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before the

U.S. House of Representatives Committee on Financial Services
2128 Rayburn House Office Building
Washington, D.C. 20515
June 20, 2001

Good morning. First of all, Chairman Oxley, Congressman LaFalce, and members of the committee, thank you for allowing me the opportunity to address you on the impact and causes of the California energy crisis. My name is Vernon Smith. I am currently the Regent's Professor of Economics and director of the University of Arizona's Economic Science Laboratory. Later next month my colleagues and I will be moving to Northern Virginia to become affiliated with George Mason University and its Mercatus Center. This statement is based largely on my joint work with Stephen Rassenti and Bart Wilson, also with the Economic Science Laboratory.

BACKGROUND OF THE CRISIS

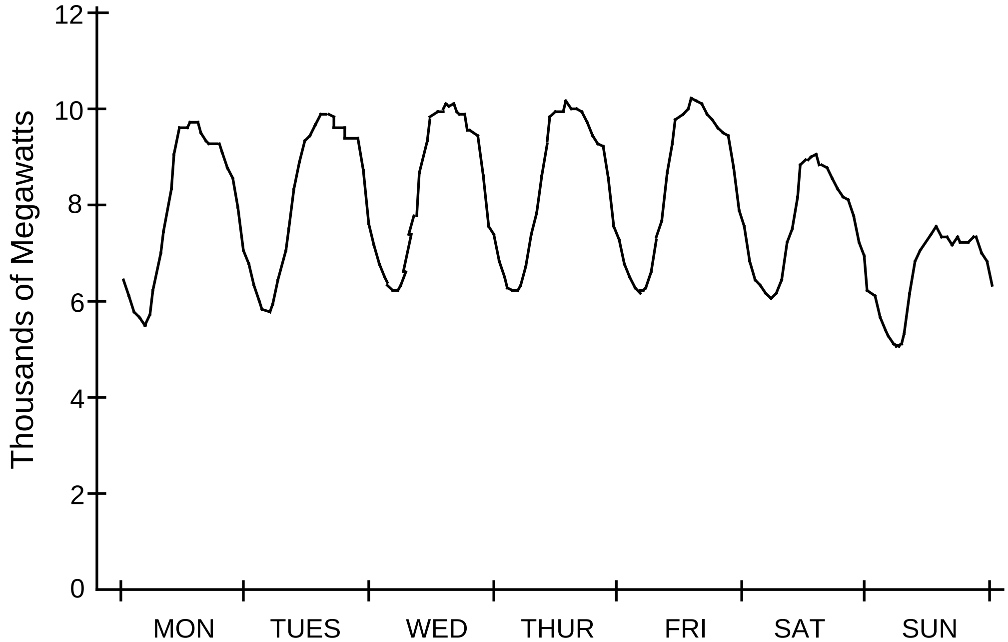
The California energy crisis neither started in California nor was it special to California. The sharp increases in electricity prices (price spikes) in the hourly spot market began in the Midwest and parts of the East Coast in the summer of 1998, and were repeated in the summers of 1999, 2000 and are likely to be repeated again in the summer of 2001. Well before the California crisis these earlier spike prices reached levels of $2 to $3 per kilowatt-hour and higher (the highest, according to FERC was a transaction at $7.50 per kilowatt hour). For comparison, the average retail price is only about $0.10 to $0.12 per kilowatt-hour. These price increases have had the effect of attracting increased capacity, which will moderate future price increases to a degree that is not predictable. The difference with California is only that the earlier price spikes were temporary. As in California, however, they were absorbed in the form of losses by wholesale buyers who did not pass on the increase to their end use customers, and therefore did not provide needed incentives for conservation. Hence, price spikes in California were predictable and expected by anyone who was informed of this history. Temporary shortages can be expected in any electrical market, anywhere. It is therefore essential that the market be designed to encourage demand responsiveness to price on the part of all end use customers whose circumstances do not require an uninterruptible supply of power at all times of the day, week or season. This demand responsiveness, sufficient to prevent price spikes does not have to be a large percentage of peak demand. My coworkers (Stephen Rassenti and Bart Wilson) and I have studied laboratory market experiments in which wholesale buyers who participate as demand side bidders in the spot market can interrupt 16% of peak demand. Compared with control experiments where the market is organized as a one-sided seller bid market only, as in California and elsewhere, price spikes are eliminated, average prices are greatly reduced, and price volatility is very modest.

HOW ENERGY MARKETS OPERATE

The normal consumption of electricity undergoes a cycle each day beginning in the off-peak hours in the early morning, increasing in the late morning, reaching a peak in the hours of 1-4 pm in the afternoon then decreasing in the late afternoon and evening. From off-peak to on peak, consumption can easily increase by a factor of two or more, as illustrated below in Figure 1.

Figure 1.
Actual Weekly Load Curve

An example of the demand for electricity over one week



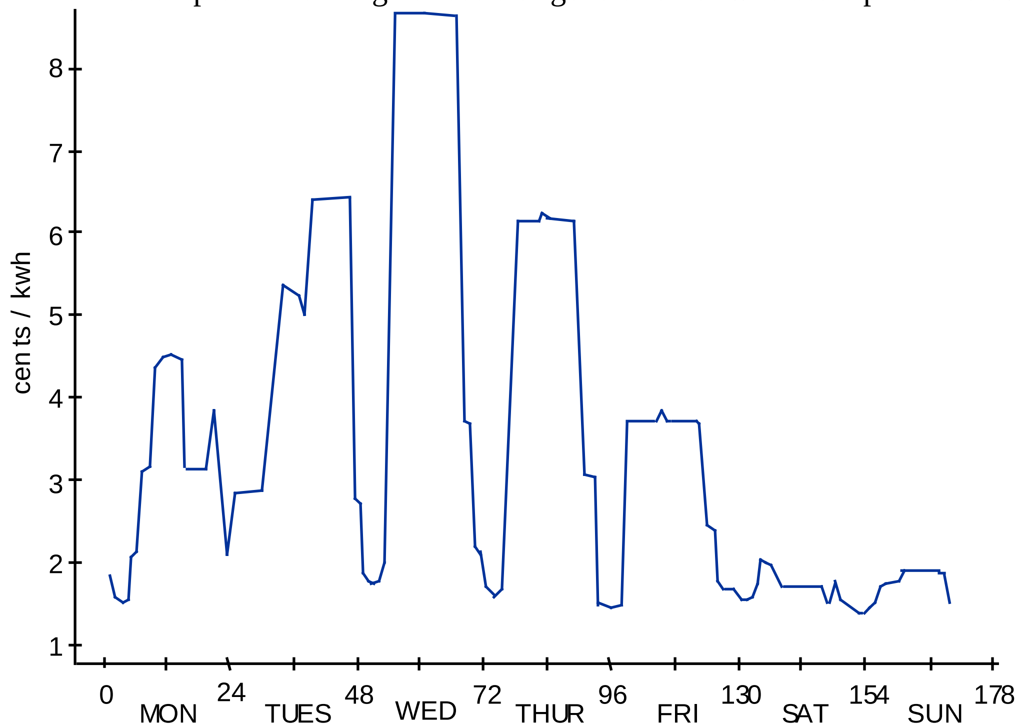
Adapted from: Power Technologies, Inc., “Technical Background and Considerations in Proposed Increased Wheeling, Transmission Access and Non-Utility Generation,” contractor report prepared for the Office of Technology Assessment, March 1988, pp 2 - 3

This cycle in consumption in supplied by three types of generators: (1) low cost, base load capacity units that produce at a steady hourly rate; (2) intermediate cost, load-following generator capacity units that are able to ramp up their output as consumption increases from the low off-peak hour levels, and down from the peak hours; (3) high cost, peaking capacity generators that are only turned on for the peak consumption hours.

The marginal cost of energy supply alone during the peak hours of consumption can easily be six or more times the corresponding cost for off-peak consumption. This is shown in Figure 2 for a typical hot August week in the 1980s.

Figure 2.
Actual System Lambda

An example of the marginal costs of generation or wholesale purchase over one week



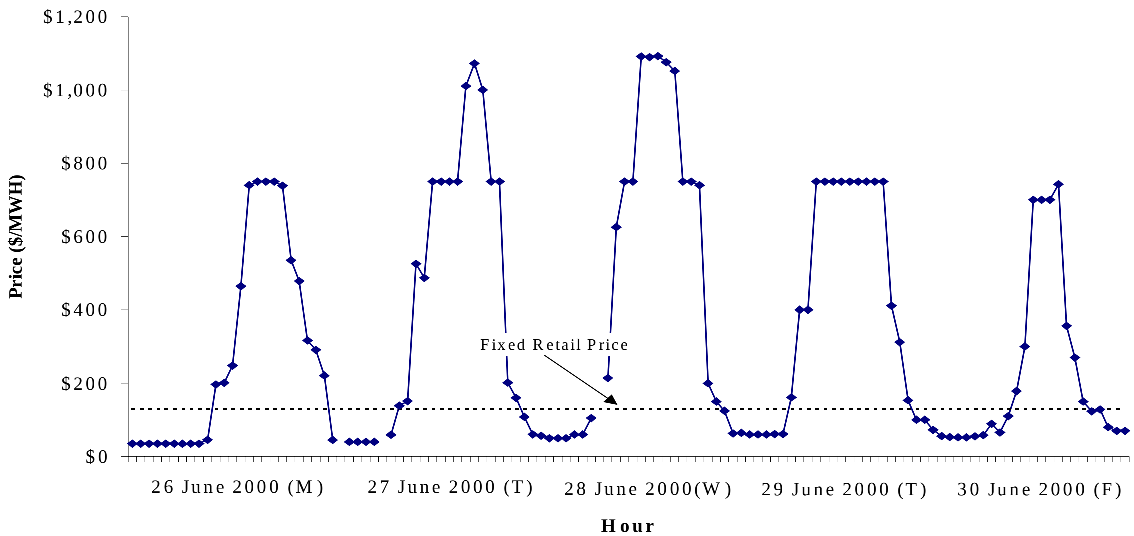
Adapted from: Bohn, R., Caramanis, M. and Schweppe, F., "Optimal Pricing in Electrical Networks over Time and Space", Rand Journal of Economics, 1984, 15:3, pp 360 - 376

Market efficiency, however, requires the capital investment cost of peaking generators and peak transmission capacity to be charged only to the peak end users, whose demand requires such investments. Hence, the on-peak energy and capital costs could easily be estimated to be ten or more times the off-peak costs.

As expected and as desired, the California market price cycles reflected this pattern of large fluctuations in wholesale cost over the daily cycle. But in days and weeks of extreme shortage (for example low reservoirs of water in the Northwest) the price cycle also became very extreme. In one particular week (26-30 June 2000) the price spikes reached as high as $1100 per megawatt hour or $1.10 per kilowatt-hour. This week of hourly prices is shown in Figure 3.

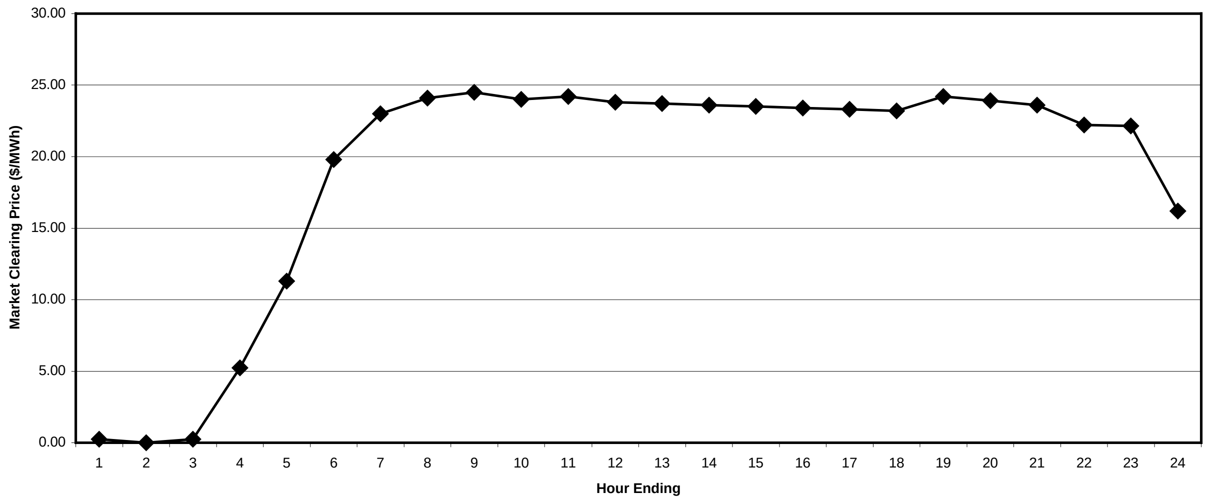
Distribution companies who purchase in this market resell the power at a fixed hourly price of about $130 per MWH. As a consequence these utilities have lost some $8-9 billion dollars according to some media reports. It is called buying high and selling low and is not a good business strategy, and it is not in the long run interest of either consumers or suppliers.

Figure 3. California PX Prices



But prices have not always been so volatile in California. Thus, on April 1, 1998, prices ranged from a low of zero at 2 am to almost $25 per MWH (2.5 cents per KWH). The hourly pattern throughout that day is shown in Figure 4. Note that a price of zero did not attract media attention, nor did it invite claims of "market failure."

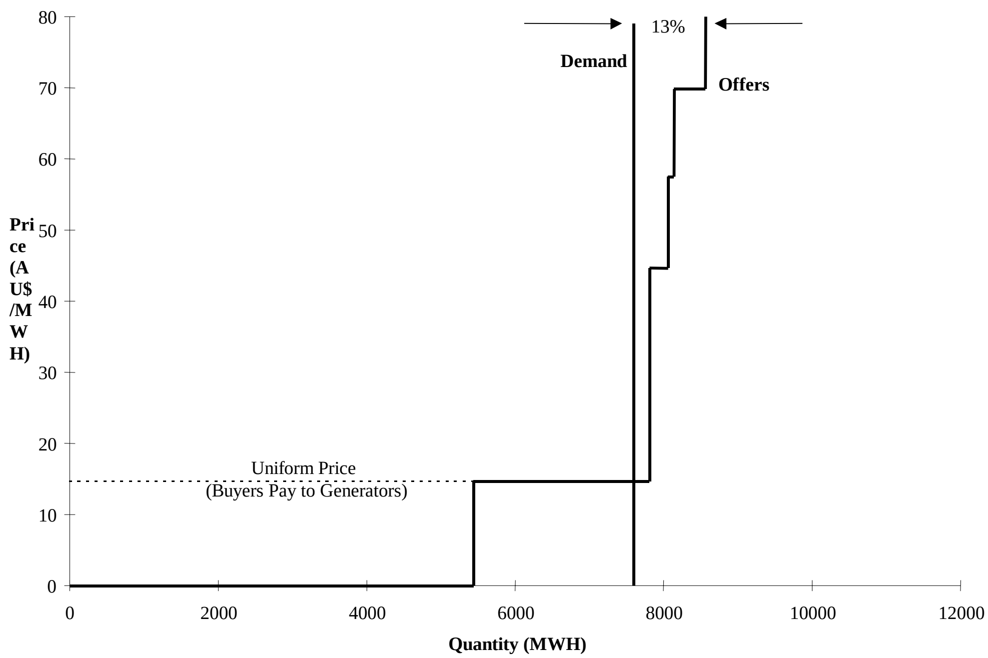
Figure 4. Unconstrained Market Prices
California PX, April 1, 1998



To illustrate the problem of price spikes, and how they occur, Figure 5 shows the generator supply bids for power in the Australian spot market for which we have compete data on a particular hour back in 1996 near the beginning of the Australian market. In this real live example most (up to 5500 MWH) bids to supply energy were at a price of zero. These zero bids are from baseload generators offering to sell at any price they can fetch. Then there is a supply step offering an additional 2400 MWH at about $15 per MWH. These are the load following generators. Next, there are small additional increments of power offered at $45, $56 and $71 per MWH. Consumption demand is about 7600 MWH yielding a spot price of $15, as indicated, which is received by all generators who bid at this price or less up to the total demanded. Note, however, that if demand had been 8000 MWH the price would be $45; at 8200 MWH the price $56; at 8600 MWH the price would be $71. Hence, small changes in consumption produce large leaps in price. Indeed, only a 13% increase from 7600 to 8600 would have cause price to increase by 273%. Finally, note that the price would have been zero if demand has been 5000

MWH. This sensitivity to large changes in price for small changes in demand explains the price spikes in California and earlier in the Midwest and East.

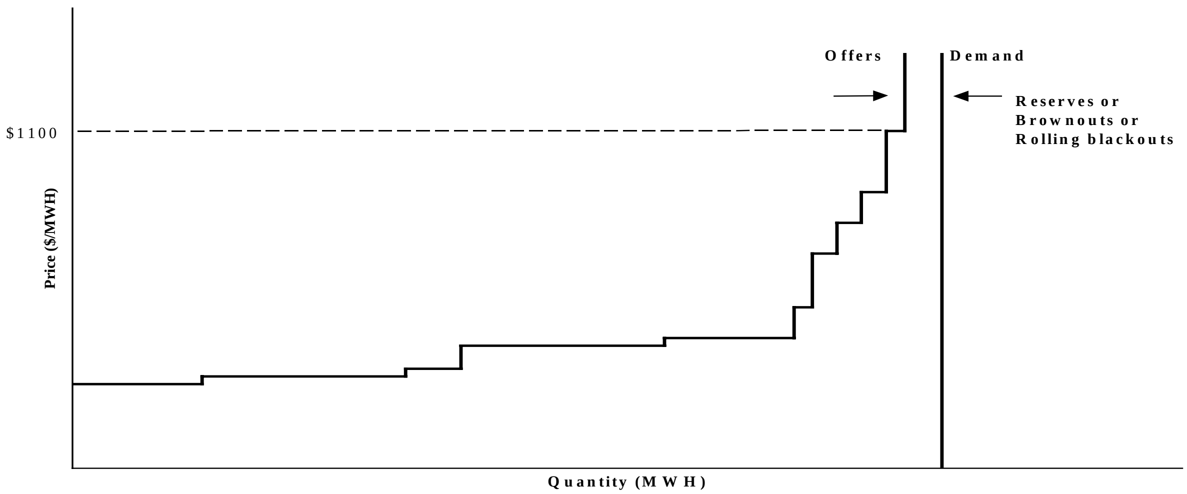
Figure 5. Price Determination in the Australian Electricity Market



Source: This graph is drawn from Hugh Outhred's presentation entitled, "Australia: Spot Trading Results and Implications for Ancillary Services," 5 January 2000. The data are for the 17 May 1996, targeting 20:00.

So what happened in California to bring the higher price level and extreme price spikes shown in Figure 3, along with occasional blackouts? Very simply, the demand was at or above the highest price supply units offered to the market. The shortfall in supply, as shown in Figure 6, was provided from (1) emergency reserves; (2) brownouts (reduced power causing lights to dim); or (3) rolling blackouts.

Figure 6. Illustration of a "Shortage" and Price Determination on the CAL PX on Peak



CAUSES OF THE CRISES

The primary rationale for deregulation is to allow the time variation in wholesale cost to be reflected in corresponding time variable prices paid by bulk buyers and received by generator sellers. This should provide incentive signals to consumers as to where and when to conserve, and to suppliers as to what forms of investment are most profitable and efficient. What has been missing are the needed market and metering mechanisms for passing wholesale price variations through to the end user. Hence, the root cause of the crisis in California and the high temporary price spikes elsewhere, has been the failure in spot market design to

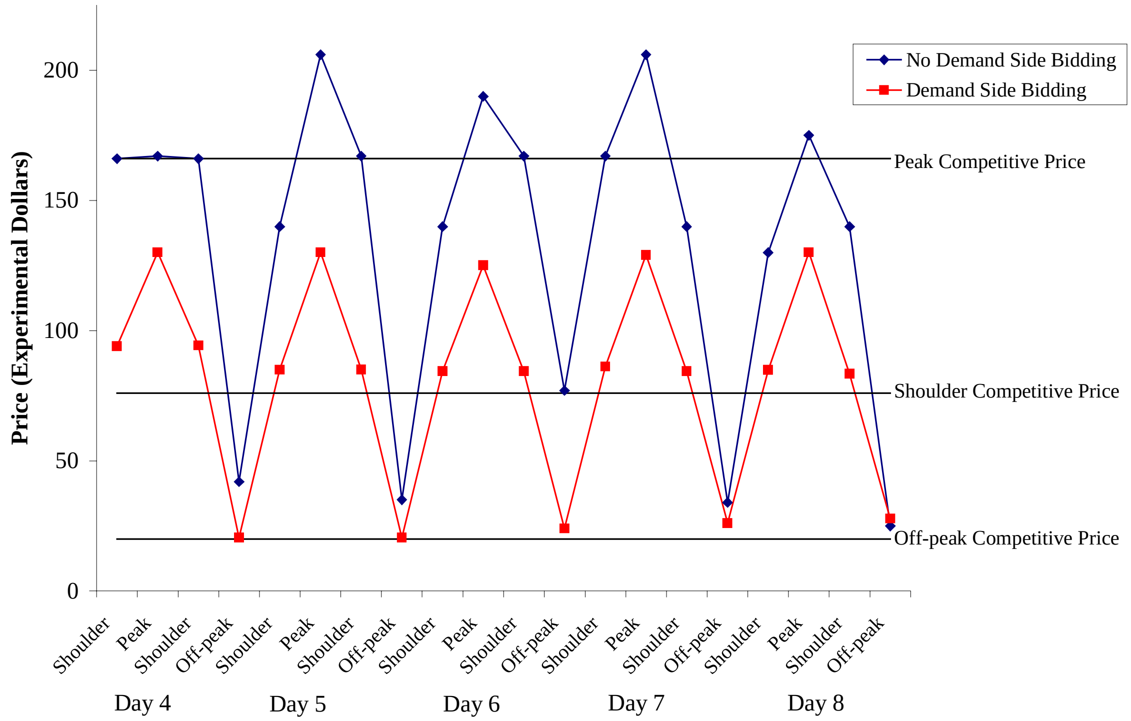
1. encourage and make explicit provision for strategic demand side bidding by wholesale buyers,
2. implement such provision by introducing time-of-day pricing at the end user's consumption points, and
3. invest in the required control switching technology for selective, voluntary reduction of the lower priority uses of electricity during peak hours. This can

be accomplished directly by the end user who invests in a load management system. It can also be provided by contractual agreements between the utility and the consumer allowing the utility to shut off selected appliances or circuits (washers, dryers, air conditioning, etc.) for limited times. In this case the utility (or a competing supplier) manages a rolling blackout of only those lower consumption priorities approved by the customer.

EFFECTIVENESS OF DEMAND RESPONSIVE PRICING TO THE END USE CONSUMER

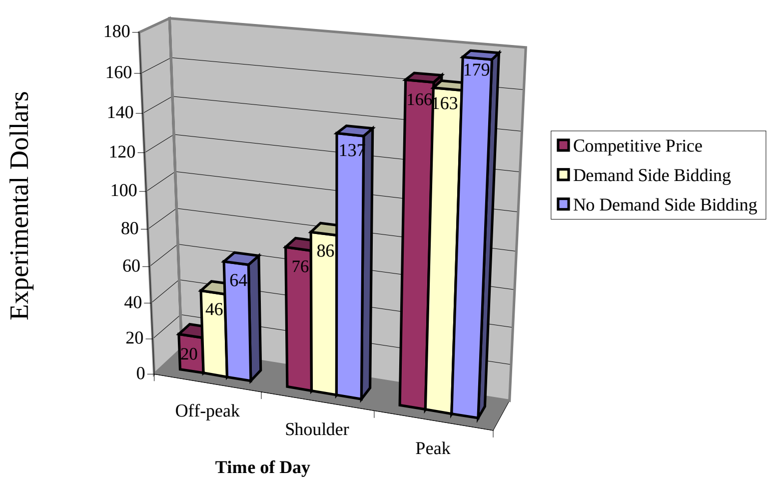
Based on our laboratory research we can compare prices over a daily cycle (for simplicity, consisting of six 4-hour block pricing periods in each experimental ‘day’) as shown in Figure 7. In the experiments, because the experimenter controls buyer value and seller costs we can identify competitive equilibrium prices on the ‘shoulder’ demands (between off and on peak), on-peak demand and off-peak demand. In the experiments, demand cycled each ‘day’ from a shoulder period to peak, back to a shoulder, and finally to off-peak. This cycle was then repeated. In Figure 7 we show the data for ‘days’ 4 through 8 for a particular week in one experiment. The price in every comparison period of each ‘day’ is lower with price responsive demand side bidding than when there is no demand responsivity.

Figure 7. An Example of the Effect of a Responsive Demand



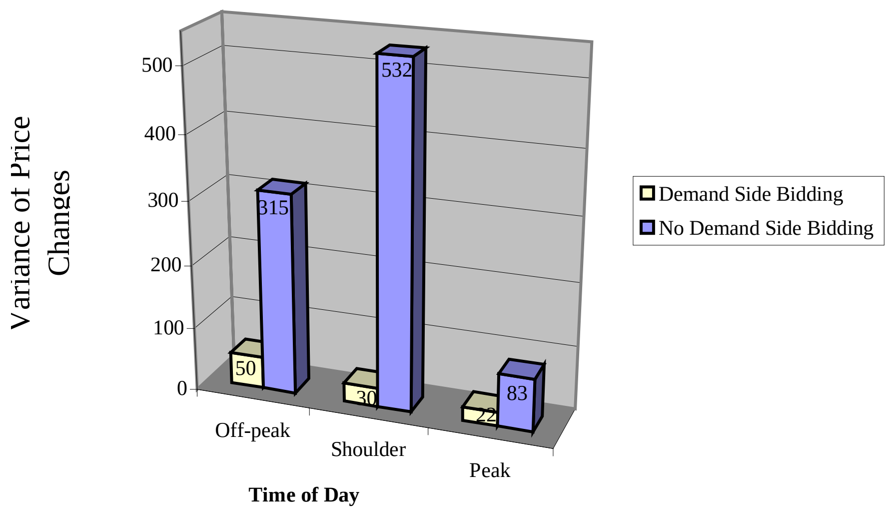
On average across all experiments prices are lower with demand side price response than without, as shown in Figure 8.

Figure 8. Average Prices



Finally, the volatility of prices, or variations in price changes from period to period is very low by comparison when demand is price responsive. This is shown in Figure 9.

Figure 9. Variance of Changes in Price from Day to Day



SUMMARY

1. With only 16% of peak demand interruptible to end users, our experiments suggest that retail time-of-day prices can be substantially lowered, and price spikes eliminated.
2. Such interruption can be entirely voluntary with consumers finding it in their interest to consume less on peak in order to capture the savings from time-of-day retail pricing. In currently structured markets elevators carrying passengers have the same high priority as porch lights left on in the daytime, and constitutes a highly irrationally structured market.
3. by rolling selective voluntary power interruptions, blackouts of whole neighborhoods can be avoided, except under extreme weather conditions when they are unavoidable.

4. The California crisis is a direct consequence of a failure to introduce time-of-day retail prices that reflect highly variable time-of-day wholesale prices, and generator costs.
5. What must change is the cultural mindset of local utility managers and their customers which has been inherited from state regulation. This mind set is that all retail demand must be served without regard to the differences in individual consumer's willingness-to-pay for energy. This mind set will change with full-cost time-of-day pricing, which will have the effect of incentivizing customers to prioritize their use of energy, making demand voluntarily responsive to prices.
6. The effect of these changes will be to create a far more efficient and smoothly functioning market that will not require government intervention. It will enormously benefit the environment by reducing the growth in demand for energy and transmission capacity, and thereby reducing air pollution and unsightly power lines.

Thank you, Mr. Chairman. I look forward to answering whatever questions you and your colleagues have.

References:

Available at http://www.econlab.arizona.edu/power/.

Rassenti, S., V. Smith, and B. Wilson. "Controlling Market Power and Price Spikes in Electricity Networks: Demand-Side Bidding," Economic Science Laboratory Working Paper, University of Arizona, December 2000.

Rassenti, S., V. Smith, and B. Wilson. "Demand Side Bidding Will Control Market Power, and Decrease the Level and Volatility of Prices," *Regulation*, forthcoming.

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Consumer Choice Will Reduce Electricity Prices and their Volatility

Results of Experiments Conducted at the Economic Sciences Laboratory at the University of Arizona

Facts

- Deregulating wholesale electric utility prices in the U.S., including California, has involved a process in which wholesale buyers of electricity provide retail customers with a guaranteed and uninterruptible supply of energy regardless of the customer's needs or individual circumstances.
- Retail customers are commonly shielded from the normal daily and seasonal fluctuations in the cost of electricity generation by paying a flat rate. The actual cost of generating extra electricity in late afternoon can be 7-8 times as much as in early morning.
- This has caused significant stress to electricity distributors who were exposed to dramatic wholesale price spikes in the Midwest last year and in California this year. Distributing firms have sometimes paid 10 times more for electricity than they resold it at retail.

Experiment

- An alternative form of purchasing electricity service, that is typical in many other industries including long distance phone service and airline ticket travel, was tested in experiments at the internationally recognized Economic Science Laboratory at the University of Arizona. This alternative form of purchasing allows and encourages end-users to voluntarily alter their access to electricity at various times of day and year in return for significant price discounts.
- In these experiments, profit motivated buyers and sellers of electricity within a network of three major centers of consumption and generation bought and sold electricity in markets where demand moved through realistic cycles.

Results and Conclusions

- <u>High prices and</u> the tendency for upward <u>price spikes</u> to occur when supplies are tight <u>are dramatically avoided</u>, even in circumstances where only 16% of the peak demand can be interrupted through voluntary bids submitted by buyers.
- <u>California and the rest of the country can avoid price shocks</u> by redesigning their markets to provide incentives for wholesale buyers to introduce simple technologies allowing energy demand to be <u>voluntarily</u> reduced by customers willing to consume less, or shift to a different time <u>in return for a discount</u> on their electricity bills.
- Such incentives <u>lower</u> short run electricity <u>prices</u>, promote appropriate conservation, reduce the need for emergency reserves, save investment in new generation and transmission lines, and <u>reduces the emission of airborne pollutants and the need to build unsightly facilities</u>.

Demand Side Bidding Will Reduce the Level and Volatility of Electricity Prices[*]

by

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March 2001

With the move to deregulate wholesale electric utility prices in the United States, each state or region needed to develop a plan for restructuring their industry and defining the auction market rules that would determine the hourly wholesale price of energy. Universally, these new markets employed supply side bidding mechanisms (mostly designed by intermediaries, consultants and the supply side, with an acquiescent demand side) in which generator firms submitted offers to supply whatever quantity of energy would be demanded by wholesale buyers for resale to end-users at regulated prices. This meant that any end-user, regardless of the individual circumstances of that consumer's need for an uninterruptible flow of energy, would be guaranteed that his demand would be satisfied. This policy of meeting all "must serve" demand, as the industry likes to call it, was inherited from a rigid regulatory system that politicized the reliability of service to all consumers without regard to cost, or to differing consumer priorities for service, and corresponding differences in the willingness-to-pay for the reliability of those services. Consequently, retail consumers were shielded from exposure to the great natural variability in energy cost from nighttime lows to daytime highs and across seasons by averaging these cost variations into flat rate prices.

The driving justification for deregulation is to improve performance by exposing the industry and its customers to real time cost-based price signals, a policy that has worked well in the transportation (air, truck, rail) and natural gas industries. Unfortunately, in electricity, deregulation in wholesale markets has not been accompanied by concurrent attention to the deregulation of retail markets, and this has exposed the industry to unusual stresses comparable

[*] For a more detailed discussion, see our paper entitled, "Controlling Market Power and Price Spikes in Electricity

to the energy crunch of the 1970s. The fact that there are very limited cost effective methods for producing and storing electricity off peak, to be consumed later on peak, means that peak consumers account for the required higher energy and investment costs incurred to satisfy their demand. Efficient pricing requires on peak consumers to pay substantially higher prices than for off peak consumption, since peak unit cost can easily be 10 or more times the off peak cost.

The same need to meet instantaneous demand applies to the unregulated prices of the motel industry. Competition in that industry long ago routinely guided the emergence of variable seasonal, and time-of-week, demand responsive prices for room accommodations, with no noticeable cultural shock to alert the news media.

Beginning three years ago in the Midwest and Southern wholesale markets summer peak prices reached levels of 10 and occasionally 100 or more times the normal price of $20-$30 per megawatt hour. This was the predictable direct consequence of completely unresponsive retail demand impinging on a discretionary responsive supply. Recently, California has been plagued by similar increases in spot prices because of supply shortages, together with insufficient investment in switching technologies that allow selective interruption of low priority uses of power at high cost peaks in demand. In Figure 1 we plot a time series of hourly wholesale prices over a typical week on the California PX (spot exchange), now shut down through the intervention of Governor Davis.

The high general level of these prices and the tendency for upward price spikes to occur when electricity supplies are tight has been shown to be avoidable in markets where no more than 16% of the peak demand can be selectively interrupted through discretionary bids submitted by wholesale buyers. This new study is based on laboratory experiments using profit motivated buyers and sellers of energy in a network with three major centers of consumption and generation in which demand cycles through transitional shoulder, peak and off-peak levels. Figure 2 compares average prices and the volatility of prices, with and without demand-side bidding for each of the three demand levels in these experiments.

California and the rest of the country can avoid these price shocks by redesigning their markets to provide better incentives for bulk buyers to introduce technologies allowing energy flows to be voluntarily reduced to customers willing to consume less in return for a discount on their electricity bills. The switching technology for the temporary appliance-specific interruption

Networks: Demand-side Bidding." The paper can be downloaded at http://www.econlab.arizona.edu/power/.

of energy deliveries to customers, by contractual agreement, has long been available. Newer technologies are available for demand management directly by households with time-of-day metering. What has been missing in utility management has been aggressive investment in the provision of customer incentives for allowing such technologies to be implemented. Trained for a century to function within a regulatory framework, it does not come naturally for such management to think in terms of profiting from the enormous savings in wholesale energy cost to be realized by buying less. Ironically, in the end, California utilities have been forced to impose involuntary area-wide brownouts and rolling blackouts on their customers, treating all with equal priority, including those stranded in elevators. A small fraction of the billions lost by the California distributors, if invested in demand responsiveness, could have stopped the hemorrhaging of their treasuries, and turned them a profit. Instead they counted on their commission to allow an increase in their average rates, which addresses neither the root problem or the need to get management to focus on prioritizing their demand instead of on their regulatory commission as a source of net profit.

Various pundits—regulators, the media and government officials—have suggested alternatives to a demand responsive spot market, such as wholesale price ceilings, and long term contracting for generation. But wholesale price volatility is entirely appropriate given the large daily variation in producer costs—the anomaly is the attempt to maintain a fixed regulated retail price. Long term contracting is simply a negotiated means of fixing (averaging) the wholesale price over the cycle for the contracting parties. It does nothing to facilitate the adjustment of time-of-day demand to cost variation. This must occur through a robust spot market.

A policy of decentralizing the demand side of the market to allow free choice is both more flexible and much less costly than allowing the utilities to recover their energy purchasing cost by a regulated new levy on all consumers. The latter policy provides all the wrong incentives for conservation as a competitive alternative to more investment in high cost peaking capacity. Empowering buyers will lower short run electricity prices, while reducing the need for emergency reserves when transmission line or generator outages occur, save investment in new generation and transmission lines, and reduce their resulting impact on the environment.

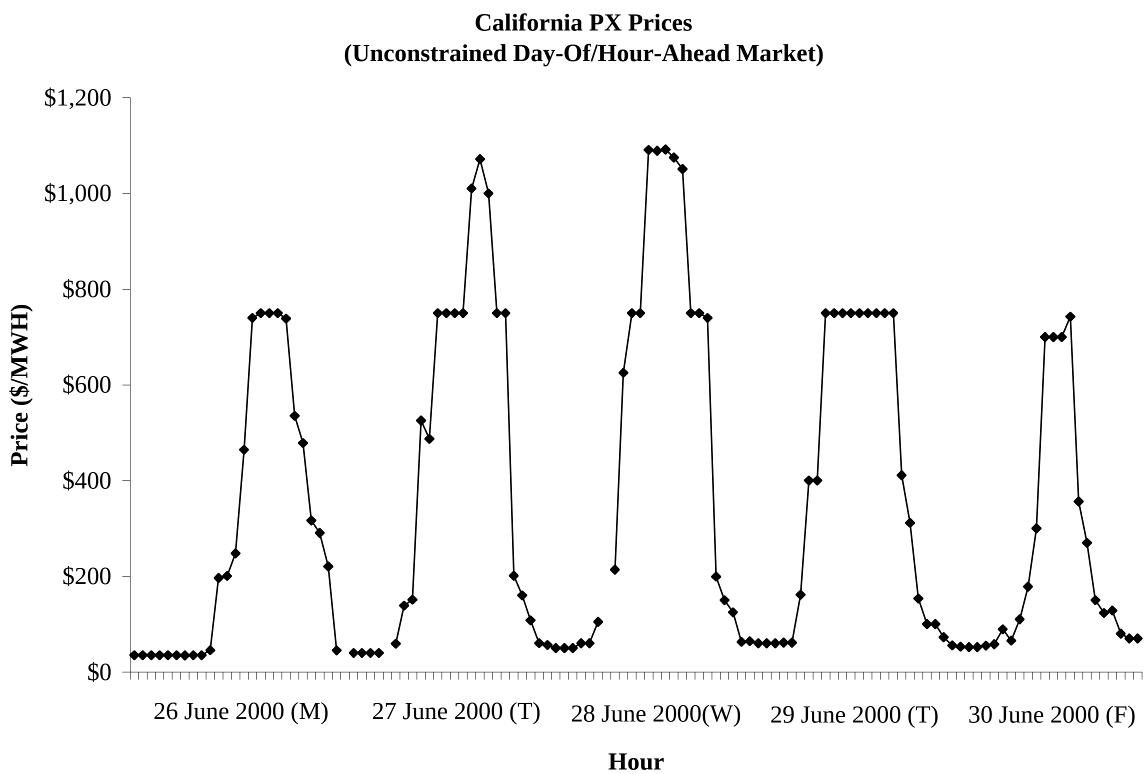
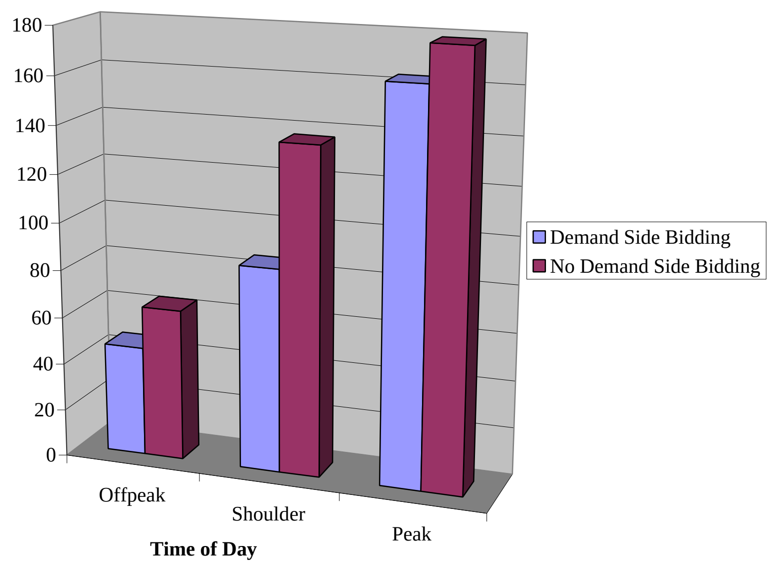

California PX Prices
(Unconstrained Day-Of/Hour-Ahead Market)
$1,200
$1,000
$800
$600
$400
$200
$0
Price ($/MWH)
26 June 2000 (M)
27 June 2000 (T)
28 June 2000(W)
29 June 2000 (T)
30 June 2000 (F)
Hour

Figure 1

Average Electricity Prices



Variance of Changes in Electricity Prices from Day to Day

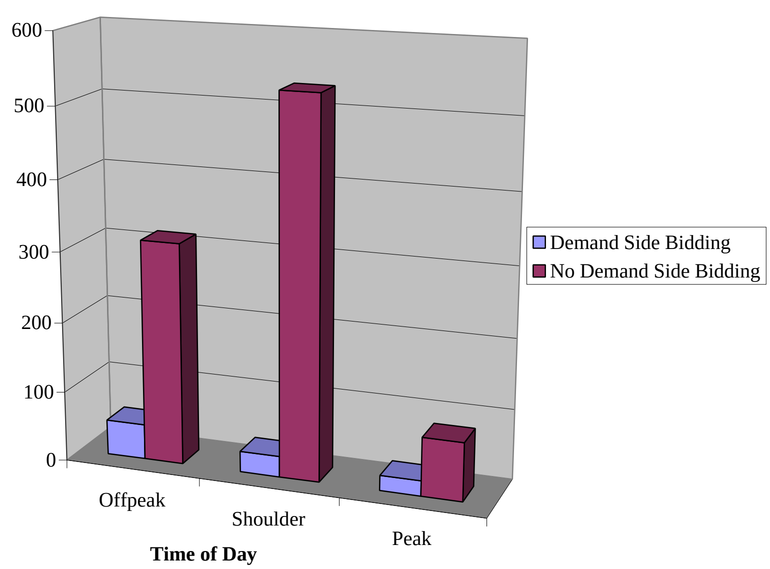


Figure 2