Reserve Enhancements for Constrained Areas (Dynamic Reserves): Prototype Phase

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Agenda

- Background
- Project Overview
- Project Scope
- Study Approach
- Prototype Phase
- Next Steps
- Appendix I: Mathematical formulation
- Appendix II: Examples

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

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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 (Dynamic Reserves) 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 (Dynamic Reserves) project study has two key components:**
  1. Dynamic Reserve Modeling
     - Explore the feasibility of dynamically determining the minimum operating reserve requirements based on the single largest source contingency during market runs.
  2. 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

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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, respecting 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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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

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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
- **The detailed mathematical formulation was presented at the August 19th ICAPWG/MIWG[1]**

1. https://www.nyiso.com/documents/20142/23946370/02 RECA MIWG 08192021.pdf/75dde96a-a02d-fa5b-bc34-0e6fb8cc871a

Incremental changes to the Formulation

- **Based on stakeholder feedback received at the August 19th ICAPWG/MIWG, the following revisions were made to the formulation and incorporated in the prototype**
  - Loss of Generation equations now cover for the loss of largest schedule (i.e., energy + reserves + regulation) for the NYCA reserve area rather than only the energy schedule
    - This is to maintain compliance with NYSRC rule for state-wide contingency
  - Loss of Generation equations for other reserve areas only cover the energy schedule
  - The transmission headroom is <u>not</u> limited by the amount of reserves scheduled outside the reserve area
    - This change ensures the shortage is one reserve area is not cascaded to other reserve areas
  - The examples in Appendix II are modified to reflect these changes
- **The revised mathematical formulation improves the prototype solution**

Prototyping Phase

- The NYISO is in the process of prototyping this mathematical formulation to study the feasibility of the prototype on the day-ahead market solution
- The NYISO is currently stress testing the prototype under various scenarios and analyzing the accuracy of the results to test the effectiveness of incorporating it into the market software and its impacts on the market solution
  - These scenarios will be presented in the Consumer Impact Analysis presentation and detailed in the study report

Prototyping Phase

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Prototype Update

- In this phase, the NYISO added the equations developed in the formulation phase to the current day-ahead (SCUC) code
  - This code can potentially be extended to the real-time software
- For SCUC, the prototype successfully set dynamic reserve requirements (10-minute spin, 10-minute total and 30-minute total) based on the single largest contingency state-wide
  - Further, the prototype proved that this concept can be extended to other reserve areas
  - The NYISO has yet to test the prototype functionality on the real-time software (RTC and RTD)
- The prototype can also use the available transmission headroom on an interface when determining the reserve requirements for a particular reserve area

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Next Steps

Next Steps

- Continue work on Prototype
- Present Consumer Impact Methodology
  - Current Target: October 2021
- Present Consumer Impact Analysis
  - Current Target: November 2021
- Present Study Findings and Recommendations
  - Current Target: November 2021
- Publish Study Report
  - Current Target: December 2021

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Appendix I: Mathematical Formulation

Equations: Securing a Reserve Area for the Loss of Generation

Calculating Actual Energy Flows in a Reserve Area

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

- $\mathrm{RA_a}$ **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)**
- $\mathrm{RA_{a_{Gen_i}}}$ **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

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

- $\mathrm{RA}_{\mathrm{aRes}_{\mathrm{Capability}_{\mathrm{i}}}}$ is the capability to secure reserves external to reserve area *a* for time step *i*
- $\mathrm{RA}_{\mathrm{a}_{\mathrm{Limit}_{\mathrm{i}}}}$ 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 $\mathrm{RA}_{\mathrm{Limit}}$ value is equal to 0 MW because external proxies are evaluated as generators

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Securing the Reserve Area for the Loss of a Generator

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

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

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

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

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Securing the Reserve Area for the Loss of a Generator

- $\max\limits_{k \in Gen_{RA_a}} \{gen_{k_i}\}$ is the resource in reserve area a for time step i with the largest energy schedule (except NYCA, where it is the resource with the largest schedule i.e., energy + reserves + regulation)
- $\mathrm{Mult}_{\mathrm{RA_a}}^{10\mathrm{Spin}}$ is the 10 – minute spin multiplier for reserve area a applied to the largest schedule where applicable, e.g., 0.5
- $\mathrm{Mult}_{\mathrm{RA_a}}^{10\mathrm{Total}}$ is the 10 – minute total multiplier for reserve area a applied to the largest schedule where appicable, e.g., 1.0
- $\mathrm{Mult}_{\mathrm{RA_a}}^{30\mathrm{Total}}$ 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

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

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

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

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

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

Tying the Loss of Generation and Loss of Transmission Together

Simultaneous Constraints 10-Minute Total Reserves

$$Res_{RA_{a_i}}^{10Total} \geq Mult_{TCG_a}^{10Total} * \{\max_{k \in Gen_{RA_a}} \{gen_{k_i}\}\} - RA_{aRes_{Capability_i}}$$

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

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

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Appendix II: Examples

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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

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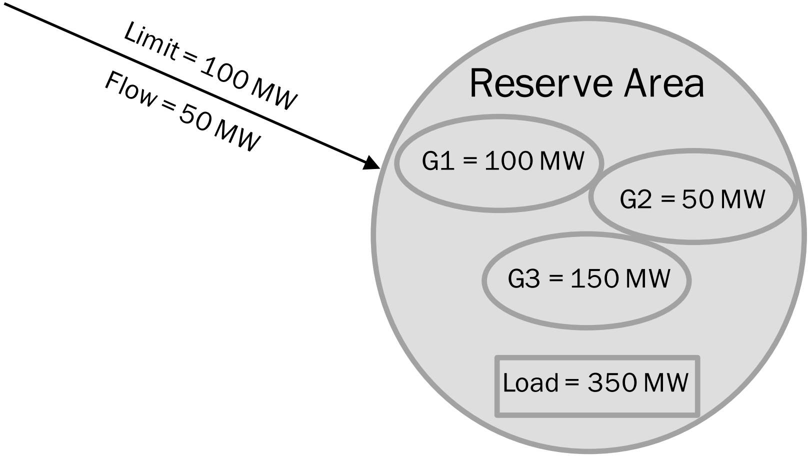
Example 1: Securing Operating Reserves for Loss of Generation in a Reserve Area

- 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
- Transmission line importing power into reserve area
  - Pre-contingency transfer limit = 100 MW; Current flow = 50 MW
- The multiplier for the 30-minute total reserve requirements is 2



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
- **10-minute total reserve requirement in reserve area:**

  = Largest source contingency – transmission headroom

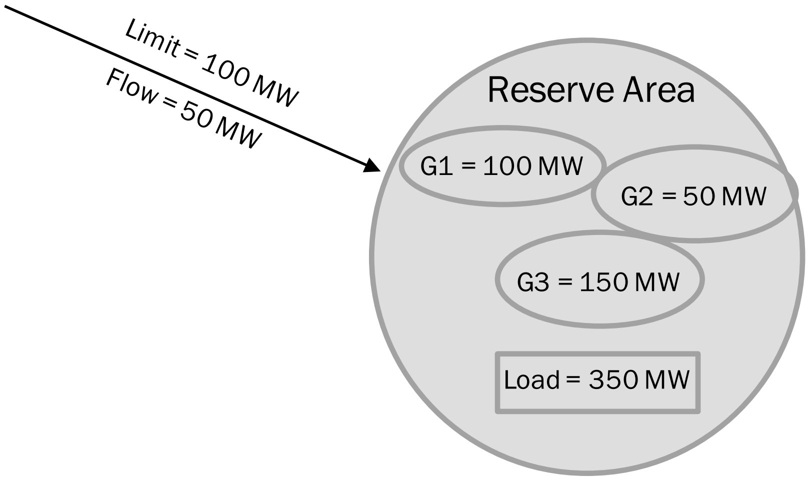
  = 150 MW – 50 MW

  = 100 MW
- **30-minute total reserve requirement in reserve area:**

  = (Multiplier * Largest source contingency) – transmission headroom

  = 2*150 MW – 50 MW

  = 250 MW



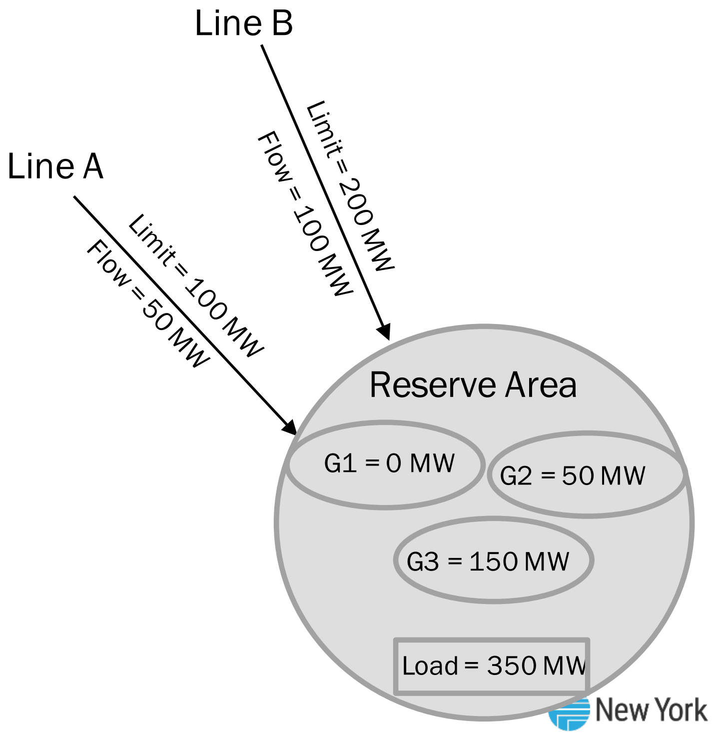
Securing a Reserve Area for the Loss of Transmission

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
- 10-minute total reserve requirement in reserve area:

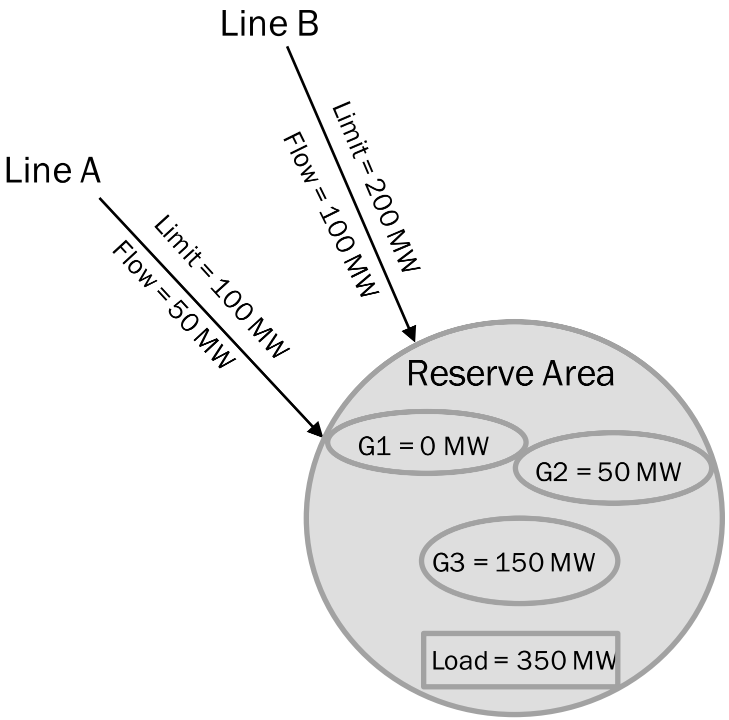
  = Post-contingency flow(A) - Post-contingency transfer limit(A)

  = 150 MW - 150 MW = 0 MW
- 30-minute total reserve requirement in reserve area:

  = Post-contingency flow(A) - Pre-contingency transfer limit (A)

  = 150 MW - 100 MW

  = 50 MW



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Tying the Loss of Generation and Loss of Transmission Together

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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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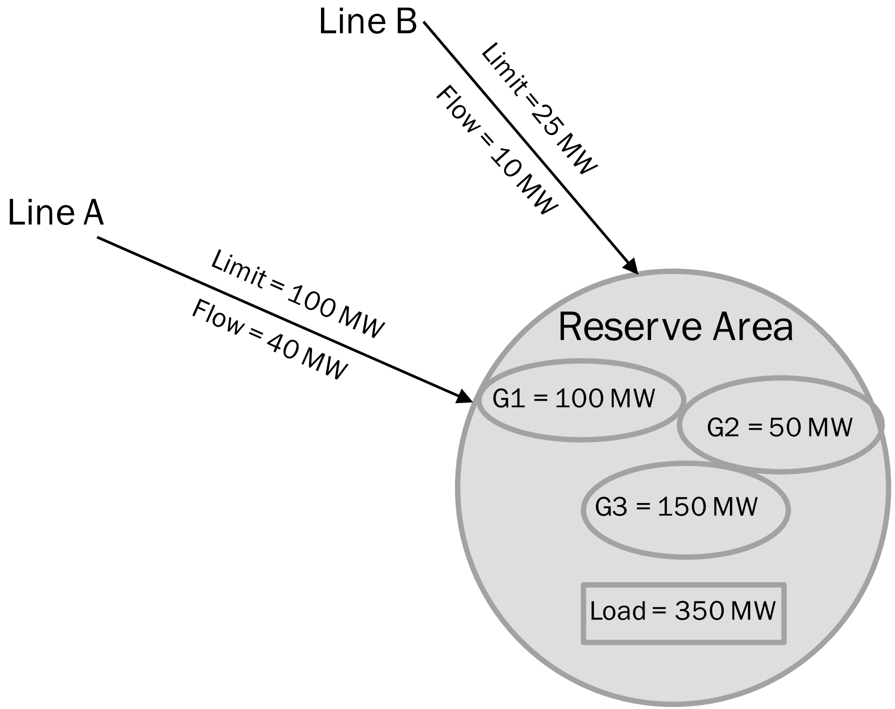
Example 3: Securing Operating Reserves in a Reserve Area

- Single largest source contingency = 150 MW
- Available transmission headroom

  = (100 MW – 40 MW) + (25 MW – 10 MW) = 75 MW

- 10-minute total reserve requirement for loss of generation in reserve area:
  - = Largest source contingency – transmission headroom
  - = 150 MW – 75 MW
  - = 75 MW

- 30-minute total reserve requirement for loss of generation in reserve area:
  - = (Multiplier *Largest source contingency) – transmission headroom
  - = 2*150 MW – 75 MW
  - = 225 MW



- Assume that the post-contingency transfer limit for Line B = 50 MW

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Example 3: Securing Operating Reserves in a Reserve Area

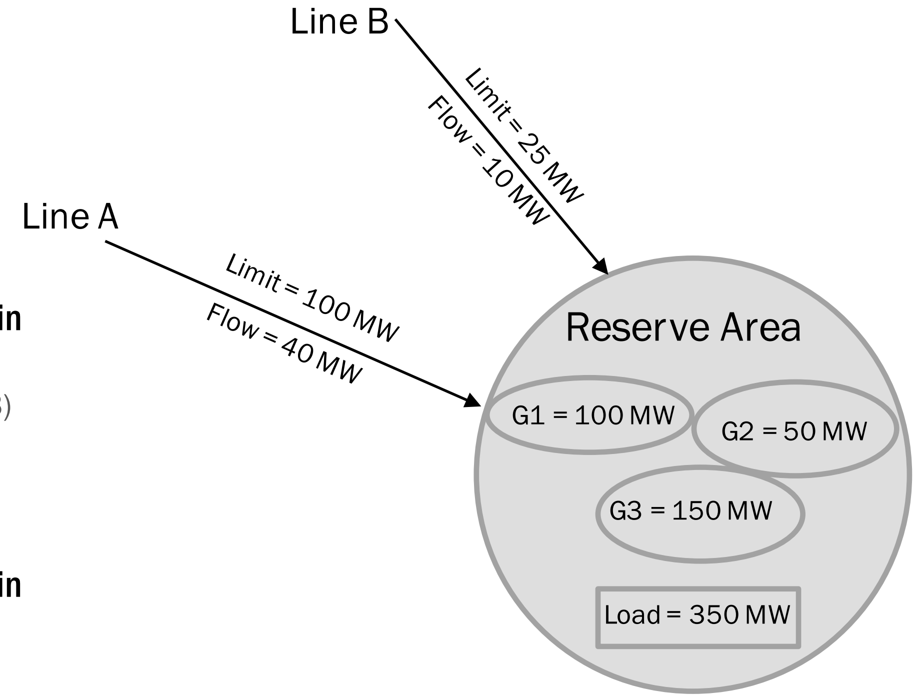
- **Largest transmission contingency is Line A**
- **For loss of Line A, post-contingency flow on Line B = 50 MW**

- **10-minute total reserve requirement for loss of transmission in reserve area:**

  = Post-contingency flow(B) – Post-contingency transfer limit(B)
  = 50 MW - 50 MW
  = 0 MW

- **30-minute total reserve requirement for loss of transmission in reserve area:**

  = Post-contingency flow (B) - Pre-contingency transfer limit(B)
  = 50 MW - 25 MW
  = 25 MW



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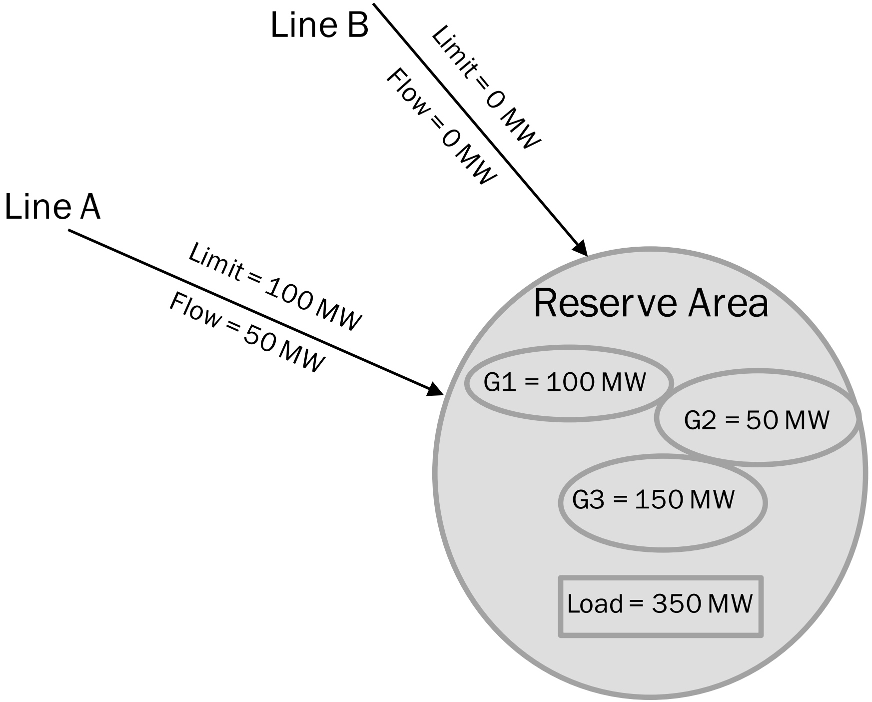
Example 3: Securing Operating Reserves in a Reserve Area

- **The more limiting of the Loss of Generation and Loss of Transmission determines the applicable reserve requirement**
  - 10-minute reserve Requirement = max(Loss of Generation, Loss of Transmission)
    - Loss of Generation requirement = 75 MW
    - Loss of Transmission requirement = 0 MW
  - 30-minute reserve Requirement = max(Loss of Generation, Loss of Transmission)
    - Loss of Generation requirement = 225 MW
    - Loss of Transmission requirement = 25 MW
- **In this scenario, the more limiting 10-minute total requirement is for the Loss of Generation**
  - max(75 MW, 0 MW)
- **In this scenario, the more limiting 30-minute total requirement is for the Loss of Generation**
  - max(225 MW, 25 MW)
- **The 10-minute total reserve requirement is 75 MW;**
- **The 30-minute total reserve requirement is 225 MW**

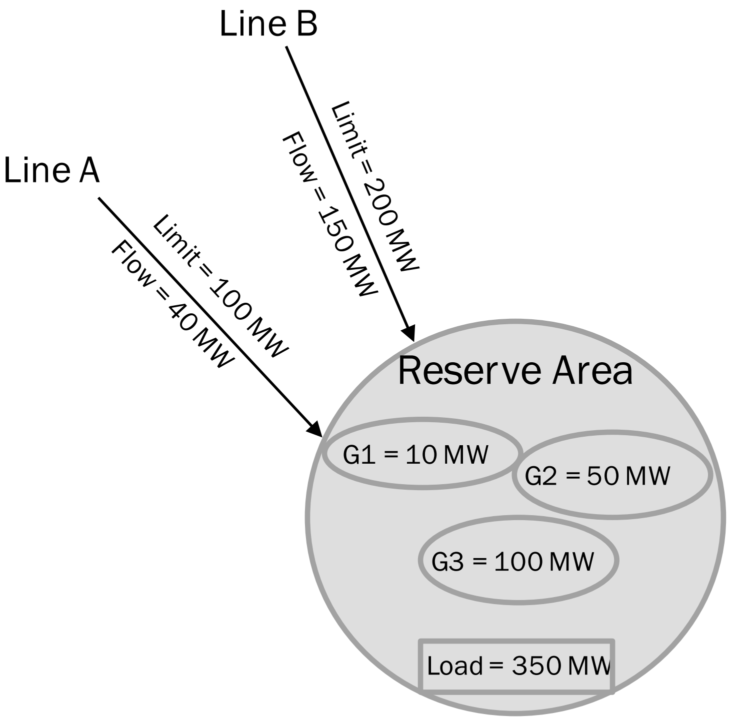


Example 4: Securing Operating Reserves in a Reserve Area

- Largest transmission contingency is Line B
- For loss of Line B, post-contingency flow on Line A
  = 40 MW + 150 MW = 190 MW

- 10-minute total reserve requirement for loss of transmission in reserve area:
  = Post-contingency flow(A) – post-contingency transfer limit(A)
  = 190 MW - 200 MW
  = -10 MW (This is limited to 0 MW because the reserve requirement cannot be negative)

- 30-minute total reserve requirement for loss of transmission in reserve area:
  = Post-contingency flow(A) – Pre-contingency transfer limit (A)
  = 190 MW - 100 MW
  = 90 MW



Note:
- Assume that the post-contingency transfer limit for Line A = 200 MW

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Example 4: Securing Operating Reserves in a Reserve Area

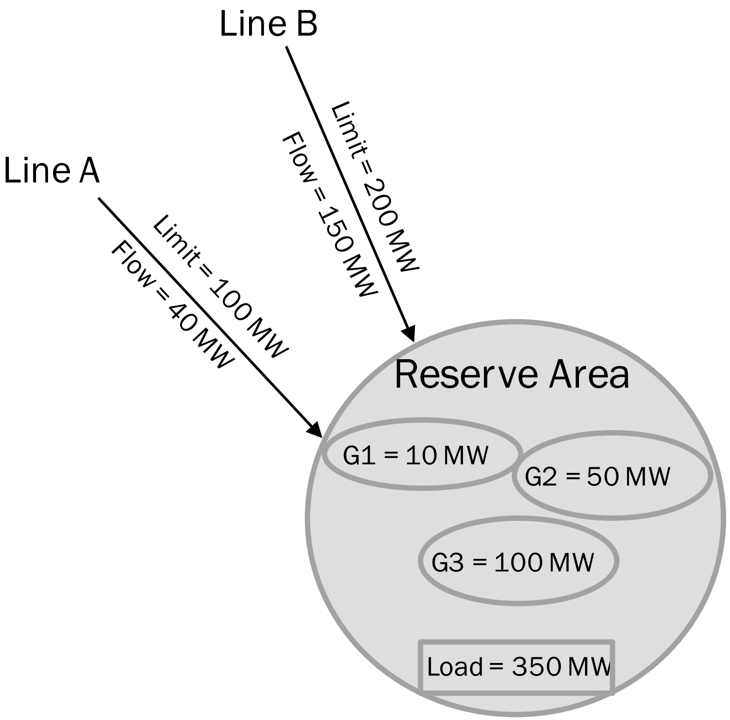
- Single largest source contingency = 100 MW
- Available transmission headroom =
  - (100 MW – 40 MW) + (200 MW - 150 MW) = 110 MW

- **10-minute total reserve requirement for loss of generation in reserve area:**

  = Largest source contingency – transmission headroom
  = 100 MW – 110 MW
  = -10 MW (This is limited to 0 MW because the reserve requirement cannot be negative)

- **30-minute total reserve requirement for loss of generation in reserve area:**

  = Multiplier *Largest source contingency – transmission headroom
  = 2*100 MW – 110 MW
  = 90 MW



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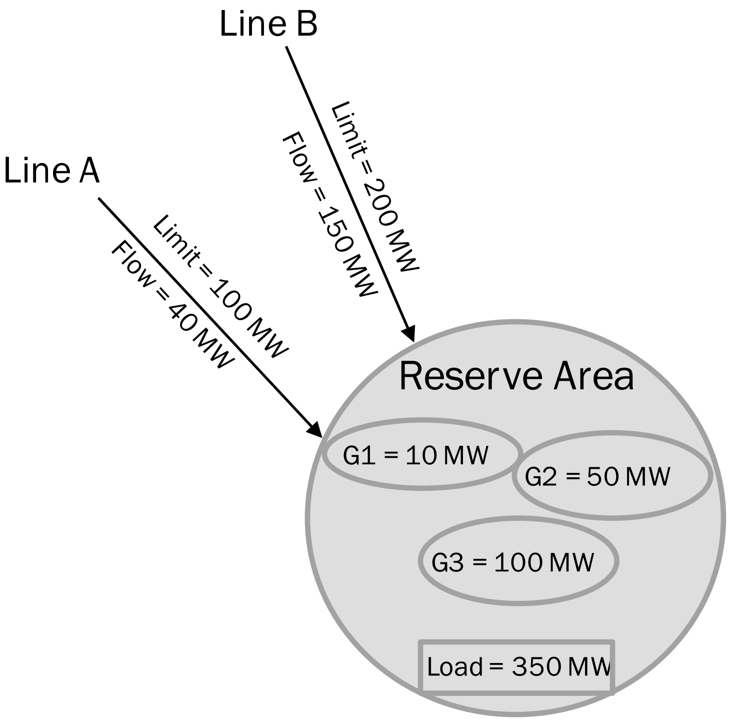
Example 4: Securing Operating Reserves in a Reserve Area

- **The more limiting of the Loss of Generation and Loss of Transmission determines the applicable reserve requirement**
  - 10-minute reserve Requirement = max(Loss of Generation, Loss of Transmission)
    - Loss of Generation requirement = 0 MW
    - Loss of Transmission requirement = 0 MW
  - 30-minute reserve Requirement = max(Loss of Generation, Loss of Transmission)
    - Loss of Generation requirement = 90 MW
    - Loss of Transmission requirement = 90 MW
- **The 10-minute total reserve requirement is 0 MW;**
- **The 30-minute total reserve requirement is 90 MW**



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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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