

Why the United States Has Yet to Benefit from Electricity Industry Re-structuring (And What Can Be Done to Change This)

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Outline of Lecture

- Why Re-structure?
 - Market versus Regulation
 - Use theory of Market Design to identify costs and benefits
- Market Design
 - Solution to Principal/Agent Problem
- How can restructuring benefit consumers
- Why has it been so difficult to realize these benefits in the US?
- Features unique to US
- Features common to virtually all markets
- How to make re-structuring benefit consumers

What is Restructuring?

- Replace explicit regulation with market mechanisms to set prices and determine how electricity is supplied
 - Price-regulated open access to
 - Inter-state transmission network
 - Local distribution network
 - Market mechanism to set prices for wholesale power and determine which generation units produce energy
 - Market mechanism to set prices for retail electricity and determine which retailers sell electricity to final consumers

Some Regulation Always Necessary

- Technology for delivering electricity implies
 - One transmission and distribution grid needed for a given geographic area
 - Competition among multiple networks would lead to single dominant network
 - Large fixed cost to construct network
 - Close to zero marginal cost to operate
- In all regimes, monopoly supplier of transmission and distribution services for each geographic area requires government oversight
 - Unregulated monopoly can set prices for use of network that extracts all monopoly profits from electricity supply

Vertically-Integrated Monopoly Regime

- One company owns all generation, transmission network, and distribution network for geographic area
 - Can have long-term supply arrangements with neighboring areas to additional energy
- Given monopoly status, firm could raise prices far above average cost without losing customers
- State-level regulation
 - Sets retail price firm can charge
 - Determines prudence of operation and investment decisions
- Portland General Electric (PGE) is regulated by Oregon Public Utilities Commission

What is Market Design?

- Why should restructured regime yield benefits to consumers relative to vertically-integrated regulated monopoly regime?
 - Need theory of market design to answer this question
- Market Design
 - Set number and size of market participants
 - Set rules for determining revenues each entity receives
 - So that *combined actions of each participant acting in its own best interest yields market outcomes as close as possible to market designer's desired outcome*
- Many feasible market designs, each of which can yield different market outcomes
 - Vertically-integrated regulated utility most common historically

What is Market Design?

- Major challenge of market design process
 - Once market rules are put in place all market participants will optimize against them
 - Market participants will push envelope of market rules
- Must analyze strategic implications of all market rules
 - Anticipate how participants will use market rules to maximize profits

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Principal/Agent Problem

- Examples—client/lawyer, patient/doctor, firm owner/firm manager, and regulator/firm
 - One familiar to everyone here—Parent/child
- Principal typically does not observe everything that agent does about its economic environment
 - Principal's payoff depends on agent's actions
 - Other factors impact principal's payoff
 - Agent's payoff depends on its own actions, method used by principal to compensate agent, and other factors
- Principal designs mechanism for compensating agent based on observable variables that causes agent to take actions desired by principal
 - Parent/child example
 - Parent promises new bicycle to child if he gets good grades

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Theory of Market Design

- Market Design involves Principal/Agent problems at multiple levels
- First level—Regulator/Firm
 - Principal = Market Designer
 - Usually government and/or regulator
 - Agents = Firms and consumers in market
- Second level—Firm Owner/Firm Manager
 - Principal = Owner of Firm
 - Agent = Management of Firm
- Two dimensions of market design
 - Market mechanisms versus price regulation
 - Government-ownership versus private ownership

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Optimal Market Design

- Proposed objective function for market designer
 - Lowest annual average retail price of electricity consistent with long-term financial viability of industry
 - In economist's language--maximize consumer surplus subject to marginal firm in industry earning zero economic profit
- Vertically-integrated monopoly regime was historical solution to market design problem
- Two major dimensions of market design
 - Government versus Private Ownership
 - Regulated versus Market Pricing

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Private versus Public Ownership

- Private ownership--Shareholder's desire for net cash flows exerts pressure on firm's management to maximize profits (return on capital invested)
 - Unregulated firms have incentive to set prices substantially above average cost to produce output
- Public ownership--Management pursues interests of government that owns it
 - Government may not wish to minimize production costs
 - Firm's management has little incentive to set price substantially above average cost to produce output

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Regulated versus Market Pricing

- Restructured regime restricts regulated portion of industry to smallest entity possible
 - Transmission and distribution are only regulated services in competitive regime
 - Generation and electricity retailing are open to competition
- Traditional regulated regime imposes regulatory process on all aspects of industry
 - Final output price of vertically-integrated monopoly is regulated
- Choice between regulation and competition depends which regime comes closer to achieving market design goals for each stage of production process
 - Choice between *imperfectly competitive market versus imperfect regulatory process* will depend on many region-specific factors

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Regulation versus Competition

- Major problem with regulation
 - Firm usually knows its technological capabilities and the demand that it faces better than the regulator
 - This leads to disputes between the firm and regulator over minimum cost mode to serve demand that firm faces
 - Regulator can never know minimum cost of providing service
 - Regulator can only know incurred costs

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Regulation versus Competition

- Major problem with regulation
 - There are laws against confiscating regulated firm's assets
 - Impossible to tell difference between regulator setting
 - Output prices that confiscate firm's assets
 - Output prices that provide strong incentives for least-cost operation
 - Long history of legal disputes in US that attempt to define process for setting prices that do not confiscate firm's assets
 - Firm understands value of superior information about its demand and technology in regulatory price-setting process

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Regulation versus Competition

- Benefit of competition
 - There are no laws against a firm's competitors confiscating its assets through their output and pricing decisions
 - Any firm unable to cover its costs at the price set by market must exit industry
 - High cost firms exit the industry and are replaced by lower cost firms
 - Contrary to regulated regime, no need to determine if a firm's incurred production costs are the least-cost mode of production
 - If market is competitive, then any firm that is able to remain in business must be producing at or close to minimum cost
 - Possibility of exit from industry provides strong incentives for minimum cost production under competition

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Regulated Monopoly

- Historical Benefits
 - Economies to scale in generation of electricity
 - Average cost of generation declines as total output increases
 - Extensive transmission and distribution network necessary to deliver power
 - More than one network raises average costs
 - Economies of scale and scope from having generation and transmission in same geographic monopoly

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Regulated Monopoly

- Costs
 - Although the potential exists for the monopoly to realize economies to scale and scope
 - As noted above, regulatory process provides few incentives for least-cost production
 - Political environment firm operates in makes least-cost operation just one of many goals
 - Conclusion--Least-cost production does not occur and limited economies to scale and scope are realized

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Competitive Market

- Benefits
 - Privately-owned, profit-maximizing firm has a strong incentive to produce in minimum cost manner
 - Any cost reductions not duplicated by competitors translate one-for-one into higher profits
 - Privately-owned, profit-maximizing firm has a strong incentive to innovate
 - Any cost reduction not duplicated by competitors yields higher profits
 - New investment decisions based on market price for electricity
 - Purely economic basis for new investment

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Competitive Market (Benefits)

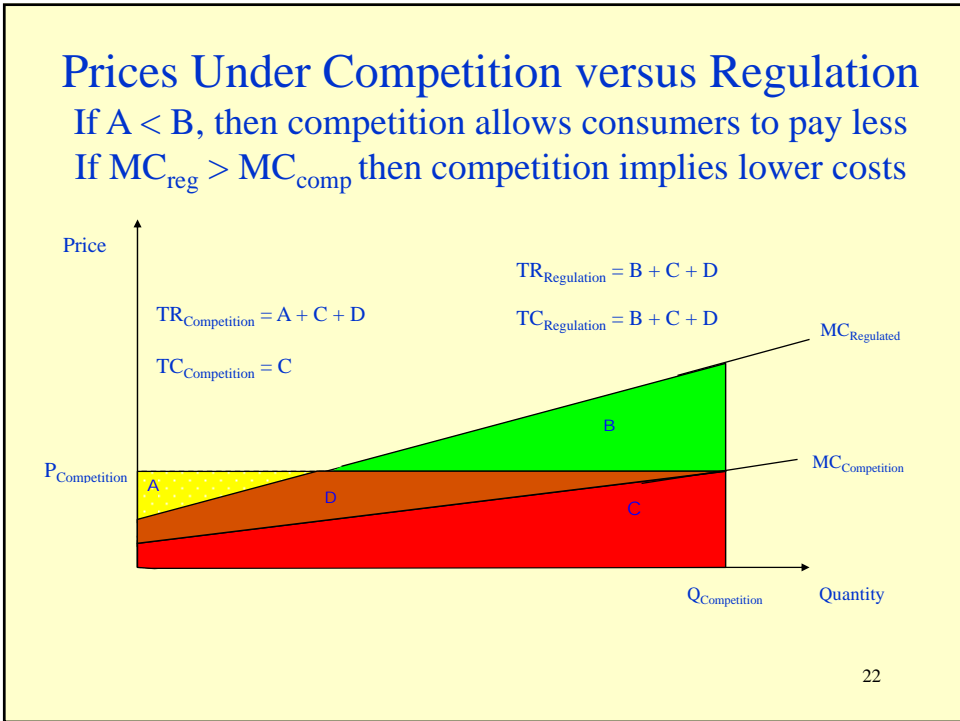
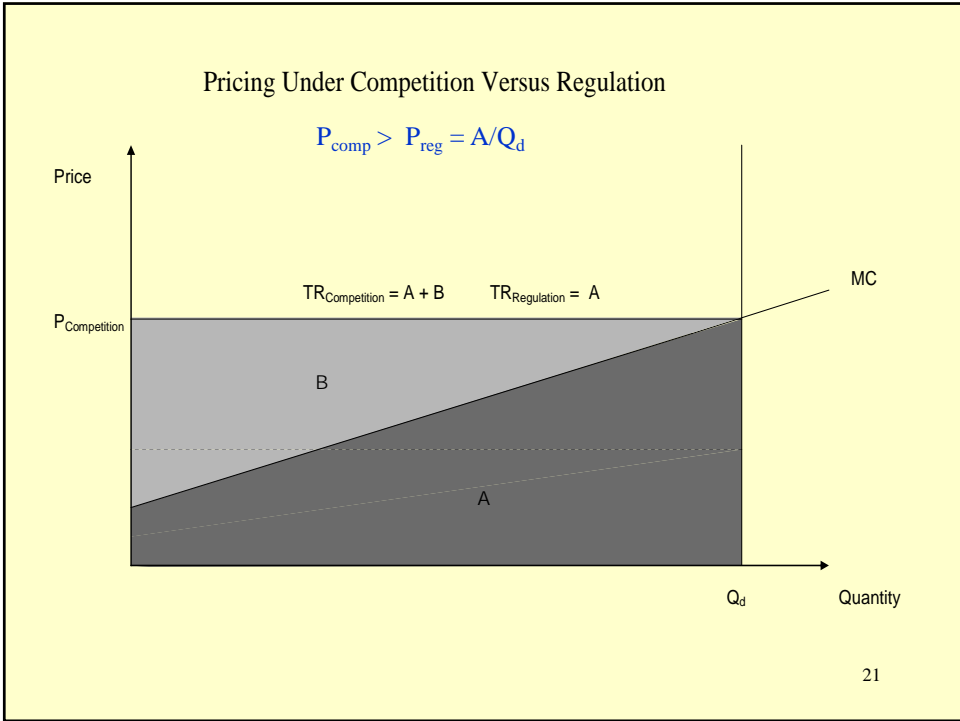
- Economies to scale and scope are less relevant than in early stages of industry
 - Technological change in generation and transmission
 - Large market demand relative to efficient size of new generation plant
 - Conclusion--modest or no economies of scale or scope over relevant range of output
- Strong incentive to provide diversity of products consumers demand
 - Profitable niche markets

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Competitive Market

- Costs
 - Firms in a competitive market have little incentive to pass on cost reductions to consumers in the form of lower prices
 - Firms may set prices far in excess of marginal cost
 - Exercise unilateral market power
 - Existing firms may take actions to prevent entry by new firms
 - Create barriers to new entry

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Regulation versus Competition

- When minimum cost of providing service is known, little reason to run a market for service
 - Cost-of-service regulation can be used to set price
- When minimum cost of providing service is unknown, run a market to determine this cost
 - Markets provide strong incentives for minimum cost production in both short-run and long-run
 - Not necessarily strong incentives to pass-on lower costs in lower prices--market power problems
- Unless potential for significant cost reductions exist, introducing market pricing makes little sense

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Regulation versus Competition

- Considerable uncertainty over minimum-cost method to serve electricity demand in both short-run and long-run
- Two sources of supply-side benefits of restructuring
 - In short-run, lower variable cost operating of existing fleet of generation units
 - In long-run, lower cost investments in mix of generation capacity needed to meet future demand
 - Tremendous uncertainty over least cost way to serve future demand particularly carbon-constrained world

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Regulation versus Competition

- Empirical evidence for these sources of benefits of restructuring
 - Lower non-fuel operating costs for investor-owned utilities in restructured states
 - Fabrizio, Rose and Wolfram (2007)
 - Lower heat rates (heat input per kWh of energy produced) for generation units operating in restructured markets
 - Bushnell and Wolfram (2005)
 - Lower cost dispatch of units in organized wholesale markets
 - Mansur and White (2008)

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Major Market Design Challenge with Privately-Owned Firms = Market Power

- Electricity supply industry extremely susceptible to the exercise of market power in the spot market
 - Demand must equal supply at every instance of time at every location in the transmission network
 - All electricity must be delivered through transmission network
 - Non-storability of product (very costly to store electricity)
 - Demand varies throughout the day
 - Production subject to severe capacity constraints
 - How electricity has been priced to final consumers makes real-time demand elasticity effectively equal to zero
- Implication--Firms can exercise enormous amounts of market power in a very short time
 - Firms produce at least cost but take unilateral actions that set prices substantially in excess of marginal cost of highest cost unit produced

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Demand-Side Benefits of Restructuring

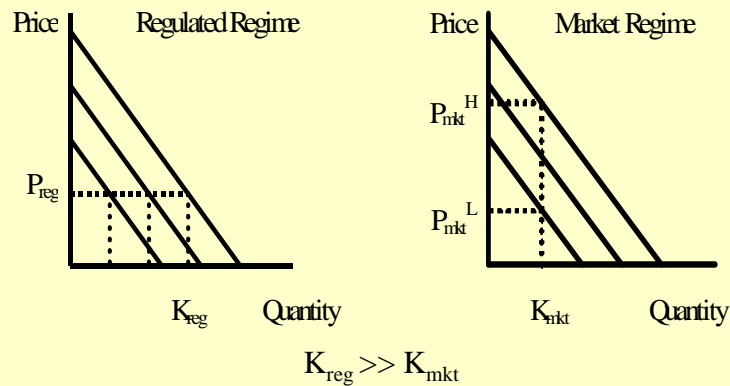
- Symmetric treatment of producers and consumers of electricity
 - From perspective of grid reliability, a consumer is a supplier of “negawatts”-- $SN(p) = D(0) - D(p)$
- Default price consumers face is hourly wholesale price
 - Consumer is not required to pay this price for any of its consumption, just as generator is not required to sell any output at short-term price
 - To receive fixed price, consumer must sign a hedging arrangement with load-serving entity or electricity supplier
 - Strong incentive to reduce consumption during high-priced periods
- Example of hedging of short-term price risk
 - Health, automobile and home insurance, cellular telephone

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Active Participation of Demand

- Symmetric treatment of load and generation
 - Requires customers to have interval meters to record their real-time consumption
 - Limits ability of suppliers to exercise unilateral market power in wholesale market
 - Suppliers experience lost sales if they charge higher prices
- Less generation capacity needed to serve same number customers
 - This implies lower capacity costs for market
 - Even if dispatch costs are close to the same, average market price should be less than average regulated price

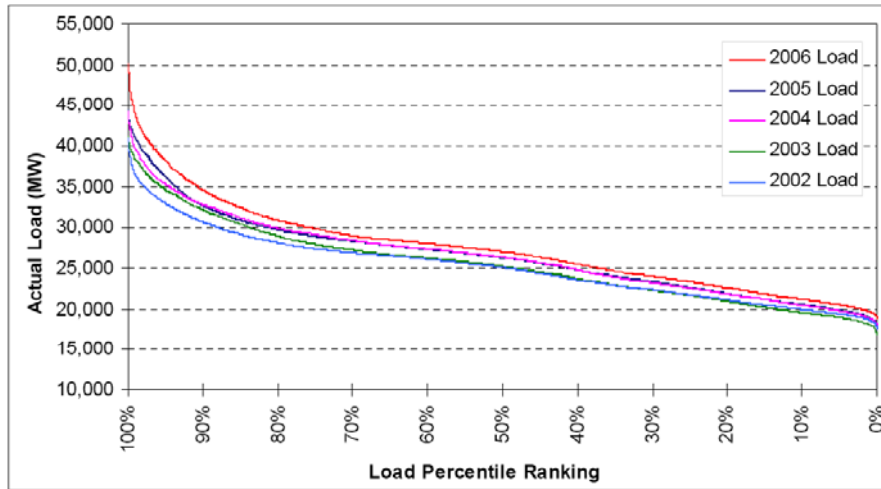
Optimal Capacity Choice Under Regulated versus Market Pricing



Active Participation of Demand

- Recall that all installed capacity must be paid for by consumers or it will exit
 - If $K_{reg} > K_{mkt}$ with same dispatch costs, then average prices do not need to be as high under market pricing
- Suppose $0.9K_{reg} = K_{mkt}$ and capital costs are 40 percent of price of electricity
 - Reducing peak demand by 10 percent could be accomplished through symmetric treatment of load and generation
 - Wolak (2006) and Patrick and Wolak (1998) measure price-responsiveness of residential and industrial demand
 - Average wholesale price can be 4 percent lower under market pricing

Figure E.5 Hourly Load Duration Curves



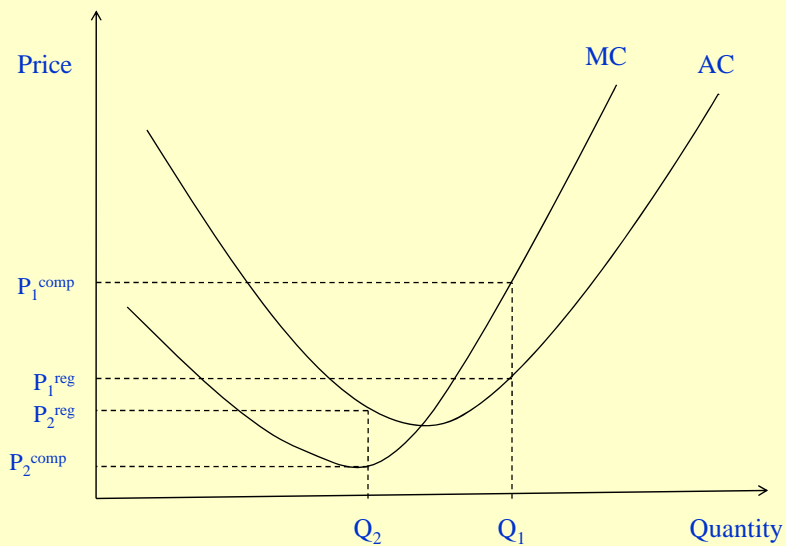
Low-Hanging Fruit on Demand Side

- Variation in California demand throughout day and year
 - On 7/24/06 demand ranged from 28,300 MW to 50,200 MW
- Average MW consumption per hour during 2006
 - Approximately 27,000 MW
 - Peak demand for 2006 is 50,200 MW
- Reducing peak demand
 - Eliminate need to construct new generation capacity
 - Can retire old inefficient units located close to large cities
- In California approximately 5,000 MW (10 percent of peak demand) used less than 2 percent of hours of the year

False Benefits of Market versus Regulated Pricing

- Regulated prices must only recover incurred costs
 - Price can be set at average cost (AC) of supply
- Prices from a perfectly competitive market set at marginal cost (MC)
 - Marginal cost can be less than or equal to average cost of supply
- Depending on level of demand
 - $MC > AC$ or $MC < AC$
- Regardless of relationship between incurred (regulated) and minimum costs (market)

Markets versus Regulation



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Benefits of Market versus Regulated Pricing

- Market pricing “preferred” at Q_2
- Regulated pricing “preferred at Q_1
- This distinction misses sources of benefits of restructuring
- Benefits of restructuring due to
 - Short-run and long-run cost differences between regulated and market-pricing regimes
 - Not due to movements along same cost curves
 - Active participation of final demand in wholesale market implies need for less capacity to serve consumers

Why US Has Not Realized Benefits

- Reasons Specific to United States
 - Separate wholesale and retail market regulators
 - Federal Power Act mandate for wholesale prices
 - History of effective state-level regulation of vertically-integrated utilities
 - Increasing regulatory intervention in wholesale market operation

Federal-State Regulatory Separation

- United States one of few countries with clear separation between wholesale and retail market regulation
- Federal Energy Regulatory Commission (FERC) sets wholesale market policies
- State Public Utilities Commissions (PUCs) set retail market policies
- Wholesale and retail market policies must be coordinated or enormous consumer harm is possible
 - Designing a wholesale market assuming final load responds to real-time prices can create a disaster if retail market policies prohibit this
 - Designing retail market policies ignoring need for retailers to hedge spot price risk can create a disaster if wholesale market policies allow spot prices to fluctuate hourly or on a shorter time horizon

Federal-State Regulatory Separation

- Retail market policies consistent with wholesale market policies may appear to state PUCs like giving up regulatory authority
 - Give consumers the ability to protect themselves from price volatility
 - Allow retailers to protect themselves from spot price risk
 - Allow retail competition to set retail prices instead of state PUCs
- Conclusion—Divergent goals of state-level and federal-level regulation harms consumers
 - In vertically-integrated regime state regulatory body dominates process
 - In wholesale market, federal has much greater role

Federal Power Act

- Wholesale electricity industry in US is still regulated despite existence of wholesale markets
- Federal Power Act requires Federal Energy Regulatory Commission (FERC) to regulate wholesale electricity prices
- Federal Power Act (FPA) of 1930 requires FERC to
 - Ensure that wholesale prices are “just and reasonable”
 - If they are not, take action to make them “just and reasonable”
 - “Whenever the Commission, after a hearing had up its own motion or upon complaint, shall find that any rate, charge, or classification, demand, observed, charged or collected by any public utility for transmission or sale subject to the jurisdiction of the Commission, or that any rule, regulation, practice, or contract affected such rate, charge, or classification is unjust, unreasonable, unduly discriminatory or preferential, the Commission shall determine the just and reasonable rate, charge, classification rule, rule, regulation, practice or contract to be thereafter observed and in force, and shall fix the same by order.” (Section 206(a), Federal Power Act)
 - Order refunds for prices in excess of “just and reasonable” levels

Federal Power Act (FPA)

- What is a “just and reasonable” wholesale price?
 - Many possible definitions
 - Enormous wealth transfers can occur before this issue is resolved—Ask California
 - FPA introduces uncertainty about which transactions will be subject to refund
- No other country subjects its wholesale market to a “just and reasonable” price standard
- Creates moral hazard problem for market participants
 - If FERC must ensure that prices are just and reasonable, why take costly actions to protect against or prevent unjust and unreasonable prices?

History of Effective State-Level Regulation

- Restructuring in US preceded by more than 70 years of state-level oversight of privately-owned vertically-integrated utilities
- Two tenets of state-level regulation
 - Obligation to serve all demand at regulated price
 - Regulated price allows utility the opportunity to recover all prudently incurred costs of serving its demand
- State regulators set retail prices and privately-owned, profit-maximizing utilities minimize production costs once prices were set
 - Utilities owned vast major of generation units needed to serve demand
 - States could control retail price in spite of input cost increases

History of Effective State-Level Regulation

- The combination of state-level regulation and profit-maximizing behavior of investor-owned utilities squeezed out many inefficiencies in operation of vertically-integrated utilities
- Many wholesale markets in US started as tight power pools
 - Vertically-integrated utilities jointly dispatched their generation units to reduce operating costs
- Wholesale markets in other countries formed from government-owned national or regional monopolies
 - Government-owned companies have limited incentives to minimize production costs
 - Face other pressures besides delivering output at least cost
 - For example, regional jobs program

History of Effective State-Level Regulation

- Inefficiencies in industry operation before re-structuring far greater in these countries
- Conclusion—US industry had significantly less productive inefficiencies than other countries
 - Fewer sources of potential benefits from restructuring in US versus Rest of World
 - Two-headed regulatory structure makes achieving these limited benefits more difficult
- Open research question—Was major source of benefits of re-structuring in these countries privatization with effective regulation rather than wholesale and retail competition?

Increasing Regulatory Intervention

- Wholesale market operation in US has evolved to look like very inefficient form of cost-of-service regulation
- Lesson regulators have learned from California Electricity Crisis is that a price \$1000/MWh too high for one hour is far worse politically than a one that is \$10/MWh too high for 1000 hours
- FERC (federal regulator) has adopted mechanisms that raise average prices but lower price volatility
 - Automatic mitigation procedure (AMP) designed to limit ability of suppliers to exercise market power in spot market
 - Capacity payment mechanisms (with or without demand curve)

Features Common to Virtually All Markets

- Asymmetric treatment of load and generation
 - Free wholesale price hedge provided to regulated retail consumers
- New role of transmission network in wholesale market regime
 - Transmission network as facilitator of competitiveness of wholesale market
- Inability to distinguish between failure of market design and failure of individual investments
 - Not all generation investments need to earn a positive economic profit

Symmetric Treatment of Demand

- Substantial state-level regulatory barriers to active demand-side participation
 - “Consumers must be protected from short-term price risk”
 - “Electricity is a right, not a commodity”
 - Wolak, Frank (2007) “Managing Demand-Side Economic and Political Constraints on Electricity Industry Re-structuring Processes,” on web-site.

Symmetric Treatment of Demand

- Interval meters have up-front installation costs and communications network cost
 - Variable cost per meter per month is less than \$0.50 per meter
 - Economic case for hourly meters can almost be made based on metering cost saving alone
 - Estimated wholesale energy purchase costs savings improves economics
- A number of large retailers in the United States, Canada, Australia, Italy have or are installing universal hourly metering
 - Metering is a regulated distribution network service

Symmetric Treatment of Demand

- Important point--Fixed-retail price does not imply customers do not pay real-time hourly wholesale price in retail prices
 - Retailers will go bankrupt if this outcome does not hold on annual basis
 - Customers just cannot benefit from lower annual bill from reducing consumption during high-priced hours
- Conclusion—Cannot “protect customers from volatile wholesale prices”
 - Can only prevent them from taking actions to limit wholesale price volatility and reduce their monthly bill

Symmetric Treatment of Demand

- All California investor-owned utilities are installing hourly meters for all customers
 - Major barrier to active demand-side participation in California will soon be eliminated
- Remaining challenge is regulatory barrier
 - Recent empirical evidence on “politically acceptable real-time pricing” is promising
 - Methods to share risk of responding short-term prices between consumers and retailers

The New Role of Transmission

- Benefits of a given transmission upgrade different in wholesale market regime relative to vertically-integrated regime
- Marginal increase in transmission network has different net benefit to consumers
 - Imperfectly competitive wholesale market whose efficiency can be improved by transmission investments that increase the number of competitors that can serve load at each location in the network
 - Imperfectly regulated vertically integrated regime where firm can benefit from economies to scope between transmission and generation to meet its load obligations
- State PUC regulation and prospect of re-structuring left the US with a significantly less transmission investment over past 30 years than comparable state-owned vertically-integrated utilities around the world

The New Role of Transmission

- Economically reliable transmission network may require far greater inter-connection capacity than network operated by vertically-integrated utility according to engineering reliability standards
- Economic reliability--All locations in transmission network are contestable--firms face substantial competition from a number of independent suppliers--a large fraction of the time
- State regulators may need to provide incentives to invest early on to overcome initially inadequate network for competition in generation
- Consider case that “over-invest” in transmission capacity to increase delivered prices by \$1/MWh
 - If increased capacity of transmission network results in more competitive wholesale market, average wholesale prices may fall by \$2/MWh so that consumers benefit from upgrade

Imprudent versus Prudent Investments

- All generation investments should not be guaranteed full cost recovery
- “Imprudent” investments (capacity build in advance of when it is needed) should not be rewarded
 - These investors should lose money as is the case in all other markets
 - Imagine if all dot-coms were required to recover costs
 - Many examples of poorly timed, but ex post profitable investments
- Generation units will still exist
 - Initial investor will lose money
- Assets will sell for much less than initial construction cost but they will be used according to their variable cost of supplying energy
- Clear distinction between these two types of investments is a major source of benefits from restructuring

How US Can Realize Benefits

- Provide strong incentives for least cost production in short-run and long-run by suppliers
 - Low entry barriers, extensive transmission network
- Treat electricity like any other product
 - No free insurance against wholesale price volatility
 - Default price consumers and producers face is real-time price
- Treat transmission network as facilitator of competitive wholesale market
 - Benefit versus cost analysis must account for market-efficiency benefits (less exercise of unilateral market power) of transmission network
- Provide opportunity for firms to recover costs not a guarantee of cost recovery
 - Higher powered than former vertically-integrated regime

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