Establishment of the Regional Energy Shortfall Threshold (REST)

ISO's current thinking regarding preventive relief and 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 insight into ISO's current thinking with regard to
  - Accounting for preventative and corrective relief in PEAT
  - 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

PEAT MODELING ENHANCEMENTS: PREVENTIVE AND CORRECTIVE ACTIONS

Introduced at August RC Meeting

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

- To better assess the region's energy shortfall risk against the REST criteria, the PEAT modeling is being enhanced to incorporate a reasonable amount of preventive action relief in addition to corrective action relief
- Incorporating both preventive and corrective actions directly into PEAT allows for a robust quantitative estimate of the impacts of these actions on shortfall amounts
- With these PEAT enhancements, for any single case, energy shortfall amounts will be quantified "with" and "without" preventive actions with the delta between the two quantifying what is manageable

Existing Modeling of Corrective Actions in the PEAT Framework

- Corrective actions reflect the magnitude of energy shortfall relief estimated to be available from actions defined within ISO's emergency procedures (*e.g.,* OP-4* and OP-21*)
  - These actions include the curtailment of exports, scheduling of additional imports, voltage reductions, and appeals for conservation
- Corrective action relief is modeled in the PEAT as two MW blocks, each up to 500 MW, representative of relief from OP-4 actions 2-5 (net import relief) and OP-4 actions 6-11 (voltage reduction and appeals for conservation)
- In the ISO's initial 2027 and 2032 energy adequacy studies, the PEAT's 21-day energy assessment was performed by solving a series of single-hour economic dispatch problems, one for each hour of the 21 days
  - Due to the myopic nature of the single-hour economic dispatch, corrective actions are utilized in the model only during hours when the system is close to or in energy shortfall

*OP-4, Actions During a Capacity Deficiency, and OP-21, Operational Surveys, Energy Forecasting & Reporting and Actions During an Energy Emergency

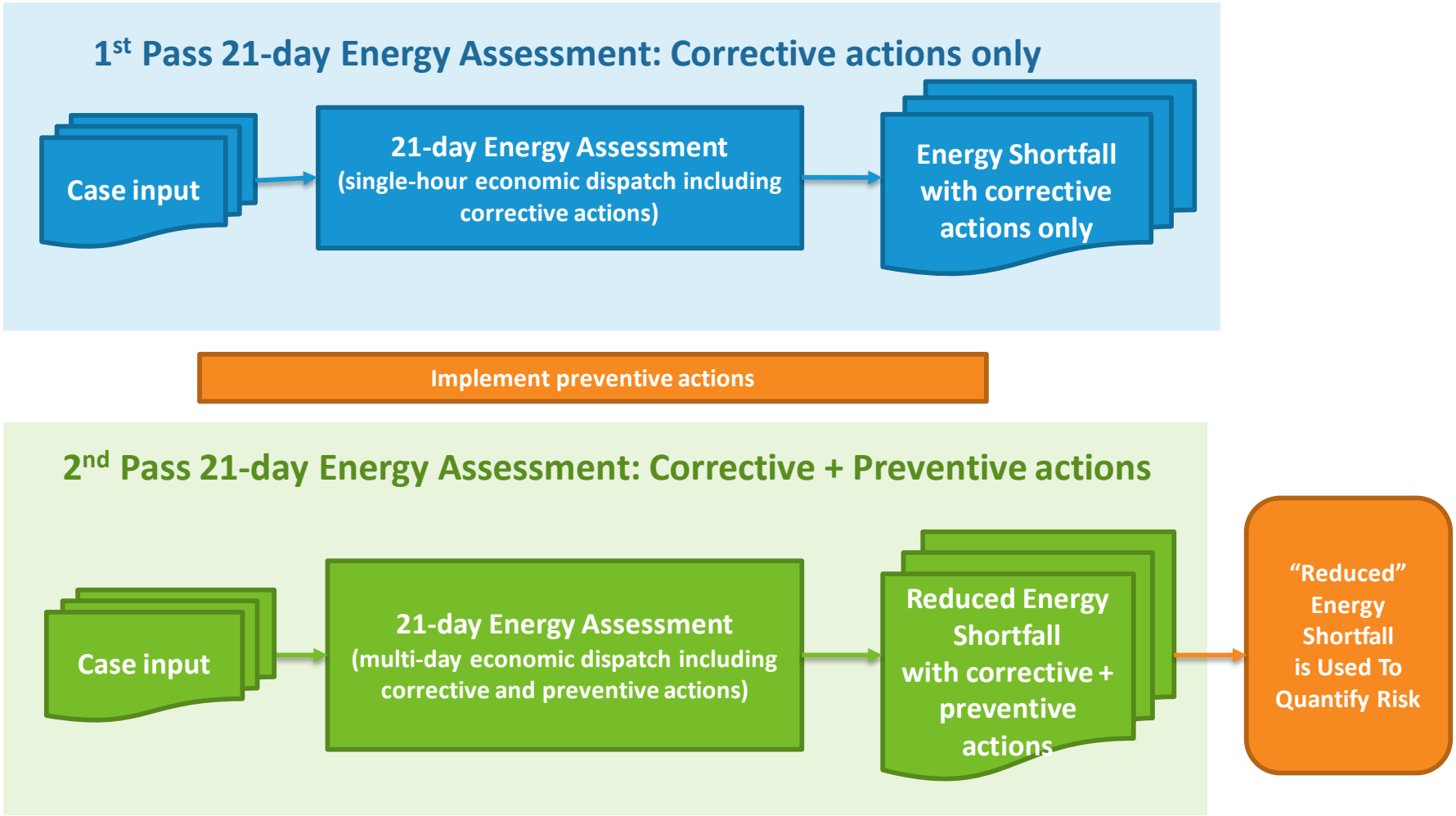
ISO is Incorporating Preventive Actions Directly in the PEAT Framework

- Preventive actions reflect the estimated energy shortfall relief available from actions defined within ISO's emergency procedures as well as Market Participant responses
  - In general, preventive actions are measures ISO or Market Participants would likely take in advance of a forecasted energy shortfall in order to better position the system (ISO) or to more effectively manage resource availability (ISO and/or Market Participant)
- Preventive actions include market response/supply logistic relief (*e.g.*, opportunity cost mechanisms), net import relief, and conservation relief
  - Market response/supply logistic relief modeling is intended to approximate the impact of opportunity cost mechanisms
  - Preventive net import relief, modeled as a block of up-to 500 MW, represents OP-4 actions 2-5 taken in advance to mitigate potential energy shortfall by increasing net imports (see slide 16)
  - Preventive conservation relief, modeled as a block of up-to 500 MW, represents OP-4 actions 6-11 taken ahead of time to appeal for conservation to reduce potential energy shortfall (see slide 17)
- Preventive actions are applied in the model, as needed, in the days leading up to a forecasted energy shortfall

PEAT Enhancements Allow for Multi-Day Dispatch

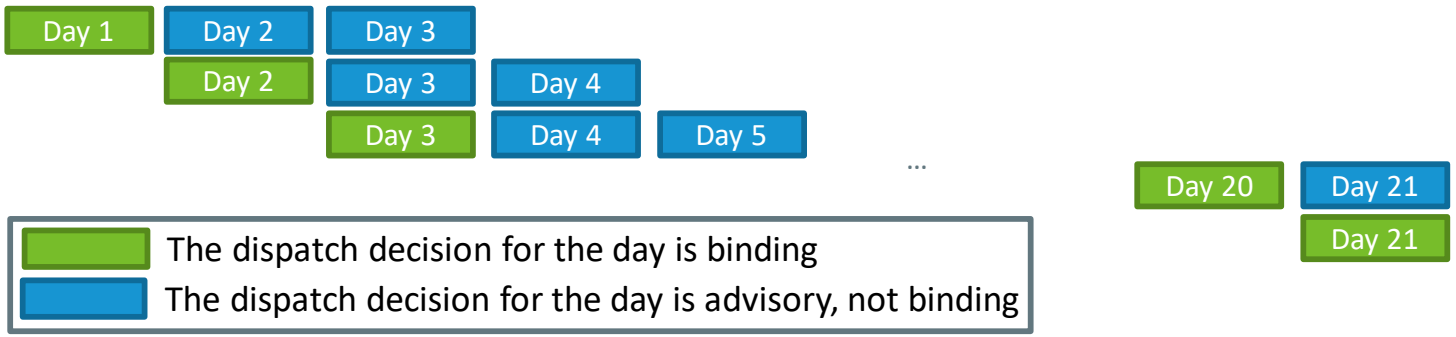
- ISO has significantly enhanced PEAT to incorporate a multi-day rolling-horizon economic dispatch for the 21-day energy assessment
- The multi-day economic dispatch modeling aligns more closely with the proactive nature of preventive actions
  - Preventive actions are those taken days before a potential energy shortfall whereas corrective actions are taken immediately before or during an energy shortfall period
  - Opportunity costs are accounted for in the multi-day economic dispatch to more efficiently model the use of stored fuel to help mitigate potential energy shortfall
- This enhancement of PEAT represents a significant innovation of the 21-day energy assessment, requiring substantial effort to integrate forward-looking analytics with dispatch and OP-4 action decision-making processes

High-Level Process Flow



Multi-Day Rolling-Horizon Economic Dispatch

- Multi-day economic optimization dispatches resources, allocates fuel inventories, and determines OP-4 action decisions across multiple days
  - Potential system costs, including dispatch, reserve violation and load shed costs are considered not just for the current hour, but also for future days
- The rolling horizon allows for continuous updates to the solutions as the dispatch problem progresses through the 21-day period
- ISO's current implementation is a three-day look-ahead window
  - Using a three-day horizon keeps the computation time manageable, whereas a longer horizon makes the problem computationally intractable
  - A three-day look-ahead strikes a balance; it provides enough time to estimate preventive actions without over-optimizing preventive actions based on perfect foresight



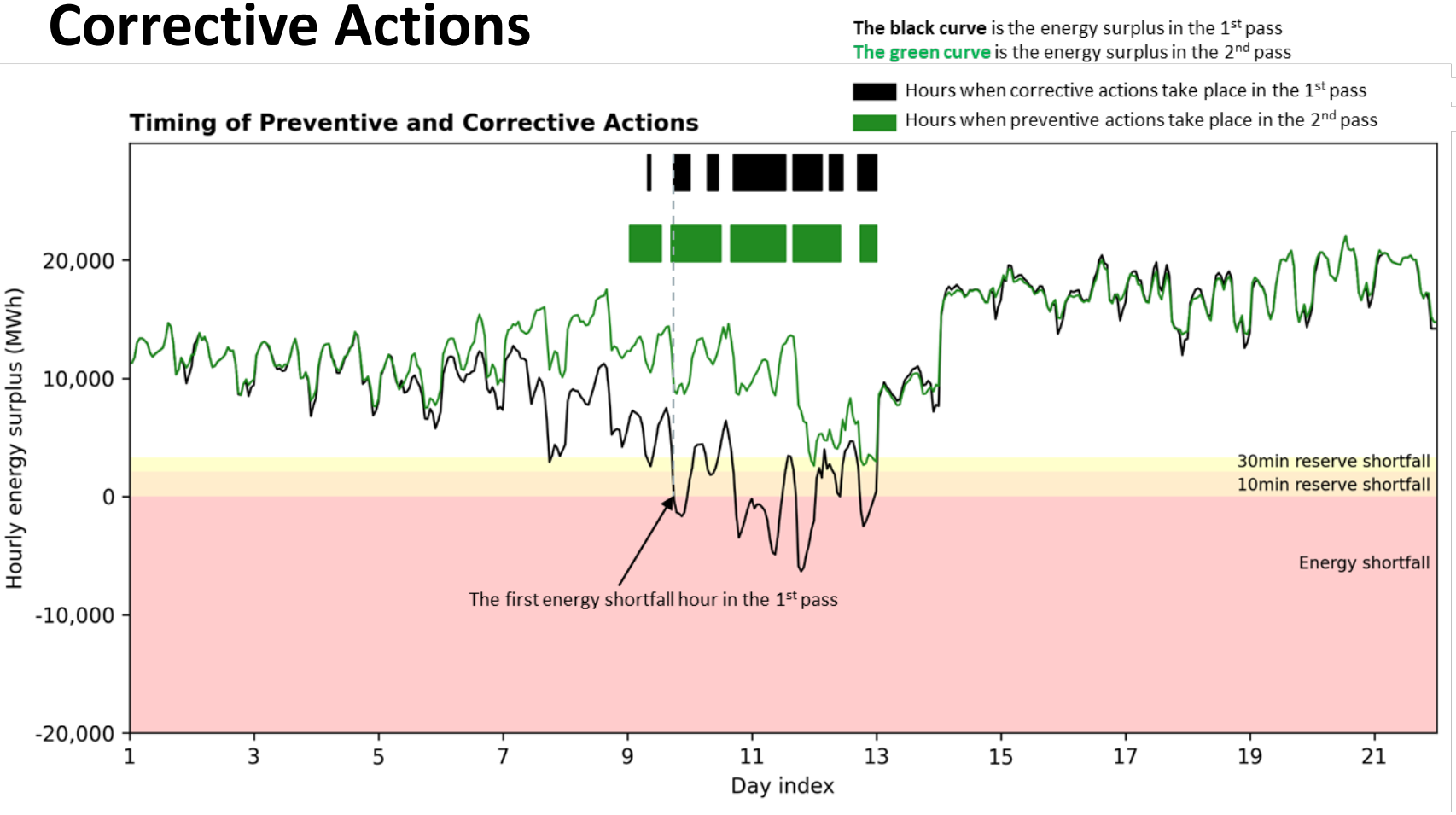
Multi-Day Rolling-Horizon Economic Dispatch, cont.

- Opportunity costs are accounted for in the multi-day economic dispatch decisions made each hour
  - The multi-day dispatch process balances the trade-off between using fuel inventory early and conserving it for later usage
  - It incorporates opportunity costs, which are inherently determined by the multi-day dispatch optimization model
  - Such opportunity costs are dynamically adaptive to changes in fuel availability and system conditions
- The timing and quantities of preventive and corrective actions are determined by the multi-day economic dispatch
  - Based on system conditions and fuel availability in the future days, the model can decide the appropriate time to trigger preventive actions and allocate the appropriate amount as needed to alleviate an anticipated energy shortfall
  - Just before and during an energy shortfall, the multi-day economic dispatch will implement corrective actions in order to reduce energy shortfall; the use of corrective actions to reduce energy shortfall is not a change to PEAT (*i.e.,* corrective actions were included as part of ISO's initial PEAT-based energy adequacy studies)

Illustrative Example of the Timing and Effectiveness of Preventive and Corrective Actions and Opportunity Cost Modeling

- The following example shows how preventive and corrective actions could impact the outcome of a projected energy shortfall event
- The example is shown using the previously discussed multi-day rolling-horizon economic dispatch techniques to account for opportunity cost modeling and other preventive actions (net imports and load conservation)
- Note that the example is for illustration only and not necessarily indicative of any actual modeled events

Illustrative Example of the Timing of Preventive and Corrective Actions



- In the 1st pass, the corrective actions are implemented shortly before the first energy shortfall hour and throughout the shortfall period
- Energy shortfall is diminished in the 2nd pass due to the opportunity cost mechanisms as well as preventive actions
- The actions in the 2nd pass are preventive actions because there is no energy shortfall; corrective actions would be applied, as needed

Preventive Actions – Market Response/Supply Logistics Relief

- In the event of a forecasted energy shortfall, ISO anticipates that its 21-Day Energy Forecasts and existing market-based incentives will encourage relief in the form of market response and enhanced supply logistics
- The enhanced PEAT is able to estimate market response/supply logistics relief to reflect the following behaviors:
  - If an energy shortfall were expected to occur, Market Participants evaluate the allocation of their limited fuel inventories not only based on the immediate effects, but future days' consequences to estimate opportunity cost
  - Market Participants can incorporate opportunity costs in their offers in the wholesale market, increasing their ability to deliver energy and reserve at hours when they are most needed
- In the illustrative example, the 2nd pass of the enhanced PEAT results in more efficient fuel allocation
  - Less efficient oil units with large fuel inventories, which have smaller opportunity costs, are utilized more frequently prior to shortfall hours, without significantly affecting their fuel availability during shortfall hours
  - More efficient oil units with smaller fuel inventories, which have larger opportunity costs, are dispatched less frequently before shortfall hours. As a result, their fuel inventories are more likely to be available during shortfall hours

Preventive Actions – Net Import Relief

- Modeling of net import relief as a preventive action is intended to approximate the quantity of energy shortfall relief obtained by curtailing exports or scheduling additional imports in the event ISO has declared an Energy Emergency, in accordance with OP-21, in advance of a forecasted energy shortfall
  - As described in OP-21, ISO may need to take action in advance of a forecasted Energy Emergency to manage and preserve fuel supplies within the region; this may include the curtailment of exports and/or scheduling of additional imports as prescribed by OP-4
- ISO believes that a value of 500 MW/hr, which is consistent with the value of corrective net import relief in the model, is also a reasonable estimate to model for preventive net import relief

Preventive Actions – Conservation Relief

- Modeling of conservation relief as a preventive action is intended to approximate the quantity of energy shortfall relief obtainable by the initiation of appeals for conservation in the event ISO has declared an Energy Emergency, in accordance with OP-21, in advance of a forecasted energy shortfall
- ISO currently assumes a certain level of conservation relief in OP-4A, Action During a Capacity Deficiency, Appendix A
- ISO continues to work with the New England utilities to either confirm its current conservation estimate or develop a more informed estimate of feasible conservation relief

CURRENT THINKING ON REST METRICS

REST Metric – Current Thinking

- With regard to REST metrics, ISO's thinking to-date has centered around a single metric – Maximum Normalized 7-day Energy Shortfall
- ISO's recent PEAT modeling enhancements allows for more precise determination of the magnitude and timing of energy shortfall
- As a result of these modeling enhancements and in consideration of stakeholder feedback ISO is considering a multi-metric criteria which may include an additional metric that captures the duration of energy shortfall (*i.e.,* describes how long the region would be experiencing shortfall)
  - A report from the Energy System Integration Group (ESIG), published in March 2024, as well as a report from the National Academy of Engineering (NAE) and NERC, published in July 2024 emphasize the benefits of a multi-metric framework for resource and energy adequacy that considers the impacts of extreme events

SUMMARY AND NEXT STEPS

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

- Recent modeling enhancements have allowed ISO to
  - Approximate opportunity cost mechanism
  - Capture the impact of preventive actions
  - Consider multi-metric criteria
- Since the ISO's May 2024 presentation, there have been no notable changes in ISO's current thinking with regard to REST periodicity
  - A seasonal assessment of energy shortfall risk against the REST criteria; longer-term assessments are useful for informing risk trends over time
- ISO will continue to evaluate the potential for multiple metrics in REST and their thresholds
  - ISO continues to refine its thinking in these areas 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 2024	Review of ISO's current thinking regarding REST
Reliability Committee November 2024	Presentation of ISO's initial REST proposal
Reliability Committee December 2024	Review stakeholder feedback on ISO's initial REST proposal
Reliability Committee January/February 2025	Presentation of any modifications to ISO's REST proposal pending stakeholder feedback
Reliability Committee February/March 2025	Review ISO's revised REST proposal

Questions