Wind Integration Study: Study Results

Continuation of Dec. 21 Material

NYISO Wind Study Workshop

February 17, 2010 – Final Draft February 9, 2010

Wind Plant Integration Issues

- **Transmission (Task 5, 6 and 7)**
  - ***Will local area limitations affect wind plant output?***
  - ***Are transmission limitations 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**

Review of December 21 Meeting

- **An estimate of the amount of wind plant energy “bottling” was presented by wind plant penetration level and LBMP zone**
- **To fully utilize the wind plant energy output that was studied local transmission upgrades will be required**
- **Identified transmission constraints that impact wind plants**
- **Presented preliminary stability analysis**
- **For the conditions studied locational marginal prices (LMPs) decrease as wind plant penetration increases**

Review of December 21 Meeting

- **System LBMP prices and system production costs decline as wind plant penetration increases.**
- **Overall system emissions decline as wind plant penetration increases.**
- **Scheduling of wind resources can provide operational and reliability benefits as well as impact LBMP.**
- **Wind plant output primarily replaces gas fired generation followed by a smaller percentages of oil and coal fired generation**

Review of December 21 Meeting

- **The intermittent nature of wind generation increases overall system variability as measured by the net-load.**
- **This increased variability will result in an increase in regulation requirements.**
- **The NYISO will continue to monitor ramping and net load following performance**
- **Power systems are inherently designed to respond to system variability and this study did not observe for the wind levels evaluated any increase in variability that would adversely impact the system or result in reliability issues.**

Next Steps Identified at 12/2/09 Meeting

- **Address Action Items**
- **Coordinate the identification of potential transmission upgrades**
- **Evaluate the benefits of the upgrades in terms of the amount of wind energy that is unbottled**
- **Complete Stability Analysis**
- **Continue to investigate ramping and scheduling issues**
- **Draft Report**

Action Items from 12/21/09 WS

- **Develop cleaner version of slide 9 summary wind plant energy bottling**
- **Can results for individual location/plants be provided?**
- **Determine at what level of wind plant MW that transmission becomes binding, or bottling begins.**
- **Slide 37 make LBMP scales consistent**
- **Slide 49 and 50 (uplift calculation) determine whether GridView does this hourly or daily**
- **Slide 51 define congestion used in graphic**

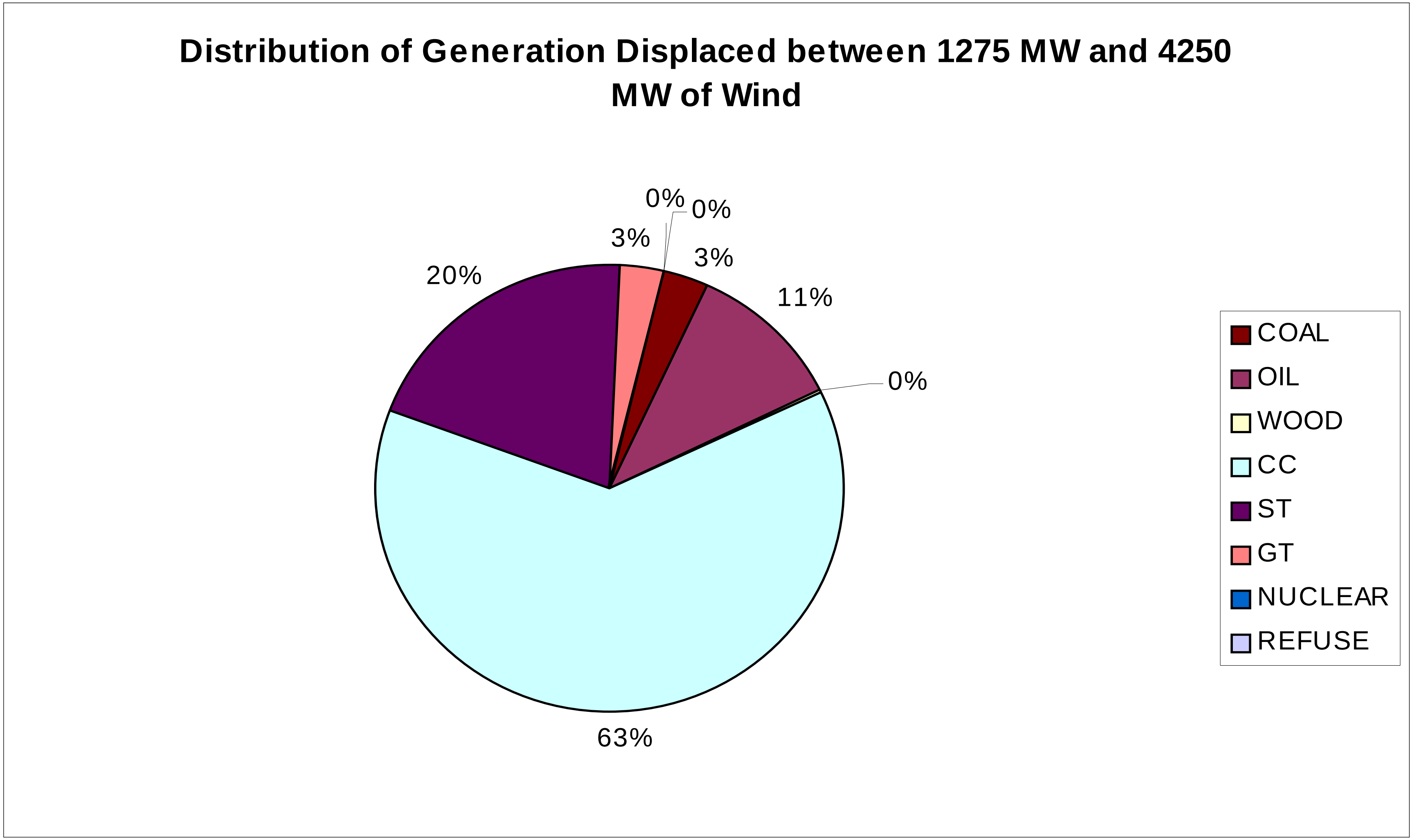
Action Items from 12/21/09 WS

- **Slide 64 shows fuel displacement pie chart for other levels of wind penetration plus breakdown of gas by plant type – note initial chart overstated impact on gas and understated impact on oil.**
- **Show more detail for exports and imports**
- **On slide 68 rewrite second bullet regarding impact of wind resources on reserve margin.**

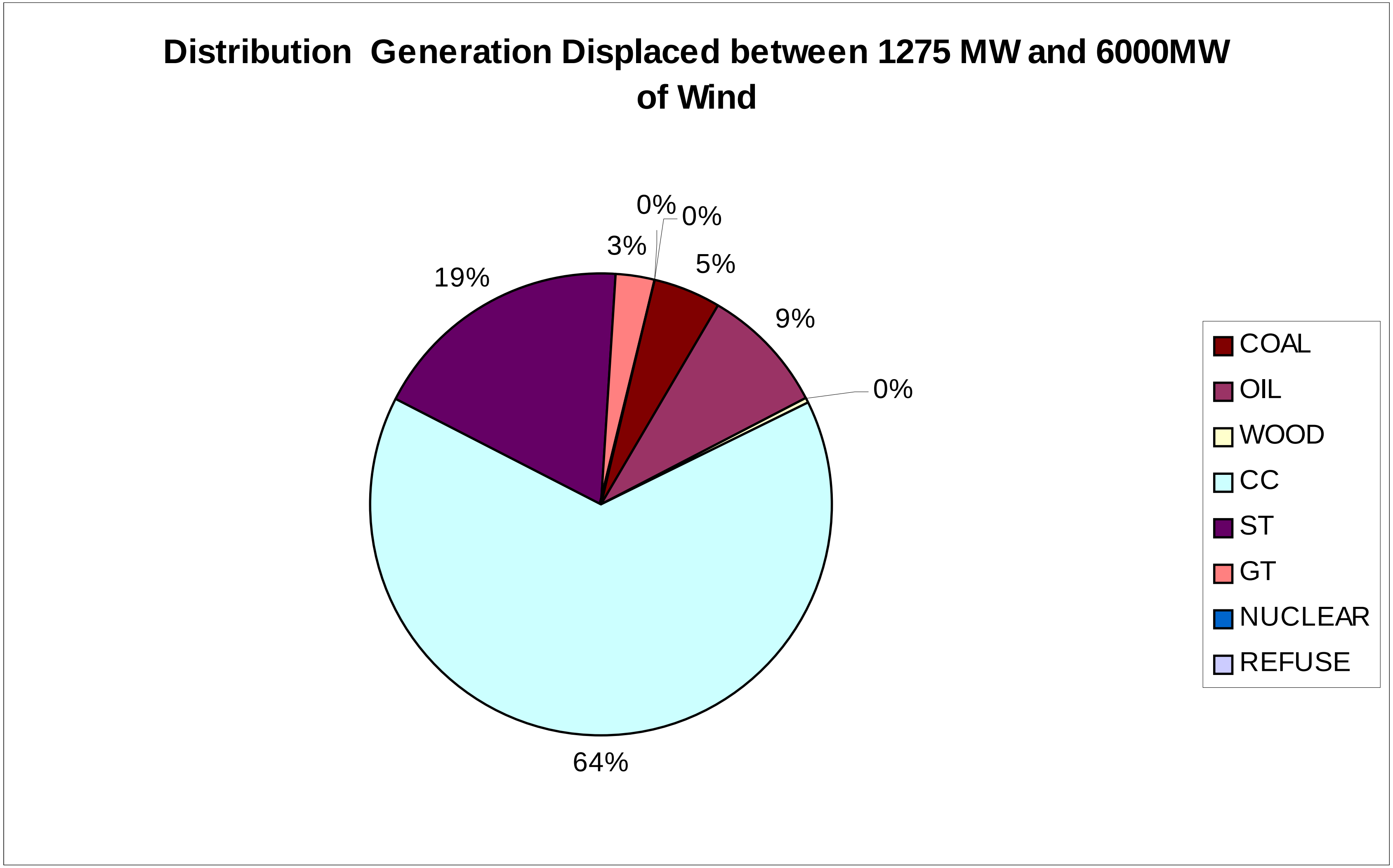
AI – Wind Plant Energy Bottling

Installed Nameplate Wind Capacity										
	1275 MW		1275 MW 2018 Load		4250 MW		6000 MW		8000 MW	
Zone	Capacity	Cap. Factor Reduction	Capacity	Cap. Factor Reduction	Capacity	Cap. Factor Reduction	Capacity	Cap. Factor Reduction	Capacity	Cap. Factor Reduction
A	119	0.0%	119	0.0%	935	0.0%	1309	0.1%	1510	0.1%
B	6	0.1%	6	0.1%	86	0.0%	281	0.1%	418	0.1%
C	393	0.0%	393	0.0%	1110	6.7%	1591	6.1%	1860	6.0%
D	387	3.7%	387	3.7%	717	9.4%	1068	15.0%	1068	15.0%
E	368	0.0%	368	0.0%	1398	6.8%	1648	15.8%	1648	16.0%
F							70	0.1%	70	0.1%
J									700	0.0%
K									700	0.0%
Total	1275	1.1%	1275	1.1%	4247	5.6%	5967	8.8%	7974	6.7%

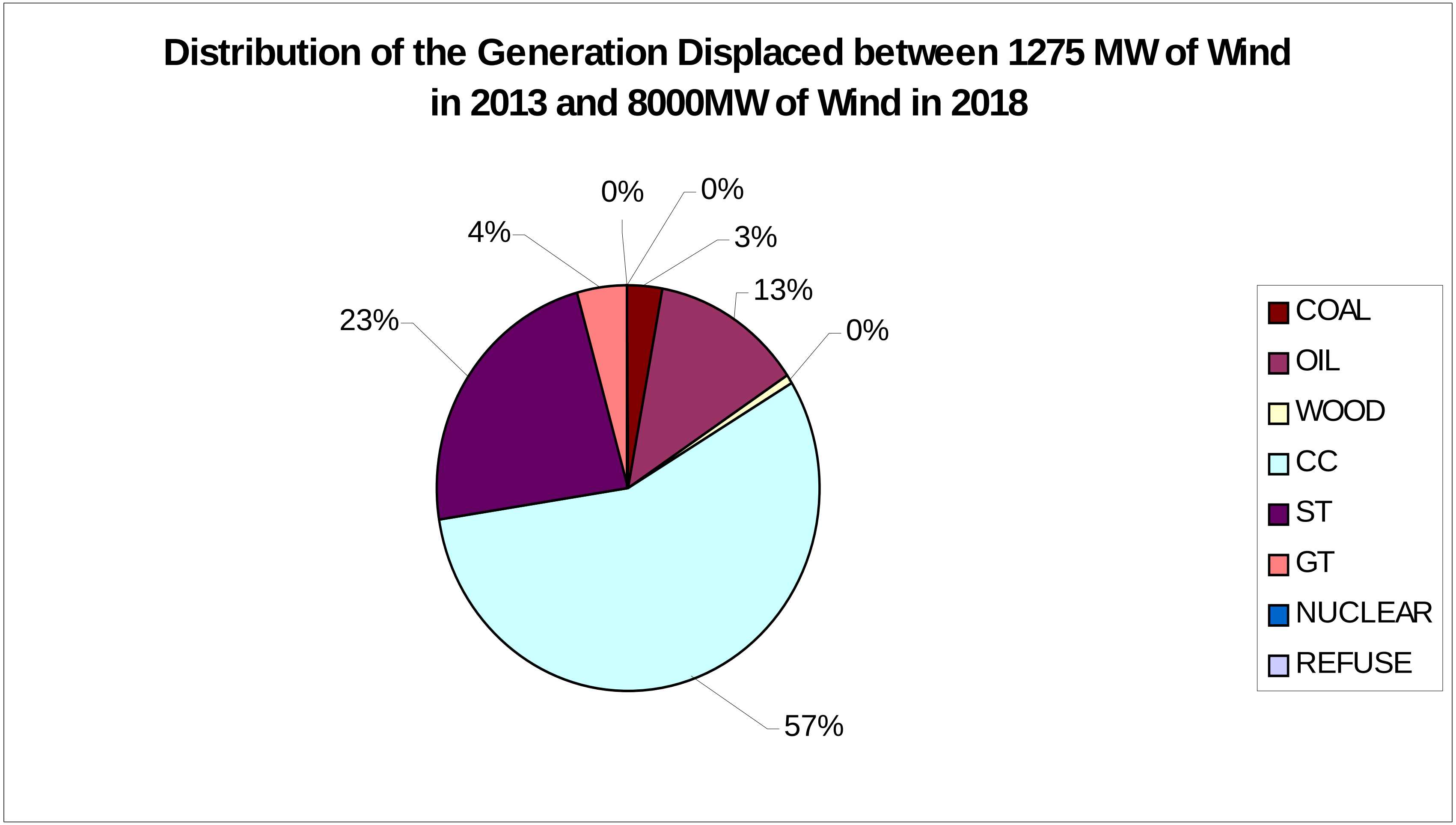
AI – Fuel Displacement – 4250MW



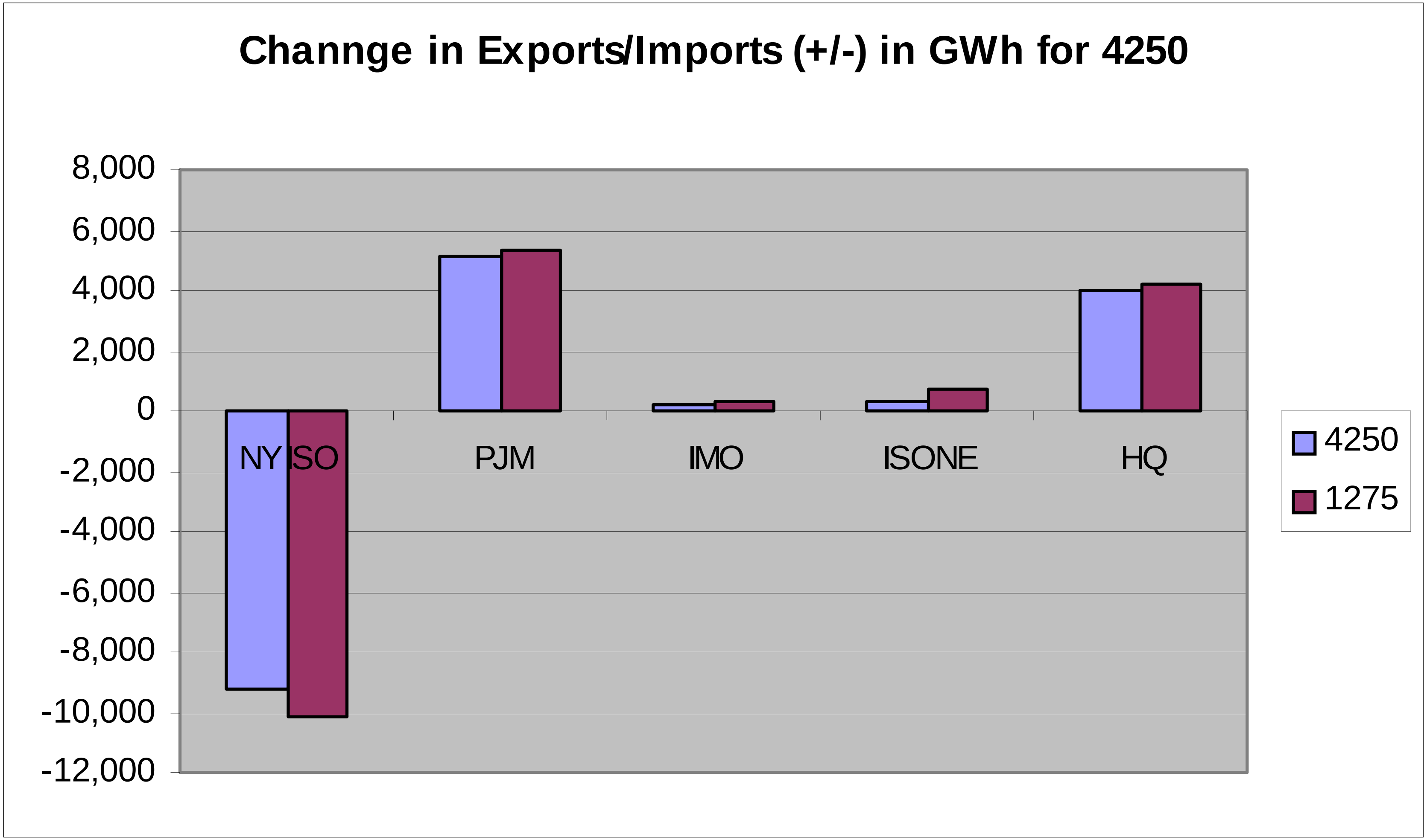
AI - Fuel Displacement - 6000 MW



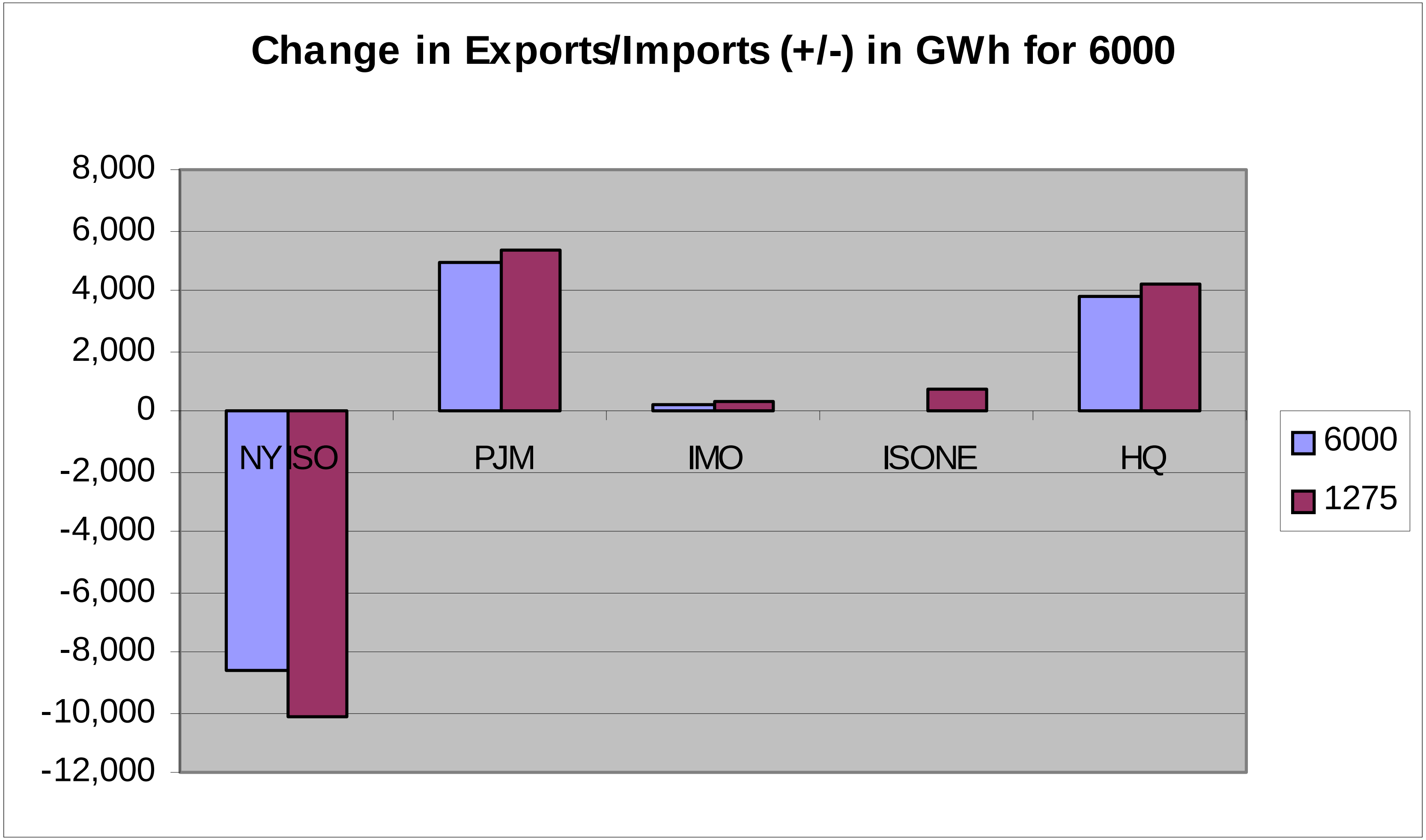
AI – Fuel Displacement – 8000 MW



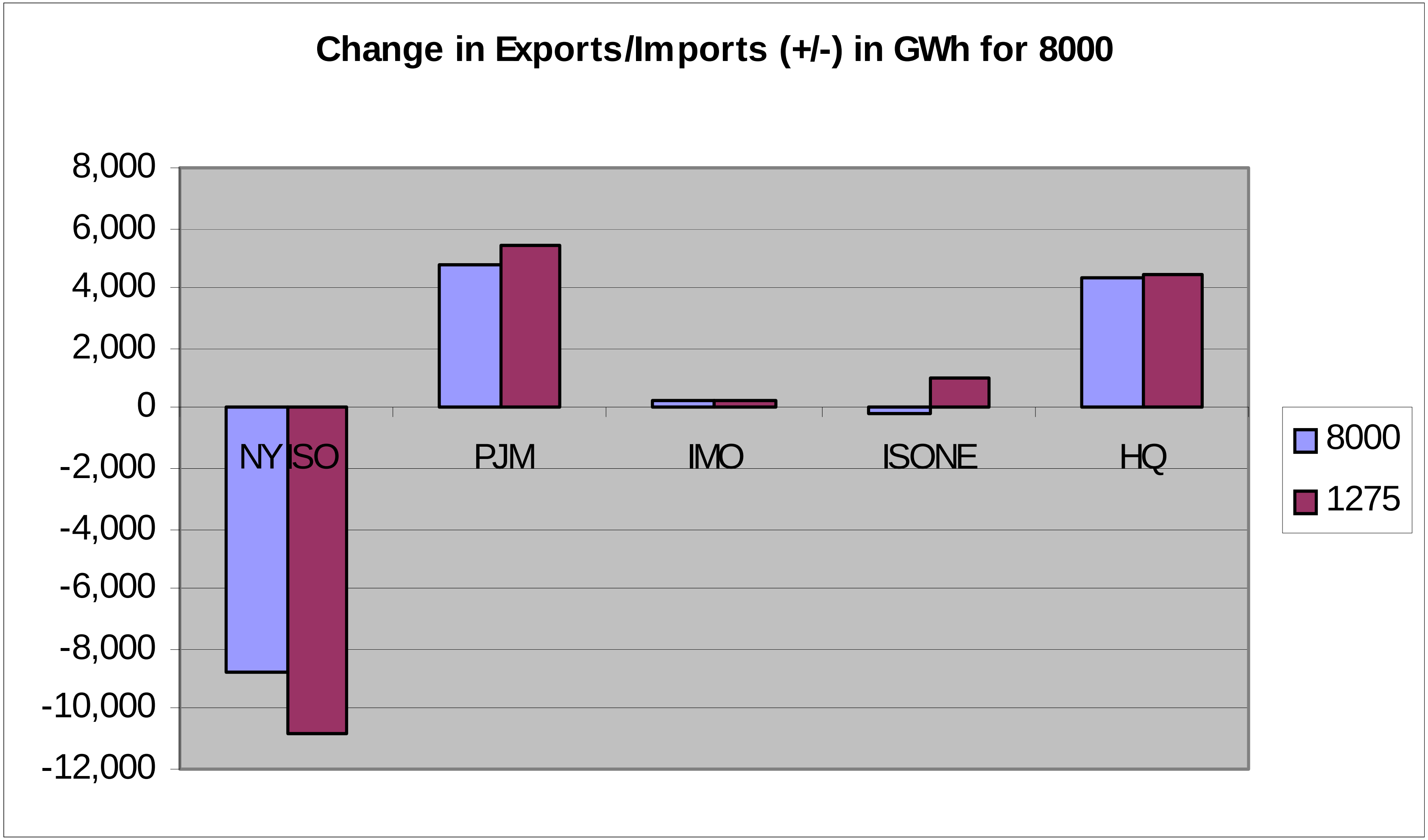
AI – Impact on Imports - 4250 MW



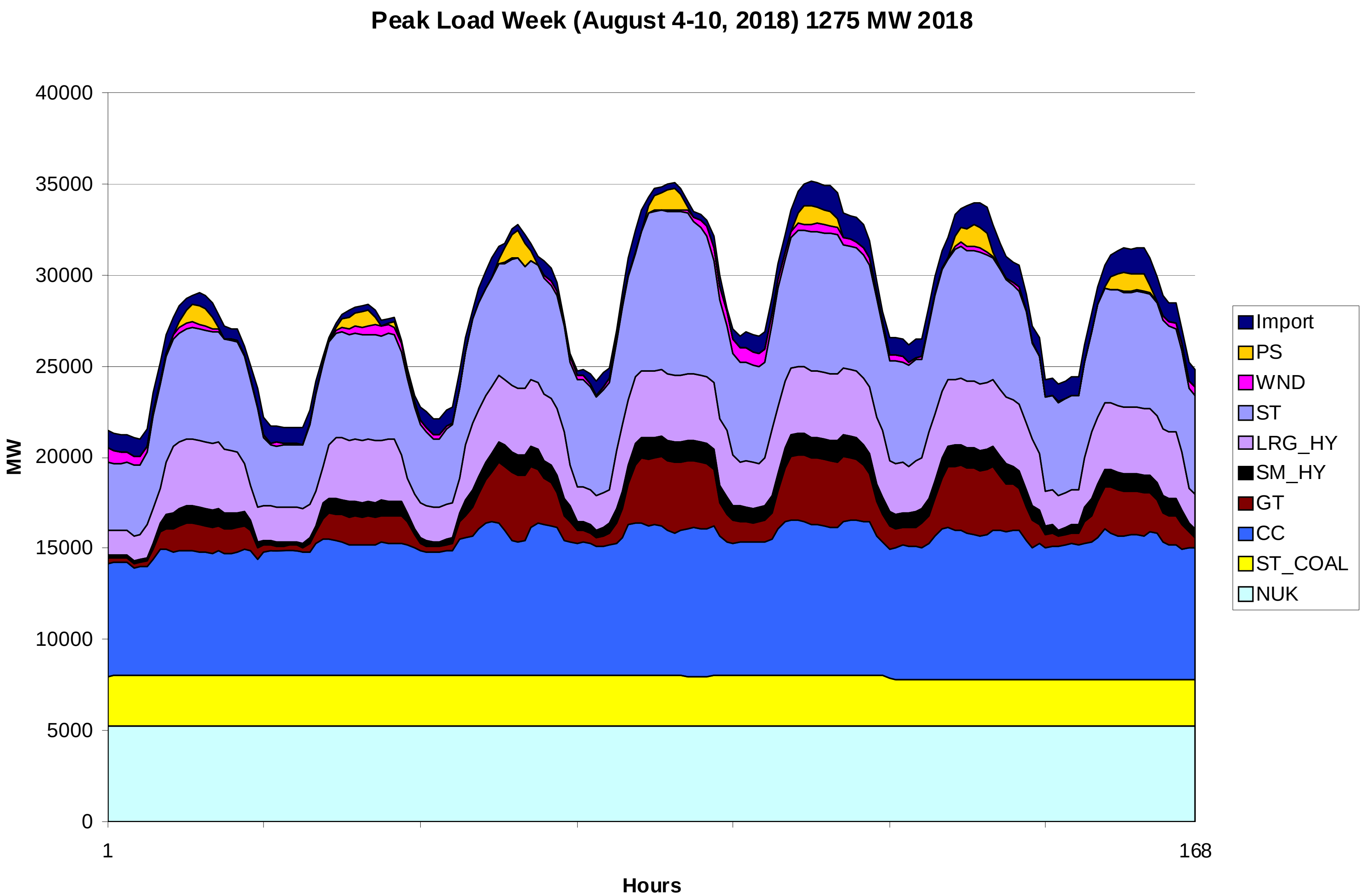
AI – Impact on Imports - 6000 MW



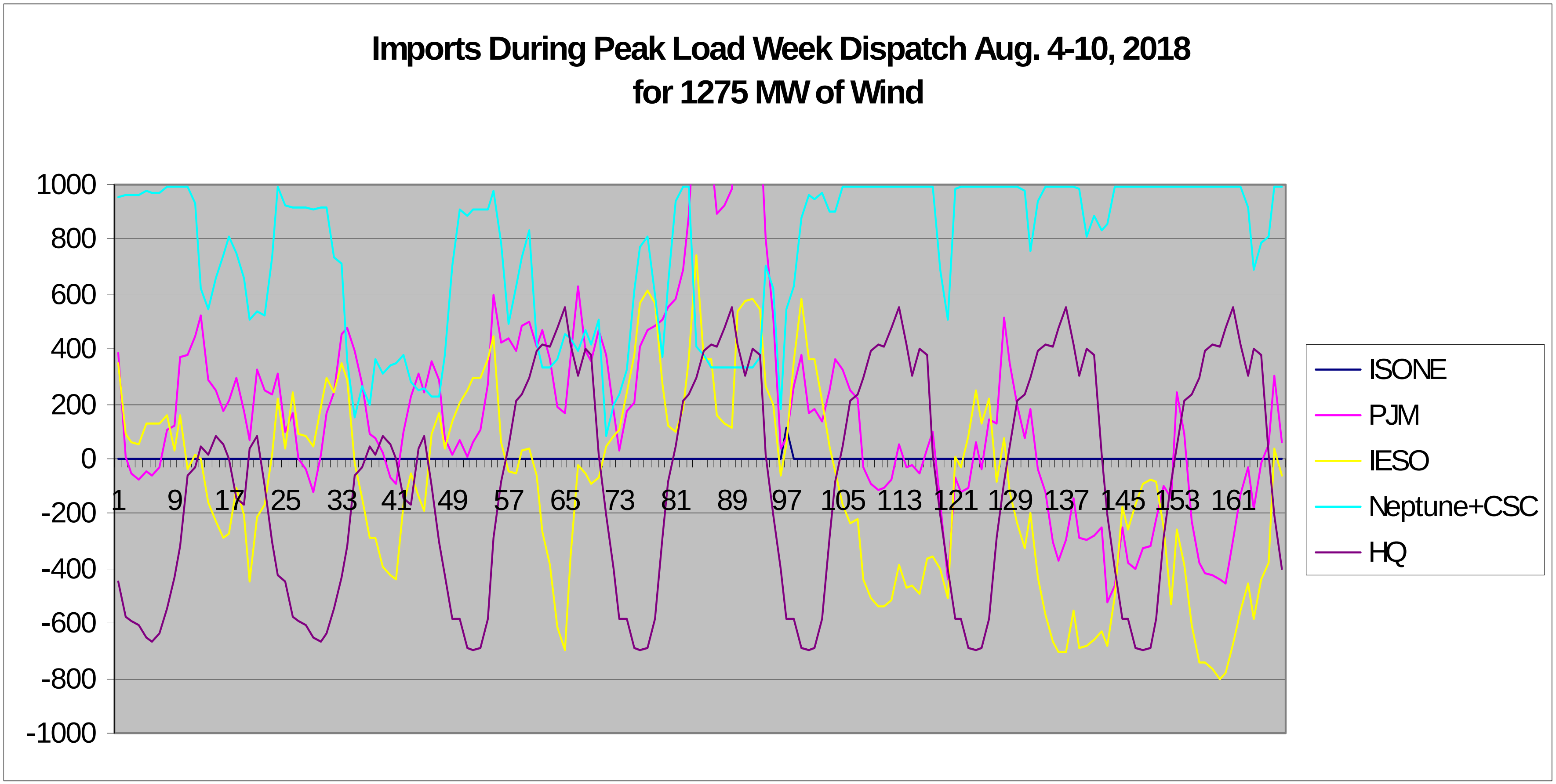
AI – Impact on Imports - 8000 MW



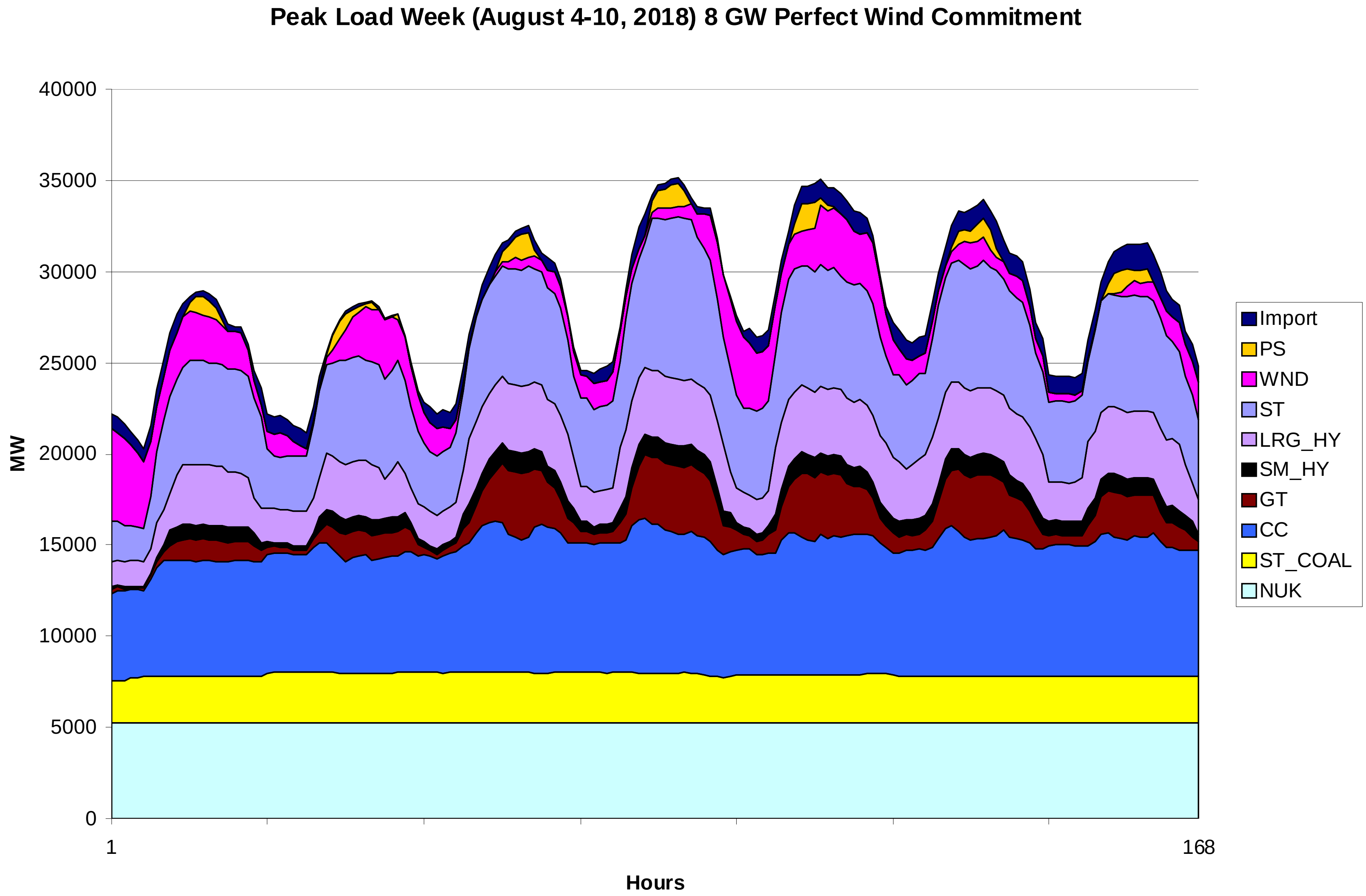
Task 6 - Impact on Dispatch



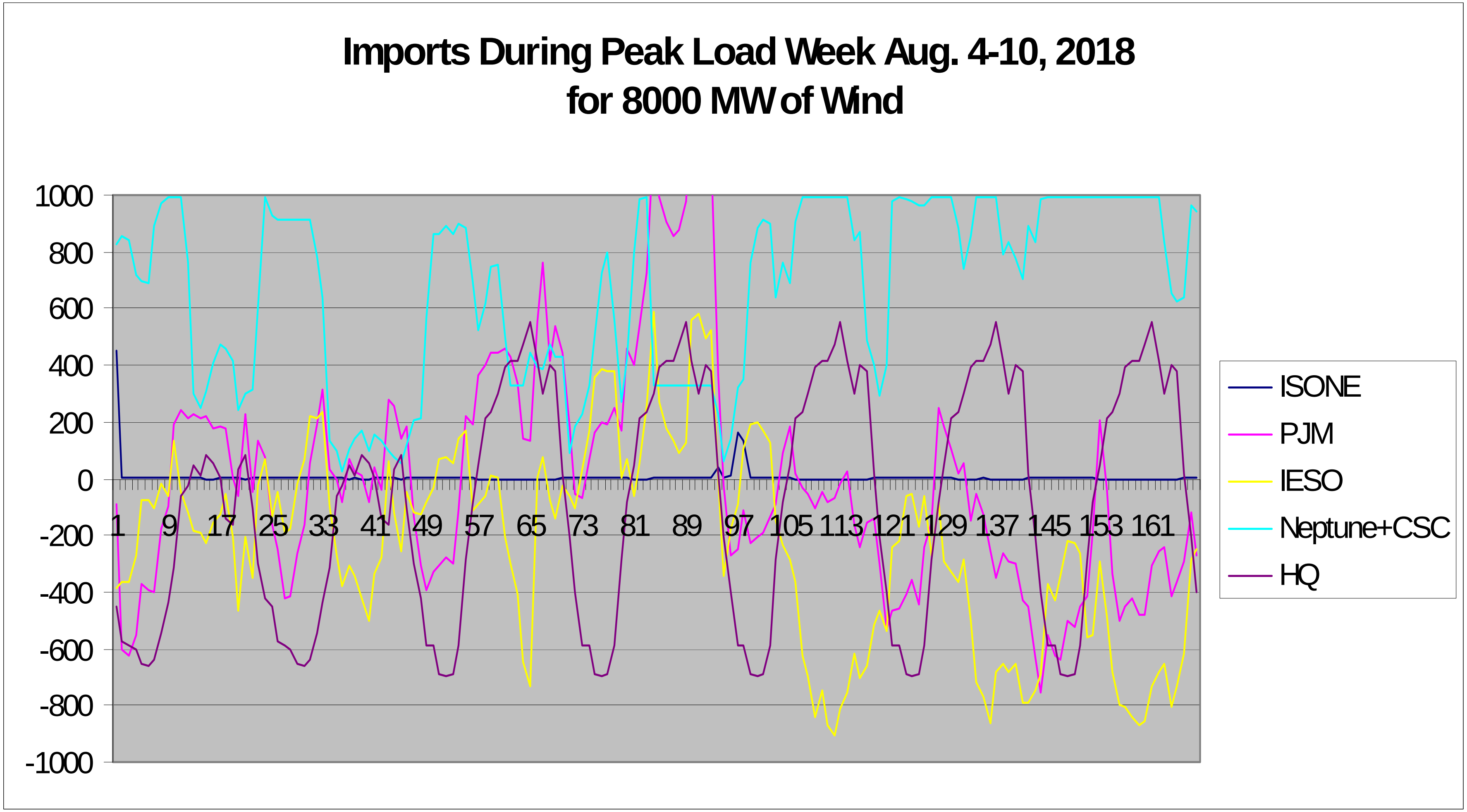
AI – Hourly Import/Export for 2018



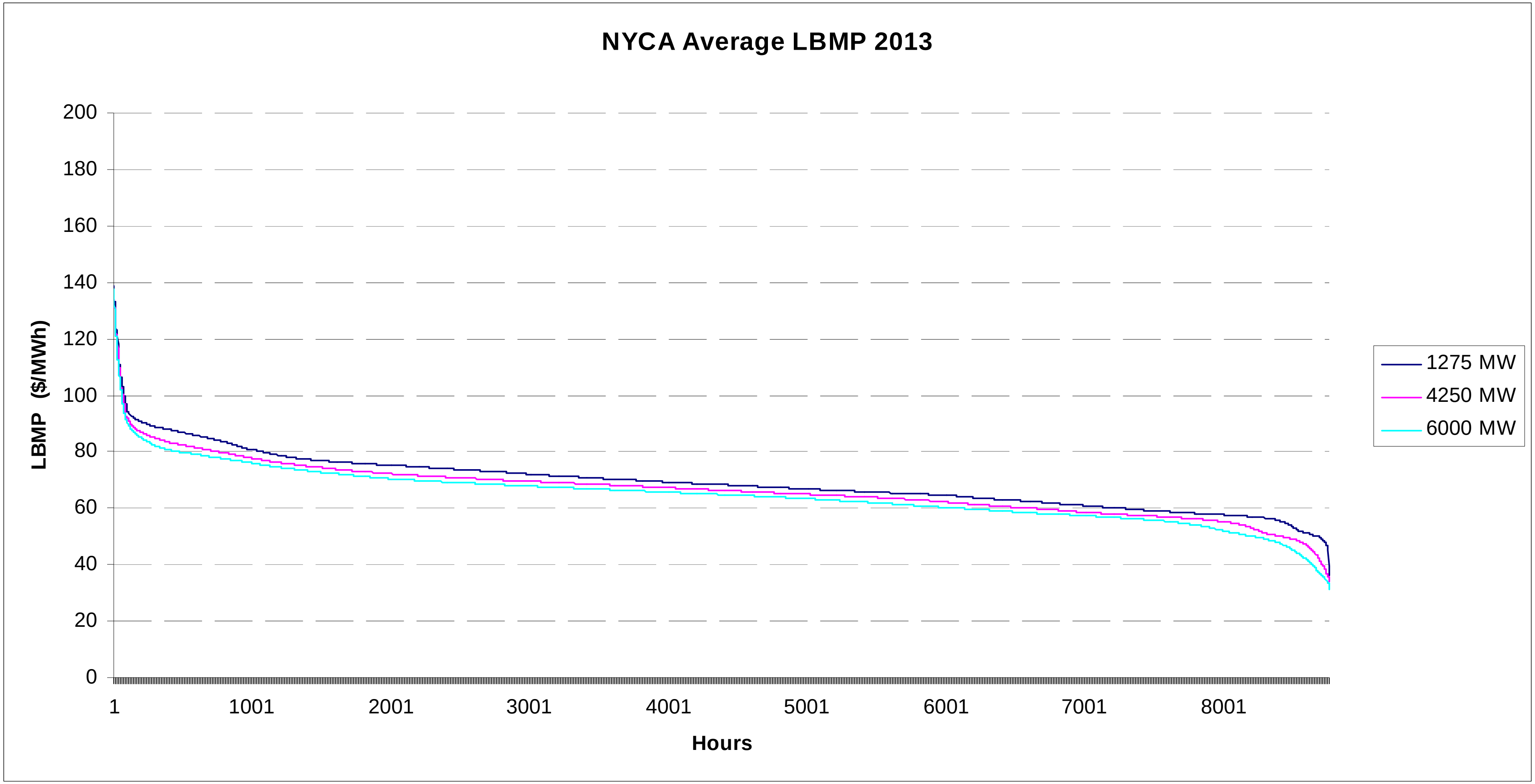
Task 6 - Impact on Dispatch (cont.)



AI – Hourly Import/Export for 2018



AI – Revise Scale for LBMP Curve



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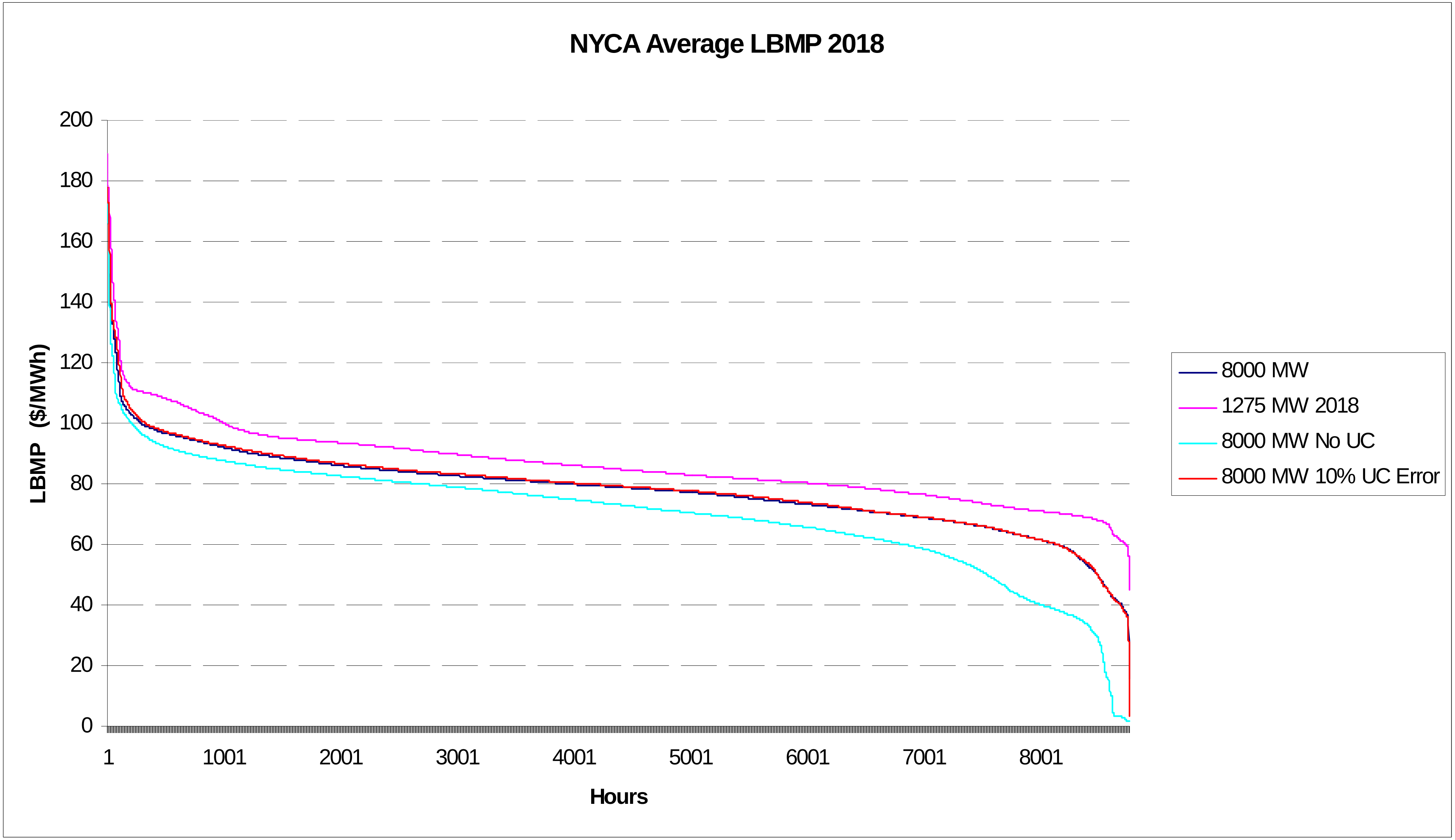

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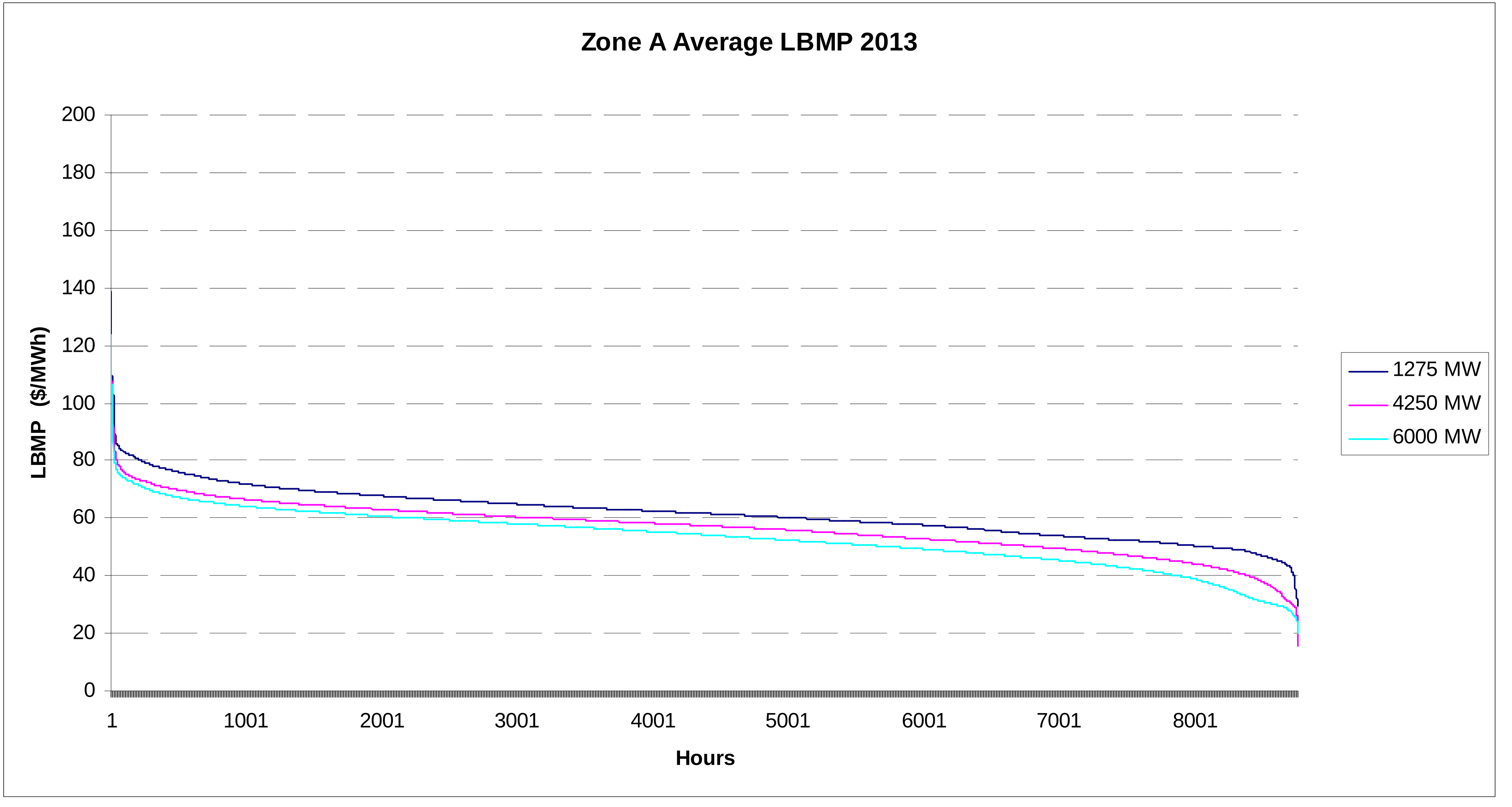

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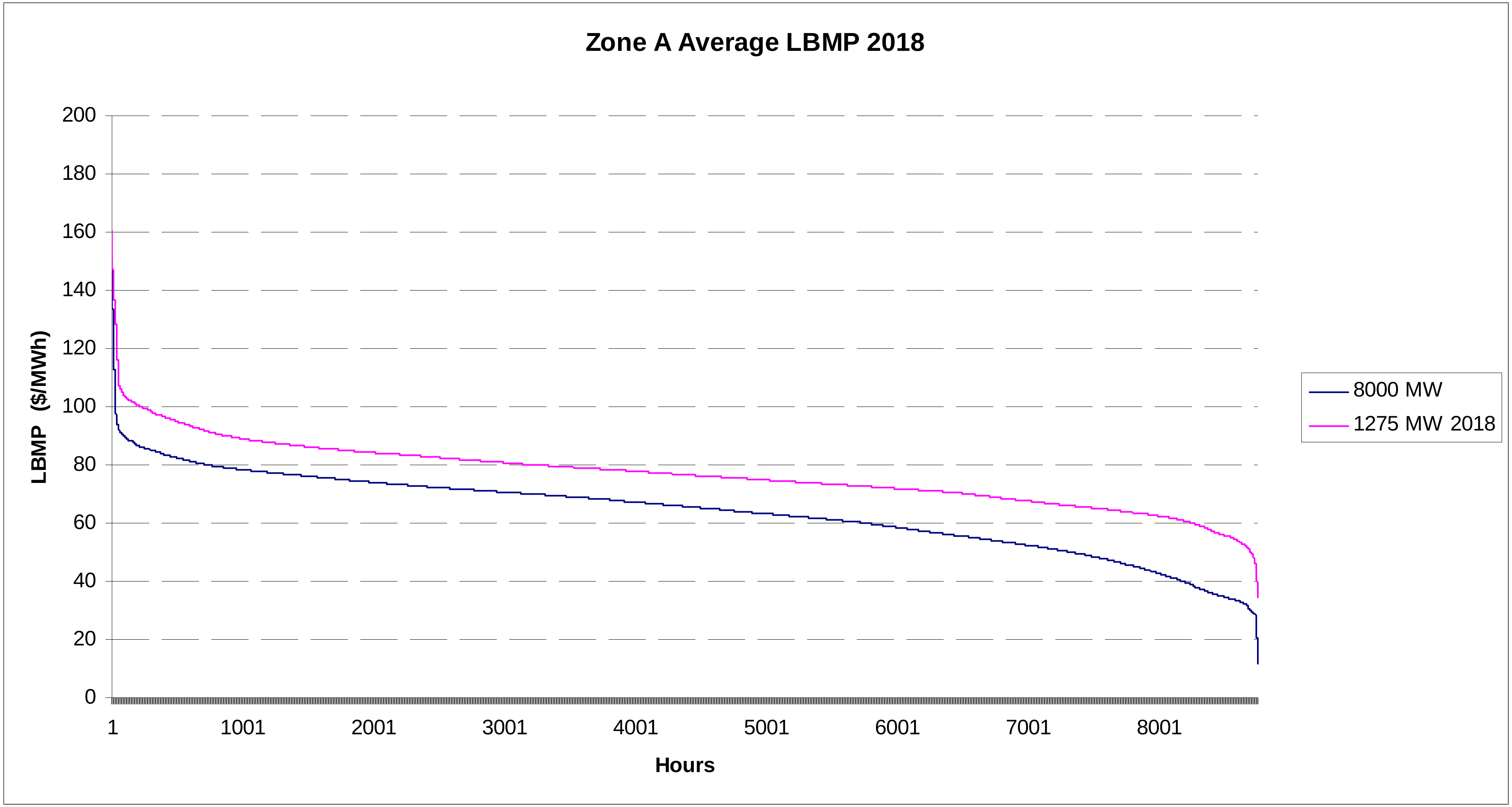


AI – GridView Uplift/BPGC and Congestion calculation

- **GridView calculates uplift on an hourly basis**
- **Uplift calculation being modified to reflect daily basis**
- **GridView calculates demand congestion which are congestion $ paid by demand.**
- **Demand congestion by constraints is the sum of the shadow price x zonal GSF x zonal load for all zones and all hours**

AI – Discussion of Reserve Margin

- **The following observation was presented at the Dec 21 meeting:**
  - ***This lower and correlated unavailability will likely result in a significant increase in installed reserve margins (IRM) as overall percentage of the resource mix that is wind generation increases along with a site to the recent IRM study.***
- **It was suggested that this observation be revised**
- **Also, it was pointed out that the NYSRC sensitivity did not reflect a full integration of the wind resources from a transmission perspective**

AI – Discussion of Reserve Margin

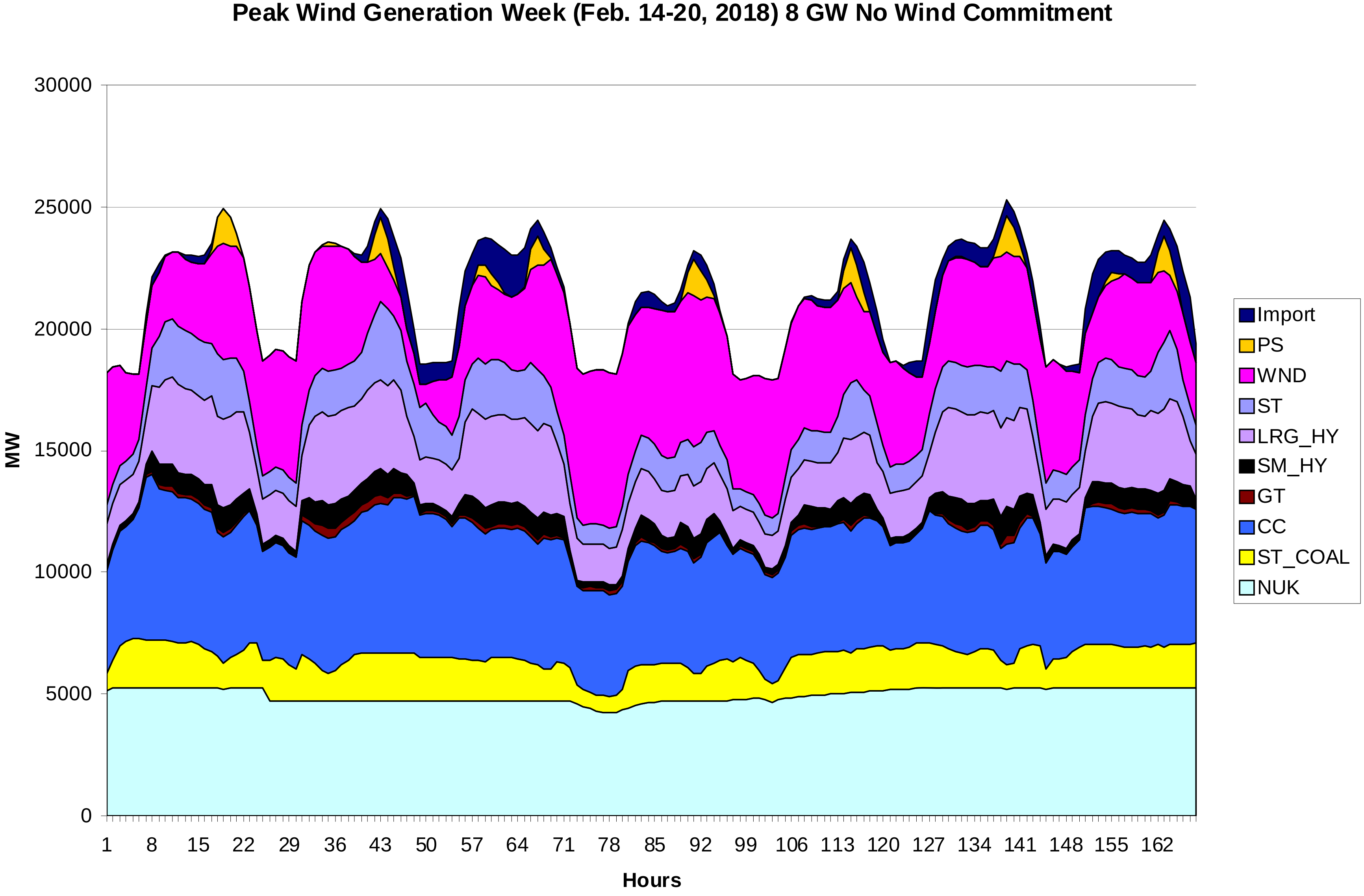
- **Study was updated to reflect the addition of UPNY- SENY transmission capability to meet CRIS requirements**
- **Wind shapes were updated to reflect the shapes used in the wind study**
- **The result of the analysis was a IRM of approximately 30%**
- **If wind resources are not participating in the ICAP market, the IRM would be significantly less**

Impact of Wind Plants On Dispatch Continued

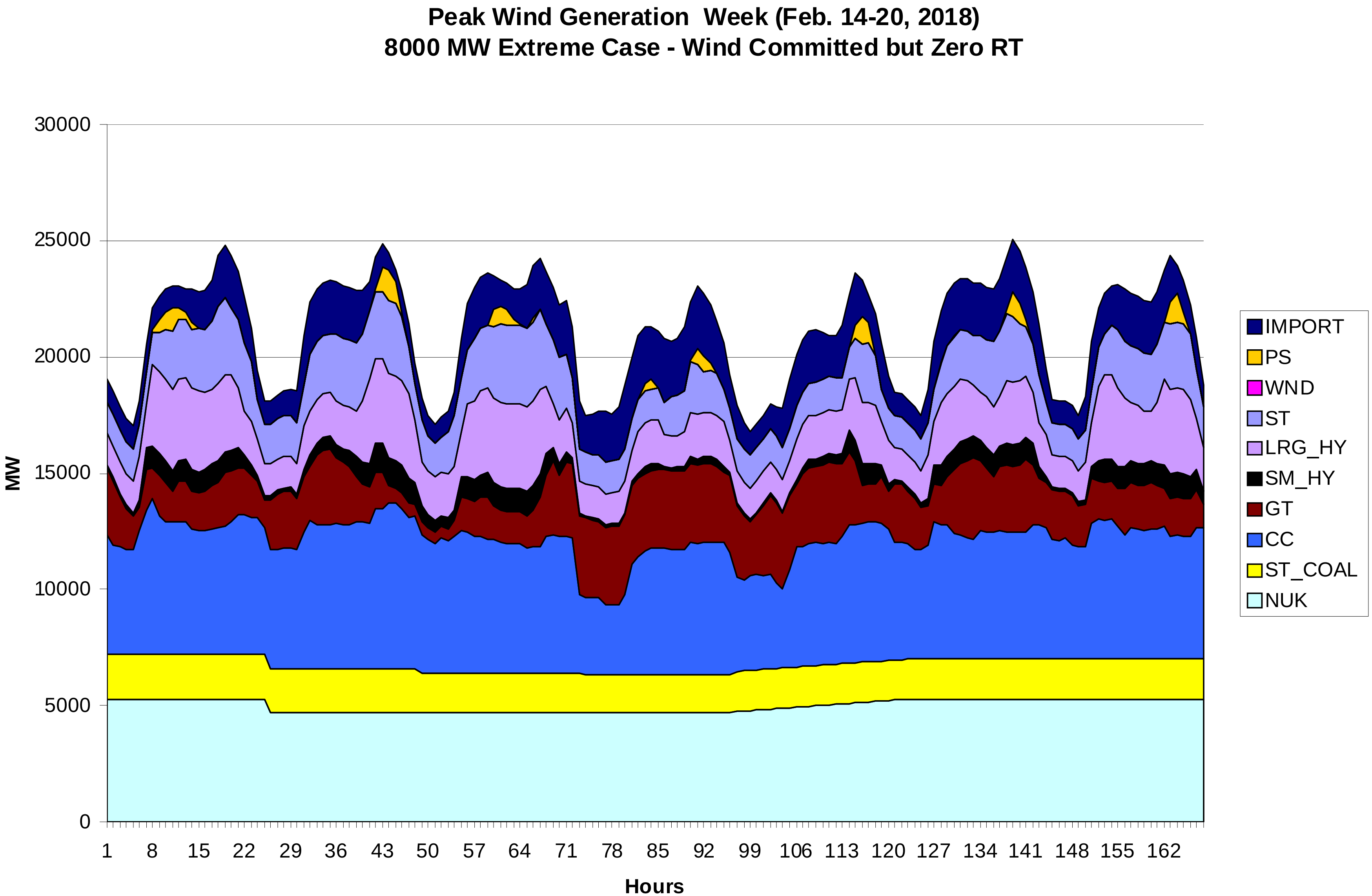
Legend for Impact on Dispatch Slides which follow:

1. Imports = Imports from External Areas
2. PS = Pump Storage
3. Wind = Wind Generation
4. ST = Gas and Oil Steam
5. LRG_HY = Large Hydro
6. SM_HY = Small Hydro
7. GT = Gas Turbine
8. CC = Combined Cycle
9. ST_Coal = Steam Coal
10. NUK = Nuclear Power Plants

Impact on Dispatch



Impact on Dispatch

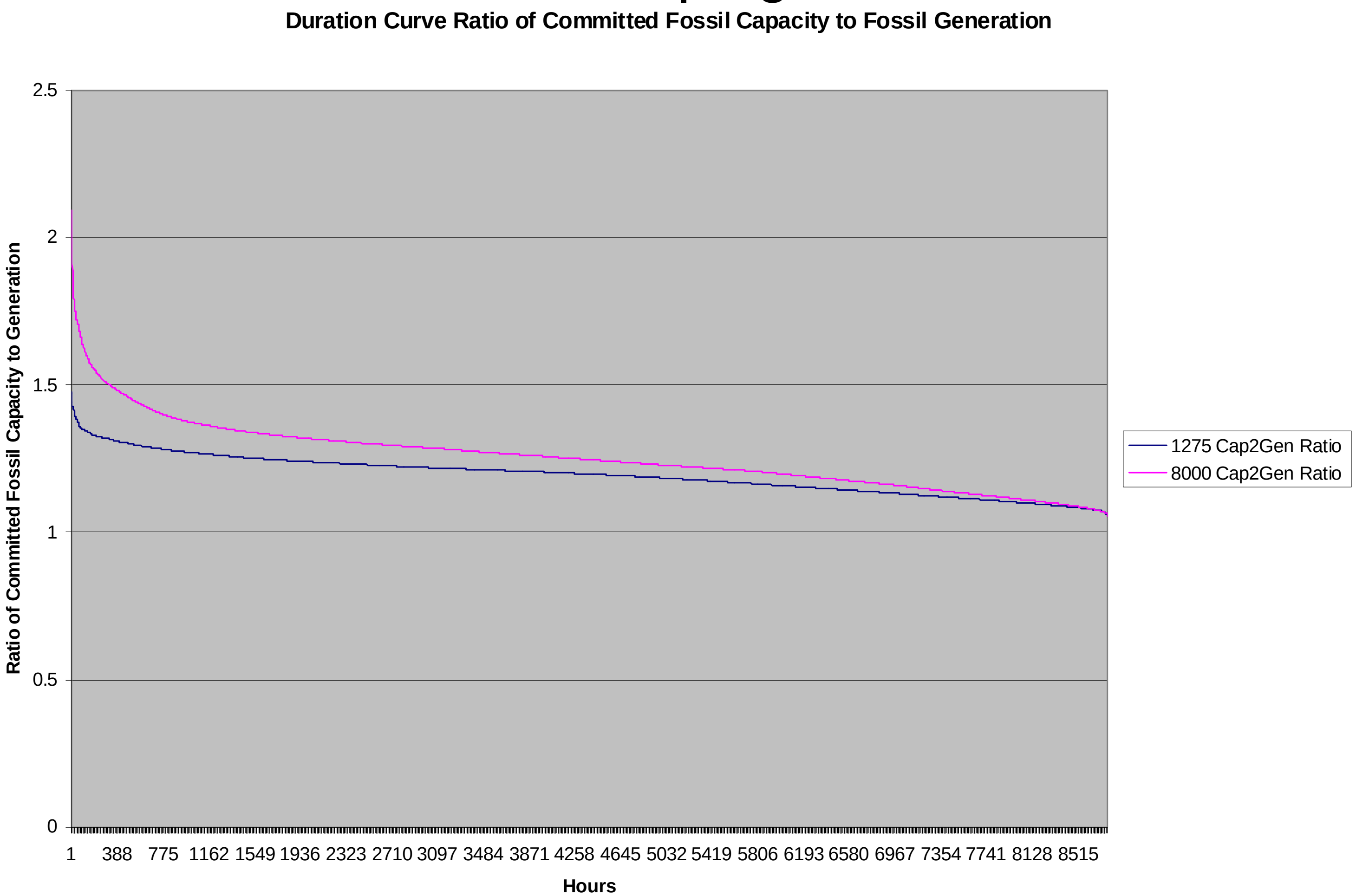


Ramping Issue

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

Ramping Issue

- Increase in committed NYCA fossil units to satisfy intra- and inter-hour ramping



Ramping Issue – Source IEEE

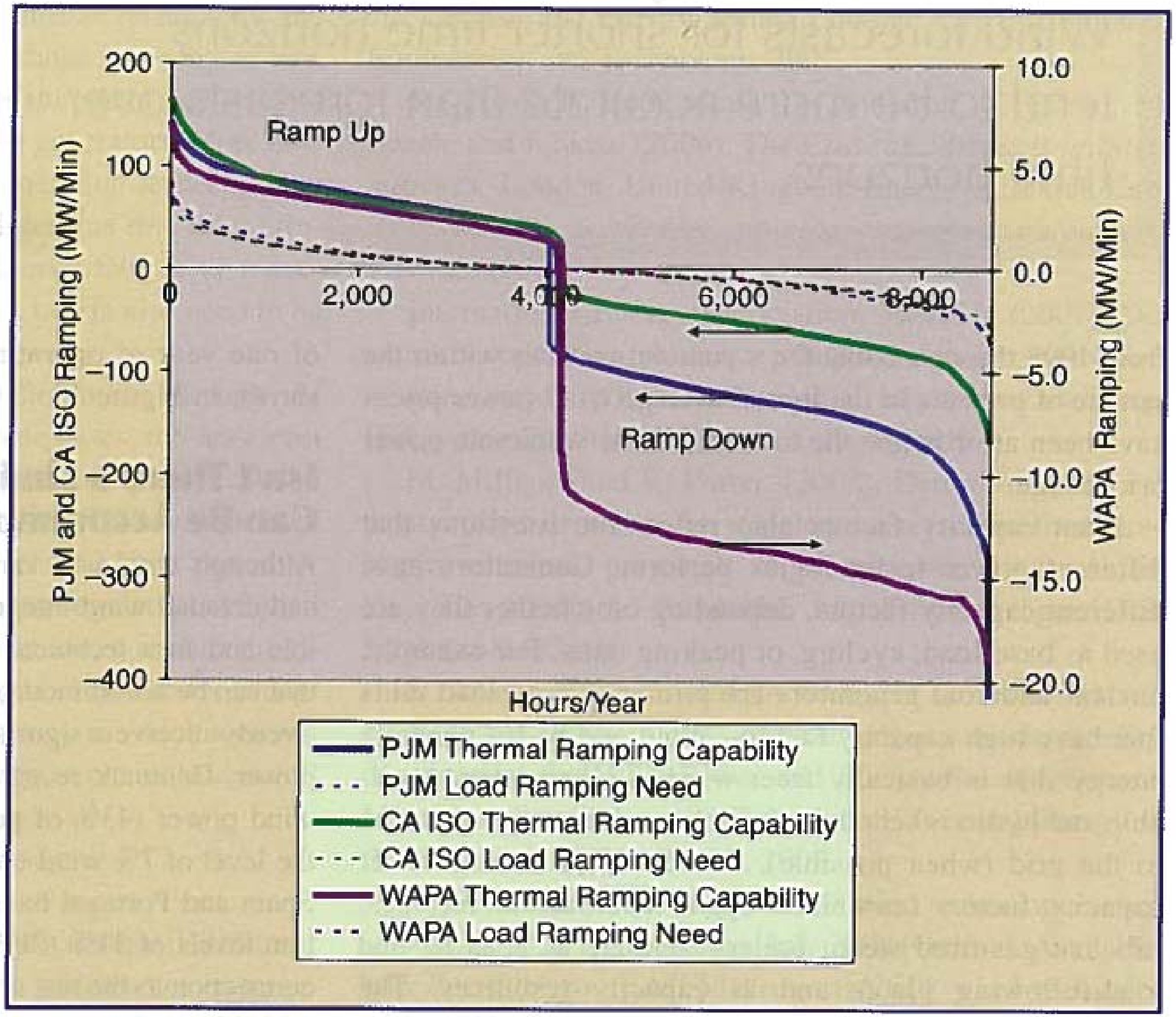
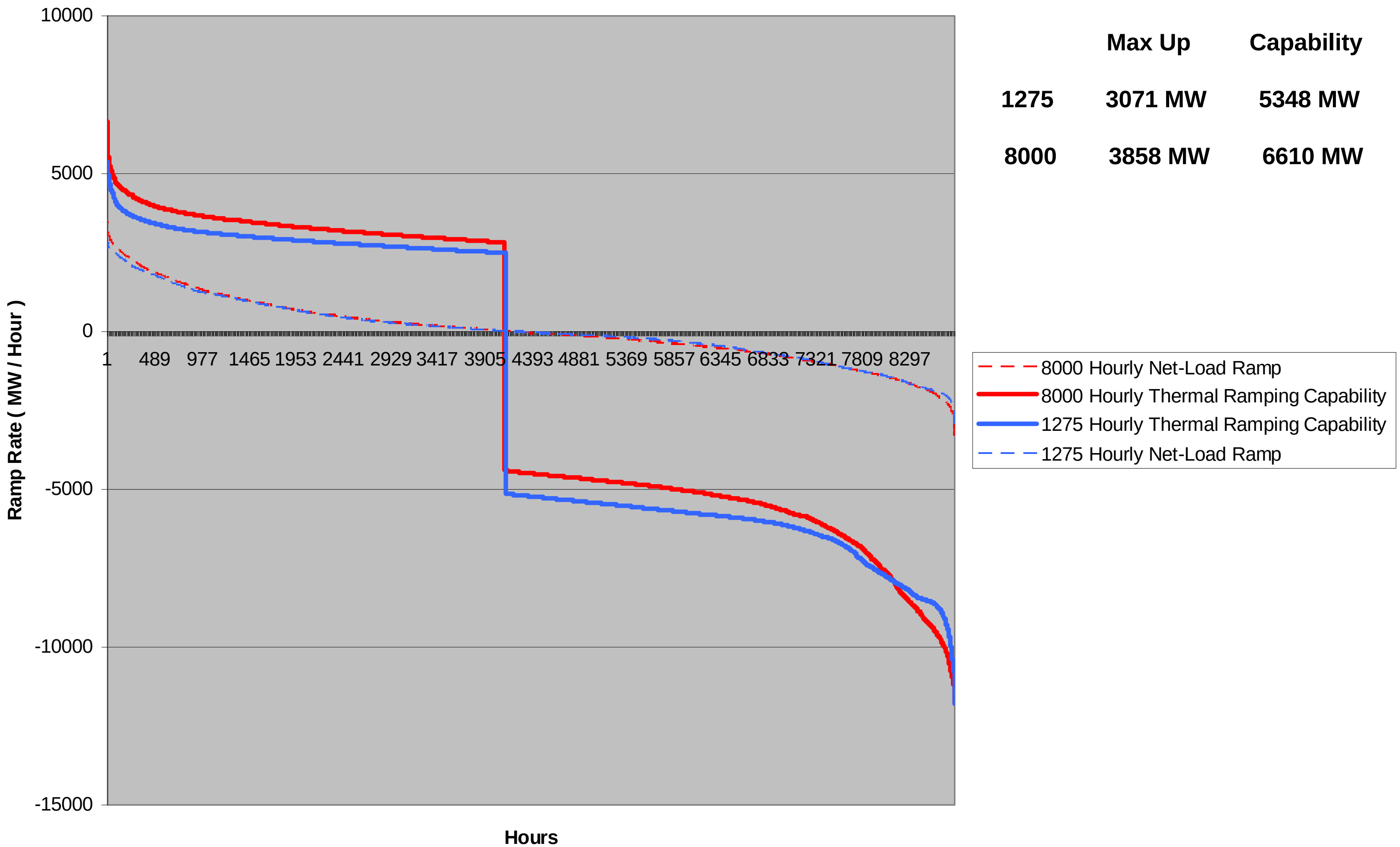


figure 10. An analysis of three different balancing areas showed that all three have excess load-following capability inherent in the conventional thermal-generation mix.

NYISO - GridView Simulations

- Thermal ramping capability VS Hourly ramp

Hourly Net-Load Ramp vs Capability



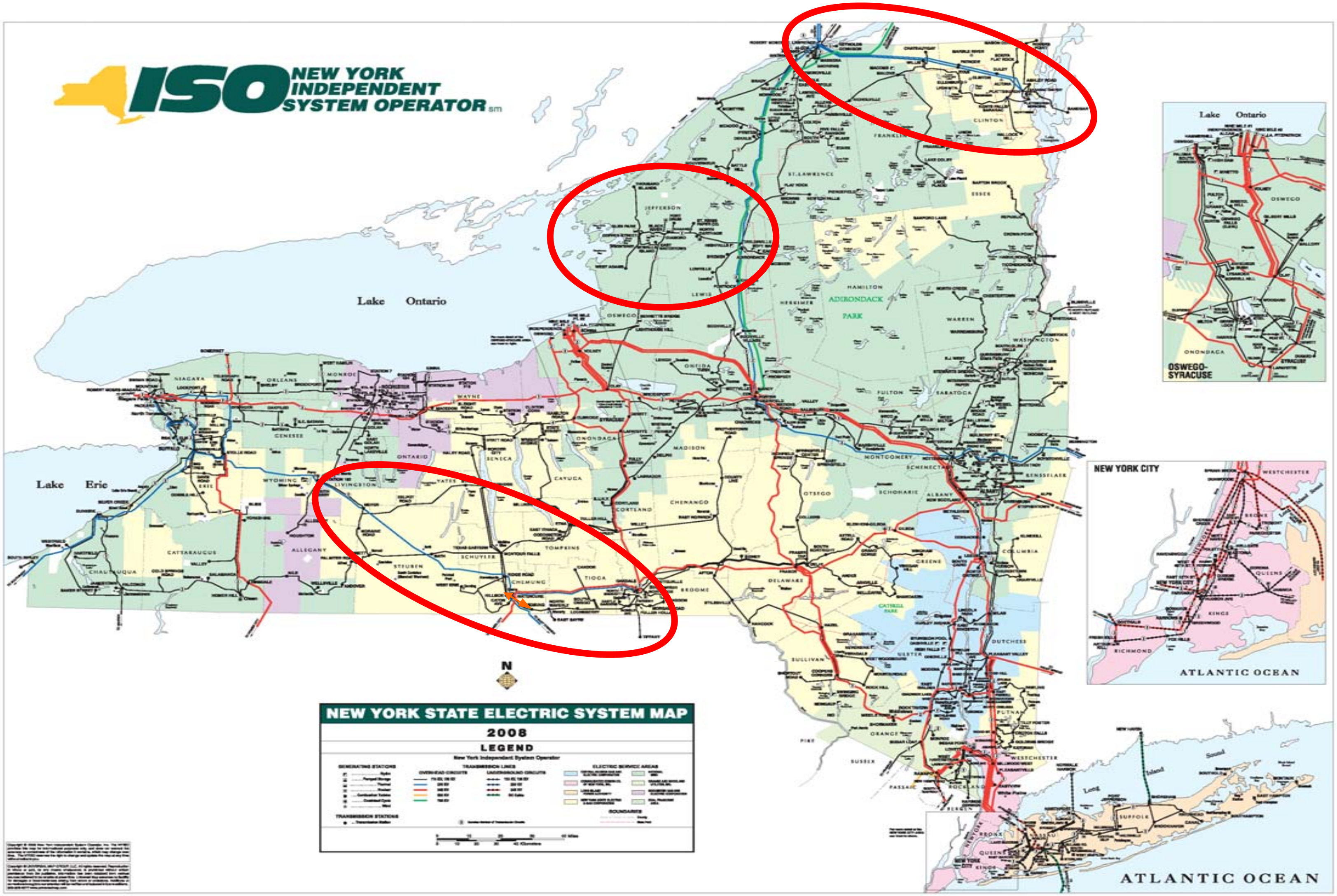
	Max Up	Capability	Max Down
1275	3071 MW	5348 MW	3134 MW
8000	3858 MW	6610 MW	3481 MW

Ramping Issue - Findings

- GridView simulations demonstrate that additional resources will need to be committed to support increased ramping and load following
- GridView simulations demonstrate that there should be sufficient capacity to support the increased ramping for the 8 GW of wind studied

Task 7

Congestion Analysis
and
Transmission System Upgrades


NEW YORK INDEPENDENT SYSTEM OPERATOR
Lake Ontario
Lake Erie
ADIRONDACK PARK
OSWEGO-SYRACUSE
NEW YORK CITY
ATLANTIC OCEAN
NEW YORK STATE ELECTRIC SYSTEM MAP
2008
LEGEND

Task 7 – Methodology

- **Evaluation of Transmission Limitations**
  - ***Review projects' actual capacity factor vs. perfect production to determine level of bottling***
  - ***Identify specific transmission constraints (limiting element/contingency) for each project (or group of projects)***
    - ***Consistent with TOs local Planning Criteria, Rules, Standards and Operating Procedures***
  - ***Identify possible upgrades on limiting elements/transmission facilities***

Transmission Upgrades

- Considerations
  - ***Scope of upgrade***
    - **Single project**
    - **Small group of projects**
    - **General system (wide-area) projects**
  - ***Type of upgrade***
    - **Terminal limitations**
    - **Conductor limitations**
    - **Complete rebuild**
    - **Reconfiguration**
- Upgrades included in project facility studies are assumed available

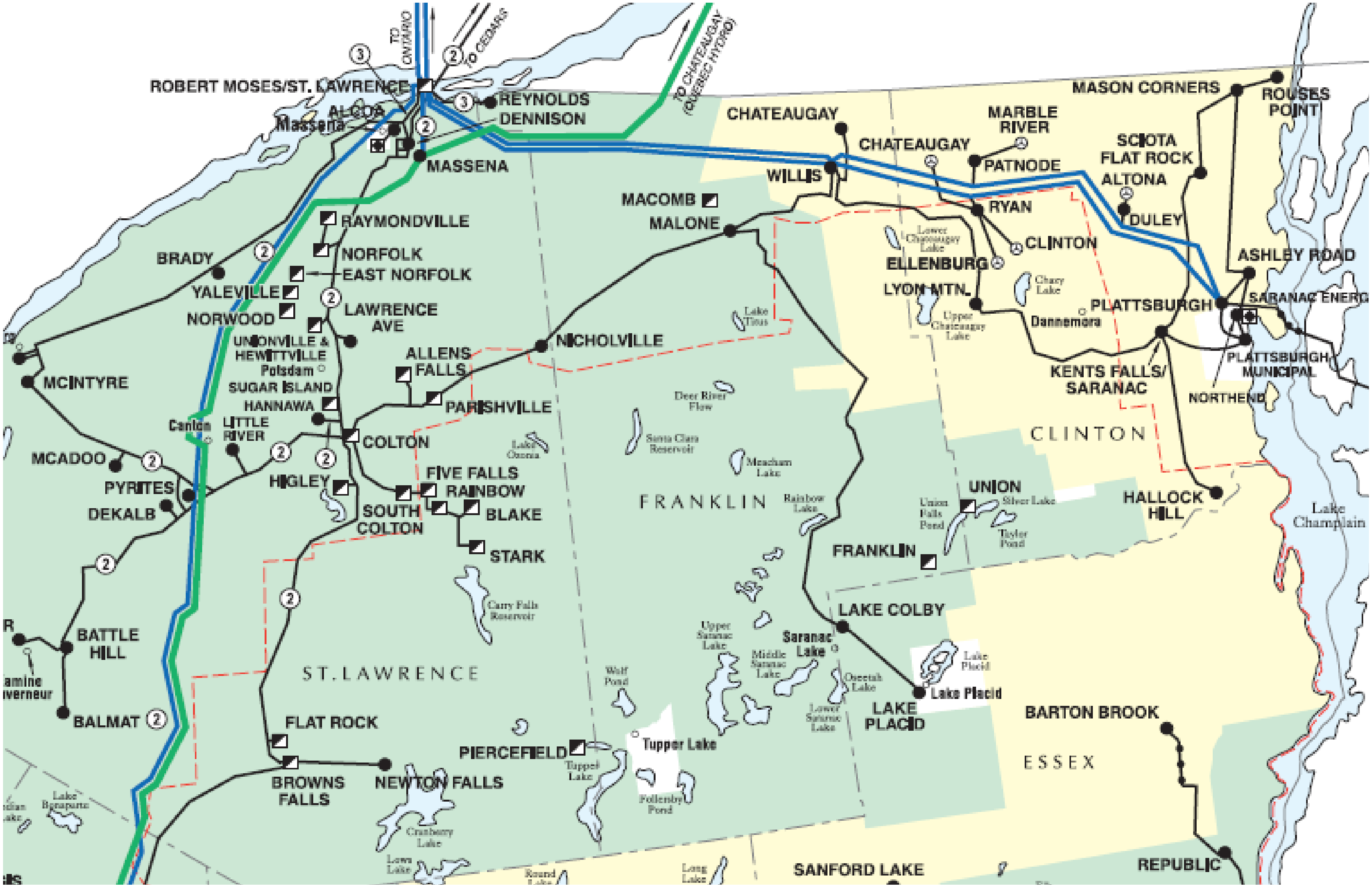
Transmission Constraints

- Major transmission constraints identified in three local areas:
    - **Willis/Plattsburgh**
    - **Watertown/Thousand Islands**
    - **Corning/Elmira**
  - *Limiting elements are primarily local 115kV*
  - *Limiting contingencies include*
    - **115kV double circuit (d/c) tower**
    - **Parallel path 115kV**
    - **EHV contingencies (d/c tower, stuck breaker)**
    - **Parallel path EHV**

Willis/Plattsburgh Area

- Existing wind capacity 387MW
- Proposed additional capacity 681MW
- 1st constraint – 115kV Willis-Malone-Colton for loss of d/c 230kV St. Lawrence-Willis (tower)
  - ***Assume reconfiguration of the Moses/St. Lawrence exit to mitigate the d/c tower contingency***
  - ***Next transmission constraints:***
    - **Plattsburgh 230/115 transformers**
    - **Moses-Willis-Plattsburgh 230kV terminal equipment**

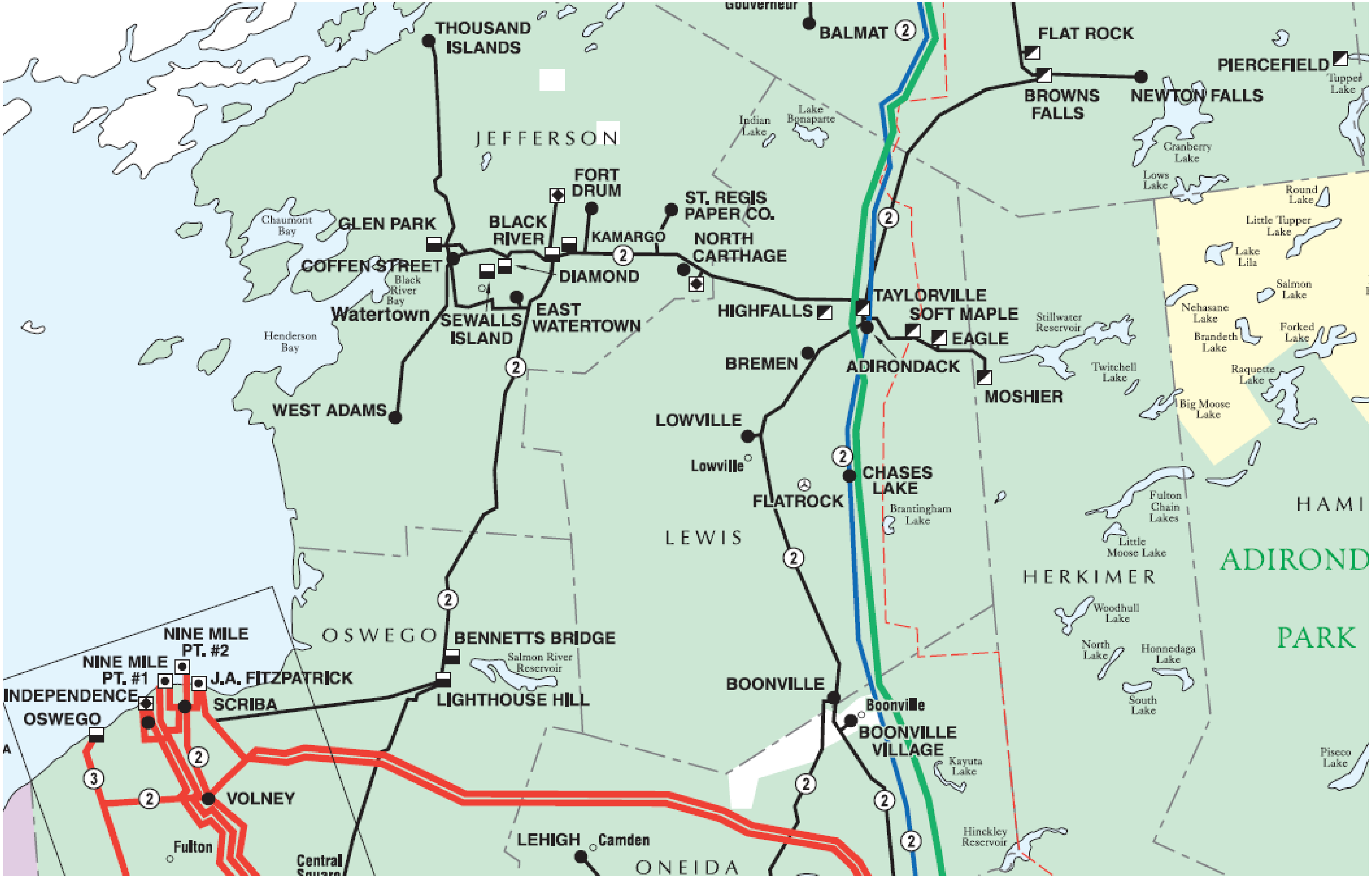
Northern NY Constraints



Watertown/Thousand Islands

- Proposed capacity 716MW
- Identified constraints
  - *Local 115kV radial from projects to Watertown*
    - **Lyme Tap – Coffeen St 115kV (pre-ctg loading)**
    - **Coffeen St – Black River 115kV**
  - *115kV tower contingencies (east, south) cause severe overload of remaining circuits*
    - **Black River – Taylorville 115kV**
    - **Black River – Lighthouse Hill 115kV**
  - *Reconductor/rebuild transmission paths*
    - **Black River – Taylorville 115kV**
    - **Lighthouse Hill – Mallory 115kV**
    - **Coffeen St – Black River 115kV**
  - **Constraints on the Taylorville – Boonville 115kV path indicate reconductor/rebuild may also be necessary**

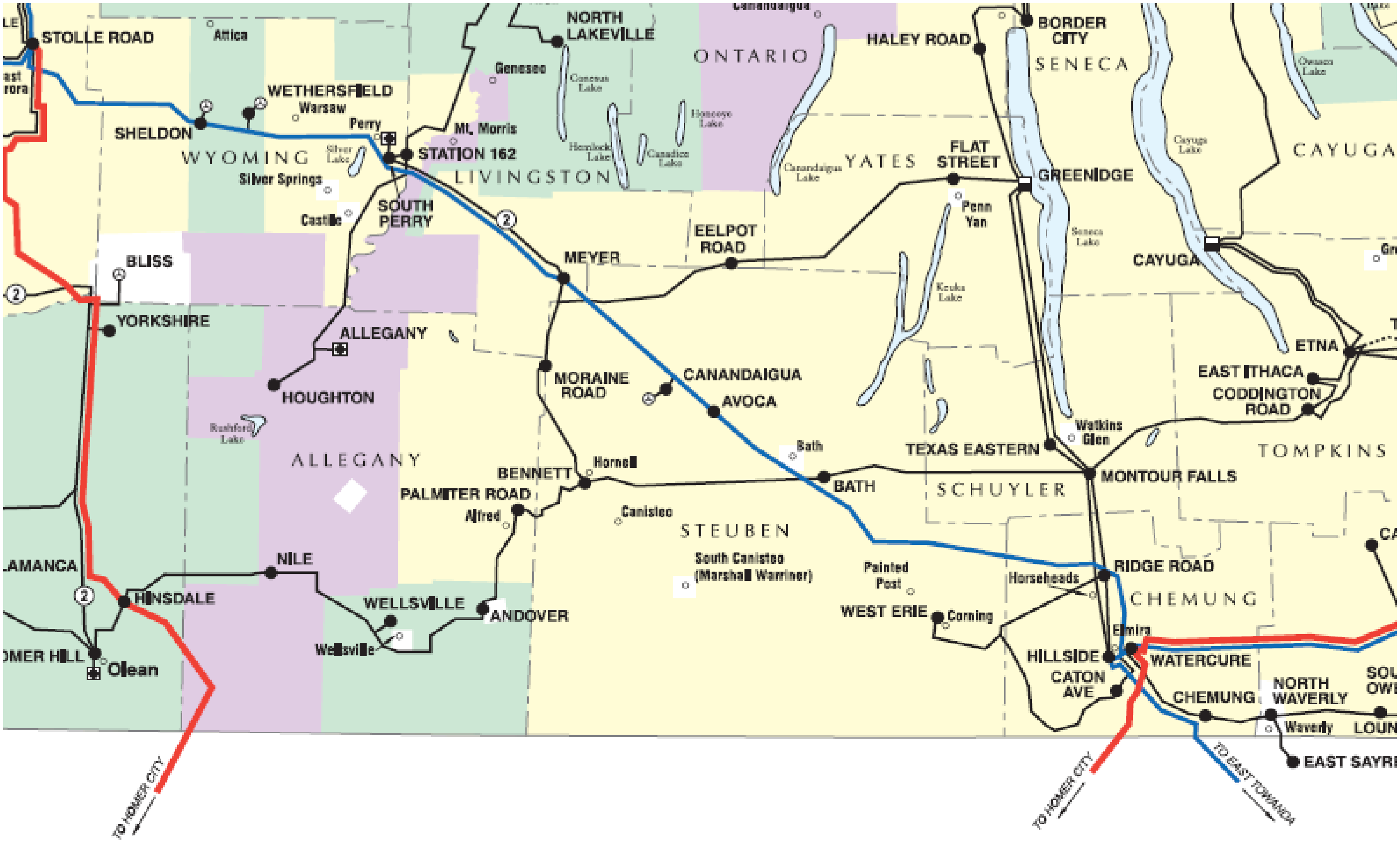
Watertown Area Constraints



Southern Tier

- *NYSEG portion of Zone C*
- Existing capacity 364MW
- Proposed additional capacity 586MW
- Identified constraints in several locations
  - ***Locations potentially limited by local 115kV (pre-contingency loading)***
    - ***Bennett – Bath 115kV***
    - ***Meyer – Greenidge 115kV***
  - ***Pre-contingency loading limitations may be resolved by line terminal upgrades and/or reconductoring***

Southern Tier Constraints (west)



Southern Tier (2)

- Larger group of projects limited by 115kV line for EHV contingencies
  - ***(preceding group + additional 490MW)***
    - ***Hillside 230kV tower***
    - ***Oakdale 345kV transmission***
      - ***Oakdale 345kV tower***
      - ***Oakdale 345kV stuck breaker***
  - ***EHV station exit reconfiguration to mitigate tower contingencies at Hillside, Oakdale***
  - ***Reconductor/rebuild limiting elements:***
    - ***Montour Falls – Ridge Road 115kV (2 circuits)***
    - ***Hillside – No. Waverly 115kV***

Southern Tier (3)

- Constraint in Zone E impacts all projects in So. Tier (Zone C) and project in Zone E:
  - ***Delhi – Fraser Tap 115kV limiting for Contingencies:***
    - ***Oakdale – Fraser 345kV***
    - ***Oakdale 345kV stuck breakers***
  - ***Upgrade to conductor design rating:***
    - ***Delhi – Fraser Tap section of Delhi – Colliers 115kV***

Southern Tier Constraints (east)

System Limitations

- A number of EHV constraints have been identified in the simulations
  - ***These are (historically) constraints that are not unique to the addition of wind generation***
    - ***Leeds – Pleasant Valley 345kV***
    - ***Rock Tavern – Ramapo 345kV***
  - ***Existing contingencies – New constraints***
    - ***Oakdale 345kV (exit) tower, stuck breaker***
    - ***Hillside 230kV (exit) tower***

Evaluation of Upgrades

- Identify specific transmission line(s) and needed capacity (rating)
  - ***Review upgrades with Transmission Owner(s)***
    - **Identify line terminal upgrades necessary**
    - **Determine feasibility of reconductoring as remediation option vs. rebuilding**
  - ***Identify projects' benefit***
- Other considerations
  - ***Timing of wind projects***
  - ***TO plans for facility upgrade/renewal***

Simulation of Upgrades

- Develop a sequence of upgrades to address the identified wind resource bottling
  - *Up to 7 simulation scenarios were developed to quantify the upgrades to reduce bottled energy <2% within any Zone*
  - *Used production cost simulations to identify the limiting contingency(ies) and elements and “needed relief” to size the upgrade (and quantify benefit)*

Zone C Constraints

- Pre-contingency loading
  - Bennett – Bath – Montour Falls 115kV
  - Bennett – Moraine Rd – Meyer 115kV
- Contingency overloads
  - Avoca – Hillside 230kV
  - Montour Falls – Ridge Rd 115kV
  - Eel Pot Rd – Flat St – Greenidge 115kV
  - Hillside – No. Waverly 115kV
- Mitigations
  - Upgrade 230kV to design conductor rating
  - Reconductor 115kV

Zone D Constraints

- Pre-contingency loading
  - (none)
- Contingency overloads
  - Moses – Willis 230kV
  - Duley/Ryan – Plattsburgh 230kV
  - Plattsburgh 230/115kV
  - Willis – Colton 115kV
- Mitigations
  - Reconfigure Moses 230kV exit tower
    - *115kV no longer limiting*
  - Upgrade 230kV to design conductor rating
    - *Upgrade terminal equipment*

Zone E Constraints

- Pre-contingency loading
  - Rockledge – Coffeen St 115kV
  - Coffeen St – Black River 115kV
  - Lighthouse Hill – Mallory 115kV
- Contingency overloads
  - Coffeen St – Black River 115kV
  - Black River – Taylorville 115kV
  - Taylorville – Boonville 115kV
  - Black River – Lighthouse Hill – Mallory 115kV
  - Delhi – Fraser Tap 115kV
- Mitigations
  - Upgrade to design conductor rating (Delhi-Fraser)
  - Reconductoring Watertown area facilities may not be feasible due to required conductor size
  - Alternative EHV overbuild may be indicated specifically for the Watertown pocket

Summary of Energy Bottling

- Wind Resource Energy bottling is based on a project's actual capacity factor vs. "perfect production" capacity factor
  - *Identify transmission constraint(s) causing the capacity factor reduction*
  - *Identify project(s) constrained by limitation*
- Modify simulation model with upgrade(s) and repeat simulation to measure benefit

Upgrade Scenario Results

Zone	Wind Capacity	Base Case	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7
A	1309	0.1%	0.1%	0.0%	0.0%	0.0%	0.1%	0.1%	0.1%
B	281	0.1%	0.1%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%
C	1591	6.1%	4.5%	4.2%	1.3%	0.3%	0.0%	0.0%	0.0%
D	1068	15.0%	12.0%	2.5%	1.7%	1.7%	1.7%	1.7%	1.7%
E	1648	15.8%	15.9%	14.5%	10.7%	9.8%	9.5%	7.0%	4.6%
F	70	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%
Total	5967	8.8%	7.9%	5.6%	3.6%	3.1%	3.0%	2.3%	1.6%

Task 7

Stability Analysis
Update

Off-Peak / High Wind Case

- Central East level **3399** MW based on Oswego Complex commitment (3/5, 4/6 Sithe)
  - *Total Wind generation dispatch 6572 MW*
  - *NYCA load+losses 17202 MW*
  - *Total NYCA generation (net) 14796 MW*
    - *Total pump/gen -1555 MW*
- Interface flows
  - *Dysinger East 1602 MW*
  - *West Central 887 MW*
  - *Moses-South 1587 MW*
  - *Total East 7494 MW*
  - *UPNY-SENY 4789 MW*
  - *UPNY-ConEd 2264 MW*

Peak Load / High Wind Case

- Central East level **3390** MW based on Oswego Complex commitment (5/5, 6/6 Sithe)
  - ***Total Wind generation dispatch 3400 MW***
  - ***NYCA load+losses 33559 MW***
  - ***Total NYCA generation (net) 33510 MW***

- Interface flows
  - ***Dysinger East 2048 MW***
  - ***West Central 943 MW***
  - ***Moses-South 1689 MW***
  - ***Total East 7671 MW***
  - ***UPNY-SENY 6872 MW***
  - ***UPNY-ConEd 4145 MW***

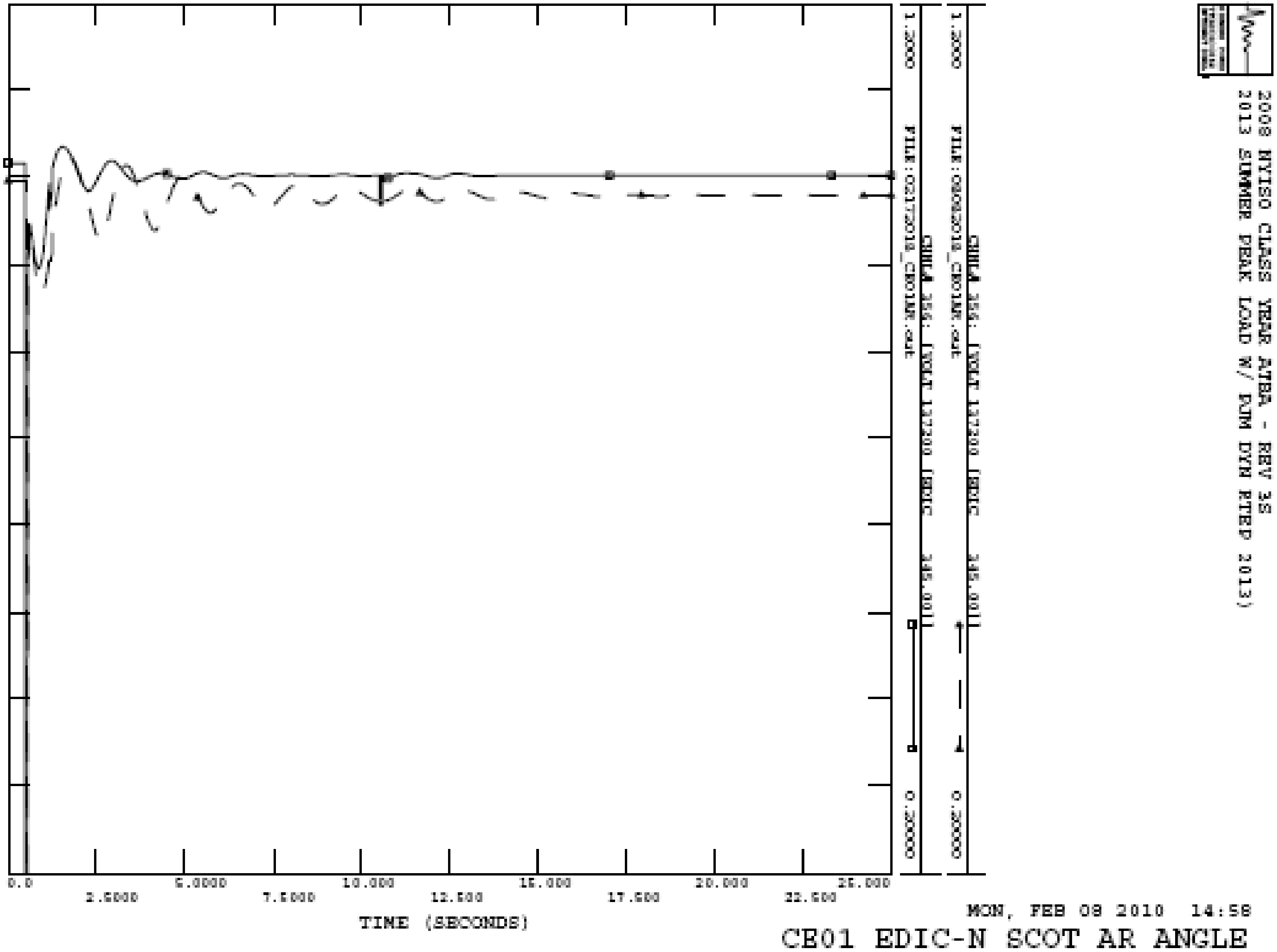
Stability Analysis

- Previously discussed analysis of peak wind week base case results
- Additional analysis of a peak load/high wind base case is in progress
- Summary of base case set-up
  - *Import data from GV simulation*
    - **Generation commitment and dispatch**
    - **NYCA load**
    - **External schedules**
  - *Primary testing: Central East interface*
  - *Increase available generation in western NY to margin transfer test level ~ 3400 MW*

Contingency tests

- Central East contingencies
  - **CE01 – 3ph NC Edic-N.Scotland #14**
  - CE02 – 3ph NC Marcy-N.Scotland #18
  - **CE07 – LLG NC Edic/Marcy EF40/UCC41**
  - CE08 – LLG NC Coopers Corners #33/UCC41
  - **CE15 – SLG-stk Marcy #19/UE1-7**
  - CE18 – LLG NC Rock Tavern CCRT34/CCRT42
- *Comparison of selected quantities in each of the 2 tested cases*

CE01



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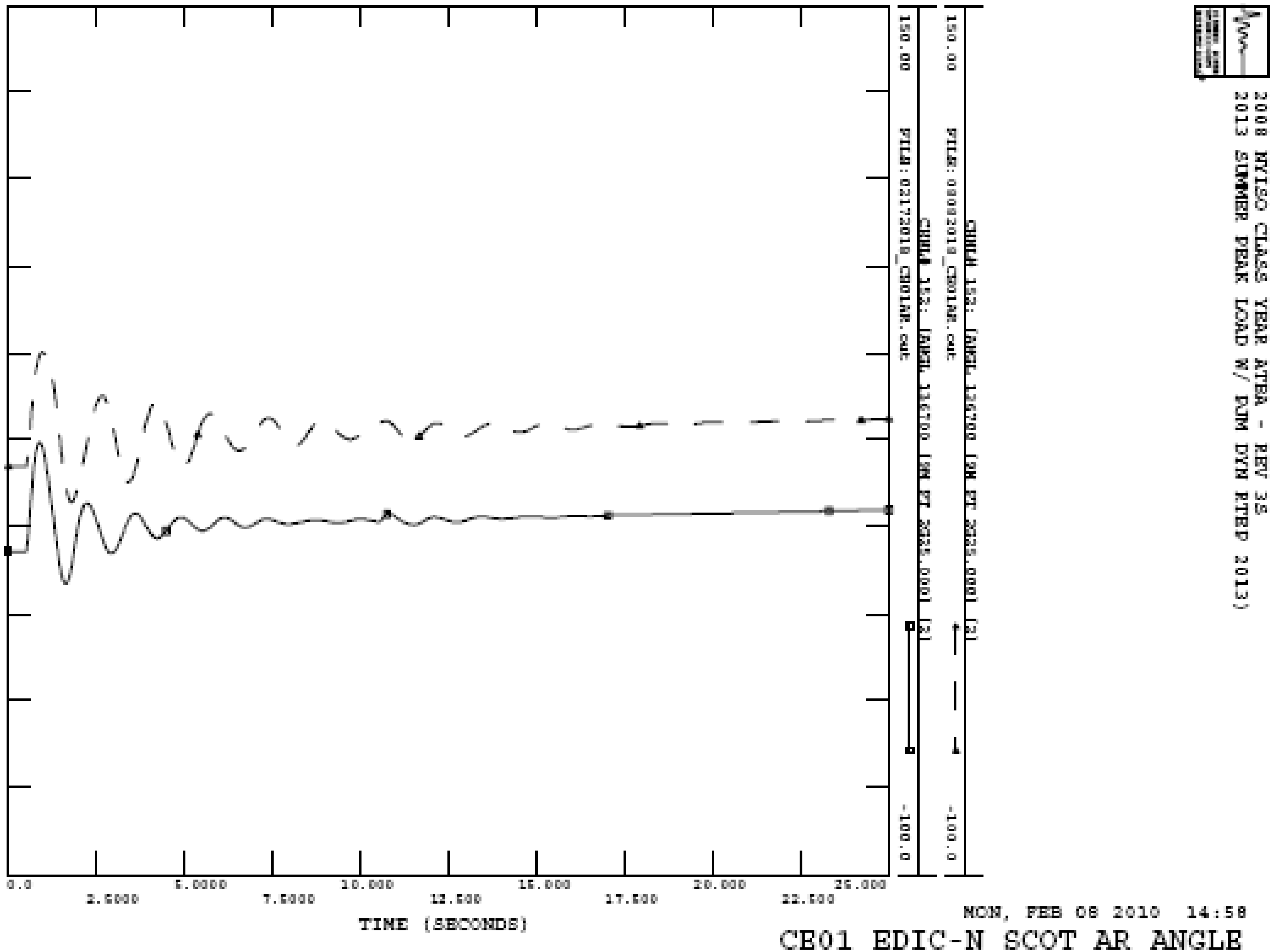
CE01



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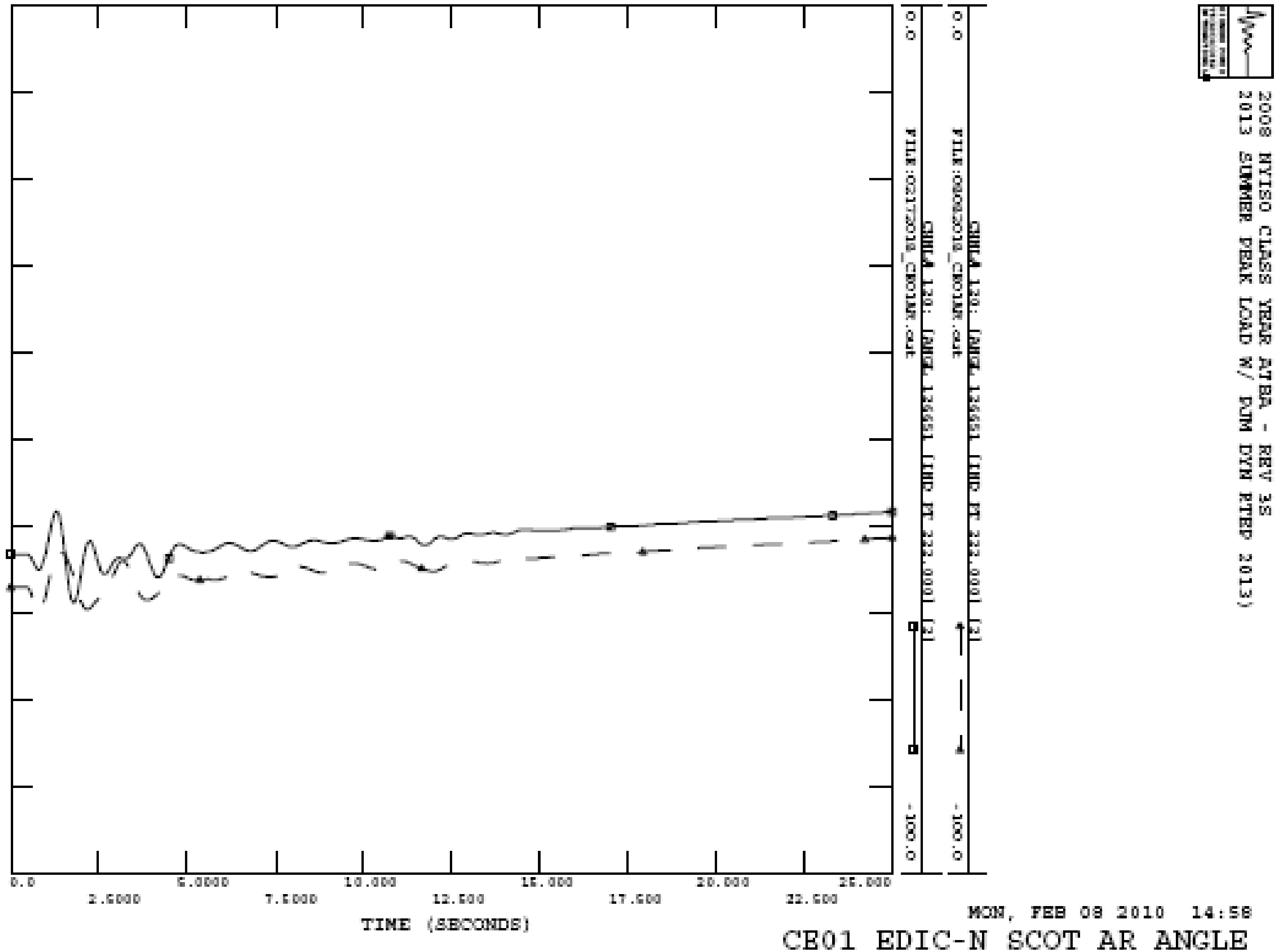
CE01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2008 NYISO CLASS YEAR ATBA - REV 3S
2013 SUMMER PEAK LOAD W/ PJM RTEP 2013)
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CE01 EDIC-N SCOT AR ANGLE

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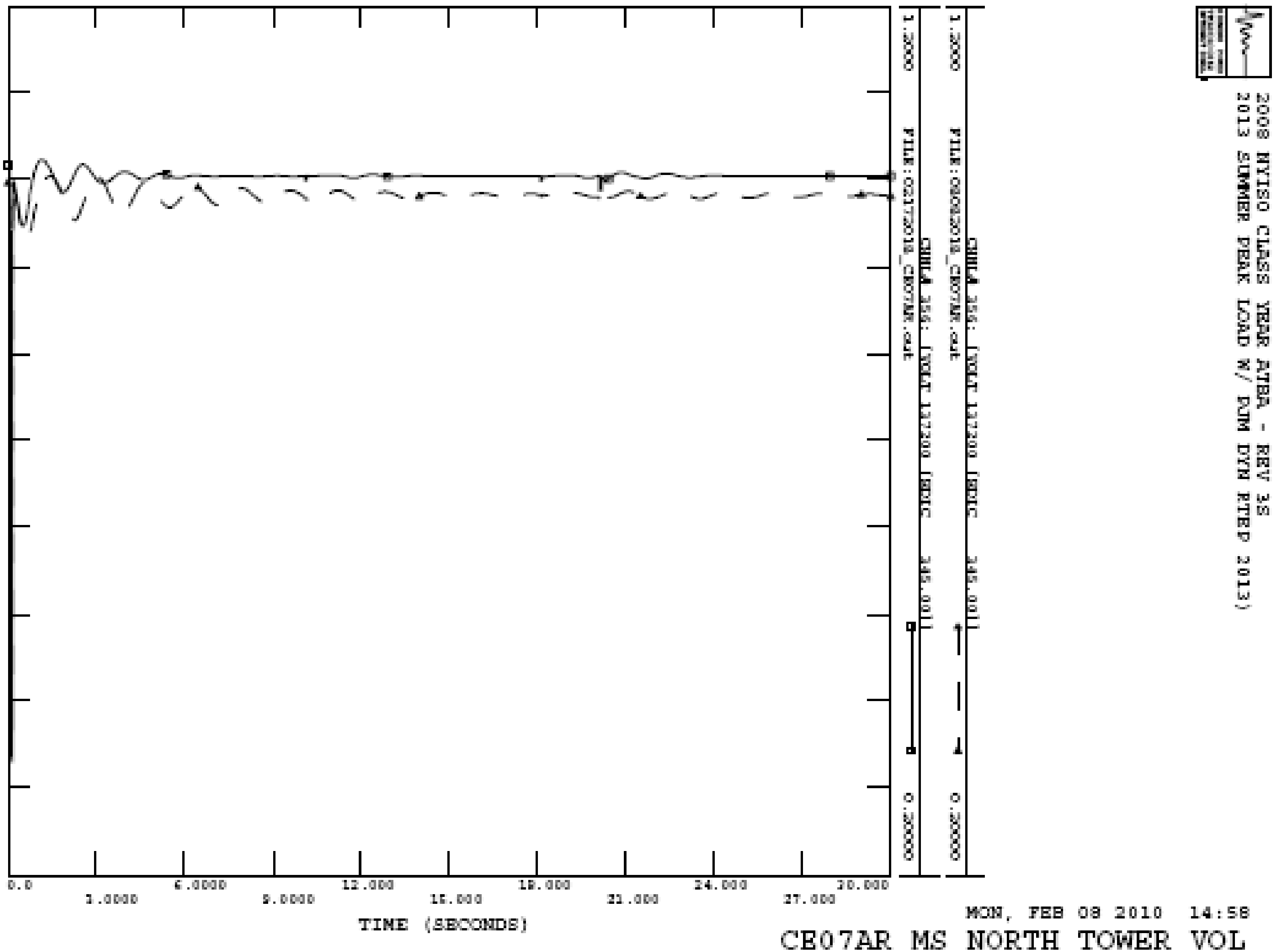
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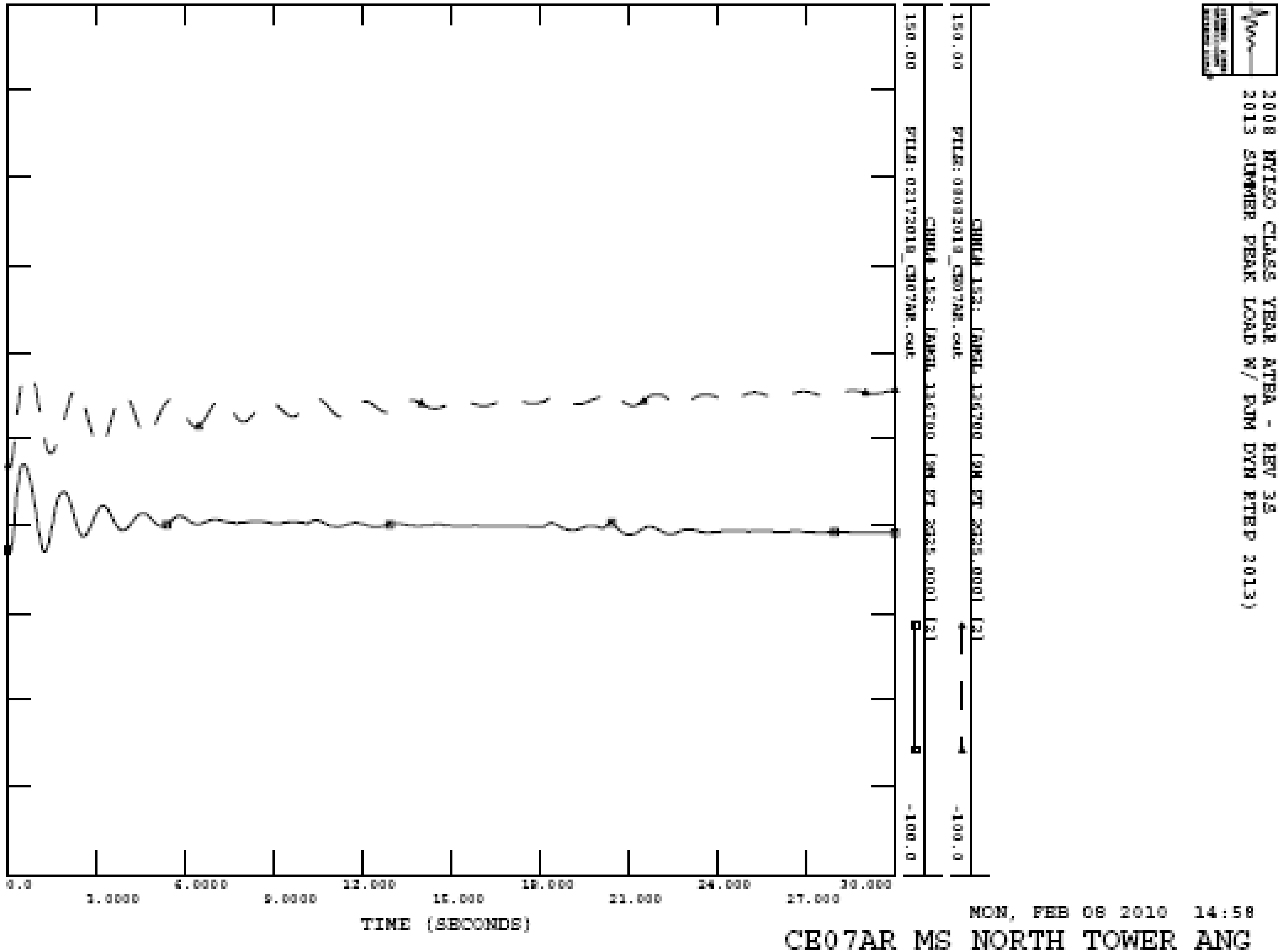

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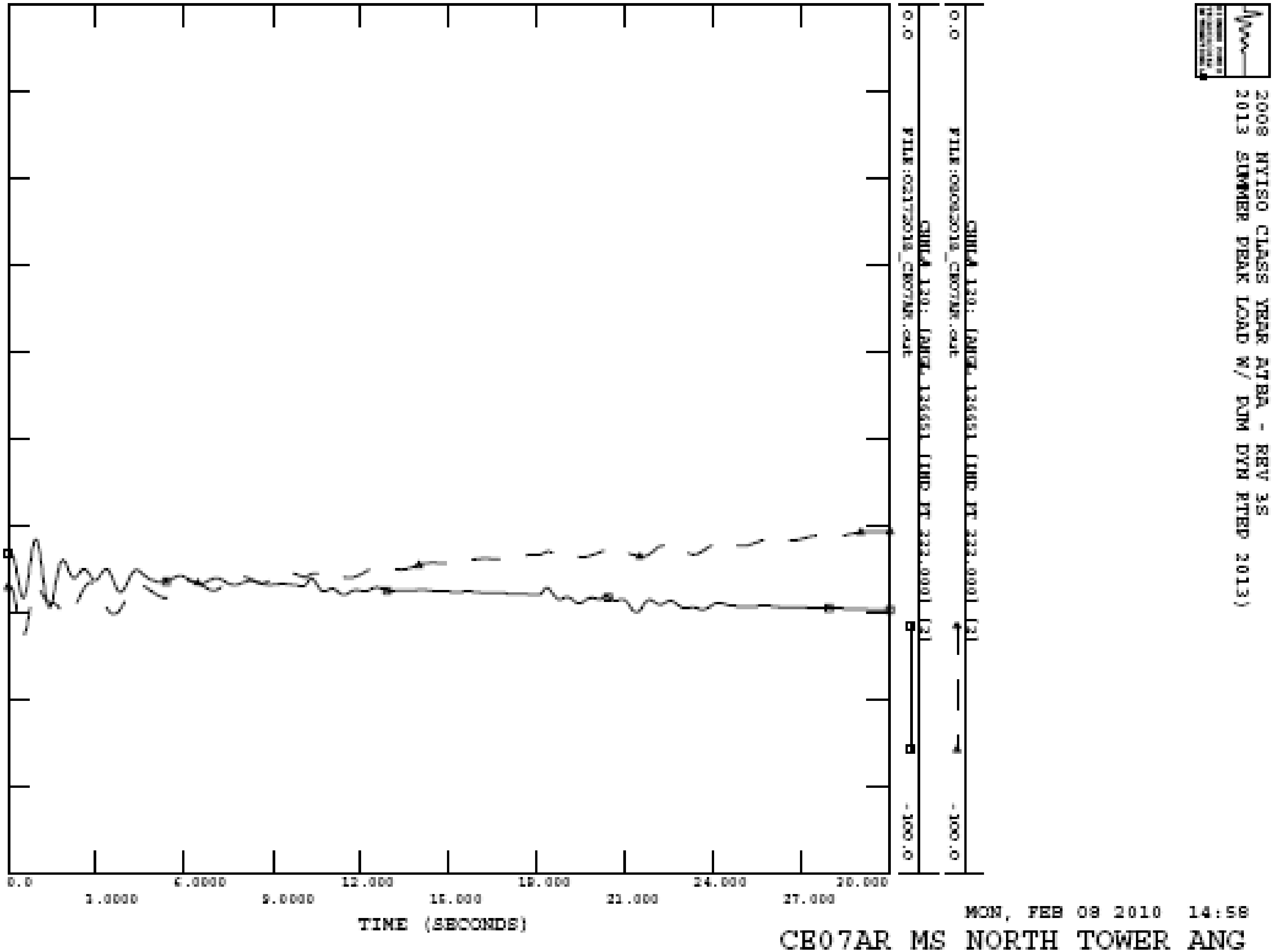

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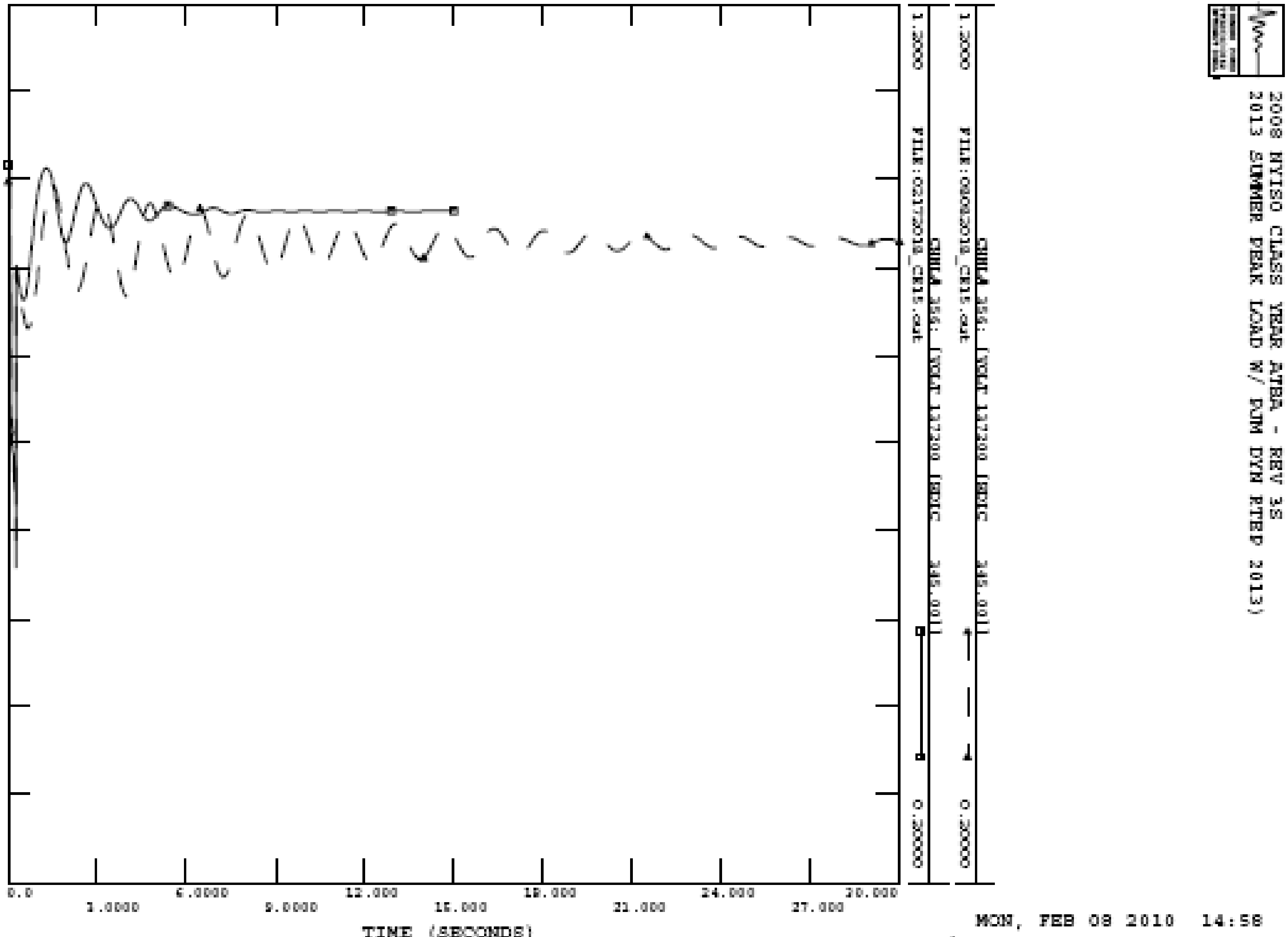

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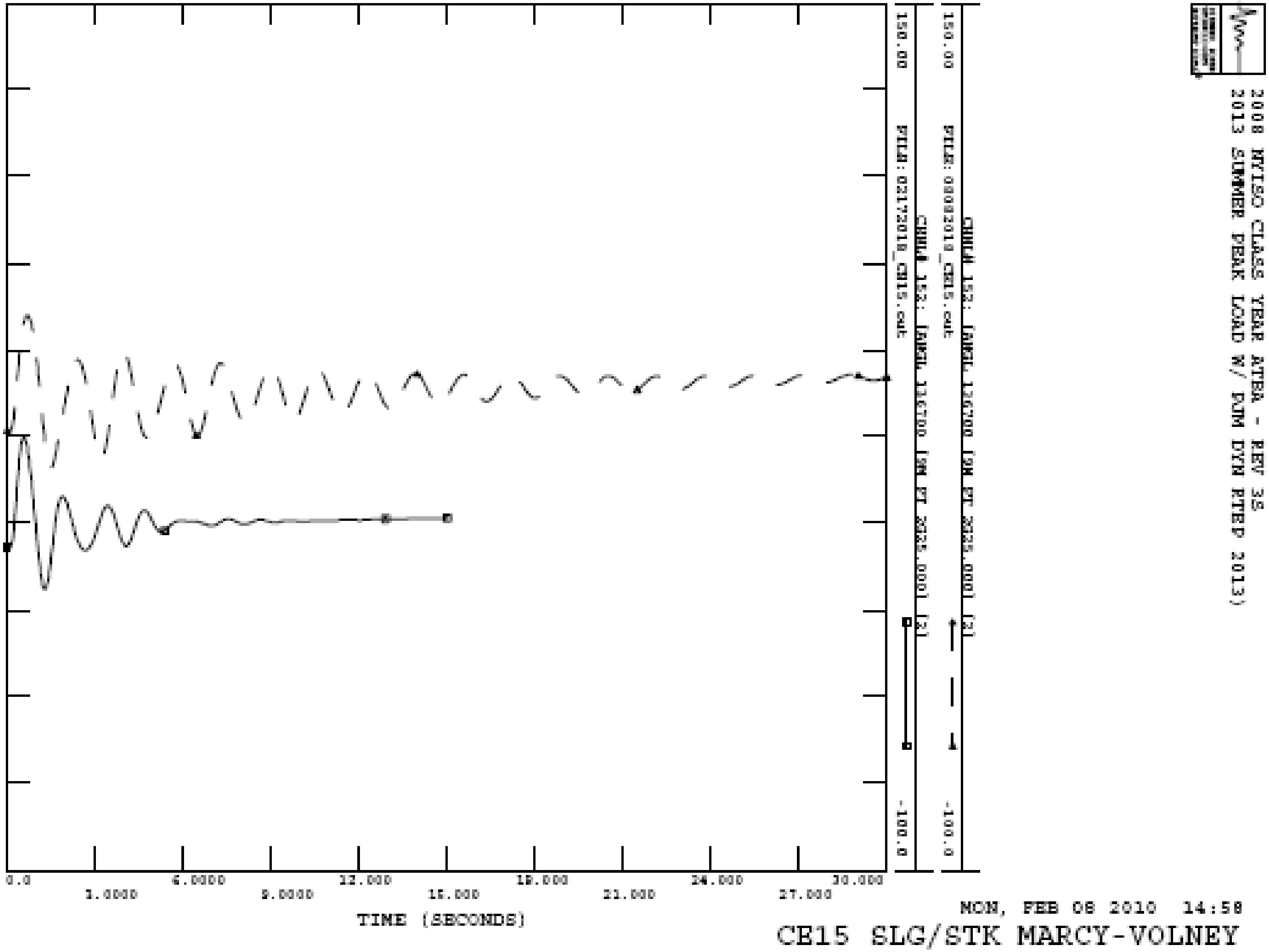
CE15 SLG/STK MARCY-VOLNEY

CE15



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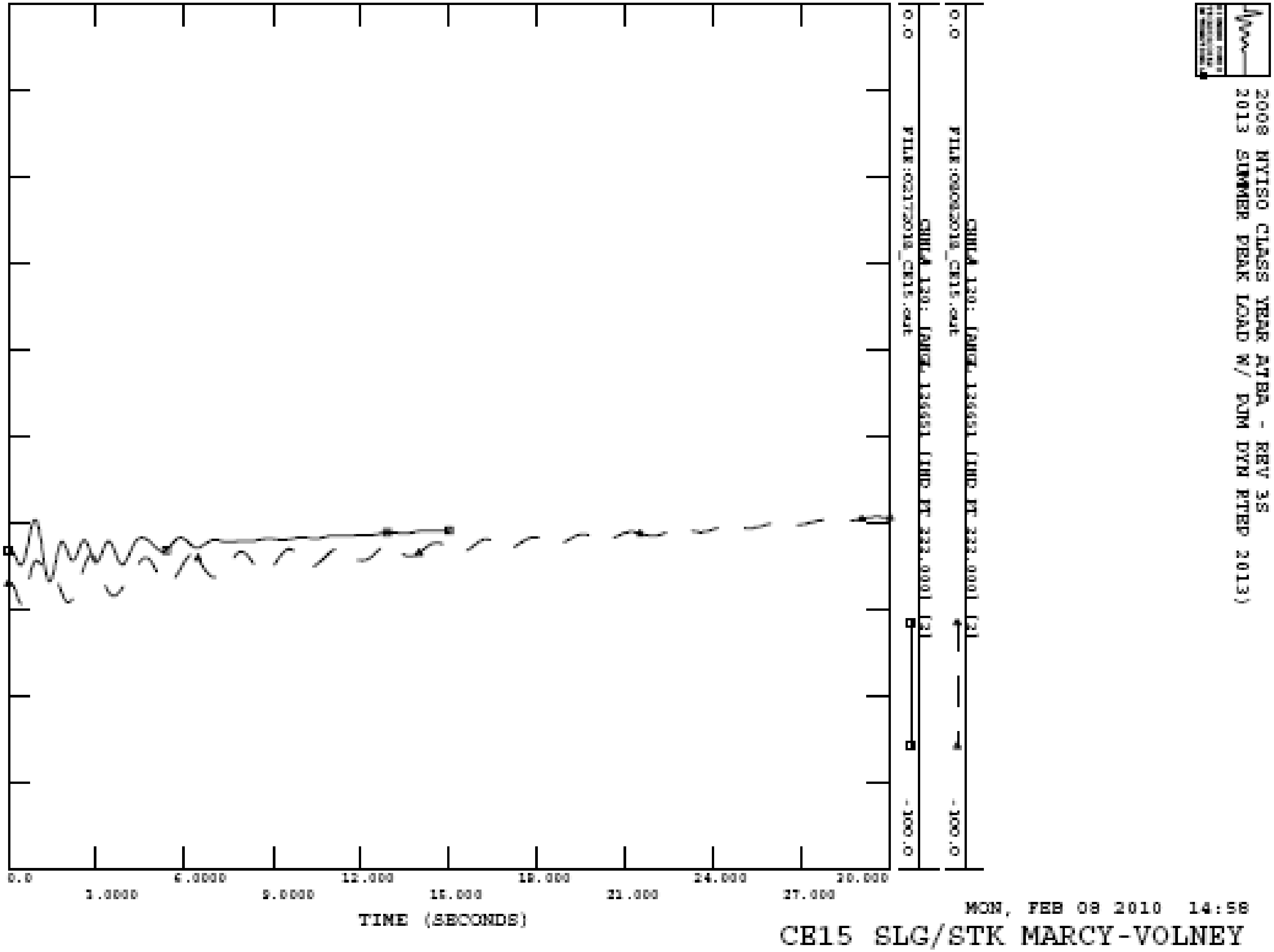
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MON, FEB 08 2010 14:58
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The New York Independent System Operator (NYISO) is a not-for-profit corporation that began operations in 1999. The NYISO operates New York's bulk electricity grid, administers the state's wholesale electricity markets, and conducts comprehensive planning for the state's bulk electricity system.

www.nyiso.com