

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

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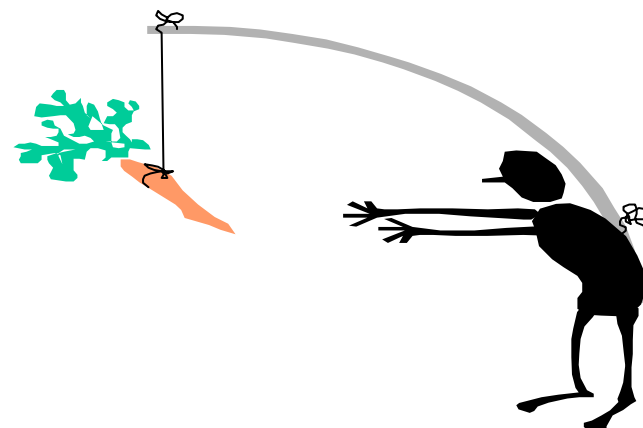
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1. Why markets for capacity?
2. Design choices
3. Designing the PJM market (“RPM”)
  - Dynamic simulation
4. Have capacity markets delivered?
5. Conclusions



# 1. Why Markets for Capacity?

- **Adequacy  $\equiv$  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'

# 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  $\ll$  Cost of undercapacity**
  - ⇒ Capacity markets = insurance

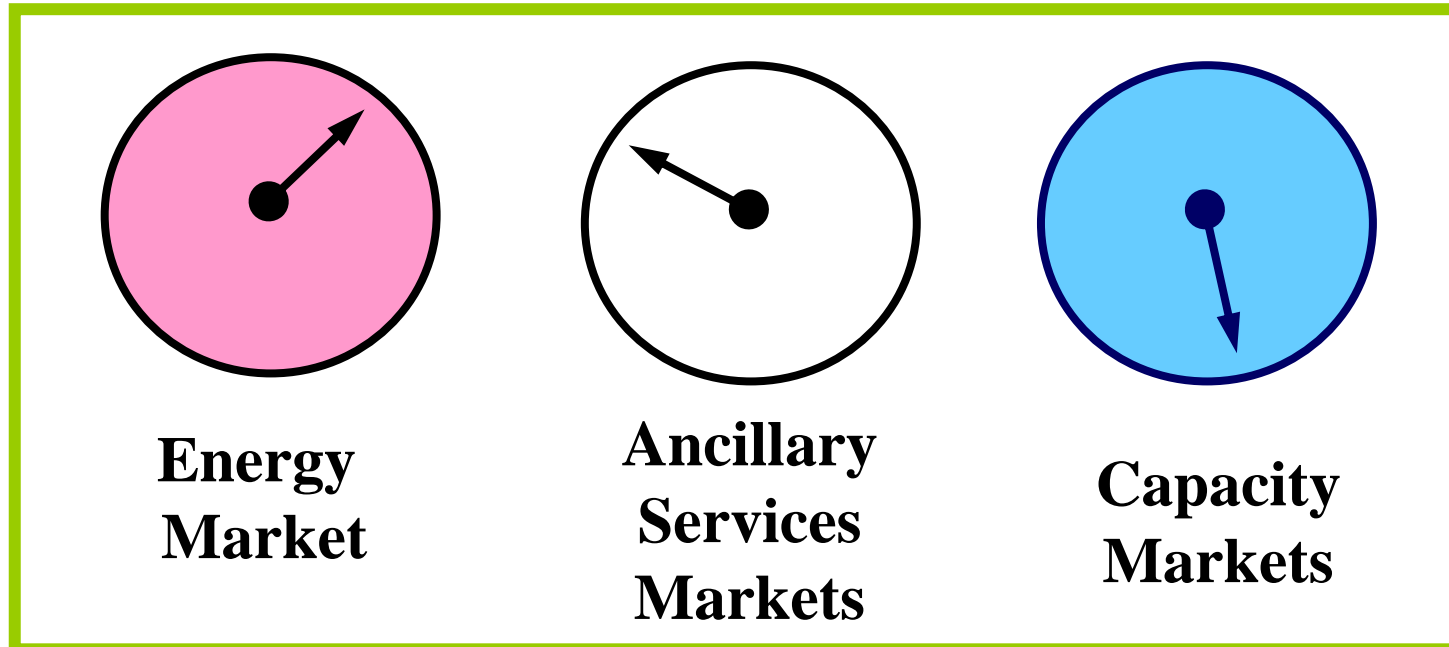
## **In response to California melt-down:**

- (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)**

## 2. Design Choices

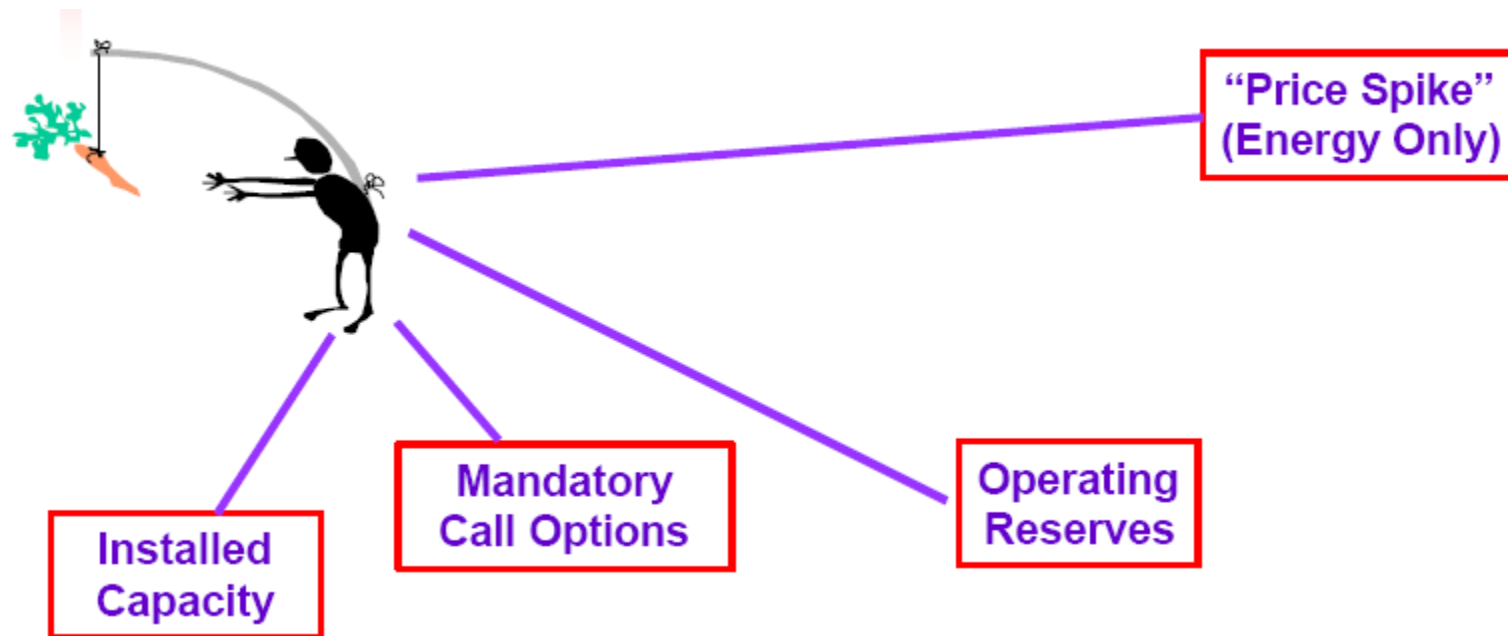
Key to Power Market Design: *Balance the Three Dials*  
(thanks to Steve Stoft)



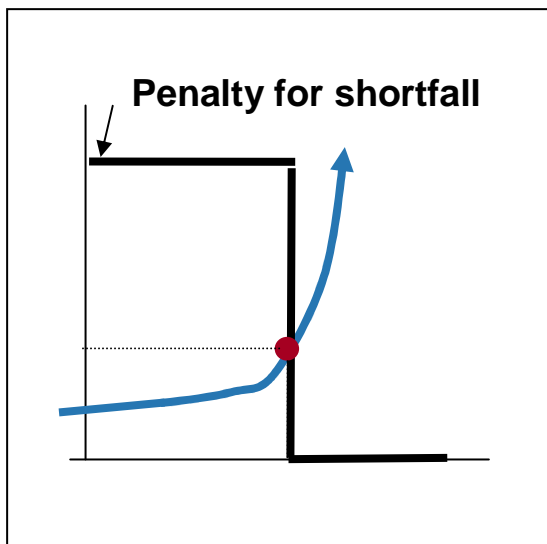
- Dials: scarcity pricing, market power mitigation rules, ...
- Settings should:
  - *Prevent market power abuse*
  - *Provide appropriate investment incentives*
    - Ample when generation shortage
    - Absent under surplus

# How Can Market Designers Respond?

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

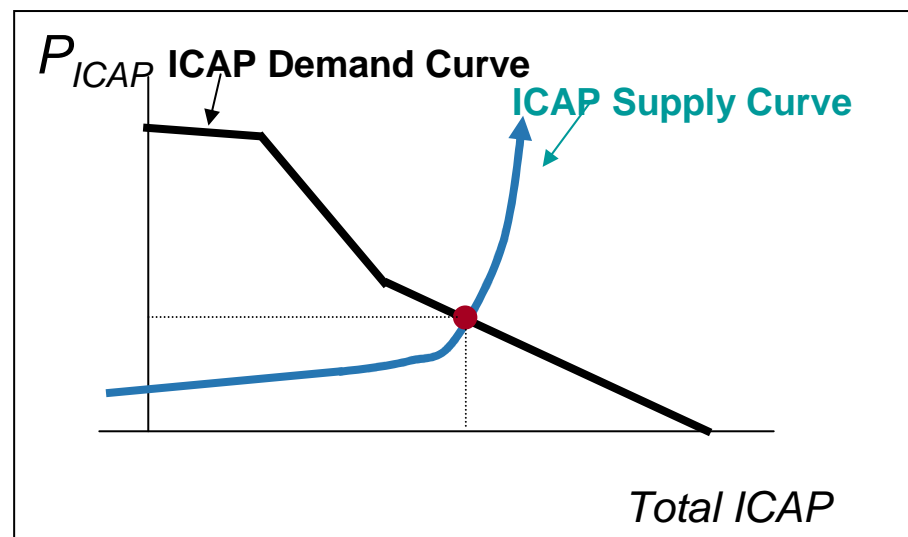


# ICAP Variant: Demand Curves for Capacity



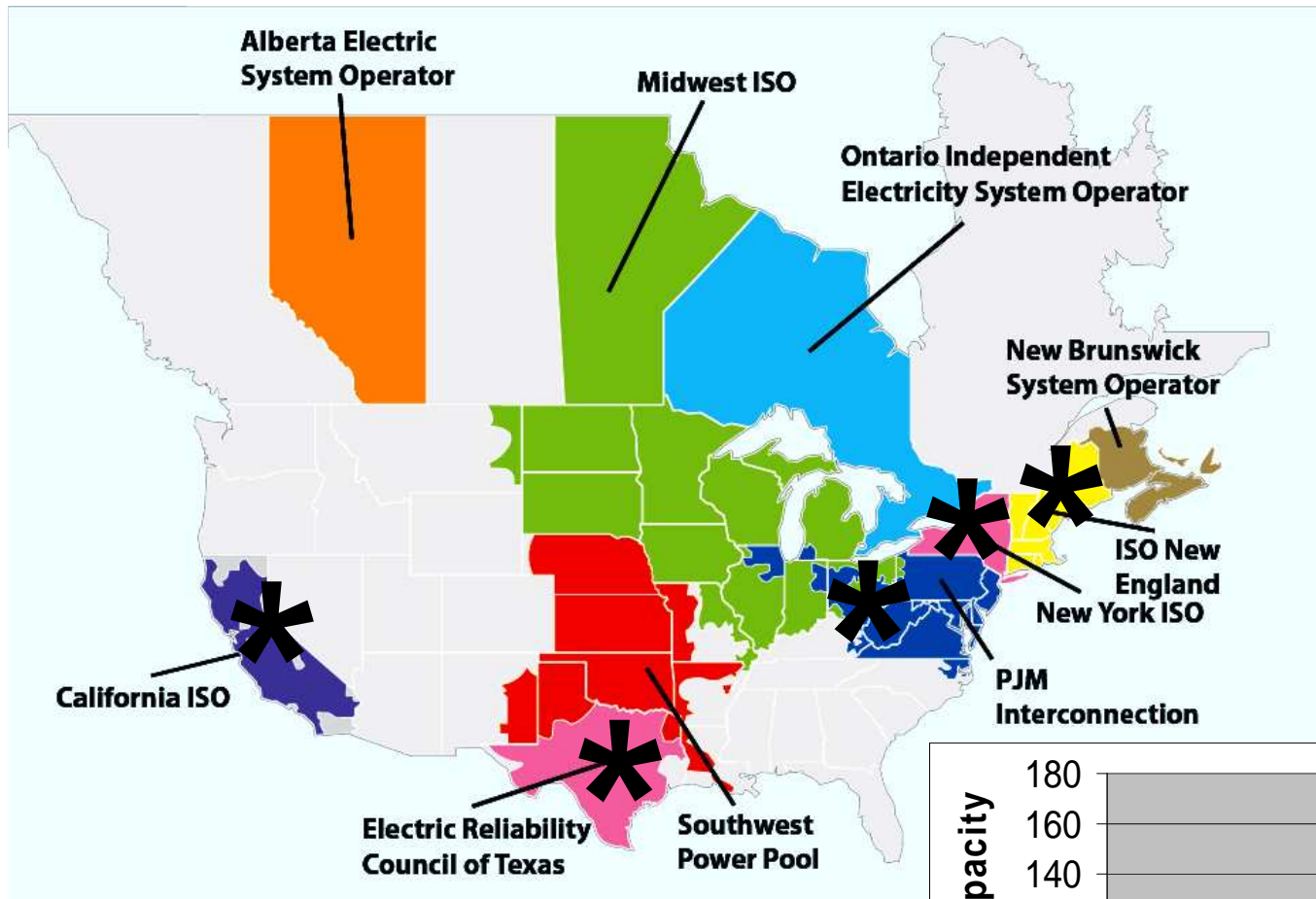
**Old ICAP systems: fixed requirements, with penalty for falling short (“vertical demand”)**

**New systems: Administrative payment from ISO depends on reserve margin**

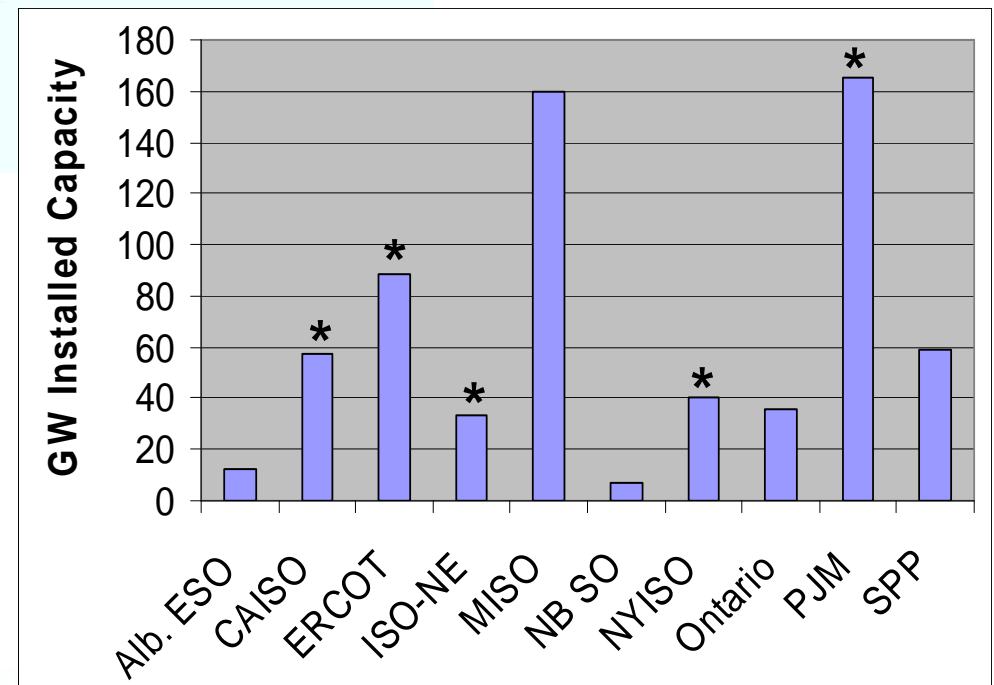




# Status of Capacity Markets in North America



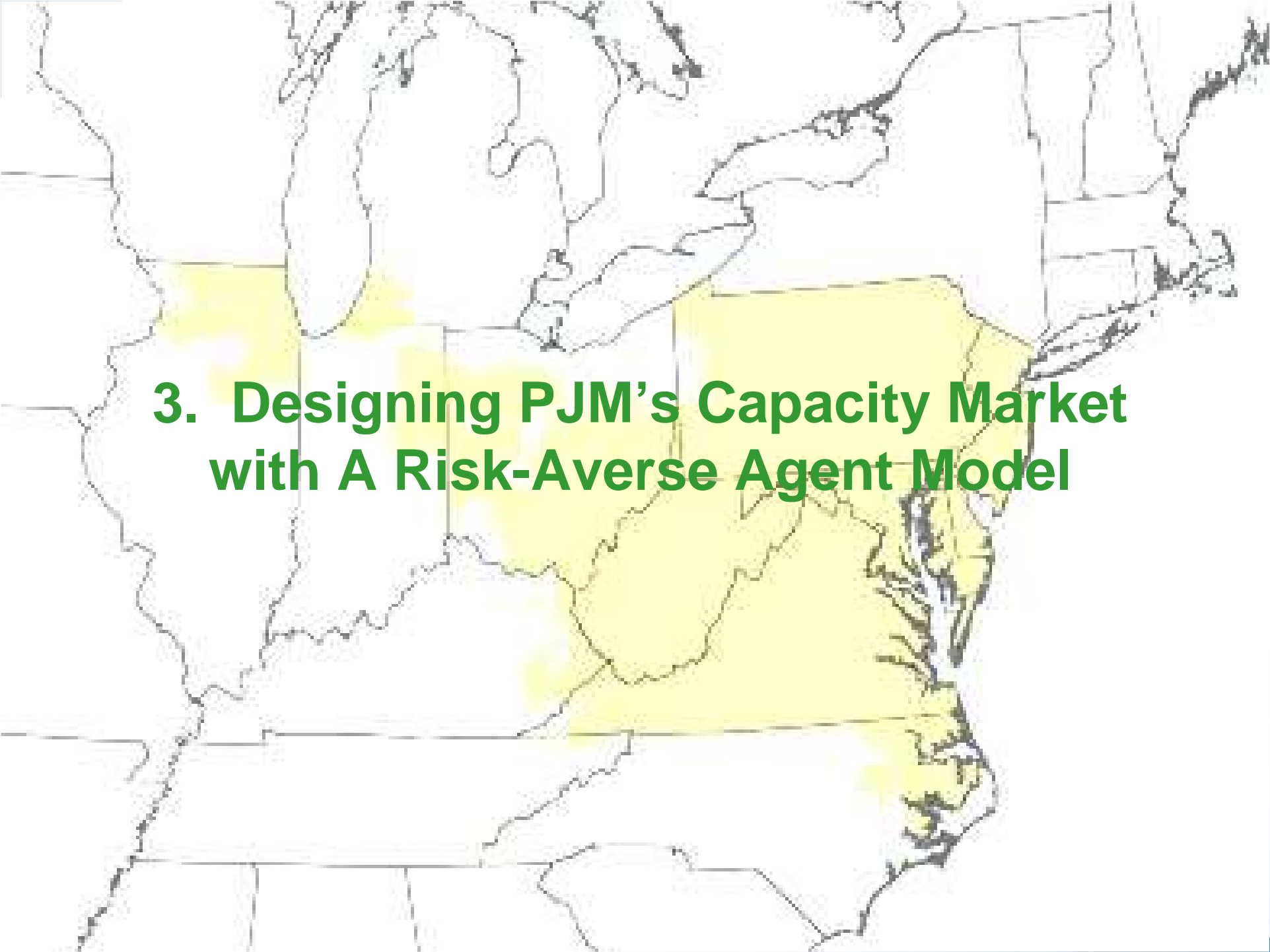
**\* Mandatory capacity markets**



# Desirable Design Features

- **Reward availability when & where 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**
- **Allow opt-out, with penalties for leaning on system**
- **Adapt**



A map of the United States with the PJM (Piedmont, Jersey, and Maryland) power grid region highlighted in yellow. The highlighted area covers parts of the Midwest, Northeast, and Southeast, including states like Ohio, Pennsylvania, New Jersey, and Maryland.

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

# 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:

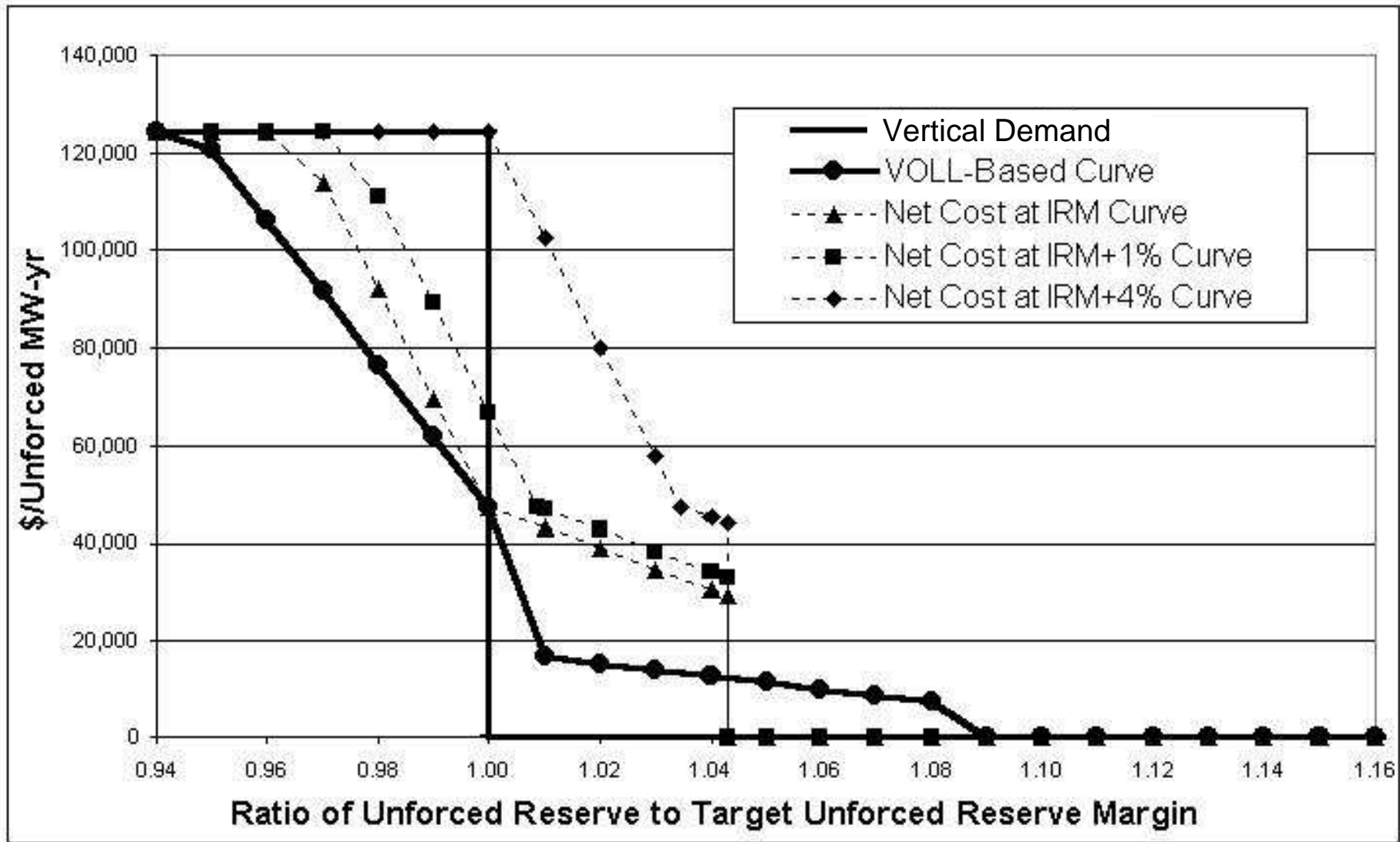
- Locational 3 yr-ahead prices, sloped demand
- Development schedule:
  - Stakeholder process, JHU analysis 2004-2005
  - August 2005: initial filing
  - Settlement talks, Fall 2006, JHU reanalysis
  - FERC approved settlement, Dec. 2006
  - Implemented: June 2007

- 1. How do different RPM curves affect....**
  - *Stability of capacity market?*
  - *Costs to consumers?*
  - *Ability to meet reserve requirement, reliability criterion?*
  
- 2. How robust are these conclusions to different assumptions about....**
  - *Generator behavior?*
  - *Demand curve parameters?*

# 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

# Initial PJM Analysis: 5 Curves Considered



# PJM Results: Summary

1. Sloped curve stabilizes capacity payments

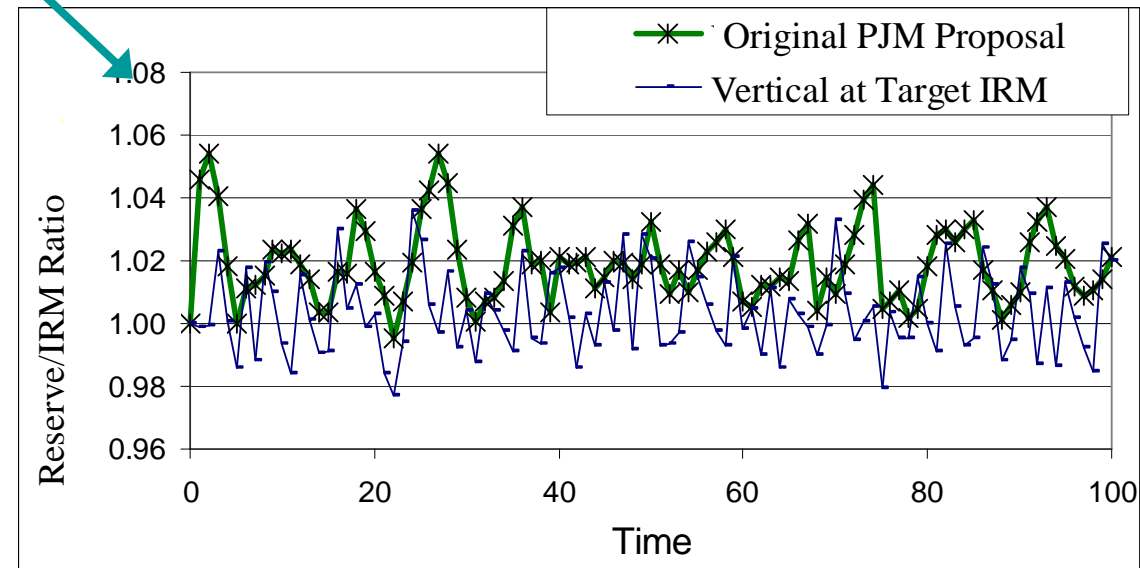
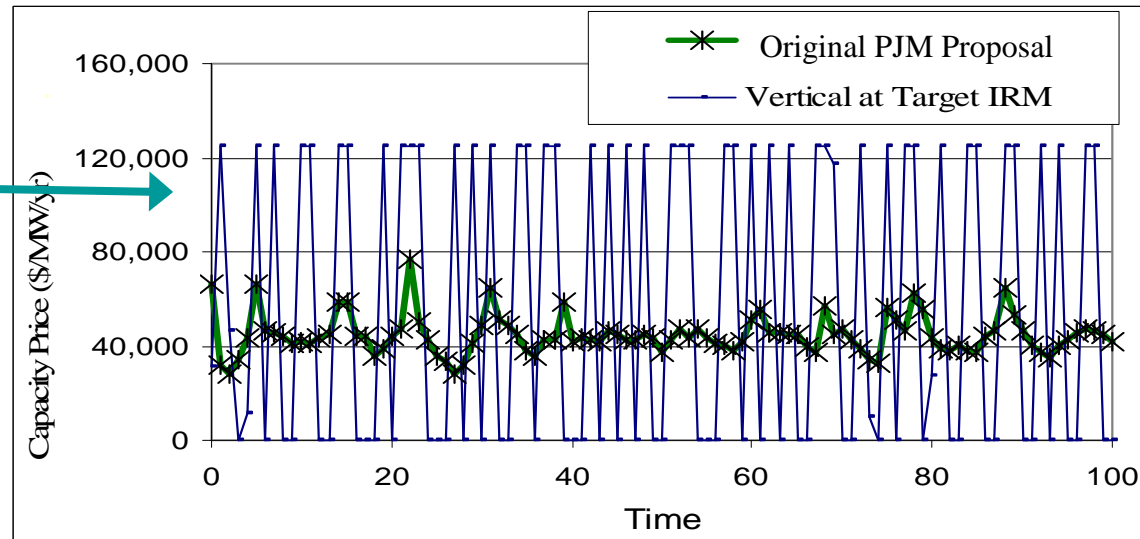
2. More stable payments even out investment, forecast reserves

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)

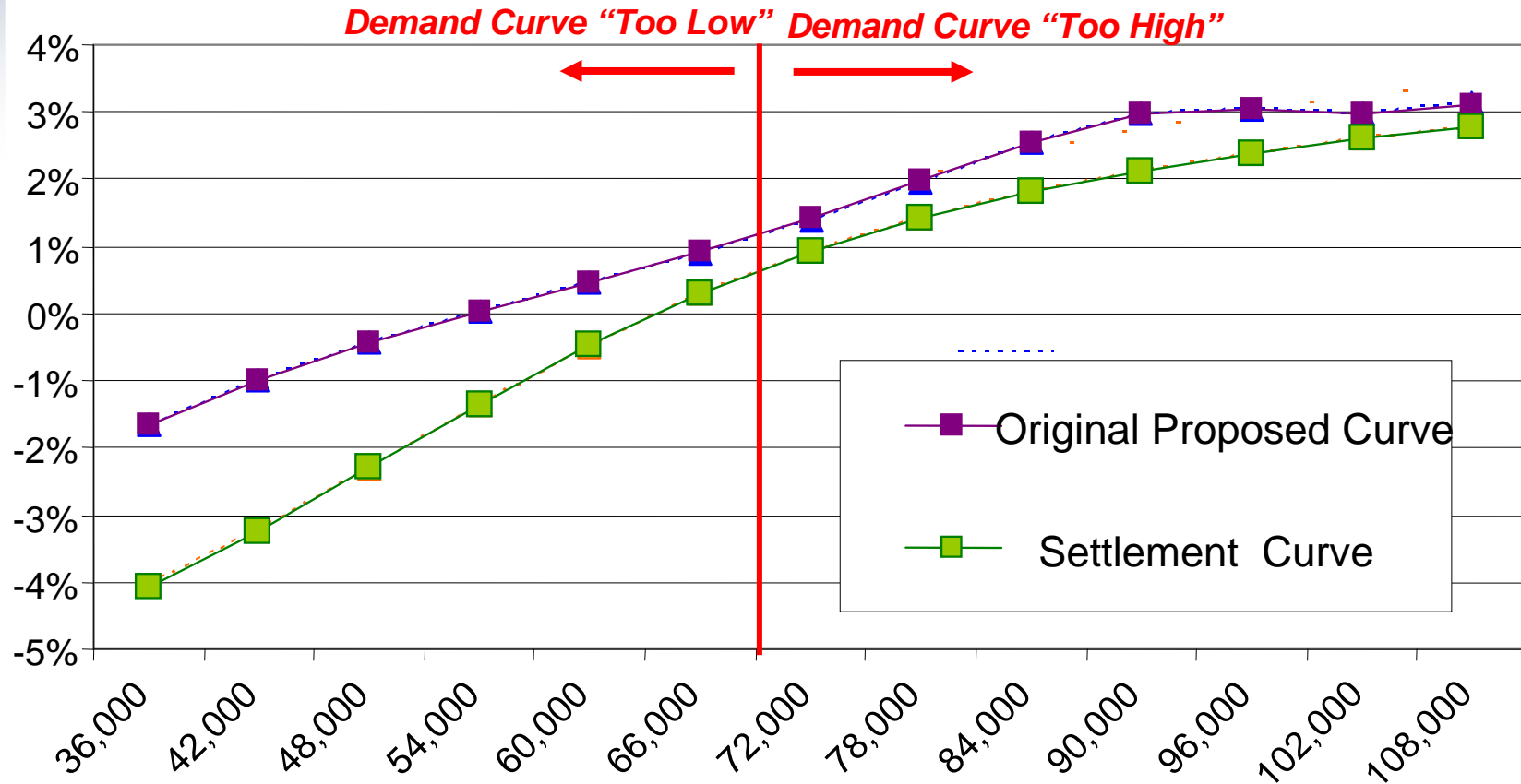
4. Results robust





# But misguessing the “Cost of New Entry” can affect system performance

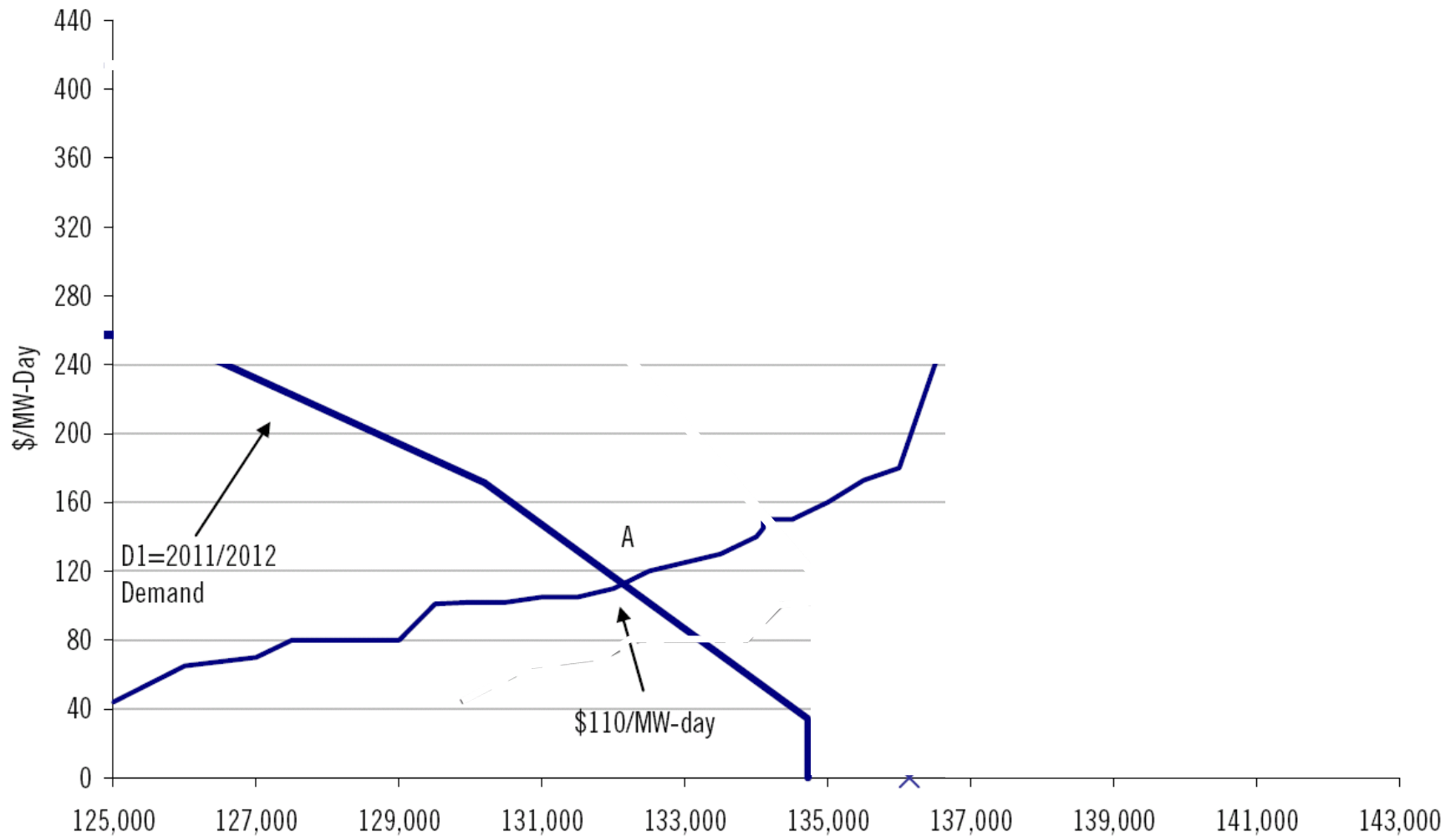
Average % by which actual reserve margin exceeds target



**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

# Changing PJM Demand & Supply Curves Over Time

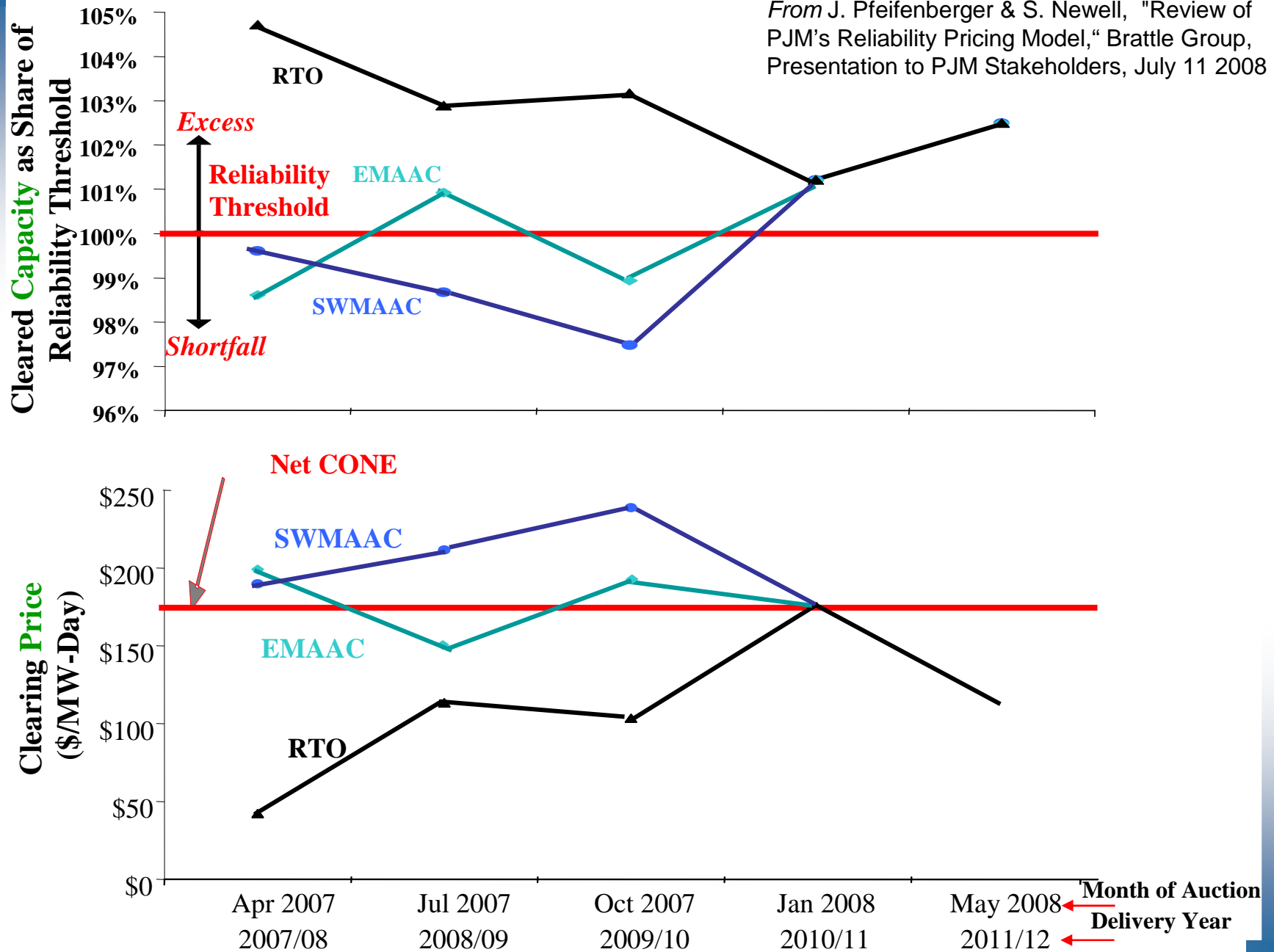


## PJM Conclusions: Advantages of Sloped Demand

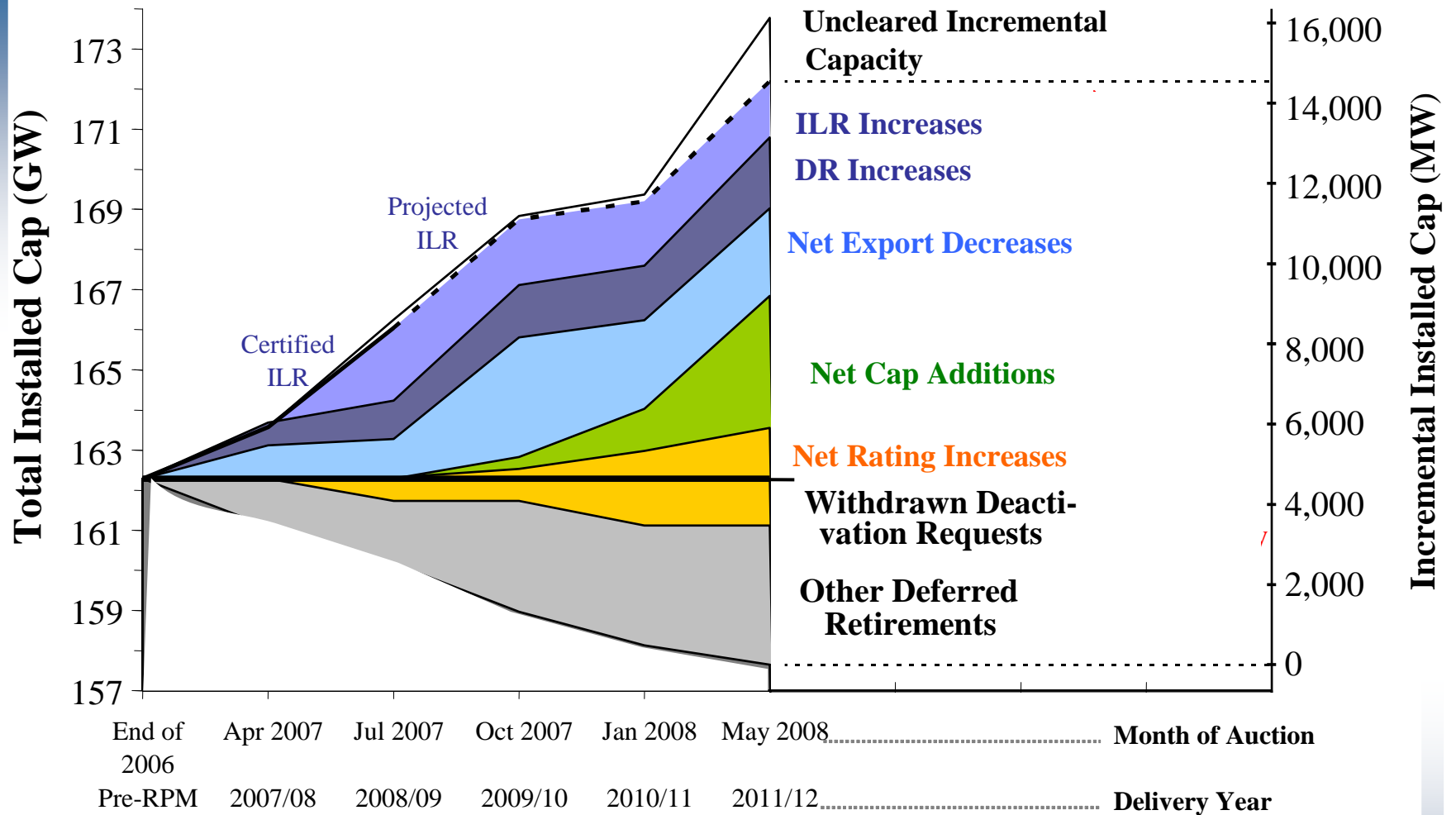
- **Compared to vertical demand, lower risk to generators. Result:**
  - *Lower required return to capital*
  - *More investment in generation*
  - *Dampened capacity cycles*
  - *Lower consumer cost*
- **More advantageous if generators more risk averse**
  - *Risk neutrality  $\Rightarrow$  sloped demand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

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

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



# Breakdown of New & Retained Resources



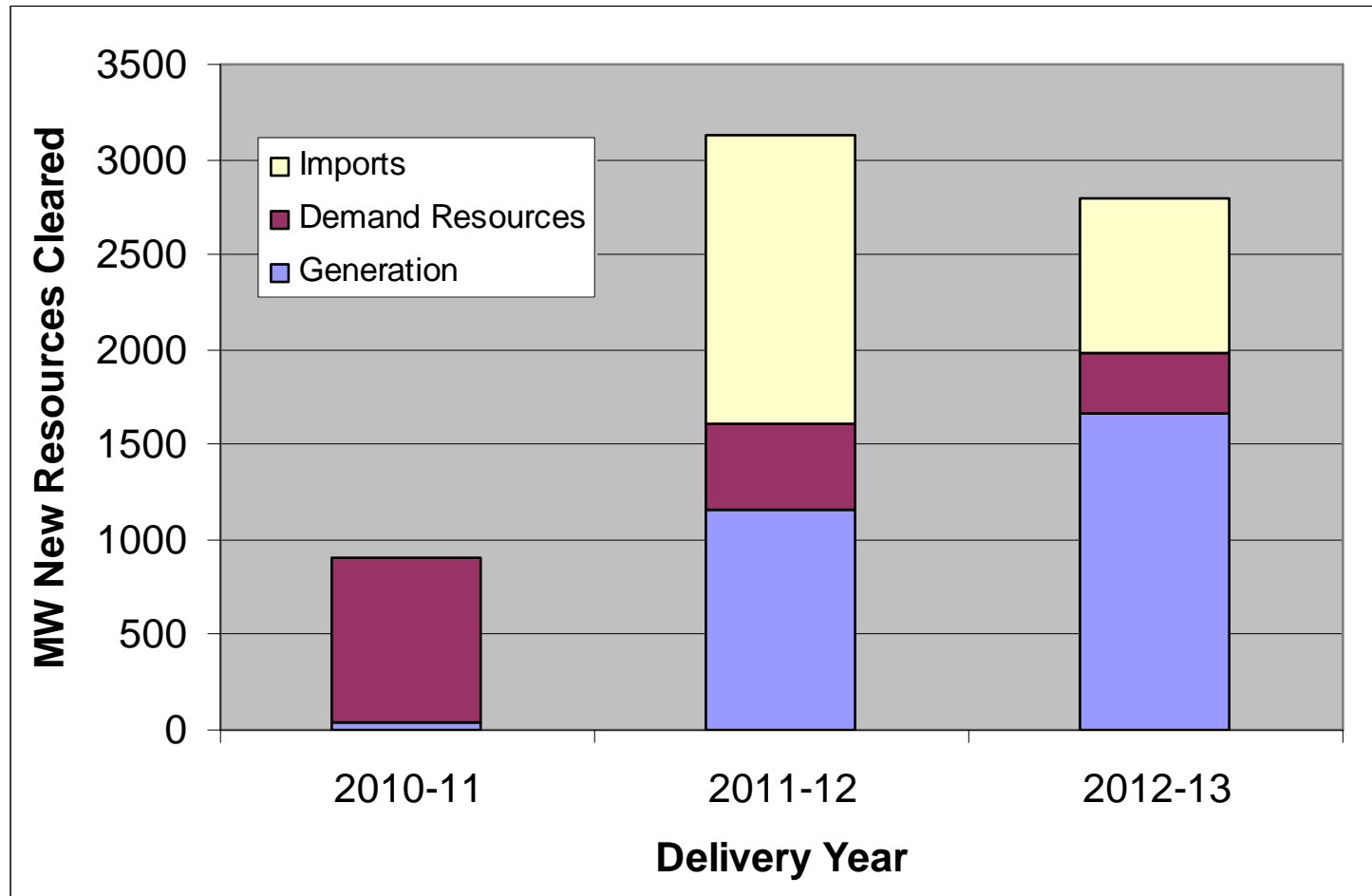
Source: Brattle analysis of PJM data, market participant interviews.

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

# 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**

- The “Forward Capacity Market” has cleared large amounts of new capacity



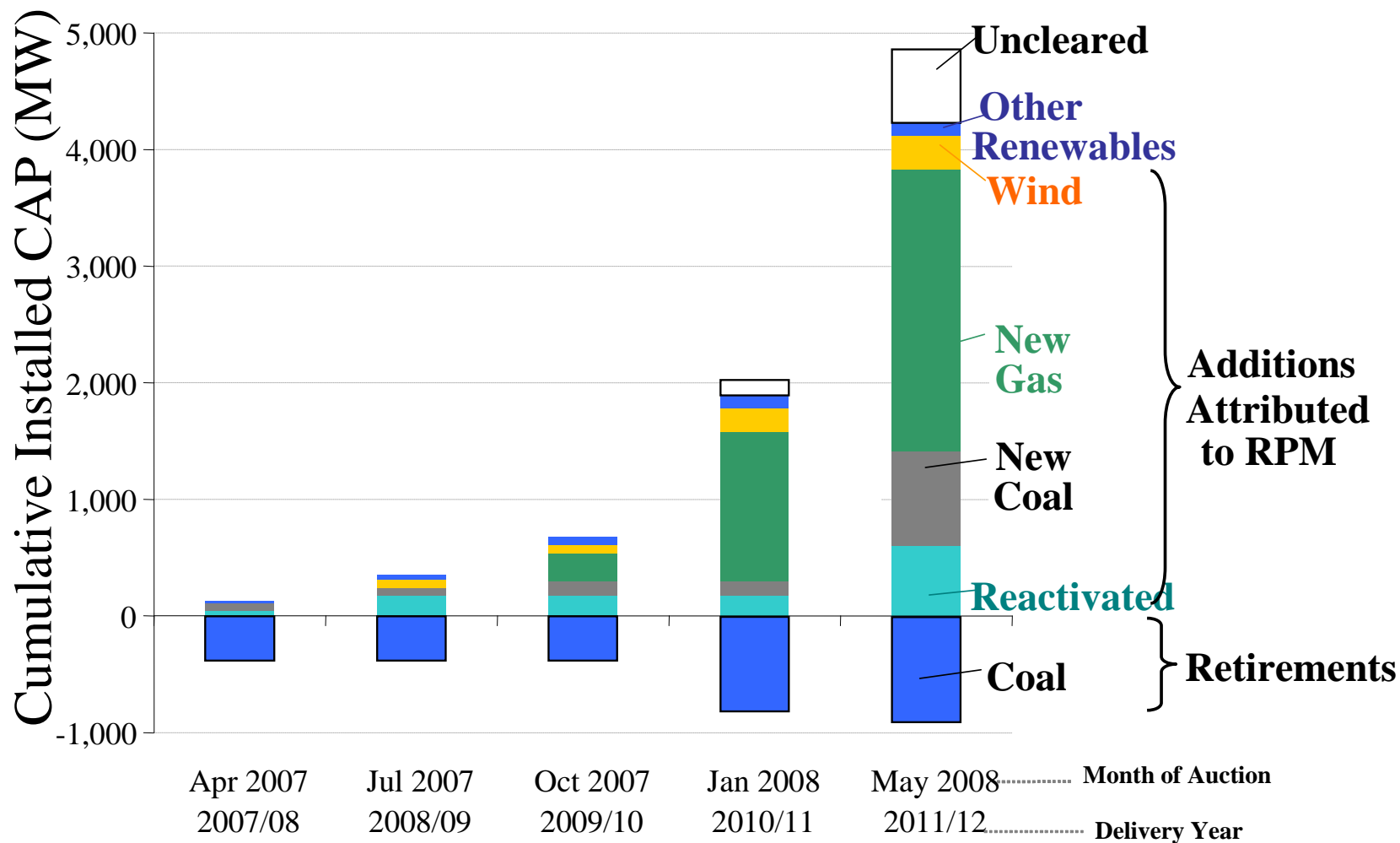
- **Challenges to capacity markets** (Brattle et al.)
  - **Political consequences of explicit capacity costs**
  - **Contentious administrative decisions:**
    - *Right amount of capacity?*
    - *CONE?*
    - *Load forecast?*
  - **Monitoring/verifying demand response**
  - **Tension between short- (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