# Dynamic Reserves

## Market Design Concept Proposal


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December 6, 2022

# Agenda

- Background
- 2022 Market Design Concept Proposal
- Other Considerations
- Implementation Considerations
- Next Steps

# Background

# Project Background

- The current static modeling of reserve regions and their associated requirements may not optimally reflect the varying needs of the grid to respond to changes in system conditions, such as consideration of the following:
  - Scheduling economic energy above 1,310 MW from individual suppliers when sufficient reserves are available, and/or
  - Shifting reserve procurements to lower-cost regions when sufficient transmission capability exists.
- A more dynamic reserve procurement methodology could potentially improve market efficiency and better align market outcomes with how the power system is operated

# Key Concepts

- **A Dynamic Reserve procurement will depend on two key concepts:**
  - Reserves should cover for the largest source contingency in a reserve region, less the available transmission headroom
  - Reserves should account for loss of transmission capability into a reserve region
- **These concepts reflect the reliability rules that drive the current static requirements for each reserve region**

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# 2022 Market Design Concept Proposal

# Market Design Concept Proposal

## Components of NYISO's Market Design Concept Proposal will be discussed today:

- Formulation for Loss of Generation constraints
- Formulation for Loss of Transmission constraints
- Formulation for Loss of Generation and Loss of Transmission
- 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
- 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
- LBMP formation (pricing and scheduling of resources under Dynamic Reserves)
- Impacts on scarcity pricing logic
- Interplay with current/future efforts: More Granular Operating Reserves, Long Island Constraint Pricing, Reserves for Congestion Management

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# Securing Reserve Area for the Loss of Generation

- **The first concept is that reserves should cover for the largest source contingency, less available headroom**
  - Available headroom would reflect the ability to import reserves into the existing reserve region
  - Currently, largest source contingency is determined by the maximum single generation schedule
- **In addition to the largest single-source contingency, NYISO is proposing additional constraints to be considered when evaluating the largest source contingency:**
  - Correlated loss of multiple generators: Multiple resources that share a single point of failure (transmission tower, gas regulator valve)
  - Intermittent resource contingencies: Resources in close geographic proximity that may be susceptible to a common weather pattern, which poses a risk of simultaneous loss or reduction of energy output
- **An example of the generic formulation for Loss of Generation (applied to a 30-Minute Reserve product) is:**

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

# Securing Reserve Area for the Loss of Transmission

- **The second concept is that reserves should account for the loss of transmission (energy imports) into an existing reserve area**
  - This evaluation calculates the difference between the post-contingency interface limits and the current flow, following the loss of the largest line on the interface
  - Loss of Transmission constraints are not considered when evaluating NYCA reserve requirements because external proxies are evaluated as generators
- **An example of the generic formulation for Loss of Transmission (applied to a 30-Minute Reserve product in a locality) is:**

$$30minute_{PostCon_{Import_{RA_{a_i}}}} = Limit_{N-2Emer_{RA_{a_i}}} - RA_{Flow_{a_i}}$$

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# Tying Loss of Generation and Loss of Transmission Together

- The equations for the generation and transmission constraints would be co-optimized along with energy, reserves, and transmission
- The reserve requirements would be determined by the most restrictive equation for each reserve product in each reserve area
  - Would be dynamically determined in DAM and RTM

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# Forecast vs. Bid Load in SCUC

- To determine the available transmission capability into a reserve area in the Day-Ahead Market (DAM), the 2021 RECA Study and prototype used the forecast load
  - The study noted that the forecast load had been selected rather than the bid load
  - Some stakeholders sought more information to support the use of the forecast load vs. the bid load
- Forecast load was selected as it does not include virtual transactions, which may not be representative of expected physical flows and generation in real time
- Dynamic Reserves provide a reliability test against expected system conditions, which can not be guaranteed using the bid load
  - For example, virtual generation could represent energy that is either a) imported into a reserve area or b) generated within a reserve region – would not know until real time
- Prototyping completed in 2021 indicated that using bid load led to under securing reserves
- The NYISO proposes to continue the use of the forecast load to determine available transmission capability in the DAM

# NYCA 30-Minute Reserve Requirement

- **NYCA reserve requirements do not account for transmission headroom to import reserves as reserves must be procured internally**
- **In order to facilitate efficient Day-Ahead scheduling and to support reliable DA operations, NYISO identified a change to the calculation of the 30-Minute NYCA requirement**
  - The NYISO proposes that this potential solution continue to be evaluated during the Market Design Complete phase in 2023
    - This will allow the opportunity for more analysis and understanding of the potential implications on topics such as scheduling and pricing
  - The change would increase the reserve requirement by a positive difference between Forecast Load and Bid Load (there would be no other change to the formulation)
  - When Forecast Load exceeds Bid Load, the difference could be added to the reserve requirement as such:

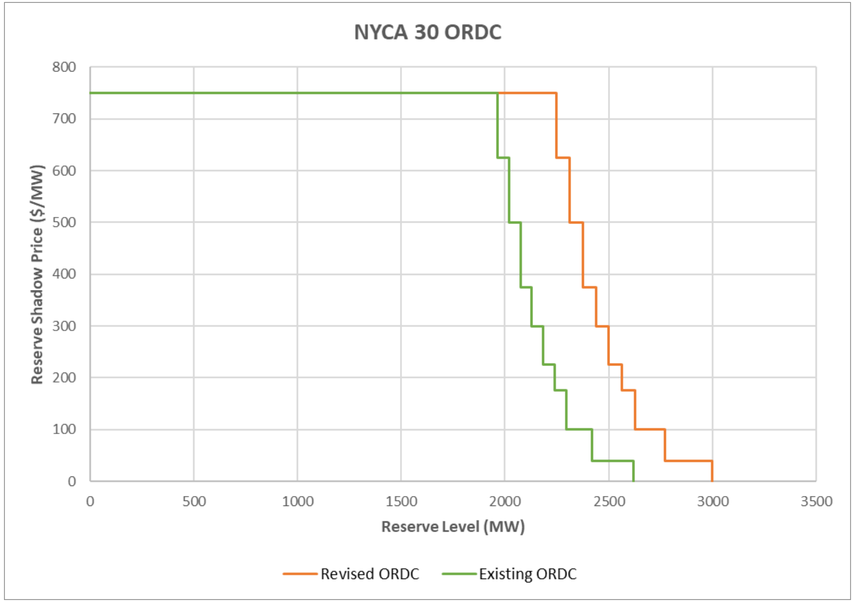
$$Res_{RA_{ai}}^{30Total} \geq Mult_{\mathrm{RA}_a}^{30Total} * \{\max_{\mathrm{k \in Gen}_{RA_a}} \{gen_{k_i} + res_{k_i}^{30Total}\}\} + \max[(\text{Forecast Load} - \text{Bid Load}), 0]$$

# NYCA 30-Minute Operating Reserve Demand Curve

- Dynamic Reserves would allow for the scheduling of economic energy above 1,310 MW from individual suppliers when it is economic to do so, while procuring enough reserves to cover the largest source contingency that may result from the energy schedules
- The existing ORDC is based on a procurement of 2,620 MW, but is not sufficient for the procurement of reserves above that amount
- NYISO is proposing to introduce a dynamic demand curve that would be proportional to the steps of the existing demand curve
  - The NYCA 30-Minute Operating Reserve Demand Curve would be formulaically updated such that the percent of the largest contingency that is procured at each step of the demand curve is maintained
  - NYISO is not proposing any changes to the shortage prices as part of Dynamic Reserves
  - The proposed change to the NYCA 30-Minute reserve requirement (adding the difference between the Forecast Load and Bid Load) will require further changes to the NYCA ORDC. These changes will be studied as part of the MDC in 2023.

# NYCA 30-Minute Operating Reserve Demand Curve: Formulaic Example

- Assume that the largest generator in NYCA is 1500 MW, which will increase the NYCA 30-Minute Reserve Requirement to 3000 MW
- The NYCA 30-Minute Operating Reserve Demand Curve would be formulaically updated such that the percent of the largest contingency that is procured at each step of the demand curve is maintained
  - The second step of the existing demand curve is equal to 4% of the largest contingency (55/1310)
  - The second step of a revised demand curve would be equal to 4% of the largest contingency. In this example, 4%*1500 MW = 63 MW
  - This maintains the stepped approximation of an exponential curve between the difference of 1.5x and 2x the largest contingency (e.g., between 1,965 and 2,620 in the existing ORDC)

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# Dynamic Procurement of Reserves on Long Island

- **Long Island is an export constrained area**
  - For reserves, this means that the Long Island reserve requirement is limited to a static value
  - Reserves cannot be scheduled in excess of those requirements
- **A dynamic reserves procurement would have several benefits:**
  - The LI reserve requirement would secure LI in the market and reflect system conditions on LI
    - At times when the reserve requirement is 270 MW, reserves would potentially only replace about 75% of the capacity of the largest generator on Long Island (assuming no transmission headroom)
  - Reserves could be economically scheduled up to transmission limits
    - Activation of reserves on LI would reduce import energy flows to LI
    - LI reserves would be able to contribute to the reserve requirement for all reserve areas that it is apart of, up to export capabilities

# Long Island Reserve Scheduling: Proposal

- **To implement Dynamic Reserves on Long Island, the following would need to occur:**
  - Deactivate/Remove static limits on reserve scheduling
  - Eliminate penalty cost for scheduling reserves over the requirement
- **Efficiently scheduling reserves on Long Island will be an important component to realize the full benefits of Dynamic Reserves**

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# Intermittent Resource Contingency Constraint

- **The NYISO proposes 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, whose combined output may be the largest 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)
  - 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
  - Wind resources that share a single point of interconnection would be considered a single generator

# Intermittent Resource Contingency Constraint: 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
- **NYISO proposes to use the difference between the schedules and the forecasted values based on a higher POE, in the standard format:**

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

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# Correlated Loss of Multiple Generators

- **The NYISO is proposing a constraint that would account for the potential loss of multiple resources that share a single point of failure**
  - 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
- **This constraint would capture the potential risk of losing multiple resources whose combined output may be the largest 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

# Correlated Loss of Multiple Generators: Definition

- **NYISO's proposal would allow generators to be linked such that their combined output would be evaluated in the standard form below:**

$$Res_{RA_{a_i}}^{30Total} \geq Mult_{\mathrm{RA}_a}^{30Total} * \{\{gen_{\mathrm{A_i}} + gen_{\mathrm{B_i}}\}\} - RA_{aRes_{Capability_i}}$$

- **Applicable groups of generators are currently identified by NYISO**
  - This constraint may not apply to a reserve area if there is not a set resources that have been identified as correlated
  - There are currently less than 5 sets of resources that this constraint would apply to
    - The combined output of each resource set is less than the current single largest generator in NYCA (*i.e.*, less than 1,310 MW)

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# Other Considerations

# Posting of Dynamic Reserve Requirements

- **Under a dynamic procurement, the reserve requirement for each reserve product would be calculated in each time step**
- **NYISO will develop a new method for posting reserve information. This could include:**
  - Calculated reserve requirement for each reserve region in DA and RT
    - This would be similar to the static reserve requirements posting
  - Zonal clearing prices (same as provided today)
  - Reserve area clearing prices
  - Reserve product shadow prices
    - NYISO could limit the posting of shadow prices to only when constraint binds
      - This would be in line with how NYISO only posts transmission line constraints when binding

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# Thunderstorm Alert (TSA) Activations

- **During TSA events today, the system is operated as if the first contingency has already occurred (NYSRC Reliability Rules, Section I)**
  - Power transfer into SENY and NYC is lowered by increasing generation in SENY and NYC
  - In the event of a contingency, line flows could be increased to deliver more power into SENY and NYC
  - TSAs are real-time event only
- **Given that sufficient headroom exists to import power during a TSA, NYISO currently reduces the 10-Minute Total requirement for NYC and 30-Minute Total Requirements for SENY and NYC to 0 MW**
- **The Dynamic Reserves formulation uses transmission headroom to account for the ability to import reserves into a reserve area**
  - Under TSA conditions, the increased headroom would decrease the calculated reserve requirements

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# Thunderstorm Alerts: Proposal

- **NYISO has identified two options for handling a TSA with Dynamic Reserves:**
  - Disable reserve requirements
    - This would be the same process as it done currently
  - Allow Dynamic Reserves to solve for the reserve requirement. Given the logic of Dynamic Reserves and the amount of available transmission headroom during a TSA, it is anticipated that the solution would set a reserve requirement close to or equal to 0
- **The NYISO will prototype the second approach and review the outcomes to determine if the Dynamic Reserve solution would solve as anticipated and set a near-zero reserve requirement during TSAs**

# Transmission Demand Curves

- **No impact or design considerations have been identified, and it is expected that the transmission demand curves will continue to interact with ORDCs as they have with static reserve regions**
  - Transmission headroom is calculated based on limits calculated in offline studies, and therefore any transmission relief due to transmission shortage pricing would not impact/modify the reserve requirement
- **NYISO will identify test cases to confirm expectations and understand any unexpected interactions**
  - Test cases will include enhancements to the current transmission constraint pricing logic that were proposed as part of the Constraint Specific Transmission Shortage Pricing project in 2021 and 2022

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# Scarcity Reserve Requirements

- **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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# Supplemental Reserves

- **NYISO proposed a method for procuring additional reserve requirements beyond minimum reliability requirements ("supplemental reserves") as part of the 2020 Ancillary Services Shortage Pricing project**
  - The supplemental reserves proposal would have allowed NYISO to establish reserve procurement levels in excess of minimum reliability requirements to account for system uncertainty introduced by weather-dependent resources (distributed and grid-connected)
  - This proposal was rejected, without prejudice, by FERC and, therefore, has not yet been implemented
- **With the inclusion of the Intermittent Resource Contingency constraint, Dynamic Reserves would fulfill the intent of the Supplemental Reserves proposal**
  - While this is a different method than what was proposed under the prior supplemental reserves proposal, the construct of Dynamic Reserves would account for the potential under-forecasting of intermittent resources by determining the MW at risk between different confidence levels of forecasts
  - As the method proposed for Dynamic Reserves does not depend on historic data, this method can more readily account for new resources that interconnect into NYCA and is based on location-specific data
- **Supplemental Reserves also could have been triggered by under-forecasting net load and/or an increase in the number of adverse operating state declarations that occur on a monthly basis**
  - The potential for under-forecasting net load, and modeling enhancements available to address it, will be discussed in the Balancing Intermittency project proposed for 2023
  - Given that market design enhancements may avoid increases in the number of adverse operating state declarations, this metric is best evaluated upon completion of the stakeholder process for these enhancements

# Pricing and LBMP Formation

- **NYISO presented stylized examples to demonstrate RTM scheduling and pricing outcomes**
  - That presentation included several potential future topics for future examples
  - Several stakeholders asked for further examples that would demonstrate the Intermittent Resource Contingency constraint
- **During the Market Design Complete, NYISO will continue to present stylized pricing examples in order to gain an understanding of the potential market outcomes**
  - These examples would include DAM examples

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# Reserve Cost Allocation

- **Currently, DAM and RTM operating reserve costs are allocated statewide on a load-ratio share basis**
- **Dynamic Reserves will align reserve requirements with reliability requirements**
  - NYISO received some stakeholder feedback that updating reserve cost allocation could lead to further improvements in economic efficiency and operational incentives
    - Feedback includes concepts such as reserve area cost allocation, difference in energy prices for different resources (*e.g.*, physical, virtual) depending on ability to satisfy reliability needs, payments to the largest generator net of reserve shadow prices
  - Cost allocation outcomes depend on the specific Dynamic Reserves design, which is being presented during today's Concept Proposal
  - NYISO believes that the MDCP is a reasonable basis for discussing cost allocation during the MDC

# 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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# Implementation Considerations

# Implementation Considerations

- As discussed at the 10/19/22 MIWG, NYISO is exploring the option of a phased project plan such as the following:
  - 2023: Market Design Complete (Phase 1)
  - 2024: Functional Requirements, Development Complete (Phase 1); Market Design Complete (Phase 2)
  - 2025: Deployment (Phase 1); Functional Requirements, Development Complete (Phase 2)
  - 2026: Deployment (Phase 2)
- The proposed phases would be defined by specific constraints and design elements

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# Implementation Considerations: Project Phases

- **Phase 1:**
  - Loss of Generation Constraint (based only on the largest single-source generator)
  - Loss of Transmission Constraint
  - Simultaneous Loss of Generation and Transmission Constraints
  - Dynamic 30-Minute NYCA ORDC
  - Enhancements to Long Island reserve scheduling
  - Updates to the posting of reserve requirements
- **Phase 2:**
  - Correlated Loss of Multiple Generators Constraint
  - Intermittent Resource Contingency Constraint
  - Phase 2 could also include additional changes that have been further vetted and included in the 2023 Market Design Complete effort, such as Transmission Demand Curves, Thunderstorm Alerts, and Scarcity Pricing

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# Next Steps

# 2023 Market Design Complete

- **The 2023 Deliverable for Dynamic Reserves is Market Design Complete**
  - In the near future (Q1 2023), NYISO is targeting stakeholder discussions on:
    - Scheduling and pricing examples for the Day-Ahead Market
    - Determining necessary updates to posting of reserve requirements

# Questions?

# Appendix I: 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 for Generation

$$RA_{a_{Headroom}} = RA_{a_{EmerLimit_i}} - RA_{a_{Flow_i}}$$

- $\mathrm{RA}_{Headroom}$ is the capability to secure reserves external to reserve area *a* for time step *i*
- $\mathrm{RA}_{\mathrm{a}_{\mathrm{EmerLimit}_\mathrm{i}}}$ is the pre-contingency emergency 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

# Multipliers Determine Product Quality Ratios

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

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

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

- $\mathrm{Res}_{\mathrm{RA}_{a_i}}^{10\mathrm{Spin}}$ 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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# Securing a Reserve Area for the Loss of Transmission

# Contingency Headroom on Interface

$$10minute_{PostCon_{Import_{RA_{a_i}}}} = Limit_{N-1Emer_{RA_{a_i}}} - RA_{Flow_{a_i}}$$
$$30minute_{PostCon_{Import_{RA_{a_i}}}} = Limit_{N-2Emer_{RA_{a_i}}} - RA_{Flow_{a_i}}$$

- $10\mathrm{minute}_{\mathrm{PostCon}_{\mathrm{Import}_{\mathrm{RA}_{a\,i}}}}$ is the applicable post-contingency transfer limit of reserve area *a* for time step *i* that the flow should be under within 10 minutes
- $30\mathrm{minute}_{\mathrm{PostCon}_{\mathrm{Import}_{\mathrm{RA}_{a\,i}}}}$ is the applicable post-contingency transfer limit of reserve area *a* for time step *i* that the flow should be under within 30 minutes
- $\mathrm{Limit}_{N-1\mathrm{Emer}_{\mathrm{RA}_{a_i}}}$ is the emergency transfer limit of reserve area *a* for time step *i*, with the largest in-service element taken out of service
- $\mathrm{Limit}_{\mathrm{N}-2\mathrm{Emer}_{\mathrm{RA}_{a_i}}}$ is the emergency transfer limit of reserve area *a* for time step *i*, with the two largest in-service element taken out of service

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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

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# Securing the RA for Loss of Transmission

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

$$Res_{RA_{a_i}}^{10Total} \geq -(10minute_{PostCon_{Import_{RA_{a_i}}}})$$

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

**The multiplier is only used for Spin as it represents a quality flag (percentage) of the 10T requirement which should be held as spinning. Any number from 0 to 1 is valid.**

# Tying the Loss of Generation and Loss of Transmission Together

# Securing for one source contingency and N-1 transmission contingency

- $Res_{RA_{a_i}}^{30Total} \geq \{\max_{\mathrm{k \in Gen}_{RA_a}} \{\mathrm{gen}_{k_i} + res_{k_i}^{30Total}\}\} - (Limit_{N-1Emer_{RA_{a_i}}} - RA_{Flow_{a_i}})$

# Simultaneous Constraints 30-Minute Total Reserves

- **Secure multiple of largest generator to emergency transfer capability:**

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

$$RA_{a_{Headroom}} = RA_{a_{EmerLimit_i}} - RA_{a_{Flow_i}}$$

- **Secure transmission for N-2 to emergency transfer capability:**

$$Res_{RA_{a_i}}^{30Total} \geq -(Limit_{N-2Emer_{RA_{a_i}}} - RA_{Flow_{a_i}})$$

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

$$Res_{RA_{a_i}}^{30Total} \geq \{\max_{\mathrm{k} \in \mathrm{Gen}_{RA_a}} \{\mathrm{gen}_{k_i} + res_{k_i}^{30Total}\}\} - (Limit_{N-1Emer_{RA_{a_i}}} - RA_{Flow_{a_i}})$$

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

# Simultaneous Constraints 30-Minute Total Reserves

- **Secure multiple of largest generator to emergency transfer capability:**

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

$$RA_{a_{Headroom}} = RA_{a_{EmerLimit_i}} - RA_{a_{Flow_i}}$$

- **Secure transmission for N-2 to emergency transfer capability:**

$$Res_{RA_{a_i}}^{30Total} \geq -\left(Limit_{N-2Emer_{RA_{a_i}}} - RA_{Flow_{a_i}}\right) + ORDC + RA_{scarcity_i}$$

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

$$Res_{RA_{a_i}}^{30Total} \geq \{\max_{\mathrm{k \in Gen}_{RA_a}} \{\mathrm{gen}_{k_i} + res_{k_i}^{30Total}\}\} - (Limit_{N-1Emer_{RA_{a_i}}} - RA_{Flow_{a_i}}) + ORDC + RA_{scarcity_i}$$

- **Scarcity Minimum Reserve Constraint Penalty Cost**

$$Res_{RA_{a_i}}^{30Total} \geq RA_{scarcity_i} + \$500\_Penalty\_Cost\_Curve$$

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

New York ISO