Northwest **Power** and
Conservation Council

May 3, 2022

MEMORANDUM

TO: **Power Committee**

FROM: **John Fazio, Senior Power System Analyst**

SUBJECT: **Discussion of Better Ways to Measure Resource Adequacy for the PNW**

BACKGROUND:

Presenter: John Fazio

Summary: This presentation summarizes the Council's current approach to measuring the adequacy of the PNW power supply and presents a suggested method to improve that assessment. It introduces the concept of using multiple metrics to measure adequacy and discusses ways to consider economic impacts. Further, it provides one potential method of defining and measuring the resiliency of the bulk power system.

Relevance: Resource adequacy is a critical component of the Council's mandate to develop a regional power plan that "ensures an adequate, efficient, economic and reliable power supply." The Council established a resource adequacy standard in 2011, which is used both as an early warning to gauge whether resource development is keeping up with demand growth and as a guide in developing the Council's resource acquisition strategy.

Background: Power customers expect a reliable and adequate supply that provides electricity at a reasonable cost. The challenge for electric utilities is to assess what level of adequacy its customers are willing to pay for. In general, the higher the level of adequacy, the higher the electricity rates. It

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is difficult to set a universal adequacy standard because different customer classes are willing to pay different amounts for different levels of service. But no utility plans for a 100-percent adequate supply because the cost would be unacceptable. Traditionally, providers have planned for a level of adequacy that accommodates a general cross-section of customers. Those that require a higher level of adequacy (e.g., hospitals and data centers) acquire their own supplemental resources.

An adequate power supply has the ability to meet the electric energy requirements of its customers within acceptable limits, considering a reasonable range of uncertainty in resource availability and in demand. Resource uncertainty includes forced outages, early retirements and variations in wind, solar and market supplies. Demand uncertainty includes variations due to temperature, economic conditions, and other factors. Resource availability and demand are also affected by environmental policies, such as those aimed at reducing greenhouse gas emissions. The Council uses a Monte-Carlo simulation model to assess the likelihood of a future year having one or more disruptions to service, when considering many different combinations of future resource availabilities and demands. This metric, referred to as the annual loss of load probability (LOLP), has been instrumental in the development of the Council's power plans since the early 2000s. However, due to significant changes in the power industry (e.g., increasing development of renewable and distributed resources, adoption of clean-air laws and a more dynamic market environment), LOLP is no longer sufficient to accurately measure the adequacy of the region's power supply.

The frequency, duration, magnitude, and seasonality of potential shortfalls are significant considerations when assessing an acceptable level of risk. For example, a system deemed to be adequate using the current standard (i.e., LOLP is less than 5 percent) may have shortfall events that are unacceptably large or lengthy. Conversely, a system deemed to be inadequate may have shortfall events that are small and relatively easy to mitigate. Today's discussion provides examples of metrics that measure frequency, duration, and magnitude, which could be incorporated into the Council's adequacy standard.

More Info: Three Potential Adequacy Metrics for the PNW
https://nwcouncil.box.com/s/lwweiyj6y2vs7hrcwht92rtp2sdzq3g7

Economics of Adequacy
https://nwcouncil.box.com/s/7k9fv1eum2vjjhu19zu341wbw9ingnkf

IEEE Interpretation of the LOLE Adequacy Metric
https://nwcouncil.box.com/s/hn8chh2ixlhi3d90fphlwkppniv0ug6w

Discussion of Better Ways to Measure Resource Adequacy for the PNW

NW Power and Conservation Council
Power Committee Meeting

John Fazio, Senior Power Systems Analyst

May 11, 2022

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Outline

- Reliability vs. Adequacy
- Resource Adequacy Standard
  - Council's current standard
  - Limitations of the current standard
  - Recommendations to improve the standard
- Resiliency
- Next Steps and Timeline

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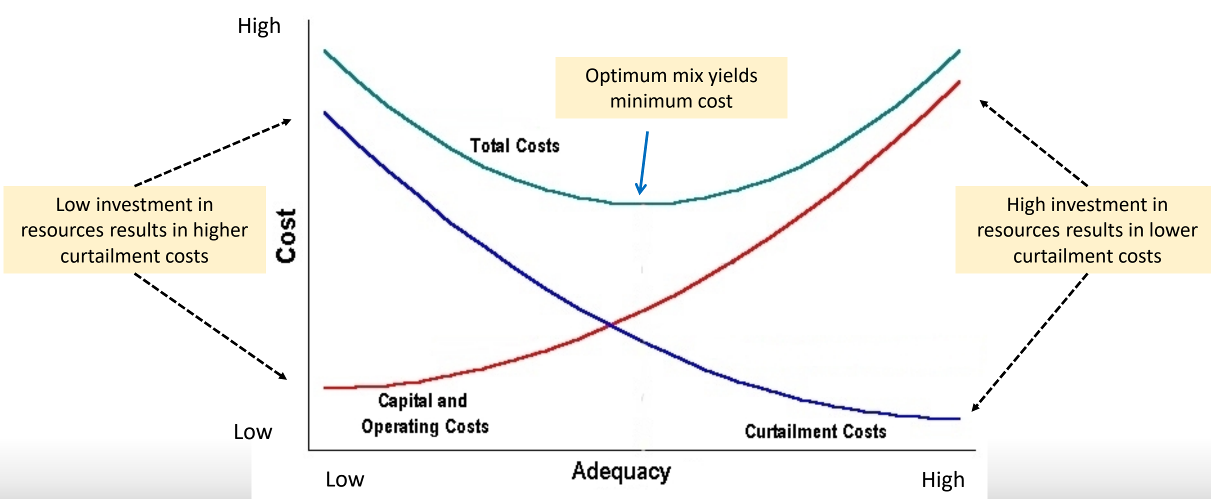
Reliability vs. Adequacy

North American Electric Reliability Corporation (NERC) Definition

- ***Adequate*** and ***Reliable*** have specific meanings in the power industry. Adequacy is a component of reliability. A power system is reliable if it is both adequate and secure
- ***Adequate*** - the electric system can supply the aggregate electrical demand and energy requirements of the customers at all times[1], taking into account scheduled and reasonably expected unscheduled outages of system elements
- ***Secure*** - the electric system can withstand sudden disturbances, such as electric short circuits or unanticipated loss of system elements

[1]The phrase "at all times" does not imply that utilities plan for systems that are 100% adequate. They should plan for sufficient capability to cover "reasonably expected" unscheduled outages.

Tradeoff: Adequacy vs. Cost

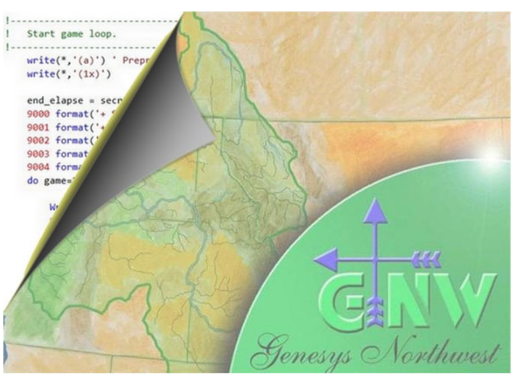


Resource Adequacy Assessment

A resource adequacy assessment is a measure of the ability of a power system to meet the electric energy requirements of its customers within acceptable limits, considering a reasonable range of uncertainty in resource availability and in demand.

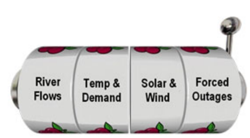
- An adequacy standard is composed of two parts
  - Metric (measure of probability, frequency, magnitude or duration of shortfalls)
  - Threshold (limit for each metric)
- No industry-wide standard
  - Most common metric is the Loss of Load Expectation (number of days with a shortfall)
  - Most common threshold for LOLE is 1-day-in-10-years
- Council's current adequacy standard
  - Metric = Annual loss of load probability (LOLP)
  - Threshold = 5 percent max

Assessing Resource Adequacy for the PNW



The Council deems the power supply to be adequate if the likelihood of having one or more shortfalls in a future year is less than or equal to 5 percent (i.e., LOLP ≤ 5%)

- **GENESYS Model:** A chronological hourly simulation of all PNW resources for one year
- Thousands of simulations with different combinations of future unknowns



- Record all hours when load cannot be served
- Annual Loss of Load Probability:

$$LOLP = \frac{\text{Number of simulations with shortfalls}}{\text{Total number of simulations}}$$

What does LOLP really Mean?

Resource	Description
Firm Hydro and Thermal	From lowest to highest operating cost
Non-firm and Markets	In-region and out-of-region markets, surplus hydro, borrowed hydro
Standby Resources Type 1	Non-declared utility resources (diesel generators, etc.)
Standby Resources Type 2	Buy-back provisions on load
Emergency Action 1	More expensive non-declared resources or contract provisions
Emergency Action 2	Governor's call for conservation
Emergency Action 3	Rolling brown outs or black outs

Modeled in GENESYS

Not Modeled

LOLP = likelihood of taking emergency actions, not necessarily curtailment

The Trouble with LOLP

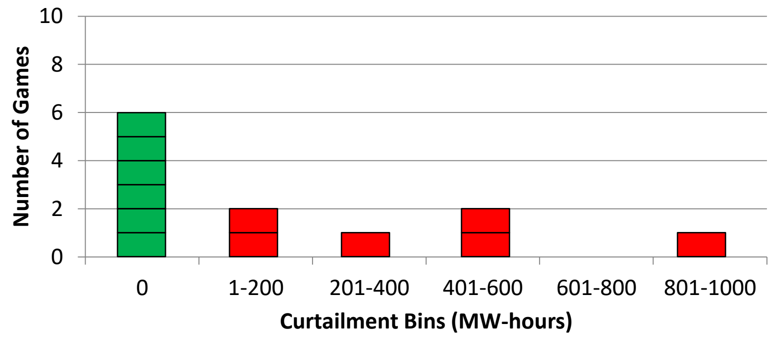
- LOLP does not measure shortfall magnitude, duration or frequency, which can be significant factors in determining acceptable risk

- Two cases that illustrate the limitation of LOLP:
  - Case 1: Deemed Adequate (but is not)
    1 out of every 20 years has 100% curtailment in every hour, LOLP = 5%
  - Case 2: Deemed Inadequate (but is)
    Every year has a 1 MW-hour curtailment, LOLP = 100%

Different power supplies with same LOLP can have vastly different curtailment magnitude (examples on the next four slides)

Counting Curtailments

(Step through games and fill curtailment bins)



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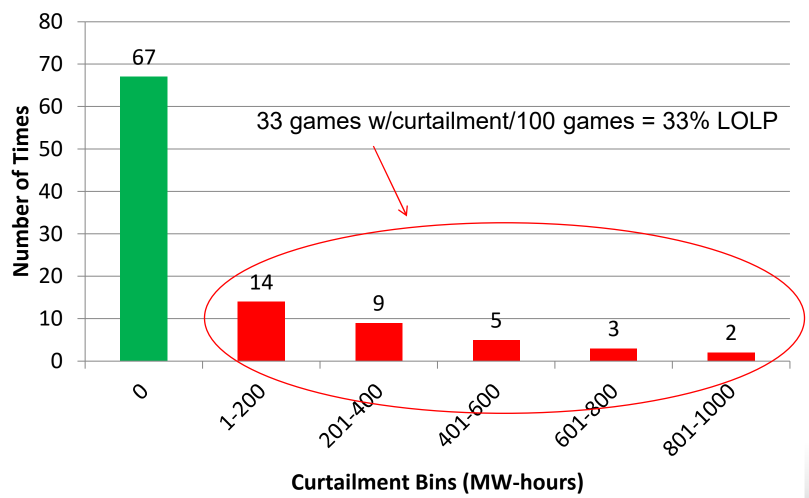
Curtailment Histogram

100 Games



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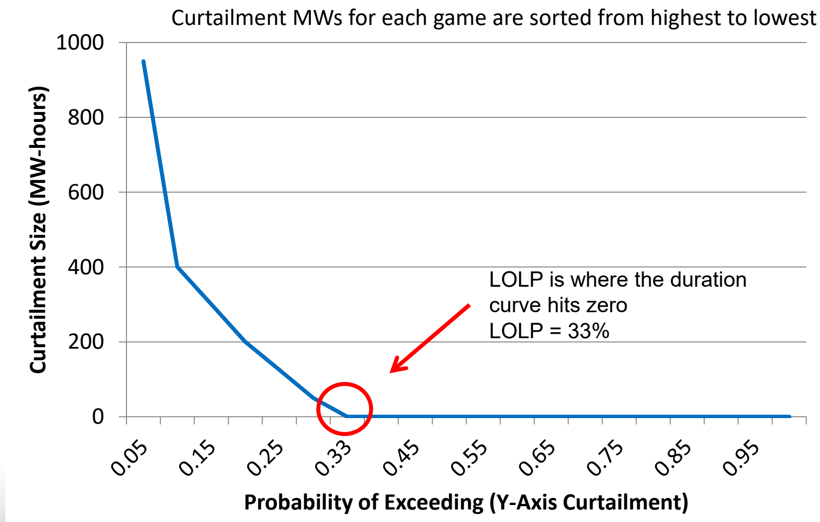
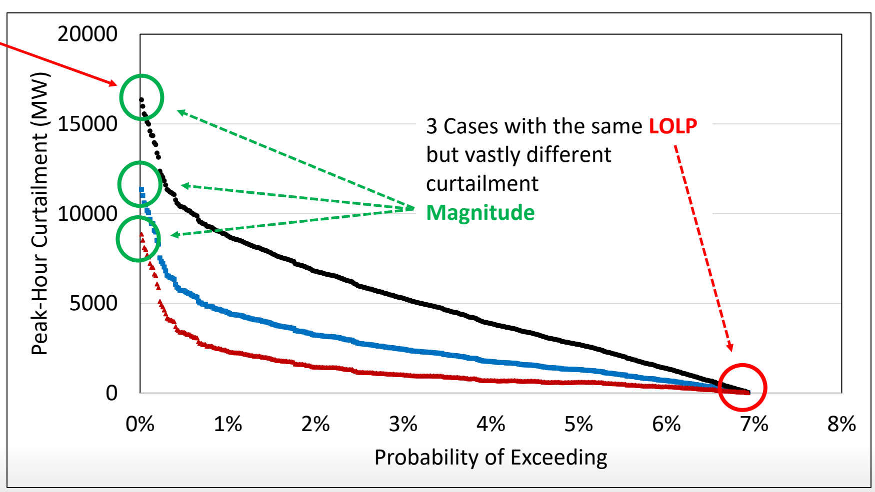
"Flip" Axes to make Duration Curve



3 Systems: Same LOLP but different curtailment size

(A 6000-simulation illustration)

Added Note:
No utility plans for a 100% adequate supply because the cost to cover an event that occurs (in this example) only once in 6000 years would be unacceptable.



Ways to Improve the Adequacy Standard

1. Multiple metrics (to measure event frequency, duration and magnitude)
   - Loss of Load Events (LOLEV) – expected shortfall events/year
   - Loss of Load Hours (LOLH) – expected shortfall hours/year
   - Expected Unserved Energy (EUE) – expected unserved demand/year (in MW-hours)
2. Add a metric for Resiliency – e.g., size of an unlikely but high impact event
   - Value at Risk (VaR) – magnitude of the N^{th} percentile worst event
   - Conditional value at risk (CVaR) – average magnitude of the N% worst events
3. Shorter temporal periods (e.g., months or seasons instead of annual)

Potential Adequacy and Resiliency Metrics

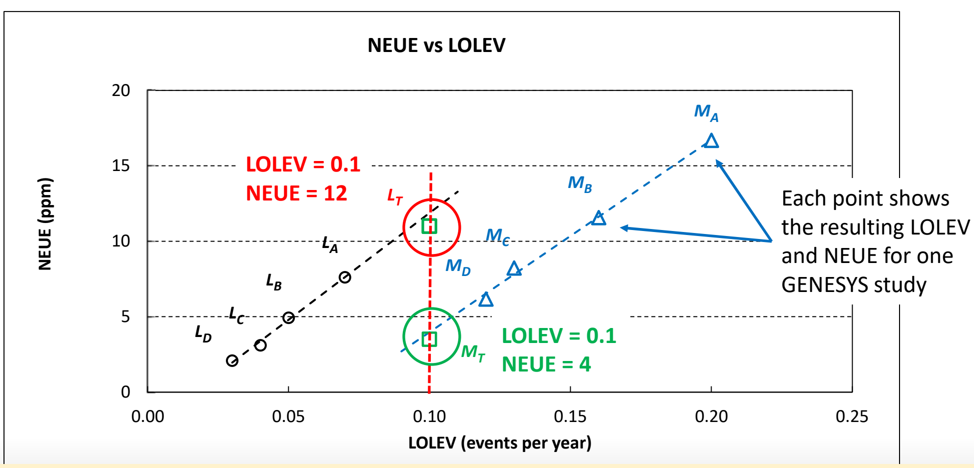
	Metric	Description
Adequacy Metrics	LOLEV (Events/year) Annualized frequency	Number of events divided by the number of games (an event is a contiguous set of hours with curtailment)
	LOLH (Hours/year) Annualized duration	Number of curtailment hours divided by the number of games
	EUE (MW-hours/year) Annualized magnitude	Total unserved demand divided by the number of games
Resiliency Metrics	VaR (MW-hours)	N^{th} percentile worst single-hour curtailment or worst annual unserved demand
	CVaR (MW-hours)	Average of the worst N% worst single-hour curtailments or worst N% annual unserved demand

A Multi-metric standard is better but setting adequacy limits can be challenging

- Knowing the size, duration and frequency of shortfall events and their seasonality leads to better resource acquisition strategies
- Although related, the *size*, *duration* and *frequency* of events are not strongly correlated, that is, setting a limit for one does not yield unique limits for the other two (see next slide)
- Therefore, limits for all three metrics must be set independently

Systems with the same LOLEV can have different EUEs

(NEUE or normalized EUE is the EUE divided by expected demand)



Studies L_T and M_T both have an LOLEV of 0.1 events/year, but L_T has a NEUE that is 3 times larger than that for M_T.

Setting Limits for Adequacy Metrics

- Define undesired conditions (shortfall events) in terms of magnitude and duration and how often they would be tolerated (frequency), then translate these data into limits for EUE, LOLH and LOLEV[1]
- Investigate using the value of lost load (VOLL) to aid in setting limits

Present the proposed methodology to the RAAC for review and forward comments and suggestions to the Council for consideration

[1]Tacoma Power and Seattle City Light have already implemented a multi-metric adequacy standard in their integrated resource plans.

Defining Undesirable Shortfall Events

- System operators define situations they would like to avoid
- Could be based on a set of (usually high-cost) emergency actions they would prefer to only use rarely
- Define the magnitude and duration of undesired shortfalls and determine the tolerance for such events
- Convert undesired event magnitude, duration and frequency into LOLEV, LOLH and EUE limits

- *Example:*
  - *Tolerance of one event per 10 years becomes an LOLEV of 0.1/year*
  - *Event duration of 10 hours becomes an LOLH of 1 hour/year*
  - *Event magnitude of 10000 MW-hours becomes an EUE of 1000 MW-hours/year*

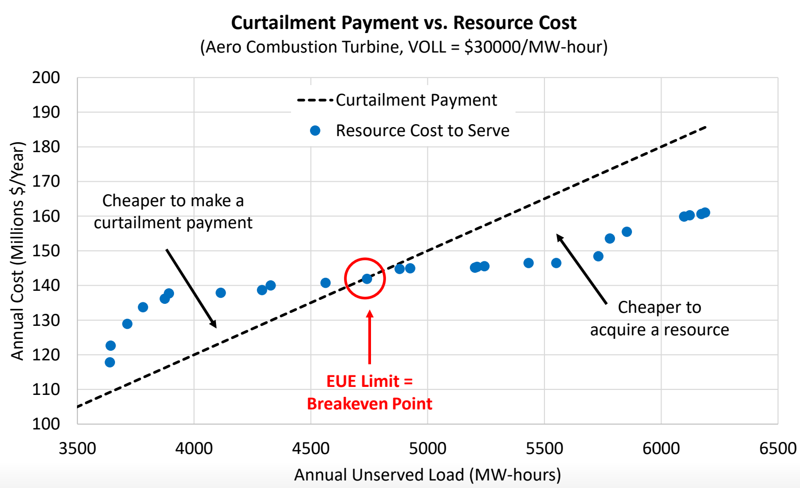
Using VOLL to aid in setting Adequacy Limits

- The Value of Lost Load is the rate of payment that customers would accept for a curtailment ($/MW-hour)
- A new resource should be added only when its cost to serve expected loss of load is less than the curtailment payment to customers

VOLL is difficult to assess and varies widely by customers classes. Nonetheless, it is used in some areas. For example, the UK uses a VOLL of about $30000/MW-hour to set its adequacy standard of no more than 3 shortfall hours per year (LOLH = 3 hours/year).

Using VOLL to set an EUE Limit

For increasing amounts of unserved load (X-axis), this graph shows both the payment made to customers for not being served and the resource cost to serve them.



New resources should be acquired when the expected annual unserved load (EUE) is greater than the limit

Bulk Power System Resiliency[1]

- Resiliency has been generally defined as "the ability to prepare for and adapt to changing conditions and withstand and recover rapidly from disruptions."
- Resiliency includes the ability to withstand and recover from deliberate attacks, accidents, or naturally occurring threats or incidents, such as recent severe weather events in Texas and California.
- Measuring resiliency is a relatively new area of research and development.

Currently there is no widely accepted metric or standard for resiliency.

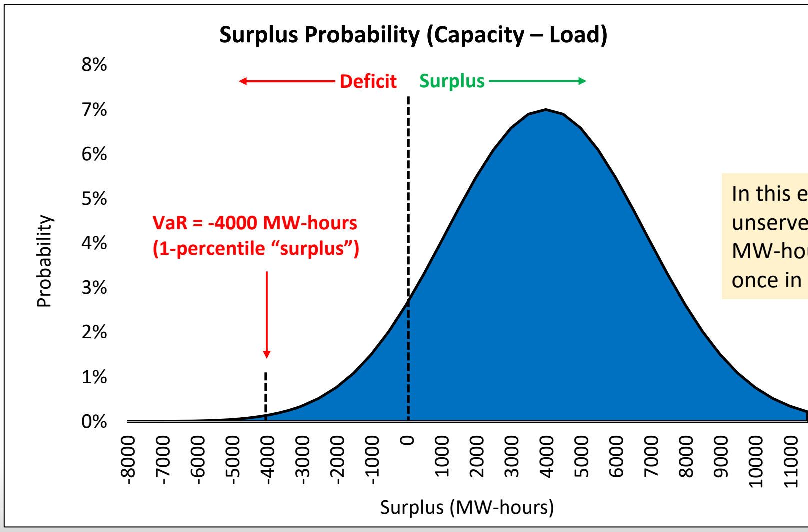
[1]It should be noted that overall resiliency must include measures for distribution systems and for EE programs that make homes and businesses more resilient to disruptions (e.g., being able to withstand a loss of power for longer periods of time).

One approach to measuring resiliency

- Identify a low probability but catastrophic (high impact) event that would be difficult to recover from
- Assess the loss of service (MW-hours) for that event
- One method[1] is to use the Value at Risk (VaR) metric:
  - Determine the tolerance (e.g., N^{th} percentile) for a catastrophic event
  - Set the N^{th} percentile VaR limit to the expected loss of service for the event
  - Example of a 1-percentile (100-year event) VaR is shown on the next slide

[1]However, this only works if all events that cause significant disruptions to service (such as wildfires, earthquakes, floods, acts of war or terrorism, etc.) are considered in the adequacy model.

Illustration of a 1-Percentile VaR

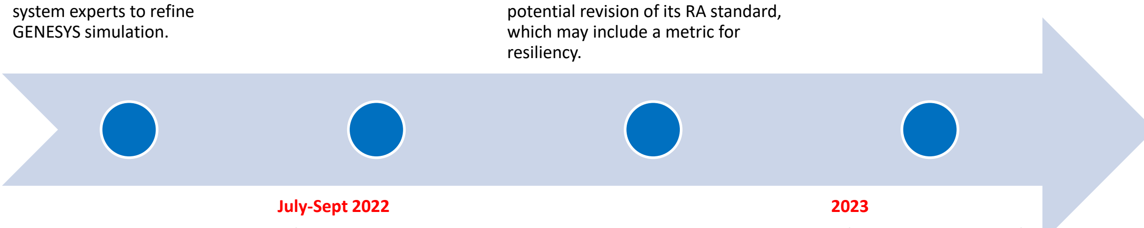


In this example, unserved load is 4000 MW-hours or greater once in every 100 years.

Project Timeline

May-June 2022
Staff reviews hydro operating constraints and market fundamentals, engages with system experts to refine GENESYS simulation.

Oct-Dec 2022
Council reviews analyses and RAAC recommendations, releases RA Assessment. Council discusses potential revision of its RA standard, which may include a metric for resiliency.



July-Sept 2022
Advisory committees review preliminary RA assessment (in particular hydro simulation and market availability) and make recommendations to Council.

2023
Advisory committees and Council consider revising the current RA standard and how to incorporate a metric for resiliency.