Industry Changes in Resource Adequacy Requirements

PRESENTED TO

MISO Resource Adequacy Subcommittee

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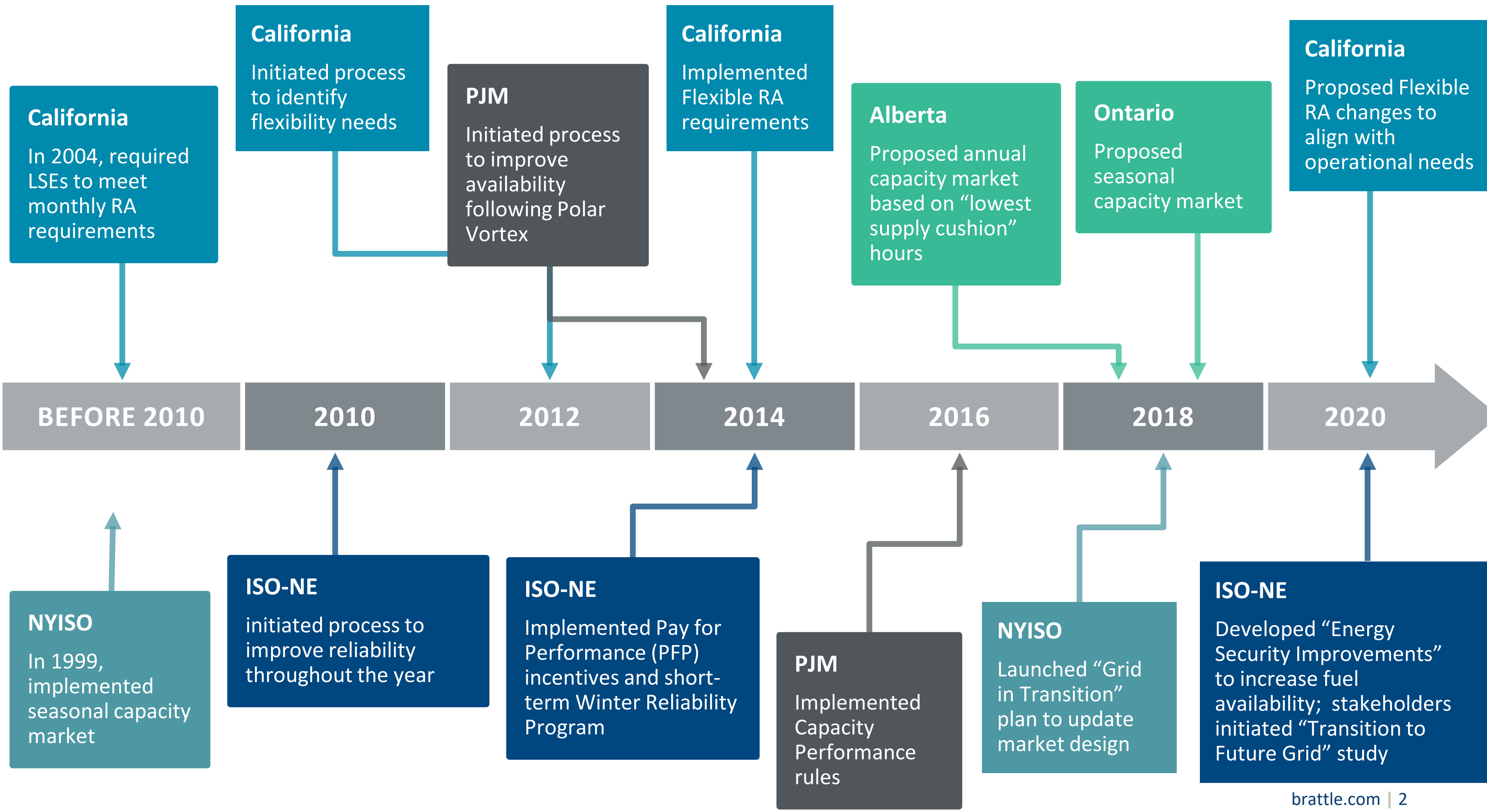
THE Brattle GROUP

Organized markets have continuously modified RA requirements since inception

…with increasing focus on a high-renewable future



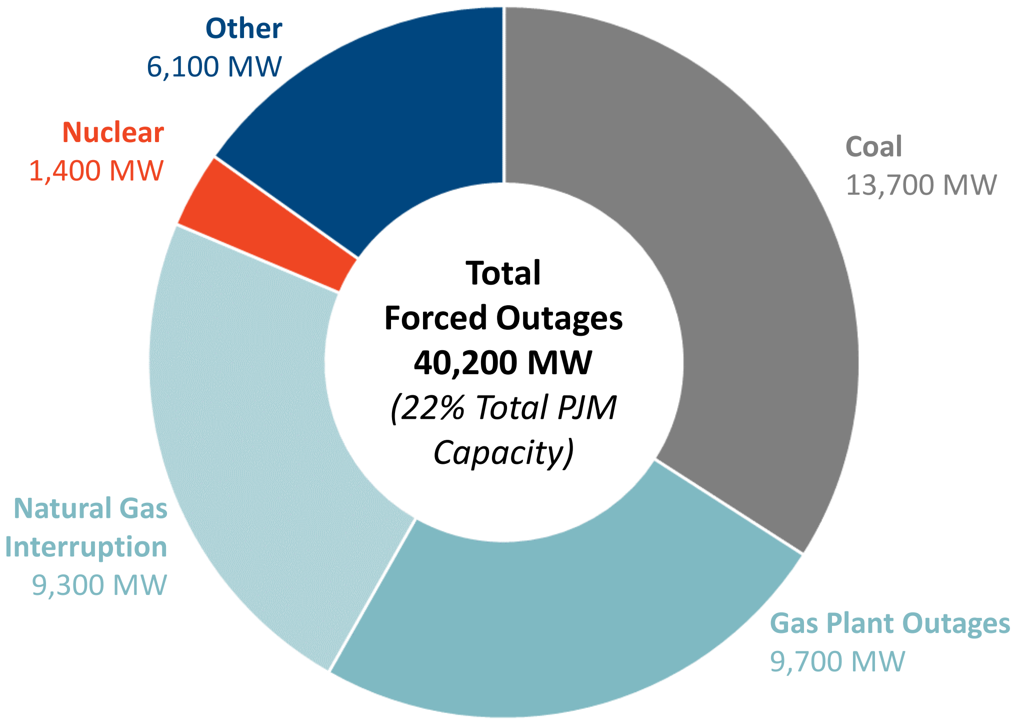
Other jurisdictions are addressing sub-annual RA needs

- The industry is reconsidering RA constructs given portfolio changes (and have in the past made changes to address seasonal availability, winter fuel assurance, and resource performance)
- There are various ways to address sub-annual RA based on regional needs and market/regulatory environment

Market	RA Period	Basis for Requirements	Basis for Resource Accreditation	Other Initiatives to Address Sub-Annual Needs
ISO-NE	Annual	Summer Peak	Year-round capability; seasonal resources have to pair with complements	Pay-for-Performance; Winter Reliability Program; Fuel Security Improvements; "Transition to Future Grid" study
PJM	Annual	Summer Peak	Year-round capability; seasonal resources have to pair with complements	Capacity Performance; Reserve Market enhancements
Alberta *(proposed)*	Annual	Tightest supply cushion hours	Tightest supply cushion hours	Identified 250 tightest supply cushion hours throughout the year
Ontario *(proposed)*	Summer & Winter	Summer & Winter Peaks	Seasonal Capability	Created additional operating reserves to address flexibility needs
Southern Co. & TVA	Summer & Winter	Summer & Winter Peaks	Seasonal Capability	Distinct summer and winter planning reserve margins
NYISO	Monthly and voluntary 6-month strips	Summer Peak	Seasonal Capability	Dual-fuel and minimum oil burn requirements; "Grid in Transition" study
CAISO	Monthly	Monthly Peaks	Monthly Capability	Flexible RA requirement; "Flexiramp" real-time product

PJM reformed following the Polar Vortex

Outages by Primary Fuel
7 pm, January 7, 2014



"Capacity Performance"

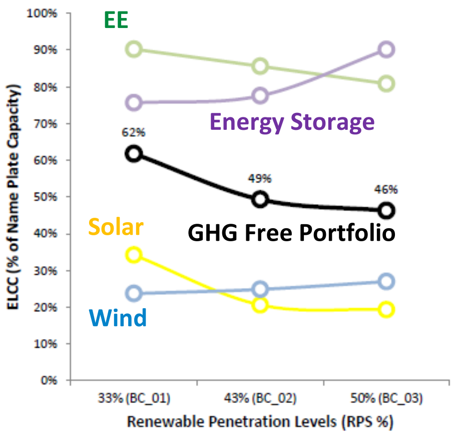
- Year-round capability required for "Annual Resources"
- $3500/MWh penalties during shortages (+LMP)

Source: "Analysis of Operational Events and Market Impacts During the January 2014 Cold Weather Events," PJM Interconnection, May 8, 2014

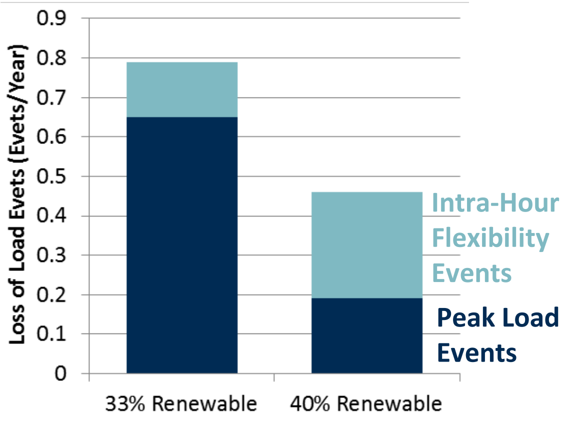
California implemented an annual and monthly RA requirement in 2004

- LSEs must meet 90% of their obligations a year-ahead and 100% a month-ahead
  - Allow LSEs flexibility to firm up remaining obligations based on updated load forecasts
- Resource accreditation revised as net peak shifted into evening hours (mostly after sunset), substantially reducing solar ELCC
- Reliability and hourly production cost simulation tool simulations show:
  - Resource availability during net peak is a good approximation of ELCC
  - As more renewables are added, shortage events will occur during ramping periods

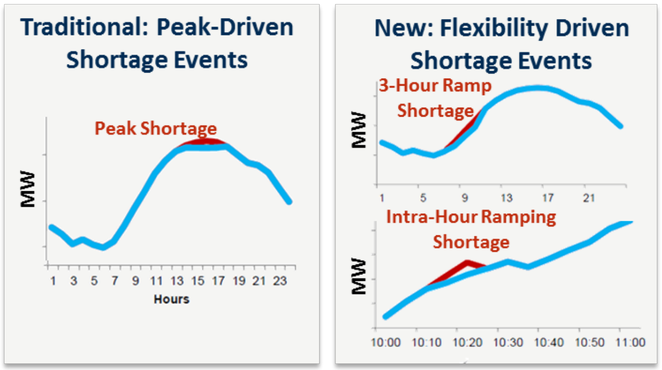
ELCC with Increasing RPS



California Reliability Events (2024)



Projected Types of Shortage Events

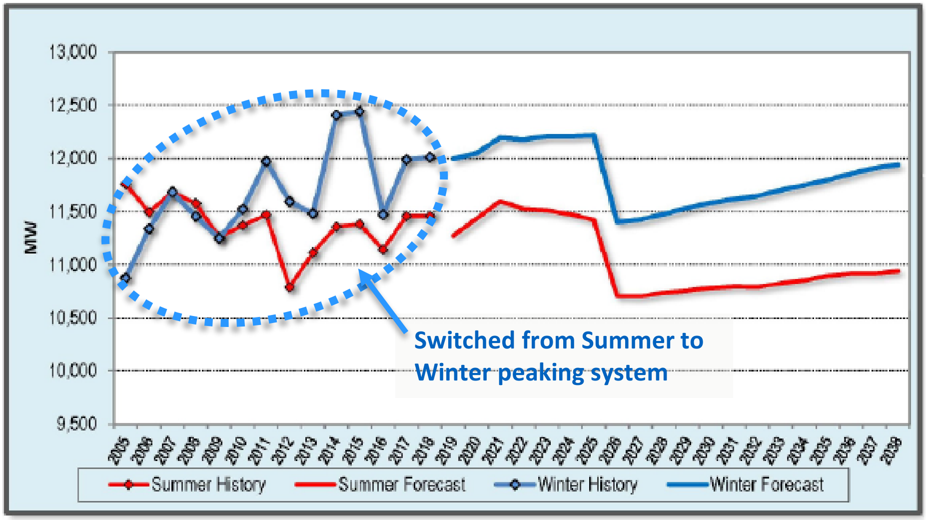


Sources: Astrape Consulting's Jan 6, 2016 and Aug 15, 2017 presentations to CPUC Flexibility Metrics and Standards workshops.

Southern Company and TVA implemented summer and winter planning reserve margins

- Winter (heating) peak loads have been growing in Southern's service area; Alabama Power shifted to winter peaking in 2011
- High weather-related peak load uncertainty and resource outages yield **25% winter PRM** for Alabama Power, compared to **15% summer PRM**
- TVA also uses summer and winter PRM but different approach based on **0.05 LOLE in each season**

Alabama Power Historical and Forecast Peak Load



Alabama Power Target Planning Reserve Margins

	Previous Reserve Margin Study	Updated Reserve Margin Study
System Long-Term Target Planning Reserve Margin (Summer)	16.25%	16.25%
System Short-Term Target Planning Reserve Margin (Summer)	14.75%	15.75%
Diversified Long-Term Target Planning Reserve Margin (Summer)	14.74%	14.89%
Diversified Short-Term Target Planning Reserve Margin (Summer)	13.26%	14.39%
System Long-Term Target Planning Reserve Margin (Winter)	-	26.00%
System Short-Term Target Planning Reserve Margin (Winter)	-	25.50%
Diversified Long-Term Target Planning Reserve Margin (Winter)	-	25.25%
Diversified Short-Term Target Planning Reserve Margin (Winter)	-	24.75%

Source: Alabama Power, "2019 Integrated Resource Plan Summary Report," 2019.

NYISO has a two-season RA construct and is looking to future needs

Seasonal resource adequacy construct

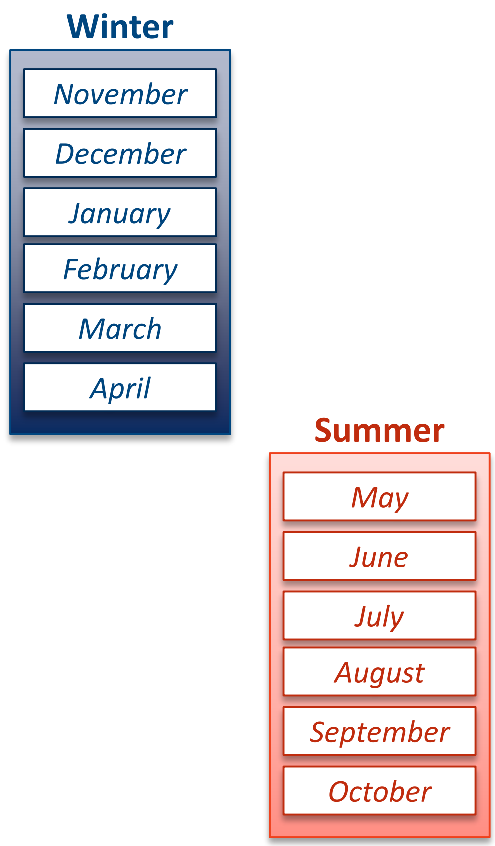
- NYISO originally implemented winter and summer obligation periods to accommodate seasonal resources, such as hydro imports from Quebec and increased winter capacity of thermal units
- Winter requirement is based on summer peak even though winter demand is lower (to spread payments more evenly across the year)
- Supported by strip and monthly spot auctions

The "**Grid in Transition**" plan will consider market design changes for a high-renewable fleet in its plan, including:

- Enhancing its resource adequacy model to account for shifts in shortage hours
- Revising resource capacity ratings
- Greater reliance on E&AS shortage pricing to complement RA changes

NYISO ICAP Market Design

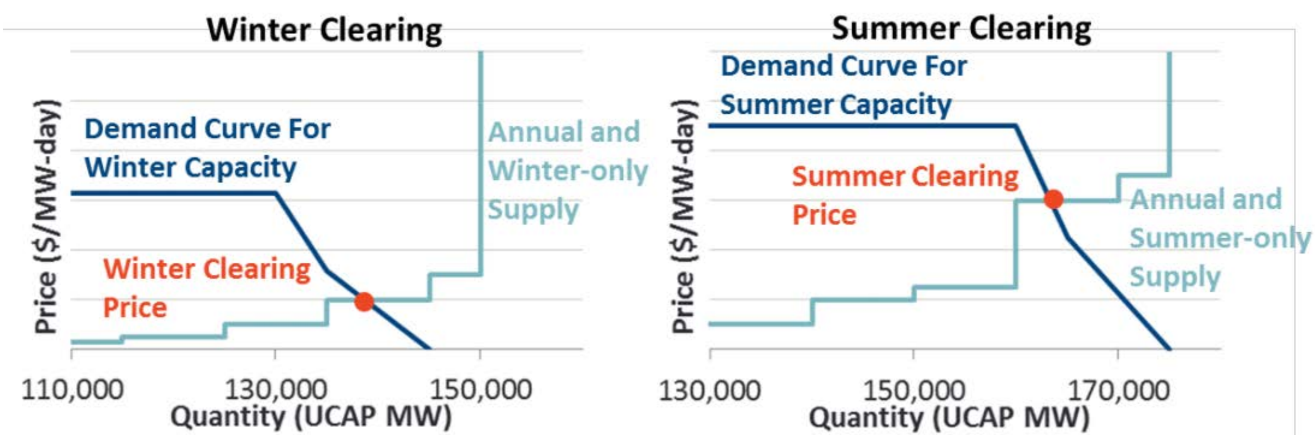
Seasonal strip auctions and month spot auctions



Ontario IESO proposed a seasonal capacity market

- Procurement target in each season reflects higher or lower peak demand forecasts in each season
- Resources qualify based on their contribution to RA need in each season
  - Allows for low-cost seasonal imports from both summer- and winter-peaking neighbors
- Clearing prices reflect each seasons' supply/demand balance, sending transparent price signal for marginal value of reliability
- Seasonal and annual bids are cleared together and co-optimized to procure the lowest-cost mix of seasonal and annual resources

Ontario's Proposed Seasonal Capacity Auctions



Source: The Brattle Group, "ICA Demand Curve Analysis: Preliminary Findings Regarding the Demand Curve for a Two-Season Auction," October 2019. Prepared for IESO stakeholder presentation.

Alberta's proposal for sub-annual RA

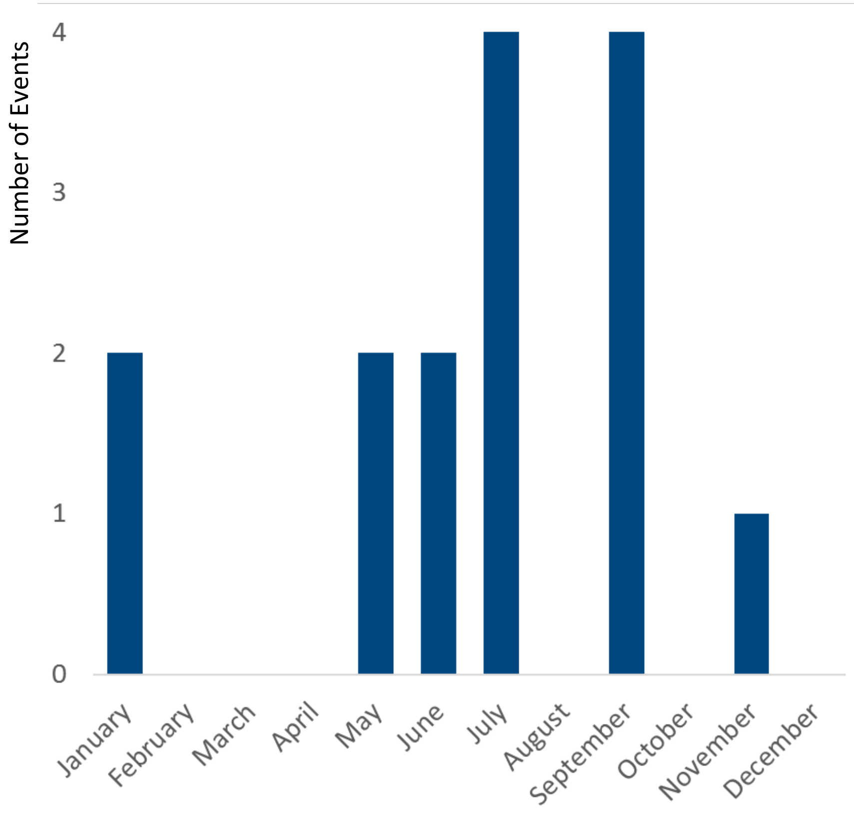
Required reserve margin: calculated using hourly (8760) probabilistic model to address **year-round shortage risks**

- Historically, events have occurred in primarily in summer, but several in winter and shoulder seasons

Resource accreditation: based on historical average availability in **tight conditions any time of year**

- 250 hours per year of tightest supply cushion over past five years
- Currently ~60% in summer, but evolving with changes in load patterns and fleet mix
- AESO originally preferred to use fewer hours (100), but increased due to stakeholder concern of excessive risk

Emergency Events in Alberta by Month, 2012-2018



Source: AESO, "Comprehensive Market Design: Rationale," 2018.

Appendix:
Resource Adequacy Metrics

Physical Resource Adequacy Metrics (1)

Metric	Description	Pros	Cons	Examples
Loss-of-Load Probability (LOLP)	The probability of demand exceeding the available resources during a given period. Can be calculated using either the daily peak loads or all hourly loads in a given period. Units: % chance of >= 1 event per 1 year	Easy to calculate and understand	Does not consider the duration or the size of an unserved load event.	Northwest Power and Conservation Council: 5% loss of load probability
Loss-of-Load Events (LOLEV)	The number of events in which some system load is not served in a year, irrespective of event duration (hrs) or depth (MW). One event in ten years translates to 0.1 loss-of-load events (LOLE) per year, regardless of the duration or depth of events. Units: Events per year	Easy to calculate and understand Most North American systems use this metric	Does not consider the duration or the size of the unserved load event.	Most U.S. Systems: 1 loss-of-load event per decade, or 0.1 event per year.
Loss-of-Load Expectation (LOLE)	The expected number of days per year for which the available generation capacity is insufficient to serve the daily peak demand. Units: Days with events per year	Easy to calculate and understand	Does not consider the size of the system and cannot be easily used to compare across different systems with different sizes	

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Physical Resource Adequacy Metrics (2)

Metric	Description	Pros	Cons	Examples
Loss-of-Load Hours (LOLH)	The expected number of hours per year when a system's demand is projected to exceed available supply. One day (24 hours) in ten years translates to 2.4 loss of load hours (LOLH) per year, regardless of the magnitude or number of such outages. Based on the summation of the probabilities for all hours in a year. Units: Hours per year	Considers the loss of load duration NERC recommended	Does not consider the size of the system and cannot be easily used to compare across different systems with different sizes	SPP: 2.4 loss of load hours per year
Normalized Expected Unserved Energy (EUE)	The expected number of MWh of load that will not be served in a given year as a result of demand exceeding the available supply across all hours. Can also be normalized as % of load not served. Units: % of expected annual load	Considers both the duration and magnitude of supply shortages. If normalized, it can be used to compare across systems of different size NERC recommended	Requires somewhat more sophisticated statistical methodologies	Alberta: Max annual EUE of 800 MWh Scandinavia: Max of 0.001% of total load shed each year Australia NEM: Max of 0.002% normalized EUE (not translated into an RA requirement)

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