Update

Reliability Filing Requirements for Load Serving Entities' 2022 Integrated Resource Plans - Results of PRM and ELCC Studies

Update to slides presented at the Modeling Advisory Group (MAG) Webinar held on July 19, 2022

Energy Division

July 29, 2022

California Public Utilities Commission

Logistics & Scope

Update

- Webinar slides are available at the 2022 IRP Cycle Events and Materials web page
- The webinar will be recorded, with the recording posted to the same webpage
- The objectives of this webinar are to:
  - Promote stakeholder understanding of reliability modeling inputs, methodology and results
  - Provide information to be used in LSE plan development
  - Gain feedback for informing modeling later this IRP cycle for updating the PRM for use in IRP modeling broadly, and as an input to the mid-to long-term procurement program, including reliability procurement need determination for 2025 and beyond
  - Provide an update on the overall schedule for IRP inputs and assumptions development

- Out of scope:
  - Development of procurement program required by D.22-02-004 – a ruling or workshop later in 2022 will initiate this

- **This July 29, 2022, slide deck contains updates to the slides presented during the July 19, 2022, webinar. Slides with updated or new information are marked with a green box.**

Questions

- We invite clarifying questions at regular intervals throughout this webinar
- All attendees have been muted. **To ask questions**:
  - In Webex:
    - Please "raise your hand"
    - Webex host will unmute your microphone and you can proceed to ask your question
    - Please "lower your hand" afterwards
  - For those with phone access only:
    - Dial *3 to "raise your hand". Once you have raised your hand, you'll hear the prompt, "You have raised your hand to ask a question. Please wait to speak until the host calls on you"
    - WebEx host will unmute your microphone and you can proceed to ask your question
    - Dial *3 to "lower your hand"
- If you are not able to use audio to ask a question, you may type into the "Q&A" feature of this Webex, though priority will be given to stakeholders who have "raised their hand" and use audio
- Should time not permit attention to every question, or **if you would like to informally comment**, please email your questions or comments to IRPDataRequest@cpuc.ca.gov

Agenda

Topic	Timing	Presenter
Introduction & context	10 min	Nathan Barcic
Background to studies	10 min	Patrick Young
PRM study • Approach • Results • *Questions*	35 min	Patrick Young Kevin Carden
ELCC study • Approach • Results • *Questions*	35 min	Aaron Burdick Neil Raffan
Studies' conclusions: Inputs to LSEs' reliability planning	10 min	Neil Raffan
Modeling parties' PRM and ELCC studies • *Questions*	40 min	SCE PG&E
2022-23 IRP cycle Inputs & Assumptions update	5 min	Ali Eshraghi
Next steps	5 min	Neil Raffan

Context

Use Cases for Reliability Modeling in 2022-23 IRP Cycle

- The April 7, 2022, MAG webinar addressed the early stages of a broad set of reliability updates to be conducted this IRP cycle
- **Near-term use case**: **LSE plan filing requirements** released in June and July, 2022
  - Reliability planning requirement, including the planning reserve margin
  - Final Resource Data Template (RDT) with resource accreditation metrics, including effective load carrying capabilities (ELCC), by resource type
- **Later use cases**:
  - Updates to RESOLVE and SERVM, and IRP planning track more broadly, including for 2023 Preferred System Plan (PSP) development
  - Mid-to long-term procurement program, including reliability procurement need determination for 2025 and beyond
- **Approach**
  - Where possible, use consistent methodologies and inputs across all use cases; near-term deadline requires deferral of some items to later this cycle
  - Implement stakeholder feedback upfront where possible, otherwise addressing for later use cases

Recap of recent LSE plan filing requirement activities

Update

- April 7, 2022, MAG webinar: communicated how staff has updated LSE plan filing requirements since 2020, including schedule and rollout, and familiarized stakeholders with the approach and inputs to develop reliability filing requirements
- June 2022, staff posted several beta versions throughout the month of the Resource Data Template (RDT) and Clean System Power (CSP) Calculator, and received informal feedback from stakeholders
- June 15, 2022, ALJ ruling formalizing LSE IRP filing requirements
- June 16, 2022, staff posted various filing requirements materials pursuant to the ALJ ruling, including LSE energy load forecasts and GHG benchmarks, filing templates and instructions documents, and LSE PRM study results
    - LSE PRM study results focused on a perfect capacity (PCAP)-based approach to reliability planning, which is different to the installed capacity (ICAP)-based approach that stakeholders are familiar with
    - A PCAP-based approach means removing from the PRM an allowance for forced outages of firm resources, and accrediting all resource types at their respective ELCC (i.e., their perfect capacity equivalent). This, along with expressing the PRM percentage relative to gross peak rather than managed peak, makes a PCAP PRM percentage lower than the ICAP equivalent.
- July 1, 2022, staff transmitted peak demand forecasts and behind-the-meter photovoltaic (BTM PV) forecasts to LSEs
- July 15, 2022, staff posted final Clean System Power Calculators (38 MMT and 30 MMT versions) and the Resource Data Template inclusive of reliability resource counting rules (38 MMT version)
- July 19, 2022, MAG webinar: presented and discussed reliability study inputs, methodology, and results available, to be used in LSEs' plan development

Opportunities to Improve IRP Reliability Planning

- **2017-18 IRP Cycle**
  - Optimistic import assumptions meant reliability planning was secondary
- **2019-21 IRP Cycle**
  - Changing assumptions led to two large procurement orders for new resources
    - Orders were not directly tied to loss of load probability (LOLP) modeling of reliability need
  - PRM assumed in RESOLVE to reflect Mid-Term Reliability (MTR) High Need scenario has led to portfolio that exceeds the reliability standard, per 2021 Preferred System Plan (PSP) analysis
- **2022-23 IRP Cycle**
  - I&A and LSE plan filing requirements present opportunity to refresh reliability planning inputs
  - Planning track PRM update for IRP modeling broadly
  - PRM for mid-to long-term procurement program

Topic	Past IRP Method	Improvement
PRM	Shifting PRMs not tied to LOLP fundamentals → RESOLVE outputs not always matched to reliability results from loss of load modeling	SERVM-based PRM to meet reliability standard
Thermal resource accounting	NQC-based (installed capacity) → can tip the scales in favor of gas plants vs. clean energy	Unforced capacity (UCAP) or ELCC-based to create a level playing field
ELCCs for RESOLVE	Solar + wind surface (RECAP) Storage ELCC curve (SERVM)	Solar + storage surface (SERVM) Wind ELCC curve (SERVM)
ELCCs for LSE Plans	Interpolation from RESOLVE outputs	SERVM-based ELCC forecast

PRM & ELCC Studies

Background to Studies

Summary of 2022 Approach

- **Reliability Modeling Approach**
  - Use the CPUC's SERVM model, with any appropriate updates, as the basis for need determination and resource accreditation
- **Need Determination**
  - Calculate total system need via a perfect capacity (PCAP) based total reliability need MW (TRN), then translate into a PCAP planning reserve margin (PRM) above median gross peak
  - A PCAP-based approach means removing from the reserve margin an allowance for forced outages of firm resources, and accrediting all resource types at their respective ELCC i.e., their perfect capacity equivalent, based on simulations that consider their risk of outages, resource availability, and their interaction with load and other resource types
  - Calculate marginal reliability need (MRN) relative to total reliability need (TRN) using a marginal ELCC study
  - Base LSE-specific need on share of marginal reliability need using new multi-year CEC LSE-specific managed peak share forecast
- **LSE Plan Resource Accreditation**
  - All resources will use marginal ELCCs
- **RESOLVE Updates**
  - Align PRM and ELCCs with LSE plan inputs (i.e. use same PCAP PRM and ELCCs from same SERVM model)
  - Change solar + wind ELCC surface to a solar + storage ELCC surface, include demand response (DR) on the storage dimension
  - Develop separate wind ELCC curves
  - All other resources will also use ELCC (firm resources, hydro, etc.)

Energy Division's reliability modeling strategy

Energy Division is using the LOLE reliability modeling framework in a variety of Commission proceedings in addition to IRP.

- Energy Division completed LOLE and ELCC studies in 2022 for the Resource Adequacy (RA) proceeding to inform the determination of wind, solar and storage resource ELCCs as well as the PRM for the 2023 and 2024 RA compliance years.
- Energy Division is using the LOLE framework with the "NoNewDER" portfolio for the Avoided Cost Calculator in the Integrated Demand Energy Resource proceeding to establish avoided costs.

These diverse applications of LOLE modeling all rely on the same IRP baseline dataset.

- Baseline dataset includes electric demand, baseline resources, generation profiles for non-firm resources, fuel prices, etc.
- Maintaining consistency and stability in datasets is critical for enabling modeling work across these proceedings to be relatable and consistent with each other.
- Modeling data is posted to the CPUC website (Unified RA+IRP Dataset page) for parties to review and comment
- Parties can provide feedback during the regular IRP Inputs/Assumptions development process and periodic MAG meetings

Key SERVM Modeling Updates

The following key updates were completed in May, 2022[1] and applied in this PRM study as part of comprehensive model updates scoped for the 2022-2023 IRP cycle. Recent studies for the 2021 IRP PSP and the RA proceeding Feb 2022 LOLE/PRM study used assumptions from the prior IRP cycle.

- Weather Years now span 1998-2020 and determine the distribution of load, wind, solar, and hydro hourly shapes
- Demand forecast updated to CEC's 2021 IEPR mid-mid case
- Updated Preferred System Plan portfolio from RESOLVE using 2021 IEPR and updated resource costs and transmission zone limits
- PG&E Bay and Valley regions collapsed into one PGE region
- Only CAISO (PGE, SCE, SDGE regions) units explicitly modeled – transfers with neighbors modeled as fixed import shapes
- Updated forced outage rates
- Relaxed Path 26 transmission limits (to ensure congestion from unbalanced retirements or additions in N vs. S does not increase system reliability need)
- Ratio of fixed to tracking solar capacity aligned with RESOLVE assumptions
- BTM battery storage treated as a load modifier using 2021 IEPR shapes

1. Staff's input data for reliability modeling is available at https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/electric-power-procurement/long-term-procurement-planning/2022-irp-cycle-events-and-materials/unified-ra-and-irp-modeling-datasets-2022

PRM Study Approach

Overview of Approach to Study PRM for LSEs' IRPs

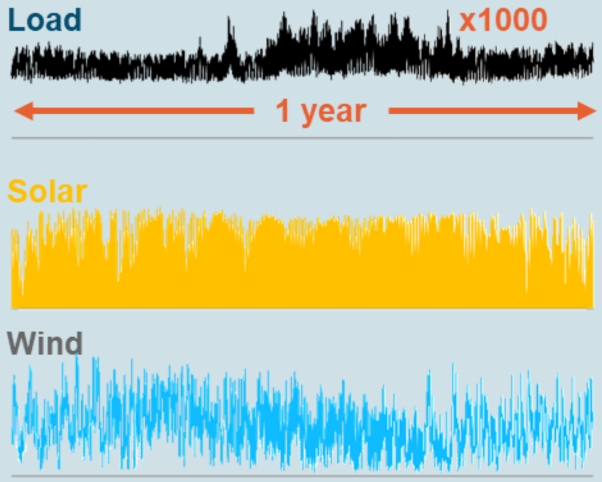
- Perfect capacity (PCAP) PRM is for use in LSEs' 2022 IRPs
  - This means removing from the reserve margin an allowance for forced outages of firm resources, and accrediting all resource types at their respective ELCC, i.e., their perfect capacity equivalent, based on simulations that consider their risk of outages, resource availability, and their interaction with load and other resource types
- Given that a PCAP PRM is less familiar to stakeholders than an installed capacity (ICAP) PRM, this study also calculates the ICAP PRM equivalent to the PCAP PRM
  - Information-only
  - Can be calculated relative to the managed peak (as well as the gross peak that IRP uses), to enable more direct comparison to the historical 15% ICAP PRM
- In July 2022 staff is providing the final RDT with resource accreditation metrics (including ELCCs) by resource type, so LSEs can determine the perfect capacity equivalent MW of their resources and compare this to their reliability need
  - As explained later in this deck, LSEs will use marginal ELCCs to plan for their share of the system’s marginal reliability need

Key Steps for Reliability Planning using LOLP Modeling

Step 1: Model + Data Development

Develop a robust dataset of the loads and resources in a loss of load probability (LOLP) model

LOLP modeling evaluates resource adequacy across all hours of the year under a broad range of weather conditions

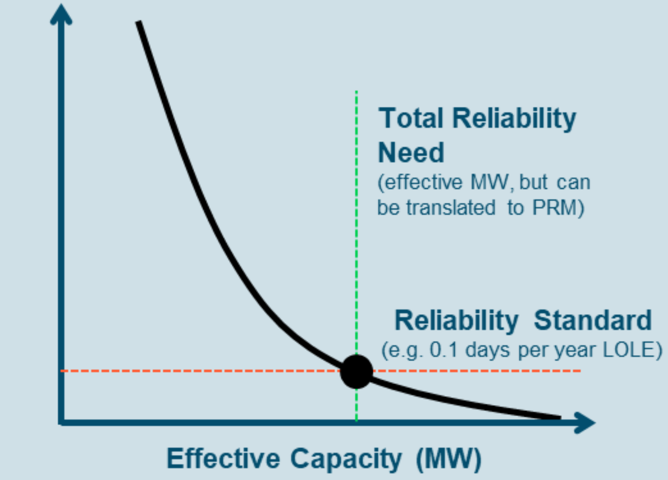


Robust probabilistic models + datasets are the foundation of any resource adequacy analysis

Step 2: Need Determination

Identify the Total Reliability Need to achieve the desired level of reliability

Factors that impact the amount of effective capacity needed include load & weather variability, operating reserve needs

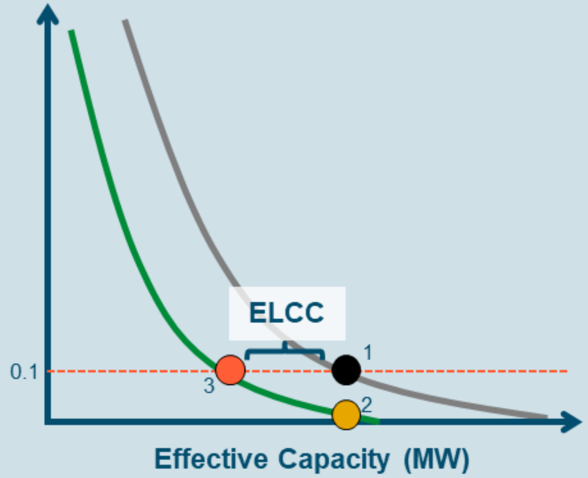


LOLP modeling provides Total Reliability Need in effective capacity MW to meet <0.1 days/yr LOLE, can be converted to a PRM

Step 3: Resource Accreditation

Calculate resource capacity contributions using effective load carrying capability

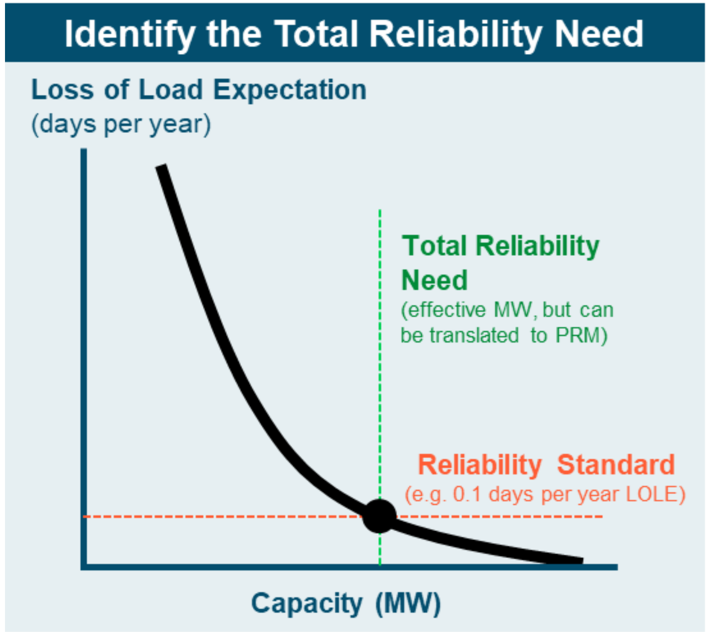
ELCC measures a resource's contribution to reliability needs relative to perfect capacity, accounting for performance across all hours

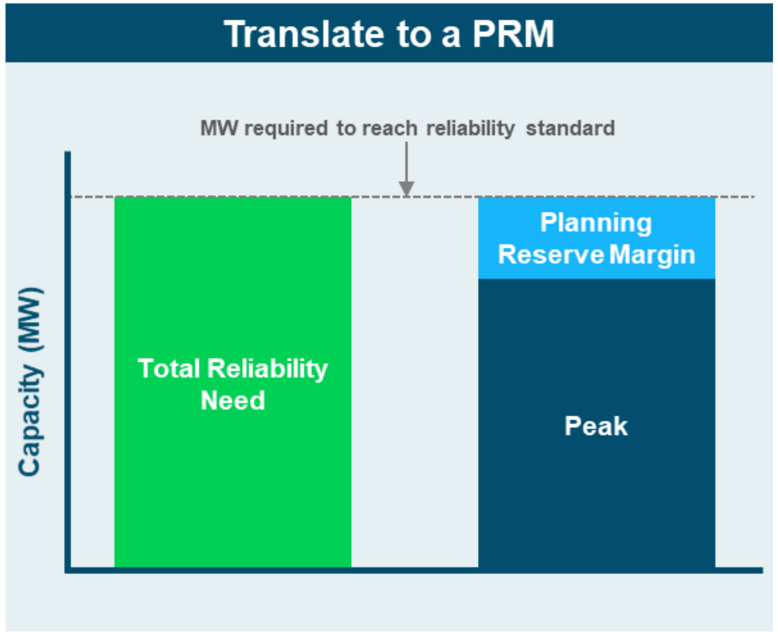


Effective or "perfect" capacity based accounting (UCAP or ELCC) counts all resources on a level playing field against that total reliability need

Using the Total Reliability Need (TRN) to Derive the PRM

- The Planning Reserve Margin (PRM) is a derivative value from the Total Reliability Need (TRN)
  - TRN is a MW value output from LOLP modeling
- The TRN/PRM can be defined using multiple approaches
  - E.g. resource accreditation methods (e.g. UCAP versus ICAP)





Total Reliability Need =
Total effective capacity (in MW) needed to maintain an adopted reliability standard (e.g. < 0.1 day/yr LOLE).

Planning Reserve Margin =
% margin above peak demand necessary to reach the TRN

$$PRM\ \% = \left(\frac{TRN}{Peak\ Demand}\right) - 1$$

Types of PRMs

- **Installed Capacity (ICAP) PRM** – ***calculated in this study for illustrative purposes only***
  - Measures resource MW using their installed capacity, accounting for forced outages in the reserve margin
- **Unforced Capacity (UCAP) PRM**
  - Measures resource MW using their unforced (i.e. outage de-rated) capacity, accounting for forced outages in resource accreditation
- **Perfect Capacity (PCAP) PRM** – ***for use in 2022 IRP LSE Plans***
  - Measures all resource MW using their perfect capacity equivalent (i.e. ELCC) capacity, accounting for forced outages and additional portfolio effects in resource accreditation

	Firm Resources	Non-firm Resources	Contributing Factors	Pros	Cons
ICAP	**Installed** capacity MW	ELCC MW	• Load/weather variability • Operating reserves • Forced outages	• Simpler firm resource accreditation	• "Tips the scales" in favor of firm resources
UCAP	**Unforced** capacity MW	ELCC MW	• Load/weather variability • Operating reserves	• Level playing field • Reliability need not impact by portfolio changes (retirements, etc.)	• UCAP may not reflect ELCC
PCAP	**ELCC** MW	ELCC MW	• Load/weather variability • Operating reserves		• More LOLP runs required

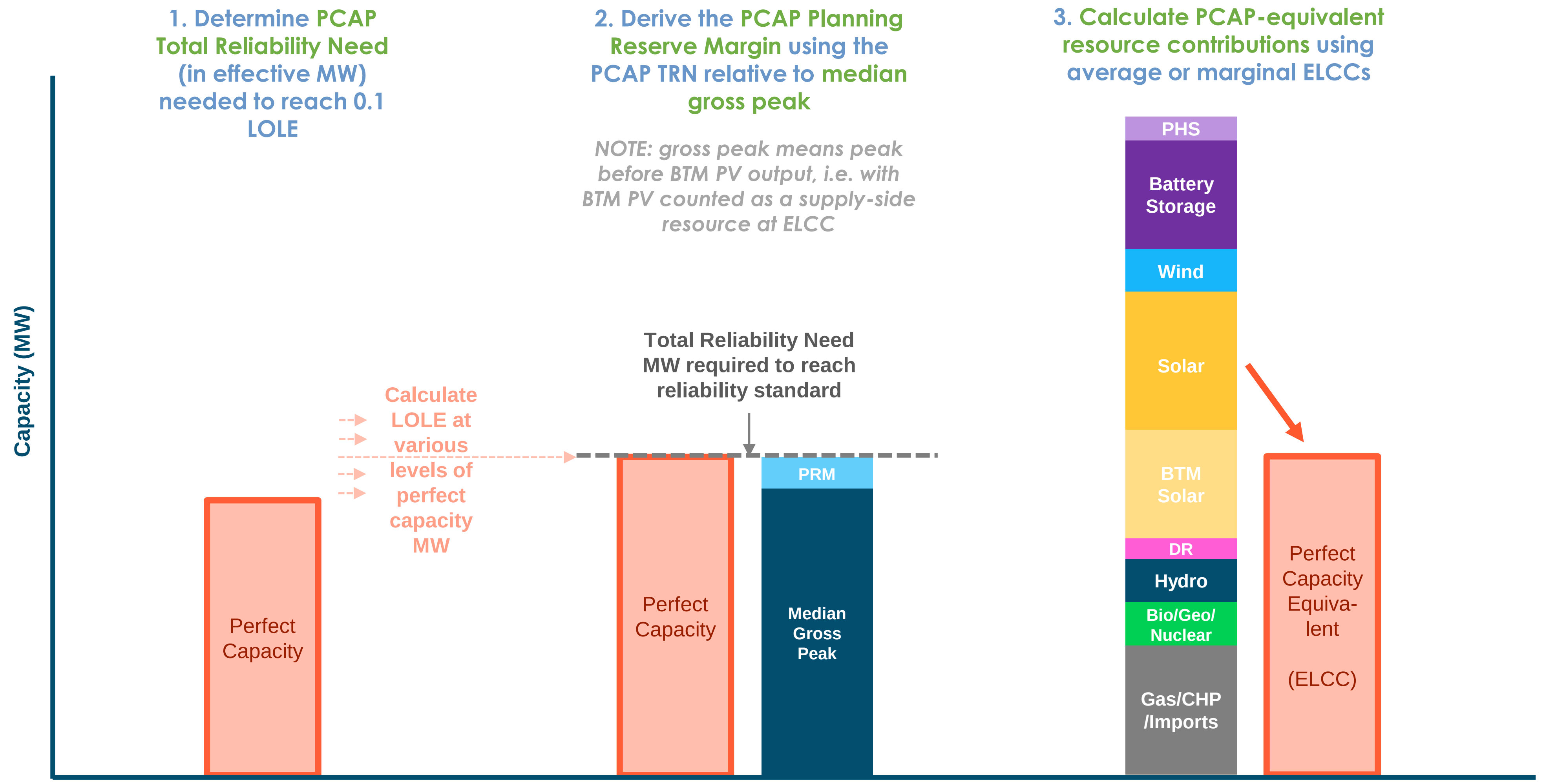
Why use the Perfect Capacity method for calculating a PRM?

- Installed Capacity (ICAP) PRM has been widely used but is increasingly challenged at higher renewable penetrations
  - ICAP PRM is not stable over time because it is a **function of the portfolio**
  - ICAP accredits thermal generation at nameplate but derates variable and storage resources based on their inherent limitations, creating an **unlevel playing field** (e.g. thermal NQC vs. renewable/storage ELCC)
  - ICAP socializes the limitations of thermal generators (forced outages) by increasing the PRM, providing inefficient investment signals
- Most resource adequacy programs have moved away from ICAP to UCAP; PCAP represents a further improvement
- PCAP PRM helps meet key design objectives
  - **Reliability**: CAISO system should meet the established reliability standard
  - **Efficiency**: properly incentivizes least-cost portfolio to meet reliability needs
  - **Fairness**: fairly establishes LSE need and fairly credits resources (not relevant to need determination)
  - **Feasibility**: administratively simple and straightforward to comply with
  - **Durability**: reliability need definition is durable to portfolio changes

	Reliable	Efficient	Fair	Feasible	Durable
Perfect Capacity (PCAP)	✔	✔	✔	✔	✔ *
Unforced Capacity (UCAP)	✔	✔ **	✔ **	✔	✔
Installed Capacity (ICAP)	✔	✘	✘	✔	✘

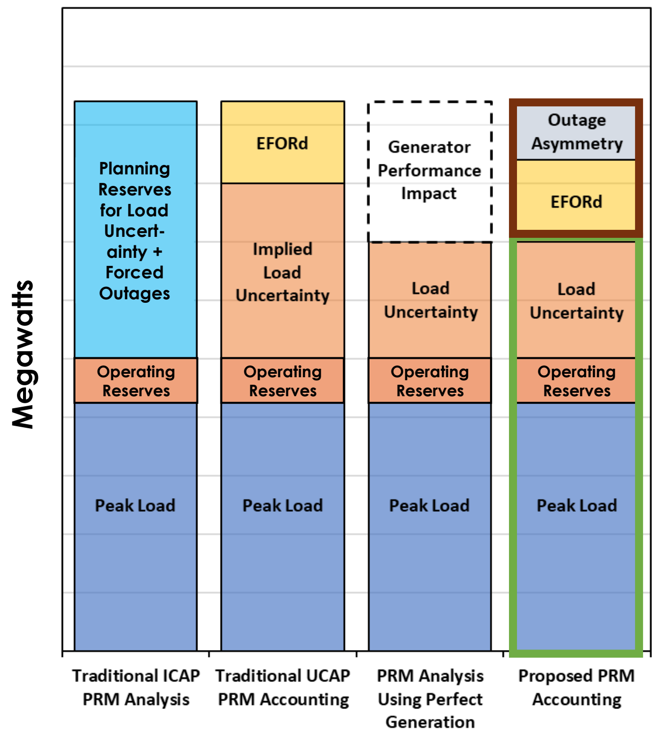
* Updating PCAP/UCAP PRM regularly is still recommended, based on evolving load shapes (e.g. more EV loads) and updated historical weather year load variability.
** UCAP has been considered a reasonable approximation of the ELCC for firm resources, but it does not necessarily capture their effective reliability value within a portfolio of resources

2022 IRP PCAP Planning Reserve Margin Study Method



Considering Firm Generator Outages in PRM Accounting

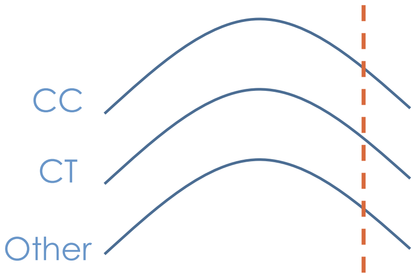
- UCAP accounting requires forced outage de-rate factors for each firm resource or resource class
  - E.g. UCAP = nameplate MW x (1 – EFORd %)*
  - UCAP PRM adjusted to remove forced outage impacts
  - However, EFORd changes as the firm fleet operations change, which would change the UCAP PRM as the resource mix changes
- Perfect capacity (PCAP) accounting utilizes *effective capacity* (i.e. perfect capacity equivalent = ELCC) accreditation for all resources, based on:
  A. Their modeled performance
  B. Interactive effects with other resources
- Firm generators can be accredited at their ELCC, providing consistency between firm and non-firm accreditation methods
- **For the 2022 RDT ELCCs, staff is using ELCC for all resources, (including firm resources)**



Outages + interactive effects captured in **firm resource accreditation**

PCAP PRM based only on operating reserves + load uncertainty

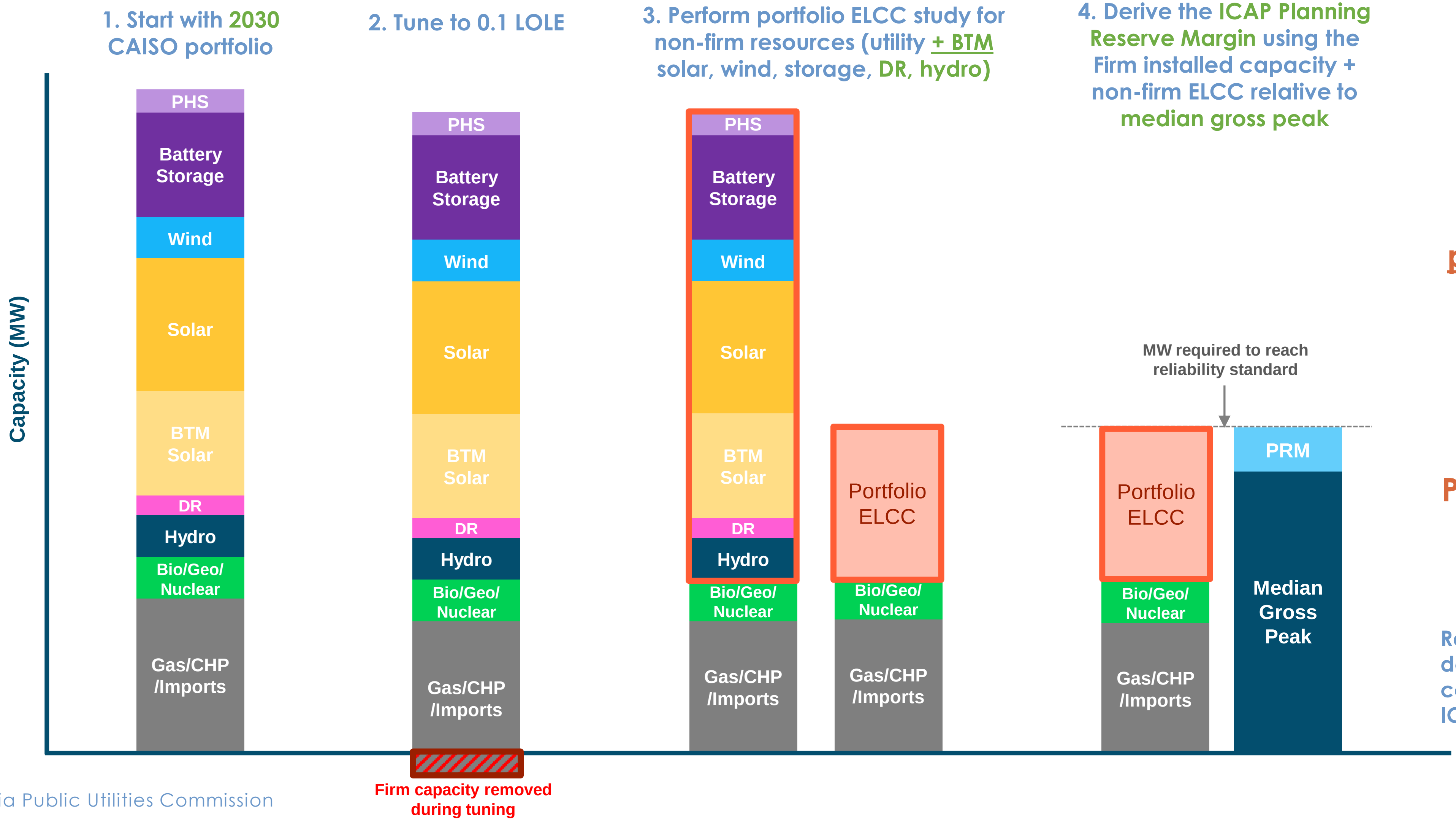
Outage Probability Distributions (illustrative)



Simultaneous outages of generators 1+2+3 has asymmetric impact on reliability

* Equivalent Forced Outage Rate demand (EFORd) is a SERVM output characterizing class average forced outage rates using generator performance data

2022 IRP ICAP Planning Reserve Margin Study Method



ICAP PRM calculated for illustrative purposes only, to compare to the historical 15% ICAP PRM…

IRP will use a PCAP PRM, not an ICAP PRM

Refer to Appendix for detail on methodology to compare PCAP PRM to ICAP PRM

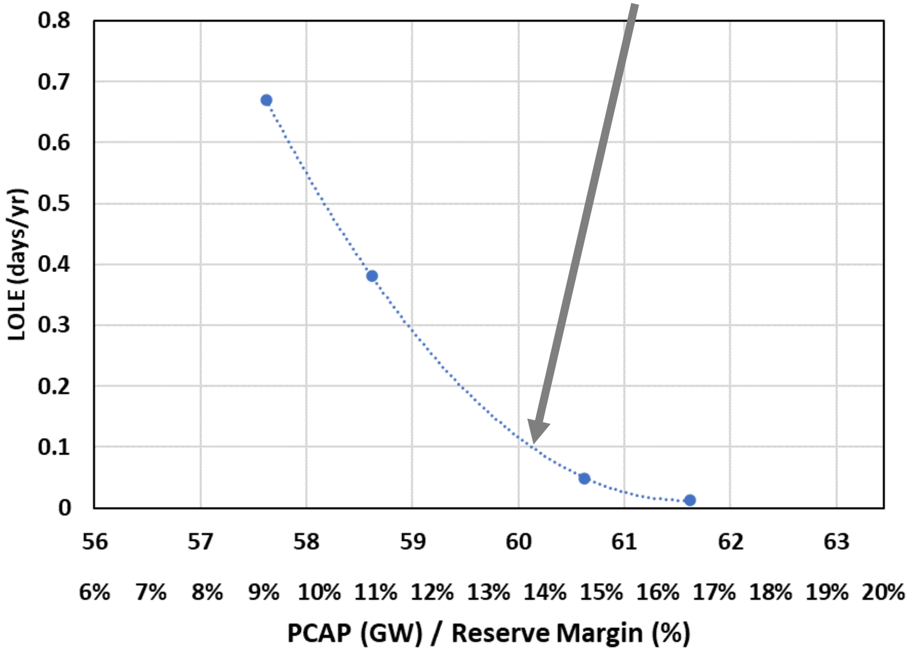
PRM Study Results

PCAP PRM Results

- A Perfect Capacity (PCAP) PRM analysis varies PCAP MW until 0.1 LOLE is achieved
- PCAP PRM is driven by
  - A. Inter-annual load variability in historical weather dataset
  - B. SERVM's load forecast error
  - C. 6% operating reserves
- PCAP PRM was calculated for 2024, 2026, 2030, and 2035
- PRM is measured relative to median gross peak (i.e. BTM PV counted as a supply-side resource at ELCC)

SERVM's CAISO PCAP PRM Simulations (2024)

LOLP simulations indicate an __13.8%__ reserve margin needed to meet 0.1 days/year LOLE

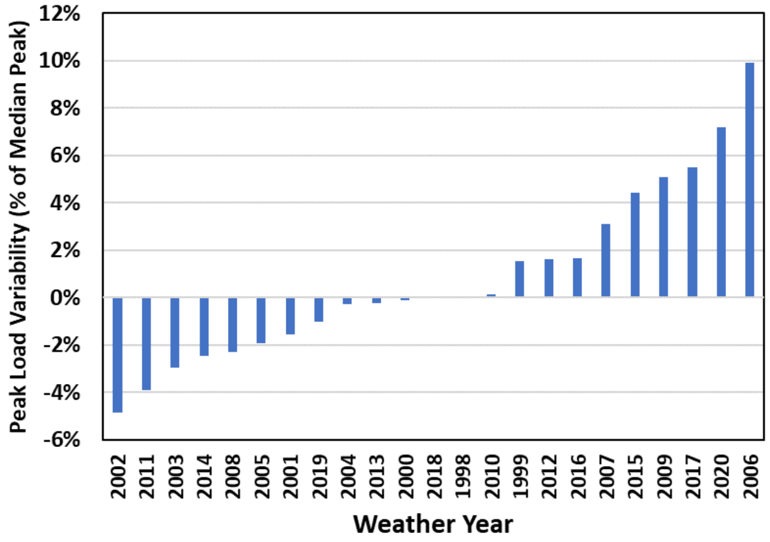


- *PCAP PRM simulations for years 2024, 2026, 2030 and 2035 ranged between ~13.5-14.0%*
- *Equivalent 2030 ICAP PRM over gross peak is ~18-21.5%, depending on the share of resources counted at ELCC vs. installed capacity*
- *All PRMs calculated relative to CAISO median gross peak*

PCAP PRM Drivers

Inter-annual Load Variability

- Reserves required to meet load under extreme weather conditions



Load Forecast Error

- SERVM includes a symmetric stochastic load forecast error of +/- 2.5%
- However, the PRM impact is asymmetric
  - Higher load years drive more additional loss of load events that are avoided in lower load years, driving a small additional reserve margin need

Operating Reserves

- CAISO holds 6% operating reserves during load shedding events to avoid cascading blackouts
- Modeled in SERVM as:
  - 3% spinning reserve
  - 3% regulation up

PRM and ELCC Interaction

- A planning reserve margin % is a function of:
  - Operating reserves
  - Load forecast error
  - Load variability

Directly impacts the total reliability need (perfect capacity MW) to reach 0.1 LOLE

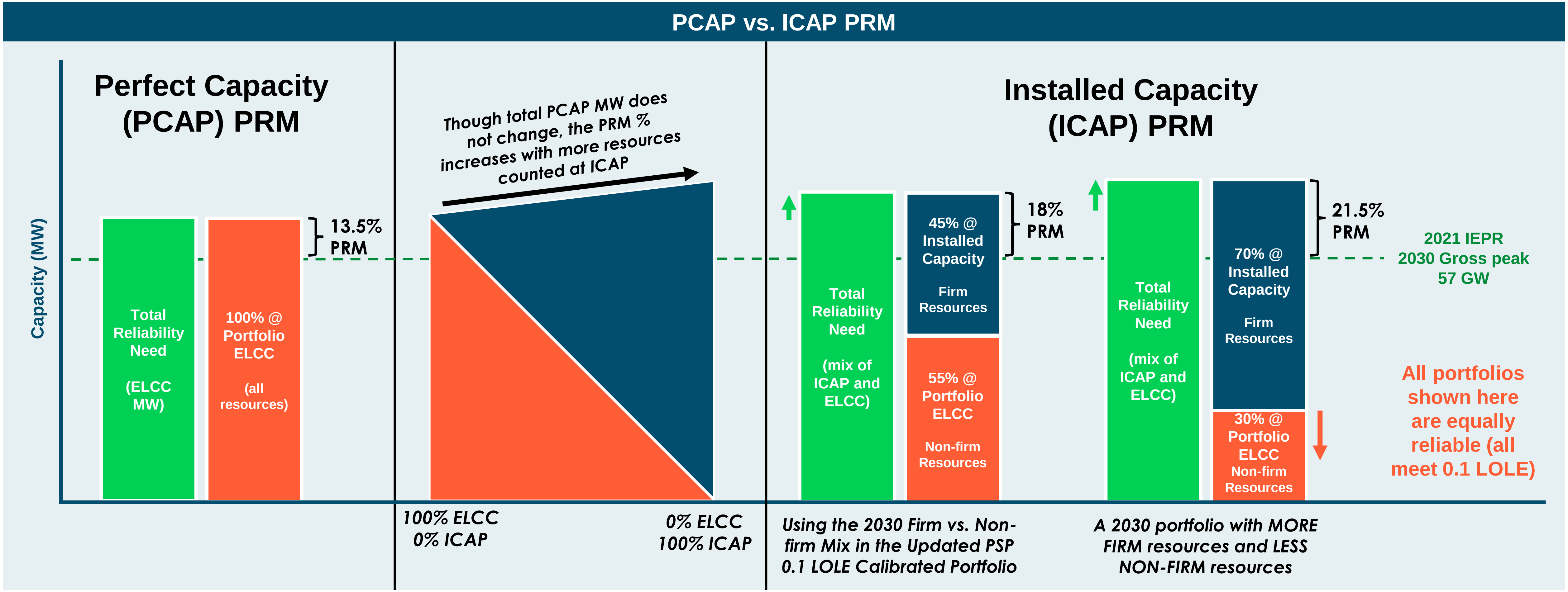
- Median peak (managed vs. gross)

Impacts the PRM % calculation that uses the TRN MW (a managed peak PRM is generally inconsistent with a PCAP approach)

- Resource mix

Does NOT impact a PCAP PRM since all resources counted at PCAP/ELCC… …but if a mix of PCAP-based and other methods used (installed capacity, exceedance heuristics, etc.), then the mix will impact the ICAP PRM

ICAP PRM Changes As the Resource Mix Changes

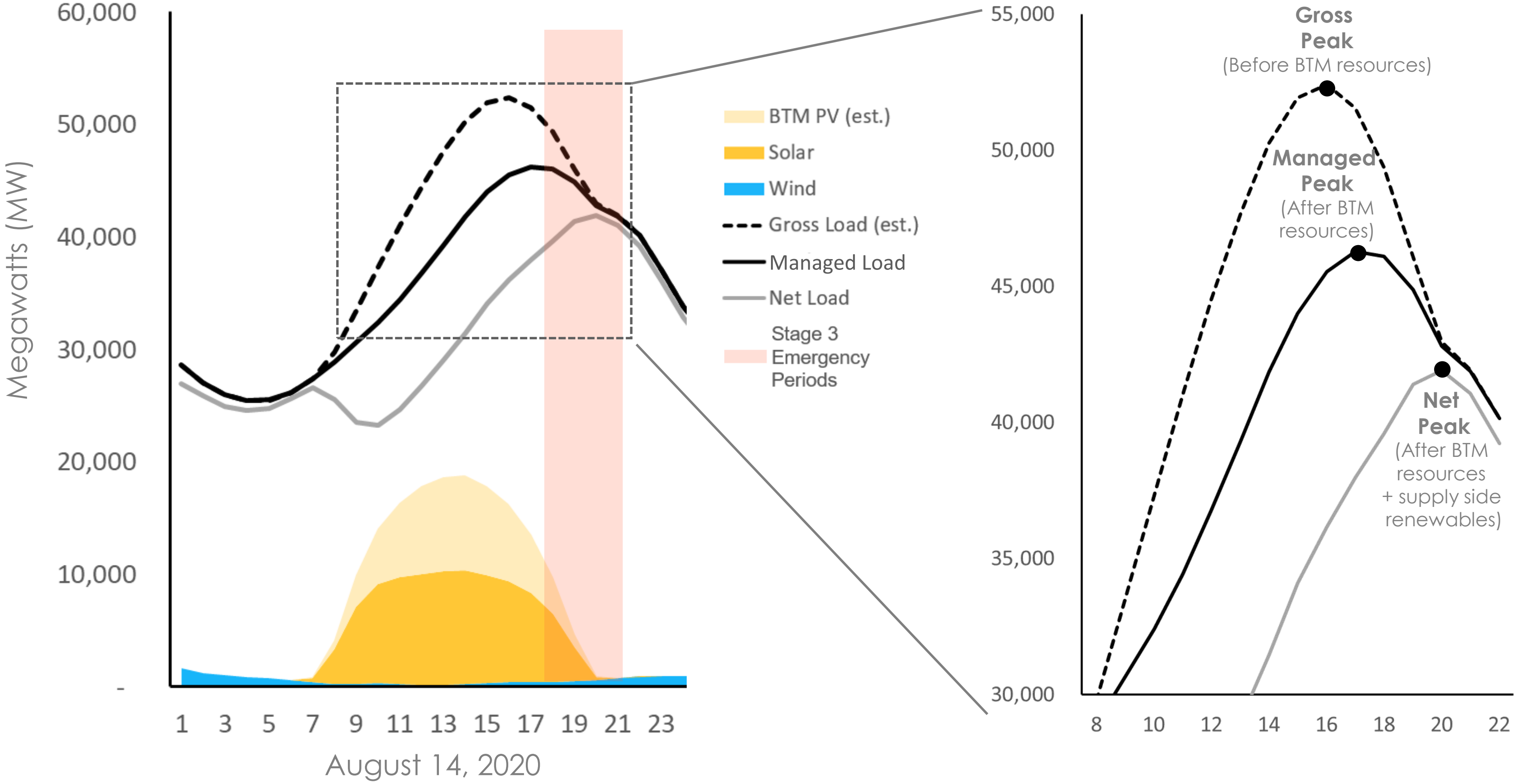


Defining the PRM Above Gross Peak (Before BTM PV Output) versus Managed Peak

- A PCAP PRM is derived from the perfect capacity needed to reach 0.1 LOLE
- This requires counting all resources at their perfect capacity equivalent MW (i.e. their ELCC) since the resources that would cause the managed peak and net peak to be lower than the gross peak are not included in the calculation of the PCAP PRM %
- Therefore, the definition of the PRM relative to the gross peak (not managed peak) is consistent with the PCAP PRM method
  - It also provides the benefit of not changing the PRM % over time as the gross vs managed peak further shifts
  - It appropriately credits BTM PV for interactive effects like storage charging and does not inappropriately credit it with reducing the reserve margin needed to meet the TRN
  - Defining the PRM relative to gross peak, BTM PV will be accredited via ELCC
- Note that a PRM % measured relative to the gross peak leads to a higher MW reserve margin versus the same PRM % applied to a lower managed peak

Why Switch from a "Managed Peak" Load Basis?
PRM % over Managed Peak changes as BTM resources change

Total Reliability Need MW to meet 0.1 LOLE does not change depending on the load determinant
...but if measured against a lower load, the required PRM % will increase



Gross Peak + 15% = 7.9 GW reserve margin

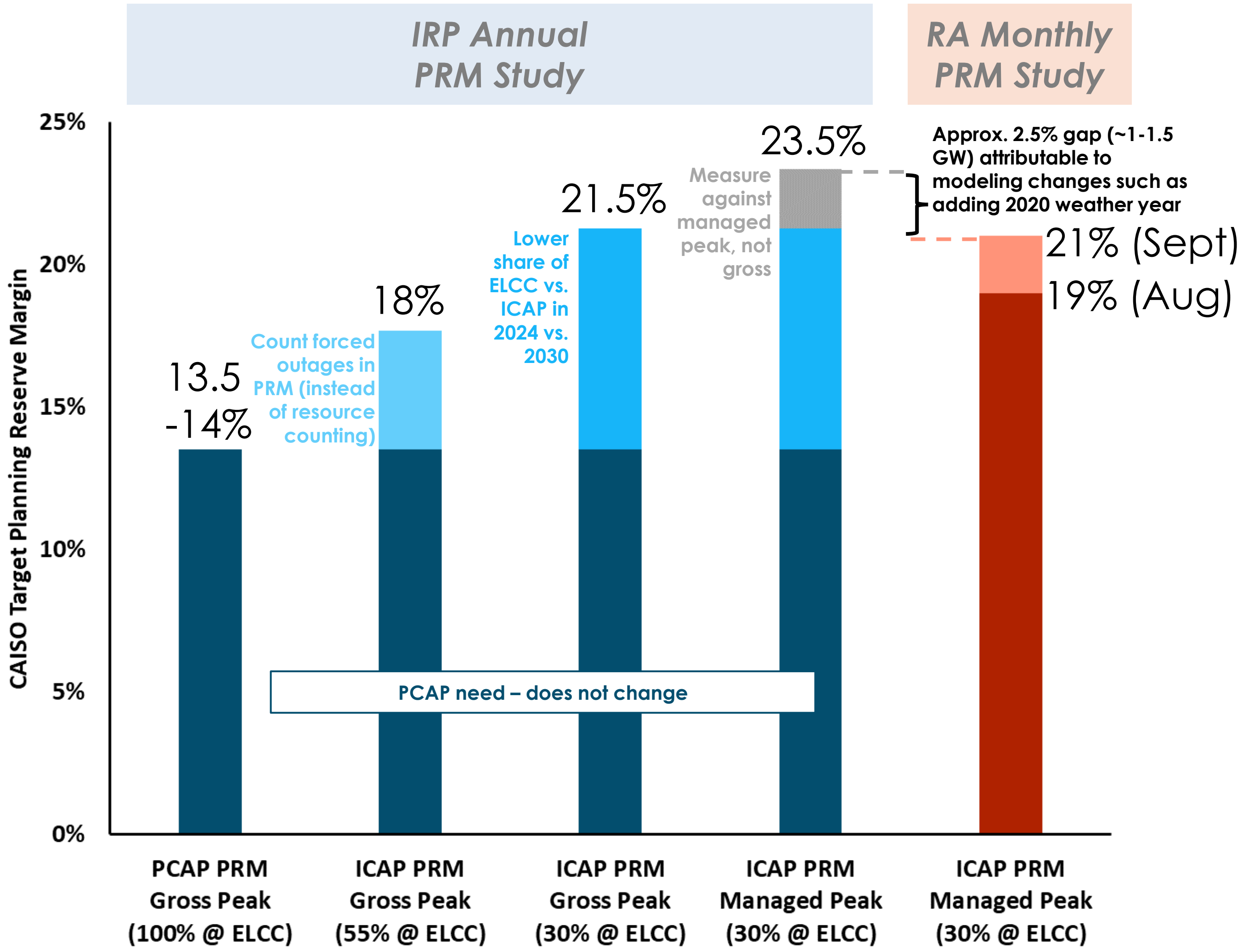
Managed Peak + 15% = 6.9 GW reserve margin

To reach the same 7.9 GW reserves, a 17% PRM is required over managed peak

Defining PRM above gross/consumption peak avoids this issue
BTM PV treated as a resource via ELCC (per current IRP methods) and its growth does not change the PRM % required

Comparing PRM Results to Recent RA Study

- Energy Division's February 2022 LOLE and ELCC Study[1] for the RA proceeding calculated monthly ICAP and UCAP PRMs above the CAISO managed peak
  - 2024 Jul-Sep ICAP PRM = 19-21% over CAISO managed peak
- This IRP study calculated an annual PCAP PRM above the CAISO gross peak using an updated SERVM model including recent extreme weather conditions in August 2020
  - 13.5-14% PCAP PRM over CAISO gross peak (2024-2035)
  - ~18% *ICAP PRM* over CAISO gross peak (2030 portfolio level of ELCC vs. ICAP)
  - ~21.5% ICAP PRM over CAISO gross peak (*2024 portfolio* level of ELCC vs. ICAP)
  - ~19.5-23.5% ICAP PRM over CAISO *managed peak*
    - Calculated by removing the IEPR peak shift from both the need and the gross peak
  - (Refer to the Appendix for methodology to compare PCAP PRM to ICAP PRM)
- Since the RA study, this IRP study found up to an extra ~2.5% ICAP PRM (or approximately 1-1.5 GW) required over CAISO managed peak to address extreme weather in 2020 captured by adding weather years through 2020 to the model (and other less significant updates)



1. Available at: https://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M452/K750/452750851.PDF

Conclusions from this PRM Study

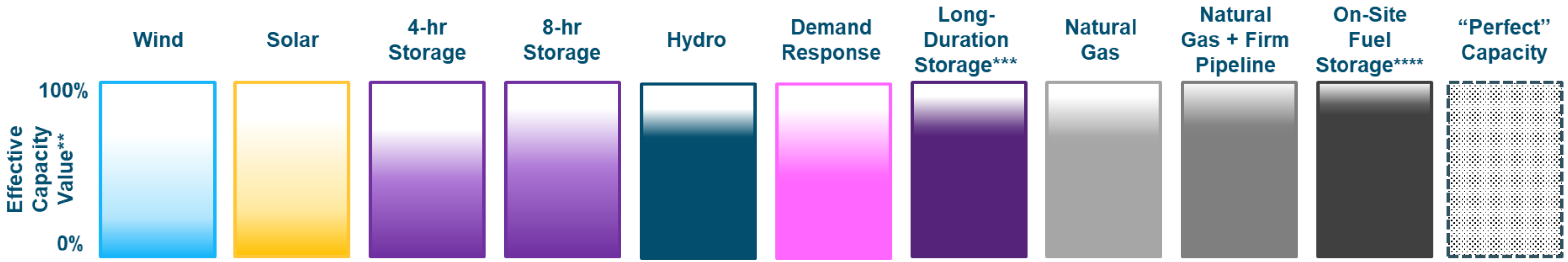
- A 14% PCAP PRM over gross peak was found sufficient to meet 0.1 LOLE across multiple years
  - Corresponds to an ICAP PRM of 18 to 21.5% above gross peak or 19.5 to 23.5% above managed peak, depending on the CAISO system's proportion of resources counted at ICAP vs. counted with ELCC
  - All resources will be accredited at their PCAP equivalent MW (i.e. ELCC)
    - Corresponding ELCC values will be released in July 2022
- This PRM study incorporated recent extreme weather from 2020 into SERVM's weather year dataset
  - This increased the total reliability need by about 1 to 1.5 GW relative to the RA proceeding study reported in February 2022
- RESOLVE portfolios from the updated PSP modeling were found to be more reliable relative to 0.1 LOLE
  - Planned updates as part of this cycle's I&A to RESOLVE's PRM and resource ELCCs are expected to better align RESOLVE inputs with SERVM LOLP modeling fundamentals

ELCC Study Approach

No Resource Provides Perfect Capacity

Resource Firmness*

Variable Energy Resources: variable output	**Use-limited**: subject to physical, environmental, or contractual limits	**Firm Capacity**: available on demand	**Perfect**

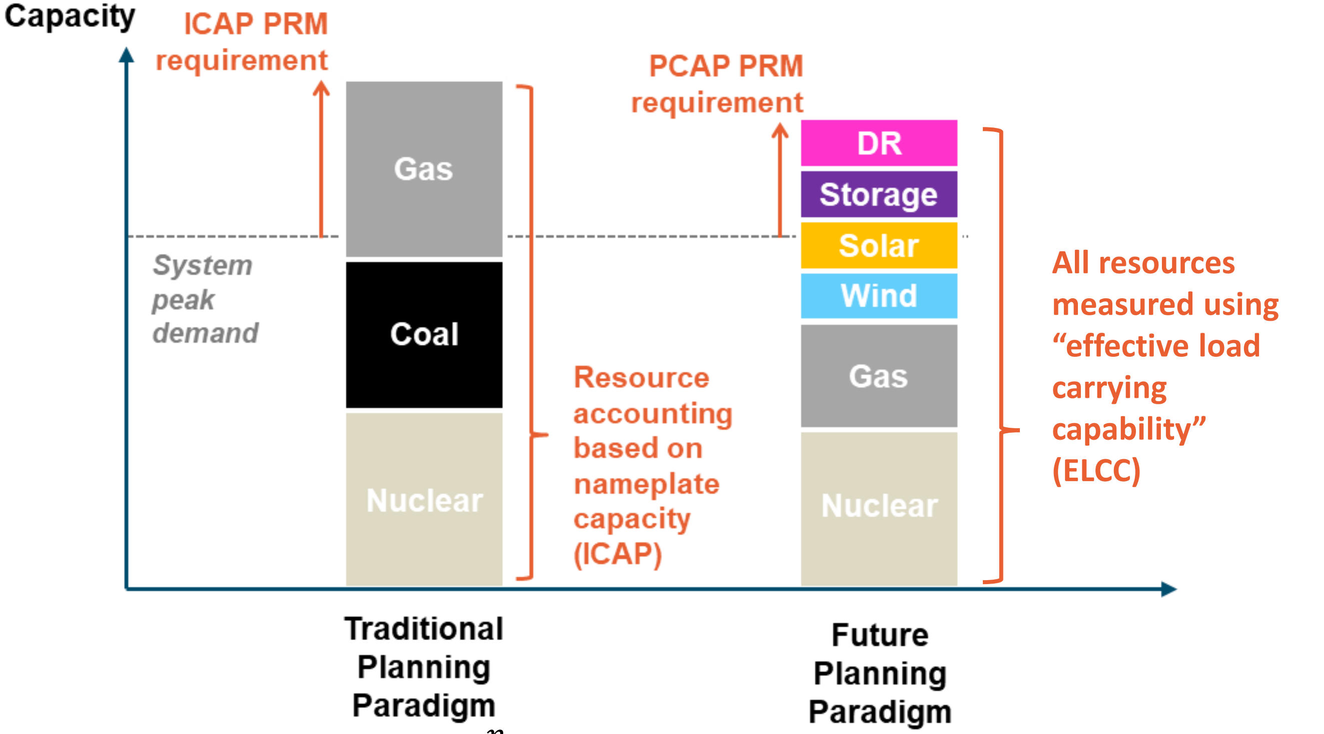


Factors Considered in Reliability Value

	Wind	Solar	4-hr Storage	8-hr Storage	Hydro	Demand Response	Long-Duration Storage***	Natural Gas	Natural Gas + Firm Pipeline	On-Site Fuel Storage****	"Perfect" Capacity
Variable output	X	X									*(Modeling construct used as comparison metric)*
Use-limitations			X	X	X	X	X				
Forced outages	X	X	X	X	X	X	X	X	X	X	
Fuel security								X	X		

** A "firm" resource can operate indefinitely when called upon, this spectrum generally ranks resources along the spectrum of least to most "firm"*
*** % Reliability values are illustrative*
**** Long-duration storage (between 12-1000 hr) may provide effectively firm capacity at long enough duration*
***** On-site fuel storage includes natural gas w/ on-site backup fuel, coal, nuclear, and biomass power*

Need Determination + Resource Accreditation Can Evolve Together to Reflect Shift to Non-Firm Resources



$$Installed\ Capacity = \sum_{i=1}^{n} G_i$$

Total accredited capacity of a set of <u>firm generators</u> was simply the <u>sum</u> of their installed capacity

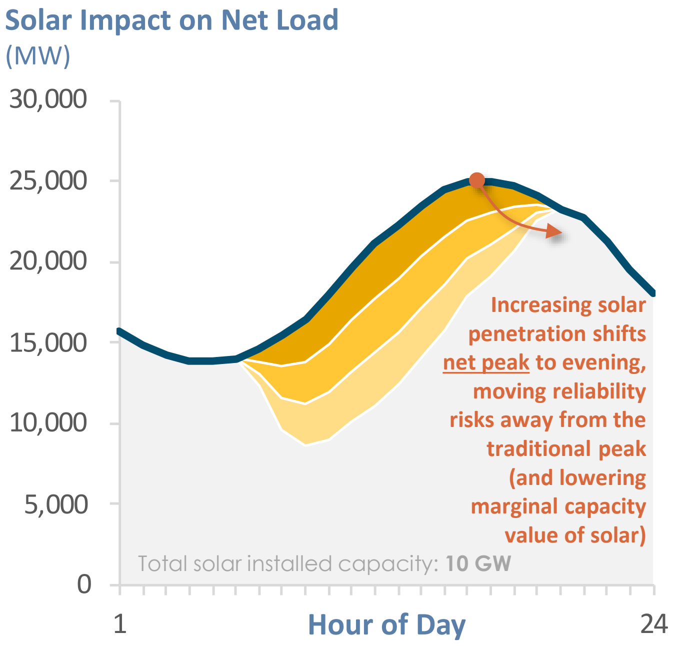
$$Portfolio\ ELCC = f(G_1, G_2, \ldots, G_n)$$

With <u>non-firm resources</u>, the total accredited capacity of a portfolio is <u>a function</u> of generator interactions

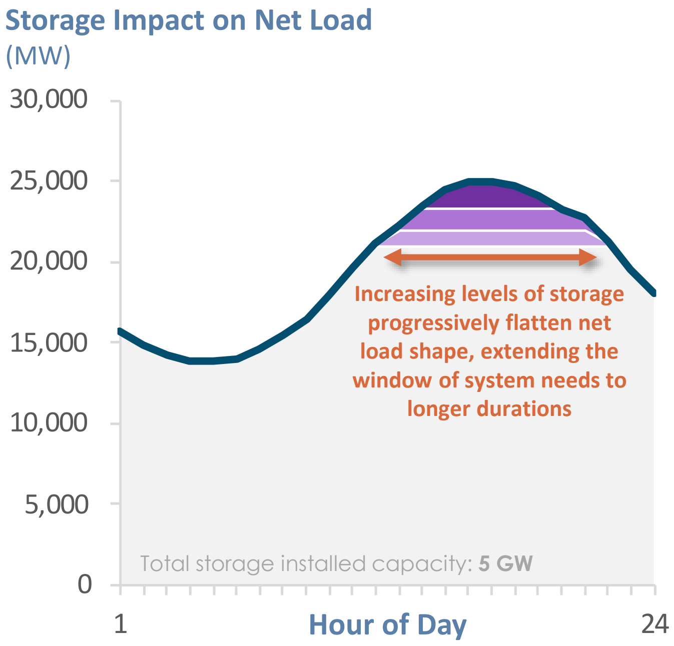
- **Need determination**: TRN/PRM defined based on Perfect Capacity (PCAP) MW
- **Resource accreditation**:
  - Non-firm resources accredited based on ELCC
    - ❑Large differences in availability during peak
    - ❑Significant interactions among resources
    - ❑ELCC values are dynamic based on resource mix
  - Firm resources accredited based on ELCC
    - ❑Outage characteristics
    - ❑Interactive effects

ELCC captures complex dynamics resulting from increasing penetrations of variable & energy limited resources

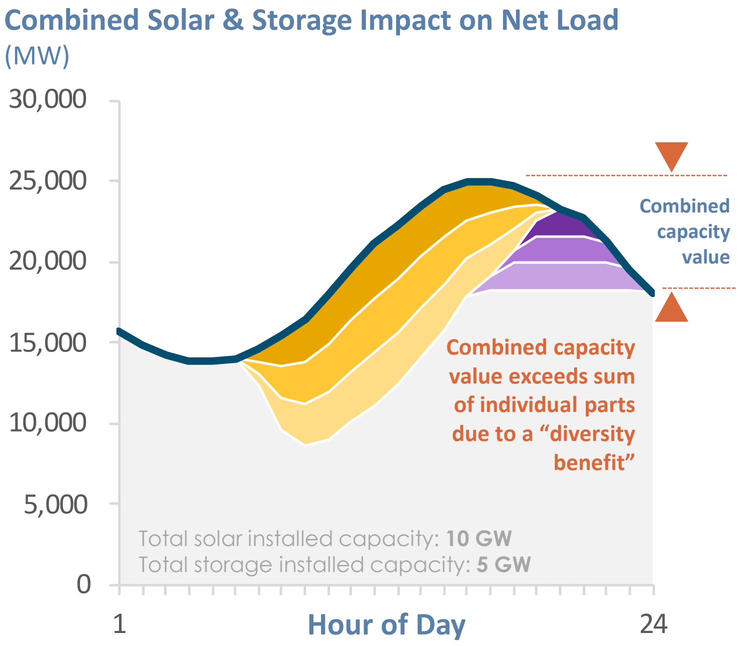
“Variable” resources shift reliability risks to different times of day



“Energy-limited” resources spread reliability risks across longer periods



A portfolio of resources exhibits complex interactive effects, where the whole may exceed the sum of its parts



The ELCC approach inherently captures both **capacity** & **energy** adequacy

Measuring ELCC of a Portfolio and Individual Resources

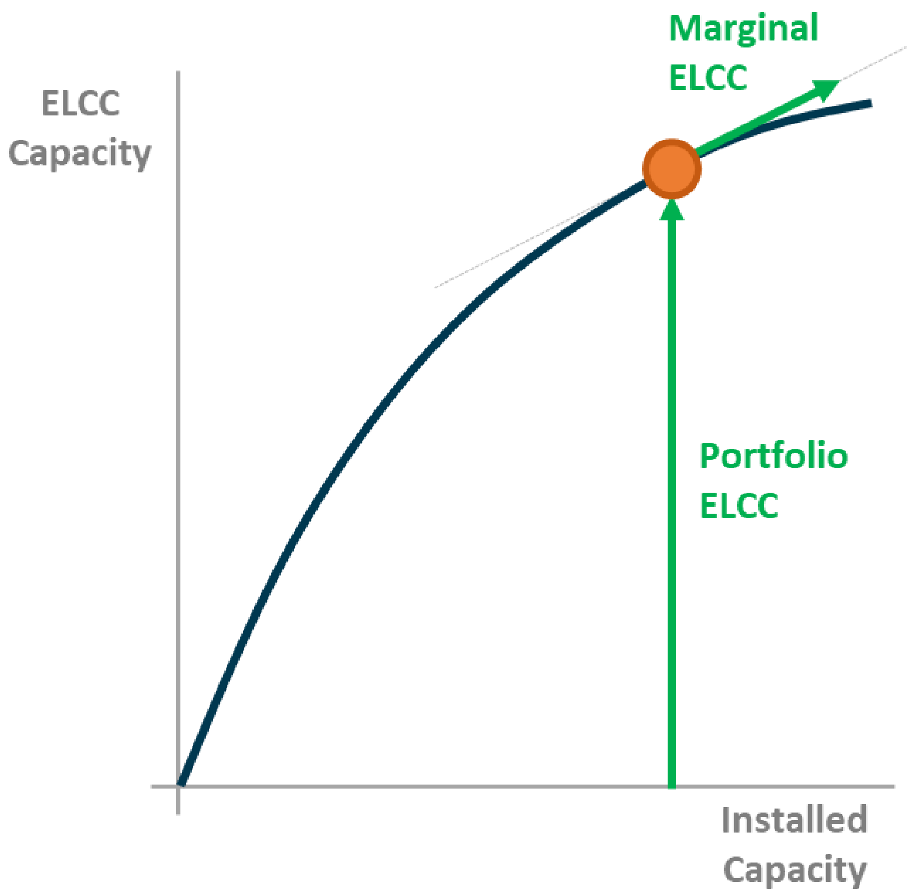
- **ELCC of is a function of the portfolio of resources**
  - The function is a surface in multiple dimensions
  - The Portfolio ELCC is the height of the surface at any given point on the surface

$$Portfolio\ ELCC = f(G_1, G_2, \ldots, G_n)\ (MW)$$

  - The Marginal ELCC of any individual resource is the gradient (or slope) of the surface along a single dimension – mathematically, the partial derivative of the surface with respect to that resource

$$Marginal\ ELCC_{G_1} = \frac{\partial f}{\partial G_1}(G_1, G_2, \ldots G_n)\ (\%)$$

- **The functional form of the surface is unknowable**
  - Marginal ELCC calculations give us measurements of the contours of the surface at specific points
    - E.g. 100 MW of incremental storage on top of a given portfolio
  - It is impractical to map out the entire surface across all resources
- Assigning resource-specific "average" ELCCs requires allocating the portfolio ELCC to individual resources



Impact of Average vs. Marginal ELCCs on LSE Resource Selection

- The ELCC method will change the relative capacity cost for different resources in LSE plan portfolio optimization
- **Average ELCCs** are compatible with a conventional PRM, crediting resources so that the sum equals the total reliability need
- **Marginal ELCCs** establishes need and credits resources based on their marginal contribution during scarcity
  - Marginal ELCCs provide a more economically efficient signal for incremental procurement
    - Mid-Term Reliability procurement order and the RPS program's least-cost best-fit approach have used incremental/marginal ELCC for this reason

Illustrative Example of Cost per Unit of Effective Capacity

		ELCC %		Cost $/effectivekW-yr	
	Cost $/kW-yr	Average ELCC	Marginal ELCC	Average ELCC	Marginal ELCC
Storage	$150	84%	76%	$179	$197
Solar	$80	36%	6%	$222	$1,333
Wind	$150	13%	16%	$1,154	$938
Geothermal	$700	92%	92%	$761	$761

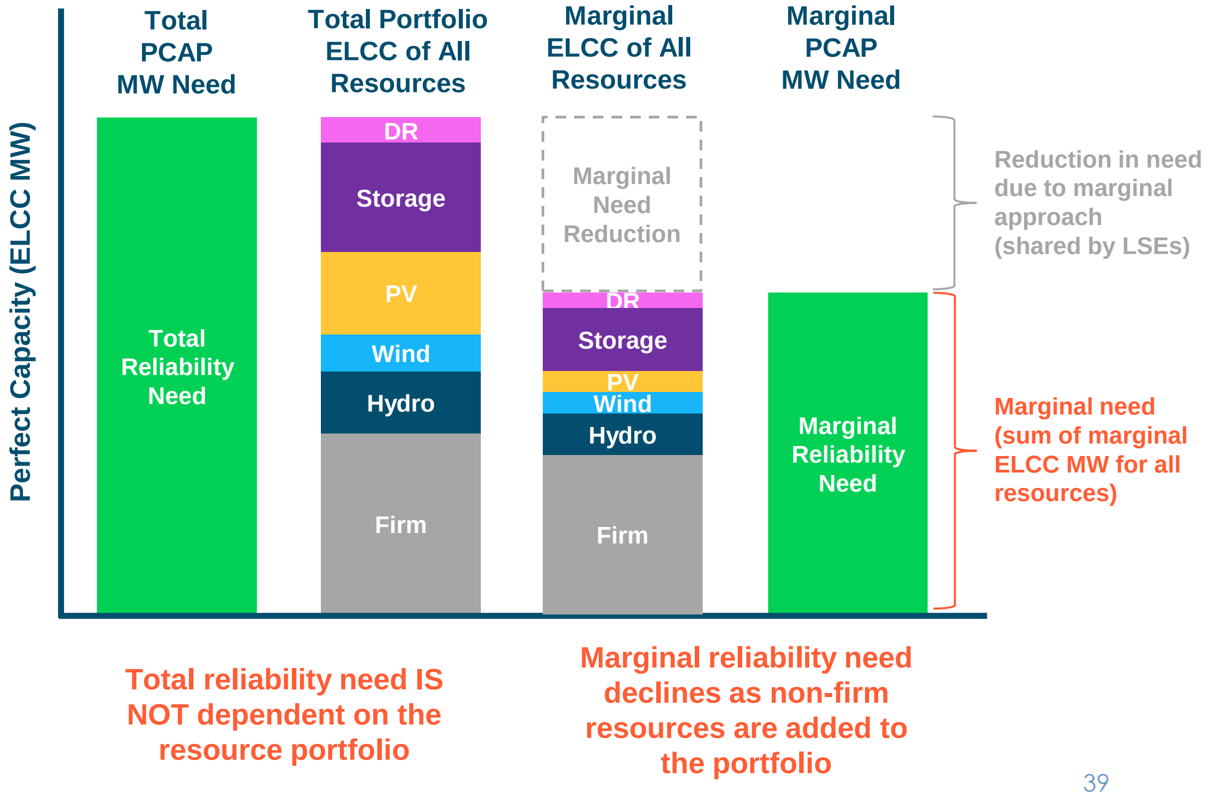
Note: these are illustrative gross costs of new entry. LSE portfolio optimization incorporates market revenues, i.e. would see the net cost of new entry by technology.

LSEs should use Marginal ELCCs for their 2022 IRPs

- Staff has considered whether average or marginal ELCCs, or some combination, should be used by LSEs to plan for reliable 2022 IRPs
- Each approach involves trade-offs between efficiency, fairness, and feasibility
  - **Marginal ELCCs** provide an efficient investment signal for marginal resource decisions (e.g., what's the reliability value of adding another solar plant) and are feasible to implement
  - **Average ELCCs** credit specific LSEs for past procurement (e.g., which LSE bought the solar that shifted the gross to net peak) and are feasible to implement
  - A **combination** of using average ELCCs for existing resources, and marginal ELCCs for new resources, may be possible in the future, but requires more thought (requires bifurcating portfolio based on contract terms, increases scope + complication of ELCC study)
- **Staff requires LSEs to use marginal ELCCs for their IRP development**, and is providing these for each resource type, by year, in the RDT
- Accordingly, **staff also requires LSEs to use their share of the marginal reliability need,** and has provided the necessary information to derive that in the RDT

Implementing a Marginal ELCC Approach

- A marginal ELCC approach uses lower marginal ELCC % values but also reduces the MWs LSEs need to show
  1. **Need Determination**: Use the Marginal Reliability Need (MRN) instead of the Total Reliability Need (TRN)
     - MRN is calculated as the sum of marginal ELCC MW for all resources in the portfolio
  2. **Need allocation**: can use LSE load share during net peak
     - IEPR LSE-level managed peak share used for this cycle (since long-term forecast of hourly LSE loads was unavailable)
  3. **Resource accreditation**: Use marginal ELCCs for all resources
     - Effectively captures resource contributions during net peak hours



Marginal ELCC Study Method

1. **Calibrate Updated PSP portfolio** to 0.1 LOLE in SERVM
   - Performed by adding or removing firm capacity resources until 0.1 LOLE is achieved
2. **Calculate marginal (last-in) ELCCs** for resource classes
   - **Classes run**: utility PV, BTM PV, in-state wind, out-of-state wind, offshore wind, 4-hr batteries, 8-hr batteries, pumped hydro storage, demand response, hydro, firm resources
   - **Years run**: 2024, 2026, 2028, 2030, 2035
3. **Define the marginal reliability need (MRN)** as the sum of the last-in marginal ELCC
4. **Calculate LSE plan inputs** by post-processing results as needed
   1. Hydro: break into large and small hydro using relative Sept NQC MW
   2. Storage durations: interpolate between modeled durations
   3. Firm resources: allocate firm ELCC by scaling EFORd values for firm sub-classes
   4. Wind: allocate to sub-classes based on sub-class wind ELCC study in the RA proceeding
   5. Non-modeled years: linearly interpolate between modeled years for ELCCs and MRN

ELCC Study Results

Update

38 MMT Scenario: Marginal Need & ELCCs

Modeled Year (results complete)	Interpolated Year

Resource Class	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
In-state Wind (SoCal)	15%	15%	15%	12%	8%	8%	8%	7%	7%	6%	5%	4%
In-state Wind (NorCal)	30%	30%	31%	24%	17%	17%	16%	15%	13%	12%	10%	9%
Out-of-state Wind (WY/ID)	43%	39%	36%	37%	39%	31%	24%	25%	26%	27%	29%	30%
Out-of-state Wind (WA/OR)	26%	24%	22%	23%	24%	19%	14%	15%	16%	17%	18%	18%
Out-of-state Wind (AZ/NM)	38%	35%	32%	34%	35%	28%	21%	22%	24%	25%	26%	27%
Offshore Wind	55%	51%	46%	49%	51%	47%	43%	40%	38%	36%	34%	32%
Utility PV	10%	10%	11%	10%	9%	8%	6%	6%	6%	6%	6%	6%
BTM PV	9%	9%	10%	8%	7%	6%	5%	5%	5%	5%	5%	6%
4-hr Battery Storage	89%	90%	92%	85%	77%	76%	75%	68%	61%	54%	47%	40%
8-hr Battery Storage	89%	91%	93%	90%	87%	86%	85%	82%	79%	76%	73%	70%
Pumped Hydro Storage	89%	91%	93%	91%	89%	89%	89%	86%	83%	80%	76%	73%
Demand Response	89%	91%	92%	77%	62%	61%	59%	50%	41%	32%	23%	14%
Hydro (large)	57%	56%	56%	53%	50%	49%	48%	47%	46%	45%	44%	43%
Hydro (small)	41%	40%	40%	38%	36%	35%	35%	34%	33%	32%	32%	31%
Firm*	85%	86%	87%	87%	86%	85%	84%	86%	87%	88%	89%	90%

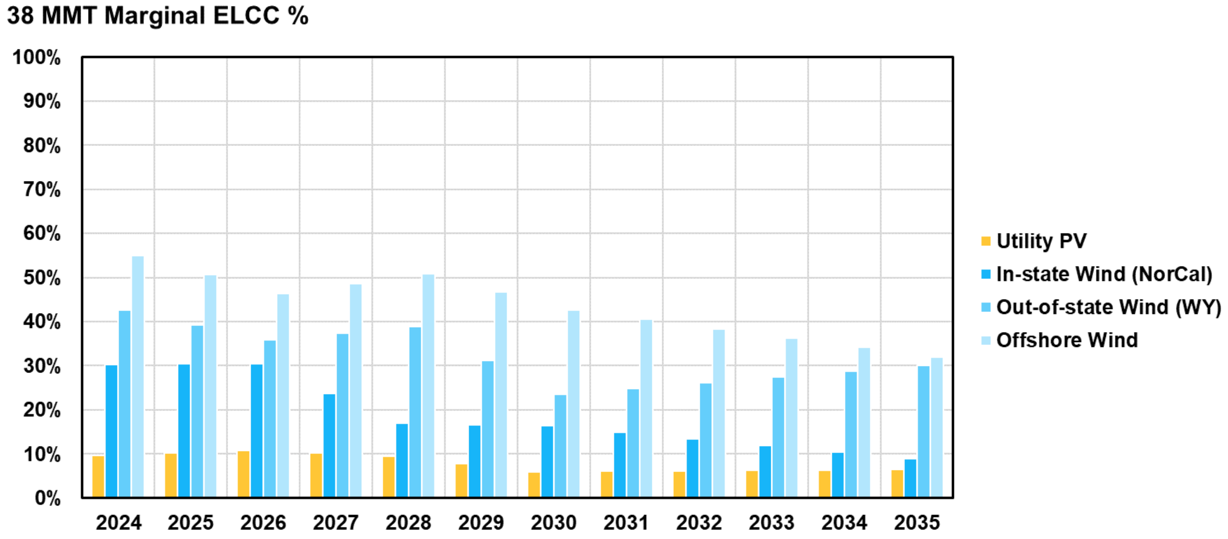
Marginal Reliability Need	48,838	50,521	52,204	50,322	48,441	47,702	46,964	46,372	45,780	45,188	44,596	44,005

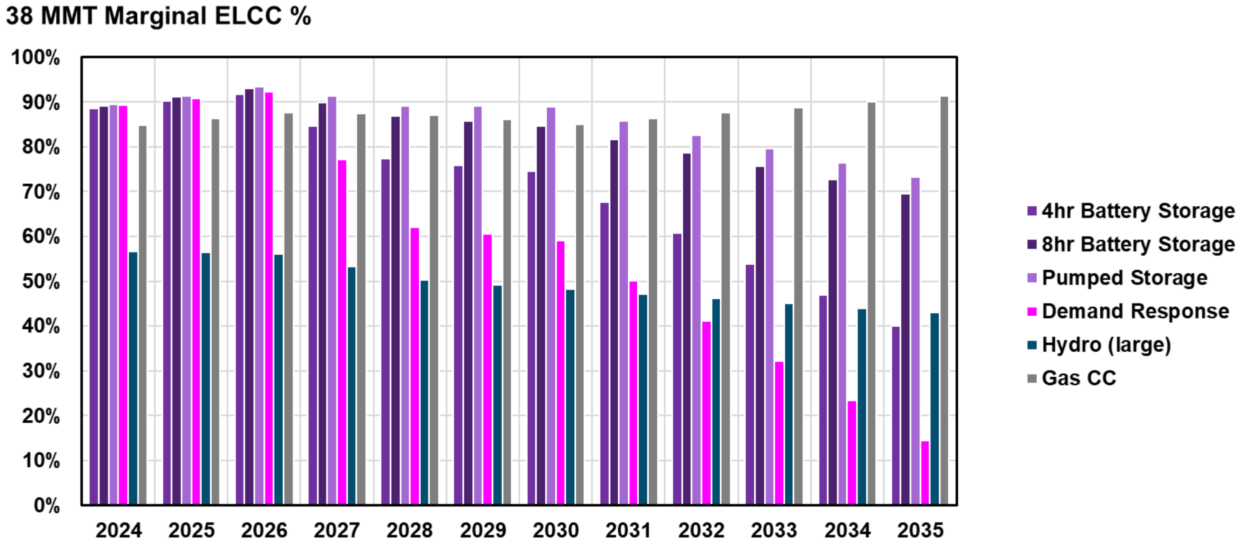
* Firm sub-class ELCCs included in Appendix slide

Update

38 MMT Marginal ELCC Trends

- Wind + solar ELCCs are low and decrease by 2035 as more renewables are added to the system
  - Solar maintains continued value for battery storage charging energy
  - Out-of-state and offshore provide higher ELCC than in-state wind
- 4-hr storage ELCCs remain high in the short term due to large solar additions, then decline as short-duration storage saturates
- Demand response (DR) follows storage trends
- Hydro ELCCs generally stable, with small decline as system becomes more energy constrained by 2035
- Firm ELCCs generally stable ~85%





Update

30 MMT Scenario: Marginal Need & ELCCs

Modeled Year (results complete)	Interpolated Year

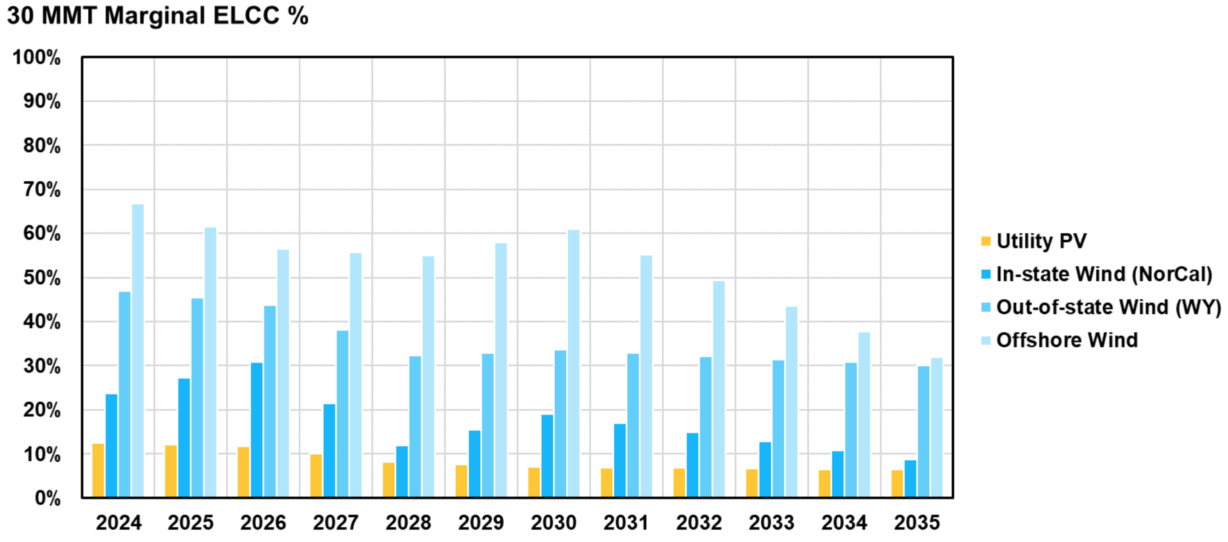
Resource Class	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
In-state Wind (SoCal)	12%	14%	15%	11%	6%	8%	9%	8%	7%	6%	5%	4%
In-state Wind (NorCal)	24%	27%	31%	21%	12%	15%	19%	17%	15%	13%	11%	9%
Out-of-state Wind (WY/ID)	47%	45%	44%	38%	32%	33%	34%	33%	32%	31%	31%	30%
Out-of-state Wind (WA/OR)	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%

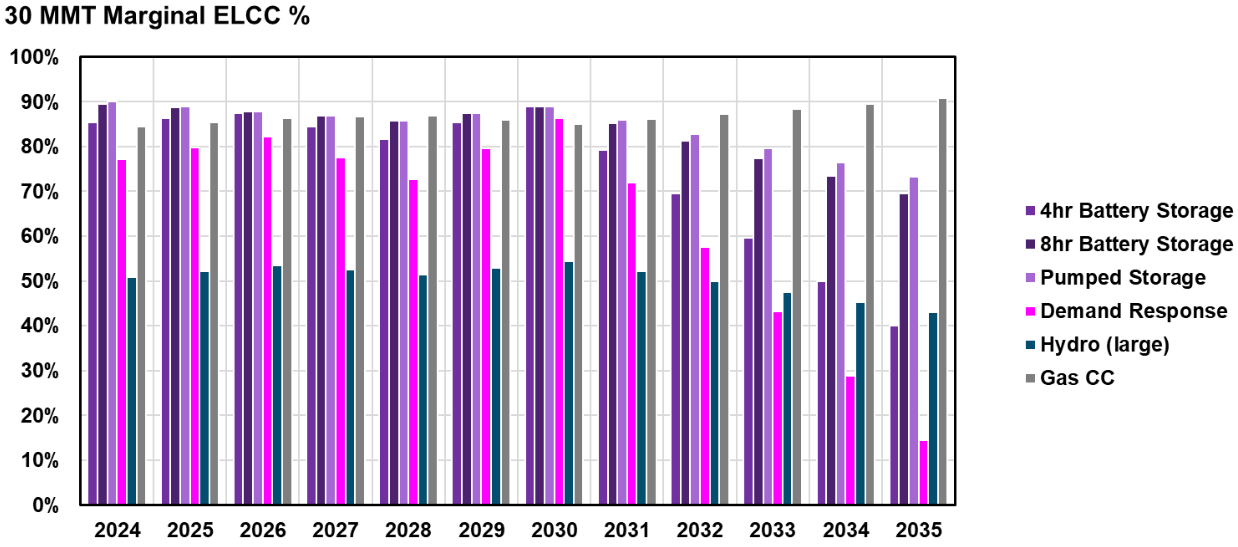
Marginal Reliability Need	47,112	48,652	50,193	49,099	48,005	49,369	50,732	49,261	47,790	46,318	44,847	43,376

* Firm sub-class ELCCs included in Appendix slide

30 MMT Marginal ELCC Trends

- Wind + solar ELCCs are low and decrease by 2035 as more renewables are added to the system
  - Solar maintains continued value for battery storage charging energy
  - Out-of-state and offshore provide higher ELCC than in-state wind
- 4-hr storage ELCCs remain above 80% through 2030 due to large solar additions, then decline as short-duration storage saturates
- DR ELCCs fluctuate in the near term, then decline by 2035
- Hydro ELCCs generally stable, with small decline as system becomes more energy constrained by 2035
- Firm ELCCs generally stable ~85%

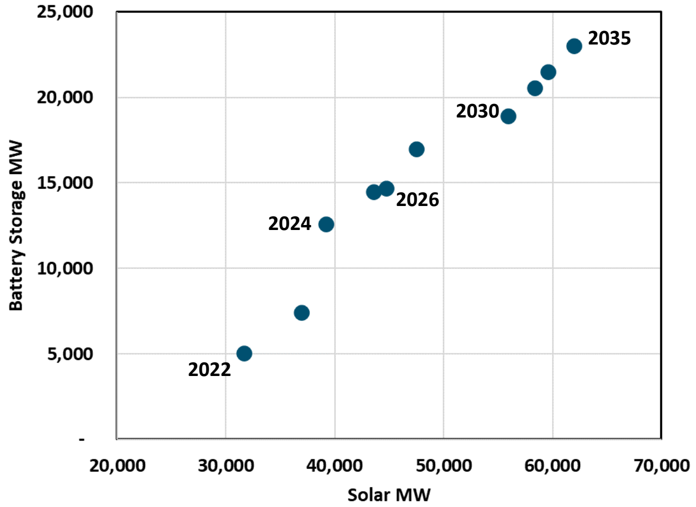




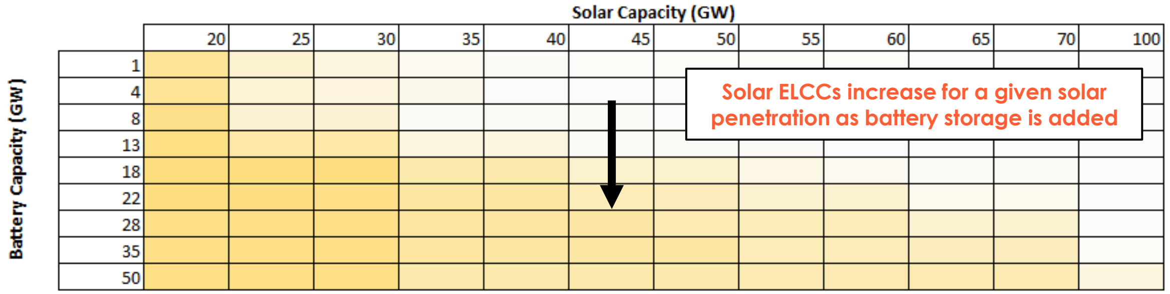
ELCC Dynamics

- By the mid-2020's, solar and storage interactive effects (i.e. "diversity benefits") become very high
  - Without the other technology, increasing penetration would cause marginal ELCCs to continuously decline
- As battery storage grows, solar marginal ELCC is maintained by A) the ability to charge batteries, and B) the delay of battery discharge
- As solar grows, battery storage marginal ELCC is maintained (or may even increase) as batteries rely more on solar and less on gas to charge sufficiently prior to the net peak

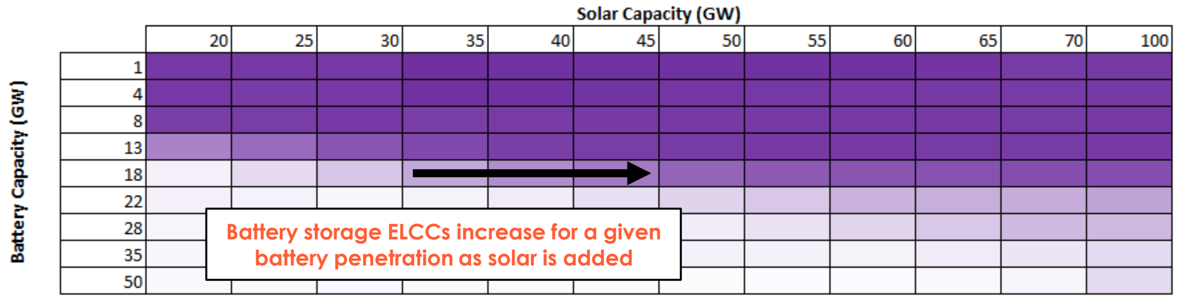
Solar and Storage Penetration in the Updated 38 MMT PSP



Marginal Solar ELCC



Marginal Storage ELCC



Studies' Conclusions: Inputs to LSEs' Reliability Planning

LSE Plan Inputs

- LSEs need the following data points to complete their reliability planning:

  1. **Reliability requirement by year**: what is their annual LSE-level MW reliability obligation?

  2. **Resource accreditation metrics by year**: how each resource type counts towards that MW obligation?

Update

RDT Implementation

- LSE marginal reliability need (MRN) = (CAISO gross peak * (1+ PRM)) * (MRN to TRN 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 = (∑ 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 = ∑ 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

Implications for LSEs of Using Marginal ELCCs

- By counting all resources (new and existing) at their marginal ELCC, each LSE's marginal need will be reduced (relative to their share of the total system need), while the marginal ELCC values ascribed to resources will be lower than they otherwise would be under an average ELCC approach
  - Differences in the reliability need under an average vs. marginal approach are reflective of the difference between average and marginal ELCC MW
  - Both methods properly measure total system-level reliability need
- Using marginal ELCCs, LSEs will see changing signals based on the incremental reliability value of adding resources as the system portfolio changes over time
- LSEs will need to balance the reliability contributions of all their existing and new resources with other procurement priorities such as the GHG reduction, contribution to other procurement requirements (e.g., Mid-Term Reliability procurement order, RPS, RA etc.), ratepayer costs, procurement/development risk, and portfolio diversity

Modeling Parties’ PRM and ELCC Studies

Some parties are conducting modeling to inform reliability work later this IRP cycle

- Refer to separate presentations from SCE and PG&E available at the 2022 IRP Cycle Events and Materials web page
- As per the objectives of this webinar discussed earlier, modeling parties' inputs, methodologies, and results, can help inform modeling later this IRP cycle for updating the PRM for use in IRP modeling broadly, and as an input to the mid-to long-term procurement program, including reliability procurement need determination for 2025 and beyond
- These will not change the filing requirements for LSEs' 2022 IRPs

Inputs and Assumptions (I&A) Update

Inputs and Assumptions (I&A) Context

- The Inputs and Assumptions (I&A) document describes the key data elements, assumptions, and methodologies for CPUC IRP modeling within a given cycle
  - This includes load forecast, baseline resources, candidate resources, resource costs and potentials, operating assumptions, etc.
- The I&A document for the 2022-23 IRP cycle (2022 I&A) will be used for developing the 2023 PSP and 2024-25 TPP portfolios for the CAISO electric system that reflect different assumptions regarding load growth, technology costs and potential, fuel costs, and policy constraints
  - Staff made limited I&A updates (e.g., updates to the load forecast to align with the 2021 IEPR, inclusion of more recent weather years (2018-2020) in RESOLVES's solar, wind and electric hourly shapes, and updated transmission constraints and resource costs) for the modeling needed to develop filing requirements
  - Staff will make limited I&A updates for developing the 2023-24 TPP portfolio(s) as well. An overview of these updates will be provided as part of the 2023-24 TPP portfolio(s) development process.

Process & Timing for I&A Updates

- CPUC staff expects to finalize the 2022 I&A document, including the stakeholder process, by mid Q4 2022
- As part of this process, CPUC staff will hold MAG(s) to cover some specific I&A topics in late Q3/early Q4 2022 and ask for stakeholders' input
  - Staff plan to hold a MAG in mid-September
    - Topics to cover: new candidate resources, resources cost and potential, transmission implementation updates, ELCC surface updates for RESOLVE, etc.
    - Stakeholders will be invited to submit their informal comments to staff following this MAG
    - Staff will notify the IRP service list with details regarding this MAG in August

Next steps

Update

Next Steps for Reliability Filing Requirements for LSEs' IRPs

- These PRM and ELCC results conclude the definition of LSEs' reliability planning requirements. This slide deck is accompanied by:
  - July 29, 2022 - Staff posted the RDT with all 38 and 30 MMT by 2030 ELCCs
- The documents associated with these are:
  - June 15, 2022 - Ruling formalizing LSE IRP filing requirements
  - June 15, 2022 – 2022 Filing Requirements Overview posted to IRP website
  - July 1, 2022 - Staff sent LSEs their final peak demand and BTM PV forecasts
  - July 15, 2022 – Staff posted:
    - The updated Resource Data Template (RDT) and updated User Guide, including
      - Resource accreditation metrics: marginal ELCC %, by resource type, for the 38 MMT by 2030 portfolio for part of the planning horizon
      - System level marginal reliability need MW
    - The first version of the 2022 Filing Requirements' Questions & Answers document. To be updated on a rolling basis as staff receives more questions.
    - The updated 2022 Filing Requirements Overview with some clarifications
- Staff will host "office hours" for each group of LSEs, by type, to answer questions and facilitate LSE IRP development

Opportunity for Feedback re other Use Cases

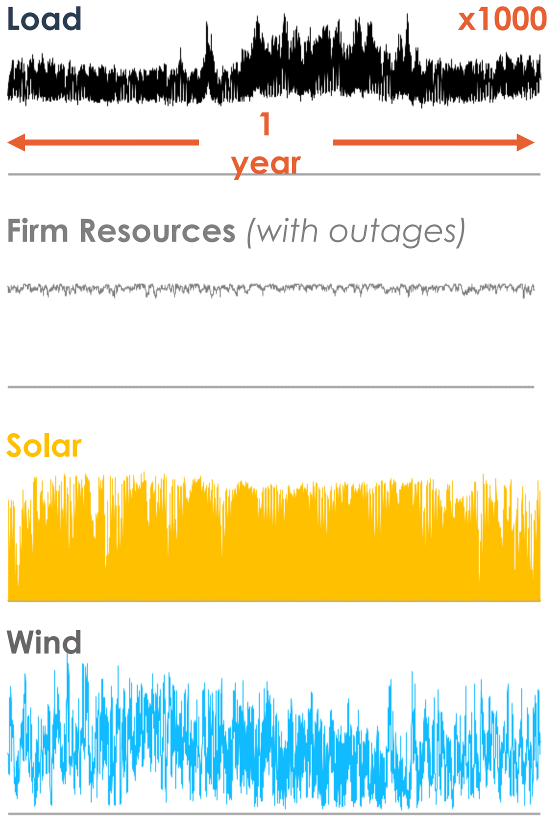
- Parties can informally comment on these PRM and ELCC results, as well as those of modeling parties, to inform the work planning for reliability modeling that will be performed later this cycle, by emailing IRPdatarequest@cpuc.ca.gov
- Staff expects there will also be an opportunity to formally comment later this year

Appendix A: LOLP, PRM, and ELCC Analysis Supplemental Material

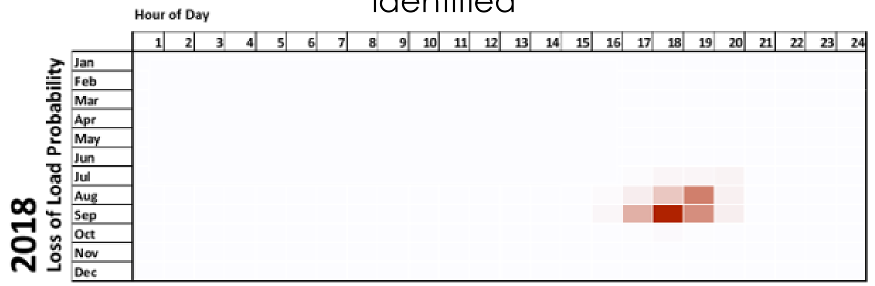
Loss of Load Probability Modeling

- Loss of load probability (LOLP) modeling is a probabilistic method to consider system reliability across a wide range of load and weather conditions
  - LOLP model inputs are tuned to historical correlations between weather, load, and renewable output
  - Monte-carlo simulations consider system operations across a range of weather conditions
- The CPUC IRP uses Astrapé's stochastic reliability model SERVM, which considers the following:
  - 23 years of historical weather conditions (1998-2020) to inform load, wind, and solar output
  - Economic-related load forecast uncertainty
  - Random unit-level forced outage draws
  - Regional market interactions

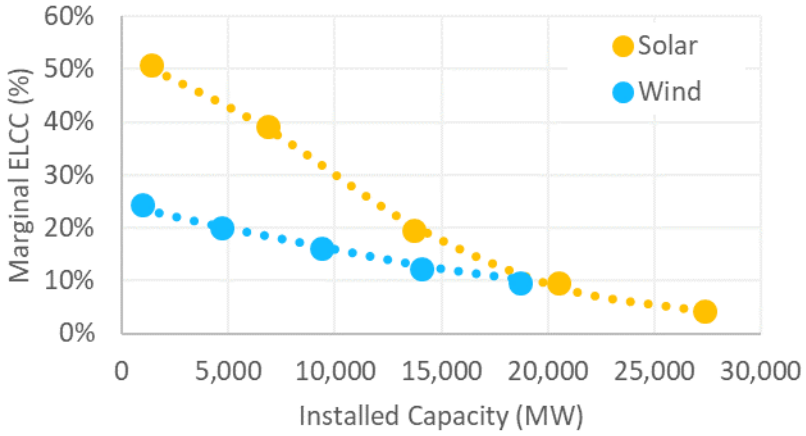
Monte Carlo simulation of loads, renewable profiles, and generator outages used to simulate 1,000 years of plausible system conditions



System reliability measured relative to "one day in ten year" standard; periods of high loss of load probability identified



Effective load carrying capability (ELCC) for a wide range of types of resources evaluated



Example RECAP result from *Long-Run Resource Adequacy under Deep Decarbonization Pathways for California* (Calpine, 2019)

LOLP Analysis Produces a Range of Useful Metrics

- Statistical reliability metrics: measures of the size, duration, and frequency of reliability events

Result	Units	Definition
Expected Unserved Energy (EUE)	MWh/year	Average total quantity of unserved energy (MWh) over a year due to system demand plus reserves exceeding available generating capacity
Loss of Load Probability (LOLP)	%	Probability of system demand plus reserves exceeding availability generating capacity during a given time period
Loss of Load Hours (LOLH)	hours/year	Average number of hours per year with loss of load due to system demand plus reserves exceeding available generating capacity
Loss of Load Expectation (LOLE)	days/year	Average number of days per year in which unserved energy occurs due to system demand plus reserves exceeding available generating capacity
Loss of Load Events (LOLEV)	events/years	Average number of loss of load events per year, of any duration or magnitude, due to system demand plus reserves exceeding available generating capacity
Total Reliability Need (TRN)	MW	***Total capacity MW necessary to maintain an adopted reliability standard*** (e.g. < 0.1 day/yr LOLE). Can be in effective MW (i.e. ELCC or perfect capacity equivalent) or defined relative to existing RA accounting (e.g. ICAP).

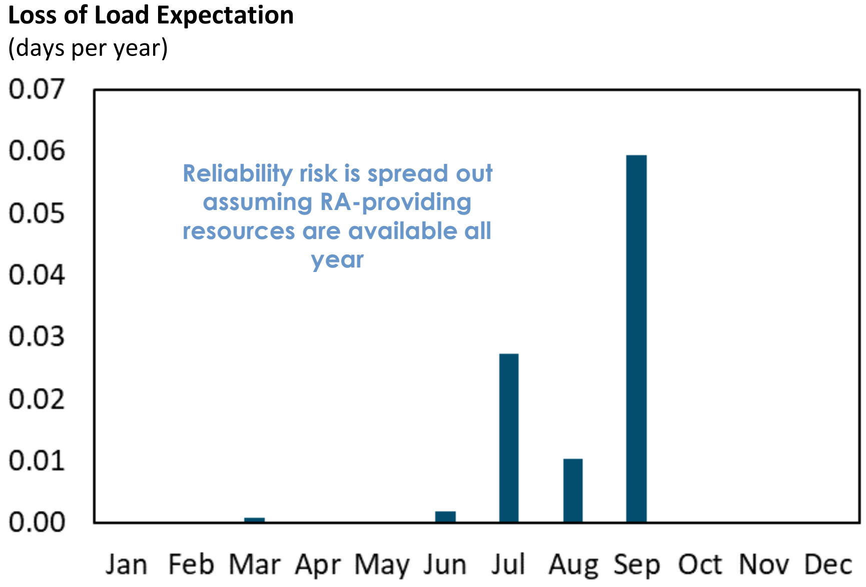
- Derivative metrics: additional useful measurements that can be derived from LOLP analysis

Result	Units	Definition
Planning Reserve Margin Requirement (PRM)	% 1-in-2 peak load	The planning reserve margin needed to achieve a given reliability metric (e.g., 1-day-in-10-years LOLE)
Effective Load-Carrying Capability (ELCC)	MW	Effective "perfect" capacity provided by energy-limited resources such as hydro, renewables, storage, and demand response
Residual Capacity Need	MW	Additional "perfect" capacity needed to achieve a given reliability metric

Annual vs. Monthly Need Determination

- **IRP Approach = Annual**
  - System tuned until annual LOLE meets reliability target

More appropriate for long-term planning, where risk periods can shift dramatically across the planning horizon

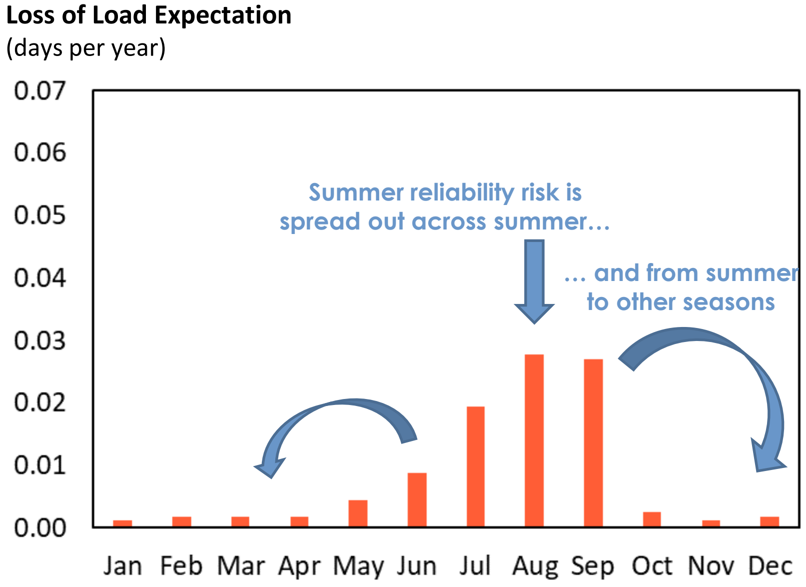


Source: estimated from draft PSP SERVM analysis (2026)

Results in 1 TRN MW + 1 PRM % value

Timing of reliability risk is a function of the portfolio

- **RA Approach = Monthly**
  - Annual reliability standard allocated to each month, then system tuned until sum of monthly LOLE equals annual target



Source: draft monthly 2024 RA PRM + ELCC study

Allocation of LOLE may result in different least-cost portfolio than annual view

As portfolio changes over time, allocation of LOLE and resulting monthly PRMs will need to be updated

Results in 12 TRN MW + 12 PRM % values

Timing of reliability risk is determined by the allocation of risk across the months

Methodology to Compare PCAP PRM to ICAP PRM

- The following steps were taken to compare the PCAP PRM to the ICAP PRM from the February 2022 RA study:
  1. Calculate the PCAP PRM in 2030 required to reach 0.1 LOLE
  2. Calculate the ICAP PRM in 2030 required to reach 0.1 LOLE
     - An ELCC study was used to calculate the non-firm fleet ELCC MW
  3. Adjust the ICAP PRM to align with the 2024 resource portfolio mix assumed in the RA study
     - ELCC MW were replaced with ICAP MW, so that the ELCC share of total capacity was reduced from the 2030 share of ~55% to the 2024 RA study share of ~30%
  4. Adjust the ICAP PRM to be calculated over managed peak instead of gross peak
     - Remove the IEPR BTM PV peak shift from the numerator (total MW to reach 0.1 LOLE) and the denominator (peak demand MW) of the PRM calculation
  5. Compare (4) above to the Jul-Sept monthly target PRM from the RA study

Common examples of synergistic or antagonistic pairings

Common Examples of Synergistic Pairings

Solar + Wind
The profiles for many wind resources produce more energy during evening and nighttime hours when solar is not available

Solar + Storage
Solar and storage each provide what the other lacks – energy (in the case of storage) and the ability to dispatch energy in the evening and nighttime (in the case of solar)

Solar/Wind + Hydro
Hydro is an energy-limited resource so increasing penetrations of solar or wind allows hydro to save its limited production for the most resource constrained hours

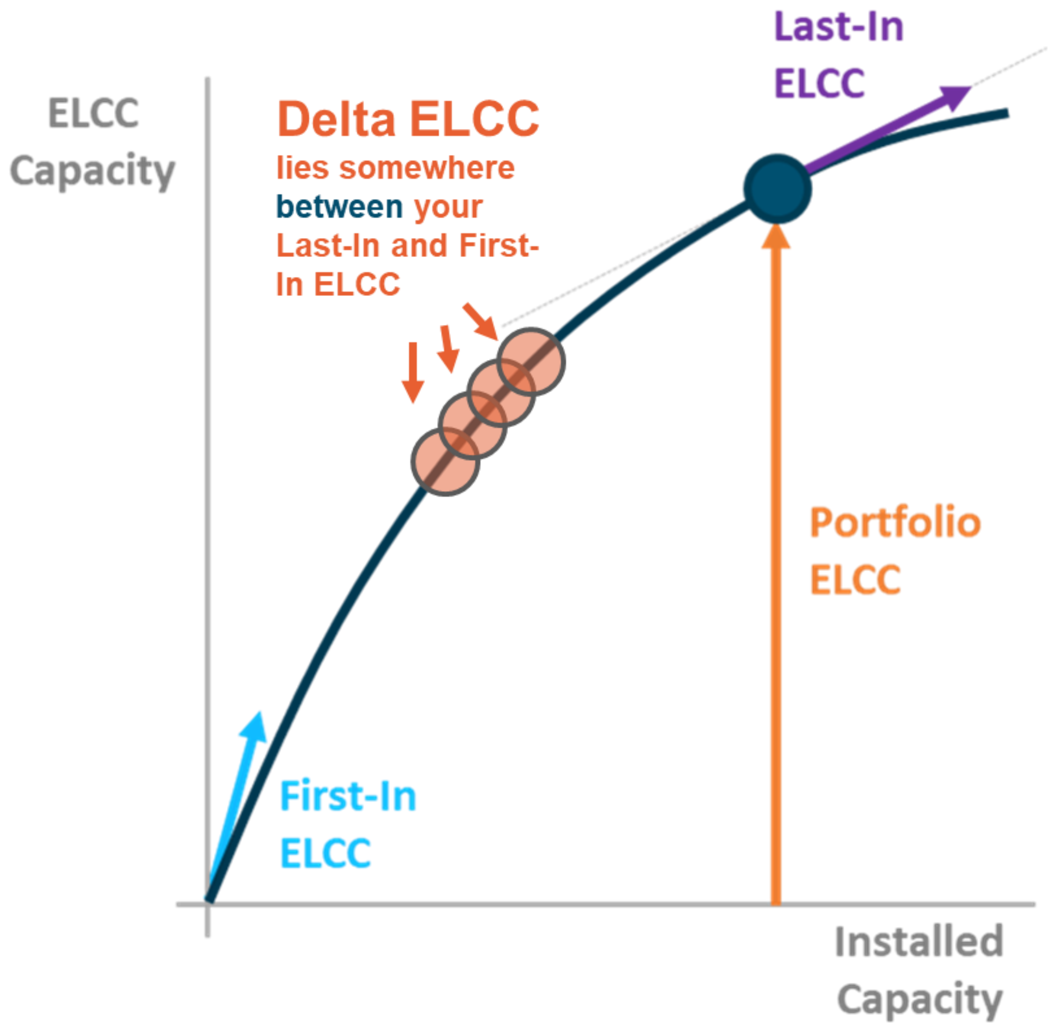
Common Examples of Antagonistic Pairings

Storage + Hydro
Energy limitations on both storage and hydro require longer and longer durations after initial penetrations

Storage + Demand Response
Energy limitations on both storage and hydro require longer and longer durations after initial penetrations

The Delta Method strikes a balance of competing objectives in an <u>average</u> accreditation framework

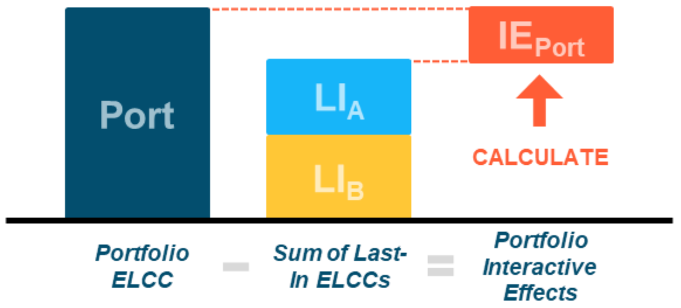
- The Delta Method was developed to ensure an “average” ELCC accreditation framework that is fair, robust, and scalable to any portfolio of intermittent and energy-limited resources
- The Delta Method relies on 3 measurable metrics:
  - **Portfolio ELCC:** total ELCC provided by a combination of variable and use-limited resources
  - **“First-In” ELCC:** the marginal ELCC of each individual resource in a portfolio with no other variable or use-limited resources
  - **“Last-In” ELCC:** the marginal ELCC of each individual resource when taken in the context of the full portfolio
- The Delta Method ensures that each resource receives an ELCC value that is in-between its First-In and Last-In values
  - Resources that exhibit diminishing returns (e.g. chart to right) receive an upward adjustment to Last-In (or equivalently a downward adjustment to First-In)
  - Resources that exhibit constant ELCC (i.e. First-In = Last-In) receive no adjustment
- This approach can simultaneously account for synergistic, antagonistic, and neutral reactions within a single portfolio
  - Different resources can receive positive, negative, or no adjustments



Delta Method: Calculation Approach

STEP 1 Calculate Portfolio Interactive Effects

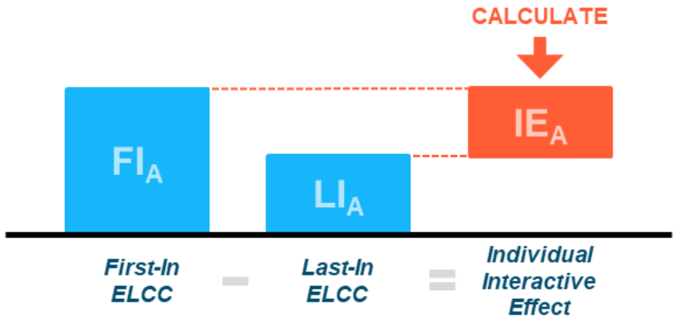
Calculated as the difference between the **Portfolio ELCC** and the sum of the **Last-In ELCCs** for all individual resources



STEP 2 Calculate Individual Interactive Effects

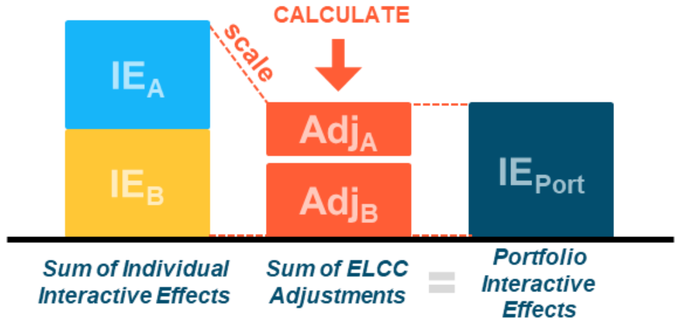
for each resource

Calculated as the difference between the **First-in ELCC** and **Last-In ELCC** for each individual resource



STEP 3 Calculate Individual ELCC Adjustments

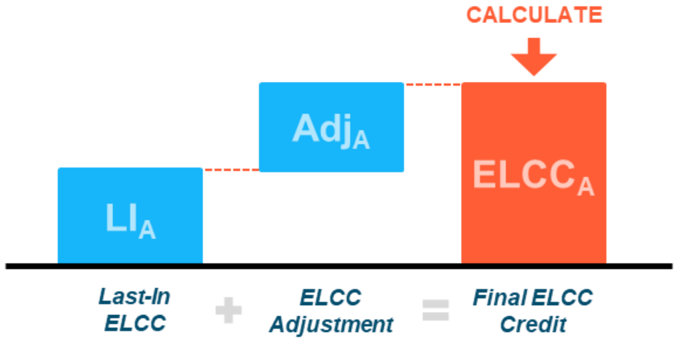
Calculated by scaling all *Individual Resource Diversity Impacts* to match the *Portfolio Diversity Impact*



STEP 4 Calculate ELCC Accreditation

for each resource

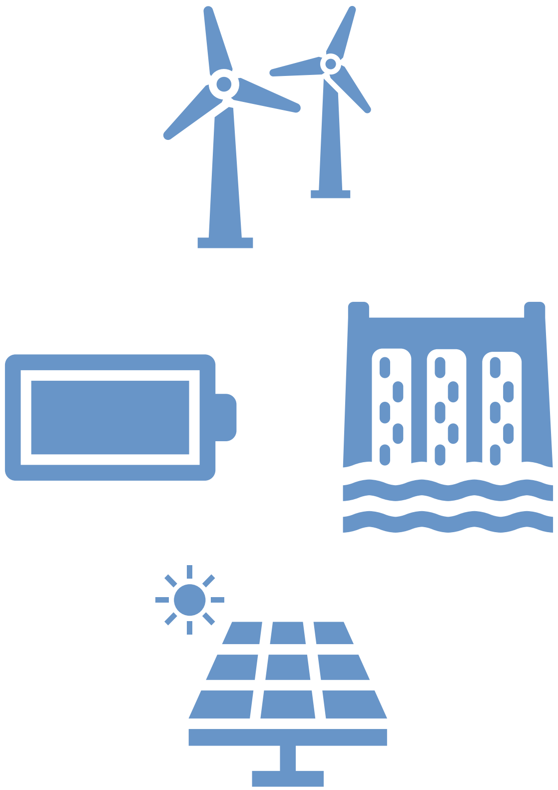
Add *Individual Resource ELCC Adjustment* to **Last-In ELCC** for each individual resource



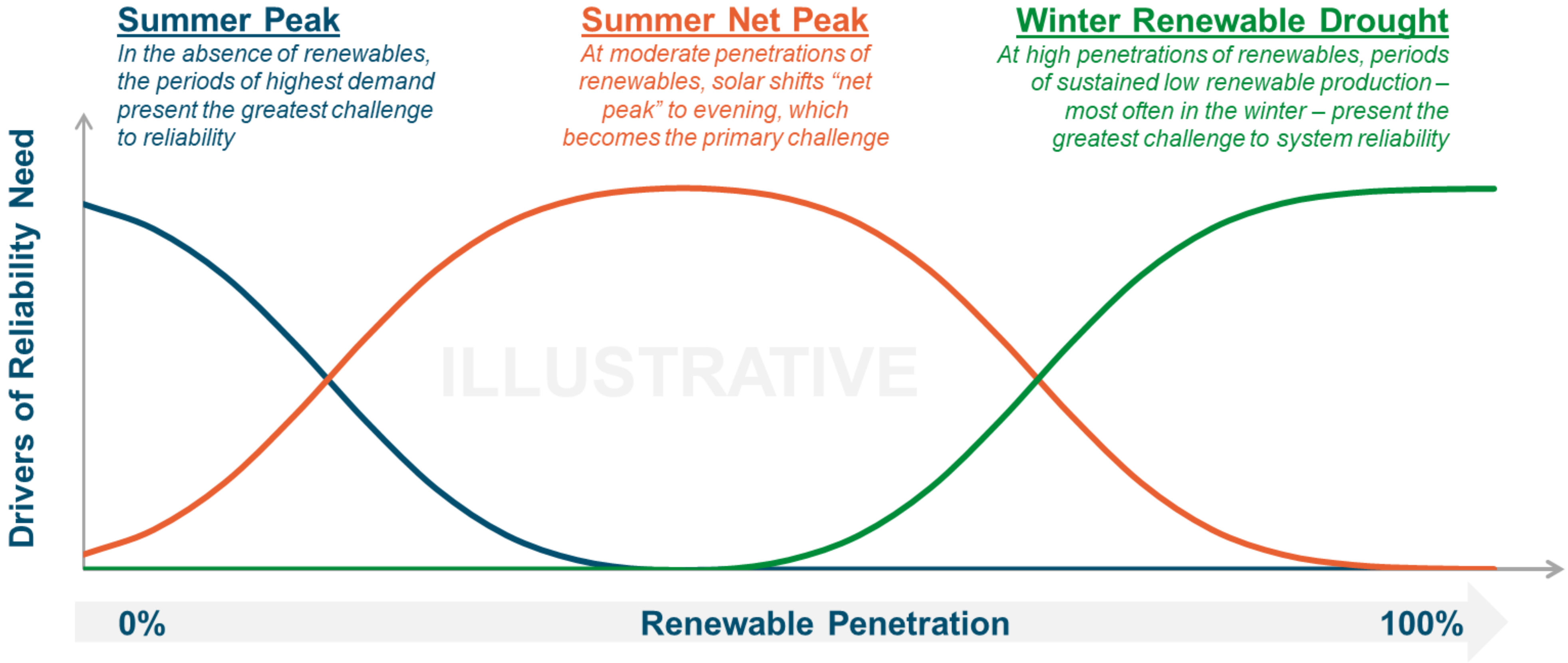
Appendix B: IRP Reliability Framework

Reliability framework standard practice

1. **Determine reliability standard**
   e.g. 1-day-in-10-years (or LOLE = 0.1 days/yr)
2. **Calculate Total Reliability Need and associated PRM**
   e.g. 17%
3. **Calculate resource accreditation metrics**
   e.g. ELCC
4. **Allow the market to provide the least-cost solution**
   e.g. through a central auction or bilateral contracting



The Transition to a Deeply Decarbonized Electricity System Will Change the Nature of Reliability Planning



Goals for an IRP Reliability Framework

- Overall goal: design a process that – when followed – can lead to an appropriately reliable CAISO system
- Key design objectives
  - **Reliability**: CAISO system should meet the established reliability standard
  - **Efficiency**: properly incentivizes least-cost portfolio to meet reliability needs
  - **Fairness**: fairly establishes LSE need and fairly credits resources
  - **Feasibility**: administratively simple and straightforward to comply with
  - **Durability**: reliability need determination is durable to portfolio changes
- The IRP process is an appropriate place to develop this framework, with its systemwide holistic view and reliability mandate
  - Coordination and collaboration with other CPUC processes and other state agencies will be critical

How to approach the analytical design?

- **Reliability planning is rapidly evolving across the world as jurisdictions are addressing the new reliability planning challenges of a decarbonizing grid**
- **The following needs can help to inform an updated IRP reliability framework:**
  1. Framework should be comprehensive and able to drive alignment between planning and procurement
  2. Ensure that IRP system portfolios (including aggregated LSE plans) meet a specified reliability planning standard
  3. Send efficient investment signals for new resource development
  4. Allow existing and new resources to substitute for one another in future reliability procurement
- **IRP can develop the reliability framework to address the unique needs of IRP planning and procurement**
  - E.g., how to trade off fairly accrediting existing resources while still sending the right investments signals for new resource procurement and retention

Appendix C: Supplemental Results

Loss of Load Heatmaps for 0.1 Tuned System from this ICAP PRM Study

2024

	Hour																							
Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1																								
2																								
3																								
4																								
5																								
6																								
7																			0%					
8													0%			0%	0%		3%	3%	4%	7%	0%	
9																		29%	47%	3%	2%	2%	0%	
10																								
11																								
12																								

Risk concentrated in the early evening (HE 18-19) as solar drops off

Capacity shortfalls drive early evening risk

2026

	Hour																							
Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1																								
2																								
3																								
4																								
5																								
6																								
7																			0%					
8																0%			1%	1%	7%	11%	1%	0%
9																		17%	51%	3%	2%	5%	1%	0%
10																								
11																								
12																								

2030

	Hour																							
Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1																								
2																								
3																								
4																								
5																								
6																								
7																			0%				0%	
8																0%			2%	6%	14%	18%	13%	2%
9	0%																	9%	16%	0%	1%	9%	10%	1%
10																								
11																								
12																								

Risk extends and shifts later into the evening (HE 21-24) when storage runs out of charge

Capacity shortfalls still drive early evening risk…

… but energy shortfalls also drive late evening risk

Heatmap shows the share of annual expected unserved energy occurring in each month/hour.

Update

38 MMT Scenario: Firm Sub-class ELCCs

- Firm resource ELCCs derived from the aggregated firm resource marginal ELCC, which was used to scale the sub-class EFORd values

Modeled Year (results complete)	Modeled Year (results still pending)	Interpolated Year

Resource Class	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Firm												
Geothermal	86%	88%	89%	91%	93%	92%	92%	93%	93%	94%	95%	95%
Biomass/wood	79%	81%	83%	83%	83%	82%	82%	83%	85%	86%	88%	89%
Biogas	76%	78%	80%	80%	79%	78%	77%	79%	81%	83%	85%	87%
Nuclear	93%	94%	95%	94%	94%	94%	93%	94%	95%	95%	96%	96%
Gas CC	85%	86%	88%	87%	87%	86%	85%	86%	88%	89%	90%	91%
Gas CT	80%	82%	83%	83%	82%	81%	79%	80%	81%	82%	83%	84%
Cogen	90%	92%	95%	92%	89%	89%	89%	90%	90%	91%	92%	93%
ICE	93%	90%	87%	90%	92%	92%	91%	90%	89%	88%	87%	86%
Coal	69%	72%	74%	74%	73%	71%	69%	72%	74%	77%	80%	83%
Steam	78%	80%	82%	81%	81%	79%	78%	80%	82%	84%	86%	88%

Update

30 MMT Scenario: Firm Sub-class ELCCs

- Firm resource ELCCs derived from the aggregated firm resource marginal ELCC, which was used to scale the sub-class EFORd values

Modeled Year (results complete)	Modeled Year (results still pending)	Interpolated Year

Resource Class	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Firm												
Geothermal	86%	89%	92%	92%	93%	92%	91%	92%	93%	93%	94%	95%
Biomass/wood	78%	79%	81%	82%	83%	81%	80%	82%	84%	85%	87%	88%
Biogas	75%	77%	78%	79%	79%	78%	77%	78%	80%	82%	84%	86%
Nuclear	93%	94%	94%	94%	94%	93%	93%	93%	94%	95%	95%	96%
Gas CC	84%	85%	86%	87%	87%	86%	85%	86%	87%	88%	90%	91%
Gas CT	81%	83%	86%	84%	82%	81%	79%	80%	82%	83%	84%	85%
Cogen	93%	93%	93%	93%	94%	93%	92%	93%	93%	93%	93%	93%
ICE	93%	94%	94%	94%	94%	95%	95%	93%	92%	91%	89%	88%
Coal	69%	71%	73%	72%	72%	69%	66%	69%	72%	75%	78%	81%
Steam	78%	79%	81%	80%	80%	78%	76%	78%	80%	82%	84%	87%

Appendix D: Other

BTM PV Forecast Methodology

- Staff developed a forecast of BTM PV MW and GWh for use in LSE IRP plan RDT and CSP tools as follows:
  - TAC-level BTM PV MW forecasts were used directly from the CEC IEPR
  - Allocation of the TAC level BTM PV forecast to LSEs was dependent upon the data provided in response to CPUC’s data request:
    - PG&E + SDG&E TAC: Due to the limited LSE data submitted via Form 4, LSE shares of the TAC-level BTM PV capacity is based on its pro-rata share of the "Final IRP Sales Forecast (GWH)" used for greenhouse gas emission benchmarks in the June 15 ruling.
    - SCE TAC: SCE provided 2020 and 2021 historical BTM PV capacity by LSE. These historical shares are used to adjust the pro-rata share of the "Final IRP Sales Forecast (GWH)" to estimate LSEs' shares of BTM PV in 2023-2035. This was done by using the ratio of LSE BTM PV MW to LSE GWh sales based on the 2020+2021 data. LSEs' final BTM PV MW were calculated by multiplying their share of sales and their BTM PV MW to sales ratios. For new CCAs that don't have sufficient data for this calculation, the ratio was assumed to be the same as SCE's bundled customers.
      - Compared to an energy-share pro rata-based approach, this approach resulted in SCE bundled customers having a higher BTM PV MW share and ESPs having a lower BTM PV share, based on SCE’s provided historical installed BTM PV by LSE data.
  - BTM PV generation GWh forecast is based on the TAC level GWh output to MW ratio in the CEC IEPR forecast