Integrated Resource Planning (IRP) Proposed Preferred System Plan Analysis

Workshop

September 1, 2021

California Public
Utilities Commission

Workshop Outline

- Background
- Aggregation of LSE Plans
- Capacity Expansion Modeling
- Q&A
- Production Cost Modeling (PCM) Study Overview
- Q&A
- Break
- IRP Resource Portfolios for the 2022-2023 TPP
- Q&A
- Procurement and/or other Potential PSP actions
  - *Intro*
  - *Retention of Existing Resources*
  - *Reliability Need: Acceleration of D.21-06-035 Procurement*
  - *Reliability Need: Fossil-Fueled Procurement & Role of Renewable Hydrogen*
  - *Geographically Targeted Procurement: Aliso Canyon Replacement*
- Q&A
  - *GHG-driven procurement*
  - *Long Lead-Time Resources: Out-of-state resources*
  - *Long Lead-Time Resources: Offshore wind*
  - *Storage Projects as Transmission Alternatives & other Procurement for System Benefit*
- Q&A

Logistics & Scope

- *Workshop slides* are available at the IRP Events and Materials webpage
- The workshop will be recorded, with the recording posted to the same webpage
- This workshop is not for the IRP proceeding record, but rather to advance stakeholders' understanding of the PSP development process and solicit stakeholder feedback during the ruling development process

Questions

- This workshop is intended to advance stakeholder's understanding of the process that led to the development of the proposed Preferred System Plan and the potential for procurement and other actions

- We invite clarifying questions and comments **in written format** during the Q&A segment at the end of each topic.

- Stakeholders will have the opportunity to provide written comments in response to the Ruling by 9/27/2021 and via reply comments by 10/11/2021

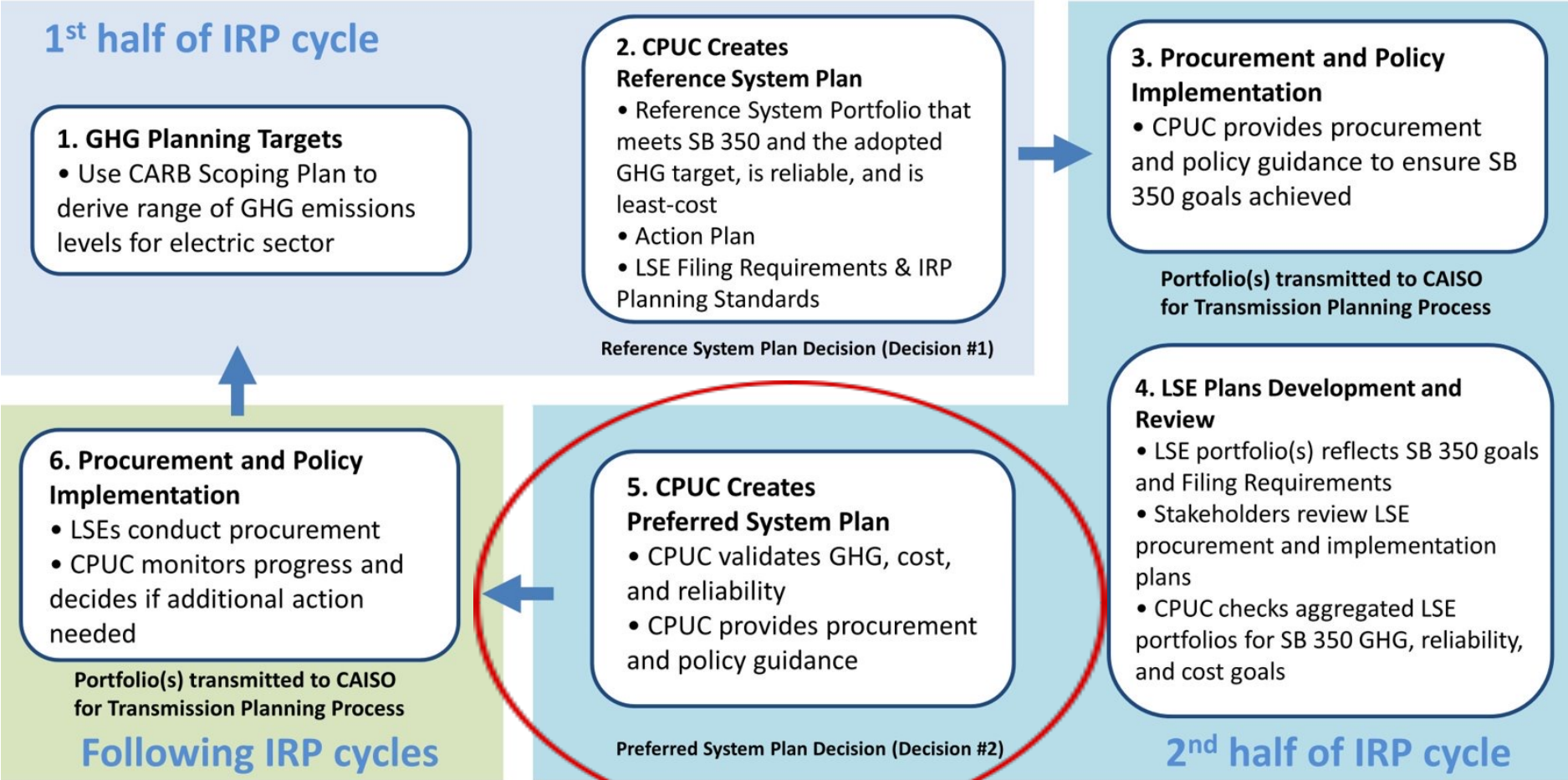- All attendees have been muted. **To ask questions:**

  In Webex:

  - Click the three dots on the lower right of the webex screeen to reveal the "Q-and-A" link. Please try to avoid submitting questions in the Chat function.
  - Write your question in the box, directed to either "Everybody" or "Panelists."
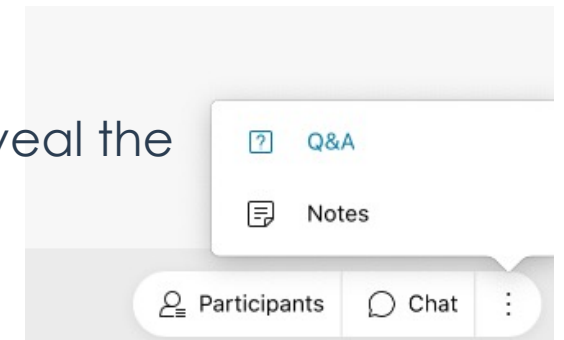
  Phone access only will not be able to verbally pose questions in this workshop.

Background

Where we are in the IRP Process

1st half of IRP cycle

1. GHG Planning Targets
• Use CARB Scoping Plan to derive range of GHG emissions levels for electric sector

2. CPUC Creates Reference System Plan
• Reference System Portfolio that meets SB 350 and the adopted GHG target, is reliable, and is least-cost
• Action Plan
• LSE Filing Requirements & IRP Planning Standards

Reference System Plan Decision (Decision #1)

3. Procurement and Policy Implementation
• CPUC provides procurement and policy guidance to ensure SB 350 goals achieved

Portfolio(s) transmitted to CAISO for Transmission Planning Process

4. LSE Plans Development and Review
• LSE portfolio(s) reflects SB 350 goals and Filing Requirements
• Stakeholders review LSE procurement and implementation plans
• CPUC checks aggregated LSE portfolios for SB 350 GHG, reliability, and cost goals

5. CPUC Creates Preferred System Plan
• CPUC validates GHG, cost, and reliability
• CPUC provides procurement and policy guidance

Preferred System Plan Decision (Decision #2)

6. Procurement and Policy Implementation
• LSEs conduct procurement
• CPUC monitors progress and decides if additional action needed

Portfolio(s) transmitted to CAISO for Transmission Planning Process

Following IRP cycles

2nd half of IRP cycle

Background on the CPUC IRP 2019-21 Cycle

- The IRP process has two halves:
  - First, it identifies an optimal portfolio for meeting state policy objectives and encourages the LSEs to procure towards that future
  - Second, it collects and aggregates the LSEs collective efforts for planned and contracted resources to compare the expected system to the identified optimal system
- 1st Half: marked by March 2020 adoption of D.20-03-028, establishing an optimal "Reference System Portfolio" of resources to meet an electric sector GHG planning target of 46 MMT by 2030 and as well as an optimal portfolio for meeting a 38 MMT electric sector target
- 2nd Half: commenced on September 1, 2020, when LSEs filed individual IRPs ("LSE Plans") detailing how they would achieve their share of a 46 MMT and 38 MMT GHG target through a mix of contracted and planned resources
- LSE plans have been aggregated and used to develop the Proposed Preferred System Portfolio ("PSP") described in the August 17 ALJ Ruling
  - LSE Plans were also used in part to develop the "Need Determination" that supported the procurement amounts ordered in D.21-06-035

IRP Procurement Track

- The Commission has issued two IRP procurement orders:
  - D.19-11-016: ordered 3,300 MW net qualifying capacity (NQC) reliability procurement, to come online between 2021-2023
  - D.21-06-035: ordered 11,500 MW NQC reliability procurement, to come online between 2023-2026:
    - 7,000 MW NQC of preferred resources
    - 2,500 MW NQC from zero-emissions generation, generation paired with storage, or demand response, by 2025 to replace Diablo Canyon Power Plant
    - 1,000 MW NQC of long duration storage resources for 2026
    - 1,000 MW NQC of firm zero-emitting resources for 2026
- The Commission seeks to maintain a strong link between planning and procurement so that both tracks of IRP send a clear and consistent signal to LSEs and the market

Timeline

- Preferred System Plan (PSP) Ruling issued on August 17 describing the PSP analysis and seeking comment on the preferred resource portfolio for use in planning and procurement decision-making

Activity	Timing
Ruling on PSP & TPP (Including proposed portfolio descriptions, busbar mapping methodology, and RESOLVE updates)	August 2021
Party comments and replies due	September – October 2021
Comment review, PSP portfolio adjustments including RESOLVE runs and production cost modeling of PSP portfolio, CEC reliability analysis	September – October 2021
Busbar Mapping by Working Group of portfolio(s)	September – October 2021
Proposed Decision	November 2021
Final Decision	December 2021

Aggregation of LSE Portfolios

Filing Requirements

- LSE IRP filings are the vehicle by which the CPUC and stakeholders gain insight into individual LSEs' plans for meeting state goals
- To facilitate the filing of useful, appropriate, and complete information by LSEs, IRP staff provide LSEs with standardized tools, instructions, and templates (aka, IRP "filing requirements documents")
- The September 1, 2020 filing included LSE information on:
  - GHG reductions
  - reliability
  - imports/exports
  - impacts on disadvantaged communities
  - costs
  - other elements of long-term resource planning

Filing Requirements Documents: Purpose

- **Narrative Template**: To describe how LSEs approached the process of developing its plan, present the result of analytical work, and demonstrate to the Commission and the stakeholders the LSE's action plans

- **Resource Data Template (RDT)**: To collect planned and existing monthly LSE contracting data, including for future resources which do not exist yet. Provides a snapshot of the LSE contracted and planned monthly total energy and capacity forecast positions over a ten year look ahead period

- **Clean System Power (CSP) Calculator**: To use in estimating the GHG and criteria pollutant emissions of LSE portfolios and verify that LSE portfolios achieve assigned GHG planning benchmarks

Evaluation of LSE Resource Data Templates

- Staff developed aggregated LSE plans using the data submitted in the LSEs' RDTs, which had to be evaluated for completeness and internal consistency by staff to ensure that they accurately reflected LSE planning

- Staff built the RDT Error Checking, Aggregation and Reallocation Tool (RECART) to aggregate, error check, and analyze LSE RDT filings

- RECART compiled energy and capacity under contract, contracted resources by technology type and LSE, and aggregated new resources that were in development or planned future purchases

- LSEs were contacted when errors were found in RECART and re-submitted RDT filings, where necessary

Aggregation of Non-Jurisdictional LSE Resources

- IRP staff worked with the California Energy Commission (CEC) to develop RDTs for in-CAISO Publicly Owned Utilities (POUs)

- These RDTs contain existing contracts held by the POUs for online and in-development resources located in or deliverable to the CAISO

- These resources were aggregated with other LSE resources to provide a full picture of resource planning across the CAISO BAA

Planned Resource Additions -- Aggregated 46 MMT Plans
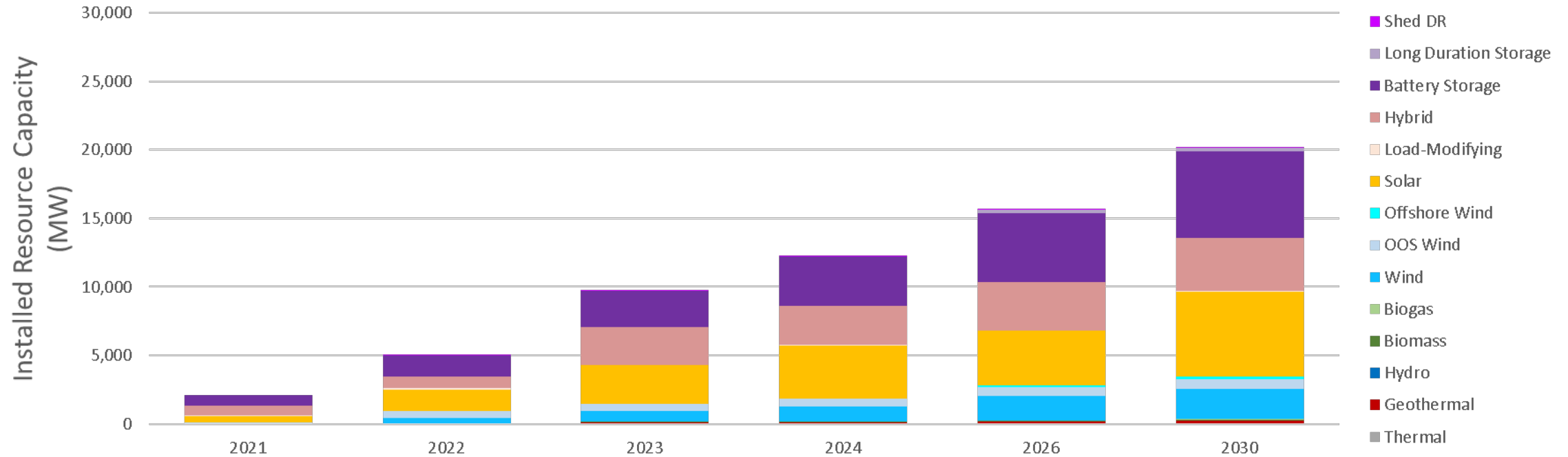
- Statewide Emissions in 2030, per aggregated LSE CSP results: **44.8 MMT**
- Statewide Emissions in 2030, per aggregated LSE SERVm results: **48.5 MMT**
- Difference between the cumulative GHG emissions of LSE plans as submitted in their CSP calculators compared to the SERVM analysis of LSE plans is largely driven by LSEs planning to contract with existing resources that may not be available in the marketplace due to multiple LSEs planning to contract with same limited pool of resources
  - IRP staff analysis of LSE plans shows that LSEs are collectively planning to contract with uncontracted renewable and zero carbon resources in the future at a faster rate than existing contracts are rolling off
  - This indicates that those LSEs planning to contract with uncontracted and existing renewable and zero-carbon resources in the future may find difficulty finding those resources and should consider alternative strategies to achieve their GHG goals

Planned Resource Additions -- Aggregated 38 MMT Plans
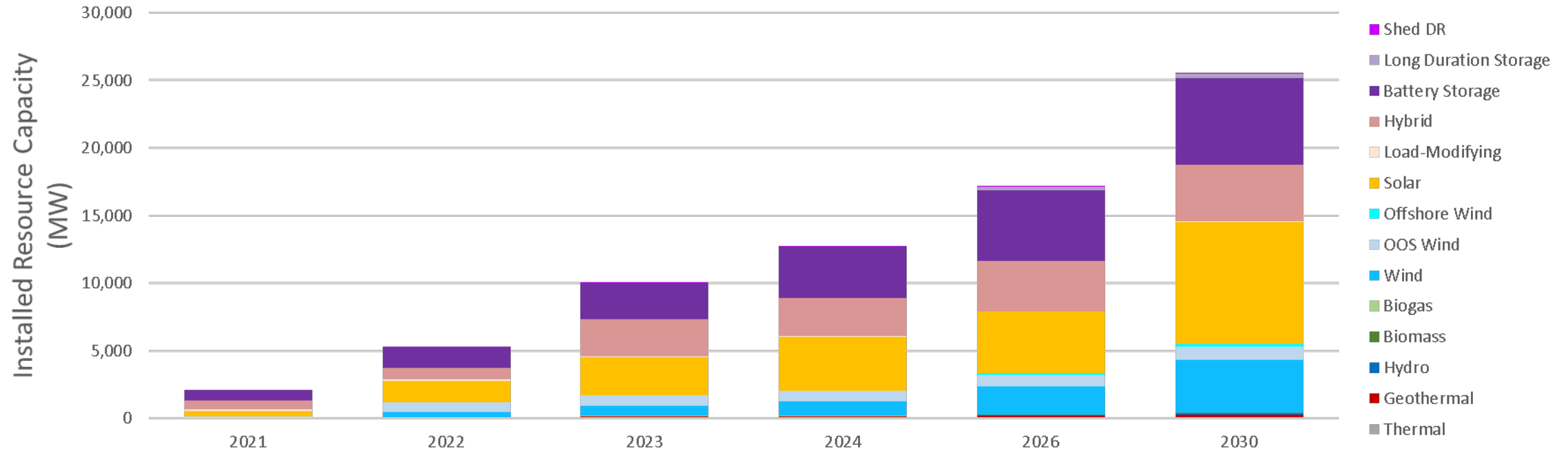
- Statewide Emissions in 2030, per aggregated LSE CSP results: **35.9 MMT**
- Statewide Emissions in 2030, per aggregated LSE SERVm results: **43.5 MMT**
- Like with the 46 MMT plans, the difference between the cumulative GHG emissions of LSE plans as submitted in their CSP calculators compared to the SERVM analysis of LSE plans is largely driven by LSEs planning to contract with more existing resources than are available in the marketplace

New Resource Additions: Growth from 46 MMT to 38 MMT Plans

- LSEs relied largely on new wind and solar resources to close the emissions gap between their 46 and 38 MMT plans

- Some LSEs planned to contract with existing GHG-free resources, which are counted in the baseline and not included in the PSP portfolio
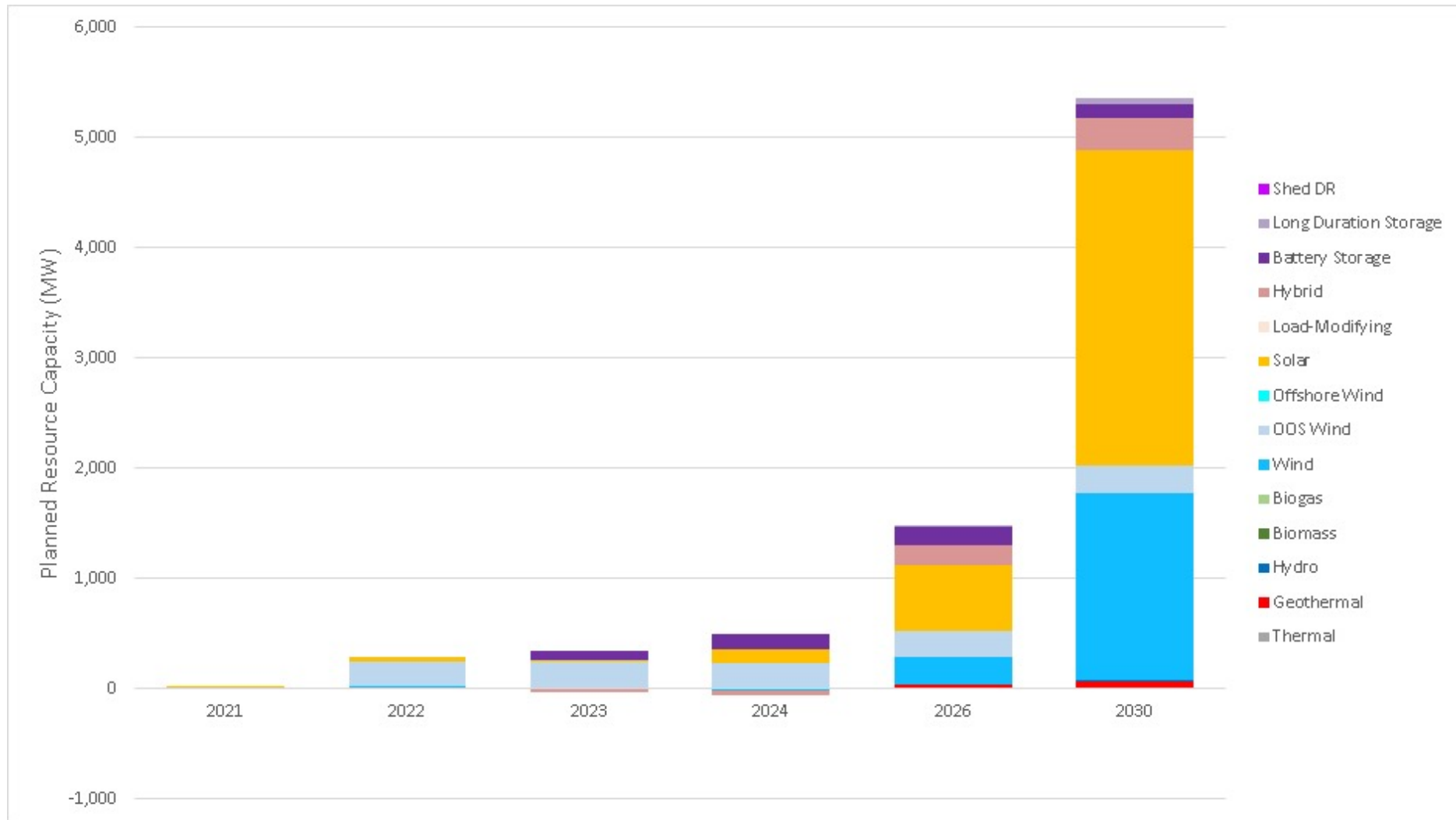
Conclusions

- Portfolio size and composition are generally consistent with the RSP, but do not contain the minimum procurement amounts recently ordered in D.21-06-035
- Aggregated portfolios include more technology types than the RSP, but the amounts of diverse resource being planned for (e.g. geothermal, long-duration storage, offshore wind, OOS wind, biomass) are generally small and uncontracted
- CCAs have the most planned procurement, with a heavy emphasis on GHG-free resources, followed by IOUs, who are planning for a higher proportion of new battery resources
- ESPs generally did not plan to procure incremental new resources in their 38 MMT plans relative to their 46 MMT plans, instead mostly planning to contract with existing resources to close the emissions gap
- All LSEs planning to contract with uncontracted and existing renewable and zero-carbon resources in the future may find difficulty finding those resources and should consider alternative strategies to achieve their GHG goals

Capacity Expansion Modeling

Modeling to develop Potential PSP Portfolios

- Staff used the RESOLVE capacity expansion model to:
  - Select additional resources incremental to the aggregated 38 MMT plans needed to meet the model's reliability and GHG constraints
  - Select resources consistent with the "high need" scenario in D.21-06-035 to ensure that ordered procurement is reflected in any PSP portfolio
  - Select resources post-2030, beyond the time horizon of LSE plans, to inform longer-term planning, including a 2032 study year for transmission planning
    - A 2045 GHG target of 14.9 MMT was applied--consistent 2018 CEC High Biofuels Scenario-- and 2031-2044 targets were interpolated linearly between the 2030 and 2045 targets.
  - Develop sensitivity portfolios to support Commission decision-making
- RESOLVE was updated prior to PSP modeling to include:
  - Alignment of modeled reliability needs with MTR need per D.21-06-035
  - An updated set of baseline resources, based on LSE Plans and consistent with the baseline used in D.21-06-035
  - An updated set of resource cost and potential assumptions
  - New constraints to ensure that LSE planned resources were selected by the model
  - Updated transmission deliverability constrains to align with CAISO
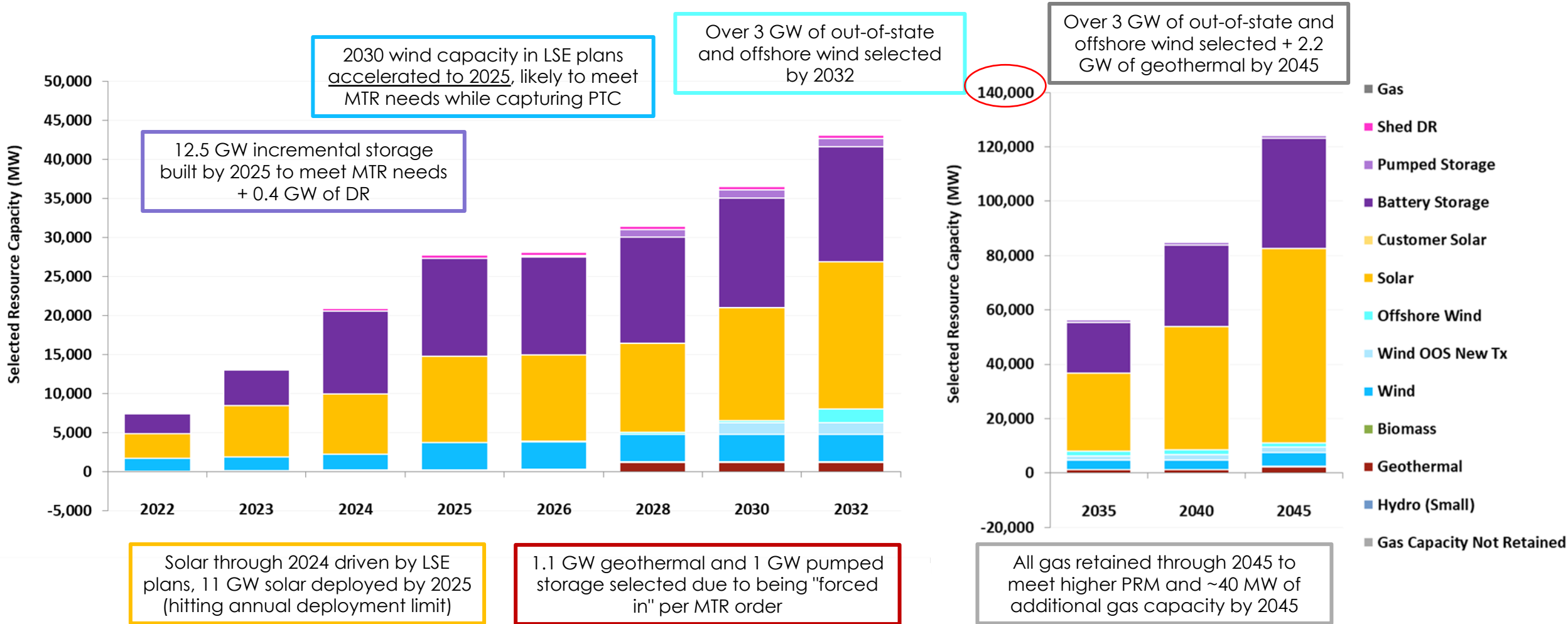 - An update to the latest RESOLVE code base

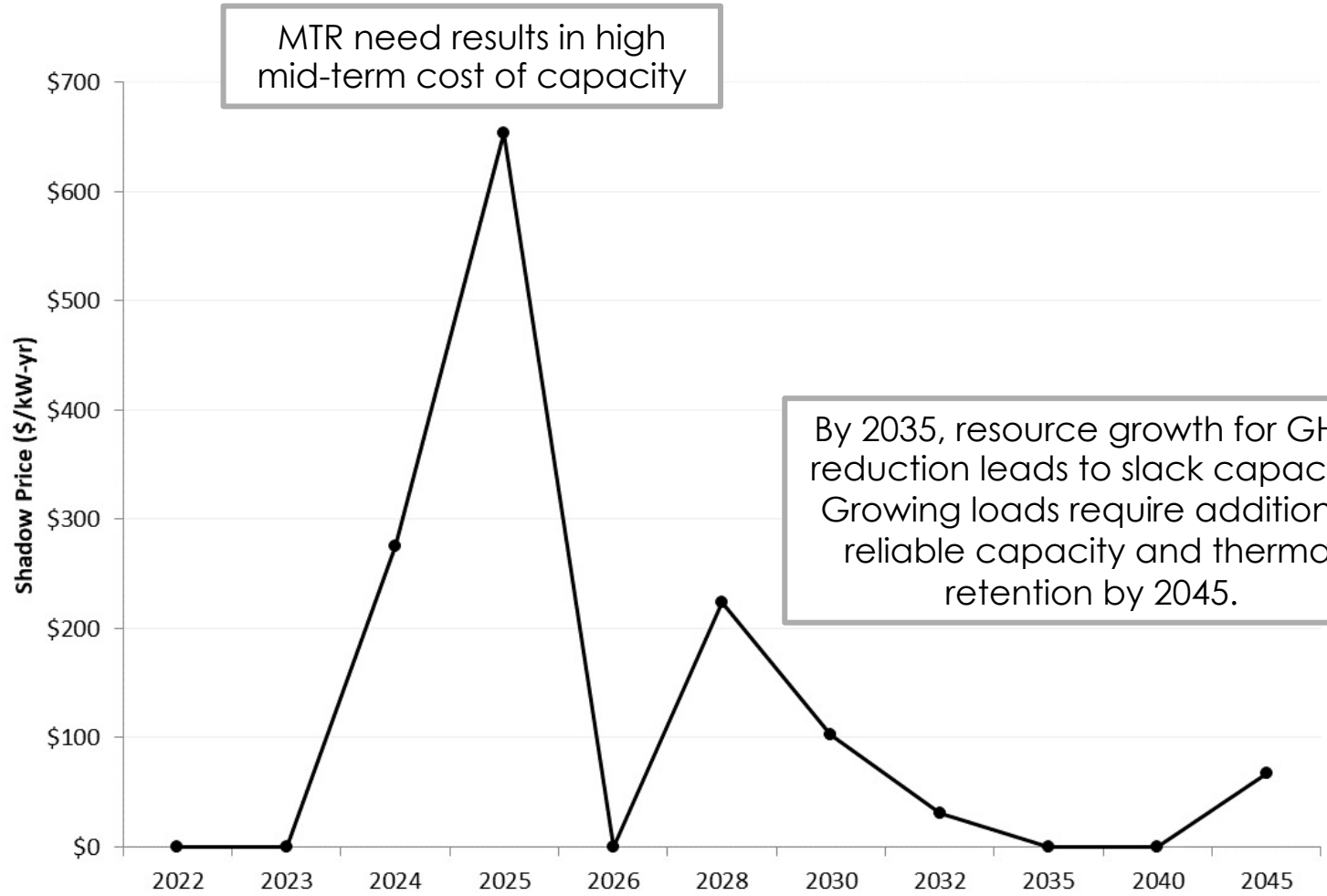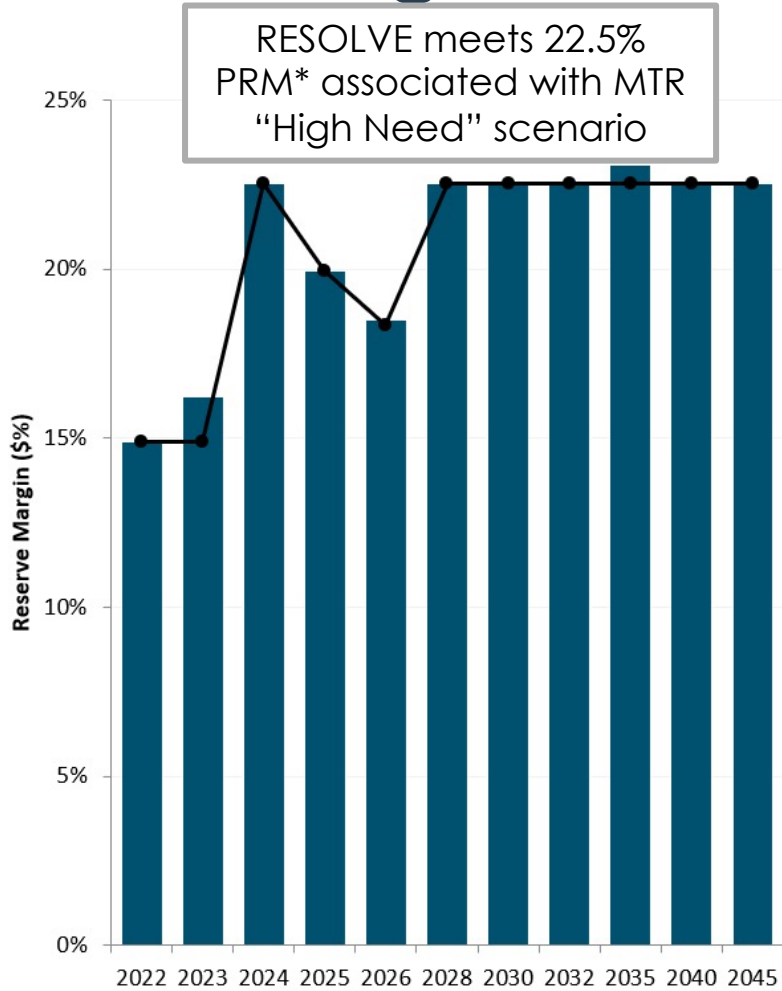# Proposed PSP (38 MMT Core Portfolio)

With LSE Plans

38 MMT Core portfolio overview

- **Purpose**: understand the CAISO system resources needs to meet the 38 MMT 2030 GHG target, accounting for the LSE plans for the 38 MMT goal and D.21-06-035

- **Key metrics to be discussed**:
  - Selected resources* throughout modeling period
  - Planning reserve margin highlights
  - GHG emissions
  - Selected resources beyond the 38 MMT LSE plans
 - Transmission selection details and insights

* Selected resources include A) baseline resources not in the CAISO transmission baseline, B) review + planned resources from LSE Plans, C) MTR resources, D) any other resources RESOLVE selects for reliability, GHGs, or economics

Selected resources – 38 MMT Core

2030 wind capacity in LSE plans <u>accelerated to 2025</u>, likely to meet MTR needs while capturing PTC

Over 3 GW of out-of-state and offshore wind selected by 2032

Over 3 GW of out-of-state and offshore wind selected + 2.2 GW of geothermal by 2045

12.5 GW incremental storage built by 2025 to meet MTR needs + 0.4 GW of DR

Solar through 2024 driven by LSE plans, 11 GW solar deployed by 2025 (hitting annual deployment limit)

1.1 GW geothermal and 1 GW pumped storage selected due to being "forced in" per MTR order

All gas retained through 2045 to meet higher PRM and ~40 MW of additional gas capacity by 2045

Legend:
- Gas
- Shed DR
- Pumped Storage
- Battery Storage
- Customer Solar
- Solar
- Offshore Wind
- Wind OOS New Tx
- Wind
- Biomass
- Geothermal
- Hydro (Small)
- Gas Capacity Not Retained

Planning reserve margin – 38 MMT Core

RESOLVE meets 22.5% PRM* associated with MTR "High Need" scenario

MTR need results in high mid-term cost of capacity

By 2035, resource growth for GHG reduction leads to slack capacity. Growing loads require additional reliable capacity and thermal retention by 2045.

* PRM need is reduced in 2025-2027 to account for the allowed 2-yr delay in the 2 GW of LLT resource additions from 2026 to 2028, per D. 21-06-035. An ~18.5% PRM is achieved in 2026.

GHG emissions – 38 MMT Core

- Combination of MTR + LSE Plans + low cost solar + batteries results in emissions target being met at no incremental cost before 2030
- LSE plans **emit slightly more than the 2030 GHG target** on their own (even with forcing LLTs + MTR on top) resulting in the selection of an additional 286 MW of utility-scale solar

GHG target binds in 2030
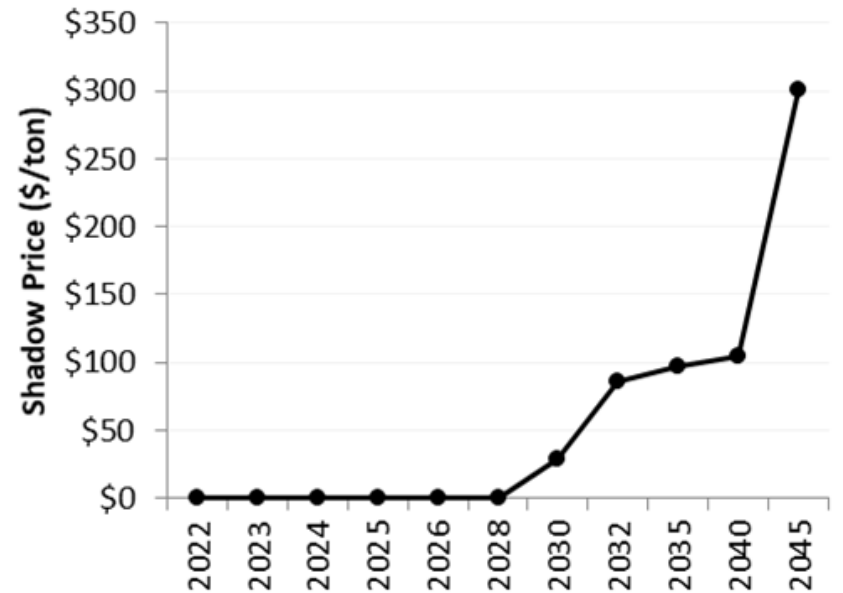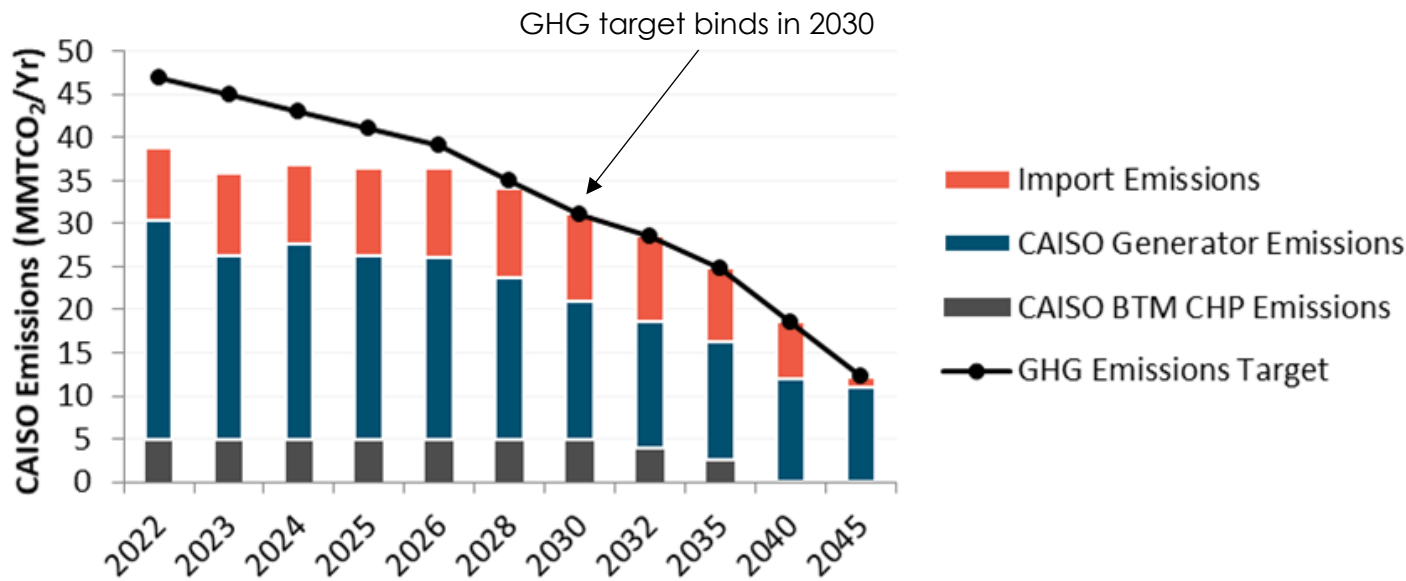
Transmission Constraint	2022	2023	2024	2025	2026	2028	2030	2032	2035	2040	2045
Silvergate Bay Boulevard	-	-	-	-	-	-	-	-	-	-	1,833
San Luis Rey San Onofre	-	-	-	-	-	-	-	-	-	-	1,287
Internal San Diego	-	-	-	-	-	148	148	148	148	148	2,067
Encina San Luis Rey	-	-	-	-	-	-	-	-	-	-	134
Imperial Valley	-								-	-	-
East of Miguel	-								-	-	438
Devers Red Bluff	-								-	-	-
Colorado River 500 230	-								-	-	-
Serrano Alberhill	-								-	-	3,648
Greater LA	-								-	-	-
Mohave Eldorado 500	-	-	-	-	-	-	-	-	-	-	-
GLW VEA	-	-	-	-	-	221	221	221	221	221	221
Eldorado 500 230	-	-	-	-	-	-	-	-	-	-	400
Lugo Transformer	-								-	980	980
South Kramer Victor Lugo	-								-	-	-
South Kramer Victor	-								-	-	-
Tehachapi Antelope	-								-	-	2,700
Moss Landing Los Banos 230 OPDS									-	-	-
Los Banos Gates 500 OPDS									-	-	-
Morro Bay Templeton 230									-	-	-
Gates Panoche 230									-	-	378
Tesla Westley 230									-	-	-
Los Banos 500 230 Transformer	-	-	-	-	-	-	-	-	-	-	-
Gates 500 230 Transformer	-	-	-	-	-	-	-	-	-	-	-
Gates Arco Midway 230	-	-	-	-	-	-	277	277	277	277	
Humboldt Trinity 115	-	-	-	-	-	-	-	-	-	-	-
Contra Costa Delta Switchyard 230	-	-	-	-	-	-	-	-	-	-	-
Delevan Cortina 230	-	-	-	-	-	-	-	-	41	41	1,340

Most upgrades cannot be built in early and mid 2020s due to construction time

Few upgrades through 2032; selected upgrades relatively inexpensive (see appendix for transmission upgrade costs)

SCE Eastern + SDG&E area constraints are unable to fully utilize the individual upgrades until significant need in 2045, because of multiple overlapping constraints

In general, there are fewer transmission upgrades selected vs. past RESOLVE analyses due to updated transmission limits and methodology

Most upgrades selected by 2045, albeit with large uncertainty on long-run transmission needs for incremental solar and batteries

PSP Scenarios and Sensitivities

Scenario Definitions

- <u>38 MMT w/ No LSE Plans</u>: 38 MMT GHG target in 2030 without LSE plans included; essentially a re-run of a reference system portfolio with updated assumptions, and is intended for comparison purposes only

- <u>38 MMT Core</u>: 38 MMT GHG target in 2030 with LSE plans incorporated, along with the MTR resources of 11,500 MW, and resource augmentation for 2031 and 2032

- <u>38 MMT w/ 2020 IEPR</u>: 38 MMT Core with the 2020 IEPR mid-demand load forecast

- <u>38 MMT w/ 2020 IEPR + 2020 High EV</u>: 38 MMT Core with the 2020 IEPR mid-demand load forecast mixed with the 2020 IEPR high electric vehicle (EV) load forecast

- <u>38 MMT High Electrification</u>: 38 MMT Core with a high electrification demand forecast for both managed and unmanaged EV profiles, based on a high electrification demand scenario developed by Commission staff using the PATHWAYS model in 2020 for modeling purposes

- <u>38 MMT No Offshore Wind ITC Extension</u>: 38 MMT Core with an assumption that developers do not invest to a level significant enough by end of 2025 to access safe harbor provisions of the offshore wind ITC, making projects ineligible for the full ITC benefits

- <u>38 MMT High Solar and batteries Cost</u>: 38 MMT Core with high solar and battery storage cost assumptions

- <u>38 MMT No MTR Persistence</u>: 38 MMT Core with MTR non-persistence assumption to test portfolio changes if the MTR "high need" scenario reliability drivers are reduced similar to the previously-established IRP planning assumptions

- <u>46 MMT Core</u>: 46 MMT GHG target in 2030, based on LSE plans and augmented with the 11,500 MW of MTR NQC and 2031 and 2032 resources

- <u>30 MMT Core</u>: 30 MMT GHG target in 2030, based on the LSE plans designed to achieve the 38 MMT target, augmented with the 11,500 MW of MTR NQC, 2031 and 2032 resources, and additional resources necessary to achieve the lower 30 MMT GHG target

- <u>30 MMT High Elec</u>: 30 MMT Core with a high electrification demand forecast, based on a high electrification demand scenario developed by Commission staff using the PATHWAYS model in 2020 for modeling purposes.
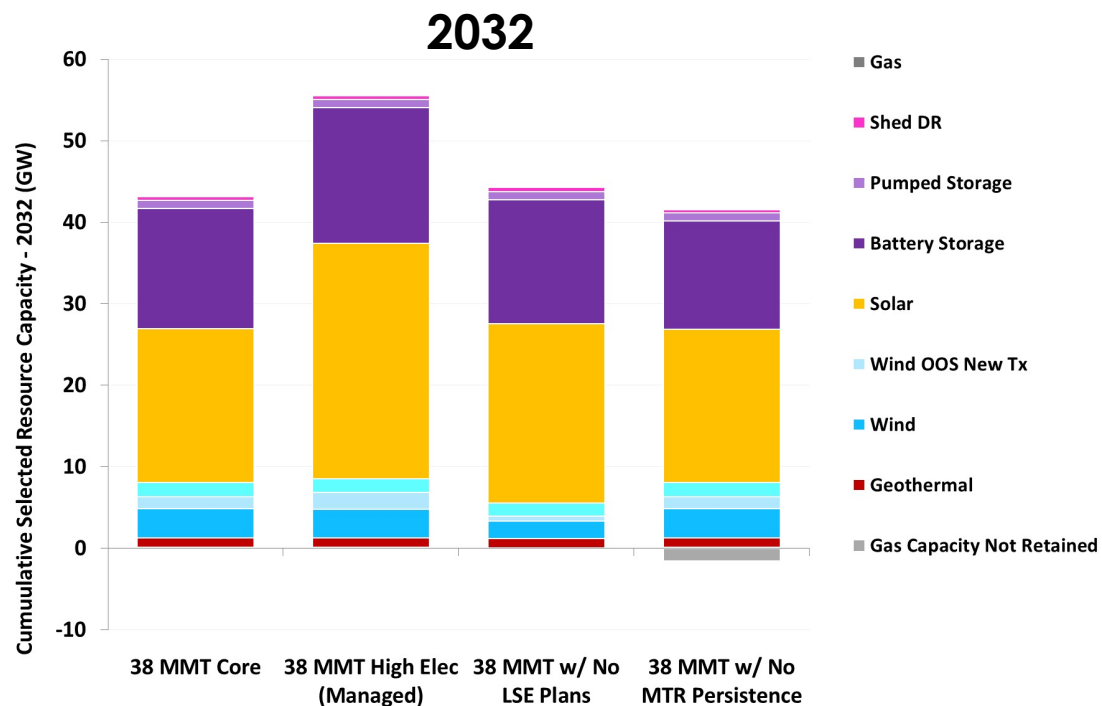
Summary of alternate GHG target sensitivities

2032
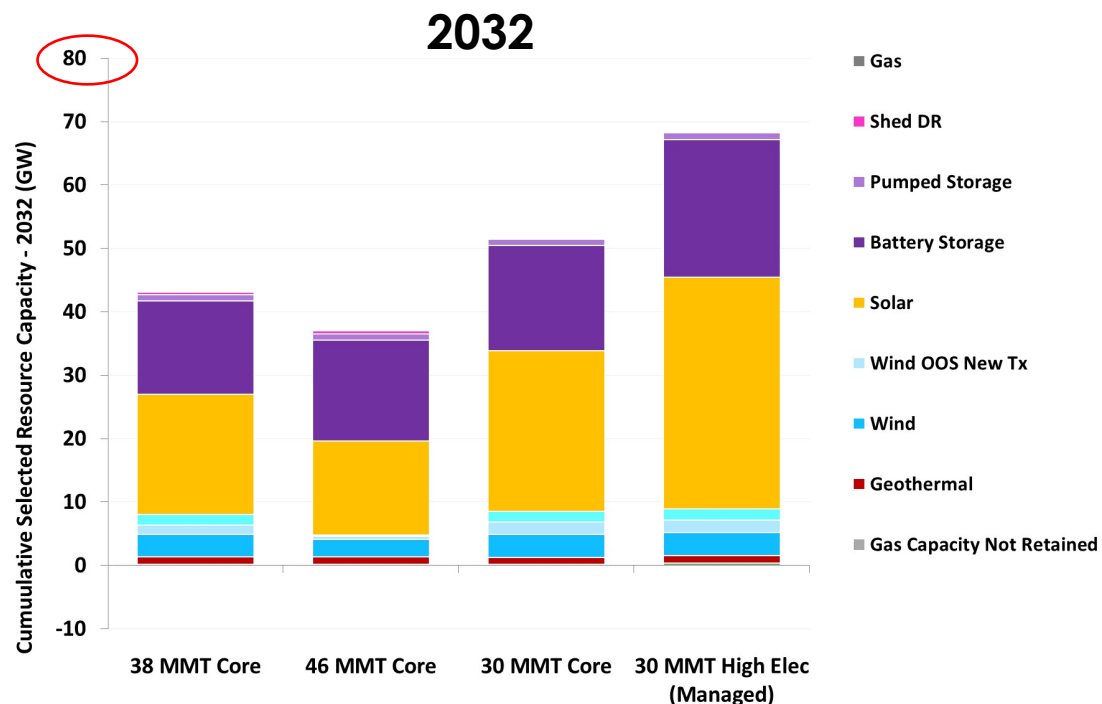
Metrics	Unit	38 MMT Core	46 MMT Core	30 MMT Core	30 MMT w/ High Electrification
PV Total Resource Cost Delta Relative to LSE Plan Scenario	$MM	$905,213	-$521	+$1,589	+$69,334
Levelized Average Rate Delta Relative to LSE Plan Scenario	cts/ kWh	19.3	-0.0	+0.0	-0.7
New Transmission for Selected Resources (within CAISO), 2032	MW	646	266	646	646
Total GHG Abatement cost (GHG shadow price + CARB floor), 2032	$/tCO2	117	33	163	176
Res. Monthly Bill at 500 kWh/mo and 600 kWh/mo, 2032	$/mo	$126.1 $151.3	+$0.67[1] +$0.80	+$1.06 +$1.26	N/A[2]

[1] Residential monthly bill is slightly higher in the 46 MMT sensitivity because the resources procured for meeting D.21-06-035 already push the GHG emissions lower than 46 MMT, so the difference between achieving the resource build out is lower than the operating cost savings achieved from reduced usage of the thermal fleet

[2] Residential monthly bill for High Electrification will depend on how much the monthly usage increases due to adoption of electrification

Summary of 38 MMT scenarios and sensitivities

2032

[1] Residential monthly bill for High Electrification will depend on how much the monthly usage increases due to adoption of electrification

Metrics	Unit	38 MMT Core	38 MMT w/ High Electrification (Core)	38 MMT w/o LSE Plans	38 MMT w/ MTR Non-Persistence
PV Total Resource Cost Delta Relative to LSE Plan Scenario	$MM	$905,213	+$67,849	-$3,211	-$843
Levelized Average Rate Delta Relative to LSE Plan Scenario	cts/ kWh	19.3	-0.7	-0.1	-0.0
New Transmission for Selected Resources (within CAISO), 2032	MW	646	527	256	646
Res. Monthly Bill at 500 kWh/mo and 600 kWh/mo, 2032	$/mo	$126.1 $151.3	N/A[1]	-$0.48 -$0.58	-$0.17 -$0.21

Summary of additional scenarios and sensitivities

2032

Legend:
- Gas
- Shed DR
- Pumped Storage
- Battery Storage
- Solar
- Wind OOS New Tx
- Wind
- Geothermal
- Gas Capacity Not Retained

Y-axis: Cumuulative Selected Resource Capacity - 2032 (GW)

X-axis categories: 38 MMT Core | 38 MMT w/ High Elec (Unmanaged) | 38 MMT w/ High Solar PV and Battery Costs | 38 MMT w/ No Offshore Wind ITC Extension

[1] Residential monthly bill for High Electrification will depend on how much the monthly usage increases due to adoption of electrification

Metrics	Unit	38 MMT Core	38 MMT w/ High Electrification (Unmanaged)	38 MMT w/ High PV and Battery Costs	38 MMT w/o OSW ITC Extension
PV Total Resource Cost Delta Relative to LSE Plan Scenario	$MM	$905,213	+$72,469	+$23,072	+$773
Levelized Average Rate Delta Relative to LSE Plan Scenario	cts/ kWh	19.3	-0.6	+0.1	+0.0
New Transmission for Selected Resources (within CAISO), 2032	MW	646	527	3,349	369
Res. Monthly Bill at 500 kWh/mo and 600 kWh/mo, 2032	$/mo	$126.1 $151.3	N/A[1]	+$0.52 +$0.62	+$0.07 +$0.08

Summary of additional scenarios and sensitivities

2032
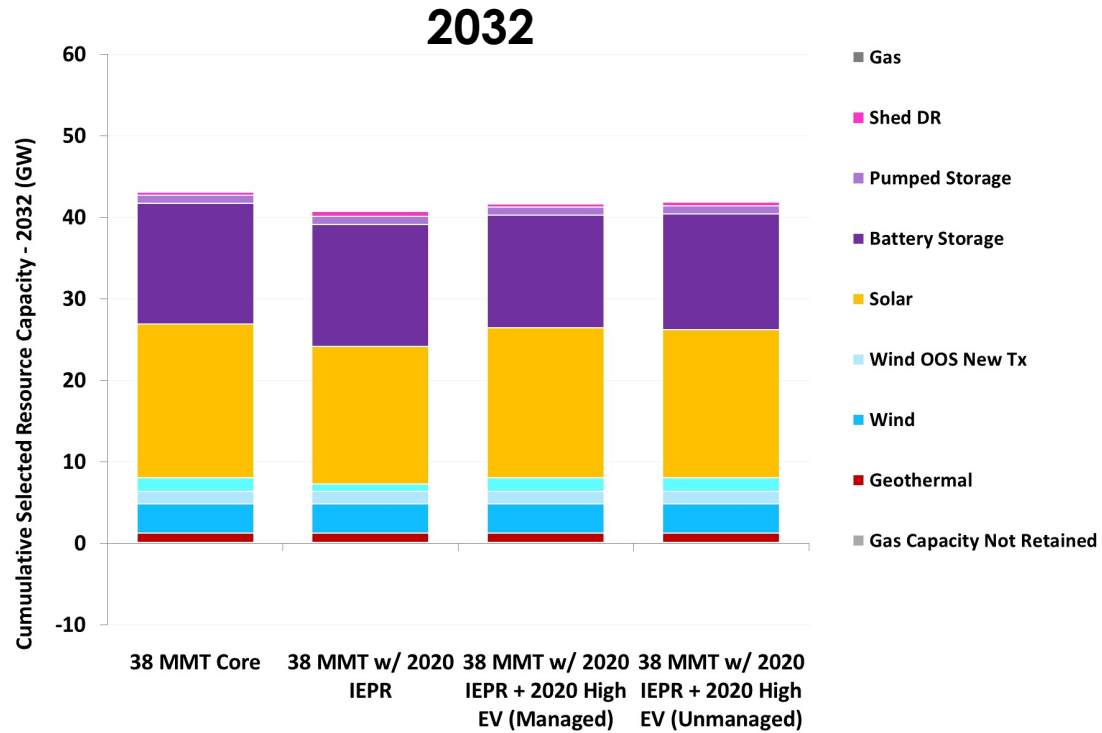
Metrics	Unit	38 MMT Core	38 MMT w/ 2020 IEPR	38 MMT w/ 2020 IEPR + 2020 High EV (Managed)	38 MMT w/ 2020 IEPR + 2020 High EV (Unmanaged)
PV Total Resource Cost Delta Relative to LSE Plan Scenario	$MM	$905,213	-$2,800	-$1,218	+$773
Levelized Average Rate Delta Relative to LSE Plan Scenario	cts/ kWh	19.3	+0.22	-0.01	+0.01
New Transmission for Selected Resources (within CAISO), 2032	MW	646	414	646	678
Res. Monthly Bill at 500 kWh/mo and 600 kWh/mo, 2032	$/mo	$126.1 $151.3	+$2.94 +$3.52	N/A[1]	N/A[1]

[1] Residential monthly bill for High Electrification will depend on how much the monthly usage increases due to adoption of electrification

Questions?

Production Cost Modeling Study Overview

Production Cost Analysis of Aggregated LSE Plans and
38 MMT Core Portfolio

Preferred System Plan Development

September 1, 2021
Energy Resource Modeling Team
Energy Division

California Public
Utilities Commission
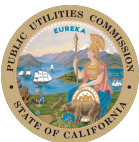
Outline of this Presentation

- Summary of Results

- Background/Definitions – Loss of Load and Production Cost Modeling

- Study Definitions - LOLE studies conducted on Aggregated System Plan
  - 46 MMT Aggregated LSE Plans
  - 38 MMT Aggregated LSE Plans

- Study Definitions - 38 MMT Core portfolio
  - 2026 38 MMT Core Results
  - 2030 38 MMT Core Results

- Study Definitions - sensitivities
  - 2026 38 MMT Sensitivity – Geothermal moved to 2026
  - 2026 38 MMT Sensitivity – PSH moved to 2026
  - 2026 38 MMT Sensitivity – 1000 MW batteries moved to 2026

- Conclusion and next steps

Background

LSEs submitted IRP plans in September 2020

- Reached Aggregated LSE Portfolios for both 46 MMT and 38 MMT GHG scenarios after several rounds of corrections and resubmittals.

Modeling of Aggregated LSE Plans:

- Staff used Aggregated LSE IRP portfolios to design portfolios of new resources expected to meet electric system planning goals at least cost.
- Staff used the SERVM software to validate the reliability, operability, and emissions of the Aggregated LSE Portfolios. Staff modeled 38 MMT and 46 MMT portfolios for both 2026 and 2030 study years.

Modeling of 38 MMT Core Portfolio:

- Based upon results from modeling of the Aggregated LSE Plans, staff ran RESOLVE and filled in the Mid Term Reliability resources to fill in reliability shortfalls. Staff created a 38 MMT Core portfolio

- 38 MMT Core Portfolio = Aggregated 38 MMT LSE plans
+ Mid Term Reliability procurement
+ RESOLVE resource additions
  - Staff used SERVM to test for reliability and GHG emissions

Summary of results

Aggregated LSE Plans

- LSE IRP plans - Aggregated 46 MMT and 38 MMT Portfolios are not reliable.
  - LOLE are greater than 0.1 in all studies and all years.
- GHG targets exceeded in both 46 MMT and 38 MMT cases, though closer in 46 MMT case.
- More renewable and reliability capacity is needed in order to make the LSE plans meet state objectives.

38 MMT Core Portfolio and Sensitivities

- The 38 MMT Core portfolio is reliable – LOLE is below 0.1 - and modeling confirms GHG emissions are significantly lower than the Aggregated LSE Plans.
- The 2026 sensitivity, enforcing 2026 rather than 2028 delivery dates on a portion of the MTR resources, demonstrates significantly lower GHG emissions and reduced reliability risk.
  - LOLE of 0.065 is below 0.1 but there is some uncertainty as to operational constraints and resource viability.
- Additional operational and LOLE results data will be made available to stakeholders for their review.

PCM results – Aggregated LSE 38 MMT and 46 MMT Portfolios

Study Definitions

- **Aggregated LSE Plans 46 MMT for 2026 and 2030**

  - Staff began with the PCM baseline and electric demand inputs used to produce the Transmission Planning Process (TPP) portfolios sent to the California Independent System Operator (CAISO) for their 2021-2022 TPP process. These portfolios are described in a CPUC ruling from October 2020. Staff updated the baseline resource fleet with new units online in CAISO information, then replaced RESOLVE planned capacity with capacity included in aggregated LSE 46 MMT portfolios to generate Aggregated 46 MMT LSE Plans.

- **Aggregated LSE Plans 38 MMT for 2026 and 2030**

  - The Aggregated LSE Plans 38 MMT Portfolio is also based on the TPP portfolios sent to the CAISO, adjusted for new baseline units and RESOLVE planned capacity replaced by aggregated LSE 38 MMT portfolios. The resulting Aggregated 38 MMT LSE Plans were also tested in PCM model.

CPUC ruling issuing proposed 2021-2022 TPP portfolios linked here: **https://docs.cpuc.ca.gov/SearchRes.aspx?docformat=ALL&docid=348821790**

Specific updates to SERVM PCM model since TPP studies

- The LSEs Portfolio represents a combination of the existing baseline resources with the new resource build-out proposed by LSEs in their IRP plans, adjusted for assumed physical limitations.

- Steps used to build the LSEs Portfolio:

  1. Began with the PCM inputs to SERVM for the TPP portfolios. The TPP portfolios are based on updated 2019 IEPR forecasts.

  2. Replaced the "Selected Resources" (new build) from RESOLVE to reflect the LSE new build portfolio preferences as submitted in their IRP plans

- Staff updated the resource baseline in SERVM in four steps - baseline reconciliation with updated CAISO generator lists, performed ground truth adjustments for data errors particularly in the WECC Anchor Data Set, added LSE IRP filings by adding Development resources firmly under contract, then finally added Review and Planned_new resources that are not highly certain units or contracts yet

Capacity Comparison of LSE 38MMT and 46MMT Portfolios
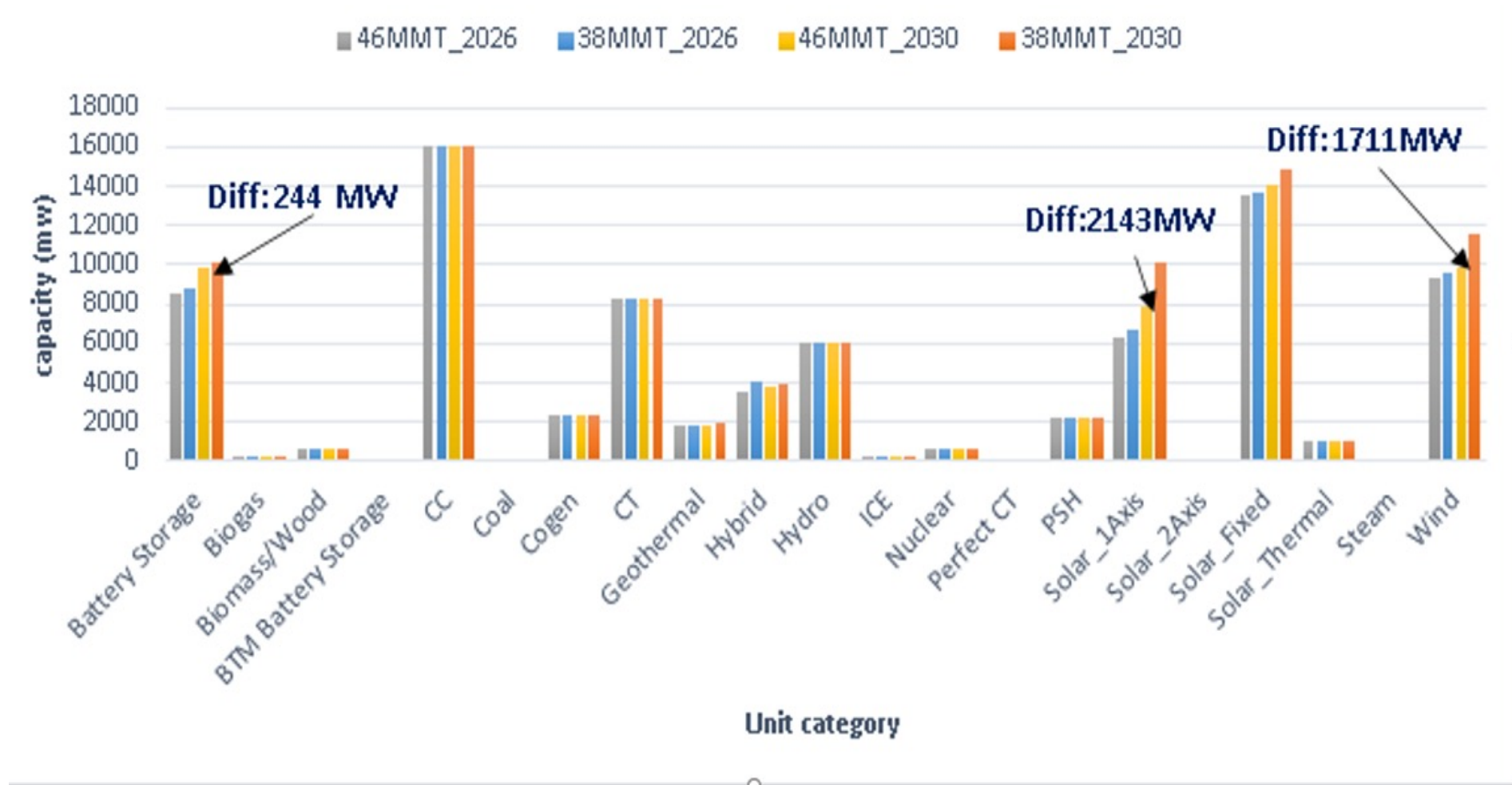
Aggregated LSE Plans – CAISO LOLE Exceeds 0.1 target in all studies

Reliability Metrics	46MMT 2026	46MMT 2030	38MMT 2026	38MMT 2030
LOLE (expected outage events/year)	**0.36**	**0.68**	**0.29**	**0.41**
Loss of Load Hours (hours/year)	0.76	1.63	0.61	0.94
LOLH/LOLE (hours/event)	2.09	2.38	2.07	2.26
Expected Unserved Energy (MWh)	1,436.66	2,468.93	1,176.91	1,364.54

Findings: LOLE is greater than 0.1 in all studies and all years, meaning the Aggregated LSE Plans portfolio is unreliable.

SERVM Annual Energy Generation Results (GWh)

Resource type/Annual GWh	46MMT_2026	46MMT_2030	38MMT_2026	38MMT_2030
CAISO_CCGT1	44,715	46,109	43,721	41,023
CAISO_CCGT2	5,323	5,616	5,211	4,984
CAISO_Peaker1	2,795	3,138	2,852	3,002
CAISO_Peaker2	1,453	1,789	1,482	1,682
Perfect CT	0	0	0	0
Steam	0	0	0	0
Coal	0	0	0	0
Biomass	6,609	6,547	6,534	6,046
BTMPV	32,301	39,177	32,256	38,100
All Solar: fixed PV, tracking PV, solar thermal	51,436	57,487	53,075	63,541
Wind	23,534	24,730	24,570	28,056
Scheduled Hydro Plus ROR Hydro	25,122	25,394	25,392	24,735
Geothermal	14,486	14,951	14,714	14,760
Cogen	12,010	12,285	11,997	11,738
Nuclear	5,563	5,136	5,563	4,995
ICE	71	88	70	75
Generation Subtotal Before Curtailment	225,418	242,446	227,437	242,736
Non-PV Load Modifiers (net effect of AAEE, EV load, TOU)	-858	-2,698	-858	-2,623
Curtailment not included inline above	-551	-1,370	-674	-3,107
TOTAL not including Non-PV load modifiers	224,867	241,076	226,763	239,628

SERVM Annual GHG Emissions Results

CAISO Emissions accounting	46MMT_2026	46MMT_2030	38MMT_2026	38MMT_2030
In-CAISO and gross direct imports thermal generation in GWh	66,367	69,024	65,332	62,504
In-CAISO and gross direct imports CO2 emissions in MMT	27.21	28.41	26.82	25.78
In-CAISO and gross direct imports average emissions factor in MT/MWh	0.41	0.412	0.411	0.412
Unspecified imports netted hourly (no NW Hydro) in GWh	20,109	17,134	19,239	13,922
NW Hydro imports in GWh	11,000	11,000	11,000	11,000
Carbon-free imports from RPS energy, RECs contracts	0	0	0	0
Unspecified imports netted hourly (no NW Hydro) CO2 emissions in MMT	8.61	7.33	8.23	5.96
Unspecified imports netted hourly (including NW Hydro) average emissions factor in MT/MWh	0.277	0.261	0.272	0.239
Total CAISO CO2 emissions in MMT	35.8	35.7	35.1	31.7
BTM CHP emissions in MMT	5	5	5	5
Total CAISO CO2 emissions in MMT, including BTM CHP	**40.8**	**40.7**	**40.1**	**36.7**

Aggregated LSE Plans portfolio GHG results exceed both the prorated 46 MMT target in 2030 as well as the 38 MMT LSE targets.

The 46 MMT portfolios exceed the prorated share of 46 MMT by about 2.5 MMT, and the 38 MMT portfolios exceed the 38 MMT target by 5.5 MMT.

Aggregated LSE Plans PCM Conclusions

- LSE IRP plans - 46 MMT and 38 MMT LSE Aggregated Plans are not reliable by themselves.
  - LOLE are greater than 0.1 in all studies and all years.
- GHG targets not met in either 46 MMT or 38 MMT case, though 46 MMT case is closer to target.
- In developing the subsequent 38 MMT Core portfolio, staff further increased operating reserve requirements and restricted imports more to be more conservative, meaning the LOLE results of the Aggregated LSE Plans portfolio (which did not include MTR procurement) would have been even larger.
  - Reinforces that Aggregated LSE Plans portfolio is unreliable.

38 MMT Core Portfolio and Sensitivities

Study Definitions – 38 MMT Core Portfolio

38 MMT 2026 and 2030 Core Portfolio Definition:
    Existing Baseline
    + Aggregated 38 MMT LSE plans
    + Mid Term Reliability procurement
    + RESOLVE resource additions

Definition of 38 MMT sensitivity cases:
    2026 38 MMT Sensitivity – Geothermal moved to 2026
    2026 38 MMT Sensitivity – Pumped Storage Hydro moved to 2026
    2026 38 MMT Sensitivity – 1,000 MW Battery Storage moved to 2026

38 MMT Core – Notes on Methodology

- **Climate Change affects not modeled yet**
  - **Hydro projections based on weather year 1998-2017, which means recent low hydro years since 2018 are not informing the analysis.** Current low hydro conditions may become more common in future years given climate change; likewise, other planning assumptions may not fully represent a climate change future such as higher electric demand caused by higher temperatures.
  - Forecast of future climate change effects will exacerbate reliability problems and lead to higher LOLE

- 4,000 MW import restriction – imposed from Hour Ending 17-22 (meaning 4 pm to 10 pm), Jun thru Sep.

- CAISO reserve requirements (including load following and regulation requirements) to create a LOLE event when 3% spinning reserves or 3% regulation up reserves are not met. In addition, other types of reserves (Quickstart reserves and load following reserves) were matched to CAISO requirements and likely affect LOLE indirectly.

Aggregated LSE Plans vs. 38 MMT Core (2030)

Unit capacity comparison

■ 38 MMT LSE plans   ■ 38 MMT Core

38 MMT Core case:

- +47% in battery storage
- +46% in geothermal
- +36% in PSH
- +21% in DR
- Slight increase in solar and wind
- ~950 MW thermal retirement (Cogen and CT)

Generation in GWh RESOLVE vs. SERVM

Technology (GWh)	RESOLVE_2026	SERVM_2026	RESOLVE_2030	SERVM_2030
CAISO_CCGT1	46,106	47,036	32,273	41,118
CAISO_CCGT2	2	5,812	2	5,179
CAISO_Peaker1	1	4,341	1	4,431
CAISO_Peaker2	1	2,269	0	2,653
Battery Storage	-3,562	-3,555	-4,234	-3,838
PSH	-664	-1,772	-1,506	-2,274
Steam	0	0	0	0
Coal	0	0	0	0
Biomass	4,957	6,592	5,148	6,580
BTMPV	32,779	32,256	39,528	39,177
Utility Solar	70,302	68,749	78,547	74,688
Wind	27,334	25,066	32,980	28,849
Scheduled Hydro Plus	22,964	25,393	22,962	25,394
Geothermal	10,082	14,311	17,411	22,069
Cogen	8,967	10,156	8,967	9,961
Nuclear	5,108	5,563	5,108	5,136
ICE	7	75	6	62
Generation Subtotal	224,383	242,292	237,193	259,184
Imports (unspecified)	24,134	20,686	23,832	18,065
Exports	-3,877	-16,041	-7,030	-20,564
Net Import	20,257	4,645	16,803	-2,499
Generation+NetImport	244,640	246,937	253,996	256,685

- SERVM produces similar amounts of GHG-free energy to RESOLVE (about 201 TWh total in 2030), but more GHG emitting energy. SERVM also produces 13 TWh more exports relative to RESOLVE

- SERVM produces 9% more in-CAISO generation than RESOLVE but lower net imports, totaling about 4% more total net energy for CAISO.

GWh	2026 RESOLVE	2026 SERVM	2030 RESOLVE	2030 SERVM
GHG emitting	55,084	69,689	41,249	63,404
GHG free	173,526	177,930	201,684	201,892
Total	228,610	247,619	242,933	265,296
% different		8.3%		9.2%

38 MMT Core LOLE Capacity results for the CAISO area

Reliability and GHG Metrics	38 MMT 2030	38MMT 2026
LOLE (expected outage events/year)	**0.054**	**0.064**
LOLH (hours/year)	0.15	0.21
LOLH/LOLE (hours/event)	1.72	1.76
EUE (MWh)	187.45	292.28
annual load (MWh)	265,753,062	255,345,985
normalized EUE (%)	7.054E-07	1.145E-06
GHG (MMT)	**34.67**	**38.14**

Findings: LOLE is less than 0.1 in both 2026 and 2030, meaning this portfolio is reliable. GHG emissions in 2026 are about 1.5 MMT higher than RESOLVE but GHG emissions in 2030 are about 3 MMT higher than RESOLVE.

38 MMT Core Total CAISO CO2 emissions in MMT, including BTM CHP

LOLE for 2026: Core case vs. Sensitivities
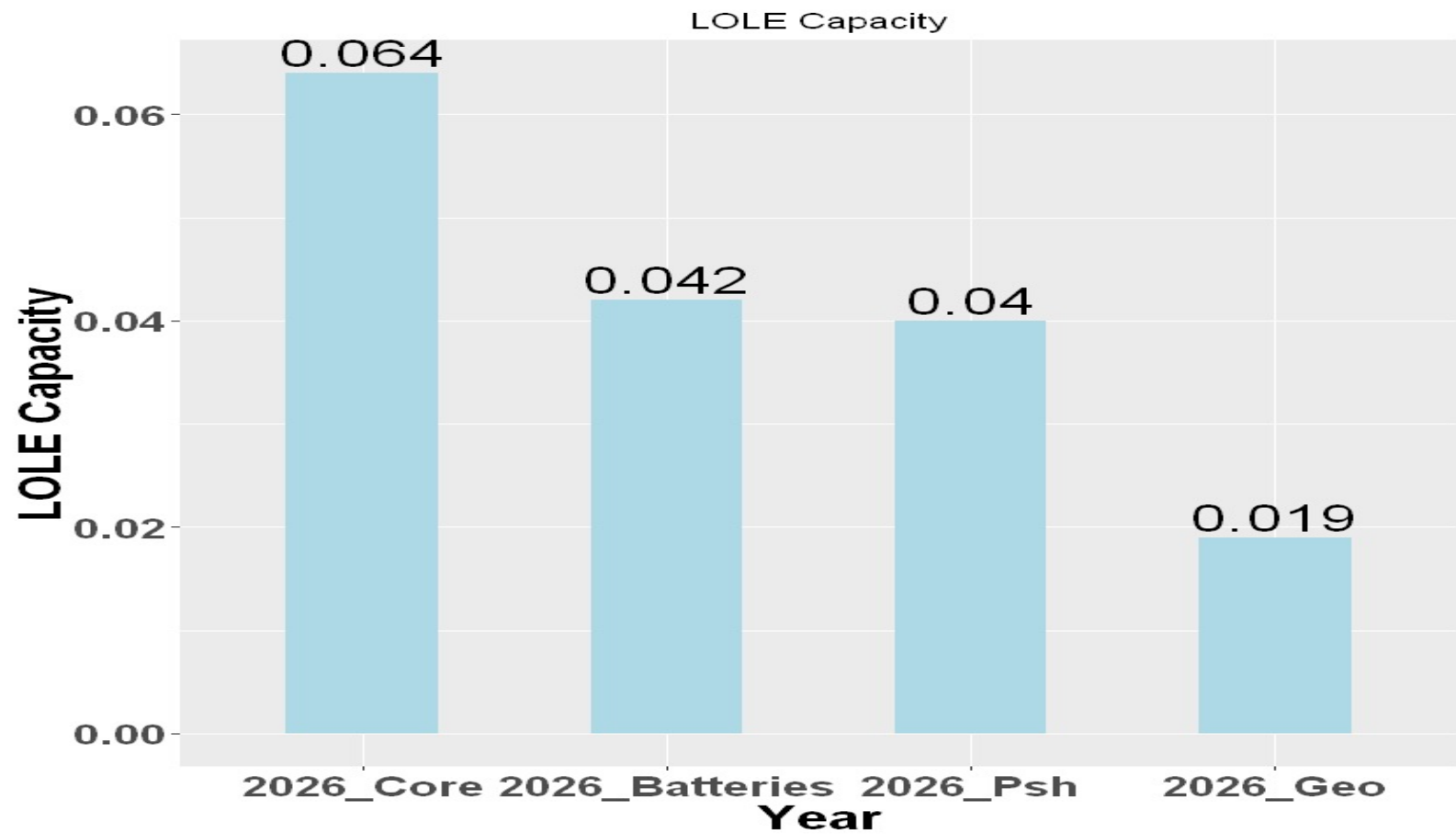
GHG for 2026: Core case vs. Sensitivities
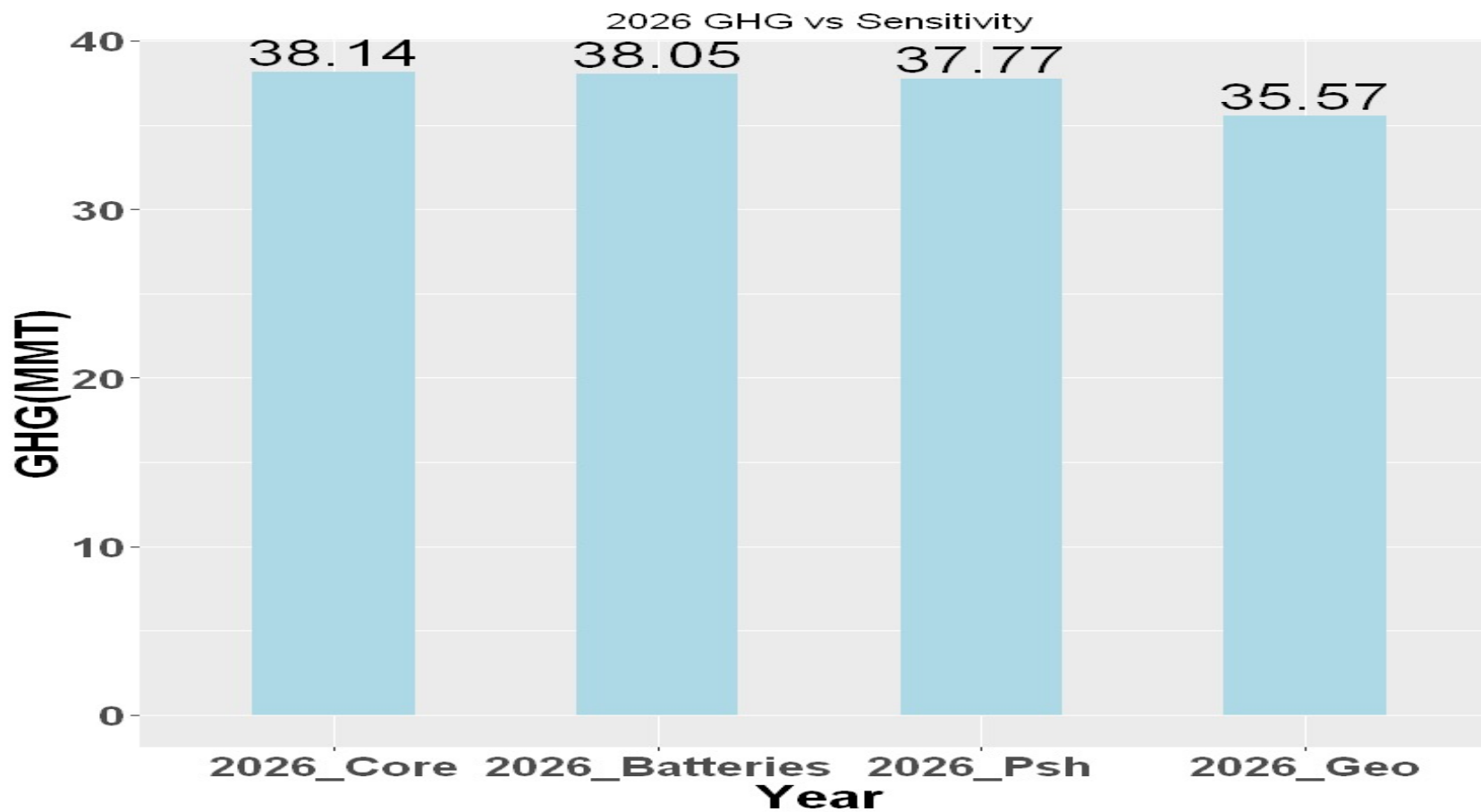
38 MMT Core (2030) : EUE (MWh) by Hour and Month
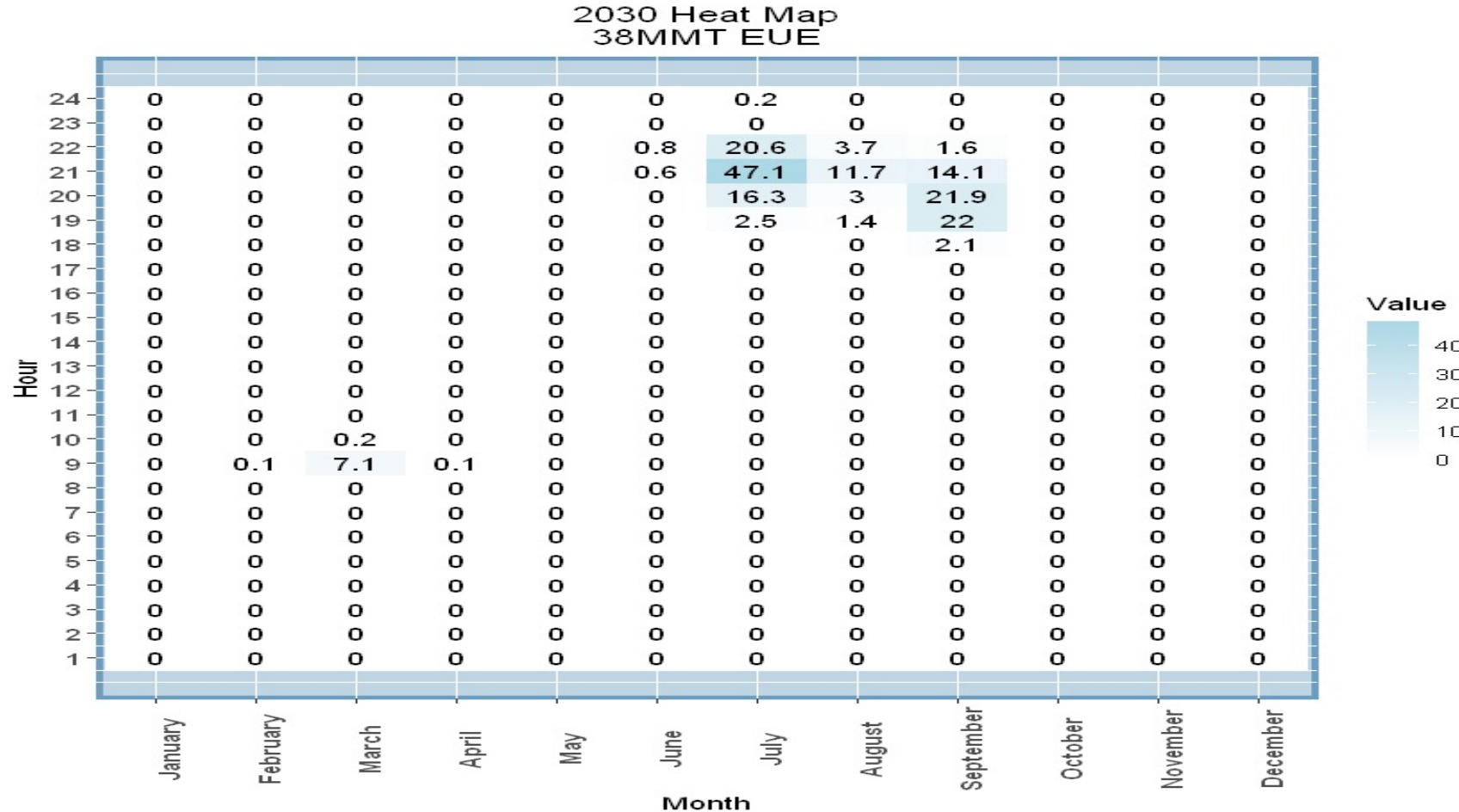
2030 Heat Map
38MMT EUE

Total EUE is less than the LSE Aggregated Plans because it is a more reliable case, but EUE is spread to different hours of the day and year.

38MMT Core CA criteria pollutants comparison in metric tons: SERVM mix vs CARB projection

POLLUTANTS	2026 CARB	2030 CARB	2026 SERVM	2030 SERVM	2026 Difference	2030 Difference
NOX	7,341	7,567	6,038	5,891	-1303	-1675
SOX	1,356	1,409	221	208	-1135	-1201
PM	2,096	2,145	2,085	1,964	-11	-181

The SERVM results reflect a cleaner resource mix than when CARB made their projections. Some of the cleaner resource mix may be driven by CPUC/LSE actions, and some may be driven by non-CAISO resource mix change.

Source for CARB projections here: https://www.arb.ca.gov/app/emsinv/fcemssumcat/fcemssumcat2016.php

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Conclusions and Next Steps

- The 38 MMT Core portfolio is reliable – LOLE is below 0.1 – and GHG emissions are significantly lower than the Aggregated LSE Plans.

- The 2026 sensitivity, enforcing 2026 rather than 2028 delivery dates on a portion of the MTR resources, demonstrates significantly lower GHG emissions and reduced reliability risk in 2026.

  - LOLE of 0.065 in 2026 for the 38 MMT Core portfolio is below 0.1 but there is some uncertainty as to operational constraints and resource viability particular with the large volume of new resources installed.

- Additional operational and LOLE results data will be posted in the coming days.

- Staff will continue to analyze the PSP pursuant to party comments and after implementing 2020 IEPR

Questions?

Break

10 minutes

IRP Resource Portfolios for the 2022-2023 TPP

Overview of Planning Processes

Interaction between Integrated Resources Planning (IRP) and the CAISO's Transmission Planning Process (TPP)

Information Flow Between the Two Planning Processes

CPUC IRP produces resource portfolios

- In accordance with a May 2010 MOU between the CAISO and the CPUC, and in coordination with the CEC, the CPUC develops resource portfolios used by the CAISO in its annual Transmission Planning Process (TPP)
- The CPUC typically transmits multiple distinct portfolios developed in the IRP process:
  - Reliability and Policy-Driven Base Case portfolio
  - Policy-Driven Sensitivity portfolio(s)

Annual

CAISO conducts TPP assessments

- Reliability and Policy-Driven Base Case portfolio
  - Identified transmission solutions go to the CAISO Board of Governors for approval
- Policy-Driven Sensitivity portfolio(s)
  - Identified transmission solutions are considered Category 2 and typically do not go to the CAISO Board of Governors for approval
  - Results often provide useful information for future IRP work

CAISO conducts TPP assessments

- CAISO produces transmission capability limits and upgrade cost estimates
  - These serve as an input to RESOLVE, which accounts for the cost of new transmission when optimizing for a least-cost portfolio, and as criteria for mapping resources to specific busbars.

Overview of How the IRP Resource Portfolios are Used within the TPP
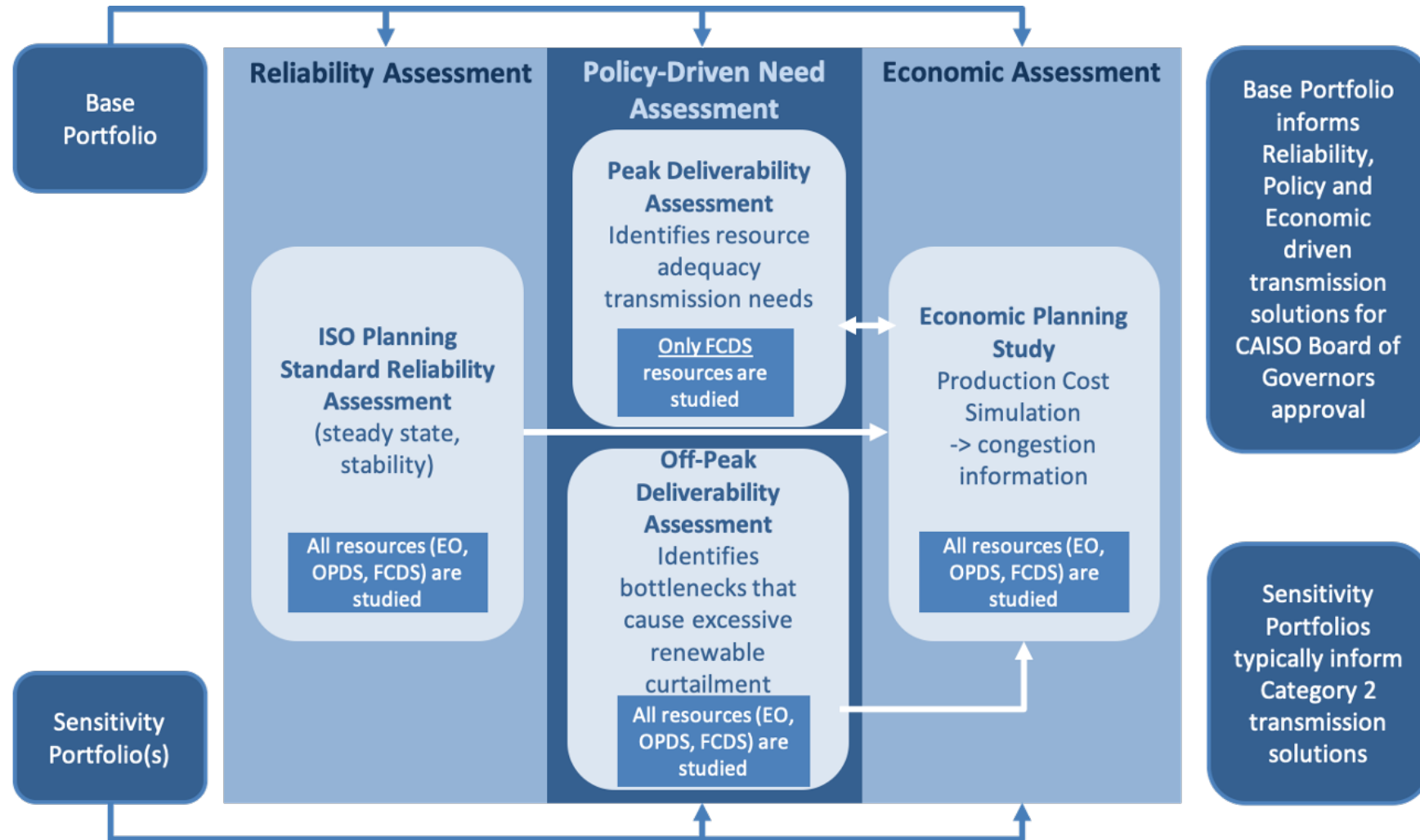
Schedule for the 2022-2023 TPP

- CPUC aims to transfer resource portfolios to the CAISO by February 2022 for the CAISO's 2022-2023 Transmission Planning Process (TPP)

- Expected schedule for CAISO's public release of 2022-23 TPP results:
  - Preliminary policy-driven study results available in mid-November 2022
  - Final policy-driven study results available in February 2023

- CAISO TPP results may inform:
  - Development of the next IRP Preferred System Plan (PSP) in 2023
    - It is unlikely that these results will inform the next Reference System Plan, of which the development is scheduled to begin in early 2022
  - Future procurement orders - if resource needs are identified
    - E.g., Understanding the transmission implications (transmission upgrades required, online date, estimated cost) of a specific resource build out allows the CPUC to make more informed decisions when providing planning guidance to LSEs or issuing a procurement order

RESOLVE Model Updates

Improvements made for the purpose of developing the PSP portfolio and policy-driven sensitivity portfolios for the 2022-2023 TPP

Role of RESOLVE in IRP and TPP Analysis

- RESOLVE is used in the CPUC IRP process for capacity expansion modeling to create optimal least-cost portfolios that inform the resource types and quantities needed within specific time horizons
  - Portfolios inform generation + transmission infrastructure planning needs within the planning horizon
- RESOLVE results 10 years out serve as an indication of where transmission upgrades may be needed to accommodate resource needs
  - However, the indicative transmission upgrade information requires additional analysis to determine if the indicated transmission upgrades are necessary
  - This analysis is done via:
    - The mapping of all selected resources to specific busbars (substations)
    - The CAISO's TPP process
- RESOLVE modeling updates implemented to improve the accuracy of the transmission indications provided by RESOLVE by addressing issues that have been identified in the previous IRP and TPP processes

RESOLVE updates for 2022-2023 TPP
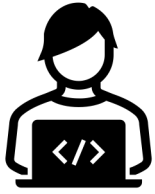
Upgrade Code Base:
ALL proposed updates require new codebase
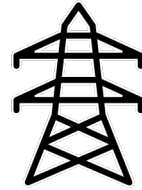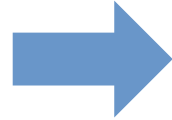
Enforce Upgrade Limits:
Limit transmission build to CAISO-determined levels
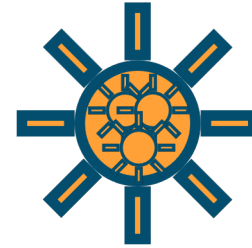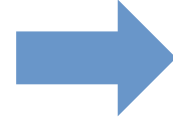
Consolidate Solar Resources:
Makes incorporation of other resource upgrades easier

Locational Batteries
Partial Hybrid modeling, provide locational info to bus-bar mapping

Independent upgrades

Dependent upgrades
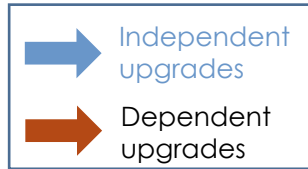
Pumped Storage Deliverability:
Storage can be included in deliverability constraints in new code base
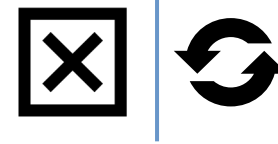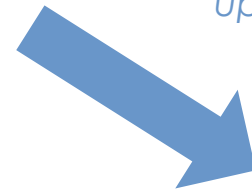
"Ex" Zone Reformulation:
Reformulate challenging transmission zones w/ new CAISO transmission data
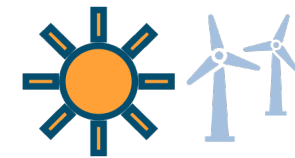
Incorporate New CAISO Deliverability Data:
Use new CAISO equations for peak and off-peak deliverability

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Transmission Updates: Limits and Constraints

- CAISO updated on-peak and off-peak transmission capability and included technology-specific transmission information
  - CAISO released a white paper in July 2021 entitled "Transmission Capability Estimates for use in the CPUC's Resource Planning Process" which documents the updated capability estimates
    - Available at: http://www.caiso.com/Documents/WhitePaper-2021TransmissionCapabilityEstimates-CPUCResourcePlanningProcess.pdf
  - New transmission constraint limits generally increase the amount of available capacity on the transmission system relative to the 2019 CAISO white paper values, though this is not true for every constraint
    - The new limits also include geographic areas that were not covered in the 2019 white paper
      - 2019 CAISO white paper available at: https://www.caiso.com/Documents/WhitePaper-TransmissionCapabilityEstimates-InputtoCPUCIntegratedResourcePlanPortfolioDevelopment.pdf

Transcription Updates: Storage + Solar

- Previous RESOLVE modeling did not consider interactions between storage and transmission constraints
  - Instead, interactions were addressed downstream in the bus-bar mapping process
- RESOLVE has been updated to:
  - Account for the fact that storage capacity selected requires transmission availability to receive full deliverability
    - Lithium-ion battery and pumped storage resources were previous modeled as a single CAISO-wide resource; multiple resources are now modeled such that transmission limits in different areas of the CAISO grid can be considered
  - Model the interaction between storage charging and off-peak transmission limits by expanding off-peak transmission limits when storage is built
    - Storage consumes on-peak transmission capability
    - Storage creates off-peak transmission capability
  - Solar and battery locations aligned as a step towards modeling co-located and hybrid resources
    - Full hybrid modeling out of scope
      - No interactions are modeled between solar and storage in hourly dispatch
      - Cost reductions from shared infrastructure are not modeled

Proposed Portfolios for the CAISO's 2022-2023 TPP

Reliability and Policy-Driven Base Case Portfolio

- An input to reliability assessments used by the CAISO to:
  - Identify facilities with thermal overloads, voltage concerns, and stability concerns, and to;
  - Ensure that NERC standards are met
- Base Case Portfolio transmitted for the 2021-2022 TPP
  - 46 MMT Portfolio: This portfolio is being used by the CAISO to identify and authorize transmission development needed to accommodate new resource capacity expected to be built to meet the 46 MMT GHG target established in D.20-03-028 but with minor updates to include more updated information
- **For the 2022-2023 TPP, the ruling proposes the 2021 38 MMT Preferred System Plan (PSP) portfolio be transmitted as the base case portfolio**
  - Objective: Understand transmission implications of the PSP portfolio which will serve as the most up-to-date planning guidance for LSEs
  - GHG target: 38 MMT PSP electric sector target by 2030
    - Interpolation between 2030 and 2045 GHG target to arrive at 28.6 MMT by 2032

On-Peak Transmission utilization and upgrades: 2032 – 38 MMT Core

Using the new CAISO transmission limits, RESOLVE results indicate that in many areas of the grid, available space will remain on existing transmission even with the buildout included in the 38 MMT Core portfolio

Legend

| Existing Space Used | Existing Space Available | Upgrade Space Used | Upgrade Space Available |

Northern California Constraints

Southern California Constraints
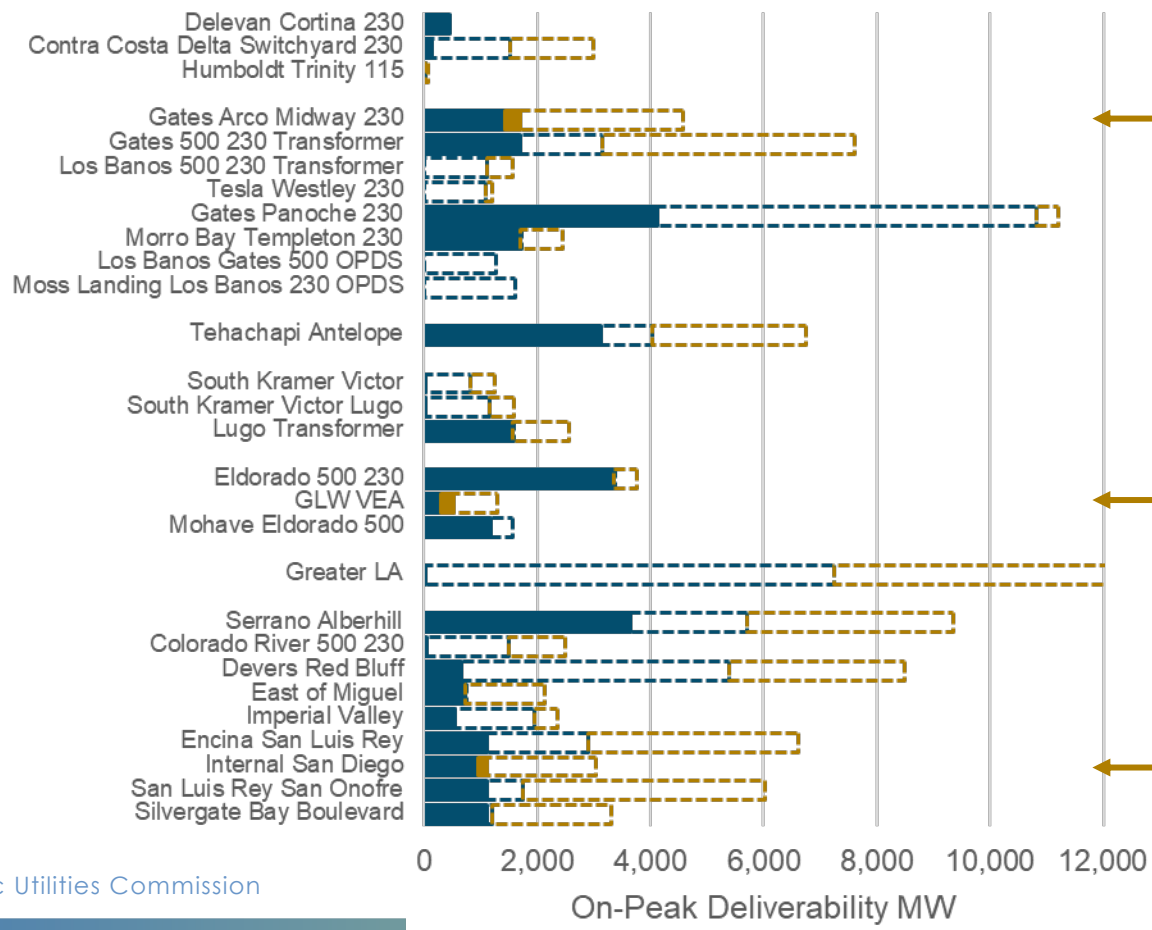
Midway – Gates 230kV Line
- Partial upgrade selected in 2032
  - 277 MW selected out of 3,137 MW on-peak (ADNU) max
- Limiting constraint for wind development, especially offshore wind – selection of Morro bay offshore wind in 2032 drives upgrade timing. Morro Bay-Templeton constraint also limits offshore development but has expensive upgrade.

GLW VEA Area Constraint
- Partial upgrade selected in 2028
  - 221 MW selected of 1000 MW on-peak max
- Driven by diverse resources in GLW-VEA
  - Geothermal to meet long-lead-time MTR requirement in 2028, wind to meet LSE plan demand for wind

San Diego Internal Constraint
- Partial upgrade selected in 2028
  - 148 MW selected out of 2,067 MW on-peak max
- Limiting constraint for Imperial Geothermal development
  - Off peak limit on existing system only 290 MW; on peak limit is less limiting at 968 MW
  - ~500 MW batteries built by mid 2020s to expand off-peak limits
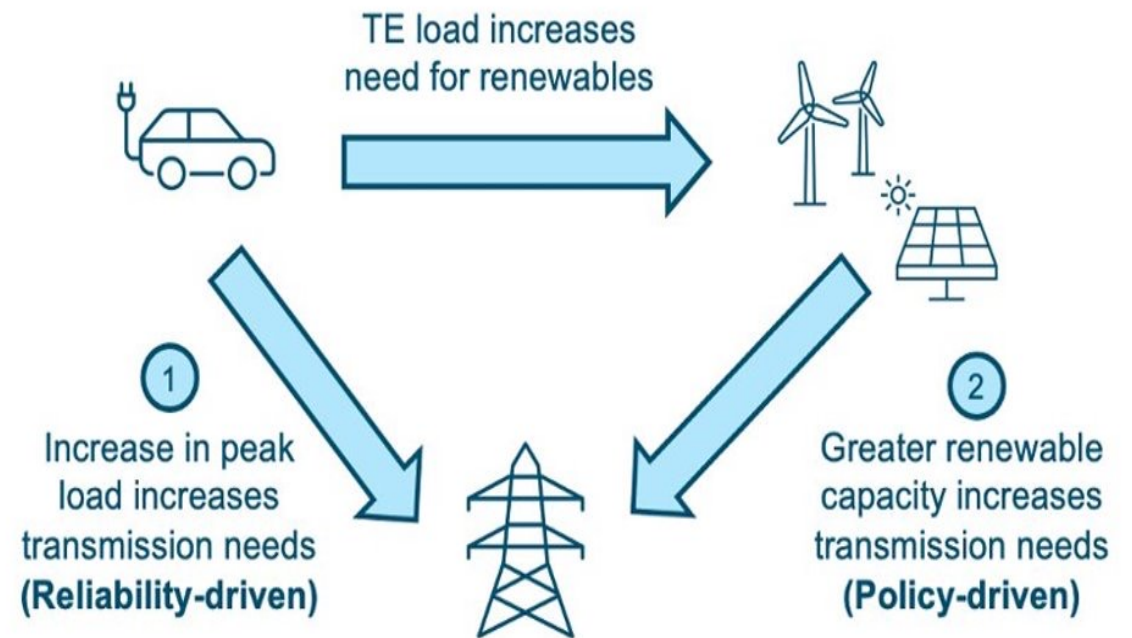
Policy-Driven Sensitivity Portfolio

- An input to policy-driven assessments conducted by the CAISO to:
  - Plan for renewable grid integration issues and policy goals that may drive the need for new transmission

- Sensitivity Portfolios transmitted for the 2021-2022 TPP
  - 38 MMT Sensitivity Portfolio: This portfolio will allow the CAISO to study transmission development needed to accommodate a resource planning future that closely reflects the most recent 38 MMT portfolio included as planning guidance for LSEs in D.20-03-028 but with minor updates
  - Offshore Wind Sensitivity Portfolio: Will allow the CAISO to study transmission infrastructure needs, and associated costs, that would be triggered to connect over 8,000 MW of offshore wind generation at various potential locations — information currently lacking
    - This information could then be used as an input for future IRP analysis and decision-making related to offshore wind resources, including examining tradeoffs between different locations

- For the 2022-2023 TPP, the ruling suggests one option for a sensitivity portfolio
  - **30 MMT with High Electrification Sensitivity Portfolio**

Sensitivity Portfolio: Objective

- Objective: Understand transmission implications under a future that would require more resource development to meet a more stringent GHG target and a higher load.
  - GHG target: 30 MMT electric sector target by 2030 and 27.7 MMT by 2032
  - 2019 IEPR used as load forecast baseline and assumptions consistent with the 2020 E3 report for CARB on Achieving Carbon Neutrality in California (High CDR Case) layered on

- Relevant statutes and executive orders:
  - Senate Bill (SB) 350 (De León, 2015)
  - SB 32 (Pavley, 2016)
  - AB 841 (Ting, 2018)
  - SB 100 (De León, 2018)
  - Executive Order B-55-18
  - Executive Order N-79-20

Transportation electrification is an important element of this portfolio because it can impact infrastructure needs in two ways:

TE load increases need for renewables

1 Increase in peak load increases transmission needs (Reliability-driven)

2 Greater renewable capacity increases transmission needs (Policy-driven)

Sensitivity Portfolio: New Resource Build Out

Comparison of New Resource Buildout in 2032 between the 30 MMT with High Electrification Portfolio and the 38 MMT Core Portfolio
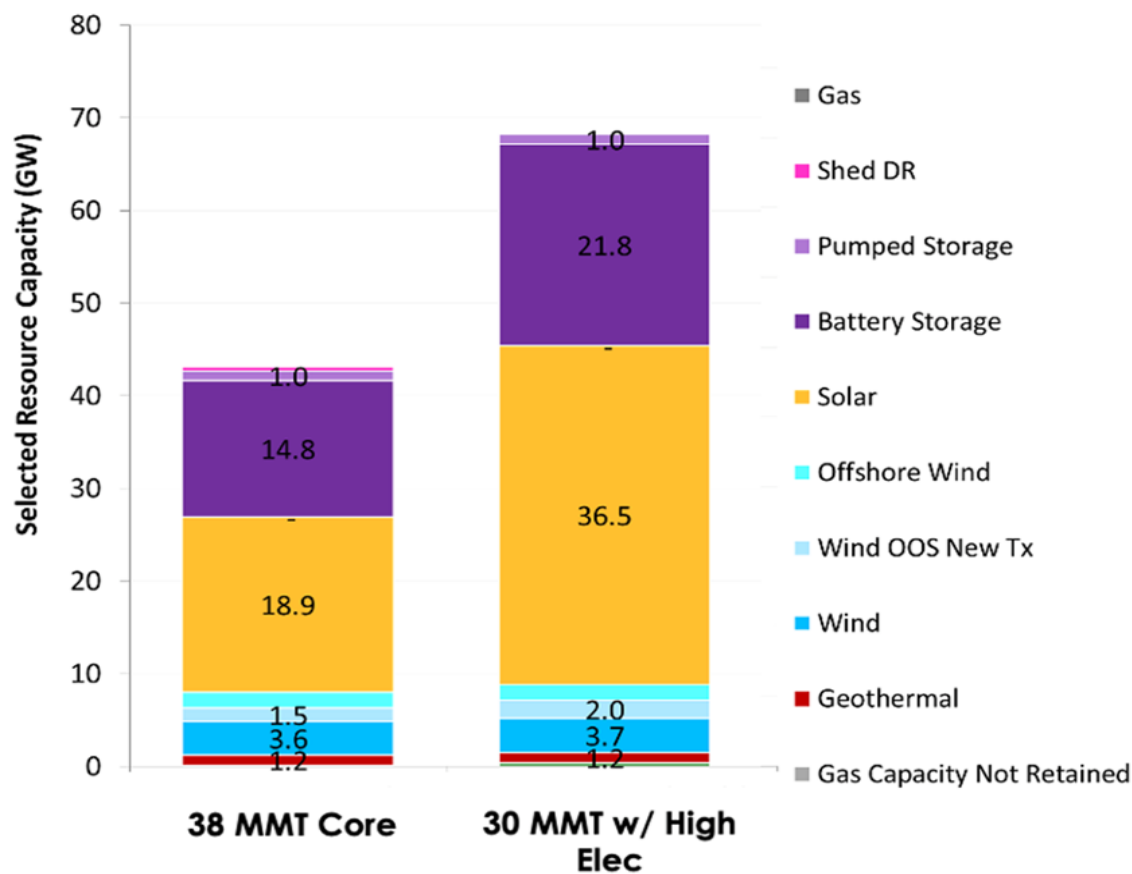
- The 30 MMT HE portfolio includes nearly 25 GW more of new resource capacity than the 38 MMT Core portfolio – mostly new solar and battery resources
- Approximately 8.5 GW of the additions are driven by moving to the lower GHG target
- Approximately 16.7 GW are driven by including the high electrification assumptions

Sensitivity Portfolio: Load Forecast Development

- The Commission, CEC, and CAISO staff are currently assessing the options for developing a high electrification forecast for use in the 2022-2023 TPP. Specific factors that need to be addressed include:
  - Appropriateness of the PATHWAYS model forecast for a high electrification analysis and whether additional modifications are required
  - Implications of deviating from the interagency single forecast set (SFS) agreement
  - Consistency with the RESOLVE assumptions to develop the 30 MMT with high electrification sensitivity portfolio
  - RESOLVE modifications needed to update the sensitivity portfolio
  - Mapping of EV load to plausible specific locations within the CAISO system, given that distribution is unlikely to be uniform
  - Understanding of to what extent a more granular EV load distribution is necessary for the CAISO's TPP analysis
  - How and when EV load mapping to transmission locations would occur
  - Timing implications for the State's SB 100 goals if a 30 MMT high electrification sensitivity is not considered in the 2022-2023 TPP

Busbar Mapping Methodology Updates

Proposed for the mapping of resource portfolios for the 2022-2023 TPP

Busbar Mapping Methodology

- Resource-to-busbar mapping ("busbar mapping"): process for translating geographically-coarse portfolios to plausible network locations for TPP modeling

- The busbar mapping methodology that will be used to map resource portfolios for the 2022-2023 TPP has been updated to address party comments and to reflect improvements made to RESOLVE. Updates include:
    - Utilizing new CAISO transmission deliverability data for available transmission headroom for full capacity deliverability status (FCDS) and off-peak deliverability status (OPDS);
    - Incorporating new CAISO transmission constraints definitions;
    - For non-battery busbar mapping, incorporating busbar-level granularity of commercial interest;
    - For all resources, incorporating expected online dates for commercial interest into the mapping criteria;
    - Improving the implementation process of the busbar mapping criteria to better capture mapped resources' compliance with the criteria and to incorporate the latest stakeholder inputs and updated data sets;
    - Updating the battery busbar mapping steps to account for the locational information for battery resources that will be provided by RESOLVE;
    - For co-located battery and solar PV resources, removing the transfer of FCDS status from the solar PV resources to the battery resources, based on new CAISO transmission deliverability data.

Questions?

Procurement and/or Other PSP Actions

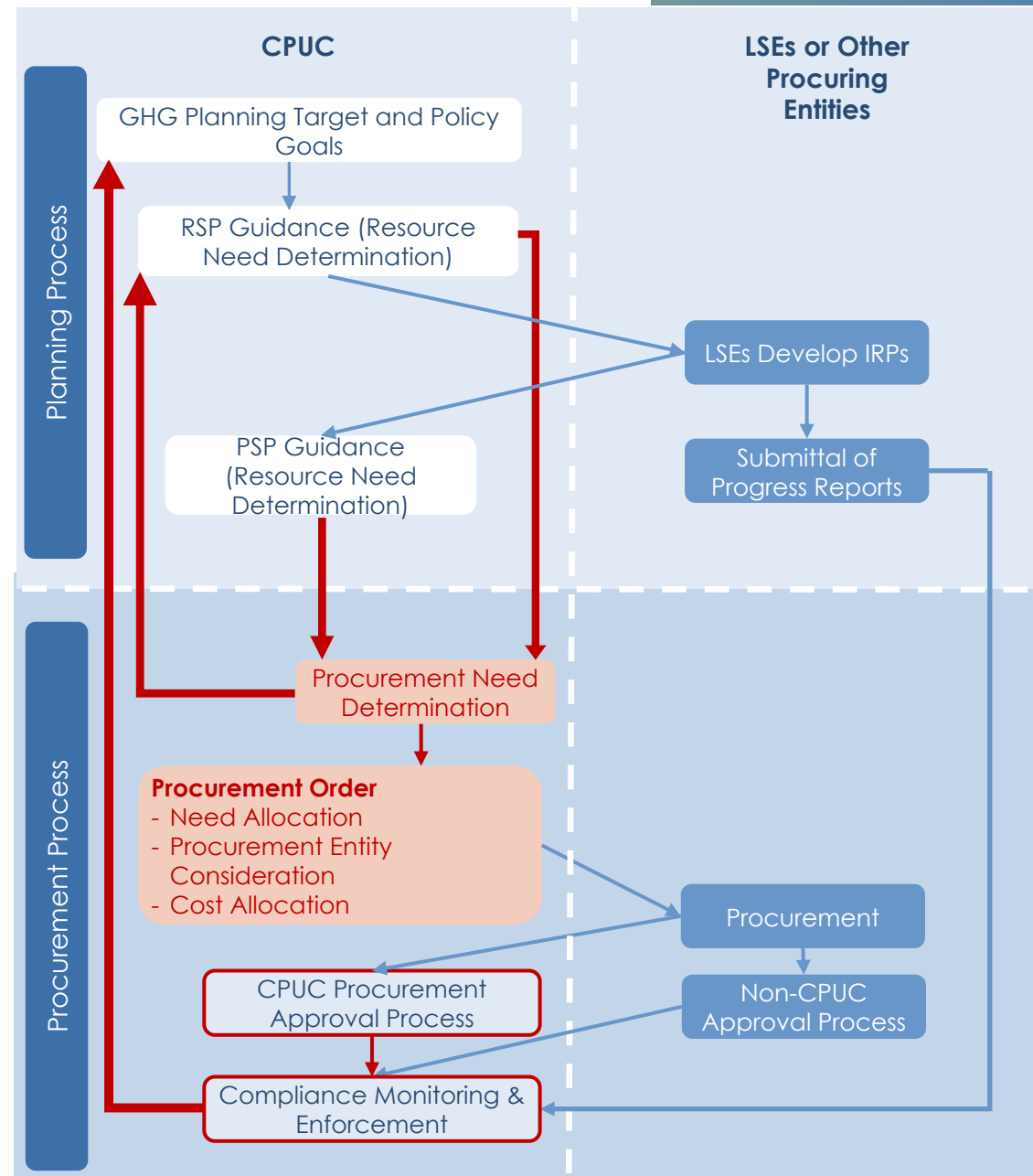# Action Required to Ensure Portfolio is Implemented?

- Preferred system plan should comprise:
  - <u>Portfolio</u> of existing and new resources; plus
  - <u>Actions</u> required to implement the portfolio
    - Procurement required of LSEs; consider in-CAISO POUs as part of this
    - Other actions required of LSEs; and/or
    - Other actions by the Commission

- Analysis of 38 MMT Core portfolio indicates:

LSE plans, fully implemented

➕

Mid-Term Reliability procurement, fully implemented

➡️

Achieve the Commission's reliability and GHG goals for 2303

- However, it is uncertain whether adoption of this portfolio, along with existing markets and programs, is sufficient
  - Additional Commission or other action required to ensure LSE plans are implemented?

Links between procurement process and planning process in IRP

- Procurement Framework Staff Proposal seeks to define connections between planning and procurement
  - Blue = existing steps
  - Red = steps to be established or updated
- This Ruling explores whether it is necessary to operationalize some of these as part of the PSP decision

CPUC

LSEs or Other Procuring Entities

Planning Process

- GHG Planning Target and Policy Goals
- RSP Guidance (Resource Need Determination)
- PSP Guidance (Resource Need Determination)
- LSEs Develop IRPs
- Submittal of Progress Reports

Procurement Process

- Procurement Need Determination
- **Procurement Order**
  - Need Allocation
  - Procurement Entity Consideration
  - Cost Allocation
- Procurement
- CPUC Procurement Approval Process
- Non-CPUC Approval Process
- Compliance Monitoring & Enforcement

Figure 5, P. 28 of Staff Proposal for Resource Procurement Framework in IRP, *11/18/2020*

Retention of Existing Resources

- How to retain existing resources that are necessary to support system reliability, GHG outcomes, or both
  - Modeling in IRP typically assumes existing resources will remain online through the planning horizon; exceptions for announced retirements, and some sensitivities assume age-based retirement of thermal
  - D.19-11-016 and D.21-06-035 require new resources
  - The issue applies to renewables, natural gas plants, and CHP facilities
- Comments are sought on specific actions the Commission can take:
  - CHP proposals in parties' comments leading to D.21-06-035
  - Addressing the increasing reliance on the existing natural gas fleet to meet emergency summer reliability needs
- Programmatic approaches (e.g., RPS and RA) can avoid the need to distinguish between existing and new resources
  - November 2020 Staff Proposal
  - Some parties recommended this in comments leading to D.21-06-035

Reliability Need: Potential Acceleration of D.21-06-035 Procurement

- July 30, 2021: Governor Newsom's Proclamation of a State of Emergency, among other things [1], requests the CPUC:
  - To work with LSEs on accelerating procurement
  - To expand and expedite demand response programs, and storage and clean energy projects
    - To ensure safe and reliable electricity supply through October 31, 2021; and
    - To ensure increased clean energy capacity by October 31, 2022
  - To, along with the California Energy Commission, California Air Resources Board, and the CAISO, identify and prioritize action to accelerate the carbon-free energy transition, including
    - Recommendations in the March 2021 SB 100 Joint Agency Report; and
    - Any additional actions
- Summer reliability rulemaking (R.20-11-003) will address possibility of accelerating D.19-11-016 and D.21-06-035 procurement to 2022
- IRP proceeding to explore actions for 2023, notwithstanding Proclamation's focus through 2022
  - D.21-06-035 requires 2,000 MW NQC by August 1, 2023
  - Should a higher amount (e.g., 4,000 MW NQC) be required?

Reliability Need: Fossil-Fueled Procurement & Role of Renewable Hydrogen

- 38 MMT Core portfolio found to be reliable via staff's PCM. Other considerations:
  - PCM sensitivity re online years for LLT resources required by D.21-06-035 found significant reliability benefit if come online in 2026 rather than 2028
  - D.21-06-035 deferred the decision on whether fossil-fueled resources should be required or allowed for mid-term reliability
  - CEC is studying CAISO system reliability, including assessment of whether additional procurement is necessary and if so, what reliability contribution different combinations of resource types would make
- D.21-06-035 discussed potential reasons to require or allow incremental fossil-fueled capacity from existing sites:
  - Uncertainty about performance of batteries, and risk of overreliance
  - Ability of existing natural gas facilities to be developed expeditiously and inexpensively
  - IRP capacity expansion modeling consistently finds the need to retain most thermal capacity throughout the planning period

Reliability Need: Fossil-Fueled Procurement & Role of Renewable Hydrogen

- The draft CEC Mid-Term Reliability study was presented at a CEC workshop on Monday, August 30th, 2021
  - The draft study found reliability when the MTR order is met from 2023-2026, with some concern regarding 2022
  - The CEC did not find a gas portfolio to provide additional reliability over preferred resources
  - Parties are invited to provide comments directly to the CEC on the study and to comment on the implications of the study for procurement actions in this proceeding

- If procurement need for fossil-fueled resources if found, ruling proposes some portion be eligible or required to use renewable hydrogen

- Proposed definition of renewable hydrogen:
  - Per self-generation incentive program (SGIP) decision
  - One amendment: if using grid-supplied electricity to produce the hydrogen, must retire renewable energy credits (or equivalent if using large hydropower)
  - Note: this does not allow use of renewable hydrogen injected into the existing utility natural gas distribution system

- Proposed use of renewable hydrogen:
  - Certain portion of facilities to use a minimum % fuel blend at beginning of contract, increasing to 100% by the end
  - Maintain or reduce NOx emissions compared to use of natural gas

Geographically-targeted Procurement: Aliso Canyon Replacement

- IRP proceeding background
  - D.21-06-035 discussed need to continue to coordinate planning for the long-term need for natural gas-fired generation capacity, as well the relationship of electric reliability to the use of the Aliso Canyon natural gas storage facility
  - A number of party comments recommended ordering geographically-targeted procurement to replace fossil-fueled generation, particularly in disadvantaged communities
- Aliso Canyon proceeding (I.17-02-002): FTI Consulting analysis of impacts of a potential closure of Aliso Canyon in 2027 or 2035 is in progress
- Ruling seeks comments:
  - On whether there are initial actions the Commission could take this year, prior to completion of FTI's analysis
  - Address need determination (amount, resource type), allocation to LSEs, entities required or eligible to conduct procurement, cost allocation arrangements, and compliance, monitoring, and enforcement mechanisms

Questions?

GHG Reduction-driven Procurement

- Staff Proposal explored options for GHG reduction-driven procurement
- Some party comments in response to February 22, 2021 ALJ ruling on Mid-Term Reliability address GHG reduction-driven procurement
- This ruling seeks to advance development of procurement process steps, specific to GHG reduction-driven procurement
  - Need determination
  - Need allocation
  - Procurement entities
  - Cost allocation
  - Compliance, monitoring, and enforcement

GHG Reduction-driven Procurement

- "Bottom up" option
  - Commission makes procurement of the planned resources in LSEs' IRPs required
    - Could require LSEs to procure the exact resource/resource types included in their plans, or the attributes of those resources like the amount clean GWh in their plans
  - Need determination, allocation, and procurement entities: addressed directly by this action
  - Compliance, monitoring, and enforcement
    - Backstop and cost allocation arrangements similar to those for D.21-06-035 and D.19-11-016
    - Penalty for failure to achieve the capacity and/or energy in LSEs' IRPs
- "Top down" option
  - Need determination performed at system level
  - Need allocated to each LSE on a pro-rata basis
  - Analogous to D.19-11-016 and D.21-06-035 approaches, but for GHG reduction
- Programmatic options

Need determination (Section 6)

- Need determination is the step of identifying what should be procured to meet a planning requirement
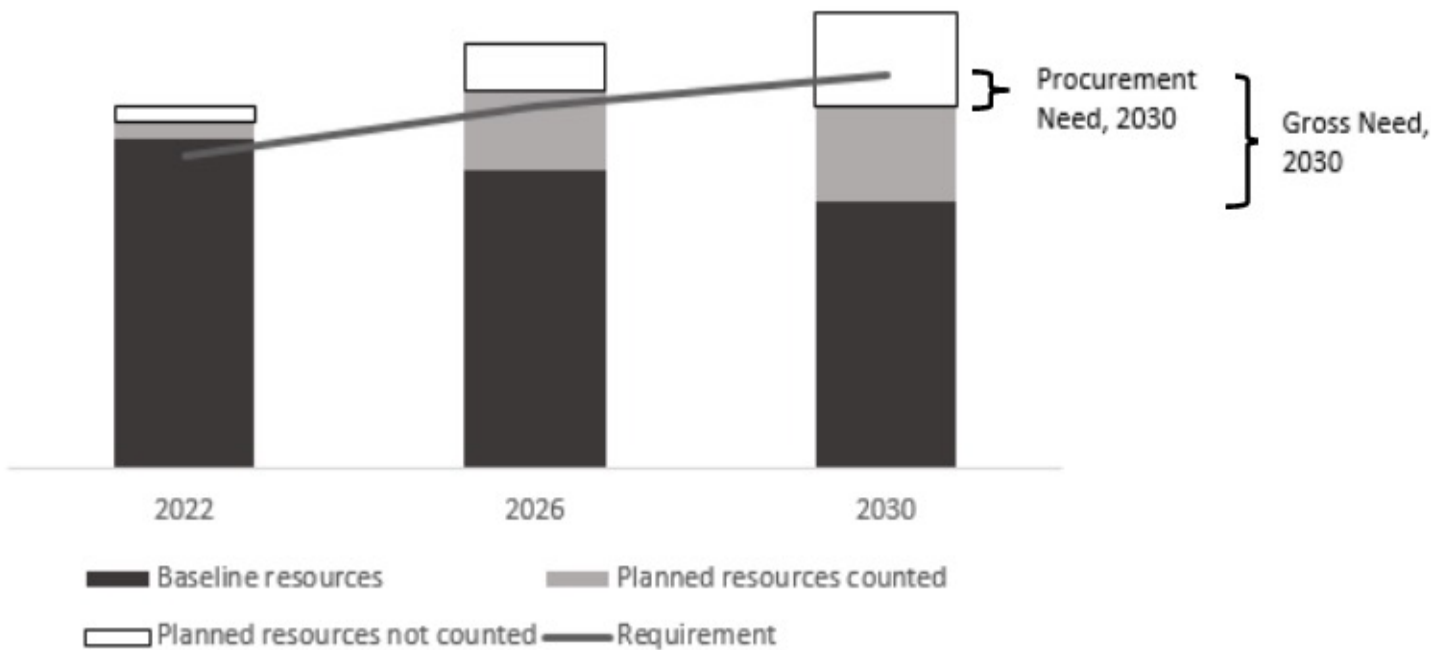
Illustrative Example: Portions of PSP Portfolio that could be subject to procurement action, 2030
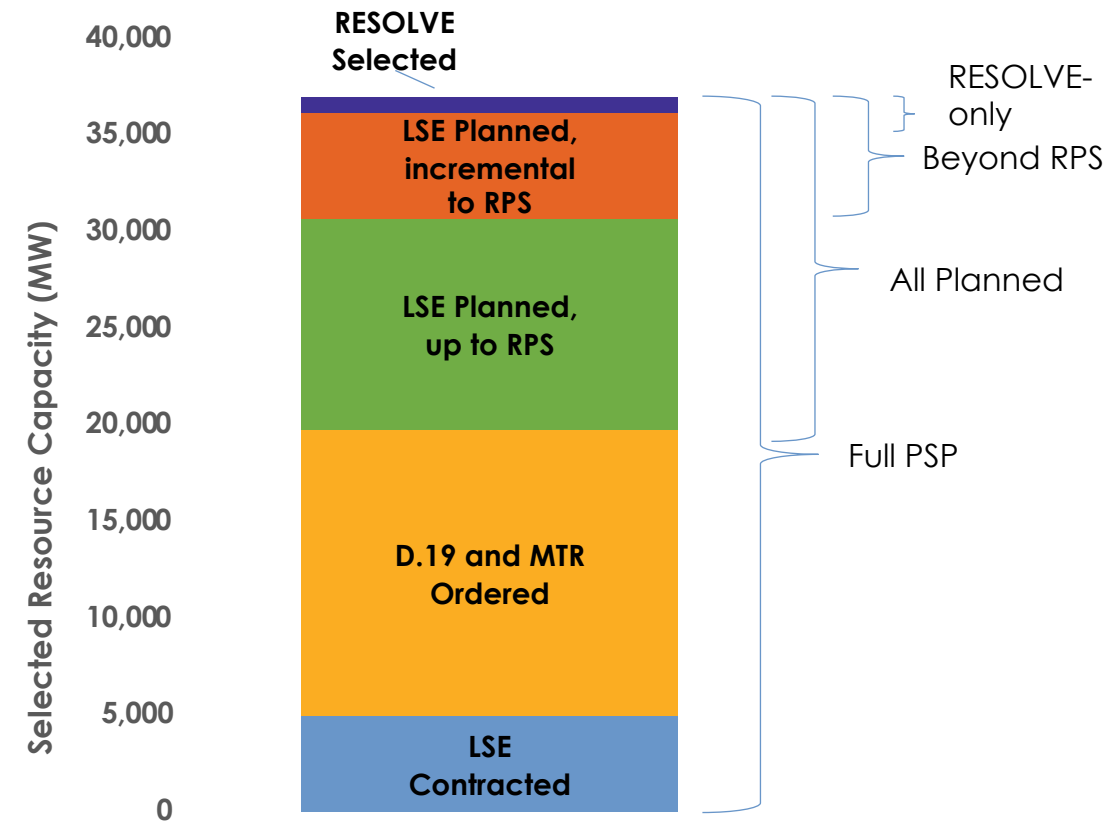
Long Lead-time Resources: Out-of-state Resources

- The reliability base case scenario transmitted to the CAISO for analysis in the 2021-2022 TPP include approximately 1,100 MW of out-of-state (OOS) resources that were preliminarily determined to need new transmission development outside of the CAISO system.
  - Preliminary TPP results will be available in November and final TPP results will be available in February of 2022.
- The proposed 38 MMT Core portfolio includes 1,500 MW of wind on new out-of-state transmission in 2030.
- There are several ways in which the Commission could act to support additional development of OOS renewables and the transmission to support them. Options include:
  - Order procurement of a specific amount of resources from a particular state or states;
  - Identify particular transmission projects, with specific end points, that should be developed to facilitate imported renewables;
  - Work with other state and federal counterparts to ensure transmission siting and construction.

Potential New Transmission Projects to Access OOS Resources
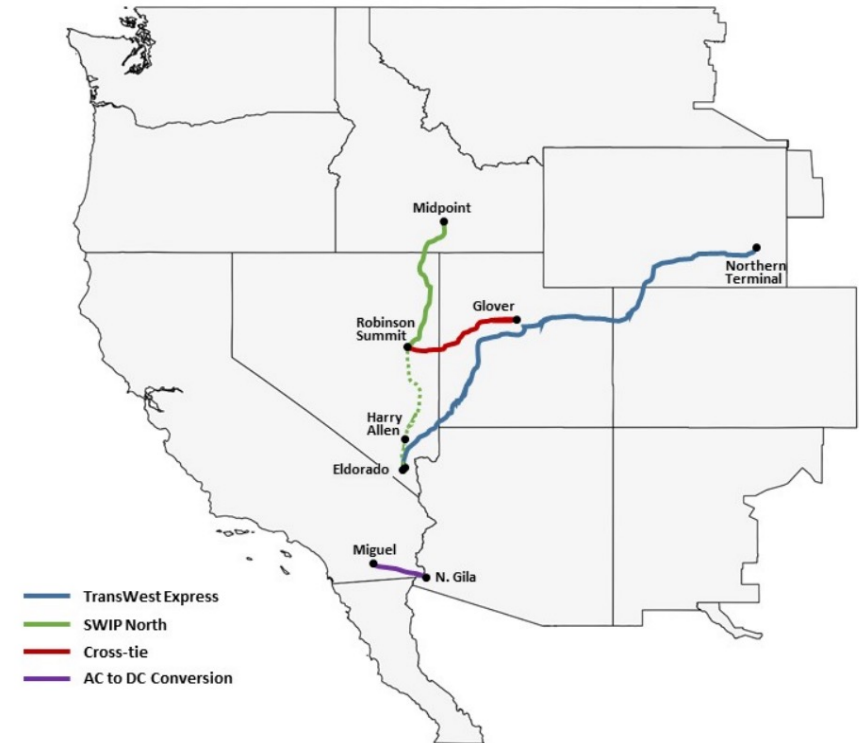
Source: https://www.caiso.com/Documents/Day2_ISO-Presentation_2017-2018TransmissionPlanningProcess_PreliminaryReliabilityResults.pdf

Long Lead-time Resources: Out-of-state Resources

- In considering actions the Commission can take to facilitate access to OOS resources, relevant factors may include:
  - The certainty of the need
    - LSE plans did not include OOS resources requiring new transmission
  - CAISO control/management
    - Projects may join the transmission control area; or they could be built without connecting directly to the CAISO grid
  - Resource adequacy eligibility and the CAISO's long-term access to the OOS resources
    - Reliance on existing third-party transmission to connect to a CAISO intertie
  - System needs the projects would fulfill, additional benefits to the grid, and state policy goals that the projects could help achieve
  - If procurement need were to be found:
    - The amount, timing, and specificity of the need;
    - How the responsibility for the procurement need should be allocated among LSEs;
    - Self-provision requirements or a central procurement entity to take on OOS resource procurement;
    - Cost allocation; and
    - Compliance, monitoring, and enforcement provisions.

Long Lead-time Resources: Offshore Wind

- Offshore wind on track to be a default candidate resource in coming IRP cycle
- CPUC is awaiting CAISO analysis of transmission implications from potentially large amounts of offshore wind resources
  - Draft results of 2021-2022 TPP sensitivity analysis available November 2021
- California Offshore Wind Task Force is coordinating offshore wind development
- Potential near-term CPUC actions to facilitate offshore wind development
  - Preserve use of transmission availability associated with Diablo Canyon Power Plant and in the Morro Bay area for central coast offshore wind
  - Include certain MW amounts of offshore wind in the reliability and policy-driven base case portfolios to be studied in the 2022-2023 TPP
  - Other actions?

Storage Projects as Transmission Alternatives & Other Procurement for System Benefit

- CAISO's 2020-2021 TPP determined that two transmission projects could be replaced by storage resources.
  - This reflects Commission guidance for the CAISO to identify, where possible, non-transmission alternatives for mitigating reliability issues.
- How should Commission encourage development of these two storage resources at these specific locations?
- Broader challenge: resources that provide benefits for the whole system yet for which there is unlikely commercial incentive for any single entity
  - How might the Commission act to encourage procurement?
  - November 2020 Staff Proposal
    - Similar to current cost allocation mechanism (CAM) but not limited to IOUs as procurement entities
    - Establish a new non-bypassable charge for procurement of resources needed for collective benefit

Questions?

Appendix

Appendix A: RESOLVE Updates for 2021 PSP / 2022-23 TPP

Summary of RESOLVE Updates since Dec 2020
2021-22 TPP Release – Inputs Related Changes

Update Category	Purpose	Key Changes
Mid-term Reliability (MTR)	Align reliability need in portfolios with MTR need per D.21-06-035	• Higher planning reserve margin (PRM) and load adders • Lower imports • Thermal generation retirements • Minimum build for long-lead time resources ordered
Baseline Resources	Update baseline generators to latest available data	• Include previously proposed ground truthing updates[1] • Update Gen List to align with LSE plan data and MTR baseline, update NQC %'s to match MTR model / 2021 CPUC NQC List
Resource Costs and Potential	Update to latest data vintage of standard IRP data sources	• Resource costs updated to match 2020 NREL ATB, Lazard Levelized Cost of Storage 6.0, NREL offshore wind study • Updated federal PTC and ITC extension to reflect statute and IRS guidance; including 10-year safe harbor option for offshore wind resources • By default, up to 4.7 GW offshore wind was allowed starting in 2030 and up to 3 GW WY+NM wind on new Tx starting in 2026 and up to 68 GW after 2030
LSE Planned Resources	Allow modeling of LSE planned additions	• Input data updated to allow forcing in of 46 and 38 MMT aggregated additions from 2020 LSE IRP plans, with changes as needed to fit within updated transmission constraints

[1] ftp://ftp.cpuc.ca.gov/energy/modeling/IRP%20Model%20Improvement%20and%20GHG%20Groundtruthing_updated.pdf

Summary of RESOLVE Updates since Dec 2020 2021-22 TPP Release – Model Development Related Changes

Update Category	Purpose	Key Changes
Code Base Update	Incorporate the latest RESOLVE code and functionality into the IRP model	• Update the model functionality to include custom Constraints and additional input data flexibility. *Used extensively for transmission deliverability constraints and LSE planned resources.* • Enable ability to model multiple reliability constraints and multiple ELCC surfaces for the same reliability constraint. *Battery ELCC curve implementation updated.* • Enable ability to model multiple emission types and constraints and more flexible emissions accounting. *Feature update not used in PSP analysis.*
Transmission Deliverability Constraints	Incorporate latest CAISO transmission deliverability methodology, transmission limits, and upgrade costs	• Update deliverability methodology to align with CAISO • Update on-peak and off-peak transmission deliverability capacity • Include technology-specific resource output factors that relate resource capacity to transmission capacity • Include Li-ion battery and pumped storage capacity under transmission constraints • Revise solar locations granularity, add locational information for batteries to match the solar location • Limit transmission build to CAISO-determined upgrade amounts • Introduce constraints on out-of-state wind and offshore wind to only be selected as fully deliverable resources

[1] ftp://ftp.cpuc.ca.gov/energy/modeling/IRP%20Model%20Improvement%20and%20GHG%20Groundtruthing_updated.pdf

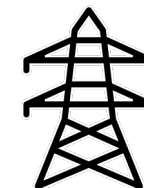# Mid-Term Reliability Decision (D.21-06-035) RESOLVE Implementation

- **PRM**: aligned with MTR Need Determination Model[1] "High Need" scenario from 2024
  - Existing requirement (**~15%**) + 2019 RSP Development calibration adder of (**4.3%**) + Operating Reserves adder of (**1.5%**) + Climate Impact adder of (**1.8%**)
  - **Total PRM = 22.5%**
- **Load Adders**: Per High Need scenario, load adders were added[2] for the managed peak impact[3] of:
  - 1) 2020 vs. 2019 IEPR
  - 2) IEPR Low vs. IEPR Mid BTM PV and 3) High Electrification vs. Mid-Demand IEPR (both held at constant values after 2026)
- **Additional Thermal Retirements:** 40-yr age based applied up to and including 2026 (~1 GW nameplate CHP + peakers)
- **Unspecified imports:** drop from 5 GW to 4 GW in 2024 per High Need scenario
- **Long lead-time resources (LLTs)**: To reflect D.21-06-035 requirements and allowances, 1 GW (NQC) geothermal and 1 GW (NQC) long-duration storage were "forced-in" by 2028 and 2025-2027 reliability need was reduced to minimize PRM overcompliance based on the allowed LLT delay (between 2026 and 2028)
- **Resource NQCs**: RESOLVE NQCs for each resource category were updated to reflect the 2021 CPUC NQC List used by MTR Need Determination Model
- **Persistence of Assumptions**: By default, the "High Need" scenario assumptions persist beyond 2026, though non-persistence of those assumptions was run as a sensitivity

[1] Available at https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/electric-power-procurement/long-term-procurement-planning/more-information-on-authorizing-procurement/irp-procurement-track
[2] Load adders were only added to RESOLVE's PRM constraint. The load forecast used in RESOLVE's dispatch module (i.e. hourly load/resource balance, GHG emissions, etc.) was not changed
[3] The managed peak impact is the IEPR peak load net of demand side resource peak impacts
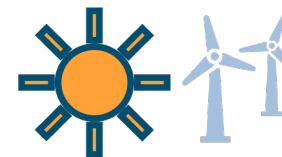
Transmission Updates: Limits and Constraints

- CAISO updated on-peak and off-peak transmission capability and included technology-specific transmission information
  - CAISO released a white paper in July 2021 entitled "Transmission Capability Estimates for use in the CPUC's Resource Planning Process" which documents the updated capability estimates
    - Available at: http://www.caiso.com/Documents/WhitePaper-2021TransmissionCapabilityEstimates-CPUCResourcePlanningProcess.pdf
  - New transmission constraint limits generally increase the amount of available capacity on the transmission system relative to the 2019 CAISO white paper values, though this is not true for every constraint
    - The new limits also include geographic areas that were not covered in the 2019 white paper
      - 2019 CAISO white paper available at: https://www.caiso.com/Documents/WhitePaper-TransmissionCapabilityEstimates-InputtoCPUCIntegratedResourcePlanPortfolioDevelopment.pdf

Transmission Updates: Deliverability Methodology

- RESOLVE has been updated to include three limits for each transmission constraint
  - On-Peak, Highest System Need (HSN) – represents net peak hours in early evening when solar output is low
  - On-Peak, Secondary System Need (SSN) – hours of very high demand, represents "shoulder" peak hours where solar output is usually more abundant
  - Off-Peak
- For a resource to receive full deliverability status, it must fit within the available transmission capacity
  - If economic, available transmission capacity can be expanded by CAISO-identified upgrades
  - RESOLVE incorporates resource-specific multipliers for each limit (HSN/SSN/off-peak)
- RESOLVE has also been updated to enforce the CAISO-identified upgrade build limits included in CAISO's 2021 new white paper

Transmission Updates: Storage + Solar

- Previous RESOLVE modeling did not consider interactions between storage and transmission constraints
  - Instead, interactions were addressed downstream in the bus-bar mapping process
- RESOLVE has been updated to:
  - Ensure that storage capacity has enough available transmission capacity to receive full deliverability
    - Lithium-ion battery and pumped storage resources were previous modeled as a single CAISO-wide resource; multiple resources are now modeled such that transmission limits in different areas of the CAISO grid can be considered
  - Model the interaction between storage charging and off-peak transmission limits by expanding off-peak transmission limits when storage is built
    - Storage consumes on-peak transmission capability
    - Storage creates off-peak transmission capability
  - Solar and battery locations aligned as a step towards modeling co-located and hybrid resources.
    - Full hybrid modeling out of scope
      - No interactions are modeled between solar and storage in hourly dispatch
      - Cost reductions from shared infrastructure are not modeled

Resource Costs

- Data source updated from 2018 (Reference System Plan, RSP) to 2020 vintage
  - Most generation technologies: NREL 2020 ATB
  - Offshore wind: NREL OCS Study BOEM 2020-048 [1](RSP: NREL ATB and E3 WECC study)
  - Storage (utility-scale and BTM Li-ion batteries): Lazard LCOS v6.0
- Other updates had smaller impacts on levelized costs compared to data source updates
 - ITC/PTC schedule, solar PV inverter loading ratio, financing lifetime, etc.
  - See details in Appendix

Total Levelized Fixed Cost % Change From RSP (2018 Vintage)

Wind PTC not included here, but is reflected in resource-level costs

After 2046, offshore wind cost slightly higher in NREL 2020 study than in 2018 ATB

Fluctuations in solar and offshore wind due to ITC schedule

Offshore wind costs assume ITC benefits are accessed through 2035 via the safe harbor exemption

Legend:
- Solar - Residential
- Solar - Utility Tracking
- Wind - 36-38% CF
- Floating Offshore Wind - 47-48% CF
- Utility-scale Battery - Li - No ITC - 4hr
- Geothermal - Hydro / Flash
- Gas - CCGT

[1] For more information on this study, refer to 8/27/2020 Modeling Advisory Group material available at: https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/electric-power-procurement/long-term-procurement-planning/2019-20-irp-events-and-materials

Appendix B: Aggregated LSE Plans by LSE Type and RSP Comparison
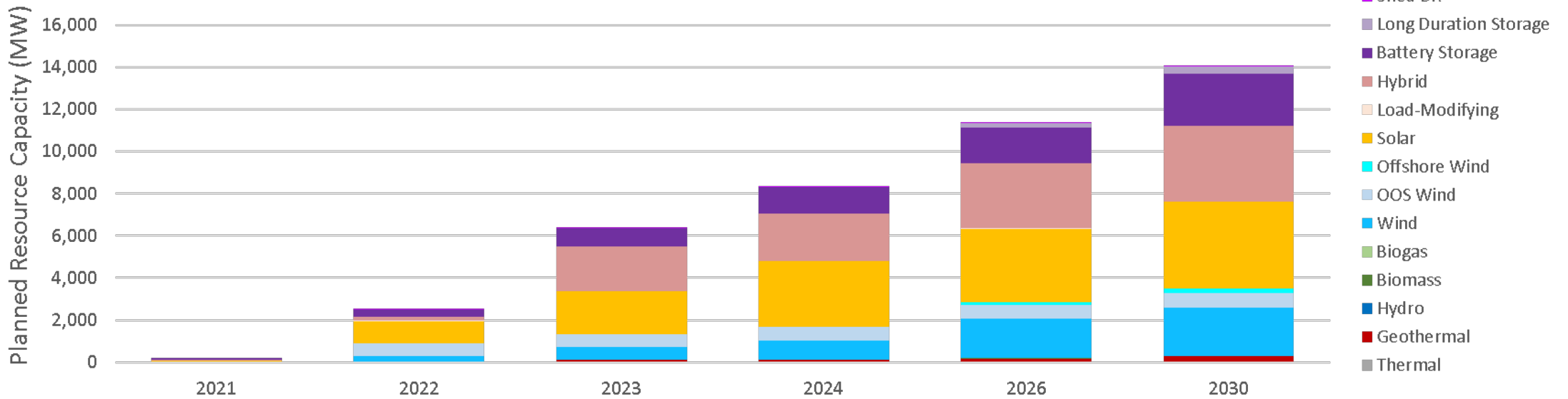
New Resource Additions: Aggregated 46 MMT Plans - IOUs
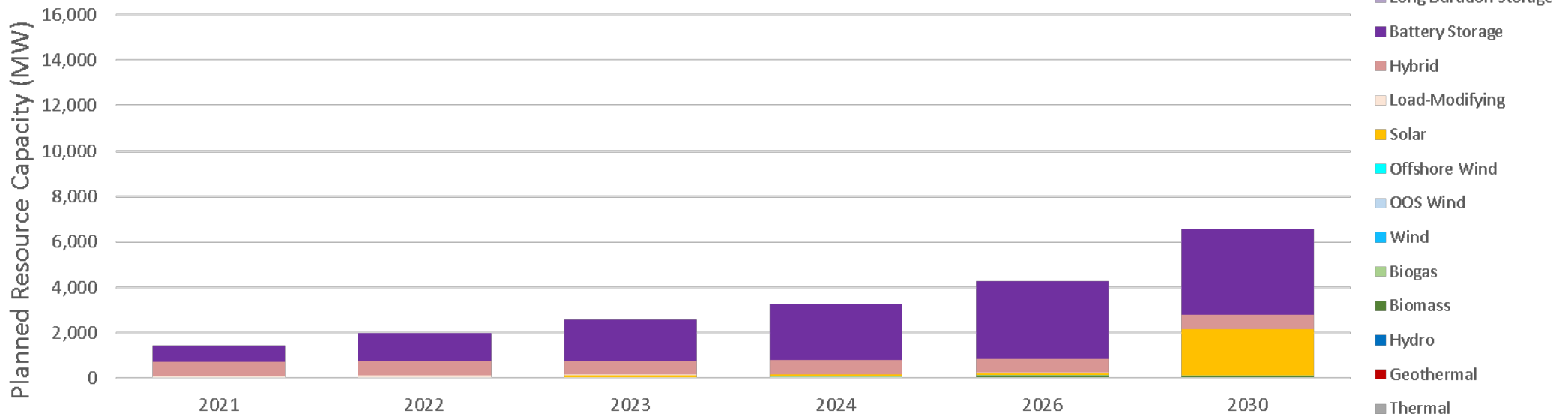
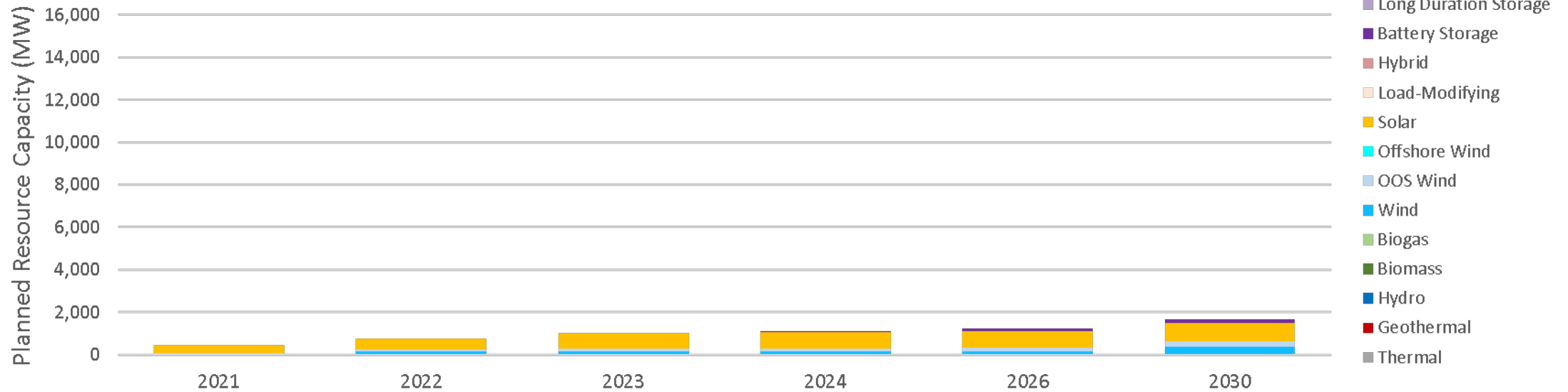New Resource Additions: Aggregated 38 MMT Plans - IOUs
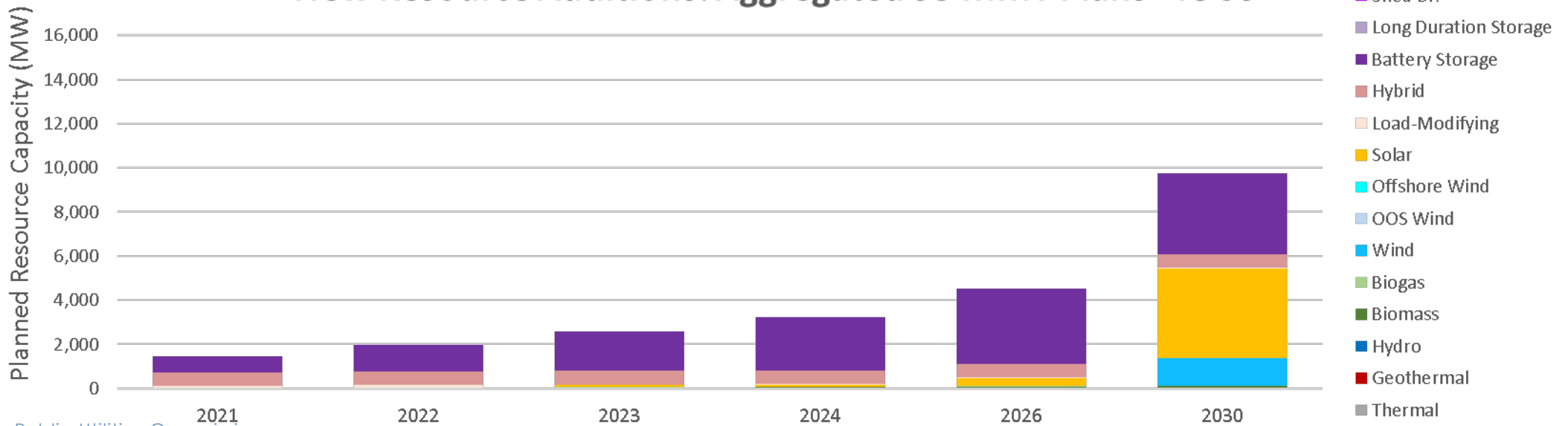
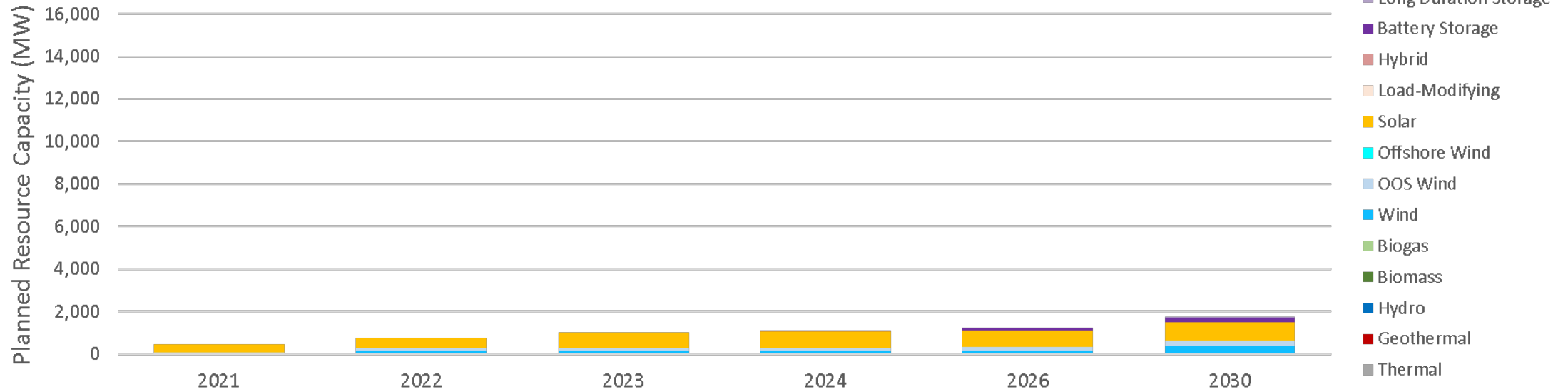New Resource Additions: Aggregated 46 MMT Plans - CCAs
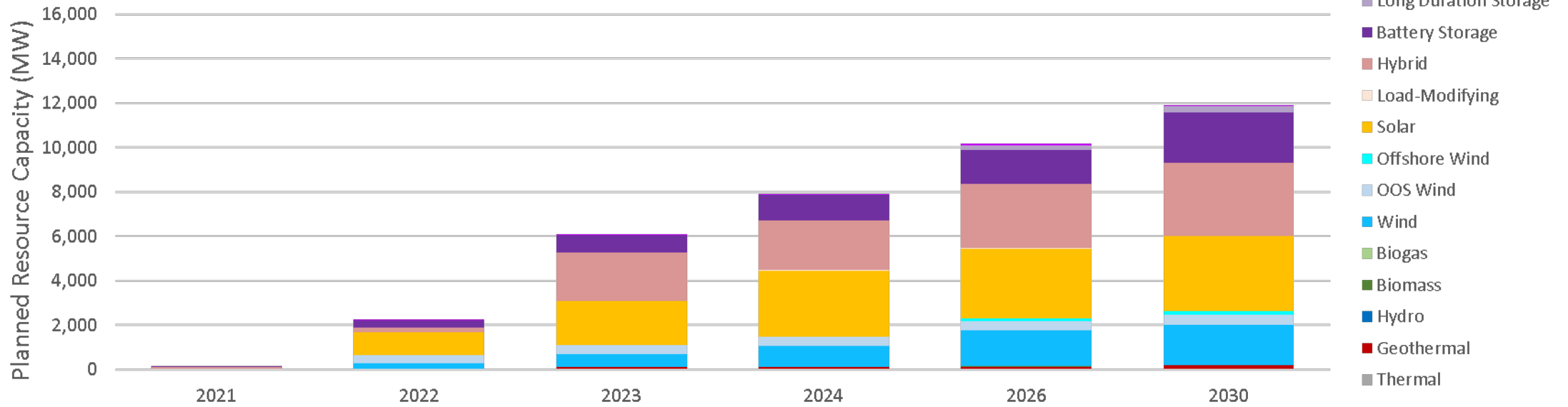
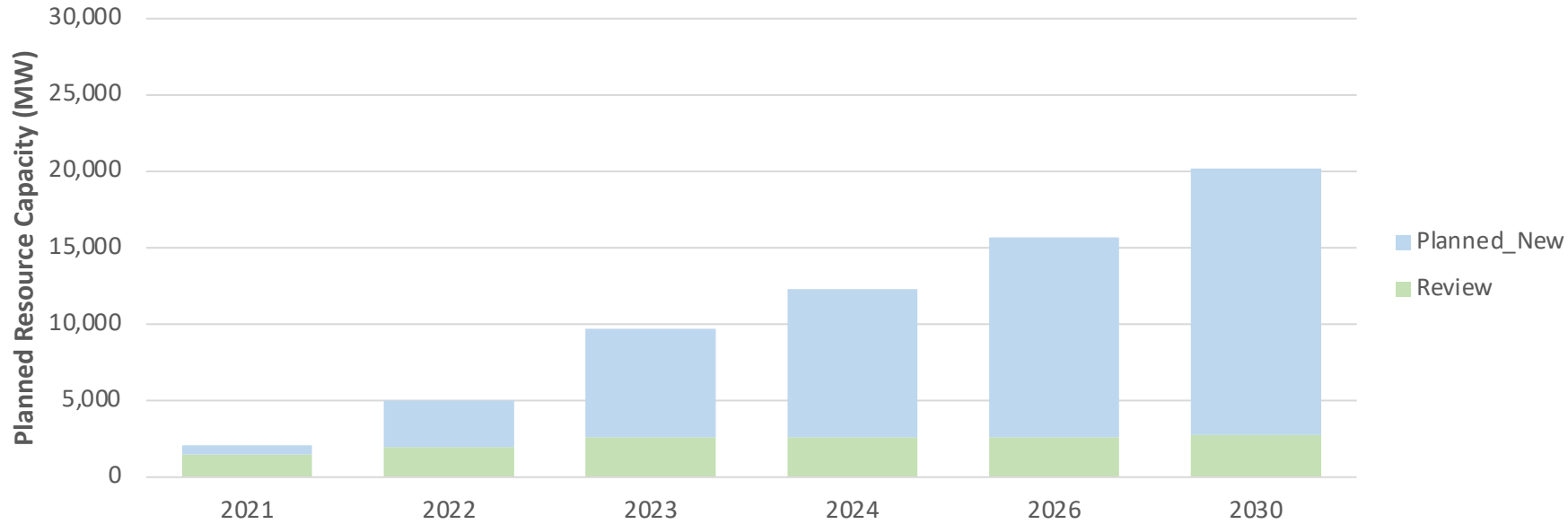New Resource Additions: Aggregated 38 MMT Plans - CCAs

New Resource Additions: Aggregated 46 MMT Plans - ESPs

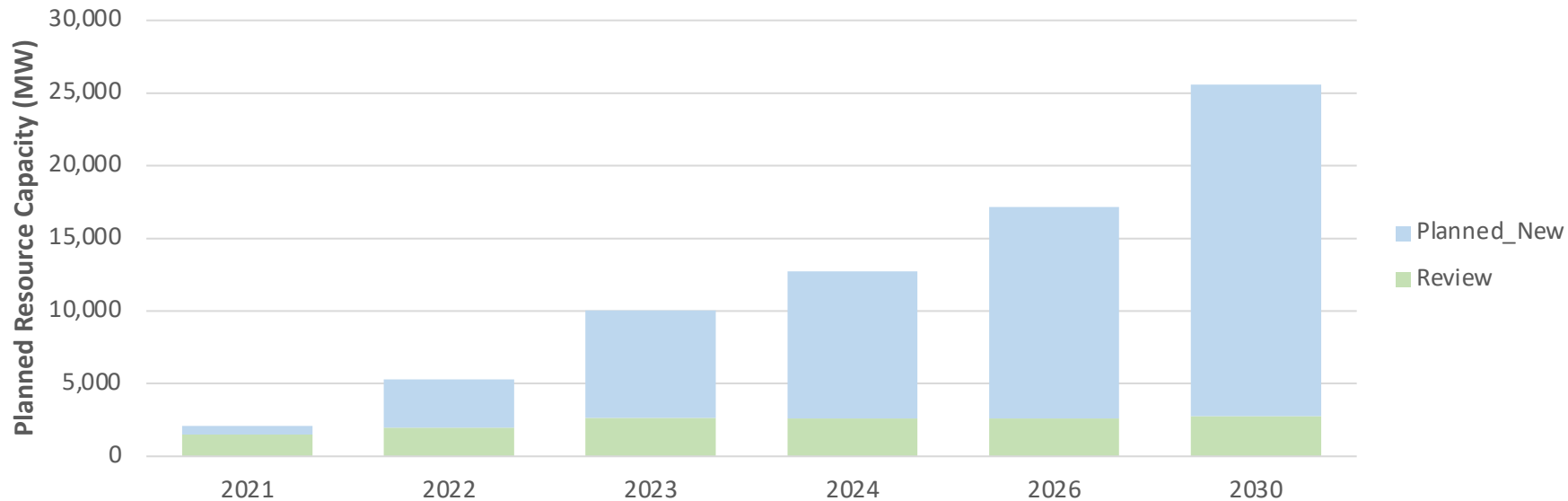New Resource Additions: Aggregated 38 MMT Plans - ESPs

New Resource Build-out: Aggregated 46 MMT Plans - by Contract Status

Planned New: Contract (or decision to own resource) is planned for the future, and has not been executed or approved as of 6/30/2020.

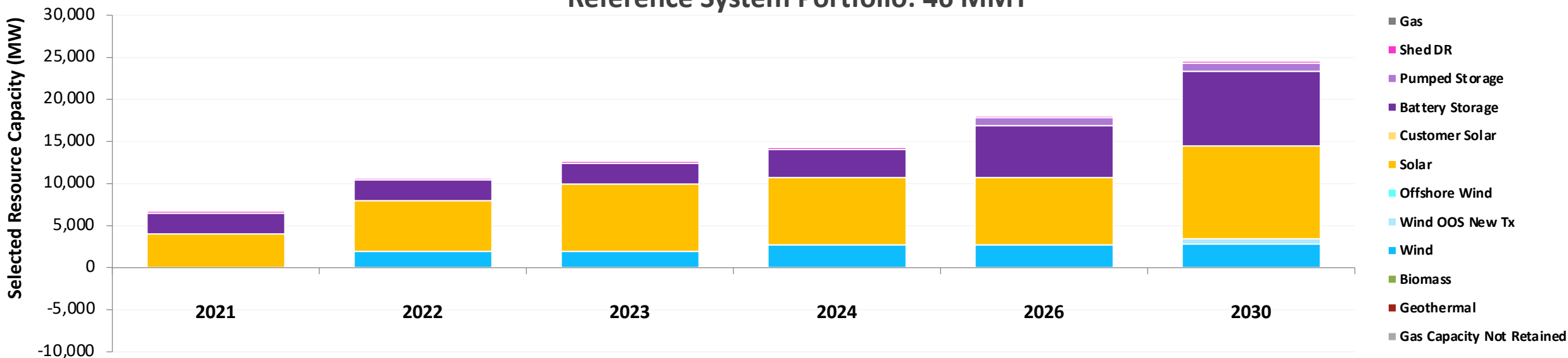**New Resource Build-out: Aggregated 38 MMT Plans - by Contract Status**

Review: Contract has been selected and is under review by LSE's highest decision-making authority (e.g. board of directors) as of 6/30/2020.
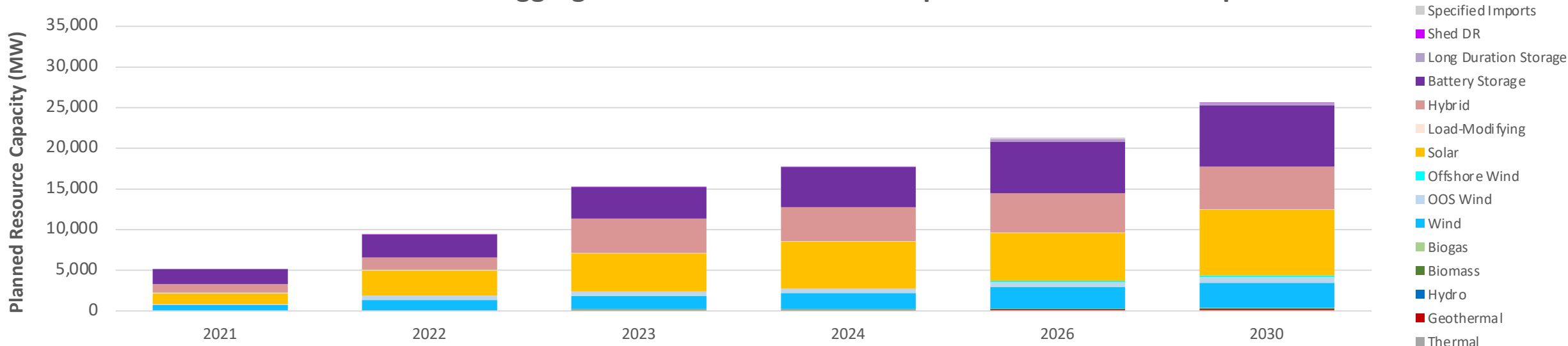
Comparison to the 2020 Reference System Portfolio (RSP)

- An apples-to-apples comparison of the aggregated portfolios to the RSP must include contracted, "in-development," resources that are incremental to the baseline that was used for RSP development but are now part of the updated baseline

- The following total resource addition slides are drawn from LSE plans but include higher resource additions than the planned resource additions shown in earlier slides due to the inclusion of these contracted resources

- Notably, the aggregated LSE portfolios include hybrid resources, which were not available as a RESOLVE candidate resource in the RSP
  - The inclusion of hybrids in LSE plans may reflect planning that is aligned with the RSP's selection of solar and battery storage resources
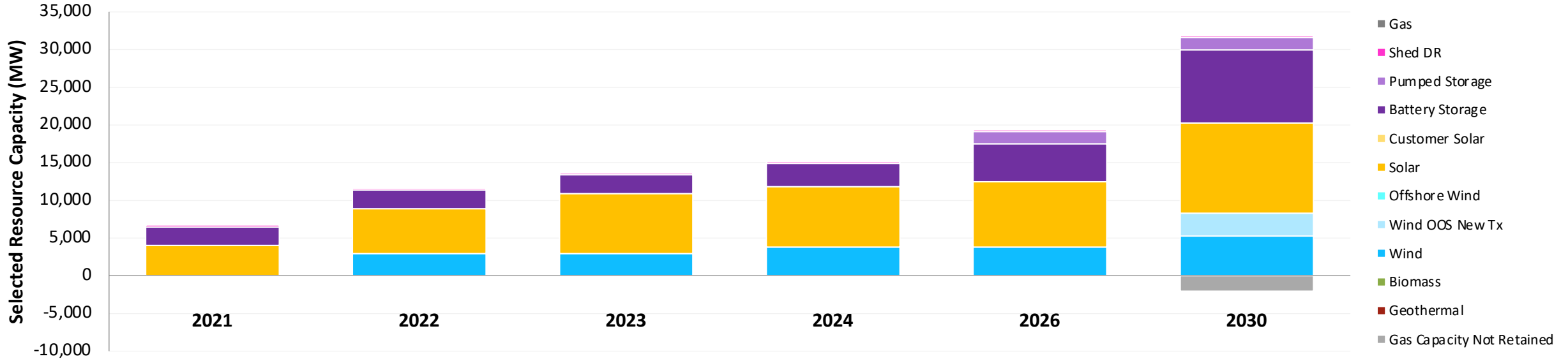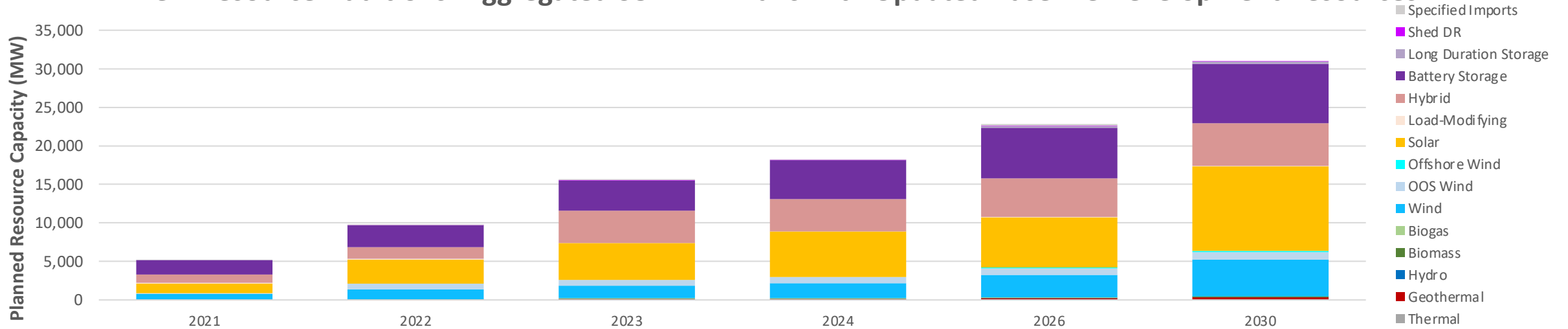
Reference System Portfolio: 46 MMT

Selected Resource Capacity (MW) — 2021, 2022, 2023, 2024, 2026, 2030

Legend: Gas, Shed DR, Pumped Storage, Battery Storage, Customer Solar, Solar, Offshore Wind, Wind OOS New Tx, Wind, Biomass, Geothermal, Gas Capacity Not Retained

New Resource Additions: Aggregated 46 MMT Plans with Updated Baseline Development Resources

Planned Resource Capacity (MW) — 2021, 2022, 2023, 2024, 2026, 2030

Legend: Specified Imports, Shed DR, Long Duration Storage, Battery Storage, Hybrid, Load-Modifying, Solar, Offshore Wind, OOS Wind, Wind, Biogas, Biomass, Hydro, Geothermal, Thermal

Reference System Portfolio: 38 MMT

Legend: Gas, Shed DR, Pumped Storage, Battery Storage, Customer Solar, Solar, Offshore Wind, Wind OOS New Tx, Wind, Biomass, Geothermal, Gas Capacity Not Retained

New Resource Additions: Aggregated 38 MMT Plans with Updated Baseline Development Resources

Legend: Specified Imports, Shed DR, Long Duration Storage, Battery Storage, Hybrid, Load-Modifying, Solar, Offshore Wind, OOS Wind, Wind, Biogas, Biomass, Hydro, Geothermal, Thermal

# Appendix C: High Electrification Load Forecast

RESOLVE High Electrification Load Forecast Assumptions

	Measure	2030 Assumptions
	Building EE	**High**: Harmonized with 2017 Scoping Plan EE
	Industry EE	**High**: Harmonized with 2017 Scoping Plan EE
	Smart Growth	**6% reduction** in per capita LDV VMT relative to 2017
	Building Electrification	**50% of new sales** for water heaters and HVAC are heat pumps (~2 TWh)
	Vehicle efficiency	**High**: retain federal waiver for CA mpg (new LDA are 45 mpg and LDTs 34 mpg in 2030)
	Light-duty vehicle electrification	**7 million on-road ZEVs** (67% sales, 23 TWh)
	Trucks & off-Road electrification	**15% MDV and 9% HDV BEVs** (60% and 22% sales, 15 TWh)
	Clean Electricity	76% RPS (**30 MMT CO_2 statewide**)
	Biofuels	**398 TBTU** (all available waste & residue feedstocks, including importing to CA population share of US feedstocks)
	Pipeline Hydrogen	**5% blend by energy** (off-grid renewable electrolysis)
	Non-Combustion	**40% reduction** in CH_4 and F-gases

High Electrification Sensitivity

Comparison of 2020 CPUC PATHWAYS
High Electrification and 2019 IEPR Mid

~7M ZEVs by 2030

Total Managed Net Energy for Load (TWh)

2019 IEPR — PATHWAYS High Electrification
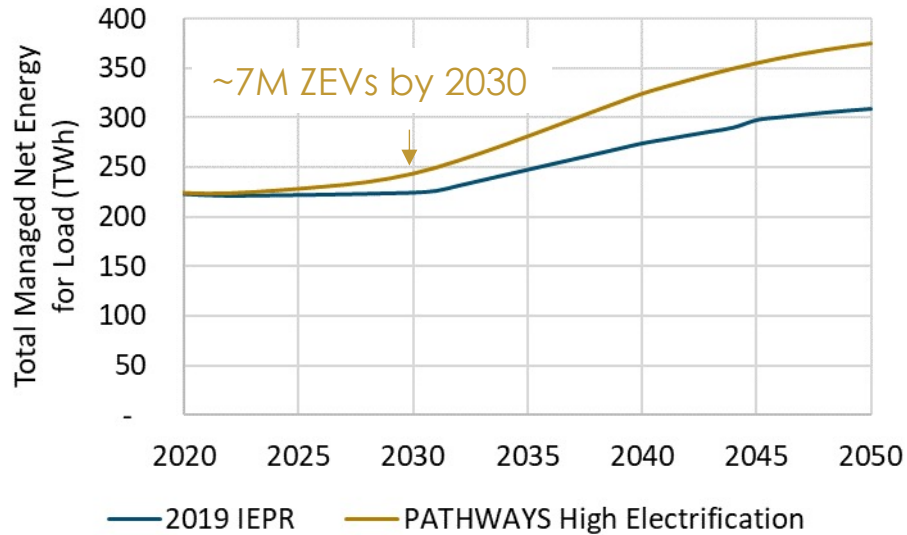
California Energy Commission

ZEV and PEV Penetration is Forecast to Rise Significantly

Light Duty ZEV Stock

Almost 4M ZEVs by 2030 in 2019 IEPR mid

Low — Mid — High
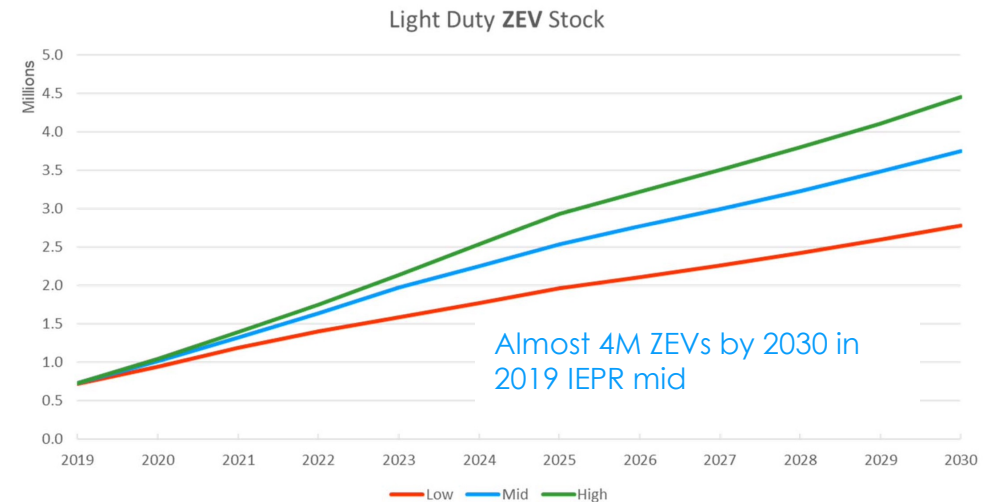
Appendix D: PCM Analysis of Aggregated LSE Plans and 38 MMT Core Portfolio

Overall PCM Framework

- Probabilistic reliability planning approach – primary goal: reduce risk of insufficient generation to an acceptable level.

- Uses the Strategic Energy Risk Valuation Model (SERVM), a probabilistic system-reliability planning and production cost model – Configured to assess a given portfolio in a target study year under a range of future weather (20 weather years), economic output (5 weighted levels), and unit performance (outages) assumptions

- Simulate hourly economic unit commitment and dispatch

- Multiple day look-ahead informs unit commitment

- Individual generating units and all 8,760 hours of year are simulated – hourly results

- 8 CA regions, 16 rest-of-WECC regions - pipe and bubble representation of regions

Probabilistic Reliability Model Definitions

- **Expected Unserved Energy (EUE):** expected magnitude of unserved energy, expressed in total MWh of firm electric demand or reserves unserved per year
- **Loss of loss hours per loss of load event (LOLH/LOLE):** expected average duration of each LOLE event expressed as hours/event
- **Normalized EUE:** EUE normalized by the average annual load level for the target study year
- **0.1 loss of load expectation (LOLE) per year target:** value for LOLE that corresponds to the "1 day in 10 year" industry standard for probabilistic system reliability, where > 0.1 LOLE indicates a less reliable system and < 0.1 LOLE indicates a more reliable system. There are no commonly accepted standards for the other forms of reliability metrics.
- **EUE Intra-Hour:** Expected unserved energy due to ramping constraints not identified 1 hour prior to the hour being simulated.
- **EUE Multi-Hour:** Expected unserved energy due to ramping constraints identified >1 hour prior to the hour being simulated
- **EUE Capacity:** Expected unserved energy due to capacity shortage

# Specific updates to SERVM PCM model since TPP studies

- The LSEs Portfolio represents a combination of the existing baseline resources with the new resource build-out proposed by LSEs in their IRP plans, adjusted for assumed physical limitations.

- Steps used to build the LSEs Portfolio:

  1. Began with the PCM inputs to SERVM for the TPP portfolios. The TPP portfolios are based on updated 2019 IEPR forecasts.
  2. Replaced the "Selected Resources" (new build) from RESOLVE to reflect the LSE new build portfolio preferences as submitted in their IRP plans

- Staff updated the resource baseline in SERVM in four steps - baseline reconciliation with updated CAISO generator lists, performed ground truth adjustments for data errors particularly in the WECC Anchor Data Set, added LSE IRP filings by adding Development resources firmly under contract, then finally added Review and Planned_new resources that are not highly certain units or contracts yet

SERVM Inputs – TPP versus Aggregated LSE Plans

- Staff studied years 2026 and 2030 of the 46 MMT and 38 MMT Aggregated LSE Plans. As a point of comparison to previous PCM results published for parties, staff compared the Aggregated LSE PSP to the TPP portfolio staff sent to the CAISO in January 2021 for the 2021-2022 TPP. The TPP portfolio showed greater capacity added, resulting in better LOLE and GHG results relative to the Aggregated PSP portfolio.
  - Large differences are seen in Solar and Battery additions, and by 2030 there is significantly less overall capacity in LSEs' plans
  - Other resource types are similar
  - Hybrid resources in LSE plans separated and added to battery and solar categories for comparison to TPP

MW capacity – TPP portfolio vs. Aggregated LSE Plans

46MMT- capacity by category - 2030

TPP portfolio included 4,041MW more batteries than Aggregated LSE Plans

Diff: 2,905 MW
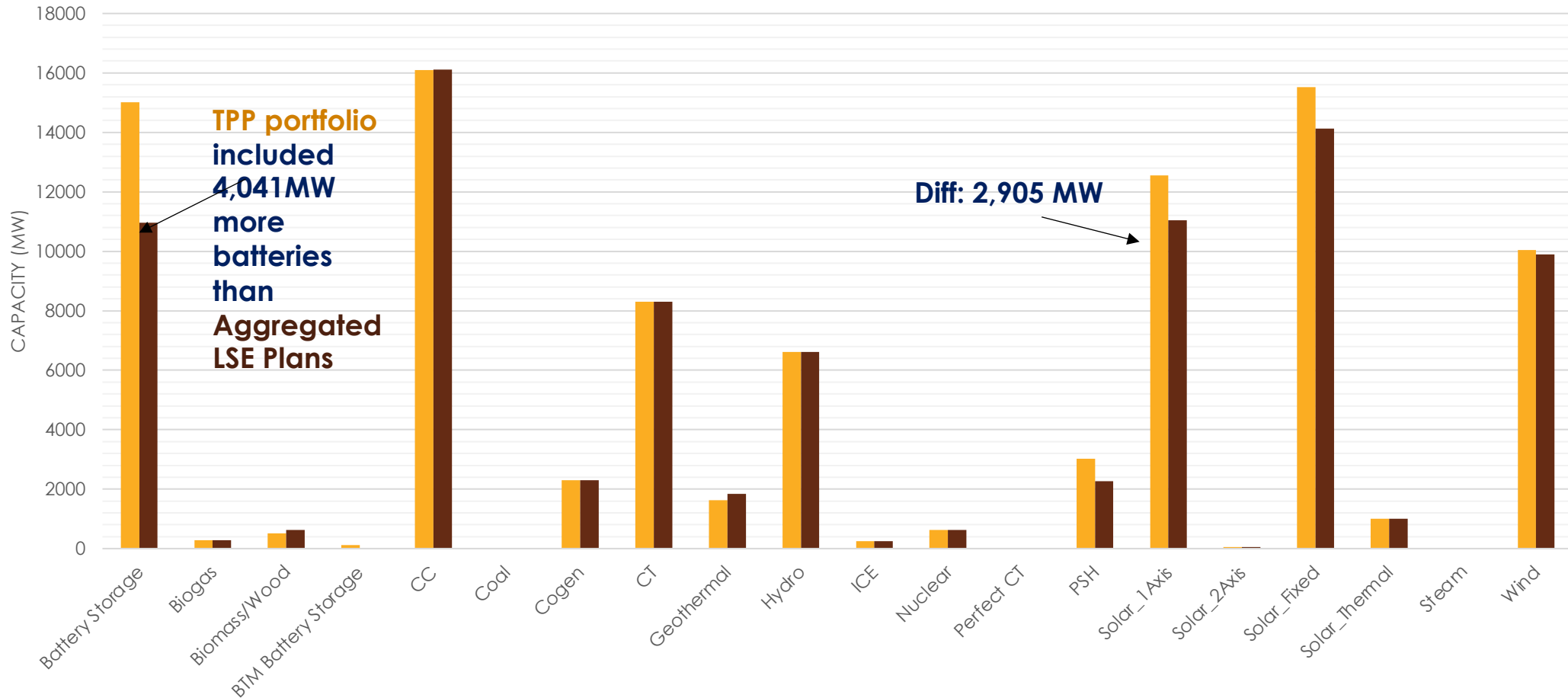
Note – For purposes of comparison, hybrids were split into battery storage and solar categories. Also hybrid batteries were restricted to only charge from the solar, not the grid.

# Capacity Comparison (MW) 46 and 38 MMT Aggregated LSE Plans

- Aggregated LSE Plans were similar between the 46 and 38 MMT portfolios, with the 38 MMT plans including slightly more solar and wind resources.

- For this chart, hybrid is not separated into batteries and solar, just compared as a category.

Unit Category	2026 38MMT_LSE Plans	2026 46MMT_LSE Plans	2030 38MMT_LSE Plans	2030 46MMT_LSE Plans
AAEE	2,121	2,121	3,279	3,279
Battery Storage	8,745	8,549	10,064	9,820
Biogas	290	290	290	290
Biomass/Wood	609	610	638	634
BTM Battery Storage	0	0	0	0
BTMPV	18,833	18,833	22,878	22,878
CC	16,116	16,116	16,116	16,116
Coal	0	0	0	0
Cogen	2,299	2,299	2,299	2,299
CT	8,307	8,307	8,307	8,307
DR	1,726	1,726	1,704	1,704
EV	-3,120	-3,120	-4,794	-4,794
Geothermal	1,803	1,768	1,910	1,840
Hybrid	4,051	3,503	3,954	3,829
Hydro	6,004	6,004	6,004	6,004
ICE	255	255	255	255
Nuclear	635	635	635	635
Perfect CT	0	0	0	0
PSH	2,273	2,273	2,273	2,273
Solar_1Axis	6,717	6,269	10,064	7,921
Solar_2Axis	47	47	47	47
Solar_Fixed	13,720	13,571	14,836	14,122
Solar_Thermal	997	997	997	997
Steam	0	0	0	0
TOU	-2,907	-2,907	-3,003	-3,003
Wind	9,658	9,393	11,602	9,891
Total	99,178	97,537	110,355	105,343

Capacity Comparison of LSE 38MMT and 46MMT Portfolios
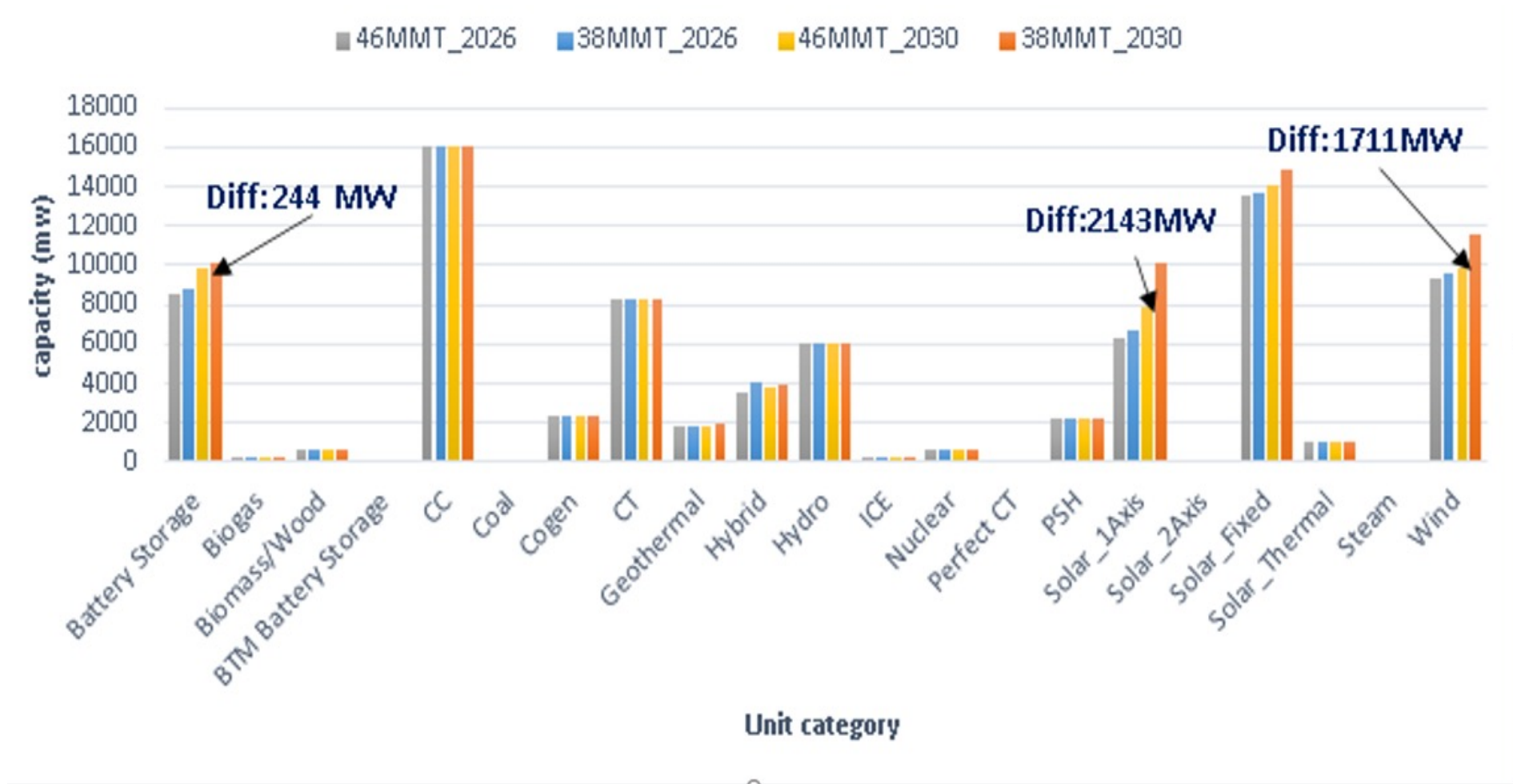
38 MMT study for 2030 : EUE (MWh) by Hour and Month
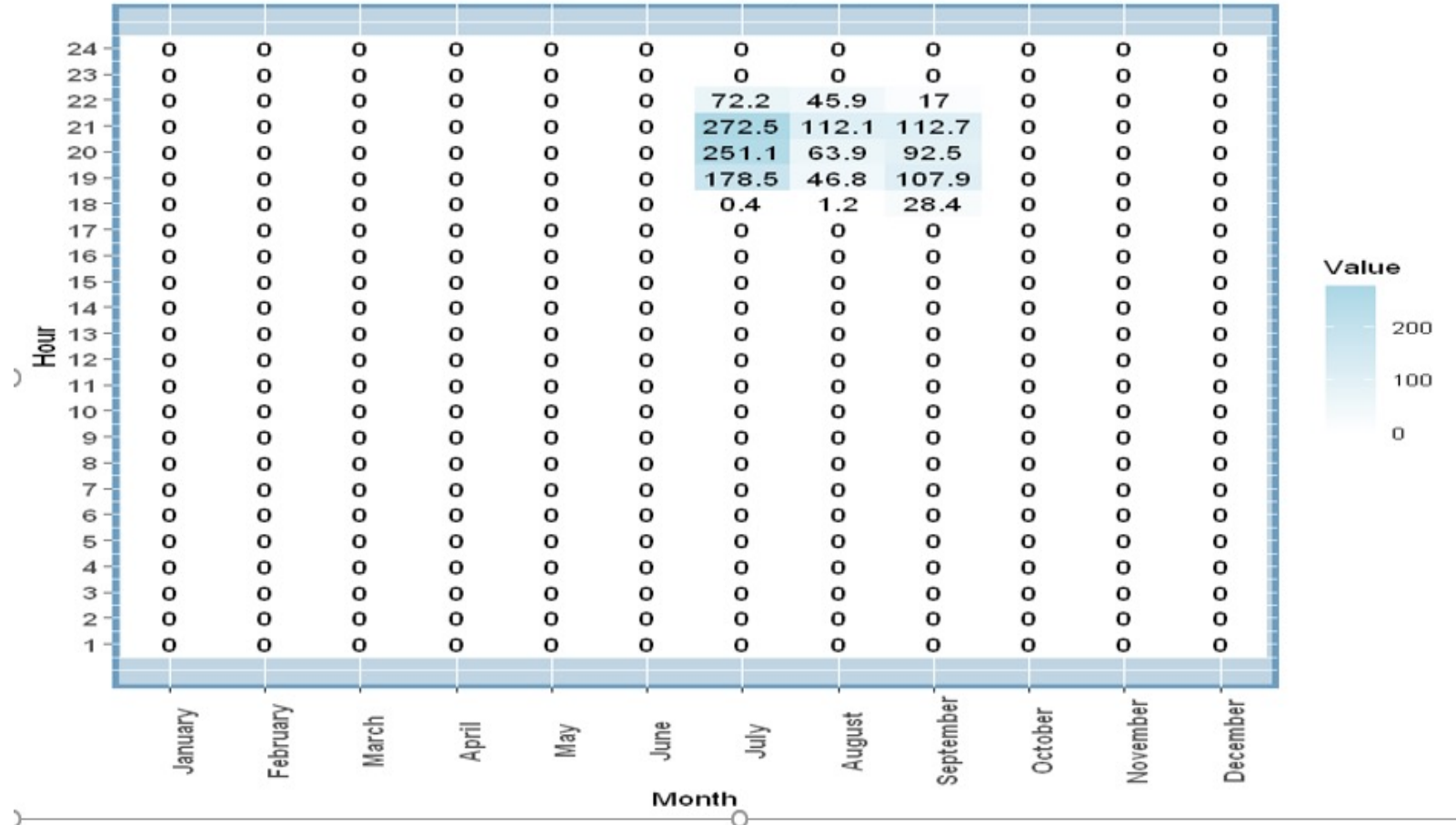
- Bulk of EUE occurs in July evening hours.
- the EUE hours shift later, likely due to further peak shift from solar penetration.

NOTE: The chart only shows hours with nonzero EUE in at least one month. The graded color scale shows the magnitude of the EUE in a given month-hour. Dark blue indicates the largest EUE, followed by light blue ,and white.

SERVM Annual Energy Generation Results (GWh)

| Resource type/Annual GWh	46MMT_2026	46MMT_2030	38MMT_2026	38MMT_2030
CAISO_CCGT1	44,715	46,109	43,721	41,023
CAISO_CCGT2	5,323	5,616	5,211	4,984
CAISO_Peaker1	2,795	3,138	2,852	3,002
CAISO_Peaker2	1,453	1,789	1,482	1,682
Perfect CT	0	0	0	0
Steam	0	0	0	0
Coal	0	0	0	0
Biomass	6,609	6,547	6,534	6,046
BTMPV	32,301	39,177	32,256	38,100
All Solar: fixed PV, tracking PV, solar thermal	51,436	57,487	53,075	63,541
Wind	23,534	24,730	24,570	28,056
Scheduled Hydro Plus ROR Hydro	25,122	25,394	25,392	24,735
Geothermal	14,486	14,951	14,714	14,760
Cogen	12,010	12,285	11,997	11,738
Nuclear	5,563	5,136	5,563	4,995
ICE	71	88	70	75
Generation Subtotal Before Curtailment	225,418	242,446	227,437	242,736
Non-PV Load Modifiers (net effect of AAEE, EV load, TOU)	-858	-2,698	-858	-2,623
Curtailment not included inline above	-551	-1,370	-674	-3,107
TOTAL not including Non-PV load modifiers	224,867	241,076	226,763	239,628

SERVM Annual GHG Emissions Results

CAISO Emissions accounting	46MMT_2026	46MMT_2030	38MMT_2026	38MMT_2030
In-CAISO and gross direct imports thermal generation in GWh	66,367	69,024	65,332	62,504
In-CAISO and gross direct imports CO2 emissions in MMT	27.21	28.41	26.82	25.78
In-CAISO and gross direct imports average emissions factor in MT/MWh	0.41	0.412	0.411	0.412
Unspecified imports netted hourly (no NW Hydro) in GWh	20,109	17,134	19,239	13,922
NW Hydro imports in GWh	11,000	11,000	11,000	11,000
Carbon-free imports from RPS energy, RECs contracts	0	0	0	0
Unspecified imports netted hourly (no NW Hydro) CO2 emissions in MMT	8.61	7.33	8.23	5.96
Unspecified imports netted hourly (including NW Hydro) average emissions factor in MT/MWh	0.277	0.261	0.272	0.239
Total CAISO CO2 emissions in MMT	35.8	35.7	35.1	31.7
BTM CHP emissions in MMT	5	5	5	5
Total CAISO CO2 emissions in MMT, including BTM CHP	**40.8**	**40.7**	**40.1**	**36.7**

Aggregated LSE Plans portfolio GHG results exceed both the prorated 46 MMT target in 2030 as well as the 38 MMT LSE targets.

The 46 MMT portfolios exceed the prorated share of 46 MMT by about 2.5 MMT, and the 38 MMT portfolios exceed the 38 MMT target by 5.5 MMT.

46 MMT 2030 CAISO average monthly Import/Export

46_2030 CAISO monthly Import/Export (GWh)
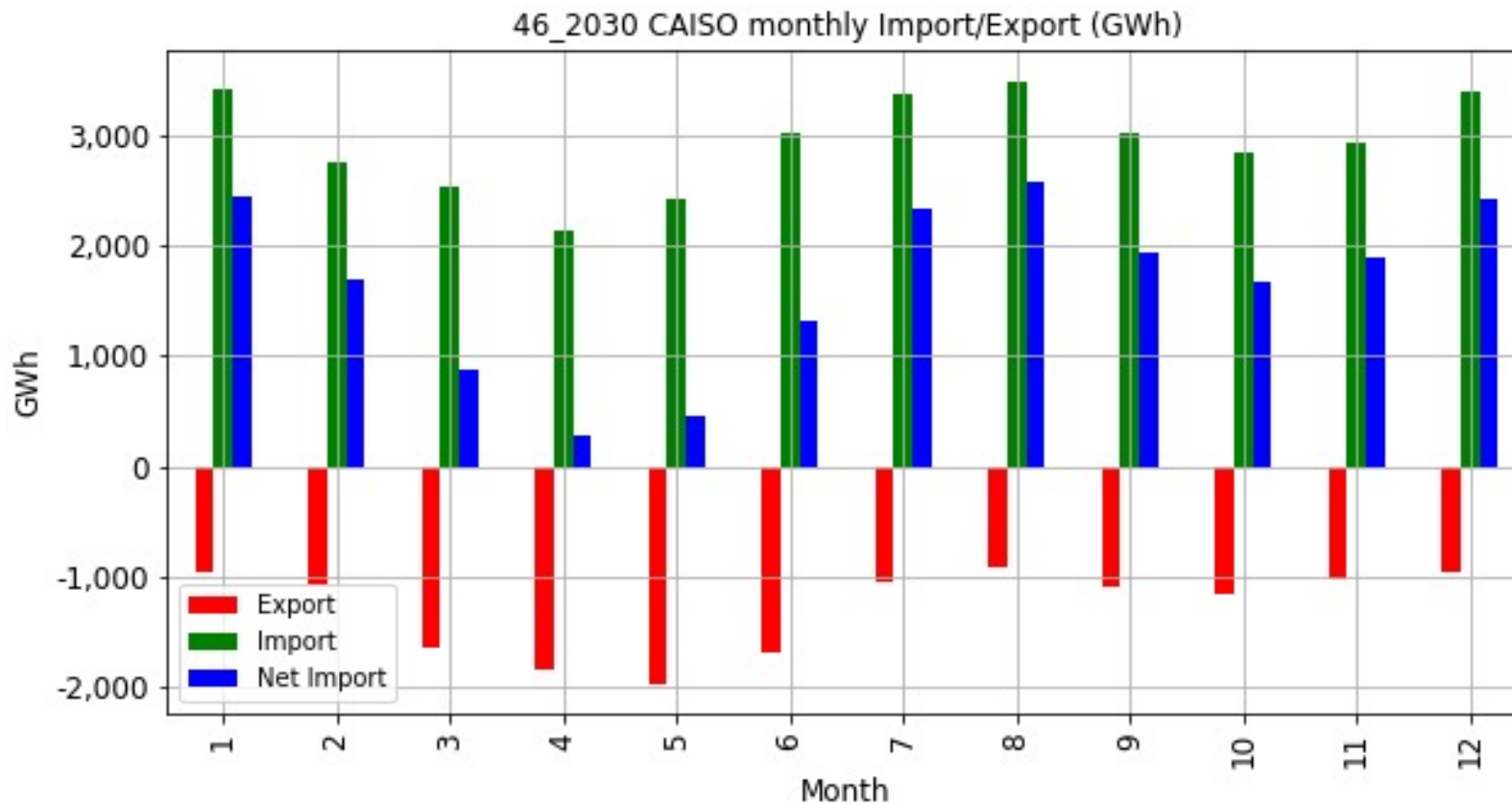
With a 46 MMT buildout from LSE plans, CAISO is a net importer for all 12 months

38 MMT 2030 CAISO average monthly Import/Export

38_2030 CAISO monthly Import/Export (GWh)
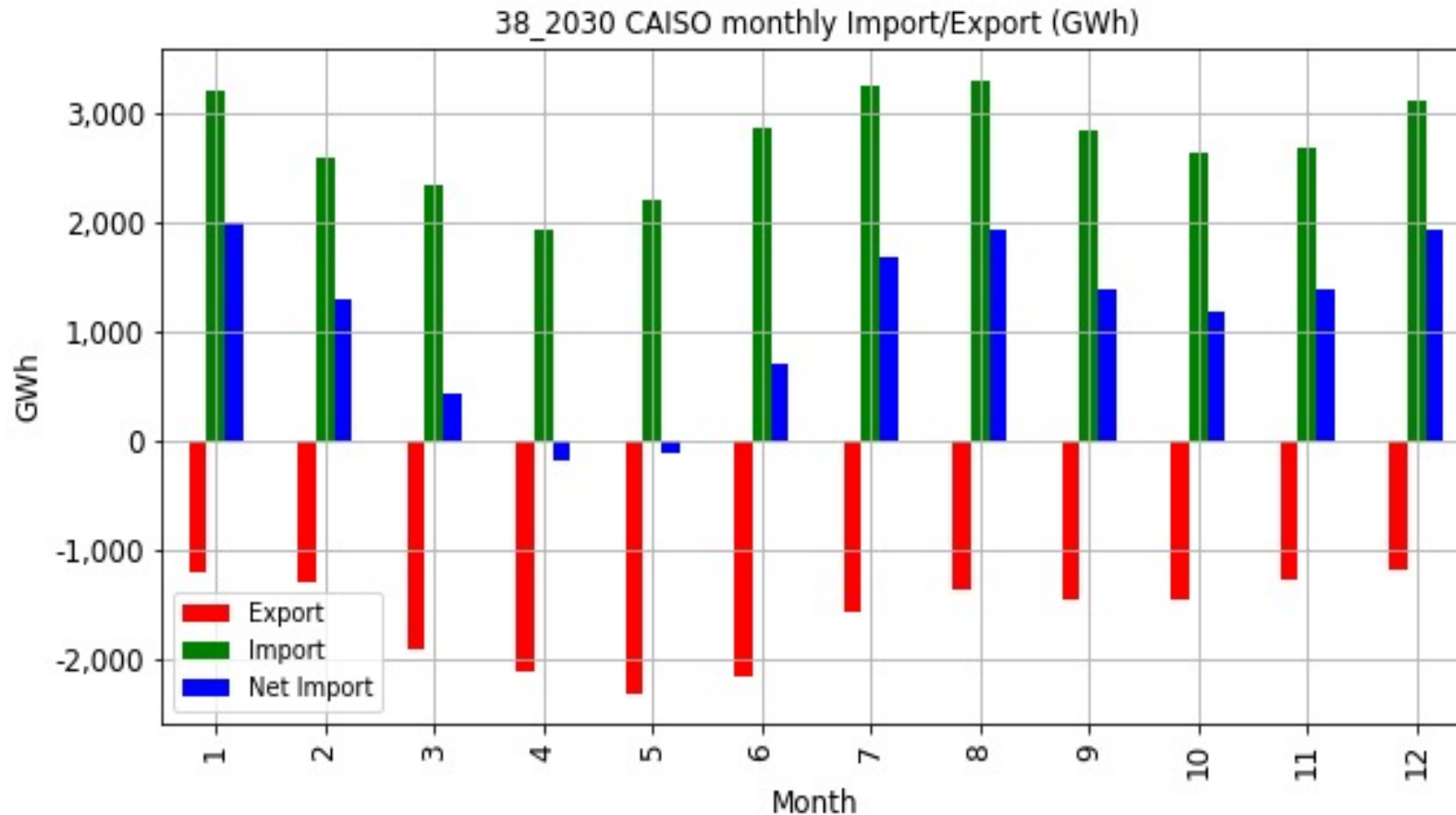
In the 38 MMT portfolio from LSE Plans, CAISO is a net importer in 10 out of 12 months and LSE plans lead to less imports in summer than 46 MMT portfolio

38 MMT Core Portfolio and Sensitivities

Study Definitions – 38 MMT Core Portfolio

38 MMT 2026 and 2030 Core Portfolio Definition:

    Existing Baseline

    + Aggregated 38 MMT LSE plans

    + Mid Term Reliability procurement
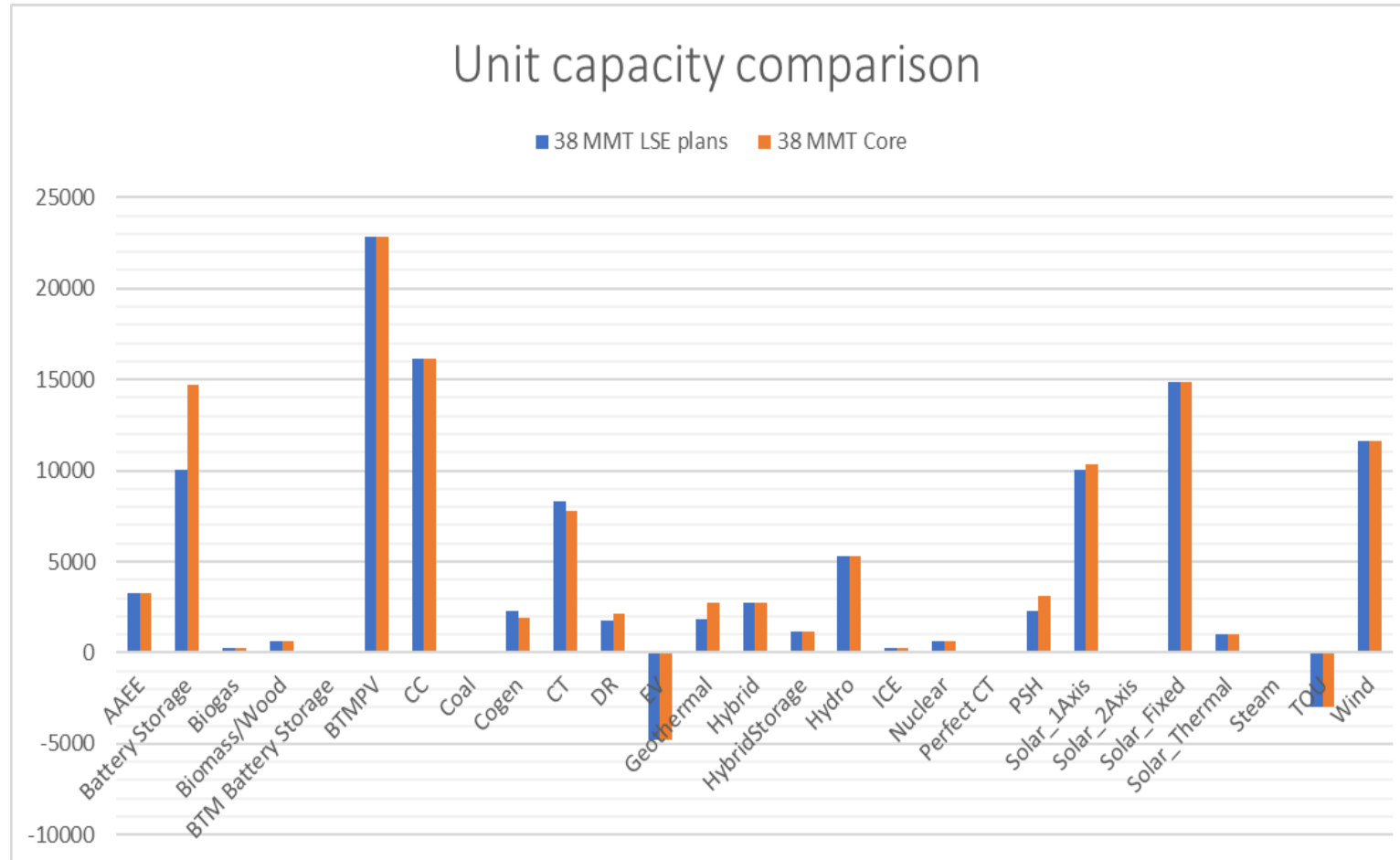
    + RESOLVE resource additions

Definition of 38 MMT sensitivity cases:

    2026 38 MMT Sensitivity – Geothermal moved to 2026

    2026 38 MMT Sensitivity – Pumped Storage Hydro moved to 2026

    2026 38 MMT Sensitivity – 1,000 MW Battery Storage moved to 2026

Aggregated LSE Plans vs. 38 MMT Core (2030)

Unit capacity comparison

■ 38 MMT LSE plans   ■ 38 MMT Core

38 MMT Core case:
- +47% in battery storage
- +46% in geothermal
- +36% in PSH
- +21% in DR
- Slight increase in solar and wind
- ~950 MW thermal retirement (Cogen and CT)

Generation in GWh RESOLVE vs. SERVM

Technology (GWh)	RESOLVE_2026	SERVM_2026	RESOLVE_2030	SERVM_2030
CAISO_CCGT1	46,106	47,036	32,273	41,118
CAISO_CCGT2	2	5,812	2	5,179
CAISO_Peaker1	1	4,341	1	4,431
CAISO_Peaker2	1	2,269	0	2,653
Battery Storage	-3,562	-3,555	-4,234	-3,838
PSH	-664	-1,772	-1,506	-2,274
Steam	0	0	0	0
Coal	0	0	0	0
Biomass	4,957	6,592	5,148	6,580
BTMPV	32,779	32,256	39,528	39,177
Utility Solar	70,302	68,749	78,547	74,688
Wind	27,334	25,066	32,980	28,849
Scheduled Hydro Plus	22,964	25,393	22,962	25,394
Geothermal	10,082	14,311	17,411	22,069
Cogen	8,967	10,156	8,967	9,961
Nuclear	5,108	5,563	5,108	5,136
ICE	7	75	6	62
Generation Subtotal	224,383	242,292	237,193	259,184
Imports (unspecified)	24,134	20,686	23,832	18,065
Exports	-3,877	-16,041	-7,030	-20,564
Net Import	20,257	4,645	16,803	-2,499
Generation+NetImport	244,640	246,937	253,996	256,685

- SERVM produces similar amounts of GHG-free energy to RESOLVE (about 201 TWh total in 2030), but more GHG emitting energy. SERVM also produces 13 TWh more exports relative to RESOLVE

- SERVM produces 9% more in-CAISO generation than RESOLVE but lower net imports, totaling about 4% more total net energy for CAISO.
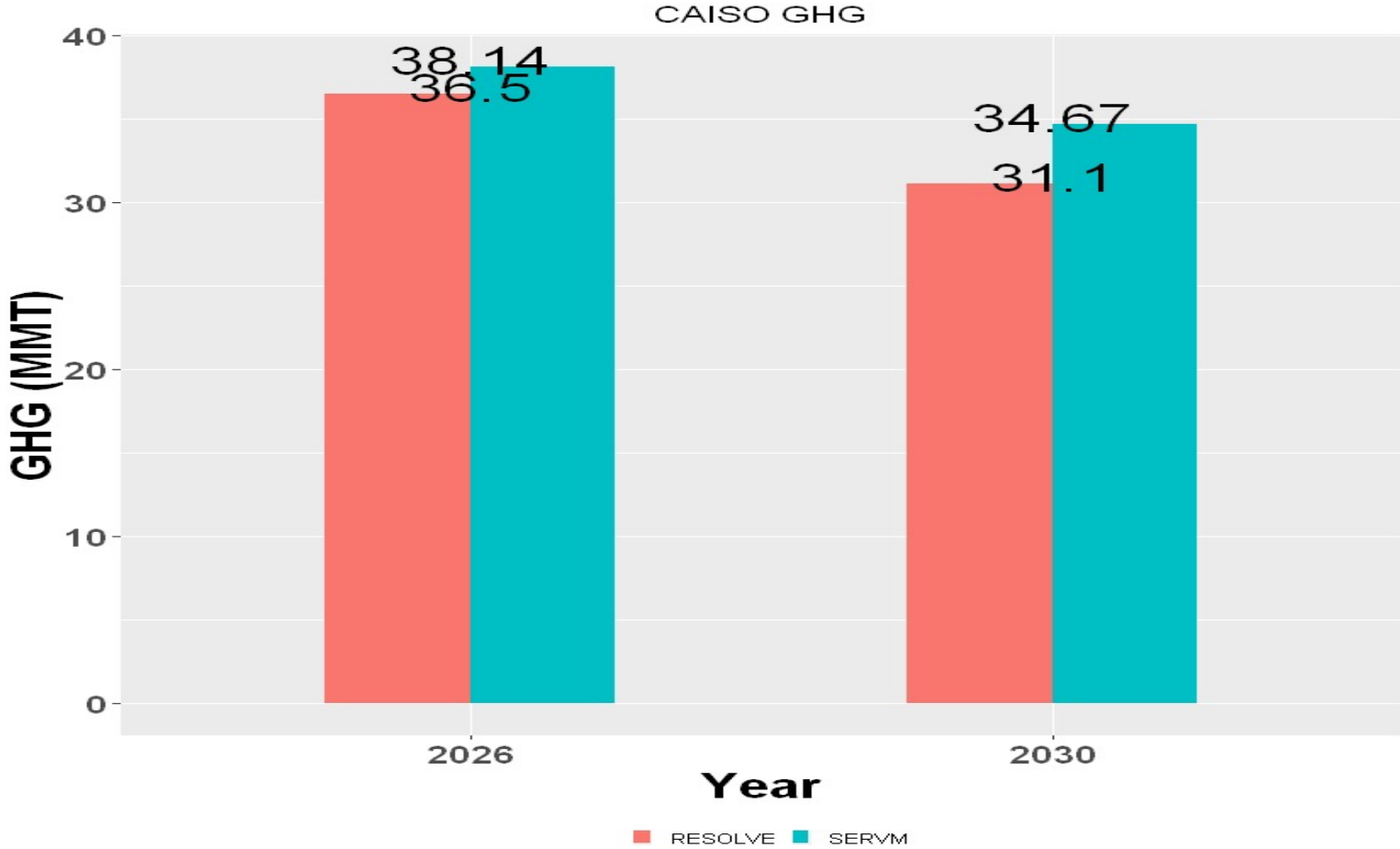
GWh	2026 RESOLVE	2026 SERVM	2030 RESOLVE	2030 SERVM
GHG emitting	55,084	69,689	41,249	63,404
GHG free	173,526	177,930	201,684	201,892
Total	228,610	247,619	242,933	265,296
% different		8.3%		9.2%

38 MMT Core LOLE Capacity results for the CAISO area

Reliability and GHG Metrics	38 MMT 2030	38MMT 2026
LOLE (expected outage events/year)	0.054	0.064
LOLH (hours/year)	0.15	0.21
LOLH/LOLE (hours/event)	1.72	1.76
EUE (MWh)	187.45	292.28
annual load (MWh)	265,753,062	255,345,985
normalized EUE (%)	7.054E-07	1.145E-06
GHG (MMT)	34.67	38.14

Findings: LOLE is less than 0.1 in both 2026 and 2030, meaning this portfolio is reliable. GHG emissions in 2026 are about 1.5 MMT higher than RESOLVE but GHG emissions in 2030 are about 3 MMT higher than RESOLVE.
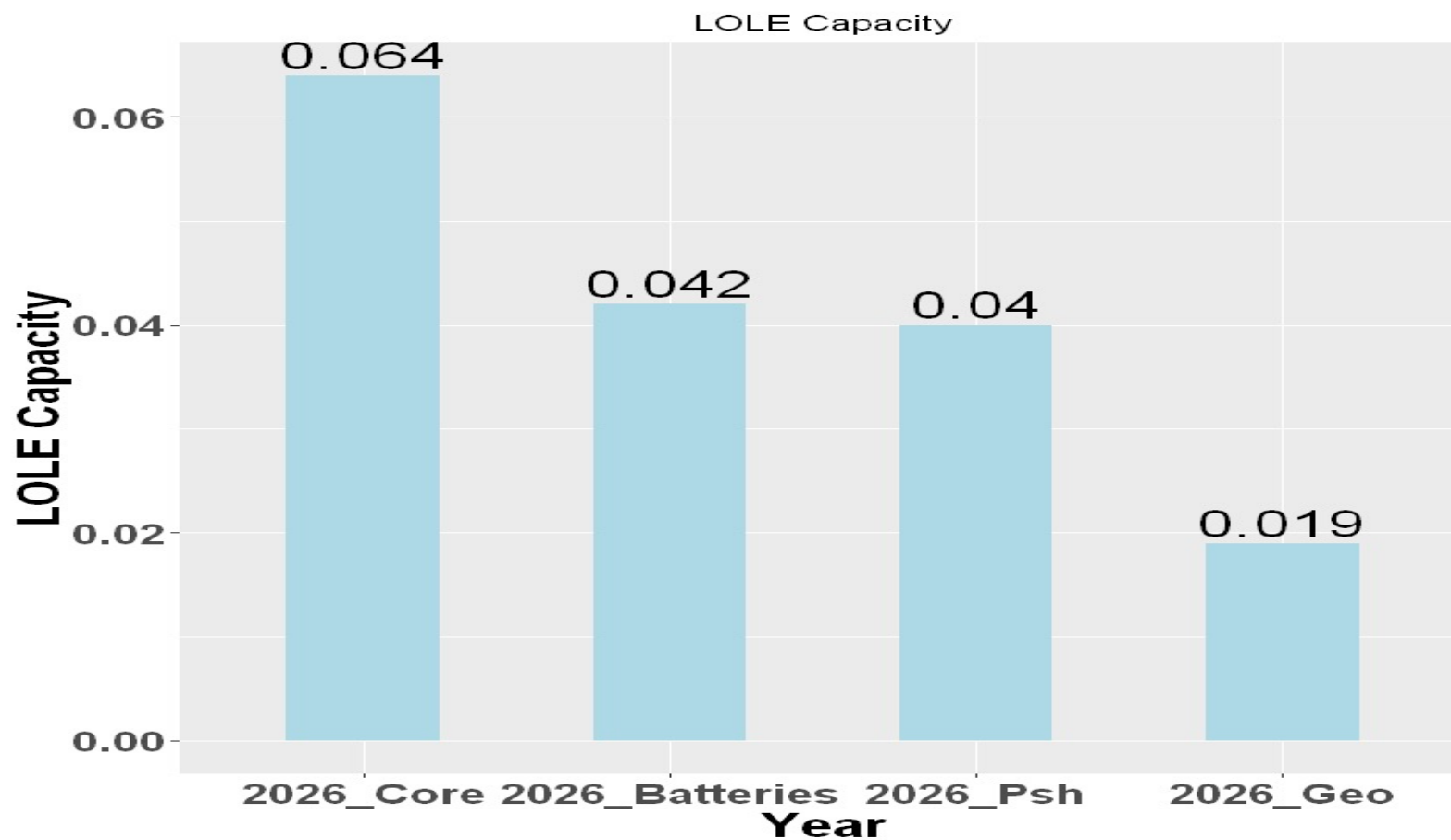
38 MMT Core Total CAISO CO2 emissions in MMT, including BTM CHP

Generation by unit category for 2026: Core vs. 3 Sensitivities
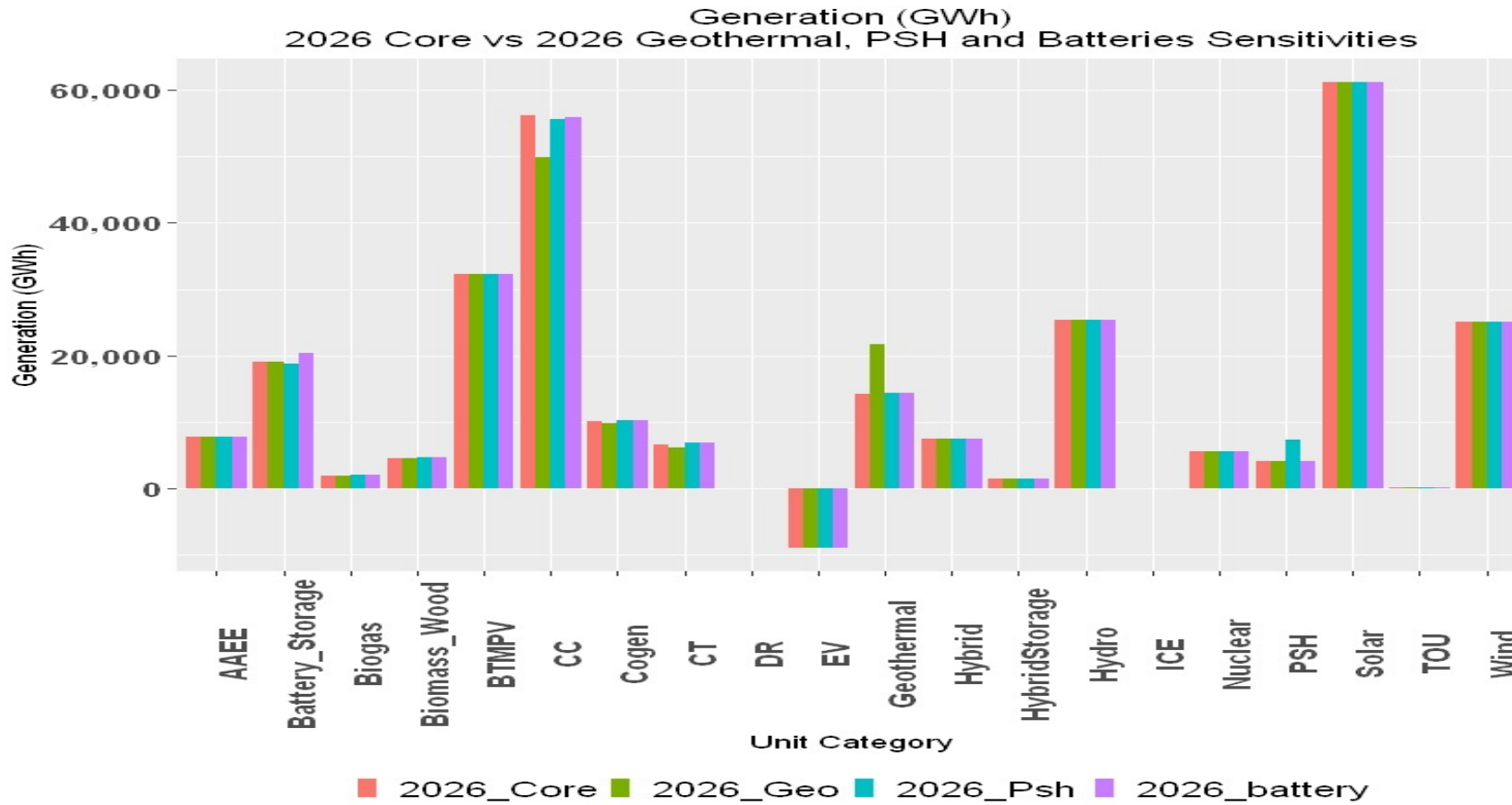
Generation (GWh)
2026 Core vs 2026 Geothermal, PSH and Batteries Sensitivities

LOLE for 2026: Core case vs. Sensitivities

LOLE Capacity chart showing: 2026_Core = 0.064, 2026_Batteries = 0.042, 2026_Psh = 0.04, 2026_Geo = 0.019

GHG for 2026: Core case vs. Sensitivities
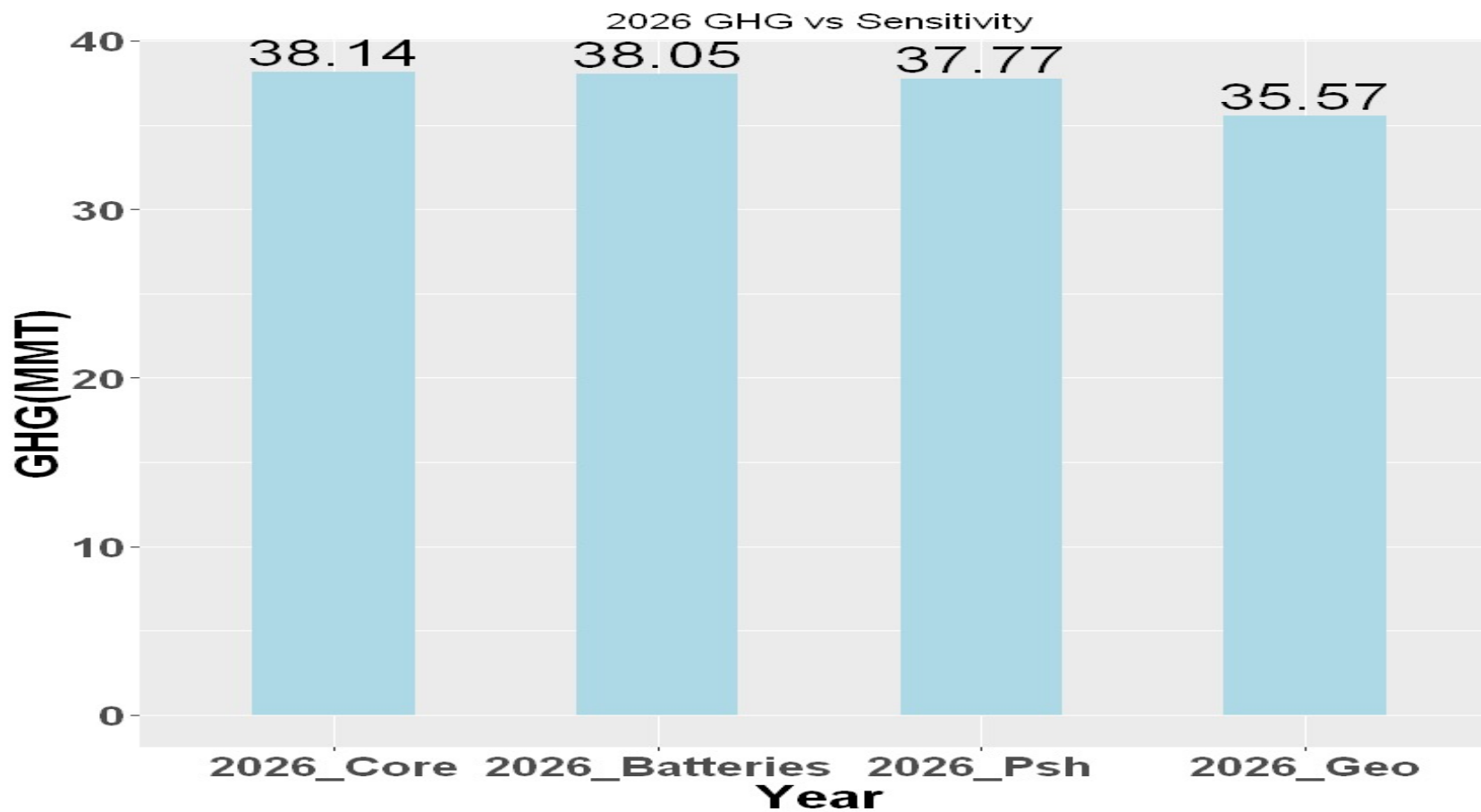
38 MMT Core (2026) : EUE (MWh) by Hour and Month
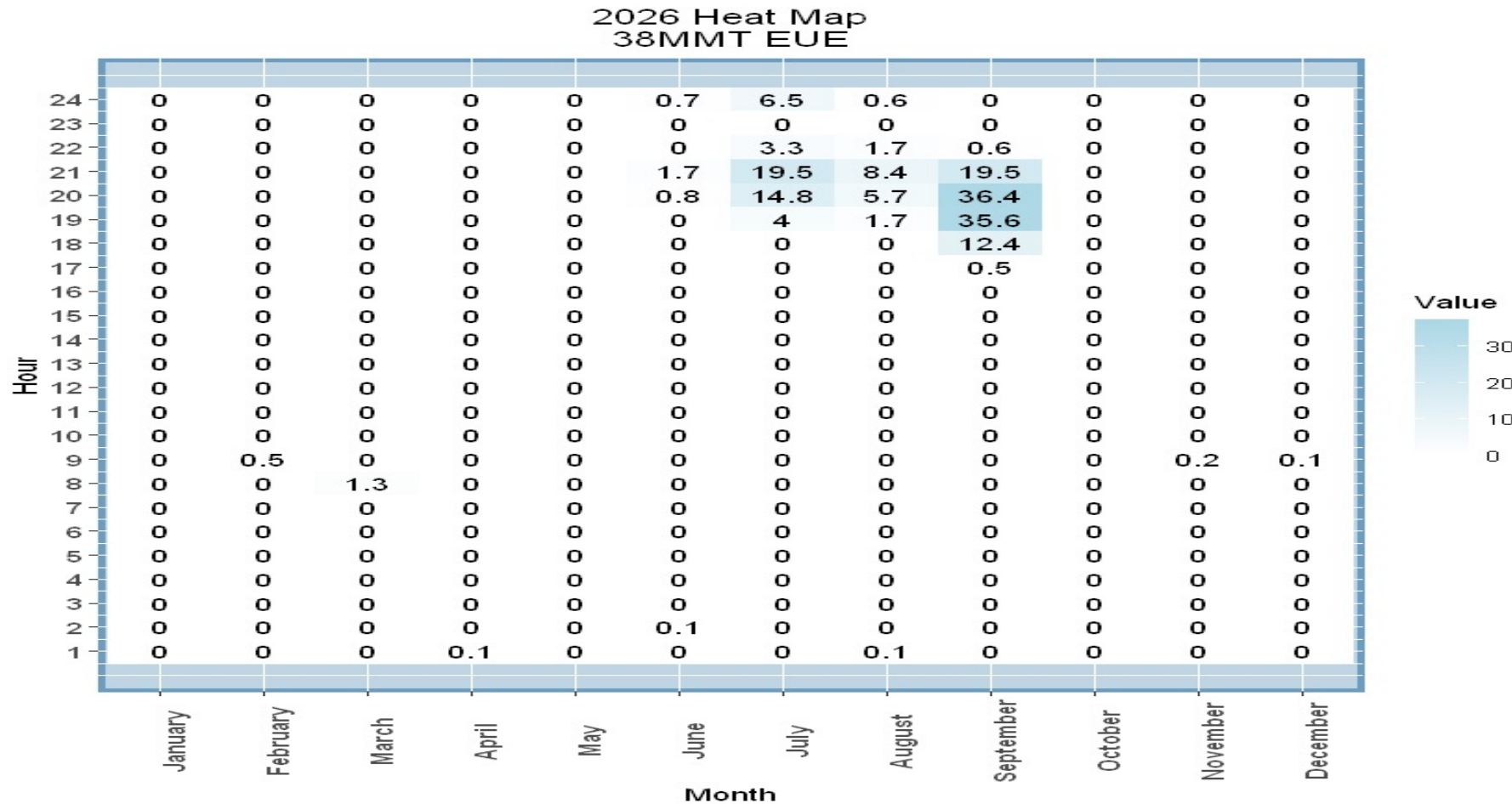
2026 Heat Map
38MMT EUE

Total EUE is less than the LSE Aggregated Plans because it is a more reliable case, but EUE is spread to different hours of the day and year.

38 MMT Core (2030) : EUE (MWh) by Hour and Month
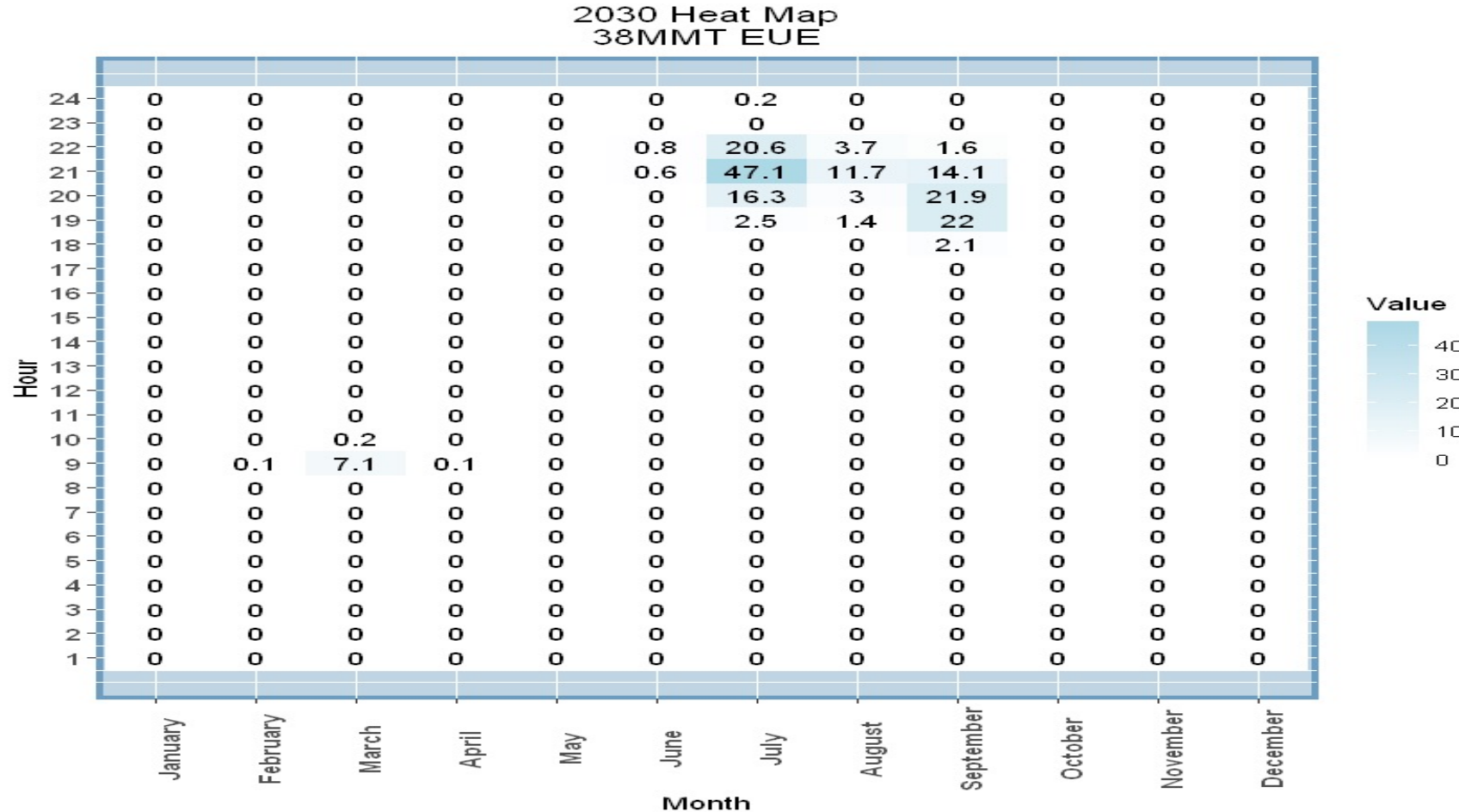
2030 Heat Map
38MMT EUE

Total EUE is less than the LSE Aggregated Plans because it is a more reliable case, but EUE is spread to different hours of the day and year.

38 MMT Core : 2026 CAISO monthly Import/Export

38_2026 CAISO monthly Import/Export (GWh)
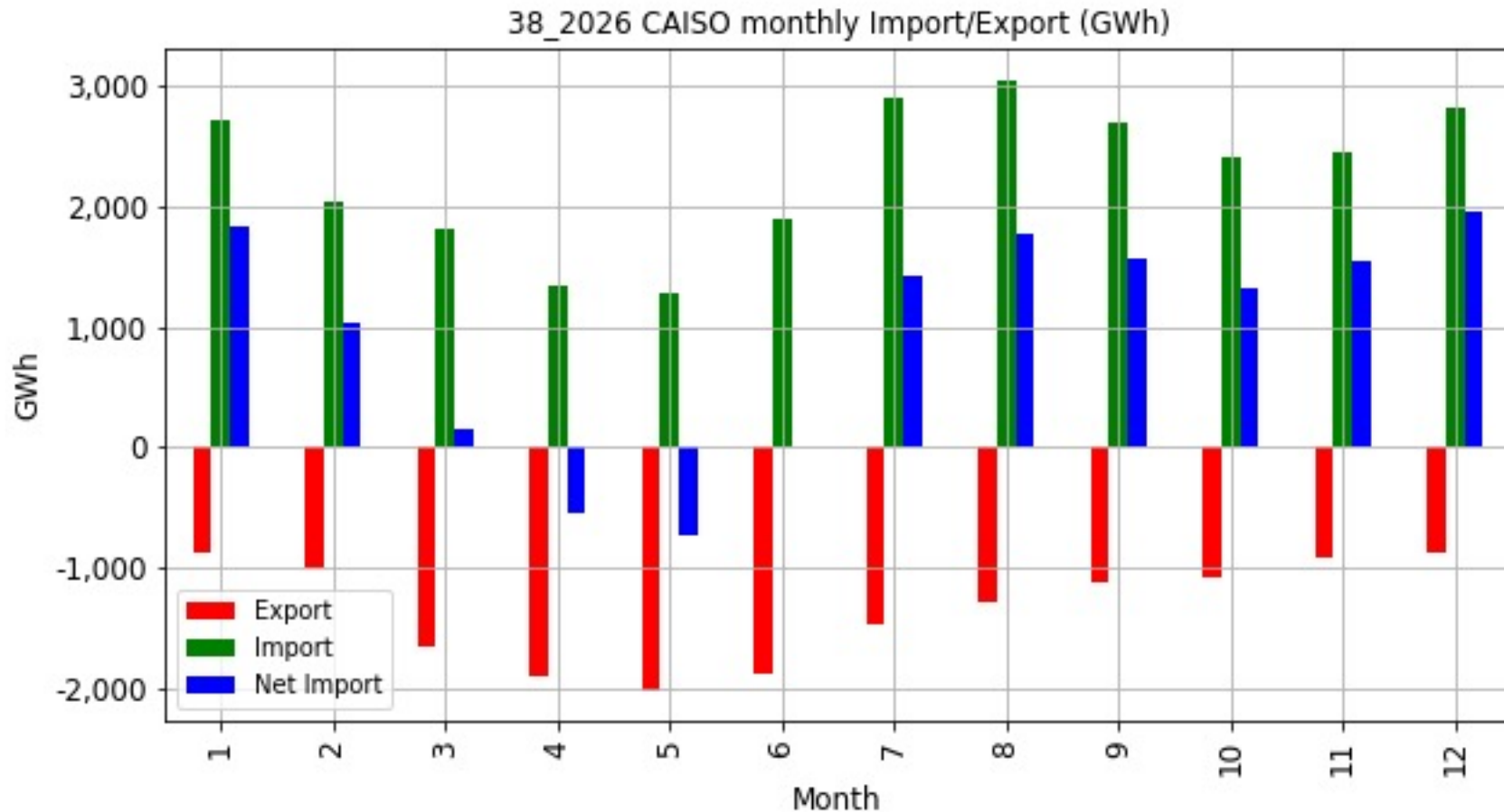
In 38 MMT Core case, CAISO is a net importer for 10 out of 12 months

38 MMT Core : 2030 CAISO monthly Import/Export

38_2030 CAISO monthly Import/Export (GWh)
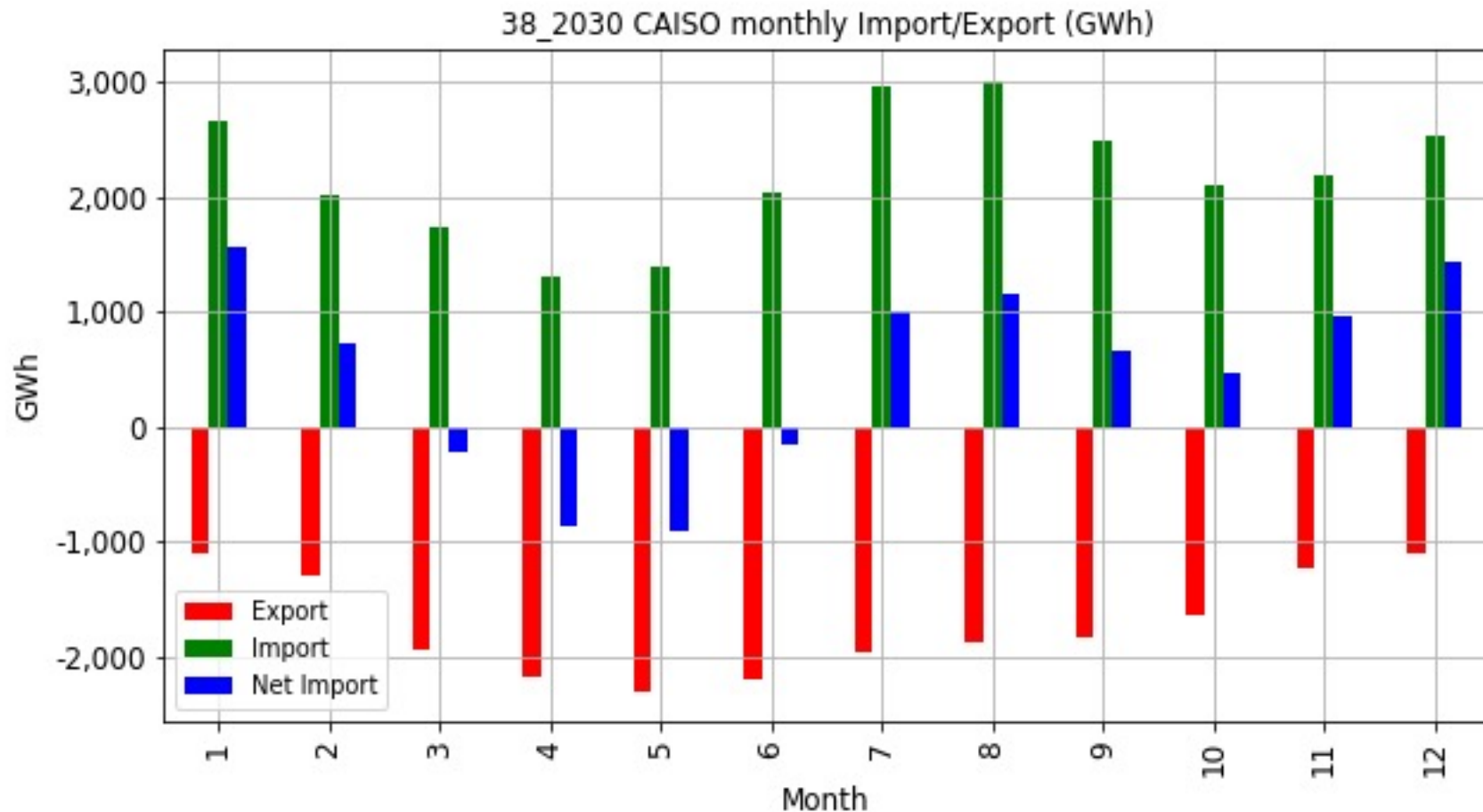
In 38 MMT Core case, CAISO is a net importer for 8 out of 12 months

38MMT 2026 Core Criteria Pollutant metric tons

CAISO total

These totals do not include biomass emissions due to incomplete data.

Unit_Category	All_NOx_Emission	Cold_Emission	Hot_Emission	Warm_Emission	NOx_Steady_Emission	PM_Emission	SO2_Emission
CC	2281.2	23.3	186.7	35.3	2035.9	1248.9	132.5
CT	1666.8	972.5	56.8	230.3	407.2	234.1	24.8
Cogen	1152.2	44.5	0.5	0.0	1107.2	231.8	24.6
ICE	19.6	0.0	5.3	0.0	14.3	2.6	0.2
Total	5119.9	1040.3	249.3	265.6	3564.7	1717.4	182.1

CAISO DAC

Unit_Category	All_NOx_Emission	Cold_Emission	Hot_Emission	Warm_Emission	NOx_Steady_Emission	PM_Emission	SO2_Emission
CC	499.6	2.8	47.3	0.7	448.9	271.0	28.7
CT	494.3	283.9	17.2	66.2	127.1	74.1	7.9
Cogen	289.5	15.3	0.1	0.0	274.1	57.4	6.1
Total	1283.5	302.0	64.6	66.9	850.0	402.5	42.7

Area_Category	All_NOx_Emission	Cold_Emission	Hot_Emission	Warm_Emission	NOx_Steady_Emission	PM_Emission	SO2_Emission
CA	6038.2	1154.0	291.8	292.2	4300.1	2085.2	220.9
OutOfCA	47122.2	731.8	182.5	37.4	46170.4	14541.2	42955.4

38MMT 2030 Core criteria pollutant in metric tons

CAISO total

Unit_Category	All_NOx_Emission	Cold_Emission	Hot_Emission	Warm_Emission	NOx_Steady_Emission	PM_Emission	SO2_Emission
CC	2042.4	17.3	206.9	37.4	1780.7	1095.3	116.2
CT	1735.5	1032.4	48.0	208.9	446.2	252.8	26.8
Cogen	1131.2	43.8	0.5	0.0	1086.9	227.6	24.1
ICE	16.3	0.0	4.5	0.0	11.8	2.2	0.2
Total	4925.4	1093.5	260.0	246.3	3325.5	1577.8	167.3

CAISO DAC total

Unit_Category	All_NOx_Emission	Cold_Emission	Hot_Emission	Warm_Emission	NOx_Steady_Emission	PM_Emission	SO2_Emission
CC	444.2	1.9	50.4	0.6	391.3	236.0	25.0
CT	511.3	306.0	14.1	57.1	134.1	77.3	8.2
Cogen	286.7	14.6	0.1	0.0	272.0	57.0	6.0
Total	1242.2	322.5	64.6	57.7	797.4	370.3	39.3

Area_Category	All_NOx_Emission	Cold_Emission	Hot_Emission	Warm_Emission	NOx_Steady_Emission	PM_Emission	SO2_Emission
CA	5891.6	1207.4	304.2	276.2	4103.8	1964.4	208.1
OutOfCA	47576.0	605.4	169.4	36.9	46764.3	15065.4	42852.9

Utilities Commission

38MMT Core CA criteria pollutants comparison in metric tons: SERVM mix vs CARB projection

POLLUTANTS	2026 CARB	2030 CARB	2026 SERVM	2030 SERVM	2026 Difference	2030 Difference
NOX	7,341	7,567	6,038	5,891	-1303	-1675
SOX	1,356	1,409	221	208	-1135	-1201
PM	2,096	2,145	2,085	1,964	-11	-181

The SERVM results reflect a cleaner resource mix than when CARB made their projections. Some of the cleaner resource mix may be driven by CPUC/LSE actions, and some may be driven by non-CAISO resource mix change.

Source for CARB projections here: https://www.arb.ca.gov/app/emsinv/fcemssumcat/fcemssumcat2016.php

California Public Utilities Commission