Reliability & Other Filing Requirements for Load Serving Entities’ 2022 Integrated Resource Plans - Approach

Modeling Advisory Group (MAG) Webinar
Energy Division

April 7, 2022

California Public
Utilities Commission

Logistics & Scope

- 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:
  - Provide an update on the overall schedule for IRP inputs and assumptions development
  - Discuss broad approaches for updating the 2020 IRP filing templates, including the anticipated development schedule and rollout
  - Familiarize stakeholders and gain feedback on the approach and inputs to developing LSE plan reliability filing requirements, and the proposed timeline and steps to update the planning reserve margin for use in the IRP planning and procurement tracks

- Out of scope:
  - GHG benchmarks and LSE load forecasts – will be addressed in an April 2022 ruling
  - Development of procurement program required by D.22-02-004 – a workshop later in Q2 2022 initiate this

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 "Chat Room" 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 by April 21, 2022 (but earlier comments encouraged) to IRPDataRequest@cpuc.ca.gov

Agenda

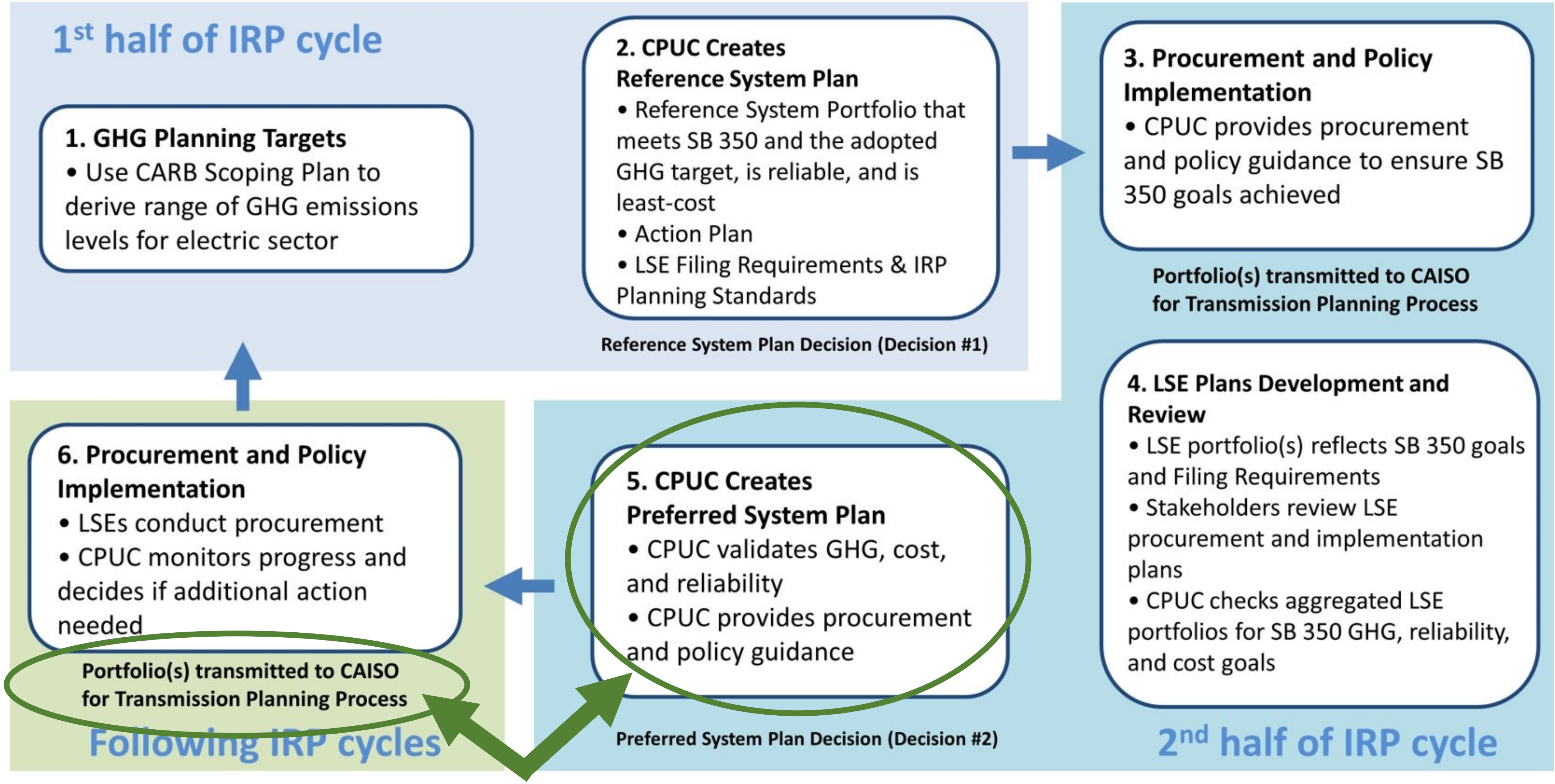
Topic	Timing	Lead
Introduction & background	5 min	Nathan Barcic
2022-23 IRP cycle Inputs & Assumptions overview	10 min	Ali Eshraghi
2022 LSE plans: non-reliability planning requirements • *Questions*	20 min	James McGarry
2022 LSE plans: reliability planning requirements • Context of IRP reliability improvements • Reliability modeling across proceedings • Need determination • Resource accreditation considerations • LSE plan reliability inputs • RESOLVE ELCC update • Summary • *Questions*	80 min	 Neil Raffan Donald Brooks Aaron Burdick Kevin Carden Jimmy Nelson
Next steps	5 min	Nathan Barcic

Background

Integrated Resource Planning (IRP) in California Today

- The objective of IRP is to reduce the cost of achieving greenhouse gas (GHG) reductions and other policy goals by looking across individual LSE boundaries and resource types to identify solutions to reliability, cost, or other concerns that might not otherwise be found.
- Goal of the 2019-2021 IRP cycle was to ensure that the electric sector is on track to help California reduce economy-wide GHG emissions 40% from 1990 levels by 2030, per SB 32, and to explore how achievement of SB 100 2045 goals could inform IRP resource planning in the 2020 to 2032 timeframe.
- The IRP process has two parts:
  - First, it identifies an optimal portfolio for meeting state policy objectives and encourages the LSEs to procure towards that future.
  - Second, it collects and aggregates the LSEs collective efforts for planned and contracted resources to compare the expected system to the identified optimal system. The CPUC considers a variety of interventions to ensure LSEs are progressing towards an optimal future.

Overview of the 2019 – 2021 IRP Cycle



Recently completed with CPUC's adoption of the 2021 Preferred System Plan

Inputs and Assumptions (I&A) Overview

Inputs and Assumptions (I&A)

- 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
  - The filing requirement assumptions that LSEs need for developing their 2022 IRP plans will be finalized by June 15, 2022 (see next section). CPUC staff will be making limited I&A updates now (e.g., updates to the load forecast to align with the 2021 IEPR, inclusion of more recent weather years (2018-2020) in our solar, wind and electric hourly shapes, transmission constraints) for the modeling needed to develop filing requirements
  - CPUC 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

- As stated in D.22-02-004, a revised scoping memo will provide details on the process for developing the complete I&A (2022 I&A) for the 2022-23 IRP cycle
  - The Commission anticipates issuing the revised scoping memo in Q2 2022
- CPUC staff expects to finalize the 2022 I&A document, including the stakeholder process, by early/mid Q4 2022
- As part of this process, CPUC staff will hold MAG(s) to cover some specific I&A topics (e.g., new candidate resources) in Q3 2022 and ask for stakeholder input

2022 LSE Plans: Non-Reliability Planning Requirements

Filing Requirements

- LSE IRP filings are the vehicle by which the CPUC and stakeholders gain insight into individual LSEs' plans for meeting state goals, and how LSEs show compliance with their requirements under PUC 454.52(a)(1)
- To facilitate the filing of useful, appropriate, and complete information by LSEs, IRP staff provides LSEs with standardized tools, instructions, and templates (aka, IRP "filing requirements documents")
  - LSEs are assigned load forecasts and GHG targets/benchmarks to use in planning
- In accordance with D.22-02-004, LSE IRP filings for the 2022-23 IRP cycle are required on or before November 1, 2022, and filing requirements will be finalized by June 15, 2022

Updates: Narrative Template (NT)

- Purpose:
  - To describe how LSEs approach the process of developing its plan, present the result of analytical work, demonstrate to the CPUC and the stakeholders the LSE's action plans, and identify areas where LSEs are seeking Commission action to support their plan/procurement
- Evaluation:
  - Commission staff utilizes a scorecard system to conduct a qualitative review of LSE NTs to determine whether each LSE adequately satisfied the NT requirements established by the Commission
  - NT sections can receive scores of "exemplary," "adequate," or "deficient." LSEs receiving deficient scores are required to re-submit those sections
- Updates Under Consideration:
  - Revise questions so that they are more relevant to the 2022-23 IRP cycle
  - Provide greater specificity around how answers will be evaluated to reduce the likelihood of LSEs submitting deficient responses
  - Provide more direction to LSEs in certain sections, particularly disadvantage communities planning requirements

Updates: Resource Data Template (RDT)

- Purpose:
  - To collect LSE contracting data for existing, in-development and planned resources, including for future resources which do not exist yet. Provides a snapshot of the LSE energy and capacity forecast positions across the planning horizon
  - RDT data is used for LSE plan aggregation and forms the basis of LSE planned resources upon which the PSP portfolio is developed
- Evaluation:
  - Staff uses the RDT Error Checking, Aggregation and Reallocation Tool (RECART), which uses python code to aggregate, error check, and analyze LSE RDT filings
  - RECART compiles energy and capacity under contract, contracted resources by technology type and LSE, aggregates new resources in development or planned future purchases, and generates LSE-specific error reports to determine if RDT re-submissions are needed
- Updates Under Consideration:
  - Update fields based on RDTv2 submission experience and relevance to 2022-23 IRP cycle
  - Improve error checking macro as part of RDT. LSEs will be required to trace the errors identified by the macro, and correct them before submitting
  - Improve interaction with Clean System Power Calculator

Updates: Clean System Power (CSP) Calculator

- Purpose:
  - To estimate the GHG and criteria pollutant emissions of LSE portfolios and verify that LSE portfolios achieve assigned GHG planning benchmarks. Estimates emissions on an hourly basis based on each LSE's reliance on system power in that hour, facilitating a common emissions accounting methodology across LSEs
- Evaluation:
  - Staff conducts a quantitative review of each LSE’s CSP Calculator to determine that they achieved their GHG benchmarks and followed all calculator instructions
  - LSEs that do not meet their targets or did not follow instructions are contacted for re-submission
- Updates Under Consideration:
  - Include new study years, inclusive of 2035, with new SERVM-based load/resource shapes
  - Add in-template functionality to check that inputs were added correctly
  - Improved interaction with Resource Data Template

Timing

- In accordance with D.22-02-004, CPUC staff will seek to finalize LSE filing requirements, including filing templates, by June 15, 2022
  - Final templates will be posted to the Commission's 2022-2023 IRP cycle website: https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/electric-power-procurement/long-term-procurement-planning/2022-irp-cycle-events-and-materials
- Non-template filing requirements such as load forecasts and GHG benchmarks will be finalized via ALJ Ruling by June 15, 2022, with an initial Ruling seeking comment issued in April 2022.
- IRP staff is accepting informal stakeholder comments and suggestions about filing templates and potential updates by April 21, 2022 (but earlier comments encouraged)
- IRP staff will hold informal "office hours" after June 15, 2022 for each group of LSEs by type, to answer questions and facilitate IRP development

2022 LSE Plans: Reliability Planning Requirements

Outline

- Context of IRP Reliability Improvements
- Reliability Modeling Across Proceedings
- Need Determination
- Resource Accreditation Considerations
- LSE Plan Reliability Inputs
- RESOLVE ELCC Update
- Summary

Context of IRP Reliability Improvements

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

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
  - RESOLVE planning reserve margin (PRM) update to reflect Mid-Term Reliability (MTR) High Need scenario has led to an overly-reliable portfolio
- **2022-23 IRP Cycle**
  - I&A and LSE plan filing requirements present opportunity to refresh reliability planning inputs

Topic	Current IRP Method	Potential Improvement
PRM	Shifting PRMs not tied to LOLP fundamentals → RESOLVE outputs are not matched to reliability results from production cost modeling	SERVM based PRM to meet reliability standard
Thermal resource accounting	NQC-based (installed capacity) → tips 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

Use cases for reliability modeling in 2022-23 IRP cycle

- This MAG webinar addresses the early stages of a broad set of reliability updates to be conducted this IRP cycle
- Near-term use case: LSE plan filing requirements due for release June 15, 2022
  - Reliability planning requirement, including the planning reserve margin
  - 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; mid-to long-term procurement program
- 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

Energy Division's reliability modeling strategy

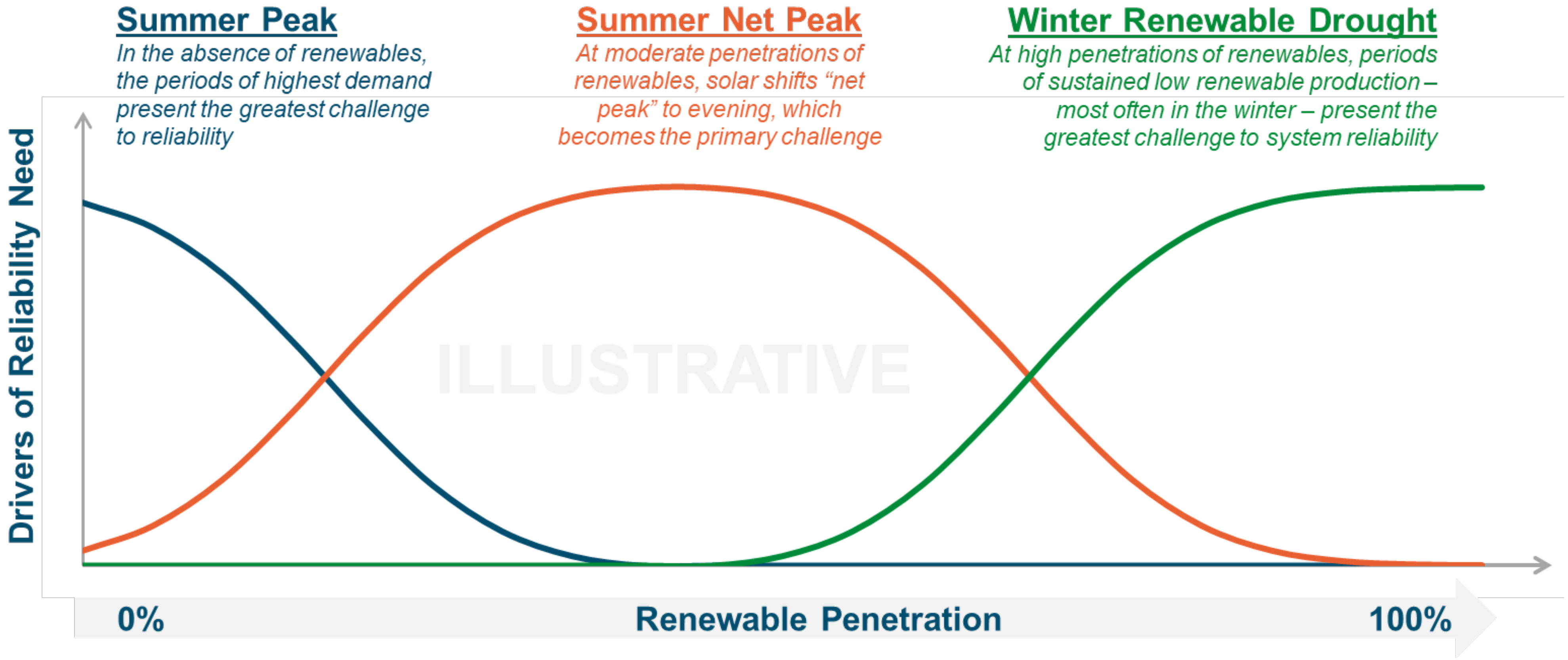
Energy Division is using this LOLE framework in a variety of Commission proceedings in addition to IRP.

- Energy Division completed a LOLE and ELCC study in the RA proceeding to determine ELCC of wind, solar and storage resources as well as the correct PRM for 2023 and 2024 RA compliance year.
- 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 cost.

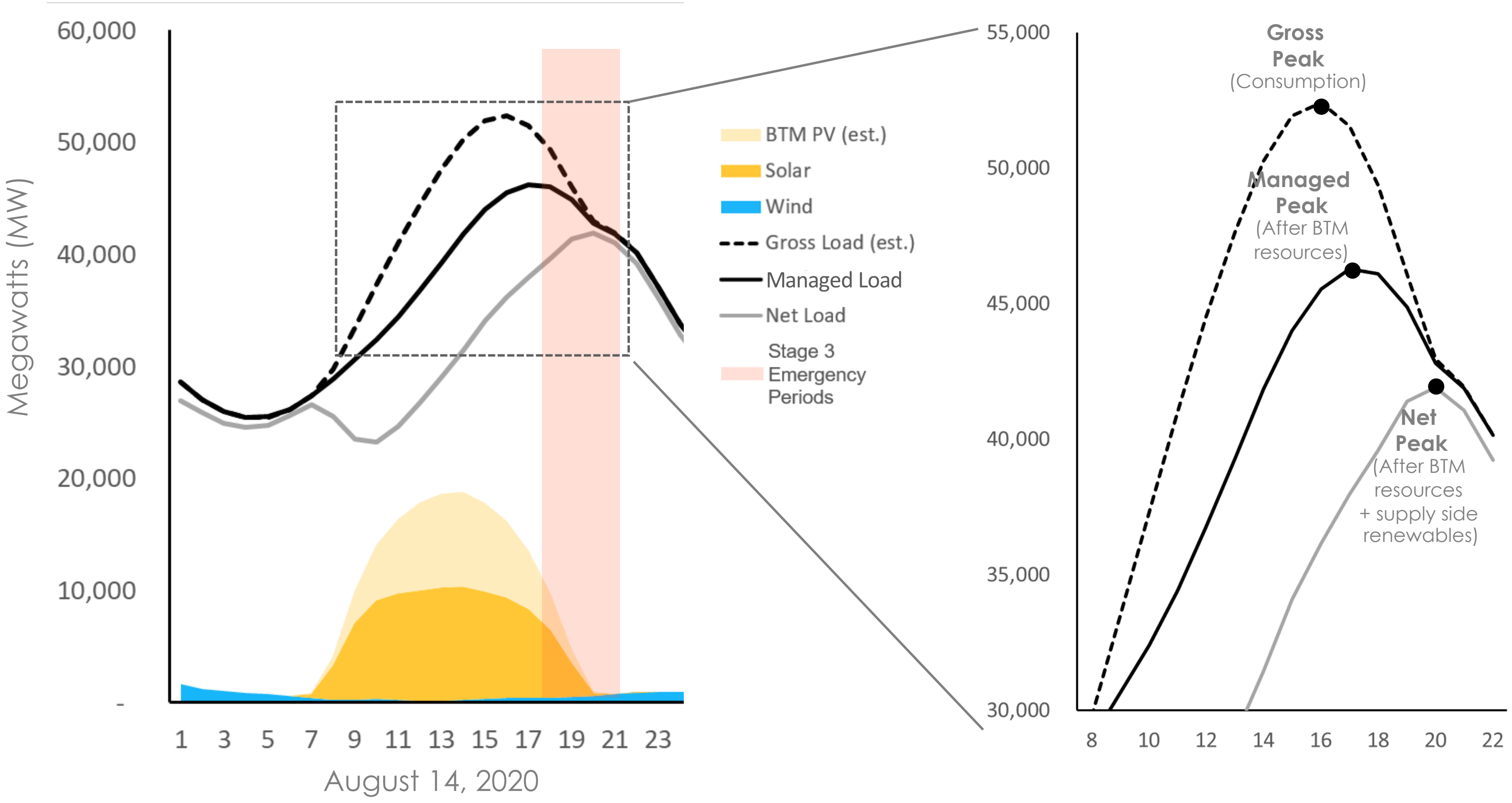
These diverse applications of LOLE modeling all rely on the same IRP baseline dataset.

- Baseline dataset includes electric demand, baseline resources, generation profiles for non-firm resources
- It is critical to maintain consistency and stability in datasets o enable consistency between modeling done in all these proceedings.
- All modeling data is to be posted to CPUC website (Unified RA+IRP Dataset page) for parties to review and comment
- Parties can review data development during I/A development and periodic MAG meetings

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



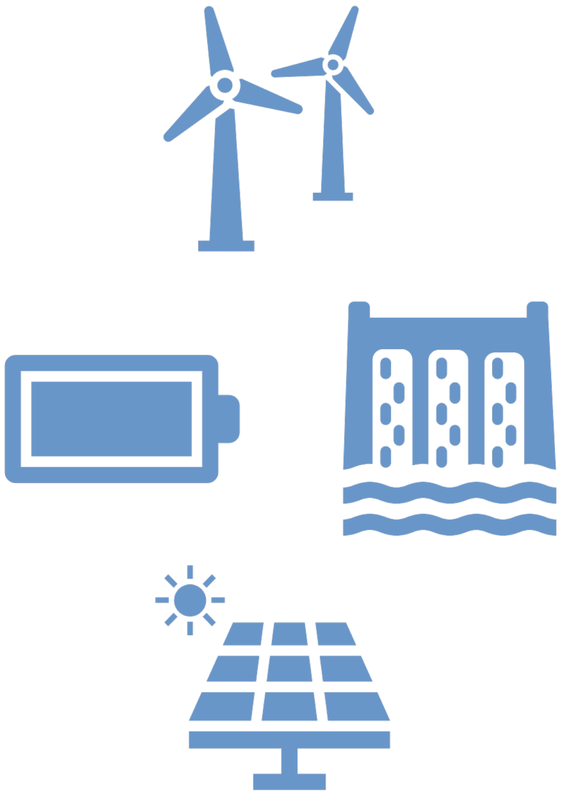
Reliability Challenged Periods are Already Shifting



A durable reliability planning approach is needed as reliability challenged periods continue to evolve

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

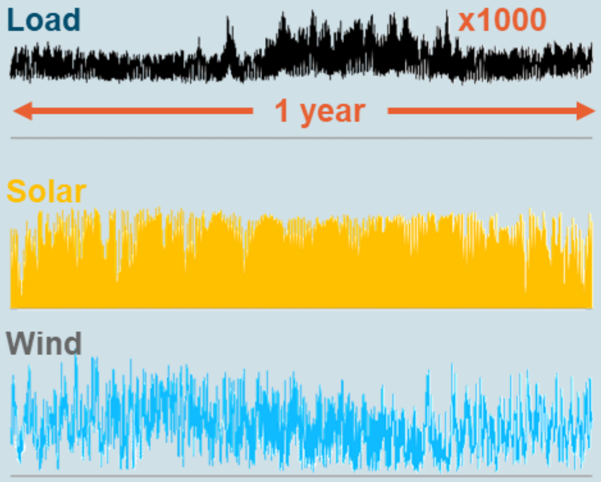


Key Steps for Reliability Planning using LOLP Modeling

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

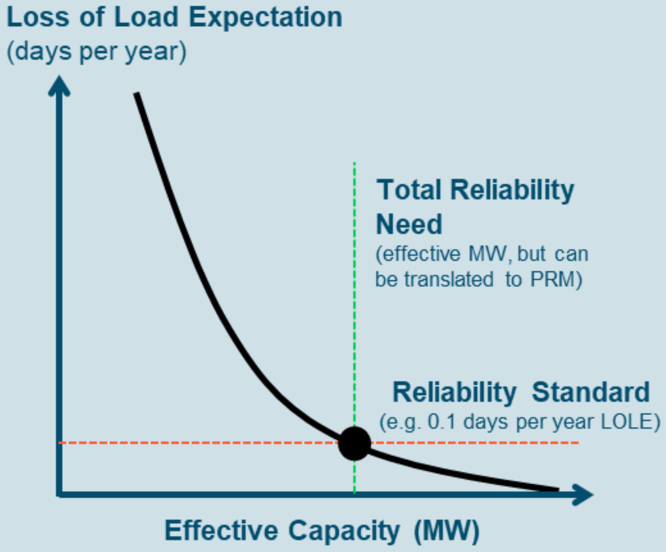


Robust probabilistic models + datasets are the foundation of any resource adequacy analysis

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

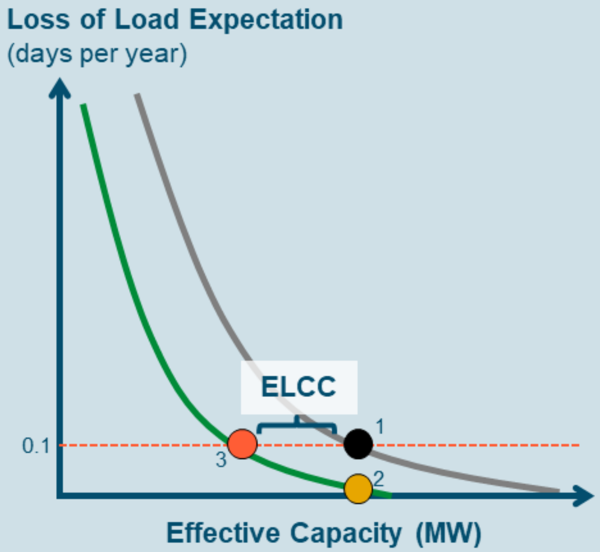


LOLP modeling provides <u>Total Reliability Need</u> in effective capacity MW to meet <0.1 days/yr LOLE, can be converted to a PRM

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



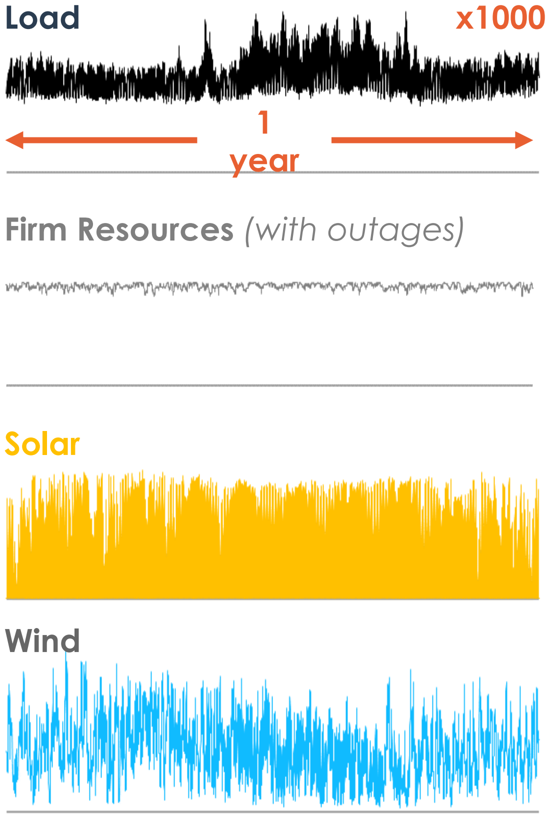
<u>Effective or "perfect" capacity based accounting</u> (UCAP or ELCC) counts all resources on a level playing field against that total reliability need

Need Determination

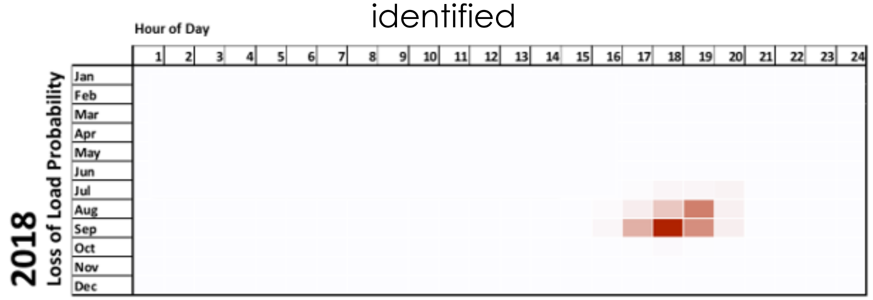
Loss of Load Probability Modeling

- 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:
  - 20 years of historical weather conditions (1998-2017) to inform load, wind, and solar output
  - Economic-related load forecast uncertainty
  - Random unit-level forced outage draws
  - Regional market interactions

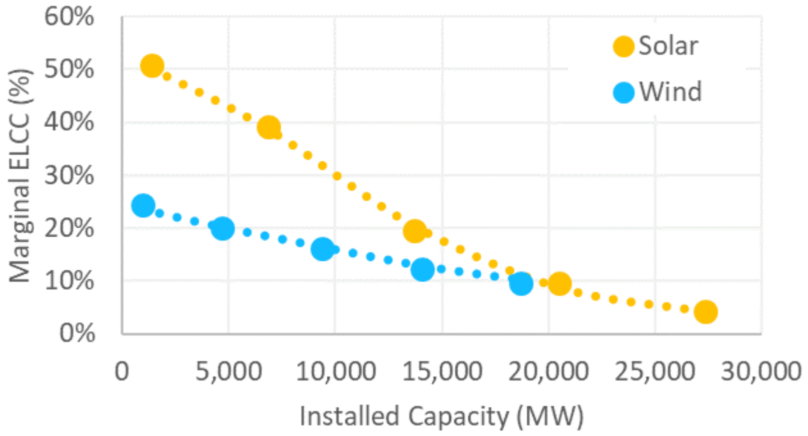
<u>Monte Carlo simulation</u> of loads, renewable profiles, and generator outages used to simulate 1,000 years of plausible system conditions



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



<u>Effective load carrying capability (ELCC)</u> 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

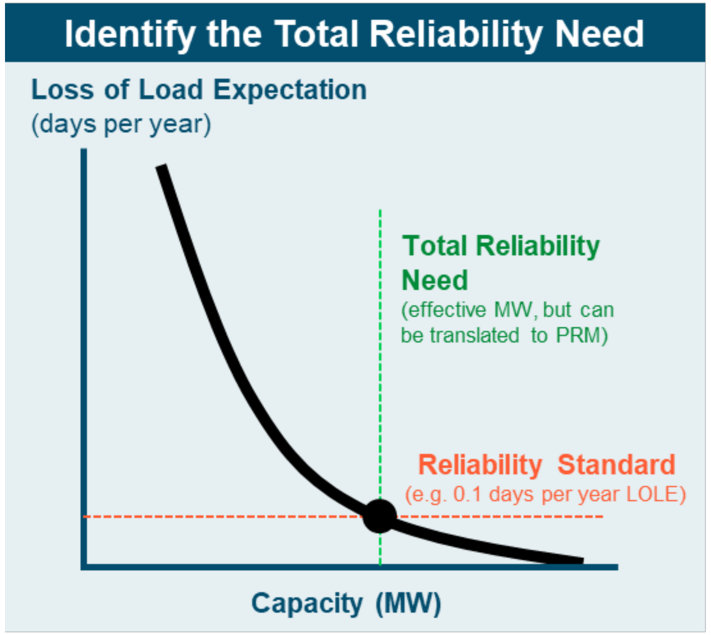
Result	Units	Definition
Expected Unserved Energy (EUE)	MWh/year	Average total quantity of unserved energy (MWh) over a year due to system demand plus reserves exceeding available generating capacity
Loss of Load Probability (LOLP)	%	Probability of system demand plus reserves exceeding availability generating 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).

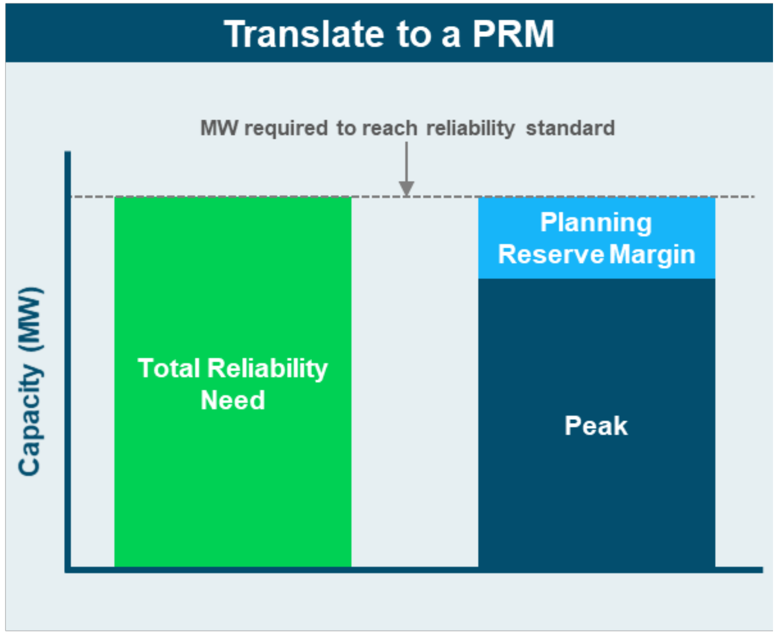
- Derivative metrics: additional useful measurements that can be derived from LOLP analysis

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

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 capacity MW necessary 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

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

Metrics for Defining Total Reliability Need

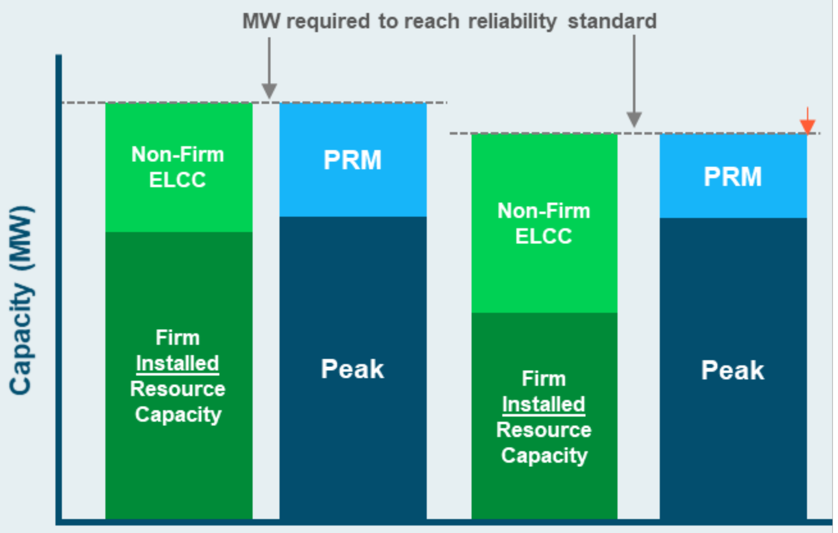
- **Installed Capacity (ICAP)**
  - Measures resource MW using their installed capacity, accounting for forced outages in the reserve margin
- **Unforced Capacity (UCAP)**
  - Measures resource MW using their unforced (i.e. outage de-rated) capacity, accounting for forced outages in resource accreditation
- **Perfect Capacity (PCAP)**
  - Measures resource MW using their perfect capacity equivalent (i.e. ELCC) capacity, accounting for forced outages and additional portfolio effects in resource accreditation
- **Non-firm resource accreditation**
  - Variable (e.g. solar and wind) and use-limited resources (e.g. storage) are typically counted at ELCC or ELCC-like heuristics across all methods

All portfolio meet the same reliability target; diagrams, are illustrative and not necessarily to scale

PRM Resource Accounting Options

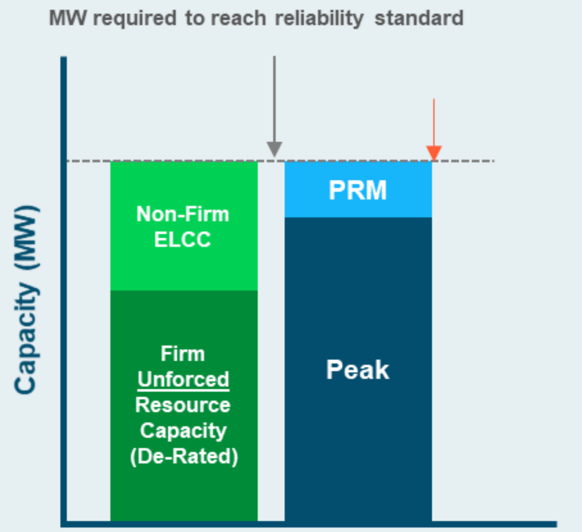
Installed Capacity (ICAP)

ICAP accounting includes reserves for forced outages, PRM decreases as firm resources replaced w/ non-firm



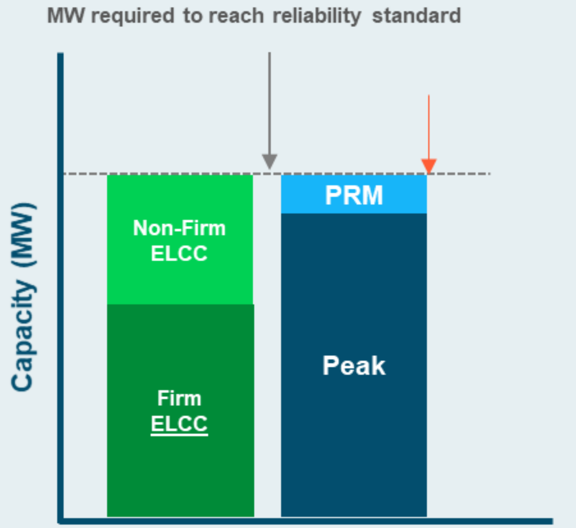
Unforced Capacity (UCAP)

UCAP accounting de-rates resources for forced outages, lowering the PRM % required for the same reliability target



Perfect Capacity (PCAP, i.e. ELCC)

PCAP PRM counts all resources at ELCC, may or may not meaningfully differ from a UCAP PRM



	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 perfectly reflect ELCC*
PCAP	**ELCC** MW	ELCC MW	• Load/weather variability • Operating reserves		• More LOLP runs required

* For large systems like CAISO, UCAP of firm resource can approximate their ELCC. However, this will be dependent upon the UCAP de-rate method and whether it properly captures the full interactive effects inherent in LOLP modeling.

Why Switch from an Installed Capacity (ICAP) PRM?

- 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
- Most RA programs have moved away from ICAP to UCAP because:
  A. ICAP creates an **unlevel playing field that favors emitting resources** over clean energy (e.g. thermal NQC vs. renewable/storage ELCC)
  B. ICAP is a **function of the portfolio**, subject to change as emitting capacity retires

	Reliable	Efficient	Fair	Feasible	Durable
Perfect Capacity (PCAP)	✓	✓	✓	✓	✓ *
Unforced Capacity (UCAP)	✓	✓ **	✓ **	✓	✓
Installed Capacity (ICAP)	✓	✗	✗	✓	✗

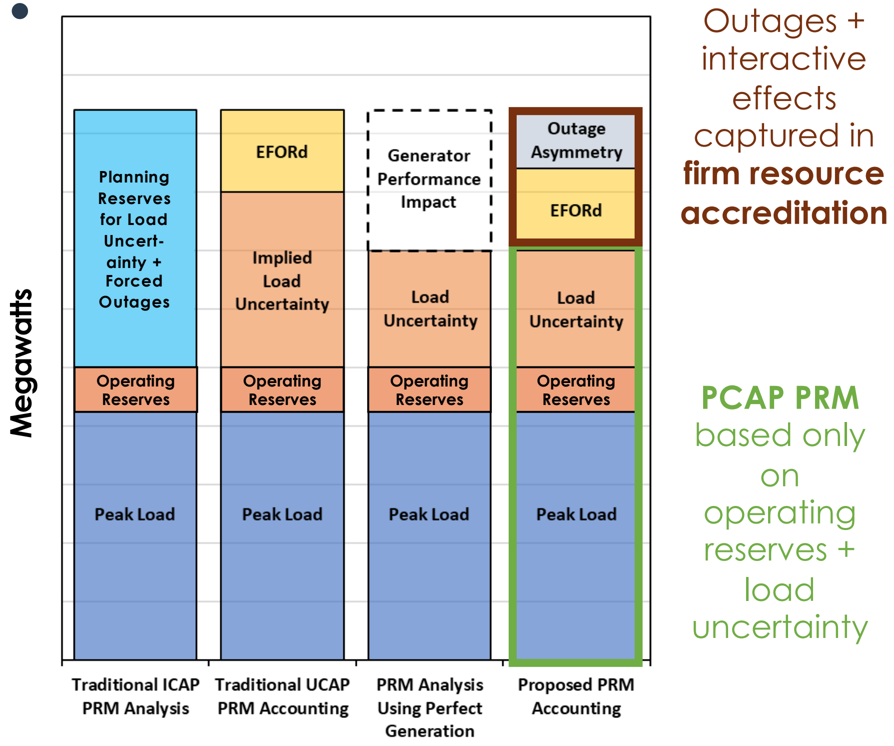
RTO	Metric	Metric Value	PRM Type
MISO	LOLE	0.1 days/yr	ICAP + UCAP
NYISO	LOLE	0.1 days/yr	ICAP + UCAP
PJM	LOLE	0.1 days/yr	ICAP + UCAP
ISO-NE	LOLE	0.1 days/yr	ICAP
SPP	LOLE	0.1 days/yr	ICAP

* 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

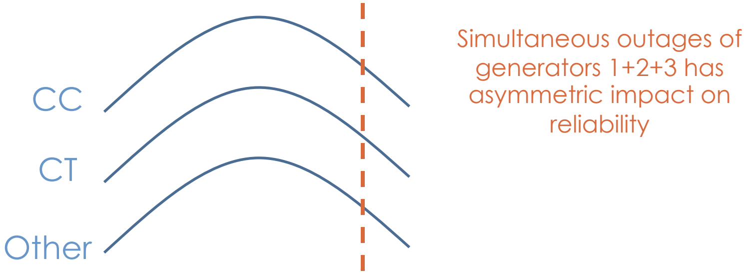
How to Switch from an ICAP PRM?

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 * (1 – EFORd %)
  - UCAP PRM adjusted to remove forced outage impacts
- Perfect capacity (PCAP) accounting utilizes *effective capacity* (i.e. ELCC) accreditation for all resources, based on
  - A. Their modeled performance
  - B. Interactive effects with other resources in LOLP modeling
- For PCAP accounting, a forced outage de-rate heuristic can approximate ELCC… but requires an adjustment for generator performance impacts
  - EFORd represents a marginal de-rate for a single resource
  - LOLP modeling considers tail events of multiple simultaneous generator outages
  - This heuristic can be developed using LOLP modeling



Outage Probability Distributions (illustrative)



Proposed 2022 IRP PRM + ELCC Study Method

1. Start with 2030 CAISO portfolio

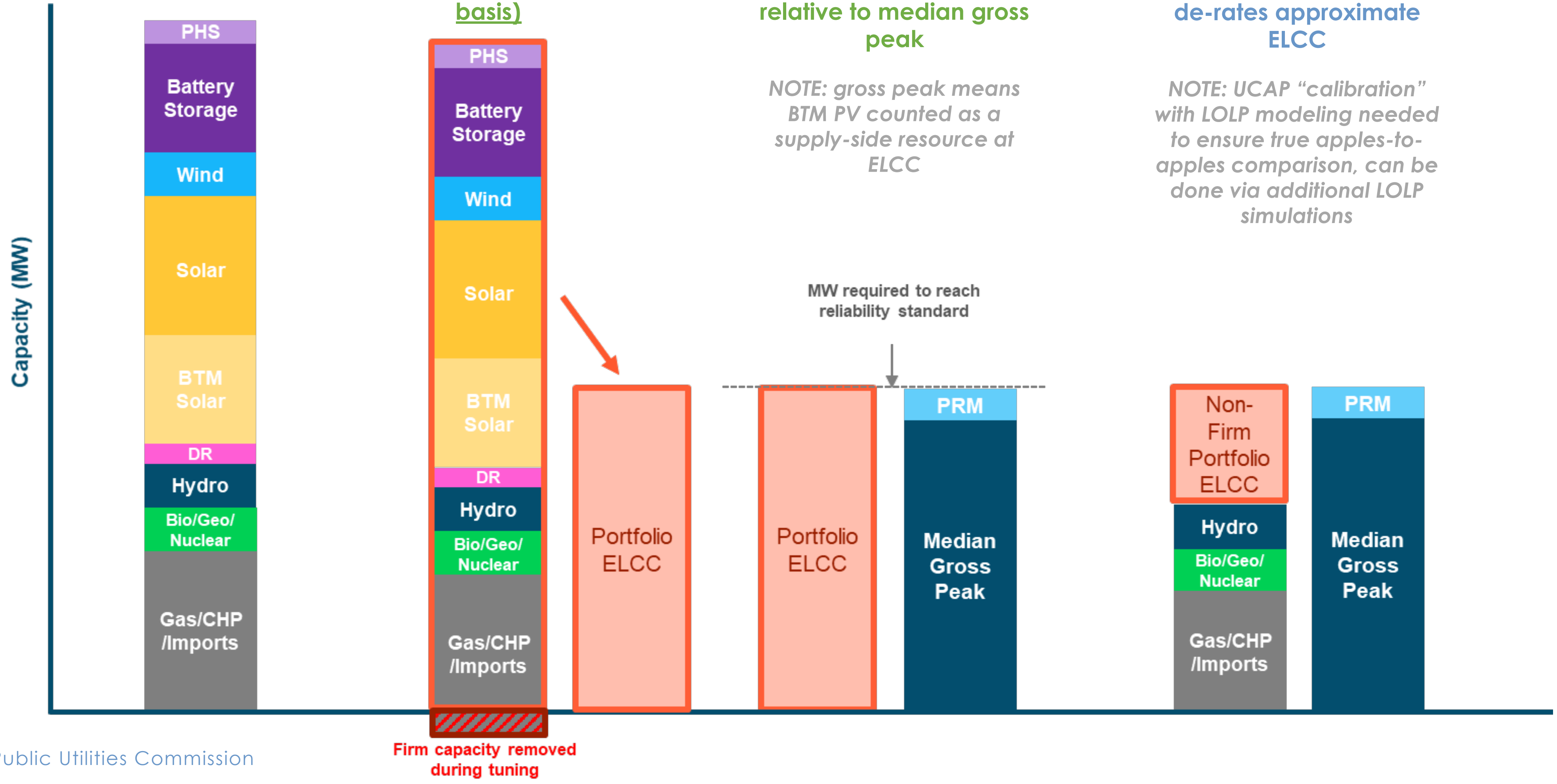
2. Replace all capacity w/ perfect capacity + tune to 0.1 LOLE (annual basis)

3. Determine PCAP TRN (effective MW) needed to reach 0.1 LOLE, and PRM relative to median gross peak

NOTE: gross peak means BTM PV counted as a supply-side resource at ELCC

4. Count firm resources at "calibrated" UCAP values, tuning to ensure de-rates approximate ELCC

NOTE: UCAP "calibration" with LOLP modeling needed to ensure true apples-to-apples comparison, can be done via additional LOLP simulations

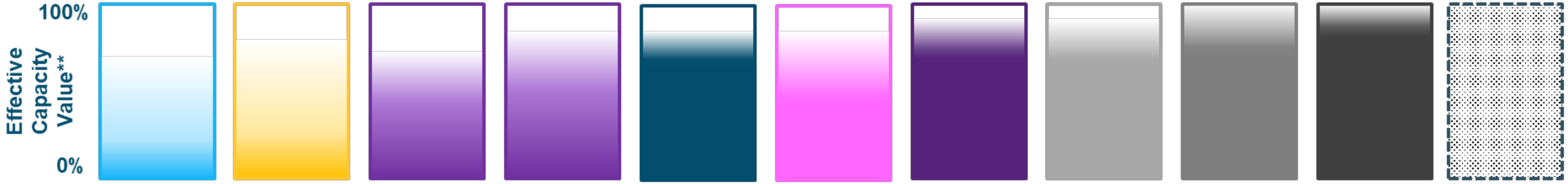


Resource Accreditation Considerations

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**
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

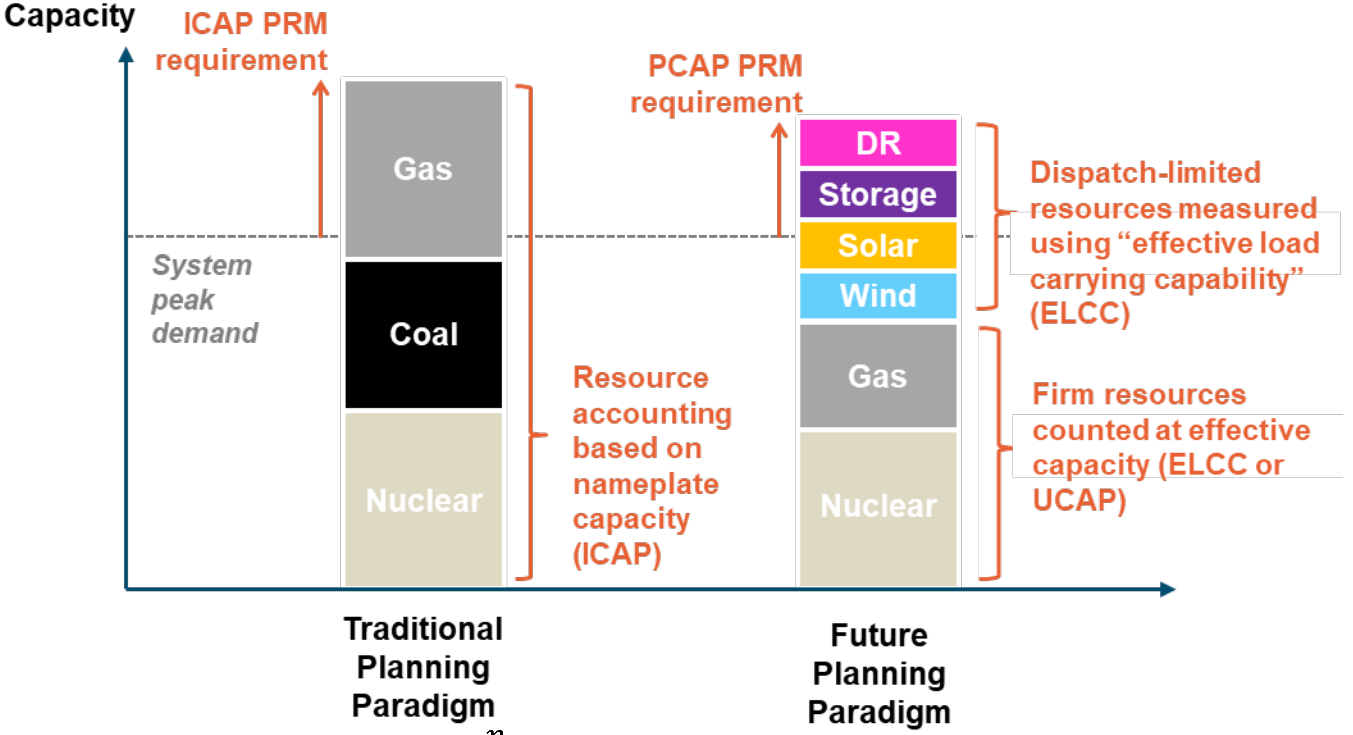


Factors Considered in Reliability Value

	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									
Use-limitations			X	X	X	X	X				*(Modeling construct used as comparison metric)*
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

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

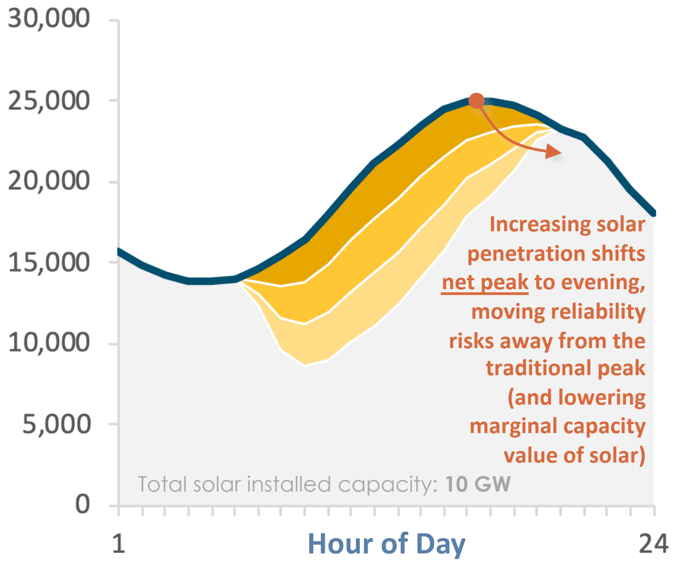
With <u>non-firm resources</u>, the total accredited capacity of a portfolio is <u>a function</u> of generator interactions

- **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 or UCAP
    - ❑Outage characteristics
    - ❑Interactive effects

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

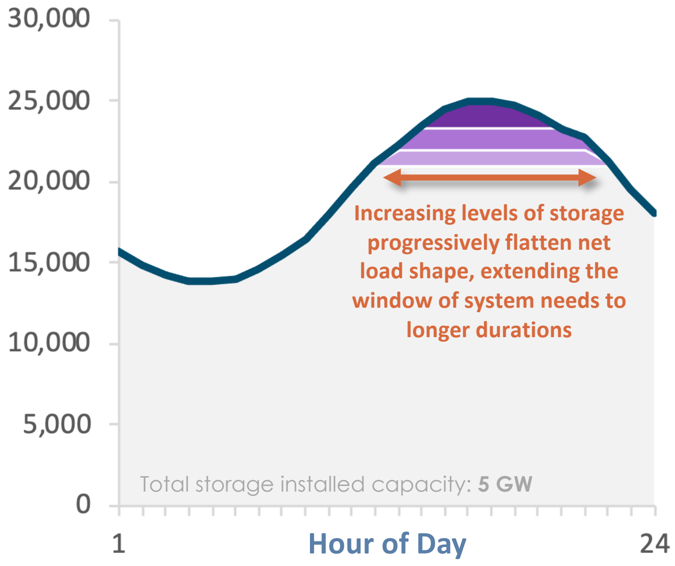
"Variable" resources shift reliability risks to different times of day

Solar Impact on Net Load
(MW)



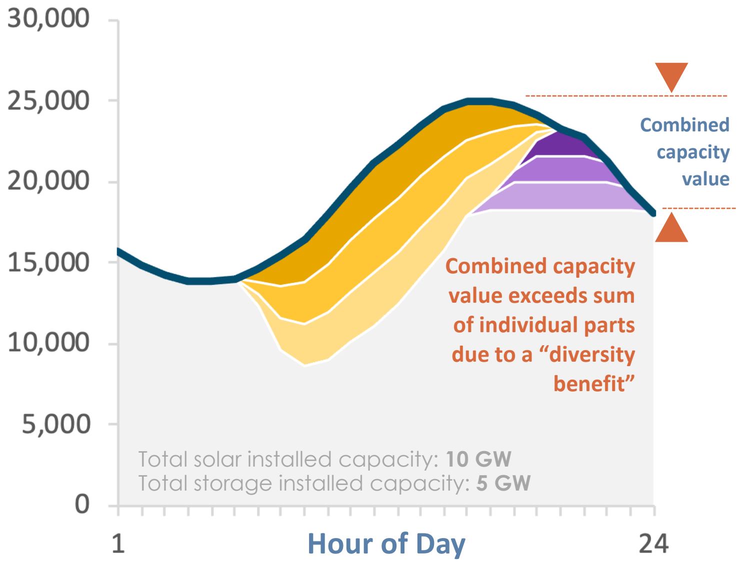
"Energy-limited" resources spread reliability risks across longer periods

Storage Impact on Net Load
(MW)



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

Combined Solar & Storage Impact on Net Load
(MW)



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

Measuring ELCC of a Portfolio and Individual Resources

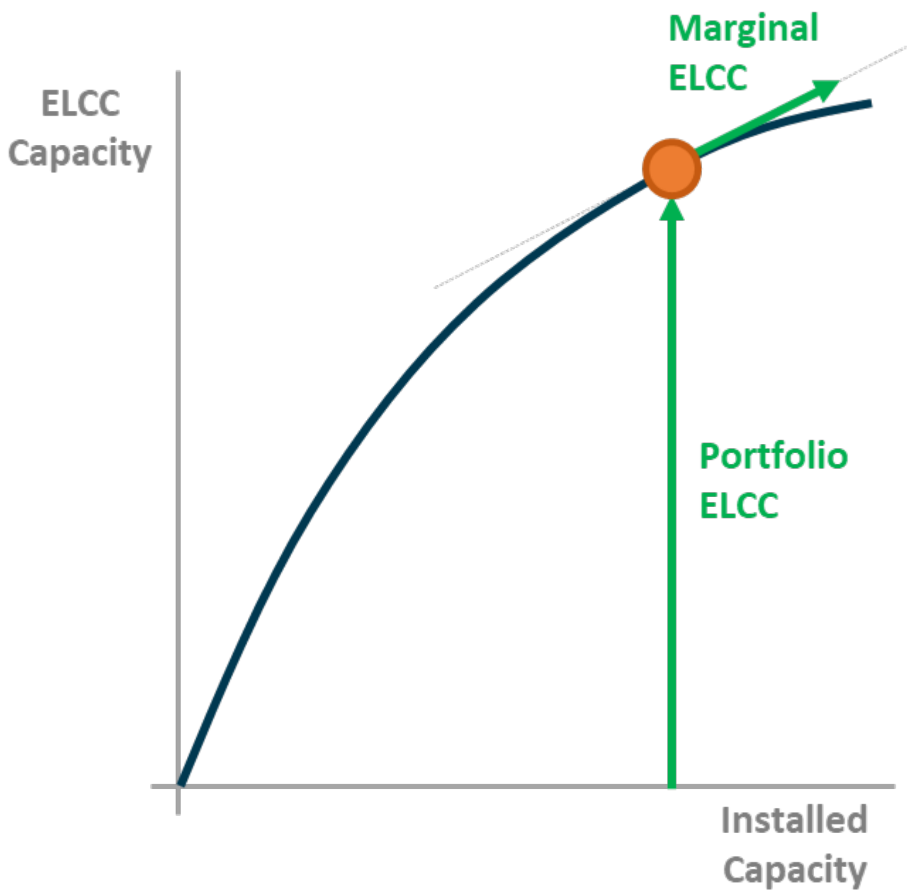
- **ELCC of is a function of the portfolio of resources**
  - The function is a surface in multiple dimensions
  - The Portfolio ELCC is the height of the surface at any given point on the surface

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

  - 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

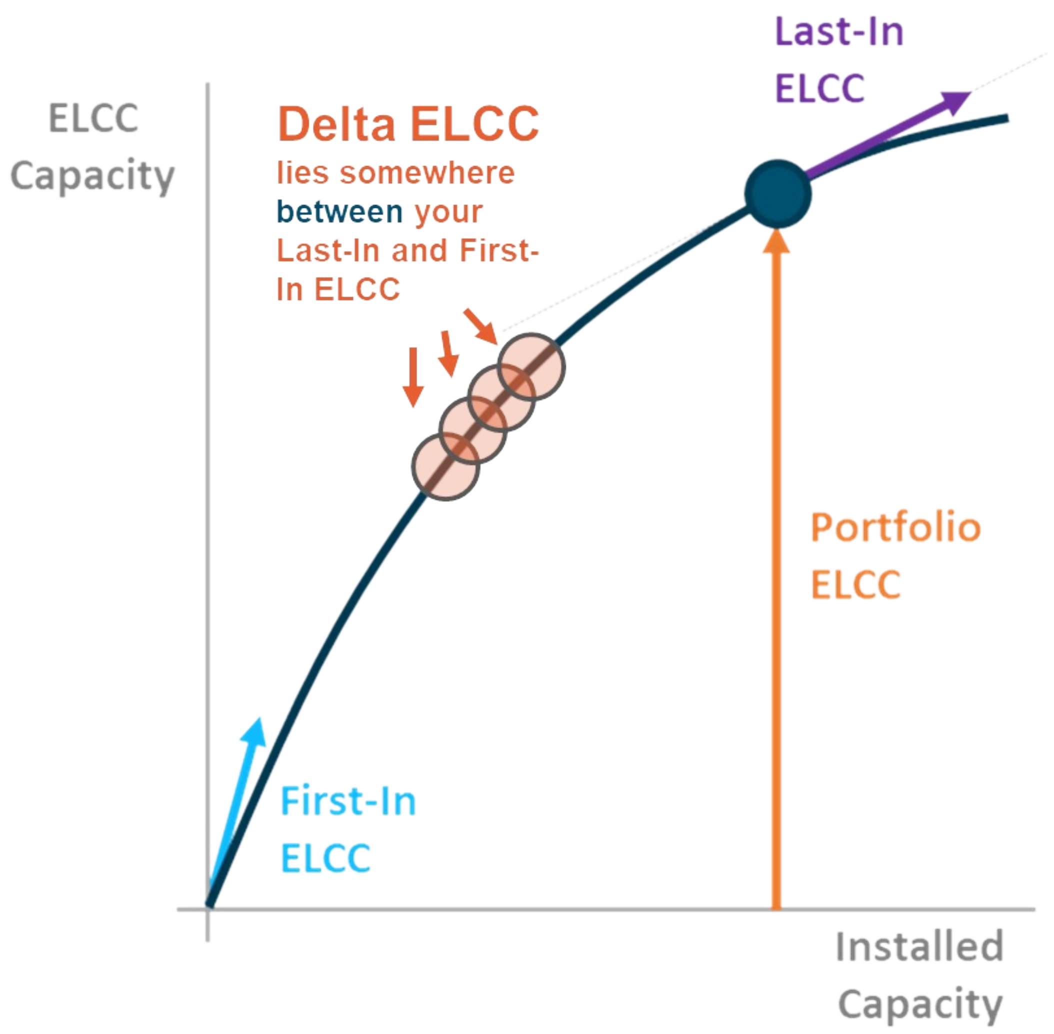
$$Marginal\ ELCC_{G_1} = \frac{\partial f}{\partial G_1}(G_1, G_2 \ldots G_n)\ (\%)$$

- **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



The Delta Method strikes a balance of competing objectives in an average 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



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
    - Past procurement orders (e.g. MTR, RPS least-cost best-fit) 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	80%	60%	$188	$250
Solar	$80	15%	10%	$533	$800
Wind	$150	20%	30%	$750	$500
Geothermal	$700	90%	90%	$778	$778

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.

LSE Plan Reliability Inputs

LSE Plan ELCCs

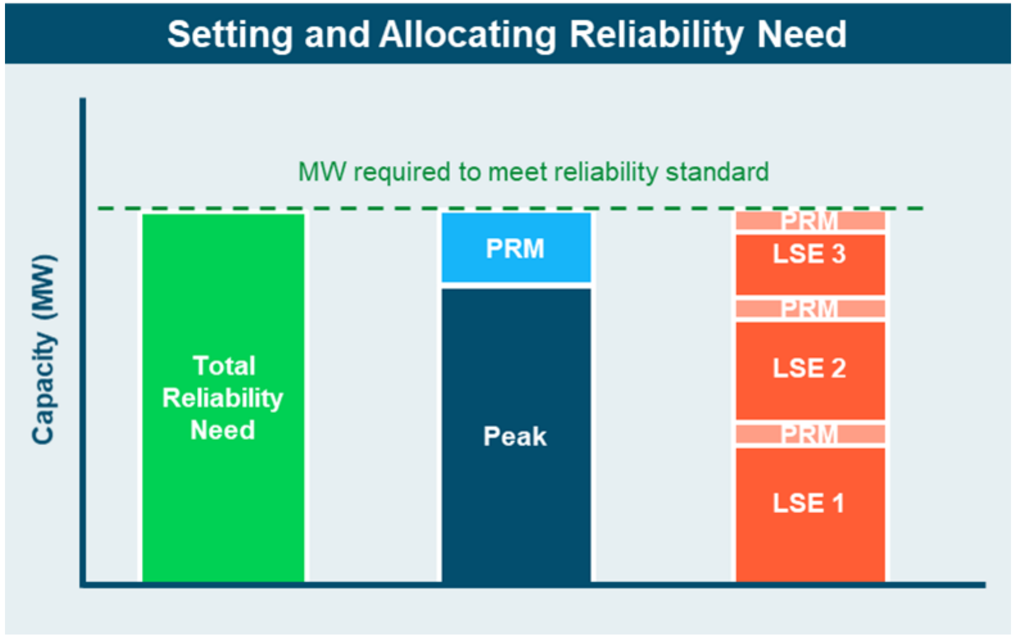
- LSEs need the following data points to complete their reliability planning:

  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?

LSE Reliability Requirement

- The RA program currently uses the CAISO managed peak load share to allocate the CAISO system level reliability need to LSEs
- IRP can follow a similar approach of accrediting based on LSE load share
  - CEC will be producing LSE-level peak share forecasts
  - Gross peak share instead of managed peak share can be used if counting BTM PV as a supply side resource in IRP accounting
- A marginal ELCC based framework may require further adjustments to LSE need
- Net peak-based allocation may become a better approach to capture changing periods of risk



LSE Plan Accreditation Metrics

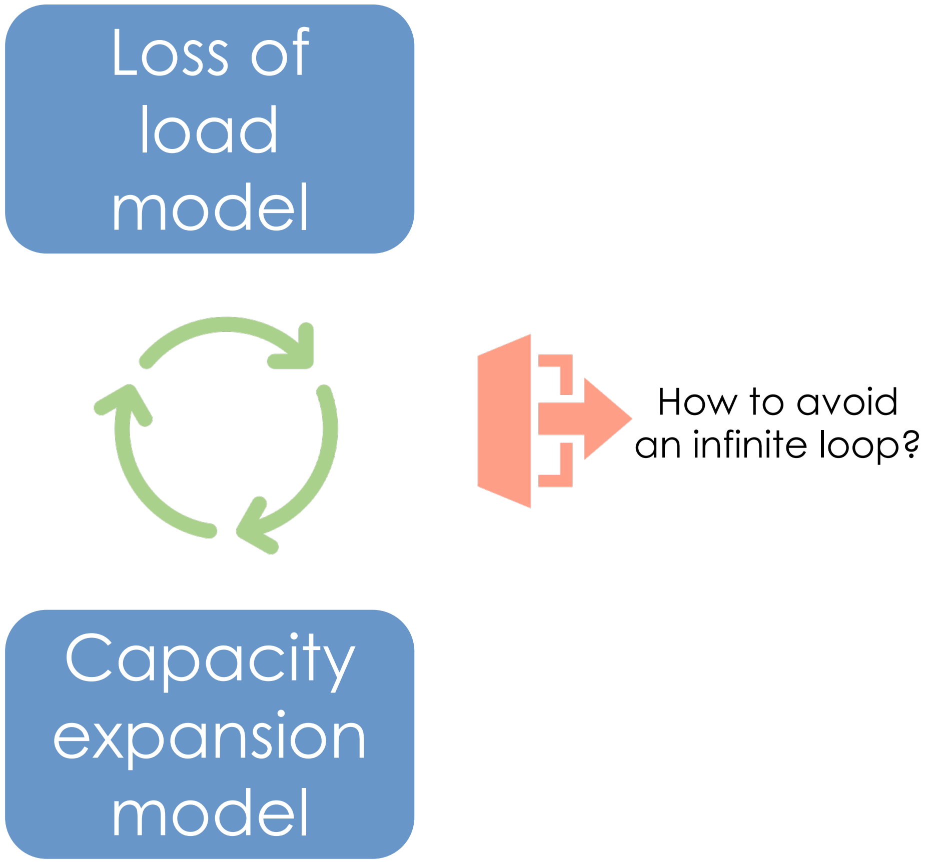
- **Goal**: provide sufficient granular accreditation metrics to enable LSEs to plan their portfolios
- **Firm resources (gas, geo, bio, hydro, nuclear)**: class-level calibrated UCAP values per ICAP vs. PCAP PRM calibration
- **Non-firm resources (solar, wind, storage, DR)**: ELCC
  - Solar: utility + BTM PV
  - Wind: in-state, out-of-state, offshore
  - Storage: 4-hr li-ion, 8-hr li-ion, 12-hr pumped hydro
  - Demand response
  - Paired generation/storage resources: heuristic based on solar + storage ELCCs
- **ELCC study design will consider a subset of years and resource classes**
  - Interpolation + ex-post heuristics can facilitate a sufficiently detailed annual ELCC forecast for LSE plans

	Proposed 2022 IRP Approach (LSE Plans)
Planning Reserve Margin	PCAP PRM over gross peak share or share of marginal procurement need
Wind	ELCC
Battery Storage	ELCC (paired generation/storage resources would use heuristic of solar + storage ELCCs)
Solar PV	ELCC
BTM PV	ELCC
BTM Storage	Either load modifier via IEPR assumptions or ELCC
Demand Response	ELCC
Pumped Hydro Storage	TBD: Calibrated UCAP or ELCC
Hydro	Calibrated UCAP
Bio/Geo/Nuclear	
Fossil (CT/peaker, CCGT, CHP, coal)	

Updating Resource Contributions to Reliability in RESOLVE

Planning models need estimates of resource adequacy contributions

- Capacity expansion models enforce resource adequacy constraints (e.g. PRM)
- To ensure reliability at minimum cost, the marginal *and* total resource adequacy contribution of energy-limited resources needs to be accurately reflected
  - But declining marginal capacity values and interactive effects between resources require <u>constant re-calibration</u> of energy-limited resource adequacy contributions
- It's not feasible to embed a detailed loss-of-load model within a capacity expansion model



Proposed 2022 RESOLVE Approach

	Current IRP Approach (RESOLVE)	Proposed 2022 IRP Approach (RESOLVE)
Planning Reserve Margin	22.5% **ICAP** PRM above managed peak	**PCAP** PRM over gross peak (i.e. managed peak + BTM PV)
Wind	ELCC (solar/wind ELCC surface)	ELCC (single or multiple wind curves)
Solar PV		ELCC (solar/storage surface)
BTM PV	ELCC (solar/wind ELCC surface), after increasing need by IEPR peak shift	
Battery Storage	ELCC curve (Battery only)	
Demand Response (Load Shed)	DR program capacity (NQC) for new + existing	ELCC (model on storage dimension of solar/storage surface)
BTM Storage	Either load modifier via IEPR assumptions or ELCC	Either load modifier via IEPR assumptions or ELCC
Pumped Storage	Installed capacity	TBD: Calibrated UCAP or ELCC
Hydro	Installed capacity (Sept NQC)	**Calibrated UCAP:** All UCAP resources will be represented with a de-rating based on forced outage rates and an adjustment to account for simultaneous outage impacts
Bio/Geo/Nuclear		
Fossil (CT/peaker, CCGT, CHP, coal)		

New SERVM ELCC runs will create ELCC representation of wind, solar, and storage in RESOLVE

UCAP calibration via SERVM

ELCC curves and surfaces address challenging issues for capacity expansion models

- Saturation impacts are addressed because marginal ELCC declines endogenously with resource penetration
- Creating ELCC curve equations using the results of a LOLE model implicitly includes energy limitations on different timescales
  - For wind and solar, production profiles across many years in the LOLE model allows for consideration of low renewable output periods
  - For storage, ELCC simulations have charging and discharging constraints
    - Charging energy sufficiency and flattening of the net peak are captured in Portfolio ELCC values from LOLE model
- 1-dimensional ELCC curve does *not* include synergistic or antagonistic impacts with other resource classes
  - 2-dimensional ELCC "surface" can include interdependent effects between two resource classes

Workflow for using ELCC curve or "surface" in planning

1. LOLE model (SERVM)

Calculate ELCC of combinations of energy-limited resources over a wide range of installed capacities

→

2. Linear equations

Convert portfolio ELCC values at a range of penetrations into linear equations for marginal and total ELCC

→

3. Capacity Expansion

Implement "surface" equations in capacity expansion model, create least-cost portfolios

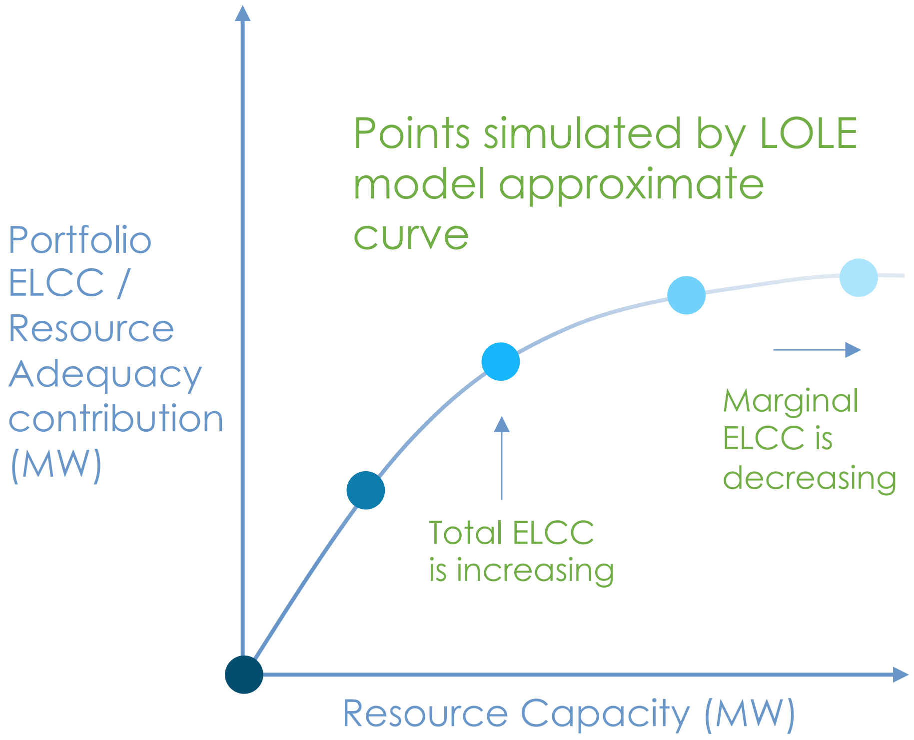
→

4. Reliability Check

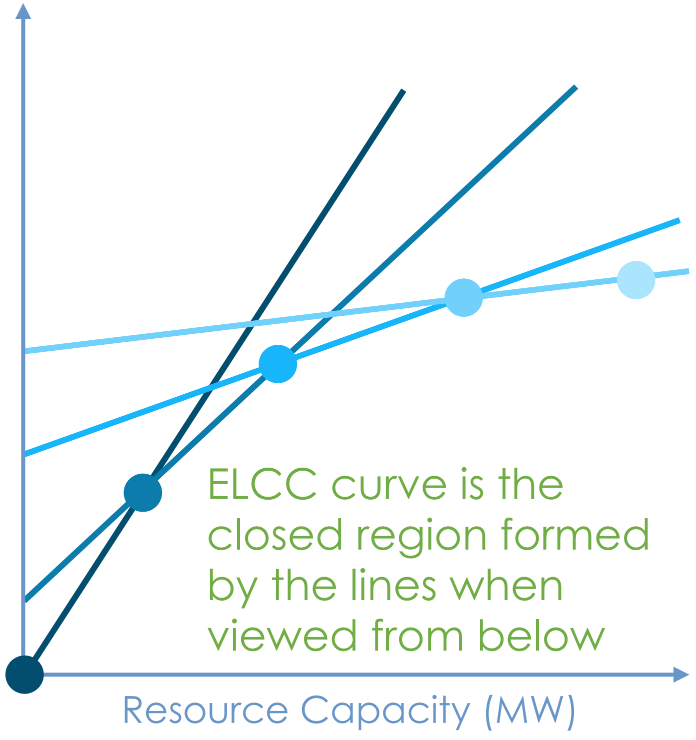
Check reliability using LOLE model, adjusting if any issues are found

Building an ELCC curve in one dimension

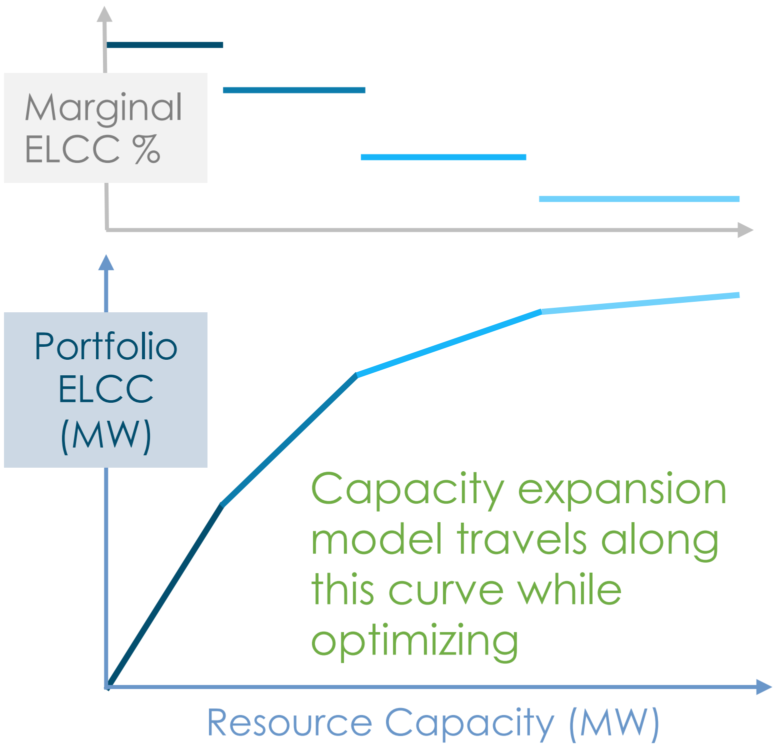
1 Calculate ELCC at Different Levels of Penetration



2 Linear equations approximate "true" ELCC curve

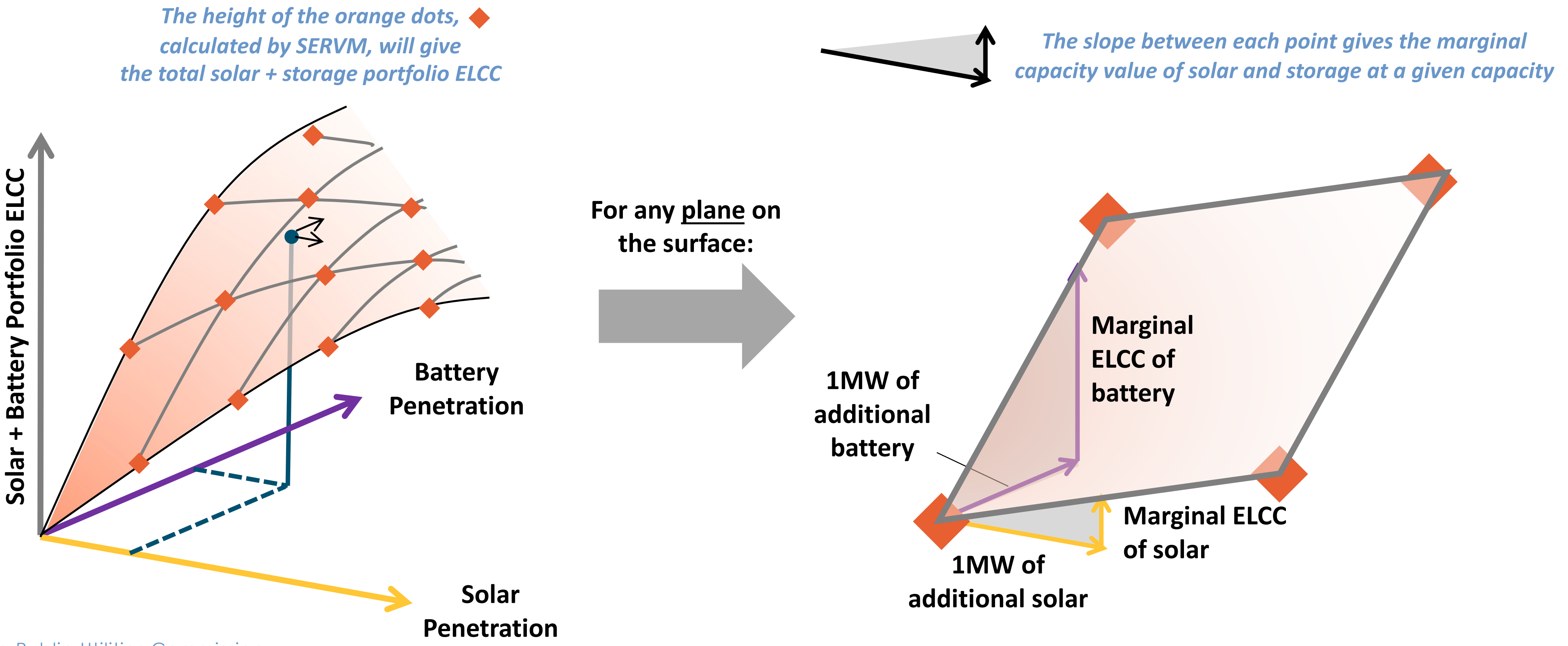


3 Implement in capacity expansion model



Now in two dimensions….

- A two-dimensional ELCC surface can capture both diminishing returns and diversity benefits between resources



Summary of Proposed 2022 IRP Approach

Summary of Proposed 2022 Approach

- **Modeling Approach**
  - Use the CPUC's SERVM model, with any appropriate updates, as the basis for need determination and resource accreditation
- **Need Determination**
  - System need calculated via a perfect capacity (PCAP) based total reliability need (TRN), translate into a planning reserve margin (PRM) above median gross peak
  - LSE-level need based on share of either on total reliability need or marginal reliability need using new multi-year CEC LSE-level forecast
- **LSE Plan Resource Accreditation**
  - **Firm resources**: use need determination analysis to derive "calibrated" UCAP values that reflect interactive effects of simulated outages
  - **Non-firm resources**: ELCC-based accreditation using either marginal or delta-method based average ELCCs
- **RESOLVE Updates**
  - Align PRM and firm resource accreditation with LSE plan inputs
  - Change solar + wind ELCC surface to a solar + storage ELCC surface, include DR on the storage dimension
  - Develop a separate 1-D wind ELCC curve

Summary of Proposed 2022 Approach

ELCC
UCAP

	Current IRP Approach (RESOLVE)	Proposed 2022 IRP Approach (RESOLVE)	Proposed 2022 IRP Approach (LSE Plans)
Planning Reserve Margin	22.5% ICAP PRM above managed peak	PCAP PRM over gross peak (i.e. managed peak + BTM PV)	PCAP PRM over gross peak share or share of marginal procurement need
Wind	ELCC (solar/wind surface w/ CF scaling)	ELCC (1-D curve w/ CF scaling or multiple curves)	ELCC***
Battery Storage	ELCC (1-D curve)	ELCC (solar/storage surface)	ELCC (paired generation/storage would use heuristic of solar + storage ELCCs)
Solar PV	ELCC (solar/wind surface w/ CF scaling)		ELCC
BTM PV	ELCC (solar/wind surface), after increasing need by IEPR peak shift		
BTM Storage	Load modifier via IEPR peak shift*	TBD: Load modifier or ELCC	TBD: Load modifier or ELCC
Pumped Hydro Storage	Installed capacity (Sept NQC)	TBD: Calibrated UCAP or ELCC	TBD: Calibrated UCAP or ELCC
Demand Response	DR program capacity (NQC) for new + existing	ELCC (model on storage dimension of solar/storage surface)	ELCC
Hydro	Installed capacity (Sept NQC)	Calibrated UCAP****	Calibrated UCAP
Bio/Geo/Nuclear			
Fossil (CT/peaker, CCGT, CHP, coal)			

* Note: current peak shift from BTM storage in the IEPR has low implied capacity value.
** Year-ahead RA LSE level forecasts use managed peak. CEC is developing an LSE-level multi-year forecast that can produce gross based peak share.
*** The LSE plan ELCC study provides more opportunity to break out sub-class ELCCs as desired, e.g. in-state wind vs. OOS wind, etc.
**** All UCAP resources will require de-rating based on forced outage rates and an adjustment to account for simultaneous outage impacts based on SERVM simulations

Next steps

Next steps

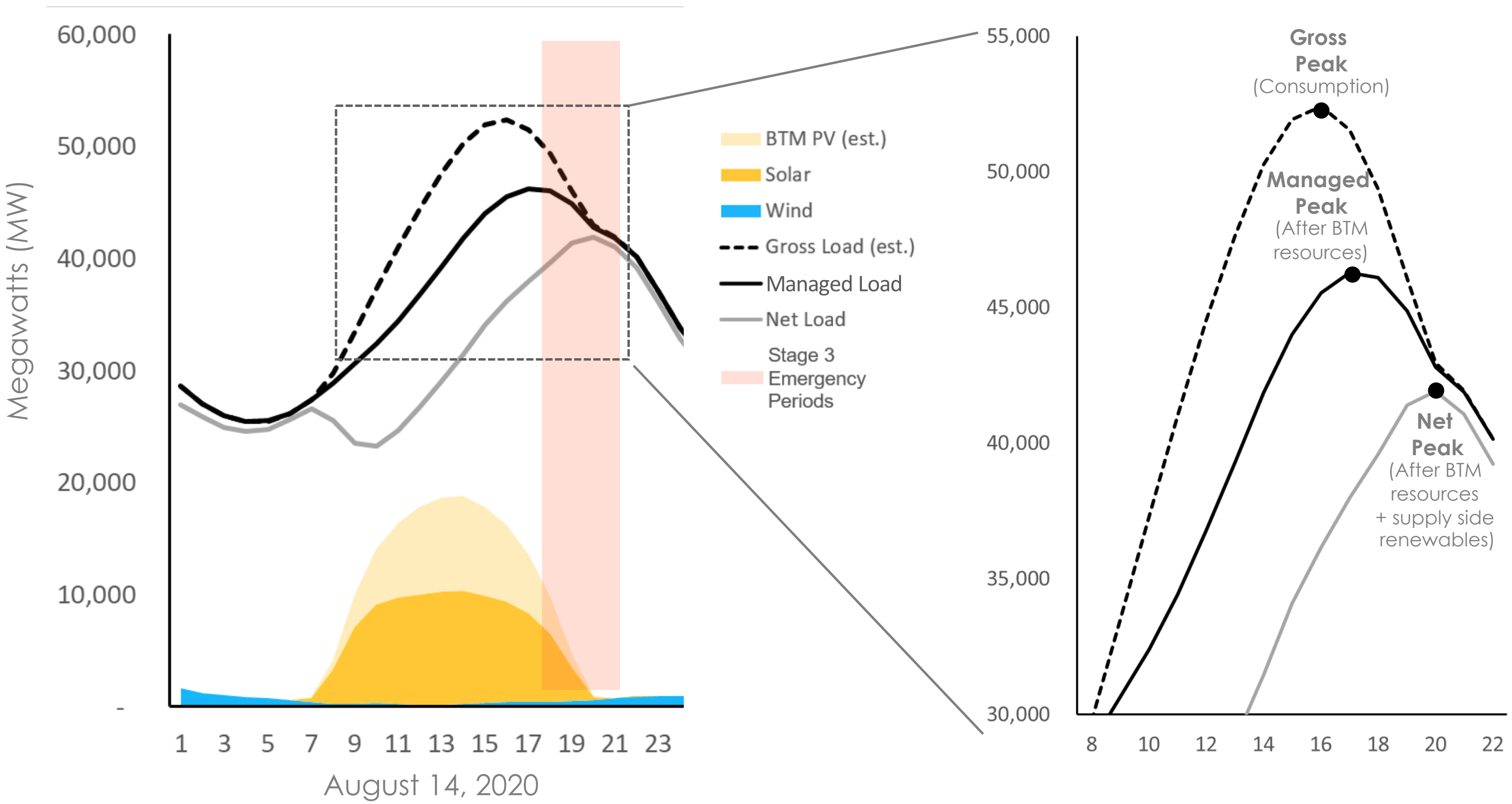
- Inputs & Assumptions
  - A revised scoping memo will provide details on the process for developing the complete I&A for the 2022-23 IRP cycle.
  - CPUC staff expects to finalize the 2022 I&A document, including the stakeholder process, by early/mid Q4 2022
  - CPUC staff will hold MAG(s) to cover some specific I&A topics in Q3 2022 and ask for stakeholder input
- LSE plan filing requirement templates
  - CPUC staff is seeking to finalize LSE filing templates by June 15, 2022
  - Parties should send informal stakeholder comments and suggestions about filing templates and potential updates prior to April 21, 2022 (but earlier comments encouraged), to: IRPDataRequest@cpuc.ca.gov
  - CPUC staff will hold informal "office hours" after June 15, 2022, for each group of LSEs by type, to answer questions and facilitate IRP development
- Staff expects to hold the next MAG webinar in early June to present the reliability modeling results to be used in finalizing the LSE plan filing requirement templates

Appendix

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

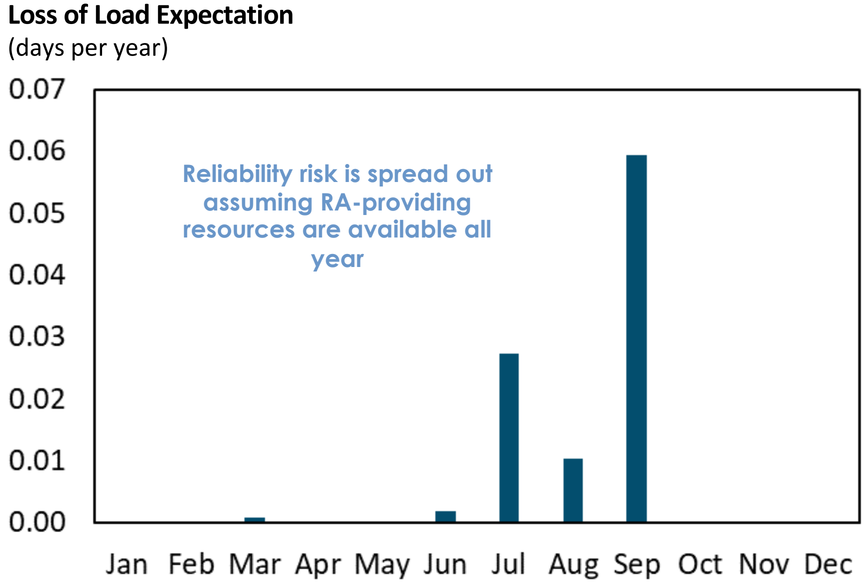
To reach the same 7.9 GW reserves, a 17% PRM is required over managed peak

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

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

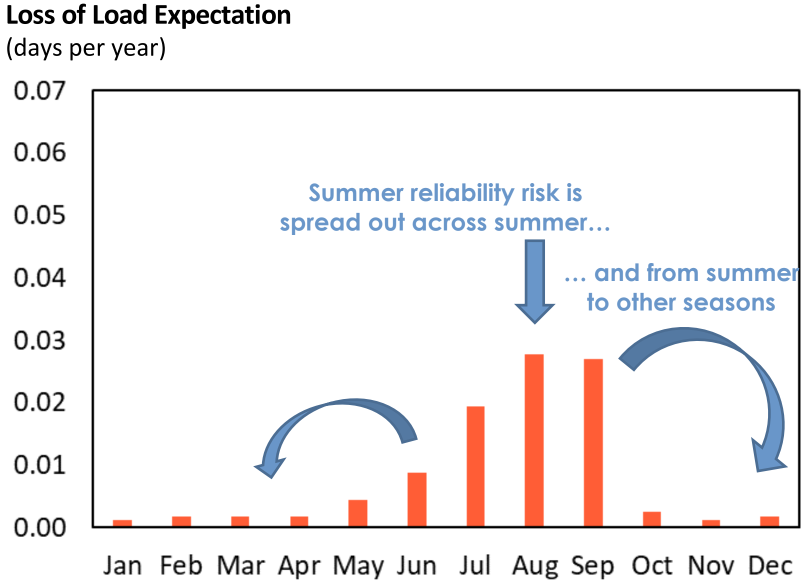


Source: estimated from draft PSP SERVM analysis (2026)

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

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

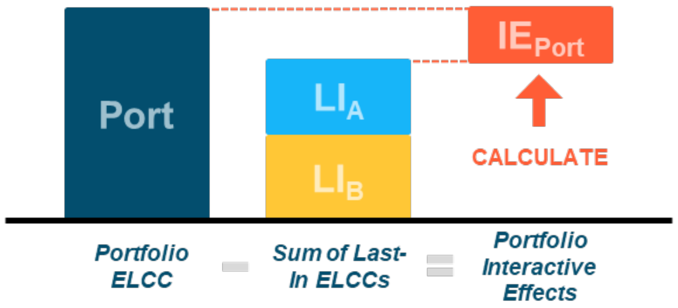
Storage + Hydro
Energy limitations on both storage and hydro require longer and longer durations after initial penetrations

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

Delta Method: Calculation Approach

STEP 1 Calculate Portfolio Interactive Effects

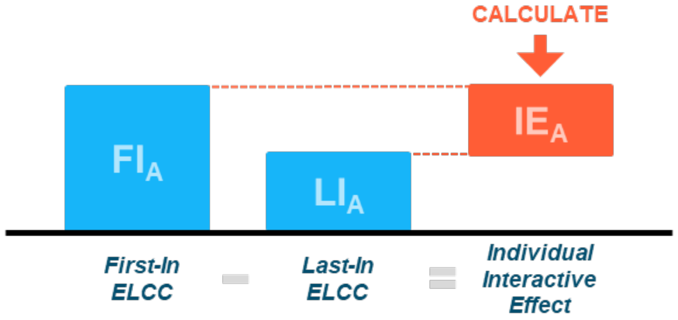
Calculated as the difference between the **Portfolio ELCC** and the sum of the **Last-In ELCCs** for all individual resources



STEP 2 Calculate Individual Interactive Effects

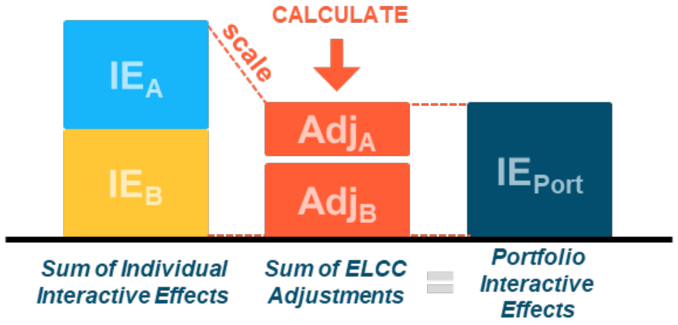
for each resource

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