



## **Hurricane Sandy**

*A report from the New York Independent System Operator*

**2/22/2013**

## Executive Summary

On October 29<sup>th</sup>, 2012 Hurricane Sandy slammed into the eastern seaboard with massive winds and an unprecedented storm surge inflicted a massive disruption to the electric power system in New York.

The NYISO first received notification of a significant tropical depression, hovering over Cuba, on October 25<sup>th</sup>. The weather services indicated various different, forecasted “tracking paths” and that there was one scenario whereby the tropical depression could turn into a significant hurricane with the possibility of tracking up the east coast and possibly hitting the New Jersey, NYC, Long Island and CT coast. NYISO Staff immediately began formulating preparedness plans as described further in the body of this report. The Category 1 hurricane, Hurricane Sandy, officially made landfall on the New Jersey shore on Monday, October 29<sup>th</sup> around 8 PM but the leading edge impacts were observed on the New York transmission system as early as 4 PM.

As the storm progressed over the New York power system, (4 PM October 29<sup>th</sup> – 12 PM October 30<sup>th</sup>), approximately 109 transmission assets tripped, including 345, 230, 138, and 115 kV transmission lines, transformer banks, Phase Angle Regulators (PARs), as well as HVDC and VFT interconnections. The storm surge was so extensive that the Transmission Owners reported that low lying stations were flooded to the degree that staff had to evacuate for safety reasons. Generating facilities over a very wide footprint were either forced or tripped off line. The NYISO observed some generators were rendered unavailable due to the loss of interconnecting transmission. The Transmission Owners reported other units were forced into pre-emptive “shut-downs” to protect assets from long term damage or for human safety reasons. Over the course of the event **8,121** MW of generation capacity was forced off line. The distribution system was also heavily damaged. By late Monday, October 29<sup>th</sup> approximately 2.2 million electric customer outages were reported on utility web sites.

None of the generator or transmission losses required load curtailments to maintain transmission security. Despite the catastrophic nature of the storm and the high number of transmission line outages, Long Island and New York City did remain connected to the Eastern Interconnections. Throughout the storm and during the recovery period, the NYISO and the utilities were able to operate within power transfer limits. Also during the storm all communications and computer systems worked properly.

An unprecedented recovery effort was initiated by the transmission, distribution, and generation asset owners. The initial recovery consisted of inspections and asset assessments. The equipment owners reported that these assessments were initially greatly hampered by flooding and unavailability of roads. The priority, as communicated by the utilities, was to restore transmission assets to generating facilities which were needed for distribution load recovery. While there was sufficient generation capacity in the state to meet the load as it was restored, in some cases customer restoration was hindered by the transmission outages in local areas.

This report describes the operations of the NYISO and does not speak to the many local operating actions of the local utilities. This report also does not document the specific actions of

the generator and utility asset owners. The NYISO is aware of the pre-emptive preparedness efforts of utilities and generator asset owners in their efforts to mobilize field resources but does not have those specific details.

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# **1. Storm Forecasting & Impact Evaluation**

The first indications of a possible hurricane were received by the NYISO on Thursday, October 25<sup>th</sup> in the form of formal storm forecasting from Telvant and publicly available weather forecasting web sites.

## **1a) Hurricane Tracking**

The NYISO Load Forecasting staff monitored the Hurricane Sandy storm developments and communicated updates to NYISO Operations Staff as forecasts were refined over the four days, 10/26-10/29. On Friday morning, 10/26, the NYISO Load Forecasting issued the following e-mail message, based on forecasting services such as NOAA and Telvant, along to Grid Operations with the associated storm projection figures.

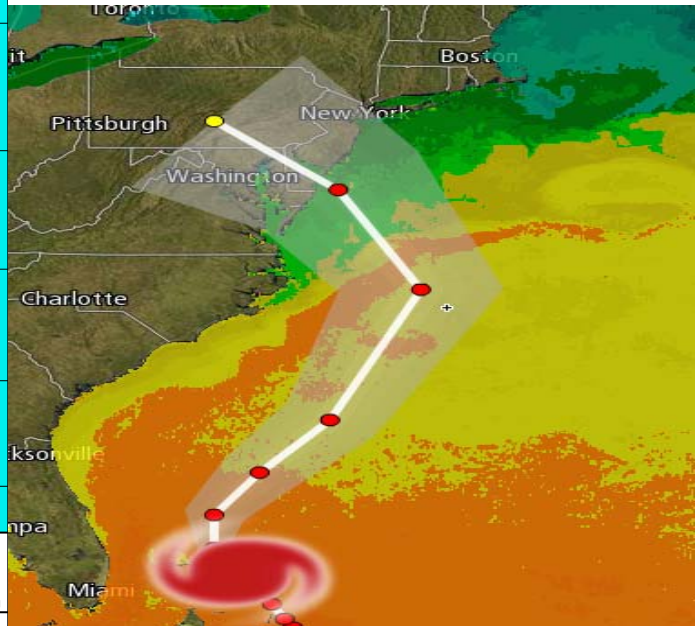
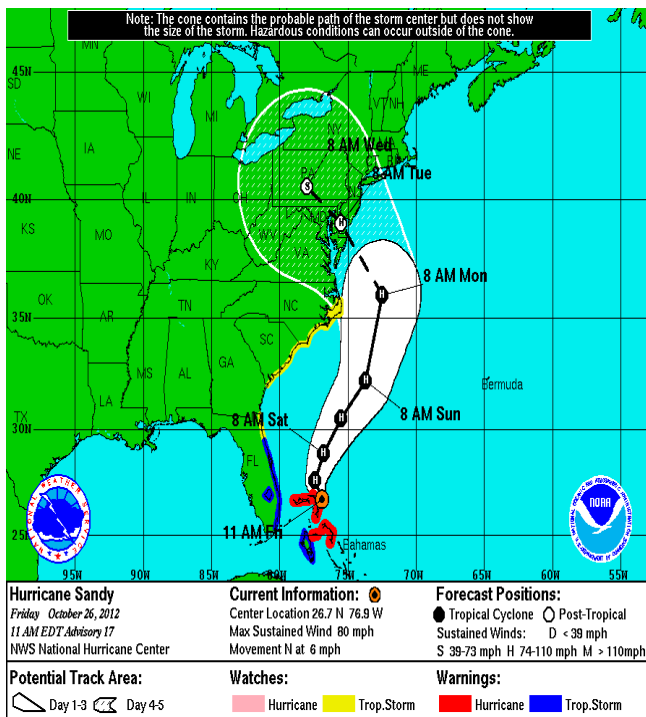
"Hurricane Sandy remains a major threat to the Mid-Atlantic and Northeast in the coming days. Sandy is currently exiting the Bahamas, with the eastern shore of Florida expected to see tropical storm conditions over the next 24 hours. The other piece of the puzzle is the cold front progressing through the Midwest, with the accompanying trough eventually favored to phase with Sandy as it moves northward. Despite a cold trough developing along the East Coast, risks are not all to the cold side. In fact, much of New York/New England will see more warm than cool risk as the storm continues to wrap in warm, moist air off the Atlantic through at least the middle part of next week. It is becoming increasingly unlikely we will see a major shift in the track of Sandy. It is with great certainty that we will see landfall somewhere between the Delmarva Peninsula and NYC at hurricane strength. The exact track and intensity depends on Sandy's interaction with the trough currently to the west of the Appalachian Mountains.

With the current official NOAA track for Sandy NYC and the Hudson Valley will see heavy rain Monday evening and continuing well into Friday. Current wind projection will have winds gusting to 45 mph inland to Albany/Syracuse with higher gust along the coast. However the risk for higher winds is greater to the north of the official forecasted track. Prolonged heavy rain is likely as Sandy as it will be slow moving through the mountains of the north east greatly increasing the chances for inland river and stream flooding.

Examples of the storm tracking information are shown in Figures 1 & 2 below.

**Figure 1**

**Figure 2**



**1b) Storm Surge and Wind Projections**

Throughout the weekend, Load Forecasting continued to update the Operations Staff on the forecast projections. Table 1 provides a record of the development of the severity of the hurricane as projected for time of landfall, magnitude of surge, impact of tides, and wind speed projections. Notably the projections of the severity of the wind and storm surge grew with every update.

**Table 1  
Hurricane Sandy  
NYISO Storm Advisory Report Timeline**

Forecast Date Time	Land Fall	Maximum Sustained Wind	Maximum Wind Gust	Storm Surge NYC (60/40)	Storm Surge NYC (90/10)	Storm Surge Long Island (60/40)	Storm Surge Long Island (90/10)	Timing of Max Wind and Surge
10/26 2:00 PM	30 October midnight - 8 am in Southern	75 MPH	95 MPH	NA	NA	NA	NA	NA
10/27 8:00 AM	30 October midnight - 8 am in Southern NJ	75 MPH	95 MPH	High Tide Costal Flooding Concern	High Tide Costal Flooding Concern	High Tide Costal Flooding Concern	High Tide Costal Flooding Concern	30 October Early Morning
10/27 11:00 AM	29 October 2 pm -midnight in Southern NJ	65 MPH	85 MPH	High Tide Costal Flooding Concern	High Tide Costal Flooding Concern	High Tide Costal Flooding Concern	High Tide Costal Flooding Concern	30 October Early Morning
10/27 2:00 PM	29 October 2 pm -midnight in Southern NJ	65 MPH	85 MPH	7 to 9 Feet	13 to 15 Feet	7 to 9 Feet	13 to 15 Feet	29 October afternoon and evening
10/27 5:00 PM	29 October 4 pm -midnight in Southern NJ	65 MPH	85 MPH	7 to 9 Feet	13 to 15 Feet	8 to 10 Feet	14 to 17 Feet	29 October afternoon and evening
10/27 8:00 PM	29 October 4 pm -midnight in Southern NJ	65 MPH	85 MPH	9 to 11 Feet	17 to 19 Feet	8 to 10 Feet	16 to 18 Feet	29 October afternoon and evening
10/28 8:00 AM	29 October 6 pm -midnight in Southern NJ	65 MPH	85 MPH	9 to 11 Feet	17 to 19 Feet	8 to 10 Feet	16 to 18 Feet	29 October afternoon and evening
10/28 11:00 AM	29 October 6 pm -midnight in Southern NJ	75 MPH	90 MPH	9 to 11 Feet	17 to 19 Feet	10 to 15 Feet	16 to 18 Feet	29 October afternoon and evening
10/28 2:00 PM	29 October 6 pm - midnight in Southern NJ	75 MPH	90 MPH	9 to 11 Feet	17 to 19 Feet	10 to 15 Feet	16 to 18 Feet	29 October afternoon and evening
10/28 5:00 PM	29 October 6 pm -midnight in Southern NJ	80 MPH	90 MPH	9 to 11 Feet	17 to 19 Feet	10 to 15 Feet	16 to 18 Feet	29 October afternoon and evening
10/28 8:00 PM	29 October 6 pm -midnight in Southern NJ	80 MPH	90 MPH	9 to 11 Feet	17 to 19 Feet	10 to 15 Feet	16 to 18 Feet	29 October afternoon and evening
10/29 5:00 AM	29 October 6 pm -midnight in Southern NJ	75 MPH	85 MPH	14 to 16 Feet	18 To 20 Feet	12 to 14 Feet	17 to 19 Feet	29 October Around the 8pm High Tide.
10/29 10:00 AM	29 October 6 pm -midnight in Southern NJ	75 MPH	85 MPH	14 to 16 Feet	18 To 20 Feet	12 to 14 Feet	17 to 19 Feet	29 October 5 to 10 PM. 2 to 4 feet of surge Observed at 10 am in NYC
10/29 11:00 AM	29 October 6 pm - 10 pm in Southern NJ	85 MPH	100 MPH	14 to 16 Feet	18 To 20 Feet	12 to 14 Feet	17 to 19 Feet	29 October 5 to 10 PM. 2 to 4 feet of surge observed at 10 am in NYC
10/29 2:00 PM	29 October 7 pm - 10 pm in	85 MPH	100 MPH	14 to 16 Feet	18 to 20 Feet	12 to 14 Feet	18 to 20 Feet	29 October Around the 8pm High Tide.

	Southern NJ							4 to 6 feet of surge observed at 10 am in NYC
10/29 4:00 PM	29 October 8 pm - 10 pm in Southern NJ	85 MPH	100 MPH	14 to 16 Feet	18 to 20 Feet	12 to 14 Feet	18 to 20 Feet	29 October Around the 8pm High Tide. 4 to 6 feet of surge observed at 10 am in NYC
10/29 8:00 PM	Land Fall Made around 7:30 PM	75 MPH	100 MPH	14 to 16 Feet	18 to 20 Feet	12 to 14 Feet	18 to 20 Feet	Occurring
10/29 11:00 PM	Last Update Storm dissipating	75 MPH	85 MPH	Receding	Receding	Receding	Receding	Improving in the next 4 to 8 hours



## **2) Transmission System Preparedness**

The NYISO acted to coordinate storm preparation plans with the New York Transmission Owners, the Northeast Power Coordinating Council and the generation companies. The New York Transmission Owners reported significant numbers of additional field operation crews were scheduled and available to respond to the expected storm disruptions. Where possible, previously scheduled outages to perform maintenance work on New York transmission facilities and generators were postponed to ensure that these facilities were available over the next several days.

### **2a) Cancellation of transmission line outages:**

The NYISO and the utilities worked together prior to the storm to return to service all transmission assets which could be recalled from outage and cancel all non-emergency scheduled outages. Six transmission lines were returned to service early and forty-nine scheduled transmission element outages were cancelled. Four generating facilities which were on scheduled maintenance, returned to service early.

### **2c) Survey of Anticipated Generator Tolerance to Storm Surge**

In preparation for the storm, the NYISO solicited from select NYC coastal generator stations the water levels at which generating facilities would become unavailable and be forced to shut down. NYISO staff monitored projected times for storm surge and tide levels for the purposes of predicting possible generation outages. Operations' understanding was that the highest previously recorded total water level since 1832 was 11.5 feet as measured at the Battery on the tip of lower Manhattan. The pre-storm sea level tolerances and the observed levels from October 29<sup>th</sup> are shown on Table 2.

<b><u>Surge Level</u></b>	<b><u>Total Capacity at Risk</u></b>	<b><u>Cumulative Risk</u></b>
Level > 11	816.0 MW	816.0 MW
13 > Level > 11	2,177.3 MW	2,993.3 MW
15 > Level > 13	1,097.4 MW	4,090.7 MW
17 > Level > 15	960.8 MW	5,051.5 MW
19 > Level > 17	1,581.1 MW	6,632.6 MW
21 > Level > 19	3,548.0 MW	10,180.6 MW

### **2d) Conference Calls**

#### **Conference calls with internal operating entities:**

The NYISO scheduled and facilitated regular conference calls with the Transmission Owners beginning on Saturday, October 27<sup>th</sup>. These calls continued throughout the preparation,

the storm itself, and the reconstruction/recovery. All Transmission owners participated in conference calls through November 2<sup>nd</sup>. NYISO, Con Ed and LIPA continued daily conference calls through November 9<sup>th</sup>. These support conference calls provided valuable information from TO operating managers regarding cancelation of scheduled transmission line work, local reliability generation commitments, storm projections, status of transmission and generation asset outages, projections of return times. The primary, immediate, and formal communications were addressed through the system operator communications protocols.

### Conference calls with external operating entities and reliability organizations:

On Sunday October 28<sup>th</sup> the NYISO participated in the first of a series of NPCC daily conference calls. On the initial Sunday conference call, ISO-NE reported the scheduling of 3,100 MW of reliability generation commitments. This was done in anticipation of the loss of coastal generation stations. PJM reported scheduling 4,000 MW of reliability generation commitments for the possible loss of coastal nuclear stations. These Regional conference calls were an important means to monitor and communicate events with adjacent Reliability Coordinators.

### **2e) Operations Support Preparedness**

On Friday, October 26<sup>th</sup> NYISO acted to cancel all scheduled work on Energy Management System and Business Market System computer hardware and software. The NYISO also required that IT receive permission from Operations prior to performing any emergency computer hardware or software work during the upcoming storm. The NYISO acted to schedule 24-hour facility support coverage at the Primary Control Center to address any building or utilities damage.

On Monday morning, the NYISO acted to schedule 24 hour engineering support for its Control Room. This support would address development of transfer limits in the face of multiple transmission outages and unanticipated operating conditions. In addition, NYISO Planning engineering staff was scheduled to provide engineering support as needed.

### **2f) Operations Control Room Staffing**

As the projected severity of the storm increased, the NYISO acted to increase staffing levels. On Saturday October 27<sup>th</sup> Operations pre-scheduled one additional Transmission Operator and one additional Generator Operator to assist with the Control Room shift crew beginning on Monday October 29<sup>th</sup> at the primary control center in Guilderland. This was in anticipation of heavy operator-to-operator phone call volume associated with the storm. The NYISO also staffed the Alternate Control Room in East Greenbush beginning the evening of Monday October 29th, for the unlikely event storm weather in the Albany Area created distribution outages at the Primary Control Center in Guilderland.

### **2g) ISO Reliability Generation Commitment**

As the storm approached, Con Edison and LIPA arranged for the local reliability generation commitments in the NYC and Long Island zones. Over the preceding weekend NYISO Operations did not believe state-wide reliability commitments would be required to

supply real power. However, on Monday morning, as the track and scope of the storm impact firmed up, NYISO acted to schedule a reliability commitment of two Hudson Valley generating units for Monday evening to assist in controlling high voltages, in the event of significant loss of electric load.

On Monday morning the NYISO acted to confirm the status of Special Protection Systems (SPS) in Eastern New York, implemented dynamic re-ratings to key facilities in the Hudson Valley, and implemented Thunder Storm Alert. Thunder Storm Alert expands the contingency list that the NYISO dispatch resolves to include select N-2 contingencies. The Thunder Storm Alert had the effect of bringing additional units on line in southeastern NY, unloading transmission and increasing downstate reserves.

### **3) System Disruption from Sandy**

Hurricane Sandy made landfall in the state of New Jersey around 8 PM, Monday, October 29<sup>th</sup>. The NYISO observed the effects on the New York transmission system beginning at approximately 4 PM and lasting through approximately midnight. The events are arranged by region for clarity and a qualitative overview description is included below:

#### **3a Interconnections Impact and Generation Outages Outages**

The scope of the storm was extensive, affecting a large geographic area for all New York utilities. Distribution outages were observed across the entire NYISO footprint. System outages of equipment 100 kV and above were reported for all utilities in New York with the exception of Rochester Gas & Electric. The over whelming number of outages were in the New York metropolitan area, including Long Island and the Hudson Valley. There were also 115KV outages in western NY near Lake Erie and there were 345 kV outages in central NY north of Syracuse.

The impacted areas are indicated above in Figure 3, in Section 4, above.

The observed storm surge values are listed in Table 5 below.

<b>Table 5</b>	
<b>October 29<sup>th</sup>, 2012 Storm Observations</b>	
Time	October 29 <sup>th</sup> , 2012 observations
19:14	Battery Park 11.5 foot storm surge
20:00	Battery Park 12.75 foot storm surge
20:00	Battery Park 13.4 foot storm surge
21:00	Battery Park 13.81 foot storm surge
21:24	Battery Park 13.88 foot storm surge
21:26	Battery Park 13.72 foot storm surge

Timelines of equipment outages are provided below. Table 4a provides a statewide overview of the damage to the BPS power system. Tables 4b through 4e provide overviews on a regional basis, i.e. Long Island, NYC, Lower Hudson Valley, and Western NY.

A high level review of the progression of storm related outages follows.

While some New York electric customer outages were noted prior to 16:00 Monday afternoon, the first significant observations of outages from Hurricane Sandy began on Long Island at that time. The Cross Sound Cable connection between Connecticut and Long Island tripped off line at 15:59 followed by eleven 138 kV Long Island transmissions lines as well as the loss of 570 MW of Long Island generation capacity. Significant numbers of distribution customer outages were observed on Long Island from LIPA web site postings.

After 18:00, the rate of outages of electric distribution customer surged. The system load was decreasing at a rate similar to if not faster than the pace of the transmission line and generation outages. At 18:28 DC Neptune cable (660 MW) between Long Island and New Jersey tripped, followed at 18:45 by the second Long Island intertie to Connecticut, the Northport-Norwalk Cable (300 MW). For the remainder of the storm Long Island was electrically connected to the Eastern Interconnection only through the four ties to Con Edison: the 138 kV 901 & 903 and the 345 kV Y49, and Y50.

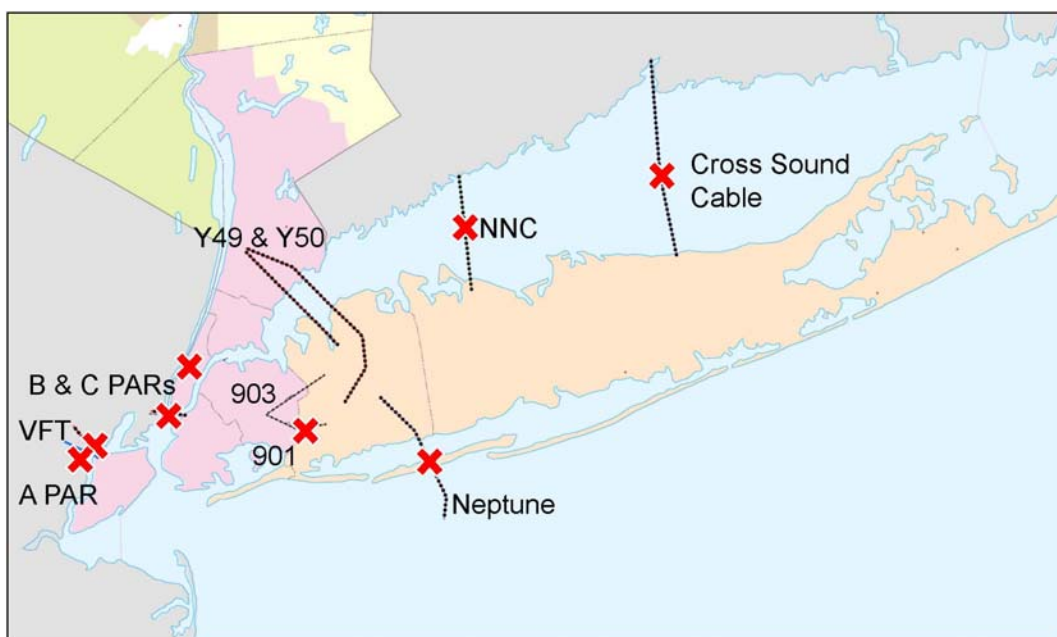
By 19:30 the predominance of new transmission losses shifted from Long Island to New York City while transmission and distribution outages continued on Long Island. In both Long Island and Con Edison areas there were generation outages and increasing numbers of customer outages.

Over the next several hours additional transmission circuits were forced out of service either by faults that occurred from the severe storm conditions or pre-emptive operator actions. Many generation outages occurred either as the result of lost transmission connections or the direct impacts of flooding.

By 21:00, the four major external interconnections between NYC and New Jersey were out of service. These included the loss of Linden-Goethals A2253, Hudson-Farragut B3402, Hudson-Farragut C3403, and the Linden VFT interconnection.

Essentially, the seven southernmost interconnections to southeastern New York were disconnected, leaving Long Island and New York City only connected to the Eastern Interconnection via the Lower Hudson Valley 345 kV transmission lines.

Figure 4 below, provides an overview diagram of the New York City and Long Island transmission external transmission line interconnections and noted outages with Connecticut and New Jersey.



At 21:02 on 10/29 the Nine Mile 1 (622 MW) nuclear generation facility in Oswego NY tripped off line as the result of transmission storm damage at the 345 kV Scriba substation. Later that same day, at 22:41 the Indian Point 3 (1050 MW) nuclear generation facility tripped as the result of loss transmission at the Buchan substation. Neither of the nuclear power plants tripped as the result of storm conditions or procedures at either nuclear facility.

While the major impacts of the storm were over by midnight on 10/29, scattered storm related outages continued till noon of Oct. 30. For the purposes of this report the last storm related outage was the loss of the Valley Stream Phase Angle Regulator.

A summary of the of the storm progression in term terms of generation capacity outages, transmission assets tripped, and customer outages is provided on Table 4, below. The customer outages for the hours specified were obtained from the utility websites, at the time of the event. The total customer loss is the sum of the maximum reported outage value posted by the utilities through October 30<sup>th</sup>.

### **3b) Transmission Impact Overviews**

On October 29<sup>th</sup> Hurricane Sandy hit the New York power system with record wind and storm surge. The storm resulted in a 14.0 inch storm surge that inundated low lying areas and flooded transmission and generation stations.

After the storm had passed, the NYISO observed the following system impacts on the system:

- Approximately 2.2 million customers out of service
  - o 900,000\* on Long Island
  - o 850,000\* in New York
- Approximately 7,738 MW of generation out of service
- Extensive transmission system outages
  - o 28 345 kV circuits
  - o 1 230 kV circuits
  - o 17 345/138 & 345/115 kV transformers
  - o 7 138 kV Phase Angle Regulators
  - o 42 138 kV circuits
  - o 15 115 kV circuits

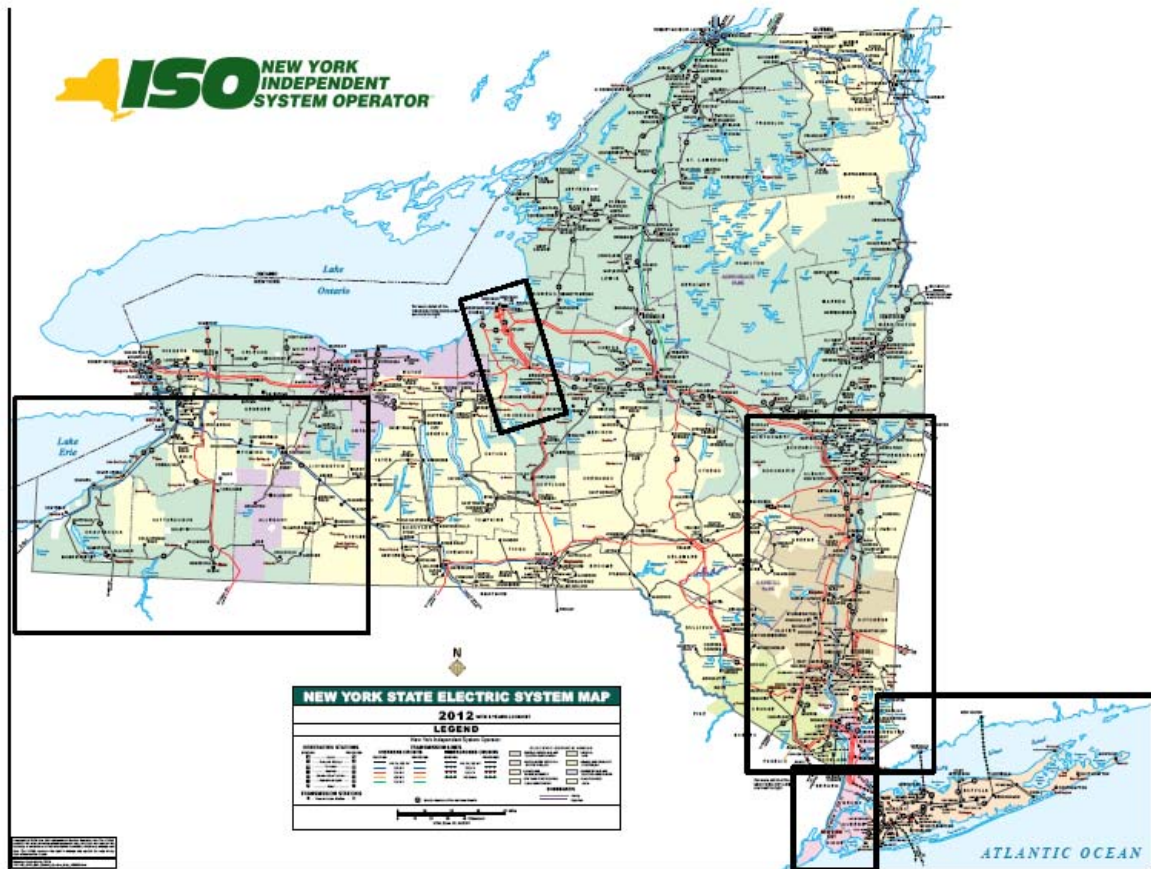
Despite the storm damage, New York State's bulk electric system met all criteria for transmission and operating reserves during the course of the storm. None of the generator or transmission losses required load curtailments to maintain transmission security.

The scope of the storm was extensive, affecting a large geographic area and numerous utilities. Diagrams of the pre and post storm configurations of the NYISO transmission system are presented on the following pages to provide an overview of the total storm damage. The figures are provided on the basis of regional views to enhance clarity. Summaries of the effected geographic region of the state are included below. The 345 kV element outages in SENY are allocated between New York City and Hudson Valley.

**Table 4A  
Statewide Event Overview**

Time	Generation Capacity Outages	Transmission Assets Tripped	Customer Outages*	External Transmission Outages
10/28/2012 3 PM – 7 PM (Preemptive)	546 MW			
10/29/2012 4 PM – 5 PM	160 MW	7	278,817	Cross Sound Cable
10/29/2012 5 PM – 6PM	416 MW	6	-	
10/29/2012 6 PM – 7PM	380 MW	16	565,315	NNC & Neptune
10/29/2012 7 PM – 8 PM	1,888 MW	9	1,063,632	Linden-Goethals A
10/29/2012 7 PM – 8 PM	1,452 MW	27		VFT & Hudson Farragut B
10/29/2012 9 PM – 10 PM	1,049 MW	20	<b>1,442,310</b>	Hudson Farragut C
10/29/2012 10 PM – 12AM	1,458 MW	13		
10/30/2012 12 AM – 12 PM	772 MW	11		
<b>TOTALS</b>	<b>8,121 MW</b>	<b>109</b>	<b>2,222,337</b>	

\*- These approximate values were skimmed from the TO posted press releases.





**Table 4B**  
**NYC Event Overview**

Time	Generation Capacity Outages	Transmission Assets Tripped	External Transmission Outages
10/28/2012 (3 PM – 7 PM) (Preemptive)	546 MW		
10/29/2012 (4 PM – 5 PM)			
10/29/2012 (5 PM – 6PM)			
10/29/2012 (6 PM – 7PM)		1	
10/29/2012 (7 PM – 8 PM)	1,548 MW	6	Linden-Goethals A
10/29/2012 (8 PM – 9 PM)	1,017 MW	22	Linden VFT & Hudson-Farragut B
10/29/2012 (9 PM – 10 PM)	160 MW	12	Hudson Farragut C
10/29/2012 (10 PM – 12AM)	361 MW	2	
10/30/2012 (12 AM – 12 PM)	234 MW	8	
<b>TOTALS</b>	<b>3,866 MW</b>	<b>51</b>	



The red dots indicate the locations of significant outages. Due to the number of elements involved, not all element outages are represented with a dot.

**Table 4C**  
**LIPA Event Overview**

Time	Generation Capacity Outages	Transmission Assets Tripped	External Transmission Outages
10/28/2012 (3 PM – 7 PM) (Preemptive)			
10/29/2012 (4 PM – 5 PM)	160 MW	7	Cross Sound Cable
10/29/2012 (5 PM – 6PM)	410 MW	5	
10/29/2012 (6 PM – 7PM)	380 MW	11	NNC & Neptune Outage
10/29/2012 (7 PM – 8 PM)	340 MW		
10/29/2012 (8 PM – 9 PM)	435 MW	3	
10/29/2012 (9 PM – 10 PM)	267 MW	1	
10/29/2012 (10 PM – 12AM)	47 MW		
10/30/2012 (12 AM – 12 PM)	44 MW	3	
<b>TOTALS</b>	<b>Total = 2,083 MW</b>	<b>30</b>	



**Table 4D  
Hudson Valley Event Overview**

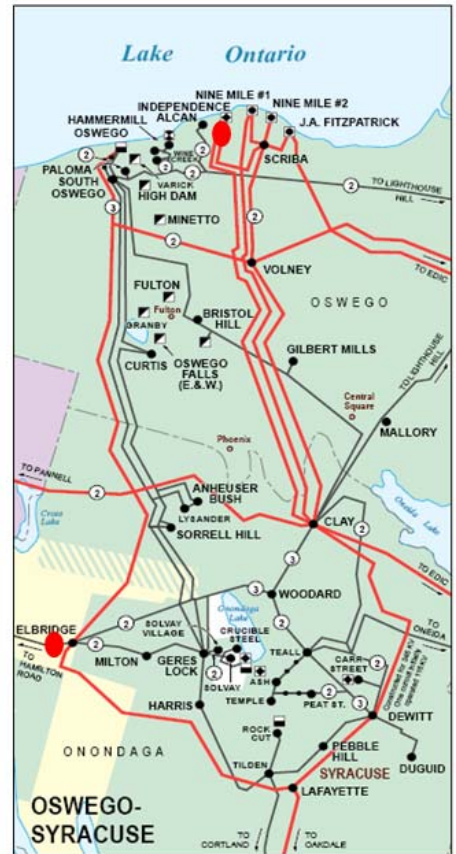
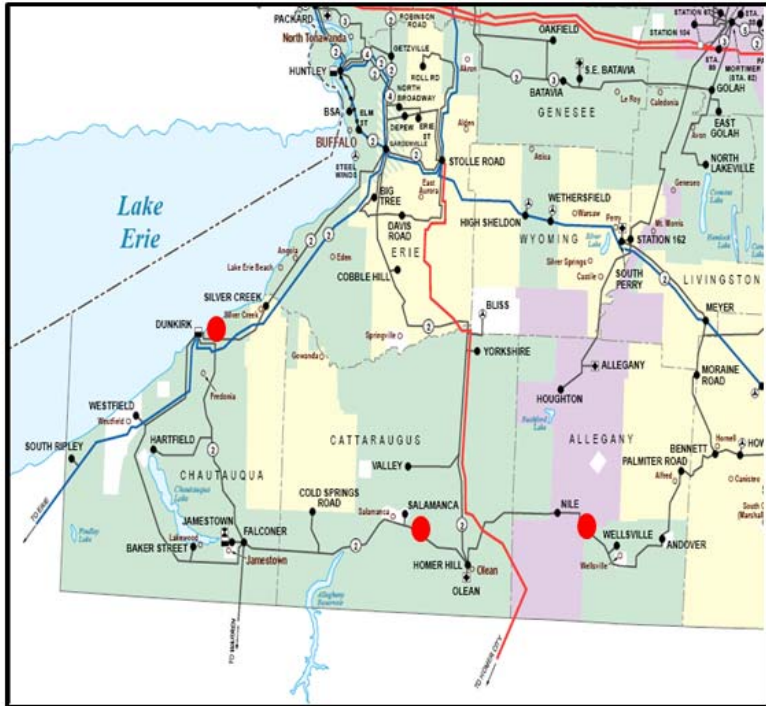
Time	Generation Capacity Outages	Transmission Assets Tripped	External Transmission Outages
10/28/2012 (3 PM – 7 PM) (Preemptive)			
10/29/2012 (4 PM – 5 PM)			
10/29/2012 (5 PM – 6PM)		1	
10/29/2012 (6 PM – 7PM)		3	
10/29/2012 (7 PM – 8 PM)		3	
10/29/2012 (8 PM – 9 PM)		2	
10/29/2012 (9 PM – 10 PM)		4	
10/29/2012 (10 PM – 12AM)	1,050 MW	10	
10/30/2012 (12 AM – 12 PM)	494 MW		
<b>TOTALS</b>	<b>Total = 1,544 MW</b>	<b>23</b>	



The red dots indicate the locations of significant outages. Due to the number of elements involved, not all element outages are represented with a dot.

**Table 4E**  
**Western New York Event Overview**

Time	Generation Capacity Outages	Transmission Assets Tripped	External Transmission Outages
10/28/2012 (3 PM – 7 PM) (Preemptive)			
10/29/2012 (4 PM – 5 PM)			
10/29/2012 (5 PM – 6PM)	6 MW		
10/29/2012 (6 PM – 7PM)		1	
10/29/2012 (7 PM – 8 PM)			
10/29/2012 (8 PM – 9 PM)			
10/29/2012 (9 PM – 10 PM)	622 MW	3	
10/29/2012 (10 PM – 12AM)		1	
10/30/2012 (12 AM – 12 PM)			
<b>TOTALS</b>	Total = 628 MW	5	



### **3C Storm Damage Observations**

- There were no reported BPS relay operations beyond storm damage which contributed to BPS facilities being out of service during the storm.
- No nuclear units were off line prior to the storm. On October 29<sup>th</sup> Nine Mile Point 1 (622 MW) tripped at 21:00 and Indian Point 3 (1,050 MW) tripped at 22:41. In both cases the unit trips were driven by loss of the transmission exits from the plants. Neither generating unit was affected by storm damage. At no time was off-site power lost to the units.
- No wind units were adversely affected by the storm
- Fossil units were forced off as stations were flooded or all transmission exits tripped. Approximately 300 MW of generation was declared unavailable in anticipation of the storm. These actions were taken in light of the expected storm surge and the low lying geography of the plant locations. A total of 8,121 MW of generation capacity became unavailable as a result of the storm. This loss did not result in any capacity issues.
- No hydro units were adversely affected by the storm
- There were two NPCC Disturbance Control Standard (DCS) criteria events related to the storm. At 21:03 on October 29 Reserve Pick Up (RPU) and Shared Activation of Reserve (SAR) were initiated for the loss of Nine Mile 1 loaded at 622 MWs. ACE crossed zero and the RPU was terminated at 21:08 and SAR was terminated at 21:20. At 22:43 on October 29 Reserve Pick Up and Shared Activation of Reserve were initiated for the loss of Indian Point 3 plant loaded at 1050 MWs. ACE crossed zero and the RPU was terminated at 22:47 and SAR was terminated at 22:55. In both cases the system response was within criteria.
- There was 8,121 MW of generation made unavailable by the storm. Some of that unavailability was due to a degree of damage at the station. By midnight November 9<sup>th</sup>, all but 2,201 MW of the generation made unavailable by the storm had returned to service.

### **3D Operational Issues during the storm and its aftermath**

As the predicted track and landfall of the storm firmed up on Monday, the day of the storm, NYISO acted to schedule a reliability commitment of two generators for the off-peak evening hours to help mitigate high transmission voltages in the event of significant loss of electric load. The NYISO also implemented Thunder Storm Alert. As noted earlier, Thunder Storm Alert expands the contingency list that the NYISO dispatch resolves to include select N-2 contingencies. The Thunder Storm Alert had the effect of bringing additional units on line in southeastern NY, unloading transmission and increasing downstate reserves. These two actions constituted a conservative operations mode, beyond the normal security constrained dispatch.

Typically, by the end of October loads are low and off peak operations must be concerned with controlling high voltages. Beyond the day of the storm, NYISO took action to commit extra generation resources at Roseton station and extended the commitment of two Hudson Valley units to provide additional reactive control capability for voltage control in the southeastern portion of the system. The lowest total NYISO load in recent years has approached 11,000 MW. In the aftermath of Sandy the state wide load that had been forecast for 12,980 at 4 AM on October 30<sup>th</sup>. The actual observed load fell to 9,660 MW.

At 21:23 NYISO took action to remove the Marcy-Coopers Corners 345 kV line from service to help control high 345 kV voltages in the lower Hudson Valley and on Long Island. At 23:44 NYISO took additional action to remove the Coopers Corners – Rock Tavern 42 line from service for voltage control. At 01:09 on October 30<sup>th</sup> NYISO declared an emergency state for voltage above post-contingency high voltage limits for more than 10 minutes at the Bowline 345 kV station. Removal of additional 345 kV circuits was evaluated and rejected as a remedial action. The NYISO took action to extend the scheduled operation of Giboa units in spin-pump mode 06:00 for voltage control. The emergency state for high voltage was cleared at 06:12.

On Long Island, loss of customer load and generation outpaced the loss of transmission to the degree that the major concern for western LIPA transmission system was high voltage. To control the voltage LIPA removed the Shore Road –Lake Success 138 kV cable from service. Later in the evening, when the Neptune cable tripped LIPA was able to utilize a 125 MVAR reactor at the Neptune 345 kV station. With the loss of the entire Barrett station at 20:33 on October 29<sup>th</sup>, it became essential to retain the maximum voltage control capability for East Garden City 345 kV. To maximize the effectiveness of voltage control from outside sources it was necessary to minimize the use of series reactors on the Con Ed LIPA ties. NYISO Transmission Planning staff conducted short circuit analysis to support leaving the Con Ed-LIPA series reactors out of service for the unusual outage conditions resulting from Sandy.

Throughout the storm and during the recovery period, the NYISO and the utilities were able to operate within transmission loading and operating reserve criteria. None of the generator or transmission losses during storm or during the recovery required load curtailments to maintain transmission security.

The end-user loads had been so severely disrupted, that even with the extensive unavailability of over 8,121 MW of generating capacity, there was more than sufficient New York generation to serve the load and no bottlenecks to delivering energy to the remaining load.



There were no BPS pre- or post contingency overloads on the BPS for during the storm or the recovery afterward. There was no load shedding required for the purpose of securing the BPS transmission system. At the local level, several loads networks were shut down in a controlled fashion to prevent damage to equipment and speed restoration.

Throughout the storm and the recovery there were no issues maintaining the load and generation balance at the Balancing Authority or Reliability Coordinator level.

With regard to post-storm operation, there was one plant, Danskammer, which while not operating at the time, was forced into retirement by Hurricane Sandy. On October 29<sup>th</sup>, 2012, Units 1 through 4 at the Facility were flooded due to high water from Super Storm Sandy; Units 1 through 4 have been in a forced outage status since that time. Units 5 and 6 were not exposed to flood water, but the power transformer for these generators was damaged by flood water. During the intervening period, Dynegy has retained contractors to assess the full extent of the damage at the Facility. Their assessment indicates that the flooding damaged approximately 90% of the motors and 60% of the switchgear in the Facility. Based on this assessment, the estimated costs to repair the Danskammer Facility are significant.

On January 3, 2013, Dynegy Danskammer, LLC announced its intent to retire all six generation units from service and that the facility would be dismantled

The NYISO is a summer peaking system. There are no long term effects of the storm which could impact serving firm load in the 2012/2013 winter season.

## **4) Transmission System Recovery**

The magnitude and scope of the damage inflicted by Sandy was unprecedented in the region. Beyond the typical wind related power system damage there was substantial salt water flooding which affected the operability, monitoring, and control of essential power system elements.

### **4a) Interconnections**

The magnitude of damage inflicted in the area of the external ties was the prime factor in restoring those interconnections. The CSC was the first tie to be restored at 16:30 on October 31<sup>st</sup>, after local support issues were resolved on both sides. NNC returned to service at 14:30 on November 1<sup>st</sup> after extensive salt contamination remediation on the Connecticut side. The substations at Linden, Hudson and Goethals experienced extensive flooding with the associated salt water contamination and required extensive cleaning and repair. The estimated recovery times oscillated between the tie to Goethals (A) and the ties to Farragut (B&C), as operability issues were uncovered. The B line to Farragut was restored at 13:38 on November 5<sup>th</sup>. The C line to Farragut followed at 16:39 on November 7<sup>th</sup>. System damage on the New Jersey side limited the import capability on the ties. The A line to Goethals was restored on at 14:14 on November 12<sup>th</sup>. Repair to storm damage to the Linden station and the surrounding New Jersey network, which supplies the Linden VFT, delayed that tie from returning to service until 23:44 on November 28<sup>th</sup>. The Neptune cable was available for service at 7:25 on November 13<sup>th</sup>.

### **4b) Nuclear Units**

On October 29<sup>th</sup> Nine Mile Point 1 (622 MW) tripped at 21:00 and Indian Point 3 (1,050 MW) tripped at 22:41. In both cases the unit trips were driven by faults on the transmission exits from the plants. Neither generating unit was affected by storm damage. At no time was off-site power lost to the units. Indian Point 3 was returned to service at 00:05 on November 2<sup>nd</sup>.

On October 30<sup>th</sup>, October 31<sup>st</sup>, and November 1<sup>st</sup> the NERC scheduled and facilitated conference calls with FERC, DoE, FEMA, the NRC, and the effected Regions including NPCC, RFC, and SERC. The Regions gave an update status of transmission conditions, generation outages, and customer outage levels.

### **4c) System Status Updates**

In the immediate aftermath of the storm, an unprecedented recovery effort was initiated by the transmission, distribution, and generation asset owners. The initial recovery effort consisted of inspections and asset assessments. The equipment owners reported that these assessments were initially greatly hampered by flooding and unavailability of roads. The priority, as communicated by the utilities, was to the restore transmission assets to generating facilities which were needed for distribution load recovery. While there was sufficient generation capacity in the state to meet the load as it was restored, in some cases customer restoration was hindered by the transmission outages in local areas.

Table 5, below provides a statewide overview of the BPS power system recovery beginning on Oct 30. Tables 5A through 5B provide a breakdown overview on a regional basis, i.e. Long Island, NYC, Lower Hudson Valley and Western NY.

<b>Table 5 Statewide Recovery Overview</b>				
Time	Generation Capacity Outages Returned	Transmission Assets Returned	Customer Outages	External Transmission Outages
10/30	977 MW	28	2,105,943	
10/31	676 MW	15	1,875,284	Cross Sound Cable
11/1	75 MW	14	1,545,885	NNC
11/2	1,375 MW	11	1,222,504	
11/3	644 MW	5	900,707	
11/4	136 MW	7	625,877	Hudson Farragut B
11/5	941 MW	5	475,496	
11/6	302 MW	1	229,741	
11/7	234 MW	2	297,446	Hudson Farragut C
11/8	16 MW	1	297,643	
11/9	181 MW	3	294,281	
<b>TOTALS Recovered</b>	<b>5,557 MW</b>	<b>92</b>		
Still out on 11/9	2,201 MW	17		Linden VFT, Neptune Linden Goethals A

One 363 MW was returned-to-service on October 29th, 2012

<b>Table 5A Regional Recovery Overview – Long Island</b>			
Time	Generation Capacity Outages Returned	Transmission Assets Returned	LIPA Customer Outages*
10/30	47 MW	7	851,369
10/31	278 MW	5	831,680
11/1	75 MW	4	632,584
11/2	193 MW	1	516,288
11/3	22 MW		459,464
11/4		1	283,459
11/5	47 MW		221,951
11/6		1	193,875
11/7	234 MW		158,247
11/8	16 MW		206,324
11/9	82 MW	1	236,248
<b>TOTALS</b>	<b>994 MW</b>	<b>20</b>	
Still out on 11/9	726 MW	8	

\* LIPA customer outage values listed were reported by LIPA.

**Table 5B  
Regional Recovery Overview- NYC**

Time	Generation Capacity Outages Returned	Transmission Assets Returned	Con Ed Customer Outages*
10/30	924 MW	9	836,312
10/31	398 MW	5	734,825
11/1		6	644,582
11/2	132 MW	8	505,648
11/3		3	285,753
11/4	136 MW	5	229,606
11/5	894 MW	4	183,905
11/6	302 MW		153,447
11/7		2	119,798
11/8		1	84,466
11/9	99 MW	2	54,233
<b>TOTALS</b>	<b>2,885 MW</b>	<b>45</b>	
Still out on 11/9	981 MW	9	

\*\* Con Ed customer outage values listed were reported by Con Edison.

**Table 5C  
Regional Recovery Overview- Hudson Valley**

Time	Generation Capacity Outages Returned	Transmission Assets Returned	Upstate**** Customer Outages
10/30		7	418,262
10/31		5	308,779
11/1		4	268,714
11/2	1,050 MW	2	200,568
11/3		2	155,490
11/4		1	112,812
11/5		1	69,640
11/6			35,713
11/7			19,401
11/8			68,853
11/9			3,800
<b>TOTALS</b>	<b>1,050 MW</b>	<b>22</b>	
Still out on 11/9	494 MW	0	

\*\*\* Upstate customer outage values listed are the sum of values reported by Central Hudson, National Grid, NYSEG, O&R and RG&E.

**Table 5D  
Regional Recovery Overview- Western NY**

Time	Generation Capacity Outages Returned	Transmission Assets Returned	Customer Outages
10/30	6 MW	5	
10/31			
11/1			
11/2			
11/3	622 MW		
11/4			
11/5			
11/6			
11/7			
11/8			
11/9			
Total restored	628 MW	5	
Still out on 11/9	0	0	

## **5) External Communications**

The NYISO provided regular Hurricane Sandy operations updates on bulk power system conditions to key state and federal regulatory and legislative contacts throughout the storm, and continued to provide updates on restoration efforts for the week following the event. A total of 13 status reports were provided; five were issued during the storm, with daily restoration status reports provided over the course of the following week. These updates reported on current load levels, key bulk system transmission outages, and aggregate levels of generation outages related to the storm, neighboring system conditions, and details on utility customer outage levels. The reports were provided to Patti Hoffman of the US Department of Energy; FERC Commissioners and key FERC staff, lead staff contacts for Senator Schumer, Senator Gillibrand and key representatives from NY delegation to the House or Representatives; key contacts for Gov. Cuomo, each NYS PSC Commissioner and key NYS DPS staff; key leadership in the NYS Senate and Assembly, and NPCC. External Affairs received inquiries from at least two FERC Commissioners in response to the updates, and received 12 media inquiries during the event.