The Evolution of Capacity Markets in the USA

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OUTLINE

• A Fork on the Road to Deregulation
  • Speculation by generators (price spikes) is almost inevitable
  • 1. Accept price spikes in an energy-only market (LRMC pricing)
  • 2. Suppress speculative behavior (SRMC pricing)
  • AND use a Capacity Market to cover the “Missing Money”

• Meeting Reliability Standards in New York State
  • Locational capacity requirements for New York State
  • Average price duration curves and long-run average costs
  • Augmented capacity market (New York’s “demand” curve)

• Summary Evaluation of Generation Adequacy
  • Forward Capacity Market in New England
  • Implications when the mix of generating capacity is not least-cost
  • Conclusions
Investment Incentives and Investment Decisions

• **Typical Regulated Market**
  – LMP is based on the true operating costs
  – Generators are paid for actual costs incurred
  – Capital costs are based on book values
  – Investment decisions are made by a planning process

• **Typical Deregulated Market**
  – LMP is based on generators’ offers to sell
  – LMP determines the payments to generators
  – Transmission is still regulated and usually partially planned
  – Decentralized decisions used for investment in generation
  – Replacement cost of capital replaces the book value
  – Generators’ income is much more fungible
A Fork on the Road to Deregulation: Energy-Only Wholesale Market or Wholesale Market + Capacity Market
Reserve Margins for Generating Capacity in a Typical Regulated Region

Florida

FRCC Capacity Margins - Summer

- 2006 Projection
- 2005 Projection
- 2004 Projection
- 2003 Projection
Reserve Margins for Generating Capacity in a Typical Deregulated Region

New York and New England
Daily Spot Prices in New York City
(1/7/99 - 1/7/05 at 2PM, $/MWh)

Automatic Mitigation Procedures have suppressed high prices. A regulatory response to the Californian Energy Crisis?
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>

(1000 Hours = 11.4% Capacity Factor)
The Financial Incentives for Peaking Capacity have Disappeared in New York City

<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>860</td>
<td>815</td>
<td>336</td>
<td>323</td>
</tr>
<tr>
<td>200</td>
<td>460</td>
<td>517</td>
<td>262</td>
<td>249</td>
</tr>
<tr>
<td>500</td>
<td>220</td>
<td>279</td>
<td>188</td>
<td>178</td>
</tr>
<tr>
<td>1200</td>
<td>126</td>
<td>164</td>
<td>136</td>
<td>132</td>
</tr>
<tr>
<td>2000</td>
<td>100</td>
<td>124</td>
<td>113</td>
<td>113</td>
</tr>
<tr>
<td>3000</td>
<td>87</td>
<td>101</td>
<td>97</td>
<td>100</td>
</tr>
<tr>
<td>5000</td>
<td>76</td>
<td>80</td>
<td>80</td>
<td>86</td>
</tr>
<tr>
<td>6000</td>
<td>73</td>
<td>74</td>
<td>74</td>
<td>81</td>
</tr>
</tbody>
</table>

Av. Price > Long Run Average Cost (LRAC) is **RED**
Max. value for each row is **BOLD**
Total Cost of Generation/Year by Type of Generator

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

Capacity Factors for Least-Cost Choices
Peak    < 30%
Shoulder 30-60%
Baseload  > 60%
Annual Net-Revenue
Using Short-Run Marginal Cost Pricing
= Marginal Operating Cost

Specified Costs

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

Missing Money Needed to Cover the Capital Costs (k$/MW/Year)

<table>
<thead>
<tr>
<th>Type</th>
<th>Capital</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak</td>
<td>80</td>
</tr>
<tr>
<td>Shoulder</td>
<td>80 = 159 - 79</td>
</tr>
<tr>
<td>Baseload</td>
<td>80 = 238 - 158</td>
</tr>
</tbody>
</table>
Total Cost of Generation/Year by Type of Generator + Load Shedding

[Textbook Solution: Scarcity Pricing]

**TOTAL COST OF GENERATION BY TYPE OF GENERATOR + LOAD SHEDDING**

**Specified Costs**

<table>
<thead>
<tr>
<th></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>
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<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 (Scarcity Pricing)

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### Specified Costs

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

### Missing Money Needed to Cover the Capital Costs (k$/MW/Year)

<table>
<thead>
<tr>
<th>Type</th>
<th>Calculation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak</td>
<td>$80 - 80</td>
</tr>
<tr>
<td>Shoulder</td>
<td>$159 - 159</td>
</tr>
<tr>
<td>Baseload</td>
<td>$238 - 238</td>
</tr>
</tbody>
</table>

**Problem Solved!**

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![Graph showing annual net-revenue by type of generator.](image-url)
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
The Regulatory Choice at the Fork on the Road to Deregulation

- **Energy-Only Market**
  - Allow some price spikes to occur
  - Scarcity pricing or speculative behavior?
  - Monitor the relationship between AVERAGE ANNUAL prices and LONG RUN Marginal Costs (LRMC)

- **Wholesale Market + Capacity Market**
  - Monitor the relationship between MARGINAL HOURLY prices and the SHORT RUN Marginal Costs (SRMC)
  - Implement Automatic Mitigation Procedures
  - Use a Capacity Market to cover the “Missing Money”
  - Assume that all generating units should be paid the SAME AMOUNT in the Capacity Market
The Choice Made in Different Deregulated Markets

- **Energy-Only Market**
  - Texas (new)
  - Alberta
  - Australia

- **Wholesale Market + Capacity Market**
  - New York State (LICAP Market)
  - New England (new FCM)
  - PJM (new RPM)
  - Midwest (like PJM?)
  - California (still to be determined)

- **Objective for this presentation**
  - Focus on Generation Adequacy in New York City
PART 2

Meeting Reliability Standards in New York State
## Current Reliability Standards

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

### Map of New York Control Area Load Zones

- NYC: New York City (J)
- LI: Long Island (K)
- NYCA: New York Control Area
How the LICAP 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 when needed

• Structure of the LICAP Market
  – 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
The annual payment to generators in NYC is over $1 billion/year, but this is still not enough to bring in new merchant capacity.

The observed price is set by a regulated price cap on the annual payments made to incumbent generators - market power is exploited effectively.
Estimated Annual Net-Revenue of Combined Cycle and Combustion Turbines in Different Locations for 2004

Earnings from the Capacity Market are very important for the financial viability of Peaking Units in NYC and LI.

“Capital” is the upper Hudson valley
Source: Figure 16 on p. 23 of the “NYISO 2004 State of the Market Report”
<www.nyiso.com>
Generation Adequacy in Reality
Projected Reserve Margins for New York

NYISO standard ---
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
The Overall Performance of the LICAP Market in New York

- **Generation Adequacy** is a minimal requirement for maintaining the reliability of supply because blackouts are very expensive. Since the electric supply system is unforgiving, policies for maintaining Generation Adequacy must be **sufficient**.

- An **Energy-Only Market** works because allowing price spikes results in an average price duration curve that approximates the **long-run average costs** of different types of generating capacity. However, it is **financially risky for generators and investment** and it is **NOT sufficient**.

- Giving more **>$1 billion/year** to generators in New York City through the LICAP market is expensive, **NOT necessary** and definitely **NOT sufficient**. Current payments increase the market value of installed generating units but have not resulted in new investment. **Profits are fungible**.

- Projected shortfalls of capacity in New York City will be met by last-minute schemes (e.g. delay retirements and count transmission links to PJM). **Decisions are made too late to be economically efficient**.

- To maintain Generation and Transmission Adequacy effectively, it is essential to **plan ahead** and provide enough time for the completion of new construction projects.
PART 3

Summary Evaluation of Generation Adequacy and the Forward Capacity Market Proposed by ISO-NE
Proposed Improvements in the ISO-NE Forward Capacity Market (FCM)

- **Purchase Generation Capacity THREE Years Ahead**
  - This allows NEW ENTRANTS and incumbent firms to participate in the FCM and build new (peaking) capacity if their offer prices are accepted in the auction. In addition, the market price can be locked-in for up to FIVE years for any new capacity.

- **The Ability of Incumbent Firms to Exploit the Auction is Restricted by the ISO**
  - The ISO requires all installed capacity to enter the auction, authorizes all exceptions (e.g. having a contract to export firm capacity), and enforces a low cap on the offer prices submitted for installed capacity (new capacity can submit higher offers).

- **ISO Announces How Much Capacity to Purchase in Advance**
  - A DESCENDING CLOCK Auction is used to purchase a specified amount of capacity. Hence, all potential sources of capacity are in the auction initially, and it is possible for the ISO to cancel the auction if insufficient capacity is offered to make the auction reasonably “competitive”.

- **Specify Capacity Requirements for sub-regions (ZONES)**
  - This enables the ISO to specify more stringent capacity requirements for congested regions, such as Boston and SW Connecticut. The market-clearing prices of capacity may be higher in these congested zones.

- **Use “Excess” Earnings in the Spot Market to Reduce FCM Earnings**
  - Earnings in the FCM are treated as a “Make-Whole” Payment to supplement earnings in the spot market for real energy. Earnings in the spot market above a specified cap (e.g. $150/MWh) reduce payments for capacity in the FCM.
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
Effects of Doubling the Cost of Natural Gas on the Profits of Generators

LOW COSTS: Mix of Generating Capacity is Least-Cost
HIGH COSTS: Mix of Generating Capacity is Unchanged

Annual Profit for Installed Capacity

<table>
<thead>
<tr>
<th>Type of Generation</th>
<th>LOW COSTS Profit ($/kW/Year)</th>
<th>HIGH COSTS Profit ($/kW/Year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peaking</td>
<td>-80</td>
<td>-80</td>
</tr>
<tr>
<td>Shoulder</td>
<td>-80</td>
<td>+159</td>
</tr>
<tr>
<td>Baseload</td>
<td>-80</td>
<td>+238</td>
</tr>
</tbody>
</table>

The standard economic rationale for paying all generating units the same price in a capacity market is NO LONGER VALID with HIGH COSTS
Total Cost of Generation/Year by Type of Generator

[Higher Fuel Costs for Peak and Shoulder Capacity]

**Specified Costs**

<table>
<thead>
<tr>
<th>Type</th>
<th>Variable Capital ($/MWh)</th>
<th>Capital Cost (k$/MW/Year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak</td>
<td>128 (60*)</td>
<td>80</td>
</tr>
<tr>
<td>Shoulder</td>
<td>38 (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**: $< 10\%$ (30%*)
- **Shoulder**: 10-40%
- **Baseload**: $> 40\%$ (60%*)

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

ANNUAL NET-REVENU BY TYPE OF GENERATOR (without Load Shedding)

Specified Costs

<table>
<thead>
<tr>
<th>Type</th>
<th>Variable ($/MWh)</th>
<th>Capital (k$/MW/Year)</th>
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<td>238</td>
</tr>
</tbody>
</table>

Annual Profit for the Legacy Mix of Capacity
(k$/MW/Year)

<table>
<thead>
<tr>
<th>Type</th>
<th>Profit (k$/MW/Year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak</td>
<td>-80</td>
</tr>
<tr>
<td>Shoulder</td>
<td>78 = 237 - 159</td>
</tr>
<tr>
<td>Baseload</td>
<td>117 = 355 - 238</td>
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</table>
# Alternative Ways of Maintaining Generation Adequacy: Summary

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

• **Maintaining the Reliability of Supply**
  – Generation and Transmission Adequacy are essential regulatory responsibilities because blackouts are very costly for customers
  – Merchant projects can contribute, but some form of planning ahead is essential to maintain reliability effectively
  – Many generating units needed for reliability have low capacity factors and low annual earnings --- a genuine financial problem

• **Conclusions about Capacity Markets**
  – Designed by regulators for markets using SRMC pricing to provide the “missing money” for generators
  – Purchasing capacity ahead of time is a step in the right direction because it is consistent with planning and purchases are backed by the ISO
  – One price (policy instrument) does NOT meet all of the needs for New Capacity, Peaking Units, and Baseload Capacity
  – Earnings are more fungible in deregulated markets. The real problem in NYC is “Missing Investment” not “Missing Money”
  – It is still too early to determine if the new forms of capacity market proposed for New England and PJM will be economically efficient