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?

Transmission Expansion

IPP Plant Siting

A

15 $/MWh

D

25 $/MWh

B

10 $/MWh

C

17 $/MWh

1 $/MWh

18 $/MWH

2 $/MWh

3 $/MWh

7 $/MWh

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The Starting Point: GridView

**Goal:**
Combine

Power System Details with Market and Economic Aspects

- **Supply Model:** Generator Capacity, Heat rate, Fuel cost/operation, Constraint
- **Demand Model:** Location dependent load
- **Detailed transmission system model**
- **Market Scenarios**
- **Competitive Energy Market Simulation Engine**
- **Power System Reliability Measures**
- **Transmission Line Utilization Level**
- **Generator Utilization and Asset Value**
- **Locational Market Clearing Price**
- **Bottlenecks & Economic value of expansion**
Power Market Simulation Models

Supply Curve
• Ignores transmission

‘Bubble’ View
• Major interconnects only

Detailed View
• Very complex

GridView is a detailed model with a nice Graphical User Interface!
What’s Behind?

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

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

\[ \bar{G}_{\text{Min}} \leq \bar{G} \leq \bar{G}_{\text{Max}} \] (Real Power Gen. Limits)

\[ \bar{D}_{\text{Min}} \leq \bar{D} \leq \bar{D}_{\text{Max}} \] (Dispatchable Demands)

\[ \bar{\theta}_{\text{Min}} \leq \bar{\theta} \leq \bar{\theta}_{\text{Max}} \] (Phase Shifter Limits)

\[ \left| \bar{T} \right| \leq \bar{T}_{\text{Limits}} \] (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

\[ aX + bY + cZ + ... \leq L \]
Price & Performance Evaluation Model

- Optimal Load Flow
- Market Modeling
- Market Simulation
- Opportunity Analysis
- History Information
- Workably Competitive System Operating Cases (Non-cost issues)
- Scenarios

Generation
- size
- bids
- availability

Transmission
- power flow
- constraints
- operating rules
- FTR/Tariffs

Load
- hourly variation
- location
- growth

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 Hourly Average LMP

- Volatility Prices
- Cost-based Prices
- Discounted Prices
PJM Simulation Results

Cost-based Simulation Results for PJM 2002

Actual LMP in PJM 2002

PJM 2002 Load

Average LMP ($/MWh) for PJM 2002

From the first hour of 1/1/2002 to the last hour of 12/31/2002
Simulated PJM Eastern Interface in 2002
Merchant Plant Evaluation - Energy Sales

Market Clearing Price Duration: Plant X

Dispatch Cost for Plant X

‘Profit’

Running Hours

$/MWh

Hours
Capacity Market Assessment

Net Profit ($/kW)

Capacity (MW)

Capacity Target

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## Top 5 Most Congested NY Interfaces *

<table>
<thead>
<tr>
<th>Ranking</th>
<th>Interface Name</th>
<th>Average Power Flow (MW)</th>
<th>Shadow Price ($/MW)</th>
<th>Congestion Cost (k$)</th>
<th>Congestion Hours (Hrs)</th>
<th>Loading Factor</th>
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<tr>
<td>1</td>
<td>SPR/DUNW SOUTH</td>
<td>3895.67</td>
<td>3.32</td>
<td>114836.24</td>
<td>5290</td>
<td>0.99</td>
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<td>2</td>
<td>UPNY CONED</td>
<td>3939.10</td>
<td>1.66</td>
<td>61486.87</td>
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<td>0.93</td>
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<td>3</td>
<td>CONED-LILCO</td>
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<td>4</td>
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<td>UPNY SENY</td>
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<td>1341</td>
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* 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”

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?
In-City Requirements
NYCA Transmission Network and Interfaces

New York State
Transmission System
(230 kV and above)

Legend:
- 765 kV
- 500 kV
- 345 kV
- 230 kV

Transmission Bottlenecks.
NYC is right inside the transmission congestion.
NY State Price Forecast

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

<table>
<thead>
<tr>
<th>Case</th>
<th>Solution Approach</th>
<th>Production Cost (M$/yr)</th>
<th>Congestion Cost (M$/yr)</th>
<th>(%)</th>
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<tbody>
<tr>
<td>1</td>
<td>unlimited network capacity</td>
<td>2451.0</td>
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<td>2</td>
<td>w/ transmission constraints</td>
<td>2640.6</td>
<td>189.6</td>
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<td>3</td>
<td>w/ security constraints</td>
<td>2768.4</td>
<td>317.4</td>
<td>12.95</td>
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NYCA Zonal Average LMPs

NYCA Zonal Average LMP ($/MWh)

- Capital
- NY City
- West
- Central
- Dunwoodie
- Genesee
- Hudson
- Long Island
- Millwood
- Mohawk
- North

# NYCA Interface Utilization Analysis

<table>
<thead>
<tr>
<th>Interface Name</th>
<th>Loading Factor (%)</th>
<th>Expansion Value ($/MW-yr)</th>
<th>Path Cost (M$/yr)</th>
<th>Congestion Hours (Hrs/yr)</th>
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<tbody>
<tr>
<td>CENTRAL EAST</td>
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<td>MOSES SOUTH</td>
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<td>TOTAL EAST</td>
<td>60.30</td>
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<td>LILCO-IMPORT</td>
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<td>DYSINGER EAST</td>
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<td>SPR/DUNW SOUTH</td>
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<td>77.10</td>
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<td>UPNY CONED</td>
<td>92.74</td>
<td>20204</td>
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# NYCA Interface Congestion Analysis

<table>
<thead>
<tr>
<th>Interface Name</th>
<th>System Peak Hour (on/off)</th>
<th>Expansion Value ($/MW-yr)</th>
<th>Path Cost (M$/yr)</th>
<th>Congestion Hours (Hrs/yr)</th>
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<tbody>
<tr>
<td>CONED-LILCO</td>
<td>on</td>
<td>31372</td>
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<td></td>
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<td>SPR/DUNW SOUTH</td>
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<td>9085</td>
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<td></td>
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<td>19483</td>
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<td>1935</td>
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<td></td>
<td>off</td>
<td>722</td>
<td>3.0</td>
<td>85</td>
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### Heavily Loaded NYCA Interface Components

<table>
<thead>
<tr>
<th>From Bus</th>
<th>To Bus</th>
<th>Congestion Hours (Hrs/yr)</th>
<th>Loading Factor (%)</th>
<th>Interface Name</th>
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</thead>
<tbody>
<tr>
<td>SPRBROOK</td>
<td>W 49 ST</td>
<td>4951</td>
<td>98.76</td>
<td>SPR/DUNW SOUTH</td>
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<tr>
<td>DUNWODIE</td>
<td>RAINEY</td>
<td>2023</td>
<td>96.48</td>
<td>SPR/DUNW SOUTH</td>
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<tr>
<td>TREMONT</td>
<td>PARK TR1</td>
<td>5727</td>
<td>99.12</td>
<td>SPR/DUNW SOUTH</td>
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<tr>
<td>DUNWODIE</td>
<td>DUN NO</td>
<td>3760</td>
<td>97.78</td>
<td>SPR/DUNW SOUTH</td>
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<td>REACBUS</td>
<td>5877</td>
<td>89.96</td>
<td>CONED-LILCO</td>
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<tr>
<td>DUNWODIE</td>
<td>SHORE RD</td>
<td>5639</td>
<td>99.24</td>
<td>CONED-LILCO</td>
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<table>
<thead>
<tr>
<th>From Bus</th>
<th>To Bus</th>
<th>Expansion Value ($/MW-yr)</th>
<th>Path Cost (M$/yr)</th>
<th>Interface Name</th>
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</thead>
<tbody>
<tr>
<td>SPRBROOK</td>
<td>W 49 ST</td>
<td>188182</td>
<td>138.4</td>
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<td>DUNWODIE</td>
<td>RAINEY</td>
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<td>TREMONT</td>
<td>PARK TR1</td>
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<td>SHORE RD</td>
<td>43109</td>
<td>24.5</td>
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# NYCA Interface Upgrade Options

<table>
<thead>
<tr>
<th>Option</th>
<th>Capacity Improvement</th>
<th>Production Cost (M$/yr)</th>
<th>Congestion Cost Savings (M$/yr)</th>
<th>(%)</th>
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<tbody>
<tr>
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<td>WEST CENTRAL</td>
<td>100</td>
<td>2638.5</td>
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<tr>
<td>2</td>
<td>CONED-LILCO</td>
<td>90</td>
<td>2632.4</td>
<td>8.21</td>
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<tr>
<td>3</td>
<td>SPR/DUNW SOUTH</td>
<td>150</td>
<td>2631.9</td>
<td>8.70</td>
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<tr>
<td>4</td>
<td>SPR/DUNW SOUTH</td>
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<td>3.69</td>
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<td>5</td>
<td>2+3</td>
<td>90+150</td>
<td>2625.3</td>
<td>15.31</td>
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## Impact of SPR/DUNW Interface Upgrades

<table>
<thead>
<tr>
<th>Load Area</th>
<th>Total Generation (MWh)</th>
<th>Generation Revenue (M$)</th>
<th>Generation Cost (M$)</th>
<th>Load Payment (M$)</th>
<th>Average LMP ($/MWh)</th>
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<tr>
<td>Capital</td>
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<td>5.0</td>
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<td>Hudson Valley</td>
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<td>0.1</td>
<td>0.5</td>
<td>0.06</td>
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<td>North</td>
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<td>0.4</td>
<td>0.06</td>
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<td>-8.7</td>
<td>1.6</td>
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## Interconnection Options and Benefits

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<thead>
<tr>
<th>Option</th>
<th>NY City Injection</th>
<th>Production Cost (M$/yr)</th>
<th>Congestion Cost Savings</th>
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<tbody>
<tr>
<td></td>
<td>Location</td>
<td>MW</td>
<td>(M$/yr)</td>
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<tr>
<td>1</td>
<td>W49 ST</td>
<td>800</td>
<td>2551.2</td>
</tr>
<tr>
<td>2</td>
<td>RAINEY</td>
<td>600</td>
<td>2571.1</td>
</tr>
</tbody>
</table>

- Around New York City -
Tuesday, July 15, 2005
($/MWh)

LMP and Transmission Utilization Screening

• LMP Forecast
• Congestion Assessment
• Line Loading Evaluation
Contact Information

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