Trying to Maintain Generation Adequacy in “Deregulated” Markets

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OUTLINE

- Consequences of the Californian Crisis
  - Suppress price spikes in the spot market
  - Insufficient investment in new generation

- Paying for Reliability: The Textbook Solution
  - NERC’s short-run and long-run reliability standards
  - Locational capacity requirements for New York State
  - Optimal composition of generating capacity

- Paying for Reliability: Alternative Solutions
  - Average price duration curves and long-run average costs
  - Price spikes in the spot market (Australian market)
  - Augmented capacity auction (New York’s “demand” curve)
  - Capacity auction in theory and in practice
  - Conclusions
PART 1

The Indirect Consequences of the Californian Energy Crisis On Generation Adequacy

References on <www.e3rg.pserc.cornell.com>
1. Yoo-Soo Lee
   “Risk Premium in Forward Prices during the Californian Crisis”
2. Xiaobin Cai
   “Investment Incentives for new Generation Capacity”
Spot Prices in Southern California and
Price Caps in the CAISO Spot Market

The Federal Energy Regulatory Commission (FERC) introduced
a new, untested “soft-cap” auction in Dec. 2000

Figure 1: Spot Prices at Southern California and the Price Caps in California,
Blue  CAISO Hard Cap
Red   CAISO Soft Cap
Black WECC Hard Cap
(Source, Energy Market Report and the CAISO)
The Estimated Risk Premium in the Forward Market for Electricity for Three Delivery Months at the Palo Verde Trading Hub

The risk premium is conditional on the forward price of natural gas at Henry Hub
The Indirect Consequences in New York State
Daily Spot Prices in New York City
(1/7/99 - 1/7/05 at 2PM, $/MWh)

N.Y.C. real time price time plot(14:00)

Automatic Mitigation Procedures and regulatory “threat” have suppressed high prices
--- No Californian Crisis here!
THE PROBLEM: Some new power plants (with construction licenses) have been cancelled in New York State ---> Possible threat to reliability

FORECASTED SUMMER RESERVE MARGIN FOR THE NEW YORK CONTROL AREA

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

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

Source: NYISO PowerTrends
The lack of investment in new power plants is really a national problem.

Source: “2005 NERC Long-Term Reliability Assessment”, Fig. 4
PART 2

Paying for Reliability in “Deregulated” Markets: The Textbook Solution
DEFINITIONS OF RELIABILITY
North-American Electric Reliability Council (NERC), 2005

1. **Adequacy** — The ability of the electric system to supply the aggregate electrical demand and energy requirements of customers at all times, taking into account scheduled and reasonably expected unscheduled outages of system elements.

   *Ensuring there is enough generation and transmission capacity --- the investors’ problem*

2. **Operating Reliability** — The ability of the electric system to withstand sudden disturbances such as electric short circuits or unanticipated failure of system elements.

   *Determining the dispatch of installed capacity and levels of reserves --- the system operators’ problem*
# Current Reliability Standards II

Capacity requirements set by state regulators for the New York Control Area (NYCA)

## Locational Capacity Requirements for New York State in 2005/06

<table>
<thead>
<tr>
<th>Locality</th>
<th>Forecasted Peak Load MW</th>
<th>Locational ICAP % of Peak</th>
<th>Required Locational ICAP, MW</th>
<th>Actual ICAP, MW</th>
<th>Actual ICAP % of Peak</th>
<th>Ratio of Actual ICAP to Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>NYC</td>
<td>11,315</td>
<td>80</td>
<td>9,052</td>
<td>9,887</td>
<td>87</td>
<td>1.09</td>
</tr>
<tr>
<td>LI</td>
<td>5,231</td>
<td>99</td>
<td>5,179</td>
<td>5,318</td>
<td>102</td>
<td>1.03</td>
</tr>
<tr>
<td>NYCA</td>
<td>31,692</td>
<td>118</td>
<td>37,715</td>
<td>39,647</td>
<td>125</td>
<td>1.05</td>
</tr>
</tbody>
</table>

Source: NYISO 2/17/05

NYC New York City (J)
LI Long Island (K)
NYCA New York Control Area
Current Reliability Standards III
Power plants needed to maintain reliability in New York City and Long Island


<table>
<thead>
<tr>
<th>Name Zone Unit and Fuel Type*</th>
<th>Summer Capacity MW</th>
<th>Generation GWh</th>
<th>Capacity Factor %**</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Ravenswood ST 01-03 LI ST F06/NG</td>
<td>1765</td>
<td>4751</td>
<td>31</td>
</tr>
<tr>
<td>2. Barrett ST 01-02 LI ST NG/F06</td>
<td>390</td>
<td>1336</td>
<td>39</td>
</tr>
<tr>
<td>3. Far Rockaway ST 04 LI ST NG/F06</td>
<td>107</td>
<td>264</td>
<td>28</td>
</tr>
<tr>
<td>4. Glenwood ST 04-05 LI ST NG</td>
<td>238</td>
<td>545</td>
<td>26</td>
</tr>
<tr>
<td>5. Northport 1-4 LI ST NG/F06</td>
<td>1539</td>
<td>7507</td>
<td>55</td>
</tr>
<tr>
<td>6. Wading River 1-3 LI GT/F02</td>
<td>245</td>
<td>306</td>
<td>14</td>
</tr>
<tr>
<td>7. Port Jefferson 3-4 LI ST F06/NG</td>
<td>385</td>
<td>1399</td>
<td>41</td>
</tr>
<tr>
<td>8. Flynn LI CC NG/F02</td>
<td>136</td>
<td>1069</td>
<td>89</td>
</tr>
<tr>
<td>9. East River 6-7 NYC ST F06/NG</td>
<td>304</td>
<td>543</td>
<td>20</td>
</tr>
<tr>
<td>10. Brooklyn Navy Yard NYC CC NG/F02</td>
<td>262</td>
<td>1983</td>
<td>86</td>
</tr>
<tr>
<td>11. Cogen Tech-Linden NYC GT/NG</td>
<td>661</td>
<td>4286</td>
<td>74</td>
</tr>
<tr>
<td>12. Poletti 1 NYC ST F06/NG</td>
<td>882</td>
<td>2629</td>
<td>34</td>
</tr>
<tr>
<td>13. Arthur Kill ST 2-3 NYC ST NG/F06</td>
<td>860</td>
<td>675</td>
<td>9</td>
</tr>
</tbody>
</table>

Only 1 of the 9 conventional power plants (> 80MW) in New York City and Long Island has a capacity factor > 50%

* ST Steam Turbine, CC Combined Cycle Turbine, GT Combustion Turbine
NG Natural Gas, F06 Residual Oil, F02 Distillate Oil

** Capacity Factor = 100xGWhGenerated/(365.25x24xMWSummer Capacity/1000)
Current Reliability Standards IV
FERC is now in charge of enforcing standards

The Energy Policy Act of 2005 (EPAct05) was signed into law in August 2005, and it gives greater authority to the Federal Energy Regulatory Commission (FERC) to enforce reliability standards by imposing penalties on end-users if the standards are violated.

In addition, a new organization, the Electric Reliability Organization (ERO), will be given the authority to establish these reliability standards. Prior to EPAct05, FERC was primarily an economic regulator of the wholesale transactions and tariffs on the bulk power system. At this time, it is not clear exactly how FERC will implement the new responsibilities for enforcing reliability.

[FERC will enforce standards for Operating Reliability but not for System Adequacy?]
Load Duration Curves for 2002-05
New York City and Long Island

Reserves --->
Peak --->
Shoulder --->
Baseload --->

Load MW

N.Y.C. & Long Island, 2002-2005

Integrated Load (MW)

Hours/Year
Total Cost of Generation/Year by Type of Generator

Specified Costs

<table>
<thead>
<tr>
<th>Type</th>
<th>Variable Capital ($/MWh)</th>
<th>Capital (k$/MW/Year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak</td>
<td>60</td>
<td>80</td>
</tr>
<tr>
<td>Shoulder</td>
<td>30</td>
<td>159</td>
</tr>
<tr>
<td>Baseload</td>
<td>15</td>
<td>238</td>
</tr>
</tbody>
</table>

Capacity Factors for Least-Cost Choices

- Peak: < 30%
- Shoulder: 30-60%
- Baseload: > 60%
Annual Net-Revenue
Using Short-Run Competitive Prices
= Marginal Operating Cost

Specified Costs
Variable Capital
($/MWh) (k$/MW/Year)
Peak 60 80
Shoulder 30 159
Baseload 15 238

Additional Revenue
Needed to Cover the
Capital Costs
(k$/MW/Year)
Peak 80
Shoulder 80 = 159 - 79
Baseload 80 = 238 - 158
Total Cost of Generation/Year by Type of Generator + Load Shedding

[Textbook Solution]

**Specified Costs**

<table>
<thead>
<tr>
<th>Type</th>
<th>Variable ($/MWh)</th>
<th>Capital (k$/MW/Year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak</td>
<td>60</td>
<td>80</td>
</tr>
<tr>
<td>Shoulder</td>
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<td>159</td>
</tr>
<tr>
<td>Baseload</td>
<td>15</td>
<td>238</td>
</tr>
</tbody>
</table>

**Capacity Factors for Least-Cost Choices**

- **Shed Load**: <10%
- **Peak**: 10-30%
- **Shoulder**: 30-60%
- **Baseload**: >60%

**Shed Load**

- (10% = 36.5 Days/Year)
- $152/MWh

**NERC Reliability Standard**

- (2.4 Hours/Year)
- $33,393/MWh
Annual Net-Revenue
Using Short-Run Competitive Prices + Load Shedding

Specified Costs

<table>
<thead>
<tr>
<th>Type</th>
<th>Variable</th>
<th>Capital</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak</td>
<td>60</td>
<td>80</td>
</tr>
<tr>
<td>Shoulder</td>
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<td>159</td>
</tr>
<tr>
<td>Baseload</td>
<td>15</td>
<td>238</td>
</tr>
</tbody>
</table>

Additional Revenue Needed to Cover the Capital Costs

<table>
<thead>
<tr>
<th>Type</th>
<th>Additional Revenue</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak</td>
<td>0 = 80 - 80</td>
</tr>
<tr>
<td>Shoulder</td>
<td>0 = 159 - 159</td>
</tr>
<tr>
<td>Baseload</td>
<td>0 = 238 - 238</td>
</tr>
</tbody>
</table>

Problem Solved!
PART 3

Paying for Reliability in “Deregulated” Markets: Alternative Solutions

References not yet on <www.e3rg.pserc.cornell.com>
1. Jaeuk Ju
   “Spatial Prices and the Value of Transmission Congestion Credits”
2. Surin Maneevitjit
   “Paying for Reliability in Deregulated Markets”
3. Steen Videbaek
   “Testing Alternative Market Designs for Energy and VArS”
Alternative Ways of Covering the “Missing” Capital in a Competitive Market
($80k/MW/Year needed using Short-Run Competitive pricing)

1. Traditional Regulation
   Set the rates paid by customers to yield a target rate of return on the BOOK value of capital

2. Deregulated Market + Shedding Load (Textbook solution)
   Focus on SHORT-RUN competitive prices, and use load-not-served as an expensive source of “supply” that has NO capital costs

3. Deregulated Market + ICAP (NE states & California?)
   Pay all Installed CAPacity the REPLACEMENT capital cost of a Peaker for being available (showing up) in the spot market

4. Deregulated Market + Price Spikes (Australia & Texas?)
   Allow price spikes and place the primary regulatory focus on maintaining LONG-RUN competitive prices

5. Performance Based Regulation (UK & National Grid?)
   Share profits and losses based on target operating costs
Annual Earnings of a Generator
1. Traditional Regulation

TRADITIONAL REGULATION

Regulators intervene >
< Generator files a rate increase

Actual Net-Revenue: $20-160k/MW/Year
Annual Earnings of a Generator

2. Fully Deregulated Market

No intervention by regulators
Generators bear all financial risk

Actual Net-Revenue: $20-160k/MW/Year
Annual Earnings of a Generator
3. Deregulated Market + ICAP

DEREGULATED MARKET + ICAP
($20k/MW/Year Payment for Installed CAPacity)

Actual ICAP Earnings are Risky
All Capacity is Eligible

Actual Net-Revenue: $20-160k/MW/Year
Annual Earnings of a Generator
3b. Deregulated Market + ICAP

DEREGULATED MARKET + ICAP
Cramton/Stoft Modification

Realized income is less risky
Realized income is capped

Actual Net-Revenue: $20-160k/MW/Year
Annual Earnings of a Generator

4. Deregulated Market + Price Spikes

DEREGULATED MARKET + PRICE SPIKES

Higher and Riskier Net-Revenue in the Spot Market for Peak Capacity

Actual Net-Revenue: $40-200k/MW/Year
Annual Earnings of a Generator

5. Performance Based Regulation

Performance Based Regulation

Actual Net-Revenue: $20-160k/MW/Year

Share excess profits >
< Share losses + a low floor
Average Price Duration Curves for New York City

<table>
<thead>
<tr>
<th>Hours/Year</th>
<th>2000-01</th>
<th>2002-03</th>
<th>2004-05</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>815</td>
<td>336</td>
<td>322</td>
</tr>
<tr>
<td>500</td>
<td>279</td>
<td>188</td>
<td>178</td>
</tr>
<tr>
<td>1000</td>
<td>182</td>
<td>146</td>
<td>141</td>
</tr>
<tr>
<td>5000</td>
<td>80</td>
<td>80</td>
<td>86</td>
</tr>
</tbody>
</table>

Average Price Duration Curves for N.Y.C. (May-April)

(1000 Hours = 11.4% Capacity Factor)
Average Long-Run Cost (LRAC) of Generating Capacity $/MWh

Specified Costs

<table>
<thead>
<tr>
<th></th>
<th>Variable Capital ($/MWh)</th>
<th>Capital (k$/MW/Year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak</td>
<td>70</td>
<td>85</td>
</tr>
<tr>
<td>Baseload</td>
<td>15</td>
<td>155</td>
</tr>
</tbody>
</table>
## The Financial Incentives for Peaking Capacity have Disappeared in the NYC Spot Market

<table>
<thead>
<tr>
<th>Number of hours/year of operation</th>
<th>Minimum LRAC ($/MWh)</th>
<th>Av. Price 2000/01 ($/MWh)</th>
<th>Av. Price 2002/03 ($/MWh)</th>
<th>Av. Price 2004/05 ($/MWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>920</td>
<td>815</td>
<td>336</td>
<td>323</td>
</tr>
<tr>
<td>200</td>
<td>495</td>
<td>517</td>
<td>262</td>
<td>249</td>
</tr>
<tr>
<td>500</td>
<td>240</td>
<td>279</td>
<td>188</td>
<td>178</td>
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<tr>
<td>1200</td>
<td>140</td>
<td>164</td>
<td>136</td>
<td>132</td>
</tr>
<tr>
<td>2000</td>
<td>92</td>
<td>124</td>
<td>113</td>
<td>113</td>
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<tr>
<td>3000</td>
<td>67</td>
<td>101</td>
<td>97</td>
<td>100</td>
</tr>
<tr>
<td>5000</td>
<td>46</td>
<td>80</td>
<td>80</td>
<td>86</td>
</tr>
<tr>
<td>6000</td>
<td>40</td>
<td>74</td>
<td>74</td>
<td>81</td>
</tr>
</tbody>
</table>

Av. Price > LRAC is **RED**
Max. value for each row is **BOLD**
How an ICAP Market Should Work

Implicit Assumptions

- Generation Adequacy is an effective proxy for maintaining NERC/FERC standards of Operating Reliability
- Locational requirements for generation capacity in NYC and LI are an effective proxy for the limitations of the transmission network, and specifying these requirements is the primary responsibility of regulators
- Requiring Load Serving Entities (LSE) to hold contracts for generation capacity to meet forecasted peak load plus a required reserve is an effective way to decentralize decisions about maintaining generation adequacy (similar to a Cap-and-Trade policy for controlling emissions from power plants)
- Ensuring that payments for generation capacity cover the annualized capital cost of peaking capacity when new generation capacity is needed provides a sufficient incentive for investors to build new power plants

Structure of the Capacity Auctions

- The price of Installed Capacity is determined in a voluntary two-sided auction for a six-month strip followed by auctions for individual months
- The final monthly auction requires all LSEs to submit all existing capacity contracts and to purchase additional capacity, if necessary, using a demand curve specified by regulators
Least Cost Mix of Installed Generation Capacity

**Installed Capacity (GW)**

- Baseload (C.F. >60%) 8.7
- Shoulder (C.F. 30-60%) 2.0
- Peak (C.F. 10-30%) 1.3
- Shed Load (C.F. 0-10%) 4.0
- Reserves (C.F. 0-0.03%) 2.0
- **TOTAL 18.0**

**Real Problems for NYC**

1. Insufficient Load Shedding
2. Limits on Baseload Capacity
3. A lot of Peak Capacity with low Capacity Factors and insufficient net-revenues
4. High prices for Natural Gas
Total Cost of Generation/Year by Type of Generator

[Higher Fuel Costs for Peak and Shoulder Capacity]

**Specified Costs**
- **Variable Capital** ($/MWh) (k$/MW/Year)
  - Peak: 128 (60*) 80
  - Shoulder: 38 (30*) 159
  - Baseload: 15 238

**Capacity Factors for Least-Cost Choices**
- Peak: < 10% (30%*)
- Shoulder: 10-40%
- Baseload: > 40% (60%*)

* Optimum values before higher fuel costs
Annual Net-Revenue Using Short-Run Competitive Prices
[Inefficient Mix of Legacy Generators]

The lack of net-revenue is no longer an issue for Shoulder and Baseload, but it is still the big problem for Peak capacity.

Specified Costs

<table>
<thead>
<tr>
<th>Type</th>
<th>Variable Capital</th>
<th>Capital Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>($/MWh)</td>
<td>(k$/MW/Year)</td>
</tr>
<tr>
<td>Peak</td>
<td>128</td>
<td>80</td>
</tr>
<tr>
<td>Shoulder</td>
<td>38</td>
<td>159</td>
</tr>
<tr>
<td>Baseload</td>
<td>15</td>
<td>238</td>
</tr>
</tbody>
</table>

Additional Revenue Needed to Cover the Capital Costs (k$/MW/Year)

- Peak: 80
- Shoulder: -78 = 159 - 237
- Baseload: -117 = 238 - 355
Estimated Annual Net-Revenue of Combined Cycle and Combustion Turbines in Different Locations for 2004

“Capital” is the upper Hudson valley
Source: Figure 16 on p. 23 of the “NYISO 2004 State of the Market Report”
<www.nyiso.com>
### Alternative Ways of Maintaining Generation Adequacy: Summary

<table>
<thead>
<tr>
<th>Allow Price Spikes</th>
<th>Capacity Auction</th>
<th>Power Purchase Agreements</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Real-Time Operations</strong></td>
<td>ISO</td>
<td>ISO</td>
</tr>
<tr>
<td><strong>Regulatory Objective</strong></td>
<td>Long-run Efficiency</td>
<td>Short-run Efficiency</td>
</tr>
<tr>
<td><strong>Volatility of Spot Prices</strong></td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td><strong>Fairness for Generators</strong></td>
<td>Fair</td>
<td>Fair</td>
</tr>
<tr>
<td><strong>Additional Cost to Customers</strong></td>
<td>Low?</td>
<td>High</td>
</tr>
<tr>
<td><strong>Regulatory Responsibility</strong></td>
<td>Fully Decentralized</td>
<td>Set Reserve Margins</td>
</tr>
<tr>
<td><strong>Length of Commitment</strong></td>
<td>None</td>
<td>1-3 Years</td>
</tr>
<tr>
<td><strong>Sufficient for Adequacy?</strong></td>
<td>No?</td>
<td>No</td>
</tr>
</tbody>
</table>
Conclusions

- **Generation Adequacy** is a minimal requirement for maintaining the reliability of supply because blackouts are very expensive.
- The electric supply system is unforgiving, and policies for maintaining Generation Adequacy must be **sufficient**.
- The **Australian market** works because allowing price spikes results in an average price duration curve that approximates the long-run average costs of different types of capacity. However, it is **risky for operations and investment** and is NOT sufficient.
- Giving more $ to all generators in New York through an **ICAP market** is **expensive**, NOT necessary and definitely NOT sufficient.
- Current shortfalls of capacity in New York State will probably be met in mysterious ways through **ad hoc Power Purchase Agreements (PPA)**. In other words, the customers in the state will have to **pay twice**.
- There is a better way even if the Australian solution is ruled out but it will have to be **discriminatory**. PPAs will be necessary, and regulators should develop **explicit rules** for identifying eligible capacity (i.e. needed for reliability). Eligible generators should be given a **choice** between relying on market outcomes or getting some form of **Performance Based Return**.