OE Visualization and Controls Peer Review

Project Area: Resource Adequacy
Reliability and Markets: Project 3A

Long-term Planning and Investment for Transmission and Generation

Tim Mount, Cornell University
Fernando Alvarado, U. of Wisconsin

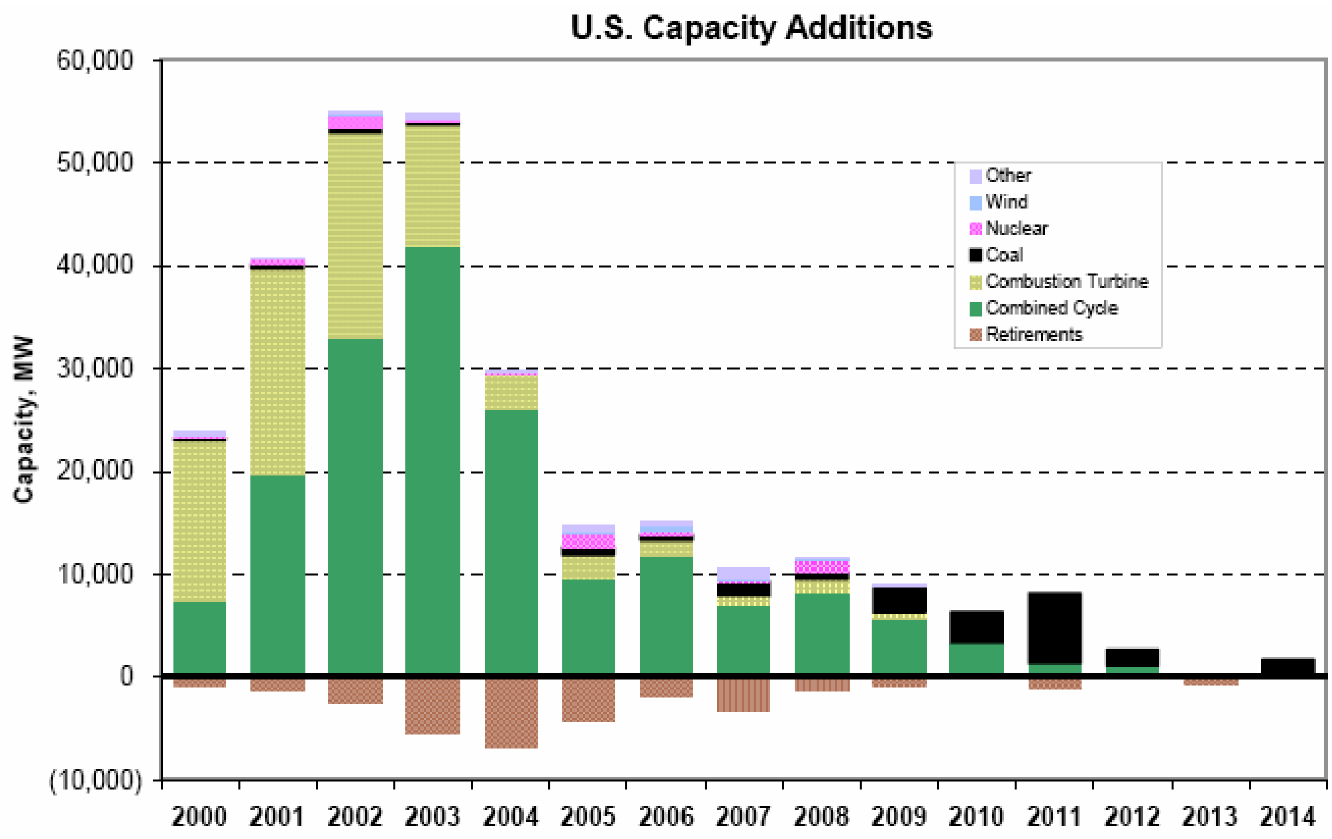
18 October 2006
Arlington, VA

CERTS
Consortium for Electric Reliability Technology Solutions

OUTLINE

- **Maintaining Generation Adequacy**
  - Missing Money and Capacity Markets.
  - Co-Optimization in Markets for Energy and Reserves.
  - Testing the Forward Capacity Market in New England.
- **Economic Cost of Congestion**
  - Increasing Transmission Congestion due to Voltage.
  - Modeling the Financial Risk of Spatial Price Differences.
  - New Responsibilities for FERC in EPAct05.
- **Summary and Outreach to Stakeholders**
  - Publications
  - Collaboration with System Operators
  - Next steps

Maintaining Generation Adequacy I



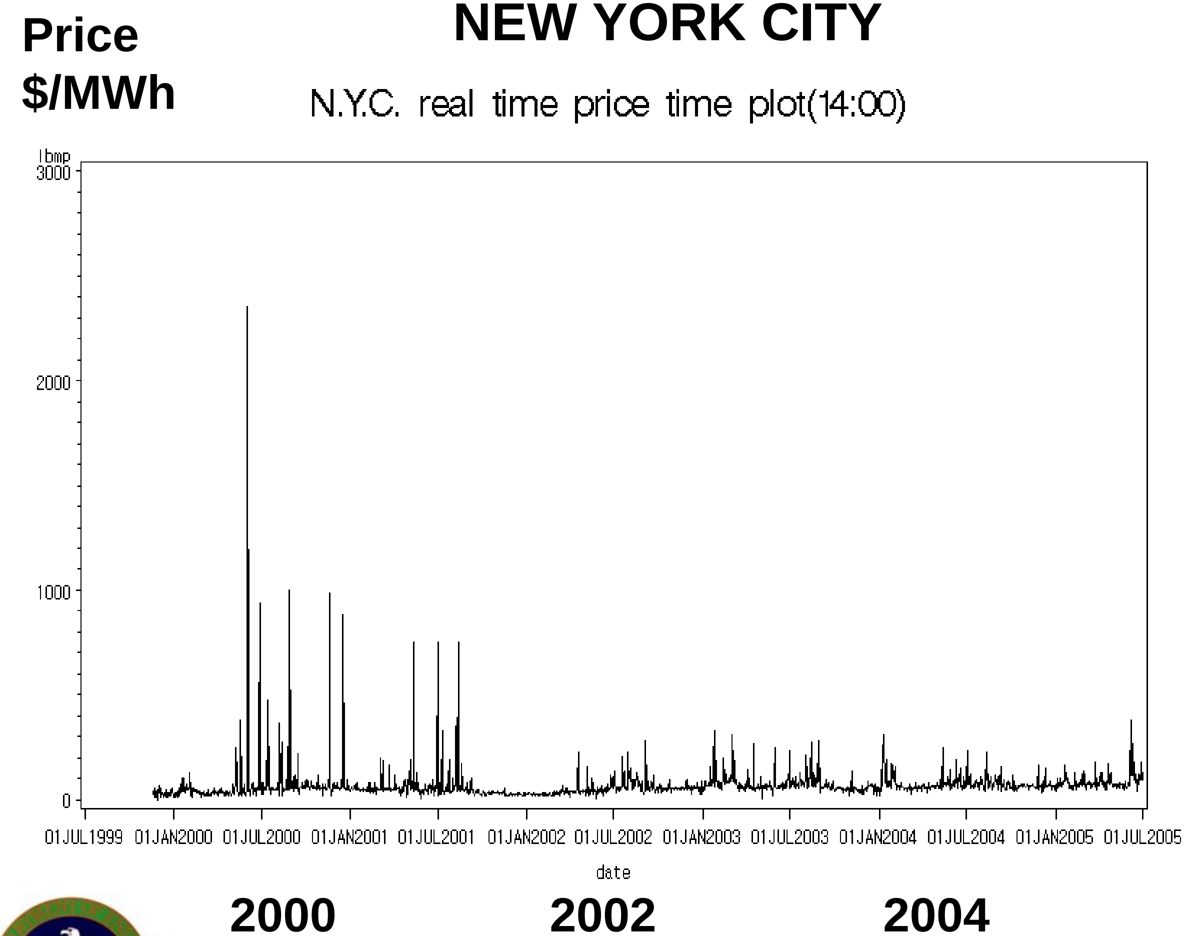
----> Substantial reductions in the annual additions of generating capacity are projected.

Source: "2005 NERC Long-Term Reliability Assessment", Fig. 4

CERTS
CONSORTIUM FOR ELECTRIC RELIABILITY TECHNOLOGY SOLUTIONS

Maintaining Generation Adequacy II

NODAL PRICE OF REAL ENERGY IN NEW YORK CITY

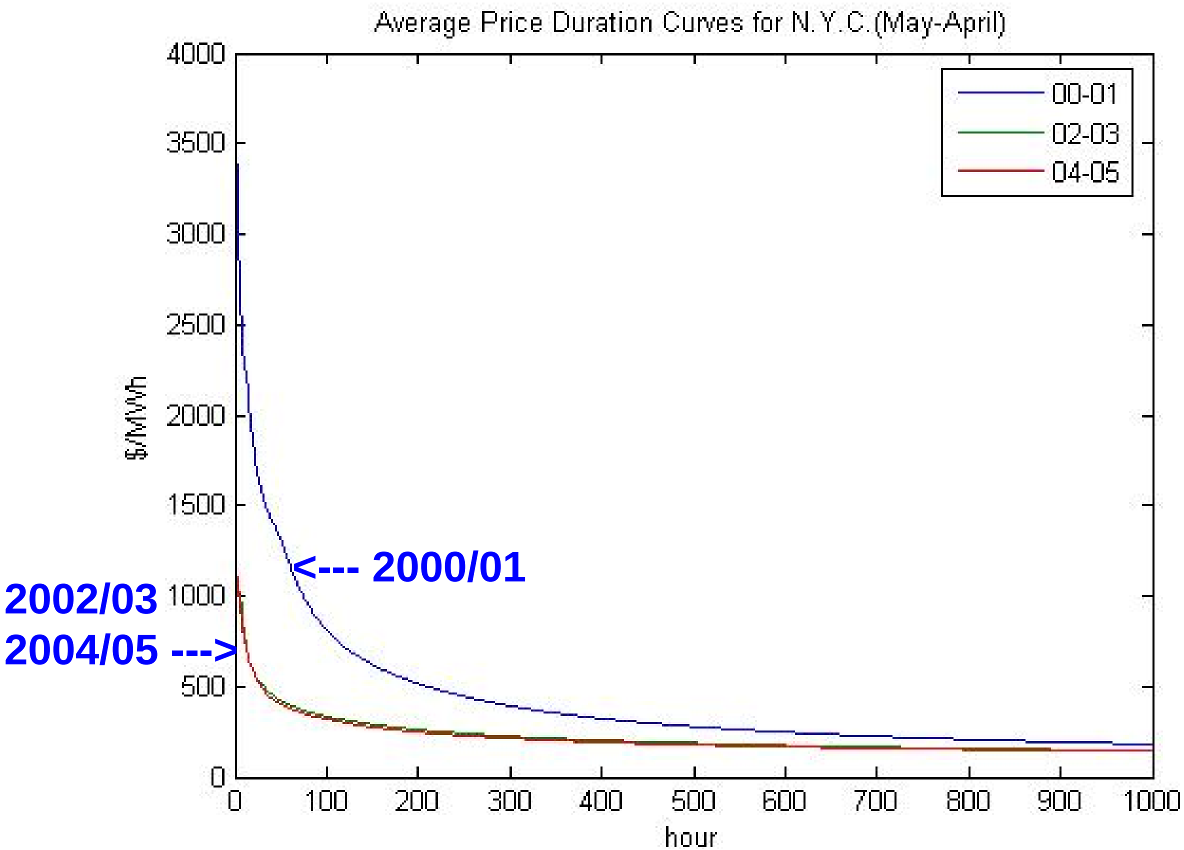


Regulatory response in New York to the Californian Energy Crisis ---> Automatic Mitigation Procedures and regulatory "threat" have suppressed high prices and made the PRICE DURATION CURVE incompatible with the TOTAL COST of generation

CERTS
CONSORTIUM FOR ELECTRIC RELIABILITY TECHNOLOGY SOLUTIONS

Maintaining Generation Adequacy III

Average Price
$/MWh



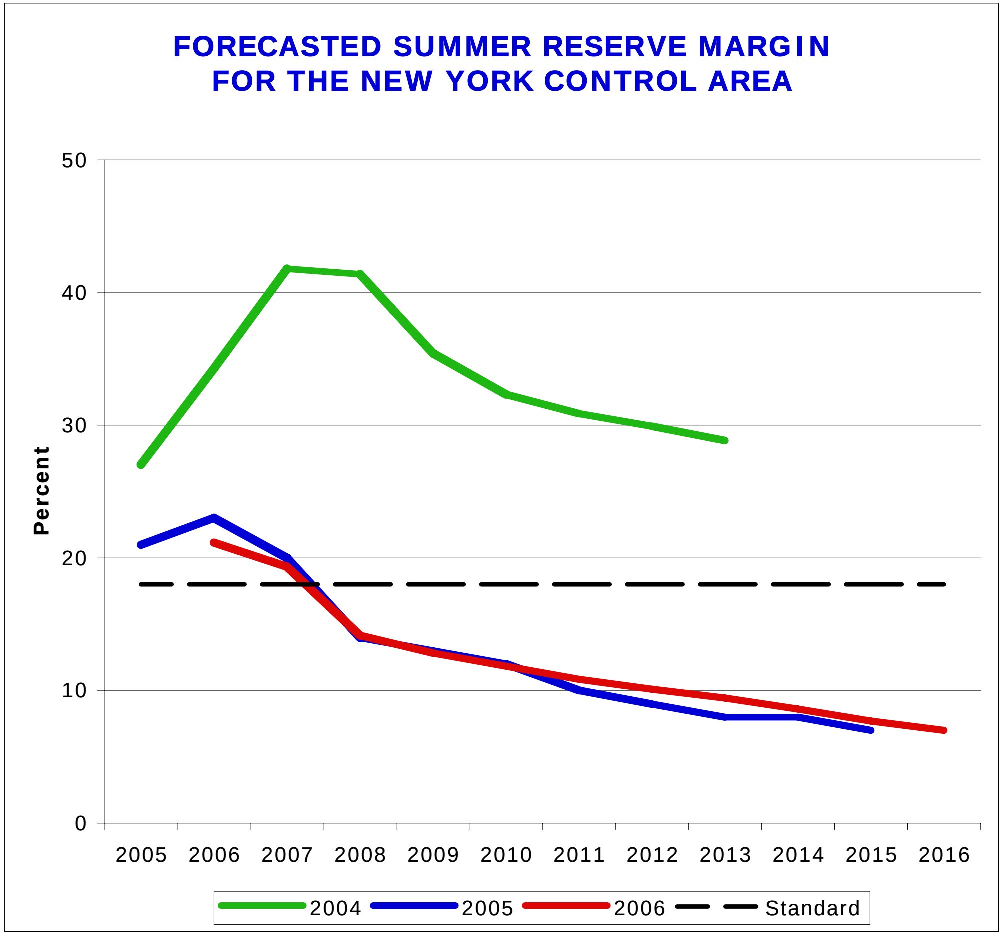
Hours Dispatched/Year
(1000 Hours = 11.4% Capacity Factor)

	Average Price($/MWh)		
Hours/Year	2000-01	2002-03	2004-05
100	815	336	322
500	279	188	178
1000	182	146	141
5000	80	80	86

When the market in New York was first deregulated, peaking capacity could earn enough in the spot market to cover both capital and operating costs. This is a key feature of a viable ENERGY-ONLY market, but this is no longer a feature of the New York market.

CERTS
Consortium for Electric Reliability Technology Solutions

Maintaining Generation Adequacy IV



NYISO STANDARD FOR RELIABILITY

A reserve margin of 18% is needed to meet the proposed NERC reliability standard (Fail <1 day in 10 years).

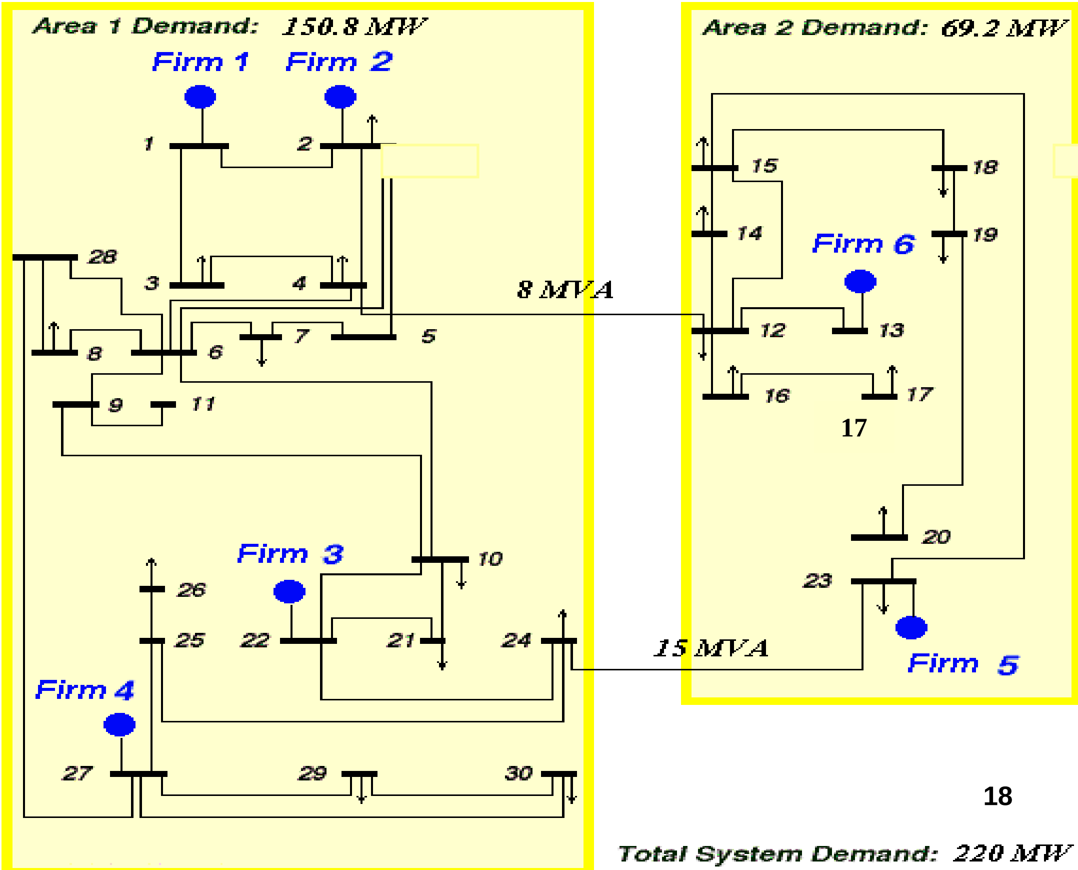
Reserve Margin is the amount of Installed Capacity above the Forecasted PEAK LOAD (%).

Source: NYISO PowerTrends

CERTS
CONSORTIUM FOR ELECTRIC RELIABILITY TECHNOLOGY SOLUTIONS

Maintaining Generation Adequacy V

Region A: Competitive **Region B: Load Pocket**



POWERWEB
30-Bus AC Network used to test the performance of different market designs.

CERTS
Consortium for Electric Reliability Technology Solutions

Maintaining Generation Adequacy VI

- ***Testing Markets for Energy and Reserves***
- ***PowerWeb Network has two Regions***

Region A : Competitive

4 firms --- marginal cost offers submitted by software agents

Region B : Load Pocket caused by limited transmission capacity

2 firms --- price/quantity offers submitted by students

- ***Three markets were tested***

Test I – Joint Market with Fixed Locational Reserves (JMwFR),

The current market structure used in New York State

Test II – Joint Market with Responsive Reserves (JMwRR),

Co-Optimization for an explicit set of Contingencies

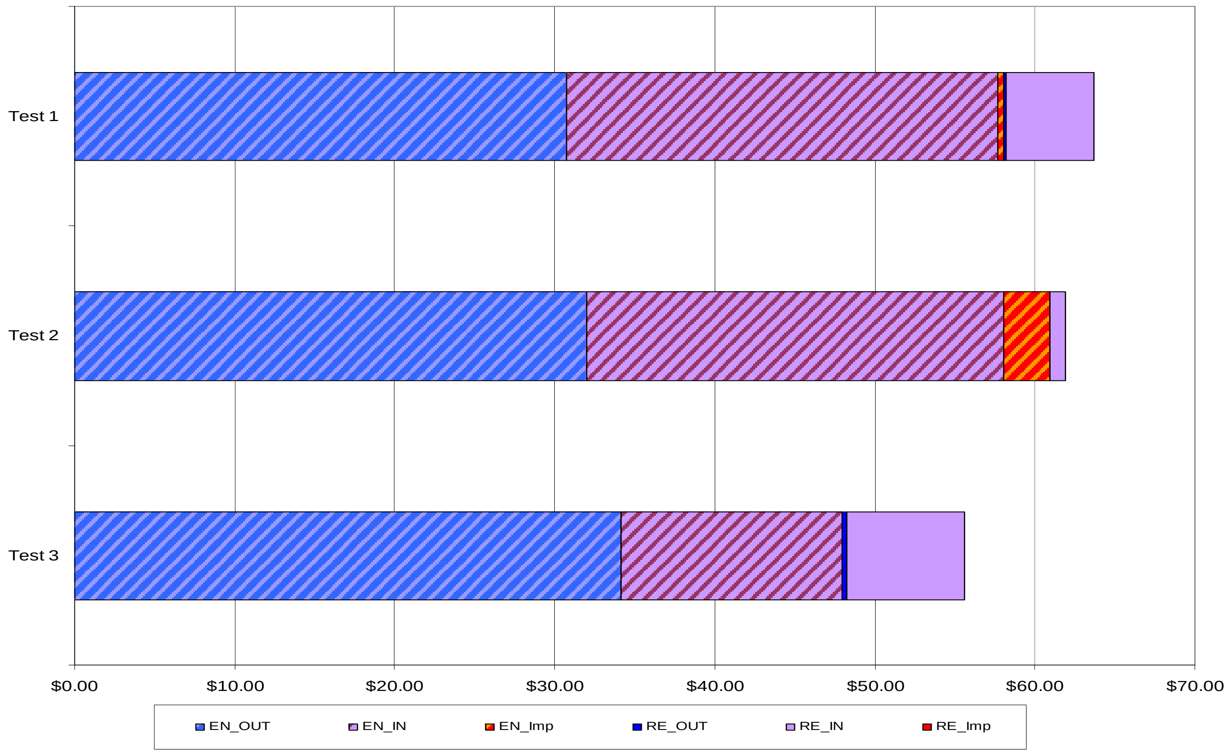
Test III – Integrated Market with Responsive Reserves (IMwRR)

Co-Optimization and pay the Opportunity Cost for Reserves plus a "Make-Whole" Startup Cost

CERTS
CONSORTIUM FOR ELECTRIC RELIABILITY TECHNOLOGY SOLUTIONS

Maintaining Generation Adequacy VII

Average Cost paid by the ISO ($/MWh of Real Energy for Load)



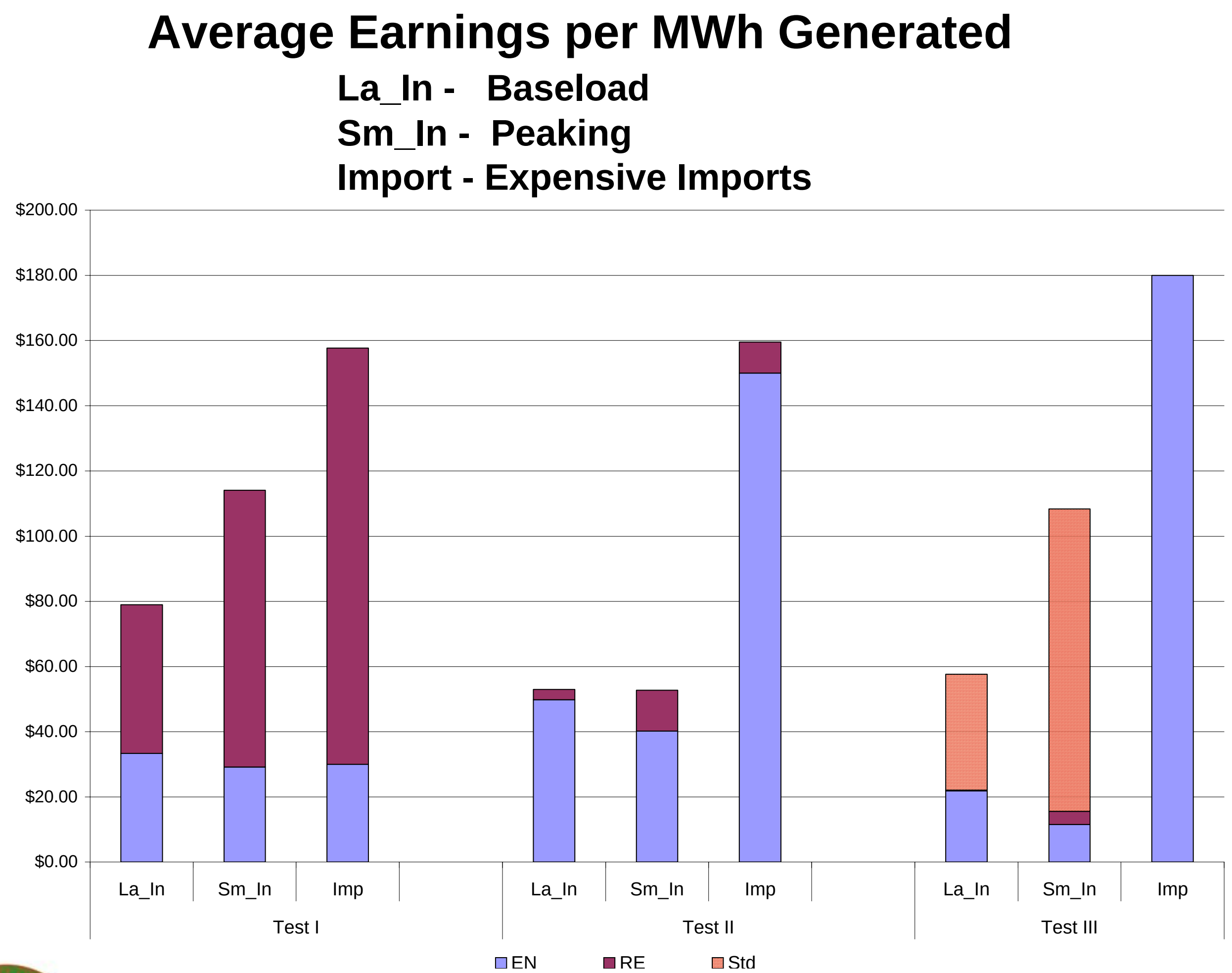
Test I (JMwFR)
Test II (JMwRR)
Test III (IMwRR)

1. Test II CO-OPTIMIZATION is more competitive than FIXED RESERVE requirements.

2. Test III Paying OPPORTUNITY COSTS for Reserves + Co-Optimization is even more competitive.

CERTS
CONSORTIUM FOR ELECTRIC RELIABILITY TECHNOLOGY SOLUTIONS

Maintaining Generation Adequacy VIII



Test I (JMwFR)
Test II (JMwRR)
Test III (IMwRR)

EN - Energy
RE - Reserves
Std - Make-Whole Startup Cost

Test results confirm actual experience in New York - More competitive markets reduce the ability of peaking units to cover capital costs in the spot market, but STARTUP COSTS can offset this effect.

CERTS
Consortium for Electric Reliability Technology Solutions

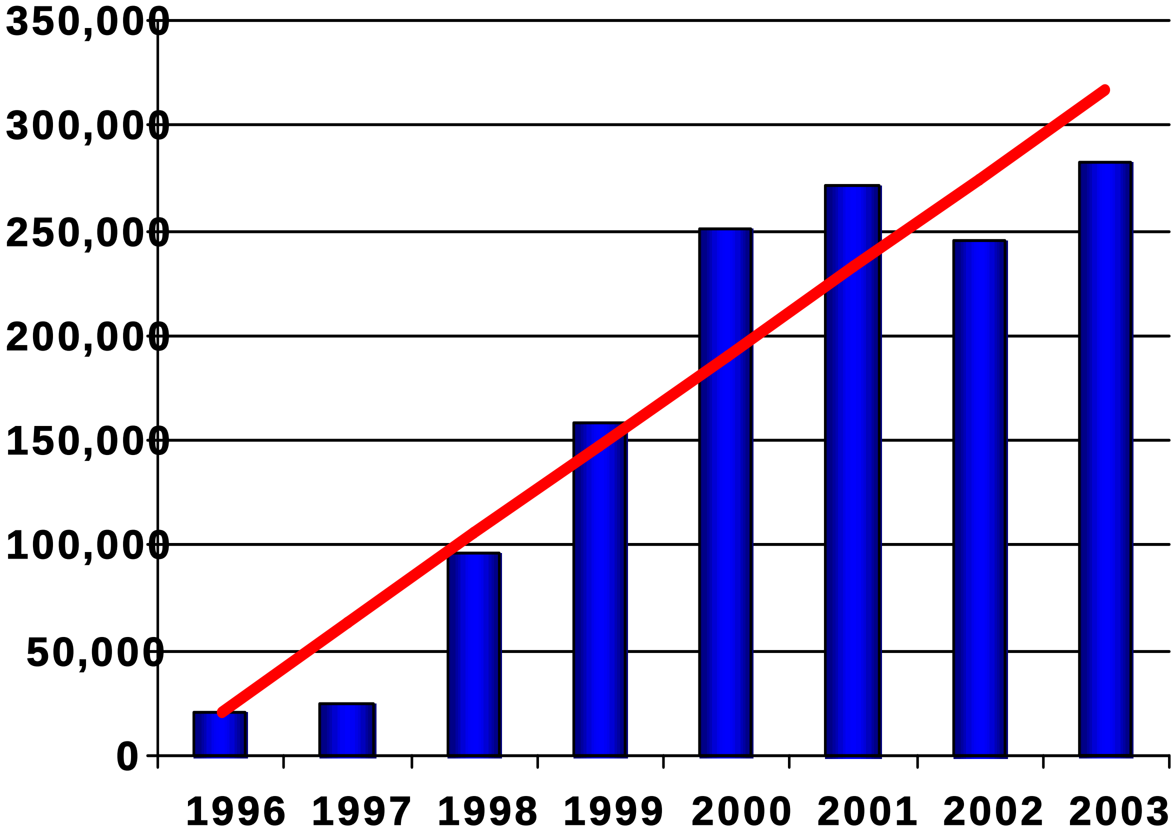
Maintaining Generation Adequacy IX

- ***CONCLUSIONS***
- *Using Responsive Reserves (Co-Optimization) is an effective way to make the market more competitive and reduce the average price paid to meet system load compared to Fixed Locational Reserves.*
- *Paying the the Opportunity Cost for reserves using co-optimization is even more effective because speculating in the energy auction is "punished" by lower opportunity costs for reserves.*
- *BUT there is an underlying incompatibility between competitive prices and maintaining system reliability because capacity is withheld in competitive auctions and additional expensive imports are needed.*
- *In competitive spot markets,supplementary payments are needed to ensure that the peaking units are financially viable. Make-Whole Startup Costs are used in the experiments, and Capacity Markets are used or proposed in the Northeastern markets.*
- *This fall, tests of the proposed Forward Capacity Market in New England are being conducted at Cornell in collaboration with ISONE.*

CERTS
CONSORTIUM FOR ELECTRIC RELIABILITY TECHNOLOGY SOLUTIONS

Economic Cost of Congestion I

Number of Merchant Transactions in TVA



Merchant Transactions on the TVA system have grown over 1,000% since 1996

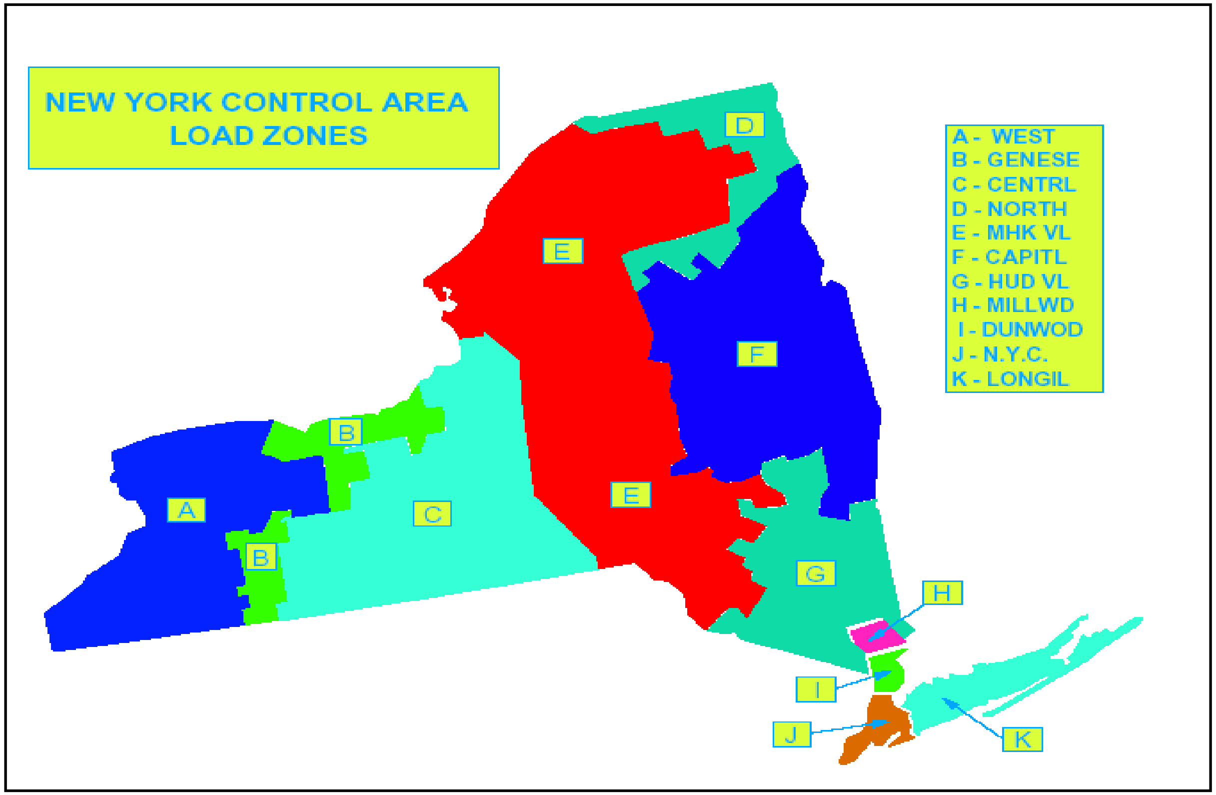
These transactions increase congestion on the transmission grid --- e.g. new voltage limits are experienced on some lines.

Source: Tennessee Valley Authority

CERTS
CONSORTIUM FOR ELECTRIC RELIABILITY TECHNOLOGY SOLUTIONS

Economic Cost of Congestion II

Load Zones in the New York Control Area (NYCA)

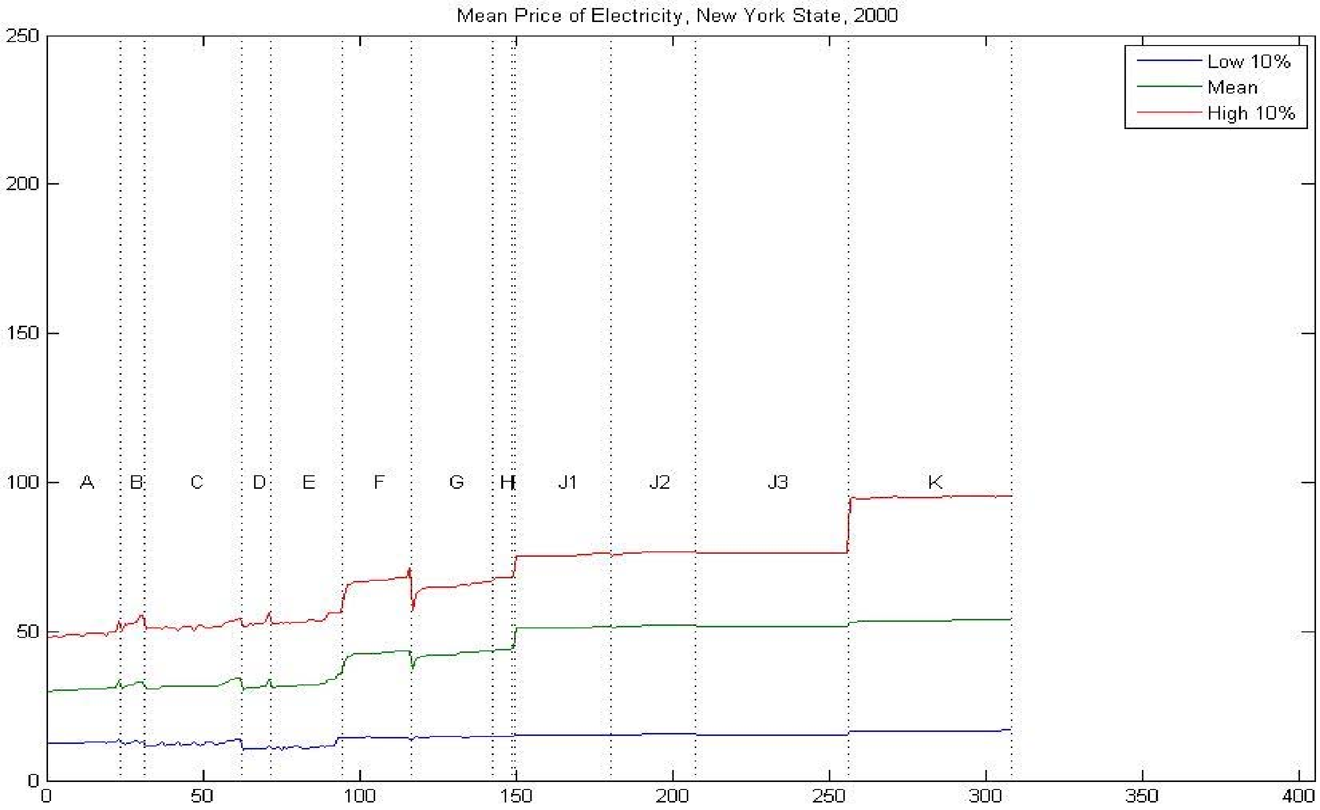


Zones Analyzed
(NYMEx trades zones A,G and J)
A - Niagara
G - Hudson Valley
J - New York City
K - Long Island

CERTS
CONSORTIUM FOR ELECTRIC RELIABILITY TECHNOLOGY SOLUTIONS

Economic Cost of Congestion III

Ranked Nodal Prices in NYCA for 2000

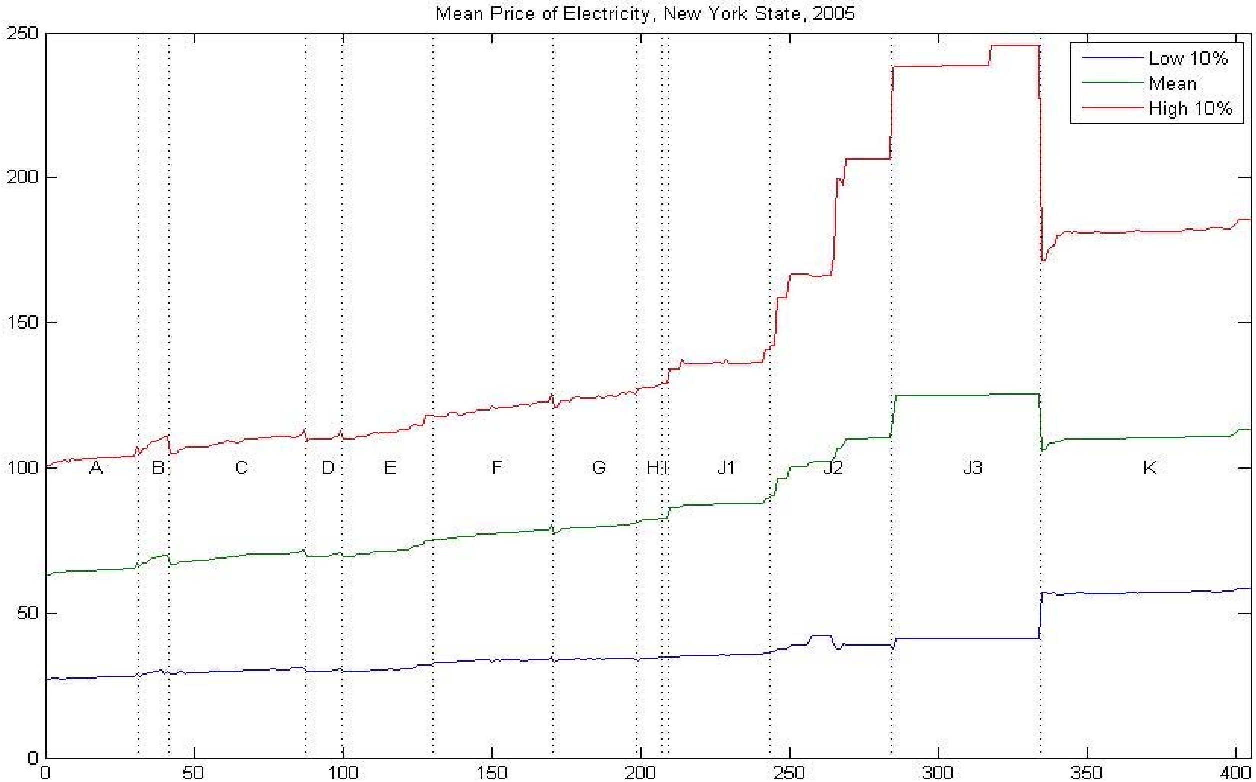


Relatively simple spatial structure of nodal prices in 2000

CERTS
CONSORTIUM FOR ELECTRIC RELIABILITY TECHNOLOGY SOLUTIONS

Economic Cost of Congestion IV

Ranked Nodal Prices in NYCA for 2005



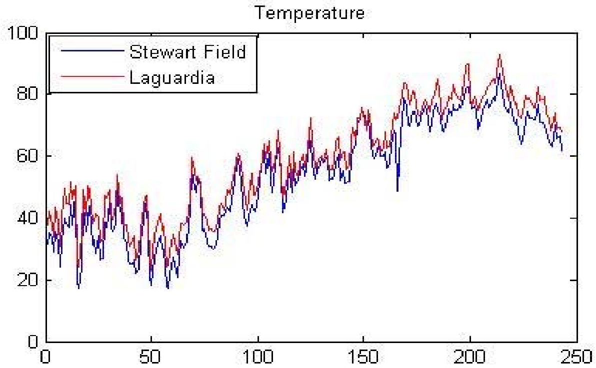
The spatial structure of nodal prices in 2005 is much more complicated due to voltage constraints in New York City.

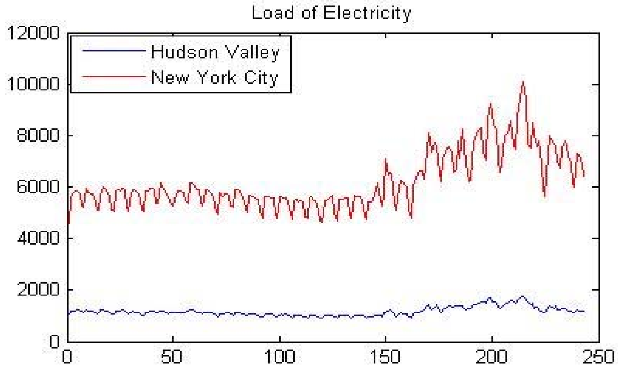
CERTS

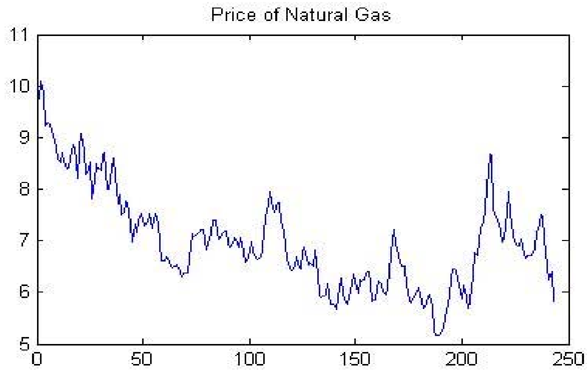
CONSORTIUM FOR ELECTRIC RELIABILITY TECHNOLOGY SOLUTIONS

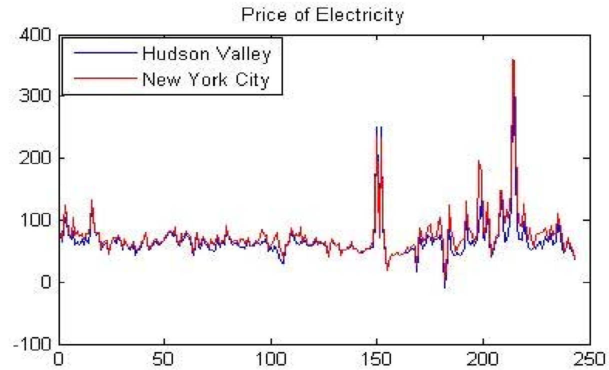
Economic Cost of Congestion V

Temperature, Load, Price of Natural Gas and Price of Electricity in New York City (J) and Hudson Valley (G) (1/1/06 ~ 8/31/06)







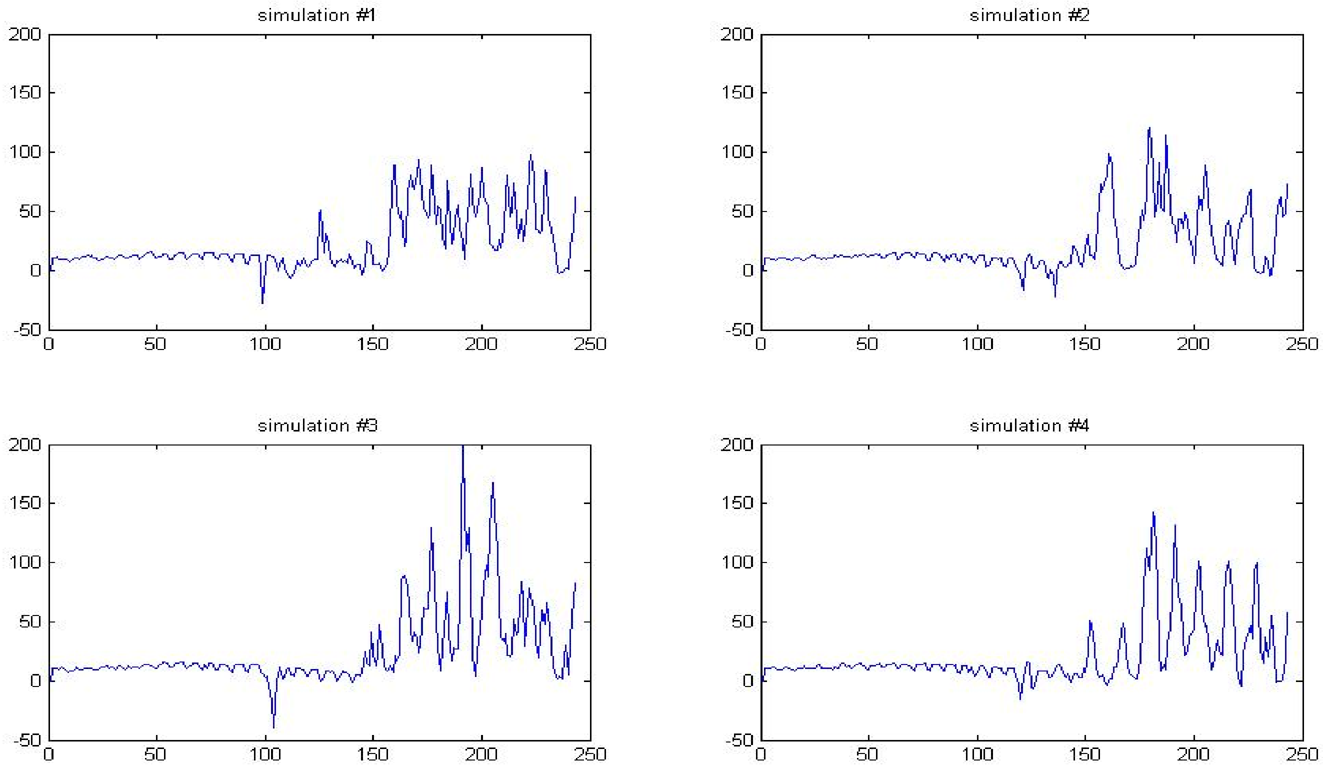


Load and Price Volatility increase with high temperatures

CERTS
CONSORTIUM FOR ELECTRIC RELIABILITY TECHNOLOGY SOLUTIONS

Economic Cost of Congestion VI

Simulated Differences in the Prices of Electricity between New York City (J) and Hudson Valley (G) (1/1/06 ~ 8/31/06)



Volatility of the Price Difference affects the Financial Risk of Transmission Congestion

CERTS
CONSORTIUM FOR ELECTRIC RELIABILITY TECHNOLOGY SOLUTIONS

Economic Cost of Congestion VII

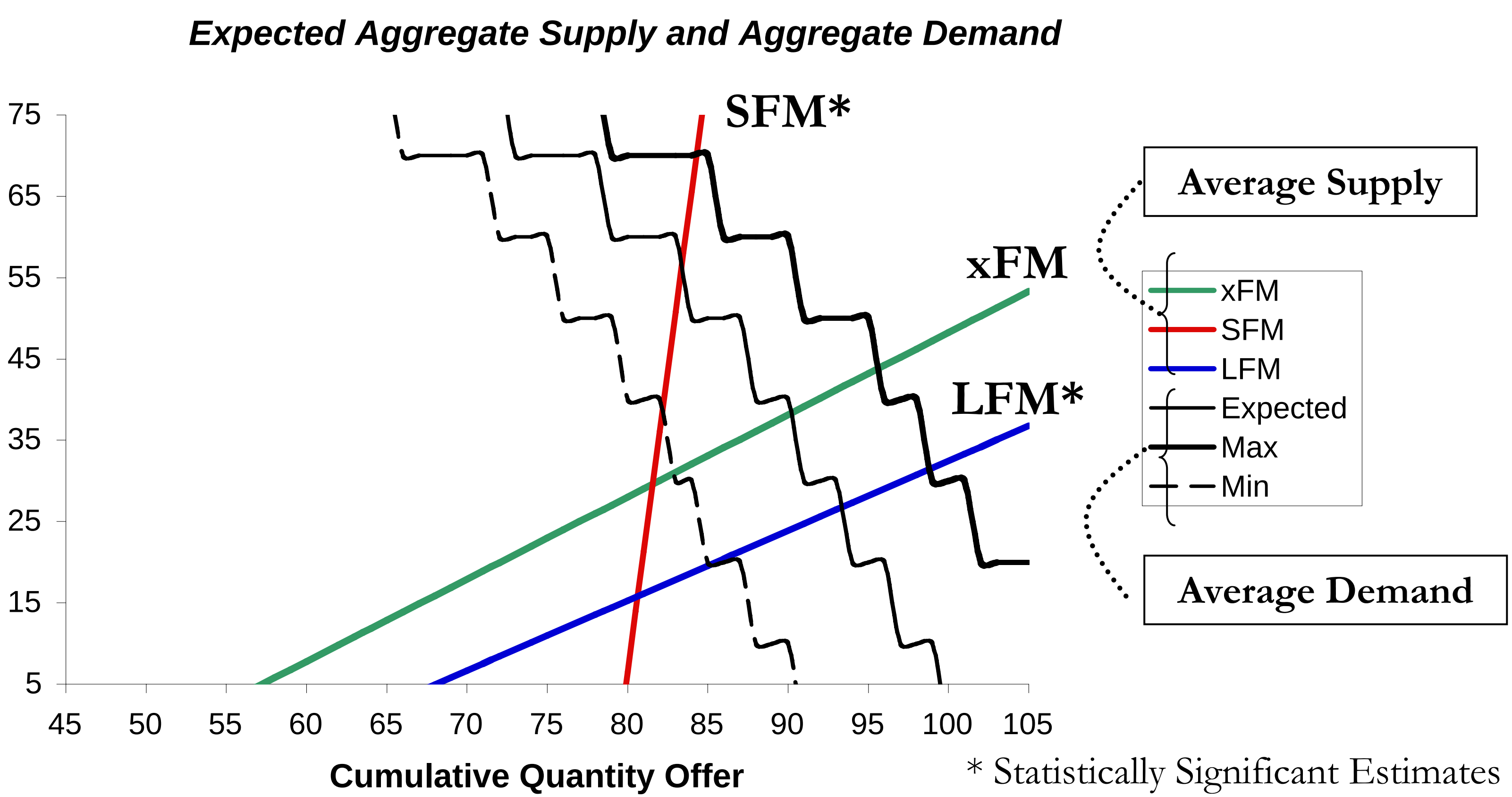
- ***CONCLUSIONS***
- *Congestion on the Transmission Network has increased in many regions and this has resulted in substantial changes in the cost and financial risk of congestion.*
- *Financial risk (Volatility) of spot prices and of locational differences in spot prices are important for determining the viability of investment in both generating capacity and transmission upgrades (the cost of capital is much higher for risky projects, and deregulation has generally made investment projects riskier).*
- *EPAct05 has given FERC has new responsibilities for enforcing standards of Operating Reliability by imposing penalties on States if reliability standards are violated. However, this new authority will still not be sufficient to maintain system adequacy.*
- *In deregulated regions, there is a need for new tools to evaluate reliability and determine when standards are likely to be be violated. This evaluation should consider both engineering and economic factors (i.e. the financial viability of investment).*

CERTS
Consortium for Electric Reliability Technology Solutions

Summary and Outreach with Stakeholders I

- ***New Premises for Investment Decisions***
  - ***Reliability is primarily a public good.***
    - *There is a critical need to develop a workable division between decentralized decisions by market participants and centralized decisions by regulators for making efficient investment decisions in both transmission and generating capacity.*
  - ***Reliability is valuable, and it is socially optimum to avoid blackouts and to anticipate and cover most contingencies.***
    - *Although it is feasible to measure the total cost and the total benefit of reliability, there is no established way to allocate the benefits of reliability to individual components of a network, and therefore, to decentralize decisions effectively to market participants.*
  - ***In a truly competitive market, the earnings of participants are highly dependent of receiving scarcity (high) prices when contingencies or unexpected shortages in supply occur.***
    - *Tools for evaluating system reliability and investment viability should consider contingencies on an AC network explicitly because using proxy limits on transmission lines to deal with voltage constraints distorts price signals.*

Summary and Outreach with Stakeholders II



Short-term forward markets are the most speculative.
Long-term forward markets are the least speculative.

CERTS
CONSORTIUM FOR ELECTRIC RELIABILITY TECHNOLOGY SOLUTIONS

Summary and Outreach with Stakeholders III

Co-Optimization considers contingencies explicitly.

- *Objective for Dispatch using Co-Optimization*
  - *Minimize the total expected cost (operating energy cost $C_P(G)$ for generating G MW plus the spinning reserve cost $C_R(R)$ for R MW of reserves) for N generators over the predefined base case and K credible contingencies.*

$$S = \sum_{k=0}^{K} p_k \sum_{i=1}^{N} \left[C_{Pi}(G_{ki}) + C_{Ri}(R_{ki}) \right] \qquad \sum_{k=0}^{K} p_k = 1$$

  - *Subject to AC network and other system constraints.*
- *This framework can be extended to account for:*
  - *Value of Lost Load*
  - *Capital investment in additional capacity.*

CERTS
CONSORTIUM FOR ELECTRIC RELIABILITY TECHNOLOGY SOLUTIONS

Summary and Outreach with Stakeholders IV

Papers.

- 1) Thomas, R., J. Whitehead, H. Outhred and T. Mount, "Transmission System Planning – The Old World Meets the New", IEEE Proceedings, v5.1, 2005.
- 2) Chen, J., T. Mount, J. Thorp and R. Thomas, "Location-based scheduling and pricing for energy and reserves: a responsive reserve market proposal", *Decision Support Systems,* Volume 40, Issues 3-4, Pages 563-577 in *"Challenges of restructuring the power industry"*, Edited by Shmuel Oren and John Jiang, Oct. 2005.
- 3) Mount, T., Y. Ning and X. Cai, "Predicting price spikes in electricity markets using a regime-switching model with time-varying parameters", *Energy Economics,* v 28, Nov. 2005.
- 4) Mount, T. and S. Maneevitjit "Paying for Reliability in Deregulated Electricity Markets," Proceedings of the
- 5) Mount, T. and Thomas, R. "Testing the Effects of Power Transfers on Market Performance and the Implications for Transmission Planning," Proceedings of the IEEE PES Conference, June 2006.
- 6) Mount, T. and J. Ju, "Cost of Transmission Bottlenecks in New York", Proceedings of the IEEE HICSS 40 Conference, Jan. 2006.
- 7) Zhang, N., R. Boisvert, and T. Mount, "Generators' Bidding Behavior in the NYISO Day-Ahead Wholesale Electricity Market", Proceedings of the IEEE HICSS 40 Conference, Jan. 2006.

Presentations and Collaboration

- 1) Mount, T., PSERC Internet seminar on "Trying to maintain generation adequacy in deregulated markets", May 2006.
- 2) Mount, T., Presentation to PJM staff, "PSERC Markets Stem: Current Research Activities", Aug. 2006.
- 3) Organized presentations by staff from ISONE and PJM on electricity markets at the 25th Annual Eastern Conference, Center for Research on Regulated Industries, Rutgers, May 2006.
- 4) Collaboration with staff at ISONE to set up a series of experiments to test the performance of the proposed Forward Capacity Market, Fall 2006.
- 5) Collaboration with the American Public Power Association to evaluate the effect of deregulated electricity markets on the retail rates paid by customers, Fall 2006.

CERTS
CONSORTIUM FOR ELECTRIC RELIABILITY TECHNOLOGY SOLUTIONS