

Consideration of Cost vs. Risk to set an Adequacy Standard

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GridLAB Outline

- NERC's authority regarding resource adequacy (RA) standards
- Costs and risks relating to RA standards
- Evolution of RA standards
- NW Power and Conservation Council's multi-metric RA standard
- Assuring an Adequate and Cost-Effective Power Supply

GridLAB NERC's Authority Regarding RA Standards

- **2005 Energy Act:**

FERC designated NERC to be the Electric Reliability Organization (ERO)

- NERC has authority to develop enforceable *reliability* standards that apply to the delivery of energy (i.e., transmission)
- But NERC is not authorized to “set and enforce compliance with standards for *adequacy*”
- Thus, regions, states, independent system operators and load serving entities can develop their own resource *adequacy* standards

However, regional and local RA standards must lead to sufficiently adequate supplies to ensure compliance with NERC's grid reliability standards

GridLAB RA Standard should focus on Cost vs. Risk

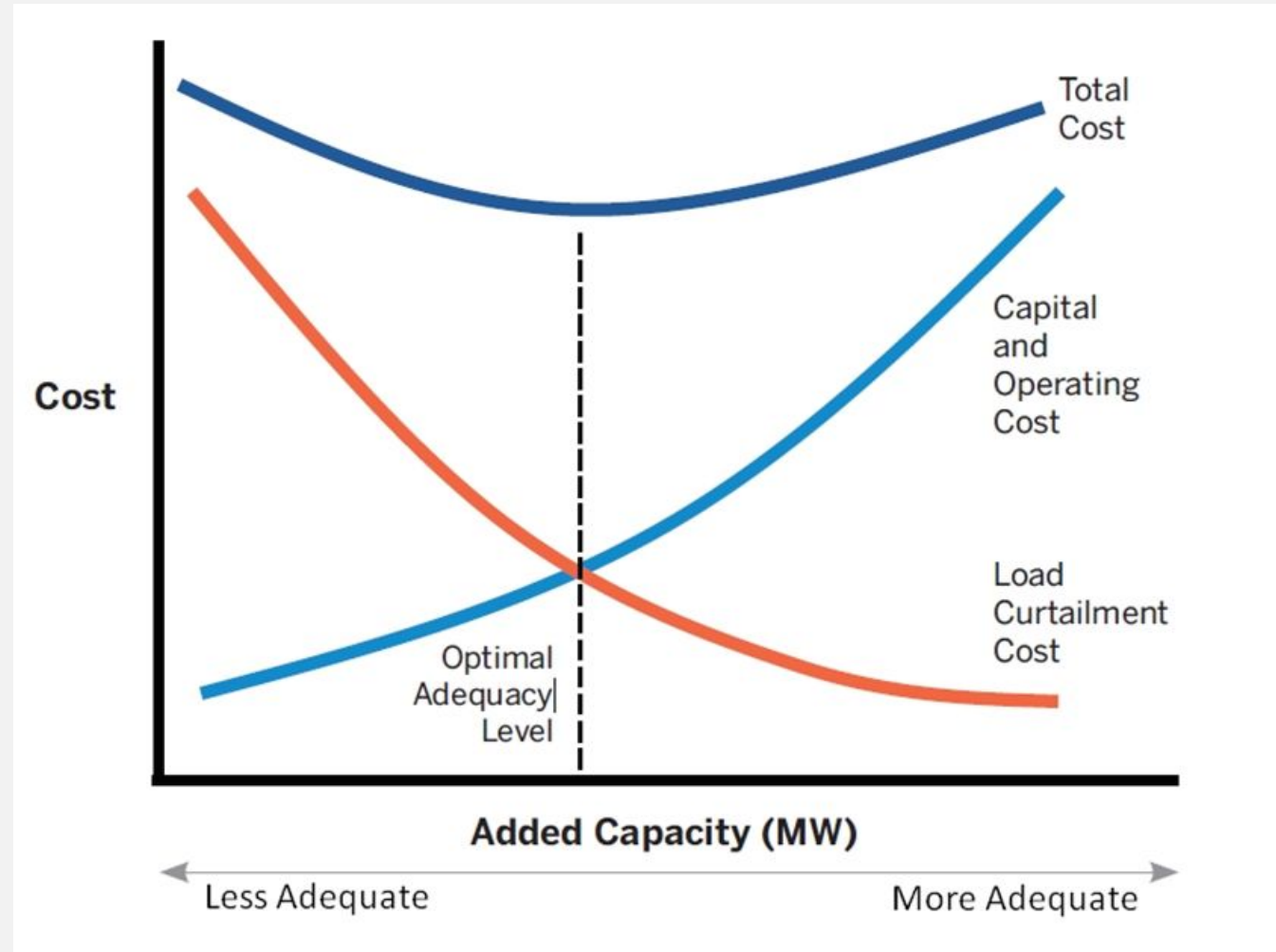
Fundamentally, the objective of an RA standard is to minimize total system cost, which is the sum of capital costs (**CAP**), operating costs (**OPER**) and outage costs (**VOLL** × **EUE**), where VOLL is the Value of Lost Load and EUE is the Expected Unserved Energy.

The objective function for the optimization is:

$$\text{Min [CAP + OPER + VOLL} \times \text{EUE]}$$

Theoretically, this method determines the optimal value for EUE – *resource additions with a higher or lower EUE have higher costs* – and the optimal EUE can be used as a target for an RA standard.

Unfortunately, using this method is problematic because VOLL is difficult to quantify and can vary drastically by customer class.



GridLAB Evolution of Resource Adequacy Standards

An alternative approach is to first identify critical shortfall characteristics – generally some form of frequency, duration and magnitude – and then set maximum limits for those measures

- Historically, an RA standard consisted of a single measure of adequacy
- The most common measure, Loss of Load Expectation (LOLE) – *the expected number of shortfall days/year* – was limited to 0.1 days/year (or 1 day per 10 years)
- Currently, due in part to the increasing complexity of power supplies, planners are moving away from LOLE to multiple measures of adequacy, such as:
 - **LOLH** – Loss of load hours (expected number of shortfall hours/year)
 - **EUE** – Expected unserved energy (expected amount of unserved load/year)
 - **LOLEV** – Loss of load events (expected number of shortfall **events**/year)*
- In addition, planners are considering setting limits on rare but high impact (tail-end) events, such as excessively long and/or excessively large outages

*Not to be confused with LOLE, which is the expected number of shortfall **days**/year, where a shortfall day has one or more shortfall hours and a shortfall event is a contiguous set of shortfall hours.

GridLAB Council's Resource Adequacy Objectives

- Prevent overly frequent use of emergency resources
 - Emergency resources are contingency actions taken to keep the lights on
 - Frequent use of emergency resources indicates a non-cost-effective power supply
 - *Objective is accomplished by limiting the frequency of shortfall events*
- Limit the risk of low probability, high impact shortfalls
 - Because no utility plans to cover all eventualities, a limit must be set to define the maximum tolerable tail-end shortfalls
 - *Objective is accomplished by setting limits for the frequency, duration and magnitude of rare, high-impact shortfalls*

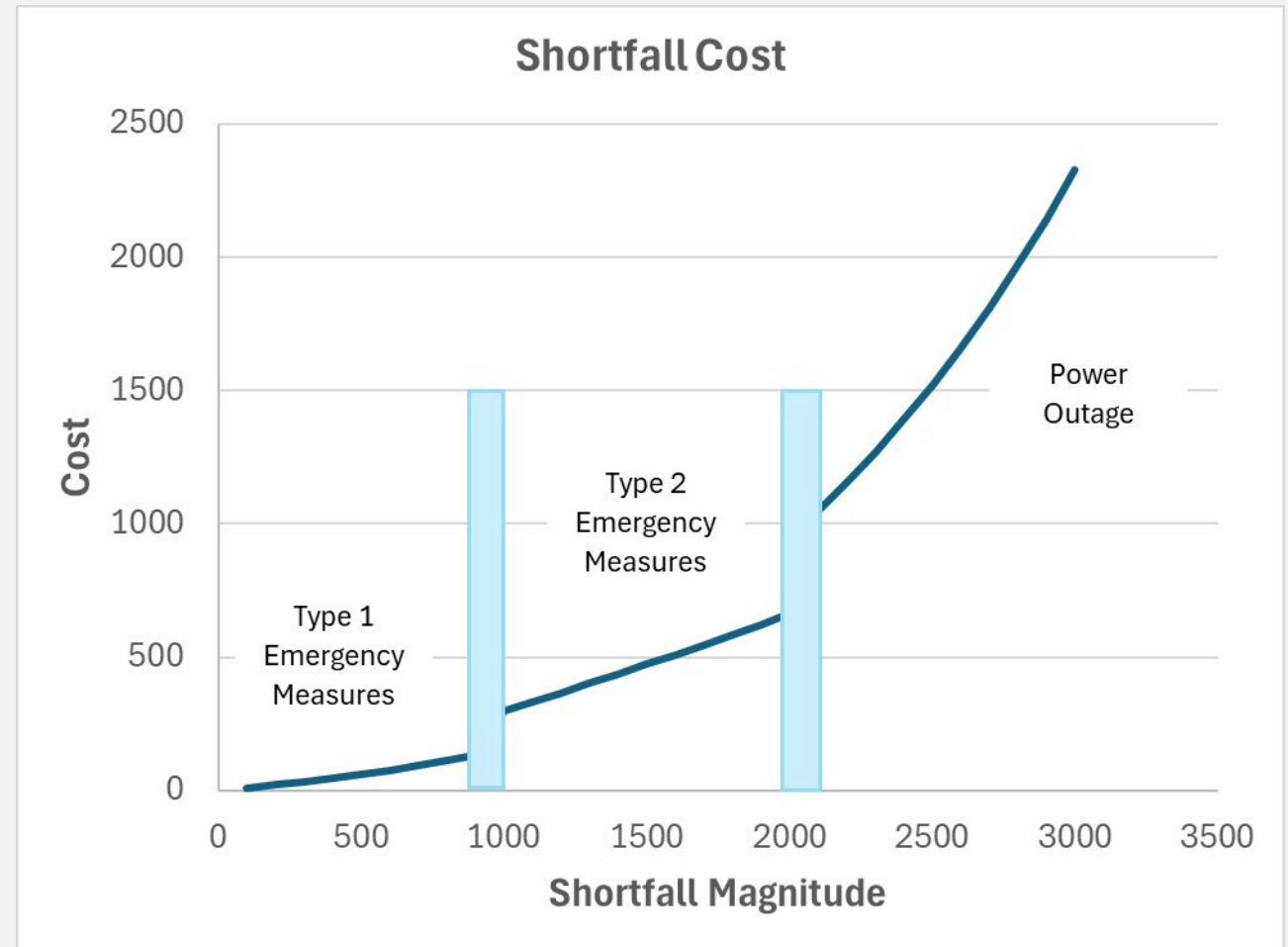
GridLAB Council's Resource Adequacy Metrics*

Objective	Metric	Definition
Prevent overly frequent use of emergency resources	LOLEV	Expected number of shortfall events/year
Limit the risk of excessively long shortfalls to <i>once per 40 years</i>	Event Duration VaR _{97.5}	97.5 th percentile of the probability distribution of each year's longest event duration
Limit the risk of excessively large peak shortfalls to <i>once per 40 years</i>	Peak VaR _{97.5}	97.5 th percentile of the probability distribution of each year's highest single-hour (peak) shortfall
Limit the risk of excessively large annual energy shortfalls to <i>once per 40 years</i>	Energy VaR _{97.5}	97.5 th percentile of the probability distribution of each year's total annual unserved load

*Value at Risk (VaR_N) is the Nth percentile value of a probability distribution.

GridLAB Setting Adequacy Limits for Tail-End Metrics

- Shortfall costs include the cost of emergency measures plus the cost of any sustained power outages
- Cost increases significantly once emergency measures are exhausted
- The Council chose to set the tail-end ($\text{VaR}_{97.5}$) *peak* and *energy* shortfall limits to the aggregate capacity and energy capabilities of Type 1 emergency measures
- The tail-end ($\text{VaR}_{97.5}$) shortfall event *duration* limit was set to the number of consecutive outage hours before damage costs jump to severe levels



GridLAB Examples of Type 1 and Type 2 Emergency Measures

Type 1 Measures: Less severe and lower relative cost

- Deploy high cost (and possibly high emission) resources not in active portfolio
- Lease potentially available but less efficient resources
- High-priced market purchases
- Load buy-back provisions
- Access industry backup generators

Type 2 Measures: More severe and higher cost

- Official's call for conservation
- Reduce less essential public load
- Utility emergency load reduction protocols
- Curtail environmental restrictions (e.g., emission limits, hydro system fish & wildlife operations)
- Controlled rolling brownouts or blackouts

GridLAB NWPCC's Multi-Metric Resource Adequacy Standard

The Council's multi-metric RA standard has 2 objectives:

- To prevent overly frequent use of emergency resources by limiting shortfall event frequency
- To limit the risk of low probability, high impact events by setting a once per 40-year limit ($VaR_{97.5}$) for max event duration, max peak shortfall and max annual unserved load

Max Event Frequency

LOLEV 0.1 event/season
Winter and Summer

Max Event Duration

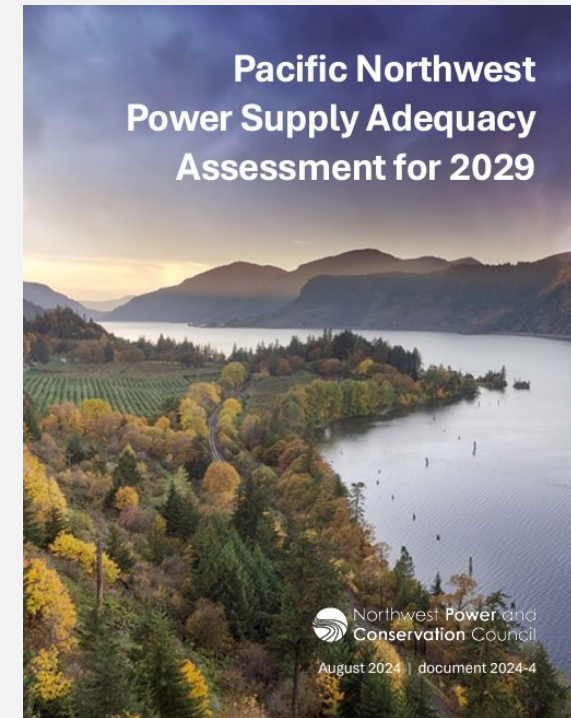
$VaR_{97.5}$ 8 hours

Max Peak Shortfall

$VaR_{97.5}$ 1200 MW
(3.5% peak load)

Max Energy Shortfall

$VaR_{97.5}$ 9600 MW-hours
(0.005% annual load)



GridLAB Assuring an Adequate and Cost-Effective Power Supply*

1. Assess the *effective firm capacity* for all existing and potentially new resources (commonly referred to as the effective load carrying capability or ELCC)
2. Add resources to an inadequate power supply until it is exactly adequate (i.e., when the binding RA metric value equals its adequacy limit)
3. From the exactly adequate power supply, extract the aggregate effective firm capacity and the expected peak load
4. Calculate the target *planning reserve margin* (PRM), which is the amount of surplus effective capacity needed, as a percent of expected peak load, to ensure adequacy

$$PRM = \frac{\text{Aggregate Effective Firm Capacity} - \text{Expected Peak Load}}{\text{Expected Peak Load}}$$

5. Use the PRM as a minimum build requirement in a System Expansion Model that produces a cost-effective resource expansion
6. To verify, test the resource buildout to ensure that it satisfies the RA standard

*This is a generic description of a process that is typically very complex. For some power systems, *effective firm energy* and the *energy planning reserve margin* are also needed to ensure adequacy.