2023 Proposed Preferred System Plan Reliability and Emissions Analysis

Energy Division Staff
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California Public
Utilities Commission

Outline

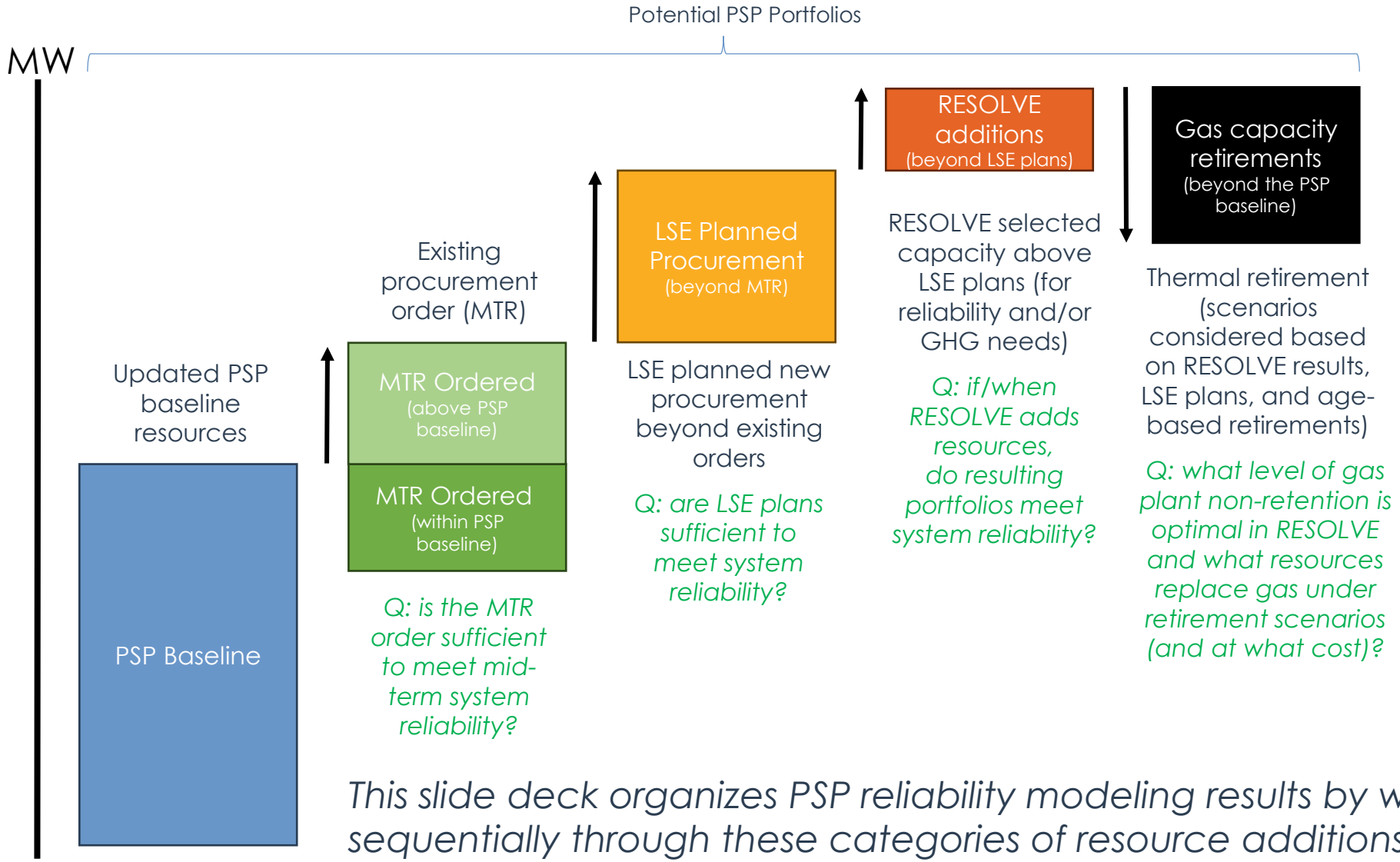
- Baseline resources & key inputs to SERVM
- Reliability analysis
  - Baseline-only
  - Baseline + ordered procurement
- Reliability & emissions analysis
  - Baseline + LSE Plans
  - Potential PSP portfolios
- Other observations

Context: Overview of Preferred System Plan (PSP) Analysis Categories

- This deck focuses on reliability and emissions analysis needed to support PSP development. The table below shows the sections of this deck **in bold**, in the context of the other analyses supporting PSP development.
- The names are used consistently throughout this deck, as well as the 2023 Proposed PSP and 2024-2025 TPP RESOLVE Analysis deck. More detailed information is available in the corresponding sections referenced in the table.

Analysis Name	Description	Model(s) Used	Use Case(s)	PSP Slide Deck (Section Name)
Baseline-Only	Determine current reliability situation based on A) planned retirements and B) baseline existing and in-development resources coming online between 2024-2028	SERVM	Inform Baseline + Ordered Procurement analysis	2023 PSP Reliability and Emissions Analysis Slides (**Reliability Analysis – Baseline-Only**)
Baseline + Ordered Procurement	Estimate sufficiency of the Mid-Term Reliability (MTR) orders after analyzing MTR incremental capacity in the 2023 PSP baseline	SERVM	Inform 2023 PSP development, determine need for additional procurement action, and comparison to SB 846 and CAISO's 2023 Summer Assessment	2023 PSP Reliability and Emissions Analysis Slides (**Reliability Analysis – Baseline + Ordered Procurement**)
Baseline + LSE Plans	Examine the reliability and emissions of aggregated LSE plans	SERVM	Reliability and emissions analysis to inform the use of RESOLVE to develop potential PSP portfolios	2023 PSP Reliability and Emissions Analysis Slides (**Reliability & Emissions Analysis – Baseline + LSE Plans**)
Potential PSP Portfolios	RESOLVE portfolios simulated in SERVM to examine reliability and GHG emissions		Decision-making for 2023 PSP and 2024-25 TPP	2023 PSP Reliability and Emissions Analysis Slides (**Reliability & Emissions Analysis – Potential PSP Portfolios**)
Core Cases	*Potential PSP cases optimized with 11/1/2022 LSE Plans as minimum build constraint*	*RESOLVE SERVM*	As above	*2023 Proposed PSP and 2024-2025 TPP RESOLVE Analysis (25 MMT Core Case; 30 MMT Core Case)*
Least-Cost Cases	*Potential PSP Cases optimized to least-cost without 11/1/2022 LSE Plans*	*RESOLVE SERVM*	As above	*2023 Proposed PSP and 2024-2025 TPP RESOLVE Analysis (25 MMT Least-Cost; 30 MMT Least-Cost)*
Sensitivity Cases	*Test changes to portfolio results to least-cost cases, using alternative assumptions for key variables*	*RESOLVE*	*As above*	*2023 Proposed PSP and 2024-2025 TPP RESOLVE Analysis (multiple sections)*

PSP Reliability & Emissions Studies Focus on Building Up the PSP Portfolios from the Baseline



This slide deck organizes PSP reliability modeling results by walking sequentially through these categories of resource additions/ retirements

Baseline Resources & Key Inputs to SERVM

Modeling Updates Since February 2023

- Staff has made various input updates since those used to model the Base Portfolio for use in CAISO's 2023-24 Transmission Planning Process, released by the CPUC in February 2023
- Refer to 2023 Inputs & Assumptions (I&A) documents, including June 2023 workshop materials at 2022-2023 IRP Cycle Events and Materials (ca.gov)
  - Staff has made updates to the draft 2023 I&A; final version is being posted in conjunction with this slide deck
- In this section staff describes the key inputs and updates made to the SERVM model, relevant to reliability and emissions analysis

Generating Units

- Staff updated its Baseline resource list, which involved reconciling data from multiple sources (CAISO, WECC, EIA, CPUC, CEC) and developing a common list of units for both SERVM and RESOLVE models
    - CAISO Master Generating Capability (MGC) List as of 1/2023 (updated online status of in development resources and reconciled with newly online units)
    - 11/1/2022 LSE IRP compliance filings
    - 1/2023 NQC List
    - WECC Anchor Dataset 2032
    - Unit operating data updated from 2018$ to 2022$ from latest CAISO MasterFile
    - OTC steam units assumed to go offline by 2023 and DCPP assumed to go offline in 2024/25, and no further retirements
- Cogen/Biomass/Biogas/Geothermal operating constraints: monthly capmax and capmin were calculated to reflect historical operations and minimum dispatch observed in the CAISO bidding database
    - Average production during peak managed demand used as capmax (equivalent to resource NQC)
    - The Max of Day Ahead Market scheduled and Real Time Market bid level was used to determine capmin
    - Cold and hot startup profiles updated
    - Imposing monthly capmax and capmin for Cogen/Geothermal/Biomass/Biogas units distorted heat rate curves. Corrected by using a single point heat rate curve matching the average heat rate from CAISO Masterfile data.
- SERVM-centric Generator List available here: System Reliability Modeling Datasets 2023 (ca.gov)
- RESOLVE-centric Generator List available here: Aggregated LSE Plan and Baseline and Dev Resources

Key Hydro, Transmission Topology, and External Region Inputs

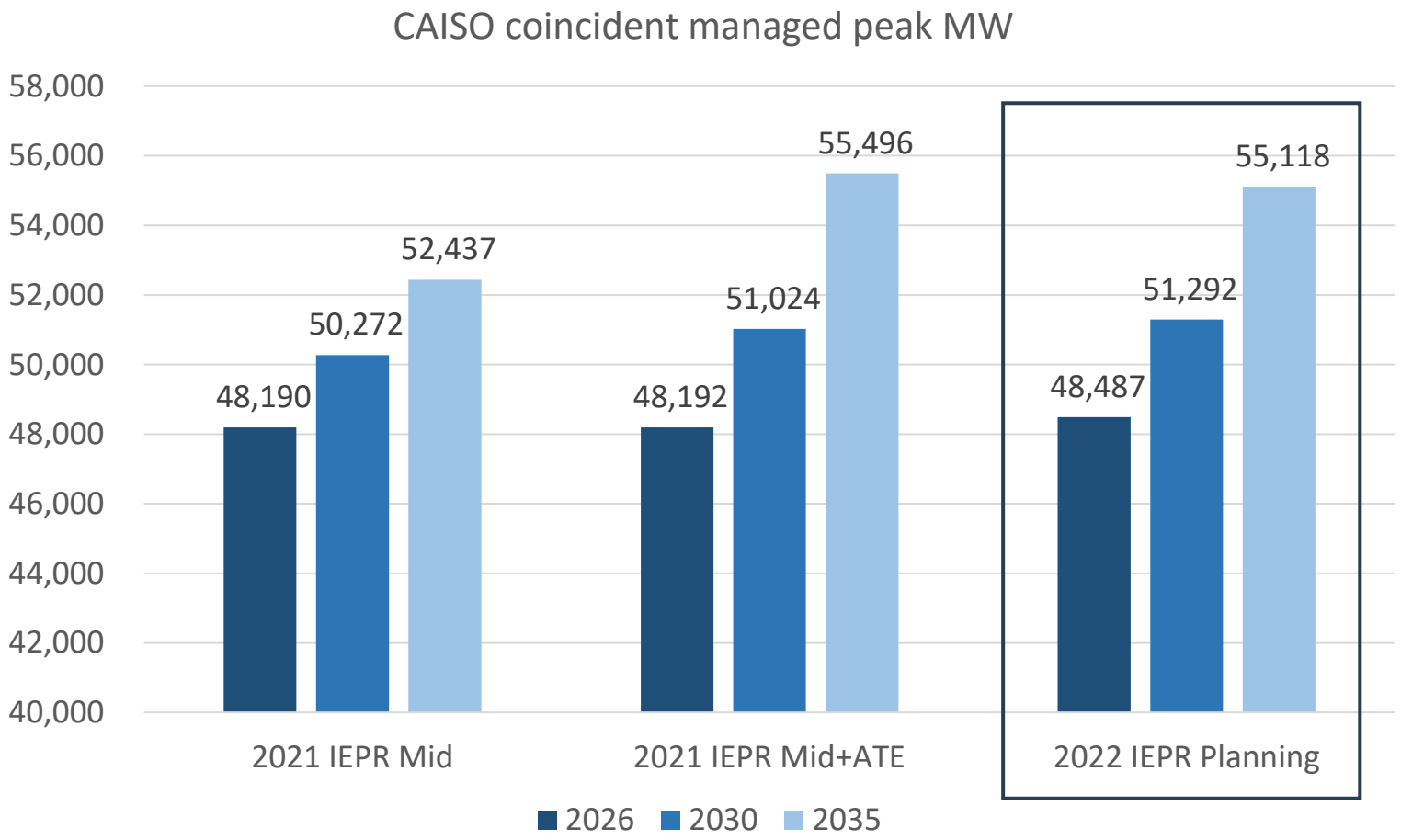
- 1998-2020 hydroelectric data and methodology refreshed
  - Hourly and monthly data collected from EIA, CAISO, BPA
  - Detrended monthly data used to develop dispatch model
  - Emergency hydro capacity added
  - Made hydro years independent of weather years in model stochastic inputs. This increases the number of hydro-demand combinations.
- Path 26 transmission limits enforced at current path rating (4,000 MW North to South and 3,000 MW South to North)
- External to California regions limited to adjacent areas in Pacific Northwest and Southwest
  - CAISO summer evening hour simultaneous imports capped at 4,000 MW, otherwise about 11 GW in all other hours
  - Load and resource balance for external regions tuned to approximate a 0.1 LOLE reliability level for all study years
- Climate change effects not yet included in hydro or weather dependent inputs, but Climate Informed Forecasting approach to be tested as a sensitivity later this year
  - Plan to test reliability impact of electric demand shape changes due to global average temperature increases of approximately 1.5 to 3 C

Electric demand and cost data updates for 2023 PSP

The following input updates were made to those used to model the Base Portfolio for use in CAISO's 2023-24 Transmission Planning Process, released by the CPUC in February 2023:

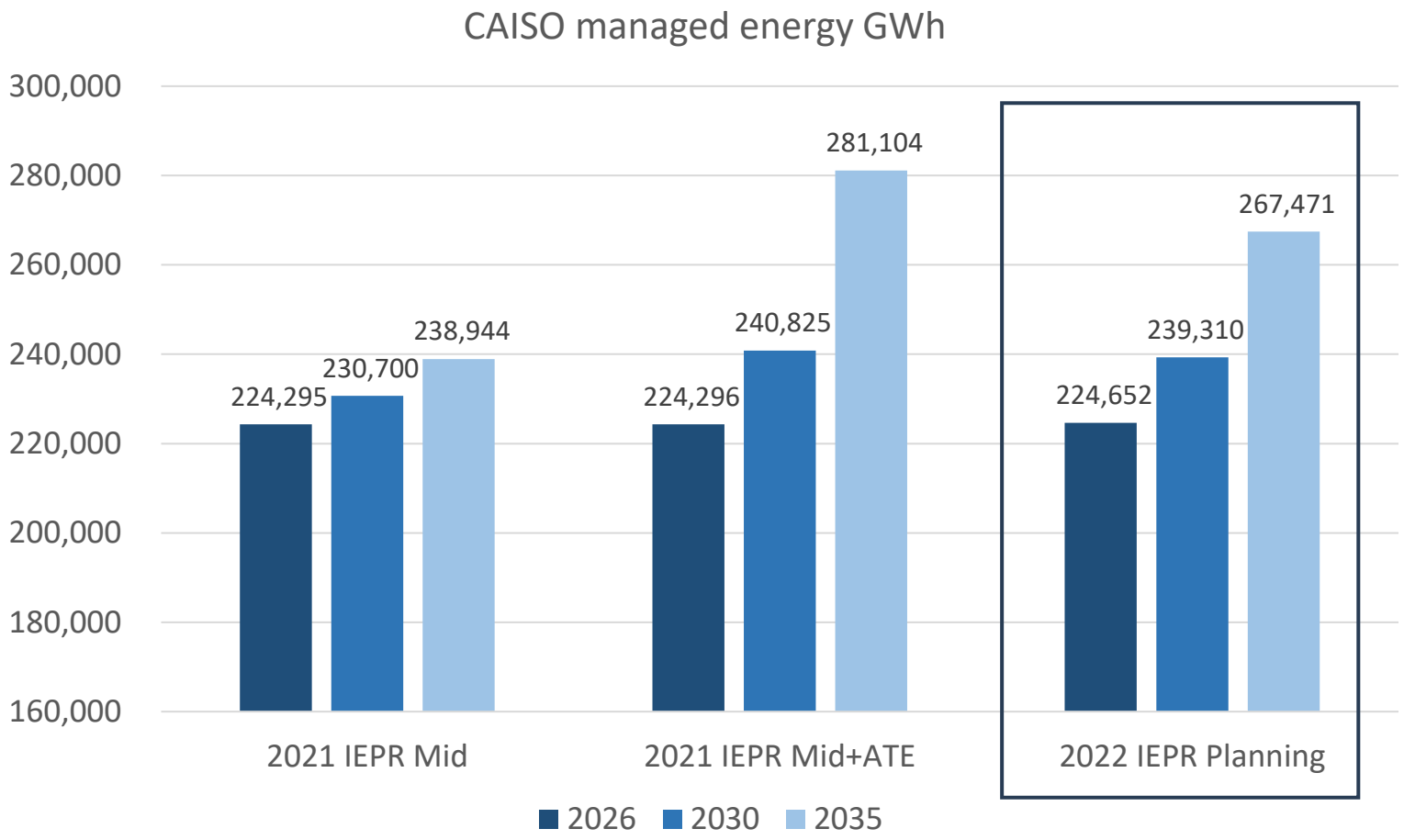
- Updated to 2022 IEPR Planning Peak and Energy Forecast data
  - Hourly demand modifier profiles (AAEE, AAFS, AATE, EVs, TOU rates, BTM storage) drawn directly from the 2022 IEPR
  - BTM PV annual energy by IEPR Planning Area drawn from the 2022 IEPR and used to calibrate SERVM's BTM PV hourly profiles
  - CAISO coincident managed peak modeled in SERVM calibrated to match with IEPR
- Cost input updates
  - Gas prices and gas delivery hubs (in 2022 dollars) updated from CEC's draft 2023 NAMGas model
  - Carbon prices derived from the GHG price forecast included with 2022 IEPR in 2022$
  - Transmission import hurdle rates escalated from 2018$ to 2022$
  - Unit variable costs updated from 2018$ to 2022$ from latest CAISO MasterFile

Comparison 2021 IEPR vs. 2022 IEPR Managed Peak Forecast



- 2022 IEPR Planning case is the primary load forecast used in current IRP studies
- 2021 IEPR Mid was used for LSE Plans filed in 2022
- 2035 managed peak rises more rapidly in 2022 IEPR Planning case than in 2021 IEPR Mid
- 2021 IEPR Mid+ATE case is also shown because it was used for the 2023-24 TPP studies

Comparison 2021 IEPR vs. 2022 IEPR Managed Energy Forecast



- 2022 IEPR Planning case is the primary load forecast used in current IRP studies
- 2021 IEPR Mid was used for LSE Plans filed in 2022
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- 2021 IEPR Mid+ATE case is also shown because it was used for the 2023-24 TPP studies

Reliability Analysis – Baseline-Only

Baseline-Only Studies: Definition and Purpose

- Baseline-only studies are designed to determine the current reliability situation based on A) planned retirements, and B) Baseline existing and in-development resources coming online over the near to mid-term years (2024-2028)
  - Modeled resources include only Baseline resources (online and/or in-development) and **excludes** "Planned New/Review" resources from the 11/2022 LSE IRP filings
  - "In-development" resources are those from 11/2022 LSE IRP filings, not online but with executed contracts as at 8/1/2022
- Baseline-only resources include a portion of ordered procurement (e.g., MTR) but not all of it
  - Baseline includes approximately 5,000 MW of in-development MTR procurement
  - Baseline does not include the remaining approximately 10,500 MW order that is not yet in-development
- Electric demand inputs use the 2022 IEPR Planning Peak and Energy Forecast
- Staff tuned/quantified the amount of "Perfect Capacity" (i.e., PCAP or ELCC MW) required to be added to the Baseline to achieve 0.1 days/year LOLE in each year from 2024 through 2028
- Results are informative to Baseline + Ordered Procurement analysis (next section)

Baseline-Only Nameplate MW, by study year

Unit Category	2024	2025	2026	2027	2028
Storage	12,385	12,845	12,946	12,946	12,946
Battery Storage	8,614	9,074	9,175	9,175	9,175
Hybrid_BattStorage	882	882	882	882	882
Paired_BattStorage	1,407	1,407	1,407	1,407	1,407
PSH	1,483	1,483	1,483	1,483	1,483
Gas	27,814	27,814	27,833	27,833	27,833
CC	17,528	17,528	17,528	17,528	17,528
Cogen	1,823	1,823	1,842	1,842	1,842
CT	8,204	8,204	8,204	8,204	8,204
ICE	259	259	259	259	259
Biomass	669	669	669	669	669
Coal (Intermountain)	480	0	0	0	0
DR	2,404	2,230	2,381	2,238	2,242
Geothermal	1,290	1,290	1,330	1,351	1,384
Hydro	5,374	5,374	5,374	5,374	5,374
Nuclear	2,935	1,785	635	635	635
Solar	19,948	19,948	19,948	19,948	19,948
Solar_1Axis	11,799	11,799	11,799	11,799	11,799
Solar_2Axis	13	13	13	13	13
Solar_Fixed	6,228	6,228	6,228	6,228	6,228
Solar_Thermal	997	997	997	997	997
Hybrid_Solar_1Axis	711	711	711	711	711
Hybrid_Solar_Fixed	200	200	200	200	200
Wind	7,713	7,789	7,789	7,789	7,789
Total MW	81,013	79,745	78,906	78,783	78,821

- For units whose MW values vary by month, the July values were used for this table

Baseline-Only Studies: Reliability Results Before and After Tuning with Perfect Capacity

Annual Reliability Metrics		Before tuning to 0.1 LOLE					After tuning to 0.1 LOLE				
Metric	Units	2024	2025	2026	2027	2028	2024	2025	2026	2027	2028
LOLE	days/year	0.43	2.04	1.92	3.14	4.10	0.12	0.10	0.10	0.10	0.10
EUE	MWh	997	12,193	12,386	23,873	29,769	187	198	191	156	188
LOLH	hours/year	0.85	5.35	5.22	9.29	11.88	0.19	0.19	0.17	0.14	0.16
LOLH/LOLE (average length of outage)	hours/day	2.0	2.6	2.7	3.0	2.9	1.6	1.9	1.6	1.4	1.5
Normalized EUE (EUE / total electric demand)	percent	0.00040%	0.00486%	0.00487%	0.0093%	0.01143%	0.00008%	0.00008%	0.00007%	0.00006%	0.00007%
PCAP added to return to 0.1 LOLE	MW	N/A	N/A	N/A	N/A	N/A	2,200	6,000	5,800	8,000	8,000

Baseline-Only Studies: Conclusions

- Baseline-only studies were performed for near- to mid-term study years 2024 through 2028. Staff identified whether the system as-is was reliable (LOLE below 0.1) and if unreliable, how much PCAP (i.e. ELCC MW) must be added to return the system to adequate reliability
- All study years were initially found to be unreliable but were returned to reliability after adding PCAP ranging from 2,200 MW in 2024 to 8,000 MW in 2028
  - While the Perfect Capacity need is smaller in 2024, due to the 2024 contracted additions in the Baseline, the need grows significantly in 2025 and beyond as Diablo Canyon retires
  - The Baseline includes some capacity that is contracted but not yet online, mainly in 2024
- This analysis demonstrates that significant new capacity in addition to the Baseline is needed to ensure reliability
  - It can be used to assess the sufficiency of the existing MTR procurement orders, and risks to that procurement (next section)
  - Staff notes that contracts for new resources entered after the cutoff date for LSEs' 11/1/2022 plans are excluded from the Baseline studied here, and help address the PCAP shortfalls found

Reliability Analysis – Baseline + Ordered Procurement

Baseline + Ordered Procurement

- After analyzing the MTR incremental capacity in the 2023 PSP Baseline (~5,000 Perfect Capacity MW by 2026), an estimation of the sufficiency of the MTR order was performed via the following method:
  1. Calculate the cumulative MTR MW targets
  2. Subtract the MTR incremental procurement in the 2023 PSP Baseline to calculate the "remaining MTR procurement"
  3. Compare the remaining MTR procurement to the calculated PCAP shortfall from the Baseline-only studies, to calculate any potential MTR "gap"
     - If PCAP shortfall > remaining MTR procurement, there is a gap
     - If PCAP shortfall < remaining MTR procurement, there is a surplus
- Initial runs were conducted using the PSP Baseline thermal retention assumptions (no gas retires beyond the modeled attrition of the OTC plants at the end of 2023)
- Key additional risks include further gas retirements, import availability, climate change impact risks, and project development delays
- Results are informative for 2023 PSP development and determining the need for additional procurement action. They are also compared to similar studies including various SB 846 required studies and CAISO's 2023 Summer Assessment (see final section).

MTR Sufficiency Analysis: Result

	(Units = Perfect capacity MW)	2023	2024	2025	2026	2027	2028	Notes
A	MTR Ordered Procurement (annual)	2,000	6,000	1,500	2,000	2,000	2,000	
B	MTR Ordered Procurement (cumulative)	2,000	8,000	9,500	11,500	13,500	15,500	Cumulative sum of A
C	MTR Incremental Procurement (in PSP Baseline)	2,896	4,219	4,578	4,700	4,719	4,750	Source: Staff analysis of RESOLVE-centric Generator List
D	Remaining MTR Procurement (above PSP Baseline)	(896)	3,781	4,922	6,800	8,781	10,750	B – C
E	SERVM PCAP Shortfall (using PSP Baseline)	n/a	2,200	6,000	5,800	8,000	8,000	Direct SERVM model outputs
F	MTR Gap: MTR ordered relative to SERVM shortfall	n/a	**(1,581)**	**1,078**	**(1,000)**	**(781)**	**(2,750)**	E – D

- Assuming full gas plant retention*:
  - 2024, 2026, 2027, and 2028 have moderate surplus capacity in the MTR order
  - 2025 has a deficit of ~1,100 MW (the MTR order is not sufficient in that year)

* Full retention here means all gas units retained except for the OTC plants, which IRP models to retire at the end of 2023

MTR Sufficiency Analysis: Result, with Gas Retirement Risk

	(Units = Perfect capacity MW)	2023	2024	2025	2026	2027	2028	Notes
F	MTR Gap: MTR ordered relative to SERVM shortfall	n/a	(1,581)	1,078	(1,000)	(781)	(2,750)	E – D
G	Reliability need impact: *40-yr age-based retirements*		**89**	**419**	**545**	**1,018**	**1,438**	PCAP impact using RESOLVE-centric Generator List
H	MTR Gap: Ordered relative to SERVM shortfall		**(1,492)**	**1,497**	**(455)**	**237**	**(1,312)**	F + G

- Gas retirement risk analyzed based on 40-year age-based gas plant retirements. The PCAP impact of these potential additional gas retirements reduces the MTR surplus or increases the MTR shortfall, dependent on year.

MTR Sufficiency Analysis: Result, with Development Risk

	(Units = Perfect capacity MW)	2023	2024	2025	2026	2027	2028	Notes
F	MTR Gap: MTR ordered relative to SERVM shortfall	n/a	(1,581)	1,078	(1,000)	(781)	(2,750)	E – D
I	Reliability need impact: *1-year delay to 20% of ordered procurement*		**1,200**	**300**	**400**	**400**	**400**	
J	MTR Gap: Ordered relative to SERVM shortfall		**(381)**	**1,378**	**(600)**	**(381)**	**(2,350)**	F + I
K	Reliability need impact: *1-year delay to 40% of ordered procurement*		**2,400**	**600**	**800**	**800**	**800**	
L	MTR Gap: Ordered relative to SERVM shortfall		**819**	**1,678**	**(200)**	**19**	**(1,950)**	F + K

- Project development risk analyzed based on 20-40% of ordered procurement failing to come online in the ordered year

MTR Sufficiency Analysis: Result, with Climate Risk

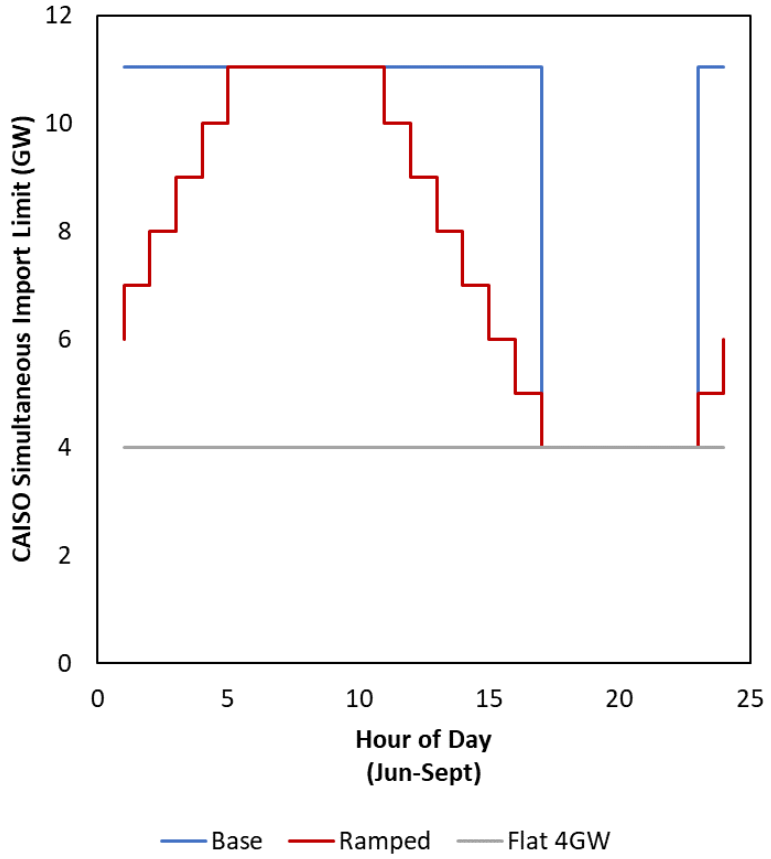
	(Units = Perfect capacity MW)	2023	2024	2025	2026	2027	2028	Notes
F	MTR Gap: MTR ordered relative to SERVM shortfall	n/a	(1,581)	1,078	(1,000)	(781)	(2,750)	E – D
M	Reliability need impact: *Weather-year re-weighting*		**1,500**	**1,500**	**1,500**	**1,500**	**1,500**	SERVM analysis
N	MTR Gap: Ordered relative to SERVM shortfall		**(81)**	**2,578**	**500**	**719**	**(1,250)**	F + M
O	Reliability need impact: *Strategic Reserve Procurement**		**(2,430)**	**(2,430)**	**(2,430)**	**0**	**0**	Staff estimate
P	MTR Gap: Ordered relative to SERVM shortfall		**(2,511)**	**148**	**(1,930)**	**719**	**(1,250)**	F + M + O

- Climate risk analyzed based on re-weighting of SERVM's 23 weather years (1998-2020)
  - 2020's extreme August heat event re-weighted to occur every 5 years, instead of every 23 years, increasing PCAP need by 1,500 MW
  - Broadly representative of more frequent extreme heat events, though not tied to any specific climate modeling scenario
- Use of OTC units in the strategic reserve during extreme climate events mitigates against the climate risk analyzed

* Strategic reserve procurement based on DWR June 2023 Investment Plan, assuming 2,859 MW @ 85% ELCC available through 2026

Imports and Reliability

- SERVM imports are currently modeled via the following base constraints:
  1. **Maximum simultaneous imports**: 11 GW during all hours except for hour ending (HE)18-22 Jun-Sept when only 4 GW are available (base or "binary" approach)
  2. **Import availability from neighbors**: during certain periods, resource availability from neighboring zones (NW, SW, other CA Balancing Areas) may limit the ability to deliver the maximum simultaneous imports
- While HE18-22 aligns well with recent reliability risk periods, as energy storage grows though MTR-driven procurement, loss of load risk hours are pushed into the 11 GW import periods before HE18 as energy sufficiency becomes a greater challenge
  - This means the current approach provides extra effective capacity value > 4 GW, but the amount is highly portfolio dependent
- Staff have conducted exploratory analysis using alternative maximum simultaneous import limits:
  - **Ramped maximum imports between 11 and 4 GW**: ramps down from 11 GW in HE11 to 4 GW in HE18
    - More conservative, recognizing imports may also be constrained in the late afternoon
  - **Flat 4 GW in all hours**: relies on a maximum of 4 GW across all hours
    - Even more conservative, recognizing increasing RA tightness across the WECC; could drive energy sufficiency / storage charging challenges earlier in the planning horizon by making CAISO more self-sufficient



MTR Sufficiency Analysis: Result, with Lower Imports

	(Units = Perfect capacity MW)	2023	2024	2025	2026	2027	2028	Notes
F	MTR Gap: MTR ordered relative to SERVM shortfall	n/a	(1,581)	1,078	(1,000)	(781)	(2,750)	E – D
Q	Reliability need impact: *Flat 4-GW imports, PSP Baseline*	*This is the extra effective capacity provided by the base (binary) approach, i.e. ~4,400 MW last-in ELCC*			**400**			SERVM analysis
R	MTR Gap: Ordered relative to SERVM shortfall				**(600)**			F + Q
S	Reliability need impact: *Flat 4-GW imports, LSE Plans*	*This is the extra effective capacity provided by the base (binary) approach, i.e. ~6,100 MW last-in ELCC*			**2,100**	*Greater shortfall shows higher reliability risk if only 4 GW of imports are available to CAISO throughout the day*		SERVM analysis
T	MTR Gap: Ordered relative to SERVM shortfall				**1,100**			F + S

- Bookend sensitivities were analyzed that remove the extra PCAP value provided by the "shaped imports" (vs. the more conservative "flat 4 GW imports" assumption)
- This was performed in two scenarios: A) PSP Baseline (moderate storage), B) PSP Baseline + LSE plans (high storage)
- The "base (binary)" imports assumption was found to have ~400-2,100 MW additional ELCC (beyond a flat 4 GW shape) due to imports outside HE18-22
- The "ramped" imports assumption was found to have ~0-1,500 MW additional ELCC (beyond a flat 4 GW shape) due to imports outside HE18-22

MTR Sufficiency Analysis: Result, if LLT PFM Relief Granted

	(Units = Perfect capacity MW)	2023	2024	2025	2026	2027	2028	Notes
A	MTR Ordered Procurement (annual)	2,000	6,000	1,500	2,000	2,000	**0**	**Extension granted from 2028 to 2031**
B	MTR Ordered Procurement (cumulative)	2,000	8,000	9,500	11,500	13,500	**13,500**	Cumulative sum of A
C	MTR Incremental Procurement (in PSP Baseline)	2,896	4,219	4,578	4,700	4,719	4,750	Source: Staff analysis of Generator List
D	Remaining MTR Procurement (above PSP Baseline)	(896)	3,781	4,922	6,800	8,781	**8,750**	B – C
E	SERVM PCAP Shortfall (using PSP Baseline)	n/a	2,200	6,000	5,800	8,000	8,000	Direct SERVM model outputs
F	MTR Gap: MTR ordered relative to SERVM shortfall	n/a	(1,581)	1,078	(1,000)	(781)	**(750)**	E – D

- D.21-06-035 and D.23-02-040 have ordered 13.5 GW NQC through 2027, and cumulative 15.5 GW NQC through 2028
- Granting the LLT PFM would delay up to 2 GW NQC from 2028 to 2031, which impacts the 2028 MTR Gap. Note a substantial portion of the 2 GW NQC is already contracted to come online by 2028, so the negative reliability impact of granting the PFM may be less than estimated here.

MTR Sufficiency Analysis: Result, if DCPP PFM Relief Granted

	(Units = Perfect capacity MW)	2023	2024	2025	2026	2027	2028	Notes
A	MTR Ordered Procurement (annual)	2,000	6,000	1,500	2,000	2,000	2,000	
B	MTR Ordered Procurement (cumulative)	2,000	8,000	9,500	11,500	13,500	15,500	Cumulative sum of A
C	MTR Incremental Procurement (in PSP Baseline)	2,896	4,219	4,578	4,700	4,719	4,750	Source: Staff analysis of Generator List
D	Remaining MTR Procurement (above PSP Baseline)	(896)	3,781	4,922	6,800	8,781	10,750	B – C
E	SERVM PCAP Shortfall (using PSP Baseline)	n/a	2,200	6,000	5,800	8,000	8,000	Direct SERVM model outputs
F	MTR Gap: MTR ordered relative to SERVM shortfall	n/a	(1,581)	1,078	(1,000)	(781)	(2,750)	E – D
G	Reduction in PCAP of 4-hr storage due to less energy			**125**		**(125)**		**Extension granted from 2025 to 2027**
H	MTR Gap: Ordered, w/ DCPP PFM, relative to SERVM shortfall	n/a	(1,581)	1,203	(1,000)	(906)	(2,750)	F + G

Baseline + Ordered Procurement – Conclusions

- Ordered procurement amounts and timing address the shortfall between the reliability standard and the Baseline except for 2025
  - The 2025 risk to reliability is too soon to be addressed by procurement action in the IRP process, however is mitigated by the Strategic Reliability Reserve (approx. 2,430 MW perfect capacity contribution*)
- Risks (beyond those allowed for in the reliability standard) to ordered procurement providing sufficient reliability include:
  - Unexpected gas retirements
  - MTR project development delays
  - More frequent extreme weather events than expected, due to climate change
  - Imports being less available than expected
- MTR DCPP Energy PFM, if granted, would have a small negative effect on reliability in 2025, resulting in a larger shortfall of capacity to the reliability standard
- MTR LLT PFM, if granted, would reduce 2028 reliability, but still leave surplus capacity above the reliability standard if the additional risks above do not materialize

*Based on DWR June 2023 Investment Plan, assuming 2,859 MW @ 85% ELCC available through 2026

Reliability & Emissions Analysis – Baseline + LSE Plans

Overview of Baseline + LSE Plans

In this section staff:

- Describe the reliability requirements LSEs had to meet in their 2022 IRPs
- Show that all LSE types showed overcompliance with the marginal-ELCC based requirement
- Show the resource type changes in the LSE plans vs. the Baseline
- Show how LSEs' plans are over-complying with the MTR order by 2028 by selecting more new resources than ordered
- Show the reliability results the LSE plans without gas retirements, then the results with the unplanned-for gas assumed to retire
- Draw conclusions about the reliability and emissions of LSE plans, leading to the use of RESOLVE to develop potential PSP portfolios

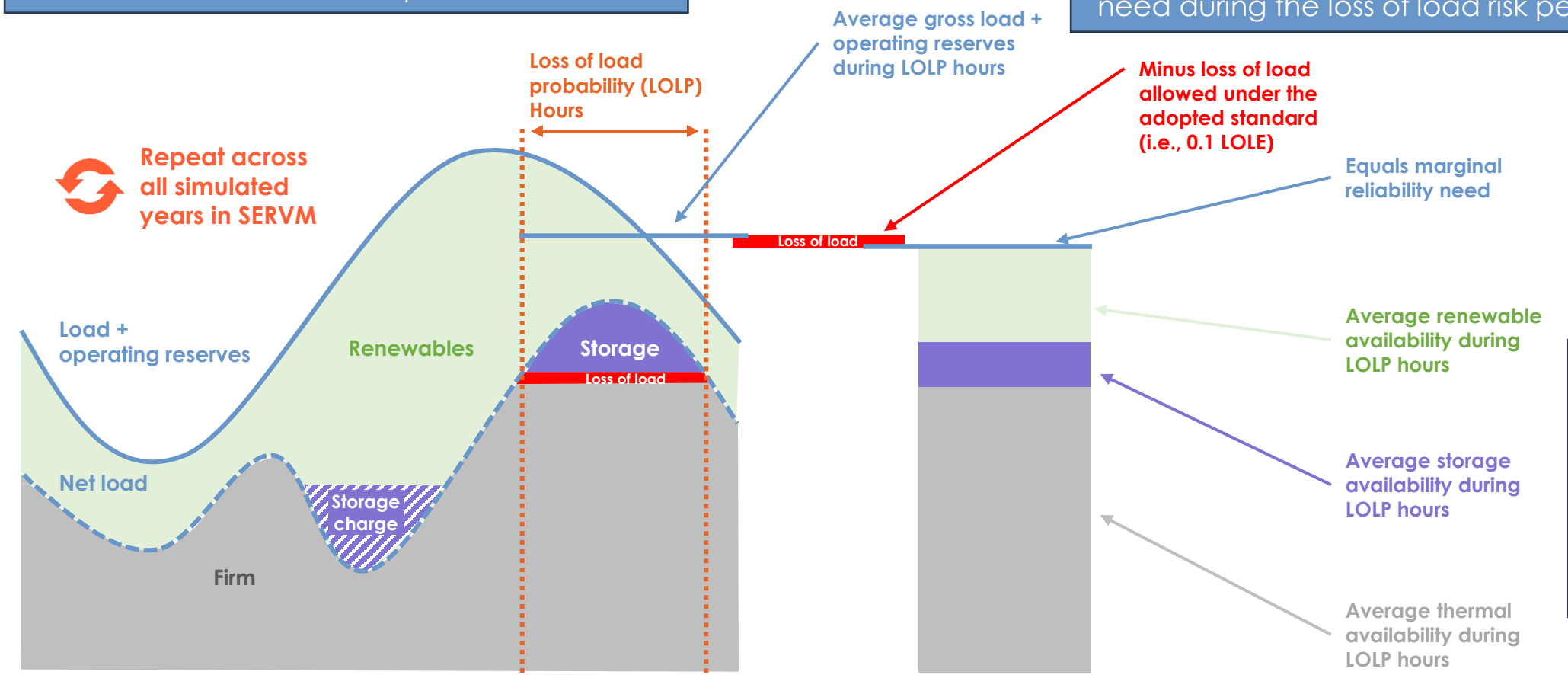
LSE 2022 IRP Filing Requirements

- LSEs were required to submit two "preferred conforming portfolios;" one achieving GHG emissions equal to or less than their proportional share of the 38 MMT by 2030 and 30 MMT by 2035 GHG targets (30 MMT Plans), and another achieving GHG emissions equal to or less than their proportional share of the 30 MMT by 2030 and 25 MMT by 2035 GHG targets (25 MMT Plans)
- LSEs used the following data points within each plan to complete their reliability planning:
  1. **Reliability requirement by year**: what is their annual LSE-level MW reliability obligation?
     - → "Marginal Reliability Need" defined for each LSE
  2. **Resource accreditation metrics by year**: how each resource type counts towards that MW obligation?
     - → "Marginal ELCC" defined for each resource type
- LSEs were required to show in their 30 MMT and 25 MMT "Resource Data Templates" that the perfect capacity equivalent MW of their preferred conforming portfolios, as measured by the template's resource accreditation methodology, was equal to or greater than their assigned reliability planning obligation in each year of the planning horizon

LSE 2022 IRP Filing Requirements: Marginal ELCC Planning

Step 1: Using forecasted resource portfolio, calculate loss of load risk periods in SERVM

Step 2: Calculate and allocate reliability need during the loss of load risk periods*



Step 3: Calculate resource marginal ELCCs during the same loss of load periods

* The 2022 LSE IRP Filing Requirements used the LSE share of the IEPR's single-hour managed peak, but future LSE allocation methods can use LSE loads over multiple hours (weighted by loss of load risk) to more directly tie need allocation to LSE contribution.

LSE 2022 IRP Filing Requirements: Reliability Requirement by Year

Resource Data Template (RDT) Implementation

- LSE marginal reliability need (MRN) =

  (CAISO gross peak * (1+ PRM)) * (MRN to Total Reliability Need ratio) * (LSE managed peak share)

- LSE resources = (BTM_PV_MW * marginal_ELCC_%) + $\sum$(Resource_MW$_X$ * marginal_ELCC$_X$ %)

LSE Input

Reliability Need

	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	
CAISO gross peak (MW)	53,530	54,113	54,769	55,494	56,125	56,797	57,454	58,178	58,827	59,511	60,161	60,803	Gross peak from IEPR hourly data (removing BTM PV)
PRM (%)	14%	14%	14%	14%	14%	14%	14%	14%	14%	14%	14%	14%	PRM based on target PRM study to reach 0.1 LOLE
CAISO total reliability need (TRN) (MW)	61,024	61,689	62,437	63,263	63,983	64,749	65,498	66,323	67,063	67,843	68,584	69,315	TRN = gross peak * (1 + PRM)
MRN/TRN ratio	0.80	0.82	0.84	0.80	0.76	0.74	0.72	0.70	0.68	0.67	0.65	0.63	MRN/TRN = ($\sum$ marginal ELCC MW) / TRN
CAISO marginal reliability need (MRN) (MW)	48,838	50,521	52,204	50,322	48,441	47,702	46,964	46,372	45,780	45,188	44,596	44,005	MRN = $\sum$ marginal ELCC MW
LSE managed peak share (%)	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	LSE managed peak share provided to LSEs by CPUC
LSE MRN (MW)	4,884	5,052	5,220	5,032	4,844	4,770	4,696	4,637	4,578	4,519	4,460	4,400	LSE MRN MW = "need" to which LSEs should plan

BTM PV

	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	
Capacity (MW)	100	100	100	100	100	100	100	100	100	100	100	100	BTM PV capacity provided to LSEs by CPUC

Source: LSE PRM and ELCC Study Results, 7/29/2022

LSE 2022 IRP Filing Requirements: Marginal Reliability Need & ELCCs

30 MMT Scenario

Modeled Year (results complete) | Interpolated Year

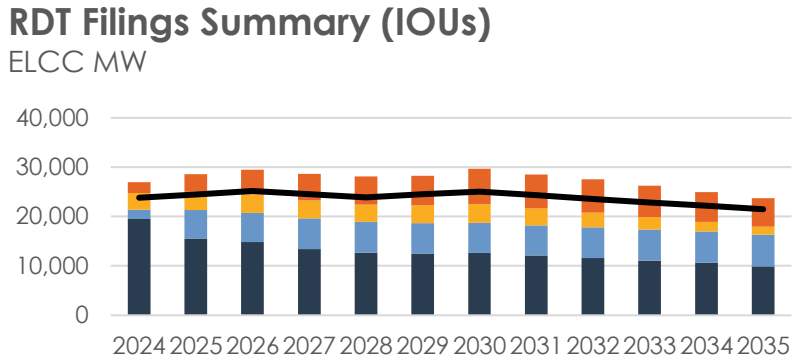
Resource Class	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
In-state Wind (SoCal)	12%	14%	15%	11%	6%	8%	9%	8%	7%	6%	5%	4%
In-state Wind (NorCal)	24%	27%	31%	21%	12%	15%	19%	17%	15%	13%	11%	9%
Out-of-state Wind (WY/ID)	47%	45%	44%	38%	32%	33%	34%	33%	32%	31%	31%	30%
Out-of-state Wind (WA/OR)	29%	28%	27%	23%	20%	20%	21%	20%	20%	19%	19%	18%
Out-of-state Wind (AZ/NM)	42%	41%	40%	34%	29%	30%	30%	30%	29%	28%	28%	27%
Offshore Wind	67%	62%	56%	56%	55%	58%	61%	55%	49%	44%	38%	32%
Utility PV	12%	12%	12%	10%	8%	8%	7%	7%	7%	7%	7%	6%
BTM PV	5%	5%	4%	5%	6%	5%	5%	5%	5%	5%	5%	6%
4-hr Battery Storage	85%	86%	87%	85%	82%	85%	89%	79%	69%	60%	50%	40%
8-hr Battery Storage	89%	89%	88%	87%	86%	87%	89%	85%	81%	77%	73%	70%
Pumped Hydro Storage	90%	89%	88%	87%	86%	87%	89%	86%	83%	80%	76%	73%
Demand Response	77%	80%	82%	77%	73%	80%	86%	72%	58%	43%	29%	14%
Hydro (large)	51%	52%	53%	52%	51%	53%	54%	52%	50%	48%	45%	43%
Hydro (small)	36%	37%	38%	38%	37%	38%	39%	37%	36%	34%	32%	31%
Firm	85%	86%	87%	87%	86%	85%	84%	86%	87%	88%	89%	90%

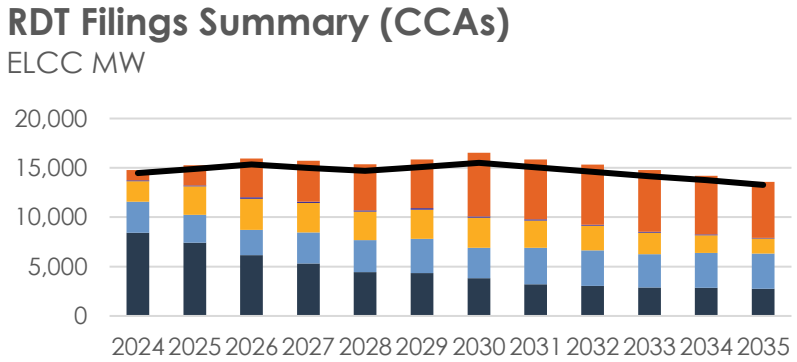
Marginal Reliability Need	47,112	48,652	50,193	49,099	48,005	49,369	50,732	49,261	47,790	46,318	44,847	43,376

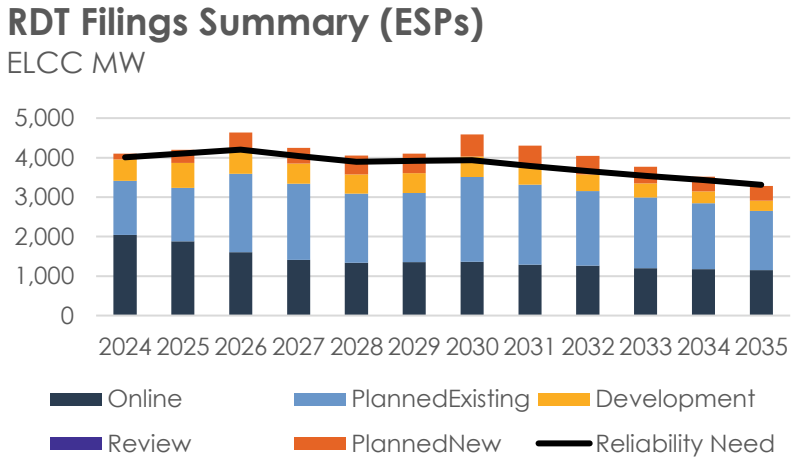
Source: LSE PRM and ELCC Study Results, 7/29/2022

Aggregated LSE Plans vs. Reliability Filing Requirement

- All LSEs met their reliability standards, with some LSEs planning for reliability levels more than their assigned reliability planning requirements
- All LSE types showed overcompliance in aggregate with their reliability planning standards
- After 2024, there is not a stark difference between the LSE types in the amount of online reliable capacity they have in their portfolios, relative to their reliability need







25MMT and 30 MMT LSE Plans Analysis - Overview

- SERVM production cost modeling (PCM) described in this section focuses on the Baseline plus LSE plans

Scenario Descriptions	Use Cases

• Updated Resource Baseline (Jan 2023)
• 25 and 30 MMT Portfolios of 11/2022 LSE plans
  • In Development resources added to Baseline
  • Review and Planned New resources are considered above Baseline
• CEC's **2021** Integrated Energy Policy Report (IEPR) Mid case managed electric demand forecast
• **With and without** additional gas retirements beyond announced
	• Evaluate the effectiveness of reliability filing requirements used in 11/2022 LSE plans
	• Comparison to other studies using same IEPR vintage

• 25 and 30 MMT Portfolios of 11/2022 LSE plans • Updated Resource Baseline (Jan 2023) • CEC's **2022** IEPR Planning case managed electric demand forecast • **With and without** additional gas retirements beyond announced	• Core scenario for consideration as the 2023 PSP • Also for consideration as the Base Portfolio for CAISO's 2024-25 Transmission Planning Process (TPP) • Basis for several sensitivity studies

25 and 30 MMT refers to a statewide electric sector GHG emissions target for 2035, as specified in CPUC's IRP filing requirements for LSEs

Aggregated LSE Plans by Resource Type - 25 MMT (MW)

- Staff aggregated all resources in LSE plans: existing contracted, existing planned to be contracted, in-development, under review, and planned new
- "Additional retired" refers to individual thermal units removed if not specifically quantified as contracted or planned for resources in LSE Plans
  - Removed units are CC, Cogen, and CT categories

Year	2024	2026		2030		2035	
Gas retention	No unannounced retirements	No unannounced retirements	-3364 MW add'l retired	No unannounced retirements	-5515 MW add'l retired	No unannounced retirements	-5903 MW add'l retired
25 MMT by 2035 LSE Plan							
Battery Storage	12,613	17,689	17,689	22,287	22,287	28,216	28,216
Biomass	713	794	794	873	853	864	852
BTMPV	16,827	19,252	19,252	24,492	24,492	31,023	31,023
CC	17,536	17,536	15,747	17,536	14,280	17,536	13,898
Coal	480	-	-	-	-	-	-
Cogen	1,938	1,957	1,185	1,957	557	940	551
CT	8,204	8,204	7,401	8,204	7,345	8,204	7,345
DR	2,822	2,804	2,804	2,851	2,851	2,851	2,851
Geothermal	1,440	2,393	2,393	2,826	2,826	2,922	2,922
Hydro	5,995	6,003	6,003	6,003	6,003	6,003	6,003
ICE	259	259	259	259	259	259	259
Nuclear	2,935	635	635	635	635	635	635
OffshoreWind	-	-	-	1,580	1,580	4,531	4,531
PSH	1,483	1,940	1,940	1,952	1,952	1,952	1,952
Solar	20,304	24,577	24,577	34,249	34,215	38,456	38,422
Steam	-	-	-	-	-	-	-
Wind	8,038	10,284	10,284	15,002	15,002	15,736	15,736

Aggregated LSE Plans by Resource Type - 30 MMT (MW)

- Staff aggregated all resources in LSE plans: existing contracted, existing planned to be contracted, in-development, under review, and planned new
- "Additional retired" refers to individual thermal units removed if not specifically quantified as contracted or planned for resources in LSE Plans
  - Removed units are CC, Cogen, and CT categories

Year	2024	2026		2030		2035	
Gas retention	No unannounced retirements	No unannounced retirements	-3364 MW add'l retired	No unannounced retirements	-5515 MW add'l retired	No unannounced retirements	-5903 MW add'l retired
30 MMT by 2035 LSE Plan							
Battery Storage	12,613	17,689	17,689	21,662	21,662	27,455	27,455
Biomass	713	794	794	873	853	864	852
BTMPV	16,827	19,252	19,252	24,492	24,492	31,023	31,023
CC	17,536	17,536	15,747	17,536	14,280	17,536	13,898
Coal	480	-	-	-	-	-	-
Cogen	1,938	1,957	1,185	1,957	557	940	551
CT	8,204	8,204	7,401	8,204	7,345	8,204	7,345
DR	2,822	2,804	2,804	2,851	2,851	2,851	2,851
Geothermal	1,440	2,390	2,390	2,806	2,806	2,902	2,902
Hydro	5,995	6,003	6,003	6,003	6,003	6,003	6,003
ICE	259	259	259	259	259	259	259
Nuclear	2,935	635	635	635	635	635	635
OffshoreWind	-	-	-	1,659	1,659	4,648	4,648
PSH	1,483	1,940	1,940	1,952	1,952	1,952	1,952
Solar	20,298	24,572	24,572	32,231	32,197	37,083	37,049
Steam	-	-	-	-	-	-	-
Wind	8,038	10,284	10,284	14,878	14,878	15,729	15,729

Aggregated LSE Plans (25 MMT) vs MTR Order

- LSE plans show over-compliance with the MTR new build requirement
- For example, 2026 shows:
  4,700 MW MTR in the Baseline
  + 9,118 MW MTR in LSE plans
  = 13,818 MW total MTR

  vs. 11,500 MW required -->
  2,318 MW over-procurement
- LSE plans generally appear to rely more on building extra new reliable capacity (above MTR) and thereby relying less on the existing gas fleet for their reliability need

MTR-eligible build (nameplate)	Details	2024	2025	2026	2027	2028	TOTAL
Solar		1,266	2,831	1,442	2,443	546	8,528
Wind	CAISO	325	720	230	601	225	2,101
Wind	NW	0	-	380	20	-	400
Wind	SW	0	-	840	661	486	1,987
Offshore_Wind		0	-	-	-	-	0
Li_Battery	4-Hr	3,989	2,295	1,717	257	775	9,033
Li_Battery	8-Hr	0	6	512	230	502	1,250
Pumped_Hydro		0	-	457	-	12	469
Shed_DR		27	2	2	69	1	101
Geothermal		137	52	845	15	94	1,143
Biomass		11	30	12	33	46	132

MTR-eligible build (ELCC)	Details	2024	2025	2026	2027	2028	TOTAL
Solar		84	187	101	183	48	603
Wind	CAISO	54	86	30	84	33	288
Wind	NW	0	-	125	6	-	132
Wind	SW	0	-	294	223	155	672
Offshore_Wind		-	-	-	-	-	-
Li_Battery_4hr_Baseline		3,618	1,724	1,315	190	593	7,440
Li_Battery_8hr_Baseline		0	5	430	200	452	1,088
Pumped_Hydro		0	-	396	-	11	407
Shed_DR		26	2	2	66	1	97
Geothermal		127	48	786	14	87	1,063
Biomass		10	28	11	31	43	123
SUM		**3,836**	**1,893**	**3,390**	**815**	**1,376**	
Cumulative		**3,836**	**5,729**	**9,118**	**9,933**	**11,309**	

MTR-eligible Over-compliance in LSE Plans (ELCC)	2024	2025	2026	2027	2028
MTR Procurement in PSP Baseline	4,219	4,578	4,700	4,719	4,750
MTR Procurement in LSE Plans	3,836	5,729	9,118	9,933	11,309
Baseline + LSE Planned Procurement	8,054	10,307	13,818	14,652	16,058
MTR Requirement	8,000	9,500	11,500	13,500	15,500
MTR Procurement Surplus	**54**	**807**	**2,318**	**1,152**	**558**
LDES in PSP Baseline					166
LDES in LSE Plans					1,495
LDES Procurement Surplus					**661**
Firm RE in PSP Baseline					116
Firm RE in LSE Plans					1,186
Firm RE Procurement Surplus					**302**

Over-procurement in LSE plans

Results: LSE Plans Scenarios 2022 IEPR

- 25 and 30 MMT Portfolios aggregated from 11/2022 LSE Plans
- 2022 Planning scenario electric demand managed forecasts
- Two alternative scenarios about thermal (gas) units retention
  - No unannounced retirement: Thermal units retained unless retirement announced by CAISO or Gen Owner
    - OTC steam units assumed to go offline by 2023 and DCPP assumed to go offline in 2024/25, and no further retirements
  - Additional retirements: Individual thermal units removed if not specifically quantified as contracted or planned for resources in LSE Plans
    - Same as "No unannounced retirement" in 2024, plus additional retirements in subsequent years increasing to 5.9 GW by 2035

Year	2024	2026		2030		2035	
Gas retention	No unannounced retirements	No unannounced retirements	-3364 MW add'l retired	No unannounced retirements	-5515 MW add'l retired	No unannounced retirements	-5903 MW add'l retired
25 MMT by 2035 LSE Plan							
LOLE Capacity (days/year)	0.029	0.003	0.061	0	0.036	0.015	0.338
CAISO Emissions (MMT)	41.2	39.4	39.1	31.4	30.2	33.9	34.1
Implied CA Emissions (MMT)	50.8	48.7	48.2	38.8	37.2	41.8	42.1
30 MMT by 2035 LSE Plan							
LOLE Capacity (days/year)	0.031	0.005	0.059	0	0.063	0.021	0.396
CAISO Emissions (MMT)	41.2	39.4	39.1	32.8	31.6	34.9	35.2
Implied CA Emissions (MMT)	50.8	48.7	48.2	40.4	39	43.1	43.4

LSE un-contracted gas retirements create an unreliable system in 2035

GHG may not be reduced when gas plants retire without replacement clean energy and capacity because increased imports and increased use of remaining CAISO gas units would replace the retired gas

- Implied CA Emissions calculated as CAISO Emissions / 0.81
- Total CAISO Emissions may be approximately 1-3 MMT overstated, depending on portfolio and year, due to these SERVM studies modeling offshore and out-of-state wind profiles with lower capacity factor than the profiles in RESOLVE. This modeling difference does not change the conclusions in this section since the effect is modest compared to the amount by which the LSE plans scenarios exceed the CAISO emissions target. For SERVM studies of RESOLVE-produced portfolios shown later in this deck, SERVM aligned its wind production to better match RESOLVE.

Results: LSE Plans Scenarios 2021 IEPR

- 25 and 30 MMT Portfolios aggregated from 11/2022 LSE Plans
- 2021 IEPR Mid-Mid Planning scenario electric demand managed forecasts
- Additional Retirement Scenario only simulated for 25 MMT LSE plans
- In 2024 there are no additional retirements driven by lack of LSE contracting/planning for existing gas plants

Year	2024	2026		2030		2035	
Gas retention	No unannounced retirements	No unannounced retirements	-3364 MW add'l retired	No unannounced retirements	-5515 MW add'l retired	No unannounced retirements	-5903 MW add'l retired
25 MMT by 2035 LSE Plan							
LOLE Capacity (days/year)	0.026	0.001	0.051	0.000	0.009	0.000	0.061
CAISO Emissions (MMT)	41.4	39.2	38.9	28.4	27.0	26.5	26.5
Implied CA Emissions (MMT)	51.1	48.4	48.0	35.0	33.3	32.7	32.7
30 MMT by 2035 LSE Plan							
LOLE Capacity (days/year)	0.025	0.002		0.000		0.001	
CAISO Emissions (MMT)	41.4	39.2		29.7		27.4	
Implied CA Emissions (MMT)	51.1	48.4		36.6		33.8	

System found reliable in SERVM, consistent with LSE overcompliance with reliability filing requirements

GHG may not be reduced when gas plants retire without replacement clean energy and capacity because increased imports and increased use of remaining CAISO gas units would replace the retired gas

- Implied CA Emissions calculated as CAISO Emissions / 0.81
- Total CAISO Emissions may be approximately 1-3 MMT overstated, depending on portfolio and year, due to these SERVM studies modeling offshore and out-of-state wind profiles with lower capacity factor than the profiles in RESOLVE. This modeling difference does not change the conclusions in this section since the effect is modest compared to the amount by which the LSE plans scenarios exceed the CAISO emissions target. For SERVM studies of RESOLVE-produced portfolios shown later in this deck, SERVM aligned its wind production to better match RESOLVE.

Results: LSE Plans Scenarios Emissions Delta

- The aggregate LSE Plan portfolios do not achieve the CAISO emissions target for two primary reasons:
  - **Load forecast updates**: Load forecasts, and the associated GHG benchmarks, were assigned to LSEs based on the 2021 IEPR. The 2021 IEPR's CAISO managed load forecast by 2035 is ~238 TWh, compared to ~267 TWh by 2035 in the 2022 IEPR. The 2022 IEPR is the basis for the 2023 PSP.
  - **POU planned resources not included**: CPUC-jurisdictional LSEs in CAISO were collectively assigned ~204 TWh by 2035 according to the 2021 IEPR, which is ~86% of CAISO managed load. The remainder is attributed to non-jurisdictional entities. Had the 2022 IEPR been used to assign load, CPUC-jurisdictional LSEs would have been assigned ~231 TWh out of ~267 TWh total managed load by 2035. Either way the aggregated LSE plans would still lack sufficient resources without accounting for the ~14% of CAISO managed load attributed to non-jurisdictional entities.
- Thus, LSE Plans were only developed to serve ~86% (204 TWh/238 TWh) of CAISO managed load by 2035 per the 2021 IEPR, and this shortfall in planning grew when updating to the 2022 IEPR, with LSE Plans only serving ~76% (204 TWh/267 TWh)
- By contrast, SERVM was configured to meet the total CAISO managed load in all hours of the year and to the extent that aggregate LSE Plans were insufficient to meet that load due to the above structural limitations of LSE planning, the model dispatched more in-state gas generation or unspecified imports to meet that missing load
- For the portion of load served by CPUC-jurisdictional LSEs, all LSEs met their assigned GHG benchmarks, with some achieving emissions well below their assigned benchmarks
  - This indicates that SERVM's emissions delta in the LSE Plans scenarios is not due to inadequate LSE planning for GHG reductions—LSEs met or surpassed their GHG planning requirements
  - SERVM's emissions delta is largely driven by SERVM trying to meet more load than LSEs planned for

Note: All energy values are system level, not sales (i.e. sales would be a lower value due to T&D losses)

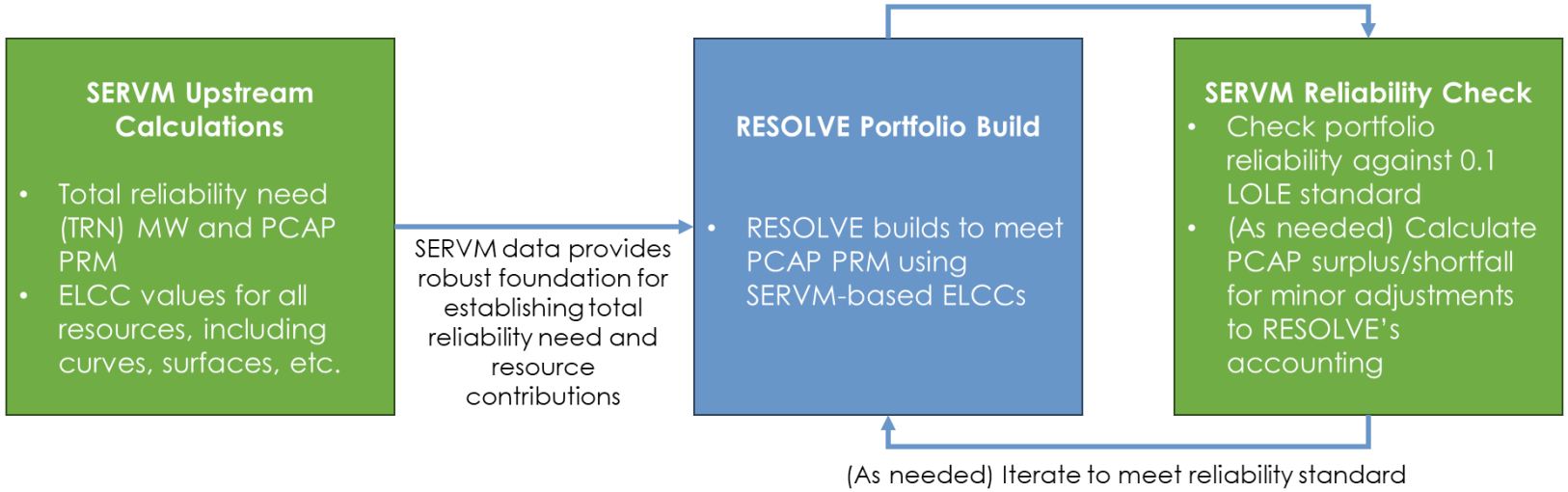
Baseline + LSE Plans - Conclusions

- This was the first IRP cycle where LSEs were assigned reliability filing requirements
- All LSEs met their reliability filing requirements, with some LSEs planning for reliability levels beyond their assigned requirements
- LSE Plans showed over-compliance with the MTR new build requirement starting in 2025, and as a result their plans appear set to rely less on the existing gas fleet leading to as much as ~6 GW of Baseline gas capacity excluded from LSE contracting/planning by 2035 (i.e., the LSE Plans appear to allow 6 GW to be uncontracted in 2035)
- SERVM analysis showed that when LSE Plans were added to the Baseline and with no additional retirements assumed (i.e., the 6 GW of gas capacity remains operational), the system maintained reliability out to 2035
- When using the 2022 IEPR and assuming Baseline gas capacity retired in line with the amounts that LSEs did not collectively plan for, the system became unreliable by 2035, with minor changes in GHG due to the remaining gas plants running about the same amount in total as before retirements. When using the 2021 IEPR, which is what LSEs planned for, and the same amounts of Baseline gas retired, SERVM analysis showed that meeting the reliability filing requirements resulted in a reliable system for all studied years.
- Aggregate LSE Plan portfolios do not on their own achieve the CAISO-wide GHG emissions targets by 2030 or 2035, but that is largely due to LSEs planning for only ~76% of the CAISO energy load (2022 IEPR). This is due to 1) non-jurisdictional LSEs' planned future procurement being unknown, and 2) the 2022 IEPR loads being significantly higher than the 2021 IEPR loads on which the LSE Plans are based. In fact, all CPUC jurisdictional LSEs met their assigned GHG benchmarks based on the 2021 IEPR, with some achieving emissions well below their assigned benchmarks.
- After aggregating LSE plans, staff used the RESOLVE capacity expansion model to top off the aggregated portfolios to the extent that more resources were needed to reduce emissions or maintain reliability (including through 2045, beyond the timeline for LSE plans). Refer to next section.

Reliability & Emissions Analysis – Potential PSP Portfolios

Aligning Reliability between SERVM + RESOLVE

- RESOLVE reliability need and resource counting metrics (ELCCs) were derived directly from SERVM
- Additionally, initial RESOLVE runs were used to develop further calibration factors to align the models based on LOLE results from preliminary RESOLVE portfolios*

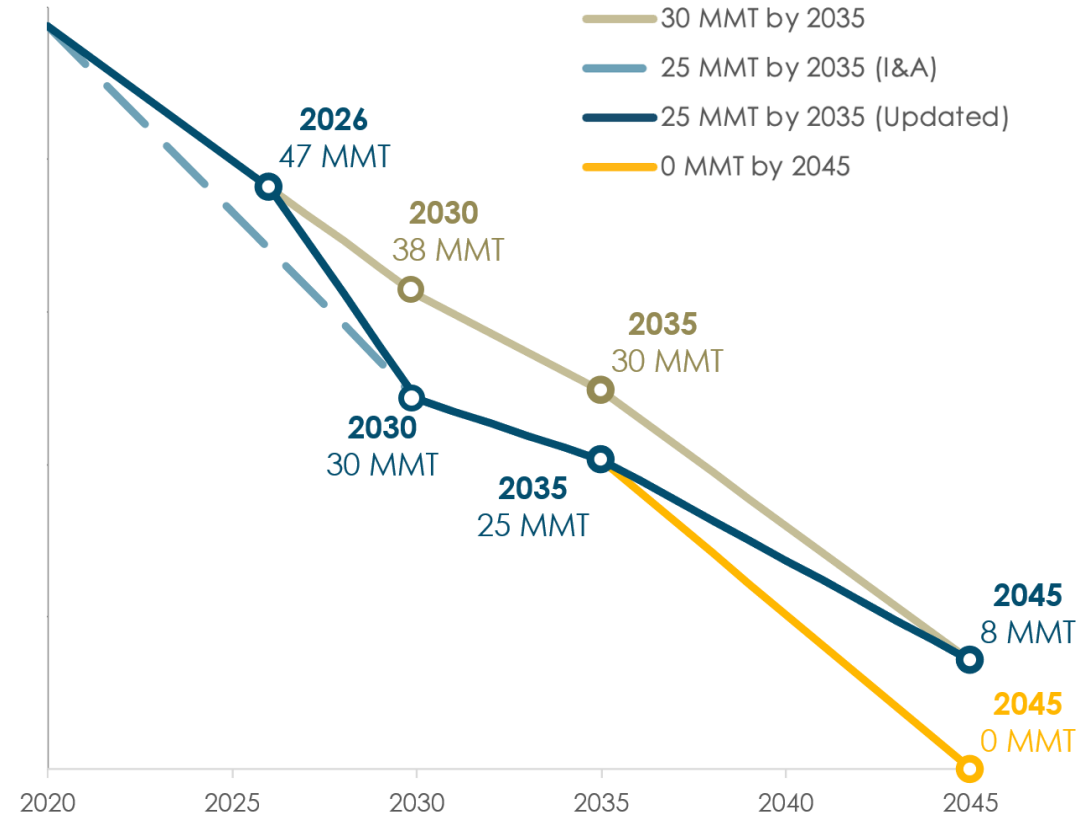


* These factors were calculated using the "least-cost" RESOLVE portfolios, since cases w/ LSE plans were found to be over-reliable in RESOLVE in the near- to mid-term. Current calibration factors ranged from adding 3,600 MW of PCAP in 2026 to removing 900 MW in 2035 (and thereafter) from RESOLVE's reliability accounting. Further calibration factors were needed when portfolio diversity effects were different than those studied in the 2030 ELCC studies used to create RESOLVE inputs. Another major factor was that the base/"binary" 11 GW > 4 GW import availability shape was found to provide significantly higher than 4 GW PCAP based on SERVM's pre-HE18 import availability.

Potential PSP Portfolios Emissions Trajectories

- Changes from previous cycle:
  - GHG targets have been renamed but *remain the same by 2030 & 2035*:
    - "30 MMT by 2030" → "25 MMT by 2035"
    - "38 MMT by 2030" → "30 MMT by 2035"
  - 2045 target updated to 8 MMT to reflect 2022 CARB Scoping Plan[1]
  - Baseline historical electric sector emissions updated to 59.5 MMT for 2020, based on CA GHG Inventory[2]
- GHG trajectory updated *through 2026* from 2023 PSP draft I&A[3] to reflect near-term resource availability constraints

CA-wide GHG Emissions Planning Target[4]
(MMT CO2)



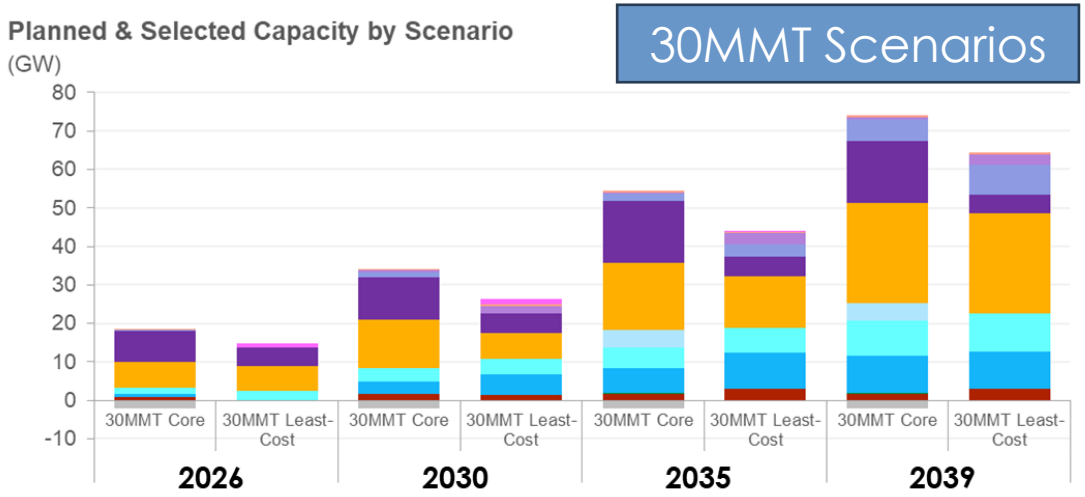
[1] https://ww2.arb.ca.gov/sites/default/files/2022-11/2022-sp-PATHWAYS-data-E3.xlsx
[2] https://ww2.arb.ca.gov/sites/default/files/classic/cc/inventory/ghg_inventory_by_scopingplan_00-20.xlsx
[3] https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/integrated-resource-plan-and-long-term-procurement-plan-irp-ltpp/2023-irp-cycle-events-and-materials/draft_2023_i_and_a.pdf
[4] CAISO-wide target is 81% of CA-wide target and includes emissions from BTM CHP equivalent to 4-5 MMT/year

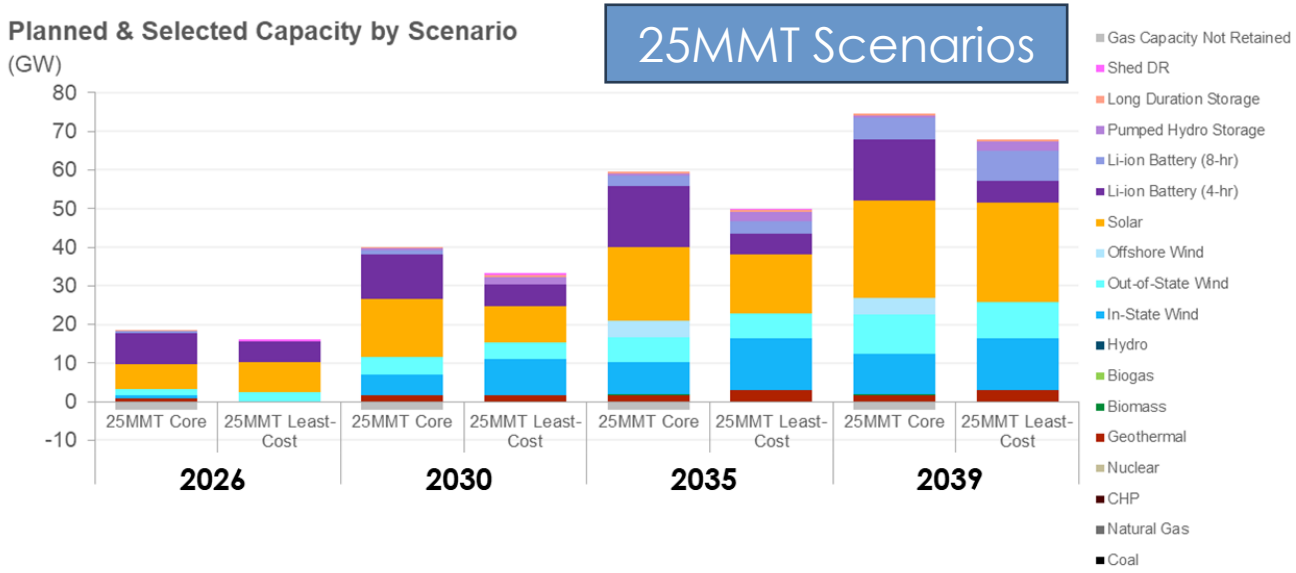
Potential PSP Portfolios Modeling Steps

- Staff used RESOLVE to produce two portfolio types:
  - Core: Baseline resources with 11/2022 LSE plans "forced in," plus RESOLVE selecting additional resources and/or gas retention to meet policy and reliability constraints
  - Least-Cost: Baseline resources only, plus RESOLVE selecting a cost-optimal portfolio of new carbon-free resources/gas retention to meet policy and reliability constraints
- RESOLVE portfolios were translated into SERVM inputs and simulated in SERVM for 2026, 2030, and 2035 to determine LOLE and GHG emissions
- Staff compared RESOLVE and SERVM GHG emissions and made further calibrations to align the models' outputs where possible
  - Some calibration adjustments led to reruns of RESOLVE, refining a portfolio, while others were adjustments to SERVM's characterization of a portfolio
- Staff is performing criteria pollutant analysis and will share results when available

RESOLVE Modeled Capacity Additions

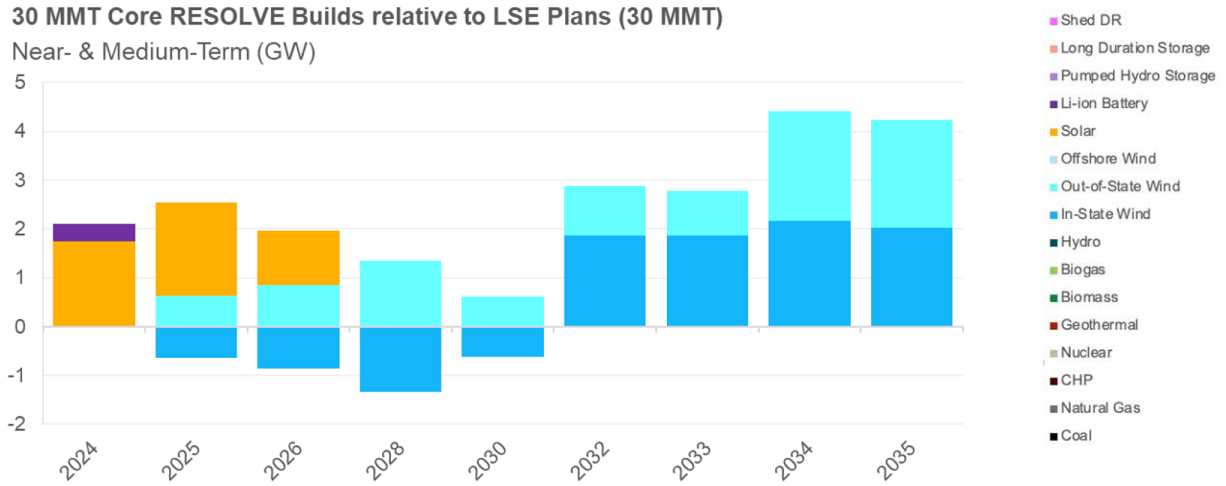
- Planned (incl. LSE-planned additions) and RESOLVE-selected capacity are shown below
- Least-cost cases show less battery storage, less offshore wind, more in-state + out-of-state wind, more long-duration storage, and more geothermal
  - The least-cost portfolios, using post-IRA 2023-vintage prices, result in lower cost portfolios
- Additional details on RESOLVE results are contained in the deck: "2023 PSP & 2024-2025 TPP: Resolve Modeling Results"





RESOLVE Additions above LSE Plans

- RESOLVE builds additional capacity above LSE planned additions in both the 25MMT and 30MMT scenarios
- This capacity is primarily selected by RESOLVE to fill the GHG gap identified in SERVM , driven by lower load forecasts used in LSE plans (i.e., 2021 IEPR vs 2022 IEPR) and lack of POU resource additions
- RESOLVE also chooses to retain more capacity than planned for in LSE plans to meet long-term (2039-2045) reliability needs
  - 2.0 GW not retained in 25MMT Core starting in 2024
  - 2.1 GW not retained in 30MMT Core starting in 2024



Reliability and GHG Results – 25 MMT Core

25 MMT CORE	2026		2030		2035		
Category	RESOLVE	SERVM	RESOLVE	SERVM	RESOLVE	SERVM	Units
LOLE		0.009		0.002		0.053	days/year
CAISO emitting generation	59,691	73,118	33,506	45,946	16,773	39,674	GWh
CAISO generator emissions	23.4	30.1	13.2	19.5	6.6	16.2	MMT CO2
Unspecified imports	16,130	9,347	15,085	12,089	21,641	9,810	GWh
Unspecified imports emissions	6.9	4.0	6.5	5.2	9.3	4.2	MMT CO2
CAISO BTM CHP emissions	4.8	4.8	4.7	4.7	4.4	4.4	MMT CO2
Total CAISO emissions	35.1	38.9	24.3	29.4	20.3	24.8	MMT CO2
Difference in GHG emissions		3.8		5.1		4.5	MMT CO2

Note: The RESOLVE portfolio was designed to and attained the 25 MMT by 2035 statewide target, which equates to 20.3 MMT attributed to CAISO. The 2035 CAISO emissions result in SERVM was 24.8 MMT, which equates to about 30.6 MMT statewide.

Reliability and GHG Results – 25 MMT Least-Cost

25 MMT LEAST-COST	2026		2030		2035		
Category	RESOLVE	SERVM	RESOLVE	SERVM	RESOLVE	SERVM	Units
LOLE		0.014		0.005		0.078	days/year
CAISO emitting generation	63,683	77,851	39,240	49,875	20,470	45,224	GWh
CAISO generator emissions	25.0	31.8	15.4	21.0	8.1	18.3	MMT CO2
Unspecified imports	15,185	7,436	9,835	10,822	18,220	9,083	GWh
Unspecified imports emissions	6.5	3.2	4.2	4.6	7.8	3.9	MMT CO2
CAISO BTM CHP emissions	4.8	4.8	4.7	4.7	4.4	4.4	MMT CO2
Total CAISO emissions	36.4	39.8	24.3	30.3	20.3	26.6	MMT CO2
Difference in GHG emissions		3.4		6.0		6.3	MMT CO2

Note: The RESOLVE portfolio was designed to and attained the 25 MMT by 2035 statewide target, which equates to 20.3 MMT attributed to CAISO. The 2035 CAISO emissions result in SERVM was 26.6 MMT, which equates to about 32.8 MMT statewide.

2035 EUE Heat Map – 25 MMT Least-Cost

- For 2035, the highest Expected Unserved Energy (EUE) occurs in July, August and September, hours ending 19 and 20 during hours of managed peak
- Small amount of EUE seen in December
- This pattern is similar in other study years, across both portfolios, though with less loss of load in 2026 and 2030

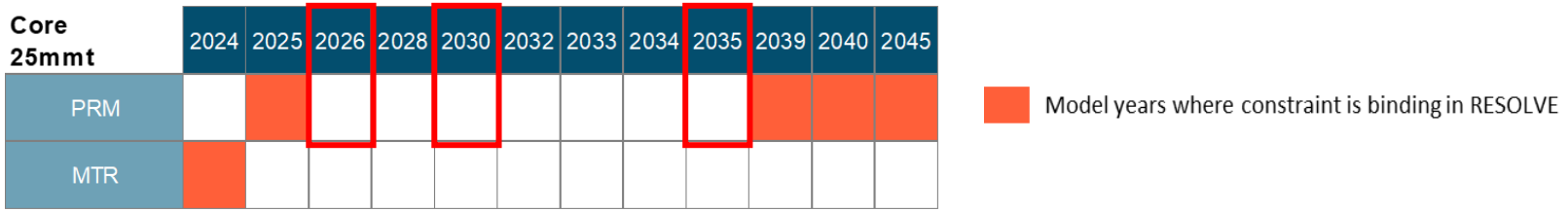
HE/Month	January	February	March	April	May	June	July	August	Sept	October	November	December
1	-	-	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-	-	-	-	-	-
8	-	-	-	-	-	-	-	-	-	-	-	-
9	-	-	-	-	-	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-	-	-	-	-
11	-	-	-	-	-	-	-	-	-	-	-	-
12	-	-	-	-	-	-	-	-	-	-	-	-
13	-	-	-	-	-	-	-	-	-	-	-	-
14	-	-	-	-	-	-	-	0.09	-	-	-	-
15	-	-	-	-	-	-	-	0.69	-	-	-	-
16	-	-	-	-	-	-	-	0.27	-	-	-	-
17	-	-	-	-	-	-	0.39	0.39	0.18	-	-	-
18	-	-	-	-	-	-	1.86	5.00	5.03	-	-	-
19	-	-	-	-	-	-	6.63	18.59	22.97	-	-	0.04
20	-	-	-	-	-	-	11.58	28.79	10.27	-	-	0.02
21	-	-	-	-	-	-	5.67	10.55	0.63	-	-	0.01
22	-	-	-	-	-	-	1.35	9.32	1.25	-	-	0.02
23	-	-	-	-	-	-	0.27	2.30	0.03	-	-	-
24	-	-	-	-	-	-	-	1.13	0.06	-	-	-

Average monthly EUE in MWh is shown for each hour of the day

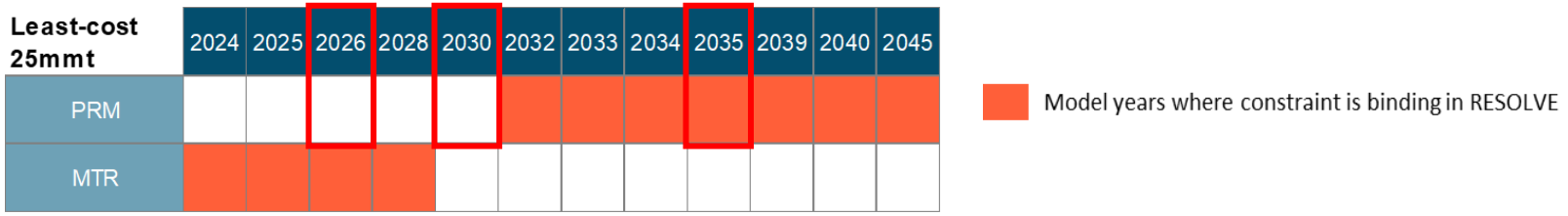
Potential PSP Portfolios SERVM Modeling Results

25MMT Scenarios

- **Reliability results**:
  - **Core 25MMT scenario**: over-reliable (vs. 0.1 days/yr LOLE) in 2026, 2030, and 2035
    - Driven by MTR, LSE over-procurement above MTR, and RESOLVE's selection of additional GHG-free resources and retention of more gas plants than LSE plans assumed
    - SERVM analysis validates RESOLVE results that showed the PRM not binding in 2026, 2030, or 2035 (indicating that system reliability should be < 0.1 LOLE)



  - **Least-cost 25MMT scenario**: over-reliable (vs. 0.1 days/yr LOLE) in 2026, 2030, and 2035
    - Over-reliability driven by MTR (for 2026 and 2030); RESOLVE-optimized selection for 2035 drives the CAISO to reach close to 0.1 LOLE (0.079 LOLE achieved) in 2035
    - SERVM analysis validates RESOLVE results that showed the PRM not binding in 2026 and 2030 (indicating that system reliability should be < 0.1 LOLE) and PRM binding in 2035 (indicating the system should be close to 0.1 LOLE)

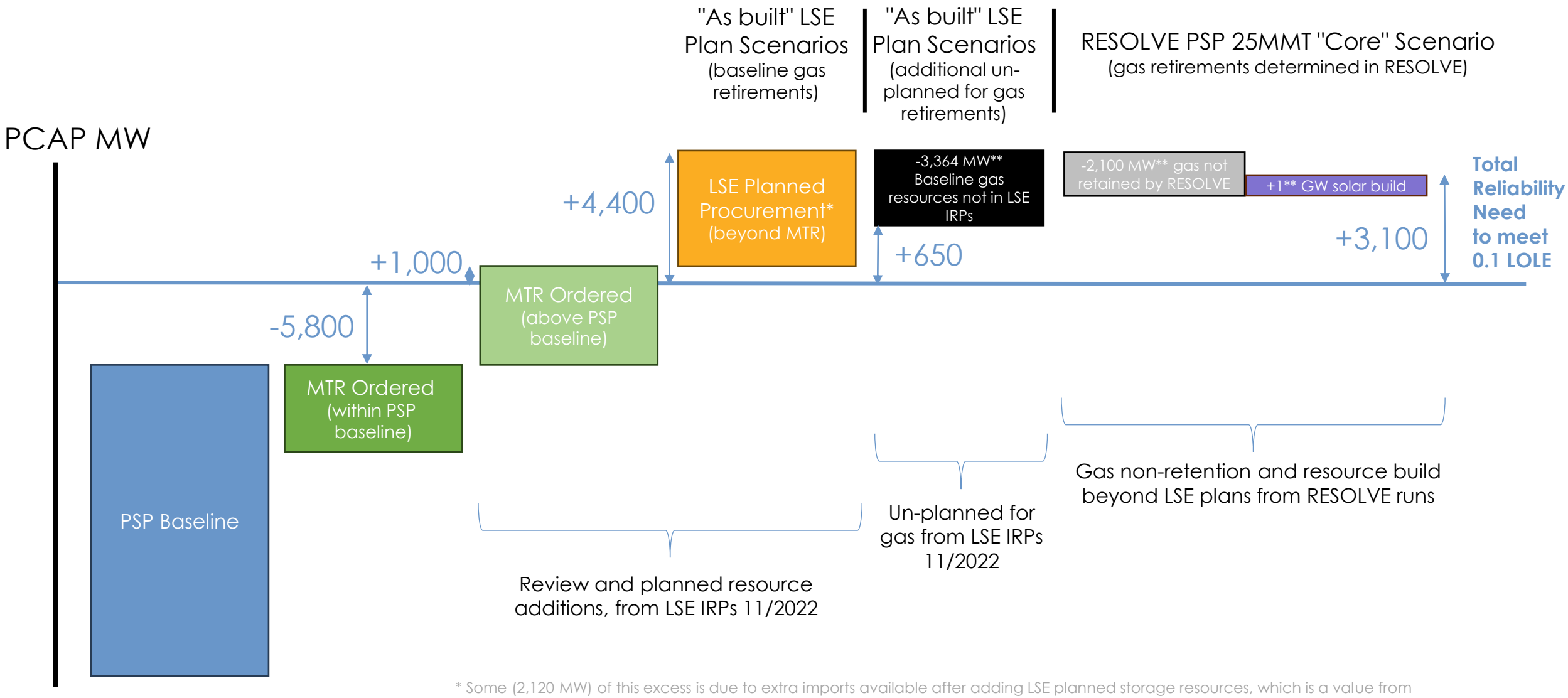


Potential PSP Portfolios SERVM Modeling Results

25MMT Scenarios

- **Greenhouse gas emission results**:
  - SERVM GHG results for CAISO are significantly higher than RESOLVE results by approximately 3-6 MMT per annum depending on portfolio and year
  - Drivers that may relate to differences between RESOLVE representative days hourly profiles and SERVM full 23 weather year hourly profiles:
    - Higher BTM PV generation in RESOLVE
    - Slightly higher storage usage and clean energy generation in RESOLVE
    - Higher curtailment in SERVM
    - Higher annual energy demand being met in SERVM than RESOLVE
  - Other drivers:
    - Lower biomass generation in SERVM
    - Different Cogen (CHP) heat rates between the models
    - Differences in the dispatched mix of in-state gas plant types and use of unspecified imports
  - Staff are continuing to explore these drivers and ways to close the GHG gap between the two models

Reliability Waterfall Chart (2026): Connecting MTR to the PSP



* Some (2,120 MW) of this excess is due to extra imports available after adding LSE planned storage resources, which is a value from shifting the loss of load risk back before HE18 vs. being solely driven by LSE resources. Values rounded from direct SERVM model outputs.
** Gas and solar MW are nameplate values

Potential PSP Portfolios – Conclusions

Staff studied RESOLVE portfolios in SERVM to check the portfolios against GHG and LOLE metrics using the full SERVM 23-weather year dataset

- **Reliability**: Both the Least-Cost and Core portfolios are reliable (LOLE below 0.1) through 2035. The Least-Cost portfolio shows higher LOLE and approaches 0.1 in 2035, but other years are well below
  - These dynamics are consistent with the dynamics of the RESOLVE model for the same scenarios
- **GHG emissions**: SERVM modeling of RESOLVE portfolios result in GHG emissions that exceed RESOLVE results, with the difference rising from 2026 to 2035, and the Core portfolio showing the largest difference
  - While staff has done significant calibration between the models in this cycle, there remain lingering differences between the models which prevent absolute reconciliation
  - Staff will continue to explore these differences. The range of results is reasonable considering the uncertainties involved. The range of emissions between RESOLVE and SERVM provide an indicator of possible outcomes for these portfolios.

Other Observations

Crosswalk to Recent Similar Studies

- To continue to develop understanding of reliability risk, staff compares relevant parts of the current studies with comparable studies published earlier in 2023:
  - CEC's stack analysis, within SB 846 1st Quarterly Report, February 2023
  - CAISO's 2023 Summer Assessment, May 2023

Connection to SB 846 Quarterly Report

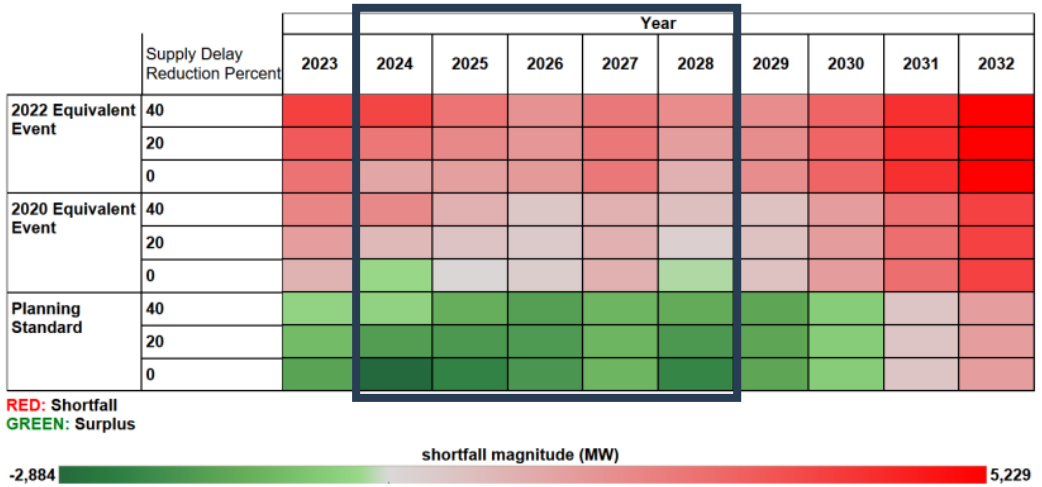
- 1st Quarterly Report analyzed the supply and demand balance, considering ordered procurement (p.48 of February 2023 report[1])
- The various supply delay scenarios were compared to the various demand scenarios, to identify shortfalls or surpluses for each year
  - Deterministic approach
  - Relatively comparable to CPUC Energy Division's probabilistic MTR Sufficiency Analysis (dark box indicates relevant results)

Ordered Procurement

10-Year Overview – Delay Scenario: This section will explore the supply and demand balance in the 10-year horizon using 0, 20, and 40 percent delay adjustments to the ordered procurement supply in each year. The annual supply was compared to a planning standard of a 17 percent reserve margin. Then, the annual supply was compared to more extreme events, which were defined as a 2022 equivalent event and a 2020 equivalent event.

Under the planning standard, the ordered procurement resulted in surplus under all delay scenarios until 2030, which is due to no new supply being ordered after 2028 and the gradual demand increase year to year. The max shortfall observed in the planning standard was 1600 MW in 2032 (*Figure 6: 10-Year Supply Imbalance Outlook – Ordered Procurement*).

Figure 6: 10-Year Supply Imbalance Outlook – Ordered Procurement



Source: California Energy Commission staff with CPUC data

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1. Joint Reliability Planning Assessment, February 2023, available at: https://efiling.energy.ca.gov/GetDocument.aspx?tn=248714&DocumentContentId=83233

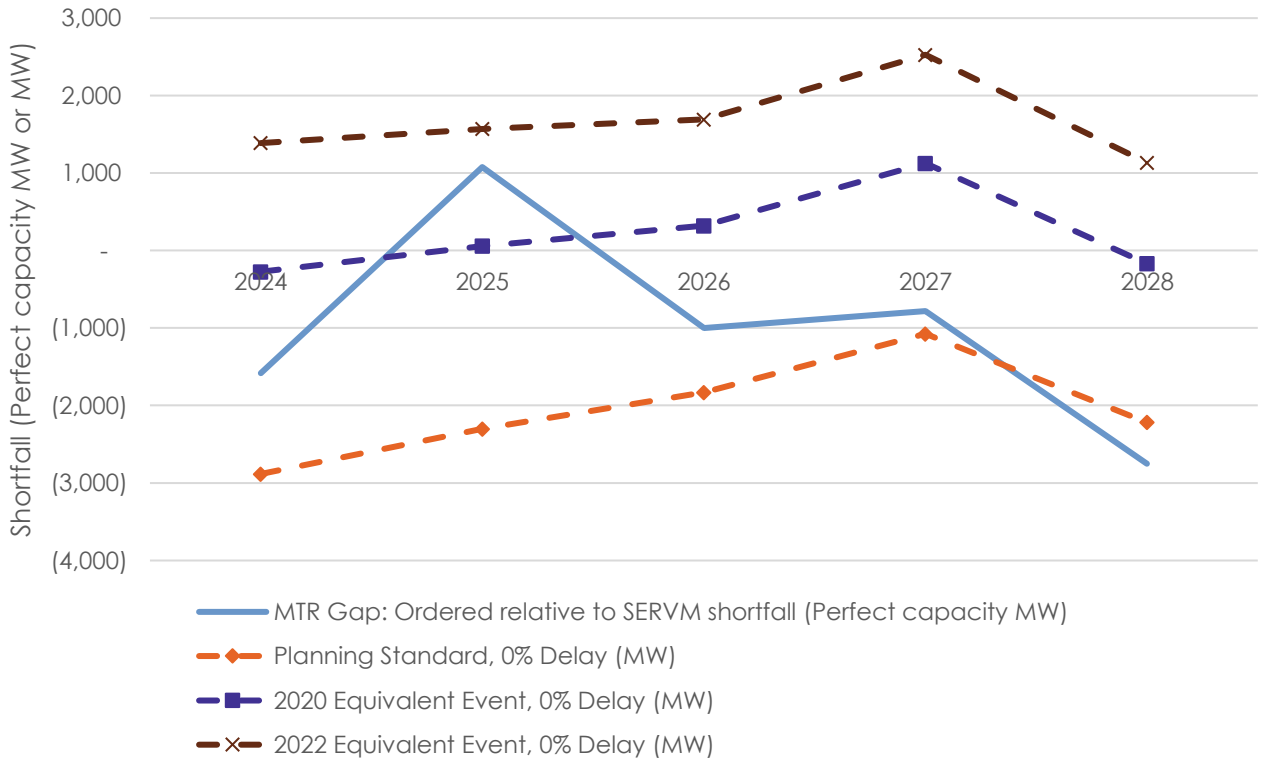
MTR Sufficiency Analysis: Result vs. SB 846 Quarterly Report

		2023	2024	2025	2026	2027	2028	Notes
F	MTR Gap: MTR ordered relative to SERVM shortfall	n/a	(1,581)	1,078	(1,000)	(781)	(2,750)	Units = Perfect capacity MW
	February 2023 SB 846 Report - Shortfall magnitude							Units = MW
	Planning Standard, 0% Delay	(1,538)	(2,884)	(2,302)	(1,832)	(1,075)	(2,218)	
	2020 Equivalent Event, 0% Delay	1,038	(273)	58	321	1,126	(170)	
	2022 Equivalent Event, 0% Delay	2,676	1,388	1,570	1,692	2,527	1,134	

- Staff notes that there are important differences in inputs and methodologies between these two analyses, that should be considered when comparing results (see next slide)
- However staff see the importance of attempting to compare analyses that have common purposes; diversity in analytical approaches can aid understanding of reliability risk

MTR Sufficiency Analysis: Result vs. SB 846 Quarterly Report

- Key methodological and input differences between these analyses include:
  - This analysis (MTR Sufficiency) is probabilistic, whereas the SB 846 1st Quarterly Report, February 2023 (SB 846) used a deterministic "stack analysis"; the probabilistic analysis is more directly based on the 1-day-in-10-year reliability standard
  - Results of a probabilistic analysis will be different to a stack analysis with the same resources because it accounts for more operational dependencies between resources across a broader range of weather conditions; the impact of this on results will not necessarily be linear or in the same direction across study years or scenarios
  - This analysis accounts for D.23-02-040 which ordered an additional 4 GW NQC of procurement, and allowed delay of 2 GW NQC of long lead-time resources to 2028. Net effect is this analysis assumes 2 GW NQC extra procurement ordered in each of 2027 and 2028 than assumed in the SB 846 analysis.
- MTR Gap results generally fall within the range of results from the February 2023 SB 846 Quarterly Report, particularly if the SB 846 results were adjusted for D.23-02-040 and/or if the additional MTR risks are layered in



Connection to CAISO's 2023 Summer Assessment

- CAISO performed probabilistic analyses[1] examining:
  - Sufficiency of "authorized" (ordered) procurement (p.11)
  - Reliability of the 2021 PSP (p.12)
- Staff compares its probabilistic MTR Sufficiency Analysis to CAISO's analysis of ordered procurement (dark box indicates relevant results)
  - The analysis of the 2021 PSP is less comparable

Table 1: Summary of Resource Requirements to Achieve Resource Planning Targets

Capacity (MW)	2023	2024	2025	2026
Calculation of Required NQC to meet LOLE Target				
Preferred System Plan New Additions	2749	5348	1955	412
Cumulative new Preferred System Plan Additions	2749	8097	10052	10464
ISO PLEXOS LOLE Simulation Results				
NQC Surplus (Shortfall) to meet LOLE Target	421	1313	(1294)	(1412)
Cumulative New NQC Additions needed to maintain 1-in-10	2328	6784	11346	11876
Comparison of Required Amounts to Authorized Procurement				
Procurement Authorizations (NQC)	2825	6000	1500	2000
Cumulative Procurement Authorization (NQC)	2825	8825	10325	12325
Cumulative surplus (shortfall) in authorizations by year	497	2041	(1021)	449
Comparison of Required Amounts to Current Projection				
NQC Installed Surplus (shortfall) above PSP by June 1, 2023	(1551)			
Surplus (Shortfall) meeting LOLE Target with June 1 resources	(1130)			
NQC Installed Surplus (shortfall) above PSP by Sept 1, 2023	543			
Surplus (Shortfall) meeting LOLE Target with Sept 1 resources	964			

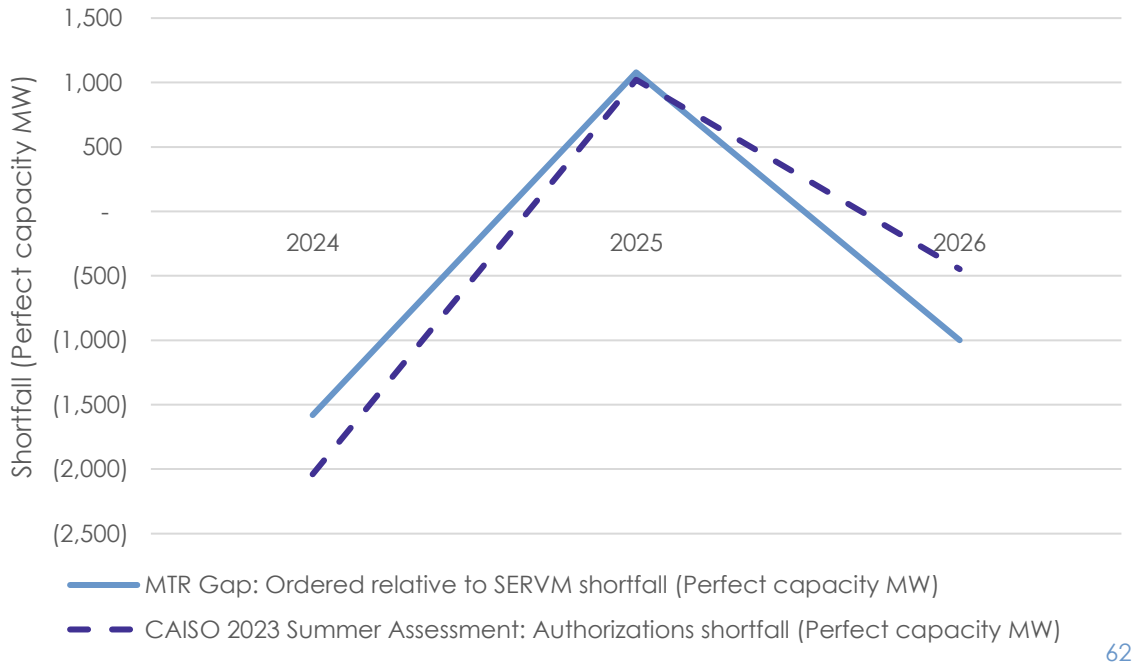
Current high hydro conditions provide an *additional* 1340 MW margin, achieving a 1-in-10 target even with only resources forecast online by June 1

1. 2023 Summer Loads and Resources Assessment, May 15, 2023, available at: California ISO - Reports and bulletins (caiso.com)

MTR Sufficiency Analysis: Result vs. CAISO's 2023 Summer Assessment

		2023	2024	2025	2026	2027	2028	Notes
F	MTR Gap: MTR ordered relative to SERVM shortfall	n/a	(1,581)	1,078	(1,000)	(781)	(2,750)	Units = Perfect capacity MW
	CAISO 2023 Summer Assessment: Authorizations shortfall	(497)	(2,041)	1,021	(449)	n/a	n/a	Units = Perfect capacity MW

- This analysis (MTR Sufficiency) and the CAISO's 2023 Summer Assessment use very similar methods and inputs
- Results are highly consistent



Priorities for Future IRP Reliability Studies

- Consider providing direction to LSEs on what to assume regarding the inclusion of existing resources in their plans, given their lack of visibility into other LSEs' planning
- Continue to improve alignment of reliability modeling inputs and methodologies across CPUC proceedings and across state agencies
- Update SERVM to include 2021 and 2022 weather years, including the September 2022 heat event
- Continue to improve baseline portfolio coordination across state datasets and ensure robust CPUC project tracking from planned → review → in-development → online
  - → to ensure accurate treatment of MTR needs vs. baseline resources
  - → to allow CEC, CPUC, and CAISO to communicate shared understanding of new resources expected as they proceed through interconnection and other development steps
- Consider adjustments to methods to model import availability, as "off-peak" imports become more critical in a storage-heavy, energy-limited system
- Add ability to model weather dependent building electrification loads, to enable more accurate reliability modeling of post-2035 scenarios
- Incorporate climate-informed forecasting to capture climate change impacts on load and resource availability
- Continue to align ELCC inputs to RESOLVE with SERVM, including treatment of reliability portfolio effects / diversity benefits

Appendix

Acronym Glossary

- BTM: Behind the Meter
- CCA: Community Choice Aggregation
- DCPP: Diablo Canyon Power Plant
- ELCC: Effective Load Carrying Capability
- ESP: Electric Service Provider
- EUE: Expected Unserved Energy
- HE: Hour Ending
- I&A: Inputs and Assumptions
- IOU: Investor-Owned Utilities
- LDES: Long Duration Energy Storage
- LLT: Long Lead-Time
- LOLE: Loss of Load Expectation
- LOLP: Loss of Load Probability
- LSE: Load Service Entity
- MTR: Mid Term Reliability
- MMT: Million Metric Tons
- MRN: Marginal Reliability Need
- NQC: Net Qualifying Capacity
- PCAP: Perfect Capacity
- PCM: Production Cost Modeling
- PRM: Planning Reserve Margin
- PSP: Preferred System Plan
- RDT: Resource Data Template
- TPP: Transmission Planning Process
- TRN: Total Reliability Need