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ELECTRICITY MARKETS DEVELOPMENT PROGRAM-GEMTP II

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Market Structure Design

Day 1

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Overview of Presentation

- Brief Background
- Objectives of Electricity Markets
- Privatization
- Preconditions for Electricity Markets
- Electricity Market Design Elements
- Key Issues with Electricity Markets
- Examples & Lessons Learned

Frank Felder's Background

Frank Felder is an expert on the economics and reliability of restructured electric power systems. Frank is Associate Research Professor at the Edward J. Bloustein School of Planning and Public Policy, Rutgers University. He is also the Director of the Center for Energy, Economics & Environmental Policy, where he conducts research in electricity and energy policy.

He also consults to a wide range of clients in industry, advising them on market design, market power, electricity price forecasting, and risk management. He has testified before the Federal Energy Regulatory Commission and several state public utility commissions. He holds a Ph.D. from the Engineering Systems Division in Technology, Management and Policy from M.I.T.

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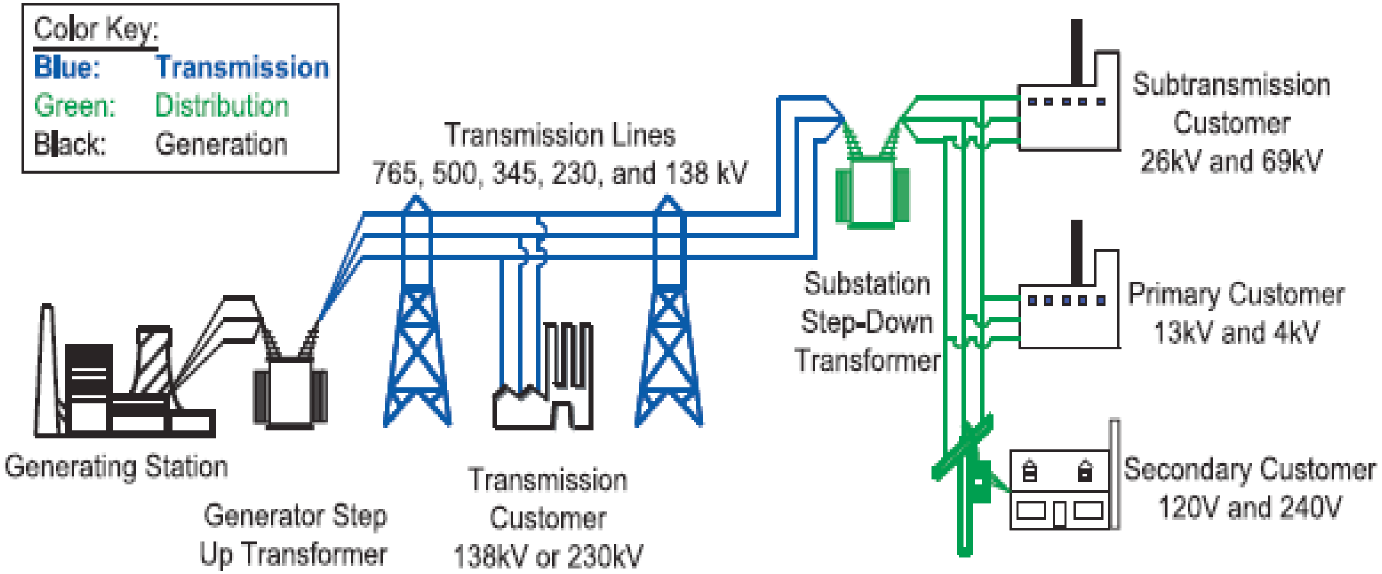
Electric Utility Industry Production & Distribution



States of Transmission Development in the United States

1885 to 1910: Isolated Generation Plants
1910 to 1935: Isolated Systems
1935 to 1960: Regional Systems
1960 to 1985: Interregional Systems

Figure from the U.S.-Candian Power System Outage Task Force final report On the 2003 Blackout, p. 5.

Electric System Timeline

Transmission Construction:
3-10 years

Generation Construction:
2-10 years

Planned Generation and Transmission Maintenance:
1-3 years

Unit commitment:
12 hours ahead for the next 24 hour day

Economic Dispatch:
Every 5 minutes but planned for 6 hours ahead

Time

Build | Maintain | Unit Commitment | Dispatch | Real Time

Note: diagram not drawn to scale

Public Policy Objectives for Electric Power Systems

- Economic Efficiency
  - Technical (production) efficiency
  - Allocative efficiency
  - Efficient product and service variety
  - Dynamic efficiency
  - Economic development
- Reliability
- Environmental objectives

Privatization Description

- In many countries, the electric power system or parts thereof is owned by the government
- Prior to or in conjunction with establishing electricity markets, at a minimum, the generation assets need to be sold to private entities
  - This is called privatization

Motivation for Privatization & Examples

- Motivation:
  - Need multiple generation companies to have sufficient competition for electricity markets
  - The premise that private companies are more efficient and less subject to political intervention
  - Raise money for the government
- Examples
  - England and Wales
  - Ontario

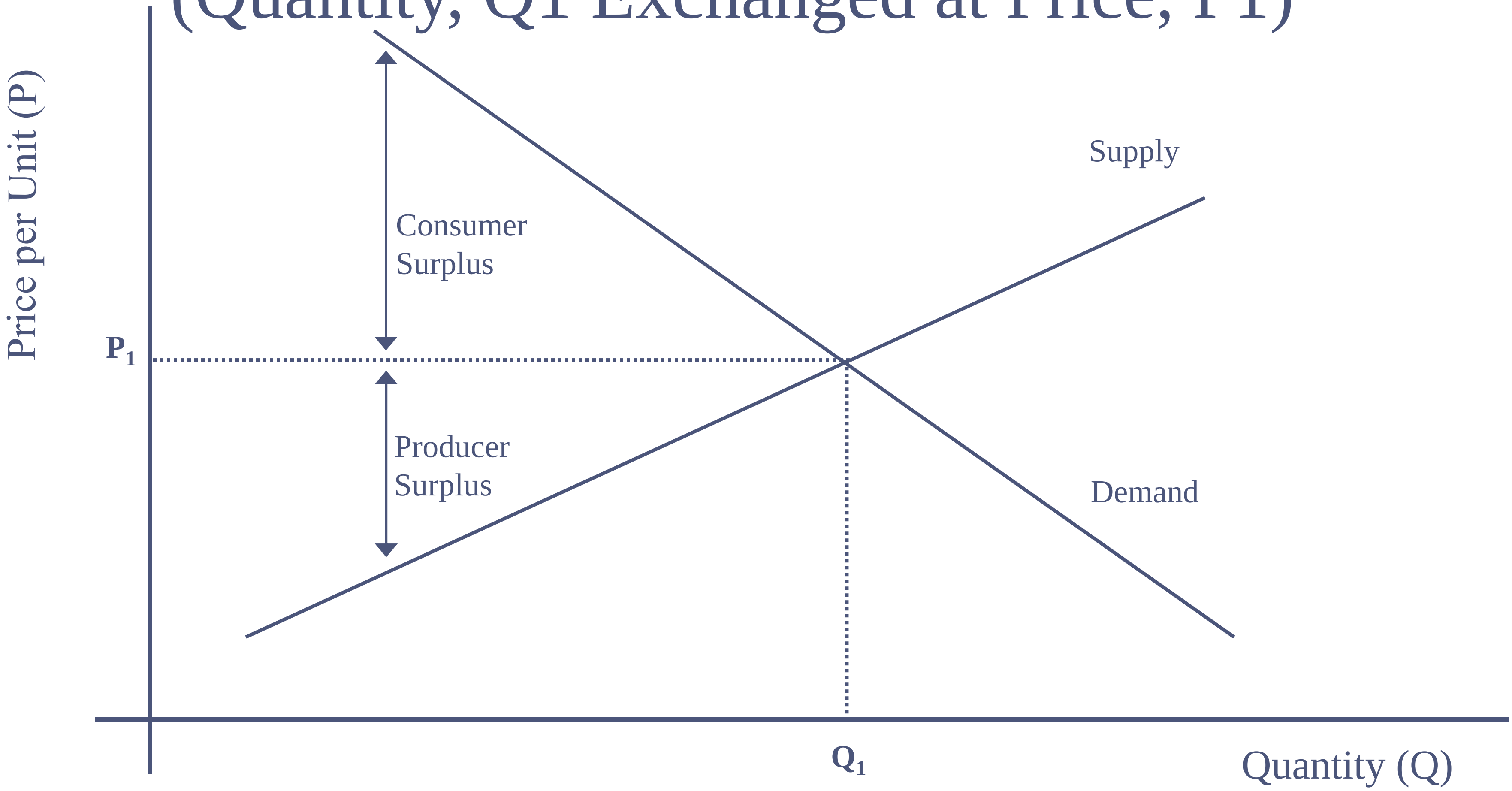
Preconditions for Electricity Markets

- Sufficient number of generation units at key locations on the transmission system
- Broad political and regulatory support
  - Understanding of electricity fundamentals as they pertain to electricity markets
  - Understanding of the benefits and limitations of markets
- => Tradeoff is between imperfect regulation and imperfect markets

Key Issues and Constraints that Electricity Markets Need to Address

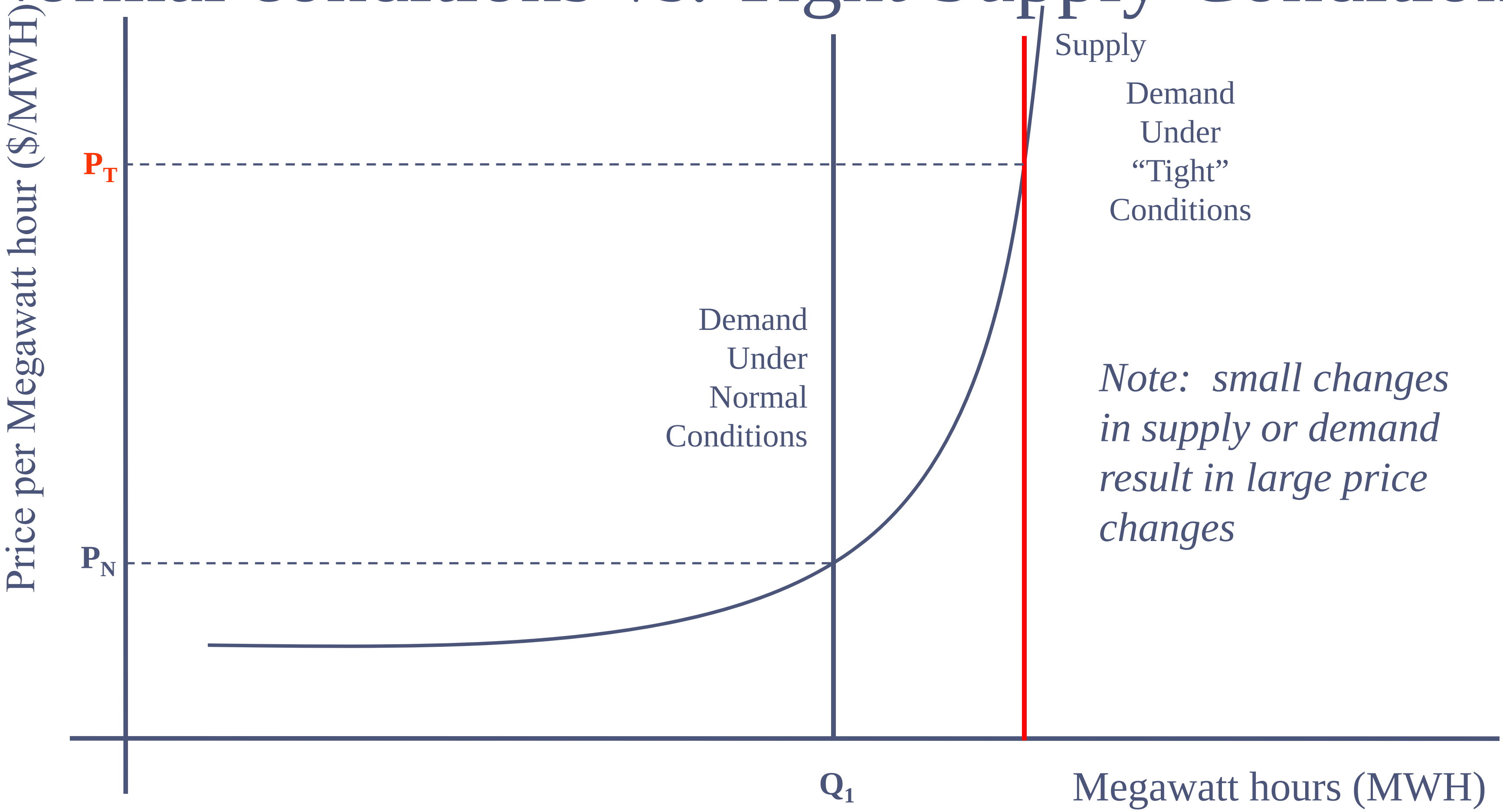
- System operations and reliability
- Loop flows (parallel flows) and transmission congestion
- Transmission expansion
- Demand response
- Market power
- => Defining property rights is difficult to do on electric power systems

Simple Illustration of Efficient Pricing: (Quantity, Q1 Exchanged at Price, P1)



Social Welfare = Consumer Surplus + Producer Surplus

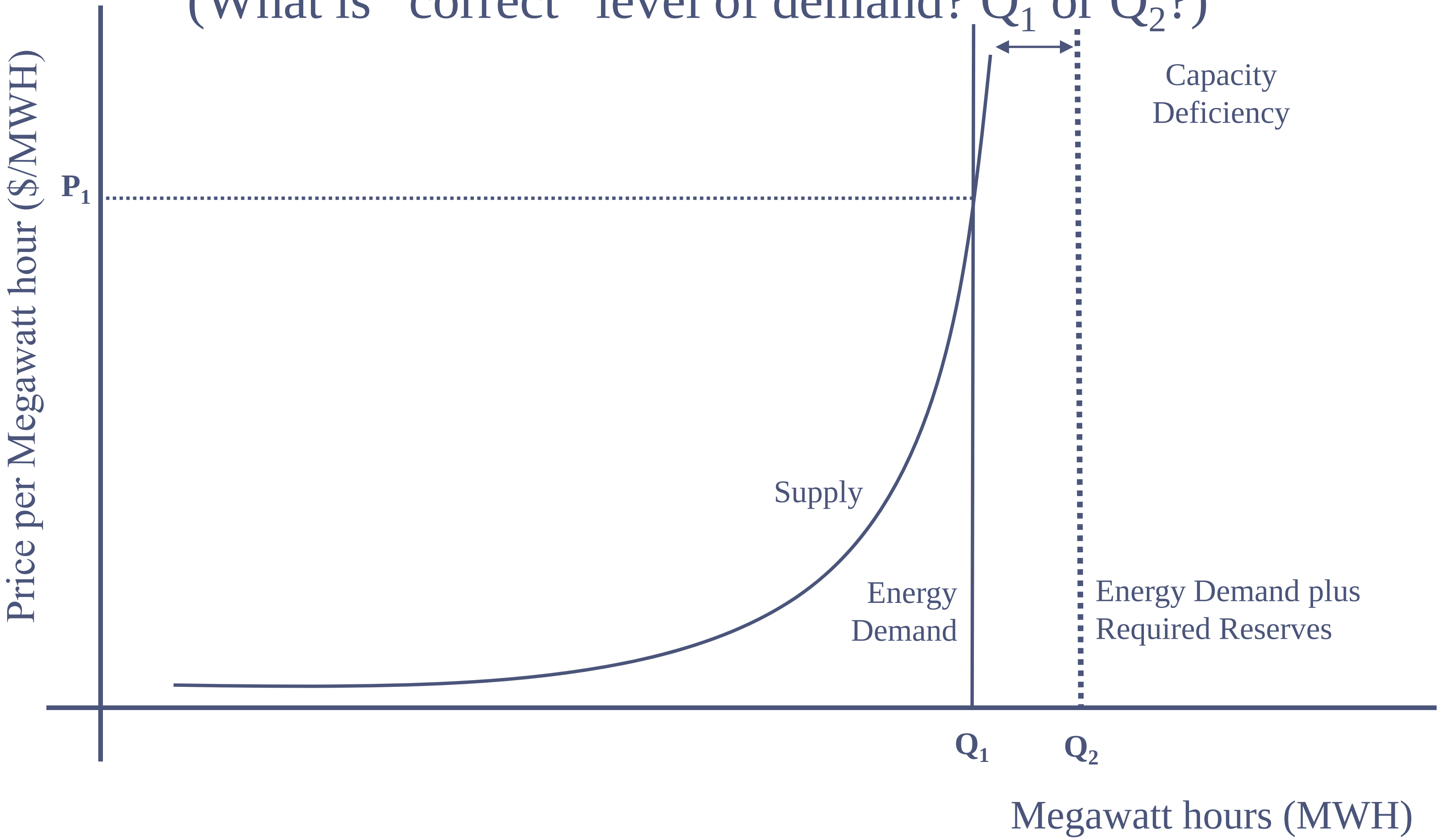
Electricity Example: Normal conditions vs. Tight Supply Conditions



Sometimes the electricity supply curve is characterized as a “hockey stick”

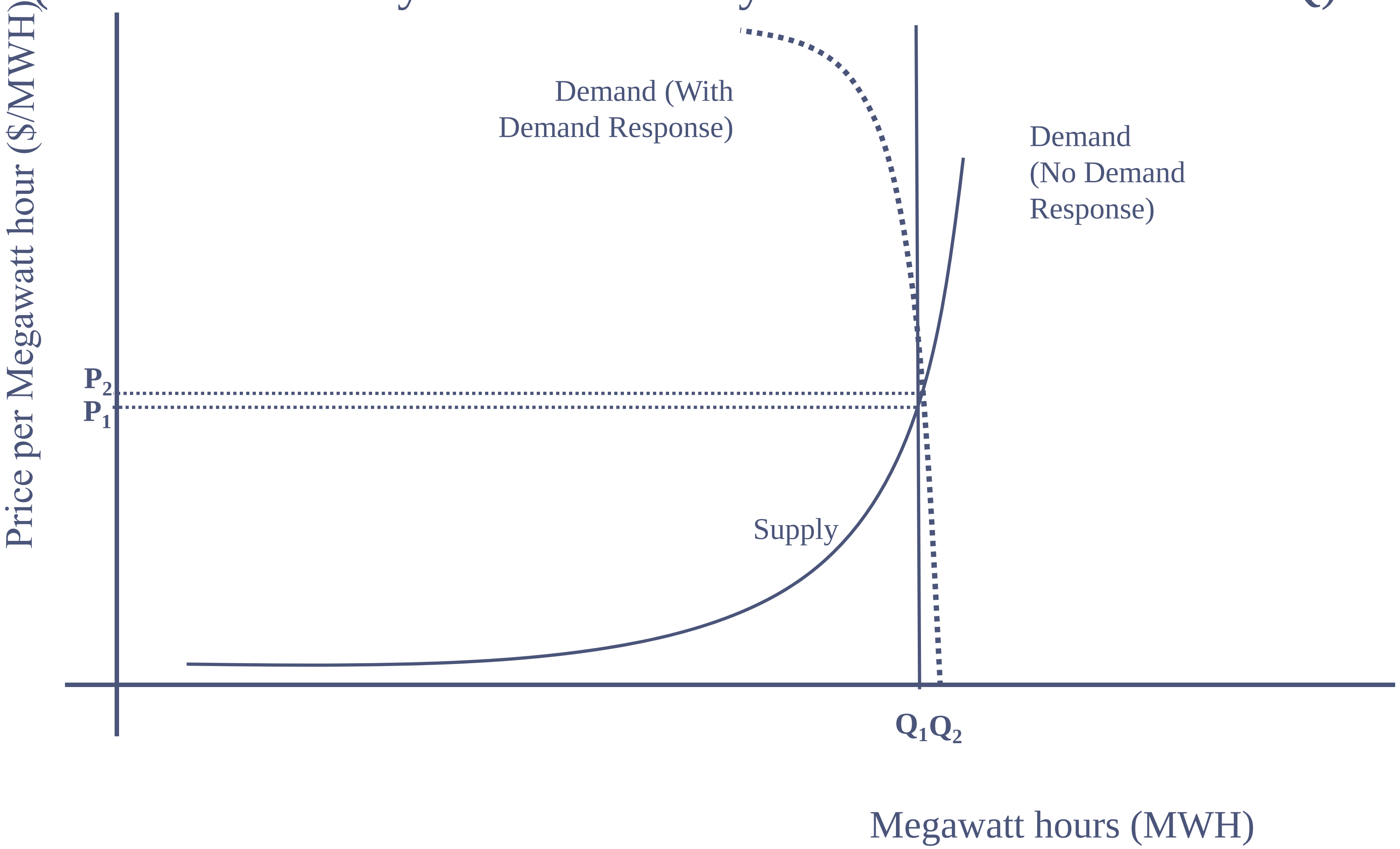
Electricity Under Capacity Deficiency Conditions

(What is "correct" level of demand? Q_1 or Q_2?)



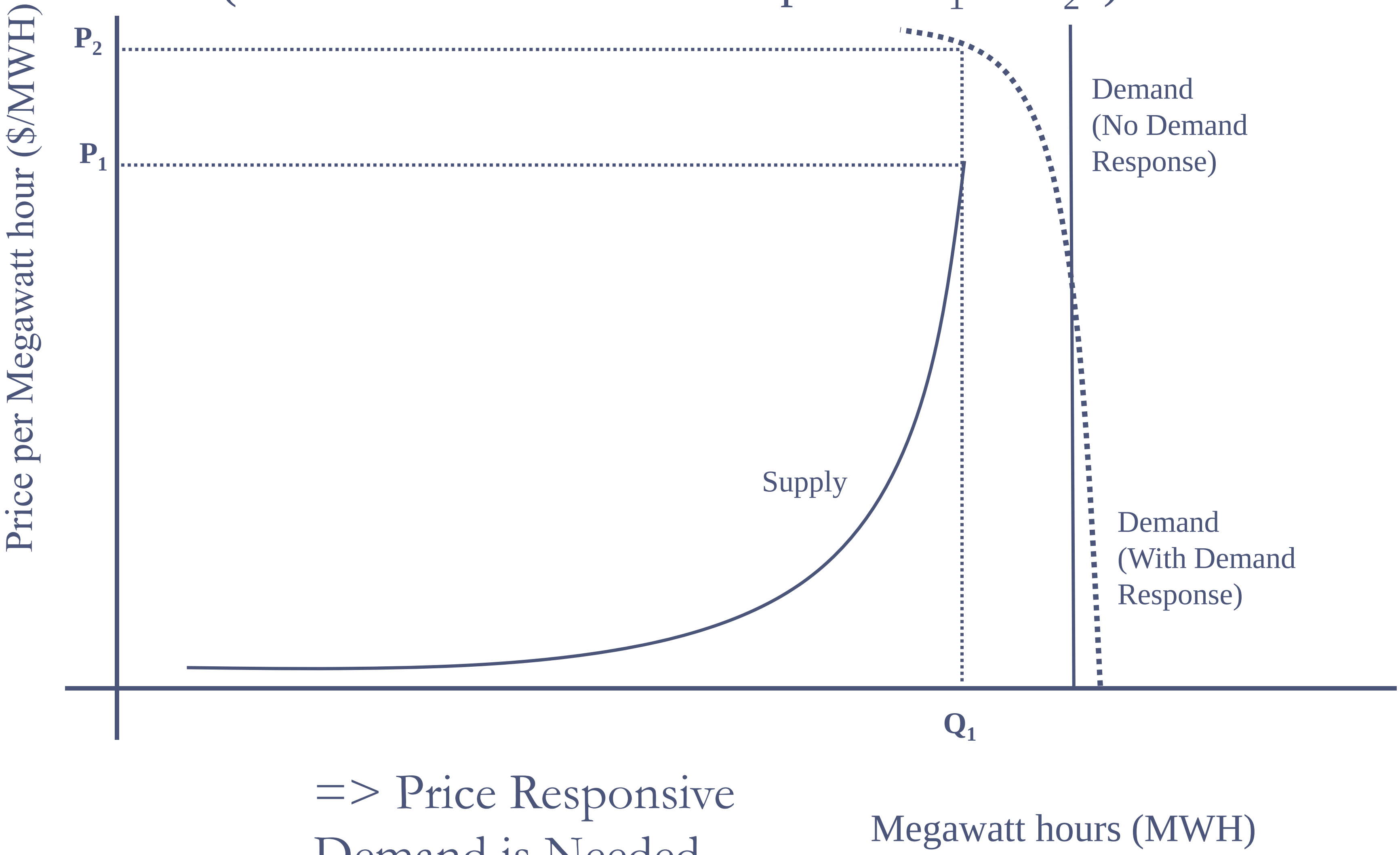
Effect of Demand Response in Normal Conditions

(Demand elasticity would normally have little effect on P or Q)



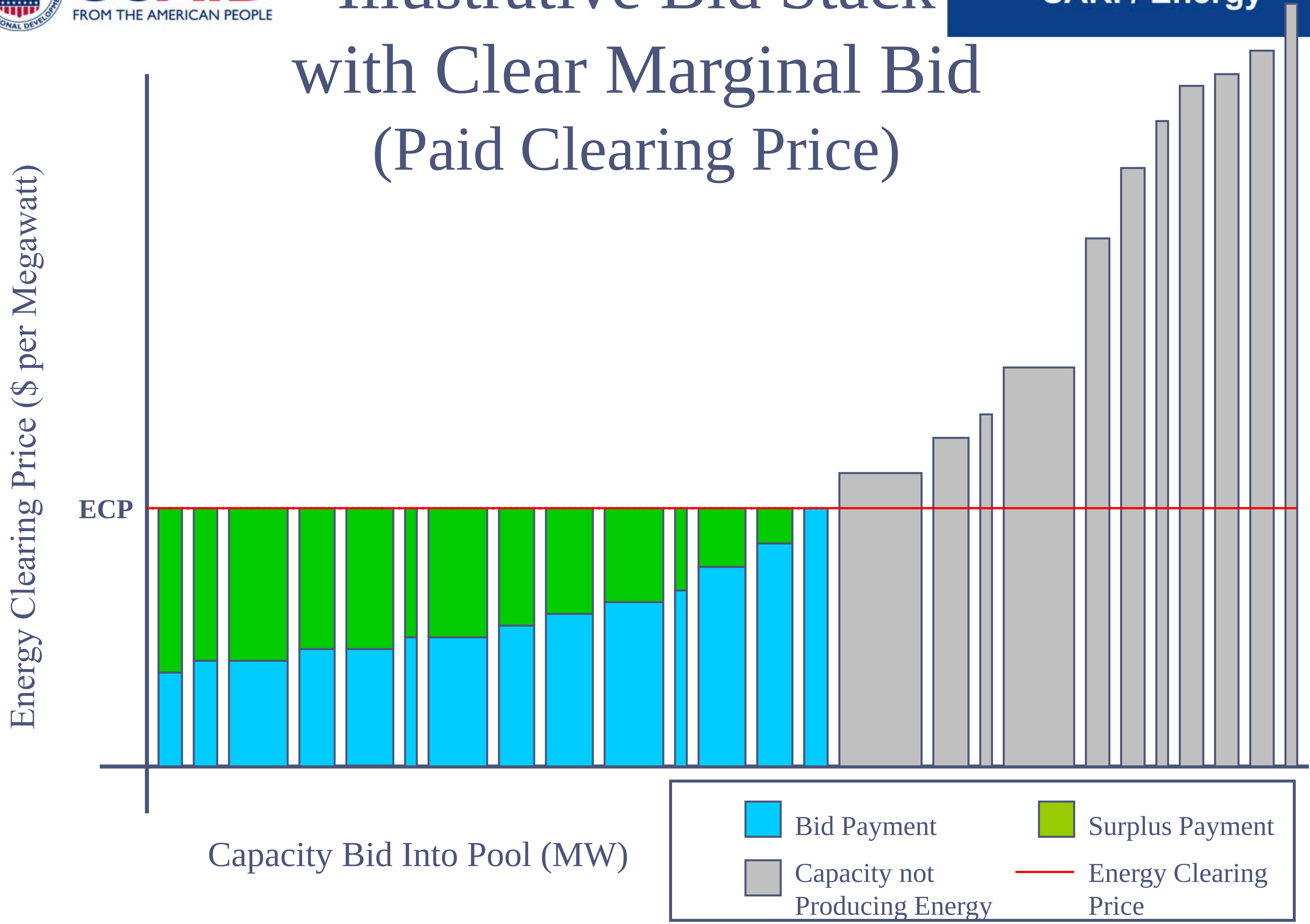
Demand Response in Capacity Deficiency Conditions

(What is "correct" level of price? P_1 or P_2?)



=> Price Responsive Demand is Needed

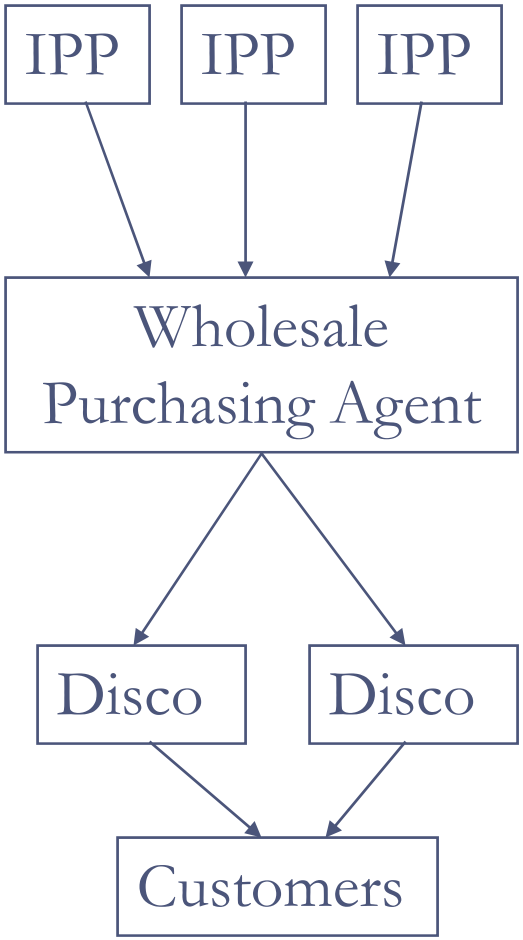
Illustrative Bid Stack with Clear Marginal Bid (Paid Clearing Price)



Possible Market Models

- Competitive procurement
- Wholesale competition
  - Physical bilateral markets
  - System operator without unit commitment
  - System operator with unit commitment
    - Zonal pricing
    - Locational (nodal) pricing
- Retail competition

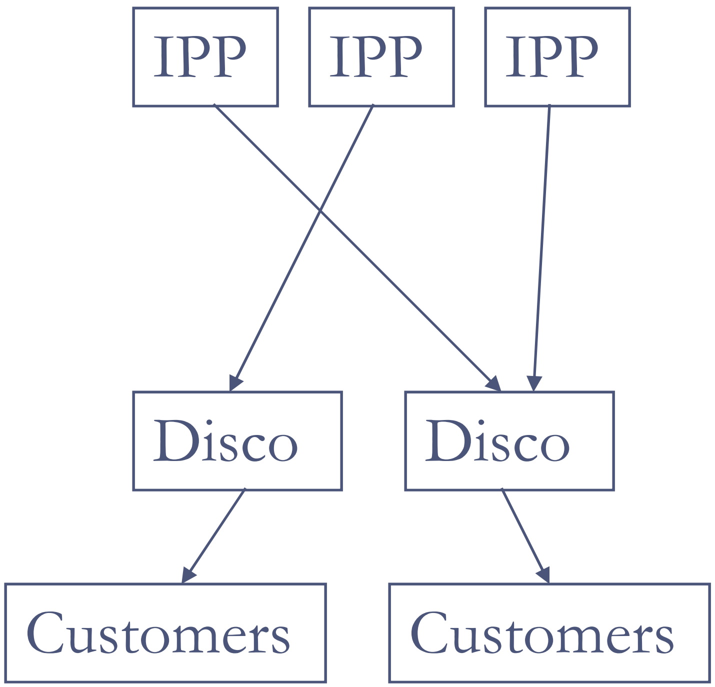
Competitive Procurement



- Independent power producers (IPP) are formed
  - From existing generation units
  - New entry
- Allows for generation competition via power purchase agreements (PPA)
- Complications with PPA
- Examples
  - US (PURPA)
  - Ireland

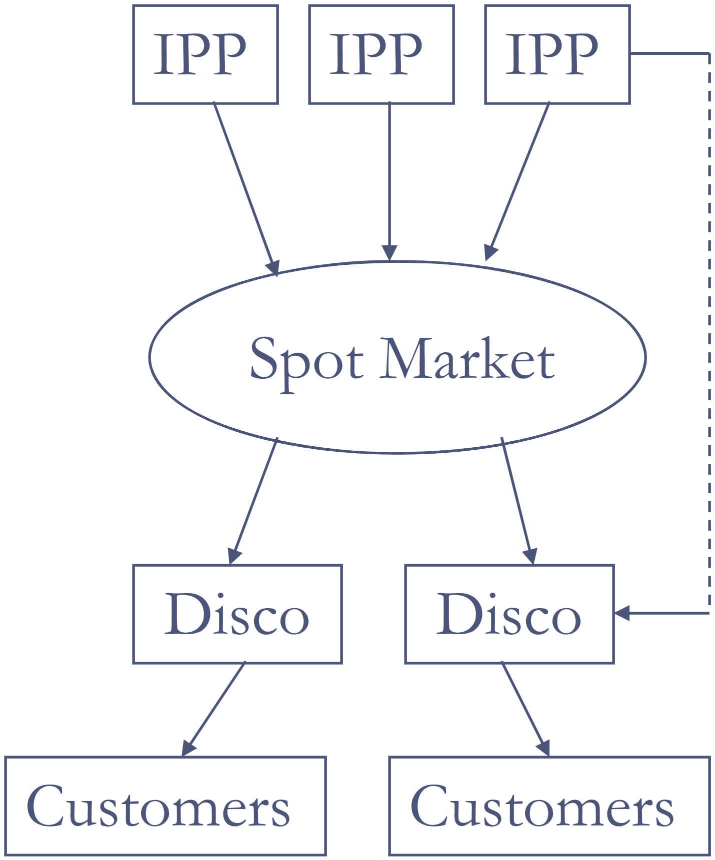
Note: Disco stands for distribution company

Wholesale Competition – Physical Bilateral



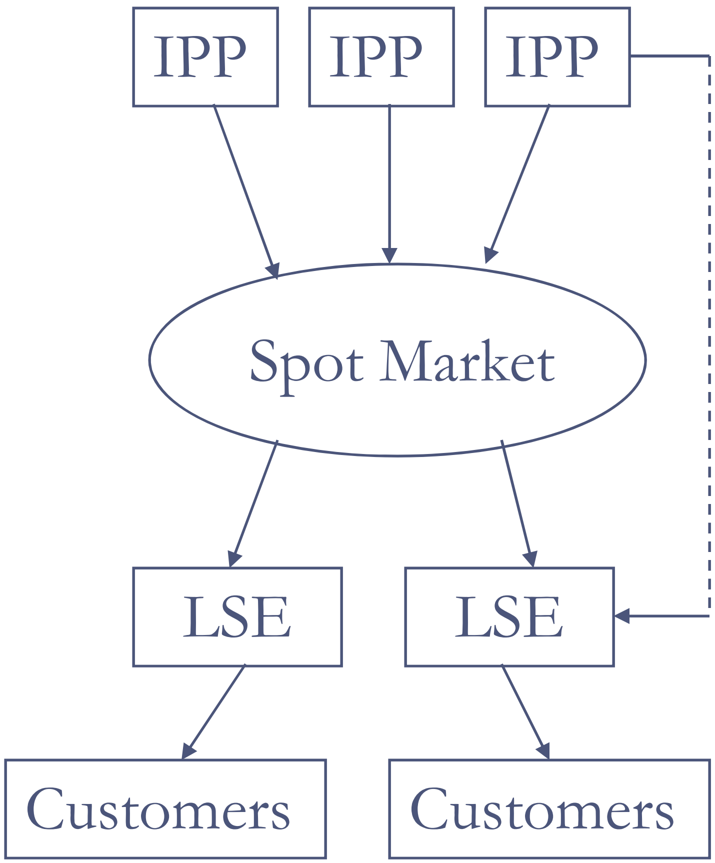
- IPPs are formed
- IPPs compete to sell to distribution companies (aka wholesale wheeling)
- Issues
  - Transmission capacity and congestion management is a concern
- Examples
  - UK in 1990s
  - US EPAct (1992)

Wholesale Competition – Organized Spot Markets



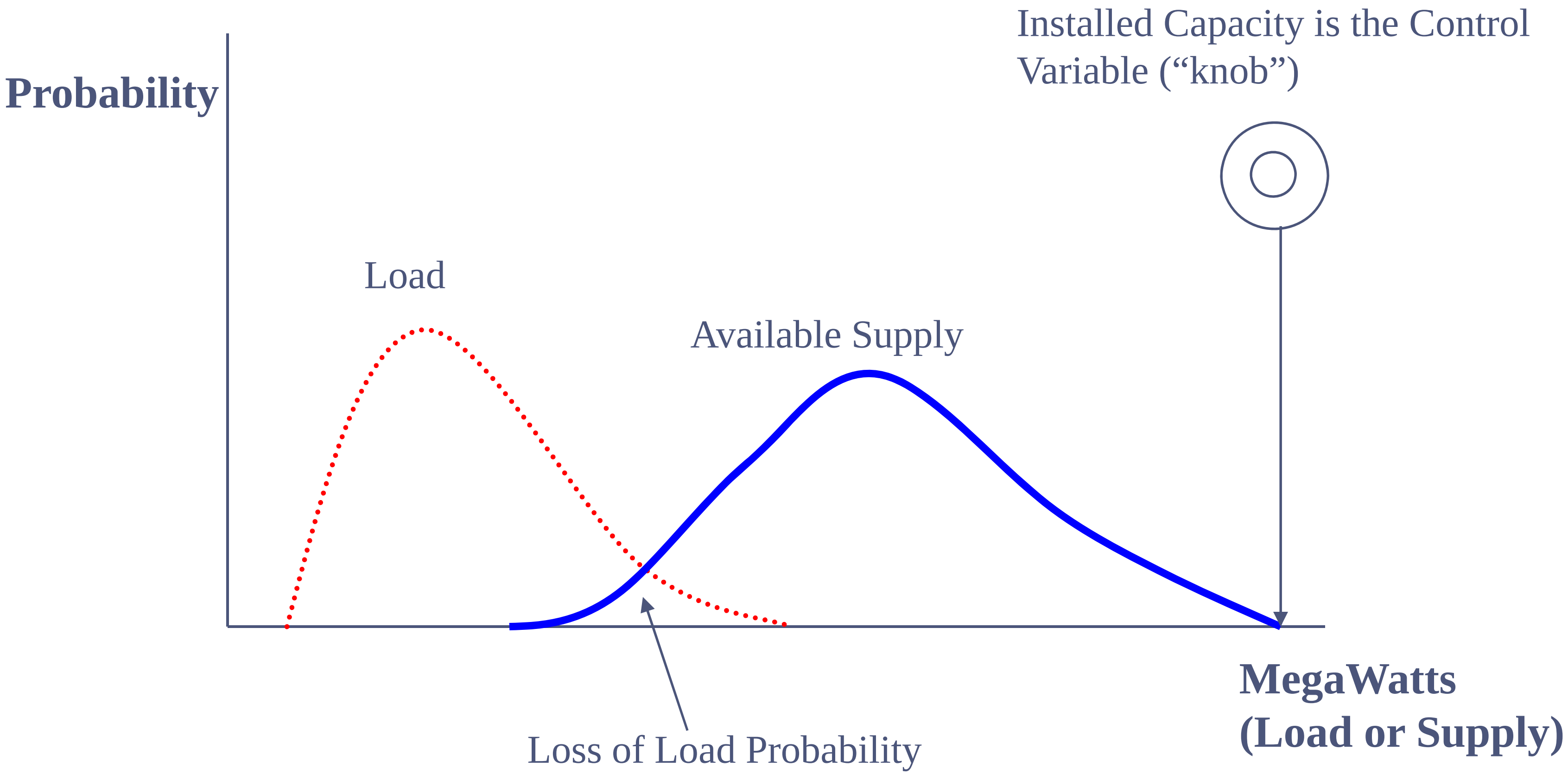
- IPPs are formed
- IPPs compete to sell to into an organized spot market or bilateral contracts to Disco
- Issues
  - Forming the ISO
  - Rules are complex
- Examples
  - PJM

Retail Competition – Organized Spot Markets



- IPPs are formed
- IPPs compete to sell to into an organized spot market or bilateral contracts to Load Serving Entities (LSEs)
- Issues with retail competition
  - Getting customers to switch
  - Monitoring & Regulating LSEs
- Examples
  - New York
  - Texas

Markets for Installed Capacity (ICAP)



Markets for Installed Capacity

- Determine the amount of installed capacity for the region
- Assign a portion to Load Serving Entities (LSEs), usually based on a LSE's % of peak load
- LSE's must procure enough ICAP to satisfy their obligation otherwise pay a deficiency penalty
  - LSE's can build or buy ICAP or reduce their peak demand
  - The deficiency charge is usually based on the cost to build new capacity

Installed Capacity Issues

- Is this market really needed?
- How to make it not susceptible to market power during times of shortages?
- What should the deficiency charge be?
- How should small generation units and load management be accommodated?
- How far in advance should ICAP be procured?
- Should there be a demand curve for ICAP?
- Are there different types of capacity resources (e.g., based on location, quick start, fuel source)?

"Competitive Electricity Markets and System Reliability: The Case for New England's Proposed Locational Capacity Market" J. Farr and F. Felder, *The Electricity Journal*, Vol. 18, Number 8, October 2005, pp. 22-33.

"Should Electricity Markets Have A Capacity Requirement: If So, How Should It Be Priced?" A. Jaffe and F. Felder, *The Electricity Journal*, December 1996.

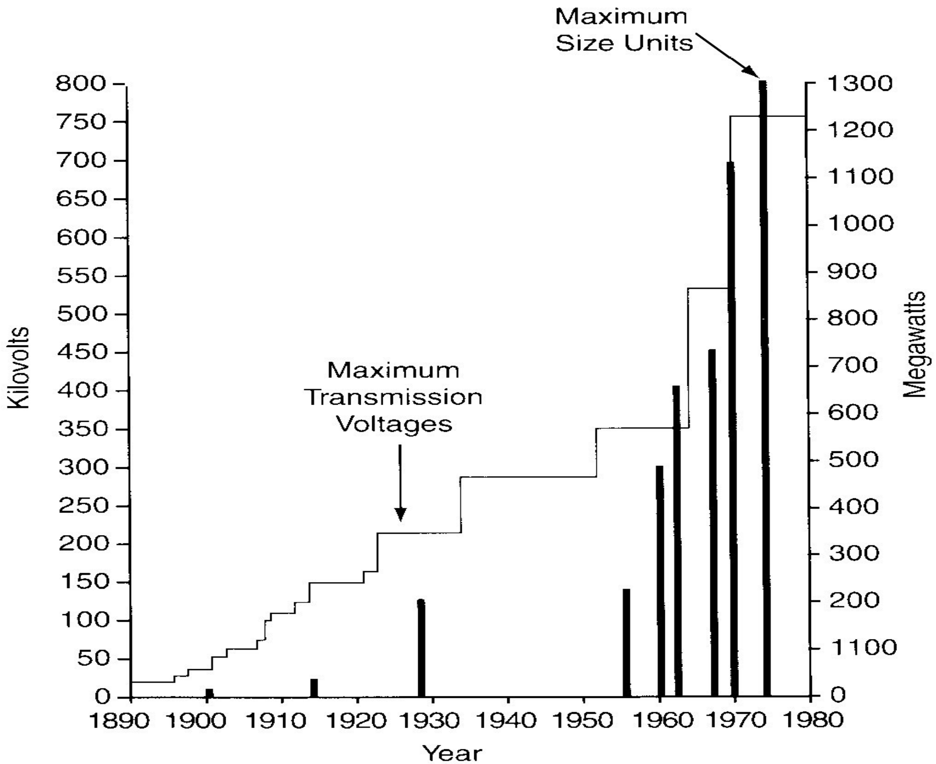
Transmission Expansion Issues

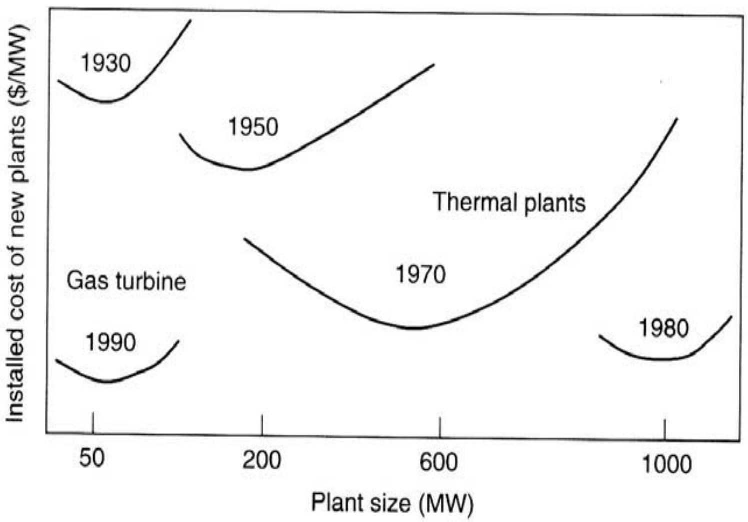
- Who is responsible for transmission expansion?
  - Transmission owners
  - Merchant transmission providers
- Under what conditions is the transmission system expanded
  - Reliability reasons
  - Economic reasons
- => Transmission expansion policy affects electricity markets

Power Pools - Motivation

- Driven by economies of scale
  - Per unit costs decrease as size increases
  - Reliability increases as size increases, resulting in smaller reserve margins as a percentage of peak capacity for larger systems than smaller systems
- As size expands beyond the size of a utility or country, a settlement system is needed, i.e., a means of paying one entity for its use of another entity's resources
  - A single utility is never perfectly positioned to serve its demand in the most cost effect manner, resulting in the need to buy power from another utility

Power Pools – Economies of Scale





Source: C. Bayliss, "Less is More: Why Gas Turbines Will Transform Electric Utilities," *Public Utilities Fortnightly*, Dec. 1, 1994, pp. 21-25.

Source: J. Casazza and F. Delea, Understanding Electric Power Systems: An Overview of the Technology and the Marketplace, IEEE Press, 2003 p. 4.

Power Pools – Need to Trade

- Even if individual utilities are perfectly built for expected demand, the "expected" may not occur
  - Changes in peak (MW) and total demand (MWh)
  - Changes in generation costs, technology and fuel prices
  - Maintenance outages
- The optimal size for a generation or transmission asset may be larger than the need of an individual utility, requiring multiple utilities to build and operate that asset
- => utilities form a power pool to take advantage of economies of scale (both in costs and reliability)

Power Pools – Need for Settlement System

- Once a power pool is set up to take advantage of reducing capital costs, it makes sense to coordinate maintenance, conduct unit commitment and dispatch jointly not utility by utility
- A settlement system is needed
  - When fuel prices are low, not volatile, and power exchanges are small among the utilities within a power pool, then settlement can be based on MWh not money
  - Otherwise, a monetary settlement system is required
    - Costs vary every dispatch decision, which is on the order of minutes, and the settlement system must reflect this

Power Pools – Key Settlement Choices

- What governance process is necessary to govern the settlement process?
  - Transaction cost economics, a branch of microeconomic, suggests under conditions of large uncertainties and limited capabilities to understand the all future outcomes, self-interested parties need to enter into governance relationships, not just contracts
- Are utilities forced to use the settlement system or can they make side deals or arrangements?
- What does the buyer pay and the seller receive?
  - A power pool creates savings and the issue is how to divide up these savings

Power Pools – Example of Savings

- Utility A
  - Load = 1,000 MW
  - Supply
    - 800 MW at $50/MWh
    - 200 MW at $70/MWh
- Utility B
  - Load = 800 MW
  - Supply
    - 600 MW at $50/MWh
    - 400 MWh at $60/MWh
- => Utility B sells 200 MWh of excess to Utility A but at what price?

Conclusion

- The powerful reasons for power pools lead towards markets
- Multiple market structures exist
- A logical transition path exists but do not need to complete the whole path
- Big Picture Outstanding Issues Issues
  - Price Responsive Demand
  - Markets for Capacity
  - Transmission Expansion
  - Market Power Monitoring and Mitigation
- Policymakers need to understand up front the advantages and disadvantages of each