New York ISO
Independent System Operator

Dynamic Reserves

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Agenda

- Background
- Congestion Rent Settlements Discussion and Examples
- Scarcity Reserve Requirements
- Tariff
- Next Steps

Background

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

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Previous Presentations

Title/Topic	Link
October 19, 2023 MIWG	https://www.nyiso.com/documents/20142/40696384/20231019%20MIWG%20-%20Dynamic%20Reserves.pdf/ef4371c2-5bff-7adb-5871-1d77d6fa98eb
November 8, 2023 MIWG	https://www.nyiso.com/documents/20142/41049783/20231108%20MIWG%20-%20Dynamic%20Reserves.pdf/e38b6d72-aa3f-69f3-b43f-8b3591b0e314
November 17, 2023 MIWG	https://www.nyiso.com/documents/20142/41273741/20231117%20MIWG%20-%20Dynamic%20Reserves_final.pdf/d18195bc-c940-1a1f-51c1-3220a02c23bd
November 27, 2023 MIWG	https://www.nyiso.com/documents/20142/41393553/20231127%20MIWG%20-%20Dynamic%20Reserves.pdf/ec047167-4bcb-2610-4e15-2a57565d9d18

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Current Progress

- **This presentation will provide examples to support materials previously presented and follow-up on stakeholder questions, and includes one more draft tariff section**
- **At the 12/6/23 MIWG and the 12/13/23 BIC, the NYISO will present the Market Design for Dynamic Reserves**
  - The NYISO's proposal for Dynamic Reserves is a cost-effective solution for dynamically determining reserve requirements based on grid conditions and topology
    - Dynamic Reserves at its core, maximizes social benefit by allowing a new degree of freedom in the minimization of total production cost by optimizing reserve schedules against energy and transmission
    - NYISO will continue prototyping and testing the proposed functionality through early 2024 and will return to stakeholders should any issues be identified
- **At the 12/13/2023 BIC, the NYISO intends to bring forward a presentation for consideration. The purpose of this presentation is to determine if stakeholders are comfortable with the design approach so that the NYISO may begin prototyping efforts and implementation testing. Concurrent with the prototyping and testing in 2024, the NYISO intends to continue discussions on issues not relevant to prototyping (*i.e.*, – cost allocation, congestion revenue, TCC allocations).**

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Congestion Rent Settlements Discussion and Examples

Congestion Rent Settlements

- **On 11/8/2023 and 11/17/2023, the NYISO presented DAM settlement examples that illustrated the charges and payments for energy, congestion, and reserves**
- **Using numbers from the examples presented on 11/8 and 11/17, today's presentation will provide two further examples**
  - This includes an example of settlements incorporating forecast reserve constraints
  - Material from 11/17 is provided in the Appendix for reference
- **NYISO is continuing to review whether the interaction of Dynamic Reserves and today's TCC rules creates the need for further modifications**

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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
  - For 11/8 and 11/17, NYISO prepared three examples: a base case example with a static reserve requirement, a dynamic reserves example with a 10-Minute locational reserve requirement (no NYCA reserves and no 30-Minute reserves), and a second dynamic reserve case highlighting TCC interactions
    - These examples did not model forecast reserve constraints
  - For today, NYISO has prepared an example which builds upon previous presentations and incorporates forecast reserve constraints
- **The examples show that existing settlement mechanisms will continue to function effectively under dynamic reserves**

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Assumptions: Example 4

- **Example 4 introduces the forecast reserve constraints into the dynamic reserve solution**
  - In this example, Forecast Load in the load pocket is 3600 MW
  - The example solves for N-1 post-contingency transmission flows into the load pocket
  - There are no 30M reserve constraints or no static requirement
  - Example 4 utilizes the same assumptions as Examples 1 and 2 for Bid Load, energy offers, and reserve offers
- **The transmission constraints are base case energy scheduling constraints for NYC: base case energy flows can't exceed Normal limits, post N-1 contingency flows can't exceed MTE limits. The example assumes four transmission elements with the following Normal/LTE/MTE ratings:**
  - Line A: 802/1002/1052
  - 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)
Bid Load (MW)	0	3500
Forecast Load (MW)	0	3600
Reserve requirement (MW)	0	0
Energy Offer ($/MW)	5	50
Reserve Offer ($/MW)	1	2

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Results: Example 4

- **The results from Example 4 are:**
  - Energy Schedules:
    - ROS Generators: 3147 MW
    - Load pocket generators: 353 MW
  - Reserve Schedules:
    - ROS Generators: 0 MW
    - Load pocket generators: 250 MW of which 100 MW are forecast reserves
  - System Lambda = $5
  - Load pocket generator Operating Reserve price = Shadow price*SF = 6*0.333 = $2
  - Total shadow price for transmission constraints = $135
    - Shadow price for binding N-1 dynamic reserve constraint based on forecast load= $6, plus
    - Shadow price for energy scheduling transmission constraint = $129

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Results: Example 4 (continued)

- The table illustrates the charges and payments for energy, congestion, and reserves
- Total charges collected from LSEs: $175,500
  - Energy Charges (17,500) + Congestion Charges (157,500) + Forecast Reserve Charges (200) + Load Ration Share Reserve Charges (300)
- Total payments owed: $175,500
  - Energy Payment (Gen) (1,765) + Congestion Payment (Gen) (15,885) + Congestion Rents (141,615) + Reserve Payment (Gen) (500)

	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 Rents	N/A	=Flow on Constrained Element*Transmission Congestion SP + Flow on Constrained Element *Reserve Congestion SP =(1049*129) + (1049*6)=$141,615
Reserve Charges (LSEs) through RS4	N/A	=Total Reserve Payments to Gens – Forecast Reserve Charge = $500 - $200 = $300
Reserve Payments (Gens)	N/A	=Reserve Schedule*[(Reserve Congestion SP*SF)] =250*(6*0.33)=$500
Forecast Reserve Charge (LSEs where RT Actual Withdrawals > DAM Withdrawals)	N/A	=(Forecast Load – Bid/Scheduled Load)*Forecast Reserve Price =100*2=$200

Results: Example 4 (continued)

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

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

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Example 4: Congestion Rent Allocation and Settlements Example

- The table compares the congestion rent allocation and settlement results from Example 2 (Discussed on 11/17) and Example 4
- The example demonstrates how the forecast reserve constraints would impact optimization outcomes and settlements

Congestion Rent Allocation and Settlements

		Example 2: Dynamic Reserves Without Forecast Reserve Constaints	Example 4: Dynamic Reserves With Forecast Reserve Constraints
ROS LMP	($/MWh)	$ 5	$ 5
Locality LMP	($/MWh)	$ 50	$ 50
ROS OR Price	($/MWh)	$ -	$ -
Locality OR Price	($/MWh)	$ 2	$ 2
ROS Energy Sched	(MW)	3147	3147
Locality Energy Sched	(MW)	352	352
ROS OR Sched	(MW)	0	0
Locality OR Sched	(MW)	150	250
Load LMP Payments	($)	$ (175,000)	$ (175,000)
Gen LMP Payments	($)	$ 33,385	$ 33,385
TCC Congestion Payments	($)	$ 141,615	$ 141,615
Load OR Payments (RS4)	($)	$ (300)	$ (300)
Load Forecast Reserve Charge	($)	$ -	$ (200)
OR Supply Payments	($)	$ 300	$ 500
(non-wholesale)			
Load Congestion Rent Offset	($)	$ 141,615	$ 141,615
TOTAL LOAD CHARGES	**($)**	**$ (33,685)**	**$ (33,885)**

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Assumptions: Example 5

- **Example 5 introduces forecast reserve constraints into the dynamic reserve solution in a case with expensive operating reserves in the load pocket**
  - Locational Operating Reserve offers are increased from $2 to $50
  - Example 5 utilizes the same assumptions as Example 4 for all other components

	Rest-of-state (ROS)	Load Pocket (NYC)
Bid Load (MW)	0	3500
Forecast Load (MW)	0	3600
Reserve requirement (MW)	0	0
Energy Offer ($/MW)	5	50
Reserve Offer ($/MW)	1	50

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Results: Example 5

- **The results from Example 5 are:**
  - Energy Schedules:
    - ROS Generators: 2897 MW
    - Load pocket generators: 603 MW
  - Reserve Schedules:
    - ROS Generators: 0 MW
    - Load pocket generators: 0 MW
  - System Lambda = $5
  - Load pocket generator Operating Reserve price = Shadow Price*SF = 135*0.333 = $45
    - This price is less than the reserve offer, so no reserves are scheduled
  - Total shadow price for transmission constraints = $135
    - Shadow price for binding N-1 forecast load dynamic reserve constraint = $135, plus
    - Shadow price for energy scheduling transmission constraint = $0

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Results: Example 5 (continued)

- **The table illustrates the charges and payments for energy, congestion, and reserves**
- **Total charges collected from LSEs: $175,000**
  - Energy Charges (17,500) + Congestion Charges (157,500) + Forecast Reserve Charges (4,500) + Load Ration Share Reserve Charges (-4,500)
- **Total payments owed: $175,000**
  - Energy Payment (Gen) (17,500) + Congestion Payment (Gen) (27,135) + Congestion Rents (130,365)

	Rest-of-State	Load Pocket (NYC)
LBMP ($/MW)	$5	=System Lambda-[(Transmission Congestion SP*SF)+(Reserve Congestion SP*SF)] =5-[(-135*0.33)+(0*0.33)] =$50
Energy Charges (LSEs)	N/A	=System Lambda*Load =5*3500=$17,500
Energy Payment (Gens)	=System Lambda*Energy Schedule =5*2897= $14,485	=System Lambda*Energy Schedule =5*603=$3,015
Congestion Charges (LSEs)	N/A	=[(Transmission Congestion SP*SF)+(Reserve Congestion SP*SF)]*Load =[(135*0.33)+(0*0.33)]*3500=$157,500
Congestion Payments (Gens)	N/A	=[(Transmission Congestion SP*SF)+(Reserve Congestion SP*SF)]*Energy Schedule =[(135*0.33)+(0*0.33)]*603=$27,135
Congestion Rents	N/A	=Bid Load Flow on Constrained Element *Reserve Congestion SP =(966*135) = $130,365
Reserve Charges (LSEs) through RS4	N/A	=Total Reserve Payments – Forecast Reserve Charge = $0 - $4,500 = -$4,500
Reserve Payments (Gens)	N/A	=$0
Forecast Reserve Charge (LSEs where RT Actual Withdrawals > DAM Withdrawals)	N/A	=(Forecast Load – Bid/Scheduled Load)*Forecast Reserve Price =100*45=$4,500

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Results: Example 5 (continued)

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

	Energy	Congestion	Reserves
LSE Charges	$ (17,500.00)	$ (157,500.00)	$ -
Generator Payments	$ 17,500.00	$ 27,135.00	$ -
Congestion Rents	$ -	$ 130,365.00	$ -
Net	$ -	$ -	$ -

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Example 5: Congestion Rent Allocation and Settlements Example

- The table compares the congestion rent allocation and settlement results from Example 3 (Discussed on 11/17) and Example 5
- In this example, operating reserves were expensive, and the optimal outcome was to respect transmission constraints and not schedule reserves
  - Line flows decreased so congestion rents decreased
  - In this example with the forecast reserve constraints, the results indicate a credit back to loads for OR payments since there was no reserves scheduled. As proposed, the RS4 reserve charges would be net Forecast Reserve Charges (which would be non-zero considering NYCA reserves, which are 0 MW for this example)
- The example demonstrates how the forecast reserve constraints would impact optimization outcomes and settlements

Congestion Rent Allocation and Settlements

		Example 3: Dynamic Reserves Without Forecast Reserve Constraints	Example 5: Dynamic Reserves With Forecast Reserve Constraints
ROS LMP	($/MWh)	$ 5	$ 5
Locality LMP	($/MWh)	$ 50	$ 50
ROS OR Price	($/MWh)	$ -	$ -
Locality OR Price	($/MWh)	$ 45	$ 45
ROS Energy Sched	(MW)	2997	2897
Locality Energy Sched	(MW)	503	603
ROS OR Sched	(MW)	0	0
Locality OR Sched	(MW)	0	0
Load LMP Payments	($)	$ (175,000)	$ (175,000)
Gen LMP Payments	($)	$ 40,135	$ 44,635
TCC Congestion Payments	($)	$ 134,865	$ 130,365
Load OR Payments (RS4)	($)	$ -	$ 4,500
Load Forecast Reserve Charge	($)	$ -	$ (4,500)
OR Supply Payments	($)	$ -	$ -
	(non-wholesale)		
Load Congestion Rent Offset	($)	$ 134,865	$ 130,365
TOTAL LOAD CHARGES	**($)**	**$ (40,135)**	**$ (44,635)**

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Scarcity Reserve Requirements Examples

Scarcity Reserve Requirements

- **The NYISO expects that the Scarcity Reserve Requirements should continue to interact similarly with the 30-Minute Dynamic Reserve Requirements as they have with static reserve regions**
- **As defined today, the Scarcity Reserve Requirement will be calculated as: Scarcity Reserve Requirement = Expected EDRP/SCR MW – average Available Operating Capacity MW**
  - Available Operating Capacity is unscheduled energy production capability that could be provided by available resources in greater than 30 minutes and less than or equal to 60 minutes
- **The Scarcity Reserve Requirement will be added to the NYCA 30-min constraint:**

$$NYCA\ 30T \geq Largest\ Schedule + Second\ Largest\ Schedule + Scarcity\ Reserve\ Requirement$$

  - Same as today, all steps on NYCA ORDCs that are lower than $500/MW will be increased to this price level.
- **The Scarcity Reserve Requirement will be added to any applicable 30-Minute locational reserves constraint by adding the Scarcity Reserve Requirement to the Load**

$$\sum Generation\ * ShiftFactor + \sum (Loads + Scarcity\ Reserve\ Requirement)\ * ShiftFactor - \sum Reserves\ * ShiftFactor \leq LineLimit$$

  - The applicable 30-minute constraints are constraints that the Zonal load have a shift factor for
  - The 30-minute demand curve for each constraint will be adjusted in real-time to account for the Scarcity Reserve Requirement. The Scarcity Reserve Requirement MWs will be priced at $500/MW

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Scarcity Reserve Requirements (continued)

- **Under NYISO's existing nested reserve area construct, the Scarcity Reserve Requirement for the Scarcity Reserve Region is also added to the 30-Minute Reserve Requirement for any of the upstream reserve areas**
  - For example, if there is a 100 MW Scarcity Reserve Requirement in NYC, this 100 MW is also added to the SENY, East, and NYCA 30-Minute reserve requirements[1]
  - For NYCA, the ORDC is modified for any steps priced at less than $500 as follows:
    - $750/MWh "step" up to and including 1,965 MW
    - $625/MWh "step" beyond 1,965 MW through 2,020 MW
    - $500/MWh "step" beyond 2,020 MW through (2,620 + the applicable Scarcity Reserve Requirement)
- **NYISO proposes to maintain this logic under Dynamic Reserves as described in the next slide**

1: For more information, please see the Ancillary Services Manual at page 98: https://www.nyiso.com/documents/20142/16688820/11%20Ancillary%20Services%20Shortage%20Pricing%20-%2011112020%20BIC.pdf/29cc3bf3-d635-4e9c-4261-f07cab86c525

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Scarcity Pricing Formulation

- **Impute additional load equal to EDRP/SCR activation and secure flows to applicable limits**

$$\sum Gen_k * SF_{k,l} + \sum (\text{Loads} + \text{Scarcity Reserve Requirement})_{Zn} * SF_{Zn,l} - \sum_{SF<0} (Res_k * SF_{k,l}) \leq \text{LineLimit}$$

  - Calculates a reserve requirement as though the load were still there, resulting in higher locational reserve requirement. Consistent with today's logic.
  - k: Index for Gens; l: Index for constraints; Zn: Index for Zones
  - This constraint uses the existing single value locational demand curve
  - Constraint ensures sufficient reserves are available in the activated zone(s) or by electrically beneficial downstream resources (negative shift factor to the Secure Facility for Reserves Constraint) in a least cost method

- **Hold reserves at appropriate locations to cover the additional flow but/for the load reduction created by EDRP/SCR activation**

$$\sum_{SF<0} (Res_k * SF_{k,l}) \geq \sum_{Zn} \text{Scarcity Reserve Requirement}_{Zn} * SF_{Zn,l}$$

  - This constraint has a $500/MW demand curve
  - This constraint ensures that there are enough reserves to have met load but for the activation.

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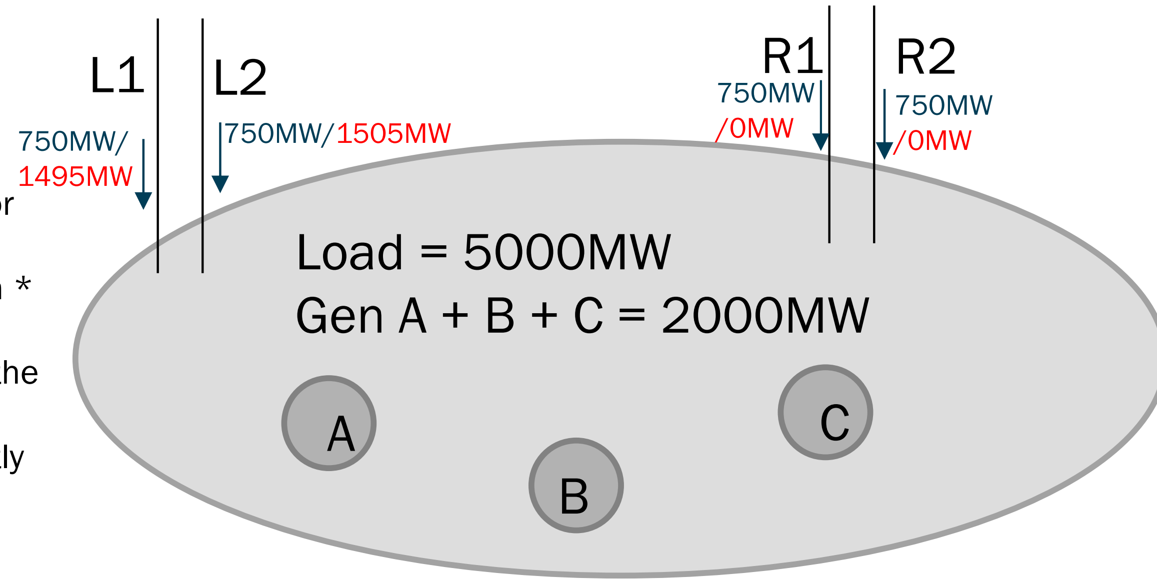
Scarcity Example Input

- Actual RT load is 5,000MW resulting in real flow on the lines of 750MW calculated here:
  - Assume zonal load and gens have a 0.25 shift factor to all lines
  - Flow on each line is: 5000*.25 – sum of generation * .25 which 1,250MW – 500MW = 750MW
- Binding Reserve Constraint for 30T is L2 is over limit for the loss of R1 and R2. Those 1500MW (750 + 750) would transfer to L1 and L2, and in this example L2 has a slightly higher distribution factor resulting in the higher overload.
- Post contingency shift factor for load is 0.501 for L2.
- Post contingency flows in Red.



$$Flow_{line} = Load * SF_{line} - \sum_{n} Gen_n * SF_{line}$$

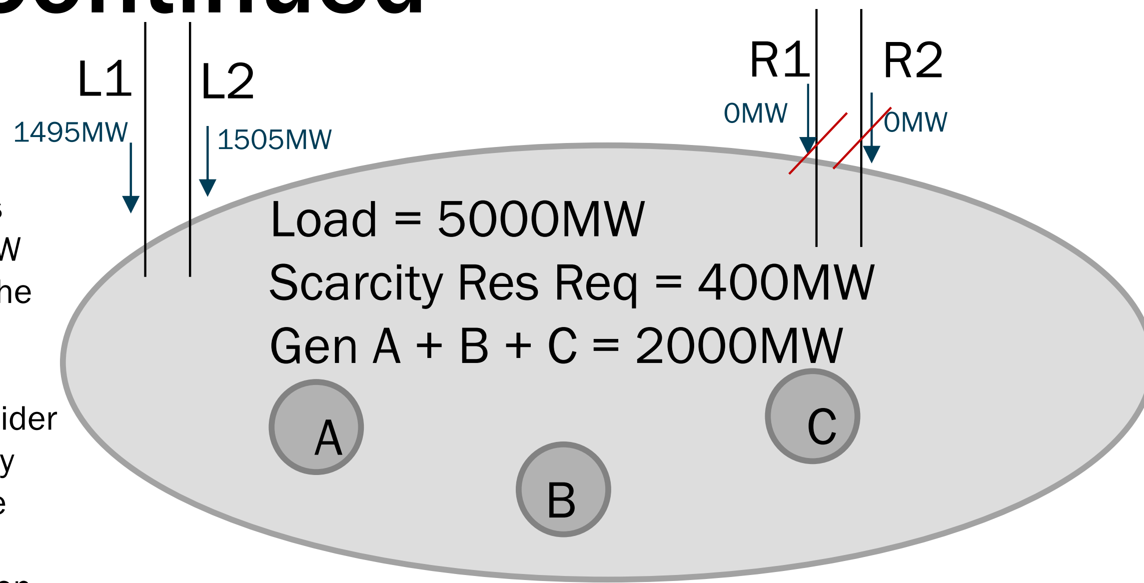
$$Flow_{line} = 5{,}000MW * 0.25 - \sum_{n} 2{,}000MW * 0.25$$

$$Flow_{line} = 750MW$$

Scarcity Example Continued

- Activated SCR/EDRP of 500MW
- Scarcity Reserve Requirement is Activation less available capacity between 30 and 60 minutes. In this case, that is 100MW, so the imputed requirement is 500-100 = 400MW
- Imputing 400MW of load would add 200.4MW of flow to the line bringing flow to 1705.4MW on L2.
- The reserve requirement would increase by "200.4MW/(SF_L2)". If Gen B was the only available provider and had a -0.5SF to L2, the requirement would increase by 400.8MW (200.4/0,5), assuming it was already above the post contingency limit.
- Additionally, a constraint is created to test but/for activation where, (Reserves * SF) ≥ 200.4MW @ $500 ORDC
  - This is for each zone load pulling on a constraint and is a direct measurement.

$$\sum_n (Res_n * SF_{line}) + ORDC_{MW} * SF_{line} \geq 200.4 \text{ @ \$500 } ORDC$$



$$\sum_n Res_n * SF_{line} \geq Load * SF_{line} - \sum_n Gen_n * SF_{line} - Limit_{line}$$

$$\sum_n Res_n * SF_{line} \geq 5{,}400 * .501 - \sum_n 2{,}000 * 0.5 - 1{,}400 = 305.4$$

$$Or$$

$$\sum_n (Res_n * SF_{line}) + ORDC_{MW} * SF_{line} \geq 305.4 \text{ @ \$25 } ORDC$$

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Draft Tariff Revisions

Draft Tariff Revisions: Summary of Substantive Draft Tariff Revisions

- **MST 2.19**
  - Removed definition of Scarcity Reserve Region

Next Steps

Next Steps

- **The deliverable for 2023 is Market Design Complete**
- **Timeline to completion of MDC**
  - Present MDC at 12/6/23 MIWG
  - Present MDC and tariff at December BIC as discussed in more detail on slide 6
- **NYISO will continue prototyping and testing the proposed functionality through early 2024 and will continue discussions with stakeholders**
- **Per the 2023 Market Vision, these concepts are expected to be deployed in 2026, assuming prototyping and testing are successful.**

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

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 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 Rents (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 Rents	N/A	=Flow on Constrained Element*Congestion SP =(1049)*135=$141,615
Reserve Charges (LSEs)	N/A	=Rate Schedule 4 Load Ratio Share Payments of $300
Reserve Payments (Gens)	N/A	=Reserve Schedule*Reserve Price =150*2=$300

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

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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 Congestion rents

	Energy	Congestion	Reserves
LSE Charges	$ (17,500.00)	$ (157,500.00)	$ (300.00)
Generator Payments	$ 17,500.00	$ 15,885.00	$ 300.00
Congestion Rents	$ -	$ 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 (continued)

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

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

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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 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 Rents (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 Rents	N/A	=Flow on Constrained Element*Transmission Congestion SP + Flow on Constrained Element *Reserve Congestion SP =(1049*129) + (1049*6)=$141,615
Reserve Charges (LSEs)	N/A	=Rate Schedule 4 Load Ratio Share Payments of $300
Reserve Payments (Gens)	N/A	=Reserve Schedule*[(Reserve Congestion SP*SF)] =150*(6*0.33)=$300

Interaction between Dynamic Reserves and TCCs

Example 3 Dynamic Reserves Case with Expensive Operating Reserves

- Examples 1 and 2 produced identical transmission Congestion Rent
- When locational Operating Reserves are expensive, the optimal outcome (i.e., minimal production cost) may be to respect transmission constraints and not schedule reserves
- Example 3 shows how Congestion Rent would change in such a case

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Assumptions: Example 3 Dynamic Reserves Case with Expensive Operating Reserves

- **Example 3 increases the cost of locational Operating Reserves**
  - There are no 30M reserve constraints or Forecast Load in this example
  - There is no static requirement
- **Example 3 utilizes the same assumptions as Example 1 and 2 for:**
  - Load
  - Energy
  - Energy scheduling constraints
  - Pre/post-contingency shift factors
- **The OR offer for locational reserves is increased from $2 to $47**

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Results: Example 3 Dynamic Reserves

- **The results from the dynamic reserves case are:**
  - Energy Schedules:
    - ROS Generators: 3997 MW
    - Load pocket generators: 503 MW
  - Reserve Schedules:
    - ROS Generators: 0 MW
    - Load pocket generators: 0 MW
  - System Lambda = $5
  - Load pocket generator Operating Reserve price = $45
  - Total shadow price for transmission constraint = $135
    - Shadow price for binding N-1 dynamic reserve constraint = $135, plus
    - Shadow price for energy scheduling transmission constraint = $0

Results: Example 3 Dynamic Reserves

- **The table illustrates the charges and payments for energy, congestion, and reserves**
- **Total charges collected from LSEs: $175,000**
  - Energy Charges (17,500) + Congestion Charges (157,500) + Reserve Charges (0)
- **Total payments owed: $175,000**
  - Energy Payment (Gen) (17,500) + Congestion Payment (Gen) (22,635) + Congestion Payment (TOs) (134,865) + Reserve Payment (Gen) (0)

	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*2997=$14,985	=System Lambda*Energy Schedule =5*503=$2,515
Congestion Charges (LSEs)	N/A	=[(Transmission Congestion SP*SF)+(Reserve Congestion SP*SF)]*Load =[(135*0.33)+(0*0.33)]*3500=$157,500
Congestion Payments (Gens)	N/A	=[(Transmission Congestion SP*SF)+(Reserve Congestion SP*SF)]*Energy Schedule =[(135*0.33)+(0*0.33)]*503=$22,635
Congestion Rents	N/A	=Flow on Constrained Element*Transmission Congestion SP + Flow on Constrained Element *Reserve Congestion SP =(999*135) + (999*0)=$134,865
Reserve Charges (LSEs)	N/A	=Rate Schedule 4 Load Ratio Share Payments of $0
Reserve Payments (Gens)	N/A	=Reserve Schedule*[(Reserve Congestion SP*SF)] =0*(135*0.33)=$0

Comparison across Examples

		Example 1 TODAY	Example 2 DR- Cheap OR	Example 3 DR - Expensive OR
Transmission DAM Congestion Rent	[A] = [E] * [F]	$ 141,615	$ 141,615	$ 134,865
Assumed TCC Sale Quantity	[B], assumed	1049	1049	1049
Assumed TCC Price	[C], assumed	$ (135)	$ (135)	$ (135)
TO TCC Revenue	[D] = [B] * -[C]	$ 141,615	$ 141,615	$ 141,615
Actual DAM Flow	[E], optimization output	1049	1049	999
Actual DAM Congestion Price	[F], optimization output	$ (135)	$ (135)	$ (135)
DAM Congestion Residual (DCR)	[G] = ([E] - [B]) * -[F]	$ -	$ (0)	$ (6,750)
TO Net of TCC Revenue and DCR	[H] = [D] + [G]	$ 141,615	$ 141,615	$ 134,865

This example assumes the TCC Sale Price equals the actual DAM Congestion Price. If the price of TCCs is consistent with Congestion Rents collected in the DAM, the impact on TCC auction revenue resulting from having sold these TCCs will be offset by the impact of these TCCs on the DAM congestion rent shortfall, so the net congestion revenue that the TOs collect will be equal to total Congestion Rents collected in the DAM. TOs would be exposed to an unhedged DAM Congestion Residual if the price of TCCs is inconsistent with Congestion Rents collected in the DAM.

Discussion: Example 3 Results

- It was not economic to schedule Operating Reserves to enable line flows over the baseline transmission limit, thus, line flows decreased relative to Example 2
  - Additional transmission capacity was available but uneconomic to utilize
  - Congestion costs still accrued across the facility at the lower flow levels
- Reduced line flows decrease total transmission DAM Congestion Rent
- Under today's TCC rules, and if TCCs continue to be sold at today's quantities:
  - DAM Congestion Rents may be insufficient to fund TCC awards;
  - Residual short-fall will be allocated to TOs.
  - See next slide for details
- NYISO is continuing to review whether the interaction of Dynamic Reserves and today's TCC rules creates the need for further modifications

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