The Economic Principles for Demand Response and Implications for Market Structure and Market Power

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Presentation Outline

I. Engineering, economics and public policy framework for analyzing restructured electric power systems

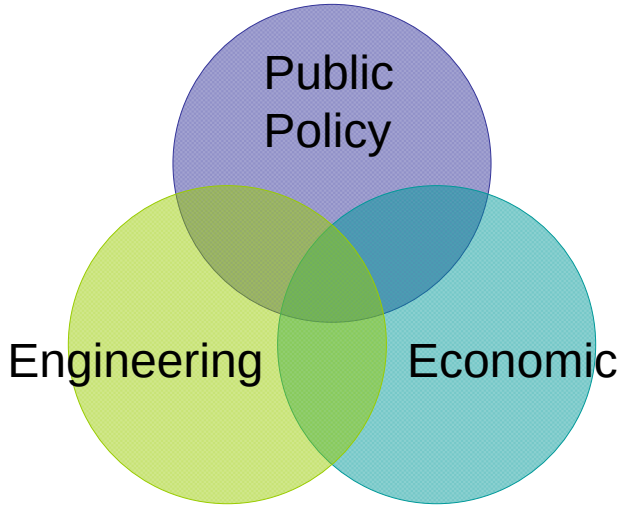
II. Major design choices for restructured electricity markets

III. Demand response

IV. Implications of demand response for market structure and market power

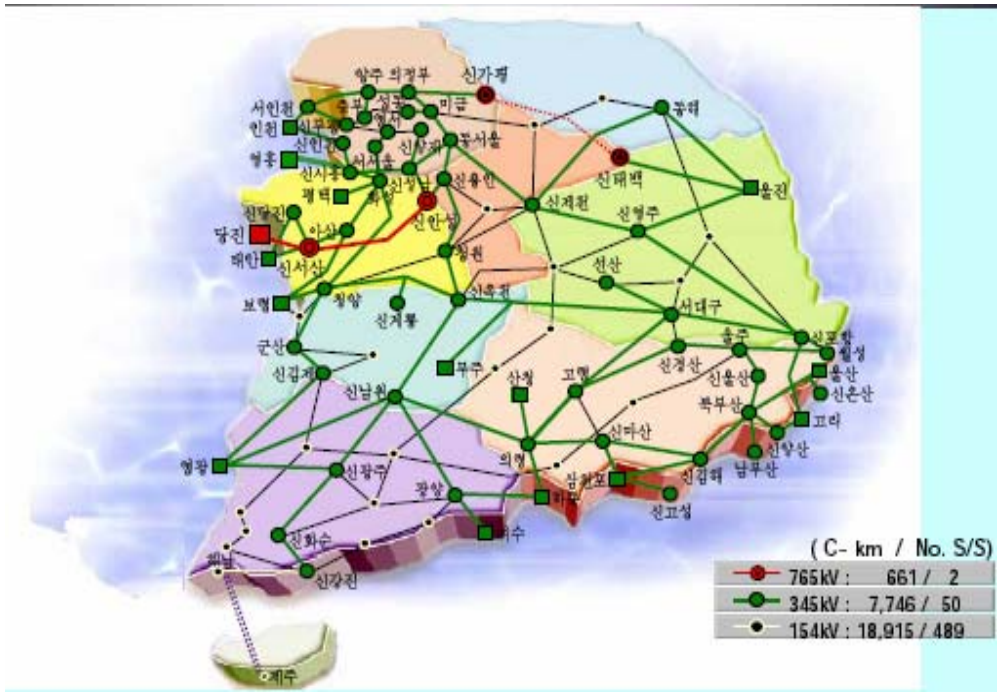
I. Framework for Analysis

Engineering	**Economic**	**Public Policy**
Network flows	Efficiency	Environment
Reliability	Transaction costs	Economic development
Extreme range of time scales	Imperfect economic regulation vs. imperfect markets	Equity



Engineering – Network Flows

- The power “grid” as one big machine
- Network flows or loop flows or parallel flows
- What happens at one part of the grid can affect all parts of the grid



Engineering - Reliability

- Adequacy
  - Generation
  - Transmission
- Security
  - Ability to withstand loss of large system components and continue operating: (n-1) or (n-2)
- Power Quality
- Reliability Measures
  - Loss of load probability, expected unserved energy, SAIFI, ….

Note: Reliability policy and electricity markets need to be integrated

Engineering – System Time Scales

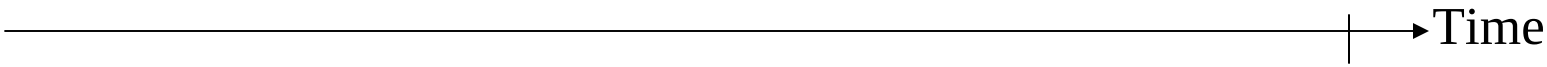
Transmission Construction:
3-10 years

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



Build | Maintain | Schedule | Operate | Real Time

Note: diagram not drawn to scale

Economic - Efficiency

- Technical efficiency
  - Products and services are produced at least cost
- Allocative efficiency
  - Those that value products and services the most are allocated them
- Efficient product/service variety
  - There is an efficient variety of products and services
- Dynamic efficiency
  - The above three types of efficiency are achieved over time

Economic – Transaction Costs

- Transaction cost – a cost incurred in making an economic exchange
  - Frequency – number of transactions among parties
  - Asset specificity – nontrivial investments in transaction-specific investments
  - Uncertainty – present in nontrivial degree
  - Bounded (limited) rationality – intendedly rational, but only limitedly so
  - Opportunistic behavior – self-interest seeking with guile
- => Governance/regulatory structure

Ref. 1

Economic – Markets vs. Regulation

- Markets are imperfect
  - Market power
  - Public goods
  - Externalities
  - Information asymmetries
- Regulation is imperfect
  - Incentive problem
  - Information asymmetries
  - Regulatory co-option
- => choice between combinations of imperfect markets and imperfect regulation

Public Policy - Objectives

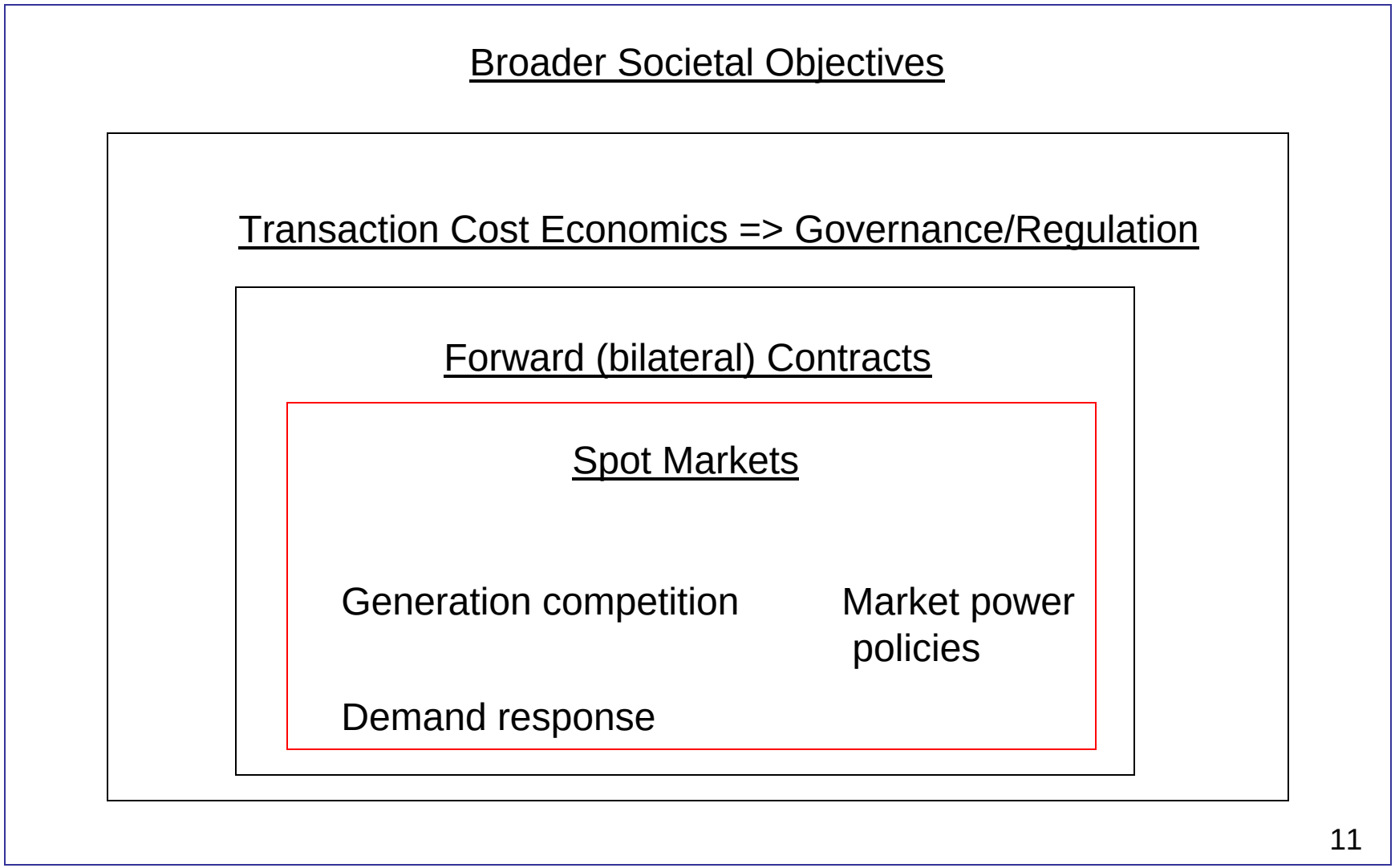
- Economic development
- Equity
- Environment
- National security

Substantive

- Stakeholder involvement

Process

Public Policy - Objectives



II. Design Choices

- Choices of overall market structure
- Choices within wholesale competition

Design Choices – Market Structure

	Monopoly (Gov't or Privately owned)	Single Buyer	Wholesale Competition	Retail Competition
Competing Generators	NO	YES	YES	YES
Choice for Retailer	NO	NO	YES	YES
Retail Choice	NO	NO	NO	YES

Ref. 2, p. 22.

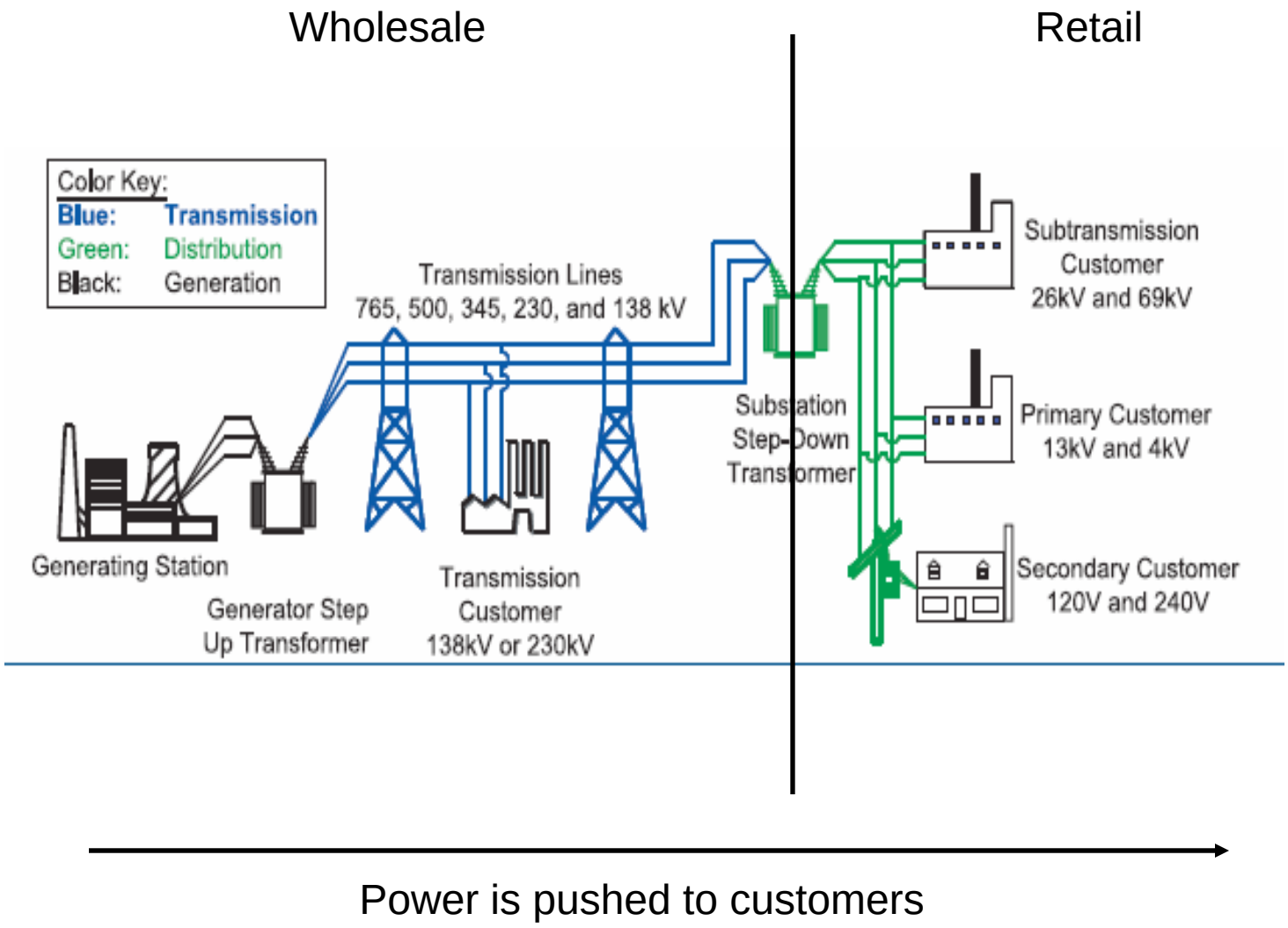
Design Choices – Korean Market Structure

	Monopoly (Gov't or Privately owned)	Single Buyer	Wholesale Competition	Retail Competition
Competing Generators	NO	YES, Cost-based	YES	YES
Choice for Retailer	NO	NO	YES	YES
Retail Choice	NO	NO	NO	YES Limited

Design Choices – Electricity Markets

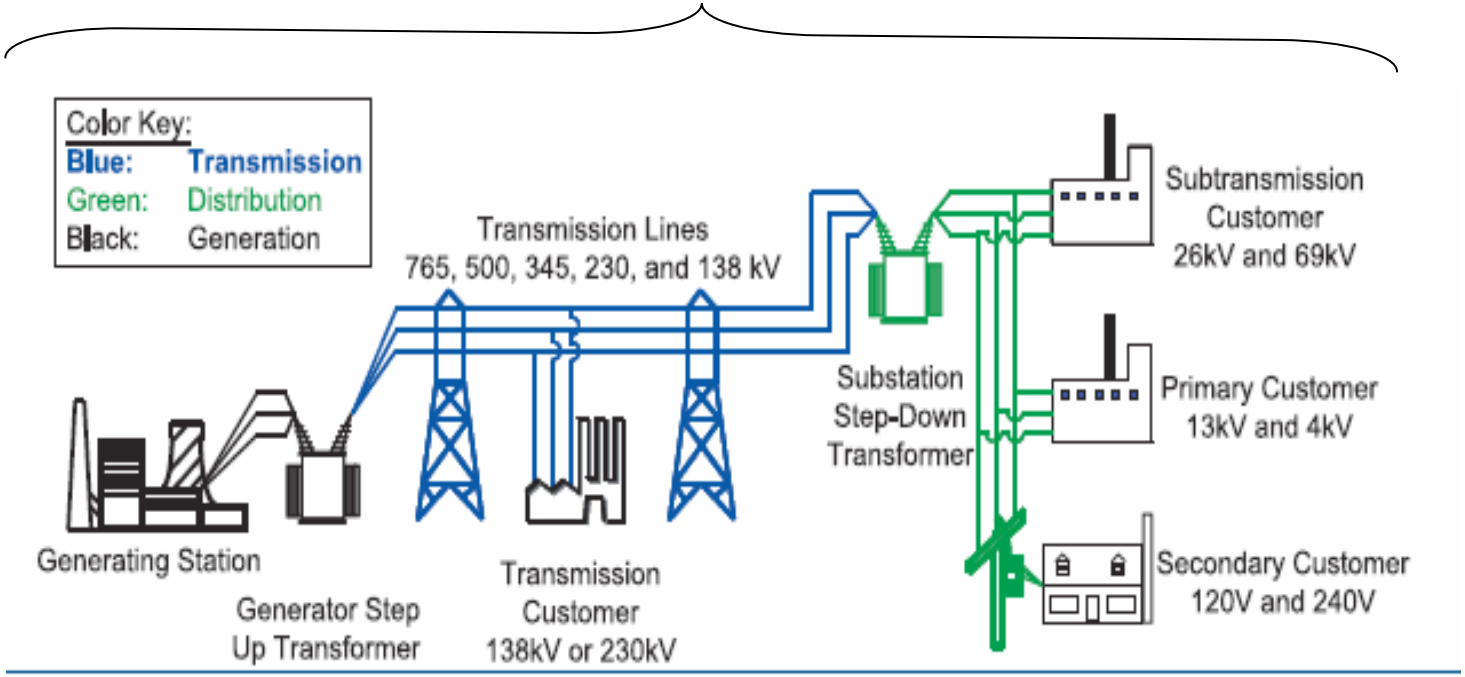
Design Element	Comment
Multi-settlement	Needed to align incentives with unit commitment problem
Congestion Pricing	Needed to reflect transmission constraints
Ancillary Services Markets	At a minimum need opportunity cost pricing
Capacity Markets	Depends on willingness to tolerate extremely high prices and amount of price-responsive demand
Transmission	Avoid having transmission policies undercut wholesale electricity markets
Wholesale Demand Response	A must if there is no retail price responsive demand
Retail Demand Response	Need political will and should consider advanced metering infrastructure (AMI)

Design Choices – Wholesale & Retail Split



Design Choices – Linking Wholesale & Retail

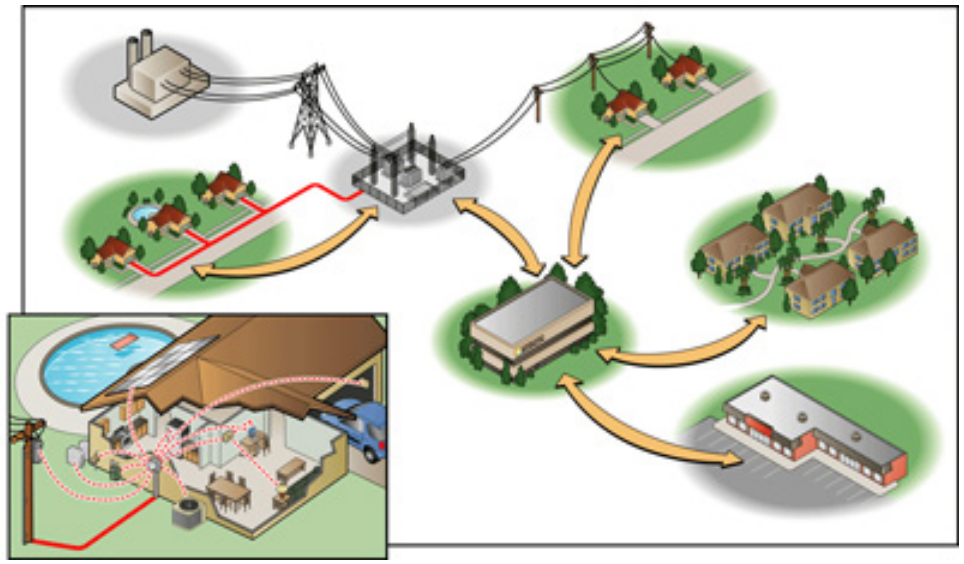
Integrated Electricity Markets



Power & Information Flows in Both Directions

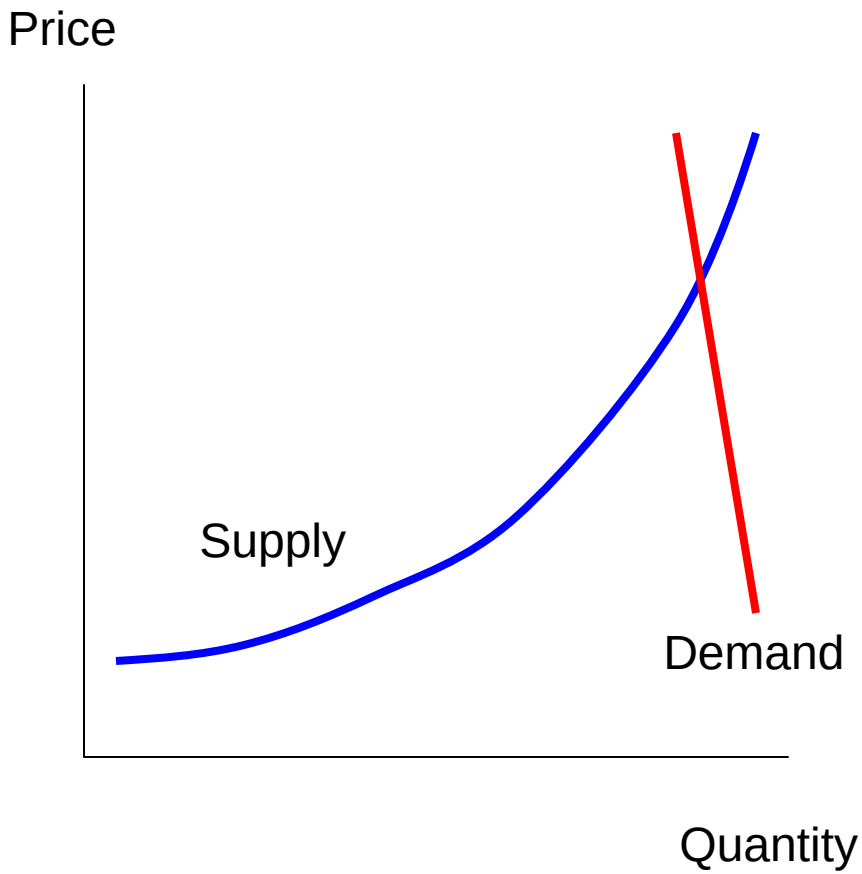
III. Demand Response (DR)

- Relevant economic characteristics of electricity
- Economic principles
- DR Options
- Empirical findings



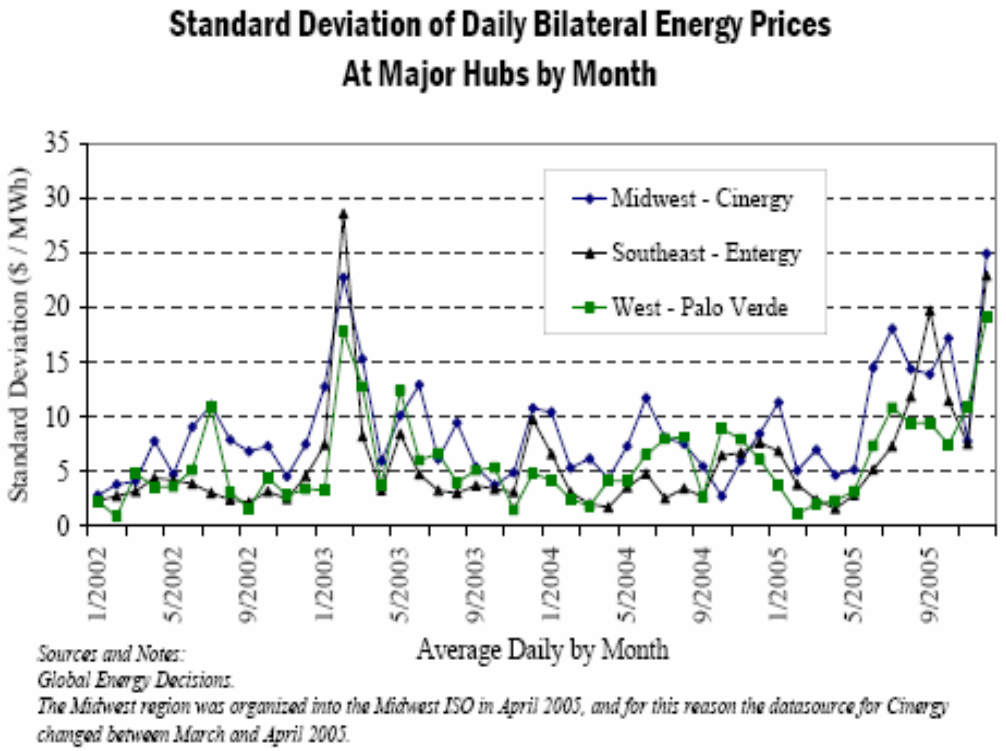
DR – Economic Characteristics

- Steep demand curves
- During shortages, steep supply curve
- Extremely limited storage
- Supply and demand must be balanced near instantaneously
- No or very limited ability to disconnect specific customers



DR – Economic Characteristics

- Electricity prices are the most volatile of energy prices
  - Volatile input fuel prices
  - Weather changes
  - Random outages (generation and transmission)
  - Transmission congestion
  - Inelastic supply and demand
  - Reliability rules



Ref. 6, Fig. 2-15

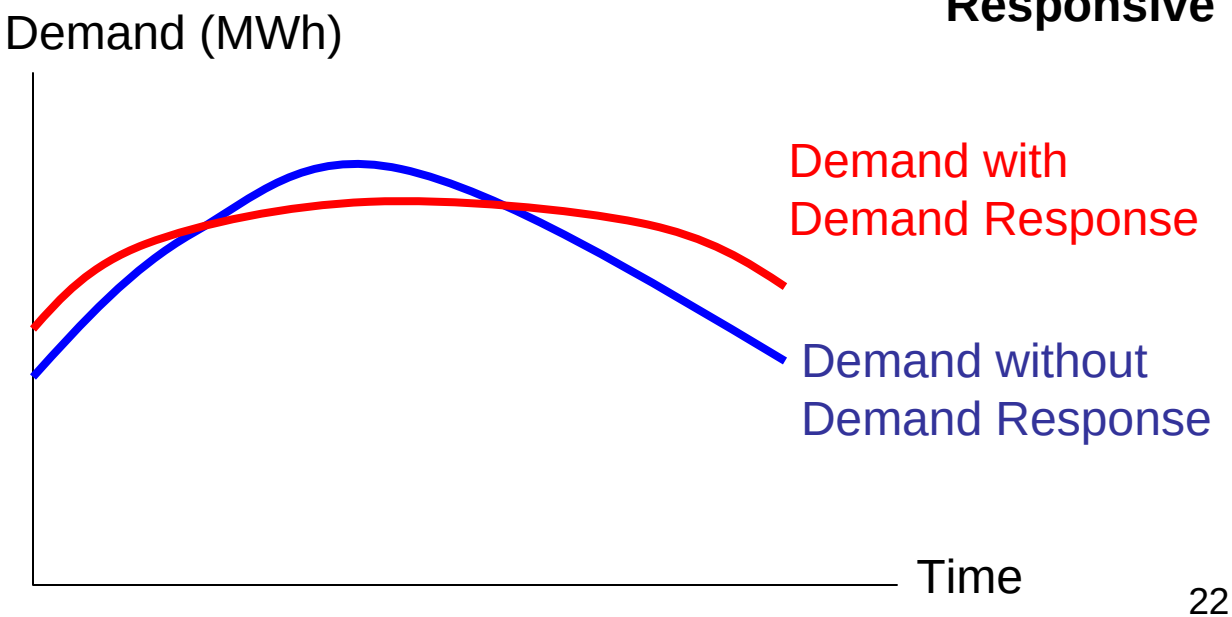
DR – Economic Principles

- Cannot have a functioning market without price responsive demand
- Without DR, adverse effects include
  - Decreased reliability
  - Enhanced market power
  - Reduced market efficiency
  - Less efficient mix of products and services
- DR should be integrated into the market design
  - => Retail policies are part of market design
- Prices are a powerful control variable
  - High prices increase supply and decrease demand, which push the market to equilibrium

Demand Response – Major Options

Flat rate | Seasonal Rate | Time-of-use (TOU) Rate | Critical Peak Pricing | Real-time pricing

Least Price Responsive — **Most Price Responsive**



Demand Response – Incentive-based Options

- Types of incentive-based programs
  - Emergency demand response
  - Curtailable service
- Can be implemented by utilities or ISO/PX
- Voluntary vs. mandatory
  - Whether you participate in the program
  - Given that you are in the program, whether you must respond
- Who controls load?: Participant or Utility
  - Direct load control with or without customer override

Demand Response – Price-based Options

- No customer bidding vs. customer bidding at the wholesale level
  - Which wholesale markets the customer participates in: energy, ancillary services, capacity?
- Customer response to prices
  - Manual
  - Automatic
  - Third party manages customer response

Demand Response – Other Options

- DR triggers
  - Prices or grid conditions or both
- Advanced Metering Initiative
  - Two way communication, interval meters
  - Install meters: Yes or No
  - If yes, how to phase in
    - New customers, customer class, by location
- DR rates and tariffs
  - Mandatory or optional
  - If optional, opt-in or opt-out
- Integrate with energy efficiency programs and distribution utility planning and operations

Demand Response – Empirical Findings

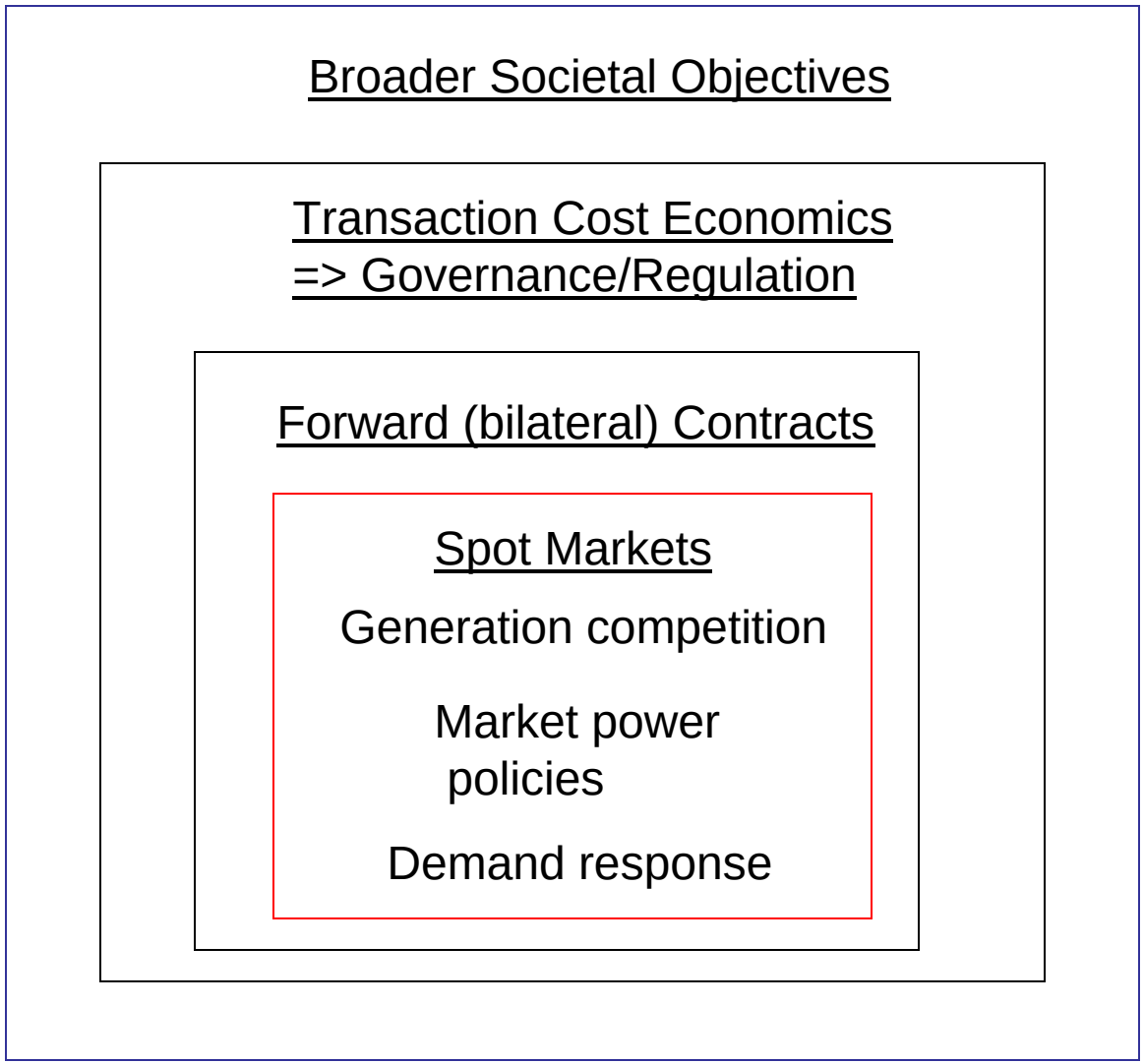
- Customer Response – They Respond!
  - Not every customer will respond to prices
  - Some will respond a little
  - Some will respond a lot
  - In aggregate, customers respond
- Not every or even most customers need to respond to have a significant impact on prices and demand
- Environmental impacts are ambiguous

Ref. 3-5

Demand Response – Some Objections and Responses

- Customers do not want to spend the time responding to electricity prices
  - Use technology to give customers the level of involvement they want
- It is too complicated for customers
  - Customers respond to varying prices in other contexts
- What about low-income customers and those on life-support systems?
  - Other policies can address these issues
- What about customers that cannot respond to prices?
  - They benefit as well
- If customers sign fixed-price contracts, they have no incentive to reduce demand when prices are high
  - But these contracts also have fixed quantities so the incentives are correct on the margin

Conclusion



- DR improves spot market performance, increases product and service variety, links forward with spot markets, enhances broader public policy objectives but requires navigating through electricity market governance

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