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# 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

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# 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?

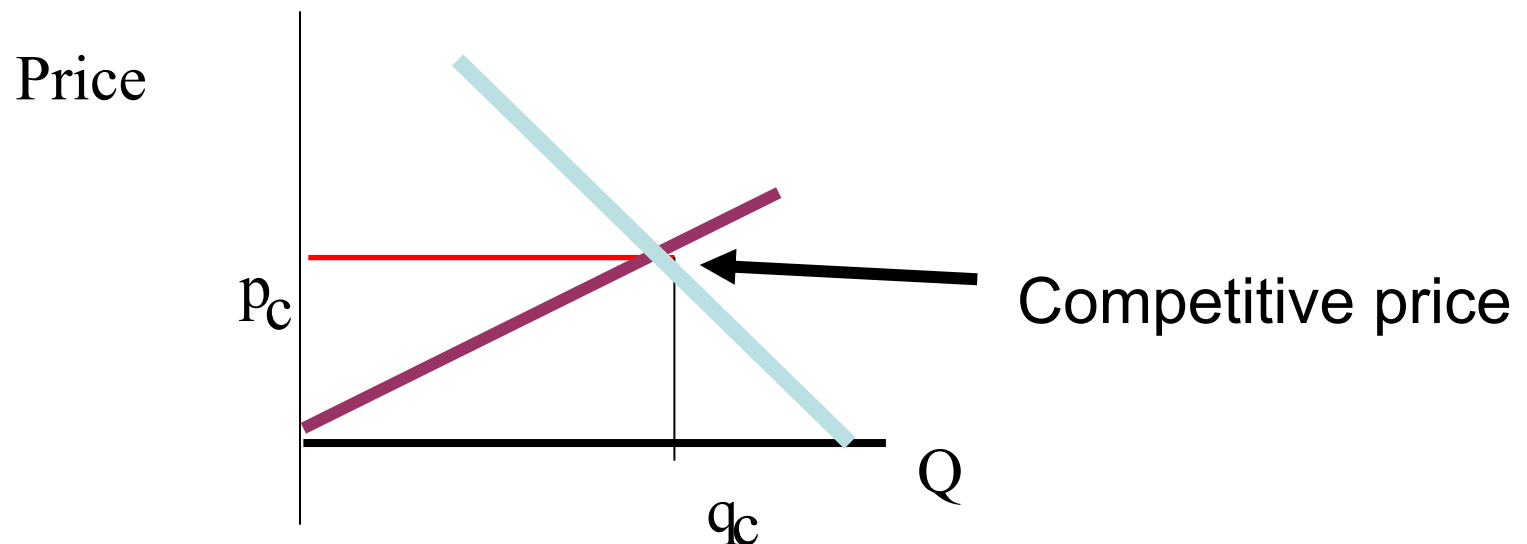
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# Questions

- 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?

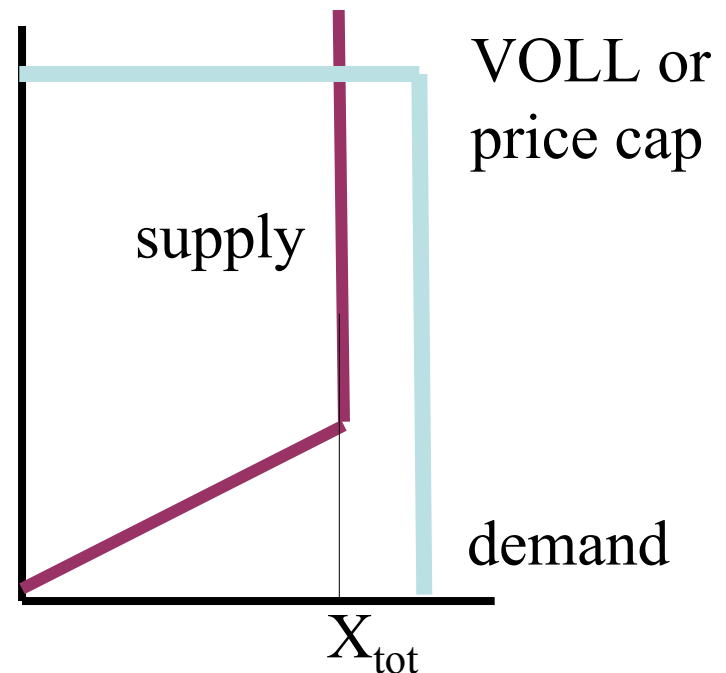
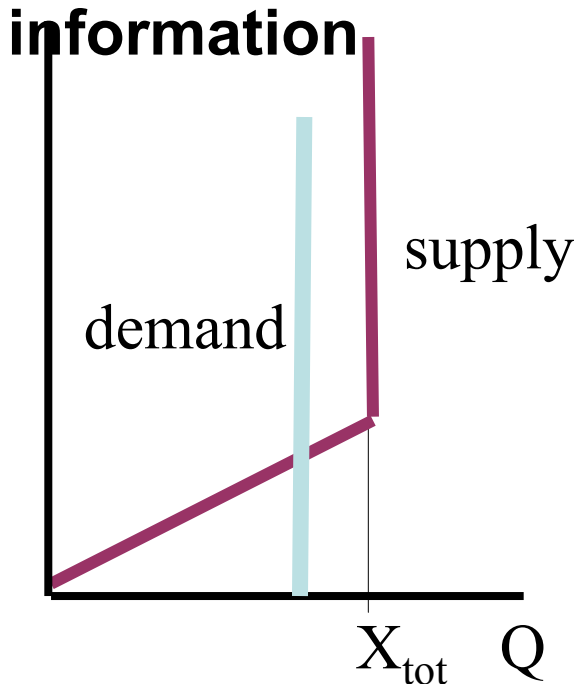
# Market failures affecting price signals

- **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**



# Market failures affecting price signals

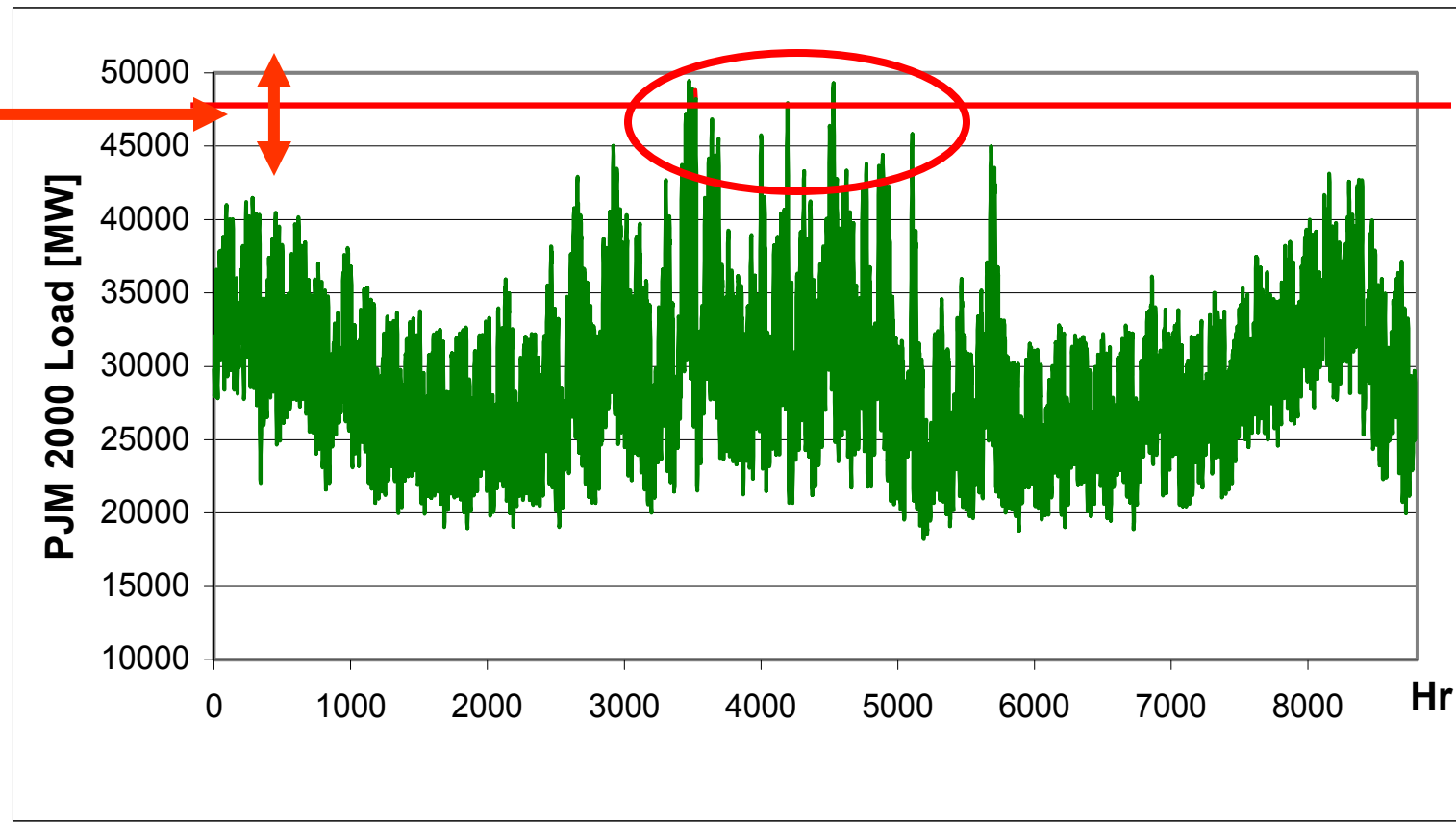
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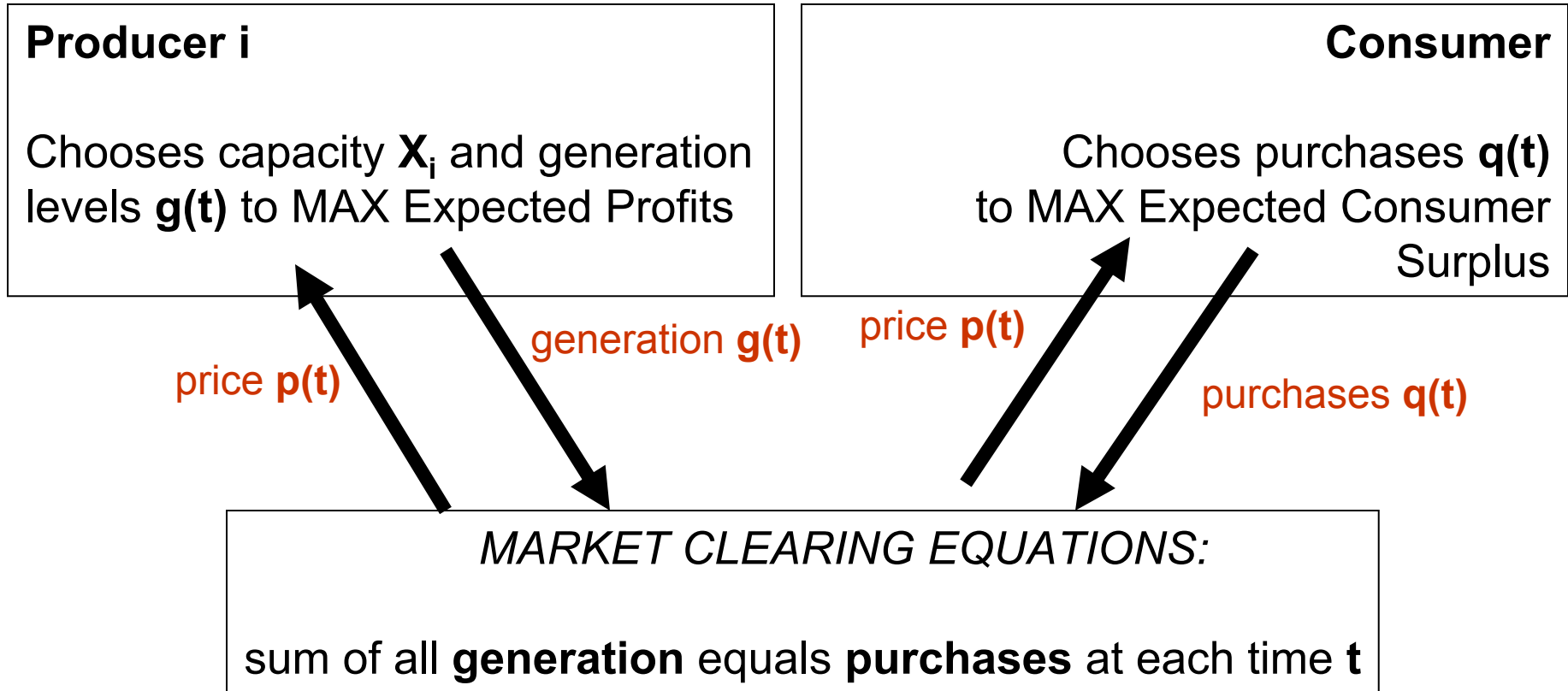
# Model Implementation

- 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



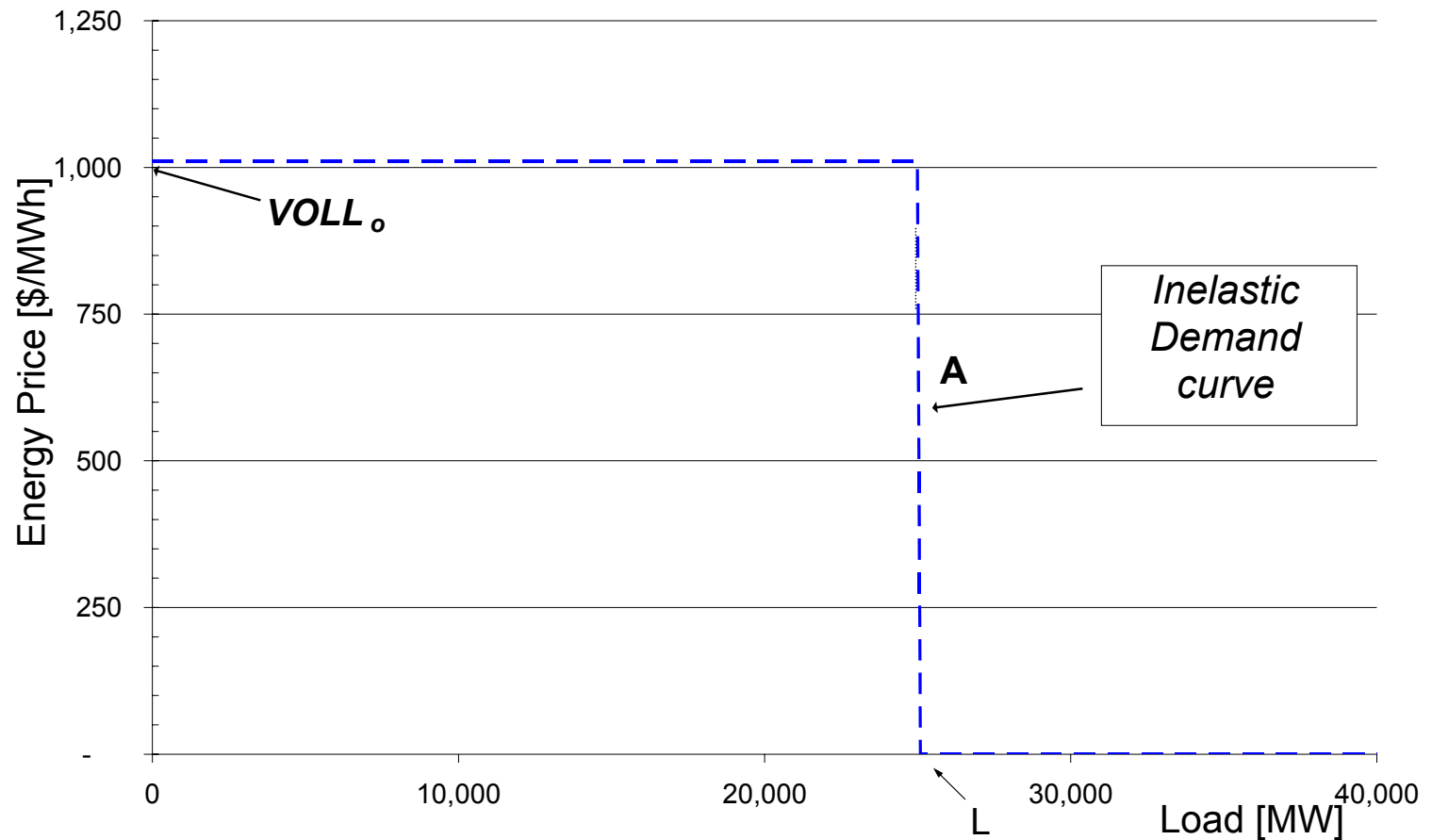
# Stochastic model



- 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

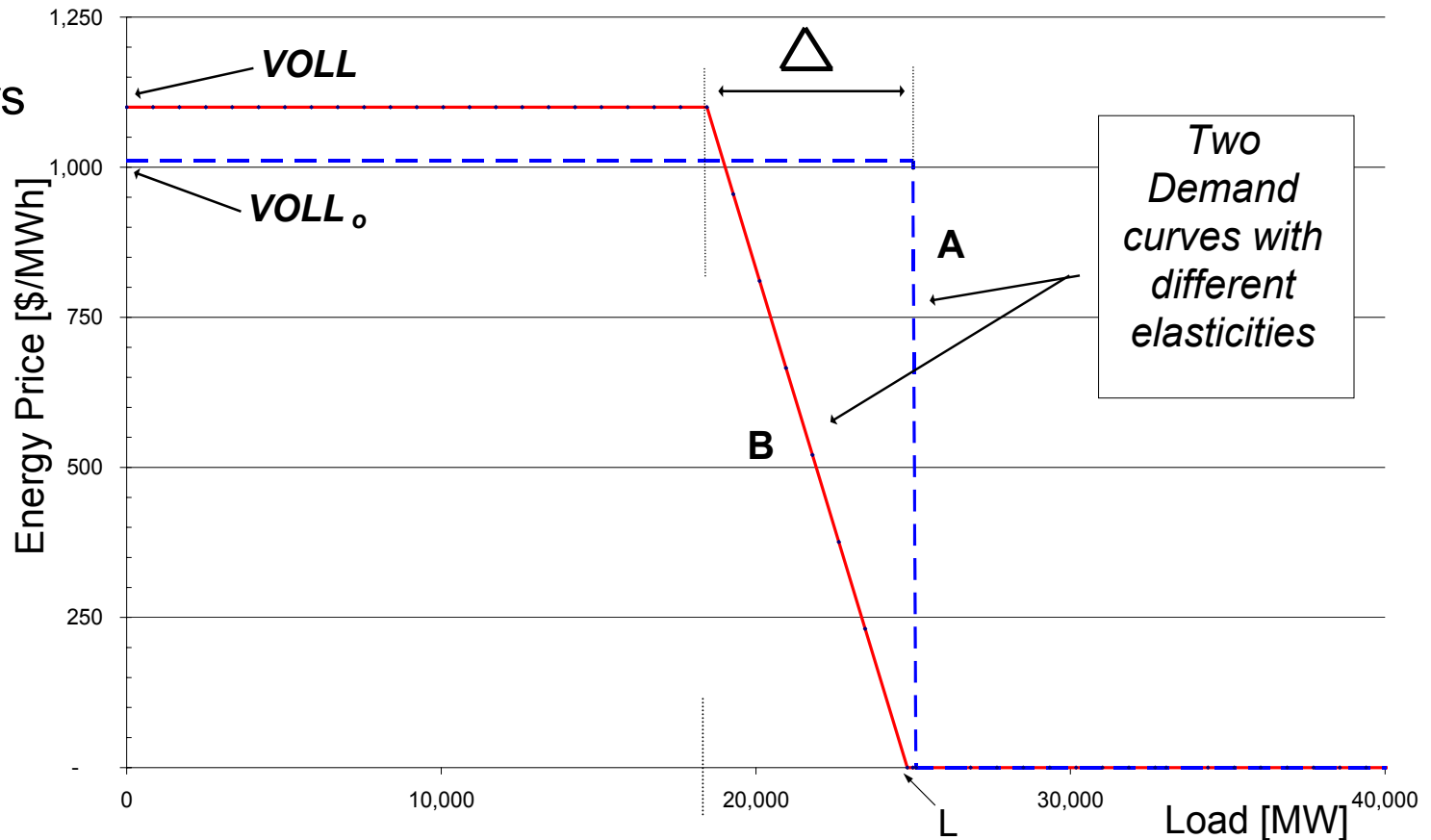
- Inelastic and Elastic Demand curves



# Assumptions

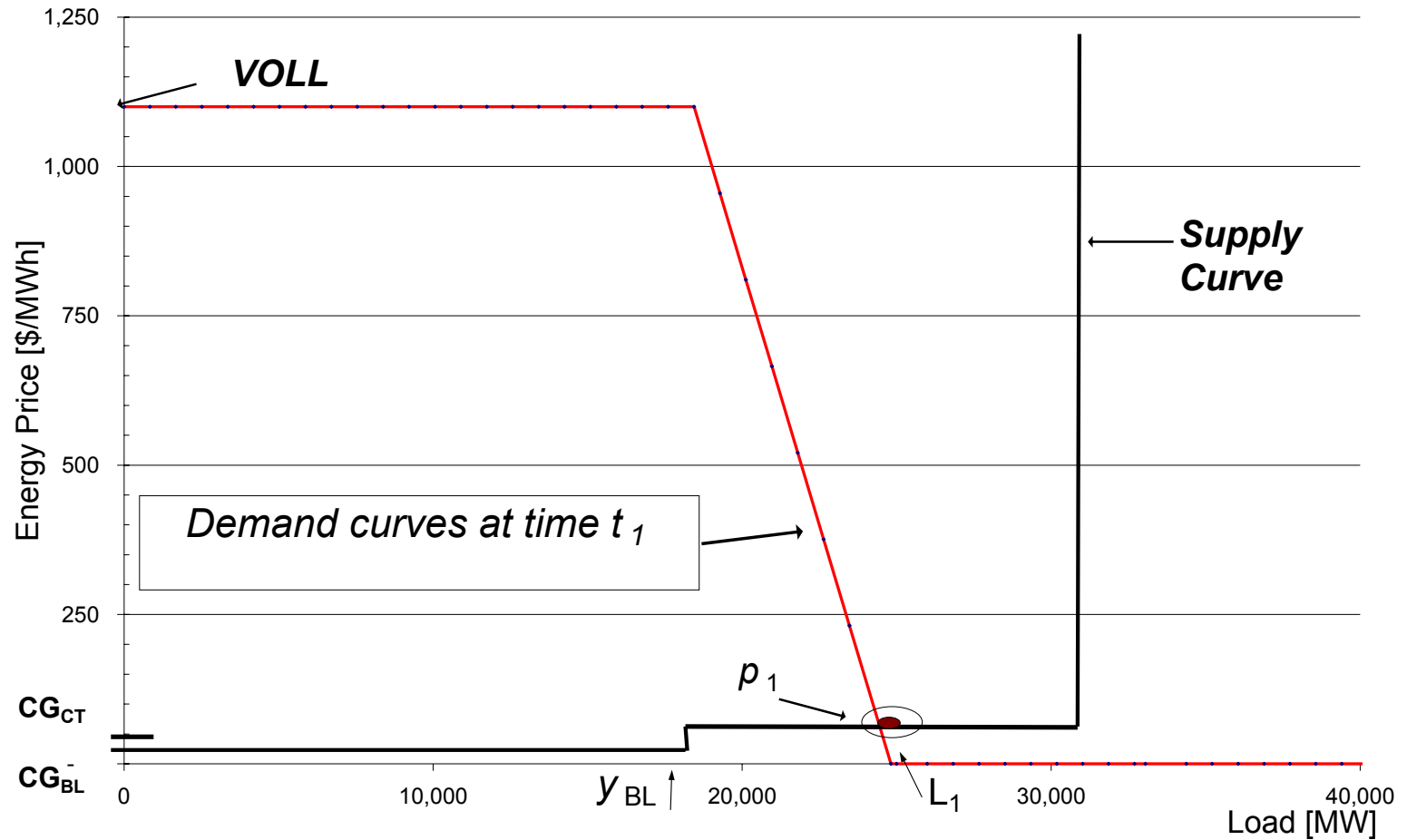
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- The consumers value, ie, the area under the curve, must remain constant



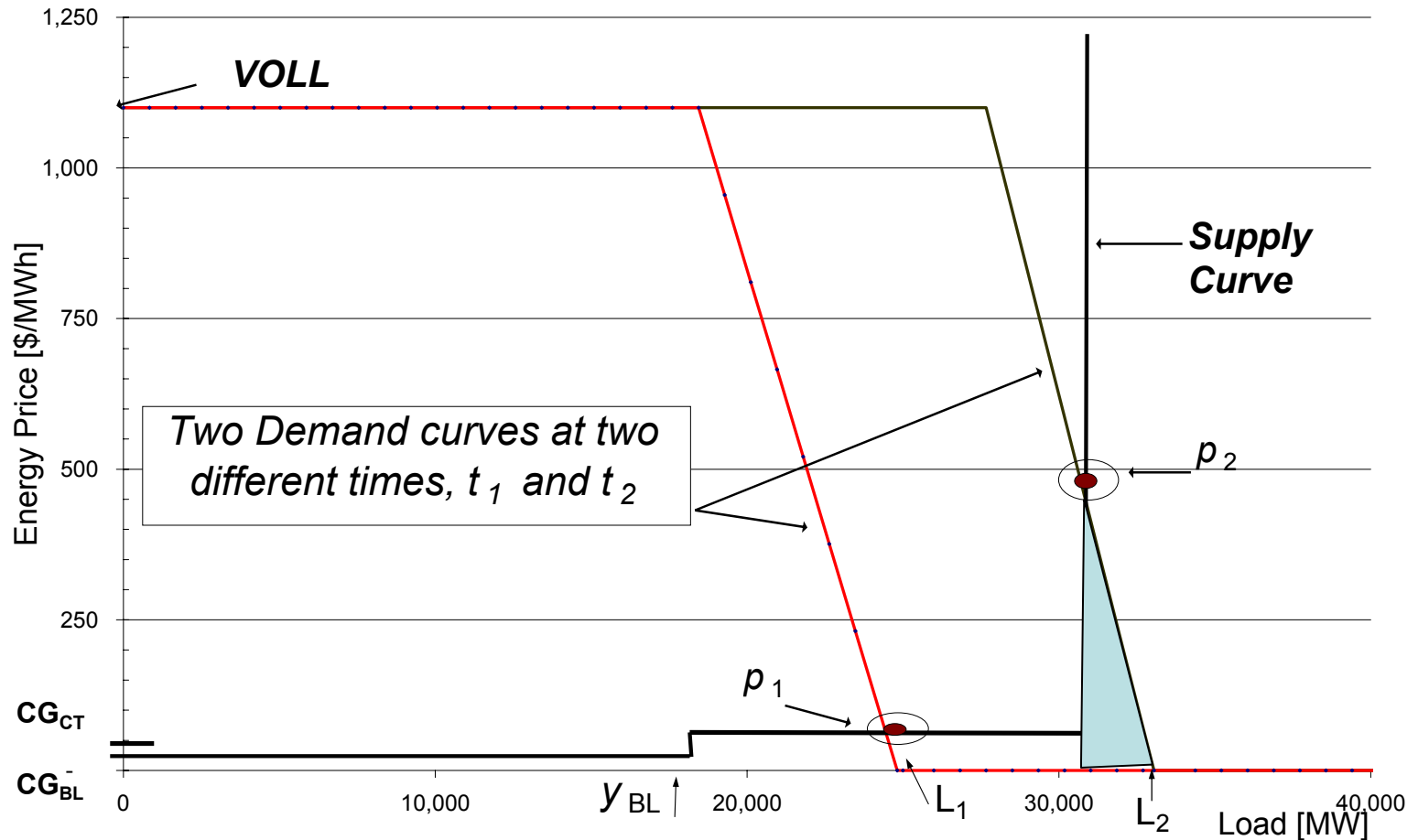
# Assumptions

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



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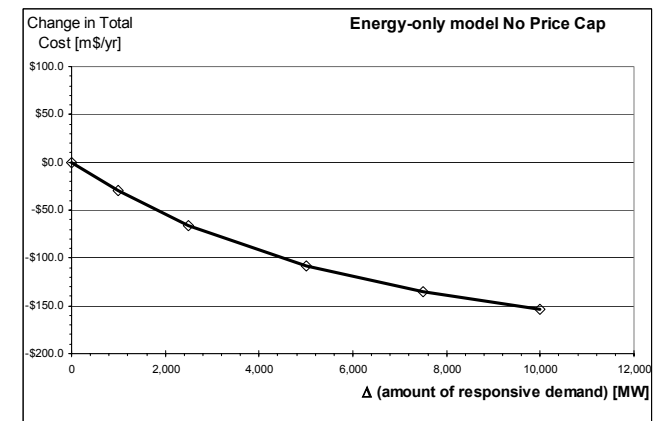
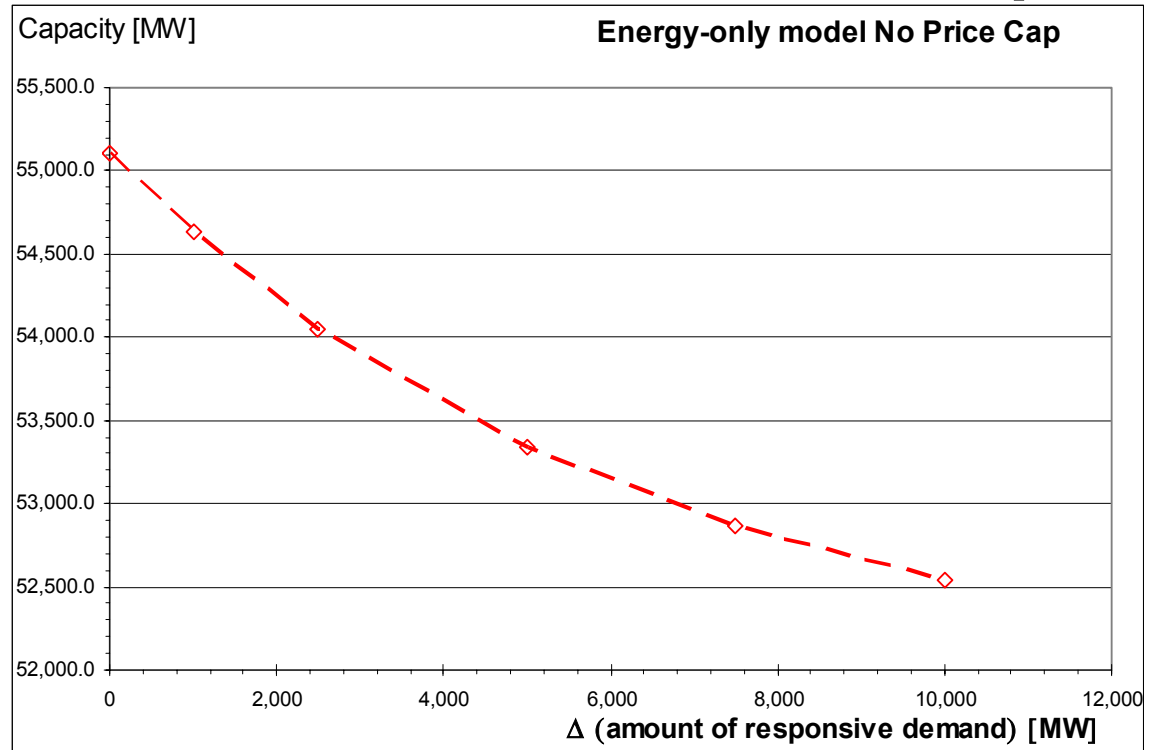
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# Results

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

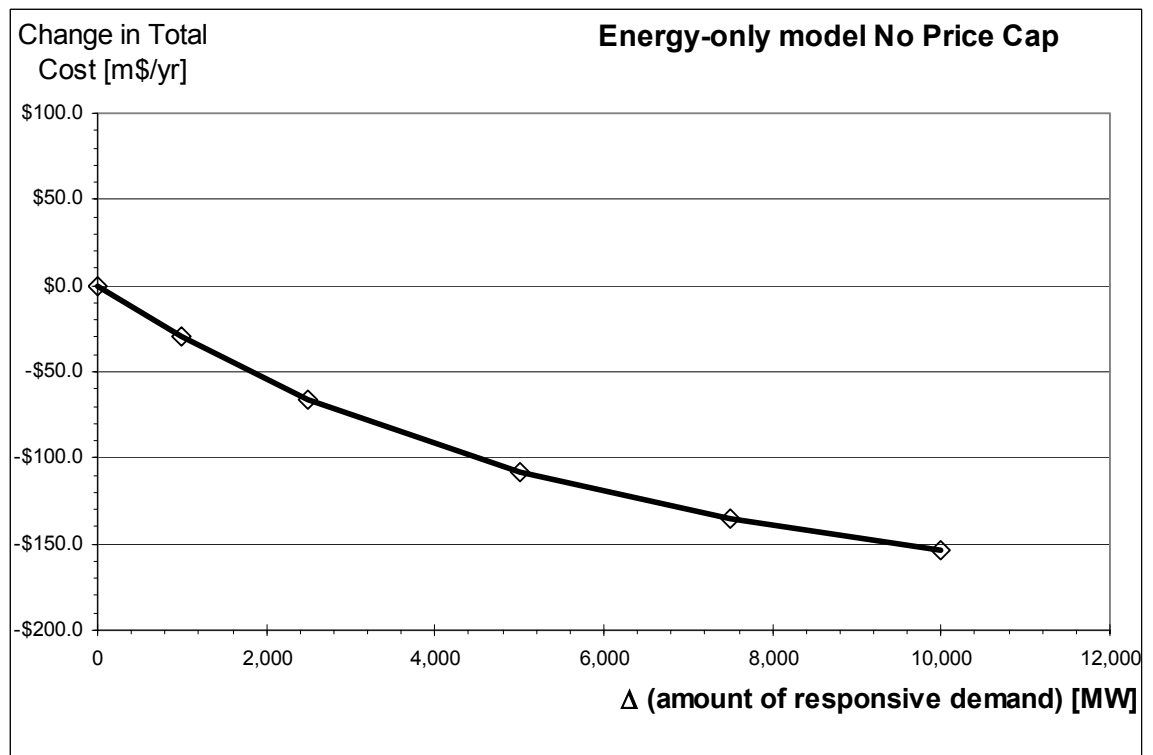
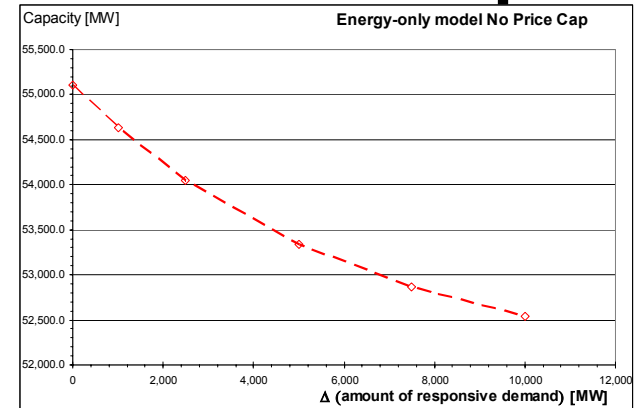
# Results 1. No Price Cap

- NO price cap
- Each point is an equilibrium solution
- **Total system costs and total capacity decrease with increasing demand elasticity (cost of  $\Delta$  not included)**



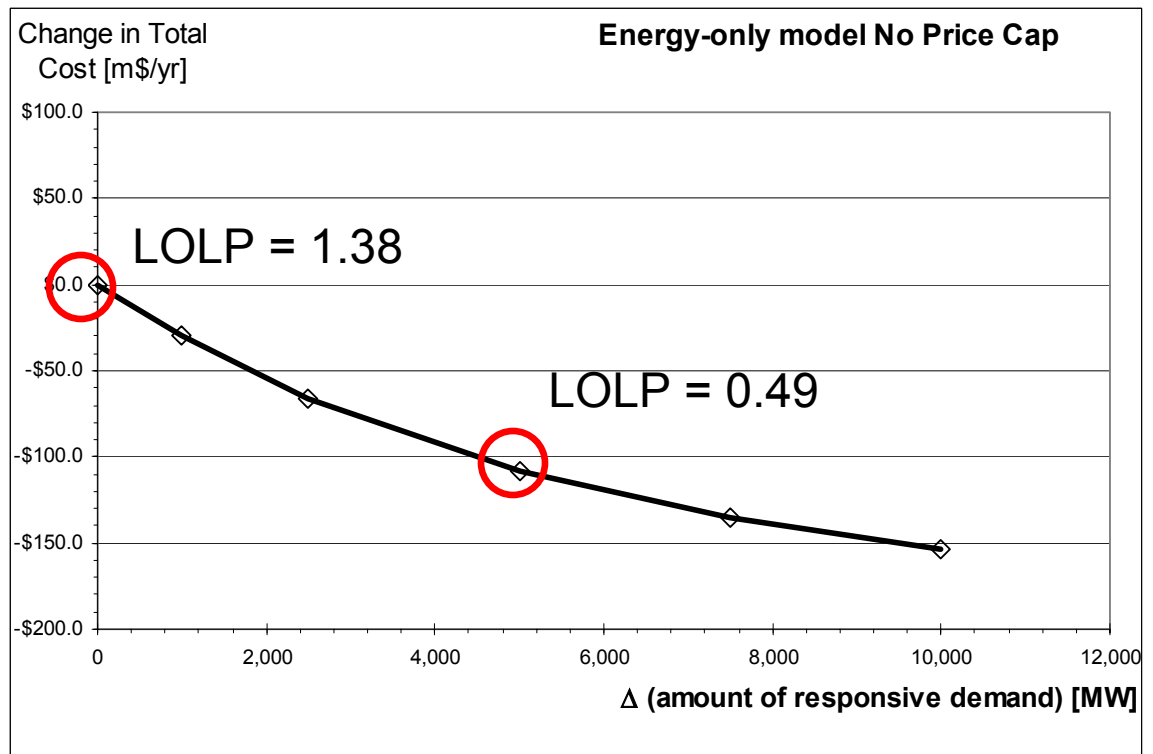
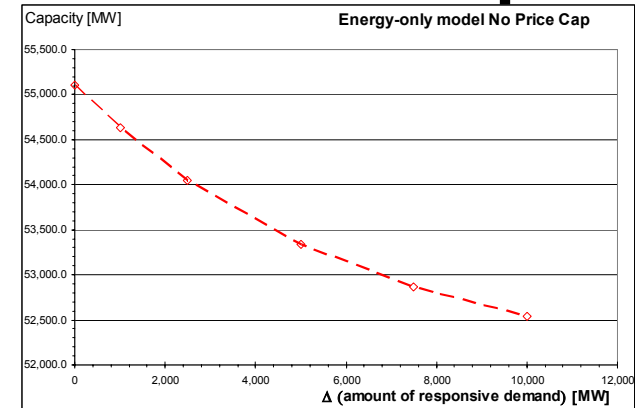
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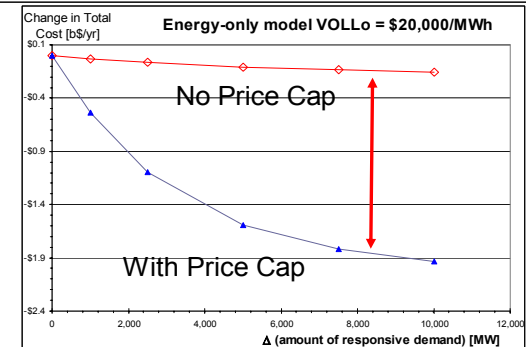
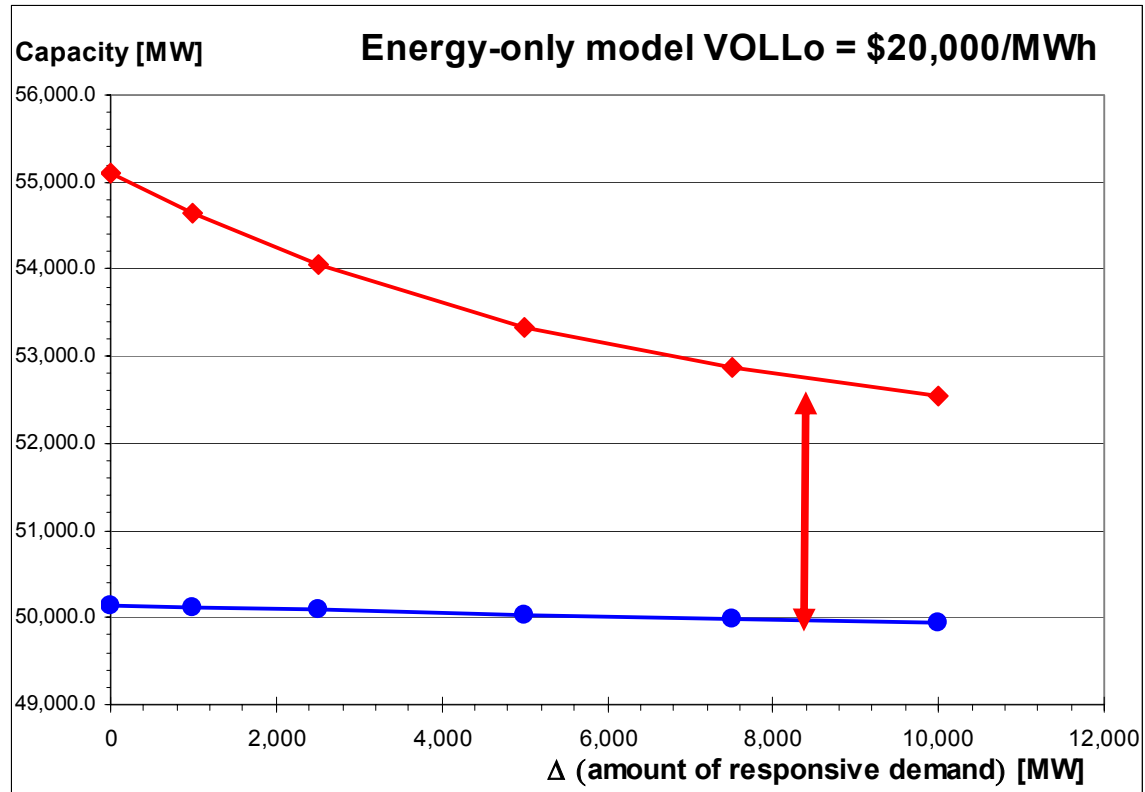
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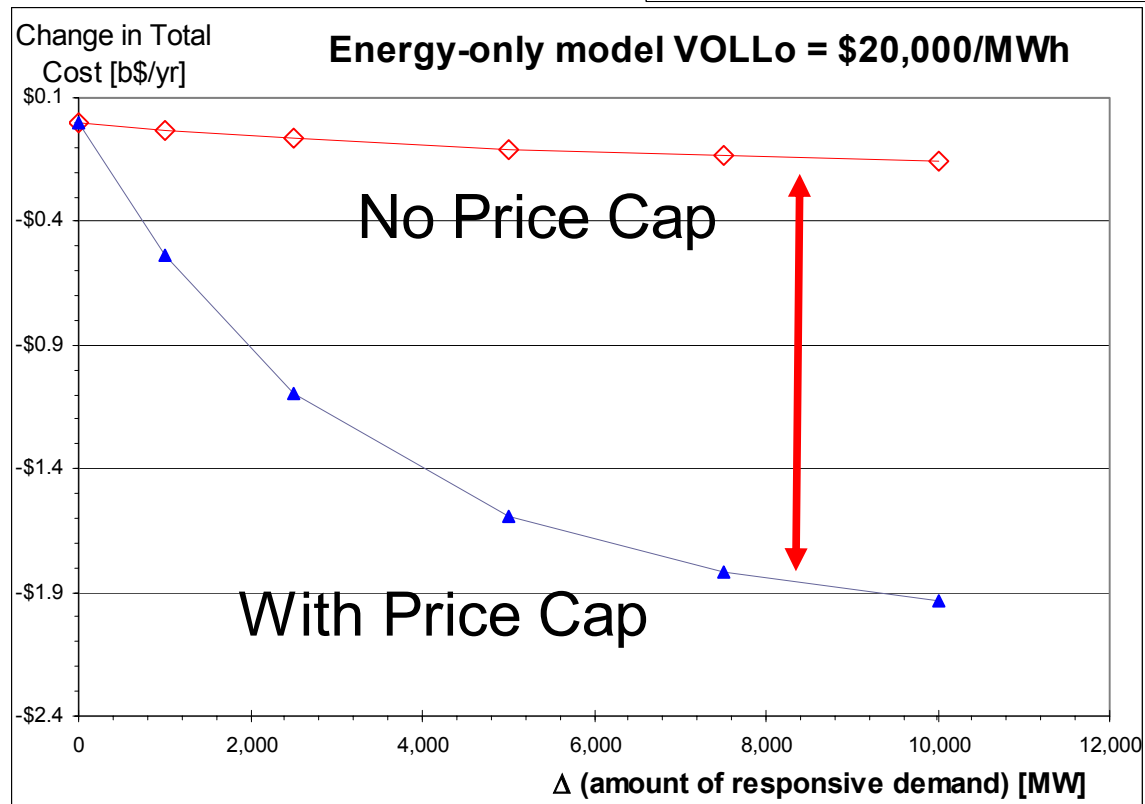
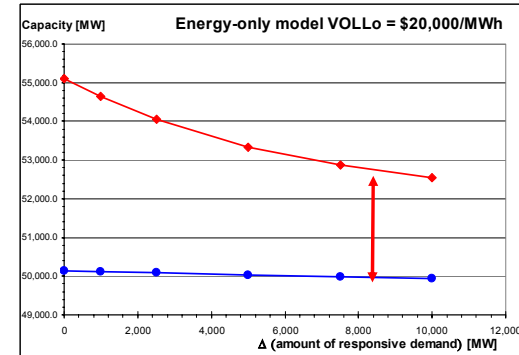
# Results 2. Price Cap

- 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  $\Delta$  not included)



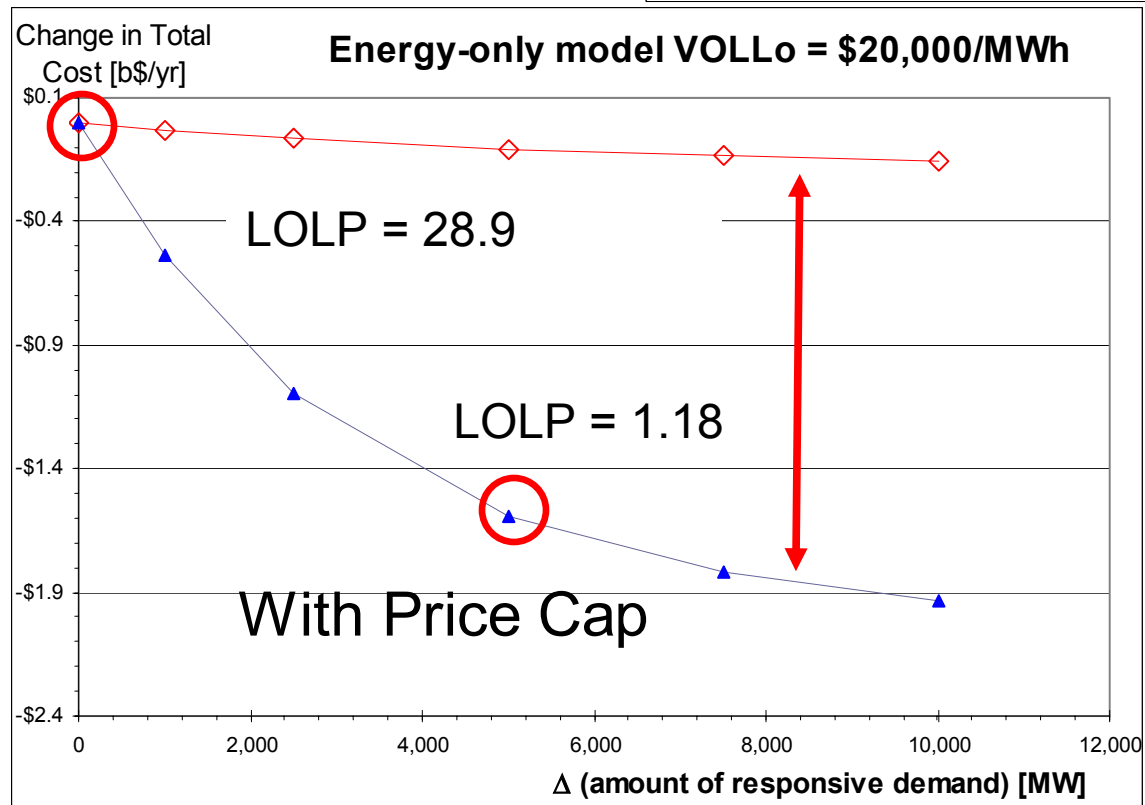
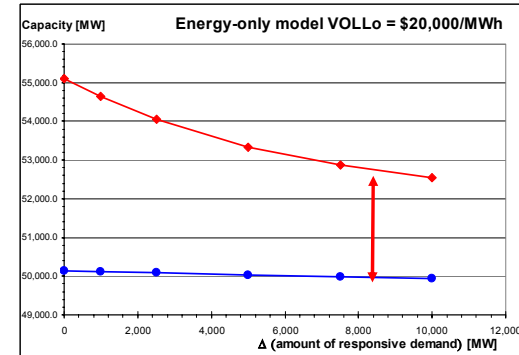
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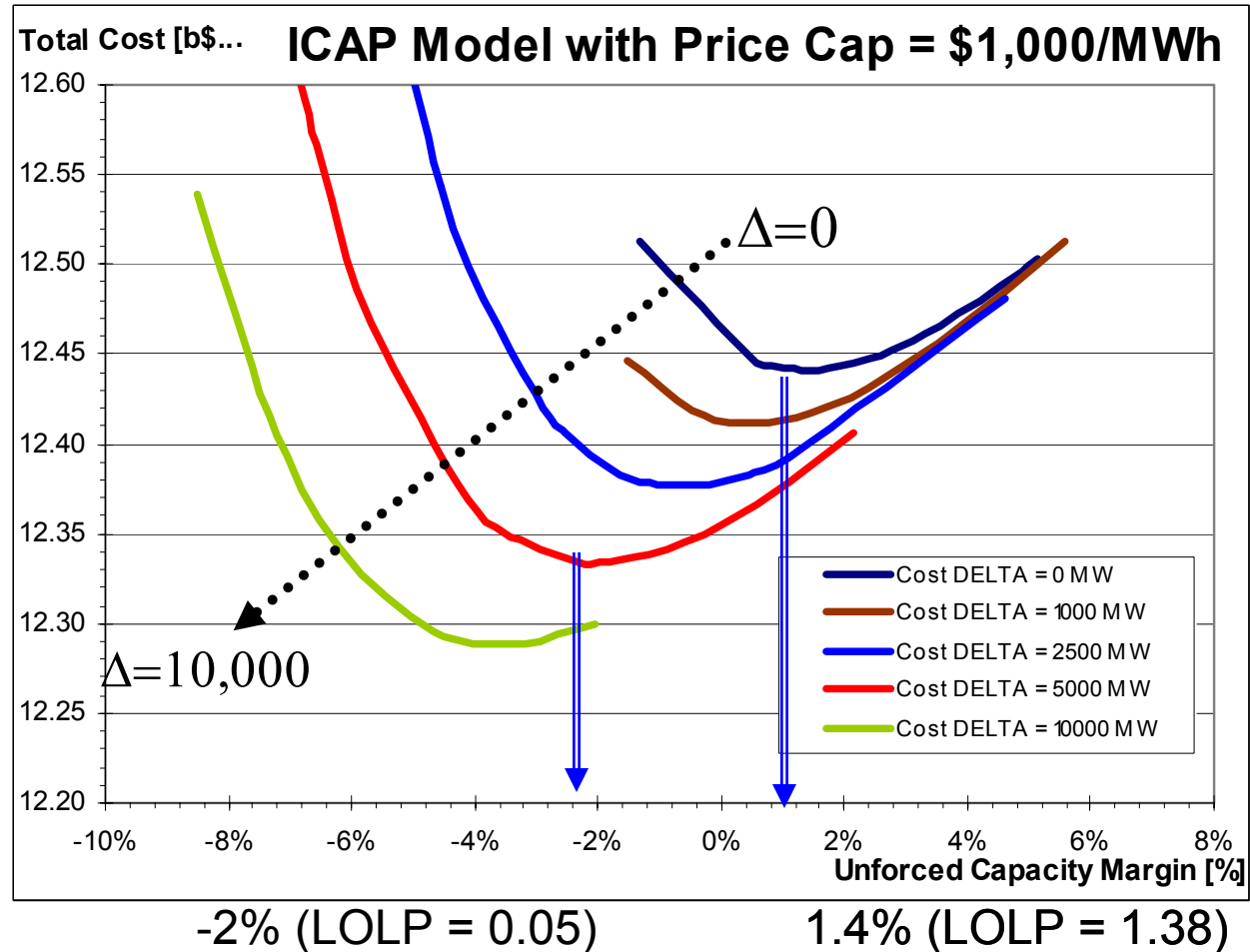
# Results 3. ICAP

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



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# 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

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Thanks for your attention.

Comments or Questions?

