Designing an Electricity Market that Benefits Consumers

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Outline of Talk

- Market Design Problem—What is it?
  - Principal-Agent Problem
  - Necessity of Market Design in Electricity Markets
- Constraints Facing Market Designer
  - Market Power by Generation Unit Owners
- Measuring Market Power in Electricity Markets
  - Role of Congestion Management in Limiting Market Power
- Limiting Ability of Firms to Exercise Market Power
  - Role of Forward Markets
  - Role of Transmission Network
  - Role of Price-Responsive Demand
    - Necessary Retail Market Infrastructure
- Buyer Power to Combat Supplier Market Power

Theory of Market Design

- Market Design Requires Solving Principal-Agent Problems at Multiple Levels
- Principal-Agent Problem
  - Principal designs payment scheme which causes agent to act to maximize principal's payoff function
  - Agent behaves to maximize its own payoff function once payment scheme is set
- Market Designer = Principal
    - Usually government and/or regulator
  - Agents = Firms and consumers in market
    - Owner of Firm = Principal
    - Management of Firm = Agent

Principal/Agent Problem

- W(x,s) = Payoff of Principal (regulator or government)
  - x(a,s) = observable market outcomes x
  - s = state of world s (level of market demand)
- V(a,y,s) = Payoff of Agent (firm)
  - a = actions (bids, maintenance, employment, fuel use decisions)
  - y(x) = compensation function set by principal (how firms are paid for actions they take)
- Usually assume that Principal
  - Cannot observe all actions a or true state of world s
  - Can observe x(a,s) outcome that depends on a and s

Principal-Agent Theory

- Principal's problem is to choose function, y(x), to maximize $E_s[W(x,s)]$ subject to
  - (1) Individual rationality of agent--agent will choose a to maximize V(a,y(x),s) or its expectation given y(x) and s
  - (2) Participation constraint--y(x) must allow agent to achieve reservation payoff or expected payoff V*
- Regulator must recognize that once y(x) is set, agent will choose a to maximize its payoffs
- Regulator must set y(x) to allow agent to achieve at least reservation payoff V*

Adam Smith on Market Design

- "It is not from the benevolence of the butcher, the brewer, or the baker, that we expect our dinner, but from their regard to their own interest. We address ourselves, not to their humanity but to their self-love, and never talk to them of our necessities but of their advantages."

  The Wealth of Nations, Book I Chapter II

Example Principal-Agent Problem

- Example from vertically-integrated US electricity industry
  - Principal is regulator
  - Agent is vertically-integrated monopoly supplier
- Regulator would like firm to produce at minimize cost so that it can set low regulated price that only recovers this cost
  - Unfortunately regulator cannot observe firm's true minimum costs of production, only incurred costs of production
  - Can't make agent play game (participation constraint)
- Must design incentive scheme for compensating firm that leads profit-maximizing firm to produce at minimum cost
    - Examples include, cost-of-service regulation, price-cap regulation

Principal-Agent Problem

- Optimal compensation scheme for regulator to set for firm depends on
  - Preference or payoff functions of regulator and firm
  - Informational asymmetries between the firm and regulator
- Competitive market is one of many possible incentive schemes that can be used to solve this agency problem
  - Strong incentives for minimum-cost production by firm
  - Market may not pass on these minimum costs in prices
- The conditions that guarantee a competitive market solves this agency problem may not hold for electricity
  - One condition is atomistic (very small relative to the size of the market) buyers and sellers

Optimal Market Design

- Proposed objective function for market designer
  - Lowest possible average annual delivered price consistent with financially viable industry
  - In economist's language--maximize consumer surplus subject to marginal firm in industry earning zero economic profit
- Minimum requirement for competitive market is lower average price than under vertically-integrated regime
  - Otherwise it is hard to rationalize industry restructuring

Necessity of Market Design

- Most markets do not require explicit market design process
  - Markets evolve from locations where economic agents trade
    - New York Stock Exchange (NYSE)
- Economic agents are free to trade at any market they like
  - Buyers search for markets offering lowest selling price
  - Sellers search for markets that offer highest buying price
- Why do network industries, particularly electricity, require market design process?

Necessity of Market Design

- Network required to deliver electricity
  - Despite Nikola Tesla's attempts, cannot beam electricity to final customers
  - Cost structure favors a single transmission network for a given geographic area
- Network owner is privately-owned and regulated or government-owned in all markets
  - All generation owners have equal access to network
  - All electricity markets require single entity that manages transmission network
- This requires designing a regulatory mechanism
  - To compensate entity that manages transmission network
  - To set prices charged for use of transmission network

Regulation versus Competition

- "Competitive" regime restricts regulated portion of industry to smallest entity possible
  - Transmission and distribution are only services with their prices set through a regulatory process
  - Generation and electricity retailing are open to competition
    - Economies of scope difficult to capture under this regime
- "Vertically integrated" regime imposes regulatory process on all aspects of industry
  - Final output price of vertically integrated monopoly is regulated--economies of scope possible
- Choice between regulation and competition depends which regime achieves market designers objectives

Re-structuring not De-regulation

Allow market as opposed explicit regulatory process to discipline prices consumers pay in some segments of industry

Agency relationship between firms and regulator remains

- Conflict between regulator's objectives and firm's objectives
- Firm still wants to maximize profits and it does this by increasing its price

New form of "regulation" gives rise to a new set of problems

- Market Power—Ability of firms to increase the market price and profit from this price increase
- Explicit exercise of market power is not possible under traditional forms of regulation because regulator, not firm, sets market price, but firm still tries to influence price indirectly
  - Wolak (1994) has examined this issue in context of traditional regulatory process "An Econometric Analysis of the Private Information Regulator-Utility Interaction"

Market Power = Major Market Design Challenge

- Measure of market power
  - Extent that market prices are in excess of perfectly competitive ideal
  - Standard measure used in markets for all other products
  - Provides assessment of the efficiency of the market reflecting production costs in market prices
- Many other measures, but this is bottom line

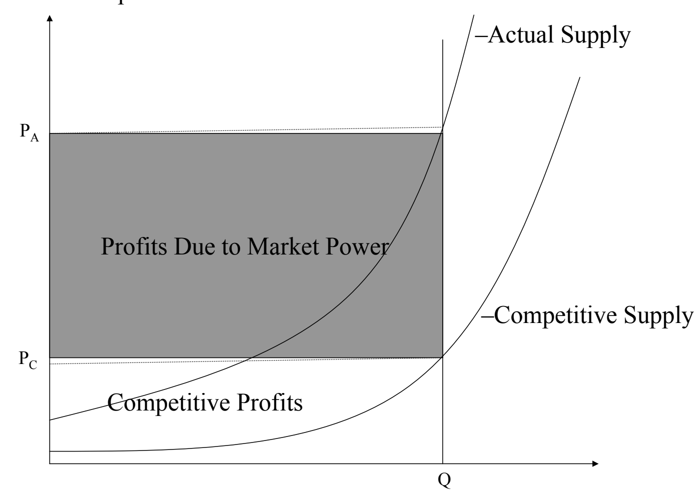
Compute Measures of Market Power from 6/1/98 to 12/31/00

1) Extent of market power exercised in market on hourly basis
   a) Compare actual quantity-weighted average price to competitive benchmark weighted average price over given time horizon

2) Account for increase in competitive benchmark prices due to
   a) Input fuel price increases in 2000 versus 1999 and 1998
   b) Emission cost increases in 2000 versus 1999 and 1998

See Borenstein, Bushnell, and Wolak (2002) "Measuring Market Inefficiencies in California Re-structured Electricity Market" *American Economic Review*, December, for detailed methodology.

Competitive Profits versus Profits Due to Market Power



Energy, A/S Costs and Market Power Markup from 4/98 to 12/00

Month	Energy Cost $/MWh	A/S Costs $/MWh of Load	Total Costs per MWh	MP(S) $/MWh
Jun-98	13.52	2.95	16.47	-9.39
Jul-98	35.85	5.18	41.03	8.48
Aug-98	44.04	6.18	50.22	16.31
Sep-98	37.62	4.37	41.99	11.53
Oct-98	27.43	2.69	30.12	1.63
Nov-98	26.65	2.24	28.89	-0.62
Dec-98	30.17	2.99	33.16	4.88
Jan-99	21.73	1.75	23.48	-0.78
Feb-99	19.70	1.14	20.84	-1.65
Mar-99	19.40	1.51	20.91	-1.53
Apr-99	24.80	2.1	26.90	0.39
May-99	24.91	2.37	27.28	-0.46
Jun-99	25.85	2.26	28.11	-0.07
Jul-99	31.84	2.6	34.44	3.95
Aug-99	35.13	1.85	36.98	0.63
Sep-99	35.46	1.52	36.98	5.25
Oct-99	49.40	2.28	51.68	15.24
Nov-99	38.35	1.19	39.54	9.90
Dec-99	30.35	0.55	30.90	2.93
Jan-00	31.85	0.62	32.47	4.61
Feb-00	30.49	0.58	31.07	1.30
Mar-00	29.49	0.06	29.55	-1.92
Apr-00	27.76	0.95	28.71	-5.00
May-00	51.81	3.16	54.97	10.88
Jun-00	141.40	20.19	161.59	85.52
Jul-00	121.93	5.71	127.64	42.14
Aug-00	181.59	12.18	193.77	101.71
Sep-00	122.85	7.39	130.24	43.96
Oct-00	103.84	2.95	106.79	35.55
Nov-00	172.29	6.13	178.42	60.66
Dec-00	388.21	22.65	410.86	143.50

What Explains Differences Across Years in Market Power?

- Borenstein, Bushnell and Wolak (2002) Compute hourly Lerner Index as a function of amount energy produced by in-control-area fossil-fuel units
- LI = (P(actual) - P(comp))/P(actual)
- LI = Lerner Index
  - LI is bounded by 0 and 1
  - High values of LI indicate more market power
- LI = f(Instate Thermal Production) + error

Figure 3: Kernel Regressions of Lerner Index for August & September

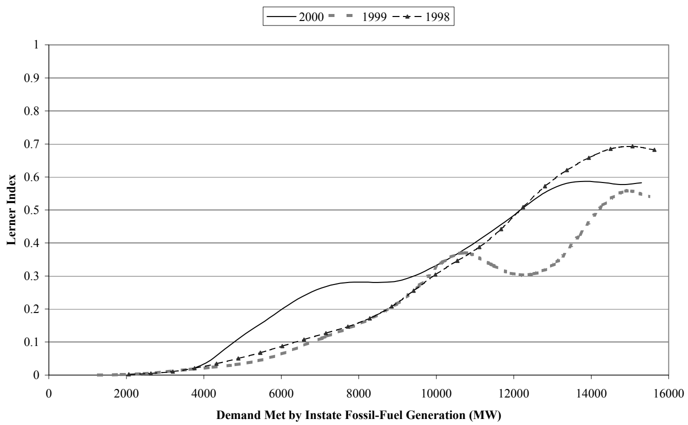
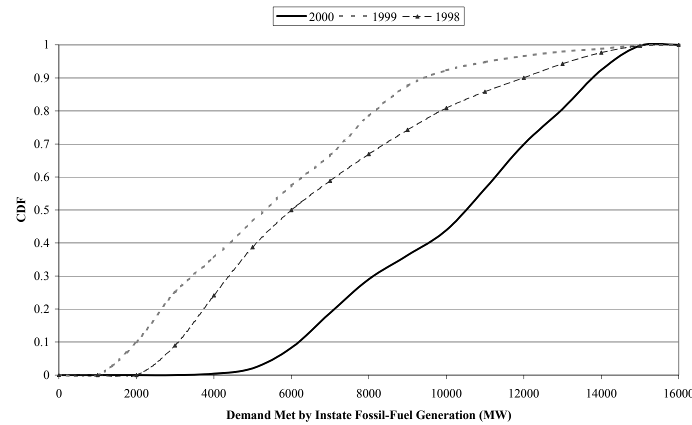


Figure 4: CDFs of demand for August & September



Summary of Market Performance from April 1998 to April 2000-Competition Works

1) Market power historically exercised during months of August to September

2) Little market power exercised during months of October to April

3) For one year period October 1998 to September 1999 little market power P(actual) - P(comp) approximately equal to zero

Summary of Market Performance from May 2000 to June 2001--Competition fails

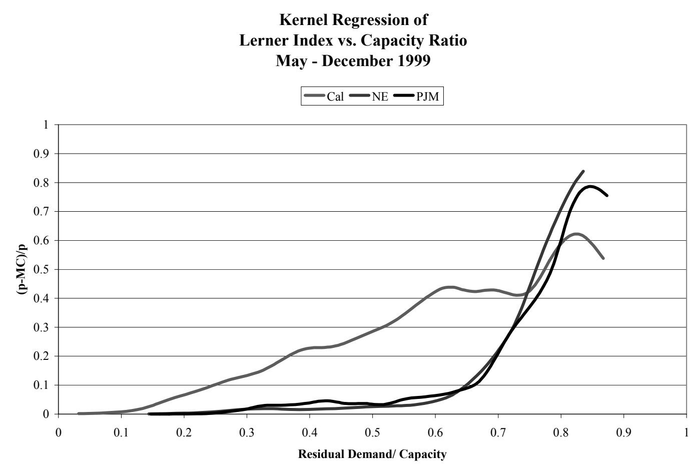
1) Extraordinary amount of market power exercised from June 2000 to June 2001

2) Average market power markup P(act) – P(comp) for
   Calendar year 1999--$4/MWh
      Average P(act) = $33/MWh
   Calendar year 2000--$45/MWh
      Average P(act) = $110/MWh
   January 2001 to June 2001--More than $100/MWh
      Average P(act) more than $200/MWh

California's Flawed Market Design?

For Nodal, Zonal, and Single-Price Markets, Compare Relationship between
   Hourly Value of Lerner Index = (P(act)-P(comp))/P(act)
   (Hourly Demand for Capacity in Control Area)
      /(Capacity in Control Area)

Time Period = May 1999 to December 1999
   Mansur (PJM)--Nodal
   Bushnell & Saravia (New England)--Single Price
   Borenstein, Bushnell, and Wolak (CA)--Zonal



Source: Bushnell and Savaria (2002)

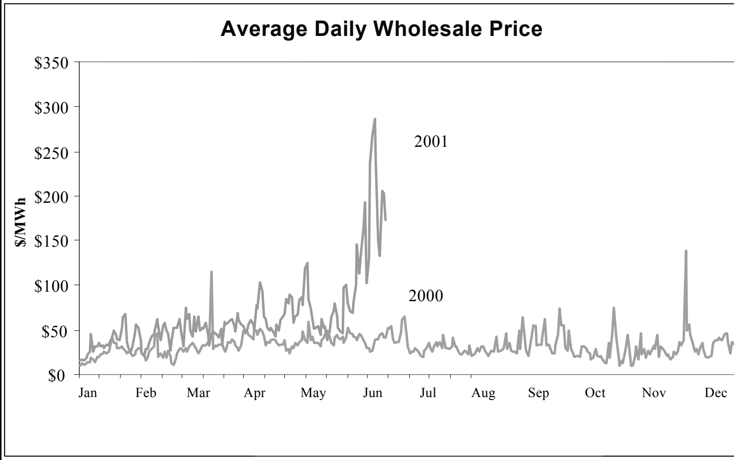
California's Flawed Zonal Market Design?

All electricity markets susceptible to exercise of market power

- Overall amount of market power exercised during this time period highest in PJM market (nodal market)
- Least amount of market power exercised during this period was in ISO-NE, single price market

Congestion management method does not appear to impact ability of firms to exercise market power.

Guess the Locational Pricing Scheme?



Guess the Locational Pricing Scheme?

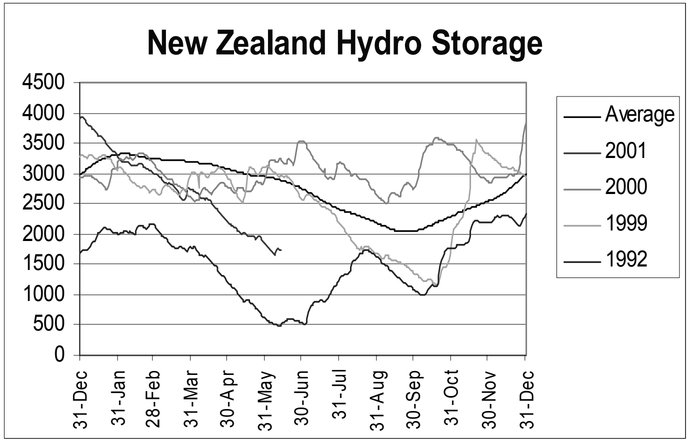
The wholesale price is 5 times its usual level

Daily average normally $40-50 per MWh

Averaging around $200 per MWh in June

Sounds like California, but it's the wrong year!

New Zealand's Flawed Nodal Pricing Scheme?



Cause of CA and NZ Market Meltdowns

- Insufficient hedging of spot price risk by California load-serving entities and significantly less imports available to California in 2000 (relative to '98 and '99) was major cause of "crisis"
  - Generators had virtually no forward market obligations to California load-serving entities which considerably enhanced their ability and incentive to exercise market power in spot market—see Wolak (2003) "Measuring Unilateral Market Power in Wholesale Electricity Markets: California 1998 to 2000" available on web-site
- For similar reasons, market meltdown occurred in New Zealand, which has FERC's recommended spot market design
    - New Zealand runs a nodal market design
    - System very dependent on hydroelectric capacity
    - Insufficient forward contracts held by load-serving entities
    - Concentration of fossil-fuel capacity ownership

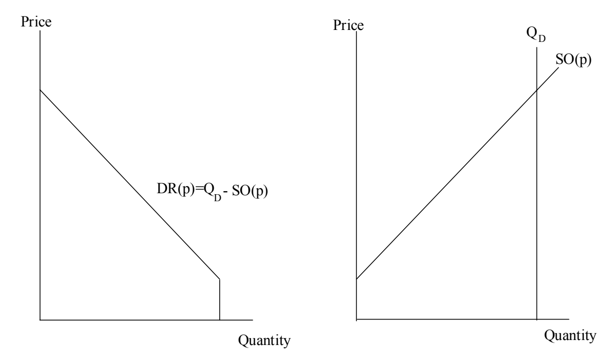
Bidding in Competitive Markets

- First Step in Market Design Process
  - Understanding how firms bid to maximize profits under given set of market rules, y(x)
  - How do firms exercise their unilateral market power
- Allows Market Designer to define constraint set it faces in maximizing its payoff function
  - Firms will maximize profits given market rules
    - Individual Rationality
  - Firm must be expect to earn return sufficient for it to participate in market
    - Participation Constraint

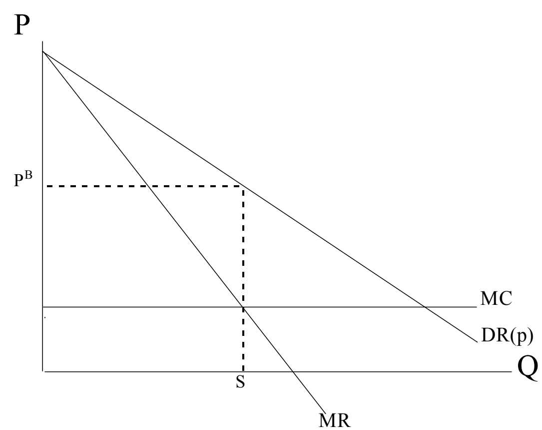
Bidding in Competitive Markets

- Simple model of profit-maximizing bidding behavior in competitive market
- Q_{id}: Total market demand in load period i of day d
- $SO_{id}(p)$: Amount of capacity bid by all other firms besides Firm A into the market in load period i of day d as a function of market price p
- $DR_{id}(p) = Q_{id} - SO_{id}(p)$: Residual demand faced by Firm A in load period i of day d, specifying the demand faced by Firm A as a function of the market price p
- $\pi_{id}(p)$: Variable profits to Firm A at price p, in load period i of day d
- MC: Marginal cost of producing a MWH by Firm A

Residual Demand Curve faced by Firm



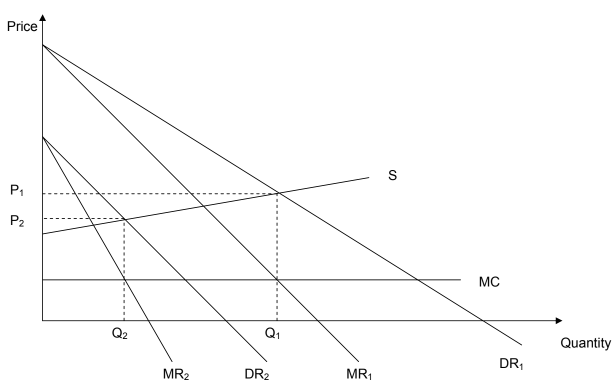
Bid to Maximize Profits Subject to Residual Demand



Profit-maximizing behavior implies an profit-maximizing price above marginal cost

- Residual Demand Curve unknown at time generator submits bids
  - Demand uncertainty
  - Uncertainty about actions of other suppliers
- Optimal bid curve depends on distribution of elasticities of residual demand function

Bid to Maximize Expected Profits



Market Design = Limiting Market Power of Firms

- Make residual demand curves perceived by all unit owners as elastic as possible
  - Generators facing infinitely elastic residual demand curve perceive themselves as being unable to impact the market price by their bids
  - Optimal strategy for generation unit owner facing infinitely elastic residual demand curve is to bid marginal cost curve (MC) as willingness to supply curve [S(p)]
  - This will lead to market prices as close as possible to market designer's optimum

Limiting Market Power of Firm

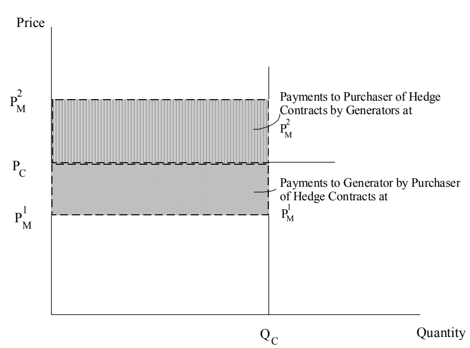
- Market Power problem increasingly more extreme the closer market gets to real-time
  - Set of potential competitors increases as time between price negotiation and delivery increases
  - Only those plants operating with unloaded capacity can deliver energy in real-time
- Forward Financial commitments make firm bid more aggressively in spot market
  - This makes other firms want to bid more aggressively

Limiting Market Power of Firm

- Transmission upgrades to face all unit owners with more elastic residual demand curves
  - Economic reliability of transmission network versus Engineering Reliability of transmission network
- Price Responsive Demand makes residual demand curves perceived by all unit owners more elastic

Impact of Forward Contracts on Bidding Behavior

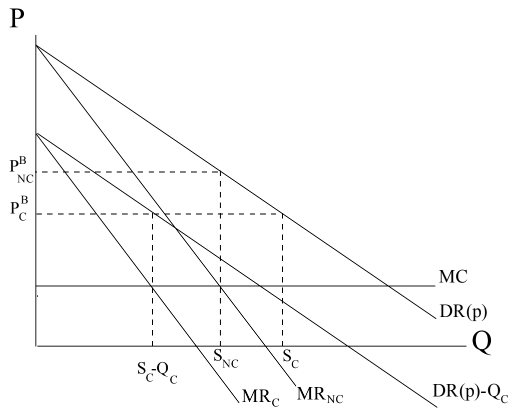
- QC_{id}: Contract quantity for load period i of day d for Firm A
- PC_{id}: Quantity-weighted average (over all hedge contract signed for that load period and day) contract price for load period i of day d



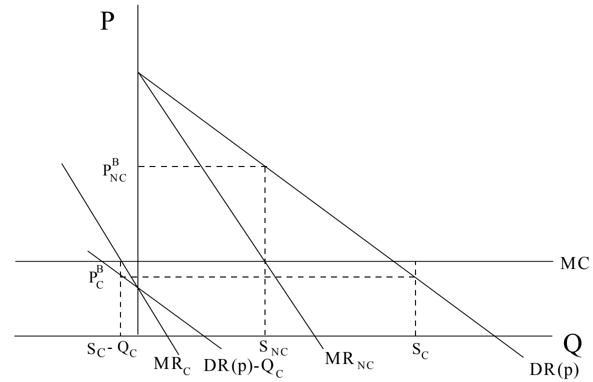
Spot Market Bidding With Forward Contracts

- Assume market clearing price p is determined by solving for the smallest price such that the equation $SA_{id}(p) = DR_{id}(p)$ holds.
- The magnitudes QC_{id} and PC_{id} are set far in advance of the actual day-ahead bidding process
- Generators sign hedge contracts with electricity suppliers or large consumers for a pattern of prices throughout the day, week, or month, for an entire or fiscal year
- Variable profits (profits excluding fixed costs) to Firm A for load period i during the day d at price p as:
  - $\pi_{id}(p) = DR_{id}(p)(p - MC) - (p - PC_{id})QC_{id}$
- This can be re-written as:
  - $\pi(p) = (DR(p) - QC)(p - MC) + (PC - MC)QC$
- Note that second part of expression is fixed from a day-ahead perspective.

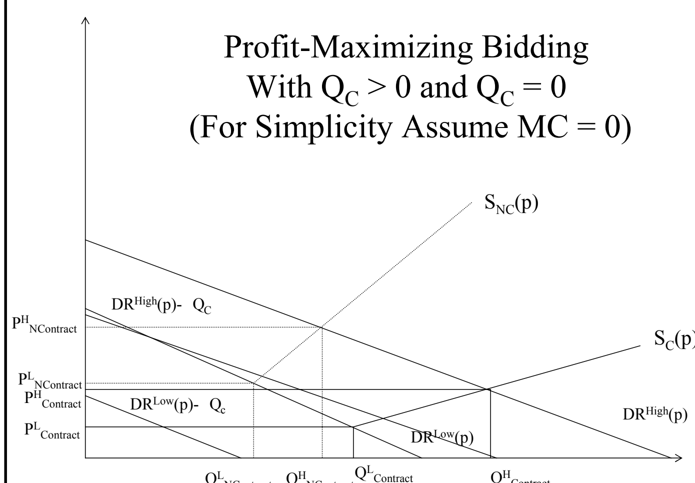
Bidding With Hedge Contracts



More Contract Cover than Spot Sales



Profit-Maximizing Bidding With $Q_C > 0$ and $Q_C = 0$ (For Simplicity Assume MC = 0)



Transmission Network and Market Power

- Transmission networks were built for former vertically integrated monopoly regime
  - Built to take advantage of economies to scope between transmission and generation to meet local energy needs
  - Integrated resource planning by vertically integrated monopolist considers both local generation and transmission to find least-cost solution to serve additional load
  - Transmission capacity across control areas of vertically integrated monopolists built for Engineering Reliability
    - Sufficient transmission capacity so imports could be used to manage large temporary outages within control area
    - Few examples where transmission capacity was built to facilitate significant across-control-area electricity trade--California/Oregon

Regulating Transmission Network

- Wholesale market has independent system operator (ISO) for transmission network
  - Owner of local generation financially independent of ISO
    - In both short-term and long-term, ISO cannot take advantage of economies to scope between transmission and generation that current transmission network was designed to utilize
  - Local generators have strong incentive to cause transmission constraints into their local area
    - Raise local prices for energy either (withholding capacity or bidding high prices) to cause congestion
    - Generation assets of former vertically integrated monopolist sold in bundles of units in located small geographic areas
  - During early stages of re-structuring process transmission network is ill-suited to support competitive market
    - This transition period can last a very long time

Regulating Transmission Network

- Strategy for regulating transmission network
  - Transmission network cost recovery is 10-15% of delivered price of electricity
  - Construct transmission network to support competitive market assuming profit-maximizing entry decisions by generation unit owners
    - Economically reliable transmission network
  - Competition to provide upgrade once location and magnitude has been determined
  - Potential sources of informational asymmetries in operation of transmission network services small
    - Relative to generation and supply

Transmission Network and Market Power

- "Over-investment" in transmission capacity relative to engineering reliability concerns can benefit market
  - Economically reliable transmission network requires far greater inter-connection capacity than technologically reliable network
  - Economic reliability--All locations in transmission network are contestable a large fraction of the time
  - May need strong incentives to invest early on to overcome initially inadequate network for competition in generation
- Consider case that "over-invest" in transmission capacity to increase prices by $1/MWh
  - If increased capacity of transmission network results in more competitive wholesale market and average prices fall by $2/MWh, consumers benefit from upgrade

Asymmetric Treatment of Load versus Generation

- Generators can fully benefit
  - From change in their output in response to hourly electricity prices
    - Produce more in higher-priced hours
  - From their ability to alter hourly price
    - Generator can take actions to raise hourly price
- In US, virtually all consumers are prevented from realizing full benefits
  - From change in output in response to hourly price
    - Even though wholesale price is $0.75/KWh consumer only saves $0.11/KWh for each KWh not consumed
  - From their ability to alter hourly price

Asymmetric Treatment of Load versus Generation

- Default price loads pay for wholesale energy in virtually all US states is constant over time and space
  - State regulator allows consumers to switch to and from this default price at any time
- Option to buy at default price at any time can be extremely valuable to consumers
  - Creates a enormous liability for load-serving entities that can arise with high probability during certain system conditions such as those in California from June 2000 to June 2001
- Default price generators receive in all of US markets is hourly wholesale spot price at their location
  - Generator must sign a hedging agreement to receive pre-specified fixed price for its output

Retail and Wholesale Market Interactions

- 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 for all consumers should be 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 spot price
  - To receive fixed price, consumer must sign a hedging arrangement with load-serving entity or electricity supplier
- There is nothing unusual about hedging spot price risk
  - Health, automobile and home insurance, cellular telephone

Necessity of Interval Metering

- Analogy to long-distance competition
  - Can only measure total minutes of phone calls in month
  - Cannot measure duration, destination, time-of-day
  - Compute monthly bill on “calling profile” set by regulator
  - Would not think of doing “load-profile” billing in long-distance industry
  - Ratio of higher to lowest cost call can easily be 50:1
  - Consumers would have strong incentive to receive favorable “calling profiles” that impose huge costs on others
    - Receive local calling plan that assumes few long-distance calls of short duration and distance
    - Once receive plan make many long-distance calls of long duration and distance
  - Creates enormous across-customer subsidies

Load-Profile Billing

- Measure total monthly consumption of electricity
- Representative load shape used to compute weighted-average energy price for month
  - p(h,d) = price for hour h of day d,
  - w(h,d) = weigh for hour h of day d, $\sum_{h,d} w(h,d) = 1$
  - Monthly bill = (monthly consumption) x (monthly weighted-average energy price). $\sum_{h,d} w(h,d)\,p(h,d) = p$
- Demand reduction when hourly energy price is \$0/MWh leads to same monthly savings as same demand reduction when hourly price is \$250/MWh.
- Want consumer to realize maximum benefit from reducing consumption when wholesale price is highest
  - Imagine difficulty in running competitive long-distance telephone company only measuring minutes of phone use per month

Necessity of Interval Metering

- Variation in hourly electricity prices over month
  - Regulation--ratio highest to lowest cost in month is ~5:1
    - Efficiency costs of monthly load profile-billing is limited
  - To the extent that hourly wholesale prices are very similar limited to benefits to interval metering
  - Competition--ratio highest to lowest price in month, or even week or day, can be much greater than 100:1
    - Many hours with negative prices of electricity in CA
    - Would never have negative wholesale prices if consumers had ability to participate in market
      - How many consumers would be willing to be paid to consume more electricity?
  - Efficiency costs of monthly load-profile billing are enormous in a competitive wholesale market

Universal real-time metering

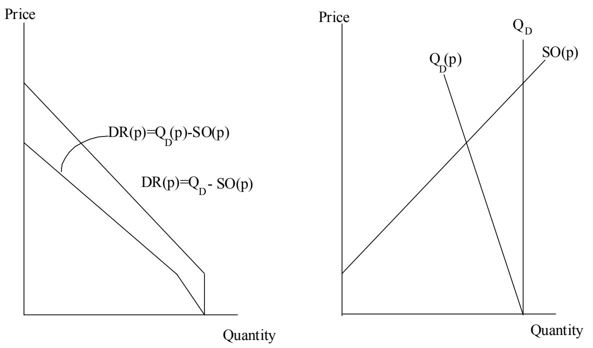
- Cost is not a barrier to ubiquitous interval metering
  - Puget Sound Energy serves ~400,000 customers
  - Recent study for 7 million meters in NY
    - Average monthly bill increase of $2 for universal metering
- Price of metering technology falling rapidly
- Sophistication of metering technology rising rapidly
- Increasing number of households with Internet access
- State regulators can run competitive procurement process for provision of interval metering infrastructure to regulated distribution companies

State oversight of risk management

- Electricity retailing = spot price risk management
  - State regulator must ensure that retailers don’t speculate
  - Monitor forward contract holdings and obligations
    - 500 MWh fixed price retail obligation 1 year from now requires 400 MWh fixed price wholesale commitment 1 year from now
  - May be expected profit-maximizing to satisfy fixed price retail obligation from spot wholesale market
    - Go bankrupt if spot price increases too much

- Analogy to retail banking sector
  - Banks take in deposits and may be tempted speculate with deposits to earn higher returns
  - Regulators set short-term reserve requirements to prevent this

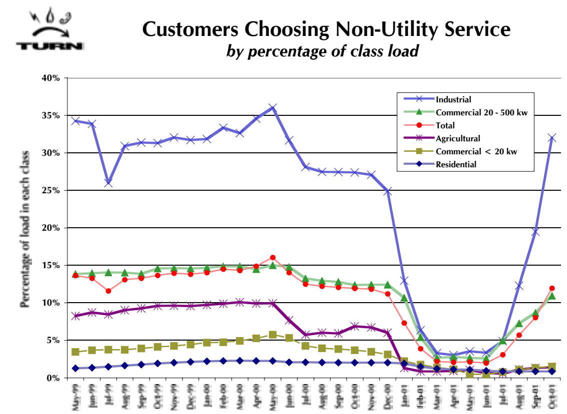
Benefits of a Price Responsive Demand



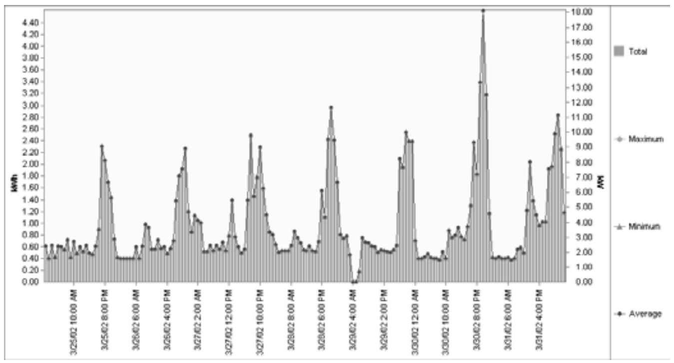
Can Consumers Play in the Market?

- To the extent that regulatory process allows them, they are already do
  - Reduction in demand in response to increase in fixed retail rates in early 2001
  - California Governor’s 20-20 program--Roughly 1/3 of state’s consumers qualified for rebates
- Extremely dull price incentives were surprisingly successful at making wholesale market performance improve

Consumers very sophisticated to the extent they are allowed

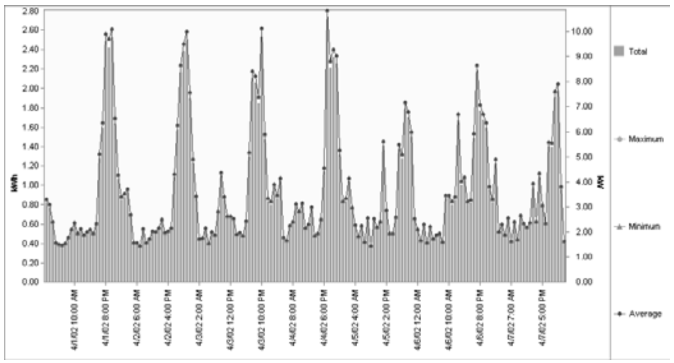


Even Residential Consumers Can Respond



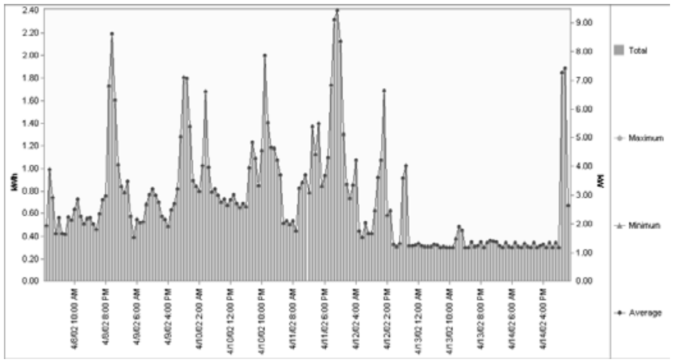
Weekly Consumption Monday to Sunday

Even Residential Consumers Can Respond



Weekly Consumption Monday to Sunday

Even Residential Consumers Can Respond



Weekly Consumption Monday to Sunday

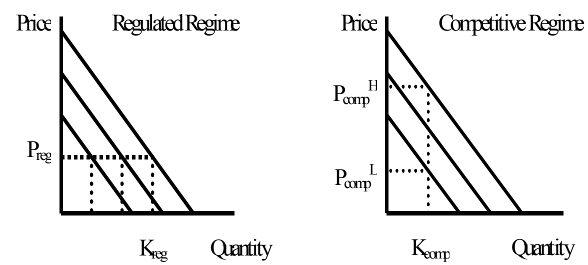
Limited Benefits of Restructuring Without Involving Demand

- US has privately-owned, profit-maximizing firms facing cost-of-service price regulation or incentive regulation plan
  - Detailed prudence review of investment
  - Hard to argue there are large deviations from minimum cost production
  - Vertically integrated ownership and centralized dispatch should be able to improve on bid-based dispatch on true production cost basis

Markets use prices to allocate scarce resources

- Competitive market should be able to get by with lower level of capacity and serve same customers
  - This implies lower capacity costs for market at large
  - If dispatch costs are close to the same, then average price in competitive market should be less than average price in regulated market
- A necessary condition for this to occur is a sufficient number of price-responsive consumers

Optimal Capacity Choice Under Regulation versus Competition



$K_{reg} >> K_{comp}$

Example--US Airline Industry

- Load Factors = (Seats Filled)/(Seats Total),
  - In regulated regime highest load factors approximately 55% in 1976
  - Pre-9/11/02, Load Factors were close to 77%
- This increased capacity utilization rate allows real average fare per passenger-mile to be significantly less than under regulated regime
- Regime works because of large number of sophisticated price-responsive consumers.

Using Buyer Power to Counteract Supplier Market Power

P(RTP,t) = real-tme price announced to consumers in hour t

P(W,t) = wholesale purchase price in hour t

Q(t) = quantity of energy RTP consumer purchases in hour t

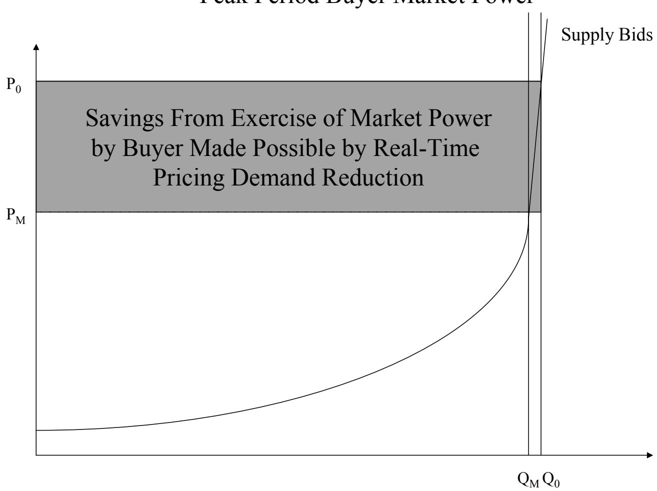
Retailer makes commitment to earn zero profit on RTP customers

$$\Sigma P(RTP,t)Q(t) = \Sigma P(W,t)Q(t)$$

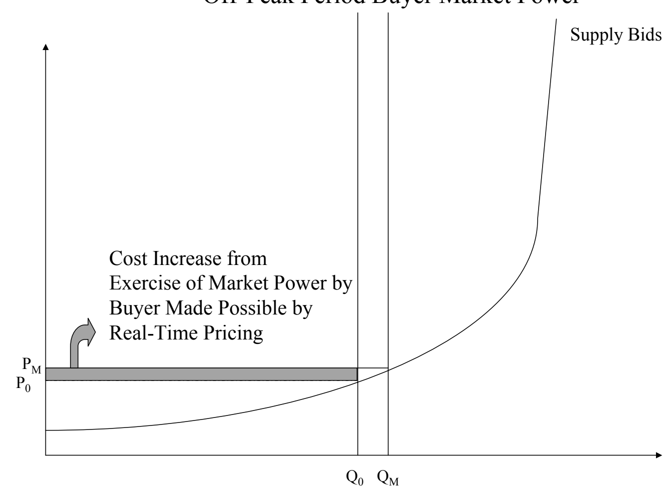
During high load hours P(RTP,t) > P(W,t)

During low load hours P(RTP,t) < P(W,t)

Peak Period Buyer Market Power



Off-Peak Period Buyer Market Power



Real-Time Pricing Allows Retailers to Obtain Lower Forward Contract Prices

Generators will recognize that effects shown on previous slides will operate to reduce spot prices and demand

Spot market prices will be lower in future than they would be in the absence of significant real-time pricing

Lower future spot prices creates lower opportunity cost to a generator signing a forward contract

Generators more likely to sign forward contracts at lower prices than they would in the absence of a large commitment to real-time pricing

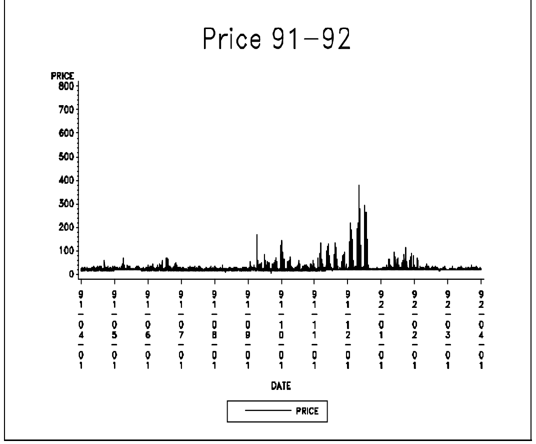
The Role of Price Volatility

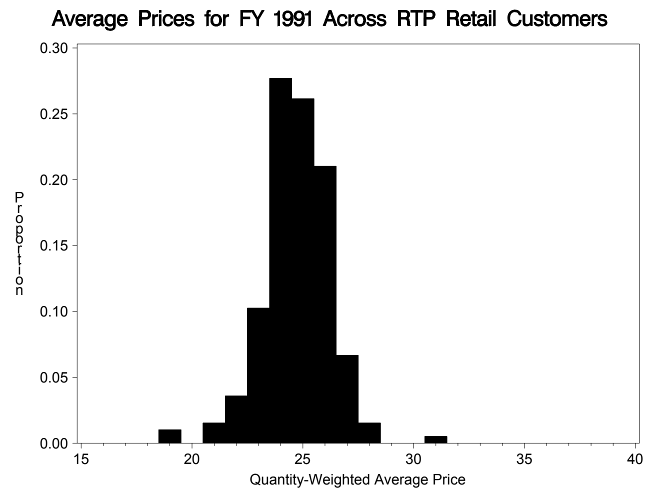
- Wholesale price volatility makes potential benefits of real-time pricing greater
- Real-time pricing encourages demand flexibility across hours in the day
- In California, total annual energy demand in 2000 divided by number of hours in year is ~27,000 MW
- Total in-state capacity is 44,000 MW and 12,000 MW import capacity
  - Price-responsive demand makes market power problem goes away
  - Real-time pricing accomplishes this
- Encourages development of renewable and distributed generation technologies

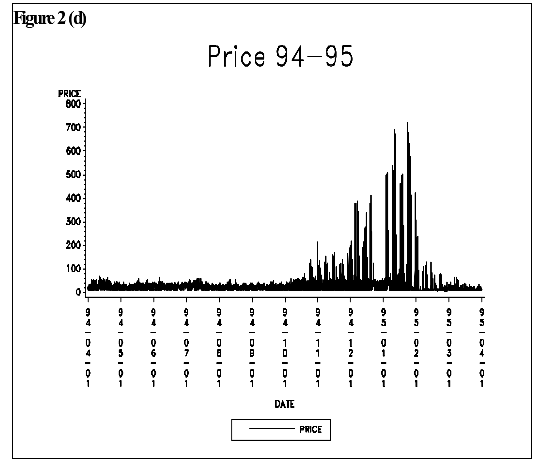
Real-time pricing contracts

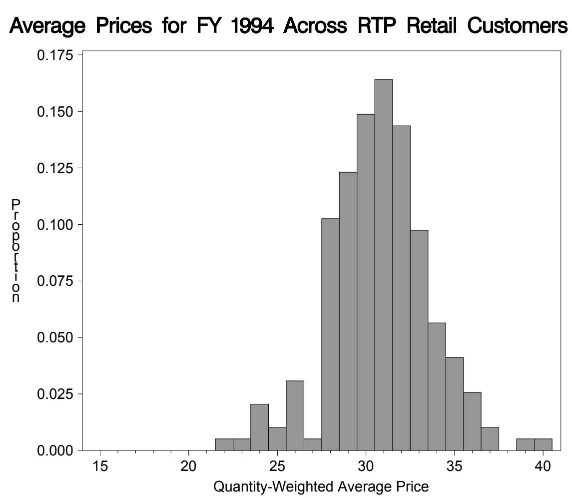
- All England and Wales retail customers have option to purchase hourly consumption according to hourly pool price plus transmission charge
- Many large industrial customers purchase according to this pool price contract
- "Estimating the Customer-Level Demand for Electricity Under Real-Time Market Prices" Patrick and Wolak
- Estimate half-hourly price responsiveness of a sample of large industrial and commercial customers in England and Wales
  - Significant price response from all classes of industrial customers--water suppliers, industrial process plants, retail stores
  - Even with a small fraction of these customers bidding into demand side of pool, market power can be mitigated.

Figure 2 (a)









Implications for Re-structuring

- For consumers to benefit from a competitive market they must face to real-time hourly price signals
- In competitive market a firm must make profits on each customer
- Regulated firm only needs to make profits across all customers
- All customers with same cost to serve will face same price in competitive market
  - Need not be true in regulated regime

Implications for Re-structuring

- Inability to cross-subsidize under competition
  - Requires greater attention to protecting low-income consumers from high prices that may impoverish them
  - Regulator may need to require explicit subsidies
- Regulator must provide significantly more information to consumers to help them protect themselves
  - Emphasize importance of hedging spot price risk
  - Information on load-shifting technologies

Competition Can Benefit Consumers

- No free lunch
  - Benefits from re-structuring must come from a change in behavior of market participants
  - Firm operate more efficiently
    - Short-term operation at least cost
    - Investment decisions based on market signals
  - Consumers make greater effort to use existing capacity more efficiently
    - Get by with less capacity to serve same number of consumers
    - Holding excess capacity is costly, because capital costs of unused capacity must be paid for regardless