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ELECTRICITY MARKETS DEVELOPMENT PROGRAM- GEMTP II

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Market Structure Design

Day 1

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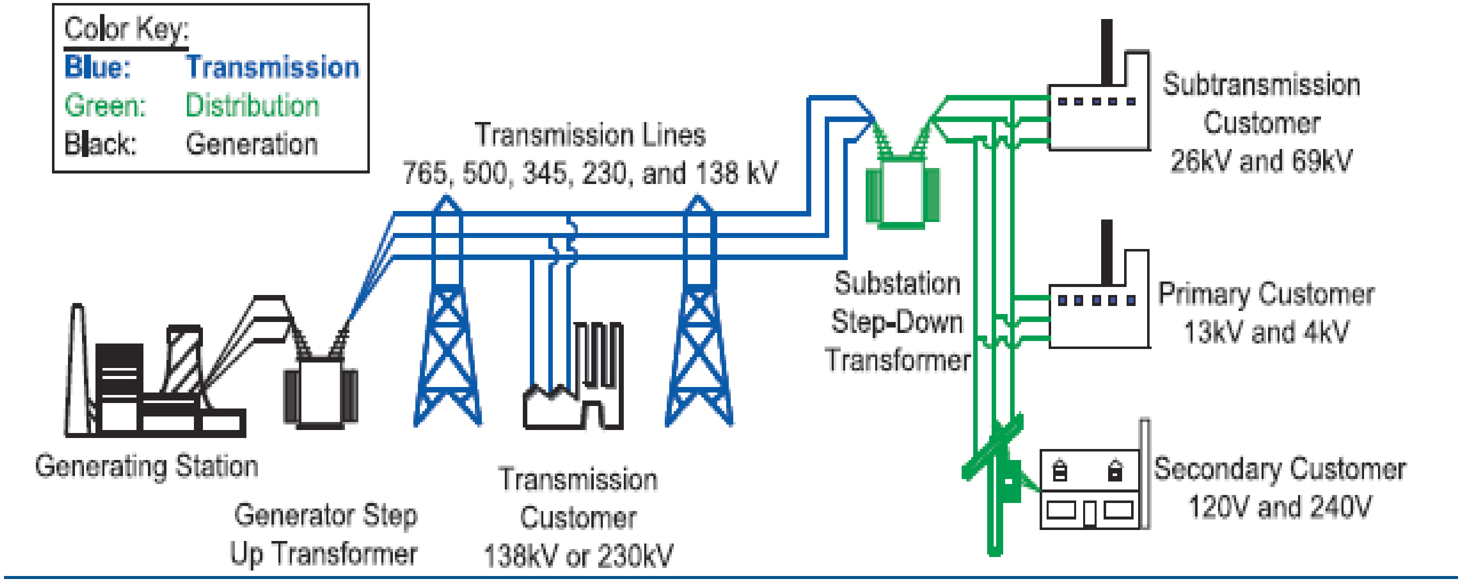
Overview of Presentation

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

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

Structural Evolution of the Electric Industry

- *Competitive Model: Small Private Systems*
  - Inefficiencies in Operation
  - Inefficiencies in Interconnection
  - Limited local regulation
- *Rise of Vertical Integration*
  - The influence of Sam Insull
  - Incentives for capital attraction and infrastructure development
  - Development of the Regulatory Model

Structural Evolution of the Electric Industry

Regulation of the For-Profit or Quasi-Government Entity: The Regulatory Compact

- Rates Sufficient to Attract Capital for Needed Investment
- Rates just and reasonable to the consumer
  - No “monopoly” rents
  - “Just and reasonable” standard

Structural Evolution of the Electric Industry

The Regulatory Compact: Additional Elements

- Universal Service
  - Line Extension Policies
- Nondiscriminatory Service
- Regulation of Service Quality

Structural Evolution of the Electric Industry

The Regulatory Compact---Additional Elements: The Rise of the Regulatory Commission

– Principles of Independence
– Principles of Transparency
– Customer Participation in the Process
– Judicial vs. Legislative Models

Structural Evolution of the Electric Industry

Government Electrification

- Rural Electrification
- Development of Hydro and Fossil Sources
- Socialized Rates
- Special Subsidies to Agriculture, Residential and Government
- Capitalization through taxation
- Adherence to Ministerial Policy

Structural Evolution of the Electric Industry

- 1920’s to 1970’s---Co-existence in U.S. of Private and Government Models
- Certified Service Territories
- “Yardstick Competition”
- Each utility plans its system individually
- Exception: Power Pool and Generator Sharing Arrangements

Structural Evolution of the Electric Industry: Worldwide

- Government Monopolies
- Introduction of IPPs and Creation of Regulatory Bodies
- Liberalization: Accommodate New Entry
  - Benefits: Risk Sharing, Credit & Currency Risk
  - Attract New Investment
  - Problems: Lack of investment in remaining units
  - Enforcing Obligation to Serve
  - Contract Disputes

Privatization vs. Liberalization

- Privatization of Generation Sector
  - Benefits: Introducing Competitive Forces to manage risk
  - Ease in attraction of new investment
  - Problems: Accountability, Regulatory Risk
- Complete Privatization
  - Benefits: Can spur needed investment
  - Problems: Regulatory Challenges, Obligation to Serve

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

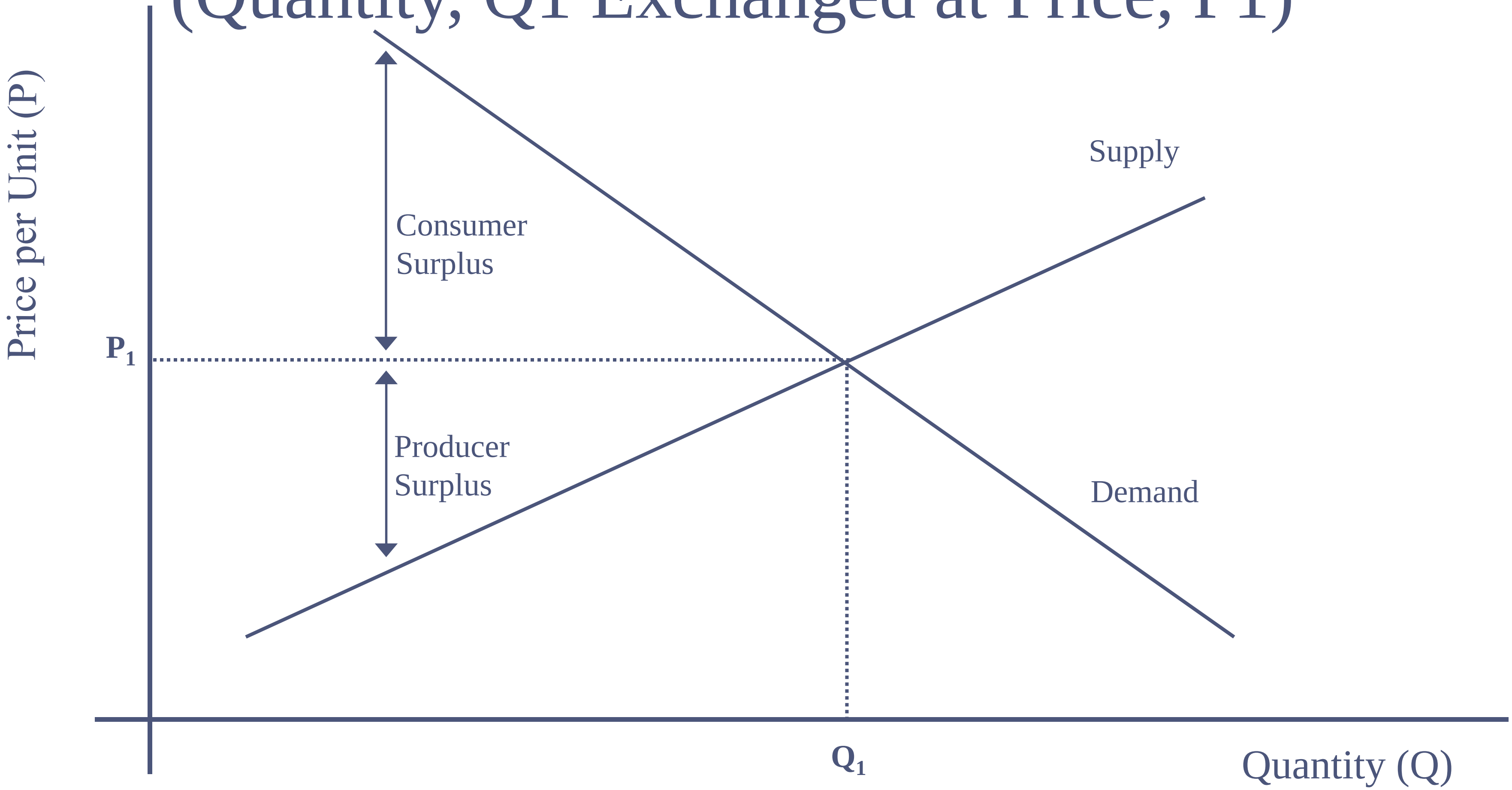
Preconditions for Electricity Markets

- 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

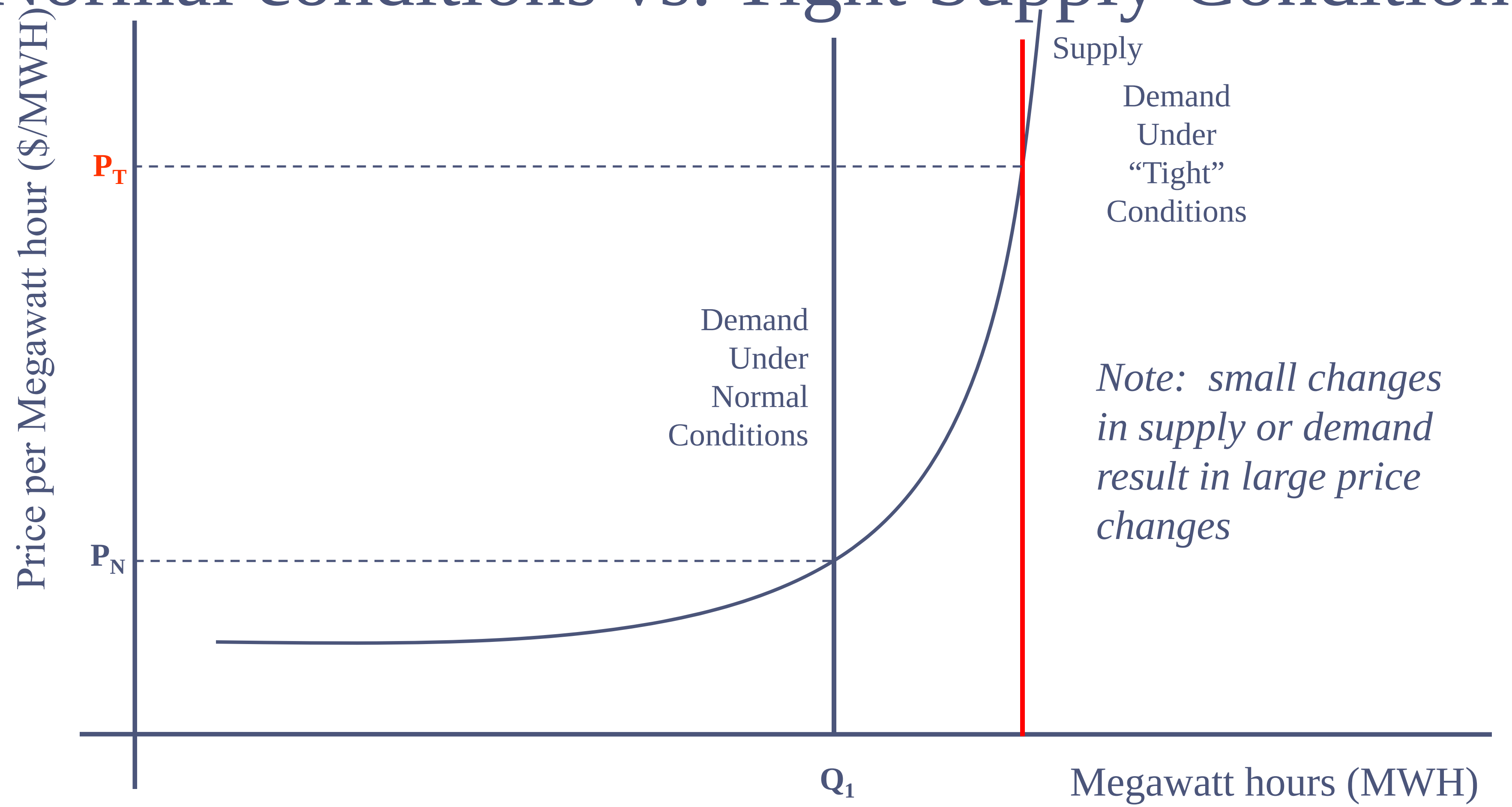
- System operations and reliability
- Loop flows (parallel flows) and transmission congestion
- Transmission expansion
- Demand response
- Market power
- => Defining property rights is difficult to do on electric power systems

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



Social Welfare = Consumer Surplus + Producer Surplus

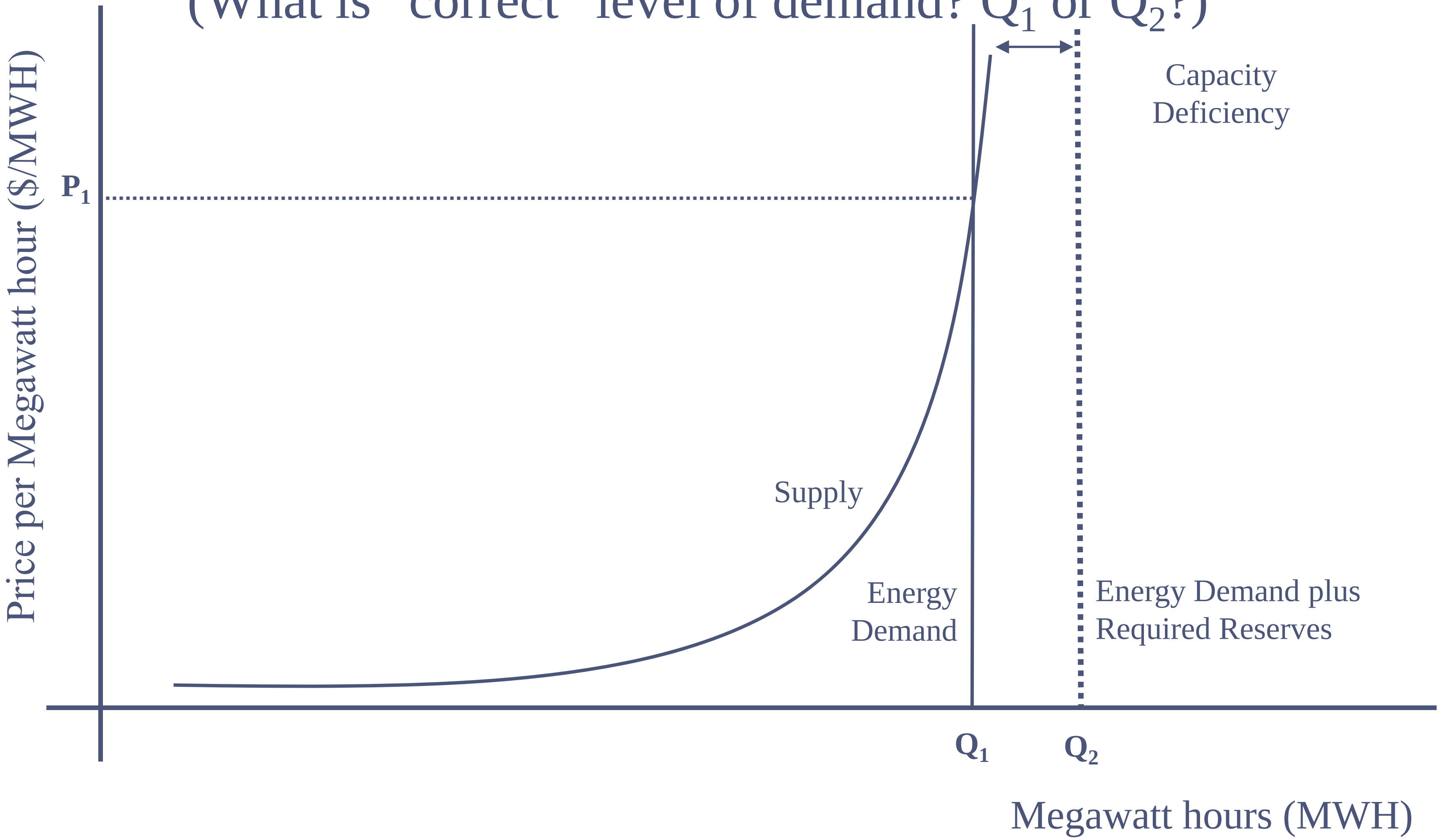
Electricity Example: Normal conditions vs. Tight Supply Conditions



Sometimes the electricity supply curve is characterized as a "hockey stick"

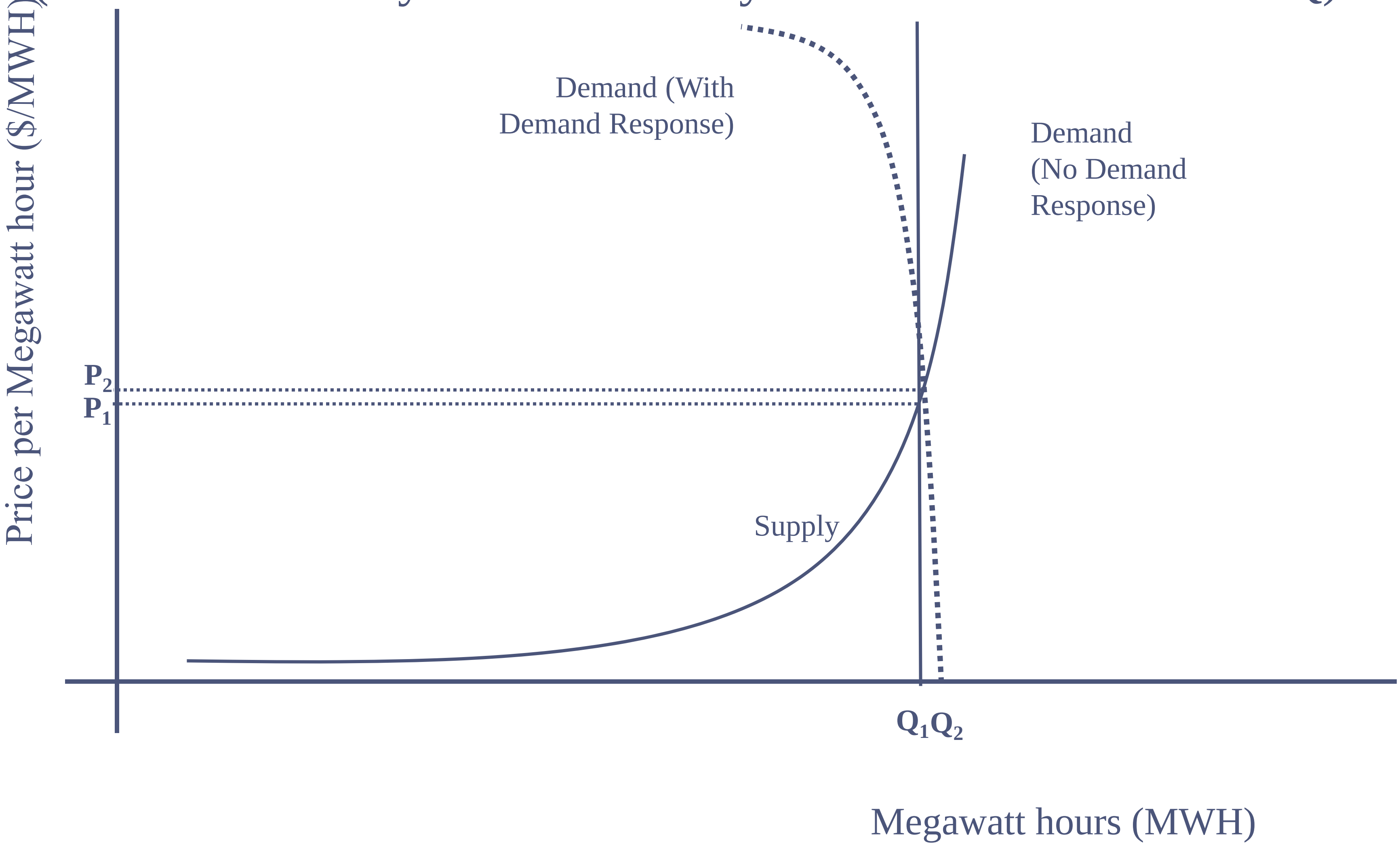
Electricity Under Capacity Deficiency Conditions

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



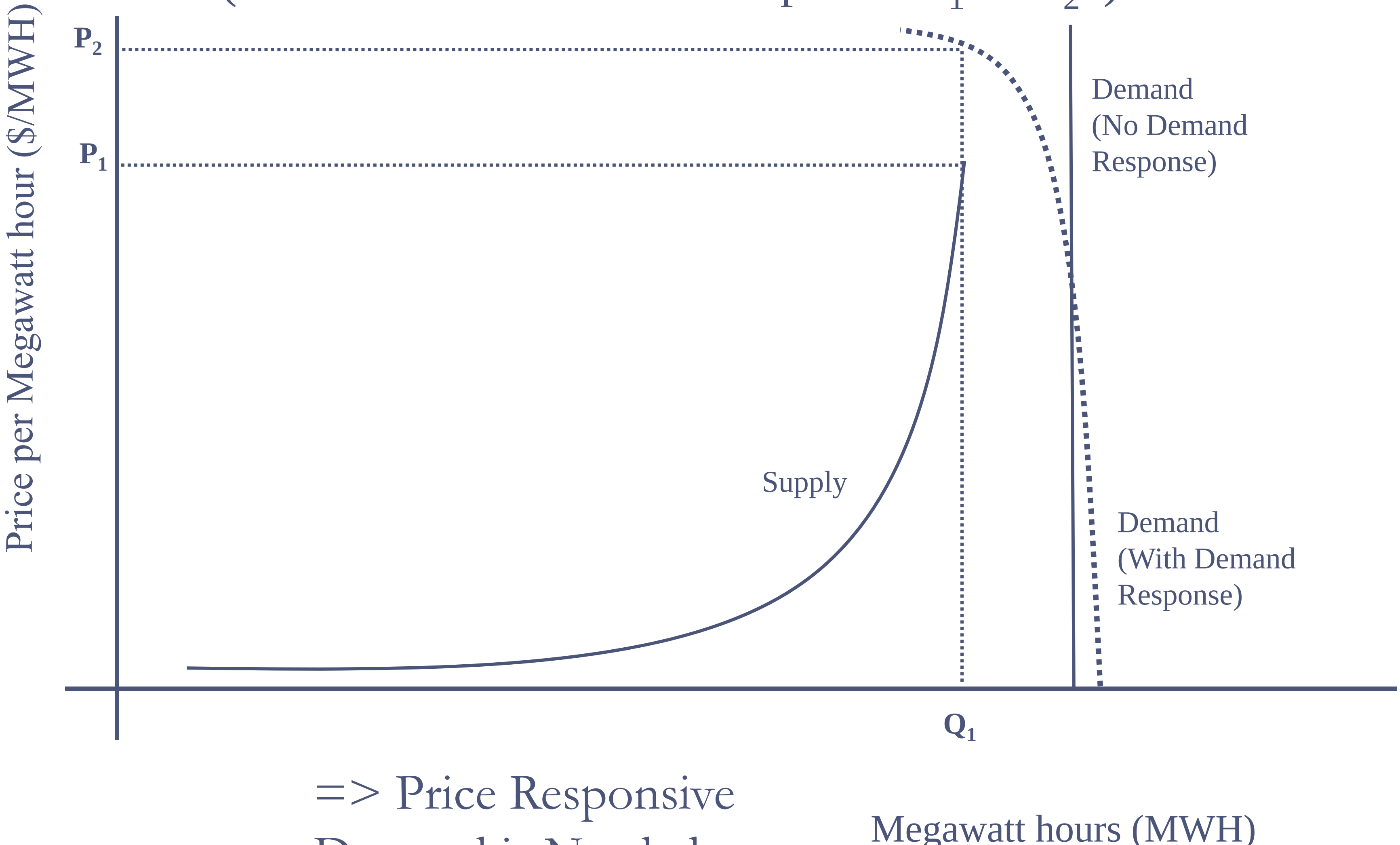
Effect of Demand Response in Normal Conditions

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



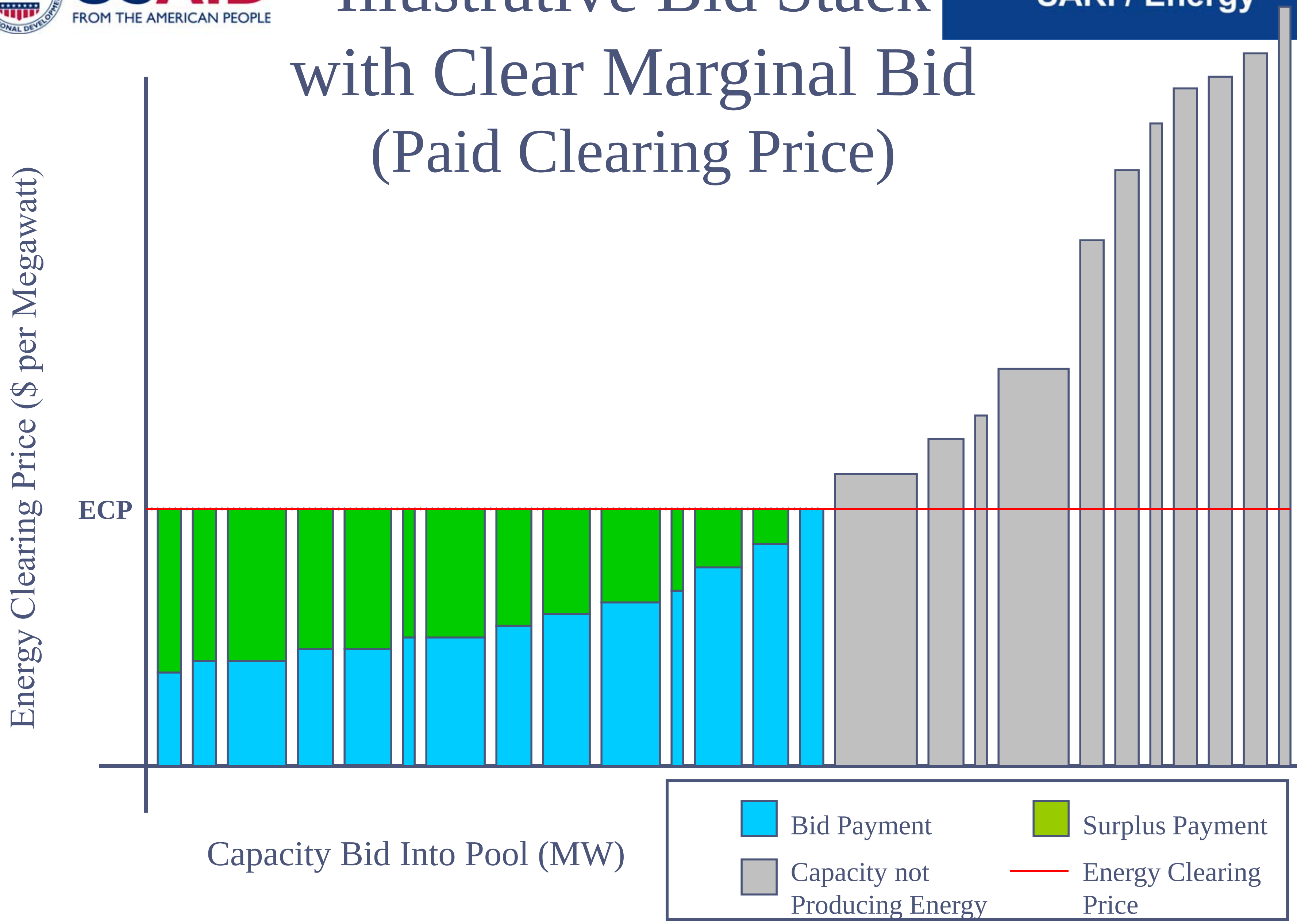
Demand Response in Capacity Deficiency Conditions

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



=> Price Responsive Demand is Needed

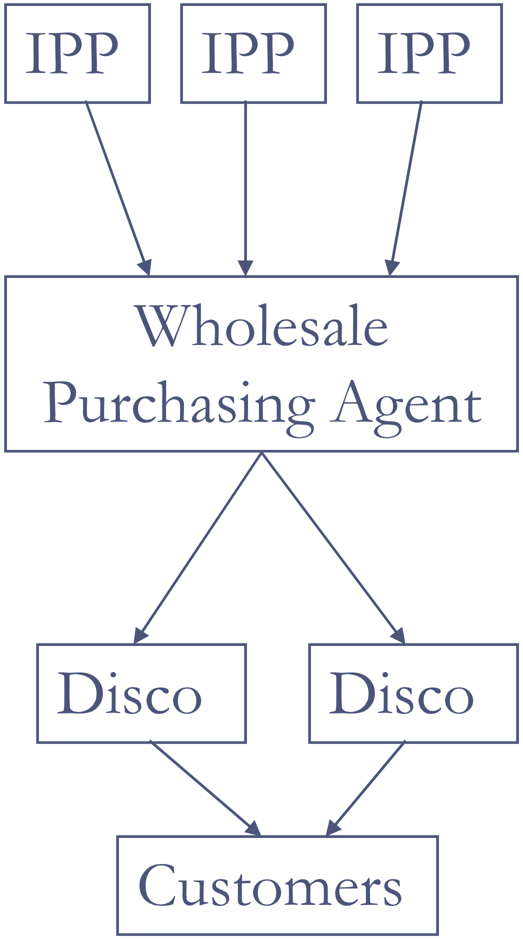
Illustrative Bid Stack with Clear Marginal Bid (Paid Clearing Price)



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

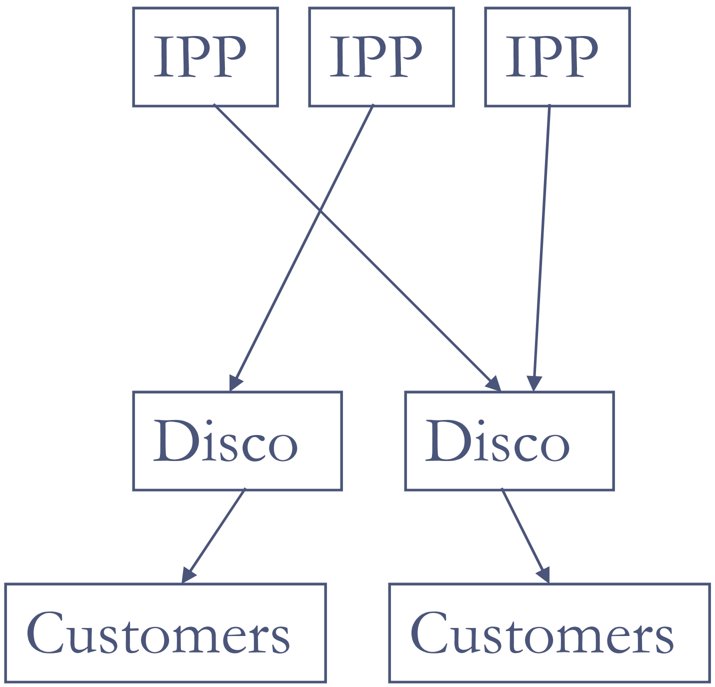
Competitive Procurement



- 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

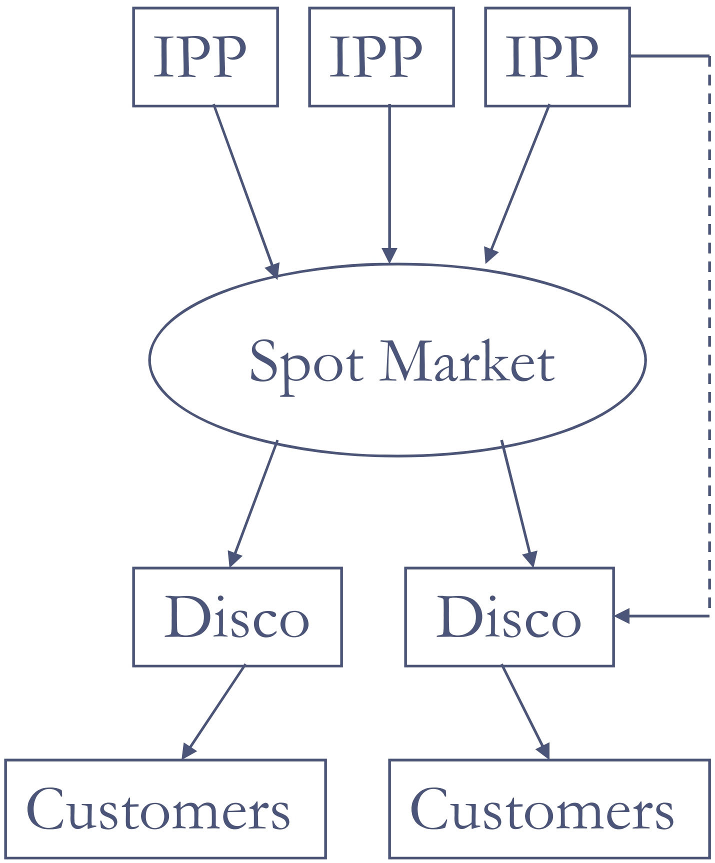
Note: Disco stands for distribution company

Wholesale Competition – Physical Bilateral



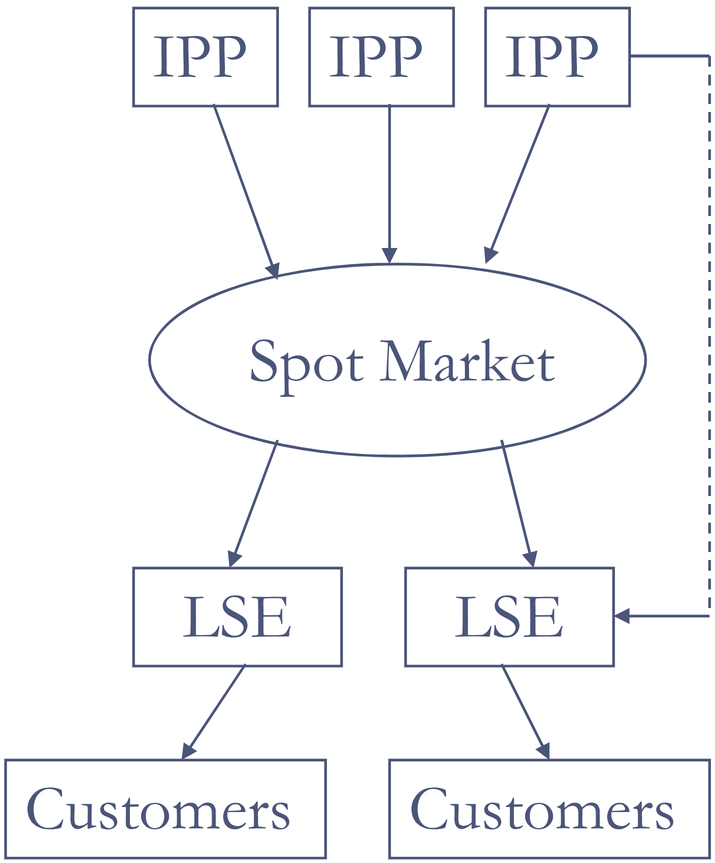
- IPPs are formed
- IPPs compete to sell to distribution companies (aka wholesale wheeling)
- Issues
  - Transmission capacity and congestion management is a concern
- Examples
  - UK in 1990s
  - US EPAct (1992)

Wholesale Competition – Organized Spot Markets



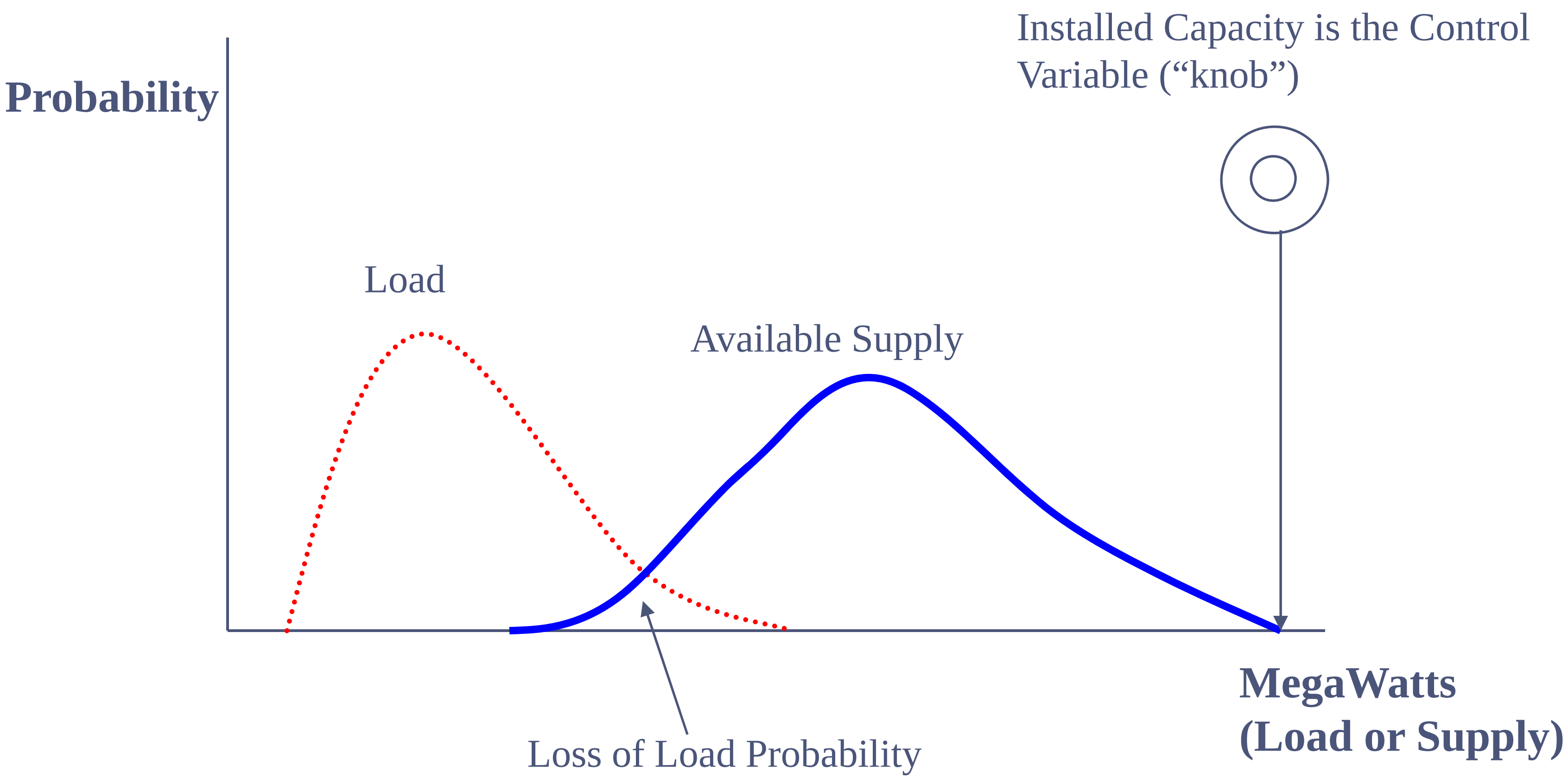
- IPPs are formed
- IPPs compete to sell to into an organized spot market or bilateral contracts to Disco
- Issues
  - Forming the ISO
  - Rules are complex
- Examples
  - PJM

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)?

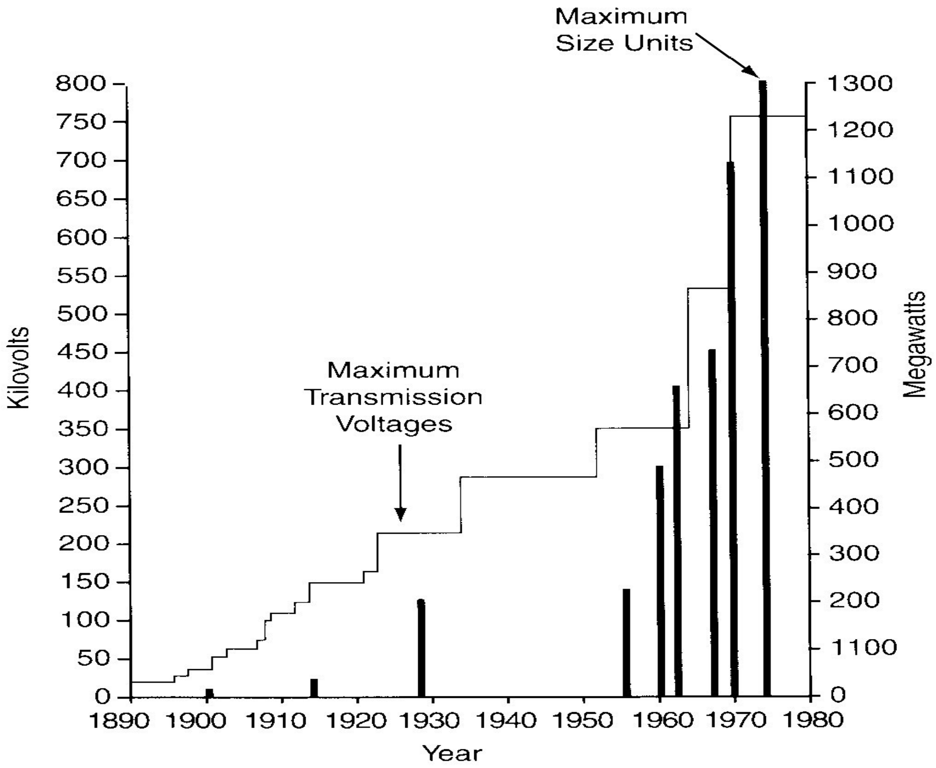
Transmission Expansion Issues

- 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

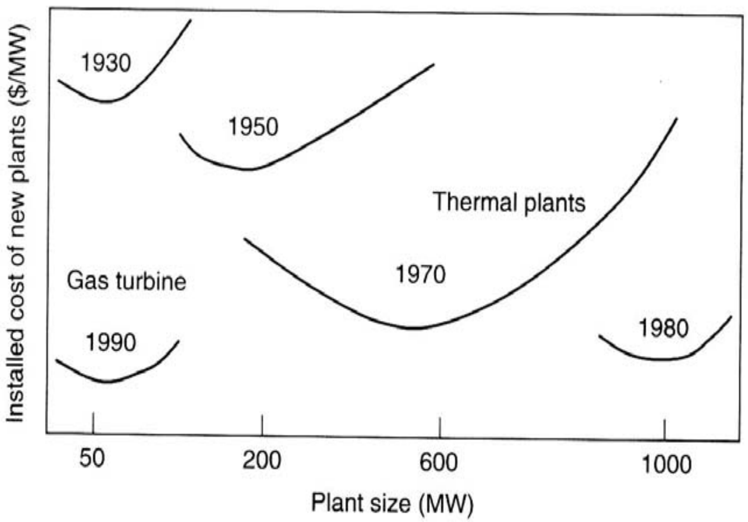
Power Pools - Motivation

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



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

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