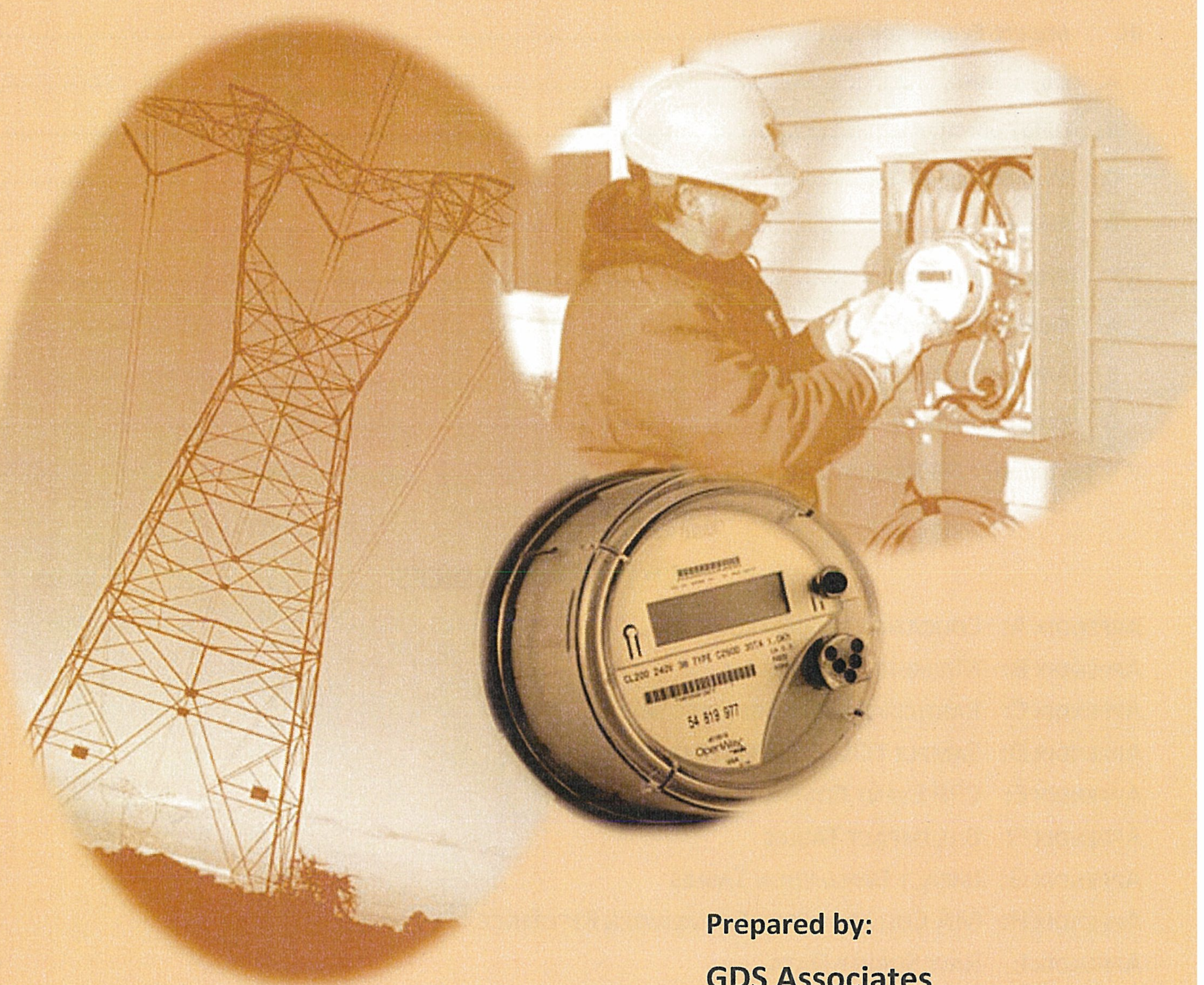
Unitil

ENERGY SAVINGS MANAGEMENT PILOT

EVALUATION REPORT



Prepared by:

GDS Associates
1181 Elm Street, Suite 205
Manchester, NH 03101

January 2012

TABLE OF CONTENTS

LIST OF APPENDICES

LIST OF TABLES

I. EXECUTIVE SUMMARY

This evaluation report presents a high level summary and detailed results from a Time-of-Use (TOU) smart grid pilot program, conducted on behalf of Unitil's electric utility subsidiaries Fitchburg Gas and Electric Light Company (FGE), serving customers in Massachusetts, and Unitil Energy Systems, Inc. (UES), serving customers in New Hampshire, that ran from June through August of 2011. GDS Associates, Inc. was retained by Unitil to assist in the design, development, implementation, and evaluation of the smart grid pilot program. This report has been prepared in accordance with the Common Evaluation Framework developed by the Massachusetts Smart Grid Collaborative to satisfy the reporting requirements of the Massachusetts Department of Public Utilities applicable to FGE under Docket DPU 09-31, and to serve as the final report for UES to the New Hampshire Public Utilities Commission under Docket DE 09-137. This report does not provide any assessment or evaluation of the costs and benefits which may be attributable to larger scale implementation of the treatments under study.

PILOT OVERVIEW

The primary focus of Unitil's smart grid pilot program was to meet and exceed the requirements from Section 85 of the Massachusetts Green Communities Act, which required each Massachusetts electric distribution company to establish a smart grid pilot program that achieves reductions in peak demand and average load of at least 5% for all customers participating in the program. The pilot program was also focused on implementing a New Hampshire TOU pilot program in support of the New Hampshire Public Utilities Commission's TOU rates policy. Therefore, the pilot was conducted with customers from both Massachusetts and New Hampshire so as to share development and deployment costs between the two states and to be as representative of Unitil's overall service territory as possible.

Unitil chose to run its pilot during the June, July and August summer months that have historically been the Company's peak demand months. The pilot was originally designed to run in summer 2010, however implementation was delayed due to the length of the regulatory review process and so that Unitil could participate in the Massachusetts Smart Grid Collaborative group that helped shape the content and approach to the evaluation. The Time-of-Use (TOU) rate structure featured on-peak, off-peak and critical peak periods. On-peak periods were from 12 p.m. – 6 p.m. weekdays only (excluding holidays). All other hours, including mornings, evenings, weekends and holidays, were all off-peak periods. Critical peak periods were from 12 p.m. – 6 p.m. on weekdays and occurred only as declared by Unitil on forecasted high load days. A total of five (5) critical peak periods were declared during the course of the three month pilot.

A time-differentiated rate structure with on-peak, off-peak and critical peak charges was developed for the FGE and UES default energy service rate component based on an analysis of wholesale energy and demand costs for the prior summer period. Delivery rate components were not changed. The off-peak rate was approximately 70% of the default energy service rate, the on-peak rate was approximately 130% of the default rate, and the critical-peak rate was approximately 900% of the default rate, with minor differences between the two states. These rates were designed to be revenue neutral, on average, for residential customers, assuming six Critical Peak Day events in the three month period.

In addition to satisfying the requirements of the Massachusetts Green Communities Act, key objectives of the pilot were to test the time-of-use capabilities of Unitil's Advanced Metering Infrastructure (AMI) including integration with back end systems and to evaluate a range of pricing and technology options. These objectives manifested into the specification of three treatment groups comprised of residential customers with central air conditioning. These groups were:

- Simple TOU: The Simple TOU group was placed on the Time-of-Use / Critical Peak Price rate structure and was provided with information (educational materials) only and feedback on daily energy use and consumption. This group represents the least cost option and is supported by the AMI system currently in place with no additional equipment or modification needed at the customer premises, however significant modifications would be required to Unitil's internal billing and IT systems for large scale deployment.

- Enhanced Technology: The Enhanced Technology group was also placed on the Time-of-Use / Critical Peak Price rate structure and provided with educational materials. However this group was also provided with a full home area network (HAN) that included sub-hourly feedback on energy consumption, a programmable controllable thermostat and plug load outlet, and an in-home display. This group represents the high technology option and provided the opportunity to review the incremental impact of the home area network on customer engagement and impacts.

- Smart Thermostat: The Smart Thermostat group remained on their existing fixed electric rate and was thus not subject to any time varying price signals. This group received a one-way communicating thermostat which allowed Unitil to cycle their air conditioning compressor using a 50% strategy during critical peak events. In exchange for allowing this control, customers were offered an incentive and allowed to keep the programmable digital thermostat. This group represents the traditional direct load control approach to demand response and was both the mid-cost and mid-technology option.

In addition to the information and technology specific to each individual treatment group, all participants were provided with access to a web portal hosted at www.unitil.com that provided information on daily energy consumption and estimated costs. This "Unitil Web Portal" was developed specifically for the pilot and included presentation of energy usage by time period for those participants on Time-of-Use rates. To facilitate the posting of daily AMI data on the web portal, a pre-cursor Meter Data Management (MDM-p) system was designed and implemented; this system served as the repository of Time-of-Use data for both presentation on the web portal and billing purposes.

In addition to these three treatment groups, a control group was also identified to serve as an important comparative population from which changes could be assessed.

Impact Findings

The impact evaluation was a critical component of the pilot program seeking to measure the impact of the various rate and control programs on average customer energy and peak demands. The evaluation focused on measuring the impact of a CPP event for every hour of the day since customer behavior can be altered throughout the day and not just during critical hours. For instance, many customers precooled their homes prior to the event and there was often recovery after an event as air conditioners ran to cool the home back to thermostat set points. By measuring every hour of the day, the evaluation determined if there were impacts on total energy consumption during event days.

As required by the Massachusetts Statewide Common Evaluation Framework, the impact evaluation was extended to analyze the impacts on certain sub-groups. Sub-groups included participants with a senior in the household, high use customers, high and low income customers, and large and small home customers. Impacts for these various subgroups were evaluated to the extent that there were enough customers in a category to make the results statistically meaningful. More detail on sub-group impact evaluation results is provided as part of Section III of this report.

Following is a high level summary of impact results at the total pilot group participant level:

TABLE 1: SUMMARY IMPACT FINDINGS

	Simple TOU		Enhanced Technology[1]		Smart Thermostat	
	Impact	%	Impact	%	Impact	%
On-Peak Period Impact	(0.42) kW	-21.2%	(0.76) kW	-34.8%	-	
Critical Peak Period Impact	(1.56) kW	-42.3%	(2.55) kW	-69.8%	(0.87) kW	-19.7%
Post Critical-Peak Period Impact[2]	0.31 kW	7.6%	0.47 kW	10.2%	0.19	4.0%
Critical Peak Day Energy Conservation	(5.13) kWh	-7.3%	(14.14) kWh	-19.7%	(6.07) kWh	-7.5%

Several primary impacts were of interest. First was the impact of the TOU rate during on-peak days, but not CPP days. Second is the impact on CPP days for all treatment groups. Third is the snap-back effect of the critical peak period in the three hours immediately following an event. Finally, as highlighted in the final column of the table above, energy conservation impacts during CPP days were assessed to evaluate the extent to which the CPP rates affected overall energy consumption and did not result solely in load shifting. Overall, the impact results demonstrate considerable load reduction and overall energy consumption during peak periods. Detailed hourly results and sub-group analyses are presented in Section IV of this evaluation report.

A billing analysis was prepared for customers in the Simple TOU and Enhanced Technology treatment groups. The billing analysis compared customer bills during the three-month pilot to the price they would have paid on the standard fixed flat rate. Smart Thermostat pilot participants were not included in the billing analysis because they remained on the standard billing rate while in the pilot and did not experience any change in bills apart from a fixed one time incentive at the end of the pilot.

Overall during the three month pilot, customers saved an average of $28.92 on the TOU rate representing approximately 5.8% of their total monthly bill. For the average customer, the three month

[1] Issues with data continuity were encountered with the Enhanced Technology group which impact the statistical validity of results

[2] Impacts results for 3 hours immediately following Critical Peak Periods (Hours Ending 19-21)

cost on the standard flat rate structure would have been $497.87, while the three month cost on the pilot was actually $468.95. Simple Time of Use customers saved an average of $27.62 over the three month pilot, representing about 5% of their total standard bill. Enhanced Technology customers saved approximately 6.8% or $30.29. Smart thermostat customers received a one-time fixed rebate of $35 at the end of the summer which represented approximately 7% of their total bill over the pilot period. Detailed analyses of bill impacts, including evaluation of sub-group performance, is presented in Section V of this report.

Process Findings

An important aspect of the pilot was for Unitil to gain experience in the design and delivery of Time-of-Use and direct load control programs that would help inform future initiatives. The process for delivering the pilot program involved many components ranging from recruitment of customers to field installations, billing, data management and presentment, customer service, and field support. The complete process evaluation is presented in Section IV of this report. Following are key findings from within each of the component areas:

- **Customer Recruitment and Installations:** Unitil experienced many challenges associated with the recruitment of customers and the subsequent rate of technical turn downs due to incompatibility with the types of technologies being tested. Limiting the program to customers with central air conditioning eliminated nearly 70% of the total population from eligibility and it proved difficult to accurately target those customers with central air conditioning. Once customers with central air were recruited, many had to be turned down because their systems were incompatible with the thermostats being tested. Broadening the eligibility criteria to all residential customers and making the thermostats an optional, not mandatory, element of the program would have eased recruitment but would have an unknown impact on energy and load impacts.
- **Billing:** Overall, the process of billing customers on TOU rates was successful in that customers were billed accurately for consumption in each time period, and these charges were effectively presented on the monthly billing statements. However, the billing process was manually intensive and a number of billing problems were encountered that had to be addressed. The complexity and variety of Unitil's rates by service territory and customer class presented added complexity to the process and increased the need for manual review and treatment of many of these accounts. Feedback from personnel responsible for managing the pilot billing included needs to further automate the process and for additional dedicated staff resources should a broader program be targeted.
- **Data Management and Presentment:** Large volumes of usage data were generated during the pilot and presented to customers in the form of a Unitil hosted web portal. A pre-cursor meter data management system was developed for the pilot and was largely successful as was the process of presenting the data visually to customers. The web portal did require more time to support and fine tune than expected which placed stress on the Information Technology (IT) department. Similar to billing, improved process automation and staffing were the two primary points of feedback from personnel involved with the pilot.

- **Critical Peak Event Selection and Dispatch:** This process involved continuous monitoring of weather forecasts for potentially high load days as well as the internal (Unitil) and external (customers) notification of pending critical peak days. The process was successful in that all high load days were captured, load control and CPP pricing processes were initiated, CPP usage data was captured, and customers were notified in advance of all critical peak events. However, some challenges were identified that would exist in an expanded program; these challenges would be related primarily to the management of an ever changing customer population as customers enter and exit the program, and ensuring that customers are appropriately notified of pending events.
- **Customer Service:** Unitil provided Tier 1 customer service support for customers in the pilot using dedicated resources who underwent training on the program. However, many of the questions that arose were technical in nature and required intervention from vendors and/or consultants supporting the program. Customer service support for a full program would require careful planning as representatives would require a holistic understanding of the types of technologies deployed, troubleshooting processes, and Time-of-Use billing mechanics.

Technology Findings

The pilot afforded Unitil the opportunity to test the capabilities of its existing Advanced Metering Infrastructure (AMI) system and in home technologies supported by third party vendors. Section III.A of this report presents detailed accounting of the experience with these technologies and recommendations for any future program deployments. Key findings are summarized below.

- **AMI System Time-Of-Use Capabilities:** Unitil's AMI system was installed on the basis of the savings in O&M expense, but with the understanding that the system could potentially serve as a platform that would facilitate additional technological, management, and evaluative capabilities including, but not limited to, the ability to offer TOU programs to customers at low or no cost. The TOU elements of the pilot program provided the Company with the opportunity to test and report on a number of capabilities of the AMI system including remote configuration of meters and the capture, management and quality assurance of Time-of-Use data. Through the pilot, the capabilities of the AMI system were confirmed and valuable experience was gained delivering this type of program.
- **Tendril Residential Energy Ecosystem (TREE):** The TREE system is the home area network (HAN) that in addition to the Time-of-Use Rate was the principle treatment of the Enhanced Technology Group. The TREE HAN provided a number of excellent features and capabilities, first and foremost being the ability for customers to preset how they wanted their air conditioning system and plug load device to respond during high price events. Most customers elected to turn off or aggressively set back their equipment during these periods and this showed in the impacts for the Enhanced Technology Group. Overall, the customer experience with the technology was mixed due in part to some technical barriers encountered; some customers actively engaged with the HAN and had a very positive experience while others reported infrequent use. The granularity of feedback on energy consumption to customers was restricted by the resolution of the meters (1 kilowatt-hour) and this is believed to have negatively impacted some of the customer experience. In addition, a number of technical

challenges were encountered with respect to field installations, account maintenance, and continuity of data, as are detailed later this this report.

- **Honeywell UtilityPro™ Thermostat:** The Honeywell thermostats were deployed as part of the Smart Thermostat treatment group that featured a direct load control, 50% cycling strategy during critical peak events. Customers were able to log onto an online web portal that allowed customers to change the setting on their thermostat and to amend schedules. Overall, customers were very satisfied with the thermostats they received and with their participation in the program. Because the thermostats communicated via a paging network and were standalone devices, fewer technical barriers were encountered in the field throughout the installation phase and during the pilot. Unitil had a very positive experience with the equipment vendor who provided professional and consistent support throughout the duration of the pilot. The majority of customers who received these thermostats elected to keep their thermostats after the pilot ended rather than have their old thermostat reinstalled.
- **Unitil Hosted Web Portal:** The pilot program provided an opportunity to develop and gain experience administering a web portal to a small number of customers in a controlled environment providing display and analysis of daily energy consumption by time period. Unitil gained experience in the capture and presentment of Time-of-Use data including the algebraic algorithms needed to estimate daily cost. However the process required refinement during the pilot and was labor intensive. Overall, the Unitil portal was positively received by customers.

II. EXPERIMENTAL DESIGN

A. TARGET POPULATION

The target population for the pilot program was residential customers with central air conditioning systems. Customers with central air conditioning were specifically targeted for the pilot because air conditioning is a significant contributor to summer peak demands in the Northeast, and air conditioning presents a good opportunity for customer or utility initiated demand response. Applying the central air conditioning criteria across the control group and each of the three treatment groups also allowed for better comparison of performance among the groups, a primary goal of the study.

Due to the difficulties in completing recruitment of the required sample (see section F. below), a total of six (6) customers in the Enhanced Technology group were admitted into the pilot program without having central air conditioning. These customers all utilized multiple window air conditioning units which were controllable using the controllable and programmable outlets that came with the home area network systems. Participation by these customers provided a functional test of the ability to control window air conditioners, which are extremely prevalent in the Northeast.

All participants had high speed internet access, did not take any extended vacations (more than two weeks in length) over the course of the summer and were responsible for paying their own electric bills. Special recruiting efforts were targeted to low-income customers in an attempt to secure participation in this subject, however very few low income customers actually elected to participate in the study.

B. TREATMENT GROUPS

Unitil's smart grid pilot program was designed to evaluate a range of approaches to peak load reduction and energy conservation. Table 2 summarizes the three treatment groups with respect to rate structure, enabling technologies, and information feedback.

TABLE 2: SUMMARY OF TREATMENT DESIGN

Treatment Group	Rate Plan	Enabling Technologies	Information Feedback
Simple TOU	Time-of-Use with Critical Peak Price (TOU-CPP)	None	Written educational materials Daily total usage and cost via utility hosted web portal
Enhanced Technology	Time-of-Use with Critical Peak Price (TOU-CPP)	Tendril HAN w/web portal, PCT, IHD, Controllable outlet	Written educational materials Sub-hourly feedback on usage and cost through HAN web portal Daily total usage and cost via utility hosted web portal
Smart Thermostat	Pre-existing fixed flat rate	Programmable controllable thermostat (PCT)	Written educational materials Daily total usage, web-based thermostat control and monitoring and cost via utility hosted web portal

Simple TOU: Customers enrolled in the Simple TOU program were set up on the Time-of-Use (TOU) rate structure that is discussed in more detail in Section III-D of this report and included on-peak, off-peak and critical-peak time periods. These customers were provided with written educational materials that described the TOU rate, the goals and objectives of the pilot program, and simple tips and tactics for shifting energy usage to off peak hours. Customers were also provided access to a web portal hosted by Unitil that provided daily feedback on total energy consumption by TOU period and the associated daily cost of energy. The treatment for this group of customers consisted solely of the TOU rate, written educational materials, and online web portal. No additional enabling technologies were included.

Enhanced Technology: The Enhanced Technology group received the identical treatment as the Simple TOU group but also received the Tendril Residential Energy Ecosystem (TREE), an in-home ZigBee-based wireless energy management system that included a handheld in-home display (IHD), programmable controllable thermostat (PCT), portable controllable outlet for plug loads, and an online web portal that provided sub-hourly feedback on energy consumption, notification of CPP events and detailed billing and usage analytics. The system included the ability for customers to pre-set control settings for the thermostat and outlet to respond to various price levels.

This treatment group was designed to test the *incremental* impact of the TREE Home Area Network in assisting customers conserve energy and reduce on-peak and critical-peak consumption compared to the Simple TOU group that received the same TOU rate and simple educational materials. The TREE system allowed for both utility- and customer-automated load control and demand response, however only customer-automated load control was implemented in the pilot.

Smart Thermostat: The Smart Thermostat group tested a more traditional approach to direct load control of central air conditioning systems. This group remained on their existing fixed flat electric rate and received a Honeywell UtilityPro™ thermostat that was utility controlled using a paging network. The thermostats were configured to cycle customer's air conditioning systems on a 50% cycle on critical peak days – meaning the systems were cycled off for 30 minutes out of every hour during the critical peak periods. Customers had the ability to opt out of control events on critical peak days and remotely monitor and control their thermostats through a Honeywell web portal. In exchange for allowing Unitil to control their air conditioning systems on critical peak days, customers in this group were eligible to receive a $35 incentive at the end of the program. Customers who opted out of more than one event forfeited a portion or all of their incentive depending on the number of opt outs.

Educational materials provided to each treatment group are provided in Appendix A.

C. Control Group

The control group was used as the baseline against which demand response actions of the pilot participants was measured. The control group was comprised of residential customers with central air conditioning who did not receive any treatment. The control group consisted of a combination of Unitil's load survey sample that existed prior to the pilot, supplemented with customers who volunteered to participate in the pilot but who were randomly assigned to the control group.

Phone surveys were conducted with the existing load survey sample to determine which customers had central air conditioning and those customers were utilized in the control group; these existing load survey customers represented approximately half of the final control group. These load survey customers had already been provided interval meters and had historical peak and usage data to serve as a reference.

The remainder of the control group was comprised of residential customers with central air conditioning who volunteered to participate in the pilot but were randomly assigned to the control group. These customers were also randomly selected from the qualified participant pool as needed to match the target usage stratification. These customers participating in the control group were provided a one-time incentive payment of $20 that was issued at the conclusion of the pilot. Except for the original program marketing materials, control group customers were not provided with any educational materials or access to the Unitil web portal.

D. TIME-OF-USE RATE STRUCTURE

The Time-of-Use (TOU) rate structure featured off-peak, on-peak and critical peak periods. On-peak periods were from 12 p.m. – 6 p.m. weekdays only (excluding holidays). All other hours, including mornings, evenings, weekends and holidays, were all off-peak periods. Critical peak periods were from 12 p.m. – 6 p.m. on weekdays and occurred only as declared by Unitil on forecasted high load days. Unitil utilized the forecasting methodology discussed in Section III-E to identify critical peak days and notified customers by 5 p.m. the day prior that the following weekday would be a critical peak period. In total, five (5) critical peak periods were declared during the course of the pilot. The rate design was based on a minimum of two (2) critical peak periods and a maximum of eight (8) critical peak periods. The default service (supply) component of the bill was the only component that changed based on the time period; delivery and customer charges were constant regardless of when the energy was consumed.

The TOU rates were designed to be revenue neutral for an *average* residential customer based upon actual Company appropriate load zone locational marginal pricing for June through August 2010, and the assumption of six Critical Peak events for the test period. This data was compiled to determine the ratio of the average price during the on-peak period to the average price during the off-peak period. For Unitil's Massachusetts territory, the ratio was 1.67 and for the New Hampshire territory the ratio was 1.68. Critical peak pricing was developed based on the Independent System Operator Forward Capacity Market (ISO-FCM) clearing price for the upcoming period and adjusted to account for ancillary services, distribution losses, and other adjustments to capacity costs. Detailed derivations of the final TOU rates have been previously submitted to and approved by the respective State regulatory agencies. Tables 3 and 4 show the final TOU default service rate structure for non-low-income customers in each state:

TABLE 3: NH DEFAULT SERVICE TOU RATE STRUCTURES FOR NON-LOW INCOME

Hours	(Peak / Off-Peak / CPP)	Rate ($/kWh)
6 p.m. - 12 p.m. Non-Holiday Weekdays, all hours Weekends and Holidays	Off-Peak	$0.05131
12 p.m. - 6 p.m. Non-Holiday Weekdays Only	Peak	$0.08487
12 p.m. - 6 p.m. Non-Holiday Weekdays Only	Critical Peak	$0.61494

TABLE 4: MA DEFAULT SERVICE TOU RATE STRUCTURES FOR NON-LOW INCOME

Hours	(Peak / Off-Peak / CPP)	Rate ($/kWh)
6 p.m. - 12 p.m. Non-Holiday Weekdays, all hours Weekends and Holidays	Off-Peak	$0.04748

12 p.m. - 6 p.m. Non-Holiday Weekdays Only	Peak	$0.10846
12 p.m. - 6 p.m. Non-Holiday Weekdays Only	Critical Peak	$0.64642

E. CRITICAL PEAK SELECTION METHODOLOGY

Unitil utilized a 2010 temperature vs. load model as a means to schedule demand reduction events on a day-ahead basis. An average daily temperature of 78 degrees F was selected as a reasonable threshold to result in approximately six (6) critical peak events; this threshold does not correlate directly with previous system peak conditions and would need to be reviewed if a full program were undertaken. The Company received a daily seven day weather forecast that was monitored for the potential for higher temperatures, providing plenty of notice for consideration and communication to customers of planned events. The seven day weather forecast that Unitil received provided temperatures for Portsmouth, NH, which was most central to its operating centers.

The temperature vs. load model was developed as a function of Unitil's normal planning process. Unitil develops a temperature vs. load model for each of its operating areas. The basis for each model is a series of yearly regressions that are developed to correlate daily loads to daily temperatures in that season. Once a model is established, an estimated peak load can be derived for any given temperature. The probability distribution for annual highest temperatures is assumed to follow the discrete distribution of past historical highest temperatures. The random possibilities of peak load outcomes for any specific temperature are assumed to follow a standard probability distribution model with a mean centered on the point estimate of the peak load at that temperature and varying based on its individual standard deviation according to the fit of the seasonal model to the actual historical values.

For the pilot program, an average daily temperature of 78 degrees F was established as the threshold for declaring critical peak events. Table 5 summarizes the day ahead forecasted average daily temperatures, and actual average daily temperatures for the five critical peak days:

TABLE 5: CPP DAYS CALLED AND FORECASTED AVERAGE DAILY TEMPERATURE

Critical Peak Event	Forecasted Daily Temperature	Actual Avg. Daily Temperature
7/6/2011	78°F	78°F
7/11/2011	79°F	79°F
7/12/2011	80°F	80°F
7/21/2011	85°F	85°F
7/22/2011	83°F	83°F

This table illustrates that the forecasted temperatures were in fact identical to the actual average daily temperatures realized on each critical peak day. Due to the number of critical peak days declared in July and a concern for potentially exceeding the number of design days through the full course of the Pilot, the threshold was adjusted up to an average daily temperature of 80 degrees F after the last critical peak event. However, temperatures never reached this threshold for the remainder of the pilot.

F. MARKETING AND RECRUITMENT

Customers were recruited to participate in Unitil's pilot program utilizing an "opt-in" enrollment model. Customers were engaged using a variety of media channels. In addition to the development of a marketing brochure and a letter from Unitil's CEO inviting customers to enroll in the program, email marketing and publicity on Unitil's website were also employed to maximize the response on recruitment activities. Copies of the marketing material are included for reference in Appendix B.

The program brochure introduced customers to the Energy Savings Management Program, providing a general overview of the pilot's goals and technologies. The brochure highlighted the opportunity to reduce expenditures on energy bills and to test cutting edge smart grid technologies as the key customer incentives to opt-in to the program. Additionally, the mailing identified a number of other beneficial impacts of the pilot, including the reduction of energy usage during periods of peak demand and the reduction of harmful greenhouse emissions. In order to better illustrate the importance these outcomes, one page of the brochure also provided a description of the root causes of peak demand and the potential negative impacts of exceeding a utility's electrical capacity.

It is important to note that the initial marketing materials did not describe any of the three program segments in any detail, rather just the program as a whole. This was done to mitigate self-selection bias within the various treatment groups. Interested customers were able to register by signing and returning a post card, calling a toll free number or entering their information on-line.

In order to better focus outreach and recruitment efforts to eligible participants, customers with characteristics representative of central air conditioning usage were identified to receive the first round mailing of marketing materials. An initial mailing of the brochure, along with the letter from Unitil's CEO, was sent to a randomly selected group of 5,000 customers derived from this pre-screened list. In deriving the mailing list from the pre-screened list, Unitil first identified and selected all customers on low-income rates (196-MA, 191-NH), then randomly selected candidates from among the remaining residential customers until the target quotas were reached. The enhanced low-income sampling was done in accordance with the Settlement Agreements included as part of Unitil's TOU pilot proceedings in both Massachusetts and New Hampshire.

Due to the relatively low saturation of central air conditioning in the region, and compatibility restrictions with some of the technologies being tested, the initial marketing efforts proved insufficient to recruit the target number of customers. Because the marketing material specifically identified the presence of central air conditioning as a prerequisite for participation and without knowing for certain which of the pre-screened customers did, in fact, have central air, it was difficult, if not impossible, to accurately assess the response rate of qualified customers. Phone surveys were administered to a representative sample of customers with central air conditioning who declined to participate and who remembered receiving the promotional material. The most common reasons customers gave for not participating were general lack of interest, uncertainty about what the program was supposed to accomplish and what would be asked of them, and concern that they couldn't make changes based on Time-of-Use rates because they were home all day.

The challenge of recruiting qualified customers was compounded when the field installations began in early April and it was discovered that more than 40% of the customers who had been "pre-screened" for compatibility with the Enhanced Technology group were being disqualified for a variety of field conditions, and approximately 5-10% of customers who had previously volunteered to participate were not responsive to efforts to schedule an installation appointment. These factors caused Unitil to pursue additional outreach strategies. First, email outreach was also used as a low cost option to reach a broader base of eligible customers and was targeted towards customers with online accounts with Unitil that had been active within the past 12 months. The emails were standard text emails that provided information on the pilot program, eligibility requirements, and provided information for eligible customers to learn more. A copy of the email used is included for reference in Appendix B. Additionally, a number of condominium complexes that were known to have central air conditioning were identified and targeted mailings of program marketing materials were disseminated to homeowners to encourage participation.

During the recruitment and assignment process, customers were screened for qualification on the basis of having a functional central air conditioning system, owning their home, not having any plans to move within the pilot period, and not planning any extended vacations during the pilot period (of more than two weeks). Qualified customers were then assigned to one of the three program segments which were described in detail over the phone by a program representative. It should be noted, however, that while the customers were assigned to test groups as randomly as possible, placement was also influenced partly by technical requirements and statistical stratification requirements. In order for the various program segments to be considered statistically representative, quotas were determined for each monthly energy usage stratum during the program design phase. The limited number of customers who met the general and technical eligibility requirements, particularly for the Enhanced Technology group, in certain cases necessitated the non-random assignment of customers to program segments.

Once a customer was deemed qualified, expressed an intention to participate and was assigned to a technology group, an installation contractor called to arrange a time to visit their home and install analysis meters and the technology components. The contractor reviewed the program in detail with the customer again, including the specific descriptions of the pricing plan and technology associated with the customer's assigned test group. The installation contractor also provided customers with educational materials that further described the program and offered tactics for reducing peak demand and average load.

A phone survey of 69 customers who declined to participate, and who were qualified to participate (central air conditioning) was completed in spring 2011. Results of the survey are included in electronic form as Appendix I. More than 3 in 10 respondents indicated that they received the promotional material but did not read it. Of those who did read it, 45% stated they originally intended to participate but did not get around to it. The most common reasons for not wanting to participate was that the program was not sufficiently described such that customers knew what they were getting into or had home life situations that they felt was not conducive to time of use pricing (i.e. persons working from home).

G. Sample Design and Assignment

The sampling plan was designed to provide measurable results with a precision of 90% confidence with a 10% sampling error for each of the three treatment groups and the control group.[3] In order to achieve the necessary level of precision, a sample requirement of 68 customers was estimated for each of the four sample groups *(three treatments and one control)*. Unitil's initial proposal called for a sample size of

[3] Based on a mean impact of 1.0 kW and a standard deviation of 0.5 kw

76 customers to account for expected drop-outs and still achieve the desired confidence levels. Each sample contained a proportional balance of customers from both New Hampshire and Massachusetts based on the total number of electric customers served in each state. The purpose of developing samples using customers from both states was to accurately represent Unitil's entire service area while minimizing costs to customers. Table 6 shows a breakdown of targeted sample sizes by state.

TABLE 6: SAMPLE SIZES AND DISTRIBUTION BY STATE

Sample Group	Massachusetts		New Hampshire	
Simple TOU	24	25%	52	25%
Enhanced Technology	24	25%	52	25%
Smart Thermostat	24	25%	52	25%
Control Group	24	25%	52	25%
Total Received	96	100%	208	100%

Additionally, during the design phase of the pilot, sampling strata were determined for each of the three programs as well as for the control group. Stratification was based on average kWh consumption during the summer months and a target sample size for each stratum was developed to mirror the kWh distribution of Unitil's residential central air conditioning population. This was based on the actual stratification of customers who volunteered to participate because they represented the only known population of customers with central air conditioning.

A systematic assignment approach was initially used to select customers for each sample once they had been prequalified for eligibility. This was done by sorting the eligible customers by consumption strata, then randomly assigning customers to one of the three treatment groups or the control group. However, while all efforts were made to adhere to this sampling approach, the large volume of turn downs necessitated the non-random assignment to the Time-of-Use groups. It was quickly determined during the installation phase that technical compatibility restrictions of the thermostats for the Enhanced Technology group were resulting in a large number of turn downs for "pre-screened" customers. The most common reasons for field turn downs were non-forced hot air heating systems (i.e. hot water baseboard, radiant floor, etc.) and multi-zone systems that utilize dampers. The Tendril thermostat was essentially limited in compatibility to single zone forced air systems. The Honeywell thermostat (Smart Thermostat group) was also incompatible with multi-zone systems that included dampers, but was able to control all types of heating systems without dampers.

In order to reduce attrition from the program due to technical turn-downs, an assignment strategy was developed whereby customers were randomly assigned to the Time-of-Use program but were not initially assigned to either the Enhanced Technology or Simple TOU segment. Instead, customers were informed they had been selected to receive the time-of-use rate and some customers received additional technology depending upon whether their home was compatible. The installation contractors evaluated on-site whether the home was compatible with the Tendril TREE package based on the type and condition of the HVAC system, internet availability, and other site logistics such as the distance from the meter base to the home. If the customer was found to be incompatible with the enhanced technologies, they were assigned to the Simple Time-of-Use group. While this reduced the number of customers who had to be turned away from the program and helped reach the target enrollment numbers, it had the effect of introducing some bias in the selection of the Enhanced Technology and Simple TOU groups. Generally, the Enhanced Technology group included customers with smaller, newer single zone homes and the Simple TOU group included customers with larger multi-zone homes. Similarly, homes with multiple zones and a single condensing unit were not compatible with the Smart Thermostat group so this group tended to include smaller homes than the Simple TOU and control groups. Table 7 shows the final group assignment and stratification of customers in the pilot program.

TABLE 7: NUMBER OF PARTICIPANTS BY CONTROL GROUP AND STRATA

Strata	Control	Smart Thermostat	Enhanced Technology	Simple TOU
0-800	17	18	29	27
801-1200	23	18	24	20
1201-1600	13	21	13	17
1601-2000	13	10	4	5
2001-3000	8	8	2	4
>3000	1	1	0	2

Pilot results were weighted to correct for the differences in consumption strata between the groups. The methodology for weighting the results is addressed in the Impact Evaluation section of this report.

As per the evaluation framework established by the Massachusetts Smart Grid Collaborative, Unitil collected demographic data for all pilot treatment group participants and a portion of the control group in order to compare the demographic composition of the pilot sample relative to Unitil's customer base at large, and also for differences between groups. Participant demographic data was collected in the pre-pilot survey that was administered to each treatment group. An identical survey was administered to the 38 participants that were added to comprise the control group.[4] A summary of the data is provided in Appendix C. Overall, one key findings is that homes in each of three treatment groups were newer and more modern in comparison to Unitil's total Massachusetts base. A significant number of homes were built after the year 2000. Households were relatively young in the two technology groups compared, and were generally higher income households that had completed higher levels of education compared with the statewide average. The Enhanced Technology group was the youngest, with a high concentration of household heads that were under 50 years of age. The Smart Thermostat group had a slightly older composition, with a higher concentration of middle aged household heads (40-60 years).

[4] Existing load research customers utilized in the control group were not surveyed. Demographic data for control group is based on the 21 survey responses that were received.

III. IMPACT EVALUATION

A. OBJECTIVES

The impact evaluation is a critical component of the pilot program, seeking to measure the impact of the various rate and control programs on average customer energy and peak demands. The evaluation focuses on measuring the impact of a CPP event for every hour of the day, since customer behavior can be altered throughout the day and not just during critical hours. For instance, customers may try to pre-cool their homes prior to the event or there may be recovery after an event as air conditioners run to cool the home back to thermostat set points. By measuring every hour of the day, the evaluation also determines if there are impacts on total energy consumption during event days.

The pilot focused on residential homes in the Unitil service territory with central air conditioning. To ensure representation of this defined population in the impact evaluation, the participants were stratified based on average summer usage prior to being assigned to the various control and treatment groups. However, as discussed earlier a number of technical compatibility barriers restricted Unitil's ability to perfectly match the target strata composition of each group. This has been corrected in the impact analysis through the weighting of individual customer data to ensure proper representation of the results to the population and to the other treatment groups.

As required by the Statewide Evaluation Collaborative Framework, the impact evaluation was extended to analyze the impacts on certain sub-groups. Sub-groups included participants with a senior in the household, high use customers, high and low income customers, and large and small home customers. Impacts for these various subgroups were evaluated to the extent that there were enough customers in a category to make the results statistically meaningful. More detail on this sub-group analysis is provided in the methodology section below.

The remainder of this section of the report describes the data collected and used for the impact evaluation, discuss the methodologies used to estimate the impacts, and presents the results of the evaluation.

B. DATA COLLECTION

The impact evaluation required a significant amount of data which was collected from various sources. Interval meters were installed for customers in the Simple TOU and Smart Thermostat groups, and for the control group members that were not part of the existing load research sample[5]. Continuous fifteen-minute interval data was collected for all of these customers for June through September, 2011.

Interval data for the Enhanced Technology Group was obtained from Tendril. In concept, the home area network (HAN) is designed to log each kilowatt-hour and transmit that data for each customer to Tendril via the internet connection. Tendril then utilizes algorithms to estimate the average demand during each 15 minute interval. The main concern of relying on this data during the planning phase was the implication if communications between the HAN and Tendril failed. This concern was assuaged because

[5] Customers in the existing load research sample were already provided with interval meters.

the HAN had the capability to store data locally in the event of a communication failure, and upload the data when communications were restored. Utilizing the HAN for interval data was also viewed as a way to reduce project costs by eliminating the need for interval meters for Enhanced Technology customers; the benefit and cost implications of installing interval metering was questioned by regulators in both States during the planning phases.

In practice, Unitil experienced a wide range of errors with the data received through the HAN and this had a strongly negative impact on the ability to draw conclusions from this group. When data was recorded by the HAN, it was found to be in near perfect agreement with Unitil's AMI system for each time period which validated the accuracy of the data when received. The main issue was with the consistency of the data received. Data failures experienced in the pilot can be broadly categorized into the following two groups:

Offline HAN: A number of scenarios can cause a HAN to go offline, ranging from equipment failures, equipment being unplugged, data transmission issues (between devices in the home) and so forth. Monitoring and troubleshooting the offline accounts was a constant challenge and would be an integral component of any full deployment featuring HAN's. During the pilot, Unitil was informed by Tendril that 10-15 percent of accounts being offline should be anticipated at any time. Any time the HAN went offline interval data was lost and is not retrievable.

Data Gaps: The second category of missing data is attributable to reading/data gaps in otherwise online and active accounts. These errors were not discovered until later in the pilot when the detailed interval data was reviewed and it was found that many customers' data showed gaps in readings of variable length. These gaps are not attributable to low usage because the next reading after the gap always showed multiple accrued kWh. Tendril attributed the data gaps to customers switching off or unplugging equipment, and while this may account for some of the gaps it seems an unlikely explanation for all. Many times, gaps in data spanned a time-of-use period making it impossible to parse consumption as off-peak from on-peak. The gaps in data also affected our ability to evaluate impacts from this segment of the program. The interval data was screened by account to assess the significance of missing data intervals. Table 8 summarizes the sufficiency of the interval data, indicating good data for the control, simple time-of-use, and thermostat control groups. The Tendril data had significant data gaps and many of the accounts were therefore unusable for the evaluation. The Tendril system would record total energy consumption during data gaps, but the gaps in many cases were so long (sometimes even days long), that trying to estimate loads during the gaps would have been counterproductive to the analysis. AMI data that stores cumulative on- and off-peak kWh usage was examined as a possible alternative to help fill some gaps. Although the data from the AMI system accumulated kWh usage during on- and off-peak periods, GDS would still have to use simplifying assumptions to estimate the hourly demands in order to use that data for the analysis. Therefore, GDS elected not to use the AMI data but rather to proceed with the analysis with fewer than desired customers and show a greater level of uncertainty with that portion of the analysis.

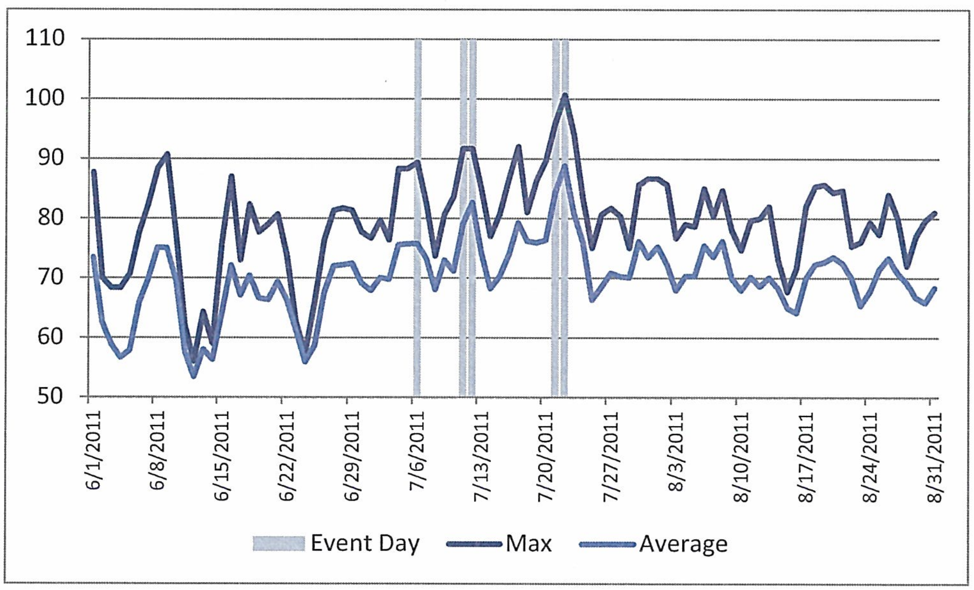
TABLE 8: QUALITY OF INTERVAL METER DATA

Group	Number in Pilot	Number with Major Data Gaps	Percent with Major Data Gaps	Number Excluded*	Final Number in Evaluation
Control	74	2	3%	1	73
STOU	76	2	3%	0	76
T-STAT	72	4	6%	1	71
Tendril	72	44	61%	44	28

* Customers with major data gaps were excluded if there were significant hours missing specifically from event days.

Two other major data sources were also used to complete the dataset for the impact evaluation. Hourly temperatures were obtained from the National Oceanic and Atmospheric Administration ("NOAA"). Temperatures were obtained for Concord NH, Fitchburg MA, and Portsmouth NH, representing the three distribution operating centers for Unitil.[6] Figure 1 shows maximum and average daily temperatures for each day of the pilot. Finally, customer survey data was used to determine some of the sub groupings, as described below.

FIGURE 1: MAXIMUM AND AVERAGE DAILY TEMPERATURES
AVERAGE OF CONCORD, FITCHBURG, AND PORTSMOUTH



[6] Portsmouth weather is used for day-ahead forecasting, which was used to help determine when to call CPP events.

C. METHODOLOGY

STRATIFICATION

Unitil used a stratified sampling plan to ensure that the pilot participants were representative of the population of interest. The population was defined to be all residential consumers that own central air conditioners. The sample was stratified based on average summer usage, based on the Dalenius and Hodges method. Due to few very high usage customers (average summer usage in excess of 3,000 kWh), that stratum was assigned as a census in the design. Four out of the five very high usage customers ended up in the pilot program. A stratified sampling plan has several advantages:

- A stratified random sample can provide greater precision than a simple random sample of the same size.
- Therefore, a stratified sample often requires a smaller sample, which makes it more cost-effective. The tradeoff is extra administrative burden.
- A stratified sample can guard against drawing a sample that is significantly different from the population of interest.
- The design allows for assurance of assigning enough sample points to appropriately analyze subgroups, if the subgroups are based on one of the variables upon which the sample is stratified.

Once the sample design was in place, Unitil assigned pilot participants to the various control and treatment groups. However, various practical issues resulted in a final sample that did not perfectly match the design. Such a result is expected. The primary issues encountered were due to compatibility limitations with thermostats being tested, more specifically with larger homes that have multi-zone damper systems. In order to ensure that the impact evaluation is representative of the population, the results were weighted based on the stratification plan. The weights were calculated by comparing the sample design proportion to the actually sample proportion, as shown in Table 9.

TABLE 9: STRATIFICATION PLAN AND SAMPLE WEIGHTS FOR IMPACT EVALUATION[7]

	Design		Control			Simple TOU		
Strata	Count	%	Count	%	Weight	Count	%	Weight
0-800 kWh	10	14.1%	16	21.9%	0.6420	18	24.0%	.05863
801-1200 kWh	22	30.4%	23	31.5%	0.9634	18	24.0%	1.2648
1201-1600 kWh	13	18.7%	13	17.8%	1.0527	21	28.0%	0.6695
1601-2100 kWh	12	16.8%	13	17.8%	0.9330	10	13.3%	1.2461
2101-3000 kWh	14	20.2%	8	11.0%	1.8445	8	10.7%	1.8950

[7] The over 3,000 kWh stratum was weighted to represent 2.3% of the total, which is the proportion of the population represented by the stratum

	Design		Smart Thermostat			Enhanced Technology		
Strata	Count	%	Count	%	Weight	Count	%	Weight
0-800 kWh	10	14.1%	23	33.3%	0.4222	7	25.0%	0.5629
801-1200 kWh	22	30.4%	20	29.0%	1.0472	9	32.1%	0.9444
1201-1600 kWh	13	18.7%	17	24.6%	0.7609	10	35.7%	0.5249
1601-2100 kWh	12	16.8%	5	7.2%	2.2928	1	3.6%	4.6520
2101-3000 kWh	14	20.2%	4	5.8%	3.4868	1	3.6%	5.6597

Model Specification

The primary purpose of the impact evaluation is to estimate, via some kind of model, what usage would have been on event days had a CPP event not occurred and on on-peak days had customers not been subject to on-peak rates – both called a baseline. For the simple and enhanced TOU groups, another goal is to estimate the impact on loads due to the on-peak rate on non-CPP event days. There are two basic regression model specifications that can be used to estimate a baseline. A panel model inputs data for all the customers into one regression model with indicator variables included for each customer (customer fixed-effects), calendar variables (day of week, hour of the day), for event hours, and for weather. The second approach is to build a regression model for each customer in the pilot. The individual regressions each have calendar, event, and weather variables included in them.

Both model specifications were tested for the Unitil pilot. The individual regressions performed better than the panel model in two respects. First, the initial panel model gave impact estimates that were inconsistent with theory and with a simple comparison of means test. For the thermostat group, it showed little or no impact on events. This is not likely to be realistic since this is the group where Unitil had direct control of air conditioners. The panel model in this instance is also difficult to specify correctly because of the many elements involved in the three different control groups. The two TOU groups have both on- and off-peak periods as well as CPP event periods whereas the thermostat group only had CPP event periods. The individual regressions also make it much easier to summarize impacts for any subgroups of interest, since impacts are estimated for each customer. GDS used the control group data as an input into the regressions, making valuable use of the control group to help establish baselines for treatment group customers.

The model specification for each regression model is designed to capture the impacts of weather and of the on-peak and critical peak events in every hour of the day. By measuring the impact in every hour, it is easy to assess if there is significant load build-up prior to the critical hours on the day of an event or if there is a significant recovery peak in the one-to-two hours following an event. The model specified for each customer is shown below.

$$kW_h = \alpha + \beta \cdot contkw_h + \sum_{m=6}^{8} \gamma_m \cdot month_m \cdot cdh_h + \sum_{h=13}^{18} \delta_h \cdot onpeak_h + \sum_{h=13}^{18} \zeta_h \cdot onpeak_h \cdot cdh_h + \sum_{h=13}^{18} \eta_h \cdot onpeak_h \cdot {cdh_h}^2 + \sum_{h=1}^{24} \theta_h \cdot event_h + \sum_{h=1}^{24} \iota_h \cdot event_h \cdot cdh_h + \sum_{h=1}^{24} \kappa_h \cdot event_h \cdot {cdh_h}^2 + \varepsilon_h$$

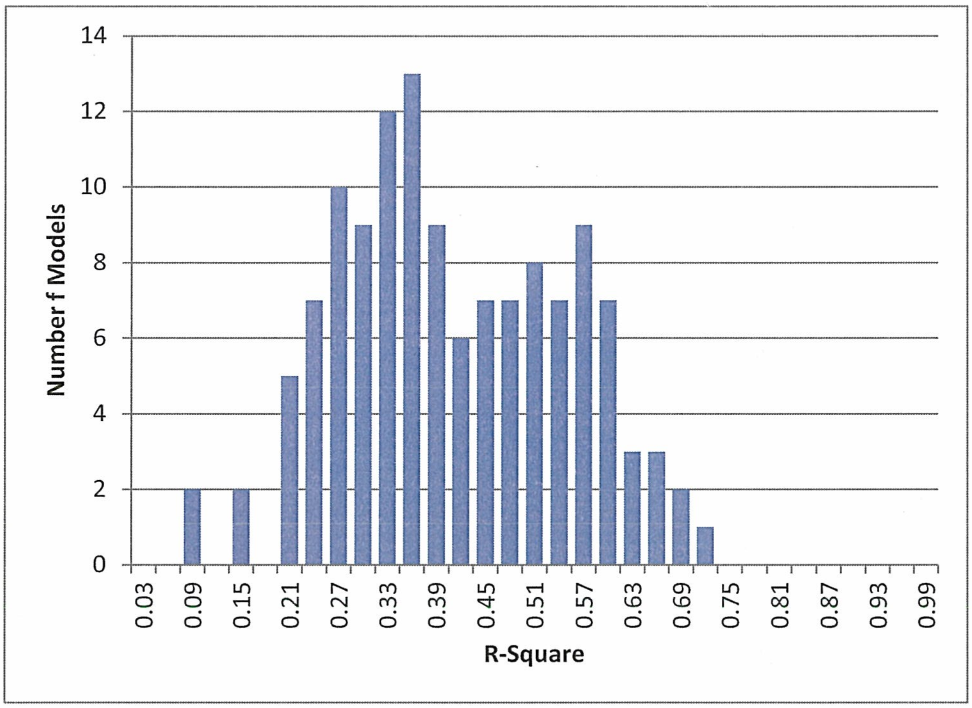
Where:

Notation	Description
h	Index for the hour
m	Index for the month
kW	Hourly kW
α	Estimated constant
$\beta, \gamma, \delta, \zeta, \eta, \theta, \iota, \kappa$	Estimated model coefficients
contkw	Average control hourly kW
month	Indicator (binary) variable for each month
onpeak	Indicator (binary) variable for an hour that is defined as an on-peak hour
event	Indicator (binary) variable for an hour that is a CPP event day hour
cdh	Cooling degree hours, defined as the maximum of 0 or the hourly temperature minus 65°F. It is used to represent intensity of air conditioning load.
ε	The error term

GOODNESS-OF-FIT

With individual regression models, goodness-of-fit statistics are generated for each customer in the pilot program. As would be expected, there is a wide range of R-square (or R^2)[8] values across the 200+ models that were generated in the evaluation. The distribution of R^2 values is shown in Figure 2 below. The average R^2 is 0.395, with a standard deviation of 0.139.

FIGURE 2: DISTRIBUTION OF R2 VALUES FOR INDIVIDUAL REGRESSIONS



Individual homes exhibit many variations in behavior that make prediction of household hourly loads difficult. Therefore, R^2 values in this range for the individual models are expected.[9] However, aggregate behavior is easier to predict, and the impact evaluation really seeks to predict impacts for the average customer in the population. Therefore, the more important goodness-of-fit tests should be conducted for the average customer. To assess the R^2 and other fit statistics, then, the hourly loads for each customer are averaged using the weighting factors. The hourly modeled predictions are also weighted and averaged. Then, goodness-of-fit statistics can be calculated for an average customer.

Table 10, which is shown below, indicates that all models had good fit statistics for the average customer. The Simple TOU group will be used as an example to demonstrate interpretation of the statistics shown. For the average Simple TOU customer, 91.1% of the variation in hourly summer loads can be explained by the regression models, meaning only 8.9% of the variation is unexplained. The

[8] R^2 is a measure of how much variation in the variable of interest can be explained by the model. R^2 is a ratio between 0 and 1. A higher R^2 indicates better model fit.

[9] Relative, for instance, to a model designed to predict total class monthly energy consumption. Such models tend to have R^2 values above 0.85, but the good fit is achieved by the effect of individual customer load variation being "averaged out" at the class level. Much like a portfolio of stocks demonstrates more stable performance than individual stocks, a "portfolio" of customer loads is more stable than individual loads.

model was able to predict hourly loads to within an error of ±0.14 kW. With a mean load of 1.61 kW, that represents an average hourly error of ±9.0%. With high R^2 values and low rates of error, these models demonstrate sufficient goodness of fit for the impact evaluation.

TABLE 10: SUMMARY OF GOODNESS OF FIT MEASURES FOR AVERAGE CUSTOMER

Group	R-Square	Mean Hourly Load (kW)[1]	Mean Absolute Deviation (kW)[2]	Mean Absolute Percent Error[3]
Control	0.999	1.70	0.02	1.0%
Simple TOU	0.911	1.61	0.14	9.0%
Thermostat	0.941	1.60	0.13	9.0%
Tendril	0.915	1.65	0.17	10.8%

1 Represents the average load across all customers and for every hour of the summer.
2 Represents the average absolute model error in kW across all customers and for every hour of the summer.
3 Represents the average absolute percent model error across all customers and for every hour of the summer.

For the enhanced technology (Tendril) group, the models still fit fairly well, even with limited data availability. The model specification was able to predict with some accuracy Tendril performance for the data that we did have, however, the limited amount of data means we have less confidence that the estimated impacts produced by the models are representative of the population as a whole. This is evidenced by wider confidence intervals on the impact estimates.

Sub Group Analysis

Per the Massachusetts Statewide Evaluation Collaborative Framework document, several sub groups of the population were isolated for evaluation: small/large home size, low/high income, high usage, and if a senior is present in the home. This report presents impacts by these various groups if the impact in any CPP event hour is statistically different than the impact for the group as a whole.[10] In the Appendix, data is presented for any group that has at least 10 participants. Table 11 indicates the number of participants with good load data in each group and whether their impacts are reported in the Appendix[11].

TABLE 11: NUMBER OF PARTICIPANTS IN PILOT BY GROUP

Sub Group Category	Simple TOU	Enhanced TOU (Tendril)	Smart Thermostat
Small Home Size	1*	0*	10
Large Home Size	28	11	25
Low Income	3*	0[12]*	1*

[10] Statistical difference is measured by using a comparison of means hypothesis t-test with 90% confidence. The null hypothesis is that the subgroup mean impact in any hour is equal to the impact for all participants at that same hour.

[11] Note the sample included no "low-use" customers based on Collaborative definition of low use

[12] The Enhanced Technology Group did have one LI customer however this customer did not have good contiguous load data that could be utilized in the analysis. Bill impacts for this customer are presented in Appendix F

High Income	32	15	20
High Usage	35	14	28
Presence of a Senior	17	3*	17

* Data for this group is not reported in the Appendix.

D. Results

Simple Time-Of-Use

For the TOU rate, three impacts are of interest. First is the impact of the TOU rate during on-peak days, but not CPP days. Second is the impact on CPP days. In both these cases, the regression models are used to estimate baseline loads for the average Simple TOU customer, representing what load would have been had the customer not been on the rate. The third impact of interest is an assessment of what load would have been on CPP days had the customer still been on the TOU rate, but not on a CPP event day.

Figure 3 and Table 12 display the impact evaluation results for Simple TOU participants during on-peak periods (non-CPP days). This represents the impact of the on-peak portion of the rate. The impacts represent an average impact of all non-CPP on-peak days in June through August 2011. They are the weighted results representing the average Unitil customer with central air conditioning. The data are summarized and presented in hour ending notation, so an on-peak period of 12:00 PM to 6:00 PM is represented by hours ending 13 through 18. The average load reduction during on-peak hours for this group is 0.4 kW, or 21%. Total daily energy savings were 5.9%, or 2.5 kWh.

FIGURE 3: IMPACTS FOR NON-CPP ON-PEAK DAYS – SIMPLE TOU
(AVERAGE OF ALL NON-CPP ON-PEAK DAYS IN JUNE-AUGUST)

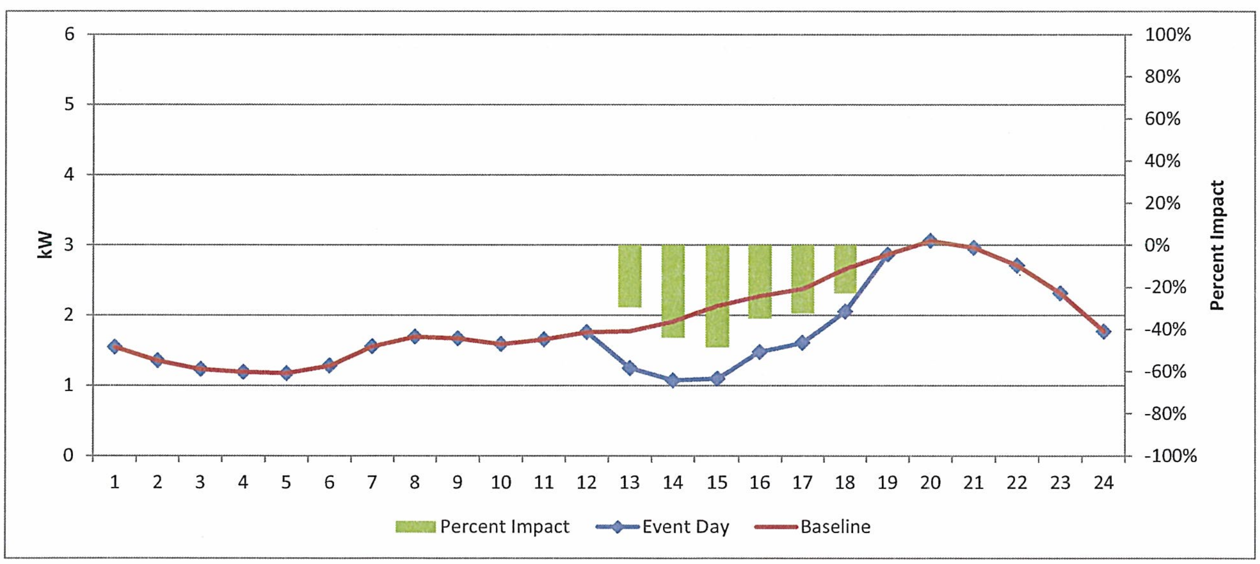


TABLE 12: IMPACTS FOR NON-CPP ON-PEAK DAYS – SIMPLE TOU
(AVERAGE OF ALL NON-CPP ON-PEAK DAYS IN JUNE-AUGUST)

Hour Ending	Event kW	Baseline kW	kW Impact	% Impact	*90% Confidence Interval on kw Impact*	
13	1.40	1.73	(0.33)	-19.1%	*(0.23)*	*(0.44)*
14	1.42	1.82	(0.40)	-21.8%	*(0.28)*	*(0.52)*
15	1.49	1.96	(0.47)	-23.9%	*(0.35)*	*(0.59)*
16	1.57	2.05	(0.48)	-23.5%	*(0.36)*	*(0.61)*
17	1.66	2.13	(0.47)	-22.1%	*(0.34)*	*(0.59)*
18	1.89	2.28	(0.39)	-17.0%	*(0.25)*	*(0.52)*
Average	***1.57***	***1.99***	***(0.42)***	***-21.2%***		
Daily kWh	***40.09***	***42.63***	***(2.53)***	***-5.9%***		

Figure 4 and Table 13 display the impact evaluation results for Simple TOU on CPP days. The impacts represent an average impact of all CPP days in July 2011. They are the weighted results representing the average Unitil customer with central air conditioning. The data are summarized and presented in hour ending notation, so an on-peak period of 12:00 PM to 6:00 PM is represented by hours ending 13 through 18. The entire day is analyzed to assess if any pre-cooling or snapback of loads after CPP event hours are evident in the data. The average load reduction during CPP event hours is 1.6 kW, or 42%. The average impact of hours just prior to the event is nearly zero, indicating little evidence of precooling on event days. However, there is evidence of a snapback or recovery of loads in the hours immediately following a CPP event. In hours ending 19-21, the load increases by an average 0.3 kW (8%). On CPP event days, overall kWh consumption was down by approximately 8% (5 kWh).

FIGURE 4: IMPACTS FOR CPP EVENT DAYS – SIMPLE TOU
(AVERAGE OF ALL CPP EVENT DAYS IN JULY)

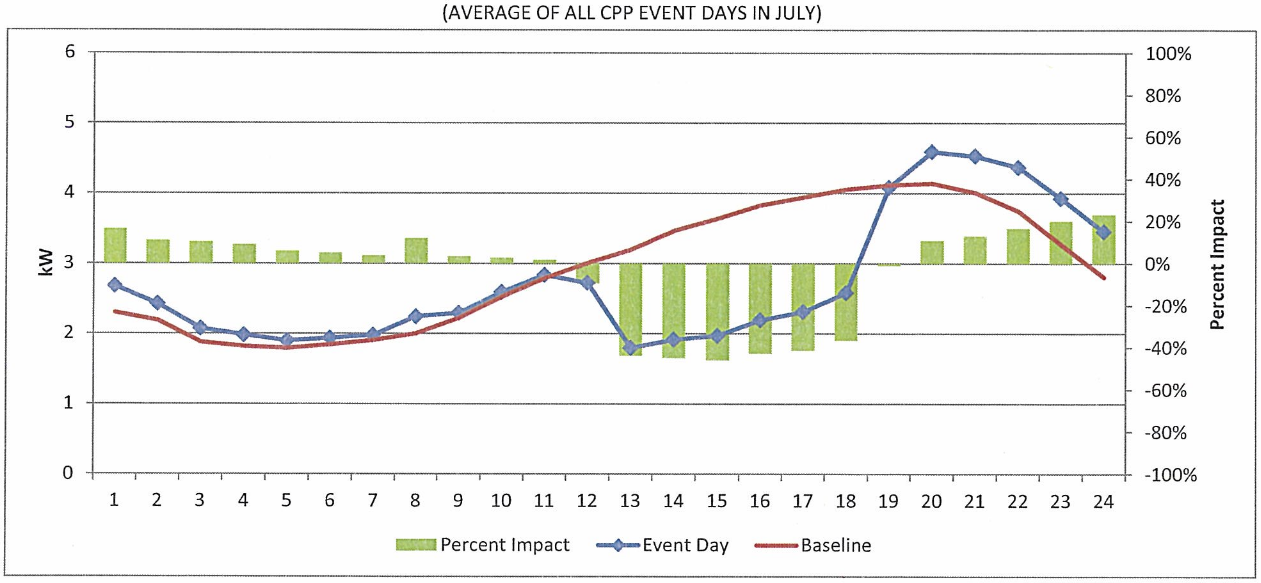


TABLE 13: IMPACTS FOR CPP EVENT DAYS – SIMPLE TOU
(AVERAGE OF ALL CPP EVENT DAYS IN JULY)

Hour Ending	Event kW	Baseline kW	kW Impact	% Impact	*90% Confidence Interval on kw Impact*	
1	2.68	2.30	0.38	16.4%	*0.14*	*0.61*
2	2.42	2.19	0.24	10.8%	*0.02*	*0.45*
3	2.07	1.88	0.19	10.3%	*0.00*	*0.39*
4	1.98	1.82	0.16	9.0%	*(0.02)*	*0.35*
5	1.90	1.80	0.10	5.8%	*(0.07)*	*0.28*
6	1.93	1.84	0.09	5.0%	*(0.09)*	*0.27*
7	1.98	1.91	0.07	3.9%	*(0.13)*	*0.28*
8	2.25	2.00	0.24	12.0%	*0.01*	*0.47*
9	2.30	2.22	0.07	3.2%	*(0.17)*	*0.31*
10	2.59	2.53	0.07	2.6%	*(0.24)*	*0.37*
11	2.84	2.79	0.04	1.6%	*(0.27)*	*0.36*
12	2.72	3.01	(0.29)	-9.5%	*(0.58)*	*0.01*
13	1.80	3.20	(1.40)	-43.8%	*(1.15)*	*(1.65)*
14	1.92	3.47	(1.55)	-44.8%	*(1.26)*	*(1.84)*
15	1.97	3.64	(1.67)	-45.9%	*(1.41)*	*(1.94)*
16	2.19	3.83	(1.64)	-42.7%	*(1.34)*	*(1.93)*
17	2.31	3.94	(1.63)	-41.4%	*(1.33)*	*(1.94)*
18	2.58	4.06	(1.48)	-36.4%	*(1.16)*	*(1.80)*
19	4.08	4.12	(0.04)	-0.9%	*(0.34)*	*0.27*
20	4.59	4.14	0.45	10.8%	*0.14*	*0.75*
21	4.53	4.01	0.52	13.0%	*0.23*	*0.81*
22	4.37	3.75	0.62	16.6%	*0.35*	*0.89*
23	3.93	3.27	0.66	20.1%	*0.37*	*0.95*
24	3.45	2.80	0.65	23.2%	*0.37*	*0.93*
Hours 10-12	***2.72***	***2.78***	***(0.06)***	***-2.1%***		
Hours 13-18	***2.13***	***3.69***	***(1.56)***	***-42.3%***		
Hours 19-21	***4.40***	***4.09***	***0.31***	***7.6%***		
Daily kWh	***65.40***	***70.53***	***(5.13)***	***-7.3%***		

Finally, Figure 5 and Table 14 show the impacts of an average CPP event day compared against the group's impacts on Non-CPP days during on-peak periods. These impacts isolate the price differential between the on-peak and critical peak prices for the average event day.

FIGURE 5: IMPACTS FOR CPP EVENT DAYS WITH BASELINE OF ON-PEAK RATE – SIMPLE TOU
(AVERAGE OF ALL CPP EVENT DAYS IN JULY)

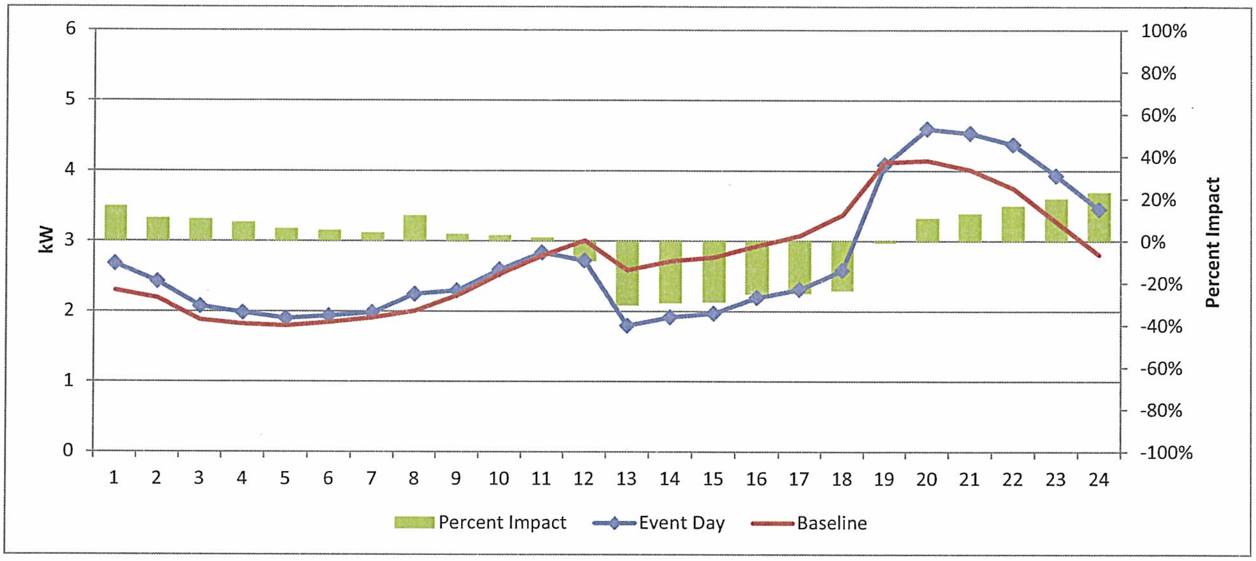


TABLE 14: IMPACTS FOR NON-CPP ON-PEAK DAYS WITH BASELINE OF ON-PEAK RATE – SIMPLE TOU
(AVERAGE OF ALL NON-CPP ON-PEAK DAYS IN JUNE-AUGUST)

Hour Ending	Event kW	Baseline kW	kW Impact	% Impact	*90% Confidence Interval on kw Impact*	
1	2.68	2.30	0.38	16.4%	*0.14*	*0.61*
2	2.42	2.19	0.24	10.8%	*0.02*	*0.45*
3	2.07	1.88	0.19	10.3%	*0.00*	*0.39*
4	1.98	1.82	0.16	9.0%	*(0.02)*	*0.35*
5	1.90	1.80	0.10	5.8%	*(0.07)*	*0.28*
6	1.93	1.84	0.09	5.0%	*(0.09)*	*0.27*
7	1.98	1.91	0.07	3.9%	*(0.13)*	*0.28*
8	2.25	2.00	0.24	12.0%	*0.01*	*0.47*
9	2.30	2.22	0.07	3.5%	*(0.17)*	*0.31*
10	2.59	2.53	0.07	2.6%	*(0.24)*	*0.37*
11	2.84	2.79	0.04	1.6%	*(0.27)*	*0.36*
12	2.72	3.01	(0.29)	-9.5%	*(0.58)*	*0.01*
13	1.80	2.58	(0.79)	-30.5%	*(0.65)*	*(1.21)*
14	1.92	2.71	(0.80)	-29.4%	*(0.60)*	*(1.21)*
15	1.97	2.77	(0.80)	-28.9%	*(0.65)*	*(1.21)*
16	2.19	2.93	(0.73)	-25.1%	*(0.69)*	*(1.39)*
17	2.31	3.07	(0.76)	-24.8%	*(0.65)*	*(1.24)*
18	2.58	3.37	(0.79)	-23.4%	*(0.62)*	*(1.28)*
19	4.08	4.12	(0.04)	-0.9%	*(0.34)*	*0.27*
20	4.59	4.14	0.45	10.8%	*0.14*	*0.75*
21	4.53	4.01	0.52	13.0%	*0.23*	*0.81*
22	4.37	3.75	0.62	16.6%	*0.35*	*0.89*
23	3.93	3.27	0.66	20.1%	*0.37*	*0.95*

24	3.45	2.80	0.65	23.2%	*0.37*	*0.93*
Hours 10-12	***2.72***	***2.78***	***(0.06)***	***-2.1%***		
Hours 13-18	***2.13***	***2.91***	***(0.78)***	***-26.8%***		
Hours 19-21	***4.40***	***4.09***	***0.31***	***7.6%***		
Daily kWh	***65.40***	***65.83***	***(0.43)***	***-0.7%***		

ENHANCED TIME-OF-USE (TENDRIL)

For the TOU rate, three impacts are of interest. First is the impact of the TOU rate during on-peak days, but not CPP days. Second is the impact on CPP days. In both these cases, the regression models are used to estimate baseline loads for the average Simple TOU customer, representing what load would have been had the customer not been on the rate. The third impact of interest is an assessment of what load would have been on CPP days had the customer still been on the TOU rate, but not on a CPP event day.

Figure 6 and Table 15 display the impact evaluation results for Enhanced TOU participants during on-peak periods (non-CPP days). This represents the impact of the on-peak portion of the rate. The impacts represent an average impact of all non-CPP on-peak days in June through August 2011. They are the weighted results representing the average Unitil customer with central air conditioning. The data are summarized and presented in hour ending notation, so an on-peak period of 12:00 PM to 6:00 PM is represented by hours ending 13 through 18. The average load reduction during on-peak hours was 0.8 kW, or 35%. The average daily energy reduction was 4.6 kWh, or 9.8%. The confidence intervals for the enhanced TOU group tend to be wider than the intervals for the Simple TOU and Thermostat groups. This is due to the fact that only 28 customers had usable data when the sample design was for a minimum of 68 customers.

FIGURE 6: IMPACTS FOR NON-CPP ON-PEAK DAYS – ENHANCED TOU
(AVERAGE OF ALL NON-CPP ON-PEAK DAYS IN JUNE-AUGUST)

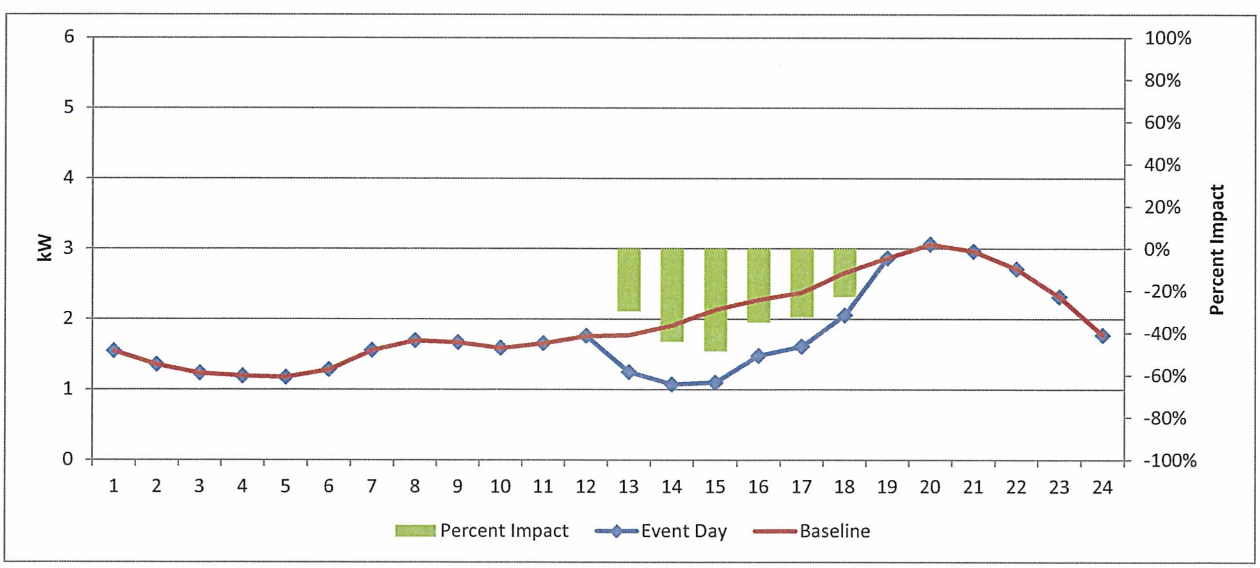


TABLE 15: IMPACTS FOR NON-CPP ON-PEAK DAYS – ENHANCED TOU
(AVERAGE OF ALL NON-CPP ON-PEAK DAYS IN JUNE-AUGUST)

Hour Ending	Event kW	Baseline kW	kW Impact	% Impact	*90% Confidence Interval on kw Impact*	
13	1.25	1.77	(0.52)	-29.5%	*(0.19)*	*(0.86)*
14	1.07	1.91	(0.84)	-43.8%	*(0.52)*	*(1.15)*
15	1.10	2.14	(1.04)	-48.5%	*(0.79)*	*(1.29)*
16	1.48	2.27	(0.79)	-34.9%	*(0.54)*	*(1.05)*
17	1.61	2.38	(0.77)	-32.3%	*(0.43)*	*(1.11)*
18	2.06	2.66	(0.60)	-22.7%	*(0.34)*	*(0.87)*
Average	***1.43***	***2.19***	***(0.76)***	***-34.8%***		
Daily kWh	***41.97***	***46.54***	***(4.57)***	***-9.8%***		

Figure 7 and Table 16 display the impact evaluation results for Enhanced TOU on CPP days. The impacts represent an average impact of all CPP days in July 2011. They are the weighted results representing the average Unitil customer with central air conditioning. The data are summarized and presented in hour ending notation, so an on-peak period of 12:00 PM to 6:00 PM is represented by hours ending 13 through 18. The entire day is analyzed to assess if any pre-cooling or snapback of loads after CPP event hours are evident in the data. The average load reduction during on-peak hours is 2.6 kW, or 70%. The average impact of hours just prior to the event is also negative, indicating customers tended to begin to respond prior to the actual event hour. However, there is evidence of a snapback or recovery of loads in the hours immediately following a CPP event. In hours 19-21, the load increases by an average 0.5 kW (10%). On CPP event days, overall kWh consumption was down by about 20% (14 kWh).

FIGURE 7: IMPACTS FOR CPP EVENT DAYS – ENHANCED TOU
(AVERAGE OF ALL CPP EVENT DAYS IN JULY)

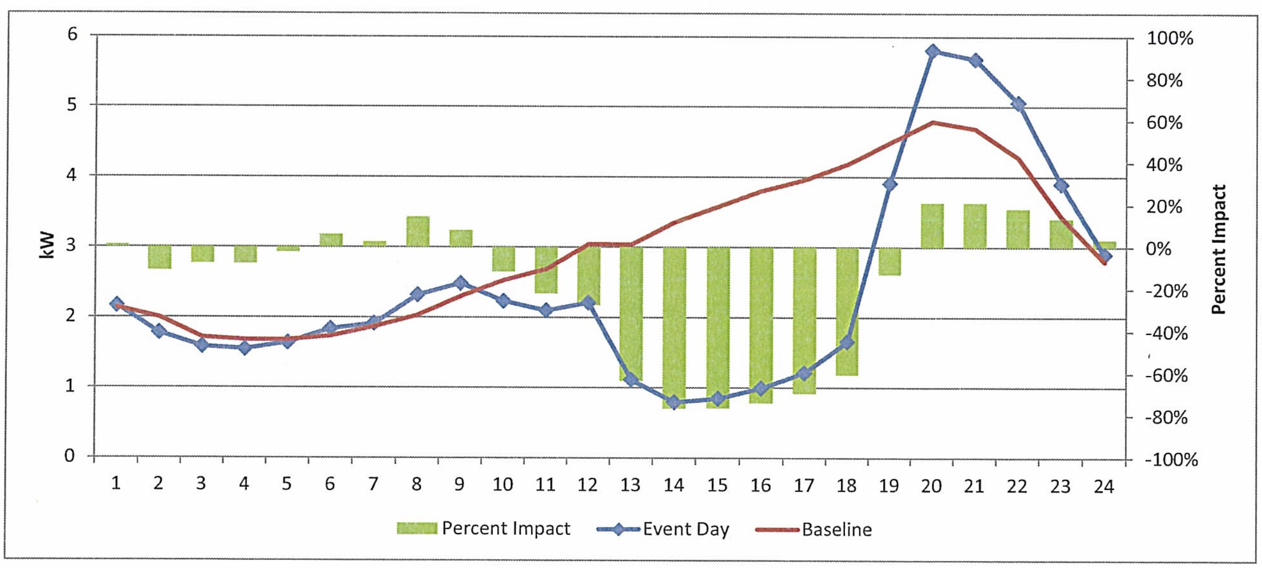


TABLE 16: IMPACTS FOR CPP EVENT DAYS – ENHANCED TOU
(AVERAGE OF ALL NON-CPP ON-PEAK DAYS IN JUNE-AUGUST)

Hour Ending	Event kW	Baseline kW	kW Impact	% Impact	*90% Confidence Interval on kw Impact*	
1	2.16	2.14	0.02	1.1%	*(0.45)*	*0.49*
2	1.78	2.00	(0.22)	-11.0%	*(0.66)*	*0.22*
3	1.59	1.72	(0.13)	-7.7%	*(0.44)*	*0.17*
4	1.55	1.68	(0.13)	-7.9%	*(0.36)*	*0.10*
5	1.64	1.68	(0.04)	-2.5%	*(0.32)*	*0.23*
6	1.84	1.73	0.10	6.0%	*(0.21)*	*0.42*
7	1.91	1.87	0.05	2.4%	*(0.40)*	*0.49*
8	2.32	2.03	0.29	14.3%	*(0.14)*	*0.72*
9	2.48	2.30	0.18	8.0%	*(0.24)*	*0.61*
10	2.23	2.53	(0.30)	-11.7%	*(1.02)*	*0.42*
11	2.10	2.69	(0.59)	-21.9%	*(1.32)*	*0.14*
12	2.21	3.05	(0.84)	-27.4%	*(1.73)*	*0.06*
13	1.12	3.04	(1.92)	-63.3%	*(1.42)*	*(2.43)*
14	0.79	3.36	(2.56)	-76.3%	*(1.92)*	*(3.21)*
15	0.85	3.58	(2.73)	-76.3%	*(2.19)*	*(3.28)*
16	0.99	3.80	(2.81)	-73.8%	*(2.25)*	*(3.37)*
17	1.21	3.96	(2.75)	-69.4%	*(2.34)*	*(3.15)*
18	1.66	4.19	(2.53)	-60.5%	*(1.75)*	*(3.31)*
19	3.91	4.49	(0.58)	-13.0%	*(0.10)*	*(1.06)*
20	5.80	4.79	1.01	21.1%	*0.44*	*1.58*
21	5.68	4.69	0.99	21.1%	*0.53*	*1.45*
22	5.06	4.28	0.78	18.3%	*0.33*	*1.23*
23	3.90	3.43	0.47	13.6%	*(0.03)*	*0.96*
24	2.90	2.79	0.10	3.6%	*(0.35)*	*0.56*
Hours 10-12	***2.18***	***2.75***	***(0.57)***	***-20.8%***		
Hours 13-18	***1.10***	***3.66***	***(2.55)***	***-69.8%***		
Hours 19-21	***5.13***	***4.66***	***0.47***	***10.2%***		
Daily kWh	***57.68***	***71.81***	***(14.14)***	***-19.7%***		

Finally, Figure 8 and Table 17 show the incremental impacts of a CPP event day compared to a baseline of a typical on-peak day. These impacts isolate the incremental impacts driven by the critical peak price differential relative to the on-peak rate for the average event day.

FIGURE 8: IMPACTS FOR CPP EVENT DAYS WITH BASELINE OF ON-PEAK RATE – ENHANCED TOU
(AVERAGE OF ALL CPP EVENT DAYS IN JULY)

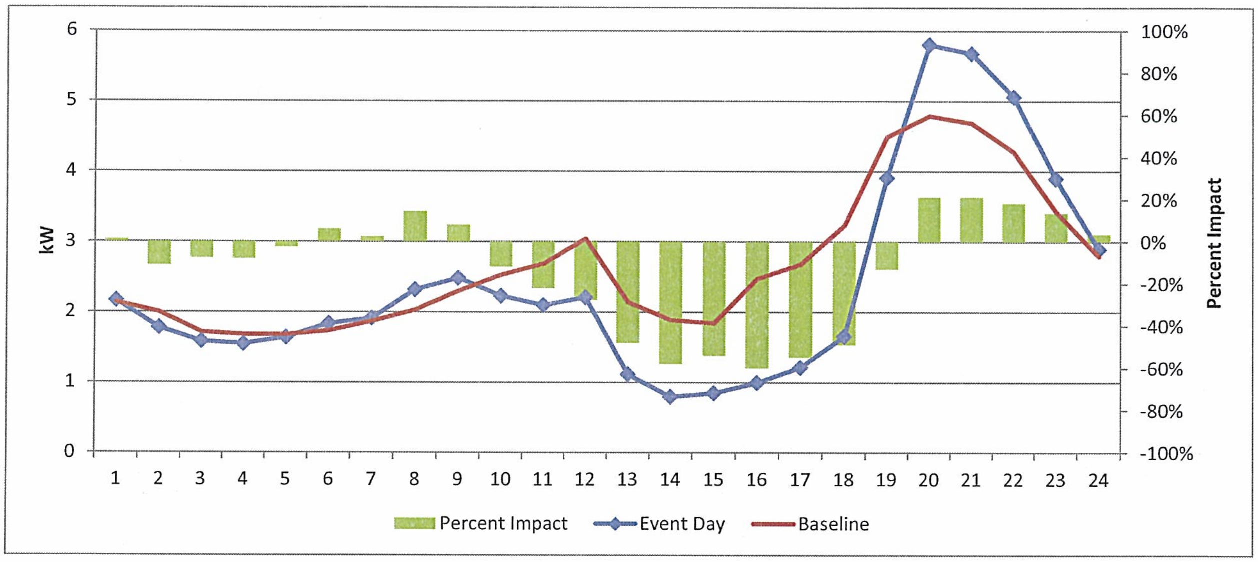


TABLE 17: IMPACTS FOR CPP EVENT DAYS WITH BASELINE OF ON-PEAK RATE – ENHANCED TOU
(AVERAGE OF ALL NON-CPP ON-PEAK DAYS IN JUNE-AUGUST)

Hour Ending	Event kW	Baseline kW	kW Impact	% Impact	*90% Confidence Interval on kw Impact*	
1	2.16	2.14	0.02	1.1%	*(0.45)*	*0.49*
2	1.78	2.00	(0.22)	-11.0%	*(0.66)*	*0.22*
3	1.59	1.72	(0.13)	-7.7%	*(0.44)*	*0.17*
4	1.55	1.68	(0.13)	-7.9%	*(0.36)*	*0.10*
5	1.64	1.68	(0.04)	-2.5%	*(0.32)*	*0.23*
6	1.84	1.73	0.10	6.0%	*(0.21)*	*0.42*
7	1.91	1.87	0.05	2.4%	*(0.40)*	*0.49*
8	2.32	2.03	0.29	14.3%	*(0.14)*	*0.72*
9	2.48	2.30	0.18	8.0%	*(0.24)*	*0.61*
10	2.23	2.53	(0.30)	-11.7%	*(1.02)*	*0.42*
11	2.10	2.69	(0.59)	-21.9%	*(1.32)*	*0.14*
12	2.21	3.05	(0.84)	-27.4%	*(1.73)*	*0.06*
13	1.12	2.14	(1.03)	-47.9%	*(3.78)*	*0.40*
14	0.79	1.89	(1.09)	-57.9%	*(0.94)*	*0.54*
15	0.85	1.84	(0.99)	-54.0%	*(0.27)*	*(1.50)*
16	0.99	2.48	(1.48)	-59.8%	*(0.66)*	*(1.62)*
17	1.21	2.68	(1.47)	-54.7%	*(0.47)*	*(1.86)*
18	1.66	3.24	(1.58)	-48.8%	*(1.03)*	*(2.97)*
19	3.91	4.49	(0.58)	-13.0%	*(0.10)*	*(1.06)*
20	5.80	4.79	1.01	21.1%	*0.44*	*1.58*
21	5.68	4.69	0.99	21.1%	*0.53*	*1.45*
22	5.06	4.28	0.78	18.3%	*0.33*	*1.23*

23	3.90	3.43	0.47	13.6%	*(0.03)*	*0.96*
24	2.90	2.79	0.10	3.6%	*(0.35)*	*0.56*
Hours 10-12	***2.18***	***2.75***	***(0.57)***	***-20.8%***		
Hours 13-18	***1.10***	***2.38***	***(1.27)***	***-53.6%***		
Hours 19-21	***5.13***	***4.66***	***0.47***	***10.2%***		
Daily kWh	***57.68***	***64.15***	***(6.47)***	***-10.1%%***		

SMART THERMOSTAT

For the Smart Thermostat group where direct control was initiated only on CPP event days, only the impacts on critical event days are of interest (there is no TOU rate component). The regression models are used to estimate baseline loads for the average thermostat customer, representing what load would have been had the customer's thermostat not been controlled.

Figure 9 and Table 18 display the impact evaluation results for thermostat group on CPP event days. The impacts represent an average impact of all five CPP event days in July 2011. They are the weighted results representing the average Unitil customer with controlled thermostat. The data are summarized and presented in hour ending notation, so a control period of 12:00 PM to 6:00 PM is represented by hours ending 13 through 18. The average load reduction during CPP event hours is 0.9 kW, or 20%. There is also a slight decline in overall daily average usage on event days, a savings of 6 kWh or 8%. As would be expected, there is an immediate snapback in the hour following the event. In the first hour, demand increases by nearly 8% (0.4 kW), and the average increase of the three hours after an event is 4%.

FIGURE 9: IMPACTS FOR CPP EVENT DAYS – SMART THERMOSTAT
(AVERAGE OF ALL CPP EVENT DAYS IN JULY)

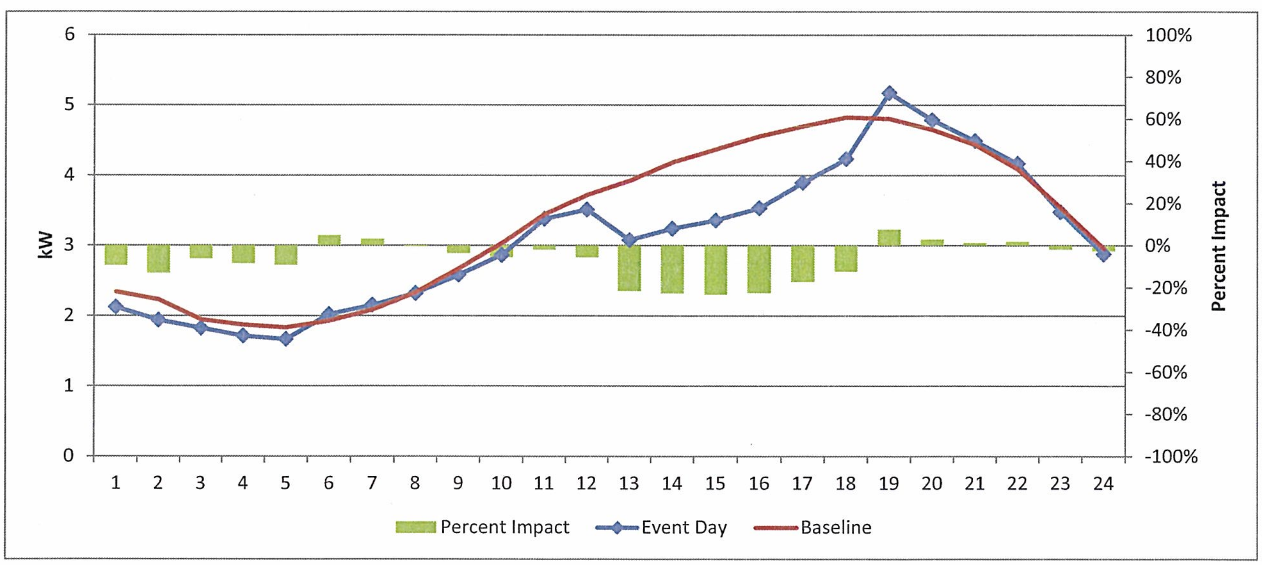


TABLE 18: IMPACTS FOR CPP EVENT DAYS – CONTROLLED THERMOSTAT
(AVERAGE OF ALL CPP EVENT DAYS IN JULY)

Hour Ending	Event kW	Baseline kW	kW Impact	% Impact	*90% Confidence Interval on kw Impact*	
1	2.12	2.34	(0.22)	-9.4%	*(0.46)*	*0.02*
2	1.94	2.23	(0.29)	-13.1%	*(0.08)*	*(0.51)*
3	1.83	1.95	(0.12)	-6.2%	*(0.33)*	*0.09*
4	1.71	1.87	(0.16)	-8.6%	*(0.36)*	*0.04*
5	1.67	1.83	(0.17)	-9.2%	*(0.35)*	*0.02*
6	2.02	1.93	0.09	4.8%	*(0.13)*	*0.32*
7	2.15	2.08	0.07	3.2%	*(0.18)*	*0.31*
8	2.32	2.33	(0.01)	-0.5%	*(0.27)*	*0.25*
9	2.58	2.67	(0.09)	-3.5%	*(0.35)*	*0.16*
10	2.87	3.03	(0.17)	-5.5%	*(0.41)*	*0.07*
11	3.38	3.45	(0.07)	-2.0%	*(0.35)*	*0.22*
12	3.51	3.72	(0.21)	-5.6%	*(0.49)*	*0.07*
13	3.08	3.92	(0.85)	-21.6%	*(0.55)*	*(1.14)*
14	3.24	4.19	(0.94)	-22.5%	*(0.58)*	*(1.30)*
15	3.36	4.37	(1.01)	-23.2%	*(0.68)*	*(1.34)*
16	3.53	4.55	(1.02)	-22.4%	*(0.67)*	*(1.37)*
17	3.90	4.70	(0.80)	-17.1%	*(0.45)*	*(1.15)*
18	4.23	4.83	(0.60)	-12.3%	*(0.26)*	*(0.94)*
19	5.17	4.80	0.37	7.7%	*0.04*	*0.69*
20	4.79	4.65	0.14	3.0%	*(0.16)*	*0.44*
21	4.49	4.44	0.06	1.2%	*(0.25)*	*0.37*
22	4.17	4.09	0.08	1.9%	*(0.21)*	*0.36*
23	3.48	3.54	(0.06)	-1.7%	*(0.32)*	*0.20*
24	2.88	2.96	(0.08)	-2.6%	*(0.33)*	*0.17*
Hours 10-12	***3.25***	***3.40***	***(0.15)***	***-4.3%***		
Hours 13-18	***3.56***	***4.43***	***(0.87)***	***-19.7%***		
Hours 19-21	***4.82***	***4.63***	***0.19***	***4.0%***		
Daily kWh	***74.41***	***80.48***	***(6.07)***	***-7.5%***		

PERSISTENCE

Of the five event days in July, two followed a prior event day (July 11/12 and July 21/22). Therefore, there is opportunity to investigate whether there was customer fatigue a second day into an event or if impacts tended to persist. To assess persistence in response, average loads and baselines for day 1 and for day 2 were calculated and compared.

For the Simple TOU group, the average impact during event hours for days 1 and 2 of consecutive events were 49% and 42%, respectively. However, in terms of kW savings, both days average 1.6 kW savings. Although the relative average impacts declined slightly, it is not significant enough a reduction to assume significant customer fatigue. The same can be said for the enhanced TOU group, with average impacts during event hours of 66% (1.9 kW) during day 1 events and 61% (2.0kW) during day 2 events.

Since the utility has direct control in the thermostat group, we would expect to see no fatigue associated with second-day events, which is the case. It can be concluded that load reductions persisted on the second day of a two-day event, at least for the two two-day events in July. Adding a third day or having several more two-day events may indeed lead to customer fatigue in responding to events, but that cannot be determined from this study.

FIGURE 10: AVERAGE HOURLY IMPACTS ON TWO-DAY EVENTS – SIMPLE TOU

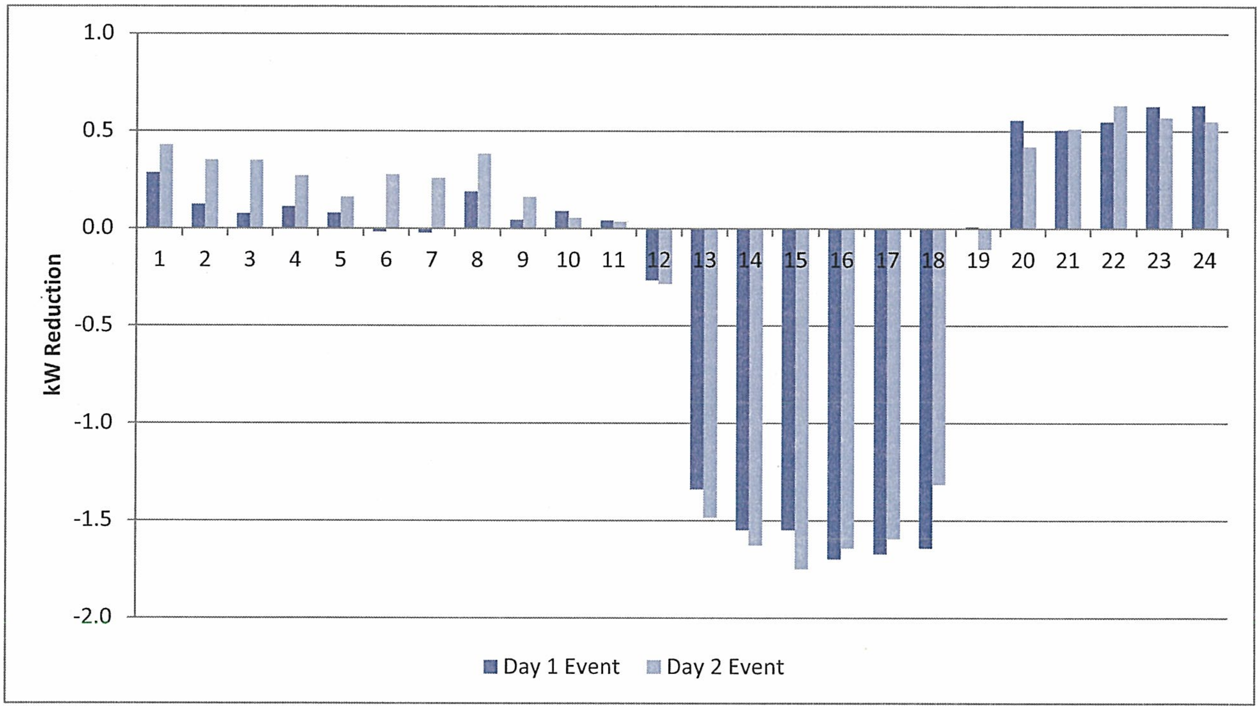


FIGURE 11: AVERAGE HOURLY IMPACTS ON TWO-DAY EVENTS – ENHANCED TOU

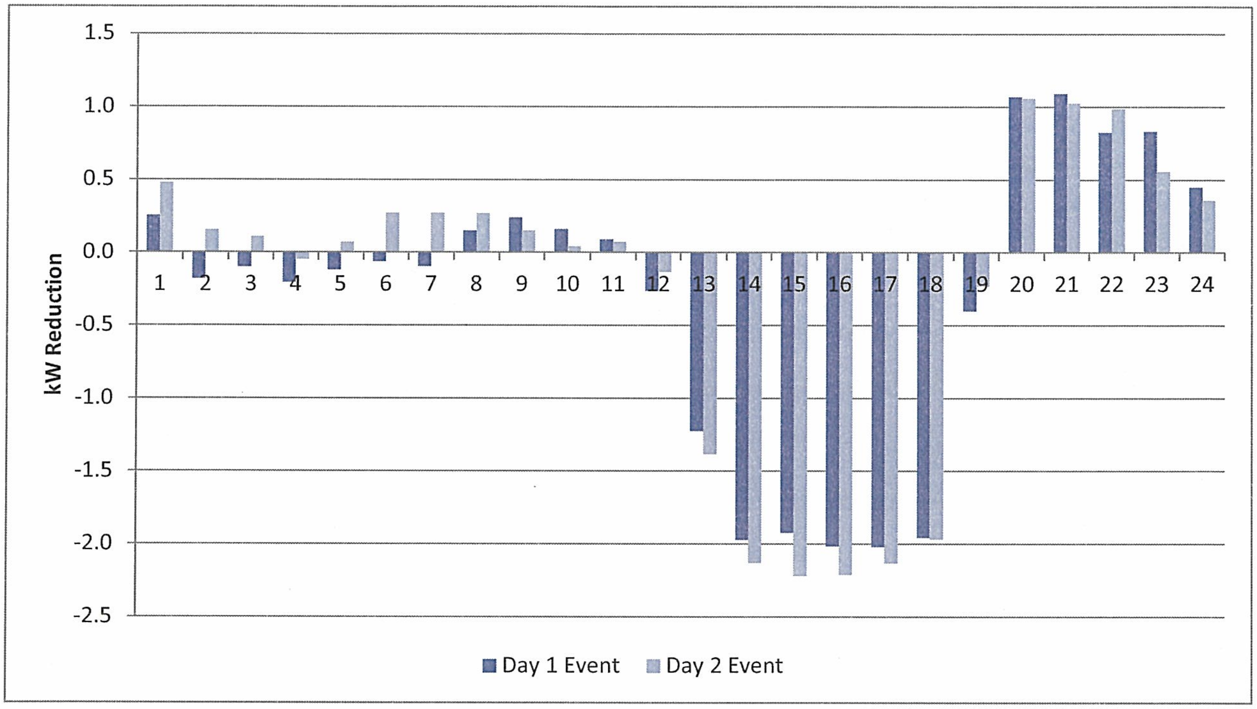
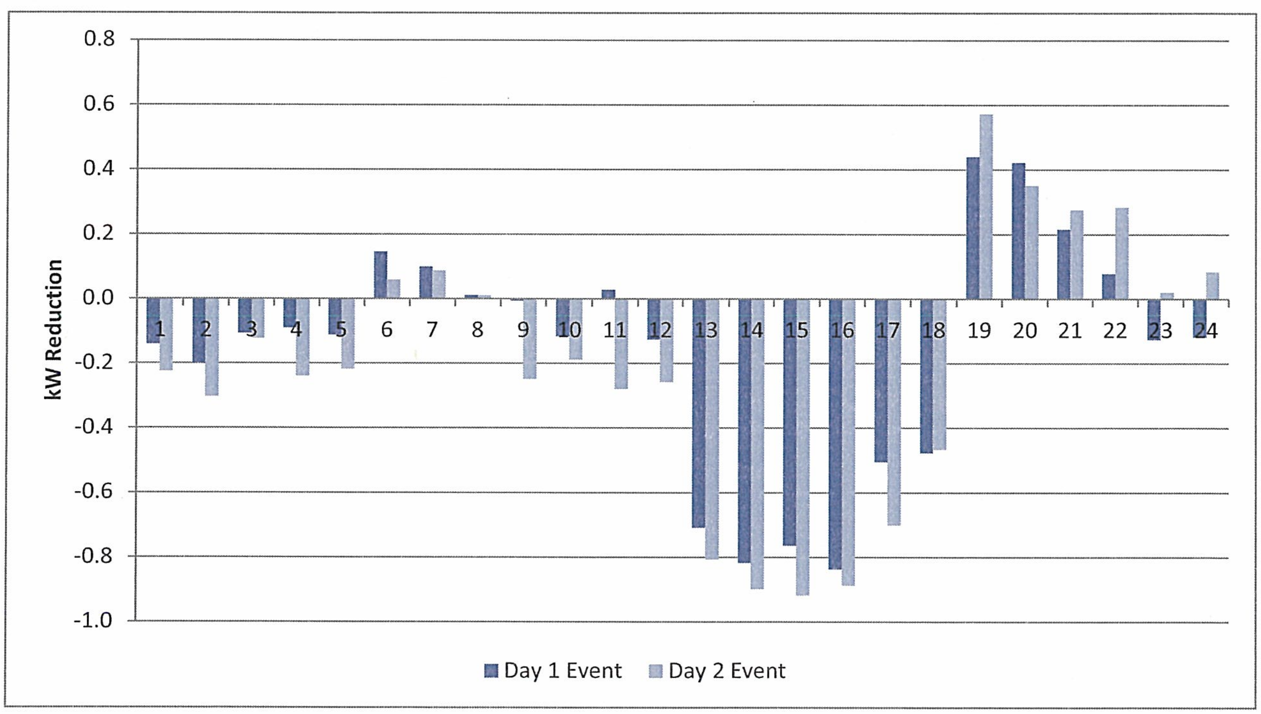


FIGURE 12: AVERAGE HOURLY IMPACTS ON TWO-DAY EVENTS – CONTROLLED THERMOSTAT



Sub Group Impacts

Table 19 below shows the average hourly impact during event hours for the simple TOU group as a whole and for the sub groups where there were at least 10 participants in the sub group[13]. Of the groups of interest, only the senior group had impacts that were statistically different than all STOU customers based on a comparison of means test with 90% confidence. The presence of a senior group had a lesser impact than all STOU customers. The detailed impact results for that sub group are presented below. Although some of the impacts are much larger than the group as a whole, the small sample size in the sub group makes it difficult to conclude a statistical difference. A larger pilot study with many more participants may be more successful at identifying differences in these sub groups. Tables with more detailed results by sub group are provided in Appendix G.

TABLE 19: PERFORMANCE OF VARIOUS SUB GROUPS – SIMPLE TOU

Impact	All Customers	High Income	Large Home	High Use	Presence of a Senior
Average KW Impact					
HE 10-12	**(0.06)**	(0.09)	0.14	(0.10)	0.15
HE 13-18	**(1.56)**	(1.66)	(1.97)	(1.67)	(1.00)
HE 19-21	**0.31**	0.16	0.15	(0.01)	0.24
Average % Impact					
HE 10-12	**-2.1%**	-2.6%	4.4%	-3.6%	7.2%
HE 13-18	**-42.3%**	-37.3%	-48.0%	-42.9%	-36.0%
HE 19-21	**7.6%**	3.6%	3.2%	-0.3%	8.0%
Different from all STOU		**NO**	**NO**	**NO**	**YES**

TABLE 20: PERFORMANCE OF SIMPLE TOU, PRESENCE OF A SENIOR

Hour Ending	Event kW	Baseline kW	kW Impact	% Impact	*kW Impact – All STOU*	*Sub Group Diff from All?*
1	1.55	1.57	(0.02)	-1.4%	0.38	*Y*
2	1.48	1.51	(0.03)	-2.0%	0.24	*Y*
3	1.19	1.33	(0.14)	-10.3%	0.19	*Y*
4	1.28	1.29	(0.01)	-0.7%	0.16	*Y*
5	1.20	1.27	(0.07)	-5.2%	0.10	*Y*
6	1.26	1.32	(0.06)	-4.6%	0.09	*N*
7	1.23	1.43	(0.21)	-14.3%	0.07	*Y*
8	1.64	1.55	0.09	5.6%	0.24	*N*
9	1.87	1.70	0.17	10.2%	0.07	*N*
10	2.12	1.94	0.18	9.3%	0.07	*N*
11	2.36	2.15	0.21	9.7%	0.04	*N*
12	2.40	2.32	0.07	3.2%	(0.29)	*N*

[13] The impacts for sub groups are un-weighted averages. To properly weight these data, one would need the distribution for the variable of interest for the entire population, which is not available for these variables.

13	1.44	2.44	(1.00)	-40.9%	(1.40)	*N*
14	1.68	2.63	(0.94)	-36.0%	(1.55)	*Y*
15	1.69	2.75	(1.06)	-38.6%	(1.67)	*Y*
16	1.95	2.88	(0.93)	-32.1%	(1.64)	*Y*
17	1.94	2.94	(1.00)	-34.1%	(1.63)	*N*
18	1.95	3.02	(1.07)	-35.4%	(1.48)	*N*
19	2.94	3.06	(0.11)	-3.7%	(0.04)	*N*
20	3.33	2.99	0.35	11.6%	0.45	*N*
21	3.38	2.90	0.48	16.6%	0.52	*N*
22	3.04	2.66	0.38	14.2%	0.62	*N*
23	2.57	2.31	0.27	11.5%	0.66	*Y*
24	2.32	1.96	0.36	18.4%	0.65	*N*
Hours 10-12	***2.29***	***2.14***	***0.15***	***7.2%***		
Hours 13-18	***1.78***	***2.78***	***(1.00)***	***-36.0%***		
Hours 19-21	***3.22***	***2.98***	***0.24***	***8.0%***		
Daily kWh	***47.82***	***51.91***	***(4.09)***	***-7.9%***		

As shown in Table 21 below, none of the enhanced technology sub groups had impacts that are statistically different from the group as a whole. This result is almost certainly due to the small sample sizes of each sub group and of the group as a whole. Tables with more detailed results by sub group for the Enhanced TOU group are provided in Appendix G.

TABLE 21: PERFORMANCE OF VARIOUS SUB GROUPS – ENHANCED TOU (TENDRIL)

Impact		**All Customers**	**High Income**	**Large Home**	**High Use**
Average KW Impact					
	HE 10-12	(0.57)	(0.03)	(0.06)	(0.06)
	HE 13-18	(2.55)	(2.06)	(2.24)	(2.23)
	HE 19-21	0.47	0.50	0.56	0.21
Average % Impact					
	HE 10-12	-20.8%	-1.2%	-2.4%	-2.2%
	HE 13-18	-69.8%	-65.6%	-65.1%	-62.3%
	HE 19-21	10.2%	13.0%	13.7%	4.9%
Different from All ETOU			**NO**	**NO**	**NO**

For the Smart Thermostat sub groups, only the larger homes had statistically different impacts from the thermostat group as a whole. The larger homes achieved higher savings, which would make sense. Once again, small sample sizes are likely inhibiting the ability to deduce statistically significant differences between the sub groups and the larger set of all participants. However, with a direct control program, it makes more sense that many demographic factors would not exhibit different impacts. The details for the larger home sub group are shown below. Details on all the groups with 10 or more participants are provided in Appendix G.

TABLE 22: PERFORMANCE OF VARIOUS SUB GROUPS – SMART THERMOSTAT

Impact	All Customers	High Income	Large Home	Small Home	High Use	Presence of a Senior
Average KW Impact						
HE 10-12	**(0.15)**	(0.21)	(0.19)	(0.02)	(0.15)	0.03
HE 13-18	**(0.87)**	(1.50)	(1.32)	(1.23)	(0.94)	(1.52)
HE 19-21	**0.19**	0.64	0.44	0.07	0.21	0.54
Average % Impact						
HE 10-12	**-4.3%**	-7.4%	-6.7%	-0.9%	-3.8%	1.5%
HE 13-18	**-19.7%**	-39.4%	-36.4%	-43.9%	-17.4%	-48.5%
HE 19-21	**4.0%**	15.3%	12.7%	2.1%	3.7%	15.8%
Different from all TSTAT		**NO**	**YES**	**NO**	**NO**	**NO**

TABLE 23: PERFORMANCE OF SMART THERMOSTAT, LARGE HOMES

Hour Ending	Event kW	Baseline kW	kW Impact	% Impact	*kW Impact – All TSTAT*	*Sub Group Diff from All?*
1	1.59	1.59	0.00	0.0%	(0.22)	*N*
2	1.54	1.58	(0.04)	-2.2%	(0.29)	*Y*
3	1.33	1.38	(0.05)	-3.5%	(0.12)	*N*
4	1.25	1.35	(0.09)	-7.0%	(0.16)	*N*
5	1.30	1.39	(0.08)	-6.1%	(0.17)	*N*
6	1.75	1.57	0.18	11.3%	0.09	*N*
7	1.85	1.75	0.11	6.2%	0.07	*Y*
8	1.95	1.79	0.16	8.8%	(0.01)	*N*
9	2.12	2.18	(0.06)	-2.8%	(0.09)	*N*
10	2.55	2.57	(0.01)	-0.5%	(0.17)	*N*
11	2.69	2.80	(0.10)	-3.7%	(0.07)	*N*
12	2.66	3.11	(0.45)	-14.5%	(0.21)	*N*
13	1.96	3.22	(1.26)	-39.1%	(0.85)	*Y*
14	1.97	3.40	(1.43)	-42.0%	(0.94)	*Y*
15	2.16	3.56	(1.40)	-39.5%	(1.01)	*Y*
16	2.33	3.74	(1.41)	-37.6%	(1.02)	*N*
17	2.51	3.85	(1.33)	-34.7%	(0.80)	*N*
18	2.89	3.96	(1.08)	-27.2%	(0.60)	*N*
19	4.15	3.73	0.42	11.1%	0.37	*N*
20	3.94	3.44	0.50	14.5%	0.14	*Y*
21	3.66	3.25	0.41	12.7%	0.06	*Y*
22	3.08	2.90	0.18	6.3%	0.08	*N*
23	2.66	2.40	0.27	11.1%	(0.06)	*Y*
24	2.15	1.95	0.20	10.2%	(0.08)	*N*

Hours 10-12	*2.64*	*2.83*	*(0.19)*	*-6.7%*		
Hours 13-18	*2.30*	*3.62*	*(1.32)*	*-36.4%*		
Hours 19-21	*3.92*	*3.47*	*0.44*	*12.7%*		
Daily kWh	*56.07*	*62.45*	*(6.38)*	*-10.2%*		

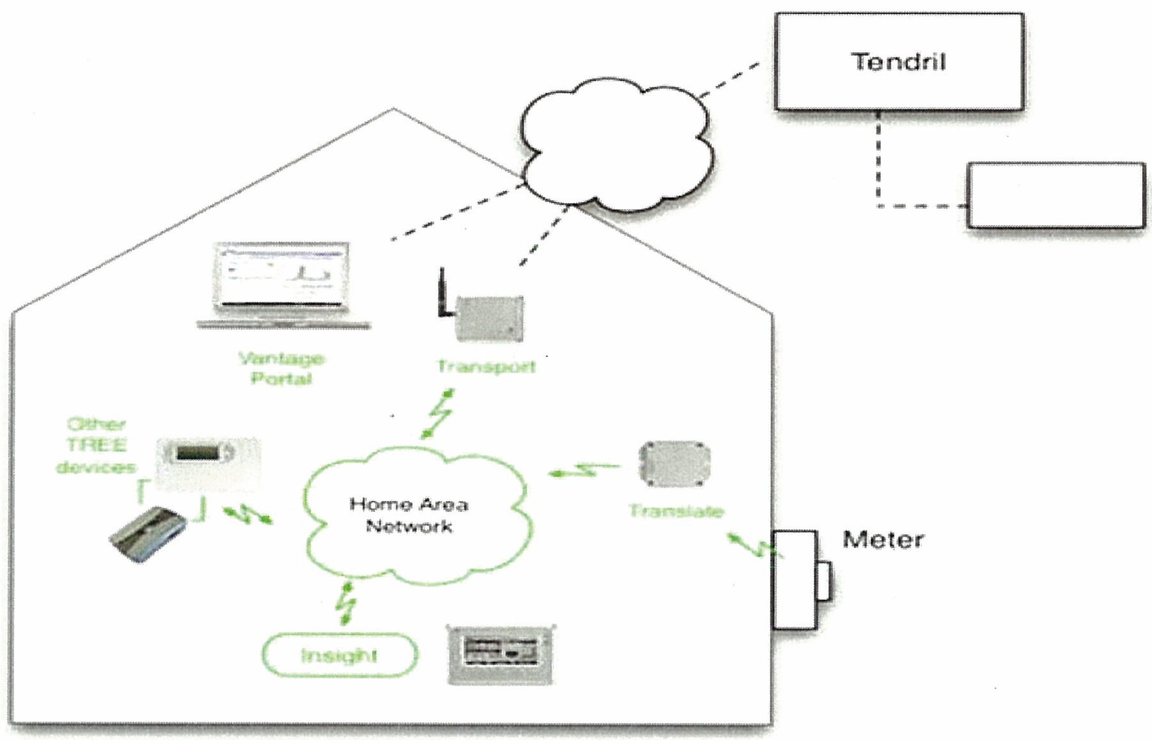
IV. Process Evaluation

A. Enabling Technologies

A number of technologies were tested in the pilot, ranging from daily feedback on energy consumption and costs through the Unitil hosted web portal, to a complete home area network (HAN) featuring sub-hourly feedback on consumption and costs, in home displays, and price responsive thermostats and outlets. This section discusses the operation of, and key findings regarding these different technologies that were tested during the pilot.

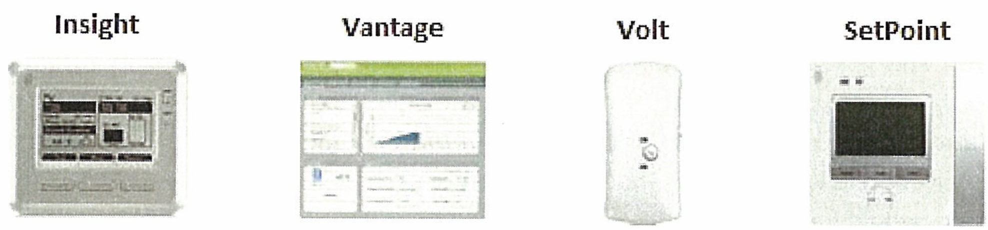
Tendril Residential Energy Ecosystem (TREE)

The TREE system is an in-home ZigBee-based wireless energy management system that included an in-home display (IHD), programmable controllable thermostat (PCT), controllable outlet for plug loads, and an online web portal that provided sub-hourly feedback on energy consumption and detailed billing and usage analytics. The system communicates directly with the electric meter to provide usage information to the customer. The graphic below illustrates the arrangement of devices within a typical home:



Unitil's AMI system is a power line carrier system and was therefore not able to communicate directly with the TREE system. It should be noted that the AMI vendor has since released a ZigBee based dual capable meter endpoint that is both PLC and wireless capable. To work around this restriction, a secondary Centron ERT meter (04 series) was installed in a dual socket arrangement at the homes of participating customers. The Centron meter emitted a continuous radio signal that was received by the *Translate* device which was installed in close proximity to, but not directly behind, the electric meter. The *Translate* device converts the RF signal to ZigBee standard and communicates with the *Transport* device. The *Transport* connects to the customer's wireless router and is effectively the hub of the network. Once a communication link has been established between the meter and the *Transport* through the *Translate* device, the home network is essentially operational and the other devices are simply able to locate and join the network once they are powered on. The following additional devices were included for the Enhanced Technology Group:

FIGURE 13: TENDRIL'S SUITE OF TREE DEVICES



Insight: The *Insight* is a Zigbee-enabled In-home Display (IHD) that is capable of providing the user with near real-time consumption feedback.[14] The IHD allowed customers to program the device to notify them, either through visual alerts or via text messages, when user-specified key conditions occurred (i.e. monthly bill target was reached). The *Insight* also displayed messages from Unitil about critical peak or other demand response related events.

Vantage Web Portal: The *Vantage* is an internet based web portal which allows customers to monitor and manage their TREE devices from anywhere. It provided the customer with more detailed analysis of their consumption behavior and usage history and enabled them to make more informed decisions about future consumption.

Volt: The *Volt* is a ZigBee-enabled smart outlet that, when used in conjunction with either the IHD or the web portal, gives users detailed information on their appliances usage and gives customers control over plug loads. The *Volt* was capable of being set to automatically switch plug load on and off based on the customers programmed price settings.

SetPoint Thermostat: The *SetPoint,* is a programmable controllable thermostat which communicates with the other TREE devices using the ZigBee language. The SetPoint can be programmed on the unit itself or via the IHD or web portal. The device allowed customers to adjust the temperature of their house automatically in response to the customer's price settings.

Unitil Experience

Unitil had considerable involvement with the planning, implementation, and support of the TREE systems throughout the three-month pilot. This section discusses their experience with the Tendril system and equipment during each phase of the project, as well as key findings and lessons learned.

---

[14] The IHD did not actually display consumption in "real-time" during the pilot. The IHD only displayed a new reading every time a kilowatt-hour was accrued.

Planning Phase: The initial planning phase of the pilot included selecting the in-home technology that would be included for the Enhanced Technology group, confirming communicative ability between the TREE system and the meters, working through the back of house integration, and pre-testing the equipment. This phase occurred over a period of many months and required close coordination between Unitil and Tendril. Following are key takeaways regarding this phase of the deployment:

» During the initial specification phase, discussions focused on the ability for customers to view near "real time" feedback of energy consumption. However the meters that were ultimately specified and purchased provided kilowatt-hour resolution (despite continuous transmission) meaning the web portal and IHD only displayed a new reading every time a kilowatt-hour was accrued. This granularity of data presented to customers was significantly less than what was expected, and is hypothesized to have had a negative impact on this group as the kilowatt-hour granularity negated some of the effectiveness of the in home displays. For slightly higher cost per meter, meters with decawatt-hour resolution could have been specified and the feedback to customers would have been improved ten-fold.[15]

» The thermostats ended up being the most prominent factor in turning down customers to participate in the pilot. An alternative design would have been to use multiple test groups, one with the thermostat and one without, which would have helped mitigate this issue. However, that would have added considerably to the overall study costs.

» The back of house integration processes between Unitil and Tendril required a more significant commitment of resources to compile pricing data, user accounts, consumption and billing histories than was originally contemplated. While the processes was ultimately successful, planning for a full program deployment would require more careful consideration of resources for this effort and how the process could be more efficiently automated.

Implementation Phase: The implementation phase of the pilot involved the physical deployment of meters and equipment to customer homes. The actual field installation work was subcontracted to professional installers; however Unitil was responsible for much of the logistical planning and coordination. Key takeaways and lessons regarding the implementation phase included the following:

» The field installation process for Unitil was significantly more complicated than was originally anticipated, in large part because each customer needed to be pre-registered with a certain meter ID before the installation. This would be a simple process if the meters in the field could have been utilized, but Unitil needed to install a secondary meter to support the TREE system. Managing the meter inventory became a major logistical challenge with multiple installers, the need to pre-assign meters to customers before they could be evaluated for compatibility, and returning the meters to inventory for customers who were turned down for installations.

  o Though not directly relevant to the Unitil pilot, in a service territory where the existing utility meters can be utilized, the deployment process would be much simpler.

  o If Unitil were to pursue a full program with the TREE systems, one key change would be to make the thermostats optional and not mandatory. This would cut down on roughly

[15] Note the specification of kilowatt meters was not made based on cost but was rather made jointly as it was believed that the continuous reading output of the meters would enable near real time consumption feedback.

90% of the technical turn downs encountered and simplify the deployment process dramatically. Additional controllable outlets (volts) could be utilized to control window A/C units, as in the few customers who participated without central air conditioning, or control other large loads within the household.

- The actual process of installing in-home equipment and ensuring that the equipment was communicating properly also proved to be a significant challenge. A number of separate barriers to the successful deployment of home area networks were encountered at homes that were otherwise compatible with the technology. Primary barriers to successful installations are summarized below:
  - Locations where the meters were more than 75-feet from the home were prohibitive to installations. Examples included townhouses with meter banks and single family homes where the meter was not set directly on the house.
  - Inability to connect the translate device to the internet prohibited several installations. In most cases, the router had blocked ports with security settings that neither the homeowner nor the installers could breach.
  - In some situations, the physical layout of the home precluded the setup of the system. The translate device needed to be plugged in and located in close proximity to the meter without being located in a 6-foot zone of influence directly behind the meter. There had to be a line of sight between the meter and the translate and static elements such as fireplaces or electronic elements like entertainment centers sometimes interfered with the signal. Similarly, the transport device needed to be plugged into the wireless router but could not be too far from the translate device for the system to effectively communicate. In many situations, the installation process included testing multiple locations and arrangements trying to establish communication between the devices.
- Some pre-pilot testing of the equipment was conducted using volunteers from Unitil. While this pre-testing provided valuable insight into the capabilities of the equipment and the process for installing and registering the equipment, it was not of sufficient breadth to understand the myriad of barriers that were ultimately encountered during the field deployment. In particular, only one pre-test location was installed with a thermostat because that was the only home with central air conditioning; the thermostats were ultimately the main point of technical incompatibility at many of the customer sites. More expansive and thorough pre-testing may have helped identify and prepare Unitil for more of the technical barriers and situations that were ultimately encountered. However, such learning would have been weighed against the increased cost of this effort.
- Unitil subcontracted the installation of the TREE packages to a reputable installation firm but one that did not have specific experience with the Tendril equipment. A week of training was dedicated for the installers to learn the equipment and installation process, and how to educate customers. This week involved three days of classroom instruction and two days of field installations. Ultimately, this amount of training was insufficient for the installers to fully understand the equipment and the range of field issues that would be encountered. This

affected the program both in terms of the typical installation times which were over two hours in length, and the customer's understanding of the equipment function and capabilities, which affected their experience with the pilot.

» The typical time to complete installations was longer than originally anticipated, often exceeding two hours in length. The installation process frequently required an iterative approach to locating equipment and calls into Tendril's technical support line to register and troubleshoot equipment.

Pilot Phase: The pilot phase was the actual period of the pilot and included on-going support and troubleshooting of customer equipment and addressing customer issues. Unitil provided Tier 1 customer service support and field support during this phase. Tendril provided Tier 2 customer service support and was actively engaged in the remediation of issues that arose. Key takeaways and lessons learned regarding the actual execution of the pilot with the TREE equipment included the following:

» The process of identifying and troubleshooting "offline accounts" [16] was continuous and more burdensome than originally anticipated. There was originally some confusion as to who was responsible for monitoring and following up with inactive accounts. Ultimately, this led to some accounts being inactive for extended periods of time and customers disengaging from the equipment. A more robust and defined process for identifying inactive accounts and immediately addressing the issues would have resolved some of these issues.

  o Some offline accounts were caused by devices being unplugged or switched off. These causes are fairly simple to diagnose and correct with the customer over the phone as long as they are engaged and interested in bringing the system online. Some customers were very difficult to reach at home.

  o Many offline accounts were either identified as being faulty equipment or could not be diagnosed over the phone. These situations required a site visit to the customer's home which had to be made by Unitil representatives. The scope of work for the installation contractors did not assume a large number of follow up visits, thus the resources and cost burden of these visits fell on Unitil. Requiring the customer to be home for another site visit was also a burden that frustrated several customers.

» Customers experienced problems with the usability of thermostats deployed as part of the pilot. The main issues that customers experienced with the thermostats were the inability to change from the heat to the cool mode and the ability to program a schedule into the device. At the time of installation, customers were not provided with a written manual documenting operation of the thermostats. Instead, they were directed to the web portal where they could access user guides for all of the equipment. In a full program that involved thermostats, a one page guide that summarized key features and operation of the thermostat and the other devices would be beneficial to help mitigate some of these issues.

» Overall, the reliability of the equipment was fair. It was often difficult to diagnose whether there was an issue with the equipment itself or the arrangement of devices when

[16] Locations where no readings were being received by Tendril, due to some failure in the communication network

communication could not be established. Approximately 5% of the thermostats that were installed ultimately failed and had to be replaced with another field visit.

- A key finding of the study had to do with the identification of gaps in the Tendril evaluation data that were reported through the system. Many accounts that appeared to be online, when investigated, revealed gaps of variable length between readings. When the systems finally received a reading, it would have accumulated multiple kWh. This was a disturbing finding in that it was not contemplated and Unitil relied on the data from the systems for evaluation purposes. Some, but not all, of the gaps can be explained by power disturbances to the system (i.e. switched outlets) however there did not appear to be repetitive trends in the timing or duration of the gaps. Attempts to assess root cause of the issues experienced with Tendril were unsuccessful. The main lesson learned is that while the data proved to remain accurate for monthly billing purposes, when the gaps transcended a time-of-use period, it was not possible to accurately calculate time-of-use billing charges. Unitil utilized their AMI solution for billing customers but was impacted in the ability to evaluate interval usage data in the impact evaluation for this group.

Overall Experience and Findings: Overall, deployment of the Tendril technology required considerably more resources and support time than was originally contemplated. The large percentage of technical turn downs was driven by the mandatory inclusion of thermostats, which was ultimately more of a pilot design flaw than an equipment issue; however it was found that the thermostats tested were incompatible with a large number of homes in this region. Establishing communication links between the meters (dual meters required) and the home networks was often troublesome and Unitil would not likely pursue a further deployment that required the use of dual meters and intermediate translate devices. The AMI vendor has released a ZigBee enabled endpoint compatible with the meters in place. This endpoint is also compatible with the PLC capability currently being utilized. This capability would eliminate some of the issues experienced due to RF signal strength, eliminate the need for the intermediate translate device, and simplify the user enrollment process.

There were many positive features about the TREE package. The ability to pre-set price response controls to automate control of the thermostat and Volt during on peak and critical peak periods is one of the stronger features of the system. Most customers elected to set price rules at the time of installation and those rules applied throughout the pilot. The utility portal that Unitil used to set up and dispatch CPP events was simple and intuitive. Information feedback through the web portal would have been more impressive if decawatt hour meters had been specified which was a planning issue and not one specifically related to the TREE platform.

The TREE system, as with other HAN vendors, is rapidly evolving. A new version of the web portal and equipment was released during the course of the pilot, making it difficult to project how customers will react with new versions of the system and equipment as it evolves. If Unitil decides to pursue a further deployment of the technology, there are three main takeaways from the pilot:

- Focus on installer training, both in regards to field installations and training of customers. The installation experience can leave a lasting impression, positive or negative, on customers.

» Pre-test the technology thoroughly for an extended period of time and in a broad range of homes. This will help to understand compatibility of the equipment, typical installation barriers, and typical questions about operating the systems, which will help anticipate and respond to customer questions.

» Develop a rigid process for identifying and addressing offline accounts. This is a continuous process that requires swift action and a commitment of resources that can be available to monitor and address these situations as they arise.

CUSTOMER EXPERIENCE

This section highlights some of the key findings from the Enhanced Technology customer feedback surveys that were collected using post-installation and post-pilot surveys. The goal of the surveys was to assess the customers experience with the installation process and gauge their experience using the Tendril TREE equipment.

Installation Experience

Responses from the post-installation surveys convey that overall customer satisfaction with the installation process of Tendril's TREE technologies was more negative than positive. This negative sentiment stems primarily from the duration of the installations, which were frequently longer than two hours, and insufficient education on the features and capabilities of the system. Customers were overall very satisfied with installers keeping to scheduled appointment times but unsatisfied with installer proficiency. Some key issues referenced by customers included the following:

- **Installation time**: 43.6% of customers who responded to the post-installation survey were less than completely satisfied with the time it took to complete their installation. As was detailed in the previous section, the majority of installations took multiple hours to complete and many installers did not finish installations on their first visit to the customer's home. There were multiple customers who reported that the installer needed as many as three visits to complete the installation. This was a burden on customers who had to be home at the time of the site visits.

- **Quality of installation:** 34.2% of customers who responded to the post-installation survey were less than completely satisfied with the quality of their installation. Most of the issues focused on the equipment that was installed being faulty and not operating properly after the installation. It is not possible to differentiate these types of issues as equipment versus installation deficiencies.

- **Educational Materials:** 48.7% of customers who responded to the post-installation survey were less than completely satisfied with the usefulness of the informational materials that installers left behind. These materials consisted of basic printed information on the pilot, however detailed information on the TREE equipment was only available online through the web portal. In several cases, the process of installing the equipment took so long that insufficient time was taken on site to properly train customers on operating the TREE system. Some customers conveyed dissatisfaction with the installers' verbal and hands on demonstration of how to operate the Tendril TREE equipment. This feedback is reflective of insufficient time to thoroughly train the installers on operating the system, and less so on the quality or capabilities of the installers themselves.

Pilot Experience

The survey feedback indicates that many Enhanced Technology customers did not actively use the TREE system frequently and suggests it did not play a significant role in reducing consumption across the group as a whole, though a percentage of users who did engage with the system found it to be beneficial. Most all of the customers in this group did pre-set their systems to automatically respond to high price events by turning up the temperature of their thermostat or turning off the Volt device. This setting did not require any active management by customers throughout the pilot and likely contributed to the increased impacts during CPP events among this group. Many of the customers who reported not using the system frequently were customers who experienced issues with the equipment or who felt they were not thoroughly trained on the operation. However, 91% of survey respondents indicated that they were either somewhat more aware (48%) or significantly more aware (43%) of their homes energy use after participating in the pilot.

Some of the issues experienced with the equipment and the installation process negatively impacted initial customer acceptance of the technologies. These issues, however, were not the only reason customers did not use the equipment. Some of the reasons that customers gave for not using the Tendril equipment frequently were specific to certain TREE devices. Many customers wrote that they did not have a practical use for the *Volt* load controllable plug outlet because their most load intensive appliances was their refrigerator. Other customers responded that they had issues with the *Vantage* web portal, finding that their consumption data was unreliable and at times confusing. Further training of customers on the operation and capabilities of the system, including webinars and Q&A are recommended solutions for helping to keep customers engaged with the equipment over an extended period of time. The primary barriers appear to be getting customers to initially engage with the equipment, and maintaining the equipment so that it functions continuously.

HONEYWELL UTILITYPRO™ THERMOSTATS

The Smart Thermostat treatment group received a new Honeywell UtilityPro™ thermostat and access to a hosted web portal that allowed customers to remotely change the temperature or schedule within their home, and to opt out of control events. The thermostats included one-way communication via a paging network. Establishing this communication link did not require any alteration to the electric meters, although the meters were changed so that interval data could be recorded for the evaluation. Each thermostat was pre-programmed in the factory to listen on the specified frequency, and once the thermostat was installed and connected to power, the equipment was registered online by Honeywell representatives. Honeywell and Cooper Systems also provided on-going assistance throughout the course of the pilot to help address equipment and software issues that arose. Their proactive management of the program underscored their commitment to the project and their knowledge and experience with their equipment and processes.

Overall, the experience with the UtilityPro™ thermostats was very positive. It was evident that this technology and the process for delivering it to the field was mature and has been refined over a number of deployments. Support staff was proactive and knowledgeable. The process for scheduling and dispatching control events was fairly straightforward.

Some field compatibility issues were encountered for homes with damper systems, but overall the installation process went smoothly. The responses to the Smart Thermostat group post-installation survey were overall very positive. Installations for this group were significantly less time consuming than the TREE system and required little customer intervention. There was also only a single piece of equipment to train customers on, and installers assisted customers in setting schedules at the unit based on their preferences at the time of installation.

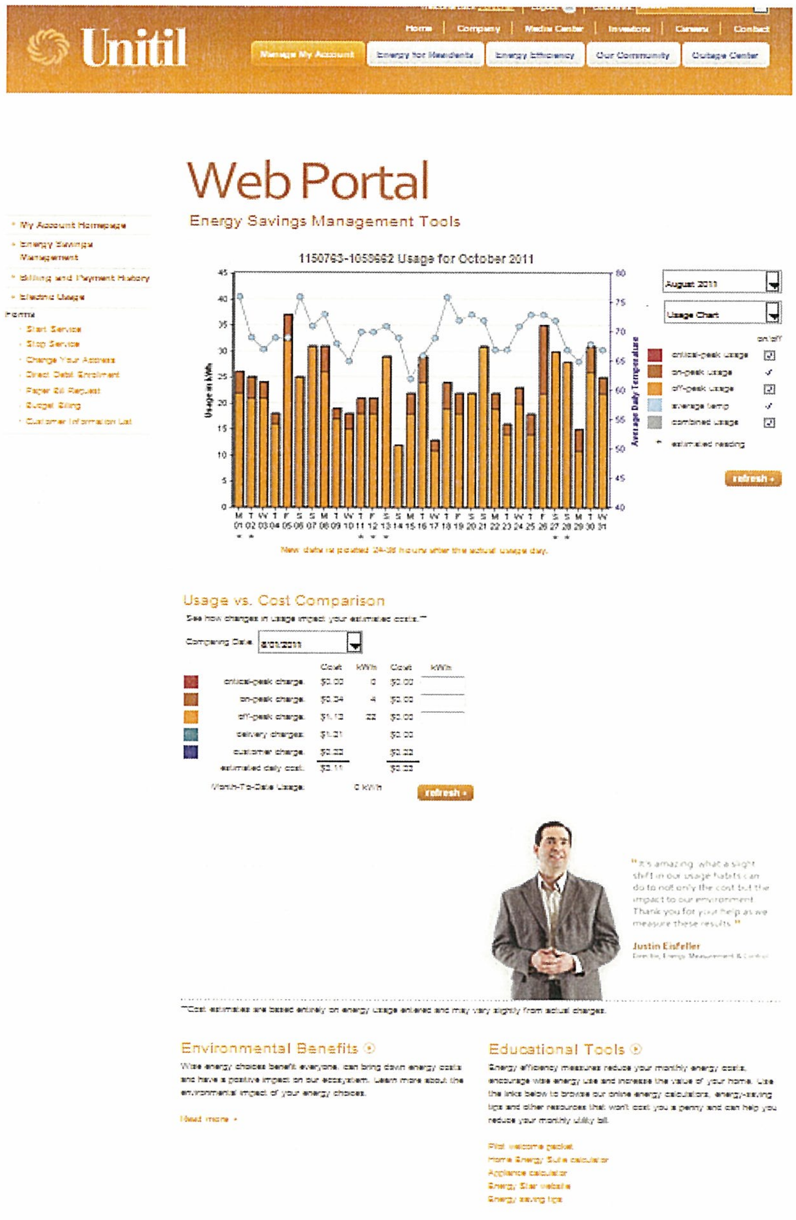
Almost all of the respondents found the installation scheduling to be convenient and reliable, and overall the customers were very satisfied with the speed of the installation which the vast majority (76%) reported took less than one hour to complete. 85% of Smart Thermostat customers who responded to the post-installation survey reported that they were completely satisfied with the quality of the installation. Smart Thermostat customers were also very much satisfied with their installer's explanations about how the Honeywell PCT worked, as well as were satisfied with the usefulness of the informational materials left behind. In comparison to the TREE system installation, installers had prior experience with the UtilityPro™ thermostats and were able to more aptly discuss the operation of the units, compared with the TREE system with which they were less familiar.

Pilot Experience:

Most Smart Thermostat customers were very pleased with the features included in Honeywell's PCT and were satisfied with how easy the device was to use; 54% found the Honeywell thermostat to be a significant improvement over their old thermostat, while 22% reported that it was slightly better. For the vast majority of customers, the equipment worked as expected, and many fewer customer issues were reported with these thermostats compared with the other thermostat tested. Moderate negative sentiment towards the Smart Thermostat program was received following the CPP events, in which some customers experienced moderate (39%) to extreme (5%) discomfort during CPP events when their air conditioning systems were cycled 50% during the critical peak events. A little more than half of Smart Thermostat customers reported on at least one occasion, having used the settings on the new thermostat to pre-cool their home before a Critical Peak event. Overall, customer feedback on pilot experience for the Smart Thermostat group was very positive and 90% of customers who responded to the post pilot survey said that they would recommend the program to a friend or family member. There were several responses from customers expressing their desire to continue the program. Only 61% of customers in the Smart Thermostat group reported an increase in their household's awareness of energy consumption as a result of participating in the pilot.

From Unitil's perspective, the Honeywell thermostats were reliable, easy to deploy, and easy to manage. The process for scheduling and managing control events, including the ability to adjust the "gear" of the control, was intuitive and simple to execute. One observation was that Unitil wished they had the ability to schedule more than one event at a time when it was known that back-to-back events would be declared. Though overall the experience with the thermostats was very positive from Unitil's perspective.

Unitil Hosted Web Portal



Unitil's AMI system is currently configured to poll individual end-points on a daily basis, even though billing data is only required on a monthly basis. This daily data is potentially available to provide daily feedback on energy consumption for all customers. Developing an ability to present this information to customers has been of interest to Unitil's for some time. The pilot program provided an opportunity to develop and gain experience administering a web portal to a small number of customers in a controlled environment. The Unitil web portal pulled data from the pilot meter data management system to post usage information (by time period for TOU customers) and used algebraic algorithms to estimate daily cost. In addition, the web portal provided a calculator for customers to estimate daily costs when they input different combinations of on-off-critical peak energy. The portal also included links to the educational material provided to the customer's specific group, and links to other Unitil sponsored tools and programs.

A screenshot of the web portal is shown to the right. The graph at the top of the screen provides the ability to review usage or cost as well as the ability to overlay average daily temperature to review the relationship between usage and temperature. The usage versus cost calculator and additional reference material are shown at the bottom of the page.

UNITIL EXPERIENCE

The process of specifying the data that was to be included, graphically designing the web portal, and developing the cost calculation mechanics was executed essentially as anticipated. Substantial planning went into the content and layout of the web portal. However, presenting actual customer data and refining the methods by which data is manipulated and presented turned out to be an extremely labor intensive process. The following are key takeaways and lessons learned regarding the web portal:

- The AMI meters as originally programmed returned a subset of four variables; total kWh, on-peak, off-peak and critical-peak. The variables were configured based upon weekday, first of the month, and the pilot program. The intention of the design was that any missing variables could be derived from the other variables based on a calculation. In principle, this approach should have worked. In practice, missing reads caused mathematical challenges that made averaging and derivation too difficult to be done automatically. Also, critical-peak readings were programmed to return only once per week and were not able to support the graphical presentation of daily usage over two critical-peak days occurring within the same week.
    - An alternative approach was designed and put into place for two test accounts that provided consistent daily variables that could be independently averaged without derivation. This approach was to bring back Off-Peak, On-Peak, and Critical Peak readings from Sunday-Friday, and total kWh on Saturday. This approach enabled critical-peak to be sent for each weekday, and provided a much better way to retrieve the data for presentation purposes and did not compromise billing.
- Another mathematical complexity encountered with respect to presentation of TOU data on the web portal was a function of the readings from each register being integers. With each of these registers sending readings, and a requirement for algebraic calculation of values based on known and unknown variables, usage calculations could be plus or minus 2 kWh. For small customers, this represents a large percentage of error on a daily basis. When meter readings are done monthly, this error is trivial and equalizes over time. To correct this moving forward, the reporting resolution of the meters should be to tenths or hundredths of kWh however this is a balance that must be struck with the size of data packets that can be retrieved daily. The alternative approach to gathering data mentioned above would also eliminate most of this error by simplifying the calculations. It should also be noted that this issue existed solely within the web portal and did not have any impact on the accuracy of monthly billing statements.
- Treatment of missing reads was another challenge. When a read was missed on a given day, the next reading is the accumulation of two days' worth of usage. If two days are missed, the next reading is three days' worth and so on. Developing an automated process for dealing with these situations proved quite difficult. The simplest solution was to present data as it was received, so if one or more days were missed the reading would be significantly larger. It was felt that this approach would generate more questions from customers and it severely distorts the scale of the graph. An alternative approach when only a single day was missed was to average the consumption over two days. This approach helped address the graph scale issue but was imperfect in that it did not provide an accurate accounting of either day. This method also

proved challenging when the missing reads spanned a weekday and a weekend, because on-peak usage accrued during the period would be averaged over the missing days and would show up on days that were strictly off-peak. It was also difficult to conduct averaging when more than one day was missed because that required the calculation to be dynamic (i.e. know the number of missing days). Ultimately, Unitil employed averaging for 1 day missing reads and larger gaps were either left blank or completed manually using best judgment. It should be noted that most customers only experienced about 3-4 days when reads were missing.

» Overall, supporting the web portal by dealing with these data issues and refining the approach, and addressing specific customer issues proved to be significantly more resource intensive than was originally contemplated for the TOU groups. The Smart Thermostat Group (no TOU rate) was much simpler and easy to present. The process was very manual for customers on TOU rates. A more automated process utilizing the alternate data gathering approach would have to be deployed before this type of web portal were offered in the future to a larger number of customers on TOU rates.

CUSTOMER EXPERIENCE

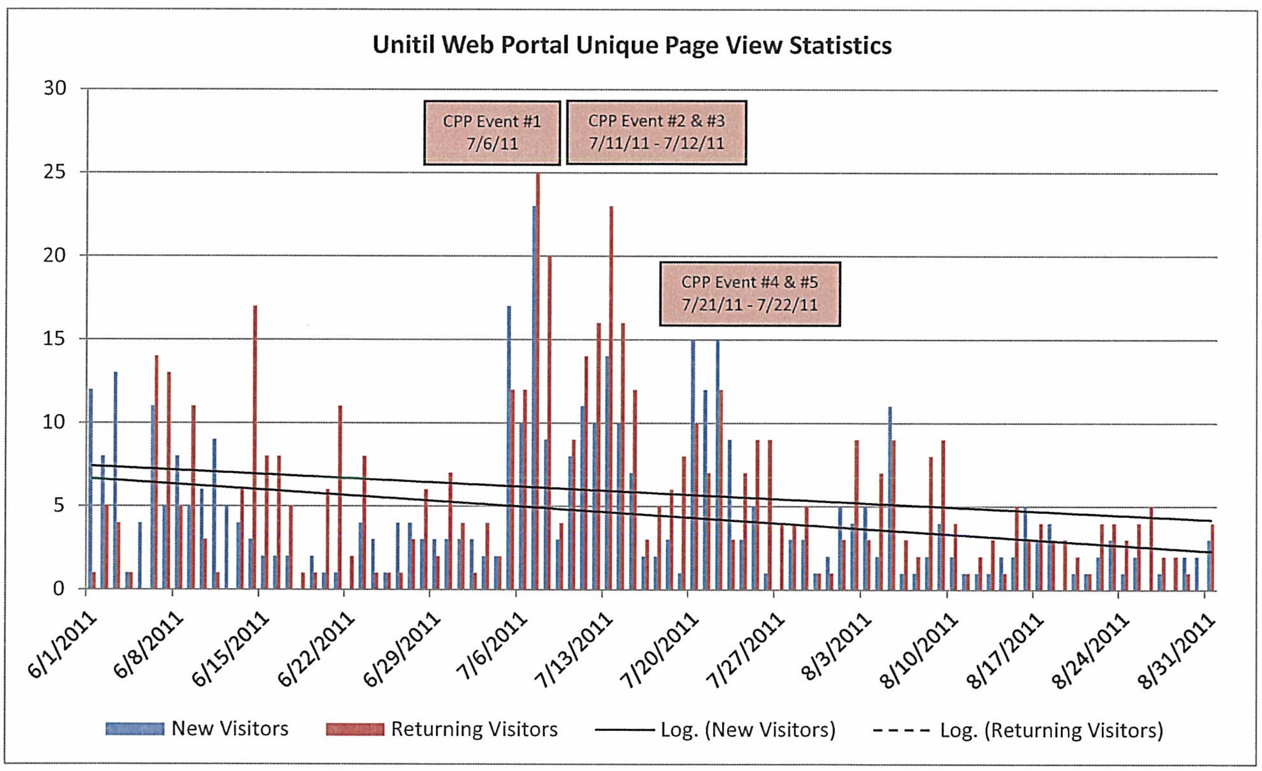
This section highlights some of the key findings from customer feedback that was collected using post-pilot surveys and analytics that captured the number of visits, time spent on site, and other pertinent data. Following are some key takeaways regarding the customer experience with the web portal:

- 70% of the Simple Time-of-Use customers responded that they had used the Unitil Web Portal during the pilot period. Of the Simple TOU customers that said they used the web portal, 70% said they found the data available in the portal to be useful, while 95% said they would be interested in using a similar web portal were it to be offered full time.
    - Customers in the Simple TOU group expressed a desire for the data to be presented quicker and with more accuracy then it was during the pilot period. Many made comments relating to the estimated data that was shown on the web portal and how long it sometimes took for a day's usage data to show up. Much of this delay was simply a product of the time needed to retrieve, sanitize and post daily usage totals which typically occurred 36 hours after the day ended. In some cases, issues with the data required more manual intervention which delayed the process further. Overall however, the time delay is generally consistent with how the web portal would function on a permanent basis.
- 68.2% of Enhanced Technology customers that responded to the post pilot survey said that they had used the Unitil web portal. However, the responses to this question are somewhat unreliable as it is likely that some customers confused the question to refer to Tendril's web portal rather than Unitil's. Of the Enhanced Technology customers that reported they had used the Unitil web portal, only 60% reported that they found the data on the web portal useful. However, 83.3% of these same customers reported that they would be interested in a similar web portal were it to be offered full time after the completion of the pilot.

- Only 48.8% of the Smart Thermostat customers reported that they used the Web Portal throughout the process. Of the Smart Thermostat customers that reported they used the web portal, 63.2% said they found the data on the web portal useful. 85% of the Smart Thermostat customers who said they used the Unitil web portal reported that they would be interested in a similar web portal were it to be offered full time.

- Overall, it seems that the two groups who used the TOU rate (Enhanced Technology and Simple TOU) were more interested in the web portal during the pilot. This is likely because of the TOU rate structure and the financial impact of their load shifting efforts. There were respondents in all groups who did not find the data on the web portal useful, but the majority of the customers found the data on the web portal somewhat or very useful. A significant portion of the respondents who used the web portal throughout the pilot expressed interest in using a similar web portal if it were to be made available full time. One comment that appeared on all groups was a desire for a comparison aspect of the web portal in which customers could directly compare current usage to previous year's usage.

Evaluation of usage analytics from Google indicated that web portal usage decreased over the course of the pilot, but experienced pronounced spikes following critical peak events. The chart below shows usage statistics for new and returning visitors.



Unique page views for both new and returning visitors spiked after the critical peak events as was expected. The trend lines for both new and returning visits indicate similar declines in access rates throughout the course of the pilot.

B. AMI System Time-of-Use Capabilities

Unitil's AMI system was installed on the basis of the savings in O&M expense, but with the understanding that the system could potentially serve as a platform that would facilitate additional technological, management, and evaluative capabilities including, but not limited to, the ability to offer TOU programs to customers at low or no cost. The TOU elements of the pilot program provided the Company with the opportunity to test and report on a number of capabilities of the AMI system. Overall, Unitil's AMI system performed as anticipated.

The Hunt TS2 endpoints deployed throughout Unitil's service territory have the capability to record energy usage in up to four pre-defined registers that can facilitate TOU billing. Utilization of this capability for recording and billing on time-of-use rates for the pilot program required the design of data packets to coordinate the daily retrieval of data, the design and construction of a meter data management system, remote reconfiguration of endpoints prior to critical peak events, and a process for importing the time-of-use data into the billing system. This section summarizes key findings regarding the process for recording and presenting TOU data to customers.

TOU Data Retrieval

Because Unitil's AMI system utilizes a power line carrier to backhaul information from the meters, there are limitations in the amount of data that can be retrieved on a daily basis (AMI bandwidth limitation). This limitation was not restrictive in the past because the meters only recorded daily kWh and peak demand, thus there was space remaining in the data packets for additional required system information.

During the planning phase of the pilot, a weekly schedule of data packets was designed to provide all of the necessary information for billing on TOU rates. The schedule initially consisted of retrieving Total kWh, On-Peak kWh, and Off-Peak kWh register readings from Sunday-Friday along with miscellaneous diagnostic information. The Saturday packet brought back On-Peak, Off-Peak, and Critical Peak readings. The intention behind this design was that the daily kWh readings provided security for billing in case the TOU registers proved problematic and that any missing variables could be derived from the other variables based on a calculation. Key findings included the following:

» A number of customer accounts in Unitil's Massachusetts territory included both electric and gas modules which was not considered during the design process. Retrieving gas readings on a daily basis, as was being done previously, severely complicated the ability to retrieve daily TOU readings. For the pilot, data packets for these customers were re-configured so that gas readings were not retrieved and instead those accounts were read by the AMI system on-demand once each month for the purpose of billing the gas account. This is an issue that would have to be addressed in a full deployment, as on-demand reading of a large number of accounts would not be practical.

» The design of the packets created some issues with respect to the presentation of data in the web portal. A revised packet configuration, which collected each billing component daily and collected the total kWh weekly, was tested during the pilot on several accounts and appeared to be an effective resolution to the issue.

- Reliability of received readings for the pilot group was commensurate with that of other AMI system meters. During the three month pilot, the AMI system averaged 1.07 missed readings per endpoint per month (0.74, 0.98, 1.48 for each month respectively). This compares with an average of 1.07 missed readings per endpoint per month the previous summer (1.79, 0.95, 0.49) which reflects the consistency of performance. Receiving a good read each day for all accounts is typical performance for the system. Once a meter is established in the system, exceptions to this performance happen when individual account signal quality drops below a quality the system can detect. The reasons behind the drop in signal quality during the pilot program were:
    - Weather related power grid outages and switching events,
    - Load related power grid switching events,
    - Power quality related power grid capacitor operation, and/or
    - Momentary power changes due to intermittent contact on the power grid by foreign objects.

Remote Configuration of Meters

Unitil's two-way AMI system provides the capability to remotely reconfigure the data capture and retrieval settings of the meters. This capability was functionally tested during the pilot for two main purposes: first, some customer meters were remotely reconfigured to capture TOU data once the installations had been complete[17]; second, all of the Simple TOU and Enhanced Technology group meters had to be sent commands prior to critical peak days so that the meters would capture critical peak usage in a separate register. Without this command, the meters would continue to capture usage from 12 p.m.-6 p.m. on a critical peak day in the "on-peak" register.

It was proven that the normal AMI functionality of configuring endpoints remotely without a visit to the account location can change an account to a TOU rate. However, when an advanced interval recording meter (sub hourly) is involved, a visit to the account location is necessary to re-program the meter. Accounts with advanced meters presently make up about 7% of the meter population.

Critical Peak Event Issuance

The AMI meters were programmed with a TOU schedule that automatically recorded on-peak and off-peak usage into separate registers. For critical peak events, a command had to be sent to the meters to capture kWh usage for that time period in a separate register. This functionality was tested and approved prior to deployment and worked properly with no failures for the first critical peak event that occurred on July 6th.

Back-to-back CPP events were declared on July 11th and 12th. The command for the second day critical peak event was sent while the first day event was still active. This caused the AMI meters to continue collecting energy consumption in the critical peak register from 6 p.m. on 7/11 until 6 p.m. on 7/12 when all energy from 6 p.m. on 7/11 through 12 p.m. on 7/12 should have been off-peak usage. This issue was identified early and rectified using data from the interval meters and Tendril systems. The root cause of the issue was reviewed with the AMI vendor and it was determined that issue was created

---

[17] Enhanced Technology Group only. The Simple TOU Group and Smart Thermostat Group received new analysis and billing meters that were pre-programmed with the TOU schedules prior to deployment.

because the second day command was sent while the first command was still active. For the second set of back-to-back CPP events that occurred on 7/21 and 7/22, the second day command was not sent until the first day event had ended and no further complications were encountered.

Accuracy of TOU Meters

The ability of meters to accurately capture energy usage in TOU registers and report this information for billing purposes is extremely important to any program development involving TOU rates. To confirm the accuracy of TOU billing data obtained throughout the pilot by the AMI system, the AMI data was compared with the interval meters that were installed and no discernable differences were found.

C. Program Delivery

The process for delivering the pilot program involved many components ranging from recruitment of customers to field installations, billing, customer service, and field support. This section provides a retrospective evaluation of the process for delivering the pilot and what changes should made if a full program were implemented.

Customer Recruitment, Installation, and Support

Challenges associated with the recruitment of customers and subsequent installations of technologies are discussed throughout this report. Implementing a full program – be it TOU rates with or without technologies or a direct load control program – would likely follow a much different process than the pilot. Key observations for recruitment and technology installation under a full program include:

» Limiting the program to customers with central air conditioning eliminated nearly 70% of the total population from eligibility. Broadening the eligibility criteria to all customers who are responsible for paying their own electric bill would ease recruitment and boost participation.

» If home area networks are utilized, thermostats should not be a mandatory element of the program. Making thermostats optional would have reduced the turn down rate by approximately 90%.

» Initiating a TOU program with the TREE system that requires dual meters and the intermediate translate devices is not advisable. Strengthening the signal and eliminating the need for the translate device is an option worth pursuing if the AMI vendor releases a ZigBee enabled endpoint that could be easily fit into the existing AMI meter.

» Any installation that includes thermostats must be conducted by an experienced, professional installer. Customers may be able to set up home area networks that consist of basic plugged equipment; however the process would need to be further evaluated and clearer directions developed.

» Communicating the details of the program and its effects will help the customer better understand the potential benefits and make a more informed decision about participation. For the Unitil pilot, detailed educational material was initially withheld to mitigate self-selection bias in the various treatment groups. Future programs would not be constrained by this restriction, allowing full disclosure from the outset that may result in reduced opt-outs and more engaged participants.

» Installer training would be an important consideration in any further program, both up front and continued training through the duration of the program. Training should be focused on two parts; the actual equipment setup and troubleshooting, and customer education. For the Unitil pilot, the focus shifted to the equipment set ups in the limited training time thus neglecting the opportunity to conduct detailed training on the customer education component.

» A concept that was discussed but not implemented during the pilot was a webinar-type training for customers on the operation of the home area network web portal and equipment. This type of training could be posted online so customers could view short videos to understand the equipment function. Any deployment that includes home area networks should include significant commitment to customer education on the technology and rates. On-going training is also a recommendation as opposed to simply up-front training.

Billing

Overall, the process of billing customers on TOU rates was successful in that customers were billed accurately for consumption in each time period, and these charges were effectively presented on the monthly billing statements. Refer to Appendix D for a sample bill presentation. However, the billing process was extremely manually intensive and a number of billing problems were encountered that had to be addressed. Following are some of the key observations from personnel involved with billing customers on TOU rates, as well as recommendations and required improvements if this type of program were offered to a larger number of customers on a permanent basis:

» The amount of work involved with TOU billing far exceeded expectations during the planning phase. This placed a tremendous stress on the Billing Department which pulled resources away from other important Unitil activities.

» While a number of planning meetings were held in 2010 and again in early 2011, Unitil could not anticipate many of the specific logistical challenges involved with billing customers on TOU rates. Some of this challenge may have been the result of this being "the first time" for TOU billing. In addition, some of the challenges could be avoided through design modifications and improved automation. The full breadth of manual intervention in these accounts was not fully realized until the pilot launched in June.

» The complexity and variety of Unitil's rates by service territory and customer class presented added complexity to the process, and increased the need for manual review and treatment of many of these accounts.

» All customers were migrated to a calendar month billing cycle. This process of cancel/rebilling customers to align with a calendar month was labor intensive, and exacerbated by the delay in the full recruitment of customers which lasted through early June. This process was necessary for the pilot program but would not likely be required if the rate were offered permanently. Thought would need to be given to identifying customers who opted into the rate, and the billing process for billing them a partial month on kWh only, and the remainder of the first cycle on the TOU components.

» The process of uploading TOU data from the meter data management system and uploading it to the billing system (i.e. the billing integration) was a manual process for the pilot and would be more efficient if automated. The MDM would need a more sophisticated solution for a larger population with less manual intervention. This process would require further planning and programming which represents additional cost.

- A number of unique circumstances were encountered where TOU billing needed to be corrected before customers could be billed. Examples include the issue with back-to-back CPP events (this has now been resolved), meter exchanges, and faulty meters. For the pilot, interval data for the Simple TOU group was utilized to help adjust the billing data; however interval data would not be available for all customers on a permanent rate. Thought should be given to processes for identifying and correcting these conditions prior to a full deployment.
    - An example of one corrective action would be to establish more specific read in / read out procedures for changing TOU meters so that an accurate reporting of all components is made, not just total kWH.
    - Another requirement would be firm procedures for handling situations with missing or irretrievable data. For example, if a meter mistakenly collects on-peak or critical peak usage for an extended period and there is no way to parse the total consumption by TOU component, would the customer simply be reverted to all off-peak hours or would usage be pro-rated to different time periods? Identification of the various potential conditions, and procedures for handling each would need to be in place. Identification should be automated; intervention could be manual as needed based on the procedures in place.
- Substantial planning would be needed to support a full deployment to address many of the issues discussed above. Having additional staff dedicated to TOU billing and responding to questions was raised by many as a need to support this type of program given the uniqueness of the rate and some of the complexities with billing. Reviewing and billing customers on three components (Off-Peak, On-Peak, Critical Peak) over multiple service territories substantially requires the time needed to review and approve the billing, and increases the number of potential issues to be addressed.

The process of inputting "initial reads" at the beginning of the pilot and "correct last reads" at the end was a very time consuming manual process for the Billing Department. Automation of this process should be considered if the rates were offered permanently.

Information Technology

The Information Technology (IT) Department was heavily involved with the pilot program. Key roles involved the design and development of the pilot meter data management system, the customer web portal, participant tracking database, and coordination with Tendril regarding customer usage information for loading the TREE web portals with historical data. Overall, consensus from the IT group was that the scope of their involvement increased significantly as the program progressed and that this placed substantial stress on the Department. If TOU rates or the web portal were offered on a permanent basis, staffing to support these endeavors would be a major consideration, as would be any opportunity to automate many of the processes. Specific findings and recommendations include:

- Resource planning during the early phases of the pilot assumed that most IT participation would be front loaded during the design and development phases. In reality, the process of supporting the on-going maintenance of the MDM and Web Portal among other activities was extremely labor intensive; approximately 40 man hours per week to support only the limited number of customers in the pilot. Specific time consuming activities included reviewing specific customer accounts to correct presentation of TOU usage when reads were missing, database maintenance, meter inventory maintenance, pilot communications via email blasts, and integration with billing.

- The program required the change out of a number of meters and communication between the Metering Department and IT were not always efficient or sufficiently detailed. This caused some situations where there was confusion about the meters in the field not matching the program database, and requiring manual review and intervention to correct the issue. Developing a more automated handshake between the Metering Department and IT would be necessary for a permanent program.

- Prior to any further deployment of TOU rates or the web portal, a more detailed review of the current AMI system data configuration was recommended. Subsequent investigation into potential AMI updates that might optimize a future TOU implementation was a further recommendation.

- Presenting cost estimates on the web portal presented an added layer of complexity and time commitment for the project. Supporting the variety of rate variations by class and territory, and keeping those rates updated, would be a significant undertaking for a larger group of customers.

Critical Peak Event Selection and Dispatch

During the planning phases of the pilot, Unitil established 78 degrees F as the threshold average daily temperature for declaring critical peak events. Figure 2 illustrates the process for identifying and declaring critical peak events during the pilot.

FIGURE 14: PROCESS FOR IDENTIFYING AND DECLARING CPP EVENTS

Unitil continuously monitored 5 day weather forecasts throughout the duration of the pilot. If the forecasted average temperature two days out was greater than or equal to 78 degrees, an internal notification of a potential critical peak day was sent to key personnel. If the forecasted temperature one day out was still greater than or equal to 78 degrees, a critical peak event was declared. Notifications went to customers via email and phone blast, and Unitil's Dispatch team set up critical peak events for the following day in the Honeywell and Tendril head end systems, respectively. Copies of the notification emails sent to customers are included for reference in Appendix E.

Table 24 shows the 15 top system load days for 2011. The top three system load days were all captured as critical peak events during the pilot period, and all had an average daily temperature above the 78 degree F threshold.

TABLE 24: TOP 15 SYSTEM LOAD DAYS FOR 2011

Date	CPP Day?	Avg. Daily Temp	Capital Load	FGE Load	Seacoast Load	Total System Load
7/22/2011	Y	83	2,512.79	1,950.73	3,274.63	7,738.16
7/21/2011	Y	85	2,396.71	1,882.26	2,969.95	7,248.92
7/12/2011	Y	80	2,319.12	1,784.93	2,833.63	6,937.68
7/23/2011	N	80	2,029.63	1,663.95	2,718.99	6,412.57
7/20/2011	N	80	2,105.62	1,732.98	2,498.18	6,336.79
7/19/2011	N	75	2,066.11	1,708.77	2,469.28	6,244.16
7/18/2011	N	77	2,066.22	1,687.68	2,468.62	6,222.51
7/11/2011	Y	79	2,047.22	1,649.43	2,509.83	6,206.48
8/8/2011	N	73	2,165.80	1,682.95	2,311.06	6,159.81
8/1/2011	N	76	2,032.26	1,666.70	2,381.53	6,080.49
7/13/2011	N	72	2,066.31	1,582.77	2,420.79	6,069.86
6/9/2011	N	77	2,088.55	1,624.93	2,278.12	5,991.60
7/6/2011	Y	78	1,996.77	1,597.26	2,389.26	5,983.28
1/24/2011[18]	N	-	2,010.44	1,638.77	2,272.12	5,921.33
8/2/2011	N	71	1,953.82	1,640.12	2,310.18	5,904.12
6/8/2011	N	75	2,066.29	1,692.74	2,093.81	5,852.84
Average			**2120.23**	**1699.19**	**2512.50**	**6331.91**
Standard Deviation			**0.07**	**0.06**	**0.12**	**0.08**
Peak % of Avg			**118.5%**	**114.8%**	**130%**	**122%**

Of note in the table above is that five of the top seven system load days in 2011 occurred consecutively during the week of July 18th. It is typical for the system load to increase each day of a persistent heat wave as air conditioning use becomes saturated in the population and customers run their systems nearly constantly to stay comfortable. As shown in the table above, Thursday and Friday of that week, 7/21 and 7/22 respectively, were both declared as critical peak days. It was decided at the time not to dispatch a critical peak event on Wednesday July 20th because it was likely that the following two days would be called events and there were concerns over customer fatigue.

Overall, this table demonstrates that the majority of high load days were captured using this methodology, and that average daily temperature is a fair predictor of system loads. Compared with the 15 system peak days of 2010, the average system load was approximately 6% lower in 2011 however the system peak in 2011 was 5.4% higher than the system peak in 2010.

[18] Outside of pilot months

Post CPP event surveys were conducted to assess the effectiveness of critical peak notification to customers. 100% of respondents indicated they were aware of the critical peak events and 97% (33 of 34) felt they had received adequate notification of the pending event day.

Customer Service

Two representatives from Unitil's Billing Department served as the primary Tier 1 customer service representatives for the pilot. In this capacity, the majority of customer calls were fielded by Unitil and technology related questions they could not immediate answer were elevated to support staff for the technology vendor. Representatives from the Billing Department were selected for this role because it was felt that customer service representatives (CSR's) may have difficulty responding to specific questions on the TOU rates, and it was anticipated that the majority of calls from customers would be related to the TOU rates.

In reality, calls coming into the dedicated pilot support line were varied and ranged from questions on the technology that was installed, to questions on billing and the presentation of TOU data on the web portal, to specific problems with the technology that was installed. Most of the call volume related to issues with equipment or questions on data, with a small percentage being complaints about high bills. Key findings and recommendations relating to customer service are as follows:

» If the program were offered on a permanent basis, particularly one with TOU rates, consideration should be given to using dedicated customer representatives for this type of program. The rate structures and technologies are sufficiently unique to the point where it would be impractical to train an entire customer service staff on the technology and rates.

» Many of the inquiries had to do with AMI usage data that was posted to the web portal. While the CSR's had access to the web portal information, they did not have the back of house access to the raw data, nor the thorough understanding of the process, to effectively communicate with customers. In many cases, the customer inquiries were dealt with by senior members of the energy measurement and control, or information technology staff – which placed a further burden on already strained resources. Dedicated CSR's would need robust access to the underlying data and be trained on how to understand the data manipulations necessary to present in the web portal.

The CSR's received training on the types of equipment installed in customer homes, and basic troubleshooting techniques, however many of the customer inquiries were in regards to detailed equipment function. In these cases, the Unitil CSR would take the contact information for the customer and pass it along to the technology vendor for follow up. In most cases this worked acceptably except that some customers expressed frustration their question could not be immediately addressed. In a full program, refinement to this process would be needed. Either the vendors should be engaged to provide full support for all of their equipment, or more rigorous training would be required for the dedicated CSR's to understand the function, operation and troubleshooting of the equipment in the field.

V. Participant Bill Impact

A billing analysis was prepared for customers in the Simple TOU and Enhanced Technology treatment groups; those who were placed on the TOU rate during the pilot period. The billing analysis compared customer bills during the three-month pilot to the price they would have paid on the standard fixed flat rate. Smart Thermostat pilot participants were not included in the billing analysis because they remained on the standard billing rate while in the pilot and did not experience any change in bills apart from a fixed one time incentive at the end of the pilot.

All customers who entered the pilot prior to June 1st were moved to a calendar month billing cycle by cancelling their May bill (if they had received it) and re-billing with a long bill through May 31st. These customers had three complete months on the TOU rates. Customers who entered the pilot in the first weeks of June also received a cancel/rebill to start them on a calendar month cycle. These customers who joined the pilot after June 1st received a bill for that month that included 4 components; kWh (June 1- date of entry, On-Peak, Off-Peak, & Critical-Peak).

Billing histories for each participating customer were received from Unitil and served as the basis for the analysis. The analysis methodology was to isolate the TOU component usage for each month (Off-Peak kW, On-Peak kWh, & Critical-Peak kWh) and to run two cost calculations off those values. The first is the total monthly cost under the customers standard fixed rate; the second the total monthly cost under the Time-Of-Use rate structure. This methodology was utilized to mitigate some of the issues with the data received from Unitil which included a number of accounts that had been cancel/rebilled at some point during the pilot, or who had been late entering the program. It was felt that utilizing these *actual* charges would be more prone to error.

Overall during the three month pilot, customers saved an average of $28.92 on the TOU rate representing about 5.8% of their total monthly bill. For the average customer, the three month cost on the standard flat rate structure would have been $497.87, while the three month cost on the pilot was actually $468.95. Breakdowns of the savings for the Simple Time-Of-Use group and the Enhanced Technology group, as well as the three month average TOU component usage are shown in Table 14, below. Simple Time of Use customers saved an average of $27.62 over the three month pilot, representing about 5% of their total standard bill. Enhanced Technology customers saved 6.8% or $30.29.[19] It can be seen that the vast majority of usage during the three month period took place during off-peak periods which demonstrates an aggressive attempt to shift energy use outside of peak hours. Average three month consumption is broken down by test group in the table below. Comparing the Simple TOU group with the Enhanced Technology, it is shown that the Enhanced Technology group did use less kWh across each TOU component than the Simple TOU group. This is an expected result because on average, the Enhanced Technology customers were lower energy users

[19] Due to late customer entry into the pilot and the occasional drop out, customer participation was not consistent throughout the three month pilot, and the reported number of participants specific to particular characteristic groups is based on a three month average

TABLE 25: SIMPLE TOU AND ENHANCED TECHNOLOGY COMPONENT CONSUMPTION AND BILL IMPACTS

Test Group	Total Jun-Aug Average Consumption			Average Customer Baseline Cost[20] ($)	Pilot (TOU) Average Cost ($)	Average Savings ($)	Average Savings (%)
	On-Peak (kWh)	Off-Peak (kWh)	Critical Peak (kWh)				
Simple TOU	535	3008	56	$547.82	$520.20	$27.62	5.0%
Enhanced Technology	395	2453	33	$445.12	$414.82	$30.29	6.8%
Average all TOU Participants	467	2738	45	$497.87	$468.95	$28.92	5.8%

Across both Test Groups, 88 percent of pilot participants saved money during the pilot. This figure is higher than the percentage of customers who perceived their bills to be lower (61%) versus those who felt their bills were higher (4%), about the same (23%) or did not know (12%). The average amount of savings over the three month pilot was $33.36. The 12% that spent more money during the pilot than on the standard rate spent on average of $10.65 more over the three month period. Within the Simple Time-Of-Use group 84% of participants had savings at the end of the three month pilot. The average savings for those customers was $35.30. The remaining 16% of participants in the Simple Time-Of-Use group spent more money on the pilot Time-Of-Use rate than they would have spent on the flat rate. The average customer from this group spent $11.70 more over the three month pilot. The Enhanced Technology group had 94% of its participants save money over the three month period. On average an Enhanced Technology participant that saved money, saved $31.55, while the 6% that spent more on the Time-Of-Use rate only spent an average of $7.22 more than they would have on the standard flat rate.

Table 15 shows the average monthly savings for the TOU treatment groups. All customers saved money in the months of June and August because there were no critical peak events. During the month of July savings were recognizably lower, and on average for a Simple Time-Of-Use customer and average customer negative, due to five Critical Peak Pricing days that were declared during the month.

TABLE 26: MONTHLY BILL IMPACTS FOR ALL SIMPLE TOU AND ENHANCED TECHNOLOGY PARTICIPANTS

Test Group	June		July		August	
	Average Savings ($)	Average Savings (%)	Average Savings ($)	Average Savings (%)	Average Savings ($)	Average Savings (%)
Simple TOU	$14.28	9.8%	($4.84)	(2.2%)	$18.18	10.1%
Enhanced Technology	$12.13	10.4%	$2.52	1.4%	$15.64	10.2%

[20] Based on customer rate code and current rates in effect at the time of the pilot

Average all TOU Participants	$13.23	10.1%	($1.26)	(0.6%)	$16.95	10.1%

As required by the Statewide Evaluation Collaborative framework document, the billing analysis was extended to examine many specific groups within the Simple TOU and Enhanced Technology categories. Variables such as income, home size, annual kWh usage, and the presence of a senior citizen were evaluated to determine if any distinct savings or losses were associated with each group. With such a small sample of participants, some of the demographic characteristics above were not present in our sample, while some were highly represented. Only four participants were characterized as low income as determined by their rate structure while nearly 64 met the criteria of high income (annual income of $100,000 +). With a sample of only four low income participants, no statistically meaningful findings can be taken from their billing analysis. No participants were deemed low use as defined by the collaborative[21]. Only two participants were small home participants, making those savings figures not statistically relevant.

Detailed reporting tables for each subgroup of interest are included in Appendix F of this report. The main finding from this subgroup analysis is that the presence of a senior citizen on average lowered savings for the Simple Time-Of-Use and Enhanced Technology groups. Simple Time-Of-Use users with the presence of a senior experienced 1.2% less savings over the pilot than did the average Simple Time-Of-Use participant. The presence of a senior in the Enhanced Technology group decreased average three month savings by 2.2%.

[21] The collaborative has defined low use as participants with average annual energy consumption less than or equal to 50 percent of the residential class average.

APPENDIX A

Educational MATERIALS

APPENDIX B

MARKETING MATERIALS

APPENDIX C

PARTICIPANT DEMOGRAPHIC DATA

Participant Demographic Data	Control Survey (21)	Simple TOU (74)	Enhanced Technology (70)	Smart Thermostat (72)	MA RASS Data[22] (2667)
Age of Head of					
Under 30 years	0%	3%	6%	3%	5%
30-39 years	5%	12%	19%	8%	12%
40-49 years	48%	18%	21%	28%	18%
50-59 years	24%	20%	36%	29%	23%
60 and older	24%	43%	19%	32%	40%
Education Level					
Elementary	0%	0%	0%	0%	1%
Some High School	0%	3%	0%	1%	3%
High School	0%	7%	4%	3%	15%
Some	29%	23%	23%	24%	19%
College Graduate	24%	41%	41%	33%	32%
Postgraduate	48%	22%	29%	38%	30%
Income					
Less than $10,000	0%	0%	0%	0%	5%
$10,000-$17,999	0%	0%	0%	1%	6%
$18,000-$29,999	0%	0%	3%	1%	9%
$30,000-$49,999	0%	11%	7%	6%	16%
$50,000-$74,999	5%	18%	11%	8%	21%
$75,000-$99,999	35%	9%	16%	10%	14%
$100,000-$149,999	30%	22%	29%	26%	16%
$150,000 or more	30%	19%	14%	15%	16%
Own Home	100%	100%	96%	99%	81%
Year-Round	100%	97%	100%	92%	93%
Mean No. of Rooms	-[23]	7.1	7.1	6.8	6.4
Building Type					
SF Detached	71%	82%	64%	74%	67%
MF (2-4 units)	5%	0%	0%	0%	20%
MF (5+ units)	10%	0%	0%	0%	12%
Other	14%	19%	36%	24%	1%
Home Built					
Before 1930	0%	8%	1%	6%	26%
1930-1969	10%	16%	16%	16%	36%
1970-1999	29%	26%	37%	37%	30%
2000 or later	62%	45%	41%	41%	8%

[22] Data reflects 2009 Massachusetts Residential Appliance Saturation Survey (MA RASS)
[23] Data not available

Participant Demographic Data	Control Survey (21)	Simple TOU (74)	Enhanced Technology (70)	Smart Thermostat (72)	MA RASS Data[24] (2667)
Home Heating					
Pay to Heat Home	100%	100%	100%	100%	92%
Heat Part of Rent	0%	0%	0%	0%	7%
No Heat	0%	0%	0%	0%	1%
Primary Heating					
Natural Gas	29%	46%	39%	32%	49%
Electric	5%	0%	0%	0%	8%
Oil	33%	35%	40%	40%	39%
Bottle Gas	29%	18%	16%	24%	2%
Wood or Coal	0%	0%	3%	0%	1%
Other	5%	0%	3%	3%	1%
Central Air Cooling					
Yes	95%	95%	97%	97%	36%
No	5%	4%	3%	1%	64%
76-100% of space conditioned	90%	80%	87%	85%	82%
Room AC					
Yes	14%	15%	11%	14%	63%
No	86%	74%	86%	83%	37%
Primary Water Heating					
Natural Gas	24%	43%	34%	29%	52%
Electric	10%	18%	14%	19%	18%
Oil	29%	19%	27%	25%	26%
Bottle Gas	24%	16%	20%	24%	4%
Solar	5%	0%	0%	0%	<1%
Other	10%	0%	1%	1%	<1%
Appliances					
Plasma TV	24%	17%	15%	29%	4%
Computer	90%	96%	94%	97%	82%
Multifunction Printer	90%	88%	79%	66%	52%
Home Network	71%	57%	57%	47%	24%

[24] Data reflects 2009 Massachusetts Residential Appliance Saturation Survey (MA RASS)

APPENDIX D

SAMPLE TOU BILL PRESENTATION

APPENDIX E

CPP EVENT CONFIRMATION EMAILS

APPENDIX F

BILL IMPACT TABLES

Billing Impact Tables
All Participants, Low Income, High Income

Bill Impacts Table – All Participants										
Test Group		# of participants	Jun		Jul		Aug		Three Months	
			%	$	%	$	%	$	%	$
1	Simple Time of Use (TOU)	75	9.8%	$1,070.75	-2.2%	-$362.79	10.1%	$1,363.58	5.0%	$2,071.55
2	Enhanced Technology	71	10.4%	$861.09	1.4%	$179.01	10.2%	$1,110.69	6.8%	$2,150.78

Bill Impacts Table - Low Income Participants										
Test Group		# of participants	Jun		Jul		Aug		Three Months	
			%	$	%	$	%	$	%	$
1	Simple Time of Use (TOU)	3	9.2%	$20.86	2.7%	$11.13	9.1%	$31.12	18.4%	$63.11
2	Enhanced Technology	1	9.5%	$4.01	5.8%	$3.22	8.4%	$3.91	23.9%	$11.14

Bill Impacts Table - High Income Participants										
Test Group		# of participants	Jun		Jul		Aug		Three Months	
			%	$	%	$	%	$	%	$
1	Simple Time of Use (TOU)	32	9.7%	$539.81	-3.4%	-$293.70	9.9%	$710.78	13.4%	$956.89
2	Enhanced Technology	32	10.4%	$473.72	1.3%	$83.62	9.8%	$589.02	19.1%	$1,146.36

Billing Impact Tables
High Use, Large Home, Presence of a Senior

Bill Impacts Table – High Use Participants

	Test Group	# of participants	Jun		Jul		Aug		Three Months	
			%	$	%	$	%	$	%	$
1	Simple Time of Use (TOU)	35	9.9%	$662.62	-3.4%	-$353.50	10.3%	$864.59	13.9%	$1,173.71
2	Enhanced Technology	20	10.7%	$361.98	0.8%	$44.28	10.3%	$469.68	19.2%	$875.94

Bill Impacts Table – Large Home

	Test Group	# of participants	Jun		Jul		Aug		Three Months	
			%	$	%	$	%	$	%	$
1	Simple Time of Use (TOU)	28	10.1%	$506.32	-0.9%	-$72.50	10.4%	$668.55	17.2%	$1,102.37
2	Enhanced Technology	19	10.0%	$274.75	2.1%	$90.56	9.7%	$371.08	19.3%	$736.39

Bill Impacts Table – Participants with the Presence of a Senior

	Test Group	# of participants	Jun		Jul		Aug		Three Months	
			%	$	%	$	%	$	%	$
1	Simple Time of Use (TOU)	18	10.1%	$220.65	-5.1%	-$163.32	10.3%	$230.58	12.9%	$287.91
2	Enhanced Technology	12	10.1%	$115.57	-1.0%	-$16.62	6.9%	$95.49	14.0%	$194.44

APPENDIX G

ENERGY IMPACT TABLES

APPENDIX H

MA COLLABORATIVE FRAMEWORK REFERENCE

Appendix I

Raw Survey Data

(Electronic Format)

APPENDIX J

RAW ENERGY CONSUMPTION DATA
(ELECTRONIC FORMAT)