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SmartPricing Options Interim Evaluation

An interim evaluation of the pilot design, implementation, and evaluation of the Sacramento Municipal Utility District's Consumer Behavior Study

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Acknowledgements

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1.0 Project Introduction

This research provides information necessary to assist in maintaining low rates and high levels of customer satisfaction, while sending appropriate price signals to customers to encourage responsible electricity consumption.

The utility industry landscape is changing at a rapid pace, breaking new ground in customer partnerships and utility operations. With the development and continued advancement of smart grid infrastructure and technology, utilities are faced with the challenge of embracing changes that provide customers and internal operational teams new value propositions. While many of the smart grid benefits may seem obscure from the customers' perspective in this early state, there are countless opportunities to leverage the enhanced grid to provide customers with choices, services, and solutions that were not feasible in the past.

As part of our Compact with the Customer initiative, Sacramento Municipal Utility District (SMUD) has committed to empowering customers with solutions and options that increase energy efficiency, protect the environment, reduce the greenhouse gas emissions that contribute to global warming and lower the cost to serve our region. SMUD's strategic approach includes boosting renewable energy supplies, becoming more aggressive with energy efficiency, and developing new demand response options. SMUD seeks to assist customers in becoming active managers of their energy use and offer better tools to shift their use from peak into the off-peak hours.

The Department of Energy's Smart Grid Investment Grant (SGIG) offered SMUD the opportunity to test the impacts of dynamic pricing and enabling smart grid technology on peak load shaving, energy conservation, and customer satisfaction using rigorous experimental research methods. SMUD is one of eleven utilities conducting a Consumer Behavior Study (CBS), a dynamic pricing trial, funded in part by the SGIG. The enclosed report describes the planning, implementation and load impact evaluation of the first summer of SmartPricing Options.

1.1 About SMUD

SMUD is a publicly-owned electric utility governed by a seven-member Board of Directors. Serving approximately 600,000 customers and a total population of about 1.4 million, SMUD is the sixth-largest public utility in the United States. Our 900-square-mile service territory encompasses Sacramento County and a small portion of Placer County.

SMUD has been providing public power to the Sacramento region since 1946, and our energy efficiency and renewable energy programs are recognized nationally for leadership and innovation. For each of the last eight years, SMUD has received the highest customer satisfaction ratings of any utility in California in the J.D. Power and Associates survey and received the second-highest score in the United States for commercial customer satisfaction in 2010.

1.2 Consumer Behavior Study Background

SMUD was awarded a $127M grant toward a $308M smart grid project from the U.S. Department of Energy (DOE) as part of the American Recovery and Reinvestment Act of 2009 (ARRA). SMUD's SmartSacramento®[1] project is a result of an effective and strategic partnership between SMUD, California State University Sacramento, State of California's Department of General Services, County of Sacramento, Los Rios Community College District, Elk Grove Unified School District, and the Sacramento City Unified School District. Together with our partners, SMUD is implementing a smart grid in Sacramento that can serve as a model for California and the rest of the United States.

Included in SMUD's proposal to DOE was an agreement to participate in a cross-utility research effort to study the impacts of dynamic pricing in various regions. This study accounted for approximately 4% of SMUD's proposed smart grid project budget. Utility participants who conducted a consumer behavior study would not only benefit from the research opportunity within our own services territories, but the findings would be publicly available both by individual utility analysis as well as an aggregate assessment across consumer behavior studies to be conducted by Lawrence Berkeley National Laboratory. Currently, there are 11 approved studies being conducted. The research results are anticipated to be referenced by strategic planners within utilities, policy makers, technology developers and manufactures, and others in the utility space with an interest in pricing design, behavior shifting, and enabling technology development.

Upon award of DOE grant funding in 2009, teams were assembled to begin the detailed planning of each of SMUD's new projects that resulted from the grant award. SMUD's consumer behavior study was among the new projects in SMUD's smart grid portfolio.

[1] ®A registered service mark of the Sacramento Municipal Utility District.

While time-variant rates weren't new to the utility industry, a large-scale implementation integrated with emerging smart grid technology was uncharted territory for SMUD. Smart meter implementation was in its early stages, smart grid systems integration was still being tested, and the true capabilities of the impending upgrades to SMUD's infrastructure were largely unrealized. The team was tasked with developing research objectives and an evaluation plan in consultation with a Technical Advisory Group (TAG) contracted by DOE and directed by Lawrence Berkeley National Lab. The plan was to account for the implementation of the study taking into consideration the transitional state of the grid, our ability to deliver a quality pilot program, resource constraints, and the overall customer experience.

As energy efficiency becomes standard in product design and new construction, the need for residential load management is shifting steadily toward demand response. Customer programs in the load management space had largely focused on energy efficiency up to the point of the SGIG award. SMUD had maintained a substantial air conditioning load management program that included switches on about 20% of residential homes; however it hadn't been operated in a programmatic function for about a decade. SMUD's legacy residential TOU rates didn't meet our changing needs and hadn't been actively marketed to customers. Adoption of the rates was extremely low for these reasons, and it was clear that our organization had come to the opportune time to utilize the emerging smart grid technology to design and test new rates that met our load management needs.

Historically, education related to SMUD rates was focused on community outreach during a formal rate process and public distribution of the tariff sheets. Customer energy education focused heavily on energy efficiency, renewable energy options, and programs that assisted with bill management or electrical equipment. SMUD leadership determined early in the planning process that customer engagement, satisfaction, and ability to succeed in bill reduction would be cornerstones to the implementation of our pricing trial. This provided a compass for both rate and research design, effectively determining that partnering with our customers on this effort would provide the most opportunity for success for both SMUD as an organization and for our customers. This partnership approach became the foundation for rate design, process design, marketing and communications, product deployment, customer support, and all other aspects of the pilot.

1.2.1 SMUD's Consumer Behavior Study Objectives

The main objective of SMUD's CBS is to investigate the effectiveness of integrating AMI-enabled time-variant pricing and enhanced information to induce behavior change[2]. The study contains three types of treatments: recruitment strategy, rate design, and information feedback technology. This research will provide information necessary to assist in maintaining low rates and high levels of customer satisfaction, while sending appropriate price signals to customers to encourage responsible electricity consumption. The study incorporates carefully designed experimental rates, a complete customer service and support portfolio, education to assist informed decision-making, and personalized information feedback to allow customers to manage their consumption daily and make it easier for customers to save.

The study was designed with the intent to determine:

a) Electric energy and demand impacts of each of the treatments
b) Customer characteristics associated with behavior
c) The role of in-home displays (IHDs) in customers' daily electricity management
d) Program impacts on customer bills and satisfaction
e) Expected value to the utility of rate and enabling technology programs
f) Expected market penetration for rate and enabling technology programs
g) Effective educational and marketing strategies for customers

1.3 How This Report Is Organized

When reviewing research findings, it is important to understand the environment in which the research was conducted and details of the implementation to assist in the interpretation of the findings. For that reason, SMUD has elected to include detailed information about the planning and implementation of the project. These details should provide appropriate context to assist in determining the applicability of the findings in various scenarios and environments.

This report is divided into three chronological sections and an appendix.

[2] End-use controls such as smart thermostats and load control switches are not included as part of this study.

Section I: Research Design and Project Planning covers the genesis of the project, project scope, planning considerations and administrative details.

Section II: Project Implementation discusses the logistics of putting the project plan and research design into action. In specific areas of interest, detailed accounts of process or framework are included.

Section III: Interim Load Impact Evaluation is a comprehensive load impact report covering the first summer's load impacts conducted by Freeman, Sullivan & Co. The report is included in its entirety as it was prepared for SMUD. This section was written in a manner in which it can be extracted from this report and stand alone as an independent document. As such, it contains some brief areas of redundancy with *Sections I* and *II* of this report, providing high level details for contextual value within the impact discussion.

Appendix contains detailed examples of marketing materials, process flows, and similar in depth materials. Also contained in the Appendix is SMUD's complete CBS Plan (CBSP) approved by the TAG and DOE. This plan served as the scope document from which all other planning documents were derived.

Within Sections I and II, where applicable, each subsection will cover the following discussion areas:

- Overview
- Details
- Quality Assurance
- Lessons Learned and Key Takeaways
- Additional Areas of Interest and Future Research

From this point forward in the report, when referring to SMUD's consumer behavior study, we will use the pilot's marketing name, "SmartPricing Options." We will also use the terms "study" or "pilot" to refer to the SmartPricing Options. The term "Consumer Behavior Study" or "CBS" will refer to the overall consumer behavior study data being collected by the DOE in consultation with Lawrence Berkeley National Lab, including all 11 studies.

SECTION I: RESEARCH DESIGN AND PROJECT PLANNING

2. 0 Research Design

2.1 Overview

SMUD had a considerable list of potential research objectives that would be of value internally which needed to be balanced with the research objectives stated by DOE.

Identifying a need to conduct research in a particular topical area can be a fairly straightforward task. The process of narrowing research objectives, balancing priorities, selecting the appropriate methodology, and thoroughly scoping the project is much more complicated. While SMUD recognized the intrinsic value in DOE's preferred research approach and stated rate structure preferences from a policy-making perspective, the DOE objectives weren't entirely congruent with SMUD's strategic directives and immediate time-based rate strategy. It was paramount that the research conducted and the manner in which it would be conducted both be clearly tied SMUD's business culture and strategic direction.

After considering the request to implement a mandatory dynamic rate with our smart meter customers, SMUD responded with an agreement to conduct a pricing trial along with a list of six key principles that would be necessary in order for SMUD to move forward with such a study. After consideration, these principles were agreed to by DOE.

The following six principles were put in place to govern our pilot design:

1. It will incorporate at least three rate options: medium and high CPP and a TOU.
2. The population from which the sample will be drawn is approximately 50,000 customers determined by smart meter installations.
3. The treatment group selected in the study will be between 5,000 and 20,000 customers depending upon the final research plan.
4. The study will include opt-out and opt-in enrollment.
5. All treatment group participants will be provided with a baseline level of quality information and education. In addition, the study will test different marketing, education, and communication strategies.
6. Enabling technology options may be offered to all treatment participants.

The development of these principals marked the beginning of the research design process. As we worked through the research planning process, these principles evolved to align with higher priority objectives, such as statistical precision. During the planning phase, SMUD had been granted an additional year to plan and implement the research study to allow for technology advancement and cleaner implementations. During that year, smart meters continued to be installed as part of our district-wide implementation of smart grid, opening up more sampling options.

A team of stakeholders in the research findings and consultants was assembled to determine research objectives and define the scope, schedule and budget. Representatives on the initial team included the following departments: Rates, Load Research, Customer Strategy, Market Research, Marketing, and the Budget Office, as well as consultants from Herter Energy Solutions. As the planning process evolved, subject matter experts from various areas potentially impacted by the implementation or the findings (e.g. Information Technology and the Contact Center) were brought into the planning team, along with ongoing consultation with SMUD's Executive team and Legal department.

The team determined that we needed internal alignment regarding SMUD's objectives, as well as reasonable schedule and budget estimates before beginning scope discussions with DOE. SMUD had a considerable list of potential research objectives that would be of value internally, which needed to be balanced with the research objectives stated by DOE. The team went through a discovery and prioritization process that narrowed the research objectives and scope to a few key components. During that time, DOE entered into an agreement with Lawrence Berkeley National Laboratory to implement a Technical Advisory Group (TAG) to act as liaison between the utilities and DOE, providing guidance, feedback, and assistance in the approval of research and evaluation plans. Once SMUD had determined our research objectives, we began discussions with our TAG to further develop and finalize our plan.

SmartPricing Options was one of several SMUD pilots funded in part by SGIG. In an attempt to optimize the learning potential and breadth of all pilot customer offerings funded by the grant, SMUD took a portfolio approach to pilot selection. The planning teams across the pilots used the same basic steps to determine research goals.

1. Review of SMUD's strategic directives and program goals
2. Assessment of existing and emerging technology and gap analysis of programs and services
3. Utility benchmark via primary interviews and secondary research

4. Internal business unit collaboration

5. Define portfolio characteristics

6. Select characteristics that enable customers along a energy literacy and engagement continuum

7. Identify research questions

8. Select balanced portfolio of research and analysis to address overall strategic directives and potential gaps

In step six, SmartPricing Options falls into the first two categories of the continuum: Customer Education and Customer Behavior and Controls, meaning that this pilot would not include appliance load management by automation or delegation (direct load control). Other pilots and research projects in the portfolio would address these categories. This narrowed the focus considerably, allowing the team to begin defining the boundaries of the scope.

This section will summarize the steps implemented to determine research objectives, methodology, sample design, and considerations that contributed to the plan. SMUD's approved CBSP, which contains detailed descriptions of sample calculations and parameters, can be found in the Appendix of this report.

2.2 Details

After prioritization of research objectives, several areas of interest had to be removed from the list of potential research questions, including areas such as:

- Rate design variations that would have allowed for robust elasticity estimates
- Impacts of varied levels of marketing, education, and communication strategies

- Multifamily and single family home comparisons
- Effects of community partnerships in incentive-based program design (e.g. school incentives for enrollment or demand reduction)
- Interaction of time-based rates with load management programs
- Interaction of time-based rates with levelized billing

Inclusion of price-responsive programmable communicating thermostats with IHD capabilities was initially included in scope; however, devices meeting SMUD's technical requirements weren't available during the procurement window, so they were removed from scope. In retrospect, this made for a much cleaner behavior study design by limiting the enabling technology treatment to an information device, rather than a combined information and automation device.

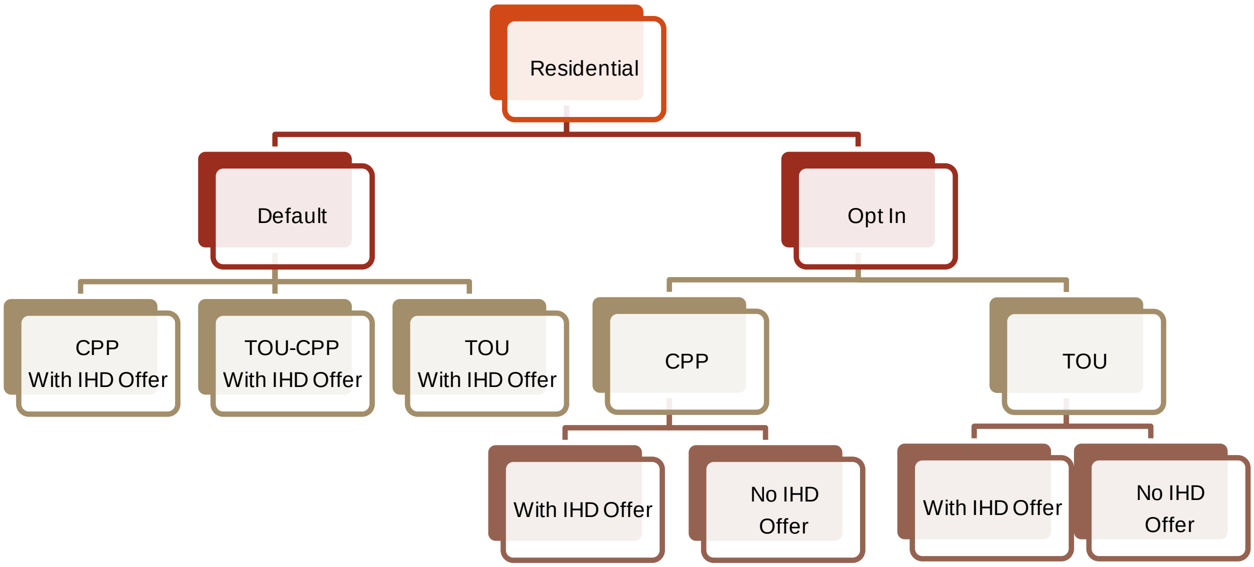
SMUD staff conducted as-is assessments, baseline research and best practice research regarding rate design, enabling technology deployment, and time-based rate research and program implementation. It became clear that very basic research questions had yet to be answered with confidence in the area of dynamic pricing. SMUD settled on focusing our effort on seven residential[3] treatment groups addressing three areas of interest: recruitment strategy, rate design, and enabling technology.

1. **Recruitment Strategy:** Four treatment groups would receive their pricing plan offer as an opt-in opportunity. Three treatment groups would receive their pricing plan offer on a default basis. All customers could leave the pricing plan at any point with minimal effort.
2. **Rate Design**: Three rate structures were included in the plan. Critical Peak Pricing (CPP), Time of Use (TOU) and a combination TOU-CPP.
3. **Enabling Technology:** Five of the seven treatment groups would receive the offer of a free IHD. Acceptance of the display was not required for participation.

Figure 1 provides a visual depiction of the treatment groups.

[3] The original plan also included the small commercial sector; however small commercial was removed from the study design because the pilot rates were adopted as permanent default rates for small commercial customers during the planning phase of the project.

Figure 1: SmartPricing Options Treatment Groups



The experimental rate options would be offered to sample population beginning October, 2011 to be in effect June through September, in both 2012 and 2013, with the intent of determining:

1. Electric energy and demand impacts of each of the treatments
2. Customer characteristics associated with behavior
3. The roles of IHDs in customers' daily electricity management
4. Program impacts on customer bills and satisfaction
5. Expected value of rate and IHD programs
6. Expected market penetration for rate and enabling technology programs
7. Effective educational and marketing strategies for customers

Negotiations with our TAG included all areas of research design and research questions. SMUD's proposed research questions address important policy questions related to acceptance rates and default pricing. As such, our research questions were approved by the TAG with minimal discussion. The primary areas of concern during negotiations were methodology and sampling.

It is not uncommon in utility research to rely on quasi-experimental methods and limited sample sizes due to resource constraints, technology limitations, and potential customer impacts. The TAG had a much higher standard for the implementation of the Consumer Behavior Study for all utility participants. In SMUD's case, the resulting research plan included three methodologies: Randomized Control Trials (RCT), Random Encouragement Design (RED), and Within Subjects. The merits of rigorous experimental methods versus econometric modeling methods which use statistical modeling to compensate for sample size, selection bias, and other issues introduced by using less than precise methods are largely unverified, based primarily on theory. This introduced an opportunity for SMUD to test the merits of each methodological approach, since various evaluation techniques would be possible within our study design. Though it is not associated directly with dynamic pricing, this research question was added to the evaluation objectives to provided added value to the academic and research communities, including SMUD's internal research teams.

It was important to SMUD to manage the size of the study, and the RCT and RED designs with the agreed upon statistical power require much larger sample sizes than the methods typically employed by SMUD. In an effort to manage the study's footprint on our service territory, we opted to assign research rigor and associated sample sizes based on the priority of the research questions that could be answered by the treatment group. This resulted in the following design:

- RED: CPP with technology offer (opt-in and default) and TOU with technology offer (default)
- RCT: TOU with and without technology offer (opt-in)
- Within Subjects: CPP without technology offer (opt-in) and TOU-CPP with technology offer (default)

Ultimately, sample sizes were larger than expected after the first summer due to much higher than expected recruitment and retention rates, which allowed FSC to conduct the evaluation using RED and RCT methods for all treatments.

Because SMUD elected to use a portfolio approach to demand response research pilots, certain customer groups were excluded from the sample frame. Additional customer groups were excluded from the sample frame for equity issues or technical constraints. It was acknowledged during the planning process that this would limit the representativeness of the findings of the SmartPricing Options research to those groups included in the sample.

Residential customers enrolled in any of the following rates or programs were removed from the sample frame:

- SMUD's legacy residential opt-in TOU rate
- Any solar rate
- Master metered customers (mobile homes not individually metered)
- Third Party Notification: A program that provides for special notifications to prevent unnecessary service interruptions because of late payments.
- Medical Equipment Discount Rate: Monthly discount for households that require use of a medical equipment device.
- Budget Billing: A voluntary program where customers receive a monthly bill with a payment amount based on the previous 12-month average
- Peak Corps[4] (ACLM): A voluntary air conditioning cycling program

Table 1 represents the minimum sample sizes and enrollment requirements to meet all required parameters across the treatment group. The columns labeled "Recruitment Goal" and "Total Invitations or Notifications" became the operational figures used to obtain the final required sample sizes for each treatment group. The TOU with IHD (opt-in) sample size was increased to allow for additional homes that would accept the IHD offering, potentially opening up opportunities for undefined post hoc analysis related to IHD acceptance and use.

[4] Peak Corps members were used for recruitment into an SGIG-funded direct load control, and the SmartPricing Options sample was excluded from that pilot sample; the sample frames were mutually exclusive.

Table 1: Sample Size Requirements

Treatment Group	Design	Type I error α	Type II error β	kappa	Detectable Effects kWh (summer)	Detectable Effects kW (daily)	Detectable Effects kW (event)	Resulting Sample Requirement (Total Enrolls + Postpones)	Recruitment Goal (Total Enrolls + Postpones before 20% attrition)	Total Invitations or Notifications at 15% opt-in and 50% opt-out
Res Opt-in TOU (no IHD offer)	RCT	0.10	0.20	0.80	0.05	0.05	0.20	1884	2355	15700
Res Opt-in TOU (with IHD offer)	RCT	0.10	0.20	0.80	0.05	0.05	0.20	3140	3925	26166
Res Opt-in CPP (no IHD offer)	Within Subject	0.10	0.20	0.80	0.12	0.12	0.12	150	187.5	1250
Res Opt-in CPP (with IHD offer)	RED	0.05	0.20	0.80	-	-	0.20	1131	1413	9425
Res Opt-out TOU (with IHD offer)	RED	0.10	0.20	0.80	0.05	0.05	0.20	992	1240	2480
Res Opt-out CPP (with IHD offer)	RED	0.05	0.20	0.80	-	-	0.20	345	431	862
Res Opt-out TOU-CPP (with IHD offer)	Within Subject	0.10	0.20	0.80	0.08	0.09	0.08	300	375	750

The minimum random control group selected for the RED treatments was determined to be 47,103, which allowed for 20% attrition due to moves or ineligibility would occur between the day the sample was selected and September 30, 2013. A final control group size of 37,682 was required after attrition to meet all minimum parameters across all RED treatments. Following is a list of basic assumptions made when calculating sample requirements.

a) 15% acceptance of opt-in rates rate by June 1, 2012
b) 50% opt out of the default rates by June 1, 2012
c) 60% IHD acceptance across treatments by June 1, 2012
d) 20% attrition for each treatment and control group from June 1, 2012 to September 30, 2013

2.3 Quality Assurance

2.3.1 Sample Calculations

To ensure quality and precision, a team of statisticians and research professionals participated in sampling design. The team consisted of three SMUD staff, two consultants hired by SMUD, and four TAG members. Sample calculations were calculated independently by a SMUD consultant and the TAG, and the methodology and calculations were reviewed and approved by all team members.

Determination of sample sizes took into account multiple factors. Once treatments of interest were identified, each treatment was assigned to one of the three study designs. For each treatment, minimum detectable effects were identified for each of the relative research questions (i.e. kW and kWh savings); type I and type II error tolerances were determined; expected participation, attrition, and end-use technology acceptance rates were applied, and the applicable power calculation was performed to determine sample sizes. For those sample sizes that were not driven by a power calculation[5], the team used the sample sizes from the Statewide Pricing Pilot and SMUD's Summer Solutions pilot, as well as Table 4-5 in EPRI's "Guidelines for Designing Effective Energy Information Feedback Pilots: Research Protocols" as guidelines for determining sample sizes that would potentially detect an effect of the magnitude in question if the effect exists.

The process used for performing the power calculations is detailed in the CBSP which can be found in the Appendix, including the specific calculations used for the RED and RCT power analysis to determine the minimum required sample sizes for 90% confidence with 10% precision. All calculations assume comparison of the treatment group to the respective control group.

2.3.2 Event Implementation

It is not uncommon in peak-event-based pricing for the actual number of peak events called to fall within a range or to have a cap, rather than having a fixed number of events. For example, if peak events are determined by temperature, a mild summer may not yield the maximum number of events allowable under the rate design. This type of event implementation was of some concern to both the SMUD rate design team as well as the team participating in the sample calculations. If Sacramento experienced a mild summer during the pilot, there would be a risk that too few events might be called

[5] The treatment groups that were planned as within subjects studies (Default TOU-CPP with IHD and Opt-In CPP without IHD) and had samples sizes that were not driven by a power calculation.

to shift enough load to meet the parameters of the sample calculations. There are also implications in rate design when considering a dynamic number of event days versus a fixed number, so this operational concern was important to address early in the planning stages. The team determined the best approach would be to ensure exactly 12 events would be called for each summer, eliminating the ambiguity introduced by a variable number of events.

The team decided that peak event determination not be based solely on temperature for the pilot. If a fixed number of events were to be called, it would be important to have criteria in place that assisted in minimizing the subjectivity of event determination. For research purposes, we wanted to ensure we had event days that represented various months, days of the week, number of consecutive days, and range of temperatures. For evaluation purposes, we wanted to exclude some qualified event days to use as potential points of comparison. For these reasons, the SMUD team felt it would be essential to establish clearly documented criteria and processes for event determination and deployment. Further discussion of this can be found in *Section II, 11.0 Implementing Critical Peak Events*.

2.3.3 Customer Communications Control

With ambitious recruitment and retention goals and a robust educational communication component, SMUD was concerned about over-communicating with customers. Additionally, it was important that the SmartPricing Options sample not be used for targeted messaging or recruitment into energy management offers that might impact their usage during the pilot. To mitigate this risk, SMUD decided to create an approval process for communicating with customers in the sample, which included and automated filtering and review process by the market research group who manages customer communication mail lists and final approval by the SmartSacramento Program Manager responsible for SmartPricing Options. This was not an inconsequential decision, given that the SmartPricing Options sample was approximately 20% of the residential population.

2.3.4 Scope Management

A project of this size and importance could easily be subject to scope creep and redefinition. To mitigate this risk, a comprehensive high-level scope was included in the CSBP that was provided to the TAG, and all terms were discussed in detail and agreed upon. The CBSP was routed internally at SMUD and approved by all team members and management stakeholders prior to submitting for approval by the TAG and DOE. The CBSP was then used to establish more detailed scope documents and business requirements used to develop a detailed implementation plan. This process proved to be a critical component to managing scope and obtaining necessary resources to complete the project. It was also a vital tool for new team members who joined the team in the years that followed to provide context and scope. As the project moved further away from the initial design stages, scope documents were often referenced to recall specific objectives of various tasks in order to manage budget and schedule.

In addition to scope documentation, the team went through a standard risk assessment during the development of the CSBP to identify any high probability or high impact risks that would obstruct the ability to meet the research requirements. For each identified risk, a mitigation strategy was created to manage the risk and increase the likelihood of successfully implementing the research plan. These risks were included in the CBSP and agreed up by SMUD stakeholders and the TAG. This effort proved to be useful, as some of the risks were realized and required quick resolution.

Early scope discussions also covered the merits of including customer tools such as bill protection, shadow billing and bill calculators. It was important to SMUD and the TAG that the pilot offerings be as similar as reasonably possible to a true program roll out. While these tools might have been attractive to participants, there were concerns that they could work against the measured impact of the rates as well as revenue recovery by discouraging customers who are at a structural disadvantage. Upon careful consideration of these factors, SMUD chose to consider these tools out of scope as a matter of external validity.

2.3.5 Maintaining Research Integrity for All Project Tasks

Maintaining research integrity in a controlled research environment can be a challenging task. Maintaining research integrity in a *business* operational setting with over 140 non-research professionals contributing to the project deliverables is a completely different type of undertaking.

Staff makes decisions about how to plan, implement, and prioritize work all day based on a number of factors. If a project contributor is unaware of the potential impacts of a decision on the outcome of the research, they are unable to process that impact as part of their decision. Since fiscal responsibility, efficiency in producing results, customer impact, and current workload all impact staff decisions, it isn't uncommon for decisions to be made at the staff level that optimize one or more of these factors, the result of which may not bode well on the research design. Consider the following examples:

- It is counterintuitive for many contributors to take a slower or more complex route in order to address 100% of customers simultaneously versus taking a route that may help 85% of customers immediately in a faster and less costly way, addressing the other 15% over time. While this practice may assist in managing customer experience, it introduces the potential for research bias.

- Staging outbound communications over a period of time by program or product offer is a common practice at SMUD. Not only does it help manage workload at the print shop and mail house, also ensuring mail lists and offers don't get confused, but it also helps to spread out the inbound calls into the Contact Center, allowing their staffing schedule to be consistent over time. From a research perspective, this wasn't an acceptable practice.

Due to the size of the project, leads were identified in business units for tasks in their areas, and all work flowed from the SmartPricing Options Project Manager to the business unit leads. The leads then worked with the implementation teams within the business unit. Leads were educated in the early project stages about the basic principles of research and the importance of upholding them. Leads were empowered to manage the work within the business unit guided by the basic research principles, and the Project Manager served as the final quality control check point. Over time, team members learned the principles and less discussion was required related to the impacts of implementation decisions on research design.

Leads were educated about and contributed to the following topics:

- The basic research objectives of the study
- The problems that SMUD was trying to solve
- The importance of addressing the research objectives for business planning
- The value of the research findings relative to each business unit
- An overview of the research process
- Common research terms such as "treatment group" and "control group," and providing context to understand the relationship of relevant concepts to the work the team was tasked with completing
- The importance of emulating a true program environment wherever possible and an overview of the risk that is introduced when deviating from what a true program rollout would look like

- Issues regarding when standard practices may not be appropriate and when they would be essential in this research project

Since SMUD did not expect all contributors to become research experts, some basic guidelines were put in place to assist in planning and ad hoc decision making.

Ensuring Equity

- Each treatment group needed to be treated precisely the same as the other treatment groups (timing, language, graphics, access to tools, etc.), with only the details related to the treatment of interest varying from group to group
- Control and treatment group customers needed to be treated equally in all matters other than the application of the treatment
- Participants who chose to leave the rate would not be permitted to re-join
- In the event that a course of action changed, or an error was made, resulting in an imbalance, balance would be restored to the extent possible and as soon as possible
- All customers and staff would remain blind to the RCT treatment and control assignment of customers in the sample until after the offer was accepted (this included customer service representatives and other support staff) with the exception of those team members who would be required to have access to complete their responsibilities

Communication Controls

- No customers within the sample frame would be targeted for any non-research purposes
- Materials would be reviewed in totality before disseminating to any particular treatment group, to ensure appropriate language used for all treatment groups
- The team established a *fact checking* process and identified subject matter experts to participate as appropriate

Business Operations

- Business rules would be applied and upheld for the duration of the project, including not allowing special treatment of customers who request to join the pilot, receive the IHD, or switch rates in a way that is not specified by the research design (including staff)

- Provide the same basic level of service to the sample frame that every SMUD customer receives

- Add an additional quality assurance layer to ensure accuracy before disseminating materials or deploying events to ensure consistent experiences for customers as well as maintain the research plan

Documentation and Reporting

- Document all exceptions or anomalies that may impact the evaluation as they occur, and file documents in the "Evaluation" folder for the evaluator to consider

- Enlist record keeping guidelines for data that aren't traditionally collected as well as data that will be collected in a new manner

- Standardize automated database reports prior to project launch

- Established a plan for data collection, storage, management, and delivery to outside parties

- Determination of master data files and sources of record early, along with guidelines for accessing these data files

Testing

- Ensure any pretests that were required would be implemented on randomly selected customers from all groups (as appropriate)

- Enlist a group of staff (referred to as “friendlies”) to be used as beta testers and pretesters as needed to preempt potential problems with customers or to confirm proper execution of pilot activities in real time

- Established new testing protocols where needed, such as those used for testing IHDs internally and at a third party laboratory

2.4 Lessons Learned and Key Takeaways

Key takeaways from the research design phase were generally related to scope and resource sponsorship.

- In negotiations with the TAG, most key research design decisions were documented as part of the formal plan. There were other areas of negotiation, however, that were of interest to the TAG but SMUD was cautious about adding to the formal plan. Where it made sense, SMUD and the TAG agreed to keep some items open for discussion as the project progressed, to determine whether or not they would be deliverables at a later time. SMUD was careful only to agree to those items that we were truly considering (such as providing more granular data sets), and the TAG was upfront with their flexibility on these topics. This helped to facilitate trust on both sides of the discussions, and allowed topics that could potentially delay plan approval to be considered at a later time. No items that would interfere with the ability to deliver were left undecided or left out of the plan. This process helped delineate contractual agreements from guidelines and preferences.

- It was critical to get internal executive support for the research objectives prior to beginning negotiations with the TAG. This ensured that the planning team was managing one set of expectations at a time, beginning with the organization’s strategic direction.

- Scope documentation and risk planning with documented agreement by stakeholders in the early project planning stages is an important step. Although a common project management tool, it isn’t always used or documented in sufficient detail. These documents proved to be of significant value throughout the project.

- Once leadership had agreed to scope and research objectives, clearly defined roles and resource needs were determined. These were reviewed and approved by SMUD leadership and communicated to employees. This was an effective way to ensure that staff were empowered to prioritize their workload to make time for the project and understood what their accountability and responsibilities were in delivering the project to DOE.

- Although managing a large group of contributors and stakeholders in the planning process can be challenging, it is important to have key people as contributors when scope is being defined. They offer insights into context, options, constraints, and optimization that might otherwise be overlooked. They also mitigate much of the risk to over-promising when resources, technology, systems or processes may interfere with the ability to deliver. There are effective ways to manage planning with large groups, such as breaking the components into manageable pieces and addressing issues hierarchically in terms of organizational goals or research goals.

2.5 Additional Areas of Interest and Future Research

The list of research questions that could be considered beyond the scope of this project is endless. Following are some topics that SMUD has considered as possible future research opportunities related to SmartPricing Options.

- The impact of various educational and communication strategies
- The impact of the actual use of enabling technology, rather than the effect of the offer of enabling technology
- The comparison of the effect of the rate alone (behavior only) versus the rate bundled with automation and delegation devices
- The impact of leveraging community partnerships during the recruitment process on enrollment, retention, and load reductions
- The impact of additional rate designs, including different structures, peak period lengths, and price ratios
- The cost-effectiveness and load impacts of an opt-in TOU-CPP
- Evaluation of multifamily versus single family homes, including assessments of environmental interference with ZigBee technology

- Persistence in load shed across treatment groups beyond two years
- The impacts of defaulting customers onto the rates without IHDs
- Acceptance rates and impacts of offering a menu of pricing plans versus a single offer

3.0 Project Administration: Budget and Schedule

The project schedule includes over 1260 tasks with start and finish dates for each task of the project. This schedule was critical for the project team to stay on task and recover through delays and surprises that are inevitable in any project.

3.1 Overview

As part of the Smart Grid Investment Grant, the SmartPricing Options pilot was one of the larger customer applications pilot projects in terms of scope, schedule and budget. The two-year pricing pilot required a seven month recruitment period and over a year and a half of planning and implementation before the rates went into effect.

3.2 Details

3.2.1 Budget

The budget process at SMUD is completed annually for the upcoming year and includes a three year planning budget. The SmartPricing Budget was created in 2010-2011 and updated annually for the pilot covering 2010 through 2014.

Total Project Budget

The initial projected total costs for the pilot totaled $12.8 million. All budget figures discussed in this section include the cost of product, services, and internal labor to administer the pilot, as well as the surcharge rate used to account for organizational overhead[6]. Due to some efficiencies and overestimated support requirements, the current forecasted project total is approximately $11.6 million.

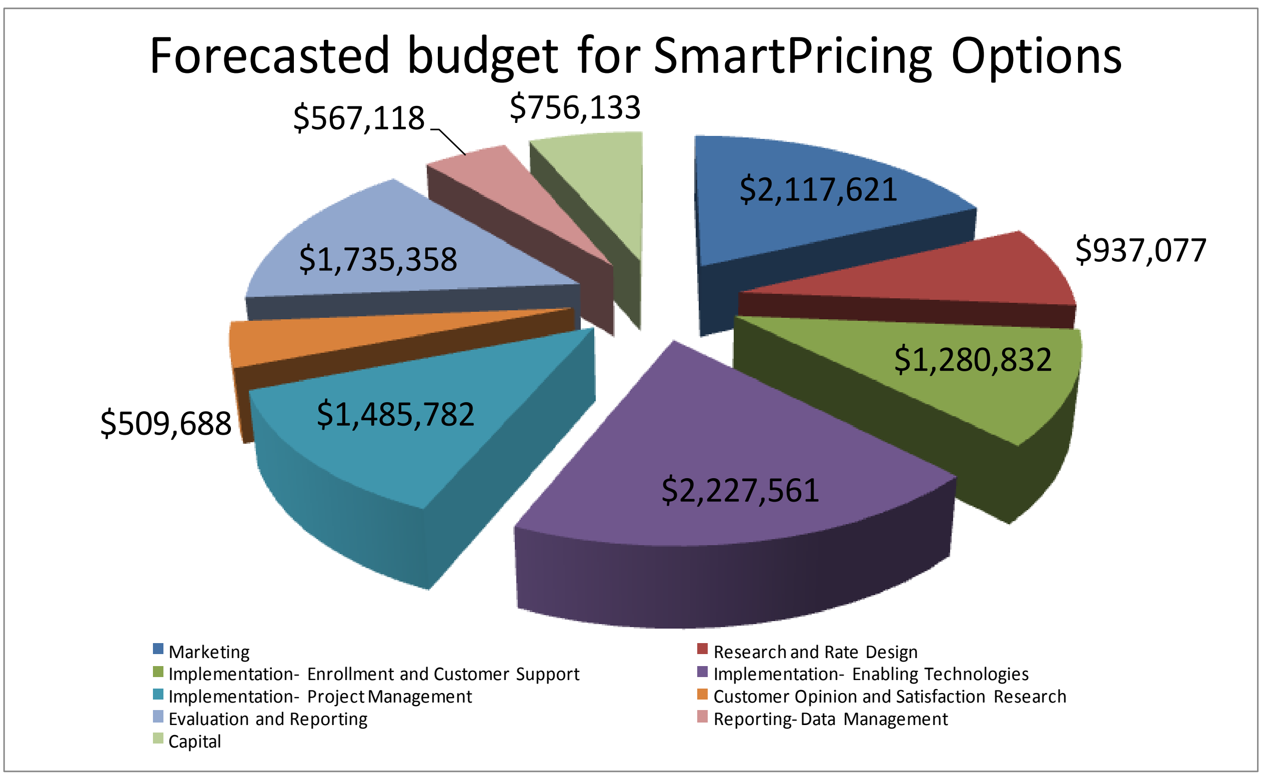
As depicted in Figure 2, the two largest costs were the implementation of the IHDs and the marketing activities, followed closely by evaluation and reporting. This is an interesting point for rate implementation planning, since many of the costs associated with the evaluation and offer-specific communications may not be applicable in a standard program deployment, and it is common for the price of enabling technology be reduced for customers by offering a rebate or incentive rather than giving the device to

[6] All budget figures reflect allowable expenses allocated in accordance with guidelines dictated by the U.S Department of energy. Figures presented in this report do not replace or supersede any reports provided to DOE and should be considered estimates.

customers for free. While these allocated expenses were appropriate in the research study environment, they may not be applicable in a program deployment.

The initial stages of the project were heavy in design, recruitment, technology and project management costs, some of which would not be applicable to a system-wide implementation since they are related to research design, study set up, and DOE reporting. Also, the complexity of managing seven treatment groups and the redundant efforts required to support each task for each of the treatment groups would be eliminated if the program manager could market the offers without mutual exclusivity. Alternatively, much of the infrastructure that was built to support time-variant rates and pilot oversight would be leveraged if a system-wide program rollout is deployed after the pilot period. For example, billing validation and bill presentment could be leveraged indefinitely, and project management tasks to oversee the pilot would be absorbed by program staff. While the project costs may be representative of a research environment, they may not represent program deployment costs.

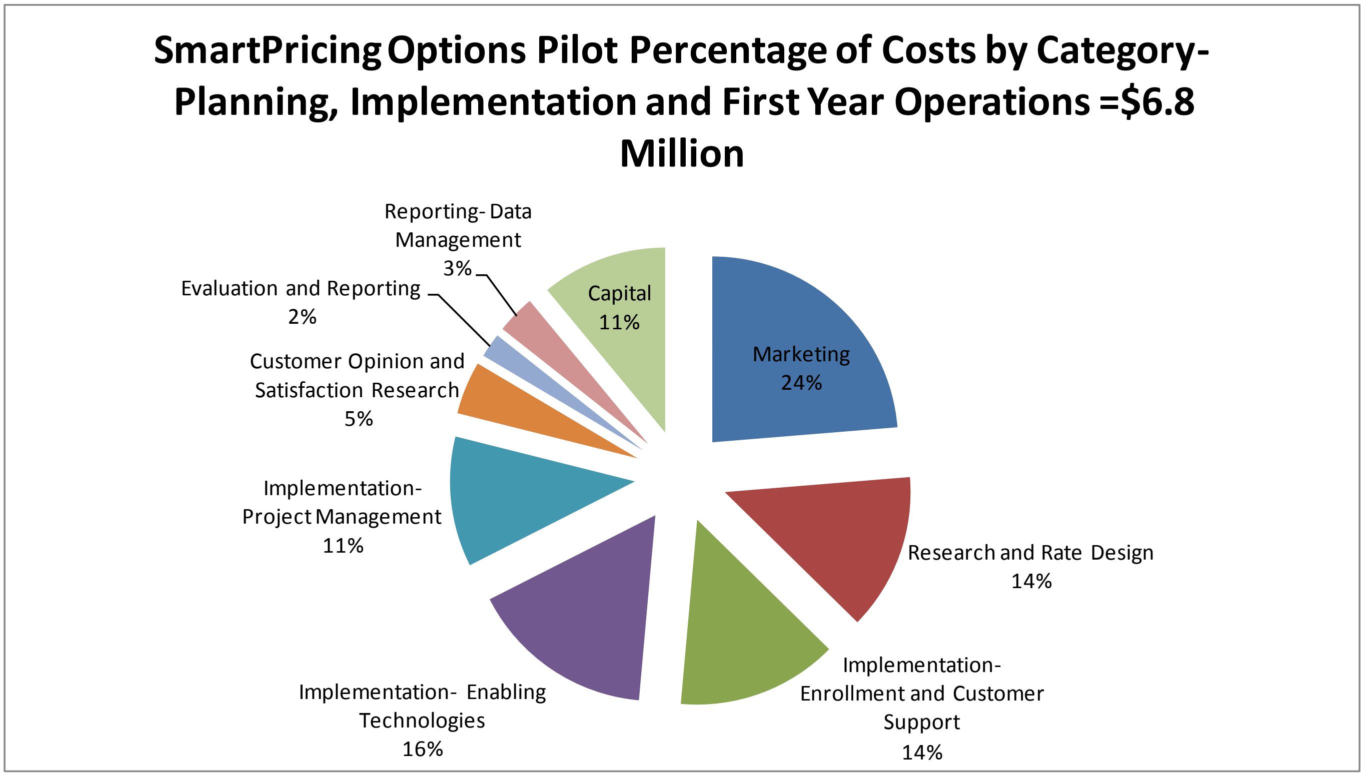
Figure 2: Forecasted Budget for SmartPricing Options



Project Costs Through 2012

Figure 3 provides the percentage of total costs by project category through December 2012. The total costs were $6.8 million for planning, implementation and first year operations for the 2010 through 2012 period. This accounts for approximately 59% of the total forecasted project costs.

Figure 3: SmartPricing Options Budget through December 2012



The following descriptions provide a summary of what expense types in each category and provide additional details.

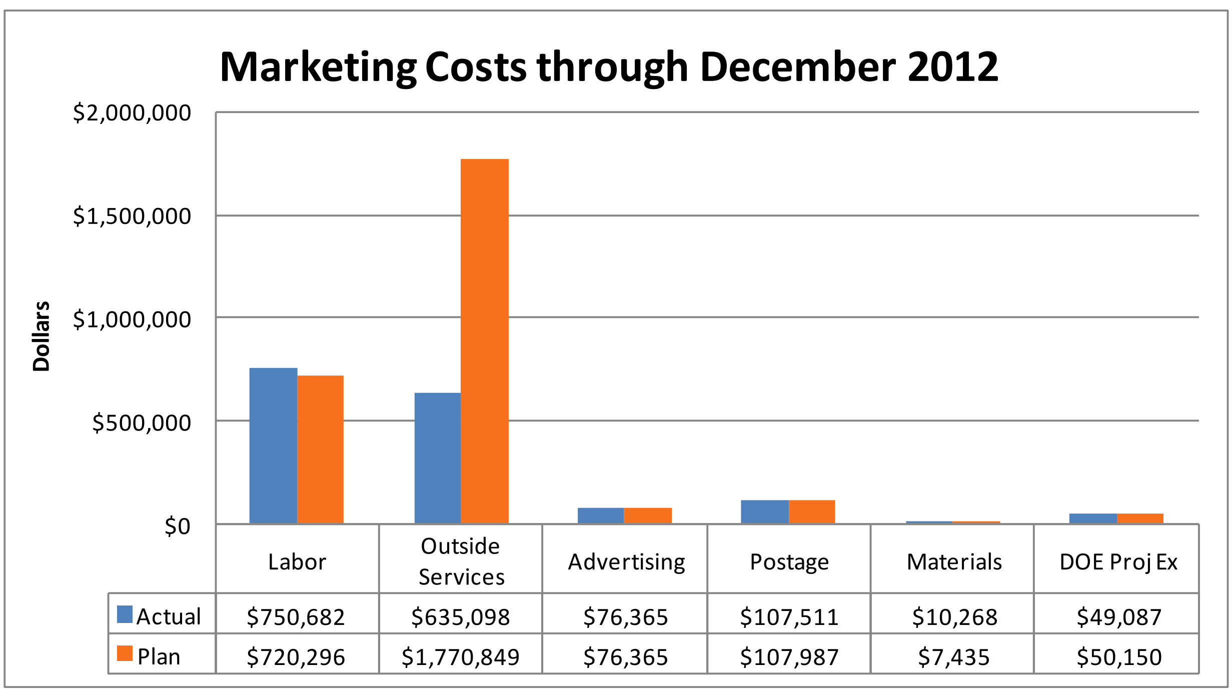
MARKETING

The marketing costs for recruitment and retention through December 2012 totaled $1.6M or 24% of the total project costs through December 2012. The pilot study design coupled with the diverse and comprehensive marketing effort required that the marketing team create seven versions of most marketing pieces, which was very labor intensive. The team worked with several local marketing firms to design materials that would resonate with customers and give them the tools that would help them be successful on the pilot.

The marketing total also includes a full time, dedicated marketing professional for 18 months during this period. As depicted in Figure 4, significant savings were realized in the procurement of outside services to assist in the development of the marketing materials. A full description of the marketing plan and the components that make up these costs can be found in *Section I, 7.0 Marketing*.

Figure 4 compares planned costs in the original budget to the actual expenditures for all marketing efforts through December 2012. Of note is the significant reduction in the expenses for outside services from the plan. This reduction resulted from a change in strategy from our marketing team to exclude radio spots, billboard advertisements, and other mass marketing strategies for recruitment that were originally planned but not implemented. Additionally, the bids for the outbound calling campaign came in much lower than budget.

Figure 4: Marketing Costs through December 2012

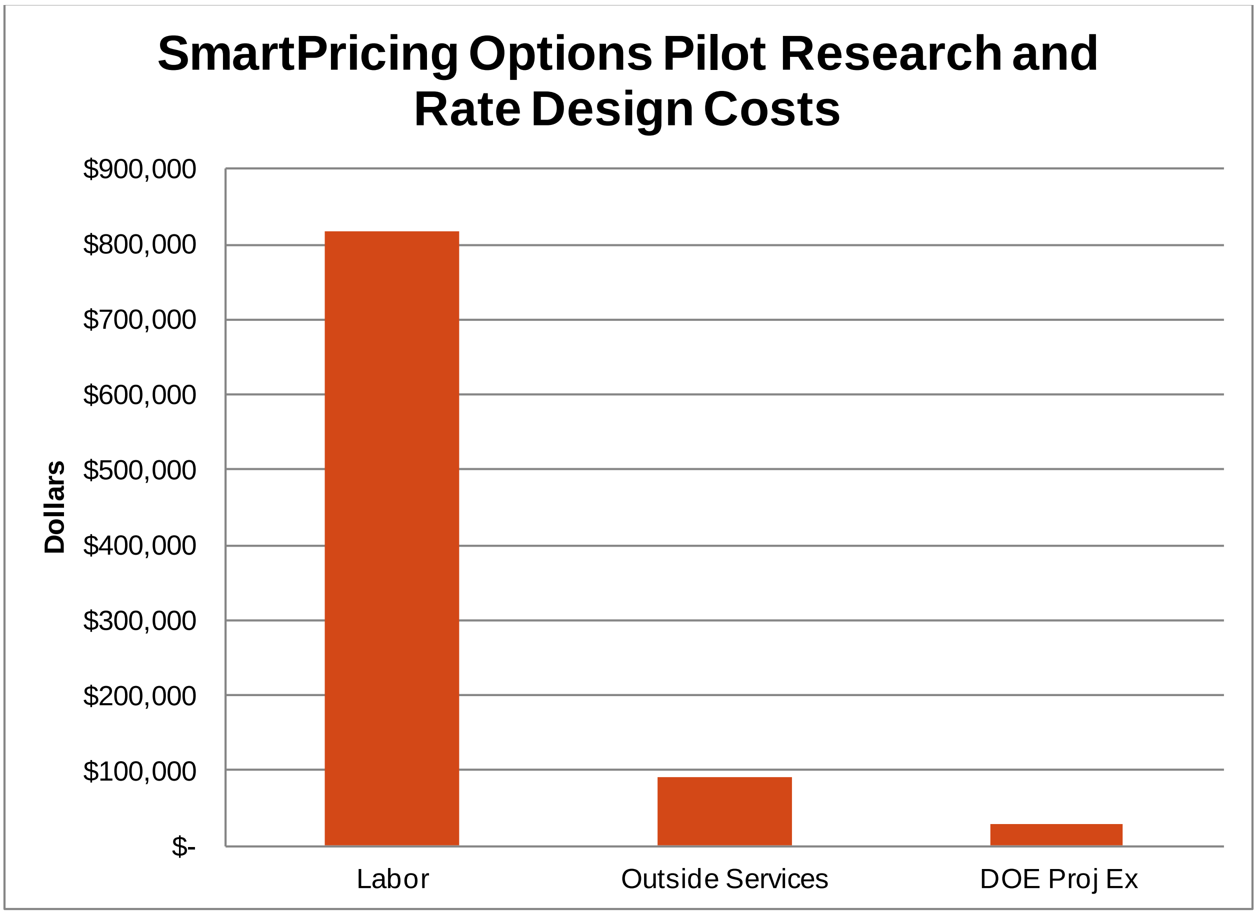


	Labor	Outside Services	Advertising	Postage	Materials	DOE Proj Ex
Actual	$750,682	$635,098	$76,365	$107,511	$10,268	$49,087
Plan	$720,296	$1,770,849	$76,365	$107,987	$7,435	$50,150

RESEARCH AND RATE DESIGN

Research and rate designs include costs for the statistical power analysis, preparation of the CBSP, the time-variant rate design, and system development in SAP to support time variant rates. These costs are largely internal SMUD labor charges, with additional costs associated with professional consultants who assisted on study design and statistical power analysis.

Figure 5: SmartPricing Options Pilot Research and Rate Design Costs

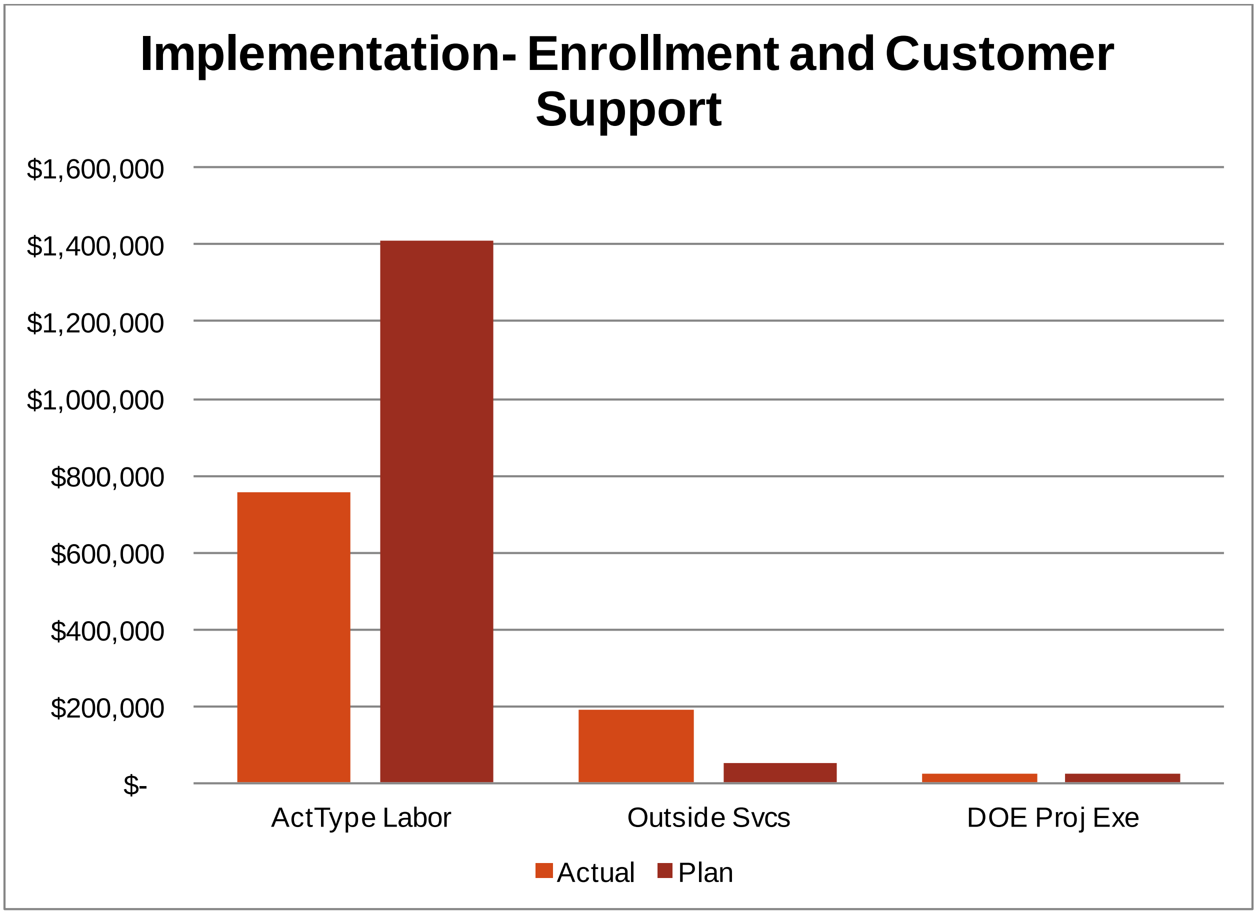


IMPLEMENTATION: ENROLLMENT AND CUSTOMER SUPPORT

Enrollment and customer support costs for the pilot account for approximately 14% of the total costs for the first year of the pilot. These costs include tasks such as customer service, billing, enrollment, un-enrollment, support of the enabling technology, and deployment of customer notifications related to the daily operations of the pilot, such as reminder postcards to call with questions or informational notifications provided for billing clarification.

Figure 6 compares planned costs in the original budget to the actual expenditures for the customer enrollment and support efforts from October 2011 through December 2012. Of note is the significant reduction in the expenses for labor. The original plan had estimated hours for customer support very conservatively. However, call volumes were much lower than the original estimate and customer support labor hours were about half of what was originally planned. In addition, we were able to achieve efficiencies in the enrollment process due to automation of several transactions for enrolling customers.

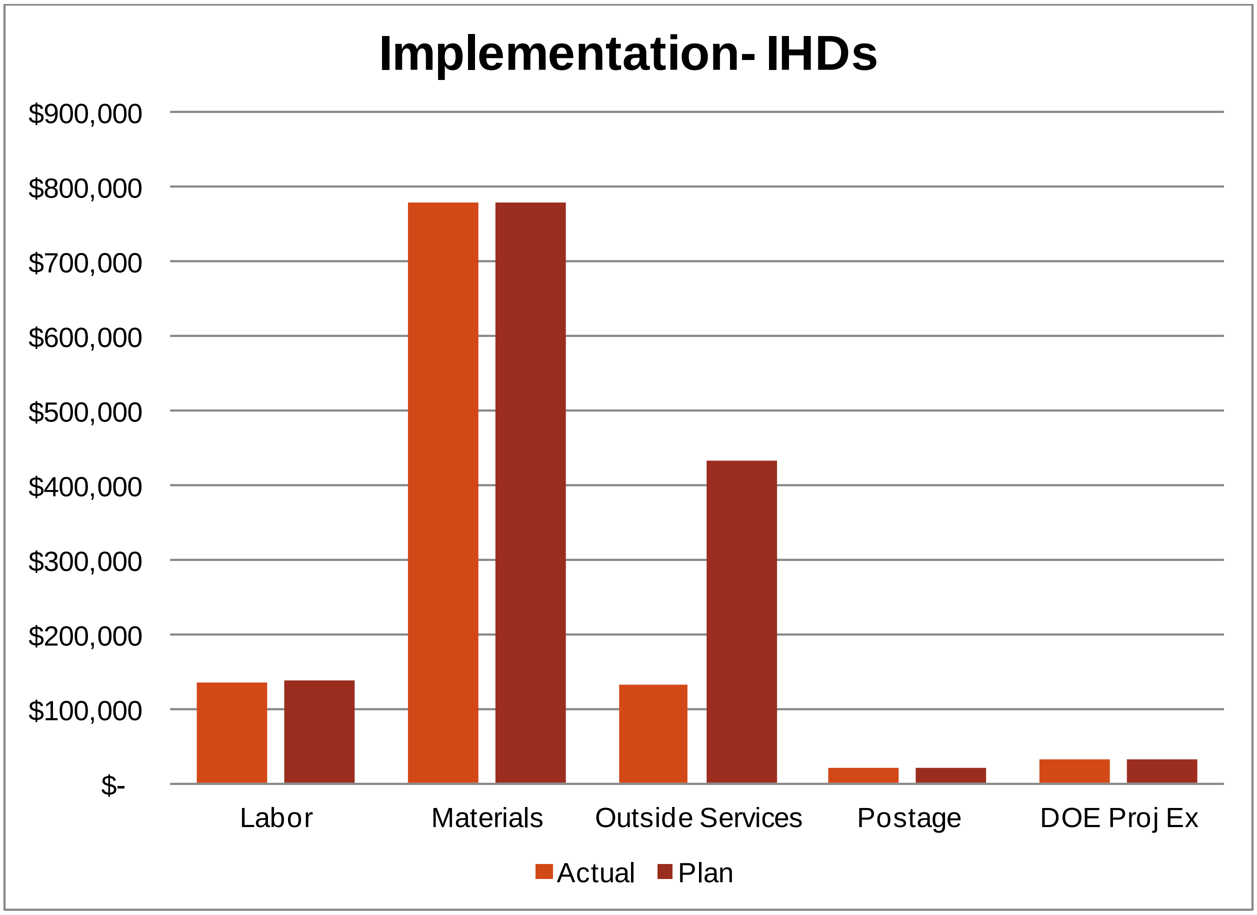
Figure 6: Implementation - Enrollment and Customer Support Costs



IMPLEMENTATION: IHDS

Figure 7 compares planned costs in the original budget to the actual expenditures for the implementation of the IHDs through December 2012. Significant reduction in the expenses for outside services was due to providing internal technical support for IHDs rather than utilizing outside services for the role. After careful evaluation of the proposed support services provided from an external party, we decided to keep all support for the devices in house, which resulted in a large costs savings for those services, since added labor costs were offset by efficiencies in other areas.

Figure 7: Implementation - IHD Costs



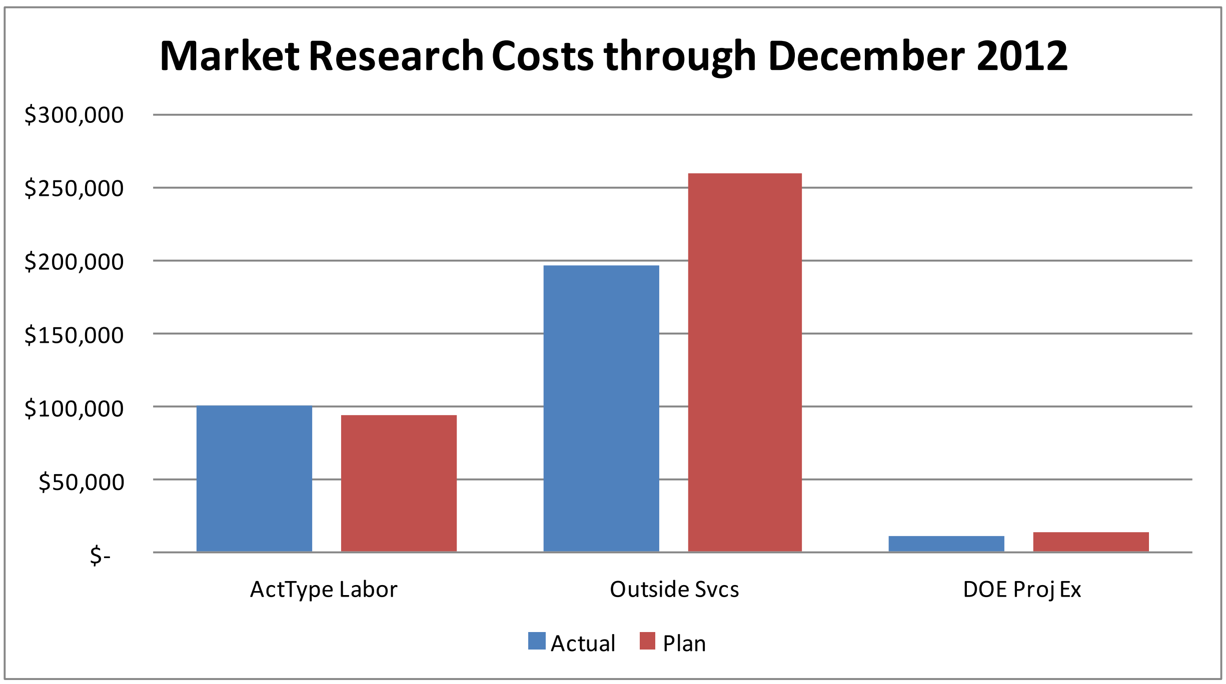
Implementation: Project Management

Project management includes all tasks associated with keeping the project planned and implemented within scope, on schedule, and within budget. Many tasks that might otherwise be handled by a program manager in a program environment, such as running reports and validating mail lists, were also handled by the project manager, since the no program manager was planned for this research project. The costs for these tasks were approximately $800,000 from the planning stages to the completion of the first summer. There were several team members billing to the project under project management based on the nature of their tasks. These tasks include development of Requests for Proposals; development of schedules, scope, and budgets; review of all marketing materials; and data management for reporting and evaluation, among other tasks.

Customer Opinion and Satisfaction Research

Market research costs include research conducted prior to recruitment and customer opinion and satisfaction research performed before and after the first year of the pilot. This includes the portfolio of research projects presented in *Section I, 6.0 Market Research.*

Figure 8: Market Research Costs through December 2012



Evaluation and Reporting

As of the end of the first summer, only a small portion of the overall of the budgeted funding had been spent on evaluation and reporting. The total expenditures for this category are forecasted at 15% of the total budget.

REPORTING: DATA MANAGEMENT

Although data management is not a large part of the overall budget, it is an important task operationally and strategically. Data management and reporting is 5% of the total budget, and after the first year over 3.5% had been spent. The majority of these costs included data analytics and statistical software (SAS) and labor expenses.

CAPITAL

Capital expenses include those costs required to upgrade system infrastructure to support time based rates in our Customer Information System (SAP), Meter Data Management systems, and the HAN Communication Manager. These costs account for approximately 11% of the costs through December 2012.

3.2.2 Schedule

The SmartPricing Options project schedule was built to accommodate implementation of a large study that included the integration of smart grid technology. The outside boundaries of the schedule were dictated by the two-year study period allowed by DOE and the start date of the grant award. DOE reportable milestones and deliverables are noted in Table 2. The CBSP was approved by the TAG in spring of 2011. SMUD's Board of Directors approved the rates in summer of 2011, though project planning began before TAG negotiations and ran concurrently with the approval process. Recruitment for the pilot began in late October 2011. The pilot rates went into effect on June 1, 2012.

Table 2 represents the milestone schedule, illustrating some of the major efforts for the SmartPricing Options pilot.

Table 2: SmartPricing Options Schedule of Milestones

Milestone	Completion Date
White Paper summary submitted to TAG	08/09/2010
Rate Development	12/31/2010
Final Plan Submitted to DOE	03/30/2011
SMUD Board Rate Approval	03/31/2011
Development of Marketing and Educational Materials	08/01/2011
Sample Selection	09/20/2011
Begin Recruiting	10/24/2011
Select IHD	12/31/2011
Deliver IHDs	05/01/2012
New Rates In Effect	06/01/2012
Interim Evaluation	04/01/2013
Market Research - Satisfaction Survey	12/31/2013
Market Research – Conjoint Study	12/31/2013
Market Research - Assess effectiveness of channels and tactics	12/31/2013
Residential Attributes and Consumer Behavior Survey	12/31/2013
Final Evaluation	04/30/2014

3.3 Quality Assurance

The project manager and business unit leads created a detailed task-level schedule for the project using Microsoft Project. The project schedule includes over 1,260 tasks with start and finish dates for each task of the project. This schedule was critical for the project team to stay on task and recover through delays and surprises that are inevitable in any project. During core team meetings, the team stepped through the project schedule so that each individual was accountable for their assigned tasks. In this way, the team identified any issues or delays and work collaboratively to find solutions to overcome them. The project schedule was stored as a protected document on SharePoint so that all team members could view it, and it was distributed to the team each month after it was updated for reporting.

In addition to regularly managing the schedule at the team level, monthly reporting to the SmartSacramento Project Management Office was required to sync DOE milestones from the SmartPricing Options schedule up with the entire SmartSacramento schedule that is used to report to DOE. This multilevel reporting process was more work than the standard approach, but it was a valuable process in terms of accountability and forecasting due to the number of reviewers included in the process and the need to have multiple tools synchronize seamlessly.

3.4 Lessons Learned and Key Takeaways

The SmartPricing Options pilot was a huge undertaking for the team to implement and manage on a very tight timeline. Managing the tasks of over 140 contributors over the course of several years requires strict schedule oversight. It is not uncommon for project schedules to be less detailed than the schedule used for this project, however having a highly detailed schedule that has a corresponding line item in the budget using the same naming conventions was extremely useful in managing tasks, budget, and resources. Using a dynamic project management scheduling software (MS Project) and budget reporting system (SAP) provided access to information that allowed for schedule and budget recovery, variance explanation, sound forecasting, and on-time and under-budget delivery.

4.0 Customer Advocacy

4.1 Overview

Customer education started with recruitment and continues throughout the pilot. We want to give our customers every opportunity to be successful.

SMUD's commitment to partnering with our customers was a chief consideration in project planning. The introduction of new rate structures on a default basis brought to light concerns regarding customer readiness and the possible perception that the new rates may be punitive. The rates team made a concerted effort to design the new offers in a fair and low-risk manner, but with the introduction of any new pricing on a default basis there is the possibility that customers may perceive it negatively. SMUD's market research indicated that customers were aware of a peak period, however there was considerable confusion regarding the relevance of the peak period to both pricing and the environment. Historical research has also indicated our customers are not universally clear on who owns SMUD and whether or not SMUD is a "for profit" organization.

Although the national media coverage related to smart meter deployment was largely controversial, SMUD managed to maintain good customer relations during our smart meter installation. We wanted to be very careful not to interfere with that effort by introducing new rates that would inadvertently cause tension or doubt with our customers.

SMUD made every effort in the case of this pilot to balance the need to move toward rates that more closely represent the cost of service with the potentially uncomfortable transition for customers. Drastic changes with limited support would go against our corporate values, and communication around default services is typically very different than the communication for opt-in services; both of which were concerns for project team. Considering the degree of change customers would be experiencing with the development of the smart grid, SMUD made the commitment to ensure that the customer experience with this pilot would be positive and the support and communications plan would be comprehensive. Because SMUD's strategic plan included the transition to time-based pricing in the future, we felt it was critical that we introduce these new pricing concepts in a palatable and positive way, ensuring we didn't discourage customers from accepting future changes in pricing. As a municipality, it is our responsibility to consider the entire customer base in a fair and equitable manner.

Figure 9 provides a visual summary of the multitude of communication and information channels to which a SmartPricing Options customer had access. The communication and support opportunities for these customers was intended to be thorough and meet customer needs in a way that would provide customers with a support network that would address the unique areas of change they would be experiencing.

Figure 9: SmartPricing Options Customer Touch Points

4.2 Details

Managing the customer experience is an ongoing, end-to-end effort. Table 3 represents the initial concerns and key strategies that were put in place to mitigate potential risks to the customer experience. Embracing these key strategies at the onset of the project set the tone for the remainder of the project in terms of customer advocacy. The basic principles then translated into other pilot efforts. Customer education started with recruitment and continues throughout the pilot. We want to give our customers every opportunity to be successful.

Table 3: Customer Relations Risk Mitigation Plan

Customer Relations Consideration	Mitigation Strategies
Avoid Punitive Billing Offer pricing plans that would optimize the benefits while avoiding drastic bill changes for those who don't change behavior.	Provide IHDs to assists in bill and energy management at no cost to the customer. Ensure all customers on the default plans have access to IHDs. Optimize the distribution processes to limit customer effort to enable the device. Provide comprehensive technical support for the IHD throughout the study period. Design and assess new billing processes that result from new smart grid infrastructure. Develop business rules related to missing or latent data and other billing situations, such as mid-billing-cycle contract closure, to ensure the customer is not penalized for system limitations. Design rates that balance customer opportunity to save on the bill with risk of bill increase.
Maintain Consistent Customer Experience Ensure that the customer experience will meet or exceed their current expectations	Automate processes or leverage existing processes and services to the extent possible. Establish a special team of customer service representatives trained in each of the pricing plans, rates, and technology. Provide custom toll free line and Interactive Voice Response (IVR) routing for pilot participants directly to this customer service team. Establish tracking and support tools to manage the customer experience. Ensure no customers feel pressured into accepting the offer. Hard sales will not be permitted and outbound calling to serve as a "customer service notification" rather than a sales call. Enrollment compensation for outbound calling firm to be based primarily on the effort put into recruitment rather than total enrollments completed.

Customer Relations Consideration	Mitigation Strategies
Customer Acceptance of the Rate Offer pricing plans in a manner that achieves high acceptance rates and avoids negative customer perception among those who choose not to accept the offer.	Limit the number of customers the overall study would proactively communicate with (i.e. receive an opt-in invitation or default notification). Keep the number of customers who receive the default notifications to the minimum required to adequately answer research questions. Restrict sample sizes of lower priority research questions. Commit to a comprehensive education and communication plan to assist customers with the transition. Provide the information through a wide variety of channels to allow customers to receive the information in the manner they prefer. Communications included messages presented in simple, easy to understand language regarding: • The overall purpose of the pilot • Explanation of the potential bill savings • Simple explanations of the rates and how they work • Ample tools and tips for bill savings opportunities • An explanation of the problem created by peak consumption • The benefit of their contribution on the environment • Focused messaging on the benefits of “off-peak” consumption • Easy, no pressure enrollment • Easy, no pressure opt-out process Measure customer expectations, concerns, and satisfaction via market research and assess incoming customer communications, and respond accordingly.
Mistaken Perception of Revenue or Rate Increase Design rates and craft communication that doesn’t lead customers to believe time-based rates are collecting additional revenue for SMUD.	Remind customers that SMUD is a not-for-profit organization, owned by our customers. Ensure rates are designed to be revenue-neutral and communicate this publically in the community leading up to the Board of Directors’ vote and final resolution. Offer the rates as “pricing plans” to assist in the understanding that the rates are optional. Keep the offer of the pricing plans separate from communication regarding the installation of smart meters to avoid influencing participation in the pilot resulting from attitudes associated with smart meters, as well as to avoid impacting the acceptance of smart meters with the potential misconception of a rate increase.

4.3 Quality Assurance

The communication strategy was driven by corporate initiatives and SMUD's brand guidelines. Once the strategy was established and presented to the executive team, it was then communicated to team members. This top down approach to stakeholder buy-in on communication strategy was an important step, since all team members needed to ensure consistent customer experience, whether through marketing materials, contact center interaction, call escalations, market research, outbound event messaging, or IHD technical support.

Each business area was assigned a lead, and all customer communications related to that area were coordinated and approved by the lead, followed by approval by the project lead. In some cases, sensitive material was reviewed and approved by various management or executives.

Multiple subject matter experts reviewed materials to ensure technical accuracy in addition to tone and positioning. For example, technical leads from SMUD's Rates, Legal, Contact Center, and Smart Grid departments reviewed materials that solicited recruitment into the opt-in pricing plans.

Considerable market research was planned throughout the pilot duration. Market research was not limited to pilot recruitment, but rather spanned a host of areas that addressed the field implementation of the pilot as well as additional research questions aimed at future pilot design. SMUD continues to use the ongoing market research efforts to hone the customer experience in the pilot and plan for future rate implementations.

4.4 Lessons Learned and Key Takeaways

4.4.1 Comprehensive Communications

Putting together a communication plan that is comprehensive and directly addresses customer concerns or potential risks is an important step. Using market research to determine how to prioritize the contents and how to position the messaging is an important step. The communication plan shouldn't consist of enrollment or marketing materials alone. Our customers preferred context, simple explanations, detailed tips and a lexicon that matched their expectations. The plan should be benefits-focused and address areas of concern presented by the customer.

Customers don't always know what they *do* want, but they tend to be very certain about what they *don't* want. Our primary research with customers indicated we should avoid certain language or insinuations that customers found off-putting or unrealistic. The project team often had to think outside the box to address an area of concern for customers because we had clear information on what not to do, but we didn't always receive feedback on what customers would like. This required persistence in the creativity of the project team and multi-phased market research efforts in order to obtain actionable results from the research.

4.4.2 The Challenges of Congruent Marketing Offers for Opt-in and Default Rates

When designing a study that has both opt-in and default rates, the rate design and communication materials need to address an array of needs and risks. The risk mitigation around default rate rollout is very different than the mitigation related to opt-in recruitment. As a research study, all materials and approaches needed to be consistent in their messaging, tone, and delivery channel. It is unknown if this requirement and the resulting materials and delivery hindered or helped the recruitment and implementation of the study (as this was not tested); however, it is very clear that it went against intuition and required active management and quality assurance. Examples include:

- Customers may consider adopting a riskier rate as long as it is an opt-in rate, since the customer is actively taking initiative to seek out the rate change. This can provide opportunities for different "risk versus reward" scenarios with pricing design. A default rate, on the other hand, should be designed in a way that moves the customer closer to the cost of providing service, yet manages the risk to customers who might otherwise have notable bill impacts if no change to consumption is made. This lower-risk approach results in limited savings opportunities for customers, which can be a difficult message to market to opt-in customers.

- In standard day-to-day operations, it is customary to use market intelligence in profiling customers and targeting marketing efforts to maximize return on investment. Educational materials can often be a direct reflection of the most likely adopters and even be provided in a single language. A change in default pricing requires much more customer care and universal approach to ensure equity. Due to the inherent nature of experimental research design coupled with the implementation of a default rate, universal "one size fits all" communication was used. In some cases, the materials were also presented in Spanish. It is unknown if this universal approach was more or less effective than the targeted approach as this was not tested.

Mass marketing can sometimes optimize costs by reducing production and labor costs when compared to direct marketing tactics. Because the research team needed to control messaging to each treatment group, mass marketing channels could not be used as a primary marketing tactic. This likely inflated the costs to communicate to customers in the pilot and provides an opportunity for cost-savings in a full program implementation.

Customer relations took a higher priority than research diversification and breadth, as long as the project continued to meet research objectives that would assist in future rate planning. Essentially, managing the customer experience was a higher priority than testing additional theories; i.e., the focus on the customer was a higher priority than expanding the research into larger sample sizes or additional rates.

4.4.3 Consistent Employee Communications

Early decisions related to the customer experience set the tone for the project. Consistency in internal messaging to employees related to goals and philosophy were just as important in project execution as the attention paid to outbound customer communication. At the time of the interim evaluation, over 140 employees had contributed to the pilot; thus, having a few key messages related to *how* we do our work was important, so we communicated those messages early and reiterated them often.

4.4.4 Balancing Individual Customer Satisfaction with Customer Equity

Maintaining the constant balance between customer relations and the need to change how we conduct business is difficult. For a municipality, customer advocacy doesn't necessarily result in 100% customer satisfaction; rather, it means that at times we have to move customers to an unfamiliar and potentially uncomfortable place to help our customer group as a whole. Some customers may not be pleased about that approach, so we proactively assessed those risks and looked for opportunities to improve the plan to mitigate risks in a manner that aligned with our brand and culture, consistent with customer expectations, while still achieving our goals.

4.5 Additional Areas and Interest and Future Research

- How much impact did the enhanced communications and marketing plan impact customer load, satisfaction, and retention compared to a more standard communication approach?
- What additional information would have assisted in customer engagement?
- What are customer expectations and concerns around the advancement or rate design and availability of optional pricing plans?

5.0 Rate Design

5.1 Overview

To further assist customer load shifting, the high-priced peak period was limited to only three hours during SMUD's system peak which occurs on summer weekday afternoons during the months of June through September.

This section presents the design of the SmartPricing Options rates and provides background on their design, pricing objectives and preliminary impacts. The rates presented here were reviewed by the public and approved by SMUD's Board of Directors in July, 2011. They became effective in June, 2012.

The SmartPricing Options rates create higher prices during summer peak periods with the aim of encouraging study participants to shift their electricity use to lower-cost off-peak periods. While focused on this overall goal, SMUD sought to design the rates following general principles of cost recovery, economic efficiency, customer equity, rate simplicity and minimal negative cost impact. To meet these objectives, the rates were designed with the following features:

- **Peak period pricing** based on marginal generation and energy-related costs to provide a realistic price signal during SMUD's peak period
- **Revenue neutrality** for the average class customer by discounting the base energy prices to offset the higher peak pricing
- **Little change to bill structure** to help minimize bill impact, for example, by keeping the original residential tier structure for the off-peak period pricing
- **A shortened peak period** of only three hours to facilitate customer load shifting

5.2 Residential Control Group Rates

The RED control group and RCT deferred control group remained on SMUD's standard residential rates as they were updated for the entire district effective January 2012. These rates feature the following characteristics:

- A two-tier inclining price structure with seasonal changes to both price and tier baseline energy allowances.
- Customers with wells for domestic water use receive an additional 300 kWh base tier allowance to compensate for required pumping energy.
- Low-income customers receive a discount in the monthly service charge and the energy charges for Base (tier 1) and Base Plus (tier 2).
- A cap on the Base Plus discount permitted for low income customers at which point they revert back to the standard Base Plus price

Table 4 shows the new undiscounted base plus for low-income customers, including those with domestic water wells.

Table 4: 2012 and 2013 Energy Tier Allowances for Low Income Customers (kWh per Month)

Low Income Residential Customer Rates	Base Discount Allowance	Base Plus Discount Allowance	Base Plus Standard Price
Standard Customer	< 700	700 - 1,425	> 1,425 kWh
With Domestic Well	< 1,000	1,000 - 1,725	> 1,725 kWh

Table 5 presents the 2012 SMUD residential rate tariff alongside proposed rate changes that were approved for implementation by June 2012. The 2012 rate action re-defined the summer months as June through September, which is consistent with the SmartPricing Options summer rate period. The tariffs increased the service charge for standard customers to $10.00 while commensurately lowering tier energy charges.

Table 5: 2011 and 2012 SMUD Residential Rates in Effect June 2012[7]

Rate	Option	Service Charge	Base	Base Plus	Base Plus Above Usage Allowance
2011 Summer Rate (May-October)	Standard	$7.20	$0.1045	$0.1859	
	Low Income	$3.50	$0.0679	$0.1301	
2012 Summer Rate (June - September)	Standard	$10.00	$0.1016	$0.1830	
	Low Income	$3.50	$0.0660	$0.1281	$0.1830

5.2.1 Peak Period Definition

To further assist customer load shifting, the high-priced peak period was limited to only three hours within SMUD's longer system peak which occurs on summer weekday afternoons during the months of June through September. Figure 10 illustrates that residential load peak later in the day and contributes heavily to SMUD's system load profile.

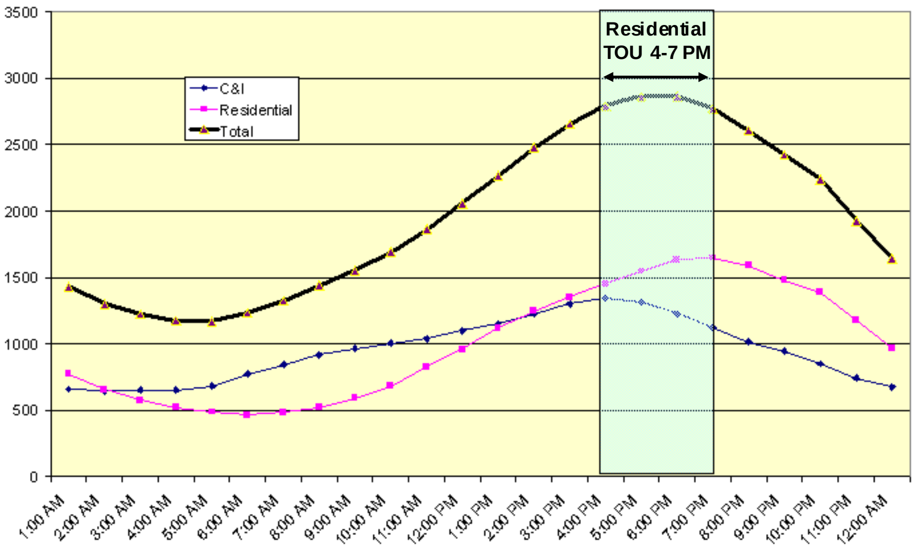
In recognition of these use patterns, the dynamic pricing established 4:00 p.m. to 7:00 p.m. as the peak period for residential customers. For Critical Peak Pricing (CPP), the call periods are the 12 days during these defined times, when market prices are highest or SMUD's system is otherwise constrained by reliability factors. SMUD called 12 CPP events each summer of the study period, regardless of actual conditions. These events were referred to as "Conservation Days" in customer communications.

[7] 1. Low income rates provide a discount for Base charges by 35% and for Base Plus charges by 30%. Service charge remains fixed at $3.50.

2.. Effective date was January 1, 2012.

3. Base Plus allowance for low income customers eliminates discount for energy use above 725 kWh of Base Plus usage, which equals 1.425 kWh for standard low income customers, and 1,725 for low income customers with wells for domestic water use.

Figure 10: Residential Load Contribution to SMUD Peak



5.3 Residential Time-Variant and Dynamic Pricing Options

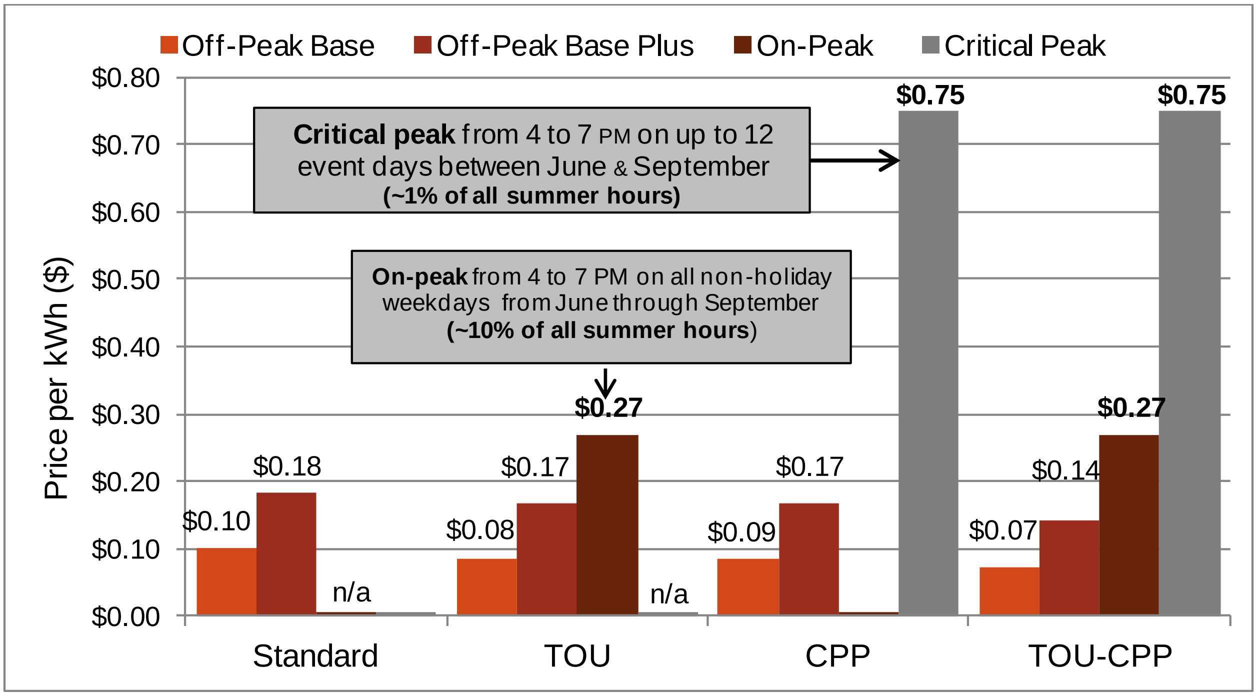
The SmartPricing Options rate design sought to minimize structural change to SMUD's residential two-tiered rate to avoid bill shock for smaller energy consumers. At the time of rate design, this subset of customers benefited from cross-subsidies from customers paying more on the second, higher-cost tier. The new rates retained the basic underlying tier structure for the discounted off-peak pricing, while adding new, non-tiered peak time-of-use (TOU) and critical peak pricing (CPP) during the months of June to September. Winter pricing was unchanged.

The three SmartPricing Options residential rates are as follows:

- Time of Use (TOU)
- Critical Peak Pricing (CPP)
- Combined TOU-CPP

In each case, the peak rates are offset by lower off-peak pricing for Base and Base Plus energy use to maintain revenue neutrality. Figure 11 illustrates the residential TOU and CPP residential rates for Base and Base Plus[8] billing days.

Figure 11: TOU and CPP Price Structure for Base and Base Plus Bill Days[9]



[8] Base Usage and Base Usage Plus refer to SMUD's first tier and second tier kWh allowances, respectively. These terms are interchanged throughout this rate section in reference to these allowances.

[9] The proposed time-variant rates have been designed to maintain the existing tier structure of SMUD's standard rates and are references as "overlays."

Table 6 presents the variation of these rates for low-income customers.

Table 6: SmartPricing Options Rates for Low-Income Residential Customers

Low Income Residential SmartPricing Options Rates	On-Peak Prices Weekdays: 4-7 PM		Off-Peak Prices (All Other Hours)			Monthly Service Charge
	Peak Price	Critical Peak Price	Base Usage	Base Plus Usage	Base Plus Usage above 800 kWh	
Time-Of-Use Peak Rate	$0.20	-	$0.0550	$0.1162	$0.1660	$3.50
Time-Of-Use with Critical Peak Pricing	$0.20	$0.50	$0.0468	$0.0987	$0.1411	$3.50
Critical Peak Pricing	-	$0.50	$0.0553	$0.1165	$0.1665	$3.50

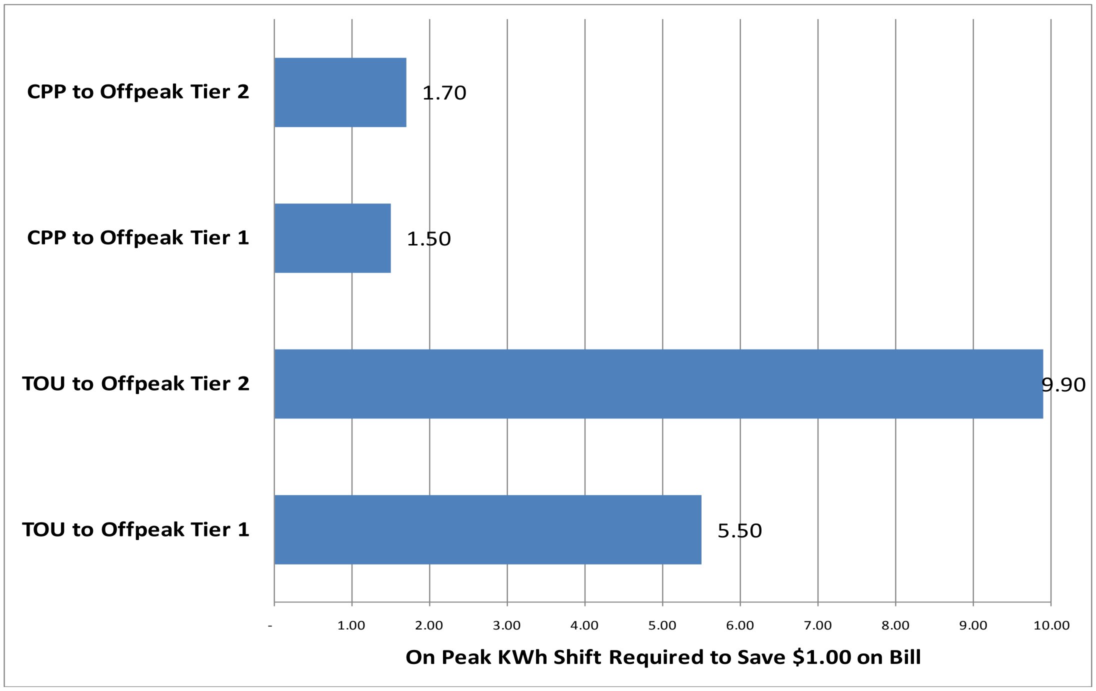
As indicated in Table 7, the peak price of $0.27 for TOU yields peak to off-peak ratios that average around 3-to-1 when weighting Base and Base Plus usage. For CPP, the weighted average peak to off-peak ratios range from 7.5 for the stand-alone rate to 9.1 for CPP combined with TOU. These differentials determine the amount of energy the participant will need to shift out of the peak period for bill savings. As illustrated in Figure 12, customers on the TOU rate would need to shift or otherwise reduce 5.5 to 10 kWh per month to save one dollar on their bills. For customers on the CPP rate, they need only shift or reduce 1.5 to 2 kWh per month to save one dollar on their bills.

Table 7: Peak to Off-Peak Price Ratios by SmartPricing Options Rate

Rate	Peak Period (4-7 PM)	Peak to Off-Peak Base Usage Ratio	Peak to Off-Peak Base Plus Usage Ratio	Weighted Peak to Off-Peak[10] Ratio
Time-Of-Use Rate	TOU	3.2	1.6	2.8
Time-Of-Use with Critical Peak Pricing	TOU	3.7	1.9	3.3
	CPP	10.4	5.3	9.1
Critical Peak Pricing	CPP	8.8	4.5	7.5

[10] Based on average residual off-peak tier energy in AMI sample (Summer 2010).

Figure 12: Residential Peak Energy Shift Required Per $1.00 Savings



5.4 Development of TOU and CPP Pricing

SMUD's approach to the TOU, CPP and TOU-CPP rate options wass to set the peak price close to the avoided cost of power. For both TOU and CPP rates, we discounted the average base energy prices by a commensurate amount. In general, this approach involved the following steps:

- Using the most current marginal cost data, we determined the value of avoided power consumption and generation capacity during the appropriate summer peak period.
- These avoided costs were allocated to customer peak energy use from normalized hourly load-shapes from SMUD's load research sample. Adjustments were made to reconcile the values to revenue requirements, existing rate contribution to energy and capacity, and other factors.
- To determine the basis for the off-peak discount, the expected added revenue from the peak pricing was divided by the expected off-peak energy.

5.4.1 Marginal Costs Used to Derive Peak Pricing

To develop the time-variant rates for this study, we utilized the following market-based cost components from the most current marginal cost study:

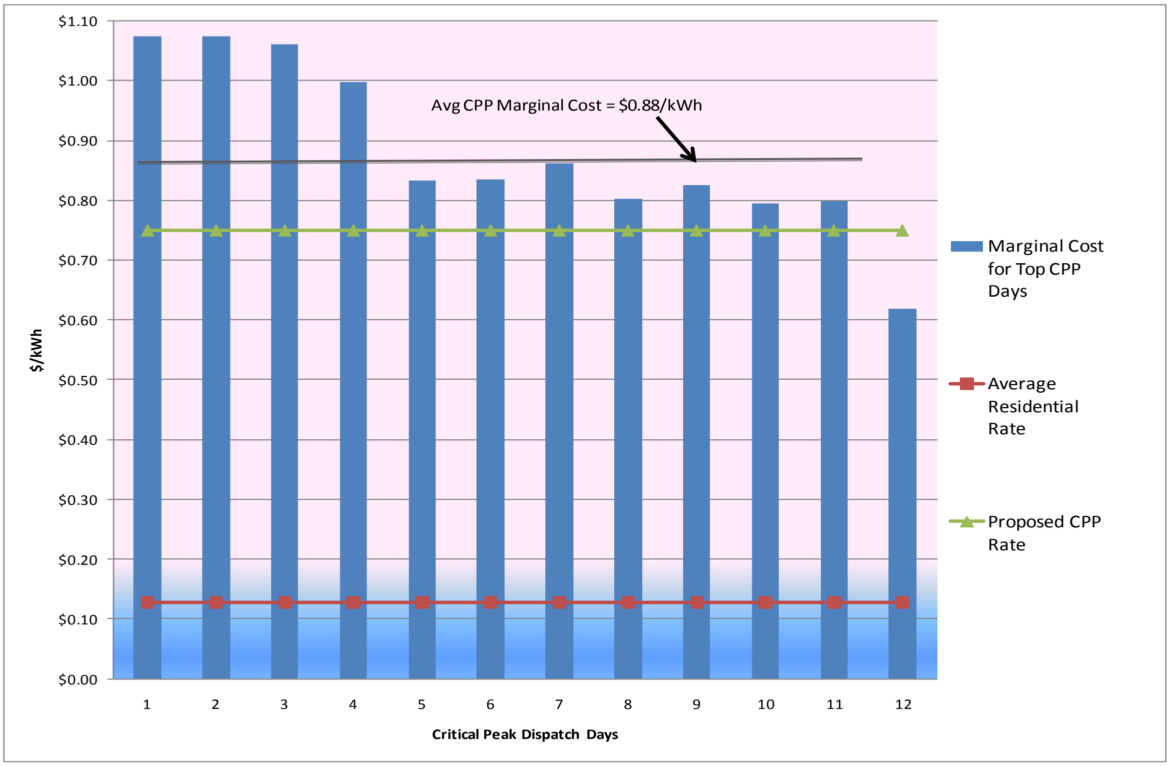
- **Market Energy,** based on a combination of SMUD's short term market forecast and the long term gas prices provided by a consultant. SMUD converts gas prices to energy prices using historical market heat rates, computed on an hourly basis.
- **Ancillary Services**, the Western Electricity Coordinating Council (WECC) establishes the amount of ancillary service requirements that SMUD must provide as a percent of generation output. SMUD must provide or purchase additional MWH of ancillary services to meet this requirement. The market prices for ancillary services relate directly to market prices for energy in California Independent System Operator (CAISO). These services include includes spin and non-spin reserves and regulation services.
- **Generation Capacity**, based on capital and non-fuel related fixed operations and maintenance costs developed by the California Energy Commission's Cost of Generation study. The assumed power source in the study is an advanced simple-cycle peak generator, financed and operated by a third-party merchant entity. SMUD adjusts the costs assigned to this capacity component by the calculated contribution from sales in the energy market. Annual capacity costs are allocated hourly, based on probability of system peak.

The final marginal costs were levelized[11] using SMUD's discount rate on an hourly basis for a three-year costing window. The hourly costs can then be applied against weather-normalized hourly load-shapes representing the target residential customers.

In the case of TOU rates, SMUD assigned the marginal costs for the non-CPP peak hours. In the case of CPP, SMUD assigned the total marginal capacity costs for the 36[12] summer hours in the top 12 peak days. The peak days used in the model were selected from historical averages of system load for days over 103 degrees. Figure 13 compares the proposed CPP price of $0.75 per kWh with energy and marginal capacity costs for these top 12 peak days in the study period, as well as the weighted average residential price.

[11] Levelizing refers to fixed payments over the selected term, based on the net present value of the stream of future costs. SMUD's discount rate is approximately 6.0%.
[12] These 36 hours represent 12 CPP event days multiplied by 3 peak hours per day *within* the 42 hours that make up the critical peak period.

Figure 13: CPP Price Compared to Marginal Cost and Average Residential Rate



5.4.2 Estimated Bill Impacts From SmartPricing Options Rates

SMUD designed the SmartPricing Options rates based primarily on residential class hourly data for a typical weather year. While this approach can optimize a rate design to approximate revenue neutrality for the residential class, individual customers will experience a range of impacts based on their energy use variance from the underlying class level load shape.

The most significant variable[13] affecting bill impact is the amount of energy used during the peak relative to the off-peak or total monthly energy. In general, customers with higher peak use relative to the class average will see higher bills, while customers with relatively lower peak use will see bill savings. The following are the relevant average peak to off-peak ratios used in the rate design from the class data:

[13] A variable of secondary importance is Base energy use, because the adoption of substitute TOU and CPP prices in the proposed rate design, (rather than adders to tiered peak pricing), to some degree adversely impacts smaller residential users.

- 13% -14% of energy in the month is used during the TOU peak period, and
- 2.5% – 3.0% of energy in the month is used during the CPP.

The installation of smart meters through early 2011 provided staff the opportunity to estimate the rate impact on actual customers based on the relatively mild summer weather conditions of 2010. In 2011, the rates team evaluated the proposed rates by comparative test billing on approximately 60,000 residential customers who had new smart meters in place for the full four months of the 2010 summer. For this evaluation, staff culled relevant TOU and CPP energy use for each monthly bill, the latter determined by matching the peak use during the top 12 days of the summer period. The comparison assumed the base rates were those proposed for 2012 implementation.

Figure 14 through Figure 16 present the bill impact estimates for the TOU, TOU-CPP and CPP standalone rates respectively[14]. They show that a reasonably high percentage (75% - 90%) of the customers in this sample group could expect rate impacts less than $10.00, with 50%-70% seeing less than a $5 impact. Of those outside this range who were adversely affected, nearly all saw average monthly bill increases of less than $25.00.

[14] The charts present results for 50,000 standard rate customers, not including low-income customers who were evaluated separately with similar results.

Figure 14: Range of Bill Impacts for TOU Rate

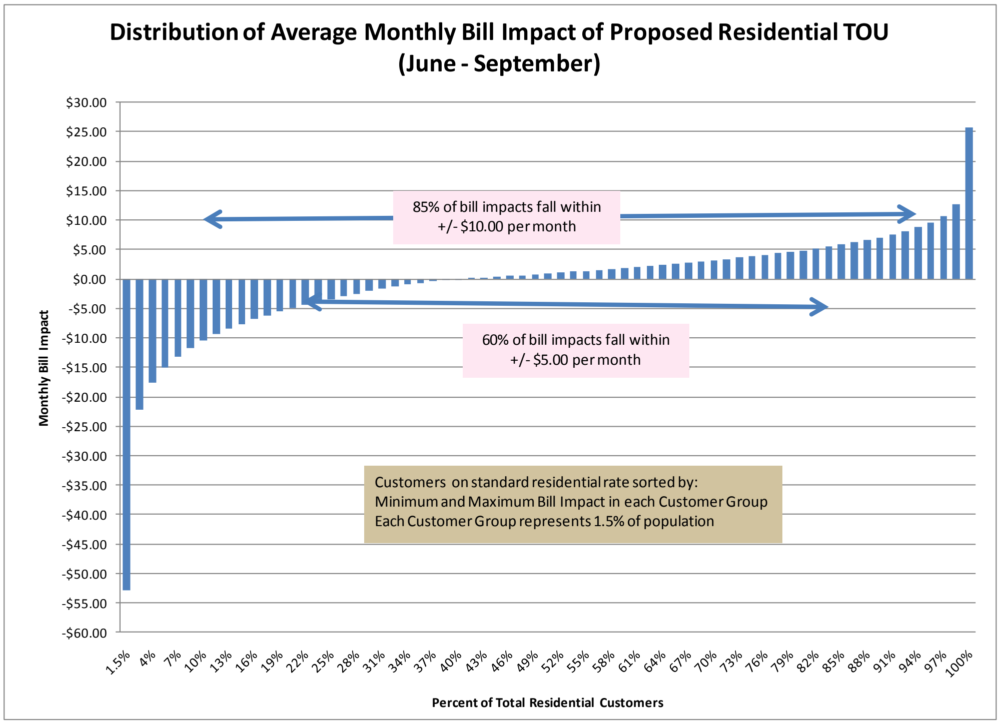


Figure 15: Range of Bill Impacts for TOU-CPP Rate

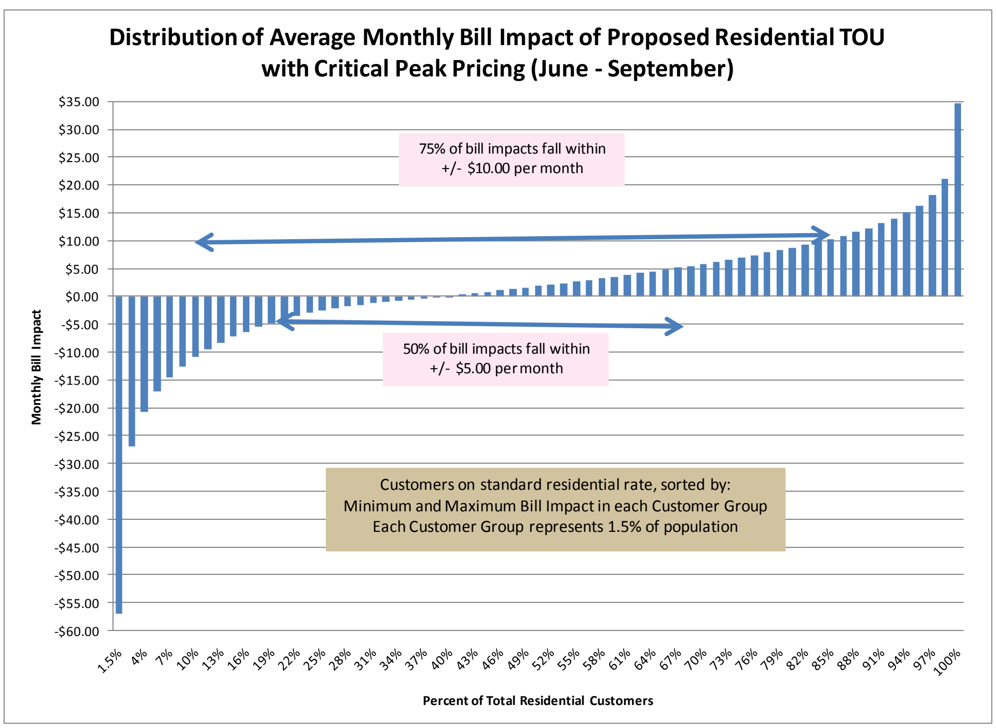
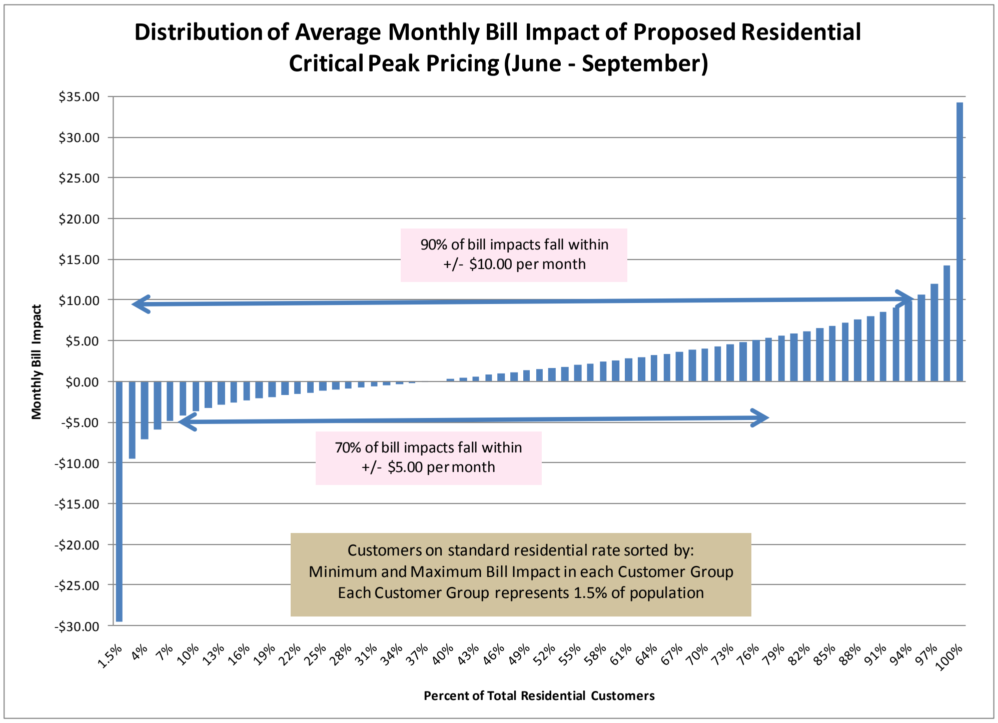


Figure 16: Range of Bill Impacts for CPP Stand-Alone Rate



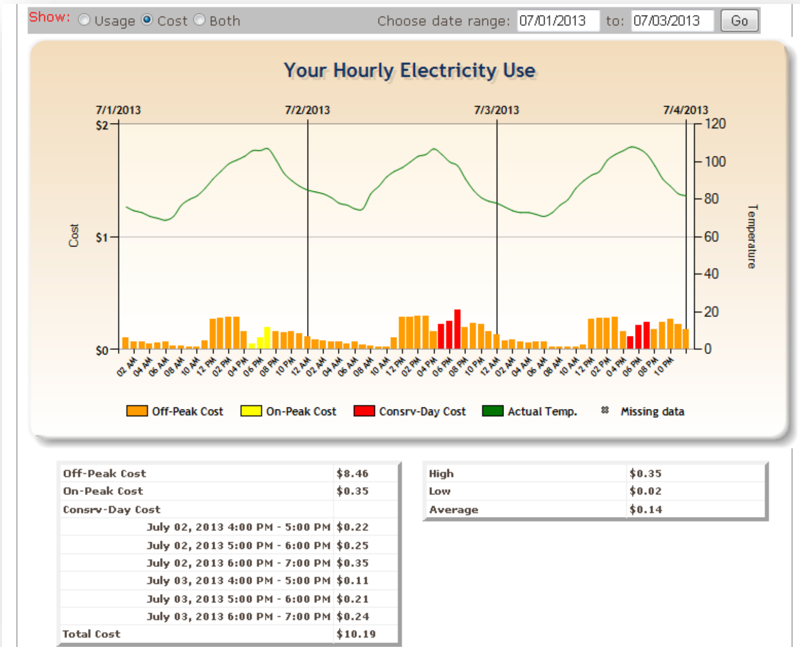
5.3 Rates and the Web Portal

SMUD provides all customers with access to a personalized web portal that displays their electricity data as measured by their smart meter. The web portal contains several screens that graph each customer's electricity use at various intervals: monthly use, daily use, and hourly use. Up to two years of monthly billing data are available. The interval data displayed range from the period when the smart meter was installed (but no earlier than March 31, 2011) through the calendar day prior to the day in which the data are being viewed, or "yesterday."

Since customers are generally more concerned with cost than kWh, the different interval graphs also overlay the cost of their electricity use and display a daily cumulative cost graph to show the impact the tier structure has on their final bill. In order to show the impact weather has on electricity consumption, the daily high, low, and average temperatures are overlaid on the daily use graph, and actual temperatures are displayed on the hourly use graph.

The graphics below represent the information that was available to customers through the web portal during the study.

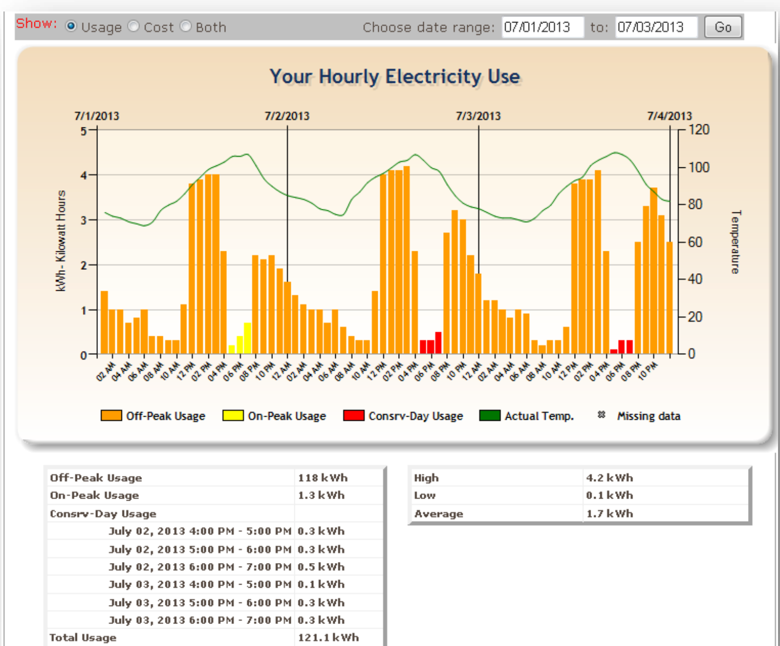
Figure 17: My Account Hourly Electricity Use (Cost)



Off-Peak Cost	$8.46
On-Peak Cost	$0.35
Consrv-Day Cost	
July 02, 2013 4:00 PM - 5:00 PM	$0.22
July 02, 2013 5:00 PM - 6:00 PM	$0.25
July 02, 2013 6:00 PM - 7:00 PM	$0.35
July 03, 2013 4:00 PM - 5:00 PM	$0.11
July 03, 2013 5:00 PM - 6:00 PM	$0.21
July 03, 2013 6:00 PM - 7:00 PM	$0.24
Total Cost	$10.19

High	$0.35
Low	$0.02
Average	$0.14

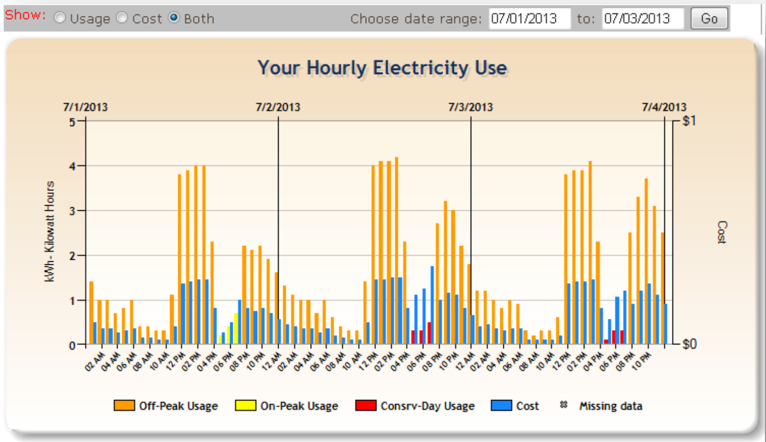
Figure 18: My Account Hourly Electricity Usage (kWh)



Off-Peak Usage	118 kWh
On-Peak Usage	1.3 kWh
Consrv-Day Usage	
July 02, 2013 4:00 PM - 5:00 PM	0.3 kWh
July 02, 2013 5:00 PM - 6:00 PM	0.3 kWh
July 02, 2013 6:00 PM - 7:00 PM	0.5 kWh
July 03, 2013 4:00 PM - 5:00 PM	0.1 kWh
July 03, 2013 5:00 PM - 6:00 PM	0.3 kWh
July 03, 2013 6:00 PM - 7:00 PM	0.3 kWh
Total Usage	121.1 kWh

High	4.2 kWh
Low	0.1 kWh
Average	1.7 kWh

Figure 19: My Account Hourly Electricity Use (Cost and kWh)



Off-Peak Usage	118.0 kWh
On-Peak Usage	1.3 kWh
Consrv-Day Usage	
July 02, 2013 4:00 PM - 5:00 PM	0.3 kWh
July 02, 2013 5:00 PM - 6:00 PM	0.3 kWh
July 02, 2013 6:00 PM - 7:00 PM	0.5 kWh
July 03, 2013 4:00 PM - 5:00 PM	0.1 kWh
July 03, 2013 5:00 PM - 6:00 PM	0.3 kWh
July 03, 2013 6:00 PM - 7:00 PM	0.3 kWh
Total Usage	121.1 kWh

Off-Peak Cost	$8.46
On-Peak Cost	$0.35
Consrv-Day Cost	
July 02, 2013 4:00 PM - 5:00 PM	$0.22
July 02, 2013 5:00 PM - 6:00 PM	$0.25
July 02, 2013 6:00 PM - 7:00 PM	$0.35
July 03, 2013 4:00 PM - 5:00 PM	$0.11
July 03, 2013 5:00 PM - 6:00 PM	$0.21
July 03, 2013 6:00 PM - 7:00 PM	$0.24
Total Cost	$10.19

High	4.2 kWh
Low	0.1 kWh
Average	1.7 kWh

6.0 Market Research

6.1 Overview

SMUD's Market Research team conducted extensive research for SmartPricing Options. This research began well before the pilot launch and will extend throughout the two-year pilot period. We conducted an array of market research projects to understand our customers' experiences and preferences for the overall pilot program, as well as specific services. The market research portfolio was intended to serve the immediate needs of the pilot, as well as inform future planning around dynamic pricing and enabling technology.

The team applied the methodology and resources based on the priority and projected actions that would be taken as a result of the outcome of the research.

6.2 Details

Early in scope planning, the SmartPricing Options team established market research as a key resource for the pilot project's success as well as long-term strategic planning for program design and associated customer communications. In order to manage project scope, many research questions could not be addressed by the field portion of the study, so the team relied on market research to address many of the remaining questions.

The market research team took into consideration research objectives, schedule requirements and resources when prioritizing the market research efforts. The team applied the methodology and resources based on the priority and projected actions that would be taken as a result of the outcome of the research. In some cases, exploratory research with convenience samples or qualitative methods were employed to begin to understand a problem; in other cases, representative samples and more conventional research methods were used to draw conclusions that could lead to actionable results.

Early research sought to address immediate project planning needs. With lofty recruitment goals and new rate structures, we had many questions related to customers' existing baseline of knowledge, expectations regarding new rate programs, perceived discretional load, and willingness to shed load. The team developed a research plan that intended to gather answers to those questions and other related topics to assist in the development of the education, recruitment and retention plan.

Concurrently, secondary research was conducted to establish best practices and lessons learned related to time-variant pricing and enabling technology programs to inform the implementation plan for the pilot.

Later research efforts focused on the implementation of the pilot and its various components. Research to ascertain the customer experience with the rates, IHDs, support, and communications were tracked over time to evaluate the impact of the pilot on overall customer perceptions. Additional information continues to be collected regarding the customers, the dwelling, appliances in the home, and attitudes and behaviors to further inform the evaluation of each treatment.

The primary market research objectives were to use findings to plan for the implementation of the pilot, illustrate the customer experience, and describe the various customer profiles. Additionally, the market research team included research questions that would aid in future program design related to time-variant rates and enabling technology. Specifically, the plan includes research to gauge the attractiveness and perceived value of various pricing and technology combinations that were not included in the field test. This research, combined with the earlier research efforts, will be used to provide depth and breadth to the load impact results; the overarching analysis will be used as critical input into the strategic time-variant pricing and enabling technology program plans.

The market research plan described in this section that has been completed to-date was conducted in two chronological stages: pre-recruitment and post-recruitment. Those projects which are not yet complete will be completed during the final phase of the pilot implementation and the evaluation periods. The pre-recruitment research consisted of 20 focus groups and five surveys in which we received feedback from nearly 2,500 customers overall. The time frame for this research was from February 2011 through September 2011. The post-recruitment research completed through July 2013 consisted of four surveys in which we received over 7,400 responses. This research started in May 2012, and will continue through December 2013. The project summaries that follow represent primary research efforts completed through July 2013.

Sections *6.2.1 Pre-Recruitment Research* and *6.2.2 Post-Recruitment Research* describe the individual research projects in detail.

Table 8: Summary of Market Research Portfolio

Market Research Project	Description	Type	Sample Size
Residential Customers' General Knowledge Survey	Exploratory survey to quickly address a broad set of questions to determine where in-depth research might be of value.	Survey	464
General Knowledge Focus Groups	Assess how customers processed information about peak consumption and the proposed pricing offers.	Focus Groups	~40
Headline and Message Survey	Assess responsiveness to various marketing concepts, specifically headline and message combinations.	Survey	536
Headline and Image Survey	Test headline and image combinations to determine which captured customer attention and preference.	Survey	778
Pilot and Rate Naming Focus Groups	Evaluate names and terms, assess emotional response to the terminology, and generate ideas for revisions.	Focus Groups	~36
Pilot and Rate Naming Survey	Establish final names and terms for use in customer communications.	Survey	500
Message Testing Focus Groups	Establish tone, key attributes, and preferred messaging.	Focus Groups	~50
Imagery Testing Focus Groups	Evaluate imagery to support printed and online marketing materials.	Focus Groups	~70
Customer Satisfaction Survey (Wave 1)	Establish customer satisfaction and expectations baseline.	Survey	761
Demographic Data Survey	Collect customer demographic data.	Survey	4,970
Technology Assessment Survey	Assess customer experience with the IHDs.	Survey	394
Social Media Tracking	Monitor the types of public discussions and the associated tone related to the pilot.	Qualitative Tracking Tool	4
Customer Satisfaction Survey (Wave 2)	Gauge customers' satisfaction after the participants experienced the first summer.	Survey	1,290

6.2.1 Pre-Recruitment Research

Table 9: Residential Customers' General Knowledge Survey Summary

Residential Customers' General Knowledge Survey	
Pre-recruitment research started with an exploratory survey to begin assessing customers' knowledge of the electricity they use and how it is acquired, the rate they pay, general terminology and the impacts of peak consumption. The purpose of the research was to quickly address a broad set of questions to determine where in-depth research might be of value.	
METHODOLOGY	**Research Design:** Cross-sectional survey **Mode:** Online survey with email invitation **Data Collection Period:** March 2, 2011 through March 16, 2011 **Sample Frame**[15]**:** MyAccount online account holders **Sample Unit:** SMUD residential contract accounts (household) **Sample Type:** Simple random sample **Sample Size and Dispositions***:* 3,500 selected, 464 completed questionnaires, 374 emails were undeliverable, 62 incomplete questionnaires omitted
OBJECTIVES	1. Gauge customer knowledge of SMUD's standard pricing structure, the environmental impact of electricity use during peak hours, general pricing concepts, and energy terminology. 2. Learn about interest and motivations for conserving or shifting electricity usage, taking control over the bill, and new pricing plans. 3. Learn what information could encourage customers enroll in SmartPricing Options (Opt-In) or to have them remain on the pilot (Default).
FINDINGS	• Only 20% of respondents felt their summer electricity usage was more than other households. • A majority of respondents accurately stated that SMUD used a tiered pricing plan; however, a majority of customers also believes they are charged different prices based on time of day. • Nearly all respondents recognized that there are times of the day or year when electricity costs more for SMUD to provide to customers. When asked why, over half stated increased demand, and an additional one in ten stated cost of generating or purchasing electricity. • Regarding the environment, a majority of respondents agree significant changes need to be made to protect the environment, feel the energy they use contributes to environmental problems, and stated it is very important that energy they use does not have a long term impact on the environment and has no immediate impact on air quality. • Customers' primary motivation for conserving electricity is to lower their bill and the secondary motivation is environmental. Nearly all respondents stated they make an effort to conserve some or all of the time. • Interestingly, eight in ten respondents felt it is important that customers are offered rates that more closely match the cost of providing electricity at different times of the day, and an equal amount are also interested in joining if SMUD offered a time-variable pricing plan, primarily to is save money. However, when asked about having control over their bills, while nearly all respondents expressed desire to have more control over their monthly bill, only about four in

[15] Unless otherwise noted, sample frames excluded SmartPricing Options sample frame (prior to SmartPricing Options sample selection) or SmartPricing Options sample (once selected).

	ten felt time-variable pricing plans give them that control.
CONCLUSIONS	• More education is needed on pricing structure, electricity usage, and cost to provide electricity. • Customers are not clear on how their rates work and how peak consumption fits into billing. • While customers indicate strong preferences related to environmental stewardship, they clearly identified finances as being the primary motivation in rate selection and conservation. • Help customers see the connection between conserving electricity, saving money and protecting the environment. • Having control over their bill is an important concern for customers, though time-variant pricing as described in this questionnaire doesn't make the customer feel empowered to control their bill. The pricing does make them feel they can save money. More information is needed to understand the disjoint responses. • There is clearly an interest in having time-variant rate options, particularly those that appear to align with the cost of providing service. • Most respondents feel they are average or less than average electricity consumers.

Table 10: General Knowledge Focus Groups Summary

General Knowledge Focus Groups

This research was intended to provide insight into how customers processed very basic information provided about peak consumption and the proposed pricing offers. The findings were intended to inform early marketing concepts and positioning to be presented in subsequent research efforts.

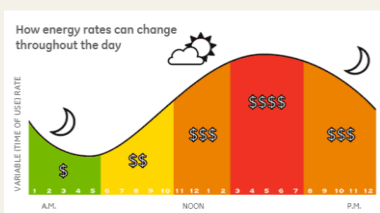
METHODOLOGY

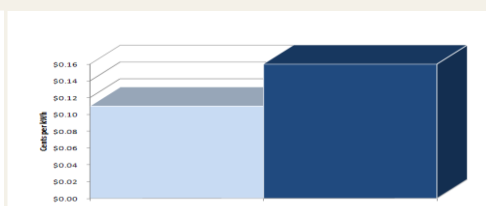
Research Design: Focus groups
Mode: In-person
Data Collection Period: March 14, 2011 through March 15, 2011
Participant Recruitment: SMUD residential customers
Incentive: $65
Number of Groups: Four two-hour groups
Group Description: Up to 10 respondents per group with a mixture of gender, age, education, housing type, and income. The groups were broken out by energy usage:

- Two groups of average energy users
- One group of low energy users
- One group of high energy users.

OBJECTIVES

1. Gauge awareness of current electricity pricing structure and rates
2. Assess reaction to an explanation of how SMUD pays for electricity and how SMUD charges for electricity – higher cost of purchasing during peak hours
3. Assess reaction to SMUD's need to purchase energy that is less clean during peak times
4. Gauge air quality concern due to energy generation from less clean sources
5. Assess reaction to an introduction to the concept of time-based pricing
6. Determine motivating factors for opting-in and concerns about switching to new pricing model





FINDINGS

- Participants are motivated by information presented from their own point of view, not SMUD's.
- The need to conserve energy when demand is high is generally understood by all. They simply need the right incentives and tools.
- Cost is a strong motivation for participants.
- Reactions to time-based pricing are positive when presented as an incentive and a choice.
- Participants generally do not understand how electricity is produced, purchased, stored, or delivered, but are accustomed to reliable energy supply; hence, they do not think availability of electricity is currently a significant problem.
- Most believe SMUD both generates and buys electricity and they don't think non-clean energy is produced in the area. They are concerned about it globally but do not believe there is an impact to them personally.
- When presented with the issue of peak hours and SMUD purchasing extra electricity,

participants saw this as SMUD's problem and increased electricity generation as a solution. Regarding cost and pricing, most customers did not understand how electricity is bought, sold, or stored and were confused about why SMUD's costs fluctuate.

- Regarding "tier" structure, participants are aware but confused on how they are applied. Most participants attempt to reduce energy so they can lower their costs by using CFL's, window coverings, and programmable thermostats.
- Customers would like to see detailed usage data and present on the bill how consumption of different times impacts their cost.
- There is confusion about the real electricity use of appliances and electronics. Participants want to understand what to do to decrease energy usage.
- Participants are driven by how situations impact them personally, which in regards to electricity, is typically the amount on their monthly electricity bill.
- Environmental concerns are important but the direct impact is less evident.
- Time-based pricing was generally seen in a positive light and the next logical step in solving the problems presented. Participants believed they would be rewarded for reducing, but wanted assurance they could switch back and felt it needed to be their choice. Some participants wanted additional information before making the decision to switch. Reducing usage during 4:00 p.m. to 7:00 p.m. in the summer did not seem like a burden to most participants.

CONCLUSIONS

- Focus communications on the customer and their point of view.
- Show customers how demand significantly fluctuates by time of day and season.
- Provide detailed usage data and show personalized usage costs by time of day.
- Position the rate offer as a customer choice with the option to switch back if they desire.
- Explain the opportunity that will be presented by new technology. Show how the future will bring more detailed information about customer's hour-by-hour and day-by-day actual usage. Provide specific information that can help customers respond with actions that impact usage.
- Provide information for customers about energy usage of specific appliances; continue to give tips for decreasing energy used; and show how new technology will assist customers in making informed choices.
- Provide customers with a plethora of information available in multiple places.

Table 11: Headline and Message Survey Summary

Headline and Message Survey	
This research was sponsored to assess responsiveness to various marketing concepts, specifically headline and message combinations. The purpose was to inform the development of the marketing strategy, messaging, and graphical presentation. SMUD sought to select communications that not only appealed to most customers, but also that didn't disengage any particular sub-segment.	
METHODOLOGY	**Research Design:** Cross-sectional survey **Mode:** Online survey with email invitation **Data Collection Period:** April 26, 2011 through May 6, 2011 **Sample Frame:** MyAccount online account holders **Sample Unit:** SMUD residential contract accounts (household) **Sample Type:** Simple random sample **Sample Size and Dispositions***:* 6,000 selected, 536 completed questionnaires, 1497 incomplete questionnaires **Notes:** Respondents were randomly assigned two of the headline/message scenarios to prevent respondent fatigue and order bias.
OBJECTIVES	1. To learn which combinations of headline and message best resonates when providing education on electricity use and energy conservation. 2. To learn what information will motivate load shifting 3. To determine what information customers would like included in the messages. *Examples of the twelve scenarios include:* **Small Changes. Big Potential.** Small changes like unplugging unused appliances, turning off lights and making energy efficient choices add up to save you money and the environment. **Use Smarter. Live Better.** I buy energy efficient appliances and reduce my electricity use from 4:00 p.m. to 7:00 p.m. to lower my impact on the environment while doing things I enjoy. **Live Green. Breathe Easy.** How you use electricity can help keep our local air quality cleaner and healthier for outdoor activities. Reduce your electricity use during peak hours and make energy efficient choices so that we can all breathe easier. **Green Life. Good Life.** Lower your impact on our local environment by reducing your electricity use during peak hours. Boost your efforts by making energy efficient choices and you'll save money, too.
FINDINGS	• Customers want specific information, particularly detailed things they can do to conserve. • They also wanted to know the actual peak times, not just "Peak Hours". • Customers also did not want to have to spend money to reduce electricity usage, like replacing a working refrigerator with a newer efficient one.

	• Customers prefer a relationship between the headline/message that is easy to associate with energy conservation. For example, when looking at a message about living green and breathing easy, some respondents didn't understand the relationship between conserving energy, clean air and healthy air quality. • Customers preferred messages not sound a lecture or a demand. • Messages written in the first person were preferred over messages written in the second person. • Customers preferred messages that emphasized ability to stay comfortable.
CONCLUSIONS	• Provide specific peak hours and details about ways to shift or save electricity. • Highlight low-cost or no-cost measures that are easy for customers to implement. • Messages should have a friendly tone, sound like a suggestion or request, be brief and simple, and help customers easily connect conservation with saving energy and money while helping the environment. • Emphasize comfort. • Make messages relevant to renters as well as owners. • Be cautious not to emphasize the environment to much, this is off-putting to some. • "Little Things. Big Potential." Was selected as the headline for the educational collateral.

Table 12: Headline and Image Survey Summary

Headline and Image Survey	
The survey tested headline and image combinations to determine which captured customer attention and preference. Results would be used in the education campaign and recruitment materials.	
METHODOLOGY	**Research Design:** Cross-sectional survey **Mode:** Online survey with email invitation **Data Collection Period:** April 27, 2011 through May 5, 2011 **Sample Frame:** MyAccount online account holders **Sample Unit:** SMUD residential contract accounts (household) **Sample Type:** Simple random sample **Sample Size and Dispositions:** ~20,000 selected, 778 returned questionnaires (including incompletes), 2,718 emails were undeliverable **Notes:** Tested four headlines with three pictures each, totaling 12 scenarios. To prevent respondent fatigue and order bias, respondents were randomly assigned only two scenarios.
OBJECTIVES	1. To further refine the information we would provide to by determining customer response to various headline and image combinations. 2. Establish desired characteristics and features to include in marketing materials that invoke positive reactions and resonate relative to pilot objectives.
FINDINGS	• Customers prefer ads with themes such as happiness, family, and or had a generally positive image. • Customers wanted an image and headline they could easily relate to SMUD. • It was important that the relationship between the image headline and image be easily identified.
CONCLUSIONS	• None of the ads had a strong appeal to respondents. The highest ranking ads featured families or children engaging in activities based in outdoor activities. • Ultimately, SMUD used feedback from this survey to hire models and produce custom images aimed at meeting customer expectations. The images were family oriented, fun, summer images featuring activities that could occur during peak hours outside the home, such as family BBQs and enjoying sprinklers.

Table 13: Pilot and Rate Naming Focus Groups Summary

Pilot and Rate Naming Focus Groups ***SMUD's creative team developed several potential names for the pilot and each of the rate offers to be tested with customers, as well as key terms that would be used to describe the pilot. The research was aimed at getting feedback on the interpretation of the proposed names and terms, emotional response to the terminology, and idea generation for revisions. The research covered related topics for other pilots as well, such as direct load control and general demand response programs.***	
METHODOLOGY	**Research Design:** Focus groups **Mode:** In-person **Data Collection Period:** June 15, 2011 through June 16, 2011 **Participant Recruitment:** SMUD residential customers **Incentive:** $75 **Number of Groups:** Four two-hour groups **Group Description:** Up to 9 respondents per group with a mix of renters/home owners and gender. The groups were not segmented into homogenous categories.
OBJECTIVES	To understand the interpretation and responses to proposed names and terminology related to: 1. The proposed pricing pilot 2. Each rate offer (TOU, CPP, TOU-CPP) 3. CPP event days 4. Umbrella names for two other future projects (residential direct load control and commercial demand response)[16]
FINDINGS	• Customers preferred names that signify key benefits of customer control over usage and expense. • Saving money by having control over the bill was the primary benefit, and the secondary dealt with the environment. Names that implied this were preferred. The following names best resonated with respondents when compared to others, though were not necessarily preferred and many were accompanied by significant critism: ➢ **Pilot Program**: Powershift Pricing Pilot, PowerOptions Pricing Pilot. ➢ **TOU:** 90/10 Plan, 90/10 Value Plan, 90/10 Power Plan, PowerShift Plan, Time of Use Plan ➢ **CPP:** Critical Peak Pricing Plan, 99/1 Peak Pricing, 99/1 Peak Powershift Plan, 99/1 Peak Vale Plan ➢ **TOU-CPP:** Optimum Value Plan, 90/10 Plus Plan, 90/10+ Peak Plan, 90/10 Value Plus Plan, Time of Use + Peak Plan
CONCLUSIONS	• Avoid words that reduce personal control or that are too general. Emphasis of increased personal control was preferred. • "Event" did not relate to energy usage but rather to celebration or entertainment.

[16] These topics were covered in the research but will not be discussed in this report, as they do not relate to the report objectives

- “Sacramento” excluded those who did not live within Sacramento. Most suggested using “SMUD” instead.
- Avoid using “critical”, which was descriptive, but carries a risk that some participants found the word more intimidating than motivating. It was seen as inflammatory, relating to catastrophe or disaster.
- Words such as “shift” and “auto” were not seen as fitting, and customers felt they related more to car insurance or the auto industry.
- Use caution not to use terms that may be interpreted as a direct load control program.
- Use of the work “peak” provided immediate recognition

Table 14: Pilot and Rate Naming Survey Summary

Pilot and Rate Naming Survey ***Responding directly to customer feedback, the proposed names and terms were refined to be tested in a survey environment. The research was directly aimed at establishing final names and terms for use in customer communications. Typically, names might be selected using a consistent naming convention across all rates; however, it was unclear if SMUD would market more than one offer so unique names were tested to most closely mirror what was expected to occur in an actual deployment.***	
METHODOLOGY	**Research Design:** Cross-sectional survey **Mode:** Telephone **Data Collection Period:** July 2011 **Sample Frame:** SMUD residential customers **Sample Unit:** SMUD residential contract accounts (household) **Sample Type:** Simple random sample **Sample Size and Dispositions***:* 15,000 selected, 500 completed questionnaires
OBJECTIVES	For each name and term: 1. Determine customers' general opinions 2. Measure perceived accuracy (in relation to a description provided) 3. Evaluate ease of understanding 4. Determine likelihood to encourage participation We tested the following names for each category: **Pilot Name:** PowerShift Pricing, EnergyWise Pricing, SmartPricing Options. **TOU:** 90/10 Value Plan, Summer Weekday Value Plan, Summer 90/10 plan, 90/10 Plus Plan. **CPP:** Peak Power Shift Pricing, 99/1 Value Plan, Off-Peak Discount Plan. **TOU-CPP:** 90/10 Plus Plan, Optimum Value Plan, Optimum Off-Peak Pricing Plan.
FINDINGS	Based on highest scores for positive opinion and accuracy, the following names and terms were considered overall best fits: • **Pilot Name:** SmartPricing Options • **TOU:** Summer Weekday Value Plan • **CPP:** Off-Peak Discount • **TOU-CPP:** Optimum Off-Peak Pricing Plan
CONCLUSIONS	For each of the pilot and offers, it was recommended use the names selected as best overall fits from the survey.

Table 15: Message Testing Focus Groups Summary

Message Testing Focus Groups	
Research findings from previous projects were used to shape initial messages for qualitative testing. Feedback from participants was intended to establish preferred tone, determine key attributes to include, discover dissuasive messaging to avoid, and refine the messages before combining with imagery and headlines for testing. Discussion areas addressed pilot background, the rate description, benefits of joining, and participation details.	
METHODOLOGY	**Research Design:** Focus groups **Mode:** In-person **Data Collection Period:** July 26, 2011 through July 27, 2011 **Participant Recruitment:** SMUD residential customers **Incentive:** Cash incentive **Number of Groups:** Five two-hour groups **Group Description:** Up to 10 respondents per group with a demographic mix. Each group saw a specific rate/recruitment combination.
OBJECTIVES	1. Evaluate messaging within the context of the pilot, identifying motivating concepts and terminology 2. Assess comprehension and perceived meaning of the messages 3. Determine how well the messages accurately communicate the benefits of the plan 4. Assess impact messages have on customers' likelihood to participate in the pilot 5. Establish which message components were perceived as positive and which were seen as drawbacks or discouraging
FINDINGS	• **Overall[17]:** Recruitment materials should focus on demonstrating the following attributes: simple (easy to understand), informative and personalized, understanding their energy usage and costs is already difficult enough. • **Simple:** Respondents want information presented to them in a simple manner. Language used should be straightforward and easy to understand, without a lot of marketing jargon. • **Informative:** Respondents had many questions about the plans and want help being educated on all aspects of the plan, their current energy use, and the impact of being enrolled. • **Personalized:** Respondents also want the information to be personalized to their situation. This appears to help them better understand and accept the plan. • **Naming of CPP Days:** While this was not a naming study, participants were asked what they would name the 12 days where the peak hour pricing would be in effect. Suggestions included: 12 Days of Summer, Hot Days, Conservation Days and Energy Savings Days.
CONCLUSIONS	• **Simple:** Be direct in explaining "who, what, when, where, why and how." Explain industry terms clearly (e.g., kWh, Peak Hours). Provide examples to help them understand the possible savings. • **Informative:** Help them understand how and why they were selected for the plan and

[17] The detailed report addressed many specific words, phrases and details that participants had strong positive and negative responses to. Although useful, providing the list in this summary table could be misleading without providing the context in which they were presented to groups.

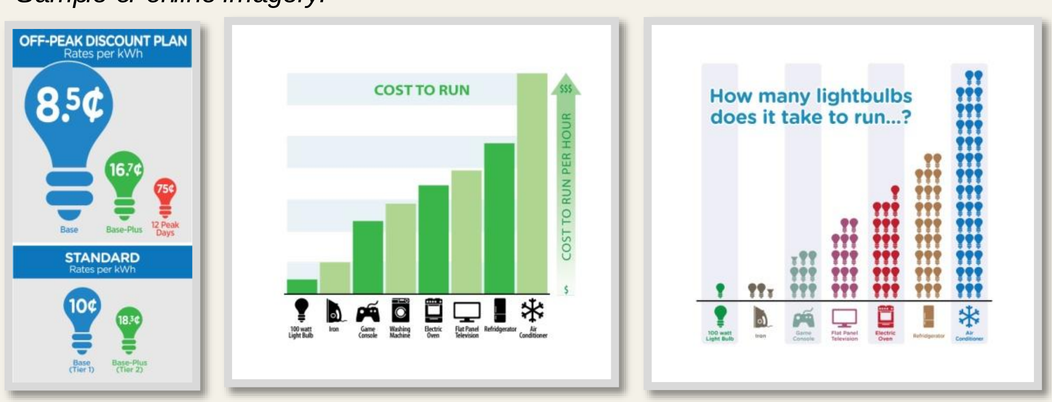
enrollment details. Recruitment materials need to demonstrate the cost/savings benefit to them and to their community at large. Expanding benefits to include community-related benefits may reinforce SMUD as a not-for-profit, community owned utility. Participants respond very positively to benefits that help them understand and improve their energy usage behavior. The countertop energy display and online use graph were seen as something that could be used year-round to monitor and improve energy usage behavior.

- **Personalized:** In examples, show their own current usage/ plan compared with new plan. Clearly spell out benefits using real-life scenarios and relevant examples of how they can shift their behavior.
- **Other Considerations:** Consider developing and testing messaging that explains the supply and demand aspect of the plan, such as further messaging on how their savings (even small) can benefit the community and environment may also serve to bolster interest in the plan. Consider testing messaging that appeals to the 'higher goal and good' of the plan for the community and the environment, which may help to bolster interest in lieu of significant monetary savings

Table 16: Imagery Testing Focus Groups Summary

Imagery Testing Focus Groups	
This research sought to evaluate potential imagery to support printed and online marketing materials.	
METHODOLOGY	**Research Design:** Focus groups **Mode:** In-person **Data Collection Period:** August 9, 2011 through August 11, 2011 **Participant Recruitment:** SMUD residential customers **Incentive:** Cash incentive **Number of Groups:** Seven two-hour groups. Five of the groups tested eight images for the printed marketing materials and two of the focus groups tested 15 images directed at online communications designed to educate on specific aspects of the pilot. **Group Description:** Up to 10 respondents per group with demographic mix. **Other:** For all groups, participants reviewed and responded to different print images within the same SmartPricing Options context. Each image, including the program background information was labeled with a Handout Letter for tracking and reference. Participants provided individual written feedback for each image prior to beginning the group discussion. *Sample of print imagery:*

Sample of online imagery:



OBJECTIVES	1. Evaluate potential imagery for printed and online marketing materials and establish which characteristics will likely yield best overall imagery. 2. Investigate initial impressions, emotional responses, perceived contextual appropriateness, motivational responses, and perceived brand consistency for each image.
FINDINGS	• Participants' current impressions of SMUD (positive or negative) greatly impact subsequent response to imagery and information about proposed new rate plans. • All participants were motivated by the possibility of saving money in the opt-in materials. For many, the message of cumulative small savings for a greater good resonated. • When reviewing default materials, those with a negative impression of SMUD are most likely to complain about perceived billing increases. Those who currently conserve during peak or already have low bills may be disappointed with small savings; and billing increases may negatively impact their perceptions of SMUD. • Participants felt that, in order to realize any real savings, they would have to endure hardships in the form of no air conditioning at all during the peak periods. • Images with a sense of realism (real places, people and situations) were favored. • Images that drew the most attention were considered motivating, fit best with program concept, and contained attributes relevant on two levels: on the ability to relate to the imagery on a personal level and on the ability to identify the imagery with the concept of saving energy. a. Learning to ride a bike and/or helping a child to learn b. Energy efficiency light bulb • Outdoor settings seem to be the best fit, particularly local, public or residential images. • Energy-relevant images (e.g. energy efficient bulbs, trees) fit the program concept as well as impressions of SMUD,. • Images related to incentives (e.g., discounts to water parks) were not as motivating. • Colors added a degree of relevancy to the image. a. Bright, vibrant colors attracted the most attention b. Green was associated with energy c. Yellow attracted attention d. Red was seen as depicting danger e. Blues were seen as calming, but not necessarily eye-attracting f. Pink seemed to have a polarizing effect • Many customers mentioned their lack of knowledge about where energy comes from, how it is priced, and the impact they can have as an individual.
CONCLUSIONS	• Use outdoor, non-business images. If using indoor settings, use images demonstrating what behaviors in the home can lead to savings. • Use local settings and typical backgrounds. • Use facial expressions that are genuine and realistic. • Evaluate age-readiness of children to engage in the activities that are depicted. • Consider how an image may give the wrong impression of the message, such as featuring a children's soccer team may look like SMUD is sponsoring a youth sport. • Focus on images of things customers can do to help conserve energy during peak hours. • Help customers better understand the big picture of energy use and how their individual, small changes, can add up to big differences. • Convey that the plans do not force customers to endure hardships or be gouged by the rates.

	• Take care with body language and staging to not create visual distractions. • Images with children were seen as best fitting with “Little Things. Big Potential.” Showing assistance from an adult strengthened the fit. • Online images can leverage mouse-over technology to provide details. The more information provided as context for the image, the more positive their reaction.

6.2.2 Post-Recruitment Research

Table 17: Customer Satisfaction and Expectations Survey (Wave 1) Summary

Customer Satisfaction Survey (Wave 1) ***After customers were recruited, we conducted a customer satisfaction survey with customers on SmartPricing Options and deferred customers. We conducted this research to determine a baseline of customer satisfaction and expectations before customers experience Conservation Days or see the impact on their bill.***	
METHODOLOGY	**Research Design:** Successive independent sample survey **Mode:** Telephone **Data Collection Period:** June 4, 2012 through June 16, 2012 **Sample Frame:** SmartPricing Options treatment groups and deferred control groups **Sample Unit:** SMUD residential contract accounts (household) **Sample Type:** Simple random sample **Sample Size and Dispositions***:* 11,000 selected, 761 completed questionnaires
OBJECTIVES	To establish a baseline of customer satisfaction and expectations, specifically: 1. Motivation for enrollment 2. Expectations for the pilot 3. Customer satisfaction with SMUD and SmartPricing Options 4. Assessment of SmartPricing Options attributes
FINDINGS	• **Motivation:** For opt-in customers, financial benefits were the strongest motivator. Using less energy was also a common response. Default customers included financial benefits, environmental benefits, using less energy, and being unaware that they could drop from the rate as being primary reasons for participation. • **Expectations:** The financial benefit was the most cited expectation with participating, though all attitudes had similar levels of agreement within recruitment type, with default customers' agreement trailing by 12%-18%. Agreement with other expectations included: control over the bill, using less energy which is vital for the future, learning how to conserve, and doing something good for the environment. Customer who received the IHD offer appear to have higher expectations to reduce energy use overall. • **Satisfaction:** Overall satisfaction with SMUD was 94% and with SmartPricing Options was 78%, with opt-ins having higher satisfaction rates in both. Participants who understand the program goals are more satisfied with SMUD as a whole, with each attribute of SmartPricing Options and three times as likely to be very satisfied with the SmartPricing Options pilot. Deferred customers' satisfaction is consistent with their enrolled cohorts. • **Attributes:** Opt-in customers have a higher level of program understanding and are more likely to agree with positive emotional statements about the pilot, while default customers responses were muted rather than oppositional. About one third agreed with the rate comprehension statement for both opt-in and default customer. Opt-In groups are most likely to indicate the benefits of SmartPricing Options directly apply to them, while default groups indicate the benefits are for the greater good. Across every cell in the study, roughly half

		prefer an email and another third prefer regular mail as the preferred communication channel, with preference for text and Facebook being negligible.
CONCLUSIONS	•	Satisfaction doesn't vary by rate or the presence of the IHD offer.
	•	Understanding the program goals appears to be the biggest factors in satisfaction.
	•	Preferred communication channel is not a function of the type of information being shared.
	•	Better understanding of the rate could have an impact on enrollment; however emotional responses to the offer are also key motivations for participation.
	•	Satisfaction scores may potentially be increased by determining what information customers feel they need to better understand the program and providing it through the channels they are most likely to respond to, which may or may not be their stated preferred channels.
	•	Marketing materials should clearly state program goals and objectives, provide additional education on reducing electricity use and lowering bill, and show the impact of reduced energy use by program participants on the overall community.

Table 18: Demographic Data Survey Summary

Demographic Data Survey ***The purpose of the research was to collect customer demographic data to be utilized for the SmartPricing Options load impact evaluation and provided to the TAG for inclusion in the meta analysis.***	
METHODOLOGY	**Research Design:** Cross-sectional survey **Mode:** Mail **Data Collection Period:** Mid-June 2012, through early July, 2012 **Sample Frame:** SmartPricing Options sample (treatments and controls) **Sample Unit:** SMUD residential contract accounts (household) **Sample Type:** Mixed methodologies: Census of participants and random samples of non-participants in the treatment groups and of the RED control group **Sample Size and Dispositions***:* 16,828 selected, 4,970 completed questionnaires, 1,493 incomplete questionnaires **Notes:** Questions and methodology were determined by the TAG to enable analysis across utilities. This entailed a pre-notification letter followed by the questionnaire delivery, a sweepstakes entry form, a reminder postcard, and a final questionnaire to non-respondents. The questionnaire was provided in English and Spanish.
OBJECTIVES	1. To collect customer demographic data to be utilized for the SmartPricing Options load impact evaluation and provided to the TAG for inclusion in the meta analysis.
FINDINGS	• An independent analysis of the demographic data collected was not performed. The data were incorporated into the load impact analysis data set and analysis was performed in that environment. See *SECTION III, INTERIM LOAD IMPACT EVALUATION* for findings.
CONCLUSIONS	• See *SECTION III, INTERIM LOAD IMPACT EVALUATION.*

Table 19: Technology Assessment Survey Summary

Technology Assessment Survey	
A component of the SmartPricing Options study was the IHD, where customers could see the current cost per kilowatt, total and cumulative kilowatts, total and cumulative cost, peak and off-peak indicators, Conservation Day reminders, and energy tips. We conducted the research to assess customer experience with the IHDs.	
METHODOLOGY	**Research Design:** Cross-sectional survey **Mode:** Mixed mode - Online survey with email invitation and telephone **Data Collection Period:** November 2012 to December 2012. **Sample Frame:** SmartPricing Options participants who received an IHD **Sample Unit:** SMUD residential contract accounts (household) **Sample Type:** Census of participants who received an IHD that had at one time joined with the meter, and random sample of participants who received an IHD that never joined with the meter[18] **Sample Size and Dispositions**: 2,400 selected, 394 completed questionnaires (194 online, 200 telephone)
OBJECTIVES	1. To assess customer response to the working technology by obtaining feedback specific to the devices we understood to have been working at one time. 2. Measure general satisfaction with the IHD, SmartPricing Options and SMUD; preference for various features and attributes; and reports on how the IHD was used.
FINDINGS	• Of those surveyed, 88% used the IHD, and 12% tried to use the IHD but could not. The most common reason for not using the IHD was a connectivity issue. • Overall satisfaction with the display is 81%, and those satisfied with the SmartPricing Options pilot are more likely to be very satisfied with the IHD. Also those satisfied with the IHD are more likely to be satisfied with both SmartPricing Options (81%) and SMUD (94%). • No difference in satisfaction with Display based on whether it is easy to use, whether they have changed their behavior or whether they have noticed smaller bills • The IHD was most likely kept in the same place (kitchen), plugged in and set to “Current use – cost per kWh” screen. Those who are satisfied with the IHD are more likely to keep it plugged in and in the same place. • What customers liked most about the IHD was they were aware of their usage (44%), followed by seeing the cost (28%). • What customers liked least was connectivity issues/resetting (32%) or that the device didn’t work/was hard to use (30%). This difference was driven by age with those under 30 significantly more likely to mention “aware of usage” and those 30-49 to mention “see the cost” • A majority of customers feel the IHD is compact and unobtrusive (72%), is a helpful tool (67%), and has an easy to read screen (63%). Most customers agreed the IHD helped them to remember peak hours and rates. 84% of customers would recommend the IHD to a friend.

[18] In the original design, only participants who had a joining IHD were in the sample frame. In the final stage of design, participants who had an IHD that never joined the meter were added. They were screened out early in the questionnaire and the major findings represent those with joining IHDs.

CONCLUSIONS	• Ensuring that SMUD customers have a positive experience with the Electricity Use Display is important for reasons beyond the obvious…those satisfied with the Electricity Use Display (very or somewhat) are more likely to be very satisfied with the Pilot and with SMUD. • The Electricity Use Display seems to act as a "string around your finger" – a reminder to be aware of your choices and your usage. • Open-ended comments related to the additional information customers would like the IHD to share suggest they may not be aware of the full functionality of the display. • Respondents requested the following features (some of which exist in the display used for the pilot) a. Current bill total b. Reset on every new billing cycle c. Running total of usage d. Average/weekly average/monthly average e. History of past cycles f. Reminders/alerts • The opportunity may exist for additional education on "How to get the most from your Electricity Use Display."

Table 20: Social Media Tracking Summary

Social Media Tracking	
With the increased use and availability of social media, we included tracking of social media chatter related to SmartPricing Options in our research portfolio to monitor the types of discussions and the associated tone related to the pilot.	
METHODOLOGY	**Research Design:** Qualitative observations of online social media interactions **Mode:** Automated online social media tracking **Data Collection Period:** March 2012 to March 2013 **Number of Observations:** Four (4) **Other:** We utilized Lithum, a social media crawling tool that locates any public discussions regarding specific topics. Lithium searches the general web and as well as public groups on Facebook, Twitter, Flickr, message boards, and forums, providing the actual content found. In addition to providing the content, Lithium classifies the sentiment as negative or positive.
OBJECTIVES	1. The primary objective was to detect any new information about the pilot, rates, and IHDs that may not come through our standard channels. This was achieved by examining discussions, comments, articles, and images that occurred related to SmartPricing Options.
FINDINGS	• Findings were very limited. There was very little discussion regarding SmartPricing Options from the pilot's initial recruitment through the first summer in the public online space. In general, comments were positive. The majority of the comments, less than half a dozen, were either general curiosity or questions regarding the program or the IHD. There were also three articles discussing the SmartPricing Options project on various smart grid related websites.
CONCLUSIONS	• No significantly positive or negative discussions were occurring in public, online web pages. Due to such little detected activity on the topic, tracking was discontinued.

Table 21: Customer Satisfaction Survey (Wave 2) Summary

Customer Satisfaction Survey (Wave 2) ***As a follow up to the first wave of customer satisfaction, we conducted a second wave to gauge customers' satisfaction after the participants experienced a summer with SmartPricing Options. In the first wave, we surveyed deferred customers, but in this round they were excluded and we only surveyed participants.***	
METHODOLOGY	**Research Design:** Successive independent sample survey **Mode:** Mixed mode – mail and telephone **Data Collection Period:** Telephone - October 10, 2012 through October 25, 2012. Mail - November 21, 2012 through December 5, 2012. **Sample Frame:** SmartPricing Options participants (excluding deferred customers) **Sample Unit:** SMUD residential contract accounts (household) **Sample Type:** Census of participants **Sample Size and Dispositions**: 8,362 selected, 1,290 completed questionnaires (626 telephone, 664 mail)
OBJECTIVES	1. Measure customer satisfaction with SMUD and SmartPricing Options 2. Compare customer satisfaction levels to Wave I and customer experience versus expectations 3. Determine if customers had any behavior changes as a result of SmartPricing Options.
FINDINGS	• Findings consisted of an increase of very satisfied with SmartPricing Options from Wave I to Wave II, but no change in total combined satisfaction (79%). Combined dissatisfaction (14%) for opt-ins also increased. Consistent with Wave I, understanding the program goals was a key to customer satisfaction with SmartPricing Options and SMUD. • Over three quarters of those who responded stated their actual participation compared to their expectation was the same or better than expected, while 15% of opt-in and 9% of default customers felt it was worse than expected. • Customers who answered that their experience was worse than the previous summer also answered that it was mostly due to not saving any money. In previous research, saving money was identified as the primary motivator. • About three quarters of those who responded felt they did something good for the environment, which in previous research was identified as the secondary motivator. • Three quarters understood their new pricing structure compared to their old pricing structure about the same or better. • Regarding energy saving tips, most strongly agree they are glad they opted in to receive them and want to continue to do so. The most frequently reported behavior change since enrolling in SmartPricing Options was to avoid washing and drying clothes during peak, closely followed by avoiding the dishwasher and changing the thermostat. • The most frequent response regarding improvements needed with Conservation Day notifications was "No improvement necessary/like how it is now." Nearly nine in ten agree that 24 hours is adequate notice to make necessary changes. • There was a 5% increase in those satisfied with their new price for electricity from Wave I to

		Wave II. When asked what to identify program goals, the most frequent answer was “conservation/peak hours/usage.” The Welcome Packet was identified as the most useful materials of those included in the question. • Customers who feel they understand the pilot pricing structure better than their old pricing structure have the highest level of satisfaction of any group.
CONCLUSIONS		• The opportunity for SmartPricing Options is in communication – customers mentioned this most often as a way that SMUD could help them feel more informed about the pilot and its goals. • Emphasize pilot goals, because feeling they understand the goals is correlated with customer satisfaction in the pilot and SMUD. • Continue with IHD and energy tips, because they are valued by those who elect to receive them.

6.3 Quality Assurance

6.3.1 Research Design

In general, the market research team followed the steps below for quality assurance in research design, which mirrored the process used for the overall pilot design.

1. Identify stakeholders.
    a. Identify who will be conducting the research, preparing the supporting materials, and using the deliverables.
    b. Get your decision makers, project leads, and lead analysts together for initial planning meeting.
    c. Get commitment for resources at the leadership level before you begin, so pooling data and contributing to the project becomes an expectation.
2. Assemble the key stakeholders and define your objectives together.
    a. Planning is the most critical step. Poorly defined objectives tend to result in more questions and more costs rather than the answers needed.
    b. Get alignment on the objectives before beginning.
3. Clearly define data collection and output needs.
    a. Determine how the data need to be collected and what the output needs to look like. Once data are collected a certain way, it can often be impossible to tease out what you are looking for if it wasn't defined in the beginning
    b. Determine what actions you will need to take as a result of the research. Ensure every question in the research instrument maps back to a research objective and that the types of responses will result in actionable results. The pretest is a good early indicator of this.
4. Plan a detailed budget and schedule based on historical information. When possible, allow time in the schedule to conduct unplanned analysis that may result from the primary analysis.
5. Identify what resources can be pooled together.

a. Data are often stored and managed in separate databases

   i. Load research and pricing have specific types of data files

   ii. Market research may have their own records and database

   iii. Contact center, billing, marketing, and technical support teams have their own logs and metrics

   iv. Contracts for third party contractors, vendors and partners may be managed by many different employees spread throughout the organization

b. Pooling data means pooling resources

   i. Plan an analysis project as you would any other project

   ii. Identify team members and pool resources to minimize the impact across the organization while providing benefit to everyone providing information

   iii. Use contract negotiations with outside contractors/partners to obtain customer level data that they collect as part of the agreement

6. Keep stakeholders informed

   a. Conduct previews and pretests, share the results with stakeholders.

   b. Show stakeholders what the output is likely to look like.

   c. Get early feedback.

6.3.2 Mailing List Quality Control Process

Market Research produces the mailing lists used for all SmartPricing Options communications that utilize direct mail. The researcher constructs mailing lists generated from the SAP Active Residential Customers file (ActiveRes). Once a mailing list is produced from ActiveRes, it is checked against the SmartPricing Options active enrollment and drop lists to confirm the correct customers are on the list. This final list will be sent to the project manager to perform a quality check. The project manager will use the latest SMUD demography file (a commonly used file containing SMUD customer data), SmartPricing Options enrollment reports, and the original SmartPricing Options sample to ensure that the list is accurate and up-to-date.

6.3.3 Managing Contractors

As part of the quality assurance process, it is important to conduct due diligence on the work of contractors to ensure that all work is logical and meets the highest standards. For each research project, a group of subject matter experts reviewed materials and results for logic and accuracy. Internal staff review can result in discoveries that may otherwise be overlooked. Internal professional research staff collaborates with research contractors on all components of the research design, tools, and implementation. Any results that appear unintuitive or are not easily explained are investigated. Tasks can range from careful review of the research findings by a core team to reviewing all disposition reports, raw survey data and analytical code.

6.4 Lessons Learned and Key Takeaways

The greatest motivator for customers is the financial aspect. Helping, protecting, saving the environment is a secondary motivator that, by itself, is often not enough to convince customers to reduce electricity use or enroll in SmartPricing Options. Customers who understand the pilot goals have a tendency to have a higher satisfaction with SmartPricing Options and SMUD.

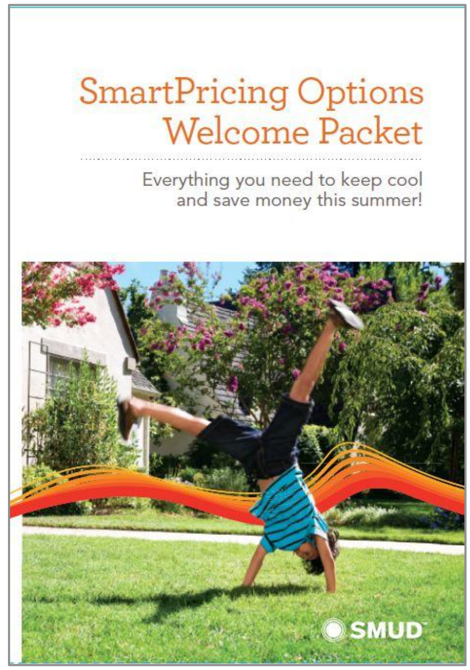
The initial messages we tested focusing on peak hours and the actions customers would need to take to conserve electricity. Once we shifted the messaging to focus on the benefits of SmartPricing Options (e.g., saving on the bill), customer response was more positive.

In the initial phases of this pilot, we were conducting research and developing marketing collateral often at the same time. For future projects, we recommend allowing more time for research activities.

SECTION II: PROJECT IMPLEMENTATION

7.0 Marketing

7.1 Overview



The SmartPricing Options team planned aggressive recruitment targets over a short period of time. Recruitment strategies and marketing collateral were developed by directly responding to customer feedback collected from about 2,500 customers through four surveys and 20 focus groups over a six month period. The primary objective of the marketing strategy was to provide adequate information in the recruitment materials for customers to make an educated decision to enroll in the pilot and to assist in successful energy savings. The recruitment materials included details about the pilot, information about their pricing plan and technology offer, the benefits of reducing energy use during summer peak hours, and tips on how to save.

7.2 Details

SMUD's marketing strategy included education, recruitment, and retention components and leveraged multiple channels of communication with the customer. The campaigns focused on four specific messages that highlighted the benefits of participating in a SmartPricing Options Plan.

1. Get a discount on your electricity during off-peak hours.
2. Take control of your summer electricity costs.
3. Manage your energy use.
4. Contribute to a cleaner environment.

We developed our materials and messaging using our findings from the early market research efforts. This research indicated that customers preferred images and content that were local and reflected real-life, residential activities. The marketing strategy included several dedicated photo shoots to capture the intention and feeling of SmartPricing Options. The resulting photographs showed local families engaging in summertime activities, including family barbeques, children playing in the sprinklers, and families relaxing outside. The photos also demonstrated energy-saving actions such as installing weather stripping, CFLs and using smart strips.

By integrating messaging and images that reflected customer preferences, the SmartPricing Options marketing campaign captured the neighborly, budget-conscious, energy-aware, and environmentally-friendly tone that we wanted for the pilot. All of the marketing materials had a consistent look and feel, which align with SMUD's overall brand.

Table 22 below provides the communication channel schedule, including a summary of the target audience and objectives for each channel. SMUD's marketing team was aware that some channels were likely to be more effective than others; however, the team felt that it was important to optimize communications by providing access to information through a variety of channels spanning customers' personal preferences.

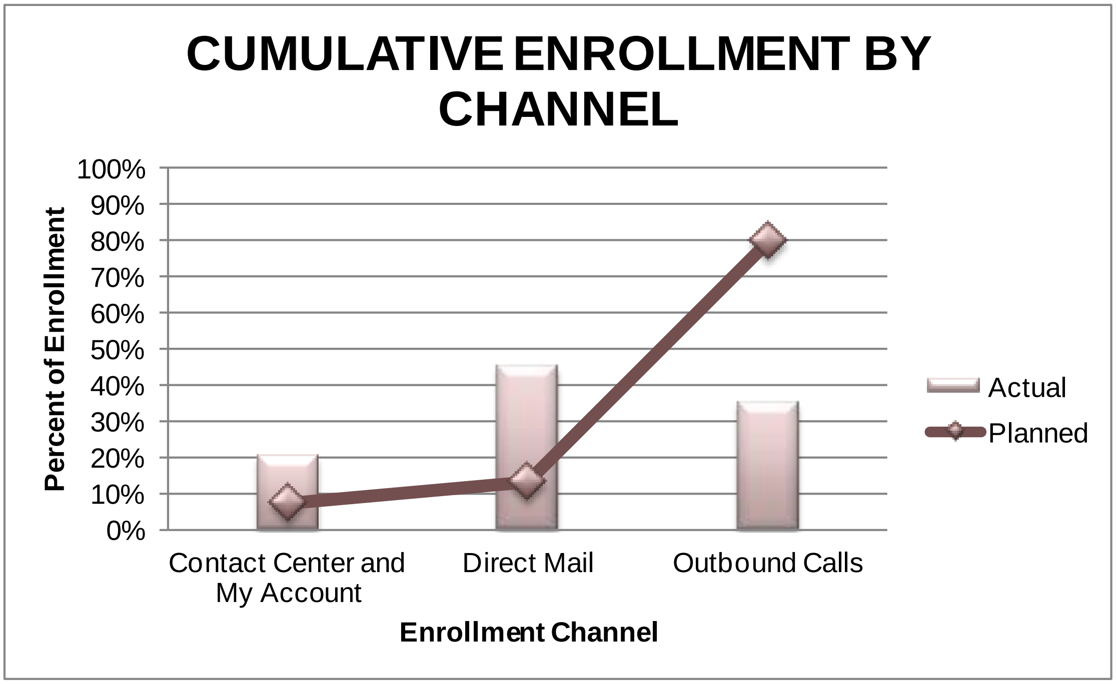
Table 22: Schedule of Marketing Activities by Channel

Channel	Start Date	End Date	Target Audience	Objectives
Mass Media	Jun-11	Sep-11	All residential customers	Education
Direct Mail	Oct-11	Oct-13	All eligible customers	Recruitment, Education, Retention
Email[19]	Mar-12	Oct-13	Opt-in and Default customers	Education, Retention
Outbound Calling	Apr-12	May-12	Eligible opt-in customers	Recruitment
Door Hangers	Mar-12	Apr-12	Eligible opt-in customers	Recruitment
Microsites	Oct-12	Oct-13	All eligible customers	Education, Retention
Facebook Groups	Jul-12	Oct-13	All enrolled participants	Education, Retention
Pinterest	Jul-12	Oct-13	All enrolled participants	Education, Retention
YouTube	Jul-12	Oct-13	All enrolled participants	Education, Retention

Figure 20 depicts the percent of enrollments that came through each channel compared to how recruitment distribution was originally planned. While the actual distribution differs significantly from the planned distribution, total enrollment goals were achieved on schedule. The order in which the channels were used varied from the initial plan, which likely impacted the distribution.

[19] Only enrolled customers with an email address on file received email communication. Email messages were consistent with the direct mail messages. The email notifications did not replace direct mail, rather they were sent in addition to direct mail.

Figure 20: Graph of Cumulative Enrollment by Channels



The subsections that follow describe the types of channels that we used to communicate with our customers during the recruitment and first implementation year of the pilot. Each subsection describes the objectives of using that channel, a description of how the channel was used, the implementation of the plan, and the outcome.

7.2.1 Mass Media Marketing

Objectives: Education and Recruitment

Description: The marketing strategy included two mass media campaigns; one that was launched prior to recruitment to increase awareness of peak energy use, and the second focusing on recruitment of eligible customers onto the pilot.

The marketing messages fell under the headline that was the front runner from our research: **Little Things. Big Potential.** The content was based on research findings that showed cost as the main driver for reducing use during peak, accompanied by messages related to convenience and comfort. Protecting the environment was also valued but not the primary motivator. Research also showed that customers want messages that provide specific actions, such as what to do and when to do it, rather than general messages about using less or an unspecific reference to peak time.

Below are examples of the types of messages used in SmartPricing Options marketing collateral.

- **Your parents were right.** Turn off the lights when you leave a room. Unplug unused appliances, too.
- **Beat the heat.** Caulking, weather stripping and FREE shade trees from SMUD help keep heat outside during the summertime.
- **Keep the heat out.** Keep curtains and blinds closed on windows that get direct sun.
- **Reduce your use.** Set your thermostat a few degrees higher from 4:00 p.m. to 7:00 p.m.
- **Give your oven a break**. Put your grill to work and enjoy dinner outside with friends and family.
- **Night time is the right time.** Do your laundry and run the dishwasher after 7:00 pm during the week.

Implementation: In 2011, the pre-recruitment education campaign directed customers to visit SMUD's website, **savewithsmud.org**, to learn about what they could do to save money, energy, and the environment. In January 2012, we launched a mass media recruitment campaign to encourage customers to log in to My Account and see if their home was selected to participate in SmartPricing Options.

The mass media channel was designed to encourage participation in the SmartPricing Options pilot. The campaign included print and web ads in the communities that were within the sample frame:

- Downtown/Curtis Park/Land Park
- Elk Grove
- Galt
- Natomas /North Sacramento
- Orangevale
- Rancho Cordova
- South Sacramento/Pocket area
- Folsom

Mass media channels included:

- Web advertisements
- Print advertisements in local publications

- Content keywords which showed our web ads when customers read content related to our project. Keyword examples include: electricity costs, save on energy, and electric rates.
- A landing page: **smud.org/smartpricing.** All ads drove customers to this page which had overview information on SmartPricing Options and invited them to login to My Account to see if their home was randomly selected to participate in this pilot.

Results and Lessons Learned:

For both mass media campaigns, SMUD's web ads delivered nicely. The click through rate (CTR) was at industry average (.6%) and the number of impressions delivered was higher than expected. As an example, although SMUD had planned for 800,000 impressions for a particular campaign that consisted of four ads of various sizes and slightly different looks, the total impressions delivered was over 2 million. This campaign was the third largest driver of traffic to savewithsmud.org during this time period (July 1, 2011 to August 31, 2011).

7.2.2 Direct Mail Marketing

Objectives: Recruitment and Retention

Description: Direct mail was an important component of our marketing strategy. SMUD customers are accustomed to receiving offers and information through the mail, and it has proven successful in marketing our traditional programs and services.

For the opt-in treatment groups, customers received the following direct mail pieces.

- A letter detailing the offer, color brochure, and business reply card
- Follow-up postcard mailed two weeks after packet
- Enrollment confirmation or notice of deferral letters
- Welcome Kit

For the default treatment groups, customers received the following direct mail pieces.

- A letter informing customers of their enrollment in the new rate plan, color brochure, and business reply card to receive the technology offer

- Follow-up postcard mailed two weeks after packet
- Welcome Kit

Implementation: Over seven months, from November 2011 through May 2012, we sent a total of three direct mail packets to opt-in treatment groups that included a letter, a brochure and business reply card. The envelope containing the packet read: *Take control of your summer energy bills.* This packet was followed by a direct mail reminder postcard about two weeks later. Opt-in customers were encouraged to enroll through one of several different channels: the enclosed business reply card, online through the My Account portal, or by calling in and enrolling with a CSR.

The letters were in English and Spanish. The brochures were available in Spanish upon request. Versions of the brochures specific to our SmartPricing Options Energy Assistance Program Rate (EAPR) were mailed to EAPR customers in lieu of the standard rate brochure.

Recruitment efforts began with a “soft launch” of the first direct mail packet to 10,000 customers to test our systems and processes. We waited approximately two weeks after the soft launch before we completed the full launch to 42,000 customers. On the day the 42,000 letters went out in the mail, we received some customer complaints from customers in the RCT deferred treatment groups who had received the notice that they were eligible in 2014. These customers felt that the language used in the enrollment process that informed them of their deferral did not properly set expectations for a delayed enrollment until 2014. We quickly revised the language on our website, direct mail, and with our CSRs to inform customers that half of the customers selected to participate were eligible in 2014, and the other half was eligible in 2012 prior to making a decision to join. This helped to set expectations from the onset and alleviated dissatisfaction related to deferral, which was later confirmed by market research.

In 2012, we sent the last two direct mail packets to our opt-in groups to encourage them to sign up. With the exception of the language in the letter, the packets were identical to the first round of direct mail. The default customer groups received the same packets of information, a brochure, a letter explaining their new rate plan, and a business reply card for the free IHD. The customers in the default group did not have to take any action with the provided material in order to be one the rate.

Customers who enrolled in the pilot received welcome kits. Our research results indicated that customers don't want to be simply told to reduce their electricity use but want to be provided with clear, accessible examples and instructions. This robust informational packet included more details on the plan, a set of recipe cards with a Quick Response (QR) code that linked to cooking videos on SMUD's YouTube channel (both the recipes and videos were developed specifically for SmartPricing Options), a discount card to use at local businesses during peak hours, a washer/dryer magnet that reminded customers not to do laundry during peak hours, and a refrigerator cling with energy saving tips. The art on the envelope was also engaging, using the phrase "Welcome to SmartPricing Options!" to capture attention and encourage engagement.

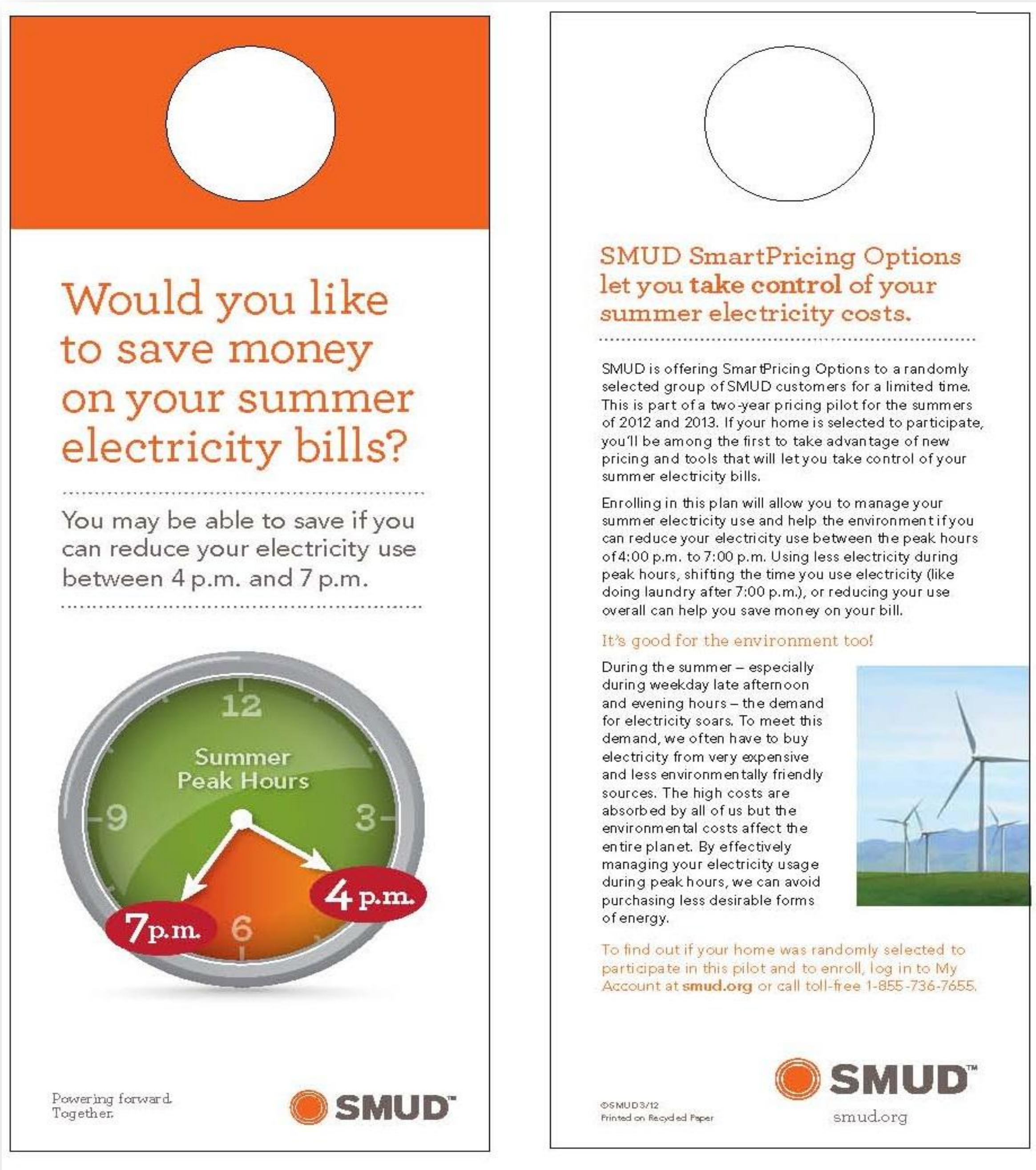
Findings and Lessons Learned:

The business reply cards were our most used recruitment channel, with more than 45% of customers enrolling with the direct mail business reply cards. The difference between our enrollment rate and our planned 7-10% enrollment rate from this channel could be attributed to several factors. For one, SMUD customers are accustomed to using business reply cards, which are commonly used in programming marketing efforts. Also, the business reply card could be simply filled out and dropped in the mail, while calling a CSR or enrolling online required a more involved transaction. The phone recruitment efforts were implemented in the final stage of recruitment, so comparing this channel to the others wouldn't be appropriate in terms of success rates.

7.2.3 Door Hanger Marketing

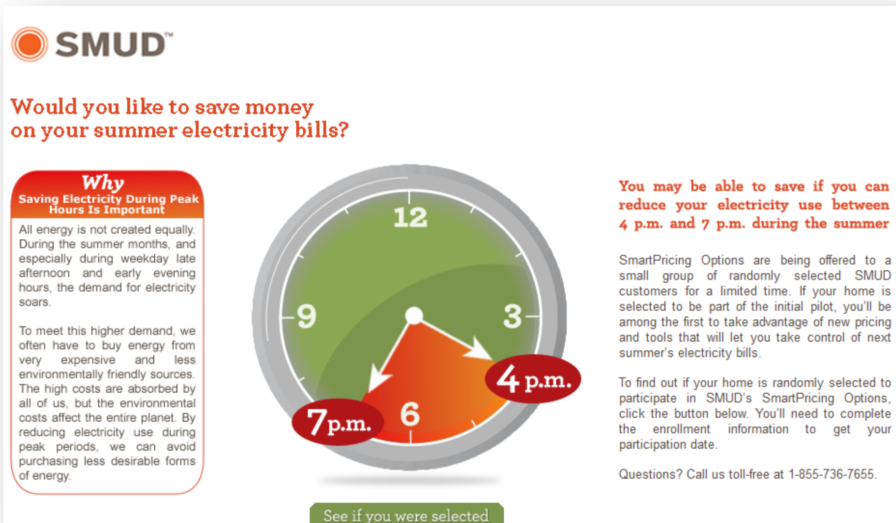
Objective: Recruitment

Description: The door hanger campaign featured a 6" x11" cardstock door hanger that was delivered to eligible customer's homes in April, 2012. The door hanger supported the previous direct mail, print and web ads recruitment efforts. The objective of the door hanger campaign was to drive eligible customers to the SmartPricing Options landing page.



Implementation: Approximately 45,000 door hangers were placed on both single family and multi-family homes of customers in the sample. Neighborhoods were not blanketed with door hangers. Instead, these customers were all in our eligibility pool and had not yet enrolled.

The door hangers directed customers to **smud.org/smartpricing**, a landing page that had overview information on SmartPricing Options, and invited them to log in to My Account to see if their home was randomly selected to participate in this pilot.



We partnered with a contractor to distribute the door hangers. As with all of our marketing efforts, we notified our Contact Center about this campaign, including the attire that the carriers would wear, in case there were any calls from customers questioning the validity of this effort. If customers asked the carriers questions about the pilot, they directed them to **smud.org/smartpricing** for more information.

Findings and Lessons Learned: The impacts from this channel were not identifiable and likely enhanced the customer enrollments from the other channels, such as outbound calling and direct mail. This channel was not considered particularly successful in terms of impacting enrollment, and implementation was costly and complicated since distribution was at the household level rather than the more typical implementation at a larger geographic area.

7.2.4 Outbound Customer Service Notifications

Objectives: Recruitment and Education

Description: We hired an experienced firm to place outbound phone calls to residential customers to inform customers of the SmartPricing Options Pilot and offer the option to enroll. Maintaining a good relationship with our customers is important to us, so we were careful to design a campaign that was intended to benefit customers and avoid creating a sense of intrusion by the call. Rather than implementing a typical telemarketing campaign, SMUD decided to use phone calls with live representatives that were intended to inform customers of their options. For the customers' convenience, they could sign up for the program over the phone, but the contractor was under clear direction not to pressure customers.

Implementation: We contracted with a call center contractor to conduct an outbound calling campaign for the opt-in treatment groups. The main purpose of this telephone outreach was to educate customers and to offer enrollment options. Customers had the opportunity to sign up during the call, ask questions, or decline. A soft launch to gauge the customer response was conducted on April 4, 2012, which received positive feedback.

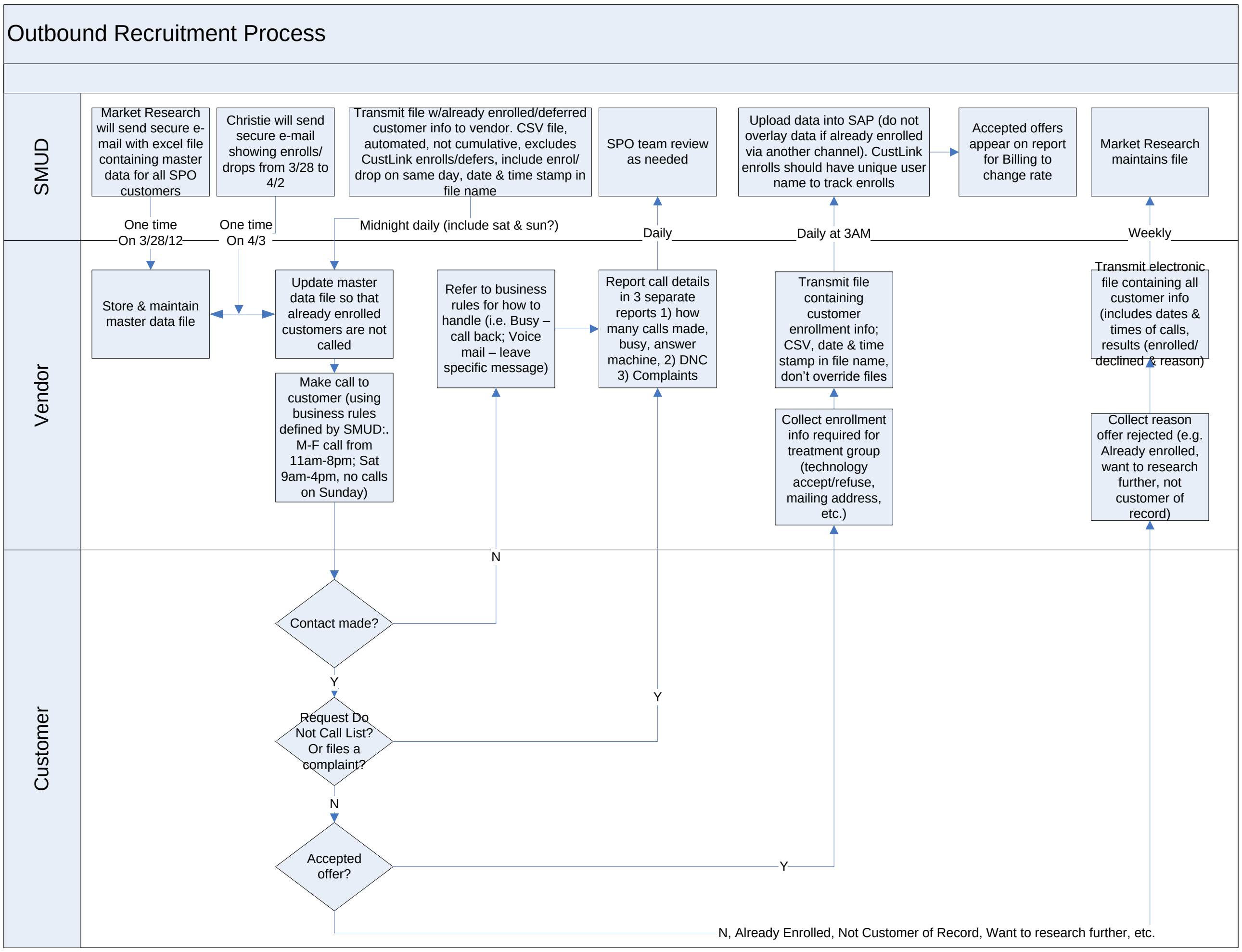
Information provided in the outbound calls included:

- A plan-specific overview of SmartPricing Options
- Forewarning of a possible deferred start date for RCT customers
- Pricing plan effective date upon enrollment (June 1, 2012 or June1, 2014)
    - Treatment group customers: June 1, 2012
    - Randomly selected deferred control group: June 1, 2014
- Duration of the pilot: two years
- Reduced prices for electricity usage during off-peak hours
- Can opt out at any time effective the following billing cycle
- Collect communication preferences: for events and/or energy saving tips

Customers who were randomly assigned to a 2014 start date received the following message: "You've been selected to participate and will be eligible in 2014. You'll receive a reminder in the mail in the spring of 2014 so that you can complete your enrollment."

Calls were recorded and samples were reviewed periodically to ensure proper implementation and to understand the customer experience. If during the call the customer had questions about a bill or had general SMUD inquiries, they were directed to SMUD's Contact Center.

Figure 21: Outbound Recruitment Process Flow



Findings and Lessons Learned: In an effort to give the outbound calls the feel of a customer notification rather than a sales call, the contractor's primary form of payment was based on the amount of work performed rather than enrollments achieved. While this proved to be a bit more challenging in terms of contract negotiations and contract management due to the atypical terms, it was successful in terms of implementation. Having this firm on contract proved to be highly beneficial for other ad hoc needs later on in the project as well. They were thoroughly trained on the pilot terms and available on short notice for other customer communications throughout the pilot.

7.2.5 Social Media Communications

Objective: Retention and Education

Description: Various commonly used social media sites were used to assist in customer education. While it wasn't expected that these channels would be widely used, we felt it would enhance the pilot for participants who are avid social media users or who have a general expectation that the pilot should have a robust online presence.

Facebook

SMUD created a dedicated group for each offer. These groups were a place for participants to get energy saving tips, share what they did to save energy, talk to other plan members, and participate in fun contests. Conservation Day notifications were also posted for the CPP and TOU-CPP groups. The following types of posts generated the most activity:

- Conservation Day notification
- Electricity Use Display
- Electricity bill questions posted by participants
- Solar thermometer giveaway
- Questions posed by SMUD to participants about summer activities
- The Home Depot Grill Sweepstakes

In addition to posting in each Facebook group and responding to customer posts, the team also implemented Facebook Giveaways. Asking a question combined with a giveaway generated more activity within the groups. We asked for customer feedback and offered a gift to everyone who answered. The following example represents the types of questions posted.

- How did you stay cool during our recent string of 100+ degree days? Tell us and we'll send you a solar-powered digital thermometer! It shows the current temperature as well as the daily maximum and minimum temperatures.

You Tube

We developed four cooking videos, two instructional videos for My Account, and a video on how to use a smart strip. The dedicated microsites contained links to these videos. We also posted links on our Facebook groups. These videos were featured in SMUD's August 2012 Easy Savings newsletter that goes to all SMUD customers and had the second highest click through rate.

Pinterest

The SmartPricing Options Pinterest page has boards showcasing summer activities, tips on saving energy at home, easy meals, and tips on how to keep pets safe and cool. Our followers steadily increased over the year. Regular pinning was important to having engaged followers and active boards.

The Home Depot Grill Sweepstakes

We launched a sweepstakes with The Home Depot as part of our efforts to keep participant engaged and retain participants in the SmartPricing Options pilot. Customers had the chance to win a new propane grill valued at $199. We provided the chance to win one of seven grills, allowing one member of each treatment group to win.

The sweepstakes was promoted to approximately all participants through direct mail, email, Facebook groups and on the microsites. Customers were directed to enter the sweepstakes online at their specific microsites or by mailing a 3.5" x 5" postcard in accordance with California law. The deadline for entering was 11:59 p.m., on September 21, 2012. Winners were randomly selected on September 25, 2012. In accordance with legal guidelines, entries were permitted outside of the SmartPricing Options pilot participant group. Winners were able to pick up their new, fully assembled grills at The Home Depot. This sweepstakes significantly increased traffic to our websites and our Facebook groups.

Implementation: All of the social media channels were set up on the popular platforms. The SmartPricing Options marketing specialist was responsible for updating the sites with new information, responding to customer inquiries, and managing contests on each Facebook group and managing the Pinterest boards. The Facebook groups were "closed groups" to ensure customers did not stumble upon one of the other treatment groups. A customer had to request to be added to the group. Once we received the request, we verified enrollment and added the customer to the appropriate group.

Findings and Lessons Learned: About 100 customers participated in the Facebook groups. Pinterest garnered more attention with recipes and family-friendly posts. We continue to get requests to join the Facebook groups, and customers use Facebook as a place to ask questions about the program or the technology, and to simply tell us how much they like the pilot. In a larger program launch, it would be possible to integrate social media more holistically and with more transparent integration with SMUD's standard communications since closed groups may not be necessary and communications would not need to be exclusive to maintain research integrity.

7.2.6 Microsites

Objective: Education, Recruitment, and Retention

Description: We designed a unique microsite for each treatment group. Features and information on the microsites were identical, with the exception of the rate and technology offer.

Implementation: The marketing specialist was responsible for updating and refreshing the microsites for each of the plans several times over the year. This differs from our main corporate site, which is maintained by corporate communications.

The microsites were hosted on SMUD.org, but there were no direct links to the sites to prevent non-participant traffic. We captured information on site traffic through Google analytics.

The microsites include links to our My Account portal where customers can view their bills and hourly usage. The sites had details about the rates, suggestions on how to save energy and money, videos, FAQs, special promotions and information on the IHDs when applicable. The sites also included educational charts such as the "Costs to Run" seen below.

The microsites included a short survey in the first year asking customers to provide feedback about the sites. We used that feedback to improve the sites several times with new content and tools. We routinely sent out letters and emails to participants letting them know about big changes or promotions that were happening on the sites, such as The Home Depot Sweepstakes.


CPP – Off-Peak Discount Plan

Save energy and money with
The Off-Peak Discount Plan
June 1–September 30, 2012 and 2013

Typical Usage Appliances & Watt Usage	Cost for 1 Hour of Conservation Day Usage	Make A Shift >	Shifting Your Usage Appliances & Watt Usage	Cost for 1 Hour of Off-Peak Usage
A/C (5 ton) – 9000 watts	$6.75	Shift Your Time of Use >	A/C (5 ton) – 9000 watts	$1.50
Stove – 2200 watts	$1.65		Stove – 2200 watts	$0.37
8x60 watt lights	$0.36		8x60 watt lights	$0.08
Clothes Washer – 400 watts	$0.30		Clothes Washer – 400 watts	$0.07
Dryer – 3000 watts	$2.25		Dryer – 3000 watts	$0.50
LCD TV – 110 watts	$0.08		LCD TV – 110 watts	$0.02
Dishwasher – 1200 watts	$0.90		Dishwasher – 1200 watts	$0.20

Findings and Lessons Learned: Access to the microsites was useful for our customer service team, although customers often needed encouragement to visit the sites. Our CSRs referred customers to the sites where customers could find answers to their questions. Customers used the sites more after the launch of a sweepstakes where the entry form was on the microsites. We found it is important to incentivize customers to visit the site early on in the pilot.

7.3 Quality Assurance

The marketing materials were carefully reviewed before a final draft was sent for production, from early drafts to final versions and proofs of each piece. Documents were checked by the marketing specialist, the market research professional, and the project manager to confirm versions, verbiage, links, titles, and identification codes against the matrix. After team members verified the content was correct, the marketing specialist or assigned team member forwarded the final materials to the appropriate department or contractor for production.

Additional steps taken to ensure accuracy included:

- Marketing firm submitted PDFs for sign-off and created art files to send to mail house
- Mail house reviewed PDFs and art files on press
- Marketing specialist and team reviewed and signed off on PDFs
- Marketing specialist conducted a press check at the mail house before the printing went out as a direct mail

7.4 Lessons Learned and Key Takeaways

- Allow at least three weeks between a soft launch and a full launch.
- Eliminate the Welcome Back letter and just send the Welcome Back Kit. The letter generated drops from the program.
- Perform quality checks on the mailing lists to ensure the right customers are included.

- Perform quality checks on letters and other materials at the mail house after production and before mailing.
- Drive traffic to the dedicated websites by starting the summer with a big promotion, like The Home Depot Grill Sweepstakes.
- Increase engagement on Facebook groups through more giveaways and Q&As.

7.5 Additional Areas of Interest and Future Research

We want to continue to educate our customers through real life examples about how to reduce their electricity use during peak hours and manage their energy costs. We also want to increase their satisfaction with SmartPricing Options and SMUD overall. Understanding customer preferences related to pilot materials would assist in achieving those goals.

It is unclear based on the research design how much the marketing strategy impacted customer engagement and load impacts. The marketing strategy was also designed to attract as many people as possible and to retain as many people as possible to allow for robust load analysis across all customer segments; this differs significantly from how a standard program is commonly implemented, typically aiming to identify and attract customers who will benefit most from the program. Additional research to further refine marketing materials to meet program needs would be a logical next step.

8.0 Enabling Technology: In-Home Displays

8.1 Overview

Over 30 SMUD employees were asked to help test the devices in their homes. Volunteers were recruited from the contact center staff who were ultimately going to support the devices as well as team members who supported SmartPricing Options in other capacities.

Defaulting customers onto a new rate structure posed many concerns for SMUD regarding customer awareness of the new rate as well as ability to save on their bills. It was important that we provide customers with appropriate tools and education to assist in bill and energy management through this transition. Alongside printed and online educational materials, we were interested in testing the impact of offering real time information feedback to customers with pricing and electricity consumption incorporated. SMUD has deployed over 5,000 IHDs to customers, with over 4,500 of them sent to customer on the SmartPricing Options pilot. The experiences with the various pilots utilizing IHDs have varied, indicating that many factors influence the performance of and satisfaction with the IHD. The discussion below addresses the deployment of IHDs for the SmartPricing Options pilot.

8.2 Details

8.2.1 Standards and Device Testing

All customers' smart meters are equipped with a ZigBee gateway embedded in their recently installed AMI meter. SMUD selected the ZigBee Smart Energy Profile (SEP) standard to provide utility communications for Home Area Networks (HAN) due to its widespread use as an emerging smart grid standard and its alignment with low power, low cost, performance objectives. It provides an open standard interface that encourages innovative and competitive development of smart energy devices the customer while ensuring communication interoperability and data security for the utility.

Immediate challenges arose in aligning utility enterprise systems and consumer devices with the release of SEP 1.1, which was ratified just a few months before SMUD's deadline to select a compliant IHD. This narrow window of time between the release of SEP1.1 and the critical schedule path for pilot deployment left little time for vendors to obtain certification and for SMUD to conduct adequate validation testing of the various components. The IHD was also required to meet the minimum hardware specifications needed to support a future upgrade to much more processor- and memory-intensive applications to be used by the preliminary version 2.0 of the SEP standard, providing forward compatibility according to SMUD's technology road map,

As a result of the shifting SEP standard during the project term from version 1.0 to 1.1, then toward 2.0, the entire HAN industry was scrambling to keep up. Product offerings were scattered across the multiple versions of the standard, with varying levels of performance and maturity. These dynamic technology shifts made it very complex for SMUD to align, select and validate system components to support the study. Ultimately SMUD selected a device that received the SEP 1.1 certification prior to deployment; however, since Silver Spring Networks (SSN) had not yet completed the SEP 1.1 version of their application stack, SMUD will planned to use the 1.0 version for the project duration.

8.2.2. Testing the In-Home Displays

SMUD implemented unit testing of IHDs using three sets of test cases: the first set was inherited directly from the SEP certification standard, the second prescribed by SSN to confirm compatibility with their AMI systems, and the third included a series of SMUD specific tests in support of internal technology requirements and functional customer requirements. We contracted with NTS to conduct all phases of this unit testing in their laboratories. NTS, the predominant provider of SEP certification testing worldwide, was in a unique position to help us sort through the evolving standards and make sense of the results as they would apply to our project requirements.

In the midst of the SEP standards shuffle, NTS conducted unit testing on a handful of proposed IHDs according to SEP 1.0, and followed up with provisional test results according to the additional requirements of SEP 1.1. Having passed these as well as the SMUD-specific requirements validation, the Energy Aware PowerTab was the only device to meet all of the minimum project criteria.

We contracted with NTS Labs to test qualifying IHDs across three categories:

- ZigBee certification
- Environmental testing (e.g. signal strength, range)
- SSN harness testing (functionality in the SSN environment)

Of those that failed, most of the critical device failures resulted from the SSN harness testing. The critical failures were due to manufacturers' interpretations of the SEP standards. The immature standards introduced interoperability issues for devices from one system to another. The environmental failures were less common but still evident. Other issues encountered with the IHDs that did not pass testing included:

- Improper display of consumption
- Improper formatting of consumption
- Messages inconsistently processed or displayed on device, especially “sleepy” devices or devices that did not communicate with the meter often in order to conserve battery
- Improper time display or display in Coordinated Universal Time (UTC) rather than local time if did not sync with meter after first attempt
- Prices mismatched with text labels or displayed with no text label after price signals were sent
- Low radio signal transmission and reception, which causes device to be susceptible to interference
- Failure to connect to the price cluster from meter potentially resulting in not receiving price updates
- Lengthy average setup and meter sync time, up to five minutes, requiring user to walk through several screens with questions about house characteristics, energy behaviors, and preferences.

Subsequent to unit testing, we embarked on a series of system tests to validate end-to-end interactions of the system from the utility operator interface all the way through to the customer. These tests were all functional and based on a series of use case scenarios identified to cover the most common interactions between SMUD and its customers via the HAN technology pipeline. The system was first tested in a controlled lab-like environment, and then with a limited set of engaged employee testers in their homes using production systems.

A test environment was developed at SMUD utilizing the limited number of meters and PowerTab IHDs available before devices began shipping in bulk. This test environment offered many benefits, since provisioning devices to home meters in order to test equipment and procedures was not allowed due to the potential negative impacts to the meter environment. The most notable limitation of the test environment, however, was the inability to perform volume testing of HAN devices assessing the impact of large amounts of communication traffic on the system.

Over 30 SMUD employees were asked to help test the devices in their homes. Volunteers were recruited from the contact center staff who were ultimately going to support the devices as well as team members who supported SmartPricing Options in other capacities.

Issues experienced by volunteers closely matched the issues customers later experienced, both in number and type. Early testing with employees gave us the opportunity to mitigate the issues in advance or prepare for these issues when customers ultimately encountered them.

- Several volunteers experienced issues with their batteries, such as limited battery life or dead batteries which prevented operation even when plugged in
- Several volunteers' homes had environmental factors that caused connectivity issues (e.g. it appeared the aluminum siding of one home prevented the smart meter signal to reach the device)
- Several volunteers never turned the device on, even after multiple requests
- Several volunteers experienced repeated and seemingly random disconnections, regardless of device location

The controlled lab testing immediately uncovered a handful of interface issues between various components of the system, all of which were fairly straightforward to resolve, mitigate, or allay by creating work-around solutions. The field testing phase with employee-customers proved to be very informative once the system was released into the field, where it was exposed to unexpected real-world user and environmental scenarios that were beyond our ability to anticipate or simulate in a lab environment. Through active feedback from SMUD testers, the project team uncovered intermittency issues related to battery health and network connectivity. These observations were tracked and documented for Energy Aware and resulted in an upgrade to their firmware to correct bugs with the PowerTab's radio frequency and power systems. Although the new firmware version was made available too late to use for SmartPricing Options, we were able to create educational materials for customers and troubleshooting processes to largely mitigate the device issues.

8.2.3 Procurement of the IHDs

Initially, we planned to provide an SEP 2.0 price-responsive programmable communicating thermostat (PCT) with an incorporated IHD. The security measures that were predicted to be embedded in SEP 2.0 were desirable to SMUD, along with many other benefits of the upgraded standard. Over time, however, it was clear SEP 2.0 would not be ratified in time for our procurement, and a compatible PCT meeting our business and technical requirements wasn't readily available. We also discovered that shipping times for these types of devices could be very lengthy, in some cases taking a several months. In an effort to provide customers with enabling technology that intended to assist in bill management prior to the rate going into effect, the technology plan shifted from procuring a price-responsive PCT to an IHD, allowing ourselves the option to purchase SEP 1.0 or SEP 1.1 compatible devices.

When preparing the Request for Proposal (RFP) for the IHDs, it became clear that some of the desirable technical features were going to present a hardship for many manufacturers. Basic functions didn't appear to create any concerns, such as backlighting, clock, price display, and rate structure support. Other requirements, however, proved to be more challenging.

Some vendors resisted providing devices that supported SEP 1.1, which was desired by SMUD because it was upgradeable to SEP 2.0, while SEP 1.0 was not. Suppliers were not inclined to provide SEP 1.1 devices, since SEP 2.0 ratification was anticipated shortly and manufacturers were hesitant to develop interim devices for SEP 1.1. Suppliers preferred SEP 1.0 devices, because they were already manufactured.

In addition to the SEP version requirements, additional preferred features also proved to be challenging.

- Reset on billing date: While this was a strongly preferred automated feature, available devices could provide this feature only by manual reset or Wi-Fi connection.
- Over-the-air upgrades: This feature was not embedded into SEP 1.0 or SEP 1.1. Suppliers were offering only Wi-Fi upgradability, which was not consistent with our sample frame requirements.

Once the devices were delivered to SMUD, the team worked the staggered shipments into the overall schedule. As shipments arrived, they were processed in batches of 500 devices. After the warehouse sent notification of shipment arrival, a team member would pick up the fourteen boxes of devices from the warehouse and drive them to the processing area. Shipments to customers would be processed in order of enrollment date.

1. After the device was provisioned to a customer's meter, two sets of mailing labels were used to ensure the right device matched with the corresponding envenlope and shipped to the proper customer. This was an important step, since the IHDs were provisioned to the customer's meter before shipment.
2. The team coordinated with SMUD's Postal Services group in advance to prepare them to receive and process large shipments. The Postal Services group then notified the postal carriers that larger than normal deliveries were to be expected and to bring an appropriately sized truck.

3. The project team was responsible for packing the devices in envelopes and affixing the mailing labels, while Postal Services was responsible for printing and affixing the postage.
4. The team created a process for receiving and processing returns, both due to incorrect addresses and customer returns.

8.2.4 Rate Publication

Although we desired the technical capability to reset the device on the billing cycle over the network, none of the vendors could meet this requirement without a Wi-Fi network. In addition, our tiered rate structure made it necessary to publish a new price on the display after the customer had exceeded 700 kWh during the off-peak period in a billing period. SMUD's information technology team created an automated work-around to address rate publication limitations in the IHD.

The code developed to address the rate publication limitations queried the current SmartPricing Options customers every night, looking for customers that had crossed the 700 kWh threshold or had completed a bill cycle. The code then created a list of customers who needed a new rate pushed over the AMI network and published the rates to the meter. HCM picked up the list and pushed the rates out to the customers' IHDs. When a customer started a new billing cycle or crossed the 700 kWh threshold, the correct rate would display on their IHD.

8.2.5 Device Troubleshooting and Technical Support

SMUD provided technical support for the IHDs using internal SMUD staff. We were interested in the number and types of calls received, resolution time, and the types of support required for the devices. The primary reason for keeping support in house was the high probability that the majority of technical issues with the IHDs would be connectivity issues with the meter.

Keeping technical support internal also gave SMUD the opportunity to train staff on how to support such technologies, which would be applicable to future enabling technology rollouts. In addition to technical questions, customers also had program or billing questions. With internal technical support, we were able to offer first call resolution.

The back office software to manage devices was an SSN's HAN Communication Manager (HCM). HCM is responsible for turning on the meter's HAN radio, pairing a device to the meter (also called "joining"), pushing rates to the device, sending price signals and messages to devices, and deactivating devices ("un-joining").

As customers reached out to SMUD for technical support, the support staff recorded the interaction along with accompanying details. The tables below provide details regarding the troubleshooting issues we encountered, the frequency of specific issues, the resolutions and time required to resolve, applicability outside the SmartPricing Options pilot, and the type of support staff required. The tables are divided into three troubleshooting categories:

1. Meter Connectivity
2. IHD Shipping and Replacement
3. Hardware Solutions

Meter connectivity issues comprised the vast majority of observations, with meter activation failure posing the most significant IHD technical interference in terms of both frequency and total resolution time. Of particular interest, the second largest time consuming troubleshooting category was not related to the technical operation of the IHD but rather the shipment of the device to the customer. Based on lessons learned from the pilot, both top time-consuming issues could likely be improved by revising operational processes and requesting bug fixes.

Table 23: Meter Connectivity Summary

	Radio Activation Failure	Device Provisioning Failure	Meter Swap
NUMBER OF OCCURRENCES	567	105	6
% OF TOTAL OCCURRENCES	66%	12%	1%
AVG. MINUTES TO RESOLVE	3 + customer phone call	7.5	23
TOTAL HOURS TO RESOLVE	29 + calls	13	2.5
COMMON RESOLUTION STEPS	1. Verify in ESP (meter) log entry. 2. Manually activate radio in HCM and confirm success.	1. Use SAP transaction to add a device as if they had not had one before. 2. Enter new device, make sure it has current date, save it, and it will process in batch that runs at night.	1. Identify if meter was replaced and why (use of UIQ, SAP/CRM and HCM). 2. Follow up with billing team to ensure SAP was updated with new meter. 3. Verify active meter in UIQ. 4. Enroll customer in HCM program to update Service Point ID with new meter MAC.
PROBLEM IDENTIFICATION SOURCE	Customer call	1. Daily SAP report 2. Identified after customer returned IHD by cross checking against returned IHDs.	1. Customer call 2. Follow up on list of known meter issues 3. Troubleshooting Altiris tickets
APPLICABILITY TO OTHER PILOTS	Yes, others require manual individual radio activation due to HCM radio activation bug.	Yes	Yes
SUPPORT TREE	SmartPricing Options CSR ↓ Technology Management ↓ Customer Solutions	Technology Management	Technology Management ↓ Meter Shop ↓ Billing

Table 24: IHD Shipping and Replacement Summary

	Customer Never Received IHD	Returned IHD	Replacement IHD
Number of Occurrences	87	53	9
% of Total Occurrences	10%	6%	1%
Avg. Minutes to Resolve	10	5 + customer phone call	3 + customer phone call
Total Hours to Resolve	14.5	4.5 + calls	< 1 + calls
Common Resolution Steps	1. Check device provisioning in SAP. 2. Investigate join attempts in HCM. 3. If original device was provisioned, un-provision and send new IHD. 4. If original device was not provisioned, follow shipping procedures for new IHD shipments	1. Call customer to identify why IHD was returned. 2. If customer does not want IHD but doesn't drop the pilot, un-provision device in HCM and SAP. 3. If customer wants to drop from pilot, un-provision device and drop from program. 4. If wrong address, update address and provisioning as needed and resend.	1. Call customer to discuss replacement options. 2. Un-provision original IHD, provision new IHD, ship to customer. 3. Place prepaid return envelope to send defective device back to SMUD in package to customer.
Problem Identification Source	Customer call	1. Customer drops off at SMUD. 2. IHD returned in the mail.	1. Customer call 2. Troubleshooting Altiris tickets
Applicability to Other Pilots	Maybe. Applies to programs mailing devices. Does not when installers or auditors hand deliver and set up.	Yes	Yes
Support Tree	SmartPricing Options CSR ↓ Technology Management ↓ Customer Solutions Staff	Project Manager ↓ Technology Management	SmartPricing Options CSR ↓ Technology Management

Table 25: Hardware Solutions Summary

	Repeater	Battery Replacement	Bottom Fed Meter
Number of Occurrences	7	7	13
% of Total Occurrences	1%	1%	2%
Avg. Minutes to Resolve	3	3	23
Total Hours to Resolve	< 1	< 1	5
Common Resolution Steps	1. Call customer to verify need. 2. Obtain customer information from SAP for HCM manual provisioning. 3. Manually provision in HCM and send to customer.	1. Send battery to customer.	1. Verify meter is on bottom fed meter master list. 2. Call customer, explain options, set up appointment for meter adapter installation. 3. Create service notification to meter shop to install adapter. 4. Confirm adapter installation with meter shop after appointment. 5. Contact billing to expedite processing of service notification if needed. 6. Re-enroll customer in HCM with update. 7. Update device location information. 8. Call customer to notify completion.
Problem Identification Source	Customer call	Customer call	1. Cross check existing list of known meters 2. Troubleshooting Altiris tickets
Applicability to Other Pilots	Yes	Maybe. Applies to battery operated HAN equipment.	Yes
Support Tree	SmartPricing Options CSR ↓ Technology Management ↓ Customer Solutions	SmartPricing Options CSR ↓ Technology Management ↓ Customer Solutions	Technology Management

8.3 Quality Assurance

Due to the tight one- to two-day turnaround between receiving the IHD shipments and shipping them to customers, quality assurance on the actual devices occurred concurrently with outbound customer shipments. We opted to test 5% of each shipment of 500. Upon arrival to the warehouse, 5% were randomly pulled from each box and shipped overnight to NTS. NTS processed each shipment in approximately two weeks. In the event the shipments were to be found defective, appropriate action would have been taken based on the findings. After testing the 250 IHDs, only a few were found defective, a number well within acceptable QA standards.

8.4 Lessons Learned and Key Takeaways

After shipment of devices began, the team continued to fine-tune processes and create new processes as the need became apparent.

Setting Expectations

Customers began receiving IHDs in May 2012, prior to the summer rates' effective date. Because we were unable to perform volume testing on the communication of rates, the technical team was concerned about how the system would handle the mass communication of our standard rates that are applicable in May quickly followed by a mass communication of the pilot rates that would be applicable in June. The team decided to mitigate the risk by not pushing any rates until June 1, when the pilot rates went into effect.

After the first few batches of displays were shipped, a few customers called to say they could not see their usage in dollars but only in kWh. To avoid further customer confusion and support calls, we included a slip of paper with the display that explained they would not see their price information until June 1.

In an effort to minimize negative technical impact on the customer, we had overlooked the need to communicate the performance expectations to customers. Over the course of the project, the team encountered a few occurrences that highlighted the need to proactively communicate with customers to set expectations related to changes in the original project plan. The need to revisit planned customer communications when project changes occurred became a key takeaway across the project.

Battery Life and Functionality

Based on repots from our volunteers, NTS, and SMUD's HAN lab, we identified a bug with the Energy Aware PowerTab related to battery life. When the PowerTab's battery drained too low to function, it continued to attempt to connect to the meter. The screen would show a continual connection attempt, which caused customer confusion since most rechargeable battery powered devices turn off before the battery fully drains. SMUD worked with Energy Aware to document the issue and Energy Aware developed a bug fix. The last 1,000 PowerTabs were shipped with the updated firmware, but because devices could not accept over the air upgrades, the PowerTabs in the field could not be updated.

Bottom Fed Meters

SMUD has a small number of meters in the field that reverse the feed of electricity as it passes through the meter, which we refer to as bottom fed meters. While this doesn't pose an issue for data processing and billing for SMUD's operational staff, it was unknown how these types of meter anomalies would interact with the IHD. Testing of the IHD with a bottom fed meter determined that the absolute value of energy consumption displayed by the IHD was accurate, but it was displayed as a negative value. Because this would be confusing to participants, SMUD's meter shop rinstalled an adapter on all participating bottom fed meters to correct the negative values displayed on the IHD. This experience highlighted the importance of conducting a due diligence assessment of the interoperability of enabling technology with non-standard meters or devices in the field.

Provisioning Quality Assurance and the Importance of HAN Reporting

The team discovered that a number of reported connectivity issues were actually the result of a failure in turning on the ZigBee radio in the meter. As part the display set up process, SMUD developed a tool that automatically performed all of the tasks necessary to provision a display. When a customer was registered, the customer database would send a web service call to HCM to turn on the ZigBee radio in the customer meter. Although HCM's status screen showed that the customer's ZigBee radio was enabled, the log files showed that the attempt to turn on the radio on failed.

Following this realization, we found and corrected a bug in the web service call. The next step was to resolve the failed attempts to turn on the ZigBee transmitters. Due to the limited reporting functionality within HCM, we were unable to determine which of the radios were on and which were not. A support member had to review the log files of every customer registered in HCM to find the true status of their ZigBee radio. If the radio had failed to turn on, the support member would activate it manually using HCM. The process took about a week due to the number of steps it took to review each log file and manually turn on each radio.

Providing Staff with the Right Tools

When a customer experienced difficulty connecting the display to the meter, the first level customer service representative would take the call and issue a support ticket. SMUD's Performance Solutions group, the second level support, would review the ticket and issue a recommended solution to the CSR or assign the ticket to the appropriate Technology Management team member, who would troubleshoot the issue. Technology Management would use the HAN Communication Manager (HCM) to resolve the issue and would contact the customer if appropriate. This is the standard procedure for SMUD when handling technology issues; however, it was causing delays as the number of support calls increased. The team determined that the majority of the technical issues customer experienced required the customer's device to be rejoined in HCM. Since this was a simple and quick procedure, we provided access to HCM to the first level CSR team so they could perform the work after receiving formal training. Once the CSRs were able to assist customers with their connectivity issues, the majority of the display problems were resolved with the first call.

Equipment Procurement Planning

The IHDs procured for this pilot required significant lead times between purchase and shipment arrival. SMUD was fortunate that Energy Aware and SSN worked collaboratively with us to expedite shipping; though shipments still required several months for arrival. Lead times on IHDs are particularly long, because the demand for a standalone IHD is not high. Many suppliers and even some manufactures did not have adequate quantities in stock, which caused a notable delay in our shipping schedule to customers. Schedules should allow for a minimum of 20 weeks to receive the first shipment and should accommodate for staggered shipments. Time of year can have an impact on lead-time as well, which should be investigated fully during contract negotiations.

8.5 Additional Areas of Interest and Future Research

Despite the efforts SMUD took to maximize the number of customers who successfully joined their IHD to the meter, we still experienced lower connection rates than we preferred. Reporting functionality within HCM was limited, and many customers never contacted SMUD for technical support, so the technical team had limited insight into the barriers with IHD joins.

Additional research into connectivity rates would be highly beneficial to future ZigBee-enabled HAN programs at SMUD. Understanding the distribution of connectivity interferences would inform product selection, resource requirements, and staff training. If equipped with robust connectivity reports showing historical customer-level data that can be manipulated, technical staff could be proactive about identifying customer issues and assisting in resolution. It is unknown at this point how many IHDs that were not joined with the meter were due to technical, environmental and behavioral issues.

While the IHDs were in fact tested prior to implementation, many of the issues identified in the field were unrelated to the tests performed. Enhanced environmental testing might assist in selecting HAN devices that would perform better in diverse residential environments. Enhanced ethnographic research would assist in determining what other issues might be contributing to low connectivity rates.

9.0 Enrollment, Billing and Contact Center Services

> *To maintain the integrity of the RCT design, CSRs were blinded from the customer's treatment group assignment until after the customer had enrolled in the pilot, avoiding bias in the recruitment process.*

9.1 Overview

SMUD had prepared for labor intensive implementation and customer support for SmartPricing Options, including heavy call volumes, manual enrollment of customers onto the rates, and manual reversal for customers wishing to be removed from the pilot. The operational processes for the pilot were expected to require thousands of hours in customer support. The actual number of hours required to support the pilot, however, did not accrue as expected. Billing hours were much greater than we expected, while contact center hours were less than one third of what was planned. While this section provides an overview of the operational challenges and successes we experienced during the first year of the pilot, detailed process flow diagrams are available in the Appendix. Please refer to these for greater detail related to specific billing, enrollment, and contact center processes.

9.2 Details

In anticipation of process changes to support new rate structures, we proactively set up processes to handle the numerous different exceptions and billing issues that we foresaw. Many of these process flows can be found in the Appendix under the process flows section. Although many changes can be anticipated, the purpose of a pilot is to test a program with the expectation that many new things will be discovered. This pilot was no exception.

Initial project plans consisted of 8,000 customers manually enrolled onto the new rate, taking approximately 15 minutes each. Time-based rates required additional steps during enrollment, and no automated process existed to allow for batch uploads. To expedite the enrollment process and reduce required labor hours, our technology department established an automated solution that allowed for hundreds of customers to be enrolled in a batch file, saving hundreds of billing staff hours.

The billing staff encountered many challenges in billing the new rates using interval data. While the nearly all SMUD customers were still billed from register reads, SmartPricing Options customers were billed from the hourly interval data. This new process added to the time that it took to process bills. Latent data issues and final billing for customers who moved out of their homes or changed account holders mid-billing cycle created delays in processing bills.

In addition to the daily billing process challenges, system upgrades to the meter data management system (MDMS) were required to improve stability of the system. During upgrades the system created mismatches between the MDMS and our Customer Information System (CIS) that were mitigated by implementing blocking automated bill processing to allow for manual processing of customer bills by cycle.

The process of dropping customers from the rate and processing the final bill also proved to be a lengthy task. Waiting for the interval data to arrive and processing the final meter read was an unexpected challenge. Ultimately, billing representatives used administrative MDMS access to push the interval data through the system and into the CIS. This allowed for bills to be issued within two days of a customer move-out, whereas before it had taken several business days.

9.2.1 Interval Data Billing

Where previous time-based pricing studies at SMUD had required manual billing of participants, automated billing from interval data was a new process available after the installation of the smart meters. While smart meters made it possible, interval billing hasn't been necessary for customers on the standard rate. Interval billing requires approximately 720 reads per billing cycle rather the single read required for the tiered rate. Heightened awareness related to missing intervals resulted in new business rules related to billing with missing or estimated date.

We created thresholds to address missing interval data for billing purposes.

- If there are contiguous missing data points, the validation for the 24-hour daily file will fail, placing the file in the queue for editing. This triggers the following process for the metering programs team:

    1) For each contiguous block of missing interval data, the estimator must provide an estimate for each missing interval and include that estimate for the

corresponding customer ID in the Automated Billing Extract Log, completing the data set.

2) Each estimate must be verified by second Metering Programs team member (the Verifier) prior to closing out the estimation process. The appropriate time for this verification is during the graphical review step prior to the saving of the estimates.

3) The initials of both the team members (Estimator and Verifier) must be entered with the Editing and Estimation log entry along with the specific role of each team member in the estimation process.

4) After each estimation process, check the estimate against the *start* and *stop* meter reads by reviewing the validation report for the day to confirm that the estimated meter data matches the register reads.

- All customers, regardless of whether or not they are billed on interval data, have a validation check for pulses against the register read. The tolerance is set for 3%, referred to as the energy tolerance. If a meter has missing data intervals and the energy tolerance exceeds 3%, the validation will fail and the file will be placed in the queue for manual editing.[20]

9.2.2 Contact Center Operations

Creating a positive customer experience and maintaining a positive relationship with customers was a critical element of the pilot. SmartPricing Options was implemented adjacent to and concurrent with other major SMUD initiatives that are highly visible to customers. In addition to providing customers with relevant educational materials, we created a complete customer support system to maintain customer satisfaction, assist in retention, and increase efficiency in the customer service experience.

The primary point of customer contact is through SMUD's customer service contact center. All customer service representatives (CSR) were trained on the fundamental elements of the pilot program in order to properly route calls. Within the contact center, SMUD selected CSRs who demonstrated a particular aptitude for the intricacies of the

[20] Currently, there is a bug in IEE that does not save the automated estimation process. Metering programs team members anticipate that this will be corrected in a few months.

program, and we trained a core team of specialists who addressed all specific questions from customers regarding the pilot program. The team was in place prior to the launch of the recruitment campaign and will remain in place through the duration of the study. This core team has access to the specific offer each customer received, allowing the CSR to tailor communications to each customer based on their specific treatment group, avoiding customer confusion about the various offers and maintaining the integrity of the research. This core team was prepared to discuss program details and handle enrollments and drops. Concerns that could not be addressed by the core CSR team or their respective supervisor were escalated to the SmartPricing Options Project Manager, who responded directly to the customer's concern.

SmartPricing Options customers were provided with a custom toll free number into the contact center. The phone number was included on all applicable communications along with a SmartPricing Options customer service email address. Calls that came into the contact center via the toll free number were automatically routed to the core CSR team. Calls that came in through the standard customer service number were offered a routing option by the IVR system, which routed them to the core team. In both circumstances, the call was automatically entered into a central tracking system that tracked the date, time, and length of the call.

To enable self-service, customers were able to access a variety of online tools. SMUD provided online enrollment and opt-out functionality. Customers were required to sign on to authenticate, at which point they could change their enrollment settings. A confirmation email was sent to the customer assigned to the account.

As a publicly-owned utility, customer service is one of the highest priorities to SMUD. When planning for SmartPricing Options, we estimated high on the contact center hours, estimating that over 6,000 hours would be required for the first summer of the pilot. We selected a supervisor to lead a specialty team of 17 CSRs to support the customers on the various pricing plans.

The SmartPricing Options Core team of CSRs was selected to support all aspects of the pilot including:

- Recruitment
- Enrollment
- Pricing plan support
- Bill impacts
- Rate design
- Customer usage

- Opportunities to save
- Peak periods and events
- Program drops
- IHD 1st tier technical support
- Conservation day support
- High bill investigations
- General inquiries

To maintain the integrity of the RCT design, CSRs were blinded from the customer's treatment group assignment until after the customer had enrolled in the pilot, avoiding bias in the recruitment process. Customers in the RCT sample were told in advance that they would be randomly assigned a start date of either 2012 or 2014. Once a customer completed the enrollment process, they were informed of the start date. A customer who enrolled online had a similar experience.

CSRs handled hundreds of calls for enrollment, but we projected thousands. Our expectation was that once we sent the notifications to the default customer treatment groups, the contact center would be in inundated with phone calls from customers requesting to be removed from the default rates. This did not occur. During the enrollment period, the contact center used only one quarter of the hours that were planned.

In addition to taking customer calls, the SmartPricing Options CSRs assumed the responsibility of entering in the business reply cards (BRC) which many customers used to enroll through the mail. This became a much larger task than anticipated as over 35% of our enrollments came from the BRCs, resulting in over 4,500 cards processed for enrollment.

For RCT customers, after a customer's enrollment was processed by the CSR, the team sent out a letter notifying the customer of the applicable start date. Those deferred until 2014 were informed of the delay, while those who were eligible in 2012 were confirmed of the upcoming start date.

The recruitment and enrollment period ended on June 1st, 2012, the same date that the pricing went into effect. The SmartPricing Options CSRs shifted gears from enrollment to retention and began troubleshooting problems with the IHDs resulting from customer calls. In addition, CSRs addressed concerns related to conservation days, peak periods, billing, and drops from the program. Call volumes for the summer months varied, with the highest volume of calls occurring at the beginning of the summer and dropped off steadily throughout the summer. The majority of calls were related to IHD connectivity issues.

The contact center received the highest volume of calls during the first few conservation days, particularly around errors in the notification messages sent from the third party vendor. CSRs clarified the conservation day details with the customers for each of these instances. For two hours during two summer days, SmartPricing Options customers who called the contact center experienced a short wait. These were the only times that our 17-person SmartPricing Options core team of CSRs reached capacity.

During the first year of the pilot, call volumes increased by a factor of two after the day-ahead notifications were delivered to customers. We received an average of five calls per hour for the first several events, but this number decreased as the summer progressed. For the last several events, our contact center was averaging two calls per hour the day before an event and the event day. The majority of these calls were from customers calling to confirm the CPP event.

The contact center team provided important customer support during the decision-making period for customers and throughout the pilot. Although call volumes realized were significantly lower than planned, it is evident that the customized and personalized support was an important pilot component.

9.3 Quality Assurance

After the enrollment process was completed by the billing staff, the project manager audited enrollment reports to ensure all customers were enrolled on the correct rate. This step was performed weekly during the enrollment process, which allowed for proactive corrections for any incorrect rate assignments prior to customer billing. The project team also kept a report of the customer's previous rate category so to ensure that customer was returned to the correct rate if they drop out of the pilot.

The project team opted to implement several changes to decrease the likelihood of missing data. We moved the meter read date in IEE from Day 1 to Day 2 to allow for an additional 24 hours for IEE to recover latent data, with an expected improvement of approximately 70%. To help improve communications between the meter and the head end system, we upgraded the meter firmware expecting to improve latent and missing data. Although missing or latent data occur in extremely small fractions of observations, occurrences during peak periods can result in costly over- or under-estimates. Data integrity and business rules for estimations were put in place to protect customers.

9.4 Lessons Learned and Key Takeaways

9.4.1 Meter Reprogramming

There was considerable unplanned manual work for the billing team and the meter shop as a result of not having TOU registers programmed on the meter or in Utility IQ(UIQ). UIQ is the Silver Spring Networks hosted head-end system that acts as the repository for all meter data. UIQ is part of the AMM suite of applications that provide all of the functionality to perform tasks such as remote meter reads, detect outages, and issue remote connects and disconnects. For customers who moved while on a pilot rate, there was a lag for the data to be available to process the final bill. This created a problem when a customer moved in to the location before the bill could be closed.

- In some cases, there were three customers on an account before the data were available to process the final bill.
- With this lag on customer move outs, billing specialist were spending over an hour for each account to process a final bill.
- For the first summer of SmartPricing Options, this accounted for approximately 500 hours processing final bills.

When reads were unavailable at the time of billing, SAP would estimate the bill, requiring a billing specialist had to manually process each bill. This resulted in several additional hours each week.

Unreachable meters also posed complications for the team. In the event that a meter needed to be replaced, there was no way to distinguish that the customer was a SmartPricing Options customer using UIQ. The ability to distinguish and quickly correct the problem for data collection is particularly important because SmartPricing Options customers are billed using hourly interval data that is needed for the load impact evaluation. A prioritization for SmartPricing Options customers for meter replacement is ideal, and having a unique program in UIQ and on the meter would allow for identification of SmartPricing Options customers. Reprogramming the meters for additional registers for TOU and TOU-CPP customers would improve the ability to process bills and final billing.

9.5 Additional Areas of Interest and Future Research

We would like to identify customer calls and track them by the type of inquiry, e.g. bill inquiry, conservation day questions, and IHD support. We do not currently have that capability but would ideally gain that in the future expansion of our CRM systems.

We will also look at the cost effectiveness of reprogramming the meters to store register reads as a solution to offsetting the costs of manual estimation for reads that we are not able to obtain immediately on a move out. Given the time constraints of implementation, we were not able to fully investigate the costs and benefits of meter reprogramming for our residential customers that are billing on interval data.

10.0 Implementing Critical Peak Events

10.1 Overview

The pilot plan called for 12 critical peak event days June through September each year, for a total of 24 events after the second year of pilot. Sacramento is very hot during the summer months, and peak load is typically driven by air conditioning. The team was tasked with establishing event day criteria, an event core team, and an implementation processes.

When dealing with high volumes of messages over any channel, whether phone, email, or home area network, the best practice we found is to stagger message deployment.

10.2 Details

In January 2012, the project team, Energy Supply, and Load Research and Forecasting began discussions to develop the Conservation Day criteria. Energy traders determined that the pilot was not expected to have a large enough impact on system load to warrant their participation in event day determination due to the limited number of participants. Since load in SMUD territory is heavily dependent on weather, we decided that high temperatures should be the primary trigger for an event, particularly temperatures greater than 100 degrees Fahrenheit when possible. System load and emergency situations would take priority if energy supply needed the load reduction, but given the unknown magnitude of potential load impacts, the energy supply team decided that using the events as a planned resource was premature.

The project team took full responsibility for calling and executing the events. Event selection criteria hinged on several objectives. The pilot needed to call events that represented various time and temperature conditions for analysis, which meant potentially calling events on days that were not the hottest days in order to capture days in each month of the summer and day of the week. The research design also called for 12 events, which could result in calling events on days that were possibly cooler than the 100 degree threshold. In order to optimize event selection and minimize the subjectivity of calling any single event, the team established business requirements and criteria for calling events.

10.2.1 Business Rules and Requirements

1. An event will trigger an increase in the cost per kWh as the Critical Peak price, as approved by SMUD's Board. The event for SmartPricing Options only affects residential customers enrolled on the rate and always occurs at the 4:00 p.m. to 7:00 p.m. timeframe.

2. All events will be called at least 24 hours in advance. Monday events will be called on Sunday (not the previous Friday). Events will not be called earlier than the calendar day prior to the event.

3. Events can only occur Monday – Friday. Events are not permitted on weekends and holidays (July 4th and Labor Day). The operational team requires the technical ability; however, to notify customers of an event the day before the event occurs so that *notification* may fall on a weekend or holiday.

4. Since all events are defined as a set timeframe (4:00 p.m. to 7:00 p.m.) then an event cannot be a partial event. Once the event begins, the full three-hour event will be billed as a Conservation Day for those participants.

5. Once an event has been called, it will not be canceled or rescheduled.

6. Since the objective of this study is to collect data points surrounding the event at different temperatures over different months, there is a need to have two events per month for the first year. The second year of the study, each month will have a minimum of 1 event per month, with greater sensitivity to temperature driving event days.

7. Frequency of Events:
    - 12 events for the summer (June 1 –Sept 30)
    - Within a calendar month: 2 - 6 events
    - Within a week: 0 - 5 events
    - Within a billing cycle: 0 - 9 events
    - Max sequential days: 3 days[21]

[21] In 2013, the max sequential days was set to 5 to test attrition and endurance.

10.2.2 Conservation Day Criteria and Parameters

The criteria for calling the events were driven by temperatures and system needs[22]. The tables below illustrate the temperature-based dispatch of Conservation Days. If, during the months of June through September, the energy traders had determined that system reliability, market prices, or an emergency would have justified a Conservation Day, their determination would have overridden the standard criteria, the event would have been called for the following day, constituting one of the 12 Conservation Days[23].

The table below illustrates the upper and lower thresholds that defined the temperature parameters for calling events each month. The ideal scenario for each Conservation Day would have been three events per month, with minimum temperatures at or above 100 degrees Fahrenheit. No more than six events could be called during a single calendar month.

To allow for comparison of event days to 2012 non-event days at similar temperatures, every fourth event day over 101 degrees was not called. This allowed us to capture data for high-temperature, non-event days spread over the four month period, leaving an acceptable number of days for actual events. On these days, the energy supply team was notified by the SmartPricing Options Project Manager that the event would not be executed for research purposes.

To maintain customer retention, no more than three consecutive days could be called during a heat storm, and we imposed a limit of four events per week in the first summer. The number of events to be held each calendar month is dependent on the number of events called over the prior months. For example, if there were only two events called in June, and 6 events were called in July, only four event days could occur in August and September.

[22] AMI system upgrades and other infrastructure limitations superseded the event criteria put in place for the CPP and TOU-CPP rates, making some days unavailable for event calling.
[23] This exception process will exist again in 2013.

Table 26: Year 1 Parameters for Events Called[24]

Variable	June			July-September		
	Min	Ideal	Max	Min	Ideal	Max
Event Temperature 95-99	1	0	3	1	0	3
Event Temperature >=100	1	3	3	1	3	6
Week (MTWThF)	0	2-3	3	0	2-3	4
Month	2	3	5	2	3	6
Heat wave	1	3	3	1	3	3

The temperatures in the Sacramento area have been mild over recent years and the need to have events during the study in June with temperatures around 95 degrees was considered probable. It was decided that if the weather has been relatively mild (less than 100 degrees), during the first month of the study and no events have been called by June 15th, an event would be called at a temperature less than 100 degrees. Data collected at these temperatures was considered desirable for analytical purposes.

10.2.3 Operational Processes and Implementation

Customers were notified 24 hours in advance of a Conservation Day using one to three notification channels selected by the participating customers: text (SMS), phone, email. In addition, for those customers who received an IHD, a message was sent to the IHD, notifying them of a Conservation Day. The IHD also displayed the current price, which during a Conservation Day was $0.75.

Customers selected their preferred method of communications during the enrollment process and were periodically asked to update their information if it had changed. For email and phone notifications, customers simply provided their contact information online, to a CSR who entered it into the system, or on the business reply card used during recruitment.

For text messages, customers provided us with the number, but then needed to take additional steps to verify that they were opting in to receive text messages from a third party. They needed to send the word "conserve" to a specific number in order to be verified. Once our vendor validated that the number was on a SMUD-provided list that

[24] The column labeled "Ideal" represents the number of events would be called for that category during a hot summer implementation of this program. The research design called for exactly 12 events. In order to obtain reads on varied days of the week and summer months that totaled exactly 12, there are cases where the minimum number of days to be called in a category exceeds the ideal number that would be called in a non-research situation.

we sent each day, the customer would receive verification from the vendor stating that they would now receive text messages for CPP events.

This process was essentially a double verification process, and most customers that signed up for text messages never completed this step. As a result, they did not receive text messages. We made sure that each and every customer had at least one method of communication aside from text messages to ensure that all customers were notified of CPP events. All of the notification preferences and contact information was stored in a separate table in SAP.

SMUD's IT team built An SAP "cockpit" that triggered the notification, rate and billing processes for each event. The cockpit built the file with the list of customers to be notified of the event and triggered the process for the notification to be sent to the IHDs over the AMI network. Finally, the cockpit initiated the billing process by sending each customer account to a billing module in SAP that is designed to handle Conservation Days.

The figures below summarize the steps taken during a Conservation Day. The first figure outlines the operational process for internal notification of events, while the second figure outlines the process for notifying customers and triggering the billing process for the Conservation Day.

As noted in the Figure 22, internal stakeholders were notified of the Conservation Day prior to customer notifications, allowing all customer support teams several hours prior to customer notification to prepare for an increase in call volume prior to the event. The internal distribution list included Silver Springs Network and resources from more than half of SMUD's business units, including Contact Center, Information Technology, Billing, Pricing, Marketing, Market Research, Load Research and Forecasting, Energy Supply and Trading, Meter Shop, Media and Communications, the Board Office, Grid Assets, Customer Strategy, Residential Services, and Customer Facing Training.

Figure 23 indicates the process for executing an event in the SAP cockpit and the creation of the data files for each of the systems.

![SMUD logo]

Figure 22: Internal Event Notification Process Flow

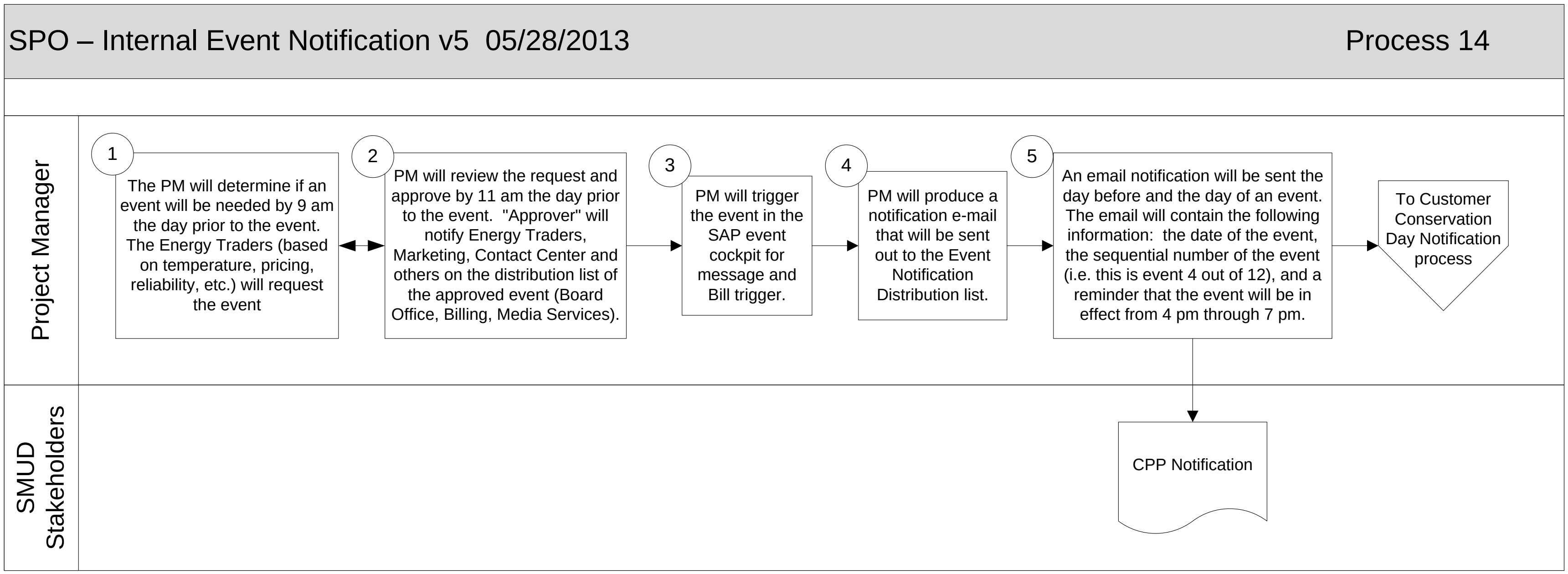
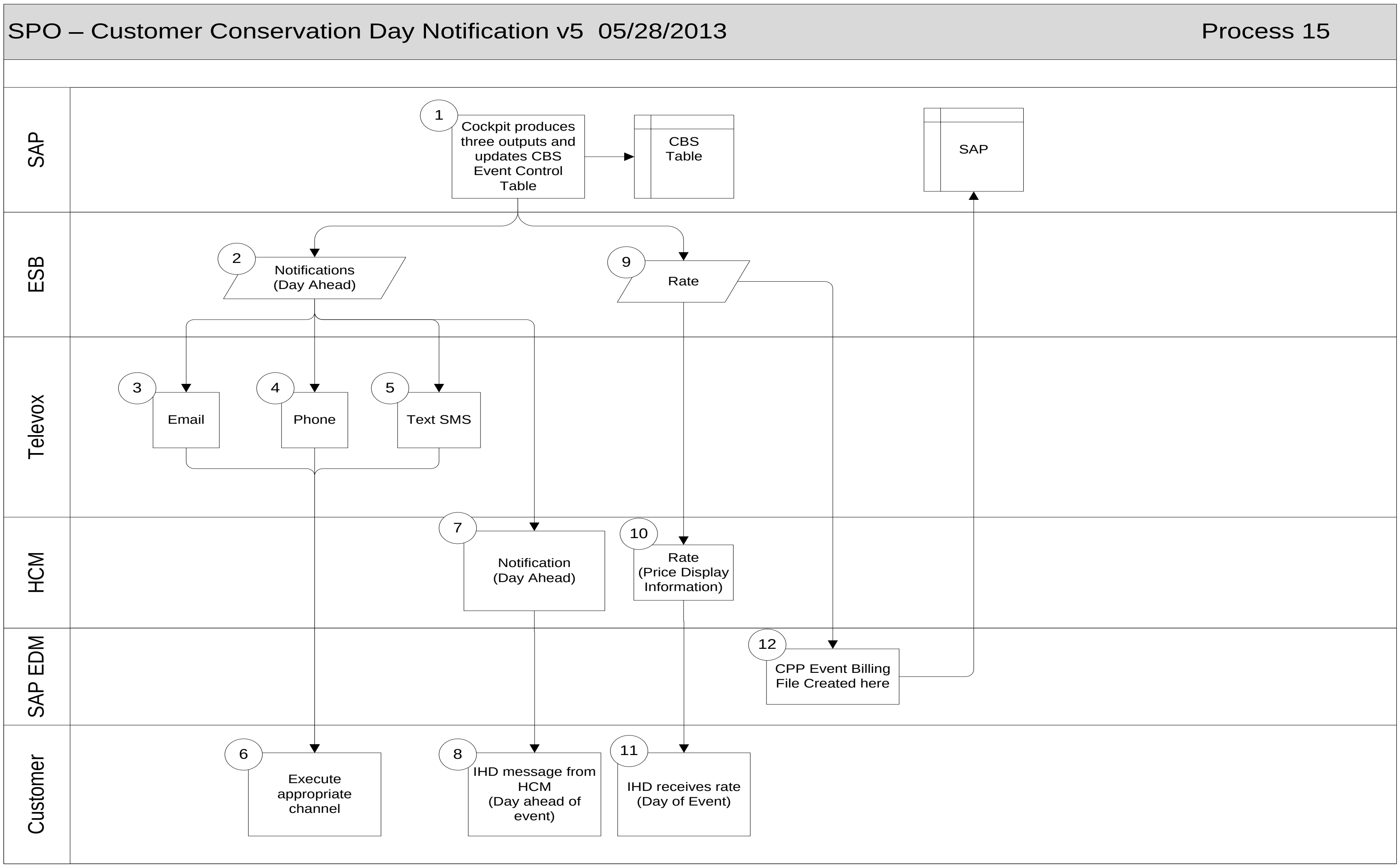


Figure 23: Customer Conservation Day Notification Process Flow



During enrollment, opt-in customers were required to provide an email address, a telephone number or an SMS number (for text messages) that could be used for notifications of the conservation days. For customers who were defaulted to their experimental rate, we asked that they update their preferences for notification online or by calling our contact center. This ensured that all default CPP customers would be sent a notice of each conservation day using their preferred channel. If a default customer did not provide us with contact information, we used the contact numbers on record for notification.

SMUD used a third party contractor to manage the notifications and informational message campaign for SmartPricing Options. The contractor was responsible for delivering the pre-recorded and pre-programmed messages to customers at least 24 hours in advance of the event. We worked with the vendor several months in advance to create the messages and prepare the systems for reporting the success or failure of each notification to the customer. At the beginning of the summer, we implemented a "day-ahead notification" and a "same-day notification" for the Conservation Days. After the first several events, we changed this process and eliminated the "same-day notification" based on customer feedback and complications we experienced in scheduling back to back events.

After the first event was called for June 20th, 2012, we became aware that several hundred customers were omitted from the process that enabled them to get day-ahead messages, and they were not notified of the conservation day. The entire CPP Without Technology treatment group did not receive their day-ahead message and therefore were not aware that event was going to occur. If these customers had logged onto the web portal that displayed their energy use, the conservation day would show up in their displayed data. The project team responded immediately by preparing the billing team to remove the omitted customers from the peak billing module and the communications team drafted letters to notify customers explaining what had occurred and ensuring they would not be charged for it. We sent out letters and emails that notified this group that they would not be charged.

Due to the potential bias introduced by the omitted treatment group, the research team determined that the best way to solve this problem was to call a separate conservation day unique to the treatment group that had been omitted in the first event. The following Friday, June 29, 2012 we called a conservation day for the only that treatment group to get them on the same schedule as the rest of the study participants. We decided at that point to remove the first conservation day from the load impact evaluation. Although this wasn't ideal from the experimental design perspective, it was a valuable learning experience as related to program implementation.

A second challenge we experienced with the conservation days was with the HAN Communication Manager (HCM), the tool we use to push pricing and messages to our customers over the In Home Displays. When we prepared for the 4,500 IHDs and testing the functionality of sending messages to the devices, we were not able to test the system for volume. As a result, we were not sure how the system would behave when we attempted to send 3,000 messages and pricing out to our customers devices over the ZigBee network simultaneously. When we scheduled the first event, the system bogged down under the volume of tasks it needed to perform and was unable to complete the scheduled tasks. We were not able to send pricing information out to all customers for that first event.

After conducting an assessment, we determined that we would need to stage messaging and pricing in smaller batches to increase system stability. This approach solved the problem. Too much traffic from the first event made the system unpredictable, while staggering the messaging and pricing over the course of several hours significantly increased stability so that customers received their notifications and pricing information to the IHDs.

After resolving issues in the first event, processes were updated resulting in much better system performance. The remaining conservation days were called without significant interference. In one instance the wrong date was merged into the event notification due to a programming error with vendor's dispatch. In this case, customers contacted SMUD for clarification. We responded by using our outbound calling vendor to make human phone calls to customers clarifying the correct date for the conservation day. We were able to dispatch and complete the outbound calling campaign in a matter of hours, so customer concerns were addressed quite quickly. The value of having an outbound calling resource on-hand did not go unrecognized by the project team; had we not had the ability to call customers immediately, it is likely that we may have backed out yet a second conservation day due to only a minor typo in the mass communication. This situation also highlighted the value of adding internal staff to the group of recipients who received messaging in exactly the same manner customers would receive it to allow for immediate verification of messaging accuracy and delivery.

We received notable feedback from our customers regarding the same day notification of the event. Our practice for the first few events had been to send a day-ahead message and follow up on the day of an event with a reminder notice. Customer feedback indicated that this was excessive and that the day-ahead message was adequate. After the 3rd conservation day, we stopped sending out the same-day notification and relied only on the day ahead messaging.

Managing the messaging and notification for the Conservation Days was significantly more challenging than the project team anticipated in the planning phase of the project. Many of the processes that we had set up to be automated had to be modified and thus became manual processes that required staff to intervene and execute. By the end of the summer, we had successfully implemented all of the conservation days, but the staff time required to complete each event was much greater than originally planned.

10.3 Quality Assurance

In order to ensure that all customers on the CPP and TOU-CPP rate had received notice of the event 24 hours in advance, we had to check the list of delivered messages against the list of customers that had signed up for the messages. This was done after each event was called.

For each CPP event that was called, a CPP implementation team was on standby to receive to perform QA checks and ensure processes went through as scheduled for the event. All events were coordinated by the project manager, and all confirmations were communicated to the entire team. While the process was fairly informal when the rates first went into effect, this process was improved over time, including formal notifications, increased accountability, and standardized quality checks by specified team members. Improvements were formalized at the end of the first year in preparation for the second summer of the pilot.

Additionally, a group of SMUD employee customers agreed to sign up on the rate plans as “friendly” participants. These employees received the messages and let the project manager know what time each message arrived and if there were any problems with the messages that were delivered. This alerted the project team of the issues encountered discussed earlier in this section, and we were better prepared to handle customer calls. The team was able to take action in advance of customer calls and alert the contact center to prepare for high call volumes.

10.4 Lessons Learned and Key Takeaways

Our early events allowed for us to learn a great deal about how to best prepare for messaging and events. When dealing with high volumes of messages over any channel, whether phone, email, or home area network, the best practice we found is to stagger message deployment. The systems are better able to handle the volume.

We also learned it is very valuable to have employees who receive the messages for each channel. This ensures that a number of people can experience the messages in the same environment as the participants. Even if one person receives a message successfully, another customer could experience problems, as we learned.

The most important lesson that we learned was having a back up plan for when things go wrong. Although we didn't have a method to cancel events because our business rules stated that events would not be canceled once initiated, we had to establish processes to handle when event notification did not go as planned. We created a manual process to upload the billing for the event, so that each customer was loaded into our CIS system after each event, allowing for us to exclude some customers if we needed to. We also had a contractor available who could execute an outbound calling campaign to notify customers of any necessary messages. We created a template for email to send to customers and staffed extra resources for handling emails from customers.

Finally, we have worked very closely with our contractor for messaging and notifications to run regression testing on the messaging campaigns and coding for each of the conservation day events. We asked for detailed reports on these tests and were heavily involved in their in the QA processes for the code testing. This has improved the implementation.

10.5 Additional Areas of Interest and Future Research

The process for SMS messaging with our current vendor has limitations that have not allowed us to have a robust messaging campaign over this channel. We would like to expand the messaging over this channel and see if we could obtain more subscribers. Customer Satisfaction Survey Wave I indicated that SMS is the preferred method of communication among younger pilot participants and it is of interest to see if a greater subscription to this channel would have any effect on load impacts.

11.0 Data Management

11.1 Overview

> *Today, data storage is cheap and labor hours are expensive. Trying to piece together data that weren't directly collected and stored at the time of generation is a costly endeavor.*

Throughout the SmartPricing Options pilot, vast amounts of data were generated, organized, and utilized for planning, implementation and evaluation of the pilot. Establishing data management protocols was an important step in each stage of the project to ensure proper execution of the study, optimize the customer experience, and make possible a robust and reliable evaluation.

Given the complexity of the SmartPricing Options study design, and the number of other Smart Grid Investment Grant pilots at SMUD running in parallel, the SmartPricing Options study sample needed to be generated and handled with great attention to detail. The entire sample frame required isolation from other pilot programs and marketing efforts to avoid contamination of the study design. Additionally, each treatment cell needed complete isolation of one another to maintain the integrity of the research study design with regards to marketing and communication materials. Data collection and organization was essential for analysis of the load impacts of the rates, as well the customer acceptance of time-varying rates and IHDs. These data were also used to track operational metrics of interest such as impacts to call volume in the Contact Center. Data were stored, organized, filtered, manipulated, and cleaned using a combination of tools, including Excel spreadsheets, Access databases and Python scripts.

11.2 Details

11.2.1 Sample Generation

The SmartPricing Options sample was generated in October, 2011 using SAS and extracted to Excel. This master list was considered the data of record for the sample frame and stored in a limited access location where it was not permitted to be altered. As needed, the file was copied into databases for manipulation and to generate other lists, but it was never directly modified.

11.2.2 Recruitment and Retention Marketing Data

The most common use of the master sample frame file was to maintain the isolation and integrity of each treatment cell during the recruitment and ongoing retention marketing campaigns. The recruitment campaign was one of the most complex processes of the pilot for data management. When enrollment peaked, we were enrolling over 120 customers per day from four different sources.

The enrollment lists were generated from SAP each day for the outbound calling campaign. This required daily management to prevent the outbound calling campaign files from conflicting with the direct mail campaign to ensure recruitment materials would not be sent to customers who had already signed up or had indicated that they would not like to receive materials from SMUD. This was achieved using the following methods.

- Filtering the master sample list using the latest enrollment, opt-out report and “do not contact” reports
- Creating separate mailing lists for each treatment cell
- Labeling and archiving the mailing lists for tracking and analysis purposes

Mailing lists for retention materials also utilized the master sample frame file and filtered as appropriate relative to the marketing materials. For example, a postcard reminding customers to turn on their IHDs required several filters to ensure that only active SmartPricing Options customers with IHDs received a reminder. For evaluation and analysis purposes, these mailing lists were also tracked and archived in Excel spreadsheets.

11.2.3 Hourly Interval and Billing Data

SMUD now collects hourly interval usage data for all residential customers. Interval data are processed and stored on the SMUD IT network on a monthly basis. Usage data for the study sample were stored in hourly intervals and are available for one year prior to and throughout the duration of the study period.

The Meter Data Management System (MDMS) runs an automatic data validation, estimation and editing (VEE) for the interval data. Once the data have gone through the VEE process, any exceptions are handled by an analyst on the Metering Programs team. Once a month, the data are transported to a mirror database that houses the interval data for analysis. The mirror system allows for SMUD staff to access the data as needed without causing heavy traffic on the MDMS system. The mirror system is then connected to SAS for analytical purposes. In addition to providing the SMUD users access to the data without interrupting other MDMS processes, this leaves the data of record in the MDMS where it is safe from modification.

11.2.4 Evaluation Preparation

For the interim pilot evaluation, all of SPO's data had to be organized, consolidated and checked for errors. Table 27 indicates which data files were submitted to Freeman, Sullivan & Co., SMUD's third party evaluator for the load impact portion of the evaluation.

Table 27: Interim Evaluation Data Files

Data Sets	Description
Master Sample	Record of all customers in the SmartPricing Options sample frame
Hourly Interval Load Data	Hourly kWh readings for each customer for 2011 and 2012 summers
Monthly Billing Data	Monthly usage and bill amounts of each customer in the sample for 2011 and 2012
Weather Data	Hourly air temperature readings that represent SMUD's service territory
Marketing Data	Record of each collateral piece sent to each customer
Enrollment, Opted Out, Deferred Report	Daily current status report of each customer who was enrolled, opted-out, or deferred
CPP notifications report	Record of each Conservation Day notification sent for each customer by channel
IHD Signup Report	Record of each customer who signed up to receive an IHD
Third Party Demographic Data	Demographic data for the SmartPricing Options sample frame
Demographics Survey Data	Responses to demographic survey of SmartPricing Options sample
Outbound Calls Report	Record of each outbound recruitment call that was made
Customer Satisfaction Survey Data	Results of a two waves of surveys of SmartPricing Options sample
Technology Assessment survey Data	Results of a survey of SmartPricing Options sample
My Account Data	Record of each My Account login and My Usage graph view by SmartPricing Options customers
Contact Center Data	Daily volumes and handle times for calls to the contact center from SmartPricing Options customers

11.3 Quality Assurance

Quality assurance is an essential component of data management and having clean, high quality data files was identified as a key objective of the data management work performed for SmartPricing Options. This process began with sample selection.

11.3.1 Generating the Master List

The master sample file was generated, administered and maintained by a single team member at the supervisory level to ensure prevent any accidental alterations or corruptions, and convenience copies could always be re-pulled for manipulation in the event of a processing error. As appropriate, the master file was copied and distributed to specific team members to generate lists for implementation and analysis. Convenience copies were not to passed from group to group; if a copy of the master list was needed, a request of the master list administrator was required. This request process assisted in access management and the prevention of accidentally using an altered convenience copy.

11.3.2 Pulling Mailing Lists

When mailing lists were generated, several checks existed to minimize cross-contaminating treatment cells and spamming customers with irrelevant information. At the time of generation, each mailing list was validated by comparing the total number of mailing recipients against a weekly enrollment report. This served as the most basic logic check, confirming that the number of recipients in each treatment group was in an acceptable range.

SMUD customers have multiple unique identification fields that address different levels of the customer's account. For example, one field captures all current residences under a particular account holder, meaning that several addresses may have the same identifier. Another field, however, is unique to the specific account holder at an individual residence, at a given point in time. This field has only one occurrence of each identifier per residence. These layers of identification can be a source of error when referencing non-dynamic tables, such as the master sample file.

Customers were not permitted to take the SmartPricing Options rate with them if they changed residences, so particular caution was taken when pulling data from district-wide tables to ensure a customer who had been on an SmartPricing Options rate but later moved was not being flagged as a current participant. This was done by joining the master sample list to district-wide tables over several fields to ensure that a customer would only show up if they were under the same contract (the most discrete identification field) as shown in the master sample file. In addition to list validation, team members often performed spot checks on a few random customers within a mailing list to ensure that they belong in the list and will be receiving the correct marketing collateral. Finally, each mailing list would be reviewed for accuracy by several team members before being sent off to the mail house. This provided multiple opportunities to spot and correct errors.

11.3.3 Data Aggregation

Aggregating and managing data from a multitude of data sources was a significant undertaking. Table 28 represents types of data sources and how they were used in SPO:

Table 28: SmartPricing Options Data Source Summary

Data Source Type	Uses
District-Wide SQL Server Tables	Original sample, program participation rates, customer contact information
SAP Reports	Implementation data, enrollments, opt-outs, deferrals, outbound calls, technology signups, Conservation Day notifications
Vendor Reports	IHD join rates, Conservation Day notifications by customer, market research results and data files
User-Generated Lists	Marketing material mailings, “do not contact” lists, technology issue resolution lists

These tables and reports came in a wide variety of formats. Naming conventions and formats often varied based on the source. Below are two examples provided to illustrate the types of variance experienced across sources.

- **Naming Conventions:** The contract account field in one report might be labeled “Contract Account” while in another report could be labeled as “Cont_acc”. Assembling these reports for analysis required both manual and programmatic manipulation. The different formats include daily reports, cumulative reports, weekly reports, or “rolling window” weekly reports. This made aggregating data from a given set of reports a custom process that was often performed manually.

- **Formats:** A Daily Energy Saving Tips signup report, which came in a seven day rolling window, would report on the customers who enrolled in information tips from the last seven days. Aggregating signups required combining all of the daily reports then filtering out the duplicates as well as all of the meta-data that came along with each daily report.

Given these labor-intensive manual manipulations that were required to ensure consistency from file to file, future implementations of such a large scale pilot would be greatly served by developing consistent naming conventions and report formats that could be automatically generated or manipulated prior to report generation.

11.4 Lessons Learned

In implementing and analyzing a pilot that has generated large volumes of data, several lessons have been learned collectively by the SmartPricing Options team.

- **Collect and store all data possible**: During analysis, seemingly unimportant data can often play a vital role in developing detailed answers to primary and secondary research questions. This makes it important to record and store as much of the data generated as possible. Today, data storage is cheap and labor hours are expensive. Trying to piece together data that weren't directly collected and stored at the time of generation is a costly endeavor. Developing consistent and relational data schema and report formats for even obscure data sources can be worthwhile.

- **Consistent data schema**: Data that get passed between team members with different naming conventions for the same set of fields can cause simple, yet often hard to spot mistakes. Having automated reports and user generated lists follow a consistent naming convention can often prevent many of these problems, also making manipulating, managing and analyzing data easier and less error prone.

- **Version control**: One of the standout lessons is in regards to version control of data files, and consistency in naming conventions across different files and users. Searching through past emails and local folders then sorting by date modified is a poor substitute for version handling and tracking. As a list gets edited by team members then passed to other team members who may alter and return the file, the number of versions of the given file rapidly increases. If tracking using email records or personal file folders, there may not be dependable records regarding which file is in fact the latest or final. This can be resolved by working in a shared workspace, such as a shared folder or SharePoint, and only passing links to a file. Files saved in SharePoint can maintain version history, and various programs allow history and change tracking. This will ensure that all team members will access and reference the same, up-to-date file and that a single file gets archived. This ensures the correct file is easy to find when it needs to be revisited at a later date. Files should be saved to a central server that is backed up regularly by the system administrator.

- **Contractor reports**: Data collected by contractors involved in the implementation process has great value in ensuring the implementation process is going smoothly. Setting up reporting functionality and some high level analytics with a vendor ahead of time can greatly assist a project manager in identifying and addressing operational issues as they come up rather than after the fact.

- **Quality assurance protocols**: Having established, well understood quality assurance protocols from the query development process to the delivery of mail lists to the mail house will save time and money, resulting in higher quality research findings.

11.5 Additional Areas of Interest and Future Research

Centralizing Data Hosting and Data Requests

In the current data system, one team member may make a request for another team member to generate a list and email it to them. When this happens, the generated list "lives" on both team member's computers and the record of who made the request and who generated the list is buried within email chains. In addition, the actual details of how the list was generated may never have been recorded or may be very difficult to retrace. A shared database administered by a particular team member and accessible to all team members that is capable of tracking, and perhaps automating data requests, is an investment that may be worth considering. Requests can be directly saved to the end user's desired location thus reducing the versions and number of files passed via email. Requiring team members to place "formal" data requests provides the ability to log and track data requests for future auditing and quality assurance purposes. There are also potential efficiency gains since common requests can be developed and tested once, then used by any team member with confidence.

SAP Reports

The SAP reports generated for SmartPricing Options often required several steps of merging and manipulation to be formatted in a manner useful for delivery and analytics. The SAP reports typically occurred daily or weekly, and were written to csv files that were accessible to SmartPricing Options team members. The formats of these csv files, however, varied and often contained data in a non-relational format. In addition, some reports were cumulative, some contained regular intervals, and others used a sliding window. These different reporting formats each needed to be handled differently prior to importing into a relational database. Having a relational database set up to which SAP reporting tools directly write data would save these steps and allow for queries based on SAP reports to be up to date.

SECTION III: INTERIM LOAD IMPACT EVALUATION

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SMUD Smart Pricing Option Pilot

Interim Load Impact Evaluation

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Table of Contents

1 Executive Summary

This document presents the interim impact evaluation for Sacramento Municipal Utility District's (SMUD) SmartPricing Options (SPO) pilot. SPO is a multi-year pricing pilot that is testing several time-variant rate options, different recruitment strategies and real time information feedback. The SPO pilot includes:

- Three rate options: time-of-use (TOU), critical peak pricing (CPP) and a TOU-CPP combination;
- Two recruitment strategies: opt-in and default (or opt-out);
- One technology offer: an In Home Display (IHD) that streams usage information to consumers in real time; and
- Three different experimental designs: Random Encouragement Design (RED), Randomized Control Trials (RCT) and Within-subjects.

1.1 Customer Acceptance of Time-Variant Rates

Although numerous pricing pilots and program evaluations have been implemented in the electricity industry in the last decade, most have focused on estimating the load impact of participating customers rather than on investigating the acceptance rate of customers who were offered time-variant rates under alternative marketing strategies. SPO is one of the few pilots to systematically examine the very important issue of customer acceptance of time-variant rates. Specifically, SPO allows for a comparison of:

- Acceptance rates for CPP and TOU rates based on opt-in and default enrollment and for the TOU-CPP rate based on default enrollment; and
- The impact of offering enabling technology, in the form of a free IHD, on customer acceptance of CPP and TOU rates.

Understanding if there are significant differences in acceptance rates for various forms of time-variant rates, how acceptance rates (and demand response impacts) differ between default and opt-in marketing, and whether offering an IHD to customers affects acceptance rates, are all critical issues in developing an effective pricing strategy. Findings from the SPO pilot provide some of the first and best empirical evidence to help settle debates about these issues that have been waged for more than a decade based largely on assumptions, assertions and, at best, qualitative evidence from focus groups.

Table 1-1 shows the customer acceptance rates for each SPO treatment. Among the most important findings are:

- SMUD's multi-faceted marketing strategy for opt-in tariffs led to acceptance rates that ranged from 16.4% to 18.8%. These high acceptance rates contradict the often cited claim that very few customers will voluntarily enroll on time-variant rates.
- The offer of enabling technology in the form of a free IHD did not materially increase customer acceptance of either the CPP or TOU rate.

- The default treatment groups display extremely high enrollment rates, ranging from a low of almost 93% for the TOU-CPP rate to a high of almost 98% for the TOU rate.
- Once enrolled, less than 2% of opt-in customers chose to leave the selected rate over the course of the 2012 summer.[1] For default enrollment, the attrition rate ranged from 2.0% to 3.6%, which was slightly higher than, but comparable to, that of opt-in customers.

Table 1-1: Customer Acceptance Rates for SPO Treatments

Marketing Approach	Rate	IHD Offer	Acceptance Rate
Opt-in	CPP	No	18.8%
		Yes	18.2%
	TOU	No	16.4%
		Yes	17.5%
Default	CPP	Yes	95.9%
	TOU	Yes	97.6%
	TOU-CPP	Yes	92.9%

1.2 TOU Rate Impacts

The TOU peak period covers 4 to 7 PM on all non-holiday weekdays from June through September. During the peak period, the price per kWh is $0.27 for standard customers, which is 1.6 to 3 times higher than the off-peak price, depending on whether a customer's energy use puts them in usage tier 1 or 2.[2]

Table 1-2 shows the average estimated absolute and percentage load impact across all summer peak hours for the TOU treatment options. The largest load impact was provided by the opt-in group that was offered an IHD.[3] The 0.24 kW average hourly impact is equal to a reduction of approximately 13% in whole-house peak-period electricity use. The opt-in group that was not offered an IHD showed a lower average impact of 0.17 kW, or 10% of peak-period electricity use, which was statistically different at the 95% confidence level from the opt-in group that was offered an IHD. Both default groups showed lower average impacts per customer than the opt-in group that received an IHD offer, and these differences were statistically significant. The difference in impacts between default TOU and default TOU-CPP was not statistically significant.

[1] A greater number of customers left the rate because of account closures due to customer relocation.

[2] EAPR (Energy Assistance Program Rate) customers are subject to a different rate that has a peak period price of $0.20/kWh.

[3] Importantly, any differences in load impacts for treatment groups that did and did not receive an IHD offer should not be interpreted as the incremental effect of the IHD on load reduction. See the discussion in Section 1.4 and the much more detailed discussion in Section 8 for insight into the estimated load impact of IHDs.

Table 1-2: Average Peak Period Load Impacts for TOU Rate Treatments

Group	Average Impact per Enrolled Customer (kW)	95% CI[4] Lower	95% CI Upper	Reference Load (kW)	Impact as % of Reference Load
Opt-in TOU, No IHD Offer	0.17	0.13	0.22	1.71	10%
Opt-in TOU, IHD Offer	0.24	0.19	0.28	1.80	13%
Default TOU, IHD Offer	0.12	0.09	0.15	1.87	6%
Default TOU-CPP, IHD Offer	0.16	0.11	0.21	1.90	8%

Analysis of TOU impacts outside of the peak period showed no evidence of load shifting. That is, peak period impacts appear to come primarily from reductions in peak period use without commensurate increases in off-peak use. While the estimated reduction in monthly energy use was not found to be statistically significant, the findings suggest that there is a modest level of overall conservation. It is reasonable to conclude that the estimated conservation effect is not due to random chance since all of the estimated monthly impacts were in the same direction, the peak period load reductions are significant, and load shifting is absent.

A critical policy issue is whether aggregate demand reduction is likely to be greater based on opt-in or default enrollment of time-variant rates. While the average impact per customer for default TOU is lower, the acceptance rate is much higher among default customers than opt-in customers. The opt-in acceptance rate for TOU with an IHD offer was 17.5% whereas the initial acceptance (prior to the rate going into effect) of the default TOU with an IHD offer was 97%. Thus, if 100,000 customers who met the sample selection criteria had been offered TOU on an opt-in basis during the pilot period compared to defaulting 100,000 customers onto the rate and allowing them to drop out, the aggregate peak-period load reduction would have equaled roughly 4.2 MW (0.24 kW x 100,000 x .175) for the opt-in program, ±0.5 MW, and nearly three times as much for the default program, at 11.4 MW (0.12 kW x 100,000 x .97), ±2.2 MW.[5]

1.3 CPP Rate Impacts

The peak period for the CPP rate treatments is the same as for the TOU rate treatments, 4 to 7 PM. The electricity price during the peak period on CPP event days is $0.75/kWh. Over the 2012 summer, 12 CPP event days were called.[6]

Table 1-3 shows the average impact across all event hours in 2012 for each CPP treatment group. The largest observed load reduction is for the opt-in CPP treatment that received an IHD offer, which produced an average reduction of almost 0.70 kW per enrolled participant, or about 26% of whole-

[4] CI stands for confidence interval.

[5] In this example, the 95% confidence interval for the opt-in program is from 3.6 MW to 4.7 MW. The 95% confidence interval for the default program is 9.2 MW to 13.7 MW. The mean values for each rate differ slightly from the values determined from the calculations shown in the parentheses due to rounding.

[6] On the first event day, June 20, 2012, customer notifications did not go out to everyone. However, to ensure that all customers received 12 event notifications during the summer, for customers who did not receive notification for the June 20th event, an additional "first" event was called. Neither of these first events was included in the database when estimating impacts. The second event for all customers occurred on July 10th .

house reference load. The opt-in CPP group that was not offered an IHD had a slightly lower average impact of 0.52 kW, or 22% of household load, but the difference in impacts between the groups with and without the IHD offer was not statistically significant. The average load reduction for the two default options, CPP and TOU-CPP, are nearly identical to each other but are about half the size of the average load reduction for the opt-in groups. The difference in impacts between the opt-in and default groups is statistically significant.

Table 1-3: Average Peak Period Load Impacts for CPP Rate Treatments

Group	Average CPP Impact Per Enrolled Customer (kW)	95% CI Lower	95% CI Upper	Reference Load (kW)	Average Impact as % of Reference Load
Opt-in CPP, No IHD Offer	0.52	0.26	0.78	2.38	22%
Opt-in CPP, IHD Offer	0.69	0.58	0.79	2.62	26%
Default CPP, IHD Offer	0.32	0.24	0.40	2.64	12%
Default TOU-CPP, IHD Offer	0.33	0.25	0.41	2.60	13%

Analysis was conducted to determine if there were any significant changes in electricity use outside of the peak period on CPP event days or whether an overall conservation effect was found. The only treatment group that showed changes outside the CPP day peak period was the opt-in CPP group that was offered an IHD. This group had lower usage in the two hours preceding and following the event period on CPP days and also during the peak period on nonevent days, suggesting behavioral changes were made on event days that carried over to other weekdays. There was also a modest overall conservation impact for this group.

Given the significant difference in the number of enrolled customers between the opt-in and default CPP rate, these results suggest strongly that a default rate program would produce much larger aggregate impacts than an opt-in program. Indeed, when combined with the customer acceptance rates shown in Table 1-1, if a CPP rate with an IHD offer was made to 100,000 customers on both an opt-in and default basis, the estimated average load reduction on event days would equal roughly 12.6 MW (100,000 x .182 x .69 kW), ±1.6 MW for the opt-in rate and 30.7 MW (100,000 x .959 x .32 kW), ±6.6 MW, for the default rate. Notably, mean load impacts for the default CPP rate would be almost three times larger than the 11.6 MW mean load reduction estimated for default TOU, based on specific prices tested in the SPO pilot. [7]

1.4 Customer Acceptance and Impact of In Home Displays

The SPO pilot tested the impact of the offer of an IHD on customer acceptance of opt-in CPP and TOU rates. It was also designed to determine if there are differences in load impacts for customers who were offered an IHD as part of the rate offer, and those who were not offered an IHD as part of the rate offer. Importantly, testing the load impact of an IHD offer is different from testing the load impact of an IHD, because there were people that were offered an IHD did not accept one and many

[7] In this example, the 95% confidence interval for the opt-in program is from 10.9 MW to 14.2 MW. The 95% confidence interval for the default program is from 24.0 MW to 37.2 MW.

who accepted an IHD did not use it. To keep costs and logistics manageable, SPO was designed to determine if load reductions differ between treatment groups that were and were not offered an IHD, not if load reductions differed between customers who accepted and used an IHD and those who did not. Nevertheless, as discussed below, an analysis of the impact of accepting an IHD was also conducted using a quasi-experimental comparison.

The IHD was offered free of charge and a pre-commissioned device[8] was mailed to customers who requested it. Interest in receiving an IHD for opt-in treatments was assessed at the time of enrollment and nearly all opt-in customers indicated they would like to receive one. Default customers received a solicitation of interest shortly before they were scheduled to go on the rate and the majority did not accept the offer.

Table 1-4 shows the percent of customers on each rate option that solicited an IHD, the maximum percent of customers who received an IHD that had the device connected during the summer, the percent who asked to receive the device that were connected at the end of the summer and the percent of all customers on the rate at the end of the summer that had the IHD connected to the meter. Each of these values is different but all are of interest.

Table 1-4: IHD Acceptance and Connection Rates

Treatment Group	% of Customers Who Asked to Receive IHD	Max. # of IHDs Connected as % of Those Who Asked	% of Those Who Asked for IHD that Were Connected on 9/30/12	% of All Customers on Rate With IHDs Activated on 9/30/12
Opt-in CPP, IHD Offer	95%	39%	28%	27%
Opt-in TOU, IHD Offer	96%	38%	29%	28%
Default CPP & TOU, IHD Offer	23%	60%	49%	11%
Default CPP, IHD Offer	24%	54%	40%	10%
Default TOU, IHD Offer	21%	45%	38%	8%

Key findings from the IHD offers include:

- Almost all customers who enrolled on an opt-in tariff asked for and received an IHD. For this group, asking to receive an IHD was done at the time of enrollment and required essentially no incremental effort over and above what was required to enroll on the rate.
- For default customers, transaction costs associated with asking for an IHD were greater and less than one quarter of these customers asked to receive one.
- Fewer opt-in customers who asked to receive an IHD successfully connected the device to their meter compared with default customers who asked to receive an IHD. One hypothesis that is consistent with this finding is that default customers who asked to receive an IHD had greater interest in receiving one and therefore were more likely to use it once it was received.

[8] Pre-commissioned means that the device is programmed to connect to a consumer's meter once it is turned on. While distance from the meter, structural materials and other factors can result in signal failure, pre-commissioning is intended to make using an IHD as simple as possible for participating consumers. Importantly, this approach does not require consumers to incur the transaction costs associated with having a professional installer come to their home and commission the IHD.

Opt-in rate customers may not have given as much thought to the decision because it was so easy to say yes at the time of enrollment, which would explain the lower connection rate.

- When the percent of customers who asked to receive an IHD is combined with the percent of devices that were connected at the end of the summer period, only between 8% and 28% of all customers on each rate treatment had an IHD connected to their meter on September 30, 2012.

Comparisons of peak-period load impacts between TOU and CPP groups who did and did not receive an IHD offer show that, on average, those receiving an IHD offer had larger load reductions compared with those that did not. These differences were not statistically significant for the CPP rate. For the TOU rate, they were statistically significant, even after adjusting for pretreatment differences between the two treatment groups. However, the difference was small and attributing this difference to the use of an IHD requires restrictive assumptions that suggest significant caution be applied when interpreting this as an IHD effect, rather than an IHD offer effect. In addition to the above analysis, the SPO also found that the decision to accept the offer of an IHD is strongly correlated with a customer being more likely to respond to the SPO price signals. This additional analysis, as detailed in Section 8 of this report, found that customers that were offered and accepted the IHDs show a clear behavioral response to the price signals during the peak period while those who declined the offer show little if any response.

1.5 Comparative Analysis of Impact Evaluation Methods

SPO was designed to allow for estimation of load impacts based on RCT and RED analysis methods except for two treatment cells that were designed to rely on within-subjects methods. When RCT and RED designs are used and implemented as designed, they produce the most accurate impact estimates possible.

For many utilities, it is not always feasible to implement RCT or RED designs due to time and budget constraints or other practical concerns (e.g., not wanting to deny treatment to volunteers in order to develop a valid control group). In these cases, alternative evaluation methods are often used. Two of the most commonly used methods are within-subjects designs and matched control group methods. Each of these methods attempts to construct an accurate counterfactual (reference load) in the absence of a randomly chosen control group by relying on modeling. Within-subjects methods estimate the counterfactual based on usage observed by treatment group customers during nonevent periods that are chosen and/or adjusted to be similar to event periods in expected usage aside from the event. Matched control group methods estimate the counterfactual based on average for a control group chosen using statistical methods to identify customers with similar characteristics to treatment customers based on observable variables, including similar usage at nonevent times.

SPO provides a very rare opportunity to compare impact estimates based on different analysis methods. Section 9 of this report compares load impact estimates based on three different methodologies for a CPP treatment – within-subjects analysis, difference-in-differences estimation based on a control group selected using statistical matching, and difference-in-differences analysis based on an RED. For a TOU treatment, comparisons were made for two methodologies – matching and an RCT – both using difference-in-differences estimation procedures.

For an event-based tariff such as CPP, the biggest risk to producing unbiased, event-day load impact estimates using both types of quasi-experimental methods is that the necessary assumption that there are no load impacts on nonevent days may not be true. This risk is present whenever pretreatment data is not available. In the treatment used for this analysis, this assumption was violated and the estimated event-day load impacts using the quasi-experimental methods were biased downward in all scenarios in which pretreatment data were not used. The absence of pretreatment data represents the most common scenario for CPP impact evaluations that have been conducted in the industry to date, but may be less prevalent in the future as rate programs are implemented by utilities that have had advanced meter deployments in place long enough to generate pretreatment data for customers signing up for the new tariffs.

With or without the existence of pretreatment data, within-subjects analysis is subject to model specification error. Modeling the relationship between weather and load is challenging. In the analysis presented here for the CPP rate, in spite of using cross-validation methods to test numerous models and multiple datasets consisting of different proxy days, the impact estimates differed from the RED estimates even when pretreatment data was available. This was true, at least in part, because event days were preceded by much hotter days than proxy days, which led to much higher event-day reference loads than predicted by the best fitting model. In this case, estimates based on propensity matching along with difference-in-differences regression analysis using pretreatment data did much better because this methodology does not rely on modeling the relationship between weather and load. If pretreatment interval data exists, we believe propensity matching with difference-in-differences analysis is superior to within-subjects analysis both because it does not require modeling the relationship between weather and load and also because it does not require assuming that nonevent day loads are unaffected by the CPP rate. Even in the absence of pretreatment data, propensity matching may be superior because it does not require modeling weather effects, although it can produce biased impacts if nonevent day loads change as a result of the treatment.

The comparative methods analysis for the TOU rate showed statistically significant differences in average load impacts based on RCT analysis and analysis using a control group selected based on propensity score matching and impact estimation using difference-in-differences calculations. Two matching scenarios were examined, one in which pretreatment interval data was available and one in which the matching was based on pretreatment monthly usage data. The latter has been the more common application of matching in the industry to date but matching using interval data should be more common in the future.

It is difficult to know why the impact estimates using matching are not more closely aligned with the RCT estimates in this instance. The matching process was relatively good although different propensity models could produce better matches and possibly lead to different estimates. Importantly, in the absence of having the RCT results with which to compare, many researchers might not have looked for a better match even with the best pretreatment data available because a comparison of treatment and control group loads in the pretreatment period was quite good. In the absence of an RCT or RED evaluation design, statistical matching is really the only approach that can be used for TOU rate analysis. In light of the findings here, when possible, we suggest producing impact estimates based on multiple matching algorithms to see how robust the estimates are. If different algorithms produce similar results, there should be greater confidence that the estimated impacts are reasonably accurate. If estimates based on multiple algorithms are quite different, this uncertainty should be factored into any policy decisions based on the estimates.

The analysis presented Section 9 demonstrates the superiority of sound experimental design when estimating load impacts from time-variant rates and other policies designed to change the timing and amount of electricity use among consumers. Although the specific results regarding the relative performance of these designs cannot be generalized, we believe they still validate DOE's objectives in funding numerous consumer behavior studies based on rigorous experimental designs and the diligence of SMUD in rigorously adhering to sound design principles in implementing the SPO pilot.

2 Introduction and Pilot Overview

SMUD is located in California's Central Valley where hot summer temperatures and a very high saturation of air conditioning equipment result in peak load requirements concentrated over a relatively short number of hours. SMUD has approximately 530,000 residential customers and a peak load of roughly 3,000 MW. The top 42 hours of system load each year account for approximately 400 MW of incremental load on the system.

The primary objective of SPO is to investigate the effectiveness of AMI-enabled time-variant pricing and enhanced information to induce behavior change in electricity consumers. Of particular interest is reduction in peak-period electricity use. By implementing time-variant pricing, SMUD seeks to:

- Provide a clear high price signal to consumers during SMUD's summer peak period;
- Encourage customers to shift loads by lowering prices during non-peak periods; and
- Assure that customers who choose not to shift, or cannot shift load, are not penalized with bills that are significantly higher than they would be on SMUD's otherwise applicable rate.

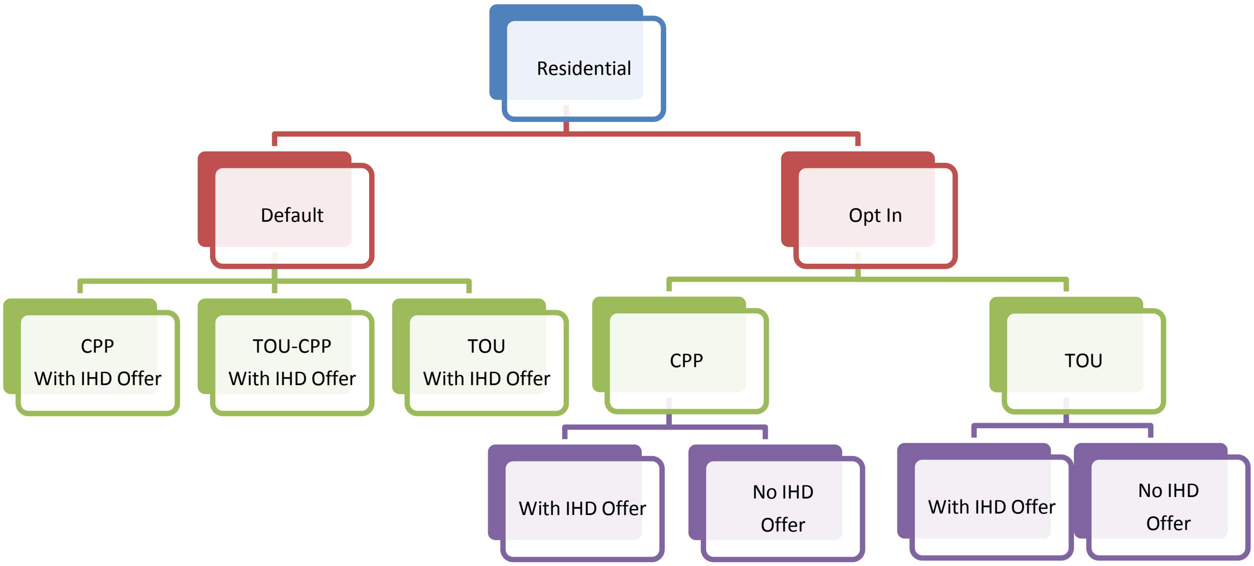
SMUD's SPO is 1 of 11 Consumer Behavior Studies funded by the U.S. Department of Energy (DOE) in an effort to assess customers' response to time-variant rates and increased access to information about electricity consumption. SPO is also one of the major components of SMUD's SmartSacramento®[9] project. The SmartSacramento smart grid project embodies SMUD's public spirit and mission to empower its customers with solutions and options that increase energy efficiency, protect the environment, reduce global warming and lower the cost to serve. When completed, SMUD's comprehensive smart grid will be a customer-centric system designed to enable informed participation by customers as well as the creation of new customer services and solutions. In addition, the project will improve the reliability and efficiency of utility operations, facilitate integration of distributed and intermittent forms of clean and renewable energy, and optimize asset utilization along the entire energy chain—from electricity generation to the air conditioning unit in a customer's home.

Figure 2-1 summarizes the key features of the SPO pilot, which include:

- Three rate options: time-of-use (TOU), critical peak pricing (CPP) and a TOU-CPP combination;
- Two recruitment strategies: opt-in and default (or opt-out);
- One technology offer: an In Home Display (IHD) that streams usage information to consumers in real time; and
- Three different experimental designs: Random Encouragement Design (RED), Randomized Control Trials (RCT) and Within-subjects.

[9] A registered service mark of the Sacramento Municipal Utility District.

Figure 2-1: Overview of SPO Treatments



2.1 Rate Design Options

The SMUD Board of Directors approved SPO in August 2011. SPO rate options are applicable during the summer months of June through September. Participants revert to their otherwise applicable rate schedule during non-summer months. Participating customers were first placed on the SPO rates on June 1, 2012 and the pilot will end on September 30, 2013. The three rate options offered through the SPO pilot include:

- **TOU Rate Option:** Participants are charged an on-peak price of $0.27/kWh between the hours of 4 PM and 7 PM on weekdays, excluding holidays. For all other hours, participants are charged $0.085/kWh for the first 700 kWh in each billing period, with any additional usage billed at $0.166/kWh.
- **CPP Rate Option:** Participants are charged a price of $0.75/kWh during CPP event hours, when temperatures and SMUD's system loads are expected to be unusually high. SMUD plans to call 12 CPP events each year, between the hours of 4 PM and 7 PM on weekdays, excluding holidays. Customers are notified 24 hours in advance of an event day. For all other hours, participants are charged $0.085/kWh for the first 700 kWh in each billing period, with any additional usage billed at $0.167/kWh.
- **TOU-CPP Rate Option:** The third and final SPO rate combines the pricing structures of the TOU and CPP rate options. The TOU-CPP off-peak electricity rate is $0.072/kWh for the first 700 kWh in each billing period, with any additional off-peak usage billed at $0.141/kWh. Participants are charged an on-peak price of $0.27/kWh between the hours of 4 PM and 7 PM on weekdays, excluding holidays. A CPP price of $0.75/kWh is charged to participants between the hours of 4 PM and 7 PM on CPP event days, which will be called 12 times during the summer months. The 12 days are the same as those called for the CPP-only rate.

For all three SPO rate options, customers with domestic wells are allowed a base kWh usage up to 1,000 kWh per billing period (rather than 700 kWh). In addition, customers who are currently on the Energy Assistance Program Rate (EAPR) receive about a 30% discount on the price they pay for all SPO rates, depending on how much energy they use. Table 2-1 summarizes the prices in effect by rate period for each relevant rate, as well as for the standard SMUD rates.

Table 2-1: Electricity Prices by Rate Period and Tariff

Category	Rate	Fixed Charge	Critical Peak	On-peak	Off-peak Base	Off-peak Base Plus	Off-peak Non-discounted Base Plus
Regular Pricing	Standard	$10.00	–	–	$0.10	$0.18	–
	EAPR	$3.50	–	–	$0.07	$0.13	$0.18
SPO Pricing Standard	TOU	$10.00	–	$0.27	$0.08	$0.17	–
	CPP	$10.00	$0.75	–	$0.09	$0.17	–
	TOU-CPP	$10.00	$0.75	$0.27	$0.07	$0.14	–
SPO Pricing EAPR	TOU	$3.50	–	$0.20	$0.06	$0.12	$0.17
	CPP	$3.50	$0.50	–	$0.06	$0.12	$0.17
	TOU-CPP	$3.50	$0.50	$0.20	$0.05	$0.10	$0.15

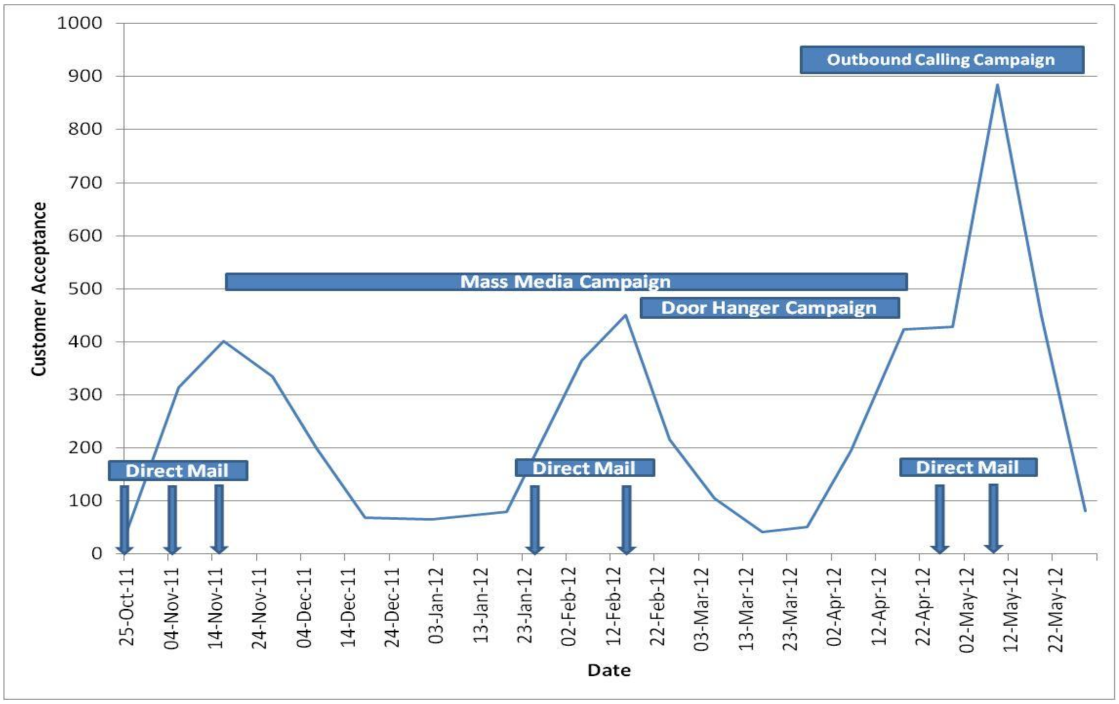
2.2 Marketing and Recruitment Strategies

In the SPO pilot, SMUD is examining two recruitment strategies: opt-in and default enrollment. Each customer chosen for inclusion in the pilot was randomly assigned to a treatment group and was then recruited for that specific rate/IHD offer/recruitment combination. Under the opt-in strategy, participants were invited to enroll in the pricing plan specific to their treatment group. Customers were solicited through a multi-faceted marketing campaign that involved direct mail letters, brochures, print ads, web-based marketing, SMUD website announcements, outbound calling and door hangers. The TOU-CPP rate was not offered on an opt-in basis. Opt-in recruitment began on October 24, 2011 and the various marketing activities were deployed in waves as depicted in Figure 2-2. Enrollment for opt-in cells largely ended on June 1, 2012.[10]

For default treatments, customers were placed on either TOU, CPP or TOU-CPP pricing plans and were told to contact SMUD if they did not wish to participate. Customers were initially notified of the change in their rate in early April 2012 and a follow-up notification occurred in early May. Welcome packets were sent to all customers on May 29, just prior to the new rates going into effect.

[10] A very small number of customers were enrolled after June 1.

Figure 2-2: Recruitment Timeline for Opt-in Treatment Cells



The two opt-in TOU treatment groups utilized a *recruit and delay* RCT design. Two randomly chosen groups of customers were chosen and recruited in the same manner. One group of volunteers were placed on the new rate on June 1 and the other group were told that their rate change would be deferred until summer 2014. The purpose of the deferred enrollment is to create a control group for each treatment group that allows for self selection but avoids selection bias in the estimated impacts.

SMUD spent a significant amount of time and money developing an effective marketing and educational campaign to encourage customer enrollment. From February through August 2011, SMUD conducted 25 focus groups and 4 surveys involving more than 2,000 customers to solicit input on marketing messages, naming conventions and other communication issues as input to the marketing and education plan. SMUD also focused significant effort and attention on maintaining consistency in communication and education across treatment cells in order to ensure that differences in enrollment rates and electricity use across rate options and other treatment conditions are due to differences in the treatments themselves and not due to differences in messaging or communication.

2.3 In Home Displays

Each of the default recruitment groups was offered a free IHD. For opt-in customers, both the TOU and CPP treatment groups were divided into two, with one group receiving an IHD offer and the other not. The IHDs allow participants to see the real-time (kW) and cumulative electricity (kWh) use of their home, the total cost of that respective electricity use and the prices that are in effect at any point in time. Figure 2-3 shows the IHD used in the SPO pilot. The purpose of the IHD offer was to examine its effect on customer acceptance and retention rates, program satisfaction and, where possible, electricity use.[11] For default customers, all of whom were offered an IHD, the intent was also to ensure that these customers were given tools to help them manage their energy use. Customers did not need to accept the IHD in order to participate in the pricing plan. The IHDs were preset to communicate with each customer's meter when they were turned on and were sent to customers through the mail.

Figure 2-3: In Home Display Used in SPO Pilot

Customers in the opt-in treatment cells were asked to indicate at the time of enrollment whether or not they wished to receive an IHD and almost everyone indicated they would. Customers in the default treatment cells were also asked to indicate their interest in receiving the IHD. However, default customers had to be more proactive than opt-in customers since they couldn't indicate their interest at the time of enrollment (because default customers didn't have to enroll). As a result, a little more than 20% of default customers asked for and received an IHD.

Not all customers who asked for an IHD used it. Indeed, of those who received an IHD, the maximum number of devices connected with meters at any point in time during the summer ranged from a low of 38% (for the opt-in TOU group) to a high of 60% (for the default TOU-CPP group). When the connection rates are combined with the acceptance rates, the maximum number of devices connected at any time during the summer ranged from a low of 9% (for default TOU) to a high of 38% (for opt-in CPP).

[11] As discussed in Section 1 and at greater length in subsequent sections, the SPO was designed to assess the impact of an IHD offer on electricity use, which is different from assessing the impact of an IHD on energy use.

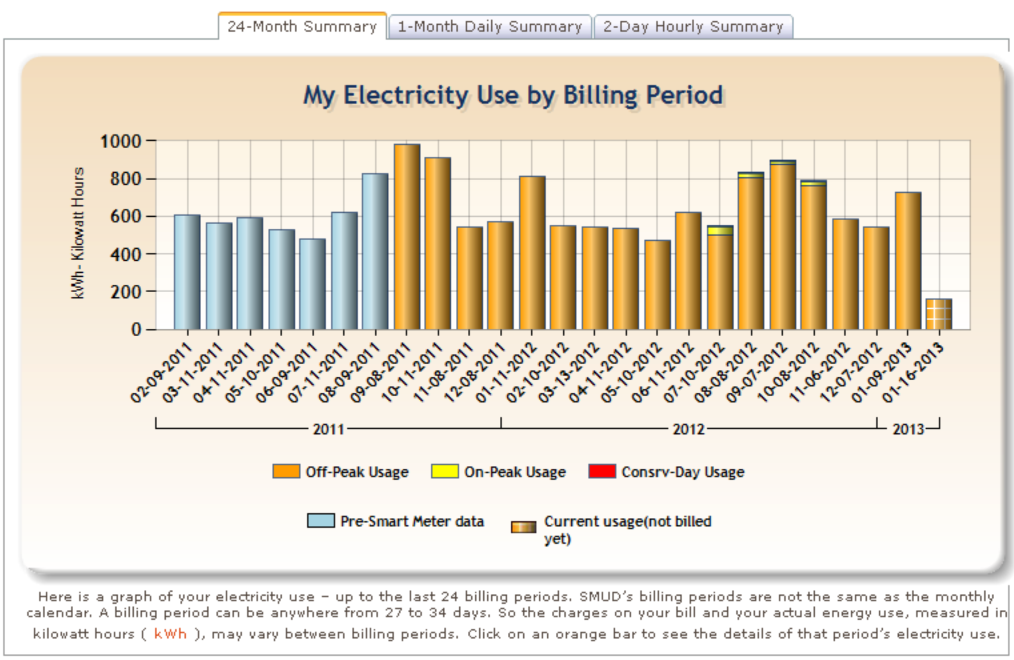
Table 2-2: Acceptance and Connection Rates for IHDs

Group	Enrolled 6/1/12	# Accepting IHD	Acceptance Rate	Maximum # of IHDs Activated	Maximum % of IHDs Activated	Maximum # Activated as % of All Enrolled
Opt-in CPP	1,569	1,498	95%	590	39%	38%
Opt-in TOU	2,092	2,017	96%	768	38%	37%
Default TOU-CPP	588	136	23%	81	60%	14%
Default CPP	701	167	24%	91	54%	13%
Default TOU	2,018	418	21%	190	45%	9%

2.4 Web Portal Information

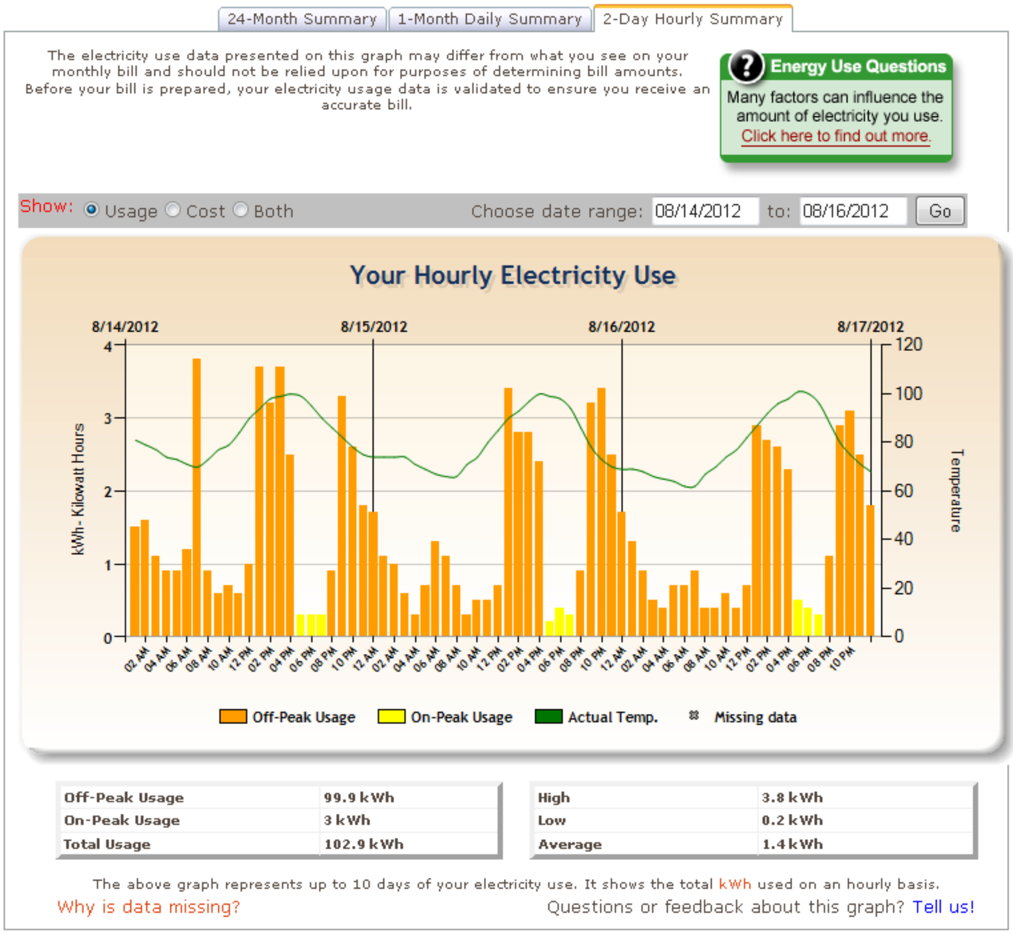
In addition to information provided in real-time through an IHD offered to some treatment groups, all pilot participants could access information about their usage profile through a web portal. Figures 2-4 and 2-5 show the landing page and the more detailed hourly information that are accessible to all pilot participants, respectively.

Figure 2-4: SPO Web Portal Landing Page on My Account[12]



12 All SMUD residential customers have access to interval data through My Account. Data for customers on time-variant rates is formatted differently to show usage by rate period.

Figure 2-5: Hourly Usage Page for SPO Participants



2.5 Terminology

When evaluating the impact of a pricing pilot, it is important to precisely define the variables of interest. Too often, terminology can be misleading as the same term can mean different things to different people. For example, when examining marketing effectiveness, one could compare the enrollment rate at a point in time (say, on June 1 in this instance, when all customers were placed on the new rate) with the number of customers solicited. However, this ratio would under report marketing effectiveness because some customers may have moved, and therefore become ineligible for the new rate, between the time they responded affirmatively to the marketing solicitation and the time when the new rates went into effect. Similarly, someone might compare enrollment on a rate at the beginning and end of the summers and conclude (incorrectly), for example, that 10% of customers left the new rate because they didn't like it. In reality, many of those customers who left may have done so because they moved, not because they no longer wanted to be on the rate. These examples indicate why it's important to precisely define the impact measures that are reported so that reviewers do not misinterpret their meaning. Below, we define the key output variables that are reported in subsequent sections. A few additional definitions of terms is contained in the glossary in Appendix A.

- **Enrolled Customers**: Enrolled customers are customers who are on a new rate at a given point in time. For opt-in rates, this group consists of customers who accepted the marketing offer, were assigned to the treatment group (rather than the control group), did not change their mind or move prior to the rate going into effect, and are still on the rate (e.g., have not dropped out or moved) at the time that the enrollment snap shot is taken. For default enrollment, enrolled customers at a point in time are customers who did not opt-out prior to or after going on the rate, or did not move or leave the rate for any reason between when they were initially enrolled and when the enrollment is reported.

- **Enrollment Rate:** The enrollment rate consists of all customers who were ever actually on a rate for some period of time (meaning they enrolled at some point in time and did not de-enroll, opt-out or move before June 1, 2012) divided by the number of customers who were offered the rate. This is different from the customer acceptance rate, as defined below.
- **Customer Acceptance Rate:** The customer acceptance rate consists of all customers who agreed to go on a rate divided by the number of customers who were offered the rate. This value will typically be larger than the enrollment rate (and can't be less than it) as it includes everyone who signed up for a rate even if they never went on the rate.
  - For opt-in treatments, the *numerator* in the customer acceptance rate would include all customers who agreed to go on the rate but who may have never done so because, for example, they moved before the rate went into effect. It would also include customers who went on the rate but later dropped out. The denominator would include all customers who received the marketing offer. This includes everyone chosen in the original sample less those who moved before the first marketing packets were sent. The customer acceptance rate is the best measure of the effectiveness of a marketing campaign.
  - For default treatments, the *numerator* of the customer acceptance rate consists of all customers who were defaulted onto the rate and did not drop out prior to going on the rate. If a customer goes on the rate and later drops out of the program, they would still be included in the numerator of this variable. Only customers who drop out prior to going on the rate are excluded from the numerator. The *denominator* of the customer acceptance rate for default programs equals the number of customers who were defaulted onto the rate. It excludes customers who moved before June 1, 2012.
- **Decliners:** A decliner is a customer who was offered a rate option but declined to accept the offer. For opt-in treatments, the number of decliners equals the total number of customers marketed to minus the total number of customers who accepted the offer. For default treatments, the number of decliners equals the total number of customers defaulted onto the rate minus those who dropped out prior to going on the rate. It does not include customers who were actually placed on the rate and then later drop out.
- **Drop outs:** Drop outs consist of customers who went on a rate at some point in time, but who later requested to be taken off the rate. It does not include customers who drop out due to changing their location (e.g., moving). These are called movers. Customers who went on to MedRate or budget billing are also counted as drop outs though they may not have had a choice to stay in the SPO pilot. However, their numbers are so small that they are categorized with drop outs.
- **Movers:** Movers are customers who were either defaulted onto a new rate or accepted a rate offer on an opt-in basis, but subsequently moved and, therefore, are no longer enrolled on the rate. A mover may or may not have ever actually gone on the new rate. For example, some customers may have accepted the new rate offer several months prior to the new rate going into effect and may have moved before they were placed on the rate. Similarly, default customers may have not consciously declined the default option but may have moved between the time they were notified that a rate change would be going into effect and when the rate actually went into effect.

2.6 Report Organization

The remainder of this report is organized as follows. Section 3 provides a summary of the analytical methods used to estimate load impacts for each treatment group. Section 4 extends this technical discussion with a high-level summary of the validation analysis that was used to assess the internal integrity of the experimental design used by the SPO. Section 5 summarizes the marketing efforts undertaken to recruit customers onto the various rates and documents customer acceptance, enrollment and retention for each rate option. Sections 6 and 7 contain the primary findings for load impacts for each treatment. Section 8 summarizes an analysis of the incremental impact of IHDs on demand response. It also presents acceptance and connection rates for IHDs for each treatment group in which IHDs were offered. Section 9 discusses an analysis that was done comparing load impact estimates for the same group of customers using three estimation methods for one of the event-based pricing plans: an analysis using the experimental control group to estimate the reference load; an analysis using a non-experimental control group developed using statistical matching; and a within-subjects analysis that estimates reference loads based on nonevent days for CPP customers. The section also compares impacts estimated using two methods, the RCT and statistical matching, for one of the nonevent-based TOU pricing plans. This comparison provides useful insights regarding the accuracy of impact estimates based on different research strategies. Additional analysis and information is contained in various appendices.

3 Analytical Methodology

SMUD has implemented an experimental design that encompasses multiple treatments and multiple methods of evaluation. This design enables a large number of useful analyses to be done that will help SMUD and the industry at large to make more informed decisions about time-variant pricing. Perhaps most importantly, the design allows for estimation of load impacts and acceptance rates without the risk of selection bias; this is quite rare and valuable in the realm of utility program evaluation.

The discussion in this section focuses on the methods that will be used to estimate the load impacts reported in Sections 6 and 7. Determining customer acceptance and attrition rates for each treatment is also a primary objective of SPO. The acceptance rates and attrition analysis contained in this interim evaluation are based primarily on summary statistics which are straightforward to calculate and, therefore, are not discussed in this methodological exposition.

3.1 General Approach

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. SPO relied primarily on two experimental methods for developing reference loads—a randomized control trial (RCT) and a randomized encouragement design (RED). In addition, two treatments, opt-in CPP with and without an IHD offer, were designed to be analyzed using a within-subjects analysis, which constructs reference loads based on treatment customer loads during a time when the treatment is not in effect. The decision to rely on this design was based on an assumption that opt-in rates would be lower than they actually were. Because of the higher opt-in rates obtained in the study, it was possible to develop impact estimates using an RED. In Section 9, a comparison is made between estimates using an RED and a within-subjects analysis.

An RCT refers to a research strategy in which customers who volunteer for a treatment are randomly assigned to treatment and control conditions. This method ensures that the only difference between treatment and control customers, other than differences due to random sampling variation, is that one group receives the treatment and the other does not. 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.

In practice, randomization can be achieved using either a *recruit and deny* process or a *recruit and delay* process. In the former, control customers are never given the treatment whereas in the latter, customers assigned to the control group are placed on the treatment after the end of the trial measurement period. Prior to that time, they act as the control group against which treatment effects are measured. SMUD used the recruit and delay method. Deferred customers will be placed on the new rate in 2014. Conceptually, the important issue is that because the groups were identical in expectation prior to the start of the experiment, the behavior of the group not on the treatment can be assumed to be an accurate representation of what the behavior of the group on the treatment would have been in the absence of the treatment. This study design was applied to two treatments: opt-in TOU and opt-in TOU plus IHD.

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 the control group after the treatment goes into effect (in this instance, after June 1, 2012). A second difference value is calculated equal to the difference in peak period loads prior to the treatment going into effect (during the summer of 2011 in this instance). 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. As seen in Section 4, adjustments due to random variation are small for all treatments in the SPO.

Figure 3-1 summarizes the design and evaluation of impacts using an RCT design. This approach was used for the two opt-in TOU treatments (with and without an IHD offer). Note that the randomization into either the immediate treatment or deferred treatment groups took place before customers were offered the rate. Offers to customers, however, were exactly the same for both groups. Customers were blind to whether they had been pre-assigned to the immediate or deferred start as were customer service representatives (CSRs). Customers and CSRs only learned which group they were in after the customer enrolled.[13]

The experimental method used for the opt-out TOU treatments and for all CPP treatments is an RED. From the perspective of internal validity, an opt-in RCT and an RED are equivalent—both control equally well for selection bias and both allow one to estimate effects for those who accept the treatment, not just those that are offered a treatment, although the analysis required to estimate the treatment effect on the treated using an RED requires an extra step as outlined later in this section.[14] Each requires the assumption that the offer of a treatment not taken or not received has no effect on energy consumption.

In an RED, we observe the behavior of two randomly-chosen groups of customers who were subjected to different levels of encouragement to take up a treatment. For example, one group—the control group—could have received no offer to be on a new rate, while the treatment group could have received an invitation to opt in to a new rate. In a more complicated example, one group could have received an invitation to opt-in, while the other group could have received notification that they would be put on the rate by default unless they chose to opt-out. The key in both situations is that the two groups receive different levels of encouragement to be on the rate. The different levels of encouragement induce different participation rates between two groups that had the same expected

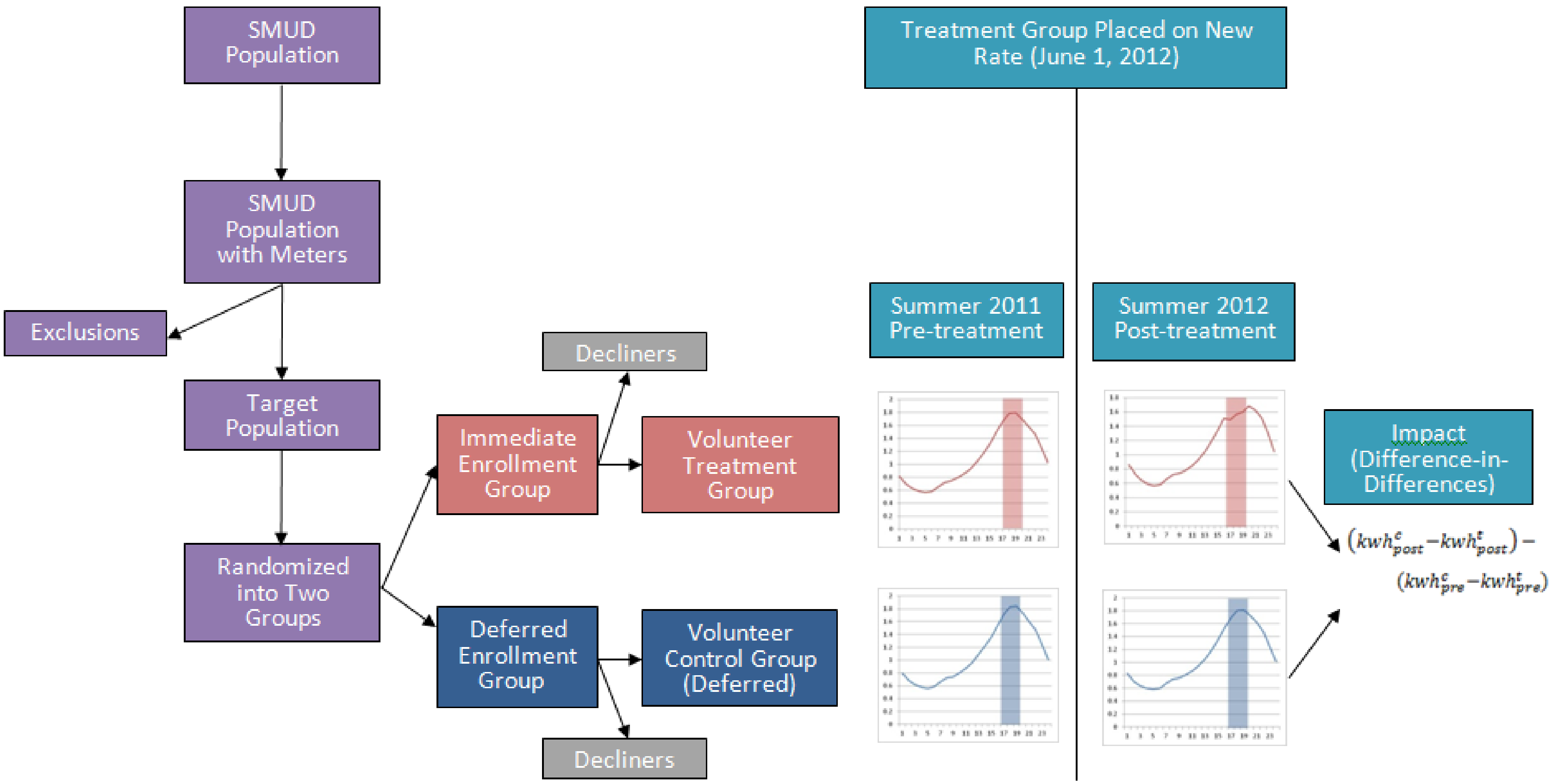
[13] The initial group of customers recruited for opt-in treatments were not told about the delay until after they agreed to participate. Some complaints from customers put in the delayed group prompted SMUD to modify the recruitment material for all customers, both those pre-assigned to the treatment and delayed groups, to indicate that enrollment for some customers would be delayed. It is possible that a different set of customers would enroll in a program that only 50% of customers will be able to take part in immediately as compared to a program where all people who are interested are immediately enrolled. This could lead to an issue with external validity. However, this issue was unavoidable in designing an internally valid experiment and we believe is unlikely to cause any significant bias.

[14] For further discussion of RCTs and REDs, see "Using Randomization in Development Economics Research: A Toolkit," by Duflo, Glennerster and Kremer. Handbook of Development Economics.

characteristics prior to the experiment. This allows one to estimate the effect of the treatment on customers who were affected by the encouragement, as discussed below.

Using an RED design to estimate unbiased treatment effects requires the assumption that customers who are offered the treatment but decline are unaffected by the offer, and the only effect the treatment has is through the price signal (and the offer of the IHD, if applicable). 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 the rate through a default process, but would have opted in if the rate had been offered as voluntary, behave the same way no matter which way the offer was made. Some of the analyses also require the assumption that there are no customers who would

Figure 3-1: Overview of RCT Implementation and Analysis



accept the offer on an opt-in basis, but decline it on a default basis. Each of these assumptions seem quite reasonable.

An RED was used for the following five treatments: default TOU plus IHD; default TOU-CPP plus IHD; opt-in CPP; opt-in CPP plus IHD; and default CPP plus IHD. Additionally, the design can be used to compare the effect of opt-in encouragement to default encouragement for both the TOU plus IHD and CPP plus IHD treatments. In that case, the impact estimate can be interpreted as the effect of the treatment on customers who would not choose the treatment on an opt-in basis, but who also would not choose to opt out in the default case.

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 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 towards 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.

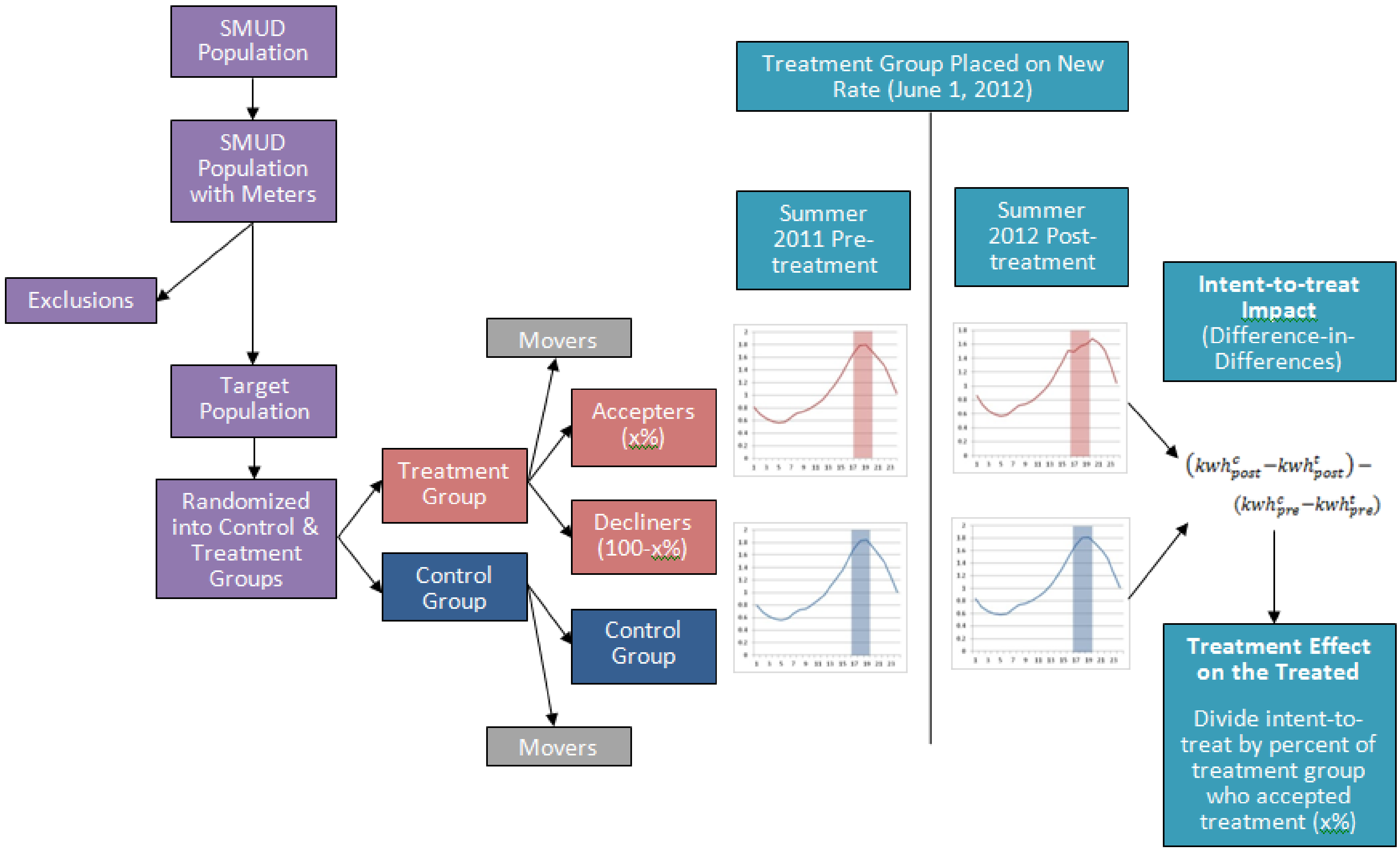
For an RED there are two treatments of interest, each vital to producing the final treatment effect estimate. First, there is the encouragement treatment, which gives an RED its name. In this case, that treatment consists of invitations to opt-in to the rate (and for some the additional offer of an IHD) for opt-in cells and default assignment to a rate (plus an IHD offer) for default cells. Second, there is the rate itself, with or without an IHD offer. In all discussions involving an RED, we adhere to the following terminology: the treatment group is synonymous with the encouraged group and refers to the group of customers who received a higher level of encouragement toward the treatment, including those who decline; takers and compliers are synonymous and refer to customers who accept the rate they are offered or defaulted to, which does not necessarily mean they also took the IHD offer.[15] Non-complier refers to a customer that has declined the rate, either by not opting in or by requesting not to be defaulted onto the rate. The control group refers to all customers receiving the lower level of encouragement—which in most, but not all cases, is no encouragement.[16]

Figure 3-2 summarizes the conceptual design and analysis of an experimental treatment using an RED. As discussed above, there are two load impacts of potential interest. One is the difference in load during, say, the peak period, between the encouraged (treatment) and non-encouraged (control) groups. As with the RCT, this analysis is based on a difference-in-differences calculation. This load impact is primarily of interest in this context because it is a necessary step to obtain the primary effect of interest, namely, the load reduction of associated with compliers—that is, those customers in the encouraged group that actually take up the treatment. This impact is estimated by dividing the

[15] Definitions of treatment group and control group are also included in the glossary in Appendix A.

[16] In some cases the control group contains takers. These cases are reserved for the REDs comparing default cells to opt-in cells. We use this terminology because it allows us to compactly discuss RED and RCT analyses using the same terminology referring to the same regression specification; in each case, the treatment group consists of the group of customers who have the same expected characteristics as the control group, and the regression function includes load data from all of both groups.

Figure 3-2: Overview of RED Implementation and Analysis



impact for the encouraged group by the percent of encouraged customers who accept the treatment offer. This is explained more fully in Section 3.2.

Another important detail is the treatment of the IHD option in the analyses. IHDs were offered within several treatment cells, but customers could choose to take the rate offer with or without the IHD. Additionally, even if a customer chose an IHD, they did not necessarily turn it on or successfully connect the device to their meter. Therefore, from the standpoint of estimating load impacts, the offer of an IHD is viewed as a separate characteristic of a treatment that applies to some cells and not others. When it applies to a cell, it applies to all customers in a cell, for the sake of the main load impact estimate. Following the main load impact estimate, there is discussion and analysis of the effect of choosing an IHD over and above agreeing to go on the rate. This analysis is contained in Section 8. However, this analysis is not based on an experimental design because there is no comparison that can be made between a group with IHDs and a group without that might not suffer from some amount of selection bias. Nevertheless, as discussed later, some useful conclusions can be drawn about the effect of technology.

So far, the discussion has focused on estimating raw load impacts, without fitting them to models including price or temperature. Those types of models are useful for predicting future load impacts under prices and temperatures not observed in the data. Those analyses are part of this project and will be included in subsequent analyses to be documented in the final report.

Table 3-1 summarizes at a high level how the various treatment and control groups will be analyzed and the key questions that will be answered in each case. As the table shows, in several cases, the analysis goes beyond what the experiment was designed for. This additional analysis addresses key issues, although it is important to be clear about its limitations.

Table 3-1: Summary of Analysis Methods for Each SPO Treatment

<table>
<tr><th>Group</th><th>Role in Analysis</th><th>Outcome</th><th>IHD Offered?</th><th>Opt in or Default</th></tr>
<tr><td>Control group not offered any of the pilot rates</td><td>Used as control group for many REDs</td><td>n/a</td><td>No</td><td>n/a</td></tr>
<tr><td rowspan="2">TOU, Opt-in, No IHD Offer</td><td>Non-experimental comparison with RITTE (pseudo-RED†)</td><td>Effect of IHD on customers who opt in to TOU rate</td><td rowspan="2">No</td><td rowspan="2">Opt in</td></tr>
<tr><td>Treatment group in RCT compared to RITND</td><td rowspan="2">Effect of TOU rate without IHD on customers who would opt-in to the rate</td></tr>
<tr><td>TOU-Deferred, Opt-in, No IHD Offer</td><td>Control group in RCT compared to RITNE</td><td>No</td><td>Opt in</td></tr>
<tr><td rowspan="3">TOU, Opt-in, IHD Offer</td><td>Non-experimental comparison with RITNE (pseudo-RED†)</td><td>Effect of IHD on customers who opt in to TOU rate</td><td rowspan="3">Yes</td><td rowspan="3">Opt in</td></tr>
<tr><td>RED* compared to ROTTE</td><td>Impact of a default TOU rate for customers who would not opt in and who do not opt out when switched to the rate, given the offer of an IHD</td></tr>
<tr><td>Treatment group in RCT compared to RITTD</td><td rowspan="2">Effect of TOU rate on customers who would opt in to rate when offered with an IHD</td></tr>
<tr><td>TOU-Deferred, Opt-in, IHD Offer</td><td>Control group in RCT compared to RITTE</td><td>Yes</td><td>Opt in</td></tr>
<tr><td rowspan="2">TOU, Default, IHD Offer</td><td>Treatment in RED* compared to CCCCC</td><td>Effect of TOU rate on customers who would not opt out when switched to TOU rate with optional IHD</td><td rowspan="2">Yes</td><td rowspan="2">Default</td></tr>
<tr><td>RED* compared to RITTE</td><td>Impact of TOU rate for customers who would not opt in and who do not opt out when switched to the rate, given the offer of an IHD</td></tr>
<tr><td rowspan="3">CPP, Opt-in, No IHD Offer</td><td>Treatment in RED* compared to CCCCC</td><td rowspan="2">Effect of CPP rate on customers who would opt in to the rate</td><td rowspan="3">No</td><td rowspan="3">Opt in</td></tr>
<tr><td>Within-subjects</td></tr>
<tr><td>Non-experimental comparison with RICTE (pseudo-RED†)</td><td>Effect of IHD on customers who opt in to CPP rate</td></tr>
<tr><td rowspan="2">CPP, Opt-in, IHD Offer</td><td>Treatment in RED* compared to CCCCC</td><td rowspan="2">Effect of CPP rate on customers who would opt in to the rate when offered with an IHD</td><td rowspan="2">Yes</td><td rowspan="2">Opt in</td></tr>
<tr><td>Within-subjects</td></tr>
</table>

Group	Role in Analysis	Outcome	IHD Offered?	Opt in or Default
	RED* compared to ROCTE	Impact of a default CPP rate for customers who would not opt in and who do not opt out when switched to the rate, given the offer of an IHD		
	Non-experimental comparison with compared to RICNE (pseudo-RED†)	Effect of IHD on customers who opt in to CPP rate		
CPP, Default, IHD Offer	Treatment in RED* compared to CCCCC	Effect of CPP rate on customers who do not opt out when switched to the CPP rate with optional IHD	Yes	Default
	Within-subjects			
	RED* compared to RICTE	Impact of CPP rate for customers who would not opt in and who do not opt out when switched to the rate, given the offer of an IHD		
TOU-CPP, Default, IHD Offer	Treatment in RED* compared to CCCCC	Effect of TOU-CPP rate on customers who do not opt out when switched to the TOU-CPP rate with optional IHD	Yes	Default
	Within-subjects	Effect of CPP rate on TOU-CPP customers who do not opt out when switched to a rate with optional IHD		

= Experiment was designed to include this analysis. Other analyses may have less statistical power or may include the possibility of selection bias, as discussed in the text.

*All RED-based analyses include non-compliers in the analysis in order to produce unbiased intent-to-treat estimates, which are then scaled up based on the fraction of compliers to produce estimates of the local average treatment effect. Therefore, the "Group Code" and "Group Description" columns refer to both compliers and non-compliers for those treatments in the case of RED-based analyses.

†The non-standard term *pseudo-RED* is used here to refer to the comparison that can be made between opt-in TOU with IHD and opt-in TOU without IHD; and between opt-in CPP with IHD and opt-in CPP without IHD. In each case, an estimate of the effect of the IHD offer can be recovered by using the basic assumptions of an RED, plus the additional assumption that the IHD offer does not change customer sign-up decisions. We consider that a highly restrictive assumption compared to the standard RED assumptions and so labeled this a non-experimental comparison. This issue is discussed further in section 4.

3.2 Analysis of RCT and RED Treatment Groups

As discussed in Section 3.1, the logic underlying all RCT and RED analysis is that an unbiased reference load can be estimated by taking average loads among a group of customers with the same average pretreatment characteristics as customers who are subject to the treatment or encouragement of interest. The primary impact estimation process is referred to as a difference-in-differences analysis because the impact estimates equal the difference between loads in the treatment and control group at the time of interest (in this case, summer 2012) minus the difference between loads in the treatment and control group during particular times prior to when the treatment goes into effect (e.g., summer 2011).

Difference-in-differences calculations can be done using regression analysis or simple averaging. Regression analysis is used here rather than simple averaging because regression 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.[17]

The pretreatment differences adjusted for by the regression should be as close as possible to the differences between the groups that would have been expected if the treatment had not been in place. Therefore, in all cases, the pretreatment loads included in each regression were chosen to be the loads most directly analogous to the loads during the period for which impacts were measured. For example, the pretreatment loads included in the analyses of TOU peak periods were the loads from the same groups during the peak period on weekdays from summer 2011. Similarly, the pretreatment loads used in the regressions for estimating CPP impacts were loads from the 4-7 PM peak period on weekdays with high temperatures above 90°F in summer 2011. Those days were chosen because CPP events are typically only called on hot days. It is important to note, however, that because the sample sizes are fairly large and because treatment and control group pretreatment loads are quite close in all cases, the adjustment for pretreatment differences generally has only a small impact on the results. Repeating all calculations as simple differences without pretreatment adjustments would lead to similar conclusions about the overall effect of each treatment. The reader can verify this by examining the pretreatment differences between groups in Section 4.

The regression specification underlying all the treatment effect estimates reported from RCTs and REDs in this report is:

$$load_{it} = a_i + b_1 T_i I_1 + b_2 I_1 + u_{it} \qquad (1)$$

The dataset used and the exact definition of each variable and parameter differs across treatment cells, as discussed below.

3.2.1 Opt-in TOU With and Without IHD Offer (RCT)

There are two groups analyzed using the RCT framework—TOU and TOU plus IHD offer—and the dataset and variable definitions are the same for both. The primary analysis of interest for each

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

treatment provides estimates of the peak period demand impact from the TOU rate (or TOU rate plus IHD offer). In this case, the dataset includes all customers who opted in to the selected rate, including both enrolled and deferred customers. The enrolled customers are the treatment group and the deferred customers are the control group. The variable $load_{it}$ in equation (1) contains hourly load only during the peak period hours of weekdays from 4-7 PM for summer 2011 and summer 2012 for both groups. The index *i* refers to customers and the index *t* refers to time measured in hours.

In this version of the regression, $a_i$is an estimated parameter equal to the mean peak period weekday usage over both summers for each customer. The primary parameter of interest is b_1, which provides the estimated demand impact of TOU during the peak period. The parameter is the estimated coefficient on $T_i I_1$. T_i is equal to 1 for the treatment group during summer 2012 and 0 otherwise. Finally, I_1 is the variable equal to 1 during summer 2012 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 between 2011 and 2012.

Demand impacts have also been estimated for each weekday peak period hour separately for each summer month—meaning there is a separate estimate of the TOU impact for 4-5 PM in June, 5-6 PM in June and so forth, with each estimate providing an average value over that hour for all weekdays in the respective month. This is accomplished using an identical regression specification as above, with a more limited dataset. For example, to produce the estimate for 4-5 PM in June, the dataset is restricted to contain only the hour from 4-5 PM for each weekday during June 2011 and June 2012. All other aspects of the specification remain the same and the interpretation of the variables and estimated parameters are very similar to the case of estimating the overall average effect.

Additionally, demand impacts were estimated for all non-peak periods during the summer, as described in the results section. In these cases, again, the regression specification and interpretation are the same; the only difference is that different hours were included in the regression. These sets of hours can be directly inferred from the results given. In no case were hours of the day included in the regression that were outside the hours that impacts were being estimated for. For example, to estimate the effect of TOU on the hours immediately before the peak period, the regression only includes hours immediately before the 4-7 PM peak period during summer 2011 and 2012.

Finally, energy conservation impacts have been estimated in addition to demand impacts. Energy conservation is not the primary goal of the treatments, but the treatments could lead to measurable energy savings, which could provide additional value to SMUD. Alternatively, TOU rates could lead to overall increases in usage if customers primarily shift usage from peak to off-peak periods while simultaneously increasing overall usage in response to the lower off-peak prices, which are in effect many more hours than higher peak period prices. Determining whether these rates decrease or increase usage, or leave it largely unchanged, is important for cost-effectiveness analysis.

To estimate energy conservation effects, the same specification is used but the estimation is based on monthly usage data rather than hourly or rate-period usage. The dataset includes monthly usage for June-September 2011 and 2012 for the same sets of customers as in the demand impact estimates. The impacts are calculated based on differences in usage between the treatment and control groups during the summer of 2012 and were adjusted based on differences seen in the pretreatment data, the summer of 2011. In this version of the regression, a_i is an estimated parameter equal to the mean monthly usage over both summers for each customer. The primary parameter of interest is b_1, which is equal to the estimated monthly energy savings due to TOU during summer 2012. The definitions and interpretations of $T_i I_1$ and $b_2 I_1$ are identical to the demand impact case.

3.2.2 Default TOU Plus IHD Offer and TOU-CPP Plus IHD (RED)

The rest of the TOU analyses are based on REDs rather than RCTs. There are two rates analyzed in the RED framework: default TOU and default TOU-CPP. Both of these treatments included the offer of an IHD. For the TOU-CPP rate, the analysis method summarized in this section focuses on the impact on all summer weekdays. The analysis method used to estimate the incremental effect of the CPP price is discussed in Section 3.2.3.

For both TOU default treatments, the primary analysis of interest is estimation of the peak period demand impact from the TOU rate. The regression specification in equation (1) does not directly provide this estimate; instead it provides an estimate of the load impact for the average customer that received a rate offer, not the average for customers who accepted the offer. This initial load impact estimate is often referred to as the intent-to-treat estimate. Under the reasonable assumption that non-compliers were unaffected by the treatment, the intent-to-treat estimate can be transformed into the effect of the treatment on compliers by dividing the intent-to-treat estimate by the fraction of the population enrolled on the rate. This scaled up effect is often referred to as the local average treatment effect. The word “local” is used to indicate that the effect is only measured for customers who responded to the encouragement. In the case where a comparison is made between an encouraged group and a control group with no one on the treatment, it is also referred to as the treatment effect on the treated. If the comparison is made between two groups that are encouraged in different ways (e.g., opt-in encouragement versus default encouragement), the local effect represents the change in usage for customers who would not have opted in if given that option and who did not opt out from the default enrollment.

It is important to understand how equation (1) is used in the RED analyses because it is the first step of each such analysis. In the case of the TOU and TOU-CPP treatments, the dataset includes all customers who were offered the respective treatment (either TOU plus IHD offer or TOU-CPP plus IHD offer) and all customers in the control group. The dataset contains hourly load only during the peak period hours of weekdays from 4-7 PM for summer 2011 and summer 2012 for both groups. The interpretation of the variables and estimated parameters for these two groups is essentially the same as in the TOU RCT cases above, with the important difference being that all parameters include the effect of non-compliers and are therefore intent-to-treat estimates rather than estimates of the local average treatment effect.

Also analogous to the TOU RCT case is that estimates are developed for individual hours or non-peak periods by altering the set of hours in the regression dataset. Similarly, energy savings impacts are estimated by substituting monthly data for hourly data, in the same way described above for the TOU RCTs. Again, this produces intent-to-treat estimates which must be scaled up.

In each case, intent-to-treat estimates are scaled up to local average treatment effects by dividing by the fraction of customers enrolled at the relevant time. This is complicated somewhat by the fact that customer enrollment changes over the summer as some customers drop out of the treatment. For monthly TOU impacts, the enrollment fraction used for scaling was the average enrollment during that month among the relevant treatment group. For overall TOU impacts, the fraction used was the average enrollment fraction over the whole summer.

For impact estimation, the TOU-CPP plus IHD group can be treated identically to the TOU-only groups. The interpretation of the results must take into account the fact that these customers face much higher prices on certain days. For this reason, we also examine the effect of TOU on this group of customers, excluding CPP days. The method for doing this is to use the same regression analysis, but to exclude CPP days from the dataset.

3.2.3 Opt-in CPP, Default CPP and Default TOU-CPP (RED)

The RED analysis of CPP rates is the same as the analysis described above for TOU rates, with equation (1) again being the regression specification and the dataset including the full treatment and control group for each rate. This method applies to opt-in CPP with and without the offer of an IHD and default CPP and TOU-CPP, both of which included the offer of an IHD. The only difference in the analysis of the CPP rates and the TOU rates is that the set of times included in the regression is different. To estimate the average effect over all CPP events, each hour of each event is included in the dataset, and the pretreatment data includes all peak period hours from all weekdays above 90°F in 2011. To estimate the effect of each CPP hour individually, only loads observed during that hour from that day and pretreatment loads observed during that hour from all weekdays above 90°F in 2011 are included in the dataset.

Again, for REDs, equation (1) produces the intent-to-treat estimate, which must be scaled up by the fraction of customers within the treatment group that is enrolled to produce the local average treatment effect. Due to customers leaving the rate during the summer, this fraction differs across events, and so each CPP event impact is estimated using the fraction of enrolled customers at that point during the summer. Overall, average CPP effects are scaled by the average enrollment fraction over all CPP events.

For the TOU-CPP with IHD group, the effect of the CPP rate on CPP days is estimated in the same way as the effect of the CPP treatment for the other CPP cells.

3.2.4 RED Comparison of Opt-in Versus Default

The recruitment for opt-in TOU plus IHD and default TOU plus IHD was undertaken on groups randomly-drawn from the same population; the same is true for opt-in CPP plus IHD and default CPP plus IHD. This allows for estimation of the effect of TOU plus IHD and CPP plus IHD for the set of customers who would not choose to opt in to the rate but also would not choose to opt out if the rate was the default option.

To estimate impacts for this group of customers, the same type of RED analysis that was conducted for default TOU or CPP plus IHD is used but in this case, the control group consists of the opt-in CPP group rather than the original RED control group. Equation (1) produces the intent-to-treat estimates, which are scaled up by the difference in enrollment fractions between the default and opt-in groups to produce estimates of the local average treatment effect.

In addition to the assumption that non-compliers are unaffected by the treatment, this analysis requires two additional assumptions. First, it requires the assumption that any particular customer enrolled on a rate will behave the same whether they were offered the rate on a default or an opt-in basis. Put differently, this assumes that a customer who opts in to a CPP rate and reduces load during events would provide the same load reduction if the same customer had been defaulted onto the same CPP rate.[18] Second, it requires the assumption that any customer who would choose to opt-in to the rate will also accept it on a default basis and that any customer who would not accept it on a default basis would not choose to opt in to the rate. These assumptions are probably reasonable for the vast majority of the population.

3.3 Standard Errors

In order to interpret the results of each analysis, it is important to understand not just the point estimates for each variable, but also the variance of each estimate and the associated confidence interval. For RCT analyses, the regression software automatically produces standard error estimates, and the only complication is that those estimates must be calculated using the cluster option, which assumes that the regression errors are correlated with each other within each customer's set of errors.

For RED analyses, the first step is to estimate the standard errors of the intent-to-treat estimates, as produced by the regression with the cluster option. Those standard error estimates are then scaled up using the same scaling factor used to scale the intent-to-treat estimates themselves—the difference in the fraction of compliers between the treatment and control groups. This produces correct standard error estimates for the estimates of the local average treatment effects.[19]

With point estimates and standard errors, confidence bands and tests of statistically significant differences can be calculated. To calculate the p-value of the hypothesis that the point estimates arise from the same distribution, we first calculate the standard error of the difference, which is the square root of the sum of the standard errors from each point estimate. Next, the ratio of the difference to the standard error of the difference is calculated. Under standard assumptions and the central limit theorem, this ratio is distributed with a Gaussian (Normal) distribution with mean zero and variance

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[18] Importantly, this is not the same as saying that the average opt-in and default customer behaves the same. It says that each individual customer who would opt-in to a rate would not opt-out of a default rate and would behave the same regardless of how they happened to go on the rate.

[19] There is a second way to perform an RED analyses that produces identical results, but requires a different regression specification and somewhat different structuring of the data. This second method is based on the econometric concept of instrumental variables and we have used it as a method of checking the results for all RED analyses. In this method, the assignment to either the encouraged or control group constitutes an instrument for enrollment on the rate, and a two-stage least squares analysis is used to produce estimates of the local average treatment effect. Additionally, when this method is used with the cluster option, it produces identical standard error estimates to the method described above. This analysis was performed in addition to the main regressions to ensure that results were accurate. Results are identical when the dataset used in both cases excludes all customers who move away or otherwise have incomplete data during the analysis period. Since this is a small fraction of customers, results are still quite close when the two methods are used but these customers are not excluded. For more detailed discussion of instrumental variables in the context of an RED analysis, see "Identification of Causal Effects Using Instrumental Variables" by Joshua Angrist, Guido Imbens and Donald Rubin. Journal of the American Statistical Association, June 1996.

equal to one. Therefore, the p-value is determined by finding the fraction of the Gaussian distribution that is more extreme (i.e., further from zero) than the calculated ratio.[20] Because two-sided hypothesis tests are performed in all cases, this fraction is doubled and that equals the p-value. The p-value indicates the probability of observing an estimated difference that large if the two estimates came from the same distribution. Therefore, a low p-value indicates that it is unlikely that a difference that large would be observed if the two estimates came from the same distribution. In that sense, a low p-value increases confidence that the observed differences are not due to chance alone and therefore are statistically significant.

3.4 Within-subjects Analysis and Propensity Matching

SPO was designed to allow for estimation of load impacts based on RCT and RED analysis methods except for two treatment cells that were designed to rely on within-subjects methods. As discussed above, given the high customer acceptance rates that were obtained in SPO, even these treatments could be analyzed using an RED. When such designs are used and implemented as designed, they produce the most accurate impact estimates possible.

For many utilities, it is not always feasible to implement RCT or RED designs due to time and budget constraints or other practical concern (e.g., not wanting to deny treatment to volunteers in order to develop a valid control group). In these cases, alternate evaluation methods are often used. Two of the most commonly used methods are within-subjects designs and matched control group methods. Each of these methods attempts to construct an accurate counterfactual (reference load) in the absence of a control group by relying on modeling. Within-subjects methods estimate the counterfactual based on usage observed by treatment group customers during nonevent periods that are chosen and/or adjusted to be similar to event periods in expected usage aside from the event. Matched control group methods estimate the counterfactual based on average usage among a group of customers chosen to have similar characteristics to treatment group customers based on observable variables, including similar usage at nonevent times.

The SPO provides a rare opportunity to compare impact estimates based on three different research designs using the same set of customers for the analysis. In Section 9 of this report, load impacts are estimated and compared for the opt-in CPP treatment (with the offer of an IHD) using an RED analysis, a similar analysis with a control group developed using statistical matching and a within-subjects analysis.

3.5 Impact Persistence

When policy discussions associated with time-variant pricing occur, an important topic of interest is impact persistence. One school of thought is that load reductions in the first year of a pilot will overestimate long-term price response because customers will tire of the inconvenient behavioral changes that for many result in small bill impacts and will therefore revert back to pretreatment behavior patterns. Others claim that impacts will increase over time as consumers learn more ways to shift and reduce load and/or invest in more efficient appliances that reduce both peak-period and overall consumption. Which is true cannot be determined definitively in a two-year pilot, but it is at

[20] Technically, a t-distribution should be used for such a test, but the t-distribution and Gaussian distribution are virtually identical for large sample tests such as this.

least possible to compare the magnitude of load reductions across summers for all customers who are enrolled in both years to assess whether there are any observable changes from one year to the next after controlling for differences in weather across the two seasons. This analysis will be completed after the end of the 2013 summer and documented in the final pilot evaluation report to be completed in early 2014.

3.6 Estimating Price Elasticities

The load impact estimates discussed in this report resulted from the specific prices that were employed in the SPO. Knowing how impacts might change if peak-to-off-peak price ratios differed from those used in the SPO is very useful for determining how to structure such rates in the future. Developing estimates of the impact of alternative prices on electricity use requires estimation of a demand model. Demand models relate changes in electricity use to changes in price. Own price elasticities summarize this relationship in a simple parameter equal to the percentage change in electricity use given a percentage change in price. Cross-price elasticities equal the percentage change in the quantity used in one period (e.g., non-peak period) given a percentage change in price in another period (e.g., the peak period price). As part of the final evaluation of the SPO pilot, FSC will estimate own and cross-price elasticities using a suitable demand model specification (e.g., a constant elasticity of substitution; generalized Leontief, etc.).

3.7 Data Description

The load impact analysis summarized above and presented in the remainder of this report relied almost exclusively on interval data provided to FSC by SMUD. The data received by FSC had missing values in less than 0.05% of the intervals included in the estimating sample. Missing values were dropped from the hourly impact analysis and were simply considered zero when aggregated over the month for use in estimation of overall conservation effects.

For validation purposes (discussed in Section 4) and for purposes of comparing the characteristics of customers who enroll or decline to enroll in various rate options, SMUD conducted a demographic survey among a sample of treatment and control customers for each SPO treatment using the survey questionnaire developed by DOE and contained in DOE guidance document #9.[21] A copy of the questionnaire is contained in Appendix B. Survey response rates varied from roughly 30% to 40% across different treatment and control groups. The data was used as coded by SMUD and provided to FSC. Other data used for comparison purposes came from a third-party vendor. The percent of customers with missing values varied significantly across variables. This data was not modified by FSC.

[21] This document can be found at http://www.smartgrid.gov.

4 Validation of Experimental Design

Before any analysis of impacts could be performed, the implementation of the SPO experiment had to be validated. A fundamental assumption underlying the analysis for each SPO treatment is that the control group used provides an unbiased estimate of what the average loads would have been in the treatment group in the absence of the treatment. As such, treatment and control customers were compared using three types of data:

- Hourly usage during the pretreatment period;
- Monthly usage during the pretreatment period; and
- Customer characteristics.

In this section, comparisons are made between all customers in a group who were *offered* a pricing plan, not customers who took the offer. No meaningful differences were found for any of the comparison variables. These validation checks indicate that the experiment was effectively implemented according to the experimental design and has a high degree of internal validity.

4.1 Hourly Usage

To validate the control group for each TOU treatment, average usage in each hour for the average summer weekday in 2011 was compared for each treatment and corresponding control group. Figure 4-1 shows these comparisons for the following groups:

- Opt-in TOU, no IHD offer versus Deferred Group;
- Opt-in TOU with an IHD offer versus Deferred Group;
- Default TOU with an IHD offer versus RED Control Group; and
- Default TOU-CPP with an IHD offer versus RED Control Group.

For all four groups, usage through the day is very similar for treatment and control groups. Small differences are noticeable in the Opt-in TOU with and without IHD graphs. None of the differences, however, are statistically significant.

A similar figure is provided for the four CPP treatment groups and corresponding control groups. Figure 4-2 is similar to Figure 4-1 but shows usage only on days that had a maximum temperature over 90°F during summer 2011. These hot days are more representative of CPP event days than are days with cooler temperatures. The four comparisons depicted in Figure 4-2 are:

- Opt-in CPP, no IHD offer versus RED Control Group;
- Opt-in CPP with an IHD offer versus RED Control Group;
- Default CPP with an IHD offer versus RED Control Group; and
- Default TOU-CPP with an IHD offer versus RED Control Group.

Just as with the validation for TOU, the treatment and control groups show similar usage on hot, nonevent days. For Default CPP with IHD there are some differences between treatment and control group usage during the peak period. However, these differences are not statistically significant. Additionally, differences between treatment and control usage during the peak period in pretreatment months are accounted for by the difference-in-differences regression used to estimate load impact.

Figure 4-1: Treatment Versus Control Average Hourly Usage for TOU Treatments on Summer Weekdays in 2011

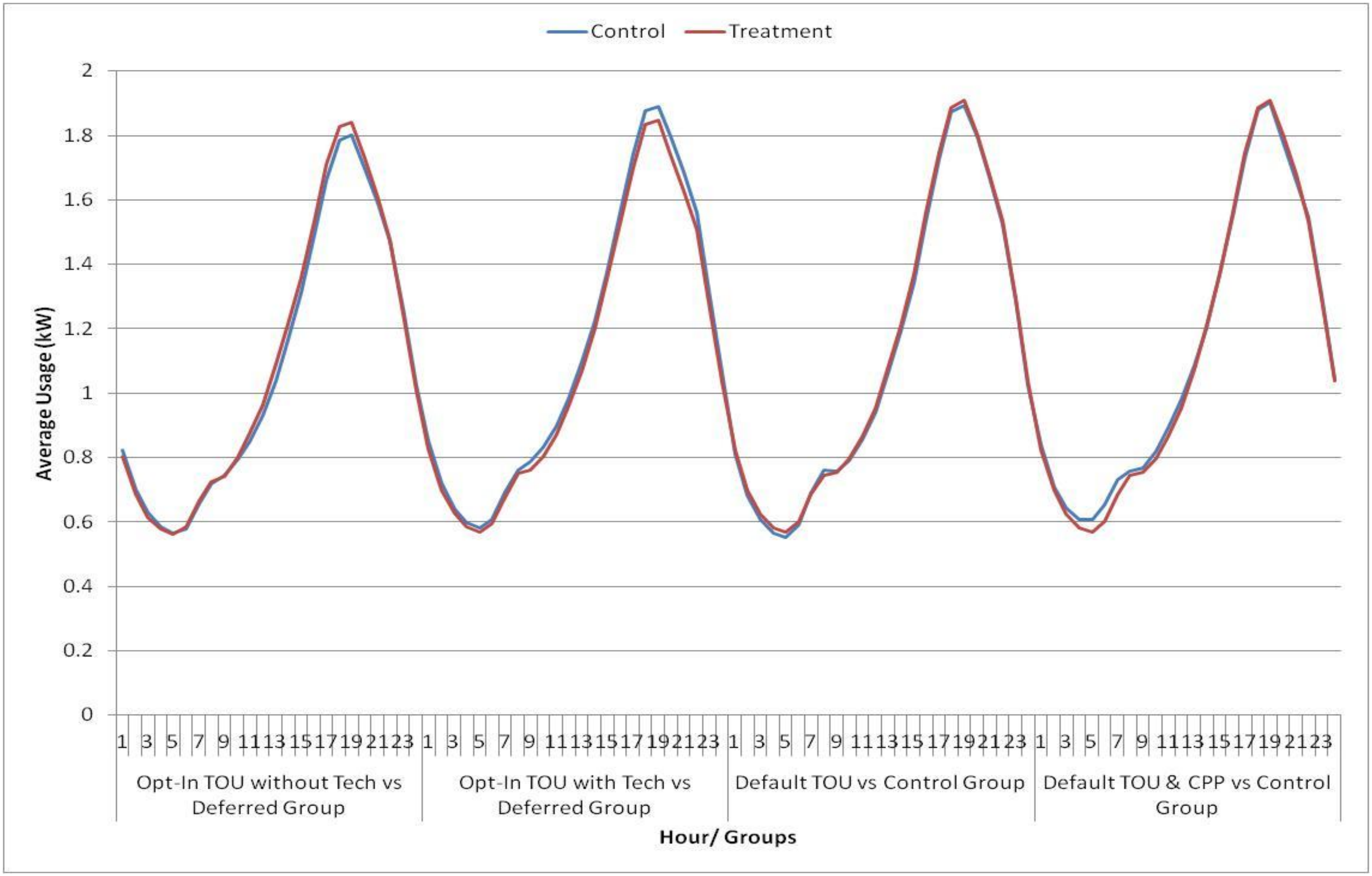
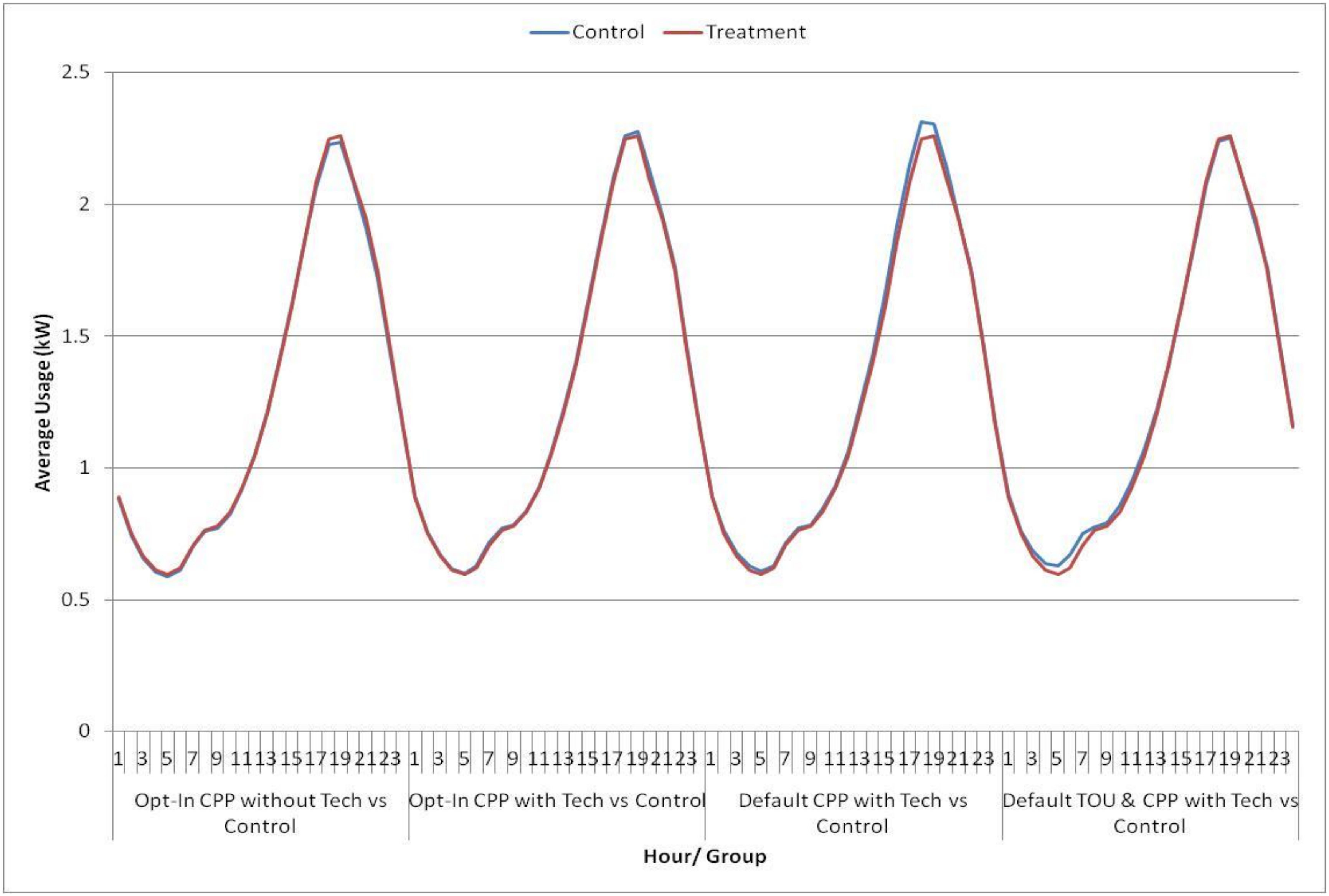


Figure 4-2: Treatment Versus Control Average Hourly Usage for CPP Treatments on Hot, Nonevent Days During Summer 2011



4.2 Monthly Usage

Treatment and control groups were also compared using average monthly usage during the pretreatment months. Average monthly usage was calculated by summing hourly usage for each customer for each hour of the day in each month (including weekends). As with hourly usage over the summer, total monthly usage for the 2011 pretreatment period was very similar for each pair of treatment and control groups. Appendix C includes tables showing these results.

4.3 Customer Characteristics

This section explores some of the customer characteristics of treatment and control group customers based on several data sources. One data source is SMUD's tariff database showing which customers are on the low-income Energy Assistance Program Rate (EAPR) so that treatment and control groups can be compared based on this important customer characteristic. Another data source comes from a survey conducted by SMUD. Just under 17,000 surveys were sent out to customers in treated and deferred cells as well as in the RED control group. On average, roughly 30% of customers returned completed surveys while an additional 9% returned partially completed surveys. A final data source was purchased from a third-party vendor.

Table 4-1 shows the percentage of customers in each treatment and control group that are on the EAPR rate. Tables 4-2 through 4-5 compares each group based on characteristics for customers who returned the survey, whether completed or partial. The first numerical column in each table shows the combination of survey and item response for each cell. The last two columns of each table show the p-value and the statistical significance of whether characteristics for treatment group is different from the corresponding control group. In the last column, one star means the difference is significant at the 10% level, two stars represents the 5% level of significance, three stars represents the 1% significance level and N/S stands for not significant. For the first five treated groups, the corresponding control group is the RED control group in the first row. In the final four rows, the comparison is between the corresponding enrolled and deferred groups for treatments implemented using the recruit and delay design. The main conclusion from these numerous comparisons is that each treatment cell is very similar to its corresponding control group. Of the 42 tests of treatment versus control shown in the table, only four are statistically significant.

As seen in Table 4-1, in the RED control group, about 20% of customers are enrolled on the low-income rate. Each of the five RED treatment groups has between 19% and 24% of customers on the EAPR program. The biggest difference is seen for the default CPP with IHD group, where 24% of customers are enrolled in EAPR. This small difference is statistically significant at the 5% level, but this is likely due to the small sample size of the treatment group.

Table 4-1: EAPR Status By Treatment Group

Group	Design	% Response	Not EAPR	EAPR	P-value	Statistical Significance
RED Control Group	RED	100%	80%	20%	N/A	N/A
Opt-in CPP, No IHD Offer		100%	78%	22%	0.24	N/S
Opt-in CPP, IHD Offer		100%	80%	20%	0.85	N/S
Default TOU-CPP, IHD Offer		100%	81%	19%	0.56	N/S
Default CPP, IHD Offer		100%	76%	24%	0.01	***
Default TOU, IHD Offer		100%	79%	21%	0.43	N/S
Opt-in TOU, No IHD Offer, Deferred	RCT	100%	79%	21%	0.68	N/S
Opt-in TOU, No IHD Offer, Enrolled		100%	80%	20%		
Opt-in TOU, IHD Offer, Deferred		100%	79%	21%	0.44	N/S
Opt-in TOU, IHD Offer, Enrolled		100%	79%	21%		

Table 4-2 shows the percent of customers in each group that own their home. Keep in mind that these values are based on the roughly 30% of respondents who completed the survey. In the default TOU-CPP group, about 74% of customers own their homes. This is the only group that has a statistically significant difference from its respective control group (e.g., the RED control group with 61% home ownership). For all other groups listed, the percentage of customers who own their homes ranges from 61% to 67% and the differences between treatment and control groups are not significant.

Table 4-2: Home Ownership

Group	Design	% Response	Does Not Own Home	Owns Home	P-value	Statistical Significance
RED Control Group	RED	31%	38%	61%	N/A	N/A
Opt-in CPP, No IHD Offer		31%	35%	64%	0.68	N/S
Opt-in CPP, IHD Offer		42%	35%	65%	0.54	N/S
Default TOU-CPP, IHD Offer		32%	25%	74%	0.01	***
Default CPP, IHD Offer		36%	33%	67%	0.22	N/S
Default TOU, IHD Offer		31%	36%	63%	0.81	N/S
Opt-in TOU, No IHD Offer, Deferred	RCT	39%	37%	63%	0.81	N/S
Opt-in TOU, No IHD Offer, Enrolled		39%	37%	63%		
Opt-in TOU, IHD Offer, Deferred		42%	38%	62%	0.25	N/S
Opt-in TOU, IHD Offer, Enrolled		42%	35%	65%		

Table 4-3 shows the percentage of customers in each group that have central air conditioning (CAC). All of the groups are very similar, with between 86% and 91% of customers having CAC in their homes. For the opt-in TOU with IHD offer enrolled and deferred groups, the difference in the percentage of customers with CAC (91% vs. 88%) is statistically significant at the 10% level. The differences between all other treatment and control pairs are not statistically different.

Table 4-3: Central Air Conditioning (CAC) Ownership

Group	Design	% Response	Does Not Have CAC	Has CAC	P-value	Statistical Significance
RED Control Group	RED	31%	12%	88%	N/A	N/A
Opt-in CPP, No IHD Offer		31%	14%	86%	0.43	N/S
Opt-in CPP, IHD Offer		42%	11%	89%	0.72	N/S
Default TOU-CPP, IHD Offer		32%	11%	89%	0.56	N/S
Default CPP, IHD Offer		36%	11%	89%	0.77	N/S
Default TOU, IHD OFFER		31%	12%	88%	0.69	N/S
Opt-in TOU, No IHD Offer, Deferred	RCT	39%	12%	87%	0.36	N/S
Opt-in TOU, No IHD Offer, Enrolled		39%	11%	89%		
Opt-in TOU, IHD Offer, Deferred		42%	12%	88%	0.06	*
Opt-in TOU, IHD Offer, Enrolled		42%	9%	91%		

Table 4-4 shows the percentage of customers in each group that have a programmable thermostat (PT) in their home. For 9 of the 10 groups, somewhere between 78% and 83% of customers have a PT. The exception is default TOU with an IHD offer, where PT ownership was roughly 74%. This is statistically different from the RED control group at the 10% significance level. Additionally, enrolled and deferred customers in the opt-in TOU with IHD offer group have statistically different percentages of customers with PTs (83% vs. 80%).

Table 4-4: Programmable Thermostat Ownership

Group	Design	% Response	Does Not Have PT	Has PT	P-value	Statistical Significance
RED Control Group	RED	30%	17%	82%	N/A	N/A
Opt-in CPP, No IHD Offer		31%	18%	80%	0.85	N/S
Opt-in CPP, IHD Offer		42%	19%	81%	0.88	N/S
Default TOU-CPP, IHD Offer		32%	19%	80%	0.78	N/S
Default CPP, IHD Offer		36%	16%	83%	0.90	N/S
Default TOU, IHD OFFER		30%	25%	74%	0.06	*
Opt-in TOU, No IHD Offer, Deferred	RCT	38%	21%	78%	0.81	N/S
Opt-in TOU, No IHD Offer, Enrolled		39%	21%	78%		
Opt-in TOU, IHD Offer, Deferred		41%	19%	80%	0.05	*
Opt-in TOU, IHD Offer, Enrolled		42%	16%	83%		

Table 4-5 summarizes the percent of customers in each group that work full time. This percentage ranges from 53% to 60% across the 10 groups. None of the differences between treatment and control groups are statistically significant.

Table 4-5: Full Time Employment Status of Survey Respondent

Group	Design	% Response	Does Not Work Full Time	Works Full Time[22]	P-value	Statistical Significance
RED Control Group	RED	30%	41%	57%	N/A	N/A
Opt-in CPP, No IHD Offer		31%	45%	54%	0.69	N/S
Opt-in CPP, IHD Offer		42%	43%	56%	0.46	N/S
Default TOU-CPP, IHD Offer		32%	39%	60%	0.50	N/S
Default CPP, IHD Offer		36%	39%	58%	0.90	N/S
Default TOU, IHD OFFER		30%	38%	60%	0.73	N/S
Opt-in TOU, No IHD Offer, Deferred	RCT	38%	45%	54%	0.64	N/S
Opt-in TOU, No IHD Offer, Enrolled		39%	46%	53%		
Opt-in TOU, IHD Offer, Deferred		41%	44%	55%	0.61	N/S
Opt-in TOU, IHD Offer, Enrolled		42%	43%	56%		

Finally, Table 4-6 shows the percentage of customers in each group that work from home. None of the comparisons between treatment and control groups are statistically significant. Across all four groups, between 15% and 20% of customers work from home while another 21% to 28% of customers did not respond to the question.

[22] As can be seen in Appendix B, the survey question asked respondents, "Is there anyone in your household working full time for pay?" The responses suggest that between 30% and 42% of households have no one who works full time for pay. This seems high and might suggest that respondents did not read the question carefully, perhaps answering as if the question was about them personally rather than about the entire household.

Table 4-6: Working from Home Status

Group	Design	% Response	Does Not Work From Home	Works from Home	P-value	Statistical Significance
RED Control Group	RED	24%	62%	16%	N/A	N/A
Opt-in CPP, No IHD Offer		23%	56%	16%	0.23	N/S
Opt-in CPP, IHD Offer		32%	56%	20%	0.22	N/S
Default TOU-CPP, IHD Offer		26%	64%	15%	0.91	N/S
Default CPP, IHD Offer		26%	56%	16%	0.21	N/S
Default TOU, IHD OFFER		24%	59%	18%	0.63	N/S
Opt-in TOU, No IHD Offer, Deferred	RCT	30%	60%	17%	0.12	N/S
Opt-in TOU, No IHD Offer, Enrolled		29%	58%	15%		
Opt-in TOU, IHD Offer, Deferred		31%	59%	16%	0.59	N/S
Opt-in TOU, IHD Offer, Enrolled		32%	58%	18%		

In addition to data collected from the SMUD survey, comparisons were made for selected variables based on data SMUD purchased from a third-party vendor. The percent of customers with missing values varies across variables. The list of variables for which comparisons were made is as follows:

- Educational attainment;
- Income level;
- Dwelling type;
- Average square footage of housing stock;[23] and
- Average vintage of housing stock.

Each table below is set up in the same manner but shows the comparison for a different characteristic. The first six rows of each table show each group that was analyzed using an RED. For each of the five treatment groups (rows 2-5), the meaningful comparison is between that group and the RED control group (row 1). The last two columns show the p-value from a t-test of the hypothesis that the treated group is different from the control group and the statistical significance of that test. One star means the difference is significant at the 10% level, two stars means the 5% level, three stars means the 1% level and N/S stands for not significant. The RED groups contain all customers who were offered the rate, not just customers who accepted it or that did not opt out for default rates.

The last four rows show all the groups analyzed using an RCT. The meaningful comparisons here are between the enrolled and deferred groups for each pair (row 7 vs. row 8, row 9 vs. row 10). The p-

[23] Square footage was reported for about 94% of single-family homes but only about 13% of multi-family homes. This is true across all treatment and control groups so it does not bias the results but does mean that the average house size is not representative of the general SMUD population.

value for those comparisons comes from a t-test of the hypothesis that the enrolled group is different from the control group. For the RCT comparisons, only customers who actively enrolled (including those who enrolled in the deferred group) are included. Table 4-7 compares the groups by educational attainment. For all the RED groups, educational attainment is very similar. For example, the range of percentage of customers with a college degree is only 3% (30% to 33%). However, opt-in CPP with IHD has a statistically significant p-value at the 5% level. Looking at the percentage in each education category, however, shows that the difference between opt-in CPP customers and control group customers is always 1% or less. For the two RCT comparisons, educational attainment is also very similar between treatment and control groups. Both comparisons show that the groups are not statistically different from each other.

Table 4-7: Educational Attainment By Treatment Group

Group	Design	% Missing	Some HS or Less	HS	Some College	College	Graduate School	P-val.	Stat. Sig.
RED Control Group	RED	26%	1%	13%	29%	31%	0%	N/A	N/A
Opt-in CPP, No IHD Offer		27%	2%	13%	26%	32%	0%	0.19	N/S
Opt-in CPP, IHD Offer		27%	2%	12%	28%	31%	0%	0.03	**
Default TOU-CPP, IHD Offer		25%	1%	13%	29%	32%	0%	0.95	N/S
Default CPP, IHD Offer		24%	2%	11%	31%	33%	0%	0.23	N/S
Default TOU, IHD OFFER		26%	1%	12%	30%	30%	0%	0.82	N/S
Opt-in TOU, No IHD Offer, Deferred	RCT	16%	3%	17%	33%	32%	0%	0.57	N/S
Opt-in TOU, No IHD Offer, Enrolled		15%	2%	16%	36%	31%	0%		
Opt-in TOU, IHD Offer, Deferred		15%	2%	18%	32%	34%	0%	0.62	N/S
Opt-in TOU, IHD Offer, Enrolled		15%	2%	16%	34%	34%	0%		

Table 4-8 shows the average income of customers in each group. None of the differences between treatment and control groups (RED or RCT) were statistically significant at the 5% level. Across all groups, about 18% of customers had incomes between $100,000 and $150,000 with another 25% of customers between $50,000 and $100,000.

Table 4-8: Average Income By Treatment Group

Group	Design	% Missing	<$50K	$50K-$100K	$100K-$150K	$150K+	P-value	Stat. Sig.
RED Control Group	RED	26%	24%	26%	18%	8%	N/A	N/A
Opt-in CPP, No IHD Offer		27%	25%	25%	18%	7%	0.08	*
Opt-in CPP, IHD Offer		26%	23%	26%	18%	8%	0.49	N/S
Default TOU-CPP, IHD Offer		24%	22%	26%	21%	8%	0.20	N/S
Default CPP, IHD Offer		24%	22%	27%	19%	9%	0.27	N/S
Default TOU, IHD Offer		25%	24%	26%	18%	8%	0.14	N/S
Opt-in TOU, No IHD Offer, Deferred	RCT	16%	31%	26%	17%	8%	0.41	N/S
Opt-in TOU, No IHD Offer, Enrolled		15%	33%	25%	18%	7%		
Opt-in TOU, IHD Offer, Deferred		15%	32%	25%	17%	8%	0.12	N/S
Opt-in TOU, IHD Offer, Enrolled		14%	28%	26%	18%	9%		

Tables 4-9 and 4-10 compare the groups by dwelling type, average home size and average year home was built. Across all of these variables, all RED control and treatment groups are very similar. There are no significant differences in any of the comparisons. The same is true for the RCT comparisons. Customers who enrolled in the RCT experiments show comparable housing characteristics across the board.

Table 4-9: Dwelling Type By Treatment Group

Group	Design	% Missing	Multi-Family	Single Family	P-value	Stat. Sig.
RED Control Group	RED	23%	19%	59%	N/A	N/A
Opt-in CPP, No IHD Offer		25%	19%	56%	0.21	N/S
Opt-in CPP, IHD Offer		23%	18%	59%	0.23	N/S
Default TOU-CPP, IHD Offer		21%	16%	63%	0.06	*
Default CPP, IHD Offer		21%	18%	61%	0.26	N/S
Default TOU, IHD Offer		22%	20%	57%	0.10	*
Opt-in TOU, No IHD Offer, Deferred	RCT	13%	23%	65%	0.57	N/S
Opt-in TOU, No IHD Offer, Enrolled		12%	24%	65%		
Opt-in TOU, IHD Offer, Deferred		12%	23%	65%	0.06	*
Opt-in TOU, IHD Offer, Enrolled		12%	20%	68%		

Table 4-10: Selected Housing Characteristics By Group

Group	Design	% Missing	Avg. Square Feet	P Value	Stat. Sig	Avg. Year Built	P Value	Stat. Sig
RED Control Group	RED	42%	1850	N/A	N/A	1983	N/A	N/A
Opt-In CPP, No IHD Offer		45%	1829	0.47	N/S	1984	0.43	N/S
Opt-In CPP, IHD Offer		43%	1867	0.11	N/S	1983	0.93	N/S
Default TOU-CPP, IHD Offer		40%	1886	0.30	N/S	1984	0.44	N/S
Default CPP, IHD Offer		40%	1870	0.53	N/S	1983	0.75	N/S
Default TOU, IHD OFFER		44%	1869	0.35	N/S	1983	0.49	N/S
Opt-In TOU, No IHD Offer, Deferred	RCT	41%	1897	0.32	N/S	1985	0.36	N/S
Opt-In TOU, No IHD Offer, Enrolled		42%	1860			1984		
Opt-In TOU, IHD Offer, Deferred		43%	1838	0.07	*	1984	0.14	N/S
Opt-In TOU, IHD Offer, Enrolled		43%	1888			1985		

5 Program Marketing, Customer Acceptance and Retention

As discussed in Section 1, SPO is one of the few pricing pilots that has been done in the industry that systematically examines the issue of customer acceptance of time-variant rates. Specifically, SPO allows for a comparison of:

- Acceptance rates for CPP and TOU rates based on opt-in and default enrollment, and for the TOU-CPP rate based on default enrollment; and
- The impact of offering enabling technology, in the form of a free IHD, on customer acceptance of CPP and TOU rates.

Understanding if there are significant differences in acceptance rates for various forms of time-variant rates, how acceptance rates differ between default and opt-in marketing, and whether offering an IHD to customers affects acceptance rates, are all critical issues in developing an effective pricing strategy. Findings from the SPO pilot provide some of the best empirical evidence to help settle debates about these issues that have been waged for more than a decade based largely on assumptions, assertions and, at best, qualitative evidence from focus groups.

Table 5-1 summarizes the customer acceptance rates for each SPO treatment. Among the most important findings are:

- SMUD's multi-faceted marketing strategy for opt-in tariffs led to acceptance rates that ranged from 16.4% to 18.8%. These high acceptance rates contradict the often cited claim that very few customers will voluntarily enroll on time-variant rates.
- The offer of enabling technology in the form of a free IHD did not materially increase customer acceptance of either the CPP or TOU rate.
- The default treatment groups display extremely high enrollment rates, ranging from a low of almost 93% for the TOU-CPP rate to a high of almost 98% for the TOU rate.
- Once enrolled, less than 2% of opt-in customers chose to leave the selected rate over the course of the 2012 summer.[24] For default enrollment, the attrition rate ranged from 2.0% to 3.6%, which was slightly higher than, but comparable to, that of opt-in customers.

[24] A greater number of customers left the rate because of account closures due to customer relocation.

Table 5-1: Customer Acceptance Rates for SPO Treatments[25]

Marketing Approach	Rate	IHD Offer	Acceptance Rate
Opt-in	CPP	No	18.8%
		Yes	18.2%
	TOU	No	16.4%
		Yes	17.5%
Default	CPP	Yes	95.9%
	TOU	Yes	97.6%
	TOU-CPP	Yes	92.9%

The remainder of this section is organized as follows. Section 5.1 provides an overview of the SPO marketing campaign. Section 5.2 focuses on customer acceptance, enrollment, retention and attrition for the opt-in rates while Section 5.3 covers the same topics for default rates. Customer acceptance of and connectivity for IHDs is discussed in Section 8.

5.1 Marketing and Education

The high acceptance rates for opt-in treatments and low opt-out rates for default treatments resulted in part from a well-researched, multi-faceted marketing effort implemented by SMUD. SMUD spent a significant amount of time and money understanding how to communicate the benefits of, and address concerns about, time-variant pricing programs and how to manage potential dissatisfaction stemming from the fact that some volunteers in selected opt-in treatment cells would have enrollment deferred for two years. From February through August 2011, SMUD conducted 25 focus groups and 4 surveys involving more than 2,000 customers to solicit input on marketing messages, naming conventions and other communication issues as input to development of the marketing and education plan.

Based in part on the above research, SMUD used the following names for the three pricing plans tested in the SPO:

- **Summer Weekday Value Plan** for the opt-in and default TOU treatments;
- **Off-peak Discount Plan** for the opt-in and default CPP treatments; and
- **Optimum Off-peak Plan** for the combination TOU-CPP treatment, which was implemented as a default rate only.

The primary messages and content used the initial solicitation letters included the following:

- The lead marketing message was that customers get a discount off the standard price during non-peak hours, which is most of the time (the amount of time varies across the three rates).

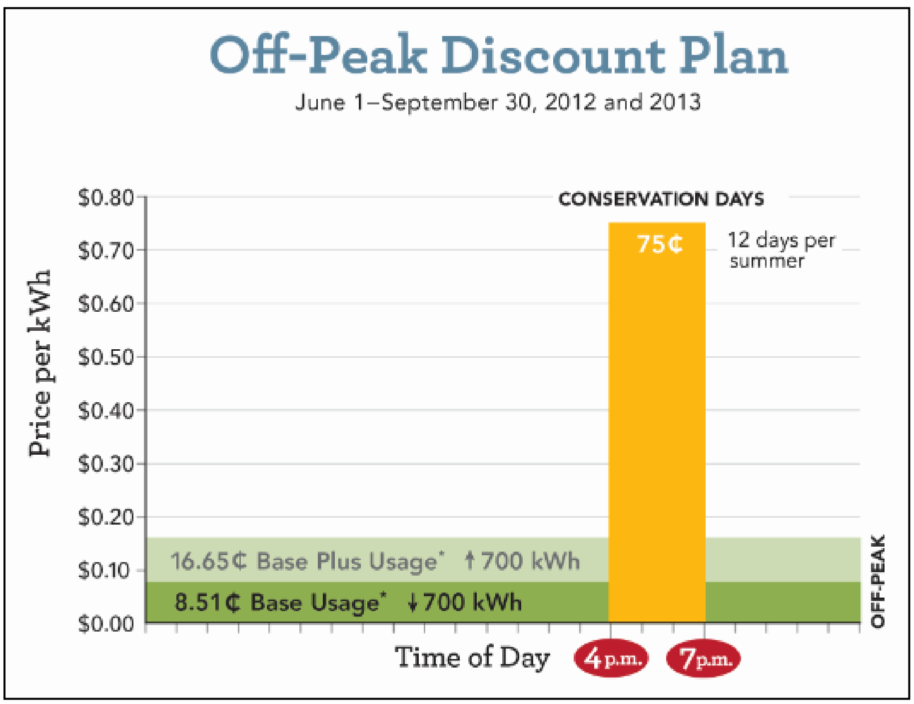
25 For opt-in treatment groups, the acceptance rate was calculated by taking the number of customers who enrolled at any point prior to or during the summer of 2012 and dividing it by the number of customers who received marketing materials. For default treatment groups, the acceptance rate was calculated by taking the number of customers who did not opt out of the rate as of June 1, 2012 and dividing it by the number of customers who received marketing materials.

The secondary message was that prices are higher for relatively few hours (e.g., only 1% of the time for the CPP rate).

- The primary message concerned "saving money on your summer electricity bills." Secondary messages included taking control and helping the environment.
- Using less electricity during peak hours, shifting usage to before 4 PM or after 7 PM and/or reducing use overall will save money.
- Additional perks include a free countertop electricity use display (for those treatment cells where IHDs are offered), access to an informational graph on My Account that shows hourly and daily usage, access to a website with energy saving tips, and discounts on activities, like movie tickets and water parks that can make using less electricity during peak hours easy and fun.

Many of these same themes were elaborated in color brochures that were included with the solicitation letter. The cover letter itself did not provide any information about the actual prices but the brochure provided this information in the form of a graphical display. An example of the graph for the CPP Off-peak Discount Plan treatment is shown in Figure 5-1. Appendix D contains examples of selected marketing materials used for customer recruitment.

Figure 5-1: Graphical Display of Off-peak Discount Plan Pricing



To help maintain the internal validity of the experiment, SMUD focused significant effort and attention on maintaining consistency in communication and educational content across treatment cells. Keeping messages and content as consistent as possible across treatment cells helps to ensure that differences in enrollment rates and electricity use across rate options and other treatment conditions are due to differences in the treatments themselves and not due to differences in messaging or communication. For example, the only differences in the initial letter sent to customers in the opt-in and default CPP treatment cells are summarized below.

The opening line in the opt-in and default letters is, respectively:

- Sign up today and you could save on your electric bills next summer!
- You're now on a new pricing plan that can help you save on your summer electricity bills!

The next sentence in the two letters, respectively, is as follows:

- You are invited to participate in a two-year SmartPricing Options pilot that can help you manage your energy bills.
- You're among the first SMUD customers to be randomly selected for a two-year SmartPricing Options pilot that can help you better manage your energy use during the summers of 2012 and 2013.

The final paragraph in the default letter indicates that customers who do not want to stay on the new plan can opt out by calling SMUD. Specifically, the letter says:

- If you would like to remain on your standard rate plan, call 1-855-736-7655. However, should you decide not to participate, you won't be able to enroll later and you will miss out on the cost savings and energy management benefits.

The final difference between the opt-in and default treatments concerned the IHD offer. The IHD was offered to some opt-in customers and not others and was offered to all default customers. Opt-in customers receiving the IHD offer could indicate their interest at the time of enrollment and nearly all customers said they would like to receive the IHD. Default customers needed to be more proactive since an enrollment transaction was not needed for the rate itself. As such, default customers had to ask for an IHD by calling SMUD, returning a business reply card (BRC), or going online. These options were outlined in the letter received by customers indicating that they had been defaulted onto the new rate. Between 20% and 25% of default customers asked to receive an IHD.

For opt-in treatments, the first direct mail solicitation occurred in October 2011. A second letter was sent in January to customers who had not yet enrolled. Because of concerns that some treatment cells might not reach their target enrollment rates through direct mail solicitation alone, starting in March 2012, SMUD implemented a door hanger and outbound calling campaign, which continued into May. Through these various efforts, SMUD exceeded target enrollment for all opt-in treatments prior to June 1, 2012, when customers were placed on the new rate.

Letters were sent to all customers chosen for default enrollment in April 2012. A reminder letter was sent to all customers in April, reiterating that they would be placed on a new rate on June 1 if they did not notify SMUD that they wished to stay on their current rate. SMUD had based the design and sampling for the SPO on the assumption that half of all customers would drop out prior to going on the rate. In reality, the opt-out rate prior to June 1 when the default rates went into effect ranged from 3% to 7%.

Both opt-in and default customers were sent a welcome package in May. Customers who were in IHD treatment cells and who indicated that they wished to receive an IHD were sent the device in the mail in May. The IHDs were preset to communicate with each customer's meter when they were turned on. As discussed later in Section 8, connection rates were generally low. It is not clear how much of the cause of the low connection rates was due to lack of customer interest, communication failures, or other technical problems.

5.2 Opt-in Treatments

The SPO pilot included two opt-in rates, CPP and TOU. Each rate was offered to two randomly chosen groups of customers, with one offer including a free IHD while the other did not. Thus, there were four treatment cells for opt-in rates. Comparing the acceptance rates for CPP and TOU rates will indicate whether the customers generally have a stronger preference for one rate over the other when comparing it to the standard rate. Importantly, this comparison is not the same as asking a group of customers to choose between CPP and TOU rates, which would be a more direct measure of customer preferences among time-variant rate options. Even if the same percent of customers took the two rates, it could be that customers who accept the CPP rate might prefer the TOU rate over CPP if they had a choice, and vice versa. Comparing acceptance rates for CPP with and without IHD, and TOU with and without IHD, is a direct measure of whether the offer of a free IHD materially increases acceptance rates for the two rates.

Before summarizing the acceptance rates and other outcomes associated with marketing and enrollment, it is worth noting that there is a difference between the number of customers drawn into the various treatment samples and the number who received treatment offers. SMUD pulled the treatment samples in late August 2011. Between the time when the sample was pulled and the marketing materials were first sent, some customers moved, in which case these customers were dropped from the research sample as they no longer qualified to participate in the study.[26] Table 5-2 reports the number of customers in the original sample and the number of customers who received marketing offers. These differences are small for the opt-in treatments because the time between when the sample was drawn and the first solicitations were sent was relatively brief. As shown in Section 5.3, more customers were lost between the sample draw and the initial offer for default customers, as default notifications were not sent until April 2012, more than seven months after the sample was drawn. In the remainder of this section, the basis for all estimates of customer acceptance and enrollment rates is the number of customers receiving the offer, not the number in the initial sample.

Table 5-2: Number of Customers Sampled and Number of Customers For Whom Opt-in Offers Were Made

Group	Total in Sample	Total Offered	% Offered
Control Group	45,863	45,183	99%
Opt-In CPP, No IHD Offer	1,214	1,187	98%
Opt-In CPP, IHD Offer	9,198	9,060	98%
Opt-In TOU, No IHD Offer, Control (Deferred)	7,630	7,513	98%
Opt-In TOU, No IHD Offer, Enrolled	7,634	7,500	98%
Opt-In TOU, IHD Offer, Control (Deferred)	12,707	12,553	99%
Opt-In TOU, IHD Offer, Enrolled	12,743	12,554	99%

26 Any customer that moved from their associated premise at any point after the sample was pulled would be removed from the study and analysis.

5.2.1 Customer Acceptance of Opt-in Treatments

Table 5-3 summarizes the main findings concerning customer acceptance of the opt-in rates. Overall, acceptance rates are quite high relative to participation in most other opt-in, time-variant rate programs, especially when considering the relatively short period over which marketing occurred. By comparison, PG&E's SmartRate tariff, a CPP rate first marketed in 2008 that is structurally similar to the SPO CPP rate, had an acceptance rate of roughly 8% in its first two years of offering the rate.[27] With two exceptions (Salt River Project and Arizona Public Service), most other utility programs have acceptance rates of 5% or less, often much less.[28] The fact that SPO obtained acceptance rates approaching 20% from the general population in a single campaign suggests that other utilities can achieve similar acceptance rates using a well researched and concerted marketing effort.

Table 5-3: Acceptance Rates for Opt-in Treatments

Group	Total Offered	Total Accepted	Acceptance Rate
Opt-in CPP, No IHD Offer	1,187	223	18.8%
Opt-in CPP, IHD Offer	9,060	1,651	18.2%
Opt-in TOU, No IHD Offer	7,500	1,229	16.4%
Opt-in TOU, IHD Offer	12,554	2,199	17.5%

The differences in acceptance rates across the various treatments are small, although some are statistically significant. Table 5-4 shows the p-statistic associated with the pair wise comparisons of acceptance rates across the various treatments. A p-value of 0.05 indicates the difference is statistically significant at the 95% confidence level. The acceptance rate for the CPP treatment with no IHD offer, 18.8%, is more than 2 percentage points higher than the 16.4% acceptance rate for the TOU treatment, and this difference is significant at the 95% confidence level, with a p-value of 0.04. The acceptance rates for the same two rates when the IHD is included in the offer are 18.2% and 17.5%, respectively. This difference is not statistically significant at the 95% confidence level. Overall, one could argue that there is a slight preference for the CPP rate over the TOU rate for the average customer, but the difference is not material and a more reasonable planning assumption would be that SMUD can expect to obtain between 15% and 20% participation in either an opt-in CPP or opt-in TOU rate, if either of these rates was offered by itself in the future using marketing methods similar to those utilized in the SPO. This statement assumes that future marketing would be to customers with similar characteristics as those included in the study population. If the roll out was to a materially different population, acceptance rates could differ.

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27 See "2009 Load Impact Evaluation for Pacific Gas and Electric Company's Residential SmartRate—Peak Day Pricing and TOU Tariffs and SmartAC Program, Volume 2: Ex Ante Load Impacts" by S. George, J. Bode, M. Perry & A. Goett. Prepared for PG&E.

28 Based on personal correspondence between Stephen George and representatives from APS and SRP conducted for a confidential client, as of late 2010, Arizona Public Service had roughly 51% of residential customers, and 65% of residential kWh served, enrolled on one of five TOU rates. Around the same time, Salt River Project had 28% of its residential accounts on one of two TOU rates, and estimate that it had nearly 50% of its target market of high use customers on these rates.

Table 5-4: P-values for Pair Wise Comparisons of Customer Acceptance Rates for Opt-in Treatments

Group	Opt-in CPP, No IHD Offer	Opt-in CPP, IHD Offer	Opt-in TOU, No IHD Offer	Opt-in TOU, IHD Offer
Opt-in CPP, No IHD Offer	n/a	n/a	n/a	n/a
Opt-in CPP, IHD Offer	0.64	n/a	n/a	n/a
Opt-in TOU, No IHD Offer	0.04	0.00	n/a	n/a
Opt-in TOU, IHD Offer	0.27	0.18	0.04	n/a

What cannot be determined from this study is what the acceptance rates would be for each rate if both were offered at the same time. If the two rates appealed to completely different households and they were both offered simultaneously to the eligible population, the acceptance rate for each, based on this study, would be expected to be between 15% and 20% after only one year of marketing, and the combined enrollment could potentially be greater than 30%. However, under the more likely hypothesis that there is a significant overlap in the types of households that accepted each rate, the overall acceptance rate when both were offered simultaneously wouldn't be expected to be much larger than when only a single rate is offered. However, what we can't determine is whether the breakdown between the two rates is likely to be 50/50, 0/100 or somewhere in between these extremes. A comparison of the characteristics of customers who accepted the two rates can shed some light on the likely outcome. If the characteristics of customers accepting the TOU and CPP rates are quite similar, it is more likely that a joint offer will produce a similar take rate for each one than if we found, for example, that the CPP rate appealed only to highly educated, high income customers while the TOU rate appealed largely to low income EAPR customers.

Table 5-5 compares the customers who accepted and declined the CPP and TOU treatments based on three variables for which information is available on all consumers—participation in the EAPR rate program, summer usage that occurs during the peak period on weekdays and what percent of summer usage occurs during peak hours. EAPR participation is an indicator of income status and the share of summer usage during the peak period is an indicator of whether or not a customer might be a structural winner if they went onto a time-variant rate. Table 5-5 includes p-values for comparisons of average characteristics between those who accepted each offer and those who declined. A shaded cell indicates that the difference is statistically significant at the 95% confidence level or greater.

Table 5-5: Selected Customer Characteristics for Opt-in Treatments[29]

Group	Accept	Customer Count	% EAPR	P-value	% on Peak Usage	P-value	On Peak Usage (kWh)[30]	P-value
RED Control	-	39,273	20%	-	20.7%	-	122	-
Opt-in CPP, No IHD Offer	N	811	19%	0.00	20.4%	0.00	122	0.16
	Y	212	31%		19.8%		114	
Opt-in CPP, IHD Offer	N	6,257	18%	0.00	20.3%	0.00	122	0.49
	Y	1,567	29%		20.0%		124	
Opt-in TOU, No IHD Offer	N	5,373	18%	0.00	20.2%	0.40	124	0.00
	Y	1,156	32%		20.5%		115	
Opt-in TOU, IHD Offer	N	8,761	19%	0.00	20.2%	0.46	121	0.84
	Y	2,087	30%		20.3%		121	

The most striking difference by far is the percent of EAPR customers who accepted the offers, which is roughly 50% more than the percent of non-EAPR customers who accepted each offer. EAPR customers also constitute a significantly greater share of the participant population than they represent in the control group. This high participation rate among low income customers who qualify for the EAPR rate is consistent with what has been observed for PG&E's SmartRate tariff.[31]

Somewhat surprisingly, there is no difference in the percent of weekday consumption used during the peak period between customers who accept the rate offers and those who decline. Similarly, for three of the four comparisons of absolute on peak usage, there is no difference between customers who accepted the rate versus those who did not. Customers who use a smaller share of their summer usage during the peak period are more likely to benefit from a TOU or CPP rate and are often called "structural winners," meaning that they will save money on the new rate without making any behavioral changes. Interestingly, the fact that the percent of usage that occurs during the peak period does not vary much between customers who did and did not enroll shows that structural winners are not more likely to accept the SPO pilot rates. This finding may be relatively unique to SMUD, or at least different from what might occur at other utilities with lower saturations of central air conditioning (CAC). When close to 90% of the target population have CAC, load shapes may be very similar for nearly everyone and it may be more difficult for customers to know whether or not they are likely to be a structural winner. In service territories where, for example, half the population has CAC and half does not, it may be easier for customers to self select according to their likelihood of being a structural winner if customers are using this level of scrutiny when deciding whether or not to enroll.

[29] P-values in this table compare average characteristics between those who accepted each offer and those who declined.

[30] The values in this column represent average kWh used during the weekday peak period per month.

[31] *2011 Ex Post Load Impact Evaluation of Pacific Gas and Electric Company's Residential Time-Based Pricing.* By Stephen George, Josh Bode, Michael Perry, Liz Hartmann and Dries Berghman. Prepared for Pacific Gas and Electric Company.

Table 5-6 shows comparisons across treatment groups and between accepters and decliners within each treatment group based on selected information obtained from a survey done by SMUD. Roughly one third of all customers responded to the survey. The customer counts in the table represent customers who responded. It is important to keep in mind that some rows have quite small sample sizes and that these characteristics may be subject to response bias.

Table 5-6: Selected Customer Characteristics for Opt-in Treatments Based on SMUD Survey Data

Group	Accept	Customer Count	% Work Full Time	P-value	% Work From Home	P-value	% Home Owner	P-value
RED Control	-	232	58%	-	21%	-	62%	-
Opt-in CPP, No IHD Offer	N	149	58%	0.16	22%	0.73	70%	0.03
	Y	93	49%		24%		56%	
Opt-in CPP, IHD Offer	N	187	56%	0.86	22%	0.25	66%	0.88
	Y	779	57%		27%		65%	
Opt-in TOU, No IHD Offer	N	165	59%	0.11	25%	0.20	75%	0.00
	Y	575	52%		20%		60%	
Opt-in TOU, IHD Offer	N	169	54%	0.60	21%	0.57	69%	0.29
	Y	1,017	57%		24%		64%	

Group	Accept	Customer Count	% CAC	P-value	% Have PT	P-value
RED Control	-	232	88%	-	83%	-
Opt-in CPP, No IHD Offer	N	149	87%	0.73	82%	0.78
	Y	93	85%		80%	
Opt-in CPP, IHD Offer	N	187	88%	0.65	78%	0.16
	Y	779	90%		82%	
Opt-in TOU, No IHD Offer	N	165	89%	0.75	80%	0.73
	Y	575	89%		79%	
Opt-in TOU, IHD Offer	N	169	88%	0.15	85%	0.68

The largest difference across all the treatment cells is in home ownership for customers accepting the CPP rate in the group with an IHD offer compared with customers accepting the TOU rate with no IHD offer. However, this small difference (5 percentage points out of roughly 60%) completely disappears when comparing CPP and TOU customers when an IHD offer is included. This suggests that the 5 percentage point difference in the prior comparison is likely due to random noise. It also appears that home owners are slightly less likely to accept an offer than non-home owners, but this difference is relatively small.

In addition to examining customer characteristics, it is interesting to compare customers who accepted SPO rates and those who did not based on participation in other programs that SMUD offers. Table 5-7 shows the participation rates of customers in the opt-in treatment groups in four SMUD programs. MyAccount is an online platform that allows customers to access many features including viewing their energy usage, paying bills and signing up for energy savings rebates. The Paperless Billing program lets customers opt-in to receive their monthly bill online instead of through the mail. The Greenergy program offers customers the ability to increase the share of electricity that comes from renewable resources. Finally, the rebate/loan programs offer financial assistance for energy efficiency improvements around the home, including loans for up to $30,000 that customers can apply for to make investments in energy efficient improvements and cash rebates from SMUD on qualified energy efficient residential appliances.

Table 5-7: Participation in Selected SMUD Programs for Opt-in Treatments

Group	Accept	# of Customers	% MyAccount	P-val.	% Paperless	P-val.	% Greenergy	P-val.	% Rebate/ Loans	P-val.
RED Control	-	39,273	41%	-	21%	-	11%	-	14%	-
Opt-in CPP, No IHD Offer	N	807	42%	0.04	18%	0.57	12%	0.22	13%	0.53
	Y	216	50%		20%		17%		13%	
Opt-in CPP, IHD Offer	N	6,215	38%	0.00	20%	0.00	10%	0.00	15%	0.21
	Y	1,609	54%		24%		14%		14%	
Opt-in TOU, No IHD Offer	N	5,325	39%	0.00	19%	0.00	9%	0.00	14%	0.71
	Y	1,204	50%		24%		15%		13%	
Opt-in TOU, IHD Offer	N	8,714	39%	0.00	20%	0.00	9%	0.00	14%	0.16
	Y	2,134	53%		24%		14%		14%	

The first row of Table 5-7 shows program participation rates for customers in the RED control group, which acts as a baseline. The remaining rows show program participation among participants in each of the four opt-in treatments. Customers who accepted the opt-in rates look similar across the four treatment groups in terms of program participation. For all four groups, about 50% of customers are enrolled in MyAccount, around 24% in paperless billing, 15% in the Greenergy program and 13% in the rebate loan programs.

When comparing customers who did and did not accept the rate offer in each treatment cell, there are many statistically significant differences. For all opt-in treatments, customers who accepted the treatment were more likely to be signed up for MyAccount. [32] For all opt-in groups except opt-in CPP with no IHD offer, customers who enrolled were more likely to participate in paperless billing and the Greenergy program. Even for the opt-in CPP treatment with no IHD offer, participation in paperless billing and Greenenergy is higher than for decliners, but the difference is not statistically significant. This lack of statistical significance may be due in part to the smaller sample size for this treatment group.

[32] Customers who were contacted about opting in to the SPO program were directed to My Account as a way to enroll. This could be inflating the numbers for customers who accepted the offer.

5.2.2 Customer Retention

Table 5-8 shows retention rates for each treatment cell. As discussed in Section 5.2, when examining retention rates, it is important to distinguish between customers who leave the rate because they move and are no longer eligible and customers who drop out because they no longer prefer the rate relative to an alternative choice. As shown in Table 5-8, over the course of the four month summer period when the rate was in effect, roughly 10% of customers de-enrolled. However, the vast majority of these customers were movers, not dropouts. Less than 2% of customers dropped out of the program for each treatment option. For the opt-in TOU rate with no IHD offer, only 1 person out of more than 1,100 left the program voluntarily. The average dropout rate for the two CPP treatments is more than twice that of the two TOU treatments, but the overall rate is so small that this difference is not material from a policy perspective.

Table 5-8: Customer Retention for Opt-in Treatments

Group	Total Enrolled June 1, 2012	Total Enrolled Sept 30, 2012	Movers	Dropouts	Summer Retention Rate[33]	Dropout Rate[34]
Opt-in CPP, No IHD Offer	212	193	15	4	90.1%	1.9%
Opt-in CPP, IHD Offer	1,569	1,454	87	28	91.5%	1.8%
Opt-in TOU, No IHD Offer	1,157	1,074	82	1	89.8%	0.1%
Opt-in TOU, IHD Offer	2,092	1,936	130	26	91.4%	1.2%

5.3 Default Treatments

The SPO pilot included three default treatments—CPP, TOU and a combination TOU-CPP rate. In addition to being defaulted onto the new rate, all groups were offered a free IHD. Comparing the acceptance rates for the three treatments will indicate whether the average customer prefers one rate over the others. As mentioned above, this comparison is not the same as asking the same group of customers to choose between CPP, TOU and TOU-CPP rates. This would be a more direct measure of customer preferences among these specific rate options but was purposefully not executed as it would have compromised the ability to analyze the effect of each rate.

As mentioned in Section 5.2, it is worth noting the difference between the number of customers drawn into the various treatment samples and the number who were defaulted onto the new rates. SMUD pulled the treatment samples in late August 2011. Between the time when the samples were pulled and when the default notifications were sent, some customers moved, in which case these customers were dropped from the research sample as they no longer qualified to participate in the study.[35] Table 5-9 reports the number of customers in the original sample and the number of customers who received marketing offers. These differences are larger for the default treatments than for the opt-in treatments because the time between when the sample was drawn and when the first solicitations

33 The retention rate equals the number of customers enrolled on September 30 divided by the number enrolled on June 1.

34 The dropout rate equals the number of drop outs divided by the number of enrolled customers as of June 1, 2012.

35 Any customer that moved from their associated premise at any point after the sample was pulled would be removed from the study and analysis.

were sent was longer for default treatments. Notifications were not sent until April 2012, which was more than seven months after the sample was drawn. In the remainder of this section, the basis for all estimates of customer acceptance and enrollment rates is the number of customers receiving the offer, not the number in the initial sample.

Table 5-9: Number of Customers Sampled and Number of Customers Defaulted Onto the New Rate

Group	Total in Sample	Total Offered	% Offered
Default TOU-CPP, IHD Offer	729	680	93%
Default CPP, IHD Offer	846	780	92%
Default TOU, IHD Offer	2,410	2,219	92%

5.3.1 Customer Acceptance of Default Treatments

Table 5-10 summarizes the main findings concerning customer acceptance of the default treatments. For default treatments, acceptance is defined by customers who did not dropout prior to going on the rate, but the acceptance rate excludes those who moved between receiving a default notification and going on the rate. In this way, the acceptance rate reflects only customers who proactively chose not to be defaulted onto the new rate, not those who never got on the rate because of other factors such as moving. Overall, acceptance rates were extremely high, ranging from 93% to over 97%. This far exceeded SMUD's pilot design assumptions, which were that 50% of customers would opt out prior to being placed on the default rate.

Table 5-10: Acceptance Rates for Default Treatments

Group	Total Offered	Movers Prior to 6/1/12	Dropouts Prior to 6/1/12	Total Accepted	Total Offered Less Movers	Acceptance Rate
Default TOU-CPP, IHD Offer	680	47	45	588	633	92.9%
Default CPP, IHD Offer	780	49	30	701	731	95.9%
Default TOU, IHD Offer	2,219	152	49	2,018	2,067	97.6%

Although the range of acceptance rates across the three default rates is less than five percentage points, each is statistically different from the other two at the 95% confidence level. Table 5-11 shows the p-values for the pair wise comparisons of acceptance rates for the default treatments. The acceptance rate for the TOU-CPP treatment, 92.9%, is more than 3 percentage points lower than the acceptance rates for the CPP rate and the TOU rate. The acceptance rates for the CPP and TOU rates are just over 2 percentage points different and this is also significant at the 95% confidence level.

Table 5-11: P-statistics for Pair Wise Comparisons of Customer Acceptance Rates for Default Treatments

Group	Default TOU-CPP, IHD Offer	Default CPP, IHD Offer	Default TOU, IHD Offer
Default TOU-CPP, IHD Offer	n/a	n/a	n/a
Default CPP, IHD Offer	0.02	n/a	n/a
Default TOU, IHD Offer	0.00	0.01	n/a

Table 5-12 compares customers who accepted and declined based on EAPR status, summer on peak usage and the share of summer usage that is on peak. The table contains p-values for the differences in average characteristics between those who did and did not accept each rate. As with the opt-in treatments, the largest difference across all the treatment cells is in EAPR status for customers accepting the CPP rate compared with customers accepting the TOU-CPP rate. Of the customers who accepted the CPP rate, for example, 24% are on EAPR whereas only 18% in the TOU-CPP group are on EAPR. It is interesting to note that there is virtually no difference in the percent of weekday usage that occurs during the peak period for customers who accepted each rate offer. In terms of absolute on peak usage, however, customers who accepted the rate showed greater usage than customers who did not for all three default group.

Table 5-12: Customer Characteristics for Default Treatments

Group	Accept	Customer Count	% EAPR	P-value	% on Peak Usage	P-value	On Peak Usage (kWh)	P-value
RED Control	-	39,273	20%	-	20.7%	-	122	-
Default CPP-TOU, IHD	N	45	13%	0.44	19.5%	0.20	95	0.02
	Y	588	18%		20.4%		123	
Default CPP, IHD	N	31	16%	0.30	18.8%	0.00	99	0.02
	Y	699	24%		20.4%		127	
Default TOU, IHD	N	48	10%	0.08	19.4%	0.39	104	0.00
	Y	2,017	21%		20.1%		122	

Table 5-13 compares the characteristics of customers who stayed on the default rate and those who declined for selected characteristics obtained from the SMUD survey. When reviewing this table, it is very important to note the sample sizes for each row. Given the low response rate to the survey, combined with low original sample sizes for some treatments and low opt-out rates, the sample sizes for all rows showing the decliner population are extremely small. While we report the statistical significance of the pair wise comparisons for acceptors and decliners for each rate, we advise against drawing any significant conclusions from these comparisons given the small sample sizes.

Table 5-13: Selected Customer Characteristics for Default Treatments Based on SMUD Survey Data

Group	Accept	Customer Count	% Work Full Time	P-value	% Work From Home	P-value	% Home Owner
RED Control	-	232	58%	-	21%	-	62%
Default TOU-CPP, IHD Offer	N	18	53%	0.46	36%	0.09	94%
	Y	189	62%		17%		73%
Default CPP, IHD Offer	N	8	13%	0.01	17%	0.75	50%
	Y	259	61%		22%		68%
Default TOU, IHD Offer	N	15	57%	0.76	45%	0.08	80%
	Y	624	61%		23%		63%

Group	Accept	Customer Count	% CAC	P-value	% Have PT	P-value
RED Control	-	232	88%	-	83%	-
Default TOU-CPP, IHD Offer	N	18	100%	0.12	83%	0.77
	Y	189	88%		81%	
Default CPP, IHD Offer	N	8	88%	0.85	71%	0.36
	Y	259	90%		84%	
Default TOU, IHD Offer	N	15	93%	0.53	86%	0.35
	Y	624	88%		75%	

In addition to looking at customer characteristics, it is also interesting to compare customers who accepted SPO rates and those who didn't by participation in other programs that SMUD offers. Table 5-14 shows the participation rates of customers in the opt-in treatment groups in four of SMUD's most popular programs.[36] Once again, the small sample sizes for decliners suggest caution in drawing conclusions about even large differences in characteristics between those who do and do not accept the default rate offers.

36 Each program is described in Section 5.2.1

Table 5-14: Program Participation by for Default Treatments

Group	Accept	# of Customers	% MyAccount	P-val.	% Paperless	P-val.	% Greenergy	P-val.	% Rebate Loans	P-val.
RED Control	-	39,273	41%	-	21%	-	11%	-	14%	-
Default TOU-CPP, IHD Offer	N	45	56%	0.07	27%	0.23	9%	0.86	18%	0.54
	Y	588	42%		19%		10%		14%	
Default CPP, IHD Offer	N	31	35%	0.45	23%	0.81	6%	0.35	26%	0.06
	Y	699	42%		21%		12%		14%	
Default TOU, IHD Offer	N	48	46%	0.46	19%	0.97	8%	0.72	21%	0.19
	Y	2,017	41%		19%		10%		14%	

The first row of Table 5-14 shows the program participation rates for customers in the RED control group, which acts as a baseline. The remaining rows show program participation for each of the four opt-in rates by customer acceptance. Customers who accepted the default rates look very similar across the four treatment groups in terms of program participation. For all four groups, about 42% of customers are enrolled in MyAccount, around 20% in paperless billing, 10% in the Greenergy program and 14% in the rebate loan programs.

Differences between customers who accepted the rates and those who didn't within each rate option are generally not statistically significant. Of the 12 comparisons, only 2 are statistically different from each other. Customers who accepted the default TOU-CPP treatment were less likely to have enrolled in MyAccount and customers who accepted the default CPP rate were less likely to participate in the rebate loans program.

5.3.2 Customer Retention

Table 5-15 shows retention rates for each treatment cell. As discussed in Section 5.2, when examining retention rates, it is important to distinguish between movers and dropouts. As Table 5-15 shows, over the course of the four month summer period when the rate is in effect, roughly 10% of customers de-enrolled. However, the vast majority of these customers were movers, not dropouts. The lowest dropout rate was 2%, for the default TOU group. The rate was slightly higher for CPP at 2.6% and almost twice as high for TOU-CPP at 3.6%.

Table 5-15: Customer Retention for Default Treatments

Group	Total Enrolled June 1, 2012	Total Enrolled Sept 30, 2012	Movers	Dropouts	Summer Retention Rate	Dropout Rate
Default CPP & TOU, IHD	588	527	40	21	89.6%	3.6%
Default CPP, IHD	701	645	38	18	92.0%	2.6%
Default TOU, IHD	2,018	1,839	138	41	91.1%	2.0%

6 TOU Rate Impacts

This section presents the demand and energy impact estimates for the TOU and TOU-CPP rate options included in the SPO. The SPO design was intended to provide adequate statistical power to measure treatment effects[37] averaged over the entire summer for the peak period for each rate option (for TOU, TOU-CPP and CPP options). These average impact estimates are the primary focus of this evaluation, although sample size calculations also focused on estimating conservation effects. Other impacts of interest can be obtained from the data, including impact estimates by month, estimates for individual hours of the peak period, individual CPP event day effects and non-peak period effects. When reviewing these additional estimates, it should be kept in mind that the experiment was not designed to estimate these effects and so standard error estimates for these parameters tend to be larger. Some of these estimates are summarized in this section while others are contained in Appendix E. When reviewing impact estimates in the remainder of this section and in Section 7, keep in mind that the convention used is that positive impact values indicate reductions in use and negative values indicate increases.

6.1 Peak Period Load Reductions

The TOU peak period covers 4 to 7 PM on all non-holiday weekdays from June through September. During the peak period the price per kWh is $0.27 for non-EAPR customers, which is 1.6 to 3 times higher than the off-peak price, depending on whether a customer's energy use puts them in usage tier 1 or 2. For customers on the low-income EAPR rate, the peak period price is $0.20, which is 1.2 to 3.6 times higher than the off-peak price.

Table 6-1 shows the average estimated absolute and percentage impacts for the TOU rate options across all summer peak hours. Table 6-2 shows the p-values for pair wise comparisons of load impacts across treatments.

Table 6-1: Average Peak Period Load Impacts for TOU Rate Options

Group	Average Impact per Customer (kW)	95% CI Lower	95% CI Upper	Reference Load (kW)	Impact as % of Reference Load
Opt-in TOU, No IHD Offer	0.17	0.13	0.22	1.71	10%
Opt-in TOU, IHD Offer	0.24	0.19	0.28	1.80	13%
Default TOU, IHD Offer	0.12	0.09	0.15	1.87	6%
Default TOU-CPP, IHD Offer	0.16	0.11	0.21	1.90	8%

[37] See CBS Power Analysis in Appendix F.

Table 6-2: P-values for Pair Wise Comparisons Of Load Impacts Across TOU Treatments

Group	Opt-in TOU, No IHD Offer	Opt-in TOU, IHD Offer	Default TOU, IHD Offer	Default TOU-CPP, IHD Offer
Opt-in TOU, No IHD Offer	n/a	n/a	n/a	n/a
Opt-in TOU, IHD Offer	0.03	n/a	n/a	n/a
Default TOU, IHD Offer	0.05	0.00	n/a	n/a
Default TOU-CPP, IHD Offer	0.67	0.01	0.19	n/a

As seen in Table 6-1, the largest impact was provided by the opt-in group that was offered an IHD. The 0.24 kW average hourly impact is equal to a reduction of approximately 13% in whole-house peak-period electricity use. The opt-in group that was not offered an IHD showed a significantly lower average impact of 0.17 kW, or 10% of peak-period electricity use. As seen in Table 6-2, this difference is statistically significant at the 95% confidence level.

Both default groups showed lower average impacts per customer than the opt-in group with the IHD offer, and these differences are statistically significant. The difference in impacts between TOU and TOU-CPP was not statistically significant. For customers on the default TOU-CPP treatment, the impacts in Table 6-1 include impacts on the 11 CPP days when they faced even higher peak period prices. In order to compare all 4 groups, TOU demand impacts were also calculated excluding the 11 days that were called for CPP events. Despite the fact that these were hot, high load days, the average peak period load reduction showed little change for any of the treatments.

A critical policy issue is whether the aggregate demand reduction is likely to be greater based on opt-in or default enrollment of time-variant rates. While the average impact of default customers is lower, as seen in Section 5, the acceptance rate for TOU is much higher among default customers than opt-in customers. The acceptance rate for the opt-in treatment for TOU with an IHD offer was 17.5% whereas the initial dropout rate (prior to going on the rate) for default TOU with an IHD offer was only 3%. Thus, if 100,000 customers who met the sample selection criteria had been offered TOU on an opt-in basis during the pilot period compared to defaulting 100,000 customers onto the rate and allowing them to drop out, the aggregate peak-period load reduction would have equaled roughly 4.2 MW (0.24 kW x 100,000 x .175) for the opt-in program, ±0.5 MW, and nearly three times as much for the default program, at 11.4 MW (0.12 kW x 100,000 x .97), ±2.2 MW.[38]

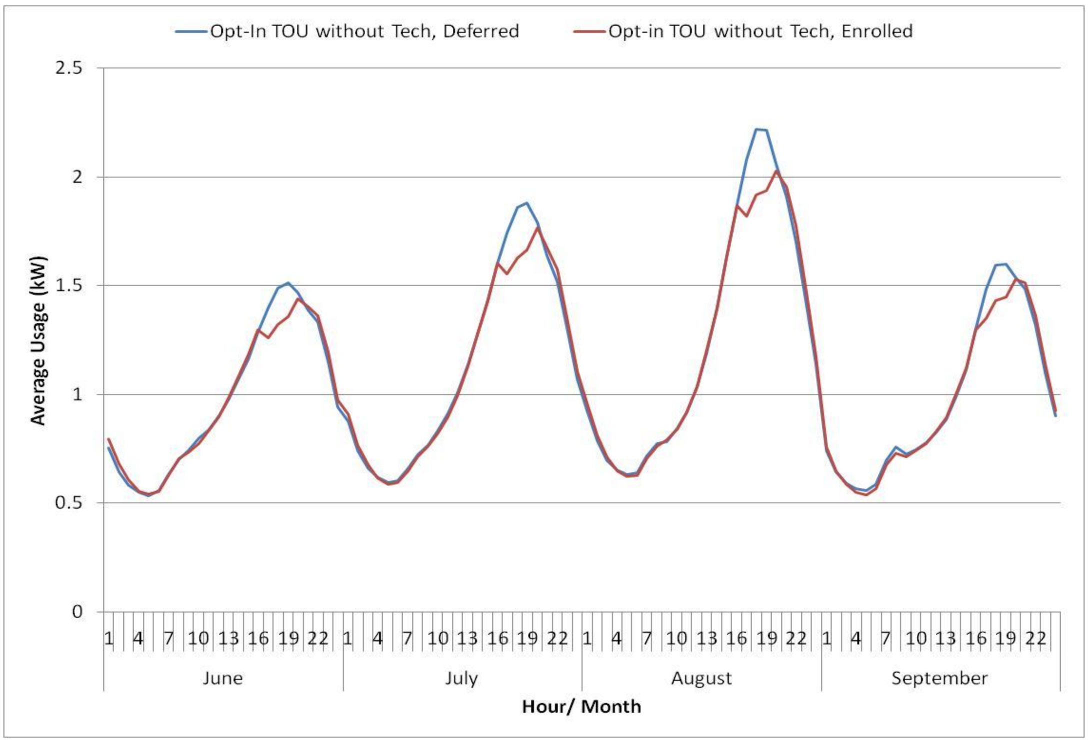
The impact estimates for the opt-in TOU treatment with and without the IHD offer included in the estimating dataset the loads of customers who de-enroll after opting in, some prior to the summer and some during the summer. This means that the RCT-based impact estimates for these groups can technically be considered intent-to-treat estimates in the sense described in Section 3. In contrast with the REDs in this pilot, recovering the local average treatment effect in this case requires scaling up the values only slightly because de-enrollment rates are low. The average summer retention rate in the opt-in TOU group with the IHD offer was 97%, where the denominator is the fraction that ever

38 In this example, the 95% confidence interval for the opt-in program is from 3.6 MW to 4.7 MW. The 95% confidence interval for the default program is 9.2 MW to 13.7 MW. The mean values for each rate differ slightly from the values determined from the calculations shown in the parentheses due to rounding.

enrolled.[39] In the opt-in group without the IHD offer, it was also 97%. This means that each set of estimates and standard errors can be scaled up by 3%, which has little actual effect on the point estimates.

In addition to knowing how average impacts vary across treatments, it is useful to observe how impacts vary across months. For illustration, Figure 6-1 depicts average hourly, weekday loads by month for the TOU treatment cell with no IHD offer. Table 6-3 shows the monthly values for all four TOU treatments. As seen, the largest impacts occur in August when peak loads are highest in the control group. Even in the cooler months, however, large TOU impacts can be seen during the peak period. Comparing the absolute and percentage impacts and the reference loads across months for each treatment suggests that higher load impacts in July and August compared with June and September is due to higher reference loads, not to greater price responsiveness in these months.

Figure 6-1: Load Impacts by Month for Opt-in TOU, No IHD Offer



[39] Note that this rate is different than the rate implied by Table 5-6 because this rate includes all customers who drop-out any time after accepting (excluding movers). This is to ensure comparability between the treatment and deferred groups. Customers in the treatment group may be more likely to drop out as the summer approaches than customers in the deferred group.

Table 6-3: Average Load Impacts by Month for TOU Treatments

Month	Group	Average Impact per Customer (kW)	95% CI Lower	95% CI Upper	Reference Load (kW)	% Impact
June	Opt-in TOU, No IHD Offer	0.16	0.11	0.20	1.45	11%
	Opt-in TOU, IHD Offer	0.18	0.14	0.21	1.51	12%
	Default TOU, IHD Offer	0.10	0.07	0.13	1.58	6%
	Default TOU-CPP, IHD Offer	0.11	0.06	0.16	1.61	7%
July	Opt-in TOU, No IHD Offer	0.19	0.13	0.25	1.79	11%
	Opt-in TOU, IHD Offer	0.29	0.24	0.33	1.91	15%
	Default TOU, IHD Offer	0.12	0.09	0.16	1.97	6%
	Default TOU-CPP, IHD Offer	0.17	0.11	0.23	1.99	9%
August	Opt-in TOU, No IHD Offer	0.24	0.17	0.30	2.11	11%
	Opt-in TOU, IHD Offer	0.31	0.26	0.36	2.20	14%
	Default TOU, IHD Offer	0.16	0.12	0.20	2.30	7%
	Default TOU-CPP, IHD Offer	0.22	0.14	0.29	2.31	9%
September	Opt-in TOU, No IHD Offer	0.09	0.04	0.15	1.50	6%
	Opt-in TOU, IHD Offer	0.16	0.12	0.21	1.59	10%
	Default TOU, IHD Offer	0.09	0.05	0.12	1.65	5%
	Default TOU-CPP, IHD Offer	0.13	0.07	0.20	1.69	8%

6.2 Load Impacts Outside the Peak Period

Although the peak period hours are of most interest, it is also useful to know what happens to electricity usage during non-peak hours for customers on the TOU treatments, especially those hours just before the peak period when pre-cooling might occur and right after the peak period, when a snapback impact might exist. Table 6-4 shows impacts for each of the four TOU groups for the two hours before the peak period (2 to 4 PM) and the two hours after the peak period (7 to 9 PM) across all summer weekdays. The results in the table show that there are minimal changes in electricity use for TOU customers outside the TOU peak period. Of the eight estimated impacts for pre- and post-peak periods, the pre-peak impact for the opt-in TOU with no IHD offer is the only one that is statistically significant at the 95% confidence level. This estimate indicates that this group uses slightly more energy than the deferred group in the two hours before the peak period, suggesting the possibility of pre-cooling behavior.

Table 6-4: TOU Load Impacts Before and After Peak Period

Group	Average Pre-Peak Impact per Customer (kW)	95% CI Lower	95% CI Upper	Average Impact Post-Peak (kW)	95% CI Lower	95% CI Upper
Opt-in TOU, No IHD Offer	-0.04	-0.08	-0.01	-0.02	-0.06	0.02
Opt-in TOU, IHD Offer	0.00	-0.04	0.05	-0.01	-0.05	0.03
Default TOU, IHD Offer	0.00	-0.02	0.02	0.02	0.00	0.04
Default TOU-CPP, IHD Offer	0.03	-0.03	0.09	0.04	-0.01	0.10

Beyond pre- and post-peak period hours, we also analyzed impacts during all other hours of summer weekdays (12 AM to 2 PM and 9 PM to 12 AM) and on weekends. There was no evidence of shifting in these hours either. This suggests that customers are not shifting load outside of the TOU peak period.

The estimates described above fall into the category of variables that the experiment was not designed to measure. It is worth noting that in addition to the fairly wide confidence intervals, which are expected, the point estimates are all close to zero.

6.3 Energy Savings

In addition to calculating demand impacts during the TOU peak period, overall energy savings was estimated for each treatment. Table 6-5 summarizes this analysis. All four treatment groups showed energy savings, although three of the four monthly impacts are not significantly different from zero. These impacts represent a reduction of between 1% and 2% in overall monthly usage during the summer. Although only the monthly impact for the default TOU group with an IHD offer is statistically significant, it may be the case that the impacts seen for the other three groups are real because they are all in the same direction (that is, all groups showed savings) and because no evidence of load shifting to non-peak periods was found. With significant peak period reduction and no evidence of load shifting, the net result would need to be a modest reduction in overall energy use. Importantly, there is no evidence of an increase in overall electricity use in response to the lower off-peak prices that are in effect the majority of hours.

Table 6-5: TOU Energy Savings

Group	Design	Average Monthly Impact (kWh)	95% CI Lower	95% CI Upper	Monthly Reference Load (kWh)	Impact as % of Reference Load
Opt-in TOU, No IHD Offer	RCT	4	-8	17	804	1%
Opt-in TOU, IHD Offer		7	-5	20	835	1%
Default TOU, IHD Offer	RED	13	3	22	835	2%
Default TOU-CPP, IHD Offer		13	-6	31	868	1%

7 CPP Rate Impacts

This section presents the demand and energy impact estimates for the CPP rate options and for CPP days for the TOU-CPP rate. As in Section 6, which covered the TOU treatments, the primary focus of this section is on average peak-period load impacts across all CPP events for the entire summer. We also examine how impacts vary across events and with variation in temperature on event days. Impact comparisons are also made for customers who were and were not offered an IHD. As in the TOU section, additional estimates are developed for time periods that the experiment was not designed to produce, but that are nevertheless of interest. Additional CPP impacts can be found in Appendix F.

7.1 Peak Period Load Reductions

The peak period for CPP rates is the same as for the TOU rates, 4 to 7 PM. Over the 2012 summer, 12 CPP event days were called. However, on the first event day, June 20, 2012, customer notifications did not go out to everyone. As a result, the June 20 event day was not included in the analysis. For customers who did not receive notification for the June 20 event, an additional first event was called but not analyzed. This way, when the second event was called on July 10, it was the second event for all customers. Table 7-1 shows the dates and the daily maximum temperature on the eleven event days for which impacts were estimated. The daily maximum temperature exceeded 90°F on all CPP days and exceeded 95°F for 7 of the 11 event days.

Table 7-1: CPP Event Days for 2012 Used in the Load Impact Analysis[40,41]

Date	Day of Week	Daily Maximum Temperature (°F)
10-Jul-12	Tuesday	100
12-Jul-12	Thursday	102
2-Aug-12	Thursday	98
8-Aug-12	Wednesday	99
9-Aug-12	Thursday	102
10-Aug-12	Friday	102
14-Aug-12	Tuesday	95
15-Aug-12	Wednesday	94
12-Sep-12	Wednesday	91
13-Sep-12	Thursday	96
14-Sep-12	Friday	91

[40] Daily maximum temperature was taken from hour-level data. Maximum temperatures based on 15-minute data may be higher for some days.

[41] On the first event day, June 20, 2012, customer notifications did not go out to everyone. However, to ensure that all customers received 12 event notifications during the summer, for customers who did not receive notification for the June 20th event, an additional "first" event was called. Neither of these first events was included in the database when estimating impacts. The second event for all customers occurred on July 10th .

Table 7-2 shows the average impact across all CPP event hours in 2012 for each treatment group and Table 7-3 shows the p-values for each pair wise comparison of load impacts by treatment. The largest observed load reduction is for the opt-in CPP group that received an IHD offer, which produced an average reduction of almost 0.70 kW, or about 26% of whole-house reference load. The opt-in CPP group that was not offered technology had a slightly lower average impact of 0.52 kW, or 22% of household load, but the difference in impacts between the opt-in groups with and without the IHD offer was not statistically significant. The average load reductions for the two default options, CPP and TOU-CPP, are nearly identical to each other but are about half the size of the average load reduction for the opt-in groups. The difference in impacts between the opt-in and default groups is statistically significant at the 95% confidence level.

Table 7-2: Load Impacts for CPP Treatments

Group	Average CPP Impact (kW)	95% CI Lower	95% CI Upper	Reference Load (kW)	Average Impact as % of Reference Load
Opt-in CPP, No IHD Offer	0.52	0.26	0.78	2.38	22%
Opt-in CPP, IHD Offer	0.69	0.58	0.79	2.62	26%
Default CPP, IHD Offer	0.32	0.24	0.40	2.64	12%
Default TOU-CPP, IHD Offer	0.33	0.25	0.41	2.60	13%

Table 7-3: P-values for Pair Wise Comparisons of Load Impacts Across CPP Treatments

Group	Opt-in CPP, No IHD Offer	Opt-in CPP, IHD Offer	Default CPP, IHD Offer	Default TOU-CPP, IHD Offer
Opt-in CPP, No IHD Offer	n/a	n/a	n/a	n/a
Opt-in CPP, IHD Offer	0.25	n/a	n/a	n/a
Default CPP, IHD Offer	0.15	0.00	n/a	n/a
Default TOU-CPP, IHD Offer	0.18	0.00	0.82	n/a

Given the significant difference in the number of enrolled customers between the opt-in and default CPP rate options, these results suggest strongly that a default rate program would produce much larger aggregate impacts than an opt-in program. Indeed, when combined with the customer acceptance values discussed in Section 5, if a CPP rate with an IHD offer was made to 100,000 customers on both an opt-in and default basis, SMUD could expect to obtain demand reductions on event days equal to 12.6 MW (100,000 x .182 x .69 kW), ±1.6 MW for the opt-in rate and 30.7 MW (100,000 x .959 x .32 kW), ±6.6 MW, for the default rate.[42] Notably, mean load impacts for the default CPP rate would be almost three times larger than the 11.6 MW mean load reduction estimated for default TOU, based on specific prices tested in the SPO pilot.

[42] In this example, the 95% confidence interval for the opt-in program is from 10.9 MW to 14.2 MW. The 95% confidence interval for the default program is from 24.0 MW to 37.2 MW.

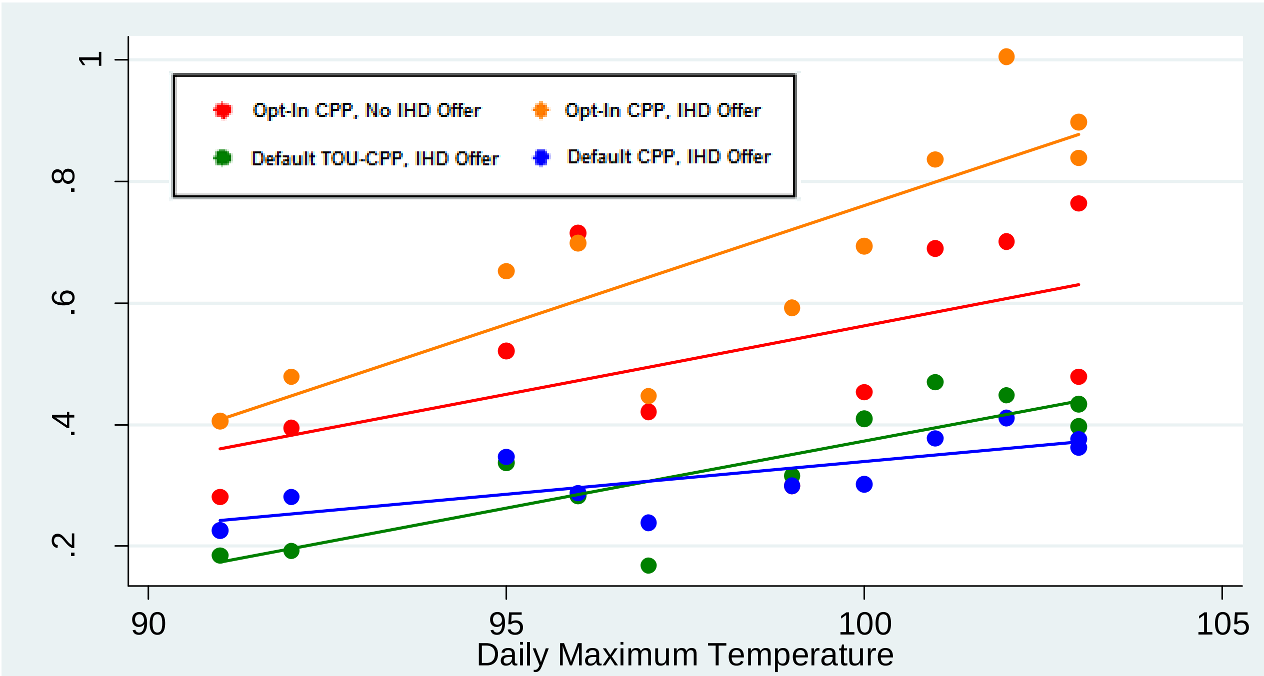
Although the sample sizes used in SPO were not designed to estimate individual event day load impacts, it is still possible to do so, while recognizing that the confidence intervals around these estimates will be larger than for the average event day. Table 7-4 shows the estimated load impacts for each event day for one of the four treatments, the opt-in CPP rate with IHD offer. Appendix F contains impact estimates for each hour of each event day for all four treatments. As seen, the load impacts vary significantly across event days, from a low of 0.41 kW on the coolest day (September 14) to a high of 1.0 kW on the hottest day (July 12). In general, load impacts are higher on hotter days than on cooler ones. One issue of interest is whether impacts drop off across event periods. There were three multi-day event sequences during the summer – a three-day period from August 8 through 10; a two-day period from August 14 and 15; and a three-day period from September 12 through 14. As seen in the table, there is no evidence that impacts decline over consecutive event days.

Table 7-4: Event Day Load Impacts for Opt-in CPP With IHD Offer

Date	Day of Week	Daily Maximum Temperature (°F)	Load Reduction	95% CI Lower	95% CI Upper
10-Jul-12	Tuesday	100	0.84	0.68	0.99
12-Jul-12	Thursday	102	1.00	0.83	1.18
2-Aug-12	Thursday	98	0.59	0.43	0.75
8-Aug-12	Wednesday	99	0.69	0.55	0.84
9-Aug-12	Thursday	102	0.84	0.67	1.00
10-Aug-12	Friday	102	0.90	0.72	1.07
14-Aug-12	Tuesday	95	0.70	0.55	0.85
15-Aug-12	Wednesday	94	0.65	0.50	0.80
12-Sep-12	Wednesday	91	0.48	0.34	0.62
13-Sep-12	Thursday	96	0.45	0.30	0.59
14-Sep-12	Friday	91	0.41	0.26	0.55
Average	n/a	n/a	0.69	0.58	0.79

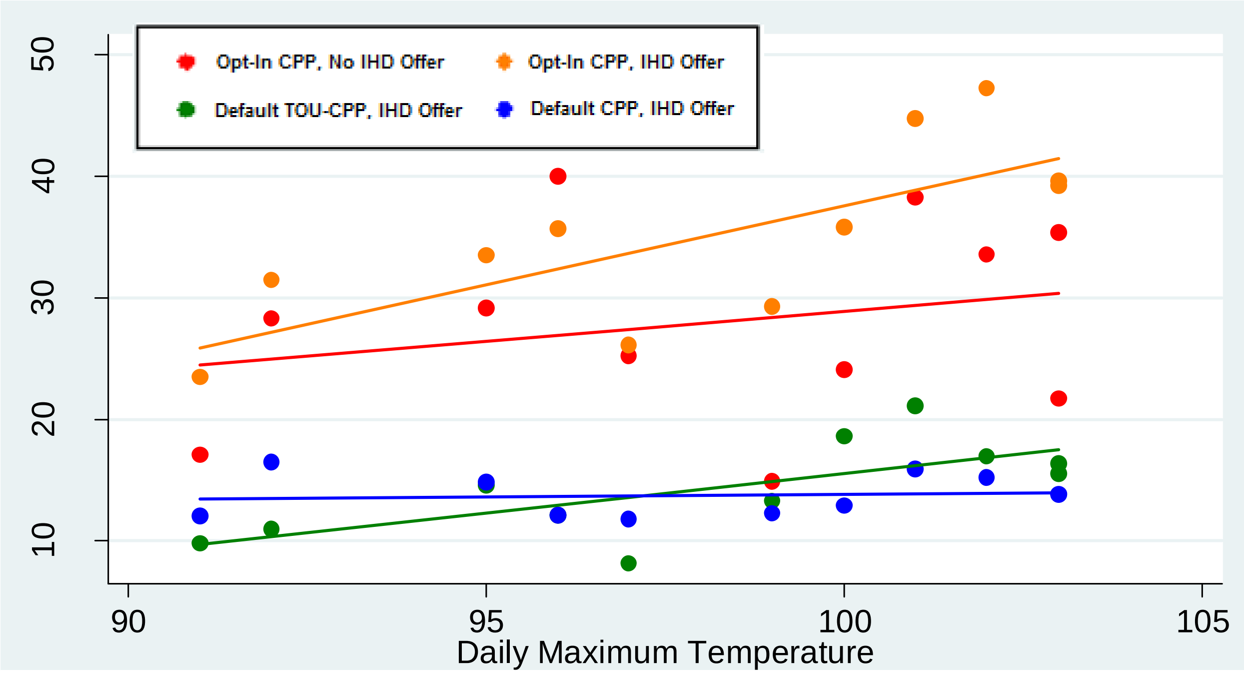
The relationship between load impacts and weather is explored more fully in Figures 7-1 and 7-2. Figure 7-1 shows the average impact for each of the 11 CPP event days plotted against the daily maximum temperature for the day for each treatment. For all four groups, as the daily maximum temperature increases, so does the average event impact. The relationship between impacts and maximum temperature appear to be strongest for the two opt-in treatments compared with the default treatments.

Figure 7-1: CPP Impacts and Daily Maximum Temperature by Treatment Group



An interesting question is whether the observed correlation between temperature and load impacts is due to differences in the reference load across days or due to differences in price responsiveness across days. An important related question is whether price responsiveness, that is the willingness of customers to reduce load in response to higher price signals, increases, decreases, or stays constant as temperatures rise. Figure 7-2 shows the average percent impact for each of the 11 CPP event days plotted against the daily maximum temperature for the day for each treatment. For three of the four groups, there appears to be a positive correlation between percent load reduction and maximum temperature, but this correlation is weaker than the correlation between absolute load reduction and maximum temperature. There certainly is no evidence that price responsiveness decreases as temperatures increase, as some have speculated (e.g., some policymakers have expressed concern that customers will "buy through" the high price signal in order to maintain their comfort on the hottest event days).

Figure 7-2: CPP Percent Impacts and Daily Maximum Temperature by Treatment Group



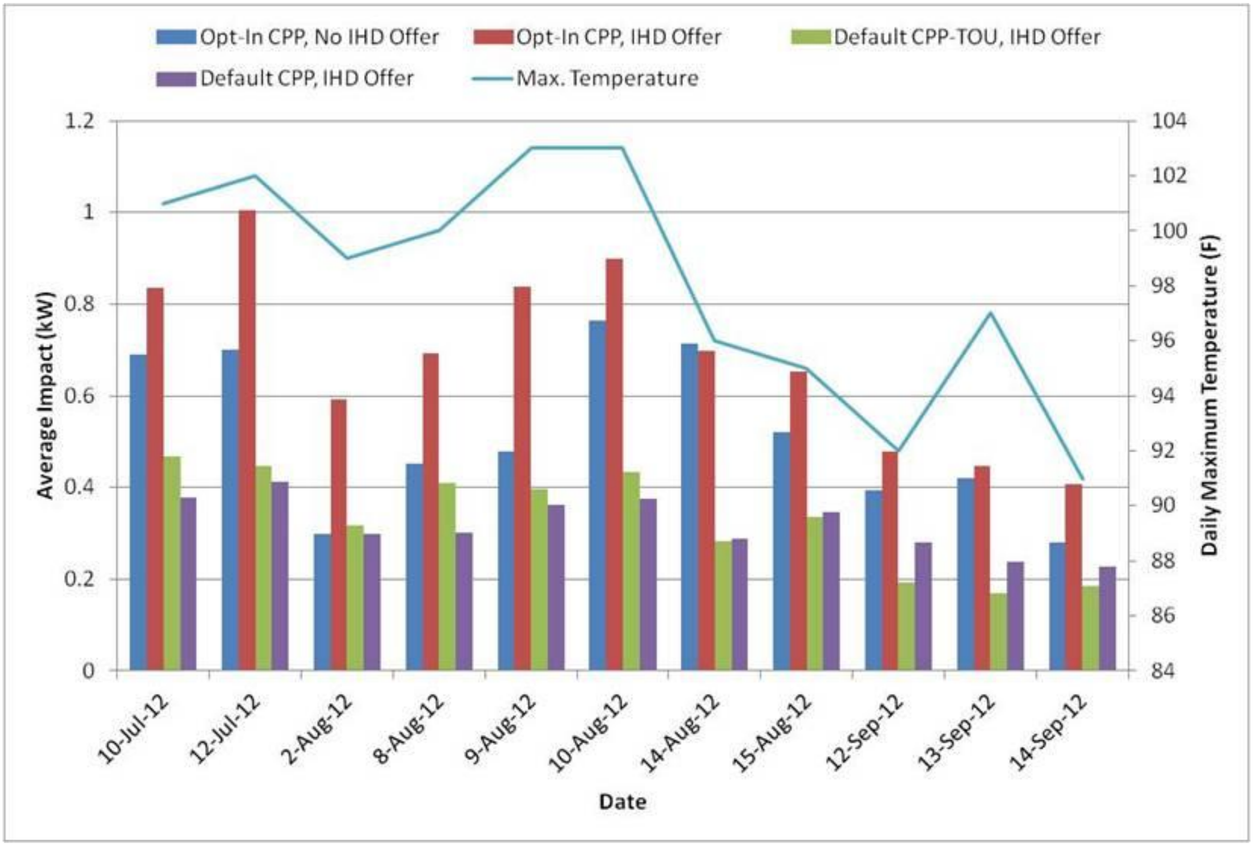
In order to determine whether the relationships observed in Figures 7-1 and 7-2 are statistically significant, regressions were run relating event-day load reductions to weather. Separate regressions were run with weather represented by the daily maximum temperature and represented by a variable equal to the mean temperature for the hours from midnight until 5 PM on the peak day (referred to as mean17). This variable does a better job capturing heat buildup prior to the peak period than does the simpler daily maximum temperature variable. Humidity clearly has an impact on how hot people feel, and therefore how much cooling load they use. However, within one region, the level of variation in humidity over one summer, independent of temperature, is often so low as to be practically useless for modeling and, therefore, was not used in this analysis. The results from these regressions are shown in Table 7-5. As seen, all but one of the weather coefficients in the regressions of weather against absolute load reductions is statistically significant. On the other hand, for five of the eight regressions of weather against percent load impacts, the coefficients are not statistically significant. These results suggest that most of the underlying reason for the higher load impacts on hotter days is because reference loads are higher on hotter days. They also suggest that concerns that price responsiveness may fall as event day temperatures rise are unwarranted.

Table 7-5: Regressions of Event Day Load Reductions and Weather

Type	Group	Temp	Slope	Lower Bound	Upper Bound	Statistically Significant?
Impact	Opt-in CPP, No IHD Offer	Max. Temp	0.02	0.00	0.05	**No**
	Opt-in CPP, No IHD Offer	Mean17	0.04	0.01	0.07	Yes
	Opt-in CPP, IHD Offer	Max. Temp	0.04	0.02	0.06	Yes
	Opt-in CPP, IHD Offer	Mean17	0.06	0.03	0.08	Yes
	Default CPP, IHD Offer	Max. Temp	0.01	0.00	0.02	Yes
	Default CPP, IHD Offer	Mean17	0.01	0.01	0.02	Yes
	Default CPP & TOU, IHD Offer	Max. Temp	0.02	0.01	0.03	Yes
	Default CPP & TOU, IHD Offer	Mean17	0.03	0.01	0.04	Yes
% Impact	Opt-in CPP, No IHD Offer	Max. Temp	0.49	-0.94	1.92	No
	Opt-in CPP, No IHD Offer	Mean17	1.18	-0.63	2.99	No
	Opt-in CPP, IHD Offer	Max. Temp	1.30	0.42	2.18	Yes
	Opt-in CPP, IHD Offer	Mean17	1.78	0.60	2.97	Yes
	Default CPP, IHD Offer	Max. Temp	0.04	-0.26	0.34	No
	Default CPP, IHD Offer	Mean17	0.02	-0.39	0.43	No
	Default CPP & TOU, IHD Offer	Max. Temp	0.65	0.15	1.14	Yes
	Default CPP & TOU, IHD Offer	Mean17	0.62	-0.20	1.45	No

Figure 7-3 shows how load impacts vary across event days for each treatment group. Each bar represents one of the four CPP treatment groups and the blue line shows the daily maximum temperature for each day. The highest average impact (weighting all groups equally) was seen on July 12. That is also the only day that any group (the opt-in CPP group with the IHD offer) showed an impact of 1 kW or greater.

Figure 7-3: CPP Impacts by Group and Date



7.2 Load Impacts Outside the Peak Period

In addition to determining load impacts during the peak period, there is also value in knowing if usage patterns change at other times of day. Table 7-6 shows the estimated impacts for the two hours immediately before and after the event period for the average event day. This analysis focuses on determining if pre-cooling behavior occurs before the event period and if a snapback effect can be observed after the event period when customers might adjust their thermostat to a cooler temperature or conduct activities that they avoided doing during the high priced event period. The values in the table for the pre-peak period represent the hours from 2 to 4 PM and the post event hours are from 7 to 9 PM. For three of the four groups: opt-in CPP with no IHD offer and both default groups, there are no statistically significant impacts seen outside of the peak period on CPP days. For the opt-in CPP group that received an IHD offer, not only is there no evidence of pre-cooling or snapback, the opposite occurred. This group of customers appears to reduce load prior to the event period and to maintain lower usage for the two hours after the peak period. In fact, the pre- and post-period load reductions, roughly 0.14 kW in both periods, are equal to about 20% of the estimated load reduction during the peak period.

Table 7-6: CPP Impacts Before and After Peak Period on CPP Event Days

Group	Average Impact Pre-Peak (kW)	95% CI Lower	95% CI Upper	Average Impact Post-Peak (kW)	95% CI Lower	95% CI Upper
Opt-in CPP without Tech	0.01	-0.21	0.22	-0.06	-0.26	0.14
Opt-in CPP with Tech	0.14	0.05	0.22	0.13	0.05	0.21
Default CPP with Tech	0.04	-0.02	0.09	0.02	-0.04	0.07
Default TOU & CPP with Tech	0.03	-0.03	0.09	0.04	-0.02	0.10

Table 7-7 explores impacts in two additional periods of interest, the remaining hours on CPP days not covered in the prior two tables (that is, the hours from midnight to 2 PM and from 9 PM to midnight) and the peak period hours on nonevent days. The first set of hours in the table assesses whether customers shift load from the peak period to other hours on event days, and the second set of hours explores whether changes during peak period hours on event days carry over to nonevent days. The first numerical column in Table 7-7 shows estimated impacts for same-day load shifting and the fourth numerical column shows estimated impacts during the peak period on nonevent days.

There were no statistically significant impacts during the non-afternoon hours on CPP event days. This set of hours included all hours on CPP event days except 2 PM to 9 PM (the peak period plus the two hours before and after it). Interestingly, however, there were statistically significant reductions during the peak period on nonevent days for the opt-in CPP group with the IHD offer and for both the default CPP and TOU-CPP groups. This reduction makes sense for the TOU-CPP rate since TOU pricing is in effect on these days. However, for the other two groups, prices are not higher during the peak period. This result suggests that CPP customers may be adjusting their thermostat settings on all weekdays in order to avoid the higher event day prices and/or permanently adjusting their behavioral patterns for other end uses on all weekdays.

Table 7-7: TOU Impacts During Non-peak Hours and Non-CPP Peak Period Impacts

Group	Average Impact Between 12 AM and 2 PM and 9 PM and Midnight on Event Days (kW)	95% CI Lower	95% CI Upper	Average Impact During Peak Hours on Nonevent Weekdays (kW)	95% CI Lower	95% CI Upper
Opt-in CPP, No IHD Offer	0.00	-0.08	0.08	0.02	-0.14	0.19
Opt-in CPP, IHD Offer	-0.01	-0.05	0.03	0.16	0.10	0.22
Default CPP, IHD Offer	-0.01	-0.03	0.01	0.08	0.03	0.12
Default TOU-CPP, IHD Offer	0.00	-0.02	0.03	0.13	0.08	0.18

7.3 Overall Energy Savings

Table 7-8 contains estimates of overall energy savings for customers on CPP rates. In this analysis, the monthly usage of each treatment and control group was compared for the summer of 2012. Pretreatment data from the summer of 2011 was also included to account for any differences between the groups before the treatment began. For opt-in CPP with no IHD offer and both default groups, monthly impacts were minimal and not statistically significant. For the opt-in CPP group that was offered an IHD, however, there were savings of 34 kWh per month, which is equal to about 4% of monthly usage. This result is consistent with the prior finding that the opt-in CPP with IHD group showed the largest amount of load reduction during non-CPP hours, which cover a much greater percentage of the summer than CPP peak hours.

Table 7-8: CPP Energy Savings

Group	Design	Average Summer Energy Savings (kWh)	95% CI Lower	95% CI Upper	Monthly Reference Load (kWh)	Impact as % of Reference Load
Opt-in CPP, No IHD Offer	RED	10	-49	68	764	1%
Opt-in CPP, IHD Offer		34	7	61	825	4%
Default CPP, IHD Offer		15	-1	32	856	2%
Default TOU-CPP, IHD Offer		13	-6	31	868	1%

8 The Influence of In Home Displays

SMUD's SPO was designed to assess the impact of the offer of an IHD on customer acceptance of opt-in time-variant rates by marketing TOU and CPP rates with and without the offer of an IHD. This was discussed in Section 5. As seen there, there is no evidence that the offer of a free IHD changes the customer acceptance rate for time-variant rate offers.

Another useful investigation concerns the acceptance and connection rates for IHDs among treatment groups that received an IHD offer. What percent of customers who receive an IHD offer accept it and what percent of those customers receiving an IHD connected the device with their meter? These issues are discussed below in Section 8.1.

A third important issue in the industry is whether IHDs influence consumer behavior. The SPO was designed to determine if there are differences in load impacts for customers who were *offered* an IHD as part of the rate offer, and those who were *not offered* an IHD as part of the rate offer. As seen in Sections 6 and 7, there is some difference in load impacts across treatment cells that did and did not include an IHD offer. However, testing the load impact of an IHD *offer* is different from testing the load impact of an IHD, because many people who were offered an IHD did not accept one and many who accepted an IHD did not. Given the general interest in whether or not IHDs influence usage behavior, it is likely that some readers will draw conclusions about the influence of IHDs by observing these differences. To reduce the likelihood that readers will draw incorrect conclusions about the influence of IHDs on energy use and demand response, we have analyzed this issue using quasi-experimental comparisons. That analysis is reported in Sections 8.2 and 8.3.

8.1 IHD Acceptance and Use

Customers in the opt-in IHD treatment groups were offered a free IHD if they enrolled on the rate. Acceptance of the IHD was not a condition of going on the rate. Opt-in customers could indicate at the time of enrollment whether or not they wanted the IHD. If they did, the IHD was mailed to them pre-commissioned, so that when they unpacked it and turned it on it was supposed to automatically connect with their meter and start displaying information.

All customers in the default treatment groups were offered a free IHD. Because customers did not have to do anything to enroll on a default rate, those who wanted the IHD had to take a proactive step to request an IHD. Once requested, a pre-commissioned IHD was mailed to the customer and all that was needed to use it was to unpack it and turn it on.

Through its HAN Communication Manager (HCM), SMUD could tell whether or not an IHD was communicating with the meter at a given point in time. Over the course of the summer, SMUD took multiple snap shots of the number of meters that were communicating with an IHD for the IHD treatment cells. For each treatment group, Table 8-1 shows the number of customers who requested an IHD, the maximum number of customers who were connected at a point in time during the summer, and the number of devices that were still communicating with the meter at the end of the summer rate period.

Table 8-1: IHD Acceptance and Connection Rates

Group	Enrolled 6/1/12	# That Accept IHD	Acceptance Rate	Peak # of IHDs Activated	Peak % Connected	Total Connected 9/30/12	% Connected 9/30/12	% of Enrolled Customers Connected 9/30/12
Opt-in CPP, IHD Offer	1,569	1,498	95%	590	39%	426	28%	27%
Opt-in TOU, IHD Offer	2,092	2,017	96%	768	38%	591	29%	28%
Default TOU-CPP, IHD Offer	588	136	23%	81	60%	67	49%	11%
Default CPP, IHD Offer	701	167	24%	91	54%	67	40%	10%
Default TOU, IHD Offer	2,018	418	21%	190	45%	159	38%	8%

As seen in Table 8-1, roughly 96% of all opt-in customers requested an IHD. However, the maximum number of devices connected at any point in time was less than 40%. Looked at differently, although nearly all opt-in customers indicated their interest in receiving a free IHD, only about one third of them had the device connected at any specific point in time (37% = 96% x 39%). By the end of the summer, the connection rate for those accepting the IHD had fallen below 30% and only about one quarter of all opt-in customers had received an IHD and had it connected to the meter. The small differences between the opt-in CPP and TOU acceptance and activation rates is not statistically significant.

The reasons underlying these low connection rates are currently unknown. In June 2012, SMUD hired a third party to call each customer that had received an IHD to confirm receipt and to help with the setup process if needed. Many customers confirmed receipt of the IHDs, but stated that they had not yet set it up, while others stated that they had successfully installed it, and still others reported connectivity issues. Based on inquiries from customers receiving the IHD, and the experience of SMUD employees who tested the IHD, communication issues requiring frequent re-commissioning were not uncommon. Additionally, some customers reported having battery issues. Another contributing factor may have been how easy it was for opt-in customers to indicate they would like to receive the IHD. The incremental transaction cost of checking the box or saying yes to a call representative at the time of enrollment was very low and, as a result, customers may not have carefully considered whether they really wanted the device. As such, when it was received in the mail, some customers may not have bothered to unpack it or try and use it. In combination, all of the issues described above, and perhaps others, may have contributed to the low overall connection rates for opt-in customers.

In contrast to the opt-in treatments, most customers on the default rates did not request IHDs. The acceptance rates ranged from 21% to 24% across the three rate options. On the other hand, a greater percent of customers accepting an IHD connected the device with the meter compared with the opt-in treatments. The maximum connection rate for those accepting the IHD for default treatments ranged from 45% for the TOU rate to 60% for the TOU-CPP rate. These higher connection rates are consistent with the hypothesis that the higher transaction costs associated with getting an IHD for default customers caused them to think more carefully about whether or not they wanted the device compared with opt-in customers and, therefore, these customers were more likely to use it once it came.

By the end of the summer, connection rates for default customers receiving an IHD had fallen below 50% for the TOU-CPP treatment and to roughly 40% for the other two treatments. When combined with the low initial acceptance rate for these treatment groups, only about 8% of all customers enrolled on the default TOU rate had IHDs connected with their meters by the end of the summer. The overall connection rate for default CPP customers was only 10% and equaled 11% for default TOU-CPP customers. Comparing these overall connection rates across the three groups, only one of the comparisons is statistically significant. Customers in the default TOU-CPP group were more likely to have their IHDs activated on September 30, 2012 than customers in the default TOU group and this difference was significant at the 1% level.

8.2 Load Impacts for Treatments With and Without an IHD Offer

There are two comparisons that can be made between similar groups of customers offered the same rate treatment, opt-in TOU and opt-in CPP, where one group received an IHD offer and the other did not. Neither of these comparisons constitutes an RCT or RED on the effect of the IHD because the technology offer was contingent on accepting the rate. However, if we make the assumption that the choice of whether or not to accept a rate offer is not influenced by the offer of an IHD, which seems to be supported by the results reported Section 5, then a comparison between the compliers in each group can be viewed as an RED on the effect of the IHD. Given the very similar opt-in rates for the offers with and without an IHD, to believe that this restrictive assumption is highly inaccurate is to believe that there is a substantial group of customers who declined the opt-in rate simply because the IHD was offered. This seems about as unrealistic as the assumption itself. If we take this pseudo-RED framework and treat it is as an RED, it is possible to use treatment groups that did not receive the IHD offer as control groups in each case.

As an initial step, the effect of an IHD can be estimated by comparing the estimated treatment effects for opt-in TOU with and without an IHD offer and opt-in CPP with and without an IHD offer in Tables 6-1 and 7-2. As seen in Section 6, for the TOU case, the estimated effect with an IHD offer was 0.24 kW and without an IHD offer it was 0.17 kW. As seen in Section 7, for CPP, the estimated impacts with and without an IHD offer were 0.69 kW and 0.52 kW respectively. These comparisons suggest a simple estimate of the effect of the IHD offer (an intent-to-treat estimate for the IHD) of 0.07 kW for TOU and 0.17 kW for CPP. However, the standard errors of these estimates are fairly large at 0.04 kW and 0.14 kW, implying that only the effect for the TOU rate is statistically significant at a 95% confidence level.

Using the RED regression framework to make the same comparison produces an intent-to-treat estimate of 0.05 kW with a standard error of 0.02 for the TOU groups and 0.11 kW with a standard error of 0.08 for the CPP groups. These estimates are fairly similar to the estimates produced by the simple comparison of estimates calculated above. For the CPP case, the estimate is not statistically significant and for the TOU case, it is significant with a p-value of 0.02. Although we do not know precisely who activated their IHDs, if we assume that roughly 50% of customers did so at some point during the summer, then the local average treatment effect estimate for the TOU group would be 0.1 kW with the same p-value as the intent-to-treat estimate, 0.02. The higher p-value for the CPP rates may result, in part, from the small sample size for the group that did not receive an IHD offer, which was only about 200 customers. The sample size for the TOU opt-in group with no IHD offer was roughly 1,200 and the samples for the groups that received an IHD offer were roughly 1,600 in the case of the CPP tariff and over 2,100 for the TOU tariff.

Figure 8-1 shows average 2011 and 2012 loads on summer weekdays for each of the TOU groups, including only customers who were enrolled on TOU as of June 1, 2012. Notable in the graph is that the two groups have differences in 2011 weekday loads (pretreatment) of about 0.09 (5%) kW during peak periods prior to the treatment. This difference is large compared to the estimate of the IHD effect when you consider that it will be used to adjust the impact calculated for 2012 TOU days. This means that that effect's accuracy depends heavily on the assumption that the differences in pretreatment loads between groups are an accurate reflection of what the differences would have been in 2012 if these customers were not on TOU and not offered IHD.

This does not necessarily mean that the estimate is wrong; all of the impact estimates in this paper rely on this assumption. However, in the RCT or RED cases, as shown in Figure 4-1 and 4-2 in Section 4, the pretreatment differences are much smaller than this, which means that that the impact estimates are influenced much less by this assumption and similar load impact estimates would result even in the absence of pretreatment data. This suggests that more caution should be applied when interpreting this IHD impact estimate, particularly given that there is the possibility for selection bias.

Figure 8-1: Usage by TOU Opt-in Customers With and Without IHD Offer

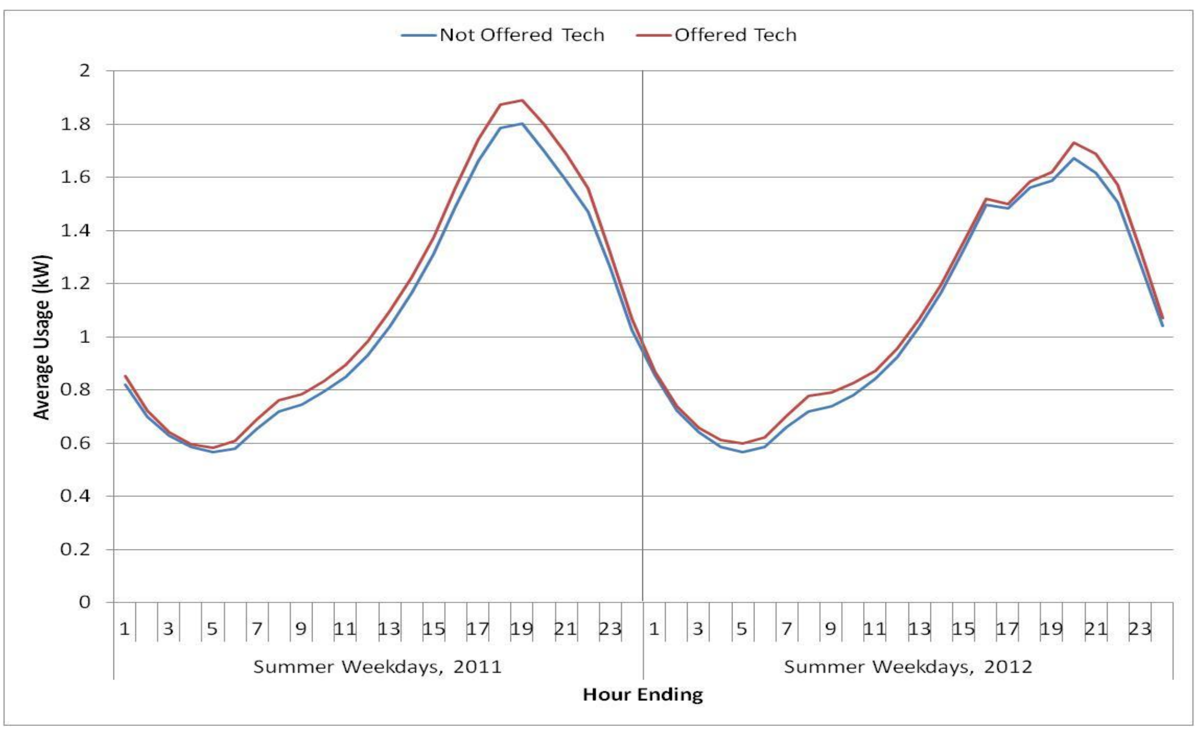
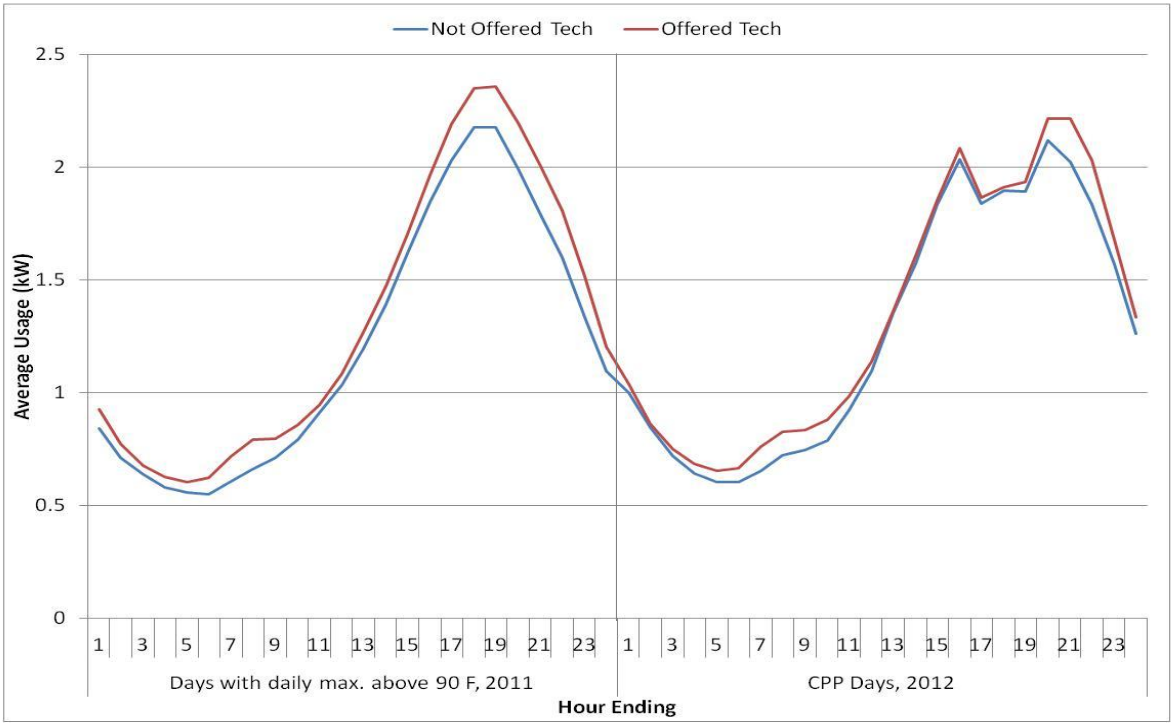


Figure 8-2 compares load for CPP customers with and without the IHD offer for customers who were enrolled on CPP as of June 1, 2012. For 2011, the graph is based on days on which the high temperature exceeded 90°F. As in the TOU case, the pretreatment differences between the groups are substantial (8% during the peak period), implying that the correction for pretreatment load has a strong effect on the treatment impact estimate.

Figure 8-2: Usage by CPP Opt-in Customers With and Without IHD Offer



Based on this analysis, FSC recommends that significant caution be applied in using these results to draw conclusions about the effect of IHDs on customer behavior for the following reasons:

- The study was not designed to address this issue;
- Addressing it requires an additional restrictive assumption to rule out selection bias;
- The estimate for the effect of IHDs for the CPP group is not statistically significant; and
- Although the estimate in the TOU group is statistically significant, its accuracy relies strongly on the assumption that the pretreatment loads between the groups provide an accurate reflection of what the differences between the groups would have been one year later in the absence of the rate and the IHD.

8.3 Comparing Those Who Accepted IHDs with Those Who Did Not

An alternative approach to assessing the influence of IHDs on demand response or energy use is to compare usage for customers who received and connected an IHD and with usage for those that did not within the group of customers to whom IHDs were offered. Unfortunately, SMUD does not have data that identifies whether or not specific customers have a device connected at any point in time.[43] However, SMUD did track which customers accepted the offer of an IHD. Although customers in each rate group that chose to accept the IHD are not necessarily comparable to customers who did not take the IHD, it is possible to look at the load shapes of each group to obtain a general idea of the differences in behavior between those who accepted the IHD offer and those who did not. Because customers who did and did not accept the IHD are likely to be different, any observed difference may be due to selection effects rather than the effect of the IHD.

Figures 8-3 through 8-5 make these comparisons for the three default treatment groups. Comparisons for the opt-in treatments are not productive because almost everyone in the opt-in groups that received an IHD offer took it. As such, the sample sizes for the groups that did not receive an IHD are so small that any comparisons are not meaningful.

The load comparisons for default TOU customers who accepted and declined an IHD offer are shown in Figure 8-3. Figure 8-4 shows the same comparison for the default TOU-CPP treatment group for the average summer weekday. As was seen in Table 8-1, 21% of these customers indicated that they wanted an IHD, while in the TOU-CPP group, 23% did so. The two graphs are similar in that during the pretreatment period, IHD accepters have similar levels of load to those who declined. For the default TOU group, customers who accepted the IHD offer had peak period usage during the summer of 2011 that was about 2% greater than customers who did not accept the IHD. For the default TOU-CPP group, this difference was about 4%. Additionally, in both graphs, the accepters show a clear behavioral response during the peak period while those who declined show little if any response. This suggests that in these default treatment cases, customers who asked for the IHD were also customers who were aware of the rate and responded to it. It also suggests that a substantial share of customers in the default groups did not respond to the rate at all and may not even have been aware they were on a time-variant rate. If lack of awareness was a key driver of non-response, it might be possible to increase load response through an awareness and education campaign.

[43] As discussed in Section 5, SMUD tracked the number of IHDs connected to meters at various points in time over the summer, but did not track connectivity at the individual customer level. SMUD is currently working with the meter vendor to determine whether data on device connections at the individual customer level can be obtained for 2012. If so, it will be possible to compare usage for customers who received the device but did not connect it with those who connected it.

Figure 8-3: Usage by Customers who Did and Did Not Accept an IHD Default TOU with IHD Offer

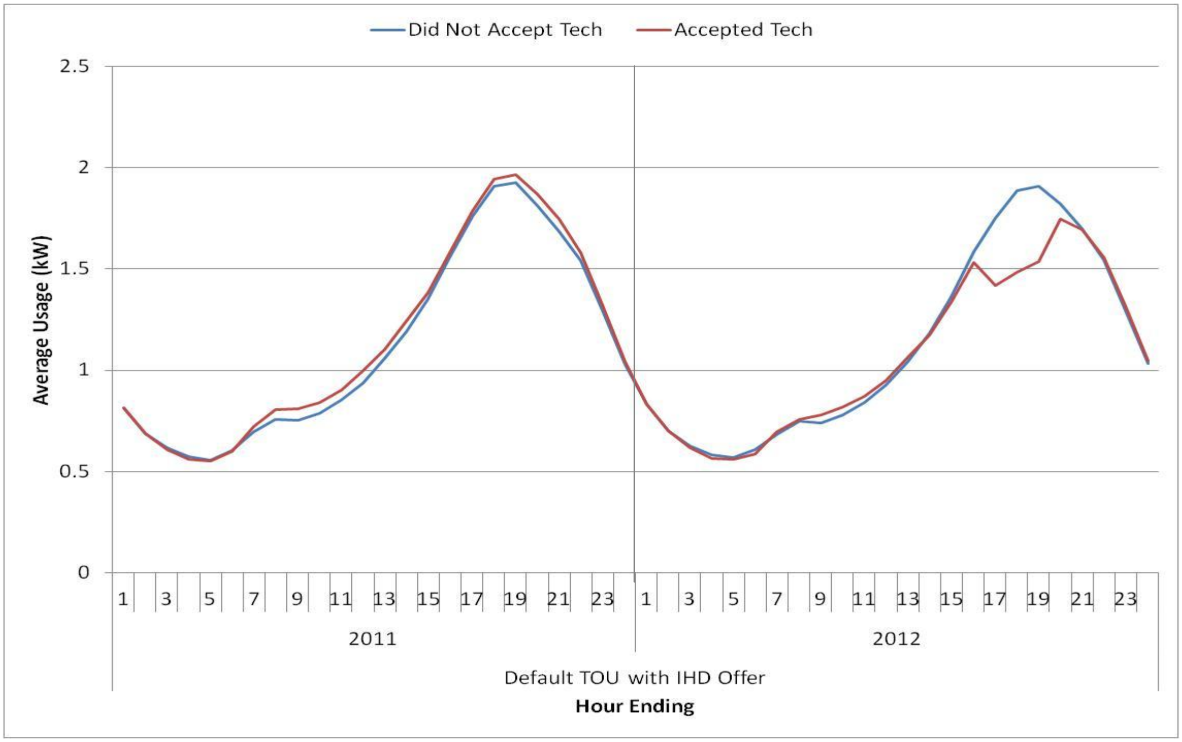
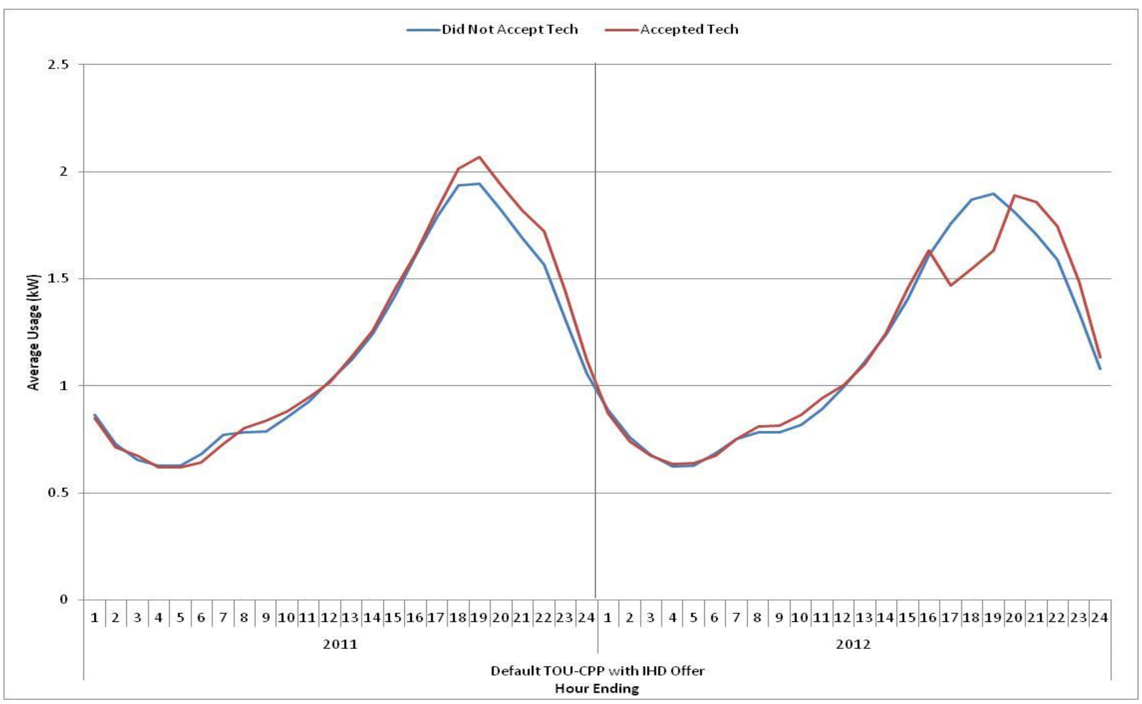


Figure 8-4: Usage by Customers who Did and Did Not Accept an IHD Default TOU-CPP with IHD Offer (Average Summer Weekday)



Figures 8-5 and 8-6 show loads for customers who accepted and did not accept an IHD for the default CPP and default TOU-CPP treatments, respectively, for hot pretreatment days and for CPP event days. Both graphs show that customers who accepted the IHD offer have greater usage during the peak period on hot days in the summer of 2011. For default CPP customers, those who accepted the IHD show 10% greater usage in the peak period in 2011. For default TOU-CPP customers, the pretreatment difference is 5%. For both default treatments, it appears that customers who declined the IHD offer show very little if any response to peak period prices on CPP event days. This suggests that customers who did not request the IHD (about 80% of customers in both default groups) generally do not respond to CPP events in a significant way or at all. Whether this is largely due to lack of interest, ability or awareness is unknown.

The main conclusion from these comparisons is that it appears that there is a substantial amount of diversity in the degree to which different customers respond to the rate treatments. The IHD may be a useful indicator of who is aware of and willing to respond to the rate (though some customers may be willing to respond but for some reason remain unaware of the new rates). One hypothesis is that the observed differences are not due to the IHD and more likely is that customers who were inclined to reduce load during peak periods wanted to obtain an IHD to help them determine the impact of behavioral changes that they were planning to make anyway.

Figure 8-5: Usage by Customers who Did and Did Not Accept An IHD
Default CPP with IHD Offer

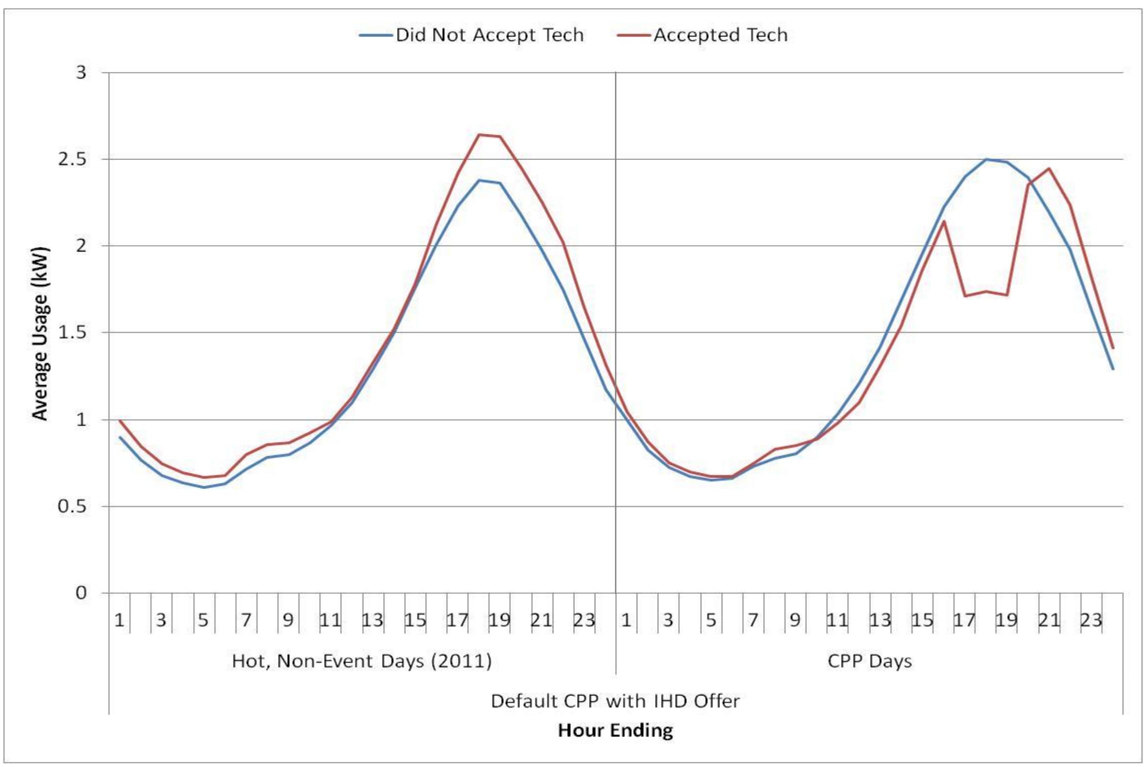
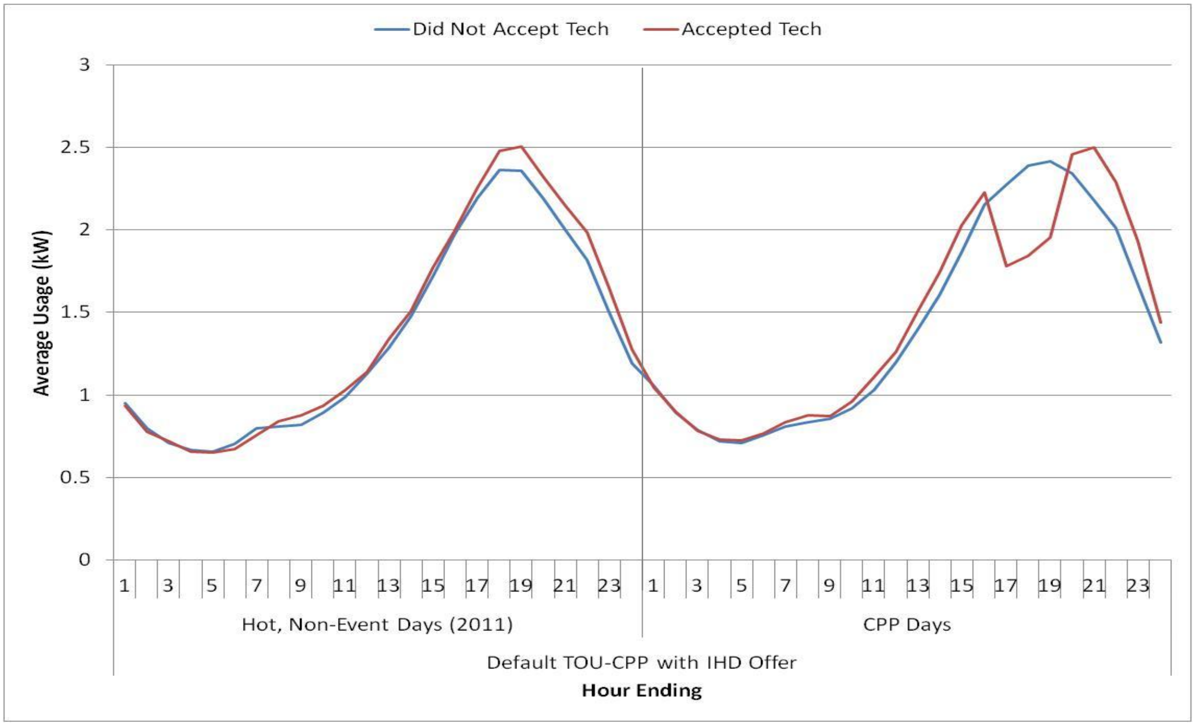


Figure 8-6: Usage by Customers who Did and Did Not Accept An IHD Default TOU-CPP with IHD Offer (Hot, Nonevent Days for Pretreatment Period)



9 Comparative Analysis of Impact Evaluation Methods[44]

SPO was designed to allow for estimation of load impacts based on RCT and RED analysis methods except for two treatment cells that were designed to rely on within-subjects methods. As discussed above, given the high customer acceptance rates that were obtained in SPO, even these treatments could be analyzed using an RED. When RCT and RED designs are used and implemented as designed, they produce unbiased impact estimates. The precision of the estimates, however, depends on the size of the sample and, in the case of an RED, on the proportion of customers who accept the encouragement.

For many utilities, it is not always feasible to implement RCT or RED designs due to time and budget constraints or other practical concerns (e.g., not wanting to deny treatment to volunteers in order to develop a valid control group). In these cases, alternative evaluation methods are often used. Two of the most commonly used methods are within-subjects designs and statistically matched control groups combined with the same type of difference-in-differences analysis that are used with RCT or RED methods. Each of these methods attempts to construct an accurate counterfactual (reference load) in the absence of a randomly selected control group by relying on modeling.

- Within-subjects methods estimate the counterfactual based on usage observed by treatment group customers during nonevent periods that are chosen and/or adjusted to be similar to event periods in expected usage aside from the event. In other words, this approach does not rely on external control groups. It is often implemented using individual customer regressions – that is, the regression specification is common across all customers but the estimated coefficients are allowed to vary for each customer.
- Matched control group methods estimate the counterfactual based on average usage among a group of customers chosen to have similar characteristics to treatment group customers based on observable variables, including similar usage at nonevent times or during pretreatment periods. With this approach, the demand reductions are estimated using difference-in-differences panel regression, which can net out pre-existing differences that may not be adequately accounted for in the matching process.[45]

SPO provides a rare opportunity to compare impact estimates based on different methodologies using the same set of customers and data for the analysis. In the remainder of this section, load impact estimates based on an RED analysis of an event-based pricing plan are compared with estimates using both within-subjects analysis and an analysis that relies on a control group selected using propensity score matching. Propensity score matching is a statistical technique that selects customers that are similar to treatment customers based on observable variables. For a non-event based pricing plan

[44] Preliminary results from the comparative analysis of impact evaluation methods covered in this section were summarized in presentations given at two conferences. The results provided in those presentations are incorrect. One presentation, entitled “Interim Results from SMUD’s Smart Pricing Options Pilot”, was made on June 19th at the 26th Annual Western Conference of the Center for Research in Regulatory Industries. This presentation is available only to attendees. A revised version has been posted to the CRRI conference blackboard, which is accessible by attendees. A similar presentation, entitled “Interim Load Impact Results from SMUD’s Smart Pricing Options Pilot”, was made at the National Town Meeting on Demand Response and Smart Grid on July 10th. A revised version of that presentation has been posted to the National Town Meeting website and can be obtained at http://www.demandresponsetownmeeting.com/wp-content/uploads/2012/03/1A-0830-GEORGE.pdf.

[45] In other words, the analysis method, once the control group is chosen, is the same as with an RCT or RED method.

(TOU), impact estimates using an RCT[46] analysis are compared with those developed using a propensity-matched control group.

When reviewing the comparative methods analysis presented below, it is important to keep in mind that comparisons are being made among estimated values in all cases. This is not a comparison of estimates with known values. While RCT and RED methods produce unbiased impact estimates, they are still estimates that have some degree of uncertainty associated with them. Furthermore, the impacts based on within-subjects and propensity matching methods vary depending on model specification and the datasets used for estimation purposes. As will be seen, different models and different datasets lead to different impact estimates. As such, the specific results presented below regarding the relative performance of these designs cannot be generalized.

The comparative methods analysis for event-based tariffs presented below is based on the opt-in CPP group with the IHD offer because of its size. All other things equal, a better test group would be the CPP treatment group without the IHD offer. However, this is the smallest treatment group in the study and the confidence intervals around the impact estimates are quite broad. Consequently, such a test would not be robust.[47] Unfortunately, using the opt-in CPP group with the IHD offer complicates the analysis because there is evidence that these customers reduced usage during peak times on non-CPP days as well as on CPP days as seen in Table 7-7. This reduction introduces a downward bias in the event day load impacts when using proxy data sets based on 2012 data rather than pretreatment period data. The impact estimates represent the incremental effect of the higher CPP day prices relative to nonevent day loads, which are lower than they otherwise would be for these customers if they weren’t on the CPP tariff. Put another way, the RED impact estimates show the total impact of nonevent day adjustments as well as event day adjustments, whereas the within-subjects impacts show only the incremental load impact on CPP days over and above the load impact on non-CPP days.

A comparative analysis is also presented in section 9.3 for the nonevent-based TOU pricing plan using the opt-in TOU group without an IHD offer. For nonevent based tariffs, within-subjects analysis is not appropriate because the rates are in effect every day. However, propensity matching is potentially useful as long as there is a pool of customers that have not been exposed to the tariff (which is typically the case) from which to select a control group.

The remainder of this section is organized as follows. Section 9.1 summarizes the development of load impact estimates for the opt-in CPP rate with an IHD offer using within-subjects methods, and compares those estimates to the load reductions estimated using an RED analysis that were presented in Section 7 of this report. Section 9.2 summarizes the development of load impact estimates based on a control group constructed using propensity score matching. Section 9.3 summarizes the analysis for the opt-in TOU pricing plan without an IHD offer, which compares the load impacts based on an RCT with estimates based on propensity score matching. Finally, Section 9.4 summarizes the key findings.

46 As discussed in prior sections, the SPO was designed to use RED analysis for some treatments and RCT analysis for others. Both designs control equally well for selection bias and are not subject to the same types of model misspecification that can influence within-subjects or matching methods.

47 The average load impact using the RED analysis for the CPP+IHD test cell was 26% ±4% whereas the estimated impact for the CPP only test cell was 22% ±11%.

9.1 Within-subjects Estimation for CPP Rates

Within-subjects methods are often used to estimate impacts for event-based DR programs and tariffs such as CPP.[48] This method can include pre-enrollment data but often relies exclusively on post-enrollment energy usage from nonevent days to estimate the reference load on CPP event days. When pre-enrollment data is not available, the maintained (but typically untested) hypothesis is that behavior on nonevent days is unaltered from what it would have been in the absence of the program, which means that if there are nonevent days that are otherwise similar to event days, load on those days can provide an accurate reference load for event days.[49]

The data underlying this form of analysis typically consists of one or two summer's worth of hourly load data from a sample of customers subjected to the event-based treatment. Within the DR program evaluation literature, it has become common to fit separate regressions to each customer's load data using a common specification – what is often to referred to as individual customer regressions. This approach allows for coefficients, such as the relationship between temperature and usage, to vary across customers. It is equivalent to interacting all the coefficients in a panel model with customer-level indicators. Although estimates can be quite "noisy" at the individual customer level, program level impacts are estimated by averaging over the individual estimates.[50] Individual customer regressions are particularly useful when different customers are dispatched on different days, customers are too diverse to model using panel regressions or when program enrollment changes over the course of the evaluation period.

In addition to selecting a regression model to use for evaluation, a decision must also be made about which days and times to include in the regression dataset, with the goal being to only rely on nonevent day load data that can provide an accurate counterfactual. Because a regression model is usually used to adjust for differences in temperature between event and nonevent days, this decision is roughly equivalent to deciding over what range the regression function accurately adjusts load for variations in temperature. There is a trade-off between using more load data from days with temperatures that are less similar to event days and using less load data from days with temperatures that are more similar to event days. In the former case, the analyst relies on the specification of load as a function of temperature to be accurate over a larger range. In some evaluations, every day from

48 Examples of the use of within-subjects analysis can be found at: "2011 Impact Evaluation of San Diego Gas & Electric's Peak-Time Rebate Pilot Program" by S. Braithwait, D, Hansen & D. Armstrong, prepared for SDG&E and "2009 Load Impact Evaluation for Pacific Gas and Electric Company's Residential SmartRate—Peak Day Pricing and TOU Tariffs and SmartAC Program" by S. George, J. Bode, M. Perry & Z. Mayer, prepared for PG&E.

49 Some studies explicitly recognize that only reductions relative to nonevent days are quantified by relying solely on post-enrollment data. This is often the case for evaluation of existing programs where pre-enrollment data is not available or too distant to be useful or where program managers are more interested in the dynamic response than the total impact.

50 The errors are typically aggregated using the following formula:

$$\sigma = \sqrt{\sigma_1^2 + \sigma_2^2 + \sigma_3^2 + \cdots \sigma_n^2}$$

This formula works for aggregating standard errors if they are normally distributed and independent. This latter assumption doe s not always hold up for individual events since a common specification error can lead to common errors across customers.

an entire summer is used while in other evaluations, days are chosen based on daily average or high temperatures that are similar to the weather conditions on event days.

9.1.1 Model Selection

For the comparative methods analysis presented here, numerous regressions were tested using different sets of days to simulate common scenarios seen when evaluating demand response programs. Individual customer regressions were used because these seem to be the standard in the current DR evaluation literature. Models were tested using all 11 CPP event days from the summer of 2012 and weekdays between June and September chosen as follows:

1. Nonevent days in 2011 with daily maximum temperature over 90°F (pretreatment data);[51]
2. Nonevent days in 2012 with daily maximum temperature over 75°F (no pretreatment data);
3. Nonevent days in 2012 with daily maximum temperature over 90°F (no pretreatment data); and
4. Nonevent days in 2012 with average daily temperature over 75°F (no pretreatment data).[52]

Table 9-1 shows the number of days that meet the selection criteria in each case as well as the average daily maximum temperature (°F). For comparison, the table also includes this information for the 2012 CPP event days.

Table 9-1: Days Used for Each Analysis Database

Set of Days	# of Days	Average Daily Maximum Temperature (°F)
2012 CPP Event Days	11	97
2011 Days with Max over 90°F	48	96
2012 Days with Max over 75°F	99	89
2012 Days with Max over 90°F	43	95
2012 Days with Average over 75°F	12	98

Selecting days from a pretreatment summer period during which no events were called provides maximum flexibility to choose suitable proxy days.[53] This option is particularly important if events are called on all hot days in the post treatment period. However, pretreatment data is often not available. When this occurs, the only option is to use nonevent days from the summer during which impacts are being estimated (2012 in this case). The last three sets of days could be used in such a scenario where pretreatment data is not available. The second set of proxy days tested includes all 2012

[51] All 2012 CPP days had a daily maximum temperature of 90°F or higher so this threshold was used to identify hot, event-like days.

[52] The average daily temperature across the 11 CPP days in 2012 was just over 77°F. However, there was not a sufficient number of days with an average over 77°F so the threshold was lowered to 75°F.

[53] Although pretreatment data provides maximum flexibility to select proxy days, there can still be significant differences in proxy day and event day weather conditions if, for example, the post treatment year is quite hot while the pretreatment year is very mild.

nonevent days where the maximum temperature was above 75°F. The third set includes only nonevent days in 2012 where the maximum temperature exceeded 90°F. All 11 CPP days had daily highs at 90°F or higher so this set of days, though smaller than the second set, may provide more accurate estimates if the specification of load as a function of weather is only accurate over a limited range. Finally, the fourth set tested included 2012 nonevent days where the average daily temperature exceeded 75°F. This is a subset of the days with daily highs over 90°F, and is also based on a measure of similarity with the event days because the average overall daily temperature for the 2012 event days was just over 75°F.

For each set of days, a variety of regression specifications were tested using a cross-validation method to choose the specification with the best predictive accuracy. Cross-validation refers to withholding data from proxy days during the model-fitting process in order to test model accuracy. The process involves running the regressions without allowing the model to use three randomly-chosen days out of the hot proxy days. The regression model is used to predict electricity use on the proxy days that were withheld, and then the model's predictions are compared directly to actual electricity use observed on those days. This process provides an indication of the overall level of accuracy of the model under relevant conditions, while also providing some protection from over-fitting. The equation that produced the lowest mean absolute error (MAE) was used to run the final regressions for the load impact estimates.

A variety of models were tested in this manner. First, various weather variables were tested, including a variable equal to the average temperature in the 17 hours leading up to 5 PM (labeled mean17), both by itself as well as squared, and cooling degree hours in each event hour. The best performing specification was with mean17 plus mean17 squared. Next, dummy variables representing different days of the week and summer months were added to the model to see if the predictive accuracy was improved. Adding monthly binary variables improved model accuracy more than did adding weekday binary variables and having both sets of variables in the model lowered the accuracy relative to the model with just the monthly variables. Across the four sets of days, the model shown in Equation 9-1 was found to be the best:

Equation 9-1: Model Specification for Individual Customer Regressions

$$kW_t = a + \sum_{y=2}^{24} b_y \cdot hour_y + \sum_{y=2}^{24} c_y \cdot hour_y \cdot mean17 + \sum_{y=2}^{24} d_y \cdot hour_y \cdot (mean17)^2 + \sum_{y=2}^{24}\sum_{z=6}^{9} e_{yz} \cdot hour_y \cdot month_z + \sum_{z=1}^{11} f_z \cdot eventday_z + \cdot \varepsilon_t$$

Table 9-2: Description of Energy Use Regression Variables

Variable	Description
a	a is an estimated constant
b-f	b-f are estimated parameters
hour	Dummy variables representing the hours of the day, designed to estimate the effect of occupancy schedule on weather insensitive energy consumption
month	Dummy variables representing summer months, designed to estimate the effect of the time of year on weather insensitive energy consumption
mean17	Average temperature from midnight until 5 PM on each event day
eventday	Dummy variables for the event period of each event day
ε	The error term

Figures 9-1 through 9-4 show the results from the cross-validation tests performed on each of the four datasets for the best predictive model. For all four sets of days, the predicted load closely matches the actual load throughout the day. During the peak period, the absolute percentage difference between the actual and predicted load ranges from a low of 1% in Figure 9-4 to a high of 5% in Figure 9-2. The worst performance is for the model estimated on the dataset containing proxy days with temperatures above 75°F. This dataset has the greatest number of days for use in model estimation (99), but it includes the most days by far that are significantly different from event days. The models estimated on the other three datasets containing proxy days that are more representative of actual event days perform much better on these out of sample tests.

Figure 9-1: Predicted Versus Actual Usage Based on 2011 Proxy Days (>90°F Maximum Temperature)

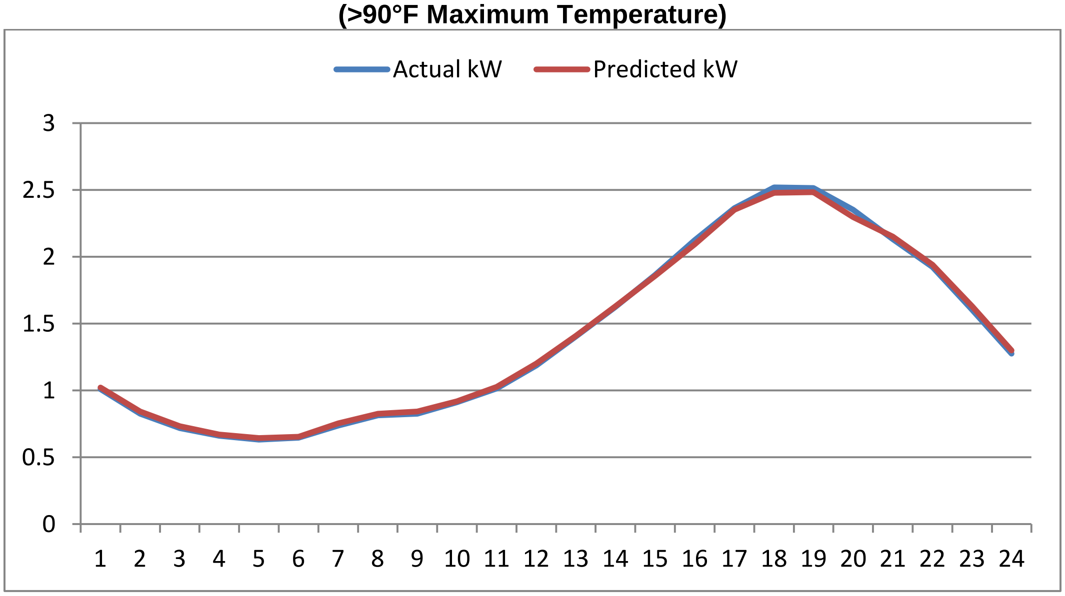


Figure 9-2: Predicted Versus Actual Usage Based on 2012 Proxy Days (>75°F Maximum Temperature)

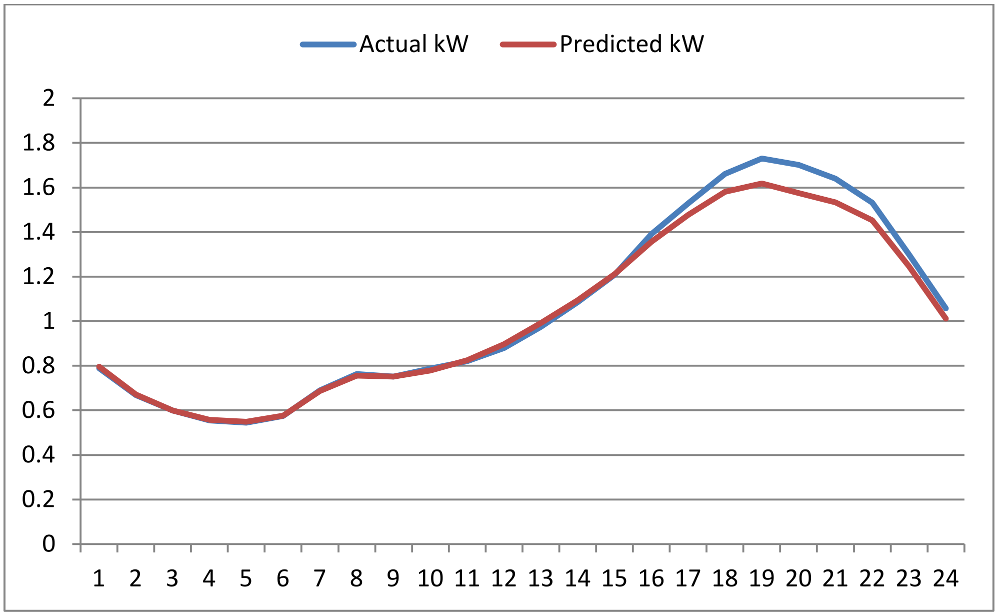


Figure 9-3: Predicted Versus Actual Usage Based on 2012 Proxy Days (>90°F Maximum Temperature)

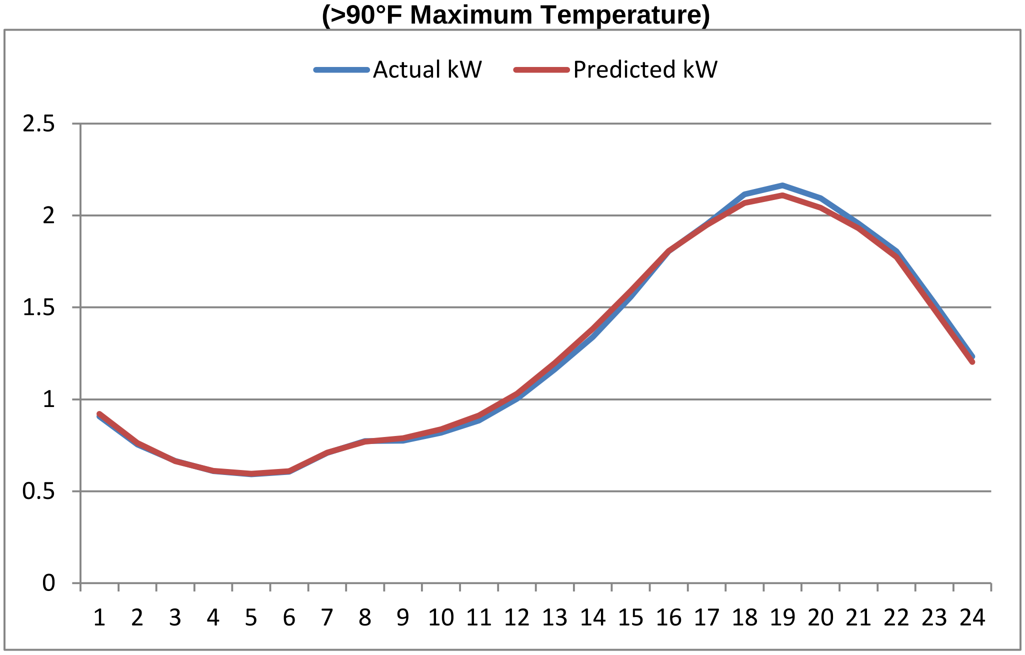
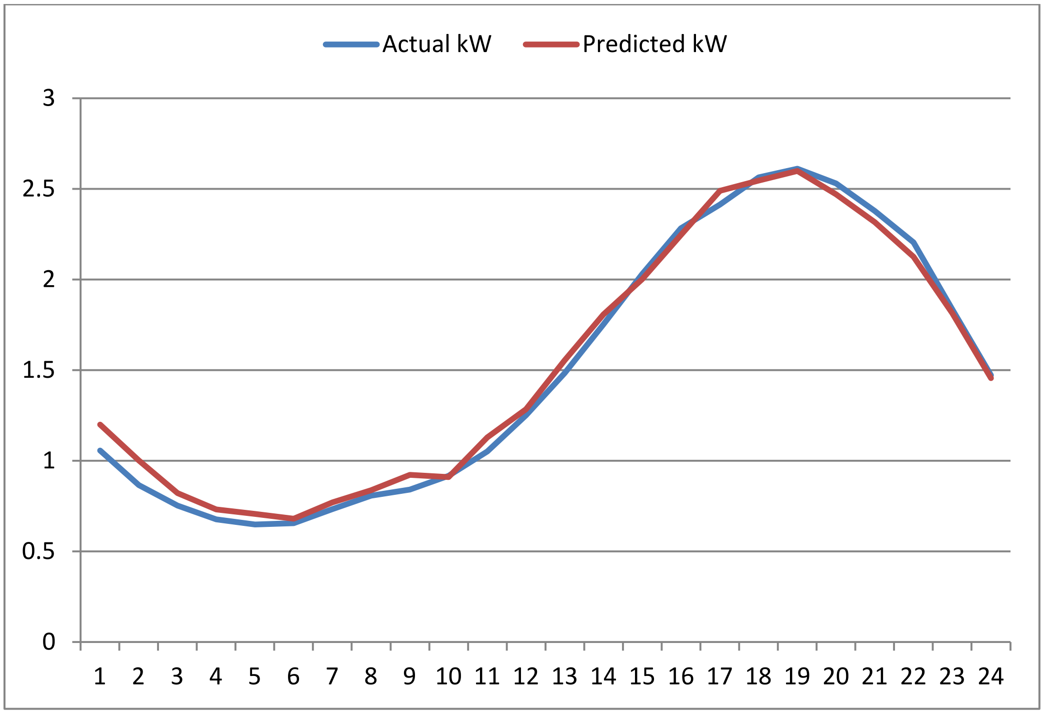


Figure 9-4: Predicted Versus Actual Usage Based on 2012 Proxy Days (>75°F Average Temperature)



9.1.2 Impact Estimates Using Within-subjects Analysis

After the cross-validation was completed and the best model was chosen for each set of days, the final regressions were run including all days in each dataset (meaning that none of the cross-validation days were held out). Table 9-3 shows the impact estimates for each of the four within-subjects analyses in addition to the impact estimates from the RED analysis. The first numerical column shows the daily maximum temperature for each event day and the second column shows the RED impact estimates. The remaining columns show the impact estimates from each set of within-subjects regressions. The second to last row in each column shows the average impact across all events and the final row shows the correlation between the daily RED impact estimates and the within-subjects impact estimates.

Table 9-3: Impact Estimates from RED Analysis and Within-subjects Regressions (Opt-in CPP with IHD Offer)

Date	Daily Maximum Temperature (°F)	RED Impact	2011 Days with Max over 90°F	2012 Days with Max over 75°F	2012 Days with Max over 90°F	2012 Days with Average over 75°F
10-Jul-12	100	0.84	0.55	0.40	0.40	0.45
12-Jul-12	102	1.00	0.72	0.59	0.61	0.62
2-Aug-12	98	0.59	0.42	0.33	0.32	0.36
8-Aug-12	99	0.69	0.47	0.38	0.38	0.43
9-Aug-12	102	0.84	0.67	0.60	0.59	0.56
10-Aug-12	102	0.90	0.62	0.55	0.55	0.52
14-Aug-12	95	0.70	0.69	0.61	0.59	0.57
15-Aug-12	94	0.65	0.45	0.36	0.36	0.42
12-Sep-12	91	0.48	0.35	0.16	0.23	0.40
13-Sep-12	96	0.45	0.50	0.29	0.32	0.24
14-Sep-12	91	0.41	0.15	-0.04	0.03	0.19
Average	97	0.69	0.51	0.38	0.40	0.43
Correlation	-	-	0.82	0.84	0.85	0.87

The average values for the within-subjects analysis, at least the analysis based on 2012 data (no pretreatment data), should be lower than the RED impacts because of the estimated reduction in peak period energy use on nonevent days as reported in Table 7.7. As seen in Table 7.7, the estimated peak-period load reduction on the average, nonevent weekday for the CPP with IHD offer treatment group was 0.16 kW based on the RED analysis. However, this value may actually understate the expected difference in the within-subjects and RED impact estimates because it represents the reduction on the average weekday and absolute reductions are typically larger on hotter days because load is higher. We can approximate what the impact might be on hot, nonevent weekdays by multiplying 0.16 kW by the ratio of the estimated reference load during the peak-period on event days (2.62 kW) and the peak-period load on nonevent weekdays (2.23).[54] Based on this approximation, the expected under prediction resulting from the nonevent weekday effect is 0.19 kW (=2.62/2.23x0.16). Given this expected average difference, nearly all of the differences in daily and average impacts between the RED and within-subjects methods will be statistically significant because

[54] It should be noted that with an RED analysis, a reference load for the enrolled group is not required and not available. As discussed in Section 3, the treatment group in an RED analysis contains customers that enroll as well as those that don't and the impacts for the enrolled group are determined in a second-stage calculation. Reference loads for those that actually enroll don't exist. In order to approximate the reference loads for event and nonevent days in this instance, we added the estimated load impact to the measured load for the enrolled group on event and nonevent days. An alternative approach would be to use the ratio of the loads for the RED control group on event and nonevent days, which is higher (1.41 rather than the 1.17 used here). However, the enrolled group may have less weather sensitive loads than the RED control group because of self selection (e.g., those with flatter loads have more incentive to enroll in dynamic rates because they are structural winners) and, as such, would likely have a lower ratio of event to nonevent loads than the control group.

of the nonevent day impact observed for this treatment group (which is a form of specification error, but one that is often not recognized in the same manner as specification error associated with, for example, modeling weather impacts). Therefore, statistical tests of differences in the daily and average values are not provided in the table.

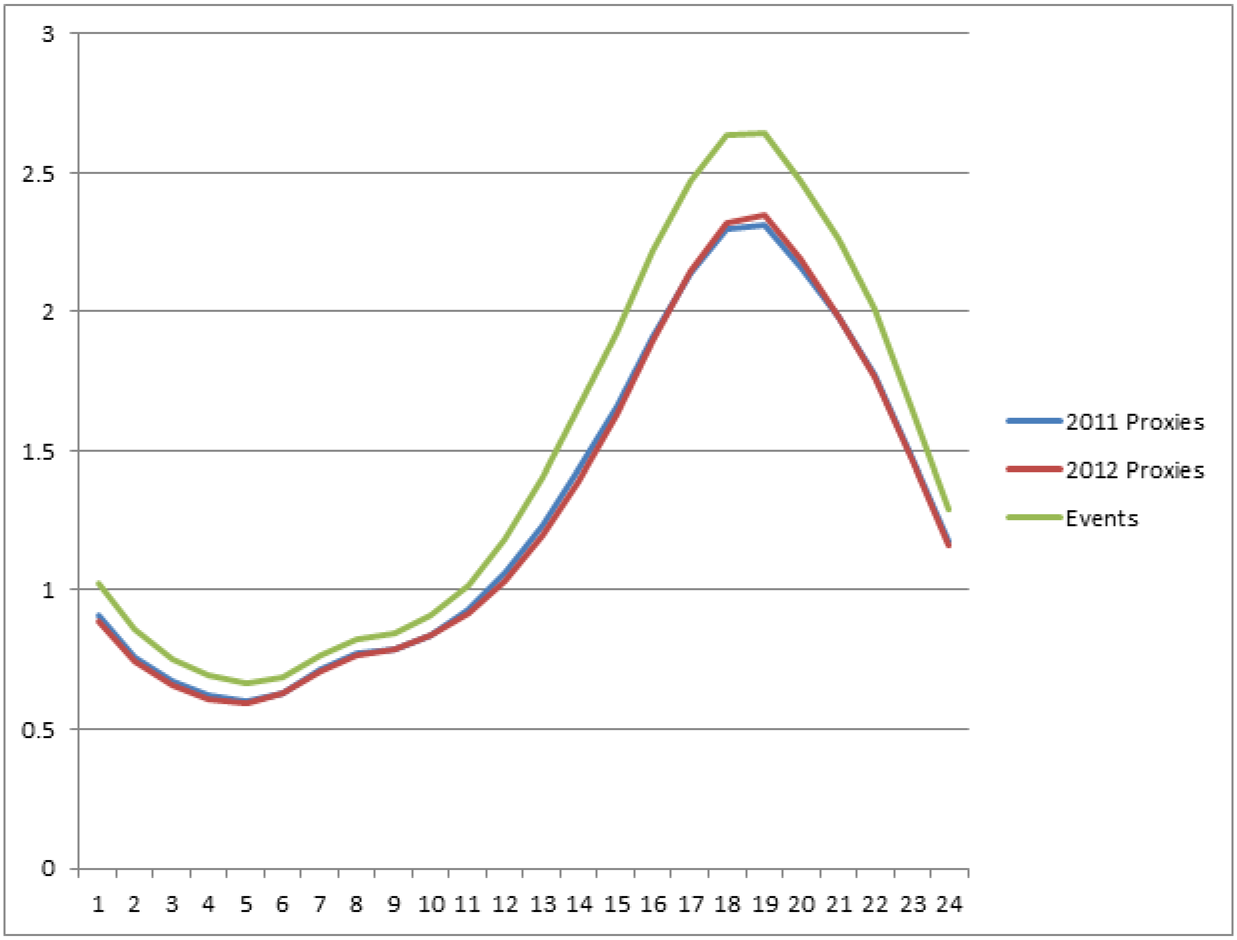
For the reasons just discussed, it is not surprising to see that the average impact from the individual, within-subjects regressions based on the data sets using only 2012 data (the last three columns in Table 9-3) are always lower than the impacts from the RED analysis. However, it is worth noting that these estimates are low even after adjusting for the expected difference due to the nonevent day impacts. Adding the expected difference of 0.19 kW to the estimated average values based on each of the 2012 datasets produces an adjusted average estimate of 0.57 kW, 0.59 kW and 0.62 kW for the three estimates shown in the last three columns in Table 9-3. The 95% confidence interval for the RED estimates ranges from 0.58 kW to 0.79 kW, so the adjusted values are clustered around the low end of this confidence interval. The fact that the within-subjects estimates based on all three sets of proxy days are lower than the RED estimates even after the adjustment suggests that the within-subjects model specification may have a downward bias relative to the actual load impact.

Table 9-3 shows the correlation between the RED and within-subjects impact estimates across the 11 event days. As seen, the correlation is high and very similar for the models estimated using all four datasets.

The fact that the within-subjects impact estimates based on 2011 pretreatment data are significantly lower than the RED estimates is arguably more problematic than the low estimates using the 2012 data for two reasons. One reason is that the estimates using the pretreatment data should not be subject to the same expected downward bias due to the fact that nonevent, weekday peak period load is lower during the treatment period because this model uses data from the pretreatment period when that impact is not in effect. The second reason is that pretreatment data often allows for selection of better proxy days than is possible when proxy days must be chosen from nonevent days during the same summer as when events are called. This may be less true in SMUD's case than with other utilities since there are numerous hot, nonevent days during the summer in SMUD's service territory. In some other regions, such as San Diego and many parts of Pacific Gas and Electric's service territory in California, events are often called on most hot days during the summer, which means that most or all proxy days will have weather that is not very representative of event-day weather.

One possible explanation for the within-subjects estimates based on 2011 proxy days being lower than the RED estimates is that actual loads may have been higher in 2012 compared with 2011 due to some exogenous factor, such as continued economic recovery. Another possibility is that the proxy days are not as representative of event day weather as previously thought. To explore these possibilities, we compared the load for the RED control group on the 2011 and 2012 proxy days with maximum temperature greater than 90°F and also with the 2012 event days. The daily load shape for these three sets of days is shown in Figure 9-5. Clearly, there is a large difference between control group load on the 2012 event days and load for the same group of customers on pretreatment proxy days and proxy days chosen from the same summer period as when the treatment was in effect. Indeed, the average load for control group customers between 4 PM and 7 PM on event days, 2.58 kW, is roughly 15% higher than the average load for both sets of proxy days (2.24 kW and 2.27 kW for the 2011 and 2012 proxy days, respectively).

Figure 9-5: Control Group Loads for 2011 and 2012 Proxy Days and 2012 Event Days



Determining whether this important difference in loads on event days and well chosen proxy days is due to differences in weather or some other exogenous factor is difficult which, of course, highlights the challenge of modeling load impacts using within-subjects analysis, even when pretreatment data are available. Table 9-4 sheds some light on these issues. It shows the average cooling degree hours (CDH) on each of the three sets of days as well as on the two days prior to the average event day or proxy day. Several things are noteworthy. First, CDH on the average event day is about 9% higher than the 2011 proxy day average and almost 23% higher than the 2012 proxy day average. The fact that proxy days chosen from 2012 have a lower average value than those chosen from 2011 is typical, even though both represent days with maximum temperature above 90°F, because many of the hottest days above this threshold in the post treatment period are event days. The fact that the 2011 proxy day average is less than the 2012 event day average reflects the inherent variation in weather across summers and is an example of how even pretreatment data may not allow for selection of proxy days that have the same weather characteristics as event days.

Table 9-4: Cooling Degree Hours (Base 70°F) For Control Customers On Proxy Days and Event Days

Day Type	CDH
2011 Proxy	210.4
2011 Day before Proxy	192.3
2011 Two day before Proxy	166.0
2012 Proxy	186.7
2012 Day before Proxy	161.4
2012 Two day before Proxy	145.1
2012 Event	229.8
2012 Day before Event	229.8
2012 Two day before Event	209.1

Even more notable than the differences in CDH on proxy days and event days is the difference in CDH on the days leading up to these days. As seen in the table, the average days leading up to event days were much hotter than the average days leading up to either set of proxy days. Indeed, weather on the average day prior to an event day is nearly identical to event-day weather, whereas CDH on the average day prior to the 2011 proxy days is 9% lower and is 16% lower on the day prior to the 2012 proxy day. The differences between proxy/event-day CDH and CDH two days prior to the average proxy/event-day is 9% for event days, 27% for 2011 proxy days and 29% for 2012 proxy days. Clearly, the impact of heat buildup on load was much greater on event days than it was on either set of proxy days. This suggests that a model with lagged weather variables might perform better than one with "day-of" weather data only. To test this, models were run using day-of CDH, day-of CDH plus CDH on the prior day, and the prior two variables plus CDH from two days prior. The model that included only day-of CDH did not produce impact estimates that were very close to the RED estimates. The model with a single lagged weather variable did much better and the one with two lagged weather variables produced estimates that were closest to the RED estimates but, interestingly, these estimates were not very different from the estimates in Table 9-3 that were based on the model using day-of, mean17 and mean17 squared.

9.1.3 Conclusions for Within-subjects Analysis

The primary conclusions from this analysis are:

- Estimated impacts using within-subjects analysis can vary significantly with model-specification and with the proxy days that are used to develop reference loads;
- Very importantly, average impacts can be significantly biased even when out-of-sample validation tests suggest that estimated reference loads are reasonable;
- Although having pretreatment data is always preferred, in this example, differences in weather patterns between event days and the days leading up to events, and proxy days and the days leading up to proxy days, still produced estimates that differed from RED estimates; and
- An assumption that impacts on nonevent days are small enough to be ignored (which an essential assumption whenever pretreatment data is not available) can produce biased estimates. Unfortunately, it is impossible to test this assumption using within-subjects analysis methods. In the above analysis, the fact that this assumption was violated (which

was only known because the RED impacts were available for comparison purposes) produced a significant downward bias in the event day impacts.

- All of the within-subjects impact estimates developed here were lower than the RED impact estimates which, from a policy perspective, is probably preferable to estimates that are biased upward since they are conservative. However, we can imagine circumstances in which the estimates might be biased upward (if, for example, the heat buildup in the pretreatment proxy days was greater than for the event days, rather than what was observed here). As such, we caution against generalizing from the specific results presented here and concluding that within-subjects analysis always understate load impacts.

The most important conclusion from this comparative analysis is that a thorough, thoughtful application of within-subjects techniques does not guarantee that the estimated impacts are unbiased. There may, indeed, be a combination of proxy days and model specification that comes quite close to producing the same impact estimates as an RED or RCT research design would produce. However, the problem is that there is no sure way of knowing whether or not the within-subjects estimates are biased. As indicated above, the cross-validation exercises produced models that predicted well for proxy days but produced downward biased estimates largely because, in this case, consumers reduced load on nonevent days. Another contributing factor in this case was the significant heat buildup on event days, which was much greater than on proxy days, especially proxy days chosen from the same summer as event days, which is often the scenario under which within-subjects analysis is used. While lagged weather terms might improve the estimates, there was nothing in the cross-validation analysis that suggested this was necessary since the out-of-sample tests for the models examined were quite good.

9.2 Estimation Using Propensity Score Matching for CPP Rates

In addition to individual customer regressions, propensity score matching can also be used to predict impacts for CPP programs. When matching is used, impacts are typically estimated using the same type of difference-in-differences panel regressions that are used to estimate impacts using an RCT or RED design. That is the approach used here. The fundamental idea behind the matching process is to find customers who were not subjected to CPP events that have similar observable characteristics to those who were. To do this, customers who were enrolled in the opt-in CPP with IHD offer group for all 11 events were matched to customers from the RED control group. In this procedure, a probit model is used to estimate a score for each customer based on a set of observable variables that are assumed to affect the decision to join the SPO pilot.

A probit model is a regression model designed to estimate probabilities—in this case, the probability that a customer would opt-in to the CPP with IHD offer group. The score can be interpreted two different ways. First, the propensity score can be thought of as a summary variable that includes all the relevant, available information on the observable variables about whether a customer would choose to be on the CPP rate. Each customer enrolled for the whole summer in the opt-in CPP with IHD offer treatment is matched with a non-enrolled customer that has the closest propensity score. The second way to think of the propensity score is as the probability that that customer would join the rate based on the included independent variables. Thinking of it this way, each customer in the control group is matched to a CPP customer with a similar probability of joining the rate given the observed variables. To assess the impact of the experimental treatment, the dependent variable(s) for the treatment and control (propensity matched) groups are compared as they would be if the subjects in the experiment were randomly assigned to treatment and control conditions (i.e., difference in differences calculations). Examples of the application of propensity score matching for impact evaluation can be found in the evaluations of PG&E's SmartRate CPP tariff for 2011 and 2012.[55]

9.2.1 Matched Control Group Development

In this exercise, the match was based on usage during the peak period on hot, nonevent days and EAPR status. In general, it is desirable to use all observable variables that are thought to be related to usage for matching. However, this application is similar to the typical case, where utilities do not have detailed demographic information about their customers. Just as with the regression analysis, different sets of hot, nonevent days were used to test days that yielded impact estimates closest to that found in the RED analysis. The same four sets of nonevent days were used for propensity score matches as were used for the individual customer regressions. These sets of days are:

1. Days in 2011 with daily maximum temperature over 90°F (pretreatment data);
2. Nonevent days in 2012 with daily maximum temperature over 75°F;
3. Nonevent days in 2012 with daily maximum temperature over 90°F; and
4. Nonevent days in 2012 with average daily temperature over 75°F.

The process of matching was the same regardless of which set of days was used. First, average usage in the treatment and control group was calculated based only on the hot, nonevent days in the dataset. Then each treatment customer was matched to a control customer based on usage in each hour from 4 to 7 PM and on EAPR status. Each treatment customer had exactly one match but control customers could match more than one treatment customer. After each treated customer was matched to a control customer, impacts were estimated by comparing the load of the control customers on event days to the load of the treated customers using the same difference-in-differences regression models as were used for the RED analysis.

Figures 9-6 through 9-9 show the load shapes of treatment and control groups on average hot, nonevent days after the propensity score match. For all four datasets, the usage of the treatment and control customers on hot, nonevent days is very similar across all hours of the day. When days from the summer of 2011 were used, as shown in Figure 9-6, the usage between treatment and control groups is nearly indistinguishable. For the other three sets of days, usage is very close between treatment and control customers, particularly during the three-hour peak period.

[55] See "2011 Load Impact Evaluation of Pacific Gas and Electric Company's Residential Time-based Pricing Programs" by Hartmann, et. al; prepared for PG&E and "2012 Load Impact Evaluation of Pacific Gas and Electric Company's Residential Time-based Pricing Programs" by Perry et. al.; prepared for PG&E.

Figure 9-6: Average Hot, Nonevent Day
Match Including 2011 Days with Daily Max. Temperature Over 90°F

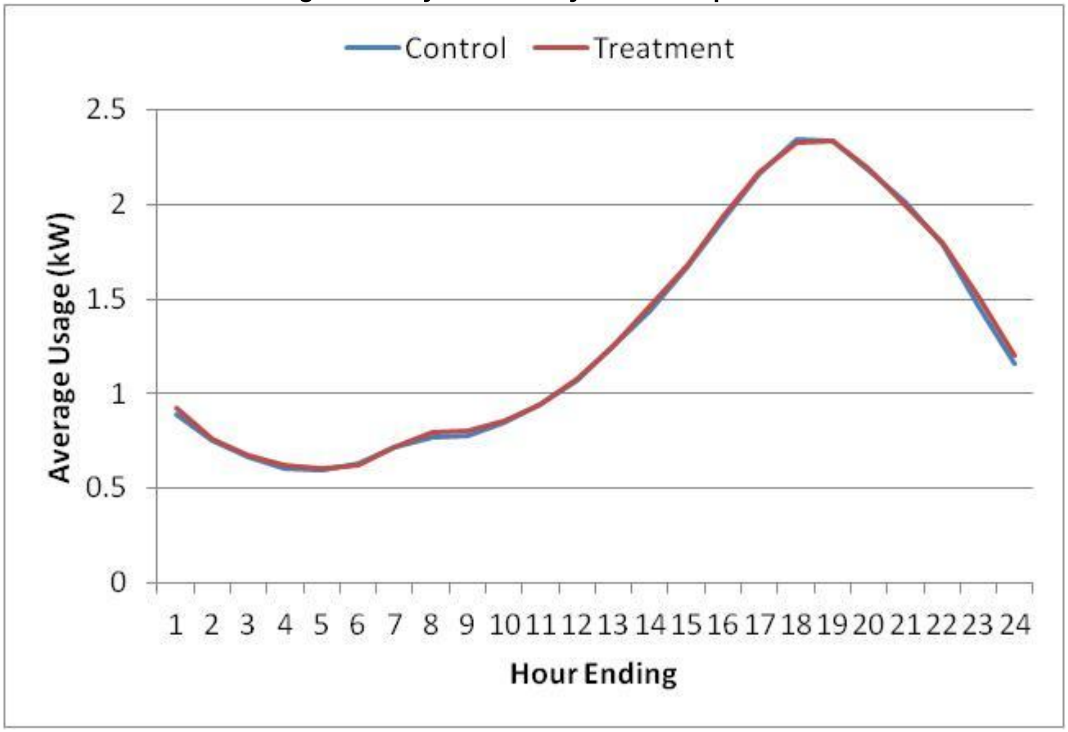


Figure 9-7: Average Hot, Nonevent Day:
Match Including 2012 Days with Daily Max. Temperature Over 75°F

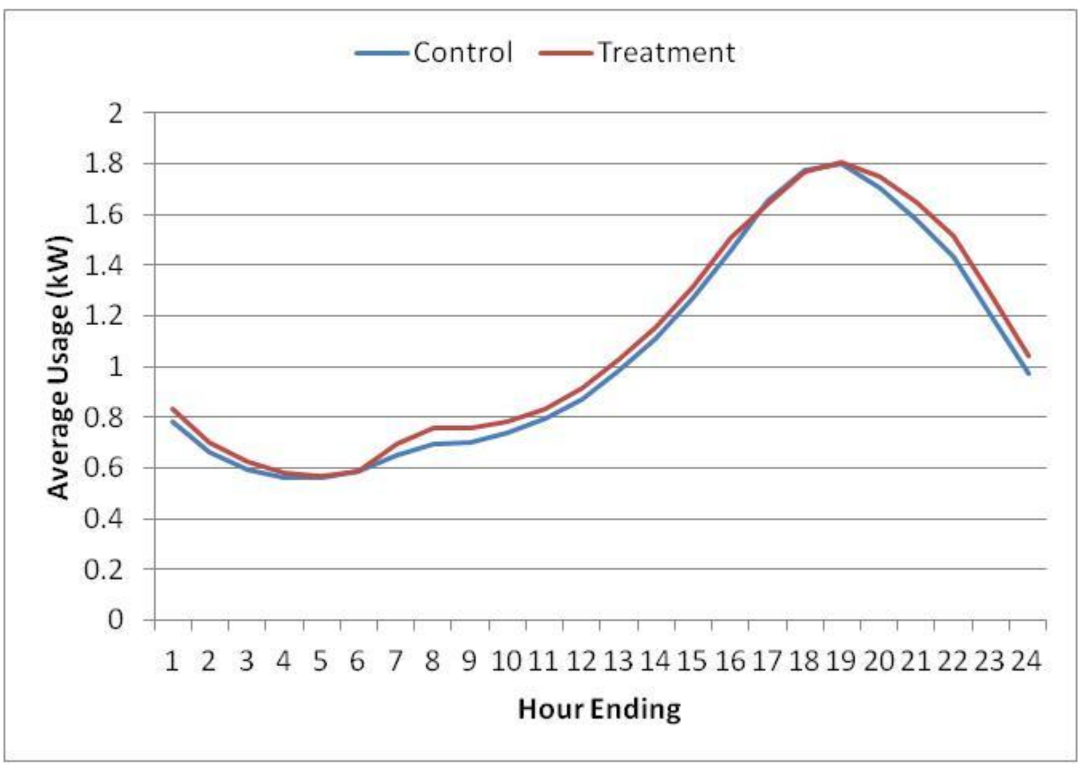


Figure 9-8: Average Hot, Nonevent Day
Match Including 2012 Days with Daily Max. Temperature Over 90°F

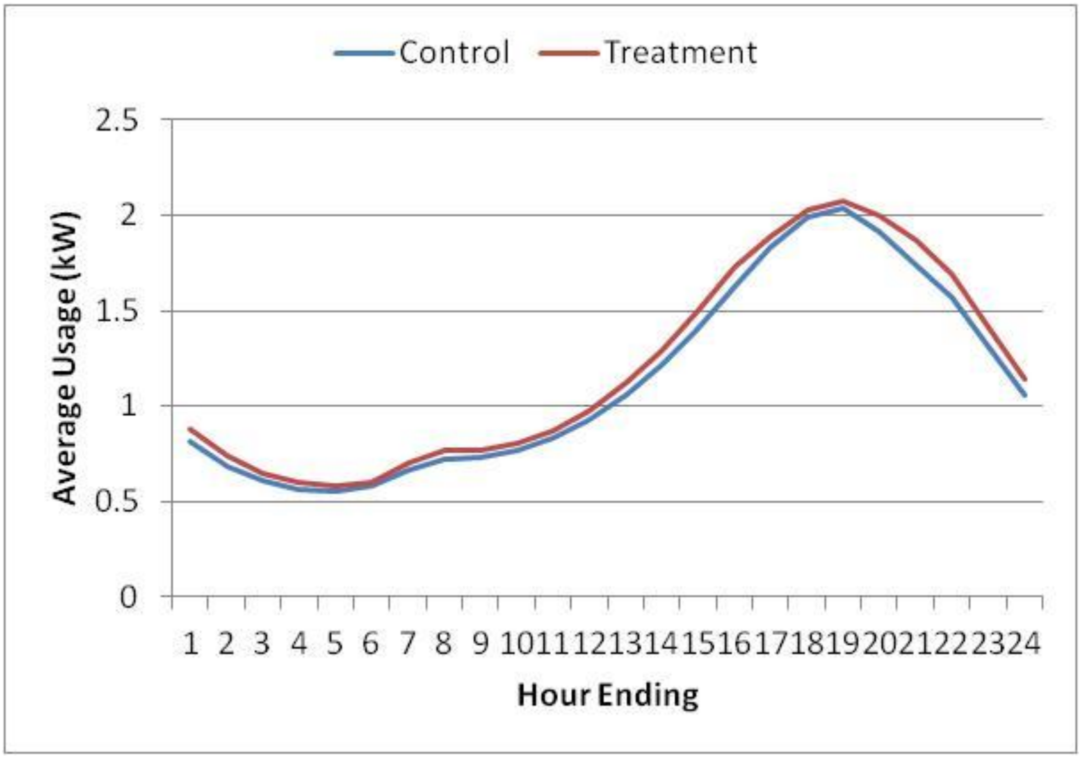
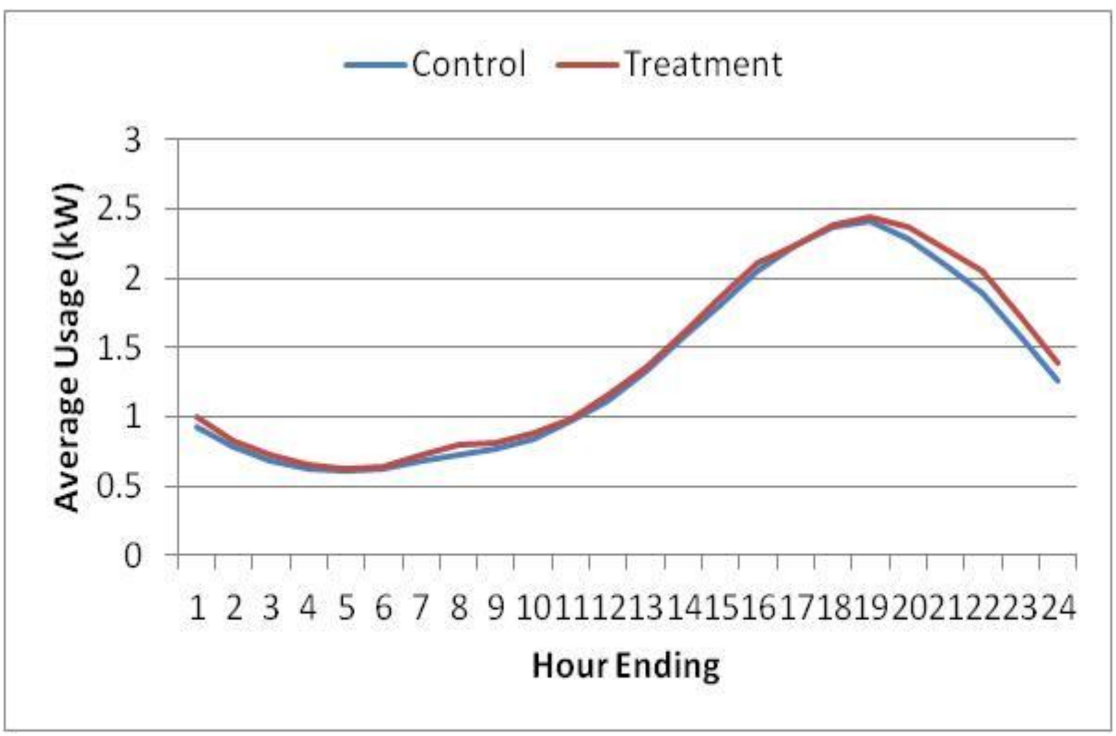


Figure 9-9: Average Hot, Nonevent Day
Match Including 2012 Days with Daily Average Temperature Over 75°F



9.2.2 Impact Estimates Using Propensity Score Matching

Table 9-5 shows the impact estimates from the propensity score matching exercise for each of the four sets of days. The table is set up in the same way as Table 9-3. The first numerical column shows the daily maximum temperature for each event day and the second column shows the impact estimates based on RED analysis. The next eight columns show the impact estimates for each of the four propensity score matches and the p-value indicating whether the estimate is statistically different from the RED impact. The p-value cells that are shaded gray indicate that the difference between that impact estimate and the corresponding RED impact estimate is statistically significant. The second to last row in each column shows the average impact across all events and the final row shows the correlation between the daily RED impact estimates and those of each regression.

As shown in Table 9-5, the set of days that is used in the propensity score match has a large effect on the average impact estimate. For the match that included days in 2011 with a daily maximum temperature exceeding 90°F, the average impacts are within 0.02 kW of the average impact from the RED analysis. On a daily basis, none of the impact estimates from the match using pretreatment data are statistically different from the RED impact estimates. This is a testament to the power of propensity score matching when based on hourly pretreatment data and a difference-in-differences estimation process. Just like for an RED or RCT analysis, propensity matching removes the need to model weather effects which, as was seen in the discussion for the within-subjects analysis, is difficult to do well. Being able to match on hourly pretreatment data using reasonably good proxy days produces estimates that are very similar to those based on the RED. To date, this scenario has been somewhat limited in terms of actual application because many CPP pilots or programs have been implemented without allowing time for pretreatment data to be used. However, it should be possible to apply this approach more frequently in the future as more and more utilities implement time-based pricing programs over several years following deployment of advanced meters.

Using the other three groups of days, the impacts are very similar to each other but significantly lower on average and for each event day compared with the RED impacts. The underlying reason for this bias is the same as for the difference between RED impacts and the within-subjects analysis, namely that usage on nonevent days changed as a result of the treatment in this instance. Under these three scenarios, the match is based on peak period usage on the three sets of nonevent days, all of which are from the post treatment period and subject to change due to spillover effects or, in this instance, potentially due to the impact of the IHD. Thus, even though the match is quite good, indeed because the match is good, the impact estimates are biased because load on nonevent days is lower than during the pretreatment period and a good match guarantees that the estimated load impacts will be biased downward by the amount of the load drop on the 2012 proxy days. Indeed, if we add the 0.19 kW expected bias to the estimated impact of 0.46 kW for the average event day, the adjusted CPP day impact equals 0.65 kW, which is very close to the RED impact estimate of 0.69 kW. Put another way, whenever pretreatment data is not available, both the within-subjects analysis and propensity matching rely on the critical assumption that there is no impact on nonevent days. If there is, event-day impacts will be biased by the amount of that impact under both approaches. The main difference between the approaches is that propensity matching removes any specification error associated with modeling the relationship between weather and load, which is a potentially important advantage. There can still be modeling error in the matching process but as seen here, if hourly data is available on a large enough sample, matching can be quite good.

Table 9-5: Impact Estimates from RED Analysis and Analysis Based on Propensity Score Matching

Date	Daily Maximum Temperature (F)	RED Impact	2011 Days with Max over 90°F	P-value	2012 Days with Max over 75°F	P-value	2012 Days with Max over 90°F	P-value	2012 Days with Average over 75°F	P-value
10-Jul-12	100	0.84	0.84	0.92	0.61	0.01	0.64	0.03	0.61	0.01
12-Jul-12	102	1.00	0.89	0.27	0.72	0.01	0.73	0.01	0.74	0.01
2-Aug-12	98	0.59	0.69	0.29	0.46	0.15	0.45	0.11	0.45	0.12
8-Aug-12	99	0.69	0.68	0.84	0.44	0.00	0.43	0.00	0.46	0.01
9-Aug-12	102	0.84	0.80	0.69	0.61	0.02	0.56	0.00	0.54	0.00
10-Aug-12	102	0.90	0.81	0.39	0.54	0.00	0.54	0.00	0.46	0.00
14-Aug-12	95	0.70	0.68	0.79	0.47	0.01	0.53	0.05	0.49	0.02
15-Aug-12	94	0.65	0.68	0.75	0.46	0.03	0.46	0.03	0.45	0.03
12-Sep-12	91	0.48	0.42	0.50	0.27	0.01	0.26	0.01	0.26	0.01
13-Sep-12	96	0.45	0.55	0.23	0.36	0.31	0.32	0.13	0.37	0.39
14-Sep-12	91	0.41	0.39	0.81	0.17	0.00	0.15	0.00	0.19	0.01
Average	97	0.69	0.67	0.84	0.46	0.00	0.46	0.00	0.46	0.00
Correlation	-	-	0.94		0.94		0.94		0.89	

9.2.3 Conclusions Concerning Propensity Matching

The primary conclusions from the analysis of propensity score matching are:

- The accuracy of impact estimates for dynamic rates based on statistical matching is a function of the availability of data used in the matching process. If pretreatment, interval data is available, matching can produce unbiased estimates of load impacts for the average event day as well as for individual event days.
- By eliminating the need to model the relationship between weather and load, propensity score matching is likely to do a better job in estimating impacts for individual event days than does a within-subjects analysis.
- In the absence of pretreatment data, the accuracy of propensity score matching relies on the same fundamental assumption as within-subjects analysis – namely that the rate does not cause customers to modify their usage on nonevent days. Event day impacts will be biased if nonevent day loads are different than they were during the pretreatment period. This assumption cannot be tested analytically in the absence of an RCT or RED control group which, if available, would mean that propensity matching would not be used for evaluation.

9.3 Estimation Using Propensity Score Matching for TOU Rates

The comparative analysis in this section is similar to what was summarized above for the CPP tariff, but applied to the TOU treatment group without the offer of an IHD. Within-subjects analysis is not appropriate for TOU tariffs because the same prices are in effect on all weekdays. In other words, TOU rates do not have the "on-off" pattern associated with a dynamic rate like CPP that is necessary for the within-subjects analysis to be used. However, propensity score matching is a valid, quasi-experimental method that can be applied to TOU impact analysis as long as pretreatment data exists for a suitable pool of customers that are not on TOU rates from which a matched control group can be chosen. Below we compare results obtained from the RCT analysis that was reported in Section 6 with results using a matched control group for the opt-in TOU pricing plan that did not include an IHD offer.

9.3.1 Matched Control Group Development

In this exercise, the matching process was based on two different data sets. The two data sets were chosen based on common scenarios that utilities face when evaluating TOU rates. The first data set included hourly usage for the summer prior to going on the TOU rate. Outside of using an experimental design, this is the best dataset a utility could have to estimate TOU impacts. The second data set contains monthly usage for the summer prior to the TOU rate going into effect. This is a common scenario representing a time when utilities have not had AMI meters in place for long and there is only monthly usage data available for most customers going onto newly offered TOU rates that were put in place after AMI meters were deployed.

The process of matching was similar across the two datasets. For the first scenario in which hourly usage data is available prior to when customers opt-in to the TOU rate, control group customers were matched to treated customers based on EAPR status and usage during each of the peak period hours (4 to 7 PM) for each of the four months of the summer of 2011. For the other data set, treatment and control group customers were matched based on EAPR status and on 2011 monthly usage data for the summer months of June, July, August and September. After each treated customer was matched to a control customer, impacts were estimated by comparing the load of the control customers during the TOU peak period on summer weekdays to the load of the treated customers. For the match involving 2011 hourly data, the analysis used the same difference-in-differences regression models that were used for the RCT analysis. For the other match, impacts were calculated by taking the difference between control and treatment usage during the peak period. A difference-in-differences calculation could not be done in this case because it represents a scenario in which hourly peak period usage data did not exist during the pretreatment period.

Figure 9-10 shows the load shapes for treatment and control groups on 2011 summer weekdays after the propensity score match was completed for the scenario in which pretreatment interval data is available. Treatment and matched control group loads are very similar across all hours of the event day. During the peak period, the control group shows usage that is about 2% greater than the treatment group. However, this small difference is largely accounted for by using the difference-in-differences regression analysis. In a more thorough investigation, it might be possible to improve the matching process by incorporating more load shape and usage variables in the model so that the pretreatment difference adjustment was smaller.

Figure 9-10: Average 2011 Summer Weekday for Treatment & Control Groups after Matching Based on Hourly Peak Period Usage for 2011

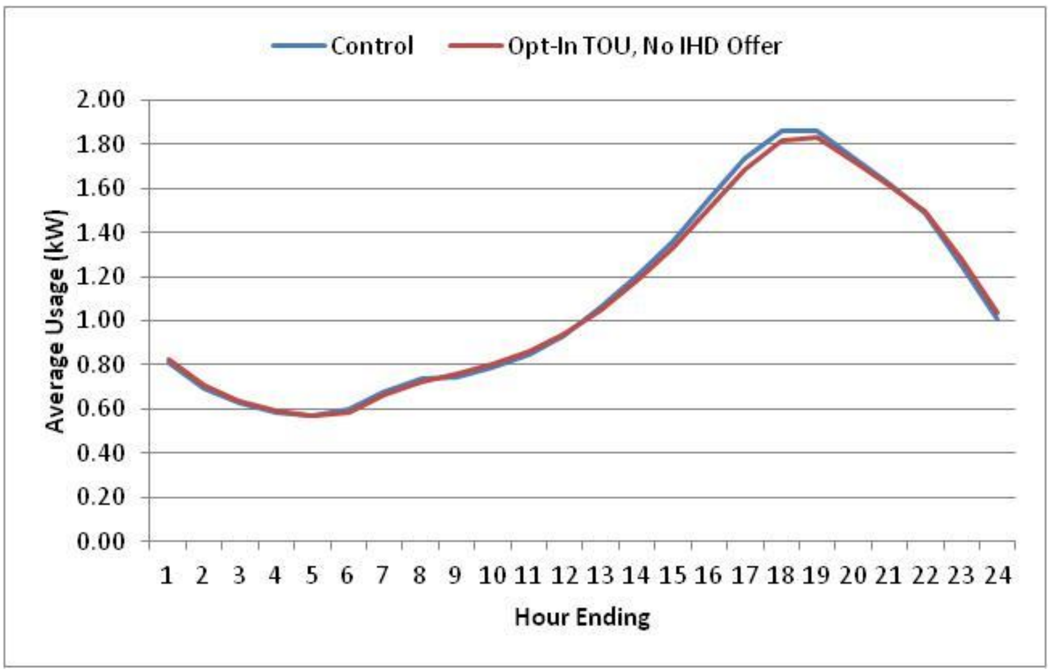
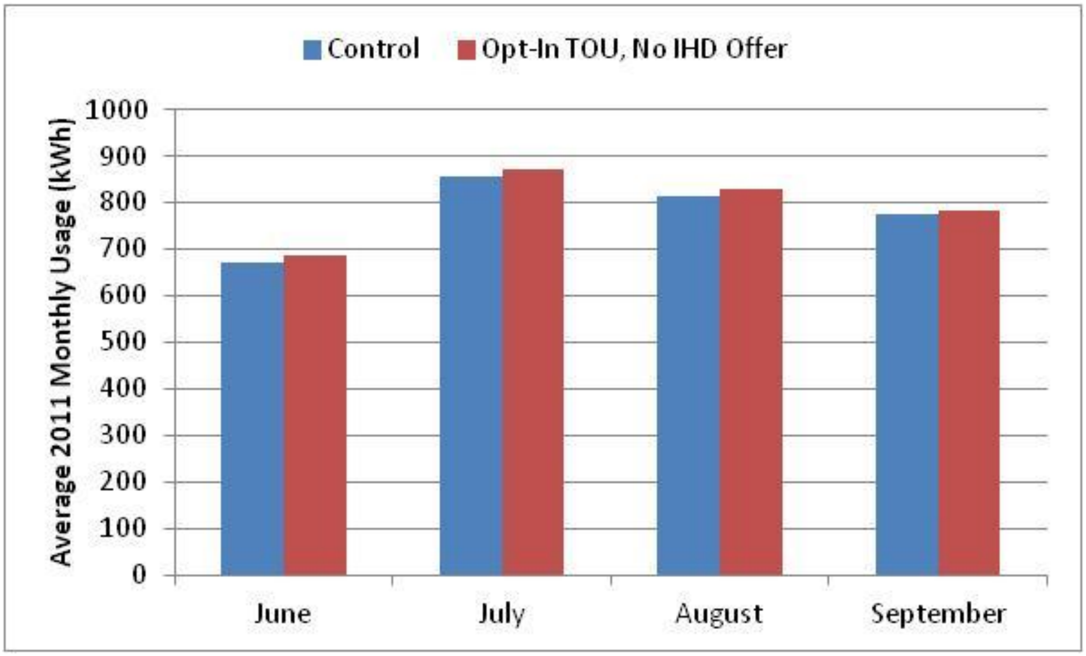


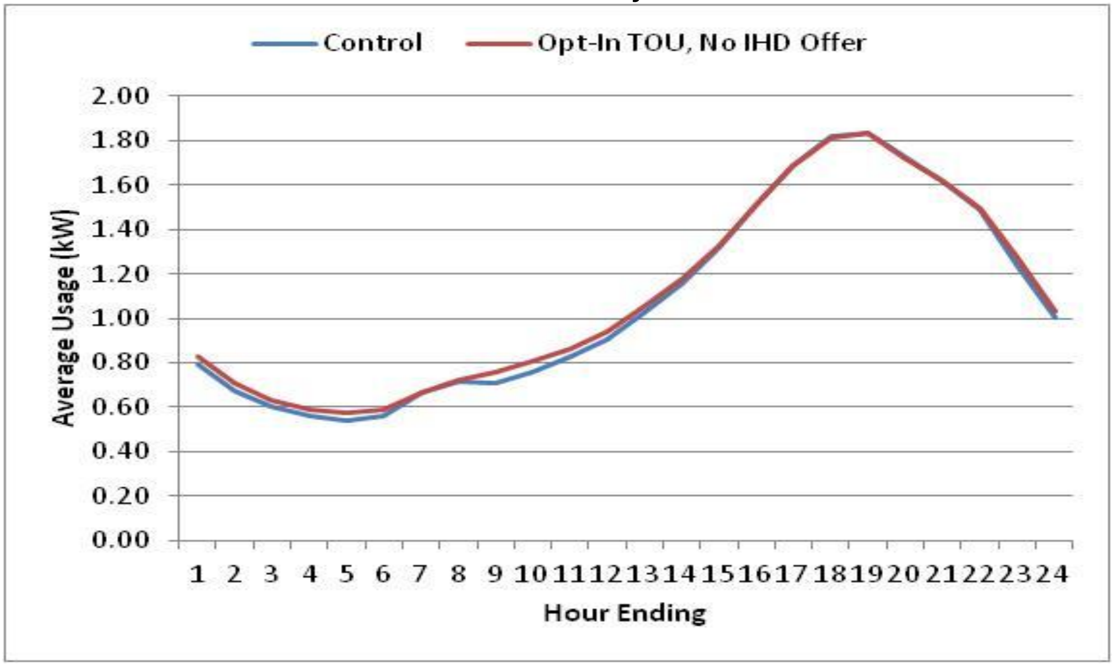
Figure 9-11 compares monthly usage for the match that was done using 2011 monthly usage data. For each of the four months used in the match, the control group shows usage that is between 1% and 2% less than the treated group. Again, a more meticulous matching exercise might have been able to reduce this difference although the number of variables that can be used for matching is limited when only monthly usage data is available.

Figure 9-11: Average 2011 Monthly Usage for Treatment and Control after Matching based on Pretreatment Monthly Usage Data



Although matching based on pretreatment monthly usage is intended to simulate a situation where hourly load data for the pretreatment period is not available, it is available here. As such, we can observe weekday loads for the treatment and control groups based on matching using monthly load data. Figure 9-12 shows this comparison. As seen, usage for the treatment and control groups is very similar across all hours. Considering that only monthly data was used, this match is incredibly close. Surprisingly, usage is actually more similar during the peak hours for this match than for the match that was made using 2011 hourly usage data. We would not expect this to occur in every situation. Including different variables in the matching process could change this outcome.

Figure 9-12: Average 2011 Summer Weekday for Treatment & Control Match Based on Monthly 2011 Data



9.3.2 Impact Estimates Using Propensity Score Matching

Table 9-6 shows the impact estimates based on a difference-in-differences analysis using the RCT treatment and control groups as well as control groups selected from a propensity score matching exercise for each of the two data sets described above. The first numerical column shows the impact estimates based on the RCT analysis. The next four columns show the impact estimates for each of the propensity score matches and the p-values indicating whether the estimate is statistically different from the RCT impact. The second to last row in each column shows the average event impact across all four months and the final row shows the correlation between the RCT impact estimates and the impacts estimated from the two matched control groups.

Table 9-6: Impact Estimates from RCT Analysis and Analysis Based on Propensity Score Matching

Month	RCT Impacts	2011 Hourly		2011 Monthly	
		Impact	P-Value	Impact	P-Value
June	0.16	0.19	0.00	0.25	0.08
July	0.19	0.29	0.00	0.34	0.02
August	0.24	0.33	0.00	0.39	0.04
September	0.09	0.18	0.00	0.22	0.02
Average	0.17	0.25	0.00	0.30	0.02
Correlation	N/A	0.92		0.94	

As shown in Table 9-6, the p-values indicate that all of the differences between the RCT estimates and the estimated values using propensity score matching are statistically significant. The correlation coefficient between the RCT and propensity score monthly estimates is quite high, indicating that all of the approaches capture well the pattern in impacts across months, with the highest estimated impact occurring in July and the lowest in September. However, the average (and monthly) point estimates based on the matched control group scenarios are between 50% and 75% higher than the RCT estimates. These values are outside of the 95% confidence interval around the RCT average impact, which ranges from 0.13 kW to 0.22 kW.

Figures 9-13 and 9-14 show load on the average summer weekday for treatment and control customers based on each of the two propensity score matches. Figure 9-13 shows the load for the average 2012 summer weekday based on the match using 2011 hourly usage data and Figure 9-14 shows the load for summer weekdays for the monthly usage data matching scenario. In Figure 9-13, the reference load looks very reasonable, matching the treatment load closely outside of peak period hours. In Figure 9-14, the reference load is higher than the treatment group load prior to the start of the peak period, which explains, in part, the higher estimated impact for this scenario shown in Table 9-6.

Figure 9-13: Average 2012 Summer Weekday Load Based on Propensity Score Matching Using Hourly 2011 Data

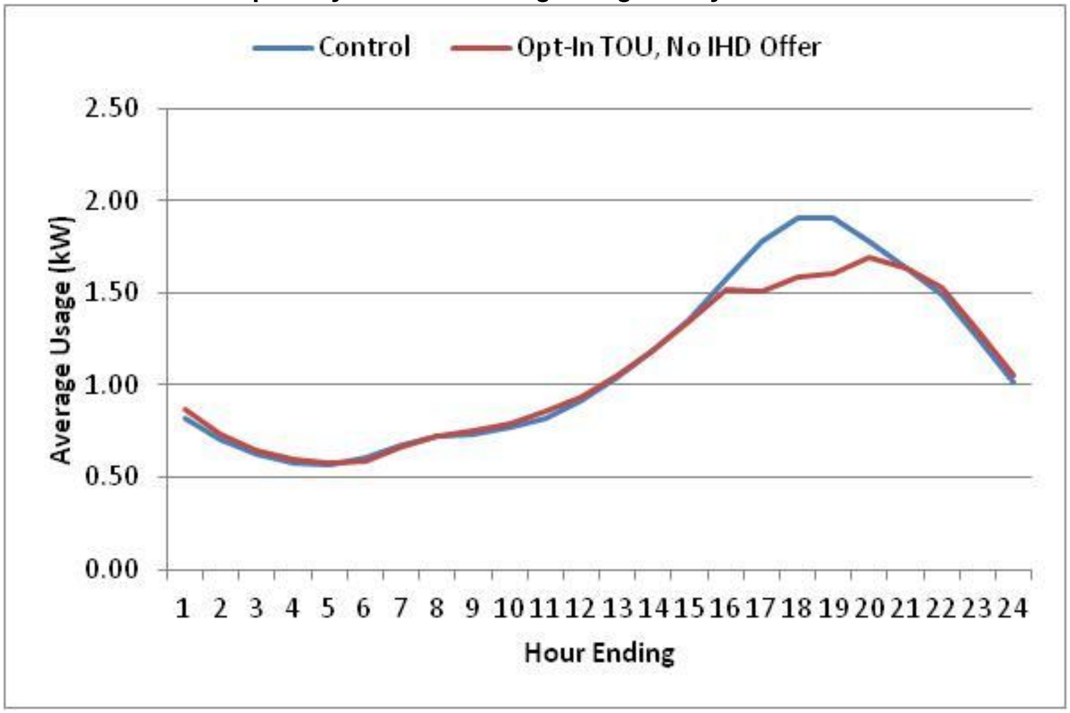
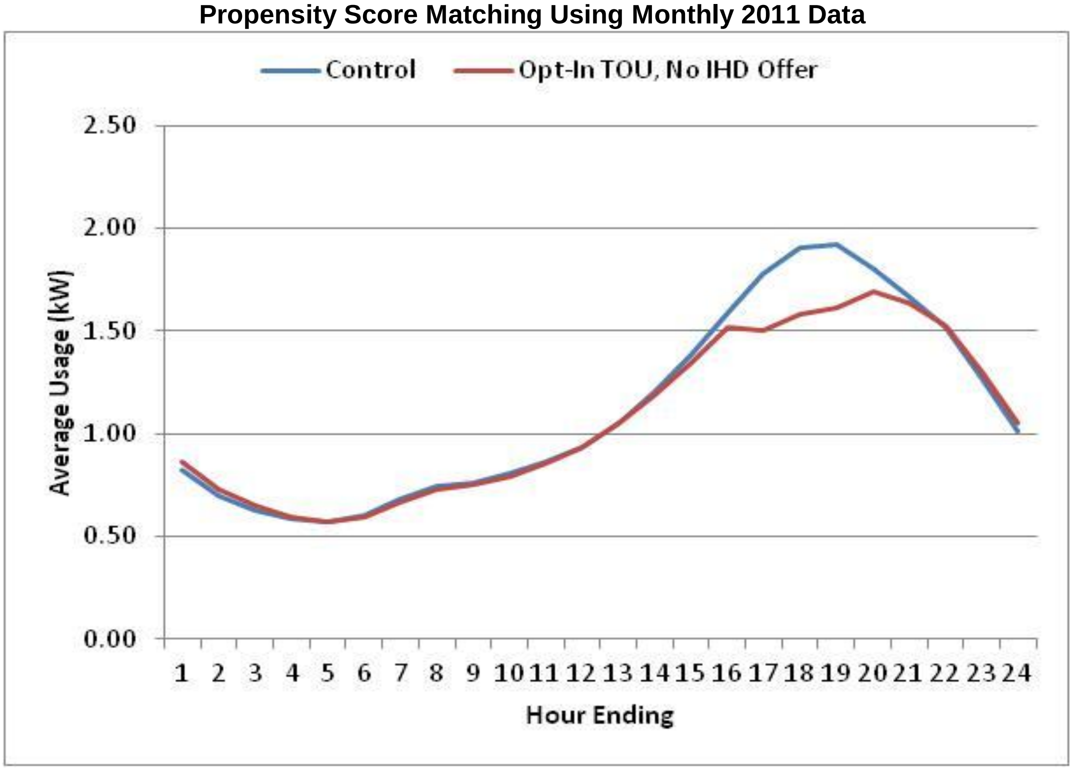


Figure 9-14: Average 2012 Summer Weekday Load Based on Propensity Score Matching Using Monthly 2011 Data



9.3.3 Conclusions Concerning Propensity Matching for TOU

Impact estimates based on propensity matching for the TOU treatment group were larger than the RCT estimates and the differences between these estimates were statistically significant. Two sets of estimates were produced, one based on a control group developed using pretreatment interval data and the second based on a control group developed using monthly data. In most evaluations to date, the latter methodology for estimation has been more common. The impact estimates were similar under both scenarios. However the estimates using interval data were closer to the RCT estimates but not by a large margin. It is possible that a different propensity matching model could produce different results. It is important to keep in mind that, as with the within-subjects analysis, in the absence of the RCT impact estimates to compare against, there would be little reason to think that a different propensity model should be explored. As was seen in Figure 9-10, a comparison of pretreatment weekday loads for the treatment and matched control group was quite good.

9.4 Comparative Methods Analysis Summary

The analysis presented here demonstrates the superiority of sound experimental design when estimating load impacts from time-variant rates and other policies designed to change the timing and amount of electricity use among consumers. Although the specific results regarding the relative performance of these designs cannot be generalized, we believe they still validate DOE's objectives in funding numerous consumer behavior studies based on rigorous experimental designs and the diligence of SMUD in rigorously adhering to sound design principles in implementing the SPO pilot.

The analysis compared load impact estimates based on three different methodologies for a CPP treatment – within-subjects analysis, difference-in-differences estimation based on a control group selected using statistical matching, and difference-in-differences analysis based on an RED. For a TOU treatment, comparisons were made for two methodologies – matching and an RCT – both using difference-in-differences estimation procedures.

For an event-based tariff such as CPP, the biggest risk to producing unbiased, event-day load impact estimates using both types of quasi-experimental methods is that the necessary assumption that there are no load impacts on nonevent days may not be true. This risk is present whenever pretreatment data is not available. In the treatment explored here, this assumption was violated and the estimated event-day load impacts using the quasi-experimental methods were biased downward in all scenarios in which pretreatment data were not used. This scenario represents most CPP impact evaluations that have been conducted in the industry to date, but may be less prevalent in the future as rate programs are implemented by utilities that have had advanced meter deployments in place long enough to generate pretreatment data for customers signing up for the new tariffs.

With or without the existence of pretreatment data, within-subjects analysis is subject to model specification error. Modeling the relationship between weather and load is challenging. In the example used here for the CPP rate, in spite of using cross-validation analysis to test numerous models and multiple datasets consisting of different proxy days, the impact estimates differed from the RED estimates even when pretreatment data was available. This was true, at least in part, because event days were preceded by much hotter days than proxy days, which led to much higher event-day reference loads than predicted by the best fitting model. In this case, estimates based on propensity matching using pretreatment data did much better because this methodology does not rely on modeling the relationship between weather and load. If pretreatment interval data exists, we believe propensity matching is superior to within-subjects analysis both because it does not require modeling the relationship between weather and load and because it does not require assuming that nonevent day loads are unaffected by the CPP rate. Even in the absence or pretreatment data, propensity matching may be superior because it does not require modeling weather effects, although it can be biased if nonevent day loads change as a result of the treatment.

The comparative methods analysis for the TOU rate showed statistically significant differences in average load impacts based on RCT analysis and analysis using a control group selected based on propensity score matching and impact estimates using difference-in-differences calculations. Two matching scenarios were examined, one in which pretreatment interval data was available and one in which the matching was based on pretreatment monthly usage data. The latter has been the more common application of matching in the industry to date but matching using interval data should be more common in the future.

It is difficult to know why the impact estimates using matching are not more closely aligned with the RCT estimates in this instance. The matching process was relatively good although different propensity models could produce better matches and possibly lead to different estimates. Importantly, in the absence of having the RCT results with which to compare, many researchers might not have looked for a better match even with the best pretreatment data available because a comparison of treatment and control group loads in the pretreatment period was quite good. In the absence of an RCT or RED evaluation design, statistical matching is really the only approach that can be used for TOU rate analysis. In light of the findings here, when possible, we suggest producing impact estimates based on multiple matching algorithms to see how robust the estimates are. If different algorithms produce similar results, there should be greater confidence that the estimated impacts are reasonably accurate. If estimates based on multiple algorithms are quite different, this uncertainty should be factored into any policy decisions based on the estimates.

Appendix A Glossary of Terms for SPO Study Design

Control Group

The control group consists of customers who are identical to treatment customers except that they are not on the new rate. For treatments implemented using RED, control group customers are not offered the rate, but are randomly chosen from the same population as the treatment group. For the RCT design, control customers consist of customers who volunteered to go on the new rate but were assigned to the deferred group (and will go on the rate in 2014).

Customer Acceptance Rate

The customer acceptance rate consists of all customers who agreed to go on the rate divided by the number of customers who were offered the rate. This value will typically be larger than the enrollment rate (and can't be less than it) as it includes everyone who signed up for a rate even if they never went on the rate. For opt-in treatments, the numerator in the customer acceptance rate would include all customers who agreed to accept the rate, even if they were assigned to a control group leading to deferred enrollment. It would also include all customers who agreed to go on the rate but who may have never gone on it because, for example, they moved before the rate went into effect. It would also include customers who went on the rate but later dropped out. The denominator includes all customers in the original sample minus customers who moved before they received an offer. The customer acceptance rate is the best measure of the effectiveness of a marketing campaign. For default treatments, the numerator of the customer acceptance rate consists of all customers who were defaulted onto the rate and did not drop out prior to going on the rate. If a customer goes on the rate and later drops out of the program, they would still be included in the numerator of this rate. Only customers who drop out prior to going on the rate are excluded from the numerator. The denominator of the customer acceptance rate for default programs equals the number of customers who were defaulted onto the rate.

Decliners

A decliner is a customer that was offered a rate option but declined to accept the offer.
For opt-in treatments, the number of decliners equals the total number of customers marketed to minus the total number of customers who accepted the offer. For default treatments, the number of decliners equals the total number of customers defaulted onto the rate minus those who drop out prior to going on the rate. It does not include customers who actually are placed on the rate and then later dropped out.

Deferred RCT Customers

Customers recruited into the opt-in RCT treatments who are assigned to the control group, and therefore whose enrollment on the rate is deferred until after the end of the pilot in 2014.

Drop outs

Drop outs consist of customers who went on a rate at some point in time, but who later requested to be taken off the rate. It does not include customers who drop out due to changing their location (e.g., moving). These are called movers.

Enrolled Customers

Enrolled customers are customers who are on a new rate at a given point in time. For opt-in rates, this group consists of customers who accepted the marketing offer, were assigned to the treatment group (rather than the control group), did not change their mind or move prior to the rate going into effect, and are still on the rate (e.g., have not dropped out or moved) at the time that the enrollment snap shot is taken. For default enrollment, enrolled customers at a point in time are customers who did not opt-out prior to or after going on the rate, or did not move or leave the rate for any reason between when they were initially enrolled and when the enrollment is reported.

Enrollment Rate

The enrollment rate consists of all customers who were ever actually on a rate for some period of time divided by the number of customers who were offered the rate. This is different from the customer acceptance rate, as defined below.

General Population

All residential customers in SMUD's service territory (approximately 530,000 customers). This differs from the SPO eligible population, as defined below.

Movers

Movers are customers who were either defaulted onto a new rate or accepted a rate offer on an opt-in basis, but subsequently moved and, therefore, are no longer enrolled on the rate. A mover may or may not have ever actually gone on the new rate. For example, some customers may have accepted the new rate offer several months prior to the new rate going into effect and may have moved before they were placed on the rate. Similarly, default customers may have not consciously declined the default option but may have moved between the time they were notified that a rate change would be going into effect and when the rate actually went into effect.

Randomized Control Trial (RCT)

RCT refers to a research strategy in which customers who volunteer for a treatment are randomly assigned to treatment and control conditions. This method ensures that the only difference between treatment and control customers, other than differences due to random sampling variation, is that one group receives the treatment and the other does not. 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. In practice, randomization can be achieved using either a *recruit and deny* process, or a *recruit and delay* process. In the former, control customers are never given the treatment whereas in the latter, customers assigned to the control group are placed on the treatment after the end of the trial measurement period. Prior to that time, they act as the control group against which treatment effects are measured. SMUD used the recruit and delay method. Deferred customers will be placed on the new rate in 2014.

Randomized Encouragement Design (RED)

RED refers to a research design in which two groups of customers are selected from the same population at random and one is offered a treatment while the other is not. Not all customers offered the treatment are expected to take it but, for analysis purposes, all those who are offered the treatment are considered to be in the treatment group. Treatment impacts are estimated initially by comparing the change in usage between the treatment and control groups before and after the treatment goes into effect. This first stage impact estimate—referred to as an intent-to-treat estimate—reflects a weighted average of those who were offered the treatment and took it and those who were offered the treatment and declined. A second stage calculation can be done to determine the impact only for those customers who accepted the treatment offer. This estimate—referred to as the treatment effect on the treated—will be unbiased by selection effects.

In another variation on RED, two groups may be subject to differing levels of encouragement to take a treatment, such as in a comparison of a group offered a rate on an opt-in basis to a group offered a rate on a default basis. In this case, intent-to-treat and treatment effect on the treated estimates are developed in the same way, with the treatment effect on the treated being equal to the effect of the treatment on customers who would respond to the higher level of encouragement (e.g., rate by default) but who would not respond to the lower level of encouragement (e.g., an opt-in offer).

SPO Eligible Population

The SPO treatments were offered to a subset of SMUD's general population, consisting of the approximately 260,000 customers who had interval meters installed prior to June 2011, but excluding customers who were participating in SMUD's Air Conditioning Load Management (ACLM) program, Summer Solutions study (a separate dynamic pricing study), medical assistance program, master metered accounts, budget billing and PV solar programs. After these exclusions, there were approximately 176,000 customers eligible for inclusion in the pilot.

Treatment Group

The treatment group consists of customers who were either offered the new rate option (under RED) or who took it and were assigned to the treatment group rather than the control group (under an RCT design). Under RED, not every treatment customer is actually on the new rate. Under the RCT design, all treatment customers are on the new rate.

Within-subjects Design

A within-subjects design does not rely on an external control group to estimate impacts. Instead, it compares usage for customers who accept a treatment under treatment and non-treatment conditions. A within-subjects design is not as strong as RCT or RED in terms of clearly establishing causality between usage changes and treatments because other factors may affect usage (e.g., weather conditions) and be the cause of the observed change. As such, analysis based on a within-subjects design typically must use statistical models to control for the potential influence of other factors. Estimates based on a within-subjects design typically are best when impacts are expected to be reasonably large and when differences in other exogenous factors are small under treatment and non-treatment conditions. For these reasons, a within-subjects design is better suited to estimating impacts for a CPP for which the treatment is in effect on one day and not the next and for which impacts are expected to be relatively large, for a TOU rate, for which the pretreatment period consists of an entire summer of usage and occurs 12 months prior to the treatment summer, and where impacts are expected to be relatively small.

Appendix B DOE Survey Instrument

As indicated in DOE Guidance Document 9, Consumer Behavior Study participants were to administer a survey to a sample of customers in control and treatment groups. SMUD used the exact wording from the DOE document. The questions asked are shown below.

The beginning of any survey is critical as the introduction can keep the person on the phone depending on the language used. We suggest something such as: "Hello, this is <name> calling on behalf of <utility>. This is not a sales call. We are calling to…" The reason for the call needs to be very short and to the point. If the name of the customer is known, we suggest asking to speak with that person. These suggestions are standard to any telephone survey, but are provided for any recipient who has not performed many such surveys. We expect that the utilities will work with their survey contractor to provide the best introduction to the survey.

Question responses that are in parenthesis should not be read during a phone survey.

MA1. Do you own or rent your home?

- 1. Own
- 2. Rent
- 3. (Other)
- 98. (Don't Know)
- 99. (Refused)

MA2. What type of residence do you live in? Do you live in a…(READ CATEGORIES)

- 1. Single-family
- 2. Duplex or two-family
- 3. Apartment/condo in a 2-4 unit building
- 4. Apartment/condo in a >4 unit building
- 5. Townhouse or row house (adjacent walls to another house)
- 6. Mobile home, house trailer
- 7. (Other)
- 98. (Don't Know)
- 99. (Refused)

MA3. Does your home have central air conditioning?

- 1. Yes
- 2. No
- 98. (Don't Know)
- 99. (Refused)

MA4. Do you have any room air conditioners?
(If asked of the telephone interviewer: A room air conditioner is a small unit that sits in your window to cool one or more rooms.)

- 1. Yes
- 2. No (GO TO MA6)
- 98. (Don't Know) (GO TO MA6)
- 99. (Refused) (GO TO MA6

MA5. How many room air conditioners do you have?

________ (Numeric open end from 1 to 20, set to 98 if don't know and 99 if refused.)

MA6. Do you have a programmable thermostat?

1. Yes
2. No (GO TO MA8)
98. (Don't Know) (GO TO MA8)
99. (Refused) (GO TO MA8)

MA7. Is the programmable thermostat currently set to automatically change temperature during the day when no one is home?

1. Yes
2. No
98. (Don't Know)
99. (Refused)

MA8. Do you have an electric clothes dryer?

1. Yes
2. No
98. (Don't Know)
99. (Refused)

MA9. Including yourself, how many adults, 18 or older, currently live in your household?

________ (Numeric open end from 1 to 20, set to 99 if refused.)

MA10. And how many of these adults are over 65?

________ (Numeric open end from 0 to 20, set to 99 if refused.)
(Put logic in place to make sure that MA10 cannot be larger than MA9)

MA11. How many children under the age of 18 live in your household at least part of the week?

________ (Numeric open end from 0 to 20, set to 99 if refused.)

MA12. Do you or does anyone in your household have a chronic illness or disability that requires regular or occasional in-home medical treatment?

1. Yes
2. No
98. (Don't Know)
99. (Refused)

MA13. Is there someone home on Monday to Friday sometime between 1 PM and 5 PM at least one day a week?
(If asked of the telephone interviewer: If your schedule varies, please think about your typical week or what is most common when answering this question.)

1. Yes
2. No
98. (Don't Know)
99. (Refused)

MA14. Is there anyone in your household working full time for pay?

1. Yes
2. No (GO TO MA16)
98. (Don't Know) (GO TO MA16)
99. (Refused) (GO TO MA16)

MA15. Do you or anyone in your household have a job where you work at home at least one weekday a week rather than go into an office or some other location?
(If asked of the telephone interviewer: If your schedule varies, please think about your typical week or what is most common when answering this question.)

1. Yes
2. No
98. (Don't Know)
99. (Refused)

MA16. Do you remember receiving information from your electric utility asking you to participate in a utility pilot program?

1. Yes
2. No (GO TO MA18)
98. (Don't Know) (GO TO MA18)
99. (Refused) (GO TO MA18)

MA17. Was the information useful in helping you decide whether or not to participate in the pilot?

1. Yes
2. No
98. (Don't Know)
99. (Refused)

MA18. What is the primary language spoken in your home?
[NOTE TO UTILITY: The choices here should be kept, but if you have additional languages that are relevant to your service territory, add them between options 6 and 7.]

1. English
2. Spanish
3. Chinese
4. Korean
5. Vietnamese
6. Russian
7. Other
99. (Refused)

MA19. Last year—that is, in 2010—what was your total household income from all sources, before taxes? Just stop me when I get to the right category. (READ)

1. Less than $10,000
2. $10,000 to less than $20,000
3. $20,000 to less than $30,000
4. $30,000 to less than $40,000
5. $40,000 to less than $75,000
6. $75,000 to less than $90,000
7. $90,000 to less than $100,000
8. $100,000 to less than $150,000
9. $150,000 or more
98. (Don't Know)
99. (Refused)

MA20. What is the LAST grade or class that you COMPLETED in school? (DO NOT READ)

1. (None, or grade 1-8)
2. (High School incomplete (grade 9-11))
3. (High School graduate (grade 12 or GED certificate))
4. (Technical, trade or vocational school AFTER high school)
5. (Some college, no four-year degree (includes associate degree))
6. (College graduate (B.S., B.A., or other four-year degree))
7. (Post-graduate or professional schooling after college (e.g., towards a Master's degree or Ph.D; law or medical school))
98. (Don't know)
99. (Refused)

DONE WITH DOE QUESTIONS

Appendix C Comparison of Monthly Usage Among Groups

Table C-1: Monthly Usage Comparison of Opt-in TOU without IHD Offer, Deferred & Opt-in TOU without IHD Offer, Enrolled

Year/Month	Opt-in TOU, No IHD Offer, Deferred	Opt-in TOU, No IHD Offer, Enrolled	Difference	P-value	Stat. Sig.
2011m6	705	699	-6	0.366	
2011m7	900	892	-8	0.367	
2011m8	863	852	-11	0.228	
2011m9	811	799	-12	0.139	
2011m10	582	569	-13	0.049	**
2011m11	635	627	-8	0.241	
2011m12	800	786	-14	0.137	
2012m1	733	719	-14	0.112	
2012m2	615	603	-12	0.105	
2012m3	634	621	-13	0.100	*
2012m4	591	582	-9	0.204	
2012m5	646	634	-12	0.128	
2012m6	769	755	-14	0.110	
2012m7	925	903	-22	0.033	**
2012m8	987	965	-22	0.039	**
2012m9	762	747	-15	0.082	*

Table C-2: Monthly Usage Comparison of Opt-in TOU with IHD Offer, Deferred & Opt-in TOU with IHD Offer, Enrolled

Year/Month	Opt-in TOU IHD Offer, Deferred	Opt-in TOU IHD Offer, Enrolled	Difference	P-value	Stat. Sig.
2011m6	702	693	-9	0.137	
2011m7	893	884	-9	0.172	
2011m8	859	849	-10	0.175	
2011m9	805	798	-7	0.251	
2011m10	577	571	-6	0.262	
2011m11	631	624	-7	0.162	
2011m12	791	780	-11	0.140	
2012m1	724	717	-7	0.323	
2012m2	607	603	-4	0.524	
2012m3	623	619	-4	0.441	
2012m4	582	579	-3	0.586	
2012m5	634	634	0	0.988	
2012m6	754	753	-1	0.913	
2012m7	913	906	-7	0.334	
2012m8	972	963	-9	0.291	
2012m9	751	748	-3	0.664	

Table C-3: Monthly Usage Comparison of Default TOU with IHD Offer & Control Group

Year/Month	Control	Default TOU with IHD Offer	Difference	P-value	Stat. Sig.
2011m6	697	691	-6	0.513	
2011m7	888	878	-10	0.405	
2011m8	854	848	-6	0.589	
2011m9	801	796	-5	0.642	
2011m10	572	567	-5	0.560	
2011m11	627	624	-3	0.790	
2011m12	787	783	-4	0.746	
2012m1	723	720	-3	0.815	
2012m2	606	599	-7	0.494	
2012m3	621	613	-8	0.406	
2012m4	579	567	-12	0.148	
2012m5	636	619	-17	0.066	*
2012m6	760	731	-29	0.008	***
2012m7	913	878	-35	0.007	***
2012m8	971	933	-38	0.006	***
2012m9	751	721	-30	0.009	***

Table C-4: Monthly Usage Comparison of Opt-in CPP without IHD Offer & Control Group

Year/Month	Control	Opt-in CPP, No IHD Offer	Difference	P-value	Stat. Sig.
2011m6	697	691	-6	0.636	
2011m7	888	880	-8	0.596	
2011m8	854	844	-10	0.530	
2011m9	801	796	-5	0.734	
2011m10	572	564	-8	0.467	
2011m11	627	613	-14	0.302	
2011m12	787	757	-30	0.088	*
2012m1	723	697	-26	0.094	*
2012m2	606	592	-14	0.297	
2012m3	621	610	-11	0.412	
2012m4	579	578	-1	0.926	
2012m5	636	634	-2	0.880	
2012m6	760	754	-6	0.685	
2012m7	913	904	-9	0.634	
2012m8	971	971	0	0.993	
2012m9	751	748	-3	0.847	

Table C-5: Monthly Usage Comparison of Opt-in CPP with IHD Offer & Control Group

Year/Month	Control	Opt-in CPP with IHD Offer	Difference	P-value	Stat. Sig.
2011m6	697	702	5	0.378	
2011m7	888	894	6	0.360	
2011m8	854	859	5	0.465	
2011m9	801	807	6	0.337	
2011m10	572	575	3	0.562	
2011m11	627	628	1	0.801	
2011m12	787	791	4	0.578	
2012m1	723	723	0	0.989	
2012m2	606	605	-1	0.990	
2012m3	621	622	1	0.824	
2012m4	579	583	4	0.478	
2012m5	636	639	3	0.608	
2012m6	760	761	1	0.875	
2012m7	913	913	0	1.000	
2012m8	971	969	-2	0.802	
2012m9	751	750	-1	0.905	

Table C-6: Monthly Usage Comparison of Default CPP with IHD Offer & Control Group

Year/Month	Control	Default CPP, IHD Offer	Difference	P Value	Stat. Sig.
2011m6	697	705	8	0.602	
2011m7	888	900	12	0.566	
2011m8	854	870	16	0.406	
2011m9	801	805	4	0.834	
2011m10	572	568	-4	0.745	
2011m11	627	611	-16	0.318	
2011m12	787	775	-12	0.567	
2012m1	723	712	-11	0.553	
2012m2	606	602	-4	0.821	
2012m3	621	613	-8	0.614	
2012m4	579	576	-3	0.806	
2012m5	636	639	3	0.846	
2012m6	760	759	-1	0.957	
2012m7	913	902	-11	0.625	
2012m8	971	958	-13	0.571	
2012m9	751	733	-18	0.343	

Table C-7: Monthly Usage Comparison of Default TOU & CPP with IHD Offer & Control Group

Year/Month	Control	Default TOU & CPP with IHD Offer	Difference	P Value	Stat. Sig.
2011m6	697	707	10	0.566	
2011m7	888	899	11	0.618	
2011m8	854	858	4	0.857	
2011m9	801	808	7	0.728	
2011m10	572	593	21	0.140	
2011m11	627	634	7	0.633	
2011m12	787	783	-4	0.873	
2012m1	723	722	-1	0.983	
2012m2	606	611	5	0.741	
2012m3	621	630	9	0.566	
2012m4	579	597	18	0.248	
2012m5	636	653	17	0.327	
2012m6	760	765	5	0.810	
2012m7	913	902	-11	0.643	
2012m8	971	967	-4	0.881	
2012m9	751	772	21	0.288	

Appendix D Selected Marketing Materials for the Opt-in and Default TOU with IHD Offer Treatment Groups

This appendix includes some of the marketing materials sent to SMUD customers in the SPO pilot. Figures D-1 and D-2 show the original offer letters that customers in the opt-in TOU with IHD group and default TOU with IHD group received, respectively. Figure D-3 shows the two-page brochure that both opt-in and default customers received. Figure D-4 shows one side of the business reply card that opt-in customers received as a means to sign up, though they could also sign up online or over the phone. Finally, Figure D-5 is the six-page welcome packet that customers in the opt-in and default TOU with IHD offers received.

Figure D-1: Opt-in TOU with IHD Offer Letter

(Mail Date)

(Customer Name)

(Address)

Sign up today and you could save on your electric bills next summer!

smud.org/smartvalue

Dear (Customer Name),

You are invited to participate in a two-year SmartPricing Options pilot that can help you manage your energy bills. The **Summer Weekday Value Plan** is being offered to a randomly selected group of SMUD customers for a limited time. Enrolling in this plan will allow you to take control of next summer's electricity costs and help the environment.

Here's how it works:

- You'll receive a discount off the standard price on the amount you pay for your electricity during off-peak hours each summer from June 1 through September 30. (This plan is effective 2012 through 2013.) Off-peak hours are Monday through Friday before 4:00 p.m. and after 7:00 p.m., all day on weekends, July 4th and Labor Day. That means that 90% of the time, you'll get a discount.
- During peak hours – weekdays from 4:00 p.m. to 7:00 p.m. – the price you pay will be higher than the standard price.

Using less electricity during peak hours, shifting the time you use electricity (like doing laundry after 7:00 p.m.), or reducing your use overall can help you save money on your bill.

Here are additional perks:

- A FREE countertop electricity use display, mailed to you in spring 2012. This display will show how much electricity you're using at that moment, and how much it's costing you.
- An online informational graph on My Account that shows your hourly and daily electricity use.
- Access to a website – smud.org/smartvalue – with energy-saving tips and tools.
- Discounts on activities – like movie tickets and water parks – that can make using less electricity from 4:00 p.m. to 7:00 p.m. easy and fun.

Choose one of these four simple ways to enroll:

- Log in to My Account at smud.org
- Fill out and return the enclosed postage-paid reply card
- Go to smud.org/smartvalue
- Call toll-free 1-855-736-7655

You could be among the first to take advantage of new pricing and energy management tools. To find out if your home was selected for participation in this pilot and to enroll, log in to My Account today!

Sincerely,

Lupe J. Strickland

Lupe Strickland,
SmartPricing Options Project Manager

Figure D-2: Default TOU with IHD Offer Letter

(Mail Date)

(Customer Name)

(Address)

You're now on a new pricing plan that can help you save on your summer electricity bills!

smud.org/valueoption

Dear (Customer Name),

You're among the first SMUD customers to be randomly selected for a two-year SmartPricing Options pilot that can help you better manage your energy use for the summers of 2012 and 2013. The **Summer Weekday Value Plan** will allow you to take control of your summer electricity bills and help the environment.

<u>Here's how it works:</u>

- You'll receive a discount off the standard price on the amount you pay for your electricity during off-peak hours each summer from June 1 through September 30. Off-peak hours are Monday through Friday before 4:00 p.m. and after 7:00 p.m., all day on weekends, July 4th and Labor Day. That means that 90% of the time, you'll get a discount.
- During peak hours – weekdays from 4:00 p.m. to 7:00 p.m. – the price you pay will be higher than the standard price.

Using less electricity during peak hours, shifting the time you use electricity (like doing laundry after 7:00 p.m.), or reducing your use overall can help you save money on your bill.

<u>Here are additional perks:</u>

- A FREE countertop electricity use display, mailed to you this spring. This display will show how much electricity you're using at that moment, and how much it's costing you.
- An online informational graph on My Account that shows your hourly and daily electricity use.
- Access to a website – **smud.org/valueoption** – with energy-saving tips and tools.
- Discounts on activities – like movie tickets and water parks – that can make using less electricity from 4:00 p.m. to 7:00 p.m. easy and fun.

To get your FREE countertop electricity use display, return the enclosed postage-paid card, visit My Account at smud.org or call 1-855-736-7655. You can also choose how you'd like to receive energy-saving tips.

If you would like to remain on your standard rate plan, call 1- 855-736-7655. However, should you decide not to participate, you won't be able to enroll later and you will miss out on the cost savings and energy management benefits.

Learn more about your new plan at **smud.org/valueoption**.

Sincerely,

Jennifer Potter

Jennifer Potter
SmartPricing Options Project Manager

Figure D-3: Opt-in and Default TOU with IHD Brochure

FAQs

What appliances or electronics should I not use during peak hours?
The biggest electricity user in your home is your air conditioning system. You'll see the most savings if you reduce or eliminate air conditioner use during peak hours. You can also reduce – or just not use – appliances like large, flat screen TVs, your pool filter or your oven. Since it is still very light outside during peak hours, be sure to turn off lights you're not using.

How will I know how much electricity I'm using?
Your electricity use display will show how much you're using and what it's costing you. You can turn appliances off and on to instantly see your change in costs. You'll also have access to an online informational graph showing your daily and hourly use up to the last 24 hours. You can log in to My Account on smud.org to view your previous usage.

How much can I save?
Everyone's energy use is different, but if you reduce the amount of electricity you use between 4:00 p.m. and 7:00 p.m., you should save on this plan. Visit **smud.org/smartvalue** for tips on how you can reduce your electricity use.

Will SMUD turn off my air conditioner during peak hours?
No. You have control over your air conditioner and all of your appliances.

Learn more about the Summer Weekday Value Plan at **smud.org/smartvalue.**

SMUD™

smud.org
1-855-736-7655

Summer Weekday Value Plan

Sign up today and you could save on your summer electric bills. Reward yourself and the environment, too!

Receive a free electricity use display when you sign up!

Powering forward.
Together.

SMUD™

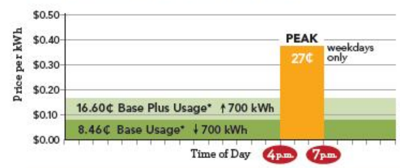
It's Never Too Early To Think About Savings!

The **Summer Weekday Value Plan** can help you take control of your summer electricity bills, manage your energy use and help the environment. This plan is part of SMUD's SmartPricing Options, a two-year pilot being offered to a small group of randomly selected SMUD customers. This pilot begins June 1, 2012 and ends September 30, 2013. When you enroll in this plan, the price you pay for electricity is based on when you use it.

Here's how it works:

- You'll receive a discount off the standard price on the amount you pay for your electricity during off-peak hours each summer from June 1 through September 30. Off-peak hours are Monday through Friday before 4:00 p.m. and after 7:00 p.m., all day on weekends, July 4th and Labor Day. That means that 90% of the time you get a discount!
- Peak hours are the hours when electricity use is typically highest – 4:00 p.m. to 7:00 p.m., Monday through Friday. During those hours, the price you pay would be higher than the standard price.

Summer Weekday Value Plan Rate
(June 1 – September 30, 2012 and 2013)



* For most customers, the current standard price for Base Usage is 10.16 cents/kWh and 18.30 cents/kWh for Base Plus Usage. To learn more about Summer Weekday Value Plan pricing, visit **smud.org/smartvalue.**

If you are on our Energy Assistance Program Rate (EAPR), this chart does not include the discount you'll receive on the price you pay for electricity.

This chart does not reflect service charges or other fees that are included in your bill.

Use less electricity during peak hours by shifting when you use (like doing laundry before 4:00 p.m. or after 7:00 p.m.) or by reducing your use overall (powering off your TV when you're not watching). If you shift your electricity use to off-peak hours or reduce your use overall, you can save on your electric bill.

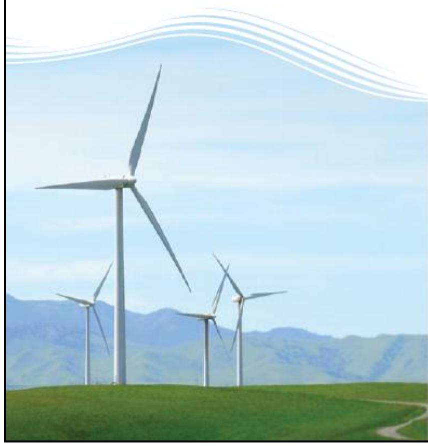
As a Summer Weekday Value Plan member, you'll get additional benefits that include:

- A FREE, convenient, countertop electricity use display, mailed to you in spring 2012. This display will show you how much electricity you're using at the moment, and how much it's costing you.

- An informational graph that shows your hourly and daily electricity use right up to the past 24 hours. Log in and view your usage anytime through My Account on smud.org.
- Access to a website (**smud.org/smartvalue**) that has energy-saving tips and tools.
- Discounts on activities like movie tickets and water parks, and chances to win barbecue grills and other prizes that can make using less electricity from 4:00 p.m. to 7:00 p.m. easy and fun.

Why Saving During Peak Hours Is Important

All energy is not created equally. We work hard to develop a reliable and environmentally clean stream of energy sources to supply you with electricity. These sources include hydroelectric, natural gas, geothermal, wind and solar. During the summer months, and especially during late afternoon and early evening weekday hours, the demand for electricity soars. To meet this higher demand, we often have to buy energy from very expensive and less environmentally friendly sources. By reducing electricity use during peak periods, we can avoid purchasing less desirable forms of energy. As your community-owned electric service, we want to work with you to find solutions that help reduce your electricity costs and build a cleaner, healthier environment.



Save energy and money with the **Summer Weekday Value Plan**

(June 1 – September 30, 2012 and 2013)

Typical Usage Appliances & Watt Usage	Cost for 1 Hour of Peak Usage	Make A Shift >	Shifting Your Usage Appliances & Watt Usage	Cost for 1 Hour of Off-Peak Usage
A/C (5 ton) – 9000 watts	$2.43		A/C (5 ton) – 9000 watts	$1.49
Stove – 2200 watts	$0.59		Stove – 2200 watts	$0.37
8x60 watt lights	$0.13		8x60 watt lights	$0.08
Clothes Washer – 400 watts	$0.11	Shift Your Time of Use >	Clothes Washer – 400 watts	$0.07
Dryer – 3000 watts	$0.81		Dryer – 3000 watts	$0.50
LCD TV – 110 watts	$0.03		LCD TV – 110 watts	$0.02
Dishwasher – 1200 watts	$0.32		Dishwasher – 1200 watts	$0.20

Little Things. Big Potential.

Energy-Savings Tips – Little changes in routine activities can help you save money and reduce your impact on the environment. Look for opportunities to combine these energy-saving tips to fit your schedule and lifestyle. Visit **smud.org/smartvalue** for more ideas to help you manage your electricity use.

Climate – Air conditioners are one of the biggest energy users during hot summer days. Reduce your use and set your thermostat to pre-cool your home before 4:00 p.m. Then, turn your thermostat up a few degrees higher from 4:00 p.m. to 7:00 p.m. and use fans to help cool your home.

Chores – Do your laundry, ironing, vacuuming, dishwashing and other chores that require electricity before 4:00 p.m. or after 7:00 p.m.

Cooking – Take the heat out of your kitchen and put your grill to work or serve cool dishes that can be prepared in advance. Enjoy dinner outside with friends and family.

Electronics – Be sure all electronic devices that are not in use are turned off completely. Even a sleeping computer or TV uses electricity. Visit **smud.org/smartvalue** to learn how much power it takes to run different electronics and appliances. During peak hours, consider activities that don't use electricity, like board games or playing with water toys outside.

Pool and Spa – If you have a pool or spa, program the system so that the filter or heating system does not run during peak hours. Let your pool pump rest from 4:00 p.m. to 7:00 p.m. while you cool off.

Sign Up Today and Save on Your Summer Electricity Bills!

Enrollment in this two-year opportunity is limited.

You could be among the first to take advantage of new pricing and tools that will help you manage your summer electricity costs and help our environment. Log in to My Account today to see if your home was selected for participation in this pilot and enroll in the Summer Weekday Value Plan.

Choose one of these three simple ways to enroll:

- Log in to My Account at smud.org
- Go online to **smud.org/smartvalue**
- Call toll-free 1-855-736-7655 to talk to a SmartPricing Options representative

SMUD™

Figure D-4: Opt-in TOU with IHD Offer Business Reply Card

□YES, I'm ready to take control of my summer energy use.

Please enroll me in the **Summer Weekday Value Plan.**

Name:____

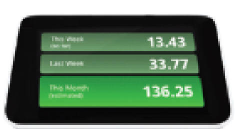
Address:____

City: ______________________State: _______Zip:____________

Phone:______________________

Occasionally, we send tips on how to manage your energy use and save on your bill. Please check the boxes below if you would like to receive these tips.
□Phone
□Text message number: (Text fees may apply. Check with your carrier.)
□Email address:

You are eligible to receive a FREE countertop electricity use display, which will be mailed to you in the spring of 2012. This display will show how much electricity you're using at the moment, and how much it's costing you.



□Yes, I want my FREE electricity use display.

Name:____

Mailing Address:______________________________________

City: ______________________ State: ___________ Zip:_______

Phone:______________________

SWVT1011

Figure D-5: Opt-in and Default TOU with IHD Offer Welcome Packet

Welcome

Welcome to the **Summer Weekday Value Plan**! Your new electricity pricing plan is effective this summer – June 1 through September 30 – and next summer – June 1 through September 30, 2013. This welcome packet is full of tools and tips to help you – and everyone in your home – better manage your electricity usage and save money on your energy bills all summer long.

These tools include:

- A magnet for your washer or dryer that reminds you to do laundry during off-peak hours
- A refrigerator cling with energy-saving tips
- Recipe cards – scan the code to link to kitchen tips videos!
- A discount card for local businesses

As a participant in SMUD's SmartPricing Options, we'll contact you periodically for surveys. These surveys may be by phone or email.

If you have any questions, you can speak to a SmartPricing Options representative at 1-855-736-7655 or send an email to **smartpricing@smud.org**. You can also visit **smud.org/valueoption.**

Printed on Recycled Paper | **SWVTOO-WEL 0512**

Messages by Text

Energy Saving Tips

Occasionally, we send tips by text on how to manage your energy use and save on your bill. If you've chosen this option and would like to receive text messages, log in to My Account and update your notification preferences.

If you'd like to get energy saving tips by text, please text "Tips" to 622622.

Text fees may apply.
Please check with your carrier.

Printed on Recycled Paper | **SWV-TXT 0512**

Energy-Saving Tips

Little Things. Big Potential.

Some of the biggest energy users in your home have programming options. By setting appliances and devices to run during off-peak hours, you won't have to give them a second thought during the summer.

Air Conditioner – If you have a programmable thermostat, set your system to come on a few hours before 4:00 p.m. to pre-cool your home. Then program your thermostat to turn off your air conditioner between 4:00 and 7:00 p.m. You can keep your fan on if you'd like to have the air moving. Fans don't use much electricity.

Pools and Spas – Filtering and heating systems need to be on a certain number of hours each day. Adjust your settings so these systems are not on between 4:00 and 7:00 p.m.

Electronic Devices – Many electronic devices use electricity even when they're not being used. Plug your devices into smart strips and have the smart strips hooked up to a timer so they automatically switch off during peak hours.

Chargeable Devices – Use your laptops, tablets, smart phones and other chargeable devices in battery mode between 4:00 and 7:00 p.m. Then charge them before 4:00 p.m. or after 7:00 p.m.

Timed Lighting – Set the timers for your lights so that they come on after 7:00 p.m.

Electric Vehicles or Plug-In Hybrids – Plug in your vehicle as soon as you get home, but set charging to start after 7:00 p.m.

Ceiling Fans – Adjust ceiling fans to turn counter-clockwise in the summer. Usually this means that the switch on the fan should be in the "down" position.

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Peak Hours

Peak Hours

Peak hours are from 4:00 p.m. to 7:00 p.m., Monday through Friday, except for July 4th and Labor Day. During these hours, the price you pay for your electricity will be higher than the standard price.

Off-Peak Hours

Off-peak hours are Monday through Friday before 4:00 p.m. and after 7:00 p.m., all day on weekends, July 4th and Labor Day. You'll receive a discount off the standard price you pay for your electricity during off-peak hours. That means that 90% of the time you get a discount!

What Is Peak Time?

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SMUD SmartPricing Options Discount Card

Saving During Peak Hours Can Be Fun!

Instead of just avoiding using electricity between 4:00 and 7:00 p.m., plan some fun activities! Use this time for shopping or family outings. Head to the river or a local park, go see a movie or go bowling. Or if you're staying home, serve refreshing cold dishes for dinner or fire up the barbecue. In addition to reducing your electricity use, you'll also spend less time in the kitchen.

To make using less energy easier, we've partnered with local businesses to offer discounts on products and services that you can enjoy during peak hours. Take a look at your SmartPricing Options Discount Card to see which businesses are participating.

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Electricity Use Display

Monitor Real-Time Usage

Your electricity use display will help you monitor your real-time electricity use and show you what it costs during peak and off-peak hours. Your display will be mailed to you and will include a Quick Start Guide. It's simple to set up and use. You can put it on your countertop or your refrigerator.

The blinking light on the front of your display will show you the price level:

BLINKING GREEN	BLINKING YELLOW	BLINKING RED	FAST BLINKING RED
Base Usage	Base Plus Usage	Peak Usage	Conservation Day

If you have questions about your display, please call 1-855-736-7655.

Appendix E Hourly TOU Impacts

This appendix presents hourly impacts for TOU treatment groups. Tables E-1 and E-2 show TOU impacts broken down by month and hour. In addition to the estimated impact, each table shows the standard error and 95% confidence interval of the estimate.

Table E-1: Average Hourly Impacts by Month for Opt-in TOU Groups

Treatment	Month	Hour	Estimated Impact	SE	95% CI Lower	95% CI Upper
Opt-in TOU, Without IHD Offer	June	4-5 PM	0.14	0.03	0.09	0.19
		5-6 PM	0.17	0.03	0.12	0.22
		6-7 PM	0.16	0.03	0.11	0.21
	July	4-5 PM	0.15	0.03	0.09	0.21
		5-6 PM	0.21	0.03	0.15	0.27
		6-7 PM	0.20	0.03	0.14	0.27
	August	4-5 PM	0.21	0.03	0.14	0.28
		5-6 PM	0.27	0.04	0.20	0.34
		6-7 PM	0.24	0.03	0.17	0.30
	September	4-5 PM	0.08	0.03	0.01	0.14
		5-6 PM	0.11	0.03	0.04	0.17
		6-7 PM	0.10	0.03	0.04	0.16
	Overall		**0.17**	**0.02**	**0.13**	**0.22**
Opt-in TOU, with IHD Offer	June	4-5 PM	0.15	0.02	0.11	0.19
		5-6 PM	0.19	0.02	0.15	0.23
		6-7 PM	0.19	0.02	0.15	0.23
	July	4-5 PM	0.26	0.02	0.22	0.31
		5-6 PM	0.31	0.03	0.26	0.36
		6-7 PM	0.29	0.03	0.24	0.34
	August	4-5 PM	0.29	0.03	0.23	0.34
		5-6 PM	0.33	0.03	0.27	0.38
		6-7 PM	0.31	0.03	0.26	0.36
	September	4-5 PM	0.15	0.03	0.11	0.20
		5-6 PM	0.18	0.03	0.13	0.23
		6-7 PM	0.16	0.02	0.11	0.21
	Overall		**0.24**	**0.02**	**0.20**	**0.27**

Table E-2: Average Hourly Impacts by Month for Default TOU Groups

Treatment	Month	Hour	Estimated Impact	SE	95% CI Lower	95% CI Upper
Default TOU with IHD Offer	June	4-5 PM	0.08	0.02	0.05	0.11
		5-6 PM	0.11	0.02	0.08	0.14
		6-7 PM	0.11	0.02	0.08	0.14
	July	4-5 PM	0.11	0.02	0.07	0.14
		5-6 PM	0.14	0.02	0.10	0.17
		6-7 PM	0.12	0.02	0.09	0.16
	August	4-5 PM	0.14	0.02	0.10	0.18
		5-6 PM	0.17	0.02	0.13	0.21
		6-7 PM	0.16	0.02	0.12	0.20
	September	4-5 PM	0.07	0.02	0.03	0.11
		5-6 PM	0.10	0.02	0.06	0.14
		6-7 PM	0.09	0.02	0.05	0.12
	Overall		**0.12**	**0.01**	**0.09**	**0.15**
Default TOU & CPP with IHD Offer	June	4-5 PM	0.08	0.03	0.02	0.13
		5-6 PM	0.12	0.03	0.06	0.18
		6-7 PM	0.13	0.03	0.07	0.18
	July	4-5 PM	0.15	0.03	0.08	0.22
		5-6 PM	0.18	0.04	0.11	0.25
		6-7 PM	0.19	0.04	0.12	0.26
	August	4-5 PM	0.17	0.04	0.09	0.25
		5-6 PM	0.24	0.04	0.16	0.32
		6-7 PM	0.24	0.04	0.16	0.31
	September	4-5 PM	0.11	0.04	0.04	0.18
		5-6 PM	0.16	0.04	0.09	0.24
		6-7 PM	0.12	0.04	0.05	0.19
	Overall		**0.16**	**0.03**	**0.11**	**0.21**

Appendix F Hourly CPP Impacts

This appendix presents hourly impacts for CPP treatment groups. Tables F-1 through F-4 show CPP impacts for each hour of the 11 event days in 2012. In addition to the estimated impact, each table shows the standard error and 95% confidence interval of the estimate.

Table F-1: Average Hourly Impacts by CPP Day for Opt-in CPP without IHD Offer

Date	Hour	Estimated Impact	SE	95% CI Lower	95% CI Upper
7/10/2012	4-5 PM	0.61	0.22	0.19	1.04
	5-6 PM	0.76	0.23	0.31	1.21
	6-7 PM	0.69	0.24	0.23	1.16
7/12/2012	4-5 PM	0.67	0.24	0.21	1.14
	5-6 PM	0.77	0.24	0.31	1.23
	6-7 PM	0.66	0.24	0.19	1.13
8/2/2012	4-5 PM	0.52	0.22	0.09	0.96
	5-6 PM	0.38	0.23	-0.07	0.82
	6-7 PM	0.00	0.23	-0.45	0.44
8/8/2012	4-5 PM	0.48	0.21	0.08	0.89
	5-6 PM	0.51	0.22	0.08	0.93
	6-7 PM	0.37	0.22	-0.06	0.80
8/9/2012	4-5 PM	0.27	0.24	-0.19	0.74
	5-6 PM	0.54	0.24	0.07	1.00
	6-7 PM	0.62	0.23	0.17	1.08
8/10/2012	4-5 PM	0.72	0.23	0.27	1.17
	5-6 PM	0.70	0.24	0.23	1.17
	6-7 PM	0.88	0.23	0.42	1.33
8/14/2012	4-5 PM	0.70	0.21	0.28	1.12
	5-6 PM	0.79	0.21	0.37	1.21
	6-7 PM	0.65	0.21	0.25	1.06
8/15/2012	4-5 PM	0.45	0.21	0.04	0.86
	5-6 PM	0.68	0.21	0.26	1.10
	6-7 PM	0.43	0.21	0.02	0.84
9/12/2012	4-5 PM	0.35	0.20	-0.04	0.75
	5-6 PM	0.26	0.21	-0.15	0.66
	6-7 PM	0.57	0.21	0.16	0.98
9/13/2012	4-5 PM	0.42	0.21	0.01	0.83
	5-6 PM	0.42	0.23	-0.02	0.87
	6-7 PM	0.42	0.21	0.00	0.84
9/14/2012	4-5 PM	0.25	0.21	-0.17	0.67
	5-6 PM	0.27	0.22	-0.16	0.71
	6-7 PM	0.31	0.21	-0.10	0.73
Overall		**0.52**	**0.13**	**0.26**	**0.78**

Table F-2: Average Hourly Impacts by CPP Day for Opt-in CPP with IHD Offer

Date	Hour	Estimated Impact	SE	95% CI Lower	95% CI Upper
7/10/2012	4-5 PM	0.71	0.09	0.54	0.89
	5-6 PM	0.89	0.09	0.72	1.07
	6-7 PM	0.90	0.09	0.72	1.07
7/12/2012	4-5 PM	1.01	0.10	0.82	1.21
	5-6 PM	0.98	0.10	0.78	1.18
	6-7 PM	1.02	0.10	0.82	1.22
8/2/2012	4-5 PM	0.59	0.09	0.42	0.77
	5-6 PM	0.61	0.10	0.42	0.80
	6-7 PM	0.57	0.09	0.39	0.75
8/8/2012	4-5 PM	0.64	0.09	0.47	0.81
	5-6 PM	0.71	0.09	0.53	0.88
	6-7 PM	0.73	0.09	0.56	0.90
8/9/2012	4-5 PM	0.78	0.10	0.59	0.97
	5-6 PM	0.88	0.09	0.69	1.06
	6-7 PM	0.86	0.10	0.67	1.05
8/10/2012	4-5 PM	0.82	0.10	0.62	1.01
	5-6 PM	0.97	0.10	0.77	1.16
	6-7 PM	0.91	0.10	0.72	1.10
8/14/2012	4-5 PM	0.64	0.09	0.47	0.82
	5-6 PM	0.72	0.09	0.55	0.90
	6-7 PM	0.73	0.09	0.56	0.90
8/15/2012	4-5 PM	0.60	0.09	0.42	0.77
	5-6 PM	0.71	0.09	0.53	0.89
	6-7 PM	0.65	0.09	0.48	0.82
9/12/2012	4-5 PM	0.41	0.08	0.24	0.57
	5-6 PM	0.49	0.09	0.32	0.66
	6-7 PM	0.54	0.08	0.37	0.70
9/13/2012	4-5 PM	0.41	0.09	0.24	0.58
	5-6 PM	0.51	0.09	0.34	0.68
	6-7 PM	0.42	0.09	0.25	0.59
9/14/2012	4-5 PM	0.32	0.09	0.15	0.49
	5-6 PM	0.48	0.09	0.31	0.64
	6-7 PM	0.42	0.09	0.25	0.60
Overall		**0.69**	**0.05**	**0.58**	**0.79**

Table F-3: Average Hourly Impacts by CPP Day for Default CPP with IHD Offer

Date	Hour	Estimated Impact	SE	95% CI Lower	95% CI Upper
7/10/2012	4-5 PM	0.31	0.06	0.19	0.43
	5-6 PM	0.39	0.06	0.27	0.51
	6-7 PM	0.43	0.06	0.31	0.56
7/12/2012	4-5 PM	0.30	0.07	0.18	0.43
	5-6 PM	0.49	0.07	0.35	0.62
	6-7 PM	0.44	0.07	0.31	0.58
8/2/2012	4-5 PM	0.28	0.06	0.15	0.40
	5-6 PM	0.29	0.06	0.17	0.42
	6-7 PM	0.33	0.06	0.21	0.45
8/8/2012	4-5 PM	0.29	0.06	0.17	0.40
	5-6 PM	0.33	0.06	0.21	0.45
	6-7 PM	0.29	0.06	0.17	0.41
8/9/2012	4-5 PM	0.33	0.06	0.21	0.45
	5-6 PM	0.40	0.07	0.27	0.53
	6-7 PM	0.35	0.07	0.22	0.48
8/10/2012	4-5 PM	0.32	0.06	0.20	0.45
	5-6 PM	0.43	0.07	0.29	0.56
	6-7 PM	0.37	0.07	0.24	0.51
8/14/2012	4-5 PM	0.30	0.06	0.19	0.41
	5-6 PM	0.32	0.06	0.19	0.44
	6-7 PM	0.25	0.06	0.13	0.37
8/15/2012	4-5 PM	0.34	0.05	0.24	0.45
	5-6 PM	0.35	0.06	0.23	0.46
	6-7 PM	0.35	0.06	0.23	0.46
9/12/2012	4-5 PM	0.23	0.05	0.12	0.33
	5-6 PM	0.33	0.06	0.21	0.44
	6-7 PM	0.29	0.06	0.18	0.40
9/13/2012	4-5 PM	0.19	0.06	0.07	0.30
	5-6 PM	0.22	0.06	0.09	0.34
	6-7 PM	0.31	0.06	0.20	0.43
9/14/2012	4-5 PM	0.15	0.06	0.04	0.26
	5-6 PM	0.26	0.06	0.15	0.37
	6-7 PM	0.26	0.06	0.15	0.38
Overall		**0.32**	**0.04**	**0.24**	**0.40**

Table F-4: Average Hourly Impacts by CPP Day for Default TOU-CPP with IHD Offer

Date	Hour	Estimated Impact	SE	95% CI Lower	95% CI Upper
7/10/2012	4-5 PM	0.42	0.07	0.29	0.55
	5-6 PM	0.50	0.07	0.37	0.63
	6-7 PM	0.48	0.07	0.35	0.61
7/12/2012	4-5 PM	0.39	0.07	0.25	0.54
	5-6 PM	0.48	0.07	0.34	0.63
	6-7 PM	0.47	0.07	0.33	0.61
8/2/2012	4-5 PM	0.28	0.07	0.14	0.41
	5-6 PM	0.36	0.06	0.23	0.48
	6-7 PM	0.32	0.07	0.19	0.44
8/8/2012	4-5 PM	0.38	0.06	0.26	0.51
	5-6 PM	0.44	0.07	0.31	0.57
	6-7 PM	0.41	0.07	0.28	0.53
8/9/2012	4-5 PM	0.36	0.07	0.23	0.49
	5-6 PM	0.40	0.07	0.26	0.53
	6-7 PM	0.43	0.07	0.29	0.57
8/10/2012	4-5 PM	0.37	0.07	0.24	0.51
	5-6 PM	0.49	0.07	0.35	0.63
	6-7 PM	0.44	0.07	0.30	0.58
8/14/2012	4-5 PM	0.25	0.07	0.12	0.38
	5-6 PM	0.32	0.07	0.18	0.45
	6-7 PM	0.28	0.07	0.15	0.41
8/15/2012	4-5 PM	0.32	0.06	0.20	0.44
	5-6 PM	0.35	0.06	0.23	0.48
	6-7 PM	0.34	0.06	0.21	0.46
9/12/2012	4-5 PM	0.16	0.06	0.05	0.27
	5-6 PM	0.25	0.06	0.13	0.38
	6-7 PM	0.16	0.06	0.05	0.28
9/13/2012	4-5 PM	0.18	0.06	0.06	0.31
	5-6 PM	0.19	0.06	0.06	0.32
	6-7 PM	0.13	0.06	0.01	0.26
9/14/2012	4-5 PM	0.21	0.06	0.09	0.33
	5-6 PM	0.23	0.06	0.11	0.35
	6-7 PM	0.12	0.06	0.00	0.23
Overall		**0.33**	**0.04**	**0.25**	**0.41**

Appendix G Power Analysis[56]

The SPO SMUD CBS plan has posed research questions in the framework of random encouragement designs and randomized control trials designed to detect and measure changes in peak kW demand, daily kWh demand, and monthly kWh consumption. The experiment has been designed to have minimum detectable effect of 5% for average monthly kWh consumption and average daily usage, and 20% for average hourly kW demand during CPP event hours. The sampling has been designed to measure these minimum detectable effects with a Type I error probability of 5% or 10%, depending on the treatment cell (see Table G-1), and a 20% Type II error.

In order to maintain a balance of cost, overall study size, external validity and internal validity, SMUD conducted a power analysis to determine the minimum sample sizes required to have an 80% probability of detecting the change in load as specified in Table G-1 for each treatment group. Table G-1 presents each of the treatment groups, desired confidence, and required sample sizes.

[56] This appendix was written by SMUD and edited by FSC.

Table G-1: Consumer Behavior Study Sample Requirements

Treatment Group	Design	Type I error α	Type II error β	kappa	Detectable Effects kWh (summer)	Detectable Effects kW (daily)	Detectable Effects kW (event)	Total Enrolls + Postpones	Total Enrolls + Postpones Before 20% Attrition	Total Invitations or Notifications at 15% Opt-in and 50% Opt-out (attrition calculated last)	Total Invitations or Notifications at 10% Opt-in and 50% Opt-out (attrition calculated last)
Res Opt-in TOU (no tech offer)	RCT	0.10	0.20	0.80	0.05	0.05	0.20	1,884	2,355	15,700	23,550
Res Opt-in TOU (with tech offer)	RCT	0.10	0.20	0.80	0.05	0.05	0.20	3,140	3,925	26,166	39,250
Res Opt-in CPP (no tech offer)	Within Subject	0.10	0.20	0.80	0.12	0.12	0.12	150	187.5	1,250	1,875
Res Opt-in CPP (with tech offer)	RED	0.05	0.20	0.80	–	–	0.20	1,131	1,413	9,425	14,137
Res Opt-out TOU (with tech offer)	RED	0.10	0.20	0.80	0.05	0.05	0.20	992	1,240	2,480	2,480
Res Opt-out CPP (with tech offer)	RED	0.05	0.20	0.80	–	–	0.20	345	431	862	862
Res Opt-out TOU-CPP (with tech offer)	Within Subject	0.10	0.20	0.80	0.08	0.09	0.08	300	375	750	750

G.1 Random Encouragement Design (RED)

RED formulas were provided by members of the Technical Advisory Group (TAG), which serves as a liason between SMUD and the Department of Energy (DOE). The calculations for the Opt-in CPP with Technology Offer and Opt-out CPP with Technology Offer were performed by Meredith Fowlie and Catherine Wolfram, members of SMUD's TAG. The same method was used by SMUD's statistician to conduct the power analysis for the remaining RED treatments. The following equation was used to estimate the load impact for each treatment:

$$\Delta\{\ln(load\_cpp_{its}) - avg[\ln(load\_noncpp_{is})]\} = \alpha_i + \beta_1 T_{in\ it} + \beta_2 T_{Out it} + \beta_3 X_{it} + \varepsilon_{its}$$

for household i in hour t, during summer s, where

α is the household fixed effect;

T_{in} is a dummy equal to one in periods after a household is invited to join the opt-in program;

T_{out} is a dummy equal to one in periods after a household is invited to join the opt-out program;

X represents additional explanatory variables to control for weather and hour-of-sample dummies; and

ε is the error term.

The dependent variable measures the change in log consumption between event hours and the same hours of the day on non-event days. This will allow SMUD to control for differences in behavior between the treatment and control groups before and after the treatment is allocated.

The precision of β1 and β2 is determined by the following relationship:

$$MDE = (t_{1-\kappa} + t_{\alpha})\sqrt{\frac{1}{P(1-P)}\frac{\sigma^2}{J}\frac{1}{c^2}}$$

where

MDE = minimum detectable effect (measured in percentage terms);

$t_{1\text{-}\kappa}$ = critical value for t given the desired statistical power κ;

$t_{\kappa/2}$ = critical value for t given type-1 error rate α;

P_J = proportion of the households receiving treatment;

P = proportion of the observations receiving treatment (equal to P_J if there are no pre-treatment observations);

σ^2 = the estimate of the variance of the outcome;

J = the number of households in the study; P*J households are in the treatment group; and

c = the expected participation rate (i.e., the share of the treated households that accept the treatment).

The equation is then rearranged and solved for J to determine the minimum number of households needed to achieve the desired MDE.

$$J = \frac{(t_{1-\kappa} + t_{\alpha})^2}{P(1-P)} \frac{\sigma^2}{MDE^2} \frac{1}{c^2}$$

Because there will be multiple observations per household there can potentially be fewer households needed if observations within households are not perfectly correlated:

$$J = \frac{(t_{1-\kappa} + t_{\alpha})^2}{P(1-P)} \frac{\sigma^2}{MDE^2} \frac{1}{c^2} \left(\rho + \frac{(1-\rho)}{T} \right)$$

where

ρ = within household correlation;

T = number of observations per household (i.e. the number of CPP events * 3 hours).

Similar calculations generate the opt-out treatment and control sample sizes, but since c, the acceptance rate, is much smaller for the opt-in study than the opt-out, we know that the control group for the opt-in study will be larger than the control group for the opt-out study. The larger control group for the opt-out study will generate a lower MDE. Next, parameter estimates for σ^2 and ρ were calculated via panel regressions on hourly TOU data with hour of sample fixed effects for the residential and commercial customers by estimating:

$$\Delta\{\ln(load\_cpp_{its}) - avg[\ln(load\_noncpp_{is})]\} = \alpha_i + \beta_3 X_{it} + \varepsilon_{its}$$

The additional parameters for the power analyses are included in Table G-2. The assumptions that are not included are: a 15% opt-in rate, 50% opt-out rate, 60% technology acceptance rate and an additional 20% attrition by the end of two summers.

Table G-2: Consumer Behavior Study Parameters

	Residential		
	kWh	Daily kW	Event kW
MSE(σ^2)	0.51	0.55	0.5
κ	0.8	0.8	0.8
K	1	1	1
ρ	0.25	0.25	0.25
T	366	256	108
T-pre	122	86	36
T-post	244	170	72
P (RCT)	0.5	0.5	0.5
P (RED)	0.05	0.05	0.05
P for opt-in CPP (with tech offer) and opt-out CPP (with tech offer)	–	–	0.35

G.2 Randomized Control Trial (RCT)

As with an RED, the goal is to effectively capture the average effect of the treatment on load, for example, consider the following OLS example:

$$Y_i = \alpha + \pi Z_i + \epsilon_i,$$

where ∏ is the average percentage load reduction of the rate treatment.

A standard randomized control trial (RCT) is a design that estimates the impact of a single treatment. This would involve randomly sampling N households from the customer population. A proportion, P, of these sampled households are assigned to the treatment group and are exposed to a given treatment of interest. The remaining (1-P)N households are assigned to a control group and are not exposed to the treatment. Assuming the variance of the outcome is identical in both the treatment and control groups, the variance of the OLS estimate of ∏ is given by:

$$MDE = (t_{1-\kappa} + t_\alpha)\sqrt{var(\widehat{\beta})}.$$

For a given power K, size α, P, and N the corresponding power equation is:

$$N = \frac{(t_{1-\kappa} + t_{\alpha})^2}{P(1-P)} \frac{\sigma^2}{MDE^2}.$$

Next, controlling for within household correlation and seasonal effects, which can reduce sample size if the within household observations are not perfectly correlated, provides the new equation to calculate the power of the sample is as follows:

$$J = \frac{(t_{1-\kappa} + t_{\alpha})^2}{P(1-P)} \frac{\sigma^2}{MDE^2} \rho + \frac{1-\rho}{T} \sigma^2.$$

where

J = number of households in the study

N = total number of observations (N=JT)

α =type I error rate

K = desired level of statistical power
P = proportion of the sample receiving the encouragement

MDE = minimum detectable effect

σ^2 = variance of the outcome variable in the population

ρ = fraction of the residual variation that is explained by the household level effect

G.3 Within-subjects Design

RED and RCT power analyses were conducted for the treatments selected for the within-subjects design. Due to the large sample sizes required for an 80% probability of detecting change in energy use for the specified MDE, it was determined that SMUD would rely on other guidelines for determination of sample size for these less critical tests. These sample sizes for these research questions were determined using California's Statewide Pricing Pilot, SMUD's Summer Solutions pilot, and Table 4-5 in EPRI's "Guidelines for Designing Effective Energy Information Feedback Pilots: Research Protocols" as guidelines.

The power analysis was then performed to estimate MDE within the repeated measures ANOVA framework. The parameters below for the Type I and Type II errors were carried through on the within-subjects analysis. Because these sample sizes were influenced by factors such as budget and feasibility rather than being driven by the power analysis, the minimum detectable effect was estimated from rearranging the following equation used to derive the minimum sample size:

$$N = \sigma^2 \left(\frac{2\rho(t_{1-\beta} + t_{\alpha/2})^2}{MDE^2} + \frac{1-\rho}{T} \right)$$

where

MDE = minimum detectable effect (measured in percentage terms)

$T_{1-\beta}$ = critical value for t given the desired statistical power κ

$t_{\alpha/2}$ = critical value for t given type-1 error rate α

T = number of observations per household

σ^2 = the estimate of the variance of the outcome

N = the number of households in the study

ρ = within household correlation

APPENDIX

![SMUD]

Appendix A

Marketing Materials

This appendix contains examples of the following categories of marketing materials:

- Pre-Recruitment Education Campaign
- Opt-In Recruitment
- Opt-In Notifications
- Retention

SMUD™

Pre-Recruitment Education Campaign

Web Ads

Print Ad

Bus Shelter Ad

Digital Billboard Ad

Opt-In Recruitment Examples

Opt-In Microsite Home Page Example

Summer Weekday Value Plan (TOU)

Direct Mail Recruitment Envelope

Direct Mail Business Reply Card Example

Off-Peak Discount Plan Opt-In

□YES, I'm ready to take control of my summer energy use.

Please enroll me in the **Off-Peak Discount Plan.**

Name:____

Address:____

City: ______________________State: __________Zip:______________

Phone: ____________________________

How would you like to receive Conservation Day notification? (Select all that apply. This information will only be used to contact you for a Conservation Day.)	**Occasionally, we send tips on how to manage your energy use and save on your bill. Please check the boxes below if you would like to receive these tips.**
□Phone	□Phone
□Text message number: (Text fees may apply. Check with your carrier.)	□Text message number: (Text fees may apply. Check with your carrier.)
□Email address:	□Email address:

You are eligible to receive a FREE countertop electricity use display, which will be mailed to you in the spring of 2012. This display will show how much electricity you're using at the moment, and how much it's costing you.

□Yes, I want my FREE electricity use display.

Name:____

Mailing Address:____________________________________

City: ______________________ State: ______________ Zip:__________

Phone:_______________________

OPDT1011

SMUD™

Direct Mail Recruitment Letter Example

Off-Peak Discount Plan Opt-In (CPP)

(Mail Date)

(Customer Name)

(Address)

Sign up today and you could save on your summer electric bills!
smud.org/discountpricing

Dear (Customer Name),

You still have time to participate in a two-year SmartPricing Options pilot that can help you manage your energy bills. The **Off-Peak Discount Plan** is being offered to a randomly selected group of SMUD customers for a limited time. Enrolling in this plan will allow you to take control of your summer electricity costs and help the environment.

Here's how it works:

- You'll receive a discount off the standard price on the amount you pay for your electricity all day, every day each summer from June 1 through September 30, except for 12 Conservation Days. (This plan is effective 2012 through 2013.) During peak hours on Conservation Days, the price you pay will be higher than the standard price.
- Peak hours on Conservation Days are from 4:00 p.m. to 7:00 p.m. Each of the 12 Conservation Days will be on a weekday (Conservation Days will never be on July 4th and Labor Day). That's just 1% of the time or 36 hours all summer, that means that 99% of the time, you get a discount!

Using less electricity during peak hours on Conservation Days, shifting the time you use electricity (like doing laundry after 7:00 p.m. on Conservation Days), or reducing your use overall can help you save money on your bill.

Here are additional perks:

- An online informational graph on My Account that shows your hourly and daily electricity use.
- Access to a website – smud.org/discountpricing – with energy-saving tips and tools.
- Discounts on activities – like movie tickets and water parks – that can make using less electricity from 4:00 p.m. to 7:00 p.m. easy and fun.

Choose one of these four simple ways to enroll:

- Log in to My Account at smud.org
- Fill out and return the enclosed postage-paid reply card
- Go to smud.org/discountpricing
- Call toll-free 1-855-736-7655

You could be among the first to take advantage of new pricing and energy management tools. Enrollment is limited, so to find out if your home was selected for participation in this pilot and to enroll, log in to My Account at smud.org today!

Sincerely,

Jennifer Potter

Jennifer Potter
SmartPricing Options Project Manager

To lessen environmental impacts, the carbon emissions from this mailing have been offset.

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Brochure Example

Summer Weekday Value Plan Opt-In (TOU with IHD Offer)

FAQs

What appliances or electronics should I not use during peak hours?
The biggest electricity user in your home is your air conditioning system. You'll see the most savings if you reduce or eliminate air conditioner use during peak hours. You can also reduce – or just not use – appliances like large, flat screen TVs, your pool filter or your oven. Since it is still very light outside during peak hours, be sure to turn off lights you're not using.

How will I know how much electricity I'm using?
Your electricity use display will show how much you're using and what it's costing you. You can turn appliances off and on to instantly see your change in costs. You'll also have access to an online informational graph showing your daily and hourly use up to the last 24 hours. You can log in to My Account on smud.org to view your previous usage.

How much can I save?
Everyone's energy use is different, but if you reduce the amount of electricity you use between 4:00 p.m. and 7:00 p.m., you should save on this plan. Visit **smud.org/smartvalue** for tips on how you can reduce your electricity use.

Will SMUD turn off my air conditioner during peak hours?
No. You have control over your air conditioner and all of your appliances.

Learn more about the Summer Weekday Value Plan at **smud.org/smartvalue**.

SMUD™
smud.org
1-855-736-7655

Printed on Recycled Paper | **SWVT1011**

Summer Weekday Value Plan

Sign up today and you could save on next summer's electric bills. Reward yourself and the environment, too!

Receive a free electricity use display when you sign up!

Powering forward. Together.

SMUD™

It's Never Too Early To Think About Savings!

The **Summer Weekday Value Plan** can help you take control of your summer electricity bills, manage your energy use and help the environment. This plan is part of SMUD's SmartPricing Options, a two-year pilot being offered to a small group of randomly selected SMUD customers. This pilot begins June 1, 2012 and ends September 30, 2013. When you enroll in this plan, the price you pay for electricity is based on when you use it.

Here's how it works:

- You'll receive a discount off the standard price on the amount you pay for your electricity during off-peak hours each summer from June 1 through September 30. Off-peak hours are Monday through Friday before 4:00 p.m. and after 7:00 p.m., all day on weekends, July 4th and Labor Day. That means that 90% of the time you get a discount!
- Peak hours are the hours when electricity use is typically highest – 4:00 p.m. to 7:00 p.m., Monday through Friday. During those hours, the price you pay would be higher than the standard price.

Summer Weekday Value Plan Rate

(June 1 – September 30, 2012 and 2013)

*For most customers, the current standard price for Base Usage is 10.16 cents/kWh and 18.30 cents/kWh for Base Plus Usage. To learn more about Summer Weekday Value Plan pricing, visit **smud.org/smartvalue**.

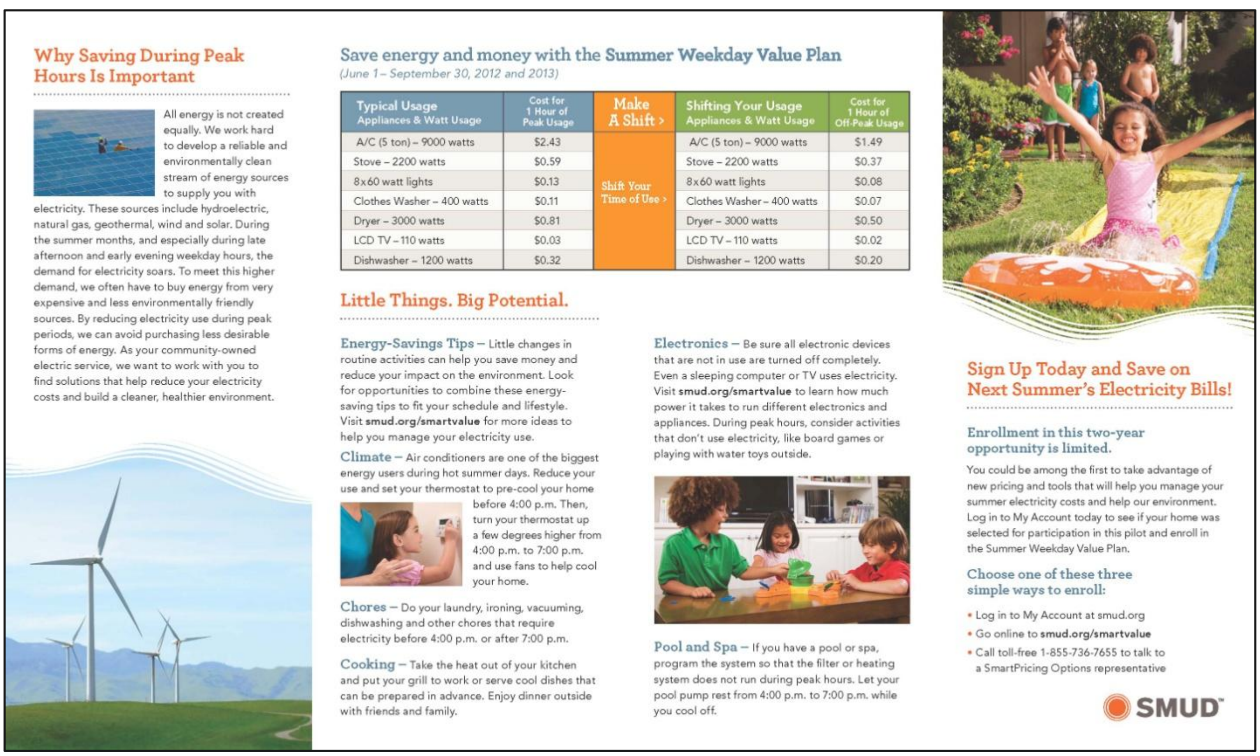
If you are on our Energy Assistance Program Rate (EAPR), this chart does not include the discount you'll receive on the price you pay for electricity.

This chart does not reflect service charges or other fees that are included in your bill.

Use less electricity during peak hours by shifting when you use (like doing laundry before 4:00 p.m. or after 7:00 p.m.) or by reducing your use overall (powering off your TV when you're not watching). If you shift your electricity use to off-peak hours or reduce your use overall, you can save on your electric bill.

As a Summer Weekday Value Plan member, you'll get additional benefits that include:

- A FREE, convenient, countertop electricity use display, mailed to you in spring 2012. This display will show you how much electricity you're using at the moment, and how much it's costing you.
- An informational graph that shows your hourly and daily electricity use right up to the past 24 hours. Log in and view your usage anytime through My Account on smud.org.
- Access to a website (**smud.org/smartvalue**) that has energy-saving tips and tools.
- Discounts on activities like movie tickets and water parks, and chances to win barbecue grills and other prizes that can make using less electricity from 4:00 p.m. to 7:00 p.m. easy and fun.



Why Saving During Peak Hours Is Important

All energy is not created equally. We work hard to develop a reliable and environmentally clean stream of energy sources to supply you with electricity. These sources include hydroelectric, natural gas, geothermal, wind and solar. During the summer months, and especially during late afternoon and early evening weekday hours, the demand for electricity soars. To meet this higher demand, we often have to buy energy from very expensive and less environmentally friendly sources. By reducing electricity use during peak periods, we can avoid purchasing less desirable forms of energy. As your community-owned electric service, we want to work with you to find solutions that help reduce your electricity costs and build a cleaner, healthier environment.

Save energy and money with the Summer Weekday Value Plan

(June 1 – September 30, 2012 and 2013)

Typical Usage Appliances & Watt Usage	Cost for 1 Hour of Peak Usage	Make A Shift >	Shifting Your Usage Appliances & Watt Usage	Cost for 1 Hour of Off-Peak Usage
A/C (5 ton) – 9000 watts	$2.43	Shift Your Time of Use >	A/C (5 ton) – 9000 watts	$1.49
Stove – 2200 watts	$0.59		Stove – 2200 watts	$0.37
8x60 watt lights	$0.13		8x60 watt lights	$0.08
Clothes Washer – 400 watts	$0.11		Clothes Washer – 400 watts	$0.07
Dryer – 3000 watts	$0.81		Dryer – 3000 watts	$0.50
LCD TV – 110 watts	$0.03		LCD TV – 110 watts	$0.02
Dishwasher – 1200 watts	$0.32		Dishwasher – 1200 watts	$0.20

Little Things. Big Potential.

Energy-Savings Tips – Little changes in routine activities can help you save money and reduce your impact on the environment. Look for opportunities to combine these energy-saving tips to fit your schedule and lifestyle. Visit **smud.org/smartvalue** for more ideas to help you manage your electricity use.

Climate – Air conditioners are one of the biggest energy users during hot summer days. Reduce your use and set your thermostat to pre-cool your home before 4:00 p.m. Then, turn your thermostat up a few degrees higher from 4:00 p.m. to 7:00 p.m. and use fans to help cool your home.

Chores – Do your laundry, ironing, vacuuming, dishwashing and other chores that require electricity before 4:00 p.m. or after 7:00 p.m.

Cooking – Take the heat out of your kitchen and put your grill to work or serve cool dishes that can be prepared in advance. Enjoy dinner outside with friends and family.

Electronics – Be sure all electronic devices that are not in use are turned off completely. Even a sleeping computer or TV uses electricity. Visit **smud.org/smartvalue** to learn how much power it takes to run different electronics and appliances. During peak hours, consider activities that don't use electricity, like board games or playing with water toys outside.

Pool and Spa – If you have a pool or spa, program the system so that the filter or heating system does not run during peak hours. Let your pool pump rest from 4:00 p.m. to 7:00 p.m. while you cool off.

Sign Up Today and Save on Next Summer's Electricity Bills!

Enrollment in this two-year opportunity is limited.

You could be among the first to take advantage of new pricing and tools that will help you manage your summer electricity costs and help our environment. Log in to My Account today to see if your home was selected for participation in this pilot and enroll in the Summer Weekday Value Plan.

Choose one of these three simple ways to enroll:

- Log in to My Account at smud.org
- Go online to **smud.org/smartvalue**
- Call toll-free 1-855-736-7655 to talk to a SmartPricing Options representative

SMUD™

Direct Mail Follow Up Postcard

Reward yourself and the environment too!

Dear (Customer Name)

There is still time to participate in the Off-Peak Discount Plan, but you must act soon as enrollment is limited.

Join today and you'll receive a discount off the standard price on the amount you pay for your electricity all day, every day from June 1 through September 30, except for 12 Conservation Days. (This plan is effective 2012 and 2013.)

During peak hours on Conservation Days – from 4:00 p.m. to 7:00 p.m. – the price you pay will be higher than the standard price. That means that you'll get a discount 99% of the time during the next two summers! (Conservation Days will never be on July 4th or Labor Day.)

By managing your energy usage during Conservation Day peak periods, you can save on your summer electricity bills and help the environment.

Sign up now for the Off-Peak Discount Plan and you could be among the first to take advantage of new pricing and energy management tools. You'll also receive a FREE countertop electricity use display that shows your real-time electricity usage!

For more details and easy registration, visit **smud.org/smartdiscount** or call us toll-free at 1-855-736-7655.

SMUD™
P.O. Box 15830,
Sacramento 95852-1830
1-855-736-7655 | smud.org

John Smith
32563 First Street
Sacramento, CA
95816-3456

Direct Mail Recruitment Letters

Summer Weekday Value Plan Opt-In (TOU)

(Mail Date)

(Customer Name)

(Address)

Sign up today and you could save on your summer electric bills!
smud.org/valuepricing

Dear (Customer Name),

You still have time to participate in a two-year SmartPricing Options pilot that can help you manage your energy bills. The **Summer Weekday Value Plan** is being offered to a randomly selected group of SMUD customers for a limited time. Half of the customers whose homes were randomly selected will be eligible to participate the summer of 2012. The other half will be eligible to participate the summer of 2014. Enrolling in this plan will allow you to take control of your summer electricity costs and help the environment.

Here's how it works:

- You'll receive a discount off the standard price on the amount you pay for your electricity during off-peak hours each summer from June 1 through September 30. (This plan is effective 2012 through 2013.) Off-peak hours are Monday through Friday before 4:00 p.m. and after 7:00 p.m., all day on weekends, July 4th and Labor Day. That means that 90% of the time, you'll get a discount.
- During peak hours – weekdays from 4:00 p.m. to 7:00 p.m. – the price you pay will be higher than the standard price.

Using less electricity during peak hours, shifting the time you use electricity (like doing laundry after 7:00 p.m.), or reducing your use overall can help you save money on your bill.

Here are additional perks:

- An online informational graph on My Account that shows your hourly and daily electricity use.
- Access to a website – smud.org/valuepricing – with energy-saving tips and tools.
- Discounts on activities – like movie tickets and water parks – that can make using less electricity from 4:00 p.m. to 7:00 p.m. easy and fun.

Choose one of these four simple ways to enroll:

- Log in to My Account at smud.org
- Fill out and return the enclosed postage-paid reply card
- Go to smud.org/valuepricing
- Call toll-free 1-855-736-7655

You could be among the first to take advantage of new pricing and energy management tools. Enrollment is limited, so to find out if your home was selected for participation in this pilot and to enroll, log in to My Account at smud.org today!

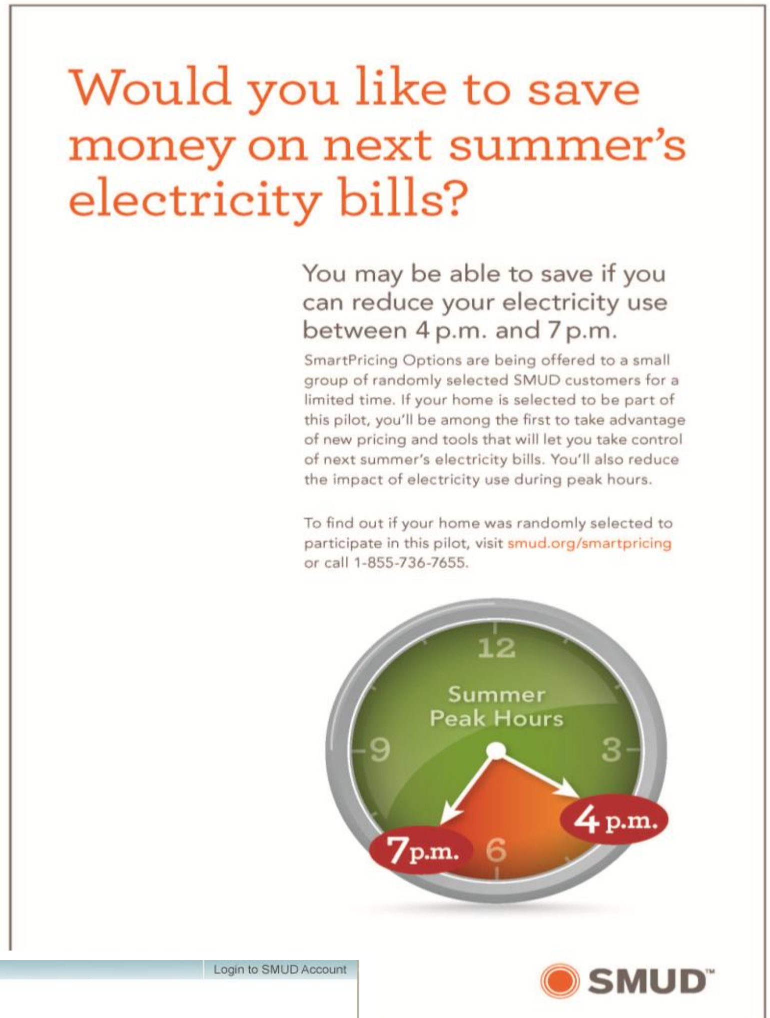
Sincerely,

Jennifer Potter

Jennifer Potter
SmartPricing Options Project Manager

To lessen environmental impacts, the carbon emissions from this mailing have been offset.

Mass Media Campaign Print Ad



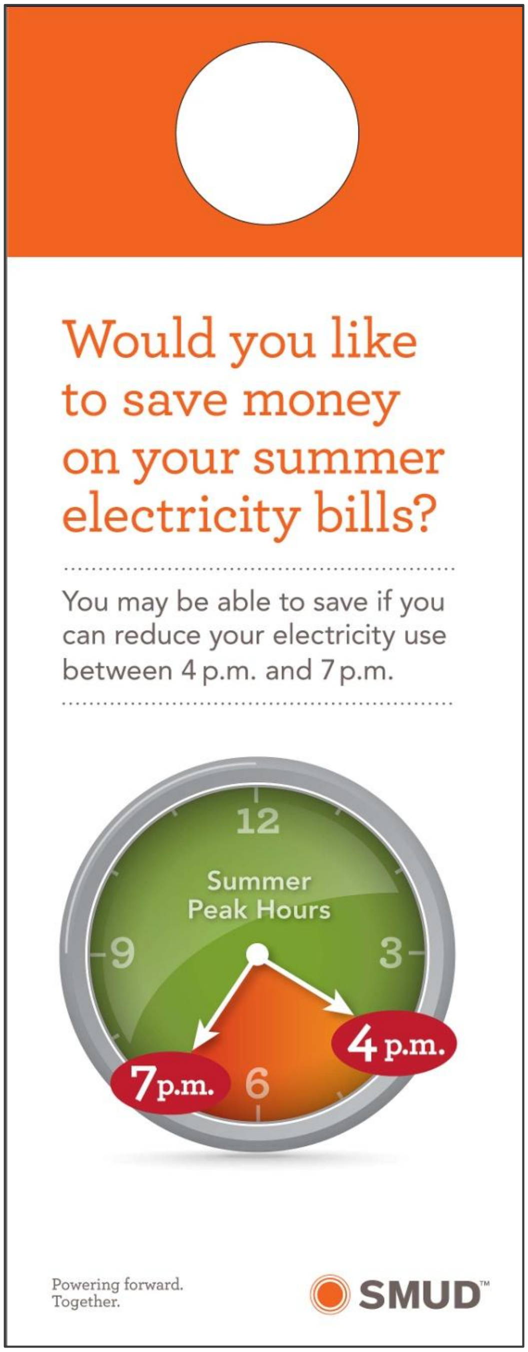
Folsom Telegraph 4 Column (6.625" x 10") 4 color

Mass Media Campaign Web Ad Example

Mass Media Campaign Landing Page

SMUD™

Door Hanger



SMUD™

OPT OUT MATERIALS

Direct Mail Letters – Opt-Out

Optimum Off-Peak Plan with IHD Offer Default** (**TOU-CPP)

(Mail Date)

(Customer Name)

(Address)

You're now on a new pricing plan that can help you save on your summer electricity bills! smud.org/optimumoption

Dear (Customer Name),

You're among the first SMUD customers to be randomly selected for a two-year SmartPricing Options pilot that can help you better manage your energy use for the summers of 2012 and 2013. The **Optimum Off-Peak Plan** will allow you to take control of your summer electricity bills and help the environment.

Here's how it works:

- You'll receive a discount off the standard price on the amount you pay for your electricity during off-peak hours each summer from June 1 through September 30. Off-peak hours are Monday through Friday before 4:00 p.m. and after 7:00 p.m., all day on weekends, July 4th and Labor Day. That means that 90% of the time, you get a discount.
- During peak hours – weekdays from 4:00 p.m. to 7:00 p.m. – the price you pay will be higher than the standard price.
- On 12 weekdays during the summer - Conservation Days – the peak rate you pay will be higher than your usual peak rate. Peak hours on Conservation Days are from 4:00 p.m. to 7:00 p.m. That's just 1% of the time or 36 hours all summer!

Using less electricity during peak hours, shifting the time you use electricity (like doing laundry after 7:00 p.m.), or reducing your use overall can help you save money on your bill.

Here are additional perks:

- A FREE countertop electricity use display, mailed to you this spring. This display will show how much electricity you're using at that moment, and how much it's costing you.
- An online informational graph on My Account that shows your hourly and daily electricity use.
- Access to a website – **smud.org/optimumoption** – with energy-saving tips and tools.
- Discounts on activities – like movie tickets and water parks – that can make using less electricity from 4:00 p.m. to 7:00 p.m. easy and fun.

To get your FREE countertop electricity use display, return the enclosed postage-paid card, visit My Account at smud.org or call 1-855-736-7655. You can also choose how you'd like to receive energy-saving tips and be notified about Conservation Days.

If you would like to remain on your standard rate plan, call 1-855-736-7655. However, should you decide not to participate, you won't be able to enroll later and you will miss out on the cost savings and energy management benefits.

Learn more about your new plan at **smud.org/optimumoption**.

Sincerely,

Jennifer Potter

Jennifer Potter
SmartPricing Options Project Manager

To lessen environmental impacts, the carbon emissions from this mailing have been offset.

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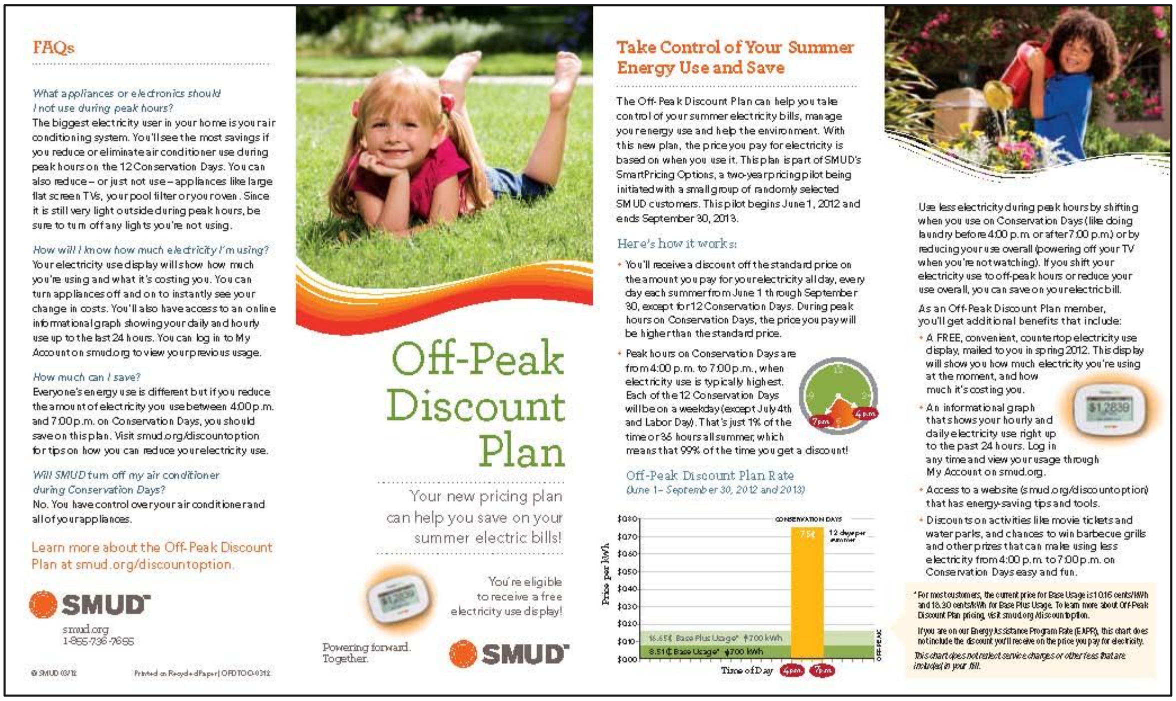
Direct Mail Brochure Example

Off-Peak Discount Plan Opt-Out (CPP)



FAQs

What appliances or electronics should I not use during peak hours?
The biggest electricity user in your home is your air conditioning system. You'll see the most savings if you reduce or eliminate air conditioner use during peak hours on the 12 Conservation Days. You can also reduce – or just not use – appliances like large flat screen TVs, your pool filter or your oven. Since it is still very light outside during peak hours, be sure to turn off any lights you're not using.

How will I know how much electricity I'm using?
Your electricity use display will show how much you're using and what it's costing you. You can turn appliances off and on to instantly see your change in costs. You'll also have access to an online informational graph showing your daily and hourly use up to the last 24 hours. You can log in to My Account on smud.org to view your previous usage.

How much can I save?
Everyone's energy use is different but if you reduce the amount of electricity you use between 4:00 p.m. and 7:00 p.m. on Conservation Days, you should save on this plan. Visit smud.org/discountoption for tips on how you can reduce your electricity use.

Will SMUD turn off my air conditioner during Conservation Days?
No. You have control over your air conditioner and all of your appliances.

Learn more about the Off-Peak Discount Plan at smud.org/discountoption.

SMUD™
smud.org
1-855-736-7655

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Off-Peak Discount Plan

Your new pricing plan can help you save on your summer electric bills!

You're eligible to receive a free electricity use display!

Powering forward. Together.

SMUD™

Take Control of Your Summer Energy Use and Save

The Off-Peak Discount Plan can help you take control of your summer electricity bills, manage your energy use and help the environment. With this new plan, the price you pay for electricity is based on when you use it. This plan is part of SMUD's SmartPricing Options, a two-year pricing pilot being initiated with a small group of randomly selected SMUD customers. This pilot begins June 1, 2012 and ends September 30, 2013.

Here's how it works:

- You'll receive a discount off the standard price on the amount you pay for your electricity all day, every day each summer from June 1 through September 30, except for 12 Conservation Days. During peak hours on Conservation Days, the price you pay will be higher than the standard price.
- Peak hours on Conservation Days are from 4:00 p.m. to 7:00 p.m., when electricity use is typically highest. Each of the 12 Conservation Days will be on a weekday (except July 4th and Labor Day). That's just 1% of the time or 36 hours all summer, which means that 99% of the time you get a discount!

7pm 4 p.m

Off-Peak Discount Plan Rate
(June 1 – September 30, 2012 and 2013)

Price per kWh: $0.80, $0.70, $0.60, $0.50, $0.40, $0.30, $0.20, $0.10, $0.00
CONSERVATION DAYS
75¢ 12 days per summer
16.65¢ Base Plus Usage* >700 kWh
8.51¢ Base Usage* ≤700 kWh
OFF-PEAK
Time of Day 4pm 7pm

Use less electricity during peak hours by shifting when you use on Conservation Days (like doing laundry before 4:00 p.m. or after 7:00 p.m.) or by reducing your use overall (powering off your TV when you're not watching). If you shift your electricity use to off-peak hours or reduce your use overall, you can save on your electric bill.

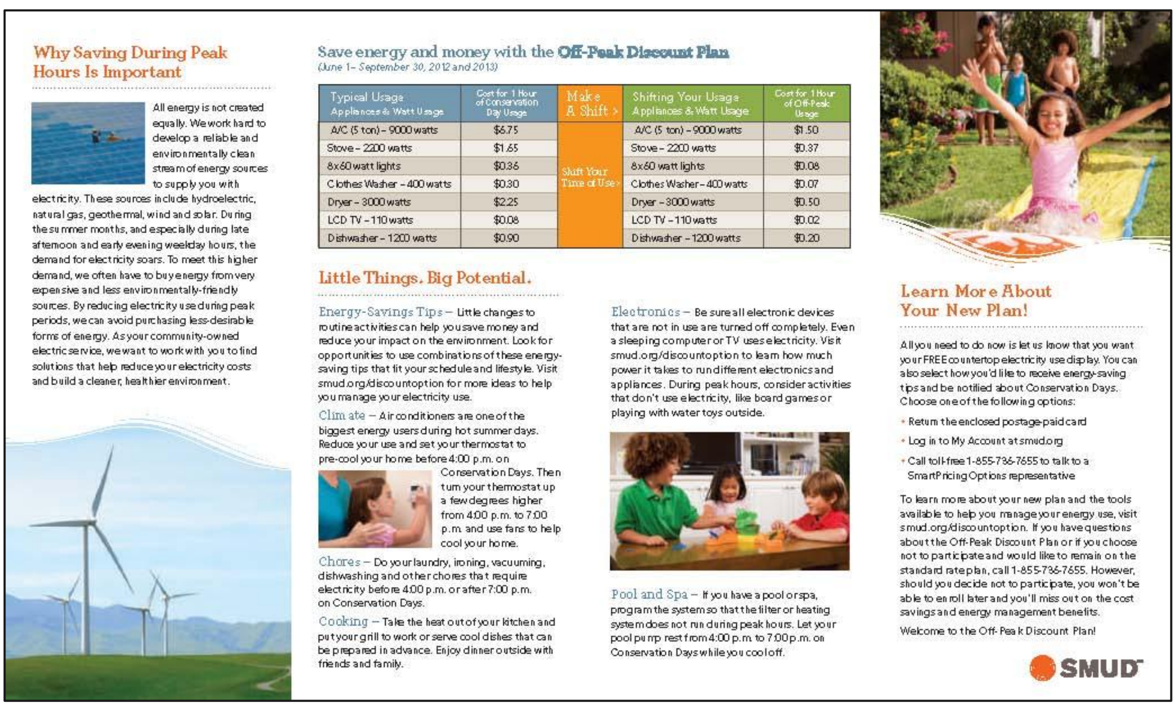
As an Off-Peak Discount Plan member, you'll get additional benefits that include:

- A FREE, convenient, countertop electricity use display, mailed to you in spring 2012. This display will show you how much electricity you're using at the moment, and how much it's costing you.
- An informational graph that shows your hourly and daily electricity use right up to the past 24 hours. Log in any time and view your usage through My Account on smud.org.
- Access to a website (smud.org/discountoption) that has energy-saving tips and tools.
- Discounts on activities like movie tickets and water parks, and chances to win barbecue grills and other prizes that can make using less electricity from 4:00 p.m. to 7:00 p.m. on Conservation Days easy and fun.

*For most customers, the current price for Base Usage is 10.16 cents/kWh and 18.30 cents/kWh for Base Plus Usage. To learn more about Off-Peak Discount Plan pricing, visit smud.org/discountoption.

If you are on our Energy Assistance Program Rate (EAPR), this chart does not include the discount you'll receive on the price you pay for electricity.

This chart does not reflect service charges or other fees that are included in your bill.



Why Saving During Peak Hours Is Important

All energy is not created equally. We work hard to develop a reliable and environmentally clean stream of energy sources to supply you with electricity. These sources include hydroelectric, natural gas, geothermal, wind and solar. During the summer months, and especially during late afternoon and early evening weekday hours, the demand for electricity soars. To meet this higher demand, we often have to buy energy from very expensive and less environmentally-friendly sources. By reducing electricity use during peak periods, we can avoid purchasing less-desirable forms of energy. As your community-owned electric service, we want to work with you to find solutions that help reduce your electricity costs and build a cleaner, healthier environment.

Save energy and money with the **Off-Peak Discount Plan**
(June 1 – September 30, 2012 and 2013)

Typical Usage Appliances & Watt Usage	Cost for 1 Hour of Conservation Day Usage	Make A Shift >	Shifting Your Usage Appliances & Watt Usage	Cost for 1 Hour of Off-Peak Usage
A/C (5 ton) – 9000 watts	$6.75	Shift Your Time of Use >	A/C (5 ton) – 9000 watts	$1.50
Stove – 2200 watts	$1.65		Stove – 2200 watts	$0.37
8x60 watt lights	$0.36		8x60 watt lights	$0.08
Clothes Washer – 400 watts	$0.30		Clothes Washer – 400 watts	$0.07
Dryer – 3000 watts	$2.25		Dryer – 3000 watts	$0.50
LCD TV – 110 watts	$0.08		LCD TV – 110 watts	$0.02
Dishwasher – 1200 watts	$0.90		Dishwasher – 1200 watts	$0.20

Little Things. Big Potential.

Energy-Savings Tips – Little changes to routine activities can help you save money and reduce your impact on the environment. Look for opportunities to use combinations of these energy-saving tips that fit your schedule and lifestyle. Visit smud.org/discountoption for more ideas to help you manage your electricity use.

Climate – Air conditioners are one of the biggest energy users during hot summer days. Reduce your use and set your thermostat to pre-cool your home before 4:00 p.m. on Conservation Days. Then turn your thermostat up a few degrees higher from 4:00 p.m. to 7:00 p.m. and use fans to help cool your home.

Chores – Do your laundry, ironing, vacuuming, dishwashing and other chores that require electricity before 4:00 p.m. or after 7:00 p.m. on Conservation Days.

Cooking – Take the heat out of your kitchen and put your grill to work or serve cool dishes that can be prepared in advance. Enjoy dinner outside with friends and family.

Electronics – Be sure all electronic devices that are not in use are turned off completely. Even a sleeping computer or TV uses electricity. Visit smud.org/discountoption to learn how much power it takes to run different electronics and appliances. During peak hours, consider activities that don't use electricity, like board games or playing with water toys outside.

Pool and Spa – If you have a pool or spa, program the system so that the filter or heating system does not run during peak hours. Let your pool pump rest from 4:00 p.m. to 7:00 p.m. on Conservation Days while you cool off.

Learn More About Your New Plan!

All you need to do now is let us know that you want your FREE countertop electricity use display. You can also select how you'd like to receive energy-saving tips and be notified about Conservation Days. Choose one of the following options:

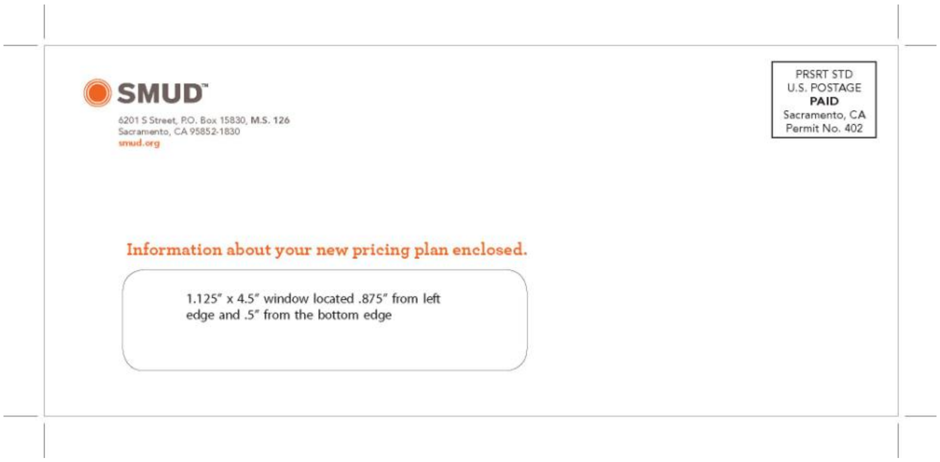
- Return the enclosed postage-paid card
- Log in to My Account at smud.org
- Call toll-free 1-855-736-7655 to talk to a SmartPricing Options representative

To learn more about your new plan and the tools available to help you manage your energy use, visit smud.org/discountoption. If you have questions about the Off-Peak Discount Plan or if you choose not to participate and would like to remain on the standard rate plan, call 1-855-736-7655. However, should you decide not to participate, you won't be able to enroll later and you'll miss out on the cost savings and energy management benefits.

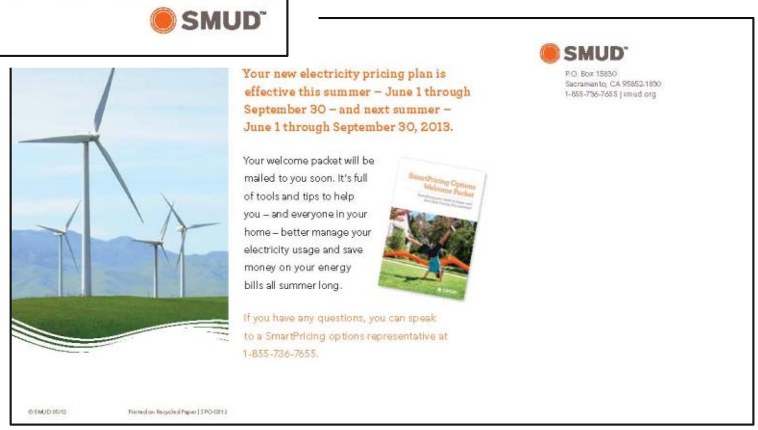
Welcome to the Off-Peak Discount Plan!

SMUD™

Direct Mail Envelope – Opt-Out



Direct Mail Follow up Postcard – Opt-Out



Opt-In Recruitment Email

SMUD™ **Sign up before summer and save**

Dear SMUD Customer,
Enroll in SMUD's Off-Peak Discount Plan and save on your summer electricity bills and summer activities!

Here's how it works:

- You'll receive a discount off the standard price on the amount you pay for your electricity all day, every day in the summer from June 1 - September 30, except for 12 Conservation Days. (This plan is effective 2012 - 2013.) During peak hours on Conservation Days, the price you pay will be higher than the standard price.

Sign up today to receive this discount card.

- Peak hours on Conservation Days are from 4 pm – 7 pm. Each of the 12 Conservation Days will be on a weekday (Conservation Days will never be on July 4th and Labor Day). That's just 1% of the time, or 36 hours all summer. That means that 99% of the time, you get a discount!

Enroll Here

For more details and easy enrollment, visit smud.org/discountpricing or call us toll-free at 1-855-736-7655.

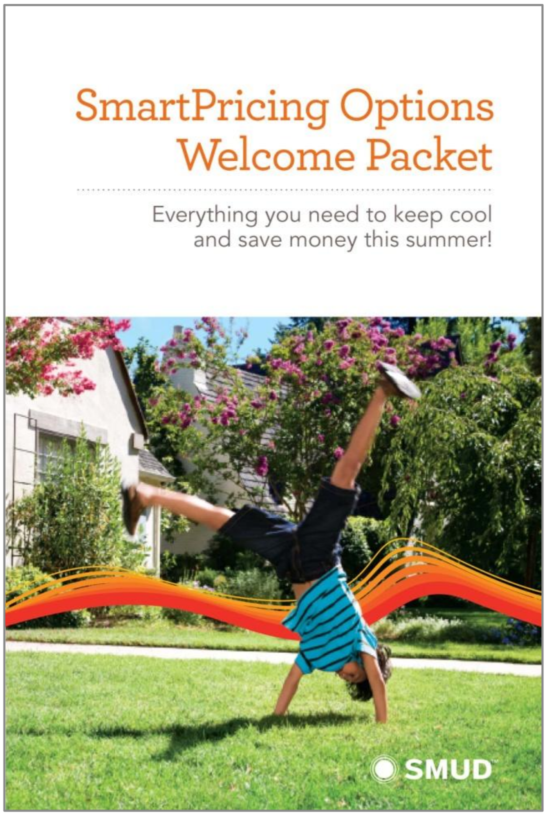
Additional perks:

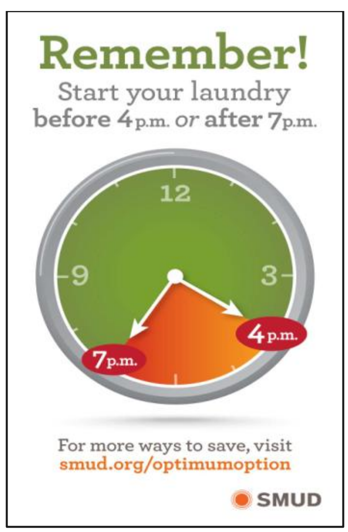
- An online informational graph on My Account that shows your hourly and daily electricity use.
- Access to a website with energy-saving tips and tools.
- A discount card for activities that can make using less electricity from 4 p.m. - 7 p.m. easy and fun.

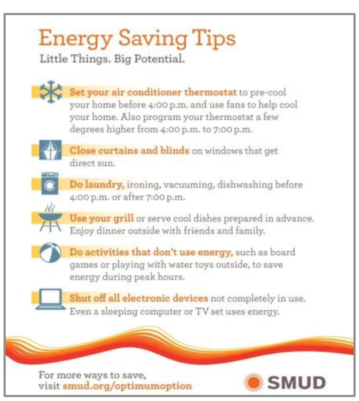
SMUD™

Retention & Education

Welcome Packet Example







SMUD™

IHD Reminder Postcard

Attack of the Phantom Appliances Online Game

Appendix B

Residential Service Rate Schedule R

This appendix contains a description of the applicable rate schedule for the pilot treatment and control groups.

I. Applicability

This schedule applies to single and three-phase service for the following types of residential premises: 1. Individually-metered residences including single-family homes, flats, apartments and condominiums, 2. General farm service where the meter also serves the residence, or additional meters on a farm where the electricity consumed is solely for domestic purposes and 3. Master-metered service to a multi-family accommodation or a mobile home park which are sub-metered to all individual mobile homes or single-family units.

II. Basic Rates

The prices in this section are subject to annual revisions in accordance with attachment 1-R-A. Revisions will occur annually on January 1.

WINTER SEASON – DECEMBER 1 through MARCH 31

Standard Rate (Rate Categories RSEH, RWEH, RSGH, RWGH)

System Infrastructure Fixed Charge per month $10.00
Electricity Usage Charge:
  Base Usage per month ¢/kWh .... 9.38¢
  Base-Plus Usage per month ¢/kWh .... 17.65¢

Electric Space Heat Rate * (CLOSED) (Rate Categories RSCH, RWCH)

System Infrastructure Fixed Charge per month $10.00
Electricity Usage Charge:
  Base Usage per month ¢/kWh .... 7.57¢
  Base-Plus Usage per month ¢/kWh .... 14.43¢

SPRING AND FALL SEASONS – APRIL 1 – MAY 31, And OCTOBER 1 – NOVEMBER 30

Standard Rate (Rate Categories RSEH, RWEH, RSGH, RWGH)

System Infrastructure Fixed Charge per month $10.00
Electricity Usage Charge:
  Base Usage per month ¢/kWh .... 9.38¢
  Base-Plus Usage per month ¢/kWh .... 17.65¢

Electric Space Heat Rate * (CLOSED) (Rate Categories RSCH, RWCH)

System Infrastructure Fixed Charge per month $10.00
Electricity Usage Charge:
  Base Usage per month ¢/kWh .... 8.49¢
  Base-Plus Usage per month ¢/kWh .... 15.35¢

SUMMER SEASON – JUNE 1 through SEPTEMBER 30

Standard Rate (Rate Categories RSEH, RWEH, RSCH, RWCH, RSGH, RWGH)

System Infrastructure Fixed Charge per month $10.00
Electricity Usage Charge:
  Base Usage per month ¢/kWh .... 10.16¢
  Base-Plus Usage per month ¢/kWh .... 18.30¢

*The Winter Season (CLOSED) Electric Space Heat Rate is no longer available to new installations of electric space heat equipment, effective May 1, 1996. Any new occupant to a current premise with (CLOSED) Rate Categories RSCH, RTC, or RWCH will be placed on the Standard Rate (Rate Categories RSEH, RWEH) or on the Time of Use Rate (Rate Category RTE) if applicable, upon application for service. New occupants and new customers installing electric space heat equipment (Rate Categories RSEH, RWEH) shall be entitled to the Base Usage and Base-Plus Usage Quantities for Electric Space Heat and billed the Standard Rate.

III. Base Usage and Base-Plus Usage Quantities

WINTER SEASON – DECEMBER 1 through MARCH 31

(Kilowatt-hours per month)

Rate Category	Standard Heat		Electric Heat	
	RSGH	**RWGH (with Wells)**	RSEH, RSCH	RWEH, RWCH (with Wells)
Base Usage	0 – 620	0 – 920	0 – 1,120	0 – 1,420
Base-Plus Usage	> 620	> 920	> 1,120	> 1,420

SPRING AND FALL SEASONS – APRIL 1– MAY 31 and OCTOBER 1 – NOVEMBER 30

(Kilowatt-hours per month)

Rate Category	Standard Heat		Electric Heat	
	RSGH	**RWGH (with Wells)**	RSEH, RSCH	RWEH, RWCH (with Wells)
Base Usage	0 – 620	0 – 920	0 – 800	0 – 1,100
Base-Plus Usage	> 620	> 920	> 800	> 1,100

SUMMER SEASON – JUNE 1 through SEPTEMBER 30

(Kilowatt-hours per month)

Rate Category	RSEH, RSCH, RSGH	**RWEH, RWCH, RWGH (with Wells)**
Base Usage	0 – 700	0 – 1,000
Base-Plus Usage	> 700	> 1,000

IV. Optional Medical Equipment Discount and Energy Assistance Programs

Refer to the following Tariff Sheets for details on eligibility and discounts on these programs:

Medical Equipment Discount Program (Rate Categories with suffix "_L"). See Sheet No. 1–MED–1.

Energy Assistance Program (Rate Categories with suffix "_E"). See Sheet No. 1–EAPR–1.

Joint Participation in Medical Equipment Discount and Energy Assistance Programs (Rate Categories with

suffix "_EL"). See Sheet No. 1–MED–1.

V. Time Based Pricing Plans

Option 1 Time of Use Rate (Rate Categories RTE, RTC, RTG)

WINTER SEASON – OCTOBER 1 through MAY 31

System Infrastructure Fixed Charge per month $10.00
On-Peak ¢/kWh .... 11.20¢
Off-Peak ¢/kWh .... 10.37¢

SUMMER SEASON – JUNE 1 through SEPTEMBER 30

System Infrastructure Fixed Charge per month $10.00
On-Peak ¢/kWh .... 24.41¢
Off-Peak ¢/kWh .... 11.51¢

Option 1 Time of Use Billing Periods

Winter Season On-Peak	Weekdays between 7:00 a.m. and 10:00 a.m., and 5:00 p.m. and 8:00 p.m.
Summer Season On-Peak	Weekdays between 2:00 p.m. and 8:00 p.m.
Off-Peak	All other hours, including holidays shown in Section (D)

Option 1 Time of Use Trial Billing

Residential customers shall be entitled to a 12-month trial period for Option 1 Time of Use in which the customer shall receive a credit (after 12 months of billing on the Option 1 Time of Use) for the accumulated difference, if applicable, between the Standard Rate and the Option 1 Time of Use, after which either the Standard Rate or the Option 1 Time of Use Rate must be selected. If the Option 1 Time of Use Rate is selected, customers subsequently requesting a transfer from the Option 1 Time of Use Rate to the Standard Rate may not return to the Option 1 Time of Use Rate for a 12-month period.

Option 2 Time of Use (Rate Categories RTE5, RTC5, RTG5)

WINTER SEASON – OCTOBER 1 through MAY 31

System Infrastructure Fixed Charge per month $11.40
On-Peak ¢/kWh .... 10.97¢
Off-Peak ¢/kWh .... 10.07¢

SUMMER SEASON – JUNE 1 through SEPTEMBER 30

System Infrastructure Fixed Charge per month $11.40
Super-Peak ¢/kWh .... 24.24¢
On-Peak ¢/kWh .... 16.14¢
Off-Peak ¢/kWh .... 9.97¢

Option 2 Time of Use Billing Periods

Winter Season On-Peak	Weekdays between 12:00 noon and 10:00 p.m.
Summer Season On-Peak	Weekdays between 12:00 noon and 2:00 p.m. and between 8:00 p.m. and 10:00 p.m.
Summer Super-Peak	Weekdays between 2:00 p.m. and 8:00 p.m.
Off-Peak	All other hours, including holidays shown in Section (D).

SmartSacramento® Pricing Pilot Rates[25]
(Rate Categories RSCH_CB, RSEH_CB, RSGH_CB, RWCH_CB, RWEH_CB, RWGH_CB)

Applicability

These rates will be offered only to selected participants for a limited trial period. They apply only during the summer season. Participants will revert to their otherwise applicable rates during the remaining months of the year.

SmartSacramento® Pricing Pilot Time of Use Rate (Summer Season Only)

System Infrastructure Fixed Charge per month $10.00
On-Peak ¢/kWh .... 27.00¢

[25] ® A registered service mark of the Sacramento Municipal Utility District

Off-Peak ¢/kWh:
Off-Peak Base Usage per month .... 8.46¢
Off-Peak Base-Plus Usage per month .... 16.60¢

SmartSacramento® Pricing Pilot Critical Peak Rate (Summer Season Only)

System Infrastructure Fixed Charge per month $10.00
Critical Peak ¢/kWh .... 75.00¢
Off-Peak ¢/kWh:
Off-Peak Base Usage per month .... 8.51¢
Off-Peak Base-Plus Usage per month .... 16.65¢

SmartSacramento® Pricing Pilot Combined Time of Use and Critical Peak Rate (Summer Season Only)

System Infrastructure Fixed Charge per month $10.00
Critical Peak ¢/kWh .... 75.00¢
On-Peak ¢/kWh .... 27.00¢
Off-Peak ¢/kWh:
Off-Peak Base Usage per month .... 7.21¢
Off-Peak Base-Plus Usage per month .... 14.11¢

SmartSacramento® Pricing Pilot Billing Periods (June 1 – September 30 Summer Only)

On-Peak Hours	Summer weekdays between 4:00 p.m. and 7:00 p.m., exclusive of July 4th and Labor Day holidays.
Critical Peak Hours	Up to twelve summer weekdays between 4:00 p.m. and 7:00 p.m., exclusive of July 4th and Labor Day holidays, announced by SMUD a day in advance as a critical peak event day.
Off-Peak Base Usage Hours	Usage in all other non-peak hours up to 700 kWh for standard customers and 1,000 kWh for customers with domestic wells.
Off-Peak Base-Plus Usage Hours	Usage in non-peak hours beyond 700 kWh of Off-Peak Base Usage for standard customers and beyond 1,000 kWh of Off-Peak Base Usage for customers with domestic wells

Time Based Pricing Plans Billing Holidays

Off-peak pricing in the Time Based Pricing Plans shall apply during the following holidays:

Holiday	Month	Date
New Year's Day	January	1st
Martin Luther King Jr.'s Birthday	January	Third Monday
Lincoln's Birthday	February	12th
Presidents Day	February	Third Monday
Memorial Day	May	Last Monday
Independence Day	July	4th
Labor Day	September	First Monday
Columbus Day	October	Second Monday
Veteran's Day	November	11th
Thanksgiving Day	November	Fourth Thursday
Christmas Day	December	25th

VI. Electricity Usage Surcharges

The following surcharges will apply to all kWh used per month, subject to the conditions detailed in the following Tariff sheets:

Solar Surcharge, established to comply with state regulation, creates a fund for encouraging customer-owned solar power generation. See Tariff Sheet No. 1–SB–1 for further details, including current surcharge amount.

Hydro Generation Adjustment (HGA) will only apply when low levels of precipitation adversely affect SMUD's hydroelectric production. See Tariff Sheets No. 1–HGA–1-2 for further information on how the HGA is calculated and when it applies.

VII. Rate Option Menu

(A) Residential Thermal Energy Storage Option (Rate Category RTT) (CLOSED)

Residential customers who are equipped with a Residential Thermal Energy Storage (RTES) system *or* who may qualify by meeting the load criteria established for RTES including the lockout of space-conditioning compressors during the on-peak period, and who are billed on the Option 1 Time of Use Rate shall be entitled to a credit as follows:

Winter off-peak credit ¢/kWh	-2.43¢
Summer on-peak credit ¢/kWh	-5.85¢
Summer off-peak credit ¢/kWh	-2.71¢

Rate Category RTT will no longer be available to new occupants as well as new installations of RTES systems, or other qualifying equipment effective June 1, 1997. At the time of application for service, new occupants of a current premise with (CLOSED) Rate Category RTT will be placed on the Option 1 Time of Use rate (Rate Category RTE) and will be informed of other rate options available to them.

(B) Standby Service Option

This option applies to residential customers who operate, in whole or in part, privately-owned generator(s) with a contract capacity (combined nameplate rating) less than 100 kW on their premises, and are connected to SMUD's electrical system requiring SMUD to standby ready to provide backup or maintenance service to replace the generator(s).

Charges for Standby Service are as follows:

Standby Charge (January 1 through December 31)

Based on contract capacity per month $/kW	$6.25

Electricity Usage:

All energy provided to the customer by SMUD will be billed at the applicable electricity usage charges under the Basic Rate or an optional rate under the Time Based Pricing Plans.

The Standby Service charge will be waived for qualifying net metered generation. See Sheet No. 1–NM–1 for further details.

(C) Plug-in Electric Vehicle (PEV) Option (Rate Category RTEV)

This option is for residential customers who own licensed passenger electric vehicles and/or passenger battery electric and plug-in hybrid electric vehicles, and take service for the vehicle charging under the optional Option 1 Time of Use Rate upon proof of vehicle registration. The term PEV is meant to be inclusive of both battery, plug-in, and plug-in hybrid electric vehicles.

This option requires installation of a time of use meter on the charging location and will be billed under the Option 1 Time of Use Rate with a credit on the off-peak electricity usage charges as follows:

Winter off-peak energy credit ¢/kWh	-2.43¢
Summer off-peak energy credit ¢/kWh	-2.71¢

The System Infrastructure Fixed Charge will be waived. The Time of Use meter will be a sub-meter to the premise's main meter unless the customer, at his own expense, elects to have installed a separate panel and meter. When sub-metered, the Residential Time-of-Use Electric Vehicle (Rate Category RTEV) rate is not available to customers whose premise load is billed on the Option 2 Time of Use Rate.

(D) Residential PV Pioneer Green Fee

This option applies to residential customers who participate in SMUD's "PV Pioneer Project." Participation in the "PV Pioneer Project" shall be at the sole discretion of SMUD.

(E) Net Metering for Solar Electric, Wind Turbine, and Biomass Generation Facilities

This option applies to customers who have a solar or other renewable power generator on their premise. Refer to Sheet No. 1–NM–1 for further details.

(F) Residential Three-phase Service Option

This option applies to customers located in areas where three-phase service is available. SMUD shall charge a monthly Special Facilities fee of $38.95 to cover the additional costs for providing this service.

(G) Green Pricing Options

1. **SMUD Community Solar Option**
   Under this premium service option, customers elect to contribute monthly payments towards the installation of a photoelectric system at a selected community locale. See the SMUD website for further information on monthly contribution options and currently identified projects.

2. **SMUD Renewable Energy Option**
   Customers electing this premium power service will receive an additional monthly electricity usage charge of no less than 1/2 cent and no greater than 2 cents per kWh. SMUD may offer up to three premium rate options representing various blends of renewable resources within the 1/2 cent to 2 cent range. The actual prices will be published each November and will be based on the expected above market cost of renewable resources for the upcoming year. Participation will be limited to the amount of resources that SMUD is able to secure below the 2 cent premium limit.

3. **Flat Fee Options:**
   Customers may opt to support SMUD renewable energy purchases through one of the following monthly fees:

   Green Fee flat charge per month 100% option $6.00
   Green Fee flat charge per month 50% option $3.00

VIII. Special Metering Charge

SMUD will charge a monthly service fee for customers who purchase and install communications hardware to transfer energy load data from their meter/recorder to a personal computer. The fee covers maintenance, software support and the annual licensing fee.

IX. Conditions for Eligibility

(A) Electric Space Heat Eligibility (Rate Categories RSEH, RSCH, RWEH, RWCH)

Residential customers with electric space heating may qualify for an additional 500 kWh in Base Usage allowance during the winter season and an added 180 kWh in Base Usage allowance during the spring and fall seasons. To be eligible, the customer's electric space heating system must be the sole source of domestic space heating installed at the metered premise, except in the case of renewable heating sources, noted in criteria 4 listed below. In addition the electric space heating system must meet one of the following eligibility criteria:

1. An electric space heating system that qualified under the Closed Electric Heat rate before May 1, 1996, **or**

2. A heat pump, including any unit with electric resistance backup, **or**
3. An electric resistance heating system that was installed prior to September 1, 1980, **or**
4. An electric resistance heating system used to supplement a geo-thermal, solar or other renewable fuel heating system.

Non-renewable sources of space heat systems that do **not** qualify for the added residential electric space heat Base Usage allowances include:

- Fossil fuels such as natural gas, propane, gasoline and oil;
- Wood and pelletized fuels.

(B) Domestic Well Eligibility (Rate Categories RWGH, RWEH, RWCH)

Residential customers who own and operate a well that is their sole source of domestic water, are eligible for an additional 300 kWh of monthly Base Usage quantity on the residential meter serving the well.

(C) Master-Metered Multifamily Accommodation and Mobile Home Park Billing (Rate Category RSMM)

The master-metered customer's electricity consumption will be billed under the Base Usage and Base-Plus Usage Quantities using the ratio of the number of occupied single-family accommodations with Electric or Standard Space Heat to the total number of occupied single-family accommodations. The billing calculation will include applicable discounts to the Base Usage Charge and System Infrastructure Fixed Charge for qualifying energy assistance and medical equipment discount program participants. The customer must advise SMUD within 15 days following any change in the number of occupied single-family accommodations wired for electric service and/or any change in the number of qualifying medical equipment discount and/or energy assistance program participants, and/or new occupants of the existing premises with Rate Categories RSCH or RWCH.

X. Billing Proration of Charges

The Base Usage and Base-Plus Usage allowances will be prorated during non-standard billing periods and when the billing period spans more than one season. The following table shows the basis for the proration during these circumstances. The monthly System Infrastructure Fixed Charge will not be prorated, regardless of the number of days in the billing period or the spanning of multiple seasons.

Billing Circumstance	Basis for Proration
Bill period is shorter than 27 days	Relationship between the length of the billing period and 30 days
Bill period is longer than 34 days	
Seasons overlap within bill period	Relationship between the length of the billing period and the number of days that fall within the respective season.

(End)

Appendix C

Process Diagrams

This appendix contains a process diagram glossary and diagrams for the following processes:

- Billing
- Provisioning IHDs
- Support Repeaters
- Replacing IHDs
- Device Swap
- Un-provision Device
- Meter Change Outs
- Internal Even Notification
- Customer Conservation Day Notification
- Billing for Interval Data

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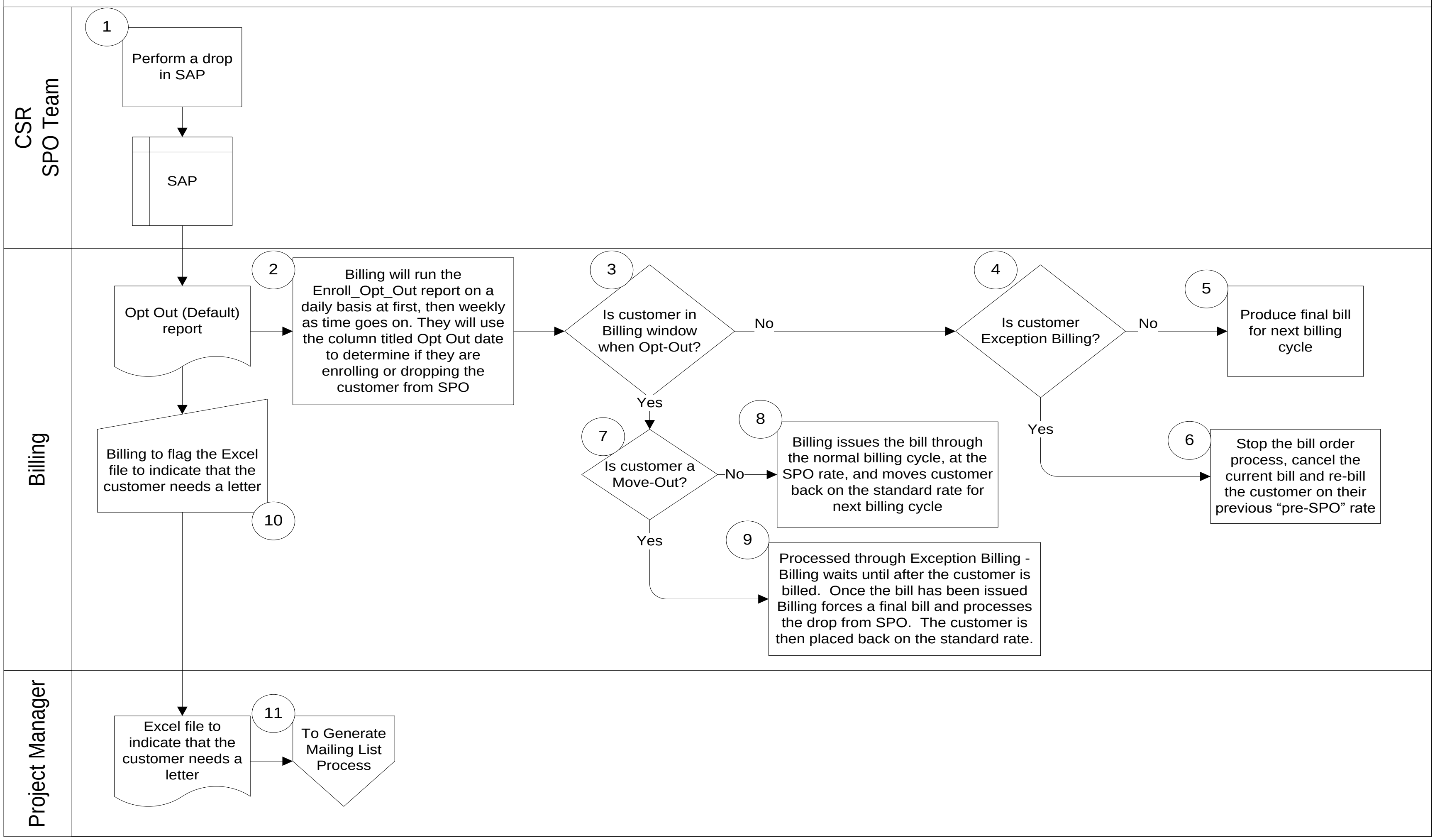
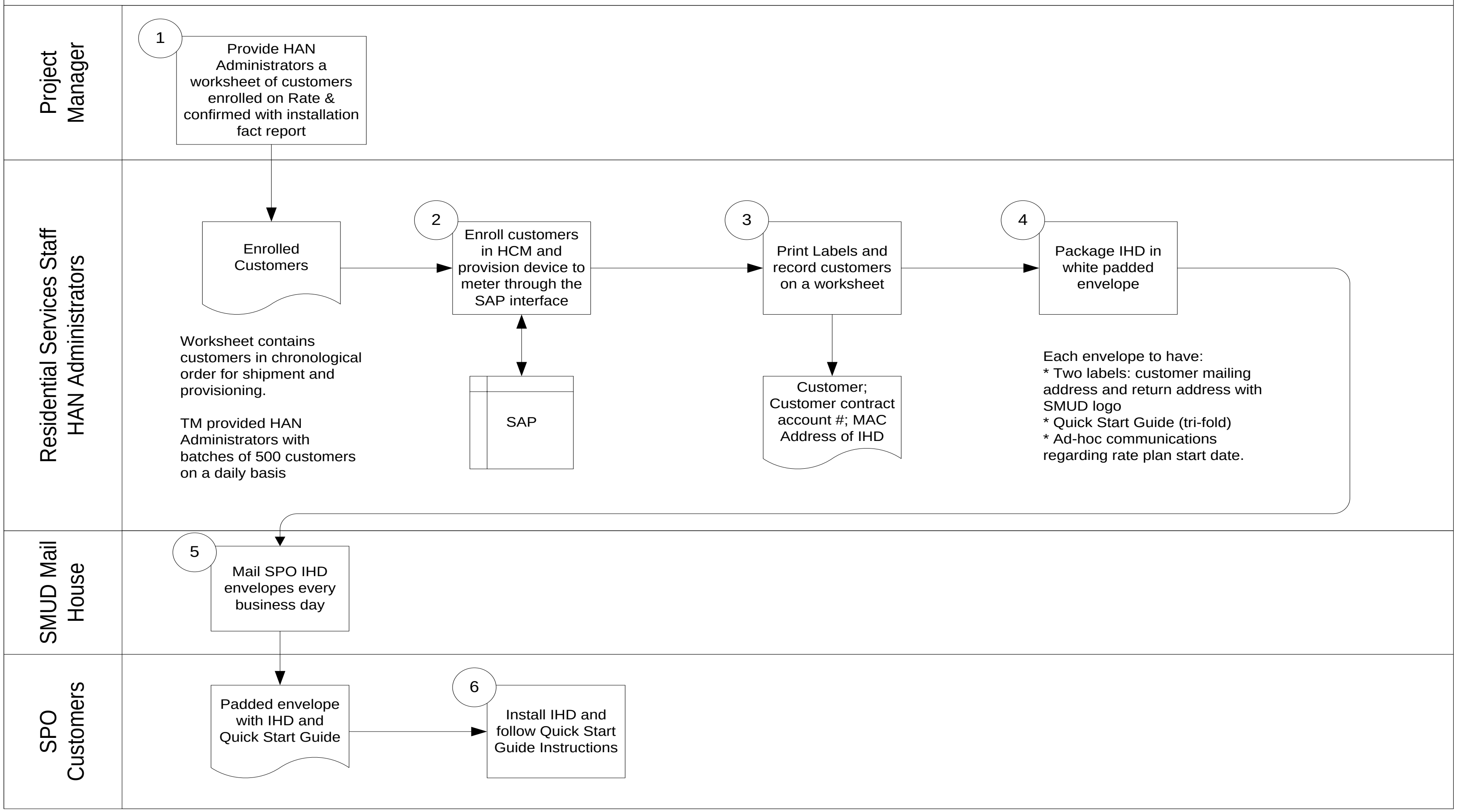
SPO – Billing – Opt-Out v5 05/28/2013 Process 03



SPO – Provisioning - IHDs v5 05/28/2013 Process 06



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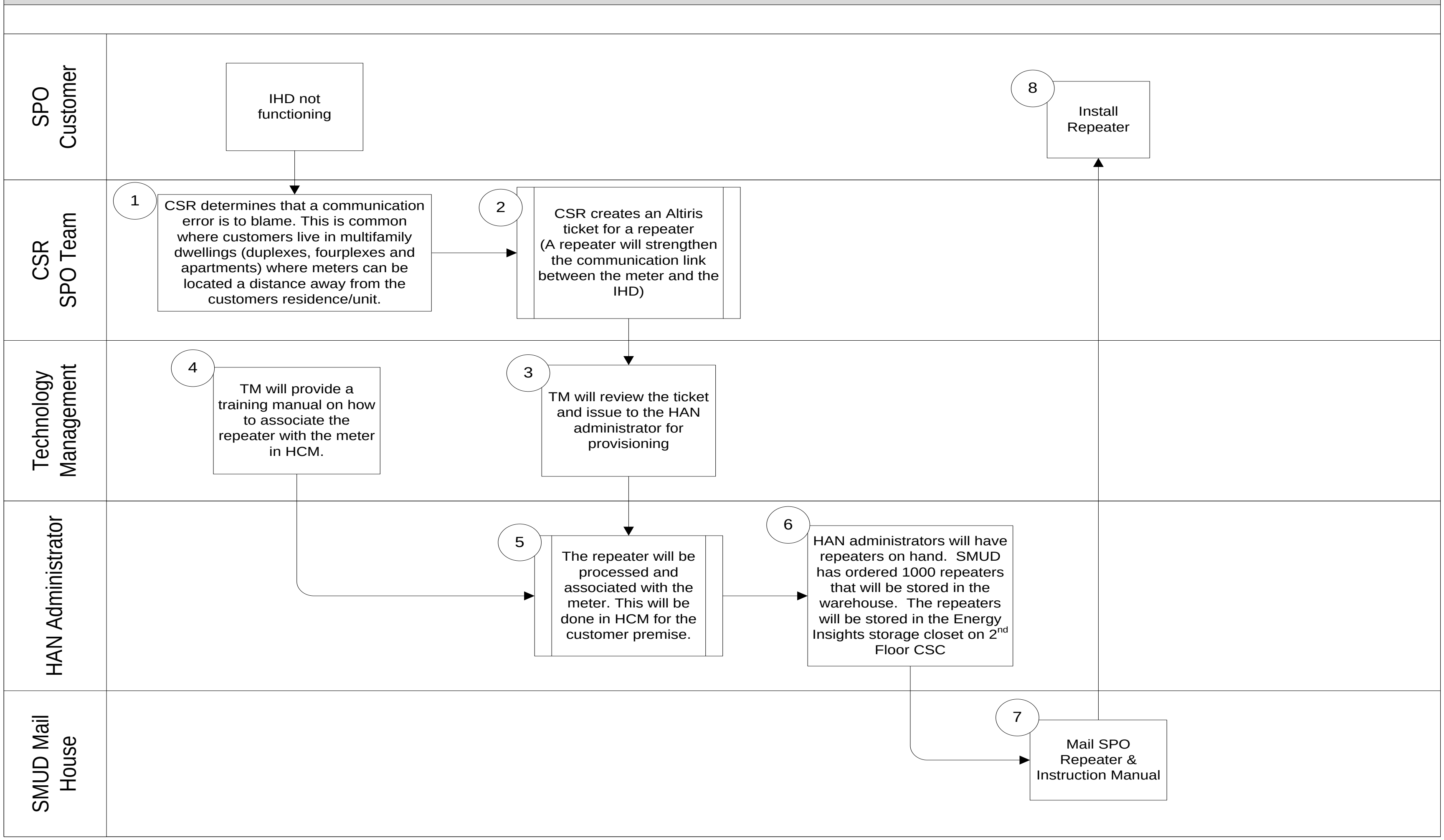
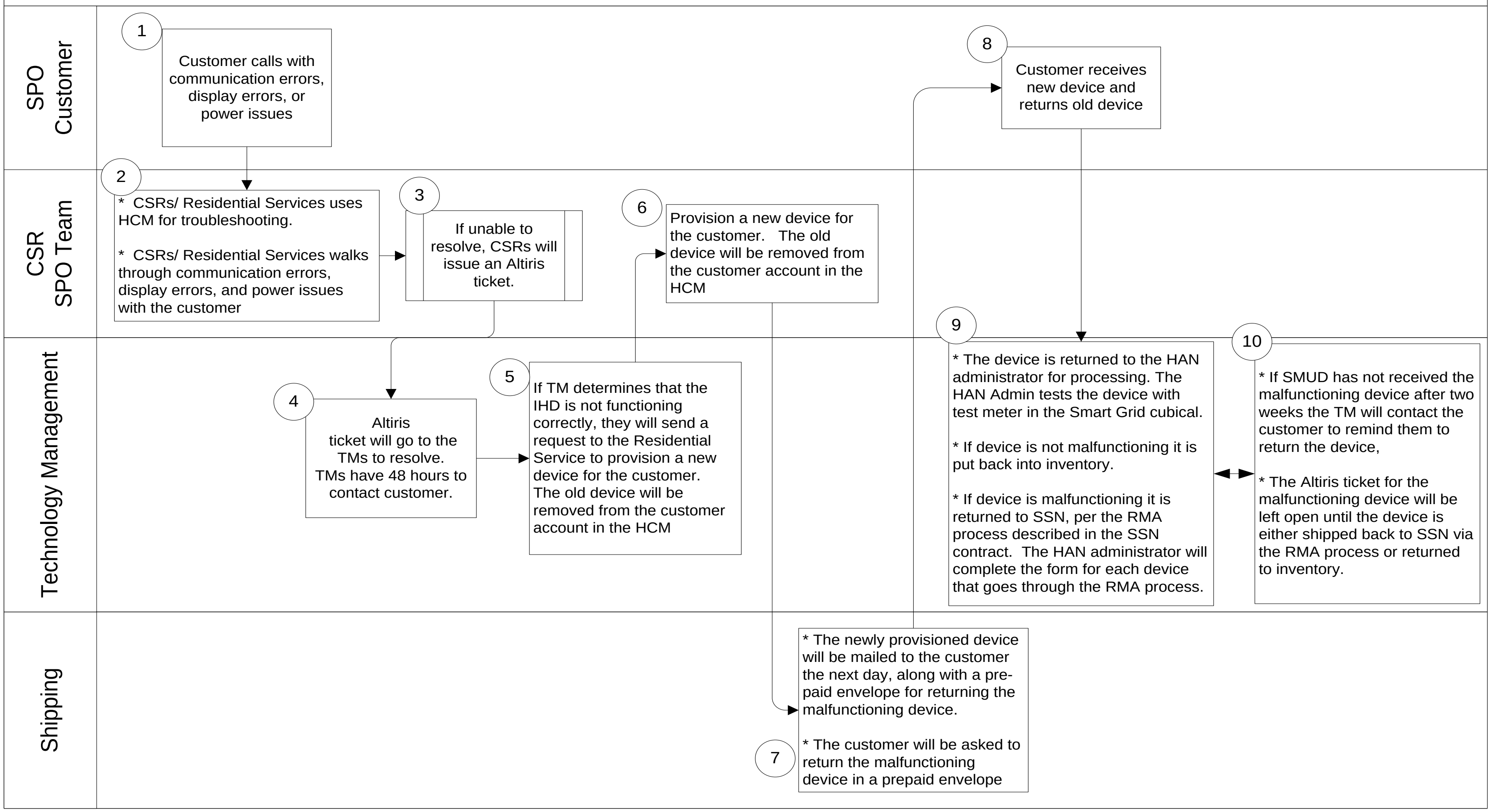
SPO – Support - Repeaters v5 05/28/2013

Process 07



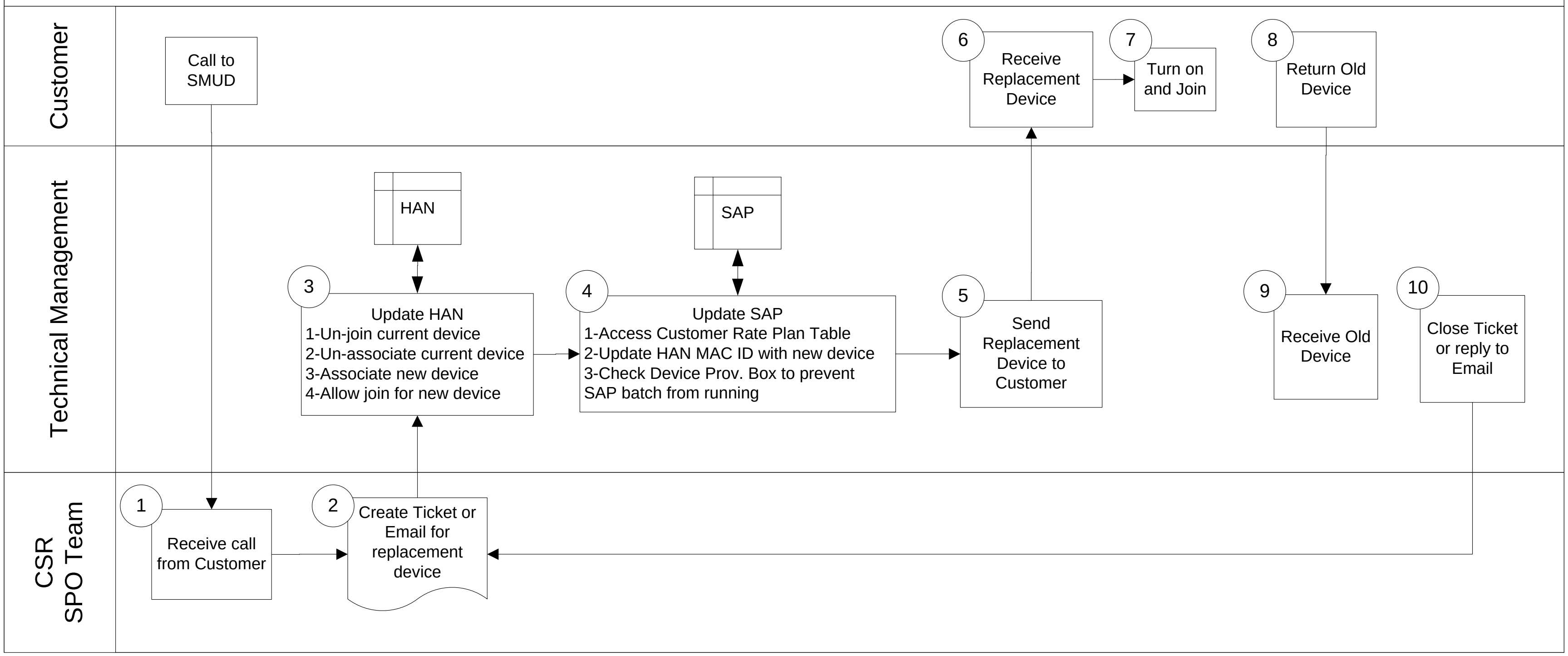
SPO – Replacing an In Home Display (IHD) v5 05/28/2013

Process 08

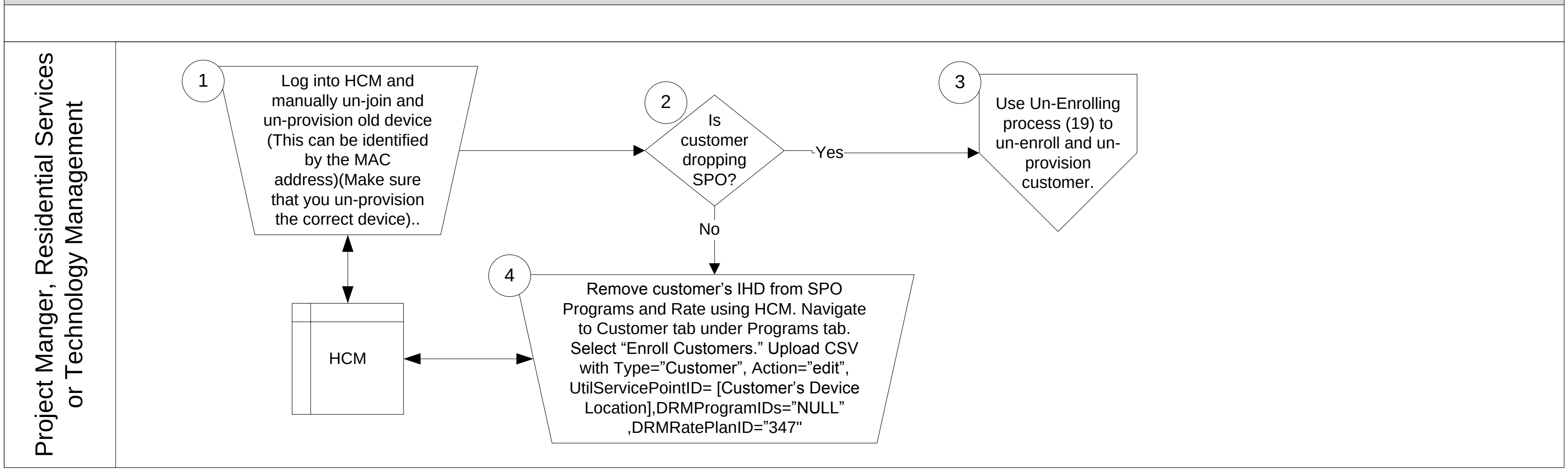


SPO – Device Swap - Provision a replacement device to meter v5 05/28/2013

Process 09



SPO – Un-provision a device v5 05/28/2013 Process 10



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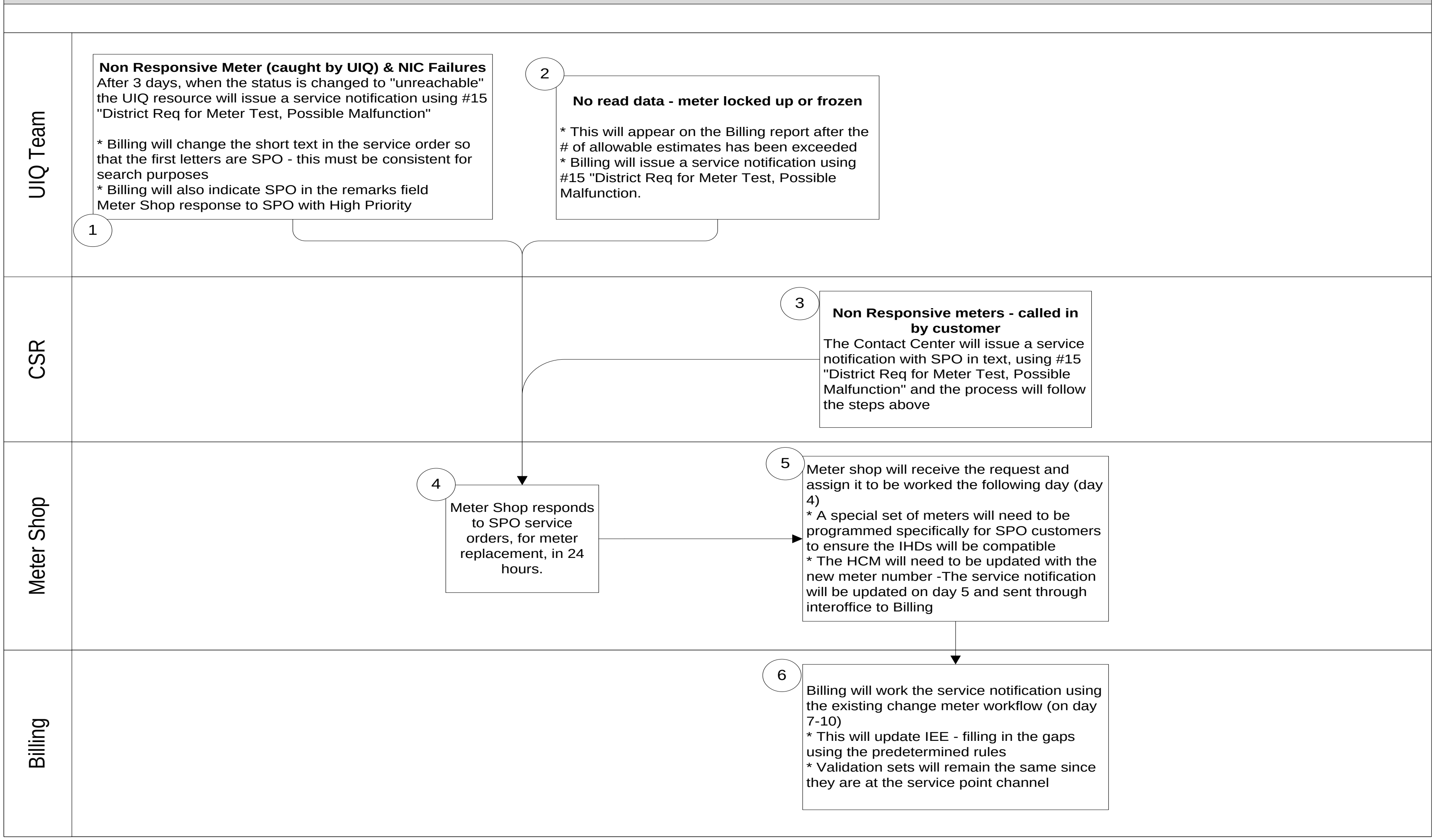
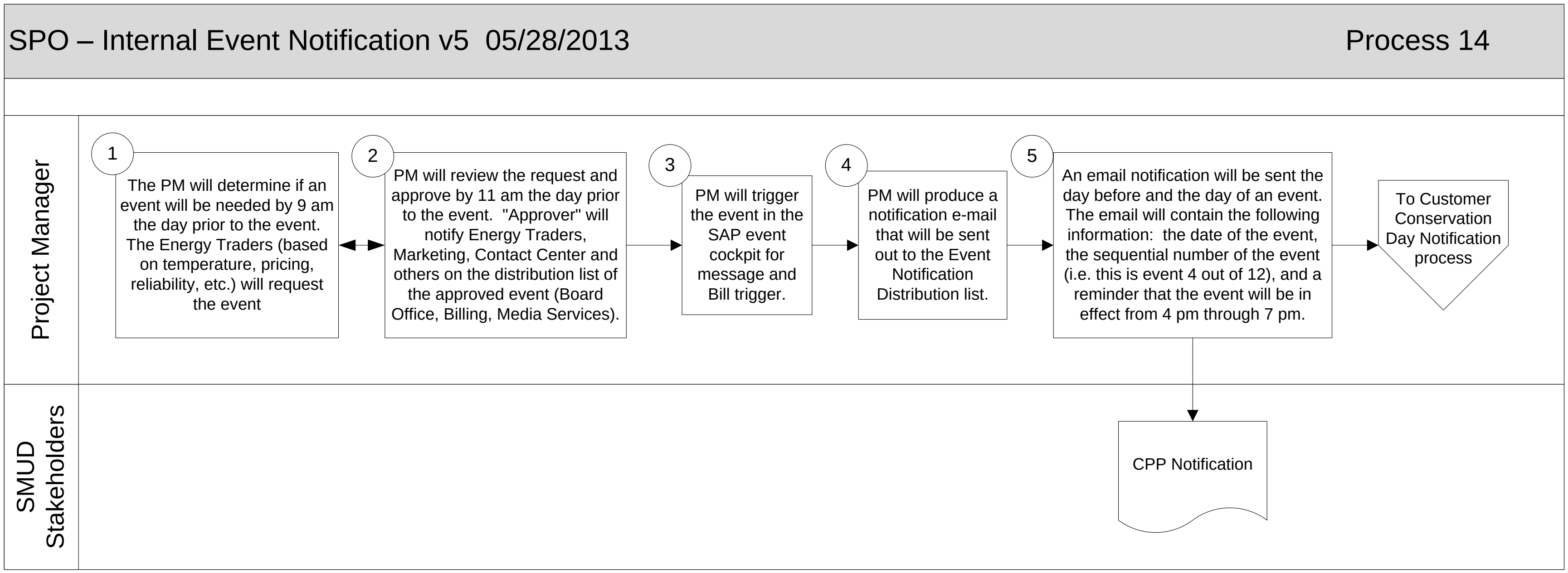
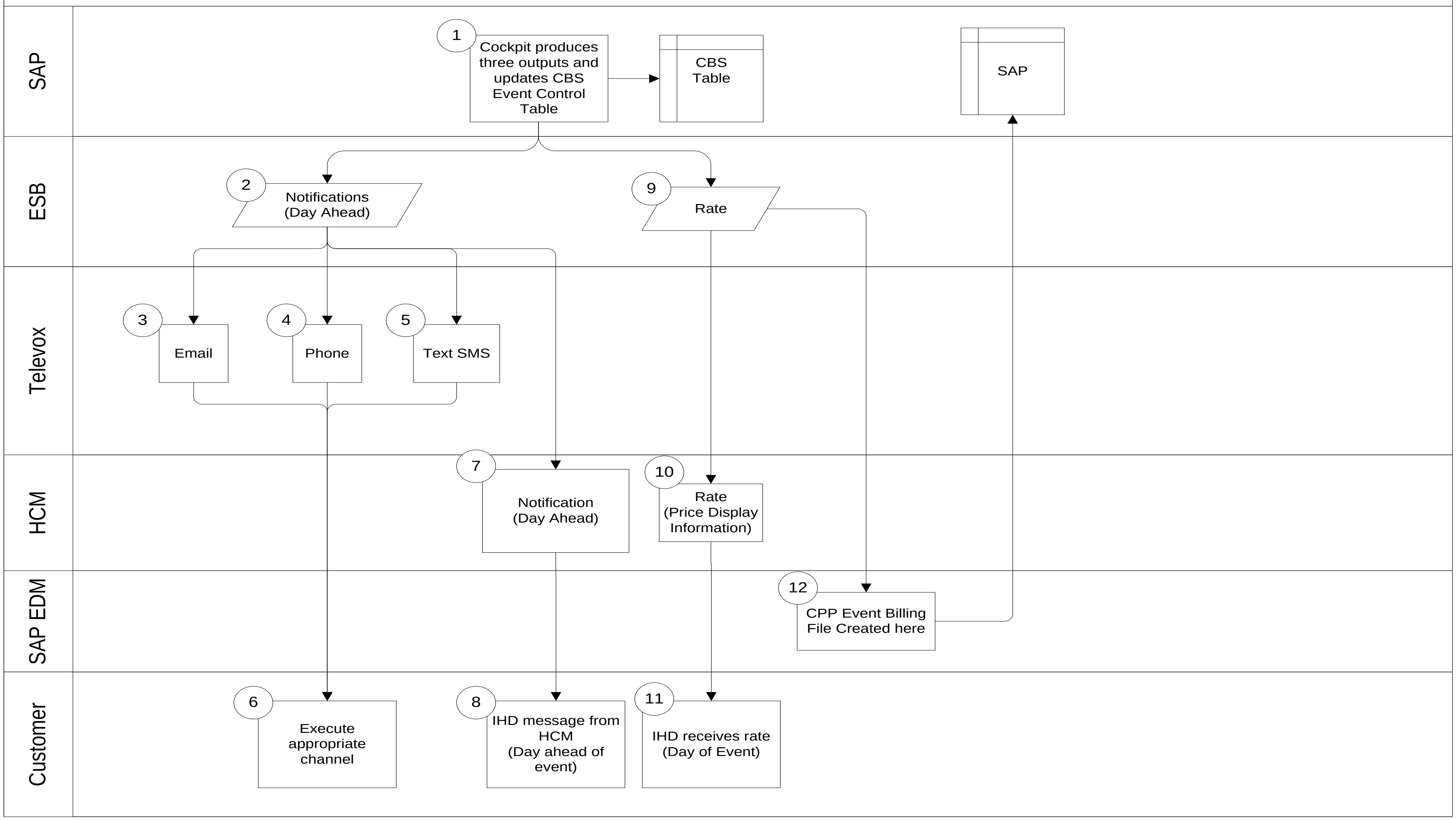
SPO – Process for Meter Change Outs v5 05/28/2013 Process 12

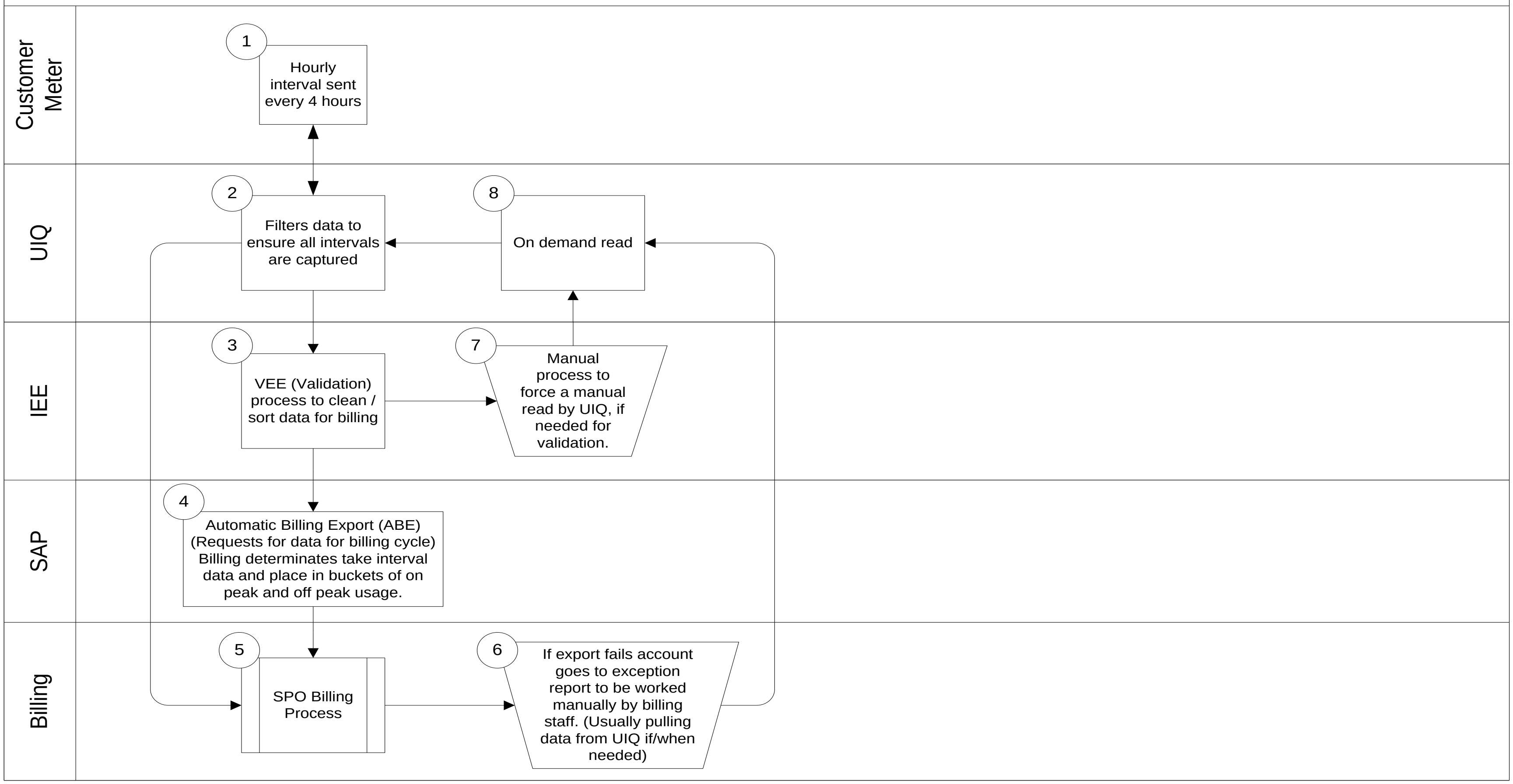



SMUD
SPO – Internal Event Notification v5 05/28/2013
Process 14
Project Manager
SMUD Stakeholders
1
The PM will determine if an event will be needed by 9 am the day prior to the event. The Energy Traders (based on temperature, pricing, reliability, etc.) will request the event
2
PM will review the request and approve by 11 am the day prior to the event. "Approver" will notify Energy Traders, Marketing, Contact Center and others on the distribution list of the approved event (Board Office, Billing, Media Services).
3
PM will trigger the event in the SAP event cockpit for message and Bill trigger.
4
PM will produce a notification e-mail that will be sent out to the Event Notification Distribution list.
5
An email notification will be sent the day before and the day of an event. The email will contain the following information: the date of the event, the sequential number of the event (i.e. this is event 4 out of 12), and a reminder that the event will be in effect from 4 pm through 7 pm.
To Customer Conservation Day Notification process
CPP Notification

SPO – Customer Conservation Day Notification v5 05/28/2013 Process 15



SPO – Billing for Interval Data (IT) v5 05/29/2013 Process 16



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Process Diagram Glossary

Acronym	Description	Area Found/Used
ABE	Automatic Billing Export	Data - Billing
BRC	Business Reply Card	Recruitment
CBS	Customer Behavior Study	Data – Customer Demographics
CINFO	Customer Information	Data - Customer
CPP	Critical Peak Price	Rate - Plan
CSC	Customer Service Center	Dept./Unit
CSR	Customer Service Representative	SMUD Staff
EAPR	Low Income Assistance Program	Rate - Plan
HAN	Home Area Network	Asset(s)
HCM	HAN Communication Manager	Provisioning
IEE	ITRON Enterprise Edition	Management Program/System
IHD	In Home Display	Asset
NIC	Network Interface Card	Asset
OMS	Outage Management System	Management Program/System
PR	Public Relations	
PRAJ	Public Relations Adjustment	Billing/Rate Adjustment
PS	Performance Solutions	SMUD Staff
QR Codes	Quick Reader Codes	Software
RDI	Raw Data Interface	
REIT	Residential Education Information Tool	Web portal for residential customers
RICNE	Opt-in CPP rate no tech	Billing / Enrollment
RICTE	Opt-in CPP rate with tech	Billing / Enrollment
RITND	Opt-in TOU no tech deferred	Billing / Enrollment
RITNE	Opt-in TOU no tech eligible	Billing / Enrollment
RITTD	Opt-in TOU with tech deferred	Billing / Enrollment
RITTE	Opt-in TOU with tech eligible	Billing / Enrollment
RMA	Return Material Authorization	Provisioning / Support

Acronym	Description	Area Found/Used
RSS	Residential Service Staff	SMUD Staff
SAP	Systems, Applications and Products	Data
SAS (code)	Statistical Analysis Software	Management Program/System
Scan Tags	Quick Reader Codes	Software
SGIG (PMs)	Smart Grid Investment Grant	DOE Funding Program
SPO	Smart Pricing Option	Rate - Plan
SSN	Silver Spring Network	Communication System
TM	Technology Management	Dept./Unit
TOU	Time Of Use	Rate - Plan
UIQ	Utility IQ	Application brand name for SSN
YDT	Yesterday's Data Today	Software

Appendix D

Sample Bills

This appendix contains sample bills for the following rates:

- Summer Weekday Value Plan (TOU)
- Off-Peak Discount Plan (CPP)
- Optimum Off-Peak Plan (TOU-CPP)
- Summer Weekday Value Plan – Energy Assistance Program Rate (TOU-EAPR)

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Power Outages 1 (888) 456-7683

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P.O. Box 15830, Sacramento, CA 95852-1830
smud.org

Account Number:

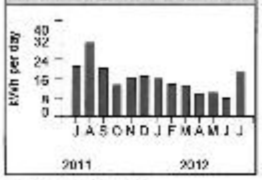
Issue Date: 08/10/12 | **Total Amount, Due 09/07/12** | **$62.30**

Location:				
Rate:	RSGH_SP:SmartPricing Options			
Cycle:	06	Location Number:		

Usage History	Dates	Days	kWh/Day	$/Day
Billing Period	07/10/12 - 08/07/12	29	19.1	$2.15
Last Year	07/12/11 - 08/09/11	29	21.3	$2.51
Last Month	06/08/12 - 07/09/12	32	8.0	$1.13

Meter No.	Current Meter Read	Previous Meter Read	Difference	Multiplier	Usage	Usage Type
	20136					Current Meter Reading
	552.5700	0.0000	552.5700	0	553	kWh
	527.5716	0.0000	527.5716	0	528	kWh Summer Off Peak
	24.9984	0.0000	24.9984	0	25	kWh Summer On Peak
	0.0000	0.0000	0.0000	0	0	kWh Winter

Your Average kWh use per day



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ELECTRIC SERVICE CHARGES/CREDITS	USAGE	TYPE	RATE	TOTAL
SmartPricing Options Summer Weekday Value Plan				
Off-Peak Base Usage	528	Summer kWh	@ 0.084600	44.67
On-Peak Weekday Usage	25	Summer kWh	@ 0.270000	6.75
System Infrastructure Fixed Charge*				10.00
Solar Surcharge	553	kWh	@ 0.001300	0.72
State Surcharge*				0.16
A) TOTAL ELECTRIC SERVICE CHARGES/CREDITS				**$62.30**

ACCOUNT ACTIVITY SINCE LAST STATEMENT	
Beginning balance from last Statement	36.22
Payment-Credit Card	-36.22
B) PREVIOUS BALANCE	**$0.00**

*See explanations on the back of the page

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Account Number:

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CURRENT CHARGES DUE 9/07/12

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Account Number:

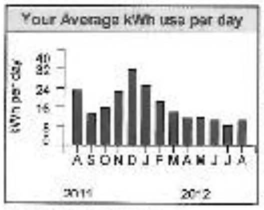
Issue Date: 09/13/12 **Total Amount, Due 10/10/12** **$43.06**

Location:	
Rate:	**RSCH_SP:SmartPricing Options**
Cycle:	08 Location Number:

Usage History	Dates	Days	KWh/Day	$/Day
Billing Period	08/11/12 - 09/11/12	32	10.7	$1.35
Last Year	08/12/11 - 09/12/11	32	23.2	$2.82
Last Month	07/13/12 - 08/10/12	29	8.8	$1.37

Meter No.	Current Meter Read	Previous Meter Read	Difference	Multiplier	Usage	Usage Type
	10027.0000	9684.0000	343.0000	0	343	kWh
					5	kWh Conservation Day

Your Average kWh use per day



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Conservation Days this Period
08/14/12
08/16/12

ELECTRIC SERVICE CHARGES/CREDITS	USAGE	TYPE	RATE	TOTAL
SmartPricing Options Off-Peak Discount Plan				
Base Usage	338	Summer kWh	@ 0.085100	28.76
On Peak Conserv Day Usage	5	Summer kWh	@ 0.750000	3.75
System Infrastructure Fixed Charge*				10.00
Solar Surcharge	343	kWh	@ 0.001300	0.45
State Surcharge*				0.10
A) TOTAL ELECTRIC SERVICE CHARGES/CREDITS				**$43.06**

ACCOUNT ACTIVITY SINCE LAST STATEMENT	
Beginning balance from last Statement	40.29
Payment-Check Free	-40.29
B) PREVIOUS BALANCE	**$0.00**

C) TOTAL DUE (A+B) **$43.06**

Please pay all current charges by the date to avoid a one-time late fee of up to $0.65 (1.5% of current charges)

*See explanations on the back of the page

SMUD Please detach and return with your payment
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ID:

Account Number:

PAY THIS AMOUNT

$43.06

CURRENT CHARGES DUE 10/10/12

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Account Number:

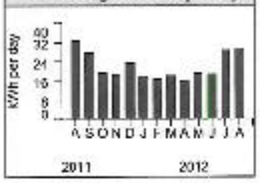
Issue Date: 09/12/12 **Total Amount, Due 10/09/12** **$102.51**

Location:	
Rate:	**RSGH_SP:SmartPricing Options**
Cycle:	07 Location Number:

Usage History	Dates	Days	kWh/Day	$/Day
Billing Period	08/09/12 - 09/07/12	30	29.9	$3.42
Last Year	08/10/11 - 09/08/11	30	32.8	$4.76
Last Month	07/11/12 - 08/08/12	29	28.8	$3.23

Meter No.	Current Meter Read	Previous Meter Read	Difference	Multiplier	Usage	Usage Type
	8587					Current Meter Reading
	898.3056	0.0000	898.3056	0	898	kWh
	871.9188	0.0000	871.9188	0	872	kWh Summer Off Peak
	26.3868	0.0000	26.3868	0	26	kWh Summer On Peak
					4	kWh Conservation Day
	0.0000	0.0000	0.0000	0	0	kWh Winter

Your Average kWh use per day



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ELECTRIC SERVICE CHARGES/CREDITS	USAGE	TYPE	RATE	TOTAL
SmartPricing Options Optimum Off-Peak Plan				
Off-Peak Base Usage	700	Summer kWh	@ 0.072100	50.47
Off-Peak Base Plus Usage	172	Summer kWh	@ 0.141100	24.27
On-Peak Weekday Usage	22	Summer kWh	@ 0.270000	5.94
On-Peak Consrv-Day Usage	4	Summer kWh	@ 0.750000	3.00
System Infrastructure Fixed Charge*				10.00
Fixed Greenergy All Renewables				6.00
Solar Surcharge	898	kWh	@ 0.001300	1.17
Sacramento County Tax*				1.40
State Surcharge*				0.26
A) TOTAL ELECTRIC SERVICE CHARGES/CREDITS				**$102.51**

Conservation Days this Period
08/09/12
08/10/12

*See explanations on the back of the page

SMUD™ Please detach and return with your payment
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Account Number:

PAY THIS AMOUNT

$102.51

CURRENT CHARGES DUE 10/09/12

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Account Number:

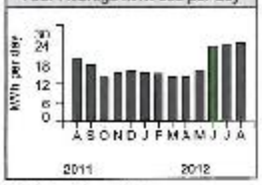
Issue Date: 08/31/12 **Total Amount, Due 09/28/12** **$62.90**

Location:	
Rate:	RWGH E SP:SmartPricing Options
Cycle:	21 Location Number:

Usage History	Dates	Days	kWh/Day	$/Day
Billing Period	07/31/12 - 08/28/12	29	24.4	$2.17
Last Year	08/02/11 - 08/30/11	29	19.9	$1.50
Last Month	06/29/12 - 07/30/12	32	23.9	$2.02

Meter No.	Current Meter Read	Previous Meter Read	Difference	Multiplier	Usage	Usage Type
	11204					Current Meter Reading
	708.7380	0.0000	708.7380	0	709	kWh
	579.1932	0.0000	579.1932	0	579	kWh Summer Off Peak
	129.5448	0.0000	129.5448	0	130	kWh Summer On Peak
	0.0000	0.0000	0.0000	0	0	kWh Winter

Your Average kWh use per day



Visit My Account at SMUD.org for more information on your usage!

ELECTRIC SERVICE CHARGES/CREDITS	USAGE	TYPE	RATE	TOTAL
SmartPricing Options Summer Weekday Value Plan				
Off-Peak Base Usage	579	Summer kWh	@ 0.084600	48.98
On-Peak Weekday Usage	130	Summer kWh	@ 0.270000	35.10
System Infrastructure Fixed Charge*				3.50
Energy Assistance Program Discount				-26.24
Solar Surcharge	709	kWh	@ 0.001300	0.92
Sacramento County Tax*				0.43
State Surcharge*				0.21
A) TOTAL ELECTRIC SERVICE CHARGES/CREDITS				**$62.90**

ACCOUNT ACTIVITY SINCE LAST STATEMENT

	Beginning balance from last Statement	64.70
08/02/12	Payment	-64.70
08/08/12	**B) PREVIOUS BALANCE**	**$0.00**
08/09/12		
08/10/12		
08/14/12		

*See explanations on the back of the page

SMUD Please detach and return with your payment ID:
Make check payable to SMUD

Account Number:

PAY THIS AMOUNT

$62.90

CURRENT CHARGES DUE 9/28/12

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Appendix E

Consumer Behavior Study Plan

This appendix contains the Consumer Behavior Study Plan submitted to and approved by the U.S. Department of Energy

SmartSacramento

Prepared for U.S. Department of Energy

Prepared by: **Sacramento Municipal Utility District**

SMUD
SACRAMENTO MUNICIPAL UTILITY DISTRICT
6201 S Street, P.O. Box 15830, Sacramento, CA 95852-1830
The Power To Do More.®

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DESIGN ELEMENTS

STUDY OBJECTIVES

The main objective of Sacramento Municipal Utility District's (SMUD) Consumer Behavior Study (CBS) is to investigate the effectiveness of integrating AMI-enabled time-variant pricing, enhanced information, and appliance controls to induce behavior change. The treatments of interest in this study are of three types: recruitment strategy, rate design, and end-use automation. SMUD believes this research will provide necessary information to assist in maintaining low rates and high levels of customer satisfaction, while sending appropriate price signals to consumers to encourage responsible electricity consumption. Moreover, SMUD is sensitive to the potential impacts the CBS may have on customer satisfaction, customer service, and monthly summer bills. In response to these concerns, the CBS Plan (Plan) incorporates carefully designed experimental rates, a complete customer service and support portfolio, education to assist informed decision-making, personalized information feedback to allow customers to manage their consumption daily, and technology to make it easier for customers to save.

SMUD is located in California's Central Valley where hot summer temperatures and a very high saturation of air conditioning equipment result in peak load requirements over a relatively short number of hours. SMUD's peak load is 3000 MW. The top 42 hours account for approximately 400 MW of peak load. The goal of dynamic pricing is to engage customers in assisting SMUD reduce its current and future power requirements during daily peak demand and the 42 hours that make up the critical peak period. The specific objectives of the CBS time-variant rates include the following:

- To provide a clear high price signal to the customer during SMUD's summer peak period
- To otherwise encourage customers to shift their loads by lowering prices during non-peak periods
- To assure that the customer who chooses not to shift, or cannot shift load, is not penalized with bills that are significantly higher than on the otherwise applicable rate.

The Plan details how SMUD will implement, evaluate, and report findings for the proposed CBS. Specifically, SMUD is interested in measuring change in electricity use (kWh), change in peak demand (kW), and participation in the CBS pricing and technology programs with residential and commercial impacts. The CBS will also measure the impact of the time-variant rates on customer satisfaction. In addition, the CBS intends to determine the demographic, housing characteristics, and customer perceptions associated with behavior change.

The Plan proposes a field study of two consecutive summers, with CBS experimental rates effective June-September 2012 and June-September 2013. A sample of customers with pre-treatment data available for June-September 2011 will be selected for enrollment in one of the proposed CBS rate treatments or control groups. The CBS rate offer will be combined with information feedback tools, educational materials, and end-use automation and offered as a SMUD program to customers in the treatment groups. Customers who enroll will be encouraged to remain in the program from June 1, 2012-September 30, 2013 or until actively dropping from the program. SMUD will allow customers to remain on the CBS rates[1] after the study has ended.

Treatment variables included in the field study are detailed below.

Recruitment

- Opt-in
- Opt-out

Rates

- Critical Peak Period (CPP)
- Time of Use (TOU)
- Time of Use with Critical Peak Period (TOU-CPP)

End-Use Automation and Information Feedback Device

- Offer for device and installation at no cost
- No offer for device or installation

[1] Rates designed for the Consumer Behavior Study may be modified by the District in subsequent rates processes after the study period has ended. Rates offered to customers on the existing CBS rates and customers who enroll on the rates after the study period will be subject to these potential changes.

Figure 1 below depicts the opt-out treatments to be included in the field study. Figure 2 depicts the opt-in treatments to be included in the CBS.

Figure 1 Consumer Behavior Study Opt-Out Treatments

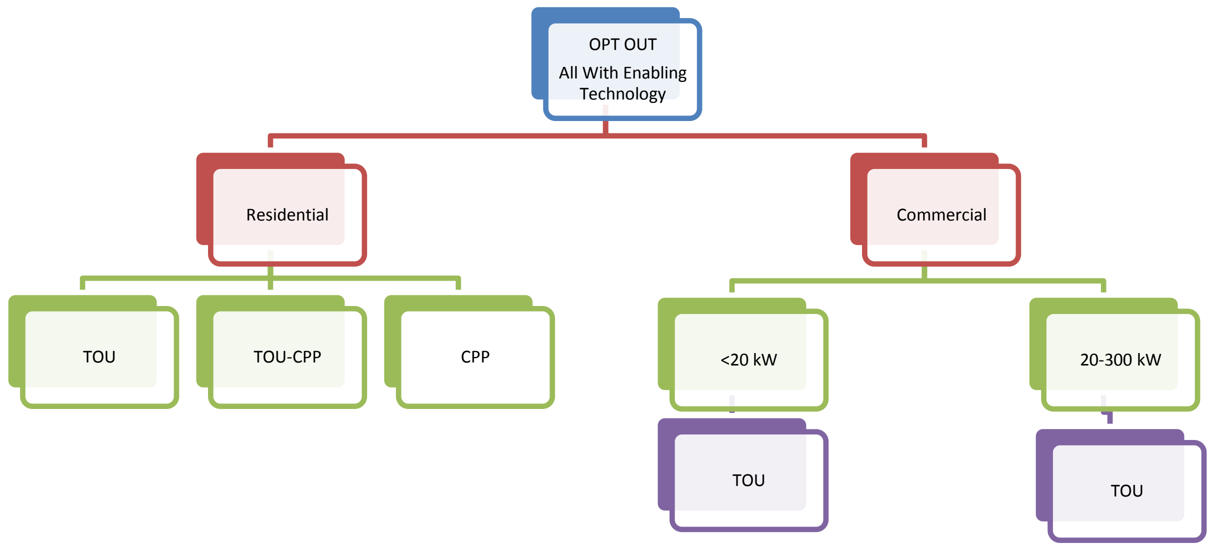
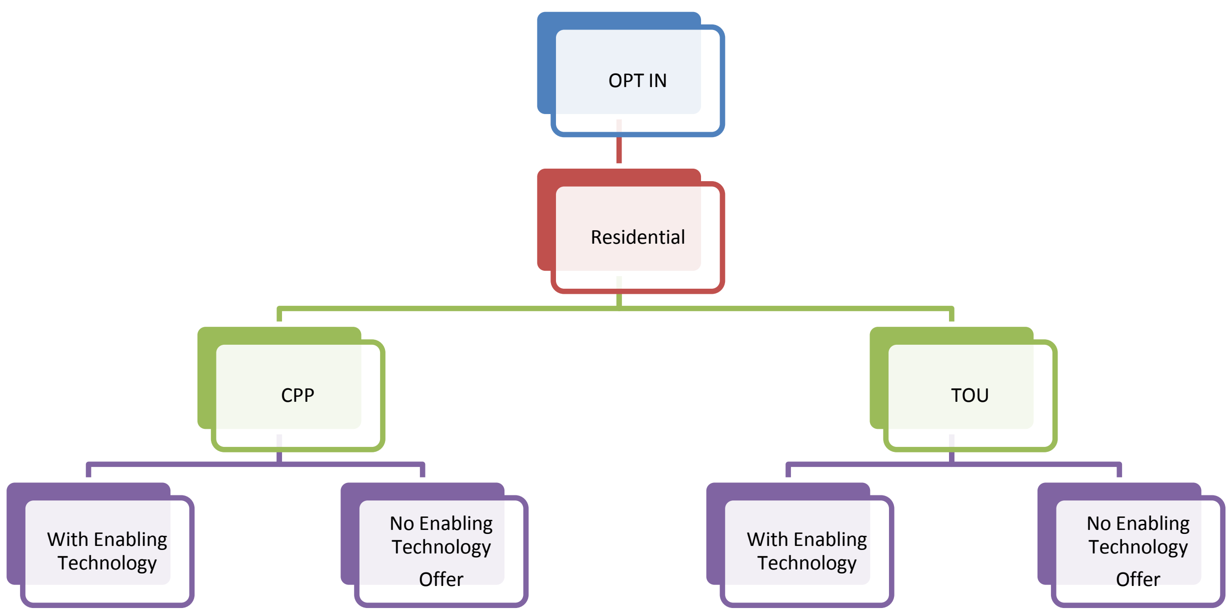


Figure 2 Consumer Behavior Study Opt-In Treatments



The Plan describes the two-year application of experimental rate options on a sample population of SMUD customers with the intent of determining:

- Electricity impacts of each of the treatments
- Customer characteristics associated with behavior
- The roles of enabling technology and end-use automation in customers' daily electricity management
- Program impacts on customer satisfaction
- Rate and enabling technology program value to utility
- Expected market penetration for rate and enabling technology programs
- Effective educational and marketing strategies for customers

RESEARCH QUESTIONS

Research Questions to Be Answered by the Field Study

Table 1 below describes the research questions related to electricity impacts that will be addressed by the field study.

Table 1 Consumer Behavior Study Electricity Impact Research Questions

Treatment Group	Research Questions to be Answered	Hypothesis
Residential Opt-in TOU without technology offer	How does an opt-in TOU rate without a free enabling technology offer affect participant summer, daily, and event load for residential customers?	1. During the test period, average daily energy use for residential customers on the opt-in TOU rate without a free technology offer is lower for the treatment group than for the control group. 2. During the test period, peak energy use for residential customers on the opt-in TOU rate without a free technology offer is lower for the treatment group than for the control group. 3. On event days, peak demand for residential customers on the opt-in TOU rate without a free technology offer is lower for the treatment group than for the control group.

Treatment Group	Research Questions to be Answered	Hypothesis
Residential Opt-in TOU with technology offer	How does an opt-in TOU rate with a free enabling technology offer affect participant summer, daily, and event load for residential customers?	1. During the test period, average daily energy use for residential customers on the opt-in TOU rate with a free technology offer is lower for the treatment group than for the control group. 2. During the test period, peak energy use for residential customers on the opt-in TOU rate with a free technology offer is lower for the treatment group than for the control group. 3. On event days, peak demand for residential customers on the opt-in TOU rate with a free technology offer is lower for the treatment group than for the control group.
Residential Opt-in CPP without technology offer	How does an opt-in CPP rate without a free enabling technology offer affect participant event load for residential customers?	1. On event days, peak demand for residential customers on the opt-in CPP rate without a free technology offer is lower for the treatment group than for the control group.
Residential Opt-in CPP with technology offer	How does an opt-in CPP rate with a free enabling technology offer affect participant event load for residential customers?	1. On event days, peak demand for residential customers on the opt-in CPP rate with a free technology offer is lower for the treatment group than for the control group.
Residential Opt-out TOU with technology offer	How does an opt-out TOU rate with a free enabling technology offer affect participant summer, daily, and event load for residential customers?	1. During the test period, average daily energy use for residential customers on the opt-out TOU rate with a free technology offer is lower for the treatment group than for the control group. 2. During the test period, peak energy use for residential customers on the opt-out TOU rate with a free technology offer is lower for the treatment group than for the control group. 3. On event days, peak demand for residential customers on the opt-out TOU rate with a free technology offer is lower for the treatment group than for the control group.
Residential Opt-out CPP with technology offer	How does an opt-out CPP rate with a free enabling technology offer affect participant event load for residential customers?	1. On event days, peak demand for residential customers on the opt-out CPP rate with a free technology offer is lower for the treatment group than for the control group.

Treatment Group	Research Questions to be Answered	Hypothesis
Residential Opt-out TOU-CPP with technology offer	How does an opt-out TOU-CPP rate with a free enabling technology offer affect participant summer, daily, and event load for residential customers?	1. During the test period, average daily energy use for residential customers on the opt-out TOU-CPP rate with a free technology offer is lower for the treatment group than for the control group. 2. During the test period, peak energy use for residential customers on the opt-out TOU-CPP rate with a free technology offer is lower for the treatment group than for the control group. 3. On event days, peak demand for residential customers on the opt-out TOU-CPP rate with a free technology offer is lower for the treatment group than for the control group.
Commercial 20-299 kW GSN Opt-out TOU with technology offer	How does an opt-out TOU rate with a free enabling technology offer affect participant summer, daily, and event load for commercial GSN customers?	1. During the test period, average daily energy use for commercial GSN customers on the opt-out TOU rate with a free technology offer is lower for the treatment group than for the control group. 2. During the test period, peak energy use for commercial GSN customers on the opt-out TOU rate with a free technology offer is lower for the treatment group than for the control group. 3. On event days, peak demand for commercial GSN customers on the opt-out TOU rate with a free technology offer is lower for the treatment group than for the control group.
Commercial >20 kW GSS Opt-out TOU with technology offer	How does an opt-out TOU rate with a free enabling technology offer affect participant summer, daily, and event load for commercial GSS customers?	1. During the test period, average daily energy use for commercial GSS customers on the opt-out TOU rate with a free technology offer is lower for the treatment group than for the control group. 2. During the test period, peak energy use for commercial GSS customers on the opt-out TOU rate with a free technology offer is lower for the treatment group than for the control group. 3. On event days, peak demand for commercial GSS customers on the opt-out TOU rate with a free technology offer is lower for the treatment group than for the control group.

Research Questions to Be Answered by Market Research

The following research questions will be addressed by primary research, integration and analysis of third-party data at the customer level, post hoc field study analysis and data mining.

Customer Characteristics

- What household and housing variables are associated with demand response, program enrollment, and acceptance of the enabling technology offer?
- What perceptions and attitudes are aligned with demand response, program enrollment, and acceptance of the enabling technology offer?

Enabling Technology

- What roles do the various enabling technology offerings (e.g. web portal, in-home display, programmable communicating thermostat) play in the customer's home and lifestyle?
- What is the initial acceptance rate of the free enabling technology offer?
- What is the final rate of installation of the enabling technology?
- What portion of customers program the end-use automation to automatically respond to daily and event peak pricing, and in what way do they respond (e.g. pre-cooling, thermostat setback)
- What characteristics of the enabling technology, end-use automation, and information feedback devices were considered useful, and which were not?
- What additional features or characteristics do customers desire in the various technology offerings?

Customer Satisfaction and Expectations

- What are customer expectations in terms of potential electricity impacts, potential bill impacts, and behavior changes or investments needed to achieve savings?
- Did participation in the experimental rates meet their expectations in terms of potential electricity impacts, potential bill impacts, and behavior changes or investments needed to achieve savings?
- How satisfied are participants with:
    - their experience with experimental rates?

    - their experience with the various technology offerings?
    - the educational materials?
    - the channels, timing, and delivery of event notifications?
- How did customer perceptions of SMUD change as a result of participation in a time-variant rate?

Value to Utility

- How much value will SMUD receive from the rate response in terms of net cost savings and firm reliability of summer load reduction?

Market Penetration

- What are the expected participation and retention rates of the various experimental rate options?
- Why do customers choose not to participate or to drop from the experimental rates?

Education Assessment

- What messaging will be most effective at transitioning customers to the various rate options?
- Which topics will be most informative to teach customers how to benefit from the various rates?
- What lexicon is most appropriate to market and educate customers about the experimental rates and the primary program components (e.g. technology, event notification)?
- To what extent do customers understand the experimental rates and how those rates relate to their energy use and monthly bill?
- To what extent are customers accessing educational materials and via which channels?

Target Population and Sample Selection

The Plan targets the initial 267,000[2] smart meters that are scheduled to be installed prior to June 1, 2011 in the SMUD service territory. Of those, approximately 241,000 will be residential and 26,000 will be commercial. Targeting these meters will allow for pre-treatment load data to be collected for one year prior to implementation of the CBS rates. Accounts with interval

[2] The number of customers available for inclusion in the CBS sample frame is dependent upon the actual smart meter deployment. The smart meter deployment schedule is owned by the SmartSacramento Smart Meter project.

meter data available beginning June 1, 2011 will be screened for the following exclusion criteria. The remaining accounts will constitute the sample frame. Estimated eligible accounts to be included in the residential sample frame is 173,878. Estimated eligible accounts to be included in the commercial sample frame is 26,129. The population for the residential treatments is the entire SMUD residential customer base, excluding those customers meeting the criteria detailed below. The population for the commercial treatments is defined as SMUD commercial customers who have a smart meter installed prior to June 1, 2010, excluding those customers meeting the criteria detailed below.

Screening

Residential customers enrolled in SMUD's current residential opt-in TOU, master meter (mobile home), solar rate, or any of the following programs will be removed from the sample frame:

- Third Party Notification: A program that provides for special notifications to prevent unnecessary service interruptions because of late payments.
- Medical Equipment Discount Rate: Monthly discount for households that require use of a medical equipment device.
- Budget Billing: A voluntary program where customers receive a monthly bill with a payment amount based on the previous 12-month average
- Peak Corps[3] (ACLM): A voluntary air conditioning cycling program

Only SMUD's two smallest commercial classes will be included in the sample frame, Small Commercial Energy Metered (GSN <20 kW) and Small Commercial Demand Metered (GSS 20-300 kW). All other commercial classes will be excluded from the sample frame, as well as customers with solar, currently enrolled in SMUD's Voluntary Emergency Curtailment Program (VECP), or previously enrolled in SMUD's Commercial Air Conditioning Load Management program.

The final database after screening will be referred to as the Master Sample.

[3] Peak Corps members will be used for recruitment into an SGIG funded demand response program. CBS sample will be excluded from demand response recruitment. Customers will not be allowed joint enrollment in both the CBS (treatment or control group) and any demand response program; the recruitment groups will be mutually exclusive. CBS customers will not be permitted enrollment in the demand response program, which can be mitigated with the explanation that the demand response program is a pilot.

Sampling

For each of the three sectors, the accounts in the Master Sample will be numbered sequentially to allow for random selection. For each of the nine treatments, SMUD will generate a number of random integers (between 1 and the number of customers in the Master Sample) equal to the combined size of the treatment plus control group. The random numbers generated will be used to identify the customers pull from the Master Sample.

> For example, if the residential Master Sample contains 100,000 customers and the treatment calls for 150 participants plus 150 control customers, we will generate 300 random numbers between 1 and 100,000 (e.g. 1, 751, 4056, 80,020, etc.). Those 300 numbers will be matched against and pulled from the Master Sample to construct the first group.

As each group is selected, the remaining customers in the Master Sample will be renumbered sequentially, and the process continues until all nine groups are chosen. Each of the nine groups will then be randomly divided between treatment and control using the same method.

Ensuring a Representative Sample

The final selections will be compared to territory-wide averages on the relevant parameters for which reliable data can be obtained. If notable differences in key variables are present, the selection process will be repeated until a satisfactory samples are drawn. The list below describes the parameters to be included in this analysis. In the event that the sample varies by 1% or greater on any of the following variables, the selection process will be repeated until a suitable[4] sample is selected.

1. Average summer electricity use
2. Housing type (single family vs. multifamily)
3. Heating (electric vs. gas)

Sample Calculations

Determination of sample sizes took into account multiple factors. Once treatments of interest were identified, each treatment was assigned to one of the three study designs. For each treatment minimum detectable effects were identified for each of the research questions; type

[4] In the event that less than 1% difference is not achieved within a reasonable number of attempts, alternative solutions will be considered, such as sample stratification or accepting the increased difference.

I and type II error tolerances were determined; expected participation, attrition, and end-use automation acceptance rates were applied, and the applicable power calculation was performed to determine sample sizes. Sample sizes which were not driven by a power calculation used the sample sizes from the Statewide Pricing Pilot and SMUD's Summer Solutions pilot, as well as Table 4-5 in EPRI's "Guidelines for Designing Effective Energy Information Feedback Pilots: Research Protocols" as guidelines for determining sample sizes that would potentially detect an effect if the effect exists.

The process used for performing the power calculations is detailed in Appendix C, includingthe specific calculations used for the RED and RCT power analysis to determine the minimum required sample sizes for 90% confidence with 10% precision. All calculations assume comparison of the treatment group to the respective control group.

Table 2 Consumer Behavior Study Sample Summary

Treatment Group	Design	Final Enrollment Sept 30, 2012	Postponed Enrollment Oct 1, 2012	Control Group Required	Type I error α	Type II error β	kappa	Detectable Effects kWh (summer)	Detectable Effects kW (daily)	Detectable Effects kW (event)
Residential Opt-in TOU without technology offer	RCT	942	942	942	0.10	0.20	0.80	0.05	0.05	0.20
Residential Opt-in TOU with technology offer	RCT	1570	1570	1570	0.10	0.20	0.80	0.05	0.05	0.20
Residential Opt-in CPP without technology offer	Within Subjects	150	0	-	0.10	0.20	0.80	0.12	0.12	0.12
Residential Opt-in CPP with technology offer	RED	1131	0	20,998	0.05	0.20	0.80	-	-	0.20
Residential Opt-out TOU with technology offer	RED	992	0	37,682	0.10	0.20	0.80	0.05	0.05	0.20
Residential Opt-out CPP with technology offer	RED	345	0	16928	0.05	0.20	0.80	-	-	0.20
Residential Opt-out TOU-CPP with technology offer	Within Subjects	300	0	-	0.10	0.20	0.80	0.08	0.09	0.08
Commercial 20-299 kW GSN Opt-out TOU with technology offer	RED	299	0	11365	0.10	0.20	0.80	0.05	0.05	0.20
Commercial >20 kW GSS Opt-out TOU with technology offer	RED	58	0	2208	0.10	0.20	0.80	0.05	0.05	0.20
TOTAL		**5787**	**2512**							

Participation

The Plan proposes testing both opt-in and opt-out recruitment. Customers will be educated about the rate offered, the benefits of the program, and tools available to assist them in managing their electricity use. Customers will be encouraged to participate in the rate; however SMUD will not interfere with customers who wish not to be enrolled in the program. There will be no time limits restricting when a customer can leave the program.

Treatment groups identified as opt-out recruitment will receive notification that they have been enrolled in a new time-variant rate program. All opt-out treatment groups will receive an offer for an end-use automation device installed at no cost. Customers who receive this enrollment notification will be given a no-pressure option to opt out of the program without penalty or repercussions. Customers who opt out will not be permitted to rejoin the program during the study period.

Treatment groups identified as opt-in recruitment will receive an invitation to participate in a new time-variant rate program. Some of the opt-in treatments will receive the device offer, while others will have the device offer withheld. Customers who enroll in the offered program and subsequently drop will not be permitted to re-enroll in the program during the study period.

In order to refine estimated enrollment rates, preferred enrollment channels, device acceptance rates, and resource planning, SMUD will conduct a recruitment test period. A subset of the treatment sample will be randomly selected for early recruitment into the respective programs. Findings from the pretest will be used to adjust the total number of planned notifications and assist in resource planning. The purpose of the pretest is to assist in operational planning rather than testing collateral; therefore, no changes to the marketing campaign are anticipated.

Rate Designs

Design of SMUD Experimental CBS Rates

Overview

This section presents the proposed CBS rates for study participants and provides background on their design, pricing objectives and preliminary impacts. The CBS rates presented here are drafts that will undergo review by the public and SMUD Board of Directors beginning in spring 2011 with final approval planned for July 2011. They become effective in June 2012. While the rates may change during the review process, the overall design elements should remain intact.

During the same rate process, the Board will be considering several structural changes to residential and small commercial rates which will affect the basis for the proposed CBS rates. At this point, the CBS rates assume adoption of these structural changes.

In particular, the restructuring will add time-of-use billing components to the small commercial rates, essentially pre-empting the planned CBS small commercial rate designs. For that reason, small commercial customers will be dropped from the CBS study if these new rates are adopted. If the new rates are not adopted, the CBS plan will include small commercial rates with added time-of-use billing components.

The primary residential change in the restructured rates under consideration will be the creation of a four-month summer season. This change will not affect the design of CBS residential rates, although it will assist study participants in transitioning to the new summer prices.

Objectives

SMUD's proposed CBS rates create higher prices during summer peak periods with the aim of encouraging study participants to shift their electric use to lower-cost off-peak periods. While focused on this overall goal, staff sought to design the rates following general principles of cost recovery, economic efficiency, customer equity, rate simplicity and minimal negative cost impact. To meet these objectives, the CBS rate designs employ the following features:

- *Peak Period Pricing* based on marginal generation and energy-related costs to provide a realistic price signal during SMUD's peak period.
- *Revenue Neutrality* for the average class customer by discounting the base energy prices to offset the higher peak pricing,
- *Little Change to Bill Structure* to help minimize bill impact, for example, by keeping the original residential tier structure for the off-peak period pricing, and
- *Shortened Peak Period* to only three hours to facilitate customer load shifting.

Residential Control Group Rates

The CBS plan assumes the residential control group will remain on the SMUD residential rates which have been proposed to be effective January, 2012. Briefly, these rates feature the following characteristics:

- They employ a two-tier inclining price structure with seasonal changes to both price and tier baseline energy allowances.
- Customers with wells for domestic water use receive an additional 300 kWh base tier allowance to compensate for required pumping energy.
- Low income customers receive a discount both in the monthly service charge and the energy charges for Tier 1 and Tier 2.
- The rates introduce a new third tier for low income customers at an undiscounted price. Table 3 shows the new Tier 3 allowance for low income customers, including those with domestic water wells.

Table 3 Proposed New Tier Allowances for Low Income Customers

	Residential Customer	Tier 1	Tier 2	Tier 3
Energy Tier Allowances (kWh per month)	Standard Customer	< 700	700 - 1,425	> 1,425 kWh
	With Domestic Well	< 1,000	1,000 - 1,725	> 1,725 kWh

Table 4 presents the current SMUD residential rate tariff alongside proposed rate changes that may be approved for implementation by June, 2012. The proposed rates re-define the summer months to June – September to align with the CBS summer rate period. They increase the service charge for standard customers to $10.00 while commensurately lowering tier energy charges.

Table 4 Current and Proposed SMUD Residential Rates In Effect June 2012

Rate	Option	Service Charge	Tier 1	Tier 2	Tier 3
Current 2011 Summer Rate (May-October)	Standard	$7.20	$0.1045	$0.1859	
	Low Income	$3.50	$0.0679	$0.1301	
Proposed 2012 Summer Rate (June - September)	Standard	$10.00	$0.1016	$0.1830	
	Low Income	$3.50	$0.0660	$0.1281	$0.1830

Notes:

1. Current rates effective January, 2011.
2. Low income rates provide a discount for Tier 1 charges by 35% and for Tier 2 charges by 30%. Service charge remains fixed at $3.50.
3. Staff proposed rates have not been presented for Board review and approval. Effective date would be January 1, 2012.
4. Proposed Tier 3 for low income eliminates discount for energy use above 725 kWh plus Tier 1 allowance, which equals 1.425 kWh for standard low income customers, and 1,725 for low income customers with wells for domestic water use.

Small Commercial Control Group Rates

General Service Non-Demand (GSN) rates apply to the smallest SMUD commercial customers whose load does not exceed 20 kW. Larger General Service (GSS) rates apply to customers whose peak load ranges between 20 – 299 kW. As noted previously, SMUD proposes to introduce new time-of-use summer rates for its small commercial customers who use less than 300 kW of load. If the Board adopts these new rates, it will be unnecessary to include this group as part of the CBS. On the other hand, if the Board does not adopt the rates, they will be included in the CBS with associated control groups which will remain on the applicable General Service commercial rates.

As shown in Table 5, GSN currently features a flat energy price with a relatively minor seasonal differential; GSS features a declining block energy structure and a 12-month ratchet demand charge[5].

[5] This bill component charges a fixed price per kW for the highest demand recorded during any 15-minute period over a rolling 12-month period.

Table 5 Current Small Commercial Rates

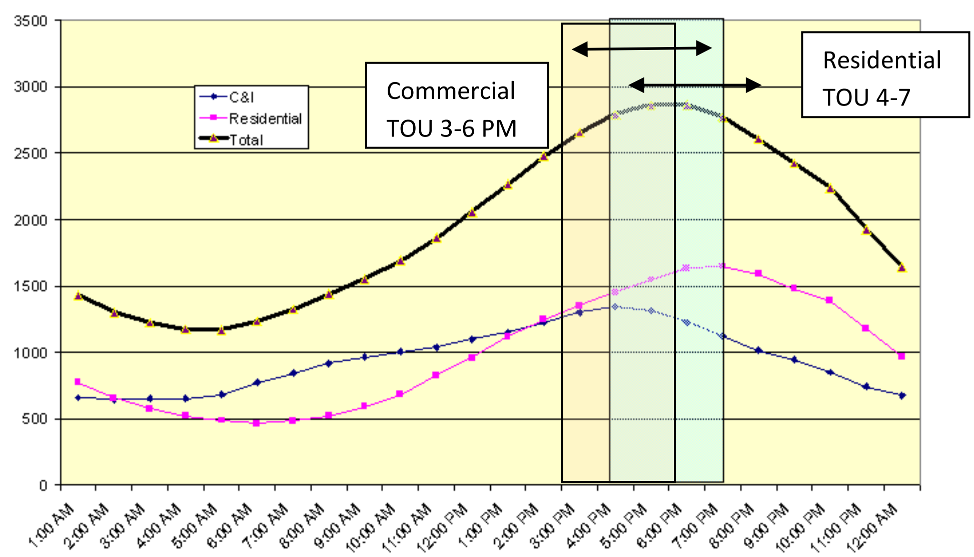
Rate Category	Service Charge	Demand Charge ($/ kW)	Energy Charges ($/kWh	
			< 7,300 kWh	> 7,300 kWh
GSN < 20 kW	$8.25	$0.00	$0.1271	
GSS 20-299 kW	$20.50	$6.80[6]	$0.1276	$0.0976

Peak Period Definition

To further assist customer load shifting, the Plan proposes limiting the high-priced peak period to only three hours during SMUD's system peak which occurs on summer weekday afternoons during the months of June through September. Figure 3 illustrates that commercial loads peak in mid-afternoon, while residential loads peak later.

In recognition of these use patterns, the proposed dynamic pricing will be established as 3 pm-6 pm for commercial customers and 4 pm - 7 pm for residential customers, creating a 2-hour overlap between 4 pm and 6 pm. For Critical Peak Pricing (CPP), the call periods are the 12 days during these defined periods, when market prices are highest, or SMUD's system is otherwise constrained by reliability factors. SMUD will call 12 CPP events each summer of the study period, regardless of actual conditions.

Figure 3 Residential and Commercial Contributions to SMUD Peak



6 Current GSS demand charge applies only to peak load in excess of 20 kW.

Residential Time-Variant and Dynamic Pricing Options

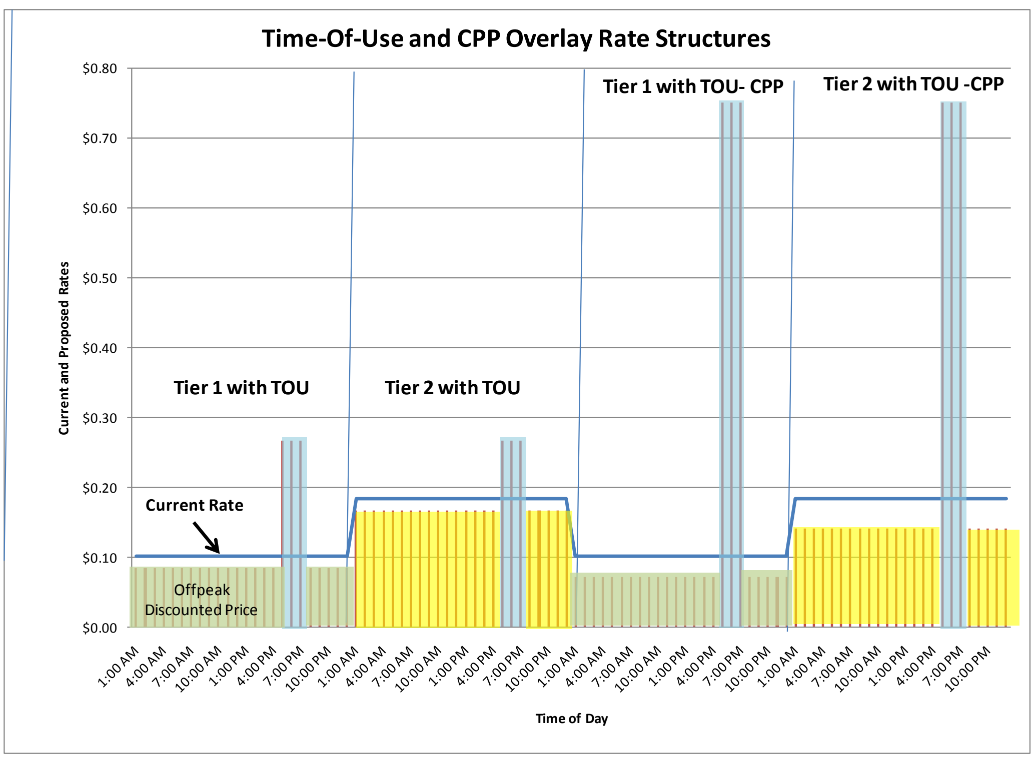
The CBS Plan seeks to minimize structural change to SMUD's residential two-tiered rate in order to avoid bill shock for smaller energy consumers. Currently, this subset of customers benefits from cross-subsidies by customers paying more on the second, higher-cost tier. The Plan will retain the basic underlying tier structure for off-peak pricing, while adding new peak time-of-use (TOU) and critical peak pricing (CPP) during the months of June – September. Winter pricing will be unchanged.

The three proposed CBS residential rates are as follows:

- A peak TOU rate for the 4-7 pm weekday afternoon period,
- A TOU rate combined with CPP, and
- A CPP stand-alone rate.

In each case, the peak rates are offset by lower off-peak pricing for Tier 1 and any Tier 2 energy use. Figure 4 illustrates the residential TOU and CPP residential rates for Tier 1 and Tier 2 billing days.

Figure 4 TOU and CPP Price Structure for Tier 1 and Tier 2 Bill Days[7]



[7] The proposed time-variant rates have been designed to maintain the existing tier structure of SMUD's standard rates and are references as "overlays."

Table 6 presents the proposed CBS rates for standard residential customers. Table 7 presents the variation of these rates for low-income customers, featuring discounted pricing and a new third tier off-peak price.

Table 6 Draft CBS Rates for Standard Residential Customers

	On-Peak Prices Weekdays: 4-7 PM		Off-Peak Prices (All Other Hours)		Monthly Service Charge
Standard Residential CBS Rate	**Peak Price**	**Critical Peak Price**	**Tier 1**	**Tier 2**	
Time-Of-Use Peak Rate	$0.27	-	$0.0846	$0.1660	$10.00
Time-Of-Use with Critical Peak Pricing	$0.27	$0.75	$0.0721	$0.1411	$10.00
Critical Peak Pricing (Stand-Alone)	-	$0.75	$0.0851	$0.1665	$10.00

Table 7 Draft CBS Rates for Low-Income Residential Customers

	On-Peak Prices Weekdays: 4-7 PM		Off-Peak Prices (All Other Hours)			Monthly Service Charge
Low Income Residential CBS Rate	**Peak Price**	**Critical Peak Price**	**Tier 1**	**Tier 2**	**Tier 3**	
Time-Of-Use Peak Rate	$0.20	-	$0.0550	$0.1162	$0.1660	$3.50
Time-Of-Use with Critical Peak Pricing	$0.20	$0.50	$0.0468	$0.0987	$0.1411	$3.50
Critical Peak Pricing (Stand-Alone)	-	$0.50	$0.0553	$0.1165	$0.1665	$3.50

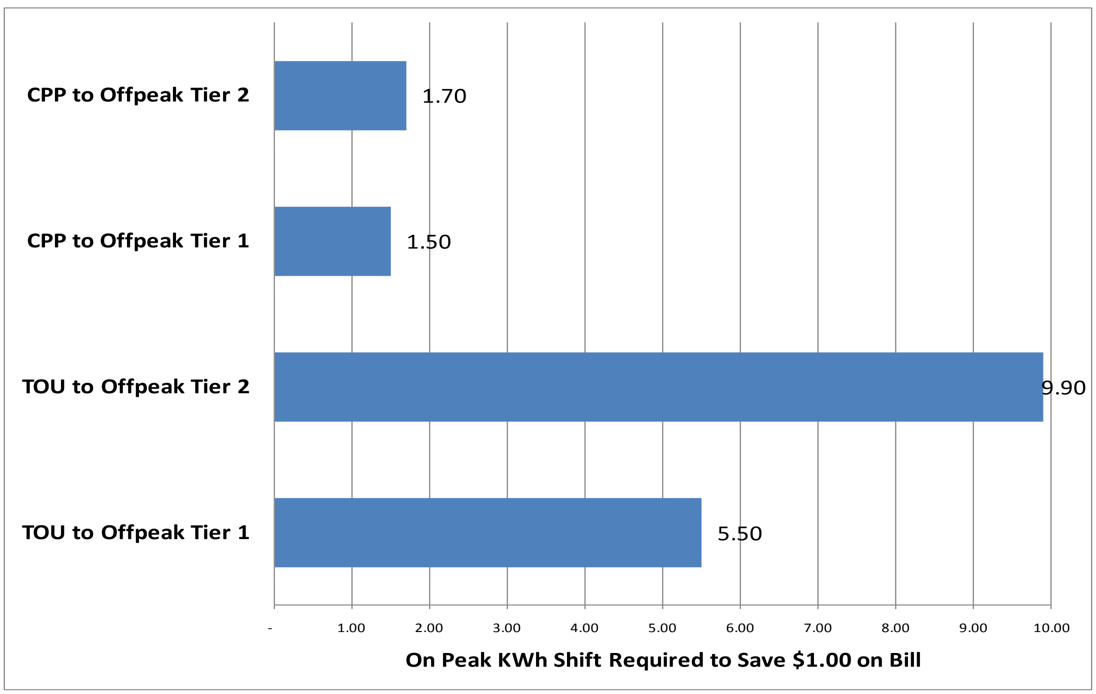
As indicated in Table 8, the draft peak price of $0.27 for TOU yields peak to off-peak ratios that average around 3-to-1, on a weighted basis. For CPP, the weighted average peak to off-peak ratios range from 7.5 for the stand-alone rate to 9.1 for CPP combined with TOU. These differentials determine the amount of energy the participant will need to shift out of the peak period for bill savings. As illustrated in Figure 5, customers on the TOU rate would need to shift 5.5 to 10 kWh per month to save one dollar on their bills. For customers on the CPP rate, they need only shift 1.5 to 2 kWh per month to save one dollar on their bills.

Table 8 Peak to Off-Peak Price Ratios by CBS Rate

Rate	Peak Period (4-7 PM)	Peak to Off-Peak Tier 1 Ratio	Peak to Off-Peak Tier 2 Ratio	Weighted Peak to Off-Peak*
Time-Of-Use Rate	TOU	3.2	1.6	2.8
Time-Of-Use with Critical Peak Pricing	TOU	3.7	1.9	3.3
	CPP	10.4	5.3	9.1
Critical Peak Pricing	CPP	8.8	4.5	7.5

* Based on average residual off-peak tier energy in AMI sample (Summer 2010)

Figure 5 Residential Peak Energy Shift Required Per $ Savings



Small Commercial Dynamic Pricing Options

As previously noted, small commercial peak rates will be included in the CBS if the SMUD Board fails to approve them in June 2011. Table 9 and Table 10 summarize the proposed rates for customers, respectively, on the GSN and GSS rates. The changes in common to both rates include re-defining the summer months to June – September, establishing a peak price period of 3-6 pm during weekdays, and increasing the monthly service charge.

For the GSN rate where customer loads are lower than 20 kW, the proposed rate will replace the flat rate with an on-peak and off-peak prices. This will create a peak to off-peak price ratio of around 2.7 to 1.0.

For the more complex GSS rate, where customer loads range between 20 kW and 299 kW, the proposed structural changes affect rates across both winter and summer seasons. However, for the CBS, the relevant changes in the summer rate include replacing the inverted tier pricing with on-peak and off-peak prices. This will create a peak to off-peak ratio of around 2.9 to 1.0.

Table 9 Proposed Time-of-Use Rate for Small Commercial (<20 kW)

Rate	Summer Months	Service Charge	On-Peak 3-6 PM Weekdays	Off-Peak (All Other Hours)
Current Rate	May - October	$8.25	$0.1271	
Proposed TOU Peak Rate	June - September	$12.00	$0.2837	$0.1050

Table 10 Proposed Time-Of-Use Rate for Small Commercial (20-299 kW)

Rate	Months	Demand Charge $/kW		Energy Charges $/kWh				Service Charge
		< 20 kW	> 20 kW	< 7,300 kWh	>7,300 kWh	On-Peak	Off-Peak	
Current Rate (2011)	May - October	-	$6.80	$0.1267	$0.0976	-		$20.50
Proposed TOU Rate	June - September	$6.80		-		$0.2336	$0.0810	$22.00

Development of TOU and CPP Pricing

SMUD's approach to both TOU and CPP options is to set the peak price close to the avoided cost of power. For both TOU and CPP pricing, SMUD will discount the average customer's base energy prices by a commensurate amount. In general, this approach will involve the following steps:

- Using its most current marginal cost data, SMUD will determine the value of avoided power consumption and generation capacity during the appropriate summer peak period.
- These avoided costs will be allocated to customer peak energy use from normalized hourly load-shapes from SMUD's load research sample. Adjustments are made to reconcile the values to revenue requirement, existing rate contribution to energy and capacity and other factors.
- To determine the basis for the off-peak discount, the expected added revenue from the peak pricing is divided by the expected off-peak energy.

Marginal Costs Used to Derive Peak Pricing

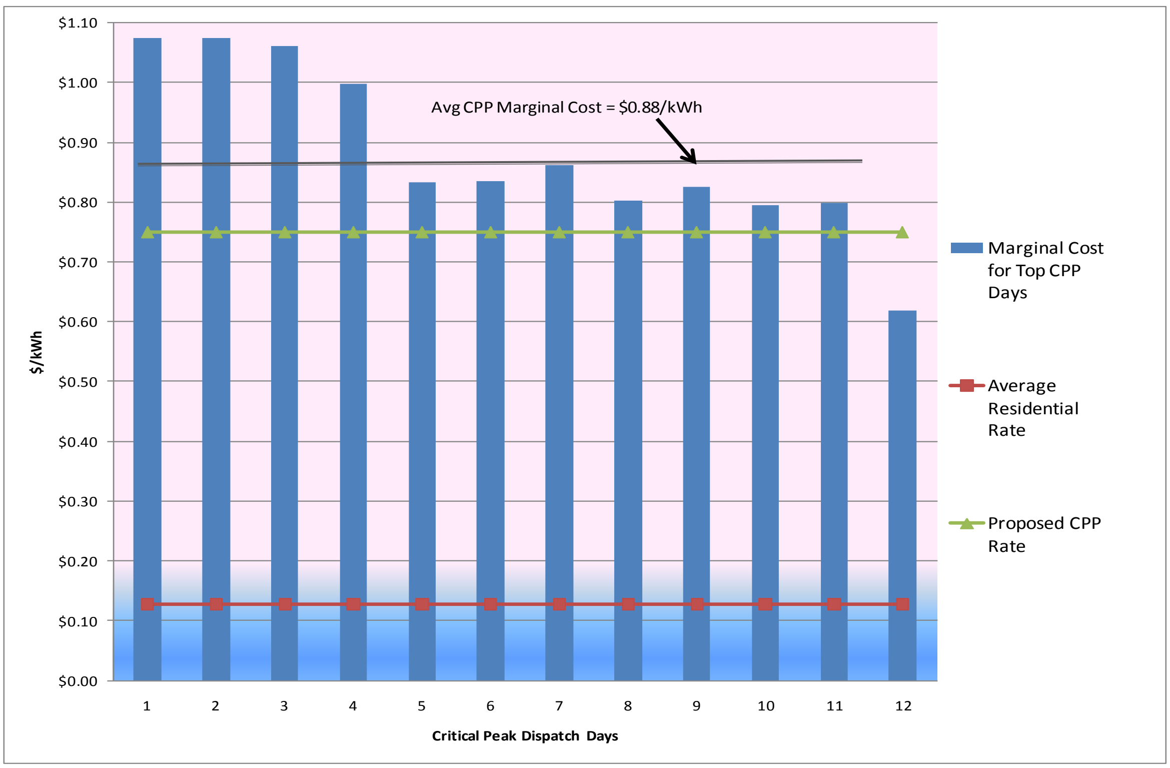
To develop the Plan's TOU and CPP pricing, SMUD utilized the following market-based cost components from its most current marginal cost study:

- *Market Energy,* based on a combination of SMUD's short term market forecast and the long term gas prices provided by a consultant. SMUD converts gas prices to energy prices using historical market heat rates, computed on an hourly basis.
- *Ancillary Services* includes spin, non-spin and regulatory costs, based on reserve requirements set by the Western Electricity Coordinating Council (WECC), and their historical relationship to market energy in California Independent System Operator (CAISO).
- *Generation Capacity*, based on capital and non-fuel related fixed operations and maintenance costs developed by the California Energy Commission's Cost of Generation study. The assumed power source is an advanced simple cycle peak generator financed and operated by a third-party merchant entity. SMUD adjusts the costs assigned to this capacity component by the calculated contribution from sales in the energy market. Annual capacity costs are allocated hourly based on probability of peak.

The final marginal costs will be levelized[8] using SMUD's discount rate on an hourly basis for a three-year costing window. The hourly costs can then be applied against weather-normalized hourly load-shapes representing the target residential customers.

In the case of TOU rates, SMUD assigns the marginal costs for the non-CPP peak hours. In the case of CPP, SMUD assigns the total marginal capacity costs for the 36[9] summer hours in the top 12 peak days. Figure 6 compares the proposed CPP price of $0.75 per kWh with energy and marginal capacity costs for these top 12 peak days in the study period, as well as the weighted average residential price.

Figure 6 CPP Price Compared to Marginal Cost and Average Residential Rate



Estimated Bill Impacts From Proposed Rates

SMUD designed the CBS rates based primarily on residential class hourly data for a typical weather year. While this approach can optimize a rate design to approximate revenue neutrality for the residential class, individual customers will experience a range of impacts based on their energy use variance from the underlying class level load shape.

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[8] Levelizing refers to fixed payments over the selected term, based on the net present value of the stream of future costs. SMUD's discount rate is approximately 6.0%.

[9] These 36 hours represent 12 CPP event days multiplied by 3 peak hours per day *within* the 42 hours that make up the critical peak period defined on page 1.

The most significant variable[10] affecting bill impact will be the amount of energy used during the peak relative to the off-peak or total monthly energy. In general, customers with higher peak use relative to the class average will see higher bill impacts, while customers with relatively lower peak use will see bill savings. The following are the relevant average peak to off-peak ratios used in the rate design from the class data:

- 13% -14% of energy in the month is used during the TOU peak period, and
- 2.5 – 3.0% of energy in the month is used during the CPP.

The current installation of smart meters provided staff the opportunity to assess the rate impact on actual customers, although in the relatively mild summer weather conditions of 2010. To that end, staff has begun to evaluate the proposed rates by comparative test billing on approximately 60,000 residential customers who had new smart meters in place for the full four months of the 2010 summer. For this evaluation, staff culled relevant TOU and CPP energy use for each monthly bill, the latter determined by matching the peak use during the top 12 days of the summer period. The comparison assumed the base rates were those proposed for 2012 implementation.

Figures 7-9 present the preliminary results for the TOU, TOU-CPP and CPP standalone rates respectively[11]. They show that a reasonably high percentage (75% - 90%) of the customers in this sample group could expect rate impacts between +/- $10.00. Of those outside this range who were adversely affected, most saw average monthly bill increases of less than $25.00.

[10] A variable of secondary importance is Tier 1 energy use, because the adoption of substitute TOU and CPP prices in the proposed rate design, (rather than adders to tiered peak pricing), to some degree adversely impacts smaller residential users.

[11] The charts present results for 50,000 standard rate customers, not including low-income customers who were evaluated separately with similar results.

Figure 7 Range of Bill Impacts For Proposed TOU Rate

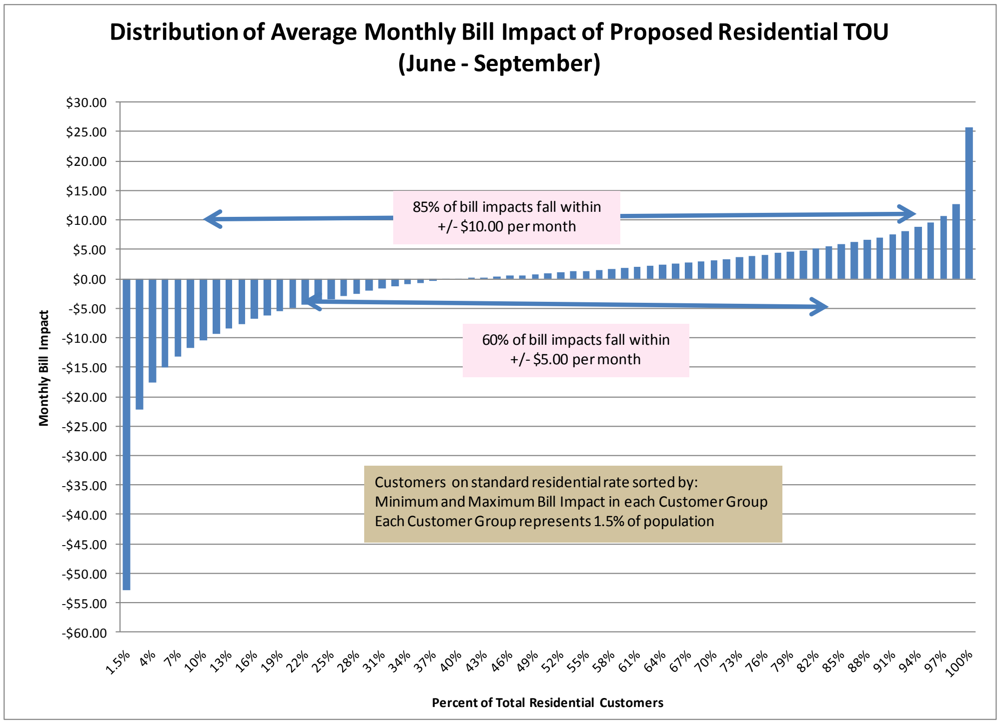


Figure 8 Range of Bill Impacts for TOU-CPP Rate

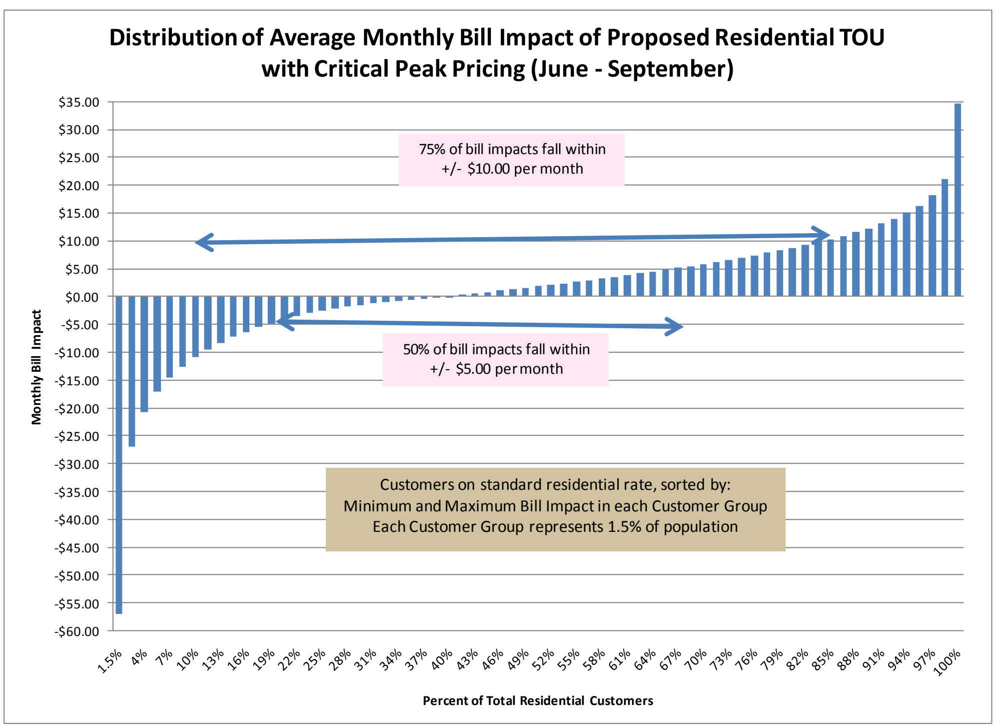
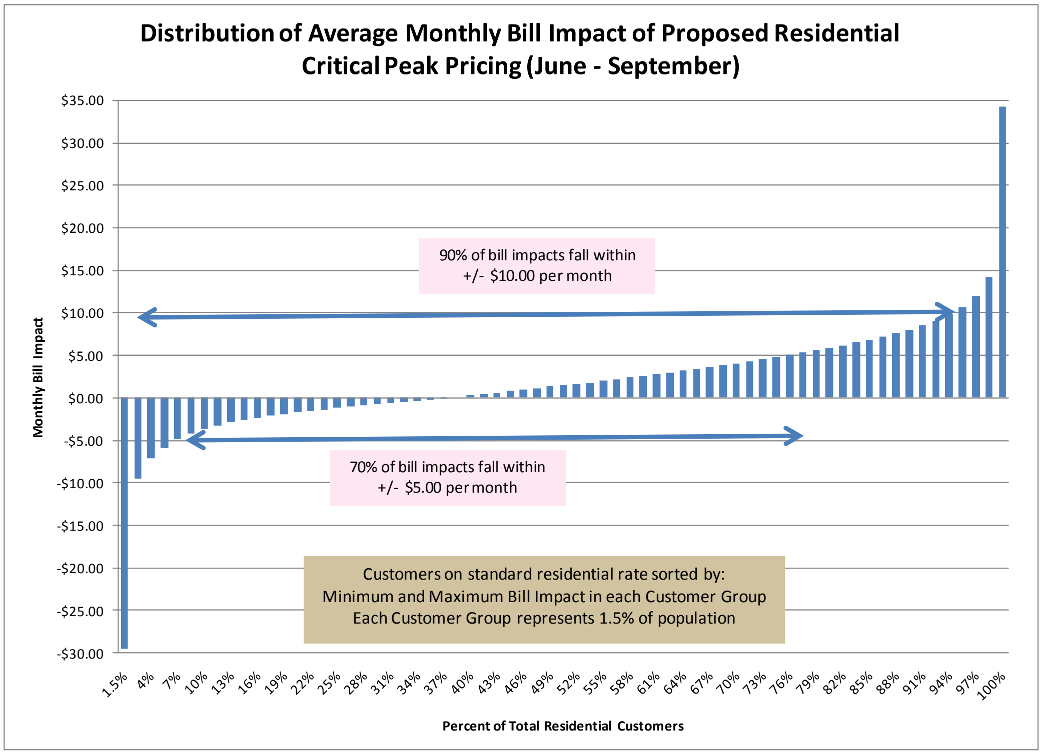


Figure 9 Range of Bill Impacts for CPP Stand-Alone Rate



END-USE AUTOMATION, INFORMATION FEEDBACK, AND EVENT NOTIFICATION

Customers in the control and treatment groups will have a variety of devices and information feedback tools available to them as SMUD's programs and services continue to be developed alongside smart grid deployment. In addition to SMUD's standard offers, the Plan proposes providing additional tools to customers enrolled in the CBS time-variant rate programs.

The Plan proposes the following energy management tools for CBS customers enrolled in the program:

- End-use automation
- In-home display
- Secure gateway device
- Web portal enhanced functionality
- Time-variant pricing on the bill

Enabling Technology

All opt-out treatment groups and a selection of opt-in treatment groups will receive an offer for an enabling technology and installation of that technology at no cost. Customers are not required to accept the device offer. The device offer will ask customers to stay in the program for both summer periods in exchange for receiving the equipment, though it will not be required. The purpose of offering enabling technology and installation at no cost is twofold:

1. SMUD prefers offering customers incentives that are closely tied to our District initiatives and core values. Enabling technology will provide customers with a tool to improve energy management, potentially reducing their consumption and bill amount. Offering this type of device is likely to be recognized by customers as being relevant, whereas cash- or entertainment-based incentives might be perceived as being ill-suited for the study objectives.
2. Providing the equipment at no cost to the customer should increase acceptance and installation rates of the equipment. This will allow SMUD to measure behavior change of CBS rates combined with enabling technology, as well as to conduct market research with customers who accept the equipment offer. Market research related to satisfaction with the equipment, desired characteristics of future equipment offers, perceived value of the equipment, performance of the equipment, and customer behavior associated with the equipment will inform future program design and product offerings.

The enabling technology offer to customers will be comprised of one or more devices that provide the following characteristics: programmable communicating thermostat for end-use automation, real-time in-home energy use display for immediate information feedback, secure data transfer between the enabling devices and the smart meter, and professional installation. All customers receiving an enabling technology offer will receive the same offer, terms, and equipment.

Characteristics and requirements of the device(s) include:

- Ability to program thermostat settings
- Secure two-way communication between the utility and the device (ideally through the Demand Response Management System or “DRMS”)
- Ability to receive a peak event notification and program an automated response to the notification
- Real-time usage and pricing display
- Transfer data securely from the meter to the Home Energy Network (HAN) devices through a central control device (e.g. gateway)

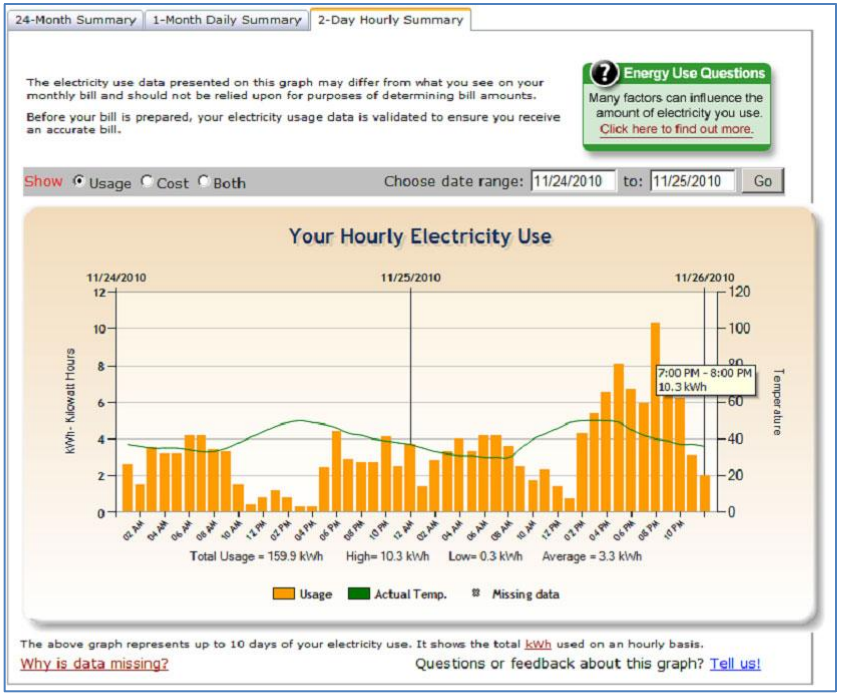
Web Portal

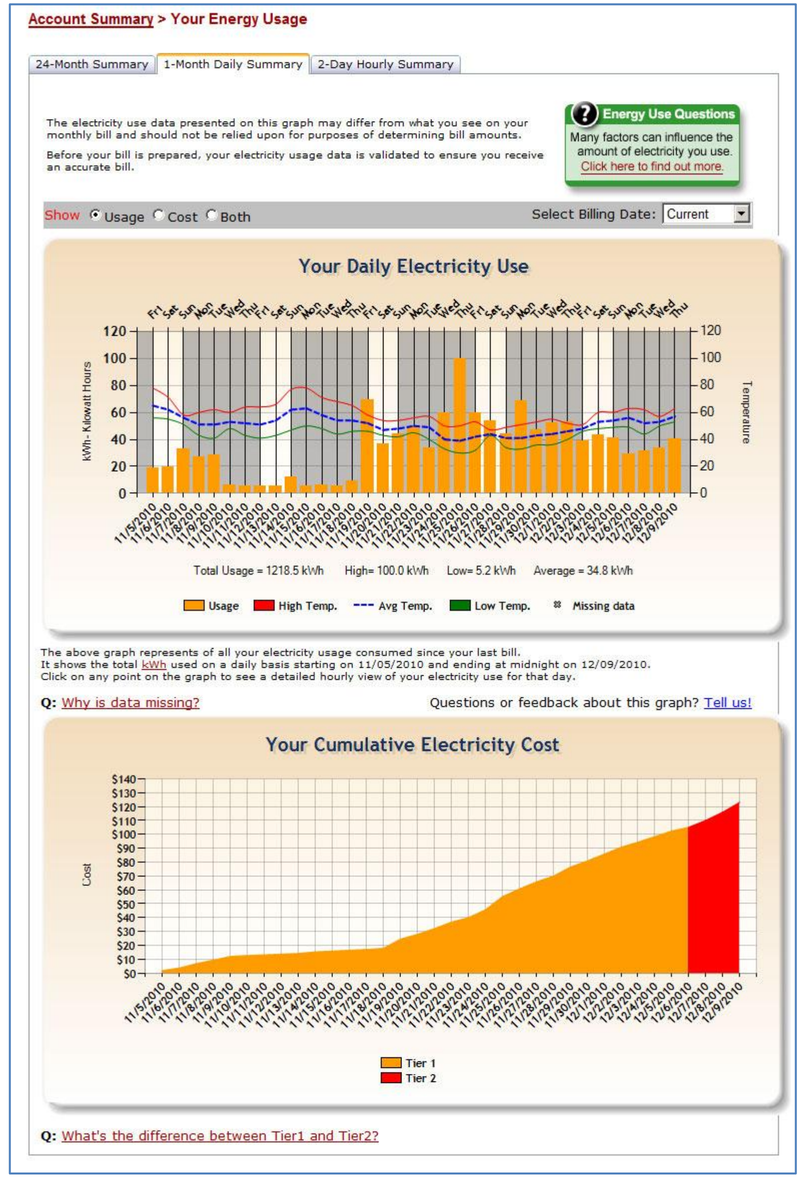
SMUD plans to provide all customers with a smart meter access to a personalized web portal that will display their electricity use. Currently, the web portal contains several screens that graph each customer's electricity use at various intervals: monthly use, daily use, and hourly use. Up to two years of monthly billing data are available, while the interval data displayed range from the period when the smart meter was installed (but no earlier than March 31, 2011) through the calendar day prior to the day in which the data are being viewed, or "yesterday." Since customers are generally more concerned with cost than kWh, the different interval graphs also overlay the cost of their electricity use and display a daily cumulative cost graph to show the impact the tier structure has on their final bill. In order to show the impact weather has on electricity consumption, the daily high, low, and average temperature are overlaid on the daily use graph and actual temperature is displayed on the hourly use graph. The web portal is presently being piloted with 5,000 SMUD customers with smart meters.

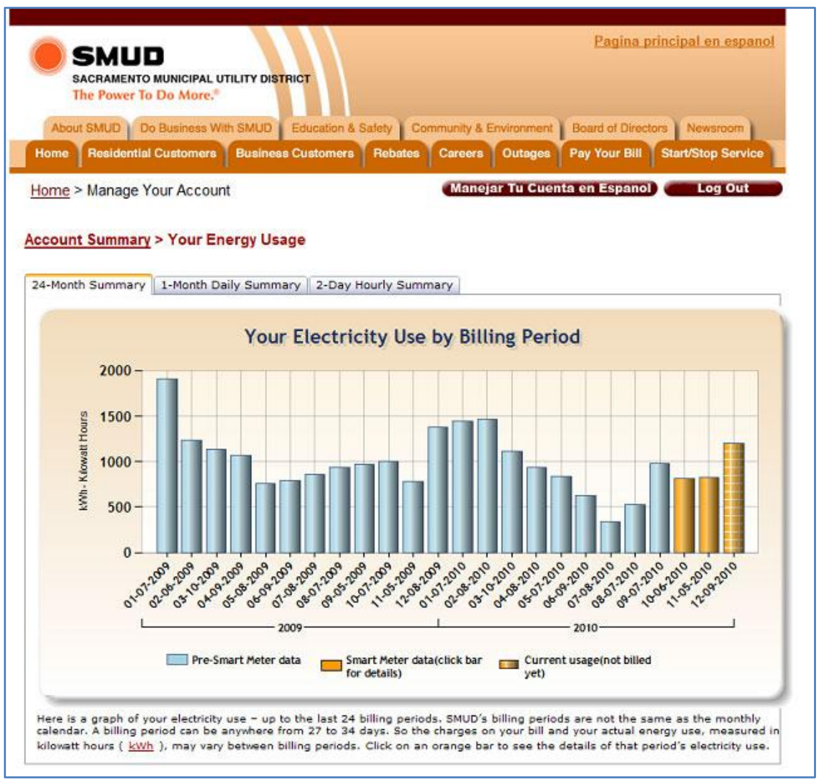
By September 1, 2011, more interactive features will be developed to help educate customers on ways to plan and manage their electricity consumption. In addition to static graphs of consumption, enhanced analysis tools will be integrated into SMUD's portal. By disaggregating the customer's electricity consumption, the tools will show customers where their electricity dollars are spent, explain trends in their electricity use, and provide tips on how to reduce their use. Budgeting and alert tools will allow customers to set usage thresholds and goals that will be tracked against their actual daily use. If their electricity use falls outside their plan, customers will have the option to be alerted via their preferred communications channel (HAN device, text, email, web). Any SMUD customer who chooses to invest in energy management devices from SMUD partners will have the option to integrate the web-based information and control modules into their SMUD portal.

Customers on the special CBS rates will have access to additional online tools to show the impact the rate has on their bill and to help them manage Critical Peak Pricing (CPP) events. New graphs will show the different kWh rates applied to their hourly electricity use to better show the overall impact to their bill. The web portal will have a section for announcements that will display the date and time of the next CPP event, the duration of the event, and the rate. Tips will also be displayed on how to mitigate the cost of the event. In addition, customers will have access to a communication preference center for alerts about the events. Due to the complexity that the new rates bring to the bill, additional graphs and analysis tools will be developed to explain how CPP events and Time-of-Use affect their total bill. A scenario tool will allow customers to model how changing a small number of variables, such as their thermostat setting, could shift load and affect their bill during events. Educational tips will guide customers to make behavioral and equipment changes to help maximize their energy savings and shift load.

The graphics below represent the information currently available to customers via the web portal.


24-Month Summary
1-Month Daily Summary
2-Day Hourly Summary
The electricity use data presented on this graph may differ from what you see on your monthly bill and should not be relied upon for purposes of determining bill amounts.
Before your bill is prepared, your electricity usage data is validated to ensure you receive an accurate bill.
Energy Use Questions
Many factors can influence the amount of electricity you use.
Click here to find out more.
Show Usage Cost Both
Choose date range: 11/24/2010 to: 11/25/2010 Go
Your Hourly Electricity Use
11/24/2010
11/25/2010
11/26/2010
kWh- Kilowatt Hours
Temperature
7:00 PM - 8:00 PM
10.3 kWh
Total Usage = 159.9 kWh
High= 10.3 kWh
Low= 0.3 kWh
Average = 3.3 kWh
Usage
Actual Temp.
Missing data
The above graph represents up to 10 days of your electricity use. It shows the total kWh used on an hourly basis.
Why is data missing?
Questions or feedback about this graph? Tell us!


Account Summary > Your Energy Usage
24-Month Summary
1-Month Daily Summary
2-Day Hourly Summary
The electricity use data presented on this graph may differ from what you see on your monthly bill and should not be relied upon for purposes of determining bill amounts.
Before your bill is prepared, your electricity usage data is validated to ensure you receive an accurate bill.
Energy Use Questions
Many factors can influence the amount of electricity you use.
Click here to find out more.
Show Usage Cost Both
Select Billing Date: Current
Your Daily Electricity Use
kWh- Kilowatt Hours
Temperature
Total Usage = 1218.5 kWh
High= 100.0 kWh
Low= 5.2 kWh
Average = 34.8 kWh
Usage
High Temp.
Avg Temp.
Low Temp.
Missing data
The above graph represents of all your electricity usage consumed since your last bill.
It shows the total kWh used on a daily basis starting on 11/05/2010 and ending at midnight on 12/09/2010.
Click on any point on the graph to see a detailed hourly view of your electricity use for that day.
Q: Why is data missing?
Questions or feedback about this graph? Tell us!
Your Cumulative Electricity Cost
Cost
Tier 1
Tier 2
Q: What's the difference between Tier1 and Tier2?


SMUD
SACRAMENTO MUNICIPAL UTILITY DISTRICT
The Power To Do More.
Pagina principal en espanol
About SMUD
Do Business With SMUD
Education & Safety
Community & Environment
Board of Directors
Newsroom
Home
Residential Customers
Business Customers
Rebates
Careers
Outages
Pay Your Bill
Start/Stop Service
Home > Manage Your Account
Manejar Tu Cuenta en Espanol
Log Out
Account Summary > Your Energy Usage
24-Month Summary
1-Month Daily Summary
2-Day Hourly Summary
Your Electricity Use by Billing Period
kWh- Kilowatt Hours
2009
2010
Pre-Smart Meter data
Smart Meter data(click bar for details)
Current usage(not billed yet)
Here is a graph of your electricity use – up to the last 24 billing periods. SMUD's billing periods are not the same as the monthly calendar. A billing period can be anywhere from 27 to 34 days. So the charges on your bill and your actual energy use, measured in kilowatt hours (kWh), may vary between billing periods. Click on an orange bar to see the details of that period's electricity use.

Bill Presentation

SMUD's standard customer bill is scheduled to be redesigned in 2011. CBS proposed rates are included in the bill redesign project. Although information feedback on the bill is not immediate, it does provide a monthly overview of how much electricity the customer used in each of the pricing categories over the course of the billing period. The proposed rates will be integrated into our billing system for automation and rigorously tested to ensure accuracy. Bill presentation of time-variant rates will be tested in customer focus groups for clarity, ease of use, and customer preferences. Customers enrolled in a CBS rate program will receive a monthly bill calculated using the CBS experimental time-variant rates during the summer season and the standard tiered rates during the non-summer season throughout their enrollment in the program.

Event Notification

Customers will receive event notification the day prior to a CPP event as well as the morning of the event. The default channel for notification will be an automated call to the primary phone number on record; however, customers will be able to select all three direct notification channels if they prefer: automated phone call, text message, and email.

Notification will automatically be displayed on the enabling technology device installed in the homes that accepted the equipment, along with an event signal that the Programmable Communicating Thermostat (PCT) can automatically respond to if the customer has chosen to program this feature.

In addition to direct notification channels where messages are pushed to the customer, customers will be able to access notifications by accessing the web portal where their hourly use is displayed, by accessing the customized microsites that educate customers on their rates and ways to save, and by joining SMUD's social networking accounts (e.g. Facebook, Twitter). CPP event days will be posted via these channels a day in advance and will remain posted throughout the event period. The following day, a reminder will be posted that indicates the previous day was an event day with information on how to sign up for additional notification channels.

When space and resources are available, electricity saving and shifting tips will be dispatched in coordination with the event notification to better enable customers to save during the event period.

IMPLEMENTATION ELEMENTS

MILESTONE SCHEDULE: IMPLEMENTATION

MILESTONE	START DATE	END DATE
Rate Design	April 1, 2010	April 6, 2011
Rate Approval	April 7, 2011	August 1, 2011
Experimental Rates in Effect for Study Period	June 1, 2012	September 30, 2013
Sample Selection	June 1, 2011	October 15, 2011
Pre-Recruitment Education Campaign	June 1, 2011	May 31, 2012
Recruitment/Notification and Enrollment	November 1, 2011	May 31, 2012
Customer Education	June 1, 2012	September 30, 2013
Enabling Technology Request for Proposal	June 21, 2011	December 1, 2011
Enabling Technology Installations	February 1, 2012	May 31, 2012

ENROLLMENT AND RETENTION

Customer Support

Creating a positive customer experience and maintaining a positive relationship with customers is a critical element of the Plan. The CBS will be implemented adjacent and concurrent with other major District initiatives that will be highly visible to customers. In addition to providing customers with relevant educational materials, which will be described in the following section, a complete customer support system will be in place to maintain customer satisfaction, assist in retention, and to increase efficiency in the customer service experience.

The primary point of contact is expected to be through SMUD's customer service contact center. All customer service representatives (CSR) will trained on the fundamental elements of the CBS program. The general CSR staff will be able to address basic questions about the program, technology, communications, and peak periods. Within the contact center, SMUD will select CSRs who demonstrate a particular aptitude for the intricacies of the program, and train a core team of specialists who will address all specific questions from customers regarding the CBS. The team will be in place prior to the launch of the recruitment campaign and will remain in place through the duration of the study. They will have access to the specific offer each customer received which will allow the CSR to tailor communications to each customer based on their specific experience, avoiding customer confusion about the various offers. This core team will be prepared to discuss bill impacts, rate design, customer usage, opportunities to save, peak periods and events, enabling technology concerns, enrollments, drops, and other programmatic details. Concerns that cannot be addressed by the core CSR team or their respective supervisor will be escalated to the CBS Project Manager, who will respond directly to the customer's concern.

In addition to contact center support, CBS customers will be provided with a custom toll free number into the contact center. The phone number will be included on all applicable communications along with a CBS customer service email address. Calls that come into the contact center via the toll free number will be automatically routed to the core CSR team. Calls that come in through the standard customer service number will be offered a routing option by the IVR system, which will route them to the core team. In both circumstances, the call will be automatically entered into a central tracking system which will track the date, time, and length of the call.

To enable self-service, customers will also be able to access a variety of online tools. To compliment the self-service information feedback tools described earlier in the plan, SMUD will also provide online enrollment and opt-out functionality. Customers will be required to sign on to authenticate, at which point they can change their enrollment settings. A confirmation email will be sent to the customer assigned to the account.

Enabling technology questions, concerns, repairs, and replacement will be handled by the contractor selected to complete the installations as a component of their contract with SMUD. Installations will be scheduled by the contractor directly to avoid errors in third party scheduling. In the event that customer cancellations or customer no-shows significantly impact program objectives, the contractor will begin scheduling appointment times rather than appointment windows. Questions regarding the equipment that arise after the installation contract period has ended will be addressed by the core CSR team or by the manufacturer, depending on the nature of the question.

Customer Education and Feedback

The Plan calls for supporting education and feedback initiatives to ensure that participants in the Treatment Group understand the implications of their assigned dynamic pricing rate as well as the available resources to help them make lifestyle adjustments to mitigate any potentially negative bill impacts. Educational material will be designed specific to the rate and recruitment option assigned to the customer explaining how their specific rate works, how to benefit from the rate, and resources that are available to help reduce energy use.

The implementation of the rates involved in this study will require a vote by SMUD's Board of Directors. As such, communications will be employed prior to the Board action to inform those customers identified for this study of the potential changes to their rates, that they have an opportunity to provide input, and to outline the processes that will take place should they be approved. Also, SMUD experts will be trained and used as spokespersons that can speak about the study to the news media and the community. The following tactics will be implemented:

- A list of SMUD spokespersons will be developed as a resource to speak at community meetings, board workshops or to respond to media inquiries as needed. The list will include:

  Executive Management

  Managers and Supervisors

  Subject Experts

  Corporate Communications

  Community Engagement

  Public Information Officers

- A comprehensive market research and marketing plan to support customer transition to the new rates.
- Customer Service Center messages – Messages will be developed for customer service representatives and training provided to ensure they have the information to respond to customer inquiries and that consistent messages about the pilot study are being delivered.
- Media messages – Messages will be developed to respond to news media inquiries and to ensure consistency of messages about the study being delivered to the public.

Once the Board approves the proposed experimental rates and the participating treatment group selected, SMUD will deploy direct communications in three phases to reach each of the target customer segments at various milestones during the project.

The first phase will prepare customers for the new time-variant rate programs that will be implemented the following year. General information about the cost of providing energy during peak demand will be available to all customers, tied into the District's Energy Efficiency Campaign.

The second phase will include informing the customers of the new rates, when they will take effect, and specific detail of how the rate will impact them. This phase will involve multiple communications to provide SMUD the assurance that proper diligence is used to inform customers of the new rates. Additionally, customers will be offered special advice as well as tools, such as Info PCTs, to help them manage their energy use in relation to their specific rate structure.

The third phase will involve ongoing communications and customer research to keep customers informed of various aspects of their specific rate -- such as timing of critical peak pricing periods -- and to obtain their feedback of how they've adapted to the new rates, including lifestyle changes and shifts in energy use. Ongoing detailed information about the rates and the resources available to customers will be highlighted and reinforced across multiple channels. Upon study completion, customers will be sent a Thank You letter for participating in the program.

The following sections outline the major market research and marketing efforts that will be used to educate and inform customers for the duration of the study.

Marketing and Market Research Overview[12]

Marketing and market research efforts will focus on engaging SMUD customers by educating them on the benefits of reducing their energy use during the summer's critical peak periods and learning internally how time-variant pricing, technology and education contribute to consumer behavior change.

Market research will establish baselines, determine optimal messaging, understand knowledge gaps, measure satisfaction, and provide insight into consumer behaviors. SMUD plans to employ various types of research, both qualitative and quantitative, to achieve these

[12] Marketing and market research activities dictated in this plan are based on the best information we have at this time. As additional information is acquired from market research, best practice research, and implementation results, marketing activities and market research approaches may be altered to better suit the CBS objectives.

objectives. Findings from the research will be implemented into the marketing plan for recruiting and retention, as well as the customer education portfolio.

The marketing team will develop material for a pre-recruitment education campaign for all SMUD customers on the foundational concepts of time-variant pricing and the challenges caused by peak demand. Following the campaign, marketing will also develop a portfolio of material to support each combination of recruitment strategy, rate design, technology offer, and customer class. Depending on research findings, the marketing portfolio will likely include support from SMUD's Speakers Bureau, community outreach meetings, direct marketing, phone recruitment strategy, streaming educational content, websites specific to the customer's rate and recruitment offer (microsites), interactive content, and social media outreach.

Recruitment Preparation Strategy

Pre-Recruitment Marketing Activities

The CBS marketing plan will include an educational campaign which will precede and overlap the recruitment period, running from approximately June, 2011 to June, 2012. The purpose of the campaign is to educate customers about the need to manage our energy use during peak periods; and how this consumption impacts customers and the environment. Energy Efficiency will be the focus of the overall District campaign in June, 2011 and is a good fit to carry the pre-recruitment education message for CBS. This campaign is for all SMUD customers.

Educational Needs Assessment

Prior to launching the pre-recruitment education campaign, the market research and marketing teams will conduct focus groups with SMUD customers to identify knowledge gaps and test concepts and messages. This study will ask customers to rate their familiarity and knowledge on various utility, conservation, and pricing topics. Specifically, SMUD will inquire about knowledge related to the cost drivers of providing power during peak periods. They will also be shown different media, such as text, graphics, video, and Flash web animation to determine which media channels are preferred for the given content.

Pre-Recruitment Education Tactics

Following are some examples of the types of educational approaches that may be used for this campaign. We will take the information from the focus groups to help us determine what approach we should use.

- Leverage energy efficiency campaign collateral with messaging on bill package pieces, direct mail pieces, email, web banners, radio, tradeshows, and events.
- Leverage existing social media channels (Facebook & Twitter).
- Banners on smud.org, savewithsmud.org, and customer online payment page
- Print and electronic signage on SMUD campus
- Community outreach meetings
- SMUD employee energy advocates: internal campaign
- Utilize our Education and Technology Center to include messaging in their classes, activities, and materials for teachers to use with students.
- Utilize commercial account representatives to share educational messages in their communication to business owners.
- Scan tags (bar codes that can be scanned by phone applications) in direct mail pieces. Recipients can scan tags on print pieces to view short educational videos or be redirected to a web education piece.
- Leverage partnerships with local thought leaders to assist in educating customers about the cost of delivering electricity at various times of the day and how those costs relate to customers.

Speakers Bureau

SMUD's Speakers Bureau arranges speaking engagements in the community for SMUD Board members, executives and employees to share information about SMUD's key initiatives and gather feedback from customers. In addition to the pre-recruitment education activities mentioned above, the Speakers Bureau will complete an overview presentation of the CBS for SMUD Board members and conduct internal training for speakers who outreach to community advocate groups. Marketing, SMUD's Community Engagement team, and Speakers Bureau will collaborate to develop training materials and customer presentations. Community Engagement will assist with the outreach efforts by scheduling speaking opportunities with community advocate groups.

Pre-Recruitment Market Research Activities

Prior to launching the recruitment efforts, Market Research will engage in the following activities:

Message Testing to Identify Optimal Messages

Different combinations of potential recruitment and retention messages and images will be created. These communication pieces will then be tested through an online survey. Respondents will be randomly selected and then comment on their perception of the main message, how they interpret the messages, what they like and dislike, what they recall, and which was their favorite option. The respondents will then be profiled and broken out by different customer groups to understand the preferences across the sampling frame.

Pre/Post Satisfaction Survey

Assess how residential and commercial customer's satisfaction levels varied before and after they experience the new rates. The study will be comprised of three areas. The first section will gauge their pre and post perception of SMUD's image. This battery of questions is already used in SMUD's brand tracker, which can be used to benchmark results. A second survey will include a series of questions to assess their energy awareness and energy IQ. A section of that will include the satisfaction with their rate, bill, and educational elements. SMUD also conducts an annual customer engagement survey that is administered by the Gallup organization. We are in the process of extending their contract for three more years and are exploring the possibility of using this survey to help with this study.

Advanced Study of Pricing Models

Conduct a discrete choice study to evaluate residential customers' preferences for each of the three rate structures. The study will use different variations of TOU, CPP, and TOU-CPP based on the length of the peak period, the price during the peak period, and the number of days critical events are called. The study will also offer the current tiered rate to represent the status quo. The research should give us an idea of customer rate tolerance, preferred rate structures, and potential penetration rates for system-wide implementation. The study will be conducted concurrently and findings compared with the CBS to inform future rate offerings.

Consumer Demographics, Housing Information and Profiles

Customer survey data for CBS participants will be collected to examine in greater detail appliance, economic, property, and demographic factors that affect electricity use, rate and technology acceptance, and customer satisfaction. Data collection efforts will include mail, web-based and telephone surveys, as well as information collected at the point of enrollment. Customer demographics will be collected with each survey administered and added to the customer demographic and housing information data set. These surveys will be augmented by customer-level, third-party demographic and property data where available.

To understand how different consumer groups responded to the pilot, we will create profiles that will define those groups who:

- participated vs. did not participate (overall and by recruitment strategy)
- measurably reduce usage vs. did not reduce usage
- were satisfied vs. dissatisfied with the program, rate, and technology

The profiles will include housing characteristics, participation in SMUD's programs, kWh data (shoulder usage, energy intensity, kWh), demographics, level of satisfaction, and geography.

Recruitment and Retention

Recruitment Marketing Activities

Opt-Out Notification and Retention Material

Using the results of the market research activities, the marketing team will develop the opt-out notification and retention materials. This includes the notification letter of enrollment, the first and second reminder letters of enrollment, and the technology offer letter. A promotional item may be included with the notification letter.

Marketing will be responsible for notifying the opt-out customer group of their enrollment in their new rate. The notification will explain the new rate and how it compares to their standard rate in easy-to-understand language. The notification will include examples of simple ways to benefit on the new rate. The current strategy plans for customers to receive three notifications of their enrollment on the new rate. Notification materials will also include the technology offer as an incentive to remain on the respective rates. Notification materials will be provided in English and Spanish[13].

Opt-In Recruiting and Retention Material

Similar to the opt-out process, the marketing team will develop opt-in material using the results of the market research activities. Customers who have been selected for the opt-in portion of the study will receive at least three notifications of their opportunity to enroll in the proposed rate. Depending on the level of interest in the community, customers will be recruited by direct mail, telephone recruitment, and possibly door hangers and in-person recruitment if higher enrollment rates are required to meet project goals. Materials will be provided in English and Spanish.

Educational Materials

Marketing will design educational materials to explain the respective rates, the purpose of the program, and ways for customers to save. When applicable and practical, material will be customized to the customer class, rate, technology offer, and recruitment method. Upon enrollment in the experimental rate, the first educational piece to be delivered will serve as a Welcome Packet, providing information about the program, tools and technology, customer support, overview of the rate, and ways to save.

Educational Microsites

If deemed appropriate, additional customer education can be accomplished through customized microsites for each recruitment strategy. Each customer would be provided with access to a website specific to their respective rate, explaining how the rate works, and how to benefit from the rate. Each site would have a customized landing page that reflects the recruitment method that was used for that specific customer to avoid confusion. SMUD's Video and Multimedia & Web teams would develop these microsites for both Residential and Commercial participants, incorporating content developed as a result of customer research. Marketing would work with the Video team to develop educational videos to post on the microsites. This would include customized "how to" conservation content, with professional shooting, editing, and voiceover talent. SMUD's Marketing and Multimedia & Web groups would coordinate to design web pages, outline content and navigation, develop Flash pieces, interactive web tools, and educational videos. All content will be quality tested prior to launch.

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[13] Only select marketing materials will be provided in Spanish. The vast majority of CBS communications will be provided in English only due to resource constraints.

The purpose of the rate- and offer-specific microsites is to educate customers during the recruitment period and to encourage savings during the participation period, ultimately driving higher retention rates and reducing peak load. Providing customized content would separate specific rates and offers to avoid customer confusion or potential bias from exposure to other experimental rates and offers. Customers would have a URL to the microsite specific to their offer; however, they would not be required to sign on or provide any type of authentication. Customers would not be able to access the microsites by searching on the Internet or on SMUD's website.

Social Media Channels

Social media sites will be leveraged to provide a customer forum for discussion and sharing of information. Sites such as Facebook and Twitter will be leveraged to push out educational information, reminders for CPP call days, and tips for saving on the time-variant rates included in the study.

Electronic Channel Analytics

To the extent possible, SMUD will capture click through rates, unique hits, number of visits and other relevant tracking information related to electronic channels and tools designed specifically for customers participating in the CBS. The information gathered will be used to determine which tools are being utilized, how frequently tools are accessed by the same account, and which components of the tools are being accessed most frequently.

Recruitment Market Research Activities

Online Chatter Tracking

SMUD will track online chatter related to SMUD in both the pre-treatment period and the study period. The market research team will conduct a qualitative assessment of the content for topics, tone, and frequency. A qualitative summary will be used as an indicator of what vocal online customers are saying about SMUD related to the CBS and the services related to the study.

Website Usability Test

Market Research will conduct standard website usability tests for the customized microsites. Respondents will sit at a computer monitor and work through the microsites to complete specific tasks. Pre and post questions will assess their familiarity with technology, what they liked and disliked about the website, and their recommendations for improving the experience. There will also be a trained observer taking notes on the subject's online actions and each test will be video recorded and analyzed.

Assess Effectiveness of Channels and Touches

For opt-in recruitment, the research team will identify which recruitment channels performed the best and which were most cost-effective. This includes creating a database to collect the channel data. The database will be a transactional table and each touch will be a row in the database that specifies the date, channel, and cost. These variables can then be related back to sign-ups to better understand which channels were the most effective with the various customer groups.

Opt-Out and Drop-Out Qualitative Feedback

Market Research will include an on-going short questionnaire in the opt-out or drop-out confirmation letter. Information gathered will provide insight into future program design. It will provide an additional opportunity to collect demographic information from customers.

Project Completion

Marketing will send Thank You letters to all participants at the end of the study, and confirmation letters will be sent to customers who elect not to participate at the point when they opt out of the rate.

Data Collection

The following types of data will be collected for the evaluation.

- Customer level data
    - Population information
    - Sample information

    - Interval meter data
    - Customer characteristics
    - Marketing data
    - Customer satisfaction indices
- Program level data
    - Temperature data
    - Operations data

Customer Level Data

Population Information

SMUD will collect and maintain a file representing a cross-section of the population at three points during the study period: the point at which the sample is selected, the point at which the rates go into effect (June 1, 2012), and the point at which the study ends (September 30, 2013). The file will contain an indication as to whether or not the customer was qualified to be within the sample frame, customer class, building type, service and mailing address, and pre-study tariff.

Sample Information

SMUD will maintain information related to the customer's designation within the sample. This will include an indicator as to whether or not the customer was selected for the control group or treatment group. Additionally, we will maintain an indicator as to whether or not the customers selected for the treatment group accepted the offer or rejected the offer. Also included will be a categorical classification identifying the specific treatment the customer was assigned to (i.e. specific recruitment, rate, and technology treatment group). Finally, a record will be maintained indicating the event notification methods selected by the customer.

Interval Meter Data

SMUD is currently collecting hourly interval data for all residential customers and 15-minute data for all commercial customers in the smart meter acceptance sample. Interval data is edited and stored on the SMUD IT network on a monthly basis. As additional smart meters are installed, these data will be added to the current interval data database. Interval data for the study sample will stored at no larger than hourly intervals and will be maintained for a minimum of five years after the study period ends.

Smart meter interval data will be available for one year prior to and for the duration of the study period. This will allow for a time-series comparison of control and treatment participants.

Customer Characteristics

SMUD will develop and maintain a CBS customer data file for customers selected to participate in the CBS study, for control and treatment groups. The database will include monthly kWh, billing periods, rate options, service address, mailing address, customer class, and CBS treatment designation.

Marketing Data

A comprehensive marketing data set will capture channels, touches, and enrollment dates for each customer. Specifically, it will track each marketing offer and incentive made to the individual customer, the order offers were made, the total number of offers, initial acceptance of free enabling technology offer, enabling technology completed installation indicator and date, enrollment date, and drop date.

Customer Satisfaction Indices

A cross-sectional assessment of customer satisfaction with SMUD overall will be established in a pre-recruitment survey and post-study survey.

Program Level Data

Temperature Data for Sacramento

SMUD collects daily and hourly temperatures for Sacramento. Historical daily high and low temperature data goes back to 1970. Hourly temperature data goes back to 1980. SMUD intends to maintain this data well beyond the CBS study period. Temperature data will be used to statistically normalize individual and group level interval data.

Operations Data

Records will be maintained that provide rate and event details. Rate information will include details of each CBS rate as well as the standard SMUD rates on record for each customers in the control or treatment groups. A record of all CPP event days will be included, as well as the number and timing of event notifications that were dispatched for each event. Any known notifications dispatches that failed at the system-level will be noted.

EVALUATION ELEMENTS

MILESTONE SCHEDULE: EVALUATION

MILESTONE	START DATE	END DATE
Preparation of Historical Usage File	October 15, 2011	December 1, 2011
Evaluation Request for Proposal	June 1, 2012	October 1, 2012
Interim Evaluation Report Data Preparation	October 1, 2012	November 15, 2012
Conduct Interim Evaluation and Prepare Report	November 16, 2012	March 31, 2013
Delivery of Interim Evaluation Report	April 1, 2013	April 1, 2013
Delivery of Historical Usage Data, Interim Project Data and Benefits and Metrics Data	April 1, 2013	April 1, 2013
Final Evaluation Report Data Preparation	October 1, 2013	October 31, 2013
Conduct Final Evaluation and Prepare Report	October 31, 2013	January 31, 2014
Delivery of Final Evaluation Report	January 31, 2014	January 31, 2014
Delivery of Final Project Data and Benefits and Metrics Data to DOE	January 31, 2014	January 31, 2014

EVALUATION APPROACH

The evaluation will address the following general research objectives:

Electricity Impacts:

1. During the test period, average daily energy use for residential customers in the assigned treatment group is lower for the treatment group than for the control group.
2. During the test period, peak energy use for residential customers in the assigned treatment group is lower for the treatment group than for the control group.
3. On event days, peak demand for residential in the assigned treatment group is lower for the treatment group than for the control group.

Customer Characteristics

- What household and housing variables are associated with demand response, program enrollment, and acceptance of the enabling technology offer?
- What perceptions and attitudes are aligned with demand response, program enrollment, and acceptance of the enabling technology offer?

Enabling Technologies:

- What roles do the various enabling technology offerings (e.g. web portal, IHD, PCT) play in the customer's home and lifestyle?
- What is the initial acceptance rate of the free enabling technology offer?
- What is the final rate of installation of the enabling technology?
- What portion of customers program the end-use automation to automatically respond to daily and event peak pricing, and in what way do they respond (e.g. pre-cooling, thermostat setback)
- What characteristics of the enabling technology, end-use automation, and information feedback devices were considered useful, and which were not?
- What additional features or characteristics do customers desire in the various technology offerings?

Customer Satisfaction and Expectations:

- What are customer expectations in terms of potential electricity impacts, potential bill impacts, and behavior changes or investments needed to achieve savings?
- Did participation in the experimental rates meet their expectations in terms of potential electricity impacts, potential bill impacts, and behavior changes or investments needed to achieve savings?
- How satisfied are participants with:
    - their experience with experimental rates?
    - their experience with the various technology offerings?
    - the educational materials?
    - the channels, timing, and delivery of event notifications?
- How did customer perceptions of SMUD change as a result of participation in a time-variant rate?

Value to Utility:

- How much value will SMUD receive from the rate response in terms of net cost savings and firm reliability of summer load reduction?

Market Penetration:

- What are the expected participation and retention rates of the various experimental rate options?
- Why do customers choose not to participate or to drop from the experimental rates?

Education Assessment:

- What messaging will be most effective at transitioning customers to the various rate options?
- Which topics will be most informative to teach customers how to benefit from the various rates?
- What lexicon is most appropriate to market and educate customers about the experimental rates and the primary program components (e.g. technology, event notification)?
- To what extent do customers understand the experimental rates and how those rates relate to their energy use and monthly bill?
- To what extent are customers accessing educational materials and via which channels?

The evaluation for the Consumer Behavior Study will follow two paths. The first will have an electric demand focus, using hourly and sub-hourly interval meter data to estimate treatment effects on participants' electricity use. The second will have a market research focus, mining the program database for demand impacts patterns related to customer demographics, attitudes, technologies and other relevant factors. Although the evaluation plan will not be finalized until an evaluation contractor has been selected, the following sections describe the general approach intended to answer the main questions addressed by this study.

Electric Demand Impacts

The evaluation plan will differ slightly for cells designed for comparison to random control groups (the RED and RCT cells) and those designed for within-subjects evaluation. In the first case, demand impacts will be estimated using pooled fixed-effects models. In the second, customer-specific models will be employed.

The evaluation of demand impacts for RED and RCT cells can make use of pooled fixed-effects models because they have unbiased control groups. Equations 1 and 2 illustrate the general form of the fixed-effects models that will be used to determine the effect on daily and event demand of the treatment variables defined by three categories: recruitment type (opt-in or opt-out), rate (TOU, CPP, or TOU-CPP), and technology (offered or not).

$$\Delta\{\ln(Pilot\_kW_{its}) - avg[\ln(Prepilot\_kW_{is})]\} = \alpha_i + \beta_1 Treatment_{it} + \beta_2 X_{it} + \varepsilon_{its} \quad (1)$$

$$\Delta\{\ln(Event\_kW_{its}) - avg[\ln(Nonevent\_kW_{is})]\} = \alpha_i + \beta_1 Treatment_{it} + \beta_2 X_{it} + \varepsilon_{its} \quad (2)$$

… for household i in hour t, during summer s, where α is the household fixed effect, Treatment is a vector of variables equal to zero before the treatment is in place, and equal to one after the treatment is in place, X is a vector of control variables (e.g. time, weather, lag and interaction variables, as appropriate) and ε is the error term.

In both equations, the dependent variable measures the change in log consumption between hours in question, i.e. between hours before and after the pilot rate is in place, and between peak hours on event and nonevent days. Provided the model includes data from both treatment and control households, both before and after the treatment is in effect, the vector of β_1 coefficients will identify differences in demand during peak hours and events during the pilot relative to demand before the pilot or on nonevent days, controlling for changes at control households.

Demand impacts for cells designed for within-subjects evaluation will be estimated using customer-specific fixed-effects equations. These models will follow the same basic forms shown in equations 1 and 2, but will be estimated for each participant individually, pre and post pilot, and on event and non-event days. Once customer-specific load shapes are determined, average load shapes for groups of customers can be aggregated as desired. For example, average daily energy use can be compared by averaging load shapes across treatment groups and then comparing the sums (or averages) of the 24 daily values. Likewise, average energy use across the 3 peak or event hours for each treatment group would allow estimates of peak and event impacts.

Demand impacts will be calculated both in actual terms (i.e., what was observed or derived during the project) as well as weather-normalized for 1 year in 10 and 1 year in 2 weather patterns. The weather normalization methodology will be consistent with the approach identified in the California Public Utility Commission's decision adopting protocols for estimating demand response load impacts (Rulemaking 07-01-041).

Additionally, DOE and the TAG will recommend demand model specifications that could account for the different prices SMUD customers see throughout the month. SMUD will consider the potential for using such a model for estimating elasticities.

MARKET RESEARCH

Quantitative market research questions will be addressed using a combined database comprised of demand impacts, survey results, building characteristics, demographic data and adoption rates. A detailed evaluation plan for the many market research questions SMUD hopes to answer with this study will be formed by the evaluation contractor to be chosen at a later date.

REPORTING ELEMENTS

REPORT CONTENTS

Interim Evaluation

- Overview of the project and its goals
- Description of how the project was designed and implemented to achieve these goals
- Synopsis of the evaluation framework and methodology
- Summary of the results and lessons learned and changes in design required to address observed issues

Final Evaluation

- Overview of the project and its goals
- Description of how the project was designed and implemented to achieve these goals
- Synopsis of the evaluation framework and methodology
- Summary of the results and lessons learned

DATA SET CONTENTS

SMUD will provide to the Department of Energy (DOE) the following Consumer Behavior Study data set files: Historical Usage Data, Project Data, and Metrics and Benefits Data. However, SMUD has confidentiality concerns relating to certain data elements within these data set files that may be distributed and used outside of the analysis effort to be inevitably undertaken by DOE or DOE contractors who are operating on behalf of and under contract with DOE.

DOE and the Technical Advisory Group have not yet developed a formal protocol for the delivery of all required Consumer Behavior Study data sets. SMUD commits to working collaboratively with the Technical Advisory Group to establish a mutually agreeable protocol for delivery of all required data sets that addresses SMUD's concerns. This protocol would include data delivery timing, format, specific variables, degree of geographic precision, and guidelines for data release to the public.

Until such time that a mutually agreeable protocol can be established, SMUD will commit to providing the Consumer Behavior Study data set files in two deliverables:

1. SMUD will provide a data set file to be maintained by DOE. This data set file may be accessed by research practitioners in the general public. This data will be referred to as “Public Data.”
2. SMUD will provide a second data set file to be maintained as confidential information by the DOE. This data is more granular and may be accessed for additional analysis by the DOE or DOE contractors who are operating on behalf of and under contract with DOE and who agree to maintain the confidential nature of the information. This data will be referred to as “Private Data.”

The description below represents the minimum frequency of data delivery, granularity of customer identifying information, and variable categories to be included in the data deliveries under such an approach:

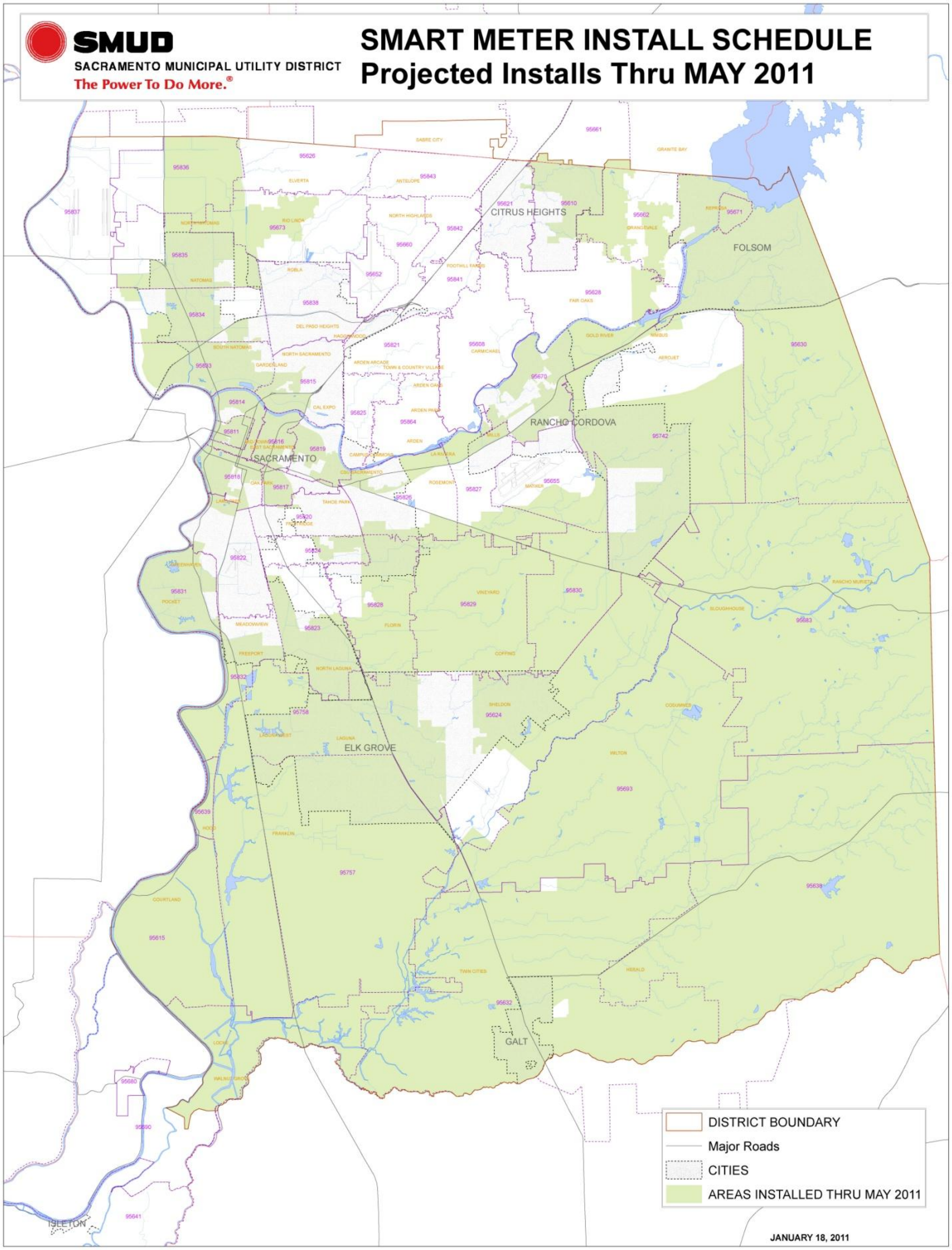
- For the Public Data files, SMUD will release to DOE anonymous, customer-level data with treatment/control data fields, interval electricity use, project variables, and housing/real property fields (to the extent that SMUD is able to populate them), all at the utility identifying level (i.e. SMUD) with the interim and final evaluations. These data sets will include the control groups, treatment groups, pretreatment data, and study period data.
- For the Private Data, SMUD will provide access to the same categories of variables described above for the Public Data files, however they will be provided at the zip code identifying level.

SACRAMENTO MUNICIPAL UTILITY DISTRICT

CONSUMER BEHAVIOR STUDY PLAN

APPENDIX

APPENDIX A: SMART METER INSTALLATION MAP



APPENDIX B: CONSUMER BEHAVIOR STUDY RISK ASSESSMENT

SMUD CONSUMER BEHAVIOR STUDY RISK ASSESSMENT	
RISK	**MITIGATION STRATEGY**
Opt-in rate is less than 15% or opt-out rate exceed 50%	A recruitment pretest will be implemented in 2011 to assess opt-in rates. Strategy will be adjusted to align with pretest findings. If opt-in rates remain low, recruitment strategy will be revisited and efforts will be increased within reason. Initial sample selection will assume a 10% opt-in rate, and the additional sample will be held in case needed.
Technology acceptance is more than 60%	To alleviate impact to study budget, will determine a set point to review rate of acceptance and if needed, reduce technology offers in treatment cells that are not testing technology
Technology acceptance is less than 60%	Will prioritize treatment cells that are testing technology and adjust recruitment efforts.
RFP for DRMS device delayed	Selection of a device that is thought to be compatible with the DRMS will be considered. Devise will require ability to transmit a signal that does not require DRMS compatibility (such as radio frequency). This will limit data collected from the devices.
Device(s) selected are not compatible with DRMS upon testing	Will use device that uses radio frequency that does not require DRMS compatibility to transmit signal. This will limit data collected from the devices.
Rates (standard or CBS experimental) are not approved on time	Strategy will be dependent upon the reason the rates were not approved and the probability that the rates would be approved in the future. Possible strategies include conducting an opt-in only study, removing the rates in question from the study, postponing recruitment until rates are approved (potentially reducing treatments tested and increasing sample size to provide adequate data), or discontinuing the study.
Smart meter installations do not occur on schedule	Strategy will depend upon the severity of the delay. • If meter deployment is delayed slightly, it should have little impact on the study. • If meter deployment is significantly delayed due to issues unrelated to operability, the study design will be altered (if possible) to adjust total number of customers required to fit within the smart meter deployment population. • If smart meter deployment is delayed in any way related to operability or if the delay impacts ability to use the meters for the CBS, SMUD will determine the feasibility of conducting the study and approach DOE to discuss.
Negative customer response to summer rates	Pre-recruitment education efforts explain the benefits and ways to save. Ongoing education for participants will explain the benefits, ways to save, and the rates. Public relations will be key in managing media and public perception. If public reaction is particularly negative and significantly impacting the customer experience, SMUD's leadership team will determine whether or not to discontinue all or part of the study.

SMUD CONSUMER BEHAVIOR STUDY RISK ASSESSMENT	
RISK	**MITIGATION STRATEGY**
Delayed customer response to recruitment efforts	Will prioritize opt-in CPP with technology and opt-out CPP with technology treatments for recruitment efforts. SMUD will then prioritize the remaining treatment cells in alignment with District goals.
Failing technology	Devices will be thoroughly tested to address any potential issues. Will rely on manufacturer's warranty and installation contract for repair of defective devices.
SMUD bill redesign delayed	Lines can be added to the current bill design to properly bill customers. There are limitations in terms of presentation and number of lines that can be added.
20% attrition by the end of two summers	Study will be complete and will have no control over attrition rates. If attrition rates attrition rates early in year one indicate a potential problem, SMUD will consider increasing recruitment efforts to the extent that it will provide value to the final evaluation.

APPENDIX C: CONSUMER BEHAVIOR STUDY POWER ANALYSIS

Sacramento Municipal Utility District
Consumer Behavior Study Power Analysis

The SMUD CBS plan has posed research questions in the framework of random encouragement designs and randomized control trials designed to detect and measure changes in peak kW demand, daily kWh demand, and monthly kWh consumption. The experiment has been designed to have minimum detectable effect of 5% for average monthly kWh consumption and average daily usage, and 20% of average hourly kW demand during the CPP event hours. The sampling has been designed to measure these minimum detectable effects with a Type I error probability of 5% or 10%, depending on the treatment cell (see Table 11), and a 20% Type II error.

In order to maintain a balance of cost, overall study size, external validity and internal validity, SMUD conducted a power analysis to determine the minimum sample sizes required to have an 80% probability of detecting the change in load as specified in Table 1 for each treatment group. Table 11 presents each of the treatment groups, desired confidence, and required sample sizes .

Table 11 Consumer Behavior Study Sample Requirements

Treatment Group	Design	Type I error α	Type II error β	kappa	Detectable Effects kWh (summer)	Detectable Effects kW (daily)	Detectable Effects kW (event)	Total Enrolls + Postpones	Total Enrolls + Postpones before 20% attrition	Total Invitations or Notifications at 15% opt-in and 50% opt-out (attrition calculated last)	Total Invitations or Notifications at 10% opt-in and 50% opt-out (attrition calculated last)
Res Opt-in TOU (no tech offer)	RCT	0.10	0.20	0.80	0.05	0.05	0.20	1884	2355	15700	23550
Res Opt-in TOU (with tech offer)	RCT	0.10	0.20	0.80	0.05	0.05	0.20	3140	3925	26166	39250
Res Opt-in CPP (no tech offer)	Within Subject	0.10	0.20	0.80	0.12	0.12	0.12	150	187.5	1250	1875
Res Opt-in CPP (with tech offer)	RED	0.05	0.20	0.80	-	-	0.20	1131	1413	9425	14137
Res Opt-out TOU (with tech offer)	RED	0.10	0.20	0.80	0.05	0.05	0.20	992	1240	2480	2480
Res Opt-out CPP (with tech offer)	RED	0.05	0.20	0.80	-	-	0.20	345	431	862	862
Res Opt-out TOU-CPP (with tech offer)	Within Subject	0.10	0.20	0.80	0.08	0.09	0.08	300	375	750	750
Com <20 kW GSN Opt-out TOU (with tech offer)	RED	0.10	0.20	0.80	0.05	0.05	0.20	299	373	747	747
Com >20 kW GSS Opt-out TOU (with tech offer)	RED	0.10	0.20	0.80	0.05	0.05	0.20	58	72.5	145	145

Random Encouragement Design (RED)

RED formulas were provided by members of the Technical Advisory Group (TAG) which serves as a liason between SMUD and the Department of Energy (DOE). The calculations for the Opt-in CPP with Technology Offer and Opt-out CPP with Technology Offer were performed by Meredith Fowlie and Catherine Wolfram, members of SMUD's TAG. The same method was used by SMUD's statistician to conduct the power analysis for the remaining RED treatments. The following equation was used to estimate the load impact for each treatment:

$$\Delta\{\ln(load\_cpp_{its}) - avg[\ln(load\_noncpp_{is})]\} = \alpha_i + \beta_1 T_{in\ it} + \beta_2 T_{Out it} + \beta_3 X_{it} + \varepsilon_{its}$$

for household i in hour t, during summer s, where
α is the household fixed effect
TIn is a dummy equal to one in periods after a household is invited to join the opt-in program
TOut is a dummy equal to one in periods after a household is invited to join the opt-out program
X represents additional explanatory variables to control for weather and hour-of-sample dummies
ε is the error term

The dependent variable measures the change in log consumption between event hours and the same hours of the day on non-event days. This will allow SMUD to control for differences in behavior between the treatment and control groups before and after the treatment is allocated.

The precision by β_1 and β_2 is determined by the following relationship:

$$MDE = (t_{1-\kappa} + t_{\alpha})\sqrt{\frac{1}{P(1-P)}\frac{\sigma^2}{J}\frac{1}{c^2}}$$

where
MDE = minimum detectable effect (measured in percentage terms)
$t_{1-\kappa}$ = critical value for t given the desired statistical power κ
$t_{\kappa/2}$ = critical value for t given type-1 error rate α
P_J = proportion of the households receiving treatment
P = proportion of the observations receiving treatment (equal to P_J if there are no pre-treatment observations).
σ_2 = the estimate of the variance of the outcome
J = the number of households in the study; P*J households are in the treatment group
c = the expected participation rate (i.e., the share of the treated households that accept the treatment)

The equation is then rearranged and solved for J to determine the minimum number of households needed to achieve the desired MDE.

$$J = \frac{(t_{1-\kappa} + t_{\alpha})^2}{P(1-P)} \frac{\sigma^2}{MDE^2} \frac{1}{c^2}$$

Because there will be multiple observations per household there can potentially be fewer households needed if observations within households are not perfectly correlated :

$$J = \frac{(t_{1-\kappa} + t_{\alpha})^2}{P(1-P)} \frac{\sigma^2}{MDE^2} \frac{1}{c^2} \left(\rho + \frac{(1-\rho)}{T} \right)$$

where
ρ = within household correlation
T = number of observations per household (i.e. the number of CPP events * 3 hours)

Similar calculations generate the opt-out treatment and control sample sizes, but since c, the acceptance rate, is much smaller for the opt-in study than the opt-out, we know that the control group for the opt-in study will be larger than the control group for the opt-out study. The larger control group for the opt-out study will generate a lower MDE. Next parameter estimates for σ_2 and ρ were calculated via panel regressions on hourly TOU data with hour of sample fixed effects for the residential and commercial customers by estimating:

$\Delta\{\ln(load\_cpp_{its}) - avg[\ln(load\_noncpp_{is})]\} = \alpha_i + \beta_3 X_{it} + \varepsilon_{its}$

The additional parameters for the power analyses are included in Table 12. The assumptions that are not included are: a 15% opt-in rate, 50% opt-out rate, 60% technology acceptance rate and an additional 20% attrition by the end of two summers. Furthermore, to correct for finite sample sizes in the commercial calculations, there will be roughly 12,307 kWh<20 GSN and 2137 299> kWh >20 GSS commercial smart meters by May 1, 2011. The sample size for the commercial customers was adjusted using a finite population correction:

$J = (N - J_0)/(N-1)$

Where J_0 is the number of customers in the study according to the uncorrected sample size calculation and N is the population size.

Table 12 Consumer Behavior Study Parameters

	Residential			Commercial <20kW (GSN)			Commercial >20kW (GSS)		
	kWh	daily kW	event kW	kWh	daily kW	event kW	kWh	daily kW	event kW
MSE(σ2)	0.51	0.55	0.5	0.82	0.45	0.29	0.3	0.17	0.14
κ	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
K	1	1	1	1	1	1	1	1	1
ρ	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
T	366	256	108	366	256	108	366	256	108
T-pre	122	86	36	122	86	36	122	86	36
T-post	244	170	72	244	170	72	244	170	72
P (RCT)	0.5	0.5	0.5						
P (RED)	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
P for opt-in CPP (with tech offer) and opt-out CPP (with tech offer)			0.35						

RCT

As with RED, the goal is to effectively capture the average effect of the treatment on load, for example, consider the following OLS example:

$$Y_i = \alpha + \pi Z_i + \epsilon_i,$$

where π is the average percentage load reduction of the rate treatment.

A standard randomized control trial (RCT) is a design that estimates the impact of a single treatment. This would involve randomly sampling N households from the customer population. A proportion, P, of these sampled households are assigned to the treatment group and are exposed to a given treatment of interest. The remaining (1-P)N households are assigned to a control group and are not exposed to the treatment. Assuming the variance of the outcome is identical in both the treatment and control groups, the variance of the OLS estimate of π is given by:

$$MDE = (t_{1-\kappa} + t_\alpha)\sqrt{var(\widehat{\beta})}.$$

For a given power K, size α, P, and N the corresponding power equation is:

$$N = \frac{(t_{1-\kappa} + t_\alpha)^2}{P(1-P)} \frac{\sigma^2}{MDE^2}.$$

Next, controlling for within household correlation and seasonal effects, which can reduce sample size if the within household observations are not perfectly correlated, provides the new equation to calculate the power of the sample:

$$J = \frac{(t_{1-\kappa} + t_\alpha)^2}{P(1-P)} \frac{\sigma^2}{MDE^2}\rho + \frac{1-\rho}{T}\sigma^2.$$

where
J = number of households in the study
N =total number of observations (N=JT)
α =type I error rate
K =desired level of statistical power
P=proportion of the sample receiving the encouragement
MDE=minimum detectable effect
σ2=variance of the outcome variable in the population
ρ = fraction of the residual variation that is explained by the household level effect

Within Subjects Design

RED and RCT power analyses were conducted for the treatments selected for the within-subjects design. Due to the large sample sizes required for an 80% probability of detecting change in energy use for the specified MDE, it was determined SMUD would rely other guidelines for determination of sample size for these less critical tests. These sample sizes for these research questions were determined using California's Statewide Pricing Pilot, SMUD's Summer Solutions pilot, and Table 4-5 in EPRI's "Guidelines for Designing Effective Energy Information Feedback Pilots: Research Protocols" as guidelines.

The power analysis was then performed to estimate MDE within the repeated measures ANOVA framework. The parameters in Table 12 for the Type I and Type II errors were carried through on the within subjects analysis. Because these sample sizes were influenced by factors such as budget and feasibility rather than being driven by the power analysis, the minimum detectable effect was estimated from rearranging the following equation used to derive the minimum sample size:

$$N = \sigma^2 \left(\frac{2\rho(t_{1-\beta} + t_{\alpha/2})^2}{MDE^2} + \frac{1-\rho}{T} \right)$$

where
MDE = minimum detectable effect (measured in percentage terms)
$t1\text{-}\beta$ = critical value for t given the desired statistical power κ
$t\alpha/2$ = critical value for t given type-1 error rate α
T = number of observations per household
σ2 = the estimate of the variance of the outcome
N = the number of households in the study
ρ = within household correlation

APPENDIX D: SAMPLE CUSTOMER TECHNOLOGY CONTRACT

Participation Agreement for the PowerStat^{SM} Pilot Program

This Participation Agreement for the PowerStat^{SM} Pilot Program (Agreement) is entered into between the Sacramento Municipal Utility District (District) and ________________________(Customer), singularly referred to herein as a "Party," collectively as "Parties". The Parties agree as follows:

1. Term. This Agreement is effective upon the date of last execution by the Parties and shall continue until December 31, 2009, unless earlier terminated by default or by either Party on thirty (30) days prior written notice.

2. Scope. The District shall remove Customer's existing thermostat and install, at the District's sole expense, a PowerStat^{SM} (programmable communicating thermostat). The District shall perform the work as soon as is reasonably practical. Under this Agreement, the District shall have the exclusive right to install, operate, maintain, and perform warranty services on the PowerStat^{SM}. During the term of this Agreement, under no circumstances shall Customer attempt to maintain, perform warranty services on, or remove the PowerStat^{SM}.

At the time of installation, Customer shall either receive educational materials or District-provided training to inform Customer of the processes involved in the operation and capability of the installed PowerStat^{SM} system and pilot program.

3. Eligibility Requirements. Customer must meet all the following requirements:

   a. Operating central air conditioner or heat pump
   b. Single-family dwelling (no apartments or mobile homes)
   c. Owner occupied home (no rentals)
   d. Access to a personal computer with Internet access and email either at home or work.
   e. Not planning on moving during 2009
   f. Not operating a child care or convalescent care business in the home
   g. Thermostat that controls air conditioner or heat pump, as applicable
   h. Only one thermostat/central air conditioner per home
   i. Not on SMUD's Medical Equipment Discount Program
   j. Not a participant on SMUD's Peak Corps program
   k. Typically use the air conditioner when the outdoor temperature is 95 degrees and higher during the months of June through September

4. Control Period. As used in this Agreement control means the use of the PowerStat^{SM} to remotely signal Customer's central air conditioner system to respond to variety of control strategies being tested. The impact could raise the Customer's temperature set-point a few degrees (2 to 5 degrees) with or without a precool period.

Control can occur periodically during the months of June through September 2009 only. Control will not exceed 8 days (weekdays only) during this period and will not last for more than four hours per day. Control will typically occur in the afternoon to early evening hours.

5. Override. Customer may elect to override a District initiated control event via the Internet.

6. Research. Customer agrees to participate in District online surveys (phone survey may also be used) to help the District assess customer satisfaction after each control period and at the beginning and end of the summer.

7. Premises. The PowerStat^{SM} shall be installed at the following address:

____ (Premises).

8. Cost. There is no cost to the Customer for the PowerStat^{SM}, the installation, and reasonably anticipated warranty services.

9. Access to Premises. Customer grants the District the right to install, operate, maintain, and perform warranty services on the PowerStat^{SM} at the Premises.

10. Ownership. Upon installation, the PowerStat℠ shall be the sole property of the Customer. If at any time the Parties terminate this Agreement or Customer otherwise ceases participation in the PowerStat℠ pilot program, the District shall remotely deactivate the PowerStat℠ to prevent future control events without Customer's prior written consent. The Customer's installed PowerStat℠ should function as the Premises thermostat and should not require removal or replacement. Beginning January 1, 2010, the Customer will not have access to program the thermostat via the Internet. However, the Customer can still program the thermostat from the thermostat controls.

11. Reinstallation of Customer's Thermostat. The District will remove the Customer's original thermostat and give it to the Customer to keep. If at or near the end of the pilot the Customer requests the PowerStat℠ thermostat be removed and Customer's previously installed thermostat be reinstalled, then the District shall conduct the work, at no charge, until December 31, 2009.

12. Warranty. The District hereby assigns the manufacturer's warranty, if any, for the PowerStat℠ to the Customer.

EXCEPT AS EXPRESSLY PROVIDED HEREIN, THE DISTRICT MAKES NO WARRANTIES, IMPLIED OR EXPRESS, WRITTEN OR ORAL, WITH RESPECT TO THE GOODS AND SERVICES PROVIDED UNDER THIS AGREEMENT INCLUDING, BUT NOT LIMITED TO, THE WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

13. Service. The District shall provide service, as needed to the PowerStat℠ during the term of this Agreement. Afterwards, the Customer is responsible for any service to the PowerStat℠.

14. Notices. All written communications or notices under this Agreement shall be directed as follows:

District: Sacramento Municipal Utility District
P.O. Box 15830, MS A353
Sacramento, CA 95852-1830
Attention: Craig Sherman

Customer: ____________________________
Print Name
____
Mailing Address
____
City State Zip
____
Home Telephone Number
____
E-Mail Address

15. Amendments: The District reserves the right, at its sole discretion, to amend the terms of this Agreement. The District will notify Customer in writing of the amendment, which will become effective as of the amendment effective date stated in the notice. If Customer objects to the amendment, Customer may terminate this Agreement by giving written notice to the District within 30 days of the effective date of the amendment.

Customer	District
________________________ (signature)	________________________ (signature)
________________________ (printed name)	________________________ (printed name)
________________________ (date)	________________________ (date)

APPENDIX E: CONSUMER BEHAVIOR STUDY UNDERLYING ASSUMPTIONS AND PROVISOS

In preparation of the Consumer Behavior Study plan, SMUD's CBS planning team made several estimates and educated assumptions which were used to determine sample sizes, schedule, budget, and other areas of the scope. Although the Plan includes a complete marketing and market research plan, incorporating best practices, SMUD cannot be sure these assumptions will hold true. It is SMUD's intention to meet the sample guidelines we present in this plan; however if one or more of these assumptions interferes with SMUD's ability to meet the specified enrollment rates, SMUD will revise the sample sizes as appropriately determined by the SMUD Consumer Behavior Study Steering Committee. SMUD will, however, make additional marketing attempts in the Residential CPP with Technology Offer cells to increase the probability of meeting the goals if needed.

a) Participants from the RCT whose enrollment is postponed to establish a control group will be delayed until summer 2013 rate is no longer in effect.
b) 15% opt in rate (pre-attrition)
c) 50% opt out rate (pre-attrition)
d) 60% technology acceptance (pre-attrition)
e) 20% attrition by September 30, 2013
f) Smart meter installations occur on schedule
g) Power calculations assumed the sample frame would require a meter installed prior to May 1, 2011
h) 150,700 eligible residential smart meters in place by May 1, 2011
i) 12,307 <20 GSN eligible smart meters in place by May 1, 2011
j) 2137 >20 GSS eligible smart meters in place by May 1, 2011
k) Proposed CBS rates are approved by SMUD's Board of Directors in 2011
l) Proposed standard rates are approved by SMUD's Board of Directors in 2011

SMUD assumed the same attrition rate for the control groups for RCT cells as the treatment cells. Customer in the control group should have no reason other than service disconnection or relocation to contribute to attrition. Therefore, the control group sample size may be updated to reduce the number of customers whose enrollment will be postponed and to control costs once additional analysis on customer move rates can be conducted closer to implementation.

The sample calculations for the commercial treatment cells assumed a population of customers with meters installed by prior to May 1, 2011. The population has since been revised to include customers who receive meters in the month of May, 2011. The finite population correction was not updated to reflect this change.

We have assumed that the rates for this plan are approved by the SMUD Board of Directors (Board). In the event the Board does not approve the rates, the SMUD Consumer Behavior Study Steering Committee will determine the feasibility of conducting the study and contact the Department of Energy to discuss the appropriate course of action.

The entire Consumer Behavior Study is subject to Board support. The Board has complete autonomy to discontinue the study at any point. The Board will receive regular updates regarding the project. SMUD's executive team is carefully tracking the planning and progress of the CBS to ensure it is within the Board's expectations.

SMUD's General Manager is currently proposing implementing time-of-use rates for both small commercial classes (GSS and GSN). In the event those rates are passed, the value of including the commercial portion of the study is greatly diminished, and therefore will be removed from the study. This will not be definitively determined until the final rate approval by the Board. In the event it is removed from the study, budget allocations for the commercial portion of the study will be redirected to support the recruitment and education of the residential treatments.

APPENDIX F: SACRAMENTO MUNICIPAL UTILITY DISTRICT RATE ADOPTION PROCESS

Public Utilities Codes

The process of new rate adoption by Sacramento Municipal Utility District is primarily directed by the Public Utilities Codes 14403, 14403.3, and 14033.5, as well as Ordinance No. 91-1 adopted by the SMUD Board of Directors on December 19, 1991. The detailed processes are described below in excerpts from the Public Utilities Code and a complete copy of the ordinance.

PUBLIC UTILITIES CODE

"14403. Before the board adopts any change in rates and charges for commodities or services furnished by an electricity district intended to increase or decrease revenues, the general manager shall file with the board a report and recommendation on the proposed changes in writing. Within 90 days, but not less than 30 days after the report is filed, except when unanticipated events cause a sudden and significant change in the electricity district's financial condition requiring an immediate response, the board shall hold a hearing on the report and recommendation. Notice of the time and place of the hearing shall be published within the district pursuant to Section 6063 of the Government Code, except that, in the case of an unanticipated event requiring an immediate response, notice may be given pursuant to Section 6063a* of the Government Code.

14403.3. The report and recommendation of the general manager of an electricity district filed pursuant to Section 14403 shall include all of the following:

a) The most recent annual report submitted pursuant to Section 11938.

b) A statement of sales volumes by customer types for the preceding two years and estimates of sales volumes for the two years following.

c) A statement of sources and disposition of funds for the preceding two years and estimates of sources and dispositions of funds for the two years following, whether or not the rate change does occur.

d) A statement of capital expenditures anticipated during the next two years following.

e) In sufficient detail to permit an assessment of the need for any proposed changes, a statement of each category of expense for the preceding two years, and estimates of each category of expense for the two years following.

f) Other information as the general manager believes will explain or justify the proposed rate change.

g) The basis for the allocation of the overall revenues among the various types of customers of the electricity district.

14403.5. At the hearing held pursuant to Section 14403, the board shall do both of the following:

a) Permit any member of the public who has given 10 days advance written notice to present nonduplicative testimony on the proposed rate change or on any alternatives.

b) Consider any report and recommendation submitted in writing by any member of the public on alternatives to the rate changes proposed by the general manager."

ORDINANCE NO. 91-1

WHEREAS, the Board-appointed citizens Rate Advisory Committee conducted a thorough review of the Sacramento Municipal Utility District's rates and, on September 27, 1991, submitted its Report and Recommendation to the Board of Directors concerning General Policy Frameworks for Rate-setting; and

WHEREAS, this Board hereby determines it to be necessary and appropriate to establish by ordinance certain procedures which will govern its rate-making process;

BE IT ENACTED BY THE BOARD OF DIRECTORS OF SACRAMENTO MUNICIPAL UTILITY DISTRICT:

Section 1. The following procedures are hereby adopted for considering rate changes and conducting hearings thereon:

(a) These procedures shall be in addition to the procedures outlined in Sections 14401 through 14403.5 of the Public Utilities Code; provided, that in the event of any inconsistency between the procedures adopted herein and the Public Utilities Code, the Code shall govern.

(b) After the General Manager has released his report and recommendation, District customers may have access, upon reasonable notice, to District staff's supporting information and documents (excluding confidential customer information and other information protected from disclosure by law).

(c) No sooner than 20 days following release of the report, the General Manager or his designees shall conduct at least two public workshops on any rate change increasing or decreasing District revenues or recommending changes in rate structure. District customers may ask questions at such workshops. Questions may be submitted in writing at any time after release of the report up until five days prior to the hearing specified in Paragraph (d) and such questions shall be responded to in writing within five days. Complex questions may require additional time, but the customer will be notified in such event. All workshops shall be recorded and transcribed.

(d) No sooner than 14 days following completion of the General Manager's workshops, the Board shall conduct one or more public hearings on the proposed change in accordance with the requirements of the Public Utilities Code. Each District customer, or group of customers, may testify for a reasonable period of time and shall have a full and fair opportunity to present comments, recommendations and alternatives for the Board's consideration. Customers with lengthy presentations (i.e., more than 15 minutes) shall notify the District in writing at least ten days prior to the hearing if they will require additional time. Written materials should be submitted five days prior to the hearing. The hearing shall be recorded and transcribed.

(e) Once the hearing(s) have concluded, the Board shall make available for public review and comment for a period of ten days a draft resolution containing its proposed rate decision and the basis for the decision. Any written comments received shall be made available to the public.

(f) Following completion of the public comment period, the Board may approve the proposed resolution. However, if the Board proposes any material modifications (i.e., modifications which change customer rates or billings) in the proposed resolution, such resolution as modified shall be made available for public review and comment for a period of ten days. The Board shall permit public testimony on the modified resolution prior to any Board action thereon. The final approved resolution shall contain the rate decision and basis for the decision.

Section 2. This Ordinance, to the extent it is inconsistent with any prior District resolutions, supersedes and repeals such inconsistent resolutions.

Section 3. Board rate decisions are promulgated pursuant to Public Utilities Code Sections 11883 and 11885 and such decisions are only reviewable pursuant to Section 14402 of the Public Utilities Code. Nothing contained herein is intended to change, modify, or provide any additional remedies at law or in equity to persons seeking to challenge a rate decision.

Section 4. This Ordinance shall take effect upon completion of publication as required by Public Utilities Code Section 11910.

Adopted by the Board of Directors of the Sacramento Municipal Utility District on December 19, 1991.

Ed Smeloff

Ed Smeloff
President
Board of Directors
Sacramento Municipal Utility District

Attested:

Jan Schori

Jan Schori
Secretary