Dynamic Reserves

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Agenda

- Background
- Posting of Reserve Requirements
- Long Island Reserve Scheduling
- Thunderstorm Alerts
- Next Steps

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

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Posting of Reserve Requirements

Current Posting of Reserve Requirements

- **NYISO's locational reserve requirements are posted on the NYISO website**
  - Markets→ Reports & Info https://www.nyiso.com/documents/20142/3694424/Locational-Reserves-Requirements.pdf/ab6e7fb9-0d5b-a565-bf3e-a3af59004672
  - This document does not go through the stakeholder approval process like a manual, but is updated when new/revised reserve requirements are implemented

NYISO
Locational Reserve Requirements

The NYISO shall define requirements for Spinning Reserve, which may be met only by Suppliers that are eligible to provide Spinning Reserve; 10-Minute Reserve, which may be met by Suppliers that are eligible to provide either Spinning Reserve or 10-Minute Non-Synchronized Reserve; and 30-Minute Reserve, which may be met by Suppliers that are eligible to provide any Operating Reserve product. The NYISO shall also define locational requirements for Spinning Reserve, 10-Minute Reserve, and 30-Minute Reserve located in East of Central–East (EAST), in Southeastern New York (SENY), in New York City (NYC), and on Long Island (LI) as shown in the following table:*

	NYCA	EAST	SENY	NYC	LI
A=most severe NYCA Operating Capability Loss (1310 MWs)	Zone A-K	Zone F-K	Zone G-K	Zone J	Zone K
10 Minute Spinning Reserve	½ A = 655 MW (I)	¼ A = 330 MW (IV)	0 MW	0 MW	0 MW
10 Minute Total Reserve	A = 1310 MW (II)	1200 MW (V)	0 MW	500 MW (VIII)	$^{1}/_{10}$ V = 120 MW (X)
30 Minute Reserve	2 A = 2620 MW (III)	1200 MW (VI)	1300-1800 MW (VII)	1000 MW (IX)	270-540 MW (XI)

I NYCA 10-minute spinning reserve is equal to at least one-half of the 10-minute total reserve. [NYSRC Reliability Rules, Section E]

II NYCA 10-minute total reserve is equal to the operating capability loss caused by the most severe contingency under normal transfer conditions. [NYSRC Reliability Rules, Section E]

III NYCA 30-minute total reserve is equal to two times the 10-minute reserve necessary to replace the operating capability loss caused by the most severe contingency under normal transfer conditions. [NYSRC Reliability Rules, Section E]

IV EAST 10-minute spinning reserve is based on the NERC requirement to plan to meet energy reserve requirements, including the deliverability/capability for any single Contingency and the NPCC requirement that reserves be distributed to ensure that they can be used without exceeding individual element ratings or transfer limitations. [NERC TOP-002-2.1b; NPCC Reliability Directory No. 5, Section 5.6]

V EAST 10-minute total reserve is based on Reliability Rules that require immediate measures (activation of EAST 10 minute reserves) be applied to bring loadings on an internal NY transfer interface to within limits in 15 minutes. [NYSRC Reliability Rules, Section D]

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Current Posting of Reserve Clearing Prices

- **NYISO posts DA and RT zonal reserve clearing prices**
  - Clearing prices represent the cascading nature of reserve products
  - Clearing prices are the sum of the shadow prices for each reserve product in that Load Zone

Time Stamp	Time Zone	Name	PTID	10 Min Spinning Reserve ($/MWHr)	10 Min Non-Synchronous Reserve ($/MWHr)	30 Min Operating Reserve ($/MWHr)	NYCA Regulation Capacity ($/MWHr)	NYCA Regulation Movement ($/MW)
5/17/2022 0:05	EDT	CAPITL	61757	0	0	0	3	0.15
5/17/2022 0:05	EDT	CENTRL	61754	0	0	0	3	0.15
5/17/2022 0:05	EDT	DUNWOD	61760	0	0	0	3	0.15
5/17/2022 0:05	EDT	GENESE	61753	0	0	0	3	0.15
5/17/2022 0:05	EDT	HUD VL	61758	0	0	0	3	0.15
5/17/2022 0:05	EDT	LONGIL	61762	0	0	0	3	0.15
5/17/2022 0:05	EDT	MHK VL	61756	0	0	0	3	0.15
5/17/2022 0:05	EDT	MILLWD	61759	0	0	0	3	0.15
5/17/2022 0:05	EDT	N.Y.C.	61761	0	0	0	3	0.15
5/17/2022 0:05	EDT	NORTH	61755	0	0	0	3	0.15
5/17/2022 0:05	EDT	WEST	61752	0	0	0	3	0.15
5/17/2022 0:10	EDT	CAPITL	61757	0	0	0	3	0.15
5/17/2022 0:10	EDT	CENTRL	61754	0	0	0	3	0.15

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Posting of Dynamic Reserve Requirements

- **Under a dynamic procurement, the reserve requirement for each reserve product would be calculated in each time step**
- **NYISO would 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 is would be in line with how NYISO only posts transmission line constraints when binding

Long Island Reserve Scheduling

Current 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
    - The amount of reserves scheduled on Long Island is limited to 270-540 MW, depending on the hour
    - No other reserve areas have a static limit of the quantity of reserves that can be held in that area
  - Reserves cannot be scheduled in excess of those requirements, even if:
    - More reserves are economically available to contribute to the SENY, East, or NYCA reserve requirements
    - Transmission system capability exists to ensure physical delivery

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Dynamic Procurement of Reserves on Long Island

- **A dynamic reserves procurement would have several benefits:**
  - The LI reserve requirement would 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 part of, up to export capabilities
- **Example:**
  - Imports into LI on Y49/Y50 = 1,000 MW; 30-Minute Reserve Requirement for LI = 500 MW
    - Up to 1,000 MW of 30-Minute reserves could be scheduled on LI, which would meet the LI reserve requirement and contribute to the NYCA and SENY 30-Minute Reserve Requirement
    - Following a Reserve Pickup, imports into LI could drop to 0 MW if 1,000 MW of reserves were economic to be activated on LI

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Result of Reruns from 2021 Study

- **NYISO performed a rerun of Day-Ahead Market outcomes for 8/5/2021 with Dynamic Reserves activated in all reserve areas**
  - To simulate typical operating conditions, major transmission line outages were brought back into service, such as Y-50 on Long Island
  - The Upper Operating Limit for three external transactions were increased to allow economic energy to flow into NYCA over the HQ Interface
    - This increased the NYCA reserve requirement, but decreased total system cost due to the ability to import more economic energy
- **Of the 4 cases ran, the case with Dynamic Reserves activated in all reserve areas resulted in the largest decrease in total production cost**
  - This was largely attributable to better modeling of transmission capabilities on Long Island
- **Additionally, scheduled reserves in Long Island often exceeded current/base case static reserve requirements and schedules**
  - This reflects the availability of economic and deliverable reserves on LI

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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Thunderstorm Alerts (TSAs)

Thunderstorm Alert (TSA) Activations

- The 2021 RECA Study included the following consideration:
  - Consideration: Disabling of the dynamic reserves requirements during Thunder Storm Alerts (TSAs)
- 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
  - TSAs are real-time event only
- NYISO currently reduces the 10-Minute Total requirement for NYC and 30-Minute Total Requirements for SENY and NYC to 0 MW, as solving the TSA constraints creates sufficient head room on the transmission system to avoid overloads in the event of the worst single contingency.

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TSAs: Grid Conditions

- **During a TSA activation, we would expect the following grid conditions as the system responds:**
  - Sum of Energy Schedules on Internal Generators: **Increases**
  - Actual Energy Flow into NYC and SENY (Load – Generation): **Decreases**
  - Reserve Capability/Headroom into NYC and SENY: **Increases**
- **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

Dynamic Reserves Formulation: Securing Operating Reserves for Loss of Generation in a Reserve Area

- **Step 1: Calculate actual flows into reserve area**
  - $RA_{a_{Flow_i}} = RA_{a_{Load_i}} - RA_{a_{Gen_i}}$
- **Step 2: Calculate available transmission headroom**
  - $RA_{aRes_{Capability_i}} = RA_{a_{Limit_i}} - RA_{a_{Flow_i}}$
- **Step 3: Determine reserve quantity**
  - $Res_{RA_{ai}}^{10Total} \geq Mult_{\mathrm{RA}_a}^{10Total} * \{\max_{k \in \mathrm{Gen}_{RA_a}} \{gen_{k_i}\}\} - RA_{aRes_{Capability_i}}$
  - $Res_{RA_{ai}}^{30Total} \geq Mult_{\mathrm{RA}_a}^{30Total} * \{\max_{\mathrm{k} \in \mathrm{Gen}_{RA_a}} \{gen_{\mathrm{k_i}}\}\} - RA_{aRes_{Capability_i}}$

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Dynamic Reserves Formulation: Securing Operating Reserves for Loss of Transmission in a Reserve Area

- **Step 1: Calculate contingency headroom on interface**
  - $10minute_{PostCon_{Import_{RA_{a\,i}}}} = Limit_{Emer(\mathrm{N-1})_{RA_{a_i}}} - RA_{Flow_{a_i}}$
  - $30minute_{PostCon_{Import_{RA_{a\,i}}}} = Limit_{Norm_{RA_{a_i}}} - RA_{Flow_{a_i}}$
  - $30minute_{PostdualCon_{Import_{RA_{a\,i}}}} = Limit_{Norm(\mathrm{N-1-1-0})_{RA_{a_i}}} - RA_{Flow_{a_i}}$
- **Step 2: Determine reserve quantity**
  - $Res_{RA_{a_i}}^{10Total} \geq -Mult_{\mathrm{RA}_a}^{10T} * (10minute_{PostCon_{Import_{RA_{a_i}}}})$
  - $Res_{RA_{a_i}}^{30Total} \geq -Mult_{\mathrm{RA}_a}^{30\mathrm{T}} * \left(30minute_{PostCon_{Import_{RA_{a\,i}}}}\right)$
  - $Res_{RA_{a_i}}^{30Total} \geq -Mult_{\mathrm{RA}_a}^{30\mathrm{T}} * \left(30minute_{PostdualCon_{Import_{RA_{a\,i}}}}\right)$

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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**

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Next Steps:

Next Steps: Intermittent Resource Contingency Constraint

- At the 5/11 MIWG meeting, NYISO introduced 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
- NYISO is developing responses to the following stakeholder comments:
  - Discussion on the use of scheduled wind output vs. forecasted wind output in the proposed constraint
  - Information on how Probability of Exceedance forecasts are calculated by NYISO's vendor

Next Steps: Q2

- **The NYISO will continue discussions at ICAP/MIWG in the coming months, targeting the following schedule:**
  - Q2 (May, June) – items in blue discussed at June 16th ICAPWG/MIWG
    - 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
    - LBMP formation (including cost allocation, pricing of virtual supply in DAM)

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Next Steps: Q3 and Q4

- **The NYISO will continue discussions on the following topics at ICAP/MIWG in the coming months:**
  - 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
  - Impacts on scarcity pricing logic
  - Interplay with current/future efforts: More Granular Operating Reserves, Long Island Constraint Pricing, Reserves for Congestion Management
  - Discussion of prototyping, which could include:
    - Impacts on day-ahead and real-time market solutions
    - Interaction with new resource models

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

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

- RA_a is the applicable reserve area
- $RA_{a_{Flow_i}}$ 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
- $RA_{a_{Load_i}}$ 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)
- $RA_{a_{Gen_i}}$ 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

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

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

- $\mathrm{RA}_{\mathrm{aRes}_{\mathrm{Capability}_\mathrm{i}}}$ 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*
- $\mathrm{RA}_{\mathrm{a}_{\mathrm{NormLimit}_\mathrm{i}}}$ 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 $\mathrm{RA}_{\mathrm{EmerLimit}}$ and $\mathrm{RA}_{\mathrm{NormLimit}}$ value is equal to 0 MW because external proxies are evaluated as generators

Multipliers Determine Product Quality Ratios

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

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

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

- $\mathrm{Res}_{\mathrm{RA}_{a_i}}^{10\mathrm{Spin}}$ 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

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

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

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

- $\mathrm{10minute}_{\mathrm{PostCon}_{\mathrm{Import}_{\mathrm{RA}_{\mathrm{a_i}}}}}$ is the applicable post-contingency transfer limit of reserve area *a* for time step *i* that the flow should be under within 10 minutes
- $\mathrm{30minute}_{\mathrm{PostCon}_{\mathrm{Import}_{\mathrm{RA}_{\mathrm{a_i}}}}}$ is the applicable post-contingency transfer limit of reserve area *a* for time step *i* that the flow should be under within 30 minutes
- $\mathrm{Limit}_{\mathrm{Emer}_{\mathrm{RA}_{\mathrm{a_i}}}}$ 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
- $\mathrm{Limit}_{\mathrm{Norm}_{\mathrm{RA}_{\mathrm{a_i}}}}$ 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**

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Securing the RA for Loss of Transmission

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

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

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

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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.

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:**

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

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

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