Impact Evaluation of a Peak Time Rebate Program with Universal Enrollment

Dr. Steven D. Braithwait and Marlies Hilbrink,
Christensen Associates Energy Consulting, Madison, WI

ABSTRACT

This paper summarizes the results of an impact evaluation of one of the first peak time rebate (PTR) programs in the United States in which all residential customers are enrolled and eligible to receive bill credits by default. The primary objective of the evaluation was to estimate hourly PTR event-day load impacts at the program level and for various subsets of customers of interest. The evaluation approach involved designing samples of two large components of the San Diego Gas and Electric (SDG&E) residential population and conducting customer-level regression analysis of hourly load data for each sampled customer.

The primary overall finding from this study is that, on average, only customers who opted to receive electronic notifications, or alerts, of PTR events reduced their electricity usage during PTR event-hours. They did so by relatively small but statistically significant amounts of 0.064 to 0.070 kWh per hour, or 5.0 to 8.5 percent of their reference load.

Introduction

This paper summarizes the results of an impact evaluation of one of the first peak time rebate (PTR) programs in the United States in which all residential customers are enrolled and eligible to receive bill credits by default. In 2012, SDG&E enrolled all of its residential customers (all of whom have received Smart Meters) in PTR.[1] SDG&E arranged for day-ahead public announcements (e.g., through radio and TV news, and weather features) of PTR event days (which are also referred to as "Reduce Your Use" days), and all customers have the opportunity to earn bill credits for usage reductions during event hours. Customers are also encouraged to sign up to receive electronic notification, or alerts, of events through email or text messages (or both).

The primary objective of the evaluation described here was to estimate hourly PTR event-day load impacts at the program level and for various subsets of customers. Among these subsets were: 1) those who requested electronic notification, or alerts; 2) customers located in the city of San Diego who enrolled in the San Diego Energy Challenge (SDEC), a separate effort within PTR that involved a competition among middle schools in the San Diego Unified School District; and 3) those who registered for an online My Account.

PTR Program Features

SDG&E's PTR program includes the following features:

- Two rebate levels are available—a basic level of $0.75/kWh and a premium level of $1.25/kWh for customers who use automated enabling technology installed through a SDG&E program. For 2012, only those customers who are enrolled in SDG&E's Summer Saver air conditioner direct load control program are eligible for the premium level.
- There is no maximum number of events, though rebate levels were designed assuming nine events each year. Seven events were called in 2012. The event window is 11 am to 6 pm.

[1] Southern California Edison also automatically enrolled nearly all of its residential customers in a similar PTR program in 2012.

- Load reductions for rebate purposes are measured relative to a customer-specific reference level (CRL) based on an average of the highest three out of the most recent five similar non-event days.[2]
- Customers who register for My Account have access to information on their consumption history, CRL, event performance, and online rebate calculation, as well as online bill paying.

Customer Characteristics

To provide an overview of the customer base that was enrolled in PTR, Table 1 summarizes the number of customers in certain subgroups in both the population and the samples used in the analysis. As indicated in the table, participants enrolled in SDG&E's Summer Saver Program (SDG&E's residential air conditioning load control program) were excluded from this evaluation, but were analyzed in that program's evaluation. All SDEC participants were included in the study.[3] Relatively large samples of the Opt-in Alert customers and the remaining population (after excluding all of the other subgroups) were selected and analyzed. Customers in the approximately 50 percent of the population that registered for My Account were represented as drawn in the samples.[4]

Table 1: PTR Subgroup Populations and Sample Sizes

PTR Subgroup	Population	Analysis Samples
Summer Saver (excluded)	23,998	-
SDEC (excluding SS)	4,633	4,631
Opt-in Alert	41,243	13,745
Remaining Population	1,154,144	29,692
Total (Excluding SS)	1,200,020	48,068

As an introduction to the type of event-day usage reductions that we might expect to find in the evaluation, Figure 1 shows load profiles for two event days and the prior non-event day for the average Opt-in Alert customer in the Inland climate zone. The loads on both the August 9 and 10 event days lie substantially below the August 8 load during the event window indicated by the two vertical lines. These results are consistent with the significant usage reductions that were estimated in the regression analysis for that group on those event days (see below).

[2] The "highest" days are those with the highest total consumption between the event window hours of 11 am to 6 pm. For events called on weekend or holiday days, the CRL is total consumption during the above hours on the highest of the three preceding weekend days.
[3] A small number of customers in each of these groups were excluded due to data issues.
[4] Certain other small subgroups, such as those that received In-Home Display units, were included in the evaluation but are not discussed here due to space limitations.

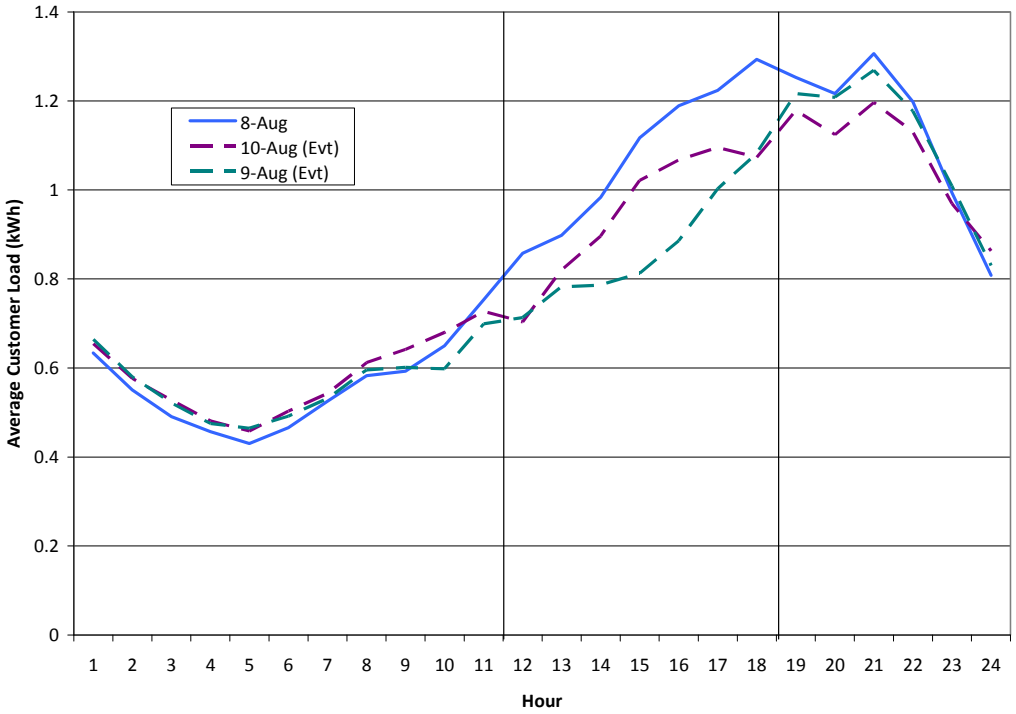

Figure 1: Observed Average-Customer Loads for August 9 and 10 Event Days - *Inland; Opt-in Alert*

Analysis Approach

The technical issues that were addressed in the study included sample design and the methods for estimating program load impacts. Sample design was based on individual customer usage data (summer average daily usage) provided by SDG&E, and was guided by targeted levels of precision (e.g., 95/5) in estimating load impacts. Samples were drawn from two populations of SDG&E residential customers—the approximately 41,000 customers who opted to receive electronic notification, or alerts of PTR events, and the approximately one million customers, other than SDEC and alert customers, who did not receive electronic event notification. The samples were stratified by two climate zones (Coastal and Inland) and three size categories (Low, Medium, and High).

Our approach for conducting the *ex post* impact evaluation involves exploration and testing of regression-based methods for estimating load impacts for event-based demand response programs.[5] These methods apply regression analysis to hourly load data for subgroups and samples of participating customers in various groups of interest, using customers' loads on non-event days as controls for their use on event days (i.e., "participant-only" approach). The analysis controls for factors other than PTR events that influence customers' load profiles, including hour of day, day of week, and weather conditions, and also includes hourly variables that indicate event days. The coefficients on the event variables allow direct estimation of hourly PTR load impacts for each event day.[6]

In the case of PTR, customer-level regression equations were estimated using hourly load data for all of about 4,600 SDEC participants, and samples of approximately 14,000 Opt-in Alert customers,

[5] In the terminology of California demand response evaluations, *ex post* load impacts represent the measured load impacts in the historical period. The evaluations typically also forecast *ex ante* load impacts based on *ex post* results and enrollment forecasts.

[6] Comparing PTR participant usage to that of a traditional control group was ruled out by the universal nature of the program and announcements of events through the media. However, impact evaluations of event-based programs such as PTR are often conducted using participants' loads on non-event days as controls.

and 30,000 customers in the remaining population. These equations resulted in estimates of hourly load impacts for each analyzed customer, for each of the seven PTR events called in 2012. Results from the estimated equations were then tabulated and summarized to provide program impacts for the various requested categories of customers.

Study Findings

Summary of Estimated Load Impacts

The primary overall finding from this study is that, on average, only customers who received electronic notifications, or alerts, of PTR events reduced their electricity usage during PTR event hours. Most of those customers signed up to request the alerts, and they reduced usage by relatively small but statistically significant amounts of 0.064 to 0.070 kWh per hour, or 5.0 to 8.5 percent of their reference load.[7] These Opt-in Alert customers include 855 of the SDEC customers (the remaining SDEC customers received default email notifications through the program) and 41,000 customers from the general population. Approximately 2,900 Summer Saver participants also opted to receive PTR alerts, and they were found to have reduced usage on average by 0.39 kW, or 23 percent, where these greater usage reductions are presumably due in part to their generally larger air conditioning usage capacity.

Table 2 summarizes PTR usage impacts for the average event for each of the customer groups that provided significant load reductions. The first two rows show usage impacts for those SDEC participants who received only default alerts and those who opted to receive PTR alerts, respectively. The third row shows usage impacts for customers outside of SDEC who opted to receive alerts. Overall, those three groups reduced usage on average during PTR events by 0.7, 8.5, and 5.0 percent, respectively, relative to their reference loads. The relatively large PTR usage impacts for the Summer Saver participants who opted to receive PTR alerts are shown in the last line.

The remaining population of non-Opt-in Alert customers is divided approximately evenly between those who registered for My Account and those that did not. Little difference was found between these groups, and the average estimated load impacts for both imply usage *increases* during PTR events. These estimates are not statistically significant, and likely reflect event-day responses to weather conditions or other factors that are not fully explained by the regression equations.

Table 2: Estimated PTR Usage Impacts by Major Customer Group

		Average Customer		Aggregate		
Customer Group	Number of Accounts	Reference Load (kW)	Load Impact (kW)	Reference Load (MW)	Load Impact (MW)	% Load Impact
SDEC Default Alert	3,776	0.81	0.006	3.06	0.021	0.7%
SDEC Opt-in Alert	855	0.83	0.070	0.71	0.060	8.5%
Non-SDEC Opt-in Alert	41,243	1.29	0.064	53.0	2.65	5.0%
SS Opt-in Alert	*2,917*	*1.69*	*0.392*	*4.9*	*1.14*	*23.2%*
Total/Average	**48,791**	**1.26**	**0.079**	**61.7**	**3.87**	**6.3%**

The above findings are generally comparable to those from an evaluation of the 2011 PTR pilot program. That study, which faced challenges due to the unusual nature of several of the events, found an average 0.06 kWh per hour usage reduction on the most typical of the five events, which translated into a 4.5 percent reduction. The pilot participants received electronic alerts of events, so their results are most comparable to the non-SDEC opt-in alert group in the table.

[7] Close examination of customer-level results indicates, as described below, that approximately 25 to 35 percent of the Opt-in Alert customers, differentiated by climate zone and size, reduced usage by consistent and statistically significant amounts on the order of five to six times the magnitude of the average Opt-in Alert customer.

Effect of Awareness

To examine the effect of customer awareness on estimated PTR usage reductions, we conducted a separate analysis of load data for a post-event survey sample of SDG&E customers conducted as part of the PTR process evaluation. Approximately 2,000 non-Summer Saver customers were surveyed, the majority of which were conduced online. The customers were asked a series of questions regarding their general awareness of the PTR program and their ability to earn credits. One question asked about their specific awareness of the September 15 event, shortly after which the survey was undertaken. We used their response to that question as an indicator of awareness, and compared usage changes for "aware" and "non-aware" customer groups.

The surveyed customers were drawn from four of the customer groups for which we have reported estimated usage reductions. They are the following:

- SDEC customers receiving only default SDEC alerts;
- SDEC customers who opted to receive PTR alerts;
- Non-SDEC customers who opted to receive PTR alerts (Opt-in Alert); and
- Non-SDEC customers who received no alerts (non-notified population).

We divided the surveyed customers into eight groups, consisting of aware and non-aware versions of each of the above four groups. We then averaged the hourly loads across all customers in each group, and applied our usual regression model to estimate hourly load impacts for each group and event. Table 3 summarizes the percentages of aware and non-aware respondents in each group, along with the estimated percentage load impacts.

With the exception of the "No Alert" group in the last row (42 percent aware), the percentages of aware customers ranged narrowly between 63 and 71 percent, with the lowest awareness in the SDEC default alert group. The aware customers in the two Opt-in Alert groups (SDEC and non-SDEC) show the greatest usage reductions, as well as the greatest disparity between aware and non-aware customers. The aware customers in the SDEC default alert group showed marginally greater percent load reductions than the non-aware customers. Both aware and non-aware customers in the no-alert group had small non-significant load increases. This limited information is consistent with the observation that the combination of taking the initiative to request electronic notification of events and understanding the operation of the program sufficiently to be aware of when events are called tends to produce the greatest usage reductions on event days.

Table 3: Effect of Awareness on Estimated PTR Usage Reductions

Group	Notice Type	Aware?	Percent	% Load Impact
SDEC	Default Alert	No	37%	3.5%
		Yes	63%	3.9%
	Opt-in Alert	No	29%	2.1%
		Yes	71%	14.8%
PTR (Non-SDEC)	Opt-in Alert	No	34%	4.5%
		Yes	66%	7.6%
	No Alert	No	58%	-1.4%
		Yes	42%	-0.7%

Estimated Hourly Load Impacts

Figure 2 illustrates the hourly profile of the aggregate estimated reference load, observed load and estimated load impacts for the overall Opt-in Alert group on the average PTR event day. Note the observable kink in the observed load in the first hour of the event (hour ending 12 noon) and the relatively constant estimated usage reduction of about 2.5 to 3 MWh per hour over the event period.

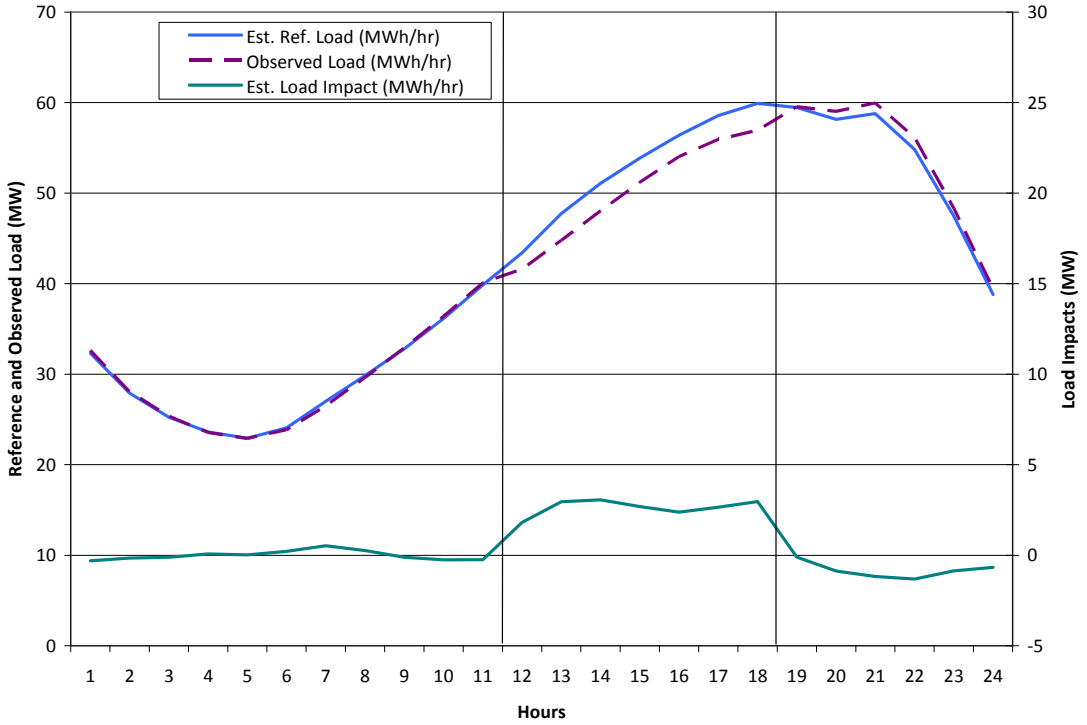

Figure 2: Hourly Aggregate Estimated Reference Load, Observed Load, and Estimated Load Impacts - *Opt-in Alert; Average Event*

Customer-level Load Impacts

One advantage of the customer-level regression approach used in this evaluation is that it provides the ability to examine the range of estimated load impacts across customers. This section provides summary statistics from the customer-level regressions on the fractions of customers in various groups whose estimated load impacts were negative and significant (*i.e.*, significant load *reductions*). Results are shown for twelve customer groups, defined by 1) Opt-in Alert vs. non-alert population, 2) climate zone (Coastal and Inland), and 3) usage-based size categories.

The sets of two bars in Figure 3 show percentages of customers whose estimated load impacts implied statistically significant load reductions on average across all events and event hours.[8] They show generally larger percentages of significant reducers at higher levels of usage among the Opt-in Alert groups, and smaller and relatively constant percentages for the non-alert Population groups. The percentages of significant reducers range from about 25 percent for low-usage customers in the Coastal climate zone to 38 percent for high-usage customers in the same zone. While the average non-alert population customer showed no significant reduction, as reported earlier, the figure shows that 17 to 21 percent of those customers were found to have significantly reduced usage.

[8] This criterion is relatively strict and indicative of consistent usage reductions or increases. That is, load impacts were estimated for each hour of each event, and the criterion used to calculate the percentage of, for example, significant reducers is that the average load impact across all hours and events was negative and significant.

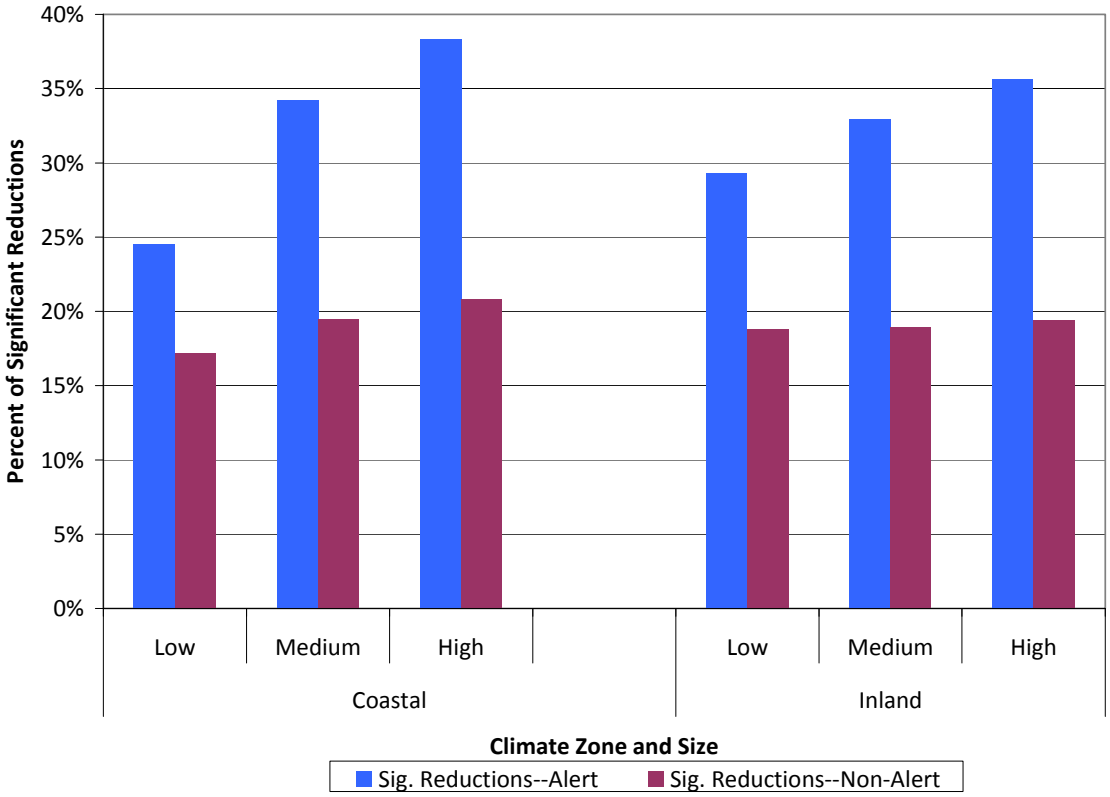

Figure 3: Fractions of Significant Customer-Level Usage Reductions - *Opt-in Alert and Non-Alert Population*

We note that generally smaller percentages of customers were found to have *positive* and significant load impacts. For example, even in the overall responsive Alert group, 14 to 24 percent of customers were found to have positive and significant event coefficients. Those percentages are higher in the Population groups, ranging from 18 to 32 percent. Since there is no logical reason for customers to increase usage *because of* an event, we can only surmise that the event variables in the regressions for those customers are picking up the effect of some unknown omitted variable, such as an extreme weather effect on event days that is not accounted for by the weather variables in the regressions.

Averaging the estimated load impacts across the Opt-in Alert reducers (accounting for appropriate sample weights) produces average per-customer usage reductions for the average event of 0.31 and 0.45 kWh per hour for the Coastal and Inland climate zones, respectively, or 0.37 kWh per hour for the entire group of Opt-in Alert responders. This value is six times greater than the estimated 0.06 kWh per hour usage reduction for the *average* Opt-in Alert customer.

It is of interest to compare the usage patterns of the customers who were found to be reducers to that of the average opt-in customer shown in Figure 2.[9] Figure 4 shows the average reducer load profile for the average event day and the average across eight event-type days, for the Coastal and Inland climate zones. The event-day load profiles, shown in heavy dashed lines, display clear evidence of "notched" usage reductions during the seven-hour event period. In contrast, the average loads on event-like non-event days show no such notched behavior. This result provides evidence that the screening for event responders has selected customers whose usage profiles are consistent with substantial usage reductions during event hours.

[9] Figure 2 actually shows the aggregate load profile for the combined coastal and inland climate zones. However, the average customer profile has the same shape, and does not feature the defined "notch" during the event window.

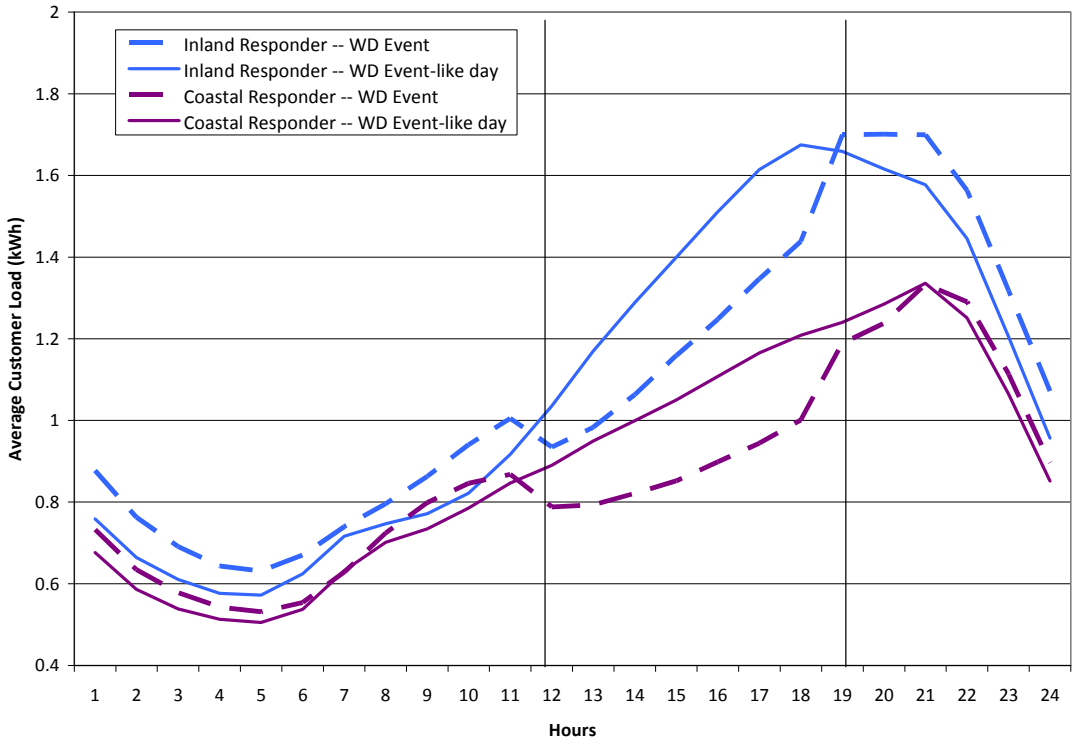

Figure 4: Average Load Profiles for Responders on Event Days and Event-like Days - *Opt-in Alert; Coastal and Inland*

Implied Price Elasticities

For comparison across customer groups that faced different PTR rebates and with other studies, it is useful to convert the estimated percentage load impacts to implied price elasticities. While SDG&E customers did not face a different nominal retail rate during PTR events, they saw their opportunity cost of consuming energy effectively increased by the amount of the available rebate. As noted earlier, most customers were eligible for a $0.75 per kWh rebate. However, the Summer Saver participants were eligible for the higher $1.25 per kWh rebate. Those values, combined with SDG&E's next to last block price of $0.27 per kWh, produce the effective event-period percentage price increases shown in Table 4.

Table 4: PTR Event-Period Price Elasticities

Group	% Load Reduction	% Price Change	Implied Price Elasticity
SDEC Opt-in Alert	8.9%	133%	-0.067
Opt-in Alert	5.1%	133%	-0.038
Opt-in Alert Responders	28.6%	133%	-0.215
Population Responders	21.3%	133%	-0.160
Summer Saver Opt-in Alert.	26.3%	173%	-0.152

Percentage load reductions are shown in the first column for the average customer in each of the indicated five customer groups, most of which opted to receive PTR alerts.[10] The implied PTR event-period price elasticities are shown in the final column. The values for average Opt-in Alert customer in

[10] The percentage changes in price and usage were calculated for this purpose as the natural logarithm of the ratio of the PTR event to non-event values. For example, an observed event-hour load of 1.0 kWh and a reference load of 1.2 kWh would imply a percentage load impact of Ln (1.0/1.2) = - 0.18.

the SDEC and the non-SDEC population are relatively small, at -0.067 and -0.038, respectively. The corresponding values for the average significant responder in the Opt-in Alert and non-alert population are substantially larger, as is the elasticity for the average Summer Saver opt-in customer, who was eligible for the larger rebate. These values are generally consistent with previous evaluations of time-of-use, critical peak pricing, and peak time rebate programs.

Conclusions

This study of one of the first PTR programs with universal enrollment in the United States found small but statistically significant usage reductions on PTR event days in 2012 for the average of the 855 SDEC participants and 41,000 other SDG&E customers who opted to receive electronic event notification, or alerts. In contrast, the more than one million customers who did not receive PTR alerts, including those who registered for My Account, showed virtually no usage reductions. Analysis of a sub-sample of customers who were identified in a post-event survey as aware of the event found substantially greater usage reductions among aware customers than for those who were not aware, particularly among Opt-in Alert customers.

References

[CAEC 2013] Steven D. Braithwait, Daniel G. Hansen and Marlies Hilbrink, Christensen Associates Energy Consulting, *2012 Evaluation of San Diego Gas & Electric's Peak Time Rebate Program*, April 1, 2013.