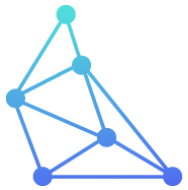
# Redefining Resource Adequacy for Modern Power Systems

ESIG December Webinar | 12/02/2020



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# Acknowledgements

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The Redefining Resource Adequacy Task Force is collaborating closely with a project team made up of industry experts:

**Aaron Bloom, Gord Stephen**, **Wesley Cole**, **Chris Dent,** and **Aidan Touhy**.

I would like to acknowledge their valuable input and support regarding these First Principles and the forthcoming modeling efforts.

# Resource adequacy making the headlines

## What happened in California?

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# The California Case Study

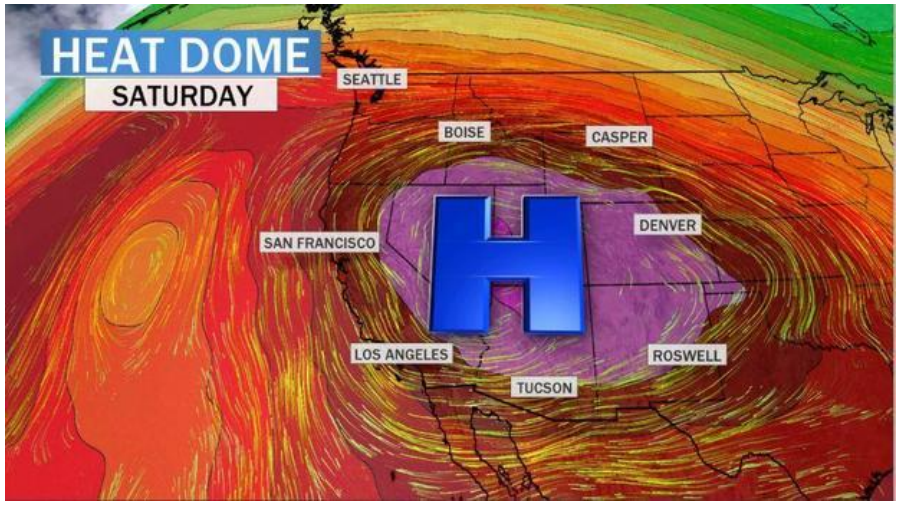
"There doesn't have to be a tradeoff between reliability and decarbonization… What caused the [August blackouts] was a lack of putting all the pieces together... You have to **rethink these old ways of doing things**, and I think that's what didn't happen."

"The resource adequacy program in California is now not matched up with the realities of working through a renewable-based system, and in a nutshell ... needs to be redesigned,"

-Steve Berberich, CAISO

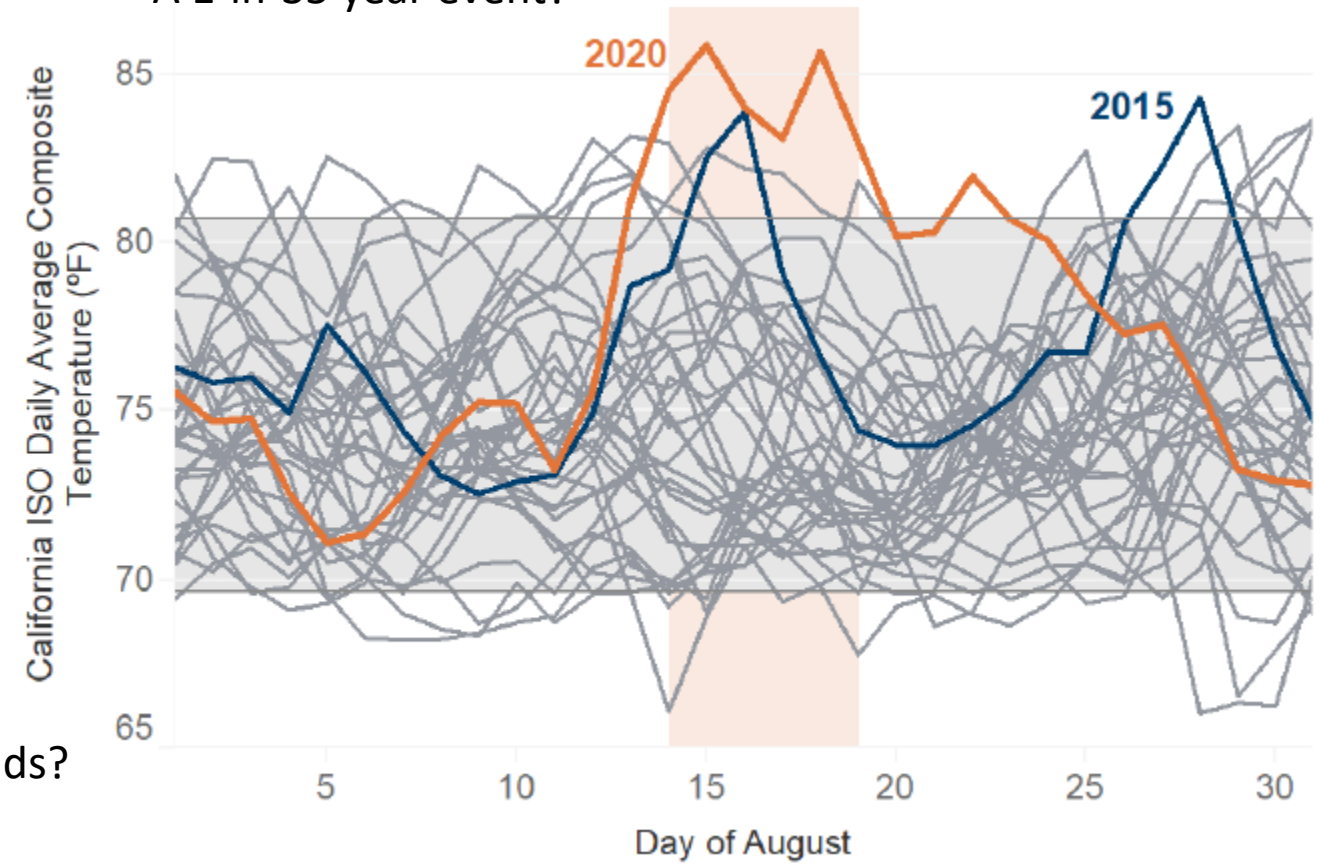
Source: S&P Global, You have to rethink these old ways: Parting advice from CAISO's retiring CEO, September 25, 2020

# What Happened in California?



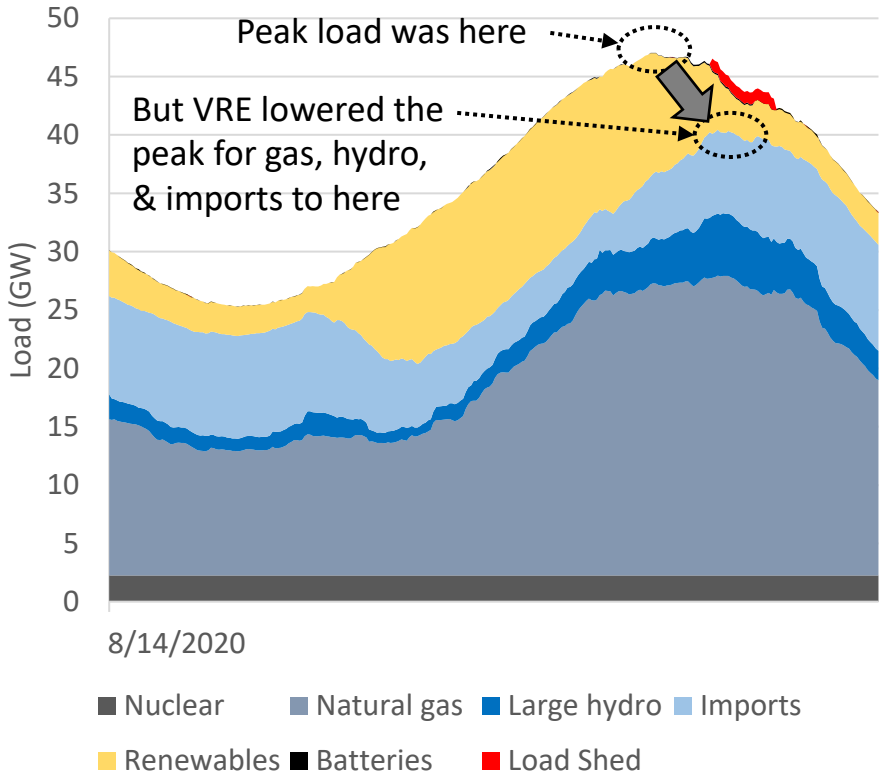

- Record breaking temperatures across the West
- *Regional* event… entire West was challenged
- Is a 1-in-35 year event reasonable to plan for?
- Should RA analysis take into account climate trends?

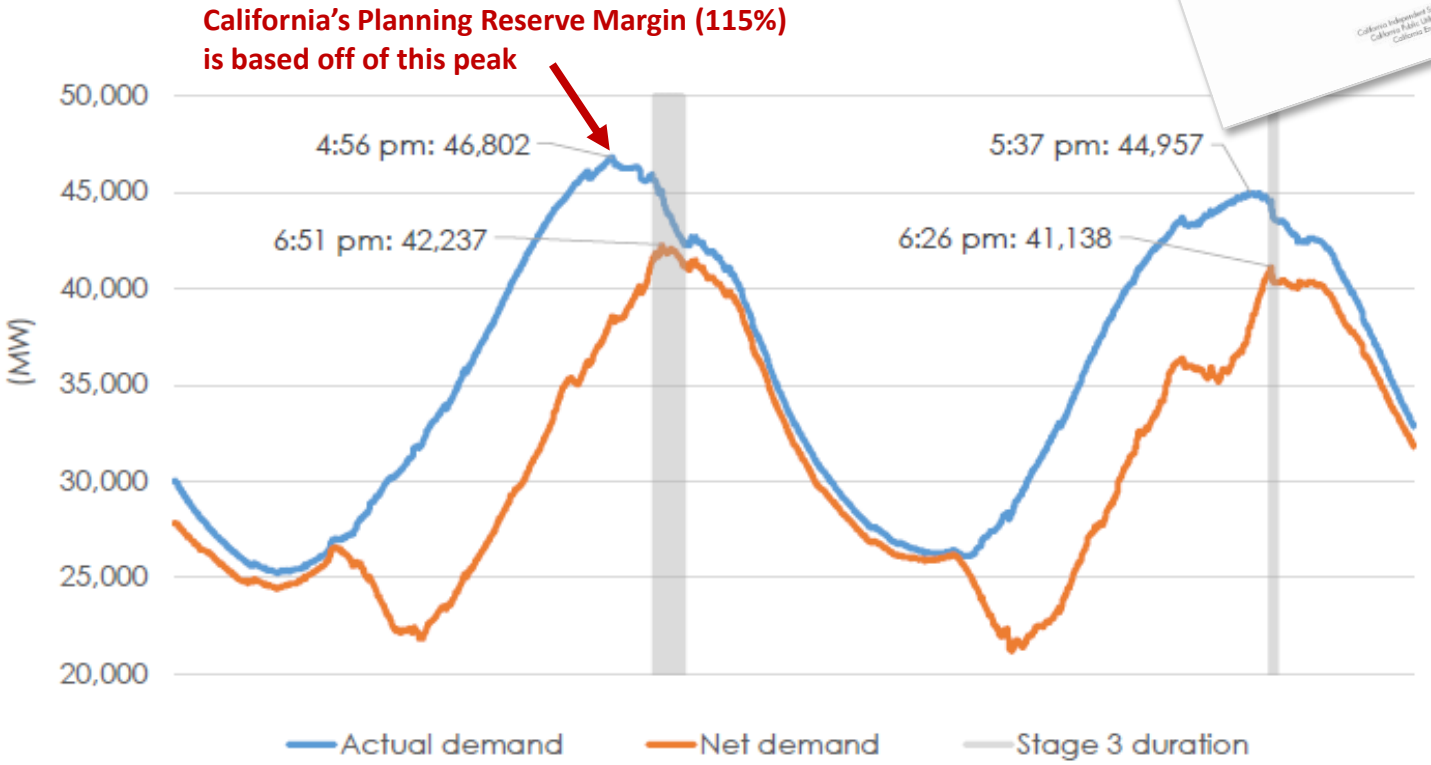
A 1-in-35 year event?




Source: CEC Weather Data/CEC Analysis, reported in CAISO Preliminary Root Cause Analysis

# What Happened in California?

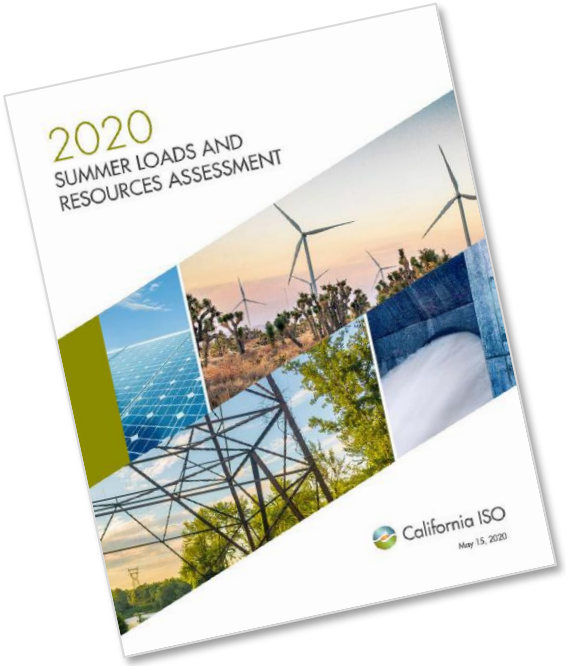




Source: CAISO Preliminary Root Cause Analysis

***Growing disconnect between planning reserve margin and reliability…***
***all hours, multiple weather years and chronological operations matter***

# What Happened…
# Could this have been predicted?




“The base case results show that the CAISO has a low probability of experiencing operating conditions that would lead to shedding firm load in summer 2020. However, if summer conditions are less favorable, resulting in **lower levels of imports as assumed** in the sensitivity case, the probability of shedding firm load will increase. The risk in 2020 primarily stems from less than average hydro conditions resulting in reduced energy from hydro resources across the summer, but particularly **impactful in late summer**. Furthermore, the CAISO daily peak period has shifted to **later in the day when solar generation is near or at zero levels,** resulting in the CAISO’s highest demand levels being supplied by the remaining non-solar fleet. With lower than normal hydro conditions, the CAISO may have to rely more heavily on imports from neighboring BAs during the CAISO summer peak hours. However, **if a heat wave occurs that impacts a broader area than the CAISO, the availability of surplus energy to import into the CAISO could be diminished**.”

-CAISO Summer Loads and Resource Assessment, **May 15, 2020**

# What can we learn from California?

PV and wind output was ~10 GW during peak load

- lowered and shortened the peak
- provided capacity value, things could have been much worse

ELCC correctly quantifies the ***average*** amount of risk PV avoids, but average doesn't matter

- For example, if PV has a 50% ELCC, we know for certain that it will provide 0% of its capacity at 9 PM
- Planning reserve margin method completely misses this obvious point!

**ELCC is useful for showing the average capacity value of a resource. Good for capacity accreditation ($$$), but cannot be relied on in isolation for system planning**

**Planning Reserve Margin requires planners to know the time periods of system stress and likelihood of VRE to be available**

**The California event was not a renewables problem, but a planning failure**

# Redefining Resource Adequacy for Modern Power Systems

How do variable renewables, demand response, energy storage and fossil retirements change RA?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# How is resource adequacy changing?

## Are there enough resources to serve load when it is needed?

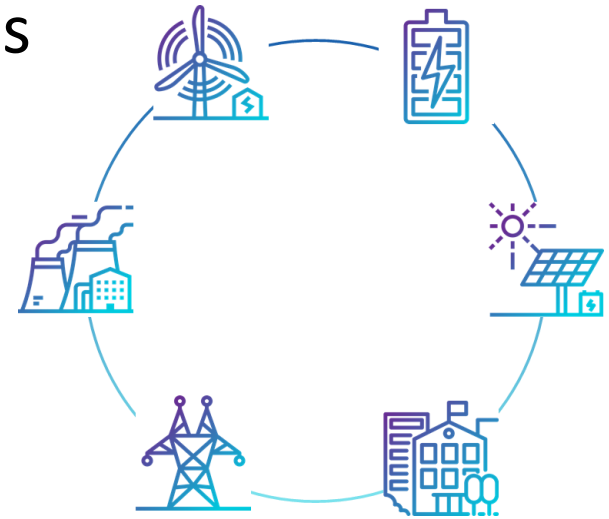
**Historical Perspective**

1. Uncertainty in load
2. Uncertainty in supply (generator outages)

Some recognition that weather effects both

**A new paradigm for resource adequacy is emerging…**

1. Variable Renewables
2. Energy Limited Resources
3. Modular Technology
4. Load Flexibility
5. Correlated Events



# Resource adequacy… starting from a blank canvas

**We asked ourselves a few simple questions…**

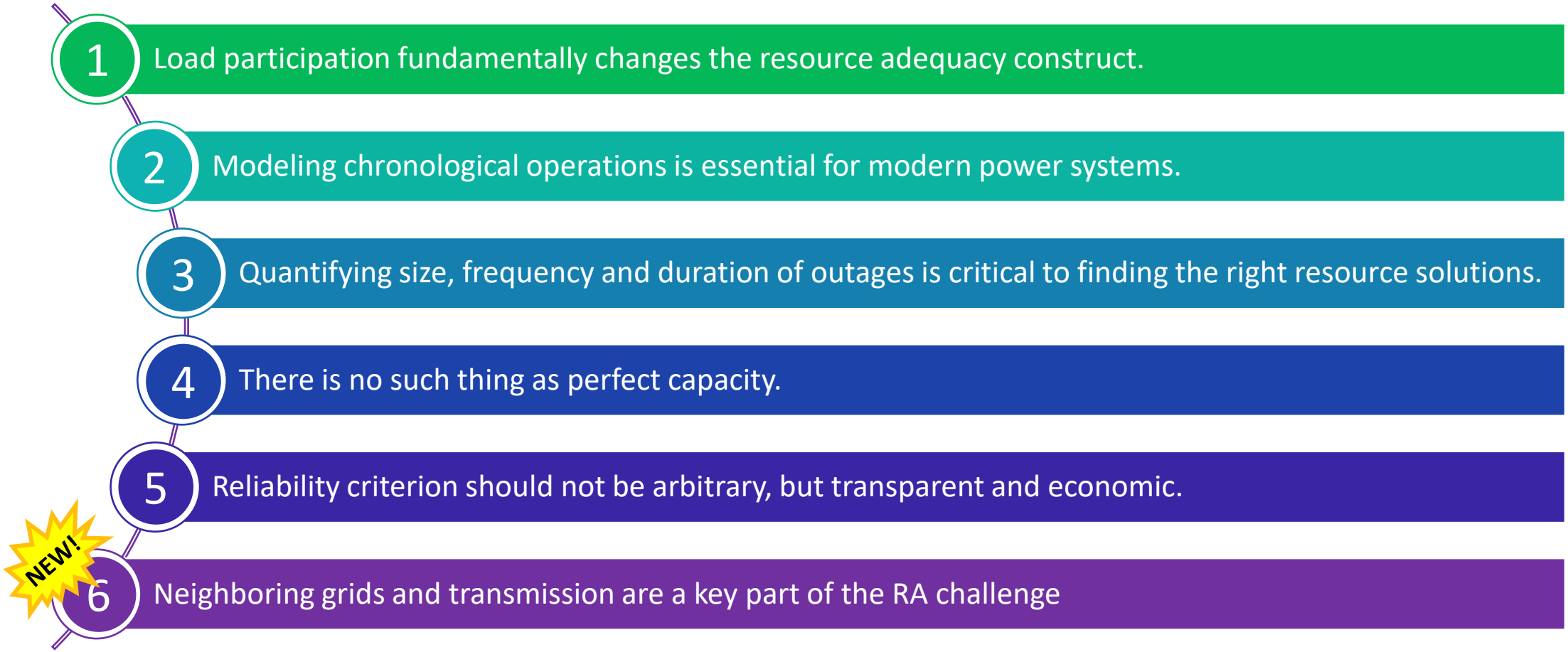
1. If we started from scratch, how would we evaluate resource adequacy for modern power systems?

2. Is there a better way to evaluate risk and reliability in a power system with increasing wind, solar, storage, and load flexibility?

3. What are the first principles that ensure enough resources are available for modern power systems, regardless of the technologies at play?

**Objective: clearly articulate these evolving concepts to regulators and policy makers**

# The result: ~~five~~ **SIX** principles of resource adequacy for modern power systems:



# How can we test these principles?

## RTS-GMLC Overview

### Starting Point (1979)

RTS-79 "IEEE Reliability Test System", *IEEE PAS*, vol. 98, no. 6, pp. 2047-2054, Nov/Dec. 1979.

- http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4113721

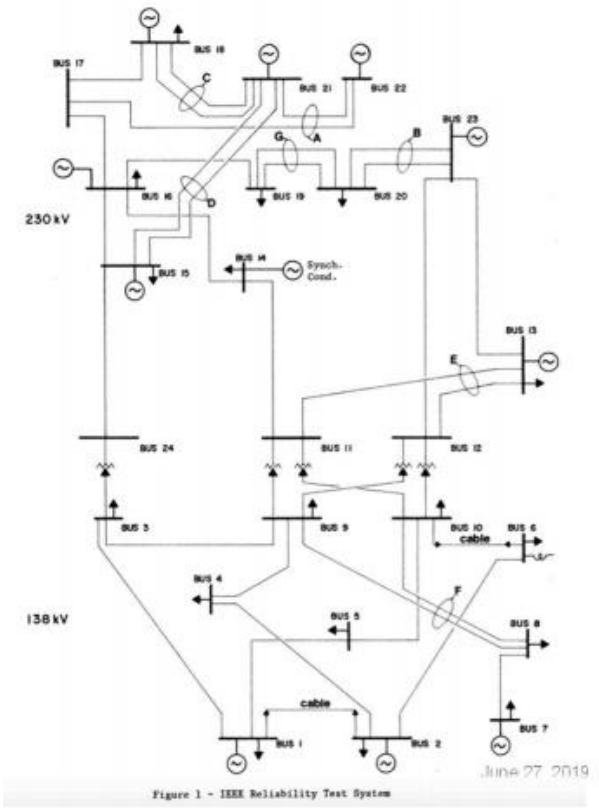



Figure 1 - IEEE Reliability Test System

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### 1996 Update

RTS-96 "The IEEE Reliability Test System-1996. A report prepared by the Reliability Test System Task Force of the Application of Probability Methods Subcommittee", *IEEE Transactions on Power Systems* vol. 14, no. 3, pp. 1010-1020, Aug. 2002.

- http://ieeexplore.ieee.org/document/780914/?reload=true&arnumber=780914&tag=1
- Data available from UW Test Case Archive
  - http://www2.ee.washington.edu/research/pstca/rts/pg_tcarts.htm
- Shortcomings:
  - Data errors
  - Intra-hourly information
  - Congestion
  - Outdated generation fleet (no Gas generation)

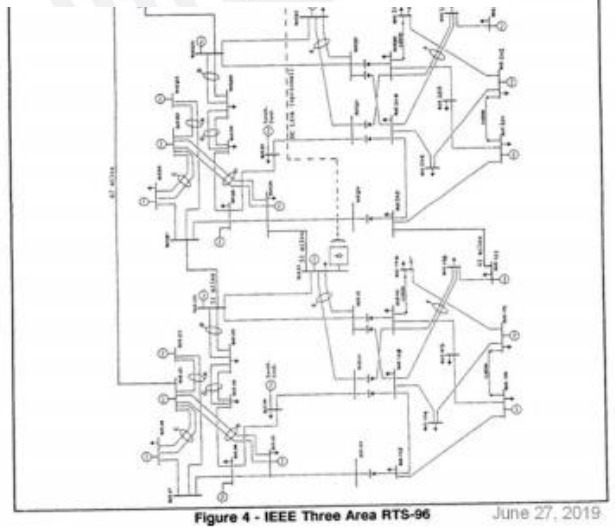

Figure 4 - IEEE Three Area RTS-96

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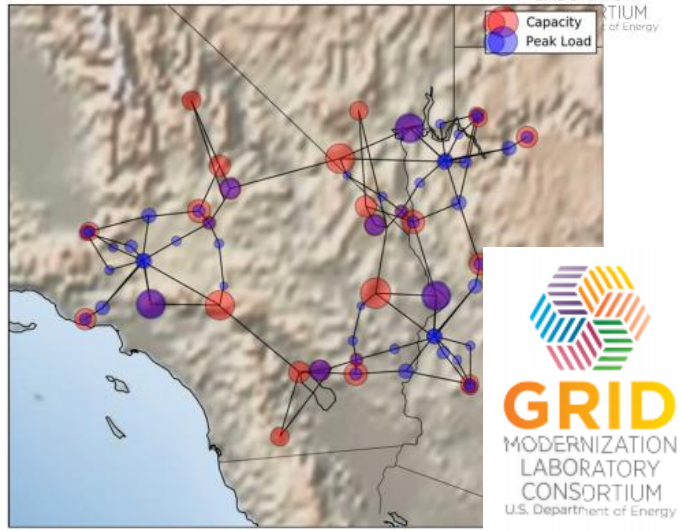
### RTS GMLC Update

Use RTS-GMLC relative node locations from GraphViz

Arbitrary choice: geographic region in SW United States that roughly covers L.A. to L.V.

- Good solar resource
- Good wind resource
- Available demand and hydro data profiles

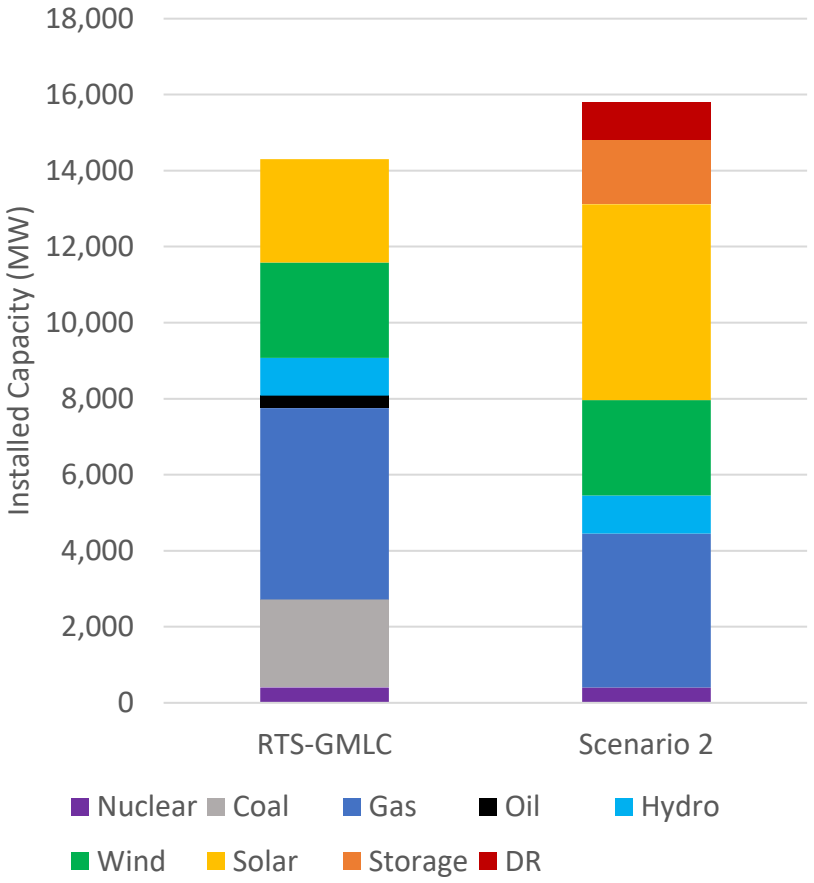


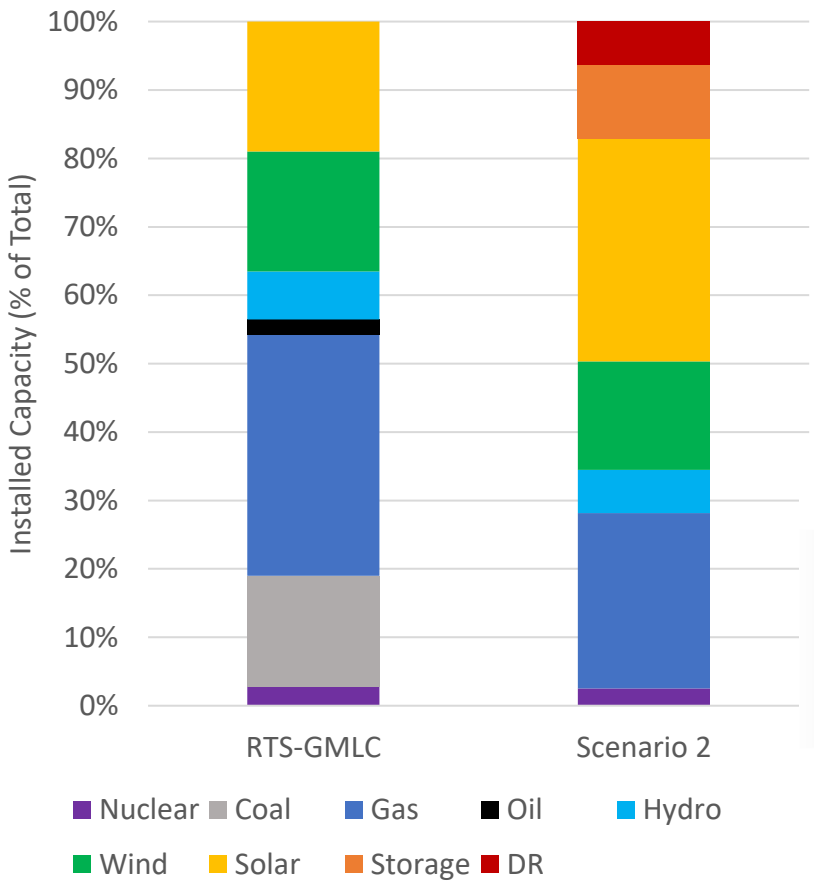

**Not intended to represent existing infrastructure**

Source: Barrows, C. *Reliability Test System of the Grid Modernization Laboratory Consortium (RTS-GMLC)*

# Modeling of a modern power system

## Two scenarios for analysis: “Base Case” and “Modern Power System”




Develop new scenarios that test out significant changes in installed capacity:

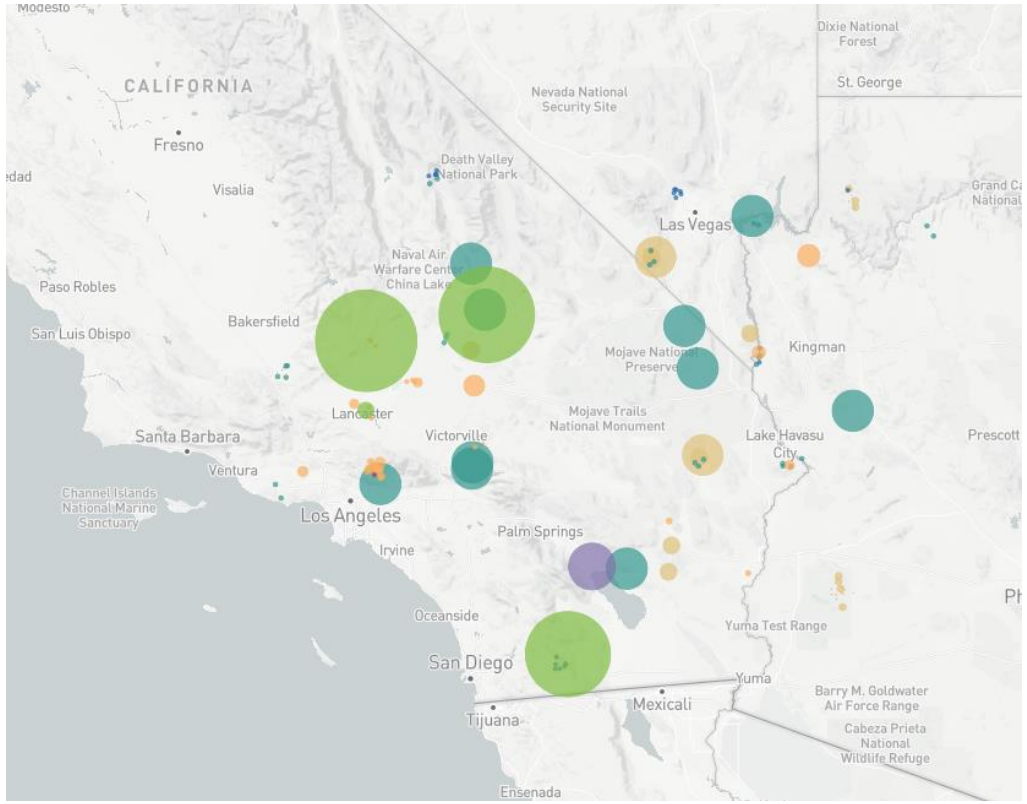
- ✓ Increase in solar
- ✓ Increase in battery storage
- ✓ Increase in demand response
- ✓ Decrease in “baseload”
- ✓ Decrease in “peaking”


Source: ENTSOE MAF

# Evaluate test system across two geographies

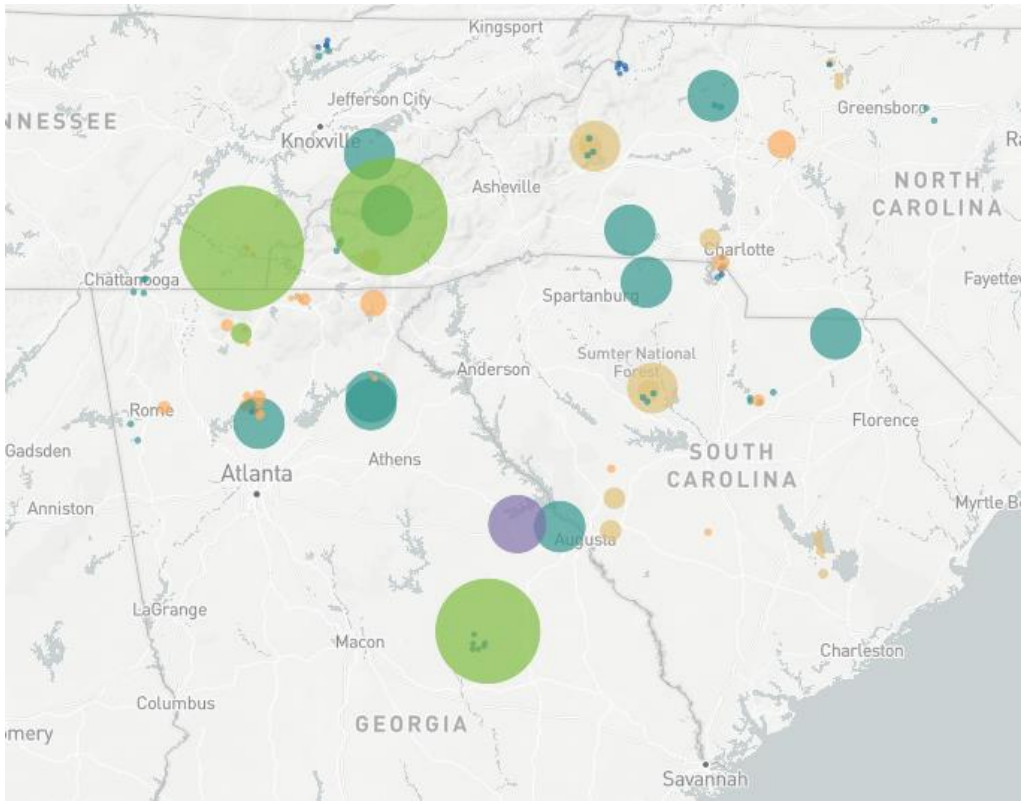
## Southwest

Summer peak load, stronger solar & wind resource




## Southeast (next step)

Dual season peaking, weaker solar & wind resource




**Same installed capacities, different underlying load and weather profiles → ensure results can transfer**

# New Metrics for Resource Adequacy

New metrics or deeper metrics? How to measure RA.

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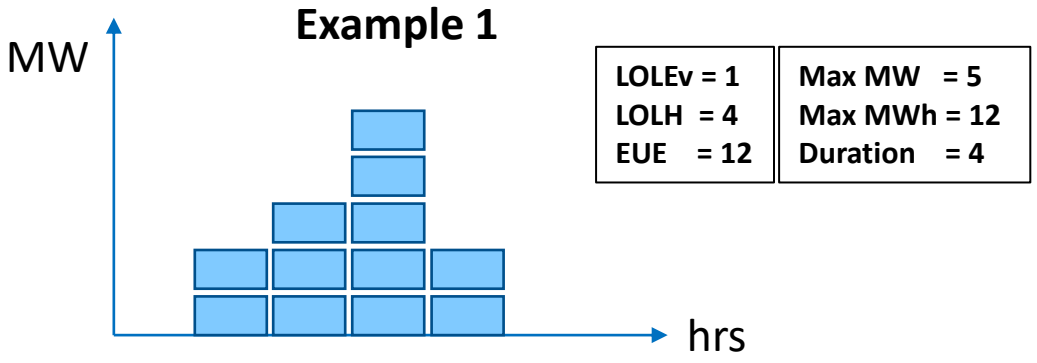
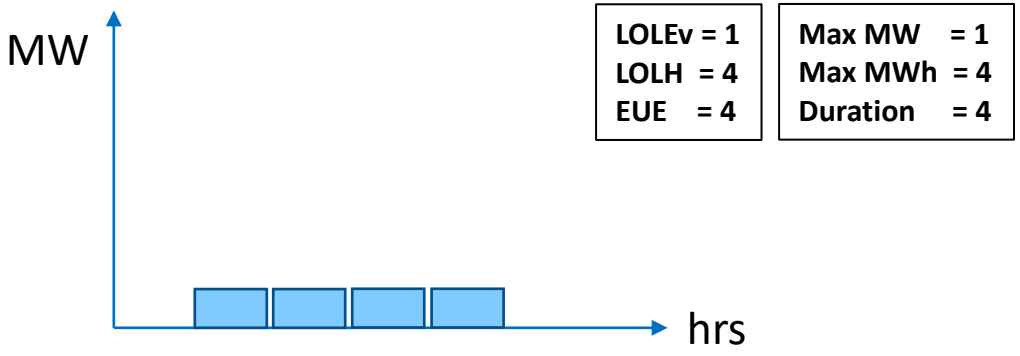
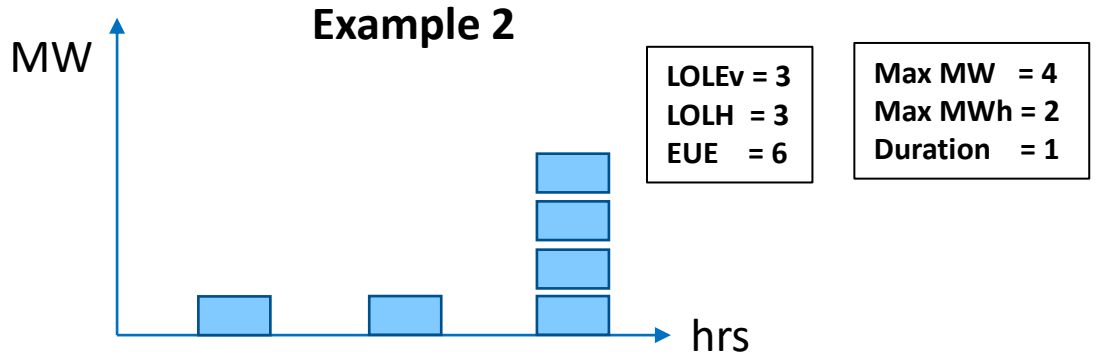
# Quantifying size, frequency and duration of outages is critical to finding the right resource solutions

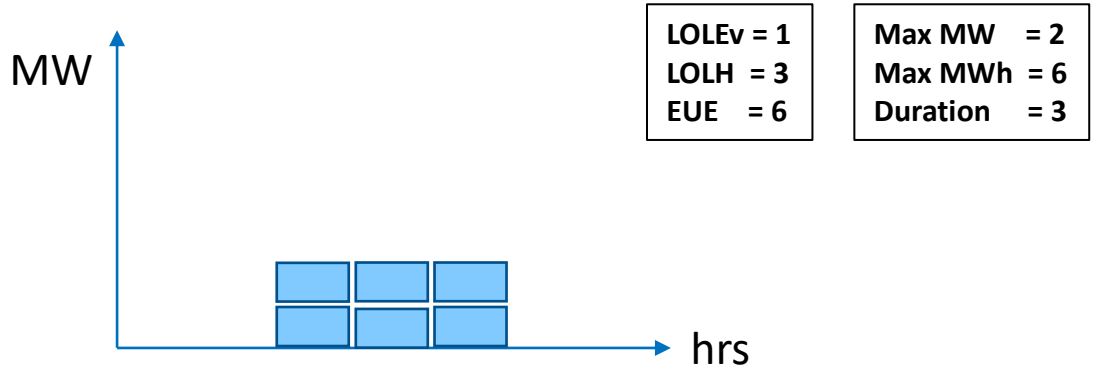
**Same LOLEv and LOLH, but very different events**




**Same LOLH and EUE, but very different events**



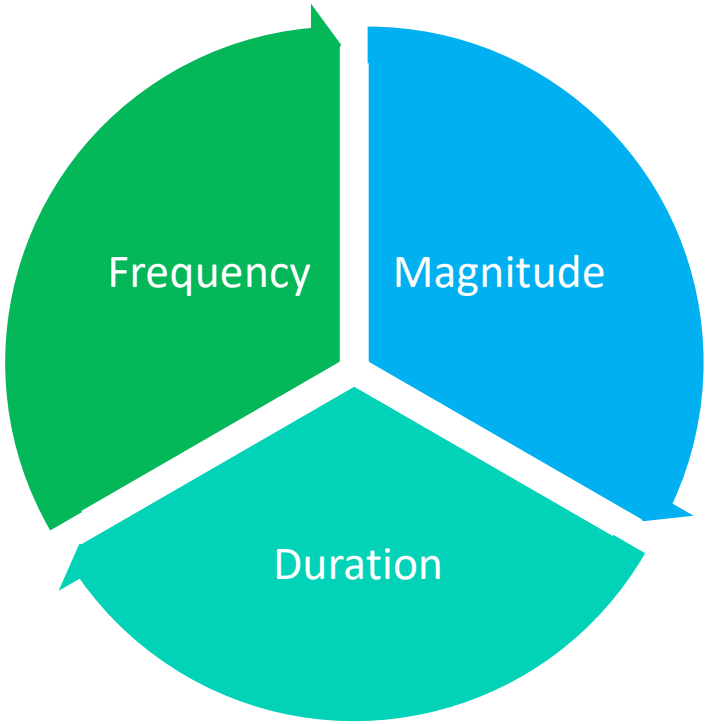




**New & multiple metrics can better select and size appropriate mitigations (DR & BESS vs. thermal capacity)**

# New metrics, more metrics, or deeper metrics? … what needs to change?

**Existing metrics:**

- Loss of Load Expectation (LOLE) & Loss of Load Hours (LOLH) quantify *frequency* of shortfalls, but not magnitude or duration
  … but the industry is well accustomed to "1 day in 10" RA criteria
- Expected Unserved Energy (EUE) quantifies the *magnitude* of shortfalls, but not frequency or duration
  … starting to be recognized as a preferred metric, but lacks common criteria (Normalized EUE getting traction)




A ***combination*** of these metrics can help provide insight into shortfall events… but they all still evaluate ***expected values***

# We need to move beyond expected values

Average of ***all*** samples

Quantifying only samples with shortfall events

| SCENARIO 1 | | Average | Average if… | 25th percentile | Median | 75th percentile | 95th percentile | Max |
|---|---|---|---|---|---|---|---|---|
| LOLE | Days per year | 0.10 | 1.38 | 1 | 1 | 2 | 2 | 3 |
| LOLH | Hours per year | 0.15 | 2.07 | 1 | 1 | 2 | 5 | 11 |
| EUE | MWh per year | 25 | 342 | 73 | 228 | 391 | 912 | 2,348 |

***Same LOLE expected value***

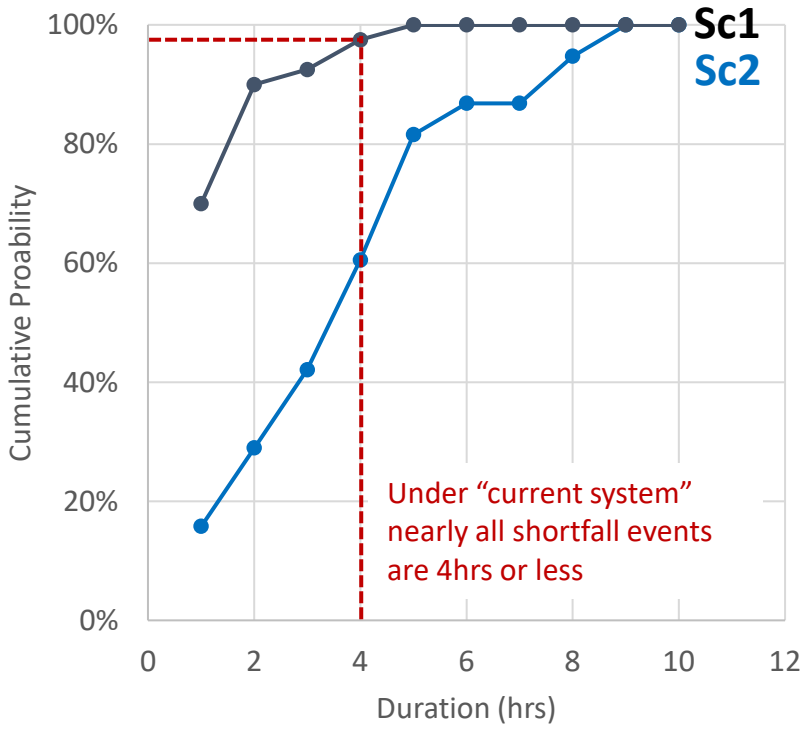
***Very different extreme events***

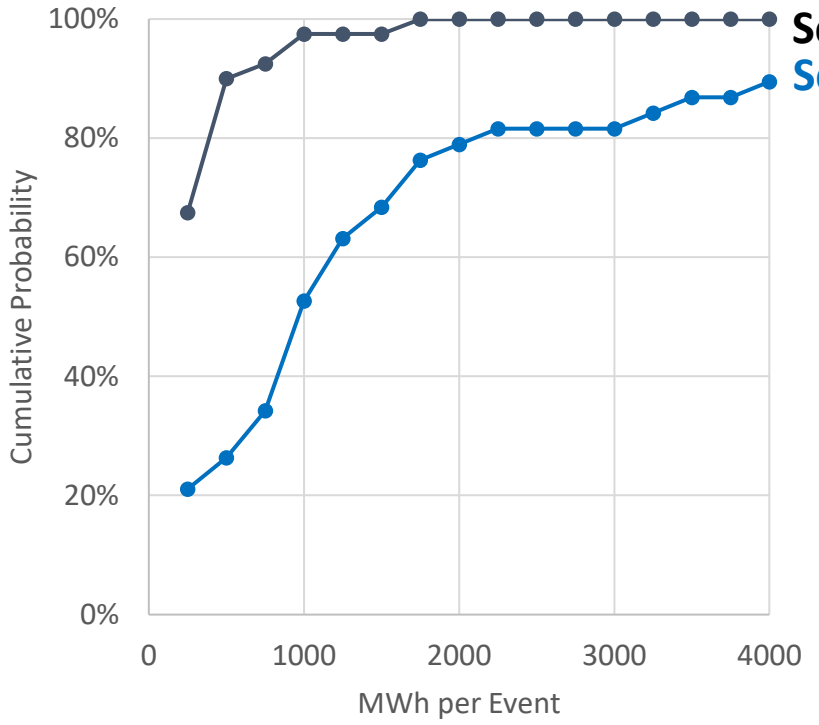
| SCENARIO 2 | | Average | Average if… | 25th percentile | Median | 75th percentile | 95th percentile | Max |
|---|---|---|---|---|---|---|---|---|
| LOLE | Days per year | 0.10 | 1.31 | 1 | 1 | 1 | 3 | 6 |
| LOLH | Hours per year | 0.39 | 5.28 | 2 | 4 | 5 | 14 | 34 |
| EUE | MWh per year | 154 | 2088 | 405 | 918 | 2,249 | 6,792 | 16,563 |

# Evaluating a *distribution* of shortfall events

**We need move beyond expected values and provide information on the distribution of events, to provide emphasis on individual, rather than aggregate, event characteristics.**

## If there is an event… what does it look like?



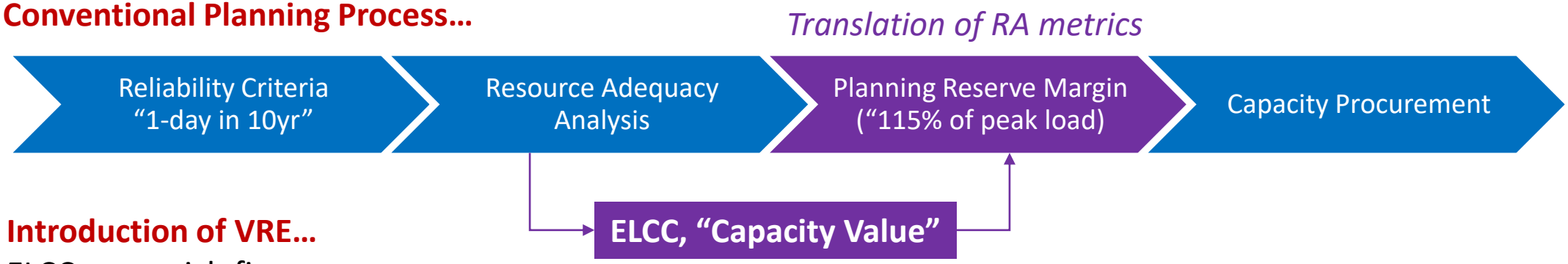

LOLE is an opaque metric when utilized in isolation.

Does not characterize the magnitude or duration of specific outage events, nor their frequency of occurrence.

EUE is an improvement, but it mixes all three dimensions together

# Where does the current planning process break down?

**Conventional Planning Process…**




**Introduction of VRE…**

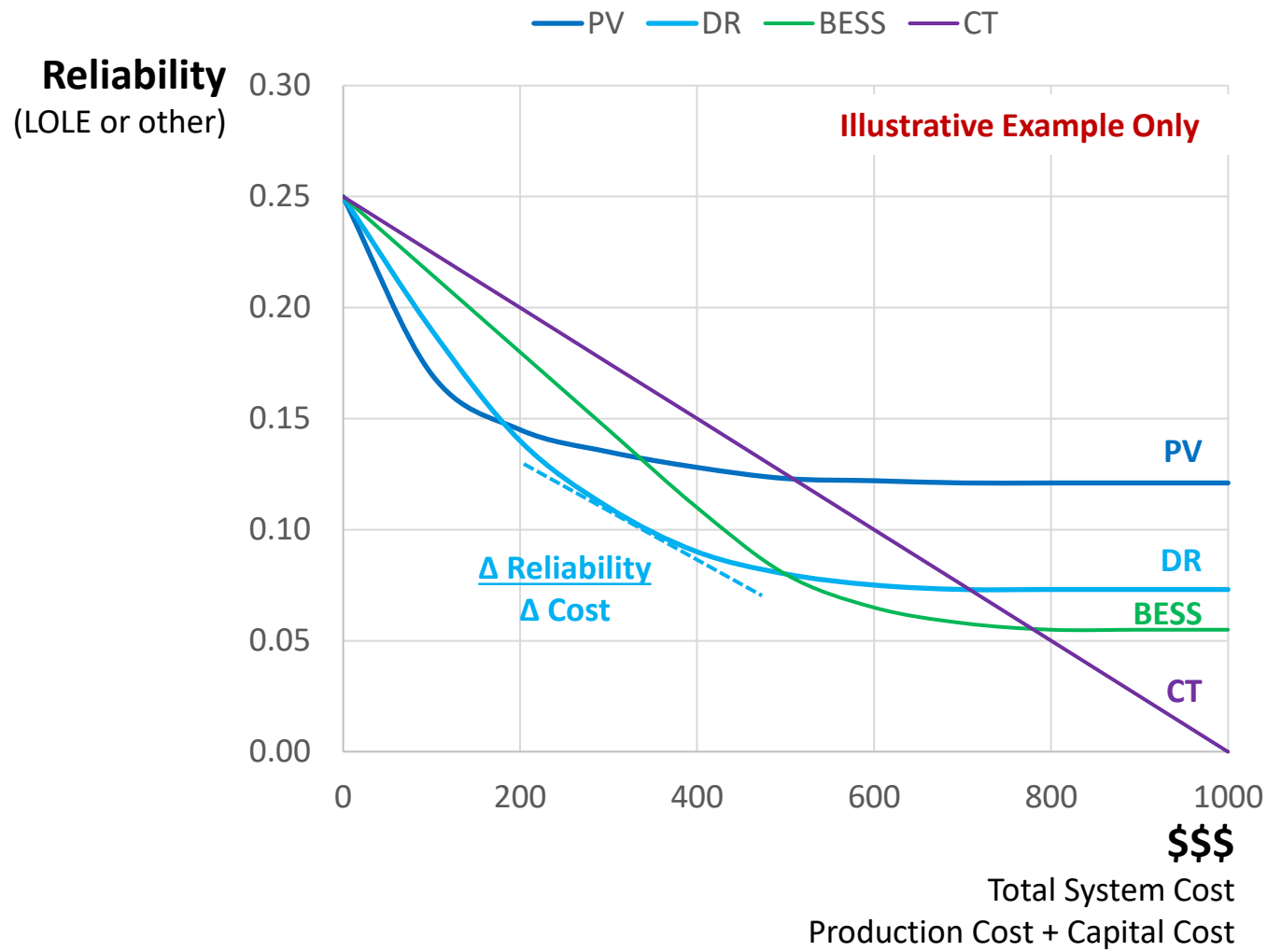
ELCC was quick-fix

**Limitations for future use…**

- Planning reserve margin looks at peak load only, and requires accurate ELCC assumptions across the horizon
- ELCC is an *expected value only,* and is an average across all hours, seasons, and does not differentiate
- ELCC for storage and energy limited resources is highly dependent on the rest of the system
- In order to be useful, ELCC calculations must be routinely updated across the planning horizon and resource mixes

# What if we cut out the “middle man” of PRM?

- Can we have a planning process that does not require the translation of resource adequacy metrics into a PRM?
- ELCC can continue to be used for accreditation and valuation
- Resource adequacy metrics could be used directly in the capacity procurement process
- Quantify a resource’s reliability benefits relative to system cost



# We want to hear from you!


We will also be sharing this work at upcoming ESIG Workshops as part of the System Planning Working Group, Resource Adequacy Task Force. We would like to see you there.

Reach out to derek.stenclik@telos.energy and let us know what you think.