Capacity Markets: *Principles & What's Happening in the US*

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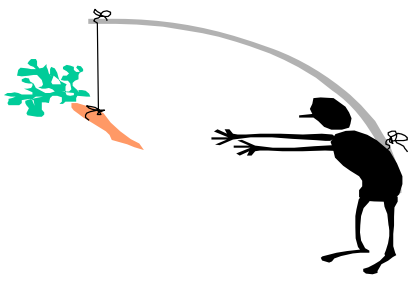
Outline

1. **Why markets for capacity?**
2. **Design choices**
3. **Designing the PJM market ("RPM")**
   - **Dynamic simulation**
4. **Have capacity markets delivered?**
5. **Conclusions**



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1. Why Markets for Capacity?

- **Adequacy ≡ Sufficient installed generation & transmission capacity to:**
  - **Meet electric load with acceptable P(outage)**
    - ***….engineering definition***
  - **Clear market; P's/Q's at efficient levels**
    - **.... *economics definition***

- **Who's responsible?**
  - **In a market, individual generators not responsible for (engineering) adequacy**
  - **Governments are! Directive 2005/89/EC:**
    - **'The guarantee of a high level of security of electricity supply is a key objective for the successful operation of the internal market …**
    - **'Measures which may be used to ensure that appropriate levels of generation reserve capacity are maintained'**

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Why Not Just Use Energy Markets?

- **Saint Fred's (Schweppe) 1978 vision of a demand-responsive market unfulfilled**
  - **Demand-side market failures lead to wrong P's, capacity shortages**
- **Reasons:**
  - **No market information on value of reliability**
    - **Height of price spikes reflect:**
      - **regulatory decisions**
      - **willingness of ISOs and suppliers to stomach political fallout**
    - **Least valued uses not curtailed during shortages**
    - **Long-term contracts with consumers infeasible**

    ⇒Optimal amount of capacity unlikely under a pure energy market
  - **Bid & price caps in response to market power**

    ⇒'Missing money' – energy revenues don't cover peaker fixed costs
- **Cost of overcapacity << Cost of undercapacity**

  ⇒ Capacity markets = insurance

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In response to California melt-down:

– ***(I)n this highly integrated business, where the system requires everyone, and not just the visionary, to be prudent or face losing service and paying high spot prices, enforced customer-side planning ahead will be a small price to pay to avoid … periodic reliability crises with energy price booms followed by price busts***

(FERC Chairman Hoecker, 4 Jan. 2001, Docket Nos. EL00-95-000,002,003)

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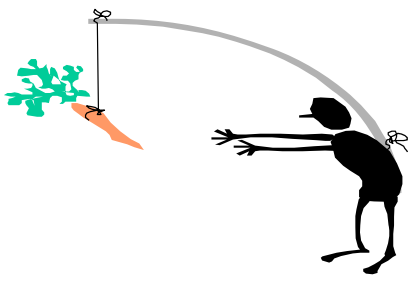

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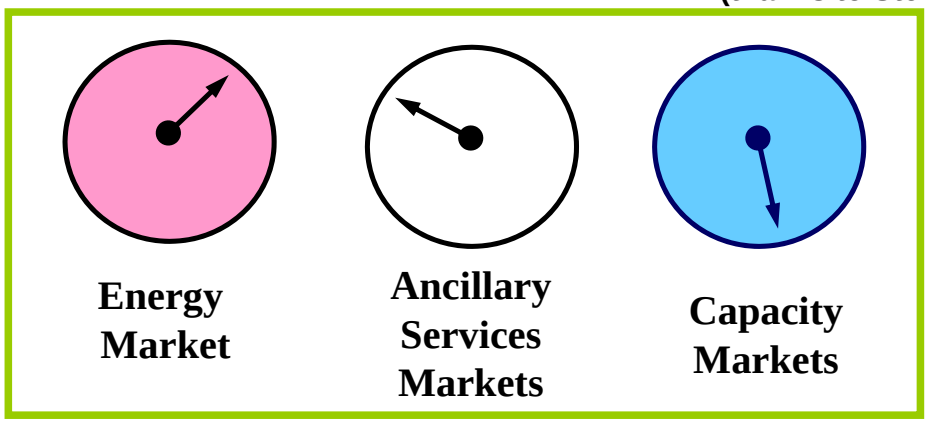
2. Design Choices

Key to Power Market Design: *Balance the Three Dials*
(thanks to Steve Stoft)



- Dials: scarcity pricing, market power mitigation rules, …
- Settings should:
  - ***Prevent market power abuse***
  - ***Provide appropriate investment incentives***
    - **Ample when generation shortage**
    - **Absent under surplus**

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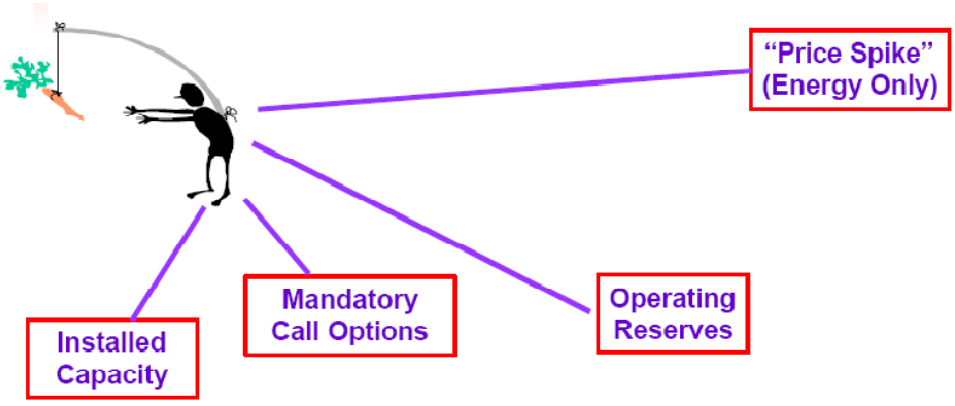
How Can Market Designers Respond?

1. **Demand-side / pricing reforms**
   - **Correct the market failure**
2. **Mandatory contracts (“bottom up”)**
3. **Capacity markets (“top down”)**



‘Set Quantity’ vs. ‘Set Price’ debate

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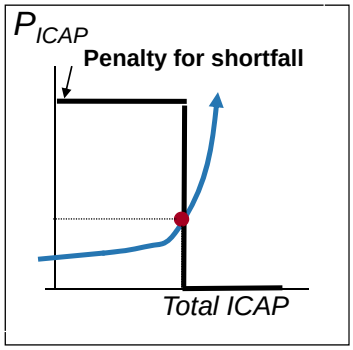
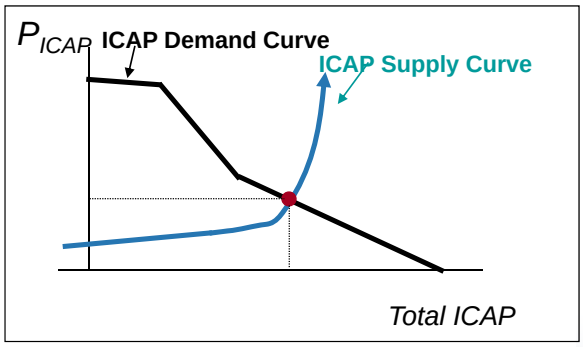
ICAP Variant: Demand Curves for Capacity

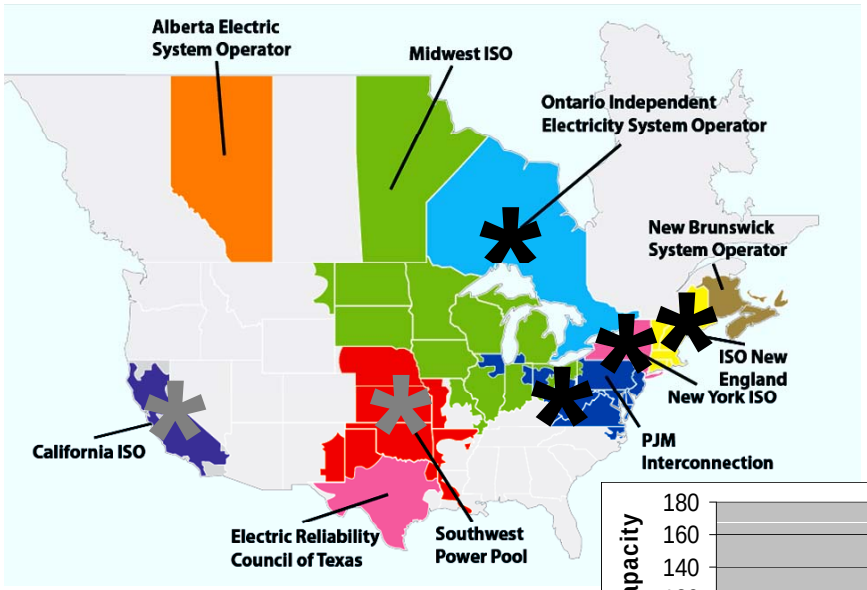


Old ICAP systems: fixed requirements, with penalty for falling short ("vertical demand")

New systems: Administrative payment from ISO depends on reserve margin

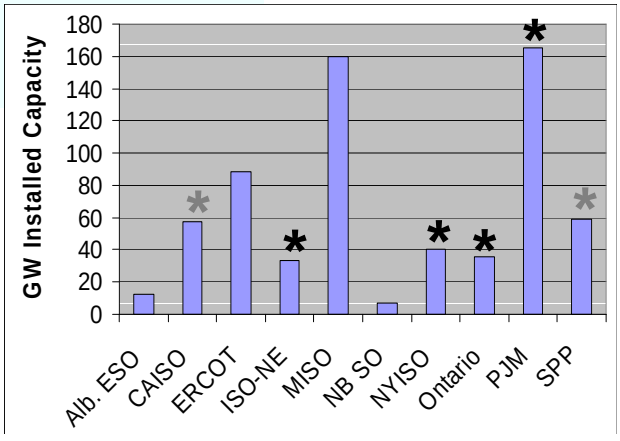


Status of Capacity Markets in North America



* Mandatory capacity markets

* Capacity requirement



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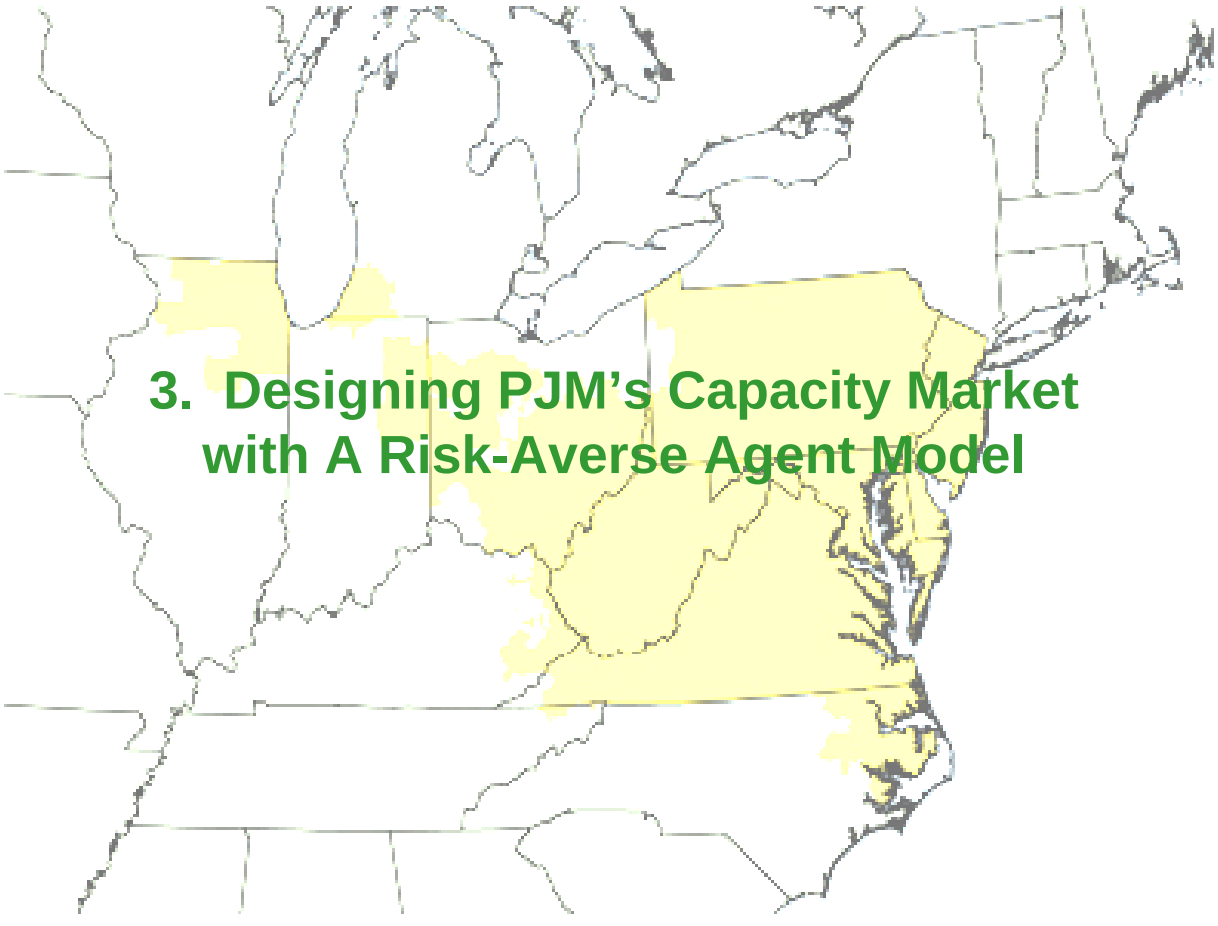
Desirable Design Features

- **Reward availability when valuable**
  - **Scarcity pricing in energy market**
  - **Penalize plant unavailability during shortages**
- **Pay all capacity**
  - **Reward renovation as well as new-build**
  - **Don't discriminate among capacity types**
  - **Pay transmission & demand-response**
    - ***Beware double-payments***
- **Avoid exacerbating volatility**
- **Pay locationally**
- **Contract 2-3 years ahead**
- **Adapt**



3. Designing PJM's Capacity Market with A Risk-Averse Agent Model

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Overview of PJM "Reliability Pricing Model" (RPM)

1. **Previous PJM system: ICAP**
   - Vertical demand curve
     - *Volatile prices: Discouraged risk-averse investors*
   - One market covering PJM
     - *Didn't reflect locational value: capacity in wrong places*
   - Short-term (annual, monthly, daily markets)
     - *Insufficient forward signal*

2. **RPM proposal:**
   - Locational 3 yr-ahead prices, sloped demand
   - Development schedule:
     - Stakeholder process, JHU analysis 2004-2005
     - August 2005: initial filing
     - Settlement talks, Fall 2006, JHU reanalysis
     - FERC approved settlement, Dec. 2006
     - Implemented: June 2007

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Dynamic Analysis: Questions

1. **How do different RPM curves affect….**
   - *Stability of capacity market?*
   - *Costs to consumers?*
   - *Ability to meet reserve criterion?*

2. **How robust are these conclusions to different assumptions about….**
   - *Generator behavior?*
   - *Demand curve parameters?*

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PJM Dynamic Analysis: Basic Assumptions

- **Capacity additions are a dynamic process, depending on:**
  1. ***Forecast revenue streams***
     More forecast net revenue
     ⇨ more investment
  2. ***Revenue stream variability***
     – **Due to forecast changes, economic fluctuations, & weather**
     Highly variable energy and capacity prices
     ⇨less investment (due to risk aversion)
     ⇨boom/bust cycles
  3. ***Risk attitudes*:**
     – **Risk aversion**
     – **Short-sightedness**

- **Simulate peaker profitability/investment over time**
  - **Representative agent model**
  - **Simple representations of:**
    - **Risk aversion**
    - **Forecasts of energy, ancillary services, capacity revenues**
    - **Investment rules**

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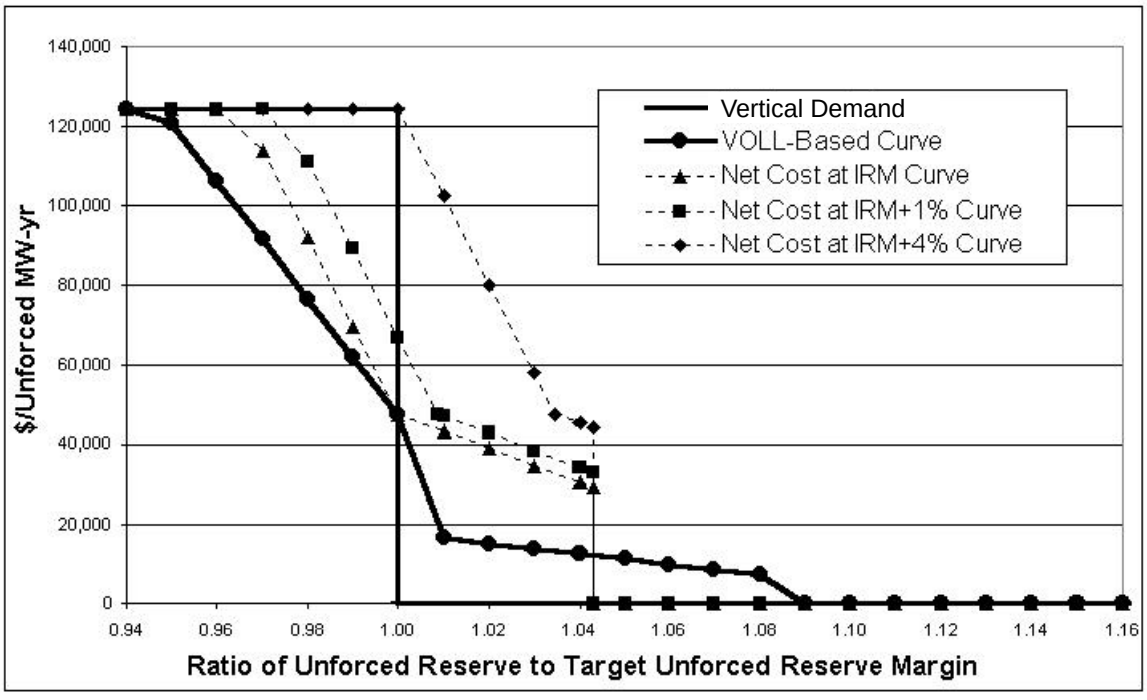
Initial PJM Analysis: 5 Curves Considered



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PJM Results: Summary

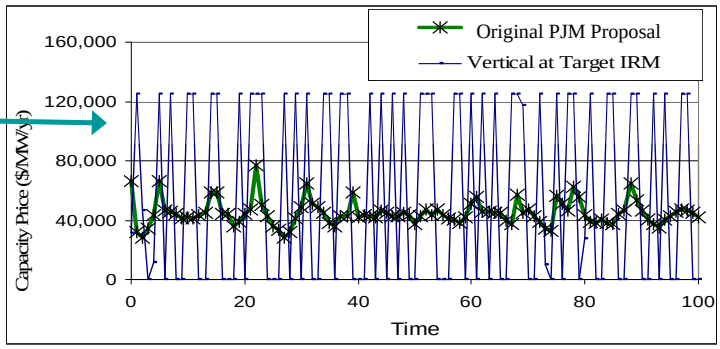
1. **Sloped curve stabilizes capacity payments**

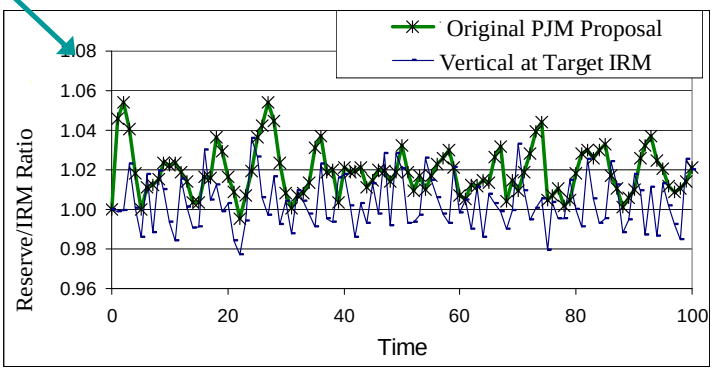
2. **More stable payments even out investment, forecast reserves**

3. **More stable revenues lowers capital costs. Consumer costs (capacity, scarcity) fall:**
   - *$127/peak kW/yr for vertical*
   - *$71/peak kW/yr for sloped curve*

   (values depend on assumptions)

4. **Results robust**





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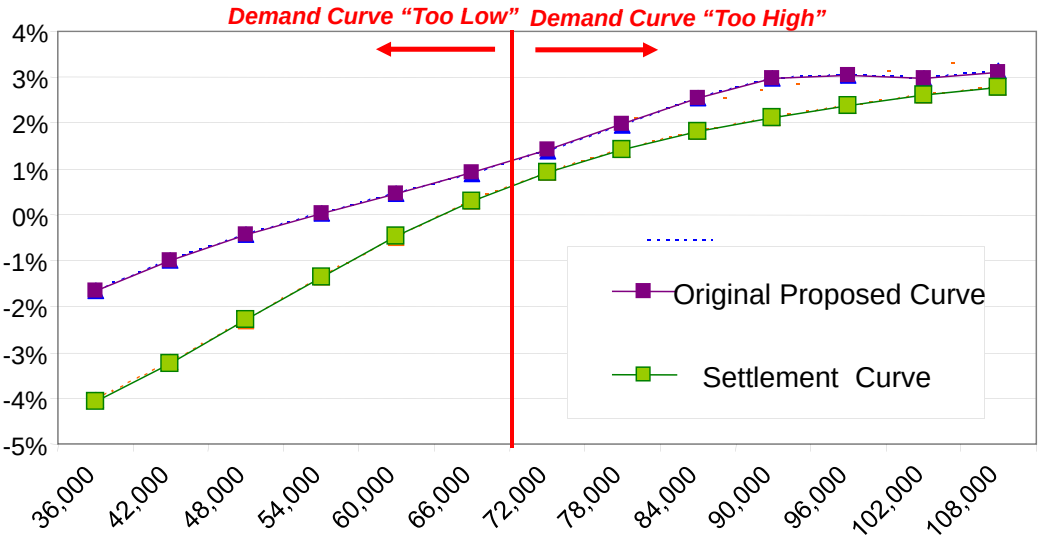
But misguessing the "Cost of New Entry" can affect system performance

Average % by which actual reserve margin exceeds target



CONE Assumed by Curve (actual developer CONE fixed at $72,000/MW/yr)

From R. Earle et al., "Summary of Probabilistic Analysis of the PJM Reliability Pricing Model," Brattle Group, Presentation to PJM, June 30, 2008; Used Hobbs et al. (2007) model

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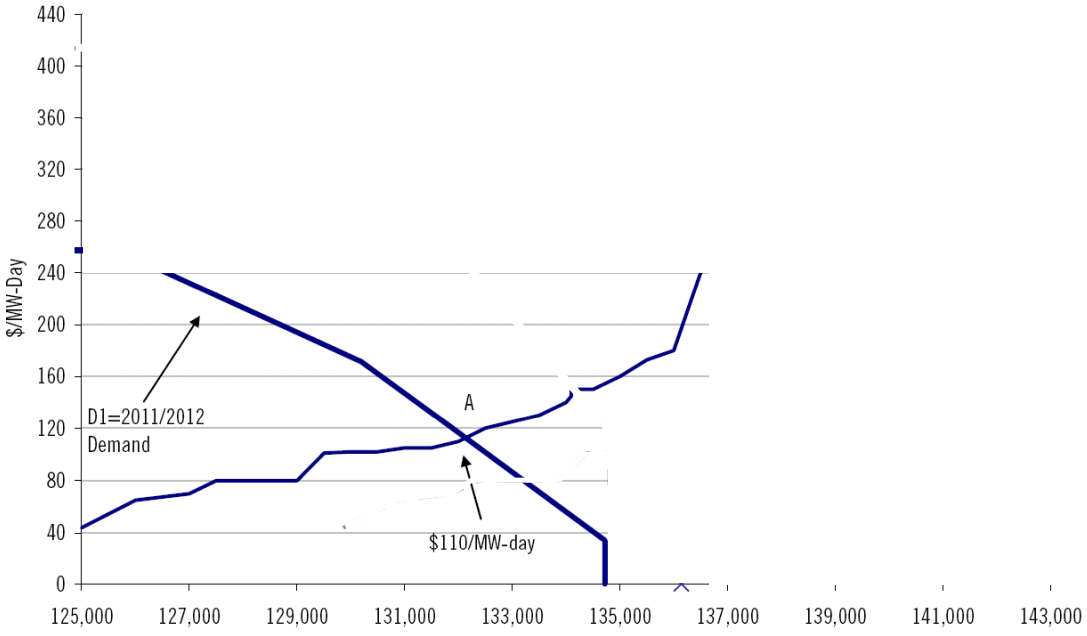
Changing PJM Demand & Supply Curves Over Time



B. Chin, Capacity Markets Update: Lowering RPM Forecast Again Due To FERC & Demand Response, Citigroup, www.citigroupgeo.com/pdf/SNA32260.pdf

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PJM Conclusions: Advantages of Sloped Demand

- **Compared to vertical demand, lower risk to generators. Result:**
  - ***Lower required return to capital***
  - ***More investment in generation***
  - ***Dampened capacity cycles***
  - ***Lower consumer cost***
- **More advantageous if generators more risk averse**
  - ***Risk neutrality ⇒ sloped demand unnecessary***

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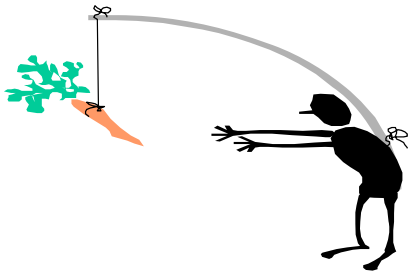

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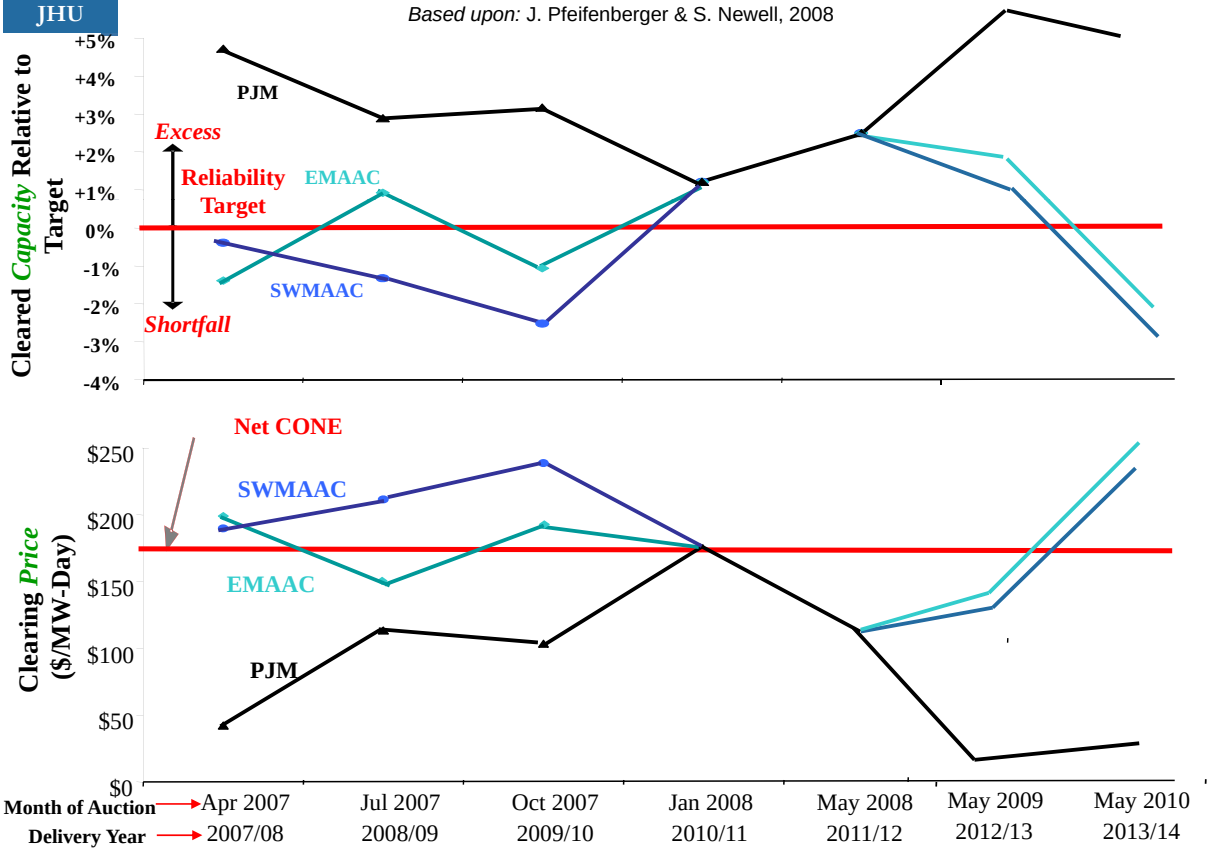
4. Have Capacity Markets Delivered? PJM & ISO-NE

Based upon: J. Pfeifenberger & S. Newell, 2008



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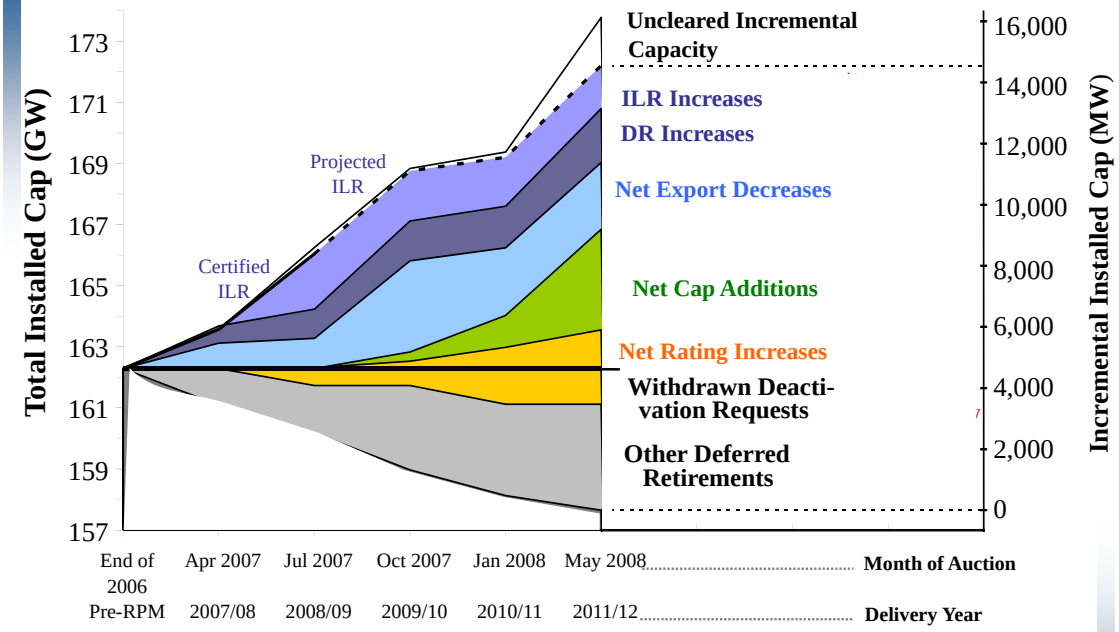
Breakdown of New & Retained Resources



Source: J. Pfeifenberger & S. Newell, "Review of PJM's Reliability Pricing Model," Brattle Group, Presentation to PJM Stakeholders, July 11 2008

Net additional resources in 2012/13: +7210 MW
2013/14: +2908 MW

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Brattle Report Conclusions

- **RPM successfully achieved its reliability & economic objectives**
  - **Attracted resources**
    - ~10,000 MW of additional new capacity
    - ~4,500 MW of capacity that would otherwise have retired
- **Recommended maintaining basic design elements**
  - **sloped demand curve**
  - **3-year forward time frame**

From J. Pfeifenberger & S. Newell, "Review of PJM's Reliability Pricing Model," Brattle Group, Presentation to PJM Stakeholders, July 11 2008

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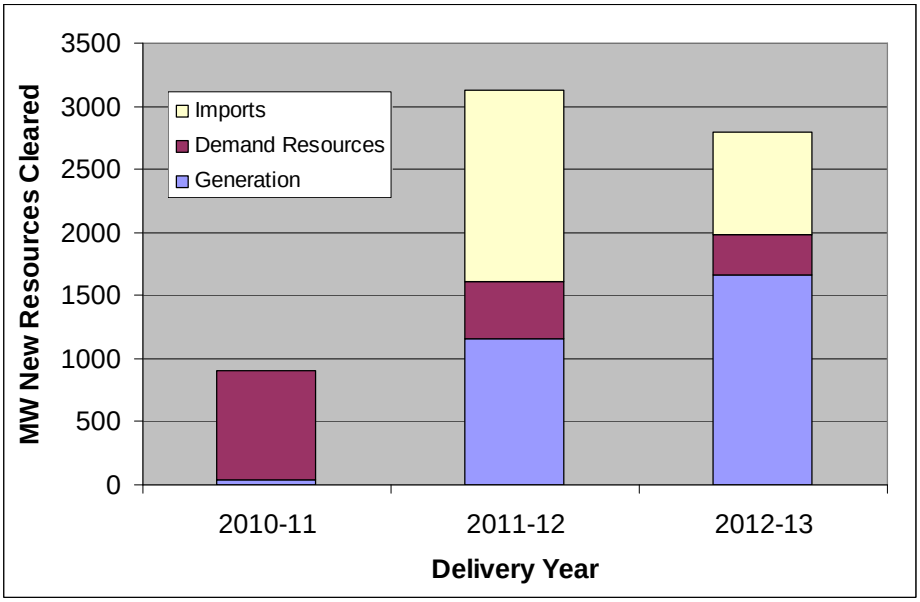
ISO-New England

- **The "Forward Capacity Market" has cleared large amounts of new capacity**



Source: Internal Market Monitoring Unit, 2009 Annual Markets Report, ISO-New England, May 18, 2010

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5. Conclusions

- **Challenges to capacity markets (e.g., Brattle et al.)**
  - **Political consequences of explicit capacity costs**
  - **Contentious administrative decisions:**
    - ***Right amount of capacity?***
    - ***CONE?***
    - ***Load forecast?***
  - **Monitoring/verifying demand response**
  - **Tension between short- (demand) & long-term (gen) resources**
  - **Transition to "promised land" of energy-only markets**
  - **Buyer market power**

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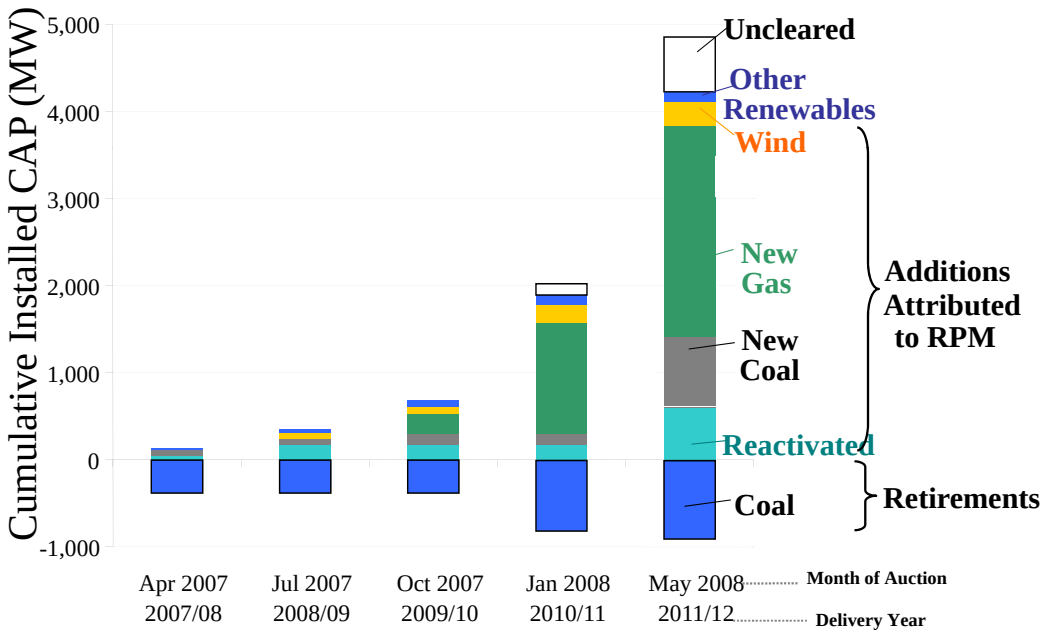
New Generation Capacity Breakdown in PJM



Source: *Brattle* analysis of PJM RPM data.
Note: A small amount of new oil (~21 MW), retired oil (~46 MW), and retired gas (~11 MW) not shown.

From J. Pfeifenberger & S. Newell, "Review of PJM’s Reliability Pricing Model,“ Brattle Group, Presentation to PJM Stakeholders, July 11 2008