

Diagnosing the California Electricity “Crisis”

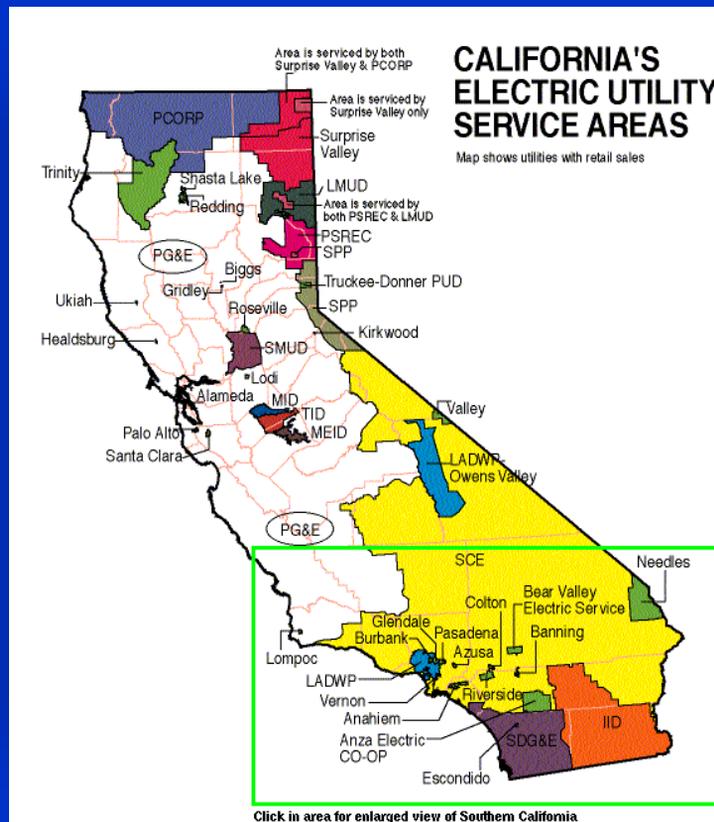
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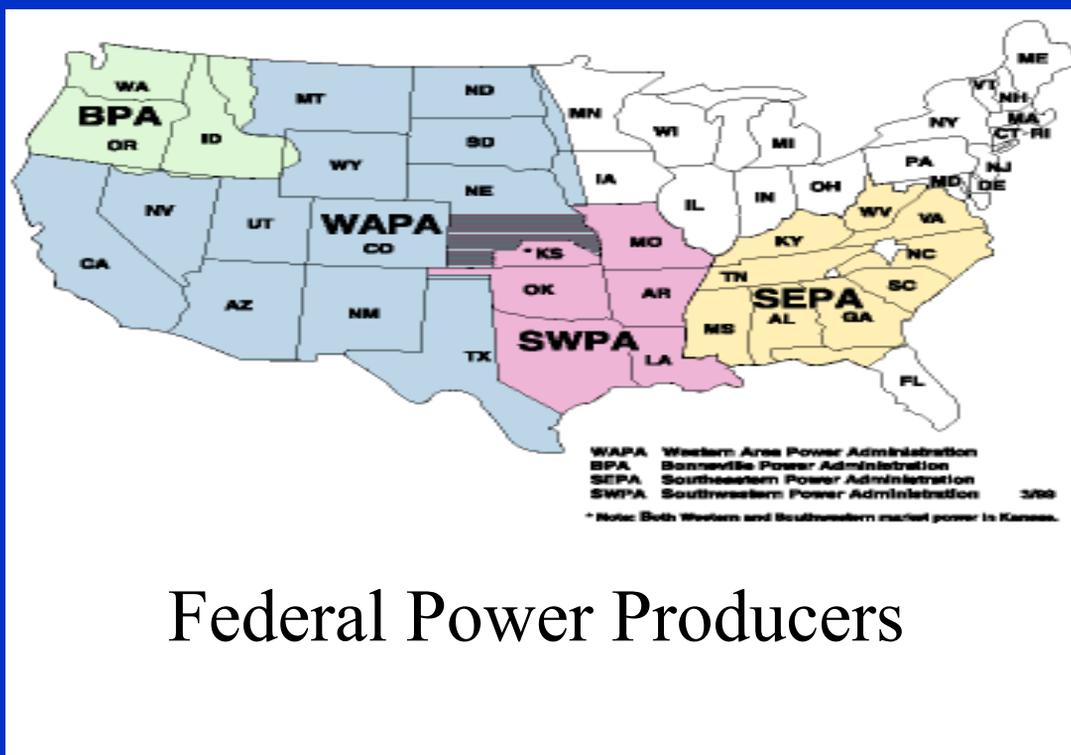
Outline of Talk

- Introduction to California electricity market
- Market Performance
 - April 1998 to April 2000--Competition works
 - May 2000 to May 2001--Competition fails
- Market structure reasons for failure
- Regulatory reasons for market failure
- The summer of 2001 in California
- The future of wholesale markets in California

Industry Before March 31, 1998

- Three Large Investor-Owned Utilities (IOUs)
 - Pacific Gas and Electric (PG&E)
 - Southern California Edison (SCE)
 - San Diego Gas and Electric (SDG&E)
- Vertically integrated into generation, transmission, and distribution
- Significant out-of-region energy needed to serve in-state demand (approximately 25%)
- Retail electricity rates regulated by California Public Utilities Commission (CPUC)

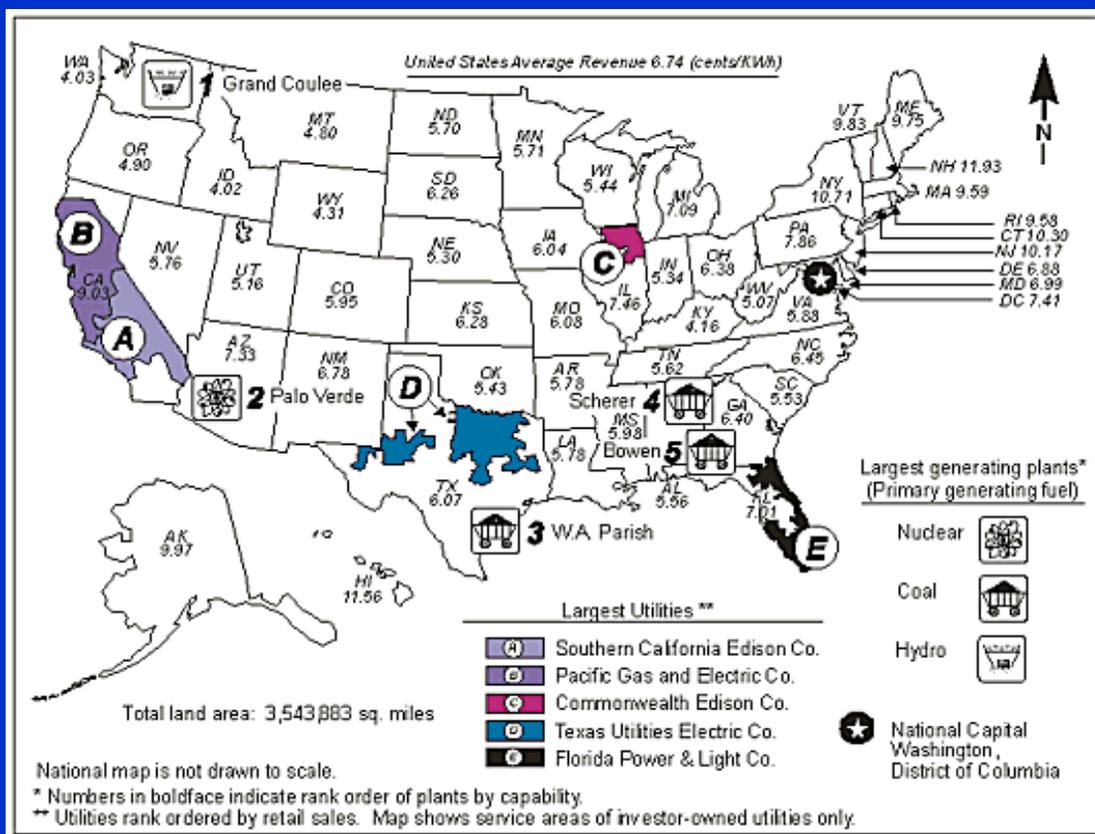




Federal Power Producers

Goals of Restructuring

- Lower retail prices through competition in wholesale electricity production
 - Existing Firms--PG&E, SCE, and SDG&E
 - New Firms--Duke, AES/Williams, Dynegy, Reliant, Mirant
 - Existing Govt Entities--BPA, WAPA, LADWP, CADWR
- Transmission and distribution remain regulated monopoly services
 - Transmission prices set by Federal Energy Regulatory Commission (FERC)
 - Distribution prices set by CPUC
- Competition in electricity supply (unclear)
 - Procuring wholesale energy and selling to final customers



After March 31, 1998

- Divestiture of 18,000 MW of in-state fossil-fuel units by IOUs to new “merchant” producers
- IOUs received 4-year opportunity for full stranded asset recovery
- Consumers received rate freeze for 4 years or until stranded assets recovered
 - Price of electricity to final customers set at 90% of 1996 retail prices
 - IOUs received difference between wholesale price implicit in frozen retail rate and actual wholesale price as Competition Transition Charge (CTC)

Stranded Asset Recovery

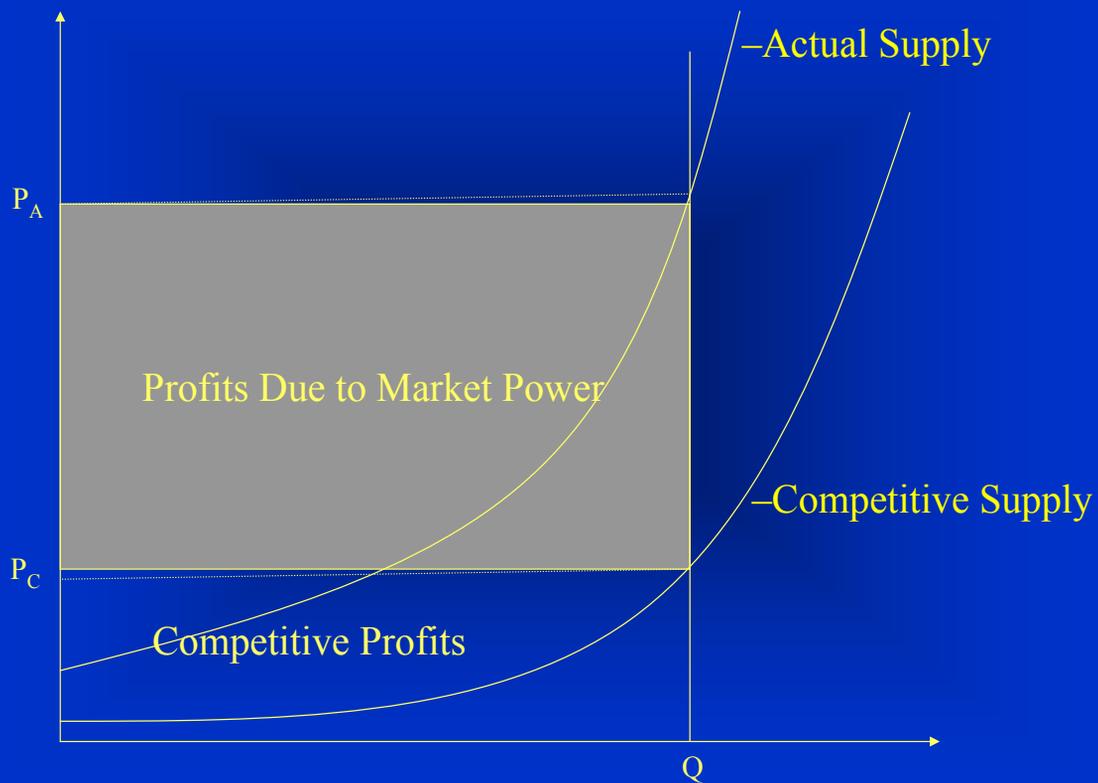
- Competition Transition Charge (CTC) paid to 3 IOUs
- $CTC \text{ Payment} = \text{Rate Freeze Retail Revenues} - \text{T\&D Revenues} - \text{Rate Freeze Bond Payments} - \text{Wholesale Energy and Ancillary Services (A/S) Costs}$
 - Equation holds on monthly basis
 - Higher wholesale energy and A/S prices implies less CTC payments and vice versa
- IOUs had four-year opportunity to earn full CTC recovery

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

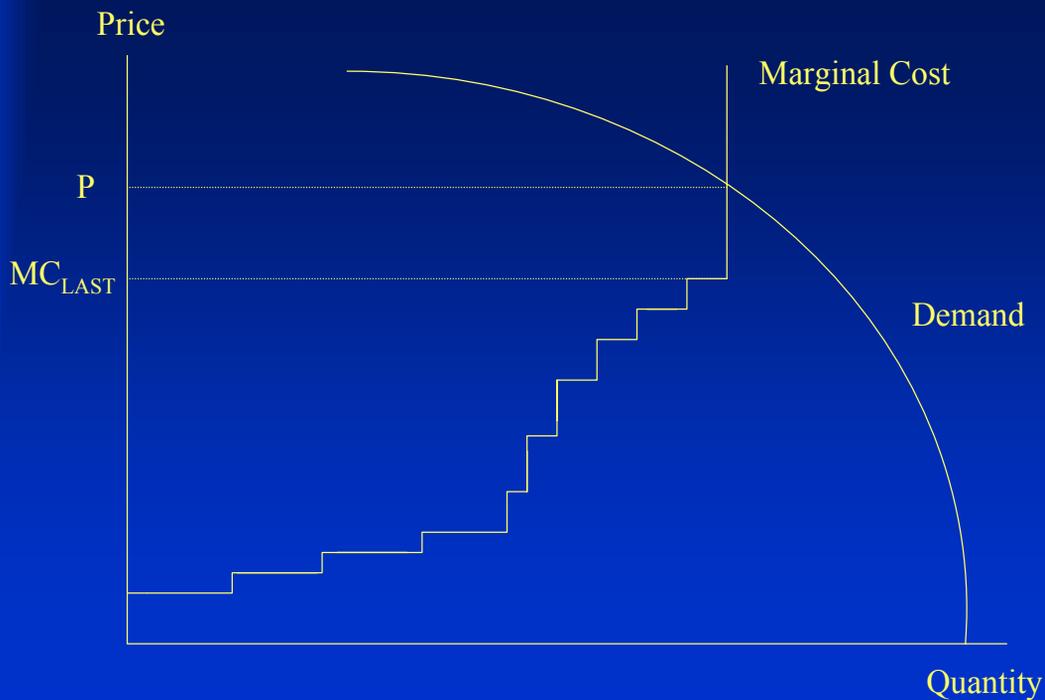
- 1) Extent of market power exercised in market on hourly basis
 - a) Compare actual quantity-weighted average price to counterfactual competitive benchmark quantity-weighted average price over same time horizon
- 2) Compute deadweight loss due to this exercise of market power
- 3) Compute increase in competitive benchmark profits due to
 - a) Input fuel price increases in 2000 versus 1999 and 1998
 - b) Emission cost increases in 2000 versus 1999 and 1998

Methodology for computing benchmark price controls for unit outages, import response due to lower instate prices, and capacity held out of energy market to provide ancillary services

Competitive Profits versus Profits Due to Market Power



Demand is marginal during high demand periods
All firms earn a positive contribution to fixed costs



Is Competitive Benchmark too high a standard for electricity?

- Even with some market power in the industry, retail prices may be lower than under the vertically-integrated utility regime.
- There are many markets in which there is virtually no market power--most agricultural and natural resource markets.
- These are industries notable for producing virtually homogenous product and selling it over large geographic market--similar to electricity

Estimating Market Power

- Know the hourly PX and ISO market electricity prices and total ISO total generation quantities
- Construct the system marginal cost curve
 - Use unit-level heat rates and time-varying locational market price of fossil fuel for each unit in California
- Intersect MC curve with ISO total generation quantity to get the competitive price that would result in the absence of market power
- Compare the actual PX price with this price to estimate amount prices are above competitive levels

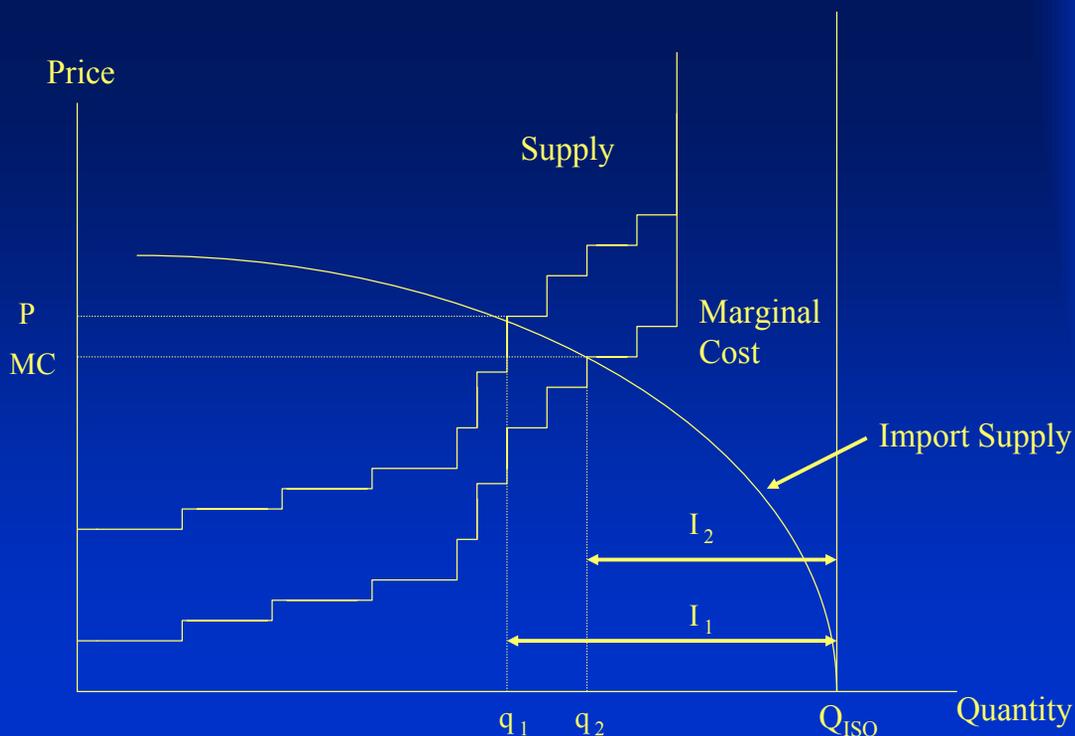
Complications in Estimation: Supply Side

- Cannot implement procedure on the supply side for must-take, hydro, or out-of-state production
 - Adjust for must-take, which is all inframarginal, by removing it from cost curve and remove equal quantity of demand
 - Assume that hydro *actual* dispatch is cost minimizing (that is, no exercise of market power in hydro) so remove it from cost curve and remove equal amount of demand
 - Out-of-state is more difficult to handle because out-of-state supply would decline if price dropped from actual level to perfectly competitive level

Import adjustment to lower prices for no market power scenario

- All generators and importers submit adjustment bids along with day-ahead energy schedules
 - Willingness to reduce and increase imports and exports as a function of market price
 - Use these bids to compute net import supply curve at each tie point
 - Counterfactual net imports and residual in state generation demand in response to lower market-clearing prices

Net Imports Reduced by Competitive Bidding



Supply Side Complications

- Account for forced outages by probabilistic simulation of forced outages at all plants.
 - Forced outage rates for each technology from NERC
 - For each realization from joint (over all plants) forced outage distribution, compute marginal cost of supplying market for that hour
 - Average these realized marginal costs over a large number of draws from the forced outage distribution to get the expected marginal cost for that hour
- Start-Up costs and other non-convexities in production are not included in the estimation.

Supply Side Complications

- Account for daily fluctuations in prices of natural gas and other fossil fuels in California
- Extremely important to analysis for Autumn and Winter of 2000
 - Natural gas prices were more than four times higher than in two previous years
- Account for fluctuations in daily costs of NO_x emissions permits to produce electricity for units in emissions-constrained areas
 - Primarily LA Basin--Could add more \$50/MWh to variable cost of production for some units

Complications in Estimation: Demand Side

- Reserve Capacity that is put into the normal dispatch is part of the industry energy cost function only when it gets used, so we include all actual power generated.
 - Unused reserve capacity is extramarginal and should not affect the energy price.
- Regulation Upwards is held out of the stack so must be treated separately. We add “Reg Up” to the demand.

Empirical Results

For various sets of days, D , and sets of hours, H , compute

$PCOMP(D,H)$ = Average competitive price

$PACT(D,H)$ = Average actual price

$MP(D,H) = PACT(D,H) - PCOMP(D,H)$

$$PCOMP(D,H) = \frac{\sum_{d \in D} \sum_{h \in H} E(c_{hd})(Q_{hd}^{ISO} - Q_{hd}^{MT})}{\sum_{d \in D} \sum_{h \in H} (Q_{hd}^{ISO} - Q_{hd}^{MT})}$$

$$PACT(D,H) = \frac{\sum_{d \in D} \sum_{h \in H} P_{hd} (Q_{hd}^{ISO} - Q_{hd}^{MT})}{\sum_{d \in D} \sum_{h \in H} (Q_{hd}^{ISO} - Q_{hd}^{MT})}$$

Implications of Results

- Results *do not* imply that any company is taking actions that violate the antitrust laws
- Imply large deviations from competitive behavior exist in this market particularly from summer of 2000 onwards
- Start-up costs can explain only a fraction of the pricing in excess of marginal cost
 - Very generous estimate of total annual start-up costs for all California units is \$30 million
 - Total overpayment during 2000 is ~\$8 billion

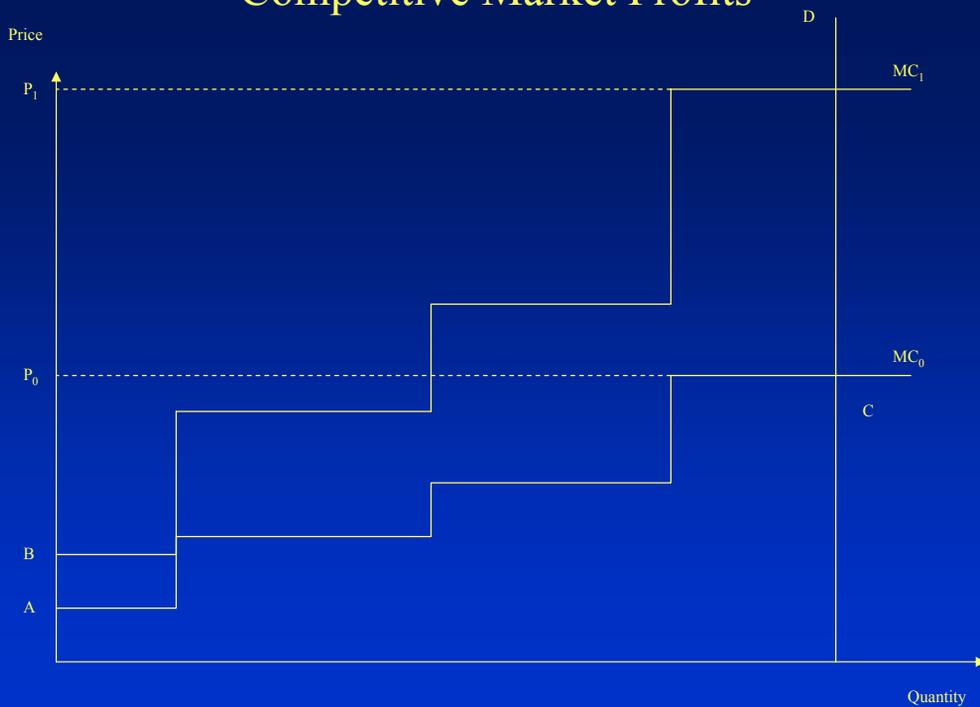
Deadweight Loss of Market Power

- Because aggregate demand is price inelastic only welfare loss occurs on supply side
 - Inefficient units are dispatched due to exercise market power
 - These can be in-state units or higher cost imports
 - Expected cost increase due to market power approximately
 - 3 % of actual costs for in-state units during all 3 summers (June through September)
 - Rose from 3% in 1998 and 1999 to 16% for imports during summers

Distribution of Rents

- Because of huge run-up in price of natural gas during 2000
 - Competitive benchmark profits increased enormously
 - Unit-level heat rate times almost four times larger price of natural gas
 - Difference in steps of aggregate marginal cost curve 4 times greater
- Run-up in NO_x emission prices also intensified steepness of aggregate marginal cost curve

The Impact of Input Fuel Price Increases on Competitive Market Profits



Distribution of Rents

- From 1999 to 2000 competitive rents
 - More than tripled because of gas price and NOx price increases
- Monopoly rents
 - Sum of $(P_{ACT} - P_{COMP})(Q(ISO) - Q(MT))$
 - Increased 20 times between 1999 and 2000
- Generators in California were quoted as saying 1999 was a good year
 - What are they saying about 2000?

Summary of Market Performance for April 2000 to May 2001

- 1) Extraordinary amount of market power exercised since June 2000
- 2) Average market power markup for
 - Calendar year 1999--\$4/MWh
 - Calendar year 2000--\$45/MWh
 - January 2001 to May 2001--More than \$100/MWh
- 3) Residential retail rate until July 2001 was \$110/MWh
 - Subtracting transmission and distribution charges yields \$70/MWh as the implied fixed wholesale rate
- 4) Initial FERC “remedies” implemented in January of 2001
 - Performance of market made much worse following remedies
 - January to April 2001 average wholesale price: > \$250/MWh
 - Can buy energy for delivery in early 2003 for less than \$35/MWh

California Electricity Crisis

Washington (FERC) and Industry View

- Shortage of generating capacity in California
- Huge demand growth outpaced available supply
 - Huge growth Silicon Valley due to server farms
- Flawed California de-regulation plan

Claim: There has not nor has there ever been a shortage of generating capacity to serve California market

All wholesale electricity markets throughout US still regulated under Federal Power Act of 1935

- California market regulated by federal regulator (FERC)
- All California market rules set by FERC

California Electricity Crisis

Regulatory crisis not an economic crisis

Conflict between Federal Energy Regulatory Commission (FERC) and California over enforcement of Federal Power Act
State's view--FERC failed to enforce Federal Power Act so California won't pass on illegal wholesale prices
FERC's view--California must pay for all of its and FERC's mistakes in California market

Shortage of competition not a shortage of supply in California

Incentives for firms to keep plants available to supply energy in competitive market very different from former vertically integrated monopoly regime
Generator sick day problem in competitive markets not present in former vertically integrated regime

Market Structure Factors Enhancing Ability of Firms to Exercise Market Power in 2000

- 1) Small amount of new capacity built in California during 1990's--approximately 1,000 MW
- 2) Very small amount new capacity built in surrounding northwestern states--approximately 800 MW
 - Large demand growth in other western states besides CA
 - Lower net summer surplus to sell to California
 - Higher winter deficit to purchase from California
- 3) High water runoff years in 1998 and 1999 in California and Pacific Northwest
 - Normal runoff year in 2000
 - Increased environmental concern further reduced summer 2000 hydroelectricity production

Market Structure Factors Contributing to Current Problems

- 4) Higher natural gas prices only partial explanation
 - a) Average price for 1999 approximately \$2.75/MMBTU
 - b) Average price for 2000 approximately \$6.50/MMBTU
 - c) Average energy and ancillary services prices
 - 1) \$33/MWh of load in 1999
 - 2) \$116/MWh of load in 2000
 - d) Market power index accounts for gas price changes
 - e) FERC regulations potential source of price increase
- 5) Unprecedented levels of forced outages since Summer of 2000
 - a) Verifiable forced outage problem (Sick day analogy)
- 6) Wholesale demand is extremely price inelastic
 - a) Very few consumers face real-time price
 - b) Retail rate freeze

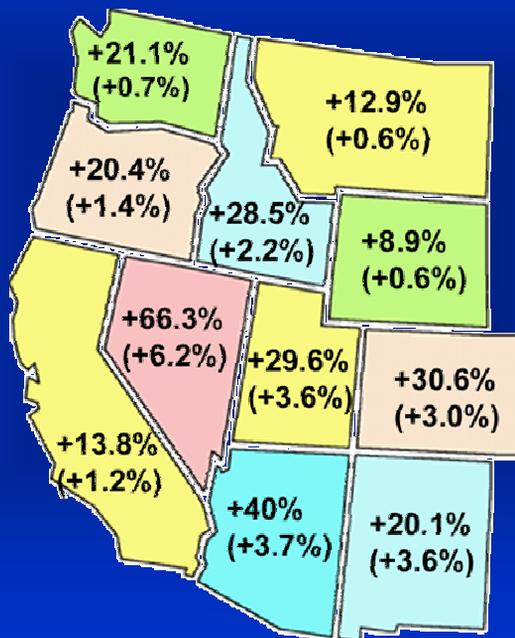
Myth and Reality in California Electricity Crisis

- 1) Myth--Unusually hot weather during summer of 2000
Reality--Summer of 2000 was milder than 1998 or 1999
Peak demand Summer 2000--43,509 MW-August 16, 43,447 MW-June 14
Peak demand Summer 1999--45,574 MW-July 12
- 2) Myth--Unusually high demand growth
Reality--Demand Growth from 1998 to 1999, approximately 4%
Demand Growth from 1999--2000 approximately 4%
1990 California Energy Commission forecast of 2000 demand is greater than actual demand in 2000
- 3) Myth--Unexpected Energy Shortage in California
In-state hydro production in 2000 approximately equal to in-state hydro production in 1999
In-state fossil-fuel production in 2000 significantly greater than in-state fossil-fuel production in 1999

Myth and Reality in California Electricity Crisis

- 4) Myth--California's demand grew much faster than rest of west
Reality--Growth in population over decade of 1990's much higher in surrounding states
NV-50%, AZ-30%, UT-24%, CO-23%, ID-24%, WA-18%
CA-13%
- 5) Myth--California's didn't re-structure enough
Reality--Measured by any metric California re-structured more than any market in US
All other ISOs formed out of tight power pools
Little forced divestiture of capacity by incumbent IOUs
Little dependence on imports to meet in-control area demand
CA consolidated three control areas--PG&E, SCE, and SDG&E
CA forced divestiture of 18,000 MW of IOU capacity
CA historically gets approximately 25% of load from imports

Population Growth 1990-2000 and Average Annual Electricity Consumption Growth 1990-1998



Myth and Reality in California Electricity Crisis

- 6) Myth--Fossil units were run harder than they have been run
Reality--Unit level load factors for many units during the summer months of 2000 were significantly less than 50%
Relative to 1994, last year of low hydro conditions in west, best available data reveals less output from in-state fossil units in 2000 than in 1994

- 7) Myth--Rolling blackouts in California in January, March and May of 2001 caused by capacity shortage in California
Reality--Daily peak demand in January and March is approximately 30,000, daily peak in May is approximately 34,000 MW and total in-state capacity is 45,000 MW and transmission capability for imports into California is at least 12,000 MW

Reported Capacity Outages (1999 to 2001)

Average Megawatts of Capacity Off-line (Planned or Unplanned)			
Month	1999	2000	2001
January	3068	2423	9940
February	5096	3243	10895
March	5740	3389	13737
April	5739	3329	14911
May	3032	4012	13431
June	1216	2683	6758
July	963	2233	5,004
August	878	2434	4,229
September	1195	3621	
October	1761	7633	
November	2988	10343	
December	2569	8988	

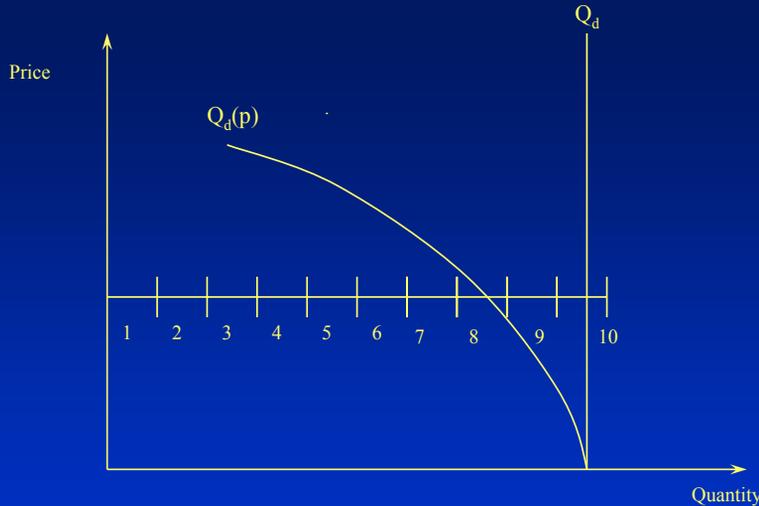
Regulatory Factors Causing to Current Problems at State Level

- Different from all other re-structuring processing around the world and in US
 - California did not assign vesting contracts to units sold
- Vesting contract is an obligation to sell a significant fraction of a unit's output at regulated price for at least two years
 - For a 500 MW unit, typical vesting contract would require selling 400 MW every hour for two years for a pre-specified price or pattern of price
- Provides wholesale price certainty for load-serving entities
 - Regulator can credibly set a fixed retail price

Regulatory Factors Causing to Current Problems at State Level

- 1) Lack of forward financial contracting for between loads and generation in California
 - a) Virtually all energy purchased on spot market
 - b) IOUs own capacity to provide less than half of their wholesale energy needs
 - c) Surrounding areas purchase less than 5% of their wholesale energy needs from spot market
- 2) A 1 percent increase in spot electricity price increased California's wholesale energy costs by more than 10 times more than wholesale energy costs in surrounding areas
 - a) Other buyers in the Western US also paid these very high prices for their spot market purchases

Market Outcomes With Inelastic Demand and No Forward Contracts



10 Firms--Each own one MW, Market Demand is 9.5 MWh
Assume variable Costs = \$0/MWh, Price Cap of \$10,000/MWh

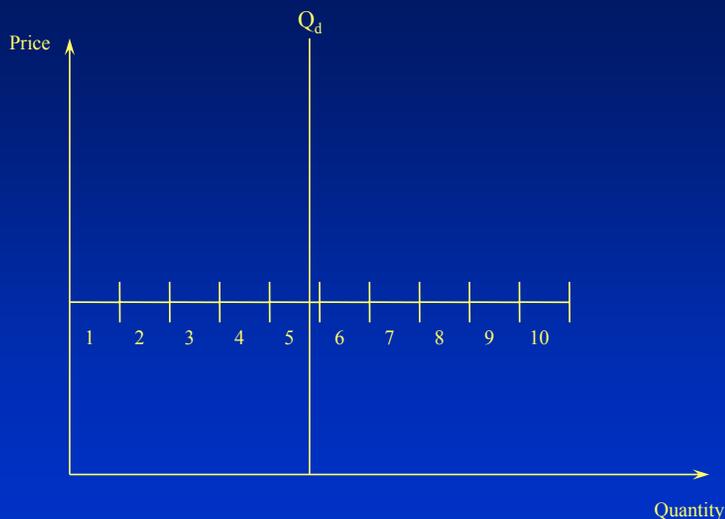
Equilibrium with No Contracts

- 9 firms all bid \$0/MWh for one 1 MWh
- 1 firm bids \$10,000/MWh for 1 MWh
- Equilibrium price is \$10,000/MWh
- Each of 9 firms bidding \$0/MWh has no incentive to unilaterally change its bid
 - Earns highest possible profit given capacity
- 1 firm bidding \$10,000/MWh has no incentive to unilaterally change its bid
 - Cannot increase price
 - Decreasing price only reduces profit
 - Reductions in quantity can only reduce profit

Impact of Forward Contracts

- Suppose all firms have forward commitment for 0.75 MWh at price less than \$10,000/MWh (say, \$50/MWh)
- Former equilibrium with \$10,000/MWh price is destroyed
- Firm formerly bidding \$10,000/MWh has no incentive to continue to do
 - Sells only 0.5 MWh, but has forward commitment to provide additional spot price insurance for 0.25 MWh at \$50/MWh
 - Would have to buy 0.25 MWh at \$10,000/MWh and sell at \$50/MWh
 - Each firm wants to set low market price until it sells 0.75 MWh of energy (covers forward market commitment)
 - All firms only want to raise market price once they cover forward market commitments

Significant Excess Capacity Can Solve These Problems (1998 and 1999 in CA)



Regulatory Factors Causing to Current Problems at Federal Level

- FERC regulates wholesale electricity rates
 - Federal Power Act requires FERC to
 - Ensure the wholesale rates 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.” (Federal Power Act)
 - Order refunds for rates in excess of just and reasonable levels
- Just and reasonable rates recover production costs, including a return to capital

Regulatory Factors Causing to Current Problems at Federal Level

- How does FERC introduce wholesale competition?
 - Competitive market yields prices reflective of production costs
 - Monopoly or oligopoly market need not set cost-reflective prices
 - If market participant can demonstrate that it cannot influence market price (cannot exercise market power)
 - FERC will deem participant eligible to receive market-based rates
 - All firms start out with cost-based rates set by FERC
 - All California market participants had to make market-based rate filing approved by FERC
 - Demonstrate that they have no ability to exercise market power
 - FERC makes determination of validity of this claim
 - Extremely difficult to determine if market is competitive on ex ante basis

Regulatory Factors Causing to Current Problems

Federal Level

- Events of May 2000 to 2001 demonstrate that FERC's logic for allowing market-based rates is false
 - Under Federal Power Act FERC has power to take corrective action
- FERC's November 1, 2000 preliminary order and December 15, 2000 final order and all subsequent orders state
 - Wholesale rates in California are "unjust and unreasonable"
 - Reflect the "exercise of significant market power"
- Since August 1998 FERC's response to problems in market
 - Hard price caps on spot prices in CA through December 2000
 - California is net importer buying in entire western states market
 - Willingness of California to pay whatever it takes to importers to keep the lights on caused enormous reliability problems--megawatt laundering
 - Price caps eliminate incentives to engage in forward contracts
 - Price caps eliminate incentives to develop price responsive retail demand

Regulatory Problems at Federal Level

- In early December 2000, FERC imposed soft price-cap
 - How does FERC-imposed soft cap at \$150/MWh work?
 - If generator can cost-justify bid above price cap and it is needed to meet demand then market participant is paid as bid
- How soft cap allows generators to increase profits
 - Merchant producers are significant players in gas market
 - Own long-term gas supply for at least half their annual needs
 - Put long-term gas deliveries into storage in California
 - Buy gas on California spot market to burn in generating facility
 - Send bill for spot gas to FERC to cost-justify high bid for electricity
 - Can work a deal with own gas affiliate (or non-affiliate with a rebate) for even higher gas price on invoice
 - Creates artificial scarcity of gas in California
 - Explains unprecedented difference between California and Henry Hub in Louisiana spot natural gas prices
 - Pre-soft cap average daily difference in prices is less than \$0.50/MMBTU
 - Post-soft cap average daily difference in prices is greater than \$8/MMBTU

Recent FERC Action

- In April of 2001, FERC issued market (power) mitigation plan that applied only to system emergency hours
 - Vast majority of market power exercised in non-emergency hours
 - Fails to account for fact that forced outages depend on generator behavior
 - Continues soft-cap problem--If generator can cost justify bid, and generator's bid is needed, it will be paid as bid
- Continuing pressure on from the public and federal legislators on FERC caused it to revise this market power mitigation plan to all hours and to apply to all western states
 - Gives generators the incentive to maintain least efficient units in best working order possible and most efficient units in worst working order possible
 - Continues soft-cap problem and forced outage problems

Apparent Low Spot Price Due Primarily to California's Actions not FERC's Plan

During winter and spring of 2001 state entered into long-term contracts with generators at prices that reflected enormous market power that all parties thought was likely to exist in the market for next two years

Contracts purchased in anticipation of a summer like 2000

More than \$45 billion in contracts were signed during this period

California's conservation efforts have paid off

Large reductions in load because of conservation ~10%

Three large baseload plants coming on-line during summer of 2001

Approximately 1,400 MW in new capacity

Supply increase and demand reduction leads to low spot prices

California is still paying 2 to 3 times current spot price for power bought on long-term and intermediate term market

FERC is doing absolutely nothing about these prices of power

Plan applies to less than 5% of power that is consumed in California

Forward Contracts that Pay for Market Power on Installment Plan

Suppose that during Winter of 2001 generators believe spot prices for

June 01 to June 02 = \$250/MWh

June 02 to June 03 = \$150/MWh

June 03 to future = \$40/MWh

Suppose California wishes to buy a 10-year contract with 1/20 of energy in first year, 1/10 in second year, and 17/20 of energy in years 3 to 10.

What price will generator charge?

Generator requires a price of at least \$61.50

$= (250 * 1/20 + 150 * 1/10 + 40 * 17/20)$ to agree to contract

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As Forward Contracts Kick-In During Summer of 2000
Outages Fall Despite More Capacity Coming On Line

Lessons from California

Bad News: California will be paying for the costs of its mistakes and FERC's mistakes and inaction for a very long time

Good News: California has a very good case to get relief from FERC and Federal Courts under Federal Power Act for market power exercised by generators in past spot market and forward contract purchases

Lessons for Rest of World: California crisis can't happen outside of US unless a similar federal versus state regulatory conflict exists in other countries

Usually have a single regulator for wholesale and retail markets