Dynamic Reserves

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ICAPWG/MIWG

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Agenda

- Background
- Illustrative DAM Settlements
- Scheduling and Pricing of 10-Minute and 30-Minute Reserve Constraints: Model Examples
- Tariff Review
- Next Steps

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Background

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Previous Presentations

Title/Topic	Link
March 7, 2023 MIWG	https://www.nyiso.com/documents/20142/36639552/Dynamic%20Reserves%20-%2020230307%20MIWG_final.pdf/a29ccf5d-4c26-5cbf-0103-5bece7edb276
March 31, 2023 MIWG	https://www.nyiso.com/documents/20142/36828420/MIWG%20March%2031%20Dynamic%20Reserves%20Postings%20and%20LMP.pdf/81c35384-2438-1e03-e021-6e7ecc18f9d7
September 5, 2023 MIWG	https://www.nyiso.com/documents/20142/39768278/2%2020230905%20MIWG%20-%20Dynamic%20Reserves.pdf/d58e28ab-de87-7a86-4296-a8c21f7c764f
September 14, 2023 MIWG	https://www.nyiso.com/documents/20142/40004830/20230914%20MIWG%20-%20Dynamic%20Reserves.pdf/a1c6d806-5b67-a8fc-9d04-a1669a926f54
September 18, 2023 MIWG	https://www.nyiso.com/documents/20142/40044890/5%2020230918%20MIWG%20-%20Dynamic%20Reserves.pdf/0b1b7e63-737d-5bee-4abc-be65c234aa3b
September 26, 2023 MIWG	https://www.nyiso.com/documents/20142/40204141/4%2020230926%20MIWG%20-%20Dynamic%20Reserves.pdf/90e8c0b2-aeaf-0935-5c4e-bd260c948f3c
October 3, 2023 MIWG	https://www.nyiso.com/documents/20142/40342797/20231003%20MIWG%20-%20Dynamic%20Reserves.pdf/51657652-ac7e-c9e2-ed5f-85b52e7e49f7
October 12, 2023 MIWG	https://www.nyiso.com/documents/20142/40559142/Dynamic%20Reserves.pdf/a17ba0a7-8e59-53b9-e028-4942f595c2f1
October 19, 2023 MIWG	https://www.nyiso.com/documents/20142/40696384/20231019%20MIWG%20-%20Dynamic%20Reserves.pdf/ef4371c2-5bff-7adb-5871-1d77d6fa98eb

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Example: Illustrative DAM Settlements

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Illustrative DAM Settlements

- **The NYISO developed a set of simplified scheduling examples to demonstrate the flow of energy and reserve costs under Dynamic Reserves**
  - Prices and schedules are optimal based on economic dispatch
  - The intent of this exercise is to demonstrate how NYISO's price formation proposal for Dynamic Reserves and existing settlement mechanisms would effectively charge LSEs for energy, congestion, and reserves; and how those payments would be allocated to generators and transmission owners
  - NYISO prepared two examples: a base case example with a static reserve requirement and a dynamic reserves example with a 10-Minute locational reserve requirement (no NYCA reserves and no 30-Minute reserves)
  - The example shows that existing settlement mechanisms will continue to function appropriately under dynamic reserves
    - Note, this example does not model the forecast energy constraint. The forecast energy constraint will require settlement changes, which NYISO will discuss with stakeholders.
    - TCC residuals, as may occur due to changes in transmission flows under Dynamic Reserves, will be discussed at a subsequent MIWG

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Assumptions: Example 1 Base Case

- The base case example demonstrates a static reserve requirement, as would be seen today
- The transmission constraints are base case energy scheduling constraints for NYC: energy flows can't exceed Normal limits or N-1 MTE limits. The example assumes four transmission elements with the following Normal/LTE/MTE ratings:
  - Line A: 798/998/1048
  - Line B: 799/999/1049
  - Line C: 800/1000/1050
  - Line D: 801/1001/1051
- The example utilizes the following shift factors:
  - Load = pre-contingency: 0.25, post-contingency: 0.33
  - Generators = pre-contingency: -0.25, post-contingency: -0.33

	Rest-of-state (ROS)	Load Pocket (NYC)
Load (MW)	0	3500
Reserve requirement (MW)	0	150
Energy Offer ($/MW)	5	50
Reserve Offer ($/MW)	1	2

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Results: Example 1 Base Case

- **The results from the base case are:**
  - Energy Schedules:
    - ROS Generators: 3147 MW
    - Load pocket generators: 353 MW
  - Reserve Schedules:
    - ROS Generators: 0 MW
    - Load pocket generators: 150 MW
  - System Lambda = $5
  - Load pocket Operating Reserve clearing price = $2
  - Shadow price for energy scheduling transmission constraint = $135

Results: Example 1 Base Case

- **The table illustrates the charges and payments for energy, congestion, and reserves**
- **Total charges collected from LSEs: $175,300**
  - Energy Charges (17,500) + Congestion Charges (157,500) + Reserve Charges (300)
- **Total payments owed: $175,300**
  - Energy Payment (Gen) (1,765) + Congestion Payment (Gen)(15,885) + Congestion Payment (TOs) (141,615) + Reserve Payment (Gen) (300)

	Rest-of-State	Load Pocket (NYC)
LBMP	$5	=System Lambda-Congestion SP*Shift Factor =5-(-135)*.33 =$50
Energy Charges (LSEs)	N/A	=System Lambda*Load =5*3500=$17,500
Energy Payment (Gens)	=System Lambda*Energy Schedule =5*3147=$15,735	=System Lambda*Energy Schedule =5*353=$1,765
Congestion Charges (LSEs)	N/A	=Congestion SP*Shift Factor*Load =135*.33*3500=$157,500
Congestion Payments (Gens)	N/A	=Congestion SP*Shift Factor*Energy Schedule =135*.33*353=$15,885
Congestion Payments (TOs)	N/A	=Flow on Constrained Element*Reserve Congestion SP =(1049)*135=$141,615
Reserve Charges (LSEs)	N/A	=Reserve MW*Reserve Price =150*2=$300
Reserve Payments (Gens)	N/A	=Reserve Schedule*Reserve Price =150*2=$300

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Results: Example 1 Base Case (continued)

- Total charges collected from LSEs equals energy, congestion, and reserve payments owed to generators and TOs

	Energy	Congestion	Reserves
LSE Charges	$ (17,500.00)	$ (157,500.00)	$ (300.00)
Generator Payments	$ 17,500.00	$ 15,885.00	$ 300.00
TO Payments	$ -	$ 141,615.00	$ -
Net	$ -	$ -	$ -

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Assumptions: Example 2 Dynamic Reserves Case

- **Example 2 introduces a dynamic reserve requirement to solve for N-1 post-contingency transmission flows into the load pocket**
  - There are no 30M reserve constraints or Forecast Load in this example
  - There is no static requirement
- **Example 2 utilizes the same assumptions as Example 1 for:**
  - Load
  - Energy and reserve offers
  - Energy scheduling constraints
  - Pre/post-contingency shift factors

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Results: Example 2 Dynamic Reserves

- **The results from the dynamic reserves case are:**
  - Energy Schedules:
    - ROS Generators: 3147 MW
    - Load pocket generators: 353 MW
  - Reserve Schedules:
    - ROS Generators: 0 MW
    - Load pocket generators: 150 MW
  - System Lambda = $5
  - Load pocket generator Operating Reserve price = $2
  - Total shadow price for energy scheduling transmission constraint = $135
    - Shadow price for binding N-1 dynamic reserve constraint = $6, plus
    - Shadow price for energy scheduling transmission constraint = $129

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Results: Example 2 Dynamic Reserves

- **The table illustrates the charges and payments for energy, congestion, and reserves**
- **Total charges collected from LSEs: $175,300**
  - Energy Charges (17,500) + Congestion Charges (157,500) + Reserve Charges (300)
- **Total payments owed: $175,300**
  - Energy Payment (Gen) (1,765) + Congestion Payment (Gen) (15,885) + Congestion Payment (TOs) (141,615) + Reserve Payment (Gen) (300)

	Rest-of-State	Load Pocket (NYC)
LBMP ($/MW)	$5	=System Lambda-[(Transmission Congestion SP*SF)+(Reserve Congestion SP*SF)] =5-[(-129*0.33)+(-6*0.33)] =$50
Energy Charges (LSEs)	N/A	=System Lambda*Load =5*3500=$17,500
Energy Payment (Gens)	=System Lambda*Energy Schedule =5*3147=$15,735	=System Lambda*Energy Schedule =5*353=$1,765
Congestion Charges (LSEs)	N/A	=[(Transmission Congestion SP*SF)+(Reserve Congestion SP*SF)]*Load =[(129*0.33)+(6*0.33)]*3500=$157,500
Congestion Payments (Gens)	N/A	=[(Transmission Congestion SP*SF)+(Reserve Congestion SP*SF)]*Energy Schedule =[(129*0.33)+(6*0.33)]*353=$15,885
Congestion Payments (TOs)	N/A	=Flow on Constrained Element*Reserve Congestion SP =(1049)*135=$141,615
Reserve Charges (LSEs)	N/A	=Reserve MW*[(Reserve Congestion SP*SF)] =150*(6*0.33)=$300
Reserve Payments (Gens)	N/A	=Reserve Schedule*[(Reserve Congestion SP*SF)] =150*(6*0.33)=$300

Results: Example 2 Dynamic Reserves (continued)

- Total charges collected from LSEs equals energy, congestion, and reserve payments owed to generators and TOs

	Energy	Congestion	Reserves
LSE Charges	$ (17,500.00)	$ (157,500.00)	$ (300.00)
Generator Payments	$ 17,500.00	$ 15,885.00	$ 300.00
TO Payments	$ -	$ 141,615.00	$ -
Net	$ -	$ -	$ -

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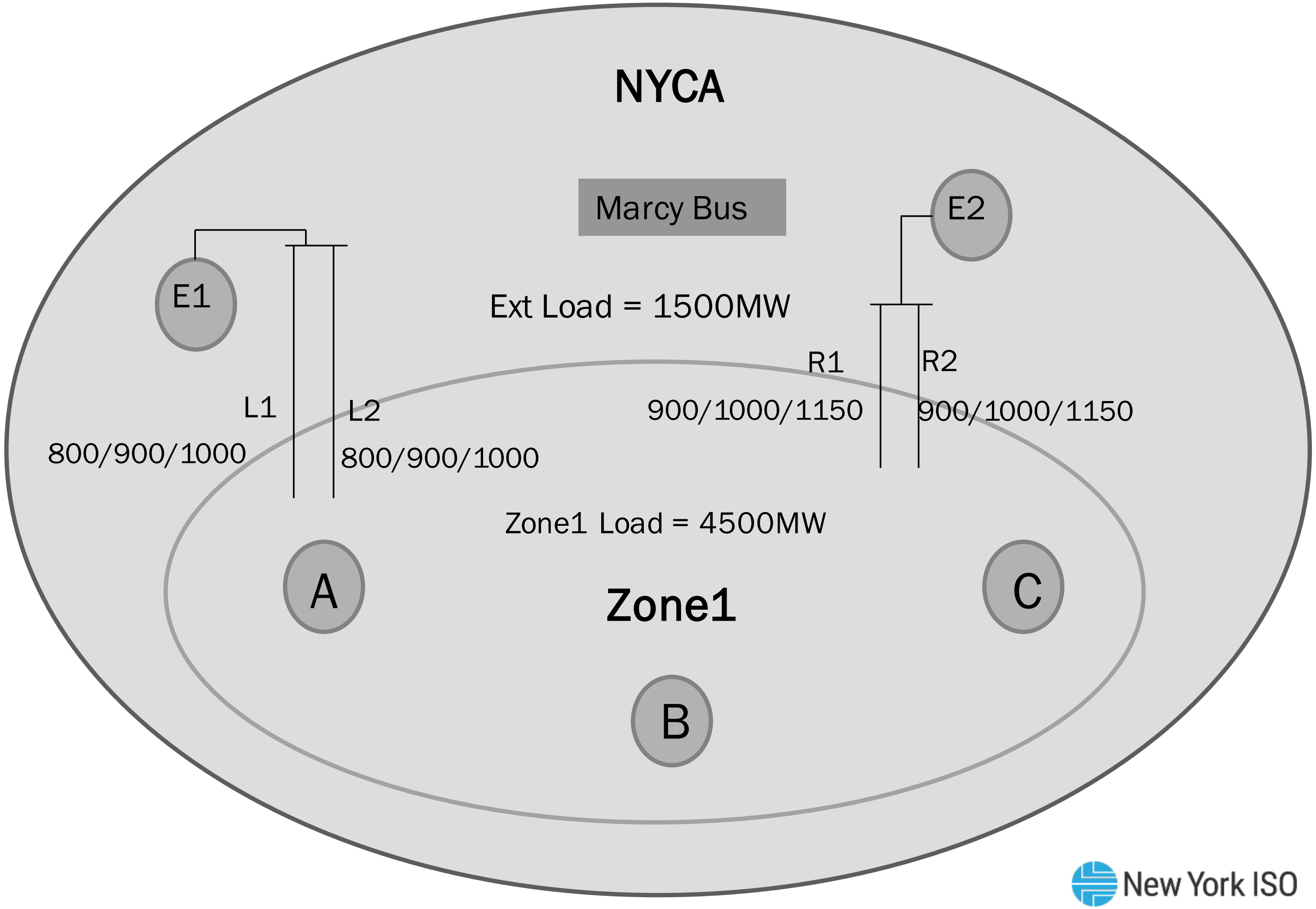
Scheduling and Pricing of 10-Minute and 30-Minute Reserve Constraints: Model Examples

Model Setup: System Topology

- The model solves for a system load of 6000 MW with a downstream load of 4000 MW
- The model consists of:
  - 4 transmission lines (2 transmission interfaces with 2 lines each)
  - 3 generators downstream of the transmission interfaces, 2 generators upstream
- Examples assume
  - Static NYCA 10T requirement = 1000 MW
  - Static NYCA 30T requirement = 2000 MW

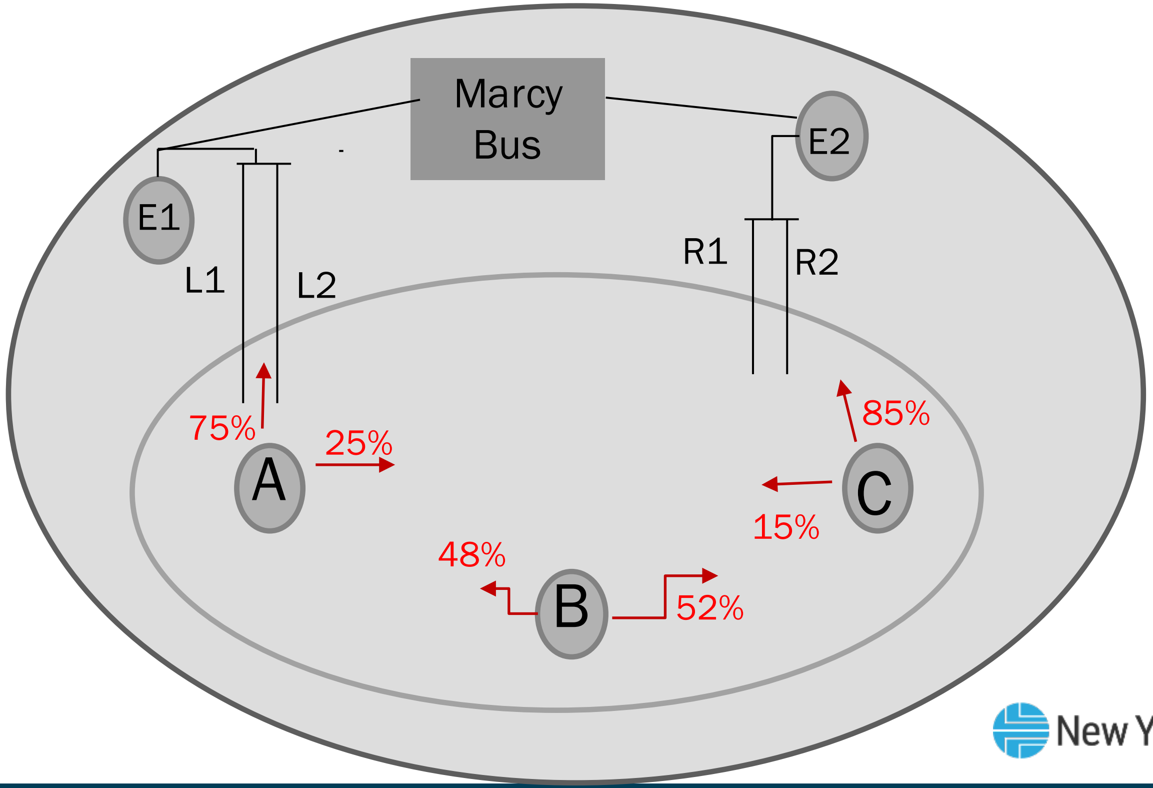


Model Setup: Pre-Contingency Generator Shift Factors

- **The model utilizes the following pre-contingency generator shift factor assumptions:**
  - Downstream generators have high negative shift factors on the transmission lines (i.e., one 1 MW of energy from an internal generator provides a higher amount of relief compared to an external generator)
  - Upstream generators have low negative shift factors or positive shift factors on interface lines
  - Pre-contingency generator shift factors are used to evaluate whether energy schedules violate limits in the base case, and whether energy plus reserve schedules violate limits in the Loss of Generation contingency cases
  - The percent of output from each generator that would flow across each line is shown in red

Pre-contingency Generator Shift Factors

	L1	L2	R1	R2	Sum
A	-0.375	-0.375	-0.125	-0.125	-1
B	-0.24	-0.24	-0.26	-0.26	-1
C	-0.075	-0.075	-0.425	-0.425	-1
E1	0.025	0.025	-0.025	-0.025	0
E2	-0.025	-0.025	0.025	0.025	0



Model Setup: Post-Contingency Generator Shift Factors

- **The model utilizes the following generator shift factor assumptions:**
  - Post-contingency generator shift factors are used for post-contingency flow analysis and Loss of Transmission reserve constraints
    - The table can be read as follows: Generator A has a shift factor of -0.65 on L2 following the Loss of L1 . For example, if L1 was lost, 1 MW of energy on Generator A would provide .65 MW of relief (reduce flows by .65 MW) on L2
  - The table on this slide shows the post-contingency shift factors for Generator A. The post N-1 line contingency shift factors and post N-2 line contingences shift factors are in the Appendix A

Generator A Post-Contingency Shift Factors

Loss of L1				
L1	L2	R1	R2	Sum
N/A	-0.65	-0.175	-0.175	-1
Loss of L2				
L1	L2	R1	R2	Sum
-0.65	N/A	-0.175	-0.175	-1
Loss of R1				
L1	L2	R1	R2	Sum
-0.4	-0.4	N/A	-0.2	-1
Loss of R2				
L1	L2	R1	R2	Sum
-0.4	-0.4	-0.2	N/A	-1

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Model Setup: Load Shift Factors

- **Load shift factors are also an input into the Dynamic Reserves solution. The load shift factors represent the impact a MW of load has on the reserve constraint. The model utilizes the following load shift factor assumptions:**
  - Upstream load: This load is modeled to be located at the Marcy Bus and therefore have a shift factor of 0 on the interface lines.
  - Downstream load: An equal distribution across each line, with a pre-contingency load shift factor .25 for each line, a post N-1 line contingency load shift factor 0.33 for each line, and a post N-2 line contingency shift factor 0.5 for each line.

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Modelled Constraints

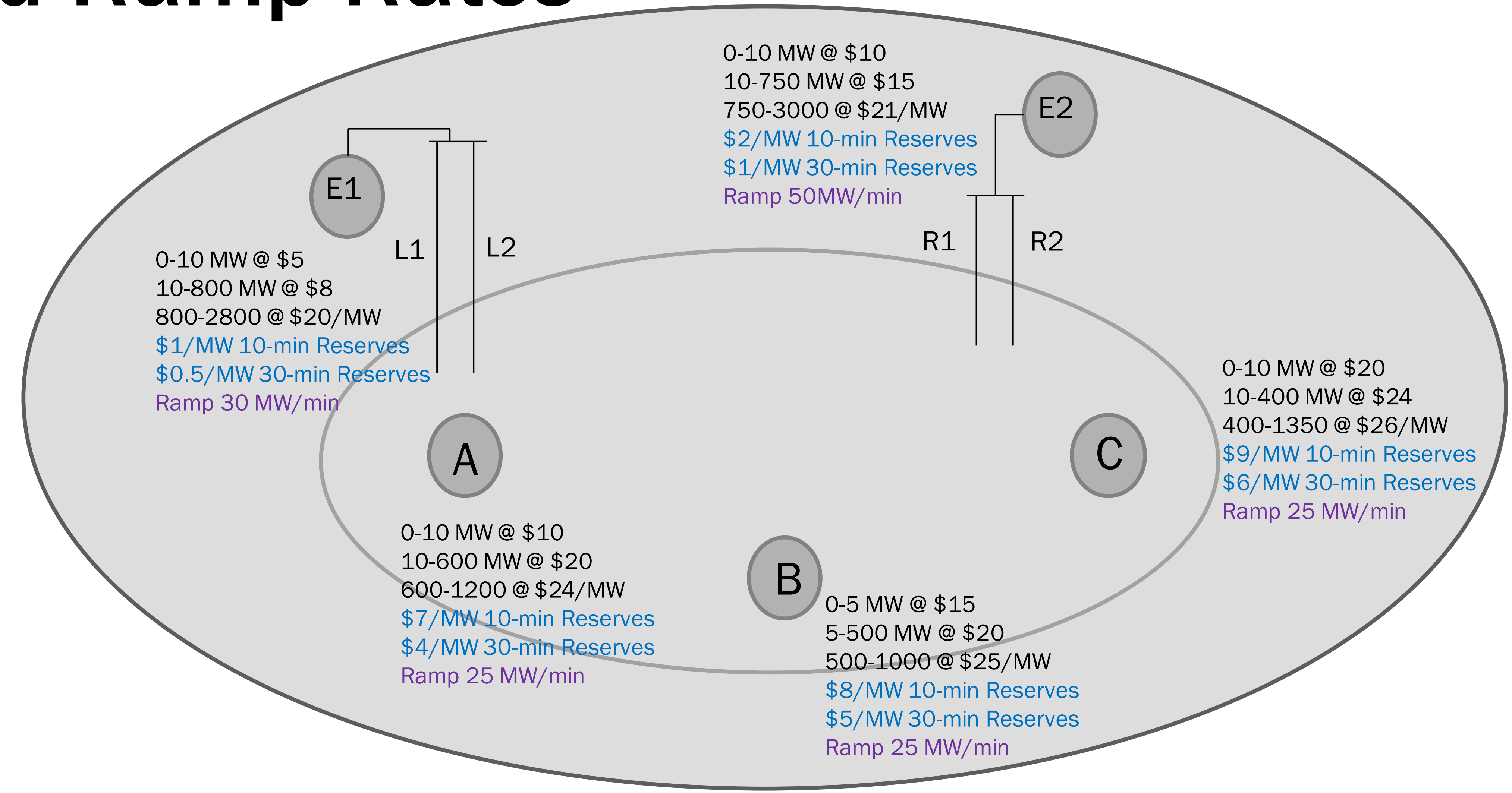
- **Modelled Reserve Constraints:**
  - For 10-Minute Reserves
    - Post N-1 line contingency, the flow on a line should not exceed the line's LTE rating. Both Energy and 10-Minute Reserves can solve this constraint
    - Post N-1 generator contingency, the flow on a line should not exceed the line's LTE rating. Both Energy and 10-Minute Reserves can solve this constraint
  - For 30-Minute Reserves
    - Post N-2 line contingencies, the flow on a line should not exceed the line's LTE rating. Energy, 10-Minute and 30-Minute Reserves can solve this constraint

Development of Examples

- **The examples presented today are intended to demonstrate pricing and scheduling outcomes with Dynamic Reserves**
- **These examples build upon previous examples and incorporate the following:**
  - 30-minute locational reserve constraints
  - Static 10-Minute and 30-Minute requirements for NYCA
  - Operating Reserve demand curves (ORDCs) or slack variables for solving locational reserve constraints
    - One step ORDC at $40/MW is used for these examples

Example 1

Example 1 Inputs: Generator Offers and Ramp Rates



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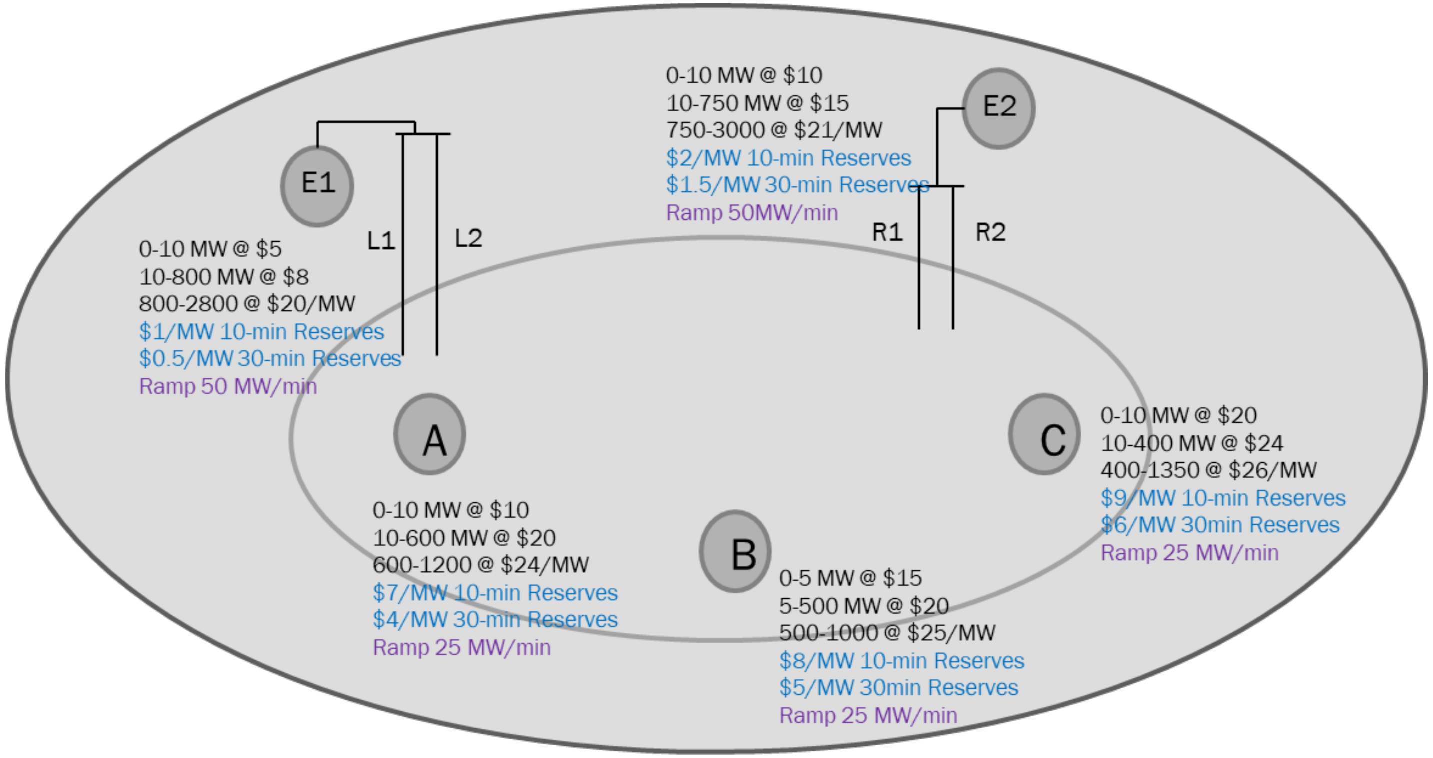
Example 1 Outputs: Energy Schedules

Case Outputs	
Production Cost ($)	
$117,025	
Energy Schedules (MW)	
Gen A	772.5
Gen B	567.7
Gen C	400
Gen E1	2010.8
Gen E2	2250



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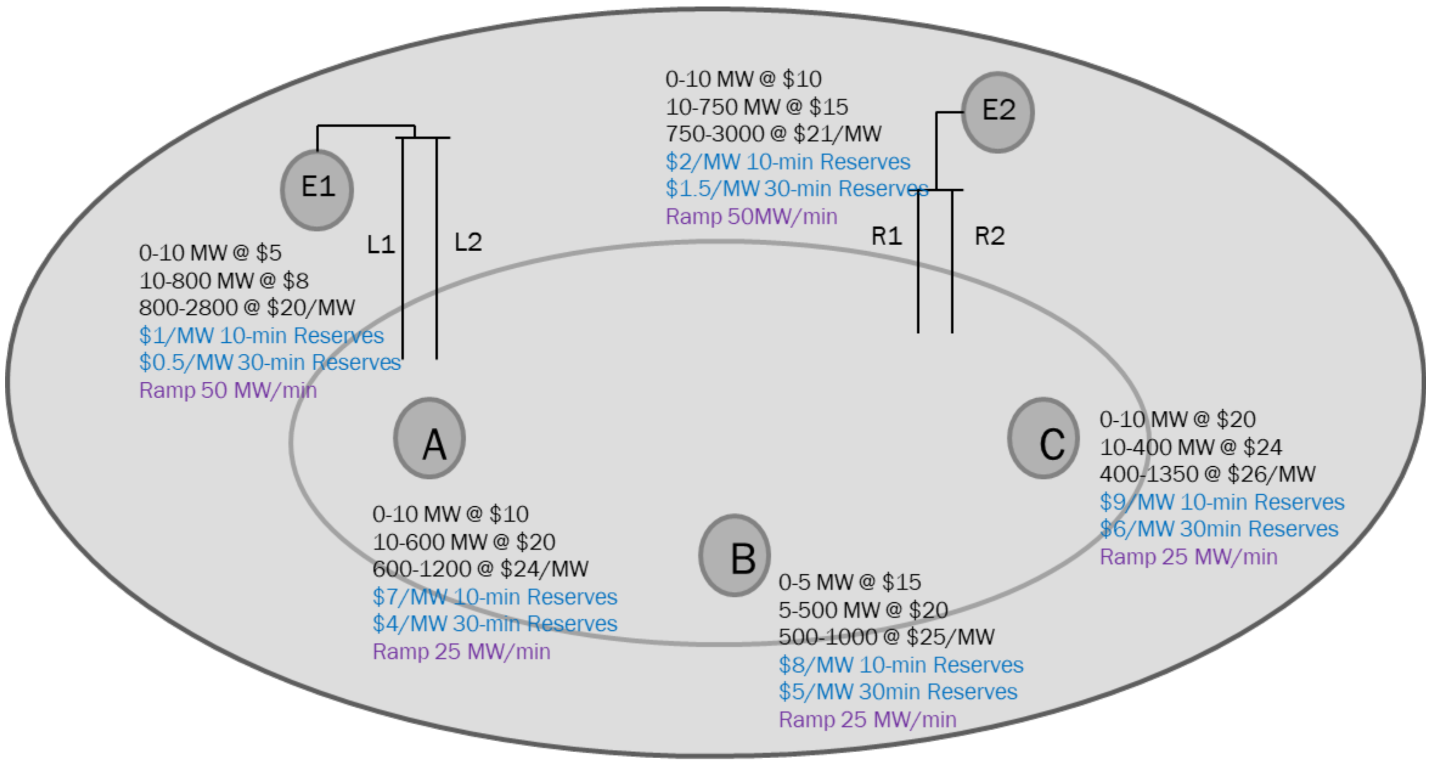
Example 1 Outputs: Reserve Schedules

10-min Reserve Schedules (MW)	
Gen A	0
Gen B	200
Gen C	0
Gen E1	300
Gen E2	500
30-min Reserve Schedules (MW)	
Gen A	427.5
Gen B	233.2
Gen C	100
Gen E1	239.3
Gen E2	0



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Example 1 Outputs: Line Flows

	L1	L2	R1	R2
Line Ratings (Normal/LTE/MTE)	800/900/1000	800/900/1000	900/1000/1150	900/1000/1150
Base Flow	663.3	663.3	717	717
N-1 Transmission Contingency Flow	965 Loss of R1 or R2	965 Loss of R1 or R2	1021 Loss of L1 or L2	1021 Loss of L1 or L2
N-1 Generation Contingency Flow	953 Loss of Gen A	953 Loss of Gen A	887 Loss of Gen C	887 Loss of Gen C
N-2 Transmission Contingency Flow	1402 Loss of L2R1 or L2R2	1402 Loss of L1R1 or L1R2	1380 Loss of L1L2	1380 Loss of L1L2

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Example 1 Outputs: LBMP Calculations

- **In this case, the following locational reserve constraints are binding**
  - N-1 constraints:
    - L2 LTE flow limit for loss of R1. Shadow price is $1.15/MW
    - L1 LTE flow limit for loss of Gen A. Shadow price is $0.48/MW
  - N-2 constraints:
    - L2 LTE flow limit for loss of L1 and R1. Shadow price is $9.19/MW
    - L1 LTE flow limit for loss of R1 and R2. Shadow price is $8.24/MW
- **Detailed calculations demonstrating the price formation are included in the Appendix**

LBMPs	
System Lambda ($/MW)	20.50
Gen LBMPs ($/MW)	
Gen A	31.51
Gen B	29.22
Gen C	25.72
Gen E1	20.00
Gen E2	21.00
Zonal Load LBMPs ($/MW)	
Upstream Load	20.50
Zone1 Load	29.72

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Example 1 Outputs: LMORP Calculations

- **NYCA Reserves shadow prices:**
  - NYCA 10-min reserve shadow price is $2.54/MW
  - NYCA 30-min reserve shadow price is $0.96/MW
- **The LMORP at a generator bus depends on the shadow price of modelled reserve constraints and the generator shift factors to those constraints**
  - LMORP include NYCA reserve shadow prices
- **Detailed calculations demonstrating the price formation are included in the Appendix**

	Gen 10-min LMORP ($/MW)	Gen 30-min LMORP ($/MW)
Gen A	14.51	11.51
Gen B	12.22	9.22
Gen C	8.72	6.00
Gen E1	3.00	0.50
Gen E2	4.00	1.42

Example 2

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Example 2 Setup

- **Example 2 demonstrates the utilization of the ORDC to solve the locational reserve constraints**
  - One step ORDC at $40/MW is used for these examples
- **To demonstrate this, the UOL of Gen C was reduced to 400MW**
  - No changes to other input parameters

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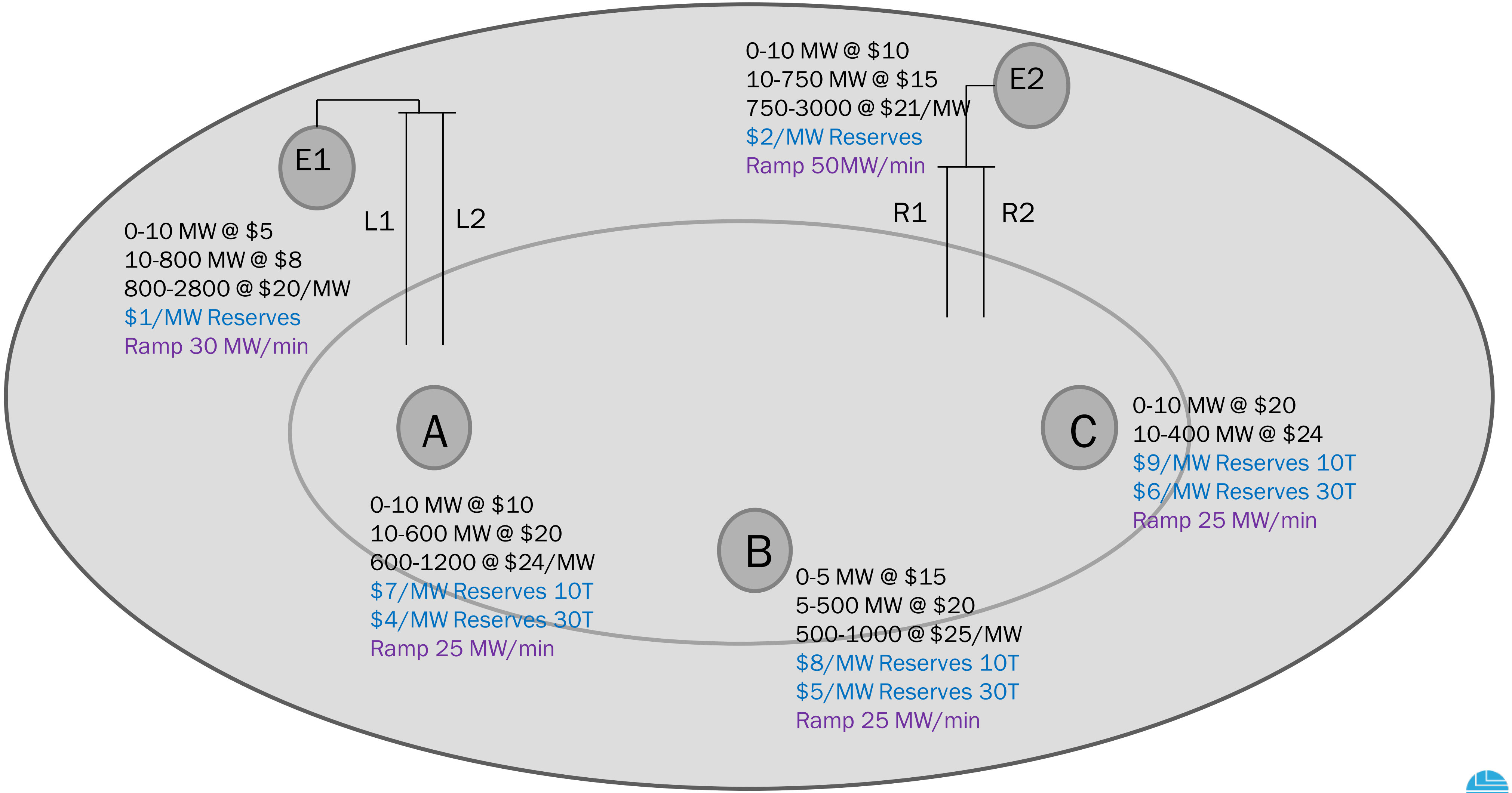
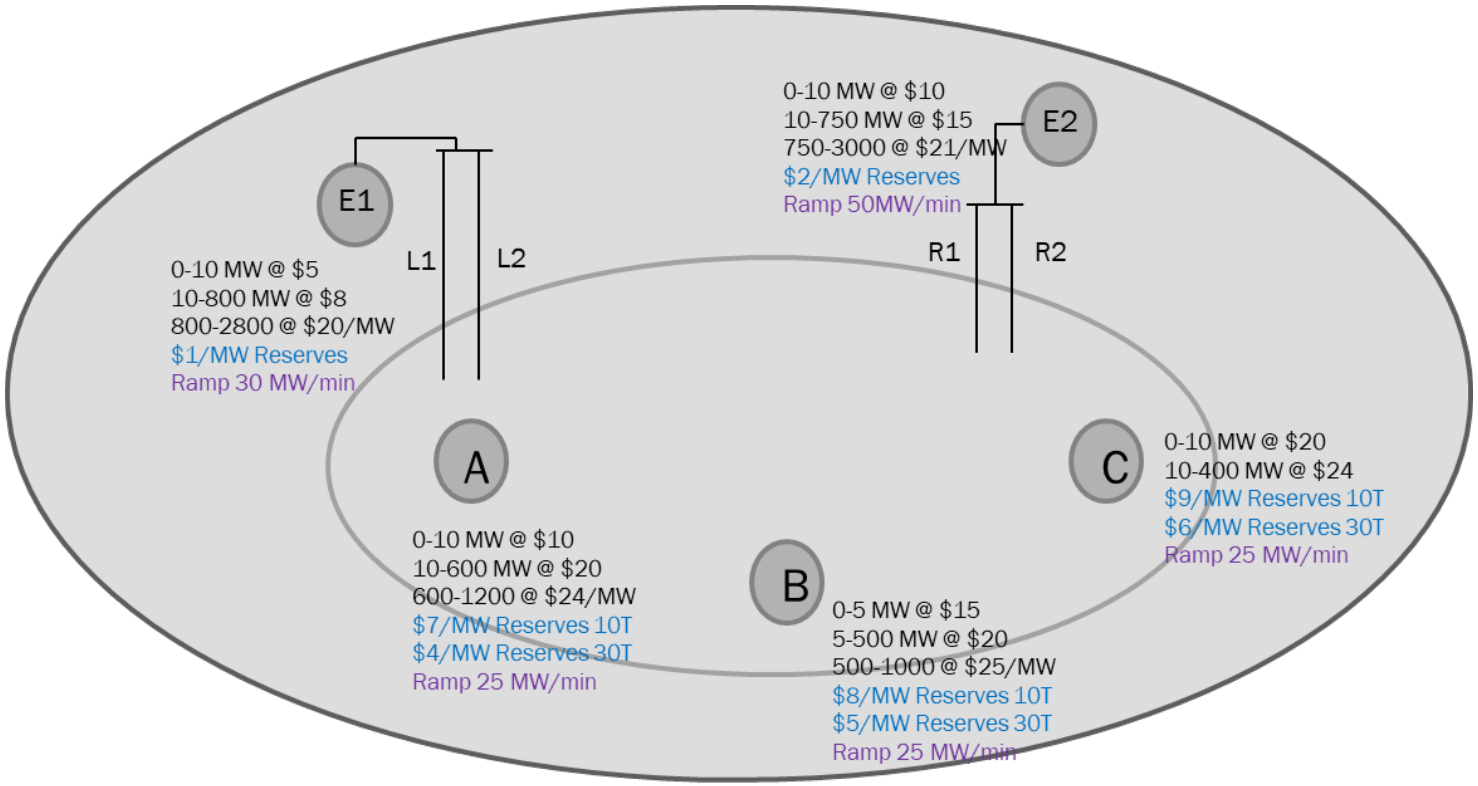
Example 2 Inputs: Generator Offers and Ramp Rates



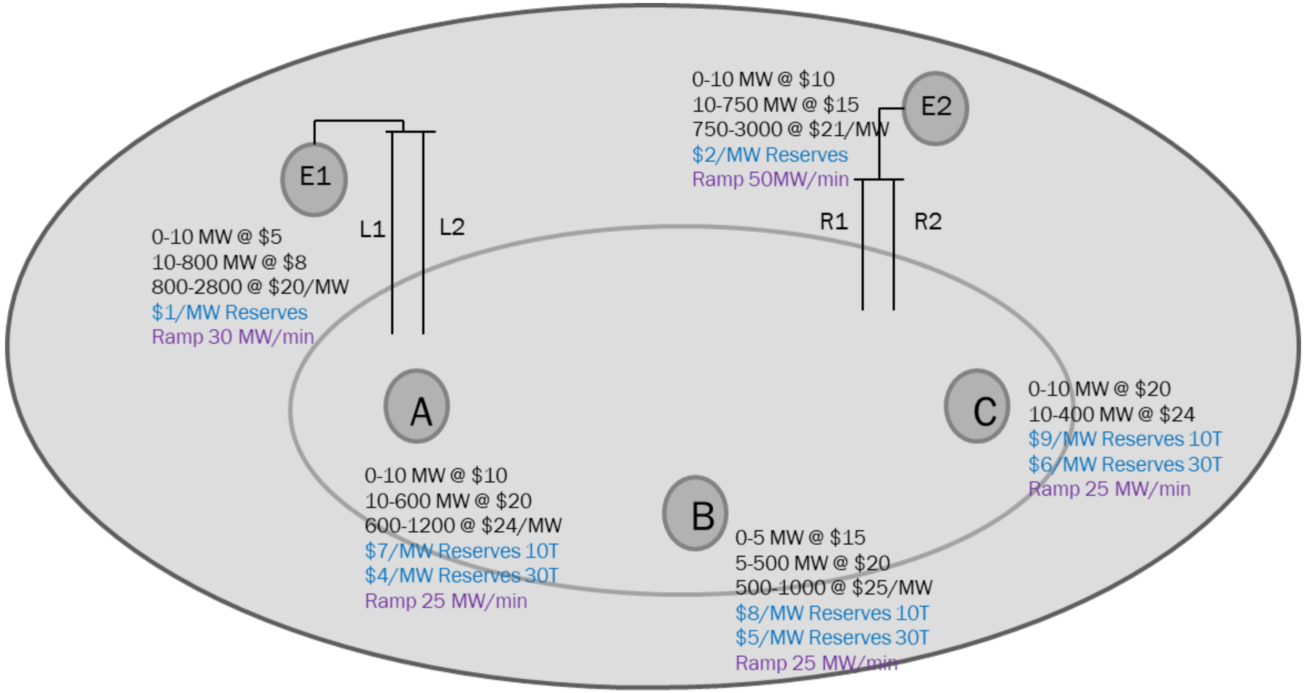
Example 2 Outputs: Energy Schedules

Case Outputs	
Production Cost ($)	
$120,612	
Energy Schedules (MW)	
Gen A	600
Gen B	714.8
Gen C	400
Gen E1	1885.2
Gen E2	2400



Example 2 Outputs: Reserve Schedules

10-min Reserve Schedules (MW)	
Gen A	177
Gen B	23
Gen C	0
Gen E1	300
Gen E2	500
30-min Reserve Schedules (MW)	
Gen A	423
Gen B	262
Gen C	0
Gen E1	315
Gen E2	0



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Example 2 Outputs: Line Flows

	L1	L2	R1	R2
Line Ratings (Normal/LTE/MTE)	800/900/1000	800/900/1000	900/1000/1150	900/1000/1150
Base Flow	686	686	707	707
N-1 Transmission Contingency Flow	983 Loss of R1 or R2	983 Loss of R1 or R2	1013 Loss of L1 or L2	1013 Loss of L1 or L2
N-1 Generation Contingency Flow	910 Loss of Gen A	910 Loss of Gen A	892 Loss of Gen B	892 Loss of Gen B
N-2 Transmission Contingency Flow	1443 Loss of L2R1 or L2R2	1443 Loss of L1R1 or L1R2	1393 Loss of L1L2	1393 Loss of L1L2

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Example 2 Outputs: LBMP Calculations

- **In this case, following locational reserve constraints are binding**
  - N-1 constraints:
    - L2 LTE flow limit for loss of R1. Shadow price is $1.15/MW
    - L1 LTE flow limit for loss of Gen A. Shadow price is $0.48/MW
  - N-2 constraints:
    - L2 LTE flow limit for loss of L1 and R1. Shadow price is $9.19/MW
    - L1 LTE flow limit for loss of R1 and R2. Shadow price is $40/MW
      - This constraint is using the relief from ORDC

LBMPs	
System Lambda ($/MW)	20.50
Gen LBMPs ($/MW)	
Gen A	47.39
Gen B	45.09
Gen C	41.60
Gen E1	20.00
Gen E2	21.00
Zonal Load LBMPs ($/MW)	
Upstream Load	20.50
Zone1 Load	45.60

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Example 2 Outputs: LMORP Calculations

- **NYCA Reserves shadow prices:**
  - NYCA 10-min reserve shadow price is $2.54/MW
  - NYCA 30-min reserve shadow price is $0.96/MW
- **The LMORP at a generator bus depends on the shadow price of modelled reserve constraints and generator shift factors to those constraints**
  - LMORP include NYCA reserve shadow prices
- **Detailed calculations demonstrating the price formation are included in the Appendix**

	Gen 10-min LMORP ($/MW)	Gen 30-min LMORP ($/MW)
Gen A	30.40	27.40
Gen B	28.00	25.00
Gen C	24.60	21.88
Gen E1	3.00	0.50
Gen E2	4.00	1.42

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Draft Tariff Revisions

Draft Tariff Revisions: Summary of Substantive Draft Tariff Revisions

- **MST 15.4**
  - Incremental revisions to MST 15.4 based on feedback received at the 10/19/23 MIWG, and
  - Revisions throughout MST 15.4.7 to describe Scarcity Pricing

Next Steps

Next Steps

- The deliverable for 2023 is Market Design Complete
- Timeline to completion of MDC
  - Review market design elements and present additional examples at November MIWGs
  - Present MDC and tariff at December BIC
- NYISO will continue prototyping and testing the proposed functionality through early 2024 and will return to stakeholders should any issues be identified.
- Per the 2023 Market Vision, these concepts are expected to be deployed in 2026, assuming prototyping and testing are successful.

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Questions?

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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: Foundation for Market Design Concepts

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*No changes to this slide from the 9/5 materials

Foundation for Market Design Concepts

- **Energy scheduling constraints are formulated as follows:**
  - $\sum Shift\ Factors\ * (Gen\ and\ Load\ Schedules) \leq \text{Line Limit}$
    - 'Line Limit' is based on the normal limit for a base case constraints and LTE or MTE limits for a post contingency constraints.
    - The associated shift factors for Generation and Load come from the Network Security Analysis (NSA) power flow tool.
- **This formulation would be extended for Operating Reserves subject to successful integration into NYISO BMS software**
  - NYISO has identified approximately 20 lines which make up key interfaces across NYCA and factor into reserve area definitions, for which NYISO would monitor for post-contingency limits
  - New reserve constraints need to be modeled similarly to the transmission constraint and validated within the market software: $\sum Shift\ Factors\ (Gen, Load, and\ Reserves) \leq Line\ Limit$
  - Reserve shift factors are negative in the above equation so that only resources which would provide relief for the constraint would be evaluated
  - The 'Line Limit' and reserve product would be based on the projected overload and timing requirements to restore the flows on the facility, after the contingency
  - The shift factors used to calculate the reserve constraints are based on the appropriate constraints operating requirements

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*No changes to this slide from the 9/5 materials

Generator Shift Factor Approach: Defining Locational Reserve Constraints

- **The locational reserve requirements (except for NYCA) would need to reflect the post-contingency system conditions as defined by reliability criteria:**
  - Loss of Transmission: The constraint would be evaluated for each monitored transmission element or interface[1] (*e.g.*, Central-East)
    - 10-Minute Total Reserves: Transmission elements must be below applicable limits[2] within 15 minutes following a single transmission contingency
      - [Post-Contingency Energy Flow – 10-Minute Reserves] <= Applicable Limits
    - 30-Minute Total Reserves: Transmission elements must be below Normal Transfer Criteria within 30 minutes following two transmission contingencies
      - [Post-Contingency Energy Flow – 30-Minute Reserves] <= Normal Transfer Criteria

1: The only interface that would be evaluated would be Central-East. All other transmission elements would be monitored individually.
2: An applicable limit for different constraints based on reliability criteria or system topology. For example, 1) reserve constraints for voltage conditions across the East interface would be based on Central East – Voltage Collapse maximum transfer capability and 2) reserve constraints for thermal conditions in NYC may be based on actual flows over LTE limits and 3) reserve constraints for thermal conditions in Long Island may be based on post contingency flows for the next contingency over LTE limits.

Generator Shift Factor Approach: Defining Locational Reserve Constraints (continued)

- **The locational reserve requirements (except for NYCA) would need to reflect the post-contingency system conditions as defined by reliability criteria:**
  - Loss of Generation: The constraint would be evaluated for each monitored transmission element or interface against the loss of each generator
    - 10-Minute Total Reserves: Transmission elements must be below applicable limits within 15 minutes following the loss of a generator
      - [Post- Generator Contingency Energy Flow – 10-Minute Reserves*] <= Applicable Limits
    - 30-Minute Total Reserves: Transmission elements must be below Normal Transfer Criteria within 30 minutes following the loss of two generators
      - [Post- Generator Contingency Energy Flow – 30-Minute Reserves*] <= Normal Transfer Criteria
  - Loss of Generation and Transmission: This constraint would be evaluated for each monitored transmission against the loss of a generation and transmission element
    - 30-Minute Total Reserves: [Post-Contingency Energy Flow – 30-Minute Reserves*] <= Normal Transfer Criteria
    - N-1 Transmission flow and loss of largest effective unit (Gen_MW * N-1_SF) for 30T requirement

* Not counting Reserves on the lost unit

*No changes to this slide from the 9/26 materials

Generator Shift Factor Approach: Defining NYCA Reserve Constraints

- **Transmission flows and limits are only used in determining the reserve distribution within the NYCA**
  - NPCC and NYSRC rules require the NYISO to procure reserves in NYCA to cover the largest capability loss; therefore, the determination of the reserve requirement for NYCA does not consider transmission from external control areas
- **Nodal transmission security will determine distribution of the requirement**
  - All Reserve providers will have a shift factor of "unity" towards NYCA requirement
- **The proposed reserve constraints for NYCA would be:**
  - 10-Minute Spin: Equal to one-half of the NYCA 10-Minute Total requirement
  - 10-Minute Total: Equal to the output of most severe contingency (*i.e.*, largest generator schedule)
  - 30-Minute Total: Equal to the output of the Largest Generator + Second Largest Generator + max(0,(Forecast – Bid))
    - Basing the requirement on the combined output of the largest and second largest generators meets the NYSRC requirement for 30-Minute reserves. The NYSRC requirements state that: 1) NYISO must have enough 30-Minute Reserves equal to one-half of the 10-Minute Reserve requirement (i.e., one-half of the capability of the largest generator; and 2) NYISO must restore 10-Minute reserves within 30 minutes of a contingency[1]
    - NYISO's use of a multiplier of 2*largest generator is an approximation of this requirement. Calculating the reserve requirement based on the capability of the largest and second largest contingency would allow NYISO to have enough reserves to restore flows and 10-Minute reserves within 30 minutes
    - The Forecast-Bid Load component is a Day-Ahead Market construct only

1: https://www.nysrc.org/wp-content/uploads/2023/07/RRC-Manual-V46-final.pdf

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Appendix: Post-Contingency Generator Shift Factors

Model Setup: Post N-1 transmission Contingency

Generator Shift Factors for Generator B and Generator C

Generator B - Loss of L1			
L1	L2	R1	R2
N/A	-0.4	-0.3	-0.3
Loss of L2			
L1	L2	R1	R2
-0.4	N/A	-0.3	-0.3
Loss of R1			
L1	L2	R1	R2
-0.3	-0.3	N/A	-0.4
Loss of R2			
L1	L2	R1	R2
-0.3	-0.3	-0.4	N/A

Generator C - Loss of L1			
L1	L2	R1	R2
N/A	-0.1	-0.45	-0.45
Loss of L2			
L1	L2	R1	R2
-0.1	N/A	-0.45	-0.45
Loss of R1			
L1	L2	R1	R2
-0.125	-0.125	N/A	-0.75
Loss of R2			
L1	L2	R1	R2
-0.125	-0.125	-0.75	N/A

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Model Setup: Post N-1 Transmission Contingency
Generator Shift Factors for E1 and E2

Generator E1 - Loss of L1			
L1	L2	R1	R2
N/A	0.05	-0.025	-0.025
Loss of L2			
L1	L2	R1	R2
0.05	N/A	-0.025	-0.025
Loss of R1			
L1	L2	R1	R2
0.025	0.025	N/A	-0.05
Loss of R2			
L1	L2	R1	R2
0.025	0.025	-0.05	N/A

Generator E2 - Loss of L1			
L1	L2	R1	R2
N/A	-0.05	0.025	0.025
Loss of L2			
L1	L2	R1	R2
-0.05	N/A	0.025	0.025
Loss of R1			
L1	L2	R1	R2
-0.025	-0.025	N/A	0.05
Loss of R2			
L1	L2	R1	R2
-0.025	-0.025	0.05	N/A

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Model Setup: Post N-2 transmission Contingency

Generator Shift Factors for Generator A and Generator B

Generator A - Loss of L1 & L2			
L1	L2	R1	R2
N/A	N/A	-0.5	-0.5
Loss of R1 & R2			
L1	L2	R1	R2
-0.5	-0.5	N/A	N/A
Loss of a combination of L1 and R1*			
L1	L2	R1	R2
N/A	-0.7	N/A	-0.3
Loss of a combination of L2 and R2*			
L1	L2	R1	R2
-0.7	N/A	-0.3	N/A

Generator B - Loss of L1 & L2			
L1	L2	R1	R2
N/A	N/A	-0.5	-0.5
Loss of R1 & R2			
L1	L2	R1	R2
-0.5	-0.5	N/A	N/A
Loss of a combination of L1 and R1*			
L1	L2	R1	R2
N/A	-0.45	N/A	-0.55
Loss of a combination of L2 and R2*			
L1	L2	R1	R2
-0.45	N/A	-0.55	N/A

* The shift factors for combination L1R2 and L2R1 will be similar to the combination L1R1 and L2R2

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Model Setup: Post N-2 transmission Contingency

Generator Shift Factors for Generator C

Generator C - Loss of L1 & L2			
L1	L2	R1	R2
N/A	N/A	-0.5	-0.5
Loss of R1 & R2			
L1	L2	R1	R2
-0.5	-0.5	N/A	N/A
Loss of a combination of L1 and R1*			
L1	L2	R1	R2
N/A	-0.1	N/A	-0.9
Loss of a combination of L2 and R2*			
L1	L2	R1	R2
-0.1	N/A	-0.9	N/A

* The shift factors for combination L1R2 and L2R1 will be similar to the combination L1R1 and L2R2

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Model Setup: Post N-2 transmission Contingency Generator Shift Factors for Generator E1 and Generator E2

Generator E1 - Loss of L1 & L2			
L1	L2	R1	R2
N/A	N/A	0.0	0.0
Loss of R1 & R2			
L1	L2	R1	R2
0.0	0.0	N/A	N/A
Loss of a combination of L1 and R1*			
L1	L2	R1	R2
N/A	0.05	N/A	-0.05
Loss of a combination of L2 and R2*			
L1	L2	R1	R2
0.05	N/A	-0.05	N/A

Generator E2 - Loss of L1 & L2			
L1	L2	R1	R2
N/A	N/A	0.0	0.0
Loss of R1 & R2			
L1	L2	R1	R2
0.0	0.0	N/A	N/A
Loss of a combination of L1 and R1*			
L1	L2	R1	R2
N/A	-0.5	N/A	0.05
Loss of a combination of L2 and R2*			
L1	L2	R1	R2
-0.05	N/A	0.05	N/A

* The shift factors for combination L1R2 and L2R1 will be similar to the combination L1R1 and L2R2

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Appendix: LBMP and LMORP Calculations

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Example 1: Gen & Load LBMPs

	System Lambda	Shadow Price L2 flow limit for Loss of R1	Shift Factor L2 flow limit for Loss of R1	Shadow Price L1 flow limit for Loss of Gen A	Pre contingency shift factor L1	Shadow Price L2 flow limit for Loss of L1 & R1	Shift Factor L2 flow limit for Loss of L1 & R1	Shadow Price L1 flow limit for Loss of R1 & R2	Shift Factor L1 flow limit for Loss of R1 & R2	LBMP Formation	LBMP
Generator A	20.5	1.15	-0.4	0.48	N/A	9.19	-0.7	8.24	-0.5	$LBMP_A = 20.5 + 1.15 * 0.4 + 9.19 * 0.7 + 8.24 * 0.5$	$ 31.51
Generator B	20.5	1.15	-0.3	0.48	-0.24	9.19	-0.45	8.24	-0.5	$LBMP_B = 20.5 + 1.15 * 0.3 + 0.48 * 0.24 + 9.19 * 0.45 + 8.24 * 0.5$	$ 29.22
Generator C	20.5	1.15	-0.125	0.48	-0.075	9.19	-0.1	8.24	-0.5	$LBMP_C = 20.5 + 1.15 * 0.125 + 0.48 * 0.075 + 9.19 * 0.1 + 8.24 * 0.5$	$ 25.72
Generator E1	20.5	1.15	0.025	0.48	0.025	9.19	0.05	8.24	0	$LBMP_{E1} = 20.5 - 1.15 * 0.025 - 0.48 * 0.075 - 9.19 * 0.05$	$ 20.00
Generator E2	20.5	1.15	-0.025	0.48	-0.025	9.19	-0.05	8.24	0	$LBMP_{E2} = 20.5 + 1.15 * 0.025 + 0.48 * 0.025 + 9.19 * 0.05$	$ 21.00
Upstream Load	20.5	1.15	0	0.48	0	9.19	0	8.24	0	$\mathrm{LBMP}_{\mathrm{UpsLoad}} = 20.5$	$ 20.50
Zone1 Load	20.5	1.15	-0.33	0.48	-0.25	9.19	-0.5	8.24	-0.5	$\mathrm{LBMP}_{\mathrm{Zone1Load}} = 20.5 + 1.15 * 0.33 + 0.48 * 0.25 + 9.19 * 0.5 + 8.24 * 0.5$	$ 29.72

Example 1: Gen 10-min LMORPs

	NYCA 10-min OR price	NYCA 30-min OR price	Shadow Price L2 flow limit for Loss of R1	Shift Factor L2 flow limit for Loss of R1	Shadow Price L1 flow limit for Loss of Gen A	Pre contingency shift factor L1	Shadow Price L2 flow limit for Loss of L1 & R1	Shift Factor L2 flow limit for Loss of L1 & R1	Shadow Price L1 flow limit for Loss of R1 & R2	Shift Factor L1 flow limit for Loss of R1 & R2	LMORP Calculation	LMORP
Generator A	2.54	0.96	1.15	-0.4	0.48	N/A	9.19	-0.7	8.24	-0.5	$\text{LMORP}_A = 2.54 + 0.96 + 1.15 * 0.4 + 9.19 * 0.7 + 8.24 * 0.5$	$ 14.51
Generator B	2.54	0.96	1.15	-0.3	0.48	-0.24	9.19	-0.45	8.24	-0.5	$\text{LMORP}_B = 2.54 + 0.96 + 1.15 * 0.3 + 0.48 * 0.24 + 9.19 * 0.45 + 8.24 * 0.5$	$ 12.22
Generator C	2.54	0.96	1.15	-0.125	0.48	-0.075	9.19	-0.1	8.24	-0.5	$\text{LMORP}_C = 2.54 + 0.96 + 1.15 * 0.125 + 0.48 * 0.075 + 9.19 * 0.1 + 8.24 * 0.5$	$ 8.72
Generator E1	2.54	0.96	1.15	0.025	0.48	0.025	9.19	0.05	8.24	0	$\text{LMORP}_{E1} = 2.54 + 0.96 - 1.15 * 0.025 - 0.48 * 0.075 - 9.19 * 0.05$	$ 3.00
Generator E2	2.54	0.96	1.15	-0.025	0.48	-0.025	9.19	-0.05	8.24	0	$\text{LMORP}_{E2} = 2.54 + 0.96 + 1.15 * 0.025 + 0.48 * 0.025 + 9.19 * 0.05$	$ 4.00

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Example 1: Gen 30-min LMORPs

	NYCA 30-min OR price	Shadow Price L2 flow limit for Loss of L1 & R1	Shift Factor L2 flow limit for Loss of L1 & R1	Shadow Price L1 flow limit for Loss of R1 & R2	Shift Factor L1 flow limit for Loss of R1 & R2	LMORP Calculation	LMORP
Generator A	0.96	9.19	-0.7	8.24	-0.5	$\mathrm{LMORP_A} = 0.96 + 9.19 * 0.7 + 8.24 * 0.5$	$ 14.51
Generator B	0.96	9.19	-0.45	8.24	-0.5	$\mathrm{LMORP_B} = 0.96 + 9.19 * 0.45 + 8.24 * 0.5$	$ 12.22
Generator C	0.96	9.19	-0.1	8.24	-0.5	$\mathrm{LMORP}_C = 0.96 + 9.19 * 0.1 + 8.24 * 0.5$	$ 8.72
Generator E1	0.96	9.19	0.05	8.24	0	$\mathrm{LMORP}_{E1} = 0.96 - 9.19 * 0.05$	$ 0.50
Generator E2	0.96	9.19	-0.05	8.24	0	$\mathrm{LMORP}_{E2} = 0.96 + 9.19 * 0.05$	$ 1.42

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Example 2: Gen & Load LBMPs

	System Lambda	Shadow Price L2 flow limit for Loss of R1	Shift Factor L2 flow limit for Loss of R1	Shadow Price L1 flow limit for Loss of Gen A	Pre contingency shift factor L1	Shadow Price L2 flow limit for Loss of L1 & R1	Shift Factor L2 flow limit for Loss of L1 & R1	Shadow Price L1 flow limit for Loss of R1 & R2	Shift Factor L1 flow limit for Loss of R1 & R2	LBMP Formation	LBMP
Generator A	20.5	1.15	-0.4	0.48	N/A	9.19	-0.7	40	-0.5	$LBMP_A = 20.5 + 1.15 * 0.4 + 9.19 * 0.7 + 40 * 0.5$	$ 47.39
Generator B	20.5	1.15	-0.3	0.48	-0.24	9.19	-0.45	40	-0.5	$LBMP_B = 20.5 + 1.15 * 0.3 + 0.48 * 0.24 + 9.19 * 0.45 + 40 * 0.5$	$ 45.09
Generator C	20.5	1.15	-0.125	0.48	-0.075	9.19	-0.1	40	-0.5	$LBMP_C = 20.5 + 1.15 * 0.125 + 0.48 * 0.075 + 9.19 * 0.1 + 40 * 0.5$	$ 41.60
Generator E1	20.5	1.15	0.025	0.48	0.025	9.19	0.05	40	0	$LBMP_{E1} = 20.5 - 1.15 * 0.025 - 0.48 * 0.075 - 40 * 0.05$	$ 20.00
Generator E2	20.5	1.15	-0.025	0.48	-0.025	9.19	-0.05	40	0	$LBMP_{E2} = 20.5 + 1.15 * 0.025 + 0.48 * 0.025 + 9.19 * 0.05$	$ 21.00
Upstream Load	20.5	1.15	0	0.48	0	9.19	0	40	0	$\mathrm{LBMP}_{\mathrm{UpsLoad}} = 20.5$	$ 20.50
Zone1 Load	20.5	1.15	-0.33	0.48	-0.25	9.19	-0.5	40	-0.5	$\mathrm{LBMP}_{\mathrm{Zone1Load}} = 20.5 + 1.15 * 0.33 + 0.48 * 0.25 + 9.19 * 0.5 + 40 * 0.5$	$ 45.60

Example 2: Gen 10-min LMORPs

	NYCA 10-min OR price	NYCA 30-min OR price	Shadow Price L2 flow limit for Loss of R1	Shift Factor L2 flow limit for Loss of R1	Shadow Price L1 flow limit for Loss of Gen A	Pre contingency shift factor L1	Shadow Price L2 flow limit for Loss of L1 & R1	Shift Factor L2 flow limit for Loss of L1 & R1	Shadow Price L1 flow limit for Loss of R1 & R2	Shift Factor L1 flow limit for Loss of R1 & R2	LMORP Calculation	LMORP
Generator A	2.54	0.96	1.15	-0.4	0.48	N/A	9.19	-0.7	40	-0.5	$\mathrm{LMORP_A} = 2.54 + 0.96 + 1.15 * 0.4 + 9.19 * 0.7 + 40 * 0.5$	$ 30.39
Generator B	2.54	0.96	1.15	-0.3	0.48	-0.24	9.19	-0.45	40	-0.5	$\mathrm{LMORP_B} = 2.54 + 0.96 + 1.15 * 0.3 + 0.48 * 0.24 + 9.19 * 0.45 + 40 * 0.5$	$ 28.09
Generator C	2.54	0.96	1.15	-0.125	0.48	-0.075	9.19	-0.1	40	-0.5	$\mathrm{LMORP}_C = 2.54 + 0.96 + 1.15 * 0.125 + 0.48 * 0.075 + 9.19 * 0.1 + 40 * 0.5$	$ 24.60
Generator E1	2.54	0.96	1.15	0.025	0.48	0.025	9.19	0.05	40	0	$\mathrm{LMORP}_{E1} = 2.54 + 0.96 - 1.15 * 0.025 - 0.48 * 0.075 - 9.19 * 0.05$	$ 3.00
Generator E2	2.54	0.96	1.15	-0.025	0.48	-0.025	9.19	-0.05	40	0	$\mathrm{LMORP}_{E2} = 2.54 + 0.96 + 1.15 * 0.025 + 0.48 * 0.025 + 9.19 * 0.05$	$ 4.00

Example 2: Gen 30-min LMORPs

	NYCA 30-min OR price	Shadow Price L2 flow limit for Loss of L1 & R1	Shift Factor L2 flow limit for Loss of L1 & R1	Shadow Price L1 flow limit for Loss of R1 & R2	Shift Factor L1 flow limit for Loss of R1 & R2	LMORP Calculation	LMORP
Generator A	0.96	9.19	-0.7	40	-0.5	$\text{LMORP}_\text{A} = 0.96 + 9.19 * 0.7 + 40 * 0.5$	$ 27.39
Generator B	0.96	9.19	-0.45	40	-0.5	$\text{LMORP}_\text{B} = 0.96 + 9.19 * 0.45 + 40 * 0.5$	$ 25.09
Generator C	0.96	9.19	-0.1	40	-0.5	$\text{LMORP}_C = 0.96 + 9.19 * 0.1 + 40 * 0.5$	$ 21.88
Generator E1	0.96	9.19	0.05	40	0	$\text{LMORP}_{E1} = 0.96 - 9.19 * 0.05$	$ 0.5
Generator E2	0.96	9.19	-0.05	40	0	$\text{LMORP}_{E2} = 0.96 + 9.19 * 0.05$	$ 1.42

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