Wind Integration Study: Study Results

Continuation of Oct. 19 Material

NYISO Wind Study Workshop

December 21, 2009 – Final Draft December 17, 2009

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 October 21 Meeting

- **Documented the importance of net load.**
- **Study results for Task 4 showed that system variability as measured by the net-load increases for all timeframes with increasing wind penetration.**
- **For the system as whole, the increase exceeds 20% on a average annual basis from current levels for the 8 GW wind scenario and 2018 loads.**
- **This increased variability will result in increased ramping requirements as well as regulation as presented at the last meeting.**
- **The study showed that the max hourly regulation requirement is expected to increase from today's 275 MW to 425 MW with 8,000 MW of wind**

Review of October 21 Meeting

- **Study results for Task 5 identified the transmission constraints which adversely impact wind plants which are primarily local area 115 kV transmission facilities**
- **Determined that the interconnection point of wind plant plays major role in the wind capacity MWs that can be integrated before significant transmission constraints are encountered.**
- **Identified the areas of the system that could experience energy bottling:**
  - ***Thousand Islands***
  - ***Willis-Plattsburgh***
  - ***Corning/Elmira area***

Next Steps Identified at Oct 21 Meeting

- **Complete Task 6 & 7 analysis and present results at next workshop**
- **Investigate ramping and minimum load issues**
- **Present Stability Analysis**
- **Any additional issues as identified by Stakeholders**

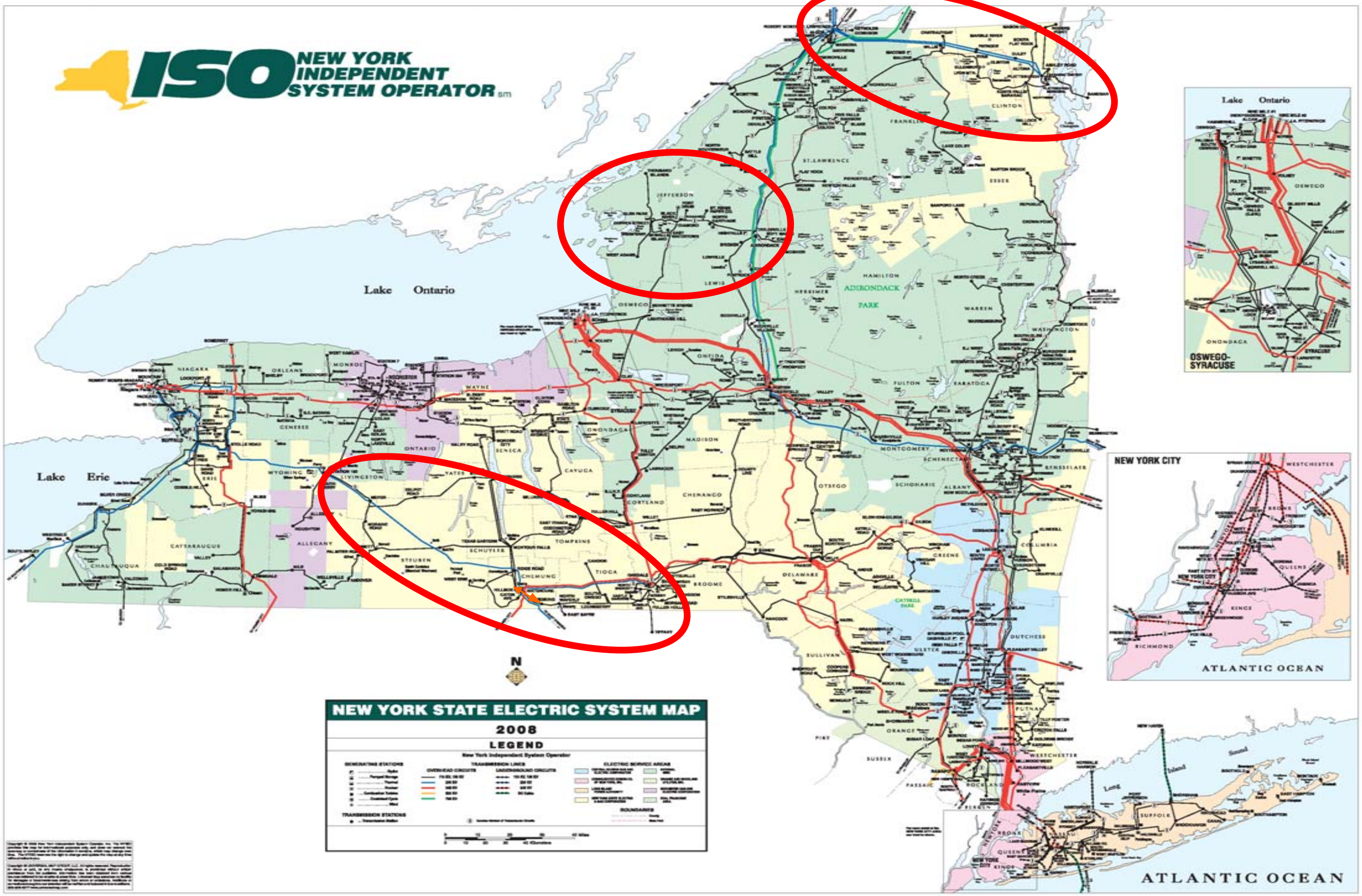
Task 5 – Continued plus Preliminary Task 7 results

1. **Summary of "Bottled Wind" Generation by Zone**
2. **Identification of Transmission Constraints**
3. **Sensitivity Analysis of Transmission Constraints**
4. **Preliminary System Stability Study Results**

Summary of Wind Plant Energy Bottling by Zone as Measured by Capacity Factor

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%

1) Capacity factor is the simulated wind generation divided by nameplate times 8760. The reduction is the ratio of what is non-dispatchable vs. simulated with no constraints.


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

Task 7 – Methodology

- **Evaluation of Transmission Limitations**
  - ***Review individual project 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

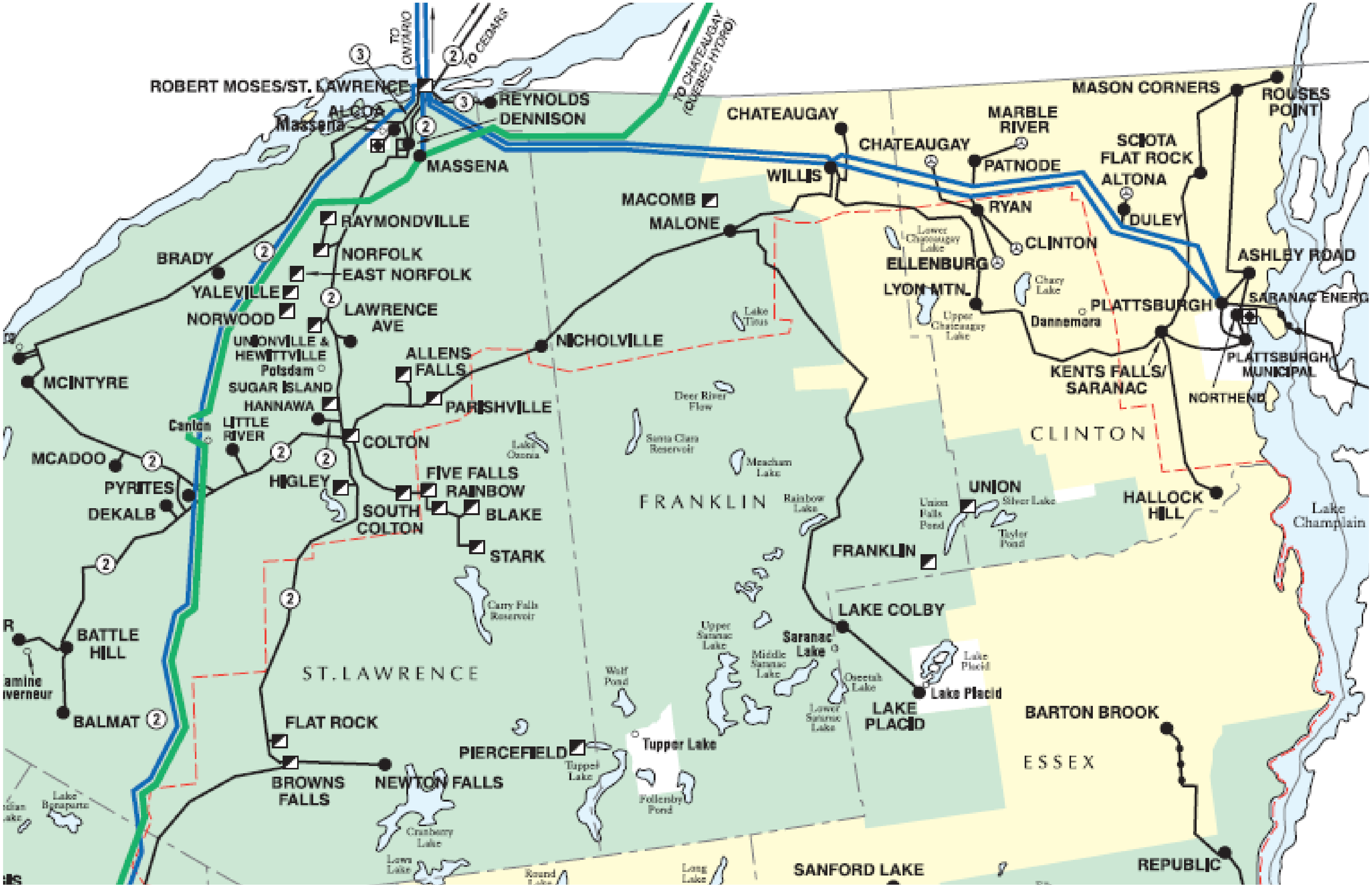
Transmission Constraints

- 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)
  - ***NYPA has committed to reconfiguration of the Moses/St. Lawrence exit to mitigate the d/c tower contingency***
  - ***Other transmission constraints may still limit production***
    - **Additional simulations necessary**
- When local constraints relieved, may require additional study of Taylorville – Porter 115kV

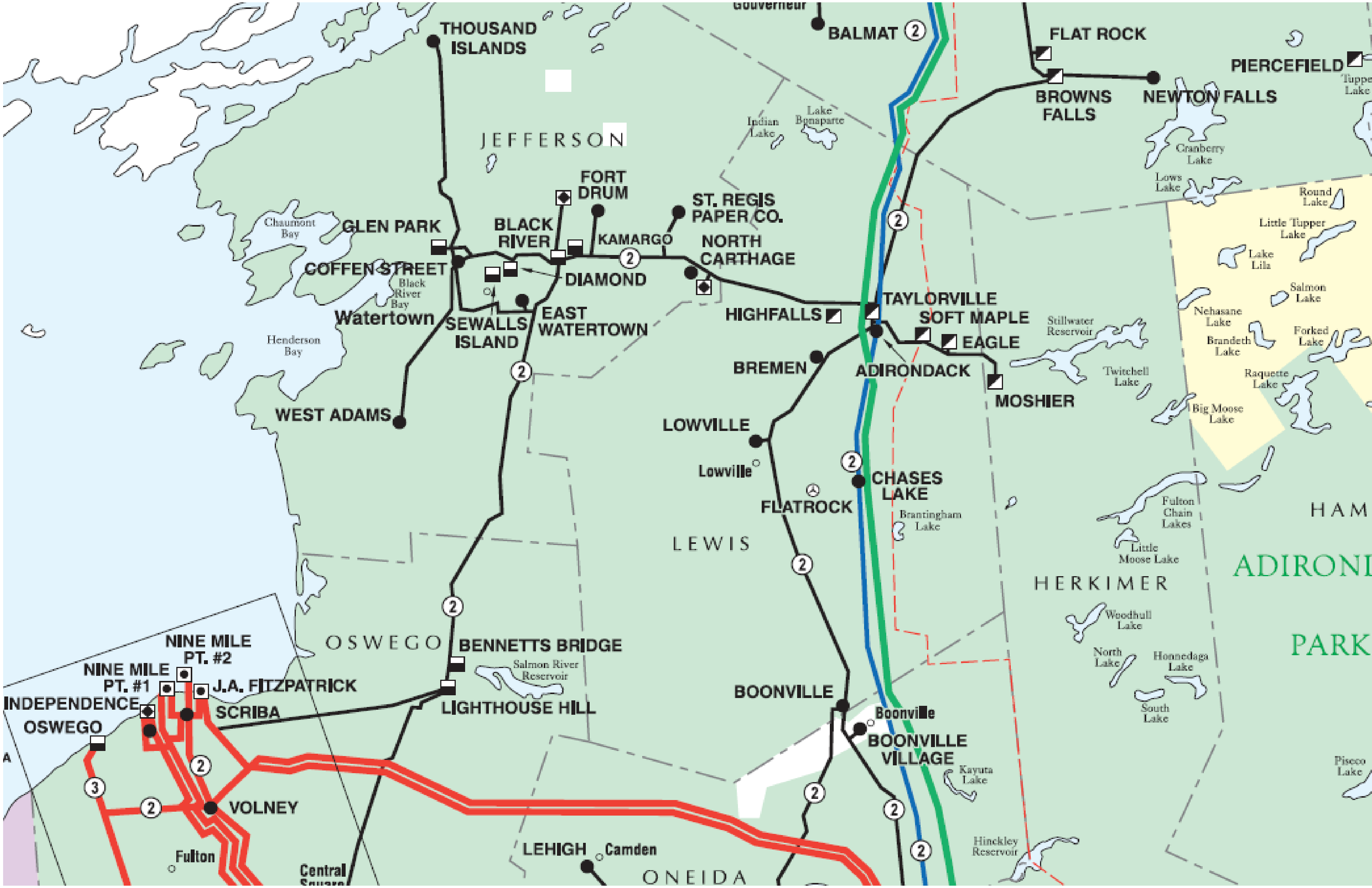
Northern NY Constraints



Watertown/Thousand Islands

- Proposed capacity 716MW
- Identified constraints
  - ***Local 115kV radial from projects to Watertown***
    - **Lyme Tap – Coffeen St 115kV**
  - ***115kV tower contingencies (east, south) cause severe overload of remaining circuits***
    - **Black River – Taylorville 115kV**
    - **Black River – Lighthouse Hill 115kV**
  - ***Mitigation is reconductoring (at least) of transmission pathways***
    - **Black River – Taylorville 115kV**
    - **Lighthouse Hill – Mallory 115kV**
- May require additional study of Taylorville – Porter 115kV path

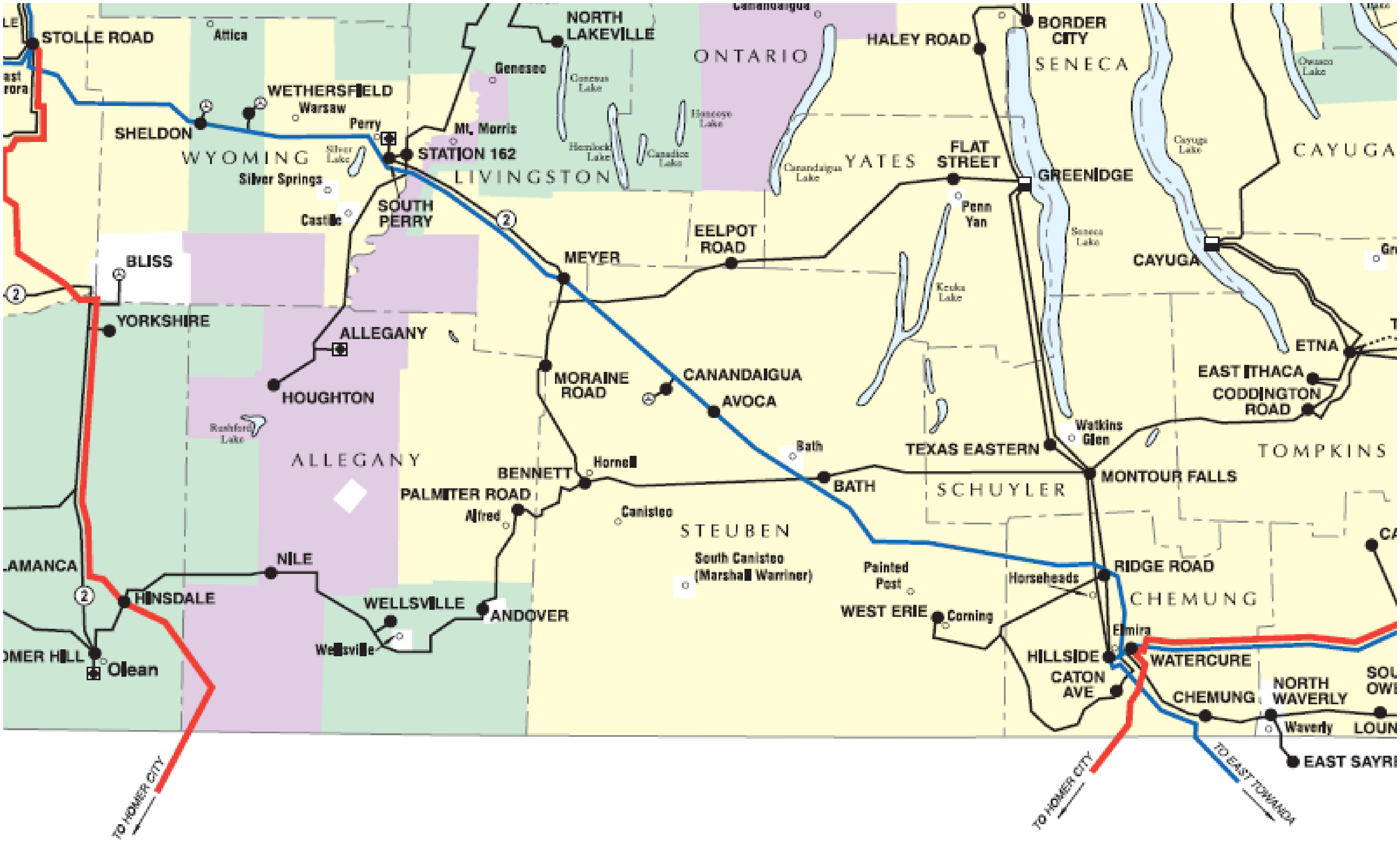
Watertown Area Constraints



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***
  - ***Possible upgrades on limiting elements:***
    - ***Montour Falls – Hillside 115kV***
    - ***Hillside – Goudey 115kV***
    - ***Oakdale – Delhi 115kV***
  - ***May also require EHV reconfiguration***

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)
  - ***Within the line, identify the specific limiting component (breaker, disconnect, conductor, etc.)***
  - ***Discuss with Transmission Owner(s) possible remediation options and associated costs***
- Other considerations
  - ***Timing of wind projects***
  - ***TO plans for facility upgrade/renewal***

Stability Analysis -- Methodology

- 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

Initial Condition Base Case

- Central East level based on Oswego Complex commitment (3/5, 4/6 Sithe) 3399 MW
  - ***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***

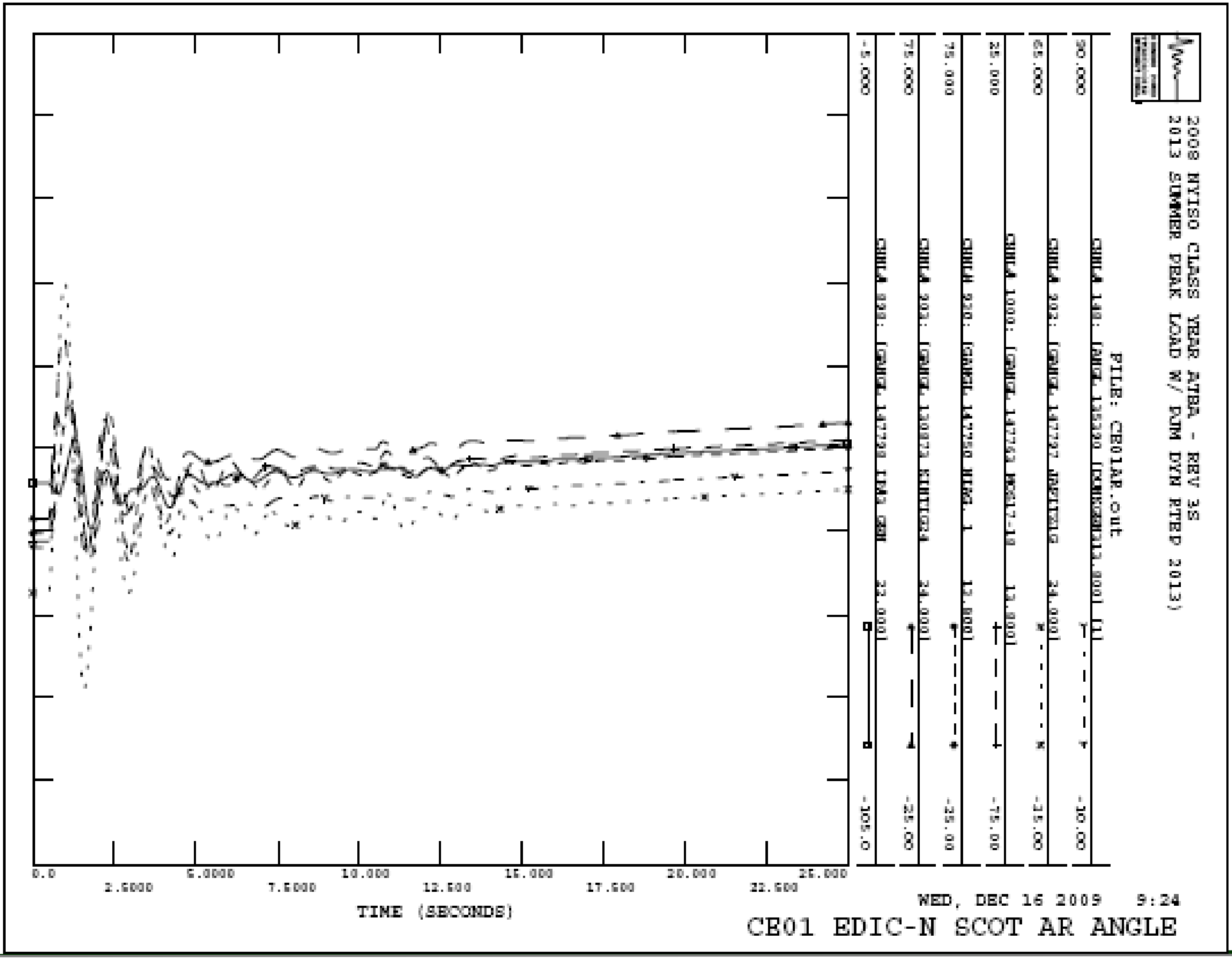
Results – Expectations

- Contingency simulations are:
  - ***Stable, well-damped***
    - ***Rotor angle***
    - ***Voltage***
  - ***No indication of unit tripping***
    - ***Over-, under-voltage***
    - ***Acceleration/deceleration***
    - ***Wind generation LVRT action***
- Additional testing will include
  - ***EHV faults in vicinity of groups of wind projects***
  - ***Highest wind dispatch at peak load***

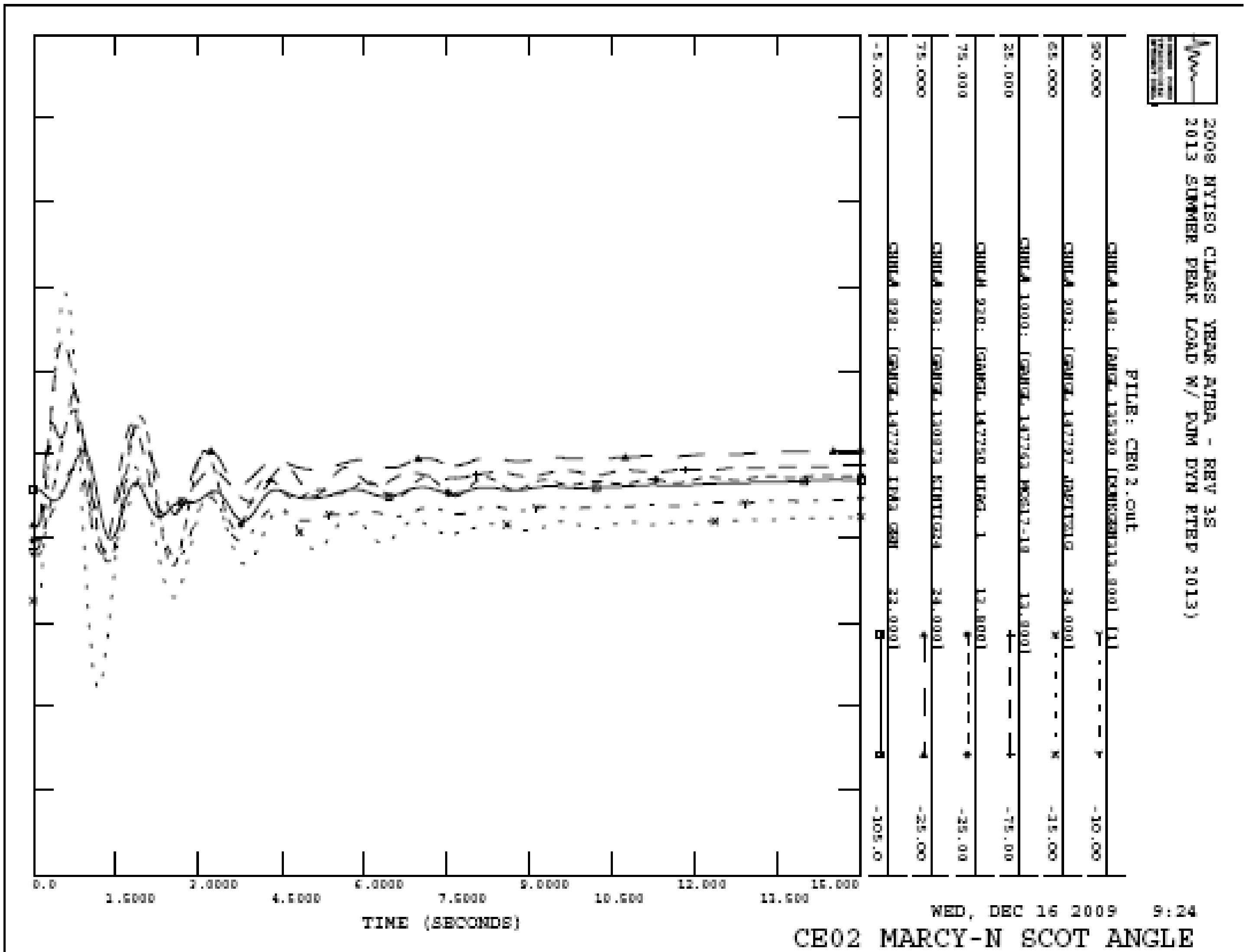
Contingency tests

- 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*

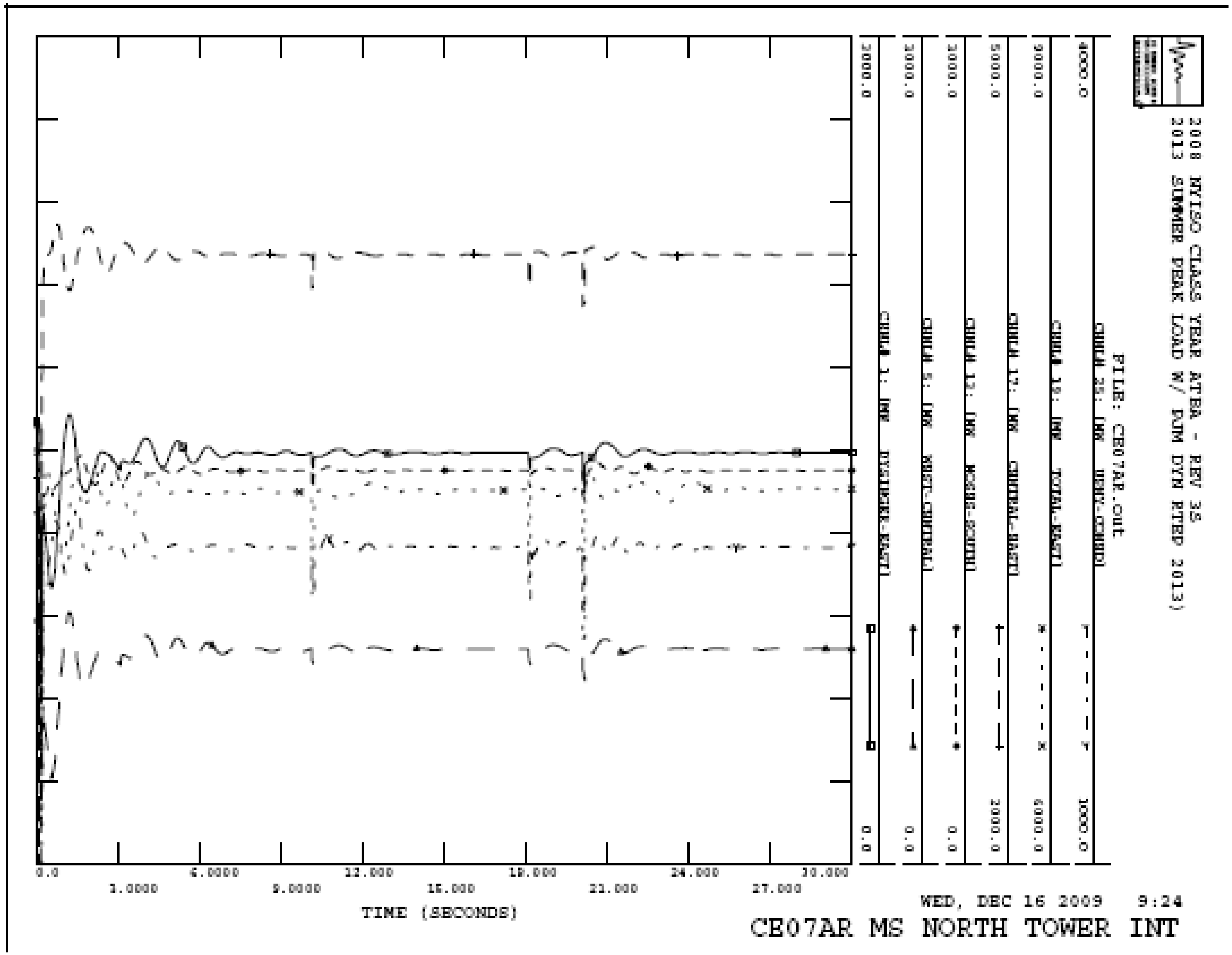
CE01 – 3ph NC Edic-N.Scotland



CE02–3phNC Marcy-N.Scotland



CE07 – LLG NC EF40 & UCC41



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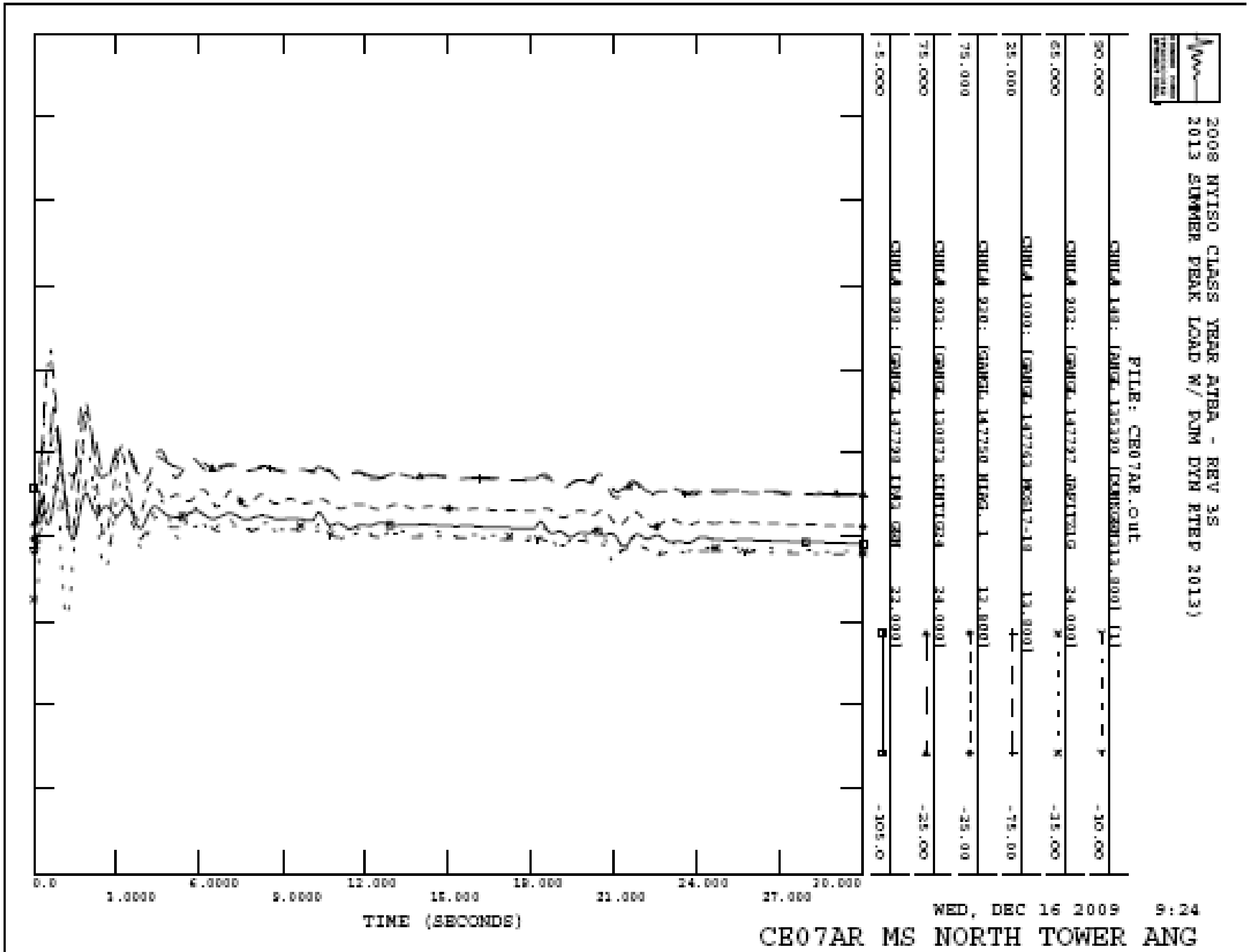
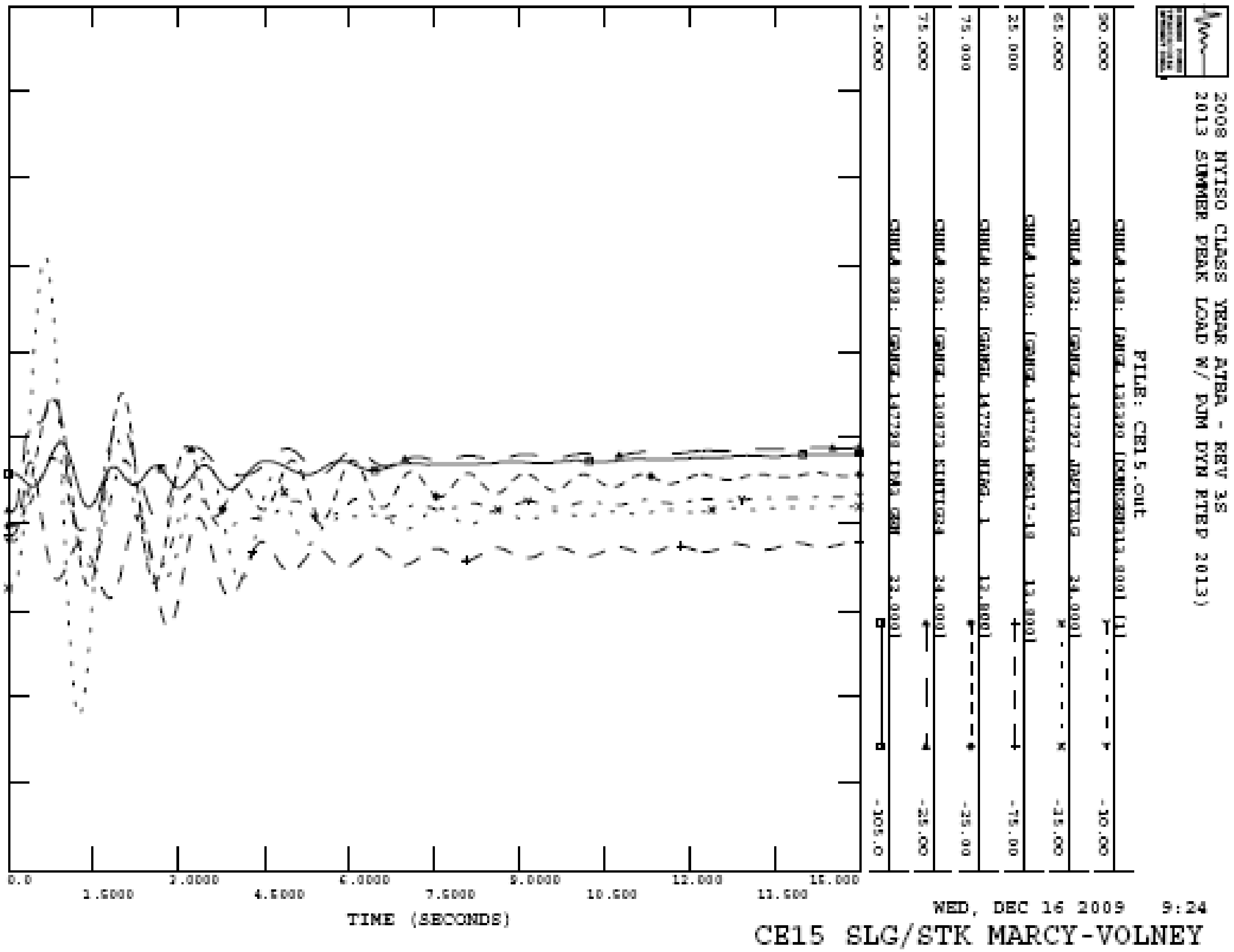
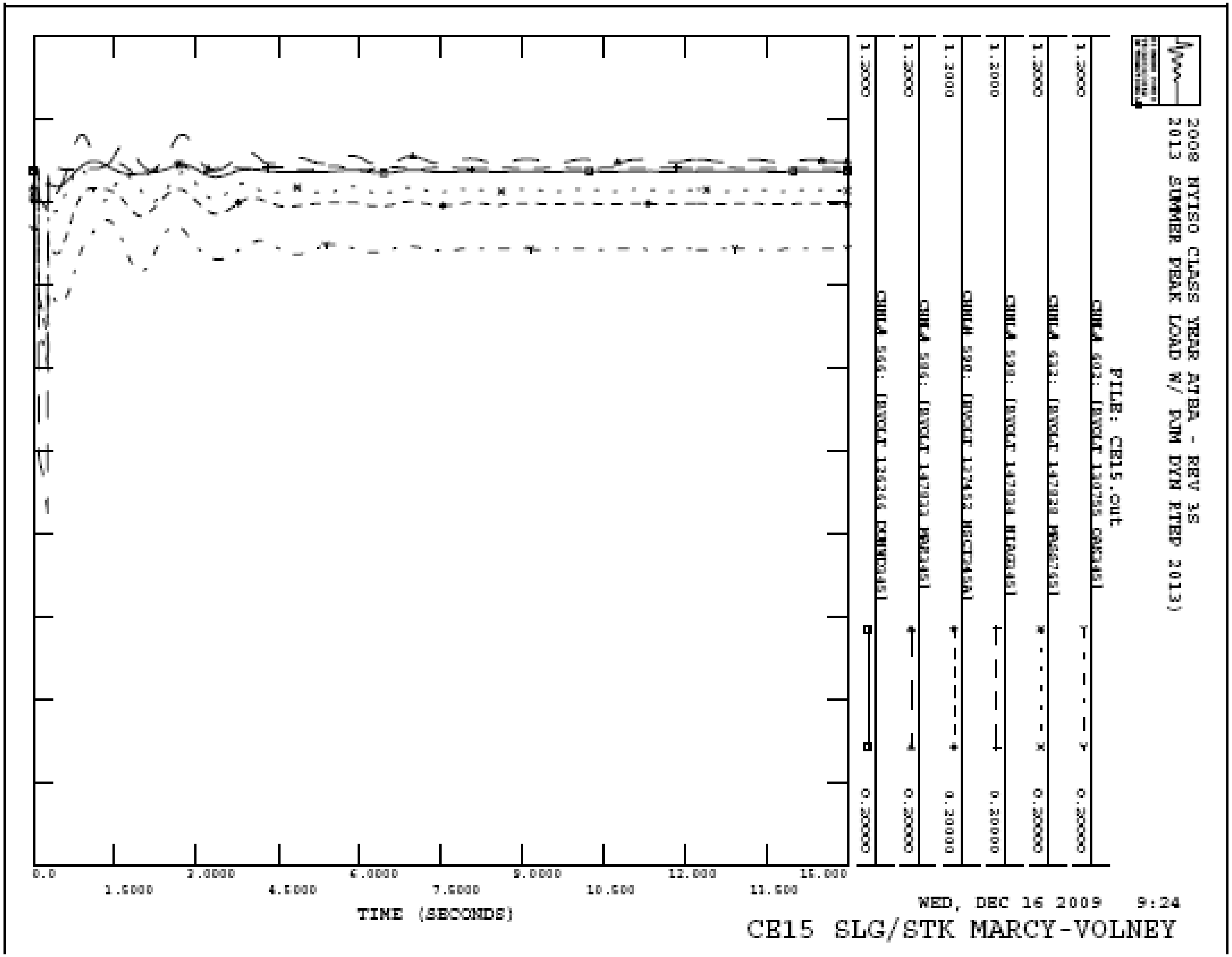


CE15 – SLG-stk #19 & UE1-7



CE15 – SLG-stk #19 & UE1-7



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***
  - ***Use CARIS economic assumptions***
- **Levels of Installed Wind Studied**
  - ***Base (1275 MW), 4,250 MW, 6,000 MW and 8,000 MW***
- **Wind Sensitivities**
  - ***Perfect Wind Forecast***
  - ***Include scenarios with no wind forecast and wind forecast with errors***
  - ***Wind plant generation profiles based on AWS simulations for selected locations in NY***

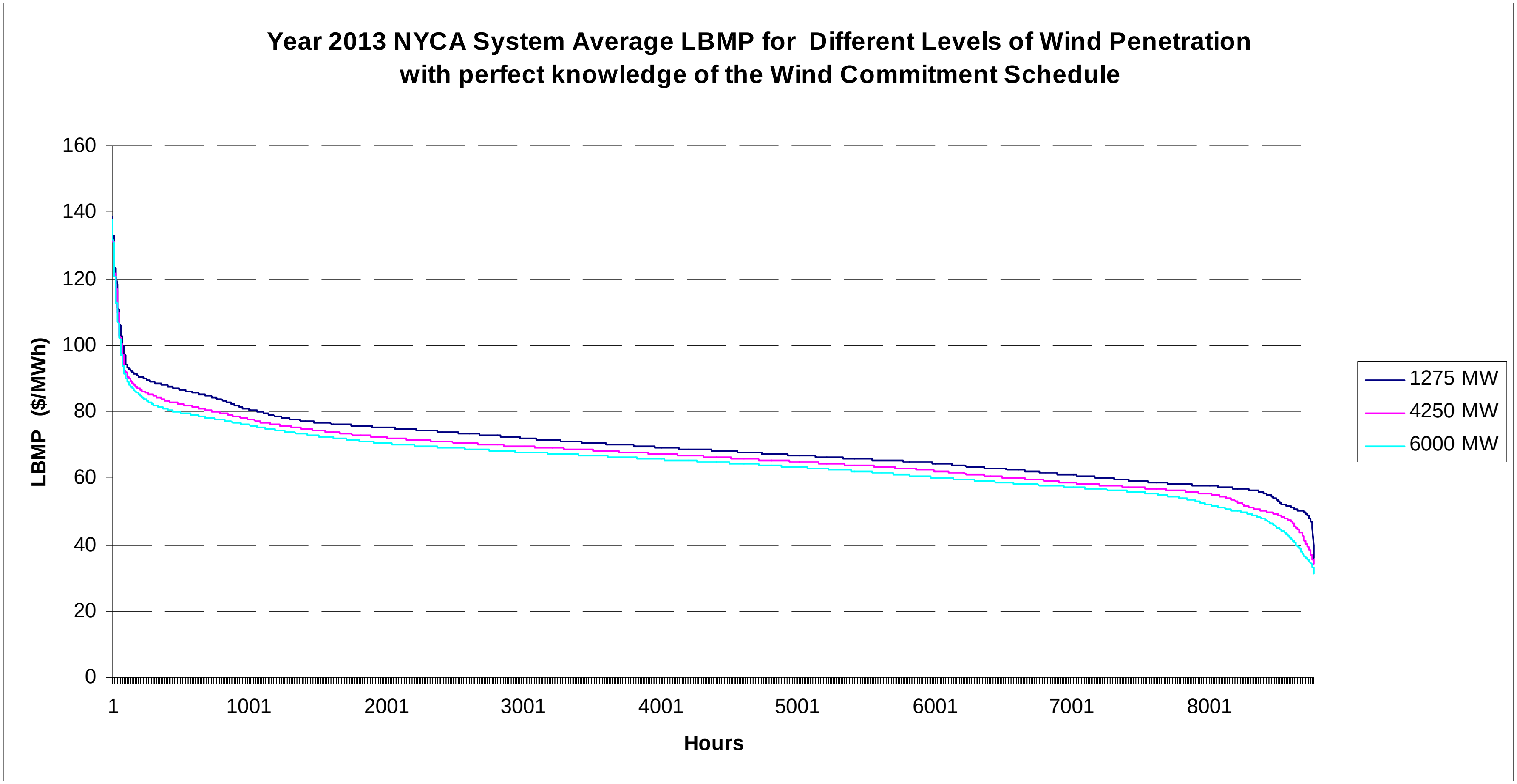
Task 6 – Methodology (cont.)

- **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 – e.g.:***
    - **Changes in LMP as wind penetration increases**
    - **Changes in congestion costs as wind penetration increases**
  - ***Fuel Displacement by type***
    - **Changes in dispatch as wind penetration increases**

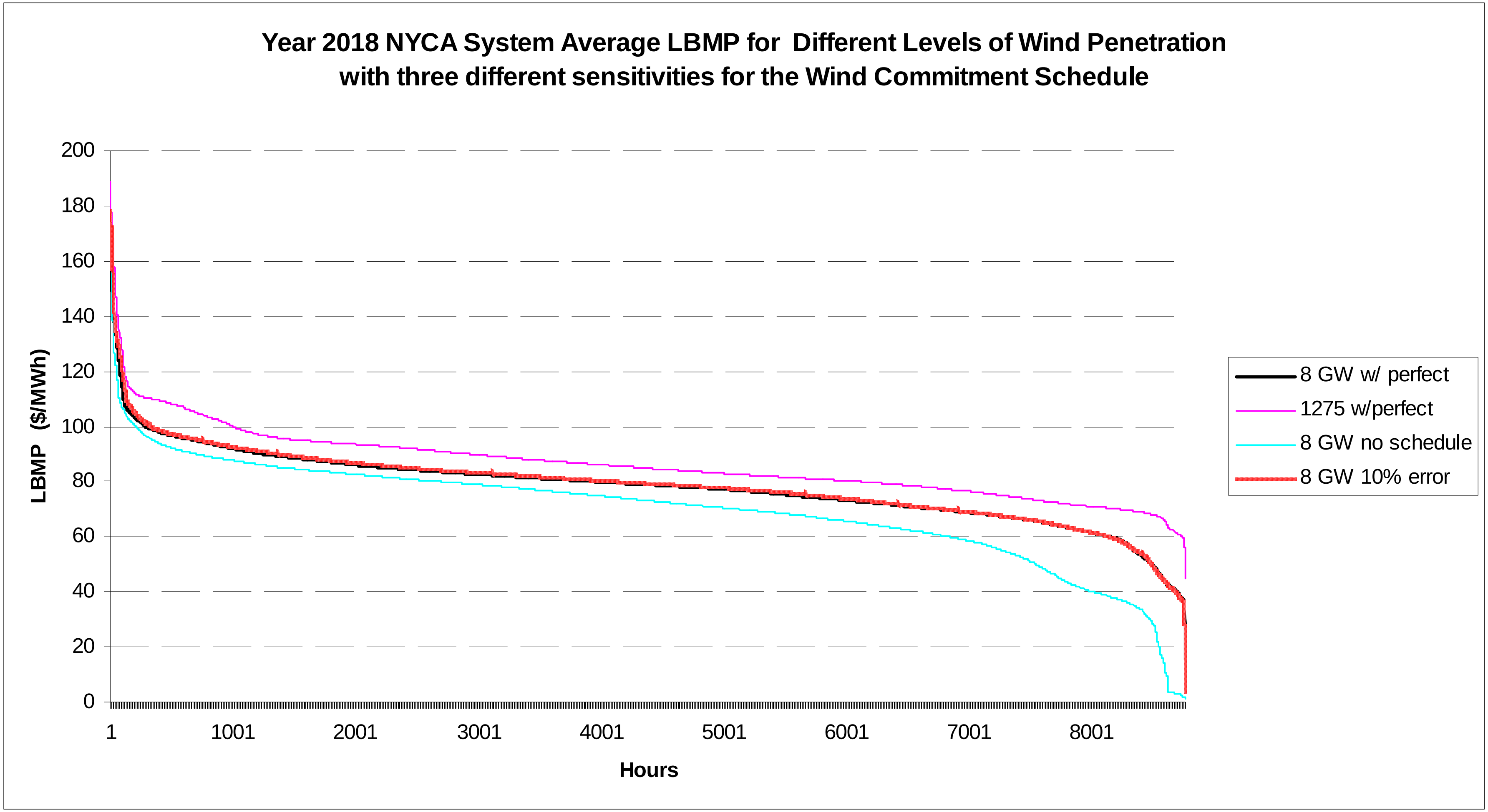
Task 6 – Methodology (cont.)

- **Report on the Impact of Increasing Levels of Installed Wind Plants**
  - ***Impact of Increasing Wind Plant Penetration on LMP***
  - ***Impact of Increasing Wind Plant Penetration on Emissions***
  - ***Impact of Increasing Wind Plant Penetration on Production Costs and Generator LMP Revenue***
  - ***Impact of Increasing Wind Plant Penetration on Dispatch***
  - ***Impact of Increasing Wind Plant Penetration During Periods of Minimum System Loads.***
  - ***Impact of Increasing Wind Plant Penetration on Ramping.***

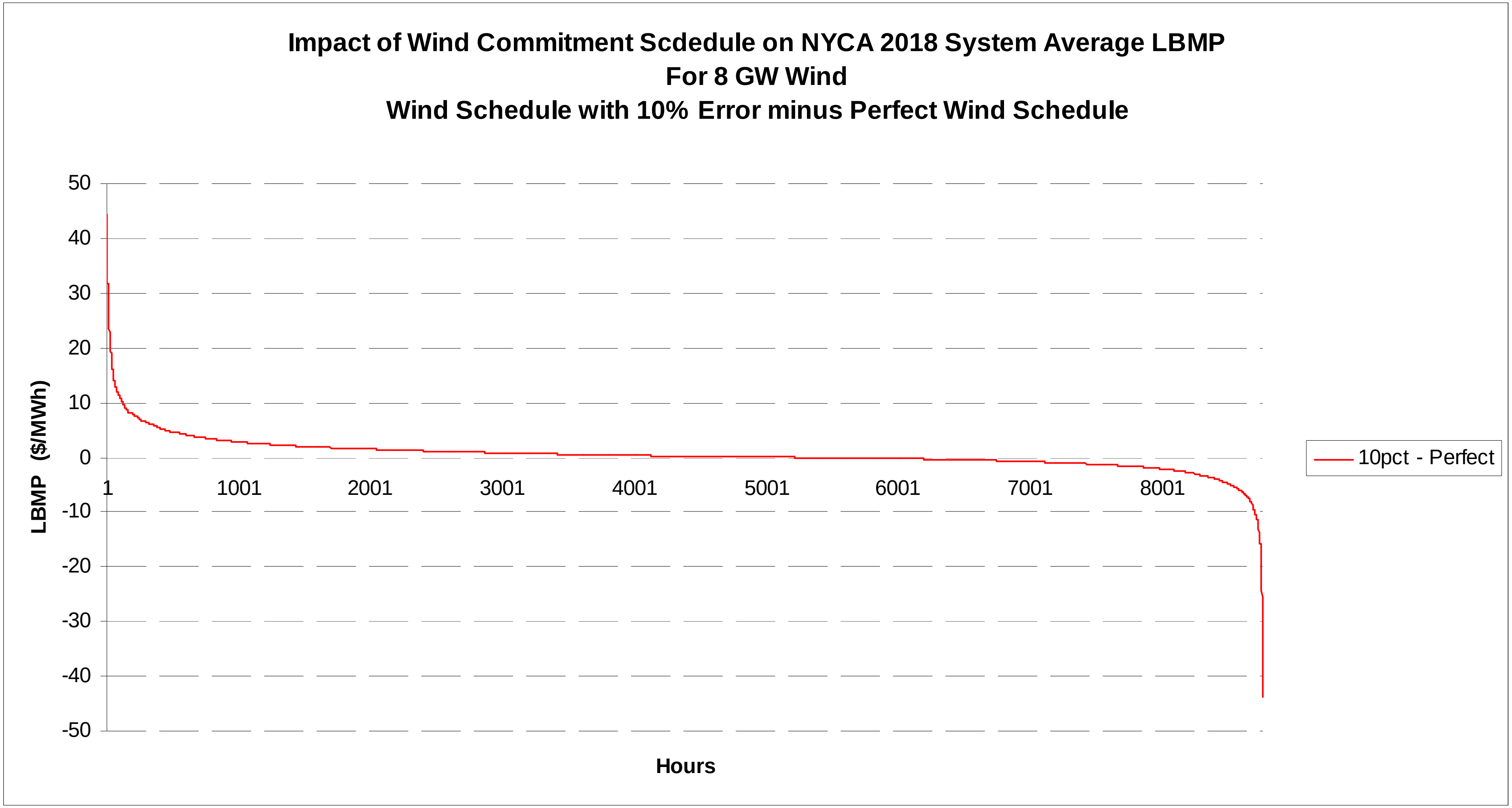
Task 6 – Impact of Increasing Wind Plant Penetration on LMP



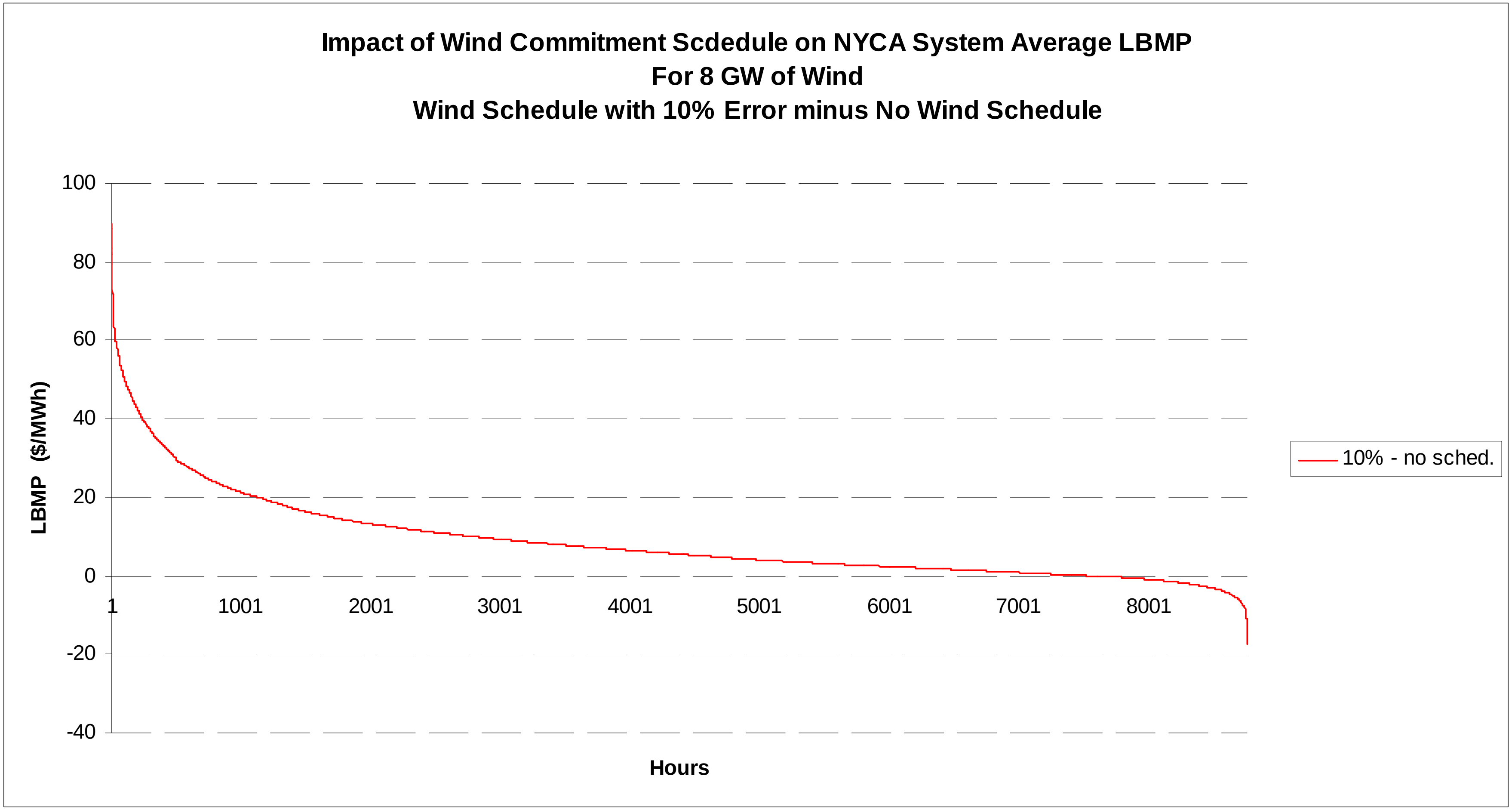
Task 6 – Impact of Increasing Wind Plant Penetration on LMP (cont.)



Task 6 – Impact of Increasing Wind Plant Penetration on LMP (cont.)



Task 6 – Impact of Increasing Wind Plant Penetration on LMP (cont.)



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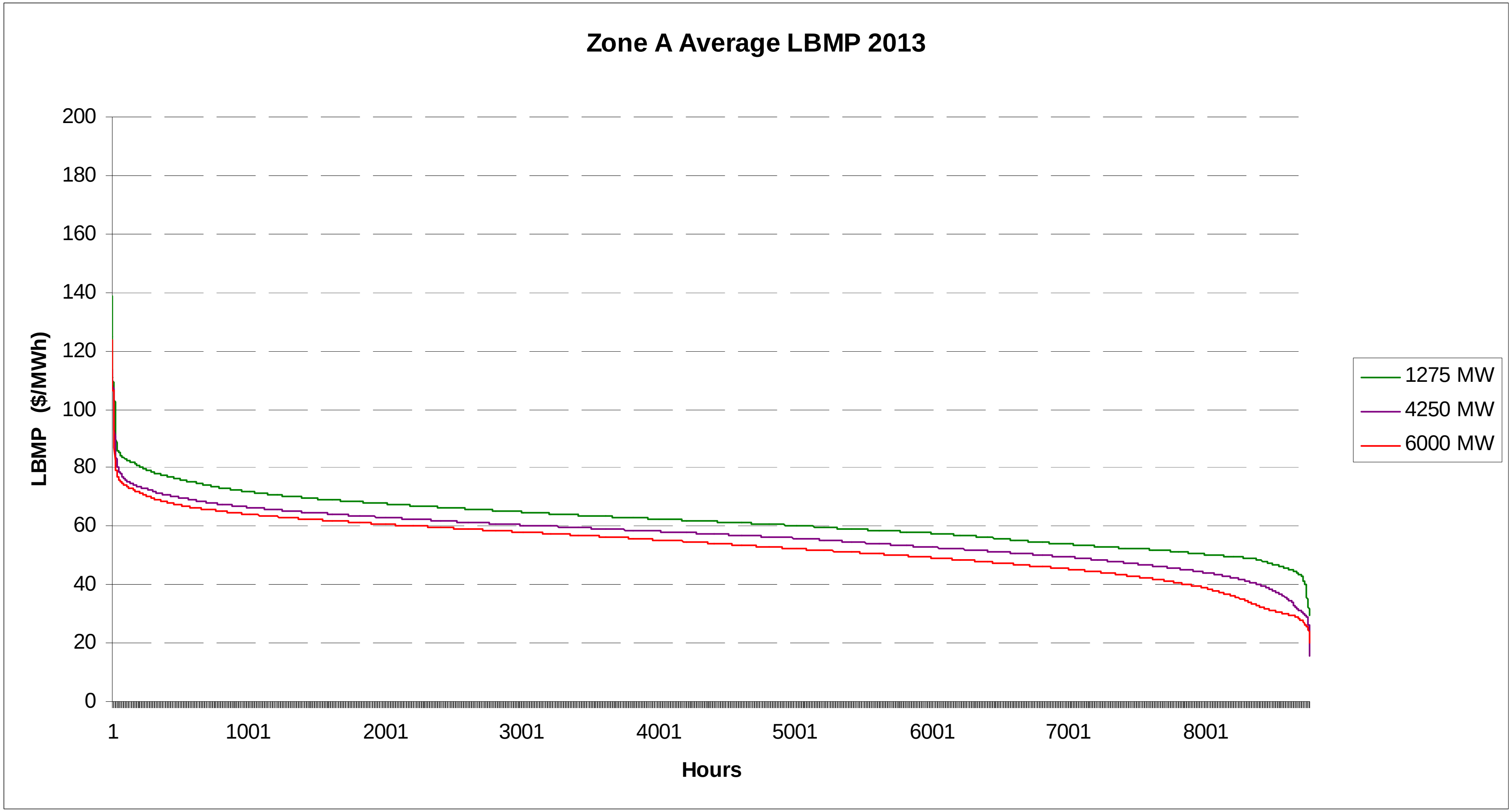
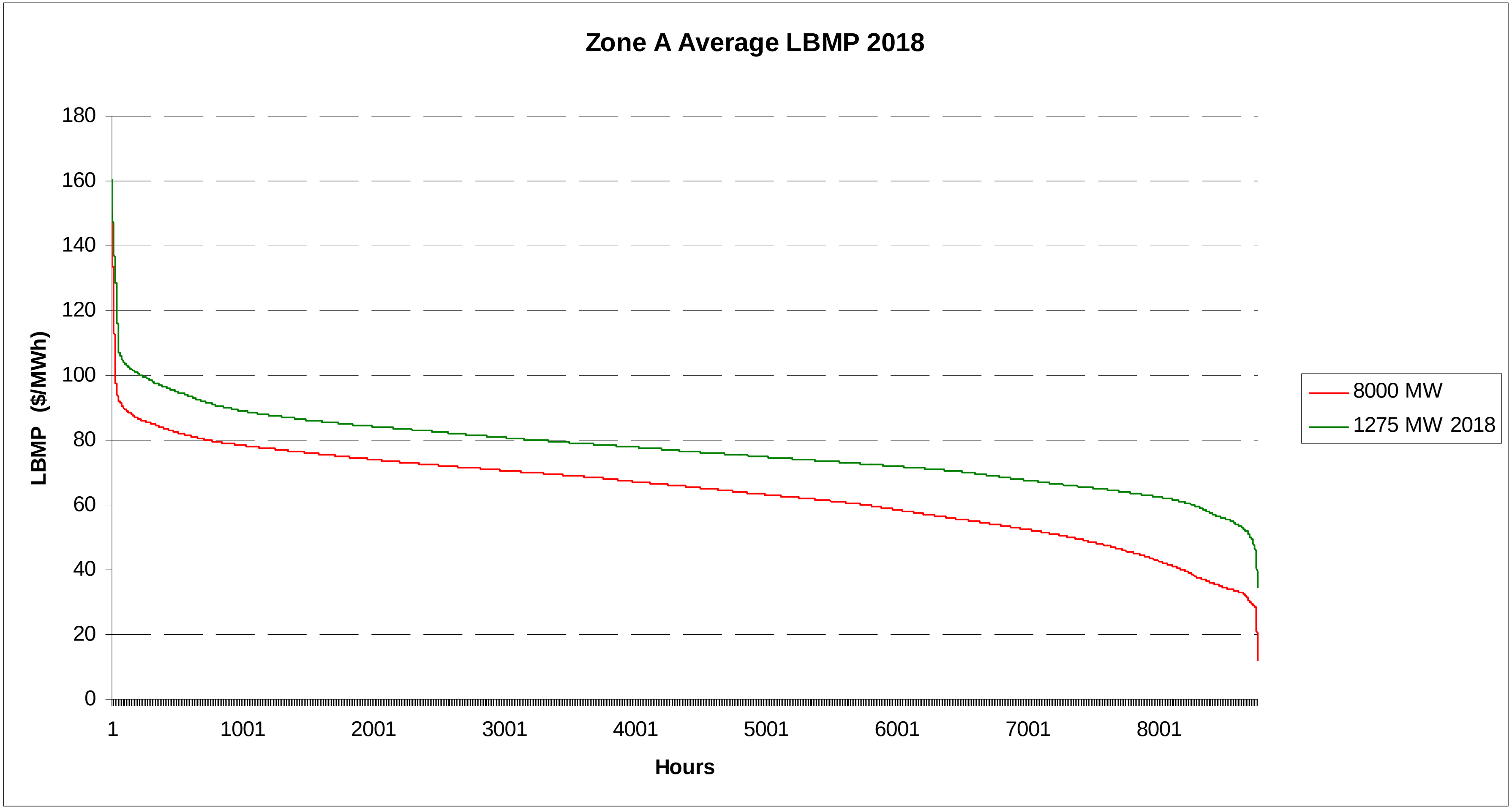
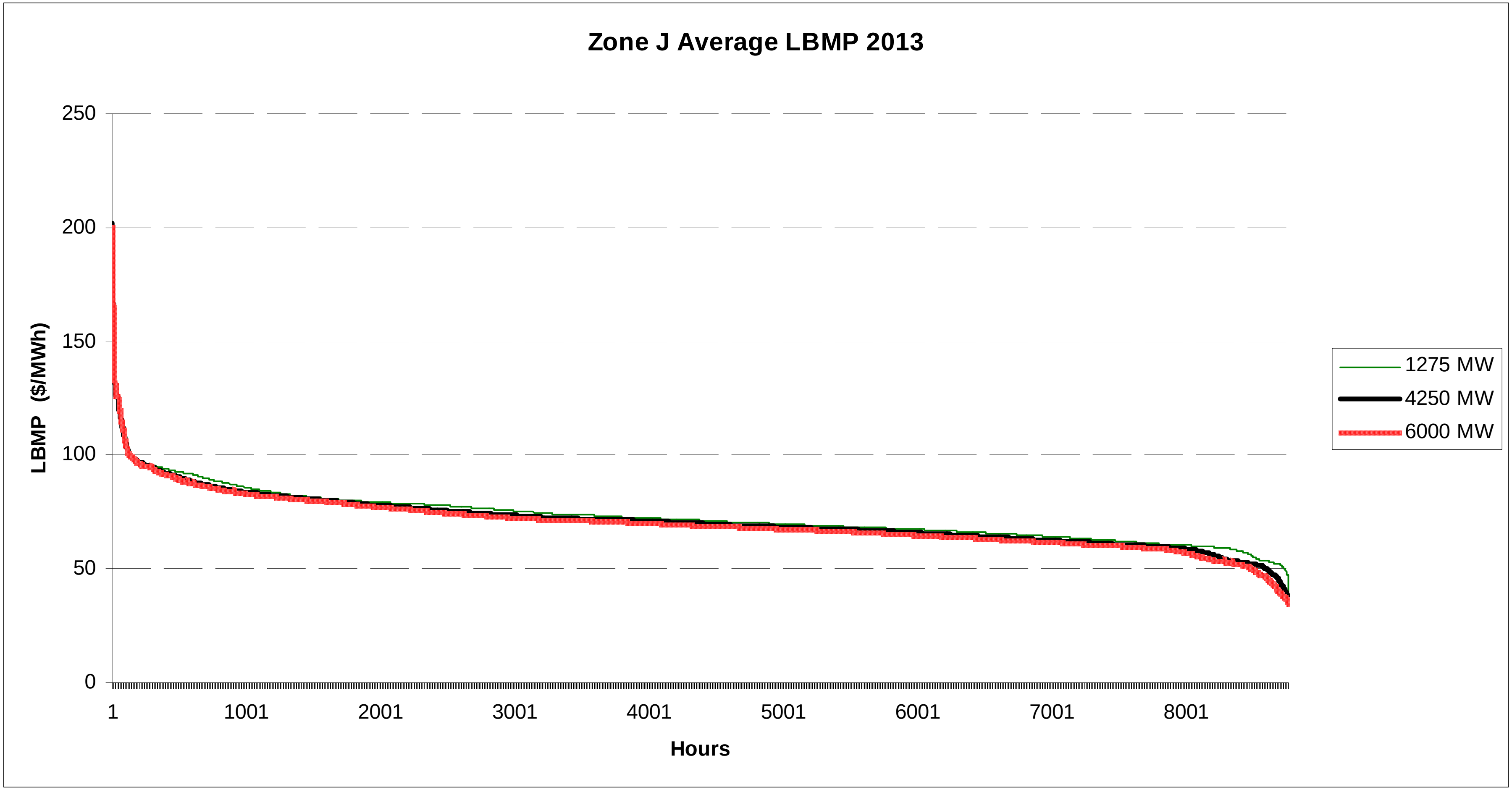


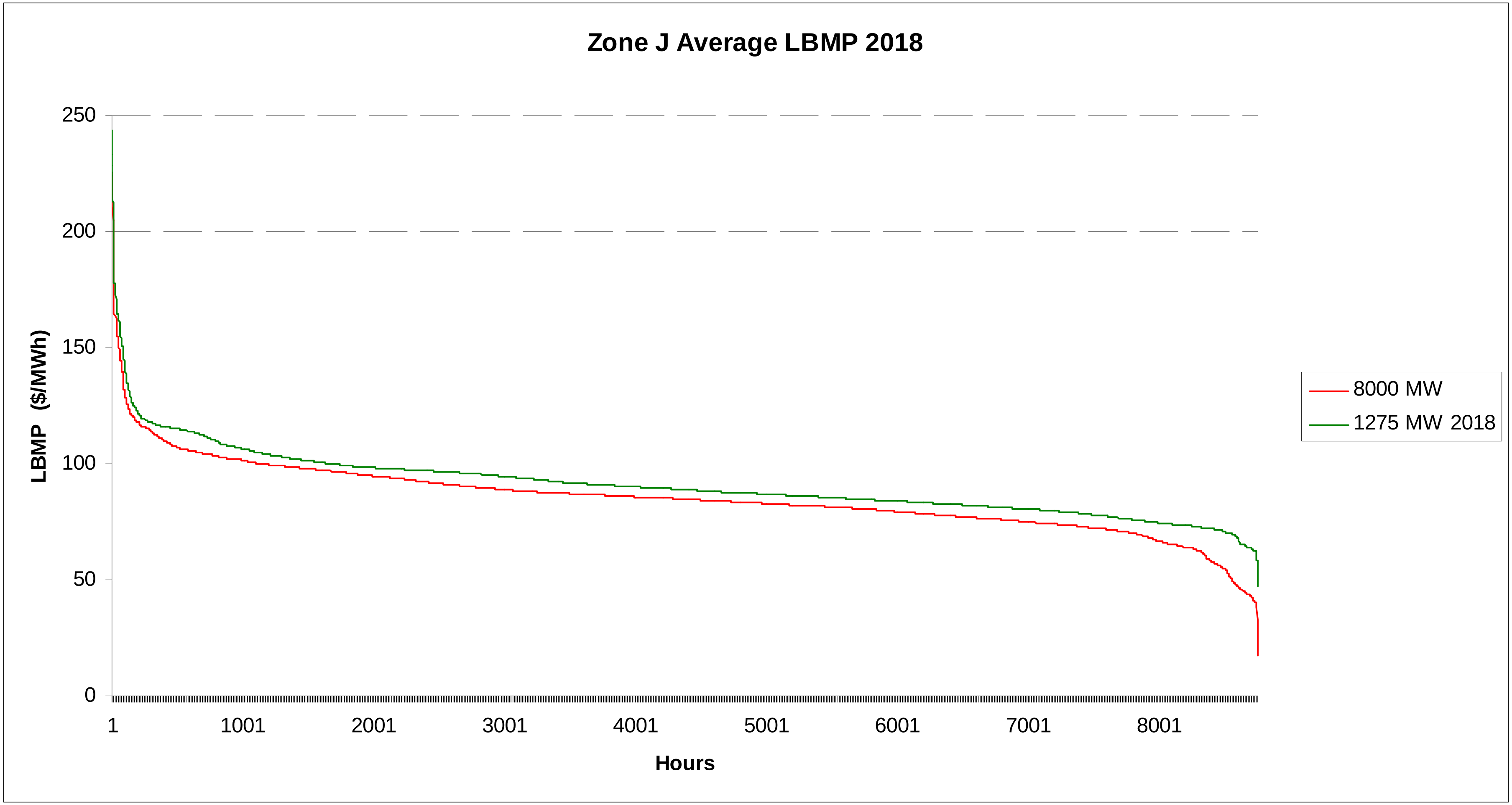
Task 6 – Impact of Increasing Wind Plant Penetration on LMP (cont.)



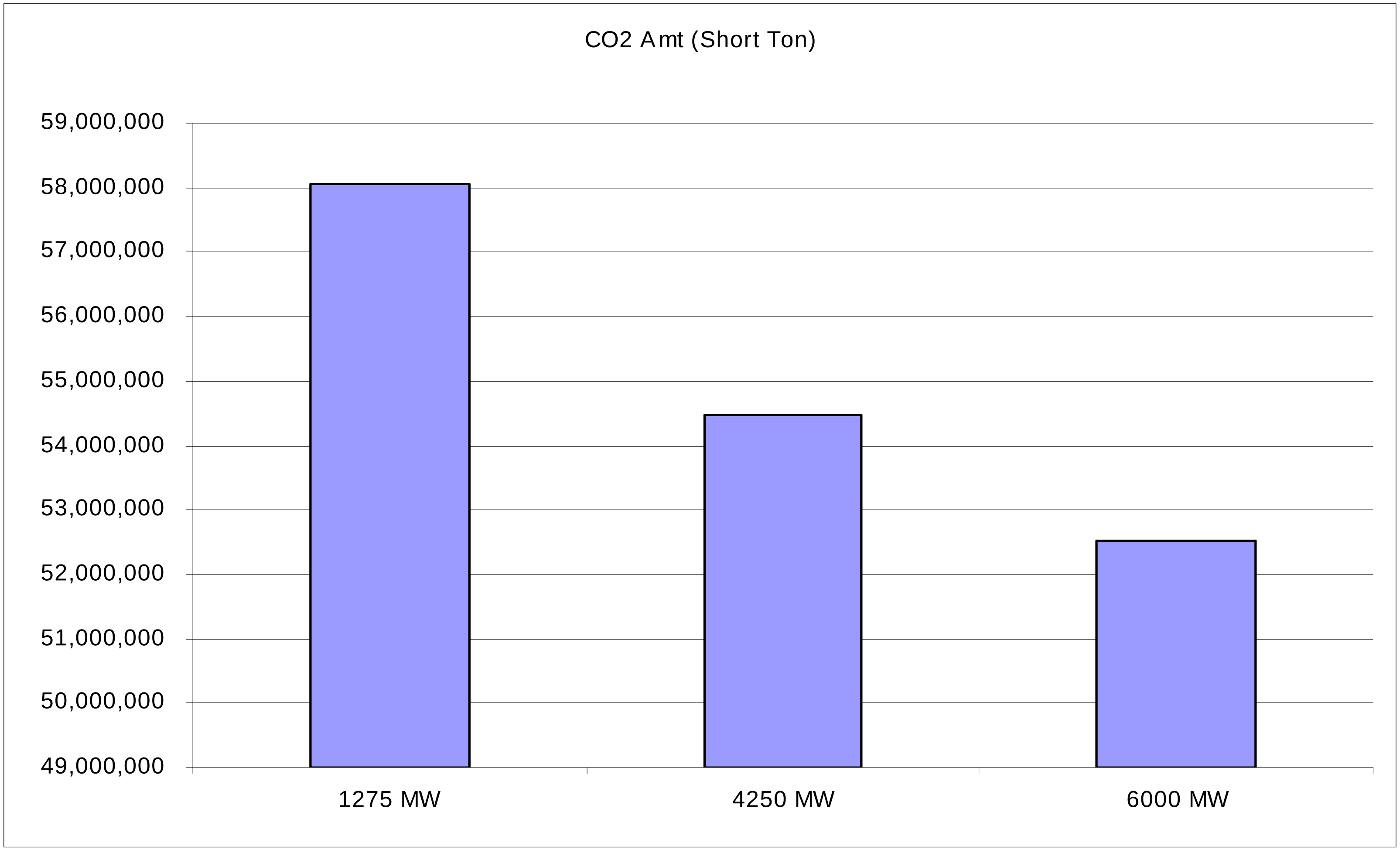
Task 6 – Impact of Increasing Wind Plant Penetration on LMP (cont.)



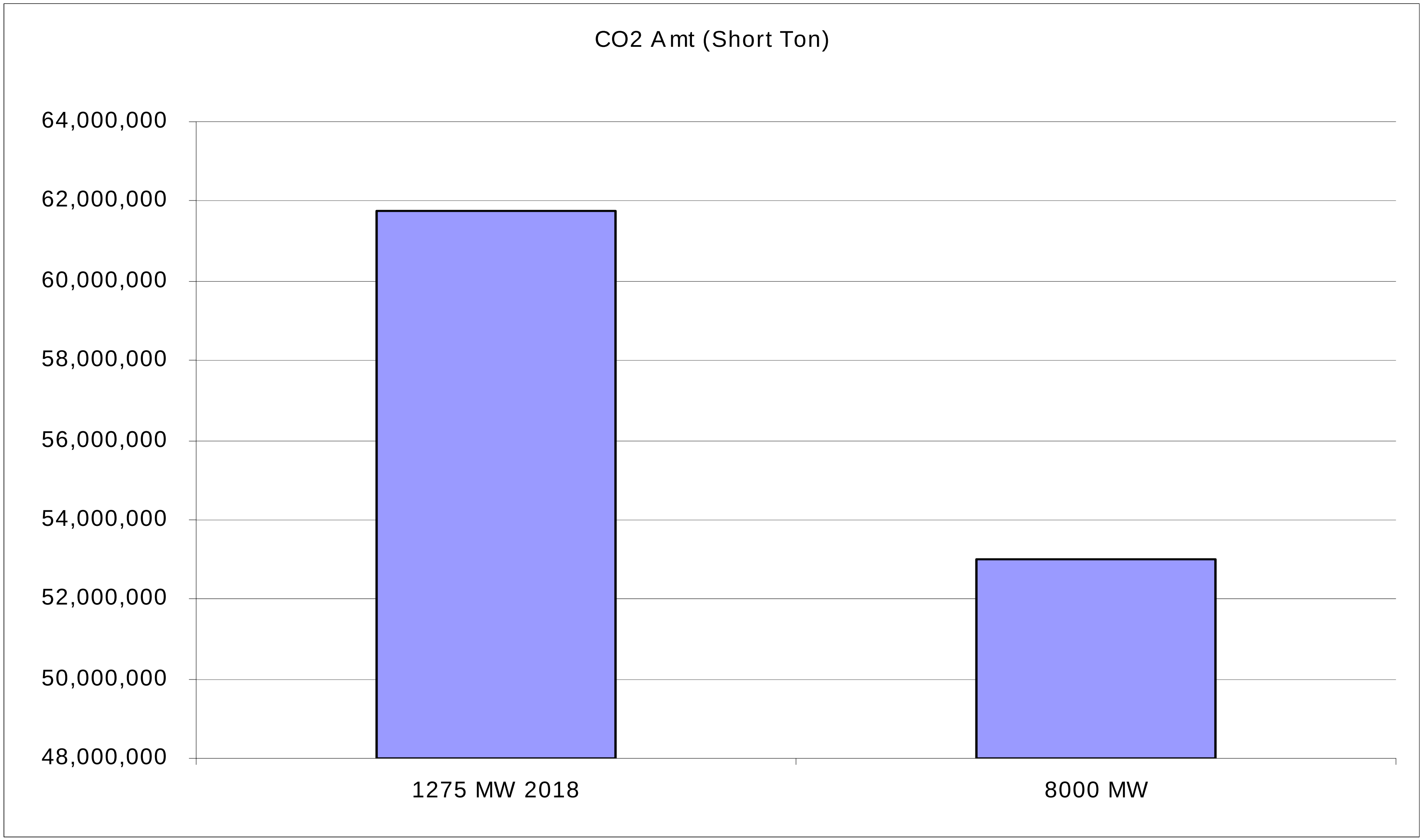
Task 6 – Impact of Increasing Wind Plant Penetration on LMP (cont.)



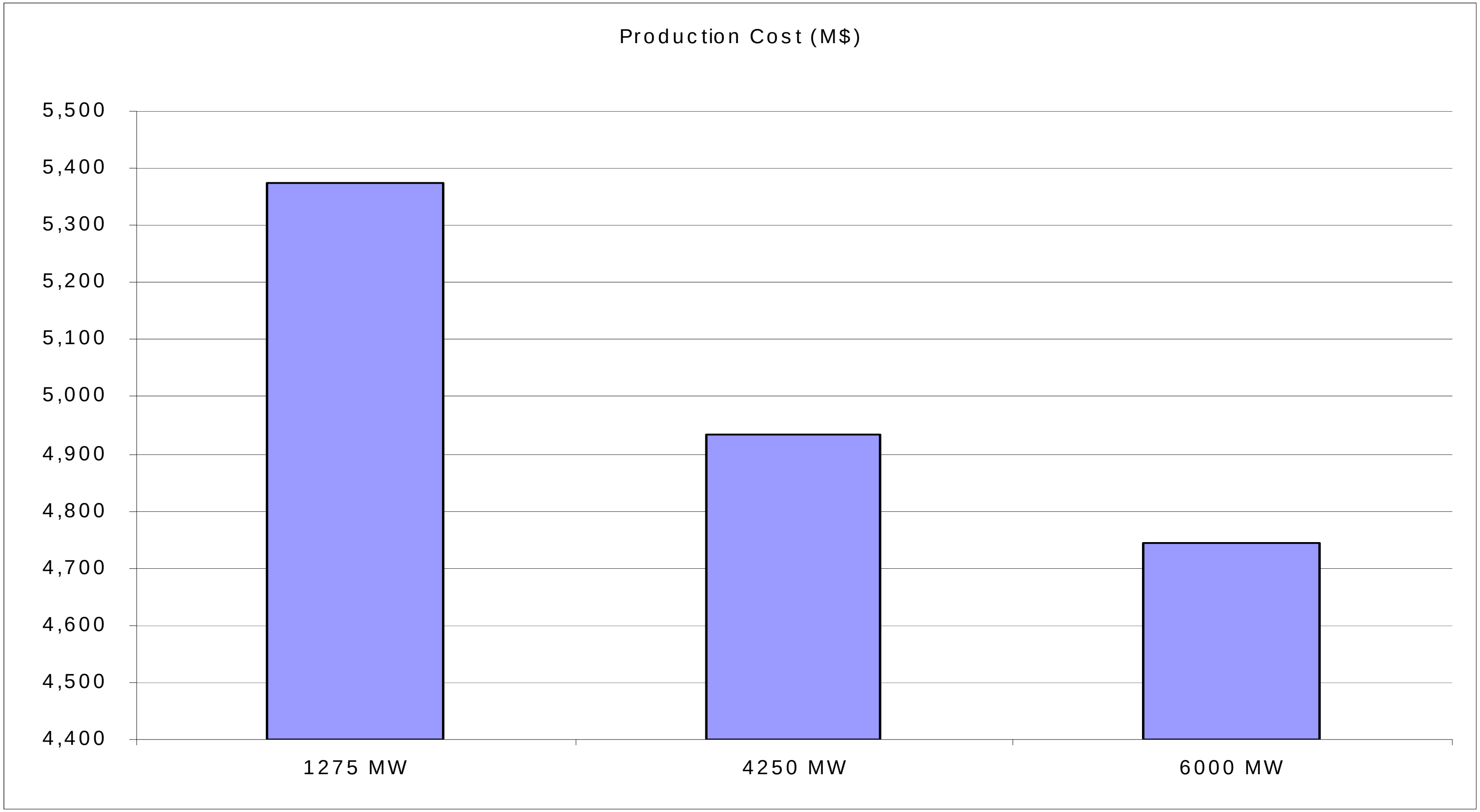
Task 6 – Impact of Increasing Wind Plant Penetration on Emissions



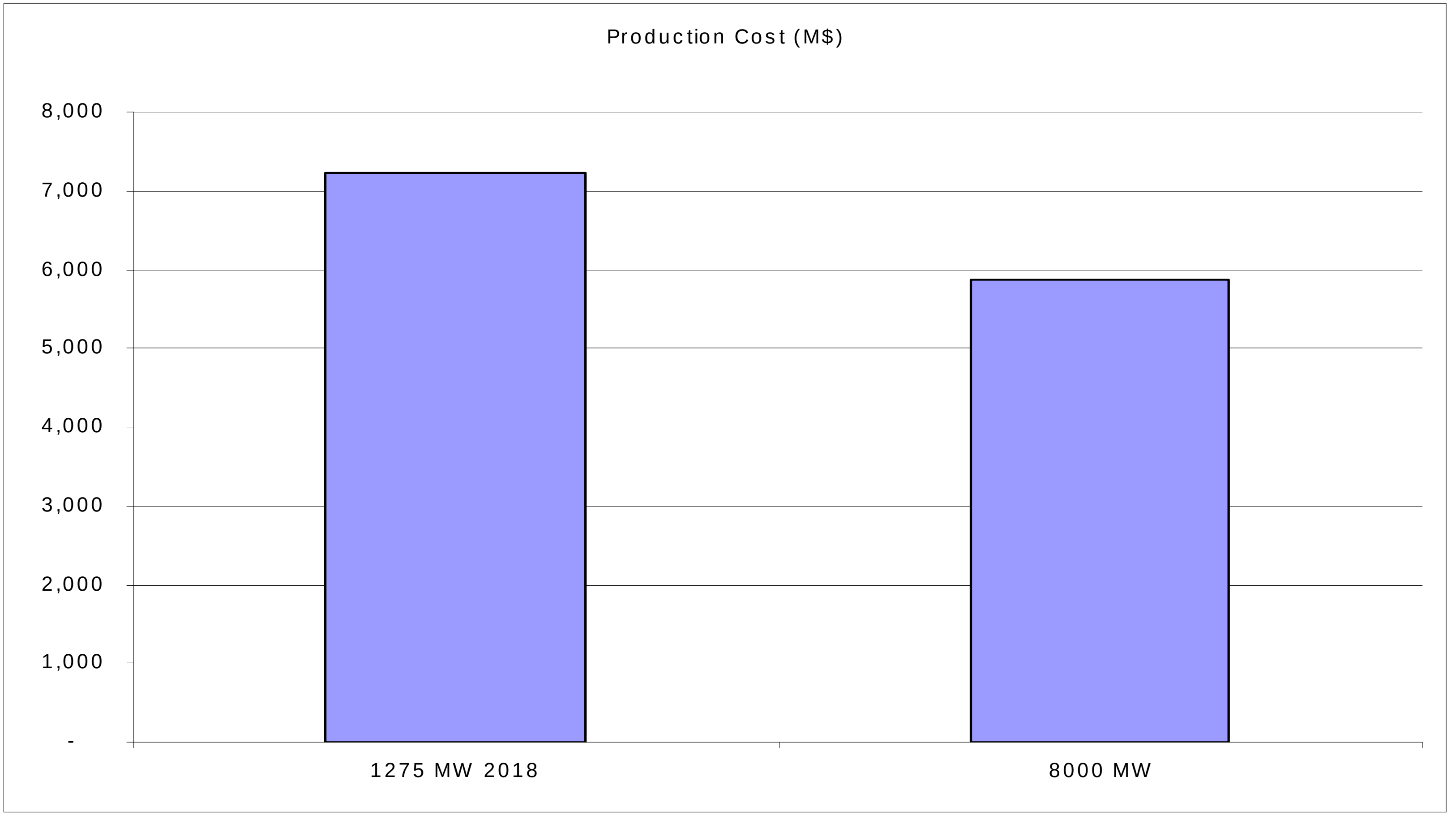
Task 6 – Impact of Increasing Wind Plant Penetration on Emissions (cont.)



Task 6 – Impact of Increasing Wind Plant Penetration on Production Costs and Generator LMP Revenue



Task 6 – Impact of Increasing Wind Plant Penetration on Production Costs and Generator LMP Revenue (cont.)



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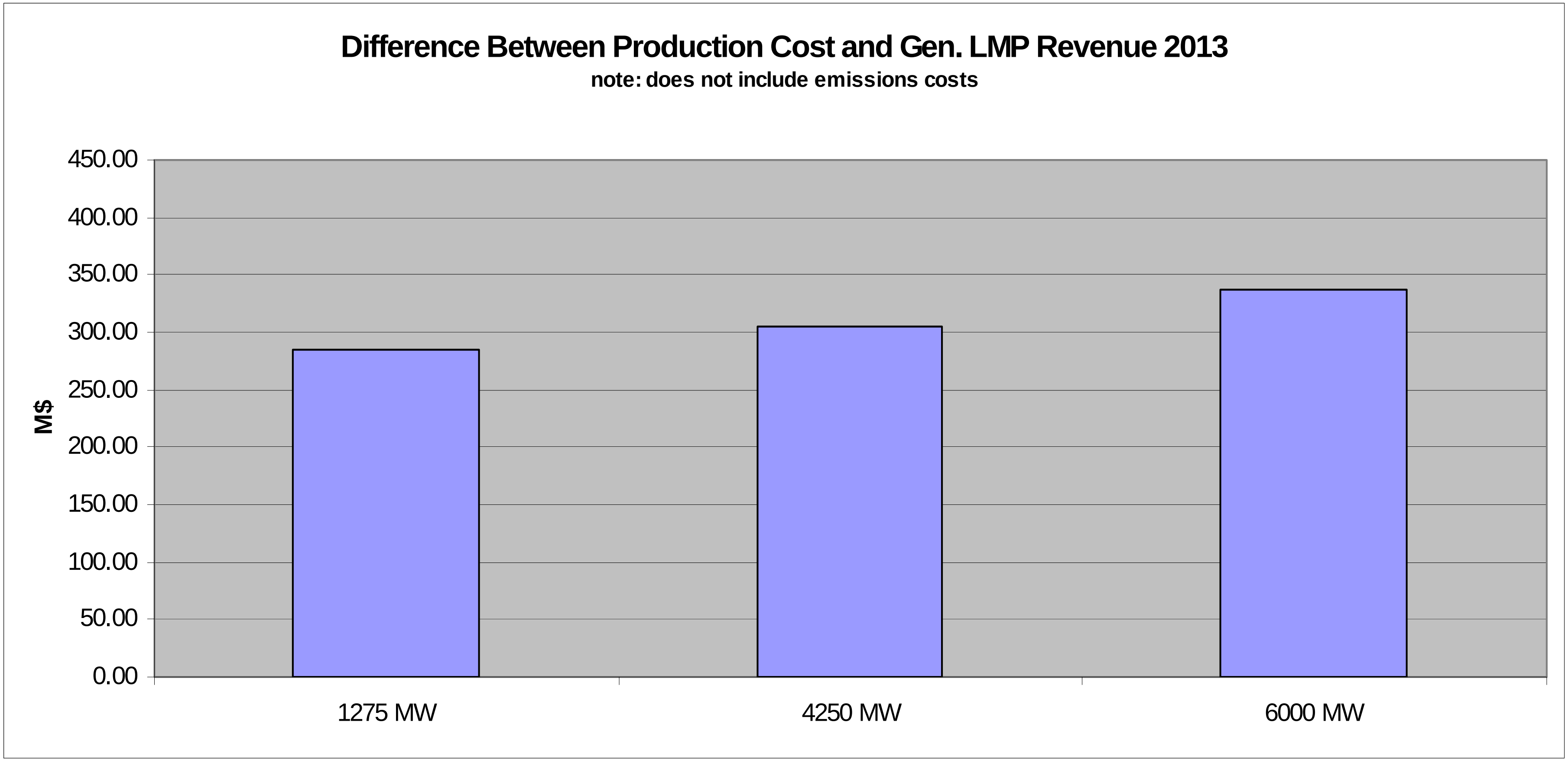
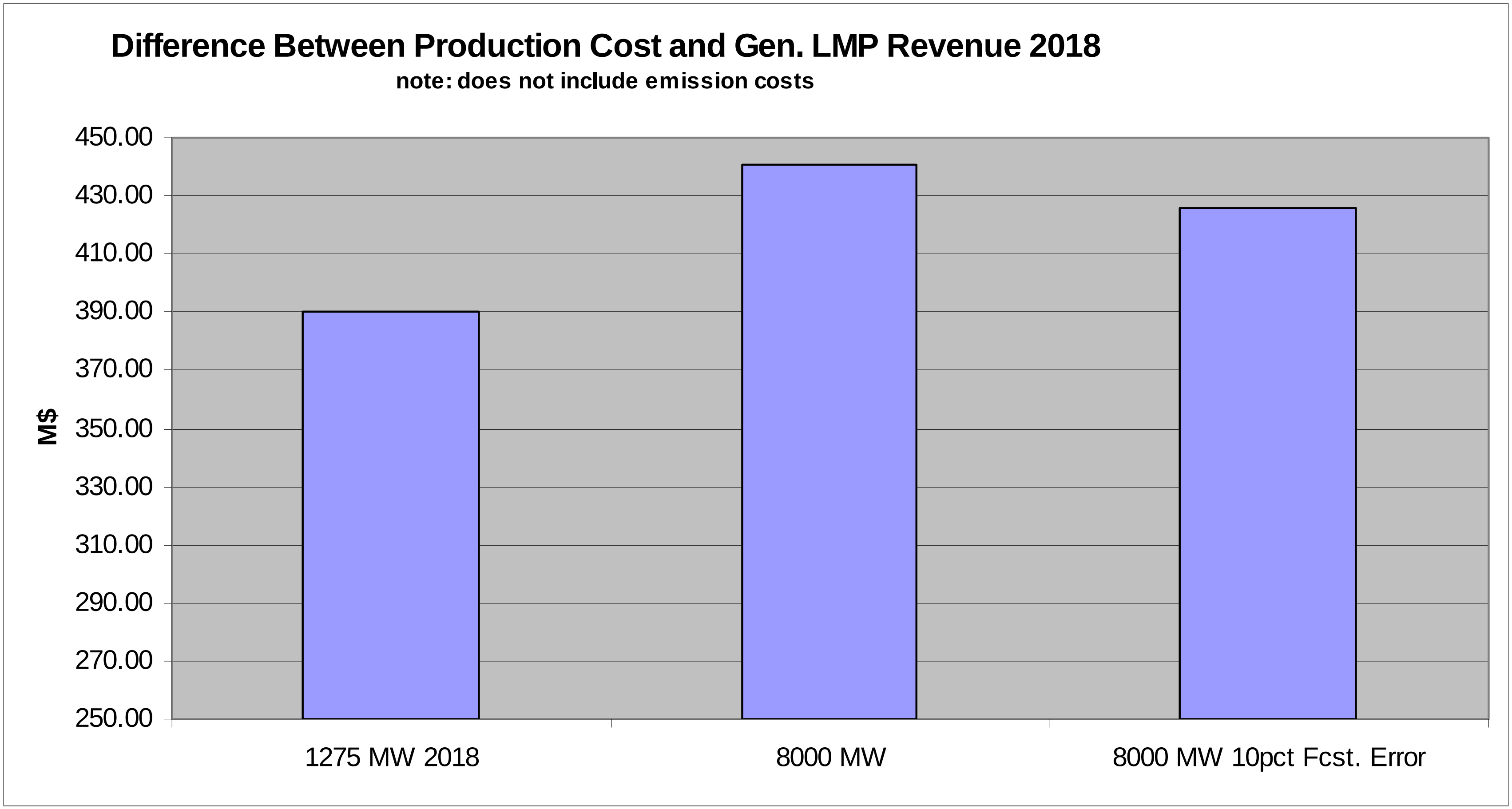
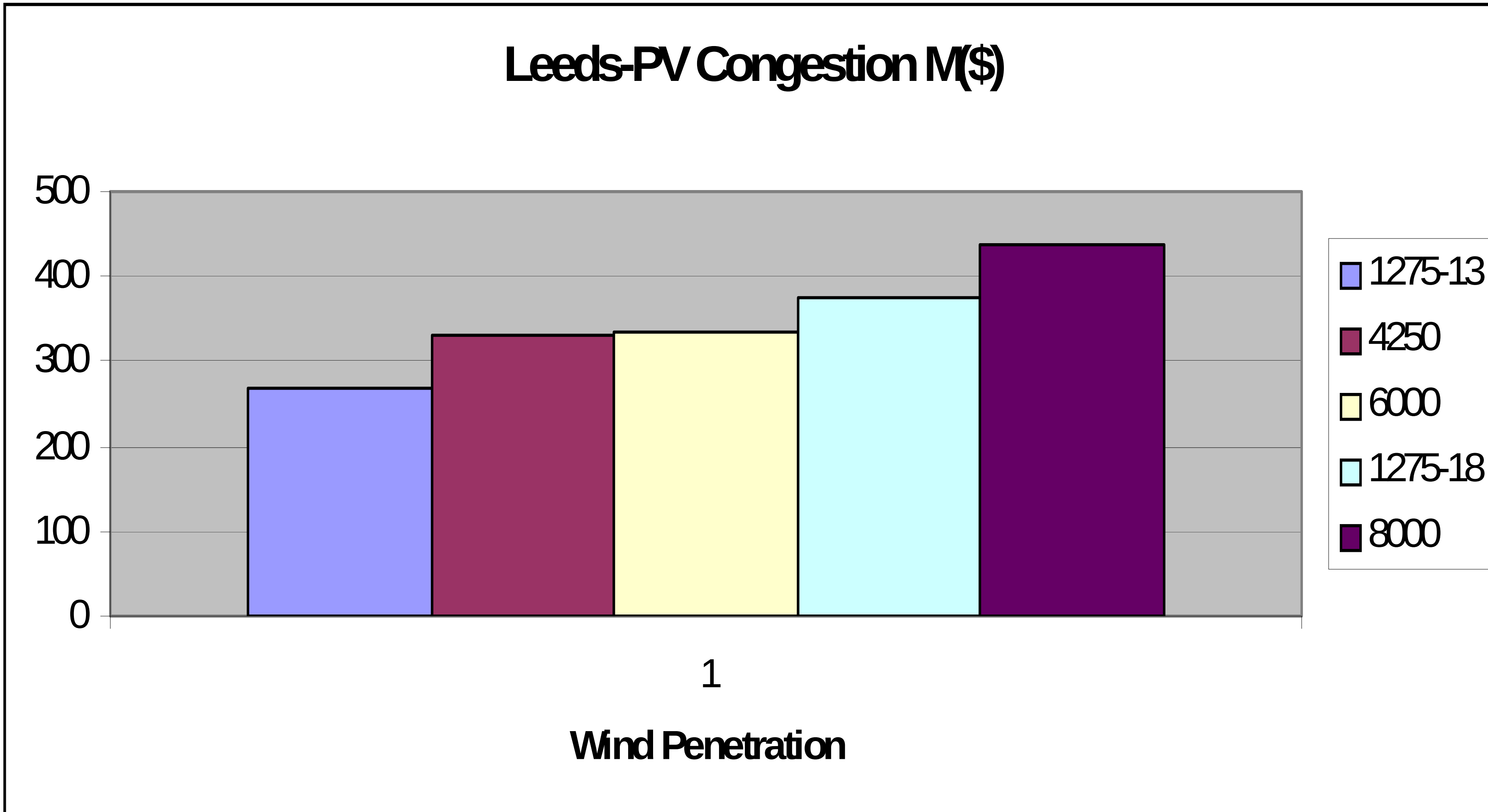


Task 6 – Impact of Increasing Wind Plant Penetration on Production Costs and Generator LMP Revenue (cont.)



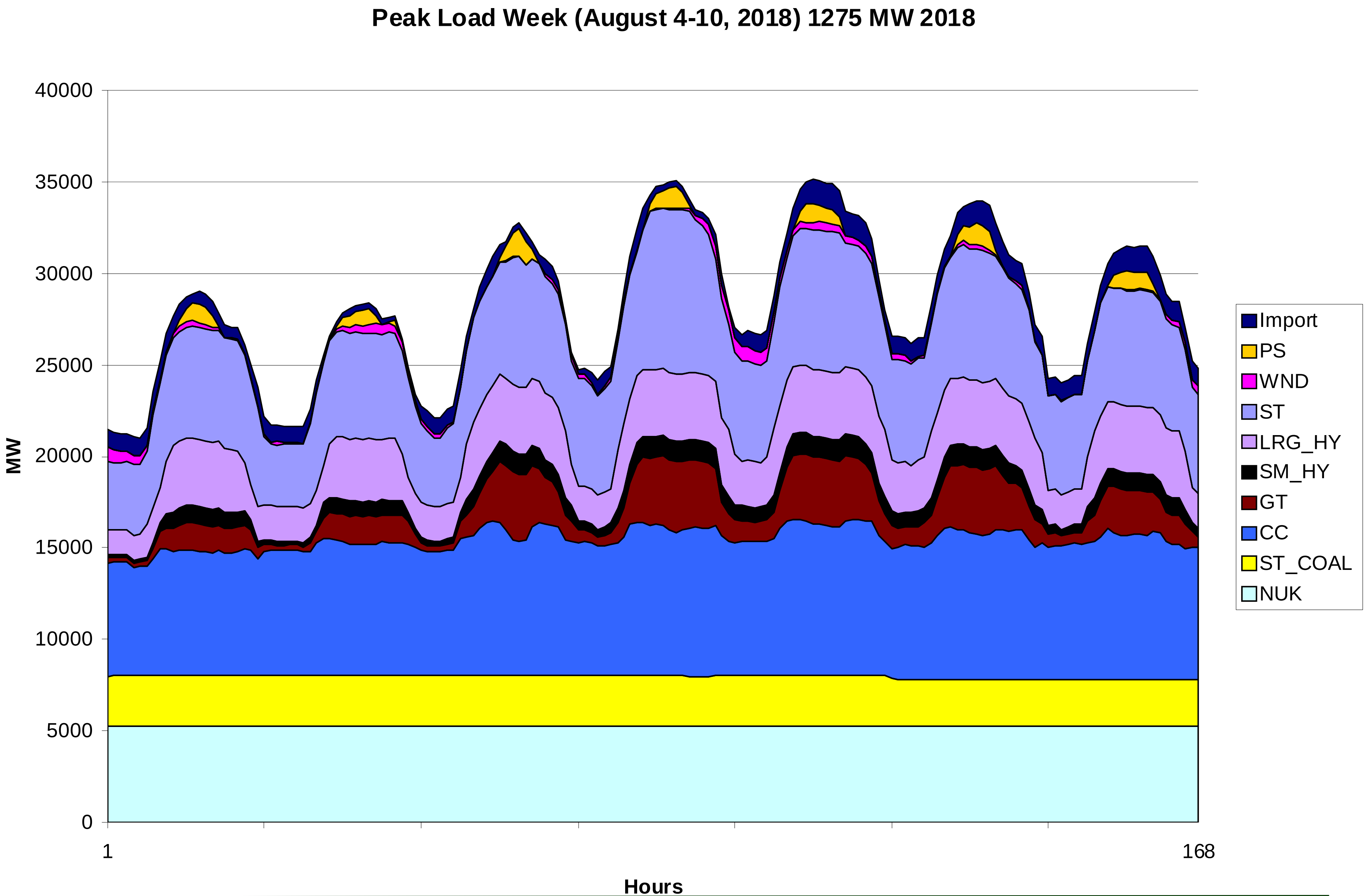
Task 6 – Impact of Increasing Wind Plant Penetration On Leeds-PV Congestion



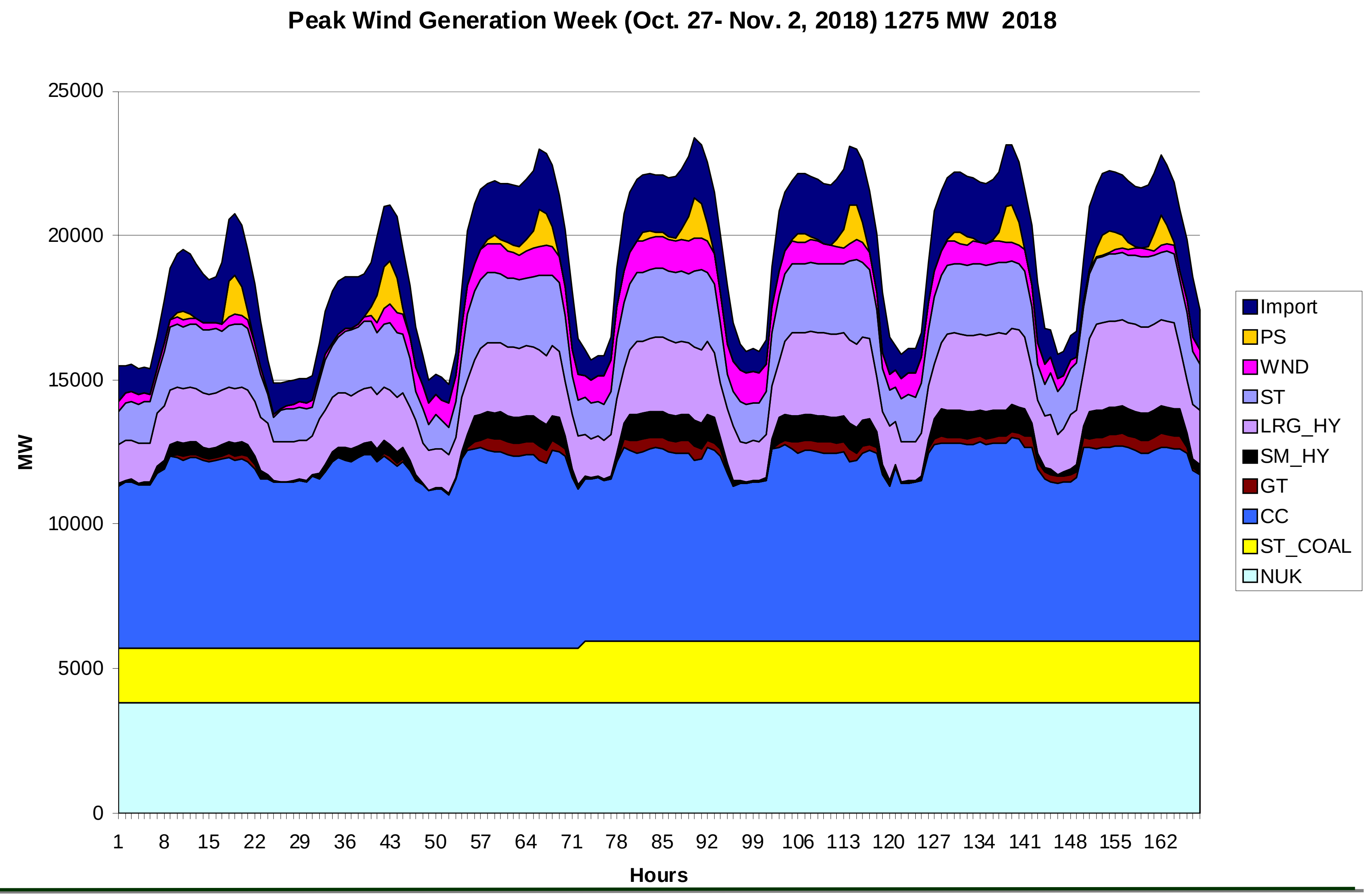
Task 6 – Legend for Impact on Dispatch Slides which follow:

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

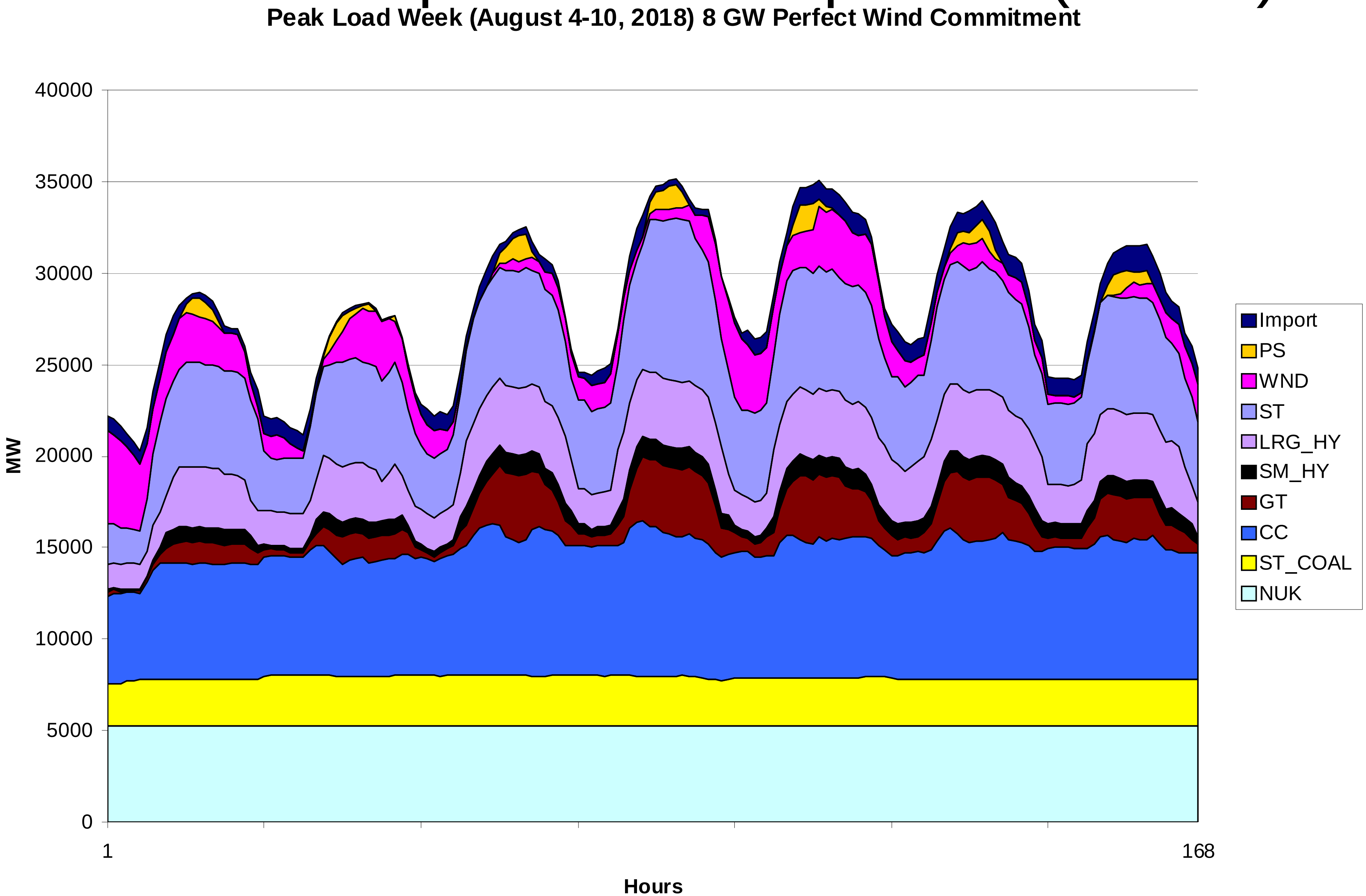
Task 6 - Impact on Dispatch



Task 6 - Impact on Dispatch (cont.)



Task 6 - Impact on Dispatch (cont.)



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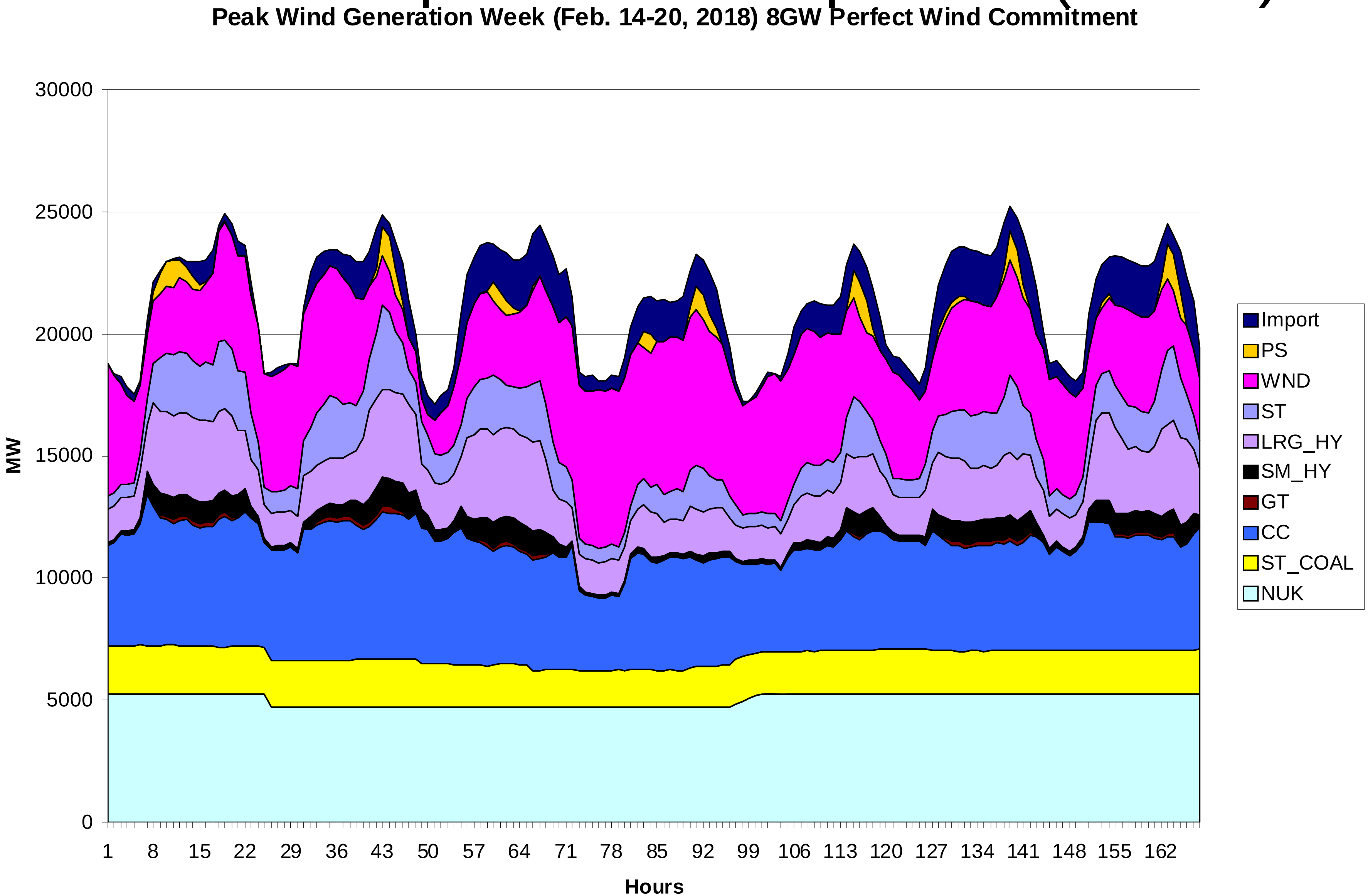
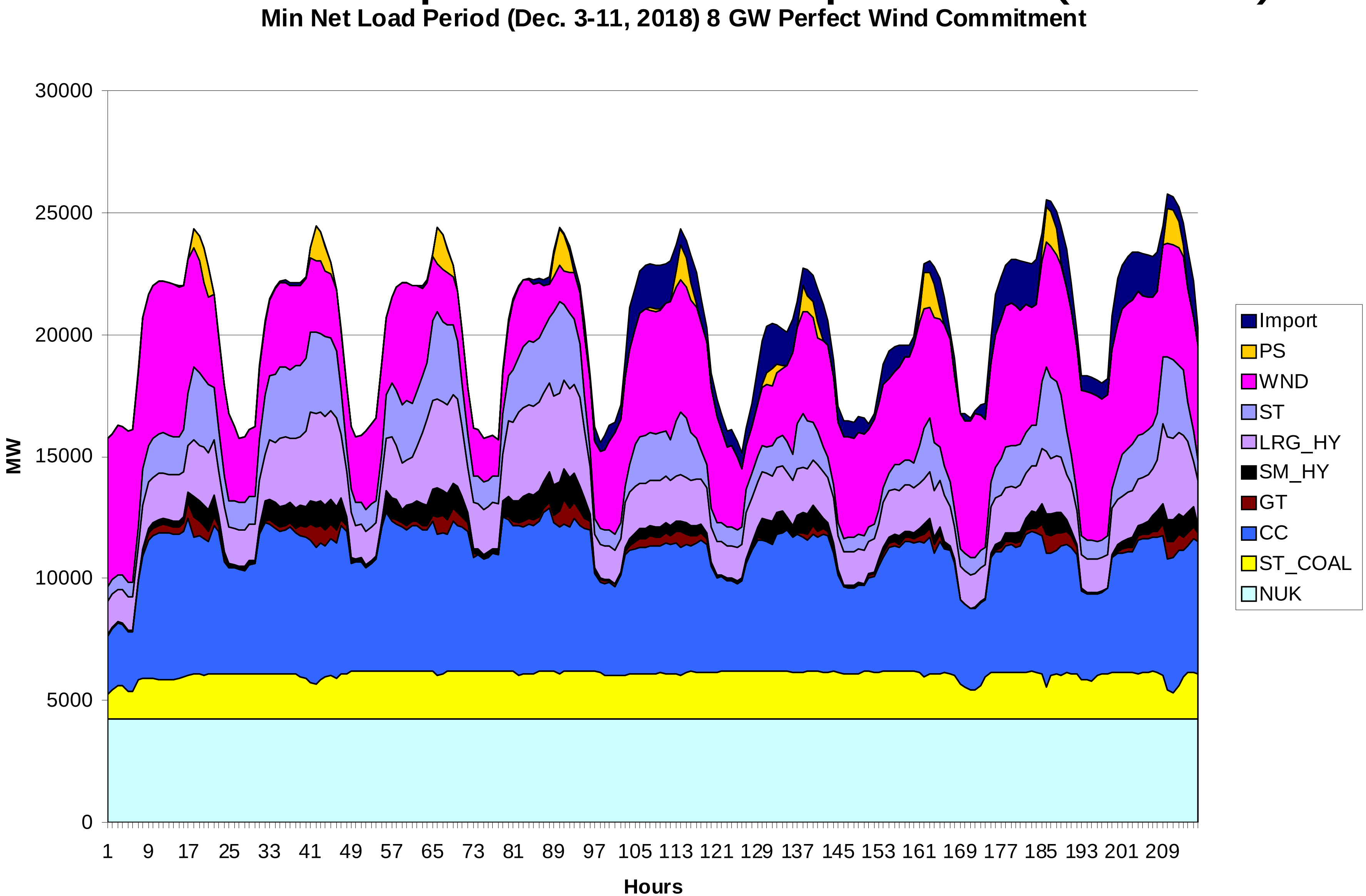


Task 6 - Impact on Dispatch (cont.)



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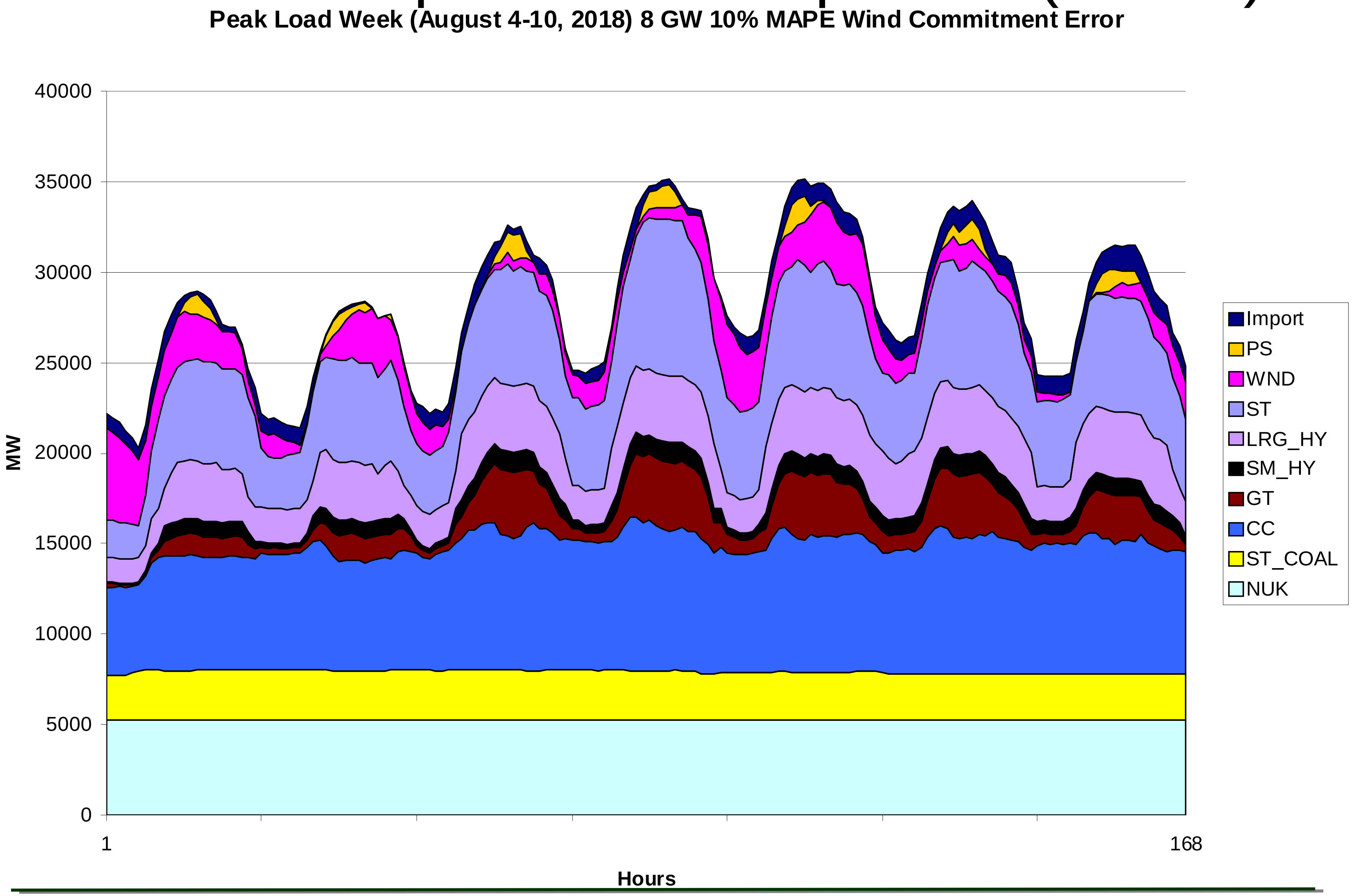

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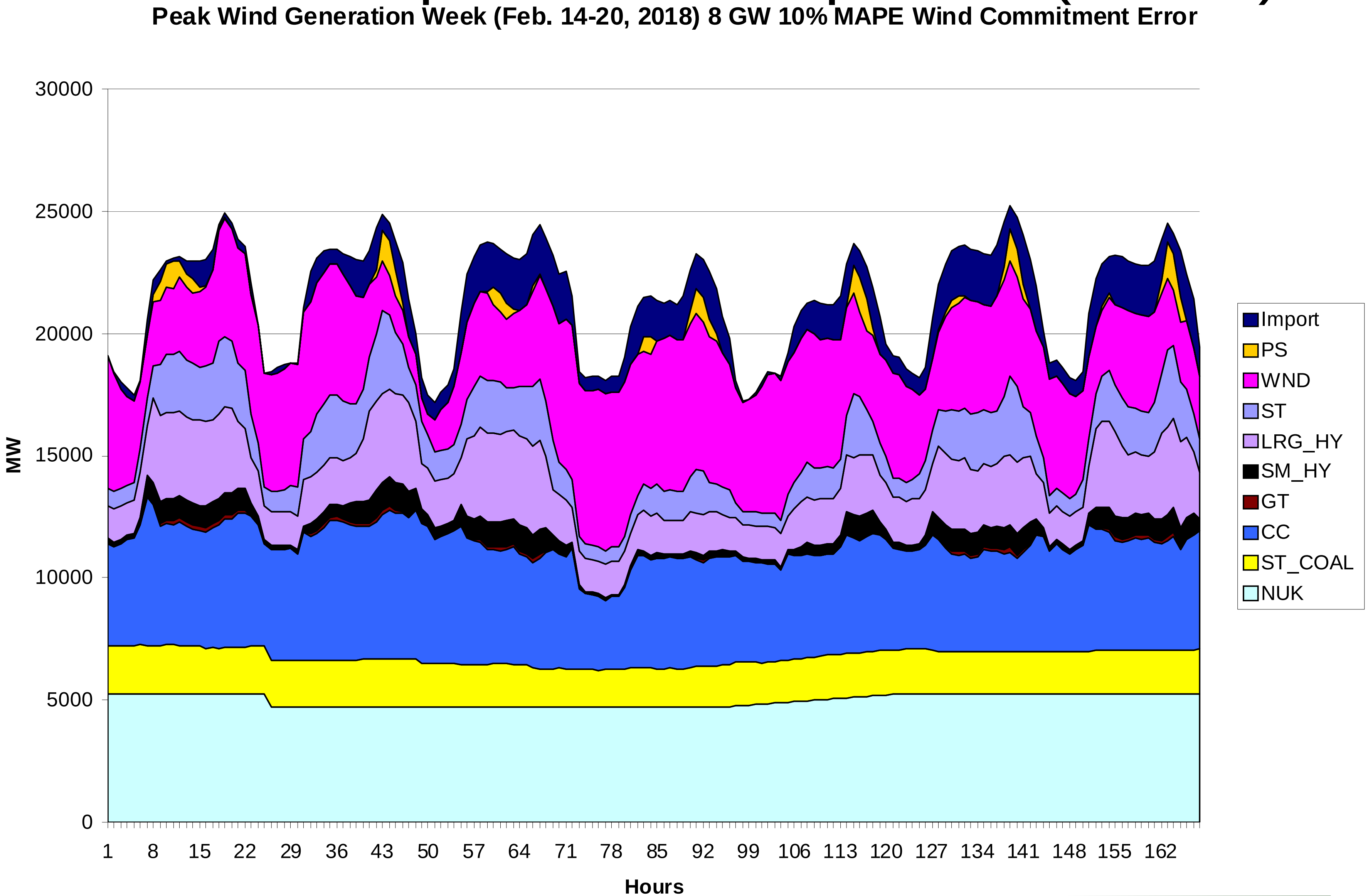

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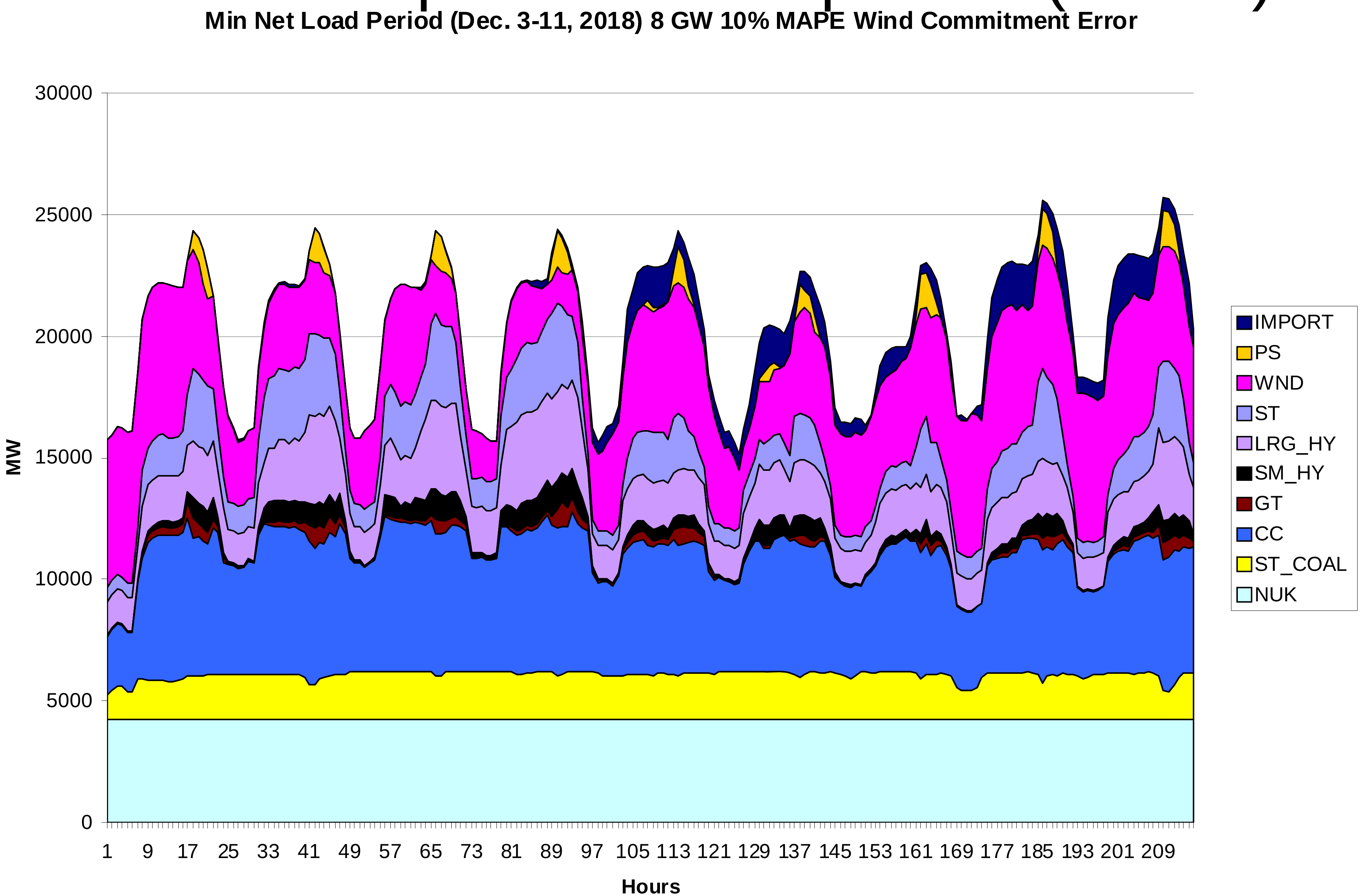

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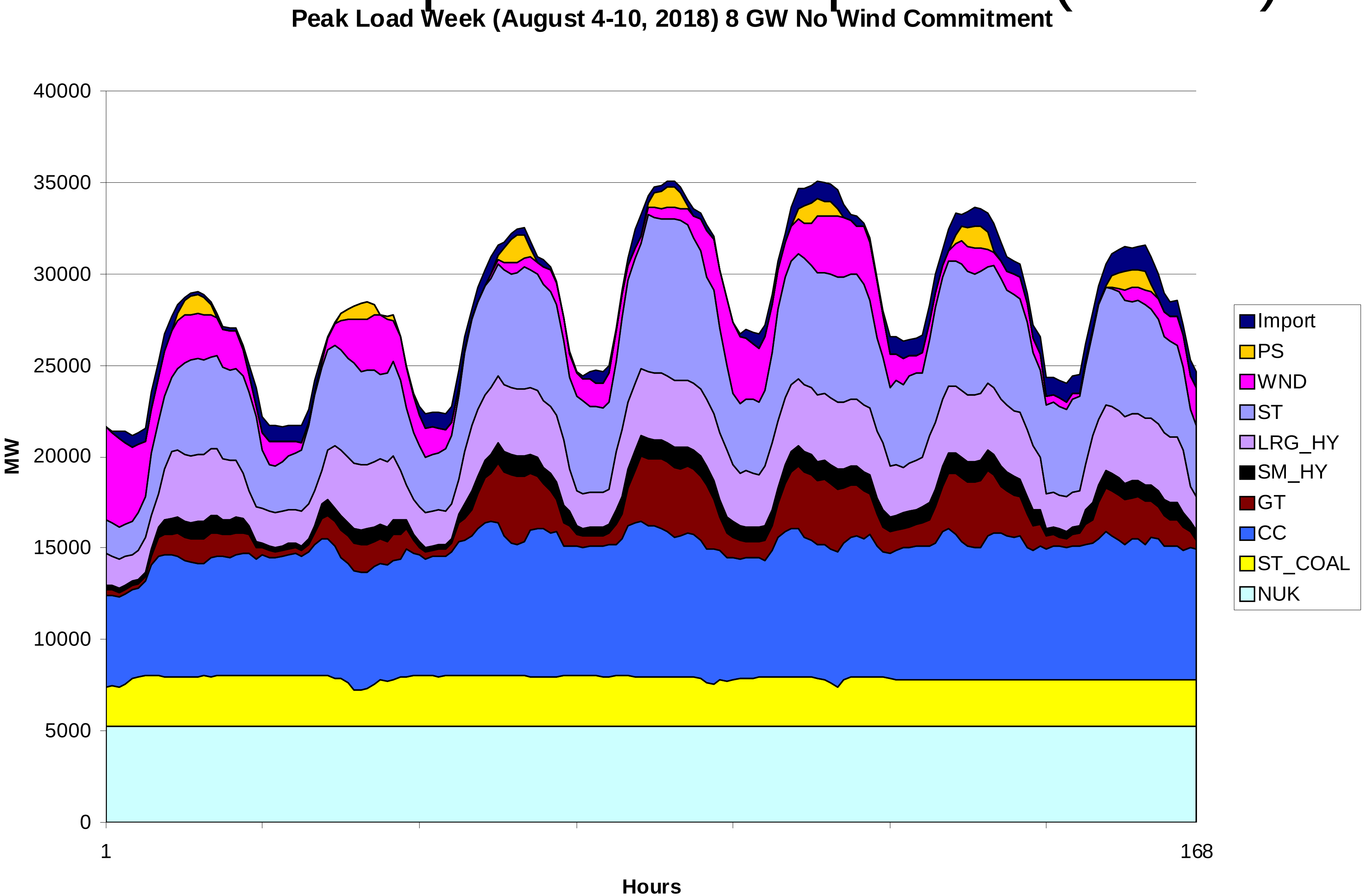

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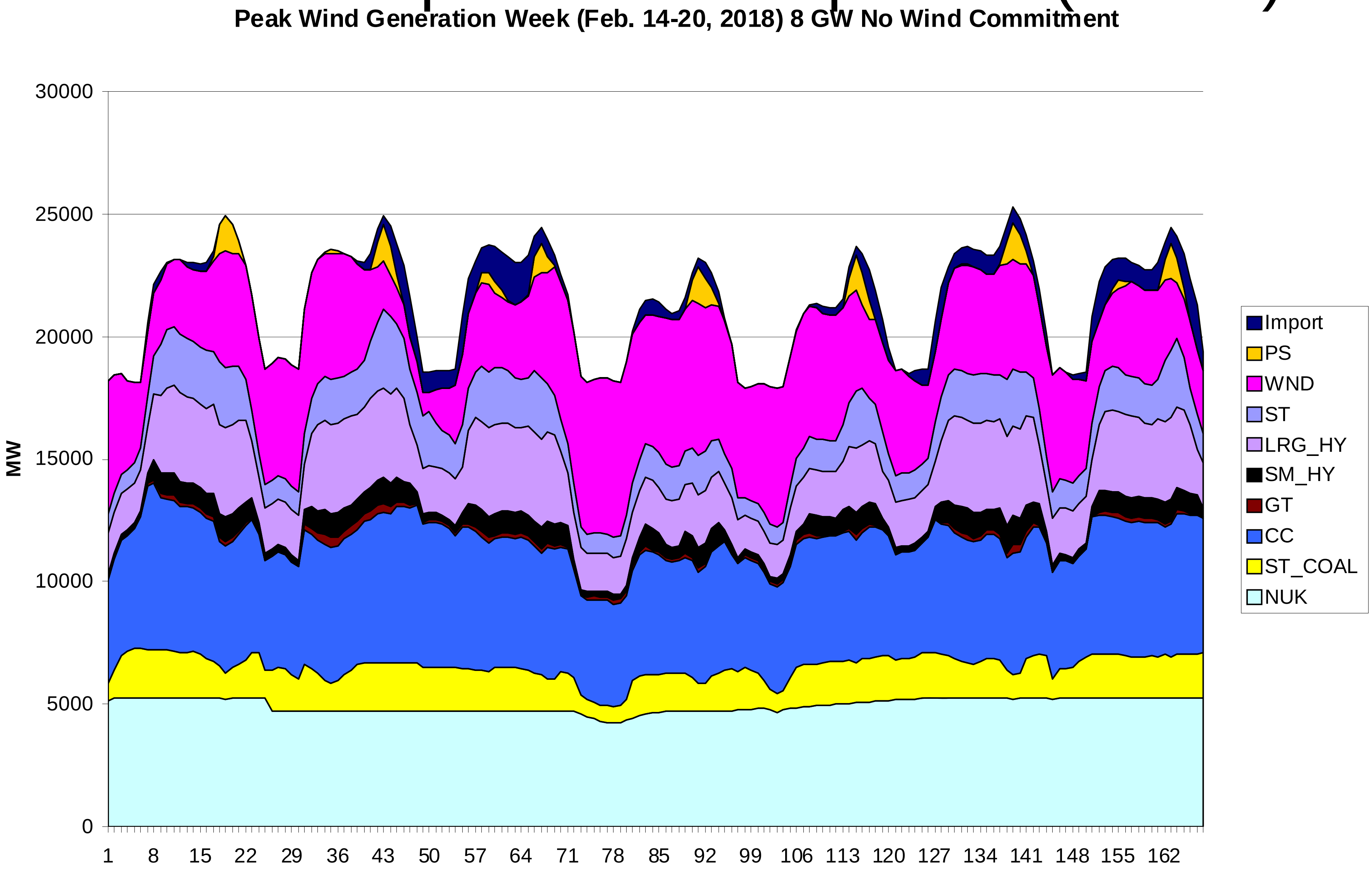

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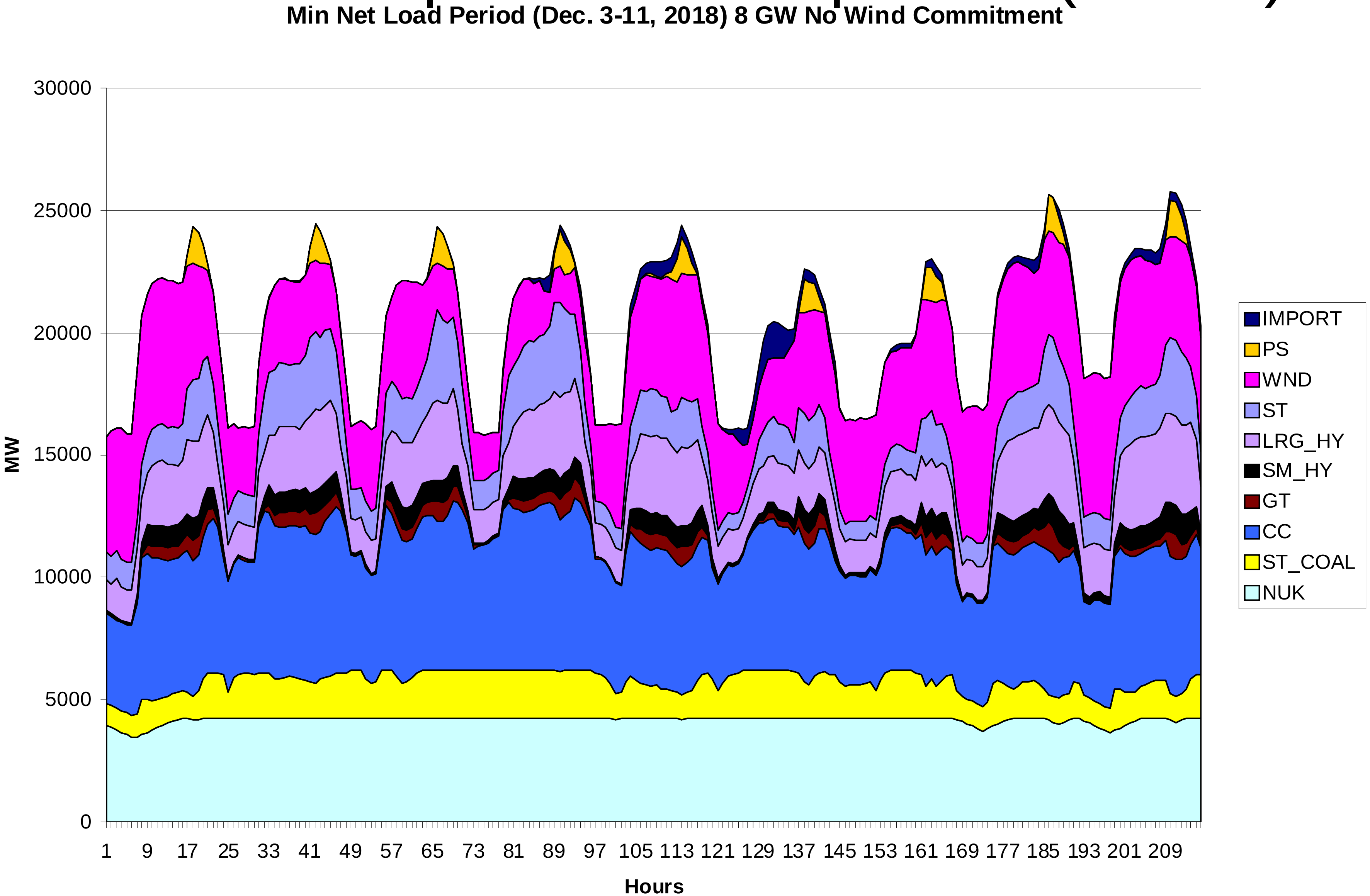
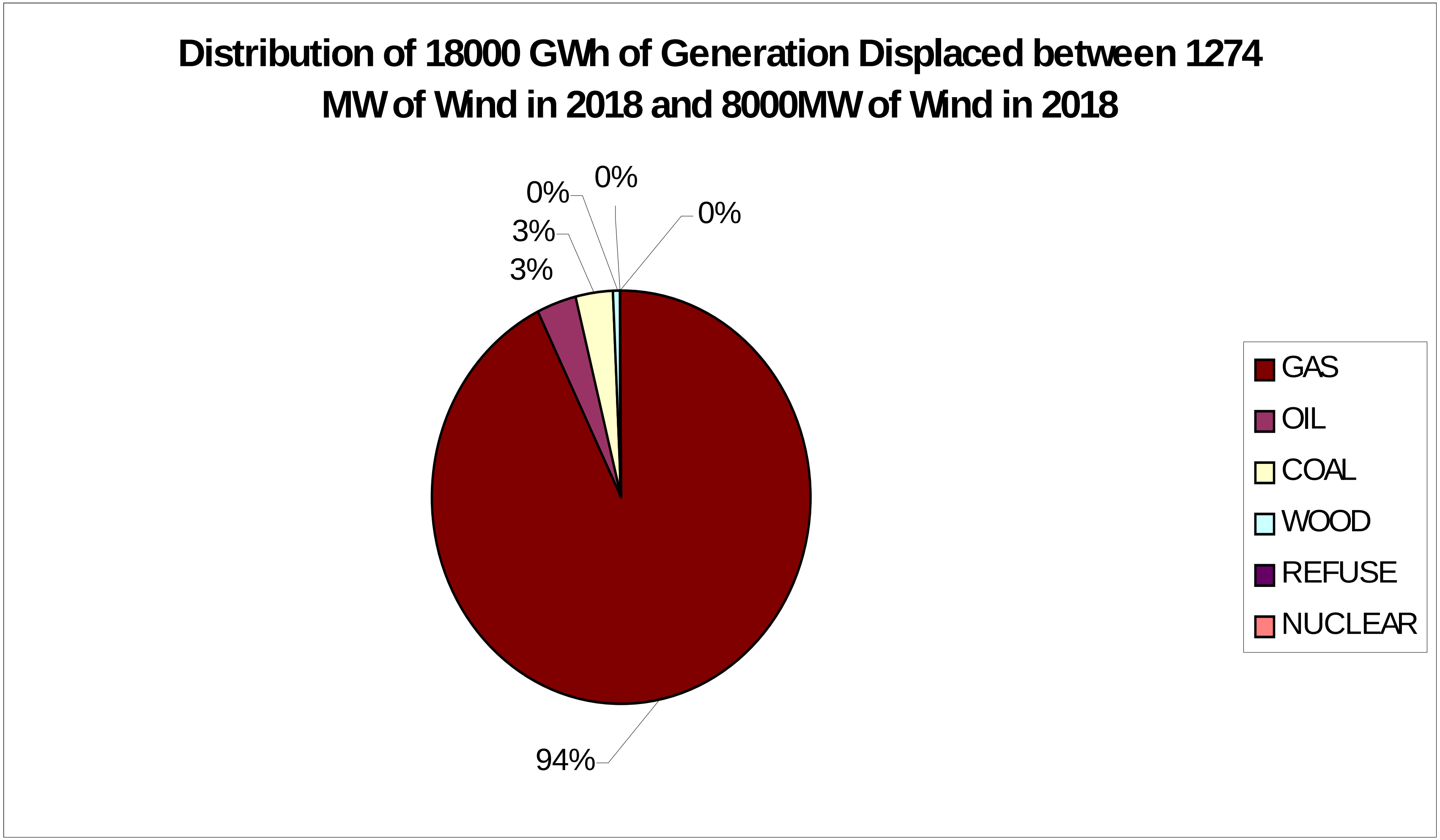


Task 6 - Results: Fuel Type Displaced by Wind Plus Wind Exports



Summary of Wind Study Findings

- **The 8 GW of installed wind studied is equivalent to approximately 23% of the system peak load and could potentially supply 10% to 12% of the systems energy requirements.**
- **To fully integrate the wind that was studied and to fully utilize the wind plant energy output will require local transmission upgrades.**
- **For the conditions studied locational marginal prices (LMPs) decrease as wind plant penetration increases.**

Summary of Wind Study Findings

- **System production costs decline as wind plant penetration increases.**
- **Overall system emissions decline as wind plant penetration increases.**
- **The spread between simulated generator LMP revenues and production cost increases as wind plant penetration increases.**
- **Scheduling of wind resources can provide operational and reliability benefits as well as have an impact on LMP.**

Summary of Wind Study Findings

- **Wind plant output primarily replaces gas fired generation followed by much smaller percentages of oil and coal fired generation.**
- **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, ramping and load following requirements.**
- **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.**

Summary of Wind Study Findings

- **Wind plants have much lower availability than conventional power plants and their unavailability is not only correlated over a local area but also can be highly correlated over an area as large as New York State.**
- **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.**
- **This potential increase in IRM was demonstrated in the recently completed New York State Reliability Council's 2010-2011 Installed Reserve Margin Requirements Study.**

Remaining Steps

- **Coordinate with Transmission Owners on identifying potential transmission upgrades.**
- **Evaluate the benefits of the upgrades in terms of the amount of wind energy that is unbottled.**
- **Draft Report.**

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.

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