# Special Public Meeting
# UM 2011 Workshop
# Notice & Webinar Registration

Oregon Public Utility Commission

**Thursday, July 9, 2020** **10:00 a.m. (PT)** **Webinar**

Register for the Webinar

The Oregon Public Utility Commission (PUC) is holding a Special Public Meeting to address the matters described below. During this meeting the PUC will conduct:

☐ Public Hearing (public comments accepted)

X Public Hearing and Commissioner Work Session (public comments accepted)

☐ Commissioner Work Session only

This meeting is open to the public and accessible to persons with disabilities. To request accommodation at least 48 hours before the meeting or for general information, please email puc.publicmeetings@state.or.us or call 503-378-6611. If held in the PUC Hearing Room, Hearing Loop assistive listening technology is available.

Meetings may be canceled due to inclement weather or other emergencies.

The PUC may enter into an executive session during this meeting to consider information exempt from disclosure by law under ORS 192.660(2)(f), or to consult with counsel under ORS 192.660(2)(h). **All executive sessions are closed to the general public.**

## Agenda

1. OREGON PUBLIC UTILITY COMMISSION
   UM 2011 General Capacity Investigation
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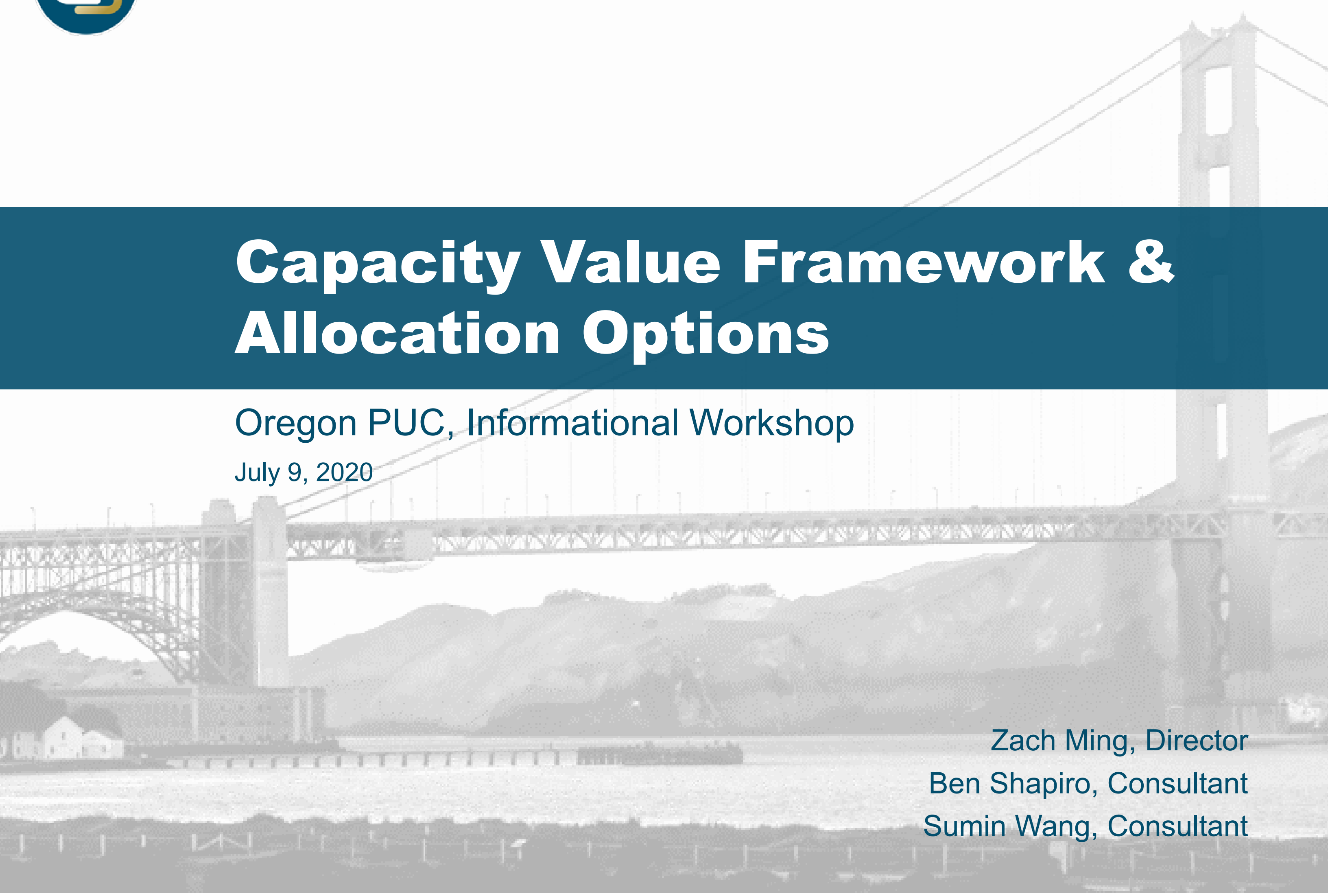
   max.st-brown@state.or.us



Energy+Environmental Economics

# Capacity Value Framework & Allocation Options

## Oregon PUC, Informational Workshop

July 9, 2020

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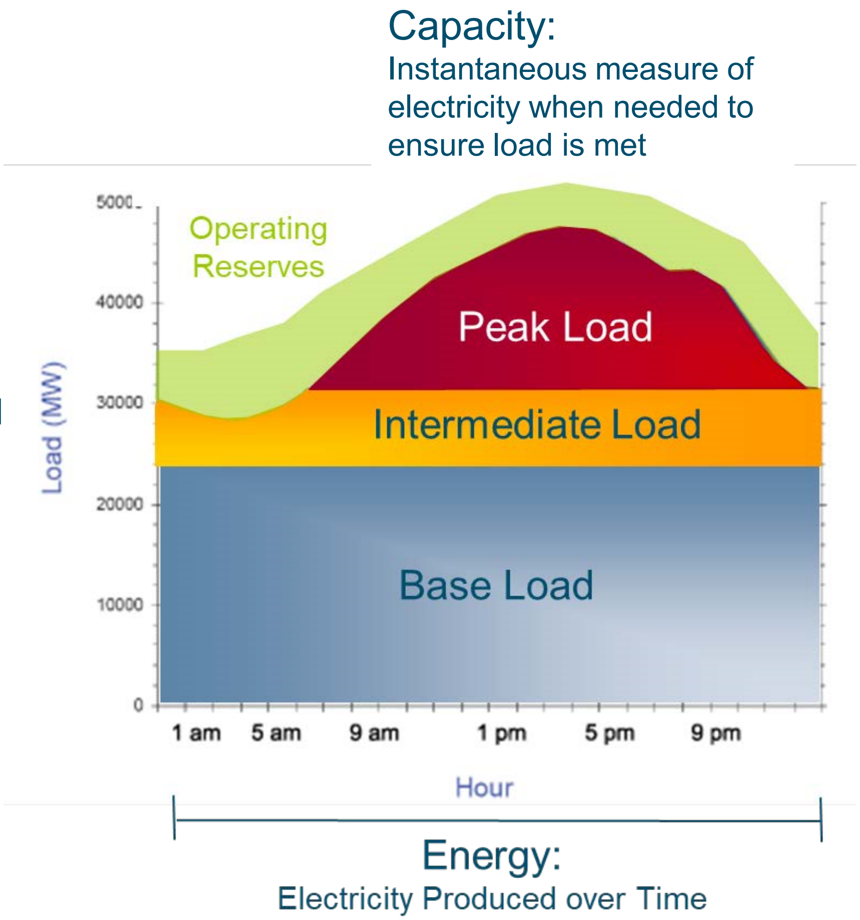
# Outline

- Introduction to the *General Capacity Investigation* proceeding (UM 2011)
- Background on Capacity
- *Key Question 1*: How much capacity can a resource provide?
- *Key Question 2*: What is the value of capacity?
- *Key Question 3*: What compensation framework should be used?
- Use Cases and Examples
- Wrap Up and Conclusions
- *Appendix*

# What is Capacity?

+ **Capacity is one critical element of a resource portfolio for reliability**

+ **Reflects portfolio's ability to:**
  - **Meet demand in all hours** (incl. peak), across a wide range of load / resource availability conditions
  - **Provide reliability on an equivalent basis to a "perfect" resource** (one that is always available without any outages)*




* "Perfect" capacity is a theoretical concept, as in reality all resources have some probability of a forced outage

# Key Questions

- Against the backdrop of the OPUC *General Capacity Investigation* proceeding (UM 2011), there are two key questions:

**1) How much capacity can a resource provide?**

**2) What is the value of capacity?**

- A separate but related question:

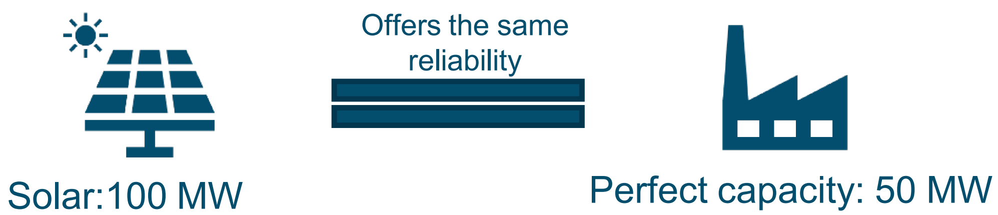
**3) What compensation framework should be used?**

  - Ideally, the compensation framework should appropriately measure the capacity contribution (#1) and reflect the value of capacity (#2)

# Key Question 1) How Muc
# Capacity Can a Resource Provide

# How Much Capacity Can a Resource Provide?

- **The "gold standard" for measuring the capacity contribution of a resource is *effective* *carrying capability* (ELCC)**
- **ELCC measures the quantity of perfect capacity that would yield equivalent system re**
- For example, 50% ELCC of a solar generator




## ELCC Calculation Process

**1**
**Calculate System Reliability**

**2**
**Add desired resource to portfolio**

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

**3**
**Remove per capacity until s reliability is re**

*Removal of perfect c results in reduces relia original level is r*

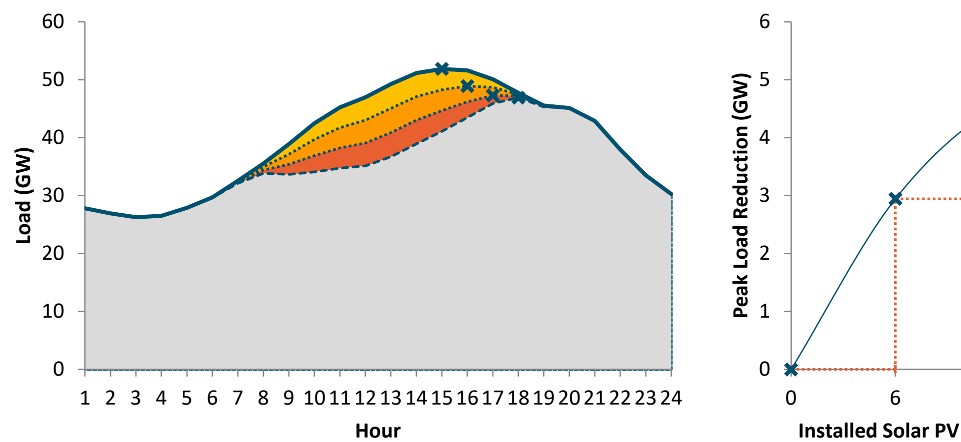
**A resource's ELCC is equal to the amount of perfect capacity remove the system in Step 3**

# ELCC Dynamics

+ **Because of complex interactions between resources** such as wind, solar, st
demand response, **it is difficult to measure the ELCC of an individual resou**

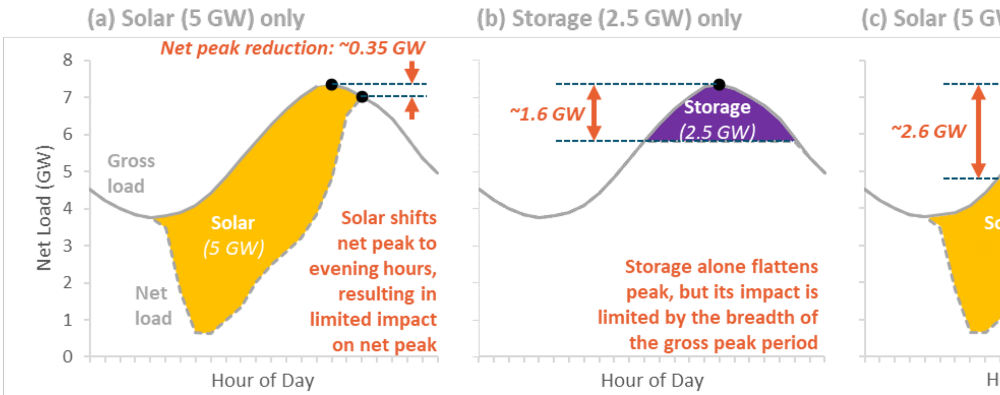
- **Antagonistic pairings:** resources with similar limitations **diminish** each other's ability to provide capacity

**Antagonistic:** *Diminishing Returns of Solar*



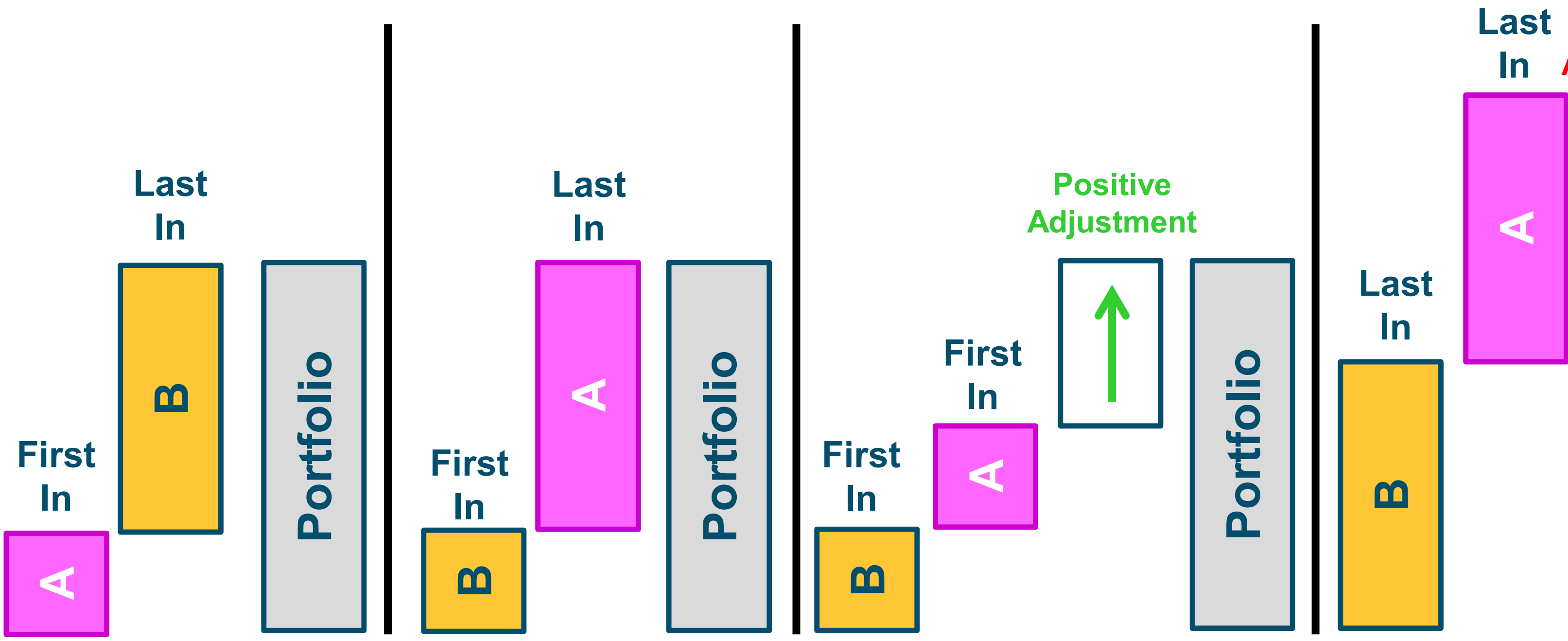

- **Synergistic pairings:** resources with different characteristics **enhance** each other's ability to provide capacity

**Synergistic:** *Benefits of Solar + Storage*



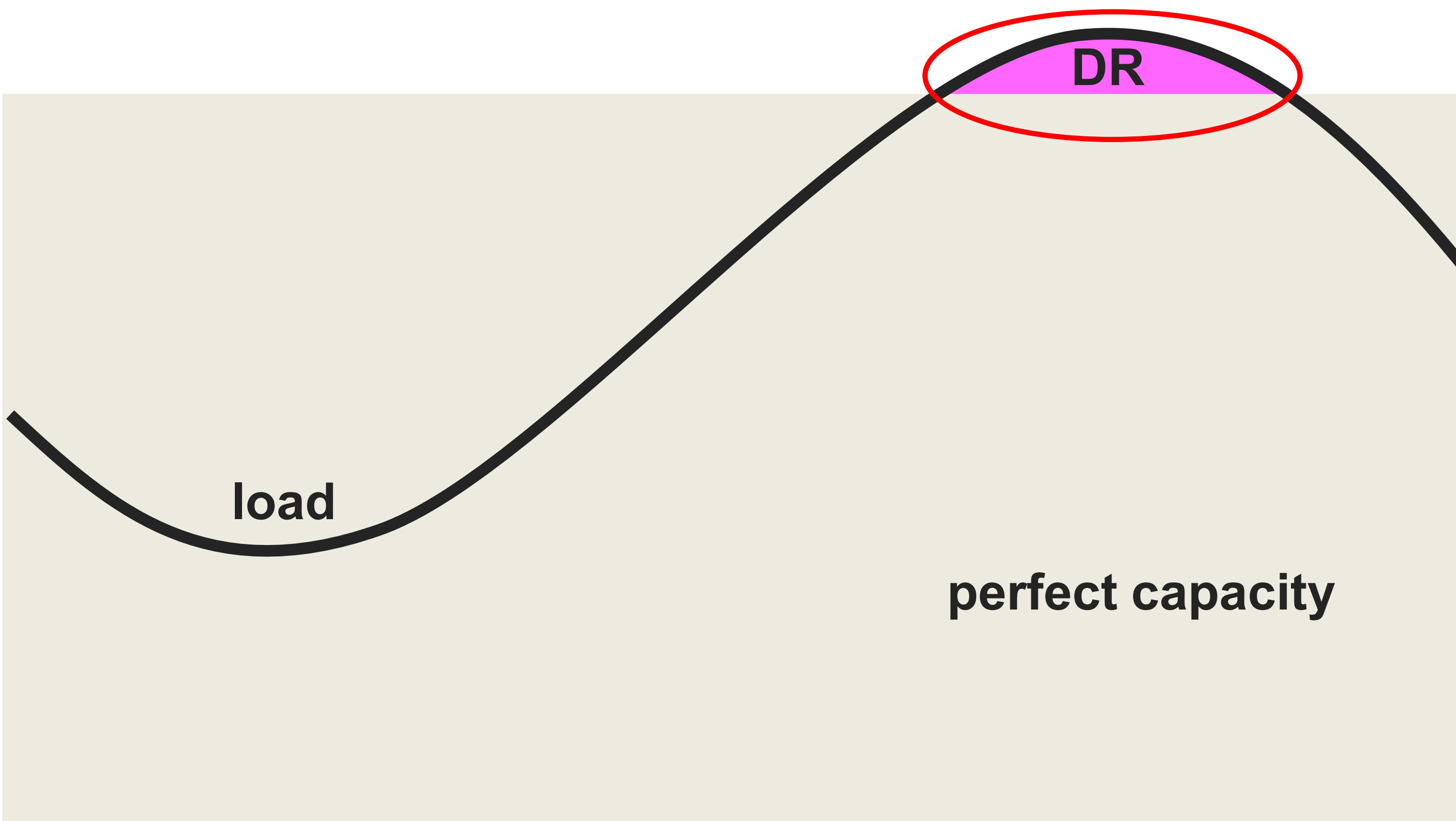
# How to Measure ELCC?

+ **There are multiple approaches to measuring the ELCC of a resource(s)**
  - **Portfolio ELCC:** measures the combined ELCC of all intermittent and energy-limited res system
  - **First-In ELCC:** measures the marginal ELCC of a resource as if it were the only intermi limited resource on the system, thus ignoring interactive effects
  - **Last-In ELCC:** measures the marginal ELCC of a resource after all other intermittent or resources have been added to the system, capturing all interactive effects with other res



# "First-In" ELCC

+ **First-in ELCC measures the ability of a resource to provide capacity, abs any other resource on the system**
    - Measures the ability of a resource to "clip the peak," and is often analogous to how m industry participants imagine capacity resources being utilized

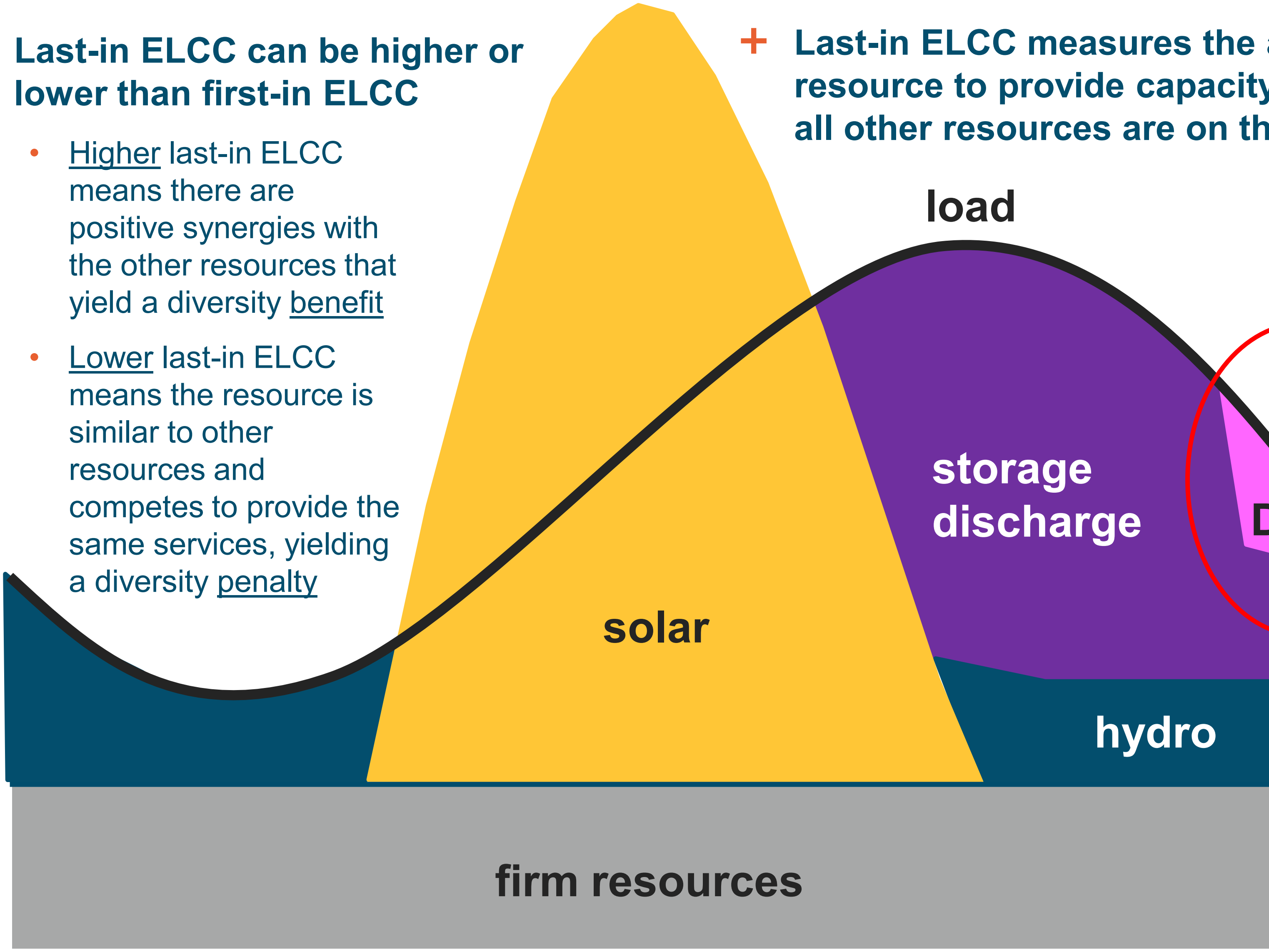



DR = Demand Response

# “Last-In” ELCC

+ **Last-in ELCC can be higher or lower than first-in ELCC**
  - Higher last-in ELCC means there are positive synergies with the other resources that yield a diversity benefit
  - Lower last-in ELCC means the resource is similar to other resources and competes to provide the same services, yielding a diversity penalty

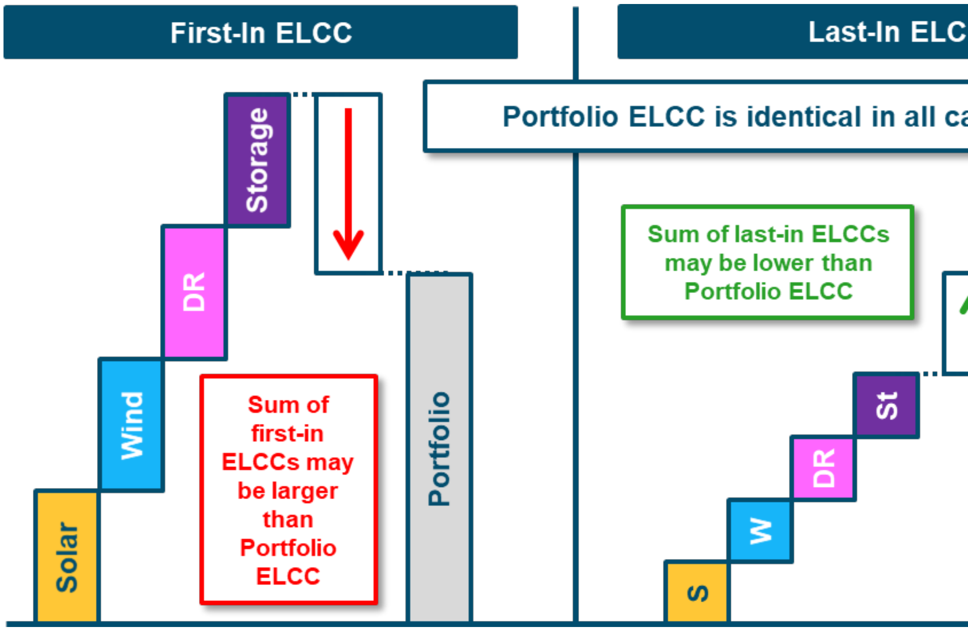
+ **Last-in ELCC measures the a resource to provide capacity all other resources are on th**



# How to Use ELCC?

+ **There are different reasons for using ELCC for different applications**
  - **Portfolio ELCC:** appropriately characterizes the capacity contribution of intermittent ar limited resources – this is ***important for assessing system reliability***
  - **Last-In ELCC:** appropriately characterizes the marginal ELCC of the next unit of an int or energy-limited resource – this is ***important for procurement*** to understand how nev resources will contribute to system capacity needs

+ **To assign a capacity credit to individual resources, one must allocate the Portfolio ELCC using a subjective method such as:**
  - First-in proportional
  - Last-in proportional
  - A combination of the two

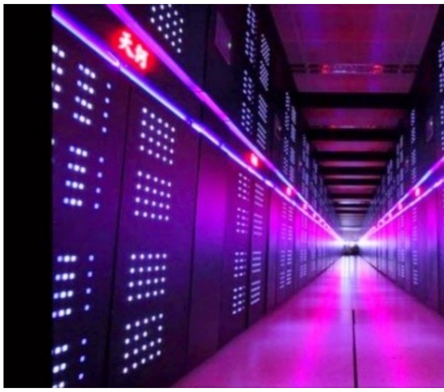


# Factors that Affect ELCC

- ***How*** **a resource is used can impact its ELCC**
  - Storage is a great example of this with multiple value streams
    - Energy arbitrage
    - Ancillary services
    - Etc.
  - Operating storage to maximize total value may limit its ability to provide cap value in order to provide other services
- **The compensation framework can also impact how a resource is dispatched, which makes the linkage between these two key que critical**

# Issues with ELCC

+ **Calculating ELCC can be time-intensive and difficult** due to:
  - Significant data requirements
  - Computational horsepower requirements



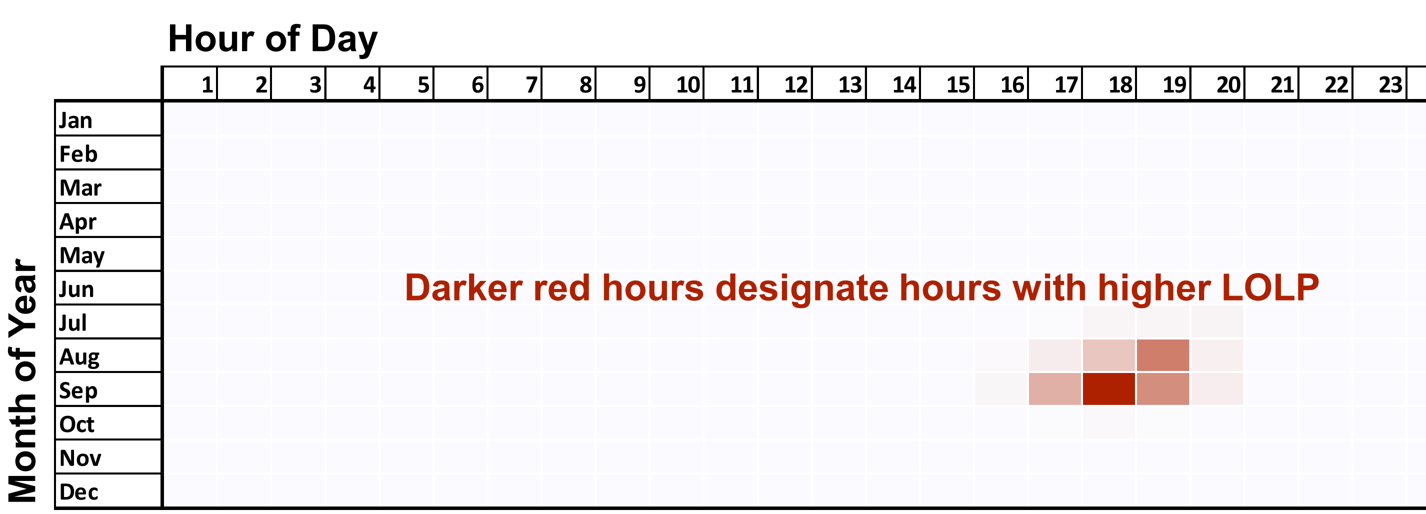
+ **"Heuristics" or simplified calculations are often used to approximate ELCC**

+ **Example heuristic approaches include:**
  - **Time-window methods**
    - Calculates the average production of a resource during pre-defined time periods
  - **Exceedance method**
    - Calculates the production of a resource that exceeds a specified percentile

# Loss of Load Probability

+ **Loss of load probability (LOLP): the most common heuristic tools for approximating resource's ELCC**
    - **LOLPs represent the probability that there will be loss of load in a given time pe** on many simulations of the electricity system under different load and resource conditi
    - LOLPs are **represented as percentage values (%)** for each hour of the year
    - Summing hourly LOLPs across the entire year yields the expected number of hours w per year

Illustrative LOLP Table

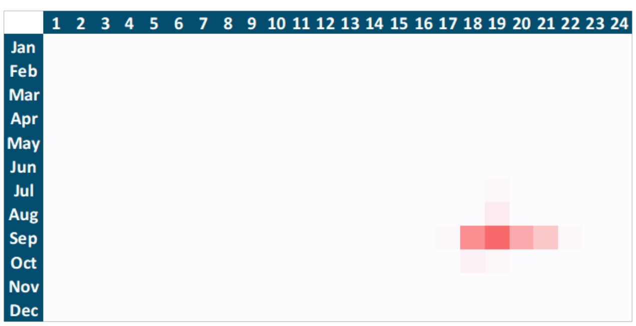



**Most electricity systems use a reliability standard of days/year instead of hou common standard is 1-day-in-10 years which corresponds to a 0.1 days/year*

# Using LOLP to Approximate ELCC

+ **Because LOLPs represent the hours when the system is most likely to need calculating a resource's production during these hours is a reasonable app of ELCC**
+ **Calculation steps:**

**Normalized LOLP % Values**

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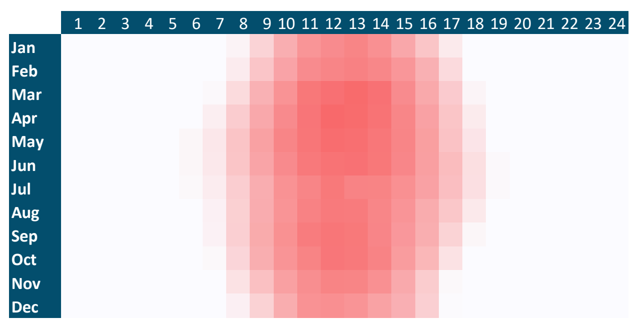
**Solar Production (MW)**

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**Ap**

**(M**

**Normalize hourly 8760 LOLP values for the year such that they sum to 1.0**

**Calculate the weighted average production (MW) of a specified resource over the year**

**wei pro by c**

+ **LOLPs approximate *last-in ELCC*** because they are measured on a system *aft* resources have contributed to minimizing LOLP

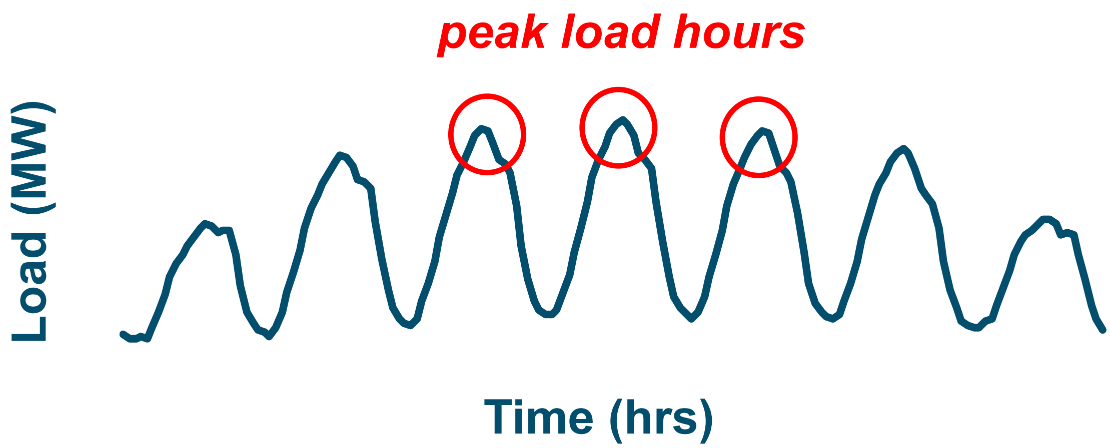
# What LOLP Misses

+ **LOLPs are a decent approximation of ELCC for non-dispatchable intermittent resources, BUT this approach**
  - **Misses key correlations between resource output during *actual* loss of load hours,** while capturing it for hours with *probability* of loss of load
    - The LOLP calculation approach essentially calculates the average production (e.g., solar output) during all days within a month instead of only the days that *actually result* in loss of load
    - Hours with loss of load tend to happen on peak days >> which tend to be hot >> which tend to be sunny >> which have high solar output
  - **Does not work as well for energy storage or other energy-limited resources since it does not capture the length of loss of load events**
    - For example, LOLP during the 4pm – 10pm period does not necessarily mean that a 6-hr resource is needed
    - If this LOLP represents loss of load events that occur independently from 4pm – 8pm on one day and 6pm – 10pm on another day, then a 4-hr resource may be sufficient to provide 100% ELCC

# Using Peak Loads to Approximate ELC

- **Another relatively accurate approximation of Last-in ELCC is to c average production of a resource during the top X "net load" hou**
  - Net load = [load] – [production from all intermittent and energy-limited resou

- **Calculating average production of a resource during the top X "g load" hours/year is a reasonable approximation for First-In ELCC**
  - Gross load does not include the impact of intermittent or energy-limited res which makes it appropriate for approximating the First-In ELCC calculation




*Reasonable values for "X": 50, 100, or 200 hours per year

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# Key Question 2) What is the Value of Capacity?

# What is the Value of Capacity?

+ The monetary value ($) of capacity is a separable question from quantifying the capacity (MW) that a resource can provide
+ To answer the monetary ($) question, two key pieces of informati are necessary:

1) Does the utility need new capacity?

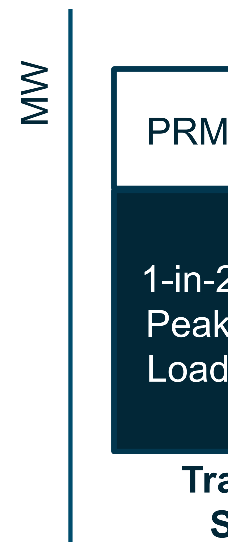
2) How much does new capacity cost?

# How Much Capacity Does a Utility Nee

+ **Utilities plan to a specified reliability target**
  - Most commonly a 1-day-in-10-year standard, or 0.1 days/year loss of load expectation (LOLE)

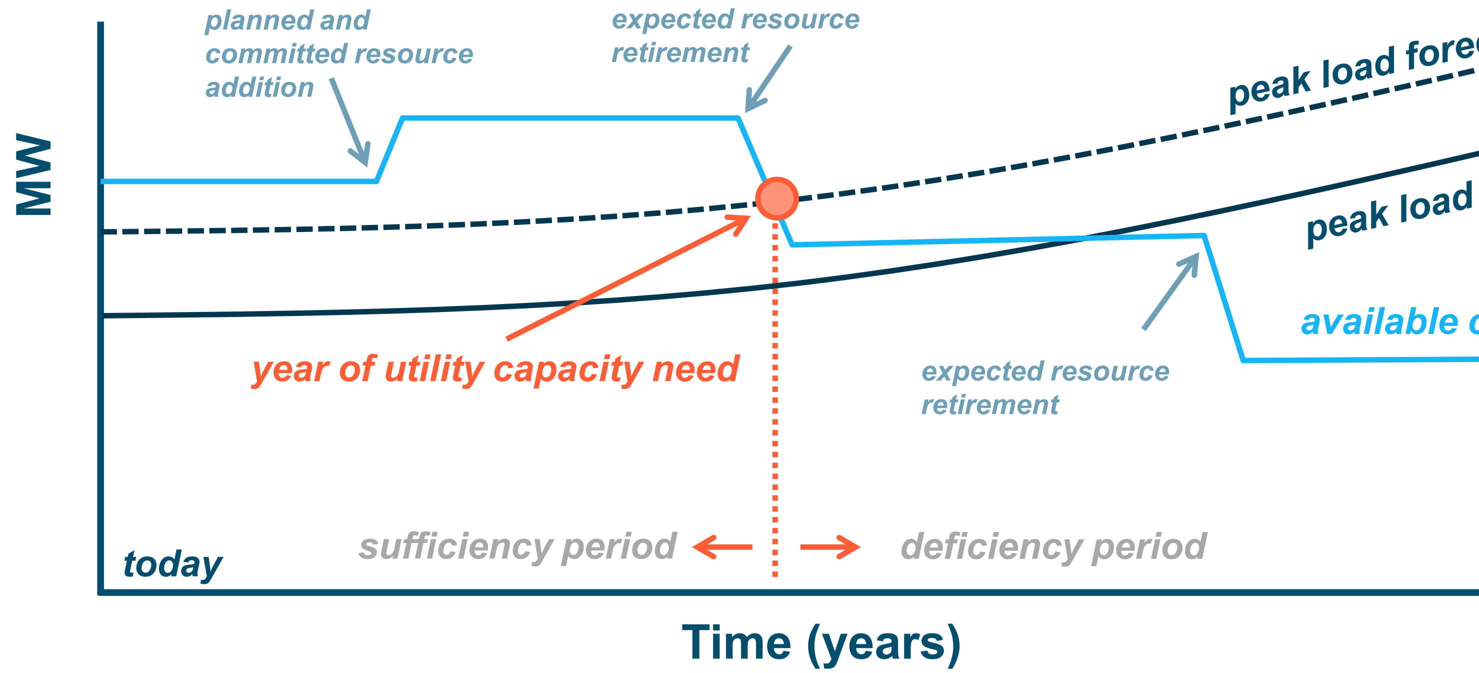
+ **Planners ensure this reliability standard is met through adherence to a planning reserve margin (PRM)** that provides excess capacity above typical peak loads to maintain reliability in the event of**:**
  - Unplanned forced generator outages
  - Higher than normal peak loads (very cold or very hot weather)
  - Operating reserve requirements

+ **Typical PRMs range from 12% to 20%** depending on a range of system characteristics



# Does the Utility Need New Capaci

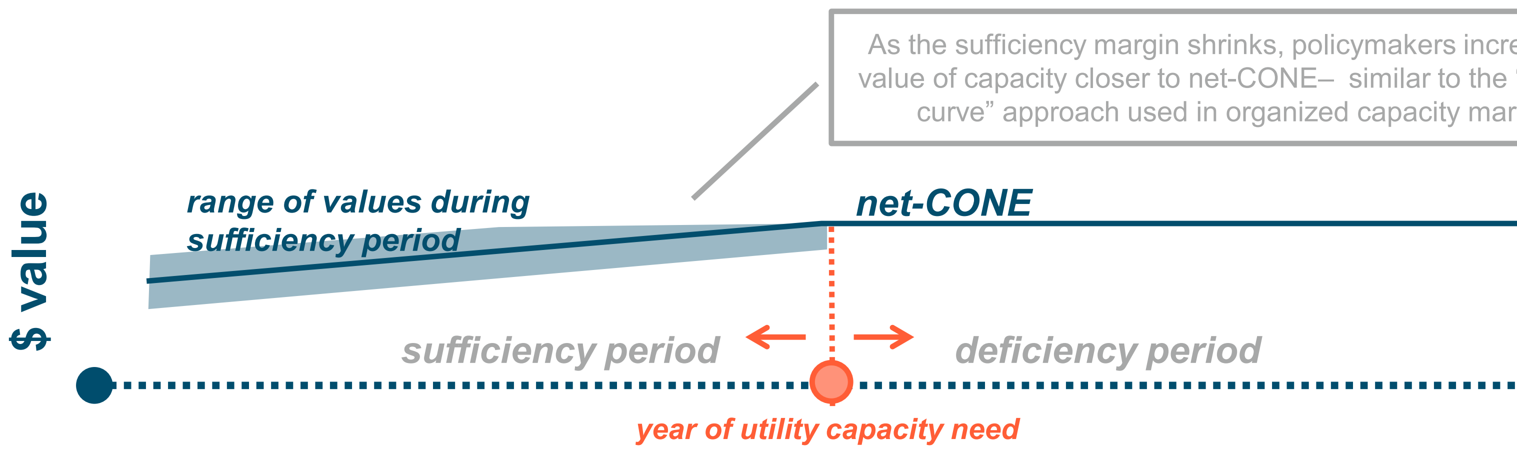
+ **It is common for utilities to hold reserves in excess of the minimum PRM t maintain reliability**
  - Peak demand is difficult to predict exactly and investments in capacity are both "lumpy" significant lead-time
  - If reserves > PRM, additional capacity is not needed
+ **Looking forward, utilities generally forecast load growth and generator re resulting in a future year in which they are expected to need new capacity**



# What is Capacity Worth?

+ **<u>Sufficiency period in Oregon</u>: times when the utility holds capacity in excess of the capacity is not needed by the utility and is less valued**
    - Multiple approaches value capacity from $0 up to net-CONE, with the fixed O&M of th resource as a widely used value
+ **<u>Deficiency period in Oregon</u>: times when the utility is forecasted to need additional capacity is valued at what it would otherwise cost the utility to procure new capacit**
    - Approach to value capacity: **net-CONE**

Illustrative Timeline




+ **Other competitive electricity markets (PJM, NYISO, ISONE, etc.) use a demand curv to adjust the clearing price of capacity based on how short or long the system is rel reliability standard**

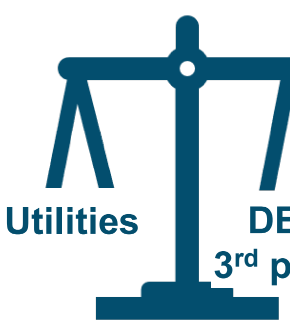
*See following slides for more i

# Equity Issues Between Utility and DERs/Third Parties

+ **Important to ensure *equity* between utilities and DERs/third-parti respective contributions that they make toward resource adequa**

+ **Potentially inequitable for a utility to be able to earn full cost reco capacity procured in excess of the PRM and not provide the sam opportunities to DERs/third-parties**
  - Policymakers and stakeholders should consider the equity impacts associa this treatment in conjunction with the potential economic inefficiency associ the cost of paying for capacity that is not needed

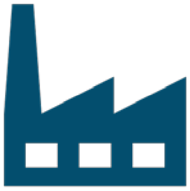
+ In assessing whether the utility is sufficient or deficient in future years, **analysis should only consider projects that are fully committed a no opportunity for deferral or modification**
  - Avoids reliance on projects that may not materialize



# Net Cost of New Entry (Net-CONE)

+ **Net cost of new entry is the industry benchmark for the value of c in periods of deficiency**
  - Net-CONE identifies the resource with the *lowest* net cost of capacity wher is defined as:

| | |
|---|---|
| Gross cost of capacity | *$/kW-yr* |
| – System benefits<br>*energy*<br>*ancillary services*<br>*etc.* | *$/kW-yr* |
| = Net cost of capacity | *$/kW-yr* |



*vs.*

**Traditionally, combustion turbines (CTs)** have been the lowest net cost of capacity resource in the electricity system

To the extent that **a different r lower cost or there are policy** lowest net cost developable res energy storage) should be

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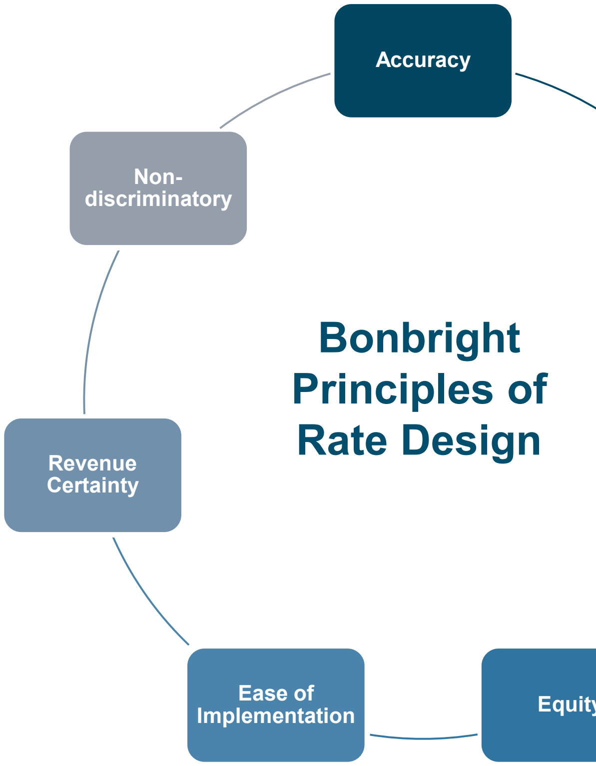
# Key Question 3) What Compensatio Framework Should Be Used

# Goals of a Compensation Framew

+ **No single compensation framework is appropriate for all use cases and all technologies**
+ **Requires some balancing of tradeoffs**
  - Bonbright rate design principles
+ **A compensation framework should seek to achieve:**

| | |
|---|---|
| Capacity (MW) (Question 1) | **Properly credit resources** for the capacity they provide to the system |
| Value ($) (Question 2) | **Properly compensate for the value** of the capacity resources provide |

+ In addition to these objectives, **a compensation framework must also balance** the following objectives
  - **Efficiency:** encourage economically efficient new resource development and procurement
  - **Acceptability:** transparent, tractable, understandable, and implementable for stakeholders and policymakers



# Approaches to Compensating Capacity

+ **There are two general approaches to compensating capacity**

| | Fixed Payment | Pay for Performance |
|---|---|---|
| **Method** | A resource is **compensated based on a fixed annual value ($/yr)** that aligns with its capacity credit (MW) and the value of capacity ($/MW-yr) | A resource is **compensated base production during capacity scar hours** (e.g., peak hours or high LO hours) |
| **Application** | **Organized capacity markets** in deregulated electricity markets (PJM, NYISO, etc.) | **PURPA and other DER contracts** where resources are compensated based on production |
| **Performance** | Evaluated though "performance penalties" | Based on production during capac scarcity hours |

# Fixed Payments

+ **Fixed payments can either be determined using**
  - ELCC calculations, or
  - Heuristic methods (e.g., LOLP-based approximations of ELCC)

+ **Performance can be ensured via performance penalty periods** wh utility evaluates a resource's performance during peak periods and pe if it does not perform according to its capabilities

+ **Works best for storage**
  - Performance discharge requirements that are sent to storage dynamically w system needs storage for capacity.
    - Could be sent on a day-ahead time frame to storage with instructions to discharge long as the duration of the storage
  - Primary limitation: implementation feasibility

# Pay for Performance

+ **Pay for performance can either be implemented via:**

| | Real-time dynamic payments | Pre-determined time p |
|---|---|---|
| **Method** | Compensates resources on **a dynamic basis** during times of system stress | Compensates resources for **performing during pre-deter time periods** (e.g. high LOLP |
| **Time Period Frequency** | Relatively **rare** | Relatively **common** |
| **Pros** | **Properly rewards resources** for generating when they are needed | **Easy to plan for; predictable outcomes** |
| **Cons** | **Difficult to plan for** as capacity periods are inherently uncertain | **Rewards resources** for perfo **when capacity is not needed**<br><br>**Does not capture the correla** output of resources on actual days* |

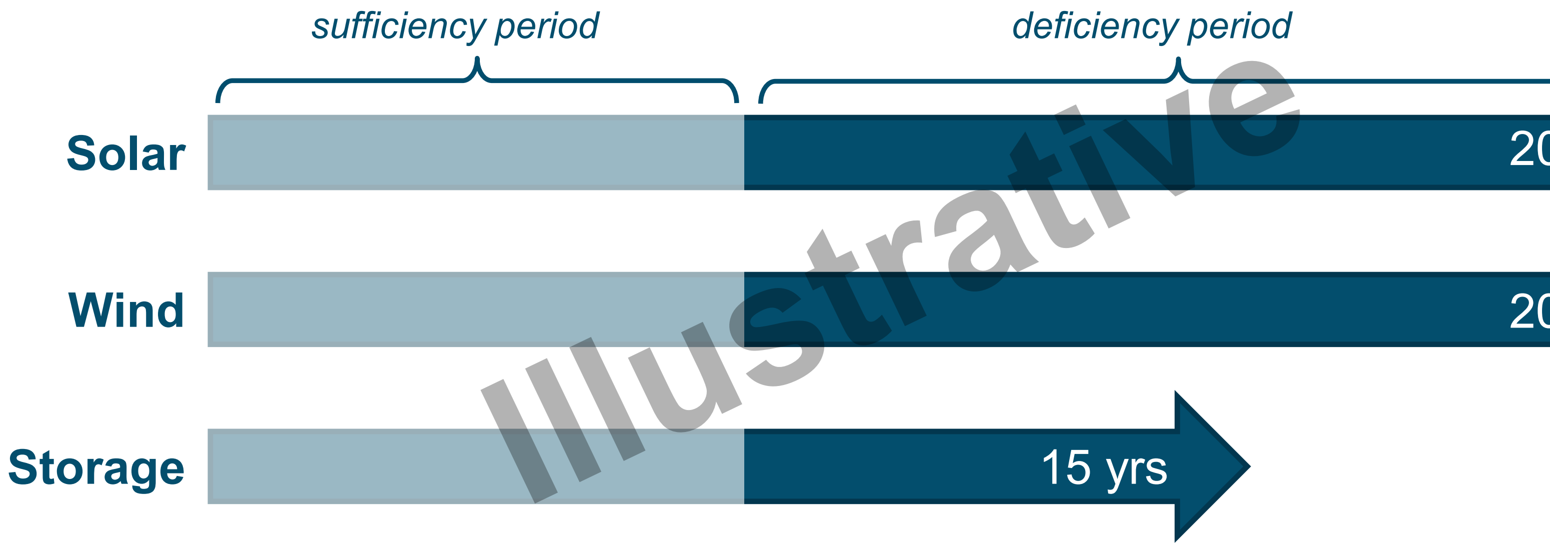
*One solution to this issue is to implement a “scalar” that grosses up capacity values to account for this factor – E3 accounted for this in the RVOS methodology through an ELCC to Solar-LOLP-coincidence ratio

# Pre-Determined Time Periods

- Pre-determined time period compensation is a **reasonable** framework to **compensate intermittent resources**
  - Analysis shows that production during high LOLP hours is a reasonable proxy for the ELCC
- Yet it has **potential limitations for energy storage resources**
  - Pre-determined time periods are generally longer than individual loss of load event windows, creating a burden of higher performance for energy storage resources than is necessary for system reliability
- **Pre-determined time period compensation must necessarily be associated with either**
  - First-In ELCC (gross load peak time periods)
  - Last-In ELCC (net load peak time periods)

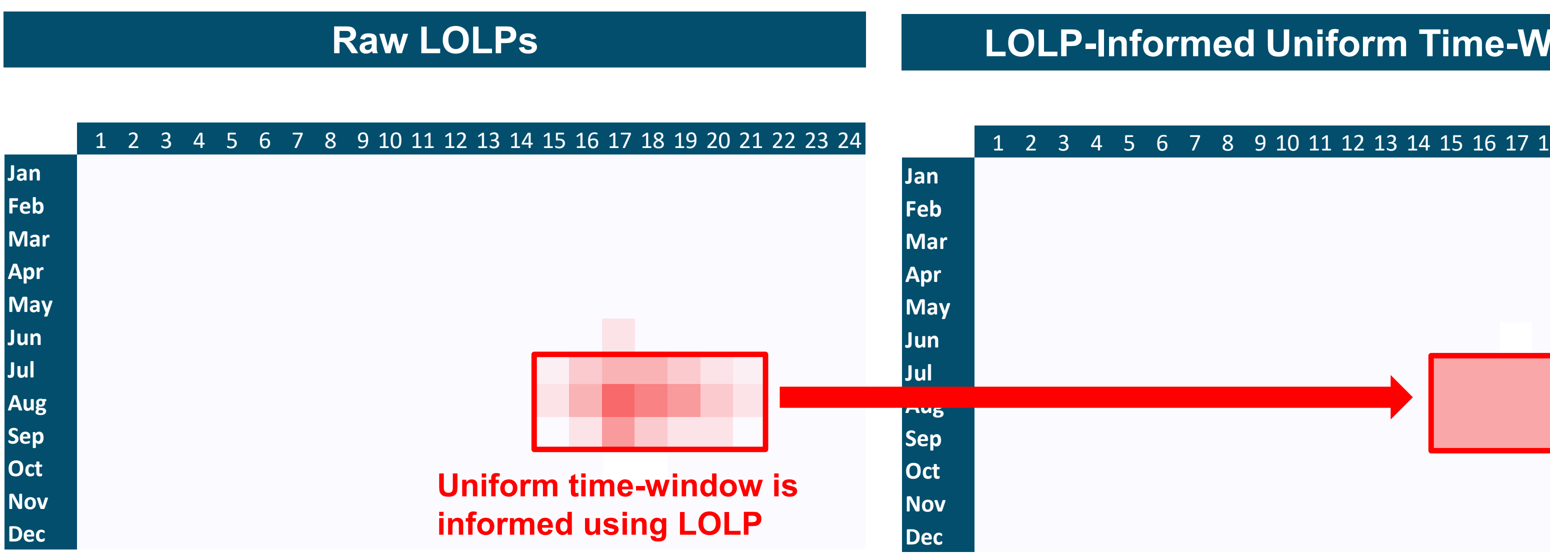
# Contract Length

- Within the context of PURPA, **contract length is an important topic**
  - Equity with utilities as well as the consistent year-to-year “excess” capacity that is mai
    the system, despite ongoing investments, lends credence to the notion that longer cor
    lengths should be used
- In this context, **contract lengths would approximate the economic life of ea particular resource**
- **Contract value should reflect the net present value of capacity for all suff and deficiency periods over the life of the contract**



# Practically Implementing LOLPs

+ **Using LOLPs as a basis for Last-In ELCC is a reasonable heuristic** (subjec
previously mentioned constraints)
  - However, even **pre-determined time periods that are proportional to LOLP weights
    complex signal to respond to**
+ **Consolidating actual LOLP values uniformly across "peak periods" can he**
simplify the implementation of PURPA contracts



# Compensation Framework Applica

- Different compensation frameworks are more or less appropriate different use cases
- For new QF contracts being executed, Last-In ELCC (i.e. margina appropriate to value their incremental contribution to system cap

| Resource | Appropriate ELCC Heuristic Methodology |
| --- | --- |
| Intermittent resources | **Uniform time-window periods** that overlap with highest hours |
| Energy Storage/ Dispatchable Resources | **ELCC analysis to determine ELCC contributio**n of vari durations (hrs) for energy storage resources<br><br>**QF contracts would update annually** with new pre-dete peak time periods to incentivize dispatch of storage resou during highest value hours |

# Features and limitations of one potent
# QF capacity compensation structure

## Key Components of QF Capacity Compensation

| | |
|---|---|
| Capacity Contribution | • Marginal (Last-In) ELCC approximated using LOLF |
| Capacity Value | • Net-CONE of lowest cost capacity resource |
| Compensation Structure | • Pay for performance based on LOLP peak periods<br>• Periods "locked in" for contract length |

## Important Limitations

+ **LOLP heuristic misses key correlations** between resource output during actual loss of l
+ **Last-In ELCCs** for each resource may under or overcount the capacity contribution of the
+ Resources are **compensated for hours of potential, rather than *actual*, capacity need**
+ **Length of loss of load events is not captured**, limiting the flexibility of storage assets to actual capacity needs

# Additional Considerations

## + Hybrid Resources

- Contain attributes and characteristics of multiple generation capacity resources
- Different compensation structures are more / less appropriate for different generation technologies
- Would need to be compensated under one of the aforementioned compensation frameworks based on stakeholder feedback

## + Transmission & Distribution

- Transmission and distribution capacity value is a separate and distinct value stream (although with many similar issues and concepts) that is not addressed in this presentation
- Should be considered and included as a utility value stream in an additive manner to the generation capacity values discussed in this presentation

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# Use Cases and Examples

# Applying the compensation framework capacity from new QF resources in Or

+ As described throughout this presentation, **there is no single "correc approach for capacity valuation and compensation applicable to scenarios**
  - E3 understands the primary use case of interest for this group to be evalua capacity contributions and associated payments for new qualifying facilities PURPA
+ Given the balance of accuracy, data requirements, and implementatio feasibility, **using LOLP values to establish pre-determined time wi or "peak periods" may be the best method for allocating capacity**
  - However, the limitations of this approach must be understood and acknowl

# PGE Allocation Using LOLP

# "Raw" LOLP values serve as the starti point for developing allocation factors

- **PGE LOLP hours are concentrated in Jul/Aug afternoons, and Nov-Jan ev**
- **Using the unadjusted LOLP values has the advantage of directly mappin capacity payments to highest-probability loss of load hours**
  - However, this may be more temporally granular than would be desired (more difficult t implement)

## PGE LOLP (2019)

| | Hour | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Month** | **0** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** | **18** | **19** | **20** |
| **1** | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 | 0.000 |
| **2** | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| **3** | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| **4** | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| **5** | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| **6** | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| **7** | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 | 0.001 | 0.000 | 0.000 | 0.000 |
| **8** | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.000 |
| **9** | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| **10** | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| **11** | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 | 0.000 |
| **12** | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 | 0.001 | 0.001 |

# Pre-defined time windows offer an alternative allocation approach

+ **The current PGE on-peak periods are defined as**
  - **6am – 10pm, Mon – Sat, year round**
  - 5,008 hours included in window (57% of *all* hours)
+ **This clearly results in unnecessary capacity payment in many non-peak h when compared to PGE's LOLP**

## PGE Time Window

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1** | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| **2** | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| **3** | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| **4** | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| **5** | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| **6** | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| **7** | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| **8** | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| **9** | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| **10** | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| **11** | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| **12** | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

# A somewhat more realistic time windo for PGE? (Alternative 1)

+ **Alternative time window 1:**
  - **12pm – 8pm, Mon – Sat, Jun – Sep**
  - 832 hours included in window (9% of all hours), 31% of unadjusted LOLPs captured*
+ **Each hour is allocated a uniform .10% of capacity value.**
  - Hourly capacity payment ($) = Price of capacity ($/MW-yr) * 0.001 * MW produced in that hour
  - Pay the full prorated share of capacity to each hour and all generators that generate during that hour
+ **Constrained window narrows capacity payment hours but misses the winter evenin**

## PGE Time Window (alternative 1)

| Month | Hour 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 2 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 3 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 4 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 5 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 6 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.000 |
| 7 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.000 |
| 8 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.000 |
| 9 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.000 |
| 10 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 11 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 12 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

* Percentage of unadjusted LOLP values captured by the time window is not a metric that can be used in isolation

# A somewhat more realistic time windo for PGE? (Alternative 2)

- **Alternative Time Window 2:**
  - **July- August: 2pm – 7pm; Nov – Jan: 5pm – 8pm**
  - 586 hours included in window (7% of all hours), 39% of unadjusted LOLPs captured*
- **Each hour is allocated a uniform .20% of capacity value**
  - Hourly capacity payment ($) = Price of capacity ($/MW-yr) * 0.002 * MW produced in that hour
- **Constrained window narrows capacity payment hours and captures winter evening**
- **Many other peak window definitions are possible**

## PGE Time Window (Alternative 2)

| Month \ Hour | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.002 | 0.002 | 0.002 | 0.000 |
| 2 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 3 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 4 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 5 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 6 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 7 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.000 | 0.000 |
| 8 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.000 | 0.000 |
| 9 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 10 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 11 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.002 | 0.002 | 0.002 | 0.000 |
| 12 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.002 | 0.002 | 0.002 | 0.000 |

* Percentage of unadjusted LOLP values captured by the time window is not a metric that can be used in isolation

Energy+Environmental Economics

# PacifiCorp Allocatio

# PacifiCorp's LOLP distribution looks fa different from that of PGE

- **PacifiCorp's LOLP heavily concentrated in July and August**
  - Much more concentrated than PGE LOLP
- **Summer evenings contain almost all LOLP hours**
  - Small amount of winter evening hours with non-zero LOLP
- **The current PacifiCorp on-peak periods are defined as:**
  - 6am – 10pm, Mon – Sat, year round

## PacifiCorp LOLP

| Month \ Hour | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 | 0.000 |
| 2 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 3 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 4 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 5 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 6 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 7 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.002 | 0.003 | 0.004 | 0.004 |
| 8 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 | 0.001 | 0.002 | 0.002 | 0.001 |
| 9 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 10 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 11 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 12 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 | 0.000 |

# Potential time window for concentrati
# PacifiCorp LOLP hours (Alternative 1)

+ **Alternative Time Window 1:**
  - **4pm – 9pm, Mon – Sat, July – Aug**
  - 270 hours included in window (3% of all hours), 52% of unadjusted LOLPs captured*
+ **Each hour receives .37% of capacity value**
  - Hourly capacity payment ($) = Price of capacity ($/MW-yr) * 0.0037 * MW produced in
+ **Constrained window narrows capacity payment hours**
  - Notably this window misses the winter evening peaks, given the selected months

## PacifiCorp Time Window (Alternative 1)

| | Hour | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Month** | **0** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** | **18** | **19** | **20** |
| **1** | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| **2** | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| **3** | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| **4** | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| **5** | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| **6** | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| **7** | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 |
| **8** | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 |
| **9** | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| **10** | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| **11** | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| **12** | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

* Percentage of unadjusted LOLP values captured by the time window is not a metric that can be used in isolation

# Potential time window for concentrati
# PacifiCorp LOLP hours (Alternative 2)

+ **Alternative Time Window 2:**
  - **July- August: 4pm – 9pm; Dec – Jan: 6pm – 8pm**
  - 434 hours included in window (5% of all hours), 68% of unadjusted LOLPs captured*
+ **Each hour receives 0.23% of capacity value**
  - Hourly capacity payment ($) = Price of capacity ($/MW-yr) * 0.0023 * MW produced in
+ **Constrained window narrows capacity payment hours**
  - Again, many other possible window definitions

## PacifiCorp Time Window (Alternative 2)

| | Hour | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Month** | **0** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** | **18** | **19** | **20** |
| **1** | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.002 | 0.002 | 0.000 |
| **2** | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| **3** | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| **4** | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| **5** | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| **6** | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| **7** | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 |
| **8** | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 |
| **9** | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| **10** | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| **11** | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| **12** | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.002 | 0.002 | 0.000 |

* Percentage of unadjusted LOLP values captured by the time window is not a metric that can be used in isolation

Energy+Environmental Economics

# Wrap Up and Conclusions

# Takeaways

1. **Several key questions frame capacity considerations:**
   1. How much capacity can a resource provide?
   2. What is the value of capacity?
   3. What compensation framework should be used?
2. **No single "correct" approach to evaluating and compensating resources' capacity contributions; inherently use case-specific**
3. **For establishing new QF contracts in Oregon, using pre-determi windows based on LOLP values is a reasonable approach**
4. **Limitations to this approach exist and must be understood**
   - Provides payment for many hours of potential (but not *actual*) capacity nee
   - Ignores interactive effects of resources
   - Can be problematic / limit value for dispatchable resources such as energy

Energy+Environmental Economics

# Thank You

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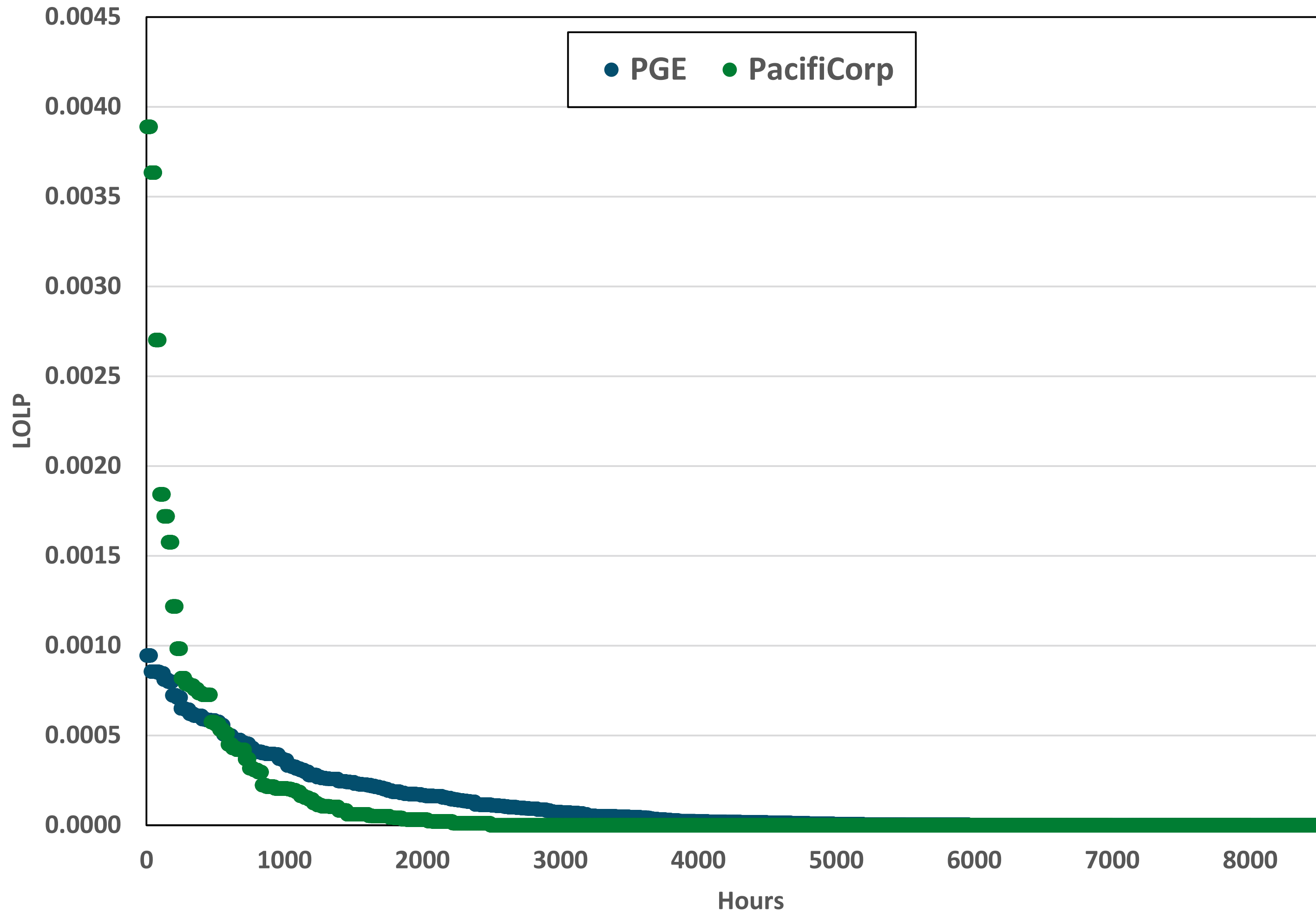
Energy+Environmental Economics
Appendix

# Direct Comparison of LOLP Values

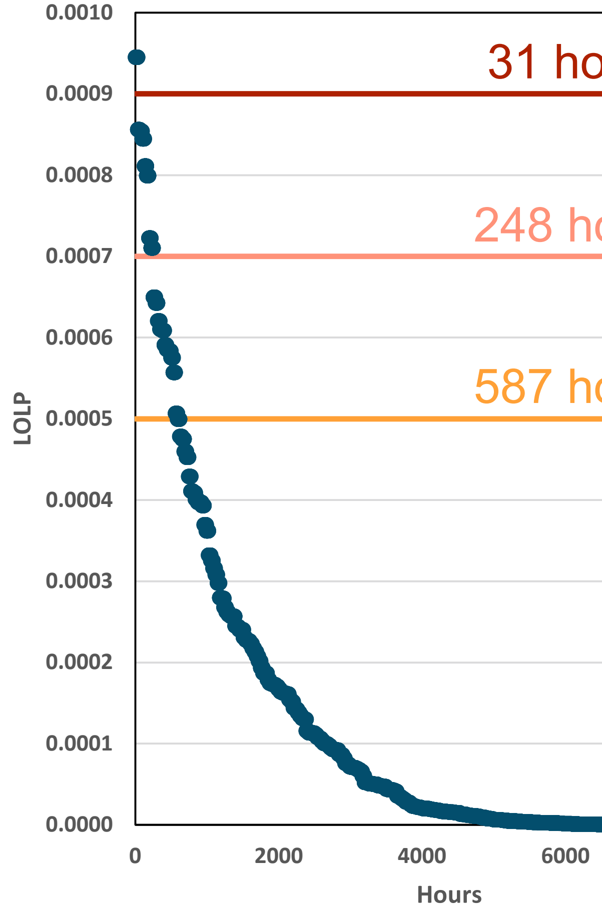


# Setting a threshold is one way to narr
# on hours with relatively high LOLP

+ **Hours with LOLP above the threshold are allocated their share of the remaining LOLP**

+ **Three illustrative threshold levels highlight the number of hours which might be counted for capacity value**
  - .09%
  - .07%
  - .05%

**PGE LOLP Hours**



# Use of a threshold approach concentra
# LOLP hours into peak periods

+ **At a .05% threshold, 587 hours remain as potential capacity value allocation hours**
+ **These hours maintain a similar shape or pattern as the "raw" LO values**
  - Outer "tails" are eliminated or reduced (e.g., January hour beginning 17 or hour beginning 11-14 and 18-20)

## PGE Threshold (.05%)

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.002 | 0.002 | 0.000 |
| 2 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 3 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 4 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 5 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 6 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 7 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.002 | 0.001 | 0.000 | 0.000 | 0.000 |
| 8 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.000 |
| 9 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 10 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 11 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.002 | 0.001 | 0.000 |
| 12 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.002 | 0.002 | 0.002 | 0.001 |

# More restrictive threshold values furth concentrate hours, eventually “too mu

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 2 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 3 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 4 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 5 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 6 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 7 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 8 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.000 | 0.000 |
| 9 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 10 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 11 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 12 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.004 | 0.005 | 0.004 | 0.000 |

## PGE Threshold (.07% above, .09% below)

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 2 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 3 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 4 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 5 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 6 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 7 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 8 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 9 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 10 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 11 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 12 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.032 | 0.000 | 0.000 |

+ .09% threshold is an extreme example, clearly a poor choice for PGE (31 hours remain, all in Dec. hour beg

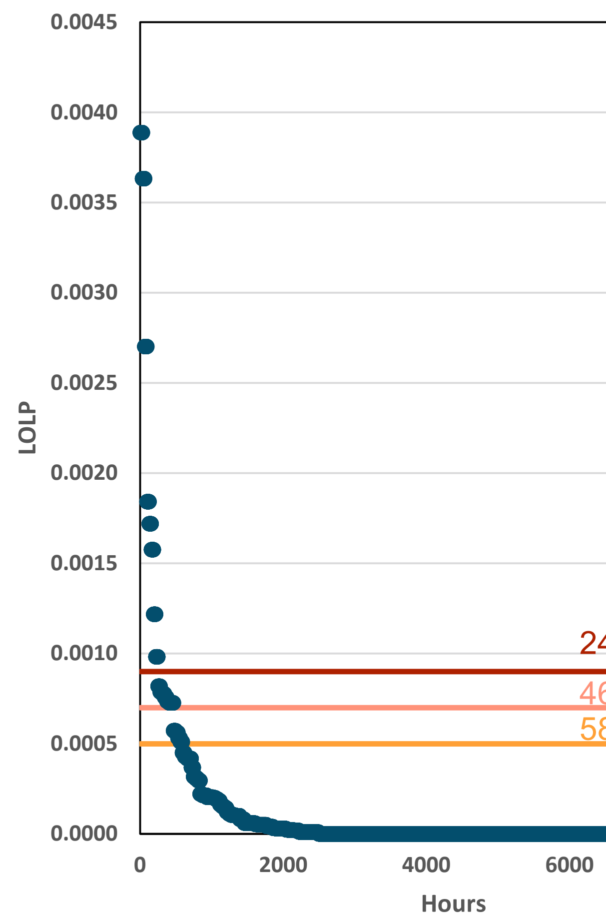
# PacifiCorp LOLP relative to threshold levels discussed previously

+ **The same threshold levels explored for PGE above result in more remaining LOLP hours for PacifiCorp**

+ **This is driven by the higher concentration of LOLP values among specific hours**
  - Presumably due to differences in LOLP modeling

+ **Over 6,000 “zero” hours**
  - Again, distinct approach from PGE

**PacifiCorp LOLP Hours**



# The initial threshold has a relatively s impact

+ At a .05% threshold, 589 hours remain as potential capacity valu allocation hours
+ This results in hours with a very similar shape as the “raw” LOL esp. given the concentration of PacifiCorp LOLPs in relatively fe

## PacifiCorp Threshold (.05%)

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 | 0.000 |
| 2 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 3 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 4 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 5 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 6 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 7 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.002 | 0.003 | 0.005 | 0.005 |
| 8 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 | 0.002 | 0.002 | 0.002 | 0.001 |
| 9 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 10 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 11 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 12 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 | 0.000 |

# More restrictive threshold values furth concentrate LOLP hours

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.000 | 0.000 |
| 2 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 3 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 4 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 5 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 6 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 7 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.002 | 0.004 | 0.005 | 0.005 |
| 8 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.002 | 0.002 | 0.003 | 0.001 |
| 9 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 10 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 11 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 12 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 | 0.000 |

## PacifiCorp Threshold (.07% above, .09% below)

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 2 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 3 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 4 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 5 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 6 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 7 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.003 | 0.005 | 0.007 | 0.007 |
| 8 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.002 | 0.003 | 0.003 | 0.002 |
| 9 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 10 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 11 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 12 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

+ **Jump from .07% to .09% has no effect on PAC allocation (no hours w/ LOLP values between .07%**

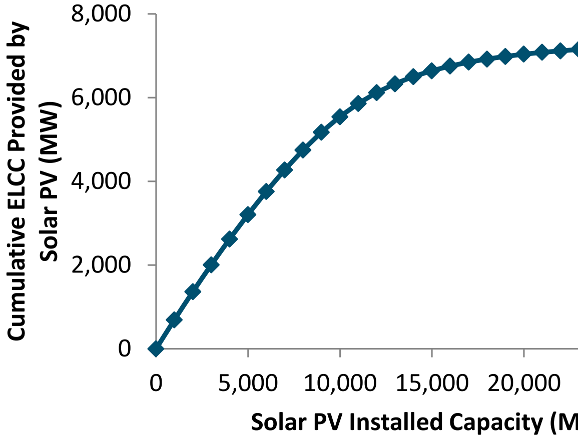
# Different ELCC calculations are appropriate for different situations

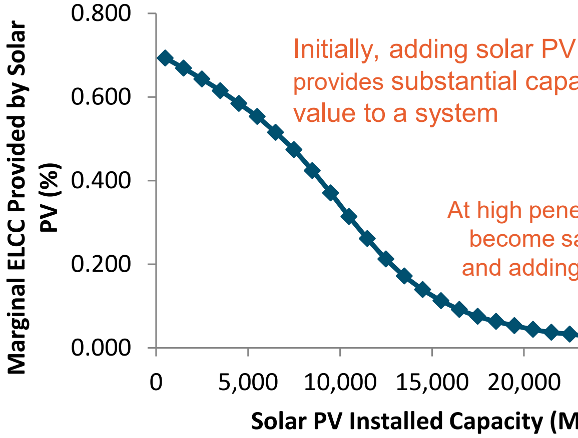
| ELCC Calculation | Description | Relevant for |
|---|---|---|
| **Portfolio ELCC** | **Combined** ELCC of all intermittent / energy-limited resources in the electricity system<br><br>Includes interactive effects | Allocation of capacity value t individual resources (e.g., in markets of RA programs) |
| **First-in ELCC** | ELCC of a resource measured as if it were the **first and only** intermittent / energy-limited resource<br><br>Ignores interactive effects | Assessing the capacity contr of a resource in the absence interactive effects with other resources |
| **Last-in (Marginal) ELCC** | ELCC of a resource measured **after** all other intermittent / energy-limited resources have been added to the system<br><br>Includes interactive effects | Planning decisions, where er incremental resource capacit contributions merit the increr cost |

# PV ELCC example

+ While the first increment of solar PV has a relatively large impact on peak, it also shifts the "net peak" to a later hour in the in day
+ Stochastic modeling reveals that the effective load carrying capability of solar PV *declines* as penetration *increases*
+ At high penetration, the conventional paradigm that additional solar PV contributes value towards meeting peak loads no longer applies

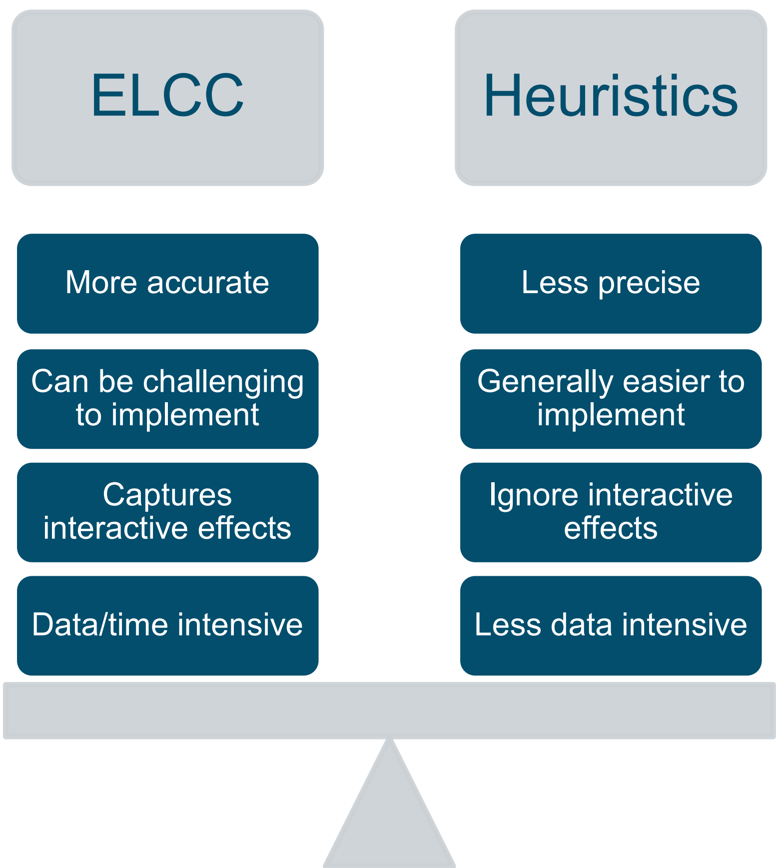
## Cumulative vs. Marginal PV EL



# Where calculating ELCC is unrealistic, heuristics can be used as a proxy

+ **Heuristics are methods that approximate more precise approach**



# ELCC vs. Heuristics

| ELCC | Heuristics |
|---|---|
| Time-sequential LOLP modeling to calculate the ELCC of a resource correctly captures the capabilities of the resource and interactions with other resources | Heuristic methods include:<br>• Average or certain percentile production during cer defined time periods meant to approximate highest<br>• Assigning an LOLP weight to each hour of the year determining the ability of a resource to generate du |
| Each resource must be run individually in order to capture these effects | Does not capture interactive effects or diminishing ret |
| There is a difference between the initial ELCC and marginal ELCC of a resource – there is also a difference between both of these and the portfolio ELCC which captures all resources and their interactions | Does not accurately capture ability of energy-limited r such as storage, demand response, or hydro to provi |
| It is necessary to allocate a final ELCC to each resource using the various ELCCs that can be calculated | Data requirements are workable. This method can be individual resources at scale |
| Running individual ELCCs is data and time intensive | |

| Key Questions |
|---|
| How should the value of transparency and simplicity be traded off against the value of accuracy? |
| How extensive should the data requirements be for new/existing resources? |
| |

# Proxy Resource

| Combustion Turbine | Storage | Portfolio |
| --- | --- | --- |
| Simple to value | Simple(ish) to value<br>• Easy to calculate costs<br>• Difficult to calculate required duration | Captures the true 'shado<br>capacity through a portfol<br>by identifying which resou<br>needed |
| Historical precedent | Growing discussion across industry about whether Li-ion battery is the new CT proxy resource | Data-intensive and comp<br>complex |
| Unclear on future appetite for new fossil generation in the NW, despite this resource's role in a least-cost deeply decarbonized portfolio | | Lack of transparency for s |

| Key Questions |
| --- |
| How should accuracy vs. simplicity play a role here? |
| |
| |

# Sufficiency / Deficiency Framewor

| Maintain Demarcation | Modify / Eliminate Demarcation |
| --- | --- |
| Appropriately reduces the value of capacity in the near-term when the system may already have sufficient excess capacity | Utility planning and foresight can keep the syst perpetual state of sufficiency |
| Reduces ratepayer costs by avoiding unnecessarily paying for capacity that is not needed | Utility investments that are made to keep the s sufficient are eligible for full cost recovery begi year they are commissioned |
| | Utilities still make short-term capacity purchase during periods of sufficiency, begging the ques appropriateness of the framework |

| Key Questions |
| --- |
| To what extent should utility and non-utility assets be treated differently? |
| What are the equity considerations with respect to utility and non-utility capacity options? |
| How far into the future should the capacity need be evaluated? How should this interact with contract term? |
| What should happen if there is a future capacity need when a resource is built, but then that need disappears? |
| |

# Compensation Structure Consideratio

| Fixed Annual Payment | Pre-Defined Time Period Compensation | Real-Time Prici |
| --- | --- | --- |
| Requires predicting the output/performance of generators in advance | Relevant time period is predictable and simple | Most accurate signal generators |
| Simple to administer once the value is determined | Rewards generators for producing during high value hours | Difficult to allocate an cost of capacity to 're |
| Does not compensate generators for continued availability and performance (e.g., good maintenance) | Pre-defined time periods are inherently much broader than the actual limited reliability hours. Generators earn a lot of money when system is constrained and could theoretically not produce during actual peak hours and still make a lot of money in the other hours | Increased complexity required |
| Does not compensate dispatchable generators for generating when the system needs them | | |

## Key Questions

Should capacity be compensated like the fixed annual cost that it is, or should it be based on production durin

Should there be concern about compensating generators during peak hours when the system has no issues?

# Sufficiency / Deficiency Framewor

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| |

# Example RVOS calculations highlight differences between allocation metho

+ **RVOS model used to calculate capacity value under several differ scenarios**

Where *y* = year and *t* = time (in hours)

RVOS Capacity Value = *Annualized NPV of:* Capacity Deferral Value$_y$ X Hourly Allocatio

RVOS Capacity Value X Solar Generation Profile = Allocated Capacity Valu

| RVOS Capacity Value | Solar Generation Profile | Allocated Capacity Valu |
|---|---|---|
| Real levelized $/kWh | kWh/kW | Real levelized $/kW-yr |
| 8760 | 8760 | |

Allocated Capacity Value / Levelized Capacity Deferral Value = % of Maximum Potential Valu

# PGE (draft updated windows)

+ **Time window (TW) 1 over-values solar relative to raw LOLP due t coincidence with PV generation**

**Annual Generation Capacity Value relative to Maximum Capacity Value (%)**

| | PGE | | | | | |
|---|---|---|---|---|---|---|
| | Raw | 0.05% Threshold | 0.07% Threshold | TW 1, Summer Peak Only | TW 2, Summer+Winter Peak | TW 3, Incl Winter Morning Peak |
| West, Single Axis, ILR 1.1 | 23.8% | 25.8% | 29.3% | 43.8% | 25.9% | 22.2% |
| West, Fixed Tilt, ILR 1.1 | 19.0% | 18.6% | 20.7% | 35.9% | 18.5% | 16.7% |
| West, Double Axis, ILR 1.1 | 26.6% | 29.1% | 33.8% | 50.0% | 30.6% | 25.6% |
| West, Rooftop Solar, ILR 1.1 | 18.7% | 18.3% | 20.4% | 35.3% | 18.2% | 16.4% |
| West, Single Axis, ILR 1.4 | 30.3% | 32.8% | 37.3% | 55.6% | 32.9% | 28.3% |
| East, Single Axis, ILR 1.1 | 25.1% | 21.7% | 24.2% | 43.0% | 21.1% | 21.8% |

# PacifiCorp (draft updated windows

## Annual Generation Capacity Value relative to Maximum Capacity Value (%)

| | PacifiCorp | | | | | |
|---|---|---|---|---|---|---|
| | Raw | 0.05% Threshold | 0.07% Threshold | TW 1, Summer Peak Only | TW 2, Summer+Winter Peak | TW 3, Incl Winter Morning Peak |
| West, Single Axis, ILR 1.1 | 15.0% | 14.0% | 13.9% | 23.9% | 17.0% | 15.1% |
| West, Fixed Tilt, ILR 1.1 | 8.7% | 6.7% | 6.2% | 12.3% | 8.8% | 7.8% |
| West, Double Axis, ILR 1.1 | 21.1% | 21.1% | 21.6% | 32.5% | 23.0% | 20.0% |
| West, Rooftop Solar, ILR 1.1 | 8.6% | 6.7% | 6.2% | 12.2% | 8.7% | 7.7% |
| West, Single Axis, ILR 1.4 | 19.2% | 17.8% | 17.7% | 30.5% | 21.7% | 19.3% |
| East, Single Axis, ILR 1.1 | 12.1% | 9.2% | 8.8% | 17.0% | 11.7% | 11.6% |

# Factors affecting the capacity value o variable generation

+ **Coincidence with load**
  - Locations with better solar resources and more production later in the day higher ELCC values
+ **Production variability**
  - Statistically, the possibility of low production reduces the value of a resourc
+ **Location**
  - Distributed resources avoid transmission and distribution losses
+ **Existing quantity of variable generation**
  - Common resource types exhibit diminishing marginal returns, each additio variable generation has less capacity credit than the previous unit

# Jurisdictional Review of Wind Capacit Value Methodology

| Jurisdiction | Method | Notes |
|---|---|---|
| SPP | Heuristic[1]<br>• 60th percentile value of wind production during top 3% of peak load hours, calculated separately for winter and summer | SPP has initiated an investigation to explo an ELCC methodology. They have condu analysis and are comparing to their existi method |
| MISO | ELCC[2] | MISO calculates ELCC for the entire portf across the system and then allocates this node within the system. All wind within ea the same value. |
| NYISO | Heuristic[3]<br>• Winter: average wind production from December to February during hours ending 16-19<br>• Summer: average wind production from June to August during hours ending 14-17 | NYISO is currently investigating more sop methods, including ELCC, using loss-of-lo modeling to capture the diversity effects o non-firm resources[4] |
| ISONE | Heuristic[5]<br>• Winter: median wind production from October to May during hours ending 18-19 plus all hours with capacity scarcity<br>• Summer: median wind production from June to September during hours ending 14-18 plus all hours with capacity scarcity | |
| PJM | Heuristic[6]<br>Average wind production from June to August during hours ending 14-17 | PJM is evaluating adopting the ELCC met currently open to stakeholder comment[7] |
| CAISO | ELCC[8] | |

[1] https://www.spp.org/documents/60434/2019%20elcc%20wind%20study%20report.pdf
[2] https://cdn.misoenergy.org/2019%20Wind%20and%20Solar%20Capacity%20Credit%20Report303063.pdf
[3] https://www.nyiso.com/documents/20142/2923635/app_a_attach_icapmnl.pdf/503354b6-0607-9a12-f2d4-f866c25eac65
[4] https://www.nyiso.com/documents/20142/6785167/Grid+in+Transition+DRAFT+FOR+POSTING.pdf/74eb0b20-6f4c-bdb2-1a23-7d939789ed8c?version=1.1&t=1558703451381&down
[5] pg 24, https://www.iso-ne.com/static-assets/documents/regulatory/tariff/sect_3/mr1_sec_13_14.pdf
[6] https://www.pjm.com/~/media/documents/manuals/m21.ashx
[7] https://www.pjm.com/-/media/committees-groups/committees/pc/20190207/20190207-item-08-elcc-update.ashx
[8] https://www.cpuc.ca.gov/uploadedFiles/CPUCWebsite/Content/UtilitiesIndustries/Energy/EnergyPrograms/ElectPowerProcurementGeneration/DemandModeling/ELCC_2_13_19.PD

# Reliability Metric Definitions

+ **Loss of load expectation ("LOLE", unit of days/yr)**
  - Average number of days per year with loss of load (at least once during the
    to system load exceeding available generating capacity
+ **Loss of load events ("LOLEV", units of events/yr)**
  - Average number of loss of load events per year, of any duration or magnitu
    to system load exceeding available generating capacity
+ **Loss of load probability ("LOLP", units of %)**
  - Probability of system load exceeding the available generating capacity duri
    given time period
+ **Loss of load hours ("LOLH", units of hours/yr)**
  - Average number of hours per year with loss of load due to system load exc
    available generating capacity
+ **Expected unserved energy ("EUE", units of MWh/yr)**
  - Average total quantity of unserved energy over a year dye to system load e
    available generating capacity

NWPP 2019, https://www.nwpp.org/resources/exploring-a-resource-adequacy-program-for-the