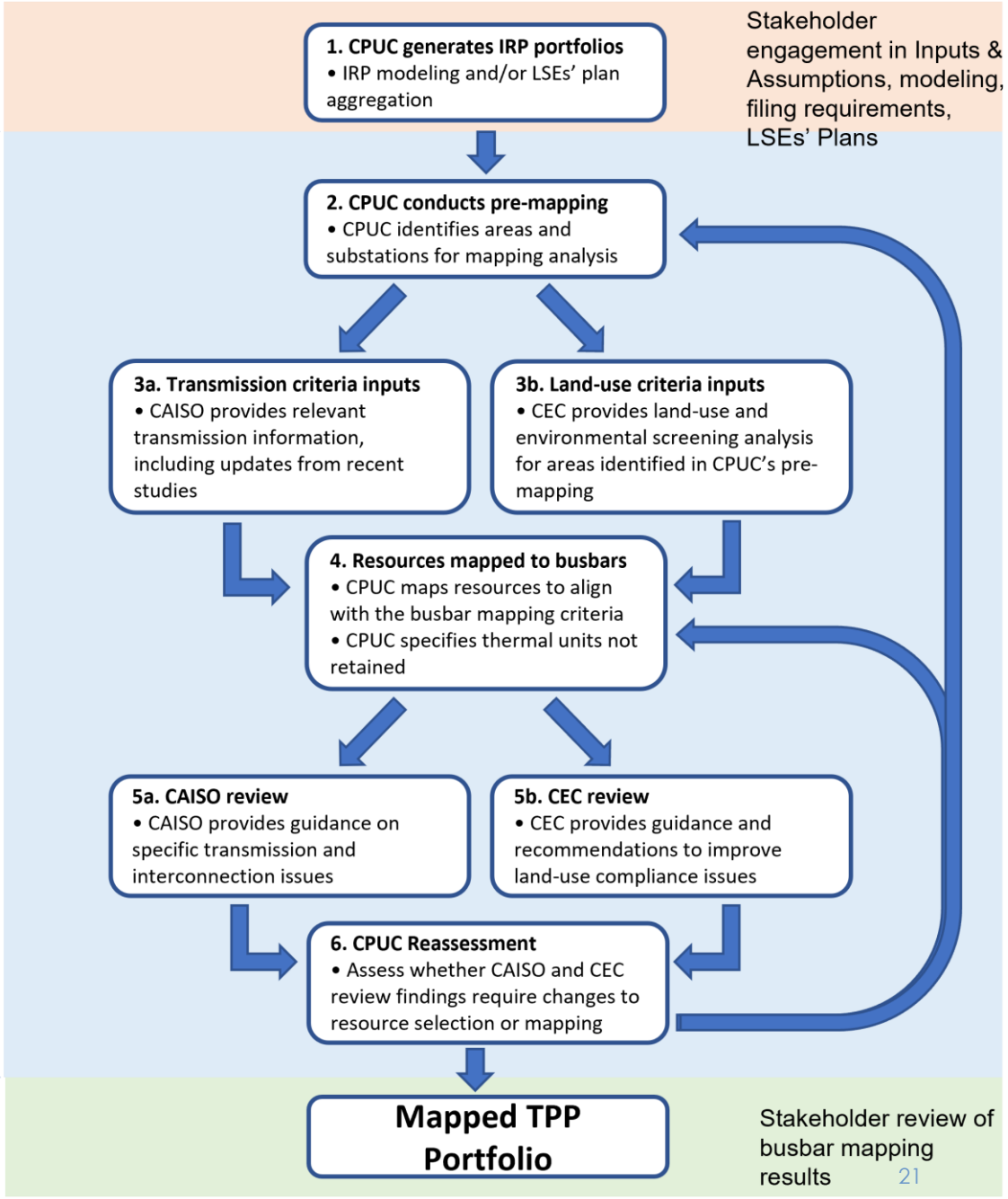
Busbar Mapping in IRP and TPP

- **Resource to Busbar Mapping** ("busbar mapping"): The process of refining the geographically coarse portfolios developed through IRP to specific interconnection locations (i.e., substations) for analysis in the CAISO's annual Transmission Planning Process (TPP).
  - First conducted as "proof of concept" for the 2018-2019 TPP portfolio (CEC proof of concept report).
  - Formalized into a joint effort by a working group comprised of CPUC, CEC, and CAISO staff.
  - Mapping is conducted based on stakeholder vetted methodology.
- **Busbar Mapping Scope:** Mapping focuses on utility-scale generation and storage resources that are not already in baseline.
- **Busbar Mapping Methodology:** Methodology document states guiding principles, establishes mapping criteria, and outlines the iterative inter-agency mapping process.
  - Updated Methodology makes refinements and updates to previous version used for the 23-24 TPP mapping efforts.
  - Staff held webinar on July 12, 2023, on the draft updated methodology and mapping process. (Link to slides and recording)
  - Incorporated minor changes from stakeholder feedback following the webinar.

Busbar Mapping Process

- Busbar Mapping can be viewed as a sequence of steps between CPUC, CEC, and CAISO after the portfolios are developed.
  - CEC staff provide land-use and environmental information, data analysis, and implications assessment.
  - CAISO staff provide similar info for transmission and interconnection topics.
  - CPUC applies analysis and information to conduct the mapping itself and coordinates the information transfers.
- Iterative effort that requires several rounds of the mapping process
- Goals of the mapping process:
  - Identify plausible locations for portfolio resources that do not violate established busbar mapping criteria.
  - Align mapped resources to the extent feasible with the mapping priorities of each criteria.

Methodology addresses these steps



Mapping Criteria Overview

- The updated mapping Methodology implemented for the 24-25 TPP portfolios overhauls the mapping criteria: updating several screens, expanding criteria with the incorporation of new data and screens, and reorganizing how the specific criteria are organized into larger categories.
- Criteria are organized into seven categories:
    1. System level transmission capability
    2. Substation level interconnection viability
    3. Land-use implications and feasibility factors
    4. Environmental (conservation and biological) impact factors
    5. Community and environmental (societal) impact factors
    6. Commercial development interest
    7. Consistency with prior TPP portfolios
- See Methodology Document and the July 12, 2023, Webinar slides and recording for detailed overview and discussion of the mapping criteria and application of datasets.

Mapping Criteria Overview

- Staff have expanded criteria alignment scale from three to five levels to provide a better summary of mapped resources alignment with the various criteria priorities.

Level 1	Level 2	Level 3	Level 4	Level 5
Strong compliance with criteria, alignment with criteria's prioritized conditions	Mostly favorable compliance with criteria, not fully aligned with priorities but not near to triggering unfavorable criteria	Mixed compliance with criteria, little alignment with prioritizes, potential alignment with conditions criteria seek to limit or avoid	Some noncompliance with criteria, some alignment with conditions criteria seeks to limit or avoid	Significant noncompliance with criteria, no alignment with stated criteria, fully meets conditions criteria seek to limit or avoid

- Minor Updates to the Mapping Methodology and criteria following stakeholder feedback to the draft methodology and July 12, 2023, webinar include:
  - Applying the community and environmental (societal) impact factors as locations to avoid mapping biomass/biogas.
  - Setting resource density assumptions for utility-scale solar as 10 acres/MW and for onshore in-CAISO wind as 40 acres/MW.
  - Clarification and additional description of parts of process and the criteria discussion including Maximum Import Capability (MIC) treatment and how commercial interest is analyzed.
  - Additional description of mapping process for gas capacity not retained.

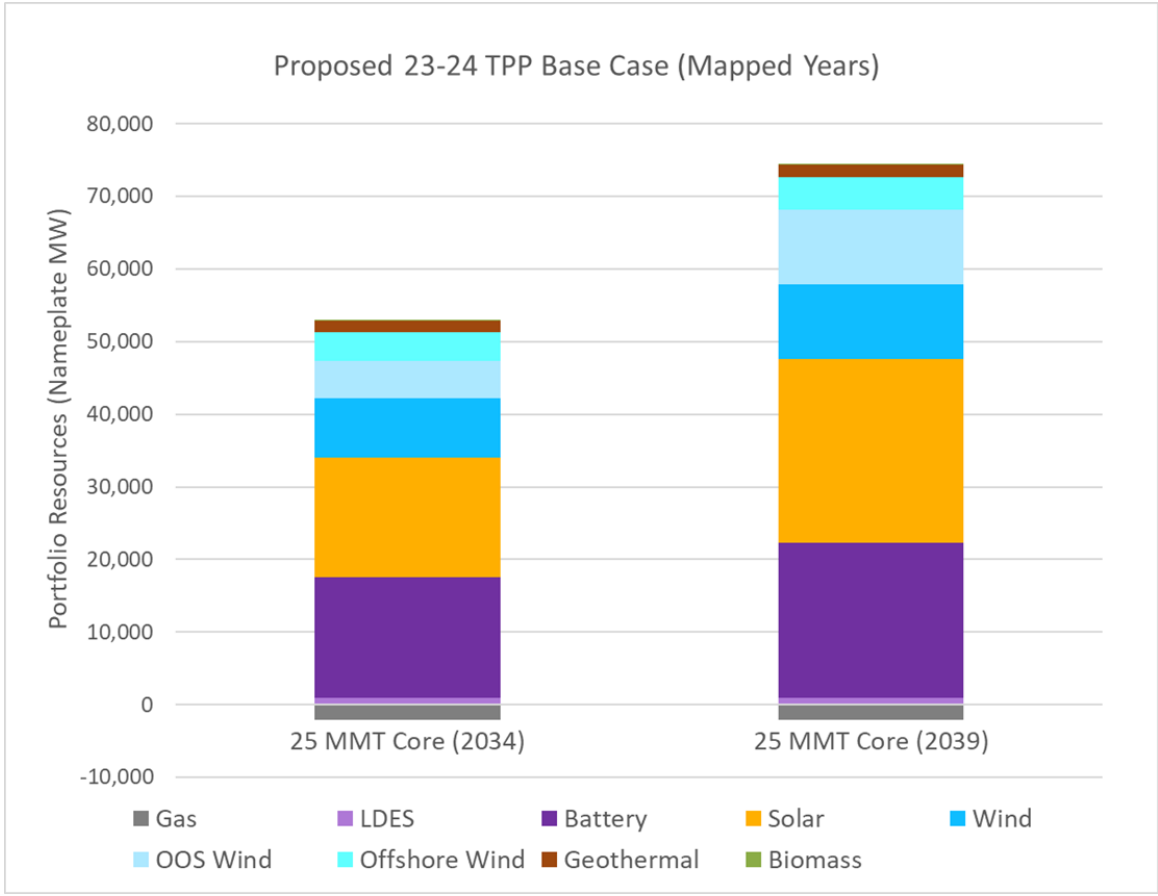
Mapping Methodology for Modeled Gas Retirements

- Portfolios can include two types of gas retirements:
  - Policy identified retirements that are forced into RESOLVE and do not appear as RESOLVE selected resources
  - RESOLVE selected generation not retained due to RESOLVE's economic costs optimization, which are reflected in the RESOLVE selected resources results
- Portfolios identify only the aggregated amount of gas capacity not retained, but individual locations need to be identified for the TPP studies.
- In identifying which units to model as offline, working group staff will score units based on the following data and prioritize those units with the higher scores.
  1. Age of plant: Older units receive higher score.
  2. Proximity to Disadvantaged communities (DACs): Units in or near a DAC receive higher score.
  3. Emission info and non-attainment zones: Units in Ozone and PM2.5 non-attainment areas receive higher score and units with higher per MWh NOx and SO2 emissions per available EIA data receive higher score.
  4. CAISO LCR study info: Units with lower effectiveness factors and identified charging capacity for potential storage alternatives will receive higher score.
- Staff will also assess the potential to map RESOLVE selected generation resources at or near a unit's location to potentially offset the units' provided capacity to limit the need to trigger additional transmission upgrades.

Preliminary Busbar Mapping Results for Proposed Base Case

Preliminary Busbar Mapping Results Overview

- Working Group staff conducted an initial round of mapping for the proposed base case only.
- Preliminary results are a snapshot from the start of the mapping process
  - Additional rounds of mapping with reallocation and relocation of resources to better optimize criteria alignment will still be conducted.
- Link to CPUC webpage containing mapping dashboard and additional files for busbar mapping work:
  - Assumptions for the 2024-25 TPP webpage
- Limited analysis for a few key criteria that staff has selected to not implement until next round:
  - Substation interconnection analysis and the identifying of additional in-development resources. Both are reliant on info requests to PTOs;
  - Gas retirement and LCR analysis.



Preliminary Mapping: Mapping Summary

- Busbar mapping results after a single round of mapping for the 2034 and 2039 model years are shown in the two tables with resources summarized by CAISO study area.
- First Round of Mapping:
  - Focused on consistency with previous base case and alignment with identified development interest.
  - Included adjustments to limit some transmission constraint exceedances and to avoid mapping to clear environmental and land-use conflicts.
- Further rounds of mapping will:
  - Fully incorporate additional community criteria analysis, interconnection analysis, and gas retirement mapping.
  - Re-map resources to better align environmental, land-use, and commercial interest criteria and to optimize use of existing transmission and cost-effective upgrades.

2034 Preliminary Mapping Summary

CAISO Study Area	Geothermal (MW)	Biomass (MW)	Onshore Wind (MW)	OOS Wind (MW)	Offshore Wind (MW)	Solar (MW)	Li_Battery (MW)	LDES (MW)	Total (MW)
PG&E North of Greater Bay	107.0	98.1	971	-	-	331	332	5	**1,844**
PG&E Greater Bay	-	29.2	875	-	-	138	1,090	0	**2,133**
PG&E Fresno	-	16.0	265	-	-	2,692	1,849	0	**4,822**
PG&E Kern	-	17.0	285	-	3,855	1,660	919	0	**6,735**
SCE Northern Area	-	1.0	614	-	-	3,084	3,409	481	**7,589**
SCE Metro	-	5.6	-	-	-	27	1,962	0	**1,994**
SCE North of Lugo	-	1.5	650	-	-	1,585	806	0	**3,043**
East of Pisgah	716.0	-	1,810	3,268	-	2,440	1,864	0	**10,098**
SCE Eastern	740.0	2.6	599	2,000	-	3,059	2,950	0	**9,350**
SDG&E	50.0	-	2,160	-	-	1,383	1,490	449	**5,532**
Total:	**1,613.0**	**171.0**	**8,229**	**5,268**	**3,855**	**16,398**	**16,671**	**935**	**53,140**

2039 Preliminary Mapping Summary

CAISO Study Area	Geothermal (MW)	Biomass (MW)	Onshore Wind (MW)	OOS Wind (MW)	Offshore Wind (MW)	Solar (MW)	Li_Battery (MW)	LDES (MW)	Total (MW)
PG&E North of Greater Bay	124.0	98.1	2,104	-	-	731	502	5	**3,564**
PG&E Greater Bay	-	29.2	875	-	-	538	1,440	0	**2,883**
PG&E Fresno	-	16.0	265	-	-	4,816	2,830	0	**7,927**
PG&E Kern	-	17.0	285	-	4,531	2,760	1,369	0	**8,961**
SCE Northern Area	-	1.0	814	-	-	4,634	3,974	481	**9,904**
SCE Metro	-	5.6	-	-	-	34	2,292	0	**2,331**
SCE North of Lugo	-	1.5	650	-	-	2,037	1,011	0	**3,700**
East of Pisgah	816.0	-	1,910	5,704	-	2,840	2,614	0	**13,884**
SCE Eastern	740.0	2.6	599	4,500	-	5,409	3,750	0	**15,000**
SDG&E	50.0	-	2,960	-	-	1,383	1,582	449	**6,424**
Total:	**1,730.0**	**171.0**	**10,462**	**10,204**	**4,531**	**25,181**	**21,364**	**935**	**74,578**

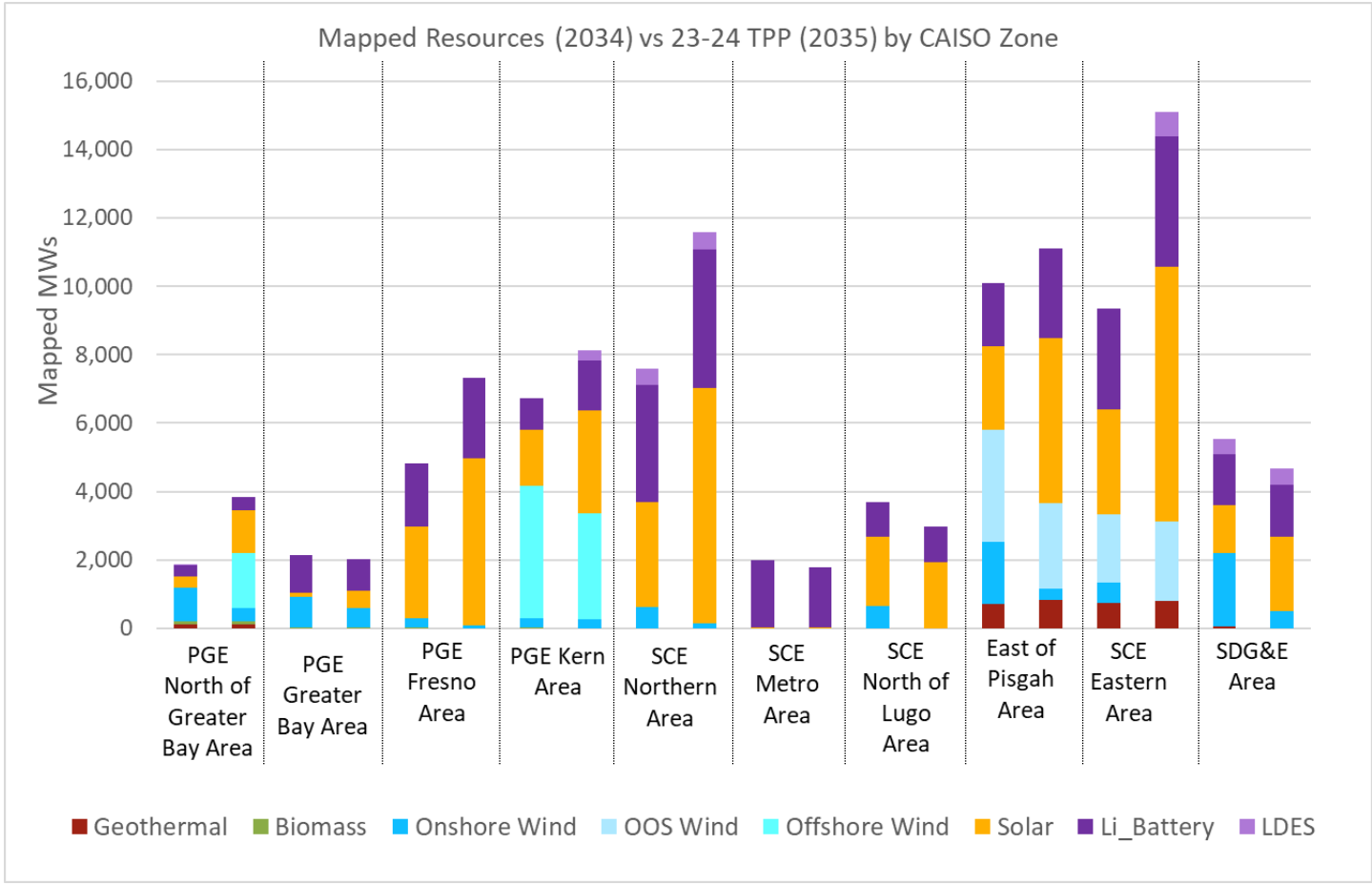
RESOLVE Resource Regions and CAISO Study Areas

- Figure on left shows the RESOLVE resources regions for solar and storage (onshore wind resources are broken down into further sub-areas).
- CAISO's ten transmission study areas do not align perfectly with these regions with some study areas split between RESOLVE regions.

RESOLVE region	CAISO Study Area(s)
Northern California	PG&E North of Greater Bay & PG&E Greater Bay
Southern PG&E	PG&E Fresno & PG&E Kern
Greater Tehachapi	Part of SCE Northern
Greater LA Metro	SCE Metro & Part of SCE Northern
Greater Kramer	SCE North of Lugo
Southern Nevada	East of Pisgah
Riverside	Part of SCE Eastern (excluding AZ buses)
Arizona	Part of SCE Eastern and Part of SDG&E (AZ buses)
Greater Imperial	Part of SDG&E
San Diego	Part of SDG&E

Preliminary Mapping Proposed Portfolio (2034): Consistency with Previous TPP Portfolio

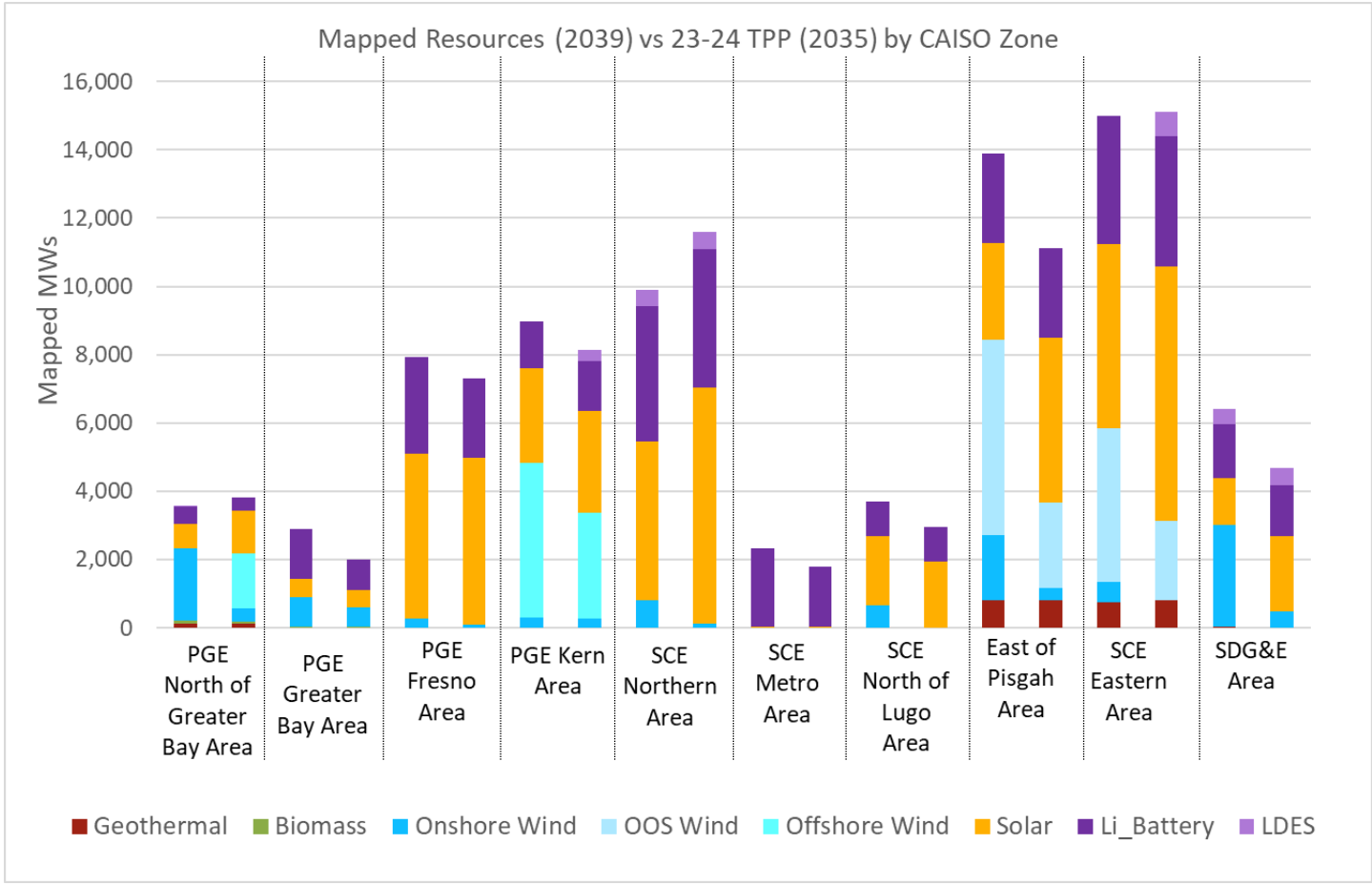
- Chart depicts 2034 mapping results by CAISO transmission study zone compared to the 23-24 TPP (2035) mapped resources, adjusted for resources added to 2023 PSP baseline.
- 2034 portfolio size is ~53 GW, compared to ~68 GW in 23-24 TPP base case's 2035 portfolio.
- Most regions have less resources mapped.
  - Significantly less solar in SCE Eastern, SCE Northern and PG&E Fresno areas due to overall less solar in portfolio.
  - Few areas (PGE Greater Bay, SDG&E, and SCE North of Lugo areas) have increases due to greater amount of onshore wind mapped.
  - 3.8 GW of offshore wind included in 2034, all mapped to Morro Bay area.



Left Column for each area is the Proposed 24-25 TPP (2034) amounts; Right Column is the 23-24 TPP (2035) amounts.

Preliminary Mapping Proposed Portfolio (2039): Consistency with Previous TPP Portfolio

- Chart depicts 2039 mapping results by CAISO transmission study zone compared to the 23-24 TPP (2035) mapped resources, adjusted for resources added to 2023 PSP baseline.
- 2039 portfolio size is ~75 GW, compared to ~68 GW in 23-24 TPP base case's 2035 portfolio.
- Most areas have slightly more total resources than the previous TPP portfolio.
  - Several areas still have less solar, but generally replaced by out-of-state or in-CAISO onshore wind.
  - Large amounts of onshore wind mapped to PG&E North of Greater Bay, East of Pisgah (S. NV & AZ wind), and SDG&E (Baja California wind)areas.
  - All 4.5 GW of offshore wind included is mapped to Morro Bay area.



Left Column for each area is the Proposed 24-25 TPP (2039) amounts; Right Column is the 23-24 TPP (2035) amounts.

Preliminary Mapping: System level transmission capability

- Utilizing CAISO's new 2023 Transmission capability estimates White Paper:
  - Worked with CAISO staff to subsequently incorporate estimates of transmission capability increases from approved transmission upgrades.
  - Capability increases for 22 constraints from approved projects in the 21-22 and 22-23 TPPs.
- Incorporating 104 constraint from the 2023 White Paper, compared to the 43 in the 2021 White Paper.
- Preliminary mapping triggers 19 exceedances in the 2034 portfolio and 31 exceedances in the 2039 portfolio
  - 23-24 TPP 2035 base case portfolio mapping had 33 exceedances in 2021 White Paper Constraints; however, many of those are likely alleviated by the approved upgrades in the 22-23 TPP.

2034 Tx Constraint Exceedances	Actual Constraints Exceeded		Default Constraints Exceeded	
	FCDS	EODS	FCDS	EODS
PG&E North of Greater Bay	2	0	0	0
PG&E Greater Bay	3	0	0	0
PG&E Fresno	3	0	0	0
PG&E Kern	2	0	0	0
SCE Northern Area	1	0	0	0
SCE Metro	0	0	0	0
SCE North of Lugo	0	0	0	0
East of Pisgah	2	1	0	0
SCE Eastern	0	0	1	0
SDG&E	4	0	0	0
Total	17	1	1	0

2039 Tx Constraint Exceedances	Actual Constraints Exceeded		Default Constraints Exceeded	
	FCDS	EODS	FCDS	EODS
PG&E North of Greater Bay	2	0	0	0
PG&E Greater Bay	3	0	0	0
PG&E Fresno	5	1	1	0
PG&E Kern	4	0	0	0
SCE Northern Area	1	0	0	0
SCE Metro	0	0	0	0
SCE North of Lugo	0	0	0	0
East of Pisgah	2	1	1	0
SCE Eastern	1	0	3	0
SDG&E	4	0	2	0
Total	22	2	7	0

Preliminary Mapping: System level transmission capability

- Analysis is only for in-CAISO transmission exceedances, does not account for potential Out-of-CAISO transmission needs.
  - Out-of-CAISO resources are mapped at CAISO intertie point and as needing Maximum Import Capability Expansion.
  - Transmission expansion needed to get to the CAISO intertie and its cost also are factored in through additional analysis.
  - The 2039 portfolio includes 10.2 GW of out-of-state wind and 1.1 GW of geothermal mapped outside of the existing CAISO system.
  - The 2039 portfolio also includes 1 GW of onshore, in-state wind mapped to north-eastern California that would require transmission expansion to realize.
- Further rounds of mapping will optimize the utilization of potential upgrades identified for these constraints and remap resources causing exceedance to areas with existing transmission or alternative upgrades if upgrades are not cost-effective.

2034 Tx Constraint Exceedances	Actual Constraints Exceeded		Default Constraints Exceeded	
	FCDS	EODS	FCDS	EODS
PG&E North of Greater Bay	2	0	0	0
PG&E Greater Bay	3	0	0	0
PG&E Fresno	3	0	0	0
PG&E Kern	2	0	0	0
SCE Northern Area	1	0	0	0
SCE Metro	0	0	0	0
SCE North of Lugo	0	0	0	0
East of Pisgah	2	1	0	0
SCE Eastern	0	0	1	0
SDG&E	4	0	0	0
Total	17	1	1	0

2039 Tx Constraint Exceedances	Actual Constraints Exceeded		Default Constraints Exceeded	
	FCDS	EODS	FCDS	EODS
PG&E North of Greater Bay	2	0	0	0
PG&E Greater Bay	3	0	0	0
PG&E Fresno	5	1	1	0
PG&E Kern	4	0	0	0
SCE Northern Area	1	0	0	0
SCE Metro	0	0	0	0
SCE North of Lugo	0	0	0	0
East of Pisgah	2	1	1	0
SCE Eastern	1	0	3	0
SDG&E	4	0	2	0
Total	22	2	7	0

Preliminary Mapping: Land-use feasibility and environmental impacts

- Implemented several new data sets for the land-use feasibility and environmental (conservation and biological) impacts criteria.
- For the Land-use feasibility criteria, the working group is using the following datasets:
  - CEC's Core Land-Use Screen,
  - CEC's Parcelization and CEC's Cropland index, both for solar only,
  - Critically overdrafted groundwater basin, and
  - Fire threat districts.
- For the environmental (conservation and biological) impacts criteria, the following are implemented:
  - ACE terrestrial connectivity, biodiversity, and irreplaceability datasets
  - Terrestrial Landscape Intactness, and
  - Wetlands.
- Generally, mapped solar resources had good alignment with criteria, with a few exceptions
  - Mapped resources around Kramer, Redbluff, and Colorado River substation had high non-alignment and will be analyzed further in subsequent mapping rounds for potential remapping.
- Generally, mapped onshore wind resources had poor alignment with criteria, showing areas with commercial interest for onshore wind having higher potential environmental implications

Preliminary Mapping: Land-use feasibility and environmental impacts — Mapped Solar Examples

- Land-use feasibility and Environmental impacts criteria analysis for solar resources mapped to selected substations.

			10 Acres/MW		CEC Core Land-Use Screen			CEC's Parcelization				ACE Terrestrial Connectivity			
Substation	RESOLVE Area	Analysis Radius	MWs Mapepd	Acres of MWs Mapped	Lower Implications Area used by MWs Mapped	High Implications Area used by MWs Mapped	Core Screen Criteria Alignment Level	10th % Value Parcel-ization	Low Parcel-ization (P ≤ 6) Area Used	Medium Parcel-ization (6 < P ≤ 30) Area Used	Parcel-ization Criteria Alignment Level	Total Potential Area Percentage Higher Impli-cations	Low Implic-ations Area used by MWs Mapped	Higher Implic-ations Area used by MWs Mapped	ACE Connectivity Criteria Alignment
Kramer	KRAMER	10	1,243	12,430	1453.6%	51.4%	5	31.00	428.6%	86.4%	5	94.1%	895.8%	50.2%	5
Colorado River	RIVERSIDE	10	1,283	12,826	83.4%	0.0%	4	7.31	40.7%	0.0%	2	35.2%	21.3%	0.0%	2
Gates	SPGE	10	930	9,296	43.4%	0.0%	2	7.00	27.3%	0.0%	2	34.8%	2.3%	0.0%	1
Arco	SPGE	10	447	4,469	18.2%	0.0%	1	7.20	14.3%	0.0%	1	64.7%	1.9%	0.0%	2
Los Banos	SPGE	10	501	5,008	27.6%	0.0%	2	7.48	11.2%	0.0%	1	63.2%	3.0%	0.0%	2
Whirlwind	TEHACHAPI	10	808	8,080	13.8%	0.0%	1	39.00	62.0%	0.0%	4	23.8%	2.5%	0.0%	1
Red bluff	RIVERSIDE	10	1,214	12,135	149.9%	13.9%	5	3.90	69.4%	0.0%	2	37.5%	52.4%	0.0%	3
Kramer	KRAMER	15	1,243	12,430	33.0%	0.0%	2	43.25	118.7%	3.5%	5	41.1%	15.4%	0.0%	1
Colorado River	RIVERSIDE	15	1,283	12,826	25.9%	0.0%	2	7.29	13.7%	0.0%	1	37.8%	8.3%	0.0%	1
Red bluff	RIVERSIDE	15	1,214	12,135	133.9%	5.6%	4	3.44	37.9%	0.0%	2	39.2%	31.4%	0.0%	2

Preliminary Mapping: Land-use feasibility and environmental impacts — Mapped Wind Examples

- Land-use feasibility and Environmental impacts criteria analysis for onshore wind resources mapped to selected substations.

			40 Acres/MW		CEC Core Land-Use Screen			Fire Threat				ACE Terrestrial Connectivity			
Substation	RESOLVE Area	Analysis Radius	MWs Mapepd	Acres of MWs Mapped	Lower Implications Area used by MWs Mapped	High Implications Area used by MWs Mapped	Core Screen Criteria Alignment Level	Total Potential Area Percentage Tier 2	Total Potential Area Percentage Tier 3	Total Potential Area Percentage Tier 2 or 3	Fire Threat Criteria Alignment Level	Total Potential Area Percentage Higher Impli-cations	Low Implic-ations Area used by MWs Mapped	Higher Implic-ations Area used by MWs Mapped	ACE Connectivity Criteria Alignment
Glenn	Nothern_CA	15	300	12,000	21.2%	0.0%	2	0.6%	0.0%	0.6%	1	52.9%	8.2%	0.0%	2
Eagle Rock (PGE	Nothern_CA	15	131	5,240	999.9%	5.7%	4	29.6%	64.2%	93.8%	5	68.1%	17.9%	0.0%	2
Los Banos	Central_Valley	15	141	5,656	313.1%	5.1%	4	7.1%	0.0%	7.1%	1	75.4%	29.6%	0.0%	3
Round Mountai	Nothern_CA	15	210	8,400	212.0%	2.5%	4	95.1%	4.1%	99.3%	5	53.4%	10.0%	0.0%	2
Birds Landing	Solano	15	300	12,000	296.9%	5.6%	4	1.9%	0.1%	1.9%	2	14.4%	9.6%	0.0%	1
Coolwater	Greater_Kramer	15	200	8,000	36.4%	0.0%	2	0.0%	0.0%	0.0%	1	52.1%	27.4%	0.0%	2
Kelso	Solano	15	195	7,800	999.9%	4.7%	4	12.7%	3.0%	15.7%	2	49.8%	9.3%	0.0%	1
Lathrop	Southern_NV	15	195	7,800	27.72%	0.00%	2								
Los Banos	Central_Valley	20	141	5,656	313.1%	3.2%	4	4.9%	0.0%	4.9%	1	61.4%	12.2%	0.0%	2
Round Mountai	Nothern_CA	20	210	8,400	212.0%	1.6%	4	95.4%	3.9%	99.3%	5	49.3%	6.0%	0.0%	1

Preliminary Mapping: Community and environmental (societal) impacts

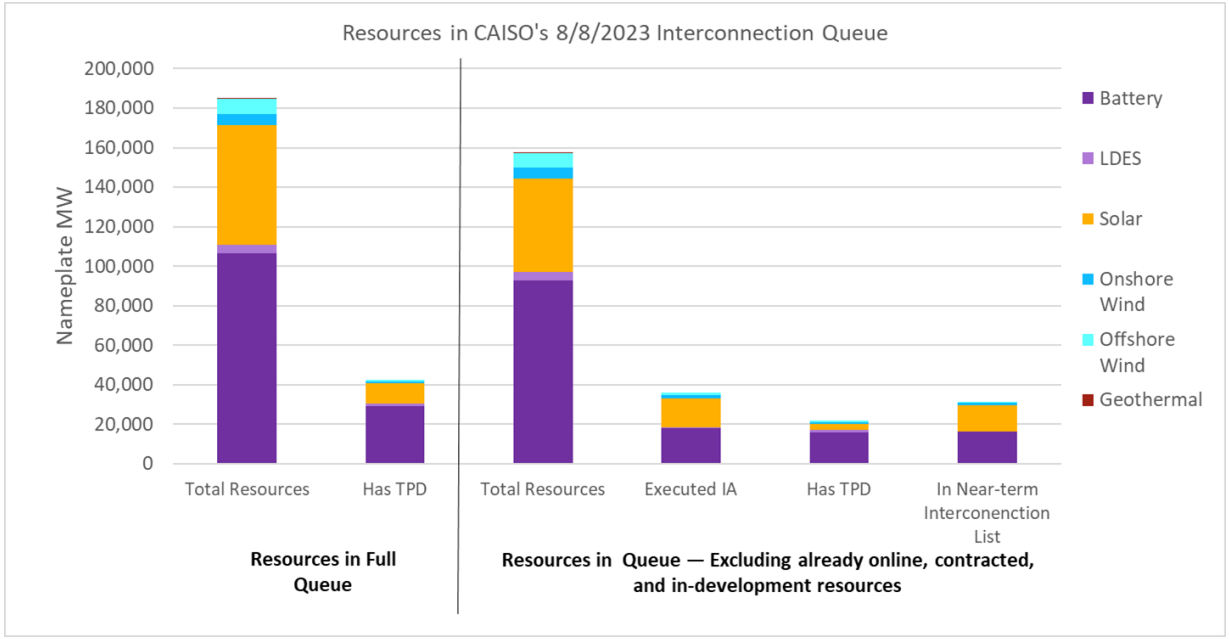
- Mapped resources should seek to bolster and benefit pollution-burdened and disadvantaged communities where feasible, particularly by reducing emissions and impacts of air-pollutant emitting fossil-fuel generators.
- For Disadvantaged Communities, IRA communities, and Air Quality Non-Attainment Zone analysis:
  - Assess if area around interconnection substation, is mostly in or near (< 5 miles) designated areas.
- Proximity to fossil fuel gas plant is assessed by location of interconnection substation.
- Further rounds of mapping will seek to further increase and optimize alignment with criteria.

	In Air Quality Non-attainment Zones		Interconnecting to Substation < 1 mi from Gas Plant		In or near Disadvantaged Communities	
CAISO Study Area	Renewable (MW)	Storage (MW)	Renewable (MW)	Storage (MW)	Renewable (MW)	Storage (MW)
PG&E North of Greater Bay	433	88	796	208	347	38
PG&E Greater Bay	1,228	820	217	906	1,198	670
PG&E Fresno	6,392	2,551	1,311	509	3,185	1,276
PG&E Kern	4,630	2,365	182	50	2,471	1,182
SCE Northern	4,617	2,015	2,245	654	1,894	575
SCE Metro	14	2,793	-	1,130	7	1,397
SCE North of Lugo	2,152	650	683	170	1,282	295
East of Pisgah	-	-	1,400	500	-	-
SCE Eastern	1,689	145	399	45	200	-
SDG&E	3,382	651	2,532	92	50	-
Total:	**24,537**	**12,079**	**9,764**	**4,264**	**10,633**	**5,433**

Preliminary Mapping: Commercial development interests

- Criteria incorporates information from the CAISO's queue, PTOs' wholesale distribution tariff queues, as well as Imperial Irrigation District's (IID) and Nevada Energy's (NVEP) queues.
- The criteria prioritizes alignment with in-development resources (top table):
  - Resources contracted, online, or under construction not included in modeling baseline.
  - In further rounds of mapping the working group will engage with PTOs to identified additional in-development resources.
- Criteria, next prioritizes "higher confidence" commercial interest which includes projects with executed interconnection agreements followed by those having completed Phase 2 studies in the CAIOS queue.
- Generally good alignment for solar and storage, while other resource types have more non-alignment.

In-Development: Contracted, online, or under construction not in modeling baseline									
CAISO Study Area	Geothermal (MW)	Biomass (MW)	Onshore Wind (MW)	OOS Wind (MW)	Offshore Wind (MW)	Solar (MW)	Li_Battery (MW)	LDES (MW)	Total (MW)
PG&E North of Greater Bay	32.0	6.0	-	-	-	52	93	0	**184**
PG&E Greater Bay	-	5.0	-	-	-	114	170	0	**290**
PG&E Fresno	-	3.0	-	-	-	1,598	1,455	0	**3,055**
PG&E Kern	-	-	-	-	-	504	186	0	**690**
SCE Northern Area	-	-	-	-	-	1,036	2,240	200	**3,476**
SCE Metro	-	5.6	-	-	-	27	895	0	**928**
SCE North of Lugo	-	-	-	-	-	535	361	0	**896**
East of Pisgah	26.0	-	-	-	-	460	624	0	**1,110**
SCE Eastern	-	2.6	-	-	-	1,759	2,255	0	**4,016**
SDG&E	-	-	-	-	-	611	1,100	0	**1,711**
Total:	**58.0**	**22.2**	**-**	**-**	**-**	**6,695**	**9,380**	**200**	**16,355**



Preliminary Mapping: Commercial development interests

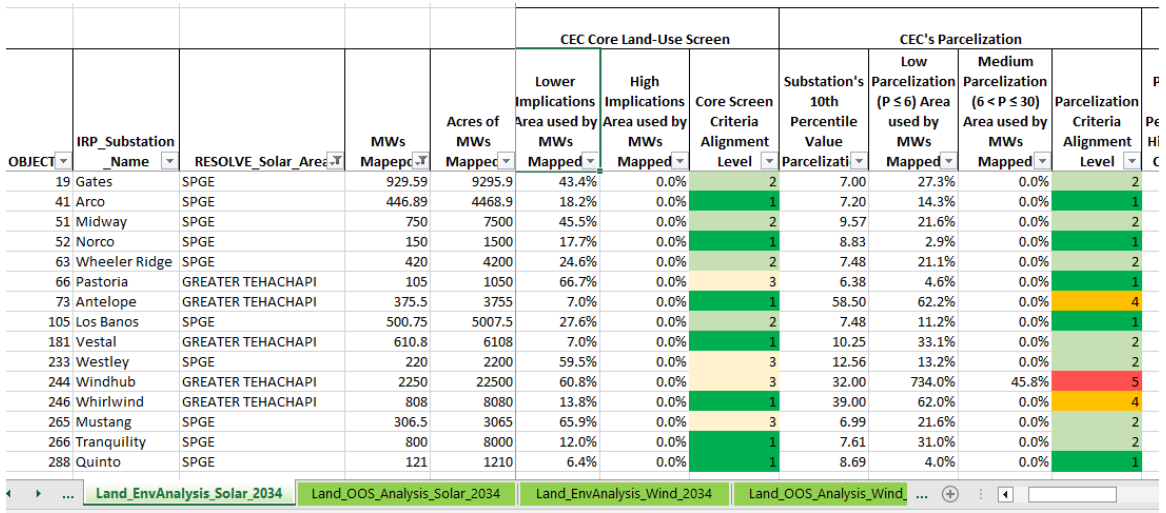
- Limited commercial interest from queues for non-solar or storage resources particularly biomass and geothermal, but also onshore wind.
  - CAISO queue predominately solar and storage (breakdown shown top right).
  - Other queues provide additional info (e.g., IID and NVEP for geothermal) as do Cluster 15 applications.
- Amount of On-shore in-CAISO wind in portfolio exceeds identified commercial interest:
  - Including incorporating the NVEP queue for potential projects in Southern Nevada and Lassen County areas.
  - Lassen area resources would require major new transmission line to connect to CAISO territory.

All Values in Nameplate MWs	Resources in Full CAISO Queue (8/8/23)		Resources in CAISO Queue (8/8/23) — Excluding already online, contracted, and in-development resources			
Resource Type	Total Resources	Has TPD	Total Resources	Executed IA	Has TPD	In Near-term Interconenction List
Battery	106,422	29,020	92,926	18,056	15,924	16,382
LDES	4,300	1,465	4,100	500	1,265	-
Solar	60,594	10,164	47,511	14,407	3,091	13,466
Onshore Wind	5,795	928	5,262	1,992	631	1,125
Offshore Wind	7,518	1,000	7,518	1,029	1,000	162
Geothermal	53	-	32	-	-	-
Total:	**184,682**	**42,577**	**157,349**	**35,984**	**21,911**	**31,135**

	2039 Mapped (MWS)	Total Commercial Intrest	Executed IA (CAISO, WDTs)	All Queue (CAISO, WDTs)	Cluster 15 Applications	NVEP Queue
PG&E North of Greater Bay	2,104	1,662	208	338	100	1,015
PG&E Greater Bay	875	1,187	787	-	400	-
PG&E Fresno	265	264	64	-	200	-
PG&E Kern	285	210	-	210	-	-
SCE Northern Area	814	324	124	-	200	-
SCE Metro	-	-	-	-	-	-
SCE North of Lugo	650	462	-	362	100	-
East of Pisgah	1,910	1,410	310	-	800	300
SCE Eastern	599	998	90	308	600	-
SDG&E	2,960	3,163	463	2,700	-	-
Total:	**10,462**	**9,679**	**2,046**	**3,918**	**2,400**	**1,315**

Preliminary Busbar Mapping Results Dashboard

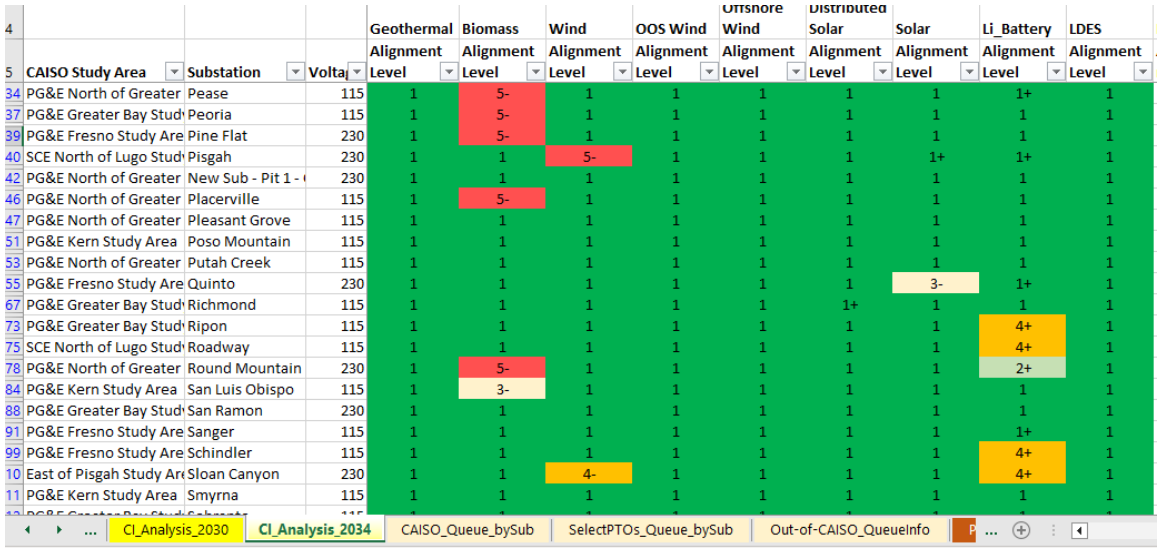
- Preliminary mapping results are compiled into a busbar mapping dashboard which includes:
  - Summary of mapping results by model 2034 and 2039 model years
  - Summary of mapping criteria alignment by model years
  - Detailed calculations for each specific criteria analysis.
- Dashboard and associated mapping datasets will be posted to the [Assumptions for the 2024-2025 TPP](#) webpage.



					CEC Core Land-Use Screen			CEC's Parcelization				
OBJECT	IRP_Substation_Name	RESOLVE_Solar_Area	MWs Mapped	Acres of MWs Mapped	Lower Implications Area used by MWs Mapped	High Implications Area used by MWs Mapped	Core Screen Criteria Alignment Level	Substation's 10th Percentile Value Parcelizati	Low Parcelization (P ≤ 6) Area used by MWs Mapped	Medium Parcelization (6 < P ≤ 30) Area used by MWs Mapped	Parcelization Criteria Alignment Level	
19	Gates	SPGE	929.59	9295.9	43.4%	0.0%	2	7.00	27.3%	0.0%	2	
41	Arco	SPGE	446.89	4468.9	18.2%	0.0%	1	7.20	14.3%	0.0%	1	
51	Midway	SPGE	750	7500	45.5%	0.0%	2	9.57	21.6%	0.0%	2	
52	Norco	SPGE	150	1500	17.7%	0.0%	1	8.83	2.9%	0.0%	1	
63	Wheeler Ridge	SPGE	420	4200	24.6%	0.0%	2	7.48	21.1%	0.0%	2	
66	Pastoria	GREATER TEHACHAPI	105	1050	66.7%	0.0%	3	6.38	4.6%	0.0%	1	
73	Antelope	GREATER TEHACHAPI	375.5	3755	7.0%	0.0%	1	58.50	62.2%	0.0%	4	
105	Los Banos	SPGE	500.75	5007.5	27.6%	0.0%	2	7.48	11.2%	0.0%	1	
181	Vestal	GREATER TEHACHAPI	610.8	6108	7.0%	0.0%	1	10.25	33.1%	0.0%	2	
233	Westley	SPGE	220	2200	59.5%	0.0%	3	12.56	13.2%	0.0%	2	
244	Windhub	GREATER TEHACHAPI	2250	22500	60.8%	0.0%	3	32.00	734.0%	45.8%	5	
246	Whirlwind	GREATER TEHACHAPI	808	8080	13.8%	0.0%	1	39.00	62.0%	0.0%	4	
265	Mustang	SPGE	306.5	3065	65.9%	0.0%	3	6.99	21.6%	0.0%	2	
266	Tranquility	SPGE	800	8000	12.0%	0.0%	1	7.61	31.0%	0.0%	2	
288	Quinto	SPGE	121	1210	6.4%	0.0%	1	8.69	4.0%	0.0%	1	

Land_EnvAnalysis_Solar_2034 | Land_OOS_Analysis_Solar_2034 | Land_EnvAnalysis_Wind_2034 | Land_OOS_Analysis_Wind

Left: Tab in dashboard depicting solar land-use feasibility analysis



4				Geothermal Alignment	Biomass Alignment	Wind Alignment	OOS Wind Alignment	Offshore Wind Alignment	Distributed Solar Alignment	Solar Alignment	Li_Battery Alignment	LDES Alignment
5	CAISO Study Area	Substation	Volta	Level	Level	Level	Level	Level	Level	Level	Level	Level
34	PG&E North of Greater	Pease	115	1	5-	1	1	1	1	1	1+	1
37	PG&E Greater Bay Stud	Peoria	115	1	5-	1	1	1	1	1	1	1
39	PG&E Fresno Study Are	Pine Flat	230	1	5-	1	1	1	1	1	1	1
40	SCE North of Lugo Stud	Pisgah	230	1	1	5-	1	1	1	1+	1+	1
42	PG&E North of Greater	New Sub - Pit 1 -	230	1	1	1	1	1	1	1	1	1
46	PG&E North of Greater	Placerville	115	1	5-	1	1	1	1	1	1	1
47	PG&E North of Greater	Pleasant Grove	115	1	1	1	1	1	1	1	1	1
51	PG&E Kern Study Area	Poso Mountain	115	1	1	1	1	1	1	1	1	1
53	PG&E North of Greater	Putah Creek	115	1	1	1	1	1	1	1	1	1
55	PG&E Fresno Study Are	Quinto	230	1	1	1	1	1	1	3-	1+	1
67	PG&E Greater Bay Stud	Richmond	115	1	1	1	1	1	1+	1	1	1
73	PG&E Greater Bay Stud	Ripon	115	1	1	1	1	1	1	1	4+	1
75	SCE North of Lugo Stud	Roadway	115	1	1	1	1	1	1	1	4+	1
78	PG&E North of Greater	Round Mountain	230	1	5-	1	1	1	1	1	2+	1
84	PG&E Kern Study Area	San Luis Obispo	115	1	3-	1	1	1	1	1	1	1
88	PG&E Greater Bay Stud	San Ramon	230	1	1	1	1	1	1	1	1	1
91	PG&E Fresno Study Are	Sanger	115	1	1	1	1	1	1	1	1+	1
99	PG&E Fresno Study Are	Schindler	115	1	1	1	1	1	1	1	4+	1
10	East of Pisgah Study Are	Sloan Canyon	230	1	1	4-	1	1	1	1	4+	1
11	PG&E Kern Study Area	Smyrna	115	1	1	1	1	1	1	1	1	1

CI_Analysis_2030 | CI_Analysis_2034 | CAISO_Queue_bySub | SelectPTOs_Queue_bySub | Out-of-CAISO_QueueInfo

Left: Tab in dashboard depicting commercial development interest criteria alignment

Next Steps

- *Workshop slides* are available at the 2022-2023 IRP Cycle Events and Materials webpage.
- The workshop is being recorded; the recording and the workshop's Q&A will be posted online to the same webpage.

- Stakeholders will have the opportunity to provide written comments in response to the Ruling by 11/13/2023 and via reply comments by 12/1/2023