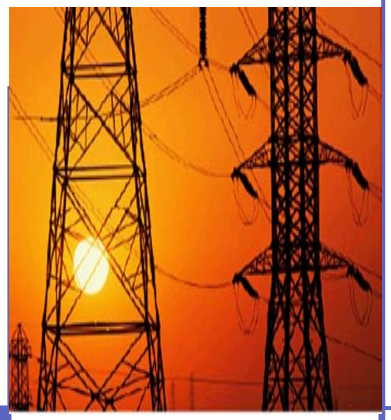
ABB Inc.
Electric Systems Consulting



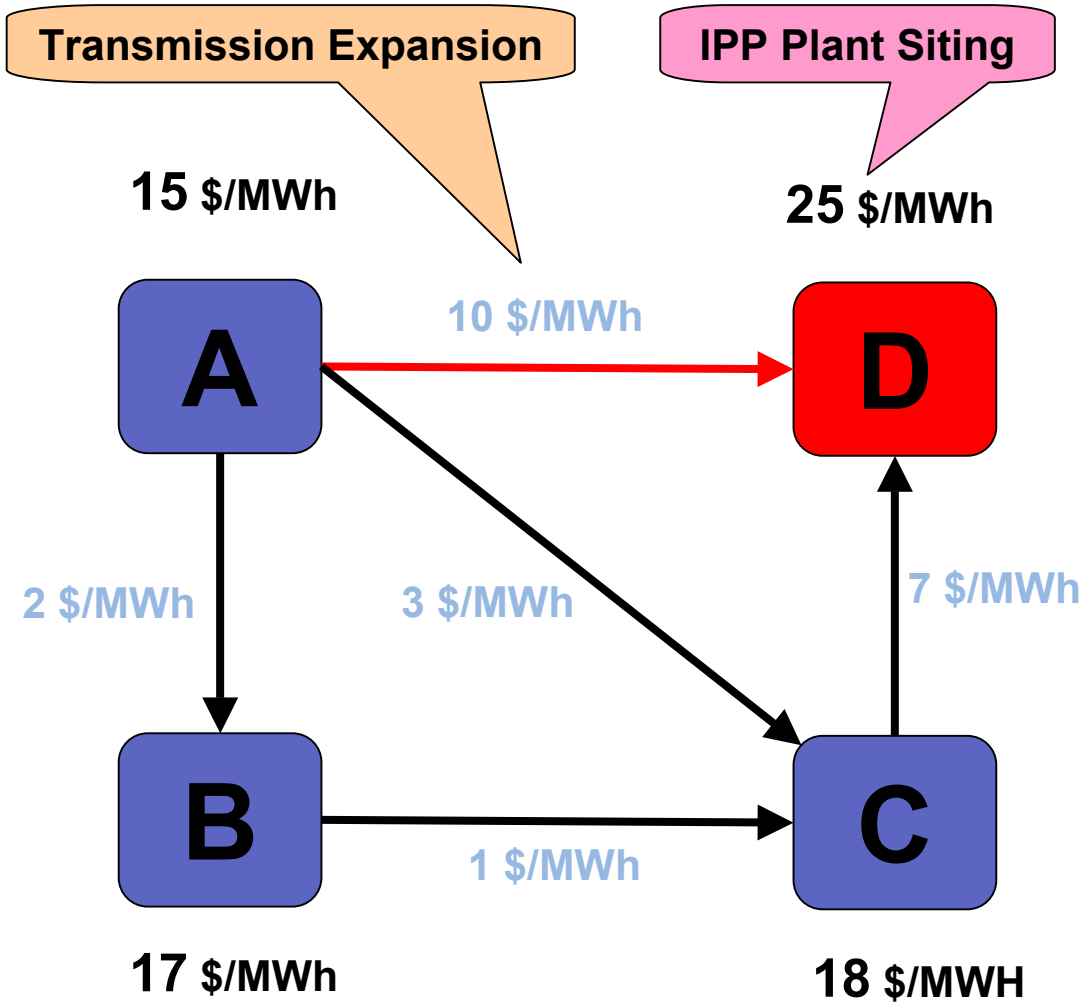
GridView – An Analytic Tool for

Market Simulation & Asset Performance Evaluations

Outline

- What is GridView about?
- GridView Capabilities and Functional Highlights
- Demonstration of GridView's Graphical User Interface (GUI) and Database preparation process
- A Case Study for the NYCA System
- Q & A

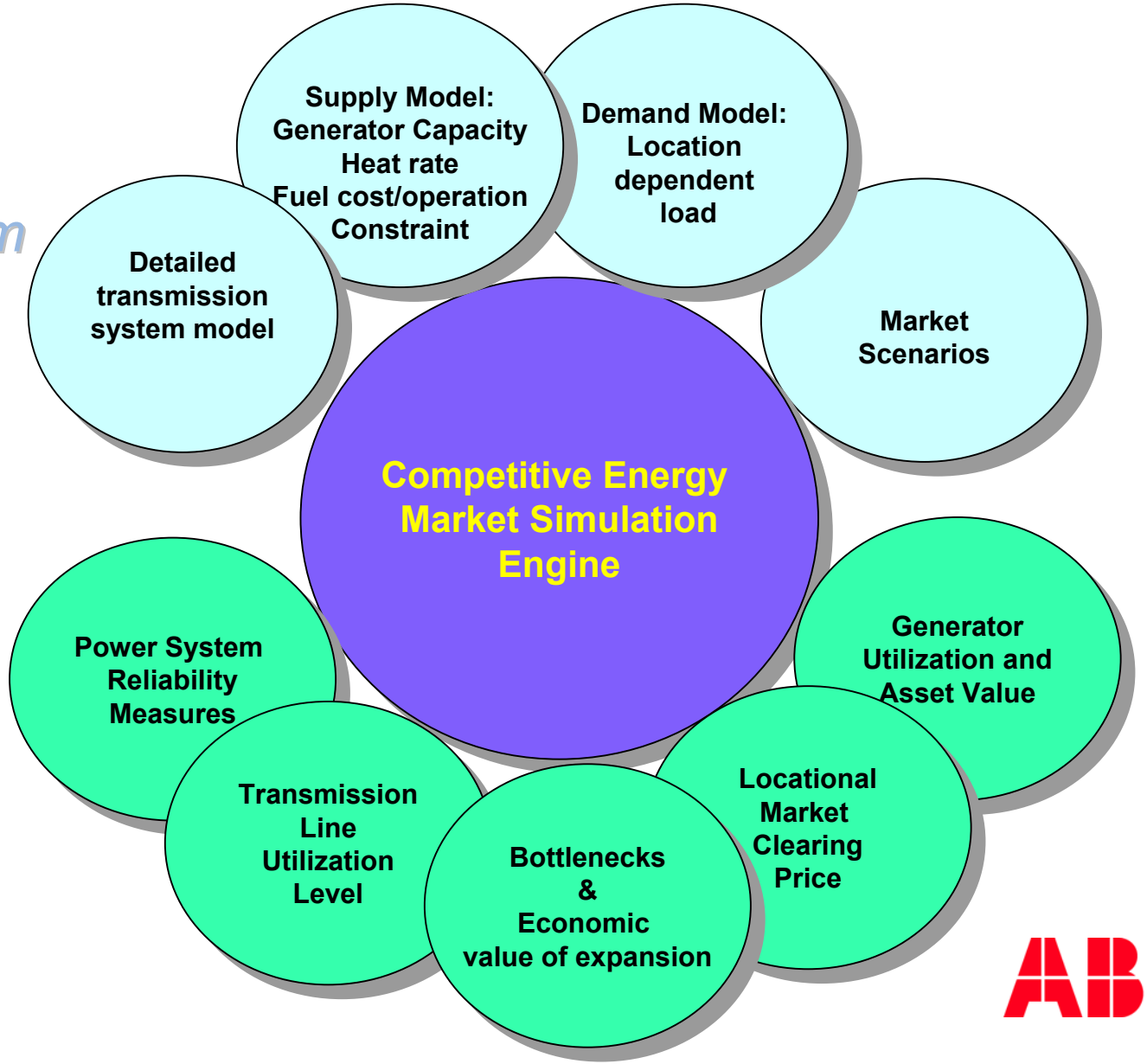
Where is the opportunity?



The Starting Point: GridView

Goal:

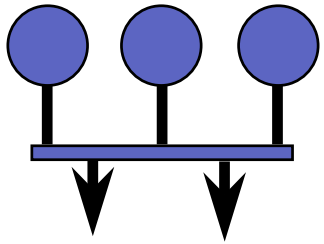
Combine Power System Details with Market and Economic Aspects



Power Market Simulation Models

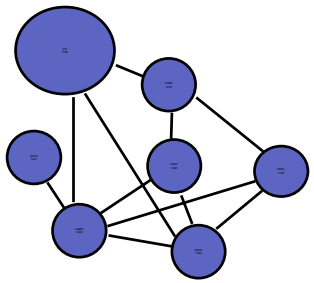
Supply Curve

- Ignores transmission



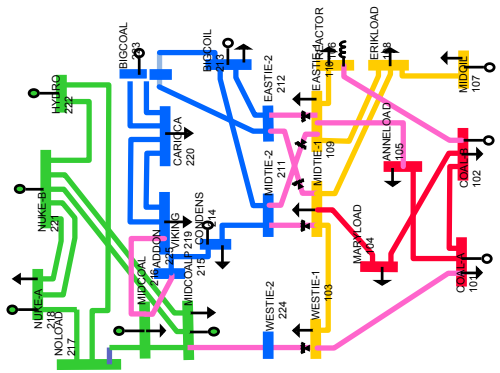
‘Bubble’ View

- Major interconnects only



Detailed View

- Very complex



Poor → Accuracy → Good

Simple → Ease → Difficult

GridView is a detailed model
with a nice Graphical User Interface !

What's Behind ?

Control Variables

$$Min \left\{ \sum \bar{c}_g \bar{G} + \sum \bar{c}_d \bar{D} + \sum \bar{c}_\theta \bar{\theta} + \sum \bar{c}_t \bar{T} \right\}$$

s.t. $$\sum \bar{G} = \sum \bar{L}$$ **(Real Power Balance)**

$$\bar{G}^{Min} \le \bar{G} \le \bar{G}^{Max}$$ **(Real Power Gen. Limits)**

$$\bar{D}^{Min} \le \bar{D} \le \bar{D}^{Max}$$ **(Dispatchable Demands)**

$$\bar{\theta}^{Min} \le \bar{\theta} \le \bar{\theta}^{Max}$$ **(Phase Shifter Limits)**

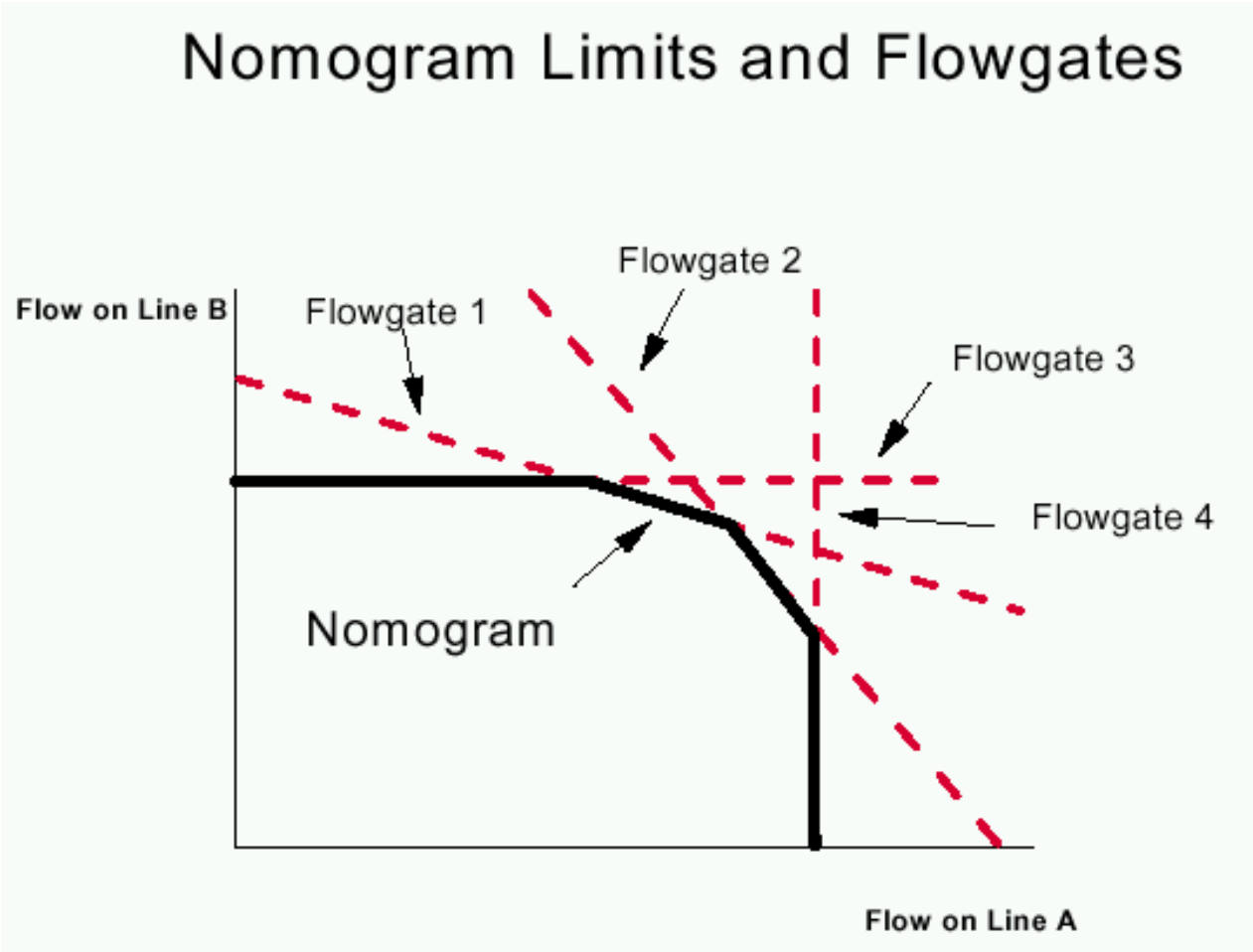
$$\left| \bar{T} \right| \le \bar{T}^{Limits}$$ **(Transmission Constraints)**

Transmission Constraints

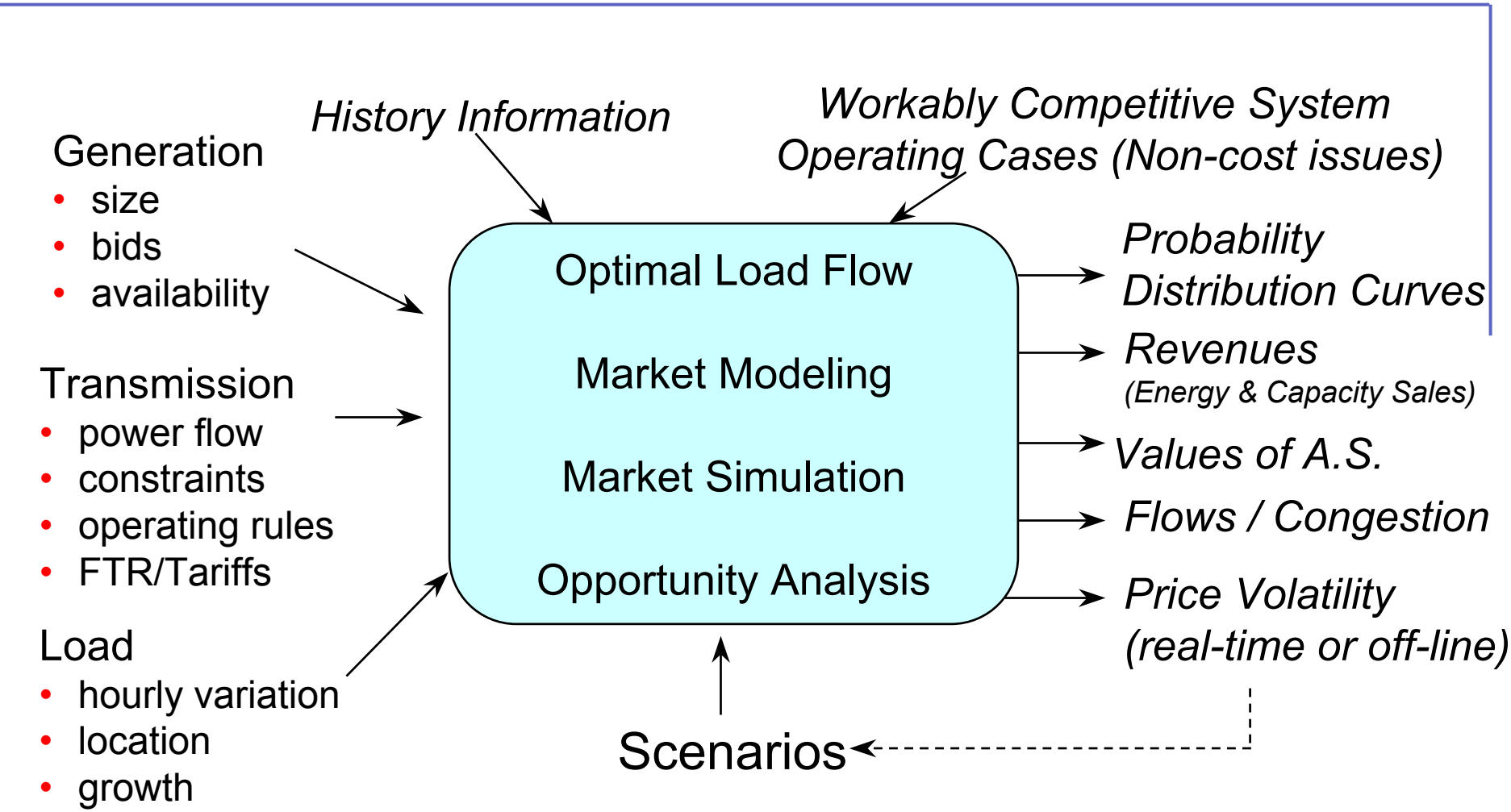
- Transmission facility (lines and transformers) thermal limits using normal ratings
- Transmission facility limits considering selected critical contingencies using emergency ratings (LTE or STE)
- Interfaces/flowgates limits and nomograms due to voltage and stability problems
- Transmission maintenance scheduling
- Monte Carlo simulation (forced outages) for major Interfaces & flowgates

Nomograms

$$aX + bY + cZ + \ldots \leq L$$



Price & Performance Evaluation Model



Goal: Combine Power Systems Analysis with Accurate Economic Models

Modeling Capabilities

- Transmission
  - large detailed system such as the WECC
  - transmission constraints explicitly modeled
- Generation
  - generators as represented in transmission model
  - generation costs - fixed and variable production costs
  - generation scheduling (maintenance and forced outages)
  - individual generator capacity adjustment
- Load
  - individual bus load
  - hourly load variations based on historical data
- Transmission Tariffs
  - directly included in dispatch decision

GridView Outputs – Market Simulation

Market Clearing Prices (LMP or Zonal Pricing)

- Hourly and duration
- Individual bus, area average

Generation

- Individual or area plant production
- Individual or area plant production costs
- Individual or area plant revenue
- Individual or area generation capacity and reserve margin
- Reliability indices

Transmission

- Individual line or interface power flows
- Transmission congestion cost and utilization measures
- Contingency analysis and reliability indices
- Budget constrained transmission expansion plans

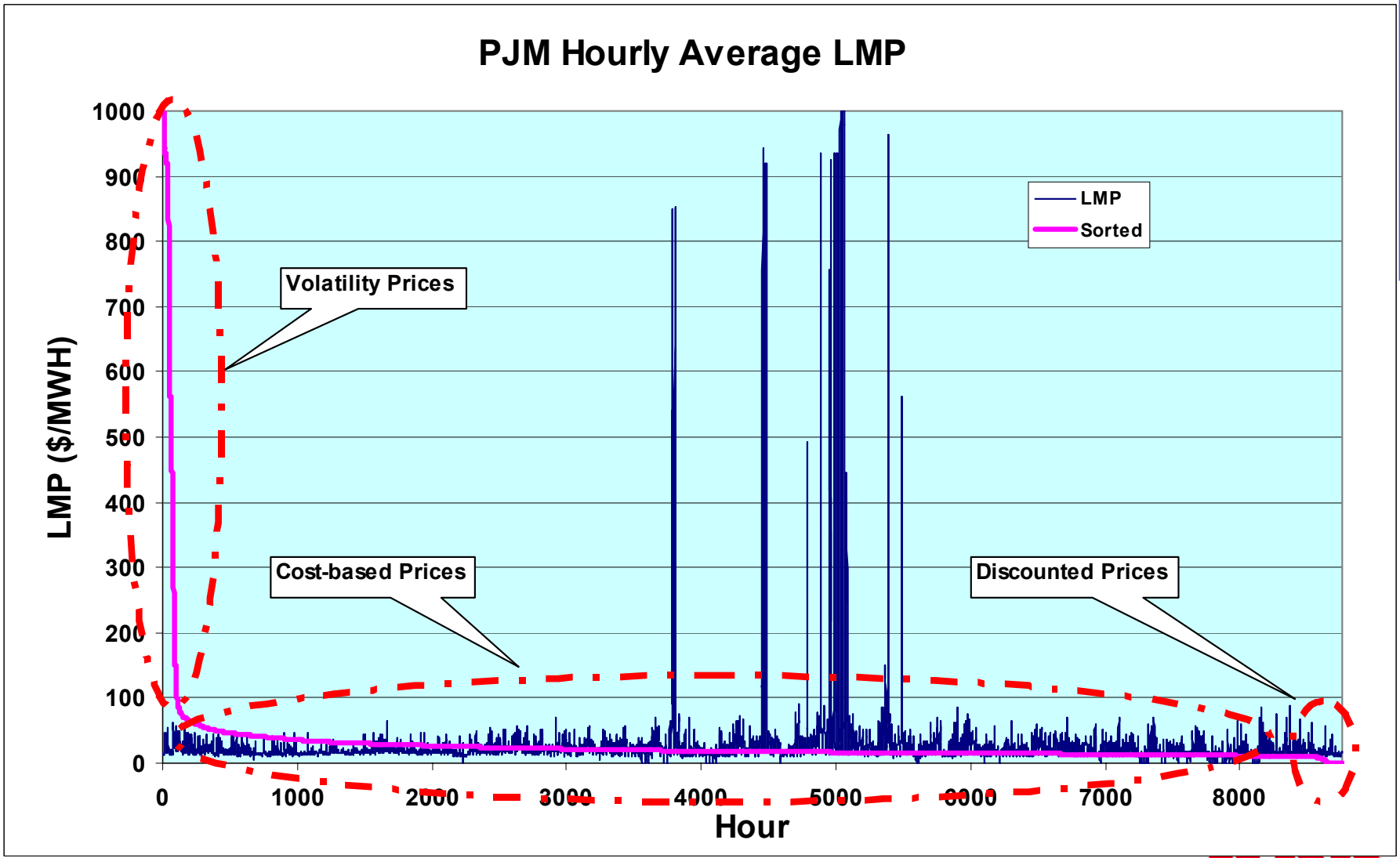
GridView Outputs – Monte Carlo Simulation and Contingency Analysis

- Frequency, duration and probability of a contingency event
- Statistic information from Monte Carlo simulations – Mean, median, standard deviation, confidence level, etc.
- Loss of Load Expectation
- Overloads, and islands under contingency conditions
- Remedial actions and system conditions after corrections
- System generation cost before and after contingency or remedial actions
- System load payment before and after contingency or remedial actions.

GridView Functional Highlights

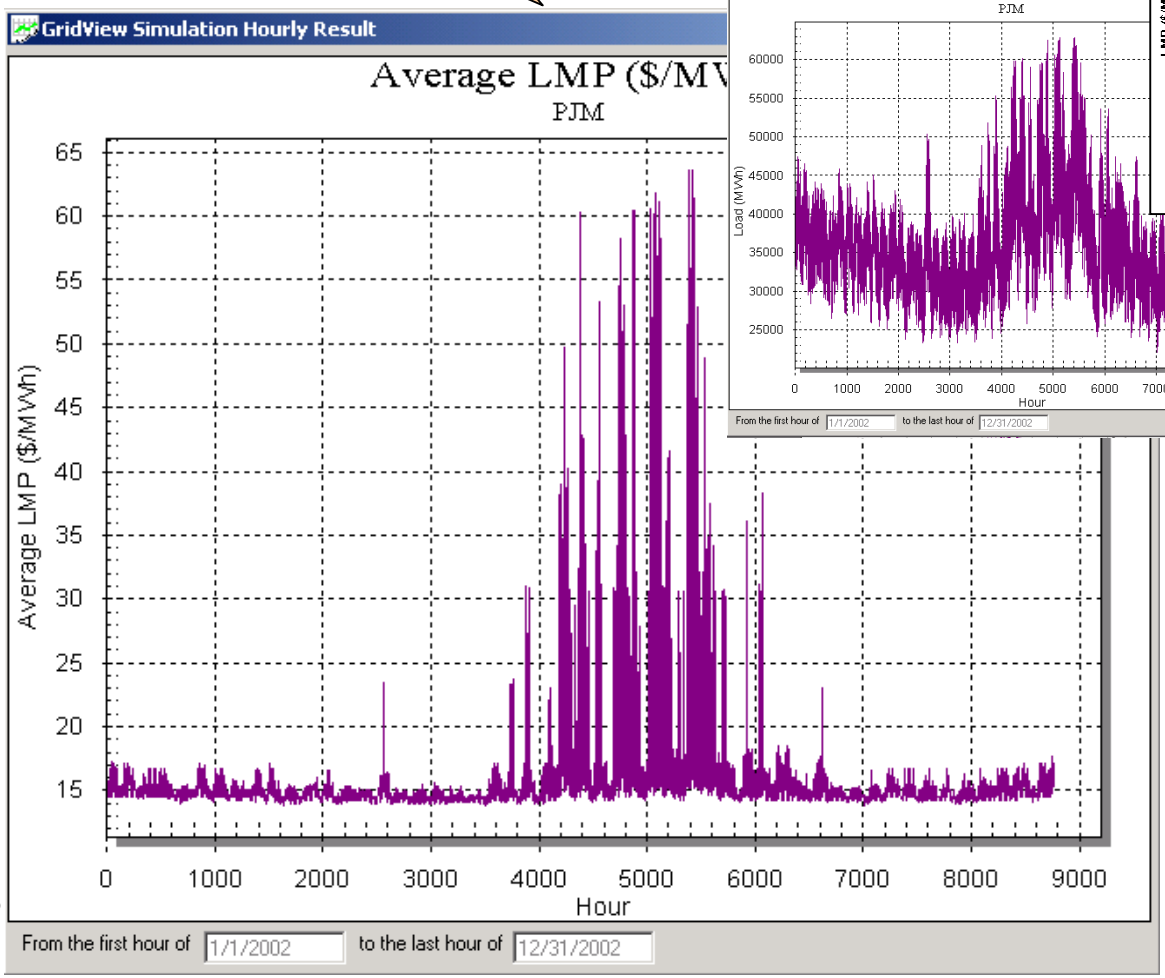
- Power Market Simulator
  - combines gen. & transmission engineering and financial data
  - simulates competitive market behavior
  - scenario (what if) analysis
- Opportunity Identification, Evaluation and Justification
  - generation and transmission expansion projects
- Market Position and Asset Worth Evaluation
  - existing plants, refurbished plants, new plants
  - transmission expansion sensitivity index
- Transmission Economics and Planning
  - identify low and high cost areas (potential customers)
  - identify transmission constraints that might exist and impede transactions, and the costs of the transmission congestion

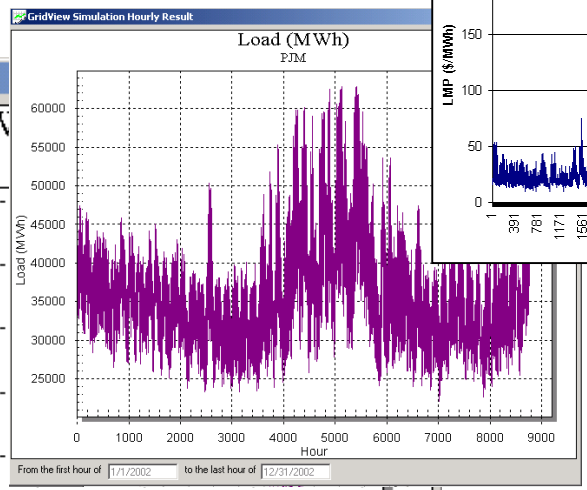
Volatility Modeling for Energy Markets

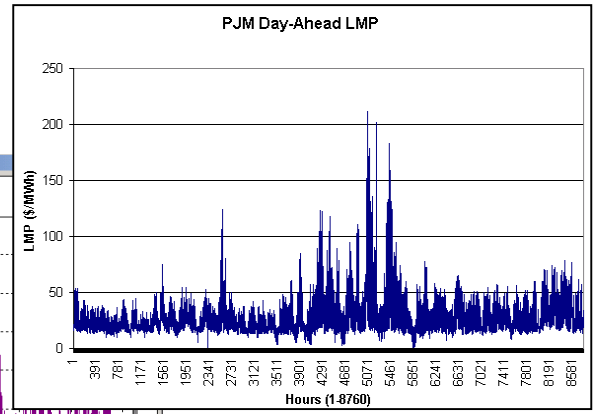


PJM Simulation Results

Cost-based Simulation Results for PJM 2002



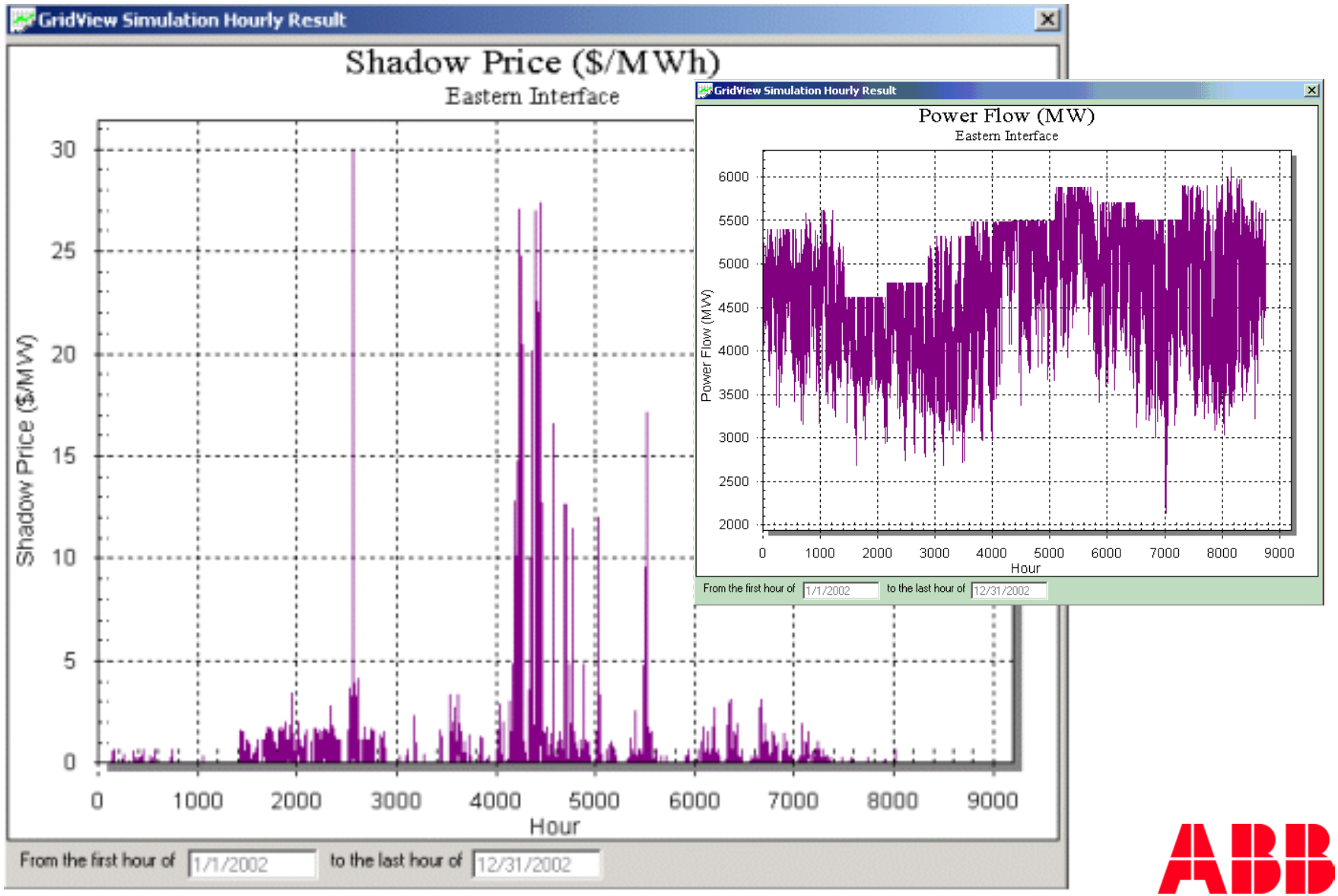




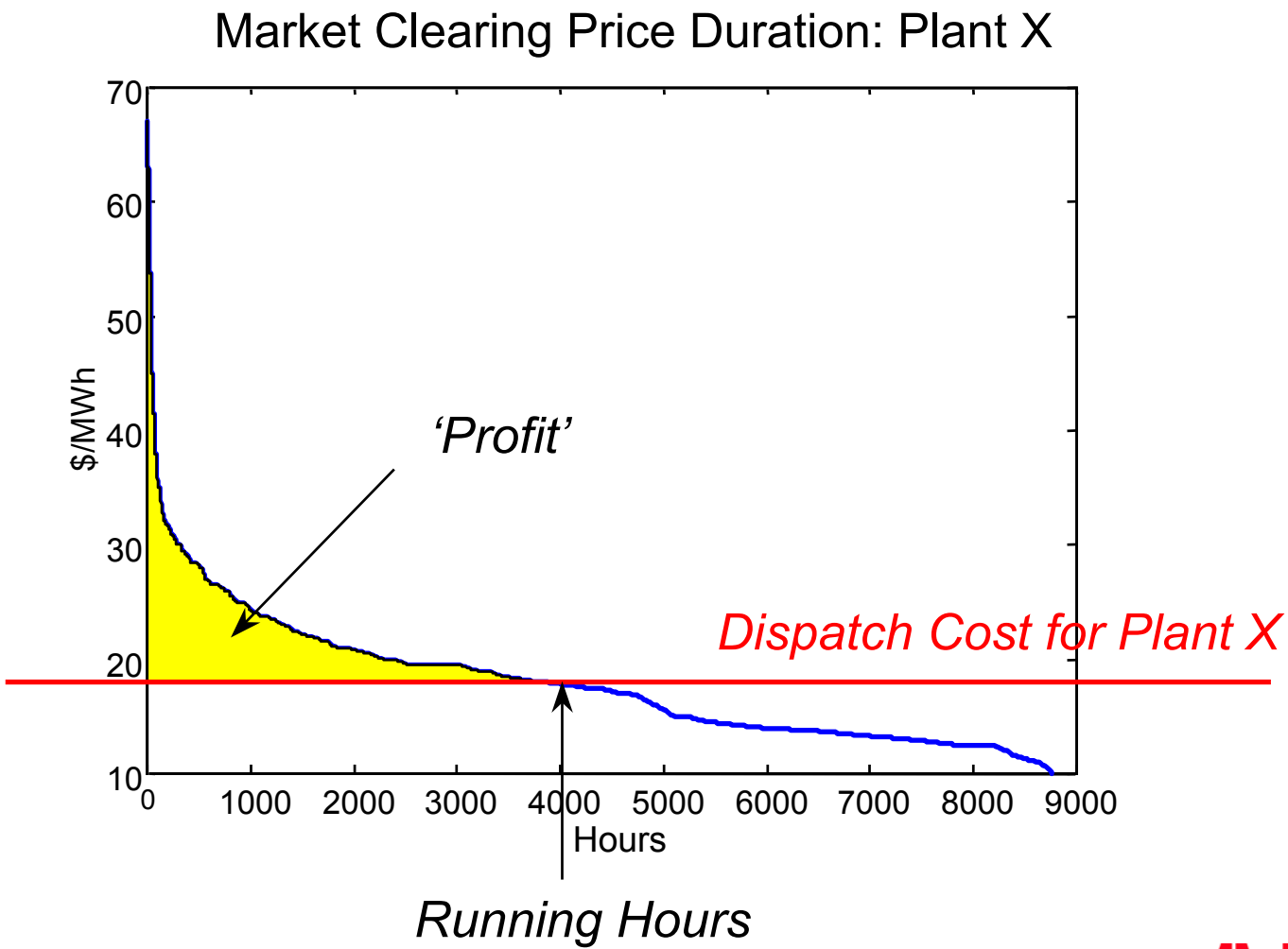
Actual LMP in PJM 2002

PJM 2002 Load

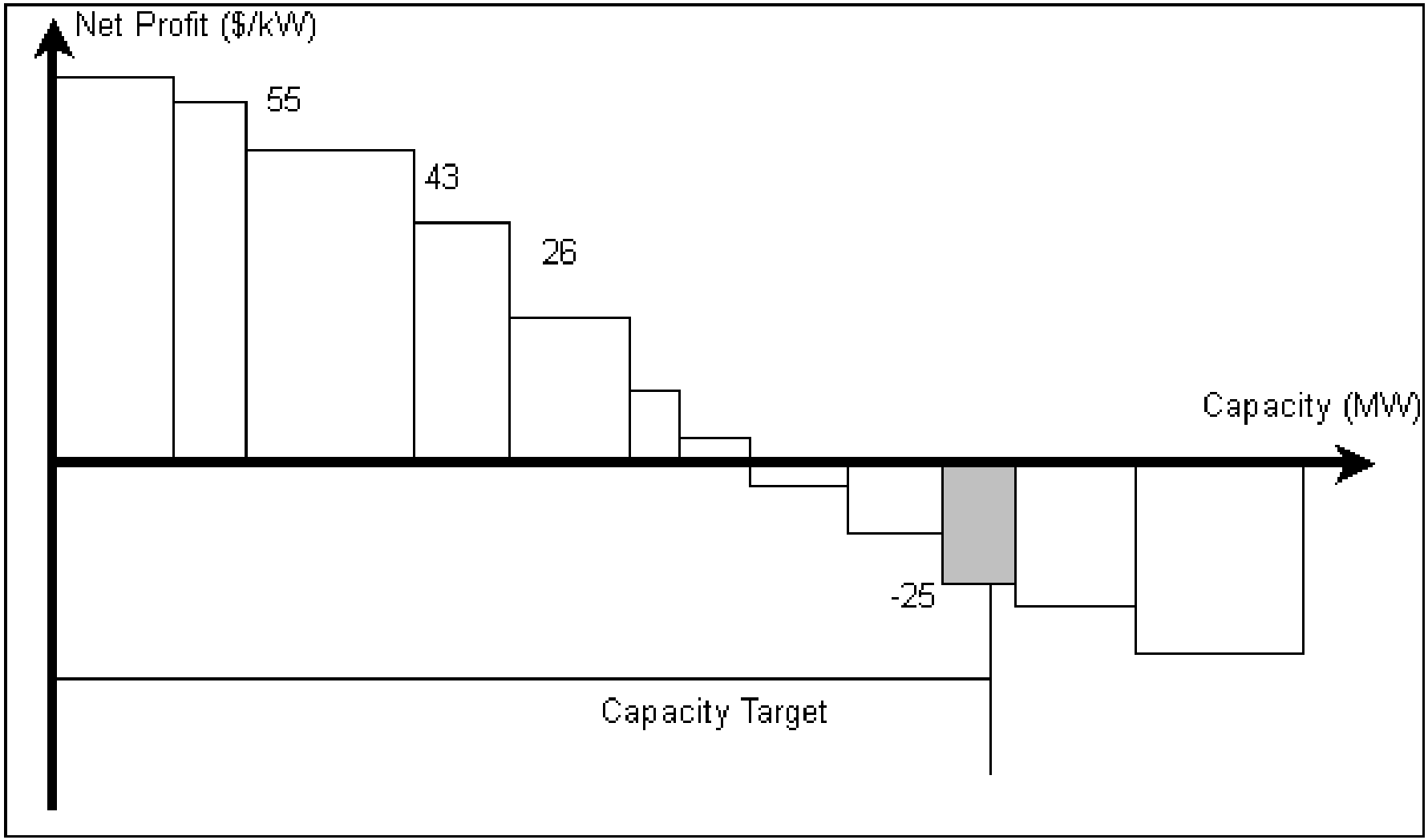
Simulated PJM Eastern Interface in 2002



Merchant Plant Evaluation - Energy Sales



Capacity Market Assessment



Top 5 Most Congested NY Interfaces *

Ranking	Interface Name	Average Power Flow (MW)	Shadow Price ($/MW)	Congestion Cost (k$)	Congestion Hours (Hrs)	Loading Factor
1	SPR/DUNW SOUTH	3895.67	3.32	114836.24	5290	0.99
2	UPNY CONED	3939.10	1.66	61486.87	1997	0.93
3	CONED-LILCO	938.52	6.53	55814.96	6886	0.96
4	WEST CENTRAL	1233.00	2.47	37359.44	1506	0.71
5	UPNY SENY	3624.70	0.55	20290.21	1341	0.87

* This is a sample report from the simulation result of year 2003 based on ABB's NYISO database.

Market Studies

- Benefits analysis and costs evaluation for RTOs and stakeholders
- Congestion management and value of congestion relief
- Energy market price forecasting & price volatility analysis
- Evaluation for forward energy contracts
- Capacity market studies
- Market power analysis and market monitoring
- Market performance benchmark
- Alternative market design and modeling
- NERC regional generation, transmission and load data collection and forecast

Generation Studies

- Generation plant siting optimization
- Generation bidding strategy assessment
- Generation asset evaluation and management
- Generation portfolio optimization and risk management
- Generation plant performance and efficiency analysis
- System impact and facility study for generator interconnection

Transmission Studies

- Transmission asset utilization monitoring
- Transmission bottleneck identification
- Transmission congestion assessment
- Transmission expansion planning and alternative evaluation
- Identification and economic assessment of merchant transmission projects

Program Services

- Program installation and setup
- Customer-site training
- ABB-site training in US
- Limited software warranty and customer support
- Database creation
- Consulting services
- Software customization

GridView's User Interface and Database preparation process

- User Friendly Graphical User Interface (GUI) by Visual Basic
- External dataset is managed by Microsoft Excel Spreadsheets and sanity checked by GUI when imported into GridView database
- Internal Database is managed by Microsoft ACCESS
- Compatible with PSS/E formatted load flow and contingency files

Demo Outline - Input

- Data Export/Import Function
  - Generator General Information
  - Fuel Price
- Data Editing
  - Generator
  - Maintenance Scheduling
  - Area/Regional Load Adjustment
  - Line Monitoring
  - Interface Monitoring
  - Contingency Monitoring (Security Constraints)
  - Simulation Parameter
  - Network Data after Imported from PSS/E
  - Generator Information from RDI – PowerDat (Matching with Information in the PSS/E Load Flow File)
  - Contingency Events

Demo Outline - Output

- Hourly snapshot in PSS/E format for further external analysis
- Load bus market clearing prices
- Generator bus report
- Transmission line utilization
- Interface utilization
- Load Area Summary
- User Defined Zone Summary
- Regional Summary
- System Summary
- Visualization of System Summary
- Contingency Analysis Results

A Case Study

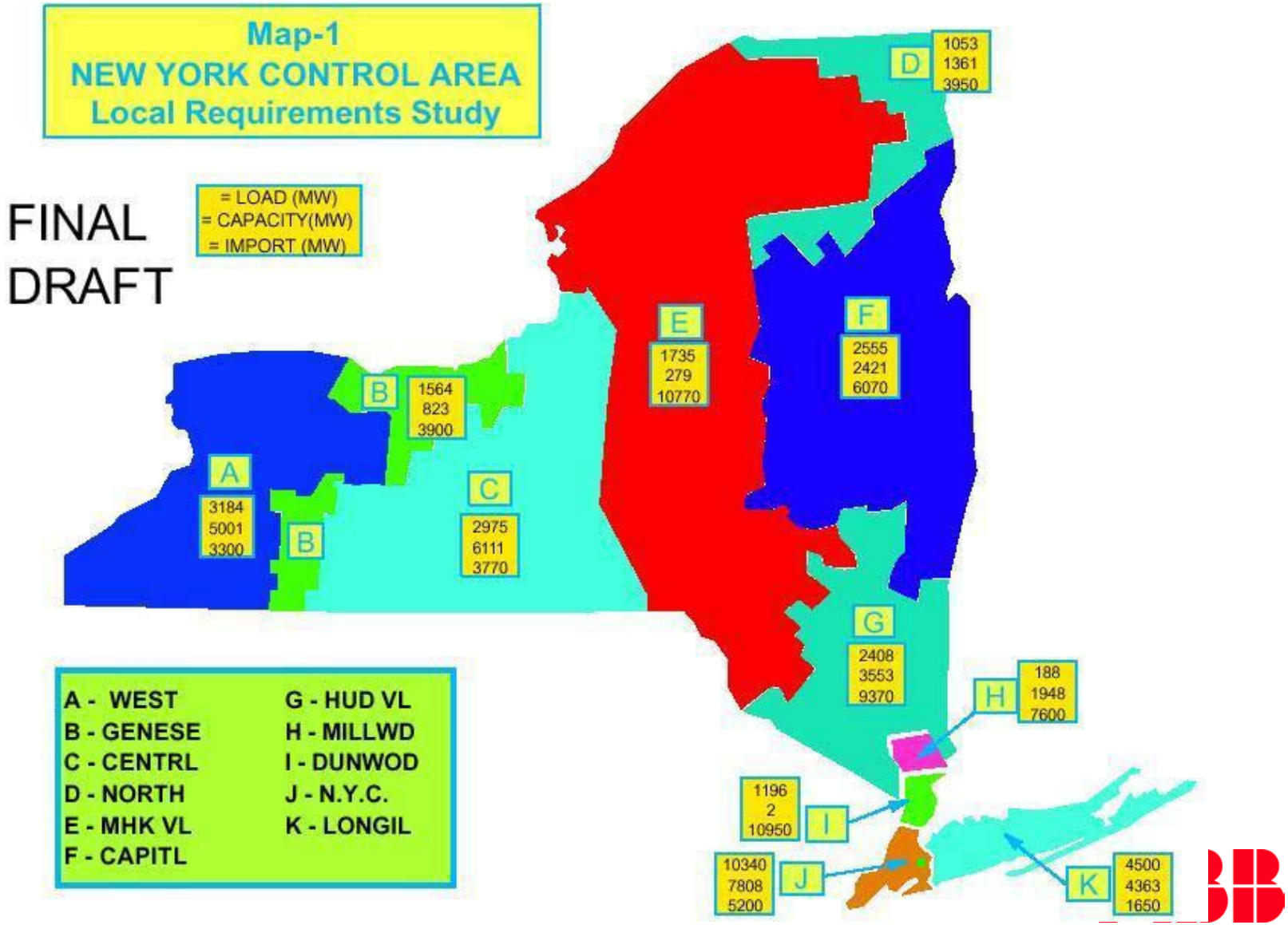
"Economic Evaluation of Transmission Congestion Relief for the NYCA System"

Reference [1] - "Economic Evaluation of Transmission Congestion Relief Based on Power Market Simulations", IEEE PES General Meeting, Toronto, Canada, July 2003.

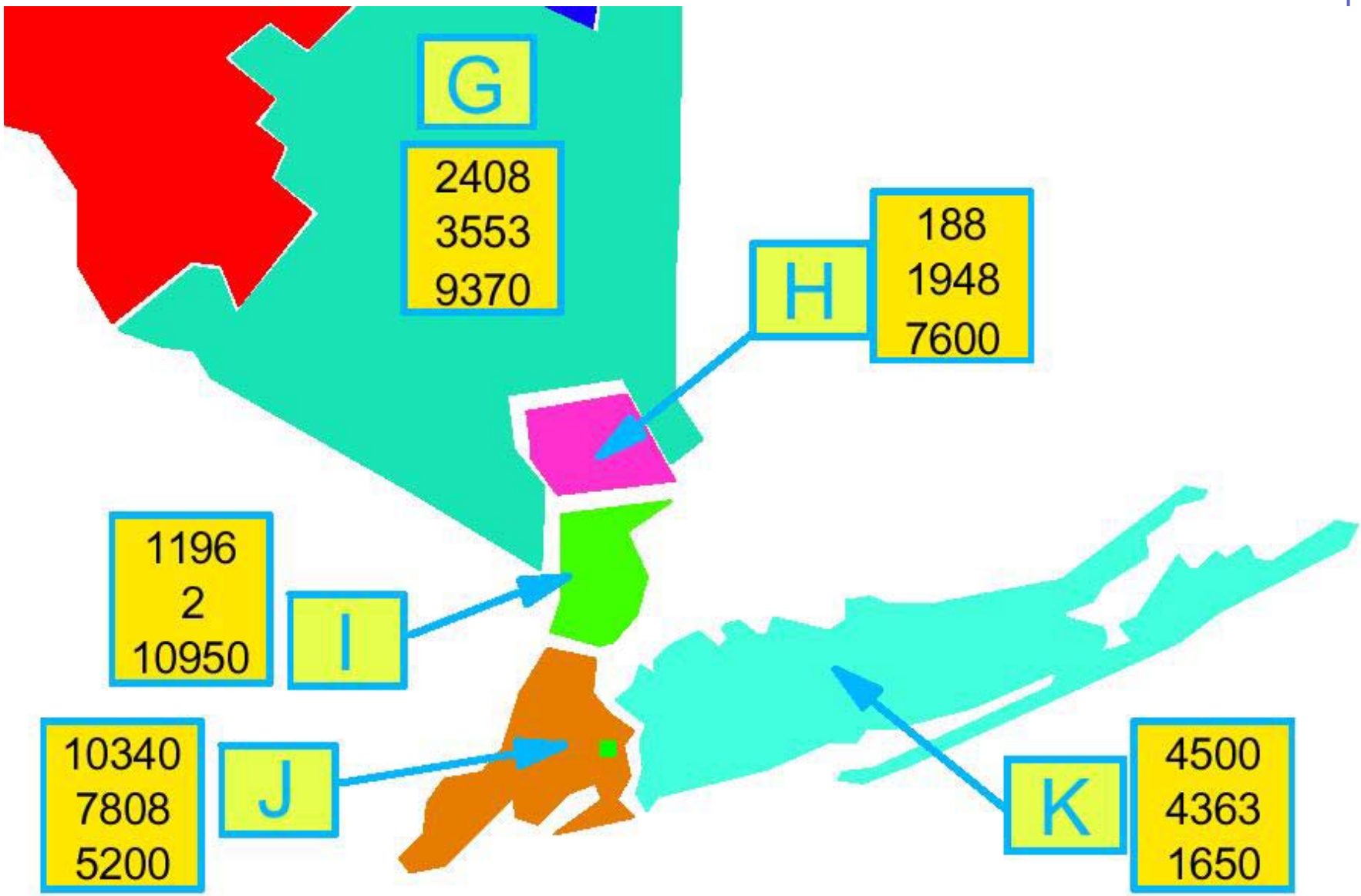
Questions for the Case Study

- Where are the bottlenecks?
- How often does transmission congestion occur?
- What are the economic consequences of inadequate transmission capacity?
- Which interface or path constraints are more attractive for improvement?
- What system expansion or upgrade options are available?
- What is the market and system impact of any proposed system expansion project?

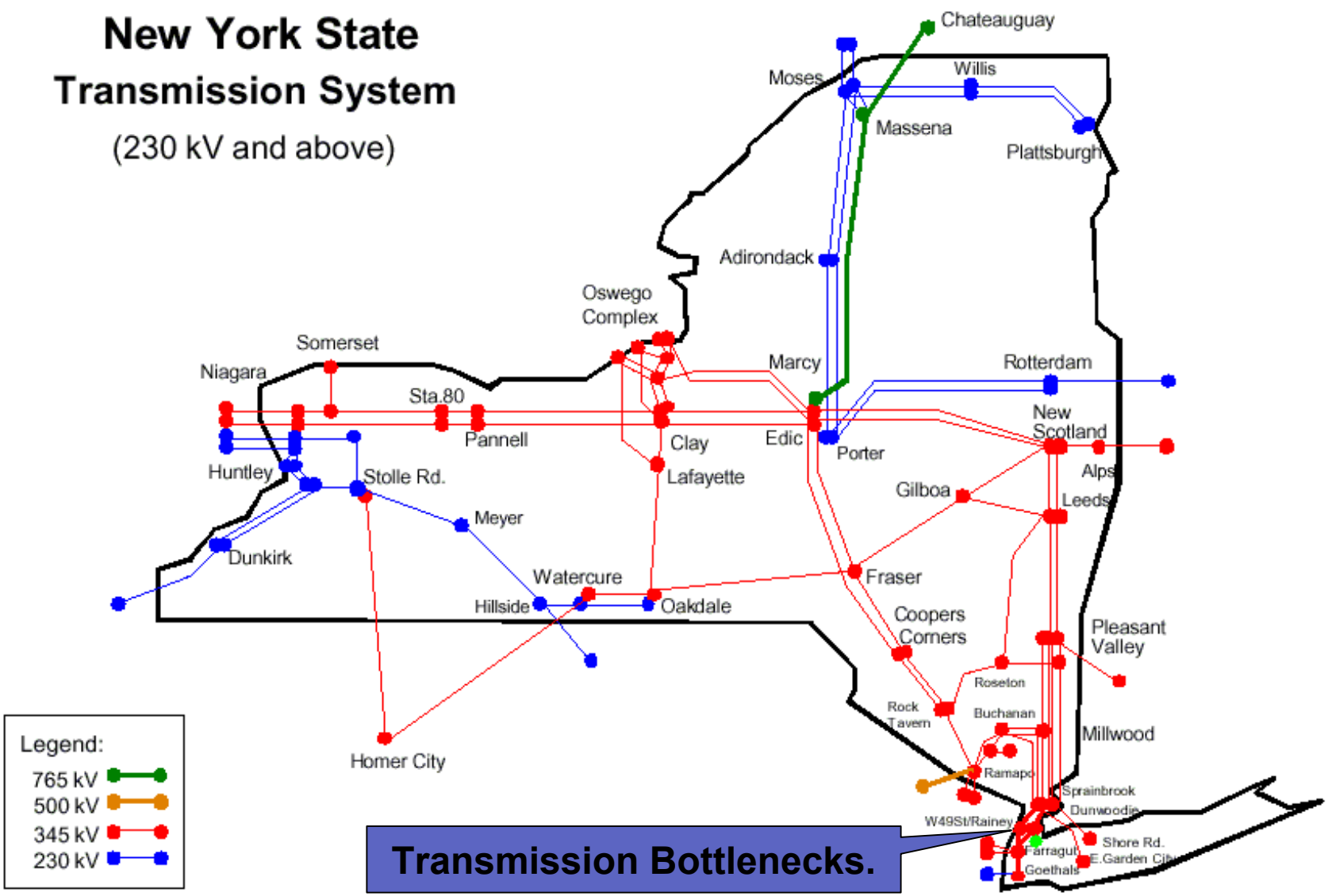
NYCA System



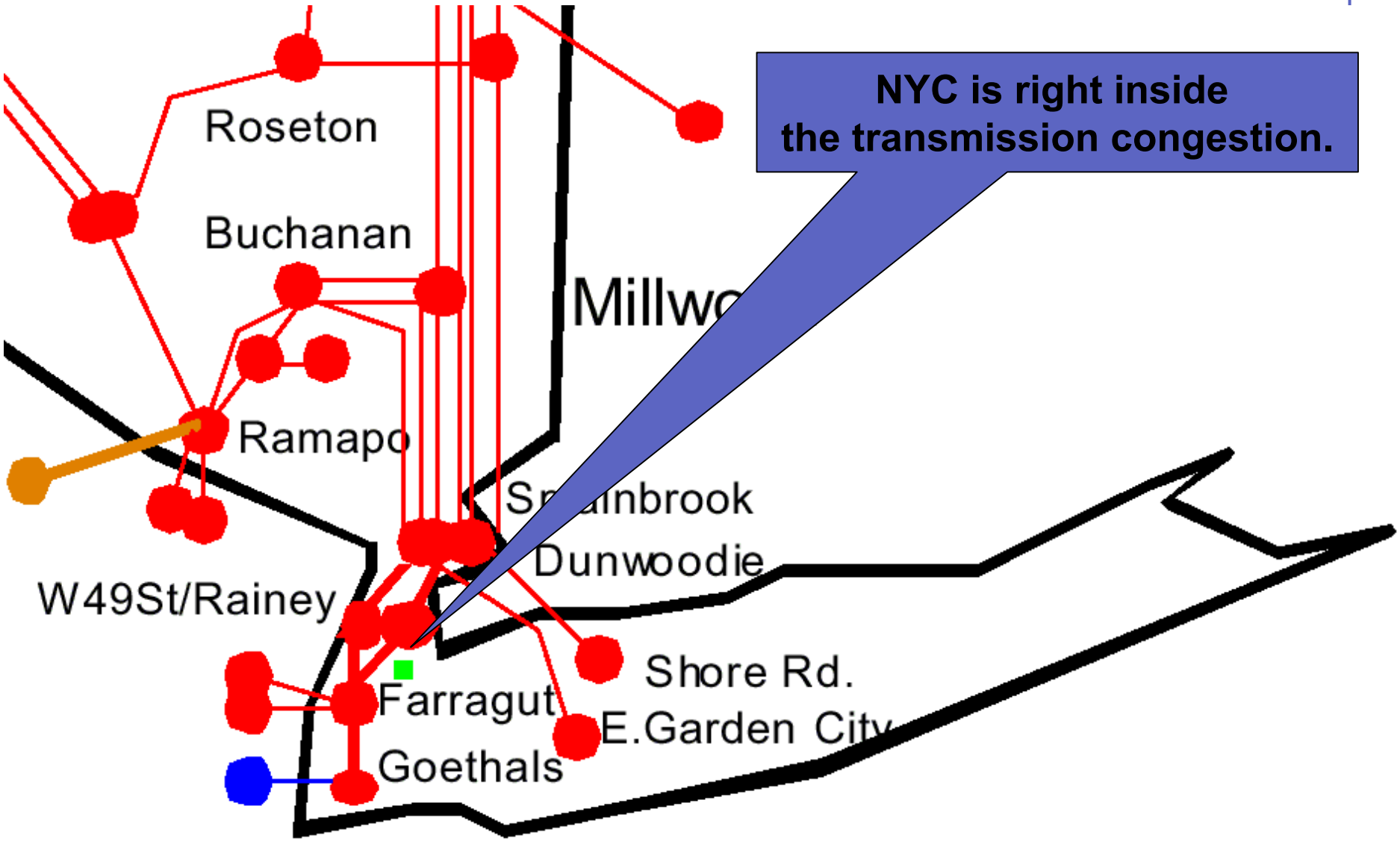
In-City Requirements



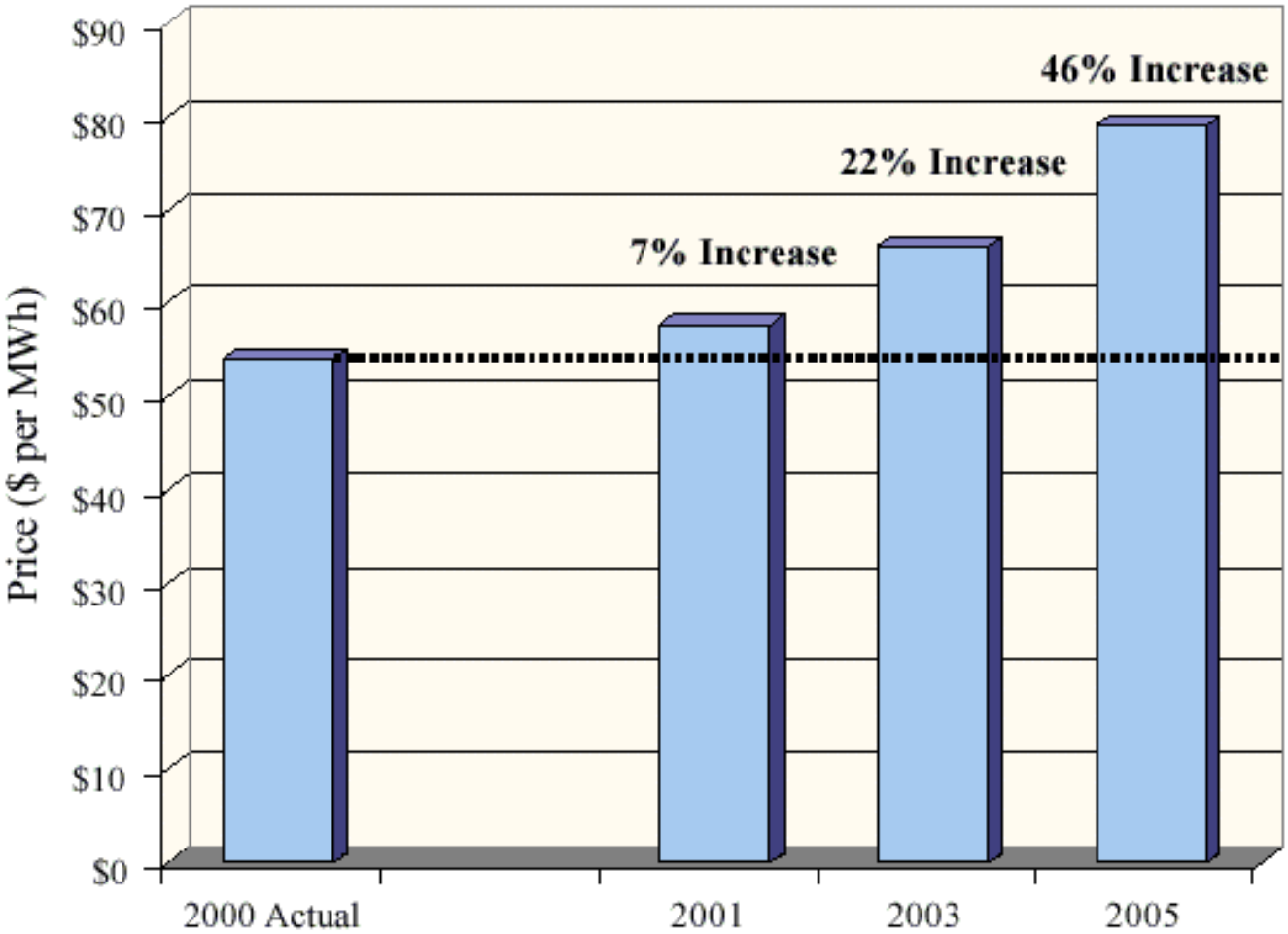
NYCA Transmission Network and Interfaces



NYC


NYC is right inside
the transmission congestion.
Roseton
Buchanan
Millwo
Ramapo
Sprainbrook
Dunwoodie
W49St/Rainey
Shore Rd.
Farragut
E.Garden City
Goethals

NY State Price Forecast



Price Spike Hours

2000 Actual = 6 Hours

2001 Summer = 9 Hours
2003 Summer = 22 Hours
2005 Summer = 45 Hours

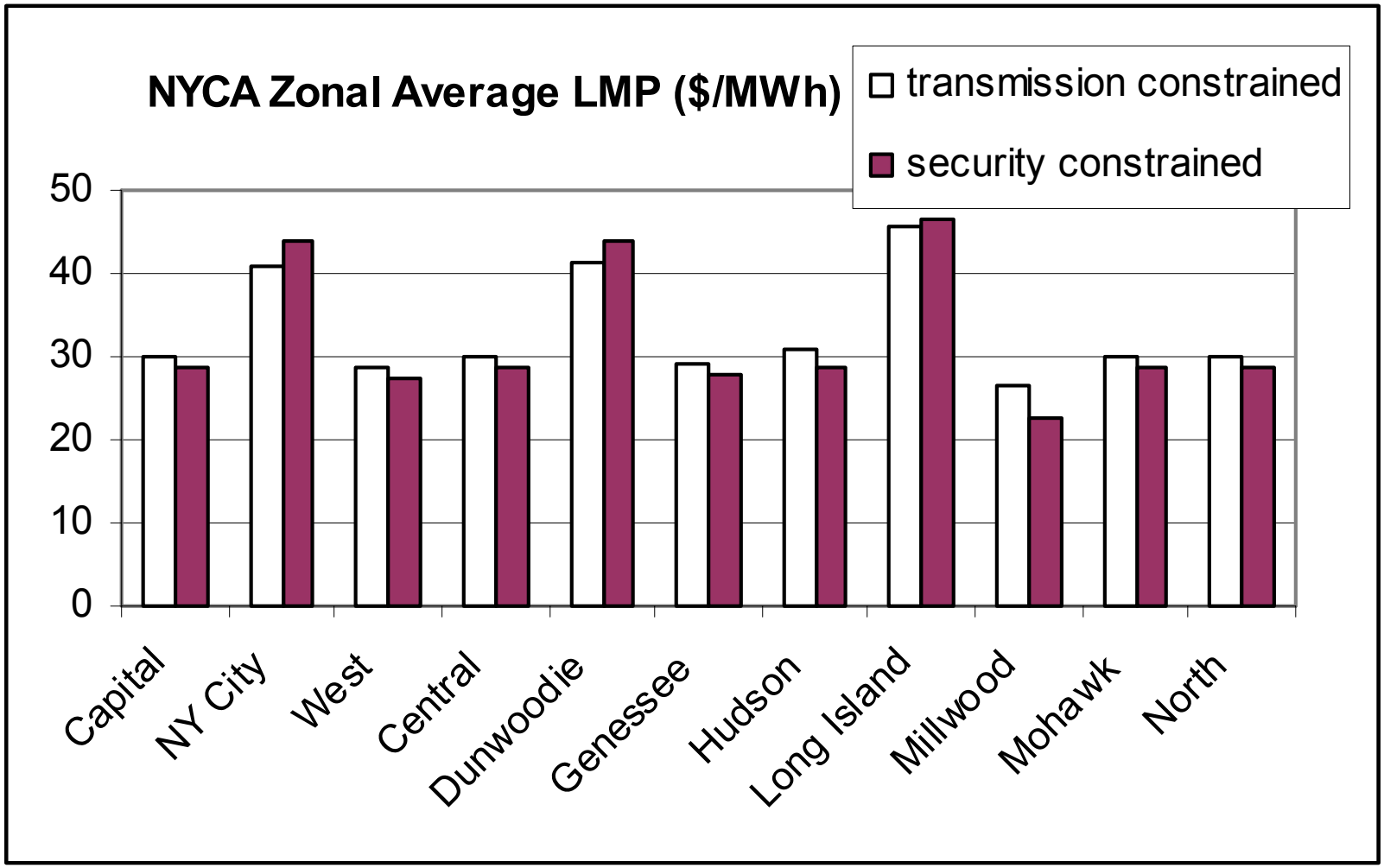
Average summer (June~August) prices in NY state forecasted by Dr. David Pattern to NY-ISO.

NYCA System Congestion Costs

Case	Solution Approach	Production Cost (M$/yr)	Congestion Cost	
			(M$/yr)	(%)
1	unlimited network capacity	2451.0	0	0
2	w/ transmission constraints	2640.6	189.6	7.74
3	w/ security constraints	2768.4	317.4	12.95

Reference [1] - "Economic Evaluation of Transmission Congestion Relief Based on Power Market Simulations", IEEE PES General Meeting, Toronto, Canada, July 2003.

NYCA Zonal Average LMPs



Reference [1] - "Economic Evaluation of Transmission Congestion Relief Based on Power Market Simulations", IEEE PES General Meeting, Toronto, Canada, July 2003.

NYCA Interface Utilization Analysis

Interface Name	Loading Factor (%)	Expansion Value ($/MW-yr)	Path Cost (M$/yr)	Congestion Hours (Hrs/yr)
CENTRAL EAST	65.10	0	0	0
MOSES SOUTH	29.09	0	0	0
TOTAL EAST	60.30	0	0	0
CONED-LILCO	98.99	67044	65.4	7974
LILCO-IMPORT	87.74	0	0	0
DYSINGER EAST	60.78	0	0	0
WEST CENTRAL	69.51	12822	22.1	1343
SPR/DUNW SOUTH	97.24	27309	107.9	3185
UPNY SENY	77.10	7567	31.6	1264
UPNY CONED	92.74	20204	85.4	2020

Reference [1] - “Economic Evaluation of Transmission Congestion Relief Based on Power Market Simulations”, IEEE PES General Meeting, Toronto, Canada, July 2003.

NYCA Interface Congestion Analysis

Interface Name	System Peak Hour (on/off)	Expansion Value ($/MW-yr)	Path Cost (M$/yr)	Congestion Hours (Hrs/yr)
CONED-LILCO	on	31372	30.6	3938
	off	35672	34.8	4036
WEST CENTRAL	on	7293	12.6	845
	off	5529	9.5	498
SPR/DUNW SOUTH	on	9085	35.9	1014
	off	18224	72.0	2171
UPNY SENY	on	7235	30.2	1155
	off	333	1.4	109
UPNY CONED	on	19483	82.3	1935
	off	722	3.0	85

Reference [1] - "Economic Evaluation of Transmission Congestion Relief Based on Power Market Simulations", IEEE PES General Meeting, Toronto, Canada, July 2003.

Heavily Loaded NYCA Interface Components

From Bus	To Bus	Congestion Hours (Hrs/yr)	Loading Factor (%)	Interface Name
SPRBROOK	W 49 ST	4951	98.76	SPR/DUNW SOUTH
DUNWODIE	RAINEY	2023	96.48	SPR/DUNW SOUTH
TREMONT	PARK TR1	5727	99.12	SPR/DUNW SOUTH
DUNWODIE	DUN NO	3760	97.78	SPR/DUNW SOUTH
SPRBROOK	REACBUS	5877	89.96	CONED-LILCO
DUNWODIE	SHORE RD	5639	99.24	CONED-LILCO

From Bus	To Bus	Expansion Value ($/MW-yr)	Path Cost (M$/yr)	Interface Name
SPRBROOK	W 49 ST	188182	138.4	SPR/DUNW SOUTH
DUNWODIE	RAINEY	62885	42.7	SPR/DUNW SOUTH
TREMONT	PARK TR1	27330	5.6	SPR/DUNW SOUTH
DUNWODIE	DUN NO	27219	7.9	SPR/DUNW SOUTH
SPRBROOK	REACBUS	46847	29.4	CONED-LILCO
DUNWODIE	SHORE RD	43109	24.5	CONED-LILCO

Reference [1] - “Economic Evaluation of Transmission Congestion Relief Based on Power Market Simulations”, IEEE PES General Meeting, Toronto, Canada, July 2003.

NYCA Interface Upgrade Options

Option	Capacity Improvement		Production Cost (M$/yr)	Congestion Cost Savings	
	Interface	Δ MW		(M$/yr)	(%)
1	WEST CENTRAL	100	2638.5	2.14	0.08
2	CONED-LILCO	90	2632.4	8.21	0.31
3	SPR/DUNW SOUTH	150	2631.9	8.70	0.33
4	SPR/DUNW SOUTH	150	2636.9	3.69	0.14
5	2+3	90+150	2625.3	15.31	0.58

Reference [1] - "Economic Evaluation of Transmission Congestion Relief Based on Power Market Simulations", IEEE PES General Meeting, Toronto, Canada, July 2003.

Impact of SPR/DUNW Interface Upgrades

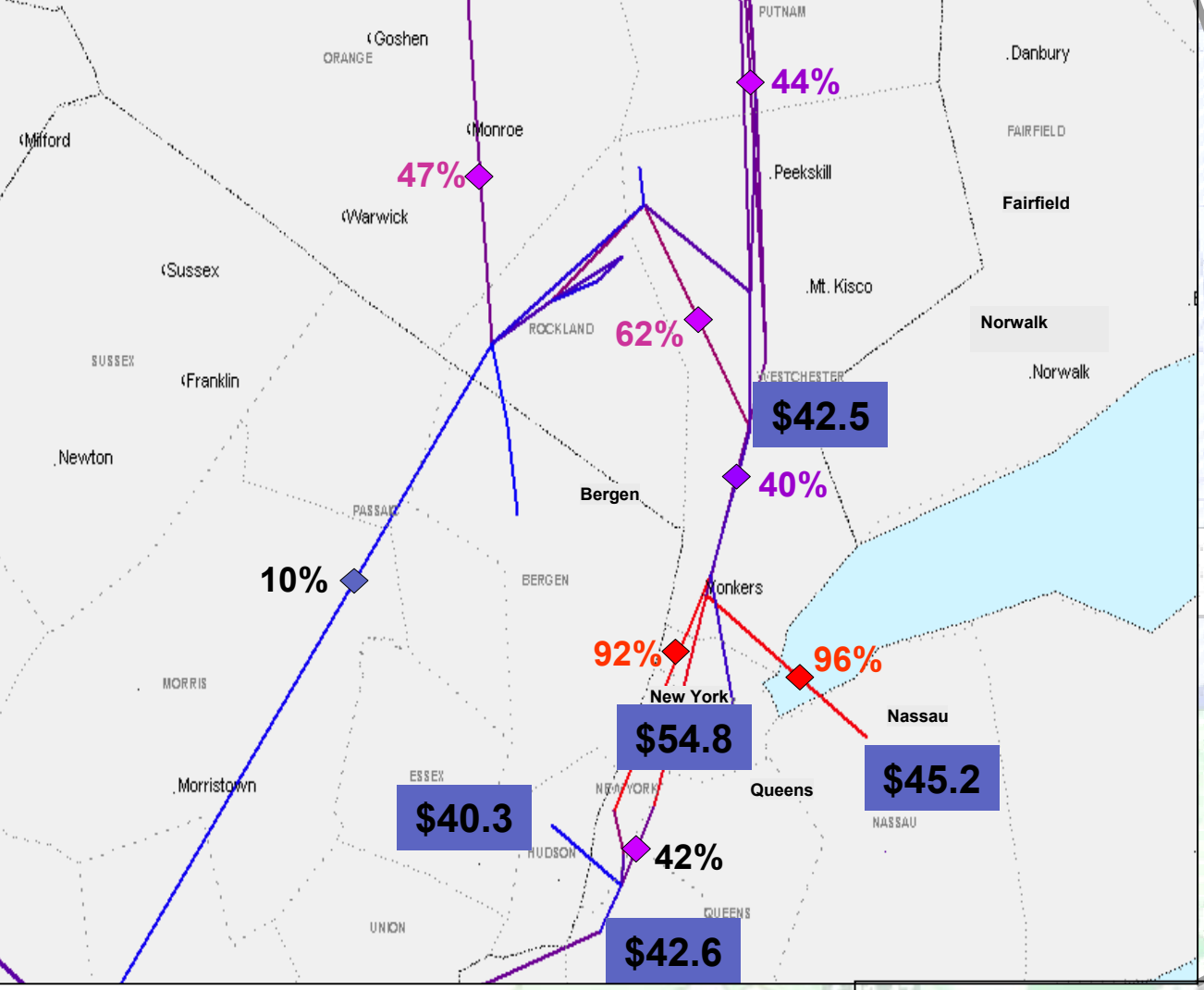
Load Area	Total Generation (MWh)	Generation Reveune (M$)	Generation Cost (M$)	Load Payment (M$)	Average LMP ($/MWh)
Capital	174957	6.2	5.0	2.0	0.13
NY City	-666616	-23.9	-28.8	-21.2	-0.39
West	15819	1.7	0.4	0.6	0.04
Central	123565	5.9	3.8	0.8	0.05
Dunwoodie	0	0.1	0.0	-1.8	-0.42
Genessee	1493	0.3	0.0	0.3	0.04
Hudson Valley	322329	16.7	9.6	7.7	0.61
Long Island	20967	1.4	1.0	1.4	0.08
Millwood	0	40.6	0.0	10.9	2.48
Mohawk Valley	1937	0.3	0.1	0.5	0.06
North	5548	0.7	0.2	0.4	0.06
Total	0	49.9	-8.7	1.6	

Reference [1] - “Economic Evaluation of Transmission Congestion Relief Based on Power Market Simulations”, IEEE PES General Meeting, Toronto, Canada, July 2003.

Interconnection Options and Benefits

Option	NY City Injection		Production Cost (M$/yr)	Congestion Cost Savings	
	Location	MW		(M$/yr)	(%)
1	W49 ST	800	2551.2	89.40	3.39
2	RAINEY	600	2571.1	69.50	2.63

Reference [1] - "Economic Evaluation of Transmission Congestion Relief Based on Power Market Simulations", IEEE PES General Meeting, Toronto, Canada, July 2003.



- LMP Forecast
- Congestion Assessment
- Line Loading Evaluation

LMP and Transmission Utilization Screening

- Around New York City -

Tuesday, July 15, 2005

($/MWh)

ABB

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