ELCC Concepts and Considerations for Implementation

Prepared for the August 30th, 2021 NYISO Installed Capacity Working Group

August 30th, 2021

Energy+Environmental Economics

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Agenda

1. Introduction to the problem of dispatch-limited resource capacity accreditation
2. Loss-of-Load Probability modeling basics
3. ELCC computation and application

Introduction

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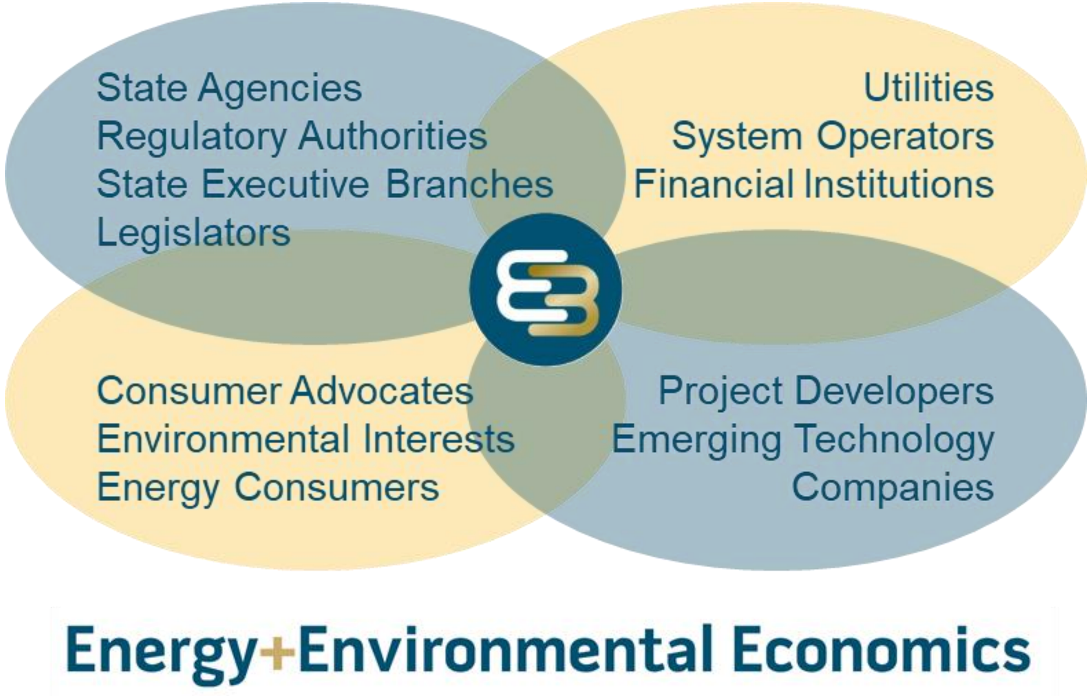
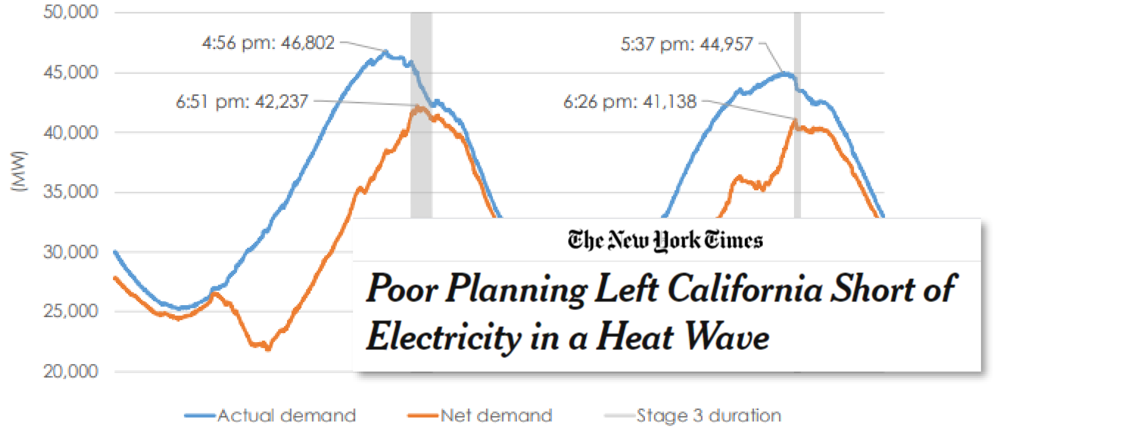
About E3

- E3 is a San Francisco-based consulting firm founded in 1989 specializing in electricity economics with approximately 75 staff
- E3 consults extensively for utilities, developers, government agencies, and environmental groups on clean energy issues
- Services for a wide variety of clients made possible through an analytical, unbiased approach
- Our experts provide critical thought leadership, publishing regularly in peer reviewed journals and leading industry publications

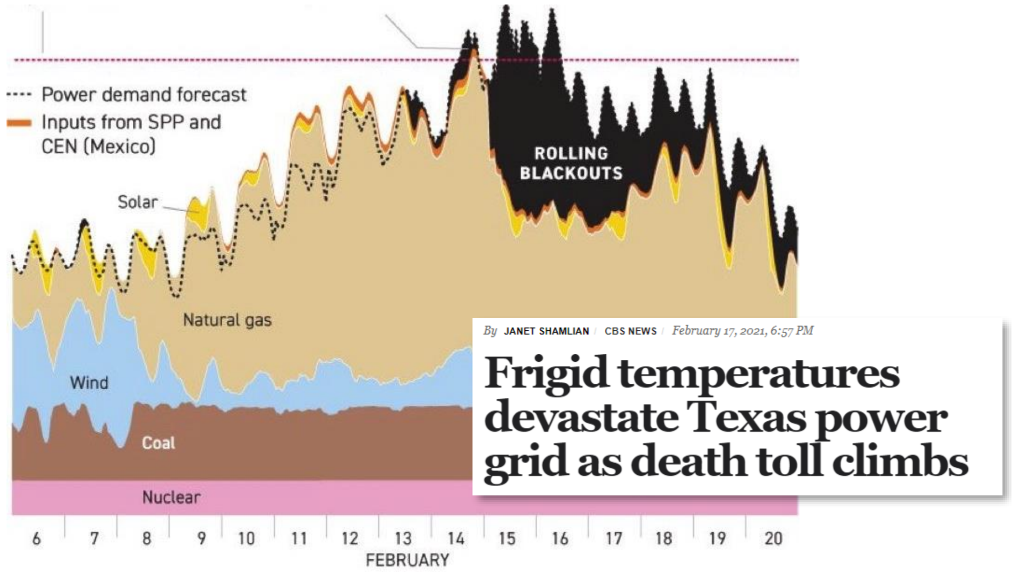


Resource adequacy is increasing in complexity – and importance

- **Transition towards renewables and storage introduces new sources of complexity in resource adequacy planning**
  - Planning exclusively for "peak" demand is obsolete
    - This was reasonable when all resources were firm
  - Resource adequacy must consider conditions across all hours of the year – as underscored by California's rotating outages during August 2020 "net peak" period
- **Reliable electricity supply is becoming increasingly important to society:**
  - Meeting cooling and heating electric demands as extreme weather events become more frequent and severe is increasingly a matter of life or death
  - Economy-wide decarbonization requires electrification of transportation and buildings, making the electric industry the keystone of tomorrow's energy economy

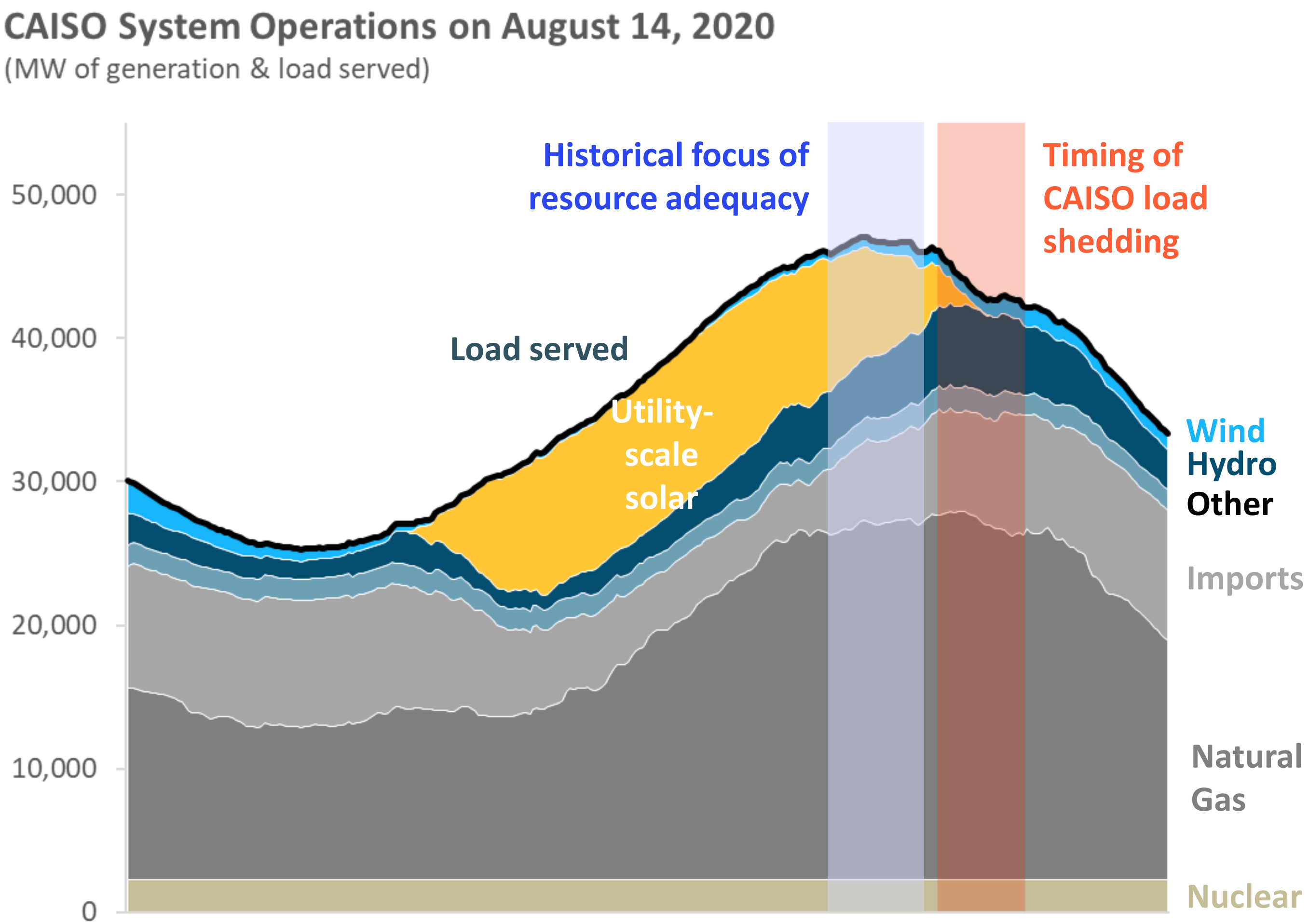


Graph source: http://www.caiso.com/Documents/Final-Root-Cause-Analysis-Mid-August-2020-Extreme-Heat-Wave.pdf



Graph source: https://twitter.com/bcshaffer/status/1364635609214586882

Resource adequacy is no longer only about planning for peak demand



Notes:
1. “Other” includes biomass, geothermal, coal, and storage
2. “Load served” represents wholesale energy demand; impacts of behind-the-meter solar not shown

+ **Traditional resource adequacy planning focuses on peak demand**
+ **Increasing penetrations of renewables and storage will cause challenges to shift to other periods of the day (and year), requiring innovation in planning approaches**

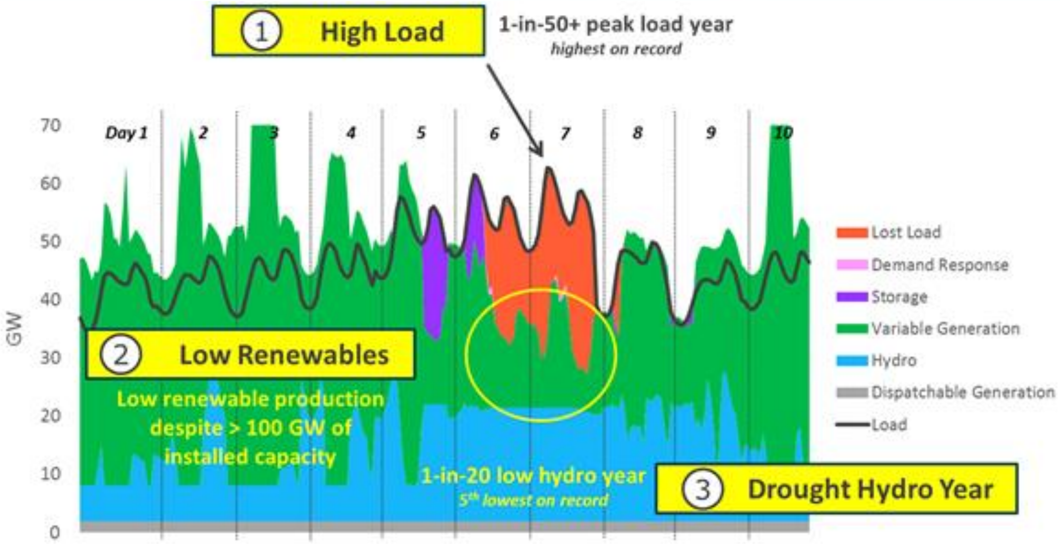
California ISO Final Root Cause Analysis

“In transitioning to a reliable, clean, and affordable resource mix, **resource planning targets have not kept pace to ensure sufficient resources that can be relied upon to meet demand in the early evening hours**. This made balancing demand and supply more challenging during the extreme heat wave.

“The rotating outages both occurred after the period of gross peak demand, during the “net demand peak,” which is the peak of demand net of solar and wind generation resources.”

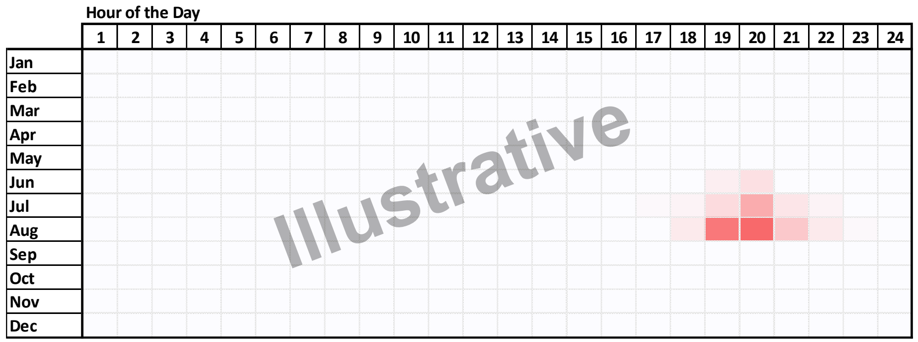
The nature of the resource adequacy challenge is changing

+ **Resource adequacy is a measure of the ability of the bulk grid (generation) to meet a reliability standard across a wide range of system conditions**
  - NY uses a 0.1 day / year standard
+ **As renewable penetration grows, planning problems shift from traditional need to meet peak demand hours (e.g., summer) to new questions of meeting net demand (e.g., over multi-day low renewable events)**
  - The timing of these needs will change
    - From summer gross peak to winter net peak
    - To account for unexpected high load and low renewable output during planned outages in the shoulder months
+ **This new planning problem highlights the need to assess reliability in a time-sequential way over full spectrum of system conditions**



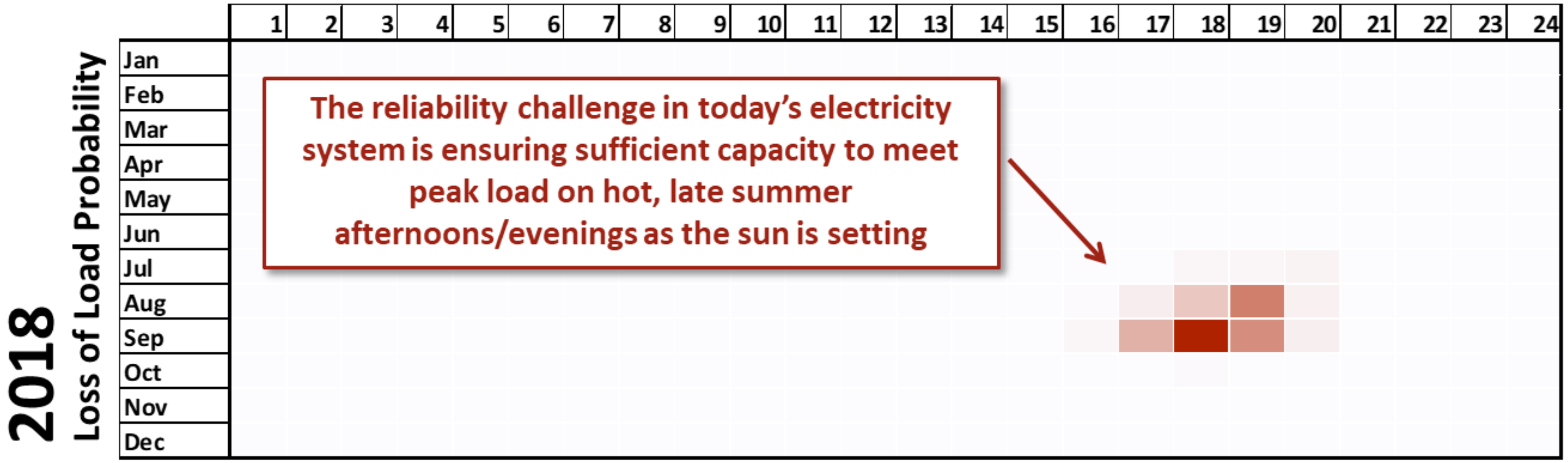
Loss of Load Probability Table

Identifies the probability of each hour to be deficient

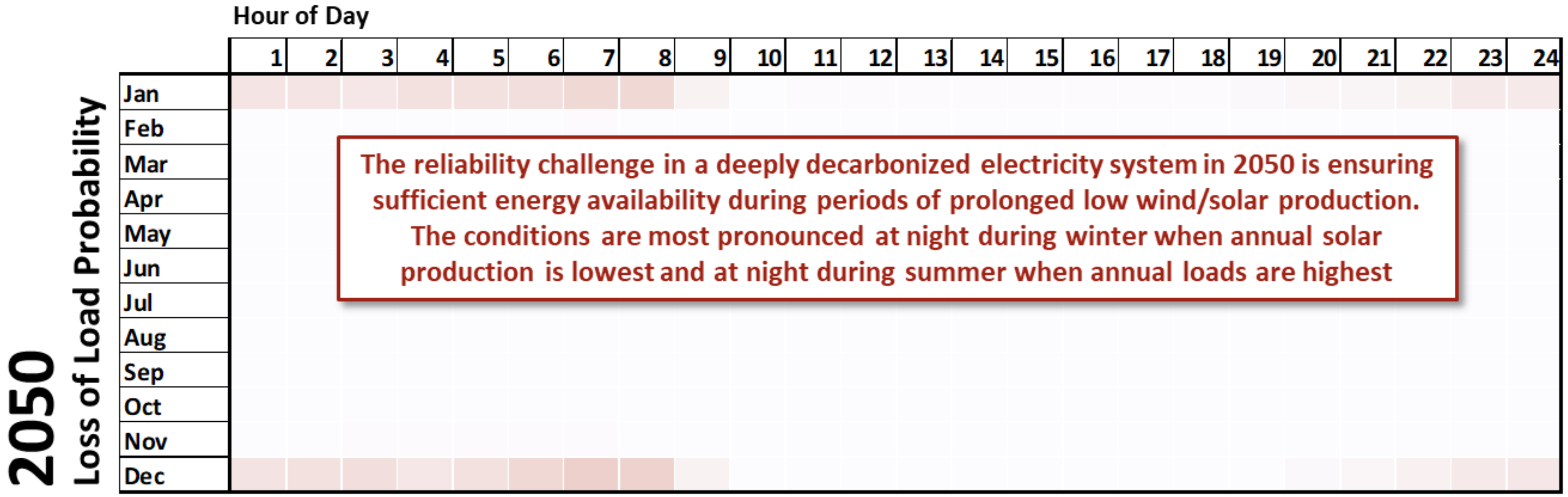


Decarbonization will eventually shift timing of loss of load events into winter months

+ **Today, reliability events are concentrated in summer "net peak" period – after sunset but while loads remain high**



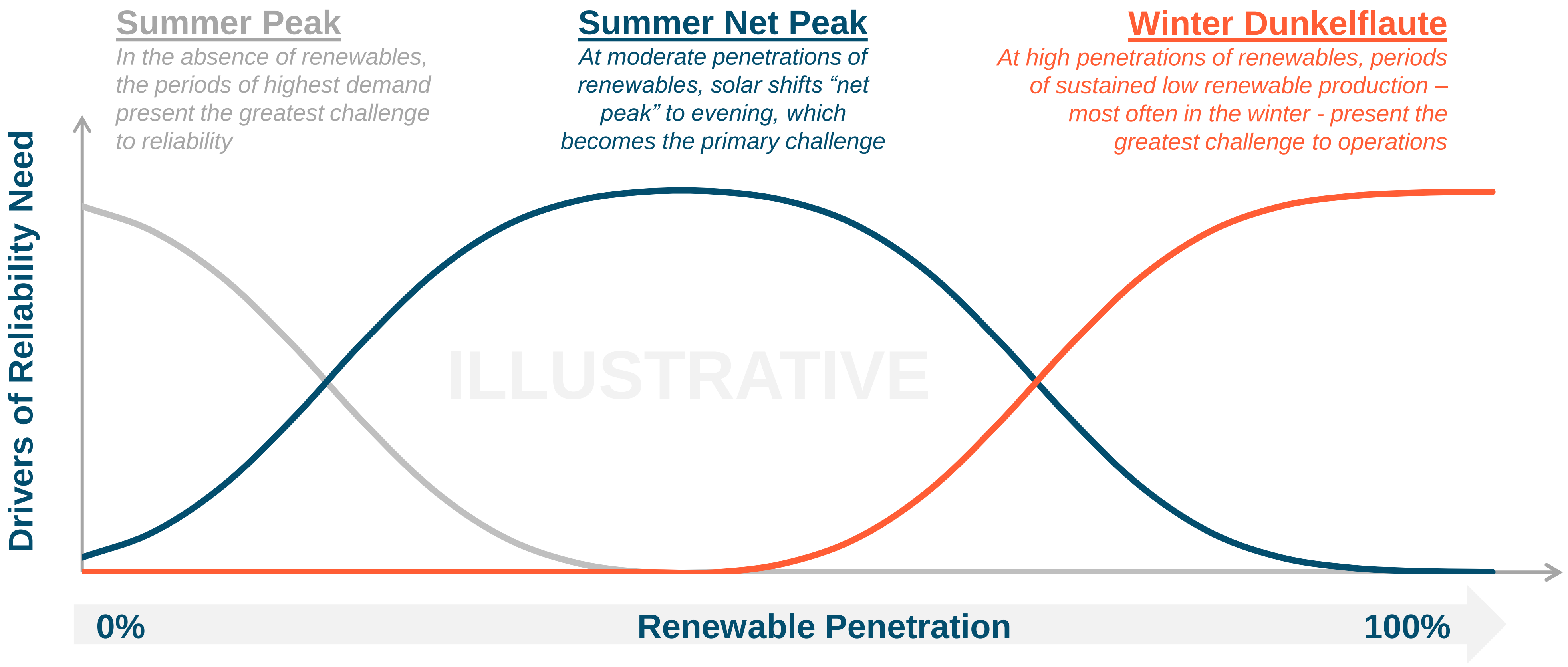
+ **In a deeply decarbonized grid, reliability events will occur in the winter, during sustained periods of low renewable production**
  - With large quantities of solar & storage, summer is no longer the "binding constraint"



Based on E3's study Long-Run Resource Adequacy under Deep Decarbonization Pathways for California

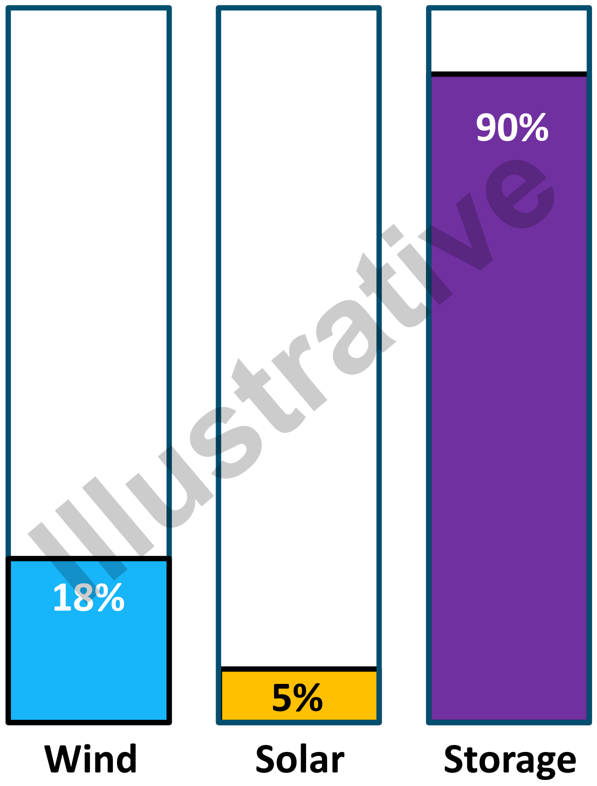
Evolving grid challenges at increasing renewable penetrations

+ **Increasing levels of renewables will cause the timing of reliability challenges to shift to different times of day – and eventually to different times of year**



Historical-based capacity accreditation does not accurately reflect reliability value

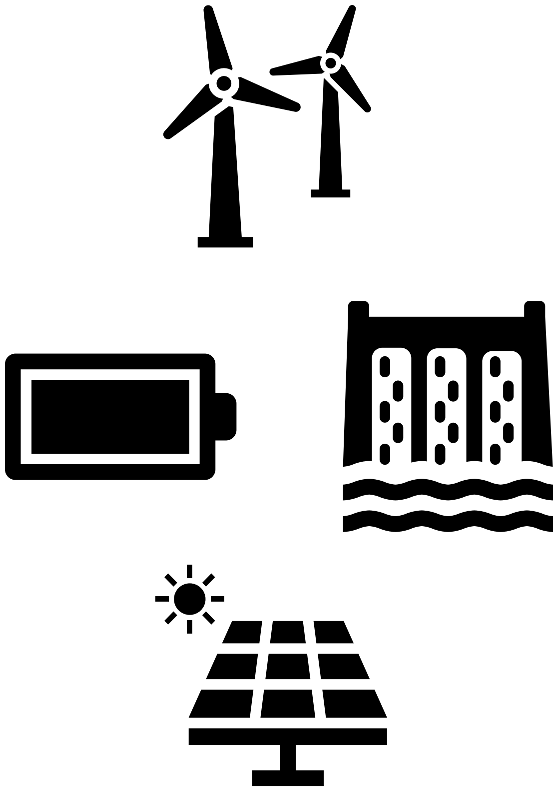
+ **Historical output based: credit resource capacity based on historical resource output during peak periods**
  - Can use gross load peaks or net load peaks
  - Typically multiple hours over multiple months (e.g. HE 16-18, Jun-Sept)
  - Can use median, mean, or "exceedance" approach (e.g. 70^{th} percentile)
+ **Historical output based methods are simple and transparent, but cannot capture load generation correlation, diminishing returns, and interaction between resources**
  - The approach works fine at small penetrations but insufficient when the system depends more meaningfully on these resources for reliability



Evolving best practices in resource adequacy

- **Best practices in resource adequacy link detailed loss-of-load-probability modeling with a more simplistic planning reserve margin accounting framework**

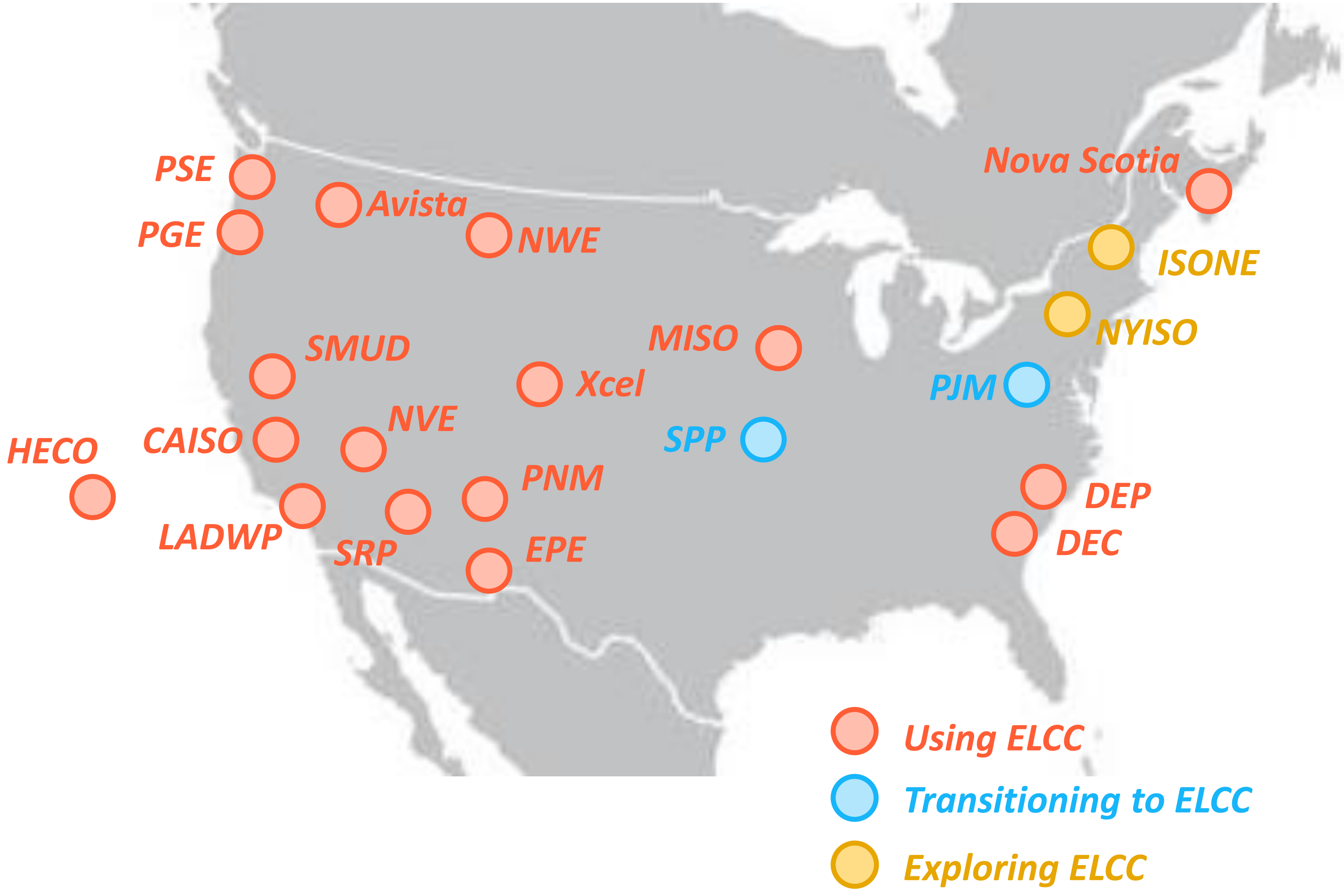
1. Determine reliability standard
   e.g. 1-day-in-10-years (or LOLE = 0.1 days/yr)
2. Calculate target PRM
   e.g. 15%
3. Calculate ELCC of existing resources
4. Calculate incremental/marginal ELCC of new resources, relative to existing portfolio



ELCC has quickly gained traction among ISOs and utilities

- Many ISO/RTOs and utilities are already using or considering a transition to ELCC for renewable (e.g., solar, wind) and/or energy limited resources (e.g., storage)

- Most have applied ELCC concepts to wind and solar; application for storage and other energy-limited resources has been limited to date



Loss of Load Probability Modeling

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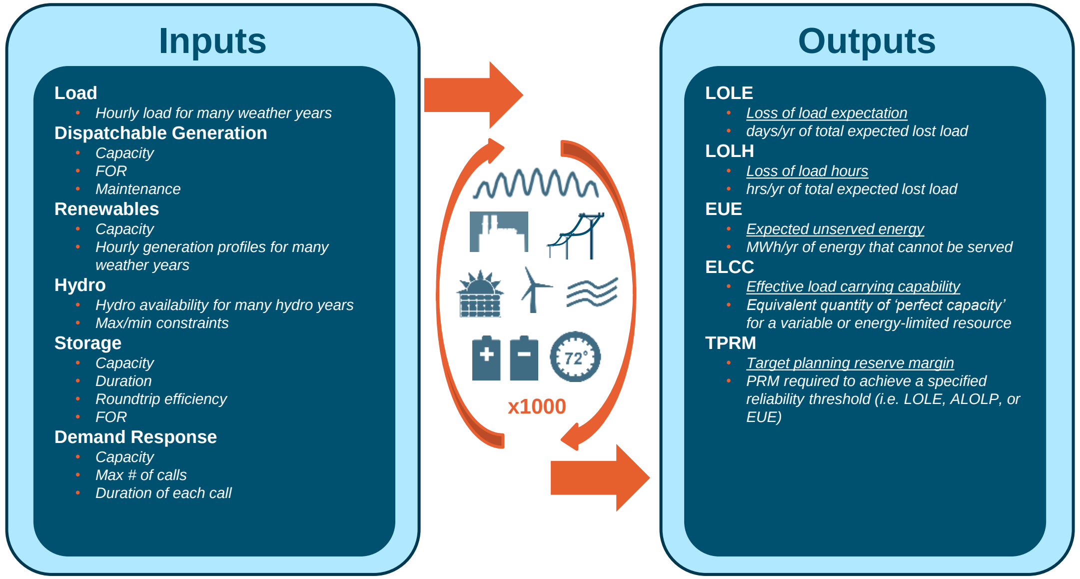
Loss of Load Probability Modeling Methodologies

+ **LOLP modeling should contain sufficient information about the probability of certain system conditions occurring, including**
  - High and low loads due to weather
  - Renewable conditions across a wide array of high and low generation events
  - Correlations between load and renewable conditions
  - Dispatch behavior of energy-limited resources such as energy storage and hydro
+ **As much data on the distribution of load and renewables should be captured as possible**
  - Weather distribution can be based on historical conditions, adjusted for expected climate change impacts
  - Renewable generation can be based on historical conditions, adjusted for climate change impacts
+ **E3 recommends at least 10 years of renewable generation conditions and as many load-driven weather years as is reasonable e.g. 30+**
  - The accuracy of individual Monte Carlo runs in arriving at the ELCC of a resource-type depends on the data within the run



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 exceeding available generating capacity
Loss of Load Probability (LOLP)	%	Probability of system demand 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 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 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 exceeding available generating capacity

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

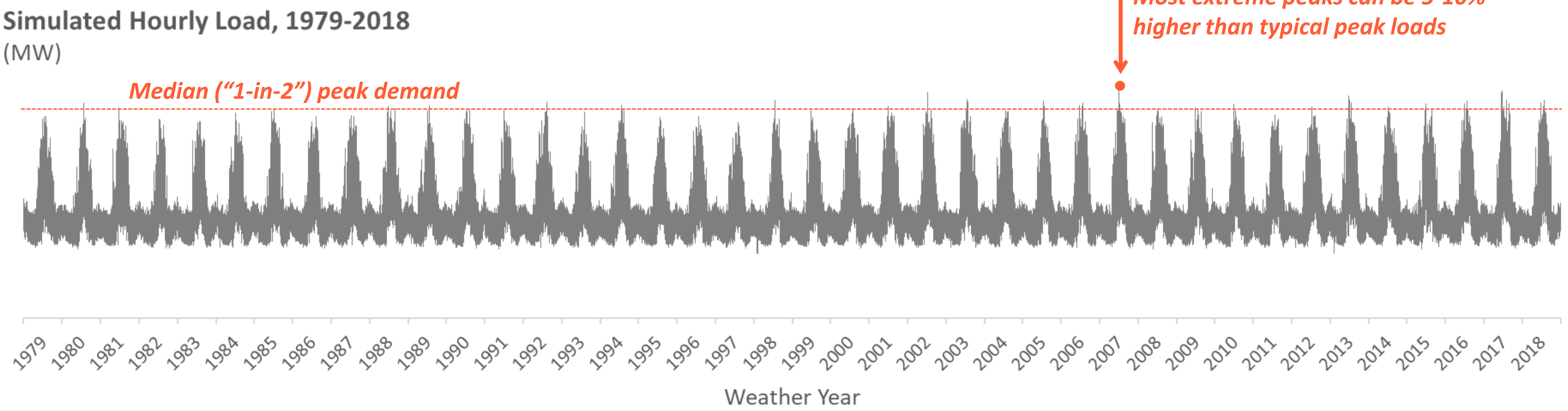
Result	Units	Definition
Planning Reserve Margin Requirement (PRM)	% 1-in-2 peak load	The planning reserve margin needed to achieve a given reliability metric (e.g., 1-day-in-10-years LOLE)
Effective Load-Carrying Capability (ELCC)	MW	Effective "perfect" capacity provided by energy-limited resources such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

Capturing the full range of potential electric demands

- Most LOLP modelers use historical weather data to develop “backcasts” of hourly load on today’s system under a broad range of weather conditions
- Neural network regression techniques rely on extensive records of historical weather data to simulate loads

Emerging challenge:
capturing climate change impacts on magnitude and frequency of extreme weather events

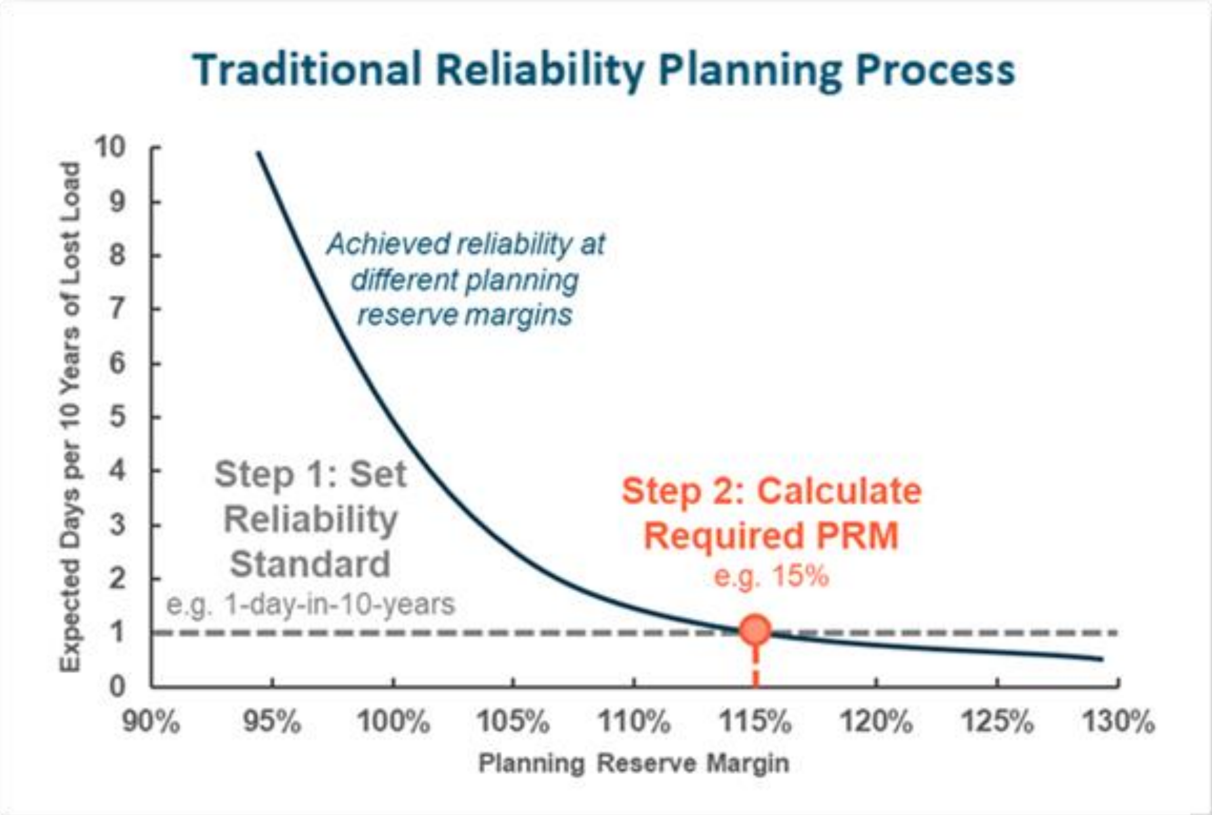
Most extreme peaks can be 5-10% higher than typical peak loads



Planning reserve margin (PRM)

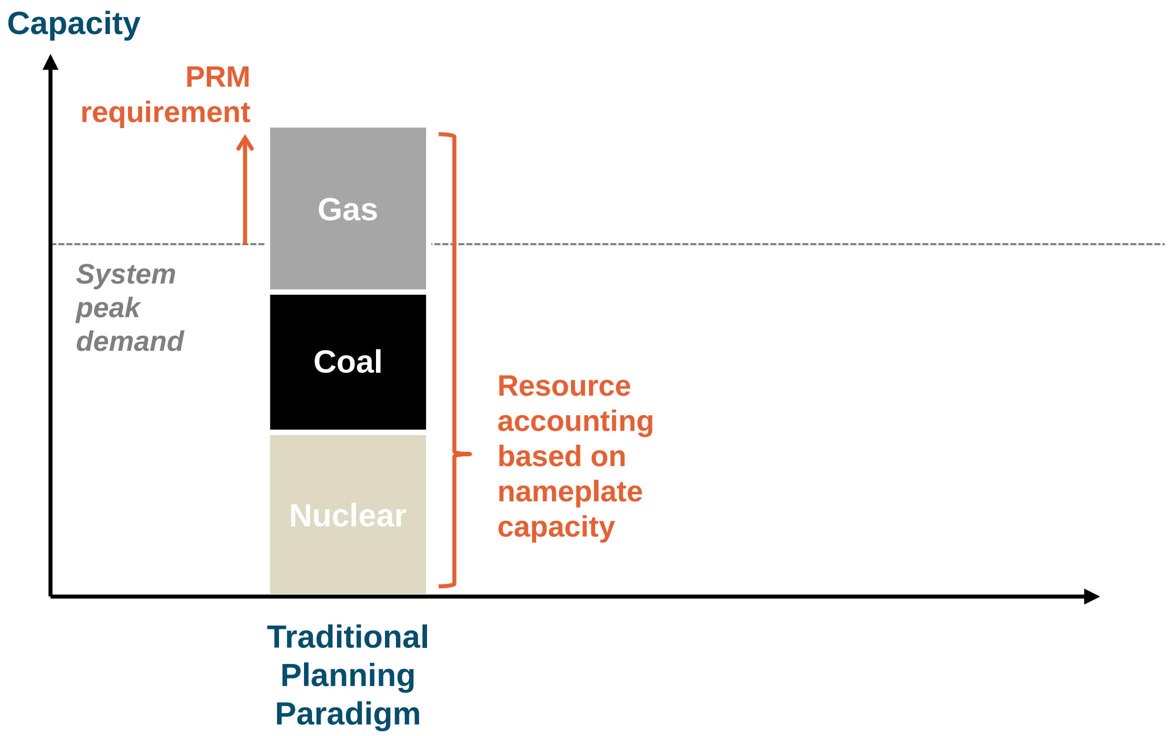
- **PRM is measured as the quantity of capacity needed above the median year peak load to meet the LOLE standard**
  - Serves as a simple and intuitive metric that can be utilized broadly in power system planning
  - Based on robust LOLP modeling

- **The integration of increasing levels of renewables and storage does not render the PRM framework obsolete**
  - Does require more advanced techniques for measuring the contribution of different types of resources towards that capacity requirement



Resource accreditation is simple in the traditional planning paradigm

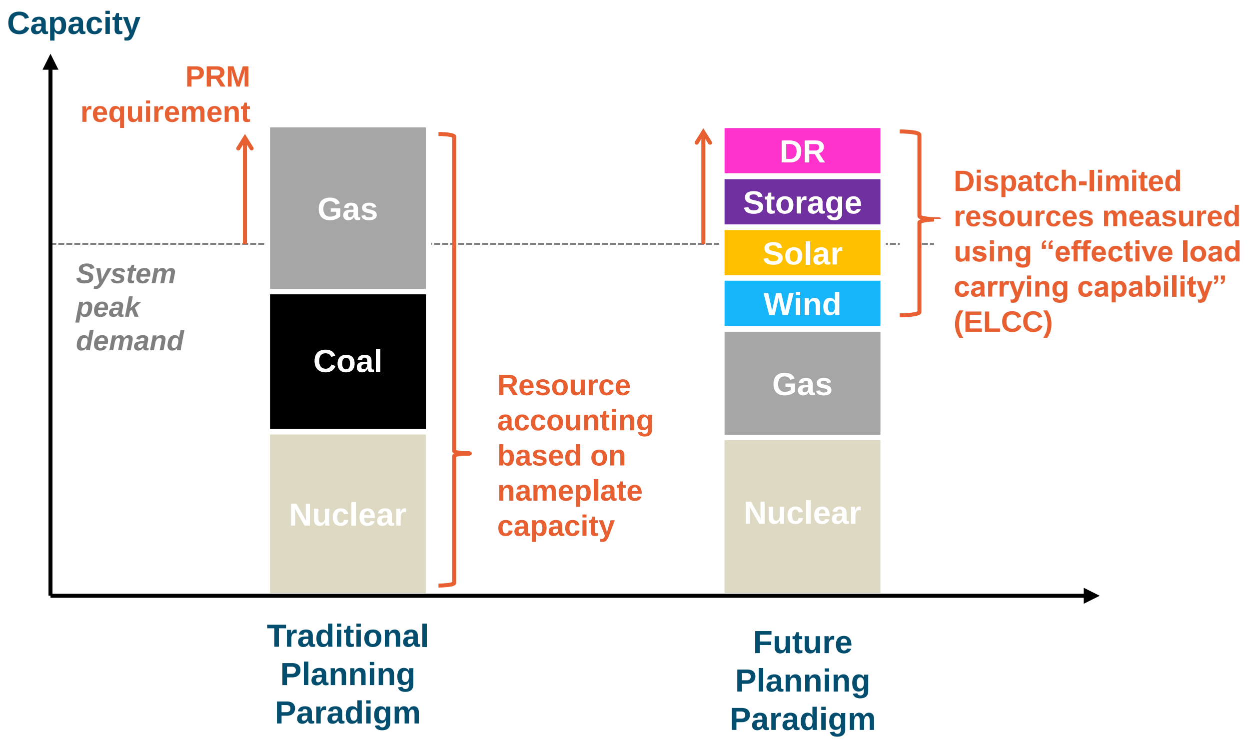
- PRM defined based on Installed Capacity method (ICAP)
- Individual resources accredited based on nameplate capacity
  - Small differences in forced outage rate
  - No interactions among resources
  - Forced outages also incorporated through performance penalties



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

Adapting the PRM framework for a high renewable future

- PRM defined based on Perfect Capacity (PCAP) or Unforced Capacity (UCAP)
- Individual resources accredited based on ELCC
  - Large differences in availability during peak
  - Significant interactions among resources
  - ELCC values are dynamic based on system conditions



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

ELCC Computation and Application

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ELCC is calculated using loss-of-load-probability modeling

+ **Effective Load Carrying Capability (ELCC) represents the equivalent "perfect" capacity that a resource provides in meeting the target reliability metric (e.g., 0.1 day/year LOLE)**
  - ELCC can also be thought of as the incremental load that can be met by an incremental resource throughout the year while maintaining the same target reliability metric

1 **Calculate existing system reliability and tune the system to the target**

2 **Add desired resource to portfolio**

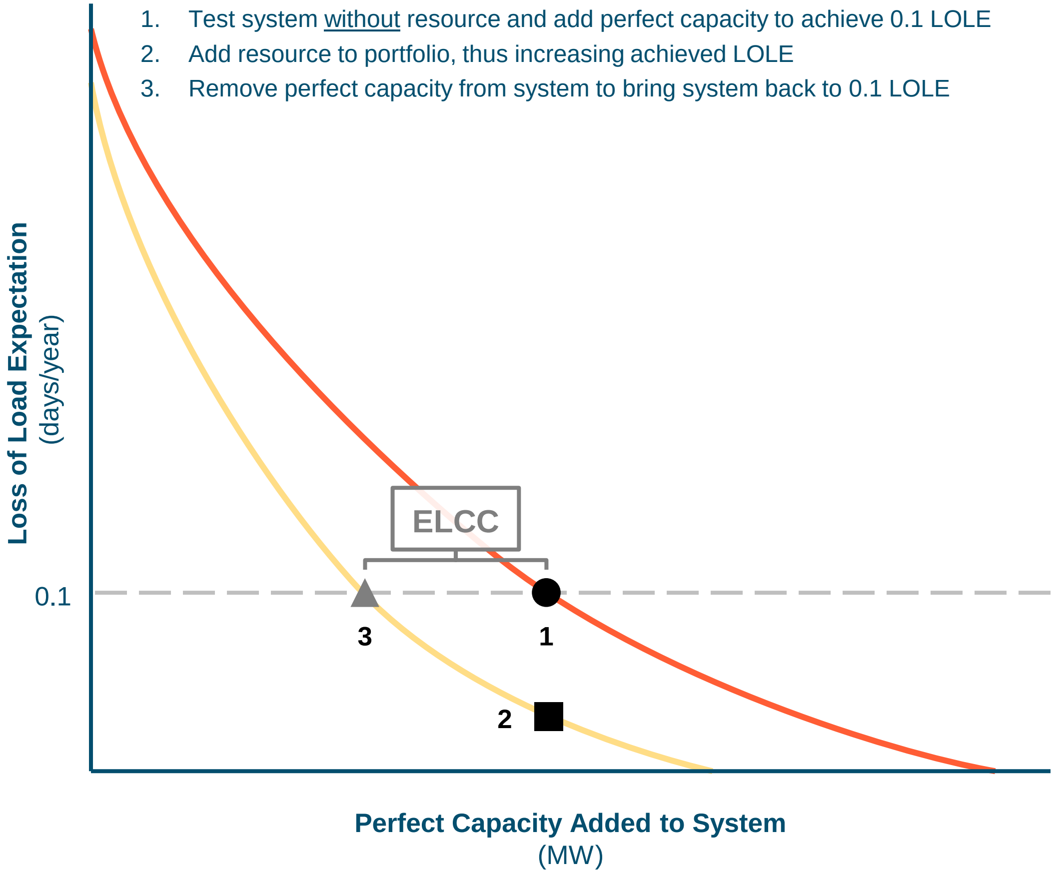
Addition of new source of generation will increase reliability relative to measurement in Step 1

3 **Remove perfect capacity until target reliability is restored**

Removal of perfect capacity results in decrease in reliability until original target is met

A resource's ELCC is equal to the amount of perfect capacity removed from the system in Step 3

Illustration of ELCC Calculation Approach



Measuring ELCC of a Portfolio and Individual Resources

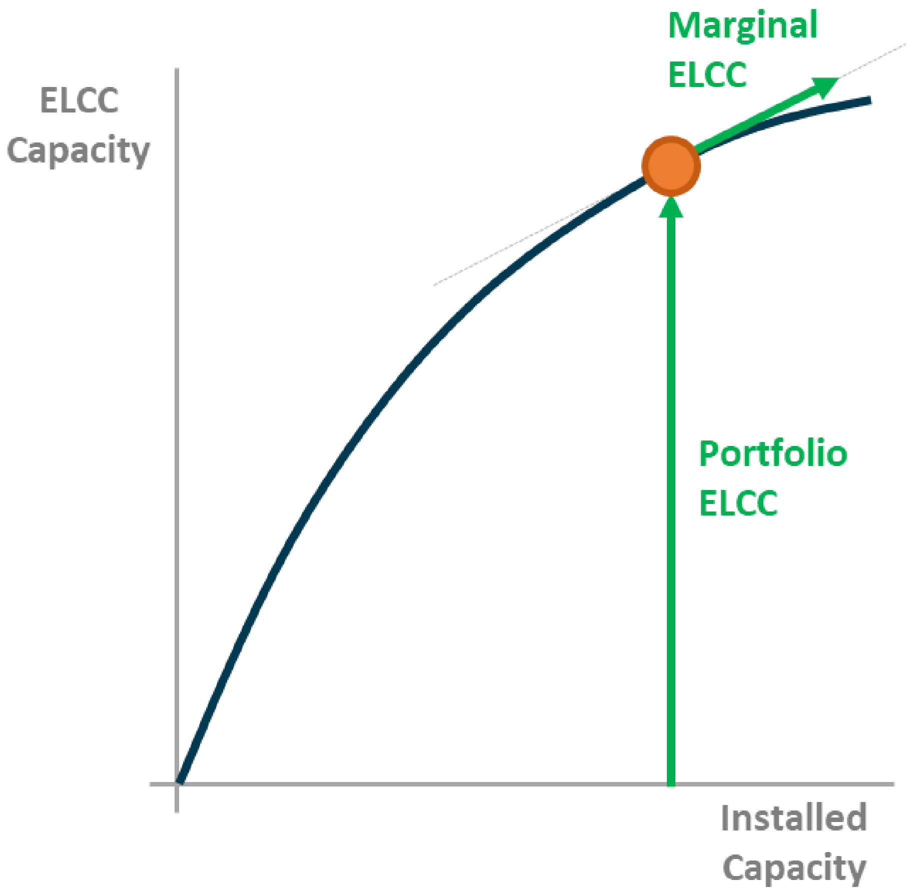
- **ELCC of is a function of the portfolio of resources**
  - The function is a surface in multiple dimensions
  - The Portfolio ELCC is the height of the surface at any given point on the surface

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

  - 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

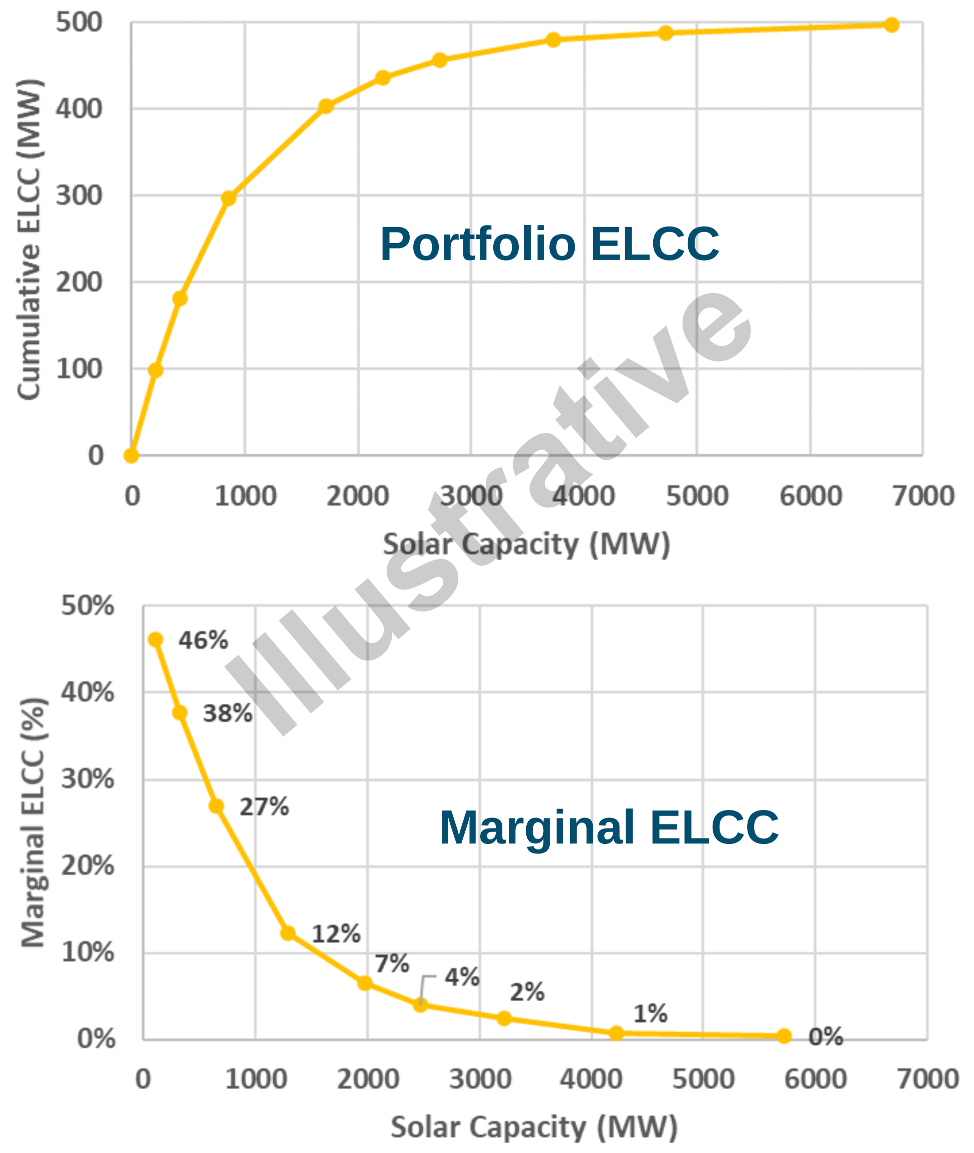
$$Marginal\ ELCC_{G_1} = \frac{\partial f}{\partial G_1}(G_1, G_2, \ldots G_n)\ (\%)$$

- **The functional form of the surface is unknowable**
  - Marginal ELCC calculations give us measurements of the contours of the surface at specific points
  - It is impractical to map out the entire surface



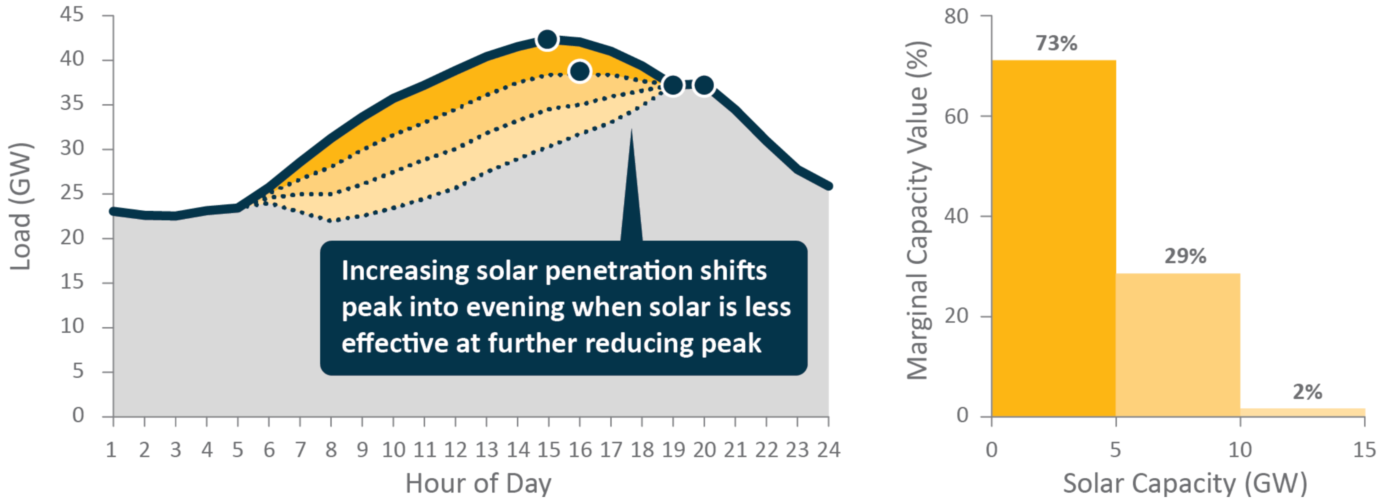
Portfolio ELCC and Marginal ELCC

- **Portfolio ELCC**
  - The combined capacity contribution of a combination of intermittent and energy-limited resources
  - Inherently captures all interactive effects
  - **Useful for measuring the total ELCC of an existing portfolio**
- **Marginal ELCC**
  - The incremental capacity value of a resource (or a combination of resources) measured relative to an existing portfolio
  - **Useful for comparing new resource options against one another at the margin**

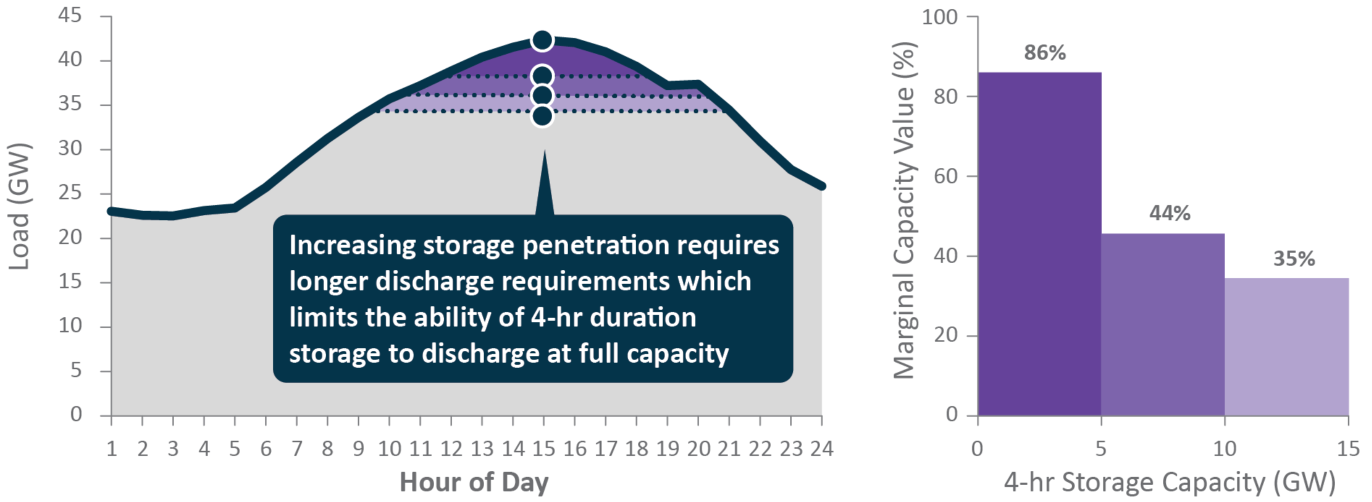


ELCC captures saturation effects at increasing penetrations

Diminishing Capacity Value of Solar



Diminishing Value of 4-hr Storage ELCC

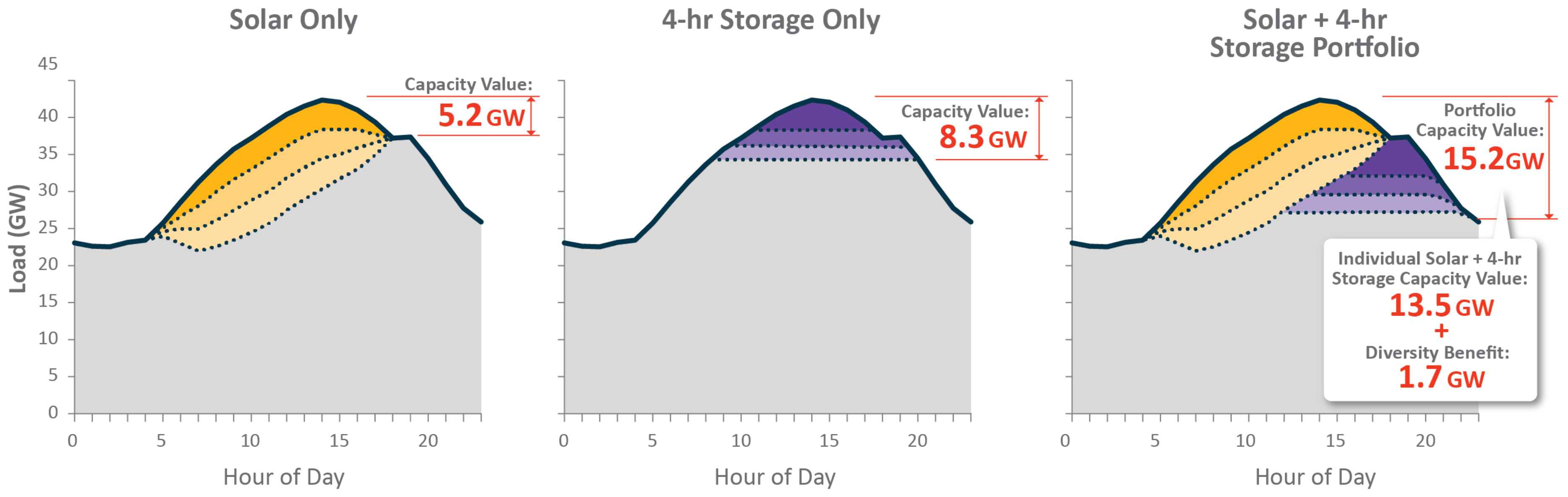


Solar and other **variable resources** (e.g. wind) exhibit declining value due to variability of production profiles

Storage and other **energy-limited resources** (e.g. DR, hydro) exhibit declining value due to limited ability to generate over sustained periods

ELCC captures diversity benefits among technologies

- Resources with complementary characteristics produce the opposite effect, synergistic interactions (also described as a "diversity benefit")
- As penetrations of intermittent and energy-limited resource grow, the magnitude of these interactive effects will increase and become non-negligible



Resource Interactions: 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

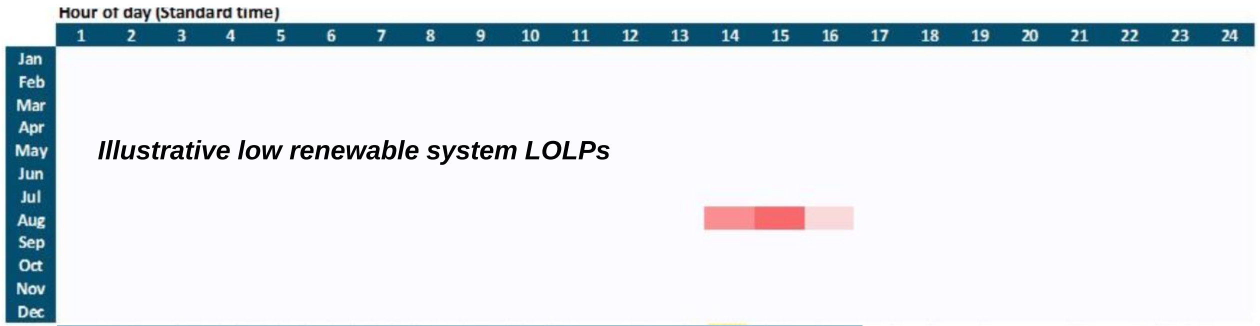
Loss-of-Load Probability Hours and Impact on ELCC

+ **ELCC captures the ability of a resource to improve reliability on the system i.e. reduce loss-of-load events**

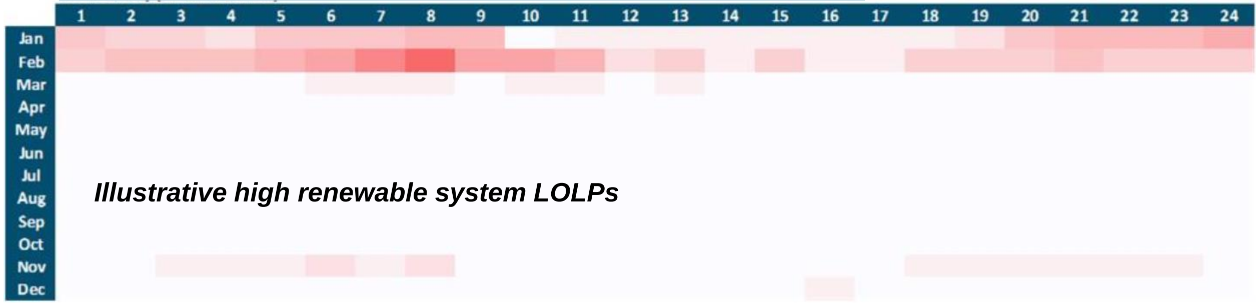
+ **The timing of loss of load events can provide a useful indicator of a resource's ability to provide ELCC**

+ **LOLP tables should be based around many potential years of conditions around**
  - Load
  - Renewables
  - Generator Outages

+ **LOLP conditions correspond with load net of intermittent and energy-limited resources – in a system with ample solar and storage, these net load conditions can shift to the winter**

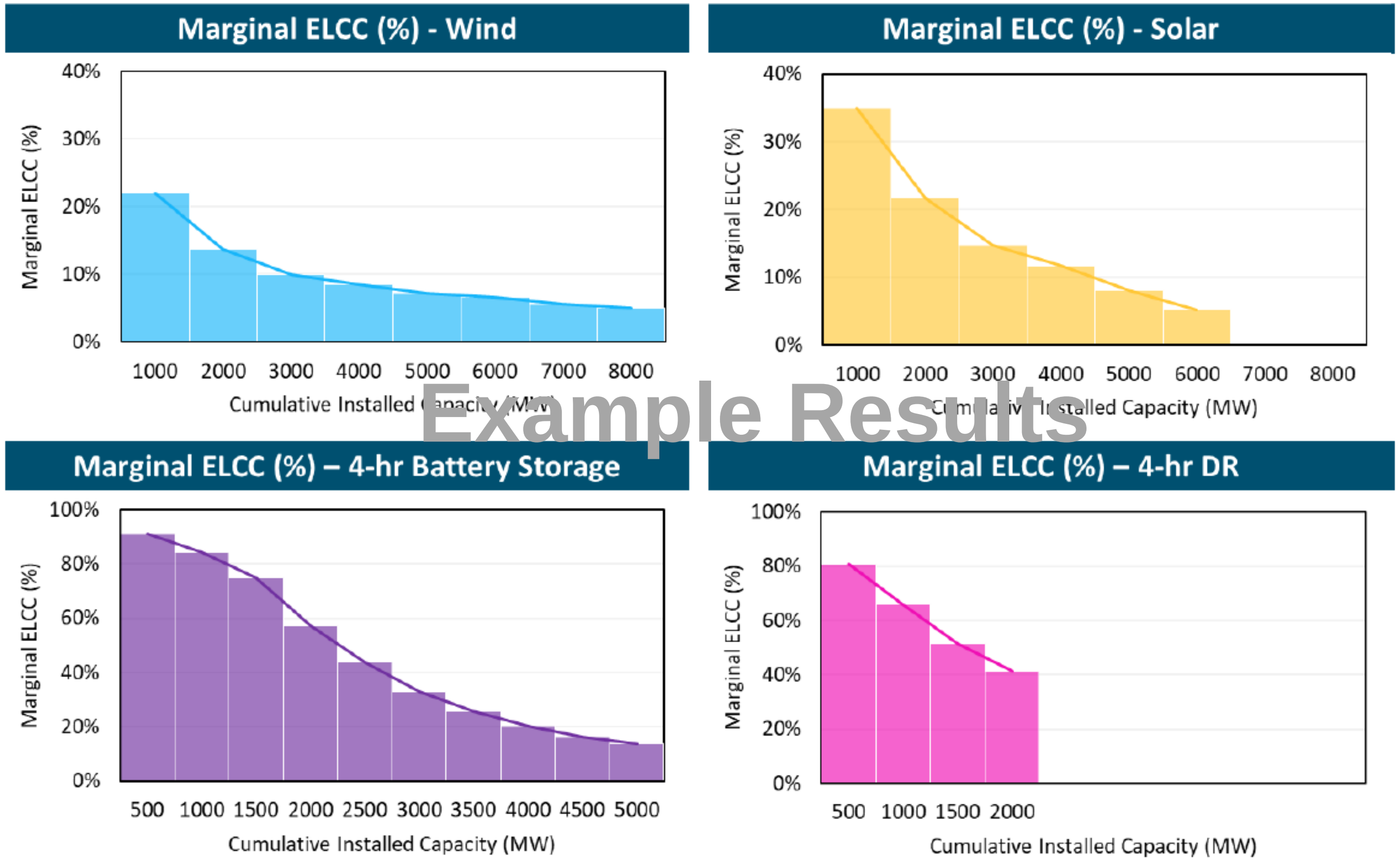


*Renewable + Storage additions drive transition from summer>winter **Net Load Peak** and **clear change to timing of LOLP Hours***



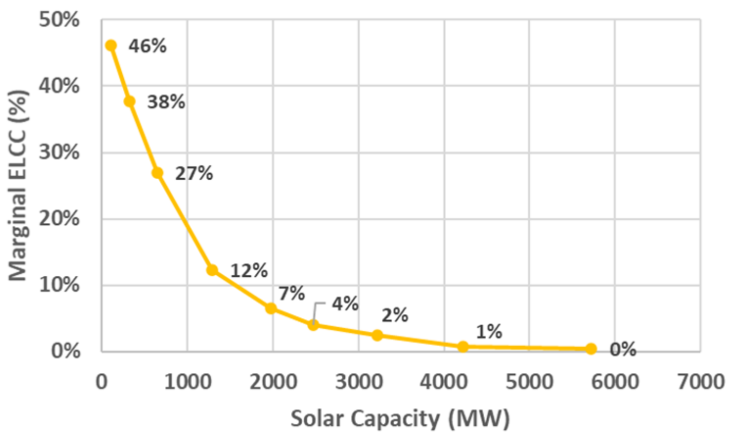
ELCC curves

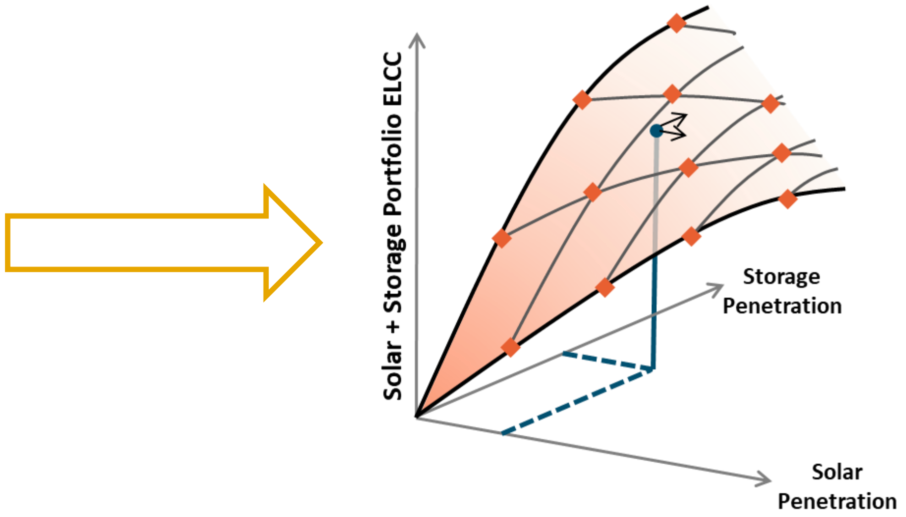
- Marginal ELCC curves can show the incremental ELCC of individual resources at increasing penetration
- While marginal ELCC represents the technical value of an additional MW of a technology-type on the system, entities have often implemented average ELCC methodologies for resource planning in order to allocate beneficial interactions between resources
- If this benefit is not allocated to resources via an averaging methodology, the benefit is realized by load



ELCC application and evolution

- **ELCC modeling applications have evolved**
  - In the past, a single ELCC is used value for each resource technology
  - Many utilities are now using a ELCC curve for each resource technology to reflect diminishing returns
  - A multi-dimensional surface captures *both* diminishing returns and interactive effects
- **A computationally useful surface is derived by repeated ELCC calculations at different penetration levels for multiple resource types**
  - E3 uses multi-dimensional surfaces in capacity expansion modeling





Practical considerations in ELCC calculations

+ **An ELCC calculation is a measurement of the gradient at a point that must be specified with the following information:**
  - What resource(s) is being measured? *(Partial derivative with respect to which variable?)*
  - How much of that resource(s) is being measured? *(Coordinate along that dimension)*
  - What resources are in the background system upon which the ELCC is being measured? *(Coordinates along other dimensions)*

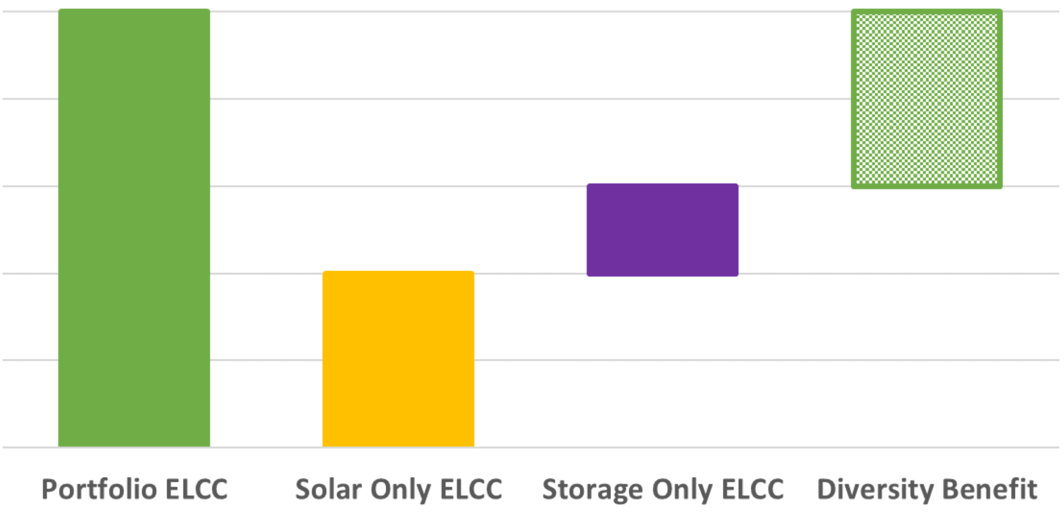
+ **In theory, each resource is its own dimension, however in practice similar resources will need to be grouped into resource classes**
  - May be desirable to use heuristics to differentiate among similar but not identical resources

+ **Because of interactive effects, the sum of marginal ELCC values will not equal the Portfolio ELCC:**
  - Marginal ELCCs do not capture diversity benefits among resources
  - Marginal ELCCs do not capture saturation effects among individual resources
  - Difference between Portfolio ELCC and sum of Marginal ELCCs is referred to as the Diversity Benefit

Complicating Factor: Portfolio Diversity Benefit

- The ELCC of a portfolio of resources is often more than the sum of their parts – creating a diversity benefit that must be allocated between the resources

ELCC Diversity Benefit Example

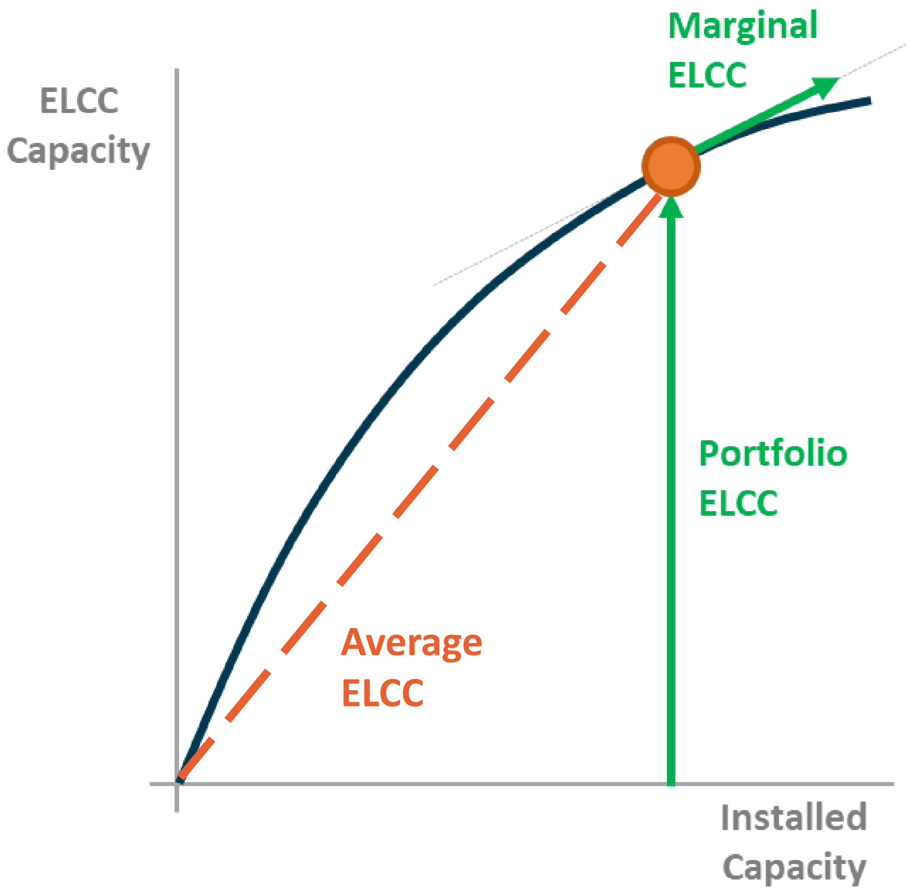


What is an “Average ELCC”?

- **With only one resource, an Average ELCC can be defined as the Portfolio ELCC divided by the total installed MW**

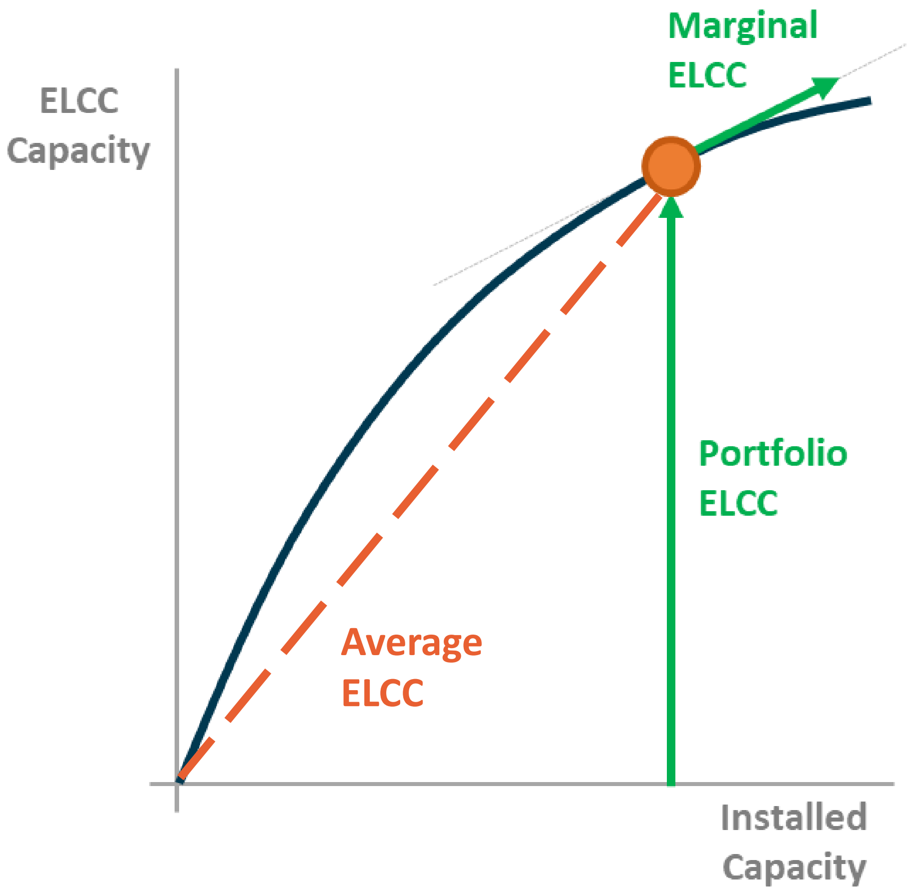
$$Averge\ ELCC_{G_1} = \frac{f(G_1)}{G_1}\ (\%)$$

- **Average ELCCs are perceived as useful because the sum of individual ELCCs can be made to be equal to the total Portfolio ELCC**
  - This is done by starting with the Portfolio ELCC and allocating it among individual resources
  - Useful for display in a load-resource table
- **Any averaging method requires an allocation of the interactive effects among the various resource types**



Challenges with Average ELCC approaches

- **There are a variety of challenges with the way Average ELCC values have been calculated to date**
  - Any averaging method requires an allocation of the interactive effects among the various resource types
- **These allocations are by definition arbitrary and can lead to counter-intuitive results**
  - If different resource classes are dramatically different in size (e.g., 10,000 MW of solar, 200 MW of storage)
  - CA: average ELCC for solar and wind with marginal diversity benefit allocation calculated on a monthly basis
- **E3 developed the Delta Method as a way to ensure intuitive allocation of interactive effects**
  - PJM's application of the Delta Method was recently approved by FERC
  - Average ELCC of a given resources is its Marginal ELCC plus an allocation of the Diversity Benefit based on its contribution to it

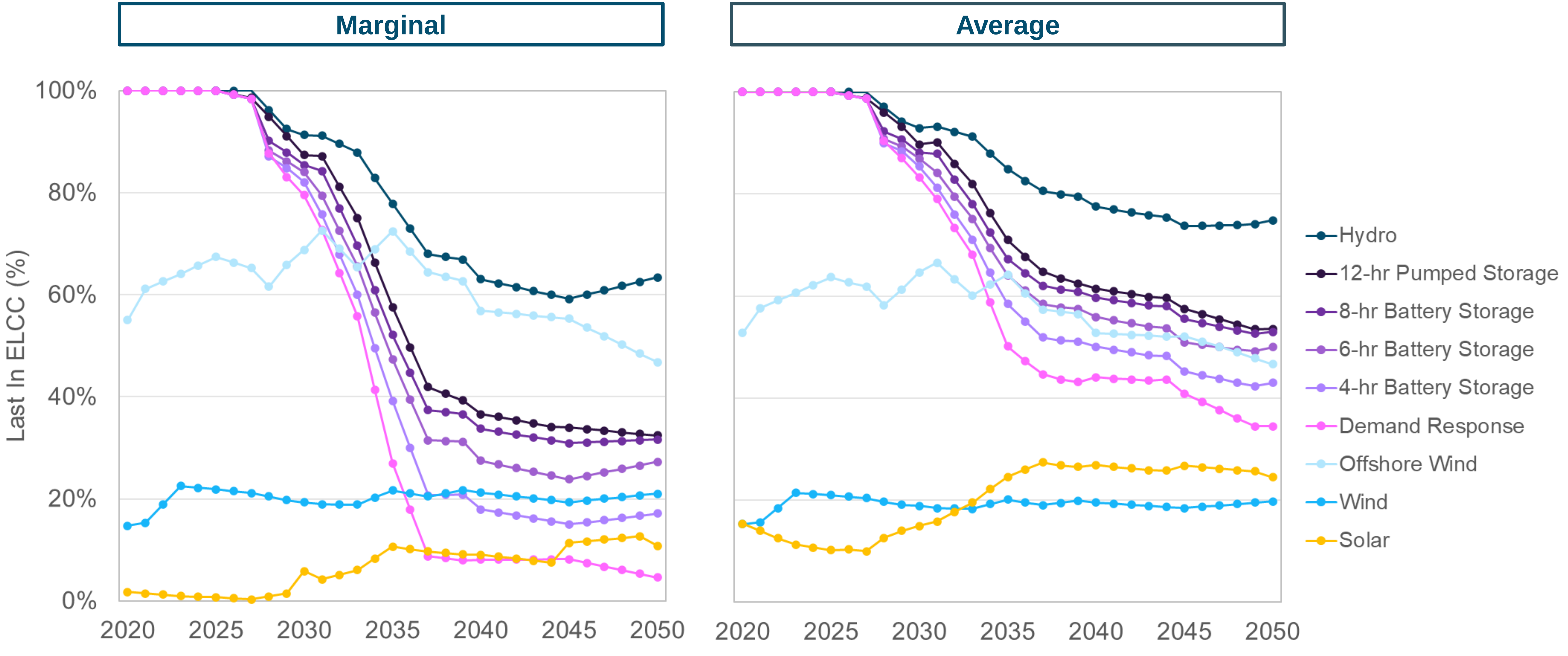


Principles for individual resource ELCC accreditation

- **The features of ELCC that make it the preferred metric to measure the capacity contributions of resource adequacy needs creates challenges for implementation**
- **Centralized capacity markets must assign a ELCC credit to individual resources**
- **The following principles are useful to consider in designing an approach**
  - In many ways, these parallel principles that must be balanced in electricity ratemaking
  - Like with rate design, these principles sometimes conflict with one another
- **The Marginal ELCC approach for resource accreditation in a capacity market context favors the Efficiency principle above all others**

1	2	3	4
Reliability	**Fairness**	**Efficiency**	**Acceptability**
The sum of all ELCC credits to individual resources should equal the total resource portfolio ELCC	*ELCC credits should be technology-neutral and properly reward resources for their characteristics*	*Credits should send signals that encourage economically efficient planning and procurement decisions*	*Credits should be transparent, tractable, understandable, and implementable for planners and market participants*

Illustrative Results: Marginal ELCC vs Avg. Method ELCC



ELCC of dispatchable resources

- **ELCC calculation can and in theory should also be applied to dispatchable resources such as thermal plants**
- **ELCC of thermal resources is determined by two major factors**
  - Forced outage rates (FOR) of the thermal unit/plant - a larger FOR will result in a smaller ELCC of the resource
  - Unit capacity size of the thermal resource – under the same FOR, if the total thermal capacity is the same, a larger plant will have a lower ELCC because its outage will be more likely to cause loss of load
- **If the unit size is small or the system size is large, the ELCC is close to 1 – FOR**
  - 1 – FOR can be an acceptable approximation of ELCC

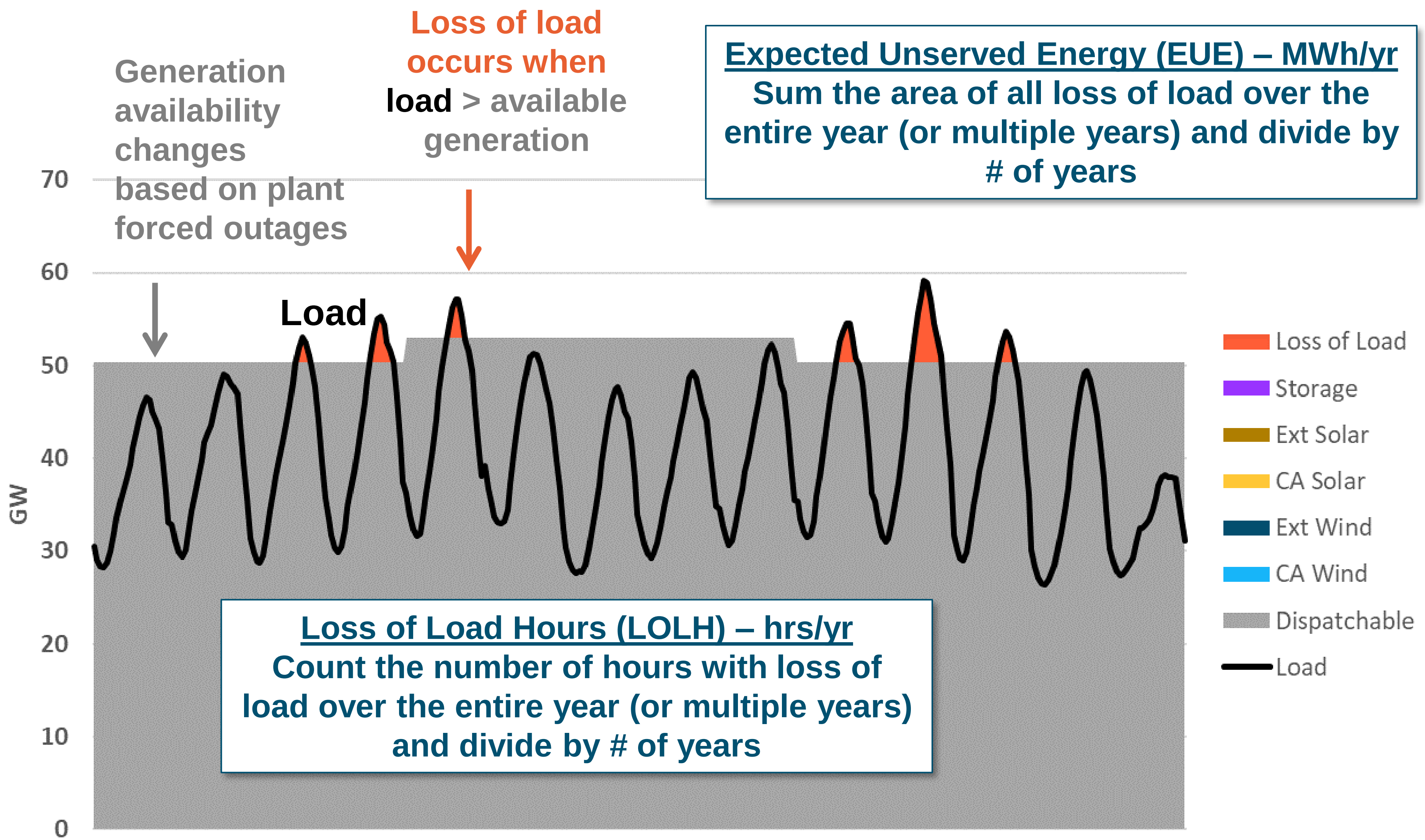
MRI and ELCC

- **On August 9th, the NYISO MMU presented on an approach to capacity accreditation called Marginal Reliability Improvement (MRI)**
  - MMU described its methodology as aiming to compensate all resource based on their marginal contribution to meeting the planning reliability metric (e.g. LOLE or expected unserved energy)
- **E3 views MRI as a specific method for calculating an ELCC value**
  - The MRI approach may have some advantages over other methods, i.e., reduced computational burden
  - Reduced computational burden may, in some cases, come at a cost of reduced accuracy
  - NYISO should investigate MRI and other alternatives for calculating ELCCs to determine an appropriate method or suite of methods based on accuracy and practicability

Appendix

Energy+Environmental Economics

Calculating Reliability Statistics



Expected Unserved Energy (EUE) – MWh/yr
Sum the area of all loss of load over the entire year (or multiple years) and divide by # of years

Loss of Load Hours (LOLH) – hrs/yr
Count the number of hours with loss of load over the entire year (or multiple years) and divide by # of years

Calculating Reliability Statistics

Traditional System w/ Dispatchable + Solar Generation

Generation availability changes based on plant forced outages

Loss of load occurs when load > available generation

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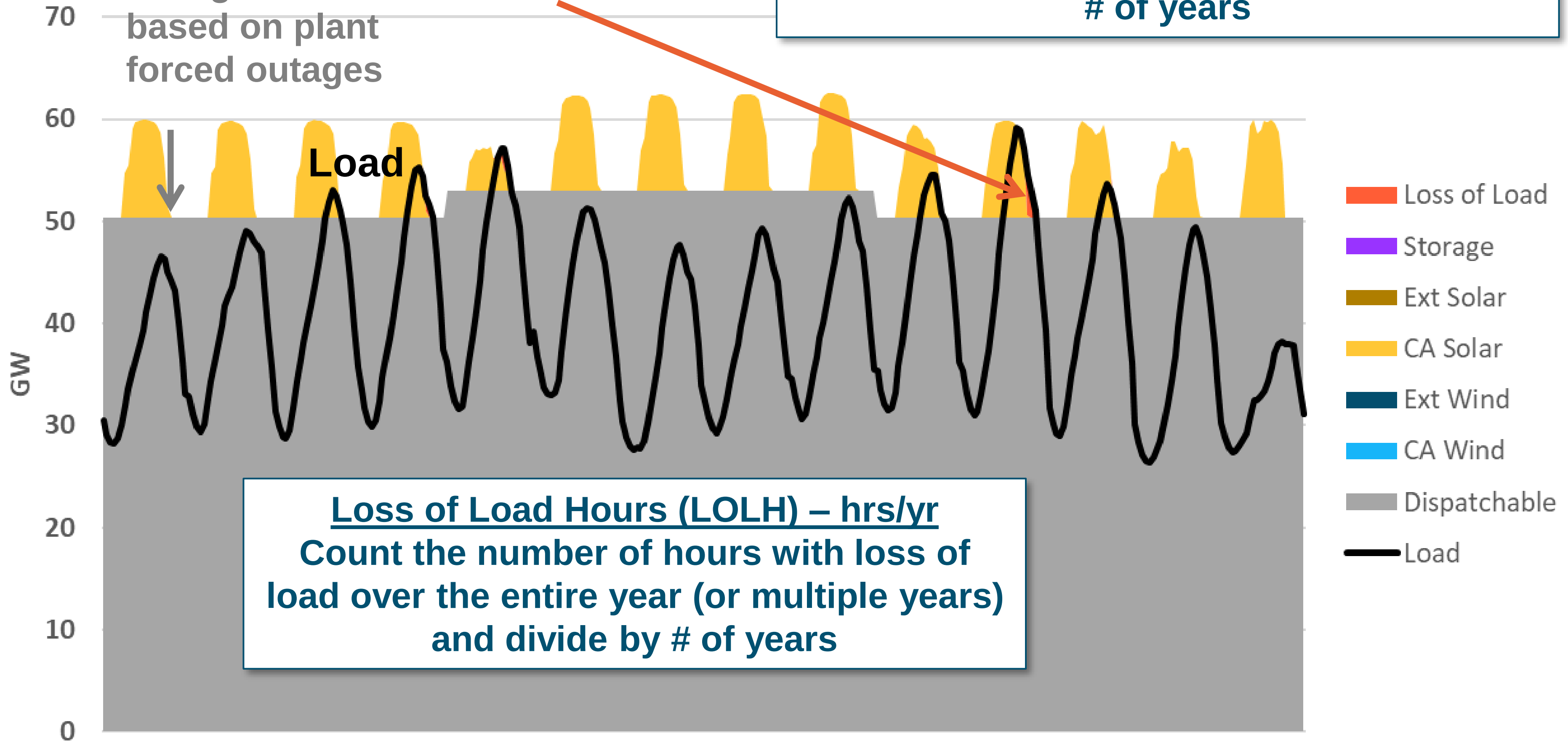
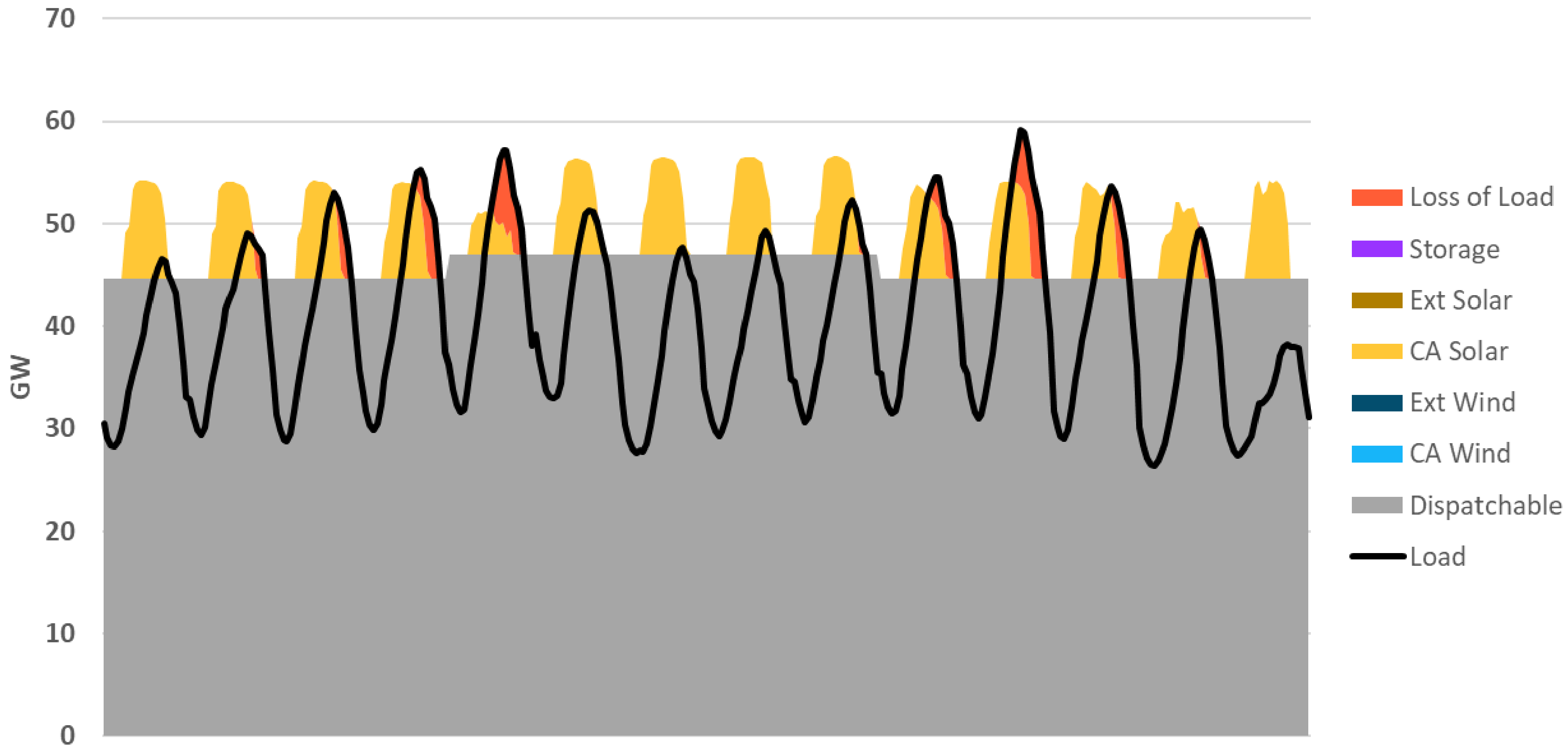


Loss of Load Hours (LOLH) – hrs/yr
Count the number of hours with loss of load over the entire year (or multiple years) and divide by # of years

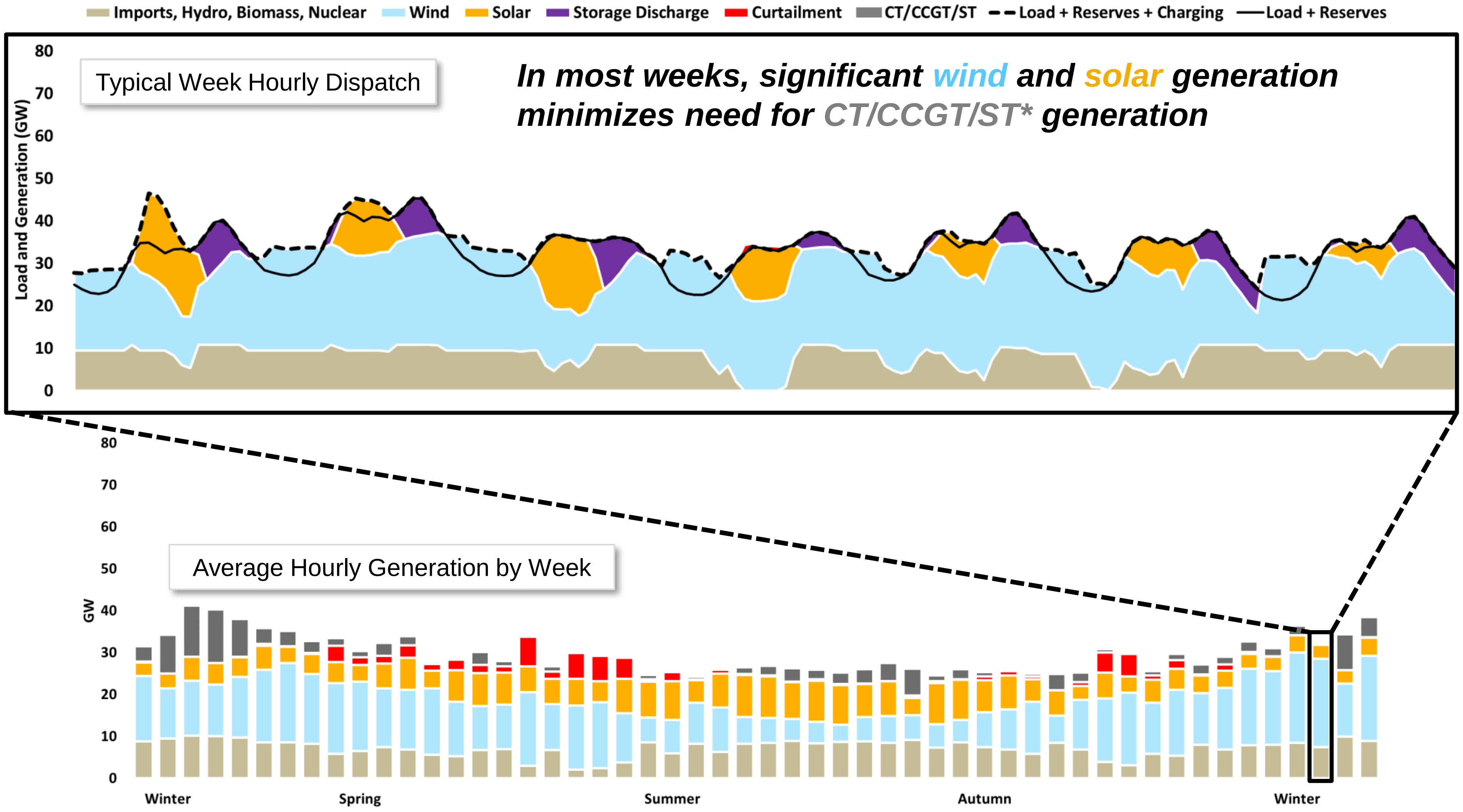
Calculating Reliability Statistics

Traditional System w/ Dispatchable + Solar Generation

Reducing dispatchable generation increases loss of load and returns system to original level of reliability



E3 Case Study: Net Zero New England



High Electrification Base Case

** Could represent natural gas, hydrogen, or other zero-carbon fuel blend burned in CT/CCGT, or dispatchable long-duration storage if viable technology emerges. More generally, this could represent any firm capacity, e.g. nuclear SMRs and Gas with CCS could also play this role.*

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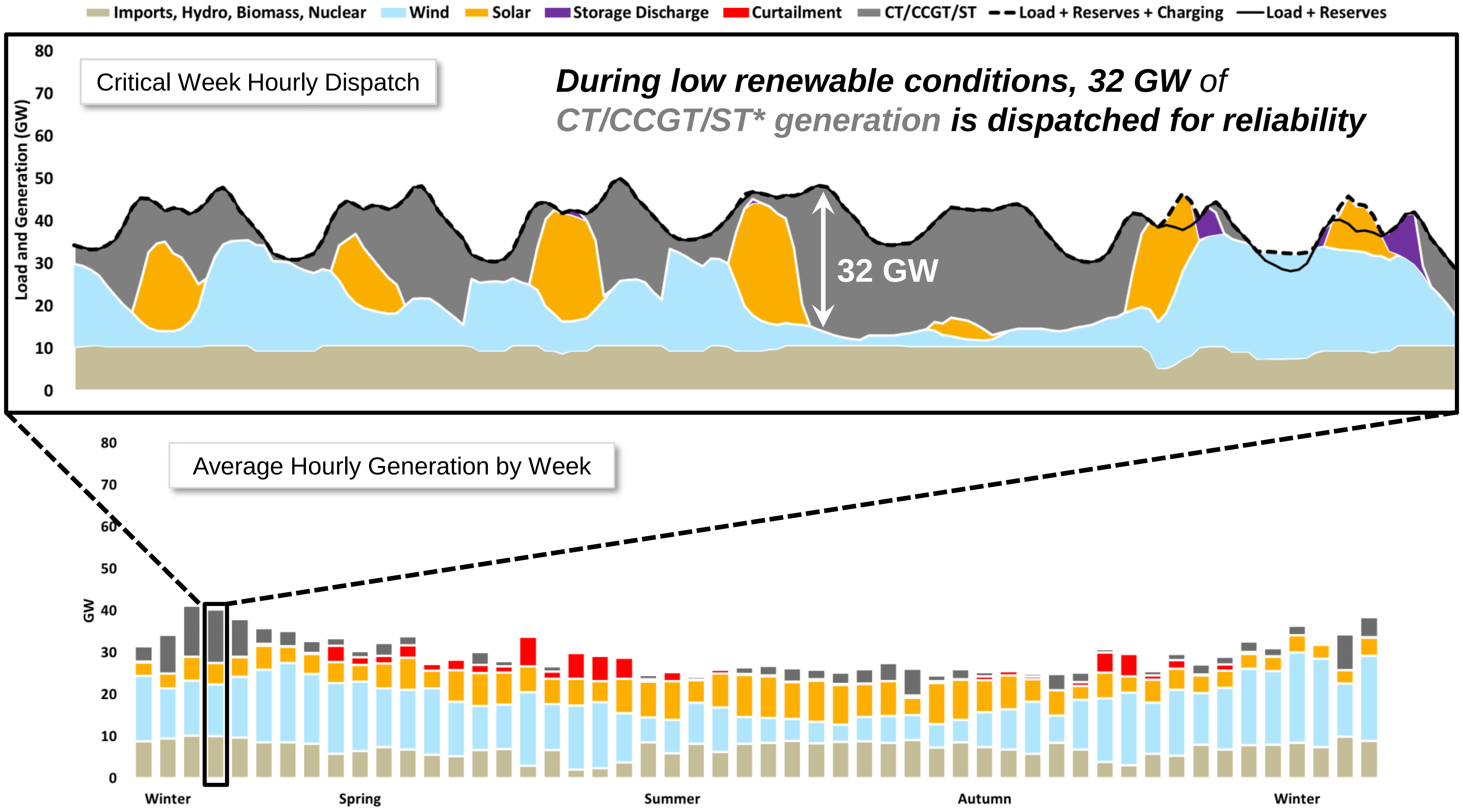

High Electrification Base Case

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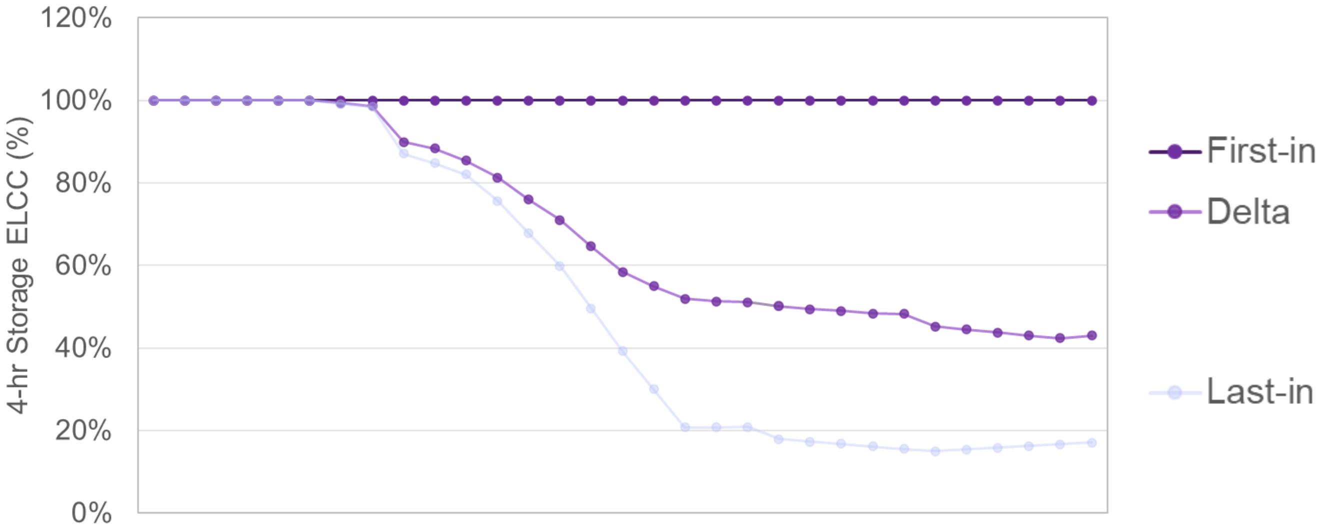
Key Design Choices

- **Marginal v. Average**
- **Unit-specific v. Technology-specific ELCC determination**
- **Resource Dispatch Logic**
- **Load Shapes**
- **Renewable shapes**
- **Resource characteristics**
  - Resource dispatch logic
  - Storage durations
  - Hydro, DR, hybrids
  - Thermal EFORd
- **ELCC calculation shortcuts**

ELCC Allocation Sensitivity Results

4-hr Storage

+ **Final ELCC allocation to specific resources will change depending on the methodology – a decision ultimately in the hands of the CPUC**
  - First-In and Last-In ELCCs are provided for reference but do not sum to portfolio ELCC across all resources

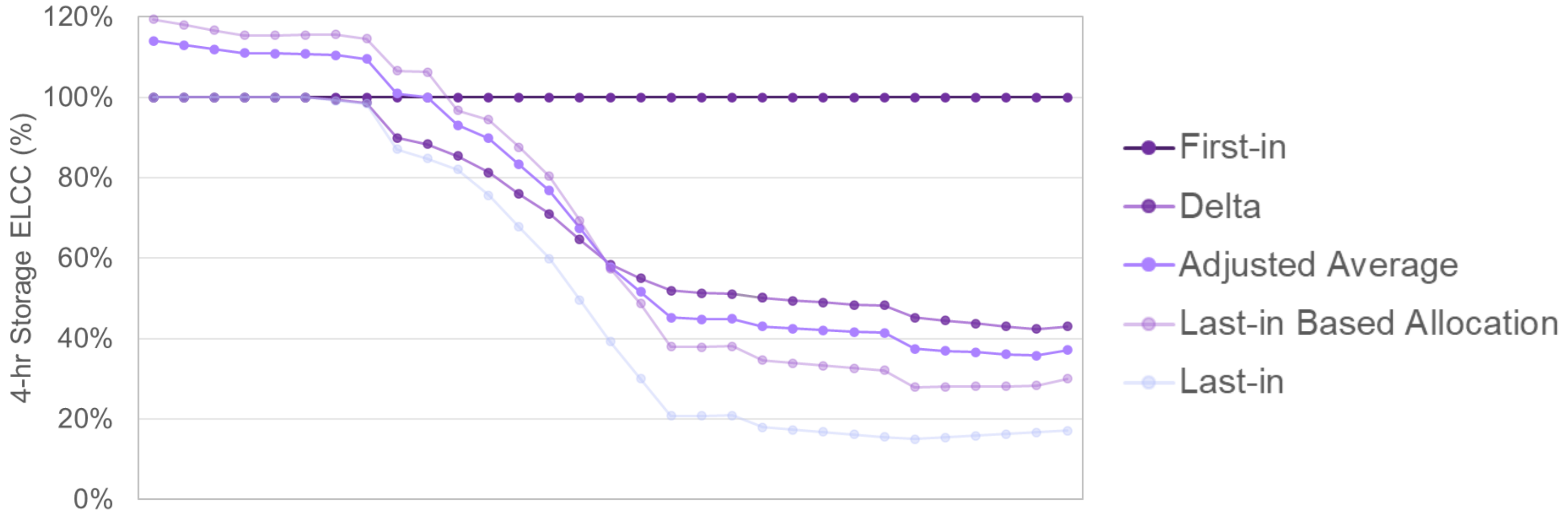


Allocation Method	2020	2025	2030	2035	2040	2045	2050
Delta	100%	100%	85%	58%	50%	45%	43%
Last-in	100%	100%	82%	39%	18%	15%	17%

ELCC Allocation Sensitivity Results

4-hr Storage

+ **Final ELCC allocation to specific resources will change depending on the methodology – a decision ultimately in the hands of the CPUC**
  - First-In and Last-In ELCCs are provided for reference but do not sum to portfolio ELCC across all resources
  - Averaging methodologies sum to portfolio ELCC across all resources but may introduce distortions such as >100% ELCC



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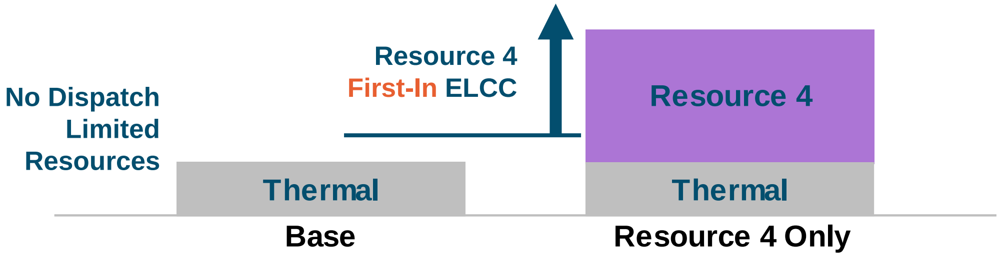
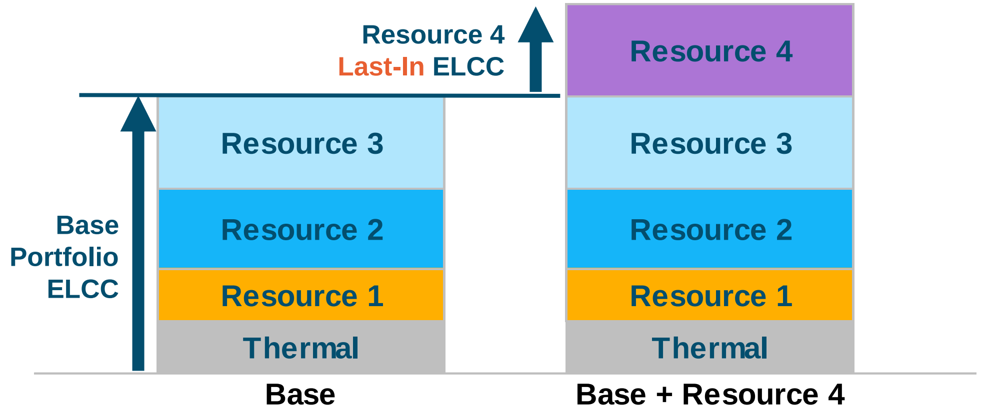
Which capacity value methodology should we use and why should we care?

- **Marginal/Incremental ELCC:**
  There are many different "marginal" ELCCs depending on your "base" portfolio. For our purposes, we define two standard types:
  - **First-In ELCC:**
    Incremental capacity contribution for a specific resource relative to a "base" portfolio with **no dispatch-limited resources**
  - **Last-In ELCC:**
    Capacity contribution of a specific resource as the **last increment** to be added to achieve the "full" portfolio with all resources
- **Each marginal ELCC tells a different story**

First-in ELCC Methodology



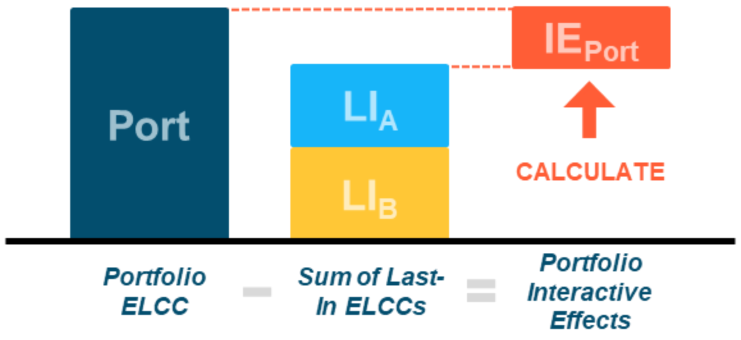
Last-in ELCC Methodology



Delta Method:
Calculation Approach

STEP 1 Calculate Portfolio Interactive Effects

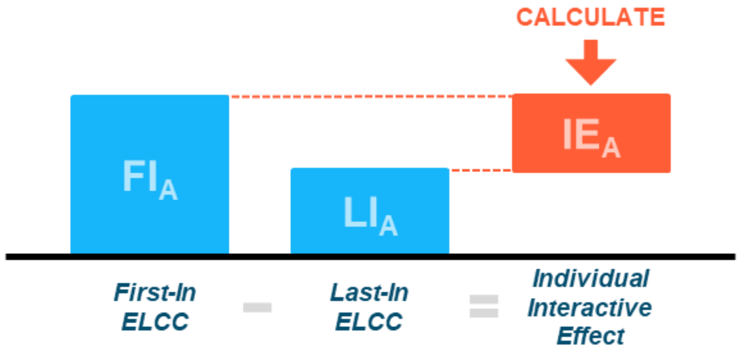
Calculated as the difference between the **Portfolio ELCC** and the sum of the **Last-In ELCCs** for all individual resources



STEP 2 Calculate Individual Interactive Effects

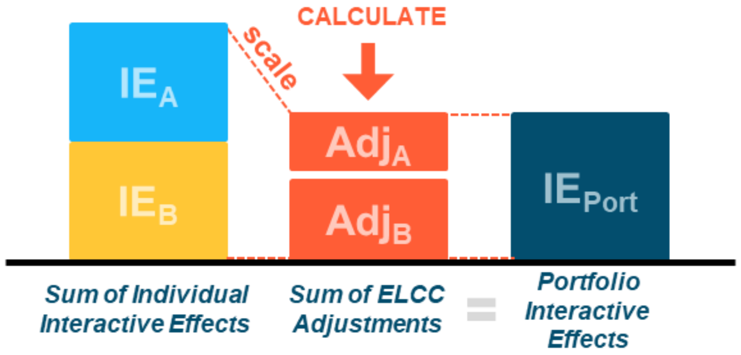
for each resource

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



STEP 3 Calculate Individual ELCC Adjustments

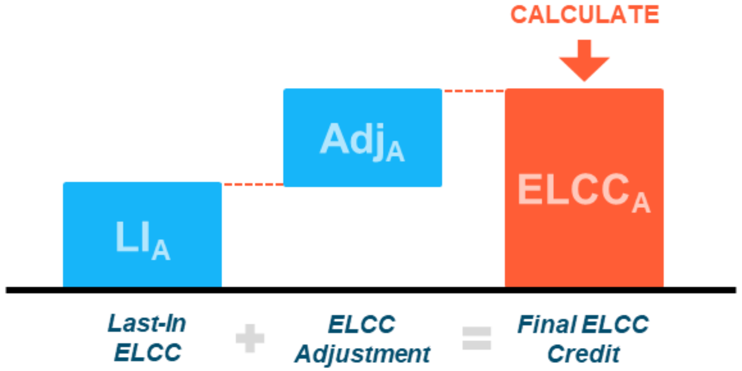
Calculated by scaling all *Individual Resource Diversity Impacts* to match the *Portfolio Diversity Impact*



STEP 4 Calculate ELCC Accreditation

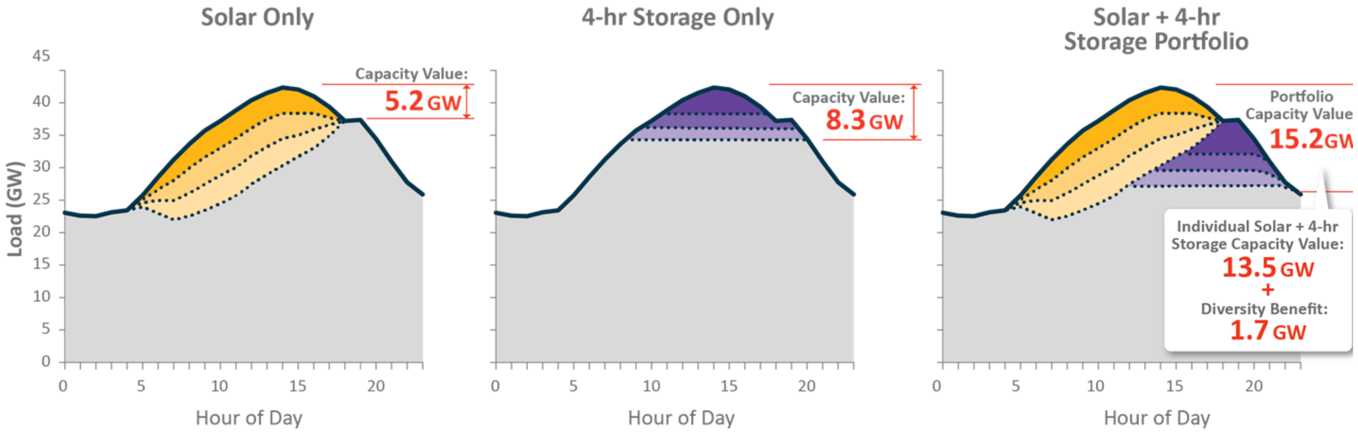
for each resource

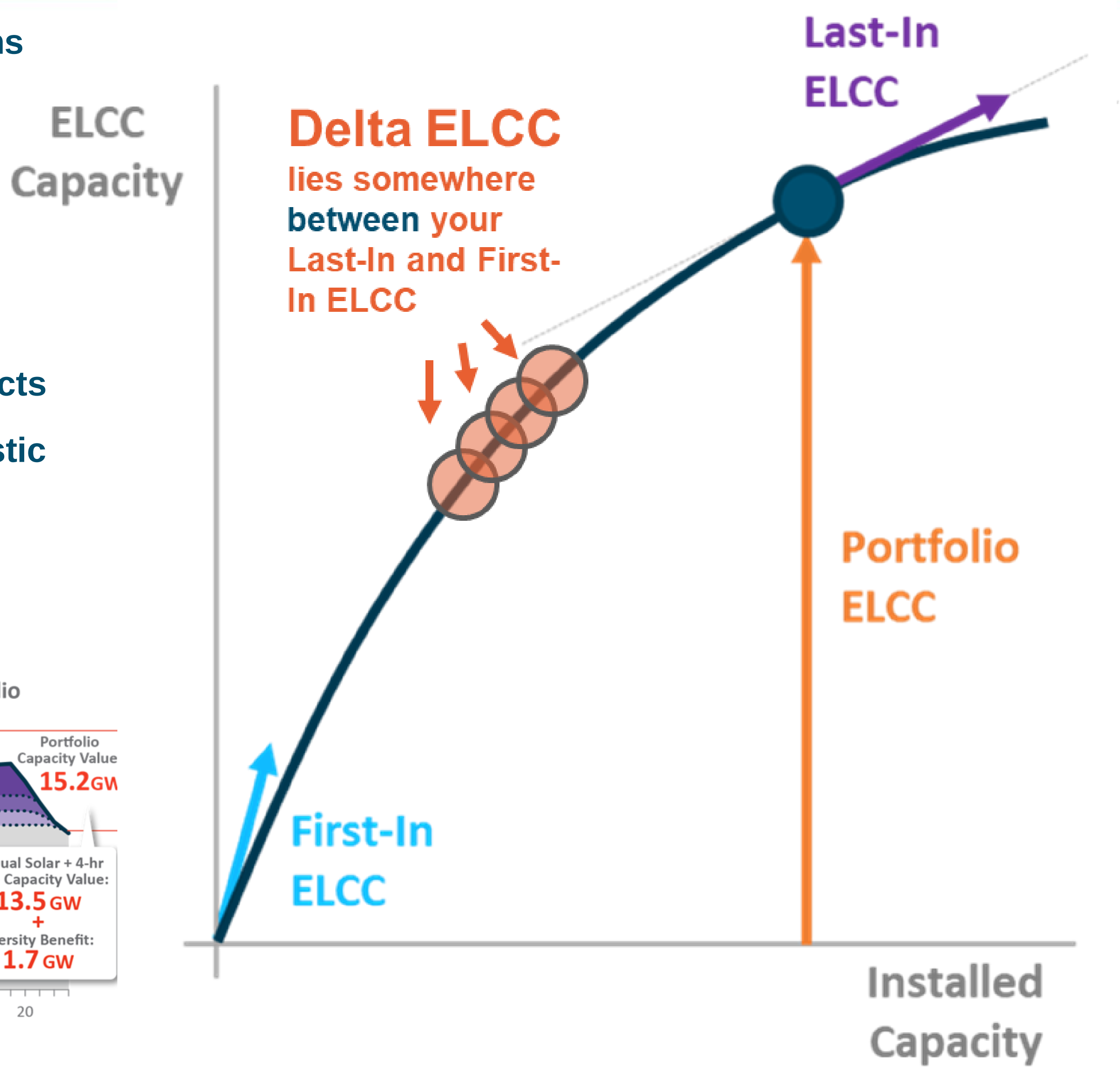
Add *Individual Resource ELCC Adjustment* to **Last-In ELCC** for each individual resource



Delta Method captures resource's capacity value and their interactions with the rest of the portfolio

+ **Goal: to calculate a resource's capacity value and its interactions with other resources in the portfolio.**
+ **There are 3 measurable metrics we can leverage:**
  - Total **Portfolio** ELCC
  - **Resource's** First-In ELCC
  - **Resource's** Last-In ELCC
+ **Problem: No one metrics alone can characterize interactive effects**
+ **The combination can characterize the synergistic and antagonistic interactions within a portfolio**
  - If Last-In ELCC > First-In ELCC, resource is **synergistic**
  - If Last-In ELCC < First-In ELCC, resource is **antagonistic**





Multiple frameworks have been considered for accreditation of ELCC to individual resources

Framework	Description	Pros	Cons
Vintaged Marginal	Assigns each resource a credit based on the marginal ELCC at the time it is added to the system	Yields correct total ELCC across all resources Provides accurate marginal signal for procurement of new resources	Distinction between otherwise identical resources undermines fair competition and isn't a feature of other electricity market products (even though the same factors apply) ELCC "lock-in" can become intractable based on resource lives and potential for upgrades or partial retirements
Marginal	All resources are attributed an ELCC based on their marginal contribution to resource adequacy	Temporarily provides correct marginal signal for procurement of new resources	Does not appropriately credit a portfolio of resources for its total contribution to resource adequacy
Adjusted Class Average	1) Calculate Portfolio ELCC 2) Calculate average[1] ELCC for each group of resources (e.g. wind, solar) 3) Apply uniform adjustment to each class average ELCC so that the sum of all classes matches Portfolio ELCC	Yields correct total ELCC	Increasingly segmented classes to capture distinctions between resources (renewable geography, storage duration, hybrid resource configuration, etc.) leads to inconsistent treatment in classes of different sizes. Small classes have an ELCC much closer to marginal where larger classes have an average ELCC much different from marginal Uniform adjustments to all resource classes to account for interactive effects does not faithfully capture nature of interactions. In a portfolio with positive synergy, adjustments should only be applied to the resources that are providing that synergy

Add note about average