Load and Billing Impact Findings from California Residential Opt-in TOU Pilots

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ABSTRACT

Three large investor owned utilities (IOUs) launched a series of opt-in Time-Of-Use (TOU) pilots in mid-2016. The pilots were designed to provide insights for development of default TOU pricing that may be implemented in the near future. Collectively, the pilots are testing nine different TOU rate options that vary in terms of the timing and length of rate periods, the number of rate periods, and changes in the rate and price ratios across seasons. A randomized control trial was implemented by offering prospective participants an economic incentive for participating. More than 50,000 households were enrolled and randomly assigned to one of the rates or to the otherwise applicable tariff (OAT) as a control customer. Using pre- and post-treatment hourly electricity usage data, load and bill impacts were estimated for each rate option and selected customer segments using a difference-in-difference methodology. This paper presents interim results for the first summer of the pilot.

A key finding from the pilots is that customers can and will respond to TOU peak price signals, even when the peak period is set during evening hours in response to the effect of solar generation. Statistically significant load reductions were found for all rates tested for each IOU service territory as a whole and for all climate regions. The smallest peak period load impact showed an average reduction of 2.7% and 0.03 kW, and the largest impact was 6.1% and 0.06 kW. Absolute bill impacts for the summer months were typically largest in the hot climate region, second largest in the moderate region and smallest in the cool region; ranging from a slight decrease of roughly $2 per month to an increase of more than $35 per month for the average customer. Bill impacts are expected to be smaller when calculated for a full year.

Introduction

For years, most utilities' residential customers have paid for energy based on the amount they use each month regardless of when it is used, which does not reflect the true cost of electricity. The true cost varies significantly by the time of day and new regulations are pushing utilities toward more cost-reflective pricing. Time-Of-Use (TOU) pricing, a rate structure in which customers pay more for electricity during peak periods and less during off-peak periods, helps to better align the price consumers pay for electricity with the actual cost. Historically, utilities have offered opt-in TOU rates, but soon more will shift toward default TOU to ensure greater power reliability and a more sustainable energy future.

This paper summarizes the first interim evaluation of the opt-in TOU pricing pilots implemented by three investor owned utilities (IOUs): Pacific Gas and Electric Company (PG&E), Southern California Edison Company (SCE) and San Diego Gas and Electric Company (SDG&E).[1] A key objective of the pilots is to develop insights that will guide the IOUs' applications proposing the implementation of default TOU pricing for all residential electricity customers and regulator's policy decisions regarding default pricing. The evaluation presents load impacts (demand reductions) by pricing period for each pilot rate and IOU

[1] See George et al. 2017 for the comprehensive evaluation report.

by climate region and for selected customer segments. Structural bill impacts, impacts due to behavior change, and total bill impacts are also presented for each pilot rate, climate region and segment.

Another key objective is to determine whether TOU rates cause unreasonable hardship on selected customer groups in hot climate regions, including senior and low income households. This assessment was based, in part, on survey information gathered from program participants. These results are reported in detail in the interim evaluation report and are presented in another IEPEC paper.[2]

Collectively, the pilots implemented across the three IOUs are testing nine different TOU rate options. For eight of the nine options, more than 50,000 households were enrolled and assigned to one of the TOU rates or retained in the study on the standard tiered rate (the otherwise applicable tariff, or OAT) to act as a control group for those who were placed on the new tariffs. The ninth rate option is a complex, dynamic rate that one IOU is testing on a very small group of customers. Recruitment for this rate began in late August 2016 and evaluation of the rate is not included in this paper.

As shown in Figure 1, all eight TOU pilot tariffs have peak periods that primarily cover late afternoon and evening hours year round. This shift towards later hours is driven by the increasing penetration of solar generation, which has been driving utility system peak loads later into the day. Most of the rates have peak periods ending at 9 PM and some have peak periods that don't start until 6 PM. As such, these pilots are among the first in the industry to study the magnitude of load reductions during evening hours.

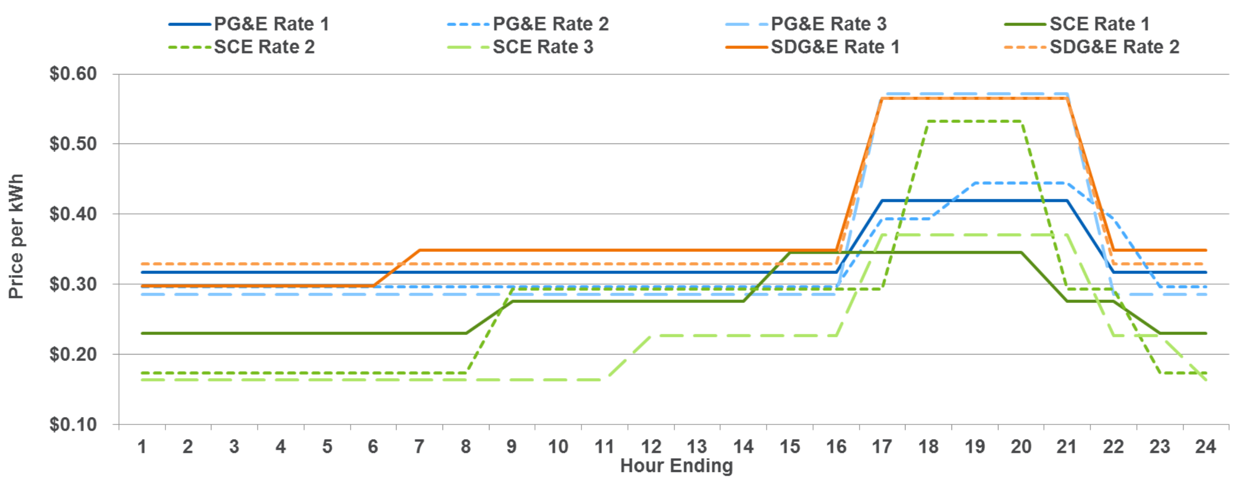

Figure 1. Price per kWh for the 8 pilot rates on summer weekdays

Another key focus of the pilot tariffs is the willingness and ability of consumers to respond to time-varying price signals that vary across more than two daily rate periods. Some of the tariffs have the same pricing structure on weekends as on weekdays, which is yet another atypical tariff feature. For most other existing TOU tariffs, off-peak prices apply on the weekend. In short, these pilots are breaking new ground in the industry with regard to the timing of peak periods, the use of TOU pricing on weekends in addition to weekdays, the frequency of price changes, and the response of customers to low daytime prices during excess supply conditions.

[2] See Messer et al. 2017.

Methodology

Experimental Design

A key objective of any pilot or experiment is to establish a causal link between the experimental treatments (e.g., TOU rates, enabling technology, etc.) and the outcomes of interest (e.g., load impacts, changes in bills, etc.). The best way to do this is through what is referred to as a randomized control trial (RCT) research design. With this approach, participants are offered a treatment and, after they agree to accept it, are randomly assigned to either the treatment or control condition. This ensures that treatment and control customers are identical in every way except for exposure to the treatment and any difference that might occur due to random sampling error. As such, any observed difference in load during the peak period between treatment and control customers, for example, is due either to the treatment of interest (e.g., TOU pricing) or random chance. An RCT design was used in these pilots.

In order to better represent the mix of customers that are likely to be enrolled under default conditions, the pilots were implemented through what came to be called a "pay-to-play" (PTP) recruitment strategy. Under this approach, rather than recruit customers onto a specific rate by educating them about the features and potential customer benefits associated with the rate, as would be done for a typical opt-in pilot or program, prospective participants were offered an economic incentive for agreeing to be in the pilot and were then randomly assigned to one of several TOU rate options or to the control condition after agreeing to participate. Since a key motivation for enrolling into the study is likely to be the PTP incentive rather than the attractiveness of any particular rate feature, it was hoped that this approach would enroll a reasonable number of participants who would likely be complacents,[3] and even some who might be unaware, under a default enrollment strategy.

Load Impact Methodology

The estimation of load impacts by rate period and changes in annual and seasonal energy use for each pilot rate were key pilot objectives. Also of interest was how load impacts varied across customer segments such as CARE/FERA[4] and non-CARE/FERA customers and for seniors and others in hot climate regions where electricity use for air conditioning is important and TOU bill impacts can be high during summer periods. The approach used to estimate load impacts for the eight rate treatments spread across the three IOUs and for each customer segment rigorously adheres to the RCT design, which ensures that the impacts are internally valid. Internal validity means that the treatments being studied (e.g., TOU rates) are the cause of any observed difference in loads by rate period between the treatment and control conditions.

Load impacts for each rate treatment were estimated by comparing loads for customers randomly assigned to each TOU tariff (i.e., treatment customers) with loads for customers randomly assigned to the OAT (i.e., control customers). The difference in loads between treatment and control customers in each rate period before customers are placed on the TOU rate (i.e., the pretreatment period) is subtracted from the difference after customers are placed on the rate (i.e., the treatment period) to ensure that there is no bias in the estimated impact due to random chance. This is referred to as a "difference-in-differences" (DiD) analysis. When applied to data collected through an RCT design, DiD analysis produces the most accurate load impact estimates possible through experimental research. With random assignment to treatment and control conditions, this straightforward analysis ensures that any estimated impacts are internally valid.

[3] Customers who would not have enrolled on an opt-in basis, but are aware that their tariff changed and do not opt out from default enrollment.

[4] California Alternate Rates for Energy (CARE) and Family Electric Rate Assistance (FERA)

The DiD analysis can be done by hand using simple averages or by using regression analysis. Customer fixed effects regression analysis allows each customer's mean usage to be modeled separately, which reduces the standard error of the impact estimates without changing their magnitude.[5] Additionally, standard regression software allows for the calculation of standard errors, confidence intervals, and significance tests for load impact estimates that correctly account for the correlation in customer loads over time. Implementing a DiD through simple arithmetic would yield the same point estimate but it would not generate confidence intervals.

Billing Impact Methodology

The impact of TOU rates on customers' bills is an important metric of interest to multiple stakeholders. A key design requirement for the TOU pilots is to estimate bill impacts based on both pre- and post-treatment usage for a variety of customer segments. Bill impacts were estimated in a similar manner to load impacts in that a DiD analysis was conducted in order to control for exogenous factors that might impact bills between the pre- and post-treatment periods. From a policy standpoint, what is of primary interest is how much individual customers' bills change as a result of being placed on a TOU rate after they adjust their behavior (or choose not to) in response to the time-varying price signals associated with the rate. Based on iterative discussions with stakeholders to determine the best way to present the analysis so that it clearly answers the policy questions of interest, the following three analyses were conducted:[6]

- **Structural benefiter/non-benefiter analysis based on pretreatment usage-** Displaying the proportions of structural benefiters and non-benefiters for each rate and relevant customer segment based on pretreatment data on an annual and summer season basis;
- **Estimation of the average bill impact due to changes in behavior-** Displaying the average bill impact resulting from changes in behavior in response to the new price signals for each rate and relevant customer segment (after controlling for exogenous factors); and
- **Estimation of the total bill impact due to differences in the tariffs (holding usage constant) and behavior change-** Displaying the bill impact for each rate and relevant customer segment due to structural differences in the rate mitigated by changes in behavior.

Structural benefiter/non-benefiter analysis based on pretreatment usage

The structural benefiter analysis was conducted for the summer and annual time periods using pretreatment data for the treatment group for each rate and relevant customer segment. Annual impacts are based on hourly load data from May 2015 through April 2016 for all three utilities. This time period was selected to ensure that customer energy use was as close to the present time as possible, but wasn't significantly influenced by the utilities' communications with customers about the pilot. Summer impacts are based on June 2015 through September 2015 for PG&E and SCE, and May 2015 through October 2015 for SDG&E due to their longer summer rate period.

Average monthly bills were estimated for each treatment group customer on the OAT and TOU rate using hourly load data. Structural bill impacts were calculated by subtracting bills calculated based on pretreatment energy usage based on the OAT from bills based on the same pretreatment usage

[5] In practice, the analysis was conducted as a Randomized Encouragement Design (RED) in order to allow for variation in levels of customer attrition between the treatment and control group. The analysis is conceptually very similar to a DiD, but adds a final adjustment to account for differential levels of customer attrition. See George et al. 2017 for additional details.

[6] A fourth billing analysis examining the change in the distribution of bill impacts due to behavior change was also conducted, but is not presented in this paper.

based on the TOU rate. A positive difference indicates a customer is a structural non-benefiter and would have a larger bill under a TOU rate, holding usage and behavior constant. A negative difference indicates a customer is a structural benefiter, and could expect their bill to decrease on the TOU rate. On some rates a significant portion of customers exhibited differences that were close to zero. As such, it could appear that a large share of customers were structural benefiters or non-benefiters even when bill impacts for a large number of customers are quite small. To address this, a neutral category of +/- $3 per month was defined. The neutral category helps ensure that assignment to the structural benefiter or non-benefiter category is more meaningful and not overly influenced by customers who would experience a difference in bills of only a few dollars.

Estimation of the Average Bill Impact Due to Behavior Change

The average bill impact due to customers changing their behavior in response to the TOU rates was estimated by first calculating bills for both the treatment and control groups under the TOU rate during the pre- and post-treatment periods. A difference-in-differences (DiD) fixed effects model, similar to that used for estimating load impacts, was then used to estimate the average bill impact for the rate and segment of interest.

In simplified terms, the estimated value equals the difference between the control group and the treatment group bills calculated on the TOU rate using post-treatment usage minus any pre-existing differences between the control and treatment group bills based on pretreatment usage. The control group bill calculated on the TOU rate represents the bill that would be expected if a customer was billed on the TOU rate, but didn't change their energy use behavior. The bill for treatment customers on the TOU rate reflects any behavioral changes in response to being on the TOU rate. By subtracting the treatment group's average bill from the control group's average bill—and removing any pre-existing differences—it is possible to estimate the average bill impact attributable to the treatment group's change in behavior resulting from exposure to the pilot rate, after controlling for exogenous factors. A positive impact indicates that customers reduced their bills relative to what they would have been without a change in behavior. This does not necessarily mean that their bills were lower under the TOU rate because the behavioral bill impact may be less than the structural bill increase experienced by most customers.

Estimation of the Total Bill Impact Due to Differences in the Tariffs (Holding Usage Constant) and Behavior Change

Total bill impacts experienced by customers on a TOU rate can be decomposed into two components: the structural impact, and the behavioral impact. The structural impact represents the change in customer's bills based solely on the change in the underlying structure and prices for the rate. In this case, it is the change from the OAT to the time-differentiated TOU pilot rates. The behavioral impact represents how the change in customers' bills resulting from a change in energy usage in response to the new tariffs—which includes higher prices in the afternoon and evening and lower prices at other times of the day. During the summer period, most customers experienced a structural increase in their bills due to transitioning to the TOU rate. However, customers also had an opportunity to offset that increase by changing their energy use behavior in response to the new price signals. As noted above, it is the combination of the structural and behavioral impacts that produces the total bill impact experienced by the average study participant.

Results

The findings obtained in the interim evaluation only cover a few summer months following shortly after customers were enrolled onto the new rates in June and July of 2016. As such, while the pilot has produced a large volume of preliminary information that will be useful in guiding California's pricing strategy, it must be kept in mind that the findings are preliminary and both load and bill impacts will differ significantly during winter months. The actions and perceptions of TOU pilot participants may be quite different over the course of a full year and even over the course of summer 2017 when customers will have had the experience of summer 2016 to rely on for input to their behavioral decisions.

Load Impacts

As previously mentioned, all eight tariffs tested in these pilots had a substantial portion of the peak period covering key evening hours. Indeed, the common hours across all eight tariffs are from 6 to 8 PM. Some tariffs had peak periods extending until 9 PM and some had shoulder periods extending until midnight. A key finding from the pilots is that customers can and will respond to TOU price signals during evening hours. Statistically significant load reductions were found for all rates tested for each IOU service territory as a whole and for all climate regions. Table 1 summarizes the percentage and absolute peak period load reductions for each rate and service territory. As seen, the smallest load impact occurred for SCE's Rate 3, showing an average reduction of 2.7% and 0.03 kW, and the largest impact occurred for PG&E's Rate 2, which had an average percentage reduction of 6.1% and 0.06 kW.

Table 1. Peak period load reductions[1]

Utility	Metric	Rate 1	Rate 2	Rate 3
PG&E	Peak Period Hours	4-9 PM	6-9 PM	4-9 PM
	% Impact	5.8%	6.1%	5.5%
	Absolute Impact (kW)	0.06 kW	0.06 kW	0.06 kW
SCE	Peak Period Hours	2-8 PM	5-8 PM	4-9 PM
	% Impact	4.4%	4.2%	2.7%
	Absolute Impact (kW)	0.06 kW	0.06 kW	0.03 kW
SDG&E	Peak Period Hours	4-9 PM	4-9 PM	N/A
	% Impact	5.4%	4.6%	N/A
	Absolute Impact (kW)	0.04 kW	0.04 kW	N/A

[1] All results statistically significant at the 90% confidence level

Another important policy question given shifting load patterns at some utilities is the magnitude of peak period load reductions on weekends. Peak period load reductions on weekends and the pattern of load reductions across rate periods on weekends were generally similar to weekday impacts. That is, customers can and will respond to TOU price signals on weekends. Also often of interest when examining TOU rates is whether peak period reductions consist primarily of load shifting or load reductions without significant shifting. TOU rates may even increase usage during the low cost off-peak hours more than the reduction during peak hours, thus leading to an overall increase in usage. The preliminary findings covering the initial summer period found that changes in daily usage ranged from very small negative values (i.e., an increase) to reductions as high as 4%.

For PG&E, absolute reductions in peak period energy use were largest in the hot climate region, second largest in the moderate region and smallest in the cool region and differences across regions were statistically significant for all three rates. As shown in Figure 2,[7] percentage reductions also followed this pattern at PG&E but the differences were not always statistically significant. This pattern was also found at SDG&E. However, at SCE, the pattern of load reductions was not the same. In general, the differences across regions were smaller than at PG&E or SDG&E and in some cases, the largest percentage load reductions were found in the cool climate region and the smallest in the hot region. It is noteworthy that SCE's hot region has many more hot days than PG&E's hot region and SCE's moderate region is much hotter than PG&E or SDG&E's moderate region. This, combined with the fact that some of SCE's rates had long shoulder periods during which prices were higher than during the off-peak period may have made it difficult for customers in hot regions to reduce energy use and still stay reasonably comfortable.

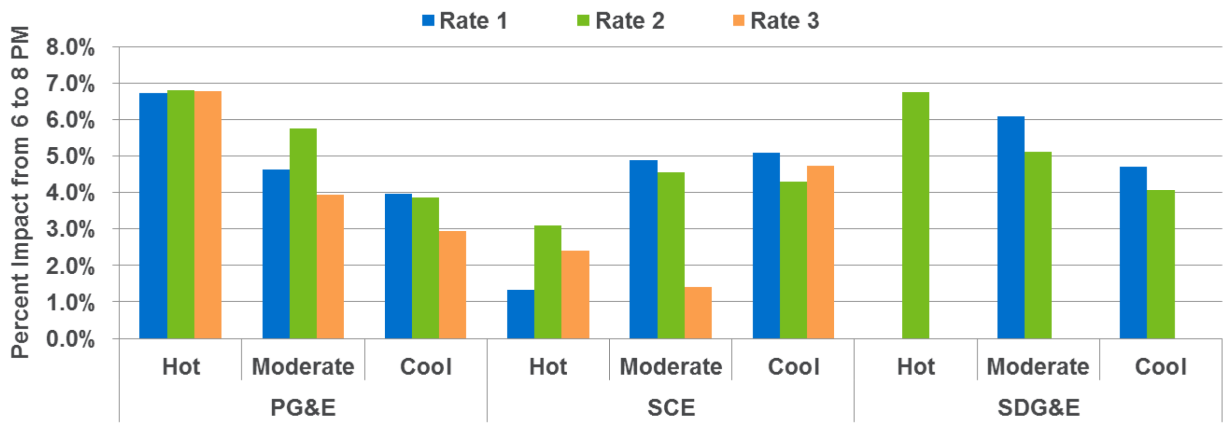

Figure 2. Load reductions from 6 to 8 PM by climate region for the "All" customer segment, average August and September weekday

For the service territory as a whole for all three utilities, CARE/FERA customers had smaller average percent and absolute peak period load reductions than non-CARE/FERA customers for all rates as shown in Tables 2 for the territory level and Table 3 for the hot climate region. This pattern was typically (although not universally) true at PG&E and SDG&E for all rates and climate regions. Once again, SCE had a different result for some rates and climate regions. In selected cases, CARE/FERA customers even had larger load reductions than non-CARE/FERA customers in SCE's service territory.

Table 2. Rate specific peak period impacts on summer weekdays (territory wide)[1]

Rate	Metric	PG&E			SCE			SDG&E		
		CARE	Non-CARE	All	CARE	Non-CARE	All	CARE	Non-CARE	All
Rate 1	%	3.1%	6.8%	5.8%	2.7%	4.9%	4.4%	3.7%	5.7%	5.4%
	kW	0.03	0.07	0.06	0.03	0.07	0.06	0.03	0.05	0.04
Rate 2	%	2.6%	7.4%	6.1%	2.9%	4.7%	4.2%	4.1%	4.7%	4.6%
	kW	0.03	0.08	0.06	0.03	0.07	0.06	0.03	0.04	0.04
Rate 3	%	2.2%	6.8%	5.5%	2.1%	2.9%	2.7%	N/A	N/A	N/A
	kW	0.02	0.07	0.06	0.02	0.04	0.03	N/A	N/A	N/A

[1] All results statistically significant at the 90% confidence level

[7] It should be noted that the load reductions in Figure 2 and also in Tables 2 and 3 are for the two hours, from 6 to 8 PM, that are common across all tariffs. As such, they differ from the load impacts presented in Table 1, which are for the entire peak period, which differs across pilot tariffs.

Table 3. Rate specific peak period impacts on summer weekdays (hot climate region)[1]

Rate	Metric	PG&E			SCE			SDG&E
		CARE	Non-CARE	All	CARE	Non-CARE	All	All
Rate 1	%	3.2%	8.7%	6.7%	1.8%	1.1%	1.3%	N/A
	kW	0.05	0.15	0.11	0.03	0.02	0.03	N/A
Rate 2	%	2.8%	9.0%	6.8%	3.5%	2.9%	3.1%	6.8%
	kW	0.04	0.15	0.11	0.06	0.06	0.06	0.08
Rate 3	%	1.9%	9.5%	6.8%	1.4%	2.9%	2.4%	N/A
	kW	0.03	0.16	0.11	0.02	0.05	0.04	N/A

[1] All results statistically significant at the 90% confidence level

Table 4 shows the average hourly impact for daily energy consumption. This analysis investigates the balance between load shifting versus simply using less or more energy overall. Percent impacts ranged from a slight increase of -0.5% from PG&E CARE/FERA customers, indicating they increased their consumption during the off peak period, to a reduction of 2.6% overall from CARE/FERA and non-CARE/FERA customers at SDG&E, indicating they reduced energy consumption in the peak period, and overall for the day; not simply shifting load.

Table 4. Impact on daily demand (territory wide)[1,2]

Rate	Metric	PG&E			SCE			SDG&E		
		CARE	Non-CARE	All	CARE	Non-CARE	All	CARE	Non-CARE	All
Rate 1	%	1.2%	1.7%	1.6%	0.6%	2.7%	2.2%	2.0%	2.5%	2.4%
	kW	0.01	0.01	0.01	0.00	0.03	0.02	0.01	0.01	0.01
Rate 2	%	-0.5%	0.8%	0.4%	1.1%	1.7%	1.5%	2.6%	2.6%	2.6%
	kW	0.00	0.01	0.00	0.01	0.02	0.01	0.01	0.01	0.01
Rate 3	%	-0.3%	2.4%	1.6%	1.3%	1.6%	1.5%	N/A	N/A	N/A
	kW	0.00	0.02	0.01	0.01	0.01	0.01	N/A	N/A	N/A

[1] Positive values indicate usage reductions
[2] Results not statistically significant at the 90% confidence level are highlighted in gray

Senior households in both PG&E's and SCE's hot climate region had load reductions very similar to those for the general population in the hot climate region. This was true for senior households overall as well as for senior households that were and were not on CARE/FERA rates. Households with incomes below 100% of the Federal Poverty Guidelines (FPG) in hot climate regions did not reduce peak period loads in PG&E's service territory but had load reductions similar to those of the general population in SCE's hot climate region.

SCE recruited customers who already owned smart thermostats into the study and randomly assigned these customers to rate and treatment groups to estimate the magnitude of load impacts for customers with smart thermostats. Absolute load impacts for smart thermostat owners were similar to those for the general population even though they had larger usage overall and, therefore, might be expected to have larger load reductions. SCE plans to work with the smart thermostat provider in the lead-up to summer 2017 to see if an offer to optimize usage in light of being on TOU rates might produce larger load reductions.

SDG&E tested whether delivery of weekly summaries of usage and bills to TOU customers would produce greater load reductions compared with households on TOU rates that did not receive this information. Differences in load impacts between customers who did and did not receive Weekly Alert Emails in SDG&E's service territory were not statistically significant.

Bill Impacts

Three different estimates of bill impacts were produced: structural impacts; impacts due to behavior change; and total bill impacts. Structural impacts represent the change in bills due solely to a change in rates, holding usage constant. Behavioral impacts represent the change in bills due solely to changes in behavior in response to the new rates, while total bill impacts reflect changes in both factors. Structural bill impacts are based on pretreatment data (reflecting pretreatment usage) and, as such, can be calculated for summer, winter, and annual time periods. Behavioral and total bill impacts are based on post—treatment usage for both treatment and control customers and can only be presented at this time for the subset of summer months included in the interim evaluation. Below, we present information on structural impacts for annual bills. For PG&E and SCE, structural impacts for nearly all customers are negative in the summer—meaning nearly all customers' bills increase relative to what they would have been on the OAT— whereas annually, bill impacts are more widely distributed as shown below. This is because prices under the OAT for PG&E and SCE do not vary seasonally while TOU prices are higher in summer than in winter. SDG&E's OAT has prices that vary seasonally. As such, the distribution of bill impacts is similar in summer, winter and annually.

Results from the structural bill impact analysis are presented in column graphs and shown as percentages in Figure 3. For each utility and rate, the percentage of customers who are non-benefiters, neutral (+/- $3 per month), or benefiters based on their average monthly bills for the time period of interest are shown as individual columns. The three columns within each rate and segment combination total to 100%, thus showing the distribution of structural benefiters and non-benefiters for each utility and rate. Figure 3 presents the outcome of the structural bill impact analysis on an annual basis. Across all utilities and rates, the largest proportion of customers are in the neutral category and range from approximately 40% to 60% of the respective populations except for SCE's rate 3. The next largest proportion of customers consists of non-benefiters, which generally includes 35% to 40% of the population. Benefiters are generally around 10% of the population, but range from a high of 17% on SCE's rates 2 and 3 to a low of 1% on SDG&E's rate 1. In the summer period, the distribution shifts significantly towards non-benefiters, with some rates experiencing a non-benefiter proportion as high as 98%.

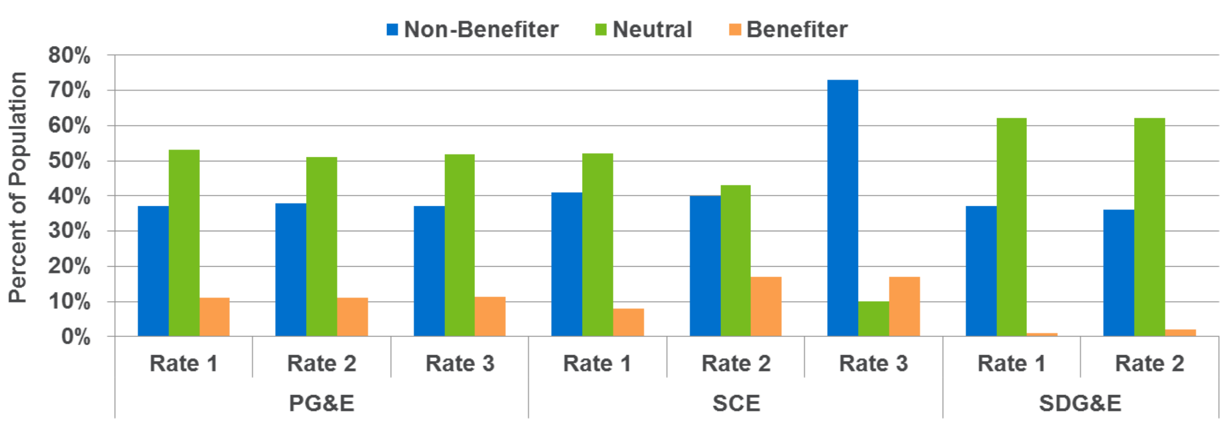

Figure 3. Pretreatment structural benefiters and non-benefiters (Annual)

Bill impacts due to behavior change are presented in Table 5 and include percentage and dollar impacts for the average summer monthly bill. Through changing their energy use the average customer was able to reduce what their average monthly bill would have otherwise been by up to $3.59, or 2.7% at SCE, $2.92 or 2.4% at PG&E and $4.33 or 4.1% as SDG&E. Behavioral impacts were small, and didn't offset a significant portion of the structural bill increases at PG&E or SCE. At SDG&E the structural increases were very small and some customers even experienced structural bill decreases. In this case, many customers were able to offset a significant portion of the structural bill increase.

Table 5. Behavioral bill impacts across utility specific summer periods (behavior change only)[1,2]

Rate	PG&E	SCE	SDG&E
Rate 1	1.6%	2.7%	3.1%
	$1.90	$3.59	$3.14
Rate 2	1.2%	2.3%	4.1%
	$1.54	$3.21	$4.33
Rate 3	2.4%	1.7%	N/A
	$2.92	$2.21	N/A

[1] Positive values indicate bill reductions
[2] All results statistically significant at the 90% confidence level

Table 6 presents the total monthly bill impacts for the average customer for each rate and service territory. At both PG&E and SCE, average total monthly bills (including changes in tariff and customer behavior) during this summer period were higher for all TOU rates than they would have been on the OAT for all customer segments and all climate regions for reasons discussed above. Total bill impacts at SDG&E were near zero because both the OAT and TOU rates were seasonally differentiated. Across the three utilities, average monthly bill impacts over three summer months ranged from a slight bill decrease to as much as $40 depending on the climate region and rate. For the service territory as a whole, the largest total bill impact was an increase of $19.05 or 18.7% for the average customer on Rate 3 at PG&E, and the smallest total bill impact was actually a slight bill reduction of $0.52 or 0.5% for Rate 2 at SDG&E.

Table 6. Total bill impacts across utility specific summer periods (behavior change and tariff)[1,2]

Rate	PG&E	SCE	SDG&E
Rate 1	16.0%	11.3%	0.9%
	$16.65	$13.33	$0.84
Rate 2	16.8%	16.1%	-0.5%
	$18.09	$18.94	-$0.52
Rate 3	18.7%	13.3%	N/A
	$19.05	$15.33	N/A

[1] Positive values indicate bill increases
[2] All results statistically significant at the 90% confidence level

Most segments on average were only able to offset only a small proportion of the structural bill increase for the summer months by reducing or shifting usage. It is important to keep in mind that these summer bill increases for PG&E and SCE are likely to be offset, at least in part, by bill reductions in the winter period for reasons discussed above. It should also be noted that some of the increases would be largely or completely offset by enrollment bill credits that were distributed during the summer as part of the pay-to-play recruitment package. Absolute bill impacts were typically largest in the hot climate region, second largest in the moderate region and smallest in the cool region.

Customer Attrition

Customer attrition is driven by three very different factors. One is customers who move, referred to as customer churn. Another is customers who become ineligible as a result of factors such as installing solar, going onto medical baseline, or switching to service from a Community Choice Aggregator (CCA). The final factor is customers who consciously opt out of the TOU rate because they are unhappy being on the rate.

Cumulative opt-out rates between the enrollment date and the end of December have been quite low for nearly all rates and customer segments.[8] For PG&E, the cumulative percent of treatment customers who dropped off the rate because they were unhappy being on it was between 1% and 2% and at SCE it was between 1.5% and 3%. There is no material difference in the cumulative percent of opt outs across tariffs at PG&E or SDG&E. At SCE, the cumulative percent of opt outs for Rate 3 was 3% for the service territory as a whole but was much higher, roughly 10%, for CARE/FERA customers in the hot climate region.

Figure 4. Treatment customer opt-out rate as of December 2016

The number of customers dropping off the TOU rates was highest in the hot region, second highest in the moderate region and lowest in the cool climate region for all tariffs (but still very low in all cases except for SCE's Rate 3 in the hot climate region). Opt out rates were slightly lower for CARE/FERA customers in PG&E's service territory compared with non-CARE/FERA customers and the opposite was true in SCE's service territory but the differences were small in all cases except for Rate 3 at SCE. Overall attrition ranged from as low as 4% to as high as 18% with the highest being for CARE/FERA customers in SCE's hot climate region on Rate 3.

[8] It should be noted that the opt-out rate is likely downward biased relative to what might occur for a non-pilot rate due to the fact that the participation incentives were paid out over time and tied, in part, to completion of two surveys. As such, some customers who would otherwise drop off might have stayed until the last participation incentive is paid in summer 2017. Opt-out rates during and after summer 2017 may be more reflective of customer preferences than those measured so far. Having said that, differences in opt-out rates across rates and segments are likely to be unbiased.

Conclusions

The pilot evaluation has yielded several important findings that will help California's IOUs and the CPUC determine how to proceed with default TOU pilots, which will be implemented in 2018, and ultimately in the final design plans for defaulting all residential customers onto TOU rates, which is scheduled to begin in 2019. Key findings include the following:

- Load Impacts
  - Customers do respond to TOU price signals during evening hours and on weekends;
  - Changes in daily usage ranged from very small increases, to reductions as high as 2.4%;
    - For PG&E, absolute reductions in peak period energy use were largest in the hot climate region, second largest in the moderate region and smallest in the cool region and differences across regions were statistically significant for all three PG&E rates; however, at SCE, the pattern of load reductions was not the same;
  - For the service territory as a whole for all three utilities, CARE/FERA customers had lower average percent and absolute peak period load reductions than non-CARE/FERA customers for all rates;
  - Senior households in both PG&E's and SCE's hot climate region had load reductions very similar to those for the general population in the hot climate region; and
  - Households with incomes below 100% of the Federal Poverty Guidelines (FPG) in hot climate regions did not reduce peak period loads in PG&E's service territory but had load reductions similar to those of the general population in SCE's hot climate region.
- Bill Impacts
  - At both PG&E and SCE, average monthly bills during this summer period were higher for all TOU rates than they would have been on the OAT for all customer segments and all climate regions, a result caused largely by comparing bills under seasonally-differentiated TOU rates to non-seasonal OAT rates;
  - Bill impacts at SDG&E were substantially smaller than those at PG&E and SCE, because of SDG&E's seasonally-differentiated OAT rates;
  - Most segments on average were only able to offset a small proportion of the structural bill increase by reducing or shifting usage; and
  - Absolute bill impacts were typically largest in the hot climate region, second largest in the moderate region and smallest in the cool region.
- Customer Attrition
  - Cumulative opt-out rates between the enrollment date and the end of December have been quite low for nearly all rates and customer segments;
  - There is no material difference in the cumulative percent of opt outs across tariffs at PG&E or SDG&E. At SCE, the cumulative percent of opt outs for Rate 3 was 3% for the service territory as a whole but was roughly 10%, for CARE/FERA customers in the hot climate region;
  - The number of customers dropping off the TOU rates was highest in the hot region, second highest in the moderate region and lowest in the cool climate region for all tariffs (but still very low in all cases except for SCE's Rate 3 in the hot climate region);
  - Opt out rates were slightly lower for CARE/FERA customers in PG&E's service territory compared with non-CARE/FERA customers and the opposite was true in SCE's service territory but the differences were small in all cases except for Rate 3 at SCE; and
  - Overall attrition ranged from as low as 4% to as high as 18% with the highest being for CARE/FERA customers in SCE's hot climate region on Rate 3.

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