Northwest **Power** and
Conservation Council

October 6, 2020

MEMORANDUM

TO: **Council Members**

FROM: **John Fazio, Senior Systems Analyst**

SUBJECT: **Resource Adequacy Primer**

<u>BACKGROUND:</u>

Presenter: John Fazio

Summary: This tutorial provides a brief history of methodologies used in North America to assess power supply adequacy, followed by a synopsis of the Council's current methodology and how it might change in the future. It will be followed by a briefing from the Northwest Power Pool on its progress toward developing its own Resource Adequacy Program.

Relevance: Through its power plan, the Council is mandated to develop a resource acquisition strategy that will ensure an adequate, efficient, economic, and reliable regional power supply. Toward that end, the Council adopted its current adequacy standard in 2011. By incorporating this standard into its planning models, the Council ensures that future resource acquisitions will not lead to costly-and-overbuilt nor risky-and-underbuilt power supplies.

Workplan: A.5.2 Related to power supply adequacy assessments

Background: Over the years, assessment of power supply adequacy has evolved from simple comparisons between resource capacity and expected demand to very sophisticated methods that account for probabilities of future uncertainties. The Council's current standard deems a power supply to be adequate if the likelihood of one or more shortfall events in a future year is no more than five percent.

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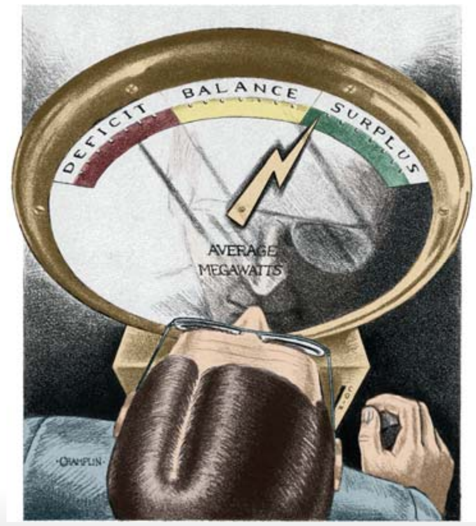
A Brief History of Power Supply Adequacy & How the PNW Assesses Adequacy

NW Power and Conservation Council Meeting
October 14, 2020
John Fazio, Senior Systems Analyst



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- Reliability vs. Adequacy
- What is an adequacy standard?
- Methods to assess adequacy
- History of adequacy assessments
- Assessing resource adequacy in the PNW
- Adequacy and resource planning

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Reliability vs. Adequacy – 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]In my opinion, the phrase "at all times" should be changed to something like "most of the time, depending on customer's tolerance for curtailment."

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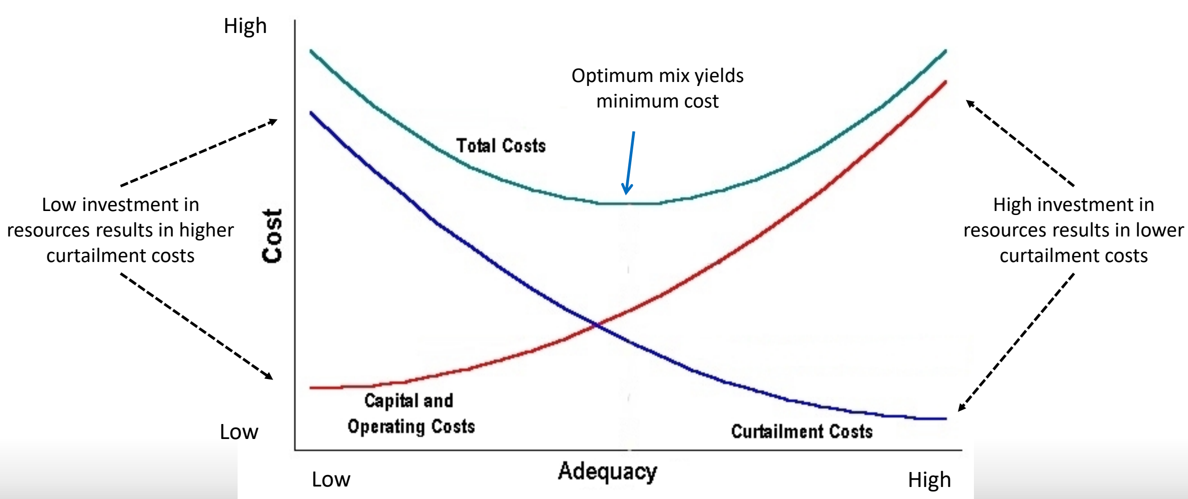
Tradeoff: Adequacy vs. Cost



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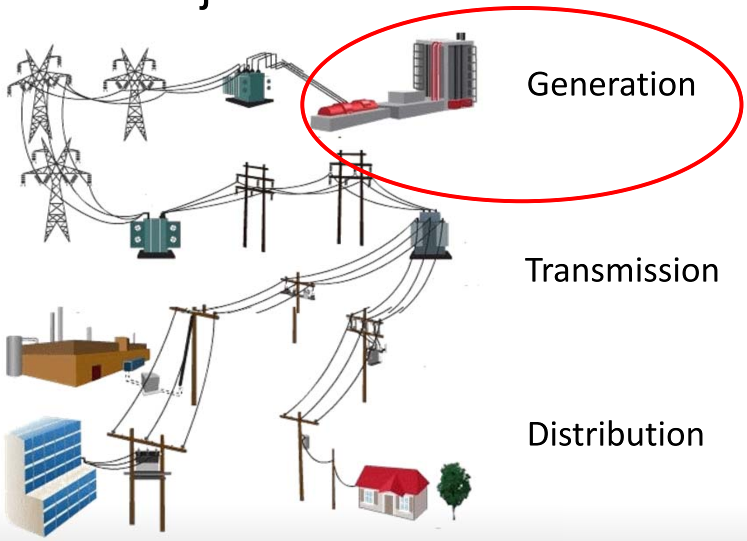
Three Major Areas for Assessment



Most adequacy standards for long-term resource planning focus only on generation

What is an Adequacy Standard?

- Adequacy standard is composed of 2 parts
  - Metric (measure of frequency, magnitude or duration of shortfalls)
  - Threshold (limit for each metric)
- Two methods of assessing adequacy
  - Deterministic – simple accounting, e.g. load/resource balance
  - Probabilistic – incorporate likelihood of future unknowns
- Industry is moving toward standards based on probabilistic methods
- No industry-wide standard, most common “standard” is 1-day-in-10-year loss of load expectation (LOLE)

Methods of Assessing Resource Adequacy

- Deterministic
  - Compares expected resource availability vs. expected demand
  - Planning reserve margin = surplus capacity to cover uncertainties
    - Usually based on peak-hour demand
    - Building block approach: needed surplus to cover generator outages + extreme temperatures + balancing and contingency reserves
- Probabilistic
  - Analytical: Shortfall probability density function
  - Simulation: Monte-Carlo chronological hourly simulation

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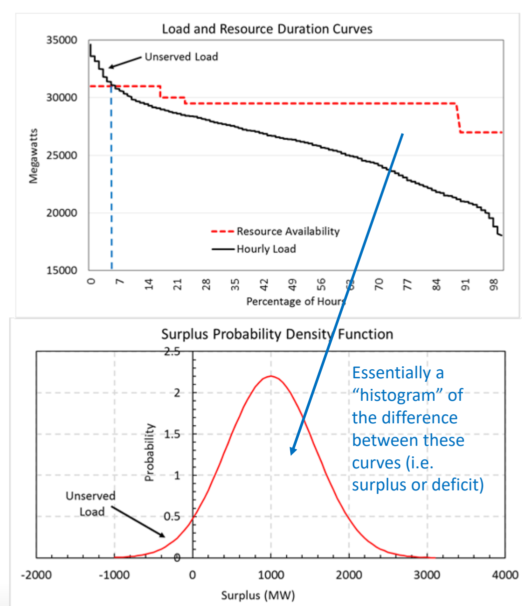
Probabilistic Analytical Methods

- Build a Resource Availability duration curve and an Hourly Load duration curve
- Combine to create a surplus probability density function (looking at the difference between the 2 curves)
- Some adequacy metrics can be derived directly from the probability density function
- This example is for a normal distribution: Where the curve represents the either surplus or deficit (generation – load)



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Simulation Methods

- Computer program that performs a chronological hourly simulation of the power supply's operation
- Monte-Carlo methodology:
  Run thousands of simulations for one operating year with different manifestations of future uncertainties
- Future uncertainties (aka random variables) can include temperature, river flows, forced outages, wind and solar generation
- Create a record of all hours when load could not be served, from which adequacy metrics are calculated

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Some Probabilistic Adequacy Metrics

- Loss of load expectation (LOLE)
  - Historically the most used
  - Ubiquitous "1-day-in-10-years" threshold
- Loss of load probability (LOLP)
- NERC recommended:
  - Expected Unserved Energy (EUE) – MW-hours of unserved load/year
  - Loss of load hours (LOLH) – Shortfall hours/year
  - Loss of load events (LOLEV) – Shortfall events/year

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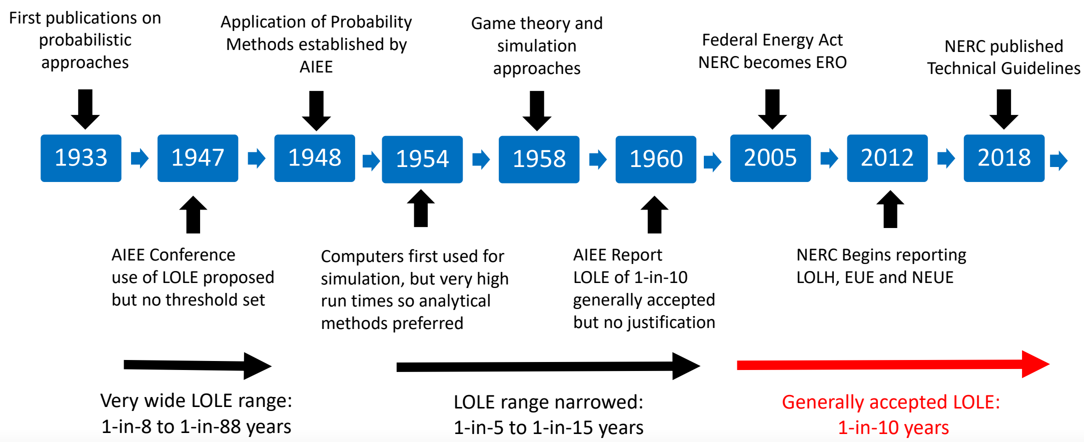
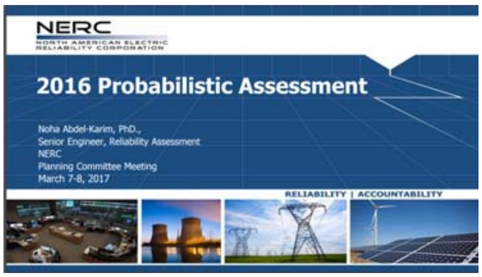
History of Adequacy Assessments



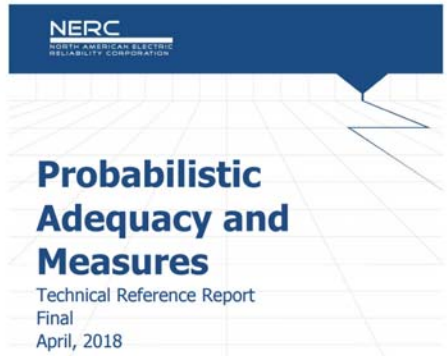
The Trouble with 1-day-in-10-year LOLE

- Means no more than 1 day in 10 years with a shortfall
  - Not a true shortfall-event frequency measure
  - Often interpreted as 24 hours of shortfall per 10 years or 2.4 shortfall hours/year
  - Arbitrary because it doesn't measure frequency of events
    - When shortfall duration is 4 hours, would allow 6 events in 10 years
    - When shortfall duration is 8 hours, would allow 3 events in 10 years
- No indication of duration or magnitude
- NERC discourages its use, not likely to include in future reports

NERC Adequacy Report and Technical Reference Report

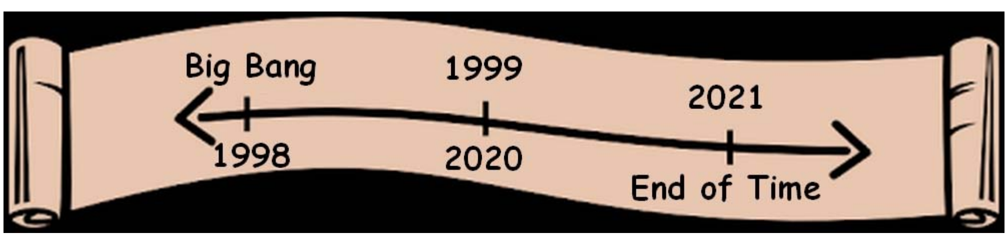


https://www.nerc.com/comm/PC/PAWG%20DL/Probabilistic%20Assessment%20Working%20Group%20Meeting%20Presentations%20March%2021,%202017.pdf



https://www.nerc.com/comm/PC/Probabilistic%20Assessment%20Working%20Group%20PAWG%20%20Relat/Probabilistic%20Adequacy%20and%20Measures%20Report.pdf

Assessing Adequacy in the PNW



Load/Resource Balance	Annual LOLP	? LOLEV, EUE & LOLH[1]

[1]Council and RAAC have discussed moving to a more robust adequacy standard and perhaps using the NERC recommended metrics. However, before relevant thresholds can be set, the redeveloped GENESYS model must be fully vetted.

Council uses a Simulation Method

- Analytical tool (GENESYS)
  - Monte-Carlo chronological hourly simulation of power supply operation
  - Run thousands of simulations for an operating year with different manifestations of future uncertainties
- Future uncertainties
  - Natural river flows
  - Temperature-sensitive loads
  - Generator forced outages
  - Wind and solar generation
- Council's Adequacy Standard
  - Metric = Annual loss of load probability (LOLP)
  - Threshold = 5 percent

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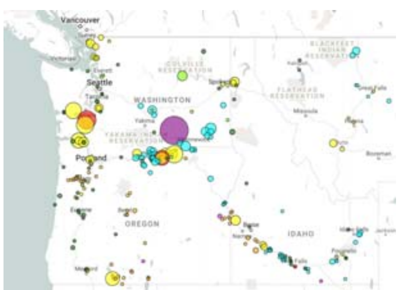
Assessing Resource Adequacy



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

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%)

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

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

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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 black outs or brown outs

Modeled in GENESYS

Modeled in Post Processor

Not Modeled

LOLP = likelihood of taking emergency actions, not necessarily curtailment

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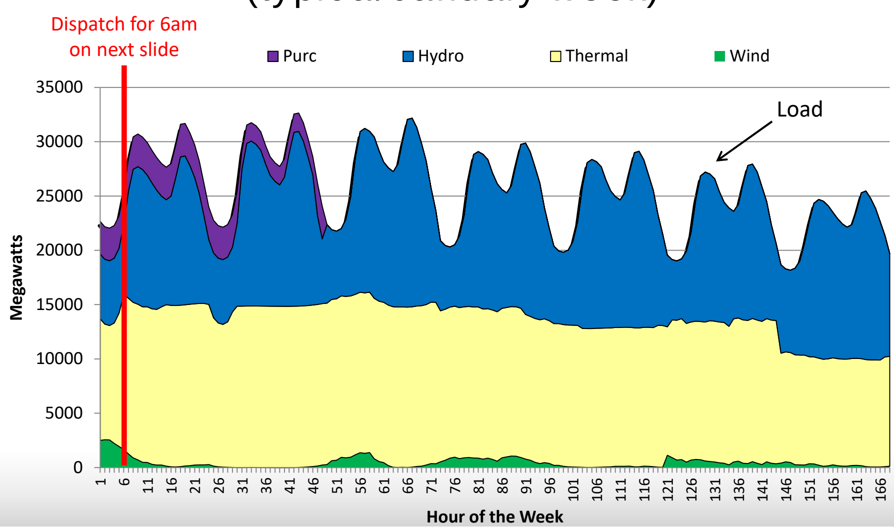
Simulated Hourly Dispatch
(typical January week)



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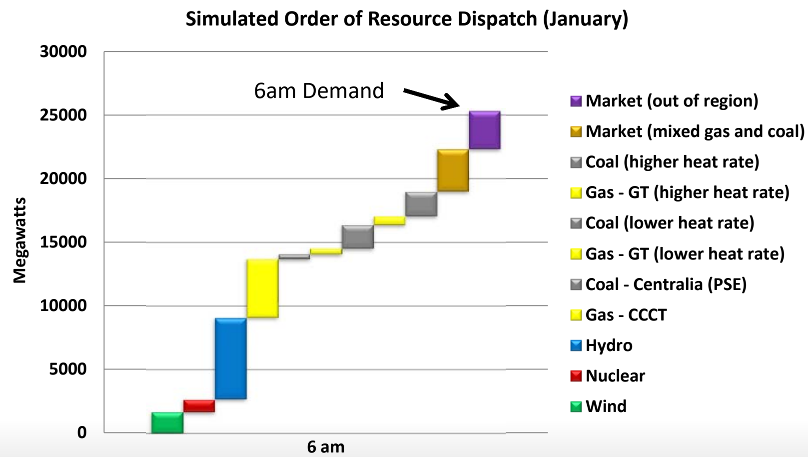
Simulated Dispatch Order
(6am January weekday)



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Sample Future Number1
No Curtailment – No Standby

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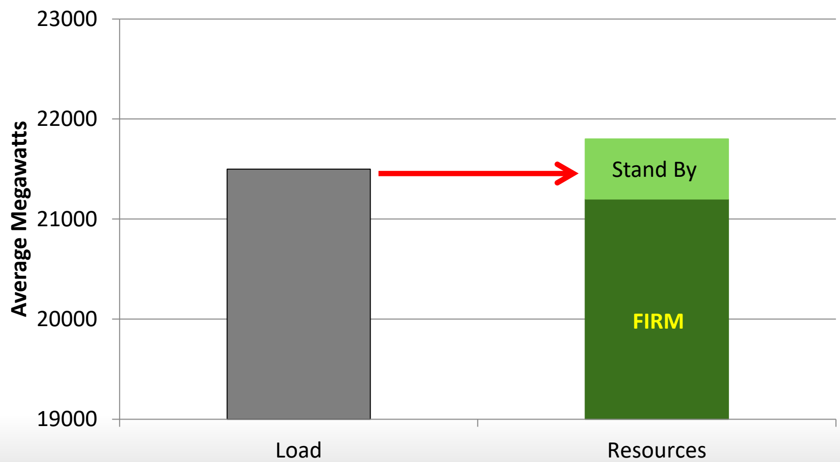
Sample Future Number 2

No Curtailment – Used Stand By



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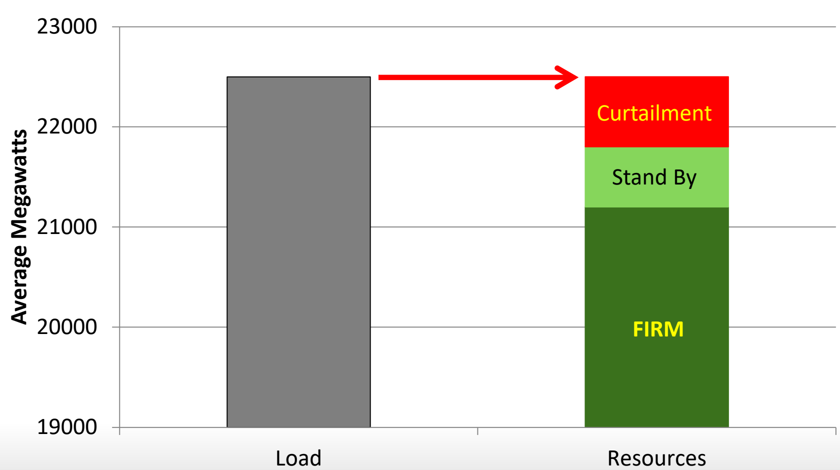
Sample Future Number 3

All resources used - Curtailment



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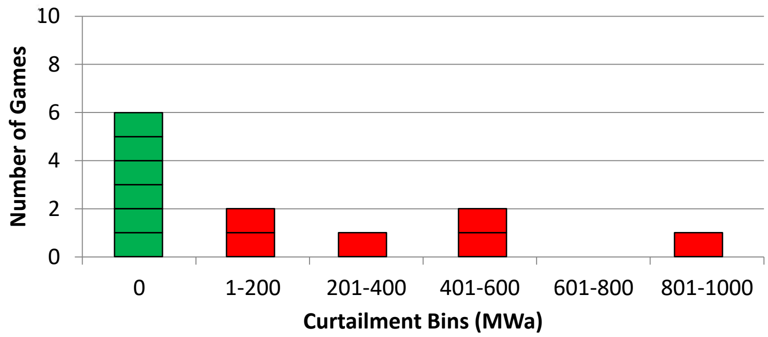
Counting Curtailments

(Step through games and fill curtailment bins)



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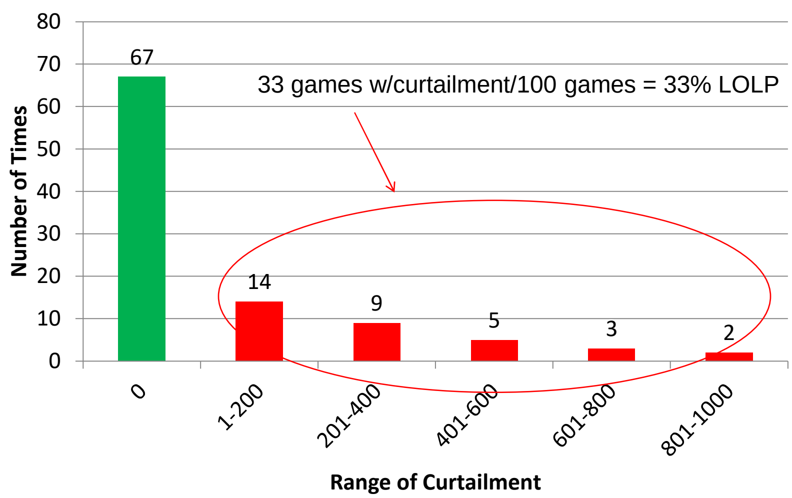
Curtailment Histogram

100 Games



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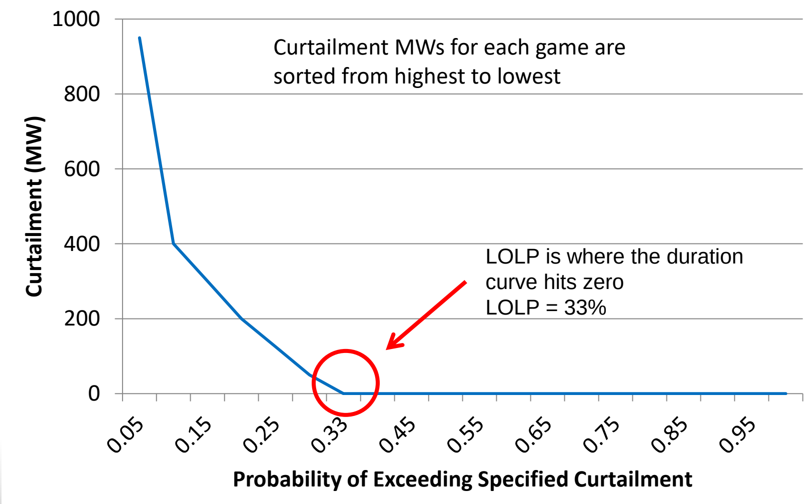
"Flip" Axes to make Duration Curve



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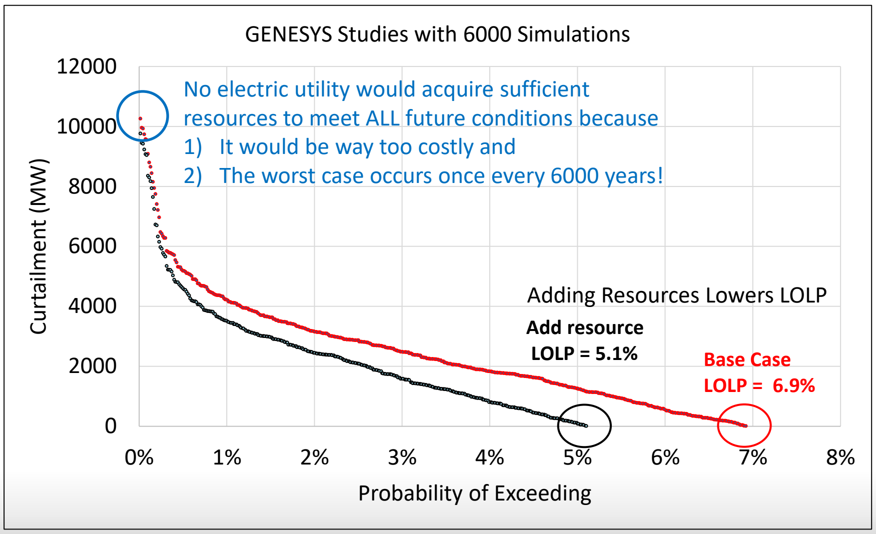
Peak-hour Curtailment Duration Curve



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PNW Resource Adequacy Assessment[1]

Operating Year	Annual LOLP	Planned Incremental Coal Capacity Retirement (MW)	Planned Cumulative Coal Capacity Retirement (MW)
2020	<5%[2]	427	427
2021	7.5%[2]	1,192	1,619
2022	8%[2]	127	1,746
2023	8%[2]		
2024	12.8%	530	2,276
:	:		
2026	26%	804	3,080
:	:		
2033	48%	1,729	4,809

[1]Based on historical flow and temperature data, include target EE savings but not IRP planned resources, 0.3%/year load growth.
[2]These annual LOLP values are estimates.

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2024 Resource Adequacy Assessment

Historic-based vs Climate-change-based Forecasts

NERC Adequacy Metrics

Draft	LOLP (%)	EUE (GW-hours)	LOLH (hours)	LOLEV (events/year)
CC Based	**17.0**	**1.7**	**2.9**	**0.39**
Historic Based	**12.8**	**7.9**	**4.6**	**0.26**

These CC-based forecasts for loads and flows yield a higher LOLP

CC scenario shortfalls have a much smaller magnitude

Have a shorter duration

But occur more often

And, perhaps more importantly… (see next slide)

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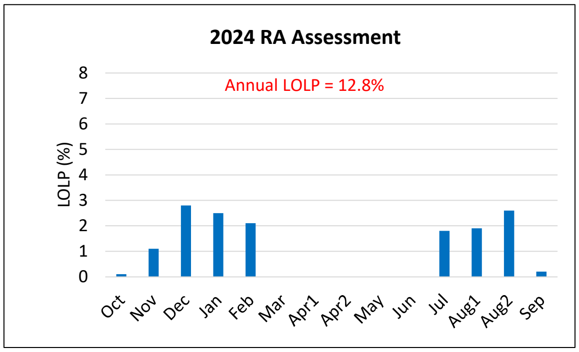
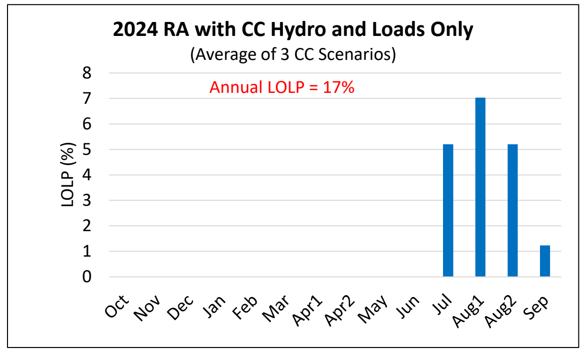
CC Data Shifts Resource Needs to Summer





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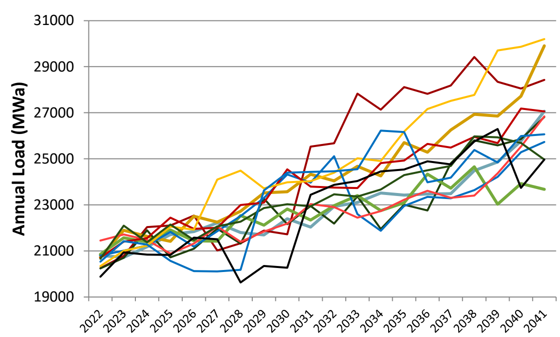
Adequacy and Resource Planning

- The RPM develops resource strategies for hundreds of load growth paths over 20 years
- Each path faces different combinations of future unknowns
- Resources are acquired if they are economic or if they are needed for adequacy, i.e. if the Adequacy Reserve Margin (ARM) is not met
- The net capacity of new resource portfolios is estimated from the Associated System Capacity Contribution (ASCC) Table
- Finally, resulting resource buildouts are tested to ensure the LOLP is close to 5%



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ASCC Table and ARM

- The Associated System Capacity Contribution (ASCC) is the net firm capacity gained when a mix of new resources (portfolio) is added to the existing power supply.
- The Adequacy Reserve Margin (ARM) is the amount of surplus capacity needed, over the expected weather-normalized peak load, to ensure adequacy. Building to this target should ensure that the resulting supply will meet the Council's 5% LOLP adequacy standard.

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NW Power Pool's Resource Adequacy Program

- The Council's and the NWPP's work on resource adequacy is strongly related, but differs in a substantive way:
- Council's adequacy standard
  - Focuses on long-term resource acquisition strategies
  - To ensure an adequate future power supply

- NWPP resource adequacy program
  - Focuses on short-term management of existing resources
  - To facilitate sharing of resources (e.g. markets)

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