Solar Integration Study

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DRAFT – FOR DISCUSSION PURPOSES ONLY

Key Takeaways

- **No reliability issues identified for solar PV and wind penetrations level studied**
  - ***Up to 4,500 MW Wind and 9,000 MW Solar PV***
  - ***Minor increases in regulation requirements easily accommodated.***
- **Recommended that the NYISO continue to monitor regulation requirements and the bulk power system's capability to provide regulation services going forward.**
- **Recommended that the NYISO continue to pursue integration of solar forecasting into market and system operations.**

Key Takeaways

- **Recommended that the NYISO continue to study the impacts of increased intermittent resources on bulk power system reliability and requirements for essential reliability services (inertia, frequency, voltage).**
- **Recommended that the NYISO engage with regulatory and industry stakeholders to support adoption of voltage and frequency ride-through capabilities for bulk and non-bulk solar PV installations.**

Primary Areas of Investigation

- **Development of hourly solar profiles**
- **Development of a 15-year solar PV projection in the NYCA**
- **Evaluation and selection of solar forecast vendors**
- **Review of integration studies from other regions experiencing significant growth in intermittent resources**

Primary Areas of Investigation

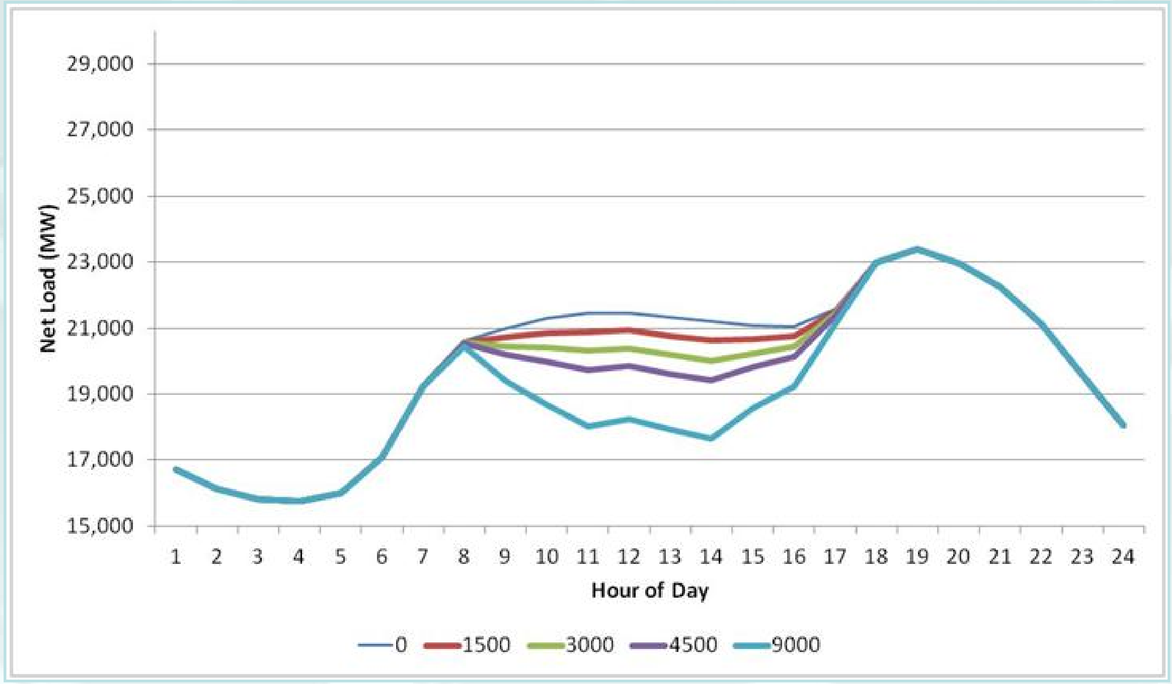
- **Review of potential reliability concerns associated with the frequency and voltage ride-through characteristics of solar installations.**
- **Analysis of the impact of various levels of solar and wind penetration on NYCA's grid operating regulation requirements.**

Data Source (Hourly Solar Profiles)

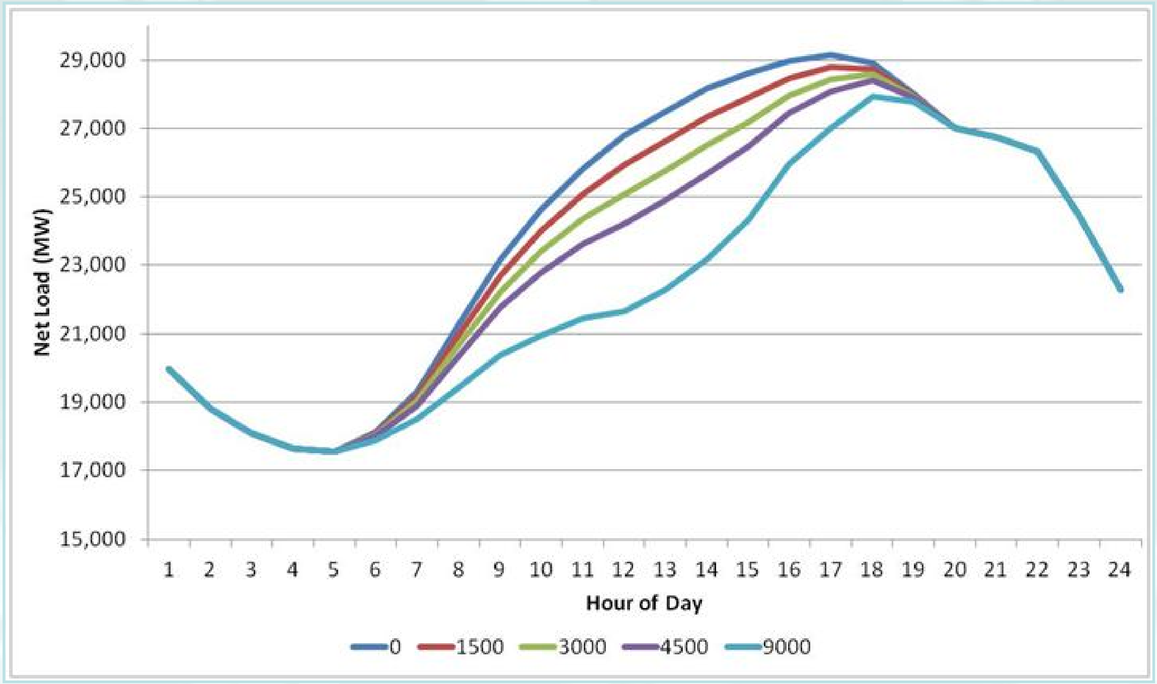
- **Typical solar PV impact shape obtained via NREL's PV Watts tool.**
  - ***Based on 20-years of actual irradiance data***
  - ***8,760 Hourly Load Shape generated for a specific location with a given system size and typical ambient conditions and technological parameters.***
- **Profiles of selected locations weighted by current solar PV distribution for NYCA load zones.**
  - ***Aggregated to calculate NYCA-wide profiles for a typical (or "normal") solar year***
- **"Business as Usual" Case – No expansion of electric storage facilities considered.**

NYCA Hourly Load Profiles

(from 2007 load and “normal” solar shapes)



Typical Winter Day: Levels of Solar Penetration



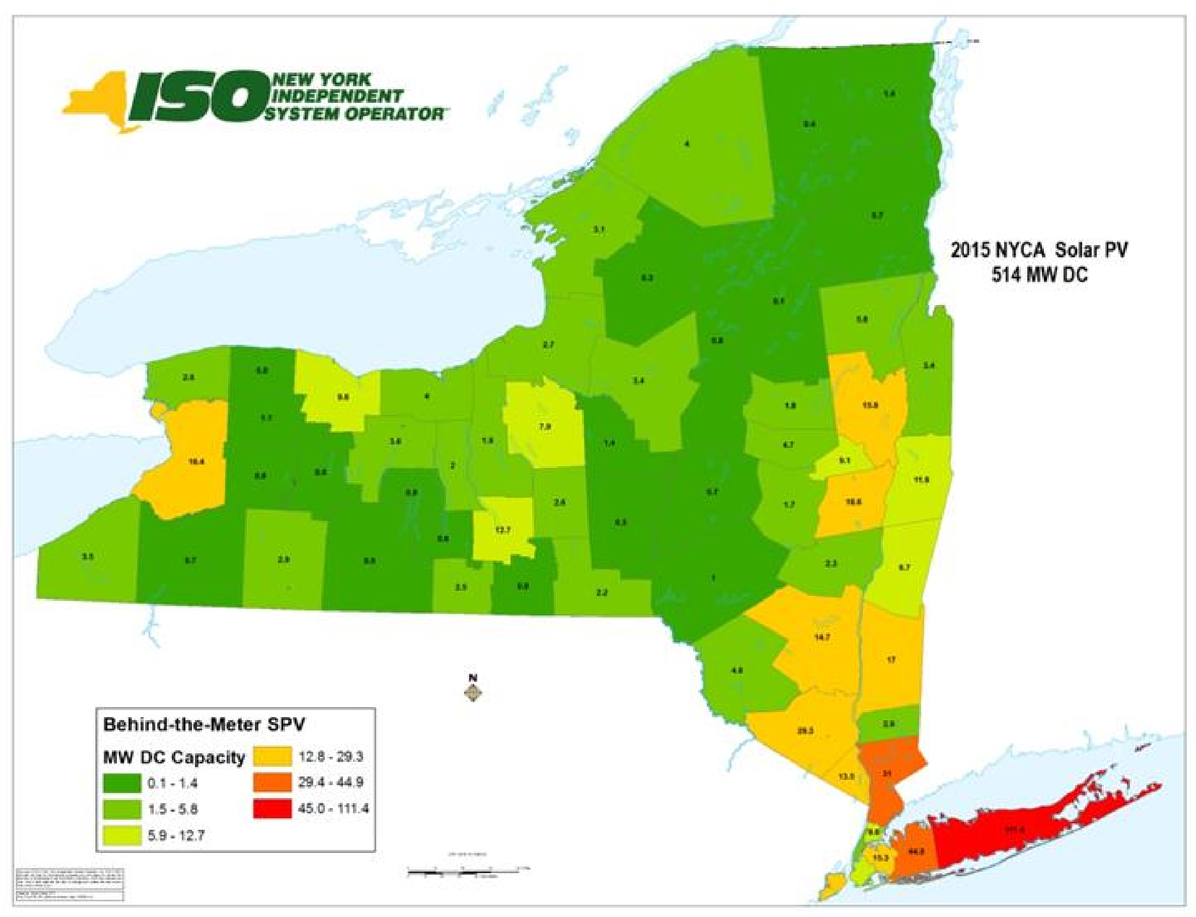
Typical Summer Day: Levels of Solar Penetration

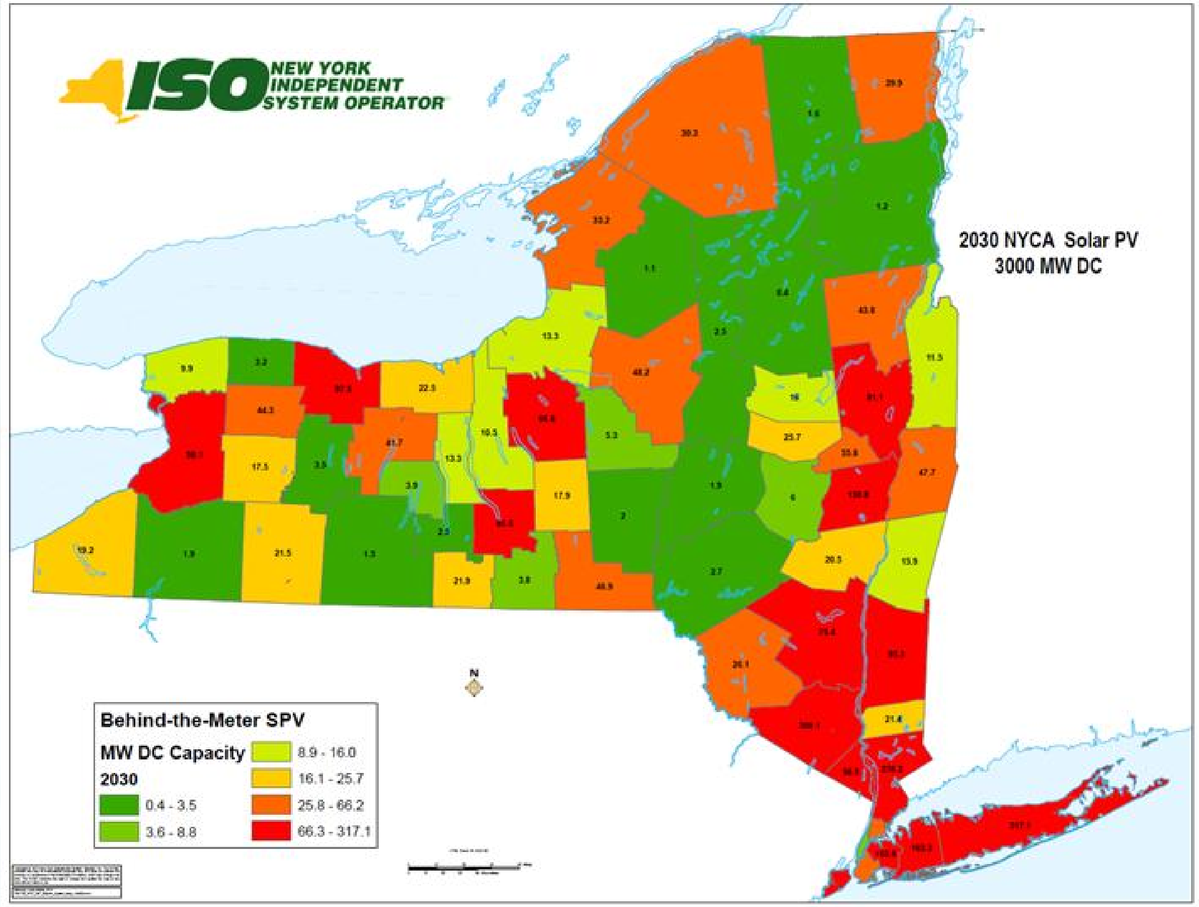
15-Year Solar PV Projection (DC MW) by Zone

Distribution of solar PV across load zones derived from current allocation of solar PV installations in NYCA and NY-Sun targets for Long Island, New York City metropolitan area, and “Rest of State.”

Load Zone	Scenario			
	C3000	C4500	C6500	C9000
A	224	412	615	837
B	119	219	328	444
C	312	538	794	1,062
D	14	24	35	48
E	137	242	356	482
F	677	1,006	1,461	2,027
G	448	561	798	1,192
H	61	76	108	159
I	104	130	185	271
J	332	530	780	1,063
K	571	761	1,040	1,415
NYCA	3,000	4,500	6,500	9,000

15-Year Growth in Behind-the-Meter Installations





Lessons Learned

California, Hawaii, PJM, Ontario and Germany

- **There needs to be sufficient flexible resources in the system to manage the transformed net load patterns; such a resource mix can consist of existing and new technologies, including storage.**
- **The availability of essential reliability services to the grid needs to be monitored, specifically: inertia, frequency, and voltage support.**
- **State public utility commissions—Hawaii (Order No. 33258) and California (Rule No. 21)—have mandated frequency and voltage ride-through capability on non-bulk power system level installations.**

Lessons Learned

California, Hawaii, PJM, Ontario and Germany

- **Improvements in wind and solar forecasting should be prioritized to inform day-ahead and real-time system operations.**
- **Planning for the large-scale integration of intermittent resources should consider the potential need for new or expanded transmission facilities.**

Evaluation and Selection of Solar Vendors

- **The NYISO conducted a six-month evaluation of the solar forecasting capabilities of three solar forecasting firms.**
- **Evaluation period ran from 5/1/2015 to 10/31/2015.**
- **Key metrics included over- and under-forecast error and frequency, standard deviation of the errors, and the r-square coefficient of actuals versus forecast.**

Evaluation and Selection of Solar Vendors

- **Two vendors selected—primary and alternate**
- **Two streams of solar forecasts to be produced**
  - ***Zonal (for behind-the-meter solar PV installations)***
  - ***Bus-level (for utility-scale solar PV installations)***
- **Solar forecasting system to go live in June 2017**
  - ***Integrated with day-ahead and real-time market operations***

Analysis of Regulation Requirements

- **Constructed load, wind, and solar PV shapes at 5-minute intervals using 2006 data**
  - ***Solar data was developed based on analysis conducted by Dr. Richard Perez (U-Albany's Atmospheric Sciences Research Center)***
  - ***The 2006 PV load shape was constructed from the 5-minute back-cast data for 10 km x 10 km cells across the state***
- **Calculated net load values (*i.e.*, load minus wind and solar PV) at 5-minute intervals and standard deviation of changes in net load**

Regulation Requirements Multiple Scenarios

Discrete MWs Studied

Scenario	Year	Projected Summer Peak Load (MW)	Projected Wind Penetration (MW)		Projected Solar Penetration (MW)
			On-Shore	Off-Shore	
1	2019	34,600	2,500	0	1,500
2	2024	35,800	3,500	0	3,000
3a	2030	37,000	4,500	0	4,500
3b	2030	37,000	3,500	1,000	4,500
3c	2030	37,000	4,500	0	9,000
3d	2030	37,000	3,500	1,000	9,000

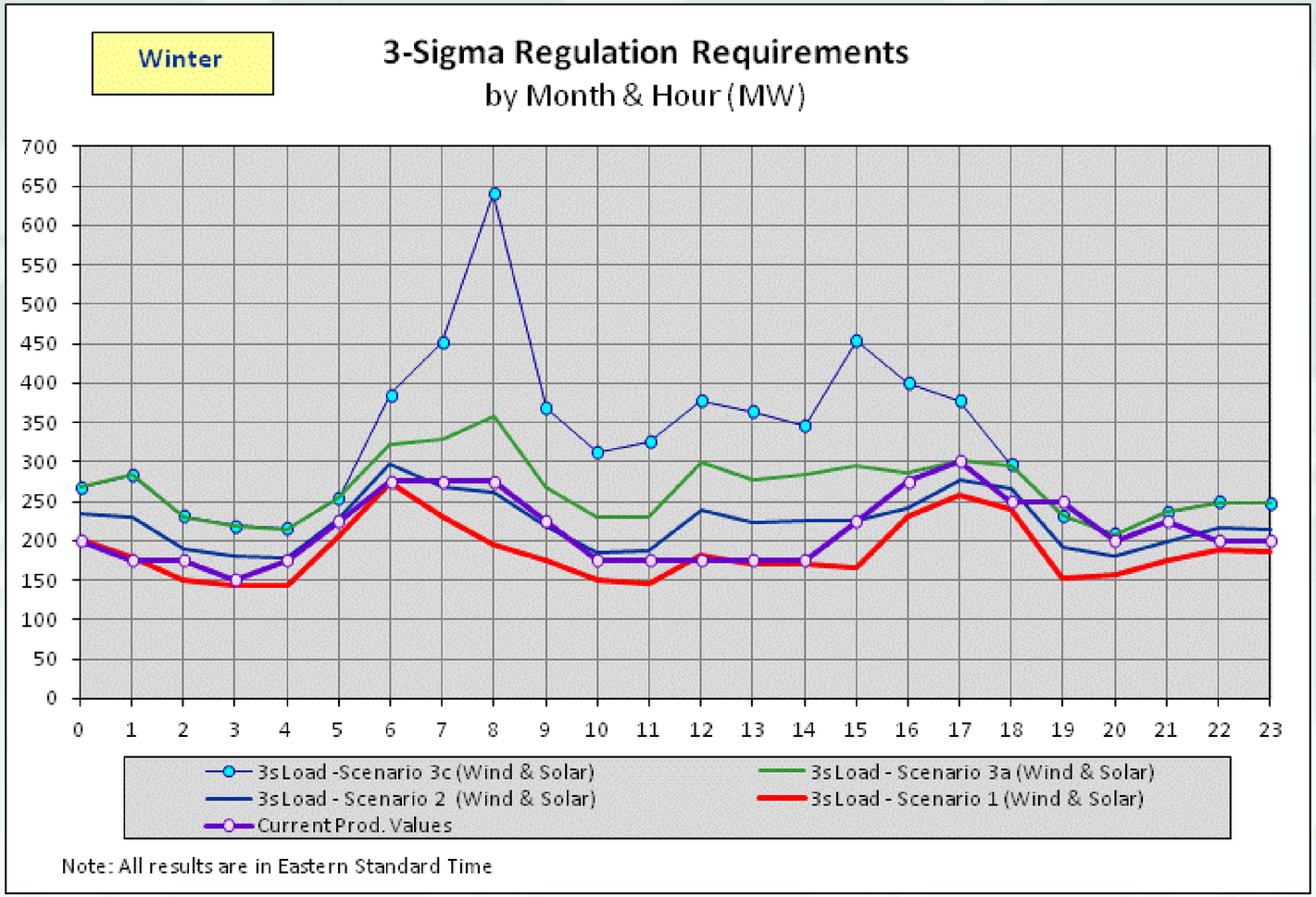
Regulation Requirements Multiple Scenarios

MW Ranges for Projected Regulation Requirements

Scenario	Wind		Solar	
	Minimum	Maximum	Minimum	Maximum
1	1,500	2,500	500	1,500
2	2,500	3,500	1,500	3,000
3a	3,500	4,500	3,000	4,500
3b	2,500 (on-shore) 1,000 (off-shore)	4,500	3,000	4,500
3c	3,500	4,500	4,500	9,000
3d	2,500 (on-shore) 1,000 (off-shore)	4,500	4,500	9,000

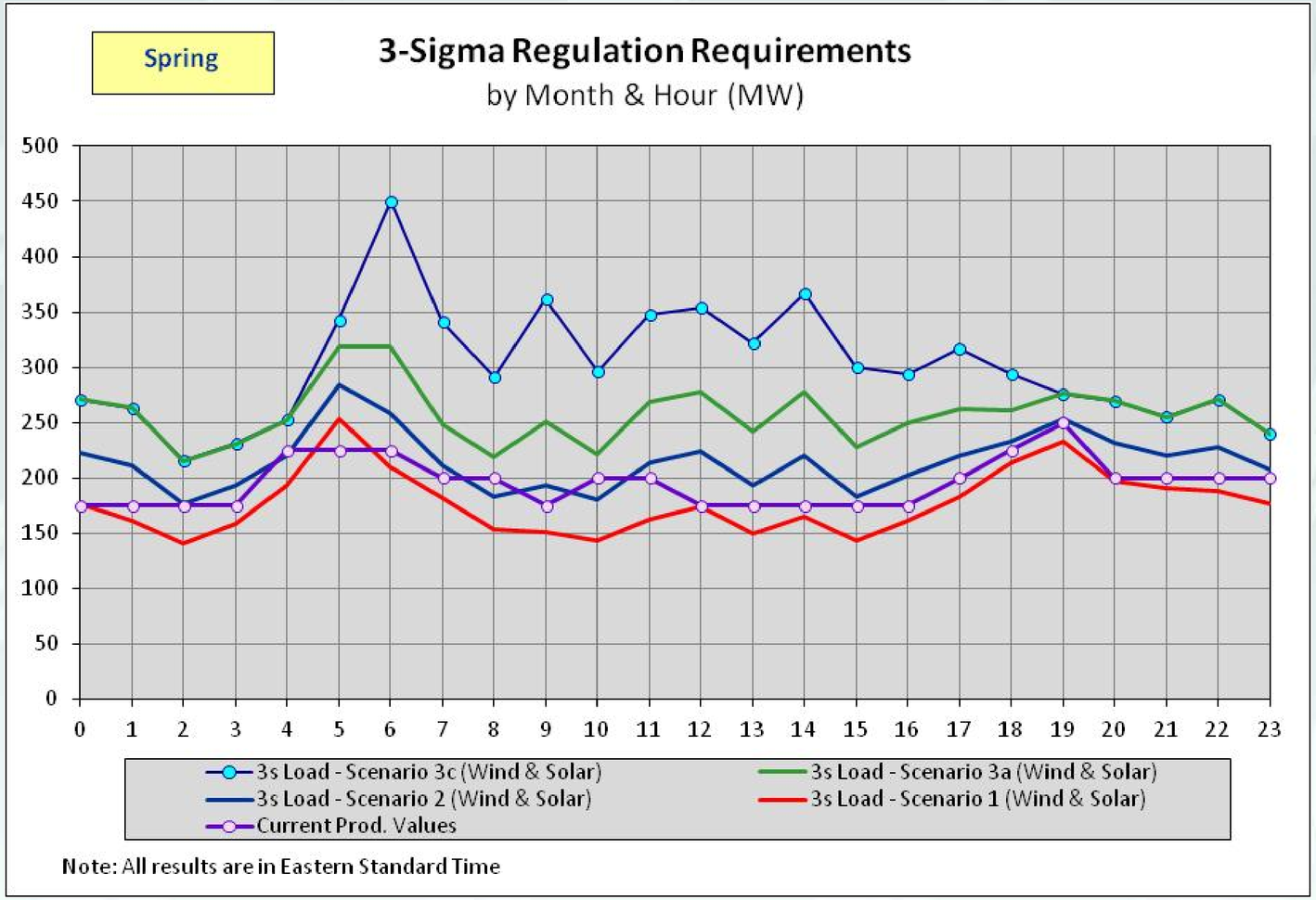
Raw Regulation Requirements

Winter (Scenarios 1, 2, 3a and 3c)



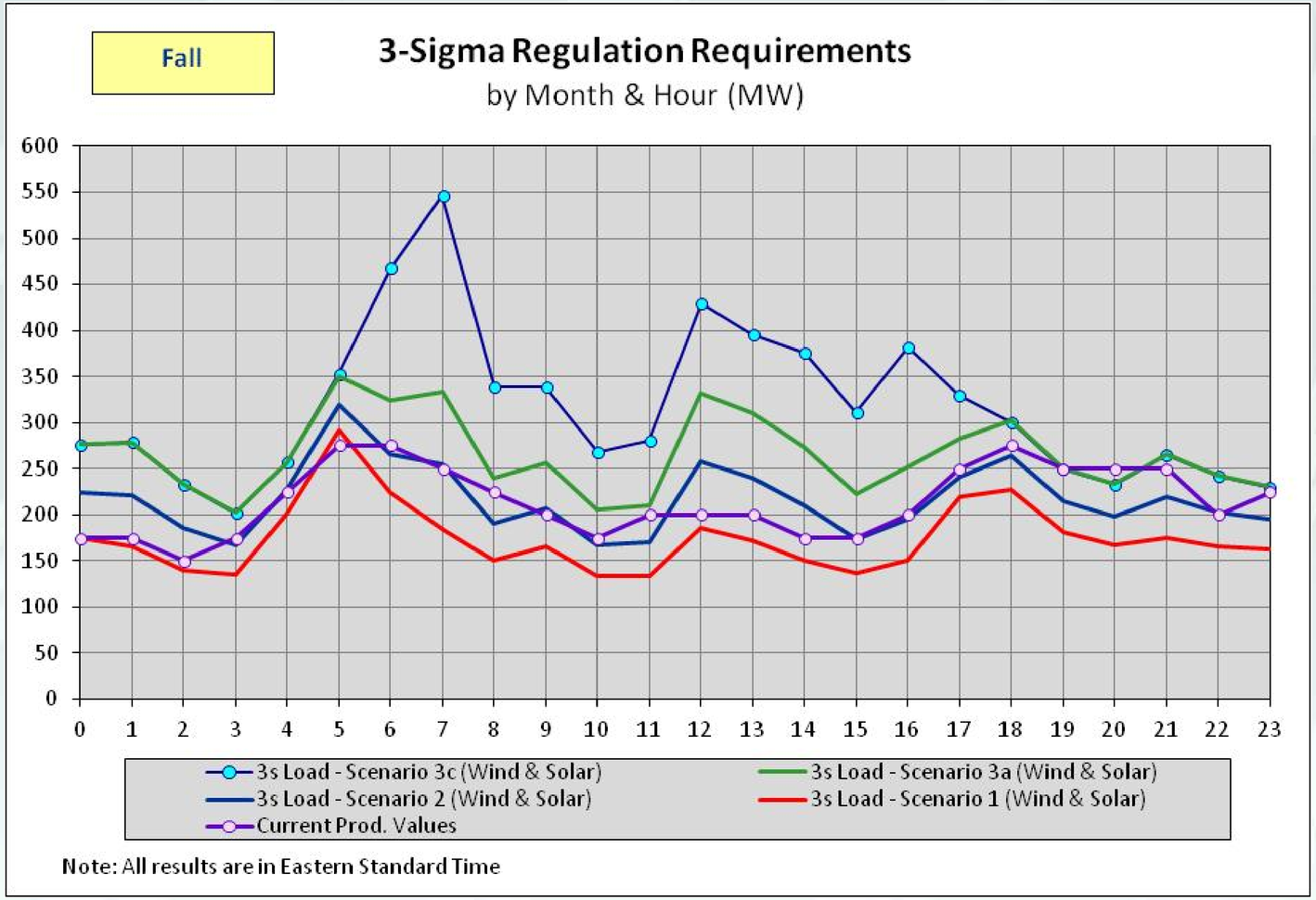
Raw Regulation Requirements

Spring (Scenarios 1, 2, 3a and 3c)



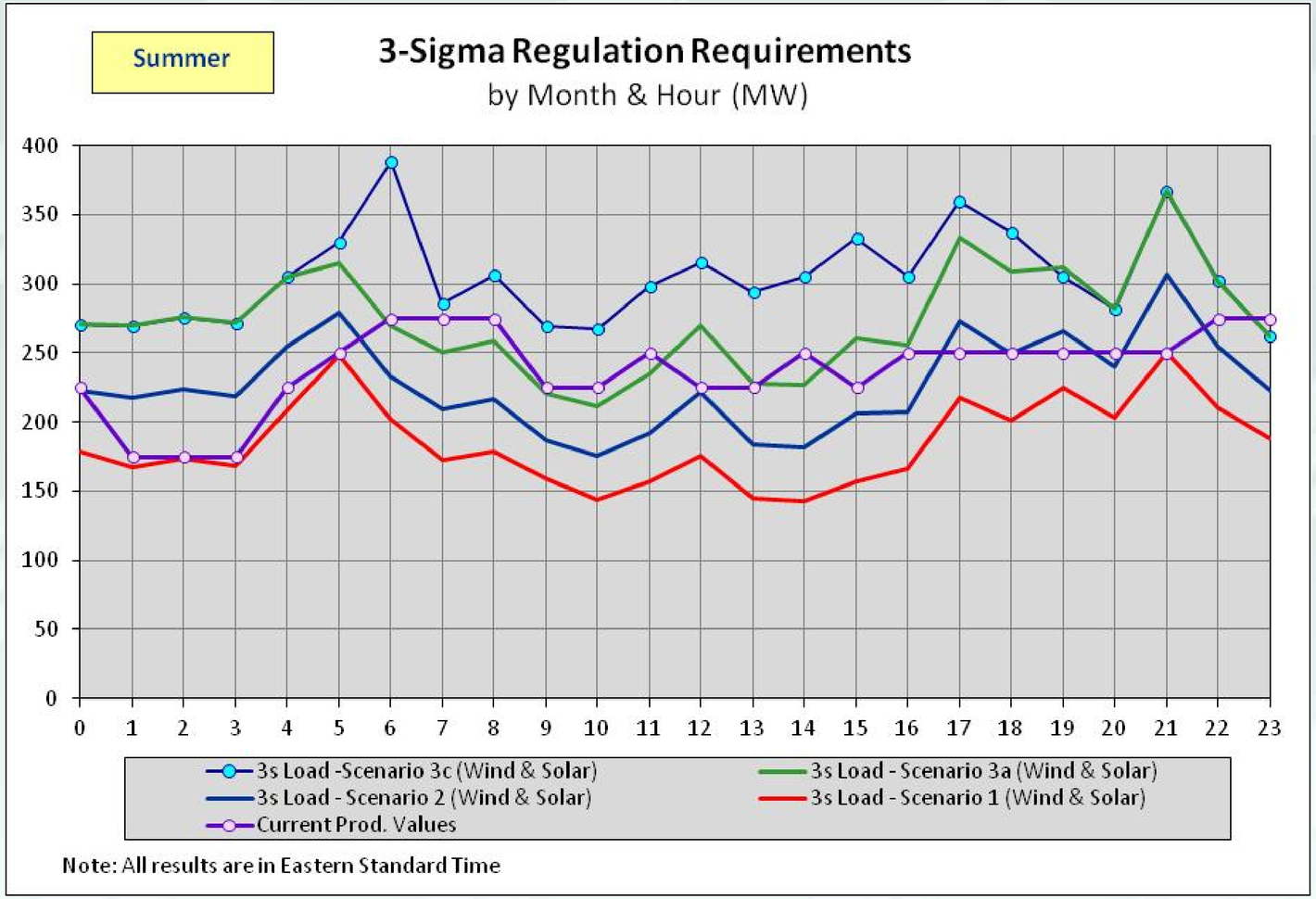
Raw Regulation Requirements

Fall (Scenarios 1, 2, 3a and 3c)



Raw Regulation Requirements

Summer (Scenarios 1, 2, 3a and 3c)



Projected Operational Regulation Requirements (Scenario 2)

Hour Beginning	April - May		June - August		September - October		November - March	
	Current Requirement	2024 3,500 MW Wind 3,000 MW Solar	Current Requirement	2024 3,500 MW Wind 3,000 MW Solar	Current Requirement	2024 3,500 MW Wind 3,000 MW Solar	Current Requirement	2024 3,500 MW Wind 3,000 MW Solar
0	175	175	225	225	175	175	200	200
1	175	175	175	175	175	175	175	175
2	175	175	175	175	150	150	175	175
3	175	175	175	175	175	175	150	150
4	225	225	225	225	225	225	175	175
5	225	225	250	250	275	275	225	225
6	225	225	275	275	275	300	275	275
7	200	225	275	275	250	275	275	275
8	200	200	275	275	225	225	275	275
9	175	200	225	225	200	225	225	225
10	200	200	225	200	175	225	175	200
11	200	225	250	200	200	225	175	200
12	175	225	225	225	200	275	175	250
13	175	200	225	200	200	250	175	225
14	175	225	250	200	175	225	175	250
15	175	200	225	225	175	225	225	250
16	175	225	250	250	200	200	275	275
17	200	225	250	275	250	250	300	300
18	225	250	250	250	275	275	250	275
29	250	275	250	250	250	250	250	250
20	200	250	250	250	250	250	200	200
21	200	200	250	250	250	250	225	225
22	200	200	275	275	200	200	200	200
23	200	200	275	275	225	225	200	200

Regulation Requirements Analysis Findings

- **The addition of solar PV and wind resources on a large-scale basis will result in a system that is more variable than a system without these intermittent resources.**
- **Current regulation requirements are sufficient to manage the net load variability associated with up to 1,500 MW of solar PV or 2,500 MW of wind.**

Regulation Requirements Analysis Findings

- **Minor upward revisions in the regulation requirements may be required as the penetration levels of solar PV exceed 1,500 MW or penetration levels of wind exceed 2,500 MW.**
- **There is also upward pressure on regulation requirements as the penetration levels increase to 9,000 MW of solar PV and to 4,500 MW of wind.**

Regulation Requirements Analysis Findings

- **Projected increases in regulation requirements are not material and can be accommodated within current market rules and system operations.**
- **The highest penetration values studied do not reflect a ceiling for the integration of intermittent resources but are a reasonable projection of the maximum achievable in the next 5 to 10 years.**

Regulation Requirements Analysis Recommendations

- **Maintain the current regulation requirements.**
- **Continue to track solar PV and wind penetration levels and availability of regulation capability on the bulk system.**
- **Assess and periodically make minor adjustments to the current minimum regulation requirements to accommodate potentially increased variability on the bulk power system introduced by solar PV resources.**

Voltage and Frequency Ride-Through Findings

- **There are presently no high/low voltage or frequency ride-through requirements for solar power in New York State.**
- **The absence of such ride-through capability could exacerbate system contingencies as solar PV drops off in response to voltage and frequency excursions.**

Voltage and Frequency Ride-Through Findings

- **Parallel Regulatory Activities On-going**
- **IEEE/UL**
  - ***The currently approved versions of IEEE 1547/1547a and UL 1741 do not permit ride through; they actually require and certify drop-out for certain operating conditions. IEEE 1547 and UL 1741 are under revision to allow the Authority Having Jurisdiction (AHJ) to require ride through.***
- **Federal Energy Regulatory Commission (FERC)**
  - ***The FERC proposes a rule (Docket No. RM16-8-000) to revise the pro forma Small-Generator Interconnection Agreement to require small generators (<20 MW) interconnecting with the transmission system to possess frequency and voltage ride-through capability.***

Voltage and Frequency Ride Through Recommendations

- **Comment in FERC rulemakings and standard-setting processes, such as IEEE, for the adoption of industry standards for solar inverter systems requiring voltage and frequency ride-through capabilities.**
- **Request that the NYPSC and the NYTOs consider establishing ride-through requirements on the non-bulk power system level.**

NYISO Actions Currently Underway

- **Deployment of solar forecasting system into market and system operations by Summer 2017.**
- **Assessment of the impact of large-scale integration of intermittent resources on essential reliability services (*e.g.*, ramping) as part of its 2016 Clean Power Plan study.**

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

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

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