Generation Adequacy, Market Regulation and Demand Elasticity in the Electricity Industry: A Stochastic Long Run Equilibrium Analysis of Capacity Markets

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Outline

- Introduction
- Model implementation
- Results
- Conclusions

Introduction

Under old regulatory regime, the monopoly utility choose how much generation capacity to install to meet demand and minimize cost

CAPACITY additions by one firm

Now, capacity additions are a result of multiple agents reading market “signals” and deciding to invest

CAPACITY additions by MANY uncoordinated firms

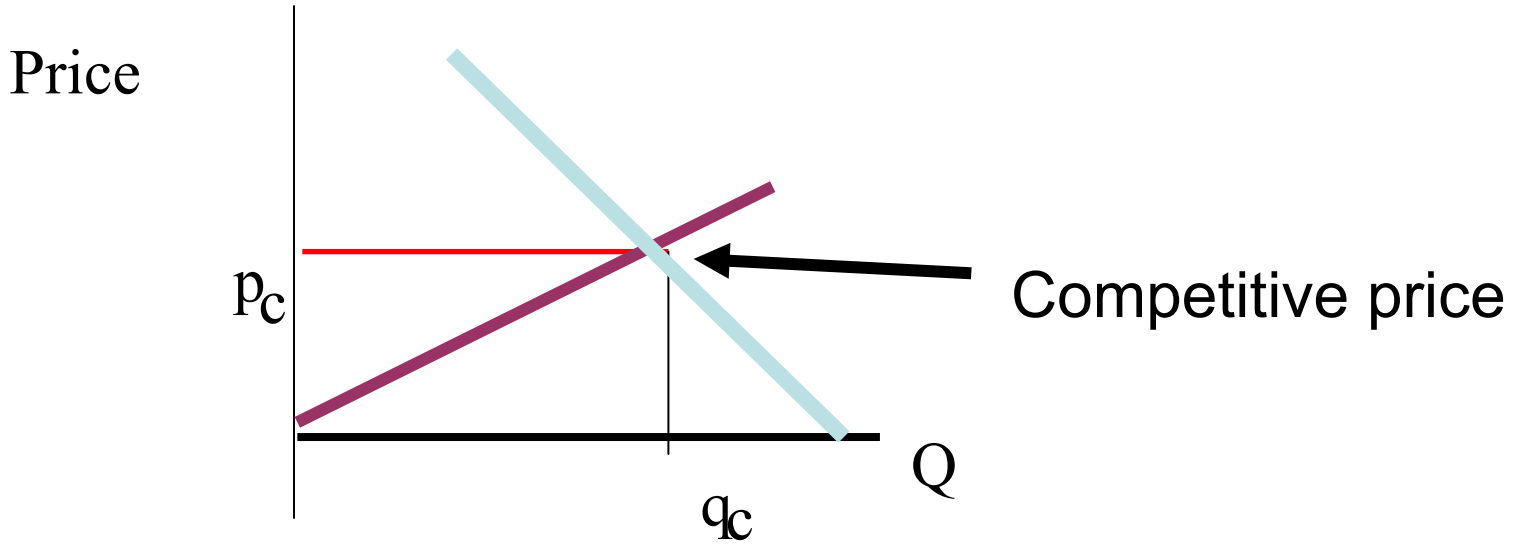
Under these conditions, how to incent investment to meet a target adequacy level?

Questions

- Which market failures affect the ability of markets to achieve a target generation “adequacy” level?
- How do the adequacy targets and energy price caps determine the generation mix and cost of the system?
- Can capacity markets correct the distortions caused by price caps?
- Is the expense of programs that promote demand responsiveness to price justified?

Market failures affecting price signals

- **Broken demand side**:
  - prices fail to reflect consumer “Willingness to Pay” for reliability
  - Lack of proper metering & controls are obstacles to selective interruption of consumers
- **Market power, barriers to entry, & imperfect information**



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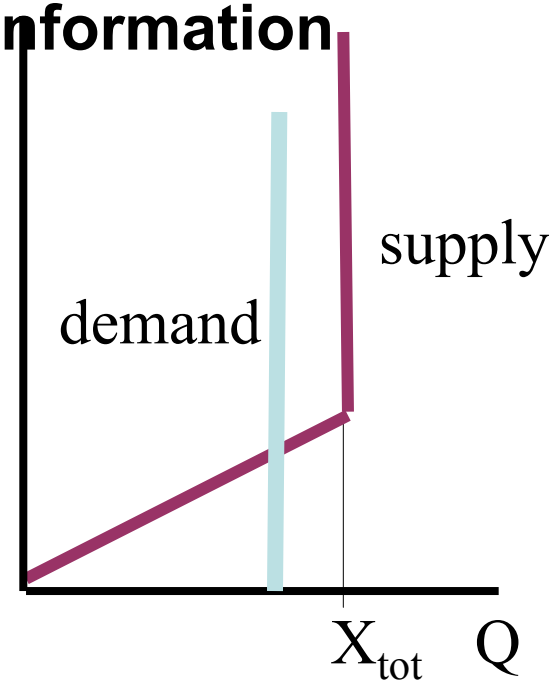
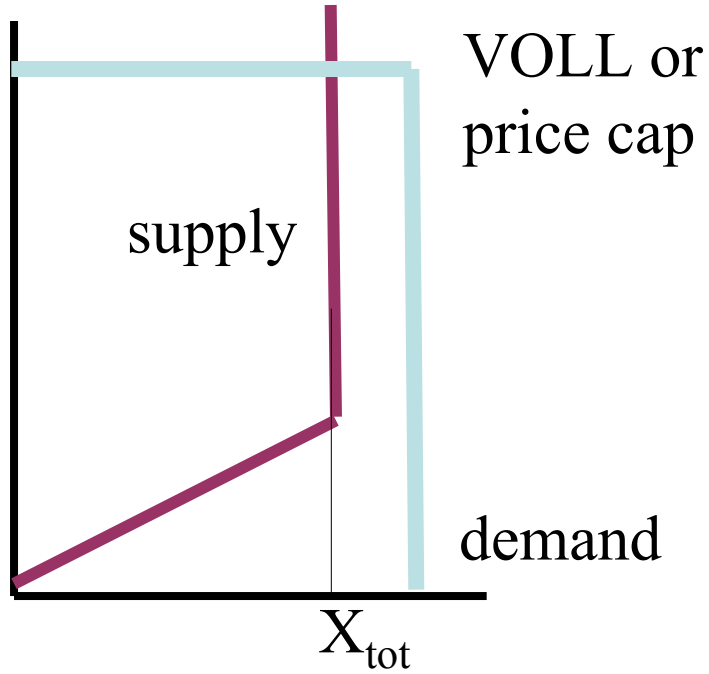
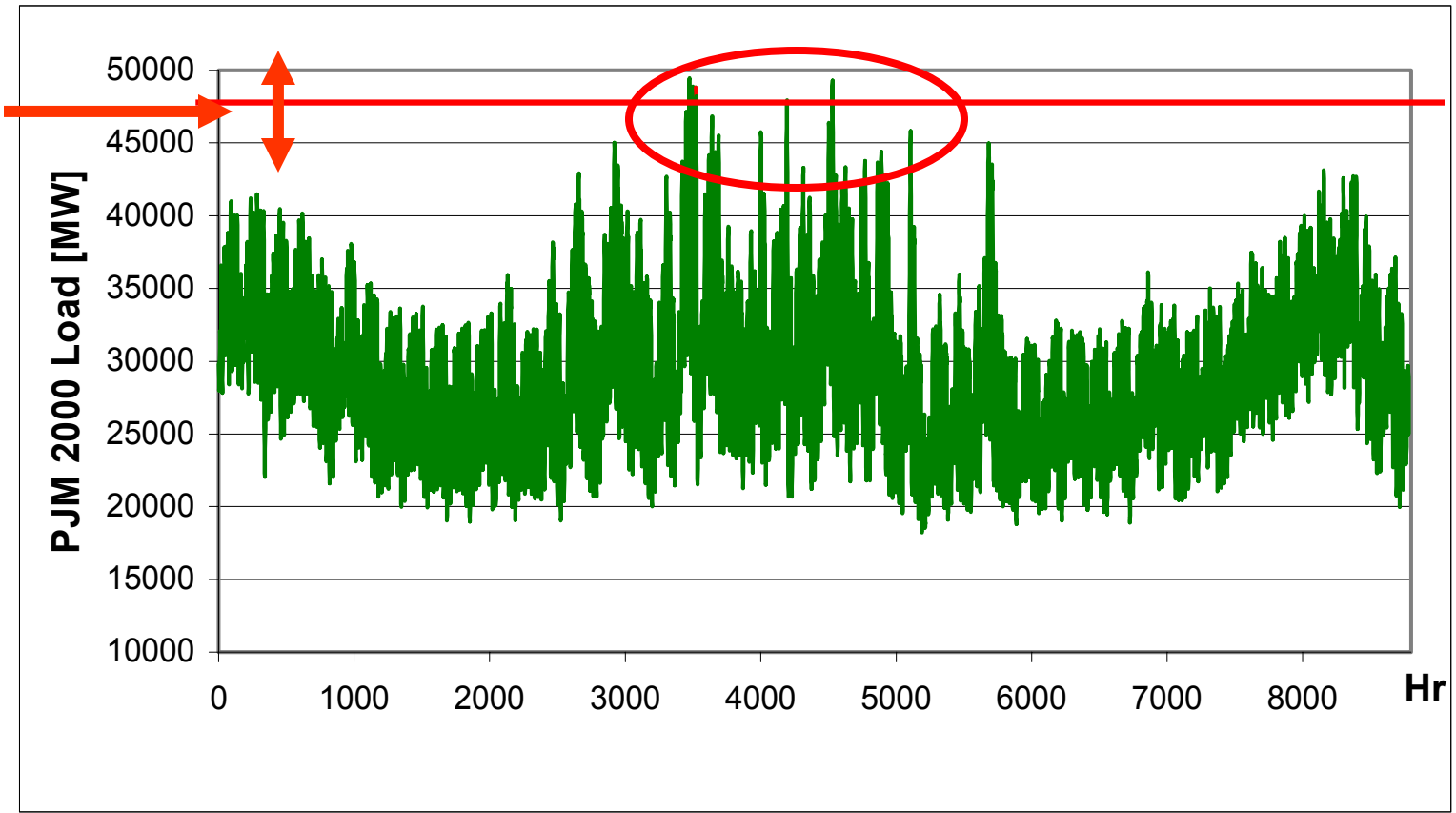




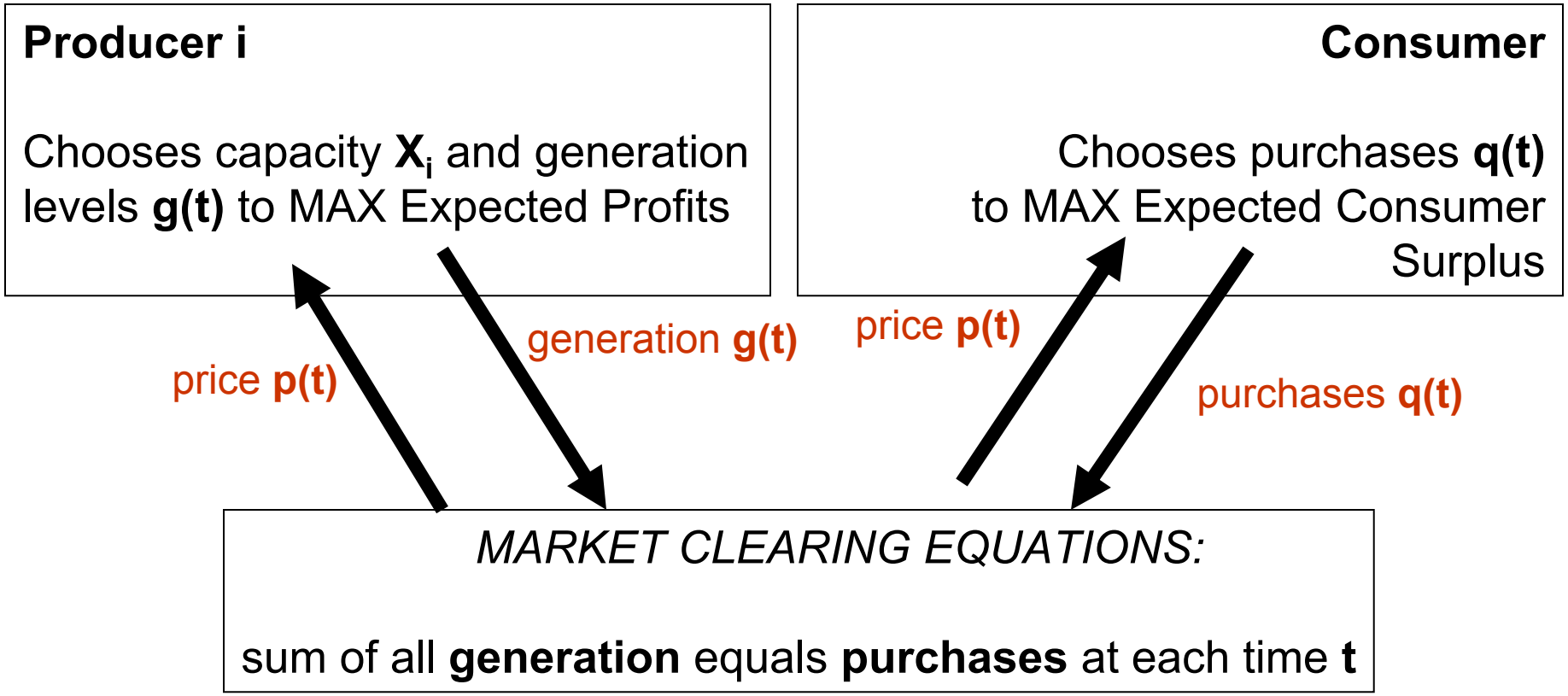
Model Implementation

- Capacity Adequacy is a measure of “enough” capacity and is determined **stochastically,**
  - by calculating the probability of the event that load exceeds available capacity
  - expressed as Loss Of Load Probability, LOLP 1 day in 10 years

Available Capacity is Random



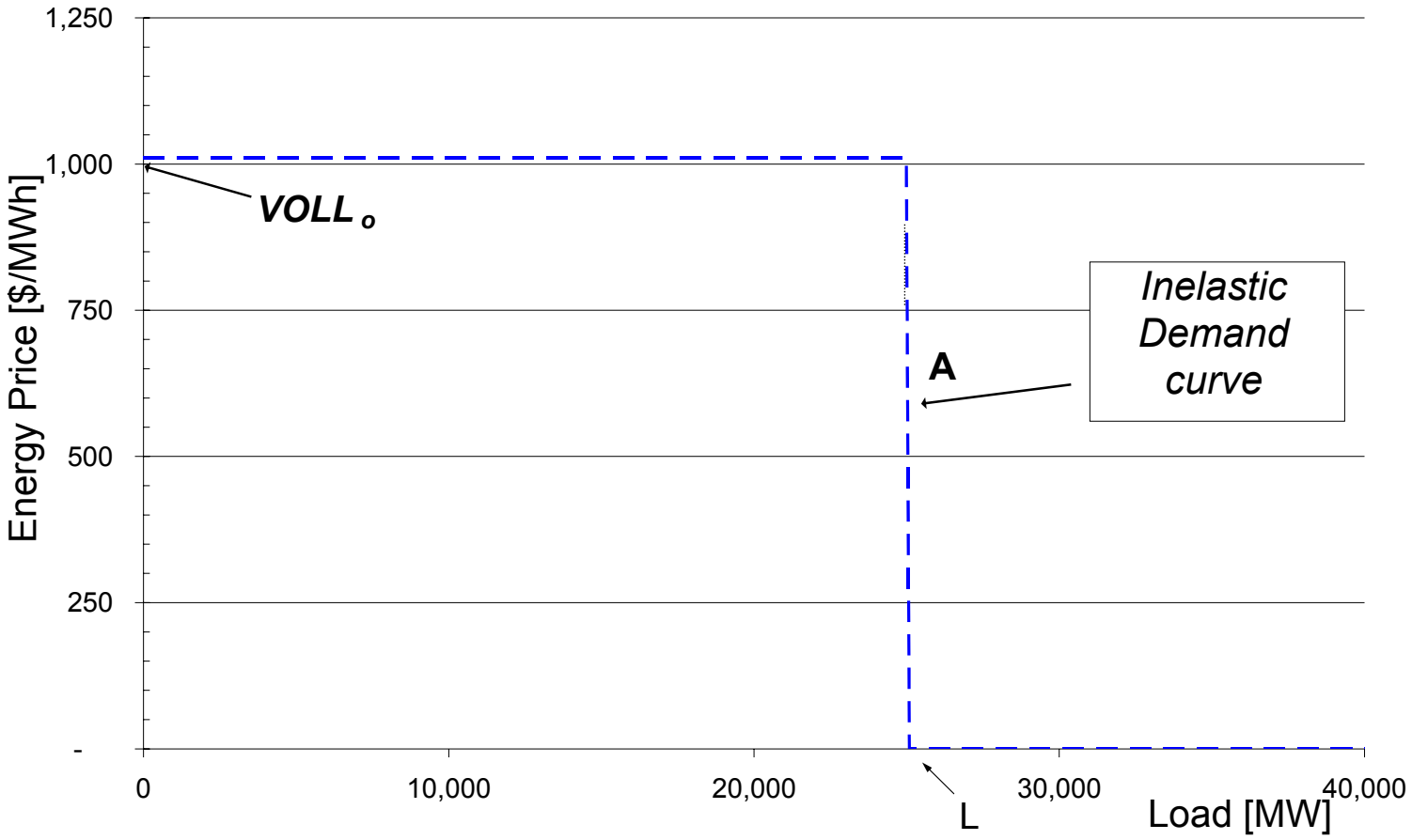
Stochastic model



- **Long-run (free entry) equilibrium under perfect competition**
- **Expected profit calculated over load and capacity outages**
- **Depends on price formation process (e.g., price caps, market power)**

Assumptions

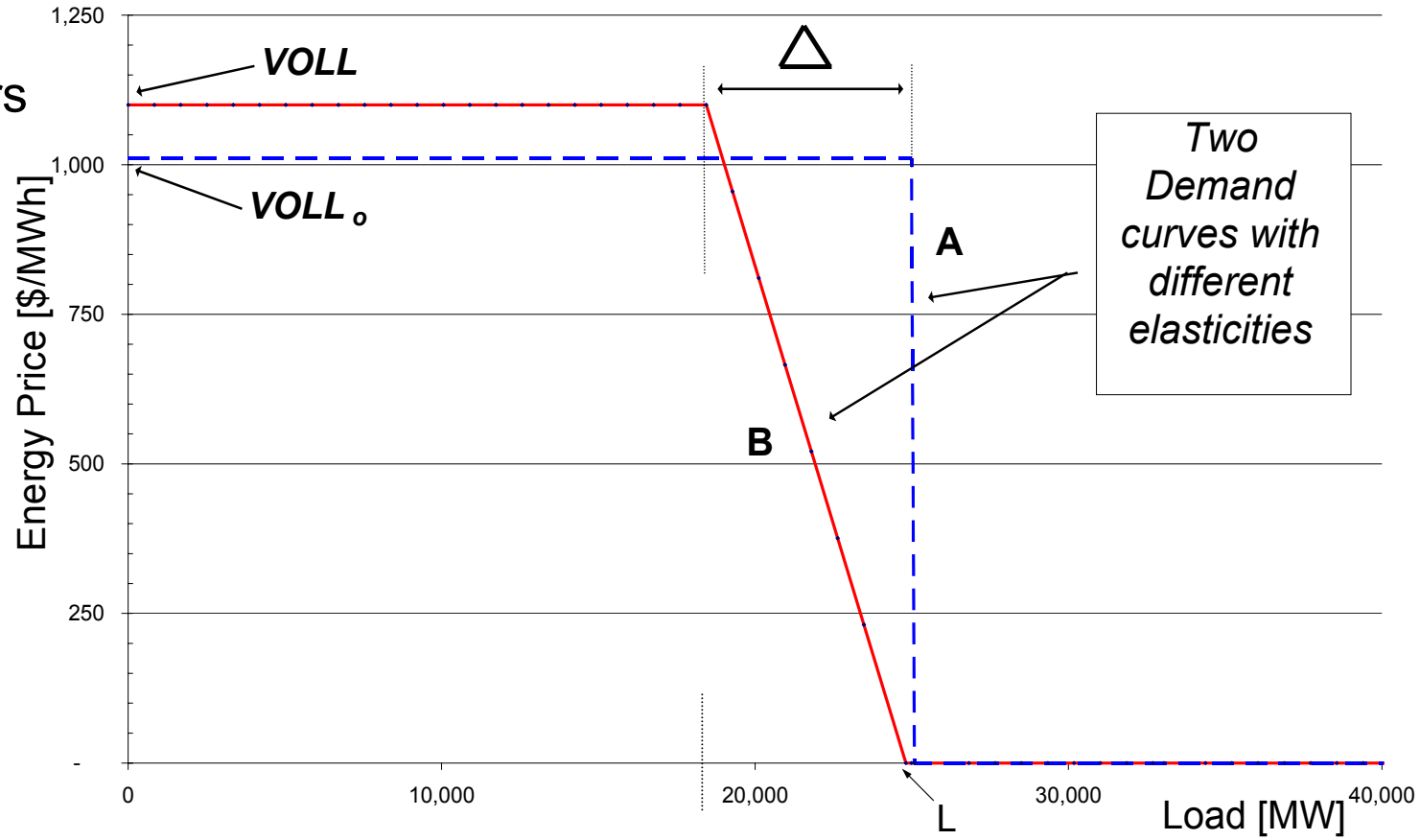
- Inelastic and Elastic Demand curves



Assumptions

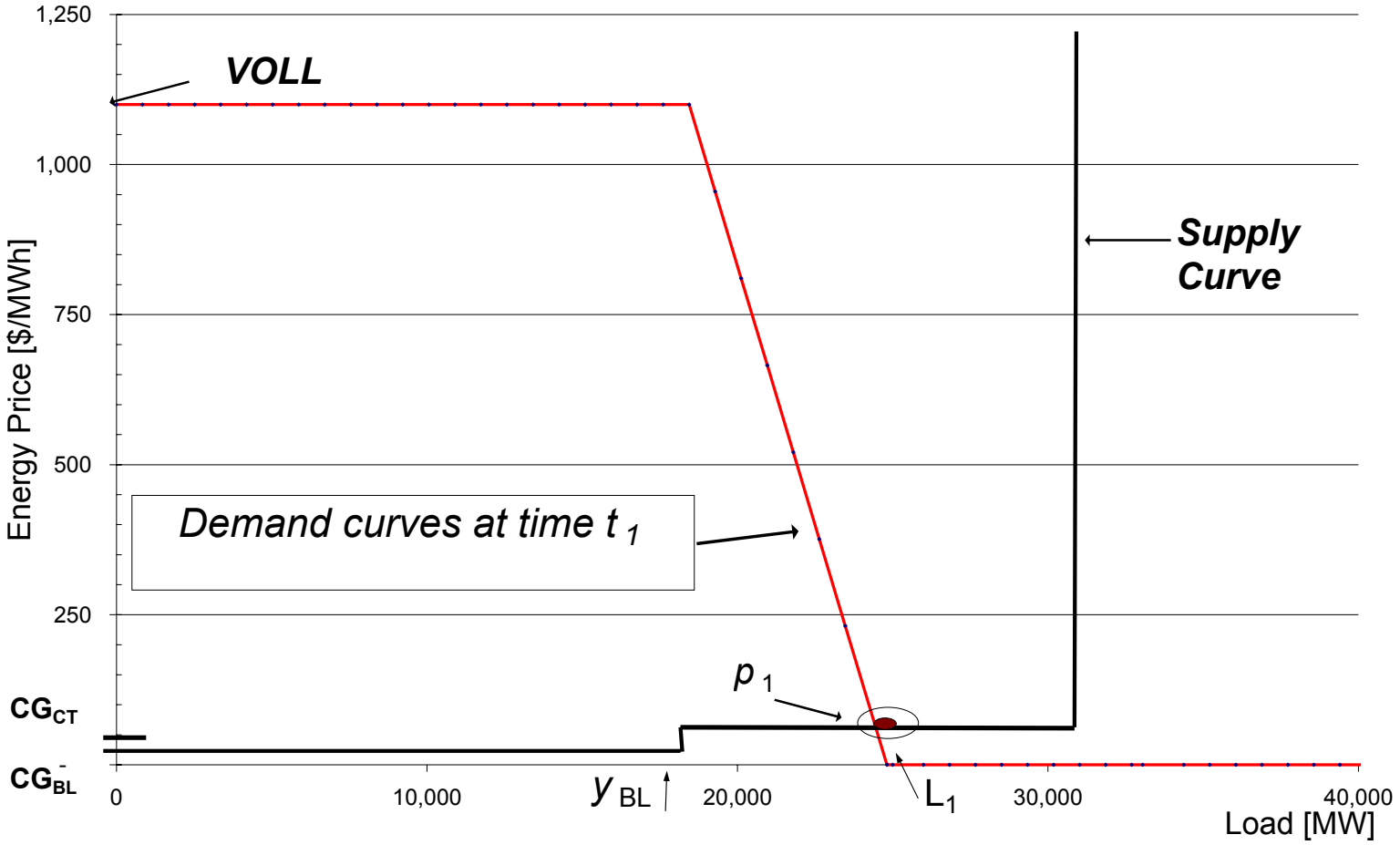
- Inelastic and Elastic Demand curves

- The consumers value, ie, the area under the curve, must remain constant



Assumptions

- Price Setting Mechanism. The prices in this two generator model can be **{**CG_{BL}, CG_{CT}, [CG_{CT}, VOLL]**}**



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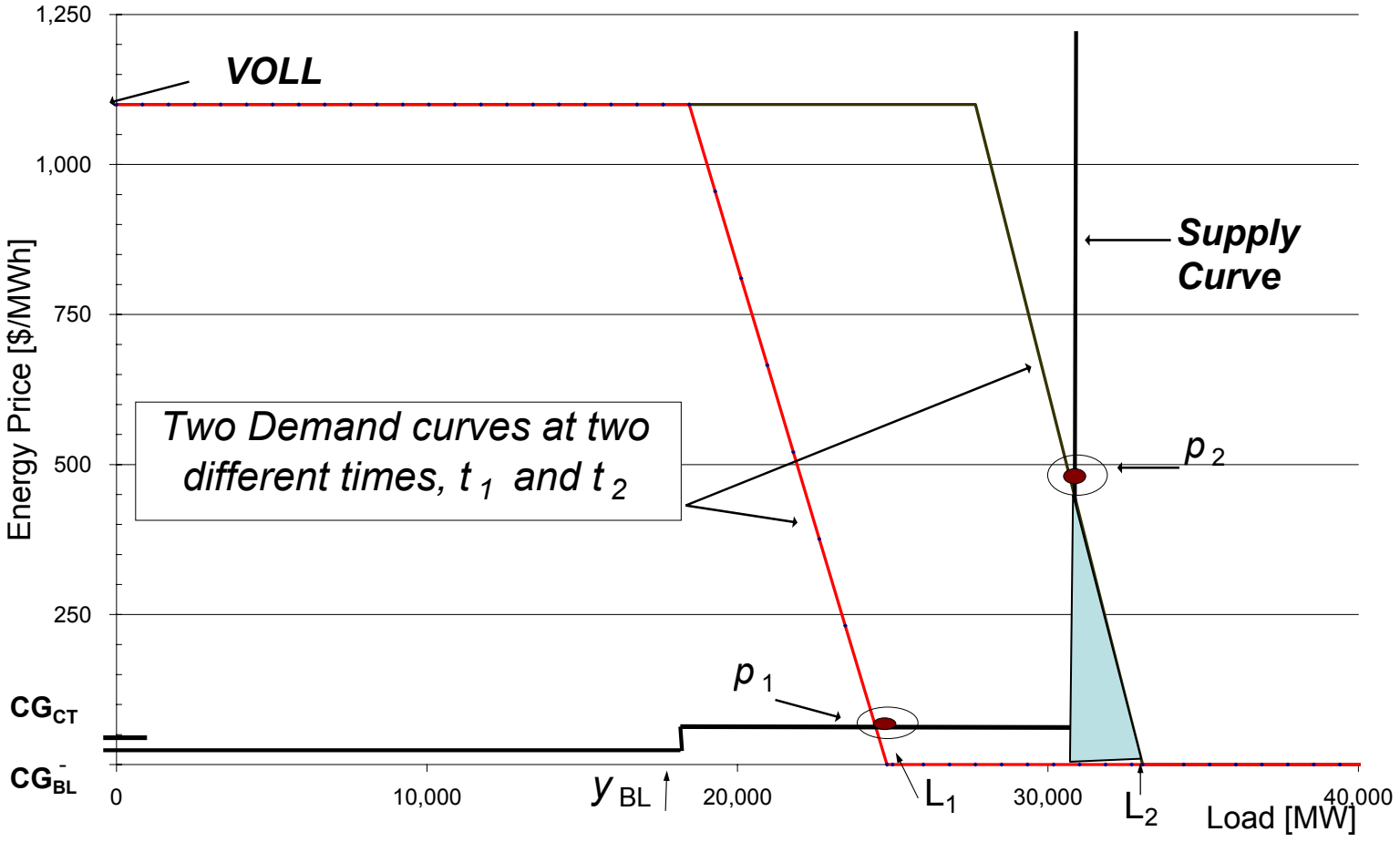


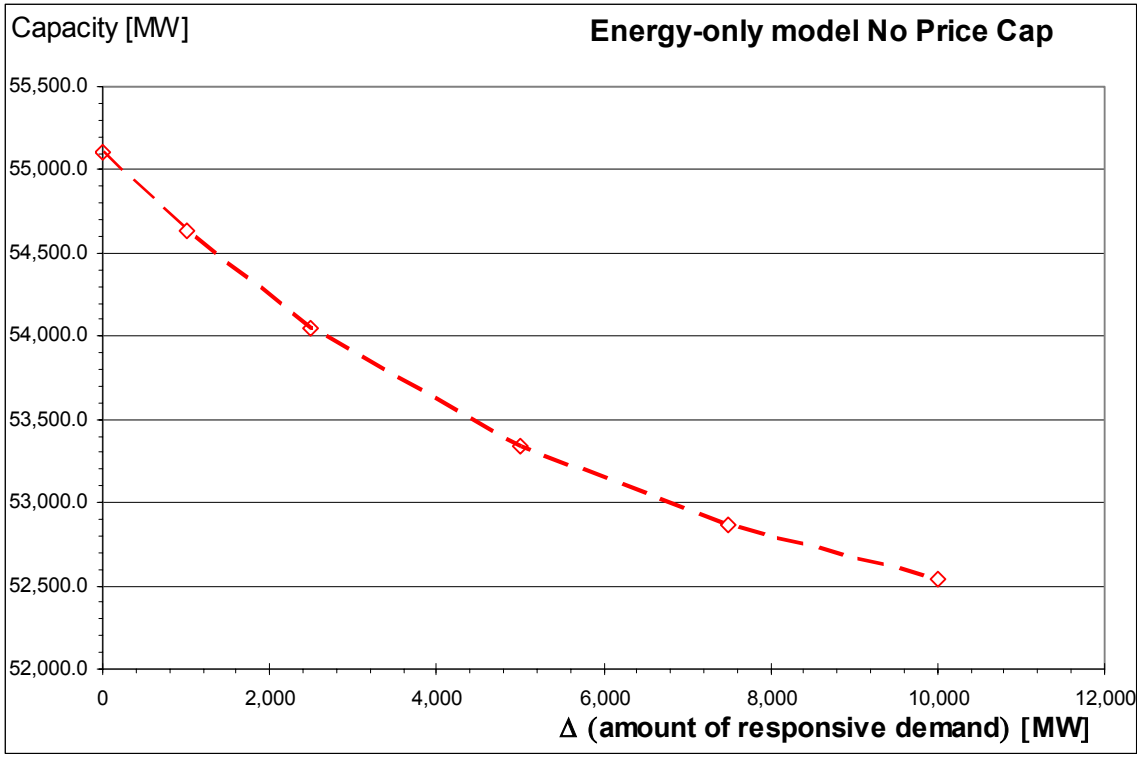
Results

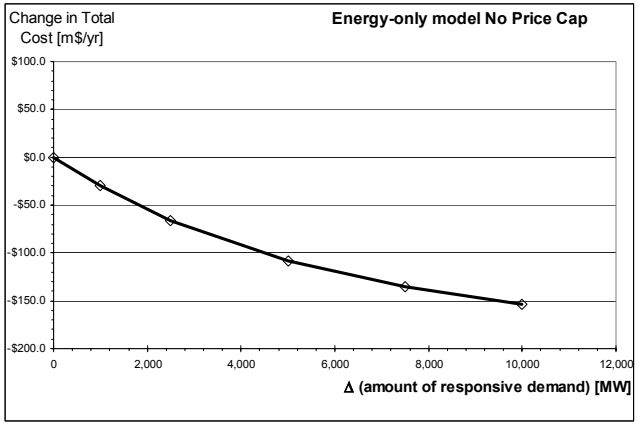
1. Comparison of Long-Run Equilibrium Solutions for Energy-Only Market (No Price Cap)
    - under different demand response programs
2. Effect of Price Cap on Energy-Only Market
3. ICAP versus Energy-Only Market
4. Optimal amount of capacity adequacy

Results 1. No Price Cap

- NO price cap
- Each point is an equilibrium solution

- **Total system costs** and **total capacity** decrease with increasing demand elasticity (cost of Δ not included)





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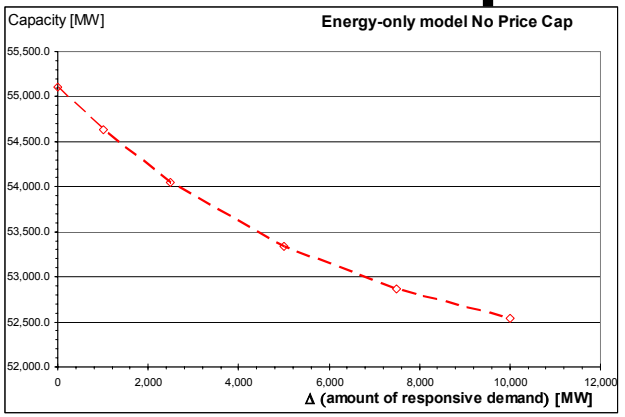

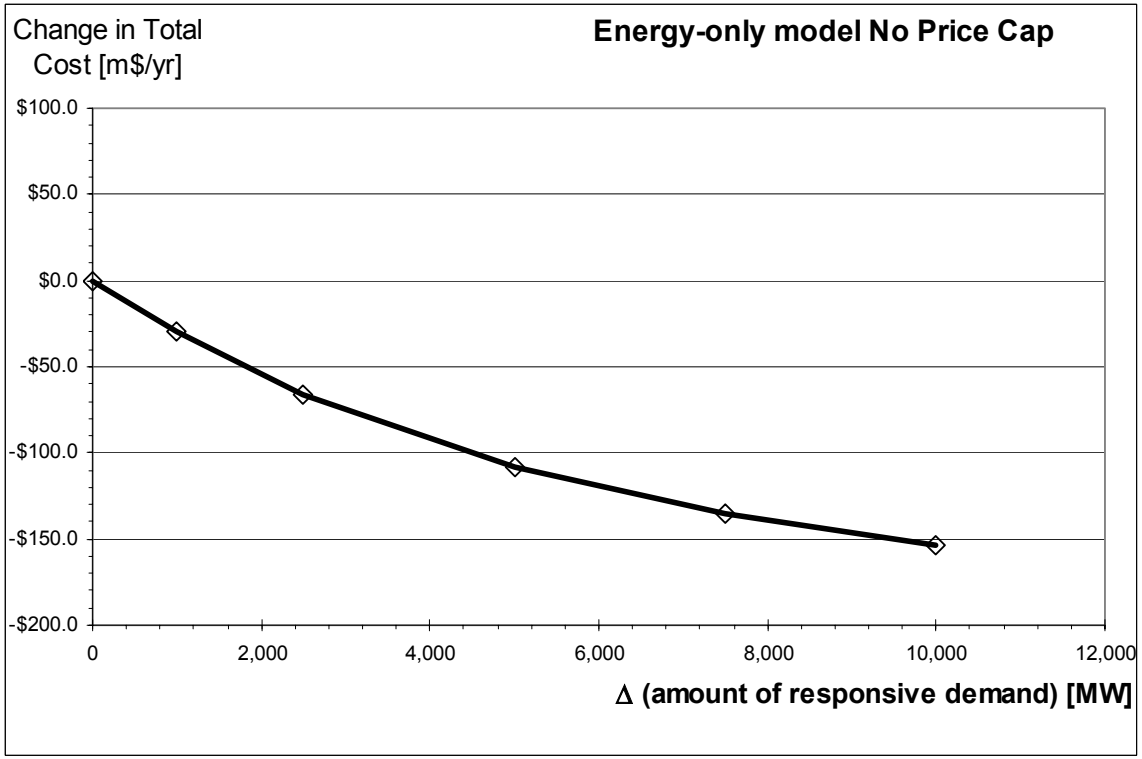

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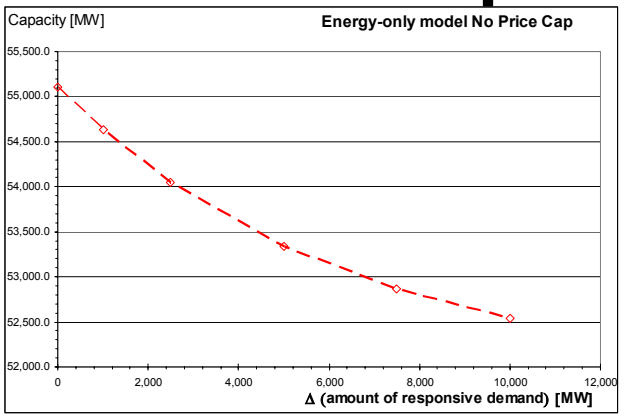
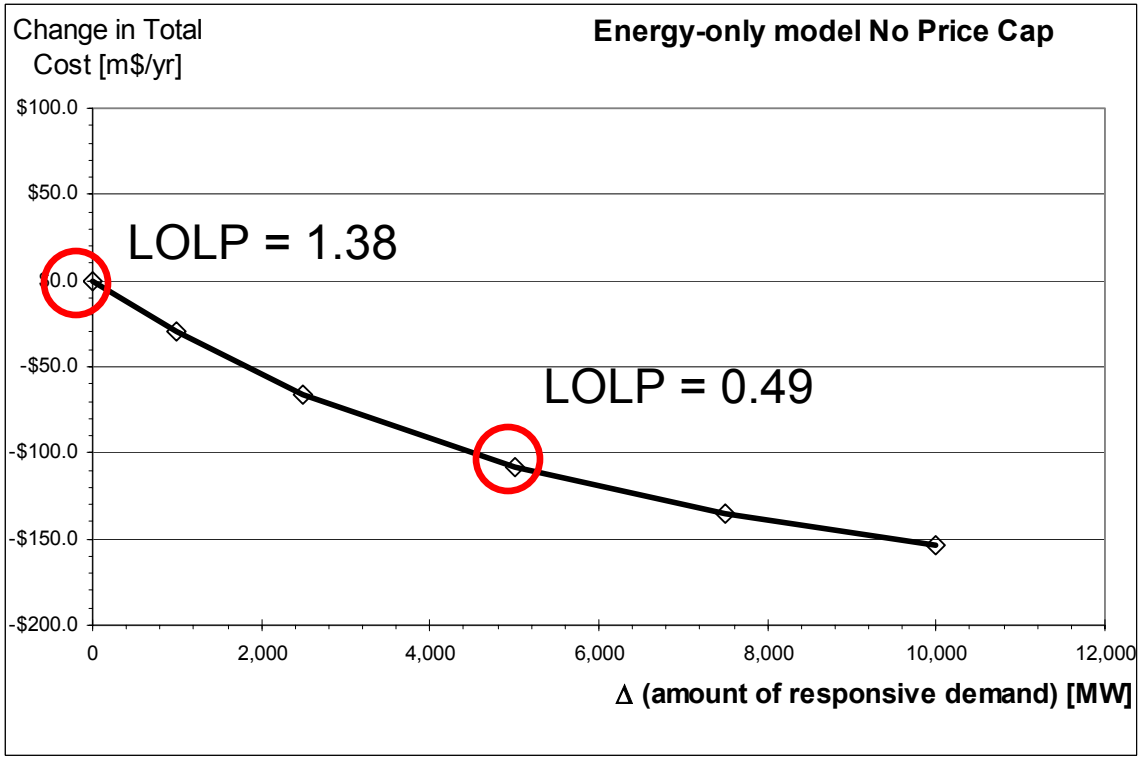
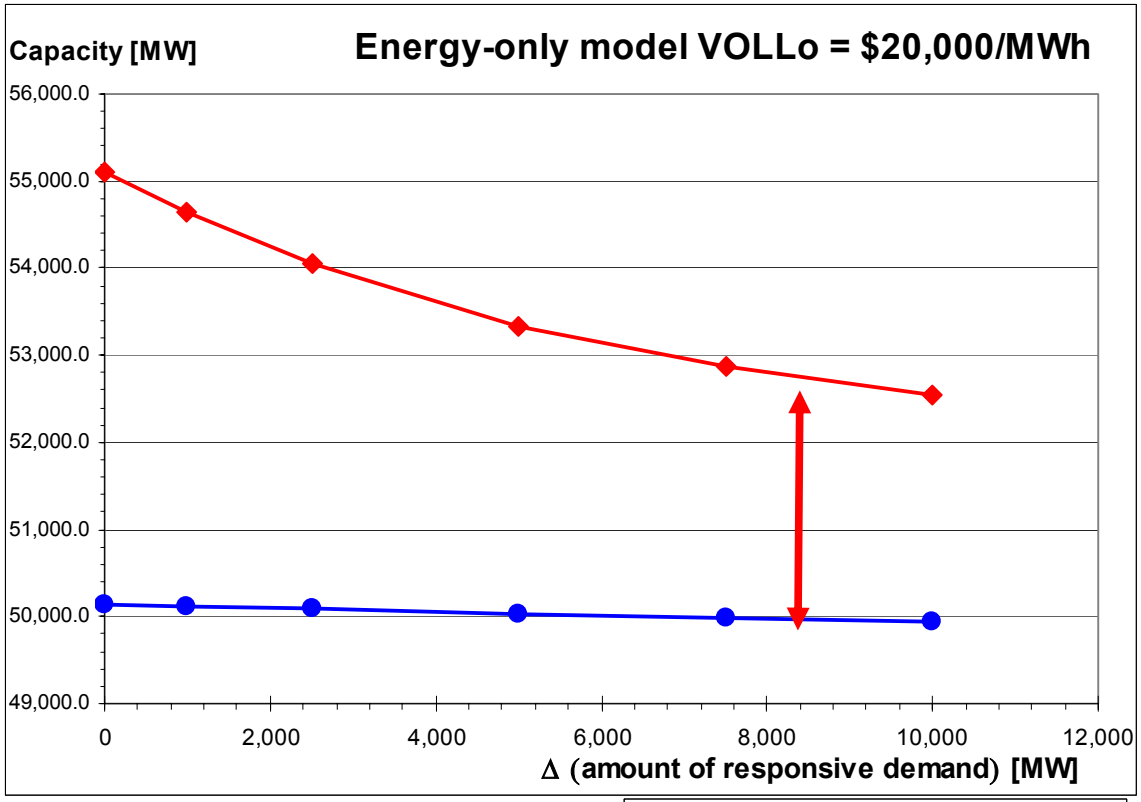
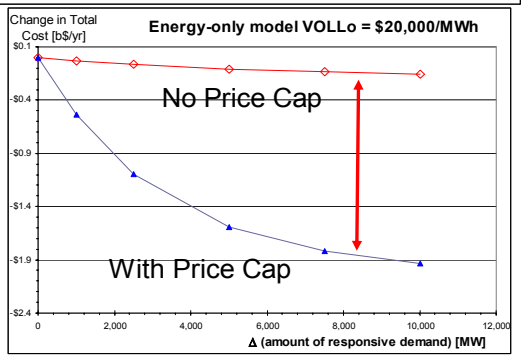




Results 2. Price Cap

- Price Cap = $1,000/MWh
- Installed Capacity decreases with a regulatory price cap
- Demand response does not add more capacity, reduces system costs (cost of Δ not included)





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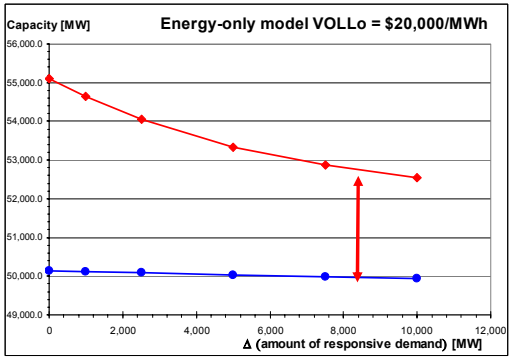

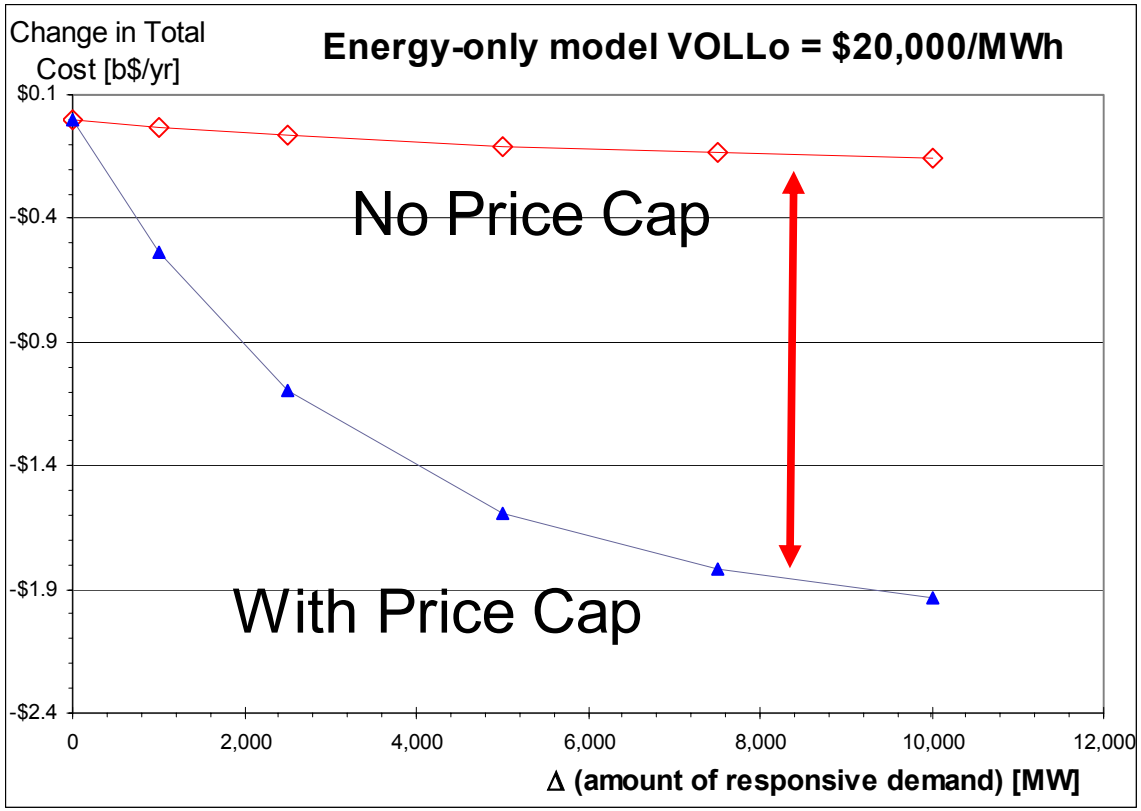

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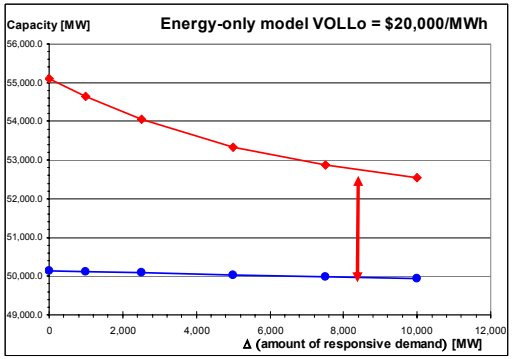
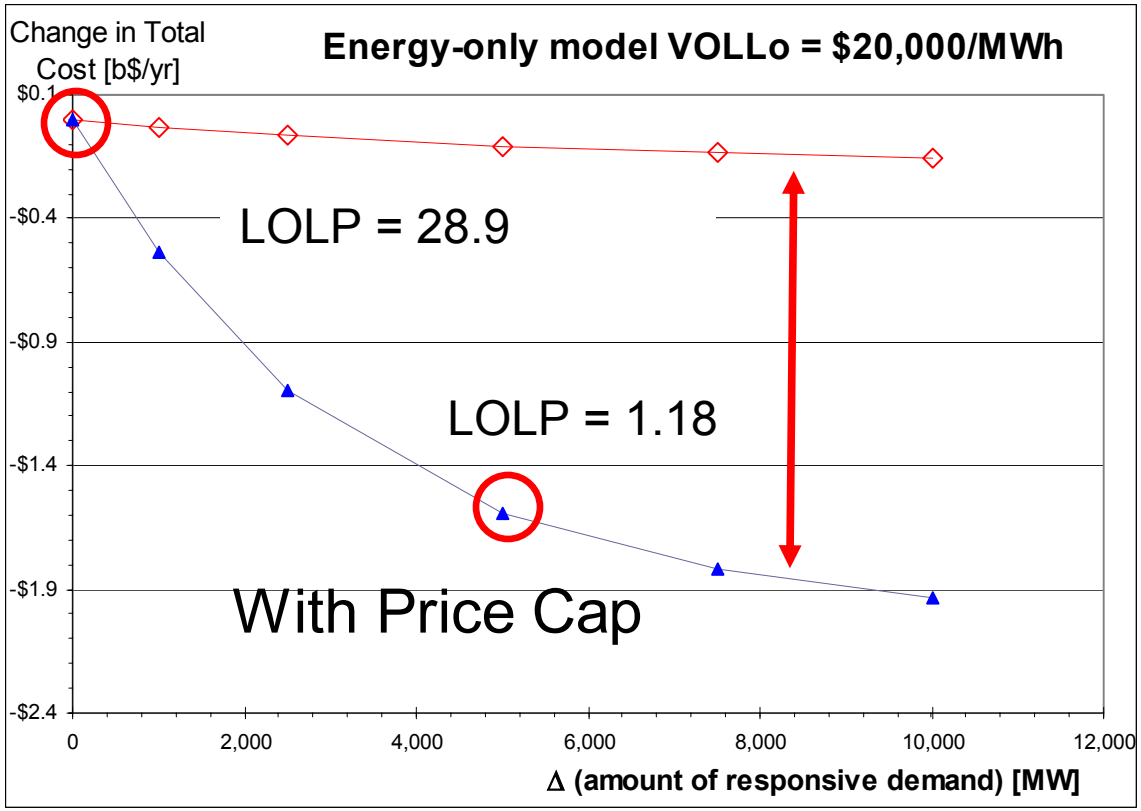




Results 3. ICAP

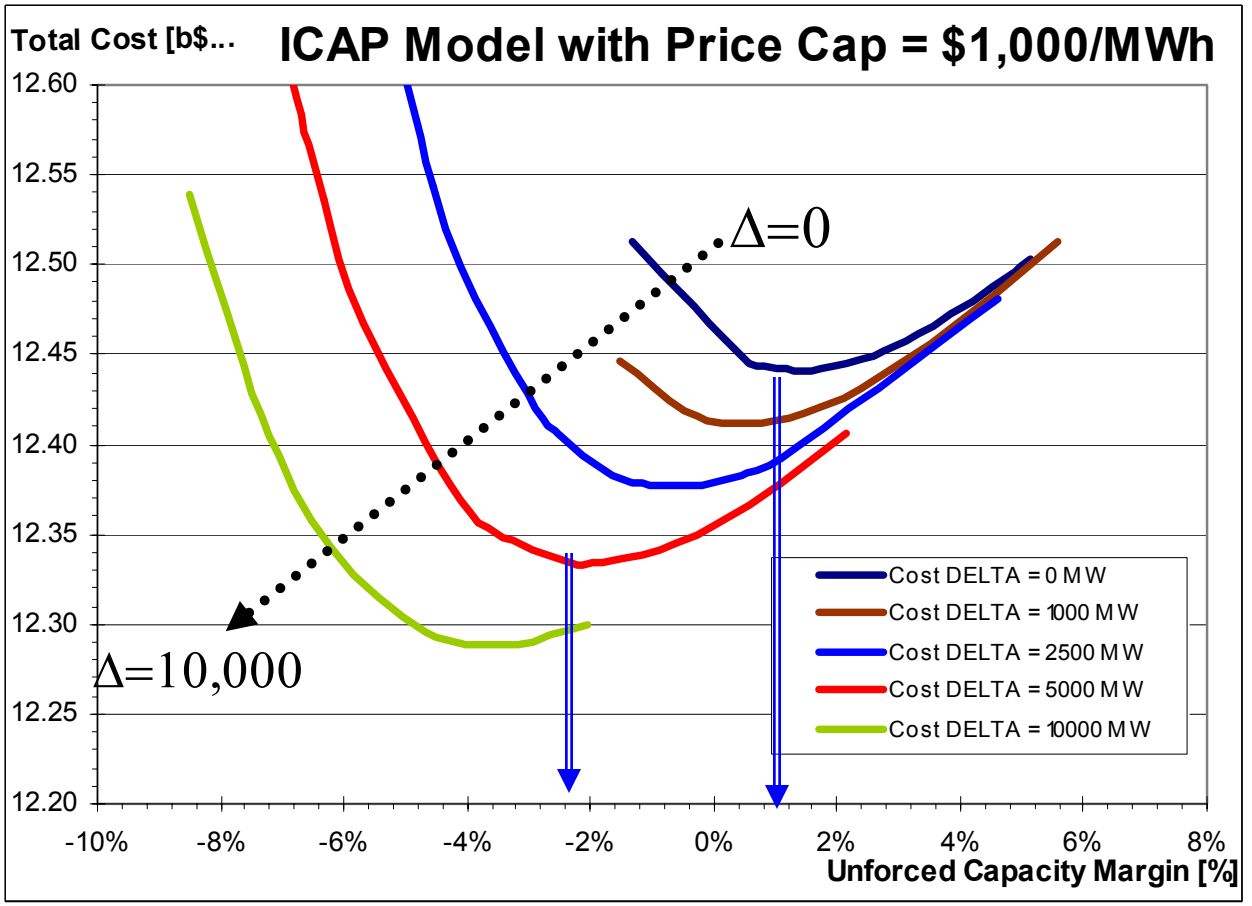
Δ (amount of responsive demand) [MW]	*LOLP* [days/ 10 yr]	Total Capacity [MW]	Unforced Reserve Margin [%]
Energy-Only without Price Cap			
0	1.38	55,109	1.41%
ICAP model with Price Cap = $1,000/MWh			
0	1.38	55,109	1.41%

- The ICAP/Price Cap solution has an ICAP price of $63,142/MW/yr; this restores the original equilibrium solution of an optimal Energy-only market **without** price cap.
  - Same cost, generation mix

- Demand response with ICAP market has the same effect as in Energy–only market

Results 4. Optimal Adequacy

- Price Cap = $1,000/MWh
- 10,000MW of responsive demand improves the adequacy level of the system



-2% (LOLP = 0.05)

1.4% (LOLP = 1.38)

Conclusions

- Energy price caps without capacity markets results in too little capacity
  - The price cap determines the amount of generation capacity installed in the system
  - Capacity markets can restore optimal investment incentives
- The following can differ:
  - The socially optimal adequacy level based on social cost
  - An engineering criterion of 1 day in 10 years

  The engineering LOLP loses meaning when demand is elastic
- With an annualized metering cost of $20,000 per MW of price responsive load, a program that puts 10% of load on real time pricing is economically justifiable
  - Potential generation capacity cost reductions of 100 $M/yr for PJM

Thanks for your attention.

Comments or Questions?