Regional Energy Shortfall Threshold (REST)

ISO's Current Thinking Regarding Tail Selection

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Framework for REST Development

- REST will reflect the region's level of risk tolerance with respect to energy shortfall during extreme conditions in a season
- REST is determined in two stages:
  - *Stage 1:* Select tail α%
    - This defines the rarity or frequency of energy shortfall to be considered in REST
  - *Stage 2:* Set magnitude and duration thresholds within the chosen tail α%
    - Once the rarity of energy shortfall is determined, the thresholds for acceptable shortfall magnitude and duration will be established
- This presentation focuses on tail α% selection in Stage 1

Rational for Choosing Tail α% First

- Tail α% sets the frequency or likelihood of energy shortfall considered
  - A lower α% captures rarer energy shortfalls, which tend to have greater impact
  - A higher α% includes more frequent energy shortfalls, which are generally less severe
  - Magnitude and duration thresholds for a once-in-100-year shortfall should not be the same as those for a once-in-50-year shortfall because they reflect different levels of severity
- Choosing tail α% first provides a clear starting point before defining acceptable energy shortfall magnitude and duration thresholds
  - Anchoring the REST development with a chosen tail α% narrows the scope for selecting magnitude and duration thresholds
  - Without Stage 1, the range of possible thresholds would be too broad, making it difficult to determine the risk tolerance level

Once Tail α% is Selected, It Provides Consistency to Tail Risk Comparison

- By fixing the tail α%, the region establishes a common reference point for measuring and comparing tail risk across years and across seasons
  - Using a consistent tail α% ensures differences in assessed tail risk are caused by underlying system conditions, not inconsistencies in the frequency of energy shortfall considered
- Using a consistent tail α% avoids apples-to-oranges comparisons
  - For example, comparing the risk of a once-in-100-year winter event with that of a once-in-50-year winter event would distort the interpretation of risk severity
- Applying the same tail α% across seasons supports meaningful comparisons of tail risk between different seasons
  - For example, comparing the risk of a once-in-100-year winter event with a once-in-50-year summer event does not accurately reflect the difference in seasonal system reliability. It simply reflects different assumptions on how rare an event is being considered

Defining REST Threshold Parameters

- **REST focuses on tail α% = _____%, meaning an energy shortfall of this severity would occur once every _____ seasons on average during a 21-day period**

- The acceptable shortfall magnitude within tail _____% is _____%

- The acceptable shortfall duration within tail _____% is _____ hours

REVIEW OF REST METRICS

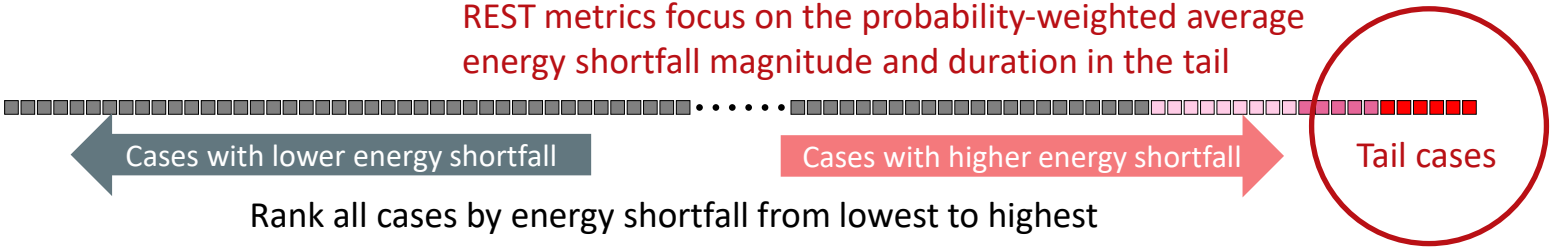
Introduced November RC Meeting

REST Metrics

- **Magnitude within tail α%** = Conditional expectation of normalized unserved energy over a 72-hour period for the cases within tail α%
  - This metric measures energy shortfall **magnitude** of shortfall within tail cases in terms of normalized unserved energy
- **Duration within tail α%** = Conditional expectation of energy shortfall hours over a 21-day period for the cases within tail α%
  - This metric measures energy shortfall **duration** within tail cases

Calculation of REST Metrics

- The calculation of the REST metrics was presented at the November 2024 RC meeting
- For a chosen tail α%, the REST metrics measure the probability-weighted average energy shortfall magnitude and duration in the tail



REST Metrics Will Be Compared to REST Thresholds

- The ISO proposes a tail α% value at this stage, representing the portion of extreme outcomes to focus on
- Once the tail α% is selected, the corresponding magnitude and duration thresholds will be defined to reflect the regions' accepted risk tolerance within that tail at Stage 2
- Using Probabilistic Energy Assessment Tool (PEAT), we will calculate the magnitude and duration metrics within the selected α% for the given season
- These metrics will be then compared against the corresponding REST thresholds, using the same α%, to assess whether the risk of extreme conditions is within the region's accepted risk tolerance
  - The same chosen tail α% value will be consistently applied to both the metrics and the thresholds to ensure the comparison is aligned and meaningful

PEAT ANALYSIS ON STRESSED SCENARIOS TO INFORM SELECTION OF TAIL α%

Understanding Likelihood and Severity of Energy Shortfall by Evaluating 2027 Winter

- The ISO evaluated tail risk under a winter 2027 baseline stress scenario and under multiple additional stress scenarios (see slide 13 for descriptions of these scenarios) to understand and demonstrate how REST magnitude and duration metrics behave under different modeled conditions
- The stress scenario analysis was performed by using PEAT
  - One climate model and one emission scenario was used to generate ~674,000 winter cases (=936 events x 720 cases) across all stress scenarios
  - Each case represents a different combination of weather, load, fuel availability, fuel price, imports, and forced outage conditions
- For each stress scenario, tail magnitude and duration were calculated across a range of tail α% levels

2027 Winter Stress Analysis Helps to Inform Tail α% Selection

- This analysis helps to inform the selection of an appropriate tail α% by illustrating how the likelihood and severity of energy shortfall vary across stress scenarios and tail levels
- By selecting tail α% based on the 2027 winter stress scenarios analysis, it ensures the high-impact winter cases are included within the tail
- The preliminary PEAT analysis has indicated that energy adequacy risk in the region is higher in winter than in summer. Therefore, applying the same tail α% to summer would adequately capture high-impact cases in both seasons, making a separate summer analysis unnecessary to determine the tail α%

Baseline and Stress Scenarios

- **Baseline stress scenario:** FCA 18 resource mix and CELT 2022 load forecast
  - Because PEAT is a probabilistic tool, a number of 21-day load profiles are evaluated in winter 2027
  - The highest hourly load observed across all simulations was ~21,000 MW
- **Modest additional stress scenario:** FCA 18 resource mix and scale up CELT 2022 load forecast by 10% throughout the season
- **Significant additional stress scenario:** FCA 18 resource mix with ~10% generation supply removed from the mix and scale up CELT 2022 load forecast by 10% throughout the season
- **Severe additional stress scenario:** FCA 18 resource mix and scale up CELT 2022 load by 20% throughout the season

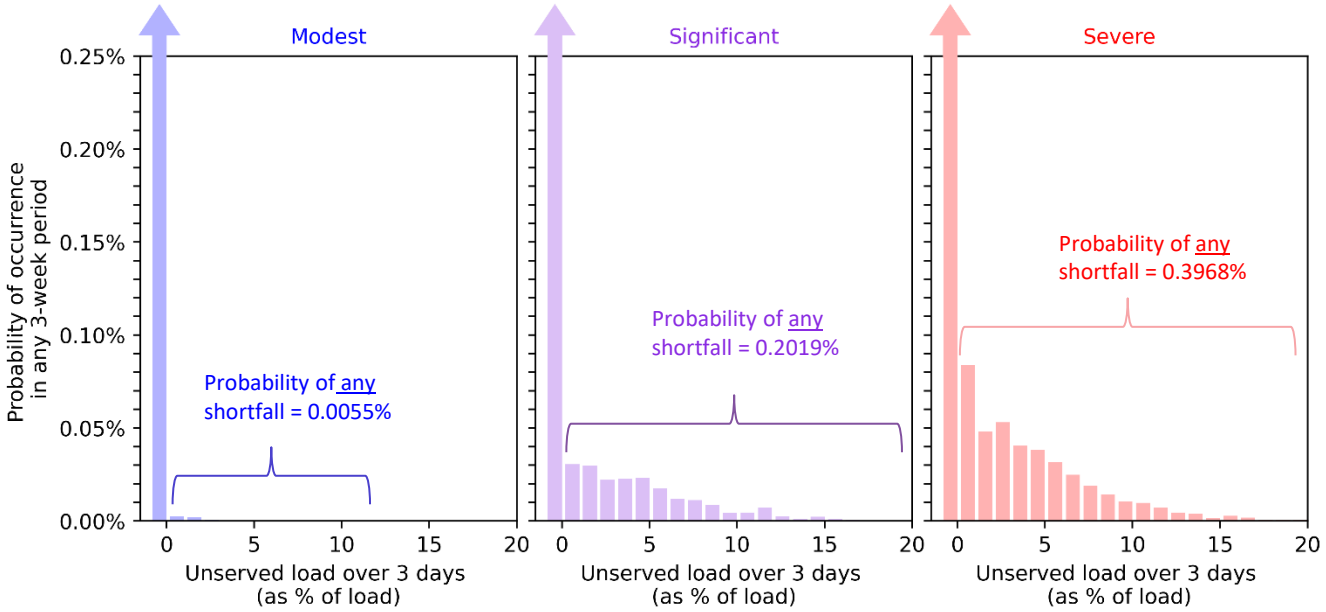
Rationale for Considering Various Stress Scenarios for Tail Risk Selection

- The goal is **not** to predict specific additional stress scenarios where the region would expect to see real-world energy shortfalls or to suggest these scenarios will occur
- Instead, this approach provides a quantitative measure of energy shortfall magnitude and duration when the grid is pushed to stressed conditions
- Without these quantitative measures across different stressed conditions, the region would not have a comprehensive understanding of potential tail risk beyond the baseline condition
  - As resource mix, load profiles, and weather patterns evolve in the region, tail risk may manifest differently from what is observed in the baseline scenario
  - Therefore, assessing tail risk beyond the baseline scenario helps to capture potential vulnerabilities that may not be evident in the baseline scenario

Takeaways of the Baseline Stress Scenario

- No statistically significant shortfall is observed
  - The probability of any energy shortfall is 0.00001%
- Tail risk is expected to be extremely low in winter 2027
  - The magnitude is on the order of $1x10^{-17}$ % within the tail 0.1%, 0.25%, and 0.4%
  - The duration is estimated to be:
    - 0.00012 hours within tail 0.1%
    - 0.00002 hours within tail 0.25%
    - 0.00001 hours within tail 0.4%

Magnitude Histograms of Stress Scenarios

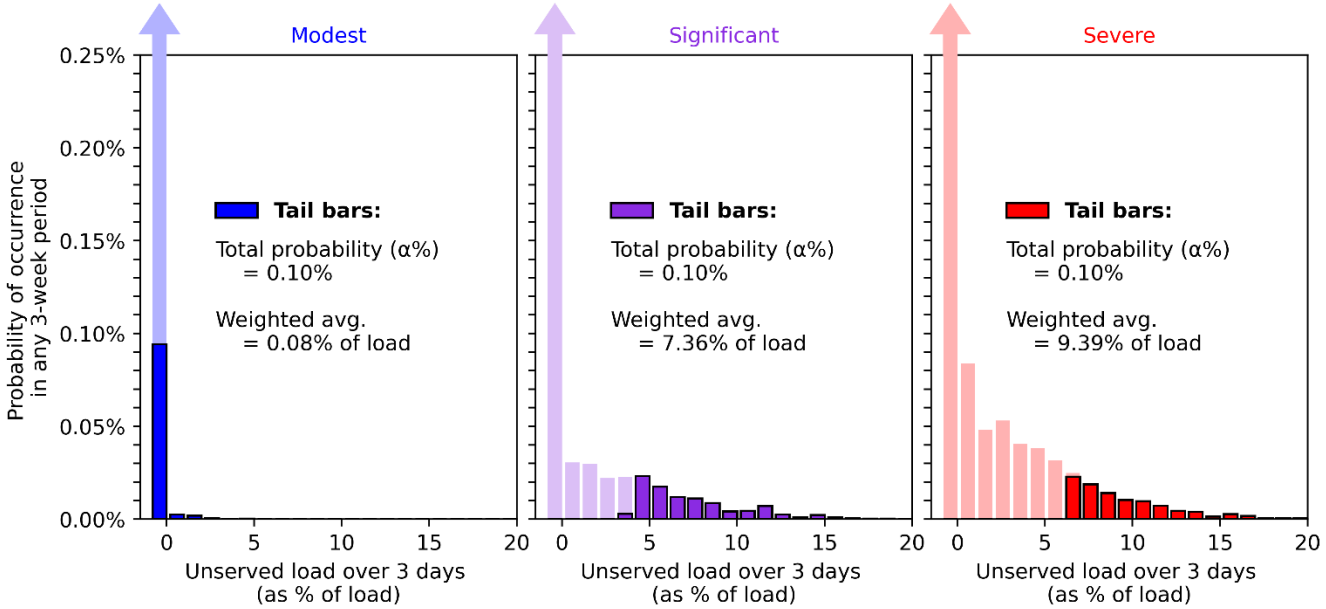


* The colored upward arrows in the histograms indicate that the probability of having zero energy shortfall is much higher than 0.25%. The y-axis is capped at 0.25% to illustrate less frequent but more severe energy shortfall results, which are critical for understanding tail risk.

Studying Tail Magnitude Behavior under Different Tail Levels

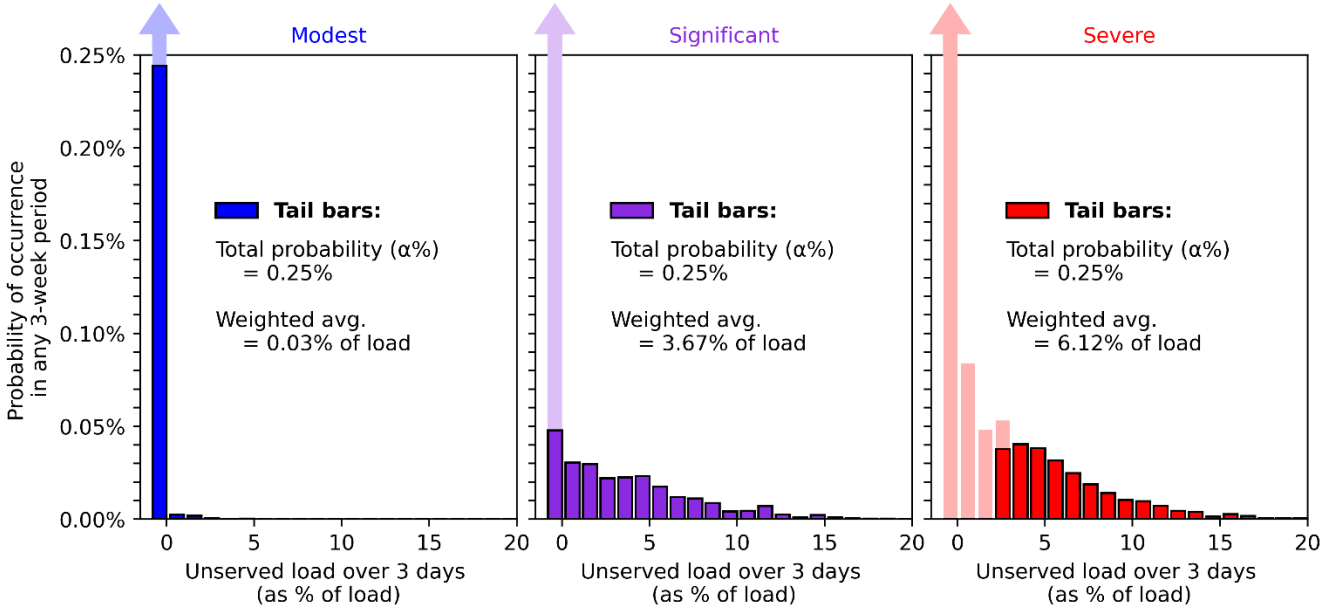
- Three tail α% levels are considered to illustrate how tail magnitude changes under different tail α%:
  - Tail 0.1% represents ~once every 230 winters
  - Tail 0.25% represents ~once every 90 winters
  - Tail 0.4% represents ~once every 55 winters

Magnitude with α = 0.10% Concentrates on High-Impact Cases



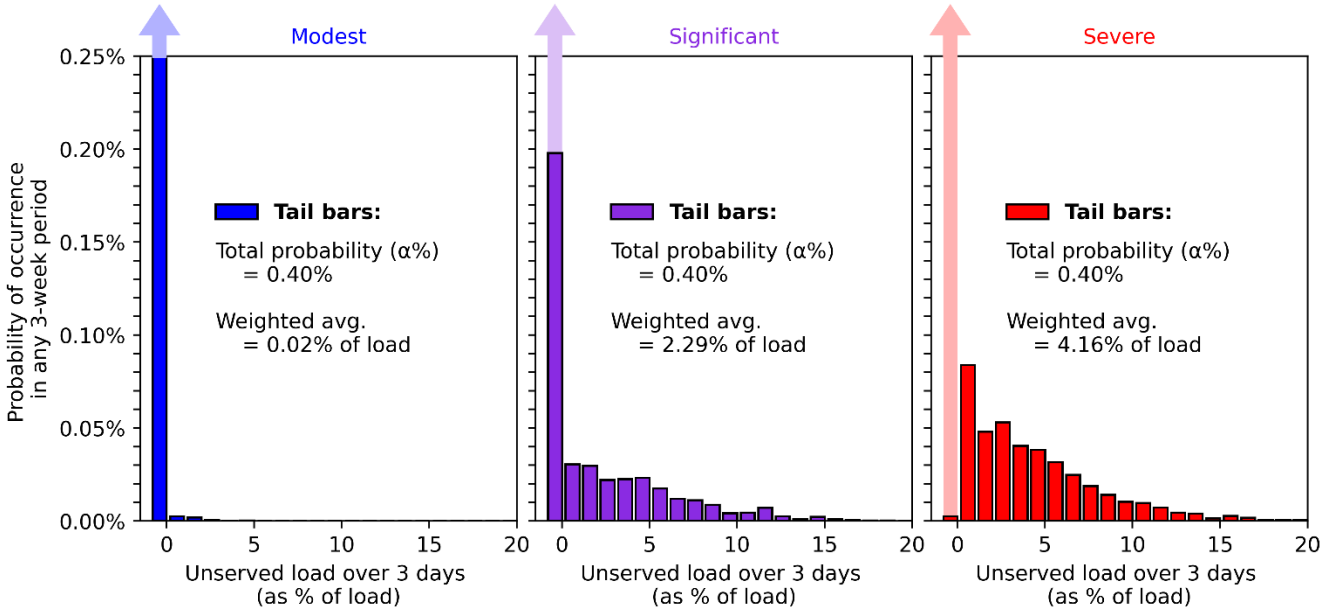
- If α% = 0.1%, the shortfall magnitude concentrates on high-impact cases, but the probability of such cases is very small
- The shortfall magnitude is higher in the Severe Additional Stress Scenario compared to less stressed scenarios. This means the magnitude metric increases as system reliability decreases

Magnitude with α = 0.25%
Balances High-Impact Cases with Limited Dilution



- The magnitude within the tail 0.25% is smaller than the magnitude within the tail 0.1%. This is because a higher α% (*e.g.*, 0.25%) includes more cases with smaller energy shortfall, whereas a lower α% (*e.g.*, 0.1%) focuses on more extreme shortfall cases.

Magnitude with α = 0.40% is Significantly Diluted with Zero Shortfall Cases

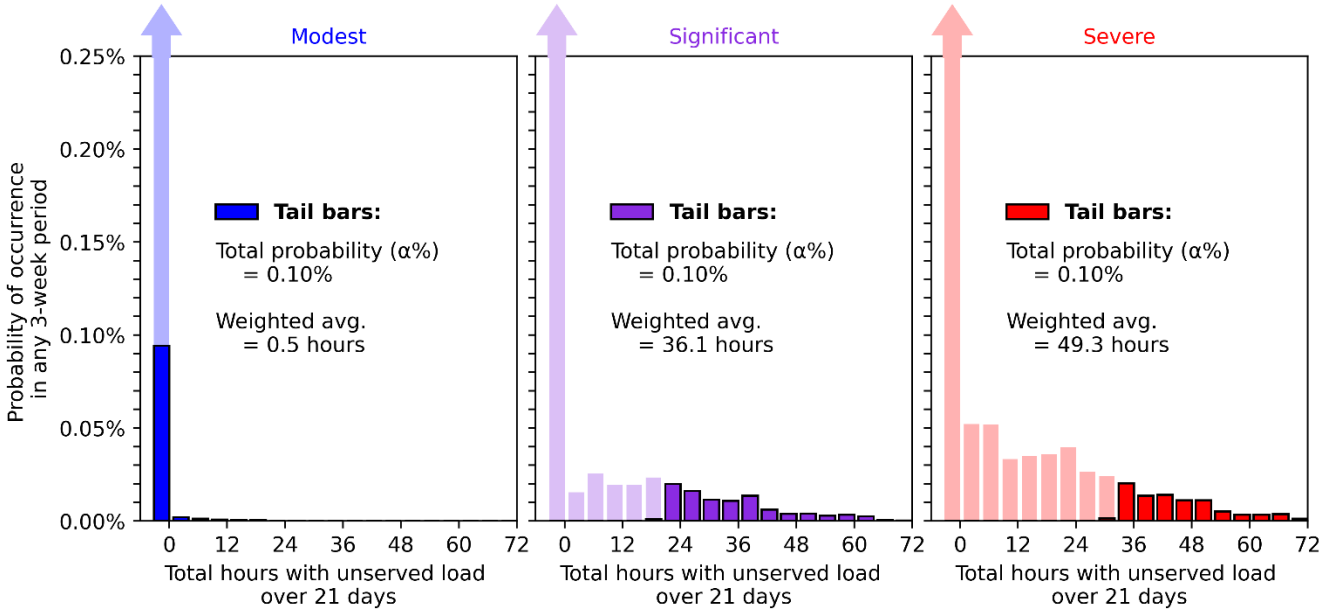


- If α% = 0.4%, the magnitude metric will include more cases with little to no energy shortfall compared to α% = 0.25%. This would dilute the focus on high-impact shortfall, making the metric less representative of extreme risk.

Tail Duration under Different Tail Levels Behaves Similarly to Tail Magnitude

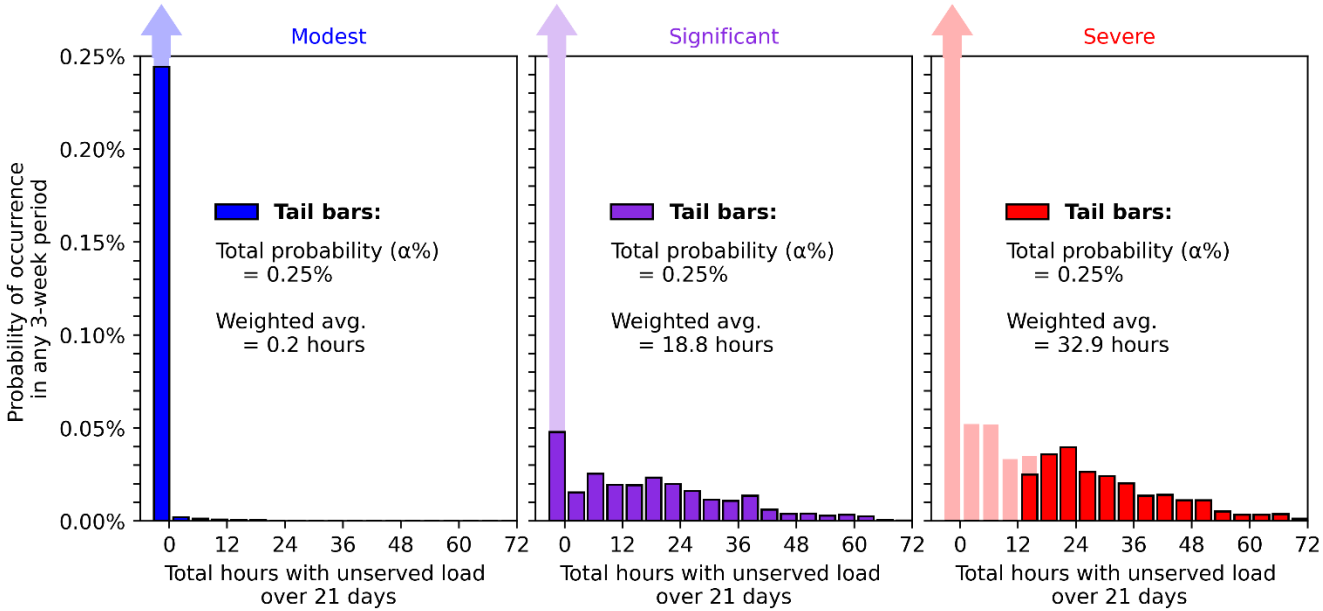
- Three tail α% levels are considered to illustrate how tail duration changes under different tail α%
- The behavior of tail duration is similar to the tail magnitude counterpart

Duration with α = 0.10% Focuses on Cases with Extended Shortfall Hours



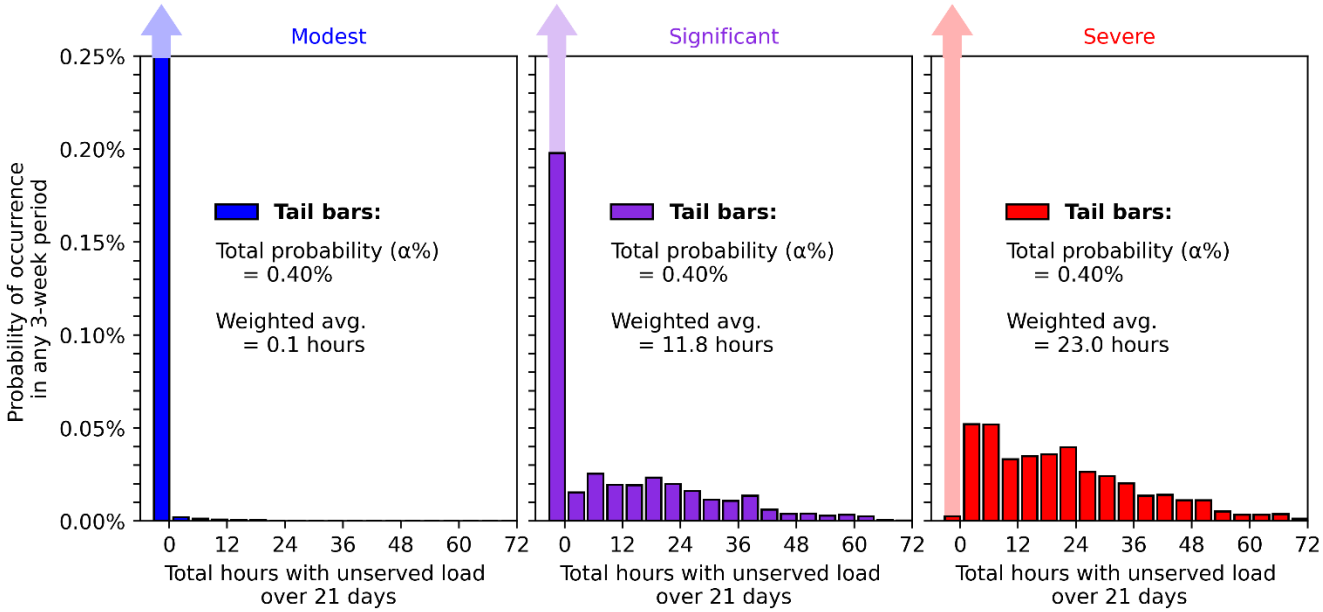
- If α% = 0.1%, the shortfall duration concentrates on the cases with extended shortfall hours, but lower probability of occurring

Duration with Tail 0.25% Exhibits Similar Behaviors as Magnitude with Tail 0.25%



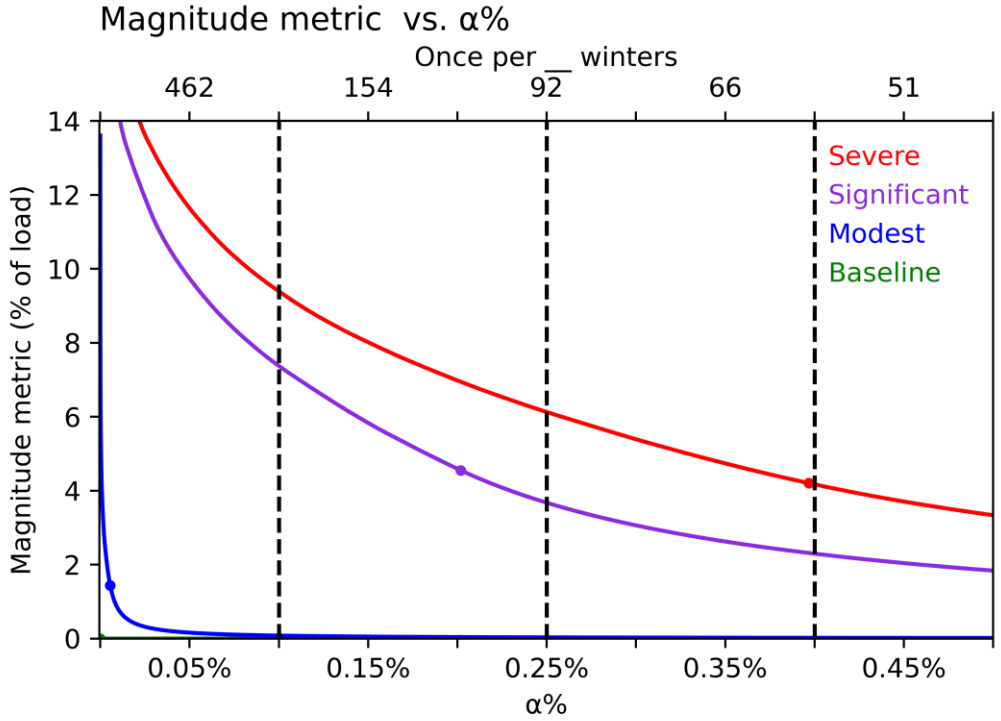
- Duration is longer in the Severe Additional Stress Scenario compared to less severe scenarios. This confirms that as system reliability declines, not only does the magnitude of shortfall increases, but they also persist for longer periods.

Duration with α = 0.40% Includes More Zero Shortfall Cases Diluting Duration Metric



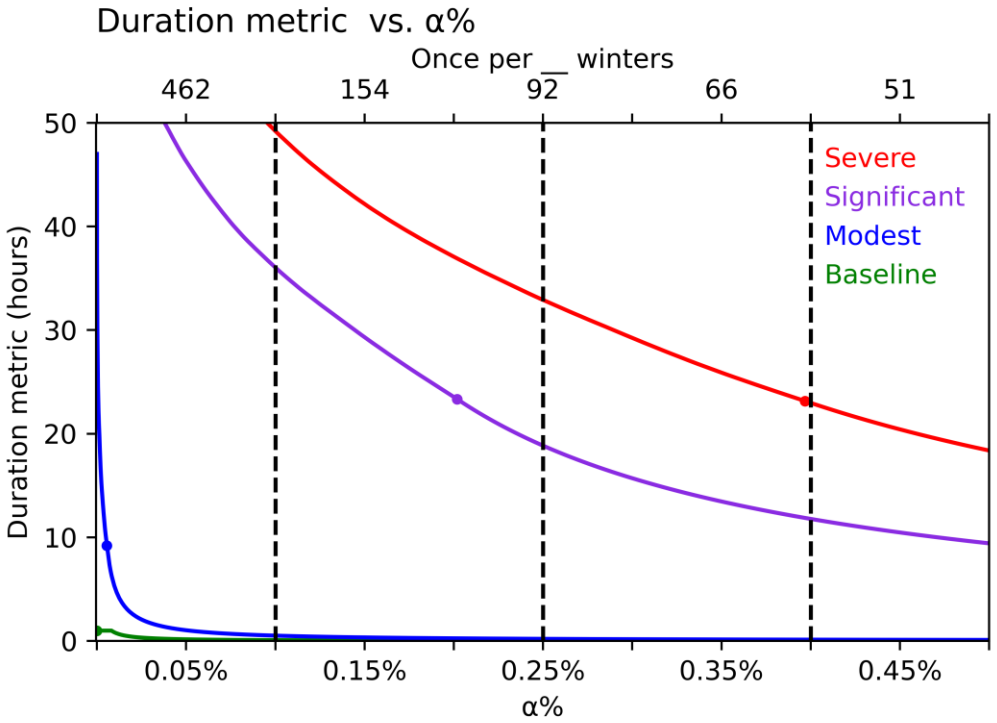
- If α% = 0.4%, the duration metric will capture more cases with brief or no energy shortfall. This could shift the focus of the duration metric away from prolonged shortfalls.

Shortfall Magnitude Across Stress Scenarios at Different Tail Levels



- Once a tail α% is selected, the corresponding magnitude provides a clear indicator of energy shortfall severity across different stress scenarios
- Different tail levels capture varying frequencies of energy shortfall occurrences
  - Lower α% focuses on rarer, more severe shortfall, whereas higher α% includes more frequent, less severe shortfall

Shortfall Duration Across Stress Scenarios at Different Tail Levels



- Selecting a tail α% determines the expected duration of energy shortfall across different stress scenarios, capturing how long shortfall may persists under various stress scenarios

REST Metrics Across Different Tail α%

Magnitude	Tail 0.4%	Tail 0.25%	Tail 0.1%	Probability of Any Energy Shortfall
Baseline	0.00%	0.00%	0.00%	0.0000%
Modest	0.02%	0.03%	0.08%	0.0055%
Significant	2.29%	3.67%	7.36%	0.2019%
Severe	4.16%	6.12%	9.39%	0.3968%

Duration	Tail 0.4%	Tail 0.25%	Tail 0.1%	Probability of Any Energy Shortfall
Baseline	0.0 hours	0.0 hours	0.0 hours	0.0000%
Modest	0.1 hours	0.2 hours	0.5 hours	0.0055%
Significant	11.8 hours	18.8 hours	36.1 hours	0.2019%
Severe	23.0 hours	32.9 hours	49.3 hours	0.3968%

THE ISO CURRENTLY CONSIDERS THAT TAIL 0.25% IS APPROPRIATE FOR REST

Interpretation of Tail 0.25%

- A 13-week season contains approximately 4.3 non-overlapping 21-day windows
- Over 100 seasons, this results in 430 non-overlapping 21-day windows
- If an energy shortfall occurs once every 100 seasons, it means 1 out of 430 windows experience a shortfall on average (1/430 = 0.23%)
- A tail 0.25% means that the region can expect an energy shortfall of this severity ~once every 90 seasons on average during a 21-day period

Why the ISO Currently Considers Tail 0.25% is Appropriate

- Tail 0.25% strikes a balance: It is small enough to focus on high-impact cases while ensuring a statistically robust set of cases for risk quantification
- Tail 0.25% targets high-impact cases
  - Under the severe additional stress scenario, the probability of any energy shortfall is 0.4%.
  - Setting α% > 0.4% would dilute the metrics by including cases without shortfall
  - This dilution worsens in less stressed scenarios, where α% > 0.4% would include even more cases without shortfall
- Tail 0.25% avoids tail case not being implausible
  - A very small α% would overemphasize only a few extreme cases, making REST overly conservative and less representative of broader system tail risks

Defining REST Magnitude and Duration Thresholds within Tail 0.25%

- **REST focuses on tail α% = 0.25%, meaning an energy shortfall of this severity would occur once every 90 seasons on average during a 21-day period**

- The acceptable shortfall magnitude within tail 0.25% is _____%

- The acceptable shortfall duration within tail 0.25% is _____ hours

SUMMARY AND NEXT STEPS

Summary of ISO's Current Thinking Regarding Tail α% Selection

- Multiple tail levels were analyzed across the baseline and stress scenarios to assess their impact on behaviors of magnitude and duration
- Selecting an appropriate tail α% requires balancing two key factors
  - Capturing meaningful energy shortfall frequency, while avoiding including too many less severe cases
- Based on evaluation of stress scenarios, a tail of 0.25% (~once every 90 seasons) was determined to effectively capture significant shortfalls without overemphasizing on cases that are too rare to matter

Next Steps

- Setting the tail at 0.25% allows ISO and stakeholders to engage in more precise discussion on the REST magnitude and duration thresholds
- Once the REST magnitude and duration thresholds are established, the region will determine whether a REST violation occurs only when both magnitude and duration exceed their thresholds, or if it happens when either one does
- Besides calculating REST metrics seasonally by using PEAT, the region also needs to determine when during the year to evaluate these metrics and compare them against the thresholds

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 April 16, 2024	Presentation of ISO's current thinking regarding tail selection

Stakeholder Schedule, cont'd

Schedule is subject to change based on progress

Stakeholder Committee and Date	Scheduled Project Milestone
Reliability Committee **June 17, 2025/July 15-16, 2025**	Presentation of ISO's proposal with initial threshold Introduction to proposed revisions to OP-21
Reliability Committee **August 19, 2025**	Presentation of any modifications to ISO's proposed REST thresholds in response to stakeholder feedback as needed Continued discussion on proposed revisions to OP-21
Reliability Committee **September 16, 2025**	Continued discussion on proposed revisions to OP-21
Reliability Committee **October 22, 2025**	Vote on proposed revisions to OP-21
Participants Committee **November 6, 2025**	Vote on proposed revisions to OP-21

Questions