SMUD's Smart Thermostat Pilot – Load Impact Evaluation

Promoting residential energy and peak savings through optimized HVAC control

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Herter Energy
RESEARCH SOLUTIONS

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Executive Summary

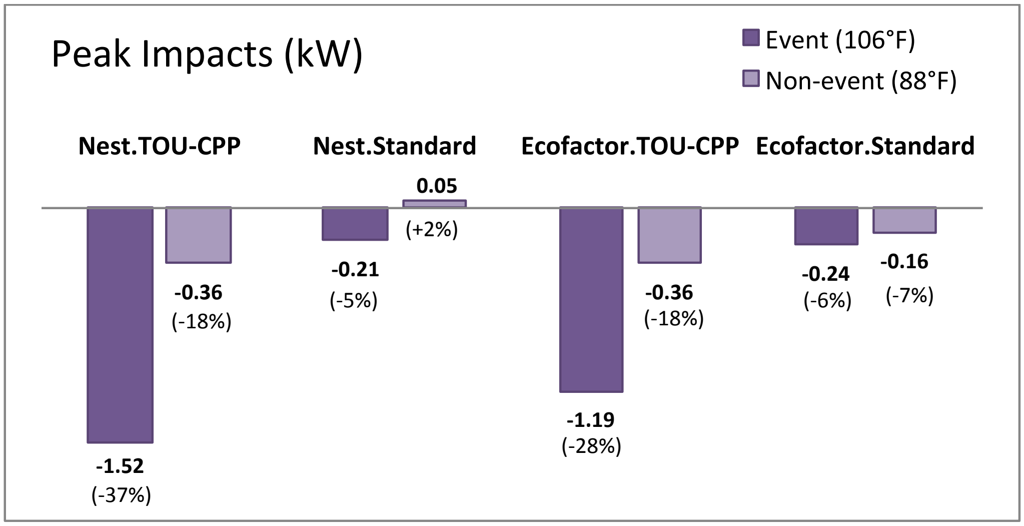
The objective of this study was to estimate the energy, peak, event, and bill impacts associated with two smart thermostat systems, the Nest Learning Thermostat and the Ecofactor Proactive Energy Efficiency service, combined with two different electricity rate structures: a time-invariant tiered rate and dynamic time-of-use rate. Each treatment was offered in isolation to a group of screened but otherwise randomly chosen customers, so the results for any one of the treatments can safely be extrapolated to the subset of SMUD's residential customers that meet the same screening criteria, at the same rate of participation as occurred for that treatment, assuming the same marketing effort.

SMUD provided smart thermostats at no cost to about 700 participating single and multi-family residences, screened to ensure central air conditioning and exclude those participating in other programs. Although the thermostats provided were "smart" in the sense that they deployed energy-saving algorithms and could be remotely accessed by the customer via the Internet, they were not connected to the utility to receive price or control signals. Thus, pricing and event notifications were not sent to the thermostats, and utility control was not implemented.

During the summer of 2013, roughly half of the participants in each thermostat group were exposed to a weekday time-of-use (TOU) rate with 12 critical peak price (CPP) events, while the other half remained on the standard 2-tier residential rate. Hourly energy data were collected and analyzed using a difference-in-differences regression technique that corrected year-over-year load impact estimates for temperature and exogenous effects.

Figure 1 summarizes the modeled peak load impacts on a 106°F (1-in-2 peak) event day and an 88°F non-event weekday. All treatment groups exhibit statistically significant peak load shed on the 106°F event day, with the Nest.TOU-CPP group showing the greatest peak savings. On non-event weekdays, the two TOU-CPP groups exhibited the greatest peak savings.

FIGURE 1. AVERAGE SUMMER WEEKDAY PEAK LOAD IMPACTS PER PARTICIPANT



Note: All load impact values are statistically significant. All differences between load impact values on like days are statistically significant with the following exceptions: (1) Nest.Standard vs. Ecofactor.Standard on event days, and (2) Nest.TOU-CPP vs. Ecofactor.TOU-CPP on non-event days.

Modeled load impacts indicate higher peak savings on event days with higher maximum daily temperatures (Figure 2). This correlation is particularly strong for the groups on the TOU-CPP rate. The Nest.TOU-CPP event savings are predicted to be the highest of the four groups at all temperatures, reaching 2.0 kW load drop on a hypothetical 110°F day.

FIGURE 2. EVENT PEAK IMPACTS BY TEMPERATURE

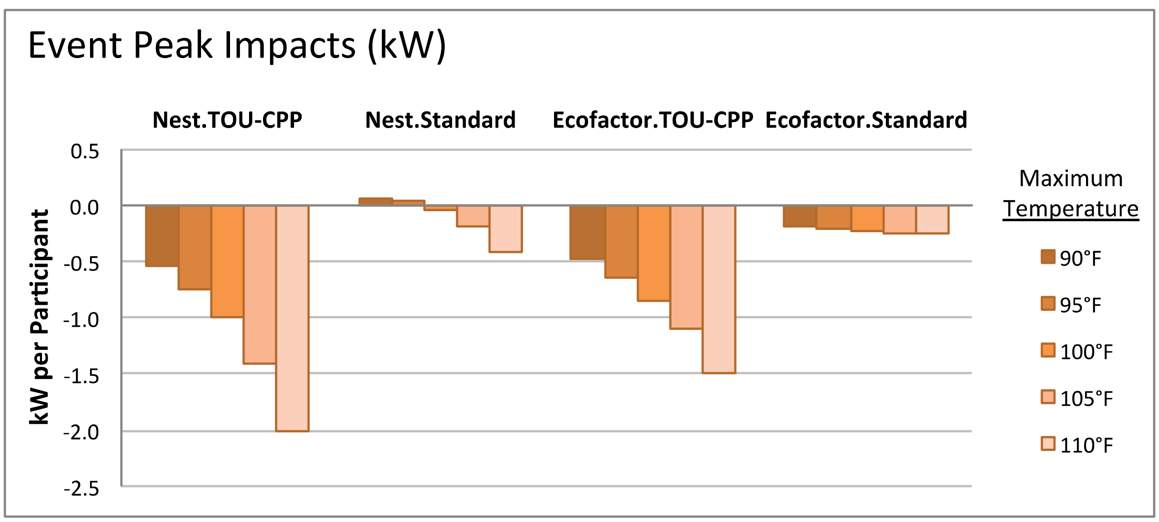
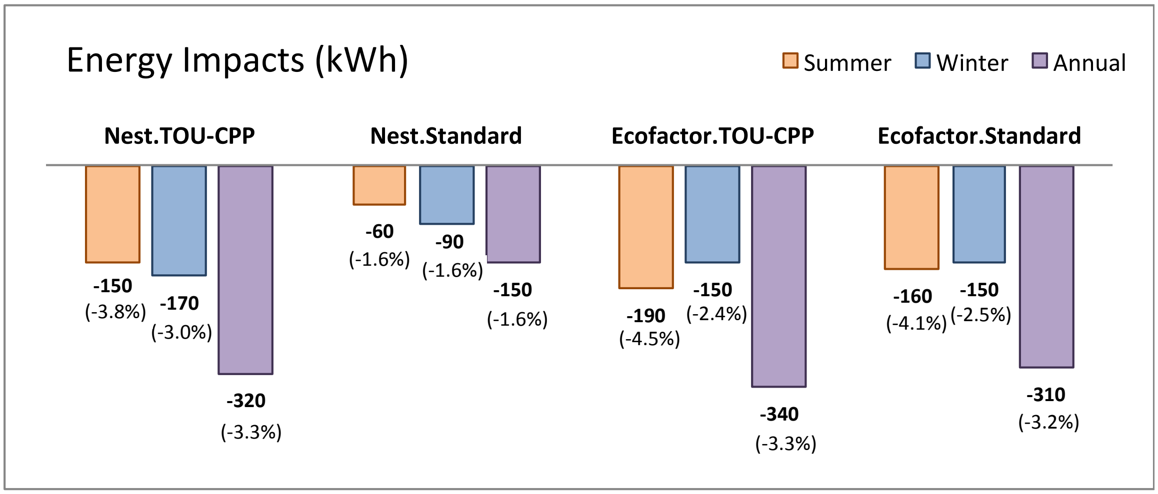


Figure 3 summarizes the total annual and seasonal energy savings for each of the treatment groups. Relative to the surveyed control group, all four treatment groups saved statistically significant amounts of energy in summer, winter, and annually. Between-treatment comparisons indicate that the 310 to 340 kWh annual energy savings (3.2% to 3.3%) per participant of the Nest.TOU-CPP, Ecofactor.TOU-CPP, and Ecofactor.Standard groups were statistically indistinguishable from each other.

FIGURE 3. ANNUAL AND SEASONAL ENERGY IMPACTS



Note: All energy impact values are statistically significant. There are no statistically significant differences between values on like days with the exception of the Nest.Standard group and all other groups.

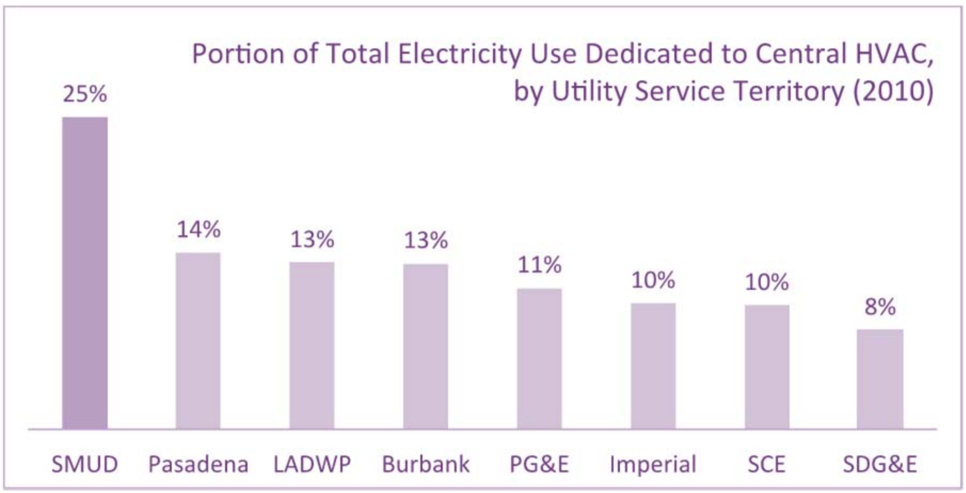
Combined with survey results showing preference for the Nest Learning thermostat over the Ecofactor system, these results support the Nest thermostat paired with a TOU-CPP rate (Nest-TOU-CPP) as the best *of the options tested in this pilot*. It is important to consider, however, that there exist variables not tested here that have the potential to result in improved savings and satisfaction. For example, other smart thermostats are available for use in utility programs – several of which scored higher in independent usability testing than those implemented here (Herter & Okuneva 2014b). In addition, different rate structures are likely to result in different outcomes. Of particular interest is a TOU rate *without* the CPP component, which is expected to become SMUD's default rate in 2018. Future research, then, might focus on (1) further usability testing followed by (2) pilot tests of highly usable devices combined with (3) the time-varying rates to which SMUD expects to transition over the next few years.

1. Introduction

Background

The thermostat is an unassuming yet ubiquitous device that plays a large role in residential electricity use through its control of central heating and air-conditioning loads. Of the largest electric utilities in California, the Sacramento Municipal Utility District (SMUD) is most shaped by air-conditioning loads, which comprise one-quarter of all residential electricity consumption (Figure 4). On the hottest summer days, residential air-conditioning is responsible for nearly 30% of SMUD's total 3,000-megawatt system peak demand.

Figure 4. Residential HVAC electricity use in California



Source: California Energy Commission 2009

Until recently, little has been done to take advantage of the energy savings opportunities inherent in thermostatic controls. Early efforts focused on the use of programmable schedules to reduce HVAC use at regularly scheduled times of occupants being away or asleep. Since the early 1980's, the California Energy Commission's Title 24 building standards have required that thermostats have four programmable time-temperature settings, describes as *Wake*, *Day*, *Evening*, and *Sleep* periods.

In 1995, the U.S. Energy Star program used the same four-setting specification for their voluntary thermostat certification program. About a decade later, however, Energy Star rescinded the thermostat certification program, citing several studies showing that the programming features were not being used properly, or at all, and that the promised savings had not materialized (Table 1). Since then, Energy Star has been working with vendors and researchers to devise a new set of specifications. The current proposed specifications require communications to allow “3rd party developers to enable access to the product’s full range of communication and remote control capabilities” (U.S. Energy Star Program 2012).

TABLE 1. PROGRAMMABLE THERMOSTAT STUDIES (GUNSHINAN 2007)

Organization	Location	Year	Homes	Conclusions
Connecticut National Gas Corp.	Connecticut	1996	100	No change
Energy Center of Wisconsin	Wisconsin	1999	299	No change
Florida Solar Energy Center	Florida	2000	150	No savings, some increases
Bonneville Power/PNNL	Northwest	2001	150	No change
Southern California Edison	California	2004	N/A	Some savings, some increases

To date, the California Energy Commission has not followed Energy Star’s lead in repealing the original scheduling requirements; however, like Energy Star, the Commission is pursuing a standards update that includes remote communications. The Commission’s first attempt at setting a standard for “Programmable Communicating Thermostats” (or PCTs) was abruptly shelved in early 2008 when the media caught wind of plans to require emergency-based remote control of thermostats by utilities (New York Times 2008). After removing the controversial requirement and renaming the devices “Occupant Controlled Smart Thermostats” (or OCSTs), the Commission introduced and passed the revised proposal for the 2013 standards (California Energy Commission 2013).

The new rules allow an option for thermostats in newly constructed California homes to have an expansion port to allow for the installation of a removable communication module that would allow the thermostat to receive and respond to price and emergency signals sent by the electric utility. According to the new specifications, the utility would initiate emergency response, the customer would schedule price response, and the customer would maintain the ability to override the PCT automation in either case.

In 2013, SMUD commissioned a paired-comparison usability test of 10 communicating thermostats for task efficiency, preference, and perceived usefulness of advanced features. Results indicated high scores for the communicating thermostats from Carrier, Ecobee and Emerson, with low to mid-range scores for the Nest and Ecofactor thermostats used in this study (Herter & Okuneva 2014b).

Study Overview

The main goal of this study is to provide SMUD with empirical data to support decisions about future residential customer programs that promote energy efficiency and demand response through smart thermostats. In addition to load reduction and load shifting goals, SMUD is investigating opportunities to increase customer satisfaction with their thermostats while minimizing the costs of implementation.

The objective of this study was to estimate the energy, peak, event, and bill impacts associated with two different types of smart thermostats designed to optimize energy efficiency:

- Nest Learning Thermostat – a unit with integrated optimization services out of the box, and optional WiFi connection for software upgrades and customer remote control.
- EcoFactor Proactive Energy Efficiency – an energy service that requires an ongoing, subscription-based WiFi link to the thermostat to run patented energy algorithms intended to minimize energy consumption through the thermostat.

To this end, SMUD provided and installed one of the two types of thermostats at no cost to roughly 700 participating single and multi-family residences. During the summer of 2013, about half of the participants in each thermostat group were exposed to a time-of-use (TOU) rate with 12 critical peak price (CPP) events, while the other half remained on the standard 2-tier residential rate.

This report describes the evaluation of electric load impacts resulting from the four treatment groups: Nest with standard rate (Nest), Nest with TOU-CPP rate (Nest-CPP), Ecofactor with standard rate (Ecofactor) and Ecofactor with TOU-CPP rate (Ecofactor-CPP). The evaluation makes use of hourly interval meter data to determine energy, peak, event and bill impacts. Survey data is also used to determine potential relationships between electric load impacts, customer demographics, and treatment period behaviors.

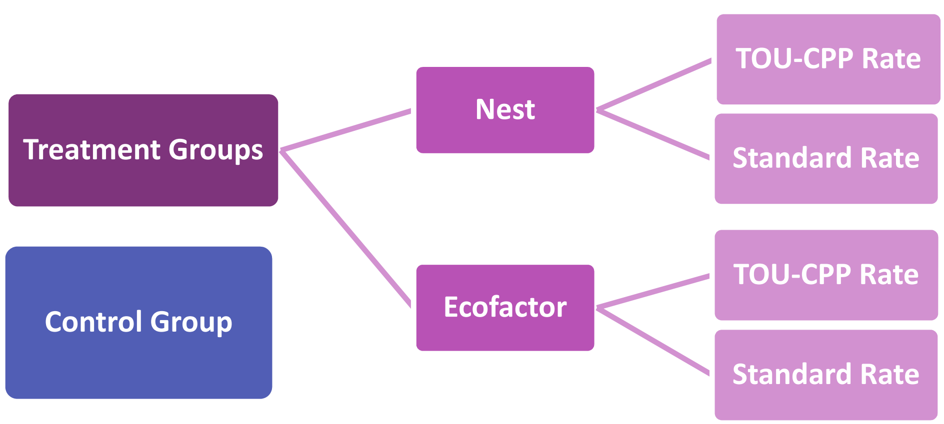
Study Design

The sample design involves the introduction of an experimental TOU-CPP rate and one of two smart thermostats – one self-optimizing and one cloud-optimizing – for a total of four treatment groups as follows:

1. ***Nest.TOU-CPP:*** This group of customers received a self-optimizing NEST thermostat and was placed on the residential TOU-CPP rate.
2. ***Nest.Standard:*** This group of customers received a self-optimizing NEST thermostat and remained on the standard residential 2-tier rate.
3. ***EcoFactor.TOU-CPP:*** This group of customers received a cloud-optimizing EcoFactor-enabled thermostat and was placed on the TOU-CPP rate.
4. ***EcoFactor.Standard*****:** This group of customers received a cloud-optimizing EcoFactor-enabled thermostat and remained on the standard residential 2-tier rate.

Figure 4 illustrates the basic sample design for this study. Target participants were randomly assigned to one of the four treatment groups. Each was then mailed an invitation for the treatment group to which they had been assigned. A total of 4,000 randomly selected customers from the same sample frame were set aside as a control group. Of these, 268 control group customers responded to a survey similar to the one collected from pilot applicants as a requirement of participation.

FIGURE 4. BASIC SAMPLE DESIGN



Evaluation Period

The pretreatment period for the Smart Thermostat Pilot starts on October 1, 2011 and ends on September 23, 2012, one day before the first thermostat installation. The treatment period spans from February 1, 2013 to January 31, 2014. Comparisons are done by month such that, for example, the baseline for August 2013 is August 2012, while the baseline period for October 2013 is October 2011.

Study Timeline

Table 1 outlines the major phases of project activity and corresponding research tasks.

Table 2. Smart thermostat pilot schedule

Task	Dates	Activities
Field Study Preparation	Mar 2012 – Aug 2012	• Develop sample frame • Prepare recruitment materials • Prepare IT and billing
Recruitment	Aug 2012 – Dec 2012	• Mail recruitment packets • Collect applications, surveys • Develop participant database
Installation	Oct 2012 – Jan 2013	• Install thermostats • Create inventory database
Field Study	Feb 2013 – Jan 2014	• TOU-CPP rate (June 1 – Sept 30) • Conservation Day notifications • Distribute & collect surveys
Data Collection & Final Evaluation	Feb 2014 – Jun 2014	• Market research evaluation • Retrieve load database • Load impact evaluation

Implementation

Participant Education

The following materials were provided to participants.

Recruitment Packet. SMUD mailed the following materials to all potential participants.

- Invitation Letter (treatment-specific)
- Application
- Participation Agreement (treatment-specific)
- Brochure (treatment-specific)
- Return envelope

Program Website. SMUD's program website contained the following sections.

- Program details
- Technology information
- Energy Savings Tips (TOU-CPP treatment groups)
- FAQ's
- Contact information

Welcome Kit. At installation, new participants were provided with the following.

- Thermostat user guide – Nest or Ecofactor
- Refrigerator magnet with customer service phone number and website address
- Welcome packet
  - Welcome letter
  - Contact Us
  - Technology
  - Rate info (TOU-CPP treatment groups only)

Event Notification. The day before an event, SMUD notified participants by email, text or phone as chosen by the customer in the participation agreement.

Electricity Rates

The standard and TOU-CPP rates used for the smart thermostat pilot are listed in Table 3 and Table 4, respectively. These rates are used to determine customer-specific bill impacts in a later section of this report.

Table 3. Summer and Winter standard rates

Rate Type	Summer Base	Summer Base+	Winter Base	Winter Base+
Gas Heat	<= 700 kWh $0.0989	>700 kWh $0.1803	<= 620 kWh $0.0911	>620 kWh $0.1738
Gas Heat - Low Income	<= 700 kWh $0.0643	>700 kWh $0.1262	<= 620 kWh $0.0592	>620 kWh $0.1217
Gas Heat - With Well	<= 1000 kWh $0.0989	>1000 kWh $0.1803	<= 920 kWh $0.0911	>920 kWh $0.1738
Electric Heat	<= 700 kWh $0.0989	>700 kWh $0.1803	<= 1120 kWh $0.0757	>1120 kWh $0.1443
Electric Heat - Low Income	<= 700 kWh $0.0643	>700 kWh $0.1262	<= 1120 kWh $0.0492	>1120 kWh $0.1010
Electric Heat - With Well	<= 1000 kWh $0.0989	>1000 kWh $0.1803	<= 1420 kWh $0.0757	>1420 kWh $0.1443

Table 4. Summer 2013 TOU-CPP rates

Rate	Base/Base+ Threshold	Off Peak Base	Off Peak Base+	TOU Peak	CPP Event
Gas and Electric Heat (N = 314)	700 kWh	$0.0721	$0.1411	$0.27	$0.75
Gas and Electric Heat Low Income (N = 6)	700 kWh	$0.0500	$0.1000	$0.20	$0.50
Gas and Electric Heat with Well (N = 1)	1000 kWh	$0.0721	$0.1411	$0.27	$0.75

Control Technologies

SMUD considered several smart thermostats and their features for this study (Table 5). Of the five considered, only two platforms made use of learned schedules: (1) the Nest Learning Thermostat, a standalone thermostat that helps customers optimize HVAC energy use from within the home, and (2) Ecofactor Service, a cloud-based software-as-a-service platform that manages HVAC energy use for the customer from outside the home. More information on these and other communicating thermostats can be found in *SMUD's Communicating Thermostat Usability Study* (Herter & Okuneva 2014b).

Table 5. 2012 Features of smart thermostats considered for this study

Thermostat Features	EcoBee	EcoFactor/ Computime	Nest	OPower/ Honeywell	Tendril
Self-Optimization *(cloud service agreement not required)*			+		
Learned Schedule		o	o		
Daily Precooling	o	o	o		
Event Precooling		o	•		o
Event Precool Optimization		+	•		
Occupancy Sensing			+		
Customer Remote Control	o	o	o	o	o
Utility Remote Control	o	o		o	o
Price Response	o	o	•		o
HVAC Energy Display		+			
Historical Home Energy		o	•	o	
Real-time Home Energy			•		

o Available; + ⍰ Only system with this function; • = In development as of 2012

It is important to note that the Ecofactor and Nest thermostats were remotely accessible by the users and by the software service provider, but were not networked to SMUD. Thus, pricing and event notifications were not sent to the thermostats, and utility remote control was not implemented for this study.

NEST LEARNING THERMOSTAT

The Nest Learning Thermostat is marketed as an energy-saving device that automatically programs a temperature schedule based on customer settings in the first two weeks of use. The main advanced features of the Nest thermostat include: Auto-Schedule, Auto-Away, Airwave, Energy History, the Efficiency Leaf, and Remote Control. All work equally well in the absence of a web connection with the exception of remote access to thermostat settings, the only feature requiring that the thermostat be connected to the Internet.

FIGURE 5. THE NEST THERMOSTAT AND SMARTPHONE APP

Optimization. The automated schedule learning is intended to simplify schedule programming for customers. It required a two-day process of manual thermostat interaction, from which the Nest defined a customized schedule. Once the first two days of 'aggressive learning' were over, the resulting schedule could be modified on the thermostat, the computer, or the smartphone app. The Nest uses pattern matching to optimize the schedule whenever it recognizes similar temperature settings on two consecutive days, weekdays, or days of the week. Occupants could disable the Auto-Schedule feature in the Nest Settings menu.

Auto-Away. The Auto-Away feature is intended to save energy by initiating energy-efficient temperature settings when the Nest motion sensors do not sense movement for a period of time. Like Auto-Schedule, the Auto-Away feature can be disabled.

Airwave. Airwave™ uses exclusive software algorithms running inside the Nest Learning Thermostat to lower air-conditioning costs by automatically turning off the compressor a few minutes before the scheduled run-time end and keeping the fan running.

Energy History. The Nest displays information about heating and air-conditioning use compared to historical use, including estimates of how weather, Auto-Away and manual adjustments had the greatest effect on energy use.

The Leaf. The Nest Leaf appears when the target temperature is set to an energy-efficient level.

Remote Control. Settings can be modified remotely via smartphone app or website interface.

A detailed review of the usability of the Nest Learning Thermostat can be found in *SMUD's Communicating Thermostat Usability Study* (Herter & Okuneva, 2014b).

ECOFACTOR

EcoFactor is a Software-as-a-Service (SaaS) vendor that has developed cloud-based energy services that interact with a subscriber's thermostat via the Internet. On losing its connection to the Internet, the thermostat will continue to run its last known program, but cannot learn, be updated or respond to events. At the time of this study, the Computime CTW218 was the only thermostat configured to work with Ecofactor's software (Figure 6).

FIGURE 6. THE COMPUTIME CTW218 THERMOSTAT AND SMARTPHONE APP

Optimization. The EcoFactor system makes use of a cloud-based processing engine to create energy-saving schedules. To optimize savings, the Ecofactor system automatically adjusts customer temperature settings to reflect manual adjustments and to conserve energy. If the occupants do not manually alter conservation settings when they take effect, the programmed schedule is modified to reflect the more efficient settings.

Remote Control. Settings can be modified remotely via smartphone app or website interface.

A detailed review of the usability of the Ecofactor-Computime CTW218 can be found in *SMUD's Communicating Thermostat Usability Study* (Herter & Okuneva, 2014b).

THERMOSTAT INSTALLATION

An outside contractor with HVAC and networking installation experience was responsible for scheduling appointments, installing thermostats, maintaining inventory, and servicing the thermostats after installation. During installation, the customer filled out the Pre-pilot Survey and watched a video for their respective thermostat system provided by the thermostat vendors designed to educate participants on the smart thermostat technology. The installer collected the completed surveys from the participants and returned them to SMUD.

Market Research

Three sets of surveys were distributed to participants during the pilot period for market research purposes: the first one shortly after participant enrollment, the second one shortly after thermostat installation, and the third one at the end of the summer.

Pre-pilot Survey. All participants were required to fill out a Smart Thermostat Pre-Pilot Survey during installation to collect participant information on household demographics and characteristics.

Interim Survey. An interim survey captured several measures related to the new thermostats: frequency of interaction, usability, perceptions, and resulting behavior changes. A link to an online survey was distributed by email to all participants within three and four months of installation. Telephone surveys were conducted for customers without email addresses.

Summer Survey. At the end of the summer, all participants were mailed a link to an online Survey, which collected responses to questions related to energy literacy, changes in energy-related behavior, perceived effort and savings, evaluation of technology, frequency of interaction, and attitudes toward the program and SMUD. Paper and phone options were made available for maximum completion rate.

An analysis of the survey data collected is documented in the market research evaluation prepared for SMUD (True North Research 2014). Of particular interest were some of the findings comparing customer experiences with the two thermostat technologies. For example, the market research analysis found that roughly twice as many Ecofactor participants (43%) complained about erratic or undesirable temperature changes as did Nest participants (23%).

Survey data also showed that 35% of Ecofactor participants contacted customer support to resolve technical issues, compared to 13% of Nest customers who did so. Perhaps more striking was the finding that 17% of Ecofactor participants and just 1% of Nest customers contacted customer support at least 3 times.

At the end of the study, 22% of Ecofactor participants said they were dissatisfied with their thermostat, while 6% of Nest participants said they were dissatisfied with theirs.

2. Data

Evaluation Period

Table 6 provides the start and end dates for which hourly load and temperature data were collected. Note that the pretreatment period did not cover the full month of September because installation of thermostats began on September 24, 2012 and ended in January 2013.

Table 6. Evaluation period start and end dates

Evaluation period	Start date	End date
Pretreatment	10/1/11	9/23/12
Treatment	2/1/13	1/31/14

Events

The 12 events for the Smart Thermostat Pilot coincided with Conservation Days called for the Smart Pricing Option tariff. On the day before chosen event days, SMUD notified participants via email, SMS, and phone, as chosen by each participant.

Table 7. Event dates and temperatures

Date	Day of the Week	Minimum Temperature	Maximum Temperature
6/28/13	Friday	67°F	104°F
7/2/13	Tuesday	74°F	103°F
7/3/13	Wednesday	69°F	105°F
7/19/13	Friday	59°F	100°F
8/15/13	Thursday	62°F	95°F
8/19/13	Monday	71°F	102°F
9/6/13	Friday	55°F	92°F
9/9/13	Monday	61°F	100°F
9/10/13	Tuesday	63°F	88°F
9/13/13	Friday	60°F	92°F
9/19/13	Thursday	53°F	90°F
9/30/13	Monday	60°F	78°F

Sample Population

The Smart Thermostat Pilot was originally designed for 200 customers in each treatment group for a total of 800 participants. Each treatment was offered in isolation to a group of screened but otherwise randomly chosen customers, so the results for any one of the treatments can safely be extrapolated to the subset of SMUD's residential customers that meet the same screening criteria, at the same rate of participation as occurred for that treatment, assuming the same marketing effort.

Initial screening of SMUD's residential customer population involved exclusion of all customers that did not meet the following criteria:

1. Residential account with move-in date prior to August 2011
2. Smart Meter installed as of August 2011, along with continuously clean data
3. Not participants in any of the following: Smart Pricing Options Consumer Behavior Study, Smart Charging Electric Vehicle pilot, Low Income Energy Management pilot, Medical Rate, Budget Billing, Master Meter account, Summer Solutions study, Third-party notification, Solar customer, Air-Conditioning Load Management (ACLM), Meter Study group, No-call list, Executive List, and Smart Meter opt-out.

The screened database of more than 45,000 customers was randomly sorted and assigned group numbers 1-5 to represent each of the four treatment groups plus the control group. About 9,000 customers were set aside to serve as the control group sample. About 19,000 customers, randomly selected from the remaining 36,000, were invited to participate in one of the four treatment groups.

The 1,350 customers (7.1% of those invited) that submitted an application for participation were further screened to ensure that: they lived at the dwelling and paid the bill; did not plan to move before October 31, 2013; were not a childcare facility or convalescent home; had central heating and air conditioning; had access to the Internet (EcoFactor treatments only); and had at most two thermostats. Customers meeting all of these criteria were contacted to schedule thermostat installation. The final installation tally showed that Nest installations reached the original goal of 400 homes, while the two Ecofactor groups – one on the TOU-CPP rate and the other on the standard rate – fell short at about 360 participants total. The initial 760 participants represent a final installation rate of 4.0% of the invited population.

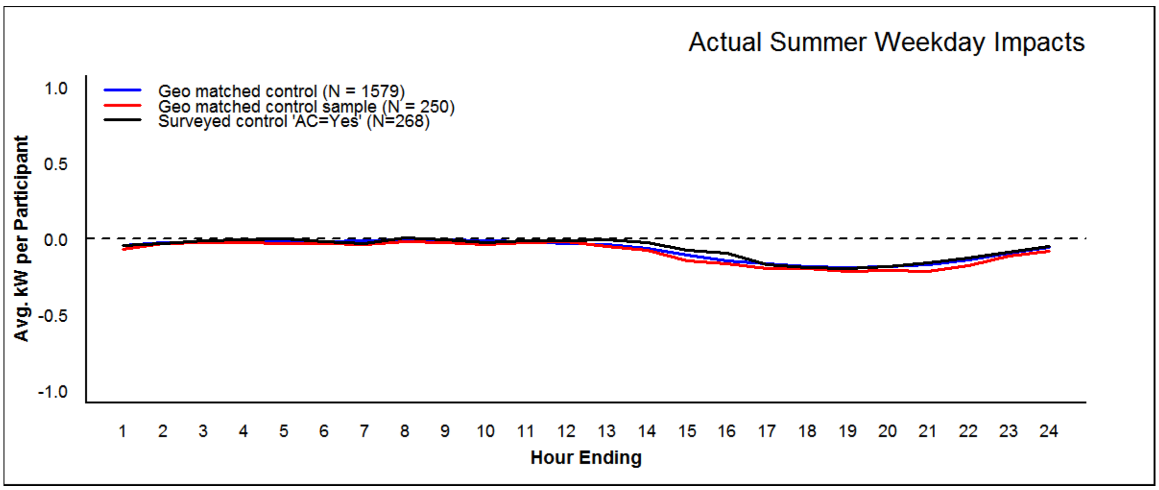
Control Group Considerations

Two issues appeared during the course of choosing a control group. First, there was a question of whether a geographically matched or surveyed control group would better reflect the exogenous effects of the participant group. Second, there was a technical requirement related to the thermostat network interface that required the exclusion of customers without a home WiFi network for the Ecofactor groups, but not for the Nest groups, leaving open a question as to whether two different control groups would be needed – one with and one without WiFi.

Matched vs. Surveyed Control Groups

The difference-in-differences (DID) evaluation approach makes use of the year-over-year change of the control group to correct for exogenous effects. A comparison between available control groups is used to shine light on how each will contribute to the final results. Figure 7 shows the observed summer weekday load impacts for three different control groups: (1) a geographically matched group of 1,579 customers; (2) a randomly chosen subset of 250 customers from (1); and (3) the 268 control group survey respondents screened for central air-conditioning. Results represent actual differences between treatment and baseline loads.

Figure 7. Summer weekday load impacts for control groups



The pre-peak, peak, and post-peak impacts shown in Table 8 are calculated as the difference between observed loads during treatment and pretreatment periods. In each case, an analysis of mean differences indicates that the year-over-year changes of the three control groups are statistically insignificant, meaning that it makes little difference which control group is used for the load impact evaluation. To allow for screening by central air-conditioning and WiFi ownership, the Surveyed control group was used.

Table 8. Mean 2012-2013 impacts for potential control groups

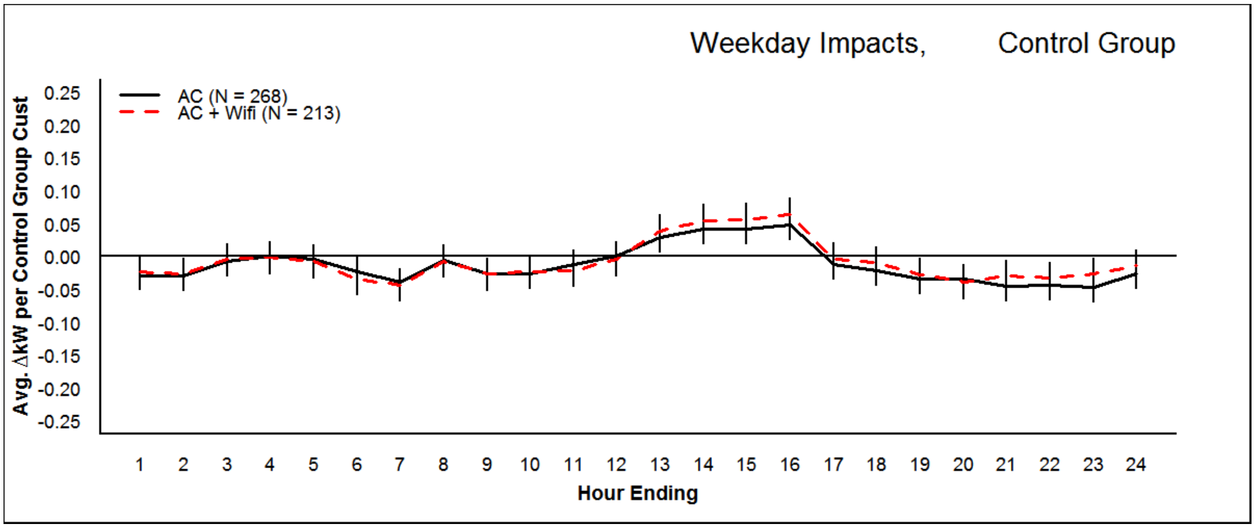
Control Group	N	Pre-Peak	Peak	Post-peak
Geographically Matched	1579	-0.10	-0.18	-0.16
Geographically Matched Sample	250	-0.12	-0.20	-0.20
Surveyed with AC	268	-0.06	-0.18	-0.15

** Differences between group means are not statistically significant (α=0.05).*

SURVEYED CONTROL GROUP – SUBGROUPS WITH AND WITHOUT WIFI

As discussed previously, the Ecofactor treatment group required a home WiFi network, but the Nest treatment groups did not. To determine whether two separate control groups should be used for the load impact analysis, the year-over-year impacts (corrected for weather effects) for the group of 268 surveyed control group participants with air-conditioning was compared to the subgroup of 213 participants with both air-conditioning and WiFi (Figure 8).

FIGURE 8. SUMMER WEEKDAY LOAD IMPACTS FOR CONTROL GROUPS



Statistical analysis concludes that the differences between the load impacts shown in Figure 8 are not statistically significant during the pre-peak, peak, and post-peak periods, indicating that it matters little which control group is used for the load impact analysis. As a result, the evaluation team decided to use the larger 268 member surveyed control group with central AC, regardless of the presence of a WiFi network.

Final Sample Sizes

Participants were removed from analysis as follows.

- Excluded 12 customers with move out dates during the treatment period
- Excluded 2 customers on the medical rate

The control group was screened as follows.

- Excluded those without central AC (survey question 18)
- Excluded 1 customer on the medical rate

The final sample sizes for each treatment and the control group are provided in Table 9.

Table 9. Final Sample Sizes

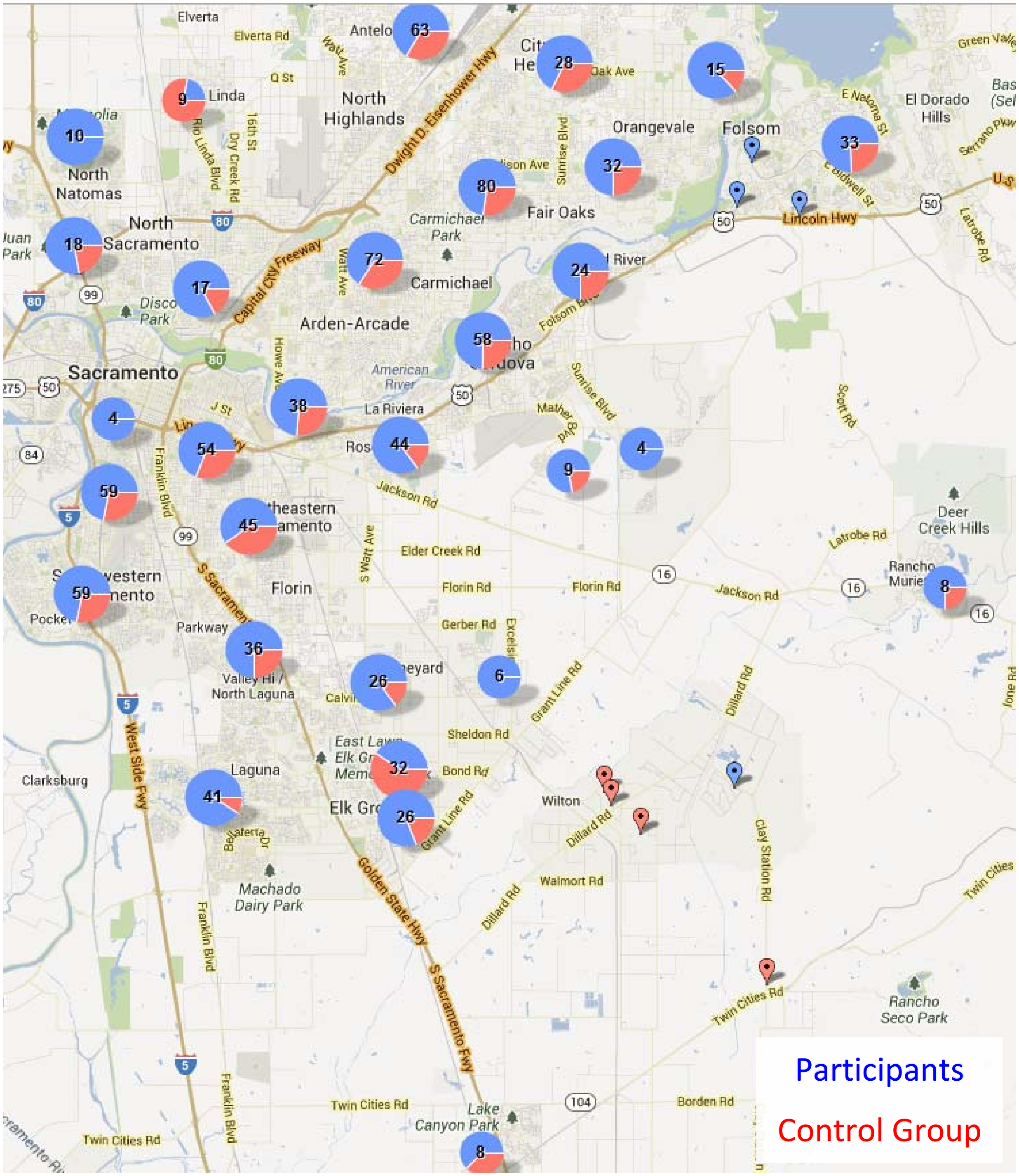
Treatment	SMUD Code	Vendor	Optim-ization	Hardware	Rate type	Homes
Nest.TOU-CPP	NIBTE	Nest	Self	Nest Learning Thermostat	TOU-CPP, 2-tier	175
Nest.Standard	NIXTE	Nest	Self	Nest Learning Thermostat	Flat, 2-tier	194
Ecofactor.TOU-CPP	TIBTE	EcoFactor	Cloud	Computime CTW218	TOU-CPP, 2-tier	147
Ecofactor.Standard	TIXTE	EcoFactor	Cloud	Computime CTW218	Flat, 2-tier	180
Control	--	--	--	--	Flat, 2-tier	268

Given that the original recruitment goal for each treatment group was 200 participants, the final numbers imply that the standard rate was more desirable than the TOU-CPP rate when combined with these thermostat offers.

Geographic Locations

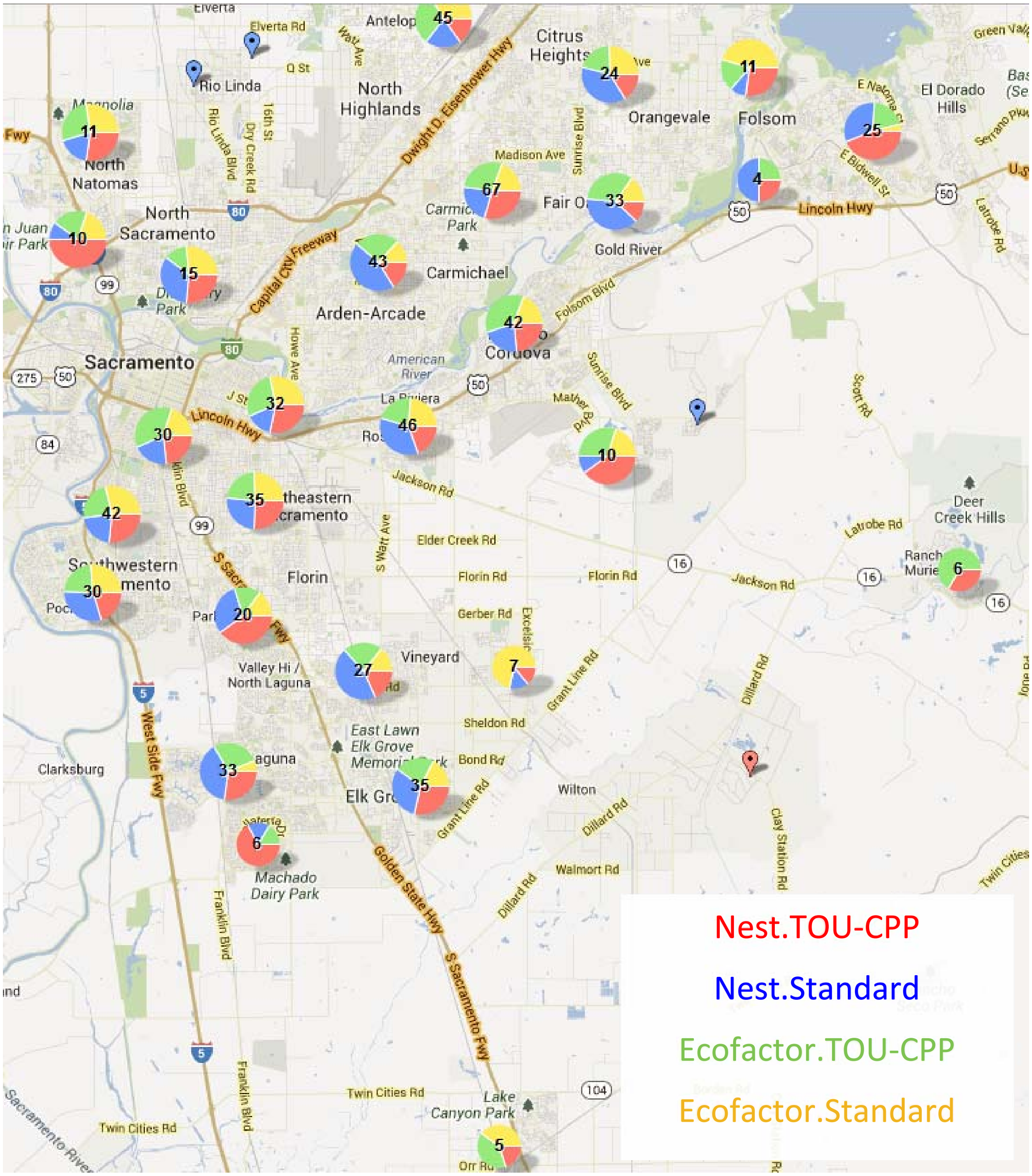
The location of participant homes (in blue) and control group homes (in red) are mapped in Figure 9. The reasonably even distribution provides evidence that a strong geographic bias is not present.

Figure 9. Map of participant and control group homes



The location of treatment group homes are mapped in Figure 10, with Nest.TOU-CPP in red, Nest.Stadard in blue, Ecofactor.TOU-CPP in green, and Ecofactor.Standard in yellow. The reasonably even distribution provides evidence that a strong geographic bias is not present.

FIGURE 10. MAP OF PARTICIPANTS BY TREATMENT



Potential Sources of Bias

This section discusses some of the most likely sources of bias for this study.

Selection bias (Invited Group)

Selection bias occurs as a result of errors or limitations in recruitment and implementation. For this study, the evaluation required interval meter data that was not available for all customers in the program target market – meaning customers with insufficient data were excluded from recruitment. In addition, the participation criteria excluded several other customer subgroups, including low-income customers and those without air conditioning. Thus, the sample frame (invited customers) was expected to differ from the program target market (service territory).

Comparisons of load data found that the average energy use and peak demand of the invited population was statistically higher than that of the general population (see Appendix A). Should the final target market be the general population, this selection bias should be taken into account when interpreting the results.

Self-selection Bias (Participant Groups)

This study was designed to offer each participant group the same self-selection criteria as might ultimately be offered to program participants. In the absence of *selection* bias, described above, the customers who agreed to participate in this pilot should be similar to those who would participate in a full rollout of each individual treatment. Note that a rollout of all of the program options (where customers could choose between the options) would <u>not</u> produce the same results, since this scenario would involve customer choices that were not offered in this pilot.

In the absence of selection bias, the results of this evaluation could be extrapolated to the target market by assigning the load impacts estimated for each treatment to the expected *participating* fraction of the program population – based on the pilot participation rate – and assuming zero load impacts for the *nonparticipating* fraction of the program population. In practice, this means that the load impacts found here should be considered *per-participant* load impacts, while *per-customer* impacts must be calculated as the product of the participation rate and the per-participant load impacts. For example, if 5% of invited customers participated in a given treatment, and annual energy savings are estimated at 2%, the expected savings of a larger rollout would be (0.05)(0.02) = 0.001 = 0.1% savings in the invited program population.

Control Group Bias

Control group bias as defined here is a type of selection or self-selection bias that results in the control group not being an accurate representation of the participant groups in the absence of the treatment. Two control group options are available for this study. Both have potential sources of bias, because the selection criteria differ between the pilot participants and each of the available control groups.

First, the randomly selected control group – and thus the surveyed subgroup – did not sign up for the study, so variables of intention and willingness to participate are different, and there is no potential for this group to exhibit the Hawthorne effect, as described below. In addition, participants were screened for central air-conditioning while the control group customers were not. While this second potential source of bias could be partially corrected, for example by geographic and load matching, the first issue is impossible to resolve.

The second available control group is comprised of the respondents from a larger group of randomly selected customers contacted for a phone survey. These survey respondents could be screened for central air-conditioning based on one of the survey questions. There is some evidence of a willingness to participate by virtue of agreeing to answer the survey questions by phone, and contact with the utility via the survey phone call might initiate some Hawthorne effect. Even so, there is still uncertainty about whether the same types of customers who answer a phone survey would sign up for the pilot, had they been offered the opportunity to participate. Compared to the randomly selected full control group described above, however, the surveyed control group seems more likely to be a closer match.

The potential impact of bias in the control group depends on its intended use. In the load impact model, the control group is used to correct for year-over-year exogenous effects, such as the impacts of the economy or home weatherization unrelated to the study at hand. If the year-over-year differences are the same for the full and surveyed control groups, it matters little which group is used. Of course, there is no certainty that the year-over-year load impacts of either control group accurately reflect what would have happened in the participant group in the absence of the treatment.

Hawthorne Effects

This study did not control for Hawthorne effects, a phenomenon in which study participants act according to the expectations of the study simply because they know they are being monitored and want to be good subjects. It is possible that the savings found in this study were enhanced by the Hawthorne effect.

A recent study of Hawthorne effects showed a 2.7% energy savings in homes that received no intervention other than weekly postcards informing them that they were in a study, suggesting that energy savings at that level might come through a heightened awareness of electricity use rather than through a better understanding of it (Schwartz et al. 2013).

LOAD DATA

Figure 11 illustrates the placement of Conservation Days and maximum temperatures in the context of hourly summer loads. Of interest are the late June start date for the first event and the late season rush in September, resulting in several events that did not meet the desired temperature criteria of having at least one hour in the day exceeding 100°F.

FIGURE 11. ACTUAL HOURLY SUMMER 2013 LOADS, ALL PARTICIPANTS

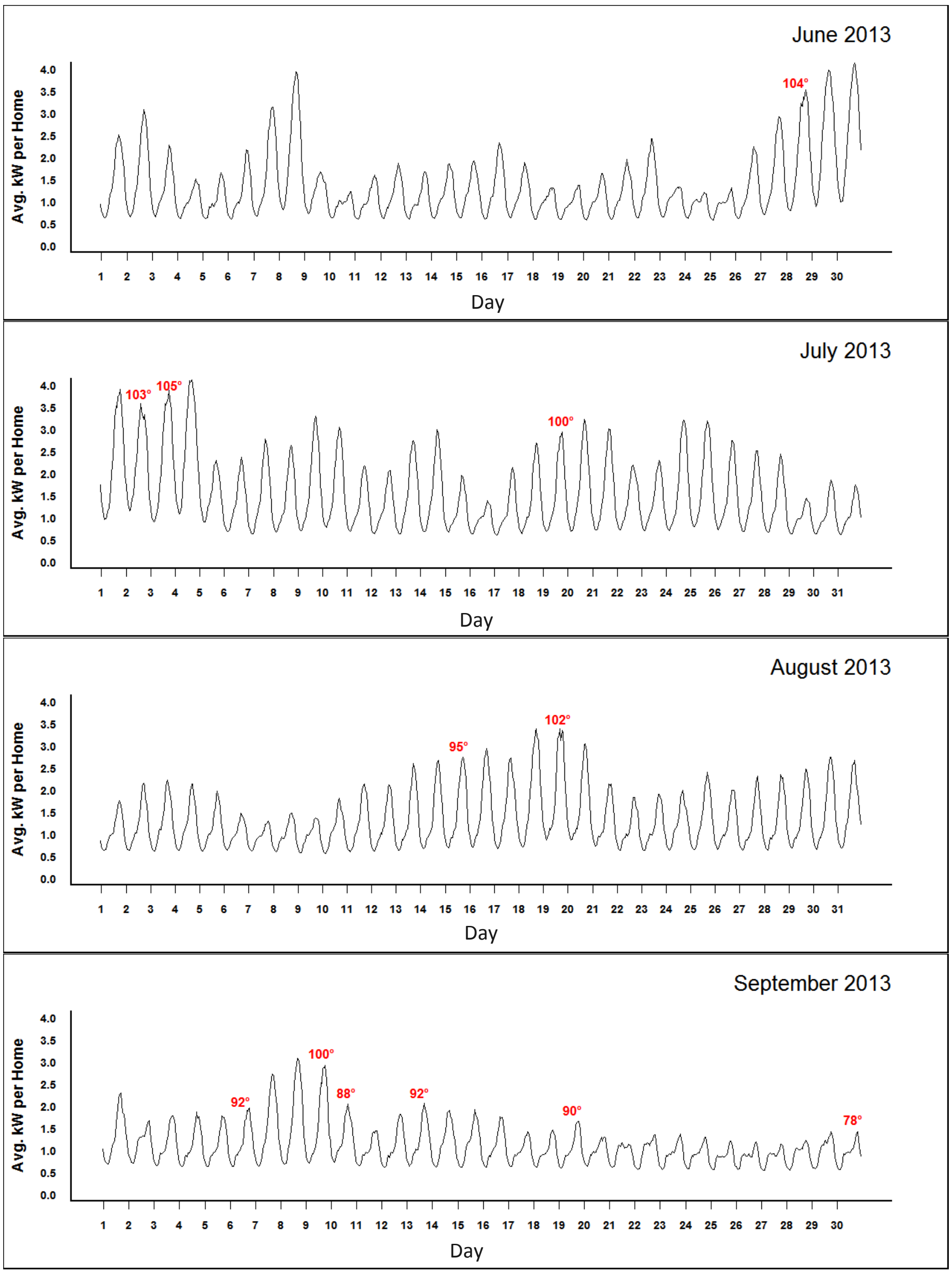


Figure 12 plots the average observed weekday loads for summer 2012 for the four treatment groups. After correction for weather and exogenous effects through regression analysis and modeling, these load shapes will provide the summer baseline for each group. While visible differences may indicate self-selection into treatment groups, results will be valid for a voluntary program with the same offerings.

FIGURE 12. AVERAGE WEEKDAY LOADS, SUMMER 2012

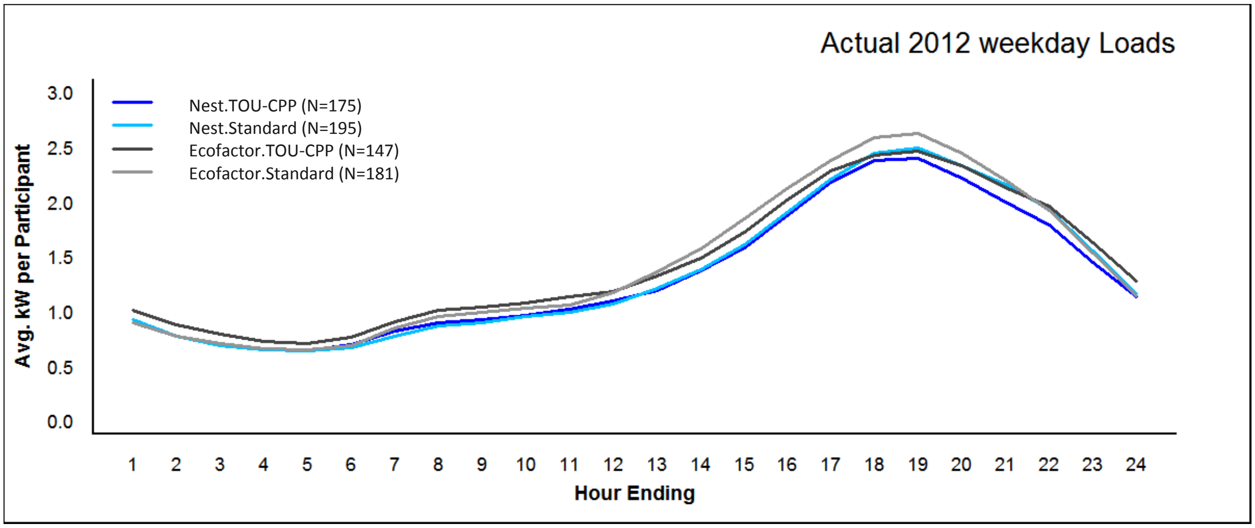


Figure 13 plots the average observed non-event weekday loads for summer 2013, during which the TOU rate was in effect. These load shapes will comprise the summer treatment loads for each group. Loads for each treatment will be compared to its respective baseline comprised of the pretreatment loads shapes (Figure 12) corrected for average weekday weather and year-over-year exogenous effects.

FIGURE 13. AVERAGE WEEKDAY LOADS, SUMMER 2013 (NON-EVENT)

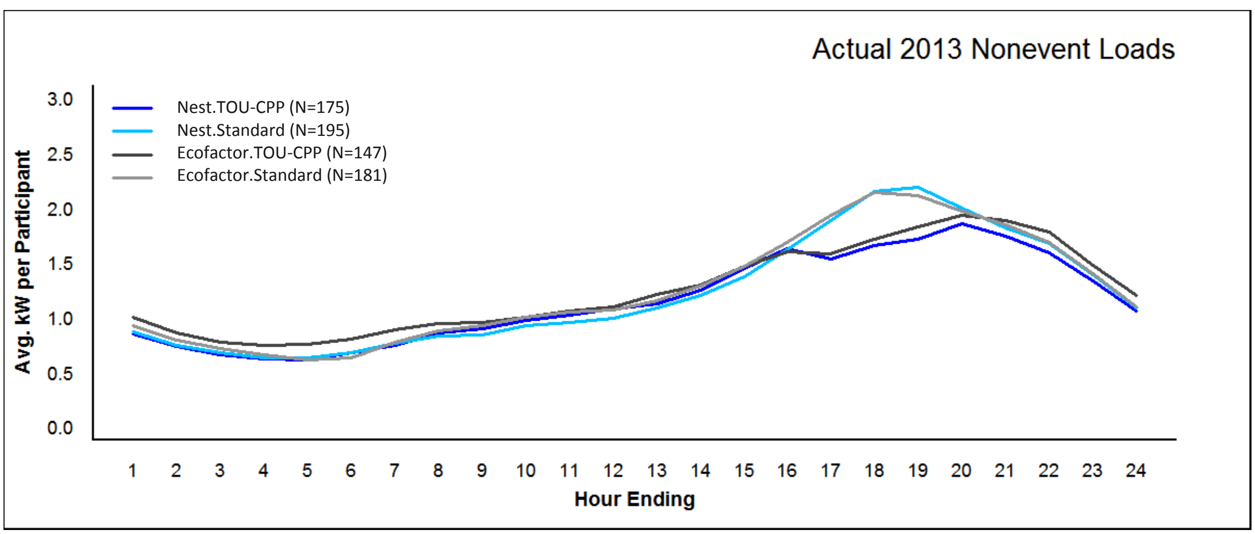
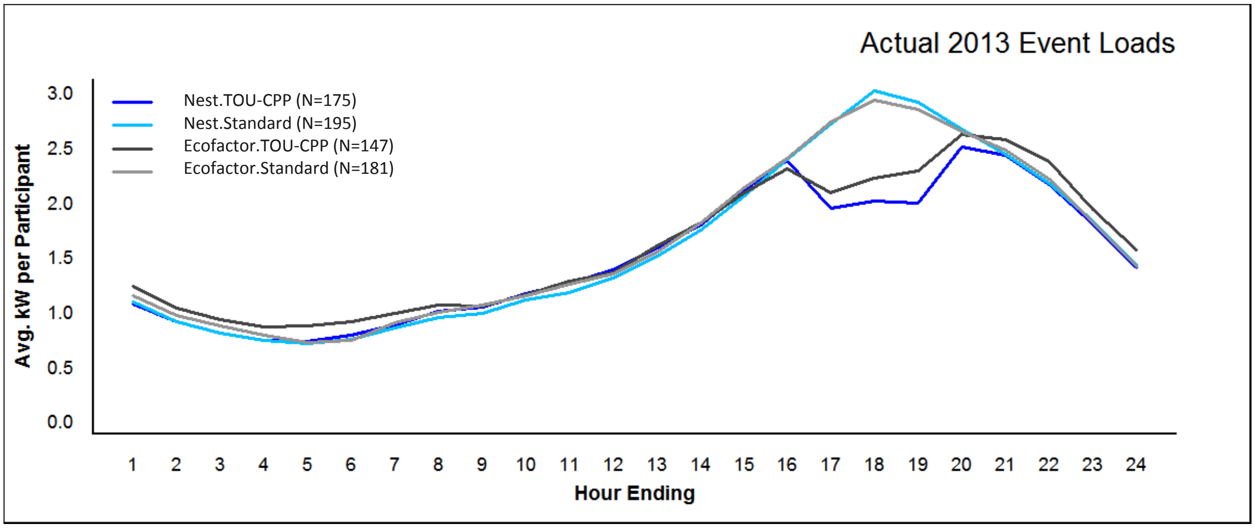


Figure 14 plots the average observed Conservation Day (event) loads for summer 2013, during which the CPP rate was in effect. These load shapes will comprise the event loads for each treatment group. These loads will be compared to their respective baselines, comprised of the pretreatment loads shapes shown in Figure 12 corrected for Conservation Day weather and year-over-year exogenous effects.

FIGURE 14. AVERAGE CONSERVATION DAY LOADS, SUMMER 2013



TEMPERATURE DATA

Figure 15 maps the ten weather stations in the SMUD service territory – charted using unique identifiers in the green boxes – for which hourly temperature data were downloaded. To ensure as-accurate-as-possible outdoor temperatures, participants were each assigned to the data recorded at the station closest to their home.

FIGURE 15. WEATHER STATIONS USED FOR LOAD IMPACT EVALUATION

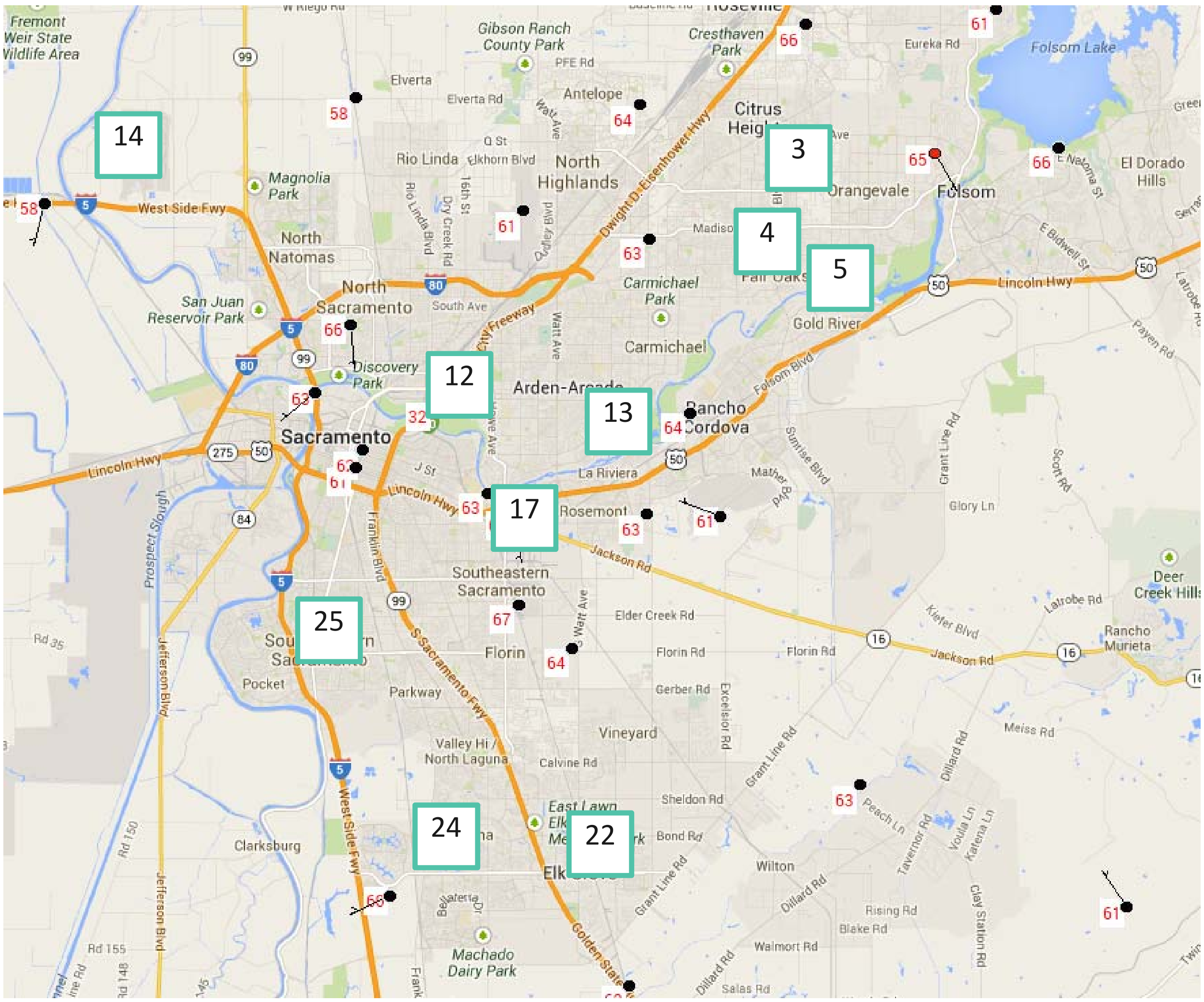


Figure 16 plots the average hourly summer temperatures at each of the 10 weather stations used in this analysis. Note that there are visible differences in temperatures across stations due to local microclimates, thus justifying the multiple-station approach.

FIGURE 16. AVERAGE HOURLY TEMPERATURE READINGS, SUMMER 2013

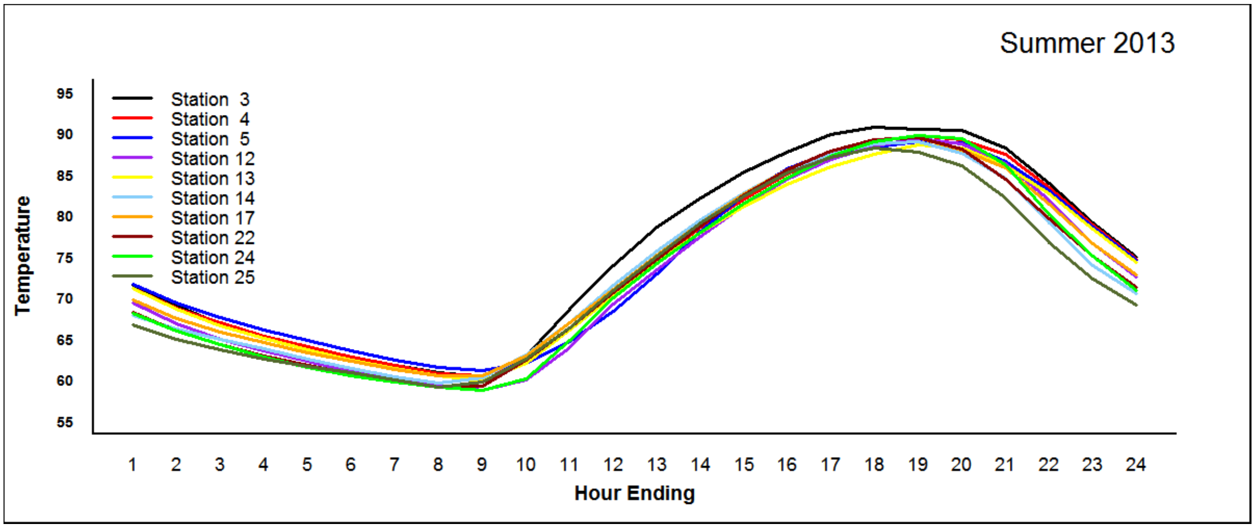
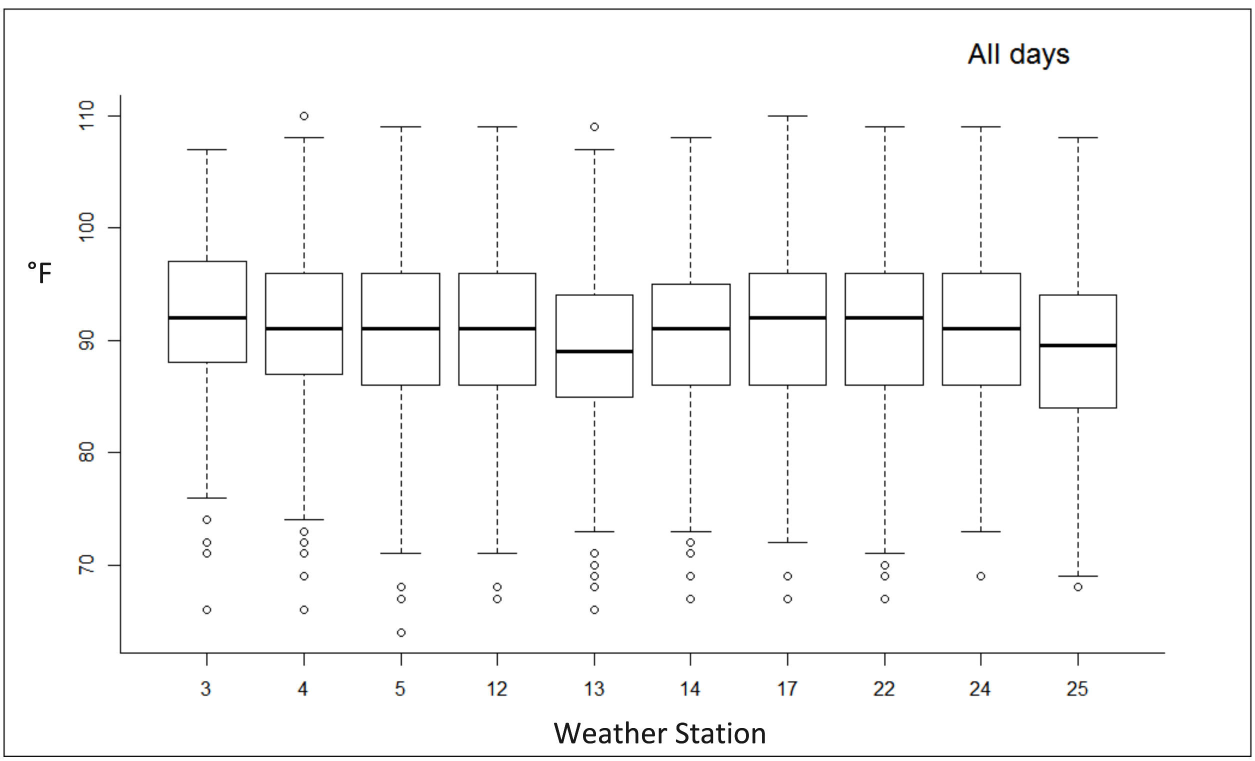


Figure 17 provides the distribution of hourly peak temperature measurements at each weather station for the summer of 2013, with the centerline of each box indicating the median, and the bottom and top edges of the boxes the first and third quartiles, respectively. Whiskers extend to the most extreme data point that is no more than 1.5 times the interquartile range. All points beyond the whiskers are outliers.

FIGURE 17. BOXPLOTS OF HOURLY PEA TEMPERATURE READINGS, SUMMER 2013



3. Analysis and Results

Approach

Loads are modeled using a three-level mixed effects model to account for variability between customers, days, and hours. The dependent variable is the average hourly kWh for each customer collected by SMUD's existing metering infrastructure. Independent variables include lagged temperature variables, treatment group indicators, among others. The summer weekday and monthly load impact model equations are given in Appendix B and Appendix C, respectively.

The model coefficients allow calculation of load values, while impact values are then calculated as the difference-in-differences (DID) of the four load shapes as described in Equation 1. The basic premise of DID evaluation is to compare the measure of interest at two points in time – before and after treatment – in both the treatment and control groups, where the pretreatment loads are normalized to treatment period temperatures.

Equation 1. Calculation of load impacts

$$Load\_Impact_{ijk} = (Part.treat_{ijk} - Part.base_{ijk}) - (Control.treat_{ijk} - Control.base_{ijk})$$

Where, for customer *i* on day *j* at hour *k*:

Load_Impact: estimate of hourly load change resulting from the treatment
Part.treat: modeled average participant loads during the treatment period
Part.base: modeled average participant loads during the pretreatment period
Control.treat: modeled average control loads during the treatment period
Control.base: modeled average control loads during the pretreatment period

This technique can be thought of as a *within-subjects* estimate of the treatment effect corrected for exogenous effects using the changes seen in a control group, where both differences are corrected for weather differences between the pretreatment and treatment periods using standard regression techniques. Without exogenous effects correction, a within-subjects comparison can overestimate or underestimate impacts by associating non-treatment effects with the treatment.

For example, a downturn in the economy might cause an overall reduction in residential electricity use. These exogenous energy savings must be removed from the treatment group impacts using the control group impacts as a proxy for exogenous effects. Otherwise, savings attributable to the treatment would be overestimated, when in fact much of the savings was simply a result of the floundering economy.

An unbiased DID methodology requires that the composition of and exogenous inputs to the treatment and control groups are as similar as possible. A standard method for accomplishing this is a random control trial, whereby portions of the recruited population are randomly assigned to treatment and control groups. For the control group, treatment is then deferred to a later date or denied altogether. Where a random control trial is not practical, as was the case for this study, a control group can be selected to closely resemble the treatment group along a subset of relevant variables, for example location or a measure of energy use. This alternative is not without bias, because "willingness to participate" is difficult or impossible to measure without putting the control group through the solicitation and recruitment process. In addition, Hawthorne effects likely prevalent in the treatment group will not be seen in the control population.

The following sections provide the modeled loads and load impacts for summer event days and non-event weekdays derived using these two formulas. For consistency and ease of comparison, all loads and impacts are presented in units of average kilowatt-hours per hour (kWh/h), abbreviated in most cases to kW, where positive impact values indicate an increase in energy use relative to the baseline, and negative impact values indicate savings. Note that these hourly kW values are easily converted to kWh through multiplication by the number of hours across the desired time period.

NULL HYPOTHESES

Linear hypotheses that were tested:

1. *Treatment loads are not different from baseline loads (adjusted for weather and exogenous effects)*

Equation 1

$$H_0: \left(\mu_{part.treat_i} - \mu_{part.base_i}\right) - \left(\mu_{control.treat} - \mu_{control.base}\right) = 0$$

$$H_a: \left(\mu_{part.treat_i} - \mu_{part.base_i}\right) - \left(\mu_{control.treat} - \mu_{control.base}\right) \neq 0$$

$\mu_{part.treat_i}$ = average participant loads during the treatment period for $(Treatment\_Period)_i$

$\mu_{part.base_i}$ = average participant loads during the pretreatment period for $(Treatment\_Period)_i$

$\mu_{control.treat}$ = average control group loads during the treatment period

$\mu_{control.base}$ = average control group loads during the pretreatment period

2. *Treatment type has no effect on impacts (adjusted for weather and exogenous effects)*

Equation 2

$$H_0: \left[\left(\mu_{part.treat_i} - \mu_{part.base_i}\right) - \left(\mu_{control.treat} - \mu_{control.base}\right)\right] - \left[\left(\mu_{part.treat_{i'}} - \mu_{part.base_{i'}}\right) - \left(\mu_{control.treat} - \mu_{control.base}\right)\right] = 0$$

$$H_a: \left[\left(\mu_{part.treat_i} - \mu_{part.base_i}\right) - \left(\mu_{control.treat} - \mu_{control.base}\right)\right] - \left[\left(\mu_{part.treat_{i'}} - \mu_{part.base_{i'}}\right) - \left(\mu_{control.treat} - \mu_{control.base}\right)\right] \neq 0$$

$\mu_{part.treat_i}$ = average participant loads during the treatment period for $(Treatment\_Period)_i$

$\mu_{part.treat_{i'}}$ = average participant loads during the treatment period for $(Treatment\_Period)_{i'}$

$\mu_{part.base_i}$ = average participant loads during the pretreatment period for $(Treatment\_Period)_i$

$\mu_{part.base_{i'}}$ = average participant loads during the pretreatment period for $(Treatment\_Period)_{i'}$

$\mu_{control.treat}$ = average control group loads during the treatment period

$\mu_{control.base}$ = average control group loads during the pretreatment period

The linear hypotheses 1 and 2 are tested by the means of employing statistical software where all the needed information is extracted from a fitted model at the user-specified levels of covariates (day type, treatment, hours of interest, temperature profile). P-values are adjusted accordingly using the Bonferroni method to correct for the increase in the likelihood of Type I error with multiple hypotheses.

Conservation Day Impacts (event days)

While event day load impacts are commonly reported at the average pilot period temperature, results for this evaluation are reported at several temperatures of interest. The main results with between-treatment comparisons are presented for a Conservation Day with maximum temperature of 106°F, representing a 1-in-2 peak day at SMUD. Secondary results show impacts by treatment for Conservation Days with maximum temperatures of between 90°F and 110°F, in 5°F increments.

Event Day Demand Impacts at 106°F

As described previously (Table 4), participants in the Nest.TOU-CPP and Ecofactor.TOU-CPP groups are encouraged to conserve energy on Conservation Days from 4 pm to 7 pm through a critical peak price of $0.75 per kWh, while the Nest.Standard and Ecofactor.Standard groups are not directly asked to conserve energy during Conservation Days. .

Figure 18 plots the modeled baseline and treatment load shapes on a Conservation Day with a maximum temperature of 106°F. Figure 19 plots the difference between the baseline and treatment load shapes for each of the four treatment groups. The difference between those on the TOU-CPP rate and those on the standard rate can be clearly seen in both figures.

FIGURE 18. PREDICTED LOADS ON AN EVENT DAY WITH MAXIMUM TEMPERATURE OF 106°F

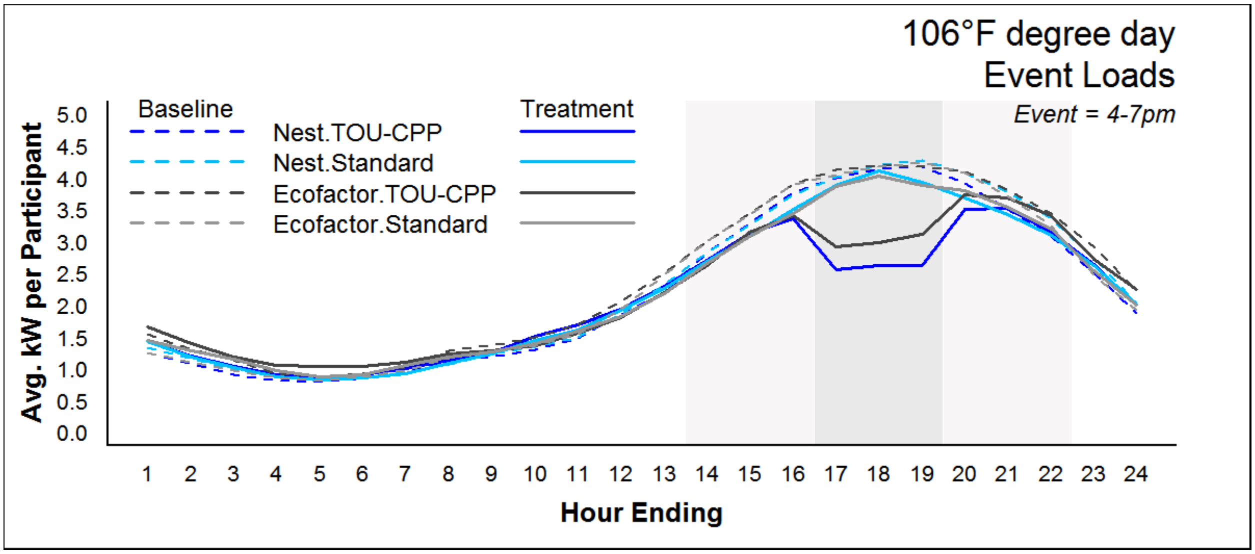


FIGURE 19. PREDICTED LOAD IMPACTS ON AN EVENT DAY WITH MAXIMUM TEMPERATURE OF 106°F

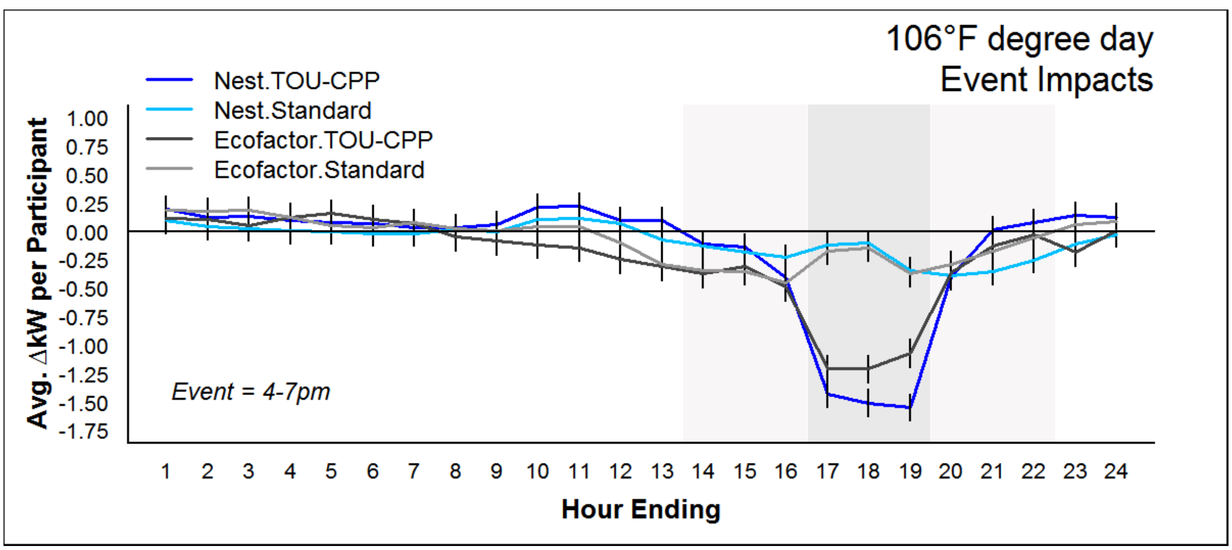


Table 10 shows the differences between the baseline and treatment load shapes. Values marked with an asterisk indicate that the impact differs statistically from zero, and that the null hypothesis of the treatment being equal to the baseline load is rejected (α=0.05). Table 11 shows the results of contrast analysis, providing between-treatment differences for the load impacts shown in Table 10. For all treatments, peak load impacts are negative and statistically significant, indicating savings during the hours targeted by the event (4-7 pm).

The Nest.TOU-CPP group offers the greatest peak impacts at 37% peak load drop, followed by the Ecofactor.TOU-CPP group at 28% peak load drop. The Standard rate groups are tied for last place at just over 5% peak load drop. The Ecofactor groups saved about twice as much energy as did the Nest groups in the pre-peak hours, while the Nest.Standard saved more than did the Ecofactor groups in the post-peak hours.

An unusual finding is that participants in all groups saved energy in the 3-hour periods preceding and following the peak period. Other pilots at SMUD have shown higher loads in the pre-peak and post-peak hours resulting from air-conditioning precool and rebound effects.[1]

TABLE 10. AVERAGE PREDICTED LOAD IMPACTS ON A 106°F EVENT DAY, PER PARTICIPANT

Treatment	N	Pre-peak (hours 14-16) *kW (%)*	Peak (hours 17-19) *kW (%)*	Post-peak (hours 20-22) *kW (%)*	Event Day (hours 1-24) *kW (%)*
Nest.TOU-CPP	175	-0.22* (-6.8%)	-1.52* (-37%)	-0.13 (-3.6%)	-0.16* (-7.1%)
Nest.Standard	194	-0.18* (-5.6%)	-0.21* (-5.1%)	-0.37* (-9.9%)	-0.08* (-3.4%)
Ecofactor.TOU-CPP	147	-0.39* (-11%)	-1.19* (-28%)	-0.19* (-5.2%)	-0.23* (-9.7%)
Ecofactor.Standard	180	-0.40* (-12%)	-0.24* (-5.8%)	-0.18* (-5.0%)	-0.07* (-3.0%)

* Statistically significant, α=0.05.

TABLE 11. DIFFERENCES BETWEEN LOAD IMPACTS AT 106°F, PER PARTICIPANT

Contrast	Pre-peak (hours 14-16) *kW*	Peak (hours 17-19) *kW*	Post-peak (hours 20-22) *kW*
Nest.TOU-CPP minus Nest.Standard	-0.041	-1.31*	0.24*
Nest.TOU-CPP minus Ecofactor.TOU-CPP	0.17	-0.33*	0.07
Nest.TOU-CPP minus Ecofactor.Standard	0.18*	-1.28*	0.06
Nest.Standard minus Ecofactor.TOU-CPP	0.21*	0.98*	-0.17
Nest.Standard minus Ecofactor.Standard	0.22*	0.03	-0.19*
Ecofactor.TOU-CPP minus Ecofactor.Standard	0.01	-0.95*	-0.01

* Statistically significant, α=0.05.

[1] See for example Herter & Okuneva 2013, Herter & Okuneva 2014a, Herter & Okuneva 2014c.

Outdoor Temperature Effects

Figure 20 through Figure 27 and Table 12 through Table 15 provide the predicted loads and impacts on event days with maximum temperatures that vary from 90 to 110°F. In all cases, graphs show that higher temperatures elicit higher baseline loads and greater peak savings.

Figure 20. Loads on event days with max temperatures of 90-110°F, Nest.TOU-CPP

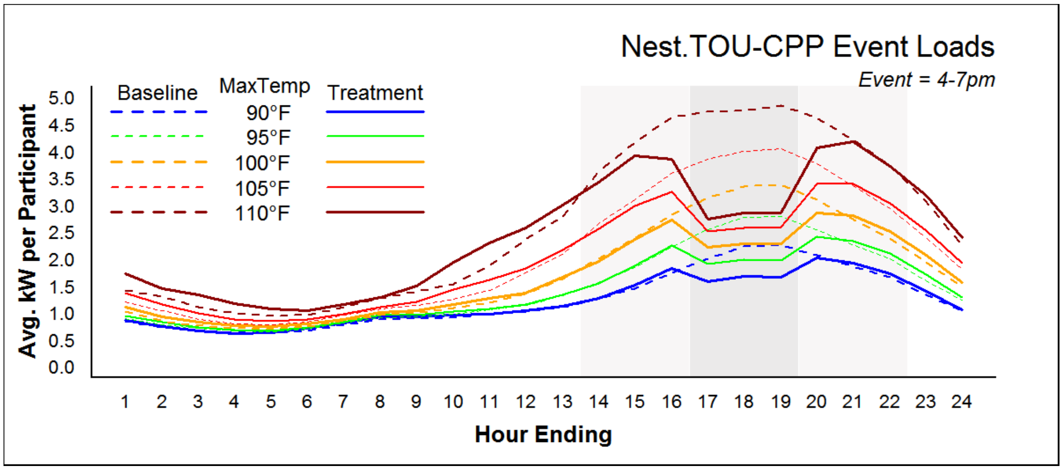


Figure 21. Load impacts on event days with max temperatures of 90-110°F, Nest.TOU-CPP

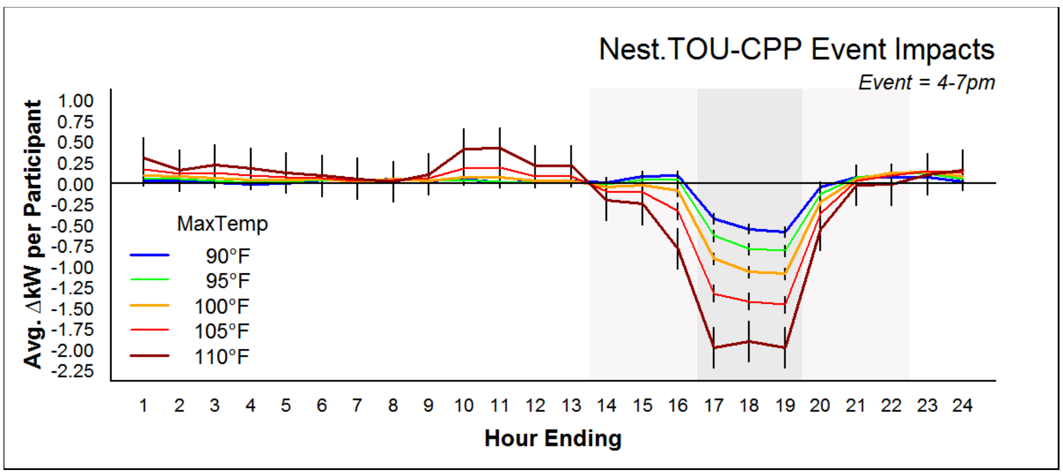


Table 12. Peak impacts on event days with max temperatures of 90-110°F, Nest.TOU-CPP

Max Temp (°F)	N	Pre-peak (hours 14-16) *kW (%)*	Peak (hours 17-19) *kW (%)*	Post-peak (hours 20-22) *kW (%)*
90	175	0.06 (4.3%)	-0.53* (-25%)	0.021 (1.2%)
95	175	0.03 (1.5%)	-0.75* (-28%)	0.0065 (0.3%)
100	175	-0.05 (-1.9%)	-1.0* (-31%)	-0.03 (-1.1%)
105	175	-0.20* (-6.0%)	-1.4* (-36%)	-0.11 (-3.2%)
110	175	-0.44* (-11%)	-2.0* (-41%)	-0.24 (-5.9%)

* Statistically significant, α=0.05.

Figure 22. Loads on event days with max temperatures of 90-110°F, Nest.Standard

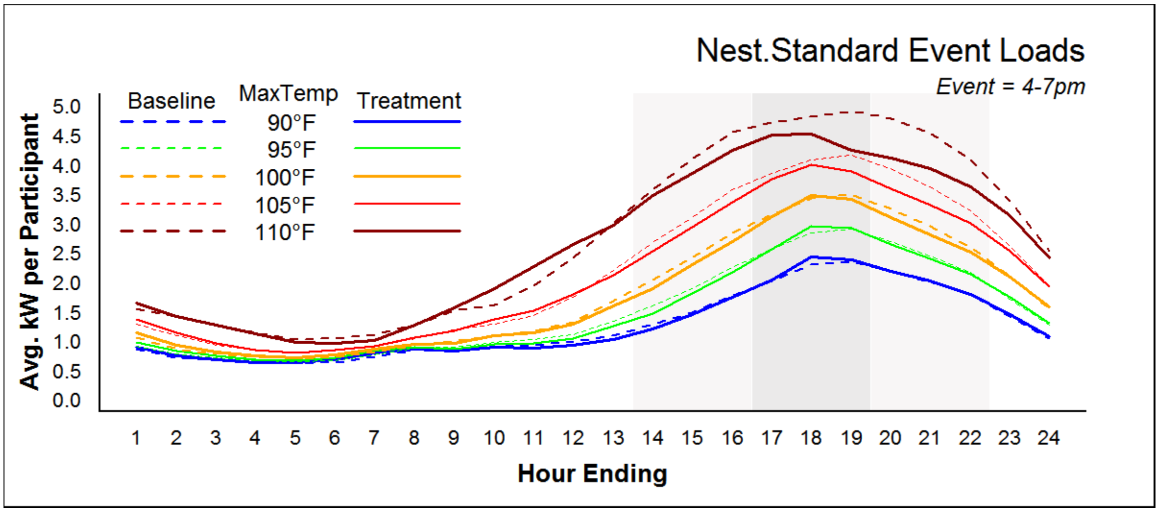


Figure 23. Load impacts on event days with max temperatures of 90-110°F, Nest.Standard

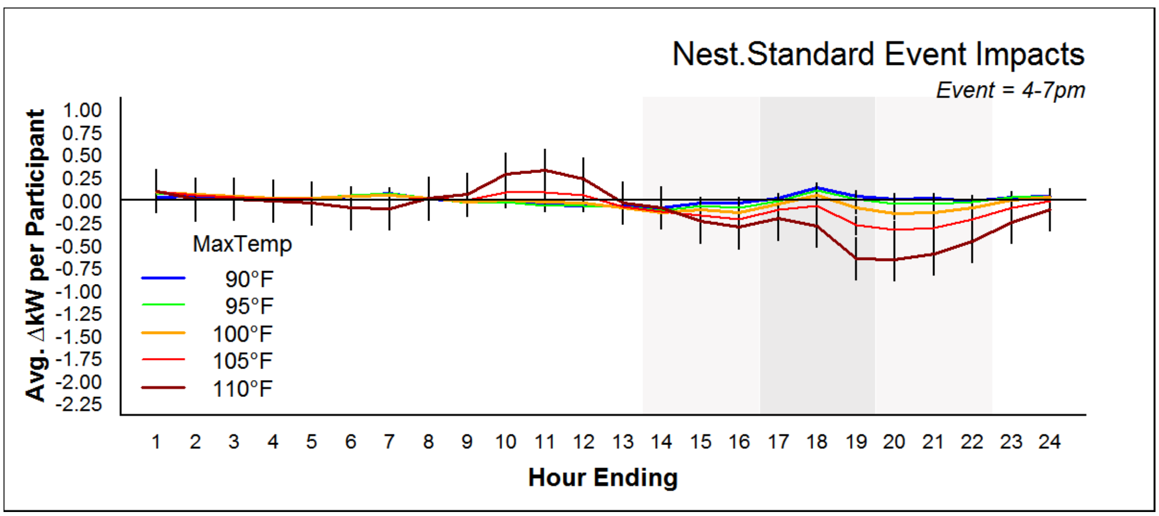


Table 13. Peak impacts on event days with max temperatures of 90-110°F, Nest.Standard

Max Temp (°F)	N	Pre-peak (hours 14-16) *kW (%)*	Peak (hours 17-19) *kW (%)*	Post-peak (hours 20-22) *kW (%)*
90	194	-0.05 (-3.3%)	0.06 (2.7%)	-0.01 (-0.6%)
95	194	-0.09* (-4.7%)	0.03 (1.1%)	-0.05 (-2.2%)
100	194	-0.13* (-5.4%)	-0.04 (-1.2%)	-0.14* (-5.0%)
105	194	-0.17* (-5.6%)	-0.18* (-4.3%)	-0.32* (-8.9%)
110	194	-0.22 (-5.4%)	-0.42* (-8.7%)	-0.64* (-14%)

* Statistically significant, α=0.05.

Figure 24. Loads on event days with max temperatures of 90-110°F, Ecofactor.TOU-CPP

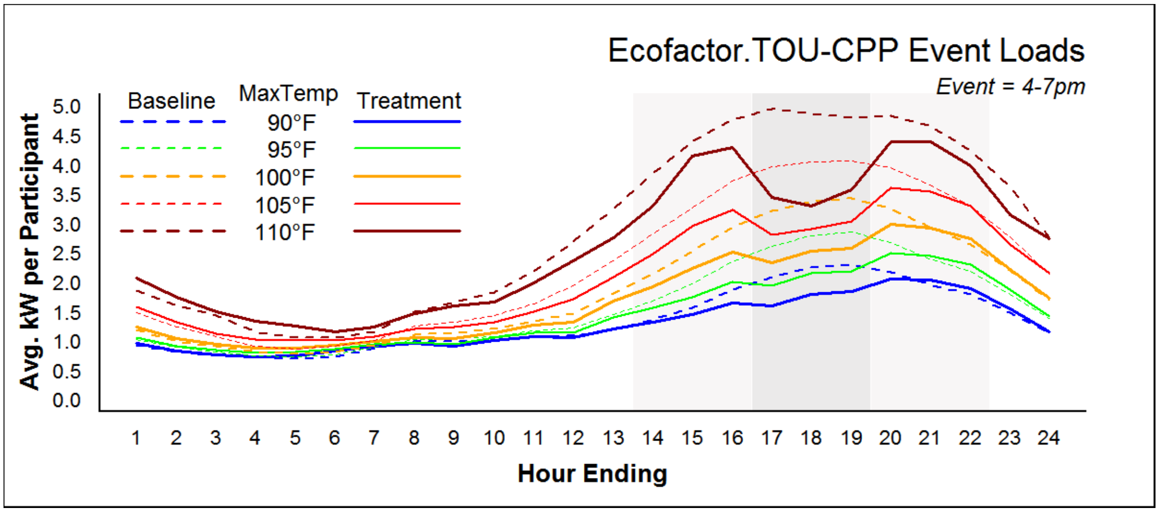


Figure 25. Load impacts on event days with max temperatures of 90-110°F, Ecofactor.TOU-CPP

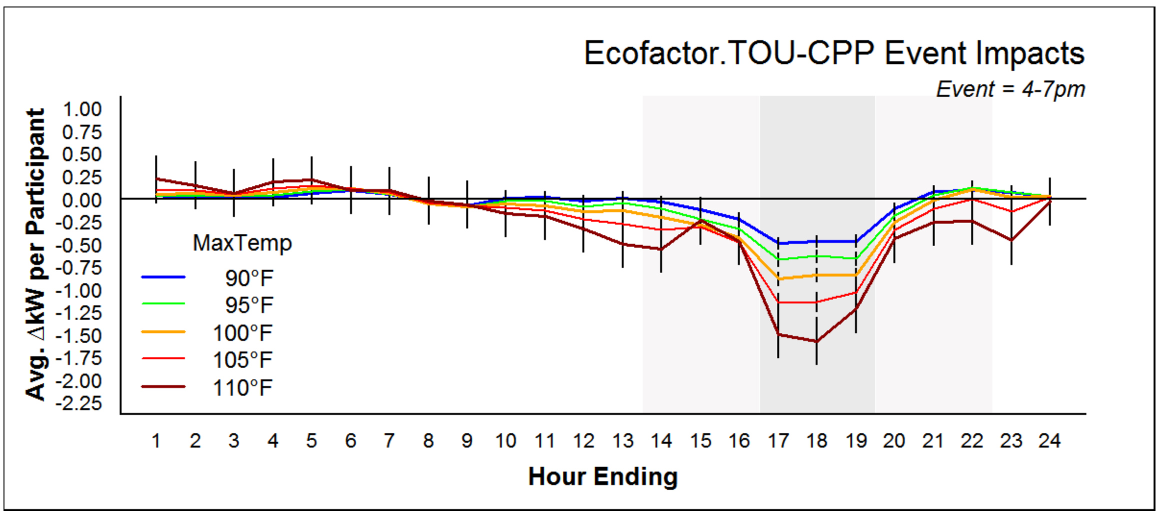


Table 14. Peak impacts on event days with max temperatures of 90-110°F, Ecofactor.TOU-CPP

Max Temp (°F)	N	Pre-peak (hours 14-16) *kW (%)*	Peak (hours 17-19) *kW (%)*	Post-peak (hours 20-22) *kW (%)*
90	147	-0.12* (-7.6%)	-0.48* (-22%)	0.015 (0.75%)
95	147	-0.21* (-11%)	-0.65* (-24%)	-0.0057 (-0.24%)
100	147	-0.30* (-12%)	-0.86* (-26%)	-0.058 (-2.0%)
105	147	-0.38* (-12%)	-1.1* (-28%)	-0.16* (-4.6%)
110	147	-0.44* (-10%)	-1.5* (-30%)	-0.36* (-8.0%)

* Statistically significant, α=0.05.

FIGURE 26. LOADS ON EVENT DAYS WITH MAX TEMPERATURES OF 90-110°F, ECOFACTOR.STANDARD

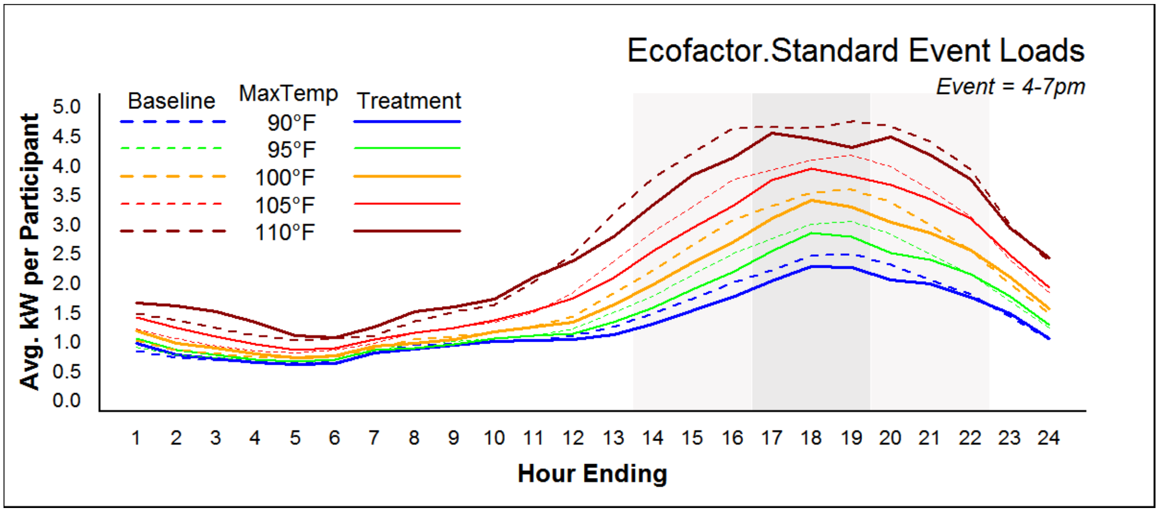


FIGURE 27. IMPACTS ON EVENT DAYS WITH MAX TEMPERATURES OF 90-110°F, ECOFACTOR.STANDARD

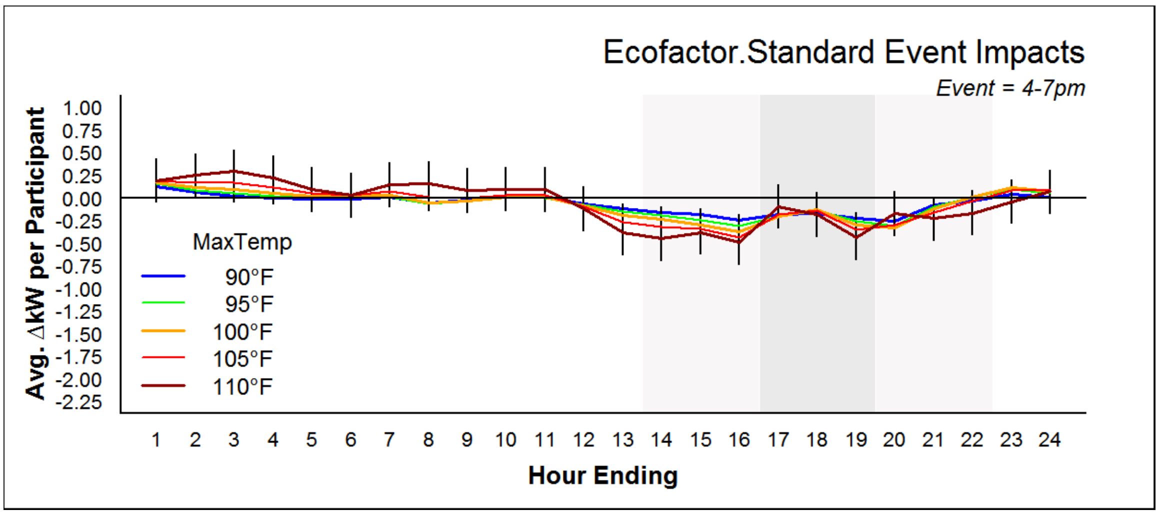


TABLE 15. PEAK IMPACTS ON EVENT DAYS WITH MAX TEMPERATURES OF 90-110°F, ECOFACTOR.STANDARD

MaxTemp (°F)	N	Pre-peak (hours 14-16) *kW (%)*	Peak (hours 17-19) *kW (%)*	Post-peak (hours 20-22) *kW (%)*
90	180	-0.20* (-11%)	-0.19* (-8.2%)	-0.14* (-6.8%)
95	180	-0.25* (-12%)	-0.20* (-7.0%)	-0.15* (-6.0%)
100	180	-0.31* (-12%)	-0.22* (-6.3%)	-0.16* (-5.5%)
105	180	-0.38* (-12%)	-0.24* (-5.8%)	-0.18* (-5.1%)
110	180	-0.48* (-11%)	-0.26 (-5.6%)	-0.20 (-4.8%)

* Statistically significant, α=0.05.

Summer Peak Impacts (non-event weekdays)

On nonevent weekdays, participants in the Nest.TOU-CPP and Ecofactor.TOU-CPP groups are encouraged to conserve energy from 4 pm to 7 pm through a TOU peak price of $0.27 per kWh, while Nest.Standard and Ecofactor.Standard groups are not asked to conserve energy.

Figure 28 plots the nonevent summer weekday load shapes for the modeled baseline and treatment period for the four treatment groups. Figure 29 plots the difference between the baseline and treatment load shapes for summer weekdays. The difference between those on the TOU-CPP rate and those on the standard rate can be seen in both figures.

Figure 28. Average summer weekday loads (nonevent)

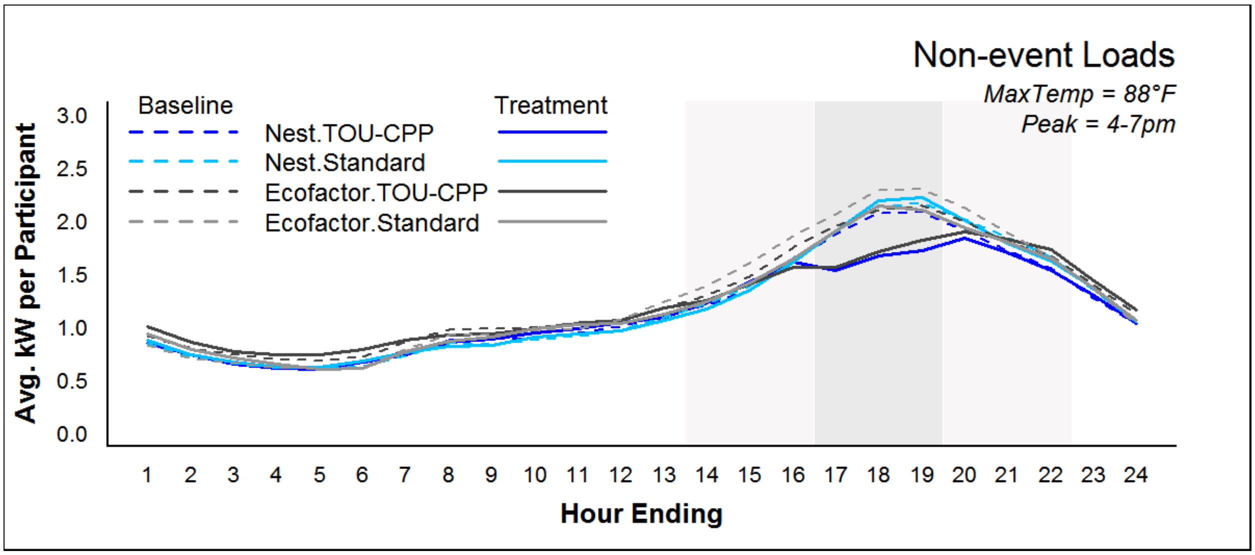


Figure 29. Average summer weekday impacts (nonevent)

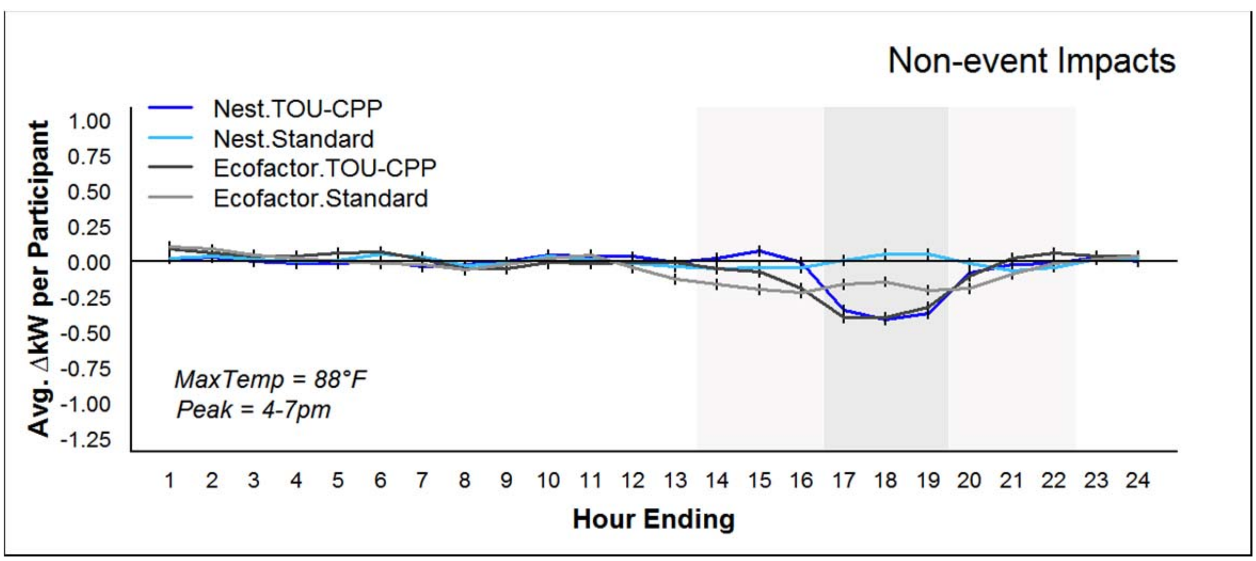


Table 16 shows the differences between the baseline and treatment load shapes. Values marked with an asterisk indicate that the impact differs statistically from zero, and that the null hypothesis of the treatment being equal to the baseline load is rejected (α=0.05).

TABLE 16. AVERAGE SUMMER WEEKDAY LOAD IMPACTS (NONEVENT)

Treatment	N	Pre-peak (hours 14-16) *kW (%)*	Peak (hours 17-19) *kW (%)*	Post-peak (hours 20-22) *kW (%)*	Non-event Day (hour 1-24) *kW (%)*
Nest.TOU-CPP	175	0.034 (2.5%)	-0.36* (-18%)	-0.03 (-1.9%)	-0.04* (-3.5%)
Nest.Standard	194	-0.043* (-3.0%)	+0.05* (+2.3%)	-0.03 (-1.6%)	0.003 (0.3%)
Ecofactor.TOU-CPP	147	-0.10* (-6.7%)	-0.36* (-18%)	-0.005 (-0.3%)	-0.05* (-3.6%)
Ecofactor.Standard	180	-0.18* (-11%)	-0.16* (-7.3%)	-0.10* (-5.1%)	-0.05* (-4.0%)

* Statistically significant, α=0.05.

Table 17 provides between-treatment differences for the impacts shown in Table 16 above. In the TOU peak hours, the TOU-CPP groups had greater impacts than did the Standard rate groups, but were statistically indistinguishable from each other. Both Ecofactor groups had statistically greater peak impacts than the Nest.Standard group.

TABLE 17. AVERAGE SUMMER WEEKDAY LOAD IMPACTS, BETWEEN TREATMENT COMPARISONS

Contrast	Pre-peak (hours 14-16) *kW (%)*	Peak (hours 17-19) *kW (%)*	Post-peak (hours 20-22) *kW (%)*
Nest.TOU-CPP minus Nest.Standard	0.077*	-0.41*	-0.0031
Nest.TOU-CPP minus Ecofactor.TOU-CPP	0.14*	-0.0024	-0.027
Nest.TOU-CPP minus Ecofactor.Standard	0.22*	-0.20*	0.064*
Nest.Standard minus Ecofactor.TOU-CPP	0.058*	0.41*	-0.024
Nest.Standard minus Ecofactor.Standard	0.14*	0.21*	0.068*
Ecofactor.TOU-CPP minus Ecofactor.Standard	0.082*	-0.20*	0.092*

* Statistically significant, α=0.05.

Energy Impacts

This section provides monthly, seasonal and annual energy impacts, in units of average kilowatt-hour per hour (kWh/h or kW) for each of the four treatment groups. Since these are average hourly values, conversion to daily kWh can be accomplished through multiplication by 24. Likewise, monthly kWh impacts can be calculated as the hourly average times 24 hours per day times the number of days in the month.

Monthly and Annual Energy Impacts

Table 18 provides the number of cooling hours (CDH) and average hourly energy impacts by treatment for each month. The Nest.TOU-CPP group shows statistically significant savings in five months of the year, including the three hottest summer months of June, July and August. Both Ecofactor groups also show statistically significant savings in these three months. All groups show statistically significant energy savings for the year, ranging from 1.6% to 3.3% savings.

Table 18. Monthly and annual energy impacts, by treatment

Month	CDH	Nest. TOU-CPP *kW (%)*	Nest. Standard *kW (%)*	Ecofactor. TOU-CPP *kW (%)*	Ecofactor. Standard *kW (%)*
January	0	-0.020 (-2.0%)	-0.036 (-3.6%)	-0.041 (-3.6%)	-0.018 (-1.7%)
February	0	**-0.068* (-6.5%)**	-0.022 (-2.1%)	**-0.050* (-4.5%)**	-0.039 (-3.7%)
March	2	-0.040 (-4.4%)	0.004 (0.5%)	-0.019 (-2.0%)	-0.020 (-2.2%)
April	29	-0.037 (-4.0%)	0.002 (0.2%)	-0.009 (-0.9%)	-0.022 (-2.4%)
May	49	**-0.052* (-5.2%)**	-0.003 (-0.3%)	-0.022 (-2.1%)	-0.027 (-2.7%)
June	112	**-0.071* (-5.3%)**	**-0.049* (-3.6%)**	**-0.081* (-5.7%)**	**-0.081* (-5.7%)**
July	135	**-0.070* (-4.6%)**	-0.030 (-2.0%)	**-0.087* (-5.4%)**	**-0.063* (-4.0%)**
August	99	**-0.048* (-3.7%)**	-0.009 (-0.7%)	**-0.063* (-4.5%)**	**-0.051* (-3.8%)**
September	58	-0.009 (-0.9%)	0.007 (0.6%)	-0.023 (-2.0%)	-0.031 (-2.7%)
October	16	-0.008 (-0.9%)	0.003 (0.3%)	-0.031 (-3.3%)	-0.034 (-3.8%)
November	0	-0.014 (-1.4%)	-0.026 (-2.8%)	-0.029 (-2.8%)	-0.040 (-4.0%)
December	0	-0.001 (-0.1%)	-0.050* (-4.2%)	-0.004 (-0.3%)	-0.002 (-0.1%)
Annual Average	**42**	**-0.036* (-3.3%)**	**-0.017* (-1.6%)**	**-0.038* (-3.3%)**	**-0.036* (-3.2%)**

* Statistically significant, α=0.05.

Summer Energy Impacts (June – September)

Figure 30 plots the modeled summer baseline (2012) and treatment (2013) load shapes for the four treatment groups. Figure 31 plots the energy impacts for each treatment, calculated as the difference between the hourly baseline and treatment load values shown in Figure 30.

Figure 30. Average summer loads, per participant

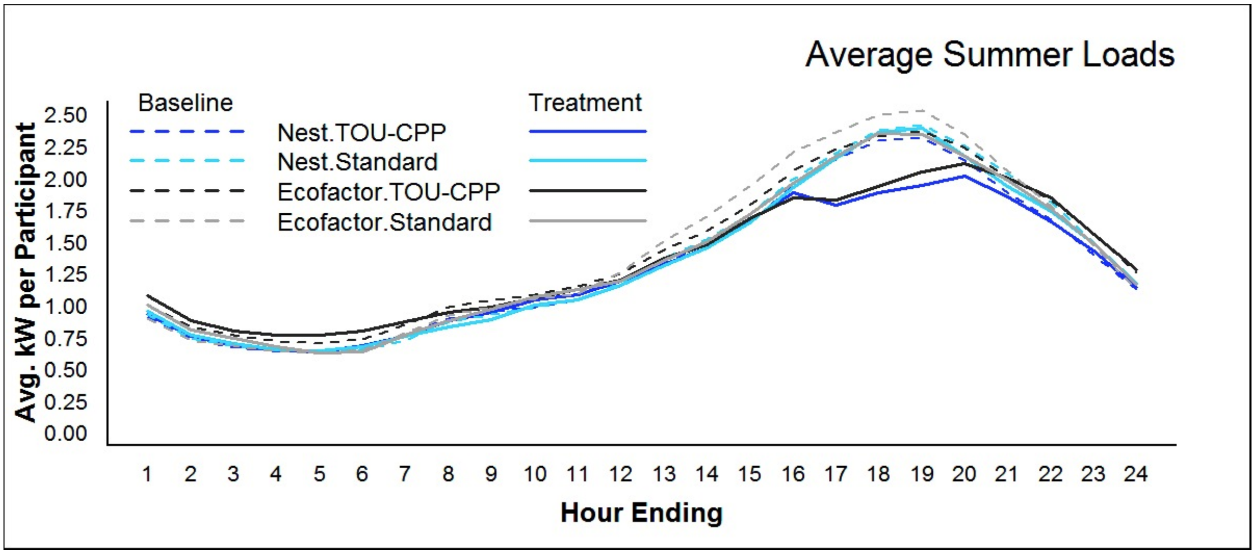


Figure 31. Average summer energy impacts, per participant

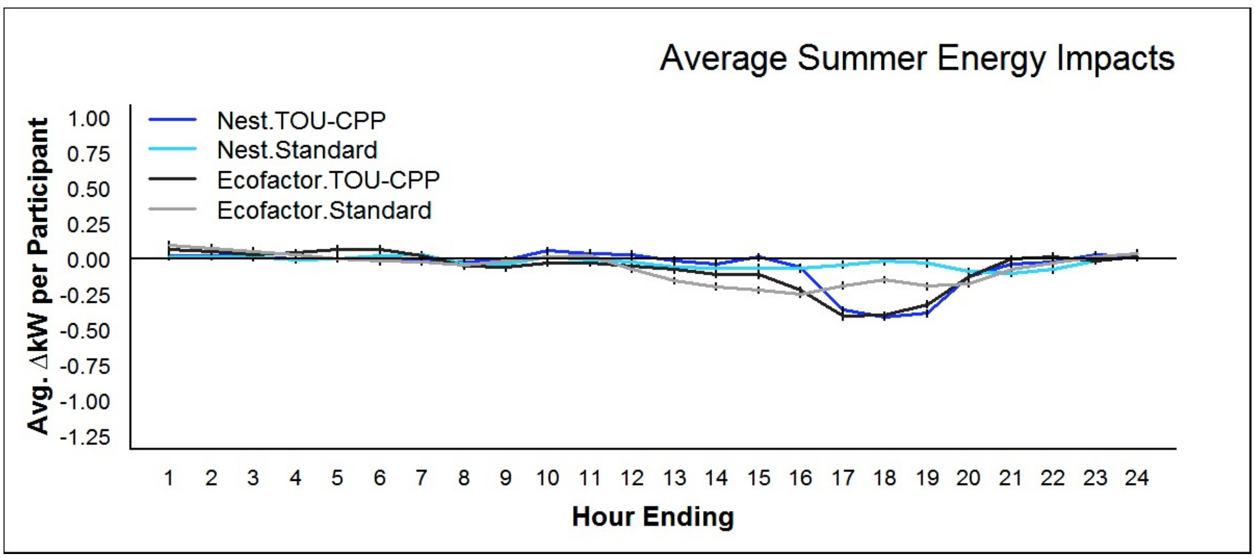


Table 19 summarizes the summer energy impacts – and the differences between those impacts – for each treatment and pair of treatments, respectively. Results show that summer energy use was statistically lower for all treatments, ranging from 1.6% to 4.5% savings. Treatment impacts were not statistically different from each other with the exception of the Nest.Standard treatment group, which saved statistically less energy relative to the other treatment groups.

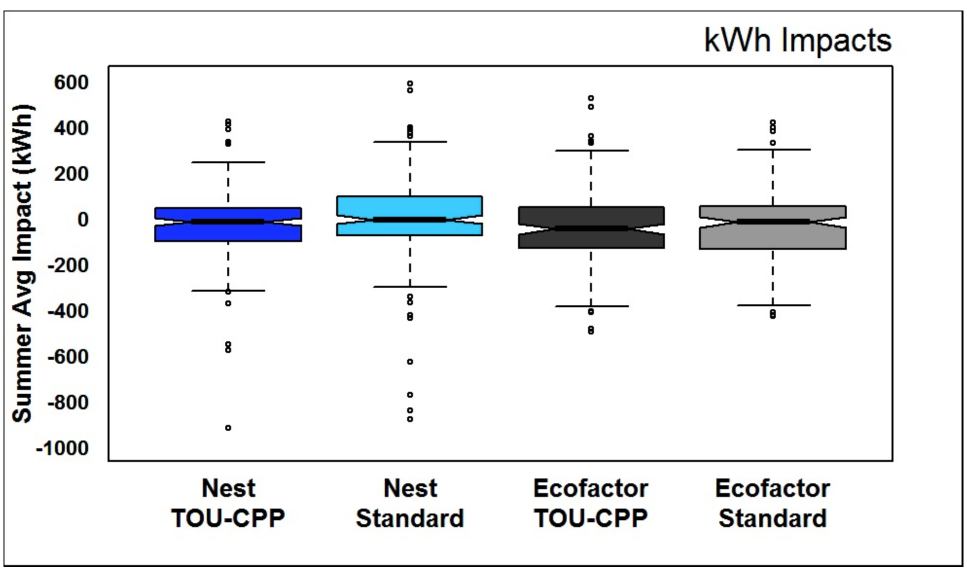
TABLE 19. AVERAGE SUMMER ENERGY IMPACTS AND BETWEEN-TREATMENT COMPARISONS

Treatment	N	Summer Energy Impact	Nest. Standard	Ecofactor. TOU-CPP	Ecofactor. Standard
Nest.TOU-CPP	174	-0.050* (-3.8%)	-0.029*	0.014	**0.007**
Nest.Standard	193	-0.020* (-1.6%)		0.043*	**0.036***
Ecofactor.TOU-CPP	147	-0.064* (-4.5%)			**-0.007**
Ecofactor.Standard	179	-0.056* (-4.1%)			

* Statistically significant, α=0.05.

Figure 32 shows similar distributions of customer-specific monthly summer energy impacts for the four treatment groups. All kWh impacts are adjusted for exogenous effects by subtracting the 6.1 kWh increase seen in the control group.

FIGURE 32. BOXPLOT OF AVERAGE MONTHLY SUMMER KWH IMPACTS, BY TREATMENT GROUP



Winter Energy Impacts (October – May)

Figure 33 plots the modeled winter baseline (2011-2012) and treatment (2012-2013) load shapes for the four treatment groups, indicating very little difference between the two. Figure 34 plots the energy impacts for each treatment, calculated as the difference between the hourly baseline and treatment load values shown in Figure 33. Again, individual hourly impacts are shown to be modest.

Figure 33. Average winter loads

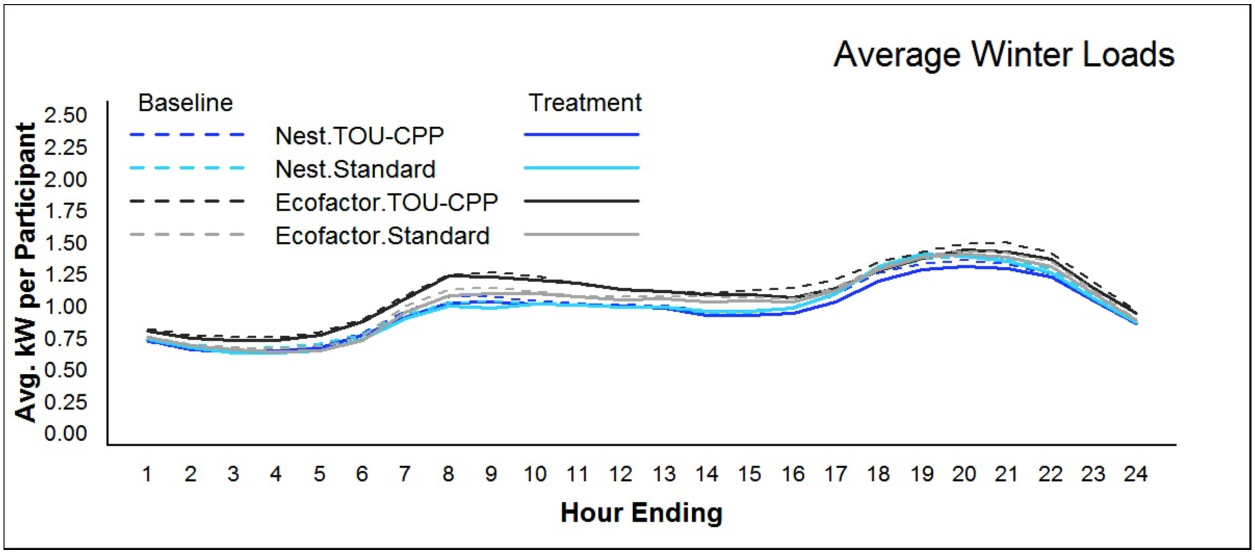


Figure 34. Average winter energy impacts

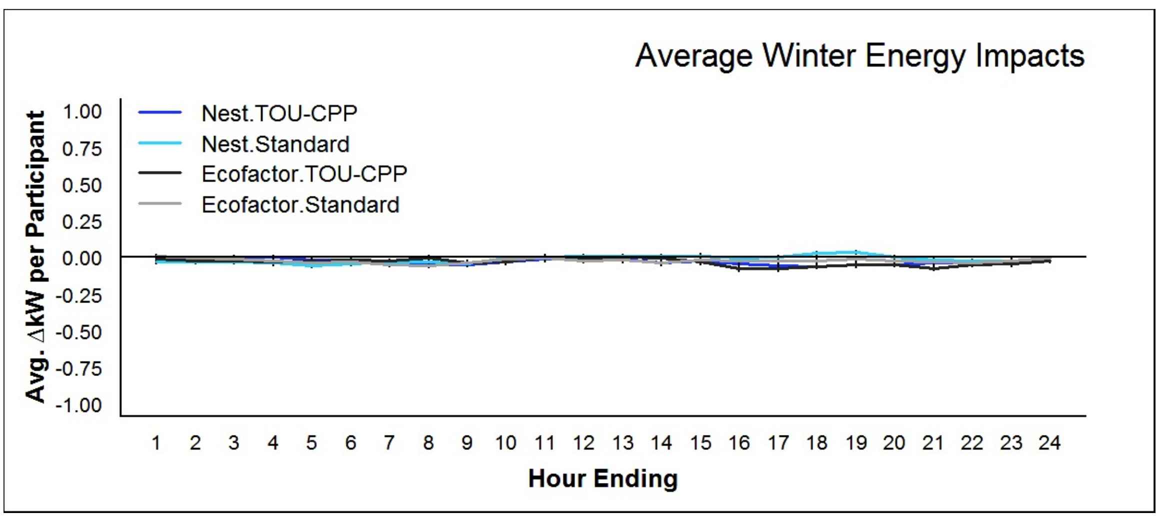


Table 20 summarizes the winter energy impacts – and the differences between those impacts – for each treatment and pair of treatments, respectively. Results show that winter energy use was modestly but statistically reduced for all treatments. Treatments were not statistically different from each other in their winter energy savings.

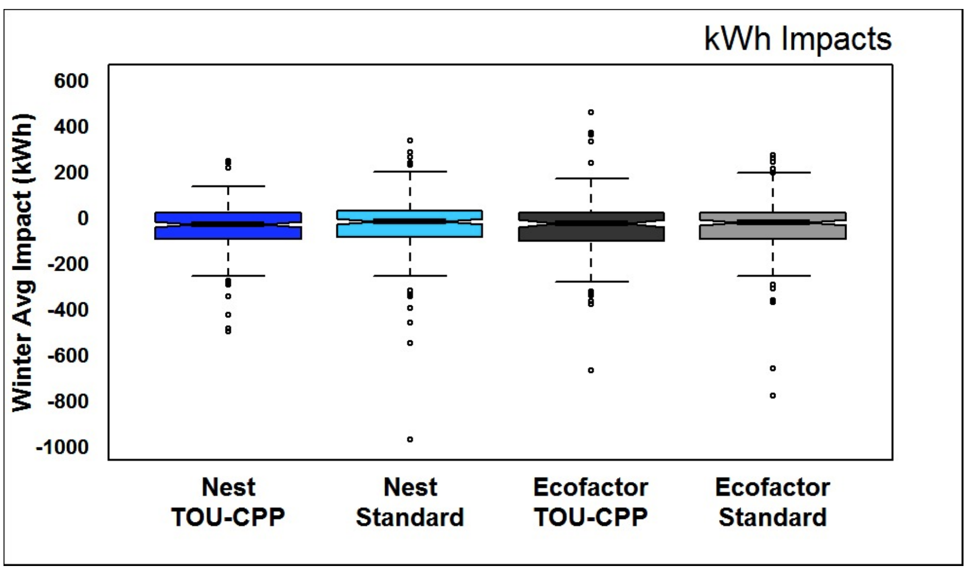
TABLE 20.AVERAGE WINTER ENERGY IMPACTS AND BETWEEN-TREATMENT COMPARISONS

Treatment	N	Winter Energy Impact	Nest. Standard	Ecofactor. TOU-CPP	Ecofactor. Standard
Nest.TOU-CPP	174	-0.030* (-3.0%)	-0.014	-0.0043	**-0.0046**
Nest.Standard	193	-0.016* (-1.6%)		0.0096	**0.0093**
Ecofactor.TOU-CPP	147	-0.026* (-2.4%)			**-0.0003**
Ecofactor.Standard	179	-0.025* (-2.5%)			

* Statistically significant, α=0.05.

Figure 35 shows the roughly even distributions of customer specific winter energy impacts for the treatment groups. Impacts for each customer are adjusted for exogenous effects by subtracting the 25 kWh savings seen in the control group.

FIGURE 35.BOXPLOT OF AVERAGE KWH IMPACTS, BY TREATMENT GROUP



Bill Impacts

The following steps were used to estimate customer-specific bills and bill impacts. Note that 2012 bills were modeled using hourly loads and rates to allow for weather correction between years. These bills are not corrected for exogenous effects.

Step 1. Calculate actual 2013 standard rate bills

1. Aggregate kWh by month
2. If kWh <= tier1 allowance then monthly bill = kWh*(tier1 price)
   else monthly bill = (tier1 allowance)*(tier1 price) + (kWh- tier 1 allowance)*(tier 2 price)
3. Summer Bill = sum of June-September bills from step 2
   Winter Bill = sum of October-May bills from step 2

Step 2. Calculate actual 2013 TOU-CPP summer bills

1. Aggregate kWh by
   - event peak (event hour 17-19)
   - non-event peak (nonevent hour 17-19)
   - offpeak (event hour 1-16,20-24 + nonevent hour 1-16,20-24 + weekend hour 1-24)
2. If offpeak.kWh <= tier1.allowance then monthly.bill = (offpeak *off.peak.tier1.price) + (nonevent.peak.kWh*nonevent.peak.price) + (event.peak.kWh*event.peak.price)
   else
   monthly.bill = (tier1.allowance*off.peak.tier1.price) + ((offpeak.kWh - tier1.allowance)* off.peak.tier2.price) + (nonevent.peak.kWh*non-event.peak.price) + (event.peak.kWh* event.peak.price)
3. Summer Bill = sum of June through September bills from step 2

Step 3. Estimate 2012 Standard rate bills

1. Customer-specific fixed effects model: kWh = CDD + HDD + month + hour*year.indicator
2. Estimate the average daily.kWh for each summer month in 2012 (1 daily value for each of the 4 summer months) using month-specific temperatures
3. Monthly.kWh = (daily.kWh)*(number of days in the month)
4. If Monthly.kWh <= tier1.allowance then monthly.bill = (kWh* tier1.price)
   Else monthly bill = (tier1.allowance*tier1.price) + ((Monthly.kWh - tier1.allowance)*tier2.price)
5. Summer Bill = sum of June-September bills from step 4
   Winter Bill = sum of October-May bills from step 4

Summer Bill Impacts (June – September)

Table 21 summarizes the per-participant summer bill impacts for each of the treatment groups. All bill impacts are adjusted for exogenous effects by subtracting the 58-cent average monthly bill increase seen in the control group. Average bill savings are modest and not statistically significant, at between 1.2% and 7.0%. However, some customers benefited substantially more than did others, with one participant saving more than $680 and one paying more than $420 extra for electricity over the course of the summer. Bill impact comparisons indicate that the differences between mean treatment values are not statistically significant (Table 22).

Table 21. Summer bill impacts summary

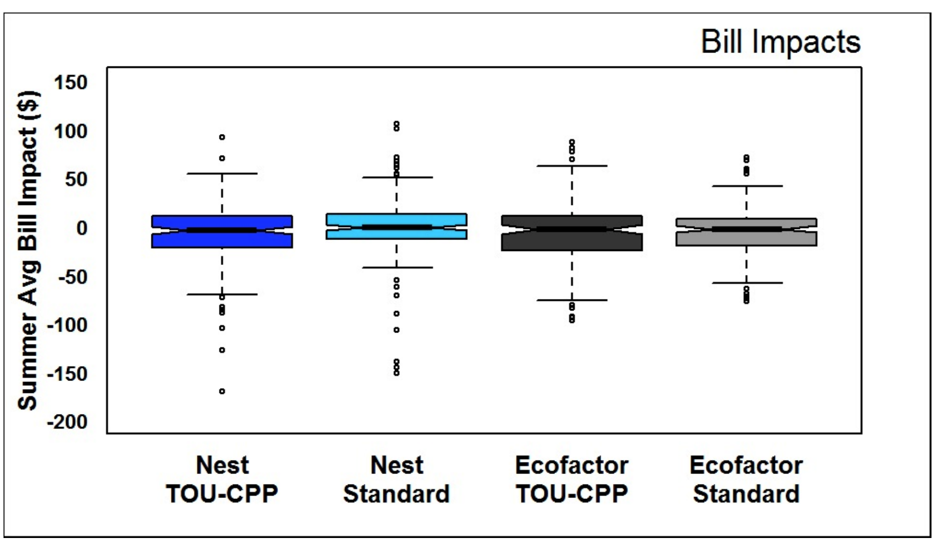
Treatment	Max Savings *($/month)*	Mean *($/month)*	Max Increase *($/month)*
Nest.TOU-CPP	-$170.57	-$8.26 (-7.0%)	+$90.94
Nest.Standard	-$151.95	-$1.49 (-1.2%)	+$105.54
Ecofactor.TOU-CPP	-$97.59	-$7.14 (-5.7%)	+$86.76
Ecofactor.Standard	-$77.25	-$5.75 (-4.5%)	+$70.98

Table 22. P-values for between treatment comparisons of summer bill impacts (t-test)

Treatment	Nest. Standard	Ecofactor. TOU-CPP	Ecofactor. Standard
Nest.TOU-CPP	0.0516	0.7652	0.4223
Nest.Standard		0.1270	0.1629
Ecofactor.TOU-CPP			0.6810

Figure 36 shows that the distributions of summer monthly bill impacts are similar for the four treatment groups.

Figure 36. Boxplot of average monthly summer bill impacts, by treatment group



Winter Bill Impacts (October – May)

Table 23 summarizes the per-participant winter bill impacts for each of the treatment groups. All bill impacts are adjusted for exogenous effects by subtracting the $3.46 average monthly bill savings seen in the control group. Average bill savings are modest and not statistically significant, at between 2.0% and 3.7%. Bill impact comparisons indicate that the differences between treatments are not statistically significant (Table 24).

Table 23. Winter bill impacts summary

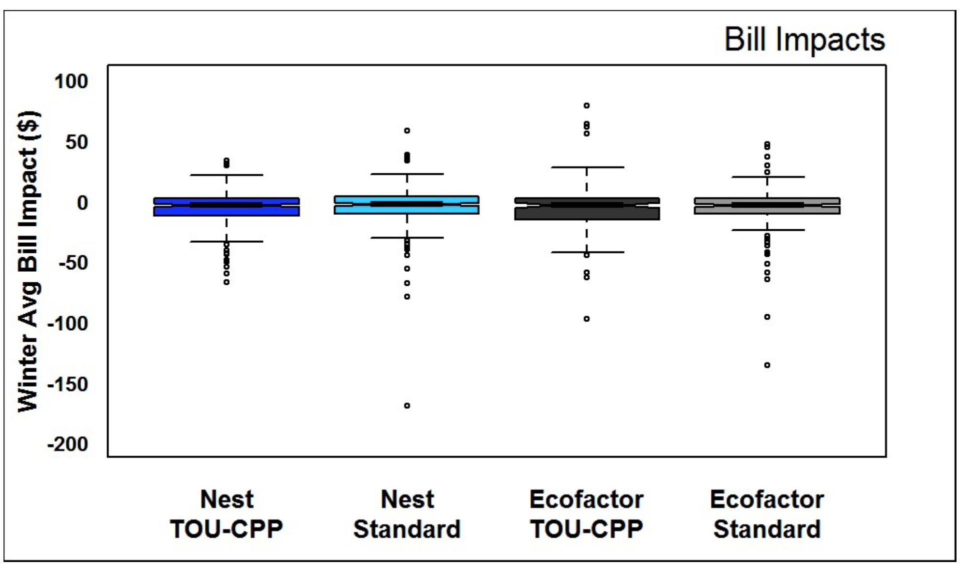
Treatment	Max Savings *($/month)*	Mean *($/month)*	Max Increase *($/month)*
Nest.TOU-CPP	-$63.37	-$2.93 (-3.7%)	+$36.98
Nest.Standard	-$165.65	-$1.61 (-2.0%)	+$61.11
Ecofactor.TOU-CPP	-$94.37	-$2.42 (-2.8%)	+$82.37
Ecofactor.Standard	-$132.03	-$2.36 (-2.9%)	+$50.29

Table 24. P-values for between treatment comparisons of winter bill impacts (t-test)

Treatment	Nest. Standard	Ecofactor. TOU-CPP	Ecofactor. Standard
Nest.TOU-CPP	0.4923	0.8116	0.7650
Nest.Standard		0.7232	0.7207
Ecofactor.TOU-CPP			0.9779

Figure 37 summarizes the similar distributions of winter bill impacts for the four treatment groups. For visual presentation reasons, one participant with an average winter bill increase of +$36.27 (+300%) per month was excluded from the graphs.

Figure 37. Boxplot of average bill impacts, by treatment group



Segmentation Effects

Customer-specific energy and peak event impacts estimated using ordinary least squares regression analysis (kWh = CDD + HDD + month + hour*year) were correlated with demographic variables collected in the pretreatment survey to investigate which customer characteristics are likely to lead to higher energy impacts.

Correlations with Annual Energy Impacts

Statistical significance of the Pearson r values provided in Table 25 show that pretreatment energy use is statistically correlated with energy impacts for the Nest treatment, meaning higher users with a Nest thermostat, regardless of the rate, are likely to save more than lower users. For customers in the Nest.TOU-CPP group, income was also a statistically significant factor, such that households with greater incomes saved more energy. For the Ecofactor.Standard treatment, the size and age of the home were statistically significant factors Newer and larger homes saved more energy, while older and smaller homes saved less.

Table 25. Correlations with annual energy impacts (Pearson's R)

Variable	Nest. TOU-CPP	Nest. Standard	Ecofactor. TOU-CPP	Ecofactor. Standard
Annual Pretreat kW	**-0.25***	**-0.22***	-0.06	-0.14
House size	-0.18	-0.11	-0.16	**-0.21***
House age	+0.12	+0.02	+0.13	**+0.19***
Income	**-0.20***	+0.02	-0.08	-0.00
Education	-0.06	+0.07	0.00	+0.03
Age of participant	+0.06	-0.13	-0.05	-0.05
# people home during peak	-0.14	+0.06	-0.08	-0.12
# people	-0.13	+0.01	-0.05	-0.01
AC age	+0.03	-0.10	+0.08	+0.03
Thermostat adjustments	-0.05	-0.03	-0.05	+0.06

* Statistically significant, $\alpha=0.05$.

Correlations with Peak Event Impacts

Statistical significance of the Pearson r-values provided in Table 26 show that pretreatment peak demand is statistically correlated with peak event impacts for the Nest.TOU-CPP treatment, meaning higher users with a Nest thermostat on the TOU-CPP rate are likely to have greater load shed during events. For customers in the Nest.TOU-CPP group, the size of the home and age of the air-conditioning unit were also statistically significant factors, with larger homes and older air-conditioners shedding more load during events. For the Ecofactor.TOU-CPP treatment, the size of the home was a statistically significant factor, with larger homes shedding more load during events.

Table 26. Correlations with predicted event peak impacts at 106°F (Pearson's R)

Variable	Nest. TOU-CPP	Nest. Standard	Ecofactor. TOU-CPP	Ecofactor. Standard
Annual Pretreat kW	**-0.35***	-0.09	-0.12	-0.12
House size	**-0.21***	-0.04	**-0.26***	-0.16
House age	+0.05	0.00	+0.11	+0.07
Income	-0.13	-0.15	-0.16	-0.08
Education	+0.03	+0.05	-0.00	+0.12
Age of participant	+0.15	-0.06	-0.02	-0.07
# people home during peak	-0.02	-0.01	-0.05	+0.13
# people	-0.07	-0.04	-0.05	+0.11
AC age	**-0.23***	-0.07	+0.13	-0.05
Thermostat adjustments	-0.01	0.00	+0.07	+0.15

* Statistically significant, α=0.05.

Elasticity of Demand

This section estimates elasticity of substitution for customers on the TOU-CPP rate.

Approach

Equation 2 specifies the model used to estimate the elasticity of substitution.

Equation 2. Elasticity of Substitution for TOU-CPP customers

$$\ln\left(\frac{peak\ kw}{off\ peak\ kw}\right)_{ij} = \beta 0 + \beta 1 CDH.difference_{ij} + \beta 2 \ln\left(\frac{peak\ price}{off\ peak\ price}\right)_{ij} + \beta 3_{t-1} Treatment_t$$

$$+\beta 4 \ln\left(\frac{peak\ price}{off\ peak\ price} * CDH.difference\right)_{ij} + \beta 5 Event + \beta 5_{m-1} Month_{m-1} + \beta 6_{w-1} Weekday_{w-1} + r_i + \varepsilon_{ij}$$

Where, for customer *i* on day *j*:

- $\ln(\frac{peak\ kw}{off\ peak\ kw})_{ij}$: average peak to average off peak kw ratio
- CDH_{ij}: difference of average peak CDH and average off peak CDH for customer i on day j
- $\ln(\frac{peak\ price}{off\ peak\ price})_{ij}$: average peak to average off peak price ratio
- $Treatment_t$: indicator variables for treatment
- $Event$: indicator variables for treatment period(baseline = 0, event (or nonevent))
- $Month_m$: indicator variables for month (June = reference level, July, August, September)
- $Weekday_w$: indicator variables for day of the week (Mon, Tue, Wed, Thu, Fri = reference level)
- r_i: random effects for customer $\sim N(0, \varphi)$, assumed to be independent for different i
- ε_{ij}: error terms $\sim N(0, \delta^2 I)$, assumed to be independent for different i or j and to be independent of random effects

Baseline and treatment data for the treatment and control group customers are included to estimate treatment effects while controlling for exogenous effects. A weather variable constructed by subtracting average off-peak cooling degree hours from average peak cooling degree hours is included to capture the effect of temperature on load shifting.

On event days participants may be driven not only by prices, but also by the fact that they were notified about the event, so separate models were run for event and nonevent days.

Results

Two sets of results were calculated to account for the tiers in the off-peak hours.

In the first set of results (Table 27), prices for off-peak hours are assigned according to each customer's current tier price; i.e. all electricity consumed in the off peak hours are charged at the Base price of $0.0721 until customer reaches 700 kWh in a given billing cycle. At that point, all off peak hours starting at 12 am the next day are charged at the Base Plus price of $0.1016.

The elasticity estimates indicate the percent change in peak to off-peak consumption ratio for every one percent change in peak to off-peak price ratio. For example, the elasticity value for Nest.TOU-CPP is -0.17, implying that a 100% change in the peak to off-peak price ratio would result in a 17% reduction in the peak to off-peak consumption ratio.

Table 27. Elasticity of demand estimates for the TOU-CPP groups

Treatment Group	Day type	Conditional R^2	Elasticity
Nest.TOU-CPP	Event	0.388	-0.17
	Nonevent	0.376	-0.14
Ecofactor.TOU-CPP	Event	0.373	-0.13
	Nonevent	0.369	-0.14

In the second set of results (Table 28), the tiers are collapsed into a single off-peak price for all customers by averaging the Base and Base Plus prices. Conditional R^2 values and elasticity estimates are marginally higher when the tiers are collapsed into an average value, providing evidence that the response to the TOU-CPP pricing may be stronger than the response to the tiered pricing.

Table 28. Elasticity of demand estimates for the TOU-CPP groups

Treatment Group	Day type	Conditional R^2	Elasticity
Nest.TOU-CPP	Event	0.389	-0.18
	Nonevent	0.377	-0.16
Ecofactor.TOU-CPP	Event	0.373	-0.13
	Nonevent	0.370	-0.16

Details of the model output are provided in Appendix E.

4. Conclusions and Recommendations

The main findings of this study indicate statistically significant differences between the energy and peak demand impacts of the four treatment groups as follows:

- **Event Peak Savings.** Those with the Nest Learning Thermostat on the TOU-CPP rate had the greatest peak load reductions during Conservation Day events, shedding 1.5 kW (37%) of their peak load. The group with the Ecofactor thermostat and TOU-CPP rate shed 1.2 kW (28%) of their peak load.
- **Pre-peak and Post-peak Impacts.** Participants in all groups saved energy in the 3-hour periods preceding and following the peak period.
- **Non-event Peak Savings.** On non-event weekdays, both groups on the TOU-CPP rate saved 0.36 kW (18%) – a statistically greater amount than did the groups on the Standard rate – regardless of the type of thermostat installed in their homes.
- **Annual Energy Savings.** Participants exposed to the TOU-CPP rate exhibited a 3.3% annual energy savings, whether they had the Nest or the Ecofactor thermostat. Participants on the Standard rate saved 3.2% with the Ecofactor thermostat and 1.6% with the Nest.
- **Bill Impacts.** Bill impacts were statistically similar for all treatment groups.
- **Elasticity of Demand.** Estimated elasticity values were between 0.13 and 0.17.

Despite the statistically significant load impacts, it is critical that programmatic decisions consider not only loads, but also customer comfort and satisfaction with the thermostats and rates. Impressive energy and demand savings can always be had – in the most extreme case by shutting off all electricity to the home – but the comfort-savings tradeoff must be considered and balanced to foster satisfied customers and sustainable programs.

In accordance with these ideas, the authors recommend that the results presented here be weighed alongside the results of other studies and evaluations completed in parallel at SMUD. For example, of concern is the high percentage of participants who expressed dissatisfaction with the Ecofactor thermostat (22%) compared to the fraction of those dissatisfied with the Nest thermostat (6%) (True North Research 2014). This large discrepancy in satisfaction scores combined with the higher energy and demand savings for those on the TOU-CPP rate appear to support the offering of a Nest thermostat paired with a voluntary TOU-CPP rate over the other offers tested in this pilot.

This outcome might be tempered, however, by the results of other studies recently completed at SMUD. For example, SMUD's *Low-Income Weatherization and Energy Management Pilot* (Herter & Okuneva 2014d) provided evidence that the Nest thermostat combined with the standard Energy Assistance Program Rate for low-income customers increased average annual energy use by a statistically significant 7.1%, implying that while the Nest thermostat benefited the participants in this study, it might not be the best technology for low-income customers.

Another concurrent study, *SMUD's Communicating Thermostat Usability Study,* compared usability and preference scores for 10 of the top communicating thermostats available in 2013, including both the Ecofactor and Nest thermostats. Consistent with the results presented here, results of the usability study showed the Nest outperforming Ecofactor's Computime thermostat – but only by a small margin. Smart thermostats that outperformed both the Nest and the Ecofactor included Carrier's ComfortChoice Touch, Emerson's Smart Energy, Ecobee's Smart Si, and Pioneer's Z100.

While different thermostats might provide improved customer satisfaction results, load impacts resulting from the use of these other thermostats have not been tested.[2] Future research might examine the energy and demand impacts of the most usable and likable thermostats as determined through usability test scores. As new communicating thermostats come to market, it would benefit future programs at SMUD to test the usability and likability of these devices prior to implementation in field studies. In addition, different rate structures are likely to result in different outcomes. Of particular interest is a TOU rate *without* the CPP component, which is proposed to become SMUD's default rate in 2018. Future research, then, might focus on:

(1) further usability testing followed by
(2) pilot tests of highly usable devices combined with
(3) the time-varying rates to which SMUD expects to transition

[2] An exception is the Pioneer Z100, which was field tested in (Herter & Okuneva 2014c) and (Sutter et al. 2014).

5. References

California Energy Commission. 2012*. 2013 Building Energy Efficiency Standards For Residential and Nonresidential Buildings.* May.

Gunshinan, J. "Energy Star Changes Approach to Programmable Thermostats." *Home Energy*, March/April 2007.

Herter, K. and Y. Okuneva, 2013. J. *SMUD's 2012 Residential Precooling Study - Load Impact Evaluation*. Prepared by Herter Energy Research Solutions for the Sacramento Municipal Utility District. June.

Herter, K. and Y. Okuneva. 2014a. *SMUD's Residential Summer Solutions Study: 2011-2012.* Prepared by Herter Energy Research Solutions for the Sacramento Municipal Utility District. January.

Herter, K. and Y. Okuneva. 2014b. *SMUD's Communicating Thermostat Usability Study*. Prepared by Herter Energy Research Solutions for the Sacramento Municipal Utility District. February.

Herter, K. and Y. Okuneva. 2014c. *SMUD's 2013 PowerStat and Pricing Study - Load Impact Evaluation*. Prepared by Herter Energy Research Solutions for the Sacramento Municipal Utility District. March.

Herter, K. and Y. Okuneva. 2014d. *SMUD's Low Income Weatherization & Energy Management Pilot – Load Impact Evaluation*. Prepared by Herter Energy Research Solutions for the Sacramento Municipal Utility District. August.

New York Times. 2008. *California Seeks Thermostat Control*. January 11.

Schwartz, D., B. Fischhoff, T. Krishnamurti, and F. Sowell. 2013. "The Hawthorne Effect and Energy Awareness," *PNAS* vol. 110 no. 38.

Sutter, M., S.Wayland, and K. Zhou. 2014. *Public Interest Energy Research (PIER) Energy Savings through Smart Controls in Multifamily Housing Study: Impact Analysis*. Prepared by Opinion Dynamics for the Sacramento Municipal Utility District. January.

True North Research, Inc. 2014. *Energy Insights Smart Thermostats Pilot Program - Final Report*. Prepared for the Sacramento Municipal Utility District. February 14.

U.S. Energy Star Program. 2012. Energy Star Program Requirements for Residential Climate Controls: Partner Commitments, Draft 3 Version 1. April 9.

6. Appendices

Appendix A. Summer Energy and Peak Demand Comparisons

Figure 38 shows that the average summer (July-August) kWh was highest for the participant population and lowest for the general population. Differences between the three means are statistically significant.

Figure 38. Summer Energy (kWh) – Participants v. Invited v. General Populations

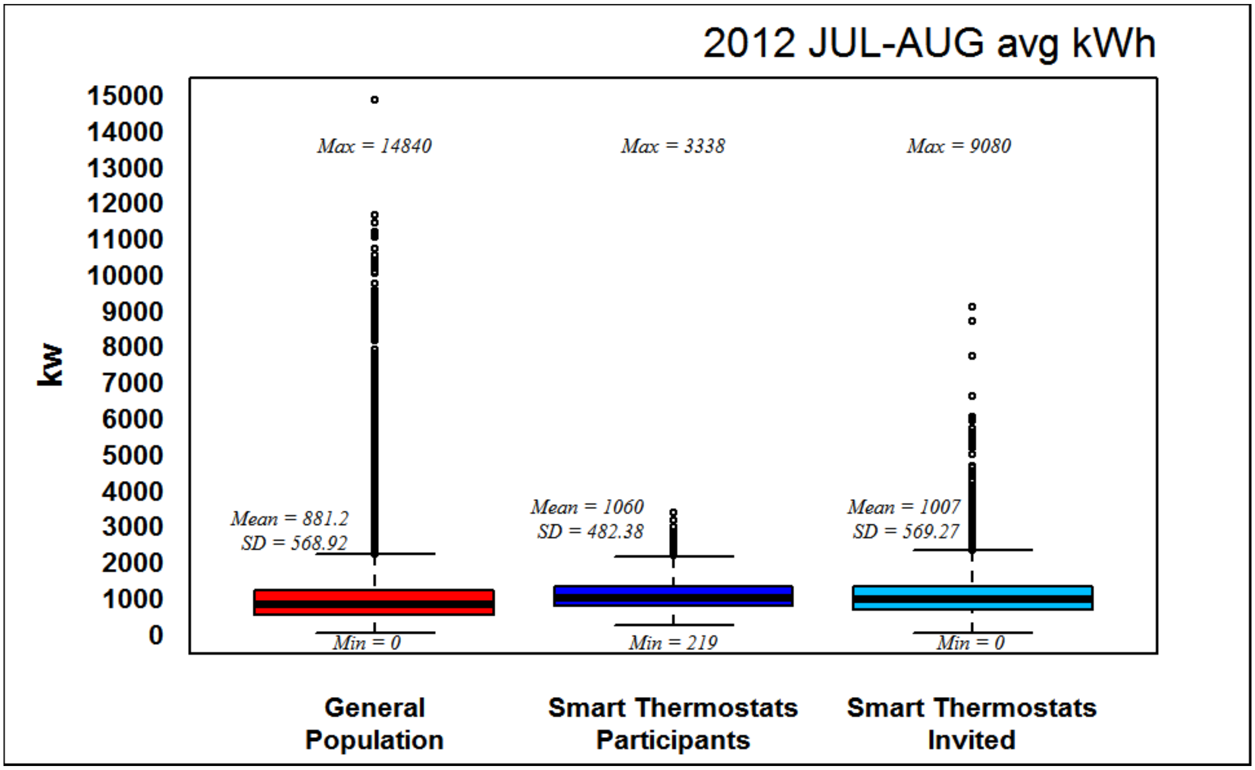


Table 29. Summer Energy Comparisons

Linear Hypotheses:	Estimate	Std. Error	t value	Pr(>|t|)	
STS - General.Population == 0	178.603	21.622	8.26	<0.001	***
STS.invited - General.Population == 0	125.56	4.238	29.63	<0.001	***
STS.invited - STS == 0	-53.042	22.006	-2.41	0.0345	*

Figure 39 shows that the average summer (July-August) peak kW was highest for the participant population and lowest for the general population. Differences between the three means are statistically significant.

FIGURE 39. SUMMER PEAK DEMAND (KW) – PARTICIPANTS V. INVITED V. GENERAL POPULATIONS

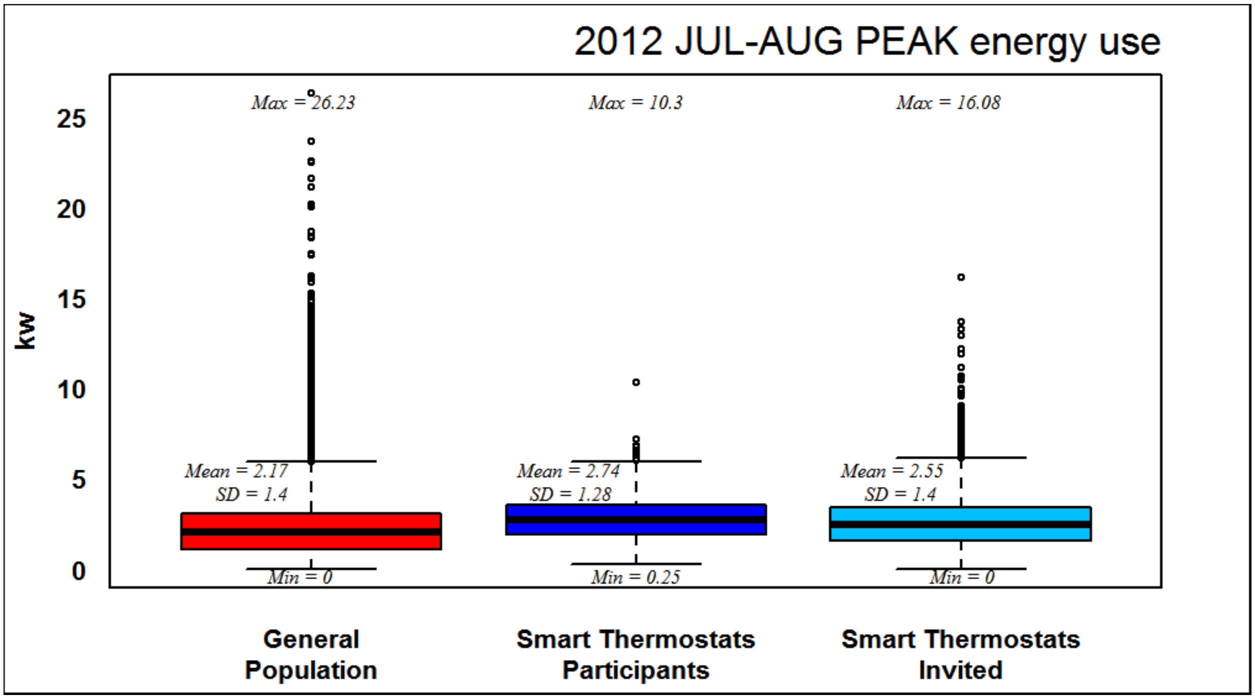


TABLE 30. SUMMER PEAK DEMAND COMPARISONS

Linear Hypotheses:	Estimate	Std. Error	t value	Pr(>|t|)	
STS - General.Population == 0	0.56765	0.05319	10.673	<0.001	***
STS.invited - General.Population == 0	0.37684	0.01042	36.157	<0.001	***
STS.invited - STS == 0	-0.19081	0.05413	-3.525	<0.001	***

Appendix B. Summer Weekday Impacts Model

All days ***except*** weekends and holidays were included in the analysis

Model Equation

Following is the equation for the 3-level model used to estimate hourly loads. Hours are nested within days and days nested within participants, with random effect for day and participant.

$$kw_{ijk} = \beta 1_k hour_{ijk} + \beta 2CDH_{ijk} + \beta 3CDD_{ij} + \beta 4{CDD^2}_{ij} + \beta 5_{m-1} Treatment_{Period_m} + \beta 6_{k-1}(CDD_{ij} * hour_{ijk}) + \beta 7_{k-1}({CDD^2}_{ij} * hour_{ijk}) + \beta 8_{m-1}(CDD_{ij} * Treatment_{Period_m}) + \beta 9_{m-1}({CDD_{ij}}^2 * Treatment_{Period_m}) + \beta 10_{(k-1):(m-1)}(hour_{ijk} * Treament_{Period_m}) + \beta 11_{(k-1):(m-1)}(CDD_{ij} * hour_{ijk} * Treatment_{Period_m}) + \beta 12_{(k-1):(m-1)}({CDD^2}_{ij} * hour_{ijk} * Treatment_{Period_m}) + r_i + r_{ij} + \varepsilon_{ijk}$$

kw_{ijk}: kilowatt load for customer i on day j at hour k

$hour_{ijk}$: indicator variable for hour of the day (1-24, or 14-16, or 17-19, or 20-22)

CDH_{ijk}: cooling degree hour for customer i on day j at hour k lagged by 2 hours. If Temperature > 75 for customer i on day j at hour k, then CDH for customer i on day j at hour k is Temperature – 75; otherwise, CDH for customer i on day j at hour k is zero.

CDD_{ij}: cooling degree day, the sum of 24 CDH values for customer i on day j

${CDD^2}_{ij}$: square of cooling degree day for customer i on day j

$Treatment\_Period_m$: indicator variables for treatment and treatment period (Nest.TOU-CPP.event = reference level, Nest.TOU-CPP.nonevent,Nest.TOU-CPP.baseline, Nest.Standard.event, Nest.Standard.nonevent, Nest.Standard.baseline Ecofactor.TOU-CPP.event, Ecofactor.TOU-CPP.nonevent, Ecofactor.TOU-CPP.baseline, Ecofactor.Standard.event, Ecofactor.Standard.nonevent, Ecofactor.Standard.baseline, control.baseline, control.treatment)

r_i: random effects for customer $\sim N(0, \varphi_1)$, assumed to be independent for different i

r_{ij}: random effects for day $\sim N(0, \varphi_2)$, assumed to be independent for different i or j and of r_i

ε_{ijk}: error terms $\sim N(0, \delta^2 I)$, assumed to be independent for different i or j and to be independent of random effects

Model Fit

Table 31 provides conditional R^2 values for the pre-peak, peak, and post-peak models.

TABLE 31. CONDITIONAL R^2 FOR PRE PEAK, PEAK, AND POST PEAK MODELS

Model	Conditional R^2
PRE peak	0.4910
PEAK	0.5068
POST peak	0.4886

Figure 40 through Figure 43 show that the modeled average hourly loads are nearly identical to the average of the actual hourly loads.

FIGURE 40. ACTUAL AND MODELED SUMMER WEEKDAYS, NEST.TOU-CPP

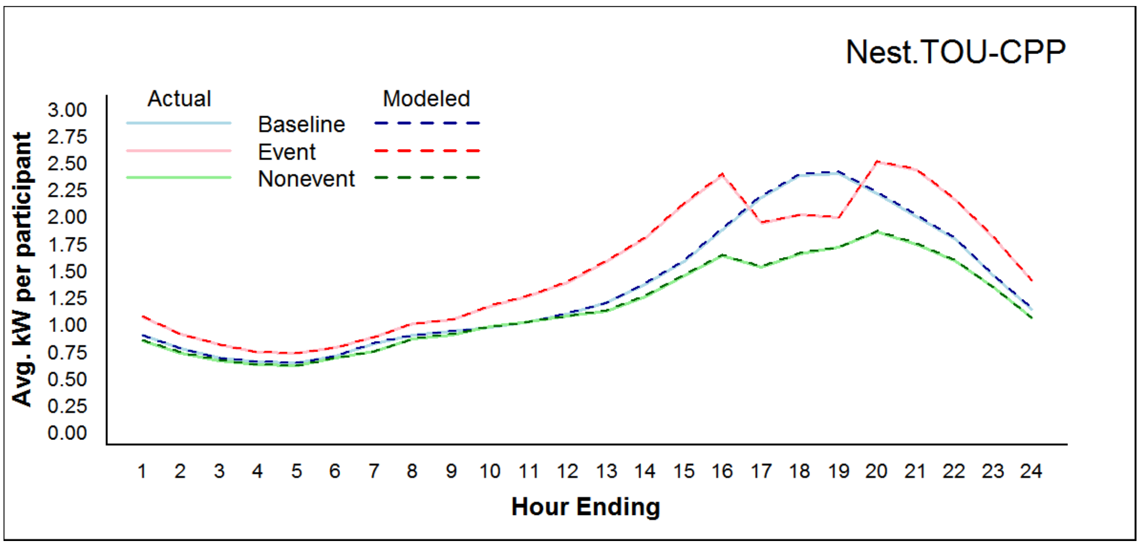


FIGURE 41. ACTUAL AND MODELED SUMMER WEEKDAYS, NEST.STANDARD

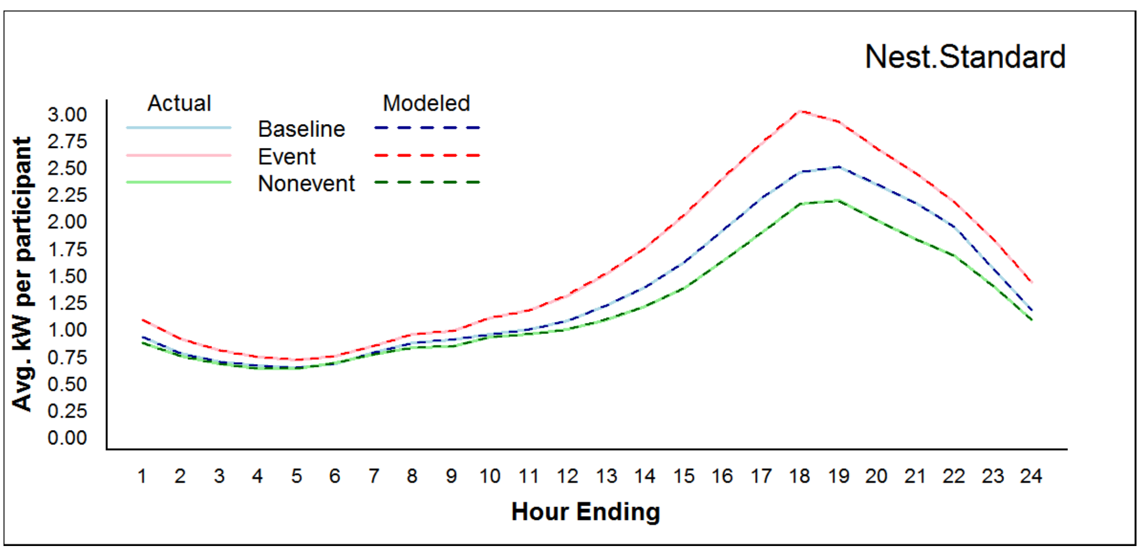


FIGURE 42. ACTUAL AND MODELED SUMMER WEEKDAYS, ECOFACTOR.TOU-CPP

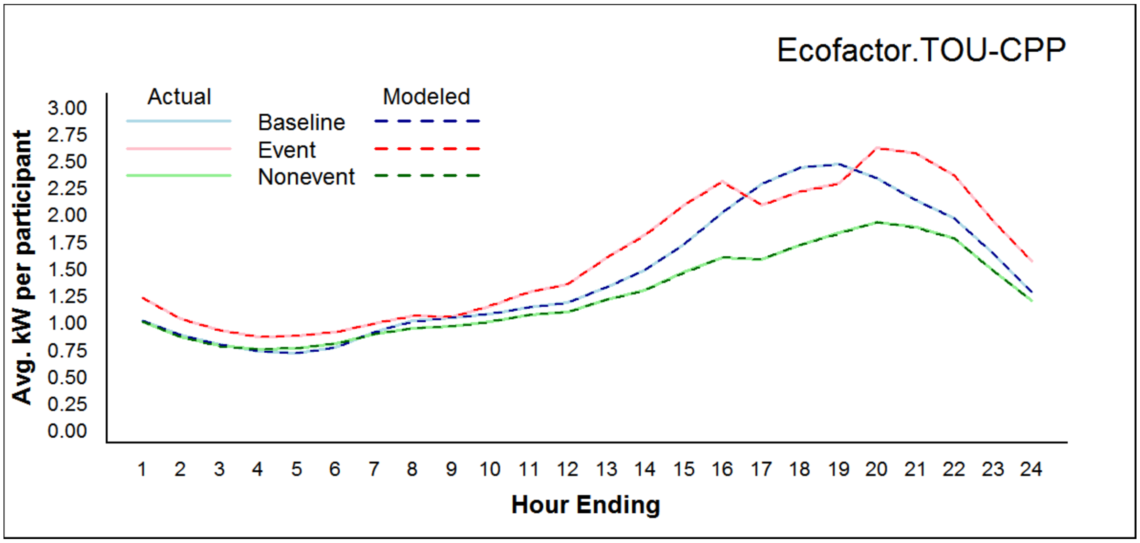
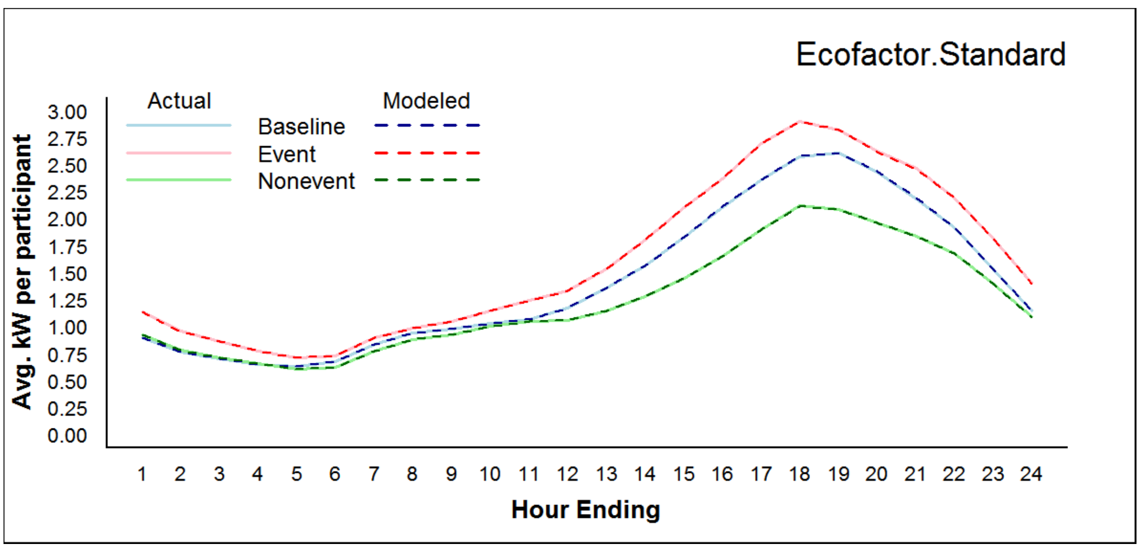


FIGURE 43. ACTUAL AND MODELED SUMMER WEEKDAYS, ECOFACTOR.STANDARD



To check model fit on extreme weather days, the average hourly loads for the five hottest days of 2012 (Table 32) were plotted against the modeled values for the average weather across those days. The results are given in Figure 44 through Figure 47.

TABLE 32. FIVE HOT 2012 DAYS USED TO COMPARE ACTUAL TO MODELED LOADS.

date	MaxTemp
2012-07-11	104
2012-07-12	103
2012-08-09	103
2012-08-10	104
2012-08-13	106

FIGURE 44. AVERAGE ACROSS 5 HOT 2012 DAYS, NEST.TOU-CPP

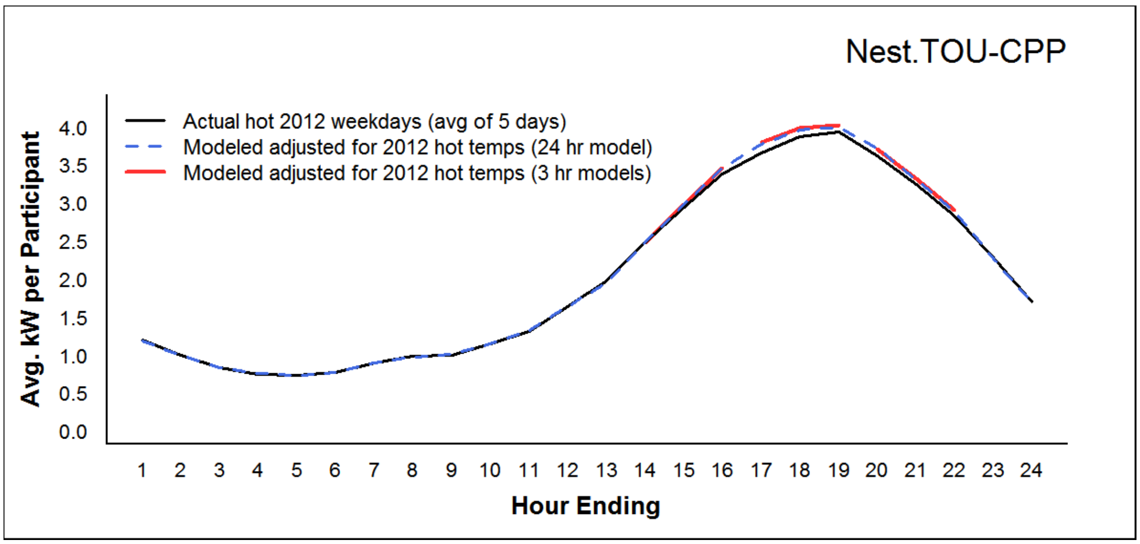


FIGURE 45. AVERAGE ACROSS 5 HOT 2012 DAYS, NEST.STANDARD

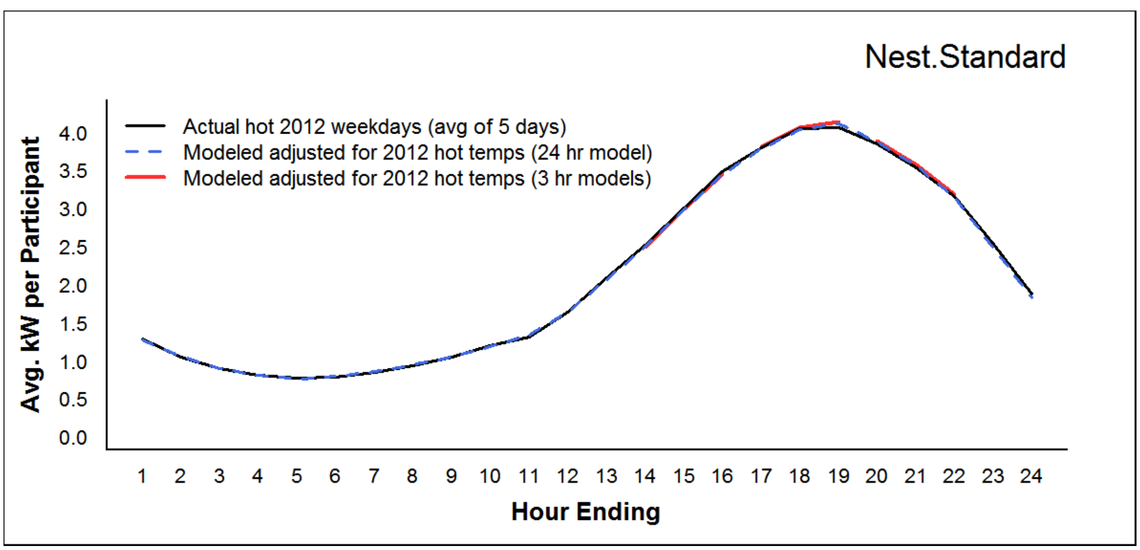


FIGURE 46. AVERAGE ACROSS 5 HOT 2012 DAYS, ECOFACTOR.TOU-CPP

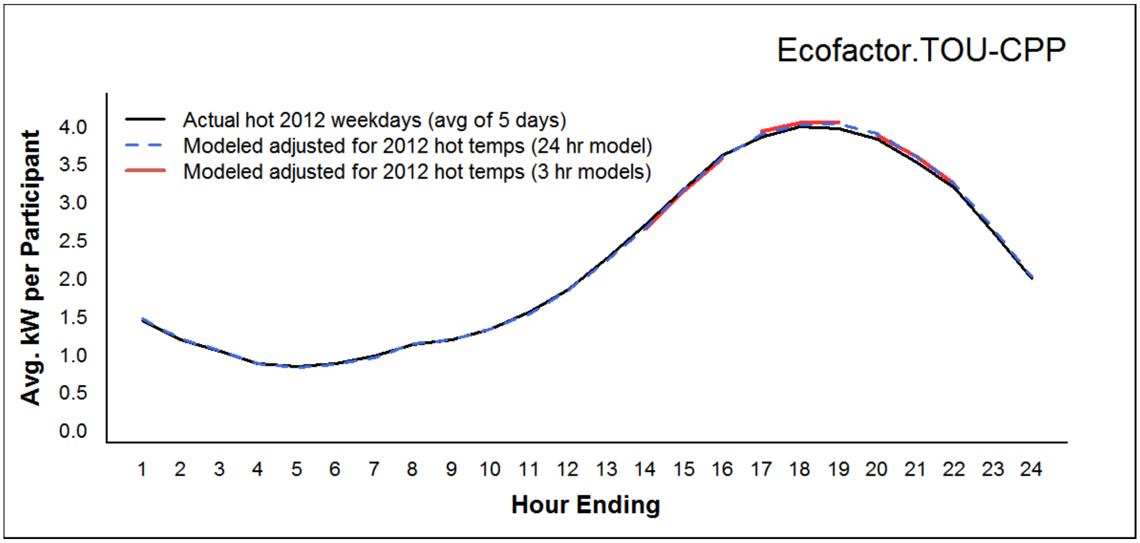
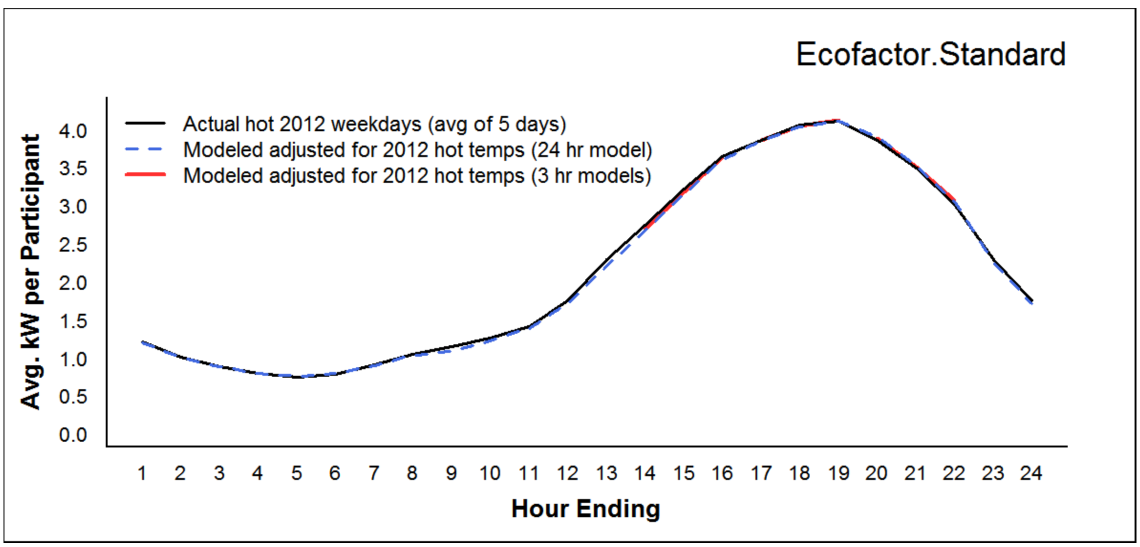


FIGURE 47. AVERAGE ACROSS 5 HOT 2012 DAYS, ECOFACTOR.STANDARD



Model Coefficients

Table 33 through Table 35 provide model coefficients for PRE peak, Peak, and POST peak models. Nest.TOU-CPP.event is the reference level in all 3 models.

Table 33. Model Coefficients, PRE peak model

Variable	Coefficient	Std.Error	DF	t-value	p-value
CDH	0.0242632	0.0011	313851	21.63	<0.0001
CDD	0.0009769	0.0010	155965	0.94	0.3491
hour14	0.9478453	0.1047	313851	9.06	<0.0001
hour15	0.9892279	0.1047	313851	9.45	<0.0001
hour16	0.8699842	0.1047	313851	8.31	<0.0001
Nest.TOU.CPP.nonevent	-0.0623903	0.0817	155965	-0.76	0.4452
Nest.TOU.CPP.baseline	0.0049314	0.0821	155965	0.06	0.9521
Nest.Standard.event	-0.0011525	0.1445	155965	-0.01	0.9936
Nest.Standard.nonevent	-0.0790375	0.1255	155965	-0.63	0.5288
Nest.Standard.baseline	-0.0388634	0.1257	155965	-0.31	0.7573
Ecofactor.TOU.CPP.event	0.1377437	0.1552	155965	0.89	0.3748
Ecofactor.TOU.CPP.nonevent	0.0703588	0.1315	155965	0.54	0.5926
Ecofactor.TOU.CPP.baseline	0.0900408	0.1318	155965	0.68	0.4945
Ecofactor.Standard.event	-0.0138854	0.1471	155965	-0.09	0.9248
Ecofactor.Standard.nonevent	0.0353227	0.1270	155965	0.28	0.7809
Ecofactor.Standard.baseline	0.1267837	0.1272	155965	1.00	0.3190
control.baseline	-0.0631384	0.1204	155965	-0.52	0.5999
control.treatment	-0.0490805	0.1200	155965	-0.41	0.6826
CDD.2	0.0000122	0.0000	155965	4.14	<0.0001
CDD:hour15	0.0014551	0.0009	313851	1.57	0.1168
CDD:hour16	0.0062997	0.0012	313851	5.37	<0.0001
CDD:Nest.TOU.CPP.nonevent	0.0015444	0.0011	155965	1.37	0.1696
CDD:Nest.TOU.CPP.baseline	-0.0006493	0.0011	155965	-0.58	0.5594
CDD:Nest.Standard.event	-0.0012297	0.0014	155965	-0.86	0.3925
CDD:Nest.Standard.nonevent	0.0006129	0.0011	155965	0.55	0.5829
CDD:Nest.Standard.baseline	0.0001059	0.0011	155965	0.10	0.9236
CDD:Ecofactor.TOU.CPP.event	-0.0008913	0.0015	155965	-0.58	0.5620
CDD:Ecofactor.TOU.CPP.nonevent	-0.0001177	0.0011	155965	-0.10	0.9177
CDD:Ecofactor.TOU.CPP.baseline	-0.0006847	0.0011	155965	-0.61	0.5426
CDD:Ecofactor.Standard.event	0.0003741	0.0015	155965	0.26	0.7978
CDD:Ecofactor.Standard.nonevent	0.0000985	0.0011	155965	0.09	0.9300

Variable	Coefficient	Std.Error	DF	t-value	p-value
CDD:Ecofactor.Standard.pretreat	0.0001121	0.0011	155965	0.10	0.9196
CDD:control.baseline	0.0002189	0.0011	155965	0.20	0.8405
CDD:control.treatment	0.0002605	0.0011	155965	0.24	0.8100
hour15:Nest.TOU.CPP.nonevent	-0.0488344	0.0726	313851	-0.67	0.5013
hour16:Nest.TOU.CPP.nonevent	0.0446281	0.0917	313851	0.49	0.6266
hour15:Nest.TOU.CPP.baseline	-0.1042890	0.0730	313851	-1.43	0.1529
hour16:Nest.TOU.CPP.baseline	0.0058265	0.0922	313851	0.06	0.9496
hour15:Nest.Standard.event	-0.1023230	0.0964	313851	-1.06	0.2884
hour16:Nest.Standard.event	0.0563995	0.1217	313851	0.46	0.6432
hour15:Nest.Standard.nonevent	-0.0756379	0.0723	313851	-1.05	0.2958
hour16:Nest.Standard.nonevent	0.0783195	0.0914	313851	0.86	0.3914
hour15:Nest.Standard.baseline	-0.0715896	0.0727	313851	-0.99	0.3246
hour16:Nest.Standard.baseline	0.0419865	0.0918	313851	0.46	0.6474
hour15:Ecofactor.TOU.CPP.event	0.0610211	0.1036	313851	0.59	0.5558
hour16:Ecofactor.TOU.CPP.event	0.0915610	0.1308	313851	0.70	0.4841
hour15:Ecofactor.TOU.CPP.nonevent	-0.0004769	0.0732	313851	-0.01	0.9948
hour16:Ecofactor.TOU.CPP.nonevent	0.0384790	0.0924	313851	0.42	0.6772
hour15:Ecofactor.TOU.CPP.baseline	-0.0505395	0.0736	313851	-0.69	0.4923
hour16:Ecofactor.TOU.CPP.baseline	0.0635300	0.0930	313851	0.68	0.4944
hour15:Ecofactor.Standard.event	0.0109569	0.0981	313851	0.11	0.9111
hour16:Ecofactor.Standard.event	0.0516951	0.1239	313851	0.42	0.6765
hour15:Ecofactor.Standard.nonevent	-0.0734313	0.0725	313851	-1.01	0.3115
hour16:Ecofactor.Standard.nonevent	0.0127437	0.0916	313851	0.14	0.8894
hour15:Ecofactor.Standard.baseline	-0.0607263	0.0729	313851	-0.83	0.4048
hour16:Ecofactor.Standard.baseline	0.0024078	0.0921	313851	0.03	0.9791
hour15:control.baseline	-0.0490559	0.0719	313851	-0.68	0.4951
hour16:control.baseline	0.0498994	0.0908	313851	0.55	0.5827
hour15:control.treatment	-0.0896512	0.0715	313851	-1.25	0.2096
hour16:control.treatment	0.0264394	0.0903	313851	0.29	0.7696
hour15:CDD.2	-0.0000015	0.0000	313851	-0.59	0.5555
hour16:CDD.2	-0.0000152	0.0000	313851	-4.58	<0.0001
Nest.TOU.CPP.nonevent:CDD.2	-0.0000072	0.0000	155965	-2.15	0.0319
Nest.TOU.CPP.baseline:CDD.2	0.0000010	0.0000	155965	0.31	0.7577
Nest.Standard.event:CDD.2	0.0000042	0.0000	155965	1.03	0.3014
Nest.Standard.nonevent:CDD.2	-0.0000033	0.0000	155965	-0.98	0.3271
Nest.Standard.baseline:CDD.2	-0.0000009	0.0000	155965	-0.29	0.7715
Ecofactor.TOU.CPP.event:CDD.2	0.0000004	0.0000	155965	0.10	0.9219

Variable	Coefficient	Std.Error	DF	t-value	p-value
Ecofactor.TOU.CPP.nonevent:CDD.2	-0.0000030	0.0000	155965	-0.88	0.3800
Ecofactor.TOU.CPP.pretreat:CDD.2	0.0000021	0.0000	155965	0.63	0.5286
Ecofactor.Standard.event:CDD.2	-0.0000014	0.0000	155965	-0.35	0.7253
Ecofactor.Standard.nonevent:CDD.2	-0.0000032	0.0000	155965	-0.95	0.3433
Ecofactor.Standard.baseline:CDD.2	-0.0000006	0.0000	155965	-0.17	0.8649
control.baseline:CDD.2	-0.0000030	0.0000	155965	-0.94	0.3463
control.treatment:CDD.2	-0.0000007	0.0000	155965	-0.23	0.8173
CDD:hour15:Nest.TOU.CPP.nonevent	-0.0000105	0.0010	313851	-0.01	0.9916
CDD:hour16:Nest.TOU.CPP.nonevent	-0.0031182	0.0013	313851	-2.47	0.0135
CDD:hour15:Nest.TOU.CPP.baseline	0.0000480	0.0010	313851	0.05	0.9612
CDD:hour16:Nest.TOU.CPP.baseline	-0.0020548	0.0012	313851	-1.65	0.0998
CDD:hour15:Nest.Standard.event	0.0014407	0.0013	313851	1.13	0.2596
CDD:hour16:Nest.Standard.event	-0.0011570	0.0016	313851	-0.72	0.4735
CDD:hour15:Nest.Standard.nonevent	0.0003062	0.0010	313851	0.31	0.7575
CDD:hour16:Nest.Standard.nonevent	-0.0022949	0.0013	313851	-1.83	0.0669
CDD:hour15:Nest.Standard.baseline	-0.0000205	0.0010	313851	-0.02	0.9833
CDD:hour16:Nest.Standard.baseline	-0.0021879	0.0012	313851	-1.76	0.0778
CDD:hour15:Ecofactor.TOU.CPP.event	-0.0028828	0.0014	313851	-2.11	0.0348
CDD:hour16:Ecofactor.TOU.CPP.event	-0.0049443	0.0017	313851	-2.87	0.0042
CDD:hour15:Ecofactor.TOU.CPP.nonevent	-0.0012644	0.0010	313851	-1.25	0.2114
CDD:hour16:Ecofactor.TOU.CPP.nonevent	-0.0037286	0.0013	313851	-2.92	0.0035
CDD:hour15:Ecofactor.TOU.CPP.baseline	-0.0001967	0.0010	313851	-0.20	0.8439
CDD:hour16:Ecofactor.TOU.CPP.baseline	-0.0022315	0.0013	313851	-1.77	0.0771
CDD:hour15:Ecofactor.Standard.event	-0.0004360	0.0013	313851	-0.34	0.7368
CDD:hour16:Ecofactor.Standard.event	-0.0024379	0.0016	313851	-1.49	0.1369
CDD:hour15:Ecofactor.Standard.nonevent	0.0003872	0.0010	313851	0.39	0.6974
CDD:hour16:Ecofactor.Standard.nonevent	-0.0019449	0.0013	313851	-1.55	0.1221
CDD:hour15:Ecofactor.Standard.baseline	0.0006635	0.0010	313851	0.67	0.5010
CDD:hour16:Ecofactor.Standard.baseline	-0.0010420	0.0012	313851	-0.84	0.4028
CDD:hour15:control.baseline	-0.0001637	0.0010	313851	-0.17	0.8655
CDD:hour16:control.baseline	-0.0027560	0.0012	313851	-2.26	0.0240
CDD:hour15:control.treatment	0.0004841	0.0010	313851	0.50	0.6150
CDD:hour16:control.treatment	-0.0022425	0.0012	313851	-1.84	0.0652
hour15:Nest.TOU.CPP.nonevent:CDD.2	0.0000019	0.0000	313851	0.63	0.5264
hour16:Nest.TOU.CPP.nonevent:CDD.2	0.0000149	0.0000	313851	3.94	0.0001
hour15:Nest.TOU.CPP.baseline:CDD.2	0.0000022	0.0000	313851	0.75	0.4534

Variable	Coefficient	Std.Error	DF	t-value	p-value
hour16:Nest.TOU.CPP.baseline:CDD.2	0.0000113	0.0000	313851	3.09	0.0020
hour15:Nest.Standard.event:CDD.2	-0.0000042	0.0000	313851	-1.17	0.2405
hour16:Nest.Standard.event:CDD.2	0.0000051	0.0000	313851	1.13	0.2596
hour15:Nest.Standard.nonevent:CDD.2	-0.0000004	0.0000	313851	-0.13	0.8957
hour16:Nest.Standard.nonevent:CDD.2	0.0000090	0.0000	313851	2.42	0.0155
hour15:Nest.Standard.baseline:CDD.2	0.0000019	0.0000	313851	0.65	0.5149
hour16:Nest.Standard.baseline:CDD.2	0.0000110	0.0000	313851	3.02	0.0025
hour15:Ecofactor.TOU.CPP.event:CDD.2	0.0000102	0.0000	313851	2.65	0.0080
hour16:Ecofactor.TOU.CPP.event:CDD.2	0.0000173	0.0000	313851	3.57	0.0004
hour15:Ecofactor.TOU.CPP.nonevent:CDD.2	0.0000046	0.0000	313851	1.52	0.1275
hour16:Ecofactor.TOU.CPP.nonevent:CDD.2	0.0000134	0.0000	313851	3.49	0.0005
hour15:Ecofactor.TOU.CPP.baseline:CDD.2	0.0000024	0.0000	313851	0.81	0.4154
hour16:Ecofactor.TOU.CPP.baseline:CDD.2	0.0000107	0.0000	313851	2.87	0.0041
hour15:Ecofactor.Standard.event:CDD.2	0.0000011	0.0000	313851	0.31	0.7549
hour16:Ecofactor.Standard.event:CDD.2	0.0000091	0.0000	313851	1.97	0.0487
hour15:Ecofactor.Standard.nonevent:CDD.2	-0.0000011	0.0000	313851	-0.36	0.7223
hour16:Ecofactor.Standard.nonevent:CDD.2	0.0000087	0.0000	313851	2.32	0.0206
hour15:Ecofactor.Standard.baseline:CDD.2	-0.0000007	0.0000	313851	-0.26	0.7956
hour16:Ecofactor.Standard.baseline:CDD.2	0.0000072	0.0000	313851	1.97	0.0490
hour15:control.baseline:CDD.2	0.0000017	0.0000	313851	0.60	0.5457
hour16:control.baseline:CDD.2	0.0000114	0.0000	313851	3.23	0.0012
hour15:control.treatment:CDD.2	-0.0000009	0.0000	313851	-0.33	0.7403
hour16:control.treatment:CDD.2	0.0000089	0.0000	313851	2.56	0.0104

Table 34. Model Coefficients, PEAK model

Variable	Coefficient	Std.Error	DF	t-value	p-value
CDH	0.027971	0.001471	313852	19.02	<0.0001
CDD	0.005545	0.001199	155966	4.63	<0.0001
hour17	0.719402	0.117753	313852	6.11	<0.0001
hour18	0.882852	0.117750	313852	7.50	<0.0001
hour19	0.814831	0.117724	313852	6.92	<0.0001
Nest.TOU.CPP.nonevent	0.112811	0.092653	155966	1.22	0.2234
Nest.TOU.CPP.baseline	0.171082	0.093089	155966	1.84	0.0661
Nest.Standard.event	0.214979	0.162526	155966	1.32	0.1859
Nest.Standard.nonevent	0.192246	0.140794	155966	1.37	0.1721
Nest.Standard.baseline	0.175912	0.141066	155966	1.25	0.2124
Ecofactor.TOU.CPP.event	0.161918	0.174566	155966	0.93	0.3536
Ecofactor.TOU.CPP.nonevent	0.170297	0.147436	155966	1.16	0.2481
Ecofactor.TOU.CPP.baseline	0.309618	0.147775	155966	2.10	0.0362
Ecofactor.Standard.event	0.228891	0.165441	155966	1.38	0.1665
Ecofactor.Standard.nonevent	0.204408	0.142434	155966	1.44	0.1513
Ecofactor.Standard.baseline	0.305013	0.142721	155966	2.14	0.0326
control.baseline	0.165530	0.135108	155966	1.23	0.2205
control.treatment	0.178729	0.134717	155966	1.33	0.1846
CDD.2	-0.000006	0.000003	155966	-1.92	0.0544
CDD:hour18	-0.001442	0.001062	313852	-1.36	0.1746
CDD:hour19	-0.001190	0.001325	313852	-0.90	0.3692
CDD:Nest.TOU.CPP.nonevent	-0.001367	0.001275	155966	-1.07	0.2835
CDD:Nest.TOU.CPP.baseline	0.001938	0.001261	155966	1.54	0.1243
CDD:Nest.Standard.event	0.001761	0.001630	155966	1.08	0.2799
CDD:Nest.Standard.nonevent	0.002500	0.001265	155966	1.98	0.0482
CDD:Nest.Standard.baseline	0.002200	0.001253	155966	1.76	0.0791
CDD:Ecofactor.TOU.CPP.event	-0.002520	0.001743	155966	-1.45	0.1481
CDD:Ecofactor.TOU.CPP.nonevent	-0.001907	0.001291	155966	-1.48	0.1395
CDD:Ecofactor.TOU.CPP.baseline	0.000989	0.001275	155966	0.78	0.4379
CDD:Ecofactor.Standard.event	0.001261	0.001655	155966	0.76	0.4463
CDD:Ecofactor.Standard.nonevent	0.002207	0.001271	155966	1.74	0.0824
CDD:Ecofactor.Standard.baseline	0.003082	0.001258	155966	2.45	0.0143
CDD:control.baseline	0.001618	0.001233	155966	1.31	0.1895
CDD:control.treatment	0.001078	0.001228	155966	0.88	0.3803
hour18:Nest.TOU.CPP.nonevent	-0.108364	0.083238	313852	-1.30	0.1930
hour19:Nest.TOU.CPP.nonevent	-0.000341	0.103820	313852	0.00	0.9974

Variable	Coefficient	Std.Error	DF	t-value	p-value
hour18:Nest.TOU.CPP.baseline	-0.096869	0.083625	313852	-1.16	0.2467
hour19:Nest.TOU.CPP.baseline	0.008997	0.104295	313852	0.09	0.9313
hour18:Nest.Standard.event	0.021976	0.110463	313852	0.20	0.8423
hour19:Nest.Standard.event	-0.051292	0.137740	313852	-0.37	0.7096
hour18:Nest.Standard.nonevent	-0.044386	0.082922	313852	-0.54	0.5925
hour19:Nest.Standard.nonevent	0.044759	0.103427	313852	0.43	0.6652
hour18:Nest.Standard.baseline	-0.070758	0.083292	313852	-0.85	0.3956
hour19:Nest.Standard.baseline	0.011754	0.103880	313852	0.11	0.9099
hour18:Ecofactor.TOU.CPP.event	-0.224858	0.118722	313852	-1.89	0.0582
hour19:Ecofactor.TOU.CPP.event	0.035281	0.148038	313852	0.24	0.8116
hour18:Ecofactor.TOU.CPP.nonevent	-0.130428	0.083886	313852	-1.55	0.1200
hour19:Ecofactor.TOU.CPP.nonevent	-0.024381	0.104626	313852	-0.23	0.8157
hour18:Ecofactor.TOU.CPP.baseline	-0.170650	0.084368	313852	-2.02	0.0431
hour19:Ecofactor.TOU.CPP.baseline	-0.103893	0.105221	313852	-0.99	0.3235
hour18:Ecofactor.Standard.event	-0.267582	0.112416	313852	-2.38	0.0173
hour19:Ecofactor.Standard.event	-0.107135	0.140174	313852	-0.76	0.4447
hour18:Ecofactor.Standard.nonevent	-0.105542	0.083152	313852	-1.27	0.2043
hour19:Ecofactor.Standard.nonevent	-0.027797	0.103713	313852	-0.27	0.7887
hour18:Ecofactor.Standard.baseline	-0.115760	0.083546	313852	-1.39	0.1659
hour19:Ecofactor.Standard.baseline	-0.026041	0.104197	313852	-0.25	0.8026
hour18:control.baseline	-0.079814	0.082417	313852	-0.97	0.3328
hour19:control.baseline	0.017939	0.102788	313852	0.17	0.8615
hour18:control.treatment	-0.056814	0.081901	313852	-0.69	0.4879
hour19:control.treatment	0.021993	0.102148	313852	0.22	0.8295
hour18:CDD.2	0.000003	0.000003	313852	1.05	0.2957
hour19:CDD.2	0.000003	0.000004	313852	0.80	0.4228
Nest.TOU.CPP.nonevent:CDD.2	0.000008	0.000004	155966	2.09	0.0367
Nest.TOU.CPP.pretreat:CDD.2	0.000008	0.000004	155966	2.04	0.0413
Nest.Standard.event:CDD.2	0.000007	0.000005	155966	1.49	0.1352
Nest.Standard.nonevent:CDD.2	0.000002	0.000004	155966	0.49	0.6268
Nest.Standard.baseline:CDD.2	0.000007	0.000004	155966	1.85	0.0645
Ecofactor.TOU.CPP.event:CDD.2	0.000011	0.000005	155966	2.20	0.0280
Ecofactor.TOU.CPP.nonevent:CDD.2	0.000011	0.000004	155966	2.75	0.0059
Ecofactor.TOU.CPP.baseline:CDD.2	0.000011	0.000004	155966	2.85	0.0043
Ecofactor.Standard.event:CDD.2	0.000008	0.000005	155966	1.77	0.0772
Ecofactor.Standard.nonevent:CDD.2	0.000004	0.000004	155966	1.04	0.2973

Variable	Coefficient	Std.Error	DF	t-value	p-value
Ecofactor.Standard.baseline:CDD.2	0.000002	0.000004	155966	0.67	0.5008
control.baseline:CDD.2	0.000005	0.000004	155966	1.44	0.1488
control.treatment:CDD.2	0.000008	0.000004	155966	2.15	0.0312
CDD:hour18:Nest.TOU.CPP.nonevent	0.002238	0.001145	313852	1.95	0.0506
CDD:hour19:Nest.TOU.CPP.nonevent	0.001814	0.001428	313852	1.27	0.2040
CDD:hour18:Nest.TOU.CPP.baseline	0.003003	0.001133	313852	2.65	0.0080
CDD:hour19:Nest.TOU.CPP.baseline	0.002228	0.001413	313852	1.58	0.1147
CDD:hour18:Nest.Standard.event	0.003639	0.001465	313852	2.48	0.0130
CDD:hour19:Nest.Standard.event	0.004502	0.001826	313852	2.47	0.0137
CDD:hour18:Nest.Standard.nonevent	0.003236	0.001137	313852	2.85	0.0044
CDD:hour19:Nest.Standard.nonevent	0.002925	0.001417	313852	2.06	0.0390
CDD:hour18:Nest.Standard.baseline	0.003167	0.001126	313852	2.81	0.0049
CDD:hour19:Nest.Standard.baseline	0.003087	0.001404	313852	2.20	0.0279
CDD:hour18:Ecofactor.TOU.CPP.event	0.004374	0.001566	313852	2.79	0.0052
CDD:hour19:Ecofactor.TOU.CPP.event	0.001786	0.001952	313852	0.92	0.3602
CDD:hour18:Ecofactor.TOU.CPP.nonevent	0.002638	0.001160	313852	2.28	0.0229
CDD:hour19:Ecofactor.TOU.CPP.nonevent	0.002978	0.001446	313852	2.06	0.0394
CDD:hour18:Ecofactor.TOU.CPP.baseline	0.003402	0.001145	313852	2.97	0.0030
CDD:hour19:Ecofactor.TOU.CPP.baseline	0.003686	0.001428	313852	2.58	0.0099
CDD:hour18:Ecofactor.Standard.event	0.005648	0.001487	313852	3.80	0.0001
CDD:hour19:Ecofactor.Standard.event	0.003751	0.001854	313852	2.02	0.0431
CDD:hour18:Ecofactor.Standard.nonevent	0.003358	0.001142	313852	2.94	0.0033
CDD:hour19:Ecofactor.Standard.nonevent	0.002075	0.001424	313852	1.46	0.1449
CDD:hour18:Ecofactor.Standard.baseline	0.003532	0.001130	313852	3.12	0.0018
CDD:hour19:Ecofactor.Standard.baseline	0.003089	0.001409	313852	2.19	0.0284
CDD:hour18:control.baseline	0.002834	0.001108	313852	2.56	0.0105
CDD:hour19:control.baseline	0.002415	0.001382	313852	1.75	0.0805
CDD:hour18:control.treatment	0.002478	0.001103	313852	2.25	0.0247
CDD:hour19:control.treatment	0.002134	0.001376	313852	1.55	0.1209
hour18:Nest.TOU.CPP.nonevent:CDD.2	-0.000006	0.000003	313852	-1.88	0.0603
hour19:Nest.TOU.CPP.nonevent:CDD.2	-0.000005	0.000004	313852	-1.12	0.2614
hour18:Nest.TOU.CPP.baseline:CDD.2	-0.000008	0.000003	313852	-2.32	0.0203
hour19:Nest.TOU.CPP.baseline:CDD.2	-0.000006	0.000004	313852	-1.41	0.1579
hour18:Nest.Standard.event:CDD.2	-0.000011	0.000004	313852	-2.65	0.0082
hour19:Nest.Standard.event:CDD.2	-0.000015	0.000005	313852	-2.89	0.0039
hour18:Nest.Standard.nonevent:CDD.2	-0.000007	0.000003	313852	-2.14	0.0323

Variable	Coefficient	Std.Error	DF	t-value	p-value
hour19:Nest.Standard.nonevent:CDD.2	-0.000007	0.000004	313852	-1.64	0.1003
hour18:Nest.Standard.baseline:CDD.2	-0.000008	0.000003	313852	-2.40	0.0163
hour19:Nest.Standard.baseline:CDD.2	-0.000008	0.000004	313852	-1.88	0.0595
hour18:Ecofactor.TOU.CPP.event:CDD.2	-0.000012	0.000004	313852	-2.80	0.0052
hour19:Ecofactor.TOU.CPP.event:CDD.2	-0.000005	0.000005	313852	-0.91	0.3635
hour18:Ecofactor.TOU.CPP.nonevent:CDD.2	-0.000007	0.000003	313852	-1.95	0.0510
hour19:Ecofactor.TOU.CPP.nonevent:CDD.2	-0.000006	0.000004	313852	-1.48	0.1386
hour18:Ecofactor.TOU.CPP.baseline:CDD.2	-0.000009	0.000003	313852	-2.69	0.0071
hour19:Ecofactor.TOU.CPP.baseline:CDD.2	-0.000011	0.000004	313852	-2.61	0.0091
hour18:Ecofactor.Standard.event:CDD.2	-0.000015	0.000004	313852	-3.60	0.0003
hour19:Ecofactor.Standard.event:CDD.2	-0.000012	0.000005	313852	-2.34	0.0193
hour18:Ecofactor.Standard.nonevent:CDD.2	-0.000007	0.000003	313852	-2.14	0.0324
hour19:Ecofactor.Standard.nonevent:CDD.2	-0.000004	0.000004	313852	-0.95	0.3439
hour18:Ecofactor.Standard.baseline:CDD.2	-0.000009	0.000003	313852	-2.82	0.0047
hour19:Ecofactor.Standard.baseline:CDD.2	-0.000008	0.000004	313852	-1.95	0.0510
hour18:control.baseline:CDD.2	-0.000007	0.000003	313852	-2.21	0.0273
hour19:control.baseline:CDD.2	-0.000007	0.000004	313852	-1.85	0.0648
hour18:control.treatment:CDD.2	-0.000007	0.000003	313852	-2.10	0.0354
hour19:control.treatment:CDD.2	-0.000007	0.000004	313852	-1.77	0.0773

Table 35. Model Coefficients, POST peak model

Variable	Coefficient	Std.Error	DF	t-value	p-value
CDH	0.01250	0.00090	313852	13.93	<0.0001
CDD	0.00687	0.00106	155966	6.48	<0.0001
hour20	1.12450	0.10351	313852	10.86	<0.0001
hour21	1.10428	0.10355	313852	10.66	<0.0001
hour22	1.03769	0.10354	313852	10.02	<0.0001
Nest.TOU.CPP.nonevent	-0.05457	0.08194	155966	-0.67	0.5054
Nest.TOU.CPP.baseline	-0.10212	0.08233	155966	-1.24	0.2148
Nest.Standard.event	-0.08548	0.14290	155966	-0.60	0.5497
Nest.Standard.nonevent	-0.02028	0.12356	155966	-0.16	0.8696
Nest.Standard.baseline	-0.08127	0.12380	155966	-0.66	0.5115
Ecofactor.TOU.CPP.event	-0.03920	0.15349	155966	-0.26	0.7984
Ecofactor.TOU.CPP.nonevent	-0.02536	0.12934	155966	-0.20	0.8445
Ecofactor.TOU.CPP.baseline	-0.07096	0.12964	155966	-0.55	0.5841
Ecofactor.Standard.event	-0.08314	0.14547	155966	-0.57	0.5676
Ecofactor.Standard.nonevent	-0.01106	0.12498	155966	-0.09	0.9295
Ecofactor.Standard.baseline	-0.04417	0.12524	155966	-0.35	0.7243
control.baseline	-0.08582	0.11862	155966	-0.72	0.4694
control.treatment	-0.05977	0.11827	155966	-0.51	0.6133
CDD.2	0.00000	0.00000	155966	-0.22	0.8260
CDD:hour21	-0.00105	0.00100	313852	-1.05	0.2935
CDD:hour22	-0.00205	0.00125	313852	-1.64	0.1000
CDD:Nest.TOU.CPP.nonevent	-0.00029	0.00113	155966	-0.26	0.7950
CDD:Nest.TOU.CPP.baseline	0.00182	0.00112	155966	1.63	0.1027
CDD:Nest.Standard.event	0.00324	0.00144	155966	2.25	0.0246
CDD:Nest.Standard.nonevent	0.00199	0.00112	155966	1.78	0.0749
CDD:Nest.Standard.baseline	0.00294	0.00111	155966	2.66	0.0079
CDD:Ecofactor.TOU.CPP.event	0.00065	0.00154	155966	0.42	0.6729
CDD:Ecofactor.TOU.CPP.nonevent	0.00007	0.00114	155966	0.06	0.9537
CDD:Ecofactor.TOU.CPP.baseline	0.00255	0.00113	155966	2.26	0.0239
CDD:Ecofactor.Standard.event	0.00079	0.00146	155966	0.54	0.5891
CDD:Ecofactor.Standard.nonevent	0.00058	0.00112	155966	0.51	0.6076
CDD:Ecofactor.Standard.baseline	0.00429	0.00111	155966	3.86	0.0001
CDD:control.baseline	0.00148	0.00109	155966	1.36	0.1751
CDD:control.treatment	0.00057	0.00109	155966	0.52	0.5997
hour21:Nest.TOU.CPP.nonevent	0.07620	0.07866	313852	0.97	0.3327
hour22:Nest.TOU.CPP.nonevent	0.15584	0.09758	313852	1.60	0.1102

Variable	Coefficient	Std.Error	DF	t-value	p-value
hour21:Nest.TOU.CPP.baseline	0.04451	0.07903	313852	0.56	0.5733
hour22:Nest.TOU.CPP.baseline	0.20189	0.09803	313852	2.06	0.0395
hour21:Nest.Standard.event	0.13575	0.10439	313852	1.30	0.1934
hour22:Nest.Standard.event	0.14608	0.12950	313852	1.13	0.2593
hour21:Nest.Standard.nonevent	0.10117	0.07836	313852	1.29	0.1967
hour22:Nest.Standard.nonevent	0.19351	0.09721	313852	1.99	0.0465
hour21:Nest.Standard.baseline	0.10912	0.07871	313852	1.39	0.1657
hour22:Nest.Standard.baseline	0.23396	0.09764	313852	2.40	0.0166
hour21:Ecofactor.TOU.CPP.event	0.13201	0.11219	313852	1.18	0.2393
hour22:Ecofactor.TOU.CPP.event	0.06964	0.13918	313852	0.50	0.6168
hour21:Ecofactor.TOU.CPP.nonevent	0.13869	0.07927	313852	1.75	0.0802
hour22:Ecofactor.TOU.CPP.nonevent	0.24115	0.09834	313852	2.45	0.0142
hour21:Ecofactor.TOU.CPP.baseline	0.06880	0.07973	313852	0.86	0.3882
hour22:Ecofactor.TOU.CPP.baseline	0.23070	0.09890	313852	2.33	0.0197
hour21:Ecofactor.Standard.event	0.08977	0.10623	313852	0.85	0.3981
hour22:Ecofactor.Standard.event	0.04442	0.13179	313852	0.34	0.7361
hour21:Ecofactor.Standard.nonevent	0.09494	0.07858	313852	1.21	0.2270
hour22:Ecofactor.Standard.nonevent	0.14917	0.09748	313852	1.53	0.1259
hour21:Ecofactor.Standard.baseline	0.09771	0.07895	313852	1.24	0.2159
hour22:Ecofactor.Standard.baseline	0.20966	0.09794	313852	2.14	0.0323
hour21:control.baseline	0.08707	0.07788	313852	1.12	0.2636
hour22:control.baseline	0.15597	0.09661	313852	1.61	0.1064
hour21:control.treatment	0.08658	0.07739	313852	1.12	0.2633
hour22:control.treatment	0.14921	0.09601	313852	1.55	0.1202
hour21:CDD.2	0.00000	0.00000	313852	1.51	0.1303
hour22:CDD.2	0.00000	0.00000	313852	1.40	0.1615
Nest.TOU.CPP.nonevent:CDD.2	0.00000	0.00000	155966	1.32	0.1885
Nest.TOU.CPP.baseline:CDD.2	0.00000	0.00000	155966	-0.07	0.9478
Nest.Standard.event:CDD.2	-0.00001	0.00000	155966	-1.99	0.0469
Nest.Standard.nonevent:CDD.2	0.00000	0.00000	155966	-1.08	0.2782
Nest.Standard.baseline:CDD.2	0.00000	0.00000	155966	-0.72	0.4691
Ecofactor.TOU.CPP.event:CDD.2	0.00000	0.00000	155966	0.18	0.8586
Ecofactor.TOU.CPP.nonevent:CDD.2	0.00000	0.00000	155966	1.25	0.2120
Ecofactor.TOU.CPP.baseline:CDD.2	0.00000	0.00000	155966	-0.32	0.7523
Ecofactor.Standard.event:CDD.2	0.00000	0.00000	155966	0.37	0.7138
Ecofactor.Standard.nonevent:CDD.2	0.00000	0.00000	155966	0.67	0.5030

Variable	Coefficient	Std.Error	DF	t-value	p-value
Ecofactor.Standard.baseline:CDD.2	-0.00001	0.00000	155966	-2.33	0.0200
control.baseline:CDD.2	0.00000	0.00000	155966	-0.67	0.4998
control.treatment:CDD.2	0.00000	0.00000	155966	0.23	0.8152
CDD:hour21:Nest.TOU.CPP.nonevent	-0.00127	0.00108	313852	-1.17	0.2401
CDD:hour22:Nest.TOU.CPP.nonevent	-0.00210	0.00134	313852	-1.56	0.1179
CDD:hour21:Nest.TOU.CPP.baseline	-0.00126	0.00107	313852	-1.17	0.2406
CDD:hour22:Nest.TOU.CPP.baseline	-0.00307	0.00133	313852	-2.31	0.0207
CDD:hour21:Nest.Standard.event	-0.00251	0.00138	313852	-1.81	0.0701
CDD:hour22:Nest.Standard.event	-0.00340	0.00172	313852	-1.98	0.0477
CDD:hour21:Nest.Standard.nonevent	-0.00283	0.00107	313852	-2.63	0.0085
CDD:hour22:Nest.Standard.nonevent	-0.00390	0.00133	313852	-2.92	0.0035
CDD:hour21:Nest.Standard.baseline	-0.00190	0.00106	313852	-1.78	0.0743
CDD:hour22:Nest.Standard.baseline	-0.00357	0.00132	313852	-2.71	0.0068
CDD:hour21:Ecofactor.TOU.CPP.event	-0.00058	0.00148	313852	-0.39	0.6956
CDD:hour22:Ecofactor.TOU.CPP.event	0.00088	0.00184	313852	0.48	0.6331
CDD:hour21:Ecofactor.TOU.CPP.nonevent	-0.00134	0.00110	313852	-1.22	0.2226
CDD:hour22:Ecofactor.TOU.CPP.nonevent	-0.00122	0.00136	313852	-0.90	0.3690
CDD:hour21:Ecofactor.TOU.CPP.baseline	-0.00187	0.00108	313852	-1.73	0.0840
CDD:hour22:Ecofactor.TOU.CPP.baseline	-0.00327	0.00134	313852	-2.44	0.0148
CDD:hour21:Ecofactor.Standard.event	-0.00037	0.00141	313852	-0.26	0.7913
CDD:hour22:Ecofactor.Standard.event	-0.00021	0.00174	313852	-0.12	0.9053
CDD:hour21:Ecofactor.Standard.nonevent	-0.00147	0.00108	313852	-1.36	0.1740
CDD:hour22:Ecofactor.Standard.nonevent	-0.00158	0.00134	313852	-1.18	0.2376
CDD:hour21:Ecofactor.Standard.baseline	-0.00280	0.00107	313852	-2.62	0.0089
CDD:hour22:Ecofactor.Standard.baseline	-0.00493	0.00133	313852	-3.72	0.0002
CDD:hour21:control.baseline	-0.00180	0.00105	313852	-1.72	0.0849
CDD:hour22:control.baseline	-0.00263	0.00130	313852	-2.03	0.0427
CDD:hour21:control.treatment	-0.00196	0.00104	313852	-1.88	0.0599
CDD:hour22:control.treatment	-0.00269	0.00129	313852	-2.08	0.0375
hour21:Nest.TOU.CPP.nonevent:CDD.2	0.00000	0.00000	313852	0.30	0.7624
hour22:Nest.TOU.CPP.nonevent:CDD.2	0.00000	0.00000	313852	1.02	0.3091
hour21:Nest.TOU.CPP.baseline:CDD.2	0.00000	0.00000	313852	-0.34	0.7365
hour22:Nest.TOU.CPP.baseline:CDD.2	0.00000	0.00000	313852	0.68	0.4976
hour21:Nest.Standard.event:CDD.2	0.00000	0.00000	313852	0.93	0.3525
hour22:Nest.Standard.event:CDD.2	0.00001	0.00000	313852	1.51	0.1308
hour21:Nest.Standard.nonevent:CDD.2	0.00001	0.00000	313852	1.64	0.1009

Variable	Coefficient	Std.Error	DF	t-value	p-value
hour22:Nest.Standard.nonevent:CDD.2	0.00001	0.00000	313852	2.30	0.0213
hour21:Nest.Standard.baseline:CDD.2	0.00000	0.00000	313852	0.50	0.6136
hour22:Nest.Standard.baseline:CDD.2	0.00001	0.00000	313852	1.40	0.1620
hour21:Ecofactor.TOU.CPP.event:CDD.2	0.00000	0.00000	313852	-0.07	0.9414
hour22:Ecofactor.TOU.CPP.event:CDD.2	0.00000	0.00001	313852	-0.66	0.5119
hour21:Ecofactor.TOU.CPP.nonevent:CDD.2	0.00000	0.00000	313852	0.58	0.5624
hour22:Ecofactor.TOU.CPP.nonevent:CDD.2	0.00000	0.00000	313852	0.04	0.9719
hour21:Ecofactor.TOU.CPP.baseline:CDD.2	0.00000	0.00000	313852	0.70	0.4843
hour22:Ecofactor.TOU.CPP.baseline:CDD.2	0.00001	0.00000	313852	1.30	0.1939
hour21:Ecofactor.Standard.event:CDD.2	0.00000	0.00000	313852	-0.75	0.4531
hour22:Ecofactor.Standard.event:CDD.2	0.00000	0.00000	313852	-0.52	0.6031
hour21:Ecofactor.Standard.nonevent:CDD.2	0.00000	0.00000	313852	0.23	0.8202
hour22:Ecofactor.Standard.nonevent:CDD.2	0.00000	0.00000	313852	-0.07	0.9424
hour21:Ecofactor.Standard.baseline:CDD.2	0.00000	0.00000	313852	1.27	0.2030
hour22:Ecofactor.Standard.baseline:CDD.2	0.00001	0.00000	313852	2.31	0.0207
hour21:control.baseline:CDD.2	0.00000	0.00000	313852	0.33	0.7394
hour22:control.baseline:CDD.2	0.00000	0.00000	313852	0.73	0.4661
hour21:control.treatment:CDD.2	0.00000	0.00000	313852	0.53	0.5989
hour22:control.treatment:CDD.2	0.00000	0.00000	313852	0.84	0.3987

Model Diagnostics

PRE peak model

Table 36 provides a summary of residuals for the PRE peak model

Table 36. Summary of residuals, PRE peak model

Min	1st Qu.	Median	Mean	3rd Qu.	Max
-6.5460	-0.5330	-0.1411	0.0000	0.3246	11.0100

Figure 48 provides scatter plot of normalized residuals versus fitted values for PRE peak model.

Figure 48. Scatter plot of normalized residuals versus fitted values for PRE peak model

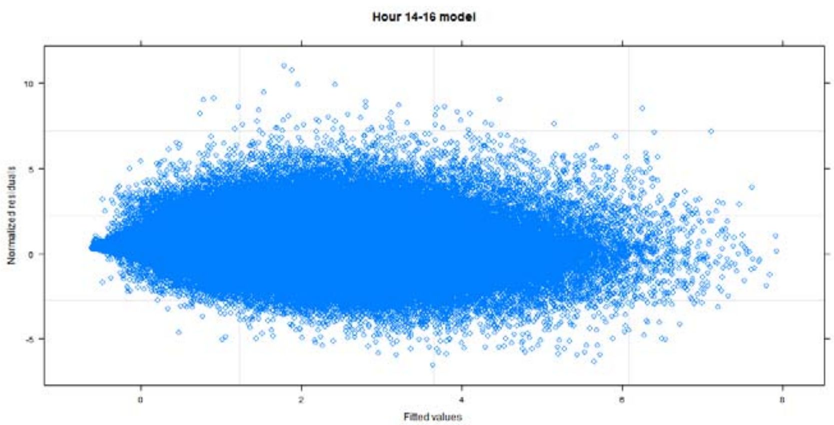


Figure 49 provides a normal plot of residuals for the PRE peak model.

Figure 49. Normal plot of residuals, PRE peak model

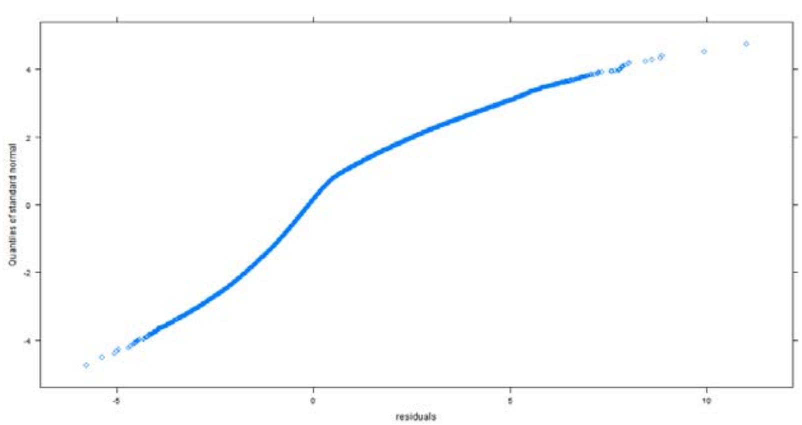


Figure 50 provides a normal plot of estimated random effects for the PRE peak model.

FIGURE 50.NORMAL PLOT OF ESTIMATED RANDOM EFFECTS, PRE PEAK MODEL

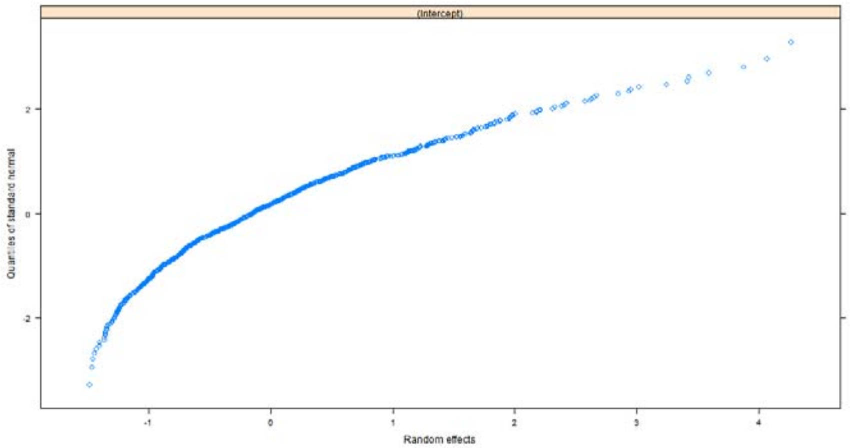
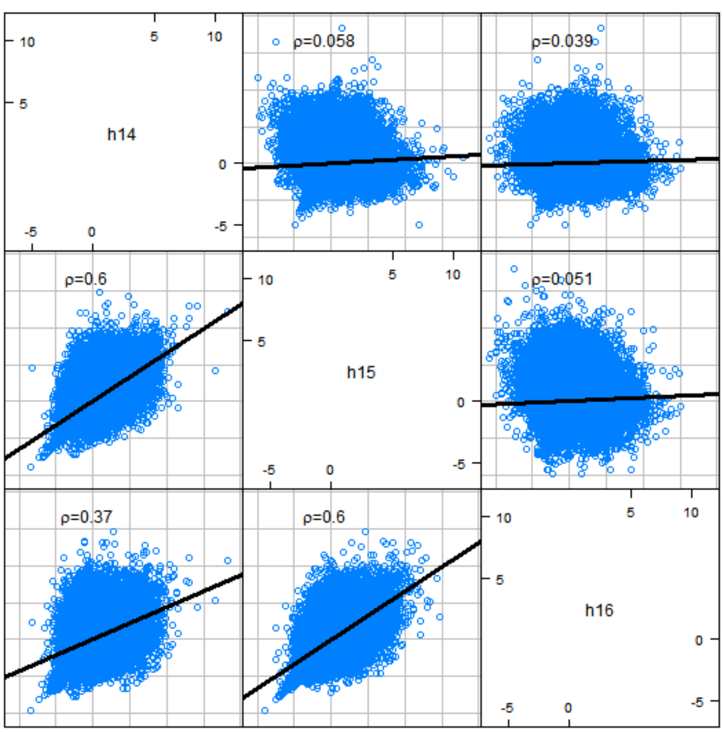


Figure 51 shows the scatter plot of Pearson and Normalized residuals (pearson - lower panel, normalized – upper panel). Pearson residuals show a correlation between the residuals for hours 14-16. Normalized residuals show that the residuals are approximately uncorrelated for hours 14-16. This correction was applied to the pre-peak, peak, and post-peak models.

FIGURE 51.SCATTER PLOT MATRIX OF PEARSON AND NORMALIZED RESIDUALS, PRE PEAK MODEL



PEAK MODEL

Table 37 provides a summary of residuals for the PEAK model.

TABLE 37.SUMMARY OF RESIDUALS, PEAK MODEL

Min	1st Qu.	Median	Mean	3rd Qu.	Max
-6.3940	-0.5529	-0.1040	0.0000	0.4388	10.1500

Figure 52 provides a scatter plot of the normalized residuals versus the fitted values for the PEAK model.

Figure 52.Scatter plot of normalized residuals versus fitted values for PEAK model.

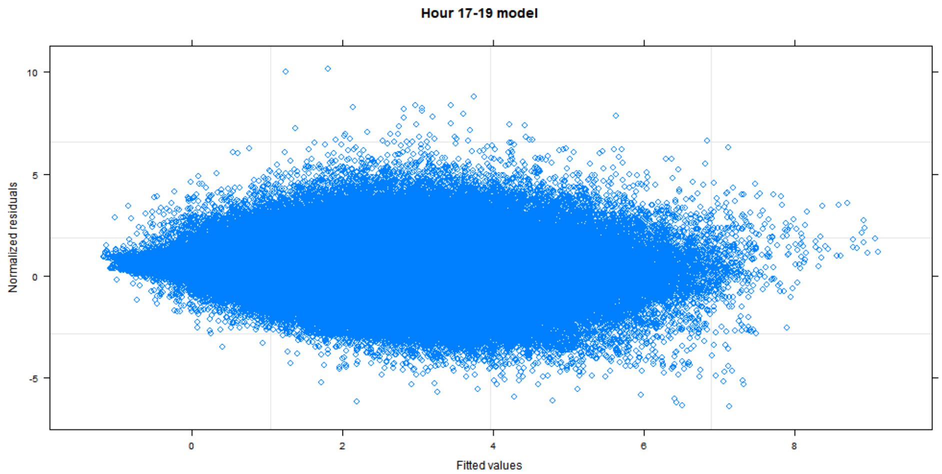


Figure 53 provides normal plot of residuals for PEAK model.

FIGURE 53.NORMAL PLOT OF RESIDUALS, PEAK MODEL

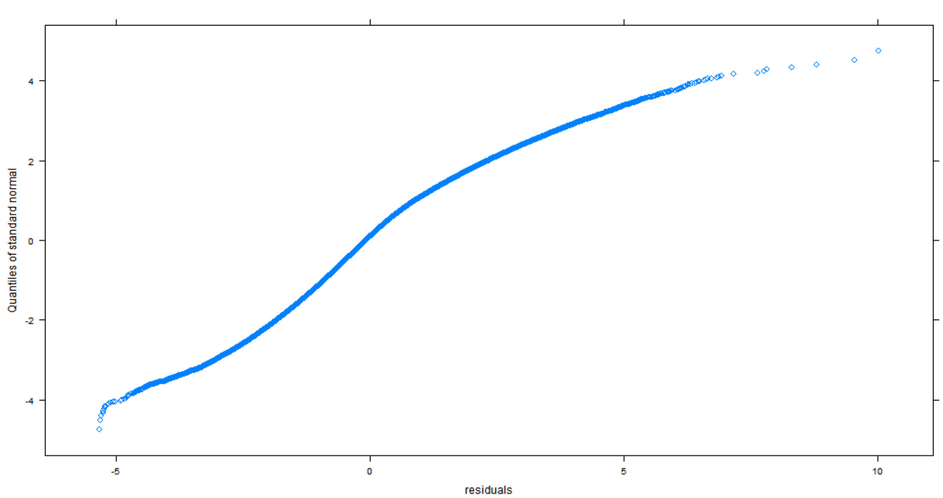


Figure 54 provides a normal plot of the estimated random effects for the PEAK model.

FIGURE 54. NORMAL PLOT OF ESTIMATED RANDOM EFFECTS, PEAK MODEL

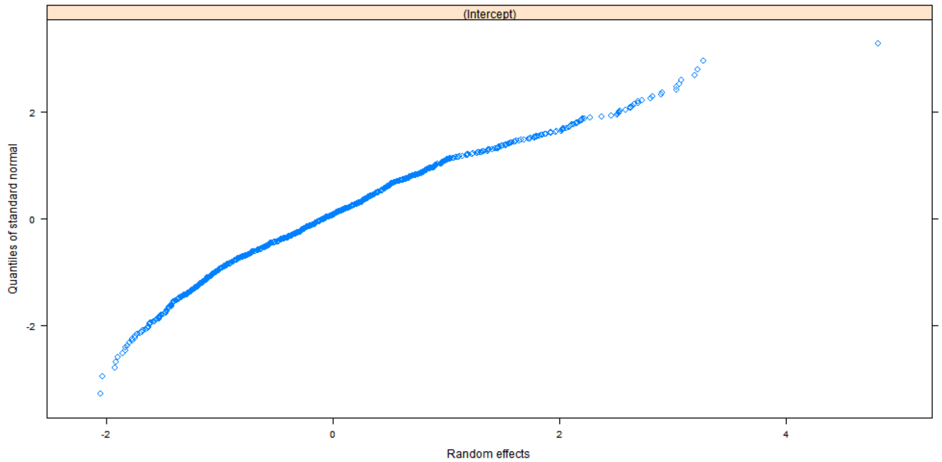
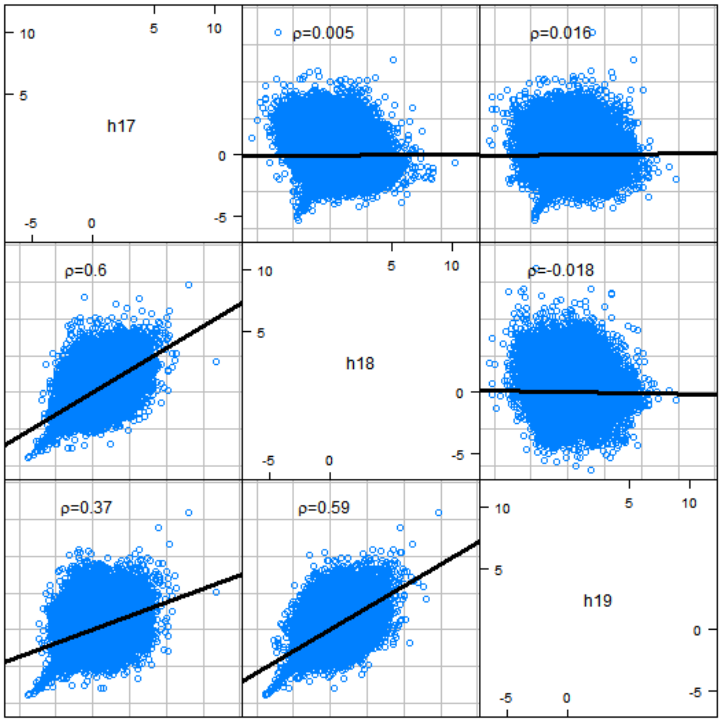


Figure 55 is a scatter plot of Pearson and Normalized residuals. Pearson residuals in the lower left panels show a strong correlation between the residuals for hours 17-19, while the normalized residuals in the upper-right panels show that the residuals are approximately uncorrelated for hours 17-19.

FIGURE 55. SCATTER PLOT MATRIX OF PEARSON AND NORMALIZED RESIDUALS, PEAK MODEL



POST PEAK MODEL

Table 38 provides a summary of residuals for the POST peak model.

TABLE 38. SUMMARY OF RESIDUALS, POST PEAK MODEL

Min	1st Qu.	Median	Mean	3rd Qu.	Max
-6.0670	-0.5222	-0.0744	0.0000	0.3874	11.4700

Figure 56 provides a scatter plot of normalized residuals versus fitted values for the POST peak model.

FIGURE 56.SCATTER PLOT OF NORMALIZED RESIDUALS VERSUS FITTED VALUES, POST PEAK MODEL

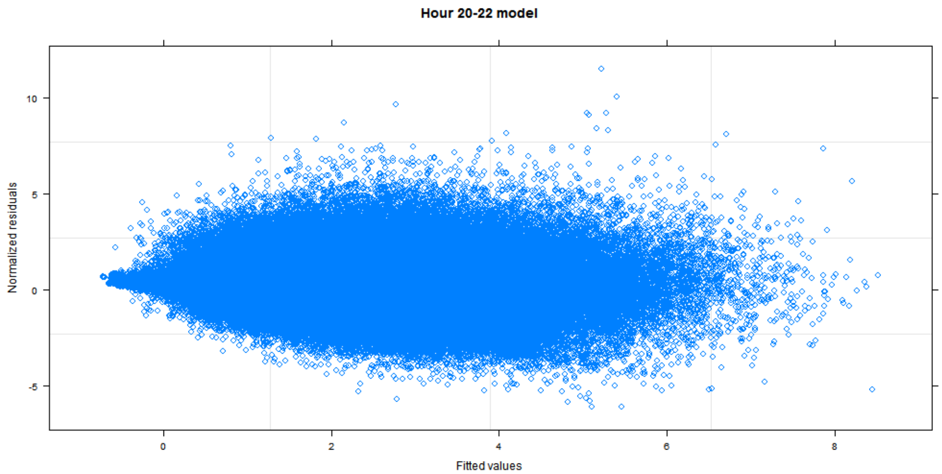


Figure 57 provides a normal plot of residuals for the POST peak model.

FIGURE 57. NORMAL PLOT OF RESIDUALS, POST PEAK MODEL

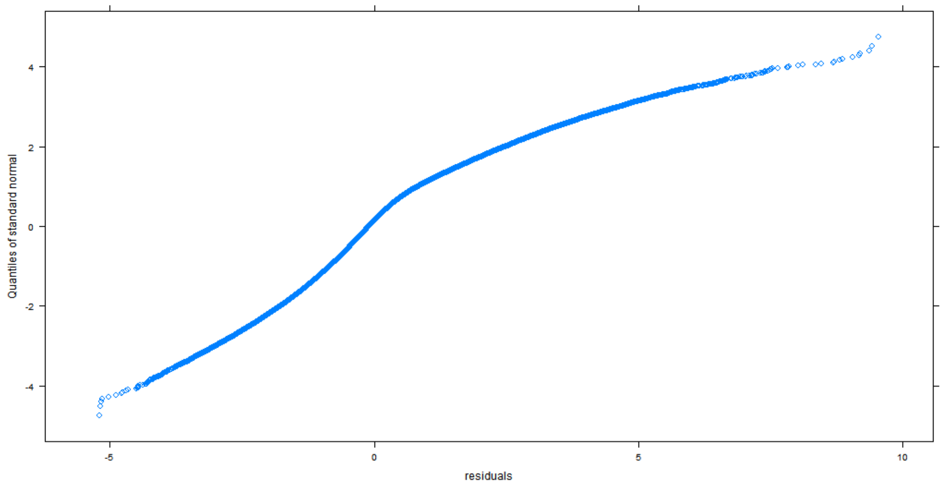


Figure 58 provides a normal plot of estimated random effects for the POST peak model.

FIGURE 58. NORMAL PLOT OF ESTIMATED RANDOM EFFECTS, POST PEAK MODEL

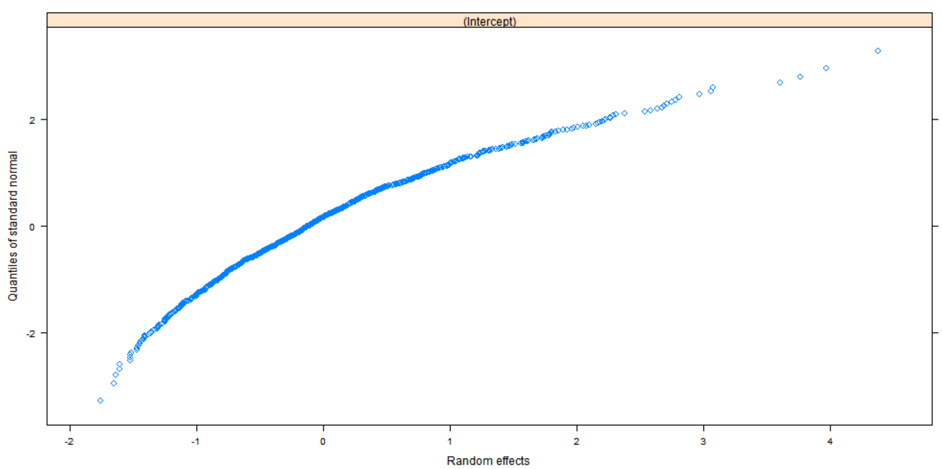
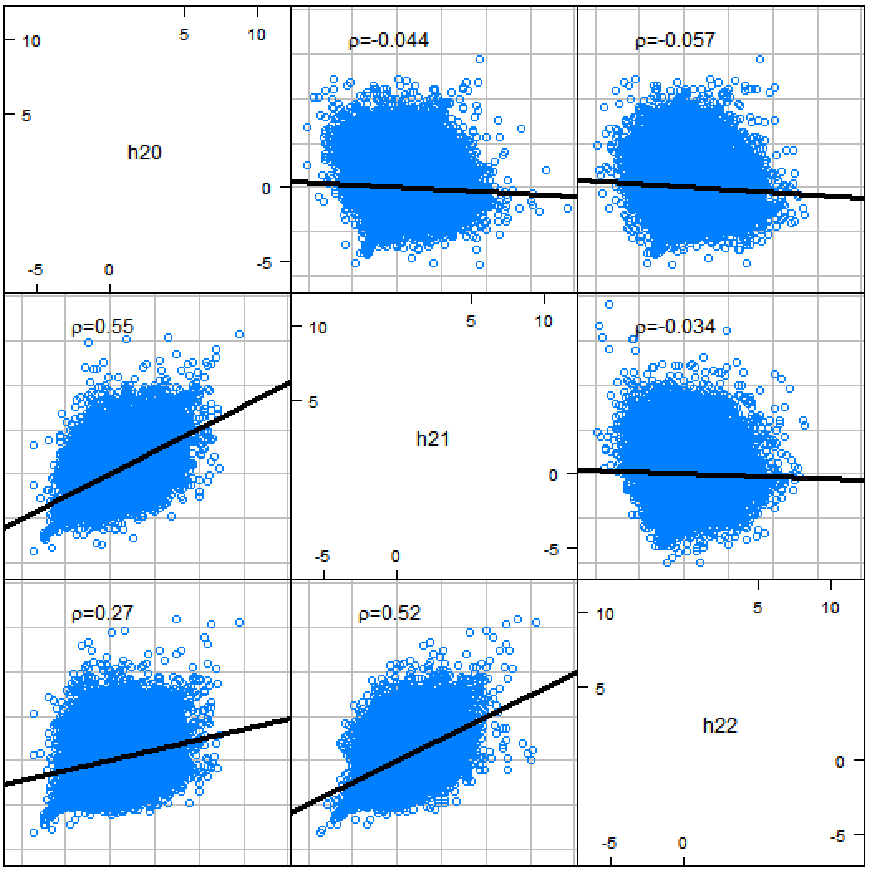


Figure 59 provides scatter plots of Pearson and Normalized residuals. Pearson residuals in the lower left panels show a strong correlation between the residuals for hours 20-22, while the normalized plots in the upper right panels show that the residuals are approximately uncorrelated for hours 20-22.

FIGURE 59.SCATTER PLOT MATRIX OF PEARSON AND NORMALIZED RESIDUALS, POST PEAK MODEL



MODEL DETAILS

CONTRASTS

1. *Treatment loads are not different from baseline loads (adjusted for weather and exogenous effects)*

$H_0: L = 0$

$H_a: L \neq 0$

$L = \sum_{i=1}^{12} c_i \mu_i \ where \ \sum_{i=1}^{12} c_i = 0, If \ |t^* = \frac{L}{\sigma^2\{L\}}| \leq t(n-p-q), then \ H_0; otherwise, H_a$

- n=number of observations
- p = number of model parameters associated with fixed effects
- q = number of covariance parameters with random effects or correlations

For peak model, $c_1 through \ c_{12} = {}^1/_3, -{}^1/_3, {}^1/_3, -{}^1/_3, {}^1/_3, -{}^1/_3, -{}^1/_3, {}^1/_3, -{}^1/_3, {}^1/_3, -{}^1/_3, {}^1/_3$

2. *Treatment type has no effect on impacts (adjusted for weather and exogenous effects)*

Same as in 1 above but different set of means (see contrast example).

CONTRASTS EXAMPLES

Nest.TOU-CPP event peak impact relative to baseline (adjusted for weather and exogenous effects), and comparing Nest.TOU-CPP and Nest.Standard treatments event peak impacts (adjusted for weather and pretreatment differences)

1. *Treatment loads are not different from baseline loads (adjusted for weather and exogenous effects)*

$$\hat{L} = \left[\frac{(\hat{\mu}_{Nest.TOU-CPP.event.at.hr17} - \hat{\mu}_{Nest.TOU-CPP.baseline.at.hr17}) + (\hat{\mu}_{Nest.TOU-CPP.event.at.hr18} - \hat{\mu}_{Nest.TOU-CPP.baseline.at.hr18}) + (\hat{\mu}_{Nest.TOU-CPP.event.at.hr19} - \hat{\mu}_{Nest.TOU-CPP.baseline.at.hr19})}{3}\right] - \left[\frac{(\hat{\mu}_{control.treatment.hr17} - \hat{\mu}_{control.baseline.hr17}) + (\hat{\mu}_{control.treatment.hr18} - \hat{\mu}_{control.baseline.hr18}) + (\hat{\mu}_{control.treatment.hr19} - \hat{\mu}_{control.baseline.hr19})}{3}\right]$$

2. *Treatment type has no effect on impacts (adjusted for weather and exogenous effects)*

$$\hat{L} = \left[\frac{(\hat{\mu}_{Nest.TOU-CPP.event.at.hr17} - \hat{\mu}_{Nest.TOU-CPP.baseline.at.hr17}) + (\hat{\mu}_{Nest.TOU-CPP.event.at.hr18} - \hat{\mu}_{Nest.TOU-CPP.baseline.at.hr18}) + (\hat{\mu}_{Nest.TOU-CPP.event.at.hr19} - \hat{\mu}_{Nest.TOU-CPP.baseline.at.hr19})}{3}\right] - \left[\frac{(\hat{\mu}_{Nest.Standard.event.at.hr17} - \hat{\mu}_{Nest.Standard.baseline.at.hr17}) + (\hat{\mu}_{Nest.Standard.event.at.hr18} - \hat{\mu}_{Nest.Standard.baseline.at.hr18}) + (\hat{\mu}_{Nest.Standard.event.at.hr19} - \hat{\mu}_{Neset.Standard.baseline.at.hr19})}{3}\right]$$

Notes:

$\mu's$ are estimated using regression coefficients (provided in (6) below) with the temperature profile of interest – average temp weekday summer 2013 days.

Models comparison

Table 39. Model Comparison, PRE peak model

		Model	DF	AIC	BIC	logLik	Test	L.Ratio	p-value
	PRE peak model Random Customer only	1	129	1444123	1445550	-721932.7			
	PRE peak model Random Customer & Day	2	130	1324775	1326213	-662257.3	1 vs 2	119350.7	<0.0001
Final Model	**PRE peak** model Random Customer & Day AR(1)	3	131	1302699	1304148	-651218.5	2 vs 3	22077.6	<0.0001

Table 40. Model Comparison, PEAK model

		Model	DF	AIC	BIC	logLik	Test	L.Ratio	p-value
	PEAK model Random Customer only	1	129	1563433	1564860	-781587.7			
	PEAK model Random Customer & Day	2	130	1444455	1445893	-722097.5	1 vs 2	118980.35	<0.0001
Final Model	**PEAK** model Random Customer & Day AR(1)	3	131	1425817	1427266	-712777.4	2 vs 3	18640.27	<0.0001

Table 41. Model Comparison, POST peak model

		Model	DF	AIC	BIC	logLik	Test	L.Ratio	p-value
	POST peak model Random Customer only	1	129	1446372	1447799	-723056.9			
	POST peak model Random Customer & Day	2	130	1361711	1363150	-680725.7	1 vs 2	84662.31	<0.0001
Final Model	**POST peak** model Random Customer & Day AR(1)	3	131	1340420	1341870	-670079.2	2 vs 3	21293.05	<0.0001

Tests for fixed effects

Table 42.F-tests for variables in the model, PRE peak model

Variable	Numerator DF	Denominator DF	F-value	p-value
CDH	1	313851	467.94	<0.0001
CDD	1	155965	0.88	0.3491
hour	3	313851	32.75	<0.0001
Treatment_Period	13	155965	1.59	0.0793
$\mathbf{CDD^2}$	1	155965	17.13	<0.0001
CDD:hour	2	313851	17.18	<0.0001
CDD:Treatment_Period	13	155965	1.83	0.0326
hour:Treatment_Period	26	313851	1.63	0.0220
$\mathbf{hour: CDD^2}$	2	313851	14.96	<0.0001
$\mathbf{Treatment: CDD^2}$	13	155965	2.47	0.0023
CDD:hour:Treatment_Period	26	313851	1.99	0.0019
$\mathbf{hour: Treatment: CDD^2}$	26	313851	2.25	0.0003

Table 43. F-tests for variables in the model, PEAK model

Variable	Numerator DF	Denominator DF	F-value	p-value
CDH	1	313852	361.65	<0.0001
CDD	1	155966	21.40	<0.0001
hour	3	313852	19.86	<0.0001
Treatment_Period	13	155966	2.01	0.0165
$\mathbf{CDD^2}$	1	155966	3.70	0.0544
CDD:hour	2	313852	0.92	0.3970
CDD:Treatment_Period	13	155966	8.91	<0.0001
hour:Treatment_Period	26	313852	1.72	0.0129
$\mathbf{hour: CDD^2}$	2	313852	0.56	0.5684
$\mathbf{Treatment: CDD^2}$	13	155966	2.70	0.0008
CDD:hour:Treatment_Period	26	313852	1.72	0.0125
$\mathbf{hour: Treatment: CDD^2}$	26	313852	1.43	0.0731

Table 44. F-tests for variables in the model, POST peak model

Variable	Numerator DF	Denominator DF	F-value	p-value
CDH	1	313852	194.11	<0.0001
CDD	1	155966	42.05	<0.0001
hour	3	313852	47.10	<0.0001
Treatment_Period	13	155966	0.87	0.5854
$\mathbf{CDD^2}$	1	155966	0.05	0.8260
CDD:hour	2	313852	1.35	0.2584
CDD:Treatment_Period	13	155966	9.65	<0.0001
hour:Treatment_Period	26	313852	1.88	0.0044
$\mathbf{hour: CDD^2}$	2	313852	1.32	0.2678
$\mathbf{Treatment: CDD^2}$	13	155966	4.86	<0.0001
CDD:hour:Treatment_Period	26	313852	3.04	<0.0001
$\mathbf{hour: Treatment: CDD^2}$	26	313852	1.88	0.0042

Variance covariance matrices

Table 45. Variance covariance matrix, PRE peak model

	Variance	StdDev
Customer (Intercept)	0.83932726	0.9161481
Day (Intercept)	0.02928096	0.1711168
Residual	1.21350283	1.1015910

Table 46. Variance covariance matrix, PEAK model

	Variance	StdDev
Customer (Intercept)	1.0398774	1.0197438
Day (Intercept)	0.1484295	0.38526655
Residual	1.4485622	1.2035623

Table 47. Variance covariance matrix, POST peak model

	Variance	StdDev
Customer (Intercept)	0.7914413	0.889629874
Day (Intercept)	1.340077e-07	0.0003660706
Residual	1.249048	1.1176080707

Corrections

AR(1) error structure was the only correction applied. See diagnostic plots.

Results, by day type

(A) Event

Table 48. Event impacts, by treatment

Treatment Group	N	Time Period (event) hour	Savings (kWh/h)	Standard Error	95% Confidence Intervals		Reference Load (2012)	% Savings
Nest.TOU-CPP	175	14-16	**-0.22***	0.0582	-0.3695	-0.0785	3.28	-6.8%
Nest.Standard	194	14-16	**-0.18***	0.0555	-0.3214	-0.0440	3.28	-5.6%
Ecofactor.TOU-CPP	147	14-16	**-0.39***	0.0606	-0.5409	-0.2380	3.43	-11%
Ecofactor.Standard	180	14-16	**-0.40***	0.0565	-0.5423	-0.2597	3.46	-12%
Nest.TOU-CPP	175	17-19	**-1.50***	0.0658	-1.6795	-1.3505	4.13	-37%
Nest.Standard	194	17-19	**-0.21***	0.0627	-0.3692	-0.0556	4.20	-5.1%
Ecofactor.TOU-CPP	147	17-19	**-1.20***	0.0685	-1.3603	-1.0177	4.20	-28%
Ecofactor.Standard	180	17-19	**-0.24***	0.0639	-0.4000	-0.0804	4.17	-5.8%
Nest.TOU-CPP	175	20-22	-0.13	0.0563	-0.2675	0.0141	3.48	-3.6%
Nest.Standard	194	20-22	**-0.37***	0.0537	-0.5013	-0.2329	3.72	-9.9%
Ecofactor.TOU-CPP	147	20-22	**-0.19***	0.0586	-0.3406	-0.0476	3.76	-5.2%
Ecofactor.Standard	180	20-22	**-0.18***	0.0547	-0.3184	-0.0449	3.64	-5.0%
Nest.TOU-CPP	175	1-24	**-0.16***	0.0123	-0.1870	-0.1256	2.20	-7.1%
Nest.Standard	194	1-24	**-0.08***	0.0118	-0.1079	-0.0489	2.27	-3.5%
Ecofactor.TOU-CPP	147	1-24	**-0.23***	0.0130	-0.2650	-0.2002	2.39	-9.7%
Ecofactor.Standard	180	1-24	**-0.07***	0.0121	-0.0995	-0.0391	2.28	-3.0%

* Statistically significant, α=0.05

Table 49. Event impacts, between-treatment comparisons

Treatment Group	Time Period (event)	Savings (kWh/h)	Standard Error	95% Confidence Intervals	
Nest.TOU-CPP vs Nest.Standard	14-16	-0.041	0.0658	-0.2180	0.1360
Nest.TOU-CPP vs Ecofactor.TOU-CPP	14-16	+0.17	0.0701	-0.0186	0.3586
Nest.TOU-CPP vs Ecofactor.Standard	14-16	**+0.18***	0.0667	0.0006	0.3594
Nest.Standard vs Ecofactor.TOU-CPP	14-16	**+0.21***	0.0679	0.0273	0.3927
Nest.Standard vs Ecofactor.Standard	14-16	**+0.22***	0.0643	0.0470	0.3930
Ecofactor.TOU-CPP vs Ecofactor.Standard	14-16	+0.01	0.0688	-0.1731	0.1971
Nest.TOU-CPP vs Nest.Standard	17-19	**-1.31***	0.0744	-1.5001	-1.0999
Nest.TOU-CPP vs Ecofactor.TOU-CPP	17-19	**-0.33***	0.0793	-0.5433	-0.1167
Nest.TOU-CPP vs Ecofactor.Standard	17-19	**-1.28***	0.0754	-1.5028	-1.0972
Nest.Standard vs Ecofactor.TOU-CPP	17-19	**+0.98***	0.0768	0.7734	1.1866
Nest.Standard vs Ecofactor.Standard	17-19	+0.028	0.0727	-0.1676	0.2236
Ecofactor.TOU-CPP vs Ecofactor.Standard	17-19	**-0.95***	0.0777	-1.1590	-0.7410
Nest.TOU-CPP vs Nest.Standard	20-22	**+0.24***	0.0636	0.0689	0.4111
Nest.TOU-CPP vs Ecofactor.TOU-CPP	20-22	+0.07	0.0678	-0.1154	0.2494
Nest.TOU-CPP vs Ecofactor.Standard	20-22	+0.06	0.0645	-0.1185	0.2285
Nest.Standard vs Ecofactor.TOU-CPP	20-22	-0.17	0.0657	-0.3467	0.0067
Nest.Standard vs Ecofactor.Standard	20-22	**-0.19***	0.0622	-0.3573	-0.0227
Ecofactor.TOU-CPP vs Ecofactor.Standard	20-22	-0.01	0.0665	-0.1909	0.1669

* Statistically significant, α=0.05.

(B) Nonevent

Table 50. Nonevent impacts, by treatment

Treatment Group	N	Time Period (nonevent)	Savings (kWh/h)	Standard Error	95% Confidence Intervals		Reference Load (2012)	% Savings
Nest.TOU-CPP	175	14-16	+0.034	0.0174	-0.0093	0.0780	1.39	+2.5%
Nest.Standard	194	14-16	**-0.043***	0.0169	-0.0853	-0.0007	1.42	-3.0%
Ecofactor.TOU-CPP	147	14-16	**-0.10***	0.0184	-0.1469	-0.0547	1.51	-6.7%
Ecofactor.Standard	180	14-16	**-0.18***	0.0173	-0.2258	-0.1394	1.61	-11%
Nest.TOU-CPP	175	17-19	**-0.36***	0.0197	-0.4142	-0.3154	2.00	-18%
Nest.Standard	194	17-19	**+0.05***	0.0191	0.00001	0.0956	2.06	+2.3%
Ecofactor.TOU-CPP	147	17-19	**-0.36***	0.0208	-0.4145	-0.3101	2.06	-18%
Ecofactor.Standard	180	17-19	**-0.16***	0.0195	-0.2092	-0.1114	2.21	-7.3%
Nest.TOU-CPP	175	20-22	-0.03	0.0169	-0.0749	0.0096	1.73	-1.9%
Nest.Standard	194	20-22	-0.03	0.0163	-0.0705	0.0114	1.85	-1.6%
Ecofactor.TOU-CPP	147	20-22	-0.005	0.0178	-0.0500	0.0393	1.83	-0.3%
Ecofactor.Standard	180	20-22	**-0.10***	0.0167	-0.1389	-0.0553	1.90	-5.1%
Nest.TOU-CPP	175	1-24	**-0.04***	0.0037	-0.0508	-0.0324	1.18	-3.5%
Nest.Standard	194	1-24	+0.003	0.0036	-0.0057	0.0122	1.20	+0.3%
Ecofactor.TOU-CPP	147	1-24	**-0.05***	0.0039	-0.0560	-0.0363	1.26	-3.6%
Ecofactor.Standard	180	1-24	**-0.05***	0.0037	-0.0601	-0.0417	1.27	-4.0%

Table 51. Nonevent impacts, between-treatment comparisons

Treatment Group	Time Period (nonevent)	Savings (kWh/h)	Standard Error	95% Confidence Intervals	
Nest.TOU-CPP vs Nest.Standard	14-16	**+0.077***	0.0190	0.0259	0.1281
Nest.TOU-CPP vs Ecofactor.TOU-CPP	14-16	**+0.14***	0.0204	0.0851	0.1949
Nest.TOU-CPP vs Ecofactor.Standard	14-16	**+0.22***	0.0194	0.1678	0.2722
Nest.Standard vs Ecofactor.TOU-CPP	14-16	**+0.058***	0.0199	0.0045	0.1115
Nest.Standard vs Ecofactor.Standard	14-16	**+0.14***	0.0189	0.0892	0.1908
Ecofactor.TOU-CPP vs Ecofactor.Standard	14-16	**+0.082***	0.0203	0.0274	0.1366
Nest.TOU-CPP vs Nest.Standard	17-19	**-0.41***	0.0215	-0.4678	-0.3522
Nest.TOU-CPP vs Ecofactor.TOU-CPP	17-19	-0.0024	0.0231	-0.0646	0.0596
Nest.TOU-CPP vs Ecofactor.Standard	17-19	**-0.20***	0.0219	-0.2589	-0.1411
Nest.Standard vs Ecofactor.TOU-CPP	17-19	**+0.41***	0.0226	0.3492	0.4708
Nest.Standard vs Ecofactor.Standard	17-19	**+0.21***	0.0213	0.1527	0.2673
Ecofactor.TOU-CPP vs Ecofactor.Standard	17-19	**-0.20***	0.0229	-0.2616	-0.1384
Nest.TOU-CPP vs Nest.Standard	20-22	-0.0031	0.0184	-0.0526	0.0464
Nest.TOU-CPP vs Ecofactor.TOU-CPP	20-22	-0.027	0.0198	-0.0803	0.0263
Nest.TOU-CPP vs Ecofactor.Standard	20-22	**+0.064***	0.0187	0.0137	0.1143
Nest.Standard vs Ecofactor.TOU-CPP	20-22	-0.024	0.0193	-0.0759	0.0279
Nest.Standard vs Ecofactor.Standard	20-22	**+0.068***	0.0183	0.0188	0.1172
Ecofactor.TOU-CPP vs Ecofactor.Standard	20-22	**+0.092***	0.0196	0.0393	0.1447

(C) AT DIFFERENT TEMPERATURES

TABLE 52. PEAK IMPACTS ON EVENT DAYS WITH MAX TEMPERATURE OF 90-110°F, NEST.TOU-CPP

Treatment Group	MaxTemp (°F)	N	Time Period (event) hour	Savings (kWh/h)	Standard Error	95% Confidence Intervals		Reference Load (2012)	% Savings
Nest.TOU-CPP	90	175	14-16	+0.06	0.0305	-0.0160	0.1411	1.48	+4.3%
Nest.TOU-CPP	95	175	14-16	+0.03	0.0335	-0.0578	0.1149	1.87	+1.5%
Nest.TOU-CPP	100	175	14-16	-0.05	0.0344	-0.1337	0.0436	2.39	-1.9%
Nest.TOU-CPP	105	175	14-16	**-0.20***	0.0497	-0.3135	-0.0575	3.11	-6.0%
Nest.TOU-CPP	110	175	14-16	**-0.44***	0.1216	-0.7530	-0.1266	4.14	-11%
Nest.TOU-CPP	90	175	17-19	**-0.53***	0.0345	-0.6154	-0.4378	2.15	-25%
Nest.TOU-CPP	95	175	17-19	**-0.75***	0.0379	-0.8489	-0.6535	2.69	-28%
Nest.TOU-CPP	100	175	17-19	**-1.0***	0.0389	-1.1323	-0.9317	3.29	-31%
Nest.TOU-CPP	105	175	17-19	**-1.4***	0.0562	-1.5667	-1.2773	3.99	-36%
Nest.TOU-CPP	110	175	17-19	**-2.0***	0.1375	-2.3382	-1.6298	4.84	-41%
Nest.TOU-CPP	90	175	20-22	+0.021	0.0295	-0.0545	0.0974	1.85	+1.2%
Nest.TOU-CPP	95	175	20-22	+0.007	0.0324	-0.0770	0.0900	2.25	+0.3%
Nest.TOU-CPP	100	175	20-22	-0.03	0.0333	-0.1167	0.0549	2.73	-1.1%
Nest.TOU-CPP	105	175	20-22	-0.11	0.0481	-0.2296	0.0180	3.34	-3.2%
Nest.TOU-CPP	110	175	20-22	-0.24	0.1176	-0.5477	0.0581	4.17	-5.9%

TABLE 53. PEAK IMPACTS ON EVENT DAYS WITH MAX TEMPERATURE OF 90-110°F, NEST.STANDARD

Treatment Group	MaxTemp (°F)	N	Time Period (event) hour	Savings (kWh/h)	Standard Error	95% Confidence Intervals		Reference Load (2012)	% Savings
Nest.Standard	90	194	14-16	-0.05	0.0292	-0.1255	0.0249	1.51	-3.3%
Nest.Standard	95	194	14-16	**-0.09***	0.0321	-0.1728	-0.0073	1.90	-4.7%
Nest.Standard	100	194	14-16	**-0.13***	0.0331	-0.2154	-0.0450	2.42	-5.4%
Nest.Standard	105	194	14-16	**-0.17***	0.0474	-0.2960	-0.0516	3.11	-5.6%
Nest.Standard	110	194	14-16	-0.22	0.1157	-0.5187	0.0773	4.08	-5.4%
Nest.Standard	90	194	17-19	+0.06	0.0330	-0.0248	0.1452	2.21	+2.7%
Nest.Standard	95	194	17-19	+0.03	0.0364	-0.0640	0.1232	2.77	+1.1%
Nest.Standard	100	194	17-19	-0.04	0.0374	-0.1363	0.0564	3.36	-1.2%
Nest.Standard	105	194	17-19	**-0.18***	0.0536	-0.3133	-0.0369	4.06	-4.3%
Nest.Standard	110	194	17-19	**-0.42***	0.1308	-0.7590	-0.0852	4.88	-8.7%
Nest.Standard	90	194	20-22	-0.01	0.0282	-0.0847	0.0608	1.97	-0.6%
Nest.Standard	95	194	20-22	-0.05	0.0311	-0.1336	0.0265	2.41	-2.2%
Nest.Standard	100	194	20-22	**-0.14***	0.0320	-0.2270	-0.0622	2.92	-5.0%
Nest.Standard	105	194	20-22	**-0.32***	0.0459	-0.4374	-0.2010	3.57	-8.9%
Nest.Standard	110	194	20-22	**-0.64***	0.1119	-0.9243	-0.3477	4.45	-14%

Table 54. Peak impacts on event days with max temperature of 90-110°F, Ecofactor.TOU-CPP

Treatment Group	MaxTemp (°F)	N	Time Period (event) hour	Savings (kWh/h)	Standard Error	95% Confidence Intervals		Reference Load (2012)	% Savings
Ecofactor.TOU-CPP	90	147	14-16	**-0.12***	0.0329	-0.2066	-0.0370	1.59	-7.6%
Ecofactor.TOU-CPP	95	147	14-16	**-0.21***	0.0360	-0.3047	-0.1193	1.99	-11%
Ecofactor.TOU-CPP	100	147	14-16	**-0.30***	0.0369	-0.3905	-0.2005	2.52	-12%
Ecofactor.TOU-CPP	105	147	14-16	**-0.38***	0.0519	-0.5087	-0.2415	3.25	-12%
Ecofactor.TOU-CPP	110	147	14-16	**-0.44***	0.1266	-0.7669	-0.1147	4.32	-10%
Ecofactor.TOU-CPP	90	147	17-19	**-0.48***	0.0372	-0.5716	-0.3798	2.20	-22%
Ecofactor.TOU-CPP	95	147	17-19	**-0.65***	0.0407	-0.7596	-0.5500	2.74	-24%
Ecofactor.TOU-CPP	100	147	17-19	**-0.86***	0.0417	-0.9693	-0.7545	3.34	-26%
Ecofactor.TOU-CPP	105	147	17-19	**-1.10***	0.0586	-1.2791	-0.9769	4.05	-28%
Ecofactor.TOU-CPP	110	147	17-19	**-1.50***	0.1432	-1.8519	-1.1141	4.92	-31%
Ecofactor.TOU-CPP	90	147	20-22	+0.015	0.0318	-0.0674	0.0966	1.96	+0.7%
Ecofactor.TOU-CPP	95	147	20-22	-0.006	0.0348	-0.0954	0.0840	2.40	-0.2%
Ecofactor.TOU-CPP	100	147	20-22	-0.058	0.0357	-0.1501	0.0338	2.92	-2.0%
Ecofactor.TOU-CPP	105	147	20-22	**-0.16***	0.0502	-0.2937	-0.0351	3.60	-4.6%
Ecofactor.TOU-CPP	110	147	20-22	**-0.36***	0.1225	-0.6783	-0.0471	4.53	-8.0%

Table 55. Peak impacts on event days with max temperature of 90-110°F, Ecofactor.Standard

Treatment Group	MaxTemp (°F)	N	Time Period (event) hour	Savings (kWh/h)	Standard Error	95% Confidence Intervals		Reference Load (2012)	% Savings
Ecofactor.Standard	90	180	14-16	**-0.20***	0.0301	-0.2754	-0.1202	1.71	-12%
Ecofactor.Standard	95	180	14-16	**-0.25***	0.0331	-0.3364	-0.1658	2.12	-12%
Ecofactor.Standard	100	180	14-16	**-0.31***	0.0341	-0.3984	-0.2228	2.63	-12%
Ecofactor.Standard	105	180	14-16	**-0.38***	0.0484	-0.5091	-0.2597	3.30	-12%
Ecofactor.Standard	110	180	14-16	**-0.48***	0.1177	-0.7823	-0.1759	4.23	-11%
Ecofactor.Standard	90	180	17-19	**-0.19***	0.0341	-0.2812	-0.1058	2.36	-8.2%
Ecofactor.Standard	95	180	17-19	**-0.20***	0.0375	-0.3007	-0.1077	2.91	-7.0%
Ecofactor.Standard	100	180	17-19	**-0.22***	0.0386	-0.3168	-0.1182	3.46	-6.3%
Ecofactor.Standard	105	180	17-19	**-0.24***	0.0547	-0.3769	-0.0949	4.06	-5.8%
Ecofactor.Standard	110	180	17-19	-0.26	0.1331	-0.6051	0.0807	4.70	-5.6%
Ecofactor.Standard	90	180	20-22	**-0.14***	0.0291	-0.2121	-0.0619	2.03	-6.8%
Ecofactor.Standard	95	180	20-22	**-0.15***	0.0320	-0.2297	-0.0647	2.45	-6.0%
Ecofactor.Standard	100	180	20-22	**-0.16***	0.0330	-0.2450	-0.0750	2.93	-5.5%
Ecofactor.Standard	105	180	20-22	**-0.18***	0.0468	-0.2982	-0.0568	3.51	-5.1%
Ecofactor.Standard	110	180	20-22	-0.20	0.1139	-0.4960	0.0908	4.26	-4.8%

Appendix C. Monthly and Seasonal Impacts Model

All days including weekends and holidays were included in the analysis

Model Equation

$$kw_{ij} = \beta 0 + \beta 1_k Month_k + \ \beta 2 HDH_{ij} + \beta 3 CDD_{ij} + \beta 4_{m-1} Treatment\_Period_m + \beta 5_{(k-1):(m-1)}(Month_k * Treament\_Period_m) \ + r_i + \varepsilon_{ij}$$

kw_{ij}: kilowatt load for customer i on day j

CDD_{ij}: cooling degree day for customer i on day j

HDD_{ij}: heating degree day (sum of 24 HDH values) for customer i on day j, where If Temperature < 65 for customer i on day j at hour k, then HDH for customer i on day j at hour k is 65 - Temperature; otherwise, HDH for customer i on day j at hour k is 0

$Treatment\_Period_m$: indicator variables for treatment and treatment period (Nest.TOU-CPP.treatment, Nest.TOU-CPP.baseline, Nest.Standard.treatment, Nest.Standard.baseline, Ecofactor.TOU-CPP.treatment, Ecofactor.TOU-CPP.baseline, Ecofactor.Standard.treatment, Ecofactor.Standard.baseline, control.baseline, control.treatment=reference level)

$Month_k$: indicator variable for month (June, July, August, September ,October, November, December, January = reference level, February, March, April, May)

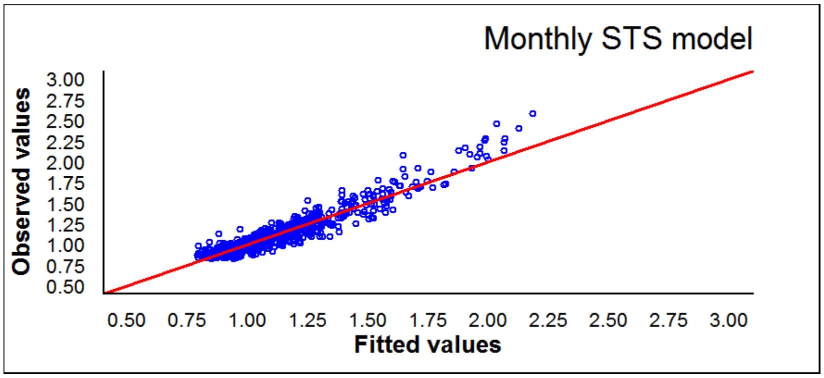
r_i: random effects for customer $\sim N(0, \varphi)$, assumed to be independent for different i

ε_{ij}: error terms $\sim N(0, \delta^2 I)$, assumed to be independent for different i or j and to be independent of random effects

Model Fit

Figure 60 shows that the modeled loads are nearly identical to the average of the actual loads.

Figure 60. Actual and modeled monthly loads



Model Diagnostics

Figure 61 provides scatter plot of normalized residuals versus fitted values for monthly model.

Figure 61.Scatter plot of normalized residuals versus fitted values, monthly model

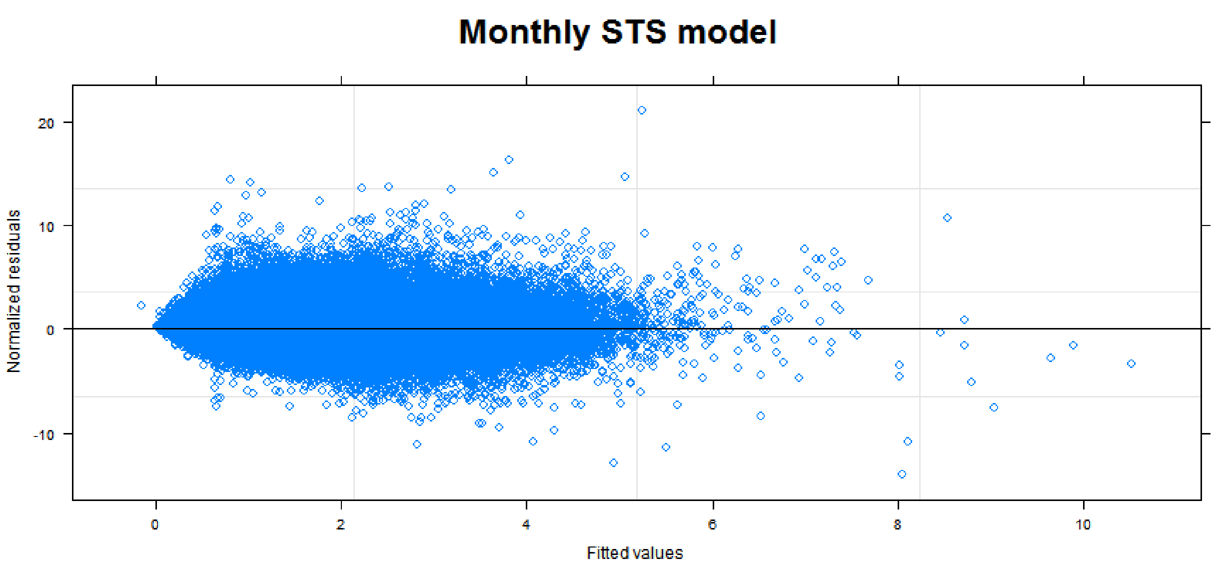


Figure 62 provides normal plot of residuals for monthly model.

FIGURE 62. NORMAL PLOT OF RESIDUALS, MONTHLY MODEL

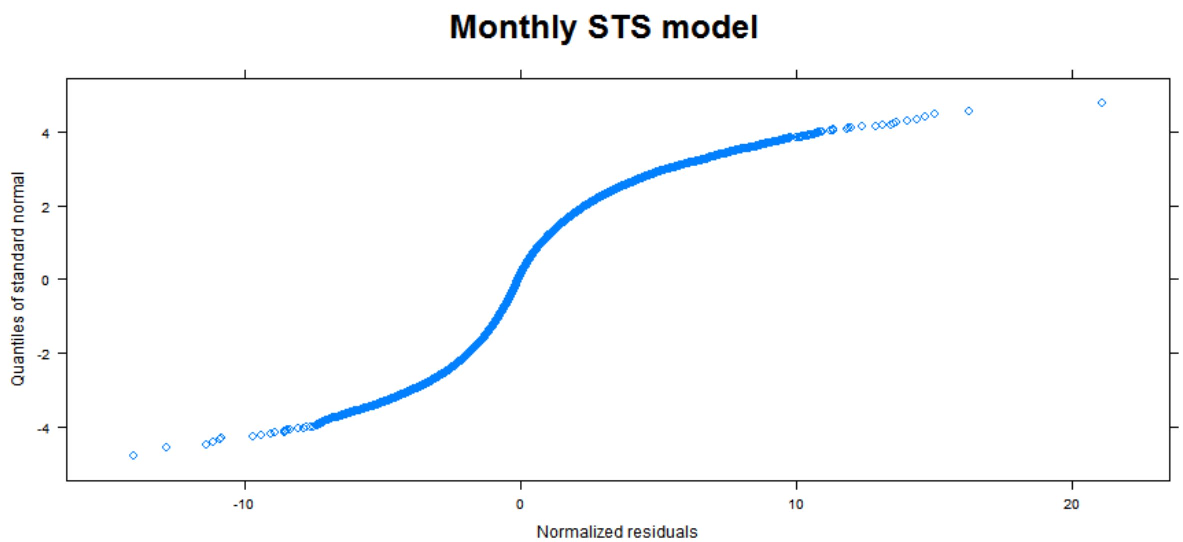


Figure 63 provides normal plots of estimated random effects for monthly model.

FIGURE 63. NORMAL PLOTS OF ESTIMATED RANDOM EFFECTS, MONTHLY MODEL

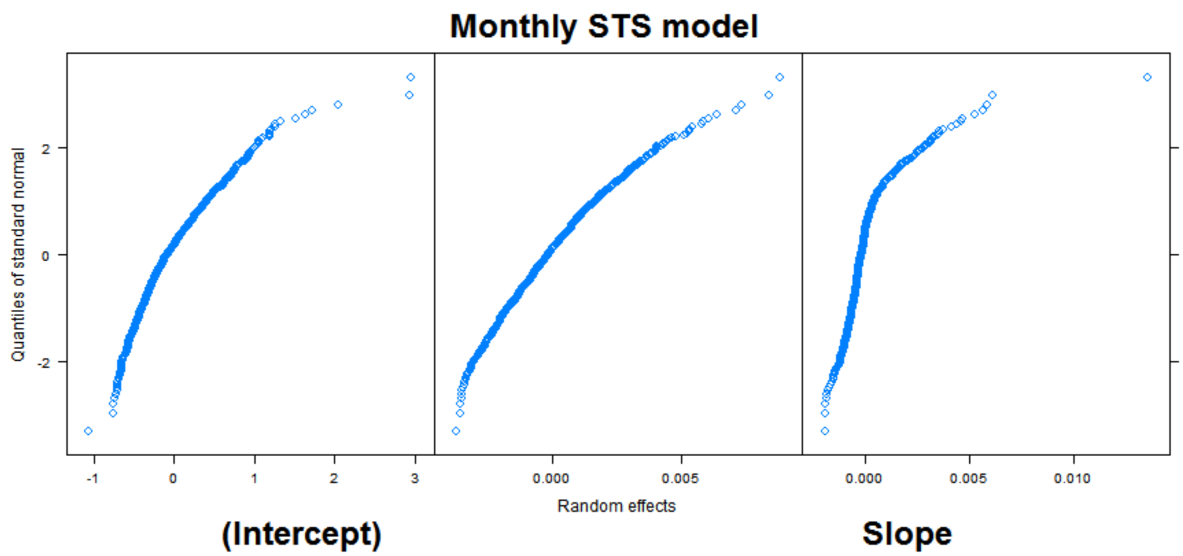
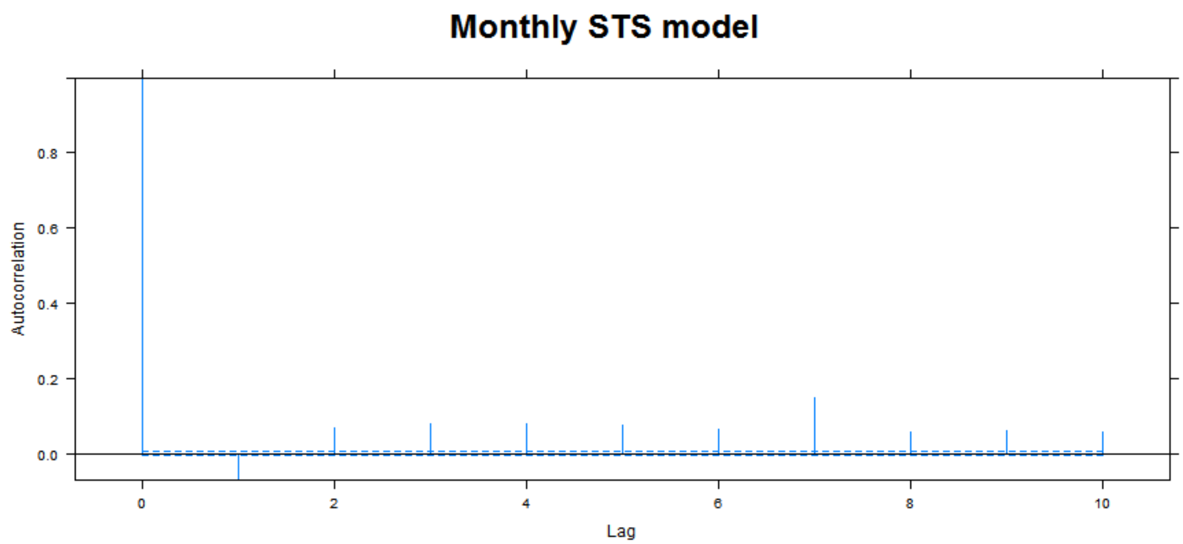


Figure 64 provides plot of the empirical autocorrelation function.

FIGURE 64. EMPIRICAL AUTOCORRELATION FUNCTION CORRESPONDING TO NORMALIZED RESIDUALS, MONTHLY MODEL



MODEL DETAILS

CONTRASTS

1. *Treatment loads are not different from baseline loads (adjusted for weather and exogenous effects)*

$H_0: L = 0$

$H_a: L \neq 0$

$L = \sum_{i=1}^{4} c_i \mu_i \text{ where } \sum_{i=1}^{4} c_i = 0, If\ |t^* = \frac{L}{\sigma^2\{L\}}| \leq t(n-p-q), then\ H_0; otherwise, H_a$[3]

For peak model, $c_1 through\ c_4 = 1, -1, -1, 1$

2. *Treatment type has no effect on impacts (adjusted for weather and exogenous effects)*

Same as in 1 above but different set of means (see contrast example below).

Contrasts Examples

Nest.TOU-CPP June impact relative to baseline (adjusted for weather and exogenous effects), and comparing Nest.TOU-CPP and Nest.Standard treatments (adjusted for weather and pretreatment differences)

1. *Treatment loads are not different from baseline loads (adjusted for weather and exogenous effects)*

$$\hat{L} = (\hat{\mu}_{Nest.TOU-CPP.treatment.at.AUG} - \hat{\mu}_{Nest.TOU-CPP.baseline.at.AUG}) - (\hat{\mu}_{Control.treatment.at.AUG} - \hat{\mu}_{Control.baseline.at.AUG})$$

2. *Treatment type has no effect on impacts (adjusted for weather and exogenous effects)*

$$\hat{L} = (\hat{\mu}_{Nest.TOU-CPP.treatment.at.AUG} - \hat{\mu}_{Nest.TOU-CPP.baseline.at.AUG}) - (\hat{\mu}_{Nest.Standard.treatment.at.AUG} - \hat{\mu}_{Nest.Standard.baseline.at.AUG})$$

Notes:

$\mu's$ are estimated using regression coefficients (provided in (6) below) with the temperature profile of interest – average temp summer 2013.

Model Comparison

Table 56. Model Comparison, Monthly model

	Monthly Model	Model	DF	AIC	BIC	logLik	Test	L.Ratio	p-value
	Monthly Model **Random Customer (Intercept)**	1	124	743964	745382.0	-371858			
	Monthly Model **Random Customer (Slope & Intercept)**	2	129	501409	502884.4	-250575	1 vs 2	242564.76	<0.0001
	Monthly Model **Random Customer (Slope & Intercept Diagonal matrix)**	3	126	501677	503118.3	-250713	2 vs 3	274.23	<0.0001
	Monthly Model **Random Customer (Slope & Intercept Blocked-diagonal matrix)**	4	127	501635	503087.7	-250691	3 vs 4	44.08	<0.0001
Final Model	Monthly Model **Random Customer (Slope & Intercept) AR(1)**	5	130	330553	332039.9	-165146	4 vs 5	171088.11	<0.0001

Tests for fixed effects

Table 57. F-tests for variables in the model, Monthly model

Variable	Numerator DF	Denominator DF	F-value	p-value
(Intercept)	1	685315	995.25	<0.0001
CDD	1	685315	4076.23	<0.0001
HDD	1	685315	307.13	<0.0001
month	11	685315	895.35	<0.0001
Treament_Period	9	685315	148.74	<0.0001
month:Treatment_Period	99	685315	8.50	<0.0001

Model Coefficients

Conditional $R^2 = 0.6828$

Control.treatment is the reference level.

Table 58. Model Coefficients, Monthly model

Variable	Coefficient	Std.Error	DF	t.value	p.value
(Intercept)	0.8950579	0.0262023	685315	34.16	<0.0001
CDD	0.0035387	0.0000600	685315	58.94	<0.0001
HDD	0.0003699	0.0000336	685315	11.01	<0.0001
FEB	0.0046576	0.0089997	685315	0.52	0.6048
MAR	-0.0691799	0.0091055	685315	-7.60	<0.0001
APR	-0.1408387	0.0095639	685315	-14.73	<0.0001
MAY	-0.1361684	0.0098009	685315	-13.89	<0.0001
JUN	-0.0019655	0.0102424	685315	-0.19	0.8478
JUL	0.0655363	0.0103216	685315	6.35	<0.0001
AUG	0.0062452	0.0101820	685315	0.61	0.5396
SEP	-0.0449481	0.0101068	685315	-4.45	<0.0001
OCT	-0.1580664	0.0092821	685315	-17.03	<0.0001
NOV	-0.0586158	0.0089619	685315	-6.54	<0.0001
DEC	0.0894598	0.0086848	685315	10.30	<0.0001
control.baseline	0.0562947	0.0088241	685315	6.38	<0.0001
Nest.TOU.CPP.treatment	-0.0285194	0.0397502	685315	-0.72	0.4731
Nest.TOU.CPP.baseline	0.0478964	0.0399103	685315	1.20	0.2301
Nest.Standard.treatment	-0.0593119	0.0385698	685315	-1.54	0.1241
Nest.Standard.baseline	0.0331914	0.0387169	685315	0.86	0.3913
Ecofactor.TOU.CPP.treatment	0.0436491	0.0418805	685315	1.04	0.2973
Ecofactor.TOU.CPP.baseline	0.1407654	0.0420570	685315	3.35	0.0008
Ecofactor.Standard.treatment	-0.0040696	0.0394129	685315	-0.10	0.9178
Ecofactor.Standard.baseline	0.0699295	0.0395722	685315	1.77	0.0772
FEB:control.baseline	-0.0773349	0.0129047	685315	-5.99	<0.0001
MAR:control.baseline	-0.0150860	0.0124462	685315	-1.21	0.2255
APR:control.baseline	-0.0083922	0.0125263	685315	-0.67	0.5029
MAY:control.baseline	-0.0615243	0.0124413	685315	-4.95	<0.0001
JUN:control.baseline	-0.0924330	0.0125531	685315	-7.36	<0.0001
JUL:control.baseline	-0.0754480	0.0124598	685315	-6.06	<0.0001
AUG:control.baseline	0.0134926	0.0124677	685315	1.08	0.2792
SEP:control.baseline	-0.0631280	0.0130134	685315	-4.85	<0.0001

Variable	Coefficient	Std.Error	DF	t.value	p.value
OCT:control.baseline	0.0130865	0.0126864	685315	1.03	0.3023
NOV:control.baseline	0.0044938	0.0126737	685315	0.35	0.7229
DEC:control.baseline	-0.0053547	0.0121373	685315	-0.44	0.6591
FEB:Nest.TOU.CPP.treatment	-0.0359212	0.0141970	685315	-2.53	0.0114
MAR:Nest.TOU.CPP.treatment	-0.0105770	0.0143555	685315	-0.74	0.4613
APR:Nest.TOU.CPP.treatment	0.0013359	0.0150702	685315	0.09	0.9294
MAY:Nest.TOU.CPP.treatment	0.0055250	0.0154406	685315	0.36	0.7205
JUN:Nest.TOU.CPP.treatment	-0.0035560	0.0161293	685315	-0.22	0.8255
JUL:Nest.TOU.CPP.treatment	-0.0238946	0.0162452	685315	-1.47	0.1413
AUG:Nest.TOU.CPP.treatment	-0.0153492	0.0160302	685315	-0.96	0.3383
SEP:Nest.TOU.CPP.treatment	0.0149136	0.0159181	685315	0.94	0.3488
OCT:Nest.TOU.CPP.treatment	0.0465090	0.0146300	685315	3.18	0.0015
NOV:Nest.TOU.CPP.treatment	0.0186817	0.0141345	685315	1.32	0.1863
DEC:Nest.TOU.CPP.treatment	0.0369006	0.0136983	685315	2.69	0.0071
FEB:Nest.TOU.CPP.baseline	-0.0651537	0.0142218	685315	-4.58	<0.0001
MAR:Nest.TOU.CPP.baseline	-0.0059923	0.0142767	685315	-0.42	0.6747
APR:Nest.TOU.CPP.baseline	0.0093316	0.0150372	685315	0.62	0.5349
MAY:Nest.TOU.CPP.baseline	-0.0241991	0.0156265	685315	-1.55	0.1215
JUN:Nest.TOU.CPP.baseline	-0.0448100	0.0162923	685315	-2.75	0.0060
JUL:Nest.TOU.CPP.baseline	-0.0496698	0.0164909	685315	-3.01	0.0026
AUG:Nest.TOU.CPP.baseline	0.0259574	0.0164705	685315	1.58	0.1150
SEP:Nest.TOU.CPP.baseline	-0.0590147	0.0167507	685315	-3.52	0.0004
OCT:Nest.TOU.CPP.baseline	0.0476741	0.0151116	685315	3.15	0.0016
NOV:Nest.TOU.CPP.baseline	0.0166705	0.0143061	685315	1.17	0.2439
DEC:Nest.TOU.CPP.baseline	0.0122861	0.0136016	685315	0.90	0.3664
FEB:Nest.Standard.treatment	0.0076042	0.0137726	685315	0.55	0.5809
MAR:Nest.Standard.treatment	0.0283267	0.0139339	685315	2.03	0.0421
APR:Nest.Standard.treatment	0.0446061	0.0146348	685315	3.05	0.0023
MAY:Nest.Standard.treatment	0.0598265	0.0150000	685315	3.99	0.0001
JUN:Nest.Standard.treatment	0.0540790	0.0156717	685315	3.45	0.0006
JUL:Nest.Standard.treatment	0.0478565	0.0157905	685315	3.03	0.0024
AUG:Nest.Standard.treatment	0.0505875	0.0155771	685315	3.25	0.0012
SEP:Nest.Standard.treatment	0.0559832	0.0154604	685315	3.62	0.0003
OCT:Nest.Standard.treatment	0.0652095	0.0141991	685315	4.59	<0.0001
NOV:Nest.Standard.treatment	0.0348173	0.0137126	685315	2.54	0.0111
DEC:Nest.Standard.treatment	0.0286500	0.0132890	685315	2.16	0.0311
FEB:Nest.Standard.baseline	-0.0842933	0.0137973	685315	-6.11	<0.0001

Variable	Coefficient	Std.Error	DF	t.value	p.value
MAR:Nest.Standard.baseline	-0.0270003	0.0138573	685315	-1.95	0.0514
APR:Nest.Standard.baseline	-0.0018589	0.0146004	685315	-0.13	0.8987
MAY:Nest.Standard.baseline	-0.0348241	0.0151720	685315	-2.30	0.0217
JUN:Nest.Standard.baseline	-0.0255667	0.0158209	685315	-1.62	0.1061
JUL:Nest.Standard.baseline	-0.0334945	0.0160151	685315	-2.09	0.0365
AUG:Nest.Standard.baseline	0.0365724	0.0159849	685315	2.29	0.0221
SEP:Nest.Standard.baseline	-0.0499052	0.0162355	685315	-3.07	0.0021
OCT:Nest.Standard.baseline	0.0394150	0.0146513	685315	2.69	0.0071
NOV:Nest.Standard.baseline	0.0291019	0.0138721	685315	2.10	0.0359
DEC:Nest.Standard.baseline	0.0365854	0.0131997	685315	2.77	0.0056
FEB:Ecofactor.TOU.CPP.treatment	-0.0089168	0.0149565	685315	-0.60	0.5511
MAR:Ecofactor.TOU.CPP.treatment	-0.0073616	0.0151288	685315	-0.49	0.6265
APR:Ecofactor.TOU.CPP.treatment	0.0161970	0.0158861	685315	1.02	0.3079
MAY:Ecofactor.TOU.CPP.treatment	0.0134411	0.0162802	685315	0.83	0.4090
JUN:Ecofactor.TOU.CPP.treatment	-0.0199614	0.0170110	685315	-1.17	0.2406
JUL:Ecofactor.TOU.CPP.treatment	-0.0165975	0.0171431	685315	-0.97	0.3330
AUG:Ecofactor.TOU.CPP.treatment	-0.0026505	0.0169104	685315	-0.16	0.8755
SEP:Ecofactor.TOU.CPP.treatment	0.0054994	0.0167840	685315	0.33	0.7432
OCT:Ecofactor.TOU.CPP.treatment	0.0233535	0.0154182	685315	1.51	0.1299
NOV:Ecofactor.TOU.CPP.treatment	0.0108172	0.0148916	685315	0.73	0.4676
DEC:Ecofactor.TOU.CPP.treatment	0.0408744	0.0144301	685315	2.83	0.0046
FEB:Ecofactor.TOU.CPP.baseline	-0.0767658	0.0149848	685315	-5.12	<0.0001
MAR:Ecofactor.TOU.CPP.baseline	-0.0443869	0.0150407	685315	-2.95	0.0032
APR:Ecofactor.TOU.CPP.baseline	-0.0243005	0.0158492	685315	-1.53	0.1252
MAY:Ecofactor.TOU.CPP.baseline	-0.0666988	0.0164904	685315	-4.04	0.0001
JUN:Ecofactor.TOU.CPP.baseline	-0.0727086	0.0171887	685315	-4.23	<0.0001
JUL:Ecofactor.TOU.CPP.baseline	-0.0455344	0.0174091	685315	-2.62	0.0089
AUG:Ecofactor.TOU.CPP.baseline	0.0334097	0.0173991	685315	1.92	0.0548
SEP:Ecofactor.TOU.CPP.baseline	-0.0756016	0.0177144	685315	-4.27	<0.0001
OCT:Ecofactor.TOU.CPP.baseline	0.0267074	0.0159527	685315	1.67	0.0941
NOV:Ecofactor.TOU.CPP.baseline	0.0031503	0.0150835	685315	0.21	0.8346
DEC:Ecofactor.TOU.CPP.baseline	-0.0015052	0.0143231	685315	-0.11	0.9163
FEB:Ecofactor.Standard.treatment	-0.0211469	0.0140779	685315	-1.50	0.1331
MAR:Ecofactor.Standard.treatment	-0.0119807	0.0142343	685315	-0.84	0.4000
APR:Ecofactor.Standard.treatment	0.0061355	0.0149417	685315	0.41	0.6813
MAY:Ecofactor.Standard.treatment	0.0145449	0.0153099	685315	0.95	0.3421
JUN:Ecofactor.Standard.treatment	0.0264856	0.0159954	685315	1.66	0.0978

Variable	Coefficient	Std.Error	DF	t.value	p.value
JUL:Ecofactor.Standard.treatment	0.0269819	0.0161173	685315	1.67	0.0941
AUG:Ecofactor.Standard.treatment	0.0242156	0.0158978	685315	1.52	0.1277
SEP:Ecofactor.Standard.treatment	0.0196633	0.0157815	685315	1.25	0.2128
OCT:Ecofactor.Standard.treatment	0.0283279	0.0145069	685315	1.95	0.0509
NOV:Ecofactor.Standard.treatment	0.0087183	0.0140147	685315	0.62	0.5339
DEC:Ecofactor.Standard.treatment	0.0452967	0.0135841	685315	3.33	0.0009
FEB:Ecofactor.Standard.baseline	-0.0772908	0.0141007	685315	-5.48	<0.0001
MAR:Ecofactor.Standard.baseline	-0.0243305	0.0141565	685315	-1.72	0.0857
APR:Ecofactor.Standard.baseline	0.0021278	0.0149111	685315	0.14	0.8865
MAY:Ecofactor.Standard.baseline	-0.0377246	0.0154979	685315	-2.43	0.0149
JUN:Ecofactor.Standard.baseline	-0.0030180	0.0161575	685315	-0.19	0.8518
JUL:Ecofactor.Standard.baseline	-0.0027419	0.0163589	685315	-0.17	0.8669
AUG:Ecofactor.Standard.baseline	0.0713389	0.0163377	685315	4.37	<0.0001
SEP:Ecofactor.Standard.baseline	-0.0305699	0.0166088	685315	-1.84	0.0657
OCT:Ecofactor.Standard.baseline	0.0582058	0.0149809	685315	3.89	0.0001
NOV:Ecofactor.Standard.baseline	0.0352389	0.0141823	685315	2.48	0.0130
DEC:Ecofactor.Standard.baseline	0.0240565	0.0134897	685315	1.78	0.0745

Variance covariance matrix

Table 59. Variance covariance matrix, Monthly model

	Variance	StdDev	Corr	
Customer (Intercept)	1.953212e-01	0.441951615	(Intr)	CDD
CDD (slope)	3.327976e-06	0.001824274	0.494	
HDD (Slope)	1.020461e-06	0.001010179	-0.059	0.088
Residual	1.206680e-01	0.347372939		

Corrections

AR(1) error structure was the only correction applied. See diagnostic plots.

RESULTS

(A) RESULTS, BY MONTH

TABLE 60. MONTHLY ENERGY IMPACTS, BY TREATMENT

Treatment Group	N	Time Period	Baseline Year	Savings (kWh/h)	Standard Error	95% Confidence Intervals		Reference Load	% Savings
Nest.TOU-CPP	174	JAN	2012	-0.020	0.0139	-0.0626	0.0223	1.03	-2.0%
Nest.Standard	193	JAN	2012	-0.036	0.0135	-0.0774	0.0050	1.01	-3.6%
Ecofactor.TOU-CPP	147	JAN	2012	-0.041	0.0147	-0.0855	0.0039	1.12	-3.6%
Ecofactor.Standard	179	JAN	2012	-0.018	0.0138	-0.0598	0.0244	1.05	-1.7%
Nest.TOU-CPP	174	FEB	2012	**-0.068***	0.0144	-0.1122	-0.0242	1.05	-6.5%
Nest.Standard	193	FEB	2012	-0.022	0.0140	-0.0643	0.0210	1.02	-2.1%
Ecofactor.TOU-CPP	147	FEB	2012	**-0.050***	0.0152	-0.0967	-0.0040	1.13	-4.5%
Ecofactor.Standard	179	FEB	2012	-0.039	0.0143	-0.0825	0.0047	1.06	-3.7%
Nest.TOU-CPP	174	MAR	2012	-0.040	0.0140	-0.0824	0.0028	0.91	-4.3%
Nest.Standard	193	MAR	2012	0.004	0.0136	-0.0373	0.0454	0.88	0.5%
Ecofactor.TOU-CPP	147	MAR	2012	-0.019	0.0147	-0.0638	0.0260	0.97	-2.0%
Ecofactor.Standard	179	MAR	2012	-0.020	0.0139	-0.0627	0.0218	0.92	-2.2%
Nest.TOU-CPP	174	APR	2012	-0.037	0.0141	-0.0796	0.0066	0.92	-4.0%
Nest.Standard	193	APR	2012	0.002	0.0137	-0.0399	0.0437	0.90	0.2%
Ecofactor.TOU-CPP	147	APR	2012	-0.009	0.0149	-0.0541	0.0367	0.98	-0.9%
Ecofactor.Standard	179	APR	2012	-0.022	0.0140	-0.0648	0.0207	0.94	-2.4%
Nest.TOU-CPP	174	MAY	2012	**-0.052***	0.0139	-0.0942	-0.0096	1.00	-5.2%
Nest.Standard	193	MAY	2012	-0.003	0.0135	-0.0441	0.0380	0.97	-0.3%
Ecofactor.TOU-CPP	147	MAY	2012	-0.022	0.0146	-0.0668	0.0224	1.05	-2.1%
Ecofactor.Standard	179	MAY	2012	-0.027	0.0138	-0.0689	0.0150	1.01	-2.7%
Nest.TOU-CPP	174	JUN	2012	**-0.071***	0.0141	-0.1143	-0.0283	1.36	-5.2%
Nest.Standard	193	JUN	2012	**-0.049***	0.0137	-0.0907	-0.0073	1.36	-3.6%
Ecofactor.TOU-CPP	147	JUN	2012	**-0.081***	0.0149	-0.1258	-0.0352	1.42	-5.7%
Ecofactor.Standard	179	JUN	2012	**-0.081***	0.0140	-0.1233	-0.0380	1.42	-5.7%
Nest.TOU-CPP	174	JUL	2012	**-0.070***	0.0139	-0.1121	-0.0275	1.52	-4.6%
Nest.Standard	193	JUL	2012	-0.030	0.0135	-0.0713	0.0107	1.52	-2.0%
Ecofactor.TOU-CPP	147	JUL	2012	**-0.087***	0.0146	-0.1319	-0.0428	1.61	-5.4%
Ecofactor.Standard	179	JUL	2012	**-0.063***	0.0138	-0.1054	-0.0215	1.59	-4.0%
Nest.TOU-CPP	174	AUG	2012	**-0.048***	0.0139	-0.0904	-0.0055	1.30	-3.7%
Nest.Standard	193	AUG	2012	-0.009	0.0135	-0.0498	0.0324	1.30	-0.7%
Ecofactor.TOU-CPP	147	AUG	2012	**-0.063***	0.0146	-0.1081	-0.0187	1.40	-4.5%
Ecofactor.Standard	179	AUG	2012	**-0.051***	0.0138	-0.0934	-0.0093	1.37	-3.8%
Nest.TOU-CPP	174	SEP	2012	-0.009	0.0151	-0.0554	0.0367	1.08	-0.9%
Nest.Standard	193	SEP	2012	+0.007	0.0146	-0.0381	0.0512	1.07	+0.6%
Ecofactor.TOU-CPP	147	SEP	2012	-0.023	0.0159	-0.0714	0.0257	1.15	-2.0%
Ecofactor.Standard	179	SEP	2012	-0.031	0.0150	-0.0762	0.0150	1.13	-2.7%
Nest.TOU-CPP	174	OCT	2011	-0.008	0.0140	-0.0508	0.0344	0.88	-0.9%
Nest.Standard	193	OCT	2011	+0.003	0.0136	-0.0386	0.0440	0.86	+0.3%
Ecofactor.TOU-CPP	147	OCT	2011	-0.031	0.0147	-0.0759	0.0138	0.95	-3.3%
Ecofactor.Standard	179	OCT	2011	-0.034	0.0138	-0.0767	0.0077	0.91	-3.8%
Nest.TOU-CPP	174	NOV	2011	-0.014	0.0145	-0.0578	0.0306	0.95	-1.4%
Nest.Standard	193	NOV	2011	-0.026	0.0141	-0.0689	0.0169	0.94	-2.8%
Ecofactor.TOU-CPP	147	NOV	2011	-0.029	0.0153	-0.0752	0.0179	1.03	-2.8%
Ecofactor.Standard	179	NOV	2011	-0.040	0.0144	-0.0836	0.0041	0.99	-4.0%
Nest.TOU-CPP	174	DEC	2011	-0.0009	0.0139	-0.0432	0.0414	1.18	-0.1%
Nest.Standard	193	DEC	2011	**-0.050***	0.0135	-0.0905	-0.0085	1.19	-4.2%
Ecofactor.TOU-CPP	147	DEC	2011	-0.004	0.0146	-0.0483	0.0407	1.26	-0.3%
Ecofactor.Standard	179	DEC	2011	-0.002	0.0138	-0.0437	0.0401	1.22	-0.2%

(B) Results, by season and 2 seasons combined

Table 61. Summer energy impacts, by treatment

Treatment Group	N	Time Period	Savings (kWh/h)	Standard Error	95% Confidence Intervals		Reference Load (2012)	% Savings
Nest.TOU-CPP	174	summer	**-0.050***	0.0073	-0.0679	-0.0313	1.31	-3.8%
Nest.Standard	193	summer	**-0.020***	0.0071	-0.0381	-0.0026	1.31	-1.6%
Ecofactor.TOU-CPP	147	summer	**-0.064***	0.0077	-0.0828	-0.0442	1.40	-4.5%
Ecofactor.Standard	179	summer	**-0.056***	0.0073	-0.0748	-0.0382	1.38	-4.1%

Table 62. Winter energy impacts, by treatment

Treatment Group	N	Time Period	Savings (kWh/h)	Standard Error	95% Confidence Intervals		Reference Load (2011-2012)	% Savings
Nest.TOU-CPP	174	winter	**-0.030***	0.0051	-0.0427	-0.0172	0.99	-3.0%
Nest.Standard	193	winter	**-0.016***	0.0050	-0.0285	-0.0035	0.97	-1.6%
Ecofactor.TOU-CPP	147	winter	**-0.026***	0.0054	-0.0391	-0.0121	1.06	-2.4%
Ecofactor.Standard	179	winter	**-0.025***	0.0051	-0.0380	-0.0125	1.01	-2.5%

Table 63. Summer+Winter energy impacts, by treatment

Treatment Group	N	Time Period	Savings (kWh/h)	Standard Error	95% Confidence Intervals		Reference Load (2011-2012)	% Savings
Nest.TOU-CPP	174	summer+winter	**-0.036***	0.0042	-0.0470	-0.0260	1.10	-3.3%
Nest.Standard	193	summer+winter	**-0.017***	0.0041	-0.0277	-0.0072	1.08	-1.6%
Ecofactor.TOU-CPP	147	summer+winter	**-0.038***	0.0044	-0.0492	-0.0272	1.17	-3.3%
Ecofactor.Standard	179	summer+winter	**-0.036***	0.0042	-0.0462	-0.0252	1.13	-3.2%

Table 64. Summer energy impacts, between-treatment comparisons

Treatment Group	Time Period	Savings (kWh/h)	Standard Error	95% Confidence Intervals	
Nest.TOU-CPP vs Nest.Standard	summer	**-0.029***	0.0078	-0.0500	-0.0080
Nest.TOU-CPP vs Ecofactor.TOU-CPP	summer	0.014	0.0084	-0.0086	0.0366
Nest.TOU-CPP vs Ecofactor.Standard	summer	0.007	0.0080	-0.0146	0.0284
Nest.Standard vs Ecofactor.TOU-CPP	summer	**0.043***	0.0082	0.0209	0.0651
Nest.Standard vs Ecofactor.Standard	summer	**0.036***	0.0078	0.0150	0.0570
Ecofactor.TOU-CPP vs Ecofactor.Standard	summer	-0.007	0.0083	-0.0293	0.0153

TABLE 65.WINTER ENERGY IMPACTS, BETWEEN-TREATMENT COMPARISONS

Treatment Group	Time Period	Savings (kWh/h)	Standard Error	95% Confidence Intervals	
Nest.TOU-CPP vs Nest.Standard	winter	-0.014	0.0055	-0.0288	0.0008
Nest.TOU-CPP vs Ecofactor.TOU-CPP	winter	-0.0043	0.0059	-0.0202	0.0116
Nest.TOU-CPP vs Ecofactor.Standard	winter	-0.0046	0.0056	-0.0197	0.0105
Nest.Standard vs Ecofactor.TOU-CPP	winter	0.0096	0.0057	-0.0057	0.0249
Nest.Standard vs Ecofactor.Standard	winter	0.0093	0.0054	-0.0052	0.0238
Ecofactor.TOU-CPP vs Ecofactor.Standard	winter	-0.00029	0.0058	-0.0159	0.0153

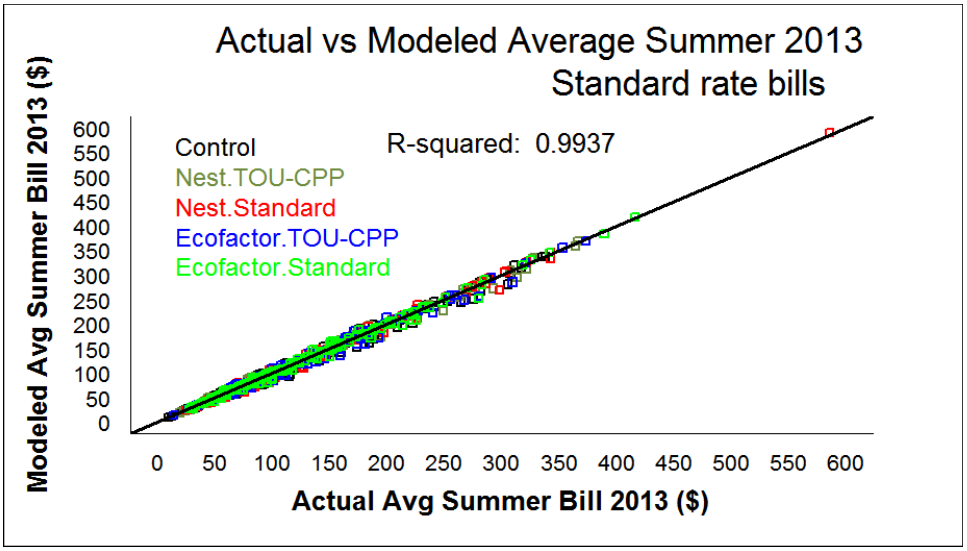
TABLE 66.SUMMER+WINTER ENERGY IMPACTS, BETWEEN-TREATMENT COMPARISONS

Treatment Group	Time Period	Savings (kWh/h)	Standard Error	95% Confidence Intervals	
Nest.TOU-CPP vs Nest.Standard	summer+winter	-0.019*	0.0045	-0.0311	-0.0069
Nest.TOU-CPP vs Ecofactor.TOU-CPP	summer+winter	0.0017	0.0048	-0.0112	0.0146
Nest.TOU-CPP vs Ecofactor.Standard	summer+winter	-0.00079	0.0046	-0.0132	0.0116
Nest.Standard vs Ecofactor.TOU-CPP	summer+winter	0.021*	0.0047	0.0084	0.0336
Nest.Standard vs Ecofactor.Standard	summer+winter	0.018*	0.0045	0.0059	0.0301
Ecofactor.TOU-CPP vs Ecofactor.Standard	summer+winter	-0.0025	0.0048	-0.0154	0.0104

Appendix D. Billing Model Fit

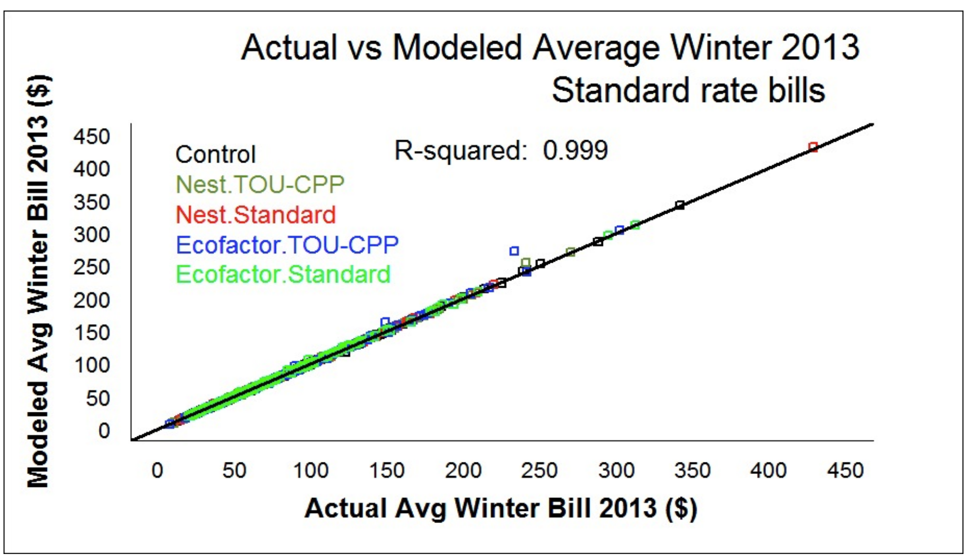
To investigate the accuracy of the modeled bills, actual summer bills calculated from actual June to September 2013 loads, and modeled bills calculated from modeled June to September 2013 loads are plotted in Figure 65 showing a nearly perfect match.

Figure 65. Actual vs. modeled standard rate bills, summer 2013



Actual winter bills calculated from February through May 2013 and October 2013 through January 2014 loads are plotted against modeled bills calculated from modeled loads during the same period, showing a nearly perfect match (Figure 66).

Figure 66. Actual vs. modeled standard rate bills, winter 2013



Appendix E. Elasticity of Demand Models

Two-Tier Off-peak Pricing

Table 67 through Table 70 show the output of the elasticity models that account for the Base and Base Plus tiered off-peak pricing.

Table 67.Nest.TOU-CPP event model results, 2-tier pricing

Variable	Value	Std.Error	DF	t-value	p-value
(Intercept)	0.1038	0.0230	38959	4.52	<0.0001
CDH.difference	0.0347	0.0006	38959	60.92	<0.0001
ln(peak.price/off.peak.price)*	-0.0044	0.0178	38959	-0.25	0.8052
event	-0.0416	0.0100	38959	-4.15	<0.0001
Nest.TOU-CPP	-0.0186	0.0340	431	-0.55	0.5842
July	0.0261	0.0073	38959	3.55	0.0004
August	0.0491	0.0078	38959	6.29	<0.0001
September	-0.0091	0.0079	38959	-1.16	0.2445
Monday	0.0099	0.0077	38959	1.28	0.1996
Thursday	-0.0088	0.0077	38959	-1.14	0.2552
Tuesday	-0.0083	0.0077	38959	-1.07	0.2844
Wednesday	-0.0214	0.0080	38959	-2.66	0.0079
CDH.difference:ln(peak.price/off.peak.price)*	-0.0117	0.0011	38959	-10.33	<0.0001

Table 68.Nest.TOU-CPP nonevent model results, 2-tier pricing

Variable	Value	Std.Error	DF	t-value	p-value
(Intercept)	0.1004	0.0225	64938	4.47	<0.0001
CDH.difference	0.0348	0.0005	64938	72.21	<0.0001
ln(peak.price/off.peak.price)*	-0.0127	0.0107	64938	-1.19	0.2347
nonevent	-0.0051	0.0052	64938	-0.98	0.3283
Nest.TOU-CPP	-0.0244	0.0338	431	-0.72	0.4705
July	0.0199	0.0057	64938	3.48	5e-04
August	0.0389	0.0058	64938	6.72	<0.0001
September	-0.0268	0.0060	64938	-4.44	<0.0001
Monday	0.0150	0.0064	64938	2.35	0.019
Thursday	0.0075	0.0063	64938	1.19	0.2339
Tuesday	0.0078	0.0063	64938	1.24	0.2137
Wednesday	0.0024	0.0063	64938	0.38	0.705
CDH.difference:ln(peak.price/off.peak.price)*	-0.0133	0.0009	64938	-15.10	<0.0001

TABLE 69.ECOFACTOR.TOU-CPP EVENT MODEL RESULTS, 2-TIER PRICING

Variable	Value	Std.Error	DF	t.value	p.value
(Intercept)	0.1064	0.0219	36529	4.87	<0.0001
CDH.diff	0.0340	0.0006	36529	58.99	<0.0001
ln(peak.price/off.peak.price)*	0.0243	0.0191	36529	1.27	0.204
event	-0.0351	0.0098	36529	-3.57	4e-04
Ecofactor.TOU-CPP	-0.0526	0.0338	404	-1.56	0.1203
July	0.0220	0.0074	36529	2.96	0.0031
August	0.0568	0.0079	36529	7.19	<0.0001
September	-0.0089	0.0079	36529	-1.13	0.2605
Monday	0.0128	0.0078	36529	1.63	0.1027
Thursday	-0.0099	0.0078	36529	-1.27	0.2036
Tuesday	-0.0012	0.0078	36529	-0.16	0.8736
Wednesday	-0.0121	0.0081	36529	-1.49	0.1365
CDH.difference:ln(peak.price/off.peak.price)*	-0.0109	0.0012	36529	-8.87	<0.0001

TABLE 70.ECOFACTOR.TOU-CPP NONEVENT MODEL RESULTS, 2-TIER PRICING

Variable	Value	Std.Error	DF	t.value	p.value
(Intercept)	0.1035	0.0213	60888	4.85	<0.0001
CDH.difference	0.0344	0.0005	60888	71.09	<0.0001
ln(peak.price/off.peak.price)*	-0.0572	0.0114	60888	-5.02	<0.0001
nonevent	-0.0036	0.0051	60888	-0.70	0.4823
Ecofactor.TOU-CPP	-0.0566	0.0336	404	-1.69	0.0925
July	0.0178	0.0058	60888	3.08	0.0021
August	0.0414	0.0058	60888	7.10	<0.0001
September	-0.0262	0.0061	60888	-4.31	<0.0001
Monday	0.0141	0.0064	60888	2.18	0.029
Thursday	0.0017	0.0064	60888	0.27	0.7864
Tuesday	0.0051	0.0063	60888	0.80	0.4216
Wednesday	0.0114	0.0063	60888	1.81	0.071
CDH.difference:ln(peak.price/off.peak.price)*	-0.0088	0.0009	60888	-9.27	<0.0001

Average Off-peak Pricing

Table 71 through Table 74 show the output of the elasticity models that use a single off-peak price, created by averaging the Base and Base Plus tiered off-peak pricing.

Table 71. Nest.TOU-CPP event model results, average off-peak pricing

Variable	Value	Std.Error	DF	t.value	p.value
(Intercept)	0.1029	0.0230	38959	4.48	<0.0001
CDH.diff	0.0347	0.0006	38959	60.95	<0.0001
ln(peak.price/off.peak.price)*	-0.0025	0.0175	38959	-0.14	0.887
event	-0.0380	0.0100	38959	-3.80	1e-04
Nest.TOU-CPP	-0.0174	0.0341	431	-0.51	0.6096
July	0.0263	0.0073	38959	3.58	3e-04
August	0.0491	0.0078	38959	6.29	<0.0001
September	-0.0084	0.0078	38959	-1.07	0.286
Monday	0.0100	0.0077	38959	1.30	0.1947
Thursday	-0.0086	0.0077	38959	-1.11	0.2653
Tuesday	-0.0082	0.0077	38959	-1.06	0.2906
Wednesday	-0.0211	0.0080	38959	-2.63	0.0085
CDH.difference:ln(peak.price/off.peak.price)*	-0.0126	0.0011	38959	-11.07	<0.0001

Table 72.Nest.TOU-CPP nonevent model results, average off-peak pricing

Variable	Value	Std.Error	DF	t.value	p.value
(Intercept)	0.0964	0.0225	64938	4.29	<0.0001
CDH.difference	0.0348	0.0005	64938	72.19	<0.0001
ln(peak.price/off.peak.price)*	-0.0241	0.0114	64938	-2.11	0.0348
nonevent	0.0009	0.0052	64938	0.16	0.8701
Nest.TOU-CPP	-0.0174	0.0338	431	-0.51	0.6071
July	0.0213	0.0057	64938	3.73	2e-04
August	0.0390	0.0058	64938	6.74	<0.0001
September	-0.0247	0.0060	64938	-4.09	<0.0001
Monday	0.0154	0.0064	64938	2.42	0.0155
Thursday	0.0074	0.0063	64938	1.18	0.2367
Tuesday	0.0079	0.0063	64938	1.27	0.2054
Wednesday	0.0024	0.0063	64938	0.39	0.7002
CDH.difference:ln(peak.price/off.peak.price)*	-0.0147	0.0009	64938	-15.47	<0.0001

TABLE 73.ECOFACTOR.TOU-CPP EVENT MODEL RESULTS, AVERAGE OFF-PEAK PRICING

Variable	Value	Std.Error	DF	t.value	p.value
(Intercept)	0.1060	0.0219	36529	4.85	<0.0001
CDH.diff	0.0340	0.0006	36529	58.97	<0.0001
ln(peak.price/off.peak.price)	0.0263	0.0186	36529	1.42	0.1565
event	-0.0344	0.0098	36529	-3.50	5e-04
Ecofactor.TOU-CPP	-0.0523	0.0338	404	-1.55	0.1228
July	0.0222	0.0074	36529	2.98	0.0029
August	0.0568	0.0079	36529	7.19	<0.0001
September	-0.0080	0.0079	36529	-1.00	0.3153
Monday	0.0128	0.0078	36529	1.64	0.1018
Thursday	-0.0097	0.0078	36529	-1.24	0.2133
Tuesday	-0.0010	0.0078	36529	-0.12	0.9023
Wednesday	-0.0118	0.0081	36529	-1.46	0.1456
CDH.difference:ln(peak.price/off.peak.price)	-0.0114	0.0012	36529	-9.38	<0.0001

TABLE 74.ECOFACTOR.TOU-CPP NONEVENT MODEL RESULTS, AVERAGE OFF-PEAK PRICING

Variable	Value	Std.Error	DF	t.value	p.value
(Intercept)	0.0998	0.0213	60888	4.68	<0.0001
CDH.difference	0.0345	0.0005	60888	71.22	<0.0001
ln(peak.price/off.peak.price)*	-0.0601	0.0120	60888	-5.02	<0.0001
nonevent	-0.0001	0.0051	60888	-0.01	0.9913
Ecofactor.TOU-CPP	-0.0522	0.0336	404	-1.55	0.1207
July	0.0193	0.0058	60888	3.35	8e-04
August	0.0417	0.0058	60888	7.14	<0.0001
September	-0.0234	0.0061	60888	-3.85	1e-04
Monday	0.0142	0.0064	60888	2.21	0.0272
Thursday	0.0015	0.0063	60888	0.24	0.8121
Tuesday	0.0048	0.0063	60888	0.76	0.4468
Wednesday	0.0112	0.0063	60888	1.77	0.0763
CDH.difference:ln(peak.price/off.peak.price)*	-0.0102	0.0010	60888	-10.24	<0.0001

APPENDIX F. DEMOGRAPHIC DATA SUMMARY

ON INCLUDING DEMOGRAPHIC VARIABLES IN THE MODEL

In order to assess differences in load impacts for different levels of demographic variables, we have to include the interaction of each demographic variable with an hour and the day type in the model. If no interaction is included then we get a "constant effect" for each demographic variable – i.e. the difference in loads won't change for different levels of demographic variables.

Calculation of the impacts can be explained in terms of simple equations where the impact equals the event day load calculated at certain level of demographic variable minus pretreatment weekday load calculated at the same level of the demographic variable. When no interaction is present, values associated with demographic variables cancel each other out. For example, consider a simple model with only one demographic variable in it – gender. A regression without interaction with the gender and day-type variables might look like this:

$$kw = coefficient.1 * gender + coefficient.2 * daytype \quad (1)$$

(let 0= female/1 = male for gender and 0=event/1=pretreatment weekday for the day type)

First calculate the impact for males ($impact = event\ load - pretreatment\ load$)

$$Pretreat\ load \rightarrow MALE = coefficient.1 * 1 + coefficient.2 * 1 \quad (2)$$
$$Event\ load \rightarrow MALE = coefficient.1 * 1 + coefficient.2 * 0 \quad (3)$$
$$Impact \rightarrow MALE = coefficient.2 * 0 - coefficient.2 * 1 \quad (4)$$

Next we calculate the impact for females:

$$Pretreat\ load \rightarrow FEMALE = coefficient.1 * 0 + coefficient.2 * 1 \quad (5)$$
$$Event\ load \rightarrow FEMALE = coefficient.1 * 0 + coefficient.2 * 0 \quad (6)$$
$$Impact\ for \rightarrow FEMALE = coefficient.2 * 0 - coefficient.2 * 1 \quad (7)$$

Note that (4) = (7) due to the model structure. We can include any number of demographic variables in the model and get similar results.

Unfortunately, adding an Interaction between gender and day-type is not practical due to:

1. Overparameterization
2. Sample size limitation – when we deal with the interaction of categorical variables (and even when there are no interactions), we need to have large enough sample sizes in each block.

Note that loads are not dependent on interactions, so if interested in loads rather than impacts, the model might work (similar to choice model), but sample size may still be an issue. As an alternative, building models with continuous demographic variables can be attempted, but in this case, overparameterization may still be an issue.

Correlations with Load Impacts

Figure 67. Load and demographic variable correlation matrix, Nest.TOU-CPP

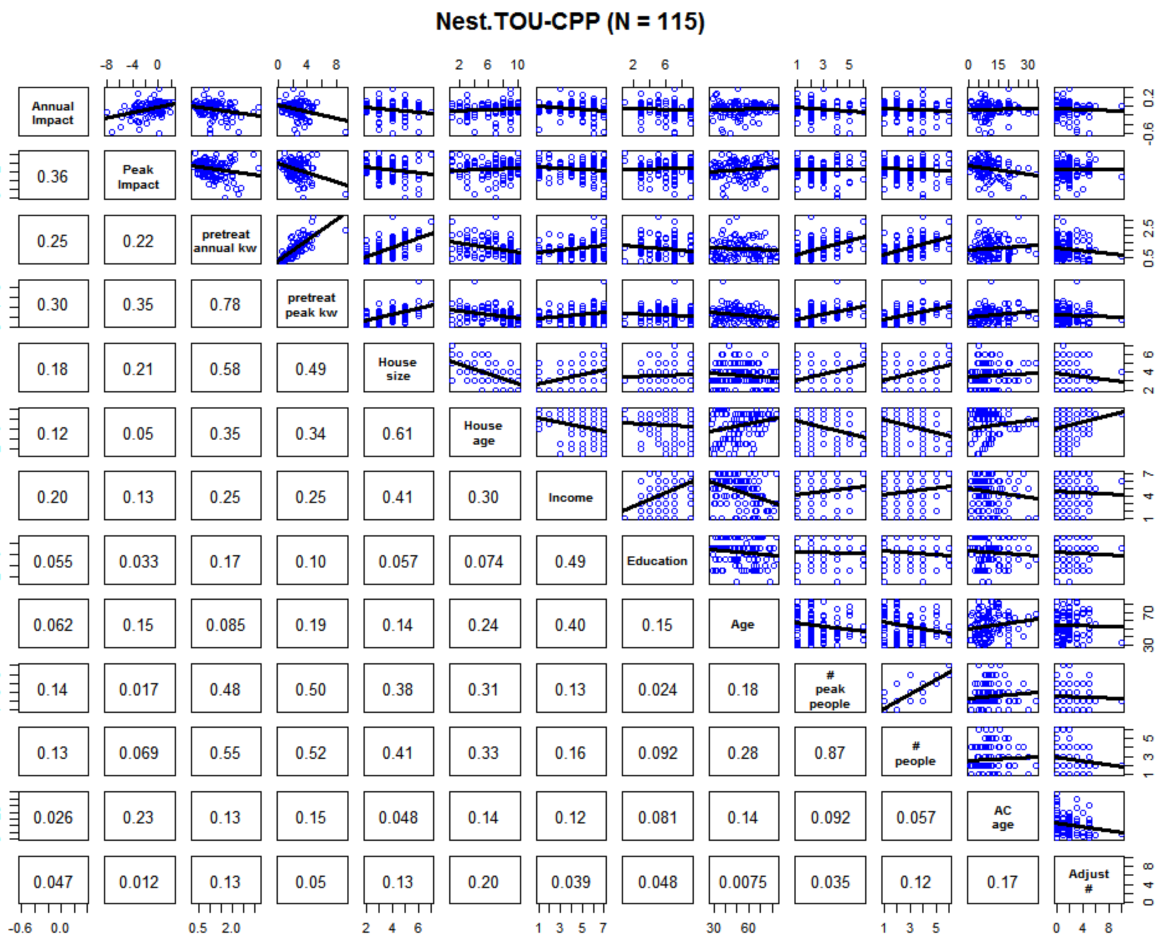


FIGURE 68. LOAD AND DEMOGRAPHIC VARIABLE CORRELATION MATRIX, NEST.STANDARD

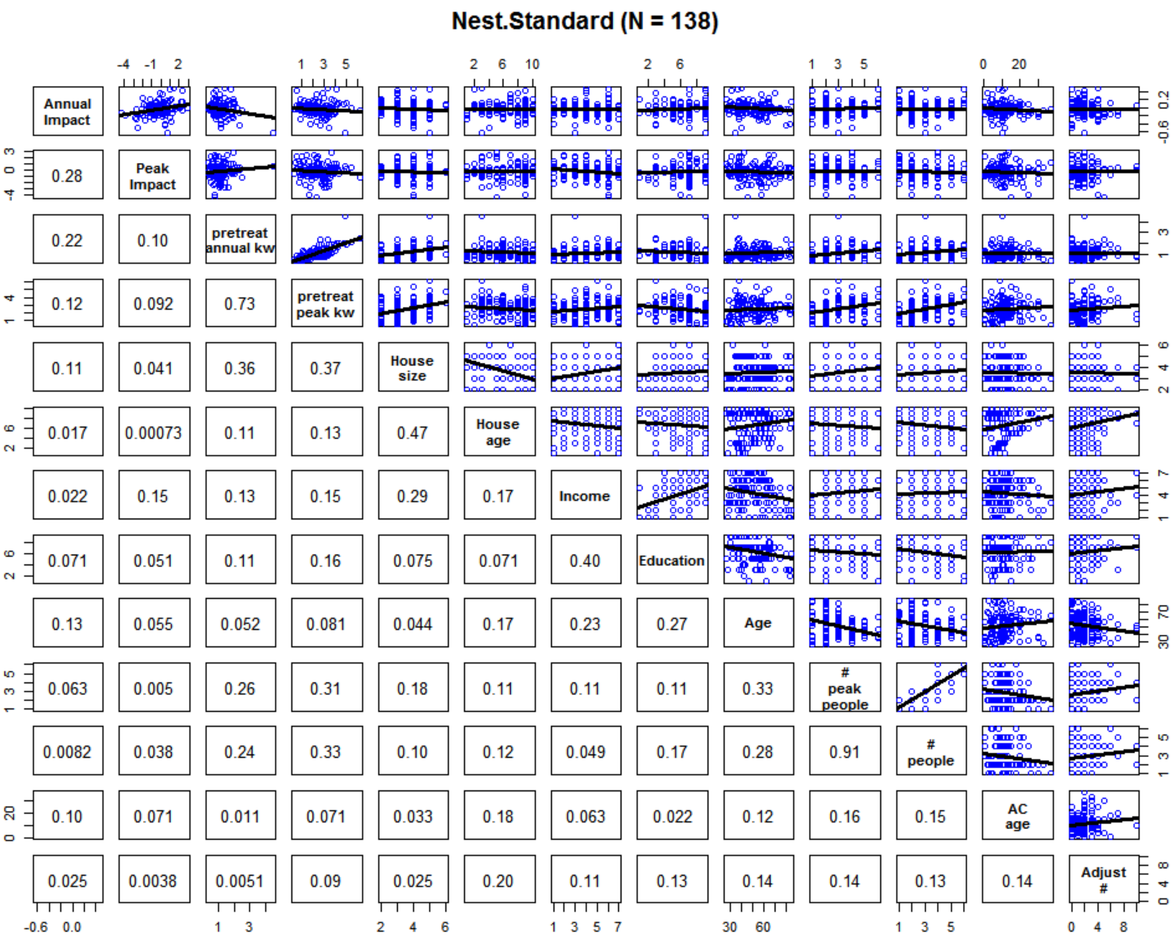


FIGURE 69. LOAD AND DEMOGRAPHIC VARIABLE CORRELATION MATRIX, ECOFACTOR.TOU-CPP

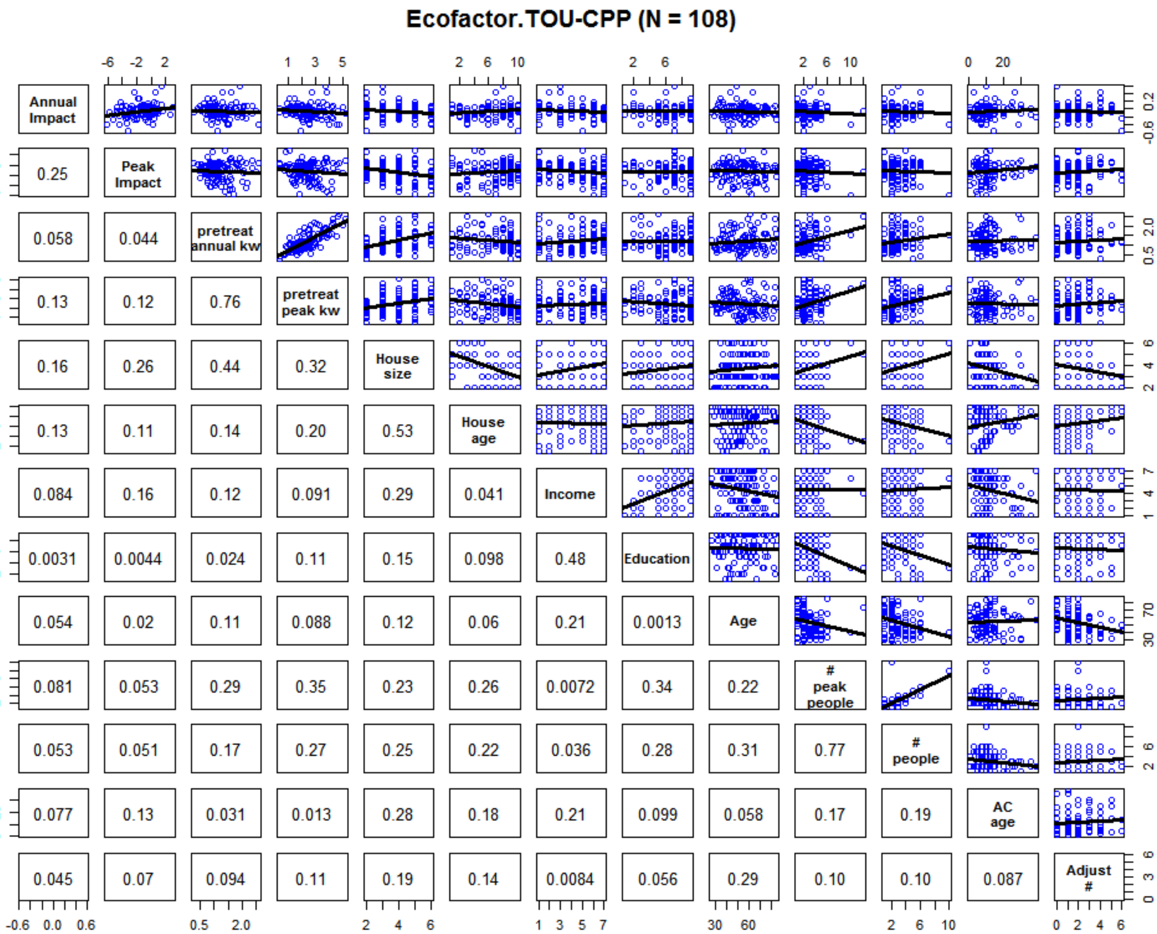
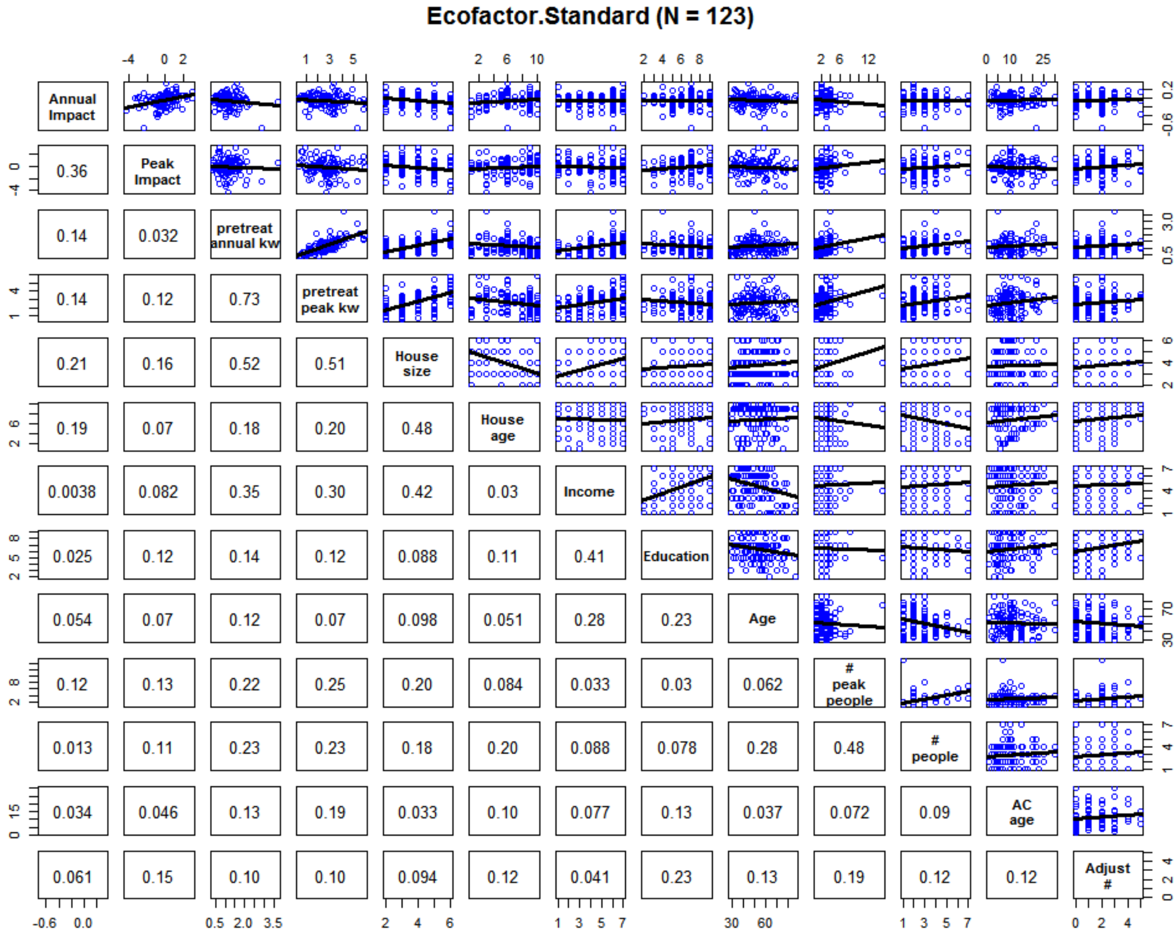


FIGURE 70. LOAD AND DEMOGRAPHIC VARIABLE CORRELATION MATRIX, ECOFACTOR.STANDARD



Survey Data Summary

This section compares the modeled Conservation Day load impacts between categories after normalizing for an average pretreatment peak demand of 2.4 kW.

Age

Table 75 shows the differences between the baseline and treatment load shapes for standard rate participants. Values marked with an asterisk indicate that the impact differs statistically from zero.

Table 75.Age, Standard Rate

Age	N	Impact	95 % Confidence Interval	
26-35	48	-0.19	0.0032	-0.3770
36-54	150	-0.20*	-0.0977	-0.3056
55-75	139	-0.15*	-0.0440	-0.2607
76 or more	22	-0.12	0.1804	-0.4243

* Statistically significant, α=0.05.

Figure 71 plots the difference between the baseline and treatment loads for standard rate participants.

Figure 71.Age, Standard Rate

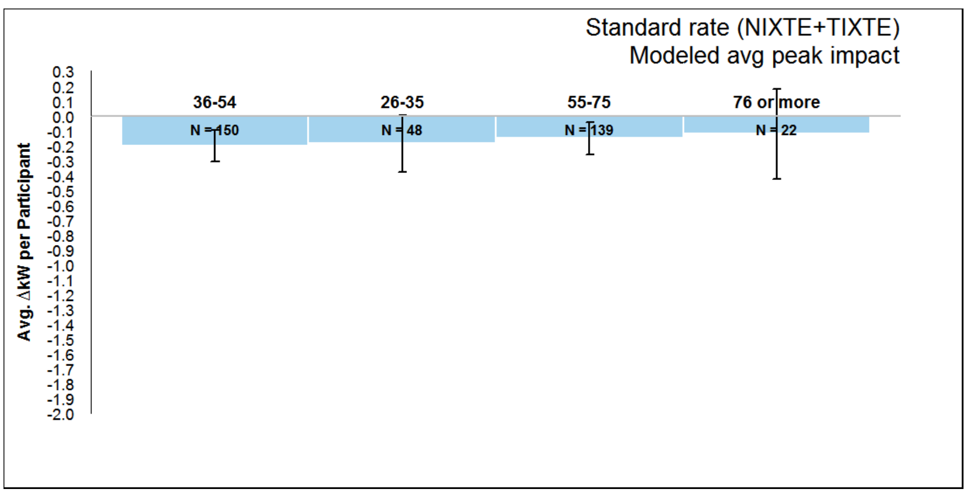


Table 76 shows the results of a contrast analysis, providing between-category differences for the impacts shown in Table 75 above. Younger participants saved more than older participants did but the differences in savings were not statistically significant.

TABLE 76.AGE - BETWEEN CATEGORY COMPARISONS, STANDARD RATE

Contrast	Impact	P-value
26-35 vs 36-54	0.015	1.000
26-35 vs 55-75	-0.035	1.000
26-35 vs 76 or more	-0.065	1.000
36-54 vs 55-75	-0.049	1.000
36-54 vs 76 or more	-0.080	1.000
55-75 vs 76 or more	-0.030	1.000

* Statistically significant, α=0.05.

Table 77 shows the differences between the baseline and treatment load shapes for TOU-CPP rate participants. Values marked with an asterisk indicate that the impact differs statistically from zero.

TABLE 77.AGE , TOU-CPP RATE

Age	N	Impact	95 % Confidence Interval	
26-35	28	-1.59*	-1.3493	-1.8312
55-75	122	-1.56*	-1.4466	-1.6780
36-54	125	-1.15*	-1.0376	-1.2686
76 or more	30	-0.94*	-0.7096	-1.1705

* Statistically significant, α=0.05.

Figure 72 plots the difference between the baseline and treatment loads for TOU-CPP rate participants.

FIGURE 72. AGE, TOU-CPP RATE

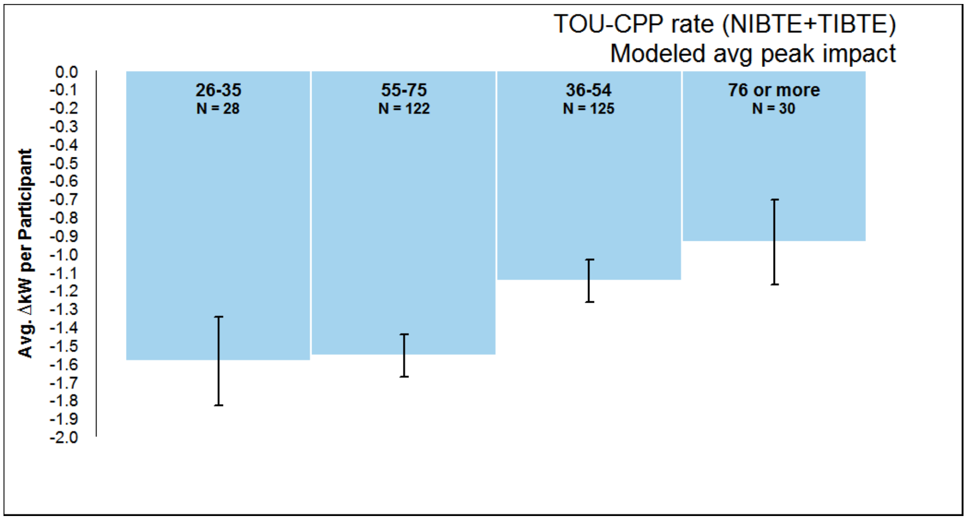


Table 78 shows the results of a contrast analysis, providing between-category differences for the impacts shown in Table 77 above. Statistically significant differences are marked with asterisks. Younger participants saved more than older participants did with an exception of "26-35 vs 55-75" and "36-54 vs 76 or more" age categories where differences in savings were statistically indistinguishable.

TABLE 78.AGE – BETWEEN CATEGORY COMPARISONS, TOU-CPP RATE

Contrast	Impact	P-value
26-35 vs 36-54	-0.44*	0.0081
26-35 vs 55-75	-0.028	1.0000
26-35 vs 76 or more	-0.65*	0.0008
36-54 vs 55-75	0.41*	<0.0001
36-54 vs 76 or more	-0.21	0.6318
55-75 vs 76 or more	-0.62*	<0.0001

* Statistically significant, α=0.05.

INCOME

Table 79 shows the differences between the baseline and treatment load shapes for standard rate participants. Values marked with an asterisk indicate that the impact differs statistically from zero.

TABLE 79.INCOME, STANDARD RATE

Income	N	Impact	95 % Confidence Interval	
< $30,000	29	-0.20	0.0507	-0.4468
$30,000 to $44,999	34	-0.18	0.0659	-0.4176
$45,000 to $59,999	41	-0.0016	0.1986	-0.2018
$60,000 to $79,999	46	-0.27*	-0.0791	-0.4513
$80,000 to $99,999	39	-0.18	0.0168	-0.3806
$100,000 to $149,999	75	-0.42*	-0.2662	-0.5643
$150,000 or more	37	-0.28	-0.0486	-0.5197
Prefer not to answer	61	-0.18	-0.0194	-0.3442

* Statistically significant, α=0.05.

Figure 73 plots the difference between the baseline and treatment loads for standard rate participants.

FIGURE 73. INCOME, STANDARD RATE

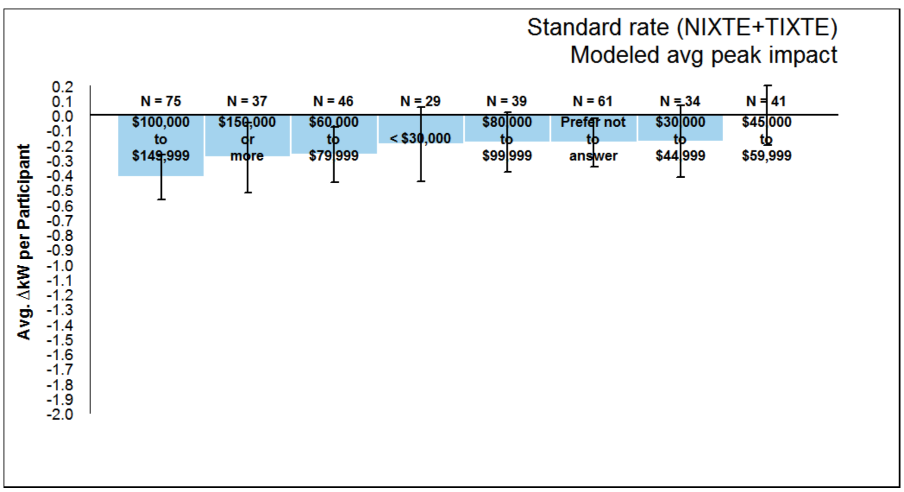


Table 80 shows the results of a contrast analysis, providing between-category differences for the impacts shown in Table 79 above. None of the differences in savings were statistically significant with an exception of “$45,000 to $59,999” and “$100,000 to $149,999” groups where the latter saved more.

TABLE 80.INCOME - BETWEEN CATEGORY COMPARISONS, STANDARD RATE

Contrast	Impact	P-value
Less than $30,000 vs $30,000 to $44,999	-0.022	1.000
Less than $30,000 vs $45,000 to $59,999	-0.20	1.000
Less than $30,000 vs $60,000 to $79,999	0.067	1.000
Less than $30,000 vs $80,000 to $99,999	-0.016	1.000
Less than $30,000 vs $100,000 to $149,999	0.22	1.000
Less than $30,000 vs $150,000 or more	0.086	1.000
Less than $30,000 vs Prefer not to answer	-0.016	1.000
$30,000 to $44,999 vs $45,000 to $59,999	-0.17	1.000
$30,000 to $44,999 vs $60,000 to $79,999	0.089	1.000
$30,000 to $44,999 vs $80,000 to $99,999	0.0061	1.000
$30,000 to $44,999 vs $100,000 to $149,999	0.24	1.000
$30,000 to $44,999 vs $150,000 or more	0.11	1.000
$30,000 to $44,999 vs Prefer not to answer	0.0060	1.000
$45,000 to $59,999 vs $60,000 to $79,999	0.26	1.000
$45,000 to $59,999 vs $80,000 to $99,999	0.18	1.000
$45,000 to $59,999 vs $100,000 to $149,999	0.41*	0.033
$45,000 to $59,999 vs $150,000 or more	0.28	1.000
$45,000 to $59,999 vs Prefer not to answer	0.18	1.000
$60,000 to $79,999 vs $80,000 to $99,999	-0.083	1.000
$60,000 to $79,999 vs $100,000 to $149,999	0.15	1.000
$60,000 to $79,999 vs $150,000 or more	0.019	1.000
$60,000 to $79,999 vs Prefer not to answer	-0.083	1.000
$80,000 to $99,999 vs $100,000 to $149,999	0.23	1.000
$80,000 to $99,999 vs $150,000 or more	0.10	1.000
$80,000 to $99,999 vs Prefer not to answer	-0.00012	1.000
$100,000 to $149,999 vs $150,000 or more	-0.13	1.000
$100,000 to $149,999 vs Prefer not to answer	-0.23	1.000
$150,000 or more vs Prefer not to answer	-0.10	1.000

* Statistically significant, α=0.05.

Table 81 shows the differences between the baseline and treatment load shapes for TOU-CPP Rate participants. Values marked with an asterisk indicate that the impact differs statistically from zero.

TABLE 81.INCOME, TOU-CPP RATE

Income	N	Impact	95 % Confidence Interval	
< $30,000	34	-0.83*	-0.6104	-1.0556
$30,000 to $44,999	27	-1.02*	-0.7750	-1.2620
$45,000 to $59,999	36	-1.35*	-1.1229	-1.5697
$60,000 to $79,999	33	-1.34*	-1.1295	-1.5543
$80,000 to $99,999	39	-1.61*	-1.4005	-1.8099
$100,000 to $149,999	60	-1.33*	-1.1685	-1.4879
$150,000 or more	38	-1.60*	-1.3851	-1.8158
Prefer not to answer	42	-1.17*	-0.9618	-1.3771

* Statistically significant, α=0.05.

Figure 74 plots the difference between the baseline and treatment loads for TOU-CPP rate participants.

FIGURE 74.INCOME, TOU-CPP RATE

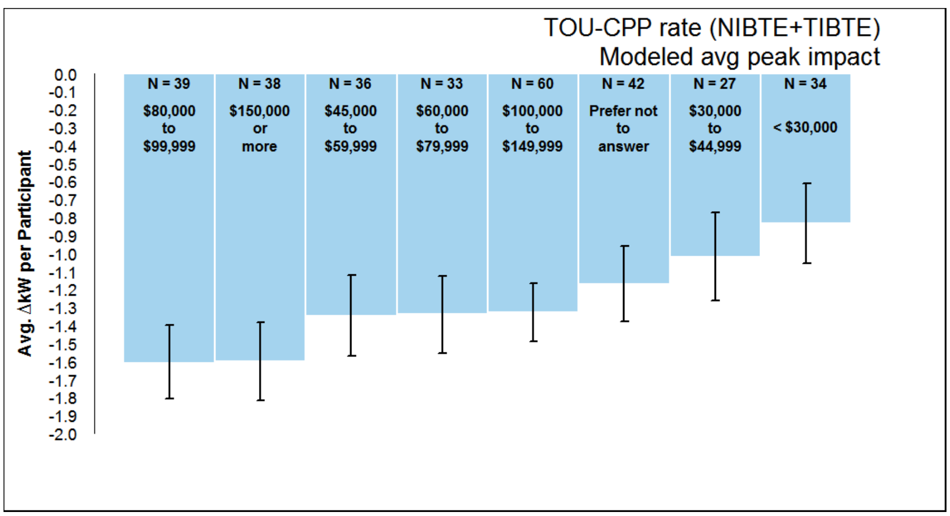


Table 82 shows the results of a contrast analysis, providing between-category differences for the impacts shown in Table 81 above. Savings in all income groups (except "$30,000 to $44,999") were statistically significant and higher than savings in "Less than $30,000" income group. Savings in "150,000 or more" group were statistically significant and higher relative to savings in "30,000 and $44,999" group.

TABLE 82.INCOME - BETWEEN CATEGORY COMPARISONS, TOU-CPP RATE

Contrast	Impact	P-value
Less than $30,000 vs $30,000 to $44,999	0.19	1.0000
Less than $30,000 vs $45,000 to $59,999	0.51*	0.0400
Less than $30,000 vs $60,000 to $79,999	0.51*	0.0330
Less than $30,000 vs $80,000 to $99,999	0.77*	<0.0001
Less than $30,000 vs $100,000 to $149,999	0.50*	0.0110
Less than $30,000 vs $150,000 or more	0.77*	<0.0001
Less than $30,000 vs Prefer not to answer	0.34	0.8500
$30,000 to $44,999 vs $45,000 to $59,999	0.33	1.0000
$30,000 to $44,999 vs $60,000 to $79,999	0.32	1.0000
$30,000 to $44,999 vs $80,000 to $99,999	0.59*	0.0085
$30,000 to $44,999 vs $100,000 to $149,999	0.31	1.0000
$30,000 to $44,999 vs $150,000 or more	0.58*	0.0130
$30,000 to $44,999 vs Prefer not to answer	0.15	1.0000
$45,000 to $59,999 vs $60,000 to $79,999	-0.0044	1.0000
$45,000 to $59,999 vs $80,000 to $99,999	0.26	1.0000
$45,000 to $59,999 vs $100,000 to $149,999	-0.018	1.0000
$45,000 to $59,999 vs $150,000 or more	0.25	1.0000
$45,000 to $59,999 vs Prefer not to answer	-0.18	1.0000
$60,000 to $79,999 vs $80,000 to $99,999	0.26	1.0000
$60,000 to $79,999 vs $100,000 to $149,999	-0.014	1.0000
$60,000 to $79,999 vs $150,000 or more	0.26	1.0000
$60,000 to $79,999 vs Prefer not to answer	-0.17	1.0000
$80,000 to $99,999 vs $100,000 to $149,999	-0.28	1.0000
$80,000 to $99,999 vs $150,000 or more	-0.0047	1.0000
$80,000 to $99,999 vs Prefer not to answer	-0.44	0.0950
$100,000 to $149,999 vs $150,000 or more	0.27	1.0000
$100,000 to $149,999 vs Prefer not to answer	-0.16	1.0000
$150,000 or more vs Prefer not to answer	-0.43	0.1300

* Statistically significant, α=0.05.

Electric Heater

Table 83 shows the differences between the baseline and treatment load shapes for standard rate participants. Values marked with an asterisk indicate that the impact differs statistically from zero.

Table 83. Electric heater, Standard Rate

Electric Heater	N	Impact	95 % Confidence Interval	
No	289	-0.21*	-0.1389	-0.2885
Yes	52	-0.14	0.0442	-0.3137

* Statistically significant, α=0.05.

Figure 75 plots the difference between the baseline and treatment loads for standard rate participants.

Figure 75. Electric heater, Standard Rate

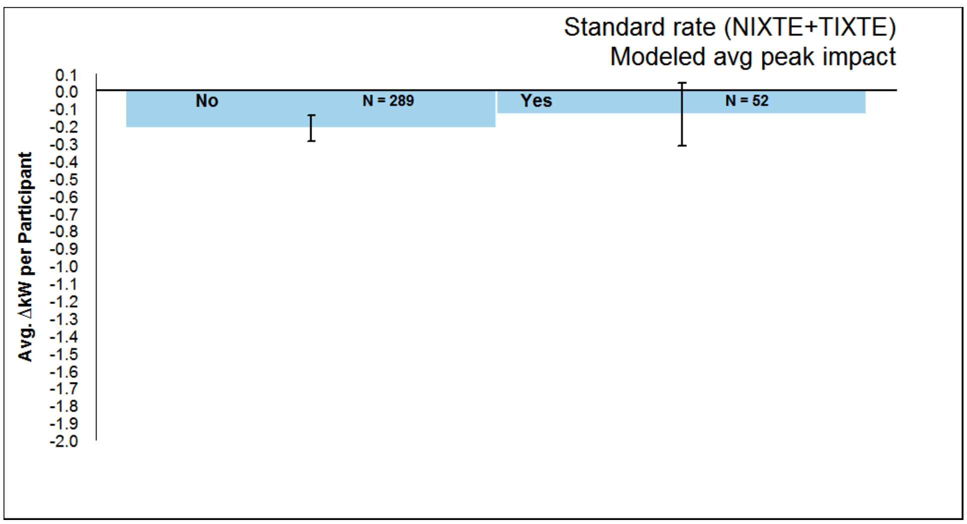


Table 84 shows the results of a contrast analysis, providing between-category differences for the impacts shown in Table 83 above. Participants with electric heaters saved less than those with no electric heaters but the difference was not statistically significant.

Table 84. Electric Heater - Between category comparisons, Standard Rate

Contrast	Impact	P-value
Yes vs No	0.079	0.4249

* Statistically significant, α=0.05.

Table 85 shows the differences between the baseline and treatment load shapes for TOU-CPP Rate participants. Values marked with an asterisk indicate that the impact differs statistically from zero.

TABLE 85.ELECTRIC HEATER, TOU-CPP RATE

Electric Heater	N	Impact	95 % Confidence Interval	
No	246	-1.40*	-1.3163	-1.4774
Yes	43	-0.88*	-0.6829	-1.0835

* Statistically significant, α=0.05.

Figure 76 plots the difference between the baseline and treatment loads for TOU-CPP rate participants.

FIGURE 76. ELECTRIC HEATER, TOU-CPP RATE

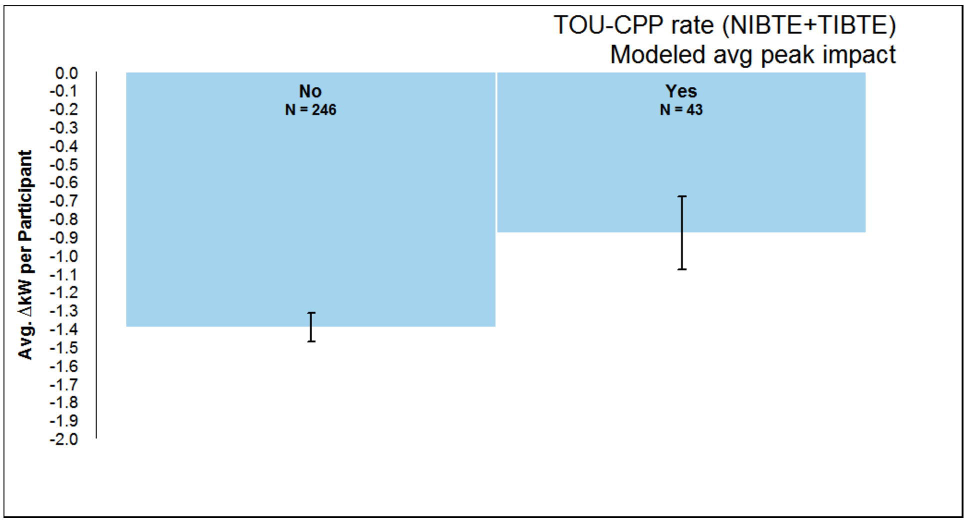


Table 86 shows the results of a contrast analysis, providing between-category differences for the impacts shown in Table 85 above. Participants with electric heaters saved less than those with no electric heaters.

TABLE 86.ELECTRIC HEATER - BETWEEN CATEGORY COMPARISONS, TOU-CPP RATE

Contrast	Impact	P-value
Yes vs No	0.51*	<0.0001

* Statistically significant, α=0.05.

Electric Dryer

Table 87 shows the differences between the baseline and treatment load shapes for standard rate participants. Values marked with an asterisk indicate that the impact differs statistically from zero.

Table 87. Electric dryer, Standard Rate

Electric Dryer	N	Impact	95 % Confidence Interval	
No	80	-0.19*	-0.0511	-0.3316
Yes	279	-0.17*	-0.0929	-0.2451

* Statistically significant, α=0.05.

Figure 77 plots the difference between the baseline and treatment loads for standard rate participants.

Figure 77. Electric dryer, Standard Rate

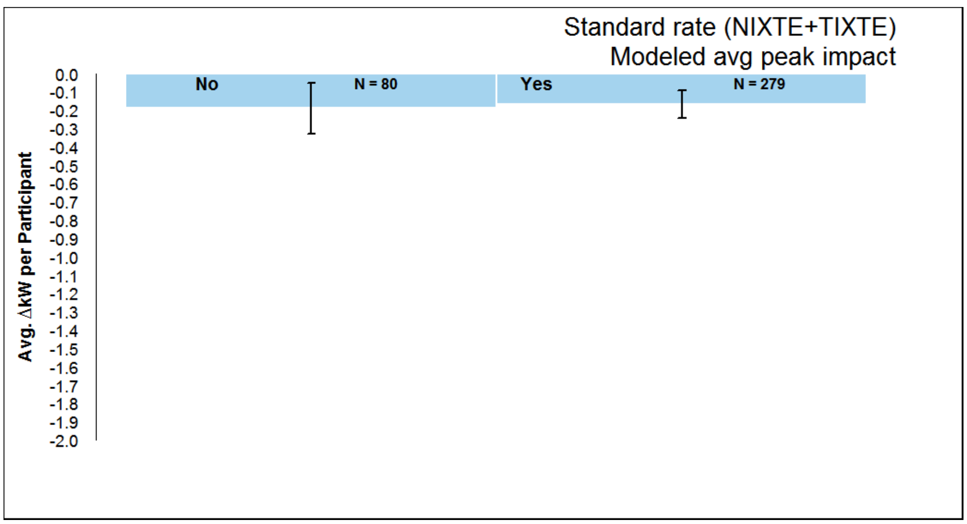


Table 88 shows the results of a contrast analysis, providing between-category differences for the impacts shown in Table 87 above. Participants with electric dryers saved less than those with no electric dryers but the difference was not statistically significant.

Table 88.Electric dryer - Between category comparisons, Standard Rate

Contrast	Impact	P-value
Yes vs No	0.022	0.7838

* Statistically significant, α=0.05.

Table 89 shows the differences between the baseline and treatment load shapes for TOU-CPP Rate participants. Values marked with an asterisk indicate that the impact differs statistically from zero.

TABLE 89.ELECTRIC DRYER, TOU-CPP RATE

Electric Dryer	N	Impact	95 % Confidence Interval	
No	54	-1.56*	-1.3976	-1.7290
Yes	249	-1.28*	-1.1960	-1.3589

* Statistically significant, α=0.05.

Figure 78 plots the difference between the baseline and treatment loads for TOU-CPP rate participants.

FIGURE 78. ELECTRIC DRYER, TOU-CPP RATE

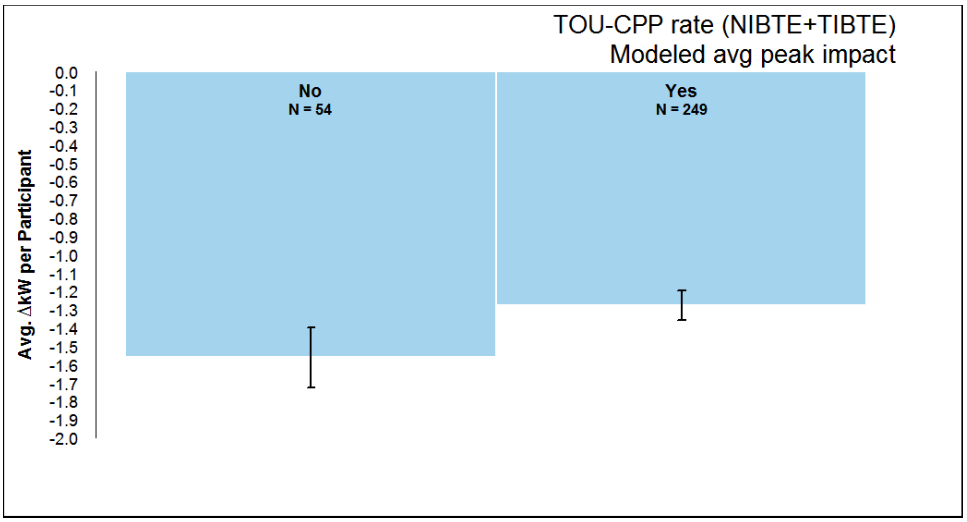


Table 90 shows the results of a contrast analysis, providing between-category differences for the impacts shown in Table 65 above. Participants with electric dryers saved less than those with no electric dryers.

TABLE 90.ELECTRIC DRYER - BETWEEN CATEGORY COMPARISONS, TOU-CPP RATE

Contrast	Impact	P-value
Yes vs No	0.29*	0.0024

* Statistically significant, α=0.05.

GENDER

Table 91 shows the differences between the baseline and treatment load shapes for standard rate participants. Values marked with an asterisk indicate that the impact differs statistically from zero.

TABLE 91. GENDER, STANDARD RATE

Gender	N	Impact	95 % Confidence Interval	
Male	221	-0.19*	-0.1029	-0.2744
Female	144	-0.18*	-0.0756	-0.2862

* Statistically significant, α=0.05.

Figure 79 plots the difference between the baseline and treatment loads for standard rate participants.

FIGURE 79. GENDER, STANDARD RATE

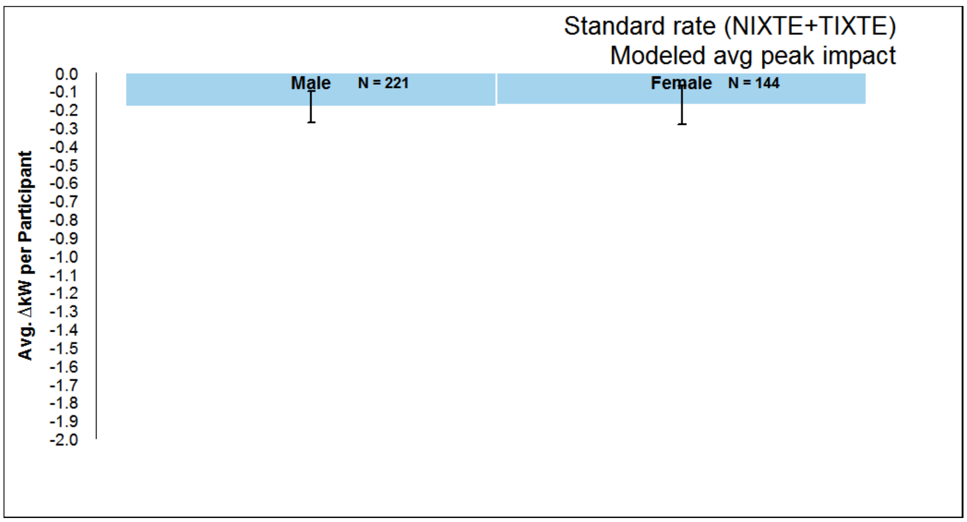


Table 92 shows the results of a contrast analysis, providing between-category differences for the impacts shown in Table 91 above. No difference in savings between males and females.

TABLE 92.GENDER - BETWEEN CATEGORY COMPARISONS, STANDARD RATE

Contrast	Impact	P-value
Male vs Female	-0.0077	0.911

* Statistically significant, α=0.05.

Table 93 shows the differences between the baseline and treatment load shapes for TOU-CPP Rate participants. Values marked with an asterisk indicate that the impact differs statistically from zero.

TABLE 93.GENDER, TOU-CPP RATE

Gender	N	Impact	95 % Confidence Interval	
Male	165	-1.32*	-1.2200	-1.4185
Female	143	-1.32*	-1.2122	-1.4241

* Statistically significant, α=0.05.

Figure 80 plots the difference between the baseline and treatment loads for TOU-CPP rate participants.

FIGURE 80. GENDER, TOU-CPP RATE

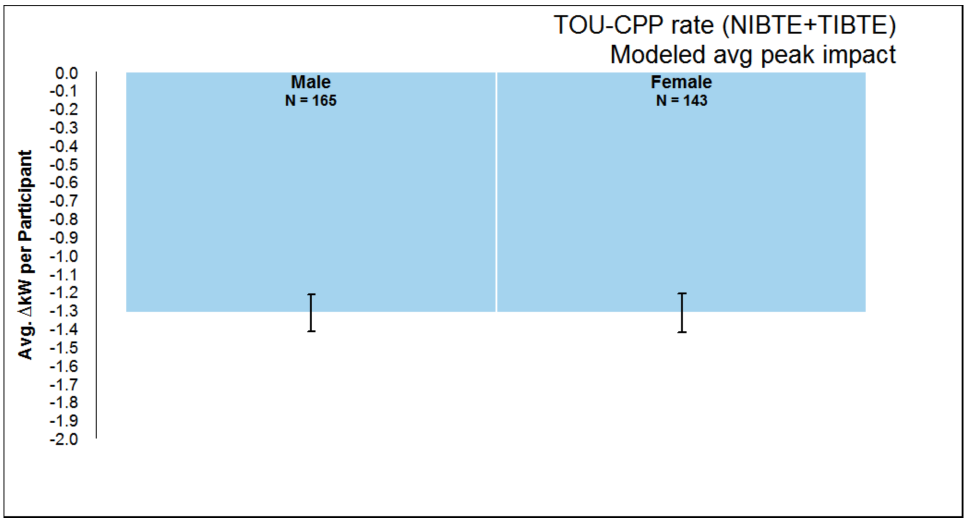


Table 94 shows the results of a contrast analysis, providing between-category differences for the impacts shown in Table 93 above. No difference in savings between males and females.

TABLE 94.GENDER - BETWEEN CATEGORY COMPARISONS, TOU-CPP RATE

Contrast	Impact	P-value
Male vs Female	-0.0011	0.9884

* Statistically significant, α=0.05.

STORIES

Table 95 shows the differences between the baseline and treatment load shapes for standard rate participants. Values marked with an asterisk indicate that the impact differs statistically from zero.

TABLE 95. STORIES, STANDARD RATE

Stories	N	Impact	95 % Confidence Interval	
One story house	266	-0.21*	-0.1356	-0.2907
Two story house	88	-0.18*	-0.0347	-0.3161

* Statistically significant, α=0.05.

Figure 81 plots the difference between the baseline and treatment loads for standard rate participants.

FIGURE 81. STORIES, STANDARD RATE

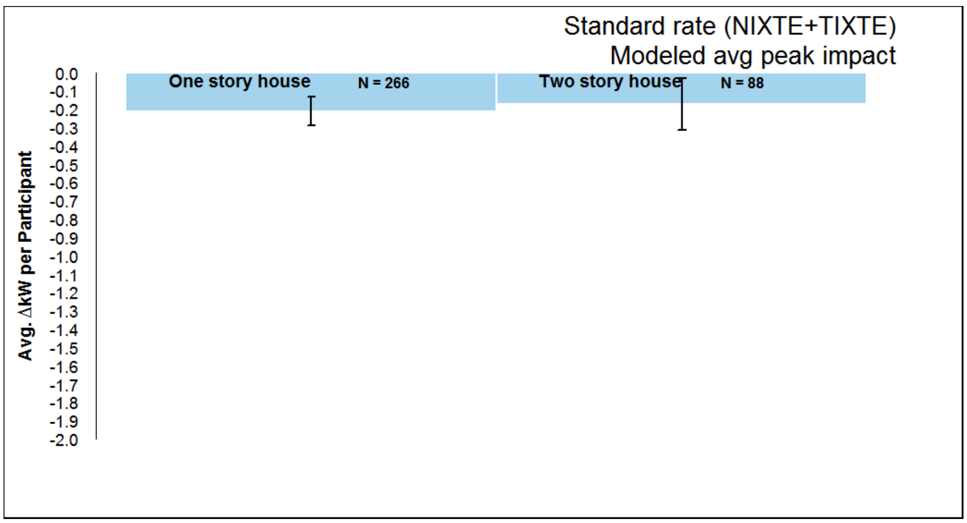


Table 96 shows the results of a contrast analysis, providing between-category differences for the impacts shown in Table 95 above. Participants with two story houses saved less but the difference was not statistically significant.

TABLE 96.STORIES - BETWEEN CATEGORY COMPARISONS, STANDARD RATE

Contrast	Impact	P-value
One story vs Two story	-0.038	0.6452

* Statistically significant, α=0.05.

Table 97 shows the differences between the baseline and treatment load shapes for TOU-CPP Rate participants. Values marked with an asterisk indicate that the impact differs statistically from zero.

TABLE 97.STORIES, TOU-CPP RATE

Stories	N	Impact	95 % Confidence Interval	
One story house	228	-1.37*	-1.2890	-1.4589
Two story house	77	-1.15*	-1.0033	-1.2975

* Statistically significant, α=0.05.

Figure 82 plots the difference between the baseline and treatment loads for TOU-CPP rate participants.

FIGURE 82. STORIES, TOU-CPP RATE

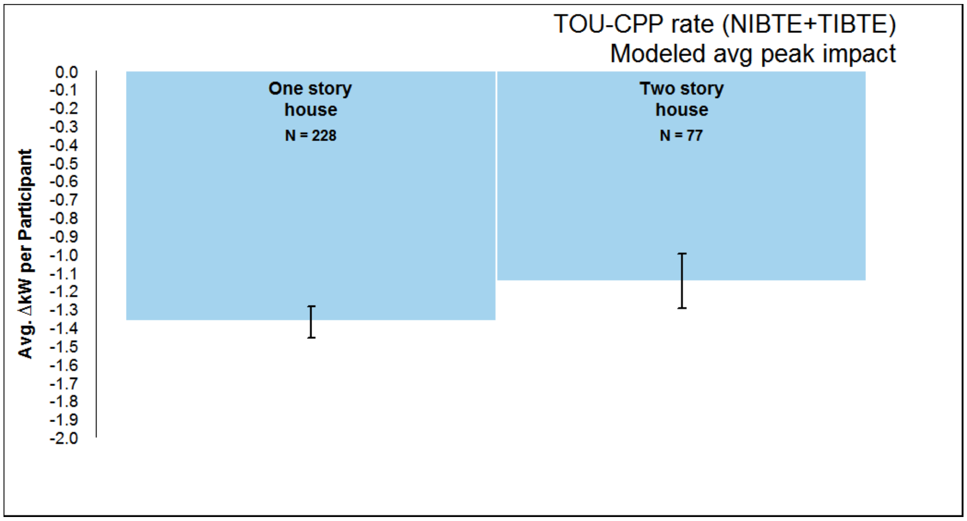


Table 98 shows the results of a contrast analysis, providing between-category differences for the impacts shown in Table 97 above. Participants in one story houses saved more than participants in two story houses.

TABLE 98.STORIES - BETWEEN TREATMENT COMPARISONS, TOU-CPP RATE

Contrast	Impact	P-value
One story vs Two story	-0.22*	0.0099

* Statistically significant, α=0.05.

Number of AC units

Majority of participants had only one AC unit which makes it unreasonable to compare participants with different number of AC units. Table 99 and Table 100 provide sample sizes for different numbers of AC units for Standard and TOU-CPP rate participants.

Table 99. Number of AC units, Standard Rate

Number of AC Units	N
0	1
1	330
2	28
3	1

Table 100.Number of AC units, TOU-CPP Rate

Number of AC Units	N
0	0
1	272
2	33
3	0

Rent or own

Only 25 Renters so doesn't make sense to compare.

Education

Table 101 shows how 11 education levels were combined into 4 categories for the analysis.

Table 101.Education, categories for analysis

Category	Education level
One	Elementary + Some high school + high school
Two	technical/vocational school + college grad (2 years) + some college
Three	College grad (4 yrs) + Some graduate school
Four	graduate,professional,doctorate degree

Table 102 shows the differences between the baseline and treatment load shapes for standard rate participants. Values marked with an asterisk indicate that the impact differs statistically from zero.

Table 102. Education, Standard Rate

Education	N	Impact	95 % Confidence Interval	
One	40	-0.0645	0.1411	-0.2701

Two	107	-0.19*	-0.0695	-0.3153
Three	143	-0.19*	-0.0798	-0.2965
Four	66	-0.22*	-0.0563	-0.3898

* Statistically significant, α=0.05.

Figure 83 plots the difference between the baseline and treatment loads for standard rate participants.

FIGURE 83. EDUCATION, STANDARD RATE

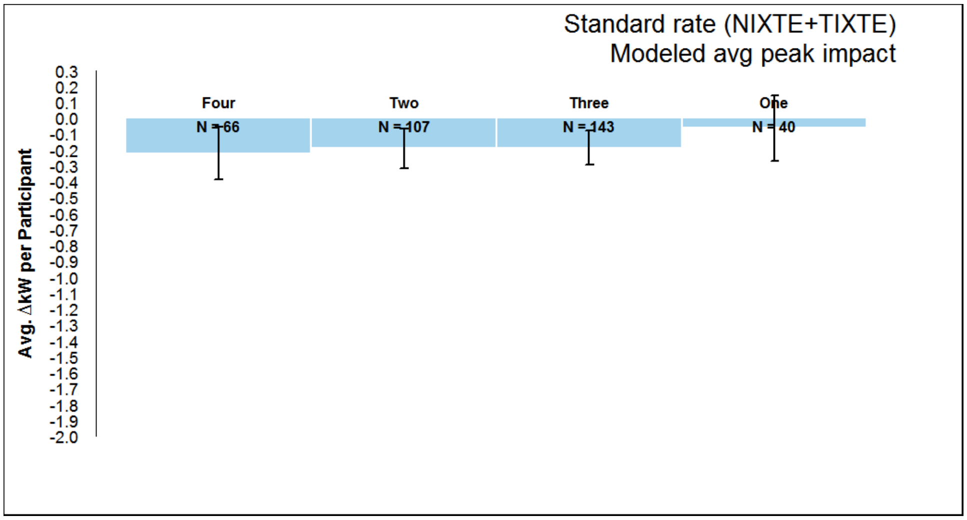


Table 103 shows the results of a contrast analysis, providing between-category differences for the impacts shown in Table 102 above. No statistically significant differences in savings between different education levels.

TABLE 103.EDUCATION - BETWEEN CATEGORY COMPARISONS, STANDARD RATE

Contrast	Impact	P-value
One vs Two	0.13	1.000
One vs Three	0.12	1.000
One vs Four	0.16	1.000
Two vs Three	-0.0042	1.000
Two vs Four	0.031	1.000
Three vs Four	0.035	1.000

* Statistically significant, α=0.05.

Table 104 shows the differences between the baseline and treatment load shapes for TOU-CPP Rate participants. Values marked with an asterisk indicate that the impact differs statistically from zero.

TABLE 104. EDUCATION, TOU-CPP RATE

Education	N	Impact	95 % Confidence Interval	
One	45	-1.10*	-0.9079	-1.2970
Two	82	-1.52*	-1.3817	-1.6620
Three	102	-1.12*	-0.9970	-1.2483
Four	73	-1.35*	-1.1997	-1.4932

* Statistically significant, α=0.05.

Figure 84 plots the difference between the baseline and treatment loads for TOU-CPP rate participants.

FIGURE 84. EDUCATION, TOU-CPP RATE

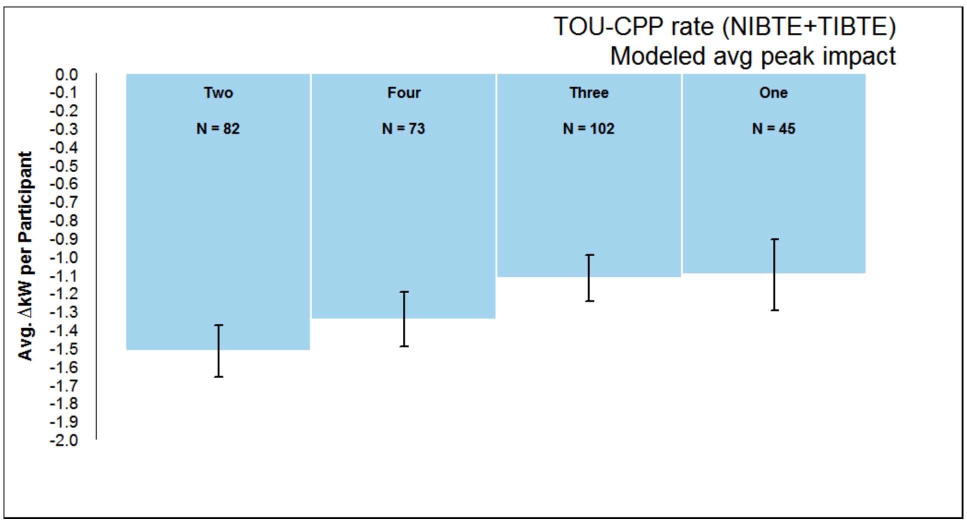


Table 105 shows the results of a contrast analysis, providing between-category differences for the impacts shown in Table 104 above. Participants in a group with high school being the highest education level saved less than participants with technical/vocational or some college education. College graduates saved less than participants with some college education.

TABLE 105. EDUCATION - BETWEEN CATEGORY COMPARISONS, TOU-CPP RATE

Contrast	Impact	P-value
One vs Two	0.42*	0.0037
One vs Three	0.02	1.0000
One vs Four	0.24	0.2982
Two vs Three	-0.40*	0.0002
Two vs Four	-0.18	0.5414
Three vs Four	0.22	0.1390

* Statistically significant, α=0.05.

Occupants

Table 106 shows the differences between the baseline and treatment load shapes for standard rate participants. Values marked with an asterisk indicate that the impact differs statistically from zero.

Table 106. Occupants, Standard Rate

Occupants	N	Impact	95 % Confidence Interval	
One	54	-0.49*	-0.2597	-0.7152
Two	128	-0.24*	-0.1250	-0.3455
Three	67	-0.45*	-0.2765	-0.6174
Four	66	-0.11	0.0537	-0.2702
Five+	42	0.090	0.2997	-0.1201

* Statistically significant, α=0.05.

Figure 85 plots the difference between the baseline and treatment loads for standard rate participants.

Figure 85. Occupants, Standard Rate

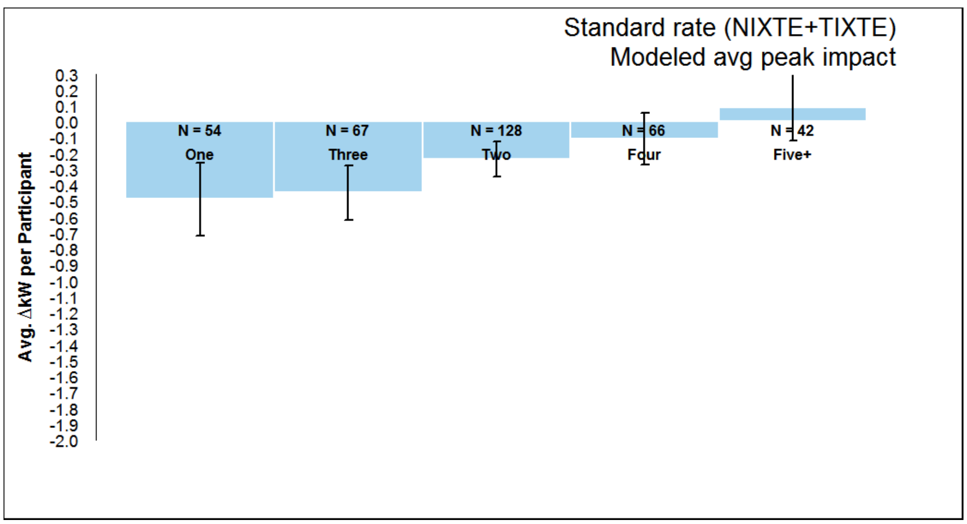


Table 107 shows the results of a contrast analysis, providing between-category differences for the impacts shown in Table 106 above. Savings are higher for households with less occupants.

Table 107.Occupants - Between category comparisons, Standard Rate

Contrast	Impact	P-value
One vs Two	-0.25	0.5085
One vs Three	-0.041	1.0000
One vs Four	-0.38	0.0785
One vs Five+	-0.58*	0.0026

Two vs Three	0.21	0.4101
Two vs Four	-0.13	1.0000
Two vs Five+	-0.33	0.0721
Three vs Four	-0.34*	0.0476
Three vs Five+	-0.54*	0.0010
Four vs Five+	-0.20	1.0000

* Statistically significant, α=0.05.

Table 108 shows the differences between the baseline and treatment load shapes for TOU-CPP Rate participants. Values marked with an asterisk indicate that the impact differs statistically from zero.

TABLE 108.OCCUPANTS, TOU-CPP RATE

Occupants	N	Impact	95 % Confidence Interval	
One	58	-1.16*	-0.9426	-1.3867
Two	109	-1.79*	-1.6682	-1.9214
Three	38	-1.81*	-1.5921	-2.0257
Four	53	-0.89*	-0.7026	-1.0791
Five+	41	-1.05*	-0.8288	-1.2645

* Statistically significant, α=0.05.

Figure 86 plots the difference between the baseline and treatment loads for TOU-CPP rate participants.

FIGURE 86. OCCUPANTS, TOU-CPP RATE

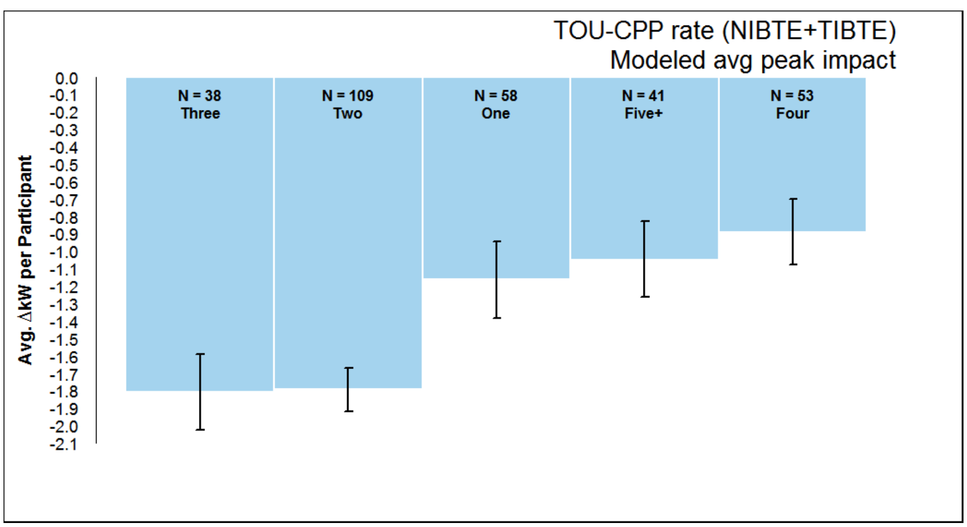


Table 109 shows the results of a contrast analysis, providing between-category differences for the impacts shown in Table 108 above. Households with two and three occupants saved more than households with only one occupant and households with more than three occupants.

TABLE 109.OCCUPANTS - BETWEEN CATEGORY COMPARISONS, TOU-CPP RATE

Contrast	Impact	P-value
One vs Two	0.63*	<0.0001
One vs Three	0.64*	0.0005
One vs Four	-0.27	0.6532
One vs Five+	-0.12	1.0000
Two vs Three	0.014	1.0000
Two vs Four	-0.90*	<0.0001
Two vs Five+	-0.75*	<0.0001
Three vs Four	-0.92*	<0.0001
Three vs Five+	-0.76*	<0.0001
Four vs Five+	0.16	1.0000

* Statistically significant, α=0.05.

Occupants during peak

Table 110 shows the differences between the baseline and treatment load shapes for standard rate participants. Values marked with an asterisk indicate that the impact differs statistically from zero.

Table 110. Occupants during peak, Standard Rate

Occupants during peak	N	Impact	95 % Confidence Interval	
One	48	-0.36*	-0.1383	-0.5725
Two	140	-0.26*	-0.1538	-0.3676
Three	72	-0.35*	-0.1838	-0.5121
Four	56	-0.076	0.1043	-0.2569
Five+	37	0.064	0.2941	-0.1665

* Statistically significant, α=0.05.

Figure 87 plots the difference between the baseline and treatment loads for standard rate participants.

Figure 87. Occupants during peak, Standard Rate

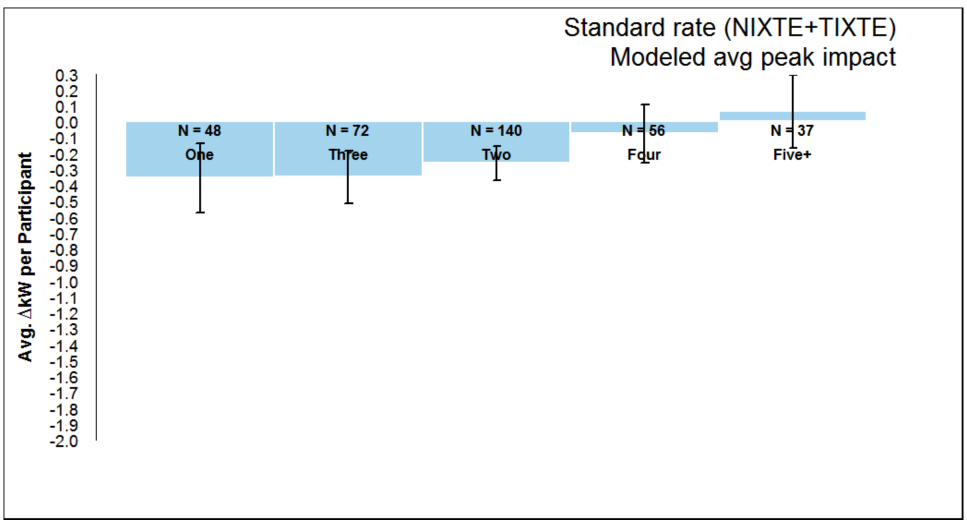


Table 111 shows the results of a contrast analysis, providing between-category differences for the impacts shown in Table 110 above. Households with more people home during peak don't save as much as households with less people home during peak.

Table 111.Occupants during peak - Between category comparisons, Standard Rate

Contrast	Impact	P-value
One vs Two	-0.095	1.0000
One vs Three	-0.0075	1.0000
One vs Four	-0.28	0.5274

One vs Five+	-0.42	0.0944
Two vs Three	0.087	1.0000
Two vs Four	-0.18	0.8502
Two vs Five+	-0.32	0.1225
Three vs Four	-0.27	0.2917
Three vs Five+	-0.41*	0.0433
Four vs Five+	-0.14	1.0000

* Statistically significant, α=0.05.

Table 112 shows the differences between the baseline and treatment load shapes for TOU-CPP Rate participants. Values marked with an asterisk indicate that the impact differs statistically from zero.

TABLE 112.OCCUPANTS DURING PEAK, TOU-CPP RATE

Occupants during peak	N	Impact	95 % Confidence Interval	
One	62	-1.51*	-1.3048	-1.7143
Two	120	-1.70*	-1.5755	-1.8169
Three	37	-1.72*	-1.5076	-1.9354
Four	47	-0.84*	-0.6341	-1.0448
Five+	37	-0.99*	-0.7543	-1.2235

* Statistically significant, α=0.05.

Figure 88 plots the difference between the baseline and treatment loads for TOU-CPP rate participants.

FIGURE 88. OCCUPANTS DURING PEAK, TOU-CPP RATE

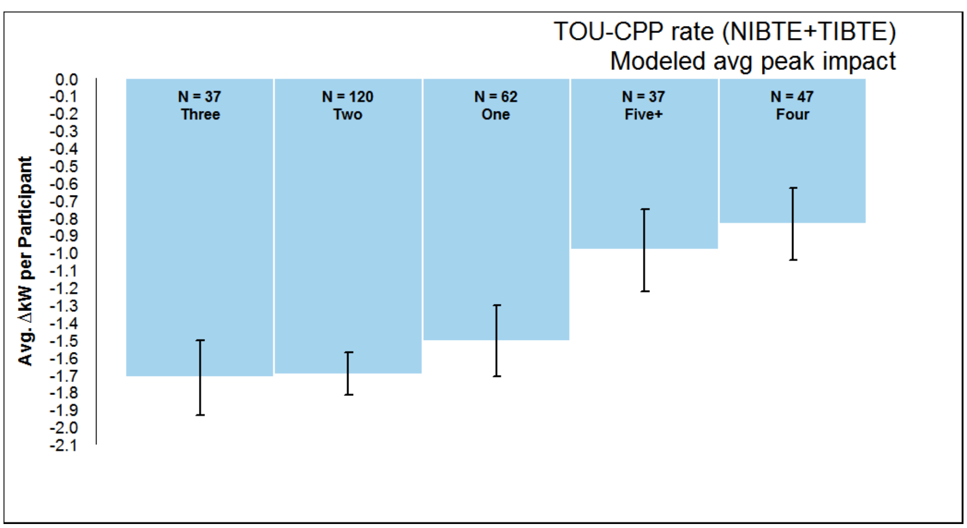


Table 113 shows the results of a contrast analysis, providing between-category differences for the impacts shown in Table 112 above. Savings are higher for households with less people home during peak.

TABLE 113.OCCUPANTS DURING PEAK - BETWEEN CATEGORY COMPARISONS, TOU-CPP RATE

Contrast	Impact	P-value
One vs Two	0.19	1.0000
One vs Three	0.21	1.0000
One vs Four	-0.67*	0.0001
One vs Five+	-0.52*	0.0105
Two vs Three	0.025	1.0000
Two vs Four	-0.86*	<0.0001
Two vs Five+	-0.71*	<0.0001
Three vs Four	-0.88*	<0.0001
Three vs Five+	-0.73*	0.0001
Four vs Five+	0.15	1.0000

* Statistically significant, α=0.05.

TYPE OF HEATING SYSTEM

Table 114 shows the differences between the baseline and treatment load shapes for standard rate participants. Values marked with an asterisk indicate that the impact differs statistically from zero.

TABLE 114. TYPE OF HEATING SYSTEM, STANDARD RATE

Type of heating System	N	Impact	95 % Confidence Interval	
Central electric furnace	52	-0.26*	-0.0826	-0.4333
Central natural gas or propane furnace	245	-0.20*	-0.1201	-0.2825
Central electric heat pump	30	-0.20	0.0225	-0.4120

* Statistically significant, α=0.05.

Figure 89 plots the difference between the baseline and treatment loads for standard rate participants.

FIGURE 89. TYPE OF HEATING SYSTEM, STANDARD RATE

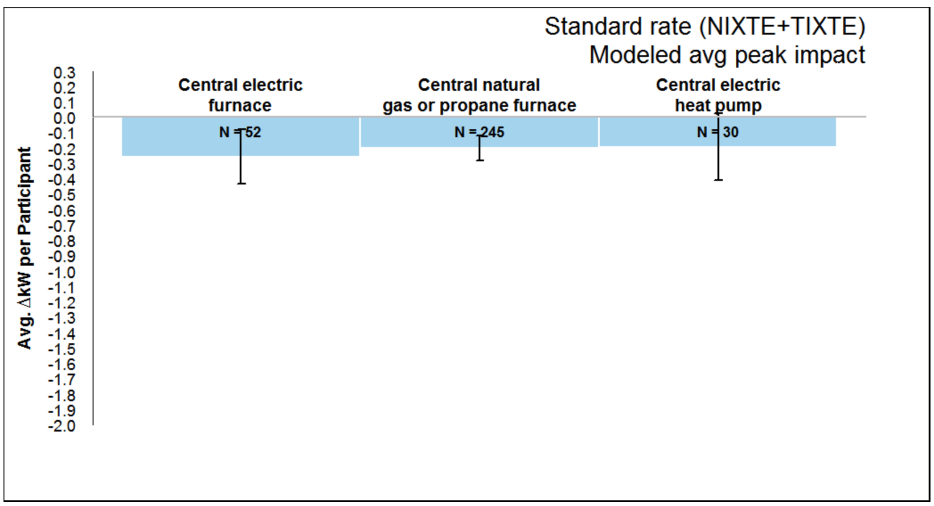


Table 115 shows the results of a contrast analysis, providing between-category differences for the impacts shown in Table 114 above. No differences in savings for households with different types of heating systems.

TABLE 115.TYPE OF HEATING SYSTEM - BETWEEN CATEGORY COMPARISONS, STANDARD RATE

Contrast	Impact	P-value
Central natural gas or propane furnace vs Central electric furnace	0.057	1.000
Central natural gas or propane furnace vs Central electric heat pump	-0.0066	1.000
Central electric furnace vs Central electric heat pump	-0.063	1.000

* Statistically significant, α=0.05.

Table 116 shows the differences between the baseline and treatment load shapes for TOU-CPP Rate participants. Values marked with an asterisk indicate that the impact differs statistically from zero.

TABLE 116.TYPE OF HEATING SYSTEM, TOU-CPP RATE

Type of heating system	N	Impact	95 % Confidence Interval	
Central natural gas or propane furnace	206	-1.50*	-1.4111	-1.5845
Central electric furnace	40	-1.01*	-0.8147	-1.2042
Central electric heat pump	25	-0.81*	-0.5462	-1.0791

* Statistically significant, α=0.05.

Figure 90 plots the difference between the baseline and treatment loads for TOU-CPP rate participants.

FIGURE 90. TYPE OF HEATING SYSTEM, TOU-CPP RATE

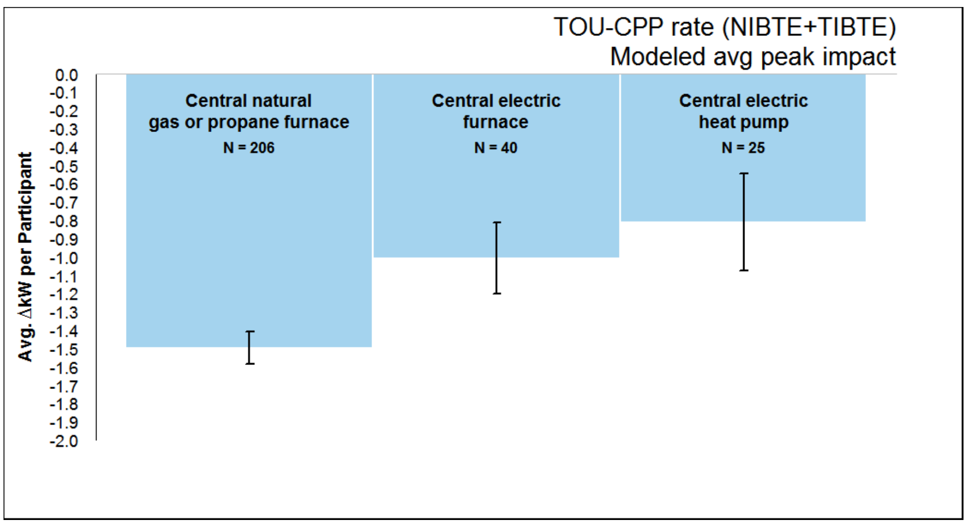


Table 117 shows the results of a contrast analysis, providing between-category differences for the impacts shown in Table 116 above. Savings for participants with Central natural gas or propane finance were higher than savings for participants with other types of heating system.

TABLE 117.TYPE OF HEATING SYSTEM - BETWEEN CATEGORY COMPARISONS, TOU-CPP RATE

Contrast	Impact	P-value
Central natural gas or propane furnace vs Central electric furnace	-0.49*	<0.0001
Central natural gas or propane furnace vs Central electric heat pump	-0.69*	<0.0001
Central electric furnace vs Central electric heat pump	-0.20	0.7274

* Statistically significant, α=0.05.

Demographic variables data summary

Pretreatment loads

Figure 91 shows the distribution of pretreatment energy use.

Figure 91. Box plot of average pretreatment energy use, by treatment

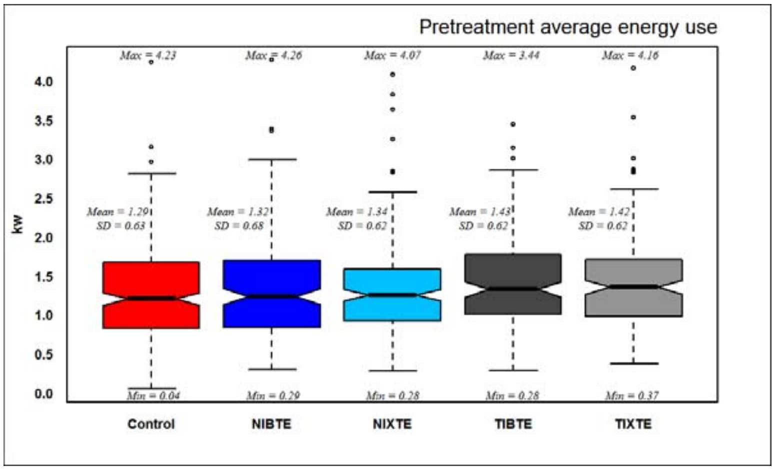


Table 118 provides p-values for mean differences analysis for pretreatment energy use. All treatments showed higher pretreatment energy use relative to control group and participants in “Ecofactor” treatments showed higher pretreatment energy use relative to “Nest” treatments but none of the differences were statistically significant.

Table 118. Mean differences analysis for pretreatment energy use

Treatment	N	Mean	Nest. TOU-CPP	Nest. Standard	Ecofactor. TOU-CPP	Ecofactor. Standard
Control	268	1.29	0.9967	0.9214	0.2485	0.2292
Nest.TOU-CPP	175	1.32				
Nest.Standard	195	1.34	0.9934			
Ecofactor.TOU-CPP	147	1.43	0.5207	0.7509		
Ecofactor.Standard	181	1.42	0.5196	0.7608	0.9999	

Figure 92 shows the distribution of pretreatment peak energy use.

FIGURE 92. BOX PLOT OF PRETREATMENT PEAK DEMAND, BY TREATMENT

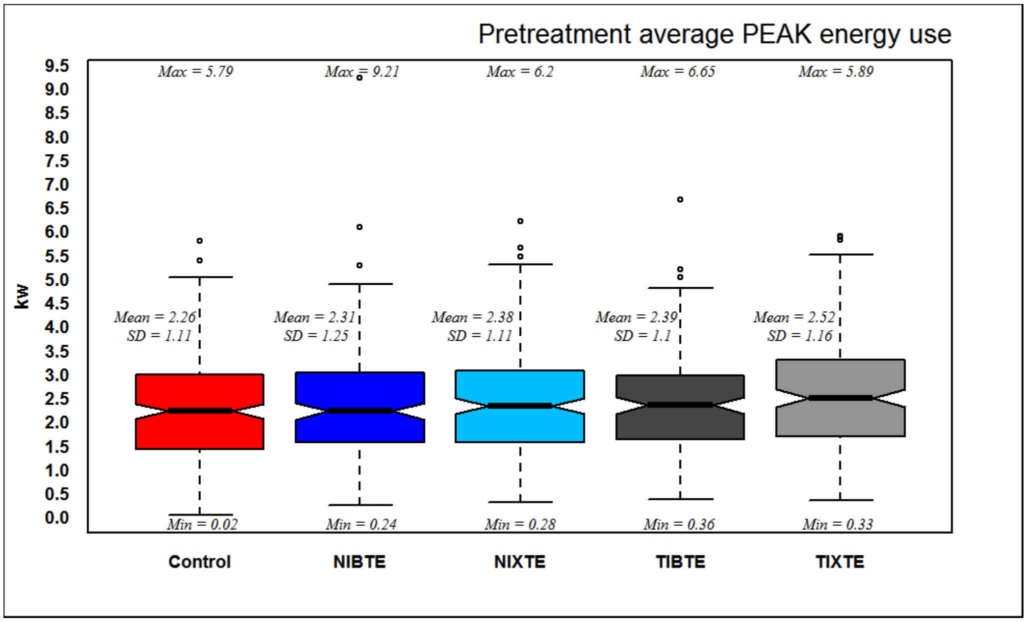


Table 119 provides p-values for mean differences analysis for pretreatment peak demand. All treatments showed higher pretreatment energy use relative to control group and participants in "Ecofactor" treatments showed higher pretreatment energy use relative to "Nest" treatments but none of the differences were statistically significant.

TABLE 119. MEAN DIFFERENCES ANALYSIS FOR PRETREATMENT PEAK DEMAND

Treatment	N	Mean	Nest. TOU-CPP	Nest. Standard	Ecofactor. TOU-CPP	Ecofactor. Standard
Control	268	2.26	0.9888	0.8151	0.8133	0.1158
Nest.TOU-CPP	175	2.31				
Nest.Standard	195	2.38	0.9845			
Ecofactor.TOU-CPP	147	2.39	0.9784	0.9999		
Ecofactor.Standard	181	2.52	0.4121	0.7211	0.8184	

In the summer, at what temperature do you typically set your thermostat when you and your family are HOME?

Table 120 shows the number of participants in each treatment that were excluded due to no response to this question. In addition, ten survey respondents with setpoint < 65 degrees were excluded from the analysis.

Table 120.Number of participants with no response, setpoint when home

Treatment	# of customers with no response
Control	12
Nest.TOU-CPP	5
Nest.Standard	5
Ecofactor.TOU-CPP	4
Ecofactor.Standard	6

Figure 92 shows the distribution of setpoints when participants and their families are home.

Figure 93. Box plot of pretreatment home thermostat settings

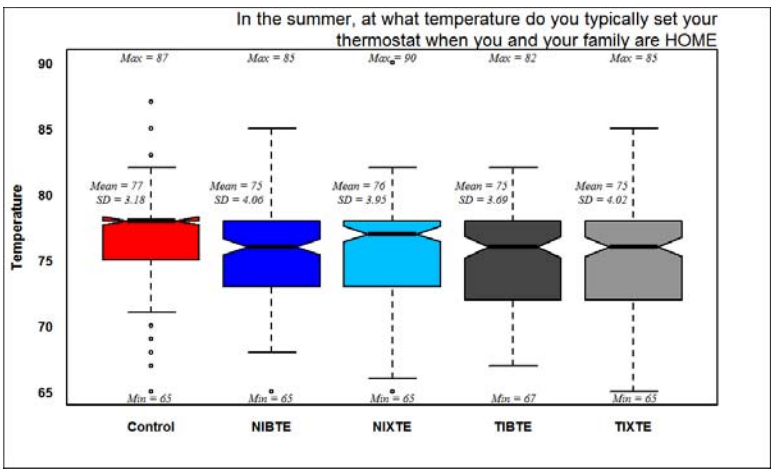


Table 121 provides p-values for mean differences analysis for home thermostat settings. Control group customers had a higher average setpoint than participants in all 4 treatments did.

Table 121. Mean differences analysis for home thermostat settings

Treatment	N	Mean	Nest. TOU-CPP	Nest. Standard	Ecofactor. TOU-CPP	Ecofactor. Standard
Control	253	76.82	0.0025	0.0098	0.0001	0.0003
Nest.TOU-CPP	164	75.45				
Nest.Standard	185	75.64	0.9904			
Ecofactor.TOU-CPP	138	75.08	0.9113	0.6746		
Ecofactor.Standard	170	75.25	0.9888	0.8692	0.9944	

In the summer, at what temperature do you typically set your thermostat when you and your family are NOT HOME?

Table 122 shows the number of participants in each treatment that were excluded due to no response to this question. In addition, 24 customers with setpoint < 65 degrees were excluded from the analysis.

Table 122.Number of participants with no response, away thermostat settings

Treatment	# of customers with no response
Control	67
Nest.TOU-CPP	45
Nest.Standard	35
Ecofactor.TOU-CPP	37
Ecofactor.Standard	38

Figure 94 shows the distribution of setpoints when participants are not home.

Figure 94. Box plot of pretreatment away thermostat settings

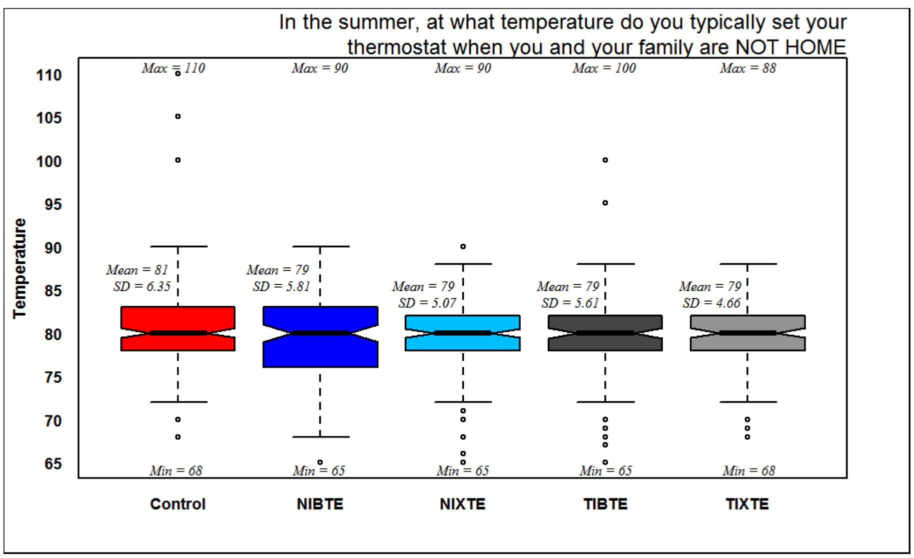


Table 123 provides p-values for mean differences analysis for away home thermostat settings. Control group customers had a higher average away setpoint than participants.

Table 123. Mean differences analysis for away thermostat settings

Treatment	N	Mean	Nest. TOU-CPP	Nest. Standard	Ecofactor. TOU-CPP	Ecofactor. Standard
Control	193	80.91	0.0497	0.0370	0.1037	0.0337
Nest.TOU-CPP	122	79.15				
Nest.Standard	150	79.19	0.9999			
Ecofactor.TOU-CPP	105	79.26	0.9999	0.9999		
Ecofactor.Standard	136	79.12	0.9999	0.9999	0.9997	

In a typical day, how many times do you or another member of your household manually adjust your thermostat?

Table 124 shows the number of participants in each treatment that were excluded due to no response to this question.

Table 124.Number of participants with no response, pretreatment daily thermostat adjustments

Treatment	# of customers with no response
Control	15
Nest.TOU-CPP	6
Nest.Standard	8
Ecofactor.TOU-CPP	5
Ecofactor.Standard	8

Figure 95 shows the distribution of the daily thermostat adjustments.

Figure 95. Box plot of pretreatment daily thermostat adjustments

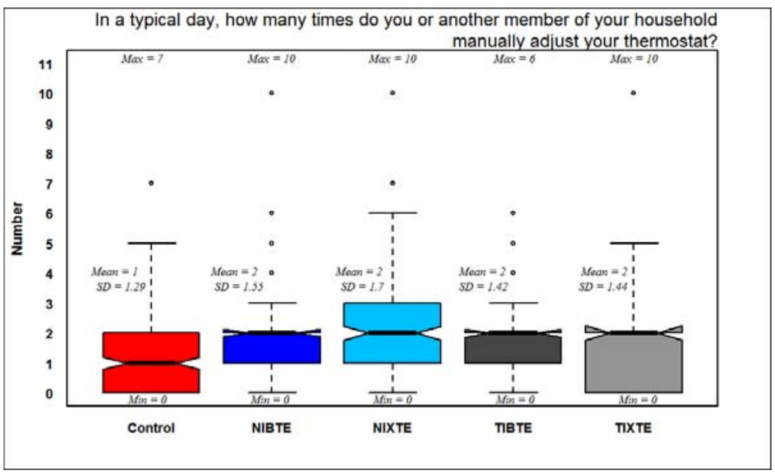


Table 125 provides p-values for mean differences analysis for daily thermostat adjustments. Control group customers adjusted their thermostats less often than did participants in all 4 treatments.

Table 125. Mean differences analysis for daily thermostat adjustments

Treatment	N	Mean	Nest. TOU-CPP	Nest. Standard	Ecofactor. TOU-CPP	Ecofactor. Standard
Control	253	1.21	0.0019	<0.0001	0.0008	0.0283
Nest.TOU-CPP	166	1.76				
Nest.Standard	185	1.98	0.6327			
Ecofactor.TOU-CPP	137	1.82	0.9953	0.8873		
Ecofactor.Standard	169	1.64	0.9457	0.1946	0.8082	

How old is your AC?

Table 126 shows the number of participants in each treatment that were excluded due to no response to this question. In addition, 3 customers with age of AC unit > 60 were excluded from the analysis.

Table 126.Number of participants with no response, AC unit age

Treatment	# of customers with no response
Control	28
Nest.TOU-CPP	9
Nest.Standard	7
Ecofactor.TOU-CPP	4
Ecofactor.Standard	5

Figure 96 shows the distribution of AC unit age.

Figure 96. Box plot of air-conditioning unit age

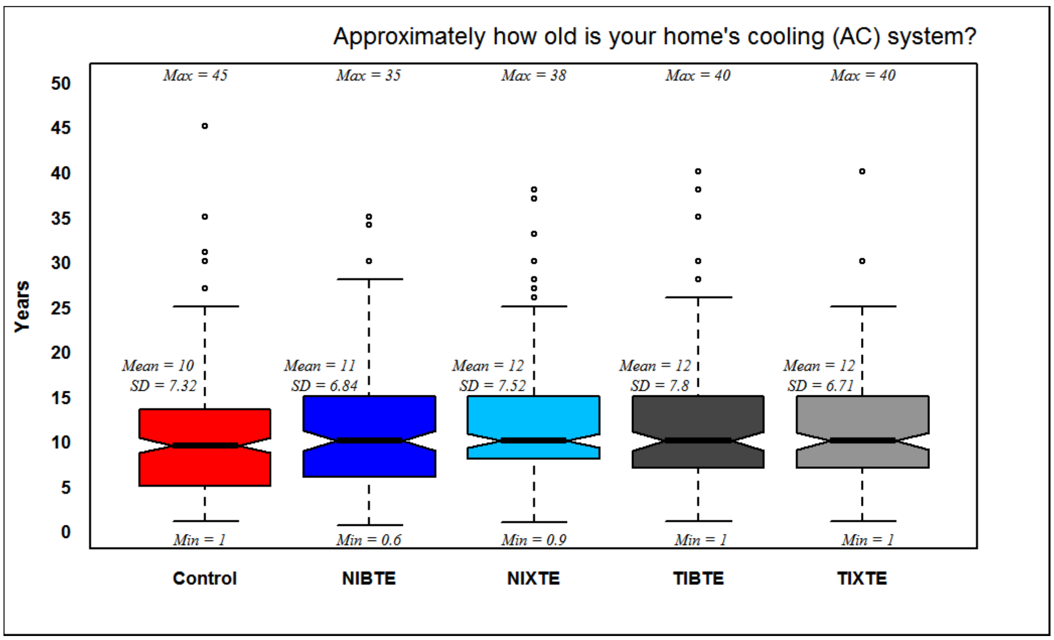


Table 127 provides p-values for mean differences analysis for the AC unit age. Control group customers had newer AC units than Nest.Standard treatment customers.

Table 127. Mean differences analysis for air-conditioning unit age

Treatment	N	Mean	Nest. TOU-CPP	Nest. Standard	Ecofactor. TOU-CPP	Ecofactor. Standard
Control	240	10.11	0.6851	0.0128	0.2392	0.3022
Nest.TOU-CPP	162	11.07				
Nest.Standard	184	12.37	0.4564			
Ecofactor.TOU-CPP	138	11.70	0.9447	0.9237		
Ecofactor.Standard	172	11.50	0.9826	0.791	0.9993	

AGE

Table 128 shows the number of participants in each treatment that were excluded due to no response to this question. In addition, 27 control group customers with “year born” = 0 (most likely 0 = NA in this case) were excluded from the analysis.

TABLE 128. NUMBER OF PARTICIPANTS WITH NO RESPONSE, PARTICIPANT AGE

Treatment	# of customers with no response
Control	0
Nest.TOU-CPP	3
Nest.Standard	3
Ecofactor.TOU-CPP	6
Ecofactor.Standard	6

Figure 97 shows the distribution of participant age.

FIGURE 97. BOX PLOT OF PARTICIPANT AGE

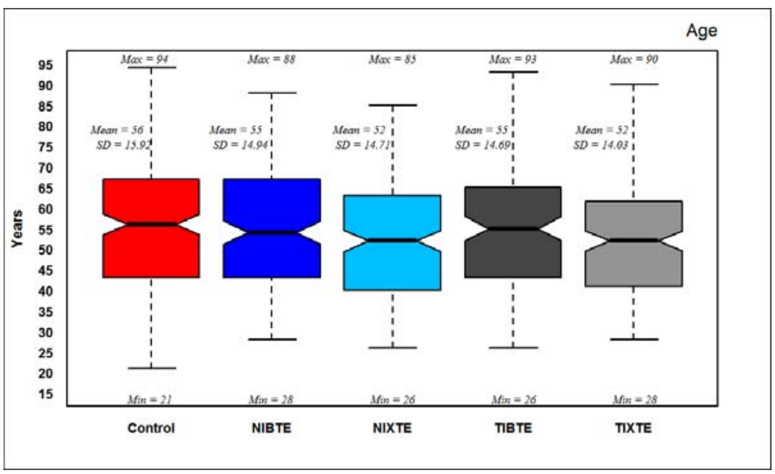


Table 129 provides p-values for mean differences analysis for participant age. No statistically significant differences were found in the participant age in different treatments.

TABLE 129. MEAN DIFFERENCES ANALYSIS FOR PARTICIPANT AGE

Treatment	N	Mean	Nest. TOU-CPP	Nest. Standard	Ecofactor. TOU-CPP	Ecofactor. Standard
Control	241	55.94	0.9882	0.1058	0.9866	0.0936
Nest.TOU-CPP	169	55.20				
Nest.Standard	190	52.40	0.3900			
Ecofactor.TOU-CPP	136	55.12	0.9999	0.4824		
Ecofactor.Standard	171	52.22	0.3502	0.9999	0.4379	

Income

Excluded 57 Refused, 103 Prefer not to answer, 8 Not sure, 11 NA's for boxplots (but not from proportion analysis). Ranked income from 1-7 with

1 = less than $30,000 and 7 = greater than $150,000

Figure 98 shows the distribution of participant income.

Figure 98. Box plot of household income

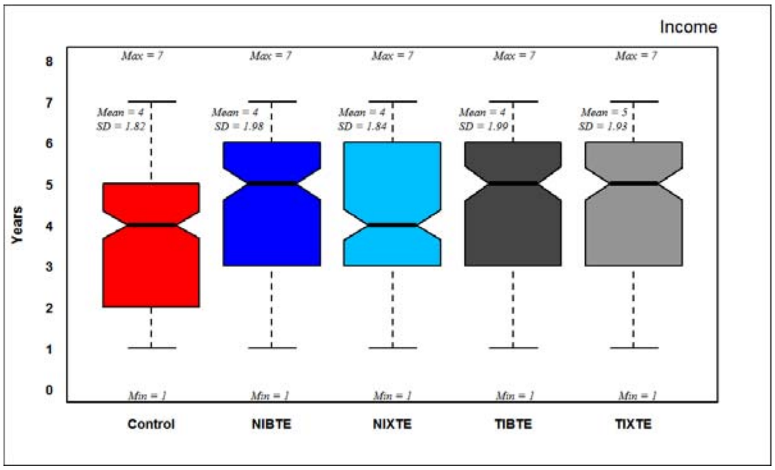


Table 130 provides p-values for mean differences analysis for income. Control group customers had lower income than participants in Ecofactor treatments.

Table 130. Mean differences analysis for Income

Treatment	N	Mean	Nest. TOU-CPP	Nest. Standard	Ecofactor. TOU-CPP	Ecofactor. Standard
Control	203	3.74	0.1054	0.1716	0.0311	0.0016
Nest.TOU-CPP	141	4.25				
Nest.Standard	163	4.18	0.9984			
Ecofactor.TOU-CPP	126	4.37	0.9872	0.9298		
Ecofactor.Standard	140	4.53	0.7306	0.5159	0.9564	

Table 131 shows the summary of responses when income is treated as a categorical variable. No statistically significant differences were found between treatments. The proportion of incomes greater than $99,999 was lower in the control group.

Table 131.Summary of responses, income

Treatment	Control	Nest. TOU-CPP	Nest. Standard	Ecofactor. TOU-CPP	Ecofactor. Standard
Less than $30,000	12%	10%	8.3%	11%	7.3%
$30,000 to $44,999	9%	8.7%	9.8%	8.5%	8.5%

$45,000 to $59,999	16%	12%	13%	11%	9.6%
$60,000 to $79,999	12%	9.3%	15%	12%	9.6%
$80,000 to $99,999	10%	12%	12%	13%	9%
$100,000 to $149,999	12%*	19%	17%	19%	**24%**
$150,000 or more	4.5%*	10%	8.8%	**14%**	11%
Prefer not to answer-parts (refused/not sure-control)	24%**	16%	**13%**	**9.9%**	20%
NA	0%	1.7%	2.6%	1.4%	0.56%

*= different from Nest.TOU-CPP *=different from Nest.Standard

*=different from Ecofactor.TOU-CPP *=different from Ecofactor.Standard

Education

Excluded 24 participants with Prefer not to answer response and 6 with no response. Ranked level of education from 1-9.

Figure 99 shows the distribution of participant education.

Figure 99. Box plot of participant education

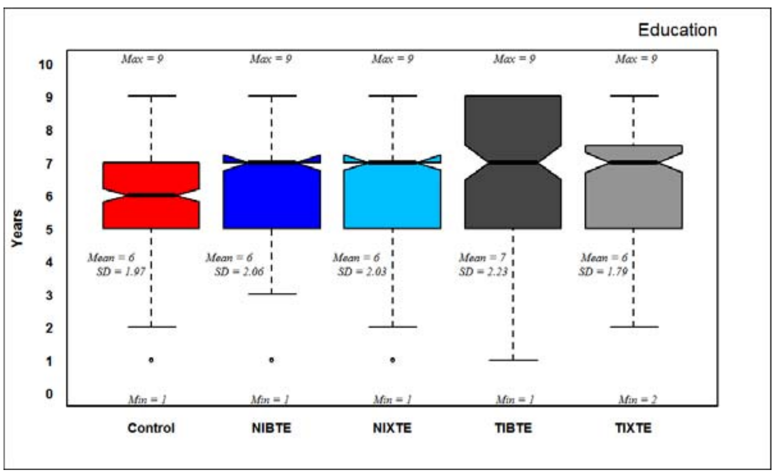


Table 132 provides p-values for mean differences analysis for participant education. No statistically significant differences were found in the participant education in different treatments.

Table 132. Mean differences analysis for participant education

Treatment	N	Mean	Nest. TOU-CPP	Nest. Standard	Ecofactor. TOU-CPP	Ecofactor. Standard
Control	262	6.13	0.8863	0.6758	0.3496	0.5251
Nest.TOU-CPP	164	6.31				
Nest.Standard	190	6.38	0.9978			
Ecofactor.TOU-CPP	138	6.51	0.9046	0.9743		
Ecofactor.Standard	168	6.43	0.9805	0.9999	0.9969	

Table 133 shows the summary of responses when education is treated as a categorical variable. No statistically significant differences between control group customers and participants in any of the treatments. A statistically higher proportion of College graduates (4 year degree) in Nest.Standard treatment relative to Ecofactor.TOU-CPP treatment. A statistically higher proportion of "Some graduate school" responses in Nest.TOU-CPP treatment relative to Ecofactor.TOU-CPP treatment.

TABLE 133.SUMMARY OF RESPONSES, EDUCATION

Treatment	Control	Nest. TOU-CPP	Nest. Standard	Ecofactor. TOU-CPP	Ecofactor. Standard
Elementary (8 or fewer years)	0.75%	1.2%	2.1%	2.1%	0%
Some high school (9 to 11 years)	1.9%	0%	1.6%	4.2%	1.1%
High school graduate (12 years)	13%	13%	10%	7.7%	6.2%
Technical / Vocational school	1.5%	4.1%	2.1%	2.8%	6.2%
Some college	19%	15%	14%	12%	15%
College graduate (2 year degree)	13%	7.6%	7.3%	11%	14%
College graduate (4 year degree)	28%	31%	38%*	**23%**	28%
Some graduate school	4.9%	1.7%*	3.6%	**9.9%**	7.3%
Graduate, professional, doctorate degree	16%	22%	19%	25%	16%
Prefer not to answer	2.2%	3.5%	1%	1.4%	4.5%
NA	0%	1.2%	0.52%	1.4%	0.56%

*= different from Nest.TOU-CPP *=different from Nest.Standard

*=different from Ecofactor.TOU-CPP *=different from Ecofactor.Standard

Is your home one, two or three stories?

Table 134 shows the number of participants in each treatment that were excluded due to no response to this question. In addition, excluded one participant with “zero” as a response. Assigned one with 4 stories to “Other” category.

Table 134.Number of participants with no response, stories

Treatment	# of customers with no response
Nest.TOU-CPP	4
Nest.Standard	5
Ecofactor.TOU-CPP	4
Ecofactor.Standard	3

Table 135 shows the summary of responses about the number of stories. No statistically significant differences between control and treatments. No statistically significant differences for between treatment comparisons.

Table 135.Summary of responses, stories

Treatment	Control	Nest. TOU-CPP	Nest. Standard	Ecofactor. TOU-CPP	Ecofactor. Standard
One story	79%	75%	72%	70%	73%
Two story	19%	22%	25%	27%	22%
Three story	0.75%	0.58%	0%	0%	2.3%
Other	0.75%	0%	0%	0%	0.56%
NA	0%	2.3%	2.6%	2.8%	2.3%

*= different from Nest.TOU-CPP *=different from Nest.Standard

*=different from Ecofactor.TOU-CPP *=different from Ecofactor.Standard

WHAT TYPE OF HEATING SYSTEM IS USED IN YOUR HOME?

Table 126 shows the number of participants in each treatment that were excluded due to no response to this question.

TABLE 136.NUMBER OF PARTICIPANTS WITH NO RESPONSE, HEATING UNIT

Treatment	# of customers with no response
Nest.TOU-CPP	3
Nest.Standard	4
Ecofactor.TOU-CPP	7
Ecofactor.Standard	5

Table 137 shows the summary of responses about the type of heating system used. No statistically significant differences in treatments. Higher proportion of control group customers had central electric heat pump compared to Nest.TOU-CPP and Nest.Standard treatments, and Nest.TOU-CPP and Nest.Standard treatments had a higher proportion of customers with central natural gas or propane furnace compared to control group.

TABLE 137.SUMMARY OF RESPONSES, HEATING UNIT

Treatment	Control	Nest. TOU-CPP	Nest. Standard	Ecofactor. TOU-CPP	Ecofactor. Standard
Central electric heat pump	15%**	**5.8%**	**6.2%**	11%	10%
Central electric furnace	17%	12%	12%	13%	16%
Central natural gas or propane furnace	56%**	**70%**	**69%**	61%	64%
Other	1.5%	2.3%	1.6%	0%	0.56%
Not sure	10%	8.1%	7.8%	11%	6.8%
Prefer not to answer	0%	0%	0.52%	0%	0%
NA	0%	1.7%	2.1%	4.9%	2.8%

*= different from Nest.TOU-CPP *=different from Nest.Standard

*=different from Ecofactor.TOU-CPP *=different from Ecofactor.Standard

APPROXIMATELY HOW OLD IS YOUR HOME'S HEATING SYSTEM?

Table 138 shows the number of participants in each treatment that were excluded due to no response to this question. In addition, excluded 3 participants with heating system's age > 60.

TABLE 138.NUMBER OF PARTICIPANTS WITH NO RESPONSE, HEATING UNIT AGE

Treatment	# of customers with no response
Control	33
Nest.TOU-CPP	9
Nest.Standard	9
Ecofactor.TOU-CPP	10
Ecofactor.Standard	8

Figure 101 shows the distribution of heating unit age.

FIGURE 100. BOX PLOT OF HEATING UNIT AGE

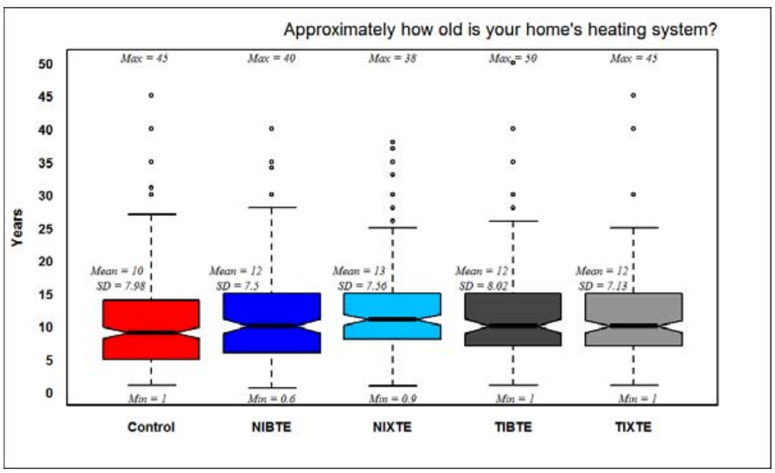


Table 139 provides p-values for mean differences analysis for the heating unit age. Control group customers had newer heating units than Nest.Standard treatment customers.

TABLE 139. MEAN DIFFERENCES ANALYSIS FOR HEATING UNIT AGE

Treatment	N	Mean	Nest. TOU-CPP	Nest. Standard	Ecofactor. TOU-CPP	Ecofactor. Standard
Control	235	10.40	0.439	0.0121	0.3504	0.4994
Nest.TOU-CPP	162	11.73				
Nest.Standard	182	12.83	0.6688			
Ecofactor.TOU-CPP	132	11.94	0.9993	0.8451		
Ecofactor.Standard	169	11.64	0.9999	0.5884	0.9972	

How many air conditioning (AC) units does your household have?

Table 140 shows the number of participants in each treatment that were excluded due to no response to this question. In addition, excluded 6 customers with more than 3 units.

Table 140.Number of participants with no response, number of AC units

Treatment	# customers with no response
Control	1
Nest.TOU-CPP	2
Nest.Standard	3
Ecofactor.TOU-CPP	4
Ecofactor.Standard	2

Table 141 shows the summary of responses about the number of AC units. No statistically significant differences found between any of the treatments.

Table 141.Summary of responses, number of AC units

How many AC units does your household have?	Control	Nest. TOU-CPP	Nest. Standard	Ecofactor. TOU-CPP	Ecofactor. Standard
Zero	0%	0.58%	0.52%	0%	0%
One	91%	86%	90%	87%	90%
Two	7.1%	11%	6.2%	9.9%	9%
Three	1.1%	0%	0.52%	0%	0%
NA	0.75%	2.3%	3.1%	2.8%	1.1%

*= different from Nest.TOU-CPP *=different from Nest.Standard

*=different from Ecofactor.TOU-CPP *=different from Ecofactor.Standard

DO YOU HAVE AN ELECTRIC CLOTHES DRYER?

Table 142 shows the number of participants in each treatment that were excluded due to no response to this question.

TABLE 142.NUMBER OF PARTICIPANTS WITH NO RESPONSE, ELECTRIC CLOTHES DRYER

Treatment	# of customer with no response
Control	0
Nest.TOU-CPP	0
Nest.Standard	0
Ecofactor.TOU-CPP	3
Ecofactor.Standard	0

Table 143 shows the summary of responses about the number of AC units. No statistically significant differences found between any of the treatments.

TABLE 143.SUMMARY OF RESPONSES, ELECTRIC CLOTHES DRYER

Do you have an electric clothes dryer?	Control	Nest. TOU-CPP	Nest. Standard	Ecofactor. TOU-CPP	Ecofactor. Standard
Yes	82%	85%	76%	73%	76%
No	16%	14%	21%	21%	23%
Not sure	1.9%	1.2%	3.1%	3.5%	1.7%
Prefer not to answer	0%	0%	0%	0.7%	0%
NA	0%	0%	0%	2.1%	0%

*= different from Nest.TOU-CPP *=different from Nest.Standard

*=different from Ecofactor.TOU-CPP *=different from Ecofactor.Standard

Do you have an electric water heater?

Table 144 shows the summary of responses about the electric water heater. No statistically significant differences found between any of the treatments.

Table 144.Summary of responses, electric water heater

Do you have an electric water heater?	Control	Nest. TOU-CPP	Nest. Standard	Ecofactor. TOU-CPP	Ecofactor. Standard
Yes	15%	13%	14%	15%	14%
No	81%	81%	79%	75%	78%
Not sure	3.7%	6.4%	5.7%	7.7%	6.8%
Prefer not to answer	0%	0%	0%	0.7%	0%
NA	0%	0%	1%	1.4%	1.1%

*= different from Nest.TOU-CPP *=different from Nest.Standard

*=different from Ecofactor.TOU-CPP *=different from Ecofactor.Standard

What is your gender?

Table 145 shows the summary of responses for gender. Higher proportion of Females and lower proportion of Males in Control group relative to Nest.Standard treatment.

Table 145.Summary of responses, gender

What is your gender?	Control	Nest. TOU-CPP	Nest. Standard	Ecofactor. TOU-CPP	Ecofactor. Standard
Male	47%*	53%	**64%**	52%	55%
Female	53%*	45%	**35%**	46%	44%
NA	0%	1.7%	1%	2.1%	0.56%

*= different from Nest.TOU-CPP *=different from Nest.Standard

*=different from Ecofactor.TOU-CPP *=different from Ecofactor.Standard

Including yourself, how many people live in your household?

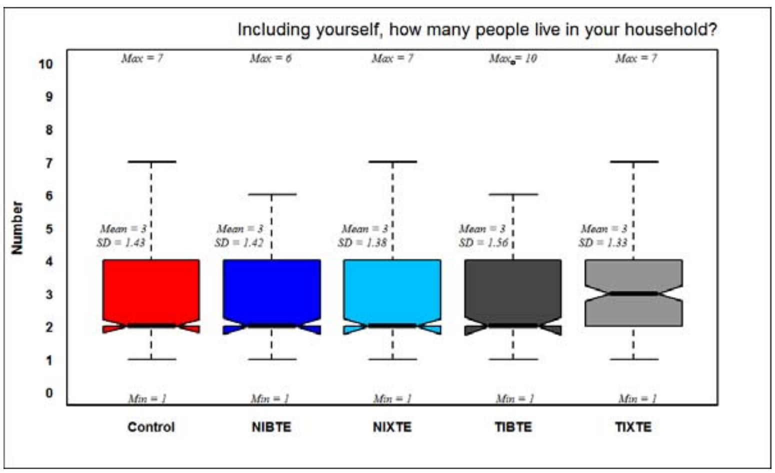
Table 146 shows the number of participants in each treatment that were excluded due to no response to this question. In addition, excluded 9 customers with "Prefer not to answer" and 5 customers with "zero" responses.

TABLE 146.NUMBER OF PARTICIPANTS WITH NO RESPONSE, HOUSEHOLD OCCUPANTS

Treatment	# of customers with no response
Control	0
Nest.TOU-CPP	5
Nest.Standard	5
Ecofactor.TOU-CPP	6
Ecofactor.Standard	5

Figure 101 shows the distribution of the number of household occupants.

FIGURE 101. BOX PLOT OF HOUSEHOLD OCCUPANTS



Possible outlier = 10 in Ecofactor.TOU-CPP group.

Table 147 provides p-values for mean differences analysis for the number of household occupants. No statistically significant differences found in the number of household occupants.

TABLE 147.MEAN DIFFERENCES ANALYSIS FOR HOUSEHOLD OCCUPANTS

Treatment	N	Mean	Nest. TOU-CPP	Nest. Standard	Ecofactor. TOU-CPP	Ecofactor. Standard
Control	259	2.67	0.9995	0.8727	0.8308	0.9408
Nest.TOU-CPP	167	2.64				
Nest.Standard	188	2.80	0.8218			
Ecofactor.TOU-CPP	136	2.83	0.778	0.9998		
Ecofactor.Standard	172	2.78	0.8999	0.9999	0.9978	

Table 148 shows the summary of responses when the number of household occupants is treated as a categorical variable. No statistically significant differences in proportion of the number of household occupants.

TABLE 148.SUMMARY OF RESPONSES, HOUSEHOLD OCCUPANTS

Including yourself, how many people live in your household	Control	Nest. TOU-CPP	Nest. Standard	Ecofactor. TOU-CPP	Ecofactor. Standard
One	19%	23%	15%	13%	15%
Two	35%	31%	37%	39%	32%
Three	17%	13%	15%	11%	22%
Four	15%	19%	17%	15%	19%
Five+	10%	11%	14%	15%	8.5%
NA or Prefer not to answer	3.4%	3.5%	3.1%	6.3%	2.8%

*= different from Nest.TOU-CPP *=different from Nest.Standard

*=different from Ecofactor.TOU-CPP *=different from Ecofactor.Standard

ON A TYPICAL SUMMER WEEKDAY, HOW MANY PEOPLE ARE AT YOUR HOME BETWEEN 4PM AND 7PM?

Table 149 shows the number of participants in each treatment that were excluded due to no response to this question. No data for Control group.

TABLE 149.NUMBER OF PARTICIPANTS WITH NO RESPONSE, HOUSEHOLD OCCUPANTS DURING THE 4-7 PM PEAK

Treatment	# of customers with no response
Nest.TOU-CPP	6
Nest.Standard	3
Ecofactor.TOU-CPP	1
Ecofactor.Standard	3

Figure 102 shows the distribution of the number of household occupants during the 4-7 pm peak.

FIGURE 102. BOX PLOT OF HOUSEHOLD OCCUPANTS DURING THE 4-7 PM PEAK

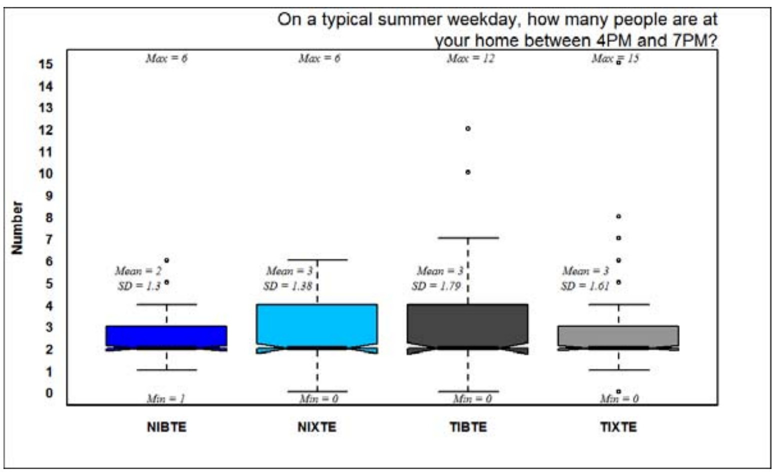


Table 150 provides p-values for mean differences analysis for the number of household occupants during the 4-7 pm peak. No statistically significant differences found in the number of household occupants during the 4-7 pm peak.

TABLE 150. MEAN DIFFERENCES ANALYSIS FOR HOUSEHOLD OCCUPANTS DURING THE 4-7 PM PEAK

Treatment	N	Mean	Nest.TOU-CPP	Nest.Standard	Ecofactor.TOU-CPP
Nest.TOU-CPP	166	2.46			
Nest.Standard	190	2.70	0.4161		
Ecofactor.TOU-CPP	141	2.84	0.118	0.8434	
Ecofactor.Standard	174	2.68	0.5377	0.9982	0.7691

Table 151 shows the summary of responses when the number of household occupants during the 4-7 pm peak is treated as a categorical variable. Nest.TOU-CPP had higher proportion of "One" relative to Nest.Standard treatment.

TABLE 151.SUMMARY OF RESPONSES, HOUSEHOLD OCCUPANTS DURING THE 4-7 PM PEAK

On a typical summer weekday, how many people are at your home between 4PM and 7PM?	Nest. TOU-CPP	Nest. Standard	Ecofactor. TOU-CPP	Ecofactor. Standard
Zero	0%	3.6%	2.8%	1.1%
One	24%*	**10%**	15%	16%
Two	38%	40%	39%	36%
Three	12%	17%	11%	23%
Four	14%	15%	16%	16%
Five+	8.7%	13%	15%	6.8%
NA	3.5%	1.6%	0.7%	1.7%

*= different from Nest.TOU-CPP *=different from Nest.Standard

*=different from Ecofactor.TOU-CPP *=different from Ecofactor.Standard

DWELLING TYPE

Table 152 shows the summary of responses for the dwelling type. The vast majority of customers were in single-family homes.

TABLE 152.SUMMARY OF RESPONSES, DWELLING TYPE

Customer dwelling type	# of customers
0	1
Multi-family	6
Residential	5
Single-family	685
Small commercial	1

RENTER

Table 153 shows the number of owners and renters.

TABLE 153.SUMMARY OF RESPONSES, OWNER/RENTER

Renter	# of customers
No	674
Yes	24

Property owner signoff

Table 154. Summary of responses, property owner signoff

Property owner signoff	# of customers
No	14
Yes	684

Signed Participation

Table 155 shows number of customers with signed participation.

Table 155. Summary of responses, signed participation

Signed Participation	# of customers
No	3
Yes	695

Rate

Table 156 shows the number of participants in each rate category.

Table 156. Summary of responses, rate

Rate category	# of customers
RSCH -> Closed Electric-heated	15
RSCH_E -> Closed Electric-heated & Low Income	1
RSCH_SP -> Closed Electric-heated on SPO Rate	2
RSEH -> Open Electric-heated	30
RSEH_E -> Open Electric-heated & Low Income	1
RSEH_SP -> Open Electric-heated on SPO Rate	2
RSGH -> Gas-heated	549
RSGH_E -> Gas-heated & Low Income	46
RSGH_E_SP -> Gas-heated & Low Income on SPO Rate	6
RSGH_L-> Medical rate	2
RSGH_SP -> Gas-heated on SPO Rate	35
RTCH -> Closed Electric-heated & Time-of-Use	1
RTGH –> Bas-heated & Time-of-Use	2
RWEH -> Electric-heated with Well	2
RWGH-> Gas-heated with Well	3
RWGH_SP-> Gas-heated with Well & SPO Rate	1