Financial Externalities and “Peak Hogs”:
New Considerations for Energy Efficiency and Rate Design Policy

As part of its work for Utility Consumers Action Network in the current San Diego Gas and Electric Company rate design case, JBS Energy has made two findings with significant public policy implications. (Marcus, 2000)

1. The value of energy demand reductions is far higher than the market price of energy.

2. Residential customers who use large amounts of summer energy use disproportionately high amounts of summer peak energy and coincident peak demand.

Both of these points are contrary to conventional wisdom. Both individually and taken together, these facts require a significant rethinking of policies on energy efficiency, load management, and rate design in competitive markets.

The Value of Energy Demand Reductions Is Far Higher than the Market Price of Energy, Particularly During Peak Periods.

There are significant differences in the cost of commodity energy by time period. Just to provide one example, for the 12 months ending July 31, 1999, the average summer peak (noon-6pm Monday through Friday) PX price was 5.77 cents/kWh. The price during the remaining portions of 14 hours per day on weekdays (7 am – 9 pm Monday through Friday, except summer peak periods) were 3.0 cents/kWh, and off-peak prices were 2.14 cents/kWh.

In addition to direct prices, there is a significant monetary externality, first pointed out by Rich Ferguson of the Center for Energy Efficiency and Renewable Technologies (Ferguson, 1999).

In the old world, in a given hour the marginal cost of energy of a bundled utility was the price of the last most expensive unit of the utility’s generation. But the cost was only incurred for that last unit. Thus, the marginal cost was the value of demand reduction, because the last unit’s generation was avoided.

In the new world of power pools, the price for <u>all</u> units of energy is set by the market-clearing bid price for the last unit (of generation or load reduction) bid in to serve demand. As demand rises, the total revenue received by all generators rises. Thus the value of demand reduction is not just the market price (bid price of the last unit). It is the market price plus the increase in the bid price multiplied by all other generators except the last unit.

As demand rises, particularly in peak periods, the price of energy rises relatively rapidly. If demand can be reduced, the price will fall along with it, benefiting not only the customer whose demand is reduced but all other customers who receive the lower prices of spot market energy.

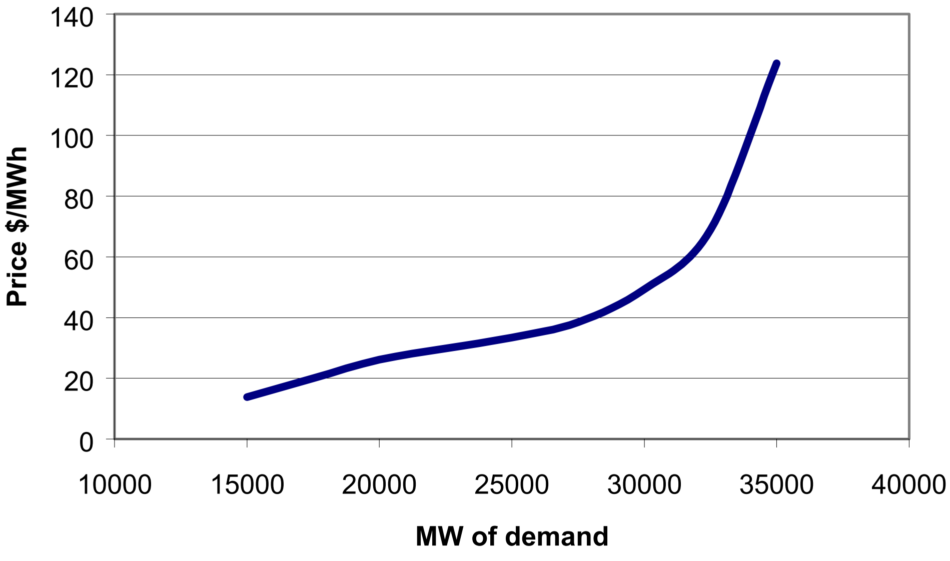
Following Dr. Ferguson's method, JBS analyzed the PX supply curve (unconstrained day-ahead price) for the period April, 1998 to August, 1999 using a Prais-Winsten regression analysis to correct for auto-correlation. We found that Ferguson's conclusion holds. The supply curve for energy generally increases more rapidly as demand rises.

The equation that we found is:

$$\begin{array}{l}
\text{Price} = -28.132 + .002479 * \text{MW} - 0.001038 * (\text{MW} -20000) + 0.002917 * (\text{MW}-27000) \\
\qquad\quad (-17.55) \qquad (30.62) \qquad\qquad (-10.28) \qquad\qquad\qquad\qquad (20.31) \\
\\
\qquad\qquad\qquad + \; 0.017534 * (\text{MW} - 32000)` \\
\qquad\qquad\qquad\quad (44.70)
\end{array}$$

Adjusted R-squared = .3846 Standard Error = 4.313 Rho = 0.9076

Figure 1: Supply Curve for PX Power
(Regression for April 1998 to August 1999)



Between minimum demand and 27,000 MW, the market price rises from under 1 cent per kWh to 3.25 cents. The value of demand reduction ranges between 4 cents and 7 cents per kWh. The price rises faster at low load levels, then rises more slowly above about 20,000 MW. Between 27,000 MW and 32,000 MW, (1030 high load hours in the 17 month period) the price rises from 3.25 cents to 5.65 cents/kWh. The value of demand reduction in this load range rises through the range but averages about 15 cents per kWh. Over 32,000 MW (the highest 269 load hours), the supply curve rises extremely sharply. The 12.1 cent average price at 35,000 MW is more than double the price of 5.65 cents/kWh at 32,000 MW. In that high peak range, reducing system demand has a value (in reducing prices to everyone) of more than 70 cents per kWh.

When one counts both the market price paid by the customers and the impact of the customer's demand on the market price, the impact of demand reduction from a high peak level is well over twice the market price at all load levels and rises almost exponentially as load rises toward a system peak.

To show an example from our equation, if demand is 32500 MW, the projected market price is 6.90189 cents/kWh. If demand rises by 1 MW to 32501 MW, the projected market price is 6.90408 cents/kWh. The market price at 32501 MW is 6.904 cents/kWh. However the value of a megawatt of demand reduction equals the market price plus 32,000 MW multiplied by 0.00219 cents/kWh, which equals $700.54. Thus, in this case of high peak loads, the market price is $69 per MWh, but the value of reducing demand by a megawatt can be expected to be $770 – eleven times the market price.

Large Residential Customers Contribute Disproportionately to the Peak Capacity and Energy Problem.

Using the Company's load research data, we were able to demonstrate that large residential users use more summer peak energy and have a higher coincident peak demand. The results of a regression analysis of the usage pattern of the 183 customers included in SDG&E's load research sample are summarized in Figures 2 and 3.

Customers with heavy summer use have a higher percentage of on-peak energy and higher coincident peak loads than customers with less summer use, as shown in Figures 2 and 3.

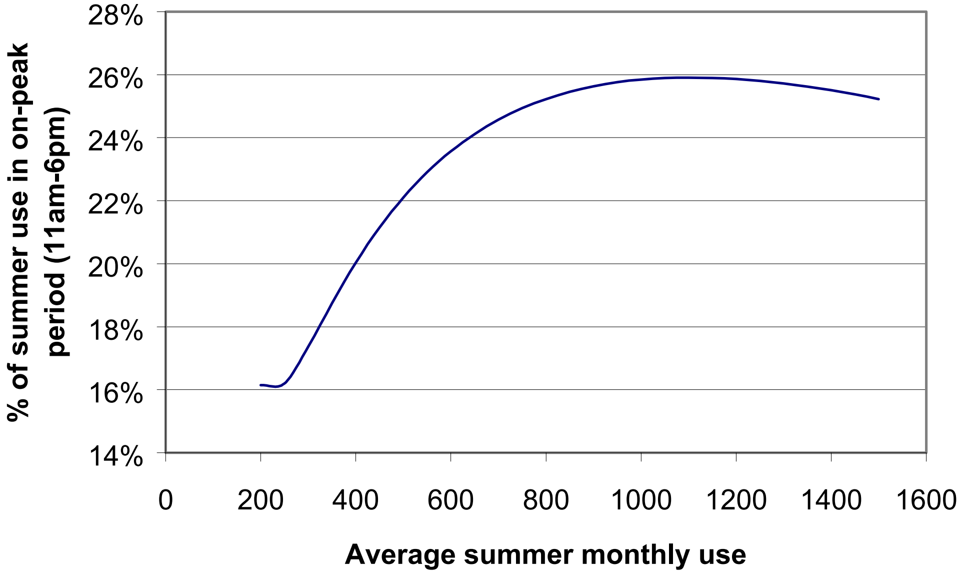


Figure 2: Summer On-Peak Use is Greater for Large SDG&E Residential Customers

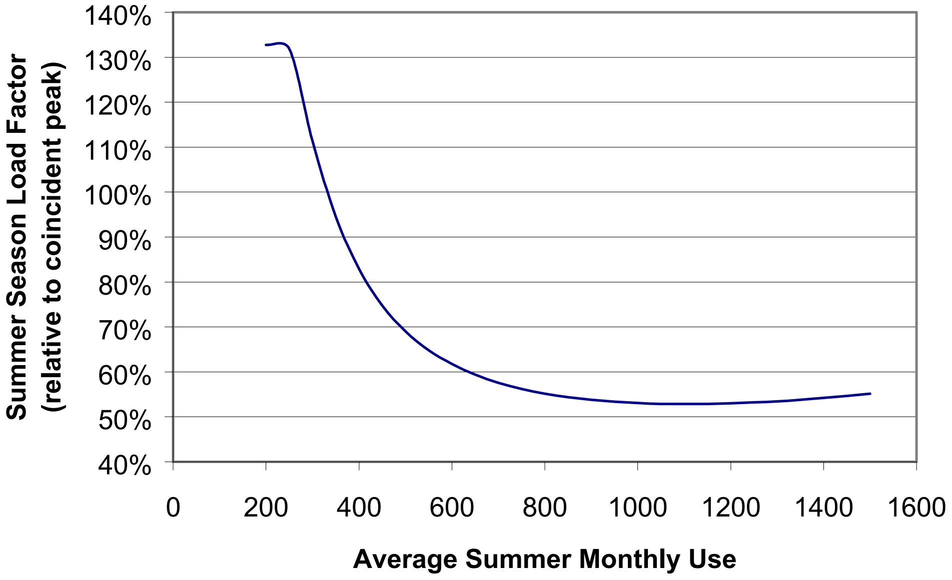


Figure 3: Large SDG&E Residential Users Have Lower Load Factors Than Smaller Customers

Table 1 shows the numbers for summer peak energy usage and coincident peak and coincident load factor for varying usage levels.

Table 1

Summer Usage by Time Period and Coincident Peak Demand by Summer Load Levels

			Average Summer Month Use			Annual coincident peak (CP)
		Total	On-peak	Mid-peak	Off-peak	
0-250	energy kWh/peak kW	197	35	58	104	0.29
	% of use by time period		17.7%	29.5%	52.8%	
	CP annual load factor					110.5%
250-400	energy kWh/peak kW	333	66	102	166	0.70
	% of use by time period		19.7%	30.5%	49.7%	
	CP annual load factor					72.7%
400-600	energy kWh/peak kW	500	111	141	248	1.08
	% of use by time period		22.2%	28.1%	49.6%	
	CP annual load factor					67.2%
600-800	energy kWh/peak kW	691	163	192	336	1.64
	% of use by time period		23.6%	27.7%	48.6%	
	CP annual load factor					57.9%
800-1000	energy kWh/peak kW	912	233	246	434	1.90
	% of use by time period		25.5%	26.9%	47.6%	
	CP annual load factor					58.7%
>1000	energy kWh/peak kW	1365	343	360	661	3.41
	% of use by time period		25.2%	26.4%	48.4%	
	CP annual load factor					46.1%

Those customers who on average stay use less than 250 kWh in the summer months use less than 18% of their summer energy on peak. Their annual coincident load factor is 110% (i.e., their use in the peak hour is less than their average use in all hours).

As loads increase, the percentage of on-peak use increases (through 800 kWh), and the coincident annual load factor decreases.

In other words, looking at the both ends of the chart above, customers who use over 1000 kWh per month in the summer use about 7 times as much summer energy as customers using less than 250 kWh per month. However, they use nearly 10 times as much summer on-peak energy, and their coincident peak demand is almost 12 times higher.

Implications for Public Policy

These two findings have significant implications for public policy in both rate design and demand reduction.

1. The fact that the supply curve for energy is steep, particularly in the high peaking range means that there is a significant financial externality (in addition to any environmental externalities) associated with demand reduction. In other words, contray to the position of economists, the market price does not tell the entire story. Contrary to conventional wisdom, there is a strong financial justification for energy efficiency and load management to reduce demand and cool off electricity prices, particularly high and volatile prices during peak periods. That justification is actually far stronger in strong power pool jurisdictions than it was the old days of marginal cost analysis and Integrated Resource Planning.

2. The fact that large users also use a higher proportion of summer peak energy and peak demand than average residential customers means that there is cost justification for rates designed to charge more to large customers than to small customers in the summer months., particularly given the financial externalities involved.

3. In a world with competitive choice and a default provider, if a single residential load profile is used, small customers are subsidizing large ones. Heavy summer users need to be assigned their own load profiles that reflect their disproportionate peak use. In addition, it is likely that transmission and distribution demand costs should be allocated more heavily to large customers (particularly since many small customers live in apartments where there are more customers per transformer and thus more diversity between customer peaks and transformer peaks). Rates like California's inverted baseline rates are likely to be cost-justified.

4. Fixed customer charges for the residential class should also be de-emphasized as a result of the strong financial externality. Reductions in energy demand are in the interest of all customers, and promotional rates that encourage customers to use energy raise everyone's costs in power pool environments. Even when the market price of energy is 1 cent per kWh, there is an additional financial externality in the range of 3 cents based on these data.

5. Efforts to reduce residential peak use must be directed at the large customers who use disproportionate amounts of both peak demand and peak period energy. Strong consideration should be given to mandatory time-of-use metering of large customers, which would both allow the

utility to reflect peak cost incurrence and give large customers incentives to shift loads away from peak.

REFERENCES

Rich Ferguson,"The Value of Energy Efficiency in Competitive Power Markets," Clean Power Journal, Summer, 1999, p. 5.

William B. Marcus, Analysis of San Diego Gas and Electric Company's Marginal Cost and Rate Design, Prepared Testimony on behalf of Utility Consumers Action Network, California PUC App. 91-11-024 (1999 Rate Design Window). March, 2000.