New York ISO
Independent System Operator

Reserve Enhancements for Constrained Areas: Study Approach

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Agenda

- Background
- Project Overview
- Project Scope
- Study Approach
- Formulation Phase
- Next Steps

Background

Operating Reserves Overview

- **Protection against contingencies**
  - Sudden loss of a generator
  - Trip of a network equipment (e.g., transmission line or transformer)
- **Locational reserve requirements**
  - Requirements for EAST (Load Zones F-K), SENY (Load Zones G-K), NYC (Load Zone J) and Long Island (Load Zone K) help ensure reserves are located where needed due to limitations on the transmission system
- **Existing reserve requirements are essentially static**

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Operating Reserves Requirements

- **The types and quantities of operating reserves procured in each reserve region vary based on the applicable reliability rule that the reserves are intended to secure.**
- **For example, for the current NYCA reserve requirements**
  - 10-minute reserves secure for the largest source contingency
    - Reliability rules require at least half of the 10-minute total reserves to be held as 10-minute spinning reserves
  - 30-minute reserves serve to replenish the 10-minute reserves following an activation

Current Operating Reserve Requirements

- Currently, the NYISO procures fixed quantities of operating reserves in specified regions across the state.*

	NYCA	EAST	SENY	NYC	LI
10 Minute Spinning Reserve	½ A = 655 MW	¼ A = 330 MW	0 MW	0 MW	0 MW
10 Minute Total Reserve	A = 1,310 MW	1,200 MW	0 MW	500 MW	120 MW
30 Minute Reserve	2 A = 2,620 MW	1,200 MW	1,300–1,800 MW	1,000 MW	270-540 MW

A = Most severe NYCA Operating Capability Loss (1310 MW)

*Refer to the NYISO Locational Reserve Requirements posting for additional details

Reserve Enhancements for Constrained Areas Project Overview

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 considerations 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.**

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Project Scope

- **The Reserve Enhancements for Constrained Areas project study has two key components:**
  - i. Dynamic Reserve Modeling
    - Explore the feasibility of dynamically determining the minimum operating reserve requirements based on the single largest source contingency during market runs.
  - ii. Transmission as Reserves
    - Explore dynamic allocation of reserves based on available transmission capability (includes SOM-2015-16)
    - Creating locational operating reserve requirements for certain load pockets within NYC
      - Consider modeling local reserve requirements within certain NYC load pockets based on available transmission capability (SOM-2017-1)
      - Builds upon prior work conducted as part of the More Granular Operating Reserves project that examined the development of reserve requirements for certain NYC load pockets (see presentation from the November 6, 2019 BIC meeting)
    - Evaluate modeling of certain NYC load pockets when operating reserve providers provide congestion relief (includes SOM 2016-1)
  - The NYISO believes an efficient more granular operating reserves concept is dependent on developing the transmission as reserves capabilities

Study Approach

Study Approach

- **The study is evaluating the feasibility of dynamically scheduling reserves in the SCUC, RTC and RTD intervals**
  - Studying the impact with current reserve products (10-minute spin, 10-minute total, 30-minute total)
  - Studying the ability to apply to all current reserve regions and potential future reserve regions (e.g., certain NYC load pockets)
- **The study is comprised of two primary phases:**
  - Formulation phase
  - Prototyping phase

Formulation Phase

- **The NYISO started with a theoretical approach by developing a generalized mathematical formulation to facilitate solving the procurement of operating reserves dynamically.**
  - The NYISO sought feedback from external consultants on the feasibility of the formulation

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Prototyping Phase

- The NYISO is now in the process of prototyping this mathematical formulation to study the feasibility and effectiveness of incorporating it into the market software and the impacts thereof on the market solution.

Formulation Phase

Mathematical Formulation

- **Objectives of the mathematical formulation:**
  - To dynamically set operating reserve requirements
  - Identifying and solving for largest generation (source) contingency for every time step
  - Co-optimize generation and reserve schedules with available transmission headroom (interface flows)
  - Secure the transmission system to pre-contingency and post-contingency interface limits with reserve requirements
  - Ensure compatibility with current SCUC and RTS systems including network topology modeling for effective implementation
  - Seeks to closely model existing reserve regions with more generic modeling to allow for easy expansion

Key Modeling Term

- **Reserve area: An area of the power system that does not have enough transmission import capability to serve its load without local generation commitments.**
  - For purposes of this project, the NYISO will focus on the defined locational reserve regions and certain NYC load pockets*

*NYC load pockets are not currently defined as separate locational reserve regions

Key Concepts for Study

- **Operating Reserves should be procured to account for the greater of the two contingencies in any reserve area:**
  1. Loss of generation (source contingency)
  2. Loss of transmission/import
- **There are two ways to secure reserves in any reserve area:**
  1. Schedule reserves on resources inside the reserve area
  2. Schedule reserves outside the reserve area within the available import capability.
- **Determination of dynamic reserve requirements and associated schedules would be a part of the optimization and considered by the objective function (i.e., minimization of total production cost)**

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Securing a Reserve Area for the Loss of Generation

Securing Operating Reserves for Loss of Generation in a Reserve Area

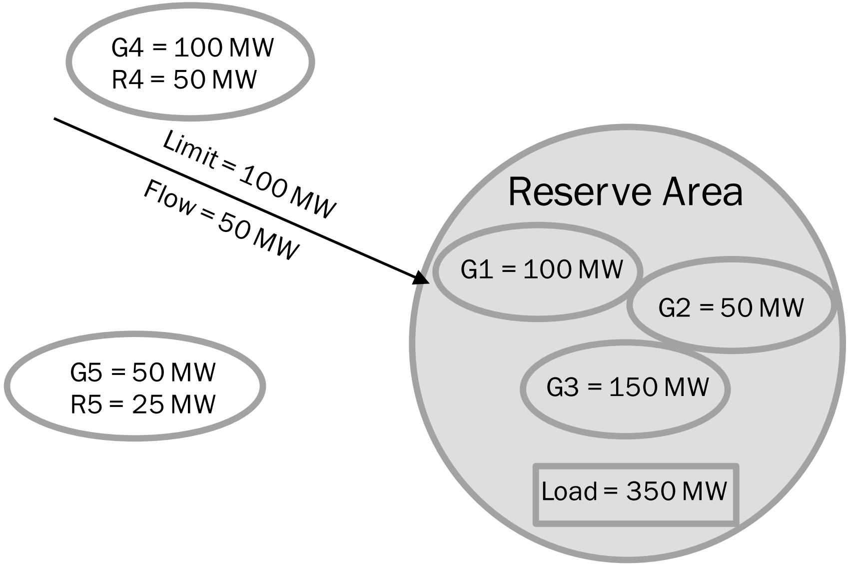
- **The reserve requirement should cover for the largest source contingency within a reserve area, less the available transmission headroom**
  - The transmission headroom is further limited by the amount of reserves scheduled outside the reserve area
- **Reserve requirements, energy and reserve schedules and corresponding flows are determined simultaneously**

Securing Operating Reserves for Loss of Generation in a Reserve Area

- **The additional security constraint for reserves allows the reserve requirement to be dynamic by either:**
  - Decreasing energy flows into the reserve area to create transmission headroom
  - Decreasing scheduled energy production inside the reserve area to create reserve capability on resources
  - Increasing reserve schedules outside the reserve area subject to available transmission headroom

Example 1: Securing Operating Reserves for Loss of Generation in a Reserve Area

- Assumptions for example:
- Three resources (G1, G2 and G3) exist within a reserve area
  - G1: Energy schedule = 100 MW; UOL = 100 MW
  - G2: Energy schedule = 50 MW; UOL = 200 MW
  - G3: Energy schedule = 150 MW; UOL = 150 MW
- Two resources (G4, G5) exist outside the reserve area
  - G4: Energy schedule = 100 MW, Reserve schedule = 50 MW ; UOL = 300 MW
  - G5: Energy schedule = 50 MW, Reserve schedule = 25 MW; UOL = 75 MW
- Transmission line importing power into reserve area
  - Transfer limit = 100 MW; Current flow = 50 MW



Note:

- Reserve schedules for all resources will be determined simultaneously.
- The reserve schedules for resources G4 and G5 (i.e., R4 and R5) are shown for illustrative purposes only

Example 1: Securing Operating Reserves for Loss of Generation in a Reserve Area

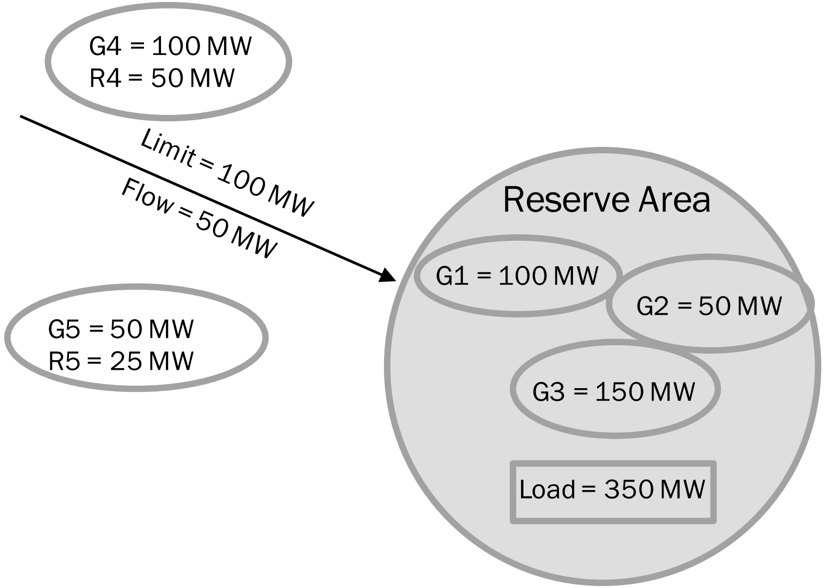
- Single largest source contingency = 150 MW
- Available transmission headroom
  = 100 MW – 50 MW = 50 MW
- Reserves outside the reserve area
  = 50 MW + 25 MW = 75 MW

Reserve requirement in reserve area=

Largest source contingency – min (transmission headroom, reserves schedules outside the reserve area)

= 150 MW – min(50 MW, 75MW)

= 100 MW



Securing a Reserve Area for the Loss of Transmission

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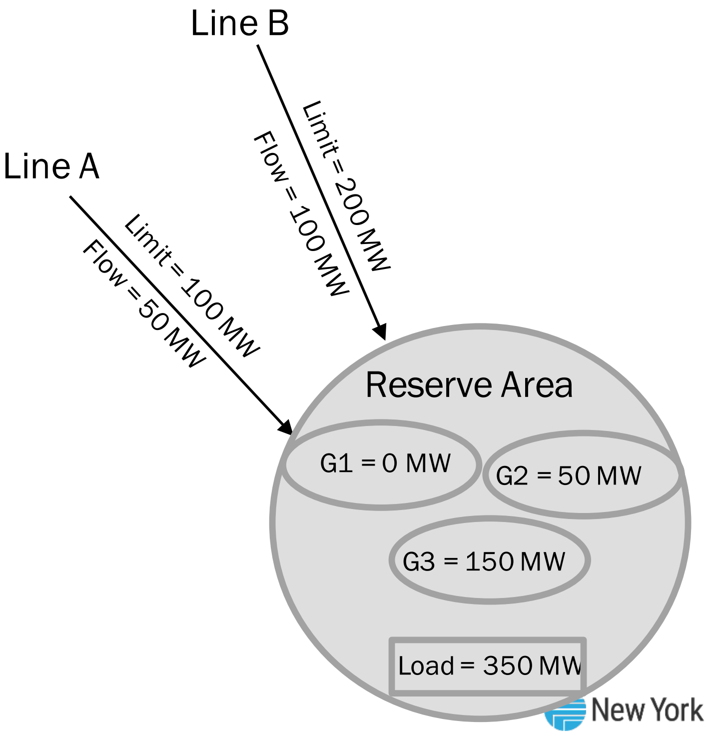
Securing Operating Reserves for the Loss of Transmission in a Reserve Area

- The reserve requirement should account for the difference between the current flow and the applicable interface transfer limit, after the loss of largest import line

Example 2: Securing Operating Reserves for Loss of Transmission in a Reserve Area

- **Assumptions for example:**
- **Three resources (G1, G2 and G3) exist within a reserve area**
  - G1: Energy schedule=0 MW; UOL= 100 MW
  - G2: Energy schedule= 50 MW; UOL= 200 MW
  - G3: Energy schedule = 150 MW; UOL=150 MW
- **Transmission line importing power into reserve area**
  - Line A: Pre-contingency transfer limit = 100 MW; Current flow = 50 MW; Post-contingency transfer limit = 150 MW
  - Line B: Transfer limit = 200 MW; Current flow = 100 MW; Post-contingency transfer limit = 300 MW



Example 2: Securing Operating Reserves for Loss of Transmission in a Reserve Area

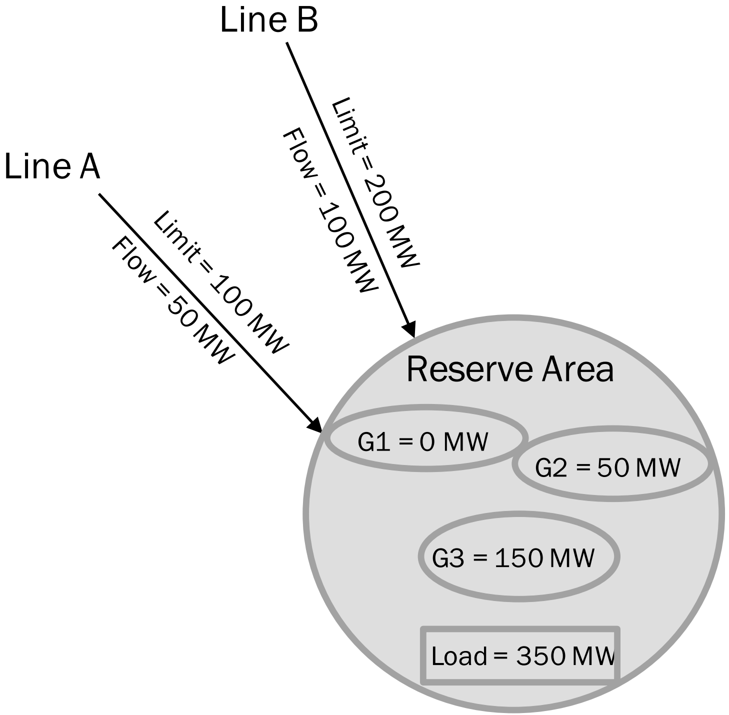
- Largest transmission contingency is Line B
- For loss of Line B, post-contingency flow on Line A = 50 MW + 100 MW = 150 MW

Reserve requirement in reserve area =

Post-contingency flow – pre-contingency transfer limit

= 150 MW -100 MW

= 50 MW



Tying the Loss of Generation and Loss of Transmission Together

Simultaneous Constraints

- Loss of Generation and Loss of Transmission equations would be modeled within the optimization for each reserve area
- The more restrictive of these constraints will drive the reserve requirement for each reserve area for every time step.
  - This seeks to ensure sufficient reserves are procured to cover for the worst case scenario
  - This allows the optimization to trade-off between reserves, energy, and transmission costs

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Example 3: Securing Operating Reserves in a Reserve Area

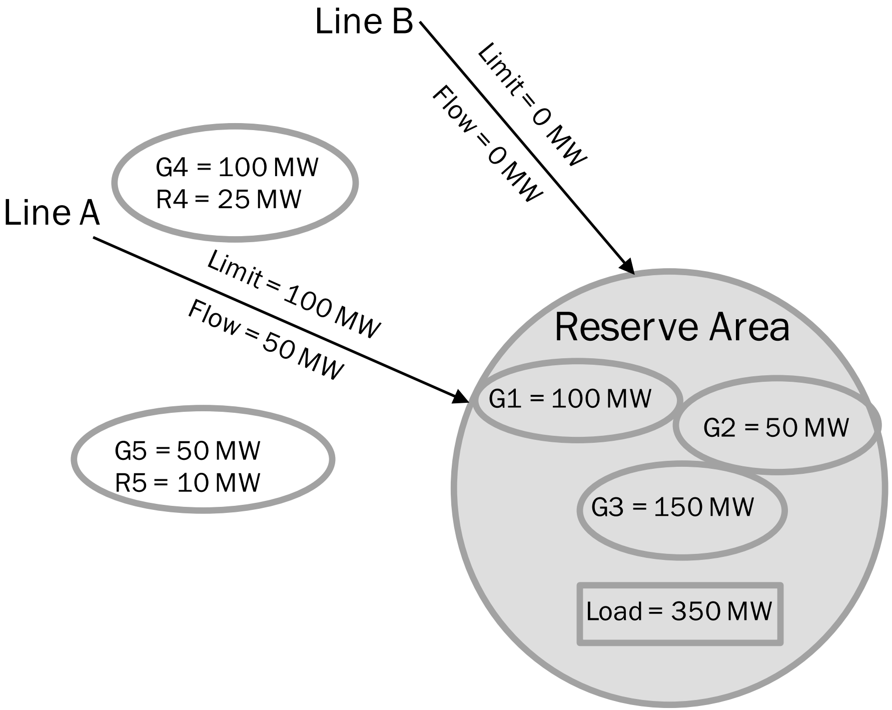
- Single largest source contingency = 150 MW
- Available transmission headroom = 100 MW – 50 MW = 50 MW
- Reserves outside the reserve area = 25 MW + 10 MW = 35 MW

- **Reserve requirement for loss of generation in reserve area=**

Largest source contingency – min (transmission headroom, reserves schedules outside the reserve area)

= 150 MW – min(50 MW, 35 MW)

= 115 MW



Note:
- Reserve schedules for all resources will be determined simultaneously.
- The reserve schedules for resources G4 and G5 (i.e., R4 and R5) are shown for illustrative purposes only
- Assume that the post-contingency transfer limit for Line B = 50 MW

Example 3: Securing Operating Reserves in a Reserve Area

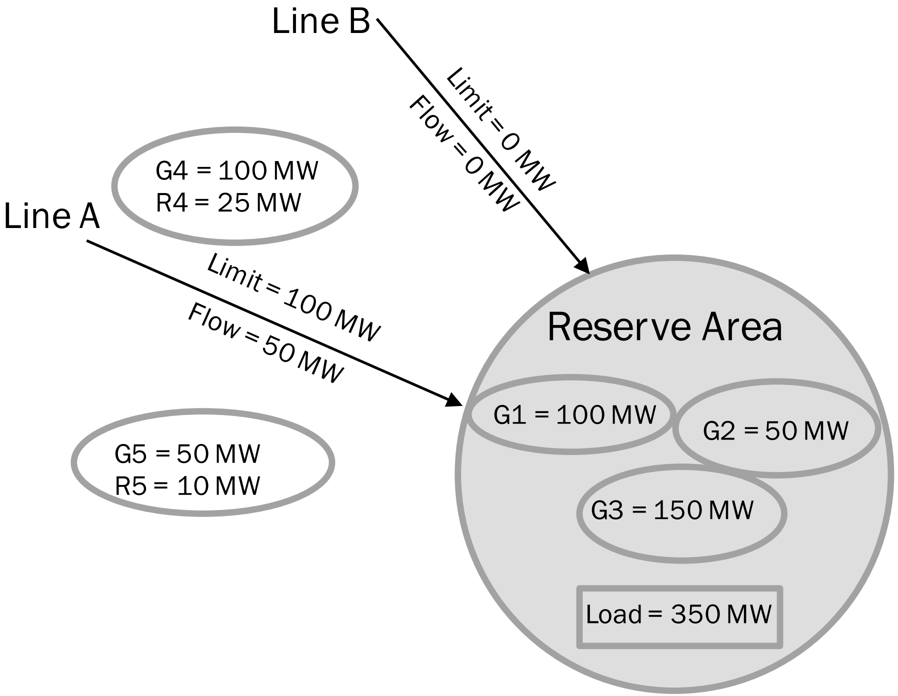
  - Largest transmission contingency is Line A
  - For loss of Line A, post-contingency flow on Line B = 50 MW

- **Reserve requirement for loss of transmission in reserve area**

Post-contingency flow – pre-contingency transfer limit

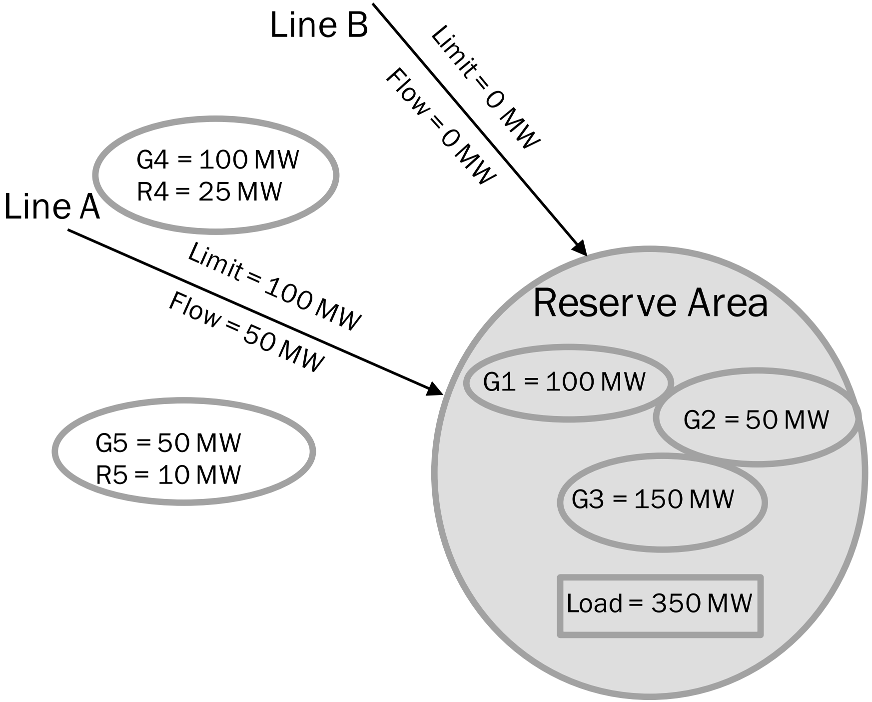
= 50 MW - 0 MW

= 50 MW



Example 3: Securing Operating Reserves in a Reserve Area

- **The more limiting of the Loss of Generation and Loss of Transmission determines the applicable reserve requirement**
  - Reserve Requirement = max(Loss of Generation, Loss of Transmission)
    - Loss of Generation requirement = 115 MW
    - Loss of Transmission requirement = 50 MW
- **In this scenario, the more limiting requirement is for the Loss of Generation**
  - max(115 MW, 50 MW)
- **Therefore, the reserve requirement is 115 MW**



Example 4: Securing Operating Reserves in a Reserve Area

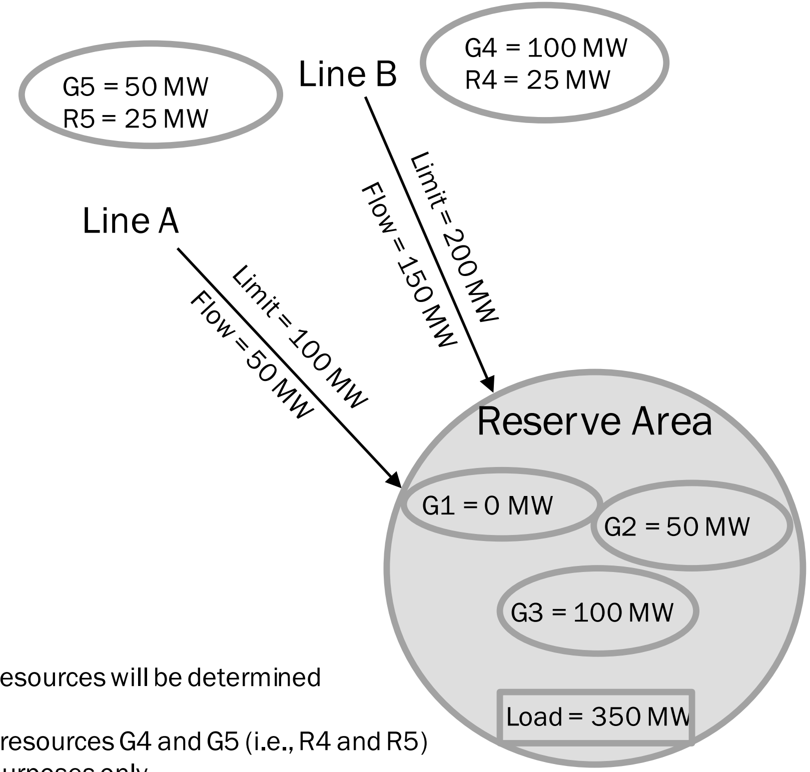
- Largest transmission contingency is Line B
- For loss of Line B, post-contingency flow on Line A = 50 MW + 150 MW = 200 MW

- **Reserve requirement for loss of transmission in reserve area =**

Post-contingency flow – pre-contingency transfer limit

= 200 MW - 100 MW

= 100 MW



Note:

- Reserve schedules for all resources will be determined simultaneously.
- The reserve schedules for resources G4 and G5 (i.e., R4 and R5) are shown for illustrative purposes only
- Assume that the post-contingency transfer limit for Line B = 50 MW

Example 4: Securing Operating Reserves in a Reserve Area

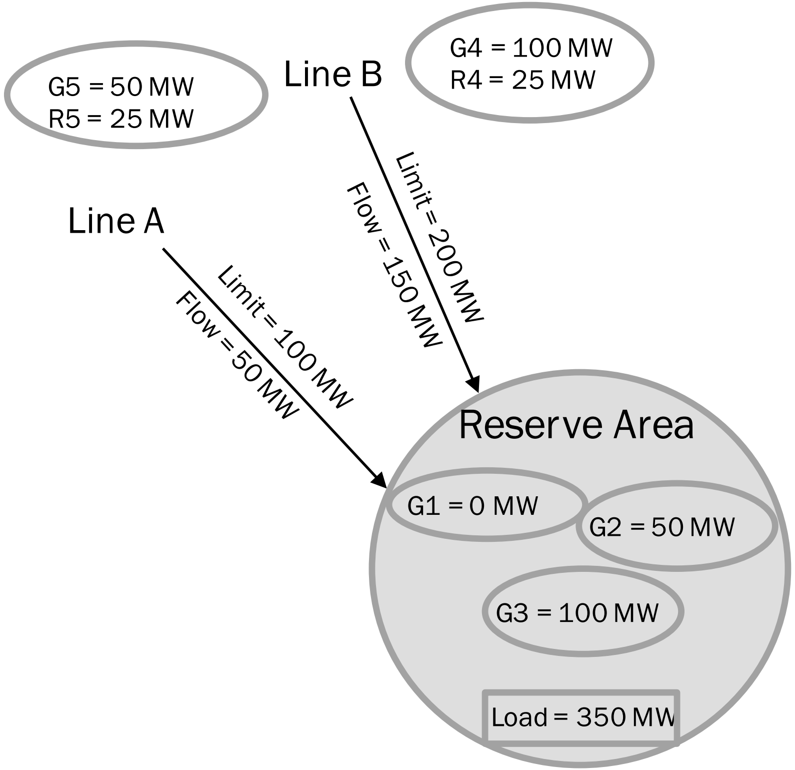
- Single largest source contingency = 100 MW
- Available transmission headroom =
  - (100 MW – 50 MW) + (200 MW - 150 MW) = 100 MW
- Reserves scheduled outside the reserve area
  - 25 MW + 25 MW = 50 MW

- **Reserve requirement for loss of generation in reserve area=**

Largest source contingency – min (available transmission headroom, reserves schedules outside the reserve area)

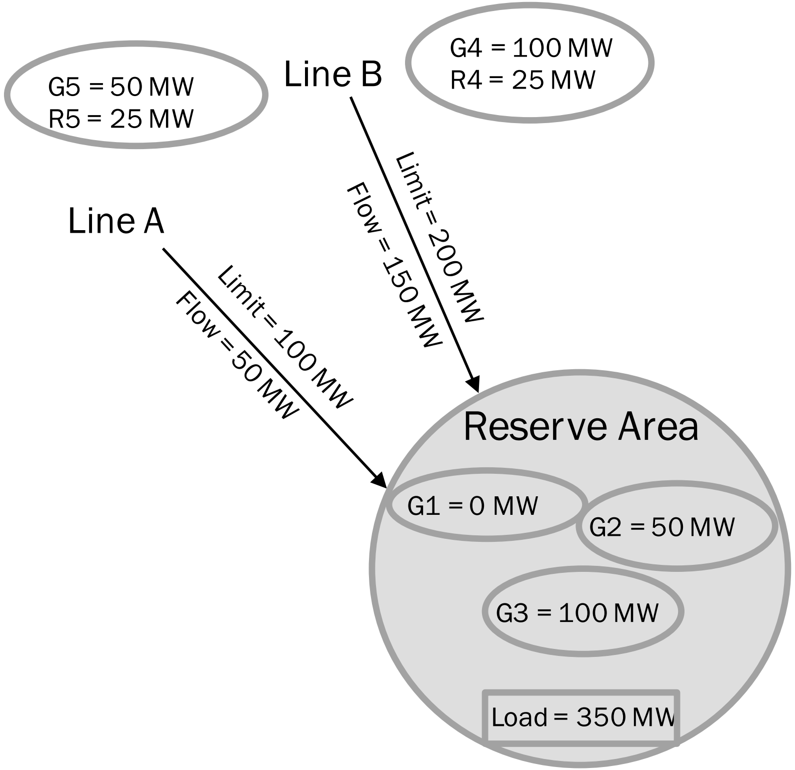
= 100 MW – min(100 MW, 50MW)

= 50 MW



Example 4: Securing Operating Reserves in a Reserve Area

- **The more limiting of the Loss of Generation and Loss of Transmission determines the applicable reserve requirement**
  - Reserve Requirement = max(Loss of Generation, Loss of Transmission)
    - Loss of Generation requirement = 50 MW
    - Loss of Transmission requirement = 100 MW
- **In this scenario, the more limiting requirement is for the Loss of Transmission**
  - max(50 MW, 100 MW)
- **Therefore, the reserve requirement is 100 MW**



Next Steps

Next Steps

- **Discuss Prototyping Phase**
  - Current Target: September 2021
- **Present Consumer Impact Methodology**
  - Current Target: September 2021
- **Present Consumer Impact Analysis**
  - Current Target: October 2021
- **Present Study Findings and Recommendations**
  - Current Target: November 2021
- **Publish Study Report**
  - Current Target: December 2021

Appendix

Equations: Securing a Reserve Area for the Loss of Generation

Calculating Actual Energy Flows in a Reserve Area

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

- 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)**
- $RA_{a_{Gen_i}}$ **is the sum of all energy schedules on resources inside reserve area *a* for time step *i***

Calculating the Available Transmission Headroom in a Reserve Area

$$RA_{aRes_{Capability_i}} = RA_{a_{Limit_i}} - RA_{a_{Flow_i}}$$

- $\mathrm{RA_{aRes_{Capability_i}}}$ **is the capability to secure reserves external to reserve area *a* for time step *i***
- $\mathrm{RA_{a_{Limit_i}}}$ **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 $\mathrm{RA_{Limit}}$ value is equal to 0 MW because external proxies are evaluated as generators

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Calculating the Import Limit of a Reserve Area

$$Import_{RA_{a_i}}^{10Spin} = \min(RA_{a\,Res_{Capability_i}}, \sum_{n \neq RA_a} \left(Gen_{10Spin_{RA_i}}\right))$$

$$Import_{RA_{a_i}}^{10Total} = \min(RA_{a_{Res_{Capability}}}{}_i, \sum_{n \neq RA_a} \left(Gen_{10Total_{RA_i}}\right))$$

$$Import_{RA_{a_i}}^{30Total} = \min(RA_{a_{Res_{Capability_i}}}, \sum_{n \neq RA_a} \left(Gen_{30Total_{RA\,i}}\right))$$

- $\mathrm{Import}_{\mathrm{RA_a}}^{\mathrm{10Spin}}$ is the amount of 10 minute spinning reserves capable of being imported into reserve area *a* for time step *i*
- $\mathrm{Import}_{\mathrm{RA_a}}^{\mathrm{10Total}}$ is the amount of 10 minute total reserves capable of being imported into reserve area *a* for time step *i*
- $\mathrm{Import}_{\mathrm{RA_a}}^{\mathrm{30Total}}$ is the amount of 10 minute total reserves capable of being imported into reserve area *a* for time step *i*

Calculating the Import Limit of a Reserve Area

- $\sum_{n \neq RA_a}\left(Gen_{10Spin_{RA_{\mathrm{i}}}}\right)$ is the sum of the 10 minute spinning reserve schedules on resources outside reserve area a for time step i
- $\sum_{n \neq RA_a}\left(Gen_{10\mathrm{Total}_{RA_{\mathrm{i}}}}\right)$ is the sum of the 10 minute total reserve schedules on resources outside reserve area a for time step i
- $\sum_{n \neq RA_a}\left(Gen_{30\mathrm{Total}_{RA_{\mathrm{i}}}}\right)$ is the sum of the 30 minute total reserve schedules on resources outside reserve area a for time step i

Securing the Reserve Area for the Loss of a Generator

$$Res_{RA_{a_i}}^{10Spin} \geq Mult_{\mathrm{RA}_a}^{10Spin} * \{ \max_{\mathrm{k}\in \mathrm{Gen}_{RA_a}} \{gen_{k_i}\} + res^{10Spin} \text{ on max } gen_{\mathrm{k_i}} \} - Import_{\mathrm{RA}_{a_\mathrm{i}}}^{10Spin}$$

$$Res_{RA_{a_i}}^{10Total} \geq Mult_{\mathrm{RA}_a}^{10Total} * \{ \max_{k\in \mathrm{Gen}_{RA_a}} \{gen_{k_i}\} + res^{10Total} \text{ on max } gen_{k_i} \} - Import_{\mathrm{RA}_{a_i}}^{10Total}$$

$$Res_{RA_{a_i}}^{30Total} \geq Mult_{\mathrm{RA}_a}^{30Total} * \{ \max_{\mathrm{k}\in \mathrm{Gen}_{RA_a}} \{gen_{\mathrm{k_i}}\} + res^{30Total} \text{ on max } gen_{k_i} \} - Import_{\mathrm{RA}_{a_\mathrm{i}}}^{30Total}$$

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

Securing the Reserve Area for the Loss of a Generator

- $\max_{\mathrm{k} \in \mathrm{Gen}_{RA_a}} \{gen_{k_i}\}$ is the resource in reserve area a for time step i with the largest energy schedule
- res^{10Spin} on max $gen_{\mathrm{k_i}}$ is the 10-minute spinning reserve schedule for the resource in reserve area a for time step i with the largest energy schedule, when applicable
- res^{10Total} on max $gen_{\mathrm{k_i}}$ is the 10-minute total reserve schedule for the resource in reserve area a for time step i with the largest energy schedule, when applicable
- res^{30Total} on max $gen_{\mathrm{k_i}}$ is the 30-minute spinning reserve schedule for the resource in reserve area a for time step i with the largest energy schedule, when applicable
- $\mathrm{Mult}_{\mathrm{RA_a}}^{\mathrm{10Spin}}$ is the 10 minute spin multiplier for reserve area a applied to the largest schedule where applicable, e. g. 0.5
- $\mathrm{Mult}_{\mathrm{RA_a}}^{\mathrm{10Total}}$ is the 10 minute total multiplier for reserve area a applied to the largest schedule where appicable, e. g. 1.0
- $\mathrm{Mult}_{\mathrm{RA_a}}^{\mathrm{30Total}}$ is the 30 minute total multiplier for reserve area a applied to the largest schedule where applicable, e.g. 2.0

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Securing a Reserve Area for the Loss of Transmission

Contingency Headroom on Interface

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

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

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

Securing the RA for Loss of Transmission

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

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

Tying the Loss of Generation and Loss of Transmission Together

Simultaneous Constraints 10-Minute Total Reserves

$$Res_{RA_{a_i}}^{10Total} \geq Mult_{TCG_a}^{10Total} * \{ \max_{\mathrm{k \in Gen_{RA_a}}} \{gen_{\mathrm{k_i}}\} + res_i^{10Total} \text{ on max } gen_{\mathrm{k_i}} \} - Import_{\mathrm{RA}_{a_\mathrm{i}}}^{10Total}$$

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

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

Our mission, in collaboration with our stakeholders, is to serve the public interest and provide benefit to consumers by:

- Maintaining and enhancing regional reliability
- Operating open, fair and competitive wholesale electricity markets
- Planning the power system for the future
- Providing factual information to policymakers, stakeholders and investors in the power system

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