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Appendix 1

Time-of-Use Pricing Opt-In Pilot Plan (Dated December 17, 2015)

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REPORT

Time-of-Use Pricing Opt-in Pilot Plan

December 17, 2015

Prepared for
TOU Pilot Design Working Group

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1 Executive Summary

In Decision 15-07-001, the California Public Utilities Commission (CPUC or the Commission) ordered California's three investor owned utilities (IOUs) to conduct certain "pilot" programs and studies of residential Time-of-Use (TOU) electric rate designs (TOU Pilots and Studies) beginning the summer of 2016, and to file applications no later than January 1, 2018 proposing default TOU rates for residential electric customers. The IOUs were also directed to form a working group (TOU Working Group) to address issues regarding the TOU pilots and to hire one or more qualified independent consultants to assist with the design and implementation of the TOU Pilots and Studies. The TOU Working Group was comprised of 37 entities and included almost 100 people. Nexant, Inc. was engaged as the independent consultant on September 18, 2015. This report summarizes the TOU Pilots and Studies that were designed over the last three months through the TOU Working Group process.

The TOU Working Group received additional guidance regarding the TOU Pilots and Studies in an Assigned Commissioner and Administrative Law Judge (AC/ALJ) ruling on September 24, which indicated that each IOU must prepare a menu of at least three opt-in TOU rate designs and that at least one rate design must have a more complex combination of seasons and time periods than traditional TOU rates that better matches system needs. Each IOU was also strongly encouraged by the CPUC Energy Division to include at least one technology treatment as part of the rate pilots.

With the CPUC direction summarized above as input, the TOU Working Group developed the following, more specific pilot objectives as input to pilot design:

- Consider treatment options and pilot designs for 2016/2017 that will provide useful insights for development of the IOU's January 1, 2018 application for default pricing that may begin as early as 2019;
- Estimate load impacts by rate period for
  - Different rate structures that vary in terms of the timing and length of rate periods
  - The number of rate periods
  - Changes in rate periods and price ratios across seasons
  - Possible other features such as low or negative prices during excess supply conditions;
- Assess customer understanding/acceptance/engagement/satisfaction with various TOU rate options;
- Calculate bill impacts for customers on each pilot TOU rate relative to the otherwise applicable tariff (OAT);
- Assess the degree of hardship that might result from default TOU rates on senior citizen households and economically vulnerable customers (and perhaps others) in hot areas as directed by Public Utilities Code Section 745;
- Assess the incremental effect of enabling technology on load impacts, bill impacts, and customer satisfaction;

- Assess adoption rates for enabling technology for customers on TOU rates; and
- Assess the effectiveness of alternative information, education, and outreach options.

1.1 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, customer satisfaction, 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 the 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 peak period between treatment and control customers, for example, is due either to the treatment of interest (e.g., TOU pricing) or random chance.

A key challenge faced by the TOU Working Group was deciding how to gain insights from residential opt-in TOU pilots that might help inform policy decisions for residential default TOU pricing. An important difference between opt-in and default conditions is the mix of customers that are enrolled under each condition. With default enrollment, there are three types of customers who remain on the tariff: those who would enroll on the tariff if it was marketed on an opt-in basis (referred to as “always takers”); those who are unaware that their tariff changed; and those who are aware and would not have enrolled on an opt-in basis but, for a variety of reasons (e.g., inertia, transaction costs associated with switching out, etc.), do not opt out from default enrollment. This latter group—referred to as “complacents”—are likely to be less engaged than the always takers. Unaware customers are, by definition, unengaged. Because of the presence of complacent and unaware customers, average load reductions have been found to be lower under default enrollment compared with opt-in enrollment. However, aggregate load reductions could be much higher under default pricing if the lower average load reduction was offset by much higher enrollment.

In order to better represent the mix of customers that are likely to be enrolled under default conditions, the TOU Working Group decided to implement what is being 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, participants will instead be offered an economic incentive for agreeing to be in the pilot and then will be randomly assigned to one of three rate options or to the control condition after agreeing to participate. Since the primary motivation for enrolling on the study is likely to be the PTP incentive rather than the attractiveness of any particular rate feature, this approach is likely to enroll a reasonable number of participants who would likely be complacents, and even some who might be unaware, under a default enrollment strategy.

This PTP approach is also believed appropriate in order to accommodate the need to recruit more than 50,000 participants in a very short time period (approximately 2 months) after the CPUC Resolution, in an effort to allow the pilot to be launched on June 1, 2016, as envisioned

by the CPUC. Prior pilots, including SMUD's well-known SmartPricing Options pilot, have taken much longer to recruit smaller numbers of participants.

1.2 Rate Treatments

Figures 1-1 and 1-2 show the weekday and weekend rates, respectively, that are proposed to be tested in the TOU Pilots and Studies. The prices shown there do not reflect the baseline credit that will also be incorporated into the pilot rates.

In addition to the two rates shown in Figures 1-1 and 1-2, SDG&E plans to test a much different, dynamic rate structure using an alternative research approach. This tariff is proposed to have a relatively high monthly fixed charge, generation charges that vary hourly based on wholesale energy costs, and adders that vary by time of day to reflect both commodity and distribution peak events. Enrollment on this tariff is scheduled to be completed by October 2016 and will be coupled with enabling technology that would automate response to the complex time-varying prices. The target audience and research design that will be used to evaluate this tariff will be provided in SDG&E's advice letter.

As seen in Figure 1-1, all eight TOU pilot tariffs have peak periods that primarily cover late afternoon and evening hours year round. This later peak period is driven by the increasing penetration of solar in California and is a significant departure from the vast majority of pilots and tariffs that have been implemented previously in California and elsewhere. With most of the rates having peak periods ending at 9 PM and some with peak periods that don't start until 6 PM, these pilots will be among the first in the industry to study the magnitude of load reductions during evening hours.

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 and across more than two seasons. Low prices in midday in the spring—when excess supply conditions may exist—is also something that has not been previously tested. 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 will break new ground both in California and in the industry with regard to the timing of peak periods, the frequency of price changes, and the response of customers to low daytime prices during excess supply conditions.

Collectively, the eight TOU pilot rates have significant variation in prices across rate periods. During the summer peak period, for example, prices are as low as roughly 41¢/kWh for PG&E's Rate 1 to as high as 69¢/kWh for SCE's Rate 2. Summer off-peak prices range from roughly 23¢/kwh for SCE's Rate 3 to almost 34¢/kWh for SDG&E's Rate 2. Super off-peak prices on spring afternoons are around 17¢/kWh.

Figure 1-1: Weekday Tariffs in the TOU Pilots[1]

Weekday Rate Periods (hour ending -- for example, 16 = hour ending at 4 PM)

Tariff	Season	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
PG&E Rate 1	Spring	Off-peak (25.1¢)																Peak (27.0¢)					Off Peak (25.1¢)		
	Summer	Off-peak (30.3¢)																Peak (40.6¢)					Off Peak (30.3¢)		
	Winter	Off-peak (25.1¢)																Peak (27.0¢)					Off Peak (25.1¢)		
PG&E Rate 2	Spring	Off Peak (24.1¢)																		Peak (26.3¢)			Off Peak (24.1¢)		
	Summer	Off Peak (29.5¢)																Partial Peak (40.2¢)		Peak (45.9¢)			PP (40.2¢)	Off Peak (29.5¢)	
	Winter	Off Peak (24.1¢)																		Peak (26.3¢)			Off Peak (24.1¢)		
PG&E Rate 3	Spring	Off Peak (24.8¢)										Super Off Peak (16.9¢)						Peak (26.3¢)					Off Peak (24.8¢)		
	Summer	Off Peak (SOP) (31.4¢)																Peak (44.3¢)					Off Peak (31.4¢)		
	Winter	Off Peak (25.0¢)																Peak (27.2¢)					Off Peak (25.0¢)		
SCE Rate 1	Spring	Off Peak (23.9¢)														Peak (28.7¢)						Off Peak (23.9¢)			
	Summer	Off Peak (24.9¢)								Partial Peak (29.8¢)						Peak (37.3¢)						PP (29.8¢)		Off Peak (24.9¢)	
	Winter	Off Peak (23.9¢)														Peak (28.7¢)						Super Off Peak (23.9¢)			
SCE Rate 2	Spring	Super Off Peak (17.2¢)								Off Peak (26.6¢)									Peak (29.1¢)			OP (26.6¢)		Super Off Peak (17.2¢)	
	Summer	Super Off Peak (17.1¢)								Off Peak (31.7¢)									Peak (68.9¢)			OP (31.7¢)		Super Off Peak (17.1¢)	
	Winter	Super Off Peak (17.2¢)								Off Peak (26.6¢)									Peak (29.1¢)			OP (26.6¢)		Super Off Peak (17.2¢)	
SCE Rate 3	Spring	Off Peak (23.2¢)											Super Off Peak (16.7¢)					Peak (28.7¢)					Off Peak (23.2¢)		
	Summer	Off Peak (23.2¢)											Partial Peak (28.7¢)					Peak (59.1¢)					PP (28.7¢)		OP (23.2¢)
	Winter	Off Peak (23.2¢)																Peak (26.7¢)					Off Peak (23.2¢)		
SDG&E Rate 1	Summer	Off Peak (30.2¢)						Partial Peak (35.5¢)										Peak (57.5¢)					Partial Peak (35.5¢)		
	Winter	Off Peak (32.4¢)						Partial Peak (33.4¢)										Peak (34.4¢)					Partial Peak (33.4¢)		
SDG&E Rate 2	Summer	Off Peak (33.5¢)																Peak (57.5¢)					Off Peak (33.5¢)		
	Winter	Off Peak (33.0¢)																Peak (34.4¢)					Off Peak (33.0¢)		

[1] The day prior to this report being completed, after examining the distribution of customer bill changes moving from the control group to the TOU pilot rates, PG&E discovered a possible problem with the rates, which it is in the process of investigating. This stems from a mismatch between the billing determinants (i.e., aggregate sales in each of the various TOU periods) used to design the rates, which were based on a sample of customers, and the billing determinants of the much larger population of customers used for the bill comparisons. If this investigation results in significant changes in the prices shown above, PG&E will update the proposed tariffs.

Figure 1-2: Weekend Tariffs in the TOU Pilots

		Weekend Rate Periods (hour ending -- for example, 16 = hour ending at 4 PM)																							
Tariff	Season	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
PG&E Rate 1	Spring	Off-peak (25.1¢)																							
	Summer	Off-peak (30.3¢)																							
	Winter	Off-peak (25.1¢)																							
PG&E Rate 2	Spring	Off Peak (24.1¢)																		Peak (26.3¢)			Off Peak (24.1¢)		
	Summer	Off Peak (29.5¢)																PP (40.2¢)		Peak (45.9¢)			PP (40.2¢)	Off Peak (29.5¢)	
	Winter	Off Peak (24.1¢)																		Peak (26.3¢)			Off Peak (24.1¢)		
PG&E Rate 3	Spring	Off Peak (24.8¢)										Super Off Peak (16.9¢)						Off Peak (24.8¢)							
	Summer	Off Peak (31.4¢)																							
	Winter	Off Peak (25.0¢)																							
SCE Rate 1	Spring	Off Peak (23.9¢)																							
	Summer	Off Peak (24.9¢)								Partial Peak (29.8¢)														Off Peak (24.9¢)	
	Winter	Off Peak (23.9¢)																							
SCE Rate 2	Spring	Super Off Peak (17.2¢)								Off Peak (26.6¢)														Super Off Peak (17.2¢)	
	Summer	Super Off Peak (17.1¢)								Off Peak (31.7¢)														Super Off Peak (17.1¢)	
	Winter	Super Off Peak (17.2¢)								Off Peak (26.6¢)														Super Off Peak (17.2¢)	
SCE Rate 3	Spring	Off Peak (23.2¢)											Super Off Peak (16.7¢)					Mid Peak (26.8¢)					Off Peak (23.2¢)		
	Summer	Off Peak (23.2¢)																Mid Peak (26.8¢)					Off Peak (23.2¢)		
	Winter	Off Peak (23.2¢)											Super Off Peak (16.7¢)					Mid Peak (26.8¢)					Off Peak (23.2¢)		
SDG&E Rate 1	Summer	Off Peak (30.2¢)														Partial Peak (35.5¢)		Peak (57.5¢)					Off Peak (35.5¢)		
	Winter	Off Peak (32.4¢)														Partial Peak (33.4¢)		Peak (34.4¢)					Off Peak (33.4¢)		
SDG&E Rate 2	Summer	Off Peak (33.5¢)																Peak (57.5¢)					Off Peak (33.5¢)		
	Winter	Off Peak (33.0¢)																Peak (34.4¢)					Off Peak (33.0¢)		

1.3 Sample Sizes and Customer Segmentation

Public Utility Code Section 745 requires that the CPUC ensure that any default TOU rate schedule does not cause unreasonable hardship for senior citizens or economically vulnerable customers in hot climate zones. It also requires that, before defaulting residential customers onto TOU rates, the Commission explicitly consider evidence addressing the extent to which hardship will be caused for customers located in hot, inland areas, or areas with hot summer weather, assuming no change in load.

The TOU Working Group spent significant time discussing the sampling requirements and evaluation metrics that should be incorporated into the TOU pilot design to provide useful insights regarding the extent to which TOU rates might cause unreasonable hardship for seniors and economically vulnerable customers in hot areas. There were strong differences of opinion regarding the definitions of seniors and economically vulnerable customers, about the metrics that should be used to assess hardship, and about what constitutes unreasonable hardship.

An important factor affecting both the segmentation scheme and the number of participants to be recruited into each test cell is the metric of interest. Load impacts, bill impacts, and responses to survey questions each have different sample size requirements for estimating outcomes of interest with reasonable statistical precision. Based on preliminary statistical analysis that was done as part of the planning process, the pilot design assumed that roughly 1,000 treatment and 1,000 control customers would be sufficient to estimate load impacts with reasonable levels of statistical precision; roughly 500 participants would be needed to accurately characterize the distribution of bill impacts for each test cell; and at most, 250 participants would be needed for outcomes based on survey questions such as those focused on assessing hardship, satisfaction, customer acceptance, changes in usage behavior, etc.

Table 1-1 summarizes the distribution of rate treatments across customer segments that the TOU Working Group agreed would meet the multiple objectives of the TOU Pilots and Studies. The scheme oversamples seniors and CARE/FERA customers with incomes greater and less than 100% of Federal Poverty Guidelines (FPG) in hot climate regions for one rate in SCE's service territory and one rate in PG&E's service territory. Oversampling is not possible in SDG&E's hot climate region because the region only contains about 16,000 customers. For the remaining rates in PG&E and SCE's hot climate regions and for all rates in the mild and cool climate regions for all three utilities, an equal number of CARE/FERA and non-CARE/FERA customers will be recruited, which means that CARE/FERA customers will be oversampled in those zones as well since they make up less than half of the regional population.

Across the three utilities, based on the planning assumptions used for sample size determination, almost 52,000 customers will need to be recruited into the pilots to meet the sample size requirements for all of the rate, technology, and information treatments that are included in the TOU Pilots and Studies. SCE will recruit roughly 22,000 participants, PG&E roughly 18,500, and SDG&E roughly 11,250. This number of initial participants factors in a potential attrition rate of roughly 25% over the course of the pilots, which are planned to last until the end of 2017. This attrition rate is comprised of both drop outs and normal account turnover, with the latter being by far the largest share of this assumed attrition rate. Importantly,

the final sample sizes needed to meet target requirements for statistical precision for load impacts in each climate region and utility and for estimating bill impact distributions will be estimated more precisely in early January. This analysis has the potential to increase or decrease the estimated sample sizes summarized above and discussed in more detail in later sections of this report.

Table 1-1: Customer Segmentation for Rate Treatments

Climate Region	Customer Segment	SCE			PG&E			SDG&E	
		R1	R2	R3	R1	R2	R3	R1	R2
Hot	Seniors ≤> 100% FPG		X		X				
	CARE/FERA ≤> 100% FPG		X		X				
	CARE/FERA	X		X		X	X		
	Non-CARE/FERA	X		X		X	X		
	General Population		X		X			X	
Mild	CARE/FERA	X	X	X	X	X	X	X	X
	Non-CARE/FERA	X	X	X	X	X	X	X	X
Cool	CARE/FERA	X	X	X	X	X	X	X	X
	Non-CARE/FERA	X	X	X	X	X	X	X	X

1.4 Technology Treatments

Numerous prior pilots and studies have shown that enabling technology such as programmable communicating thermostats and traditional load control switches can significantly increase demand response for customers on dynamic rates such as critical peak pricing where high priced peak periods occur on some days and not others. There have been relatively few studies demonstrating the impact of enabling technology on static TOU rates. We are not aware of any studies that paired technology with TOU rates with peak periods extending well into the evening when air conditioning loads in many climate regions are much lower than during the more traditional afternoon peak periods. Furthermore, there have been few studies on the impact of newer technologies, such as internet enabled and learning thermostats (e.g., smart thermostats), in conjunction with static TOU rates.

To address this shortcoming in the empirical literature, each utility will include an investigation of smart thermostats in their pilots, but each investigation will have a different focus. SCE will recruit existing smart thermostat owners onto TOU rates and will randomly assign them

to one of two TOU rates—Rates 1 or 3—or to the control condition. This study will estimate the average load impacts for this self-selected group of early adopters of smart thermostats. SDG&E will test the acceptance rate for smart thermostats at different price points/subsidies among customers who are already enrolled on TOU rates. If enough participants purchase the technology, SDG&E will estimate load impacts using a quasi-experimental evaluation method. PG&E will conduct a qualitative investigation of thermostat-using behavior through an ethnographic study of both smart thermostat and more traditional programmable thermostat owners. Together, these studies will provide useful, quantitative, and qualitative insights regarding the potential impact of advanced thermostats in combination with TOU pricing.

PG&E is also testing a smart phone app that is both a technology and education treatment. This app will convey a variety of useful information to TOU participants, potentially including: pricing information; TOU-specific performance feedback; energy saving tips informed by user-specific end use load disaggregation; and "gamification" features to encourage energy savings or load shift. PG&E plans to divide pilot rate participants into two equally sized groups and to offer the technology to all enrolled participants across all rate options and customer segments in one group. Understanding whether the acceptance rate is 5% or 50%, learning through surveys what TOU pilot participants think of this type of service and understanding whether it increases satisfaction and acceptance of the rates will be extremely useful for planning education and outreach strategies for future residential default pricing. If the acceptance rate is high, this *randomized encouragement design* (RED) will be used to estimate load impacts associated with the smart phone app and also to compare customers' satisfaction and other metrics between those who do and don't receive the offer of the app. If the acceptance rate is low, a quasi-experimental evaluation method involving ex post statistical matching can be used to develop a control group that has load characteristics similar to those who accept the app in order to estimate load impacts for those who don't take the app.

1.5 Customer Education and Outreach

Customer education and outreach (E&O) is essential to achieving one of the primary objectives of deploying TOU rates and related treatments, which is to encourage demand reductions during high cost periods (and possibly increasing usage during excess supply conditions). This is especially true with residential default pricing where, in the absence of a strong E&O initiative, many customers might not even be aware that their electricity tariff has changed. But even if aware, electricity consumers may need significant help understanding the key features of complex tariff structures, they must be informed when seasonal rate changes occur, and they need education about actions they can take to better manage their electricity bills.

There are many E&O options that could be employed to educate consumers and there are a variety of objectives to which they can be applied. The TOU Working Group discussed the tradeoffs associated with offering E&O options to some participants and not to others for purposes of quantitative assessment of the relative effectiveness of the options. There was widespread agreement that highly effective E&O is essential to the overall success of the pilots (and to TOU pricing more broadly). TOU Working Group members also generally agreed that, with a couple of exceptions, it is more important to ensure that the vast majority of

participants receive highly effective E&O than it is to withhold E&O offerings for purposes of measuring effectiveness.

With the above considerations in mind, in January and early February 2016, each IOU will develop a portfolio of E&O materials—including welcome kits and ongoing communications. These materials will be sent to all participants with the goal of ensuring that they have a good understanding of key rate features and are educated about actions they can take to reduce their bills under TOU rates. The messaging and content of these materials will be tailored as appropriate and feasible to the interests and needs of psychographic/behavioral personas and to low income, seniors, and perhaps other segments. Spanish language materials, and possibly materials in other languages, will be available. The effectiveness of these basic E&O materials will be assessed through surveys that gather information about participant perceptions of the usefulness of the materials and other metrics, such as customer satisfaction, level of understanding of key rate features, and possibly others. These assessments will largely be informative, not comparative, unless the IOUs decide to vary at least some of the materials across customers within selected segments as discussed above.

In addition, SDG&E plans to conduct a quantitative test of the impact of weekly usage alerts on load impacts for customers on TOU rates. The alert treatment will be a TOU version of an alert service that SDG&E already provides to approximately 45,000 residential customers. The weekly alert email will include bill to date and projected bill, weekly electric use, and usage by rate period. This treatment will be deployed on a default basis using email addresses that will be gathered during enrollment into the pilot. Customers will be randomly assigned to the treatment or control condition and impacts will be estimated using an RED analysis.

1.6 Pilot Cost Uncertainty

This report does not include comprehensive budget estimates for the pilots. Those estimates will be included in the Advice Letters filed by each utility to which this report will be appended. There is a great deal of uncertainty around one of the key cost drivers, which is the cost of recruiting almost 52,000 participants that the IOUs plan to enroll in various treatments. This cost uncertainty stems in part from the PTP recruitment plan and the fact that customers will be randomly assigned to one of three rates or to the control condition. This recruitment strategy, combined with a rigorous RCT design, has never been tried before. As such, acceptance rates are highly uncertain.

To address this uncertainty, each utility will conduct pretests in early January 2016. In combination, these pretests will determine: differential acceptance rates for the PTP design for different incentive levels; differences in the timing of incentive payments (e.g., how much is paid upfront versus near the end of the pilot period); different delivery channels (e.g., courier, standard letter, email); with and without bill protection (to reduce risk for participants and, therefore, increase enrollment); and different customer segments. With results from these pretests, the IOUs will be able to estimate recruitment budgets much more precisely for a given sample size and to determine whether contingency plans, such as telephone recruitment, will be needed in order to reach the enrollment goals. There is also uncertainty in the magnitude of bill

protection payments that may need to be made if the pretests indicate that bill protection should be used to increase enrollment rates and reduce costs.

In addition, there is uncertainty associated with the required sample sizes, as discussed above. For any particular desired level or precision, required sample sizes may vary across climate regions and customer segments. The IOUs will conduct statistical analysis in January that will finalize the required sample sizes. In recognition of the above uncertainties, the IOU Advice Letters will provide a fairly wide range of costs for pilot implementation.

2 Introduction

California Public Utilities Commission (CPUC of the Commission) Decision 15-07-001 (D.15-07-001), dated July 3, 2015,[2] requires Pacific Gas and Electric Company (PG&E), Southern California Edison Company (SCE), and San Diego Gas & Electric Company (SDG&E)—collectively the IOUs—to (a) conduct certain "pilot" programs and studies of residential Time-of-Use (TOU) electric rate designs (TOU Pilots and Studies) beginning the summer of 2016; and (b) file applications no later than January 1, 2018 proposing default TOU rates for residential electric customers. To support the TOU Pilots and Studies, the IOUs were directed to form a working group (TOU Working Group) to address issues regarding the TOU rate design and study as detailed in D.15-07-001. The Decision also directed the TOU Working Group to select one of the IOUs to hire one or more qualified independent consultants to assist with the design and implementation of the TOU Pilots and Studies. SCE was chosen as the IOU to solicit bids from qualified consultants and to act as the contracting agent for the independent consultant.

With assistance and direction from the CPUC's Energy Division, the TOU Working Group was formed and held its first meeting on August 25, 2015. Membership in the TOU Working Group has evolved since that time. Appendix A contains the names and affiliations of TOU Working Group members. Following a competitive bidding process, the TOU Working Group chose Nexant, Inc. as the independent consultant to assist with the design of the TOU pilots. Nexant began work on the project on September 18, 2015.

The work summarized here was led by Dr. Stephen George, a Senior Vice President at Nexant with 40 years of industry experience, all of it involving the study of consumer behavior in response to utility and regulatory demand side initiatives. Dr. George is a recognized expert on time-based pricing and experimental design. He was one of the chief architects and evaluators of California's well-known Statewide Pricing Pilot and was also the chief evaluator of SMUD's well-known Smart Pricing Options pilot.

The pilot plan presented here was developed through a series of four day-long TOU Working Group meetings; weekly calls open to the entire TOU Working Group in between the meetings; weekly calls between Energy Division and the IOUs; and numerous emails and conversations among the various parties and between the parties and Nexant. The TOU Working Group meetings that were facilitated by Nexant were held on September 24, October 8, October 28, and December 1. Slide decks from each meeting and detailed summary notes of the discussion were circulated to the entire TOU Working Group. The summary notes included action items and solicited input from TOU Working Group members and many participants provided comments. This highly interactive, stakeholder process was conducted over a very compressed time period to provide input for the Advice Letters that the CPUC Required the IOUs to file by January 1, 2016. It is not unusual to take six to nine months to design a single pilot for a single utility. The TOU Working Group designed multiple pilots involving more than a dozen

[2] Decision on Residential Rate Reform for Pacific Gas and Electric Company (PG&E), Southern California Edison Company (SCE), and San Diego Gas & Electric Company (SDG&E) and Transition to Time-of-Use Rates, July 3, 2015, (D.15-07-001)

treatments across three utilities in less than three months, through the stakeholder process summarized above.

The Decision directed the TOU Working Group to develop plans for opt-in pilots in 2016 and 2017 and for a default pilot in 2018. Given the short time available to complete the work, the TOU Working Group sought[3] permission from the Commission to delay development of the 2018 default pilots until at least mid-year 2016, after the 2016 pilots have begun. As such, there is no discussion in this report concerning the 2018 default pilots. Reviewers should keep in mind that treatment options or customer segments of interest that are not included in the 2016/2017 pilots may be investigated in the 2018 default pilots.

The pilot designs summarized in this report represent a general consensus reached among Working Group members and include numerous compromises among diverse stakeholders. Throughout this report, phrases such as "the Working Group decided" are meant to represent this general consensus. They may not represent the specific position of some Working Group members. Appendix C contains comments and recommendations from some Working Group members that may differ from the general consensus represented by the design decisions documented in this report.

2.1 Pilot Objectives

D.15-07-001 noted that there are several important empirical questions pertaining to TOU rates and customer impacts and responses, and the TOU pilots should aim to help answer those questions prior to the introduction of default TOU rates in 2019. The Decision also stated that the IOUs must "[o]ffer a menu of different residential rates designed to appeal to a variety of residential customers, with different time periods and rate differentials."[4] A subsequent ruling by the Assigned Commissioner and Administrative Law Judge (AC/ALJ) filed on September 24 directed the IOUs to develop and evaluate a variety of TOU rate designs that may either be used as a model for a default TOU rate in 2019, and/or as viable forward-looking pricing options that accommodate the changing conditions of the grid, fulfill California's long term energy policy objectives, and appeal to a variety of residential customers at that time. Specifically, the AC/ALJ ruling indicated that each IOU must:

- Prepare a menu of at least three opt-in TOU rate designs;
- Include at least one TOU rate design with a more complex combination of seasons and time periods than traditional TOU rates that better matches system needs, which may incorporate more dynamic pricing features and enabling technologies, and this pilot must begin no later than October 1, 2016; and
- All other opt-in TOU pilots must begin no later than June 1, 2016.

Additional input regarding pilot design parameters was received during the TOU Working Group meeting held on October 8. At this meeting, Simon Baker, Energy Division's Program/Branch Manager for Demand Response, Customer Generation and Retail Rates spoke to the Working Group about the Commission's interest in including technology treatments as part of the 2016

[3] Joint Letter of SCE, PG&E and SDG&E, submitted to CPUC November30, 2015.

[4] Id at p. 176

pilots. He indicated that there is an expectation that each utility will put forth at least one technology treatment to be implemented no later than October 1, 2016.

With the CPUC direction summarized above as input, the TOU Working Group developed the following, more specific pilot objectives as input to pilot design:

- Consider treatment options and pilot designs for 2016/2017 that will provide useful insights for development of the IOU's January 1, 2018 application for default pricing that may begin as early as 2019;
- Estimate load impacts by rate period for
  - Different rate structures that vary in terms of the timing and length of rate periods
  - The number of rate periods
  - Changes in rate periods and price ratios across seasons
  - Possible other features such as low or negative prices during excess supply conditions
- Assess customer understanding/acceptance/engagement/satisfaction with various rate options;
- Calculate bill impacts for customers on each TOU rate relative to the otherwise applicable tariff (OAT);
- Assess the degree of hardship that might result from default TOU rates on senior households and economically vulnerable customers (and perhaps others) as directed by Public Utilities Code Section 745;
- Assess the incremental effect of enabling technology on load impacts, bill impacts, and customer satisfaction;
- Assess adoption rates for enabling technology for customers on TOU rates; and
- Assess the effectiveness of alternative information, education, and outreach options.

2.2 Report Organization

The remainder of this report is organized as follows. Section 3 discusses the numerous technical issues and stakeholder interests that were taken into consideration during the design process and explains how each was addressed. Section 4 presents the pilot plans for each IOU. The plans summarize the rate, technology, and education and outreach treatments[5] that will be examined in each pilot as well as the climate regions and customer segments for which each treatment will be tested. Section 5 provides a high level overview of the evaluation plan that will be used to determine the load impacts and other metrics for each treatment. The evaluation plan will include statistical analysis of load data as well as customer surveys. Section 6 provides a high level summary of pilot recruitment costs, discusses the significant uncertainty that currently exists for this critical variable, and plans for reducing the uncertainty through pretesting. Budgets for other pilot costs not related to recruitment will be provided in the IOU's advice letters and are not discussed in this report. Section 7 contains a high level

[5] The term *treatment* stems from the experimental research literature, much of which was developed in the context of medical research where subjects receive medical treatments. In this context, it refers to the various rates, technology, and E&O options that are being tested in the pilots.

implementation schedule, highlighting key dates leading up to summer 2016 and through the end of the pilots in December 2017.

Appendix A contains a list of Working Group participants, Appendix B describes the power analysis that was done as input to sample size determination, and Appendix C contains the comments of selected reviewers whose opinions may differ from the consensus opinions underlying the pilot design decisions summarized here.

3 Key Issues in Pilot Design

Designing pilots that will produce useful insights for guiding important policy decisions is challenging. In order to establish a causal link between treatments (e.g., rates, technology, and information) and effects (e.g., changes in load by rate period, bill impacts, etc.), it is necessary to eliminate other possible explanations for any observed change in the outcome variables of interest. This can be hard to do in the real world where people are subject to many other influences besides the treatment of interest and where participation in the pilot is voluntary. Pilot design typically involves making numerous, often difficult, decisions that sometimes must tradeoff technical rigor, cost, feasibility, customer satisfaction/dissatisfaction, and other factors that influence pilot design. This section summarizes a number of key issues that influenced the pilot plan presented in Section 4, and explains the decisions that were made around these issues.

3.1 TOU Rates

As indicated in Section 2, among the key objectives of the pilots is to develop and evaluate a variety of TOU rate designs that may be used as a model for default pricing rate in 2019. Another important objective is to evaluate viable, opt-in pricing options that may be useful in responding to changing grid conditions, may appeal to selected customer groups, or may help fulfill California's long term energy policy objectives. With these objectives in mind, the three IOUs worked closely with the Energy Division and in consultation with the TOU Working Group to develop nine different rate options, three for each utility, that vary with respect to the timing and length of different rate periods, the number of rate periods across seasons, and prices (and price ratios) by rate period.

Figures 3-1 and 3-2 show the proposed weekday and weekend rates, respectively, that are proposed to be tested in the TOU Pilots and Studies. The prices shown there do not reflect the baseline credit that will also be incorporated in the rates. In addition to the two rates shown in the figures, SDG&E plans to test a much different, dynamic rate structure using an alternative research approach. This tariff is proposed to have a relatively high monthly fixed charge, generation charges that vary hourly based on wholesale energy costs, and adders that vary by time of day to reflect both commodity and distribution peak events. The specific characteristics of this tariff are still under discussion with Energy Division. Enrollment on this tariff is scheduled to be completed by October 2016 and will be coupled with enabling technology that would automate response to the complex time-varying prices. The target audience and research design that will be used to evaluate this tariff will be provided in SDG&E's advice letter.

Figure 3-1: Weekday Tariffs in the TOU Pilots[6]

		Weekday Rate Periods (hour ending -- for example, 16 = hour ending at 4 PM)																							
Tariff	Season	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
PG&E Rate 1	Spring	Off-peak (25.1¢)																Peak (27.0¢)					Off Peak (25.1¢)		
	Summer	Off-peak (30.3¢)																Peak (40.6¢)					Off Peak (30.3¢)		
	Winter	Off-peak (25.1¢)																Peak (27.0¢)					Off Peak (25.1¢)		
PG&E Rate 2	Spring	Off Peak (24.1¢)																		Peak (26.3¢)			Off Peak (24.1¢)		
	Summer	Off Peak (29.5¢)																Partial Peak (40.2¢)		Peak (45.9¢)			PP (40.2¢)	Off Peak (29.5¢)	
	Winter	Off Peak (24.1¢)																		Peak (26.3¢)			Off Peak (24.1¢)		
PG&E Rate 3	Spring	Off Peak (24.8¢)										Super Off Peak (16.9¢)						Peak (26.3¢)					Off Peak (24.8¢)		
	Summer	Off Peak (SOP) (31.4¢)																Peak (44.3¢)					Off Peak (31.4¢)		
	Winter	Off Peak (25.0¢)																Peak (27.2¢)					Off Peak (25.0¢)		
SCE Rate 1	Spring	Off Peak (23.9¢)														Peak (28.7¢)						Off Peak (23.9¢)		
	Summer	Off Peak (24.9¢)								Partial Peak (29.8¢)						Peak (37.3¢)						PP (29.8¢)	Off Peak (24.9¢)	
	Winter	Off Peak (23.9¢)														Peak (28.7¢)						Super Off Peak (23.9¢)		
SCE Rate 2	Spring	Super Off Peak (17.2¢)								Off Peak (26.6¢)									Peak (29.1¢)			OP (26.6¢)	Super Off Peak (17.2¢)	
	Summer	Super Off Peak (17.1¢)								Off Peak (31.7¢)									Peak (68.9¢)			OP (31.7¢)	Super Off Peak (17.1¢)	
	Winter	Super Off Peak (17.2¢)								Off Peak (26.6¢)									Peak (29.1¢)			OP (26.6¢)	Super Off Peak (17.2¢)	
SCE Rate 3	Spring	Off Peak (23.2¢)											Super Off Peak (16.7¢)					Peak (28.7¢)					Off Peak (23.2¢)		
	Summer	Off Peak (23.2¢)											Partial Peak (28.7¢)					Peak (59.1¢)					PP (28.7¢)		OP (23.2¢)
	Winter	Off Peak (23.2¢)																Peak (26.7¢)					Off Peak (23.2¢)		
SDG&E Rate 1	Summer	Off Peak (30.2¢)						Partial Peak (35.5¢)										Peak (57.5¢)					Partial Peak (35.5¢)		
	Winter	Off Peak (32.4¢)						Partial Peak (33.4¢)										Peak (34.4¢)					Partial Peak (33.4¢)		
SDG&E Rate 2	Summer	Off Peak (33.5¢)																Peak (57.5¢)					Off Peak (33.5¢)		
	Winter	Off Peak (33.0¢)																Peak (34.4¢)					Off Peak (33.0¢)		

[6]The day prior to this report being completed, after examining the distribution of customer bill changes moving from the control group to the TOU pilot rates, PG&E discovered a possible problem with the rates, which it is in the process of investigating. This stems from a mismatch between the billing determinants (i.e., aggregate sales in each of the various TOU periods) used to design the rates, which were based on a sample of customers, and the billing determinants of the much larger population of customers used for the bill comparisons. If this investigation results in significant changes in the prices shown above, PG&E will update the proposed tariffs.

Figure 3-2: Weekend Tariffs in the TOU Pilots

Weekend Rate Periods (hour ending -- for example, 16 = hour ending at 4 PM)

Tariff	Season	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
PG&E Rate 1	Spring	Off-peak (25.1¢)																							
	Summer	Off-peak (30.3¢)																							
	Winter	Off-peak (25.1¢)																							
PG&E Rate 2	Spring	Off Peak (24.1¢)																		Peak (26.3¢)			Off Peak (24.1¢)		
	Summer	Off Peak (29.5¢)																PP (40.2¢)		Peak (45.9¢)			PP (40.2¢)	Off Peak (29.5¢)	
	Winter	Off Peak (24.1¢)																		Peak (26.3¢)			Off Peak (24.1¢)		
PG&E Rate 3	Spring	Off Peak (24.8¢)										Super Off Peak (16.9¢)						Off Peak (24.8¢)							
	Summer	Off Peak (31.4¢)																							
	Winter	Off Peak (25.0¢)																							
SCE Rate 1	Spring	Off Peak (23.9¢)																							
	Summer	Off Peak (24.9¢)								Partial Peak (29.8¢)														Off Peak (24.9¢)	
	Winter	Off Peak (23.9¢)																							
SCE Rate 2	Spring	Super Off Peak (17.2¢)								Off Peak (26.6¢)														Super Off Peak (17.2¢)	
	Summer	Super Off Peak (17.1¢)								Off Peak (31.7¢)														Super Off Peak (17.1¢)	
	Winter	Super Off Peak (17.2¢)								Off Peak (26.6¢)														Super Off Peak (17.2¢)	
SCE Rate 3	Spring	Off Peak (23.2¢)											Super Off Peak (16.7¢)					Mid Peak (26.8¢)					Off Peak (23.2¢)		
	Summer	Off Peak (23.2¢)																Mid Peak (26.8¢)					Off Peak (23.2¢)		
	Winter	Off Peak (23.2¢)											Super Off Peak (16.7¢)					Mid Peak (26.8¢)					Off Peak (23.2¢)		
SDG&E Rate 1	Summer	Off Peak (30.2¢)														Partial Peak (35.5¢)		Peak (57.5¢)					Off Peak (35.5¢)		
	Winter	Off Peak (32.4¢)														Partial Peak (33.4¢)		Peak (34.4¢)					Off Peak (33.4¢)		
SDG&E Rate 2	Summer	Off Peak (33.5¢)																Peak (57.5¢)					Off Peak (33.5¢)		
	Winter	Off Peak (33.0¢)																Peak (34.4¢)					Off Peak (33.0¢)		

As seen in Figures 3-1 and Figure 3-2, all eight TOU pilot tariffs have peak periods that primarily cover late afternoon and evening hours year round. This later peak period is driven by the increasing penetration of solar in California and is a significant departure from the vast majority of pilots and tariffs that have been implemented previously in California and elsewhere. With most of the rates having peak periods ending at 9 PM and some with peak periods that don't start until 6 PM, these pilots will be among the first in the industry to study the magnitude of load reductions during evening hours.

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 and across more than two seasons. Low prices in midday in the spring when excess supply conditions may exist is also something that has not been previously tested. Some of the tariffs have the same pricing structure on weekends as on weekdays, which is yet another atypical tariff feature. For most TOU tariffs, off-peak prices apply on the weekend. In short, these pilots will break new ground both in California and in the industry with regard to the timing of peak periods, the frequency of price changes, and the response of customers to low daytime prices during excess supply conditions.

Collectively, the eight pilots have significant variation in prices across rate periods. During the summer peak period, for example, prices are as low as roughly 41¢/kWh for PG&E's Rate 1 to as high as 69¢/kWh for SCE's Rate 2. Summer off-peak prices range from roughly 23¢/kwh for SCE's Rate 3 to almost 34¢/kWh for SDG&E's Rate 2. Super off-peak prices on spring afternoons are around 17¢/kWh.

3.2 Experimental Design

A key objective of any pilot or experiment is to establish a causal link between the experimental treatments and the outcomes of interest. This is referred to as *internal validity*. In this context, the treatments of interest are TOU tariffs, enabling technology, and education and information options designed to help consumers understand and accept the tariffs and to adjust their usage in response to the time-varying price signals. The outcomes of interest are: changes in usage by rate period (e.g., load impacts); changes in bills; customer satisfaction; customer engagement in managing energy costs; customer knowledge and awareness of TOU rates; and perhaps others.

Comparing the value of outcome variables of interest before and after customers go on the TOU tariffs or take the enabling technology does not have high internal validity because there are other factors that can cause changes in the variables of interest. Unless these factors can be controlled, it is impossible to know whether the treatment of interest caused the change or whether it was caused by one of these other factors. For example, differences in weather or economic conditions could cause a change in usage for the average customer, which could bias the estimated impact of the TOU rate.

Estimating impacts by comparing the outcomes of interest between customers who do and don't receive the treatment is valid only if those two groups are identical in all respects except that one is subject to the treatment and the other is not. Comparing usage between those who

volunteer for a treatment and those who decline the treatment or who were not offered the treatment has low internal validity for voluntary pilots because customers who volunteer for the treatment may have pretreatment differences in the variables of interest. For example, if people who volunteer for a TOU rate have lower than average peak period usage compared with a control group consisting of decliners or the population as a whole, estimating the load impact as the difference in peak period usage between the treatment and control group would bias the estimated impact upward because it would include both the treatment effect as well as the pretreatment difference in usage. This is known as *selection bias* and is one of the single biggest threats to internal validity.

For voluntary pilots, the best way to avoid selection bias and to ensure a high degree of internal validity is to employ what is called a *randomized control trial* (RCT) design. With this experimental design, participants are offered a treatment and then, after they agree to accept it, are randomly assigned to either the treatment or control condition. This ensures that the 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. If samples are large, the likelihood of significant differences occurring due to random error is small.

However, even small errors might be significant if the impact that is estimated is small. For example, if the difference between treatment and control customers is 5%, a pretreatment difference of 1% due to random chance would produce a 20% error in the estimated impact. This potential error can be reduced or completely eliminated by doing what is called a *difference-in-differences* calculation. A difference-in-differences calculation estimates the impact as the difference between treatment and control customers after the treatment is in effect minus the difference between the two groups before the treatment is in effect. An RCT design with impacts estimated as the difference-in-differences has the highest internal validity of any experimental design, which is why the TOU Working Group chose this design for the TOU pilots.[7]

Another important consideration is the impact of design decisions on external validity. External validity refers to the relevance of the findings from a pilot or experiment to estimating impacts for customers or situations not included in the experiment. The highest external validity would exist for a pilot where the exact treatment, marketed in the exact same way as in the pilot, is offered to a group of customers that are identical (from a statistical perspective) to the study population. These conditions rarely exist and they certainly are not present with the 2016/2017 pilots since

[7] An alternative to an RCT that has equal internal validity is a *randomized encouragement design* (RED). With an RED, customers are randomly assigned to two groups. One group is offered a treatment and the other is not. Among those offered the treatment, some will take it and others will not. Those who are not offered the treatment need not even know they are part of an experiment. As such, an RED avoids any potential backlash associated with a recruit and deny or recruit and delay RCT design. The estimation of impacts for those who receive the treatment in an RED is obtained in a two-step process. In step one, referred to as the intention-to-treat analysis, the variable of interest for those offered the treatment, whether they take it or not, is compared with the values for those who are not offered the treatment. In the second step, the impact estimated in the first step is divided by the percent of customers in the encouraged group who take the offer. This produces an estimate of the impact of the treatment for those who accept it. An RED works well if the acceptance rate of an offer is high, the impact is large, or both. If the acceptance rate and the expected impact are low, the initial intention-to-treat effect may be too small to estimate with any reasonable sized sample. Given the relatively small expected impact for the relatively mild TOU rates being tested in the pilots, and the unknown level of acceptance, the TOU Working Group concluded that an RED was not likely to be successful for these pilots.

the objective of these pilots is to extrapolate from an opt-in pilot to future default conditions because a default pilot cannot be implemented until 2018. A key challenge faced by the TOU Working Group was deciding how to gain insights from opt-in TOU pilots that might help inform policy decisions for default TOU pricing.

An important difference between opt-in and default conditions is the mix of customers that are enrolled under each condition. With default enrollment, three customer segments remain on the tariff:

- **Always Adopters:** These are customers who would enroll on the tariff if it was marketed on an opt-in basis.
- **Complacents:** These customers are aware that their rate has changed as a result of default enrollment, but they would not have enrolled on an opt-in basis. However, for a variety of reasons (e.g., inertia, transaction costs associated with switching out, etc.), they do not opt out from default enrollment.
- **Unaware Customers:** This group of customers is not aware that their tariff changed.

There is a fourth customer segment consisting of decliners who opt-out prior to being placed on the rate. With opt-in enrollment, only the always takers as defined above will enroll on the rate.

Empirical evidence from the well-known Smart Pricing Options (SPO)[8] pilot conducted by the Sacramento Municipal Utility District (SMUD) showed that average reductions for opt-in tariffs were significantly larger on a per-customer basis than average reductions for default tariffs. However, given the significant difference in the enrollment rate between opt-in and default tariffs in the SPO (roughly a factor of 5), aggregate load impacts were much higher under default enrollment. This result can only occur if complacents also responded to the TOU price signals. Unaware customers, by definition, do not respond. Combining data on opt-in and default enrollment rates with results from a survey done by SMUD suggests that, in this particular instance, always adopters accounted for roughly 20% of those who remained enrolled on the default rate, complacents accounted for 50%, and the remaining 30% of customers were most likely unaware that they had been placed on a new tariff.

The above evidence indicates clearly that average impacts for an opt-in pilot, populated only with always adopters, will not represent well what the impacts are likely to be for a default tariff, which will also include complacents and unaware customers. This conclusion most likely applies not just to load impacts but also to other metrics of interest, including bill impacts, customer acceptance, and satisfaction and potential economic hardship associated with being defaulted onto a TOU rate. In order to better represent the mix of customers that are likely to be enrolled under default conditions, the TOU Working Group decided to implement what is being called a “pay-to-play” (PTP) recruitment strategy. Under this approach, rather than recruit customers onto a rate by educating prospective participants about the features and potential customer benefits associated with a specific rate, as would be done for a typical opt-in pilot or program, participants will instead be offered an economic incentive for agreeing to be in the pilot and then will be randomly assigned to one of three rate options or to the control condition after

[8] Stephen S. George, Jennifer Potter and Lupe Jimenez. *SmartPricing Options Final Evaluation*. September 5, 2014. See also SmartPricing Options Interim Evaluation. October 23, 2013.

agreeing to participate. This approach has several benefits in this context over a traditional opt-in marketing effort:

- It eliminates any rate-specific selection effects, since participants will be given little information about the characteristics of specific rates (except that they will be TOU rates) and won't know until after they enroll which of the three rate options (or the control condition) to which they will be assigned;
- It reduces potential dissatisfaction that may occur in a more traditional RCT application where customers are asked to enroll and then half are assigned to the treatment condition and half to the control condition. With the PTP plan, it will be made clear up front that participants will be assigned to one of four conditions and they won't know enough about the differences in the rates to be disappointed about getting one assignment over another. Most importantly, the incentive payment, which is likely to be the strongest driver of participation and which will be paid to both treatment and control customers, should be sufficient to overcome any potential dissatisfaction that might arise from a more traditional recruit and deny RCT design;
- Given that the main driver of participation is the incentive (and perhaps interest in being involved in an important research project), and not a specific rate, the PTP approach should attract a reasonable number of complacents along with the always adopters that would be the only participants in a typical opt-in pilot;
- The incentive should significantly increase the acceptance rate for the pilot compared with a traditional marketing strategy and, as a result, it should shorten the recruitment period. This is critical given the very short time available to complete recruitment after Commission approval of the pilot plans and budgets (likely in March 17, 2016) and the target enrollment date of June 1, 2016[9] (leaving only about two months or less for actual recruitment); and
- Finally, this approach reduces the number of customers that must be recruited because within each IOU the same control group can be used for each rate option. Given that each rate being offered in the pilot would have a unique set of selection effects if marketed through a traditional opt-in approach (since tariffs have different characteristics, with different peak period timing and length and differences in rate periods across seasons, etc.), if the rates were marketed on an opt-in basis, each rate would require its own control group. With the PTP approach, customers will be recruited into the study and assigned randomly to one of two or three rates (depending on the IOU) or to the control condition. As such, there are no rate-specific selection effects so a single control group is valid. This results in substantial cost savings.

One downside to the PTP approach is that it does not allow for a determination of the relative preferences of customers for each rate based on a comparison of differential opt-in rates for each tariff. Furthermore, in order to avoid gaming by customers who might enroll to receive the incentive and then immediately drop out of the pilot, only a portion of the incentive will be paid up front with the remainder being paid either at the end of one year on the pilot or perhaps at the end of the second summer period. As such, the relative preferences of customers for the different rates can't be measured by differential dropout rates in the first year, since the delayed

[9] Recruitment for SMUD's SPO pilots required an 8-month period (October-May) and included numerous iterations of opt-in TOU outreach to completely fulfil targeted recruitment levels (SMUD ultimately recruited 3,428 customers for the Opt-In TOU portion of its SPO Pilots). Although SMUD did not offer a pay-to-play incentive, it was also able to tell prospective participants the exact rate onto which they would be placed if they volunteered to participate.

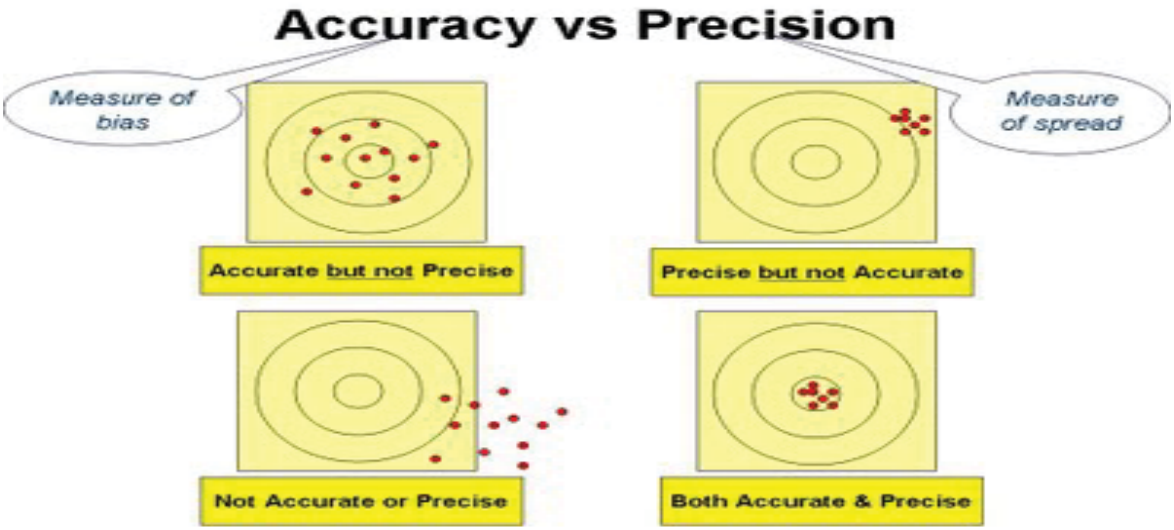
payment of the incentive is designed to keep customers on the rate. However, customer acceptance of each rate option can be assessed by asking about customer satisfaction with the rate in a survey and comparing relative satisfaction ratings for each tariff. In addition, once the final incentive payment is made, customers may opt out and it may be possible to observe differential opt-out rates as an indicator of relative preferences for the rate options offered. Another approach to assessing customer preferences would be to ask each participant near the end of the pilot whether they would have preferred either of the other two rate options over the one they were assigned. This survey question would be asked after participants have been on the rate for at least a year.

3.3 Sample Size Determination

The cost for any pilot or experiment is typically highly correlated with the number of customers that must be recruited in order to answer the key questions of interest with the desired level of statistical precision. Estimates for a variable of interest (e.g., load impact, bill impact, customer satisfaction, etc.) are not exact—they are estimates that are subject to error. Figure 3-3 illustrates two types of error that are relevant to pilot design, bias, and precision. Bias refers to the accuracy of the estimate—an unbiased estimate is one that would accurately reflect the true value for the average treatment customer across repeated samples. Precision refers to the spread of estimates across repeated samples of participants. As illustrated in Figure 3-3, it's possible to have a very precise estimate of a biased answer. Bias was discussed above and primarily stems from poor experimental design (and often from not controlling for selection effects). With the RCT design that will be deployed for these pilots, the estimates should not be biased.

Precision is tied to sample size. If samples are small, there will be greater variation in the estimated values across repeated samples than if samples are large relative to the population of interest. With small samples, there is less confidence that the estimated value from any single sample is close to the true value.

Figure 3-3: Accuracy Versus Precision



An important determinant of sample size is the desired level of confidence. Confidence level refers to the percentage of all possible samples that can be expected to include the true population parameter. For example, suppose all possible samples were selected from the same population, and a confidence interval was computed for each sample. A 90% confidence level means that 90% of the confidence intervals would include the true population parameter. If the confidence interval for an estimated value spans 0, it means that the estimate is not statistically different from 0. For example, if an estimated impact is 2 and the 90% confidence interval is ±3, it means that we can't say, with 90% confidence, that the estimated value of 2 is statistically different from 0. If the objective is to determine whether two estimated values differ from each other, if the confidence bands around the two estimates overlap, it is not possible to say that the two values are statistically different from each other. For example, if the average load impact for one customer segment is estimated to equal 5% with a 90% confidence band of ±3%, and the estimate for a different segment is 8%, with a confidence band of ±2%, it would not be possible to conclude that the two estimates are statistically different because the confidence band for one is from 2 to 8 and the other is from 6 to 10. On the other hand, if the 90% confidence bands for each estimate equaled ±1%, one could say with 90% confidence that the values of 5% and 8% were statistically different because the confidence bands from 4 to 6 and 7 to 9 don't overlap.

The remainder of this section discusses sample size targets for treatment cells and customer segments for which load impacts will be estimated, for which bill impact distributions will be produced, and for which surveys will be the primary mode of assessment. The estimates provided here for load impacts are based on a convenience sample of data from PG&E and, as discussed below, may vary across utilities and segments. Each utility will need to produce its own estimates as input to sampling for implementation, which could lead to increases or decreases in the target sample sizes relative to those shown in Section 4 for each rate treatment. Target sample sizes for bill impact distributions discussed in Section 3.3.2 are

currently an educated guess as none of the bill impacts have yet been calculated. The sample sizes for survey data analysis presented in Section 3.3.3 are based on standard power calculations and do not require further analysis prior to implementation since they will be the same across all utilities.

3.3.1 Sampling for Load Impact Estimation

The sample size required to obtain a certain level of confidence depends on a variety of variables, including the type of variable being estimated, the amount of variation in that variable, and the expected magnitude of the impact. When estimating peak period load reductions, the underlying variable of interest—electrical load during the peak period—fluctuates significantly from day to day and the estimated impact from a modest TOU rate signal is likely to be small. With these conditions, the challenge is picking out a small signal (the impact) from a lot of background noise (fluctuation in load). Doing so requires much larger samples of both treatment and control customers than if the signal was quite large and the background noise was small.

Table 3-1 shows the 90% and 95% confidence intervals for estimating peak period load impacts based on different sample sizes for combined treatment and control customers in an experiment. The estimates assume that a difference-in-differences analysis is used to estimate load impacts during the peak period. These values are based on a sample of customers from PG&E's service territory. The methodology used to produce the values in Table 3-1 is documented in Appendix B.

Table 3-1: Expected Precision for Peak Period Load Impacts Using Different Sample Sizes (Based on a sample of customers from PG&E's service territory)

Number of Treatment + Customers Combined	95% Confidence Band	90% Confidence Band
400	5.2%	4.4%
1,000	3.2%	2.7%
1,500	2.7%	2.2%
2,000	2.2%	1.9%
4,000	1.7%	1.4%

The values in Table 3-2 indicate that, with a sample of 1,000 treatment customers and an equal sized sample of 1,000 control customers (the fourth row in the table), an estimated impact of, say, 5%, would have a 90% confidence band from 3.1% to 6.9%. If the sample of treatment and control customers was doubled, to 2,000 each (4,000 total), the 90% confidence band would narrow to ±1.4% (e.g., it would range from 3.6% to 6.4% if the estimate was 5%). Importantly, in the above example using 1,000 treatment and 1,000 control customers, if the estimated value was 1% rather than 5%, the 90% confidence band would span 0. Put another way, it would not be possible to conclude with 90% confidence that the 1% load impact was statistically different from 0.

As indicated above, the values in Table 3-1 were based on a sample of customers from PG&E's service territory and are driven by the normal fluctuation in peak period electricity use for that specific sample. A sample of customers from a different service territory, or from a different customer segment within PG&E's service territory, could have confidence bands that are wider or narrower than those shown in Table 3-1 depending on the underlying fluctuation in electricity use for those customers. Table 3-2 shows how the confidence bands differ between CARE and non-CARE customers and between customers in hot and cool climate regions in PG&E's service territory.[10] The greater fluctuation in loads across days in the cooler region leads to a wider confidence band than in the hotter region where the consistently hot temperatures produce high demand levels on most summer days. This highlights the importance of each IOU conducting analysis similar to that underlying these tables based on a representative sample of the target population in each climate region. As discussed below, SCE has already completed this analysis and found that there are large differences across climate regions in the confidence bands that can be obtained from a given sample size.

Table 3-2: Expected Precision for Peak Period Load Impacts Using Different Sample Sizes (90% Confidence Band)

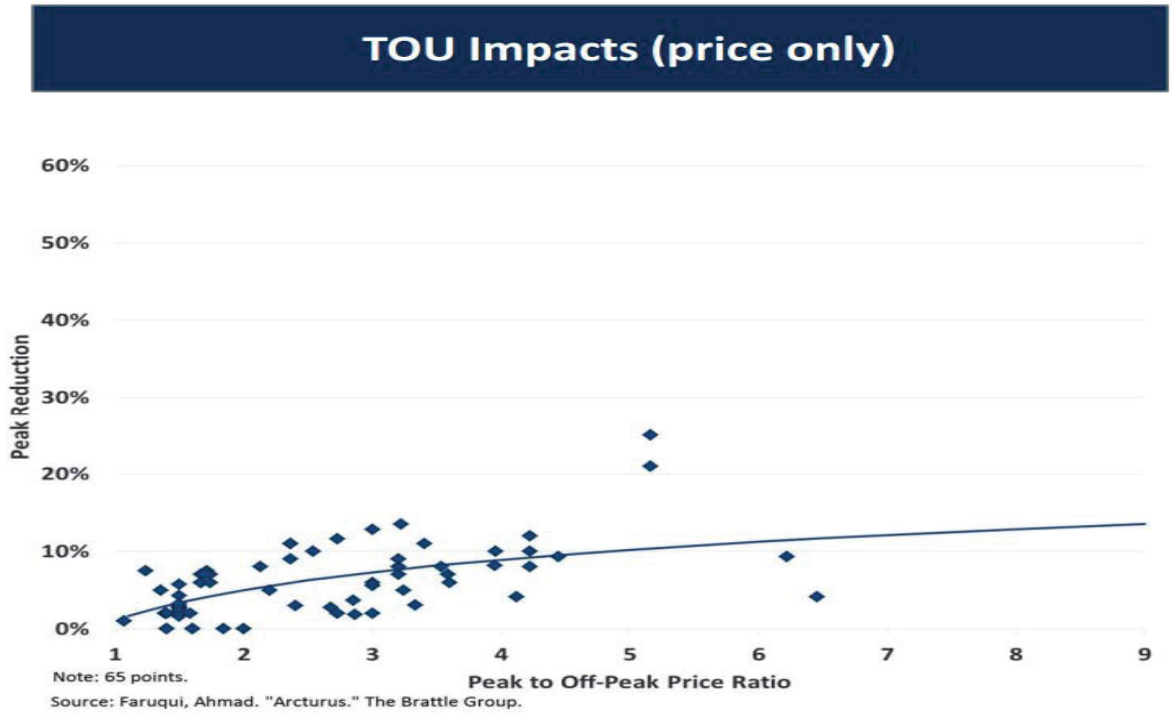
Number of Treatment Customers (Assumes Equal # of Control Customers)	Non-CARE	CARE	Cool	Hot
400	5.4%	4.2%	4.2%	3.6%
1,000	3.1%	2.6%	3.1%	2.4%
1,500	2.5%	1.9%	2.7%	2.0%
2,000	2.2%	1.8%	2.0%	1.7%
4,000	1.4%	1.1%	1.5%	1.2%

In addition to the size of the confidence bands associated with various sample sizes, another key driver of the sample size is the expected load impact. If expected load impacts are small, say 2%, and it is important to know whether the estimated values are statistically different from 0, it will be important to draw samples of at least 1,000 treatment and control customers (each) so that the confidence band is less than ±2%. On the other hand, if the expected load impact is, say 10%, and it is sufficient to know with 90% confidence that it is likely to be somewhere between 7% and 13%, then a sample size of only 500 customers would be required. Figure 3-4 shows estimates of load impacts at various peak-to-off-peak price ratios as estimated from a variety of TOU pilots and programs. As seen previously in Figures 3-1 and 3-2, the peak-to-off-peak price ratios being proposed for the various pilots range from around 1.1 to 1 to greater than 4 to 1. Based on prior studies, this suggests that the expected impacts are almost certainly less than 10% and may be less than 5%. Importantly, most prior studies have peak periods that are in the afternoon hours when air conditioning loads are relatively high and many households may be unoccupied. With some of the proposed rates having peak periods

[10] It should be noted that the difference in the size of the 90% confidence band between hot and cool climate regions may be impacted by the difference in the share of customers in each region that are CARE customers. The share of customers in PG&E's hot climate region that are CARE customers is much larger than the share in the cool climate region.

extending well into the evening when temperatures are cooler and people are home, expected load impacts may be lower than those found in most prior studies.

Figure 3-4: Load Impacts as a Function of Peak-to-off-peak Price Ratios



Based on the above sample size calculations and a review of prior studies, the TOU Working Group decided to use a sample size of 1,000 treatment and 1,000 control customers for planning purposes for each customer segment for which estimates of the average load impact is desired.[11] As discussed in Section 3.3.4, customer attrition over the course of the pilots is planned to equal roughly 25 percent; so the pilot plan is to recruit roughly 1,250 customers to be recruited for each segment for which load impacts will be estimated so that roughly 1,000 will still remain on the rate in summer 2017. This analysis is based on sample sizes for estimating summer, peak-period load impacts. The confidence level for load impacts in other rate periods and for electricity use overall may differ.[12]

As indicated above, prior to implementation, each utility will estimate the sample sizes required to achieve a similar level of confidence for their customer population by segment and climate

[11] The segments of interest are discussed later in this section and also in Section 4.

[12] It should be noted that the Environmental Defense Fund argued for much larger sample sizes and greater precision based on the importance of accurate load impact estimates for resource adequacy planning. Their comments on this issue are contained in Appendix C. They also raised this issue during the final Working Group meeting. In response, Nexant indicated that the purpose of these pilots is to provide guidance for the default rates that may be implemented in 2019. The impacts resulting from the chosen rate, which is likely to be somewhat different from the exact rates implemented in these pilots, is what matters for resource adequacy planning. Those impacts should be estimated when the rate is implemented in 2019 or in conjunction with the 2018 default pilots when much larger sample sizes can be obtained at much lower cost than the cost of recruiting participants into opt-in pilots.

region. This analysis was already completed by Nexant for SCE several days prior to completion of this report. The analysis largely confirmed the sample size estimates calculated by Nexant for pilot planning purposes, based on a convenience sample of PG&E data, with the exception of cool climate zones. The analysis showed that the width of the confidence bands in SCE's cool climate region was roughly twice as large as the confidence bands in the moderate and hot climate regions. This is due, in large part, to the greater variability in peak period load during summer months in the cooler region combined with lower mean usage, meaning that the coefficient of variation (the ratio of the standard deviation to the mean) in the cool region is much larger than in the moderate or hot regions.

In order to have confidence bands in the ±2% range in SCE's cool climate region, sample sizes would need to double compared to the other two regions. Across three rate options and the control group, the additional recruitment requirement in the cool region would total roughly 5,000 participants at a likely cost of several million dollars. If similar results are found in PG&E and SDG&E's service territories, the total incremental cost of meeting the same level of precision in all three regions could easily exceed $5 million. There is no policy reason of which we are aware for determining load impacts at the climate region level. The decision about what default rate to offer in 2019 presumably will be based on average load impacts for the service territory as a whole, not for any particular climate region. The level of precision at the service territory level exceeds ±2% since sample sizes at this level are roughly 3,000 for each rate (for a total of 6,000 for the treatment and control groups combined). As such, Nexant recommended not incurring this additional cost to maintain the same level of confidence in the cool climate region as in the other climate regions. The reasonableness of this decision is underscored by the fact that Pub. Utility Code Section 745(c) and (d) only require findings relating to hot climate regions. This issue arose too late to take it up with the entire Working Group, but it was vetted with Energy Division and with all three IOUs, and representatives from those four groups agreed with Nexant's recommendation.

3.3.2 Sampling for Bill Impact Analysis

In addition to load impacts, another variable of interest is bill impacts. There is significant interest by the Commission and selected stakeholders regarding the bill impact of default TOU rates on selected customer groups, as discussed at greater length in Section 3.5. Of particular interest is the percent of customers in selected segments that might see their bills increase by large amounts (with *large* yet to be defined) to assess whether unreasonable hardship is caused for some customers by being on the TOU rate (with *unreasonable hardship* to be determined by the CPUC after reviewing the data from this pilot). Under default TOU pricing, even with no change in usage, nearly every consumer's bill will change relative to what it would have been on the otherwise applicable tariff (OAT) except for the mythical "average customer" who would see no bill impact going from the OAT to a revenue neutral TOU rate. The distribution of bill impacts after changes in usage will differ from the distribution based on no change in usage, depending on how much customers on the rate respond by reducing their load or by shifting it from peak to non-peak hours.

Figure 3-5 shows the distribution of bill impacts associated with a hypothetical TOU tariff. In the figure, negative values represent a bill decrease relative to the OAT and positive values

represent a bill increase. In this example, there is a small percentage of customers with bill increases exceeding 20%. It is these customers on the tail of the distribution, above some specified level (e.g., 15%, 20%, or some absolute amount such as $100 or $200), that may be of greatest interest from a policy perspective because they are the customers who will see their bills go up significantly under TOU rates and may be unlikely to obtain lower bills relative to the OAT regardless of how much they reduce or shift load during the peak period. Obviously, these are customers for whom it makes economic sense to opt-out of default TOU. As such, it is important that the sampling plan for the pilots be designed to characterize with reasonable accuracy the distribution of bill impacts for the population as a whole and that samples are large enough to determine the percent of customers that will see bill increases above some predetermined level.

Figure 3-5: Hypothetical Distribution of Bill Impacts

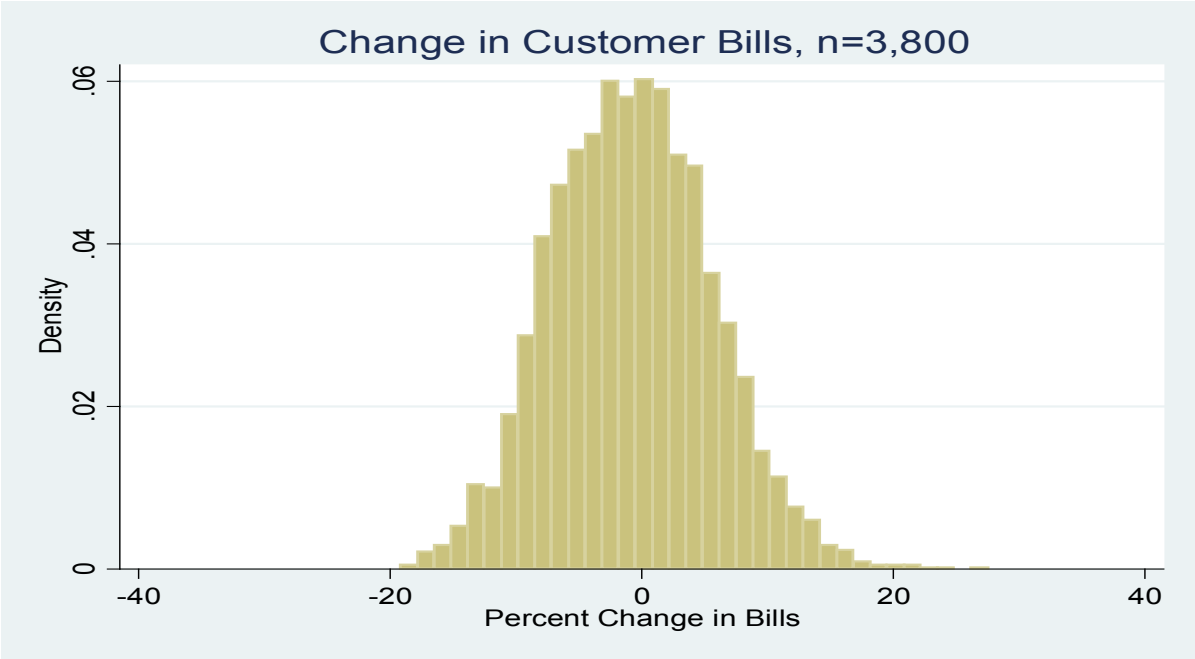


Figure 3-6 shows how the distribution of bill impacts varies with sample size for the same hypothetical tariff depicted in Figure 3-5. As seen, with very small samples, it is easy to miss the outliers that are of interest—those with high bill increases. In order to determine how large the sample size must be to adequately characterize the distribution of bill impacts for a specific customer segment of interest, it is necessary to have data on the bill impacts using pretreatment usage patterns. Because TOU rates were not finalized until quite late in the planning process, bill impacts could not be estimated in time to conduct this analysis prior to completing the report. The current operating assumption is that 500 observations will be adequate to accurately characterize the distribution of bill impacts for segments of interest and to produce reasonable confidence bands around the percent of accounts in each segment that experience bill impacts above a certain threshold. Prior to finalizing the sampling and recruitment plan, each utility will need to do the analysis necessary to either confirm this assumption or propose adjustments to the sample sizes (up or down) required to accurately characterize bill impact distributions.

Figure 3-6: Variation in Bill Impact Distributions with Sample Size

3.3.3 Sampling for Survey Questions

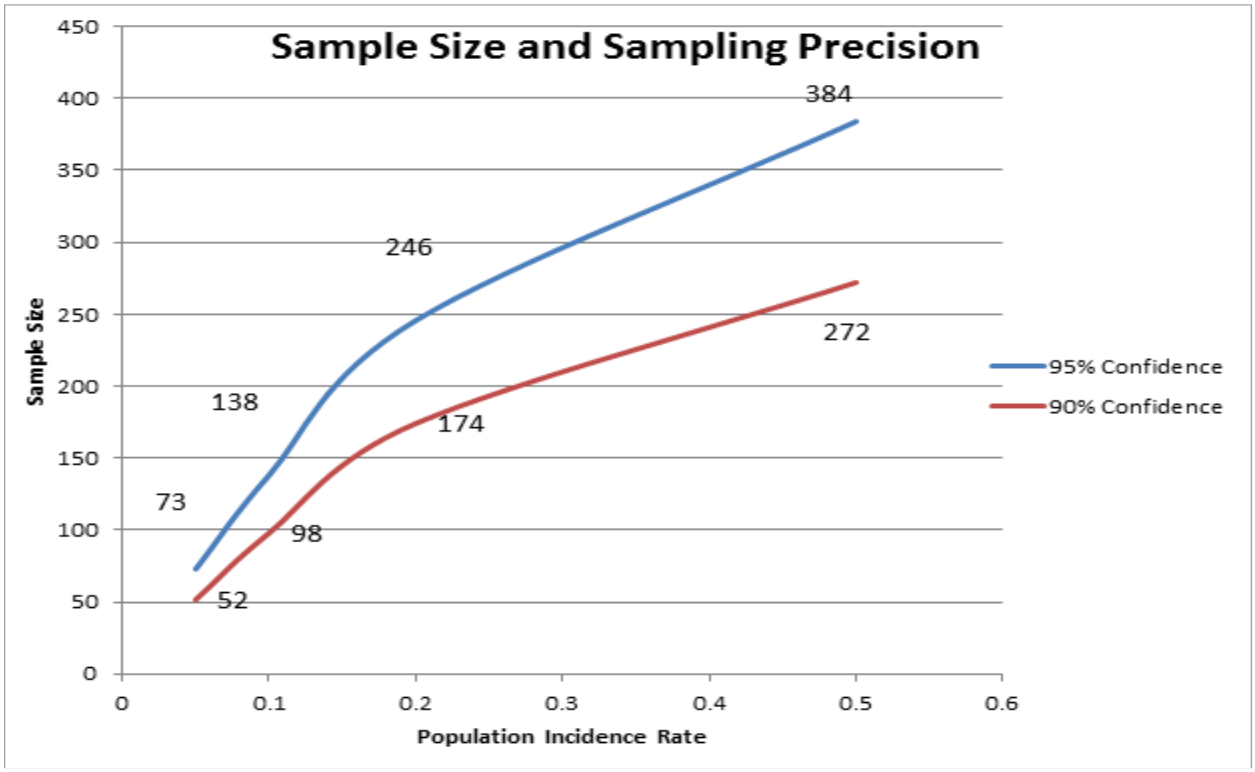
In addition to load impacts and bill impacts, decision makers will also rely on other metrics for evaluating potential pricing, technology, and education/outreach strategies. These metrics will typically involve survey questions pertaining to customer awareness, understanding of rate features, satisfaction, engagement through changes in behavior, actions driven by potential economic hardship, etc. Thus, it is important to consider sample size requirements needed to determine statistical differences in survey responses across treatments and customer segments.

There are two types of survey questions that will be used to investigate issues of interest: *categorical* and *continuous*. Categorical questions are used to quantify things such as customer characteristics (e.g., a respondent's senior status, housing type, etc.) and information about behavior that might have been driven by the treatments (e.g., Did you adjust your thermostat to reduce use in the afternoon). Continuous variables include scaler questions such as satisfaction ratings (e.g., On a scale from 1 to 10, how satisfied are you with the rate you are on), agree/disagree questions (e.g., On a scale from 1 to 10, where 1 means strongly disagree and 10 means strongly agree, please indicate your level of agreement with the following statement), and some customer characteristics information such as income, age, house size in square footage, etc. Sample size calculations differ depending on the type of variable.

For categorical variables, the required sample size is a function of the assumed incidence rate (e.g., the percent of people answering a question in a certain way) and the desired level of statistical precision and confidence. Figure 3-7 shows the relationship between sample size and incidence rate for a given level of precision and confidence. As seen in the figure, if the expected incidence rate is 5%, the required sample size to estimate the value with ±5% precision and 95% confidence is only 73. The required sample size is only 52 for 90% confidence. On the other hand, if the expected incidence rate is 20%, the required sample

size is roughly 250 for 95% confidence and about 175 for 90%. The required sample size jumps to around 385 and 275 respectively at an incidence rate of 50%.

Figure 3-7: Sample Size as a Function of Incidence Rate for Categorical Variables (±5% precision)



Sample size calculations for continuous variables vary depending on the mean and standard deviation of the answers. Table 3-3 shows how sample sizes differ with variation in the mean and standard deviation associated with actual responses from two questions that were included in a survey conducted by SMUD as part of the SPO pilot. The two questions involved a five-point, agree/disagree scale for questions pertaining to ease of understanding and perceived fairness of the pricing plans that were included in the pilot. The rows in the table pertain to the different treatment groups included in the SPO (e.g., default and opt-in TOU and CPP tariffs, etc.). The sample sizes in the far right column are based on ±5% precision and 95% confidence and differ based on the means and the variance of the survey responses. The sample sizes vary from a low of 180 to a high of 371, with the mean being 285. If the level of confidence were lowered from 95% to 90%, the required sample sizes would drop significantly, and would be below 100 participants for most groups and questions.

Table 3-3: Sample Size Requirements for Continuous Variables for Specific Questions and Treatments in SMUD's Smart Pricing Options Pilot

My current pricing plan is easy to understand

Category	N	1	2	3	4	5	Mean	Standard Deviation	Variance	Sample Size
control	300	0.25	0.313	0.263	0.137	0.037	2.40	1.11	1.24	330
default_CPP_(no_drop_outs)	163	0.247	0.381	0.212	0.11	0.049	2.33	1.11	1.23	348
default_CPP_TOU_(no_drop_outs)	141	0.256	0.423	0.186	0.123	0.013	2.22	1.00	1.00	314
default_TOU_(no_drop_outs)	417	0.275	0.386	0.177	0.134	0.028	2.25	1.08	1.18	356
deferred	736	0.258	0.419	0.204	0.089	0.031	2.22	1.02	1.05	328
opt_in_CPP_(no_drop_outs)	576	0.309	0.471	0.106	0.099	0.016	2.05	0.98	0.95	350
opt_in_TOU_(no_drop_outs)	1,017	0.35	0.438	0.118	0.075	0.02	1.98	0.97	0.95	371

My current pricing plan is fair

Category	N	1	2	3	4	5	Mean	Standard Deviation	Variance	Sample Size
control	300	0.167	0.277	0.367	0.143	0.047	2.63	1.07	1.14	253
default_CPP_(no_drop_outs)	163	0.225	0.393	0.276	0.087	0.019	2.28	0.97	0.94	278
default_CPP_TOU_(no_drop_outs)	141	0.167	0.41	0.305	0.087	0.032	2.41	0.97	0.94	249
default_TOU_(no_drop_outs)	417	0.182	0.38	0.272	0.137	0.029	2.45	1.03	1.06	271
deferred	736	0.196	0.333	0.313	0.121	0.038	2.48	1.05	1.11	279
opt_in_CPP_(no_drop_outs)	576	0.255	0.407	0.241	0.079	0.017	2.19	0.96	0.93	296
opt_in_TOU_(no_drop_outs)	1,017	0.265	0.396	0.221	0.094	0.023	2.21	1.01	1.02	322

Of course, there are many survey questions of potential interest for the pilots and it's impossible to guess what the expected incidence rate would be for categorical questions or what the means and standard deviations might be for continuous variables for all questions of interest. The pilot plan involves tying a portion of the PTP incentive to completion of surveys so survey response rates are expected to be high.[13] Based on the above analysis, treatment cells that are sized to a target enrollment of 1,000 customers in order to produce estimates of load impacts will certainly be large enough to produce a high degree of statistical precision and confidence for all survey questions of interest. As indicated in Figures 3-7 and 3-8, treatments and segments that will be assessed largely on the basis of survey data can be sized well below 1,000. Assuming a design standard of 90% confidence, a sample size of 250 should be adequate for nearly any survey question and incidence rate of interest.

[13] In California's Statewide Pricing Pilot conducted in 2003/2004, which also used a PTP approach and tied part of the incentive to survey response, the average response rate across numerous treatment cells was 90%. See Stephen S. George and Ahmad Faruqui. *Impact Evaluation of California's Statewide Pricing Pilot*. Final Report, March 16, 2005.

3.3.4 Oversampling for Attrition

An important factor affecting sample sizes and recruitment costs is the expected amount of attrition. It is necessary to factor attrition into the initial recruitment plan so that statistically valid impact estimates can still be obtained at least through the second summer of the pilot. Attrition in the pilots will be driven by two factors, account turnover from moving (or customer churn) and dropouts (participants who leave because they want to drop off the rate). Nearly all prior pilots with which we are familiar have had very low dropout rates, but customer churn can be 15% to 20% per year. For example, in SMUD's SPO pilot, the dropout rate was between 4% and 8% over two summers depending on the tariff; whereas customer churn ranged from 18% to 21%.

Given the fact that participants in the proposed pilots will be paid the largest part of the participation incentive either at the end of the first year or midway through the second,[14] dropout rates could be even lower than in the SMUD SPO pilot, at least until after the last incentive is paid. Participants will be allowed to stay on the pilot rates through the end of 2017, but from an evaluation perspective, the most valuable learnings after the end of the summer of 2017 will be what the dropout rate is once the final incentive payment has been made rather than what load impacts are in the fall of 2017. As such, the TOU Working Group concluded that over recruiting by 25% would be sufficient in each treatment cell relative to the target level of participation needed to estimate load impacts, bill impacts, or survey responses to the desired level of statistical significance. For example, for the moderate climate regions where the target enrollment rate for estimating load impacts is 1,000, 1,250 participants would be recruited to ensure that there are roughly 1,000 still on the rate during summer 2017.

3.4 Control Group Rate

Ordering paragraph 5 of D.15-07-001 required that, within 60 days of the decision, the three IOUs will file a Tier-2 Advice Letter setting forth the glide path for future rate changes to consolidate the tiers and implement the Super User Electric Surcharge. SCE, PG&E, and SDG&E filed such advice letters on September 1, 2015. The filings for all three utilities show a reduction in the number of tiers from the four-tier structure in place in 2015 and a significant reduction in the price differential between the baseline quantity (BQ) and the prices in effect up to 400% of the baseline quantity in 2019. Above 400% of baseline, a Super User Electric Surcharge comes into effect in 2017 with prices equal to roughly $0.40/kwh at PG&E and SCE and more than $0.50 at SDG&E. Table 3-4 shows the proposed glide path prices for the tiered rate for each utility in 2015, 2016, 2017 and 2019. The rate changes are to go into effect sometime between March and May each year from 2016 to 2019.

[14] The impact of payment schedule on acceptance rates will be investigated during the recruitment pretests in January.

Table 3-4: Glide Path Rates for Non-CARE Customers

	SCE ($/kWh)				PG&E ($/kWh)				SDG&E ($/kWh)			
Usage	2015	2016	2017	2019	2015	2016	2017	2019	2015	2016	2017	2019
0–100% of BQ	15.0	16.5	16.9	18.2	16.7	17.5	17.7	18.3	18.1	22.1	23.7	24.1
100–130% of BQ	20.9	25.2	25.9	23.3	19.8	21.7	24.4	23.0	20.5	22.1	23.7	24.1
130–200% of BQ	24.3	25.2	25.9	23.3	25.2	21.7	24.4	23.0	39.6	36.9	33.4	30.2
200–400% of BQ	30.2	29.8	25.9	23.3	32.1	31.9	24.4	23.0	39.6	36.9	33.4	30.2
>400%	30.2	29.8	31.8	40.8	32.1	31.9	33.8	40.3	39.6	36.9	38.9	52.9

For each utility, prices below 130% of baseline increase between 2015 and 2019 and prices between 130% and 400% of baseline decrease. For usage above 400% of baseline, prices fall modestly initially and then increase significantly when the Super User Electric Surcharge comes into effect, which occurs in 2017. Thus, customers on both the low end and the very high end of the usage distribution are likely to see bill increases between 2015 and 2019 while those in the middle are likely to see bill decreases (assuming no change in usage).

Among other things, the TOU pilots are intended to estimate the change in usage (and bills) for customers who are defaulted onto TOU rates in 2019. These TOU rates will be revenue neutral relative to the 2019 OAT shown in Table 3-4.[15] Given this, conceptually, it would seem logical to use the 2019 OAT as the rate for control group customers in the pilots and TOU rates that are revenue neutral relative to the 2019 OAT. However, this approach assumes that control group customers would adjust quickly to the change in the OAT relative to the 2016 OAT rate that will be in effect when the pilots are initiated so that their usage pattern reflects what customers would be using on the OAT after a four year period over which the tier structure gradually changes. There are reasons to believe that the change in usage in response to changes in a tiered rate structure is likely to happen much more slowly than would a change from an OAT to a TOU rate structure. If true, using the 2019 OAT and 2019 TOU rates in the pilots would not accurately reflect the TOU load or bill impact from a change in usage under the tiered rates in place in 2019.

There is substantial evidence from prior TOU pilots in other jurisdictions that residential customers can understand TOU prices quickly and make adjustments in peak period usage rapidly. For example, in the SMUD pilot, people were placed on the new rates on June 1. There were substantial load reductions in the first summer, and those impacts didn't change much in the second summer.[16] The timing of the CA Statewide Pricing Pilot many years ago was similar—people were placed on the rate very close to the summer rate period and load reductions were substantial in the first summer.

[15] In reality, it is likely that the actual rates in 2019 will differ from those shown in the table, as the final rates are yet to be approved.

[16] Stephen S. George, Jennifer Potter and Lupe Jimenez. *SmartPricing Options Final Evaluation*. September 5, 2014.

There is also evidence indicating that people have a lot of trouble understanding tiered rates and typically have no idea what tier they are in at any particular time or how prices change across tiers. In a survey conducted at the end of the SMUD SPO pilot, control group customers who were on a tiered rate (and had been for a long time) had the lowest score among all groups on the following question: "My current pricing plan is easy to understand." 56% of control group customers somewhat or strongly agreed with this statement whereas 63% to 68% of TOU default customers agreed and 78% of opt-in TOU customers agreed. On another battery of questions, control group customers had roughly the same level of accuracy (25%) in responding to questions about the characteristics of the rate they were on as default TOU[17] customers (20% to 30%) and much lower than opt-in TOU customers (42% to 48%). Most striking was that 56% of control group customers checked "don't know" to the question about rate characteristics, whereas only about one third of default customers checked "don't know" and only 20% of opt-in customers did. In short, the evidence suggests that tiered rates are harder for customers to understand compared with TOU rates. TOU pricing is common across many products in everyday life—movie prices, bridge tolls, parking, etc.—whereas tiered pricing is quite rare, especially increasing block pricing.[18]

With this in mind, if control customers were placed on the 2019 OAT at the same time that treatment customers were placed on the TOU rates, it's highly unlikely that the control group customers would modify their usage immediately to reflect the pattern of usage that customers would actually have in 2019 after going through four years of gradual changes in the tier structure. Given this, while one might think that basing the pilots on the 2019 OAT and TOU rates would produce a valid comparison of usage under the 2019 OAT with usage under the 2019 TOU rate, in fact it would more likely involve a comparison in usage under the 2019 TOU rate with usage under the 2016 OAT that control group customers will have been on for a couple of months before the start of the pilot. For these reasons, Nexant recommended that the pilot be based on the 2016 OAT and revenue neutral TOU rates relative to the 2016 OAT as a more valid basis for estimating TOU rate impacts than would using the 2019 OAT and TOU rates, which would more likely compare usage under the 2016 OAT with usage under the 2019 TOU rate.

A related decision concerned whether or not pilot rates, including the OAT, should be held constant over the course of the pilot or should be adjusted in 2017 according to the glide path rate adjustments that all non-pilot participants will experience (as shown in Table 304). Holding the rates constant through the end of 2017 and placing pilot participants back onto the 2017 OAT at a time not long before the 2018 glide path rate adjustment will occur could cause problems with large rate jumps for some consumers and multiple rate changes in a short time

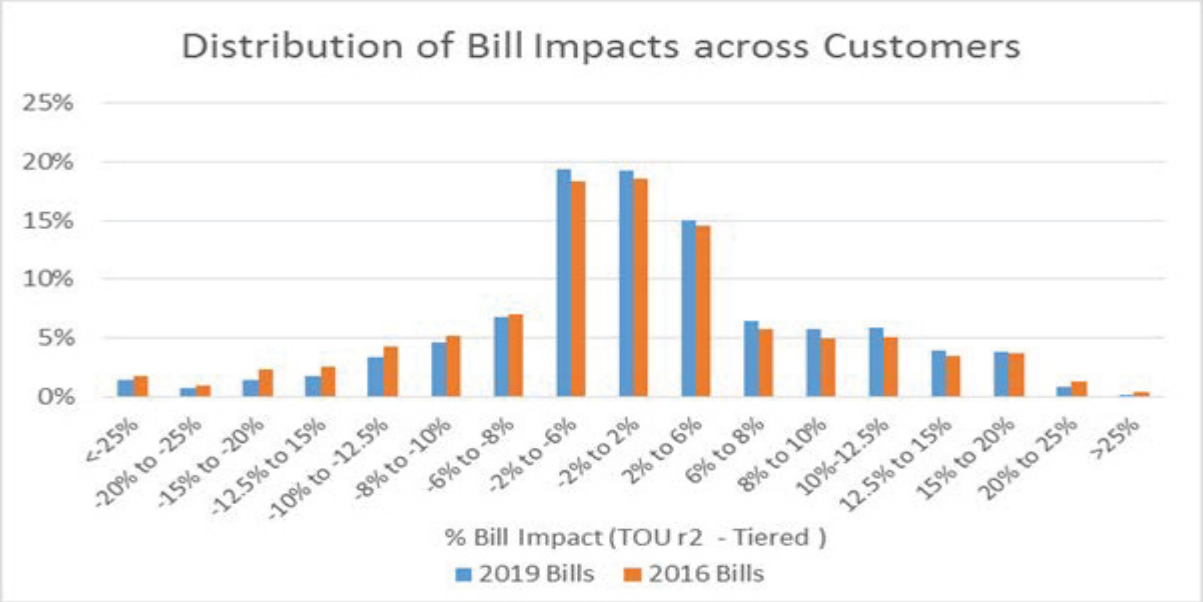
[17] Used here, TOU represents the combination of TOU, Critical Peak Pricing (CPP) and TOU-CPP rates included in the SMUD SPO.

[18] Volume discounts are, of course, quite common but these price changes are tied to quantities that consumers understand and that are easily communicated whereas for electricity pricing, in the absence of in-home displays or tier-alert services, consumers don't know what tier they are in nor can they easily relate how changes in usage would impact bills. With TOU rates, on the other hand, while these same challenges are relevant for the underlying rate structure, consumers can easily understand that electricity at certain times of the day costs, for example, twice as much as at other times of the day, and can make what many surveys suggest are relatively easy changes in certain usage patterns to reduce usage during high priced periods.

period for control group customers if the rates are held constant. For this reason, the OAT rates for control group customers will be allowed to adjust according to the proposed glide path and TOU rates will be adjusted in accordance with the OAT so as not to create anomalies between the treatment and control group tariffs.

Prior to accepting this recommendation, the Energy Division voiced concern about whether using these rates would materially distort what the bill distribution would look like under the 2019 rates, as insights regarding bill impacts will be important inputs to policy decisions. To address this concern, SCE produced distributions of bill impacts based on current usage (e.g., prior to shifting) using both the 2016 and 2019 rates. Figure 3-8 shows those two distributions. As seen, bill impacts based on pretreatment usage patterns are very similar under both the 2016 and 2019 OAT and TOU tariffs. As such, bill impacts based on post-treatment usage and the 2016 tariffs should produce a very close approximation to what the bill impact distribution would be under the 2019 tariffs after consumers on the OAT have had a chance to adjust their usage in response to the rate flattening that will occur gradually between 2016 and 2019.

Figure 3-8: Distribution of Bill Impacts Moving From OAT to TOU Rates Using 2016 and 2019 Proposed Tariffs



3.5 745 Segments and Customer Exclusions

A number of requirements embedded in Section 745 of the Public Utilities Code Section impose constraints on who will be recruited into the TOU pilots and also influence the sampling plan that will be used to recruit customers into the pilots. Practical implementation issues and other factors also influence who will be recruited.

3.5.1 Exclusions

P.U. Code Section 745(c)(1) excludes certain customers from being defaulted onto TOU rates without their affirmative consent. These customers include those who receive a medical

baseline allowance, customers requesting third-party notification pursuant to subdivision (c) of Section 779.1, and customers who the Commission has ordered cannot be disconnected from service without an in-person visit from a utility representative (Decision 12-03-054, March 22, 2012).

The cited decision, D.12-03-054, describes the vulnerable customer group that cannot be disconnected without an in-person visit to include Medical Baseline customers, Life Support Customers, and a broader group defined as follows (p. 30): "customers who certify that they have a serious illness or condition that could become life threatening if service is disconnected. We do not require the customer to produce a physician's statement in support of the certification; i.e., customers may self-certify as to the illness or condition." The decision goes on to analyze this group further and to specifically note that it is broader than the group of customers eligible for medical baseline, stating "the medical baseline designation alone may not be adequate to protect at-risk customers." This latter point recognizes that there are many households containing individuals who are not enrolled in programs such as medical baseline even though they might qualify or because they do not use above-average amounts of electricity.

IOU databases identify customers with medical baseline allowances, those that require third party notification, and those that have previously been determined to require an in-person visit prior to disconnection and these accounts will be excluded from the pilots because they are not subject to default TOU. In order to address concerns about households that may have disabled individuals living there that are not enrolled in medical baseline programs or that may include individuals who have not previously been identified but who would be subject to an in-person visit prior to disconnection, the TOU Working Group agreed that language would be included in the recruitment materials asking participants to self-certify at the time of enrollment into the pilot that losing power due to nonpayment would not put their health or safety at risk.[19]

In addition to the statutory exclusions summarized above, a number of other groups will be excluded from participating in the pilots for practical or other reasons, including:

- Direct access and community choice aggregation customers;
- Net metered customers;
- Customers that do not have a smart meter;
- Utility employees;
- Customers that are on an existing time-varying rates except for participants in SCE's Save Power Days peak time rebate, who will be included in the pilot recruitment sample.

For clarity, customers participating in each utility's load control programs (SmartAC at PG&E, Summer Discount Plan at SCE, and Summer Saver at SDG&E) will be included in the recruitment sample. Collectively, there are more than 500,000 residential accounts in these programs and prior research has shown that participants in load control programs have a higher

[19] It should be noted that this will need to be carefully crafted language so as not to suggest to potential participants that there is increased danger to the majority of customers that participating in the pilots will increase the likelihood of having their power cut off.

likelihood of also enrolling on time-varying tariffs and are more engaged in managing their energy use than nonparticipating households. Excluding these households from the pilots could bias downward the average load impacts that would be observed relative to what might occur under future default conditions when such customers will be included.[20]

Excluding customers with less than a year's worth of usage data from the pilots was considered by the Working Group but was rejected. As discussed below, this is an important issue because the pilots will oversample low income and CARE/FERA segments, which are likely to have higher average churn rates than the general population. Requiring that participants have at least a year's worth of data may significantly bias the population of participants in these segments relative to the full segment population. Not having a full year's worth of usage data means that a difference-in-differences analysis will not be able to be used to estimate impacts for all participants[21] and this could reduce the precision of the load impact estimates compared with planning assumptions. However, it was felt that trading off less bias for less precision given the importance of having these oversampled groups in the pilot was the right decision.

3.5.2 Customer Segmentation

Section 745(c)(2) of the Public Utilities Code, which was adopted in 2013 through Assembly Bill (AB) 327, states:

> "The commission shall ensure that any time-of-use rate schedule does not cause unreasonable hardship for senior citizens or economically vulnerable customers in hot climate zones."

A related section was added the following year through Senate Bill (SB) 1090, namely P.U. Code Section 745 (d), which states:[22]

> "The commission shall not require or authorize an electrical corporation to employ default time-of-use rates for residential customers unless it has first explicitly considered evidence addressing the extent to which hardship will be caused on either of the following:
>
> > (1) Customers located in hot, inland areas, assuming no changes in overall usage by those customers during peak periods.

[20] During pilot evaluation, impact estimates could be developed after excluding these customers from the sample to determine whether including or excluding them changes the average load impact.

[21] See Section 5.2 for an explanation of difference-in-differences.

[22] It should be noted that in 745(c)(2), passed in 2013 under AB 327, the phrase "unreasonable hardship" is used. And Section 745(d), added by SB 1090, which focuses solely on assuming no change in usage, refers to the considering "the extent to which hardship will be caused" in various different hot areas. The legislative history of SB 1090 shows that the legislature's concern was that the CPUC also specifically review summer bills in specific hot, inland areas, rather than on just on annual averages or through analyses that were not geographically focused. The reference to "seasonal bill volatility" in SB1090 also appears to indicate that the legislature was concerned with the difference between summer and non-summer bills.

> (2) Residential customers living in areas with hot summer weather, as a result of seasonal bill volatility, assuming no change in summertime usage or in usage during peak periods."

The TOU Working Group spent a significant amount of time discussing the sampling requirements and evaluation metrics that should be incorporated into the TOU pilot design to provide useful insights regarding the extent to which TOU rates might cause unreasonable hardship for seniors and economically vulnerable customers. There were strong differences of opinion regarding the definitions of seniors and economically vulnerable customers, about the metrics that should be used to assess hardship and about what constitutes unreasonable hardship.

With regard to the definition of seniors, no member of the TOU Working Group sought an age cut-off other than 65 years. However, some Working Group members argued to define senior households as those for which the "head of the household" or the service account holder is 65 or older. TURN argued that a senior household should be any household that had someone residing there who is 65 or older.[23]

With respect to economically vulnerable households, some stakeholders argued that this group should be defined as customers served on CARE/FERA tariffs. TURN argued that there are many economically vulnerable households who are not currently served on CARE/FERA tariffs and that the hot climate region sample should be stratified based on a broader definition that includes non-CARE/FERA households with low incomes. TURN also argued that there should be some stratification based on household income within the CARE/FERA segment.

Table 3-5 shows the number of seniors (defined by age of head of household),[24] non-seniors, CARE/FERA and non-CARE/FERA customers in SCE's hot climate region segmented further by income brackets tied to Federal Poverty Guidelines (FPG). Table 3-6 shows the FPG household income by family size. As seen in Table 3-5, there is not a clear correlation between income data reported by Experian/Acxiom that would qualify customer for CARE/FERA, on the one hand, and customer enrollment in these programs on the other. Of the 115,277 households with incomes less than 100% of FPG in SCE's hot climate region based on the Experian/Acxiom data, more than 40% (47,776) are not signed up for CARE/FERA tariffs. It is also clear that there is a wide distribution of income relative to the FPG within CARE/FERA and senior customer segments. Of the 223,450 CARE/FERA customers in SCE's hot climate region, roughly 30% have incomes below 100% of the FPG and another 30% have incomes greater than 250% of the FPG.

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[23] The three IOUs each have data purchased from either Experian or Acxiom that contains information on household income and persons per household by age. This information will be used to draw samples for segments of interest. However, actual segmentation within the pilots may be based on data gathered during enrollment.

[24] Basing the sampling on this definition does not take a position concerning whether this is the correct definition versus TURN's position that the segment should be defined by households that have anyone over 65 living there. By definition, there are more households in the population based on the latter definition than there are based on the former definition. Each definition can be used after the data is collected to determine whether there are differences in outcomes based on the two definitions.

Table 3-5: Number of Customers by Segment in SCE's Hot Climate Region

Household Income Relative to Federal Poverty Guidelines (FPG)	Non-Seniors			Seniors			All
	Non-CARE/FERA	CARE/FERA	All	Non-CARE/FERA	CARE/FERA	All	
<100% FPG	34,414	53,361	87,775	13,362	14,140	27,502	115,277
100%–200% FPG	52,697	47,266	99,963	15,500	10,954	26,454	126,417
200%–250% FPG	29,030	22,644	51,674	12,113	6,573	18,686	70,360
>250% FPG	130,643	53,180	183,823	66,570	15,332	81,902	265,725
Grand Total	**246,784**	**176,451**	**423,235**	**107,545**	**46,999**	**154,544**	**577,779**

Table 3-6: Federal Poverty Guideline Household Income by Household Size[25]

Household Size	100%	133%	150%	200%	250%	300%	400%
1	$11,770	$15,654	$17,655	$23,540	$29,425	$35,310	$47,080
2	15,930	21,187	23,895	31,860	39,825	47,790	63,720
3	20,090	26,720	30,135	40,180	50,225	60,270	80,360
4	24,250	32,253	36,375	48,500	60,625	72,750	97,000
5	28,410	37,785	42,615	56,820	71,025	85,230	113,640
6	32,570	43,318	48,855	65,140	81,425	97,710	130,280
7	36,730	48,851	55,095	73,460	91,825	110,190	146,920
8	40,890	54,384	61,335	81,780	102,225	122,670	163,560

Given that agreement could not be reached regarding the above definitions of customer segments, in a Scoping Memo and Ruling issued on October 15, 2015, the ALJ and Assigned Commissioner for Rulemaking 12-06-013[26] requested briefing on the definitions and requirements of Public Utility Code 745 in Phase 3 of the Proceeding. These issues were given priority because of their importance for TOU pilot design. In spite of this priority, a ruling will not be made until January 2016 at the earliest. As such, input from this decision cannot be used to guide TOU pilot or sample design at this time.

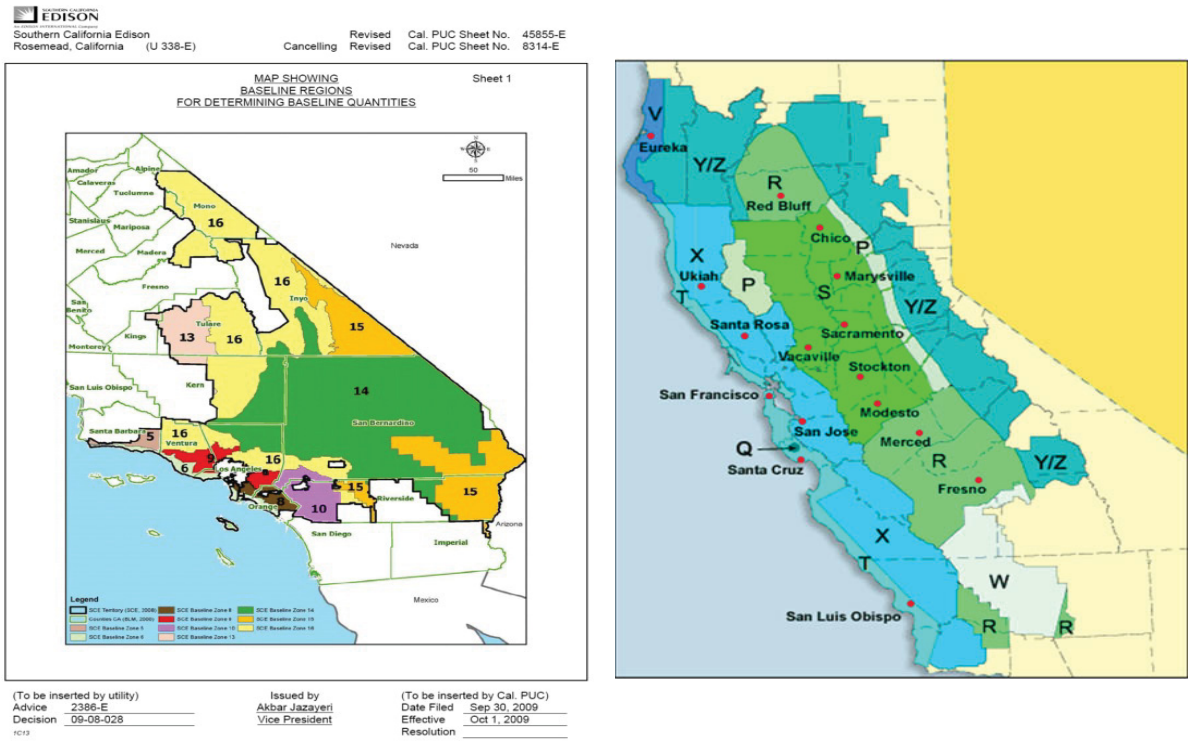
Working definitions of hot climate regions and "areas with hot summer weather" were discussed in early TOU Working Group meetings and were quickly agreed upon. The TOU Working Group decided that hot climate regions and areas with hot summer weather would be considered synonymous for purposes of pilot design and sampling. Figure 3-9 shows the climate zones used by each utility for rate purposes. For purposes of sampling for the TOU pilots, each utility will be stratified into three climate regions: hot, moderate, and cool. For PG&E, the hot region will be comprised of zones P, R, S, and W; in Figure 3-9, the moderate region will be comprised

[25] http://familiesusa.org/product/federal-poverty-guidelines

[26] http://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M155/K034/155034822.PDF

of zones Q, X, and Y; and the cool climate region will be zones T, V, and Z. In SCE's service territory, the hot region is comprised of zones 13, 14, and 15; the moderate region is 5, 9, and 10; and the cool region is 6, 8, and 16. SDG&E's hot climate region is comprised of the Mountain and Desert zones in Figure 3-9 and has only about 16,000 accounts in total.

Figure 3-9: Climate Zones



In early discussions around segmentation for purposes of assessing hardship for seniors and economically vulnerable customers in hot climate regions, certain stakeholders argued for drawing samples large enough in each segment to determine average load impacts for the segment with a high degree of statistical confidence and to be able to make statements about whether the average load impact for each segment is statistically different from the average for other segments. The initial proposals along these lines would have required samples of roughly 50,000 participants in each service territory. This would have been much more costly and difficult to achieve in the short time available for recruitment than the samples that were eventually agreed to.

Nexant argued that average load impacts are largely irrelevant to an assessment of hardship both because averages mask the underlying distribution of load and bill impacts and because load reductions are, at best, a very indirect indicator of potential hardship. Someone who is a large structural loser under TOU rates could have a very large load reduction and still incur an unreasonable hardship whereas someone who is a large structural winner will see a large bill reduction even if they do not change their usage at all. Nexant also argued that assessments of hardship should be based in large part on information gathered through surveys that more directly measure potential hardship through questions about behavioral changes that were made in response to high peak period prices (e.g., Did you turn off your air conditioning on hot summer days?), about discomfort on hot summer days, about tradeoffs that might be made in purchases of food and other necessities because of high electricity bills, etc. Nexant also recommended that the specific survey questions to be used for assessing potential hardship be based on a literature review of other studies with similar objectives and that the survey research firm used to obtain the information be skilled in this type of research. Some TOU Working Group members suggested aligning the survey questions with the Low Income Needs Assessment surveys that have been conducted in the past in California and that are currently being updated. Nexant also noted that an important advantage of using survey data to assess hardship is that sample sizes can be smaller than those required to estimate and compare average load impacts across segments.

There was broad agreement among TOU Working Group members that surveys will be used to provide valuable information for developing assessments of potential hardship for seniors and economically vulnerable customers in hot climate regions. Having accurate distributions of bill impacts is also important. TURN continued to express interest in being able to estimate average load impacts for segments such as CARE/FERA and perhaps others, particularly for customers who are structural losers in hot climate regions.

Another important factor influencing the sampling strategy is that sampling efficiencies can be obtained by recognizing that many customers represent multiple segments of interest. For example, if you want to have 500 CARE/FERA participants and 500 senior households in a sample, if 50% of seniors are CARE/FERA customers, only 750 sample points would be required, not 1,000.

With the above objectives and issues in mind, Nexant proposed to TURN and Energy Division the sampling strategy outlined in Table 3-7. The specific numbers in the cells were based on the data in Table 3-5.

The proposed approach has four oversampled segments in the hot climate region for Rate 2, which is the only SCE rate that will be subject to oversampling.[27] The four oversampled segments are seniors above and below 100% of FPG and CARE/FERA customers above and below 100% of FPG. As discussed in Section 3.3.3, the minimum requirement for the desired level of accuracy for survey-related questions such as those that will be used as input to assessing hardship is around 250. After adjusting for expected attrition, this minimum size is 313 at the outset of the pilots. Meeting this requirement only requires enrolling a total of 1,013 customers rather than the 1,250 would be needed if all segments were mutually exclusive. The proposed plan also calls for a target enrollment of 1,875 (1,500 plus 25% to cover planned attrition) drawn from the general population in the hot climate region. This sample will include many customers from the oversampled groups, which helps meet some of the other design criteria as discussed below.

[27] In order to better manage costs and enrollment requirements, the TOU Working Group decided that, given similarities in the structure of Rates 1 and 2 at SCE and PG&E, PG&E would oversample for Rate 1 and SCE would oversample for Rate 2.

Table 3-7: Target Enrollment for SCE Rate 2 in the Hot Climate Zone (includes over sampling based on 25% attrition)

Climate Zone	Customer Segment	Sample Size	Non-CARE/FERA	CARE / FERA	Senior	SR < 100% of FPG	CARE / FERA < 100% FPG	<100% FPG	101 to 200% FPG	200 to 250% FPG	> 250% of FPG	Control Group
Hot	SR < 100% FPG	313	152	161	313	313	161	313	0	0	0	313
	Non-SR CARE < 100% FPG	156	0	156	0	0	156	156	0	0	0	156
	SR > 100% FPG	313	232	81	313	0	0	0	65	46	201	313
	Non-SR CARE > 100% FOG	231	0	231	0	0	0	0	89	43	100	231
	General	1,875	1,150	725	502	89	219	374	410	228	862	1,875
	All	2,888	1,533	1,354	1,127	402	536	843	564	317	1,164	2,888
	% In Sample	100%	53%	47%	39%	14%	19%	29%	20%	11%	40%	
	% In Population	100%	61%	39%	27%	5%	12%	20%	22%	12%	46%	

The top half of Table 3-7 shows the breakdown of the enrolled population according to various segments, including additional income stratum defined in terms of household income as a percent of FPG. The two rows at the bottom of the table show the % of each cohort in the overall sample and the percent in the population. As seen, this plan significantly oversamples CARE/FERA, seniors and households with incomes less than 100% of FPG relative to their share in the hot climate region population overall. The following points are worth noting:

- The total number of enrolled customers on Rate 2 in the hot region is targeted at 2,888. A comparable control group is needed, which doubles the recruitment requirement for the rate.
- Of this total, given the over sampling of selected segments, the number of customers is fairly evenly split between CARE/FERA and non-CARE/FERA, with 1,354 and 1,533 respectively. Even after the expected attrition over the course of the pilot, this is more than enough to estimate average load impacts at desired levels of precision for CARE/FERA and non-CARE/FERA customers.
- The sample would start out with more than 1,100 senior households, which is enough to estimate load impacts for this group with good statistical precision.
- The proposed plan has very strong representation among various income groups defined in terms of the percent of FPG, starting out with a total population of roughly 843 households with incomes less than 100% of FPG, 564 with incomes between 100 and 200% of FPG, 3137 with incomes between 200 and 250% of FPG (a group just above the CARE/FERA household income threshold that is of interest to TURN), and more than 1,100 households with incomes exceeding 250% of FPG. These sample sizes are all quite robust in terms of drawing insights from surveys (assuming high response rates) and would even support precise load impact estimates for customers with incomes above and below 200% of FPG.
- These samples also exceed the assumed threshold of 500 (625 initially) required for estimating good bill impact distributions for almost all of the customer segments shown as columns in Table 3-7.

The basic segmentation scheme for the other rates in the hot region and for the two other climate regions is shown in Table 3-8. It has 1,250 enrolled customers on each rate in each region, divided equally between CARE/FERA and non-CARE/FERA. This meets the objective of initially having 625 in each sub-segment for the purpose of accurately characterizing the bill impact distribution and initially having 1,250 each for estimating load impacts by rate and climate region. The latter will require reweighting the sample using the population weights for CARE/non-CARE to get an estimate that represents the overall population within each region for each rate. This approach does not allow for a robust comparison of load impacts for CARE/FERA and non-CARE/FERA for each rate within each climate region but it does allow for such a comparison for the service territory as a whole, as seen at the bottom of Table 3-8, which shows that there are 1,875 CARE/FERA and 1,875 non-CARE/FERA for Rates 1 and 3 and more than 2,500 each for Rate 2.

Table 3-8: Target Enrollment by Rate Type, Climate Region and Customer Segment For SCE

Climate Zone	Segment	Rate 1	Rate 2	Rate 3	Control	Total
Hot	CARE / FERA	625	1,354	625	1,354	3,958
	Non-CARE / FERA	625	1,533	625	1,533	4,317
	Total	1,250	2,888	1,250	2,888	8,275
Moderate	CARE / FERA	625	625	625	625	2,500
	Non-CARE / FERA	625	625	625	625	2,500
	Total	1,250	1,250	1,250	1,250	5,000
Cool	CARE / FERA	625	625	625	625	2,500
	Non-CARE / FERA	625	625	625	625	2,500
	Total	1,250	1,250	1,250	1,250	5,000
All	CARE / FERA	1,875	2,604	1,875	2,604	8,958
	Non-CARE / FERA	1,875	2,783	1,875	2,783	9,317
	Total	3,750	5,388	3,750	5,388	18,275

The Nexant sampling plan summarized above was acceptable to all TOU Working Group members for SCE and PG&E. PG&E's plan will be conceptually identical to the above plan except the oversample segments will be placed on Rate 1 rather than Rate 2 and the precise number of customers in each cell shown in Table 3-7 will vary due to differences in the share of each segment in PG&E's hot climate region.

As mentioned previously, SDG&E''s hot climate region is much smaller than either SCE or PG&E's, with only roughly 16,000 total accounts. As such, oversampling selected segments to a specific level of enrollment is not possible. The details of the SDG&E sampling plan are described in Section 4.3.

3.6 Technology Treatments

There are a large number of specific technologies available through utility programs or, increasingly, through retail outlets that may help consumers respond to TOU price signals. The technologies fall into two broad categories:

- Devices that can automate changes in energy use across rate periods, such as load control devices, programmable communicating thermostats (PCTs), smart thermostats and home area networks;
- Devices that provide information to consumers through in-home displays (IHDs) that stream usage and cost data in near real time or through utility services that deliver periodic usage alerts, notifications, tips and other information through computers and smart phones.

As indicated earlier, the Energy Division strongly encouraged each utility to offer at least one technology oriented treatment in 2016 with the primary focus being on technology that can automate load reductions during peak periods. According to the September 24th AC/ALJ ruling, enabling technologies include, but are not limited to, programmable communicating thermostats, software packages and apps to help participating customers control energy use.

Numerous prior pilots and programs have combined various forms of load control with time-varying pricing. Most have involved load control switches or PCTs in conjunction with dynamic rates such as critical peak pricing. Nearly all of these prior pilots have shown that load impacts are larger for participants with air conditioning load control than for those without it. Relatively few prior studies have combined enabling technology with static TOU rates such as those that will be examined in these pilots. Also, it is very important to keep in mind that when comparing load impacts for the average household with and without air conditioning load control, for example, observed differences are influenced by more than just the load control technology. All households with air conditioning load control have air conditioning whereas many households on TOU rates without load control do not have central air conditioning, especially in California. As a result, the difference in load impacts for households with and without air conditioning load control reflects not just the difference due to the load control device but also the difference due to variation in the saturation of air conditioning between the two groups. Very few public studies on this subject adequately control for this significant selection effect.[28]

In addition to primarily focusing on enabling technology to support demand response for dynamic rates rather than static rates, prior studies have also primarily involved peak periods driven by high demand on hot summer afternoons. Very few have examined the impact of technology for peak periods that extend well into the evening hours, as is the case for some of the rates that will be tested in these pilots.

Finally, prior studies have primarily involved utility sponsored control devices, often provided and installed free of charge, and active control by utilities on dynamic pricing event days. We are not aware of any studies that have examined the incremental effect of customer purchased devices such as smart thermostats or simpler programmable thermostats, with or without outside control, on load reductions under static TOU rates or the impact of TOU rates on the purchase of smart thermostats. Increasingly, consumers are purchasing smart thermostats on their own. These devices may make TOU prices more attractive to these self-selected consumers and these consumers may use the devices to better manage their energy costs and produce larger peak-period load reductions. It may also be true that TOU rates, especially widespread default rates, will hasten the penetration of these devices. Furthermore, these devices offer opportunities for vendors and utilities to partner with consumers to automate adjustments in usage during peak periods. This is already happening in conjunction with dynamic rate programs at selected utilities. For example, Nest, a provider of smart thermostats,

[28] See for example Faruqui and Sergici. *Arcturus*. The Brattle Group. Figure 11 in the article shows load impacts from pilots and programs with and without load control but the points on the graph do not control for differences in air conditioning saturation between participants with and without technology. Also, many of the rates included in this graph are combination TOU-CPP rates rather than static TOU rates and the average impacts reflect both typical weekdays as well as CPP event days. As such, they may overstate the average impacts for a static TOU rate that has the same prices on all days.

offers its Rush Hour Rewards service to consumers in utility service territories where Peak Time Rebate (PTR) programs exist, such as SCE's Save Power Days (SPD) program. Nest automatically adjusts the consumer's thermostat according to directions provided by the consumer on PTR event days. It may be possible for utilities and vendors to develop similar services that enable demand reductions for consumers in conjunction with static TOU tariffs.

There was not sufficient time to do a systematic literature review concerning the use of in-home displays (IHDs), web portals, usage alerts and others options in conjunction with TOU rates. Nexant has designed, implemented and evaluated numerous information feedback pilots and programs for utilities in California and elsewhere and is generally familiar with the extensive literature in this area. From this work, Nexant offers the following general observations regarding the state of knowledge on information feedback options. These opinions were not shared in detail with the TOU Working Group and some Working Group members may disagree with some of these observations.

- There have been numerous studies of the impact of IHDs on overall energy use but very few studies that estimate impacts of IHDs on peak period usage in conjunction with TOU rates. Many IHD studies suffer from poor design and small sample sizes. Customers cannot be defaulted onto technologies such as IHDs. As such, is impossible to do a true RCT design with this technology. If acceptance rates and connection rates are high, an RED can be used for impact estimation. However, acceptance rates are often quite low and connection failures are often higher than expected or planned for even when the devices are installed by professionals. If consumers must to connect the device with the meter, evidence from the SMUD SPO pilot and from ComEd's default pricing pilot indicate that connection rates can be very low, which makes the cost of IHDs per connected household very high. Neither the SMUD or ComEd pilots found any measurable impact from IHDs in conjunction with TOU prices.
- Studying load impacts associated with accessing information through utility web portals is even more challenging than estimating impacts for IHDs. It is almost impossible to control access to web portal information, which makes RCTs very difficult to employ in this regard. Randomized encouragement designs could conceptually be used to test the impact of various offers for encouraging TOU rate participants to access web portals but, to our knowledge, few if any such studies have been done. Furthermore, most studies of web portal usage find that fewer than 25% of customers ever access the portals even once let alone the multiple times that behavioral scientists believe would be necessary to change usage in a measurable way. As such, very large samples would be necessary to estimate impacts, which are expected to be small (if they exist at all).
- There have been several recent studies of usage alerts, including two done by Nexant. One that was done for an anonymous utility in the Northeast found an average reduction in monthly energy use of roughly 2 percent from weekly usage updates and goal setting. This evaluation relied on ex post statistical matching to create a pseudo control group. Another series of tests done for Southern California Gas Company that are still ongoing found 1 to 2 percent reductions in average gas usage from weekly usage alerts offered on a default basis using an RCT design. Neither of these studies was done in conjunction with TOU rates.

With the above background in mind, the TOU Working Group decided on a set of technology treatments that will provide very useful input to setting policies and strategies for the future default TOU environment. The treatments, summarized briefly below and explained in more

detail in Section 4, involve both control technologies for air conditioning and information feedback in the form of usage alerts delivered via email in one case and using a smart phone app in another.

SCE's technology treatment will focus on smart thermostats and, more specifically, on the population of customers that already have these devices installed. Using an RCT design, SCE will seek to enroll 3,000 customers from the existing population of roughly 65,000 smart thermostat owners (in SCE's territory) using the same pay-to-play recruitment strategy that will be employed for the non-technology treatments. These customers will be randomly assigned to either Rate 1, Rate 3, or the control group. This will allow for estimation of load impacts associated with TOU rates among a population of smart thermostat owners. As discussed above, this is a growing population and could become an important segment of customers by the time default TOU rates are deployed in 2019.

SDG&E's technology treatment is designed to focus on customer acceptance rather than load response. SDG&E's treatment will be launched in the fall of 2016 after customers have experienced TOU rates for the first summer period. In this study, TOU rate customers will be offered one of two subsidy amounts if they purchase and self-install a smart thermostat. If enough participants purchase the technology, SDG&E will also estimate load impacts using a quasi-experimental evaluation method that will develop a pseudo-control group using ex post statistical matching. SDG&E also plans to test a usage alert treatment. This treatment is discussed in the next subsection, which discusses Education and Outreach options.

To complement SCE and SDG&E's technology treatments, and to expand on what can be learned through all three pilots, PG&E will explore two very different technologies in very different ways. PG&E will seek in-depth understanding of how consumers with smart thermostats who are on TOU rates operate and interact with these devices using an ethnographic study[29] of existing thermostat owners. PG&E estimates that it has at least 100,000 smart thermostat owners in its service territory, a group that is growing rapidly and will be even larger by the time pilot recruitment is completed. Given this penetration, if these consumers enroll onto the pilot tariffs at the same rate as non-owners, there will be between 300 and 400 smart thermostat owners enrolled on TOU rates among the 15,000 or so participants who will be recruited into the pilot. This is more than enough to recruit a small study group for ethnographic exploration. While, by its very nature, it is hard to predict what will be

[29] Ethnography is a collection of qualitative methods that focus on the close observation of social practices and interactions. As a result of focusing on details of individual's experiences, ethnography allows the researcher to see beyond received understandings of how a certain process or situation is supposed to work or what it is supposed to mean, and learn about the meanings that its participants ascribe to it. For example, an ethnographer interested in how a student does research would ask her to describe a particular research experience she has had, or spend time with her as she is trying to do research in the library. When the researcher spends time with the student as she works on her computer, watching her click from her assignment to Google to her evolving paper, the researcher gains rich detail about the student's lived experience of the research process. This kind of Observation helps the researcher see how the student understands and does research, and what she values as she goes about it. Ethnography's unique contributions to qualitative research are that it allows the researcher to tell a group's story from the point of view of participants by deeply examining the context in which activities occur, usually involving work by the researcher with participants as they go about their daily lives. Taken from Andrew Aker and Susan Miller. *A Practical Guide to Ethnographic Research in Academic Libraries.* http://www.erialproject.org/wp-content/uploads/2011/03/Toolkit-3.22.11.pdf

learned from an ethnographic study, this exploration could provide very useful insights regarding how to educate TOU customers about the use of smart thermostats for better managing their energy costs under default pricing.

PG&E's second technology treatment will assess customer acceptance of a multi-functional smart phone app that will convey a variety of useful information to TOU participants, potentially including pricing information, TOU-specific performance feedback, energy saving tips informed by user-specific end use load disaggregation and "gamification" features to encourage energy savings or load shift. This information-oriented technology treatment has the potential to increase load impacts for customers on TOU rates. However, even if it doesn't increase load impacts, it could improve overall satisfaction with, acceptance of, and understanding of TOU rates and, if widely accepted, might logically become a basic component of education and outreach for default TOU customers. On the other hand, if it is only adopted by a small group of tech savvy consumers, it might not be worthy of investment as part of the mainstream offer down the line. Thus, one of the primary learnings from this treatment will be to determine what the acceptance rates are across various customer segments, climate regions, usage levels and rate options.

PG&E plans to divide rate participants into two equally sized groups and to offer the technology to all enrolled participants across all rate options and customer segments in one group. Understanding whether the acceptance rate is 5% or 50% and learning through surveys what TOU customers think of this type of service and whether it increases satisfaction and acceptance of the rates will be extremely useful for planning education and outreach strategies. If the acceptance rate is high, this randomized encouragement design (RED) can be used to estimate load impacts associated with the smart phone app and also to compare customers' satisfaction and other metrics between those who do and don't receive the offer of the app. If the acceptance rate is low, a quasi-experimental evaluation method involving ex post statistical matching can be used to develop a control group that has load characteristics similar to those who accept the app and to estimate load impacts for those who take the app.

3.7 Customer Education and Outreach

Customer education and outreach (E&O) is essential to achieving one of the primary objectives of deploying TOU rates and related treatments, which is to encourage demand reductions during high cost periods (and increasing usage during excess supply conditions). This is especially true with default pricing where, in the absence of a strong E&O initiative, many customers might not even be aware that their electricity tariff has changed. But even if aware, electricity consumers may need significant help understanding the key features of complex tariff structures, must be informed when seasonal rate changes occur, and need education about actions they can take to better manage their electricity bills. Education and outreach is also useful for meeting the objective of customer acceptance and comfort with a given TOU rate.

There are many E&O options that could be employed to educate consumers and there are a variety of objectives to which they can be applied. Depending on the objectives and options employed, different metrics may be required to assess E&O effectiveness. The E&O plans of

each utility are described in Section 4 and the evaluation metrics that will be used to assess E&O options are discussed in both Sections 4 and 5.

The TOU Working Group recognized that a key objective of E&O efforts leading up to default TOU pricing will be to create awareness that consumers will soon be placed on a time-varying rate, the Working Group also recognized early on that this type of E&O is not something that can be tested through the opt-in pilots that will be implemented in 2016. Every opt-in participant is necessarily aware of being on a new rate whereas not every default customer will be aware regardless of how good the awareness program is. Furthermore, many of the E&O options that will be employed leading up to default pricing are likely to involve mass media communications which is very hard to test in a pilot setting because it is very difficult to control mass media exposure. For these reasons, E&O for purposes of generating awareness about being defaulted on a TOU rate will not be tested in 2016. It will be an important consideration for testing during the default pilots in 2018.

The TOU Working Group discussed the tradeoffs associated with offering E&O options to some participants and not to others for purposes of quantitative assessment of the relative effectiveness of the options. There was widespread agreement that highly effective E&O is essential to the overall success of the pilots (and to TOU pricing more broadly). Working Group members also generally agreed that, with a couple of exceptions, it is more important to ensure that the vast majority of participants receive highly effective E&O than it is to withhold E&O offerings for purposes of measuring effectiveness. Some stakeholders argued that “everyone should get everything” while some (including Nexant) thought that rigorous effectiveness tests should be conducted at least on a limited basis.

Another important issue considered by the Working Group was the extent to which the content and formatting of E&O materials should be tailored to specific customer segments. The Center for Accessible Technology argued that all materials should have key information in large font (14 point, Sans Serif style font) so that seniors and perhaps others can easily read the main points of the message. Most stakeholders agreed that materials should be available in Spanish as well as English. There was general acknowledgement of the value of tailoring tips to selected groups so that they are more relevant, such as low or no cost tips for low income households and renters.

Late in the planning process, Energy Division indicated that E&O materials must be tailored to appeal to the psychographic/behavioral personas that the IOUs often use for profiling households for purposes of channel communication and messaging. For example, messaging for households identified as “green” might extol the environmental benefits of TOU pricing and/or smart thermostats in marketing and educational materials, messaging to “economizers” would focus on bill savings and messaging to “technology focused” households might emphasize the cutting edge nature of the smart phone app and the learning features of smart thermostats. How best to implement this requirement to tailor messages to segments defined by personas and how many different personas should be tailored to will be determined as the IOUs develop the E&O materials in early 2016.

Nexant argued that some rigorous tests should be conducted in order to determine whether tailoring for psychographic/behavioral personas improves customer acceptance and/or understanding of rates and/or changes behavior more for those who receive the tailored messages than if more generic messaging and content was used for everyone. Whether any such tests will be conducted remains an open question at this time. At a minimum, as part of the evaluation process, metrics will be reported for selected personas to determine whether levels of satisfaction, understanding of rates and changes in behavior differ across these segments. Of course, in the absence of rigorous testing along the lines described above, it will not be possible to determine whether any observed differences are the result of the tailored messaging and content or simply the result of differences in the attitudes, preferences and behavior of the persona segments.

With the above considerations in mind, in January and early February, each IOU will develop a portfolio of E&O materials, including welcome kits and ongoing communications. The IOUs will share their materials with the TOU Working Group and seek their feedback. These materials will be sent to all participants with the goal of ensuring that they have a good understanding of key rate features and are educated about actions they can take to reduce their bills under TOU rates. The messaging and content of these materials will be tailored as appropriate and feasible to the interests and needs of psychographic/behavioral personas and to low income, seniors and perhaps other segments. Spanish language materials, and possibly materials in other languages, will be available. The effectiveness of these basic E&O materials will be assessed through surveys that gather information about participant perceptions of the usefulness of the materials and other metrics such as customer satisfaction, level of understanding of key rate features and possibly other metrics. These assessments will largely be informative, not comparative, unless the IOUs decide to vary at least some of the materials across customers within selected segments as discussed above.

During the Working Group process, SCE indicated that it plans to do a comparative test between a basic and advanced educational curriculum. As of this writing, Energy Division and SCE were still discussing what constitutes basic and advanced in this context. Once decided, the relative effectiveness of the two levels of education will be assessed using surveys and metrics associated with customer satisfaction, understanding of rate features, reported behavioral changes and perhaps others. SDG&E is also exploring the possibility of testing different types of welcome kits as discussed in Section 4.3.3.

As discussed above in Section 3.6, PG&E plans to test a smart phone app, which can be categorized as both a technology and an information treatment. This app will be evaluated using similar survey-based metrics as those described above but in this case, half the population will get the app and the other half won't. This will allow PG&E to assess whether the information delivered through the app produces greater load reductions relative to consumers on TOU rates who do not receive information through the app.

Finally, SDG&E plans to conduct a quantitative test of the impact of usage alerts on load impacts for customers on TOU rates. The alert treatment will be a TOU version of an alert service that SDG&E already provides to approximately 45,000 residential customers. The weekly alert email will include bill to date and projected bill, weekly electric use, and usage by

rate period. This treatment will be deployed on a default basis using email addresses that will be gathered during enrollment into the pilot. Customers will be randomly assigned to the treatment or control condition and impacts will be estimated using an RED analysis.

4 Pilot Plan

Section 3 summarized a wide variety of issues that were considered by the TOU Working Group in developing the rate, technology and education and outreach treatments that will be examined in the various TOU pilots starting in 2016. High level summaries of the treatments were also presented in some instances. This section contains some additional details about the specific treatments and research strategies that will be implemented by each utility.

4.1 SCE Pilot Plan

SCE will estimate load impacts for three rate plans in each of three climate regions. Average load impacts will be estimated for CARE/FERA and non-CARE/FERA customers for the service territory as a whole. In addition, SCE will estimate load impacts for customers with smart thermostats on TOU rates relative to customers with smart thermostats on the OAT. In SCE's hot climate region, the participant population for SCE's Rate 2 will be segmented according to household income relative to the Federal Poverty Guidelines (FPG), with over sampling done for CARE/FERA customers and senior households above and below 100% of the FPG. Within the hot climate region, samples will be large enough to estimate average load impacts for CARE/FERA and non-CARE/FERA households and for senior and non-senior households with confidence bands in the range of ±2%. Bill impact distributions will be produced for CARE/FERA and non-CARE/FERA customers for each rate in all three climate regions, for senior and non-senior households in the hot climate region, and for households with incomes above and below 100% of FPG in the hot climate region. SCE's E&O plans will test the relative effectiveness of a basic and advanced educational curriculum based on survey data concerning awareness and understanding of rate features, differences in usage behavior and other metrics. The assessment will not be gauged based on differential load impacts.

4.1.1 SCE Rate Treatments

SCE's three rate options are summarized in Figure 4-1. The prices shown in the figure do not reflect the credit of 10.6¢/kWh for usage below the baseline quantity in each climate zone. This credit significantly reduces average prices, especially for lower usage customers.

Rate 1 has three rate periods on summer weekdays and two on spring/winter weekdays. The peak period on Rate 1 is the same all year long and runs from 2 to 8 PM. In summer there is also a partial peak period that runs from 9 AM to 2 PM and from 8 to 10 PM. The peak to off-peak price ratio (ignoring the baseline credit) is roughly 1.5 to 1 in summer and is about 1.2 to 1 in spring/winter. Customers on SCE's Rate 1 will pay off-peak prices on weekends in spring and winter. In summer, partial peak prices are in effect on weekends from 8 AM to 10 PM, which is the time period covered by the combination of peak and partial peak prices on weekdays.

SCE's Rate 2 has three rate periods on weekdays all year long, has a much shorter peak period on weekdays and has significantly higher peak period prices in summer compared with Rate 1. The peak period runs from 5 to 8 PM. Rate 2 also features a super off-peak price of roughly 17¢/kWh between 10 PM and 8 AM on weekdays all year long. The ratio of peak to super-off-peak prices in the summer is roughly 4 to 1. In spring and winter, the peak-to-super off-peak

price ratio is roughly 1.7 to 1. On weekends, customers will pay the off-peak price between 8 AM and 10 PM and the super off-peak price during the same overnight hours as on weekdays, from 10 PM to 8 AM.

Rate 3 has a peak-period length of five hours, which is in between the peak-period length for Rates 1 and 2. In addition, the peak period starts later in the day compared with Rate 1, and extends further into the evening (until 9 PM) than either of the other pilot rates. The weekday peak-to-off-peak price ratio in the summer on Rate 3 is roughly 2.5 to 1. Another difference between Rate 3 and the other rates is the presence of super off-peak pricing between 11 AM and 4 PM in spring, when excess supply conditions may exist in California. On weekends, Rate 3 has two rate periods in summer and three in spring and winter. The peak period on weekends shown in Figure 4-1 has a different color compared with weekday peak periods because the prices on weekends don't match any of the prices during peak, partial, off-peak or super-off-peak periods.

Figure 4-1: SCE Pilot Tariffs

Weekday Rate Periods (hour ending -- for example, 16 = hour ending at 4 PM)

Tariff	Season	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
SCE Rate 1	Spring	Off Peak (23.9¢)														Peak (28.7¢)						Off Peak (23.9¢)			
	Summer	Off Peak (24.9¢)								Partial Peak (29.8¢)						Peak (37.3¢)						PP (29.8¢)		Off Peak (24.9¢)	
	Winter	Off Peak (23.9¢)														Peak (28.7¢)						Super Off Peak (23.9¢)			
SCE Rate 2	Spring	Super Off Peak (17.2¢)								Off Peak (26.6¢)									Peak (29.1¢)			OP (26.6¢)		Super Off Peak (17.2¢)	
	Summer	Super Off Peak (17.1¢)								Off Peak (31.7¢)									Peak (68.9¢)			OP (31.7¢)		Super Off Peak (17.1¢)	
	Winter	Super Off Peak (17.2¢)								Off Peak (26.6¢)									Peak (29.1¢)			OP (26.6¢)		Super Off Peak (17.2¢)	
SCE Rate 3	Spring	Off Peak (23.2¢)											Super Off Peak (16.7¢)					Peak (28.7¢)					Off Peak (23.2¢)		
	Summer	Off Peak (23.2¢)											Partial Peak (28.7¢)					Peak (59.1¢)					PP (28.7¢)		OP (23.2¢)
	Winter	Off Peak (23.2¢)																Peak (26.7¢)					Off Peak (23.2¢)		

Weekend Rate Periods (hour ending -- for example, 16 = hour ending at 4 PM)

Tariff	Season	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
SCE Rate 1	Spring	Off Peak (23.9¢)																							
	Summer	Off Peak (24.9¢)								Partial Peak (29.8¢)														Off Peak (24.9¢)	
	Winter	Off Peak (23.9¢)																							
SCE Rate 2	Spring	Super Off Peak (17.2¢)								Off Peak (26.6¢)														Super Off Peak (17.2¢)	
	Summer	Super Off Peak (17.1¢)								Off Peak (31.7¢)														Super Off Peak (17.1¢)	
	Winter	Super Off Peak (17.2¢)								Off Peak (26.6¢)														Super Off Peak (17.2¢)	
SCE Rate 3	Spring	Off Peak (23.2¢)											Super Off Peak (16.7¢)					Mid Peak (26.8¢)					Off Peak (23.2¢)		
	Summer	Off Peak (23.2¢)																Mid Peak (26.8¢)					Off Peak (23.2¢)		
	Winter	Off Peak (23.2¢)											Super Off Peak (16.7¢)					Mid Peak (26.8¢)					Off Peak (23.2¢)		

Table 4-1 shows the enrollment targets for Rate 2 and for the control group by customer segment in SCE's hot climate region where over sampling of seniors and economically vulnerable customers is required in order to assess potential hardship for these segments. Recall from the discussion in Section 3.5 that, in order to keep pilot costs down, a decision was made to include P.U. Code Section 745-driven segmentation for Rate 1 in PG&E's service territory and for Rate 2 in SCE's service territory. The third column in Table 4-1, labeled "sample size," shows the target recruitment level for each segment and for the general population. All of the other columns represent the number of customers that would be enrolled if customers represented by the column headings enroll at the same rate as their share in the segment population. For example, enrollment will be managed so that approximately 313 seniors with incomes below 100% of FPG will be enrolled. Since roughly half of seniors with incomes below 100% of the FPG are also CARE/FERA customers, and assuming that CARE/FERA and non-CARE/FERA customers in this segment enroll at roughly the same rate, this will result in enrollment of roughly 152 non-CARE/FERA and 161 CARE/FERA seniors with incomes below 100% of the FPG.

Table 4-1: Target Enrollment for SCE Rate 2 in the Hot Climate Region (includes over sampling based on 25% attrition)

Climate Zone	Customer Segment	Sample Size	Non-CARE/FERA	CARE / FERA	Senior	SR < 100% of FPG	CARE / FERA < 100% FPG	<100% FPG	101 to 200% FPG	200 to 250% FPG	> 250% of FPG	Control Group
Hot	SR < 100% FPG	313	152	161	313	313	161	313	0	0	0	313
	Non-SR CARE < 100% FPG	156	0	156	0	0	156	156	0	0	0	156
	SR > 100% FPG	313	232	81	313	0	0	0	65	46	201	313
	Non-SR CARE > 100% FPG	231	0	231	0	0	0	0	89	43	100	231
	General	1,875	1,150	725	502	89	219	374	410	228	862	1,875
	All	2,888	1,533	1,354	1,127	402	536	843	564	317	1,164	2,888
	% In Sample	100%	53%	47%	39%	14%	19%	29%	20%	11%	40%	n/a
	% In Population	100%	61%	39%	27%	5%	12%	20%	22%	12%	46%	n/a

Table 4-2 shows the target enrollment rate for all tariffs, customer segments and climate regions in SCE's service territory. These enrollment rates are designed to meet the minimum required sample sizes for each segment and tariff through the summer of 2017 based on an assumed maximum attrition rate (including customer churn and dropouts) of 25% and an assumption that the attrition rate will be the same in all test cells. As seen, the pilot plan calls for recruiting more than 18,000 customers into the study, with almost 13,000 being placed on one of the three pilot rates and with the remainder being placed on the OAT. These values do not include over sampling for the smart thermostat treatment that is discussed in Section 4.1.2 below. Roughly 45% of all participants will be in the hot climate region. With this target enrollment level, there should still be roughly 15,000 customers on the rates during the summer of 2017.

Table 4-2: Target Enrollment by Rate Type, Climate Region and Customer Segment

Climate Zone	Segment	Rate 1	Rate 2	Rate 3	Control	Total
Hot	CARE / FERA	625	1,354	625	1,354	3,958
	Non-CARE / FERA	625	1,533	625	1,533	4,317
	Total	1,250	2,888	1,250	2,888	8,275
Moderate	CARE / FERA	625	625	625	625	2,500
	Non-CARE / FERA	625	625	625	625	2,500
	Total	1,250	1,250	1,250	1,250	5,000
Cool	CARE / FERA	625	625	625	625	2,500
	Non-CARE / FERA	625	625	625	625	2,500
	Total	1,250	1,250	1,250	1,250	5,000
All	CARE / FERA	1,875	2,604	1,875	2,604	8,958
	Non-CARE / FERA	1,875	2,783	1,875	2,783	9,317
	Total	3,750	5,388	3,750	5,388	18,275

4.1.2 SCE Technology Treatments

As discussed in Section 3.6, SCE's technology treatment will focus on smart thermostats and, more specifically, on the population of customers that already have them installed. SCE will seek to enroll approximately 3,750 customers (including an extra 25% to account for attrition) from the existing population of roughly 65,000 smart thermostat owners using the same pay-to-play recruitment strategy that will be employed for the non-technology treatments. A power-analysis will be conducted to determine final sample sizes. These customers will be randomly assigned to Rate 1, Rate 3 or the OAT. The OAT assigned group will be the control group used for load impact estimation since smart thermostat owners may have different load patterns than the general participant population and the control group for the general participant population would not be valid. This RCT design will allow for estimation of unbiased load impacts for the TOU rates for a population of smart thermostat owners.

There will not be any segmentation by climate region or customer segment for this treatment since the identities of most smart thermostat owners is not currently known to SCE. As such, pre-enrollment segmentation is not possible. SCE will rely on smart thermostat vendors to distribute the recruitment letters to equipment owners.

4.1.3 SCE Education and Outreach Plans

As discussed previously, customers who agree to participate in the pilot will be randomly assigned to one of three TOU rates or to the OAT. Prior to being transferred onto the new rate, all participants will receive a welcome kit that will thank them for their participation and inform them about their rate assignment. The specific content of the welcome kit will be determined at a later date, most likely based on market research to guide creative design. For the three groups that are assigned to one of the TOU rate options, the welcome kit it is likely to include:

- A reminder of the importance of the study in terms of guiding pricing policy in CA and that all consumers will be placed on TOU rates on a default basis starting in 2019;
- A thank you for their participation;
- The date on which they will be placed on the new tariff;
- Detailed descriptions of the time periods when various prices are in effect for each season;
- A general discussion of how they might be able to reduce their energy bills by shifting usage from higher priced to lower priced time periods;
- Tips on how to reduce peak period usage through load reductions and load shifting;
- Information about the planned surveys, their importance to the study and the fact that the incentive payments are tied to completing each survey; and
- A dedicated phone number that they can call if they have any questions about the pilot or if they want to drop out of the study.

SCE is also considering including a magnet or “static cling” insert that can be affixed to a dishwasher, clothes washer or dryer or some other location to remind household members when peak and off-peak prices are in effect.

Control group customers will also receive a “welcome kit” but this will be much shorter and will focus primarily on thanking them for their participation, reminding them that their participation in the planned surveys is quite important and that their participation incentive payments are tied to completing those surveys.

In addition to this basic welcome kit, a subset of participants[30] will receive an advanced educational curriculum. Details about what constitutes basic and advanced are yet to be determined but basic will be more than just a welcome kit and will include some type of ongoing communication over the course of the pilots.

[30] The number of participants who will receive the advanced curriculum is still under discussion. ED would like it to be the majority of participants, with only a small group of participants (say 1,000) receiving the basic material.

The effectiveness of both the basic and advanced curriculum will be assessed through a survey. Effectiveness will not be gauged by load impacts. The details of the survey will be determined at a later date[31] but will likely focus on participants' awareness of being on the rate, their understanding of rate features (e.g., TOU periods, periods when prices are lowest, differences in prices on weekdays and weekends and across seasons, the block rate structure for control group participants, etc.), their specific end uses at various times of the day (to see if the advanced materials results in different behaviors), their satisfaction being on the rate and interest in staying on it, and more.

When developing the welcome kits and other educational materials to be sent to pilot participants, SCE will take into consideration the needs of special interest groups including, but not necessarily limited to, renters, low income, seniors and non-English speaking customers. These groups will be identified through questions included in the enrollment survey.

For low income participants, education (including messaging) will be very similar to that of the general pilot population except that the recruitment letter/FAQs will include language to let them know that they will not lose their CARE/FERA discount if they agree to participate in the pilot. For seniors, SCE is considering including imagery that resonates with this segment in the welcome kit and other follow up educational materials. Messaging will be similar to that of the general participant population. SCE is considering enlarging the font size to provide an enhanced customer experience for this segment.

SCE's strategy for non-English speaking participants is contingent on how many participants request educational materials in their preferred language during enrollment. SCE plans to limit language preference options to Spanish, Chinese, Korean and Vietnamese. Should very few customers state a language preference other than English at the time of enrollment, the educational materials will be sent in English and participants will be given the opportunity to go online to review the materials in their preferred language. Participants will also be able to contact SCE's call center and address any questions or concerns in their preferred language. SCE is also looking into providing follow up surveys in customers' preferred language.

4.2 PG&E Pilot Plan

PG&E will estimate load impacts for three rate plans in each of three climate regions. Average load impacts will be estimated for CARE and non-CARE customers for the service territory as a whole. In PG&E's hot climate region, the participant population for Rate 1 will be segmented according to household income relative to the Federal Poverty Guidelines, with over sampling done for CARE/FERA customers and senior households above and below 100% of the FPG. Within the hot climate region, samples will be large enough to estimate average load impacts for CARE/FERA and non-CARE/FERA households and for senior and non-senior households with confidence bands in the range of ±2%. Bill impact distributions will be produced for CARE/FERA and non-CARE/FERA customers for each rate in all three climate regions, for senior and non-senior households in the hot region, and for households with incomes above and below 100% of FPG in the hot region.

[31] A more detailed discussion of the use of surveys for evaluating the pilots is contained in Section 5.

PG&E also plans to conduct an ethnographic study of smart thermostat[32] owners who are enrolled in the pilot on both TOU and OAT tariffs to gain a better understanding of how smart thermostat owners interact with their thermostats and the device features that are most useful. This study will not involve additional recruitment of smart thermostat owners into the pilot – owners will be identified through a brief survey at the time of enrollment.

In addition, PG&E will offer a smart phone app to half of the rate treatment participants. The app will provide participants with a variety of useful information. A key focus of this test is to assess the uptake of the app by different types of participants on different rates. The app will initially be offered to half of the TOU rate participants using a randomized encouragement design (RED). If acceptance rates are high, load impacts will be estimated based on the RED. If acceptance rates are high enough to be of interest but not high enough for load impacts to be detected using a RED analysis, statistical matching will be used to develop a pseudo-control group for estimation purposes.

PG&E will also test the effects of the smart phone app on customer awareness, satisfaction and understanding. In addition, PG&E will offer a number of additional E&O materials to participants. Participant interest in and perceptions about these materials will be assessed through surveys.

4.2.1 PG&E Rate Treatments

PG&E's three rate options are summarized in Figure 4-2.[33] As with SCE's pilot rates, the prices in Figure 4-2 do not reflect the baseline credit of 8.9¢/kWh. Rate 1 has two rate periods on weekdays all year long, with the peak period running for five hours from 4 to 9 PM. Off-peak pricing is in effect on weekends throughout the year. PG&E's proposed Rate 2 has a shorter, three-hour peak period from 6 to 9 PM on weekdays all year long. During the summer, there is also a short partial peak period from 4 to 6 PM and from 9 to 10 PM. The weekend prices on Rate 2 are the same as weekday prices. This is designed to assess whether customers prefer consistency across all days of the week so they don't have to worry about changes between weekdays and weekends.

Rate 3 has the same peak period hours as Rate 1 in the summer and winter but has a third rate period in the spring, with the lowest (super off-peak) prices occurring between 10 AM and 4 PM on weekdays. On weekends, off-peak prices are in effect on Rate 3 all day long in both summer and winter. In spring, super-off-peak prices are in effect from 10 AM to 4 PM.

The same logic and drivers of the sampling plan that were discussed for SCE in Section 4.1.1 apply to PG&E as well, although the specific values in the P.U. Code Section 745-driven cells are different because of differences in the PG&E population. As of the time this report was written, PG&E had not yet received updated data from its chosen contractor, Experian, that would allow for the same precise determination of sample allocations by customer segment in hot climate regions as was shown for SCE and summarized Table 4-1. There is no reason to

[32] The definition of smart thermostat and whether or not to include a broader array of thermostats in the study is still under discussion. PG&E's current intent is to be fairly inclusive with regard to the range of specific thermostats that will be included in the study, with both lower and higher end devices included.

[33] As indicated in the footnote on Figure 4-2, these rates may change.

think that the overall sample sizes for each climate region for PG&E will be significantly different from SCE's sample sizes although the number of customers in each of the specific segments in the hot region may differ somewhat. For planning purposes, we have assumed that PG&E will seek to enroll roughly 18,500 customers into their rate treatments. As discussed in the next two subsections, neither the ethnographic thermostat study nor the smart phone app treatment will require recruiting additional participants into the pilots, so the 18,500 required for the rate treatments equals the entire sample needed by PG&E for all of the planned pilot treatments.

Figure 4-2: PG&E Pilot Tariffs[34]

Weekday Rate Periods (hour ending -- for example, 16 = hour ending at 4 PM)

Tariff	Season	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
PG&E Rate 1	Spring	Off-peak (25.1¢)																Peak (27.0¢)					Off Peak (25.1¢)		
	Summer	Off-peak (30.3¢)																Peak (40.6¢)					Off Peak (30.3¢)		
	Winter	Off-peak (25.1¢)																Peak (27.0¢)					Off Peak (25.1¢)		
PG&E Rate 2	Spring	Off Peak (24.1¢)																		Peak (26.3¢)			Off Peak (24.1¢)		
	Summer	Off Peak (29.5¢)																Partial Peak (40.2¢)		Peak (45.9¢)			PP (40.2¢)	Off Peak (29.5¢)	
	Winter	Off Peak (24.1¢)																		Peak (26.3¢)			Off Peak (24.1¢)		
PG&E Rate 3	Spring	Off Peak (24.8¢)										Super Off Peak (16.9¢)						Peak (26.3¢)					Off Peak (24.8¢)		
	Summer	Off Peak (SOP) (31.4¢)																Peak (44.3¢)					Off Peak (31.4¢)		
	Winter	Off Peak (25.0¢)																Peak (27.2¢)					Off Peak (25.0¢)		

Weekend Rate Periods (hour ending -- for example, 16 = hour ending at 4 PM)

Tariff	Season	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
PG&E Rate 1	Spring	Off-peak (25.1¢)																							
	Summer	Off-peak (30.3¢)																							
	Winter	Off-peak (25.1¢)																							
PG&E Rate 2	Spring	Off Peak (24.1¢)																		Peak (26.3¢)			Off Peak (24.1¢)		
	Summer	Off Peak (29.5¢)																PP (40.2¢)		Peak (45.9¢)			PP (40.2¢)	Off Peak (29.5¢)	
	Winter	Off Peak (24.1¢)																		Peak (26.3¢)			Off Peak (24.1¢)		
PG&E Rate 3	Spring	Off Peak (24.8¢)										Super Off Peak (16.9¢)						Off Peak (24.8¢)							
	Summer	Off Peak (31.4¢)																							
	Winter	Off Peak (25.0¢)																							

[34]The day prior to this report being completed, after examining the distribution of customer bill changes moving from the control group to the TOU pilot rates, PG&E discovered a possible problem with the rates, which it is in the process of investigating. This stems from a mismatch between the billing determinants (i.e., aggregate sales in each of the various TOU periods) used to design the rates, which were based on a sample of customers, and the billing determinants of the much larger population of customers used for the bill comparisons. If this investigation results in significant changes in the prices shown above, PG&E will update the proposed tariffs.

4.2.2 PG&E Technology Treatments

PG&E will explore two very different technologies in very different ways. PG&E will seek in-depth understanding of how consumers with smart thermostats operate and interact with these devices using an ethnographic study of existing owners. PG&E estimates that it currently has at least 100,000 smart thermostat owners in its service territory, a group that is growing rapidly and will be even larger by the time pilot recruitment begins in spring 2016. Given this penetration, if smart thermostat owners enroll onto the pilot tariffs at the same rate as non-owners,[35] there will be between 300 and 400 owners enrolled among the 18,500 or so customers who will be recruited into the pilot. With random assignment, there would be roughly 100 customers on each of the three TOU rates and the control group. Ethnographic studies are qualitative in nature so these small cell sizes do not limit the insights that can be gained through this approach and are more than large enough to conduct such a study. By including control group customers in the study, it may be possible to develop useful insights regarding differences in how smart thermostat owners use their devices when on a TOU rate compared with those who are on the OAT.

PG&E's second technology treatment will assess customer acceptance of a multi-functional smart phone app that will convey a variety of useful information to TOU participants. This information may include pricing information, TOU-specific performance feedback, energy saving tips informed by user-specific end use load disaggregation and "gamification" features to encourage energy savings or load shifting.

According to a recent Pew Center Research survey,[36] in early 2015, 64% of Americans owned some kind of smart phone, which is up 29 percentage points since a similar survey in 2011. However, ownership varies significantly across demographic groups, equaling 85% among individuals aged 18 to 29 and only 27% for individuals 65 years of age or older. Ownership among individuals living in households with annual incomes greater than $75,000 is 84% whereas ownership for individuals living in households with annual incomes below $30,000 is 50%.

To our knowledge, there is no good empirical data on the likely acceptance rate for an energy oriented smart phone app among electricity customers on TOU rates. Thus, one of the most useful learnings that will come out of this treatment is the acceptance rate for the app. If the pilot shows that a large number of TOU participants download the app, find it useful and that it increases satisfaction with and acceptance of the TOU rates, it could become an integral part of PG&E's default education and outreach plan whether or not it produces an increase in load response. On the other hand, if acceptance rates are low, it will not have a significant impact on load response or average customer satisfaction and acceptance in a default setting regardless of whether or not customers who accept it have larger load impacts or have much higher satisfaction levels than those who do not get the app.

[35] It's not unreasonable to think that enrollment rates might be higher for the smart thermostat population than for the general population.

[36] http://www.pewinternet.org/2015/04/01/chapter-one-a-portrait-of-smartphone-ownership/

Given the high degree of uncertainty in what the acceptance rate will be for the smart phone app, PG&E plans to proceed with implementation of the treatment as follows. PG&E will initially offer the app to half of the roughly 18,500 participants chosen at random who will enroll into the pilot. If acceptance rates are high (e.g., in the 50% range) and the incremental effect of the app on load reductions is large enough, say 5 percentage points, the impacts could be detected using a RED analysis methodology. As discussed in Section 3.2 (footnote 9), an RED has internal validity equal to that of an RCT.

An RED relies on a two-step evaluation methodology. In the first step, the difference in peak period load for the encouraged group, including both those who accepted the app and those who do not, and the non-encouraged group (e.g., the randomly selected group that did not receive the offer of the app) is calculated. This is referred to as the "intention-to-treat effect." If a statistically significant intention-to-treat effect is found, it can be divided by the percent of customers who accepted the app among the encouraged group to produce what is called the "treatment effect on the treated", which is a valid estimate of the incremental load impact for the group who accepted the app. The challenge with an RED is that the magnitude of the intention-to-treat effect equals the product of the acceptance rate and the treatment effect on the treated. In other words, if the acceptance rate is 50% and the load impact is 5%, the impact would equal 2.5%, so the sample would need to be large enough to produce a confidence band of less than ±2.5% to conclude that the impact was not statistically different from 0. The sample sizes for each rate will be large enough to estimate impacts of this magnitude for the service territory as a whole, but not for each climate region, using an RED design where the smart phone app is offered to half the participant sample.

Statistical power could be increased by pooling data across the three rates and estimating peak period impacts for the three hours from 6 to 9 that are common to all three rates. However, if the acceptance rate is much lower or the incremental impact is much smaller, it will not be possible to detect the impact, even using a pooled data set. For example, if the acceptance rate was 10% and the load impact was 10%, the intention-to-treat effect would only be 1% and the sample would not be large enough to distinguish an impact of this magnitude from 0.

Assuming the acceptance rate is too low to use an RED to estimate load impacts but high enough in the initial stage to be of interest, PG&E will attempt to estimate the load impact using a quasi-experimental evaluation method that creates a pseudo-control group for those who accept the app by using statistical matching methods to pair each participant with the app with a non-participant that has observable characteristics (e.g., load shape and level, demographic characteristics if available) similar to the participant.[37] This method reduces selection bias based on observable variables. Once the matching is complete, the impact evaluation proceeds in the same manner as if an RCT research design had been used. While not as valid an approach as an RCT or RED, this method is commonly used and is the best option available under the circumstances described above when the combination of acceptance and impacts is not large enough to detect an effect using an RED analysis.

[37] In this instance, demographic data will be collected on all customers during enrollment so this data could be used for matching along with pretreatment load data if matching is done from the non-encouraged half of the TOU participant population.

PG&E's marketing plan for the smart phone app will require market research and thus has not yet been developed. However, a straw plan might proceed as follows: An initial offer would be sent to half of the TOU rate participants, included in the welcome kit that customers receive after agreeing to participate in the pilot. The welcome kit will also identify the rate to which each participant is assigned. Shortly after going on the rate, each participant in the encouraged group who hasn't already signed up for the app would receive an email reminder[38] about the benefits of the smart phone app and would be encouraged again to download the app. These efforts would largely define the acceptance rates for the first summer. As described above, if the acceptance rate is high, an RED would be used to estimate load impacts based on usage in the first summer. If not, but assuming it is high enough to be of interest, statistical sampling will be used to create a control group from among the non-encouraged group to determine whether the app results in load impacts for the group accepting it.

The assessment of the smart phone app will also rely on survey questions regarding interest in and satisfaction with the app that will be included in the fall survey that will be conducted among all TOU rate participants.[39] Based on the combination of results from the survey, the initial acceptance rate and whether or not any incremental load impacts are detected during the initial summer, PG&E will decide whether any additional marketing should be done among the initial group that was offered the app and also whether it should be marketed to the other half of TOU participants who didn't receive the initial offer. For example, if feedback through surveys is very positive and the acceptance rate is encouraging (say 10%) from the initial marketing efforts, but no statistically significant load impacts were obtained, the latter result might be because the sample sizes were too small. In this case, additional marketing among the initial group of encouraged customers and also offering the app to those that did not originally receive an offer could boost acceptance to a level at which load impacts could be estimated during the second summer. It should also be noted that if the results of this analysis are encouraging, the smart phone app might be offered in conjunction with the default pilots in 2018 using an RED design where large samples may be cost-effectively employed.

4.2.3 PG&E Education and Outreach Plan

The smart phone app technology treatment described above is an important test of a potentially promising education and outreach (E&O) channel. PG&E also plans to offer a variety of additional E&O materials to participants and to assess participant interest in and perceptions about the materials through surveys. The following materials will be sent to all pilot participants:

- Pilot rate launch "Welcome kit"
  - Some form of pictorial depiction of their TOU rate (perhaps also through an appliance cling)
  - Details about their TOU rate
  - Tips for success etc.
- In-Season direct mail & email on their TOU rate and reminder about tips for bill savings

[38] Email addresses will be gathered from all participants who have them upon enrollment.

[39] See the discussion in Section 5 regarding the survey strategy for the pilots.

    - Summer versions
    - Winter and spring versions
- Post-season email on rate, performance and tips reminder
    - Summer versions
    - Winter and spring versions

PG&E is also exploring the possibility of using social media to provide participants with additional tips and reminders about energy savings.

PG&E is planning to tailor some of its E&O materials to address the needs of special interest groups. PG&E has conducted extensive research among CARE/FERA /economically vulnerable customers and has insights regarding how they want to be addressed in communications (regarding tone, manner, clarity and straightforwardness of messaging) which PG&E will incorporate in its pilot messaging.

Once customers are enrolled in the pilot, PG&E plans to assess participant needs and tailor outreach as follows:

- Different ethnicities and non-English speaking customers:
    - In-language or bilingual for Spanish and Chinese options (the list of languages that will be versioned is under discussion);
    - Acculturated materials;
- Seniors:
    - Materials in large print;
- Economically vulnerable customers:
    - Focus on low cost and no cost tips;
- Other options being explored:
    - Climate specific tailored E&O materials (e.g. areas without much A/C vs areas with high A/C saturation can affect what “tips” are most relevant);
    - Live customer call.

The various E&O materials will be assessed by asking participants in surveys what they thought of the materials (e.g., whether or not it was useful, whether or not they could understand it, what changes would make it more useful, etc.). The assessment may also include tracking open rates and click-thru rates for educational material sent via emails and tracking the number of customer engagements in channels and individual posts for social media channels. Through surveys, PG&E plans to cover the following topics:

- Awareness of outreach
- Awareness of information regarding their rate
- Engagement with content
- Understanding and clarity of messaging around rate

- Understanding of how to apply tips and tools
- Understanding how tips and tools can help them manage their bill
- Perceived value of information (usefulness)
- Attitudes to outreach
- Satisfaction with outreach

Customer awareness and engagement with outreach will be measured periodically during the pilot, in 2016 as well as 2017. PG&E envisions that questions pertaining to E&O will be included in the post-summer survey of 2016, post-winter/spring survey of 2017 and/or the end of pilot survey.

PG&E may also leverage other, more limited quantitative surveys or qualitative research at specific times when questions can be more tailored to the specific E&O piece, such as for the "Welcome Kit" and for specific target groups such as senior citizens, CARE/FERA customers, or in-language messaging recipients. Considerations such as not wanting to bias customer behavior/main survey responses through over-surveying and inundating them with survey requests will be taken into account before planning any supplemental research.

4.3 SDG&E Pilot Plan

SDG&E will estimate load impacts for two rate plans in the moderate and cool climate regions. In the hot climate region, Rate 2 will be offered but load impacts will not be estimated because of the small population size in this region and the difficulty of recruiting enough participants to populate both treatment and control groups. Enrollment onto these rates will use the same pay-to-play recruitment plan as the other utilities will use. Overall enrollment for the rate treatments will total roughly 8,750 participants. An additional 1,250 participants will be recruited onto Rate 2 in each of the moderate and cool climate regions (for a total of 2,500 additional participants) for use in testing a usage alert treatment on a default basis, bringing the total number of participants to 11,250.

SDG&E will also market a third rate option using a more traditional opt-in recruitment strategy. This rate is quite different from the other rates in that the supply component of the tariff will have (1) a monthly service fee, (2) prices that vary hourly, (3) dynamic rate components, and (4) net surplus energy credits. The rate will provide customers with the maximum number of low cost hours and will include high premiums, through price "adders", applied to the top 150 system peak hours and the top 200 circuit peak hours. Customers will be notified about these peak system and circuit hours on a day-ahead basis. In addition, participants on this option will receive credits for surplus energy events. Customers will be notified of surplus energy hours on a day-of basis. This tariff will be bundled with enabling technology that will provide greater automation for this dynamic rate than is provided simply through a smart thermostat. This treatment will be targeted at a small group of electricity consumers with the specific characteristics that are yet to be determined but may include electric vehicle owners.

Starting in fall 2016, after participants have been on the two TOU rates through the initial summer, SDG&E will market smart thermostats to a subset of customers enrolled on Rates 1

and 2. This treatment is designed primarily to determine the difference in take rates between customers offered a smart thermostat at two different price points. Assuming a sufficient number of customers install the thermostat, it may be possible to estimate load impacts by developing a control group using statistical matching.[40]

As part of its E&O plan, SDG&E will offer a weekly usage alert to roughly 1,000 participants in the inland (moderate) climate region. Email addresses will be collected during enrollment and this treatment will be tested on a default basis using an RED to estimate incremental load impacts for participants who receive the alerts. SDG&E will also assess customer interest in, satisfaction with and use of the usage alert through surveys. SDG&E will also assess other E&O options using surveys as discussed below in Section 4.4.3.

4.3.1 SDG&E Rate Treatments

Figure 4-3 shows the two rate options that SDG&E will test using the PTP RCT design that will also be deployed by PG&E and SCE. As mentioned above, in addition to these rates, SDG&E will also test a much more complex, dynamic hourly rate option using an alternative research design that is yet to be determined. As seen in the figure, SDG&E's two main rate options vary little from each other. Rate 1 is a cost-based TOU option with three rate periods and Rate 2 is a simpler TOU option with two rate periods. Both rates have two seasons rather than three like some of the rates that will be bested by PG&E and SCE. For Rate 1, the summer peak to off-peak price ratio is a little less than 2 to 1 while the winter price ratio is less than 1.1 to 1. In addition, for Rate 1, the TOU period definition for weekend and holidays differs from weekdays due to an extended off-peak period on the weekends. SDG&E's rates have the same price structure on weekends as on weekdays, and the same peak-period prices.

[40] If acceptance rates are much higher than anticipated, it may also be possible to estimate impacts using an RED analysis, but this is unlikely.

Figure 4-3: SDG&E Illustrative Rates[41]

Weekday Rate Periods (hour ending -- for example, 16 = hour ending at 4 PM)

Tariff	Season	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
SDG&E Rate 1	Summer	Off Peak (30.2¢)						Partial Peak (35.5¢)										Peak (57.5¢)					Partial Peak (35.5¢)		
	Winter	Off Peak (32.4¢)						Partial Peak (33.4¢)										Peak (34.4¢)					Partial Peak (33.4¢)		
SDG&E Rate 2	Summer	Off Peak (33.5¢)																Peak (57.5¢)					Off Peak (33.5¢)		
	Winter	Off Peak (33.0¢)																Peak (34.4¢)					Off Peak (33.0¢)		

Weekend Rate Periods (hour ending -- for example, 16 = hour ending at 4 PM)

Tariff	Season	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
SDG&E Rate 1	Summer	Off Peak (30.2¢)														Partial Peak (35.5¢)		Peak (57.5¢)					Off Peak (35.5¢)		
	Winter	Off Peak (32.4¢)														Partial Peak (33.4¢)		Peak (34.4¢)					Off Peak (33.4¢)		
SDG&E Rate 2	Summer	Off Peak (33.5¢)																Peak (57.5¢)					Off Peak (33.5¢)		
	Winter	Off Peak (33.0¢)																Peak (34.4¢)					Off Peak (33.0¢)		

[41] Rates presented are based on rates effective November 2015 and SDG&E's 2016 GRC Phase 2 filing and are subject to change. SDG&E's summer season is May through October and winter season is November through April. This differs from the four month summer season at PG&E and SCE, which runs from June 1 through September 30. Prices in the figure do not reflect the baseline credit that applies to usage below 100% of baseline, which equals 16.1¢/kWh in summer and 13.4¢/kWh in winter.

Segmentation in SDG&E's hot climate region differs from the approach taken for PG&E and SCE in light of the very small population of customers in the region. Table 4-3 shows the number of households by income stratum, CARE/FERA status and senior status in SDG&E's hot climate region. It should be noted that the household income stratum is not reported in terms of percent of FPG income as it was for SCE and PG&E because this information for SDG&E is not yet available. 100% of FPG income goes as high as $40,000 for a household with 8 members. The population of households with incomes less than 100% of FPG is almost certainly less than the number of households with incomes less than $40,000 but this higher threshold was used because of the very small number of customers in the climate region. If a cutoff of $30,000 was used instead, the number of households below this threshold in the entire climate region would be roughly half of the 2,351 shown in the table.

Table 4-3: Number of SDG&E Accounts in the Hot Climate region by Household Income, CARE/FERA status and Senior Status

Household Income	Non-seniors		Seniors		All
	CARE/FERA	Non-CARE/FERA	CARE/FERA	Non-CARE/FERA	
<$40,000	484	1,056	252	559	2,351
>$40,000	1,643	10,347	200	1,559	14,950
All	2,127	11,403	452	2,118	16,100

As seen in the table, there are only about 2,500 CARE//FERA customers in SDG&E's hot climate region and roughly the same number of senior households. Only about 18% of senior households are CARE/FERA customers and less than a third of senior households with incomes below $40,000 are CARE/FERA households.

In light of the small population, SDG&E will offer only Rate 2 in the hot climate region and will not have a control group in this region because of the small population size. Given that this population is too small to materially affect overall load impacts for SDG&E's service territory, estimated load impacts for this group will not affect any policy decisions so a control group is less important. However, estimating bill impacts and assessing hardship for key segments in the hot climate region is still important. Given these considerations, SDG&E will reach out to all CARE/FERA households in the region and all households with incomes below $40,000 and will then recruit from the remaining population to bring the total number of enrolled customers in the hot climate region to 1,250.

Table 4-4 summarizes the overall sampling plan for all climate regions and customer segments to support evaluation of the two rate treatments that SDG&E will test. The segmentation scheme in the moderate and cool climate regions is the same as for SCE and PG&E, with 1,250 enrolled on each rate, split evenly by CARE/FERA and non-CARE/FERA customers.

Table 4-4: SDG&E Target Enrollment by Rate Type, Climate Region and Customer Segment

Climate Zone	Segment	Rate 1	Rate 2	Control	Total
Hot	Total	0	1,250	0	1,250
Moderate	Non-CARE/FERA	625	625	625	1,875
	CARE/FERA	625	625	625	1,875
	Total	1,250	1,250	1,250	5,000
Cool	CARE/FERA	625	625	625	1,875
	Non-CARE/FERA	625	625	625	1,875
	Total	1,250	1,250	1,250	3,750
All	Total	2,500	3,750	2,500	8,750

4.3.2 SDG&E Technology Treatments

Whereas SCE's technology treatment will focus on load impacts under TOU rates for a group of customers that have already purchased smart thermostats, and PG&E study will conduct a qualitative study of thermostat behavior, SDG&E's technology treatment will examine the smart thermostat purchase rate of customers who are already on TOU tariffs at different price/subsidy points. This investigation is consistent with recent industry trends in which utilities seek to encourage the penetration of enabling devices such as smart thermostats through market interventions rather than by purchasing and installing devices themselves.

The challenge in studying this issue within the context of the pilot is that relatively few people are actively in the market for a thermostat at any given time. Moving technology into the housing stock is a long run process if left to its normal pace. Figure 4-4 shows national statistics on total thermostat sales and the percent that are smart thermostats. Figure 4-5 shows that utilities have not influenced much of the market to date and most of the penetration is coming through other channels. With about 134 million households in the US, the roughly 10 million thermostats projected to be sold in 2016 represents about 7.5% of households, of which about half are smart thermostats. Assuming that the sales of thermostats and smart thermostats is about the same in SDG&E's service territory as it is nationally, with roughly 7,500 households targeted to enroll on Rates 1 and 2 combined, these statistics suggest that somewhere between 500 and 600 treatment households would normally be in the market for a thermostat over the course of the first year of the pilot and roughly half of those households might purchase a smart thermostat without any subsidy from SDG&E.

Figure 4-4[42]

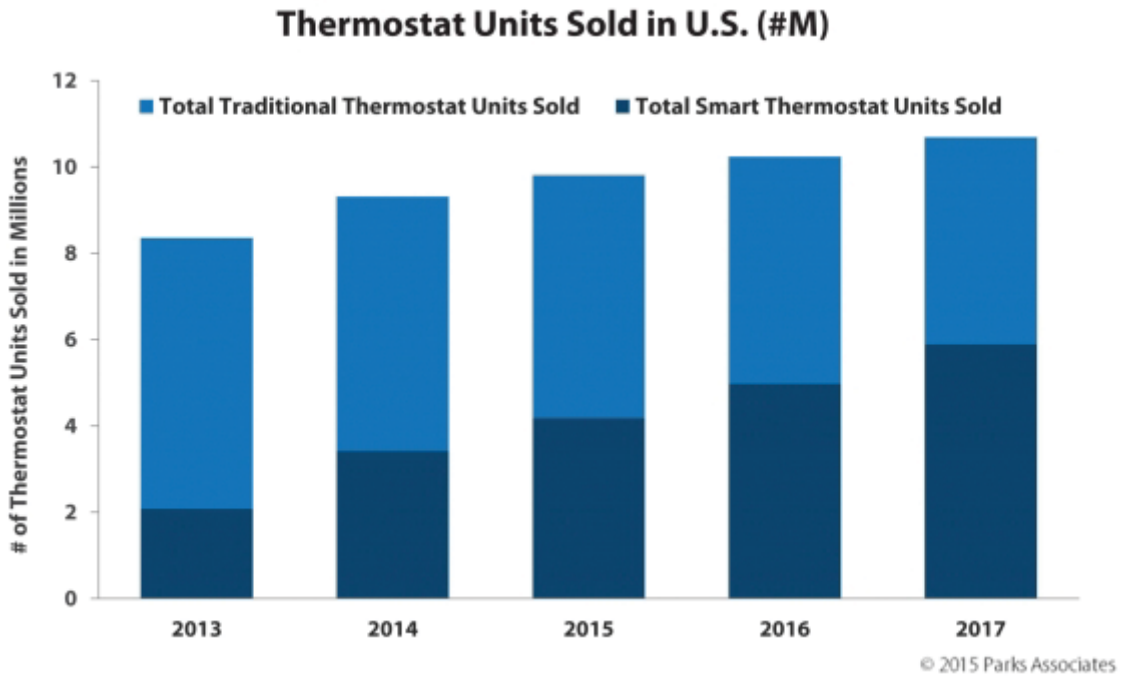
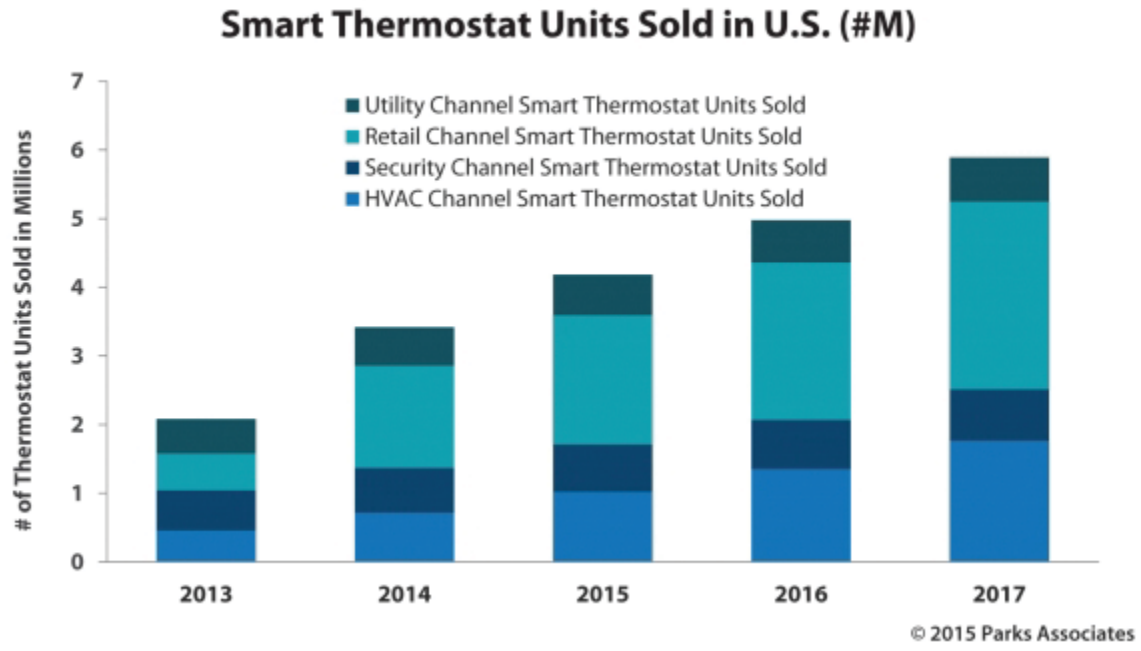


Figure 4-5



SDG&E's treatment will attempt to increase the purchase rate of smart thermostats by offering either a low or high subsidy for the purchase of a smart thermostat to two randomly selected groups of customers who have enrolled on one of SDG&E's two rate treatments. Given the normally low purchase rate, one of these offers will be made to all of the roughly 8,750

[42] Greentech Media, *Smart Thermostats Begin to Dominate the Market in 2015,* July 22, 2015. http://www.greentechmedia.com/articles/read/smart-thermostats-start-to-dominate-the-market-in-2015

customers who are targeted to be enrolled on one of SDG&E's two rate treatments,[43] including the oversample that will be recruited to evaluate the default usage alert treatment as discussed in the next subsection. Even though the purchase rate of thermostats is low, as discussed in Section 3.3.3, with a small incidence rate, statistically significant metrics can be estimated with small samples. As indicated in Figure 3-7, it is possible to estimate statistical significance with 90% confidence and ±5% precision with fewer than 100 observations.

Assuming that there will be a sufficiently large number of customers who purchase smart thermostats through the subsidies that will be offered, SDG&E will estimate load impacts for the purchasing households using a pseudo-control group developed using ex post statistical matching.

4.3.3 SDG&E Education and Outreach Plan

SDG&E's E&O plan includes elements similar to those included in PG&E and SCE's plans as discussed below. In addition, SDG&E plans to conduct a quantitative test of the impact of alerts on load impacts using an RED research design. The alert treatment will be a TOU version of an alert service that SDG&E already provides to approximately 45,000 residential customers. SDG&E has completed most of the work needed to offer this treatment and it will be ready for use prior to summer 2016. The weekly alert email will include bill to date and projected bill, weekly electric use, and usage by rate period.

The alert treatment will be deployed on a default basis to a sample of roughly 1,250 customers each in the moderate and cool climate regions for Rate 2. SDG&E expects to capture email addresses for the vast majority of pilot participants upon enrollment into the study (so that surveys can be conducted via email and perhaps for other purposes). As such, this treatment can be offered on a default basis, thus allowing for the use of an RED research design with a reasonably sized treatment sample. Given the RED design, it is not necessary to recruit a separate control group to estimate impacts for this treatment.[44] SDG&E will also assess customer interest in, satisfaction with and use of the usage alert treatment through surveys, and will compare feedback on this educational option with feedback on other education and outreach options such as welcome kits, appliance labels or other materials that SDG&E may offer.

[43] Given the small expected purchase rate for smart thermostats, any incremental impact the purchase of these devices might have on demand response under TOU rates will not bias the average impacts for the rate treatments by a detectable amount. As such, there is no concern that this treatment is being offered to the rate treatment population.

[44] Since the inland control group for the two rates will be segmented into two equal-sized groups for CARE/FERA and non-CARE/FERA, but the alert treatment will not be segmented, it will be necessary to weight the control group sample using the CARE/FERA-non-CARE/FERA population weights when using the control group for estimation of load impacts for the alert treatment.

In addition to the alert treatment outlined above, SDG&E plans to offer a variety of additional E&O materials to participants and to assess participant interest in and perceptions about the materials through surveys. SDG&E is interested in exploring the creation of welcome kits at various price points and creative approaches to determine the best options for communicating TOU rates to residential customers. These may include:

- Simple direct mail with a letter and minimal enclosures;
- A more comprehensive package with greater graphic materials;
- A "high impact" piece that might be delivered in a small box and include a small clock or another time related item along with printed materials.[45]

In addition to the welcome kit, SDG&E plans to provide ongoing communications, including:

- In-Season direct mail & email on their TOU rate and reminder about tips for bill savings;
  - Summer versions;
  - Winter and spring versions;
- Post-season email on rate, performance and tips reminder;
  - Summer versions;
  - Winter and spring versions;

SDG&E is also exploring having a unique website with information available to participants and possibly using social media to provide additional tips and reminders about energy savings. Still another possibility being explored is using bill alerts via text or e-mail (with and without goal setting) and using push notifications concerning when prices change each day through a pilot-specific functionality on the SDG&E mobile app.

- Push notifications – users can adjust settings on the mobile app to push out a notification at the time of day when prices are raised (or lowered.) Information within the app can contain all of the appropriate TOU times and prices.
- Tips and info – users who open the app can explore posted information about the cost to use certain appliances, which can be adjusted by the app depending on the time of day; the cost changes depending on what time it is in that moment, and the time could possibly be adjusted by the user to visualize the different cost to run at different times.
- Other Bill Alerts – expand My Account functionality within the mobile app to a customer's SDG&E account, to include a variety of bill notifications and alerts (e.g. when a pre-set dollar amount is reached)

SDG&E is planning to tailor some of its E&O materials to address the needs of special interest groups, including the following possibilities:

- Different ethnicities and non-English speaking customers:
  - In-language or bilingual for Spanish and Chinese options (the list of languages that will be versioned is under discussion);
  - Acculturated materials;

[45] The metrics that will be used to assess the relative effectiveness of these options are still under discussion.

- Seniors:
  - Materials in large print;
- Economically vulnerable customers:
  - Focus on low cost and no cost tips;
- Other options being explored:
  - Climate specific tailored E&O materials (e.g. areas without much A/C vs. areas with high A/C saturation can affect what "tips" are most relevant);
  - Live customer call.

The various E&O materials will be assessed by asking participants in surveys what they thought of the information (e.g., whether or not it was useful, whether or not they could understand it, what changes would make it more useful, etc.). The assessment may also include tracking open rates and click-thru rates for educational material sent via emails and tracking the number of customer engagements in channels and individual posts for social media channels. Through surveys, SDG&E plans to cover the following topics:

- Awareness of outreach
- Awareness of information regarding their rate
- Engagement with content
- Understanding and clarity of messaging around rate
- Understanding of how to apply tips and tools
- Understanding how tips and tools can help them manage their bill
- Perceived value of information (usefulness)
- Attitudes to outreach
- Satisfaction with outreach

Customer awareness and engagement with outreach will be measured periodically during the pilot, in 2016 as well as 2017. SDG&E envisions that questions pertaining to E&O will be included in the post-summer survey of 2016, post-winter/spring survey of 2017, and/or the end of pilot survey.

SDG&E may also leverage other, more limited quantitative surveys or qualitative research at specific times when questions can be more tailored to the specific E&O piece, such as for the "Welcome Kit" and for specific target groups such as senior citizens, CARE/FERA customers, or in-language messaging recipients. Considerations such as not wanting to bias customer behavior/main survey responses through over-surveying and inundating them with survey requests will be taken into account before planning any supplemental research.

5 Evaluation Plan

The pilots summarized in Section 2 are designed to answer a wide range of relevant questions using a variety of evaluation methods. Among the key objectives are determining how TOU prices impact electricity use by rate period for the tariffs being tested, determining bill impacts for various customer segments and assessing data to allow the CPUC to evaluate the extent to which TOU rates might impose unreasonable hardship on selected segments (seniors and economically vulnerable customers in hot areas). Addressing each of these objectives requires different data and methodologies, ranging from statistical analysis of load data to detailed surveys of both control and treatment customers. This report section summarizes the key research questions of interest and how each question will be addressed during the evaluation stage of the pilots.

5.1 Research Questions

Table 5-1 contains a high level overview of the primary questions that will be addressed by the TOU pilots and the conceptual approach that will be used to answer each question. More detailed discussions of the primary evaluation methods that will be used are provided in the remainder of this report section.

Table 5-1: Key Research Questions and How They Will Be Addressed

Research Question	How Addressed
1. What will load impacts be for each rate period and pilot rate under default conditions for the population as a whole in each service territory?	Default pilots cannot be implemented until 2018. The PTP opt-In TOU pilot is intended to attract participants that are more similar to the default population than would be true for a traditional opt-in pilot design. The RCT design produces internally valid load impact estimates for each tested rate. By pooling data across climate regions and all segments and properly weighting each customer, highly precise impact estimates will be produced using a difference-in-differences regression analysis as explained in Section 5.2.
2. How do load impacts by rate period vary across selected customer segments and climate regions for the pilot rates?	The same methodological approach described above will be used to estimate impacts using data partitioned for each segment of interest. For PG&E and SCE, load impacts will be estimated with confidence bands of roughly ±2 percentage points for the hot and moderate climate regions. Confidence bands in the cool climate regions may be broader for some IOUs. Load impacts will be estimated for CARE/FERA and non-CARE/FERA customers with similar levels of precision across the service territory as a whole and also for the hot climate region for PG&E and SCE. Because of the small number of customers in SDG&E's hot climate region, load impacts will not be estimated for any rate in this region for SDG&E. There will be more than 1,000 seniors on Rate 1 in PG&E's territory and on Rate 2 in SCE's territory, which will allow for estimation of load impacts for seniors and non-seniors with good statistical precision for those two rates.

Research Question	How Addressed
3. How do load impacts vary across rate options?	The tariffs included in the various pilots have significant variation in prices by rate period and in the length and timing of rate periods. As such, it will not be possible to sort out the independent impacts of price ratios, peak period length and peak period timing. It will be possible to estimate the aggregate load reduction or load increase (for super off-peak hours in spring) for specific hours of the day associated with each tariff, which will provide useful input to the selection of a default tariff for implementation in 2019.
4. How does customer acceptance vary across TOU pilot rates and customer segments?	The PTP approach does not allow for a direct measure of acceptance rates for each rate option because customers are being paid to participate in the study (and to stay on the rate) and will be randomly assigned to the rate options within each utility service territory. However, surveys will be used to assess customer satisfaction and perceptions about the rates and these metrics can be compared across rate options as an indirect measure of customer acceptance. As part of the second survey to be conducted in 2017, customers will be asked whether they would prefer to stay on the rate or return to the OAT. They will also be asked if they would prefer one of the other rates if they had an option. Following payment of the last portion of the incentive, differential dropout rates will be tracked as an indicator of customer preferences. To assess variation in acceptance across customer segments, average survey responses by segment can be compared for segments with large enough samples (primarily those mentioned in response to Q6 below). It might also be possible to estimate a regression model relating selected metrics, such as customer satisfaction or the desire to stay on the rate at the end of the pilot, to customer characteristics.
5. What actions do customers take in response to TOU pilot rates?	Survey responses to questions about the timing of end-use activities, thermostat settings by rate period, etc. will be compared across treatment and control group customers. Barriers to load shifting or load reduction activities can also be assessed through surveys.
6. What is the distribution of bill impacts associated with TOU pilot rates for various customer segments?	Bill impacts will be estimated by calculating bills based on the TOU rate and the OAT and taking the difference. This will be done based on pretreatment usage and on post-treatment usage. Sample sizes in hot climate regions will be large enough to produce valid bill distributions (such as those shown previously in Figure 3-5) for a variety of customer segments, including seniors, CARE/FERA, non-CARE/FERA, households with incomes less than 100% of FPG, and households with incomes between 100 and 200% of FPG. In moderate and cool climate regions, accurate bill impact distributions will be able to be produced for CARE/FERA and non-CARE/FERA households and for the population as a whole.

Research Question	How Addressed
7. How many seniors and economically vulnerable households in hot areas would be likely to suffer unreasonable hardship if they are defaulted onto TOU rates?	Survey questions designed to detect unreasonable hardship will be administered to both treatment and control households that fall into these segments. Answers will be compared between TOU and control households to determine whether hardship metrics are higher among households on TOU rates relative to households on the OAT. Other metrics may also be factored into the assessment of hardship, such as bill impacts.
8. What are the load impacts for selected TOU rates for households that have purchased smart thermostats?	The SCE technology treatment will address this question for a self-selected group of households that purchased a smart thermostat on their own using an RCT research design. SDG&E's smart thermostat treatment may provide additional insights for households that receive an incentive to purchase a smart thermostat equal to a portion of the cost of the thermostat. Load impacts for this treatment will be estimated using ex post statistical matching to create a control group after the fact (assuming enough participants purchase thermostats to make this feasible). PG&E's ethnographic study of thermostat owners may produce qualitative insights about how smart thermostats are being used in response to TOU rates.
9. What is the purchase rate of smart thermostats at different price points for customers on TOU rates?	SDG&E's smart thermostat treatment will offer purchase subsidies for smart thermostats to customers who are already on TOU rates. Acceptance rates for the incentives will be compared between the low and high priced incentive offers.
10. What is the impact of a TOU-oriented usage alert on load reductions, customer acceptance and customer satisfaction with TOU pilot rates?	SDG&E's usage alert treatment will offer alerts through email on a default basis to a large enough sample of customers on Rate 2 to estimate the impact of the alerts on load reductions using an RED research design. Surveys will be conducted among treatment customers to obtain data on customer interest in and satisfaction with the usage alerts. Answers to survey questions pertaining to customer satisfaction, acceptance, awareness, understanding of rates and other metrics will be compared between those who receive the alerts and those who don't to determine whether there are significant differences in these metrics.
11. What is the impact of a smart phone app on load reductions, customer acceptance and customer satisfaction with TOU pilot rates?	PG&E will divide rate treatment participants into two randomly selected groups and offer the smart phone app to one group and not to the other. If acceptance of the app is high enough, an RED impact assessment will be conducted to determine whether the information provided through the app increased load reductions for rate participants who receive it. If app acceptance is too low, statistical matching will be used to develop a control group for estimating load impacts. Answers to survey questions pertaining to customer satisfaction, acceptance, awareness, understanding of rates and other metrics will be compared between those who download the app and those who don't to determine whether there are significant differences in these metrics. App acceptance rates will also be reported and compared across rate options and customer segments.

Research Question	How Addressed
12. What E&O materials are most effective in enhancing customer acceptance and retention, engagement, satisfaction, knowledge of rates, etc.?	Answering this question requires offering E&O materials to some customers, obtaining data on the various metrics of interest and comparing the average metric values for those who receive the materials and those who don't. This type of assessment will be made for SDG&E's usage alert, PG&E's smart phone app and SCE's advanced curriculum E&O treatment. It will not be done for other E&O materials disseminated by each utility.
13. What E&O materials do TOU rate participants find most useful and most preferred?	Surveys will be used to assess customer awareness of, understanding of and engagement with the rates, to assess the usefulness and preferences for each of the primary types of E&O materials. Responses will be compared across rate options and customer segments to determine whether different treatment groups and customer segments find some materials or messages more or less useful or effective than others.
14. What E&O materials and efforts will be most effective for creating customer awareness and satisfaction leading up to default pricing in 2019?	This question cannot be addressed through an opt-in pilot with PTP recruitment. For non-mass media options, it can be addressed in conjunction with the 2018 default pilots. It can also be addressed through a controlled launch in 2019 in which various options are tested leading up to default deployment. Particularly effective options can be used on customers who did not initially get them to enhance awareness even after customers have been defaulted onto the new rates.

5.2 Load Impact Estimation Methodology[46]

The fundamental step in estimating load impacts is to determine what loads would have been for treatment customers if they hadn't been exposed to the treatment; this is referred to as a reference load. As discussed in Section 3.2, the basic approach for developing a reference load for all rate treatments in the proposed pilots is a randomized control trial (RCT). A randomized encouragement design (RED) will be used for estimating impacts for SDG&E's default usage alert and, if acceptance rates are high enough, it will be tried for PG&E's smart phone app.

An RCT randomly assigns volunteers to either treatment or control conditions. Because of the random assignment, this method ensures that the only difference between treatment and control customers, other than small differences due to random sampling variation, is that one group receives the treatment and the other does not. As such, control group load is a valid representation of what treatment customers would have used during the post treatment period if they were not on the treatment. An RCT design ensures that impact estimates are not affected by selection bias or other potential explanations for observed differences between the two groups of customers.

Load impacts can be estimated based on an RCT design by using what is called a difference-in-differences analysis. To estimate load reduction during the peak period, for example, the first difference calculation subtracts average load for the treatment group from the average load for

[46] The discussion in this section borrows heavily from Section 3.2 of SMUD's SPO final report cited previously. That section was written by Dr. Stephen George, who also authored this report.

the control group after the treatment goes into effect. A second difference value is calculated as the difference in peak period loads between treatment and control customers prior to the treatment going into effect. This second difference is subtracted from the first, which is why the analysis is called a difference-in-differences. The purpose of this second step is to adjust for any pretreatment differences between the control and treatment groups that might occur due to random variation in the assignment of customers to the treatment and control groups. This difference should be quite small if the treatment and control samples are large, since random error diminishes as sample sizes increase. If sample sizes are small, random error can be more impactful.

Difference-in-differences calculations can be done using regression analysis or simple averaging. 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. Additionally, standard regression software allows for the calculation of standard errors for load impact estimates that correctly account for the correlation in customer loads over time.[47] A typical regression specification for estimating RCT impacts using an RCT design is shown below:

$$load_{it} = a_i + b_1 T_i I_1 + b_2 I_1 + u_{it}$$

The variable $load_{it}$ equals electricity usage during the time period of interest, which might be each hour of the day, the peak or off-peak rate periods, daily usage or some other period. The index *i* refers to customers and the index *t* refers to the time period of interest. The estimating database would contain usage data during both the pre-treatment and post-treatment periods for both treatment and control group customers.

The parameter $a_i$is equal to mean usage for each customer for the relevant time period (e.g., hourly, peak period, etc.). The primary parameter of interest is b_1, which provides the estimated demand impact of TOU during the relevant period. The parameter is the estimated coefficient on $T_i I_1$. T_i is equal to 1 for the treatment group during the treatment period (e.g., after they are placed on the TOU rate or other treatment) and 0 otherwise. Finally, I_1 is a variable equal to 1 during the treatment period for all customers and 0 otherwise; this is not a parameter of primary interest, but it allows the regression to estimate the primary parameter of interest without confounding differences between treatment and control customers with differences in usage across years.

As mentioned above, the RCT will be used for estimating load impacts for all rate treatments. An RED research design will be used for SDG&E's usage alert and will be tried for PG&E's smart phone app. With an RED design, the behavior of two randomly-chosen groups of customers who were subjected to different levels of encouragement to take up a treatment is observed. In this example, one group—the control group—is not encouraged and the other, the treatment group is. The different levels of encouragement induce different participation rates between two groups that had the same expected characteristics prior to the experiment. This

[47] More accurately, they account for the correlation in regression errors within customers over time.

allows one to estimate the effect of the treatment on customers who were affected by the encouragement, as summarized below.

Using an RED design to estimate unbiased treatment effects requires the assumption that customers who are offered a treatment but decline are unaffected by the offer. Put another way, it is necessary to assume that customers who decline the offer—either on an opt-in or default basis—behave afterwards in the same way they would if they had never seen the offer. An RED analysis also assumes that customers who are placed on a treatment through a default process, but would have opted in if the treatment had been offered on an opt-in basis (in other words, the always takers as described in Section 3), behave the same way no matter which way the offer was made. The analyses also require the assumption that there are no customers who would accept the offer on an opt-in basis, but decline it on a default basis. Each of these assumptions seems quite reasonable.

One fundamental difference between the analyses used for RCTs and for REDs is that with RCTs, all customers in the treatment group are enrolled and therefore are assumed to be affected by the treatment and none in the control group are affected. In contrast, for REDs, the treatment group consists of all customers who received some form of encouragement toward a treatment and the control group consists of customers who received less encouragement or no encouragement. This means the RED treatment group contains many customers who are assumed to be unaffected by the treatment because they declined. This introduces a potential for confusion in terminology when discussing REDs because it is often convenient to consider the treatment group of an experiment to be the group of all customers who are directly affected by the treatment of interest (e.g., all customers who actually enroll).

For an RED there are two treatments of interest, each vital to producing the final treatment impact estimate. First, there is the encouragement treatment, which gives an RED its name. In this case, that treatment consists of an invitation to opt-in to a treatment (for PG&E's smart phone app for example) or it consists of defaulting customers onto the treatment (for SDG&E's usage alert). Second, there is the impact of the treatment itself. That is, the impact for those who accept the treatment, not those that are offered it.

The same regression specification discussed above for an RCT design is used to estimate the first stage impact, which estimates the impact of the encouragement. The estimating database includes all customers who were offered the treatment, whether or not they accepted it. It also includes the control group. The impact in this case represents the average for all customers that received an offer, not the average for customers who accepted the offer. This initial load impact estimate is often referred to as the intention-to-treat effect. Under the reasonable assumption that non-compliers were unaffected by the offer, the intention-to-treat estimate can be transformed into the effect of the treatment on compliers by dividing the intention-to-treat estimate by the fraction of the population enrolled on the pricing plan. This scaled up effect is often referred to as the local average treatment effect or, alternatively, the treatment effect on the treated.

5.3 Bill Impact Estimation

The impact of TOU rates on customers' bills is an important metric of interest to multiple stakeholders that will be incorporated in the pilot evaluations. As with load impacts, looking at the bills of individual customers before and after they go onto a TOU rate is not a valid estimate of the impact of TOU rates on bills because many other factors can cause bills to change over time for an individual customer (e.g., appliance purchases, changes in the number of people in the household, housing renovations, etc.). Since these exogenous factors are equally likely to occur among control and treatment households, comparing average bills for treatment and control customers for selected customer segments will provide a high level assessment of whether TOU rates increase or decrease bills on average for customers in those segments. For example, such a comparison might show that average bills for CARE/FERA customers on TOU rates are 5% higher or lower than average bills for CARE/FERA customers on the OAT. Except for SDG&E's hot climate region, the proposed sampling plan for each utility will support valid comparisons of average bills for treatment and control customers for CARE/FERA and non-CARE/FERA segments in all climate regions and for seniors and for households with incomes below 100% of the FPG in SCE and PG&E's hot climate regions.

Comparing average bills, while useful, does not paint a complete picture, however. There can be very different distributions of bills and bill impacts underlying the same average value. For example, the same average bill of $200 would result from a bill distribution where half the population has a bill of $150 and the other half has a bill of $250 and a distribution where half the population has a bill of $50 and the other half has a bill of $350. Similarly, if the interest is in bill impacts, the same average bill impact of, say $10 could result from a bill impact distribution where half the population sees a bill decrease of $10 and the other half sees a bill increase of $20 and from a distribution where half see a decrease of $100 and the other half see an increase of $110. The first distribution of bill impacts would likely raise little concern for any stakeholder while the second distribution might be of significant concern to many stakeholders if those who saw the $110 bill increase could ill afford to pay it.

Given the above, the pilot evaluations will examine the distribution of bill impacts based on post-treatment usage[48] for treatment and control customers. Bill impact equals the difference in a customer's bill calculated with the same usage under the TOU rate and the OAT. Even though control group customers will not be placed on TOU rates, estimating their bill impacts as if they were will illustrate how much of the bill impact results from structural wins and losses (the control group distribution) and how much from changes in usage in response to the TOU rates (the treatment group distribution).

5.4 Customer Surveys

As indicated in Table 5-1, customer surveys will play an important role in evaluating the impact of treatments that will be tested in the TOU pilots. Given the pay-to-play recruitment strategy and the random assignment to rate treatments that will be employed in the pilots, it is not possible to measure customer acceptance of or preferences for the different rate options by

[48] The distributions between treatment customers (on each rate) and the control group should be identical during the pre-treatment period since customers will be randomly assigned to each rate and the control group.

comparing differential enrollment rates across treatments. However, surveys can be used to indirectly assess these important metrics by asking participants on the various rates their satisfaction with and perceptions about the rates, and asking participants near the end of the pilots to determine whether they would prefer to stay on their assigned rate, go on the OAT or go onto one of the other rate options. Surveys will be used (along with other metrics) to directly assess hardship for seniors and low income participants. And surveys will be used to test customer understanding of rate features, to obtain data on reported usage behavior and to obtain feedback on the usefulness of different educational and outreach materials and information and technology treatments. In short, surveys will be used to gather essential data on many key metrics and gain important key insights on all pilot treatments.

A detailed survey plan will be developed prior to pilot launch once a survey research firm has been hired to work with the IOUs, Energy Division and other stakeholders to refine the research strategy. The specific approach that will be used to obtain additional stakeholder input on survey topics will be determined by the Commission and announced to the TOU Working Group in early 2016. Input on survey topics will be obtained through this process but specific wording of survey questions and decisions about instrument design, survey mode, sample sizes and other factors will be left to survey professionals to ensure that the data gathered is as accurate as possible and representative of the target population. Having said that, the Commission will need to approve the survey content and plan prior to implementation.

During the October 28th TOU Working Group meeting, Nexant provided a number of guidelines for survey design. These guidelines should be kept in mind when selecting a survey research firm and when developing the survey plan that will be used to for pilot evaluation.

- Obtaining high response rates is always important but particularly so in this context. As indicated above, survey data will be used to assess many critical elements of the pilots, including whether certain groups may experience significant hardship after going onto TOU rates. Sample sizes in hot climate zones for some groups of interest are based on attaining high survey response rates. Furthermore, low response rates almost certainly introduce response bias and can completely undermine the internal validity of an RCT design if the survey data is used to estimate outcomes of interest. Random assignment to treatment and control conditions doesn't matter if assessments require comparisons between treatment and control groups using survey data and response rates (and potential bias) are significantly different between the two groups (which they often are).
- Tying a share of the pilot participation incentive to completing key surveys will help significantly in securing reasonably high response rates. So will obtaining good contact information for pilot participants through the enrollment survey. Participants will also be informed during the recruitment process about the importance of the surveys in terms of meeting the primary research objectives for the pilots. All of these factors, along with selecting a quality survey research firm with a strong reputation for obtaining high response rates through mixed-mode surveys and rigorous survey methods will help ensure that response rates are high and survey data is accurate.
- In spite of the above factors, response rates will suffer if surveys are too lengthy and too frequent. Keeping survey length and frequency manageable will be a particular challenge given the broad interests of the diverse stakeholder community that will provide input to survey design. For test cells that are large enough, it may be possible to avoid survey fatigue by randomly dividing a test cell into two groups and conducting

different surveys covering different topics with each group. Recall from Section 3.3.3 that for certain types of survey questions, samples in the 100 to 200 range are more than sufficient to measure outcomes with reasonable precision. As such, with a target enrollment of 625 CARE/FERA and non-CARE/FERA customers in each climate zone, it would be possible to divide each segment into two groups of 325 each and obtain insights representing the entire population of interest from each survey as long as response rates were in the 50 to 60% range (which they should be if the surveys are done properly).[49]

- For many issues of interest, it is essential to compare responses for treatment and control customers. For example, asking low income or senior participants on TOU rates if they reduced their usage on hot days to keep their bills down or experienced hardship on those days could be quite misleading because it's possible that the same customers on the OAT also reduced usage or experienced hardship. Only by comparing responses for treatment and control groups can one be sure that the observed outcomes for the treatment group are due to the TOU rates and not something that also exists under the OAT.
- Asking participants facts about their behavior will likely produce more accurate information than asking them about whether they changed their behavior. Survey respondents have a tendency to respond to subjective questions with answers they think the surveyor is expecting or wants to hear. Comparing responses from treatment and control customers regarding what appliances were used during peak periods may be more accurate than asking treatment customers only if they shifted usage in response to higher peak period prices.
- Survey timing is important from a number of perspectives. Recall is critical to survey accuracy. Asking someone what happened a year ago or what they thought about a welcome kit that they received six months earlier is unlikely to produce accurate information. Surveys about specific actions or materials received must be conducted as close as possible to the timing of those actions. A different type of timing issue has to do with variation in impacts over time. You could get a very different answer regarding satisfaction with a rate if a survey is conducted at the end of a summer period when bills are likely to be highest for the year than if the survey is done in the spring after consumers have experienced more lower-priced periods than higher-priced ones.
- Surveys can influence behavior. Asking participants about peak period usage behavior during the summer might produce changes in behavior during the peak period for the rest of the summer that wouldn't occur for participants who didn't receive the survey.
- Although each IOU is offering different rate, technology and information treatments, and the evaluations of these specific treatments may require specific questions tailored to them, much of the information to be gathered for evaluation will be common across the IOUs. In order to support a meta analysis of results across pilots, it will be very important that each IOU use the exact same question sin their surveys whenever the topics being covered in the surveys are the same.

[49] Survey response rates for California's Statewide Pricing Pilot in 2003 and 2004 average 90% across all treatment groups.

While the specific survey plan will be determined at a later date, surveys will likely be used to collect information on the following topics:

- Customer demographic data – a small amount of demographic data will be collected at the time of enrollment, which will be done online, through a call center or through a business reply card. Essential data to gather at this juncture includes household income, persons per household and age of household members so that classification of customers into senior and income segments can be updated based on information provided by participants rather than on the pre-enrollment data used for sampling purposes. Email addresses will also be obtained since email will be used for subsequent surveys as well as for some treatment options such as SDG&E's usage alerts. Information on smart phone and smart thermostat ownership will need to be obtained from PG&E participants to support the technology treatments being tested by PG&E. Air conditioning ownership may also be included in the enrollment survey.
- Behavioral information – factual questions about:
  - Appliance use by time of day;
  - For seniors, low income and perhaps other participants (both treatment and control participants), questions pertaining to assessment of hardship such as usage of air conditioning on hot days, tradeoffs being made between paying energy bills and other purchases, etc.; [50]
  - For customers with smart thermostats (such as SCE's smart thermostat test cells), questions about temperature settings by rate period for both treatment and control customers;
  - For SDG&E and PG&E information treatments, frequency of viewing usage alerts and smart phone information,[51] how the information is used, etc.
- Awareness and understanding of tariffs – testing knowledge of rate periods, price ratios or levels, variation in rate periods and prices across seasons, understanding of tiers for control customers, etc. These types of questions will be used to assess the effectiveness of E&O and information treatments.
- Understanding of usage behavior that underlies energy bills – that is, testing whether E&O materials improve customer understanding of end uses that drive peak period use and behavioral changes that can be made to reduce monthly bills.
- Satisfaction with/acceptance of rate, technology and information treatments and the reasons why participants are or are not satisfied.
- Recommendations for changes to treatments that would improve satisfaction and acceptance.
- Perceptions about and preferences for various E&O materials.
- Preferences for staying on the rates and other treatments, or shifting to one of the alternative rates, at the end of the pilot if such treatments were to continue to be offered.

[50] The TOU Working Group discussed the importance of aligning these questions about potential hardship with similar questions from the Statewide Low Income Needs Assessment surveys that are being conducted by the IOUs.

[51] If this type of information can be obtained through the software programs and databases used to administer the treatments, that approach would be both more accurate and less burdensome on participants compared with asking about this type of behavior in surveys.

- Additional demographic and appliance data.[52]
- Reasons why customers who were solicited for participation in various treatments declined to enroll in the pilot.

In addition to the collection of data through the brief enrollment survey, Nexant recommends that each participate be asked to respond to no more than two surveys. We believe the best timing for the first survey is at the end of summer 2016. This is not a good time to ask participants how satisfied they are with the new rates since many may have experienced higher summer bills just prior to completing the survey and not had the benefit of lower bills in the late fall, winter and spring months. However, it is the best timing for many other issues such as assessing hardship for seniors and low income participants, for asking about usage behavior during peak periods in the summer and perceptions about welcome kits and other summer related E&O materials, among other things.

There are two options regarding timing of the second survey. One is to conduct the survey just prior to summer 2017 after participants have been enrolled for a full year. The second is to conduct the survey following summer 2017, which is close to when the pilot will end. The earlier timing would be much better for assessing customer satisfaction with the rate treatments for reasons discussed previously. It would also be better for obtaining information about usage behavior during winter and during the important spring period for PG&E and SCE Rate 3, which has low priced periods in midday in the spring that reflect excess supply conditions. The primary reason for conducting the survey following the summer of 2017 is the desire to keep customers on the rate treatments through summer 2017 and the fact that the final incentive payment will be tied to completion of the last survey (in order to ensure high response rates). Making the final payment prior to summer 2017 risks losing a larger portion of the research sample than if the survey and final payment were done following summer 2017. On the other hand, this timing opens up a longer time period to observe the proportion of customers who drop off the rates because they prefer the OAT. Good information on dropout rates could be very useful for planning default pricing. Near the end of the planning process, a decision was made to schedule the second survey around June 2017 in order to provide a more accurate assessment of participant's perceptions and acceptance of the rates prior to a second summer of potentially higher bills, and to gather better data on winter and spring usage and post payment dropout rates.

Decliner surveys may also be employed, although this was not discussed at length during the TOU Working Group process. Nexant does not recommend conducting a decliner survey for the PTP recruitment process since this is a unique approach to the recruitment and reasons for declining to participate in the study have no relevance to customer decisions about opting out of default rates or preferences for one rate over another. On the other hand, surveying people

[52] There will be a temptation to gather extensive demographic and end use appliance data at a level of detail similar to the periodic residential appliance saturation surveys (RASS) that are conducted by California's IOUs. Nexant strongly recommends guarding against this temptation. There are much higher priorities for information gathering to assess the impact of various treatments and adding lengthy RASS-like questions will significantly jeopardize getting high response rates for much more important survey questions. If there is need for such data, it would be better to wait until the default pilots are conducted in 2018 when larger samples can be cost-effectively obtained and surveys can be parsed out across random subsets of the population in order to reduce survey length and frequency for any particular group of respondents.

who decline PG&E's smart phone app offer or SDG&E's smart thermostat incentive offer could be insightful.

It may also be useful to survey customers who drop off the rates and other treatments over the course of the pilots. The most efficient time to capture this information is when customers call in to drop off the rate, as long as the survey is kept quite short. Pursuing customers to complete a survey after they have dropped off may prove difficult and costly. It is also likely to have low response rates and could produce misleading information. In spite of these challenges, if dropout rates are high for selected tariffs, understanding why will be quite important and dropout surveys should be conducted.

5.5 Other Evaluation Efforts Being Considered

The TOU Working Group also briefly discussed other possible evaluation activities, including focus groups, conjoint surveys and data tracking. As discussed in Section 4.2.2, PG&E plans to use focus groups and perhaps in-depth surveys as part of its ethnographic study of thermostat behavior. Focus groups might also be useful for gaining deeper insights into SDG&E's usage alerts, PG&E's smart phone app and SCE's smart thermostat treatment.

Several TOU Working Group participants mentioned the possibility of using conjoint surveys to explore the potential impact of treatment features that were not tested in the pilots. Conjoint surveys ask respondents to indicate their preferences for various product bundles. The outcome of these choice exercises can be analyzed to produce estimates of the relative attractiveness of individual product features. Conjoint surveys almost always overstate (often significantly) actual acceptance rates for specific product bundles but can accurately reflect the relative acceptance rates for different product bundles. If surveys can be anchored to actual choice data, more accurate predictive models of actual take rates for alternative bundles can be produced.[53] Conjoint surveys can prove effective in predicting how a change in a particular product feature would impact the purchase of the product or, in the context of rate options, how a change in a rate feature (e.g., shortening the peak period, increasing the price ratio, etc.) might impact enrollment onto the rate. Since these pilots are not testing opt-in rates, there is no actual choice data that can be used to anchor the conjoint exercises not is opt-in pricing the primary focus at this point in time. If pilot dropout rates are high, it might be useful to use a conjoint study to assess whether specific changes in the rate features would significantly reduce dropout rates.

A final source of information that may be used for evaluation is tracking data. Dropout rates are important metrics for assessing customer preferences and satisfaction with rates. Call center tracking of complaints and customer inquiries can also be quite useful. It might also be useful to track whether customers on TOU rates or who receive some of the technology or information treatments participate at a greater rate in other IOU programs such as energy efficiency programs. This can be done by comparing enrollment rates in utility programs between treatment and control customers.

[53] For an example of how a conjoint survey cam be used in conjunction with actual choice data for TOU rate options, see Chapter 9 in Stephen S. George, Jennifer Potter and Lupe Jimenez. *SmartPricing Options Final Evaluation*. September 5, 2014.

6 Pilot Budgets

The pilots summarized in Section 4, collectively, will involve recruitment of almost 52,000 participants in a very short time period. As discussed later in this section, the average recruitment cost per participant is highly uncertain. It is primarily a function of the incentive amount that will be paid under the pay-to-play recruitment strategy and the acceptance rate by customer segment. Based on focus group research conducted by SCE in early December, acceptance rates may vary significantly depending on whether or not bill protection[54] is included in the recruitment offer. This uncertainty will be reduced significantly in January when each utility will conduct pre-launch tests that collectively will determine how enrollment rates will differ with respect to offer features, including incentive amount, the distribution of payments over time, delivery channel (e.g., courier, direct mail, email) and whether or not bill protection is incorporated into the offer. As discussed in Section 6.1, given the current uncertainty, recruitment costs across all three utilities could range from a low of roughly $5 million to well over $20 million.

In addition to recruitment costs, each utility will incur other TOU pilot-related costs covering a wide variety of activities including, but not necessarily limited to:

- **Pilot Design and Regulatory Work**: This cost category includes the pilot design work that has already been conducted and that will continue in 2016 when planning for 2018 default pilots will occur. It also includes preparation of the required regulatory filings that will be submitted by January 1, 2016.
- **Implementation Planning:** This cost category includes development of an implementation plan (e.g., what is to be outsourced, what will be done in house, etc.), analysis required to finalize sample size requirements, pulling the sample, focus groups for development of recruitment materials and all E&O materials such as welcome kits and in season support, the pre-launch test to determine incentive payments and acceptance rates by customer segment, development of enrollment procedures (including an enrollment site) and tracking databases, call center training, IT work to prepare for billing the new rates, development of any new business processes needed to support the pilots, etc. For SDG&E, implementation planning will also include finalizing the usage alert content and software and for PG&E, it will include getting contracts and procedures in place to support the smart phone app. For SCE, implementation planning will involve working with smart thermostat vendors to market and support recruitment of current smart thermostat owners into the pilot.
- **Implementation:** The largest component of implementation costs will be for recruitment (with the largest share of those costs being for the incentive payments that will be paid out in stages). If bill protection is included in the recruitment offer, the cost for bill protection payments will be incurred at the end of the first full year of the pilot. Costs will also be incurred for incremental staff or outsourcing for enrollment processing, call center and other ongoing customer support, the cost of printing and distributing E&O materials, data tracking, manual billing (if needed) and end of pilot transition. For PG&E, implementation costs will include payments to the smart phone app contractor throughout the duration of the pilot as well as costs for the ethnographic study that will be conducted to explore how consumers interact with thermostats. For SDG&E, it will

[54] Bill protection is discussed in more detail in Section 6.2.

include costs associated with implementing the smart thermostat incentive program and for delivery of usage alerts.

- **Evaluation and Reporting:** This cost category includes expenditures for the load impact evaluation, billing analysis and all survey work described in Section 5 (including survey planning in consultation with the TOU Working Group).

Each IOU has developed estimates of costs for the majority of the activities summarized above and will include these estimates along with supporting documentation in its advice letter to be filed with the CPUC along with this report. The remainder of this section provides estimates of recruiting costs based on a variety of assumptions. It also discusses the pre-launch test activities that will be used to significantly reduce the amount of uncertainty in the recruitment cost estimates and that will allow the utilities to better manage the recruitment process so that enrollment targets are met at the lowest cost.

6.1 Recruitment Costs

As discussed in Section 3.2, recruitment for the pilots will involve what is being called a pay-to-play (PTP) approach. The reasons for using this approach were summarized in Section 3.2. The PTP approach involves paying participants an attractive incentive to enroll in the study and to be assigned to one of three rate treatments or to the control condition. A portion of the incentive will be paid at the time of enrollment, another portion upon completion of a survey following summer 2016 and the final portion upon completion of the last survey in mid-2017.

The cost of recruitment per enrolled participant is a function of the incentive amount, the delivery channel(s) used (e.g., U.S. Postal Service (USPS), courier service, email, outbound calls, etc.), the "open rate" for each channel and the acceptance rate among those who open the recruitment letter or email, or take the call. Table 6-1 shows the cost per enrolled participant under numerous assumptions about incentive payment, open rate, acceptance rate and cost per communication.

As seen in the table,[55] the cost per participant ranges from as low as $103[56] under the very optimistic assumption that 90% of those who receive the recruitment letter via USPS[57] open it and 50% of those who open it enroll. A high end cost estimate of $486 per participant was arrived at assuming that only 50% of people who receive a courier package open it and only 10% of those who open it enroll even though they are paid an incentive of $300. The actual cost of recruitment for pilot participants is likely to be in between these extremes.

[55] The shaded values in the table are used as input to Table 6-2 and are discussed more fully below.

[56] The cost per enrolled participant equals ((delivery cost)/(open rate)/(acceptance rate)).

[57] The cost of $1.50 for USPS is based on the cost of the letter, postage and handling. The courier cost also includes materials and handling plus delivery costs based on standard FedEx rates.

Table 6-1: Cost per Participant

USPS Delivery					
Incentive	Delivery Cost	Open Rate	Acceptance Rate		
			10%	25%	50%
$100	$1.50	50%	$130	$112	$106
	$1.50	75%	$120	$108	$104
	$1.50	90%	$117	$107	$103
$200	$1.50	50%	$230	$212	$206
	$1.50	75%	$220	$208	$204
	$1.50	90%	$217	$207	$203
$300	$1.50	50%	$330	$312	$306
	$1.50	75%	$320	$308	$304
	$1.50	90%	$317	$307	$303
Courier Delivery					
$100	$9.30	50%	$286	$174	$137
	$9.30	75%	$224	$150	$125
	$9.30	90%	$203	$141	$121
$200	$9.30	50%	$386	$274	$237
	$9.30	75%	$324	$250	$225
	$9.30	90%	$303	$241	$221
$300	$9.30	50%	$486	$374	$337
	$9.30	75%	$424	$350	$325
	$9.30	90%	$403	$341	$321

These cost estimates are based on a single marketing wave. It is much more typical to use multiple marketing waves for opt-in recruitment but PTP is not a typical opt-in scheme since participants will be paid to enroll in the study. The operating assumption is that the attractive incentive will negate the need for multiple marketing waves as long as there is a high open rate and an effective recruitment letter is used. However, offsetting the attractiveness of the enrollment incentive is the high degree of perceived risk and uncertainty in prospective participant's minds about the potential for large bill increases. This perceived risk is a well-known marketing barrier for any time-varying rate as consumers tend to focus more on the downside risk associated with higher peak period prices than on the upside potential of lower bills due to lower prices being in effect for most hours. However, this typical concern is exacerbated here because of the increased uncertainty stemming from the fact that the rate that each participant will be assigned to is unknown to the prospective participant and the lack of transparency around the characteristics of all rate options during recruitment. This barrier could

mean that a second marketing wave, perhaps involving telephone recruitment, might be necessary.

The single wave assumption for mailings is also in part a function of the fact that the time available for recruitment is so short that there may not be sufficient time for multiple marketing waves to occur. The reason that the higher cost courier channel is being considered and tested in January is to see if it might increase the open rate enough compared with typical USPS delivery to be cost-justified, as that might partially compensate for the lack of multiple marketing waves. As discussed in Section 6.2, the relative effectiveness of the two marketing channels will be tested by PG&E and SCE in a pre-launch test in January.

There is limited data concerning what acceptance rates are likely to be for this PTP approach. Indeed, we are unaware of any prior pricing pilot that tested recruitment with random, post-enrollment assignment to one of four experimental conditions using a PTP approach. In 2003, California's IOUs conducted a Statewide Pricing Pilot (SPP)[58] that used a PTP approach with an incentive payment of $175 spread over three installments ($25 for completing a survey, $75 for staying through the first summer and $75 for staying through the end of a full year). As with the proposed pilots, recruitment for the SPP occurred just prior to summer. In the SPP, each potential recruit was offered one of the multiple rate options included in the pilot, and knew what rate they were signing up for. But, this made selection bias an issue. The opt-in TOU pilot's blind assignment avoids such selection bias.

In the SPP pilot, relatively few people responded to the initial letter (sent via USPS in the SPP). A key finding from a post enrollment survey for SPP[59] was that "the printed materials were quite ineffective. Respondents found them neither engaging nor persuasive. The materials made scant reference to any benefit – direct or indirect – that the customer might gain by participating, nor did they leave readers feeling they fully understood the program. Readership appeared to have been unusually low." To help avoid using a similarly ineffective letter, SCE conducted focus groups in early December to test letter content, offer features and back-up information to be included with the letter. As mentioned previously and discussed more fully in Section 6.2, two key findings from the focus groups were the potential barrier associated with the perceived risk of large bill increases and the fact that offering bill protection could significantly reduce that concern.

With the low initial response rate to the recruitment letter in the SPP, telephone follow-up calls were made to those being recruited. Eventually, about half of those who were sent letters were reached by phone. The overall acceptance rate for the SPP is subject to interpretation. The worst case interpretation, which divides those who were eventually enrolled by the total number of offers sent, was 20%. However, the numerator in this calculation includes more than 300 participants who agreed to enroll but were rejected by the utilities for various reasons, including the inability to install interval meters and the fact that the participant said they planned to move

[58] Stephen S. George and Ahmad Faruqui. *Impact Evaluation of California's Statewide Pricing Pilot*. Final Report, March 16, 2005.

[59] Focus Pointe, Inc. *Statewide Pricing Pilot: Enrollment Refusal Follow-up Research*. November 2003.

within 6 months.[60] If these customers are counted as accepting the offer, the acceptance rate equaled roughly 30%. A liberal interpretation of the acceptance rate for the SPP is 70%. This interpretation excludes from the denominator anyone who could not be reached by telephone, which was roughly half of all customers who were contacted.

With the above background information in mind, cost estimates were developed based on four sets of assumptions about acceptance rates, delivery channel and incentive payments. The cost estimates per recruited participant are taken from Table 6-1 and are highlighted there in the four cells shaded in grey. The low end estimate, $108, assumes USPS delivery, a $100 incentive payment, a 75% open rate and a 25% acceptance rate. The high end estimate, $486, assumes courier delivery, a $300 participation incentive, a 75% open rate and only a 10% acceptance rate. In between these two extremes are two scenarios that assume a $200 incentive, 75% open rate and 25% acceptance rate, with the only difference between them being that one uses USPS and the other courier delivery. The 10% acceptance rate assumption is half the value of the most pessimistic interpretation of the SPP acceptance rate while the 25% assumption is halfway in between the two low-end acceptance rate interpretations from the SPP.

Table 6-2 shows the total cost of enrollment for each utility based on the four sets of assumptions summarized above. The number of recruited customers in Table 6-2 for SCE includes the target enrollment for the rate options from Table 4-2 (18,275) plus an additional 3,750 for the smart thermostat technology treatment, for a total of 22,025. As noted in Section 4.2.1, the number of customers for PG&E is still a bit uncertain pending an update of PG&E's customer characteristics database, which will allow for a refinement of the number of customers that must be recruited into each segment in the hot climate region. For planning purposes, we assume that PG&E will recruit 18,500 customers into the pilots. The 11,250 customer recruitment estimate for SDG&E comes from the 8,750 in Table 4-6 plus 2,500 for the usage alert treatment discussed in Section 4.3.3.

The cost estimates in Table 6-2 are based on the payment schedule shown under the per participant portion of the table. For the $100 total incentive scenario, we assume that $25 would be paid at the time of enrollment, another $25 for completion of the survey at the end of summer 2016 and the final $50 paid at the end of summer 2017. For the $200 scenarios, the payment schedule is $25, $50 and $150, respectively, and for the $300 incentive scenario, payments equal $100, $75 and $125. The marketing costs shown in the table equal the difference between the incentive amount and the values in the highlighted cells in Table 6-1.

[60] Interval meters were not in place in 2003 so meters had to be installed for all participants prior to placing them into the pilot. The high cost of installing meters made it very important to screen out participants who were planning to move. The pilots proposed here are not based on screening out potential movers since meters are already in place and doing so would bias the participant population.

Table 6-2: Estimated Recruitment Costs for Selected Scenarios

Utility	# Recruited	Scenario	Per Participant					Total				
			Incentive	Upfront Payment	2016 Survey	2017 Survey	Marketing cost	Upfront Payment	2016 Survey	2017 Survey	Marketing Cost	Total Costs
SCE	22,025	USPS, 75% open rate, 25% acceptance rate	$100	$25	$25	$50	$8	$550,625	$512,081	$881,000	$176,200	$2,119,906
	22,025	USPS, 75% open rate, 25% acceptance rate	$200	$25	$50	$125	$8	$550,625	$1,024,163	$2,202,500	$176,200	$3,953,488
	22,025	Courier, 75% open rate, 25% acceptance rate	$200	$25	$50	$125	$50	$550,625	$1,024,163	$2,202,500	$1,092,440	$4,869,728
	22,025	Courier, 50% open rate, 10% acceptance rate	$300	$100	$75	$125	$186	$2,202,500	$1,536,244	$2,202,500	$4,096,650	$10,037,894
PG&E	18,500	USPS, 75% open rate, 25% acceptance rate	$100	$25	$25	$50	$8	$462,500	$430,125	$740,000	$148,000	$1,780,625
	18,500	USPS, 75% open rate, 25% acceptance rate	$200	$25	$50	$125	$8	$462,500	$860,250	$1,850,000	$148,000	$3,320,750
	18,500	Courier, 75% open rate, 25% acceptance rate	$200	$25	$50	$125	$50	$462,500	$860,250	$1,850,000	$917,600	$4,090,350
	18,500	Courier, 50% open rate, 10% acceptance rate	$300	$100	$75	$125	$186	$1,850,000	$1,290,375	$1,850,000	$3,441,000	$8,431,375
SDG&E	11,250	USPS, 75% open rate, 25% acceptance rate	$100	$25	$25	$50	$8	$281,250	$261,563	$450,000	$90,000	$1,082,813
	11,250	USPS, 75% open rate, 25% acceptance rate	$200	$25	$50	$125	$8	$281,250	$523,125	$1,125,000	$90,000	$2,019,375
	11,250	Courier, 75% open rate, 25% acceptance rate	$200	$25	$50	$125	$50	$281,250	$523,125	$1,125,000	$558,000	$2,487,375
	11,250	Courier, 50% open rate, 10% acceptance rate	$300	$100	$75	$125	$186	$1,125,000	$784,688	$1,125,000	$2,092,500	$5,127,188
All	51,775	USPS, 75% open rate, 25% acceptance rate	$100	$25	$25	$50	$8	$1,294,375	$1,203,769	$2,071,000	$414,200	$4,983,344
	51,775	USPS, 75% open rate, 25% acceptance rate	$200	$25	$50	$125	$8	$1,294,375	$2,407,538	$5,177,500	$414,200	$9,293,613
	51,775	Courier, 75% open rate, 25% acceptance rate	$200	$25	$50	$125	$50	$1,294,375	$2,407,538	$5,177,500	$2,568,040	$11,447,453
	51,775	Courier, 50% open rate, 10% acceptance rate	$300	$100	$75	$125	$186	$5,177,500	$3,611,306	$5,177,500	$9,630,150	$23,596,456

The costs shown in each column in the table under the "Total" heading factor in the timing of when the marketing and incentive payments are made. As discussed previously, the number of recruited customers factors in an assumed attrition rate of 25% between the start of the pilot and the end of summer 2017 (a period of 15 months). The marketing cost and the upfront payment of $25 are both multiplied by the number of recruited customers shown in the second column in Table 6-2. However, the 2016 survey cost is multiplied by that number of recruited customers minus the attrition that is estimated to occur between enrollment and completion of the survey roughly four months later. A straight-line attrition rate of roughly 1.67% per month was assumed (which is equal to 25% divided by 15 months). Thus, the number of customers that would be paid the 2016 survey incentive would equal the total number recruited minus roughly 7% (1.67x4). The number of customers who are expected to be paid for the second survey, which is planned to be done around June 2017, is roughly 20% of the recruited number of participants. If a different incentive payment schedule is assumed, the total costs will vary depending on how much is paid up front, how much at the end of summer 2016 and how much at the end of summer 2017.

Based on the above assumptions, total recruitment/incentive costs range from roughly $2 to $10 million for SCE, $1.8 to $8.4 million for PG&E and $1 to $5 million for SDG&E based on the scenarios included in Table 6-2. Total costs for all three utilities combined range from roughly $5 million to more than $23 million.

6.2 Pre-launch Test

Given the high degree of uncertainty in acceptance rates associated with the proposed RCT PTP pilot design, all three IOUs are planning to conduct recruitment tests in January. Collectively, these pretests will determine differential enrollment rates associated with different PTP incentive levels, different timing for incentive payments over time (e.g., percent paid up front versus later), different recruitment delivery channels (e.g., email, direct mail and courier), different customer segments (e.g., CARE/FERA and non-CARE/FERA) and with and without bill protection.

As previously mentioned, the issue of bill protection surfaced in focus groups conducted by SCE in early December. Bill protection means that, at the end of the first year on pilot rates, participant's bills on the TOU rates would be compared with their bills based on post-treatment usage and the OAT. If the bill amount on the TOU rate is higher than on the OAT, participants would be paid the difference. Put another way, under bill protection, a participant's bill cannot be higher than it would have been had they been on the OAT rather than the pilot rate.

SCE's focus groups were designed to obtain input on the content of the recruitment letter, the timing of incentive payments and concerns about the uncertainty associated with rate assignment given the PTP recruitment plan and random assignment to one of several rate options. Focus group participants expressed significant concern about the risk of not knowing what the potential bill impacts would be for the rate they would be assigned to and worried that the bill impacts might be larger than any PTP incentive they might receive. After hearing of this concern, the focus group facilitator presented the concept of bill protection and participants responded very favorably to it as a way of significantly mitigating the perceived risk.

The idea of bill protection was discussed by the TOU Working Group in early meetings and a preliminary decision was made not to incorporate this into the pilot plan because of prior evidence indicating that it may reduce load impacts and also because customers who are defaulted onto TOU rates in 2019 will only have bill protection for the first year. Prior research by Nexant on PG&E's SmartRate critical peak pricing tariff found that load impacts were roughly 25% lower for customers under bill protection compared with those that were beyond the bill protection period.[61] However, this analysis was based on a small sample using a quasi-experimental evaluation method rather than on an RCT design with larger samples. It also involved a very different type of rate. As such, it is difficult to say whether similar results might occur under TOU pricing. Put another way, these prior results are suggestive but far from conclusive.

By not incorporating bill protection into the recruitment plan, the load impacts would be more representative of what would exist under default pricing after the end of the bill protection period. However, after seeing the significant concern about risk expressed in the focus groups, the TOU Working Group felt that it was very important to at least test the impact of offering bill protection during the pretest. SCE has agreed to conduct this test. If bill protection significantly increases enrollment rates, it may be incorporated into the pilot in order to achieve the targeted enrollment levels over the very brief window during which recruitment must be done.

SCE plans to conduct a pretest among 3,200 customers segmented as shown in Table 6-3. These tests will determine the impact of bill protection, delivery channel and two different incentive levels on acceptance rates for CARE/FERA and non-CARE/FERA.

Table 6-3: Pretest Plan for SCE

Incentive	Delivery Channel	Without Bill Protection		With Bill Protection		All
		CARE/FERA	Non-CARE/FERA	CARE/FERA	Non-CARE/FERA	
$200	Courier	200	200	200	200	800
	Direct Mail	200	200	200	200	800
$300	Courier	200	200	200	200	800
	Direct Mail	200	200	200	200	800
n/a	Total	800	800	800	800	3,200

PG&E's pretest will focus on delivery channel, incentive level and the timing of the incentive payments. PG&E plans to send recruitment letters to 2,000 customers according to the plan shown in Table 6-4. This pretest will assess the differential acceptance rates between courier and direct mail, two different incentive levels and two different plans for upfront payment amounts versus later payment of incentives.

[61] Stephen George, Josh Bode and Elizabeth Hartmann. *2010 Load Impact Evaluation of Pacific Gas and Electric Company's Time-Based Pricing Tariffs.* April 1, 2011. Prepared for Pacific Gas and Electric Company.

Table 6-4: Pretest Plan for PG&E

Incentive	Courier		Direct Mail Letter		All
	Upfront Incentive = $100	Upfront Incentive = $50	Upfront Incentive = $100	Upfront Incentive = $50	
$175	250	250	250	250	1,000
$250	250	250	250	250	1,000
Total	500	500	500	500	2,000

SDG&E plans to test differential acceptance rates under different incentive levels, delivery channels and messaging. Table 6-5 shows the pretest plan for SDG&E. This plan will test three different incentive levels, email and direct mail three different letter types that vary in terms of content and format. The "senior letter" test is not targeted just at seniors, but will include large font for key messages points (as discussed in Section 3.7).

Table 6-5: Pretest Plan for SDG&E

Incentive	USPS (General Population)			Email Population			
	Letter 1 (Marketing) (A)	Letter 2 (Solicitation) (B)	Letter 3 (Seniors) (C)	Letter 2 Sent to email population via USPS (D)	Letter 2 Sent via email (E)	Letter 1 sent via email (F)	Letter 3 sent via email (G)
$200	250	250	250	250	250	250	250
$300	250	250	250	250	250	250	250
$400	250	250	250	250	250	250	250

7 Pilot Schedule

The time period available for implementing the 2016 pilots described in prior sections is extremely short. With advice letters being filed by each utility no later than January 4 and a decision by the Commission at the earliest on February 25 but perhaps not until March 17, there is very little time to complete all of the work needed to implement multiple rate, technology and information treatments and to recruit more than 50,000 pilot participants by June 1, 2016. Based on Nexant's extensive experience designing, implementing and evaluating numerous rate, technology and information experiments, it is no exaggeration to say that the successful launch of the pilots and recruitment of the target number of customers across multiple utilities in the time frame available will be unprecedented within the electricity industry.

Although Commission approval of the advice letters may not occur until three months from the date of this report, the IOUs are necessarily already working hard on implementation planning. Some of the details of these plans and the implementation schedule for each IOU will be included in their advice letters. Key milestones for each utility will vary depending on the treatments they are implementing, the approach they take to implementation (e.g., outsourcing some activities versus doing everything in house), the current capabilities of existing business processes and IT systems, and many other factors. Those details will be included in each utility's advice letter.

This section presents a very high level overview of key milestones and activities for each month over the more than two-year period starting in January 2016 and ending in March 2018. The focus is primarily on the timing of regulatory proceedings, customer recruitment, enrollment and communications, and evaluation activities. Table 7-1 is meant to give readers a rough idea of when selected activities will likely occur. It is not intended to represent a comprehensive list of all of the critical path activities and milestones that will occur, especially over the first six months of 2016 when implementation preparation will be at its peak. It also doesn't represent a consensus concerning when each item listed in the table will actually occur for each IOU. If there are differences between the high level timeline shown in Table 7-1 and the timelines contained in each utility's advice letters, the advice letter timelines should be taken as accurate.

Table 7-1: High Level Overview of Key Pilot Milestones and Activities

Year	Month	Activities
2016	January	1. Advice letters filed 1/4/16 (may be filed as early as 12/24/15) 2. Recruitment pre-test launched by all three IOUs in the first two weeks 3. Commission aims to circulate draft Resolution disposing of advice letters for 30-day public comment period on 1/25 4. Reply briefs on 745 issues 1/11 (not on critical path) 5. IOUs complete sampling power analysis as input to finalizing sampling plan and budgets 6. Utilities conduct focus groups as input to development of E&O materials 7. Utilities contract out for implementation support if needed 8. SDG&E finalizes Rate 3 pilot plan and includes details in Advice Letter
	February	1. Analyze results from pre-test and finalize recruitment strategy (e.g., delivery channel, incentive level, timing of incentive payments, bill protection, letter content and format, etc.) 2. Develop revised recruitment strategy (e.g., telemarketing) if pretest results indicate that hitting required enrollment targets will be difficult 3. Finalize sampling plan and draw samples based on input from pretest and sampling power analysis 4. Update budget estimates based on 1, 2 and 3 above 5. Develop tracking databases in preparation for start of recruitment in March 6. Ensure that systems are in place to prevent participants from getting mandatory rate comparisons so as to avoid customer confusion and so as not to push customers off the rates shortly after they enroll in the pilots 7. Earliest date for Commission approval of advice letter – 2/25
	March	1. Last date for Commission approval of advice letters 3/17 2. Initiate customer recruitment 3. Hire evaluation contractor and survey research firm (if different)
	April	1. Continue recruitment 2. OAT rate adjustments for all customers (not just pilot customers) likely to occur (could occur in either March or May)
	May	1. Continue recruitment 2. Send welcome kits to all participants 3. Initiate working group meetings in early May concerning topics to be covered in planned surveys
	June	1. Customers begin being transferred to TOU rates according to their billing cycle starting 6/1 2. Enrollment incentives begin to be paid according to switch date
	July	1. Enrollment largely complete – finalize enrollment incentive payments 2. Most participants receive their first bill under TOU rates 3. Utilities initiate monthly reporting of dropouts and customer churn 4. SDG&E launches default usage alert to selected participants 5. SDG&E launches Rate 3 pilot recruitment 6. PG&E initiates ethnographic study of thermostat behavior 7. Earliest that PG&E may launch recruitment for smart phone app (could be done in August or September depending on variety of factors) 8. IOUs submit final survey plan and questionnaires for approval on July 1 9. Initiate TOU Working Group meetings for 2018 default pilot planning
	August	1. Final approval of survey plan and questionnaires for 2016 survey 2. 2018 pilot planning continues
	September	1. Survey implementation preparation 2. 2018 pilot planning continues
	October	1. PG&E and SCE initiate survey effort (summer period ends 9/30 for PG&E/SCE but not until 10/31 for SDG&E)

Year	Month	Activities
		2. PG&E/SCE deliver interval data to evaluation contractor 3. SDG&E launches smart thermostat recruitment 4. SDG&E Rate 3 enrollment complete 5. 2018 pilot planning continues
	November	1. PG&E/SCE surveys largely complete – survey analysis begins 2. SDG&E initiates survey process 3. SDG&E delivers interval data to evaluation contractor 4. Impact evaluation and billing analysis initiated 5. Finalize 2018 pilot plan and submit advice letters
	December	1. SDG&E surveys largely complete – folded into PG&E/SCE survey analysis efforts 2. Evaluation activities continue
2017	January	1. Preliminary survey, billing and impact results presented
	February	1. Draft interim evaluation report submitted for review 2. PG&E and SCE alert customers on Rate 3 to impending spring season rate change 3. Detailed planning for second survey begins
	March	1. Final interim evaluation report submitted 2. Continue planning for second survey
	April	1. SDG&E alerts customers to impending summer rate change 2. Detailed plan for second survey submitted to Commission for approval
	May	1. SDG&E sends interval data to evaluation contractor for winter and spring months – impact and billing analysis initiated for SDG&E 2. Commission approval of second survey
	June	1. Second survey sent at the beginning of the month 2. Final incentive payments begin to be paid as surveys are returned 3. PG&E and SCE send interval data to evaluation contractor for winter and spring months – impact evaluation and billing analysis initiated
	July	1. Bill protection payments are calculated after 12 months of being on the rate and begin to be paid (if bill protection is employed) 2. Surveys should be largely complete – survey analysis begins 3. Impact and billing analysis continues
	August	1. Remainder of bill protection payments are sent 2. Impact and billing analysis continues – survey analysis conducted
	September	1. Second interim evaluation report covering full year impact and billing analysis and second survey analysis completed 9/15
	October	1. PG&E and SCE send interval data for summer 2017
	November	1. SDG&E sends interval data for summer 2017 for Rates 1, 2 and 3 2. Customers notified about impending end of pilot and date on which they will be switched to other tariffs – customers presented with rate comparison reports so they can make an informed choice regarding tariff options 3. Impact evaluation for summer 2017 is initiated
	December	1. Evaluation analysis
2018	January	1. All utilities deliver final interval data through 12/31 to evaluation contractor 2. All customers transferred to other rates 3. Evaluation analysis
	February	1. Evaluation analysis
	March	1. Final pilot evaluation report submitted 3/30

Appendix A TOU Working Group Participants

Organization	Name
Barkovich and Yap	Barbara Barkovich Cathy Yap
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California Energy Commission	Lynn Marshall
California Independent Systems Operator	Delphine Hou Jordan Pinjuv
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Comverge	David Lowrey
Cross Border Energy	Patrick McGuire Thomas Beach
Distributed Energy Financial Group LLC	Nat Treadway
Ellison, Schneider & Harris	Chase Kappel
Energy Division	Bob Levin Neha Bazaj Patrick Doherty Paul Phillips
Enernoc	Mona Tierney-Lloyd
Enphase Energy	Arthur Haubentock Jason Simon
Environmental Defense Fund	Gavin Purchas Jamie Fine Jennifer Weberski Larissa Koehler
Goodin, MacBride, Squeri, and Day	Jeanne Armstrong
Greenlining Institute	Stephanie Chen
KFW Law	Joseph Wiedman

Organization	Name
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Natural Resources Defense Council	Merrian Borgeson
Nest	Aaron Berndt Jeff Gleeson
Nexant	Aimee Savage Jennifer Potter Stephen George
OPOWER	Charlie Buck Serj Berelson
ORA	Ben Gutierrez Dexter Khoury Gregory Heiden Lee Whei Tan Louis Irwin Nathan Chau
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SCE	Andre Ramirez Brandi Anderson Brian Kopec Bruce Reed Cyrus Sorooshian-Tafti Fadia Khoury Kiphan Kan Michelle Rodriguez Miriam Fischlein Paul Kasick

Organization	Name
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Siemens	Bonnie Datta Chris King
Sierra Club	Alison Seel Andy Katz
Solar City	Jaclyn Harr Juli Getchell Marc Kolb
Solar Energy Industries Association	Brandon Smithwood
Sonoma Clean Power	Nathan Kinsey Erica Torgerson
Sun Run	Susan Wise Glick
Temix	Edward Cazalet
The Utility Reform Network (TURN)	Eric Borden Marcel Hawiger Matt Friedman (?)
Utility Consumer Action Network (UCAN)	David Croyle Don Kelly
Vote Solar	Susannah

Appendix B Analysis Method to Estimate Sample Sizes for Load Impact Determination

Date: October 15, 2015

To: TOU Pilot Design Working Group

From: Jon Cook and Steve George, Nexant

Re: Monte Carlo Simulations for Determining Default TOU Pilot Sample Sizes

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Summary

This memorandum provides documentation of the process used to establish sample size requirements for the CA Default TOU Pilot. Monte Carlo simulation was used in conjunction with a false experiment to determine the precision of estimated peak period load impacts that would result from using various sample sizes. Data for the simulation came from a convenience sample of customers that Nexant already had from work underway with PG&E to evaluate the impact of the Company's Home Energy Report (HER) program.

Data

The Default TOU pilot is being designed to provide valid estimates of what the impacts of TOU pricing would be for pilots to be conducted by each of the three CA IOUs. Ultimately, each utility will need to conduct their own analysis of a similar nature to determine the sample sizes needed for each test cell based on the unique usage characteristics of the customer population targeting each segment and treatment group of interest. The data used here came from a sample of approximately 70,000 customers used as a control group for PG&E's Home Energy Report program. Customers enrolled in this phase of the HER program had to meet the following criteria:

- Dual fuel (electric and gas);
- Currently on a flat rate, TOU, or seasonal rate;
- Do not reside in San Bruno or Marin County;
- Mailing address matches service address;
- No medical baseline;
- No net-metering;
- Usage in the top 3 quartiles of electricity usage for the territory;
- Not vulnerable or disabled; and
- Must have a SmartMeter installed.

Interval data from the summer (May-October) of 2013 was used for analysis. The outcome variable of interest was the average load (kW) during a hypothetical peak period of 2-7 pm on weekdays. Data were collapsed so that the analysis dataset is a panel made up of individual customers and daily observations of average peak period load. The average weekday peak period load in the dataset is approximately 1.15 kW.

Monte Carlo Simulation

Monte Carlo simulation (or experimentation) is a methodology that is commonly used for investigating the properties of econometric estimators and verifying that valid methods of statistical inference are being used.[62] The power of the methodology lies in its use of repeated sampling to understand the properties of a particular estimator or statistic under realistic data conditions.[63]

One of the key questions for the design of the TOU pilots is how large a sample should be to detect the expected effect of for each test cell. Sample size is important because it directly affects two related properties of statistical analysis – power and precision. Power is the ability of an analysis to detect an effect if it indeed exists, while precision deals with how close the estimates would be if the analysis was repeated many times using different samples. All else equal, larger sample sizes increase both power and precision since there is more data available to use for estimation. The primary focus of this simulation is precision. Precision is not only affected by sample size, but also by the inherent variability in the data along with the estimator that is used. We are interested in understanding how precisely peak period load impacts can be estimated using different sample sizes or alternatively, how large of a sample is needed to achieve a pre-determined level of precision.

To answer these inquiries, we conducted Monte Carlo simulations that incorporate a false experiment. The idea of a false experiment is to conduct an analysis in a situation where the magnitude of the treatment is known to be zero using data that is similar to what would be used in a real experiment. Knowing the answer beforehand allows us to assess whether or not the estimator used produces biased results, while using real data gives us an idea of how precise the estimator will be.

The simulation process is shown in Figure 1. For each sample size of interest, a random sample of that number of customers is drawn from the master dataset of 70,000 described above. Next, the "experiment" is created by randomly assigning half of the customers to a "treatment" group on a TOU rate and the other half to a control group who remain on their current rate. We then assume that the imaginary TOU treatment went into effect on August 1 for all customers. With this experimental framework, the "impact" of the fictional TOU rate can be estimated using the following equation, where i subscripts denote individuals and t subscripts denote time periods (days):

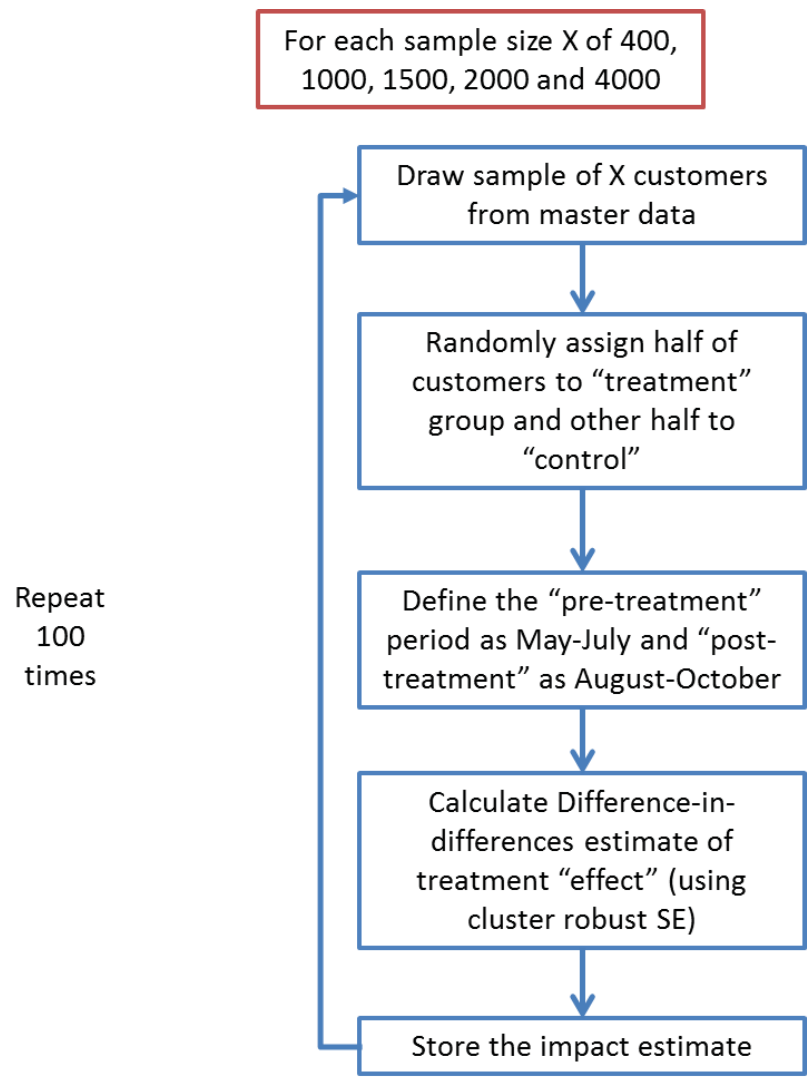
[62] For a more detailed discussion of Monte Carlo simulation, see Kennedy, Peter, "A Guide to Econometrics" (2008), Section 2.10 - http://www.masonlec.org/site/rte_uploads/files/Econometrics%20Book%20-%20Intro,%20Ch%201%20and%202.pdf

[63] Asymptotic properties of estimators are generally known, but rely on assuming sample sizes that approach infinity that are not appropriate in many applied research situations that rely on finite samples.

$$kW_{i,t}^{\text{peak}} = \alpha + \delta\text{treat}_i + \gamma\text{post}_t + \beta(\text{treatpost})_{i,t} + \varepsilon_{i,t} \quad (1)$$

In Equation 1, the variable *treat* is equal to 1 for treatment customers and 0 for control customers, while the variable *post* is equal to 1 for days in August-October and a value of 0 for days in May-July. The *treatpost* term is the interaction of *treat* and *post* and its coefficient β is the differences-in-differences estimator of the treatment effect that makes use of the "pre-treatment" data. In the simulation, Equation 1 is estimated using OLS regression with cluster robust standard errors to account for serial correlation that is likely to be present in the data. For additional robustness, bootstrapped standard errors are also calculated.[64]

Figure 1: Monte Carlo Simulation with False Experiment



[64] Serial correlation certainly exists in the variable of interest (*treatpost*) and is very likely to be present in the dependent variable (daily peak period average load). If unaddressed, serial correlation will lead to standard errors that are systematically too small. This results in overstating the precision of the impact estimate and misleading inference. To adjust for serial correlation, we follow the best practices described by Bertrand, et al. (2002), Wooldridge (2003) and Cameron (2010).

Simulation Results

At the end of the simulation, we have 100 impact estimates and 100 corresponding standard errors. The next step of the process is to use this information to draw conclusions about the precision that can be achieved with each sample size. The precision will be based on the standard error of the impact estimate, which we calculate using two methods. The first is simply to use the average of the 100 standard errors that we have for each sample size. The second is to calculate the bootstrapped standard error, which is equal to the standard deviation of the 100 impact estimates for each sample size.

The final step is to translate the estimated standard errors into confidence intervals, which form the basis of statistical inference. This is a straightforward calculation that consists of multiplying the standard error by the t-value corresponding to the desired confidence level (approximately 1.96 for 95% confidence and 1.65 for 90% confidence[65]) to obtain the margin of error (MOE) that will be added and subtracted from the impact estimate to form the confidence interval. In our false experiment, we know that the true impact is zero, however the MOE captures the precision of that estimate if it was non-zero. For this reason, we focus discussion on the MOE.

Results using each of the standard error methods are shown in Table 1. Importantly, both methods produce very similar MOEs.[66] The interpretation of the results would be, for example, "With a sample of 1,500 customers, we would expect to be able to estimate the impact of TOU rates on peak period usage to within plus or minus 2.7% with 95% confidence." Put another way, the 95% confidence interval around a true impact of 5% with a sample of 1,500 customers would be (2.3%, 7.7%).

Table 1: Expected Precision for Peak Period Load Impacts Using Different Sample Sizes

Sample Size (Treatment + Control)	Avg. SE Method		Bootstrapping Method	
	95% MOE	90% MOE	95% MOE	90% MOE
400	5.2%	4.4%	5.2%	4.4%
1,000	3.3%	2.8%	3.2%	2.7%
1,500	2.7%	2.3%	2.7%	2.2%
2,000	2.3%	2.0%	2.2%	1.9%
4,000	1.6%	1.4%	1.7%	1.4%

In addition to the precision for the average impact in the general population, certain population segments are of particular interest for the pilot—non-CARE, CARE, customers in hot areas and customers in cool areas. CARE customers are readily identifiable in the PG&E data and we

[65] We assume a two-tailed test.

[66] As an additional robustness check on the standard errors, we took advantage of the false experiment and counted the number of statistically significant results (i.e. reject the null hypothesis of zero impact) observed during the simulation for each sample size. With appropriate standard errors, the false positive rate should be roughly equivalent to the alpha used to calculate the confidence interval (by definition). For both the Avg. SE method and the bootstrap method, this is indeed the case, with the number of false positives out of 100 iterations ranging from 3-7.

define hot areas as PG&E climate region R, S and W, which are shown in Figure 2. Table 2 shows bootstrapped MOE estimates for these sub-populations at both 95% and 90% confidence.

Figure 2: PG&E Climate Regions

Table 2: Expected Precision for Peak Period Load Impacts Using Different Sample Sizes (Bootstrap Method)

Sample Size (Treatment + Control)	95% MOE				90% MOE			
	Non-CARE	CARE	Cool	Hot	Non-CARE	CARE	Cool	Hot
400	6.5%	5.0%	5.0%	4.3%	5.4%	4.2%	4.2%	3.6%
1,000	3.7%	3.0%	3.7%	2.9%	3.1%	2.6%	3.1%	2.4%
1,500	2.9%	2.2%	3.1%	2.4%	2.5%	1.9%	2.7%	2.0%
2,000	2.6%	2.2%	2.4%	2.0%	2.2%	1.8%	2.0%	1.7%
4,000	1.7%	1.3%	1.7%	1.4%	1.4%	1.1%	1.5%	1.2%

Table 2 shows that the underlying variability in peak usage is not the same across the different subpopulations. Variance is higher for Non-CARE customers due to higher usage levels, while greater variability in cool climates is likely due to more heterogeneity in demographics, home size and weather conditions on the coast versus the mountains compared to more homogeneity in the central valley.

Power

In addition to precision, a related concept that is generally of interest when determining sample sizes is statistical power. Power refers to the likelihood of finding a statistically significant impact when an impact actually exists and depends on the magnitude of the impact, sample size, inherent variability in the data and desired level of confidence. Based on the estimated standard errors from the simulations, we can map out the power level associated with different impact sizes for each sample size. These “power curves” are shown in Figure 3 for the 95% confidence level.

Figure 3: Power Curves for Sample Sizes of Interest Using Bootstrapped Standard Errors (95% Confidence)

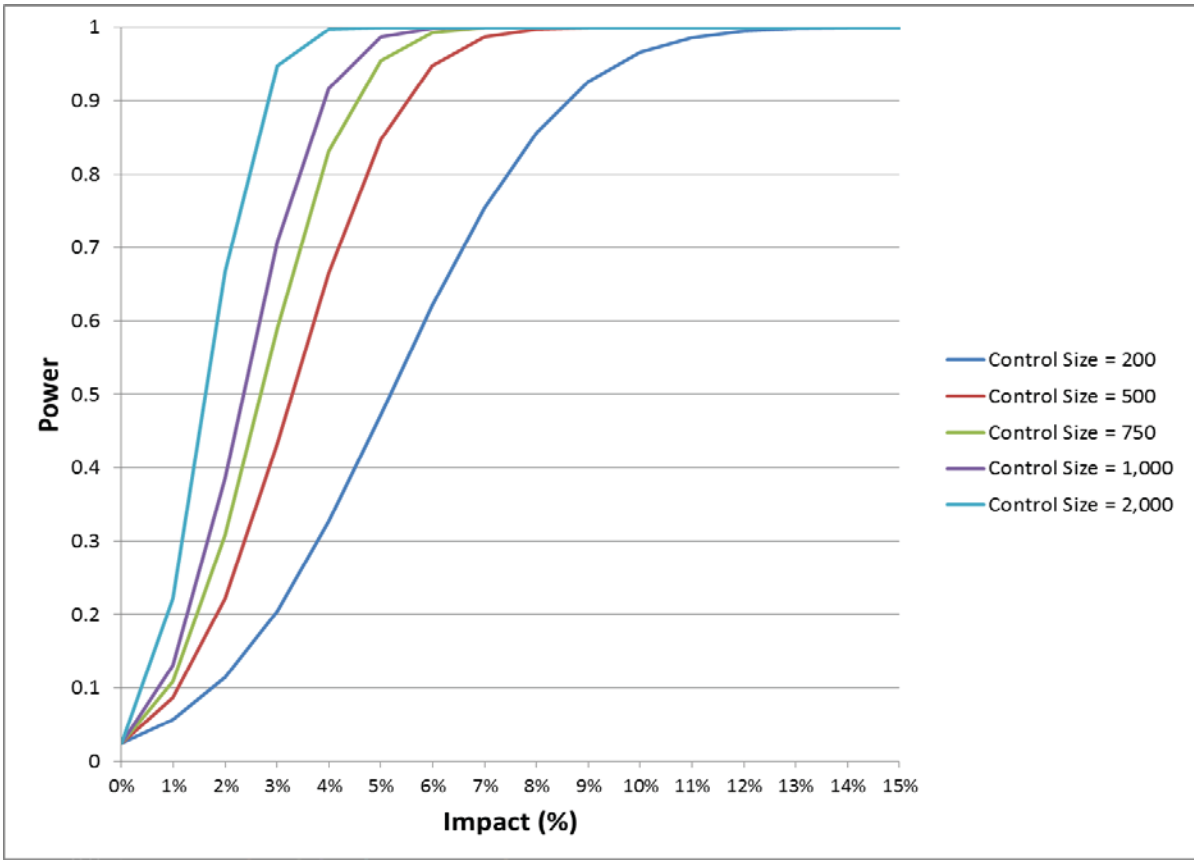


Figure 3 shows that as the sample size increases, so does the likelihood of finding statistically significant results for a given sized impact. For example, the power associated with detecting a 3% impact (95% confidence) using 500 treatment and 500 control customers is about 0.4, but with 1,000 treatment and 1,000 control customers, power increases to about 0.7.

Conclusions

The above analysis provides indicative estimates of sample sizes tied to confidence bands. The specific sample sizes for a given confidence level will vary across utilities and across customer segments within a utility. Each utility should plan to conduct similar analysis to determine target sample sizes for each test cell once the treatments and segments are finalized.

References

Bertrand, Marianne, Esther Duflo, and Sendhil Mullainathan. *How much should we trust differences-in-differences estimates?*. No. w8841. National Bureau of Economic Research, 2002.

Wooldridge, Jeffrey M. "Cluster-sample methods in applied econometrics." *American Economic Review* (2003): 133-138.

Cameron, Adrian Colin, and Pravin K. Trivedi. "Microeconometrics using stata." (2010): 166.

Appendix C Selected Comments from TOU Working Group Participants

The appendix contains selected comments (accompanied by report sections from a prior draft) from selected TOU Working Group members who may have different opinions about some of the decisions that were made by the Working Group.

Section 2.1:

Specifically, the AC/ALJ ruling indicated that each IOU must:

- Prepare a menu of at least three opt-in TOU rate designs;
- Include at least one TOU rate design with a more complex combination of seasons and time periods than traditional TOU rates that better matches system needs, which may incorporate more dynamic pricing features and enabling technologies, and this pilot must begin no later than October 1, 2016; and
- All other opt-in TOU pilots must begin no later than June 1, 2016.

EDF: *"In additional to system needs, the plan should consider customer needs and capabilities, and the goal of providing customers with a menu of rate options. Thus far, with the exception of the SDG&E Rate 3, the rate treatments differ by very little in terms of price, and the off-peak rates do not provide a significantly lower priced time to use energy. The lack of a price differential undercuts the financial rewards for load shifting, so the current proposals will tend to dampen enthusiasm for customer action. Similarly, peak price time periods that extend beyond several hours pose a more daunting load shifting objective than short period peak price windows, so shorter peak price windows should be available for the TOU pilots."*

With the CPUC direction summarized above as input, the TOU Working Group developed the following, more specific pilot objectives as input to pilot design…estimate load impacts by rate period for different rate structures that vary in terms of the timing and length of rate periods, the number of rate periods, changes in rate periods across seasons, price ratios, and perhaps other features.

EDF: "*One very important feature to test is the ability for customers to INCREASE their demand at low-priced (or negative priced) times of the day/year, such as the "spicy" Rate 3 options: so far only SDG&E has contemplated crediting bills when customers use energy at times when wholesale energy prices are negative"*

With the CPUC direction summarized above as input, the TOU Working Group developed the following, more specific pilot objectives as input to pilot design…assess the incremental effect of enabling technology on load impacts and customer satisfaction; and assess the relative effectiveness of various information, education and outreach options…

EDF: "*These are important objectives that should be pursued to identify bill impact mitigation strategies. Evaluation plans regarding the testing of mitigation strategies should be part of the TOU pilots."*

Section 3.1:

Table 3-1: Prices and Price Ratios

Tariff	Season	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
PG&E Rate 1	Spring	Off-peak														(22¢)		Peak				(22¢)	Off Peak		(22¢)
	Summer																								
	Winter																								
PG&E Rate 2	Spring	Off Peak														(22¢)		PP	(22¢)	Peak		(22¢)	PP (22¢)	Off Peak (22¢)	
	Summer																								
	Winter																								
PG&E Rate 3	Spring	Off Peak									(22¢)	Super Off Peak				(22¢)		Peak				(22¢)	Off Peak		(22¢)
	Summer	Sumer Off Peak (SOP)														(22¢)		Summer Peak					SOP		
	Winter	Off Peak																Peak					Off Peak		
SCE Rate 1	Spring	Off Peak (17.0¢)								Partial Peak (21.7¢)						Peak (22.7¢)						PP (21.7¢)	Off Peak (17.0¢)		
	Summer	Off Peak (16.8¢)								Partial Peak (22.6¢)						Peak (56.8¢)						PP (22.6¢)	Off Peak (16.8¢)		
	Winter	Off Peak (17.0¢)								Partial Peak (21.7¢)						Peak (22.7¢)						PP (21.7¢)	Off Peak (17.0¢)		
SCE Rate 2	Spring	Off Peak (17.1¢)								Partial Peak (21.8¢)									Peak (24.3¢)			PP (21.8¢)	Off Peak (17.1¢)		
	Summer	Off Peak (17.0¢)								Partial Peak (28.5¢)									Peak (58.7¢)			PP (28.5¢)	Off Peak (17.0¢)		
	Winter	Off Peak (17.1¢)								Partial Peak (21.8¢)									Peak (24.3¢)			PP (21.8¢)	Off Peak (17.1¢)		
SCE Rate 3	Spring	Off Peak (20.7¢)											Super Off Peak (16.5¢)						Peak (23.2¢)				Off Peak (20.7¢)		
	Summer	Off Peak (17.2¢)											Peak (33.9¢)						Super Peak (49.9¢)				Peak (33.9¢)		OP (17.2¢)
	Winter	Off Peak (21.4¢)																	Mid Peak (24.2¢)				Off Peak (21.4¢)		

UCAN: *"The more complex the TOU rate design, the more difficult it is to interpret the results of the pilot. SCE and PG&E have two pilots that involve relatively simple designs with shorter and longer on-peak time periods and corresponding adjustments to the on-peak to off-peak price ratios. However, each utility also offers a more complicated rate design that diverges from the simple approach and makes it more difficult to interpret the results of the rate experiment. For example, in the more complex rates with more periods and prices in which to respond, it becomes more difficult to determine to which features of the rate the customer is responding to.*

Since one goal of the experiment is to cull features from these opt-in rates for use in the TOU default rate, the more complicated the pilot TOU rate, the harder it will be to isolate the most critical design features. SDG&E is redesigning its rate options but originally had no period length differential in Pilot 1 and 2, and Pilot 3 was a dynamic pricing rate and not a TOU rate at all. Those rates were unclear regarding what features were being tested for the TOU default rate. UCAN is concerned about the usefulness of the TOU rate experiment results if there is no coordination among the pilot rates that lead to a default TOU design that serves the needs of the residential population in 2019. Will we learn what we need to know by the end of the experiment if the nine pilot rates are not logically coordinated?"

Section 3.3.1:

Table 3-2: Expected Precision for Peak Period Load Impacts Using Different Sample Sizes (Based on a sample of customers from PG&E's service territory)

Number of Treatment + Customers Combined	95% Confidence Band	90% Confidence Band
400	5.2%	4.4%
1,000	3.2%	2.7%
1,500	2.7%	2.2%
2,000	2.2%	1.9%
4,000	1.7%	1.4%

The values in Table 3-2 indicate that, with a sample of 1,000 treatment customers and an equal sized sample of 1,000 control customers (the fourth row in the table), an estimated impact of, say, 5%, would have a 90% confidence band from 3.1% to 6.9%. If the sample of treatment and control customers was doubled, to 2,000 each, the 90% confidence band would narrow to ±1.4% (e.g., it would range from 3.6% to 6.4% if the estimate was 5%). Importantly, in the above example using 1,000 treatment and control customers, if the estimated value was 1% rather than 5%, the 90% confidence band would span 0. Put another way, it would not be possible to conclude with 90% confidence that the 1% load impact was statistically different from 0.

EDF: *"1) Let's make sure the WG members are clear on what this means. I think this means that we are 90% confident that the real peak load impact is between 3.1% and 6.9% when we experimentally determine it to be 5%. If so, quadrupling the sample from 1,000 to 4,000 means we reduce the range from 3.8% (= 6.9 – 3.1) to 2.8% (= 6.4 – 3.6). That's a significant reduction in the range.*

With the NERC reliability standard of a 12% reserve margin, 1% difference in peak load is significant. If approaching conservatively, the minimum end of the band - peak load reductions to be put into the CEC IEPR forecast for the TOU default would be 3.1% or 3.6%, depending on the confidence interval used. While this is only 0.5% difference, the

financial implications can be significant; also, this would be a bigger difference if we were calculating a 99% confidence interval.

However, this confidence interval ignores bigger sources of uncertainty in the estimate, such as the assumptions used to build the baseline peak load. Nevertheless, the outputs will inform load forecasts used in Resource Adequacy assessments. There is significant potential for significant avoided capacity value associated with TOU default, so this study should endeavor to produce a 99% confidence interval.

2) The ±1.4% figure is erroneous – this is a sample size of 4,000, not 2,000.

3) A 90% confidence range isn't adequate for resource adequacy purposes; need at least a 95% confidence band, probably a 99% band would be preferable for local and state resource adequacy applications. What would CAISO and CEC expect to see for use in IEPR load forecasts?"

Section 3.4:

The objective of the TOU pilots is to estimate the change in usage (and bills) for customers who are defaulted onto TOU rates in 2019."

EDF: *"This is incomplete and misplaced. See page four's more complete list of pilot objectives."*

There is substantial evidence from many pilots that people can understand TOU prices quickly and make adjustments in peak period usage rapidly."

EDF: "*Right, so we should not be testing this question in the present TOU pilot."*

With this in mind, if control customers were placed on the 2019 OAT at the same time that treatment customers were placed on the TOU rates, it's highly unlikely that the control group customers would modify their usage immediately to reflect the pattern of usage that customers would actually have in 2019 after going through four years of gradual changes in the tier structure. Given this, while one might think that basing the pilots on the 2019 OAT and TOU rates would produce a valid comparison of usage under the 2019 OAT with usage under the 2019 TOU rate, in fact it would more likely involve a comparison in usage under the 2019 TOU rate with usage under the 2016 OAT that control group customers will have been on for a couple of months at the start of the pilot.

EDF: *"We need to reveal how customers will make long term investments in DERs. We need to test for more than short term price elasticity; we also need to test what will lead to customer actions, testing what will influence customer economics in rate design is just one factor; can also survey for customer understanding, capabilities and preferences."*

Section 3.6:

Relatively few prior studies have combined enabling technology with static TOU rates such as those that will be examined in these pilots. Also, it is very important to keep in mind that when comparing load impacts for the average household with and without air conditioning load

control, for example, observed differences are influenced by more than just the load control technology. All households with air conditioning load control have air conditioning whereas many households on TOU rates without load control do not have central air conditioning, especially in California. As a result, the difference in load impacts for households with and without air conditioning load control reflects not just the difference due to the load control device but also the difference due to variation in the saturation of air conditioning between the two groups. Very few public studies on this subject adequately control for this significant selection effect.

> EDF: *"This is an important point worth exploring in more detail as part of the TOU design; it is important to identify and engage non-central AC customers in TOU pilots."*

We are not aware of any studies that have examined the incremental effect of customer purchased devices such as smart thermostats or simpler programmable thermostats, with or without outside control, on load reductions under static TOU rates or the impact of TOU rates on the purchase of smart thermostats.

> EDF: *"Good questions; what about surveys of customers' interest in and willingness to purchase technologies and DERs?"*

It may also be true that TOU rates, especially widespread default rates, will hasten the penetration of these devices. Furthermore, these devices offer opportunities for vendors and utilities to partner with consumers to automate adjustments in usage during peak periods. This is already happening in conjunction with dynamic rate programs at selected utilities. For example, Nest, a provider of smart thermostats, offers its Rush Hour Rewards service to consumers in utility service territories where peak time rebate programs exist, such as SCE's Save Power Days (SPD) program. Nest automatically adjusts the consumer's thermostat according to directions provided by the consumer on PTR event days. It may be possible for utilities and vendors to develop similar services that enable demand reductions for consumers in conjunction with static TOU tariffs.

> EDF: "*This is what the TOU pilots can be testing: how to provide utility and vendor services that enable demand reductions for consumers in conjunction with static (default) and dynamic (optional) TOU rates."*

SCE's technology treatment will focus on smart thermostats and, more specifically, on the population of customers that already have these devices installed.

> EDF: "*This seems to refocus the rate pilot into a technology pilot; that is not what EDF has recommended. Rather, EDF recommends a dynamic "technology friendly" tariff to be deployed with a diversity of technologies and practices. With that said, this SCE proposal looks meritorious, just not what EDF was expecting in terms of a tariff for rewarding technologies."*

On the other hand, if it is only adopted by a small group of tech savvy consumers, it might not be worthy of investment as part of the mainstream offer down the line. Thus, one of the primary

learnings from this treatment will be to determine what the acceptance rates are across various customer segments, climate regions, usage levels and rate options.

> EDF: "*This is the wrong test - timing of who adopts depends on lots of factors; currently we're still in the early adopter phase and there is more innovation to come…it would be like piloting the California Solar Initiative for one summer in 1998 only to determine it wasn't worth doing (simply because it was too soon in terms of the economics.)"*

Section 4.2.1:

Figure 4-2: PG&E Pilot Tariffs

Weekday Rate Periods

Tariff	Season	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
PG&E Rate 1	Spring	Off-Peak (25.1¢)																Peak (27.0¢)					Off Peak (25.1¢)		
	Summer	Off-Peak (30.3¢)																Peak (40.6¢)					Off Peak (30.3¢)		
	Winter	Off-Peak (25.1¢)																Peak (27.0¢)					Off Peak (25.1¢)		
PG&E Rate 2	Spring	Off-Peak (25.0¢)																		Peak (27.0¢)			Off-Peak (25.0¢)		
	Summer	Off-Peak (29.0¢)																PP (36.2¢)		Peak (42.3¢)			PP (36.2¢)	Off-Peak (29.0¢)	
	Winter	Off-Peak (25.0¢)																		Peak (27.0¢)			Off-Peak (25.0¢)		
PG&E Rate 3	Spring	Off-Peak (25.3¢)										Super-Off-Peak (22.7¢)						Peak (26.6¢)					Off-Peak (25.3¢)		
	Summer	Summer Off Peak (SOP) (30.1¢)																Summer Peak (40.4¢)					SOP (30.1¢)		
	Winter	Off-Peak (25.6¢)																Peak (27.5¢)					Off-Peak (25.6¢)		

Weekend Rate Periods

Tariff	Season	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
PG&E Rate 1	Spring	Off-Peak (25.1¢)																							
	Summer	Off-Peak (30.3¢)																							
	Winter	Off-Peak (25.1¢)																							
PG&E Rate 2	Spring	Off-Peak (25.0¢)																		Peak (27.0¢)			Off-Peak (25.0¢)		
	Summer	Off-Peak (29.0¢)																PP (36.2¢)		Peak (42.3¢)			PP (36.2¢)	Off-Peak (29.0¢)	
	Winter	Off-Peak (25.0¢)																		Peak (27.0¢)			Off-Peak (25.0¢)		
PG&E Rate 3	Spring	Off Peak (25.3¢)										Super-Off-Peak (22.7¢)						Off Peak (25.3¢)							
	Summer	Summer Off Peak (SOP) (30.1¢)																							
	Winter	Off-Peak (25.6¢)																							

> EDF: *"Rate 3 is almost identical to Rate 1. EDF proposed a "smart home rate" in writing at the first working group meeting; it is appropriate for this report to include the EDF proposal, and for the IOUs to provide a response to it: why it won't work or when it will be tested as part of the TOU pilots."*

Section 4.3:

SDG&E will also market a third rate option using a more traditional opt-in recruitment strategy. This rate is quite different from the other rates in that the supply component of the tariff will have prices that vary hourly. The rate will also include adders that vary by time of day for system peak events and for distribution circuit peak events. Credits for surplus energy events will also be included. This tariff will be bundled with enabling technology that will provide greater automation for this dynamic rate than is provided simply through a smart thermostat. This treatment will be targeted at a small group of electricity consumers with the specific characteristics that are yet to be determined but may include electric vehicle owners.

> *EDF: "The third rate option should be offered with the other rate options in the pilot, not pursued thru separate traditional channels. Put differently, EDF questions the rationale for testing this rate through a separate pathway?"*

Section 5.1:

3. How do load impacts vary across rate options? The tariffs included in the various pilots have significant variation in prices by rate period and in the length and timing of rate periods. As such, it will not be possible to sort out the independent impacts of price ratios, peak period length and peak period timing. It will be possible to estimate the aggregate load reduction for specific hours of the day associated with each tariff, which will provide useful input to the selection of a default tariff for implementation in 2019.

> EDF: *"It is important to specify here that we will examine how TOU rates can inspire load *increases* to align demand with renewable generation. Traditionally, the focus has been only on how customer shift load away from peak, which is also important but not a new research question. In addition to measuring load impacts, the pilots should develop an understanding of the dynamic relationships between TOU prices, marketing strategies and technology enablement programs."*

8. What is the impact of smart thermostats on load reduction? The SCE technology treatment will address this question for a self-selected group of households that purchased a smart thermostat on their own using an RCT research design. SDG&E's smart thermostat treatment may provide additional insights for households that receive an incentive to purchase a smart thermostat equal to a portion of the cost of the thermostat. Load impacts for this treatment will be estimated using ex post statistical matching to create a control group after the fact (assuming enough participants purchase thermostats to make this feasible). PG&E's ethnographic study of thermostat owners may produce qualitative insights about how smart thermostats are being used in response to TOU rates.

> EDF: *"Based on prior studies and a Faraqui et al. study, we should be able to predict load impacts once the IOUs have specific their rates. These predictions can be used to establish performance expectations for IOU ME&O."*

9. Do customers on TOU rates purchase smart thermostats at a higher rate than customers who are not on TOU rates? SDG&E's smart thermostat treatment will offer customers who are already on TOU rates and control group customers various incentive amounts to be applied to the purchase of a smart thermostat of their choosing. Acceptance rates for the incentives will be compared between treatment and control customers to determine whether TOU customers take up thermostats at a higher rate than non-TOU customers.

> EDF: *"This is a subset of a broader question: what strategies will both mitigate risk of bill impacts and maintain/enhance customer satisfaction? This question should be answered for all customer segments, but the priority will be for customers facing a high risk of hardship impacts associated with TOU default."*

11. What is the impact of a smart phone app on load reductions, customer acceptance and customer satisfaction with TOU rates? PG&E will divide rate treatment participants into two randomly selected groups (not necessarily equal in size) and offer the smart phone app to one group and not to the other. If acceptance of the app is great enough, an RED impact assessment will be conducted to determine whether the information provided through the app increased load reductions for rate participants who receive it. If app acceptance is too low, statistical matching will be used to develop a control group for estimating load impacts. Answers

to survey questions pertaining to customer satisfaction, acceptance, awareness, understanding of rates and other metrics will be compared between those who download the app and those who don't to determine whether there are significant differences in these metrics. App acceptance rates will also be reported and compared across rate options and customer segments.

> EDF: *"PG&E could go further in specifying what it will do – in 2018 pilot and 2019 default – based on what is learned by the phone app study. If acceptance is low, then PG&E should have a plan B for communicating with and assisting customers when they are defaulted to TOU rates. What is "great enough interest", what is "too low"? If acceptance is low, then PG&E should commit now to additional studies and strategies toward a goal of increasing customer acceptance. This is particularly important if the app is funded by ratepayers; it would not be a good investment to simply do a one-off test of customer acceptance, but it would be worthwhile to commit to studies that examine and then pursue specified levels of customer acceptance (and satisfaction)."*

What E&O materials are most effective in enhancing customer acceptance and retention, engagement, satisfaction, knowledge of rates, etc.?

> EDF: *"Need to include interest in investing in distributed energy resources."*

(End of Appendix 1)