Ancillary Services Shortage Pricing- Data Analysis

Pallavi Jain

Market Design Specialist, Energy Market Design

Market Issues Working Group

October 18, 2019, Krey Corporate Center

DRAFT – FOR DISCUSSION PURPOSES ONLY

Agenda

- Background
- Frequency and persistence of reserve shortages
- September 3, 2018 event analysis
- Value of Lost Load and Loss of Load Probability analysis
- Next Steps
- Appendix

Background

Background- A Grid in Transition

- Environmentally focused public policies in New York are driving a transition to increased reliance on weather-dependent resources.[1]
- The variability and unpredictability of wind and solar generation resources and the potentially large quantities of each present a challenge for future grid operations.
  - The grid will need responsive and flexible resources to address changes in net load, as well as support reliable operations.

1. For further discussion, please see the report "Reliability and Market Considerations for a Grid in Transition" at the following link: https://www.nyiso.com/documents/20142/6785167/Grid%20in%20Transition%20DRAFT%20FOR%20POSTING.pdf/74eb0b20-6f4c-bdb2-1a23-7d939789ed8c

Background- A Grid in Transition

- **Effective pricing of energy and ancillary services products to reflect system conditions and operational needs is crucial.**
  - Reserve prices fall when and where this grid reliability service is not needed or when there is ample supply.
    - In this way, and by fostering competition, prices help to maintain grid reliability at the lowest cost.

2019 Energy Market Design Reserve Projects

- The NYISO is discussing three projects in 2019 that are directly relevant to the reserve market.
  - These projects are independent; one may be approved and implemented without the others.
- Reserves for Resource Flexibility (Proposed 2020 milestone: Deployment)
  - Increase reserve requirements to account for uncertainty on the transmission system.
- More Granular Operating Reserve (Not Prioritized for 2020)
  - Establish reserve requirements for certain load pockets in NYC.
- Ancillary Services Shortage Pricing (Proposed 2020 milestone: Market Design Complete)
  - Re-evaluate the demand curve prices used for ancillary services.

DRAFT – FOR DISCUSSION PURPOSES ONLY

Previous Presentations

Date	Working Group	Discussion points and links to materials
12-17-14	MC	Comprehensive Shortage Pricing
04-10-18	Market Issues Working Group (MIWG)	Ancillary Services Shortage Pricing Reserve Procurement for Resilience
05-09-18	Market Issues Working Group (MIWG)	Ancillary Services Shortage Pricing
05-31-18	Market Issues Working Group (MIWG)	Ancillary Services Shortage Pricing : Market Design Concept Proposal
01-24-19	Market Issues Working Group (MIWG)	Operating Reserve Background
05-22-19	Market Issues Working Group (MIWG)	2019 Master Plan: Draft & Discussion
03-27-19	MC	Establishing Zone J Operating reserve requirement
07-10-19	Market Issues Working Group (MIWG)	Ancillary Services Shortage Pricing

Study Objective

- 2019 Project Goal: Study Complete (Q4)
- Assess whether the current reserve demand curve pricing levels continue to support reliable operations
- Evaluate the appropriateness of revising the structure of the current reserve demand curves (e.g., including additional, more granular steps)

Study Outline

- **Objective: Evaluate the effectiveness/appropriateness of current reserve demand curves pricing and make recommendations for potential enhancements where appropriate**
- **Preliminary Study Outline**
  - Background and importance of Shortage Pricing
  - Other ISO/RTO
    - PJM and ISO-NE reserve shortage pricing values Prices (Note: see July 10, 2019 presentation)
    - PJM and ISO-NE pay-for-performance incentives (Note: see July 10, 2019 presentation)
    - Value of Lost Load (VOLL) and Loss of Load Probability (LOLP)
  - NYISO
    - Frequency and persistence of reserve shortages
    - September 3, 2018 event review
    - Commitment costs analysis
    - VOLL and LOLP analysis
  - Conclusions/Recommendations

NEW YORK INDEPENDENT SYSTEM OPERATOR

DRAFT – FOR DISCUSSION PURPOSES ONLY

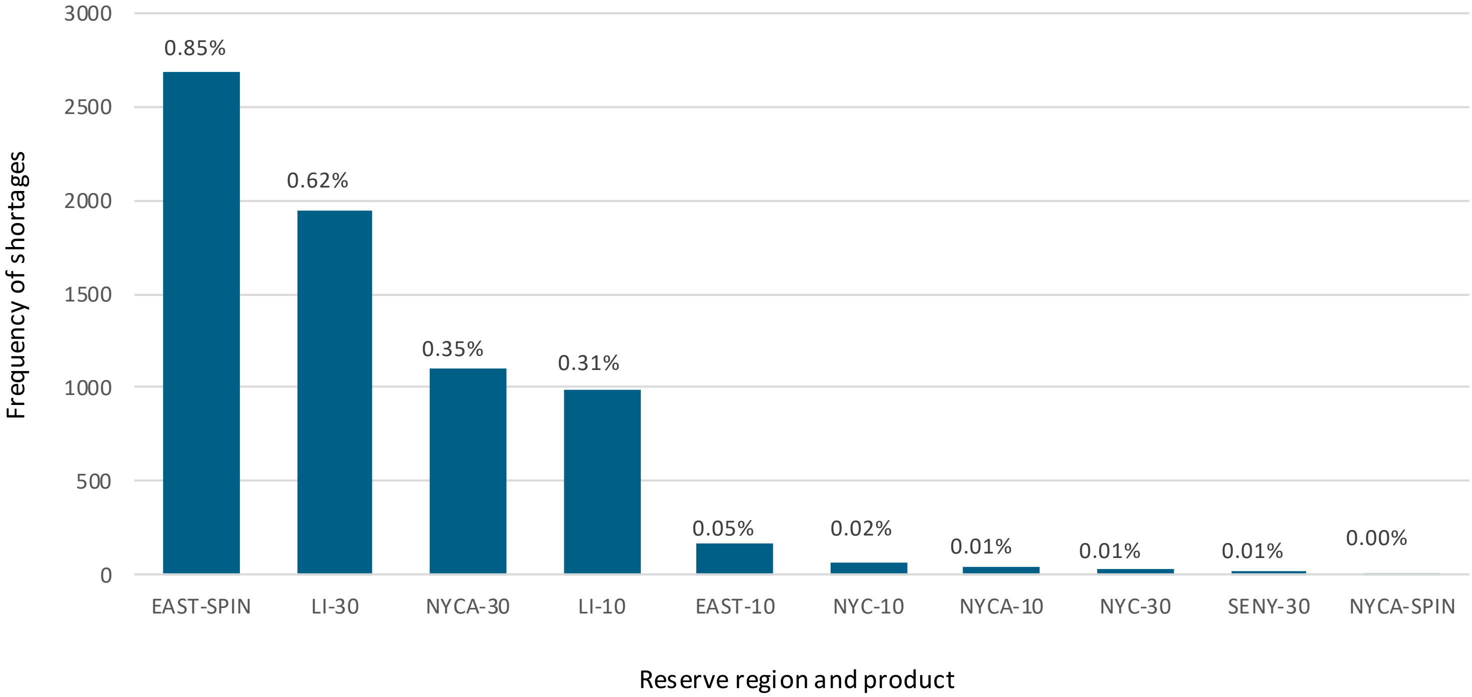
Frequency of Reserve Shortage Analysis

Frequency of Reserve Shortages

- Historic data from July 1, 2016 through July 1, 2019 was analyzed to assess the frequency of reserve shortages in real-time
- The frequency of reserve shortages by reserve region and product are shown in the graph on the following slide
  - The graph shows a histogram of the number of RTD shortages by reserve region and product during the timeframe analyzed
- The most common reserve shortages occurred in the following order:
  - EAST (zones F - K) – Spinning reserves
  - Long Island (zone K) – 30-minute reserves
  - NYCA (zones A – K) – 30-minute reserves

NEW YORK INDEPENDENT SYSTEM OPERATOR

Frequency of Reserve Shortages during July 2016 - July 2019

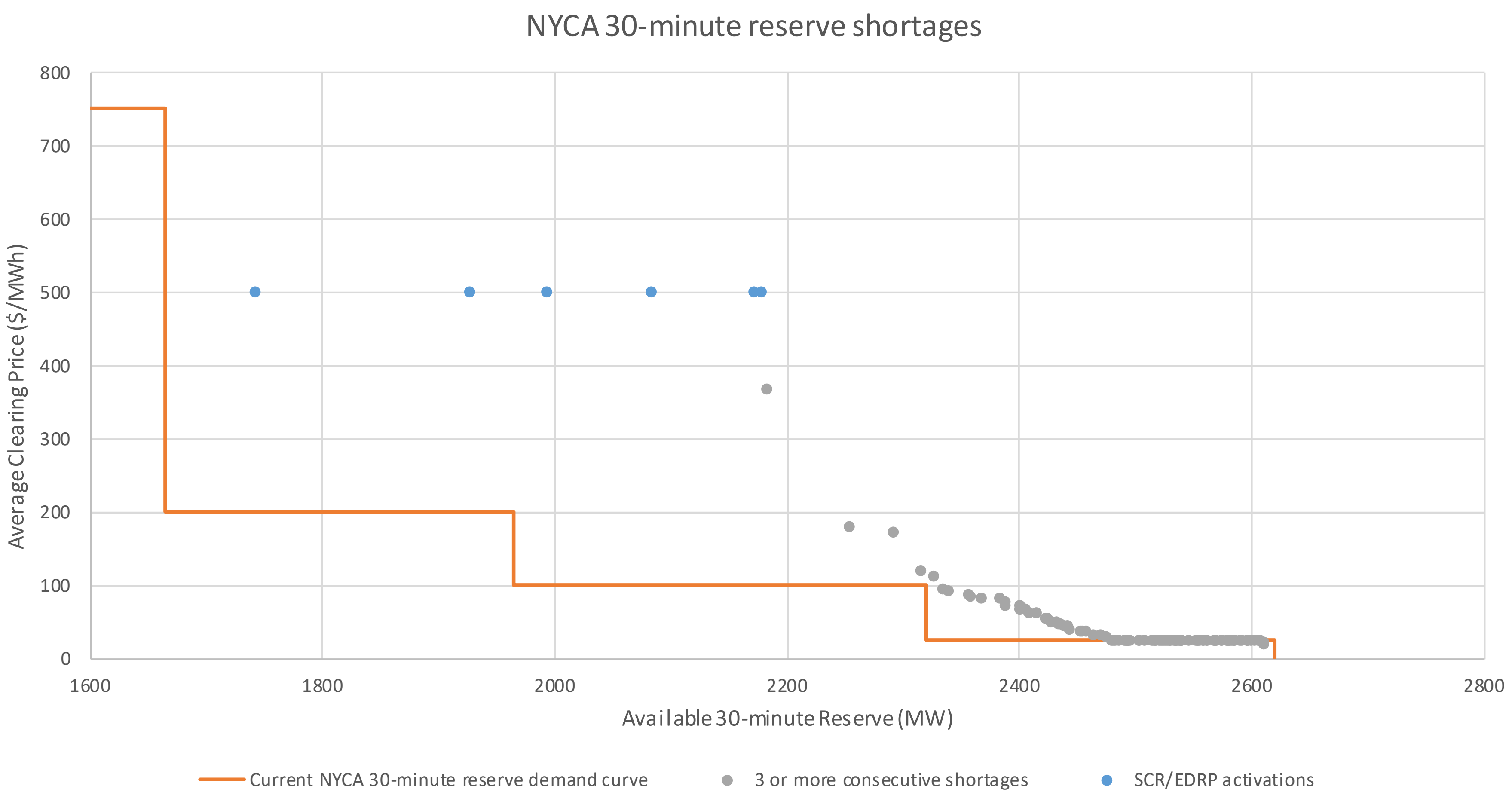


Persistent Reserve Shortage Analysis

DRAFT – FOR DISCUSSION PURPOSES ONLY

Persistent Reserve Shortage Analysis

- **Historic data from July 1, 2016 through September 1, 2019 was analyzed to assess the persistence of reserve shortages in real-time.**
- **Persistent shortages could be indicative of a systematic problem with price signals**
  - For purposes of this analysis a "persistent shortage" is defined as shortages that lasted for 3 or more consecutive Real-Time Dispatch (RTD) intervals
- **The graph shows a scatter plot of the average reserve available(MW)against the average reserve clearing price ($/MWh)**
  - SCR/EDRP activations are shown in blue as the demand curve during these activations is $500/MWh



NYCA 30-minute reserve shortages
Average Clearing Price ($/MWh)
800
700
600
500
400
300
200
100
0
1600
1800
2000
2200
2400
2600
2800
Available 30-minute Reserve (MW)
Current NYCA 30-minute reserve demand curve
3 or more consecutive shortages
SCR/EDRP activations

September 3, 2018 Event

NEW YORK
INDEPENDENT
SYSTEM OPERATOR

September 3, 2018 Overview

- The Market Monitoring Unit (MMU) has cited to market outcomes on Sept 3, 2018 in highlighting the need for potential changes to the current ancillary services shortage prices in New York.[1]
- System conditions in ISO-NE were very tight resulting from a under-forecast of load (2,500 MW under forecast) and an unexpected generation loss of 1,600 MW (in day forced outage)
- Pay-for-performance incentives were triggered in ISO-NE
  - Resources that performed in ISO-NE received additional $2000/MWh (scheduled to rise to $5,455/MWh in 2024)
  - This payment is in excess of the prevailing energy and reserve clearing prices.

[1] Potomac Economics, 2018 State of the Market report for the New York ISO Markets, Pg. 79-80

September 3, 2018 Overview

- **ISO-NE cut NENP (1385 Line) exports to Long Island from 15:25 to 18:00**
- **ISO-NE cut Cross-Sound Cable exports to Long Island (330 MW) from 16:00 to 20:00.**
  - NYISO undertook OOM action in response by starting certain peaking resources on Long Island to maintain transmission security
- **ISO-NE made emergency purchases from NY (up to 251 MW from 17:00 to 18:00).**
  - NYISO was experiencing 30-minute reserve shortages, resulting in emergency purchases from Ontario in order to provide the requested emergency energy to ISO-NE.
- **The export limit to ISO-NE was temporarily increased from 1,400 MW to 1,650 MW to facilitate the emergency purchase.**
  - NYISO wheeled emergency energy from IESO to support ISO-NE
- **NYISO curtailed several export transactions to PJM (< 100 MW).**
  - NYISO and ISO-NE both experienced shortages of 30-minute reserves.

Reserve shortages in RTC

- Persistent reserve shortages occurred in Real-Time Commitment(RTC)
- Forward horizons of the RTC software recognized the shortages in New York but, based on the demand curve pricing values, going short was the most economic decision
  - Highlights the importance of assessing the current reserve shortage pricing levels to ensure efficient outcomes

NEW YORK INDEPENDENT SYSTEM OPERATOR

Purchase of Emergency Energy from Ontario

- **ISO-NE made emergency purchases from NY (up to 251 MW from 17:00 to 18:00)**
  - Because New York was experiencing 30-minute reserve shortages, NYISO purchased emergency energy from Ontario to provide the emergency assistance requested by ISO-NE
- **Analyzing the imports and exports, it was observed that all regions except Ontario had binding interfaces**
  - In other words, although transactions were available, the market software could not schedule imports because the interfaces were import constrained between NYISO and HQ, PJM
    - Interfaces between NYISO and ISO-NE were export constrained.

Value of Lost Load (VOLL) and Loss of Load Probability (LOLP) Analysis

VOLL and LOLP

- **Value of Lost Load (VOLL) : Value that a 1MW reserve increment has in preventing the shedding of 1 MW of load**
  - Alternatively, VOLL can also be defined as the cost imposed by involuntary load curtailment
  - It is generally expressed as $/MWh of unserved energy
- **Loss of Load Probability (LOLP): The probability of losing reserves (or load, if the minimum reserves requirement is zero) at a given reserve level**
- **VOLL can be considered to inform effective reserves shortage pricing**
  - The MMU has suggested that efficient reserve demand curves should be established in consideration of the Loss of Load Probability(LOLP) multiplied by the VOLL.[1]

$$Value\ of\ Reserve\ (R) = VOLL\ * LOLP\ (R)$$

R – Reserve Level

[1] Potomac Economics, 2018 State of the Market report for the New York ISO Markets, Pg. 80

VOLL adoption across other ISOs/RTOs

ISOs/RTOs	Value of Lost Load ($/MWh)	Justification/Rationale
ERCOT	$9,000 (implemented)	Board decision based on Customer Survey
MISO	$3,500 (implemented)	Currently implemented value of $3,500/MWh is based on the results of 24 surveys conducted between 1989 and 2002.[1]
ISO-NE	$30,000 (proposed by ISO-NEs external market monitor)	Based on higher end estimates of VOLL from study on service reliability estimates for electric utility customers.[2]

[1] Lawton, Leora, Michael Sullivan, Kent Van Liere, Aaron Kalz, Joseph Eto. A Framework and Review of Customer Outage Costs: Integration and Analysis of Electric Utility Outage Cost Surveys. November 2003. https://emp.lbl.gov/sites/all/files/lbnl-54365.pdf
[2] Sullivan, Michael J., Josh Schellenberg, Marshall Blundell. Updated Value of Service Reliability Estimates for Electric Utility Customers in the United States. January 2015. http://eta-publications.lbl.gov/sites/default/files/lbnl-6941e.pdf

NEW YORK INDEPENDENT SYSTEM OPERATOR

VOLL – Estimation

- **VOLL is difficult to estimate**
  - It varies by customer, season, timing and duration of outage

- **Three broad methods of VOLL estimation as mentioned in London Economics International (LEI) study:[1]**
  - Customer surveys
  - Macroeconomic analysis – high level estimates based on Gross Domestic Product (GDP) and energy consumption
  - Case studies of outage events

[1] London Economics International LLC. Estimating the Value of Lost Load. June 17, 2013

VOLL – Estimation for NY using Macroeconomic method

- **One of the macroeconomic methods to determine VOLL is using GDP and load**
  - VOLL = GDP/Electricity consumption[1]
- **For NY state, VOLL using this method comes out to be $11,000/MWh**
  - GDP (2017 $) ~ $1,600 billion (from Bureau of Economic Analysis)
  - Load ~ 145 million MWh
  - VOLL ~ $11,000/MWh

[1] London Economics International LLC. Estimating the Value of Lost Load. June 17, 2013

VOLL – Estimation for NY using ICE Calculator

- **This estimation is based on ICE (Interruption Cost Estimation calculator)[1]**
  - ICE calculator is based upon the comprehensive study report on reliability estimates available for U.S. by Lawrence Berkeley National Laboratory[2]

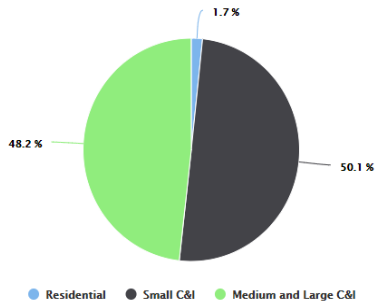
SAIFI	SAIDI	CAIDI	#Residential	#Non-Residential	
0.740	128.8	174.0	7,144,413	1,096,886	New York

Interruption Cost Estimates

Sector	# of Customers	Cost Per Event (2016$)	Cost Per Average kW (2016$)	Cost Per Unserved kWh (2016$)	Total Cost (2016$)
Residential	7,144,413	$7.10	$8.52	$2.94	$37,525,339.61
Small C&I	1,020,592	$1,489.87	$432.16	$149.02	$1,125,205,247.86
Medium and Large C&I	76,294	$19,174.87	$188.27	$64.92	$1,082,566,111.65
All Customers	**8,241,299**	**$368.17**	**$175.97**	$\boxed{\textbf{\$60.68}}$	**$2,245,296,699.12**

~ 60,000 $/MWh

Total Cost of Sustained Interruptions by Sector



[1] https://icecalculator.com/home
[2] Sullivan, Michael J., Josh Schellenberg, Marshall Blundell. Updated Value of Service Reliability Estimates for Electric Utility Customers in the United States. January 2015. http://eta-publications.lbl.gov/sites/default/files/lbnl-6941e.pdf

DRAFT – FOR DISCUSSION PURPOSES ONLY

VOLL – Estimation for NY

- Based on the above two methods, two values of VOLL ($11,000/MWh and $60,000/MWh) were considered for the preliminary analysis.

LOLP– Estimation methodology across other ISOs/RTOs

ISO/RTO	Whether ORDC is based on Loss of Load	Estimation Method
ERCOT	Yes (implemented)	Based on reserves forecast error risk
MISO	No (Proposed by Potomac Economics)	Based on: 1. Generator forced outage risk 2. Intermittent resources forecast error risk 3. Net scheduling interchange (NSI) error risk
ISO - NE	No (Proposed by Potomac Economics)	Based on generator forced outage risk
PJM	Proposal pending before FERC	Based on: 1. Forced outage risk of thermal units 2. Load forecast error risk 3. Wind forecast error risk 4. Solar forecast error risk 5. Net interchange schedule error risk

LOLP - Estimation for the NYCA

- This analysis is based on an approach Potomac Economics recommended to MISO.[1]
- LOLP values for NYCA 10-minute and NYCA 30-minute reserves were calculated using a Monte Carlo simulation to simulate possible outages due to different risks

Risks	NYCA – 30 min	NYCA – 10 min
Generator forced outage risk	Applying Potomac Economics' proposed methodology to MISO with NYISO values	Applying Potomac Economics' proposed methodology to MISO with NYISO values
Load and intermittent resources forecast error risk	Based upon 30 minute "Net Load Forecast Error" = - ((Forecast Load – Actual Load) – (Forecast Wind – Actual Wind))	Based upon 10 minute "Net Load Forecast" Error = - ((Forecast Load – Actual Load) – (Forecast Wind – Actual Wind))
Desired net interchange (DNI) error risk	Not considered	"DNI Error Risk" = RTC Net Interchange – RTD Net Interchange

[1] Potomac Economics. 2017 State of the Market Report for the MISO Electricity market, Analytic Appendix, Section V.F, Pg. 59

NEW YORK INDEPENDENT SYSTEM OPERATOR

Generator Forced Outage Risk calculation

- **Calculation Methodology**
  - Outage MW due to generator outage risks were calculated using the factors below from Potomac Economics' recommendation to MISO
    - Participation factor (PF) =

$$\frac{Sum\ of\ online\ capacity}{Sum\ of\ installed\ capacity\ across\ all\ hours}$$

    - Mean Service Time to Unplanned Outage (MSTUO) =

$$\frac{Service\ Hours}{Number\ of\ Unplanned\ outages}$$

    - Outage Recovery Period: No. of hours needed to fully respond to supply side contingencies in the Reliability Assessment Commitment (RAC) process

- **Simulating the outages for large number of iterations provides a reasonable estimate of expected outage MW**

DRAFT – FOR DISCUSSION PURPOSES ONLY

Load and Intermittent Resource Forecast Error

- Load and intermittent resource forecast error[1] represents the risk of losing reserve MW due to difference between forecasted and actual load and wind output
- Historic data from May 2016 through April 2019 was considered for this analysis
- Calculation Methodology
  - Outage risk (MW) due to net load forecast error is the inverse of the cumulative normal distribution function for the net load forecast error distribution at a given distribution probability
    - The distribution probability was varied randomly for 30,000 iterations
    - Mean and standard deviation from the net load forecast error calculation were used
      - Net Load Forecast Error is calculated as:

$$-\big((Forecast\ Load - Actual\ Load) - (Forecast\ Wind - Actual\ Wind)\big)$$

1. For details on this analysis refer to the "Resource for Resource Flexibility" presentation from Sept 26, 2019 at the link below: https://www.nyiso.com/documents/20142/8414685/9_26_2019_Reserves_for_Resource_Flexibility_FINAL.pdf/ba7fb774-49d5-0c96-1d2c-664a2c9c3c05

Desired Net Interchange (DNI) Error Risk

- DNI error risk represents the risk of losing reserve MWs due to difference between RTC and RTD Net Interchanges.
- Historic data from May 2016 through April 2019 was considered for this analysis
- Calculation Methodology
  - Outage Risk (MW) due to DNI Error is the inverse of the Cumulative Normal Distribution Function for DNI Error distribution at a given distribution probability.
    - The distribution probability is varied randomly for 30,000 iterations
    - Mean and Standard deviation from DNI Error calculation are used
      - DNI Error Risk = RTC Net Interchange – RTD Net Interchange

NEW YORK INDEPENDENT SYSTEM OPERATOR

Risk Simulation - Illustration

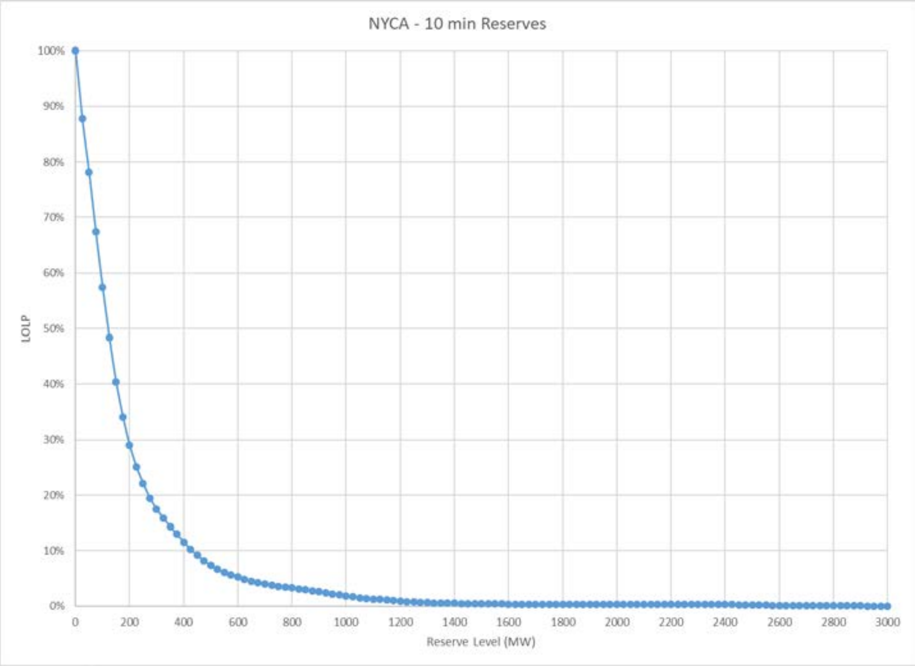
Simulation	Total Outage (MW)= Generator Forced outage Risk (MW) + Load and Intermittent Resources Forecast Error (MW) + DNI Error Risk (MW)
1	150
2	500
…	…
30,000	50

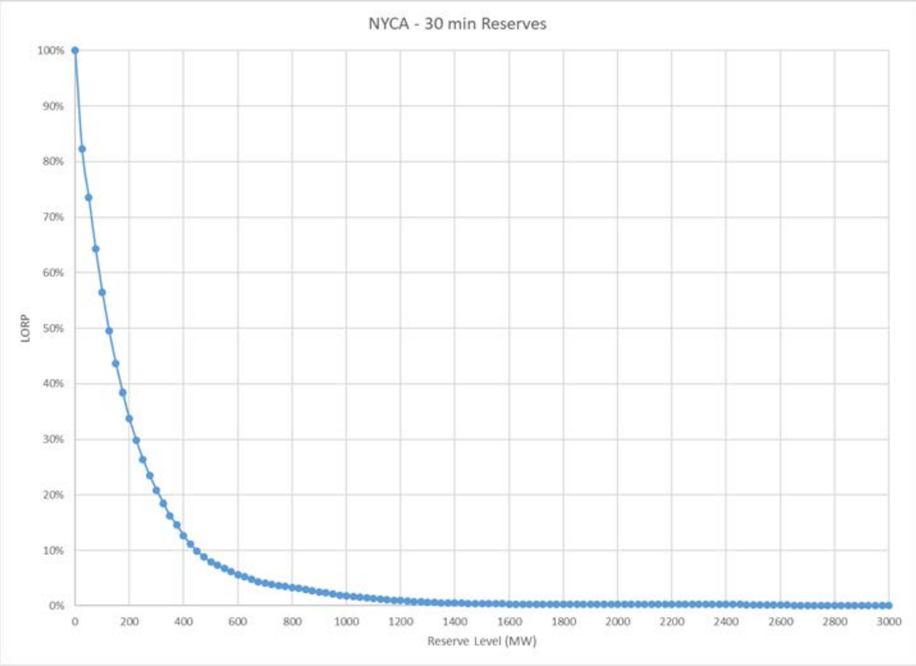
$$LOLP(at\ 100MW) = \frac{No.of\ simulations\ where\ total\ outage\ MWs \geq 100}{Total\ no.of\ simulations\ (30{,}000)}$$

NEW YORK INDEPENDENT SYSTEM OPERATOR

DRAFT – FOR DISCUSSION PURPOSES ONLY

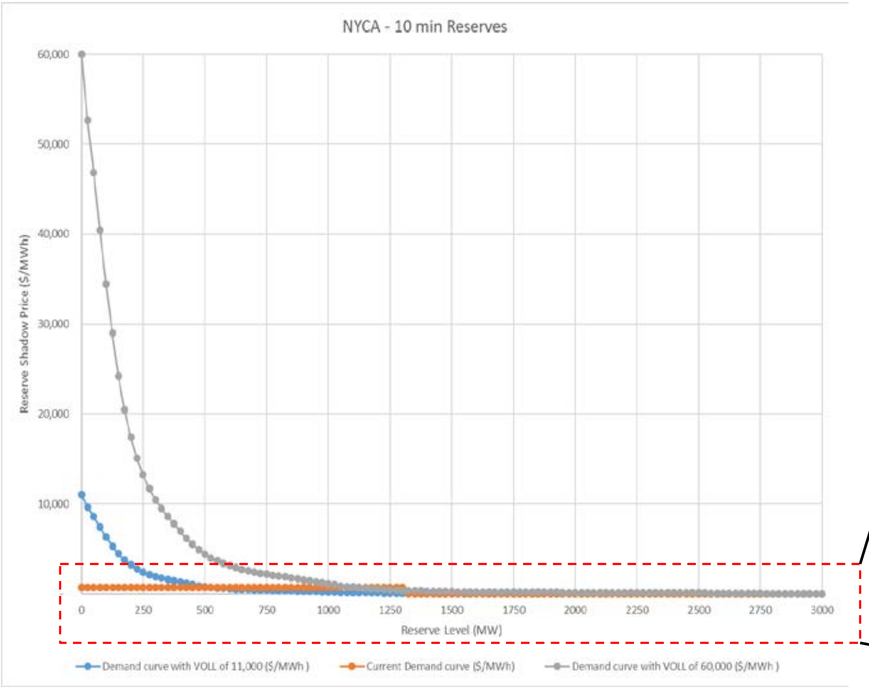
Results: LOLP Curves

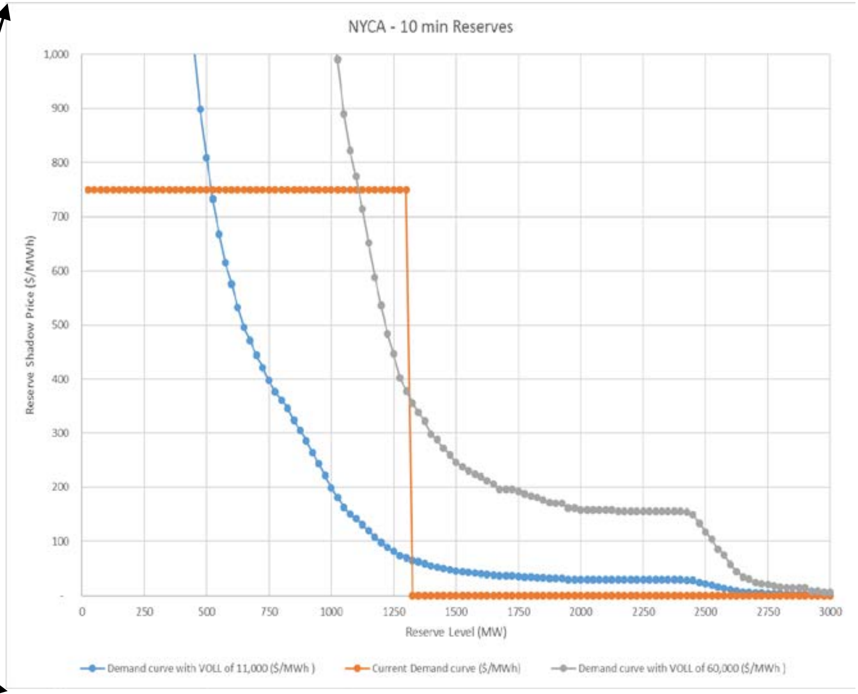




DRAFT – FOR DISCUSSION PURPOSES ONLY

Results : NYCA 10-minute Reserves

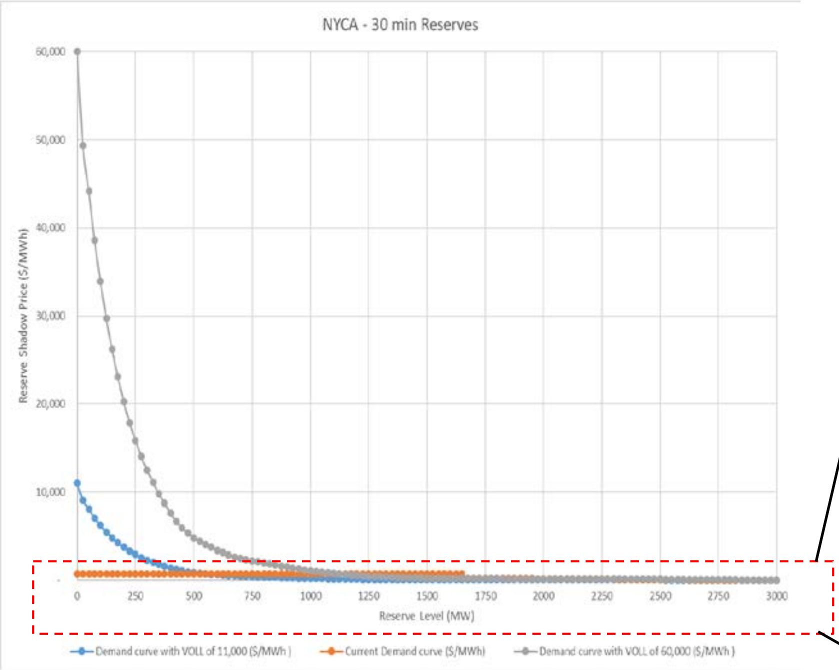


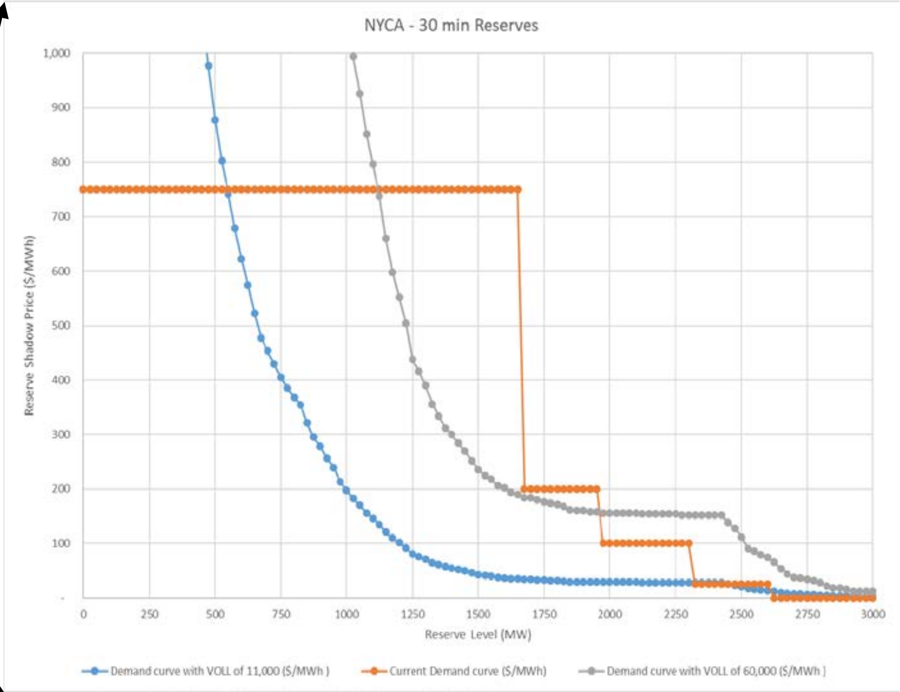


NEW YORK INDEPENDENT SYSTEM OPERATOR

DRAFT – FOR DISCUSSION PURPOSES ONLY

ORDC for NYCA 30 minute Reserves





DRAFT – FOR DISCUSSION PURPOSES ONLY

Next Steps

- **November- December 2019**
  - Discuss study and results

Feedback/Questions?

- Email additional feedback to:
  - Debbie Eckels, deckels@nyiso.com

NEW YORK INDEPENDENT SYSTEM OPERATOR

The Mission of the New York Independent System Operator, in collaboration with its stakeholders, is to serve the public interest and provide benefits to consumers by:

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

www.nyiso.com

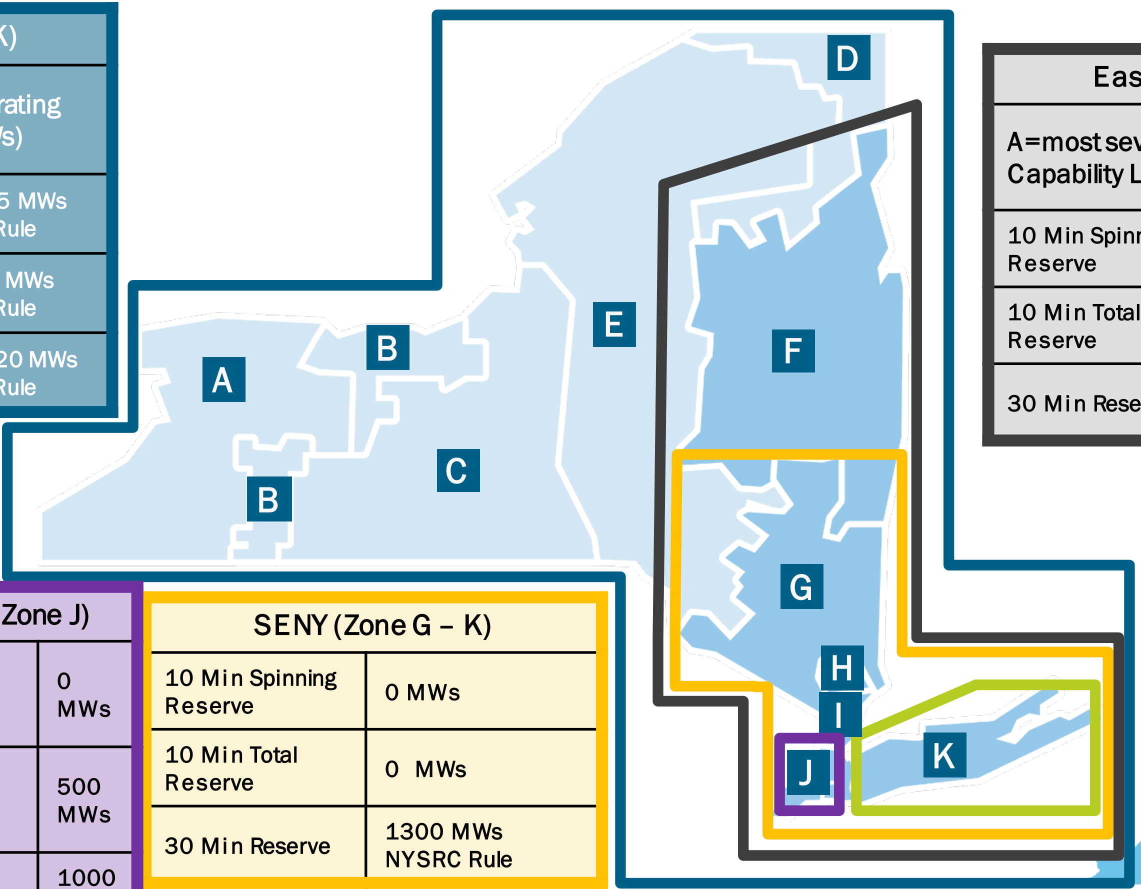
NEW YORK INDEPENDENT SYSTEM OPERATOR

Appendix

Current NYISO Operating Reserve Requirements

NYCA (Zone A – K)	
A=most severe NYCA Operating Capability Loss (1310 MWs)	
10 Min Spinning Reserve	½ A=655 MWs NYSRC Rule
10 Min Total Reserve	A=1310 MWs NYSRC Rule
30 Min Reserve	2xA=2620 MWs NYSRC Rule

A	WEST
B	GENESE
C	CENTRL
D	NORTH
E	MHK VL
F	CAPITL
G	HUD VL
H	MILLWD
I	DUNWOD
J	N.Y.C.
K	LONGIL



East (Zone F – K)	
A=most severe NYCA Operating Capability Loss (1310 MWs)	
10 Min Spinning Reserve	¼ A=330 MWs NERC, NPCC Rule
10 Min Total Reserve	1200 MWs NYSRC Rule
30 Min Reserve	1200 MWs NERC, NPCC Rule

NYC (Zone J)	
10 Min Spinning Reserve	0 MWs
10 Min Total Reserve	500 MWs
30 Min Reserve	1000 MWs

SENY (Zone G – K)	
10 Min Spinning Reserve	0 MWs
10 Min Total Reserve	0 MWs
30 Min Reserve	1300 MWs NYSRC Rule

Long Island (Zone K)	
10 Min Spinning Reserve	0 MWs
10 Min Total Reserve	120 MW NERC, NPCC Rule
30 Min Reserve	270 – 540 MWs Max limits NYSRC Rule

DRAFT – FOR DISCUSSION PURPOSES ONLY

Current NYISO Ancillary Services Demand Curves

- **Ancillary Services clearing prices are determined considering the demand curves along with resource bids**
  - The reserve demand curve values below apply during periods when the EDRP and/or Special Case Resource program have not been activated.

New York Region	Type	Demand Curve Amount (MW)	Demand Curve Price ($)
NYCA	Regulation	25.0 80.0 remainder	$25.00 $525.00 $775.00
NYCA	Spinning Reserve	All	$775.00
NYCA	10 Minute Reserve	All	$750.00
NYCA	30 Minute Reserve	300.0 655.0 955.0 remainder	$25.00 $100.00 $200.00 $750.00
Eastern New York (EAST)	Spinning Reserve	All	$25.00
	10 Minute Reserve	All	$775.00
	30 Minute Reserve	All	$25.00
Southeastern New York (SENY)	Spinning Reserve	All	$25.00
	10 Minute Reserve	All	$25.00
	30 Minute Reserve	All	$500.00
New York City (NYC)	Spinning Reserve	All	$25.00
	10 Minute Reserve	All	$25.00
	30 Minute Reserve	All	$25.00
Long Island (LI)	Spinning Reserve	All	$25.00
	10 Minute Reserve	All	$25.00
	30 Minute Reserve	All	$25.00

*The current reserve demand curve prices for each region are shown in section 6.8 of the Ancillary Services Manual and are also set forth in Section 15.4.7 of Rate Schedule 4 of MST: https://www.nyiso.com/documents/20142/2923301/ancserv.pdf/df83ac75-c616-8c89-c664-99dfea06fe2f

VOLL – Estimations across literature for U.S.

Author/Study	Region	Study Year	Data and methods	VOLL value (2012 USD/MWh)
Lawrence Berkeley National Laboratory (LBNL) study[1]	US National	2015	Meta analysis of 34 datasets from surveys/studies by 10 major US electric utilities over 16-year period (1989 – 2012). None of the utilities used for the study were located in the northeast region of U.S.	**Average value for 4-16 hours outage duration** Large C/I = $12,600/MWh Small C/I = $246,500/MWh Residential = $1,400/MWh
MISO[2]	US - Midwest	2006	Used multipliers from the Berkeley meta-database in conjunction with macroeconomic data specific to the Midwest region to calculate VOLL by customer class.	**Median value** Large C/I = $29,299/MWh Small C/I = $42,256/MWh Residential = $1,735/MWh
ICF Consulting[3]	U.S – Northeast; Canada - Ontario	2003	Macroeconomic Study of an actual outage event – the Northeast blackout of 2003. VOLL was assumed to be 80 – 120 times the retail price of electricity of $93/MWh(2003$/MWh). Total economic cost of NE blackout was estimated by multiplying assumed VOLL by the quantity of lost energy, with a resulting outcome of $8.5 – $12.9 billion USD(2012$). Basis for VOLL assumptions is not specified	$9,284/MWh – $13,925/MWh

[1] Sullivan, Michael J., Josh Schellenberg, Marshall Blundell. Updated Value of Service Reliability Estimates for Electric Utility Customers in the United States. January 2015. http://eta-publications.lbl.gov/sites/default/files/lbnl-6941e.pdf

[2] Centelella, Paul (SAIC). Estimates of the value of Uninterrupted Service for The Mid – West Independent System Operator. August 2010.

[3] ICF Consulting, "The Economic Cost of the Blackout: An Issue Paper on the Northeastern Blackout, August 14, 2003.

NEW YORK INDEPENDENT SYSTEM OPERATOR

DRAFT – FOR DISCUSSION PURPOSES ONLY