Northwest **Power** and **Conservation** Council

September 28, 2022

MEMORANDUM

TO: **Power Committee**

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

SUBJECT: **Primer on Adequacy Metrics and Update on Adequacy Assessment**

BACKGROUND:

Presenter: John Fazio

Summary: The power committee will be briefed on a proposed method to improve how resource adequacy is assessed. It introduces the concept of using multiple metrics to measure adequacy, including a measure of financial risk. Feedback from the Resource Adequacy Advisory Committee, who's members reviewed the proposal in September, will be presented. The committee will also be updated on the status of the current resource adequacy assessment.

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: An adequate power supply meets the electric energy requirements of its customers within acceptable limits, considering a reasonable range of uncertainty in resource availability and in demand. The Council uses a

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Monte-Carlo simulation model to assess the likelihood of a future year having one or more energy shortfalls. 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 all risks to electricity customers. Thus, staff (in conjunction with the Resource Adequacy Advisory Committee) has developed an enhanced adequacy standard for the Council to consider and test. The objectives of the proposed standard are to:

- Limit occurrences of big capacity and energy shortfalls
- Prevent overly frequent use of emergency measures
- Prevent spending too much for shortfall mitigation
- Identify the timing (seasonality) of shortfalls

Primer on Adequacy Metrics and Adequacy Assessment Update

NW Power and Conservation Council
Power Committee Meeting

October 5, 2022

Agenda

- Objectives for revising the Council's adequacy standard
- Metrics used to achieve those objectives
- Strawman proposal and RAAC Feedback
- Adequacy assessment timeline

Adequacy Standard and its Limitations

- *Current standard*
  - Power supply is adequate if the annual LOLP is 5% or less
  - Measures the likelihood of a future year having *one or more* shortfall events of any size and duration

- *Limitations*
  - No measure of *shortfall event* size, duration or frequency
  - No measure of shortfall cost
  - No indication of shortfall timing (i.e., seasonality)

Objectives for the New Standard

- Prevent overly frequent use of emergency measures
- Prevent spending too much for shortfall mitigation
- Limit occurrences of big capacity and energy shortfalls
- Identify the timing (seasonality) of shortfalls

Prevent High Use of Emergency Resources

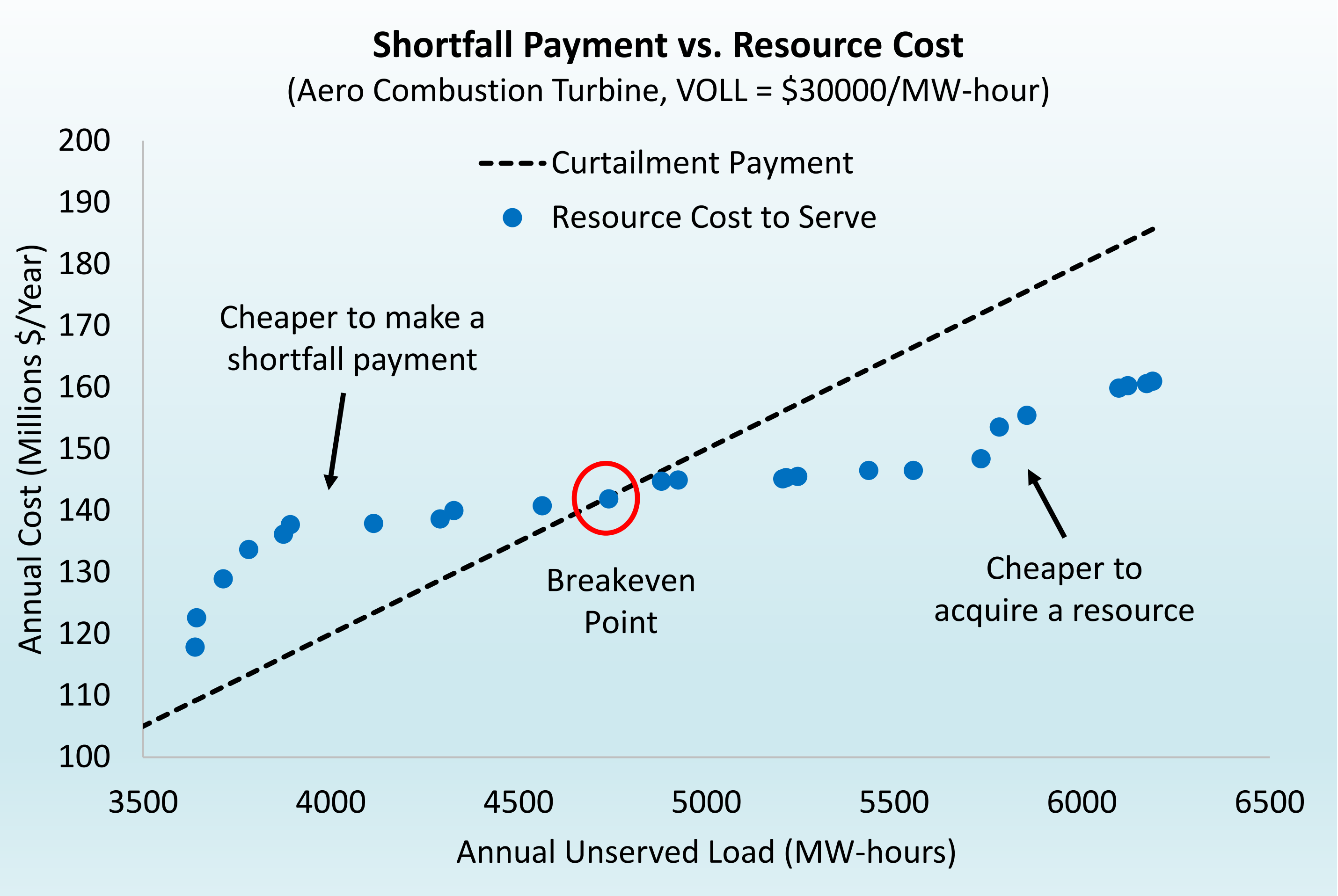
- *Probability vs. Frequency*
  - LOLP is the probability that a future year will have one or more shortfall events
  - Loss of Load Expectation (LOLE) is the number of shortfall days over a specified time (e.g., 1 day in 10 years) but it is not a true measure of shortfall event frequency
  - *The frequency of shortfall events (e.g., events/year) is a better gauge of how often emergency resources would be used*

- *LOLEV (Loss of Load Events)*
  - Frequency of shortfall events, that is, the expected number of shortfall events/year
  - Equals the total number of shortfall events divided by the total number of simulations

Prevent High Cost of Shortfall Mitigation

- *Shortfall Payment vs. Resource Cost*
  - Shortfall payment = Value of lost load times expected unserved energy
  - Resource cost = Cost of new entry times resource capacity needed for shortfall
  - *Resources should not be acquired unless their cost is less than the shortfall payment (see example in the chart)*

- *LOLH (Loss of Load Hours)*
  - Expected number of shortfall hours/year
  - *LOLH can be defined to set the maximum number of shortfall hours/year before new resources should be acquired (see next slide)*
  - In other words, a power supply is inadequate if its LOLH is greater than the LOLH adequacy limit.



Setting the LOLH Limit using VOLL

LOLH can be estimated for a specified VOLL and resource using the equation below

$$\boldsymbol{LOLH = (CONE - MR/CAP) / (VOLL - OC)}$$

Where:
- VOLL = Value of lost load ($/MW-hour)
- CONE = Cost of new entry ($/MW per year)
- CAP = Nameplate capacity (MW)
- OC = Operating cost ($/MW-hour)
- MR = Market Revenue ($/year) = Profit margin ($/MW-hour) × Marketed energy (MW-hours/year)

Note: Equation above is often simplified[1] assuming that MR/CAP and OC are small relative to CONE and VOLL, respectively. However, while OC << VOLL, market revenues can be significant.

$$\boldsymbol{LOLH = CONE/VOLL}$$

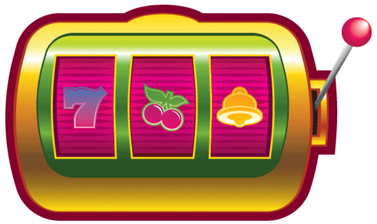
[1]Using the simplified equation, the National Grid (UK) set its LOLH limit to 3 hours/year, assuming a VOLL of £17,000/MW-hour and a CONE of £49,000/MW per year. See page 26 in National Grid's document below. http://site.ieee.org/pes-rrpasc/files/2019/04/National-Grid-Security-of-Supply-International-Review-Final-IEEE-v2.pdf.

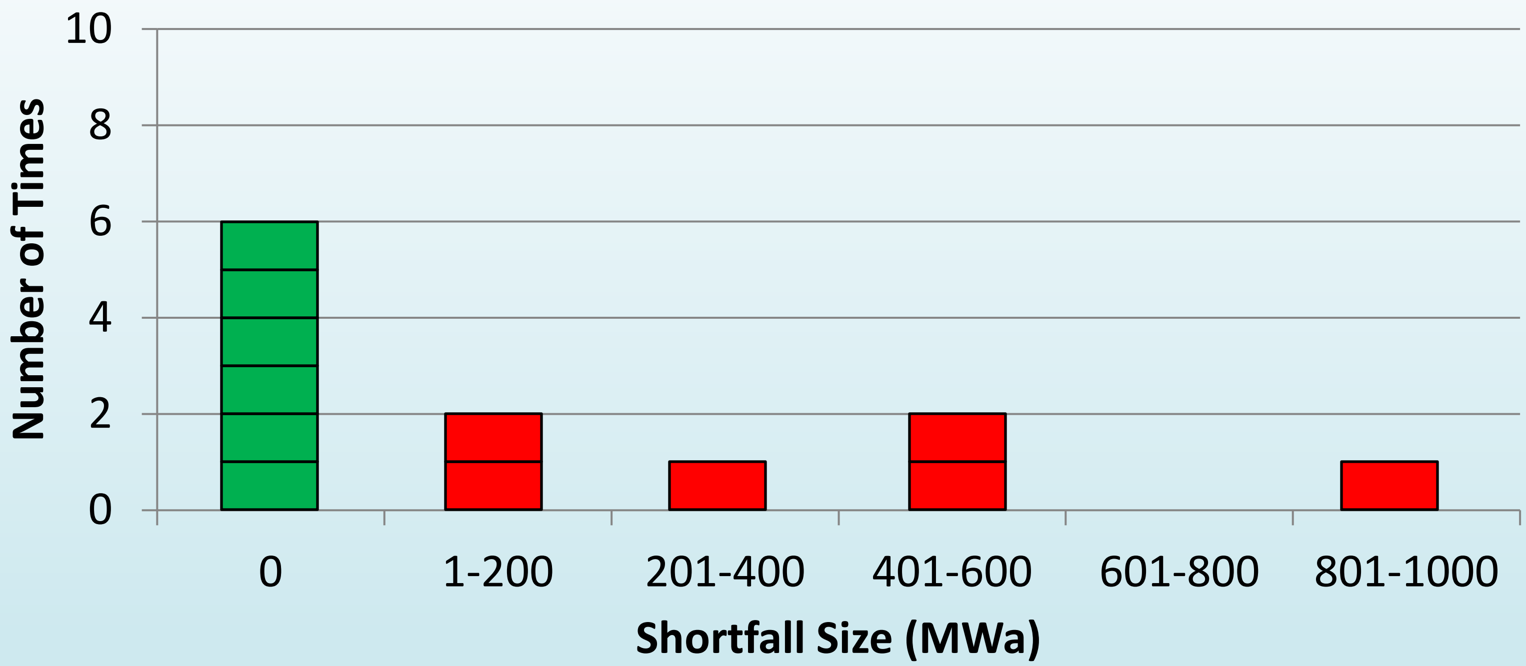
Example of using VOLL to set LOLH

- *LOLH = 2 hours/year (using the simplified equation)*
  - CONE = $50,000/MW per year
  - VOLL = $25,000/MW-hour
- *LOLH = 1 hour/year (using the full equation)*
  - OC << VOLL
  - MR/CAP = $25,000/year per MW of capacity, assuming:
    - A profit margin of $10/MW-hour
    - 2,500 MW-hours/year of marketed energy per MW of capacity

Counting Shortfalls

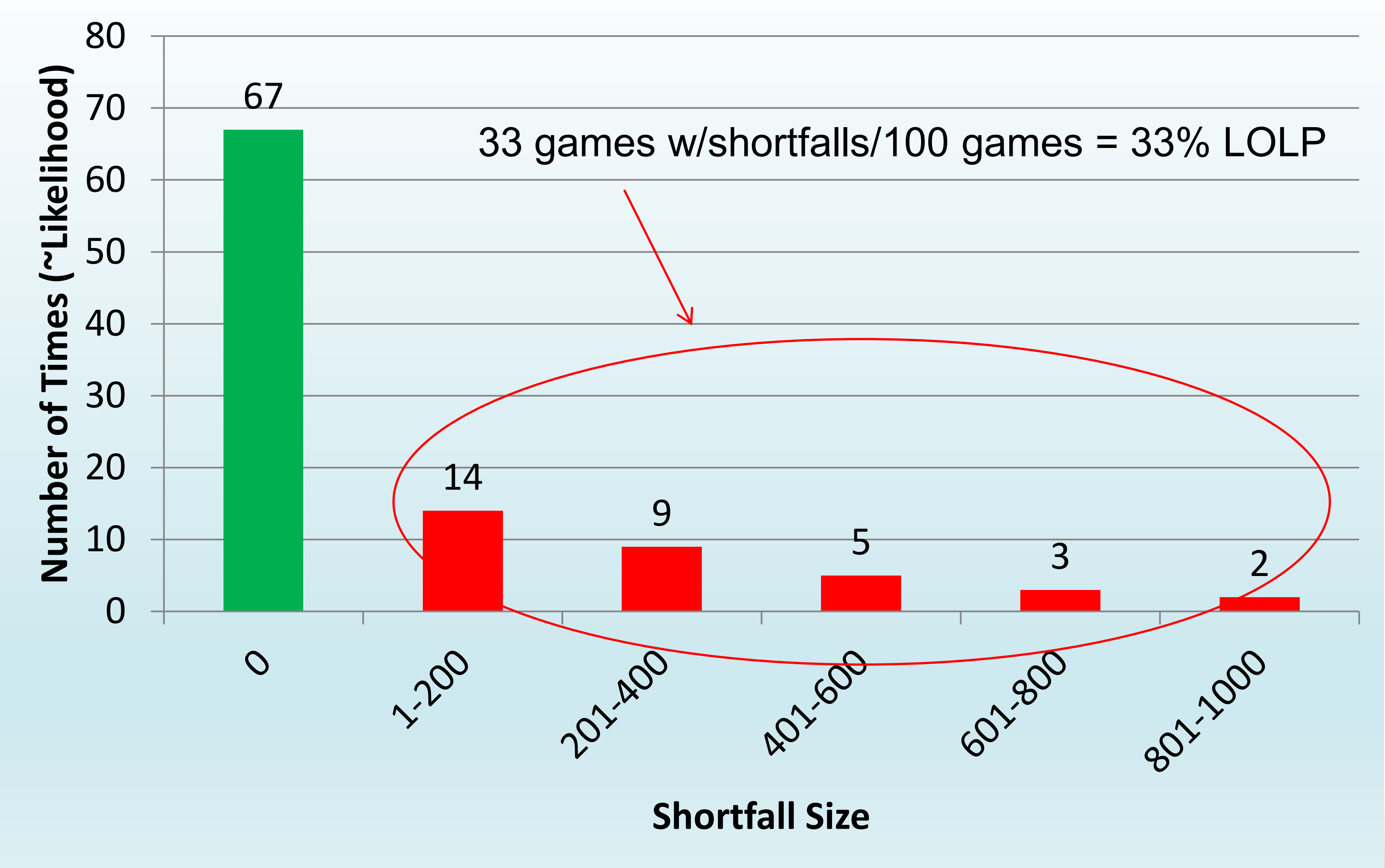
(Step through games and fill shortfall bins)



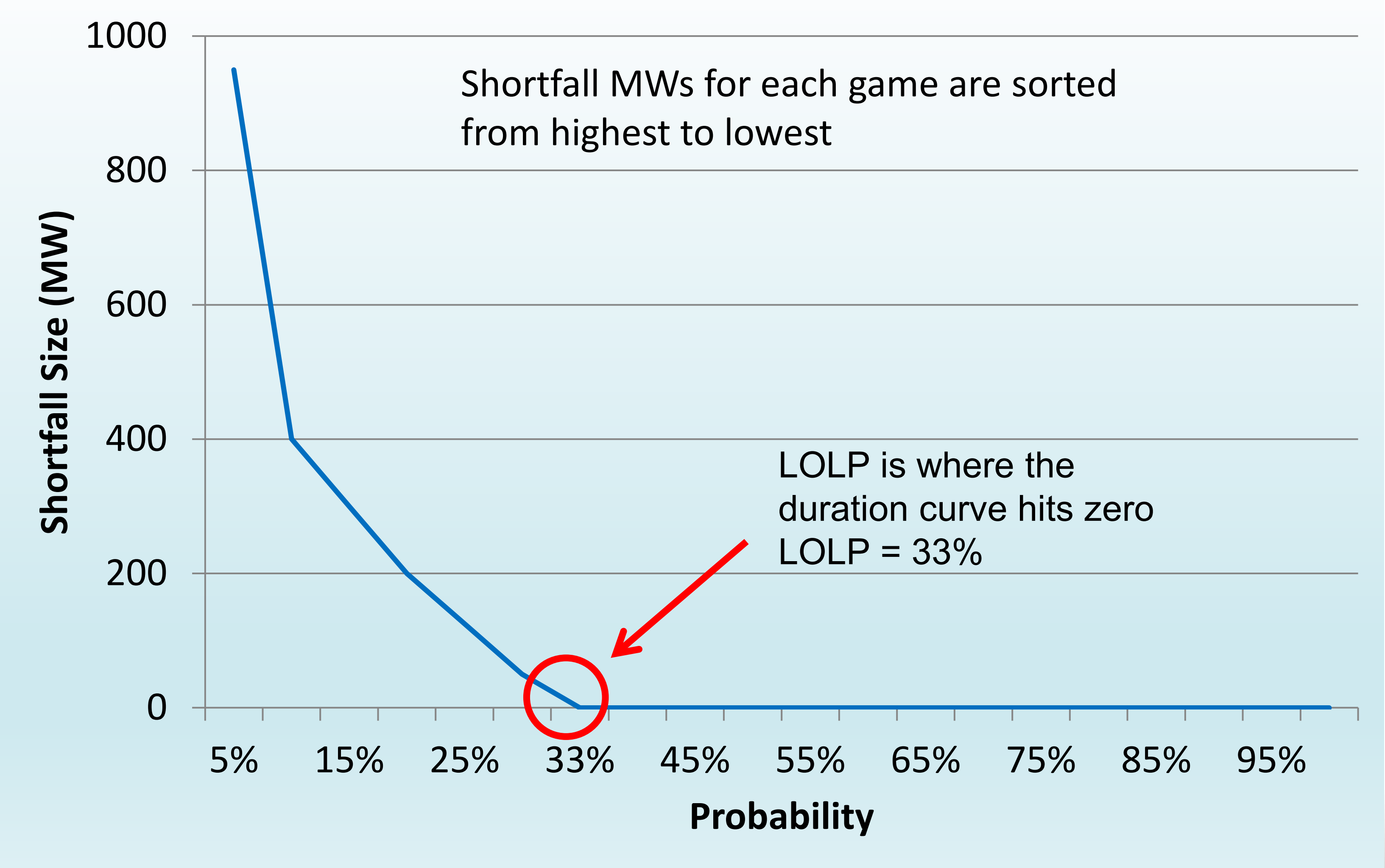


Shortfall Histogram

100 Games

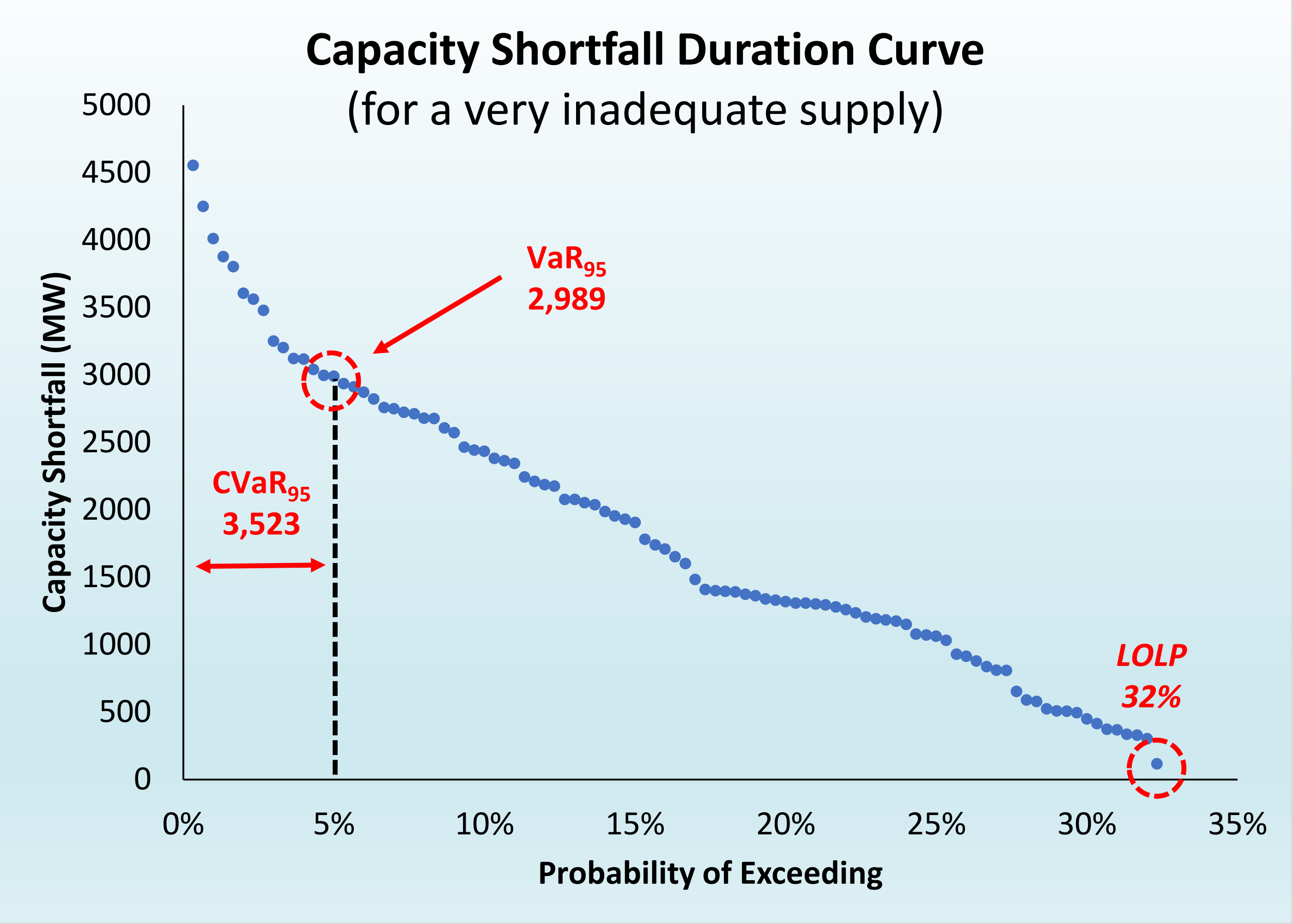


“Flip” Axes to make Shortfall Duration Curve



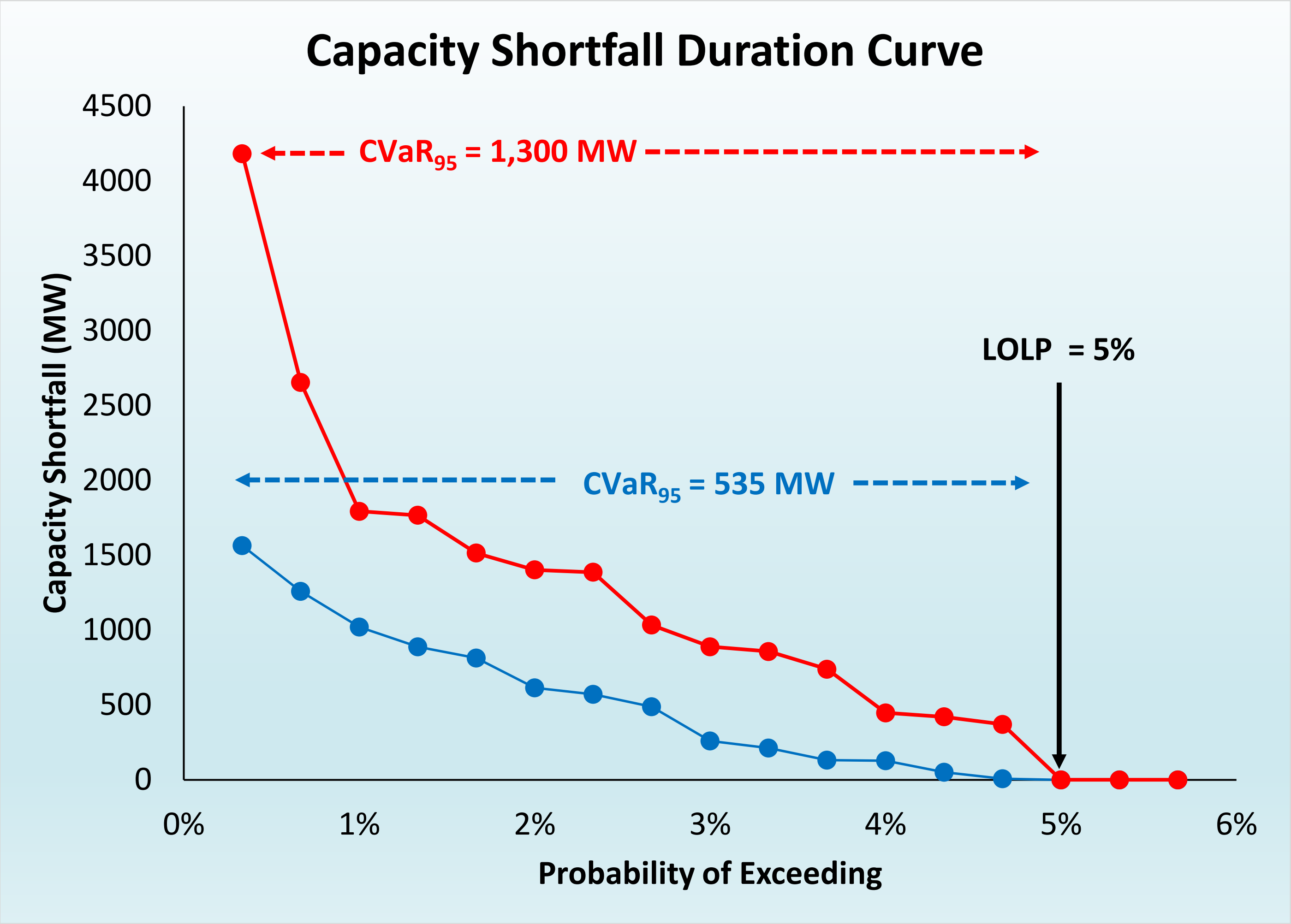
Limit Big Capacity and Energy Shortfalls

- *Shortfall Duration Curve*
  - Shows the distribution of capacity and energy shortfalls – highlights the worst shortfalls
  - Each simulated year's capacity and energy shortfalls are graphed from highest to lowest
  - The x-axis shows the probability of equaling or exceeding a specified shortfall – *LOLP is the point where the curve crosses the x-axis*
- *VaR_{95} (Value at Risk)*
  - *Capacity* shortfall for the 95th worst percentile of all simulations (see chart)
  - *Energy* shortfall for the 95th worst percentile of all simulations
- *$CVaR_{95}$ (Conditional Value at Risk)*
  - Average *capacity* shortfall between the 95th and 100th worst percentiles (see chart)
  - Average *energy* shortfall between the 95th and 100th worst percentiles



$CVaR_{95}$ is a Gauge of Shortfall Magnitude

- A significant limitation of the LOLP metric is that it provides no indication of shortfall magnitude.
- As the graph on the right shows, two different power supplies (red and blue) have identical 5% LOLP values (i.e., both are considered adequate) but they have significantly different sized shortfalls.
- *Setting a $CVaR_{95}$ adequacy limit allows us to differentiate between these two power supplies (see next slide).*

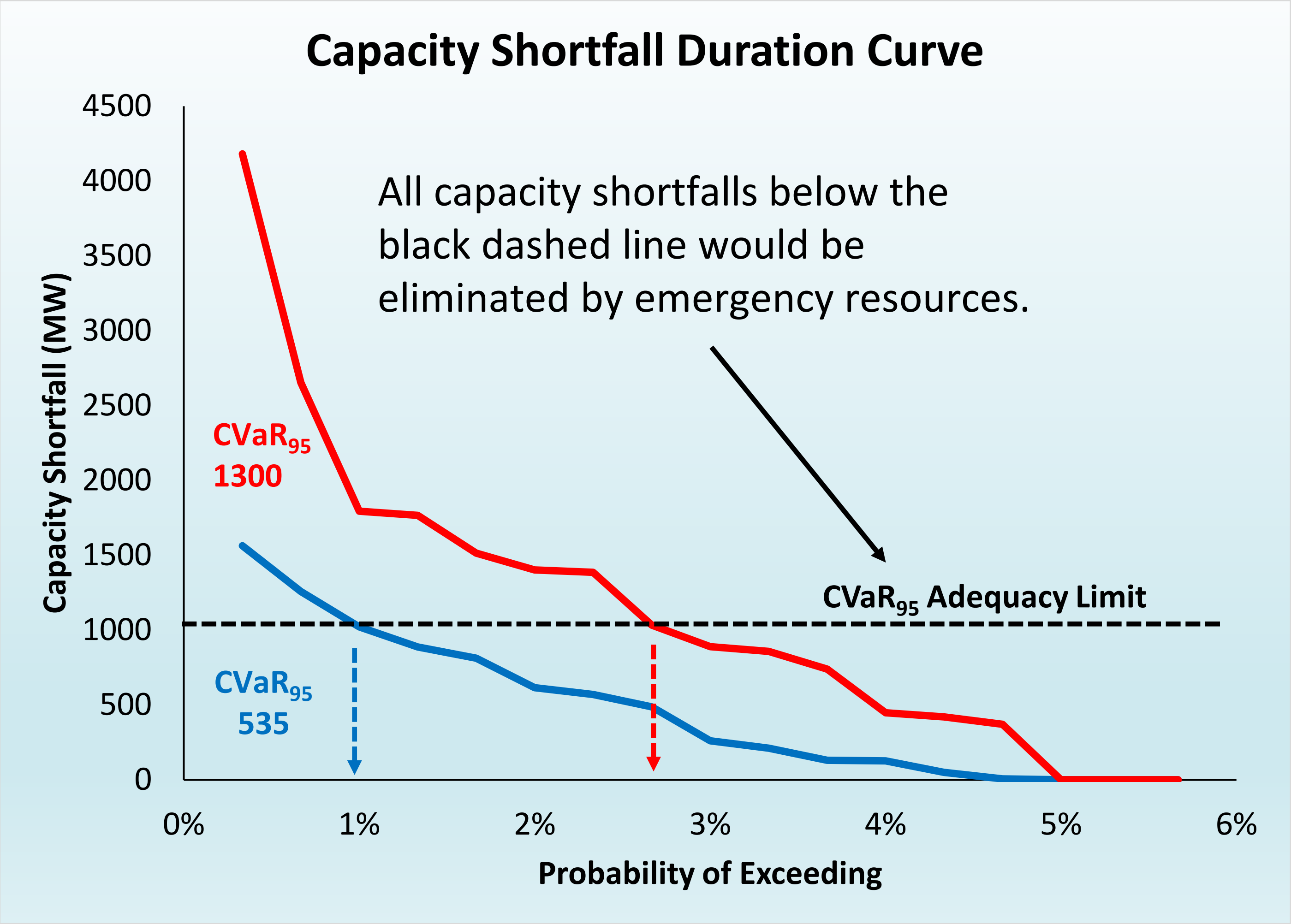


CVaR$_{95}$ limits average size of worst shortfalls

For example, setting a CVaR$_{95}$ adequacy limit to 1000 MW means that the blue case is adequate (with a CVaR$_{95}$ of 535 MW), but the red case is not adequate (with a CVaR$_{95}$ of 1300 MW).

If the 1000 MW CVaR$_{95}$ limit represents emergency resource capacity, then many shortfalls could be eliminated – *but not the very worst.*

In this example, after deploying 1000 MW of emergency resources, the likelihood of shortfalls drops from 5% to 1% for the blue case and to 3% for the red case.



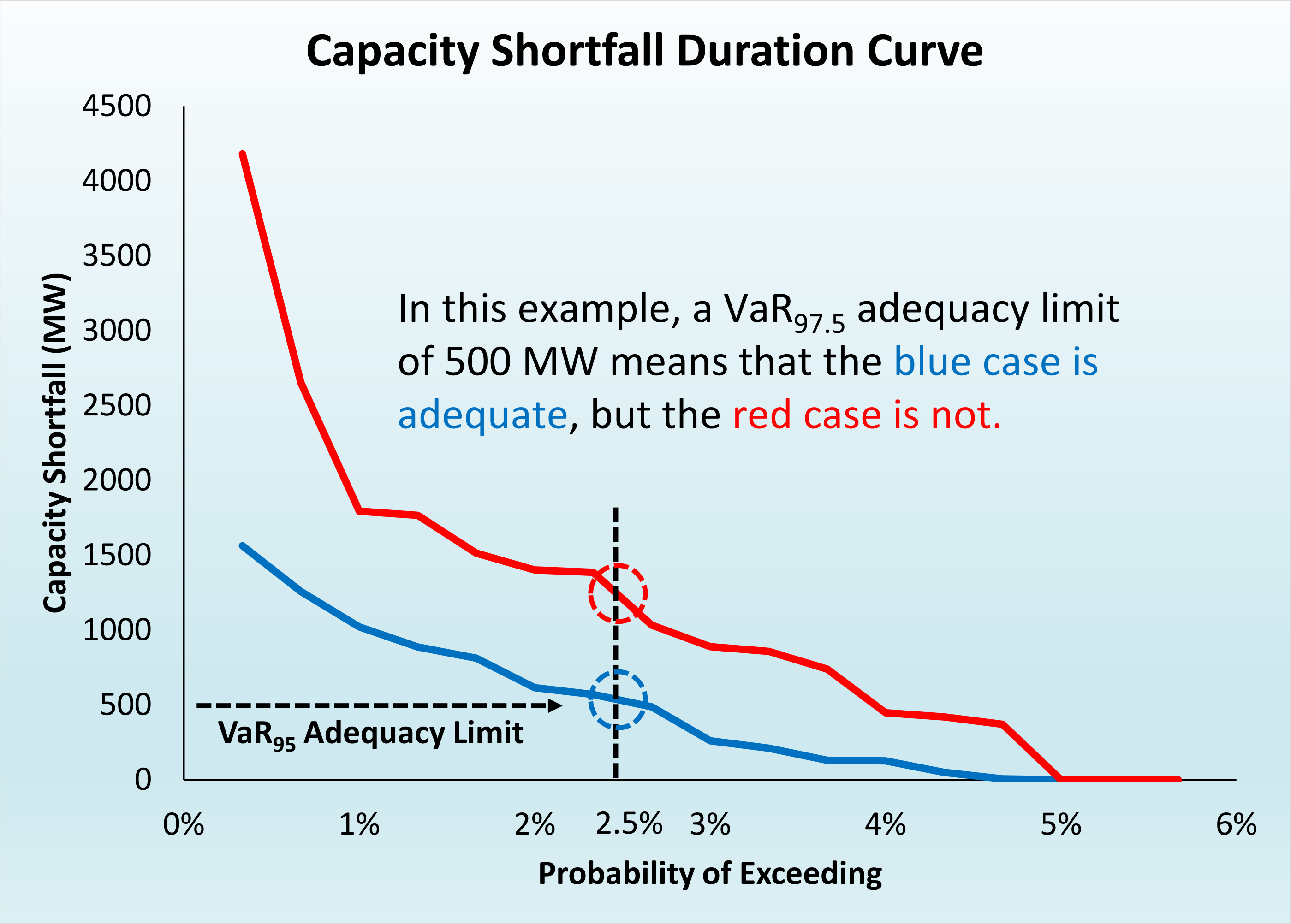
VaR is also a Gauge of Shortfall Magnitude

The VaR_N metric may be more intuitive.

A power supply is adequate if its shortfall duration curve value is less than or equal to the VaR_N limit at the N^{th} percentile.

For example, if the $VaR_{97.5}$ adequacy limit is 500 MW, then a power supply is adequate if its duration curve value is 500 MW or less at the 2.5% point on the x-axis (see chart).

As with the CVaR example, all shortfalls below the dashed line would be eliminated by 500 MW of emergency capacity.



Strawman Proposal reviewed by the RAAC

- Adequacy limits are set independently
  - Peak $CVaR_{95}$ – set limits based on aggregate emergency capacity
  - Energy $CVaR_{95}$ – set limits based on aggregate emergency energy
  - LOLEV – set limit to prevent excessive use of emergency resources
  - LOLH – set limit based on the Value of Lost Load

- Assess Peak and Energy $CVaR_{95}$ for winter and summer
- Assess LOLEV and LOLH for the entire year

- Power supply is inadequate if any one of the limits is exceeded

Strawman Proposal meets all Objectives

Option	RA Metric	Big Capacity Shortfall	Big Energy Shortfall	High use of contingency measures	Financial Risk (excessive cost)
Event-based Metrics	Frequency Duration Magnitude		✓		
Annualized Metrics	LOLEV LOLH (duration) EUE/NEUE			✓	
Tail-end Metrics	VaR_{95} $CVaR_{95}$	✓	✓		
Financial Risk/ High Cost	LOLH (financial)				✓
Proposed Standard	$CVaR_{95}$ Energy/Peak LOLEV LOLH (financial)	✓	✓	✓	✓

Implementing the New Standard

The Council can choose to accept the new standard metrics in principle, with binding limits for the adequacy metrics to be set after completion of the GENESYS model review and stakeholder feedback.

- Provisional limits for testing:
  - LOLEV = 0.2 events/year (once per five years)
  - LOLH = 2 hours/year
  - $CVaR_{95}$ limits TBD perhaps based on one or more of the following:
    - Aggregate emergency peak and energy capabilities
    - Estimate of available emergency market supply purchases
    - Regression analysis showing the range of $CVaR_{95}$ values for systems at a 5% LOLP

- RA assessments will continue to report annual LOLP and other commonly used but non-binding metrics for informational value.

- Standard is used to derive planning reserve margins used for long-term planning

RAAC Feedback

- Overall positive feedback on the use of a multi-metric approach and agreement that it provides a better assessment of risk
- General agreement on the objectives
  - Frequency of shortfall events should be included
  - A measure of financial risk should be included but some concern about how to measure it
  - A measure of shortfall size should be included
- Agreement that adequacy should be assessed on a seasonal basis
- Some concern about how the new (more complicated) standard relates to standards set by other agencies but general agreement that using resulting planning reserve margins (PRMs) for comparison is a good option
- Agreement that the set of *metrics* defining the new standard can be accepted before their *limits* are finalized.

Other Considerations

- *Metrics*
  - No explicit measure of shortfall duration, however, the number of shortfall hours/year (LOLH) is limited based on financial risk
  - Staff is considering whether $VaR_{97.5}$ would be a better metric for shortfall size than $CVaR_{95}$

- *Limits*
  - How often is too often to use emergency resources?
  - How should the value of lost load be assessed?
  - What resources are used to calculate the cost of new entry?
  - What are emergency resources and how can their aggregate capacity and energy capabilities be determined?

RA Assessment Timeline

October 2022

Model and market reviews complete. Advisory committees review preliminary RA assessment. Power committee briefed on proposed new adequacy standard.

November 2022

Advisory committees review any proposed revisions to the new standard and review final RA assessment. If needed, additional studies are run.

December 2022

Power committee briefed on final RA assessment and on the revised adequacy standard. If needed, additional studies are run.

January 2023

Council briefed on final RA assessment and revised adequacy standard. Decision to release RA assessment. Decision to adopt new standard metrics, with limits to be set after more analysis and review.

Additional Slides

Update on the Current RA Assessment

- GENESYS Hydro Operations
  - ✓ Reevaluated constraints and priorities for all hydro plants
  - ✓ Documented sources for all operating constraints
  - Currently validating simulated operation with operators and experts

- Market Availability and Price
  - ✓ Add more specificity for WECC renewable and hydro resources
  - ✓ Assess market impacts of various WECC buildouts
  - Investigate transmission availability risk
  - Explore WECC-wide thermal unit commitment challenges

Proposed Scenarios for the RA Assessment

- Reference cases
  - 2027, no new EE, no planned resources, baseline WECC buildout
  - Add 2021 plan planned resources

- Market supply variability (AURORA)
  - Limited Markets (no Planning Reserve Margins)
  - Persistent Global Instability (build limitations and high gas prices)
  - High WECC-wide demand (e.g., increased electrification)
  - No WECC buildout
  - Baseline buildout under stress (drought, gas and transmission issues)

- Early Retirement of PNW coal resources

Power Plan Resources for 2027

- Energy Efficiency – 750 to 1,000 aMW
- Renewable Resources – at least 3,500 MW (wind, solar, etc.)
- Demand Response
  - 520 MW of demand voltage regulation
  - 200 MW from time-of-use rates available
- Implementation of additional reserves for adequacy