Establishment of the Regional Energy Shortfall Threshold (REST)

Review PEAT modeling enhancements and ISO's current thinking regarding REST metrics

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Background: PEAT and REST

- Study results from ISO's probabilistic energy adequacy study have informed the region on energy shortfall risks during extreme weather events over the next decade
- The Probabilistic Energy Adequacy Tool (PEAT) framework for risk analysis under extreme weather events will be essential for evaluating regional energy shortfall risk as the resource mix evolves and as climate projections are refined
- ISO's initial 2027 and 2032 energy adequacy study results are expected to help inform the development of the REST

Introduction to REST

- Following establishment of the REST, a subsequent effort will evaluate if adherence to the REST requires development of specific regional solutions
  - ISO's REST proposal is being developed such that identified metric(s) could be reasonably translated into a solution
- This presentation provides:
  - A review of PEAT modeling enhancements
  - ISO's current thinking regarding the seasonal REST metrics
    - ISO's current thinking is intended to prompt continued discussion and invite feedback from stakeholders

Introduced at August RC Meeting

Review of the REST Scope of Work

- ISO anticipates that the REST scope of work will include, at a minimum, the following components:
  - **When:** Determine the periodicity (*e.g.,* annual, seasonal, etc.) and, as applicable, specify the time horizon over which the region's energy shortfall risk is assessed against the REST
  - **How:** Specify the event selection process to be used in determining the set of 21-day events to be considered when using the PEAT framework to assess the region's energy shortfall risk against the REST
  - **What:** Identify the key risk metrics and establish the "threshold(s)", or criteria, that define the region's level of risk tolerance with respect to energy shortfall in extreme weather
- An additional item to determine as part of this scope of work is the effective date which represents the first season where the PEAT framework will be used to measure energy shortfall risk against the REST

REVIEW OF PEAT MODELING ENHANCEMENTS: PREVENTIVE AND CORRECTIVE ACTIONS

ISO is Incorporating Preventive and Corrective Actions Directly into the PEAT Framework

- To better assess the region's energy shortfall risk against the REST criteria, the PEAT model is being enhanced to include both preventive and corrective actions
- In the event of an actual or anticipated energy shortfall, the preventive and corrective actions that ISO and participants could take are expected to provide relief and result in a reduction of energy shortfall:
  - Market response/supply logistic relief: Market Participants can incorporate opportunity costs in their energy market offers
  - Net import relief: Under the provisions of ISO's procedures, OP-4 and OP-21, ISO can curtail exports and/or schedule additional imports in the days leading to and/or during energy shortfall hours
  - Conservation relief: Under the provisions of ISO's procedures, OP-4 and OP-21, ISO can make appeals for conservation in the days leading to and/or during energy shortfall hours

ISO is Incorporating Preventive and Corrective Actions Directly into the PEAT Framework, cont'd

- OP-21 contains "Energy Emergency Actions" that include provisions to implement specific capacity and load relief measures available through actions of OP-4
  - In the event of an actual or anticipated energy shortfall, ISO would declare an Energy Emergency in accordance with OP-21, then implement specific OP-4 actions as necessary
  - In such an event, ISO's preventive actions would be targeted to conserve stored fuels that are in limited supply

PEAT's Multi-Day Dispatch Approximates Both Preventive and Corrective Actions

- ISO has significantly enhanced PEAT to incorporate a multi-day rolling-horizon economic dispatch; as a result, the 21-day energy assessment can approximate both preventive and corrective actions
  - Incorporating both preventive and corrective actions directly into PEAT allows for a robust assessment of energy shortfall risk
- The multi-day dispatch represents an innovative modeling approach, integrating forward-looking analytics with dispatch decisions
- The timing and amount of relief determined by the PEAT enhancements are modeling approximations, not exact operational limits
  - The model provides a proxy, helping the ISO assess the system's ability to respond to an extreme event in a comprehensive manner
  - In real-time operations, the quantity of relief achievable via these actions could vary by hour and by day

PEAT's Multi-Day Dispatch Approximates Both Preventive and Corrective Actions, cont'd

- Preventive net import relief is modeled as a block of up-to 500 MW/hour; this approximates relief associated with curtailing exports and/or scheduling additional imports
  - Net import relief is incremental to the hourly net imports in each case
  - Historical data shows that on average ~500 MW/hour of exports are available for curtailment; this assumption can be refined periodically based on more recent data
  - 500 MW also approximates the net import relief achieved by curtailing export transactions of around 500 to 800 MW during the December 24th, 2022 OP-4 event in New England
- Preventive conservation relief is modeled as a block of up-to 500 MW/hour; this approximates relief associated with appeals for conservation
  - It is challenging to quantify conservation relief in New England due to the lack of experience with conservation appeals in the region
  - 500 MW is an approximation based on ~3% of load reduction observed in CAISO and AESO following conservation appeals

Periodicity of Energy Shortfall Risk Assessment

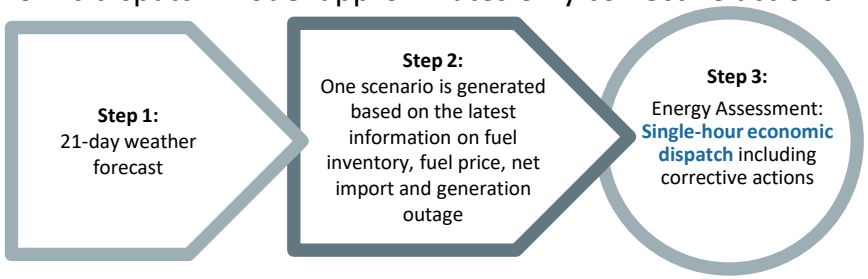
- The ISO is considering the application of the PEAT framework over three time horizons:
  - Annual (future time periods)
  - Seasonal (upcoming winters and summers)
  - In-season (contemporaneous, 21-day energy forecasting)
- ISO's current thinking is that REST will focus on the seasonal time horizon

Periodicity of Energy Shortfall Risk Assessment, cont'd

- In the annual and seasonal energy shortfall assessment, the ISO is considering using multi-day economic dispatch in PEAT Step 3 to evaluate energy shortfall risk
  - The multi-day economic dispatch model approximates both preventive and corrective actions

Overview of PEAT 3-step process in the annual and seasonal energy shortfall assessment

- In the in-season energy shortfall assessment, the ISO currently performs a deterministic energy assessment which uses single-hour economic dispatch in Step 3 of the deterministic process
  - The single-hour economic dispatch model approximates only corrective actions



Overview of the 3-step deterministic process used in the current in-season energy shortfall assessment

  - In the future, the ISO is considering enhancing the deterministic process to a probabilistic approach, similar to PEAT, to better account for uncertainty

CURRENT THINKING ON REST METRICS

Introduced at May RC Meeting

REST Metric(s)

- ISO's criteria and considerations for possible REST metric(s):
  - Sensitive to system conditions; it should be expected that margin to the threshold decreases as system conditions worsen
  - Considers the key tail risk attributes, such as the magnitude of energy shortfall over a period of time, energy shortfall duration, and the probability of energy shortfall
  - Correlates to impacts on customers (*e.g.,* potential for customer outages in extreme events)
  - Able to be calculated by ISO, given existing tools and available data
  - Simple to interpret and understand; a single REST metric may be beneficial in terms of enhancing clarity (and facilitating the establishment of well-defined thresholds)
  - Facilitates a cost/benefit comparison of actions to reduce potential energy shortfall
  - Should not need to be modified frequently as the system resource and demand profiles evolve

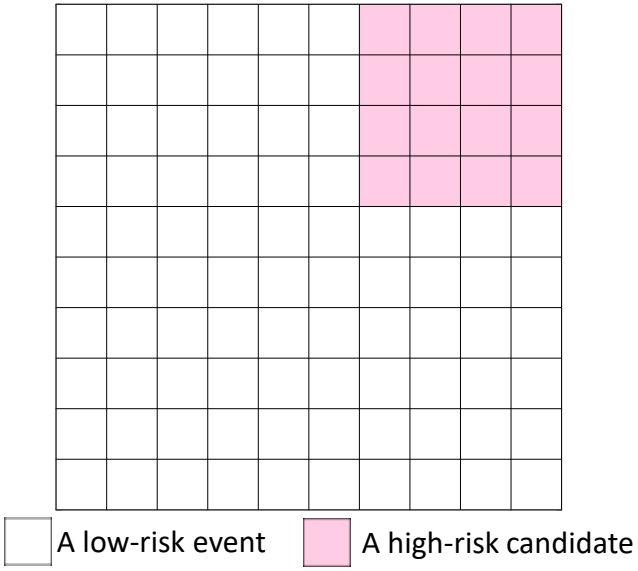
Terminology Review

- An “event” means a 21-day weather scenario
- A “case” or a “21-day case” is a combination of various factors, including an event, LNG inventory scenario, oil inventory scenario, fuel price scenario, net import scenario, and forced outage scenario
- Each event is associated with multiple cases
  - In the ISO’s initial 2027 and 2032 energy adequacy studies, there are 720 cases associated with each event
- Each case has a probability of occurrence; the sum of the probabilities across all cases is one

Review of PEAT Steps 2 and 3

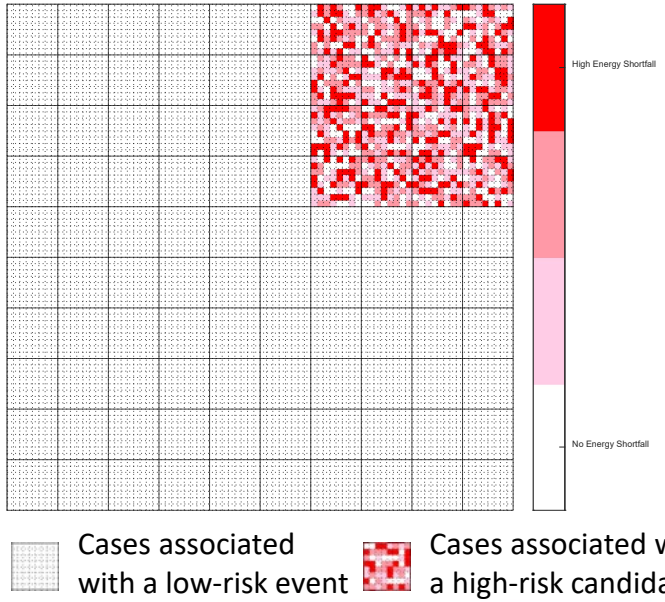
Step 2 – Risk Screening Model Development and Scenario Generation

- Risk screening model categorizes events as either low-risk or high-risk candidates
- Low-risk events are assumed to have no energy shortfall in their associated cases (assumption made to speed up computational performance)



Step 3 – Energy Assessments

- The 21-day energy assessment with multi-day dispatch evaluates all cases associated with high-risk candidates
- In the end, energy shortfall values are determined for all cases associated with both low- and high-risk events

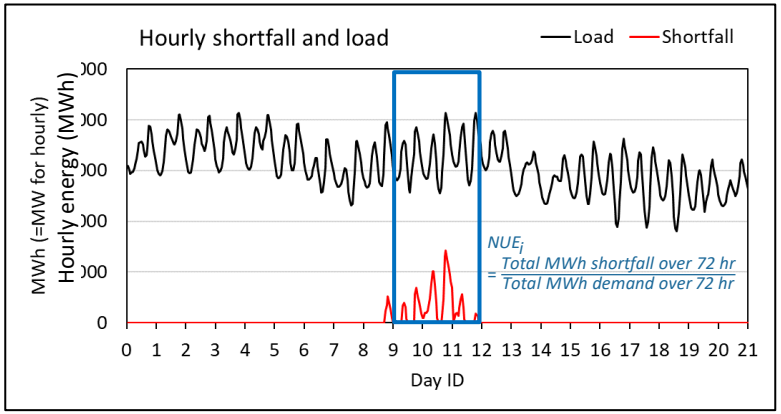


REST Metrics – Current Thinking

- ISO is currently considering two REST metrics; magnitude of tail α% and duration of tail α%
- **Magnitude of tail α%** = Conditional expectation of normalized unserved energy over a 72-hour period for the cases within the tail α% percentile
  - This metric measures energy shortfall **magnitude** of tail cases in terms of Normalized Unserved Energy (NUE)
- **Duration of tail α%** = Conditional expectation of energy shortfall hours over a 21-day period for the cases within the tail α% percentile
  - This metric measures energy shortfall **duration** of tail cases

An Illustrative Example of Calculating Magnitude of Tail 1%

- For each 21-day case *i*, identify the most intensive 72-hour period where *NUE over the 72-hour period (NUE = $\frac{\text{Total MWh shortfall over 72 hours}}{\text{Total MWh demand over 72 hours}}$)* is the largest within the 21-day window
- For each 21-day case *i*, calculate NUE_i, representing the NUE of the most intensive 72-hour period
- Rank cases in ascending order of NUE_i
- Magnitude of tail 1% = Conditional expectation of NUE_i of the cases that belong to the worst one percentile



This is an illustrative plot of energy shortfall and demand over a 21-day case. The 3 days highlighted by the blue box is the worst 3-day with the highest NUE

Case number	Case probability	NUE_i (in ascending order)
1	0.001	0%
2	0.002	0%
…	…	…
497	0.001	1%
498	0.002	5%
499	0.005	10%
500	0.002	20%

Tail 1%

This is an illustrative example, where a total of 500 cases are ranked in ascending order of NUE_i. Cases 497-500 belong to the worst one percentile in terms of NUE. The sum of their case probabilities is 0.01 (=0.001+0.002+0.005+0.002). The conditional expectation of NUE_i of these four tail cases is 10.1% (= $\frac{0.001\times1\%+0.002\times5\%+0.005\times10\%+0.002\times20\%}{0.001+0.002+0.005+0.002}$)

Magnitude of Tail α% and Energy Shortfall Magnitude under Extreme Conditions

- Magnitude of tail α% indicates the magnitude of energy shortfall under low-probability extreme conditions
  - A higher magnitude of tail α% suggests that a larger percentage of load is likely to experience energy shortfall if the region faces conditions similar to those associated with tail cases
- The conditional expectation emphasizes the risk under low-probability cases, rather than all cases
  - It provides an assessment of regional energy shortfall risk under extreme situations, not average situations
- NUE is a stable metric, providing a more consistent basis for comparison over time
  - It accounts for fluctuations in both system resources and demand profiles
  - It is less sensitive to absolute changes in supply or demand

Magnitude of Tail α% and Energy Shortfall Magnitude under Extreme Conditions, cont'd

- Rationale for using a 72-hour period for magnitude of tail α% calculation:
  - The PEAT enhancements incorporate both preventive and corrective actions, reducing the overall energy shortfall duration
    - The 72-hour period aligns better with this reduced duration, providing a more relevant NUE metric than the original 7-day time period
  - NUE over a 72-hour period better captures the intensity and impact of energy shortfall events
    - When using a longer period (*e.g.*, 7 days), the NUE can appear smaller or diluted because it is averaged over a larger number of hours, many of which might have no energy shortfall
    - The 72-hour period focuses more closely on the hours where the energy shortfall occurs, giving a clearer indicator of its intensity
- Duration of tail α% is used to complement the 72-hour NUE window to provide additional information on energy shortfall duration beyond the 72-hour timeframe

An Illustrative Example of Calculation of Duration of Tail 1%

- For each 21-day case *i*, calculate the cumulative energy shortfall hours over the 21-day period
- Rank cases in ascending order of cumulative energy shortfall hours
- Duration of tail 1% = Conditional expectation of cumulative energy shortfall hours of the cases that belong to the worst one percentile

Case number	Case probability	Energy shortfall hours (in ascending order)
1	0.001	0
2	0.002	0
…	…	…
490	0.002	60
497	0.001	70
499	0.005	90
500	0.002	100

This is an illustrative example, where a total of 500 cases are ranked in ascending order of cumulative energy shortfall hours. Cases 490, 497, 499 and 500 belong to the worst one percentile in terms of energy shortfall hours. The sum of their case probabilities is 0.01 (=0.002+0.001+0.005+0.002). The tail cases related to duration are not necessarily identical to the tail cases related to magnitude. The conditional expectation of cumulative energy shortfall hours of these four tail cases is 84 hours (= $\frac{0.002\times60+0.001\times70+0.005\times90+0.002\times100}{0.002+0.001+0.005+0.002}$).

Duration of Tail α% and Energy Shortfall Duration under Extreme Conditions

- Duration of tail α% indicates the duration of energy shortfall under low-probability situations
  - A higher duration of tail α% suggests a longer energy shortfall duration if the region faces conditions similar to those associated with tail cases
- Duration of tail α% captures prolonged energy shortfall
  - The conditional expectation of only low-probability cases, rather than all cases, enables duration of tail α% to provide a clear indictor of energy shortfall duration during stressful conditions
  - It is particularly relevant for extreme weather events that cause extended energy shortfalls

Both Metrics are Essential for Evaluating Regional Energy Adequacy Risk

- Energy adequacy can be assessed by considering energy shortfall risk over a prolonged period of time, especially during extreme conditions
- ISO's current thinking is that both magnitude of tail α% and duration of tail α% are critical metrics for assessing energy adequacy risk under extreme conditions, capturing both magnitude and duration of energy shortfall in low probability scenarios
- Relying only on magnitude of tail α% would limit the assessment to the size of energy shortfall, without distinguishing between prolonged and brief energy shortfalls
- Relying only on duration of tail α% would limit the assessment to how long energy shortfalls last, without distinguishing between low and high-intensity energy shortfalls
- ISO is still evaluating how best to incorporate these two metrics into its REST proposal

SUMMARY AND NEXT STEPS

Summary of ISO's Current Thinking Regarding the Development of the REST

- Recent modeling enhancements have allowed ISO to:
  - Incorporate an approximate opportunity cost mechanism
  - Capture the impact of preventive and corrective actions
- ISO is currently thinking to use magnitude of tail α% and duration of tail α% as REST metrics
  - Both metrics are essential to quantify the magnitude and duration of energy shortfall under extreme conditions
- ISO requests stakeholder feedback on its proposed REST metricsα
  - Note that feedback should focus on the proposed metrics
    - Discussion on thresholds and potential solutions will begin once metrics have been finalized
  - ISO continues to refine its thinking based on feedback and plans to share relevant updates at upcoming RC meetings

Stakeholder Schedule

Schedule is subject to change based on progress

Stakeholder Committee and Date	Scheduled Project Milestone
Reliability Committee December 18, 2023	Presentation of REST Scope of Work by ISO
Reliability Committee May 14, 2024	Review of ISO's current thinking and stakeholder feedback
Reliability Committee August 13-14, 2024	Review of ISO's current thinking regarding REST
Reliability Committee October 22, 2024	Review of ISO's current thinking regarding REST
Reliability Committee November 19, 2024	Presentation of ISO's currenting thinking regarding REST metrics
Reliability Committee December 17, 2024	Review stakeholder feedback on ISO's proposed REST metrics, as needed
Reliability Committee January/February 2025	Presentation of any modifications to ISO's proposed metrics in response to stakeholder feedback
Reliability Committee March/April 2025	Presentation of ISO's REST proposal with initial thresholds

Questions