Dynamic Reserves

Ashley Ferrer
Energy Market Design

Matthew Musto
Kanchan Upadhyay
Ting Dai
Market Solutions Engineering

ICAPWG/MIWG
October 12, 2023

Agenda

- Background
- Inputs into Dynamic Reserves Formulation
- Settlement Discussions
- Scarcity Reserve Activations
- Next Steps

New York ISO

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

New York ISO

Inputs into Dynamic Reserves Formulation

Use of Forecast Load in DAM

- To determine the available transmission capability into a reserve area in the Day-Ahead Market (DAM), the 2021 RECA Study and 2022 MDCP recommended the use of Forecast Load
- Forecast Load was selected as it does not include virtual transactions, which may not be representative of expected physical flows and generation in real time

New York ISO

Use of Forecast Load in DAM (continued)

- **The NYISO proposes to continue the use of the forecast load to determine line flows in the DAM for the following constraints:**
  - 30-Minute locational reserve constraints
    - The higher of Bid Load versus Forecast Load will be used in the formulation to calculate post-contingency energy flows
  - NYCA 30-Minute Reserve Requirement
    - Line flows are only included in the formulation for the locational reserve constraints
    - NYCA reserves do not consider transmission import capability from neighboring control areas
    - Therefore, the NYCA 30-Minute Reserve Requirement will increase by a positive difference between the Forecast and Bid Load [max(0,(Forecast –Bid)] to account for the fact that NYCA Reserve Requirements are based on generator schedules that solve to Bid Load, and therefore do not reflect any difference between Forecast Load and Bid Load
      - Going forward, this component of the NYCA 30-Minute requirement will be referred to as forecast reserves
      - The 9/26/2023 MIWG describes how the NYCA 30-Minute ORDC will be formulated, including accounting for these forecast reserves

Use of Bid Load in the DAM

- The NYISO proposes to use Bid Load to determine line flows in the DAM for the 10-minute locational reserve requirements
- Solving to Forecast Load for the 30-Minute constraints represents the accurate time frame to cover deviations between Bid Load and Forecast Load
  - This proposal continues to provide the reliability benefit of securing for reserves to meet Forecast Load

New York ISO

Inputs into Dynamic Reserves Formulation

- **Consideration of Virtual Supply**
  - Dynamic Reserves will treat Virtual Supply as follows:
    - Virtual Supply will be an eligible resource to meet the locational reserve constraints for the 10-Minute constraints through their energy schedule
      - The shadow cost of the reserve constraint would factor in the energy settlement for Virtual Supply since they participate in this constraint
      - As Virtual Supply is not currently eligible to provide Ancillary Services such as Operating Reserves, Virtual Suppliers' would not be able to hold a reserve schedule
    - Virtual Supply will not be an eligible resource to meet the locational reserve constraints for the 30-Minute constraints
      - An example of how this consideration will impact scheduling and pricing will be presented at an upcoming MIWG

New York ISO

Settlements for Generators

New York ISO

Energy Settlements

- **NYISO presented examples at the 9/14 and 9/18 MIWGs to demonstrate energy scheduling, reserve scheduling, energy price formation, and reserve price formation under a nodal reserve design**
  - These examples provided a quantitative example of how the reserve constraint shadow prices would be used to determine pricing
- **The next set of slides will provide a qualitative review of the settlement examples for generators**
  - These slides discuss Examples 1 and 2 from the 9/14 presentation, starting on slide 32

New York ISO

Settlements for Power Suppliers – LBMP Price Formation: Qualitative Examples

- **The Nodal Generator LBMPs would be calculated based on the System Lambda (the marginal cost of meeting load at the Marcy Bus), and the sum of the reserve constraints, with (Generator Shift Factor on each constraint) * (Shadow Price of constraint), as well as congestion costs from energy scheduling and losses (which were not modeled in the examples discussed previously)**
  - The sum of the reserve constraints will include each constraint with a non-zero shadow price
  - In the examples discussed on 9/14, there were 24 different N-1 reserve constraints which were evaluated for 10-Minute Reserves. This example did not include constraints to evaluate 30-Minute Reserves.
  - As demonstrated in the examples, there may be multiple constraints with a non-zero shift factor.

New York ISO

Settlements for Power Suppliers – LBMP Price Formation: Qualitative Examples (continued)

- **A negative shift factor is based on the ability for that generator to provide relief for a particular constraint**
  - Under a nodal design, the optimization can tradeoff between energy and reserves to determine the least-cost solution to meet the reserve constraints
    - Both the energy schedule and the reserve schedule for a generator must include the value of output from that generator
  - To provide appropriate compensation to generators, the nodal energy price (LBMP) will include the sum of the reserve constraints, with (Generator Shift Factor on each constraint) * (Shadow Price of constraint)
  - In Example 1 from 9/14, no generators had a reserve schedule, because their energy schedules were able to provide the least-cost relief to the reserve constraints
    - The nodal LBMP included the (Generator Shift Factor on each constraint) * (Shadow Price of constraint)
    - The calculations for Generators A and B are reviewed on the next slide

New York ISO

Energy Settlements for Generators– LBMP Price Formation: Qualitative Example (continued)

The first binding constraint in this example was the Loss of L1 on R1, with a shadow cost of $5.18/MW. Both generators in this example have a negative shift factor on that constraint.

To determine the nodal LBMP, each non-zero shadow is multiplied by the shadow price and added to the System Lambda. This assumes no congestion from energy scheduling and no losses.

	System Lambda	Shadow Price Loss of L1 on R1	Shift Factor on R1 for Loss of L1	Shadow Price Loss of Generator A on L1	Pre-Contingency Shift Factor on L1	LBMP Formation	LBMP
Generator A	21.09	5.18	-0.175	1.46	N/A	$LBMP_A = 21.09 + 0.175 * 5.18$	$ 22.00
Generator B	21.09	5.18	-0.3	1.46	-0.24	$LBMP_B = 21.09 + 0.3 * 5.18 + .24 * 1.46$	$ 23.00

The second binding constraint in this example was the Loss of Generator A on R1, with a shadow cost of $1.46/MW. Only Generator B has a negative shift factor on that constraint; since it is for the Loss of Generator A

New York ISO

Energy Settlements for Generators

- **NYISO's settlement process for energy payments to generators is based on their generation schedule (MW) and nodal LBMP ($/MW)**
  - These determinants are calculated during the co-optimization process and are determined by NYISO's DAM and RTM processes, which are then used by NYISO's billing system to determine payments
  - Reserve constraints introduced by Dynamic Reserves will be reflected in the nodal LBMP as determined by NYISO's software
    - This would include both the NYCA Forecast Load constraint and locational reserve constraints
    - This will be an inherent tradeoff to the optimization due to the modeling of the reserve constraints
  - Generators will be settled based on their schedule and nodal LBMP as is done today

New York ISO

Reserve Settlements for Generators

- **NYISO's settlement process for reserve payments to generators is based on their reserves schedule (MW) and the market clearing price ($/MW) for each reserve product (10-Minute Spin, 10-Minute Total, 30-Minute Total)**
  - Currently, the clearing price for each reserve product is determined by NYISO's software as part of the co-optimization process and is based on the cascading logic for reserve products and the reserve products that a generator is scheduled for
  - These determinants are used by NYISO's billing system to determine payments
- **Under Dynamic Reserves, the price setting for reserve payments to generators will change, but the settlement process will remain the same**
  - A nodal reserve price will be set at a generator bus for each product: 10-Minute Spin, 10-Minute Total, 30-Minute Total
  - The Nodal Reserve price will include the NYCA clearing price for all NYCA products
  - The Nodal Reserve price will represent the ability for a generator to provide relief to multiple constraints
  - A generator will receive a schedule for each reserve product

Impact of Forecast-Bid Reserve Component

- **The [Forecast-Bid] reserves will require additional reserves when Forecast Load > Bid Load in the Day-Ahead Market**
  - 30-Minute Total NYCA requirement = Output of the Largest Generator + Second Largest Generator + max(0,(Forecast –Bid))
    - If cleared generation is less than forecasted load, then reserves will be scheduled to cover the difference between the load forecast and scheduled physical generation
- **The introduction of this additional component creates new tradeoffs, since the physical generation is a decision variable in the market solution; therefore, solving more Bid Load or scheduling more physical generation reduces the amount of forecast reserves**
  - This tradeoff may result in price separation between the generator LBMP and zonal load LBMP
  - This necessitates the need for a new settlement construct to recover the cost of the forecast reserves
    - NYISO will be discussing these payments at a future MIWG

New York ISO

Scarcity Reserve Requirements

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 with such a requirement priced at $500/MW

New York ISO

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]
  - With the exception of NYCA and NYC (the Scarcity Reserve Region), there are no changes to the pricing for the additional MW (i.e., in SENY or East)
  - 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

New York ISO

Scarcity Pricing Formulation

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

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

  - *k: Index for Gens; l: Index for constraints; Zn: Index for Zones*
  - *This constraint has a $40/MW demand curve in this example*

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

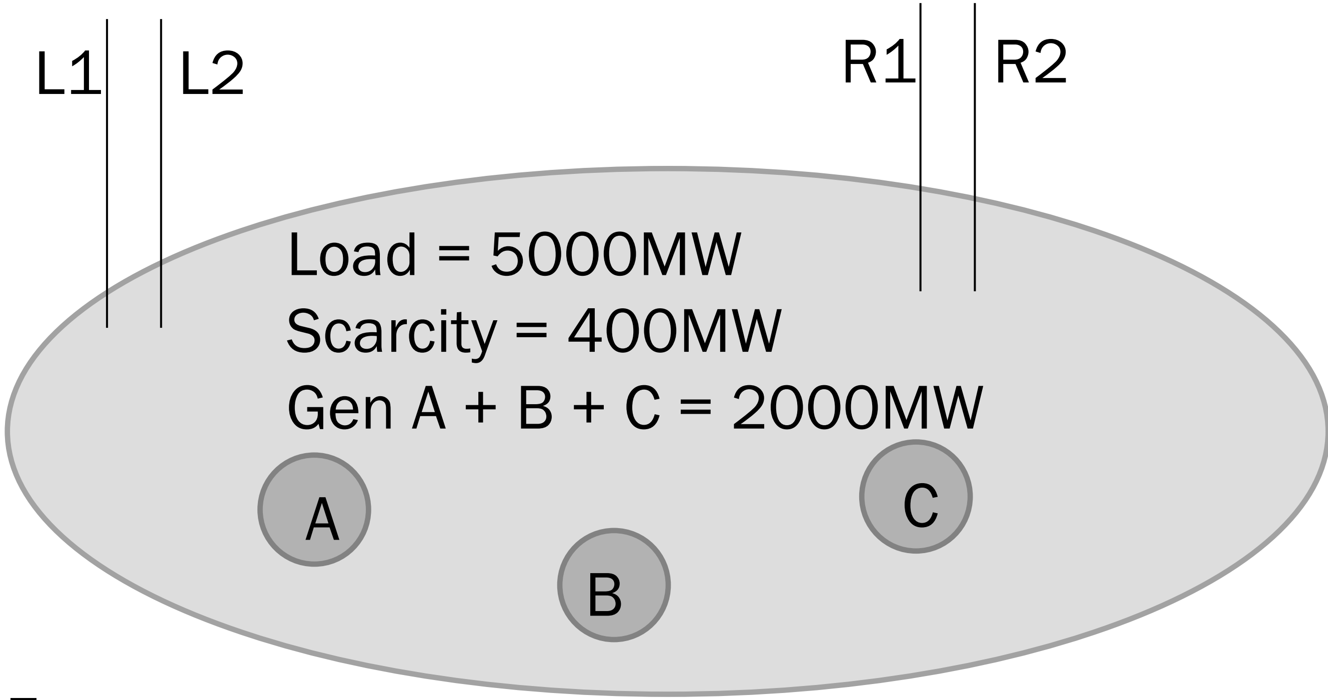
$$\sum_{SF<0} (Res_k * SF_{k,l}) \geq \sum \text{Scarcity Reserve Requirement}_{Zn} * SF_{Zn,l}$$

  - *This constraint has a* $500/MW demand curve

New York ISO

Scarcity Example

- Projected load was 5,300MW+, activated SCR/EDRP of 500MW, Available capacity 100MW, Scarcity requirement is 400MW
- Actual RT load is 5,000MW resulting in real flow on the lines of 750MW calculated here:
  - Assume all lines have a 0.25 shift factor to zonal load
  - Flow on each line is: 5000*.25 – sum of generation * .25 which 1,250MW – 500MW = 750MW
- Reserve Constraint for 30T is:
- $\sum Generation \ * ShiftFactor + \sum(Loads + Scarcity\ Reserve\ Requirement) \ * ShiftFactor - \sum Reserves \ * ShiftFactor \leq LineLimit$ @$40 ORDC
- Imputing 400MW of load would add 100MW of flow to each line bringing flow to 850MW.
- Additionally, a constraint is created to test but/for activation where, Reserves * SF > 100MW @ $500 ORDC
  - This is for each zone load pulling on a constraint and is a direct measurement.



New York ISO

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 10/19/23 MIWG
  - Discuss remaining outstanding market design elements and tariff at October MIWGs
  - Present MDC and tariff at November BIC

New York ISO

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

Appendix

*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

New York ISO

*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.

New York ISO

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

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

New York ISO

*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