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Appendix C: The California Statewide Pricing Pilot Summary

Quantifying the Benefits of Dynamic Pricing In the Mass Market

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APPENDIX C: THE CALIFORNIA STATEWIDE PRICING PILOT SUMMARY[1]

California experienced a major power crisis in its unregulated wholesale markets during 2000 and 2001. The crisis was exacerbated by the lack of dynamic pricing in retail markets, which would have given customers an incentive to lower loads during peak times. One of the unknowns in implementing dynamic pricing is whether and by how much customers would reduce peak loads in response to dynamic price signals.

To help address this uncertainty, California's three investor-owned utilities, in concert with the two regulatory commissions, conducted an experiment to test the impact of TOU and dynamic pricing among residential and small commercial and industrial customers. The primary objectives of California's Statewide Pricing Pilot (SPP) were to:

- Estimate the average impact of time-varying rates on energy use by rate period and develop models that can be used to predict impacts under alternative pricing plans
- Determine customer preferences and market shares for time-varying rate options
- Evaluate the effectiveness of, and customer perceptions about, pilot features and educational materials

This evaluation report addresses the first objective. A previous report presented preliminary impact estimates for selected pilot treatments from the initial summer of the pilot (2003). This report updates and significantly extends those results. It is a comprehensive, stand-alone document and there is no need to review the previous report. Any discrepancies between results presented previously and those presented here reflect methodological enhancements, and therefore should be resolved in favor of the current report.

The SPP involved some 2,500 customers and ran from July 2003 to December 2004. Several different rate structures were tested. These included a traditional TOU rate, where price during the peak period was roughly 70 percent higher than the standard rate and about twice the value of the price during the off-peak period. The SPP also tested two varieties of CPP tariffs, where the peak period price during a small number of critical days was roughly five times higher than the standard rate and about six times higher than the off-peak price. One CPP rate, CPP-F, had a fixed critical peak period and day-ahead notification. The other CPP rate, CPP-V, had a variable peak period on critical days and day-of notification. CPP-V customers had the option of having an enabling technology installed free of charge to help facilitate demand response. The SPP also tested an information treatment that urged customers to reduce demand on critical days in the absence of time-varying price signals.

[1] This information is taken from the Executive Summary of the final report, "Impact evaluation of the California statewide pricing pilot," March 16, 2005. The report can be accessed on the web at: http://www.energy.ca.gov/demandresponse/documents/index.html#group3.

Methodological Overview

Both the overall design of the SPP and the evaluation approach underlying the results presented here allow not only for estimation of the impact of the specific price levels tested in the SPP, but also for estimation of demand response for prices that were not explicitly used as part of this experiment. The experimental design included control groups that stayed on the standard tariff and treatment groups that were placed on new time-varying tariffs or information programs. The treatment groups for each tariff were divided into subgroups that faced different price levels so that statistical relationships between energy use by rate period and prices could be estimated.

These statistical relationships, referred to as demand models, were used to estimate the demand response impact for the average prices used in the SPP. Importantly, they can also be used to estimate the impact of other prices that are within a reasonable range of those tested. Most of the demand models also allow adjustment of the magnitude of price responsiveness to account for variation in climate and the saturation of central air conditioning. Thus, demand response impact estimates can be developed for customer segments with characteristics that differ from those included in the experiment.

As noted above, the data used to estimate demand models includes information on both treatment and control customers. For treatment customers, information on energy use by rate period is available both before and after being placed on the new rate. This type of database allows separation of the impact of the experimental treatments from the impact of other factors that might influence energy use, including self-selection bias.

The demand system estimated for each tariff consists of two equations. One equation predicts daily energy use as a function of daily price and other factors. The second equation predicts the share of daily energy use by rate period. This type of demand system is commonly used in empirical analysis of energy consumption. While the complexity of the experimental design has created numerous empirical challenges, these challenges have been addressed through careful application of widely accepted statistical methods.

Residential Sector Summary

Three rate treatments were examined for residential customers: CPP-F, CPP-V, and TOU. An Information Only treatment was also examined. The CPP-F and TOU rates were implemented among a statewide sample of customers. The sample size for the CPP-F treatment was much larger than for the TOU treatment and the results were more robust. The CPP-V rate was implemented only in the San Diego Gas & Electric (SDG&E) service territory and the Information Only treatment in the Pacific Gas and Electric (PG&E) service territory.

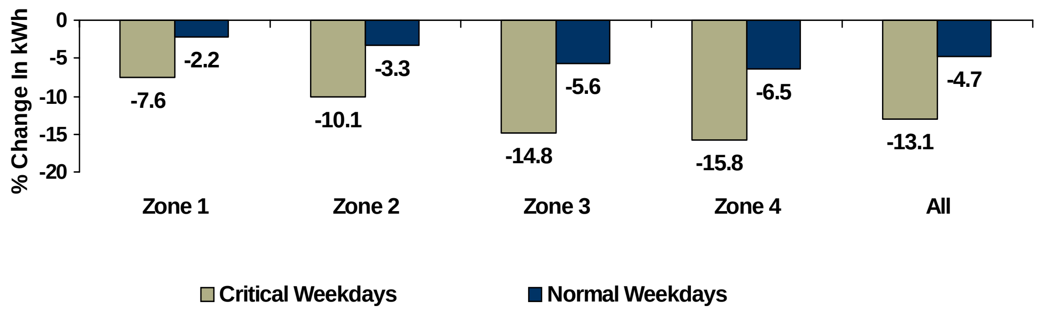
CPP-F Impacts

A key focus of the SPP was to assess the impact of dynamic tariffs. Estimated impacts vary on critical days (when the highest prices are in effect), normal weekdays (when lower peak prices are in effect), and weekends (which have the same prices as off-peak weekday periods).

Figure 1-1 summarizes the impact of the average CPP-F prices on energy use during the peak period on critical and normal weekdays. Statewide, the estimated average reduction in peak-period energy use on critical days was 13.1 percent. Impacts varied across climate zones, from a low of -7.6 percent in the relatively mild climate of Zone 1 to a high of -15.8 percent in the hot climate of Zone 4. The average impact on normal weekdays was -4.7 percent, with a range across climate zones from -2.2 percent to -6.5 percent.

The statewide impact estimate of -13.1 percent has a 95 percent confidence band of +/- 1 percentage point. This means that there is a 95 percent probability that the actual reduction in peak-period energy use on critical days based on average SPP prices would fall between 12.1 and 14.1 percent.

Figure 1-1: Percent Change in Residential Peak-Period Energy Use
(Avg CPP-F Prices/Avg 2003/2004 Weather)



Other key findings for the CPP-F rate include:

- Differences in peak-period reductions on critical days across the two summers, 2003 and 2004, were not statistically significant.
- Differences in impacts across critical days when two or three critical days are called in a row (as might occur during a heat wave) were not statistically significant.
- Average impacts on critical days were greater during the hot summer months of July through September (the "inner summer") than during the milder months of May, June and October (the "outer summer").
- Households with central air conditioning were more price responsive and produced greater absolute and percentage reductions in peak-period energy use than did households without air conditioning.
- Demand response impacts were lower in the winter than in the summer, and lower during the milder winter months of November, March and April (the "outer winter") than during the colder months of December, January and February (the "inner winter").
- There was essentially no change in total energy use across the entire year based on average SPP prices. That is, the reduction in energy use during high-price periods was almost exactly offset by increases in energy use during off-peak periods.

As previously mentioned, one of the primary advantages to developing demand models is the ability to estimate the impact of prices that were not specifically tested in the SPP.

Figures 1-2 and 1-3 show how the percentage reduction in peak-period energy use on critical days varies with changes in the peak-period price on critical days (when everything else is held constant). The curves indicate that the reduction in peak-period energy use increases as prices increase, but at a diminishing rate. Figure 1-2 shows that reductions are greater in percentage terms (and even greater in absolute terms) in hotter climate zones (where air conditioning saturations are high) than in cooler zones. Figure 1-3 shows that reductions are greater in the inner summer months of July, August and September than in the outer summer months of May, June and October. We believe the greater responsiveness in the inner summer is due primarily to the influence of air conditioning.

Figure 1-2: Percent Reduction in Peak-Period Energy Use on Critical Days
Average Summer, 2003/04

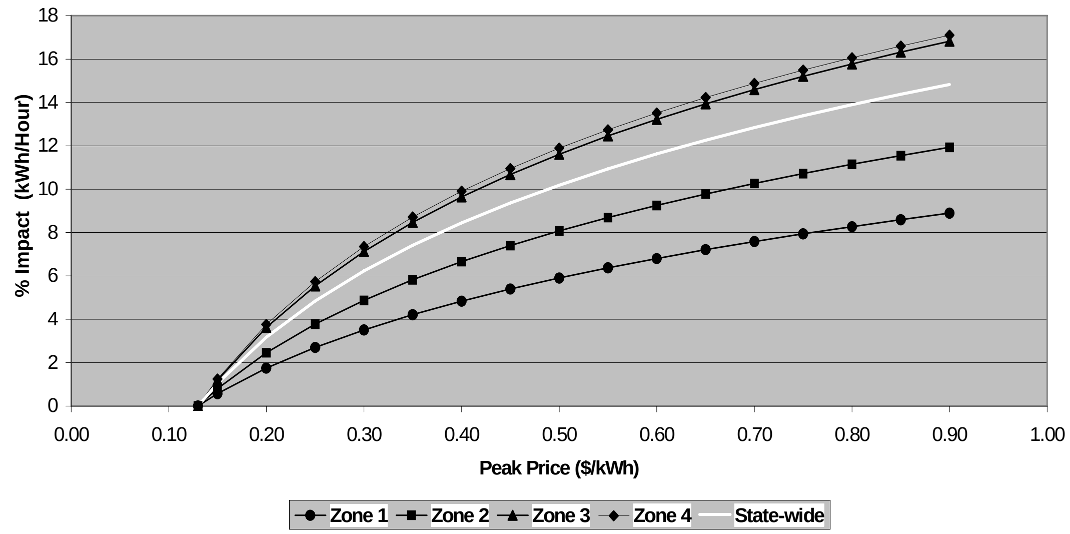
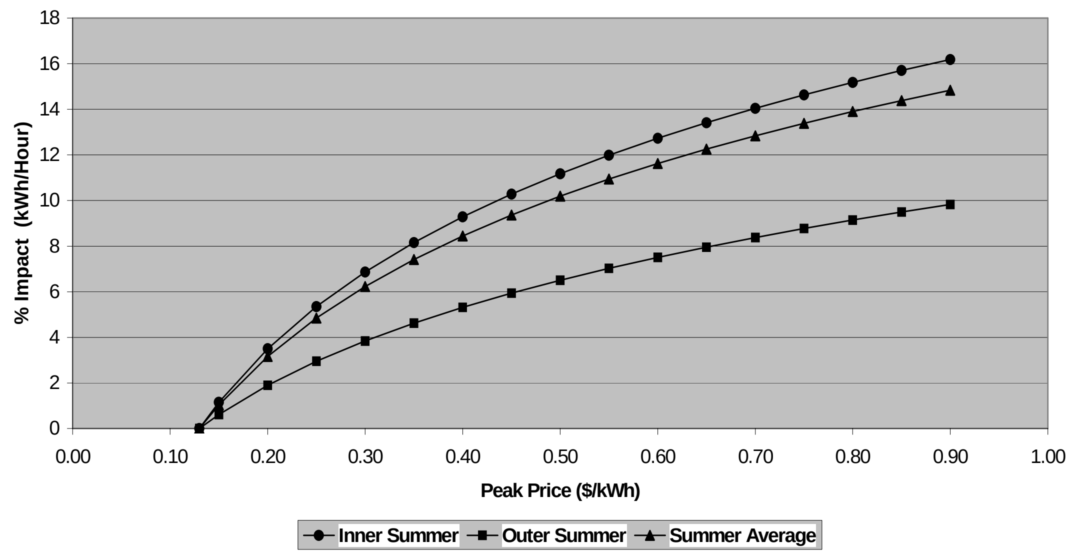


Figure 1-3: Percent Reduction in Peak-Period Energy Use on Critical Days by Season



TOU Impacts

The reduction in peak-period energy use resulting from TOU rates in the inner summer of 2003 equaled -5.9 percent. This 2003 value is comparable to the estimate for the CPP-F tariff on normal weekdays when prices were similar to those for the TOU treatment. However, in 2004, the TOU rate impact almost completely disappeared (-0.6 percent). TOU winter impacts are comparable to the normal weekday winter impacts for the CPP-F rate.

Drawing firm conclusions about the impact of TOU rates from the SPP is somewhat complicated by the fact that the TOU sample sizes were small relative to the CPP-F sample sizes. Small sample sizes are more subject to influence by outliers and changes in the sample composition over time. Further complicating the estimation of the daily energy equation is that variation in daily prices over time is quite small, which makes it difficult to obtain precise estimates of daily price responsiveness. In short, there are reasons to take the analysis of the TOU rate treatment with a “grain of salt.” Indeed, an argument can be made that the normal weekday elasticities from the CPP-F treatment may be better predictors of the influence of TOU rates on energy demand than are the TOU price elasticity estimates.

On the other hand, if the TOU results are accurate, they have very important policy implications, since they suggest that the relatively modest TOU prices tested in this experiment do not have sustainable impacts.

CPP-V Impacts

The residential CPP-V rate was tested among two different populations, both within the SDG&E service territory.

Track A customers were drawn from a population of customers with average summer energy use exceeding 600 kWh per month. The saturation of central air conditioning among the Track A treatment group was roughly 80 percent, much higher than among the general population, and average income was also much higher. Track A customers were given a choice of having an enabling technology installed free of charge to facilitate demand response. About two-thirds of participants took one of three technology options and about half of those selected a smart thermostat.

Track C customers were recruited from a sample of customers that had previously volunteered for the AB 970 Smart Thermostat pilot. All Track C customers had smart thermostats and central air conditioning. Key findings for the CPP-V rate treatments include:

- The reduction in peak-period energy use for Track A customers on critical days equaled almost 16 percent, which is about 25 percent higher than the CPP-F rate average.
- The peak-period reduction for the Track C treatment equaled roughly 27 percent. About two-thirds of this reduction can be attributed to the enabling technology, and the remainder is attributable to price-induced behavioral changes.

Although comparisons between Track A and Track C CPP-V treatments and between the CPP-V and CPP-F treatments must be made carefully due to differences in sample composition, the Track C results suggest that impacts are significantly larger with enabling technology than without it. The 27 percent average impact for the Track C CPP-V treatment is roughly double the 13 percent impact for the CPP-F rate for the average summer. It is also substantially larger than the Track A CPP-V treatment impact, where only some customers took advantage of the technology offer.

Information Only Impacts

The Information Only treatment was included primarily as a crosscheck on the results of the CPP-F rate treatment. Specifically, the purpose was to determine whether simply appealing for a reduction in energy use on critical days might produce significant impacts even in the absence of any price incentive. Information Only customers were given educational material regarding how to reduce loads during peak periods, and they were notified in the same manner as were CPP-F customers when critical days were called. However, participants were not placed on time-varying rates.

The Information Only treatment was implemented in two climate zones in the PG&E service territory. In one of the two zones in 2003, demand response was statistically significant while in the other zone it was not. In 2004, there was no evidence of any response in either zone. At a minimum, one can conclude that demand response in the absence of a price signal is not sustainable. Furthermore, we believe it is not unreasonable to consider the 2003 impact for a single climate zone to be an anomaly and to conclude that there is no clear evidence from the SPP of any significant impact from an appeal to reduce energy use on critical days in the absence of a price signal.

Residential Summary

Table 1-1 summarizes the key findings with regard to reductions in peak-period energy use resulting from the various tariff options tested in the SPP.

The most robust and generalizable estimates from the SPP are for the CPP-F rate. TOU rate impacts vary across years and are suspect due to sample size limitations and other factors. We recommend using the CPP-F models to predict TOU impacts. Although the Track C CPP-V results are more difficult to generalize to the overall population, they provide useful estimates of the incremental impact of prices and enabling technology.

It is interesting to compare the results obtained from the SPP with those that have been found elsewhere. There have been dozens of studies of the impact of time-varying rates conducted over the years, many of them quite dated.[2] Very few previous studies examined dynamic rates, which were a key focus of the SPP. Making comparisons across studies is very difficult because of differences in methodology, differences in the characteristics of underlying populations, and differences in price levels and other factors. Ignoring such complexities, a simple comparison shows that the SPP estimates of price responsiveness in California are at the low end of the range reported in the literature.

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[2] Chris S. King and Sanjoy Chatterjee. *Predicting California Demand Response.* Public Utilities Fortnightly, July 1, 2003.

Table 1-1
Summary of Average Peak-Period Impacts by Treatment Type for Residential Customers

Treatment	Day Type	Avg. Price (¢/kWh)[3]	Impacts	Comments
Track A CPP-F	**Critical Weekday**	P = 59 OP = 9 D = 23 C = 13	-13.1% average summer -14.4% inner summer -8.1% outer summer	No statistically significant difference for inner summer between 2003 and 2004 (differences across the two years can not be estimated for the outer summer or the average summer)
	Normal Weekday	P = 22 OP = 9 D = 12 C = 13	-4.7% average summer -5.5% inner summer -2.3% outer summer	Difference between critical & normal days is primarily due to price differences and secondarily to differences in weather
Track A TOU	**All Weekdays**	P = 22 OP = 10 D = 13 C = 13	-5.9% inner summer 2003 -0.6% inner summer 2004 -4.2% outer summer 2003/04	Results are suspect because of the small sample size and observed variation in underlying model coefficients across the two summers. Recommend using normal weekday CPP-F model to predict for TOU rate.
Track A CPP-V	**Critical Weekday**	P = 65 OP = 10 D = 23 C= 14	-15.8% average summer 2004 Represents average across households with and without enabling technology—could not separate price & technology impacts	Not directly comparable to CPP-F results due to differences in population (CAC saturation for CPP-V treatment group twice that of CPP-F; CPP-V average income much higher; 2/3 of CPP-V customers had enabling tech.; all households located in SDG&E service territory)
	Normal Weekday	P = 24 OP = 10 D = 14 C = 14	-6.7% average summer 2004	See above comments about population differences
Track C CPP-V	**Critical Weekday**	Same as for Track A	-27.2% combined tech & price impact for average summer 2003/04 -16.9% impact for tech only -11.9% incremental impact of price over & above tech impact	Not directly comparable to Track A results due to population differences (All Track C customers are single family households with CAC located in SDG&E service territory). Some evidence that impacts fell between 2003 & 2004
	Normal Weekday	Same as for Track A	-4.5% average summer 2003/04	See above comments about population differences
Track A Info Only	**Critical Weekday**	13 for all periods	Statistically significant response in one of two climate zones in 2003. No response in 2004.	Analysis provides no evidence of sustainable response in the absence of price signals.

3 P = peak period price; OP = off-peak price; D = daily price; C = control group price.

One study, conducted in the early 1980s by the Electric Power Research Institute,[4] allows for a more careful comparison between the SPP results and estimates based on several of the well-designed TOU rate experiments that were conducted in the late 1970s. The EPRI study used a model specification similar to the one used here so that we were able to estimate the impact of SPP prices using the price responsiveness measures from the EPRI study. Using these earlier model parameters along with average SPP prices, the estimated peak-period reduction on critical days is roughly 70 percent greater than the estimated value from the SPP (i.e., -22.5 percent versus -13.1 percent).

Based on these comparisons, it would appear that price responsiveness in California today is less than it was in California and elsewhere a quarter century ago. This is not surprising in light of the significant conservation and load management programs that were implemented in the past 25 years. Actions taken by many consumers following the energy crises of 2000 and 2001 may also have reduced the ability or willingness of California's customers to further reduce energy use. Nevertheless, it is also very clear from the results presented here that there remains a significant amount of demand response that can be achieved through TOU and dynamic pricing.

[4] Results from the EPRI study are summarized in Douglas Caves, Laurits Christensen and Joseph Herriges, *Consistency of Residential Customer Response in Time-of-Use Electricity Pricing Experiments.* Journal of Econometrics 16 (1984) 179-203, North-Holland.