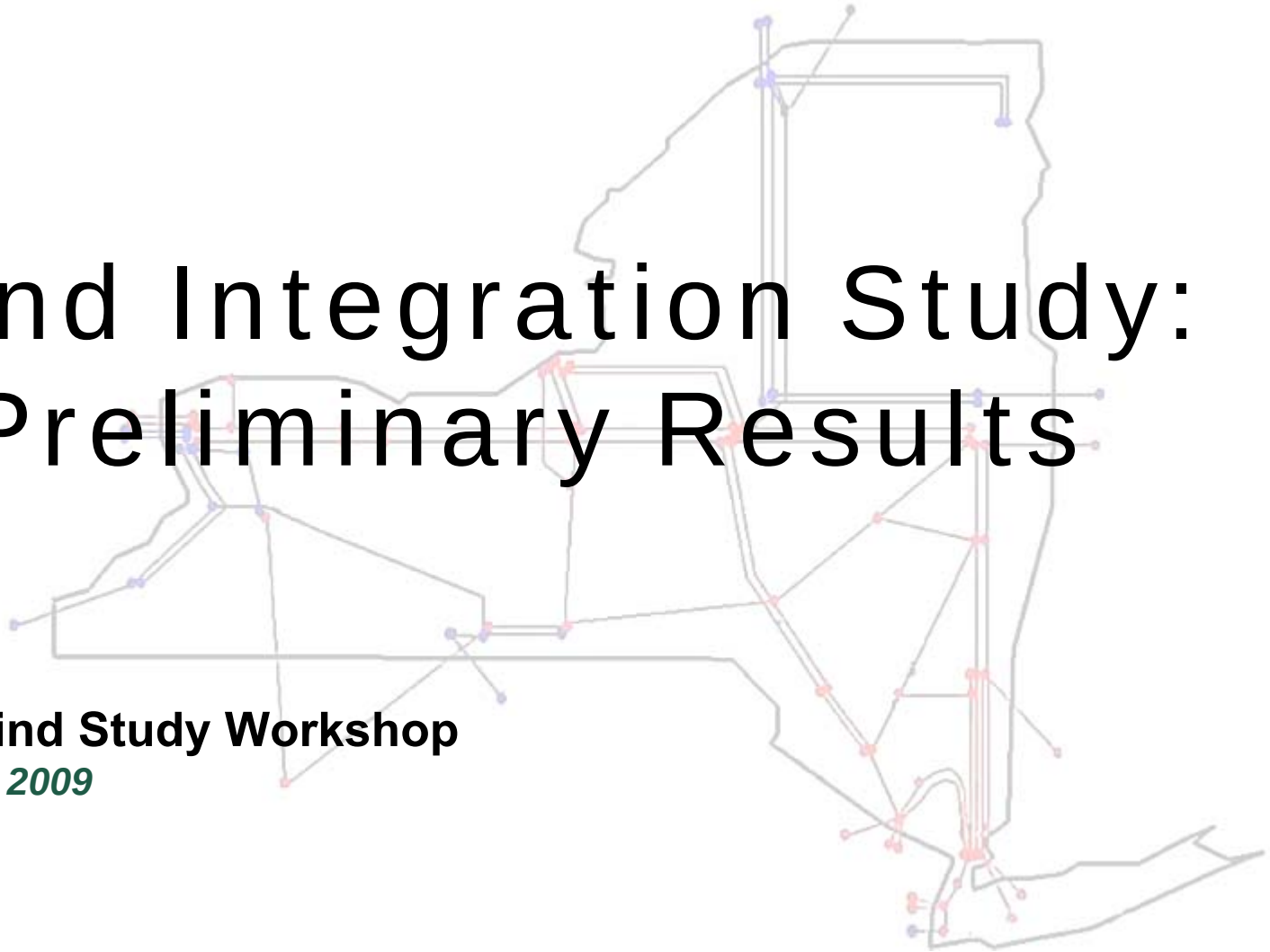
Wind Integration Study: Preliminary Results



NYISO Wind Study Workshop

October 19, 2009

Draft For Discussion Purposes Only

Wind Plant Integration Issues

- **Transmission (Task 5, 6 and 7)**
  - ***Will local area limitations will affect wind plant output?***
  - ***Are transmission limitations are a major barrier to increasing wind plant penetration in some areas?***
- **System Flexibility (Task 4)**
  - ***Will the intermittent nature of wind plant output result in increased system variability?***
  - ***Will operator awareness and practices need to be enhanced?***
  - ***Earlier study finding has led to the introduction of wind energy management and associated market rules***
- **Wind Plant Performance & Standards (Task 5)**
  - ***Wind plant dynamic models and LVRT capability***

Study Tasks Descriptions

- **Task 1 - Develop study assumptions**
- **Task 2 - Develop and implement performance monitoring for operating wind generators**
- **Task 3 - Update other regions' experience with wind generators**
- **Task 4 - Study the impacts on higher penetrations of wind on system variability and operations**
- **Task 5 - Evaluate the impact of the higher penetration of wind generation on transmission infrastructure and system performance**

Study Tasks - continued

- **Task 6 - Evaluate the impact of the higher penetration of wind generation on energy production and production costs for NY system**
- **Task 7 - Additional Task – Generate a transmission upgrade list based on #6, refine the list by TOs, and feed back to #6 to assess effectiveness of these upgrades**

Task 4 - Methodology

- **Statistical analysis utilized to evaluate the Impact of increasing wind plant integration on net load variability (load minus wind)**
- **Net-load variability for various time scales from minutes to hours quantifies the impact on such operating parameters such as regulation, load-following/ramping and operating reserves**
- **The standard deviation or sigma of the delta or first difference of the load compared to the net load is the primary metric for determining the impact of intermittent resources**
- **The NYCA net-load reflects the full impact of the NY wind plants**

Task 4 – Why Net-Load?

- **Wind generation output and system electrical demand (load) have a number of common elements, as both are:**
  - ***Cyclic on an annual (seasonal) basis, and a diurnal (daily) basis***
  - ***Subject to random short-term variations around the multi-hour trends***
  - ***Limited controllability (i.e., not dispatchable in the upward direction)***
  - ***Subject to deviations from predicted behavior***
  - ***Mutually dependent on prevailing weather conditions***

Task 4 – Findings

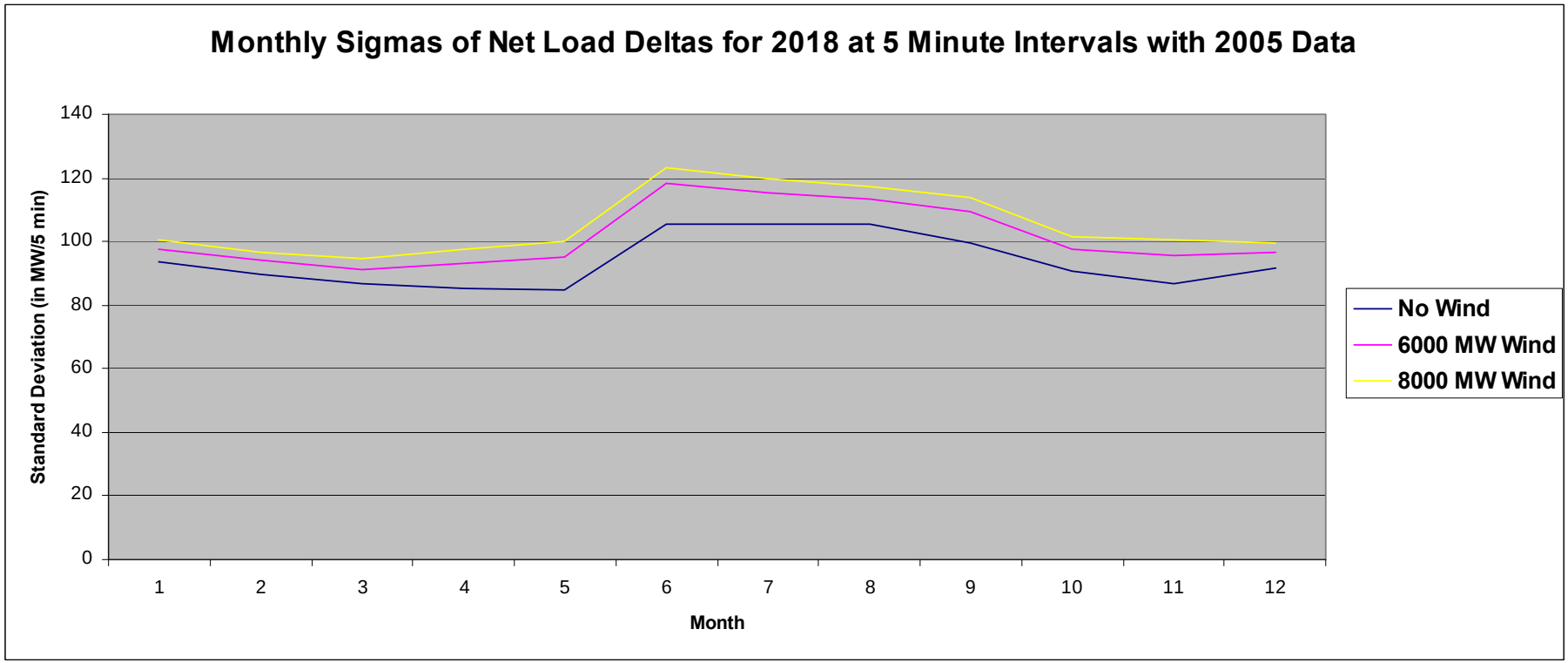
- **System variability increases with increasing wind plant penetration up to the 8 GW studied**

Case	1-min. Δ Sigma MW	Percent Increase With Wind	5-min. Δ Sigma MW	Percent Increase With Wind	60-min. Δ Sigma MW	Percent Increase With Wind
Load Alone 2011	36.6		85.4		895.9	
Net Load 3500 MW of Wind	37.6	2.8%	89.1	4.4%	916.2	2.3%
Net Load 4250 MW of Wind	37.9	3.5%	90.3	5.7%	924.2	3.2%
Load Alone 2013	37.5		87.5		918.5	
Net Load 4250 MW of Wind	38.8	3.4%	92.3	5.5%	946.4	3.0%
Net Load 6000 MW of Wind	39.6	5.6%	95.9	9.6%	967.9	5.4%
Load Alone 2018	39.8		92.8		973.8	
Net Load 6000 MW of Wind	41.8	5.0%	100.8	8.6%	1021.5	4.9%
Net Load 8000 MW of Wind	42.8	7.5%	104.8	12.9%	1039.6	6.8%

Load and net-load sigma for the first difference or Δ by 1, 5 and 60 min. timeframes by year and wind penetration as calculated on a annual basis

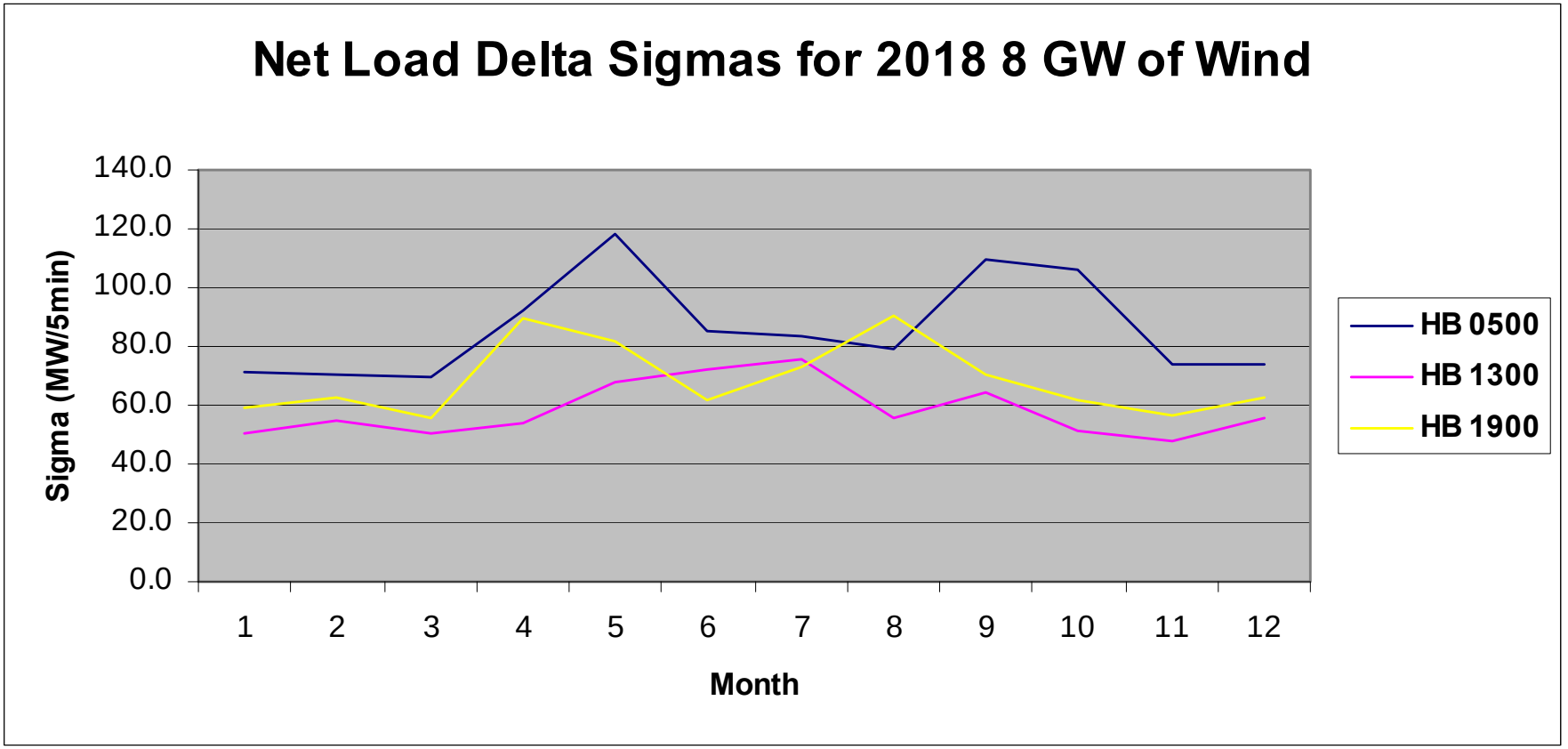
Task 4 – Findings

- **The standard deviation of the net-load deltas varies by season and month**



Task 4 – Findings

- **The standard deviation of the net-load deltas varies by season, month and time of day**



Task 4 –Increased Wind Penetration Will Result in Large Wind Changes

- For instance, the NYISO did observe major drops in wind generation for timeframes ranging from several minutes to several hours – see table below.

Case	5 Min	10 Min	30 Min	60 Min	90 Min	240 Min
3500	-253.6	-291.8	-527.7	-712.0	-1018.1	-2000.6
3500	5/31/06 13:05	10/12/06 20:10	11/30/06 17:00	11/30/06 17:00	7/21/06 1:00	11/30/06 20:30
4250	-292.9	-305.3	-570.5	-764.5	-1262.3	-2251.0
4250	5/31/06 13:05	7/20/06 22:50	8/14/06 7:30	5/31/06 7:00	8/14/06 8:00	11/30/06 20:30
6000	-368.4	-447.0	-820.5	-1134.8	-1806.6	-3225.4
6000	5/31/06 13:05	4/3/06 15:50	8/14/06 7:30	11/11/06 11:00	8/14/06 8:00	11/30/06 20:30
8000	-436.7	-629.2	-962.7	-1394.5	-2146.9	-3921.7
8000	5/31/06 13:05	7/27/06 17:30	8/14/06 7:30	9/8/06 7:00	8/14/06 8:00	11/30/06 20:30

- These drop-offs in wind generation may be addressed by resources that can provide ramping and load following capability in the appropriate timeframe

Task 4 – Task Four Findings

- System variability as measured by the net-load deltas increases with increasing wind penetration
- The magnitude of system variability changes by season, month and time day
- The addition of wind plants will result in increases in system variability for certain time periods
- What the implications of increased system variability for?
  - *Regulation Requirements?*
  - *Ramping/Load Following?*

Task 4 – What Does Increased Variability Imply for Regulation?

- See presentation entitled: “Wind Integration Study: Regulation Requirements”

Task 5 - Methodology

- Assess export capability of wind-rich zones using thermal transfer analysis – DC power flow analysis
  - ***Generation transfers increased from west and north to SENY***
  - ***Monitor constraints of 115kV and above system using "normal" transfer criteria***
- Identify limiting elements and contingencies that potentially cause wind bottling
  - ***Evaluate wind and traditional generation to determine wind impact***
- Evaluate peak load (35 GW) and light load (13 GW)
- Evaluate 4,250 MW, 6,000 MW and 8,000 MW wind penetration
  - ***Wind modeled according to NYISO Interconnection Queue***
- Screen results using voltage and stability analysis

Task 5 - Observations

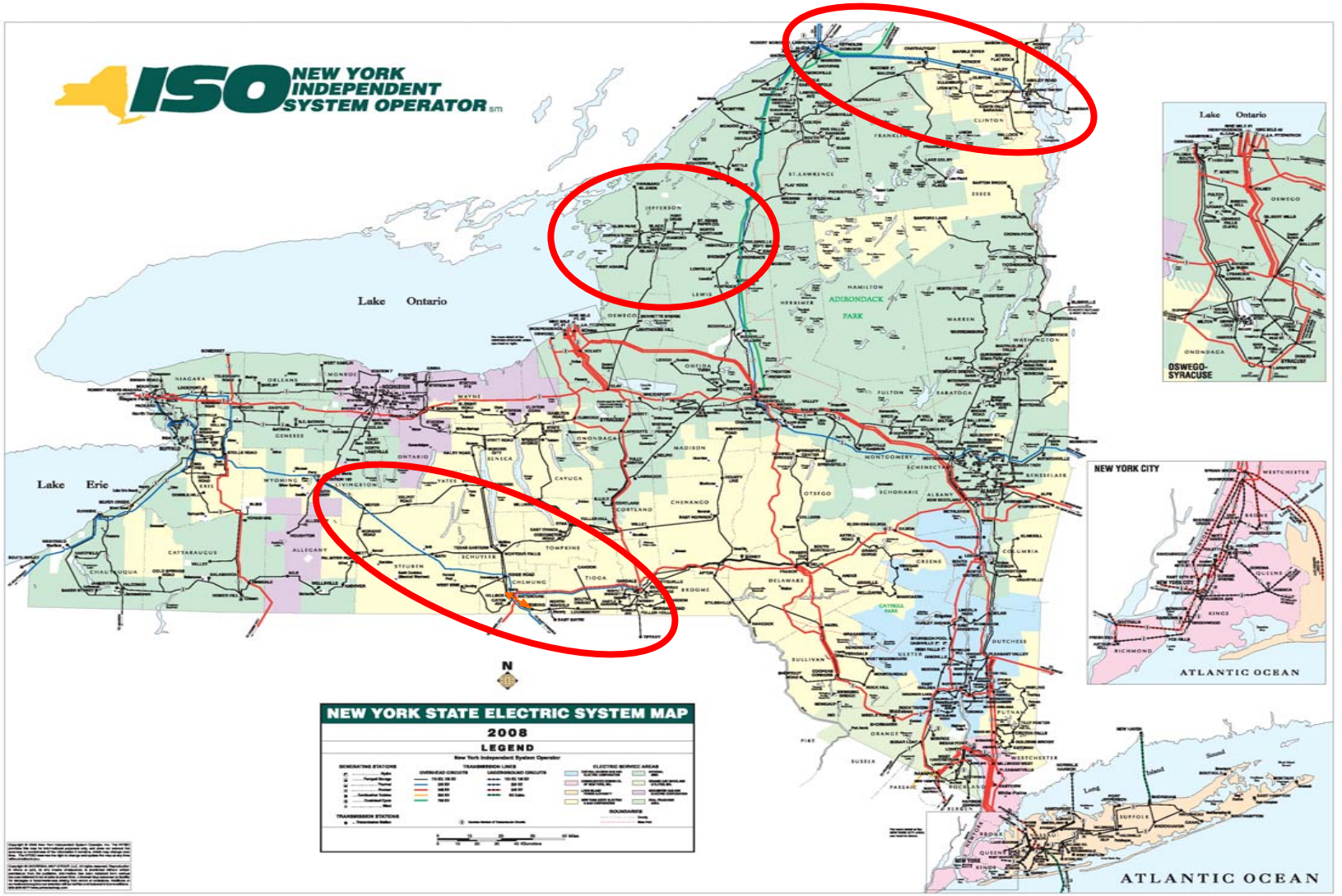
- West-Central wind is constrained locally by the underlying 115 kV system centered around Hillside
- Northern wind is constrained locally in two pockets
  - ***Willis-Plattsburgh area wind limited by the tower contingency and local transmission contingencies***
  - ***Thousand Islands area wind limited (pre-contingency) by radial 115 kV system, and local 115kV transmission contingencies***
- Leeds-Pleasant Valley transmission
  - *Insensitive to wind sources*
  - *Constrains all power transfers from upstate (zones A – F) to SENY (zones G – J)*

Task 5 - West-Central NY Constraints

Case	Shift	Total Wind	Wind Transfer Limits MW	%	Limiting Element	Limiting Contingency
Summer Peak	ABC to GHI	3181	1056	33.2	L: 126294 PLTVLLEY 345 137451 LEEDS 3 345 2	C:126294 PLTVLLEY 345 137455 ATHENS 345 1
		3181	1183	37.2	L: 126294 PLTVLLEY 345 137455 ATHENS 345 1	C:SB:LEED_345_R92
		3181	1284	40.4	L: 130774 BATH 115 115 131347 HOWARD 115 1	C:SB:HILL_230
		3181	1332	41.9	L: 131018 LOUNS115 115 131850 CNYOG115 115 1	C:SB:OAKD_345_36-3122_ITHACA
		3181	1358	42.7	L: 130848 S.OWE115 115 131850 CNYOG115 115 1	C:SB:OAKD_345_36-3122_ITHACA
		3181	1436	45.1	L: 130814 HILSD115 115 131162 CHEMU115 115 1	C:SB:OAKD_345_36-3122_ITHACA
		3181	1514	47.6	L: 130836 N.WAV115 115 131162 CHEMU115 115 1	C:SB:OAKD_345_36-3122_ITHACA
		3181	1671	52.5	L: 130836 N.WAV115 115 131018 LOUNS115 115 1	C:SB:OAKD_345_36-3122_ITHACA
		3181	1695	53.3	L: 135859 LAPPINS1 115 135866 NLEROYTA 115 1	C:SB:NIAG_345_3108
		3181	1883	59.2	L: 130803 FLATS115 115 130885 ECOGENNY 115 1	C:SB:HILL_230
		3181	1893	59.5	L: 130817 JENN 115 115 130819 KATEL115 115 1	C:TWR:36&32_ITHACA
		3181	1906	59.9	L: 95646 DEANWIND 230 130772 SHRED230 230 1	C:SB:OAKD_345_36-3122_ITHACA
		3181	1928	60.6	L: 130807 GOUDY115 115 130848 S.OWE115 115 1	C:SB:OAKD_345_36-3122_ITHACA
		3181	1949	61.3	L: 130765 OAKDL230 230 130772 SHRED230 230 1	C:SB:OAKD_345_36-3122_ITHACA
		3181	1951	61.3	L: 130765 OAKDL230 230 130838 OAKDL115 115 1	C:SB:OAKD_345_36-3122_ITHACA
Light Load	ABC to GHI	3181	904	28.4	L: 130794 DELHI115 115 130804 DEL T115 115 1	C:TWR:36&32_ITHACA
		3181	1420	44.6	L: 130814 HILSD115 115 131162 CHEMU115 115 1	C:SB:OAKD_345_36-3122_ITHACA
		3181	1471	46.2	L: 130836 N.WAV115 115 131162 CHEMU115 115 1	C:SB:OAKD_345_36-3122_ITHACA
		3181	1816	57.1	L: 130774 BATH 115 115 131347 HOWARD 115 1	C:TWR:68&69
		3181	2024	63.6	L: 95646 DEANWIND 230 130772 SHRED230 230 1	C:SB:OAKD_345_36-3122_ITHACA
		3181	2056	64.6	L: 130765 OAKDL230 230 130772 SHRED230 230 1	C:SB:OAKD_345_36-3122_ITHACA
		3181	2062	64.8	L: 130765 OAKDL230 230 130838 OAKDL115 115 1	C:SB:OAKD_345_36-3122_ITHACA
		3181	2092	65.8	L: 130803 FLATS115 115 130885 ECOGENNY 115 1	C:TWR:68&69
		3181	2273	71.5	L: 130804 DEL T115 115 130805 FRASR115 115 1	C:TWR:36&32_ITHACA
		3181	2285	71.8	L: 130803 FLATS115 115 131241 GRNDG115 115 1	C:TWR:68&69
		3181	2319	72.9	L: 130787 CODNT115 115 130830 MONTR115 115 1	C:SB:OAKD_345_31-B322
		3181	2408	75.7	L: 130761 AVOCA230 230 130763 HILSD230 230 1	C:130757 WATRC345 345 135249 ARMENMTN 345 1
		3181	2508	78.8	L: 130774 BATH 115 115 130830 MONTR115 115 1	C:TWR:68&69
		3181	2656	83.5	L: 130826 MEYER115 115 130831 MORAI115 115 1	C:130774 BATH 115 115 131347 HOWARD 115 1
		3181	2664	83.7	L: 130831 MORAI115 115 131342 BENET115 115 1	C:130774 BATH 115 115 131347 HOWARD 115 1

Task 5 - Northern NY Constraints

Case	Shift	Total Wind	Wind Transfer Limits MW	%	Limiting Element	Limiting Contingency
Summer Peak	DE to GHI	2716	757	27.9	L: 136778 LOWVILLE 115 136807 TAYLORVL 115 1	C:twr:Taylorville-Boonville #6
		2716	808	29.7	L: 137532 RTRDM1 115 137730 ROTRDM.2 230 2	C:SB:ROTT_230_R84JOR
		2716	884	32.5	L: 136216 LTHSE HL 115 136218 MALLORY 115 1	C:twr:Taylorville-Boonville #5&6
		2716	930	34.2	L: 136788 N CARTHG 115 136807 TAYLORVL 115 1	C:twr:Black River-Lighthouse Hill#1&2
		2716	939	34.6	L: 136762 CLIMAX 115 136788 N CARTHG 115 1	C:twr:Black River-Lighthouse Hill#1&2
		2716	955	35.2	L: 126294 PLTVLLEY 345 137451 LEEDS 3 345 2	C:126294 PLTVLLEY 345 137455 ATHENS 345 1
		2716	958	35.3	L: 136815 LYMETP 115 136825 RCKLDG_T 115 1	C:136816 LYME 115 136825 RCKLDG_T 115 1
		2716	973	35.8	L: 136758 BREMEN 115 136807 TAYLORVL 115 1	C:twr:Taylorville-Boonville #5
		2716	1043	38.4	L: 136815 LYMETP 115 136816 LYME 115 1	C:136815 LYMETP 115 136825 RCKLDG_T 115 1
		2716	1078	39.7	L: 136766 DEFERIET 115 136772 FT. DRUM 115 1	C:twr:Black River-Lighthouse Hill#1&2
		2716	1081	39.8	L: 126294 PLTVLLEY 345 137455 ATHENS 345 1	C:126294 PLTVLLEY 345 137451 LEEDS 3 345 2
		2716	1085	39.9	L: 136766 DEFERIET 115 136807 TAYLORVL 115 1	C:twr:Black River-Lighthouse Hill#1&2
		2716	1166	42.9	L: 136758 BREMEN 115 136761 BU+LY+MO 115 1	C:twr:Taylorville-Boonville #5
		2716	1180	43.4	L: 147843 PLAT T#1 230 147922 PLAT 115 115 1	C:SB:WILL_230_2302W
		2716	1190	43.8	L: 136783 MALONE 115 147856 WILL 115 115 1	C:TWR:MW1&2
Light Load	DE to GHI	2716	833	30.7	L: 136755 BLACK RV 115 136762 CLIMAX 115 1	C:136766 DEFERIET 115 136772 FT. DRUM 115 1
		2716	893	32.9	L: 136766 DEFERIET 115 136807 TAYLORVL 115 1	C:136755 BLACK RV 115 136762 CLIMAX 115 1
		2716	907	33.4	L: 136216 LTHSE HL 115 136218 MALLORY 115 1	C:twr:Taylorville-Black River#1&2
		2716	916	33.7	L: 136788 N CARTHG 115 136807 TAYLORVL 115 1	C:136766 DEFERIET 115 136772 FT. DRUM 115 1
		2716	917	33.8	L: 136762 CLIMAX 115 136788 N CARTHG 115 1	C:136766 DEFERIET 115 136772 FT. DRUM 115 1
		2716	923	34.0	L: 136766 DEFERIET 115 136772 FT. DRUM 115 1	C:136755 BLACK RV 115 136762 CLIMAX 115 1
		2716	960	35.3	L: 136815 LYMETP 115 136825 RCKLDG_T 115 1	C:136816 LYME 115 136825 RCKLDG_T 115 1
		2716	960	35.3	L: 136816 LYME 115 136825 RCKLDG_T 115 1	C:136815 LYMETP 115 136825 RCKLDG_T 115 1
		2716	995	36.6	L: 136815 LYMETP 115 136816 LYME 115 1	C:136815 LYMETP 115 136825 RCKLDG_T 115 1
		2716	1017	37.4	L: 130794 DELHI115 115 130804 DEL T115 115 1	C:130753 FRASR345 345 130755 OAKDL345 345 1
		2716	1119	41.2	L: 136216 LTHSE HL 115 136768 E WTRTWN 115 1	C:twr:Taylorville-Black River#1&2
		2716	1123	41.3	L: 136216 LTHSE HL 115 136755 BLACK RV 115 1	C:twr:Taylorville-Black River#1&2
		2716	1172	43.2	L: 147843 PLAT T#1 230 147922 PLAT 115 115 1	C:SB:WILL_230_2314W
		2716	1274	46.9	L: 136755 BLACK RV 115 136772 FT. DRUM 115 1	C:twr:Black River-Lighthouse Hill#1&2
		2716	1332	49.0	L: 136763 COFFEEN 115 136768 E WTRTWN 115 1	C:136763 COFFEEN 115 136773 GLEN PRK 115 1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NEW YORK STATE ELECTRIC SYSTEM MAP
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Task 5 – Stability Assessment

- **Perform Transient Stability analyses on key NYISO interfaces:**
  - **Dysinger East/West Central**
  - **Central East/Total East**
  - **Moses-South**
  - ***Simulations based on highest coincident wind production level***
    - **"Not likely" to be peak load**
    - **Initial condition base case imports the wind production level from the GV simulation; other NYCA (thermal) generation increased to margin transfer level for each interface being tested.**
    - **Compare TS performance for high wind case(s) to traditional (pre- or low wind) cases at the margin transfer level.**
    - **Results are still preliminary**

Task 5 - Key Observations

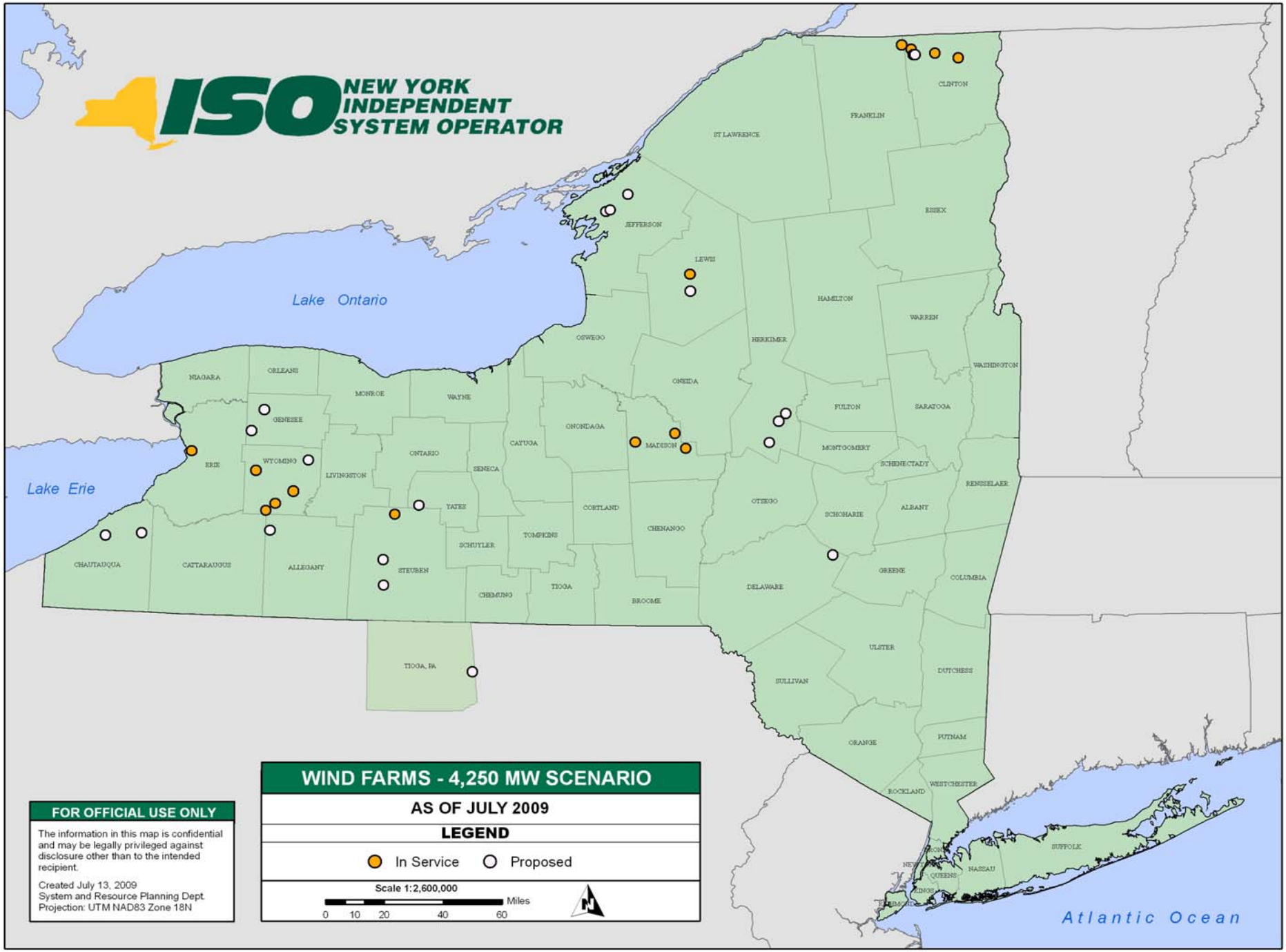
- Interconnection point of wind plant plays major role in the wind capacity MWs that can be integrated before significant transmission constraints are encountered.
- Specific areas identified that could experience energy bottling:
  - ***Thousand Islands***
  - ***Willis-Plattsburgh***
  - ***Corning/Elmira area***

Task 6 - Methodology

- **Production Cost Simulations using ABB's GridView**
  - ***SCUC/SCED model based on the marginal cost of individual units in the NY system***
- **Wind Scenarios**
  - ***Perfect Wind Forecast***
  - ***Wind plant generation profiles based on AWS simulations for selected locations in NY***
  - ***Four levels of Injection: Base (1275 MW), 4,250 MW, 6,000 MW and 8,000 MW***

Task 6 - Methodology

- **Neighboring Systems**
  - ***Used CARIS data to model systems external to NY.***
  - ***HQ energy schedule based on historical values***
  - ***Limit economic transfer of energy***
- **Report on Wind plant performance in terms of**
  - ***Wind Energy Production***
    - **Capacity Factor**
    - **Energy Bottling**
  - ***Fuel Displacement***
  - ***Transmission Constraints***
    - **Local or EHV**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WIND FARMS - 4,250 MW SCENARIO
AS OF JULY 2009
LEGEND
In Service
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Scale 1:2,600,000
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Miles
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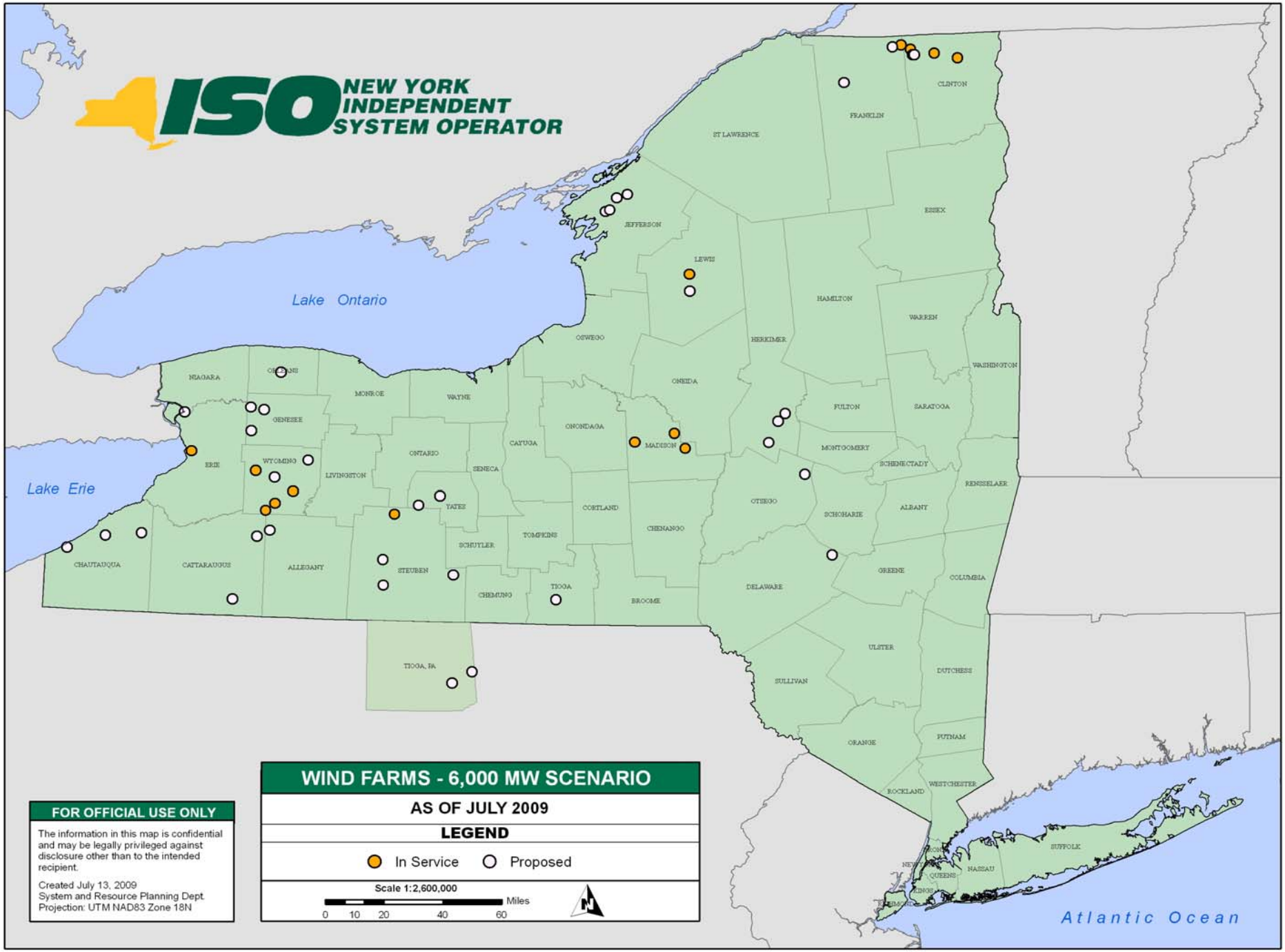
Projection: UTM NAD83 Zone 18N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WIND FARMS - 6,000 MW SCENARIO
AS OF JULY 2009
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Scale 1:2,600,000
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Miles
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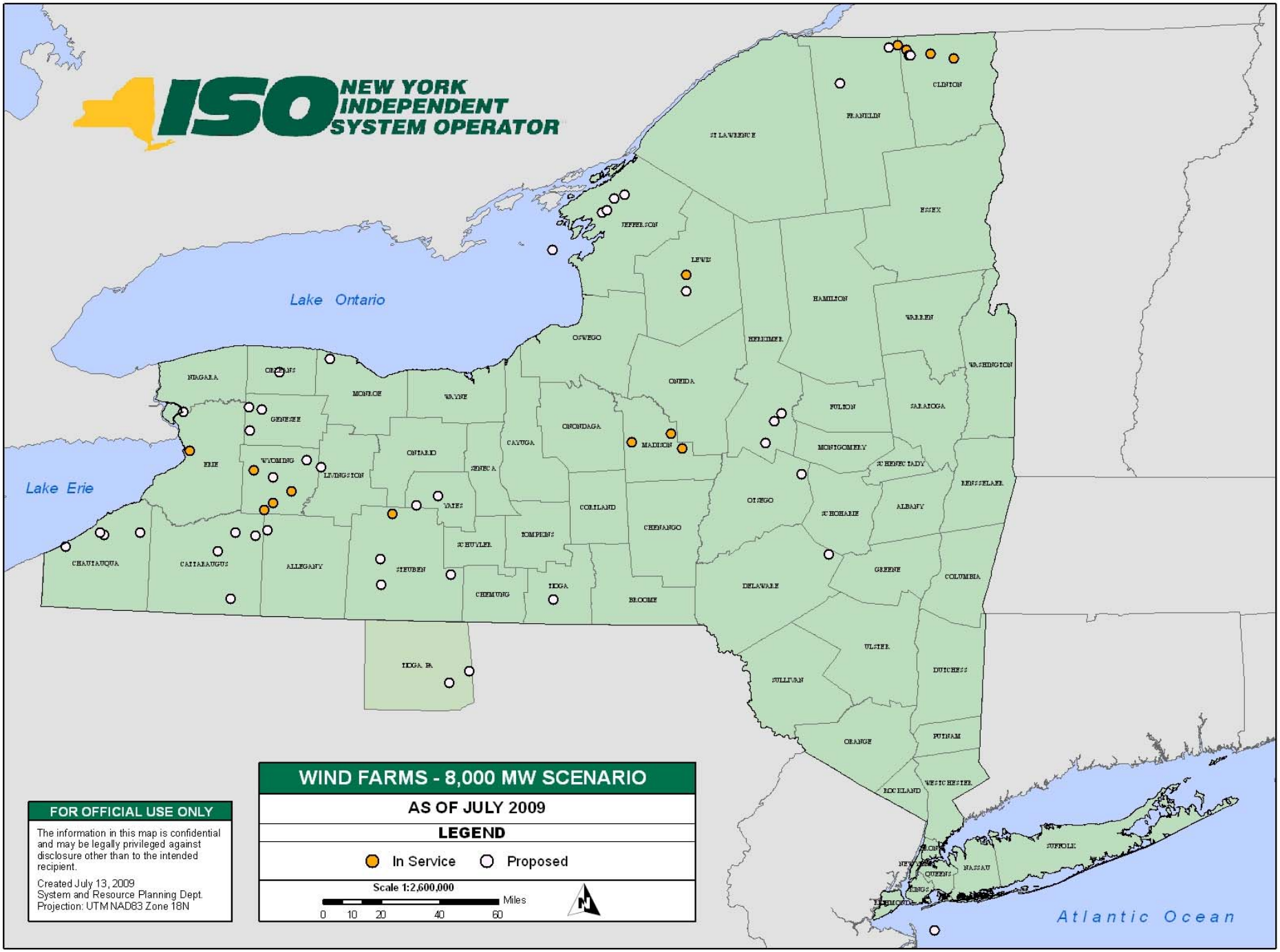
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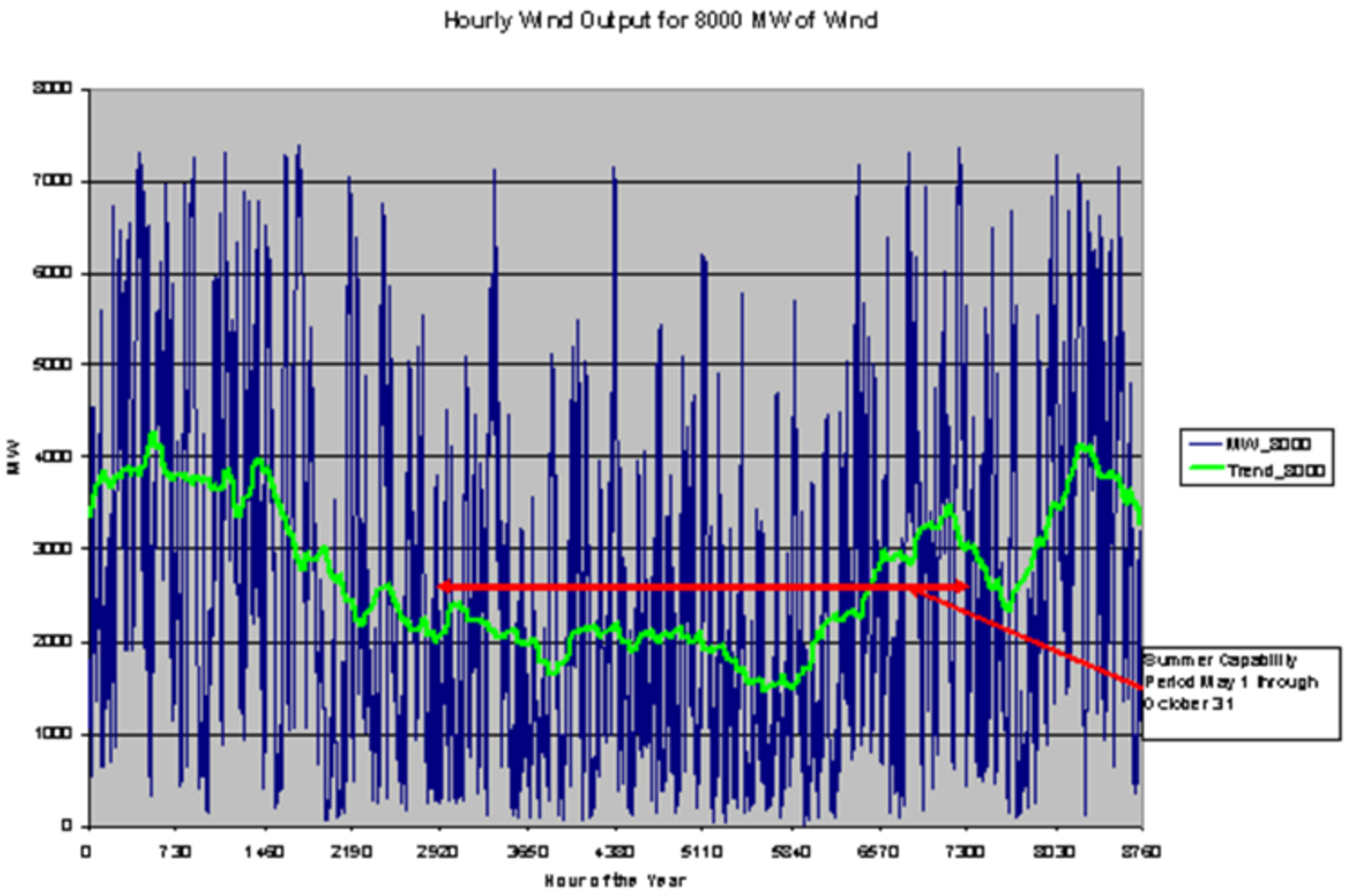
Projection: UTM NAD83 Zone 18N
WIND FARMS - 8,000 MW SCENARIO
AS OF JULY 2009
LEGEND
In Service
Proposed
Scale 1:2,600,000
Miles
0 10 20 40 60
N

Simulation -- 8,000 MW of Wind



Task 6 and 7- Status

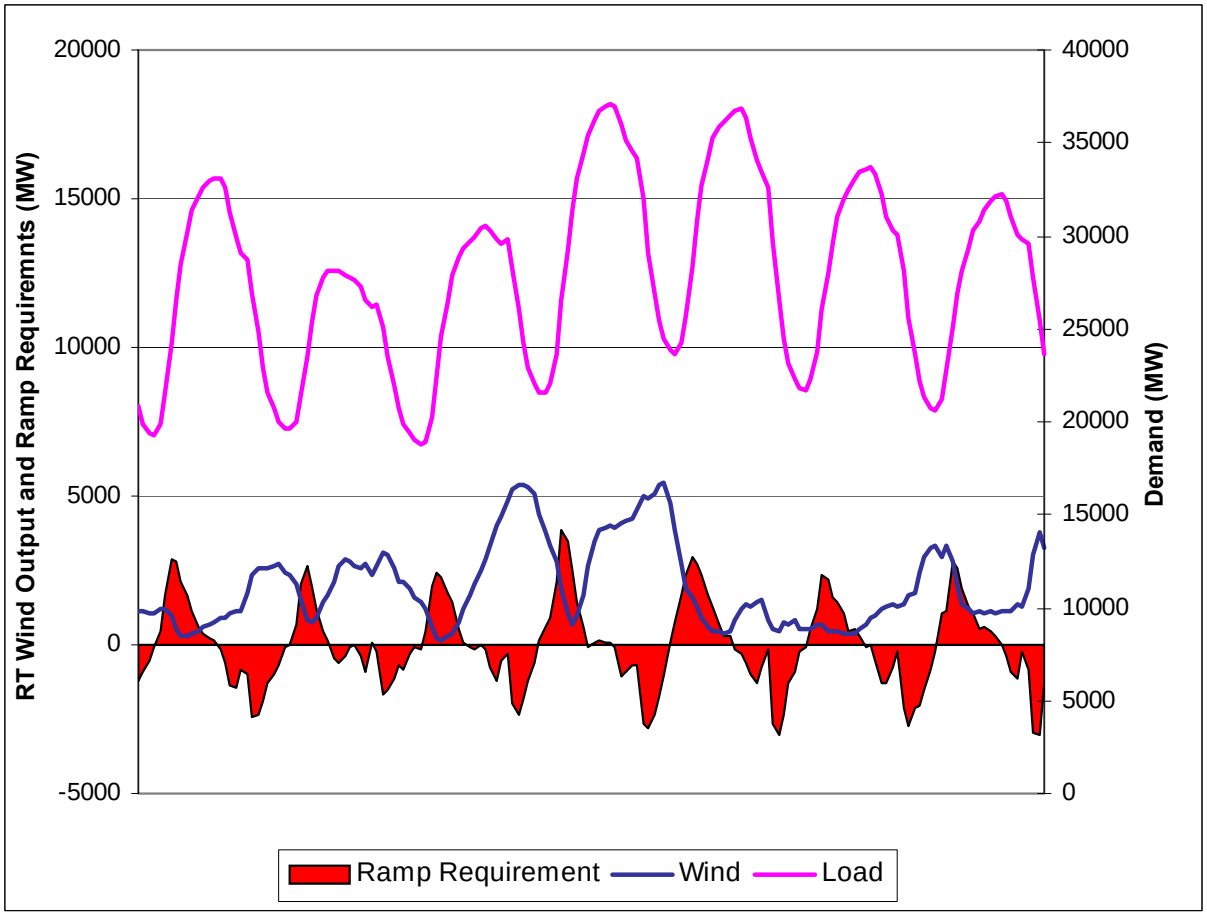
- **Still a work in progress**
  - ***Simulations complete and under analysis***
  - ***Results are still preliminary***
  - ***Develop Upgrade List***
  - ***Assess Upgrades***

Next Steps

- **Complete Task 6 & 7 analysis and present results at next workshop scheduled for Dec 10**
- **Investigate ramping and minimum load issues**
- **Any additional issues as identified by Stakeholders**

Next Steps – Ramping Issue

- Example of ramping for the summer peak week for 2018



Next Steps –Ramping Issue

- Increase in ramping resulting from wind in red for the 2018 summer peak week.

Next Steps – Load Issue

Simulated Minimum Loads and Minimum Net-Loads

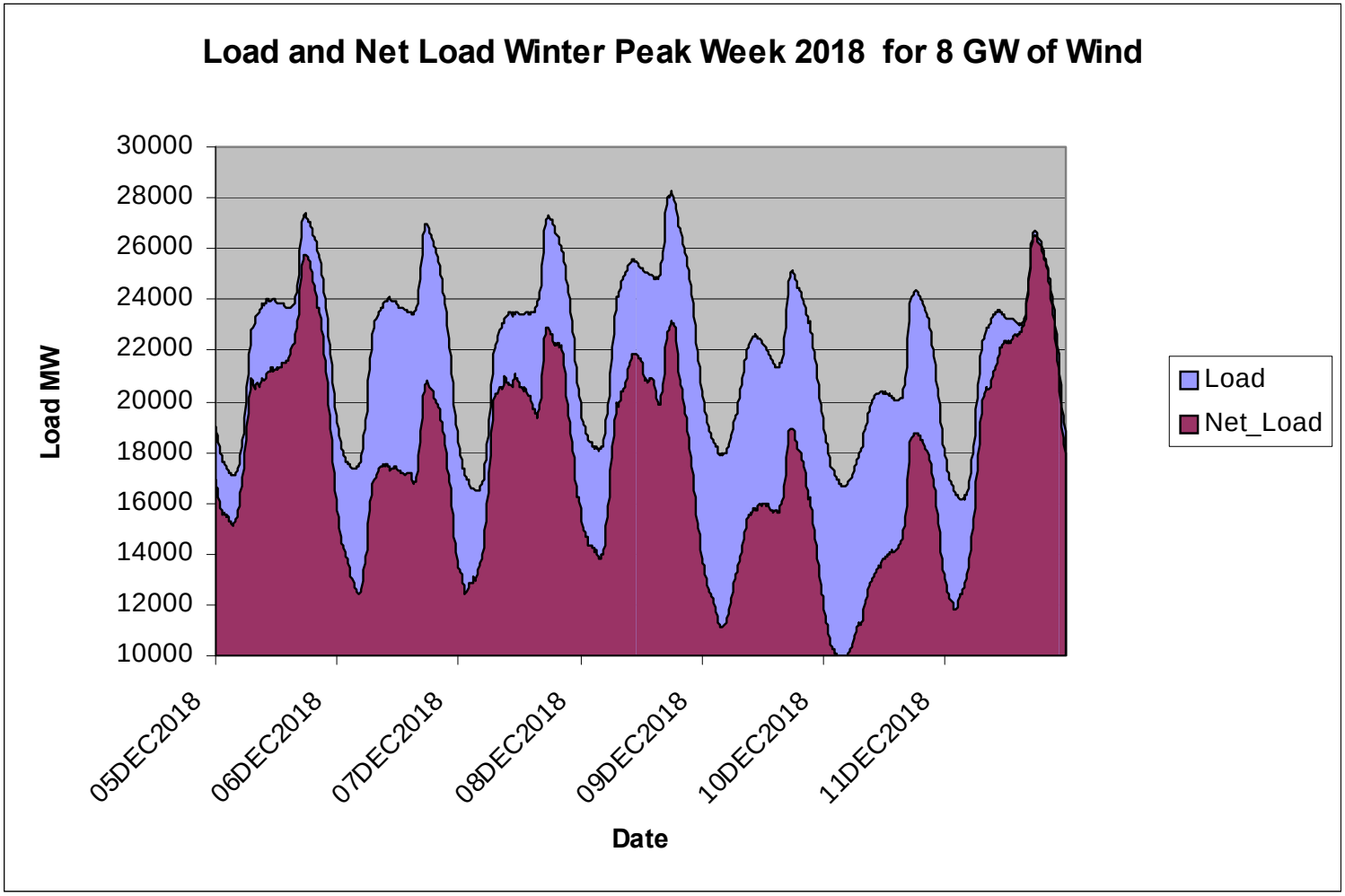
Study Year	Load No Wind (MW)	Low Wind Scenario[1] (MW)	High Wind Scenario[2] (MW)
2008	10,790		
2011	12,618	10,297	9,692
2013	12,937	10,023	8,560
2018	13,721	9,398	7,574

1) 3,500 MW in 2011, 4,250 MW in 2013 and 6,000 MW in 2018
2) 4,250 MW in 2011, 6,000 MW in 2013 and 8,000 MW in 2018

Trough to Peak Maximum Increases for Summer and Winter 2018

Load Metric\Season	Summer 2018		Winter 2018	
	Date	MW	Date	MW
Peak Load	17-Jul	37102	8-Dec	28231
Max Load Change Trough-Peak	17-Jul	15627	18-Dec	11389
Max Net Load Change Trough-Peak	18-Jul	17464	11-Dec	14734

Next Steps – Min Load Issue



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