Dynamic Reserves

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October 19, 2022

Agenda

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Background

Previous Presentations

Title/Topic	Link
2021 RECA Study (Updated 2/2022)	https://www.nyiso.com/documents/20142/26734185/RECA(Dynamic%20Reserves)%20Study%20Report.pdf/27990919-e81b-76a4-12e1-57b9458b553d
March 3, 2022 MIWG Project Kickoff	https://www.nyiso.com/documents/20142/28897222/Dynamic%20Reserves%20Kickoff%20MIWG%2003032022_Final.pdf/b2b5cd26-4740-ab35-015c-5e93bf3ca23e
May 11, 2022 MIWG	https://www.nyiso.com/documents/20142/30555355/Dynamic%20Reserves%20MIWG%2020220511.pdf/35e8b44a-6a54-c8e0-ee30-b9e0709738af
June 16, 2022 MIWG	https://www.nyiso.com/documents/20142/31532822/6%20Dynamic%20Reserves.pdf/ca9ad944-c911-1874-2710-9ba04521d789
August 9. 2022 MIWG	https://www.nyiso.com/documents/20142/32687686/20220809%20Dynamic%20Reserves%20MIWG.pdf/c63d67ab-4498-efc9-7ad6-954c0d07af04
October 4, 2022 MIWG (Presented by FTI Consulting)	https://www.nyiso.com/documents/20142/33562316/20220928%20Dynamic%20Reserves%20Examples%20MIWG%20draft%20revised%20v2%20(002).pdf/75b413e2-30b8-2cda-6100-1620deebd5de

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Review of Wind Scheduling in DAM and RTM

Review of Wind Scheduling in DAM and RTM

- **At the 5/11 MIWG/ICAPWG meeting, NYISO received stakeholder feedback to provide more information on the following:**
  - Review of NYISO's existing use of wind energy forecasts (e.g., frequency and process for forecast delivery in the Day-Ahead Market (DAM) and Real-Time Market (RTM), forecast horizon)

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Background: Wind Energy Forecasts in the DAM

- **The wind energy forecast used by NYISO in both the DAM and RTM is a plant-specific (i.e., for individual generators) deterministic forecast**
  - NYISO receives this forecast from its wind forecast vendor, Underwriters Laboratories (UL) Solutions
- **For the DAM, UL Solutions delivers forecasts twice a day, at 4:00 am and 4:00 pm**
  - Forecasts span 72 hours and are at the hourly granularity
  - Each forecast uses the most recent National Weather Prediction (NWP) model data from NOAA and other government entities
- **Wind energy forecasts are used in DAM passes that solve to the forecast load**
  - Pass 2 (Forecast Load Pass) and Pass 4 (Forecast Load Re-dispatch) solve to forecast load and use the WEF for each wind resource in NYCA
  - Pass 1 (Bid Load Pass) and Pass 5 (Bid Load Re-dispatch) solve to bid load and only consider bids from wind resources.
  - Pass 5 determines final dispatch and sets DA Hourly LBMPs - only economically committed wind resources receive DAM schedules
- **In today's presentation, the term "scheduled wind output" is used to refer to the amount of MW that is scheduled on wind resources in Pass 1**
  - These schedules are based on wind resource offers into the DAM

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Background: Wind Energy Forecasts in the RTM

- **For the RTM, UL Solutions delivers forecasts every 15 minutes**
  - Forecasts span 8 hours and are at the 15-minute granularity, representing the average 15-minute output
    - Updates are synced with the start of RTC runs
    - Forecast values are blended with persistence power values over the optimization period, at different blending percentages (ranging from 100% persistence to 100% forecast), to help capture the impact of real-time conditions and mitigate forecast uncertainty
    - In RTD, persistence is updated with actual data every 5 minutes
  - Each forecast uses the most recent generator telemetry, site meteorological data, and NWP data
  - Wind providers are subject to over-generation charges when NYISO has imposed a Wind and Solar Output Limit, during which they are not entitled to compensation when output is above their schedule plus a 3% tolerance
  - Scheduled wind output may be dispatched down from the forecast due to transmission or ramping constraints

Intermittent Resource Contingencies: Review of Proposal

Intermittent Resource Contingencies: Review of Proposal

- **The 2021 RECA Study included the following recommendation and consideration:**
  - Recommendation 6: Consider expanding the methodology definition of source contingency to ensure it includes correlated source contingencies, such as simultaneous reduction of offshore wind, as the largest source contingency.
  - Consideration: Interaction of dynamic reserve modeling with the intermittent resource contingencies, whether loss of single resource or the correlated loss of energy across multiple resources
- **The NYISO is proposing a constraint that would account for the potential risk of simultaneous loss (or reduction of energy output) of intermittent resources within a similar geographic area**

There is no change from this slide as presented on 5/11/2022

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Intermittent Resource Contingency Constraint

- **This constraint would capture the potential risk of losing multiple intermittent resources whose combined output may be the largest single source of energy in a reserve area**
  - For example, wind resources in close geographic proximity are susceptible to a common weather pattern, which poses a risk of simultaneous loss (or reduction of energy output) of many resources (which may not share a single interconnection point)
  - Wind resources that share a single point of interconnection would be considered a single generator
- **This constraint would be evaluated simultaneously against the loss of generation and loss of transmission equations, with the most restrictive (*i.e.*, largest MW at risk) constraint setting the applicable reserve requirement in each reserve region**
- **The most limiting of all generator constraints (largest source, correlated loss, intermittent resources) would feed into any equation as the MaxGen**

There is no change from this slide as presented on 5/11/2022

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Intermittent Resource Contingency: Proposal

- **NYISO's proposal would use a Probability of Exceedance (POE) (e.g., 90%, 95%) forecast to calculate the quantity of generation that may be at risk**
  - The use of a XX% POE forecast would provide greater certainty of wind output. At this time, NYISO has not determined what percentile XX% POE forecast will be used for this constraint
    - For example, a 95% POE represents a value with a 95% chance of being exceeded.
- **NYISO proposes to use the difference between the schedules and the forecasted values based on a higher POE, in the standard format:**

$$Res_{RA_{a_i}}^{30Total} \geq Mult_{\mathrm{RA}_a}^{30Total} * \left(\sum_{RA_{a_i}} IPP_{Schedule_i} - \sum_{RA_{a_i}} \mathrm{XX\%}POE_{Forecast_i}\right) - RA_{aRes_{Capability_i}}$$

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Probability of Exceedance Forecast Creation

Probability of Exceedance Forecast Discussion

- **At the 5/11 MIWG/ICAPWG meeting, NYISO received stakeholder feedback to provide more information on the following:**
  - How a Probability of Exceedance forecast is developed
    - NYISO consulted with its vendor, Underwriters Laboratories (UL) Solutions, to prepare a high-level summary of how this forecast is created

Deterministic vs. POE Forecasts

- NYISO's deterministic forecast is a single point forecast created from an ensemble of individual forecasts (such as NWP models, statistical models) and is designed to minimize bias and statistical error metrics
  - NYISO's deterministic forecast represents a mean forecast

Deterministic vs. POE Forecasts (continued)

- **POE forecasts provide the distribution of wind output for the relevant time horizon**
- **POE forecasts utilize the variation in the ensemble forecasts to capture uncertainty**
  - POE forecasts do not attempt to minimize error
  - POE forecasts produce a range of expected outputs based on percentiles
- **The inputs for a POE forecast include the deterministic ensemble forecast, the spread in the individual ensemble member and NWP forecasts, forecast horizon, and wind speed forecasts**
  - These data are processed by statistical models to compute POE values
- **A XX% POE forecast represents the percent chance that the actual output will exceed the forecast value**
  - For example, a 95% POE value of 100 MW can be expected to be more than 100 MW 95% of the time, but less than 100 MW 5% of the time

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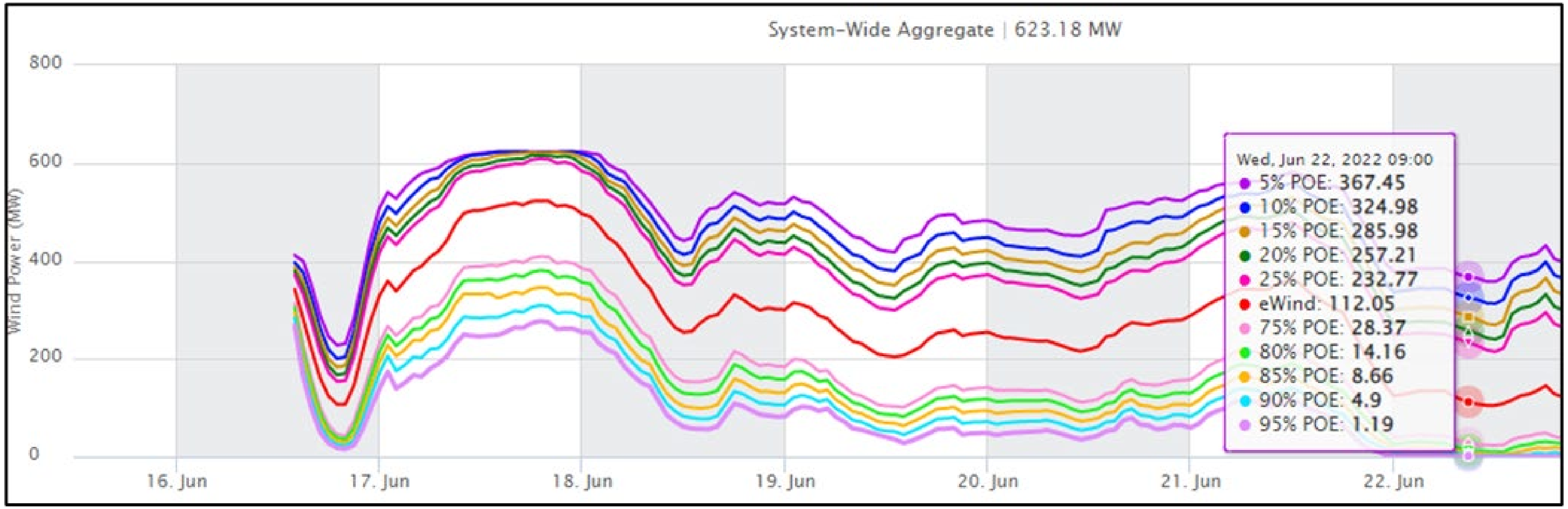
Spread of Probability of Exceedance Forecasts



- The above graph displays a deterministic forecast (eWind – solid red line) and POE forecasts of different percentiles
- This graph illustrates that in the near term, there is not much variance between these forecasts. Later in the forecast horizon, there is more spread between the different forecasts. The wider spread indicates that there is less certainty in the forecast

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Calculating Wind Uncertainty Across NYCA

- **The previous slides have discussed the use of POE forecasts for individual wind facilities**
  - Total uncertainty across NYCA is not the sum of the individual facility uncertainty
- **Aggregate POE forecasts are not the sum of the individual site POE forecasts**
  - There is less uncertainty in aggregate forecasts than individual site forecasts, as aggregate forecasts account for wider geographic areas and weather patterns
  - For example, the sum of the 95% POE forecasts for individual units within an aggregation would not be equal to the 95% POE forecast for the entire aggregation; rather, it would be expected that the sum would be equivalent to a higher confidence forecast for the aggregation (>95% POE)
  - The spread between the different confidence intervals for aggregate forecasts are less than the spread between confidence intervals for individual sites
- **The Intermittent Resource Contingency Constraint would be calculated by reserve region**
  - This constraint could utilize either individual wind facility POE forecasts or aggregate POE forecasts for resources in the same reserve region
  - Using individual site forecasts would be a more conservative approach than an aggregate forecast; and therefore, a different XX% POE value may be used for individual sites than the aggregate if individual site forecasts are used

Intermittent Resource Contingency Constraint

- NYISO has proposed the use of a POE forecast (i.e., determining the distribution of wind output) for this constraint to be able to account for uncertainty in wind output
  - The NYISO will propose the XX%POE forecast during the Market Design Complete (MDC) phase of the project
- With the expected increased penetration of intermittent resources in NYCA, utilizing a POE forecast to determine the MW at risk will set efficient reserve requirements

Use of Scheduled Intermittent Resource Output

Intermittent Resource Contingency Constraint: Scheduled Intermittent Resource Output

- **NYISO's proposed Intermittent Resource Contingency Constraint calculates a reserve requirement based on scheduled intermittent resource output**
  - In the DAM, the reserve requirement would be based on wind providers that have submitted a DAM bid and received a schedule in the Bid Pass of SCUC
  - At the 5/11/2022 ICAPWG/MIWG meeting, some stakeholders asked for information on the rationale for using scheduled intermittent resource output in this constraint
    - Stakeholders noted that an alternative would be to use forecasted intermittent resource output
  - Stakeholders noted that since wind providers are not required to bid into the DAM, historical bidding patterns indicate that less wind is scheduled in the DAM than the RTM

Scheduled vs. Forecast Wind Output in the DAM

- **Wind providers are not required to bid into the DAM and it has been observed that fewer wind MWs are scheduled in the DAM than the RTM**
  - An analysis of the percent of forecasted wind that was scheduled in the DAM found the average schedule between November 1, 2020 and October 31, 2021 to be 51% for NYCA
- **At the 5/11/2022 ICAPWG/MIWG meeting, NYISO presented an analysis of the comparison between NYISO's existing wind forecast and wind forecasts of various POE confidence levels. This analysis can also be used to understand the difference in a calculated reserve requirement using forecasted vs. scheduled wind**
  - Using a POE 75, the difference between the reserve requirement calculated using forecasted – scheduled MW = 21 MW
    - Sum of Forecast MW – Sum of POE 75; Max Hourly Difference: 457 MW
    - Sum of Schedule MW – Sum of POE 75; Max Hourly Difference: 436 MW
  - Using a POE 90, the difference between the reserve requirement calculated using forecasted – scheduled MW = 215 MW
    - Sum of Forecast MW – Sum of POE 90; Max Hourly Difference: 766 MW
    - Sum of Schedule MW – Sum of POE 90; Max Hourly Difference: 551 MW

Scheduled Intermittent Resource Output

- **The use of scheduled intermittent power output would provide the following benefits:**
  - Reserve requirements would be based on system conditions bid into the DAM.
    - The Bid Load Pass and Bid Load Re-dispatch Pass in DAM satisfies the gen-load balance by scheduling wind resources based on DAM offers from wind providers. If the scheduled wind output is less than the NYISO's deterministic wind forecast, the following is true:
      - The resultant reserve requirement from the Intermittent Resource Contingency constraint in the DAM would be lower, reflecting less uncertainty due to less scheduled wind output
      - There is less risk that RT output will be less than the DAM scheduled output (i.e., less uncertainty between DA and RT)
      - Other energy resources will still have been scheduled to meet Bid Load
  - Reserve requirements would be co-optimized, therefore wind energy schedules would be adjusted if the quantity of reserves to cover the contingency was not cost-effective or deliverable
  - Reserve requirements would be based on the actual schedules on physical resources, consistent with how NYISO has proposed to evaluate all Loss of Generation constraints for Dynamic Reserves
- **Using forecasted intermittent output has the potential to overstate reserve requirements when scheduled wind output is less than forecasted output because in these cases SCUC satisfies the gen-load balance by providing forward schedules to other resources**
  - Reserves would be scheduled in excess of scheduled wind output and would not accurately reflect uncertainty

Scheduled Intermittent Resource Output (continued)

- **NYISO proposes the use of scheduled intermittent power output in both the DAM and RTM markets for use in the Intermittent Resource Contingency constraint for Dynamic Reserves**
  - See "Review of Wind Scheduling in DAM and RTM" section above for how wind resources are currently scheduled
- **This construct would allow reserve requirements to be calculated based on uncertainty in intermittent resource output**
  - Permits financial transmission reservations for the deliverability of those resources and wind energy schedules appropriately reflect the reserve cost of managing wind uncertainty
  - This would be especially important as more intermittent resources interconnect into the NYCA

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Scarcity Reserve Requirements

Scarcity Reserve Requirements

- **The 2021 RECA Study included the following recommendation:**
  - Recommendation 1: Impacts that dynamic reserve requirements could have on Scarcity pricing: Current scarcity logic is complicated with the cascading of reserve areas and, therefore, will need further investigation.
- **Scarcity pricing is a mechanism that establishes a price when reliability-based Demand Response events are deployed**
  - Scarcity pricing rules apply to Special Case Resource (SCR) and Emergency Demand Response Program (EDRP) activations. When SCR/EDRP resources are deployed, a revised Real-Time 30-Minute Operating Reserve Requirement is calculated
  - The revised 30-Minute Operating Reserve Requirement is equal to the existing reserve requirement plus the Scarcity Reserve Requirement
    - Scarcity Reserve Requirement = Expected Load Reduction – Available Operating Capacity

Scarcity Reserve Requirements (continued)

- **The NYISO expects that the Scarcity Reserve Requirements should continue to interact similarly with the 30-Minute Dynamic Reserve Requirements as they have with static reserve regions**
  - Under the Dynamic Reserves construct, the Scarcity Reserve Requirement will be added to the 30-Minute Total Reserve Requirement (after the dynamic procurement target has been determined) for each Scarcity Reserve Region
  - As is done today, the 30-minute demand curve for the reserve region will be adjusted in real-time to account for the Scarcity Reserve Requirement with such a requirement priced at $500/MW
- **The NYISO will identify test cases to confirm expectations and revisit this concept if any unexpected interactions are identified**

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LBMP Formation

LBMP Formation

- At the 10/4/22 ICAPWG/MIWG meeting, stylized examples demonstrated potential scheduling and pricing outcomes
  - That presentation included several potential future topics for future examples
- NYISO is continuing to explore this topic and has identified a few different concepts for further investigation. NYISO will present additional examples next year.

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Interplay with Future Market Design Efforts

Interplay with Future Market Design Efforts

- Dynamic Reserves provides the necessary modeling enhancements to pursue several future Market Design projects in future years:
    - More Granular Operating Reserves
    - Long Island Reserve Constraint Pricing
    - Pricing Reserves for Congestion Management

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More Granular Operating Reserves

- **Under NYISO's More Granular Operating Reserves project, NYISO is exploring the implementation of reserve requirements within certain constrained load pockets in NYC that would better represent the value of short-notice on-demand resources**
  - Static requirements in load pockets can result in situations where holding reserves on internal supply is infeasible since supply is providing economic energy. In these situations, reserves are shifted to the headroom on transmission lines.
  - As part of the 2019 effort and as noted in 2022 Master Plan, NYISO determined that an efficient and effective solution to implement load pocket reserves is dependent on Dynamic Reserves[1]
    - Please see the November 6, 2019 BIC presentation for NYISO's proposal for load pocket reserves completed as part of the 2019 More Granular Operating Reserve project[2]
  - Dynamic Reserves would account for the flexibility of the grid to respond to system needs by utilizing the transmission system to import capacity into generation-constrained areas
- **Dynamic Reserves would provide the functionality for load pockets within reserve regions to be dynamically procured**

1: See slide 12: https://www.nyiso.com/documents/20142/8372822/More%20Granular%20Operating%20Reserves%20-%20MIWG%2009242019.pdf/4f88b294-7a3d-f991-0990-760334435ee4; Master Plan: https://www.nyiso.com/documents/20142/33257202/Draft%202022%20Master%20Plan_Sept%2020%202022.pdf/46570f66-c077-f32e-dda6-9200917eca7c

2: https://www.nyiso.com/documents/20142/9043618/More%20Granular%20Operating%20Reserves%20-%20BIC%2011062019.pdf/13ac0d1c-67dc-fb8c-6e1e-b9b543617a29

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Long Island Reserve Pricing

- **Potomac Economics has recommended that NYISO consider the ability to "[s]et day-ahead and real-time reserve clearing prices considering reserve constraints for Long Island [Recommendation 2019-1]"**
  - This recommendation reflects that reserve providers on Long Island are not paid reserve clearing prices corresponding to reserve requirements on Long Island
  - Reserve providers on Long Island are paid the SENY clearing prices
- **From a work-flow perspective, NYISO proposes to implement Dynamic Reserves before initiating Long Island Reserve Pricing**
- **To meet statewide renewable energy targets, large developments of offshore wind projects are anticipated in the Long Island Zone**
  - The Dynamic Reserves formulation would procure enough reserves within Long Island as well as sufficient transmission capability to secure Long Island
  - As a result, NYISO's wholesale markets should establish reserve prices for Long Island that properly reflect the value and associated cost of reserves being procured on Long Island. This modeling enhancement would reflect the value of reserve capability on Long Island.
  - Therefore, Long Island Reserve Pricing is dependent on Dynamic Reserves

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Pricing Reserves for Congestion Management

- Potomac Economics has recommended that NYISO "[c]onsider rules for efficient pricing and settlement when operating reserve providers provide congestion relief [Recommendation 2016-1]"
  - This recommendation reflects the ability for NYISO to operate certain transmission facilities in NYC above LTE post-contingency, using operating reserve capacity not otherwise scheduled to provide energy; therefore avoiding transmission congestion. Currently, operating reserve providers are not compensated for the avoided transmission congestion they enable
- This SOM Recommendation has been included as part of the Dynamic Reserves project scope due to the expected benefits of the Dynamic Reserves software development and formulation
  - For example, the ability to calculate transmission headroom and adjust reserve requirements to account for transmission headroom could be utilized to meet the need for this effort
- In the 2021 SOM, Potomac provided a mathematical example of how the market could compensate reserve providers that are used to reduce potential congestion. This example concluded that one option would be to calculate a shadow price for the reserves being held to manage congestion, which would require a nodal calculation to be able to accurately represent how each generator schedule contributes to the management of post-contingency flows.
  - Potomac Economics' proposal would lead to the development of nodal (rather than locational) reserves
- The NYISO agrees that a nodal reserve product could be a potential solution for this SOM Recommendation, but notes that the scope of Dynamic Reserves does not include the functionality of nodal reserves

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Prototyping Update

Prototyping Update

- As part of the 2021 RECA Study, NYISO prototyped the mathematical formulation to study the feasibility of the prototype on the Day-Ahead Market solution
- As part of the 2022 Market Design Concept Proposal, NYISO has been continuing its prototyping of the Dynamic Reserves formulation, building upon the work completed last year by:
  - Including the Real-Time Market
  - Activated dynamic reserves constraints for all reserve areas
- The prototyping completed this year does not include all constraints discussed during the MDCP in 2022, such as the Correlated Loss of Multiple Contingencies or Intermittent Resource Contingency constraints

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Next Steps

Components Previously Discussed: Q2

- **To date, NYISO has completed initial stakeholder discussions on the following topics:**
  - Correlated contingencies that might impact reserve requirements
  - Use of forecast load in mathematical formulation
  - Interaction of dynamic modeling with intermittent resource contingencies
  - Securing of reserves in export constrained areas (e.g., Long Island)
  - Interplay between Thunderstorm Alerts (TSAs) and dynamic reserves
  - Process for posting of dynamic reserve requirements

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Components Previously Discussed: Q3

- To date, NYISO has completed initial stakeholder discussions on the following topics:
  - Interaction of dynamic reserves with operating reserve demand curves
  - Interaction of dynamic reserves with transmission demand curves
  - Interplay between dynamic reserves scheduling and additional reserve requirements
  - Reserve cost allocation

Next Steps: Q4

- **At the 10/4/22 ICAPWG/MIWG meeting, FTI Consulting and NYISO presented on:**
  - LBMP formation (pricing and scheduling of resources under Dynamic Reserves)
- **Today's discussion included:**
  - Impacts on scarcity pricing logic
  - Interplay with current/future efforts: More Granular Operating Reserves, Long Island Constraint Pricing, Reserves for Congestion Management
  - Follow-up on the Intermittent Resource Contingency Constraint and LBMP formation
  - Update on prototyping
- **Project deliverable is Market Design Concept Proposed in Q4**
  - NYISO is targeting an early November ICAPWG/MIWG for the Market Design Concept Proposed presentation

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Next Steps: 2023 - 2026

- As presented in the 2022 Master Plan, the proposed project timeline for Dynamic Reserves is:
  - 2023: Market Design Complete
  - 2024: Functional Requirements
  - 2025: Development Complete
  - 2026: Deployment
- Considering the technical complexity of Dynamic Reserves, NYISO is exploring the option of a phased deployment. This could include deploying specific constraints initially in 2025, and additional constraints in 2026
  - This phased approach would apply to the Functional Requirements and Development Complete as well (i.e., only completing the Functional Requirements and Development for the initially deployed constraints)

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Questions?

Our Mission & Vision

Mission

Ensure power system reliability and competitive markets for New York in a clean energy future

Vision

Working together with stakeholders to build the cleanest, most reliable electric system in the nation

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Appendix: Mathematical Formulation

Equations: Securing a Reserve Area for the Loss of Generation

Calculating Actual Energy Flows in a Reserve Area

$$RA_{a_{Flow_i}} = (RA_{a_{Load_i}} + RA_{a_{Losses_i}} - RA_{a_{Gen_i}})$$

- $\mathrm{RA_a}$ is the applicable reserve area
- $\mathrm{RA_{a_{Flow_i}}}$ is the actual energy flow into or out of reserve area *a* for time step *i*
  - $RA_{a_{Flow_i}}$ is positive into reserve area *a*
  - $RA_{a_{Flow_i}}$ is negative out of reserve area *a*
  - Note: For the NYCA reserve area (Load Zones A-K), $RA_{a_{Flow_i}}$ value is equal to 0 MW because external proxies are evaluated as generators
- $\mathrm{RA_{a_{Load_i}}}$ is the forecasted load in reserve area *a* for time step *i* (Day-Ahead or Real-Time, as applicable)
- $RA_{a_{Losses_i}}$ is the calculated losses in reserve area a for time step *i* (Day-Ahead or Real-Time, as applicable)
- $\mathrm{RA_{a_{Gen_i}}}$ is the sum of all energy schedules on resources inside reserve area *a* for time step *i*

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Calculating the Available Transmission Headroom in a Reserve Area

$$\mathrm{RA}^{10Minute}_{aResCapability_i} = RA_{a_{EmerLimit_i}} - RA_{a_{Flow_i}}$$

$$\mathrm{RA}^{30Minute}_{aResCapability_i} = RA_{aNorm_{Limit_i}} - RA_{a_{Flow_i}}$$

- $\mathrm{RA}_{\mathrm{aRes}_{\mathrm{Capability}_i}}$ **is the capability to secure reserves external to reserve area *a* for time step *i***
- $\mathrm{RA}_{\mathrm{a}_{\mathrm{EmerLimit}_i}}$ **is the pre-contingency emergency limit for the reserve area *a* for time step *i***
- $\mathrm{RA}_{\mathrm{a}_{\mathrm{NormLimit}_i}}$ **is the pre-contingency normal limit for the reserve area *a* for time step *i***
    - Note: For the NYCA reserve area (Load Zones A-K), the $RA_{EmerLimit}$ and $RA_{NormLimit}$ value is equal to 0 MW because external proxies are evaluated as generators

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Multipliers Determine Product Quality Ratios

$$Res_{RA_{a_i}}^{10Spin} \geq Mult_{\mathrm{RA}_a}^{10Spin} * \{\max_{\mathrm{k}\in\mathrm{Gen}_{RA_a}} \{gen_{k_i} + res_{k_i}^{10SPin}\}\} - RA_{aResCapability_i}^{10Minute}$$

$$Res_{RA_{a_i}}^{10Total} \geq Mult_{\mathrm{RA}_a}^{10Total} * \{\max_{\mathrm{k}\in\mathrm{Gen}_{RA_a}} \{gen_{k_i} + res_{k_i}^{10Total}\}\} - \mathrm{RA}_{aResCapability_i}^{10Minute}$$

$$Res_{RA_{a_i}}^{30Total} \geq Mult_{\mathrm{RA}_a}^{30Total} * \{\max_{\mathrm{k}\in\mathrm{Gen}_{RA_a}} \{gen_{k_i} + res_{k_i}^{30Total}\}\} - \mathrm{RA}_{aResCapability_i}^{30\mathrm{Minute}}$$

- $\mathrm{Res}_{\mathrm{RA}_{a_i}}^{10\mathrm{Spin}}$ is the 10 − minute spinning reserve requirement in reserve area a for time step i
- $\mathrm{Res}_{\mathrm{RA}_{a_i}}^{10\mathrm{Total}}$ is the 10 − minute total reserve requirement in reserve area a for time step i
- $\mathrm{Res}_{\mathrm{RA}_{a_i}}^{30\mathrm{Total}}$ is the 30 − minute total reserve requirement in reserve area a for time step i

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Correlated Loss of Multiple Generators: Proposal

- **This constraint would capture the potential risk of losing multiple resources whose combined output may be the largest single source of generation in a reserve area**
  - The definition of correlated loss of multiple generators includes a single tower or line contingency leaving a generation complex that would result in the loss of multiple generating resources simultaneously
- **NYISO's proposal would allow generators to be linked such that their combined output would be evaluated in the standard form below:**
  - $Res_{RA_{a_i}}^{30Total} \geq Mult_{\mathrm{RA}_a}^{30Total} * \{\{gen_{\mathrm{A_i}} + 30T_{\mathrm{A_i}} + gen_{\mathrm{B_i}} + 30\mathrm{T}_{\mathrm{B_i}}\}\} - RA_{aRes_{Capability_i}}$

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Intermittent Resource Contingency: Proposal

- **This constraint would capture the potential risk of losing multiple intermittent resources whose combined output may be the largest single source of energy in a reserve area**
- **NYISO proposes to use the difference between the schedules (based on a POE50) and the forecasted values based on a higher POE, in the standard format:**

$$Res_{RA_{ai}}^{30Total} \geq Mult_{RA_a}^{30Total} * \left(\sum_{RA_{a_i}} IPP_{Schedule_i} - \sum_{RA_{a_i}} POEXX_{Forecast_i} \right) - RA_{aRes_{Capability_i}}$$

- **Scheduling of wind resources is based on a Probability of Exceedance (POE) 50 forecast**
  - A POE(50) forecast represents a value that will be exceeded 50% of the time; in turn, observations will be below this value 50% of the time
- **NYISO's proposal would use a POE forecast greater than 50 to calculate the quantity of generation that may be at risk**
  - The use of a higher POE (higher confidence) forecast would provide greater certainty of expected output. At this time, NYISO has not determined what POE forecast that will be used for this constraint
    - For example, a POE(95) represents a value with a 95% chance of being exceeded. This value is less than a POE(50) value as there is higher confidence that the forecast will be above it

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Securing a Reserve Area for the Loss of Transmission

Contingency Headroom on Interface

$$10minute_{PostCon_{Import_{RA_{a_i}}}} = Limit_{Emer_{RA_{a_i}}} - RA_{Flow_{a_i}}$$

$$30minute_{PostCon_{Import_{RA_{a_i}}}} = Limit_{Norm_{RA_{a_i}}} - RA_{Flow_{a_i}}$$

$$30minute_{PostDualCon_{Import_{RA_{a_i}}}} = Limit_{Emer\_Dual_{RA_{a_i}}} - RA_{Flow_{a_i}}$$

- $10\text{minute}_{\text{PostCon}_{\text{Import}_{\text{RA}_{a_i}}}}$ is the applicable post-contingency transfer limit of reserve area *a* for time step *i* that the flow should be under within 10 minutes
- $30\text{minute}_{\text{PostCon}_{\text{Import}_{\text{RA}_{a_i}}}}$ is the applicable post-contingency transfer limit of reserve area *a* for time step *i* that the flow should be under within 30 minutes
- $\text{Limit}_{\text{Emer}_{\text{RA}_{a_i}}}$ is the emergency transfer limit of reserve area *a* for time step *i*, depending on the applicable reliability rules to determine the need for 10 minute or 30-minutes reserves
- $\text{Limit}_{\text{Norm}_{\text{RA}_{a_i}}}$ is the normal transfer limit of reserve area *a* for time step *i*, depending on the applicable reliability rules to determine the need for 30-minutes reserves

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Contingency Headroom on Interface

- The difference between the applicable transfer limit and the flow is the available import capability
  - When negative, this number represents a deficiency that needs to be held as reserves within the reserve area due to the lack of transmission headroom to import reserves.
- All limits will be calculated via an offline study by NYISO Operations

New York ISO

Securing the RA for Loss of Transmission

$$Res_{RA_{a_i}}^{10Spin} \geq -Mult_{\mathrm{RA}_a}^{10Spin} * (10minute_{PostCon_{Import_{RA_{a_i}}}})$$

$$Res_{RA_{a_i}}^{10Total} \geq -Mult_{\mathrm{RA}_a}^{10Total} * (10minute_{PostCon_{Import_{RA_{a_i}}}})$$

$$Res_{RA_{a_i}}^{30Total} \geq -Mult_{\mathrm{RA}_a}^{30Total} * (30minute_{PostCon_{Import_{RA_{a_i}}}})$$

New York ISO

Tying the Loss of Generation and Loss of Transmission Together

Simultaneous Constraints 10-Minute Spinning Reserves

- **Simultaneous Constraints for 10-minute spinning reserves:**

$$Res_{RA_{a_i}}^{10Spin} \geq Mult_{\mathrm{RA}_a}^{10Spin} * \{\max_{\mathrm{k}\in\mathrm{Gen}_{RA_a}} \{gen_{k_i} + res_{k_i}^{10SPin}\}\} - RA_{aRes_{Capability_i}}$$

$$Res_{RA_{a_i}}^{10Spin} \geq -\mathrm{Mult}_{\mathrm{RA_a}}^{\mathrm{10Spin}} * (10minute_{PostCon_{Import_{RA_{a_i}}}})$$

The more restrictive of the two equations will determine the applicable requirement for the reserve area.

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Simultaneous Constraints 10-Minute Total Reserves

- **Simultaneous Constraints for 10-minute total reserves:**

$$Res_{RA_{a_i}}^{10Total} \geq Mult_{\mathrm{RA}_a}^{10Total} * \{ \max_{\mathrm{k} \in \mathrm{Gen}_{RA_a}} \{gen_{k_i} + res_{k_i}^{10Total}\}\} - RA_{aRes_{Capability_i}}$$

$$Res_{RA_{a_i}}^{10Total} \geq -Mult_{\mathrm{RA}_a}^{10Total} * (10minute_{PostCon_{Import_{RA_{a_i}}}})$$

The more restrictive of the two equations will determine the applicable requirement for the reserve area.

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Simultaneous Constraints 30-Minute Total Reserves

- **Securing for loss of source contingency with a security multiplier:**

$$Res_{RA_{a_i}}^{30Total} \geq \mathrm{Mult}_{\mathrm{RA_a}}^{\mathrm{30Total}} * \{\max_{\mathrm{k \in Gen}_{RA_a}} \{\mathrm{gen}_{k_i} + res_{k_i}^{30Total}\}\} - RA_{aRes_{Capability_i}}$$

- **Securing for one source contingency and N-1 transmission contingency:**

$$Res_{RA_{a_i}}^{30Total} \geq \{\max_{\mathrm{k \in Gen}_{RA_a}} \{\mathrm{gen}_{k_i} + res_{k_i}^{30Total}\}\} - RA_{aRes_{Capability_i}} + \left(30minute_{PostCon_{Import_{RA_{a_i}}}} - 10minute_{PostCon_{Import_{RA_{a_i}}}}\right)$$

Simultaneous Constraints 30-Minute Total Reserves (continued)

- **Secure transmission for N-1 to normal transfer capability:**

$$Res_{RA_{a_i}}^{30Total} \geq -Mult_{\mathrm{RA}_a}^{30Total} * \left(30minute_{PostCon_{Import_{RA_{a_i}}}}\right)$$

- **Secure transmission for N-1-1-0 to normal transfer capability (applies to NYC and NYC load pockets):**

$$Res_{RA_{a_i}}^{30Total} \geq -\left(30minute_{PostdualCon_{Import_{RA_{a_i}}}}\right)$$

- **Secure for loss of two elements within 30 minutes:**

$$Res_{RA_{a_i}}{}^{30Total} \geq -10minute_{PostCon_{Import_{RA_{a_i}}}} - \left\{\max_{\mathrm{k} \in \mathrm{Gen}_{\mathrm{RA_a}}} \left\{gen_{\mathrm{k_i}}\right\}\right\}$$

The more restrictive of the equations will determine the applicable requirement for the reserve area.

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