DTE Energy®

SmartCurrents℠

DYNAMIC PEAK PRICING PILOT

Final Evaluation Report

SGIG Project No. 10OE000146 August 15, 2014

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1. Executive Summary

DTE Electric (DTE), an electric subsidiary of DTE Energy and formerly known as Detroit Edison, conducted a two-year Consumer Behavior Study (CBS) to document the effects of dynamic peak pricing, enabling technologies, and customer education on residential consumer overall energy consumption and demand response. The goal of the study was to derive the best approaches, from the study results, that can be applied to the entire DTE service territory to induce residential consumer energy conservation (reduce overall energy consumption) and demand response behaviors while providing opportunities for customers to save on their energy bills. DTE conducted this study as part of the SmartCurrents[SM] pilot program funded in part by a grant from the U.S. Department of Energy (DOE). The DOE-sponsored Technical Advisory Group (TAG) assigned to oversee and support this study provided invaluable contributions to the study design and implementation, and to evaluation of study results.

This final report describes the program background, overview, design, implementation, analysis methodology, results, and conclusions for the two year study. The study period covered summer 2012, through calendar year 2013. Specifically, the final report covers analysis of data for approximately 1,915 randomly assigned treatment and control group customers for the 11 successful event days that occurred in 2013. The scope of the study encompassed: offering new pricing options that were made possible by Advanced Metering Infrastructure (AMI), and evaluating corresponding customer acceptance, satisfaction, and behavior changes. Further, this study offered a platform for better customer energy management and provided DTE an ability to evaluate customer acceptance and satisfaction. In general, pilot customers were satisfied with the rate, and while most did not perform their own savings analysis, they indicated in Focus Group discussions that they felt they were saving. DTE has not performed individual customer savings calculations, however, it is estimated that customers saved 10 to 15 percent in 2013 including the 11 event days.

The Dynamic Peak Pricing (DPP) rate being studied during the pilot program consists of a three-tiered Time of Use (TOU) rate for weekdays overlaid by a Critical Peak Pricing (CPP) rate ($1/kWh) on a maximum of 20 event days per year. The event days were announced to the customers a day in advance via various communication means. The data from the 11 event days were analyzed at the sub-group level, based on usage type, income level, and presence/absence of central air-conditioning (CAC). Besides analyses of data from the 11 event days, data for the identified 16 hot weather TOU days (max. temperature ≥85°F) and 16 cold weather TOU days (min. temperature <25°F) between August 2012 and December 2013 were also studied and included in this report.

Customer recruiting began in late January 2012 and continued through June 30, 2012, and involved contacting approximately 149,000 eligible customers. The customers were further surveyed, narrowed down, and randomly allotted to various study groups. Along with education initiatives, customers received monthly eNewsletters, web portal, targeted eBlasts, and Play-Learn-Win games. In addition to dynamic pricing, some customers were provided two different enabling technologies, with the effects of each studied separately and in combination. There are four main treatment groups, based on type of technology received, as follows:

- T1 Group: Education + Dynamic pricing rate
- T2 Group: Education + Dynamic pricing rate + In-home display (IHD)
- T3 Group: Education + Dynamic pricing rate + Programmable communicating thermostat (PCT)
- T4 Group: Education + Dynamic pricing rate + IHD + PCT

All of the customers could view their hourly energy consumption via an online web portal. One hundred and nine customers withdrew during the program for various reasons; however, following TAG's recommendation their data were still included for analysis. Further, four customers were dropped from the T2 group for analysis to reduce the high usage bias that existed in the T2 group. Although the study was randomized, data was not available for all customers that were randomly assigned. For the customers who were randomly assigned to a treatment group, data was only available for those that actually finalized their enrollment. Therefore, the control group serves as a matched control group (rather than a randomized control group). The hourly load impact analysis revealed that for certain customer groups, the matched control group had lower hourly means during the pretreatment period (even though they passed the ANOVA tests[1]), possibly masking the impacts of the pilot. Specifically, the T2 group faced this issue. Although results may contain bias due to these data access problems, we believe that the results presented in this section provide valuable and useful information on the effect of a DPP rate on customers.

Notwithstanding a few issues experienced at the beginning of the program, DTE completed the CBS successfully, especially during the second year of the program. Varying levels of energy conservation and peak-time demand reduction were attained from the different customer groups and sub-groups. The T1 group customers with no additional supporting technology responded to the CPP rate on event days and reduced consumption on average by 1.19 kWh (12.6%) against their control group. The T2 group customers with the IHD performed even better, with 1.65 kWh (17.5%) saved during the critical peak hours on event days. With regard to energy conservation measures as determined by total daily energy consumption, both T1 and T2 group customers exhibited no overall energy consumption improvements based on the data collected, hence showing that dynamic pricing with consumption information over the web or on an IHD might not lead to daily overall energy consumption reductions, but would help reduce peak demand on event days with potential for additional reduction from effective communication such as an IHD.

The T3 customers equipped with the PCT performed by far the best among all the groups with an average reduction of 5.07 kWh (44.5%) during the critical peak hours, as well as 6.65 kWh (14.3%) average reductions during all hours, on event days. In addition, the T3 group even managed to reduce their overall energy consumption by 4.97 kWh (11.8%) and 2.76 kWh (9.1%) on non-event hot and cold

[1] Analysis of Variance, or ANOVA, is a statistical model used to analyze the differences between group means. In the typical application of ANOVA, the null hypothesis is that all groups are simply random samples of the same population. This implies that all treatments have the same effect (perhaps none). Rejecting the null hypothesis implies that different treatments result in altered effects.

weather days, respectively. Although the T4 group customers had the PCT plus an IHD, their peak demand reductions and energy conservation improvements were not much different from those attained by the T3 group with PCT only, on event and non-event hot and cold weather days.

The T3-T4 group results indicated that the availability of a PCT device makes a significant impact on demand response and energy conservation on event and non-event days, while the additional presence of IHD does not appear to make much of a difference. These results were slightly surprisingly since surveys conducted during the study indicated customers preferred the IHD and had a few difficulties with the PCT operation.

The treatment effects of T1-T4 groups are summarized in Table ES.1, as compared to their respective control groups, on event days, hot weather days, and cold weather days.

Table ES. 1: Summary of Treatment Effects (shown as a percentage change*), Grouped by Event Days, Hot Weather Days, and Cold Weather Days

Effect	Treatment			
	Education +DPP	Education +DPP+IHD	Education +DPP+PCT	Education +DPP+IHD+PCT
Event Days				
Average Daily Energy	**2.61%**	**8.67%**	**-14.28%**	**-13.50%**
Average Critical Peak Energy	**-12.60%**	**-17.45%**	**-44.51%**	**-43.02%**
Hot Weather Days				
Average Daily Energy	**6.56%**	**13.63%**	**-11.75%**	**-10.52%**
Cold Weather Days				
Average Daily Energy	**4.78%**	**9.02%**	**-9.06%**	**-9.14%**

* The percentage change is calculated by subtracting the control value from the treatment value, and then dividing that by the control value. The % effects are also shown on Tables 21-32.

2. Introduction

This is a comprehensive final evaluation report of DTE's two year SmartCurrents[SM] pilot program, a residential consumer behavior study based on the AMI installations and an experimental three-tier TOU rate with a CPP overlay. The DOE sponsored TAG assigned to oversee and support this study provided invaluable contributions to the design, implementation, and initial evaluation of interim results. The design of the pilot program was coordinated among DTE, Ernst & Young, and the TAG, and is documented in DTE's Consumer Behavior Study Plan, originally dated September 10, 2010, and revised on February 4, 2011. Energy & Environmental Resources Group, LLC (E2RG) was retained by DTE to assist first in the DOE build metrics, and subsequently to evaluate results. Toward the end of 2013, Lawrence Berkeley National Labs (LBNL) replaced the TAG in an advisory capacity, and has likewise provided invaluable contributions to the evaluation of results for both the interim and final reports.

2.a. Project Background

Detroit Edison Company (now known as DTE Electric) is an Investor Owned Utility (IOU) and subsidiary of DTE Energy. DTE Electric generates, transmits, and distributes electricity to 2.1 million customers in southeastern Michigan. Founded as Detroit Edison in 1903, DTE Electric is the largest electric utility in Michigan and one of the largest in the nation. The SmartCurrents program application was submitted under the DOE Smart Grid Investment Grant (SGIG) topic area for "Integrated and/or Crosscutting Systems." For the purpose of both the interim and final reports, the Company is referenced as DTE instead of Detroit Edison.

2.b. Project Overview

The SmartCurrents pilot was designed to provide DTE with information about the best ways to integrate dynamic pricing rates, enabling technologies, information feedback, and customer education to:

- Induce a change in residential consumer overall energy consumption and demand response behaviors, and
- Open up opportunities for customers to save on their energy bills.

The SmartCurrents pilot deployments were split into two different types of experiments, described separately in the document:

1. A **quantitative cause and effect** experimental design with a Control Group to analyze usage and bill impacts from the different intervention approaches; and

2. A **qualitative informational** design to understand why and how customers react to pre-pay billing and smart home appliances.

The DTE quantitative experimental study was focused on testing the differences in behavior resulting from changes in pricing, enabling technology type, and educational information. One of DTE's main objectives for the informational pilot, including dynamic pricing and pre-pay billing approaches, was to create real opportunities for customers to reduce their energy spending by matching their consumption behaviors to electricity supply conditions. A major goal of the pilot was to offer innovative education and technology programs that increase customer engagement and satisfaction.

2.c. Expected Benefits

The SmartCurrents pilot provided customer service approaches such as dynamic pricing, remote meter connect and disconnect, web-based customer energy usage presentation, load control, and pre-payment options. The anticipated benefits of the SmartCurrents pilot were to provide the following:

- A platform to promote customer energy management, including energy waste reductions and energy cost savings, as well as customer control, choice, and flexibility using interactive in-home technology. The DPP rate coupled with a web-based shadow rate comparison, would allow customers to learn more about real-time supply conditions, how to change their usage patterns, and how to save money and environmental impacts by changing their usage patterns;
- Capability to leverage AMI to offer and evaluate new customer options, such as dynamic pricing, pre-pay billing, and enabling technologies;
- Capacity to leverage AMI to conduct research to learn about customer behavior and acceptance of pricing and enabling technology, as well as the recruitment strategies;
- Opportunity for customer control of HVAC applications and smart appliances, ability to respond to price signals, peak load management, and lower costs on appliance operation; and
- Ability to evaluate customer acceptance and satisfaction.

2.d. Research Questions and Hypotheses

DTE's SmartCurrents Pilot explored research questions in three areas: pricing, technology, and information feedback. DTE experimented with the following feedback attributes:

Pricing	Technology	Information Feedback
• Customer acceptance (surveys) • Character of response (analysis)	• Customer acceptance (surveys) • Character of response (analysis)	• Delivery mechanisms (web, IHD, PCT, mobile) • Persistence (24 mo)

Figure 1: The Transforming Capabilities of AMI

For the experimental treatment groups, the overall project objective was to understand both customer acceptance (use of technologies and educational materials) and customer character of response (load shifting and energy conservation, or reducing overall energy use). DTE focused on research questions and hypotheses around usage impacts, and also examined customer satisfaction and acceptance through surveys, focus groups, and marketing research.

DTE sought to understand if DPP rates would support a measurable and persistent load shift, while also enabling customers to save money by allowing them to manage when they used electricity. DTE further wished to determine the "minimum viable" education and enabling technology approach that would achieve persistent demand response.

For the informational treatment groups, the overall objective was to understand customer acceptance and behavior for two programs: Pre-pay and Smart Appliances. Informational study results are discussed briefly in 3.b.iv Survey Approach and more fully in section 7. Informational Consumer Behavior Pilot.

Table 1 depicts the Treatment Cells along with the overall research objectives of each cell as reflected in DTE's CBS. Please note, as shown in Table 10, and explained in section 3.a.i.i (Treatments section), the actual control and treatment groups recruited for this study were less than originally projected in the CBS.

Table 1: Research Objectives[2] and Original Experimental Design

Research Objective – Experimental Treatment Groups	Existing Rate	DPP Rate
Education only/Existing rate: Determine cost-effectiveness of education only by comparing Control Group (CTE) that does not receive education with Treatment Group (TE) that receives education, and both groups remain on the existing rate.	Control Group CTE, (N=1,200), and Treatment Group TE (N=1,200)	N/A
Education only: Determine cost-effectiveness of DPP rate supported with only education compared to technology-enabled approaches.	Control Group CT1, (N=375)	T1, (N=375)
Education +IHD: Explore the extent that real-time information, learning by doing, and alert features engage customers to action.	Control Group CT2, (N=375)	T2, (N=375)
Education +PCT: Explore the extent that automation based on customer preferences engages customers to action.	Control Group CT3, (N=375)	T3, (N=375)
Education +IHD +PCT: Explore the additive (or subtractive effect) of near real-time feedback combined with air conditioning/load automation.	Control Group CT4, (N=375)	T4, (N=375)
Total – Experimental Treatment Groups N = 5,400	N = 3,900	N = 1,500
Research Objective – Informational Treatment Groups	**Existing Rate**	**DPP Rate**
Education + Pre-Pay: Explore the extent of customer interest in a Pre-payment plan and if it engages them to action.	P1, (N=200)	N/A
Education + IHD + PCT + Smart Appliances: Explore the extent of customer interest in smart appliances and character of their interactions with the appliances during high price periods. Education +IHD +PCT + smart kitchen: Education +IHD +PCT + smart laundry: Education +IHD +PCT + smart kitchen & laundry:	N/A	S1, (N=100) S2, (N=100) S3, (N=100)
Total – Informational Treatment Groups N = 500	N = 200	N = 300

[2]Note, throughout this report control group CT1 is referred to as C1; control group CT2 is referred to as C2. DTE did not recruit for control groups CT3 and CT4. As discussed later in this report, control group C1 was compared to treatment groups T1 and T2, and control group C2 was compared with treatment groups T3 and T4.

DTE set out to understand if an education approach alone (on the existing Residential Service rate) would induce customer energy conservation and demand response behaviors. In addition, DTE intended to test the effectiveness of a DPP rate supported by education with and without IHD and PCT enabling technologies. Through the experiments, DTE examined whether dynamic pricing impacts complement or compete with the impact of the various enabling technologies. The DTE research incorporated the following questions and hypothesis:

1. Can a targeted and behaviorally focused education and outreach program in itself be an effective customer engagement strategy?

    H1a: A well designed education and outreach program based on individual and social behavioral leading practices on top of the existing inverted rate could induce customer energy conservation and demand response behavior (cell TE).

    H1b: A DPP rate and program with education, outreach, and pricing (i.e., financial consequences to the call to action) (cell T1) should achieve higher levels of demand response than the existing rate (cell C1).

2. What are the changes in energy usage by time period (on, off, mid, and critical-peaks)?

    H2: A DPP rate with an IHD and a PCT (feedback and automation enabling technologies) will result in the greatest levels of demand response and energy conservation (cell T4).

The DTE enabling technology question was primarily analyzed from experimental cells T2, T3, and T4 and included the following questions with resulting hypotheses:

3. What is the impact of different enabling technology combinations? What mixture of enabling technologies and pricing results in the greatest levels of demand response and energy conservation? Which achieves the most cost effective source of demand response and energy conservation?

    H3a: DPP supported by an educational approach alone could result in customer energy conservation and demand response (T1).

    H3b: DPP supported by education and enabling technologies approach could result in customer energy conservation and demand response (T2, T3, T4).

    H3c: A DPP rate with a PCT will result in the greatest level of demand response (T3),

    H3d: A DPP rate with IHD will result in the greatest level of energy conservation (T2).

    H3e: A DPP rate with IHD and PCT will result in the greatest level of energy conservation and demand response (T4).

3. Project Description

3.a. Design Elements

3.a.i. Target population

In theory, the target population for the study was all residential customers who would be interested in a rate option that would allow them to "know their own power" and to save energy and save money. In practice, the target population for the study was single family households on the standard residential inverted (moderately inclining) block rate, with AMI meter, 12 months of monthly consumption data, and at least 3-6 months[3] of AMI interval data regardless of geographic location. Internet access was a requirement for the enabling technology treatment cells. Customers with other elective discounted rates such as Interruptible Air Conditioning, Block Water Heating, Plug-In Electric Vehicle, Senior Citizen, Net Metering, etc., were excluded per the requirements of the Experimental DPP Rate. At the time lists were drawn for recruitment, AMI had been installed in the following areas: Grosse Isle, Harsens Island, and Metro Detroit (select ZIP codes/read routes); installation activity was then heavily concentrated in the Oakland County area. Thus, the bulk of the operational target audience was in Oakland County, where approximately 449,000 AMI meters (excluding Interruptible Air Conditioning) were installed as of December 2011.

3.a.ii. Treatments

Rates

DTE's pilot program focused on an experimental critical peak pricing tariff. All customers in the Treatment Groups were placed on the DPP Rate as approved by the Michigan Public Service Commission (MPSC) that included time-differentiated power supply charges as follows:

1. <u>On-Peak:</u> All kWh used only from <u>3 p.m. to 7 p.m. Monday through Friday</u>, excluding holidays, are charged at 12¢ per kWh;

2. <u>Mid-Peak:</u> All kWh used from <u>7 a.m. to 3 p.m.</u>, and from <u>7 p.m. to 11 p.m.</u>, <u>Monday through Friday</u>, excluding holidays, are charged at 7¢ per kWh;

3. <u>Off-Peak:</u> All kWh used from <u>11 p.m. to 7 a.m. Monday through Friday</u>, and <u>all weekend and holiday hours</u> are charged at 4¢ per kWh; and

4. <u>Critical-Peak:</u> All kWh used during <u>critical event hours</u>, which will replace the full on-peak time period from 3 p.m. to 7 p.m. when announced in advance, are charged at $1.00 per kWh. Critical Peak events are limited to a maximum of 20 per year, or 80 hours total.

The weekday DPP power supply costs are shown graphically in Figure 2. It should be noted that while customers did not see this particular graphical depiction of the power supply charges, all references to

[3] It was later determined that the potential population with at least 3-6 months of AMI interval meter was insufficient to meet the desired project enrollment levels. With TAG approval, the interval meter data requirement was reduced to 3 months.

the rate – both written and verbal – were in the context of power supply charges only. The monthly customer charge, distribution, and surcharges were acknowledged as part of the total billed charge; but the repeated emphasis was on the component that customers could control: power supply cost.

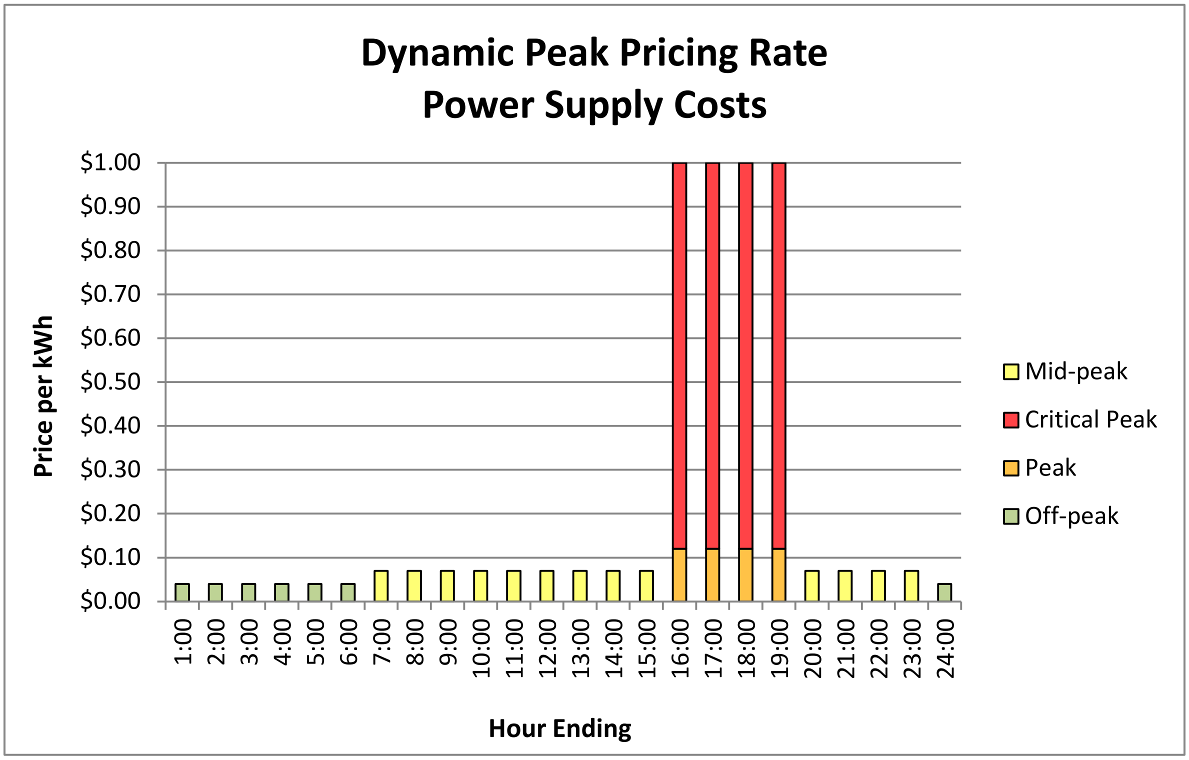


Figure 2: Dynamic Peak Pricing Rate – Power Supply Charges

Collateral materials emphasizing the DPP power supply charges are listed here and shown in the Education and Marketing appendices:

- Invitation to the Pilot – FAQs
- Welcome Kit – insert on DPP rate
- Nucleus Software – (described in 3.a.ii Treatments—Technology)
- eNewsletter articles on DPP rate
- Pilot participant Web Portal pages – How the Rate Works

On the customer bill statement, the bill detail changed to display a line item for each of the price tiers and corresponding subtotals for the bill period. The Critical Peak event line item appeared only if one or more events occurred. Where a bill period included multiple events, the usage was summed; in other words, critical peak events were not itemized by date. DPP billing detail is shown in Figure 3 below.

For Service at 123 Main Street

DTE Electric Company Experimental Dynamic Peak Pricing

Current Charges

Power Supply Charges:			
Off-Peak Period	640	KWH @ 0.04	25.60
Mid-Peak Period	382	KWH @ 0.07	26.74
On-Peak Period	59	KWH @ 0.12	7.08
Critical-Peak Period	2	KWH @ 1.00	2.00
Renewable Energy Plan Surchg			3.00
Other Power Supply Surcharges*			7.63
Delivery Charges:			
Service Charge			6.00
Distribution	1083	KWH @ 0.04195	45.43
Energy Optimization	1083	KWH @ 0.002711	2.94
VHWF Credit			−1.59
LIEAF Factor			0.99
Other Delivery Surcharges**			11.38
Residential Michigan Sales Tax			5.45
Total DTE Electric Company Current Charges			**142.65**

Current Billing Information

Service Period	Sep 03, 2013 - Oct 02, 2013
Days Billed	29
Meter Number	1234567 03
Meter Reading	15059 Actual - 16142 Actual
KWH	1083

Your next scheduled meter read date is on or around NOV 01, 2013

Usage History - Average per day

	Current Month	Last Month	Year Ago
KWH Usage	37.3	37.5	31.1
Change		0%	19%

Total Current Charges **142.65**

*Other Power Supply Surcharges include costs associated with Power Supply Cost Recovery (PSCR), and the Choice Incentive Mechanism (CIM).

** Other Delivery Surcharges include Nuclear Decommissioning, Securization Bond, Securitization Tax charges, U-16472 RRA, and Restoration Expense Tracker.

Figure 3: Dynamic Peak Pricing Rate – Bill Detail

To better understand the effect of the DPP rate, DTE compared the DPP customers' response to that of the Control Group customers on the existing rate, D1 – Residential Service Rate. This rate is a moderately inverted (moderately inclining) block rate with the power supply charges described below:

- 6.912¢ per kWh for the first 17 kWh per day, where daily usage is averaged across the 30 billing days based on monthly usage, and
- 8.257¢ per kWh for excess over 17 kWh per day.

The DPP and Standard Residential tariff sheets are included for reference in Appendix B and summarized in Table 2.

Table 2: Standard and Pilot Rate Structures

Rate Component	Standard Residential Rate – D1	DPP – D1.8
Monthly Charge	$6.00 per month	$6.00 per month
Power Supply Charges	• 6.912¢/kWh for the first 17 kWh/day* • 8.257¢/kWh for excess over 17 kWh/day* ** where daily usage is averaged across the 30 billing days based on monthly usage*	• On-Peak 3-7pm M-F (excluding holidays): 12¢/kWh • Mid-Peak 7am-3pm & 7pm-11pm M-F: 7¢/kWh • Off-Peak * 11pm – 7am M-F*: 4¢/kWh • Critical Peak 3-7pm M-F, when announced: $1.00/kWh ** plus weekends and all designated holidays*
Delivery Charges	5.003¢/kWh	4.195¢/kWh
Surcharges and Credits	As approved by MPSC	As approved by MPSC

At the time of final Consumer Behavior Plan filing in February 2011, the DPP Rate and the existing Standard Residential Rate featured an identical $6.00/month service charge, a 4.195¢/kWh delivery charge, and applicable surcharges; only power supply charges differed. Since then, the standard residential rate has experienced slight rate increases resulting from DTE's general rate case (U-16472) approved in December 2011. The Experimental DPP Rate, approved in September 2010, was not part of this general rate case increase. In its next general rate case filing, DTE will adjust the delivery rate for DPP to equal that of its standard residential rate (D1).

Critical Peak Price events

DTE was authorized to implement Critical Peak Pricing for no more than 80 hours per year, for evaluation of the tariff based on several factors including but not limited to economics, system demand, or capacity deficiency.

CPP Events were triggered at the SmartCurrents Program Management level, for any of the following conditions:

- Forecast day-ahead temperatures ≥ 85°
- Forecast Relative Humidity ≥ 65% or heat index of ≥ 90°
- Economic Dispatch Criteria: Average Day Ahead Peak Price ≥ $60.00 for MISO Michigan Hub
- Back-to-back events to be called when forecast heat/humidity is expected to span several days. If indicated, 3 or more consecutive event days would be called.

DTE was required to notify its customers by 6:00 p.m. the day before the CPP event, and in practice, typically completed this notification by 3:00 p.m. The notifications process was modified to run earlier in the day to help ensure that notifications were delivered by the 6:00 p.m. deadline, as stated in the tariff sheet. This process improvement was made in response to system issues that impacted the first event called in August 2012.

Notification was made using stated customer preferences: automated telephone message, text message, and/or e-mail. Customers were required to have at least two of these three automated notification preferences. While message length varied by notification type (text was shortest), all received the same base information:

> *"Your DTE Energy account at 123 Main Street is enrolled in Dynamic Peak Pricing. Tomorrow August 16th, from 3 pm to 7 pm will be a critical peak day."*

DTE did not utilize the message capability of the devices (IHD and/or PCT) for a combination of financial and practical reasons. While the GE devices were "message capable," adding this functionality to the Demand Response Management (DR1000) system for deployment was considered a system enhancement at additional cost. More importantly, T1 customers with rate and education only had no devices, so DTE's standard communication method was already required.

Targeted messaging and preferred communication media were used in an attempt to maximize customer CPP engagement. In May 2013, in advance of the summer cooling season, a specific communication was sent to all pilot customers advising that event activity for the year would be greater than last year, and recommending they review and update notification preferences. In addition, periodic CPP discussions were included in the monthly e-newsletter.

Over the course of the study, DTE called twelve CPP events:

Table 3: Event Day List and Details

Event	Date	Event Type	Forecast High Temp	Forecast Relative Humidity	Avg. Relative Humidity	Max Temp	AVG Temp On Peak	MISO Forecast	MISO Actual
1	8/16/2012	single	91	n/a	72%	82	79	$ 33.72	$ 35.43
2	5/30/2013	single	88	60%	74%	88	77	$ 46.67	$ 51.06
3	6/24/2013	single	89	60%	68%	87	86	$ 44.38	$ 47.38
4	7/8/2013	single	86	67%	85%	83	74	$ 43.00	$ 45.21
5	7/15/2013	back-to-back	89	64%	74%	93	89	$ 47.96	$ 51.95
6	7/16/2013	back-to-back	90	70%	81%	89	84	$ 52.04	$ 59.54
7	7/17/2013	back-to-back	93	64%	69%	94	92	$ 57.73	$ 64.93
8	8/20/2013	back-to-back	87	54%	68%	85	84	$ 38.04	$ 40.31
9	8/21/2013	back-to-back	89	55%	70%	86	85	$ 39.48	$ 43.14
10	8/26/2013	single	90	52%	66%	87	87	$ 46.54	$ 46.86
11	8/29/2013	single	89	61%	76%	86	82	$ 46.08	$ 45.20
12	9/10/2013	single	93	54%	69%	93	92	$ 48.27	$ 54.51

All CPP events were planned based on criteria 1, "Forecast day-ahead temperatures ≥ 85°." However, as can be seen above, the actual Max Temp and/or Average Temp during the event did not always meet that threshold. Forecast humidity and heat index were noted for planning purposes, but alone did not drive an event day decision. Heat index calculations used the National Weather Service heat index calculator (http://www.hpc.ncep.noaa.gov/html/heatindex.shtml). In no case did the Economic Dispatch criteria of Day Ahead forecast price ≥ $60.00 come into play; however, the settled price on July 17 was subsequently seen to exceed that metric.

In 2012, only one CPP event was called, due in part to the late summer start of data collection, and compounded by a notification system failure. Data for this day is not included in the final report due to the aforementioned notification issue. Furthermore, the day ahead forecast high of 90° for Event 1 simply did not materialize.

Eleven events were called in 2013, and notifications were successfully generated and sent for each event.

Treatments

DTE's SmartCurrents Pilot Program was comprised of four treatment groups that received "offers" and three control groups:

Table 4: Treatment Cells

Treatment Cell	Control Group	Description	Blind/Opt-in	Study
	CE	Standard Residential Rate	Blind (no direct customer contact)	Statistical
T1	C1	DPP + Education	Opt-in; randomization	Statistical
T2		DPP + Education + IHD	Opt-in; randomization	Statistical
T3	C2	DPP + Education + PCT	Opt-in; randomization	Statistical
T4		DPP + Education + IHD + PCT	Opt-in; randomization	Statistical

As briefly noted in 2.d. Research Questions & Hypotheses, actual control and treatment groups recruited for the study were less than originally projected in the CBS plan (not all of those that were offered a treatment actually enrolled in it). In December 2011, DTE requested TAG approval to eliminate the Education only cells (T1 and C1) as well as the TE and CE, which were higher level education treatments. This request was made because the target population mail file was deemed insufficient to yield the desired enrollment quantities.

In a December 9, 2011, email, TAG approved the request, with the recommendation that DTE retain the CE 1,200 point sample and draw it from the installed meter population, without exclusions for "arrears" or "load control" customers. The purpose of this sample is to collect load data only to be used to compare and benchmark the populations for the remaining treatment cells. No demographic survey data collection was required; consequently none of the 1,200 points would require any direct customer contact.

Based on TAG's guidance, DTE eliminated the TE "blind" education group and filled the CE group for comparison purposes only. Over the course of the enrollment term, customer acceptance/qualification activity suggested T1 could be supported, and it was added back into the study. Control Groups were reduced from four (C1-C4) to two groups: C1 for comparison to T1 and T2 (central air conditioning not required) and C2 for comparison to T3 and T4 (central air conditioning required). Details of the assignment to each group are in section 3.a.iii.

Education

SmartCurrents Education was designed in three phases. The first two phases—AMI Meter Installation Communications and Pilot Recruitment Communications—were intrinsic to pilot infrastructure and operations, and the third—Pilot Customer Education—is where the bulk of the educational content was implemented.

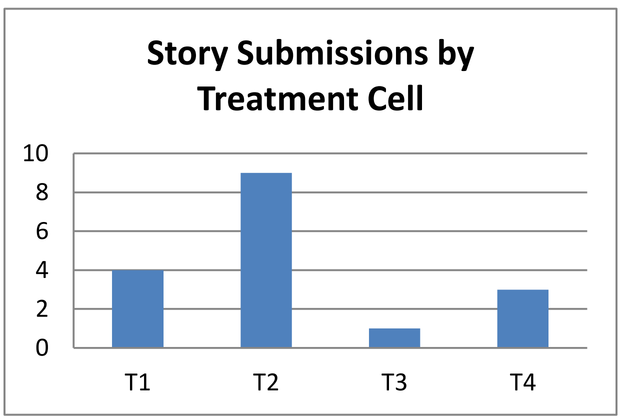
> **Phase 1: AMI Meter Installation Communications**, which prepared the customer for the installation and provided information on the benefits of smart metering. These included an advance notification letter and brochure as well as door hanger left on installation day. The entire AMI installation population receives these communications.
>
> **Phase 2: Pilot Recruitment**, which included key communications and customer touch points related to invitation, qualification survey, and installation of devices (where relevant). In addition, in the fall of 2011 (several months ahead of the start of formal recruitment), a special email blast was sent to the target population. This e-blast gave an overview of AMI benefits and pointed out the new capability to see detailed energy usage online at dteenergy.com. The intent of the communication was to "pave the way" for recognition when the recruiting effort began. These communications were received both by pilot participants and those who were invited but declined to participate.
>
> **Phase 3: Pilot Customer Education**, which consisted of customer touch points and communications related to the Dynamic Peak Pricing rate, energy conservation and energy waste management, enabling-technology operations, and other key educational components necessary to empower customers in the pilot program.

All participants in the T1 to T4 treatment groups had access to a variety of feedback and educational materials and tools presented through multiple channels. Some materials were accessed with a "pull," meaning that customers had to take a voluntary action to access them (such as a website or "paging through" the IHD), while other material was made accessible by a "push," meaning that customers automatically received the materials (such as email, direct mail, and event alerts). Core tools included:

- Monthly e-newsletter
- Customer web portal presenting a wide variety of energy information; updated monthly
- Suite of hard copy educational materials (Welcome Kit)
- SmartCurrents program support and GE Technical Support
- Play-Learn-Win energy education game

Monthly e-newsletter

Pilot participants received a monthly e-newsletter with energy conservation tips, DPP rate discussions, DPP savings strategies, etc. Content was tailored to the specific treatment cells, and included links to the web portal for additional insight and information. Focus groups conducted in fall of 2012 indicated participants felt the content was lengthy and too generic, and they wanted more program specific information. Beginning in January 2013, content was streamlined and more pilot-focused, generally limited to a main feature and secondary topic. Tech Tips were added, providing answers to common questions such as how to rebind a device and how to verify Nucleus communication status. "Submit your Story" features also were introduced, inviting participants to share their energy saving/shifting strategies for a chance to win a gift card if their story was featured in a subsequent newsletter. From February through November 2013, seventeen stories were featured, with customers in T2 sharing the most insights and customers in T3 sharing the fewest.



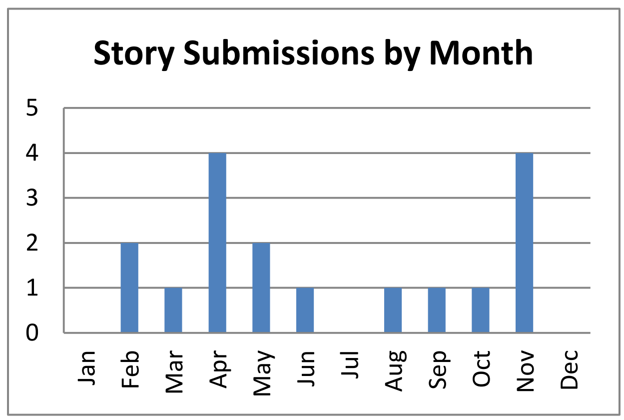


Figure 4: Energy saving strategy Submissions

Overall readership (open rate) for the pilot period was 60 percent, down slightly from the 62 percent open rate through the interim report period. While this may seem low, "open rate" tracks only customers who viewed the email with its images. A more likely open rate is one to five percent higher—61 to 65 percent—to account for recipients who viewed text only or used the preview pane. The highest readership was recorded in July 2012, with a subject line "SmartCurrents Critical Peak – What you should know." The lowest readership was recorded in August 2013, with a subject line "SmartCurrents Play, Learn and WIN," in advance of cycle 2 of game play. The average click through rate for the pilot period (excluding December 2013 because there were no links in the holiday card) was 12.5 percent. This represents unique individuals who clicked on one or more links in the email, expressed as a percentage of the total tracked opens. The links included: SmartTrivia, Submit a Story, and various websites customers could access for more information such as energy saving tips and SmartCurrents web content.

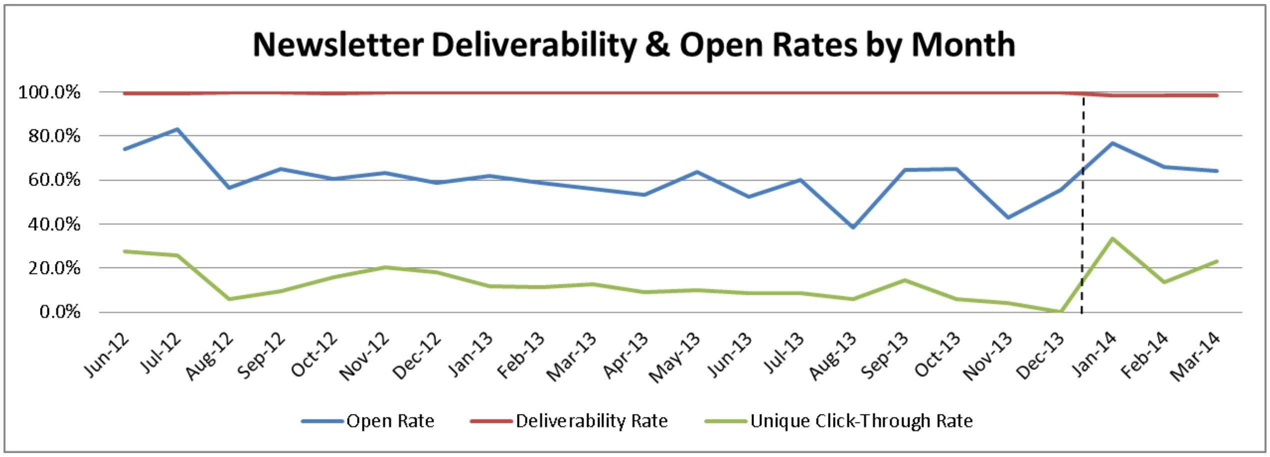


Figure 5: Newsletter Deliverability & Open Rates by Month

The SmartCurrents Communication plan included "wind down" communications for customers, after the CBS study period concluded on December 31, 2013. Monthly e-newsletters were used to provide important information for customers going forward, including "Keep the savings going," and "What's next for Smart Technology." While these communications are admittedly outside the pilot term, they do indicate that customers pay attention when they perceive content is important to them.

See Appendix D for detailed readership statistics.

Web Portal

DTE offered all customers the opportunity to view key energy usage data, and other relevant information and analytics, online through a computer or mobile phone internet browser.

Pilot customers had additional access to a special web portal that provided the following:

- Rate comparison tool that allowed comparison between their new DPP rate and their prior residential rate
- Energy Use Analysis charts
- Energy education content customized by treatment cell

This specialized content was restricted to pilot participants, and was accessed when they logged in to their accounts on dteenergy.com and pilot participation status was detected.

The rate comparison tool (powered by Aclara Technologies, LLC) allowed participants to become familiar with DPP rate impacts, and better understand how they might benefit from the DPP rate by performing rate comparisons between their new DPP rate and previous Standard Residential rate. It was intended to help participants understand how they might benefit from the DPP rate, based on levels of behavior change (i.e., none, slight, moderate, or significant). Benefit was expressed as percentage savings, not dollars per month. Usage of this tool was surprisingly low, with a total of 216 sessions over the period June 2012 through May 2013, and 299 sessions total over the term of the pilot. Those sessions yielded 257 page views in year 1 and 370 page views in year 2 ending December 31, 2013. At an assumed rate of one session per user, it would appear that only 22 percent of pilot participants utilized this tool to better understand how they might benefit from the DPP rate. DTE expected that closer to half of participants would access the tool that could estimate bill impact based on different levels of behavior change. Unfortunately, usage statistics were not broken down by treatment cell. Monthly rate comparison tool statistics are shown in Appendix D.

The portal also provided hourly and daily usage information and pricing information presented graphically to help users understand their usage trends. Examples of Energy Use Analysis screen shots are shown in Figure 6 for Standard Residential Rate (left) and DPP rate (right).

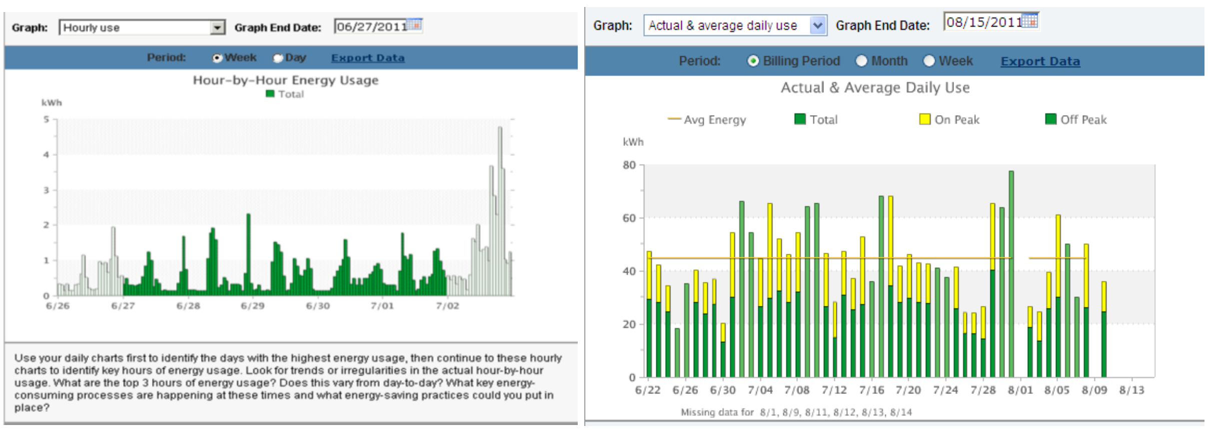


Figure 6: ACLARA Energy Use Analysis Web Portal

Finally, the portal provided energy education content customized by treatment cell. For example, content for T3 and T4 was tailored to understanding and maximizing the PCT, while T1 and T2 content was focused on the benefits of programmable thermostats, and provided links to rebates. This content changed monthly, and participants were directed here from links in the monthly e-newsletter. Following a newsletter link to the portal, customers necessarily had to login to their accounts. Once authenticated online, they were automatically directed via “destination URL” to the desired content, eliminating the need for them to navigate through the pages on their own. This portal was presented in the context of the existing DTE Energy website (www.dteenergy.com), which offers a wide range of content and services to help DTE customers better understand energy and energy savings, including energy calculators, energy saving tips, energy conservation videos, rebates, and special offers.

SmartCurrents web page views for the period August 2012 through June 2013 totaled 4,813 views. The average monthly view count was 437.5. The highest view count was March 2013, with 712 views and the lowest view count was September 2012 with 134 views. SmartCurrents web page views and rate comparison calculator usage are shown in Appendix D. Unfortunately, web page views for the period July through December 2013 are not available. In July 2013, DTE undertook a major platform change for the dteenergy.com web site. The SmartCurrents portal pages were not detected in a pre-project sweep because they were restricted access, and not public access pages; thus no provision was made to track and maintain them during the changeover. Much work was done in an effort to recreate the tracking links, to no avail.

Hard Copy Educational Materials

The Welcome Kit, sent upon pilot enrollment (and therefore included in Appendix E. Marketing Materials), was the primary hard copy educational material. Customized by treatment cell, it featured a "Getting Started" page, DPP rate sheet, and IHD and/or PCT device sheets as applicable, in a branded pocket folder. A SmartCurrents Pilot Program magnet listing DTE and GE Support phone numbers and hours of operation also was included. In addition, customers who received Nucleus with IHD and/or PCT also received "Before You Begin - Installation Tips for GE Nucleus" in the box with the device/s. This information sheet described initial installation using the Ethernet cable provided as well as steps to add Nucleus to their home's WiFi network later in the installation process. Steps for connecting devices also were provided.

In April 2013, pilot participants received a hard copy letter reminding them of the Critical Peak event component of the DPP rate, advising them to confirm their preferences for day-ahead event notifications, and announcing a system test in advance of summer "CPP" season. This communication was intentionally designed as a mail piece to help ensure timely readership, as fall focus groups had indicated participants receive but may not read every SmartCurrents program email. A follow-up letter was subsequently sent to 45 customers whose notifications failed during test. The letter reiterated the importance of up-to-date notification preferences, displayed current preferences with delivery failure reasons, and reminded them to call to update. All but seven customers responded and updated their notification preferences. When system testing was complete, customers were notified that the system was working properly and that all future CPP Notifications would be for real events and not testing.

SmartCurrents Program and GE Technical Support

A dedicated team of DTE Customer Representatives was selected and trained to handle all recruiting, enrollment and ongoing customer service matters for pilot program participants. A separate, dedicated toll free number was established for these customers to use not only during the recruiting and enrollment period, but also for the duration of the program. Anticipating that some customers might forget, and mistakenly call the well-known 1.800.477.4747 number, both the target population and the enrolled pilot population were tagged "Smart Home" in the billing system. In addition, periodic Newsflash items were sent to the DTE Contact Center reminding them to forward pilot customer calls to the dedicated SmartCurrents team.

The SmartCurrents team completed four days of training immediately before the first invitation "mail drop." This timing was deemed critical to success, in that program details would be fresh in Customer Representatives' minds as customers received the mailing and began to call.

Training covered:

- High level program background: DOE grant, SmartGrid concepts, and DTE's Smart Grid program
- Consumer Behavior Program (aka Pilot) and the different Treatment Cells or "offers"

- Understanding the GE technology & Binding Nucleus to the Meter
- Understanding the DPP rate
- Tracking enrollment and program activity
- FAQs and SharePoint location of reference materials “library”
- Call Handling instructions and enrollment call role play
- High bill analysis specific to the DPP rate

The SmartCurrents Customer Representative team was prepared to handle initial program questions and enrollment as well as provide ongoing support to pilot participants who may call for various reasons, such as:

- Seeking more information about the DPP rate and/or what they have learned from the portal
- Looking for answers to questions about the pilot or technology
- Providing feedback about pilot experience
- Understanding their bill
- Contemplating dropping the rate and withdrawing from the program

An escalation process was put in place for customer concerns that could not be resolved by the SmartCurrents Customer Representative or immediate supervision. Such escalations were routed promptly and directly to the DTE Program Management for resolution and follow up.

The GE Customer Support staff was trained to respond to enrolled customer calls for ordering, set up and system operation questions, including but not limited to:

- Fulfilling enrolled customer IHD and PCT “orders” based on master list of customers by treatment cell
- Scheduling PCT installations
- Nucleus password resets
- Binding devices to Nucleus
- Explaining how PCT responds to price signals

GE also had an internal escalation process for customer concerns that could not be resolved.

The toll-free phone numbers and hours of operation for both DTE and GE contact centers were provided on portal pages, emails, and all relevant pilot educational materials.

Play-Learn-Win

“Play-Learn-Win: Learn a Little. Save a Lot” (PLW) program developed by Vergence Entertainment was introduced in April 2013, and offered in addition to the monthly e-newsletter and web portal updates which had been in place since summer 2012. The multi-media customer education platform presented participants with information emphasizing using energy more efficiently, understanding Dynamic Peak Pricing, and responding to pricing signals such as critical peak alerts. The overall objective was to test customer acceptance of a novel approach for delivering energy information as well as measure any learning and retention of that knowledge.

PLW conveyed a curriculum of the SmartCurrents key concepts to pilot participants by distributing specialized print pieces, weekly emails and a unique data-driven game application for mobile devices and computers, called Ringorang®. The PLW app delivered incentivized social contests or "games" where learning elements were delivered as "information packets." An information packet included a clue, a multiple-choice question, an insight, "learn more" source material and links on the PLW website leading to more sources. These information packets were delivered at seemingly random times daily, multiple days each week, each on a ticking clock lasting approximately 30 seconds. Participants who took the questions "live" engaged simultaneously with all other live players, while others played the questions when convenient, in "make up" mode. A "game" was a collection of between nine and 12 questions on a given subject of the curriculum. There were 13 subjects addressed in PLW. Each game was offered live for three days in a given week, then in makeup mode for two additional days in the same week.

Pilot participants were invited to subscribe to PLW via DTE-branded email invitations, as well as featured items in SmartCurrents e-newsletters and through presence on the web portal. PLW participation was incentivized with prizes from the local communities (including Qdoba restaurant gift cards, Arthur Murray dance lessons, DTE Music Theatre tickets and more). Prizes were used to help drive PLW mobile and computer app downloads and play, specifically: achievement, persistence, and daily engagement.

The delivery of curriculum began with mailing a PLW welcome kit to all pilot participants, which included a welcome letter and a deck of playing cards branded to the SmartCurrents program and designed with 52 energy saving actions on the faces of the cards. These cards served functionally as the entirety of the PLW curriculum, with the intention to provide the answers in advance of the "test." In this way, pilot participants who did not download the computer or mobile app could still receive the PLW curriculum elements; for those who downloaded the PLW app, the deck of cards was designed to serve as a reference point. Questions delivered through the app offered the player opportunity to click through to a customized website where the image of the correlating card in the deck could be seen.

Additionally, all pilot participants (regardless of subscription status) received monthly print mailers where game challenges relating to the PLW curriculum appeared in the form of questions and puzzles. On these mailers, participants were encouraged to either text message (SMS) or call by phone to an IVR system to answer the questions presented. Participants who provided answers in this way were enrolled in a sweepstakes to win packages of prizes. This play method was subsequently dropped in cycle 2, as this method did not attract players who were not already app users.

The program was delivered in two cycles. Cycle 1 launched in early April and ran 17 weeks, wrapping up in August 2013. Cycle 2 ran between September and December 2013. The Cycle 2 games condensed the curriculum from Cycle 1, eliminated some subjects that scored especially high, and included some minor adjustments to questions based on the results of Cycle 1. A majority of the Cycle 1 participants returned to repeat the curriculum in Cycle 2 to varying degrees; and an additional 6% of the pilot participants joined as new players of PLW in Cycle 2, yielding almost 35% subscribed by the end of Cycle 2.

In order to participate, users had to first subscribe and set up a player or user account. To play "live," they had to then download the PLW app to computer and/or mobile device. The subset of participants who downloaded the app is referred to as "app users," although not all "app users" actually did use the app. Some downloaded it, but didn't use it. There were other ways to participate without downloading the app, but the app was the primary, planned delivery channel for the curriculum. For analytical purposes, a PLW participant was considered to have:

- "Participated" in a game or "Played 1+" if he/she played at least one question in either live or makeup mode in a given game,

- "Played All" in the game if he/she played every one of the questions in the game (averaging 10 per game, over a one-week game-play period) in either live or makeup mode, and

- "Engaged Significantly" if he/she participated in at least five games in a given Cycle[4], or with at least 20 learning elements (information packets).

Using the definitions above, following are several results of the PLW Program:

- Customers continued to sign on to the program over time, eventually almost tripling the initial number of app users enrolled, from 125 in the first week of Cycle 1 to 364 by the end of Cycle 2.
- The proportion of Cycle 1 players who engaged at least once with the curriculum when delivered a second time (Cycle 2) was over 60%, indicating a willingness to continue engaging and learning (or competing) even without refreshed content.
- Each game delivered an average of 11 information packets, which included clues, a question, answer choices, and an actionable insight. Across the 30 games comprising Cycle 1 and Cycle 2, an average of 57% of the app users participated in each game, suggesting that the 30 games and/or prizes were interesting enough to capture sufficient interest to motivate engagement.
- Participant learning showed measurable increases of typically 8% per month in accuracy when curriculum was repeated. Participants typically reached 90% accuracy or above on each of 13 subjects after repeat deliveries of the curriculum.

Program materials and performance metrics are shown in Appendix E.

[4] A customer who engaged in at least 5 games in Cycle 1 played an average of one game per month, which was used as the benchmark for "significant" engagement.

Energy Optimization (EO)

A sixth educational component both pre-dates and exists independent of the SmartCurrents Education Plan: DTE's Energy Optimization Program.

In October, 2008, the Michigan Legislature directed utilities to establish an Energy Optimization (EO) program designed to:

- Help customers control their energy use and save them money through rebates and energy-saving education.
- Improve the environment by controlling energy consumption.
- Help to delay the need for a base load power plant, protecting customers from incurring the cost of construction.

In 2009, DTE Energy established an EO (also known as Energy Efficiency) program to help customers lower their energy bills. DTE has been investing $100 million per year in energy efficiency program rebates and education to help both its electric and natural gas customers save energy and money. The EO Education and Awareness Program is tasked with educating customers about the benefits of energy efficiency, using a balanced mix of all communication channels (Digital, Mass, Direct mail, and Face-to-Face). The goal is to reduce electric energy use by 1 percent and natural gas use by 0.75 percent annually.

DTE's commitment to energy efficiency is further evidenced by the suite of energy efficiency measures and rebates, educational topics, and more found at dteenergy.com/saveenergy.

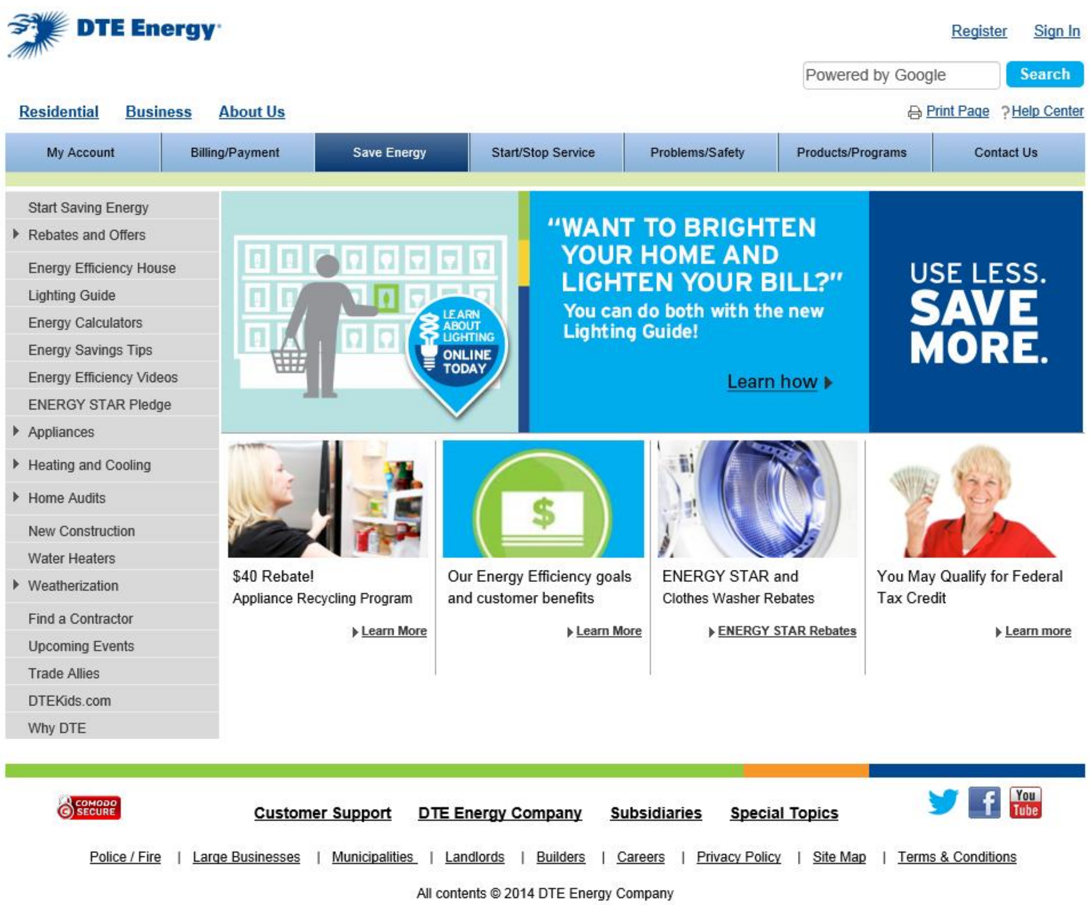


Figure 7: DTE Energy Efficiency program offerings

In addition, DTE and Fox 2 Local News (WJBK FOX 2 in Detroit) partner to share energy and money-saving tips on Fox 2 daily news broadcasts. The voice-over ad combined with a recognizable lead-in tune presents different Think Energy! Tips throughout the day:

Figure 8: Fox 2 Energy Team EE tip

This sponsorship began in August 2011, and a broad collection of EE tips runs a minimum of three times per day seven days a week. This equates to a minimum of 21 messages per week or 252 per quarter, with no upper boundaries on number of messages presented.

In light of this long-standing, dedicated messaging on energy efficiency, coupled with the energy efficiency intensive education component of the pilot program (via monthly eNewsletter, companion monthly updates to the web portal, links to the Save Energy web pages, and Play-Learn-Win), SmartCurrents pilot customer participation in EE programs was evaluated: Nearly 45 percent of the T1-4 pilot participants had claimed one or more EE program rebates in the period from 2009 – 2013.

Table 5: SmartCurrents Customer Utilization of EO Programs and Rebates 2009 - 2013

Treatment	Description	Enrolled	Who Claimed Rebates	Pct.
T1	No Technology	249	102	41.0%
T2	IHD	390	166	42.6%
T3	PCT	328	153	46.6%
T4	IHD & PCT	369	181	49.1%
		1336	**602**	**44.8%**
S1	T4 + Smart Kitchen appliances	21	13	61.9%
S2	T4 + Smart Laundry appliances	29	9	31.0%
S3	T4 + Smart Kitchen & Laundry appliances	14	6	42.9%
		64	**28**	**45.3%**
C1	Control: T1 &T2	347	112	32.3%
C2	Control: T3 &T4	356	132	37.1%
C3	Control: General	1212	173	14.3%
		1915	**417**	**27.9%**

For the period 2009-2011, preceding the pilot, 972 rebated measures were claimed by T1-4 customers who later became Pilot Participants. For the pilot period, 2012 – 2013, 1061 rebated measures were claimed by nearly 25 percent of T1-4 pilot participants. Some participants claimed rebates in both pre-pilot and pilot periods. While correlating participation in EE programs was not a study objective, it is interesting to note utilization rates both before and during the pilot program. This might suggest that the recruiting message really resonated with customers who had taken advantage of energy efficiency measures or that our pilot population was predisposed to energy efficiency messaging and behavior.

Table 6: SmartCurrents Customer Utilization of EO Programs and Rebates 2012-2013

Treatment	Description	Enrolled	Who Claimed Rebates	Pct.
T1	No Technology	249	50	20.1%
T2	IHD	390	94	24.1%
T3	PCT	328	84	25.6%
T4	IHD & PCT	369	102	27.6%
		1336	**330**	**24.4%**
S1	T4 + Smart Kitchen appliances	21	6	28.6%
S2	T4 + Smart Laundry appliances	29	7	24.1%
S3	T4 + Smart Kitchen & Laundry appliances	14	5	35.7%
		64	**18**	**29.5%**
C1	Control: T1 &T2	347	49	14.1%
C2	Control: T3 &T4	356	77	21.6%
C3	Control: General	1212	97	8.0%
		1915	**223**	**14.6%**

Technology

Three of the four treatment cells under study were provided with enabling technology. Qualified customers were randomly selected to receive an IHD, PCT, or both IHD and PCT. The IHD and PCT were "powered" by GE Nucleus, a Home Energy Management (HEM) Hardware system that acted as the gateway for monitoring electrical usage and controlling energy consumption within the home in real time. The Nucleus communication and storage device plugged into a standard 120 volt electrical outlet, and worked in combination with desktop client software to create the home area network. It interfaced with the AMI meter to show real-time (kW) and long-term (kWh) data on power consumption. Daily/monthly/yearly historical trends can be seen over a span of three years, via the desktop client or smart phone.

After Nucleus was bound to the AMI meter, compatible smart devices such as the IHD and/or PCT were added to the home energy management network. Meter usage and price and load control signals received by Nucleus were transmitted to IHD and PCT to allow customers to determine how appliances or devices could best help control energy costs. IHD and PCT relied on Nucleus for price signals; thus all IHD and/or PCT users utilized Nucleus. No customers received Nucleus only.

The IHD was a counter top device that received and displayed information from the Nucleus. Key features of the IHD included:

- Display that allowed consumers to closely track their energy consumption in near real time energy usage in kW or $
- Historical energy usage - month, day, hour – kWh or $
- Usage display to three decimal points

- Energy analysis tools – Spyglass and Stopwatch
- Show Time-of-Use (TOU) Power Supply rates: $0.04/kWh off-peak; $0.07/kWh mid-peak; $0.12/kWh on-peak; and $1.00/kWh Critical Peak

A screen shot of Nucleus device and desktop display with IHD is shown in Figure 9.

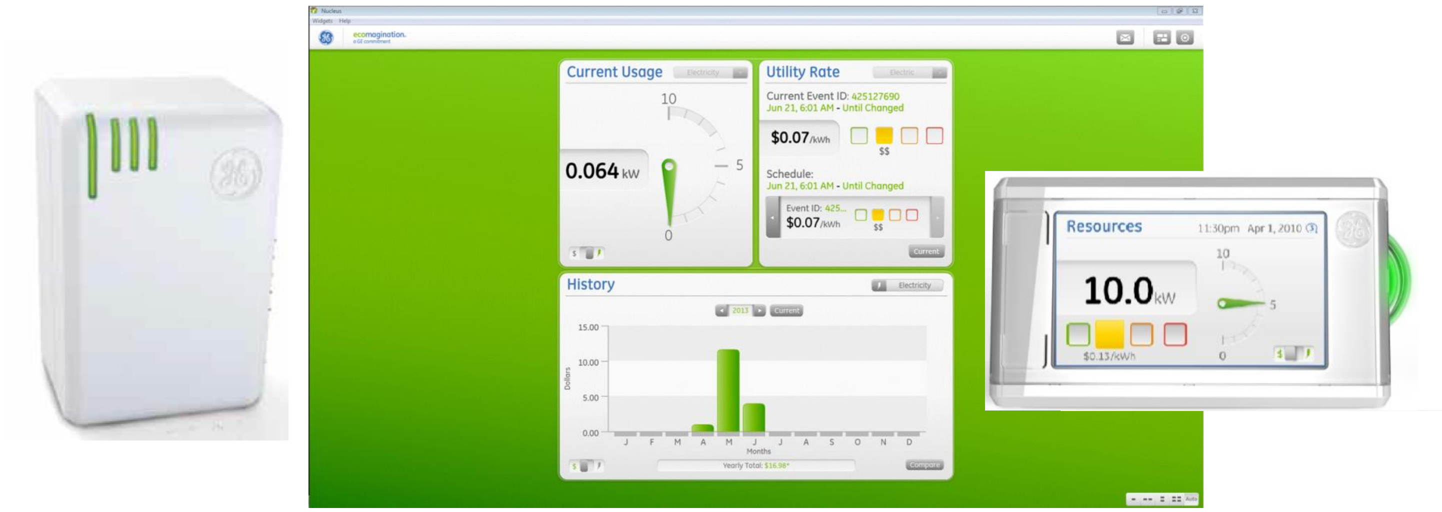


Figure 9: GE Nucleus & IHD – T2 & T4

The GE PCT was a full featured programmable communicating thermostat that provided four degree temperature offset during critical peak events to provide energy management for the period. The GE system sent two signals for events: the $1.00 price signal and the demand response signal which activated the temperature offset. Event override by the customer was possible. Operating as a 3 heat/2 cool universal thermostat, it had a touch screen/button interface and filter replacement reminder and was programmable at the wall or through the Nucleus interface. Key Design Specifications of the PCT included:

- ZigBee® Smart Energy Profile Thermostat
- Full 7 day program with 4 set points per day
- Programmable energy savings setback
- Screen selection
  - $ or KWh Usage
  - Instantaneous KWh
  - Instantaneous $ Pricing

In addition to these features, Nucleus allowed users to program and/or change the PCT settings. The PCT could also be accessed by an iPhone app (but not Android, unfortunately). Nucleus with PCT widget and PCT is shown in Figure 10.

Figure 10: GE Nucleus & PCT – T3 & T4

3.a.iii. Randomization and assignment method

The study design was a randomized controlled trial (RCT) with denial of treatment for the control group. A simple random sample of AMI-metered residential customers in the service territory who met certain eligibility criteria (as described in section 3.a.i, Target Population) received an invitation to opt in to the study where participating customers could receive one of several treatments, with the understanding that this treatment was limited in supply.

With a variety of enabling technologies, customers who opted in were screened (i.e., owned their home; were not employed by DTE or a GE competitor; had a forced air heating system) and surveyed to ensure qualification to potentially receive a treatment. Targeted customers were given the option of completing qualification and baseline survey online, or beginning the process with a printed Business Reply (BR) qualification questionnaire. Respondents who chose the BR response method were subsequently invited to complete the online baseline survey.

Those who qualified and self-identified as having central air conditioning were randomly assigned either to a control group or to receive an offer to opt in to one of four studies, each of which took service under DPP with CPP overlay and included an offer of: no technology, an IHD only, a PCT only, or both PCT and IHD.

Those who qualified and self-identified as not having central air conditioning were randomly assigned either to a control group or to receive an offer to opt in to one of two studies, each of which take service under DPP with CPP overlay and include an offer of either no technology or an IHD.

Figure 11 on the following page depicts a high level overview of this randomization and assignment process.

As noted elsewhere, usage data was not available for all customers that were randomly assigned to receive an offer to opt-in to one of the four treatments. For the customers who were randomly assigned to a treatment group, data was only available for those that actually opted in and finalized their enrollment.

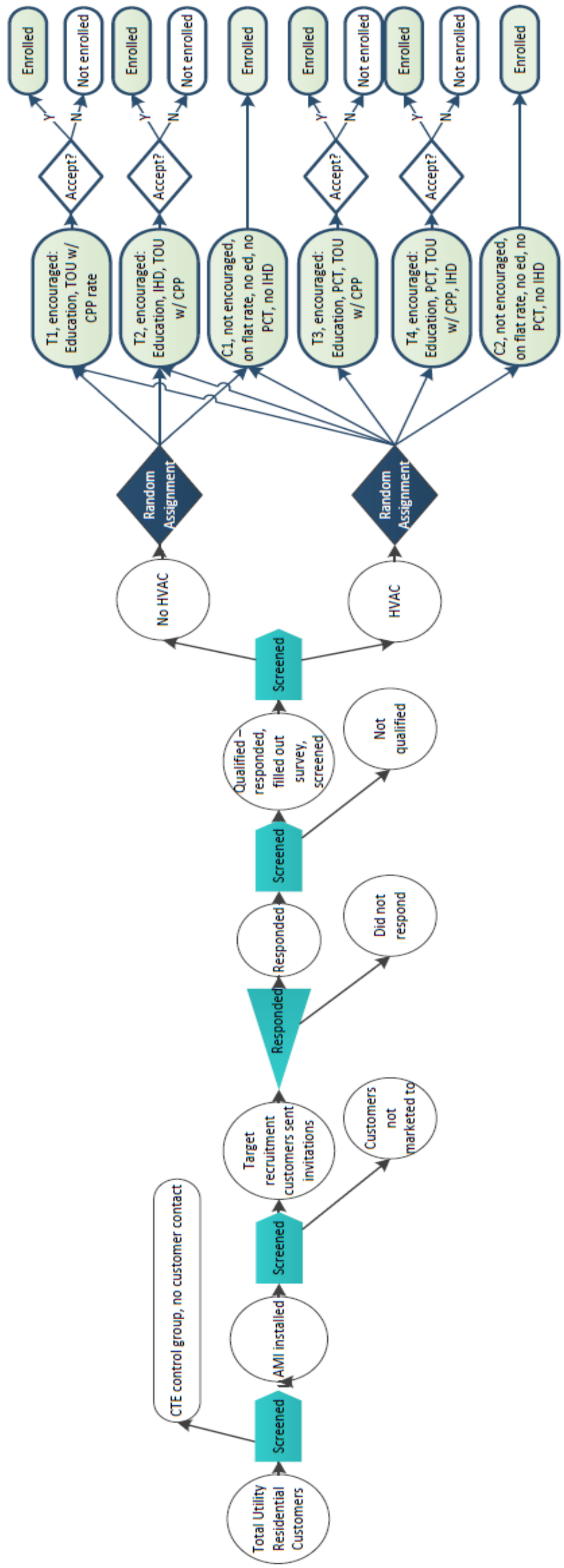


Figure 11: High Level Randomization and Assignment Process

3.b. Implementation

3.b.i. Project schedule

Key Milestones for the DTE pilot program are shown below, reflecting completed recruit/enroll activity and listing remaining deliverables.

Table 7: Key Milestones for the DTE Pilot Program

Date	Milestone
January 24, 2012	First wave of mailings sent out
April 9, 2012	Outbound calling begins
May 7, 2012	Second wave of mailings sent out
June 13, 2012	Reminder Post Card sent out
June 30, 2012	Last day to call to enroll
June 30, 2012	Last day to order from GE
July 27, 2012	Last day for GE PCT installations
August 10, 2012	Last day to bind Nucleus to meter
August 13, 2012	Pilot Observation begins
June 11, 2013	Data cut off for Interim Report
Fall 2013	Interim Report filing
December 31, 2013	Pilot Observation ends
Summer 2014	Final Report filing

3.b.ii. Recruitment and customer retention approach

Recruitment was designed to utilize two waves of invitation mailings and follow-up via reminder post card and outbound calling as necessary. On the advice of DTE's direct mail consultant Dziurman Dzign, the recruiting invitation was a personal letter in a #10 standard DTE envelope. The letter inviting customers to "join us in shaping the future of energy use" was signed by the SmartCurrents Program Manager. A four-color, glossy insert was included, featuring a message from Steve Kurmas, then President and COO, DTE Energy, and showing the energy display and thermostat that qualified candidates might be randomly selected to receive. To create an urgency to act, a deadline to respond was highlighted. Prospects could begin the enrollment qualification process online or by returning the survey registration form in a Business Response (BR) envelope.

When the SmartCurrents Pilot Program recruiting began, there were approximately 449,000 electric AMI meters installed and reading remotely with a 95% or better accuracy. That population was screened to exclude customer profiles described earlier (interruptible air conditioning, net metering, etc.). Based on direct mail estimated response rates, the direct mail consultant selected 149,307 customers to target. A larger mailing was not contemplated out of concern for driving interest that could not be satisfied due to fixed quantities of the enabling technologies.

Recruiting began in late January 2012 and was intended to be complete by the end of May 2012, as shown in the recruitment plan below.

Table 8: Recruitment Plan

Target Date	Planned Recruitment Activity
January 24, 2012	First wave of mailings
February 6, 2012	Second wave of mailings
February 29, 2012	Follow-up Post Card as needed
March 20, 2012	Outbound calling as needed
May 1, 2012	Last day to call to enroll & order from GE
May 30, 2012	Last day to bind Nucleus to meter
June 1, 2012	Pilot Observation begins

The first wave of invitation letters were sent to 100,585 customers mid-January 2012. With a variety of enabling technologies available for study, the qualification survey further screened potential participants for eligibility. They were given the option of completing a qualification and baseline survey online, or beginning the process with a printed BR qualification questionnaire. Respondents who chose the BR response method would subsequently be invited to complete the online baseline survey. Initial BR response was swift and plentiful, leading to the decision to postpone the February mailings out of concern for generating demand that could not be met. The actual rate of BR qualification was extremely low, however, because these customers did not follow through with the online demographic survey, which was a requirement for qualification.

Qualified responses were pooled and held until "critical mass" was achieved with at least 1,200 candidates to randomize and begin to populate the cells. Randomization was performed by Market Strategies International (MSI), which designed and hosted the online qualification site noted above. At such point, they were randomized into treatment (T) and control (C) cells based on presence of central air conditioning and appropriate heating system. Randomization of the T and C cells was an automated process. The end result of every randomization was to have roughly the same number of cases in the T and C cells. For each event, the process was generally as follows:

1. Confirm total number of qualified (T0) cells to be randomized.
2. Based on the total number of cases, determine roughly how many should fall into each of the T and C cells.
3. T1, T2, and C1 groups: Customers reporting they did not have central air (based on qualification baseline survey QMA3: "Does your home have central air conditioning?") could only fall into one of these three cells. These records were assigned to T1, T2, or C1 at random.

4. T1, T2, C1, T3, T4, and C2 groups: The remaining records to be randomized should now all have central air. These records could fall into any T or C cell. Records were assigned to either quota cell at random (where only the difference to get to the amount determined in step 2 was needed for the T1, T2, or C1 groups).

After treatment cells were opened in March 2012, randomization was conducted whenever the "pool" accumulated at least 100 qualified prospects. During the last eight weeks of recruiting, randomization was a weekly activity, as a result of the enrollment push noted below.

Upon randomization, candidates received an email with a link to a customer agreement (T1-T4) and phone number to call to enroll. Customers randomized into control groups received a letter saying "Sorry you weren't selected," and enclosing an Entertainment® Discount Dining Dollars gift card as our way of saying "Thank you for your interest."

Outbound calling began April 9 and ran through May 7. Outbound calls were made to customers who had not responded at all, and customers who had qualified, but had not yet called to enroll, or had not yet completed enrollment. Subsequent review of all participants' effective enrollment dates revealed that this effort yielded 235 enrollments. These customers are included in the final enrollment count.

The second mailing, sent May 7, was modified to eliminate the BR option and provide online qualification only. In addition, it included the offer of an Entertainment® Discount Dining Dollars gift card[5] for those who completed enrollment. A "Last Chance" reminder post card was mailed June 13, emphasizing that the enrollment period was coming to a close, and that June 20th was the last day to qualify to enroll. Over 900 customers enrolled in response to this second mailing and post card reminder. These customers were identified based on mail code (second mailing) and effective enrollment date and are included in the final enrollment count.

Qualified customers who called to begin the enrollment process had their rate changed from Standard Residential Service to DPP, and were then transferred to the GE Order Line to order their devices and arrange for installation of a PCT if necessary. Nucleus, IHD and/or PCT were shipped via UPS and generally arrived within five days. PCTs were installed by GE Factory Service after the appointment was scheduled by the customer. Enrolling customers also received a SmartCurrents Welcome Kit (shown in Appendix E), which included helpful information on their new DPP rate, technology set up tips, etc.

Nucleus software was self-installed by the customer, with the final step being binding to the meter after any required installations were complete. To bind Nucleus to the meter, customers called the DTE Binding Hotline and provided their meter number and Nucleus MAC ID. Binding Hotline staff entered the MAC ID in the meter's HAN table, then established and verified communication. The date and time of binding and communication was tracked for every meter. When binding was completed and

[5] Cards were good for up to $100 in dining discounts (up to 50%) redeemable at over 70,000 restaurants nationwide, allowing customers to choose the restaurants and discounts they wanted.

communication verified, the customer's status was then updated from Pending to Enrolled (Pilot Status = E). Only customers with Enrolled status were included in the statistical study.

The master list of referrals to GE was utilized for enrollment completion tracking. Outbound calls were made to customers who did not call the binding hotline within two to three weeks. For customers without technology (T1), enrollment was complete (Pilot status = E) at rate change and meter configuration from 60 to 15-minute intervals.

The period from June 30 to August 10 was dedicated to assuring that customer devices were shipped and received, PCT installations were scheduled and installed, and meters were bound (enrollment completion). While five weeks may seem overly generous for completing these tasks, the time was well spent; nearly 350 meter binding/enrollment completions were accomplished for the T2-T4 treatment cells.

A detailed flow chart of enrollment activity is shown at the end of Appendix E.

3.b.iii. Recruitment and customer retention numbers

Overall, the recruiting effort yielded a six percent response rate. Seventy percent of respondents qualified, and 20 percent of those qualified completed enrollment. Overall enrollment rate (treatments and controls) based on mailed population was two percent.

Table 9: Recruitment Effort Summary

Wave	Mailed	Responded	Percent	Qualified	Qualified Pct.
1	100,585	5,361	5%	3,602	4%
2	48,722	4,342	9%	3,192	7%
Total	149,307	9,703	6%	6,794	5%

The final enrollment numbers as observation officially began on August 13, 2012, were:

Table 10: Final Enrollment Numbers

Treatment Cell	Control Group	Description
	CE (N=1,212)	Standard Residential Rate
T1 (N=249)	C1 (N= 347)	DPP + Education
T2 (N=390)		DPP + Education + IHD
T3 (N=328)	C2 (N= 356)	DPP + Education + PCT
T4 (N=369)		DPP + Education + IHD + PCT
1,336	**1,915**	**Total enrolled Treatments & Controls**

Final enrollment numbers under study were slightly less than enrollment numbers indicated in the recruitment flowchart in Appendix D. This difference was the result of DTE's Load Research group's enrollment validation review, wherein disqualifying customer characteristics were observed, such as: not receiving AMI meter data; different or inactive customer; addition of an incompatible product such as Interruptible Air Conditioning rate or net metering (solar), etc.

Program withdrawals are summarized in Table 11 below. From observation start through close of the interim report period, June 11, 2013 (Year 1), a total of 60 customers, or approximately 4.5 percent withdrew from the pilot, fairly equally across treatment cells. From June 11, 2013, through program end (Year 2), the withdrawal rate decreased slightly and 49 additional customers withdrew, for a total program withdrawal of 109 customers representing approximately 8 percent of initial enrollment. Year 2 withdrawals were again fairly equal across treatment cells.

Table 11: Summary of Program Withdrawals

Treatment	Year 1	Year 2	Total
T1	17	13	30
T2	16	16	32
T3	13	12	25
T4	14	8	22
Total	60	49	109

Customers were permitted to withdraw from the pilot by calling the contact center to request a withdrawal for any reason, or when prescribed account activities occurred that violated program participation rules. For example, in Year 1 four participants called to advise they thought the DPP rate was too high; another five withdrew for the same reason in Year 2, for a total of 9 rate-related withdrawals. Overall, 62 system-generated withdrawals were processed as a result of service disconnects, force-outs (new buyer calls to start service before current customer calls to end it), addition of an incompatible product such as Interruptible Air Conditioning, etc. Withdrawal reasons are itemized in Table 12. In summary, for the overall program, withdrawals were driven more by forces beyond program control than by customers actively opting out for other reasons. When considering elective withdrawals only, less than 3 percent deliberately chose to exit the two-year program.

Table 12: Withdrawal Reasons

Withdraw Reason	Year 1	Year 2	Total
System generated: Disconnects, etc.	29	33	62
DPP rate to high	4	5	9
Equipment problems	9	1	10
Inconvenient to shift use	1	0	1
Moving	9	1	10
Not seeing the Benefit	7	5	12
Program too confusing or complicated	1	4	5
Grand Total	60	49	109

3.b.iv. Survey approach

Baseline Demographics

Market Strategies International (MSI) conducted the qualification and baseline demographic survey requirements. Both surveys were conducted together during the recruiting and enrollment process to ensure 100 percent completion of the baseline survey to comply with DOE requirements.

Because qualification to continue the enrollment process required completion of the baseline survey, this data was available for not only 100 percent of the enrolled pilot population, but also for those C1 and C2 control groups and qualified customers who did not complete the enrollment process, regardless of reason.

Baseline demographic information was exported to the Load Research group and E2RG for use in the analytics, notably the definition of cohort groups.

Customer focus group discussions

To capture the "Voice of the Customer," DTE engaged Consumer Insights (CI) to conduct a series of focus group studies among program participants in October 2012 and a year later in September 2013. The October 2012 sessions were to assess the initial stages of the program. This qualitative study answered issues surrounding six key questions:

- What were participants' motivations for joining the pilot program?
- How well did DTE and GE execute the initial installation and "launch" phase of the study from a customer perspective?
- What behavioral changes had occurred among participants because of DPP?
- Had the equipment and other tools provided to participants impacted behavior and consumption patterns?
- How did participants feel about the level of customer support they have received to date from DTE and GE?
- If DTE expanded DPP, how could it improve the process for future participants?

Methodology and Sample

This study consisted of focus group discussions with approximately 7 percent of the pilot program population. Discussions were 90 to 120 minutes in duration, and were conducted at Consumer Insights' Troy, Michigan, facility between October 23 and 30, 2012.

Pilot program customers were initially invited to participate in discussions by email, with follow-up phone calls for cells with smaller potential respondent pools or low initial response rates. In general, cooperation rates were very high. Respondents were paid $100 for their participation.[6]

[6] It is important to note that while DTE paid enrolled customers for their participation in Focus Groups and web surveys (excluding the baseline demographic survey required for qualification), no payment expectation was set during the recruit and enroll process. Both the invitation and the enrollment phone call specified a periodic survey requirement, without reference to payment. Survey compensation was later added in order to help maintain study participation levels with minimal attrition.

Groups were segregated based on the level of equipment provided during the pilot. Two groups were conducted among each of the "cells" as defined by equipment:

T1: DPP and education
T2: DPP, IHD, and education
T3: DPP, PCT, and education
T4: DPP, IHD, PCT, and education

Findings

Most participants reported favorable interactions with both DTE and GE. Customers learned to use the tools provided to shift a significant portion of their energy consumption into non-peak periods. In fact, on a self-reported basis, respondents estimated their energy savings to be at 10-20% per month. Learning curves were short and steep, and optimal behaviors were being sustained; virtually all respondents indicated they would continue in the program if DTE extended it beyond the two-year pilot because DPP provided them a way to actively manage electrical consumption and costs.

As of fall 2012, the most optimal equipment combination for driving concerted customer efforts to avoid peak and near peak electrical consumption appeared to be T4 because T4 provided the monitoring tools but left it up to the homeowner to figure out the best ways to shift consumption[7]. At the same time, the T1 customers who had been provided with nothing other than an education of the new rate structure indicated they were accomplishing 75-85% of the energy savings of the more technologically endowed counterparts based on behavior changes and manual shifting of appliance operating times.

In September 2013, focus group sessions were conducted to again assess on-going pilot experiences, understand participant behavior on event and non-event days, and also to plant the seed that the pilot program's two year term was coming to an end.

Methodology and Sample

This study consisted of focus group discussions with 90 pilot program participants. Discussions were two hours in duration, and were conducted at Consumer Insights' Troy, Michigan, facility between September 18 and 26, 2013.

Pilot program customers were initially invited to participate in discussions by email, with follow-up phone calls for cells with smaller potential respondent pools or low initial response rates. In general, cooperation rates were very high. Respondents were paid $100 for their participation.

Groups were segregated based on the level of equipment provided during the pilot. Two groups were conducted among each of the "cells" as defined by equipment:

T1: DPP and education
T2: DPP, IHD, and education

[7] Treatment group T4 includes a PCT, which can be set by the customer and thus DTE has no direct load control capabilities.

T3: DPP, PCT, and education

T4: DPP, IHD, PCT, and education

Findings

As the pilot program neared conclusion, DPP participants were still enthusiastic about most aspects of the program and optimistic about its positive impact:

- Virtually all participants who attended the groups expressed a solid interest in extending their DPP rate structure beyond the formal conclusion of the pilot. Their general sentiment was that they were saving some money (although few had actually undertaken a meaningful cost analysis), and that the shifts they had made in terms of behavior and household equipment had been relatively easy to make and sustain over time.
- Even most customers who did not feel they were saving money were likely to continue because they liked the greater sense of control and attribution they had under DPP. Even those who had not optimized their energy consumption under DPP recognized that the program allowed them to make decisions that could reduce their total bill.
- Attribution: simply making the connection between their consumption on a near real time basis and their bill at the end of the month provided a level of clarity and connectivity that is not present in a flat-rate, non-monitored household.

Surprisingly, most pilot participants had not performed a true cost analysis of their bill or consumption under DPP:

- Less than 1 in 10 respondents had done a "flat rate versus DPP" month-to-month analysis of their bill since the start of the pilot; in fact, most seemed almost surprised by the question when posed. Instead, the most common way of "assessing" the impact of the program was to compare year-over-year cost (not kWh) on the monthly bill without regard for the significant differences in both winter and summer weather patterns over the past two calendar years.
- At least half of the respondents had done no systematic or even casual cost or consumption analysis to decide whether they saved money under DPP—even though cost was by far the most common reason for trying DPP in the first place. For these folks, the savings were assumed based on their behavior changes—i.e., I shifted my electrical consumption to off-peak, so I must be saving money over a flat rate.

Regardless of their analytical approach, if respondents had some sense for their savings under DPP they typically guessed somewhere between 10% and 15% off flat rate cost (and most were satisfied with that level of cost reduction). At least for the focus group respondents, CPP events did not appear to inflict enough "pain" to offset the perceived gains they realized under DPP.

- During the 2013 calendar year, customers experienced 11 CPP events, including at least six within the four weeks prior to the discussions. When asked to estimate the number of events this year, most respondents under-estimated slightly, suggesting that frustration over CPP events lessens quickly once the event has passed.

- After taking extra steps to reduce consumption, some respondents rode out the events with little concern; others found the events frustrating when they occurred but were dismissive of their impact soon after they were over. There were only a handful of respondents who saw CPP events as a reason to drop out of the program at the conclusion of the pilot—a few said other family members were unhappy with what they saw as the "unfairness" of paying a higher rate when flat rate customers were not; the remaining believed that the CPP events had mitigated so much of their savings that their time-shifting efforts were no longer resulting in any overall savings.
- Very consistently, respondents believed that most of their efforts to control and reduce major electric consumption during peak hours every day ended up reducing the extra efforts they took during a CPP event—for most, CPPs just encouraged extra vigilance rather than a radically different approach to power usage during those four hours. Even so, it is important to remember that focus group respondents had all stayed on the program to date (of Focus Groups)—a better predictor of CPP impact would be an examination of program attrition after heavy concentrations of CPPs.

An analysis of attrited pilot households suggests that—at least among early adopters—attrition due to CPPs would be about 1-2% per year.

- As of October 1, 2013 there were 122 pilot households who had left the pilot early—translating into an 8% attrition rate. (Note, this number included those enrolled customers who were later removed from statistical analysis due to disqualifying account characteristics.)
- DTE records showed that 42% of those who left indicated it was because they "were not seeing the financial benefit of DPP" or because they perceived that "DPP rate is too high"—both factors that could be attributed to negative attitudes or reactions to CPP events.
- 40% of those who left for those two reasons (or about 17% of all attriters) also left within 30 days of a CPP event—which one could argue could be reflective of frustration over living with CPPs or a reaction to a bill that includes at least one CPP.
- So with an attrition rate of 8% and a probable attribution of that attrition to CPPs of 17%, we can estimate that approximately 1.4% of DPP households (8% x 17% = 1.4%) would leave as result of the frustration or financial impact of CPP events.
- This more formal analysis suggests that the frustration levels seen among focus group respondents were probably very representative of the frustration levels across the entire pilot household population.

The loss of technological aids at the end of the pilot, while a significant dissatisfier, did not appear to reduce customers' willingness to remain on a DPP rate moving forward.

- For the most part, customers in cells with installed GE equipment and software appreciated the insights gained from both as well as the equipment's ability to automatically adjust or warn the customer to delay when rates are high. The prospect of losing the functionality of this equipment was very disconcerting for recipients because they felt its absence would have left them feeling "blind" at the beginning of the pilot and its absence now would force them to start making some manual decisions that were often provided automatically to them—in essence, they would need to think more about DPP without the equipment.

- Even so, respondents also recognized that they had already accomplished the bulk of their savings based on time shifts and general efficiency improvement measures—essentially, their learning curve had already flattened. As a result, eliminating the monitoring equipment and communications capabilities of the appliances detracted very few from continuing on with DPP after the pilot because they believed even without the helping hand of these devices, their behavior had already permanently switched in a way that optimized savings under the program.

CPP event behavior typically varied only slightly from normal peak time behavior—respondents generally felt they had already shifted their biggest energy consumption sources away from that time of day already.

- This consensus matched consumption patterns tracked by DTE Load Research, which shows consumption reductions during CPPs dropped only slightly from pilot participant behavior during normal peak hours.
- When shown these patterns during the focus group discussion, respondents weren't surprised because most felt they only made minor additional changes during CPP days. For example, at least two respondents had an alarm set on their phones to go off at 3:00 p.m. every day as a reminder that anything electrical costs them more to use at that point. Some had also concluded that a CPP impact on their total bill was not as dramatic as they once thought, leading them to limit their "suffering" in terms of AC usage even during CPP days.

Additional Steps on CPP Days

- Pre-cool the house during the morning hours two to three degrees cooler than usual, then "coast" through the CPP with AC off or thermostat set above 80 degrees.
- Close window coverings, especially south and west.
- No charging or plug-in for any rechargeable devices.
- No TV usage, no cooking, no lights.
- Live in the cooler basement for a few hours.
- Cook dinner before 3 and reheat or eat hot meal for lunch and cold meal for dinner.
- BBQ for dinner or go out for dinner.
- Time errands to be out of the house for most of the CPP.

In-Home Display

- According to the focus groups, IHD continued to be the single most motivating piece of equipment included in the pilot, principally because it was always on and provided a visual reminder of usage 24/7 to the household.
- Respondents were keyed into the "current status" page: They knew what their "normal" electric consumption looked like. Some had even successfully lowered their "baseline" consumption. When they saw spikes occur, they could recognize what equipment was causing

the change…and if they couldn't, they "sleuthed" around the house until they could. Color coding provided an "at a glance" reminder of the rate in effect at any given time. Some respondents described the IHD as a "bio-feedback" device for the household that helped them learn and establish more cost-effective and energy efficient behaviors.

- If the IHD was working and maintaining its connection to the Nucleus, at least 3 out of 4 respondents still had it plugged in and positioned in a prominent place—usually the kitchen counter. Consistent connectivity is obviously critical—households with repeated Nucleus connection problems tended to discontinue use of the IHD after about 3 reboot attempts.

Nucleus Computer Software

- Nucleus software usage frequency declined dramatically since the start of the pilot. In the beginning, respondents (particularly those without an IHD) used the software to check their progress, but later in the program (fall 2013), the graphs were accessed infrequently—less than once a month.
- Because of their steep learning curve at the beginning of the pilot, respondents were less likely to check their consumption patterns unless they added new equipment or made additional changes to their established routines. Several upgrade problems and connectivity problems requiring a re-install of the software had either rendered the software unusable or less helpful due to a loss of historical usage data for some respondents.

Programmable Thermostat

- Given the initial highly negative reactions to the GE PCT, discussions were limited on the device in the fall 2013 discussions.
- A few more participants had figured out how to program the device directly, but the consensus was that even over time, the thermostat was overly complex and unintuitive. Most respondents still relied almost exclusively on the much more intuitive computer software to make adjustments to the thermostat.
- Very few respondents had maintained the default programming of the thermostat—equal numbers had either re-programmed it to a less efficient cycle or a more efficient cycle, depending on their established tendencies before the pilot began.
- Even before groups discussed the elimination of the device's connectivity to the Nucleus after the pilot concludes, the majority of respondents anticipated replacing the thermostat with a friendlier thermostat at the conclusion of the pilot anyway.

As the pilot wound down, there were multiple indications that the program had been a success and that DPP was a highly viable rate structure moving forward.

- The short, steep initial learning curves had been sustained and incremental improvements continued to be made, in many cases regardless of the level of additional monitoring equipment and smart appliances added to the household.

- CPP events, while frustrating in the short term, did not present a significant barrier to adoption and sustained membership in a DPP rate structure because engaged DPP customers made so many changes on regular days that CPP days did not require dramatic alterations to behavior. In fact, virtually all group respondents indicated they would still like to stay on DPP if DTE extended it beyond the pilot since DPP provided them a way to actively manage their electrical consumption and costs.
- Across all equipment and smart appliances provided to the different pilot cells, the most valuable function by far was the ability to monitor household electrical usage in real time via an in-home display, computer software or app—the other devices helped, but most of the benefits they provided could be replicated easily in other ways once a customer successfully attributed consumption to behavior and equipment.
- Education still was key, and low cost mechanisms such as the eNewsletter could effectively keep DPP customers on track to maintain cost-saving, energy-shifting behaviors.

Interim SmartCurrents experiential surveys

As discussed earlier, CI conducted a series of focus group studies among program participants in October 2012 to assess the initial stages of the program. CI then used the information gathered from those groups to guide the research questions for the interim web-based surveys:

- What were participants' motivations for joining the pilot program?
- What behavioral changes had occurred among participants because of DPP?
- Had the equipment and other tools provided to participants impacted behavior and consumption patterns?
- How well had the various pieces of hardware provided to participants (e.g., displays, appliances) performed?
- Had DTE effectively communicated relevant program and billing information?

Methodology and sample

Over the term of the pilot the SmartCurrents Participant Web Survey was administered biannually, approximately every six months. Survey methodology and questions were the same for comparability over time. Email invitations to participate in an online survey were sent to all customers enrolled in the program at each survey time. The surveys took approximately 18 minutes to complete. Respondents were paid $25 for their participation. Table 13 below shows overall participation rates for each of the three surveys

Table 13: Web Survey Participation Rates by Date

Survey 1	Dates	Participation
1	12/6-20/2012	59%
2	7/9-23/2013	65%
3	12/9-19/2013	63%

All conclusions are drawn from differences observed in the data that are statistically significant at the 95% confidence level. Respondents were recruited from each of the levels of treatment participation.

Table 14: Web Survey Participation by Group

Treatment	Description	12/2012	07/2013	12/2013
T1	DPP & education	113	124	113
T2	DPP, IHD & education	235	269	235
T3	DPP, PCT & education	121	230	221
T4	DPP, IHD, PCT and education	240	268	248
S1	T4 + Smart Kitchen	13	14	17
S2	T4 + Smart Laundry	18	15	18
S3	T4 + Smart Kitchen & Laundry	7	9	8

Findings

As of Survey 1, nearly every respondent had made at least one energy-saving behavioral change since joining the program. In general, higher level respondents made slightly more changes than lower level respondents (although a small sample of S-level (Informational study appliance recipients) respondents prohibited statistical significance in most cases). Many T1 respondents made significant changes to their behavior, indicating that education plus potential cost savings alone may produce at least some increase in energy conservation behaviors.

There were large gains for nearly every energy-saving behavior assessed between December 2012 and December 2013. Within treatment levels, all of the T levels saw significant increases in self-reported energy-saving actions over the year, although the S1-S3 levels retained the highest overall level of action in nearly every category, as shown in Figure 12.

Behavior Changes Since Joining SmartCurrents

Green/Red = sig. higher/lower than respective T1
* = sig. higher/lower than respective T2-T4

	Total			T1			T2-T4			S1-S3		
	12/12 (n=838)	7/13 (n=929)	12/13 (n=860)	12/12 (n=113)	7/13 (n=124)	12/13 (n=113)	12/12 (n=687)	7/13 (n=767)	12/13 (n=704)	12/12 (n=38)	7/13 (n=38)	12/13 (n=43)
Minimize all electricity usage 3pm-7pm	68%	75%↑	78%↑	66%	78%↑	80%↑	67%	74%↑	78%↑	82%	76%	81%
Run washer/dryer on the weekends, avoiding weekdays	53%	55%	60%↑	44%	45%	55%	55%	57%	60%	61%	61%	74%
Run dishwasher 11pm-7am	41%	48%↑	50%↑	33%	37%	50%↑	41%	49%↑	50%↑	58%*	71%*	65%
Set thermostat to raise AC temp 3pm-7pm	40%	50%↑	52%↑	26%	40%↑	44%↑	43%	51%↑	54%↑	42%	66%↑	49%
Better control of "vampire" sources of electric consumption	33%	37%↑	47%↑	29%	37%	48%↑	34%	38%	47%↑	26%	34%	42%
Run dishwasher 7am-3pm OR 7pm-11pm	31%	31%	33%	30%	35%	33%	31%	31%	32%	26%	26%	40%
Switched to CFL/LED bulbs (since joining the program)	31%	40%↑	50%↑	33%	44%↑	51%↑	30%	39%↑	49%↑	32%	50%	58%↑
Run washer/dryer 7am-3pm OR 7pm-11pm	30%	34%	36%↑	28%	35%	36%	29%	32%	35%↑	42%	53%*	44%
Set thermostat to lower AC temp before 3pm to "pre-cool"	21%	27%↑	34%↑	16%	23%	27%↑	22%	27%↑	35%↑	24%	32%	30%
Run washer/dryer 11pm-7am	16%	18%	18%	12%	15%	14%	16%	18%	19%	18%	24%	23%
None	5%	3%↓	2%↓	9%	5%	2%↓	5%	2%↓	2%↓	0%	0%	0%

SmartCurrents Web Study Report

Q14. Since joining SmartCurrents, have you changed any of your behavior when it comes to the electricity consumption in your household?

↑↓ = sig. higher / lower than within group 12/12

Chart 12

Figure 12: Participant-Reported Behavior Changes

Survey 3 respondents were more likely to claim major changes over a prolonged period, which may indicate that the program had a bit of a "feeling out" period before some customers would commit to meaningful household changes. Significantly fewer respondents stated that they had made very few changes, indicating that involvement has continued to increase.

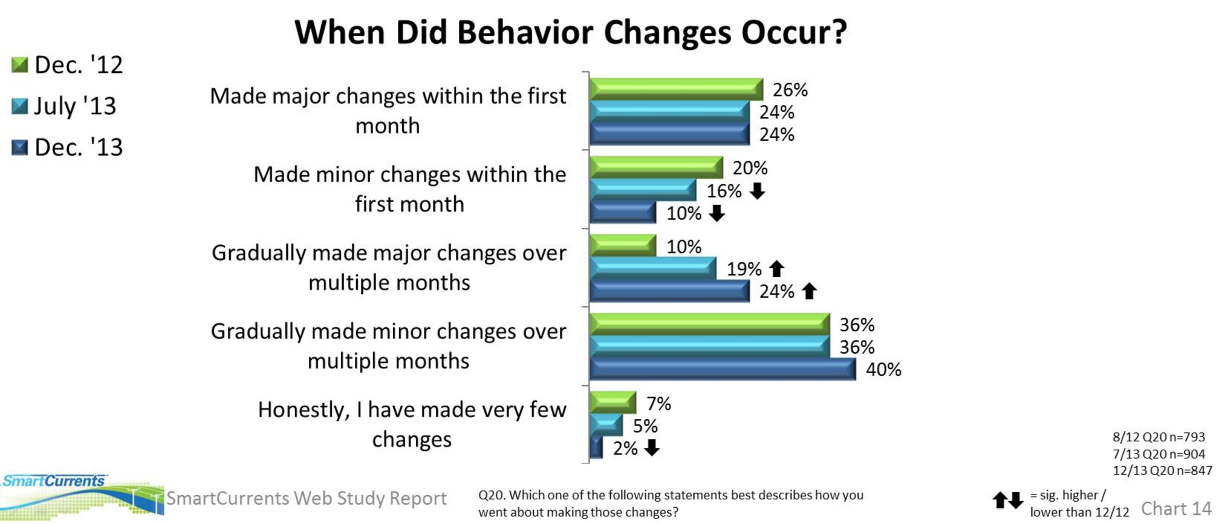
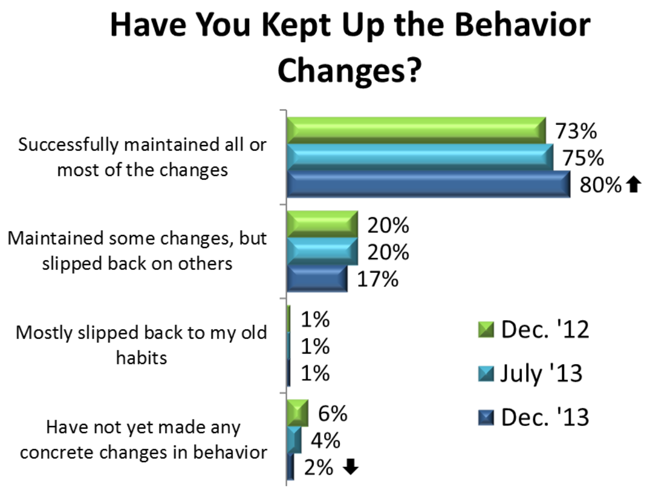


Figure 13: Timing of Behavior Changes

An increasingly vast majority of respondents claimed to have kept up with most or all of their energy-saving household changes. Treatment level had little impact on behavior maintenance, with even the majority of T1 respondents maintaining most of their changes.



December 2013 X Treatment Level

T1 n=113	T2 n=235	T3 n=221	T4 n=248	S1-S3 n=43
77%	84%	78%	79%	86%
21%	14%	19%	17%	14%
0%	2%	0%	2%	0%
2%	1%	3%	2%	0%

= sig. higher/lower than T1

SmartCurrents Web Study Report

Q21. As of today, which of the following best describes your behavior regarding SmartCurrents?

⬆⬇ = sig. higher / lower than 12/12

Chart 15

Figure 14: Behavior Change Sustainability

Program experiences

The primary reason survey respondents joined SmartCurrents was the opportunity to save money on their energy bills. Although some “lip-service” was paid to environmental benefits, when pushed to select the single most important reason for joining, financial benefit was by far the strongest reason.

From Survey 1, most survey respondents had used the Nucleus PC software tools, and found them to be useful. While there was an across the board drop in Survey 2, evaluations of those tools stabilized for the final survey. Much of the July drop was attributed to Nucleus performance during event 3, June 24, 2013, when the GE server failed to send the signals to end the event (PCT temperature offset) and reflect the evening mid-peak price. As noted elsewhere, the price signal and PCT offset were not corrected until mid-morning on June 25.

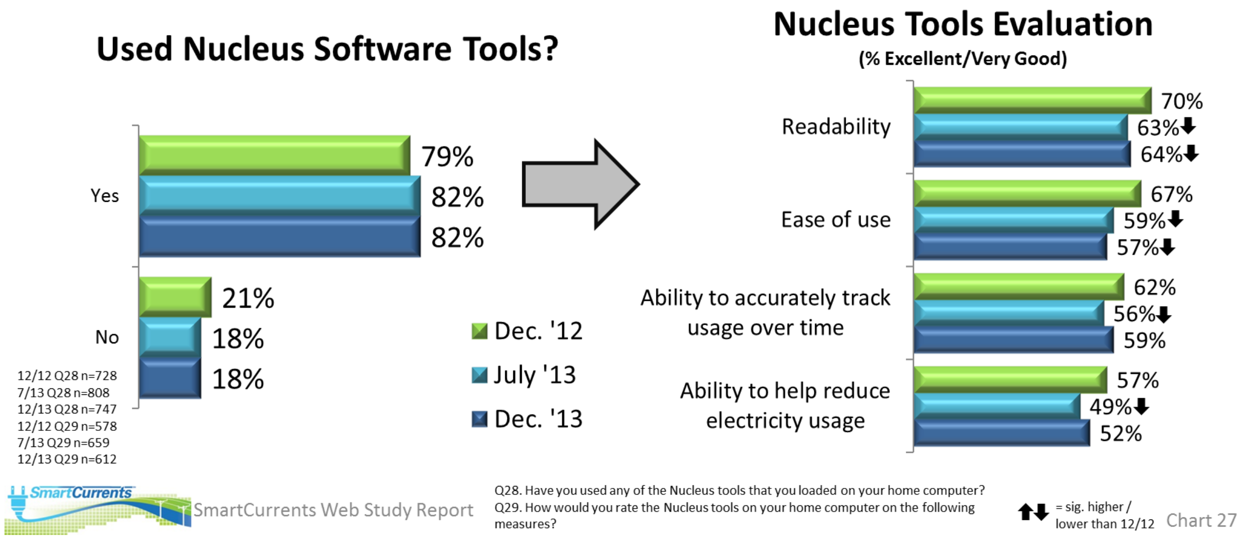


Figure 15: Participant-Reported Nucleus Software Use

Initially, only about a third of survey respondents used the SmartCurrents web tools. This was not surprising, given that web tools were the primary tools provided for T1 participants. T2-4, on the other hand had their choice of near-real time Nucleus or the web tools that provided information through the previous day. Further, in order to access the web tools, customers had to login to their dteenergy.com accounts, navigate to the energy use charts link and then select and change chart views as desired. Accessing Nucleus tools generally did not require as many clicks.

At Survey 3, overall use of the SmartCurrents web tools saw a 10% jump over the previous survey just six months prior. However, overall reactions to the tools remained lukewarm.

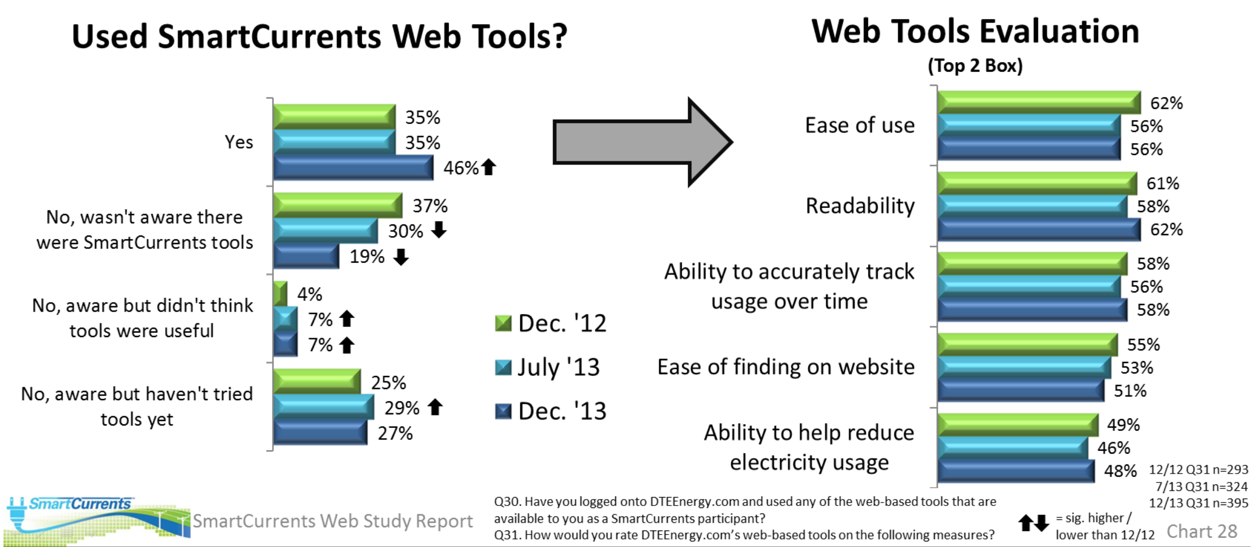


Figure 15: Participant-Reported SmartCurrents Web Tool Use

Hardware experiences

Initially, over two-thirds of respondents experienced at least temporary connectivity issues with their home Nucleus, and a quarter had difficulties with their in-home display.

Connectivity problems with SmartCurrents hardware rose sharply in Survey 2 and continued to be pervasive until pilot end, with three-quarters of respondents having experienced at least one connection failure. However, an increase in the proportion of customers experiencing problems connecting their nuclei to appliances pointed to a possible connectivity issue or troubleshooting fatigue among customers.

Although nearly all participants attempted to fix these problems, not all were successful, indicating a potentially serious problem for mass adoption of the technology.

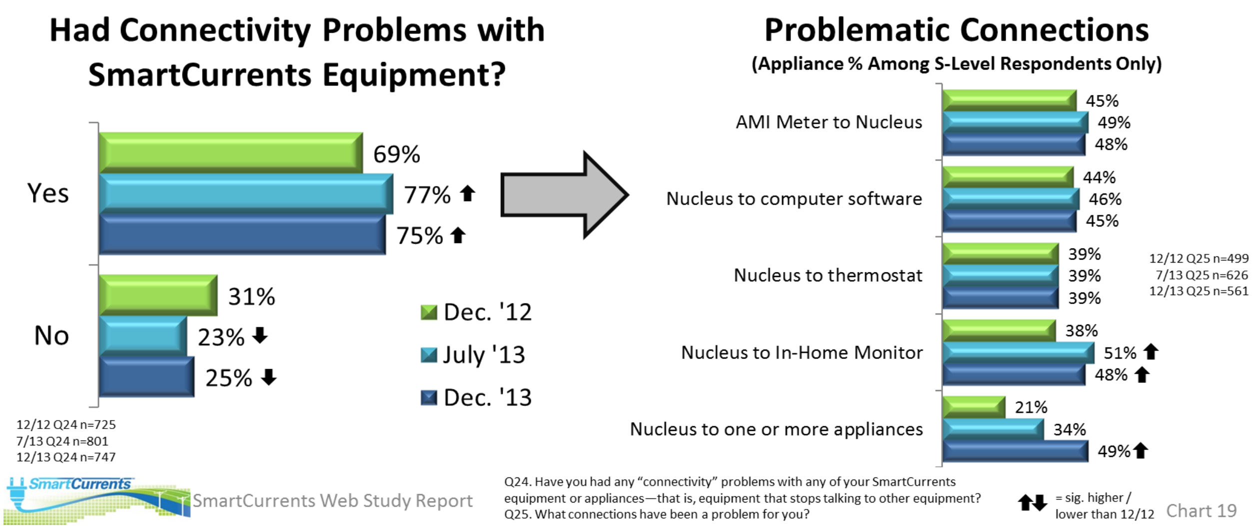


Figure 17: Participant-Reported Connectivity Problems

Initial survey findings indicated that if respondents continued to encounter difficulties with the program hardware, they would be more likely to abandon using that hardware and subsequently would be unable to benefit from information it offered. The survey respondents mentioned that including clear instructions on how to address common Nucleus/hardware issues in the program welcome package could be helpful. In direct response to this commentary, "Tech Tips" were incorporated in program communications shortly thereafter.

Although most respondents attempted to contact either DTE or GE when they encountered a connectivity problem throughout the term of the pilot, resolution rates for problems connecting nuclei to thermostats, in-home monitors, and computer software continued to drop over the year. This connectivity issue likely reflected the continued need to maintain the binding hotline for the pilot duration, periodic price signal inconsistencies, etc.

Connectivity Problem Resolutions
(Among Those with At Least One Problem)

	Attempted to Fix Problem			Contacted DTE/GE			Problem Fixed		
	12/12	7/13	12/13	12/12	7/13	12/13	12/12	7/13	12/13
AMI Meter to Nucleus	91%	88%	96%	75%	76%	77%	76%	73%	70%
Nucleus to thermostat	97%	93%	95%	68%	64%	67%	83%	74%↓	70%↓
Nucleus to In-Home Monitor	92%	94%	94%	53%	68%↑	63%	73%	64%↓	63%↓
Nucleus to computer software	97%	94%	96%	60%	69%↑	64%	75%	72%	66%↓
Nucleus to washer	67%	64%	89%	33%	27%	33%	33%	27%	44%
Nucleus to dryer	67%	70%	89%	33%	30%	33%	33%	30%	44%
Nucleus to refrigerator	83%	69%	90%	50%	31%	50%	83%	31%	40%
Nucleus to dishwasher	86%	63%	92%	57%	38%	54%	71%	31%	38%

SmartCurrents Web Study Report — Q26. All of the connectivity problems you noted are shown in the table below. Tell us a little more about each issue by answering the three questions to the right. ↑↓ = sig. higher / lower than 12/12 — Chart 20

Figure 18: Participant-Reported Connectivity Problem Resolution

When given an open forum in the final survey to comment on the program, respondents were more likely to have positive commentary about the program and less likely to take issue with technological problems than during the summer 2013 survey.

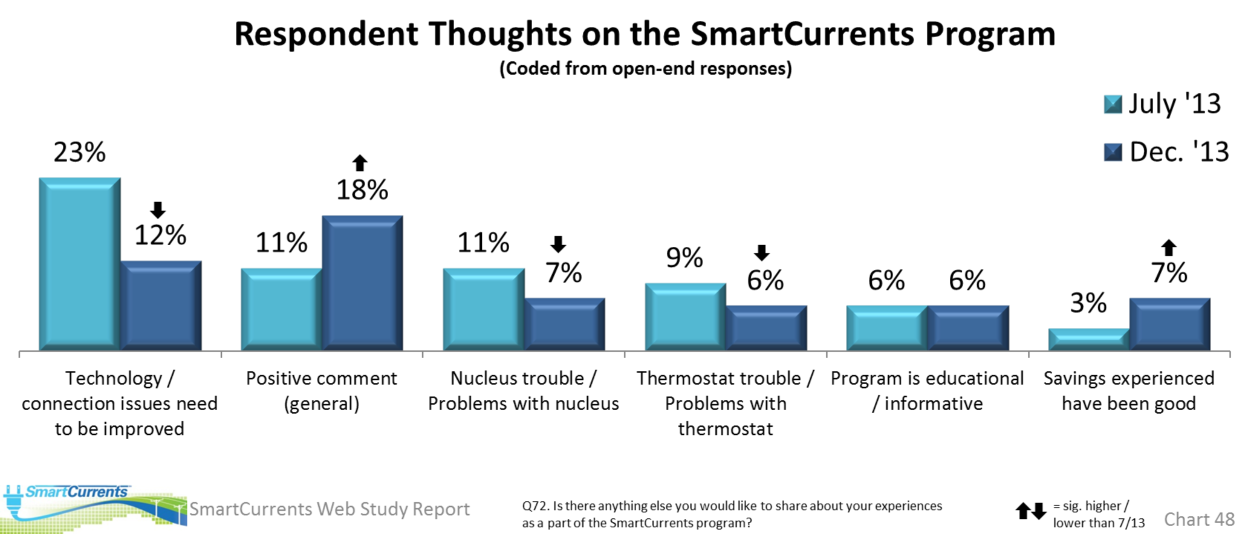
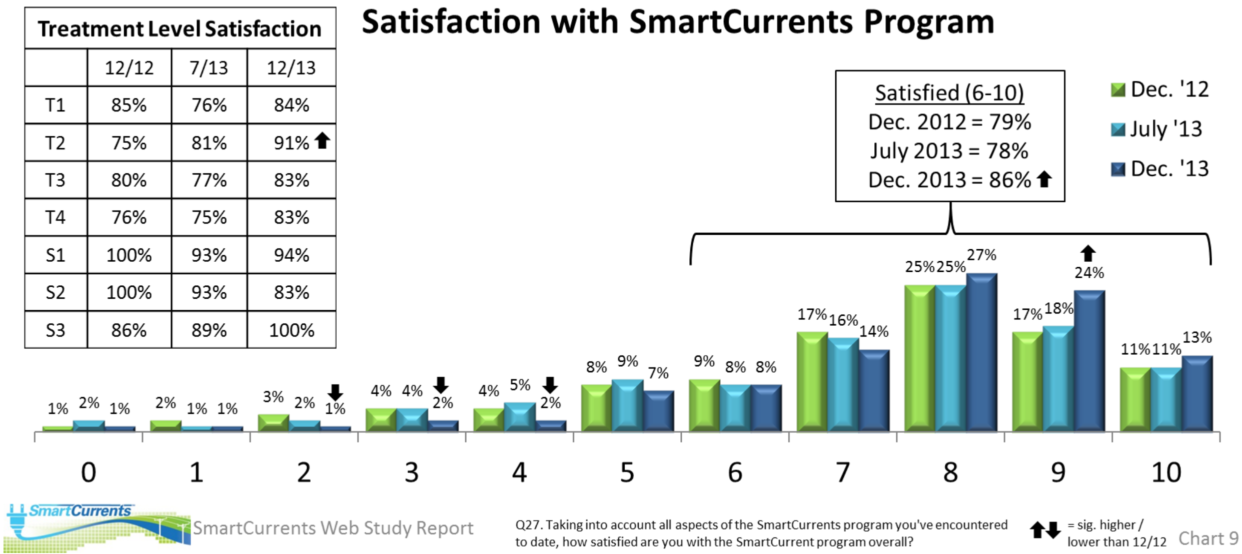


Figure 19: Program comments

Satisfaction with the SmartCurrents program rose over the course of the pilot, after a one point dip mid-way. DTE hypothesizes that the July 2013 satisfaction metric may have been impacted by the June 24 "stuck" event in combination with the three consecutive event days, July 15-17, that occurred during the second week the survey was in the field. Over half of the survey responses were logged during that second week.

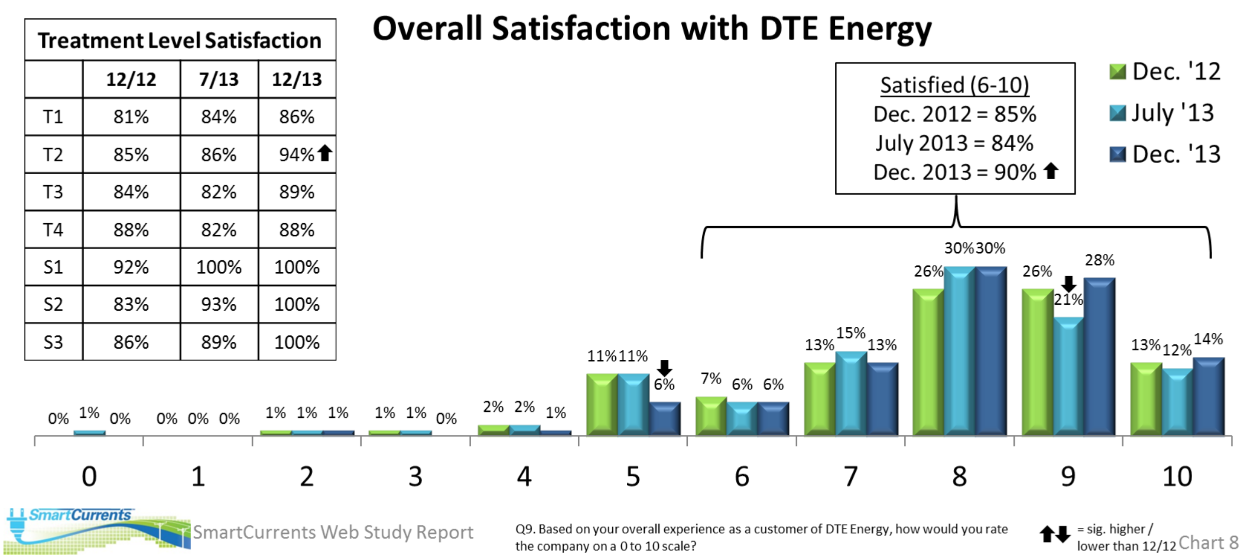


Treatment Level Satisfaction

	12/12	7/13	12/13
T1	85%	76%	84%
T2	75%	81%	91% ↑
T3	80%	77%	83%
T4	76%	75%	83%
S1	100%	93%	94%
S2	100%	93%	83%
S3	86%	89%	100%

Figure 20: Program Satisfaction

Overall satisfaction with DTE reflected a similar pattern over time, exhibiting the same one point dip in the July survey. It is interesting to note that satisfaction with both the program and DTE was driven at pilot-end by the T2 group.



Treatment Level Satisfaction

	12/12	7/13	12/13
T1	81%	84%	86%
T2	85%	86%	94% ↑
T3	84%	82%	89%
T4	88%	82%	88%
S1	92%	100%	100%
S2	83%	93%	100%
S3	86%	89%	100%

Figure 21: Overall Satisfaction with DTE

Finally, over the course of the pilot, SmartCurrents participants began to better appreciate the multiple benefits of the program from DTE's perspective.

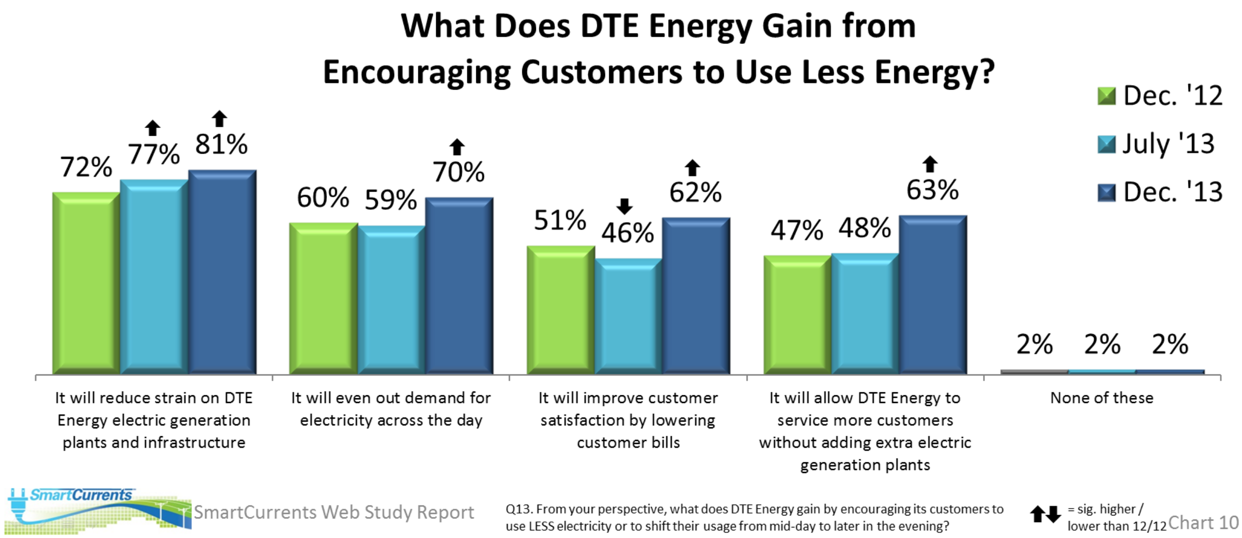


Figure 22: Perceived Program Benefits for DTE

Selected survey question responses by treatment cell are shown in Appendix A. Survey Instruments.

SmartCurrents CPP Event Surveys

Awareness and reactions to CPP events were measured in three waves over the length of the pilot program. The first two waves of CPP event awareness assessment were conducted in December 2012, and July 2013, as part of the initial and Interim SmartCurrents experiential web surveys. The December assessment is referenced as a baseline for the July and August surveys. Findings and conclusions noted here are from the vantage point of the third CPP assessment in August, looking back.

Methodology and Sample

- Email invitations to participate in the short online surveys were sent out to all customers enrolled in the program. The surveys took approximately 3 minutes to complete, and were fielded between July 9 and July 22 and between August 23 and August 26, 2013. Respondents were paid $15 for their participation in the August CPP-specific survey.
- All conclusions were drawn from differences observed in the data that are statistically significant at the 95% confidence level.
- Respondents were recruited from each of the seven levels of program participation.

Findings

CPP event awareness in December 2012 was understandably low, given the single flawed event in August 2012 and the time elapsed since that event. Subsequently, event awareness and recall increased, in part due to notification system testing in the spring as well as increased communications about events and DPP event savings strategies. By the third survey, nearly nine out of every ten respondents were fully aware of critical peak events and associated rate increase.

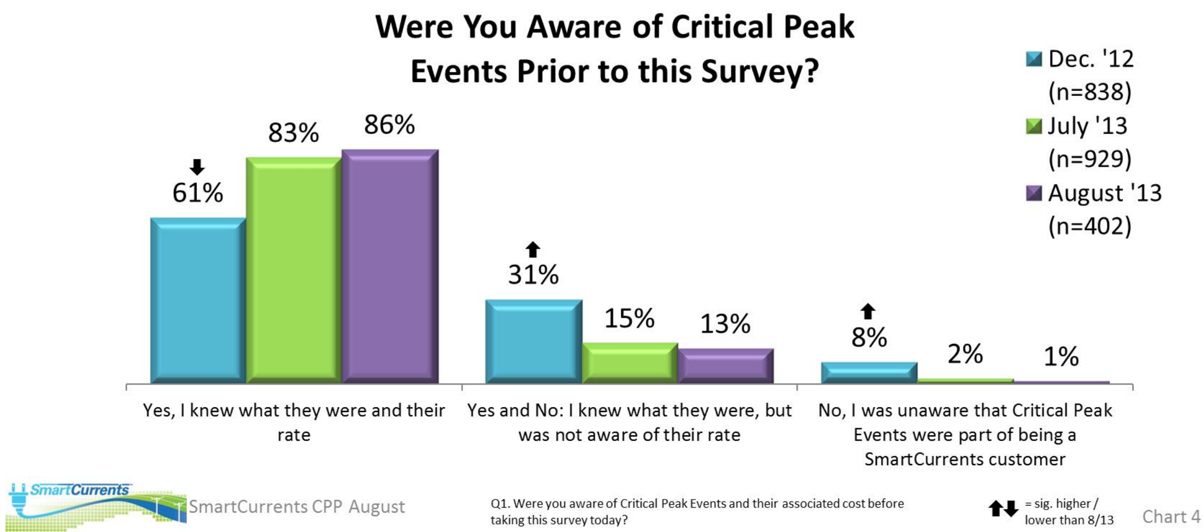


Figure 23: Overall Awareness of CPP events

July and August event awareness was very high, perhaps highly influenced by timing: The July survey was still in the field at the time of the back to back to back events July 15 to 17. The August survey fielded shortly after the back to back events of August 20-21. Participant recollection of how DTE alerted them was consistent with the notification preferences they indicated in the survey, with the majority of respondents preferring to receive critical peak notifications via email.

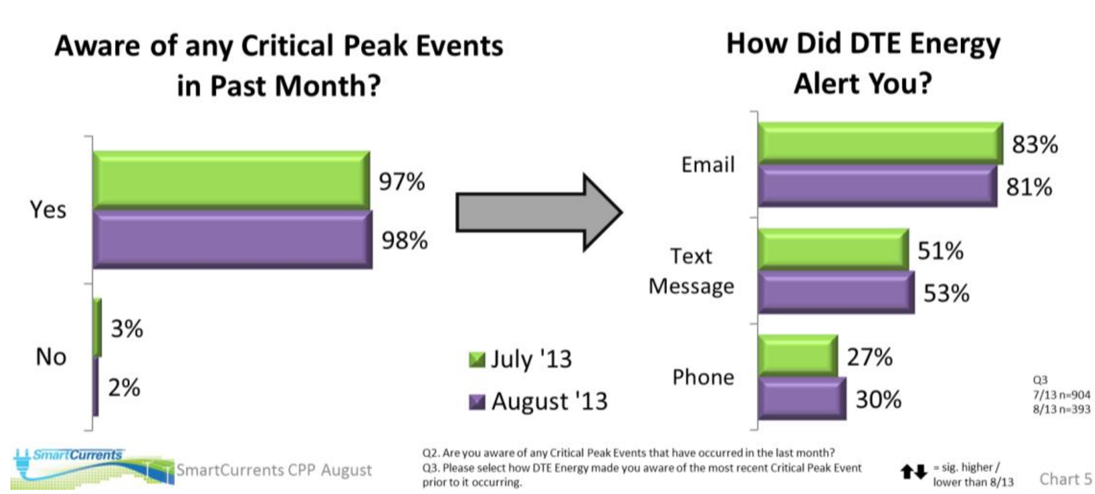


Figure 24: Awareness of Critical Peak events within the Last Month

Finally, with awareness and understanding of CPP events firmly established by summer 2013, only minimal behavior shifts occurred between July and August surveys.

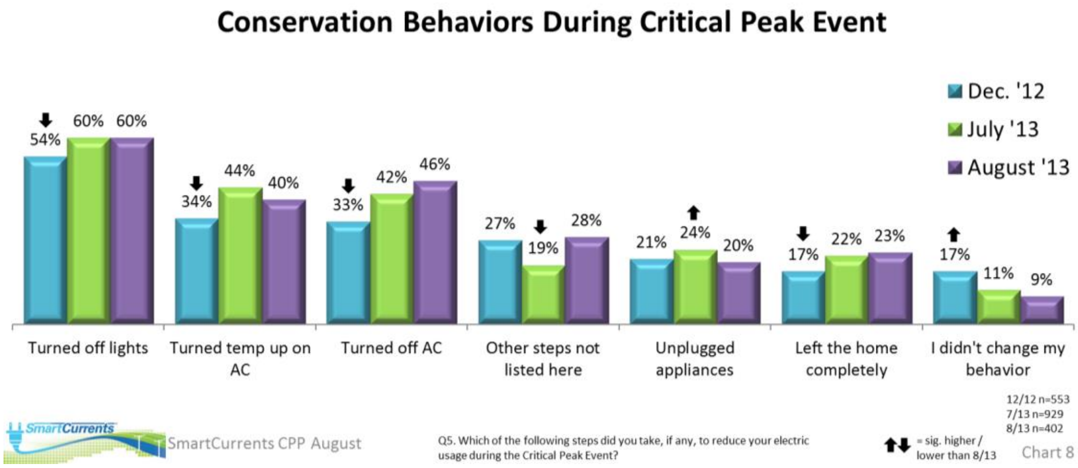


Figure 25: Conservation Behaviors during CPP Events

3.b.v. Experience with enabling technology

Technologies were shipped to customer homes after they called to start the enrollment process and their rate was changed to DPP. Nucleus software and IHD were customer-installed; PCTs were installed by trained GE Factory Service Technicians. “Binding” or establishing communication with the meter was accomplished by having the customer call the DTE “Binding Hotline” after plugging in Nucleus and installing the software.

Communication with the Smart Meter

Establishing and maintaining Nucleus communication with the meter presented its share of challenges: During the enrollment period, 266 meters dropped their Nucleus connection; 208 (78 percent) were able to rebind and complete enrollment. Of the remaining 58, connectivity was resolved for 39 by replacing the meter or the meter & nucleus combination, and enrollment was completed. In 19 cases, connectivity could not be achieved at all. The total of 25 unresolved cases noted below (representing less than two percent of the total enrolled population) never completed enrollment because communication could not be established and thus are not part of the study.

Table 15: Smart Meter & Nucleus Set up Challenges

Problem	Total	Rebound	Meter Replaced	Meter & Nucleus Replaced	Unresolved
Defective Meter	7		3	2	2
Never Connected	4				4
Dropped Connection	266	208	5	34	19
Totals	277	208	8	36	25

In most instances, the meters bound successfully to Nucleus on first try, and generally were able to re-bind if necessary. Successful re-bindings were not tracked. Meter binding activity was expected to last only through enrollment, and DTE did not anticipate the need to maintain the Meter Binding Hotline beyond that period. However, recurring meter/Nucleus connectivity issues necessitated maintaining the binding hotline through the term of the pilot, although activity was low, averaging a handful of calls per week at most. A Nucleus update from v27 to v34 resolved some issues with meter connections (and corrected an issue with the iPhone app so it would work outside a customer's home network). Nucleus compatibility with the Itron firmware in the meters also was investigated, but no firm conclusions could be drawn.

Maintaining communication between the meter and Nucleus, as well as connected devices, was an on-going activity. GE provided a weekly "Heartbeat" report indicating connectivity, or Nucleus communication with the meter. The following summary from October 2012 was representative of meter/Nucleus communication status during the entire term of the pilot program:

Table 16: Heartbeat Report

Maintaining Communication with the Smart Meter	T2	T3	T4	Total
Active Participants	375	318	380	1073
Did not heartbeat since yesterday	60	54	53	167
Did not heartbeat since the last week	51	44	39	134
Did not heartbeat since before Oct 1	21	13	12	46

GE's weekly report was a snapshot in time and an attempt to show "aging" by length of time, customer by customer. The table above summarizes that individual customer status list by treatment cell. A variety of factors could cause Nucleus to stop "heart beating," or communicating, including but not limited to: customer's internet service interruption; computer crash; wireless router problem; or power outage. The communication problem may have been between Nucleus and the meter or Nucleus and wireless router. Some of these "outages" self-corrected; for example, internet connections reestablished.

In an effort to increase connectivity, both DTE and GE initiated ongoing proactive customer communications indicating "our records show your system is not communicating" and providing instructions for power cycling Nucleus as well as GE Tech Support contact information. In some cases, individual devices were losing connection to Nucleus, and required removal from Nucleus and re-binding. This effort was made both in a targeted fashion (specific email messages to 20 or 30 customers at a time) and globally (via email blast to the entire non-communicating population). Overall, these efforts helped maintain communication levels, but did not generate significant increases from week to week.

Demand Response & Price Signals

GE DR1000 was the Demand Response system sent price signals and CPP events to customers. Besides sending this information, it also collected customer participation during those events. As such, price signals were sent by the GE server, not the DTE AMI meter. Since pilot commencement, intermittent problems occurred with sending price signals. This resulted in customer complaints and confusion, requiring the SmartCurrents program team to send email blasts acknowledging the problem and reminding customers that their billing was not affected because the DTE billing system stored the correct rates and pricing tiers. GE instituted multiple internal resolutions including price signal monitoring.

Demand Response signals to the PCTs "fired," (i.e., were sent) without incident, with the exception of event 3 on June 24, 2013. For that event, the start signal was successful, but the end signal failed. Until the correct signal was pushed the following morning, Nucleus displayed the Critical Peak Price and the PCT maintained the four degree offset. Billing was not affected, as the DTE billing system stored the prices and intervals.

An Event Participation report was generated from DR1000 after each event, to provide a measure of direct load control (DLC) signals that were successfully sent to the PCTs and to gauge customer interactivity during critical peak events. During an event, the DLC signals raised the PCT set point by four degrees (if the customer had not re-programmed the PCT). Customer interaction with the device during a CPP event was recorded; i.e., the signal was received or rejected, and whether the customer accepted the temperature offset or opted out during the event, etc. The report was found to have gaps where no signal status – received, completed, rejected, etc. – was provided. GE Energy Management investigated the root cause and determined the lack of data was the result of a number of possibilities, ranging from status of customer internet connection and/or device connection to the older DR1000 system that was in use for the pilot. Later versions of DR1000 were better equipped to provide more data, but an upgrade during the pilot term was not feasible. As a result, no meaningful conclusions about customer interaction with devices can be drawn from any of the Event Participation reports.

General usability

A portion of the pilot population required "hand-holding" with set up of the Nucleus software. While "Installation Tips for GE Nucleus" were included with all device shipments, some customers had great difficulty with the router connection, reportedly because they do not interact regularly with the router past initial set up. Others had difficulty understanding the base 16 numbering system for MAC address and install code. Much of this difficulty was attributed to the small font size in the documentation, making it difficult to distinguish between some letters and numbers. Many software set-up questions were actually answered by the DTE binding team, in the course of the binding phone call. Customers continued to call the binding hotline for connectivity issues for the duration of the pilot.

Once customers got set up and connected and understood Nucleus capabilities, they were generally able to use, navigate, and learn from the home energy management network and connected devices. Usability complaints, as noted in focus group and web survey results, almost always related to "glitches," such as connectivity, the IHD software bug, incompatibility with Adobe Air updates and Apple IOS 7 update, etc.

PCT customers expressed frustration with navigating through the set up menus on the PCT: too many screens to page through. They overwhelmingly preferred programming and managing the thermostat from Nucleus or iPhone (until they lost Nucleus connection as a result of updating to IOS7).

Functionality issues and the customer communications that they necessitated are discussed further in 6.b. Process Evaluation.

4. Data Description

Interval data is collected and stored at the meter level and then retrieved by DTE's Meter Data Management (MDM) System and stored in the MDM. DTE's Load Research Department specifies which meters' data is to be brought into the Load Research Data Management (LRDM) System for analysis by assigning each desired meter a unique Load Research key. Space limitations in the LRDM prevent DTE's Load Research Department from collecting and storing interval data from every smart meter within the service area. However, for this project, all treatment group and control group customers' interval data was loaded into the LRDM in order to generate the most accurate analysis possible.

Data was brought into the LRDM in 15 minute intervals and then was aggregated to hourly intervals for analysis. If a meter could not be communicated with or reported a missing value, the reading was flagged and the MDM system attempted to retrieve the missing interval for the next five days. If after five days, the interval still had not been recovered, the MDM system stopped attempting to retrieve the interval and the reading was considered missing and remained a blank value in the MDM system. The LRDM was designed to query the MDM for selected meters' previous day's data late in the afternoon to ensure that the data had been loaded into the MDM, which normally occurred during the early morning hours. After 10 days, the LRDM queried the MDM again in an attempt to recover any missing intervals that were not available in the MDM during the first query.

Any other values were used "as is" for analysis. No data was modified, validated, or edited in the LRDM for the DPP Pilot Program. DTE's AMI meters are currently reading with above 95% accuracy making incorrect readings a very rare occurrence. If a customer's interval reading was missing for any particular hour, it wasn't counted as an observation for that hour. If any interval was missing during any day that was used for analysis, the total energy was excluded when calculating the average event day's total energy. During the pilot program, DTE contact centers did not receive any customer calls questioning their metered quantities of interval usage for which they were billed, further validating the accuracy of DTE's AMI meters.

As discussed in 3.a.1, an existing AMI meter was a program requirement. Pretreatment data was collected prior to the January 2012 mailings, before potential pilot participants became aware of the new rate. Interval data available prior to September 1, 2011, was found to be of poor quality as the data systems were still in the early stages of set up and configuration. As a result, DTE felt it was best to use September 1, 2011, through December 31, 2011, as the pretreatment period. While formal pilot observations did not start until August 13, 2012, selection of pretreatment data was constrained by customer awareness of the rate on one end (after January 2012) and data quality (earlier than September 2011) on the other. A more detailed discussion regarding the enrollment process appears previously in section 3.

Through qualification and demographic survey questions that each pilot customer was required to answer, DTE collected data related to housing type, household income, and the existence of central air. In addition, using customer billing data DTE categorized each pilot customer into two usage groups, medium (3,960 kWh to 12,000 kWh per year) and high (>12,000 kWh per year). Pilot customers were placed into multiple groups or "cohorts" for their respective treatment and control groups and are listed in Appendix G. Cohorts represent a group of customers with a combination of one or more like demographics.

DTE's AMI rollout is geographically based, meaning that the initial AMI meter population that was available to participate in the study could not be representative of the entire service area. The AMI meter population, from which the target population was drawn, had a greater proportion of high-income residents and a smaller proportion of lower income residents compared to DTE's entire service territory. It was further hypothesized that customers in the Pilot Program had higher amounts of discretionary energy usage, creating a proportionately greater opportunity to effect change than may exist for all DTE customers. This hypothesis was later validated when the average load curves for the customers in study were compared to DTE's statistically valid residential sample of the entire service territory. Customers within the pilot used more energy on a daily basis than a typical DTE customer giving them more freedom to modify their behavior.

One hundred nine customers who volunteered to participate in the study subsequently chose to leave the study and return to their prior electric rate. However, consistent with DOE's Guidance Document #6, their usage data continued to be collected for the duration of the study and was included in the analysis of their originally assigned treatment groups and cohorts.

As discussed in more detail in Section 5, DTE removed four customers from the T2 treatment group. Data for these customers was removed from the study because their 24 hour pretreatment average usage was greater than three times the standard deviation of the entire T2 group. These study participants were deemed "outliers," and although they remained on DTE's DPP rate, their data was not included in the analysis. The removed customers were not aware that they were removed from study.

5. Analytical Methodology

Calculating the load impact metrics proved to be a bigger challenge than originally anticipated by DTE. To calculate the impact metrics, DTE chose to use the comparison of means methodology. This methodology involved comparing the mean usage for a desired time period of the treatment group to the mean usage of the control group over the same time period. The comparison of means is a simple methodology that can calculate the load impacts if the treatment groups and control groups are considered counterfactual loads.

As mentioned earlier, data was only available for customers that actually finalized their enrollment in a treatment group, and was not available for all customers originally randomly assigned to the treatment group. The control groups therefore serve as a "matched" control group (rather than a "randomized" control group). To determine that the control group was not statistically different from the paired treatment groups, each control group and treatment group combination (C1-T1-T2 and C2-T3-T4) underwent an ANOVA calculation. Because the treatment group customers were placed on the DPP rate at different times during enrollment, in order for the ANOVA analysis to provide the best results, the data used must be before the treatment group customers were made aware of the DPP rate. The pretreatment data used for the ANOVA analysis was from September 1, 2011, through December 31, 2011. An ANOVA analysis was not performed on the demographic cohorts, only on the treatment and control groups as a whole.

The first step in the ANOVA analysis was to calculate the hourly mean demand for each hour of each day of the pretreatment period for the control and treatment groups. From there, each hour was averaged across all the pretreatment days to get 24 unique values for each treatment and control group for the entire pretreatment period (not including weekends and holidays). The equations to calculate the 24 unique hourly values are as follows:

Average kW demand for customers in experimental group *g* in hour *h* of day *d*

$$kW_{g,d,h} = \frac{\sum_{i \in g} kW_{i,d,h}}{I_g}$$

Average kW demand for customers in experimental group *g* in hour *h* (across all days)

$$kW_{\boldsymbol{g,h}} = \frac{\sum_{\boldsymbol{d}} kW_{g,d,h}}{D}$$

Where:

$kW = Electricity\ demand$

$g = Experimental\ group\ (T1, T2, T3, T4, C1, C2)$

$i = Customer\ i\ in\ experimental\ group\ g$

$I_g = Total\ number\ of\ Customers\ in\ group\ g$

$h = Hour\ of\ the\ day\ (1 - 24)$

$d = Day\ of\ the\ pretreatment\ period\ (excluding\ weekends\ and\ holidays)$

$D = Total\ number\ of\ days$

Once the pretreatment average hourly mean demands were calculated for each treatment and control group, an ANOVA analysis with a 95% confidence level was performed in Microsoft Excel, but could be performed using any standard statistical analysis software. If the F value is smaller than the F critical value, one fails to reject the null hypothesis that the means are equal. Failing to reject the null hypothesis is the desired outcome of the ANOVA to prove that the treatment and control groups came from the same population of customers. If for some reason, the F value is larger than the F critical value, the null hypothesis must be rejected, meaning the groups being compared are statistically different and therefore cannot be considered counterfactual loads.

As discussed in 3.b.ii. Recruitment, MSI randomized the customers after they qualified for the program and once critical mass was reached. Since the target population was from the same county in Michigan (Oakland), and each customer expressed interest in participating in the program, it was believed that the customers would have similar characteristics resulting in six comparable groups through randomization. It was also believed that the customers who initially signed up to participate and met the program requirements would ultimately enroll, which turned out to not be the case. In hindsight, the ANOVA analysis should have been performed on the randomized groups before customers were notified of their acceptance or denial, instead of just the customers who accepted their assigned control and treatment groups. This would have allowed for re-randomization to address the issue. However, there was no reason to believe that the groups would be different and no guarantee that all of the customers would have enrolled once learning of their group assignment.

After graphing the pretreatment load curves, it was observed that the T2 group's load curve was consistently higher than the load curve of C1. Once the difference in load curves was observed, DTE had discussions with their consultant (E2RG) about different ways to proceed with the analysis to fix the high usage bias that existed with the T2 group. The first method explored was propensity score matching[8]. However, this method was quickly ruled out as it was determined DTE did not have sufficient data.

Upon examination of the individual groups, it was observed that the demographic makeup of the T2 treatment group was much different than the C1 and T1 groups. Table 17 shows the disproportion of high usage customers, high income customers (>$75K) and households with central air conditioning between the C1 control group and the T1 and T2 treatment groups. The disproportion between these three demographics may explain why the T2 group had higher demands and caused the C1-T1-T2 ANOVA to fail.

[8] Propensity score matching involves matching customers who are not in the treatment with customers who are in the treatment based on similar characteristics.

Table 17: Percentages of Demographics of C1-T1-T2

	C1	T1	T2
Income >$75K	52.74%	58.63%	62.05%
High Usage	25.07%	26.51%	32.05%
With Central A/C	71.18%	82.73%	81.79%

It was subsequently determined that the best way to improve comparability and affect the least amount of pilot participants[9], was to reduce the average hourly kW demand by the T2 group. This "outlier methodology" resulted in removing four T2 customers from the analysis whose 24 hour pretreatment usage was greater than three times the standard deviation of the entire T2 treatment group. The outlier methodology was based on the characteristics of a normal distribution where 99.87% of the data appear in a given range. This approach yielded a C1-T1-T2 grouping that was no longer statistically different from one another. The four customers who were removed from the analysis remained on the DPP rate and their data was still collected; however, for purposes of the analysis presented in this report, their data is not included.

Once the groupings (C1-T1-T2, C2-T3-T4) passed the ANOVA analysis in the pretreatment period, the treatment and control groups were considered to be counterfactual loads of each other. In being considered a counterfactual load, at any time during the pretreatment phase of the study (September 1, 2011 – December 31, 2011), the treatment and control groups would have relatively the same average customer demand. Any change in behavior since the inception of the DPP program by the treatment groups can be attributed to the change in their electric rate. The comparison of means approach can calculate the magnitude of this change by subtracting the average customer hourly load for the control group from the average customer hourly load for the treatment group. This difference between the two average hourly loads is considered the impact metric for that hour.

After discussing DTE's analytical methodology and submittal of the interim report, Lawrence Berkeley National Laboratories (LBNL) expressed a minor concern with the combination of DTE's data set and analytical calculations. DTE and LBNL agreed that for the final report, being that there would be more observations, changing the analytical methodology would be explored. The concern of LBNL was the internal validity of the study, as a selection bias may have been introduced during enrollment. LBNL wanted DTE to explore two different options that might have reduced the existing bias and potentially improve the internal validity of the study.

The cause for LBNL concern was that despite passing the ANOVA test, the treatment group and control group customers were different because of how they were enrolled in their respective groups. The control group customers were recruited for the program and expressed interest to be in the program but were ultimately not selected into a treatment group. It is at this point that these customers became part of the control group. On the other hand, the treatment group customers were likewise recruited

[9] A "trimmed down" methodology was also explored that resulted in 558 customers being dropped from the analysis. Due to the large amount of customer data that would not be analyzed, this methodology was ruled out.

and expressed interest in the program but then had to complete another step by actually contacting DTE to finalize their enrollment (for a full description of the recruitment process, see Section 3.b.ii. Recruitment and customer retention approach). Only the customers who were assigned to a treatment group and finalized their enrollment with DTE were assigned a unique Load Research Key, allowing for data collection and analysis. If a customer was assigned to a treatment group but then never finalized enrollment, while they stayed on the DPP rate, their data was never collected by Load Research for analysis. It is the extra step of having the treatment group customers finalize their enrollment where a selection bias may have been introduced.

LBNL provided DTE with two suggestions to eliminate the potential selection bias. The first was to use regression modeling. Regression modeling can account for any unobserved effects that may be affecting an individual customer's energy consumption. Unfortunately, DTE did not have the advanced statistical software available to perform this type of analysis.

The second suggestion was to add all the customers who were originally assigned to a treatment group during the initial randomization process but did not complete enrollment, to the analysis. This would essentially make the originally designed randomized control trial, a randomized encouragement design with an analysis of the treatment on the treated. In theory, this seemed like the best option for DTE to eliminate the selection bias as it did not require any additional software.

While DTE understood the benefits of including additional customers who were assigned to a treatment group to the analysis, adding these customers could not be completed for two reasons. First, DTE's LRDM system did not have the free disk space to bring in 16 months of interval data for these customers. This would be in addition to their pretreatment interval data, if that data were even available.

Second, if the disk space that would be required was available, supplying a unique Load Research key to those customers would have been a challenge, especially being over a year into the program. As previously stated, only the treatment group customers who finalized their enrollment were assigned a Load Research Key. Once the Load Research key was assigned this late in the program, the MDM would have to query the meter which then would be followed by the LRDM system retrieving the data from the MDM. This process would likely tie up system resources for an extended period of time as months of back intervals would have to be retrieved from the meter and then from the MDM.

After speaking with LBNL and expressing the concerns about their suggestions, it was determined that the best way to proceed was for DTE to perform the analysis using the comparison of means methodology with the available data set. While DTE recognizes the shortcomings of doing impact calculations without the additional customer data or performing a regression analysis, it is still believed that the study results provide valuable and useful information on the effect of a DPP rate on customers.

DTE chose to calculate the event day impacts for the T1, T2, T3, and T4 groups as well as individual cohorts 04, 05, 06, 07, 08, 09, and 10[10]. A description of the cohorts analyzed is listed in Table 18.

Table 18: Description of Analyzed Cohorts

Description of Analyzed Cohorts	
Cohort Number	**Description**
04	Medium Usage Household (3,960 kWh - 12,000 kWh annually)
05	High Usage Household (12,000+ kWh annually)
06	Low Income Household (< $30,000 annually)
07	Medium Income Household ($30,000 - $75,000 annually)
08	High Income Household (> $75,000 annually)
09	Households with Central A/C
10	Households without Central A/C

These cohorts were chosen as each has a sufficient sample size to analyze results.

Despite calling a total of 12 event days (for a list of event days, see Table 3) during the program duration, only 11 were used in the event day analysis. The event on August 16, 2012, suffered from a notification error preventing roughly a third of DPP customers from receiving advanced notification and therefore was not included in the analysis. The 11 event days used in the analysis were aggregated together for each treatment and control group to calculate the average hourly impact that the event days had on the DPP customers.

The effect the underlying TOU rate had on pilot customers was also of interest to DTE. To calculate the impact that the TOU rate has had on customers, DTE chose to analyze 16 days during the pilot period where the maximum temperature equaled or exceeded 85°F (hot weather days) and 16 days during the same period where the maximum temperature did not exceed 25°F (cold weather days). These two groups of days allowed DTE to analyze the effect of the TOU rate on hot days as well as cold days. The days chosen are listed in Table 19 and Table 20. Days that fit the temperature criteria but occurred on a weekend, DTE recognized holiday or an event day were excluded for the TOU analysis. Like the event day analysis, each hour of the selected days were aggregated together to calculate the hourly effect of the TOU rate on hot days and cold days. No TOU analysis was performed for the individual cohorts.

[10] Cohorts 09 and 10 only exist for Treatment Groups 1 and 2.

Table 19: Hot Weather Days Chosen for TOU Analysis

Date	Day of Week	Avg. Relative Humidity	Max Temp.	Avg. Temp.	Avg. Temp. On Peak
8/23/2012	Thursday	57%	85	73	83
8/24/2012	Friday	66%	87	76	86
8/31/2012	Friday	59%	94	79	93
9/6/2012	Thursday	74%	85	74	83
5/20/2013	Monday	68%	89	76	86
5/21/2013	Tuesday	57%	87	79	86
5/29/2013	Wednesday	62%	85	77	84
6/17/2013	Monday	56%	87	74	85
6/21/2013	Friday	60%	85	75	83
6/25/2013	Tuesday	74%	86	76	85
7/9/2013	Tuesday	82%	89	77	83
7/10/2013	Wednesday	78%	88	78	78
7/18/2013	Thursday	71%	93	84	91
7/19/2013	Friday	66%	95	85	94
8/30/2013	Friday	73%	87	78	87
9/11/2013	Wednesday	72%	90	79	89

Table 20: Cold Weather Days Chosen for TOU Analysis

Date	Day of Week	Avg. Relative Humidity	Max Temp.	Avg. Temp.	Avg. Temp. On Peak
1/2/2013	Wednesday	75%	24	18	24
1/21/2013	Monday	64%	20	15	13
1/22/2013	Tuesday	62%	11	6	11
1/23/2013	Wednesday	69%	18	12	17
1/24/2013	Thursday	61%	20	15	18
1/25/2013	Friday	72%	21	19	20
2/1/2013	Friday	68%	19	15	15
2/4/2013	Monday	79%	23	20	23
2/20/2013	Wednesday	60%	23	21	23
12/10/2013	Tuesday	64%	22	18	21
12/11/2013	Wednesday	71%	23	17	19
12/12/2013	Thursday	65%	18	13	15
12/16/2013	Monday	74%	24	15	17
12/24/2013	Tuesday	65%	21	17	18
12/30/2013	Monday	63%	22	19	20
12/31/2013	Tuesday	75%	21	17	18

In each case, the control group was subtracted from the treatment group to show a kW reduction as a negative number. The formulas to calculate the load impact for event days and the TOU reductions are as follows:

Average kW demand for customers in experimental group *g* in hour *h* of event day *d*

$$kW_{g,d,h} = \frac{\sum_{i \in g} kW_{i,d,h}}{I_{g,h}}$$

Where:

$kW = Electricity\ demand$

$g = Experimental\ group\ or\ cohort$

$i = Successful\ Meter\ Read\ i\ in\ experimental\ group\ g$

$I_{g,h} = Total\ number\ of Successful\ Meter\ Reads\ in\ group\ g\ during\ hour\ h$

$h = Hour\ of\ the\ day\ (1 - 24)$

$d = Day\ of\ analysis\ period$

Comparison of means

$$Y_{g \in T,d,h} = kW_{g \in T,d,h} - kW_{g \in C,d,h}$$

$Y = Impact\ metric\ of\ treatment\ group\ T\ during\ hour\ h\ of\ day\ d$

$T = Experimental\ treatment\ group$

$C = Experimental\ control\ group$

To construct the 95% confidence interval around the load impact, DTE used the pooled estimate of the common standard deviation. In using the pooled estimate of the common standard deviation to calculate confidence intervals, the confidence interval provided a range of values of the difference between the control and treatment group during any given time on an event day. The formula for the pooled estimate of the common standard deviation is as follows:

$$Sp_t = \sqrt{\frac{(I_{c,t} - 1)s_{c,t}{}^2 + (I_{d,t} - 1)s_{d,t}{}^2}{Count_{c,t} + Count_{d,t} - 2}}$$

Where:

$Sp_t = Pooled\ estimate\ of\ common\ standard\ deviation\ at\ time\ t$

$I_{c,t} = Number\ of\ successful\ control\ group\ meter\ reads\ at\ time\ t$

$I_{d,t} = Number\ of\ successful\ treatment\ group\ meter\ reads\ at\ time\ t$

$s_{c,t} = Standard\ deviation\ of\ the\ control\ group\ kW\ meter\ reads\ at\ time\ t$

$s_{d,t} = Standard\ deviation\ of\ the\ treatment\ group\ kW\ meter\ reads\ at\ time\ t$

Once the pooled estimate of the common standard deviation is available, the confidence interval around the impact metric was calculated with the following formula:

$$CI_t = Y_t +/- TSp_t \sqrt{\frac{1}{Count_{c,t}} + \frac{1}{Count_{d,t}}}$$

Where:

$CI_t = Confidence\ Interval\ at\ time\ t$

$Y_t = Impact\ metric\ at\ time\ t$

$T = t\ statistic\ at\ desired\ confidence\ level$

$Sp_t = Pooled\ estimate\ of\ common\ standard\ deviation\ at\ time\ t$

$Count_{c,t} = Number\ of\ successful\ control\ group\ meter\ reads\ at\ time\ t$

$Count_{d,t} = Number\ of\ successful\ treatment\ group\ meter\ reads\ at\ time\ t$

If the calculated confidence interval did not include zero, the impact metric was said to be statistically significant. With the impact metric being statistically significant, DTE could specify the direction of the effect (DPP rate), whether it be positive (i.e., customers increased their energy use) or negative (i.e., customers decreased their energy use). Hours that were considered statistically significant reductions are indicated by an asterisk next to the hour in tables that appear in section 6.a.

6. Results

6.a.i. Group Event Day Impact Evaluation Results

CPP days or "events" are described previously in Section 3.a.ii. The first event DTE called was on August 16, 2012. After the event, it was learned that nearly a third of the customers in the treatment groups did not receive any notification informing them of the event day. DTE later determined that T1 and T2 groups were most affected by the notification failures, with nearly 40 percent of T1 and nearly 25 percent of T2 not receiving notice. For this reason, the August 16, 2012, event day was not included in the event day analysis.

Instead of analyzing each event day individually, DTE chose to analyze the event days as a group to better represent the average behavior on event days and reduce the variation. During the summer of 2013, DTE was able to call 11 event days. These 11 event days were aggregated together to produce an average event day load shape for each control group and treatment group. The two curves were then compared to examine the effect that the DPP rate was having on the treatment group customers.

Although these results may contain bias due to data access problems (data were only available for customers that actually finalized their enrollment in a treatment group, and were not available for all customers originally randomly assigned to the treatment group), we believe that the results presented in this section provide valuable and useful information on the effect of a DPP rate on customers.

Table 21: C1-T1 Average Event Day Demand

C1 - T1 Average Event Day Demand (kW)						
Hour Ending	C1 Demand	T1 Demand	Impact	Impact %	Lower Bound	Upper Bound
1	1.436	1.570	0.134	9.33%	0.066	0.202
2	1.234	1.336	0.102	8.30%	0.043	0.161
3	1.125	1.200	0.075	6.70%	0.020	0.130
4	1.042	1.114	0.072	6.87%	0.021	0.122
5	1.000	1.059	0.058	5.82%	0.011	0.106
6	1.033	1.105	0.071	6.91%	0.023	0.120
7	1.124	1.165	0.040	3.58%	(0.010)	0.090
8	1.199	1.200	0.002	0.15%	(0.050)	0.054
9	1.219	1.261	0.042	3.45%	(0.015)	0.099
10	1.293	1.334	0.042	3.23%	(0.023)	0.106
11	1.400	1.491	0.090	6.45%	0.017	0.163
12	1.560	1.664	0.104	6.68%	0.024	0.184
13	1.719	1.857	0.138	8.04%	0.051	0.225
14	1.894	2.034	0.139	7.36%	0.046	0.233
15	2.018	2.170	0.152	7.52%	0.054	0.249
16*	2.142	1.956	(0.186)	-8.69%	(0.282)	(0.090)
17*	2.315	2.043	(0.271)	-11.72%	(0.371)	(0.172)
18*	2.469	2.112	(0.357)	-14.47%	(0.458)	(0.256)
19*	2.532	2.151	(0.381)	-15.05%	(0.482)	(0.280)
20	2.473	2.526	0.052	2.12%	(0.048)	0.153
21	2.444	2.653	0.209	8.55%	0.109	0.309
22	2.444	2.675	0.230	9.43%	0.131	0.330
23	2.220	2.492	0.272	12.26%	0.178	0.366
24	1.877	2.127	0.250	13.34%	0.168	0.333
Total Energy (kWh)	**41.222**	**42.297**	**1.075**	**2.61%**	**(0.387)**	**2.537**
Critical Peak Energy (kWh)*	**9.460**	**8.268**	**(1.192)**	**-12.60%**	**(1.565)**	**(0.818)**

Table 21 displays the hourly demands for the C1 control group and the T1 treatment group (education only) and the impact analysis for the event day. The T1 customers experienced a statistically significant reduction during each hour of the event period (HE 16-19). The majority of the day, however, the T1 group used more energy when compared to the C1 group, although the total energy difference for the day was not statistically significant. This would seem to indicate that on an event day, the T1 group shifted their load to the non-critical peak hours instead of reducing their load as a whole. During the four hour event period, the T1 customers reduced their load by 1.192 kWh or 12.6% when compared to the C1 customers.

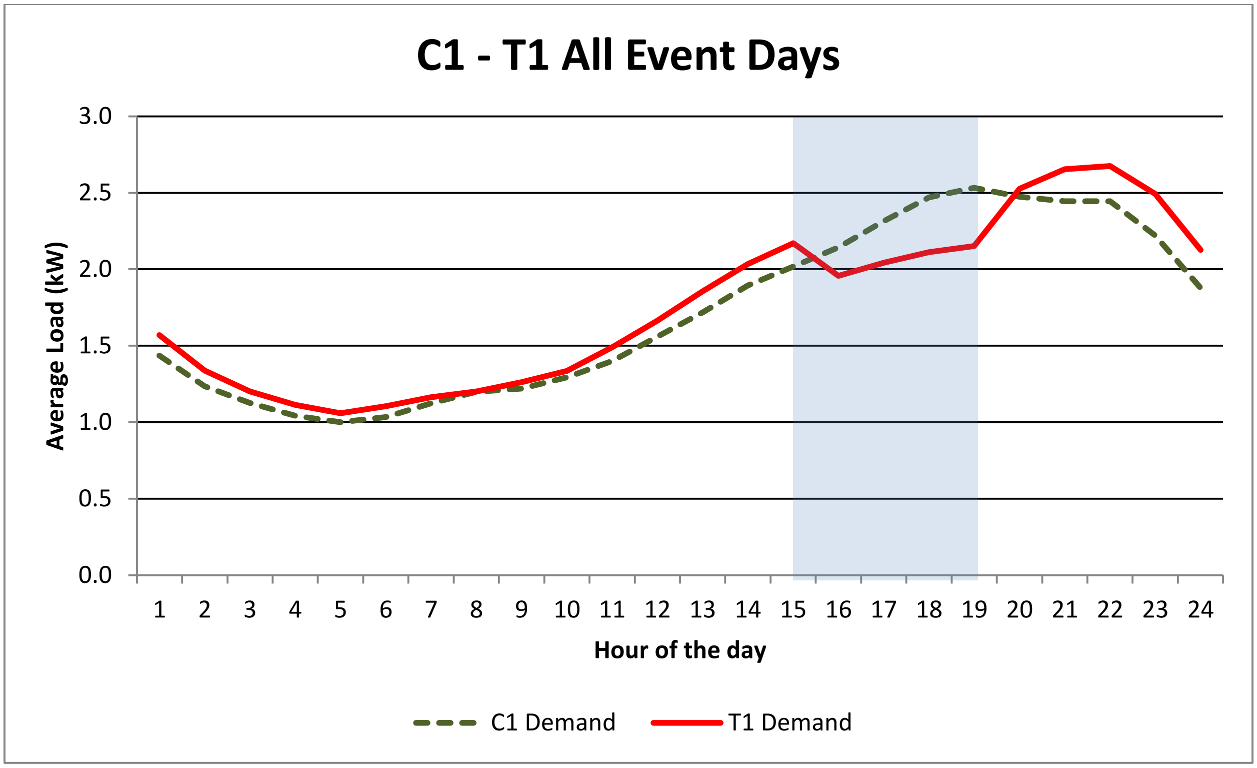


Figure 26: C1-T1 Event Day Load Curves

Figure 26 shows the event day load curves for the T1 treatment group and C1 control group. Leading up to the event, it can be seen that the load curve for the T1 treatment group rose more quickly than that of the C1 control group, indicating an increase in energy consuming activities in preparation for the event. When the event started (the event period is highlighted in blue), the T1 treatment group reduced their hourly demand to below C1 levels and maintained that reduction through the duration of the event. Once the event concluded, the T1 group returned to having a higher demand for the duration of the curve; note that this difference is also statistically significant. This is known as the payback period, as the treatment group customers resume the activities that they have put off for the previous four hours. While the T1 load resumed a normal load shape that mimics that of the control group, the curve never returned to the levels of the C1 group after the event.

Table 22: C1-T2 Average Event Day Demand

C1 - T2 Average Event Day Demand (kW)						
Hour Ending	C1 Demand	T2 Demand	Impact	Impact %	Lower Bound	Upper Bound
1	1.436	1.738	0.302	21.00%	0.238	0.365
2	1.234	1.475	0.242	19.58%	0.186	0.297
3	1.125	1.322	0.197	17.50%	0.146	0.248
4	1.042	1.210	0.168	16.09%	0.120	0.215
5	1.000	1.140	0.140	13.96%	0.096	0.183
6	1.033	1.148	0.115	11.12%	0.071	0.159
7	1.124	1.288	0.164	14.60%	0.118	0.210
8	1.199	1.330	0.131	10.95%	0.083	0.179
9	1.219	1.336	0.117	9.62%	0.066	0.169
10	1.293	1.441	0.148	11.47%	0.089	0.207
11	1.400	1.620	0.219	15.65%	0.151	0.287
12	1.560	1.821	0.261	16.72%	0.186	0.335
13	1.719	2.023	0.304	17.71%	0.224	0.385
14	1.894	2.192	0.297	15.71%	0.213	0.382
15	2.018	2.273	0.255	12.62%	0.168	0.341
16*	2.142	1.863	(0.279)	-13.02%	(0.363)	(0.195)
17*	2.315	1.904	(0.411)	-17.74%	(0.497)	(0.324)
18*	2.469	1.986	(0.482)	-19.54%	(0.571)	(0.394)
19*	2.532	2.054	(0.478)	-18.88%	(0.566)	(0.390)
20	2.473	2.676	0.203	8.22%	0.114	0.293
21	2.444	2.914	0.470	19.24%	0.380	0.560
22	2.444	2.931	0.487	19.92%	0.399	0.575
23	2.220	2.715	0.494	22.27%	0.411	0.578
24	1.877	2.323	0.446	23.75%	0.370	0.521
Total Energy (kWh)	**41.222**	**44.796**	**3.574**	**8.67%**	**2.275**	**4.872**
Critical Peak Energy (kWh)*	**9.460**	**7.809**	**(1.651)**	**-17.45%**	**(1.977)**	**(1.325)**

Table 22 displays the interval usage and impacts for the T2 treatment group (education and IHD) and the C1 control group on the average event day. Outside of the four event hours when the T2 group reduced their total load by a statistically significant amount of 1.651 kWh, the T2 group used more energy. It can also be seen that the T2 customers on average had a statistically significant amount of higher demand during all of the non-critical peak hours.

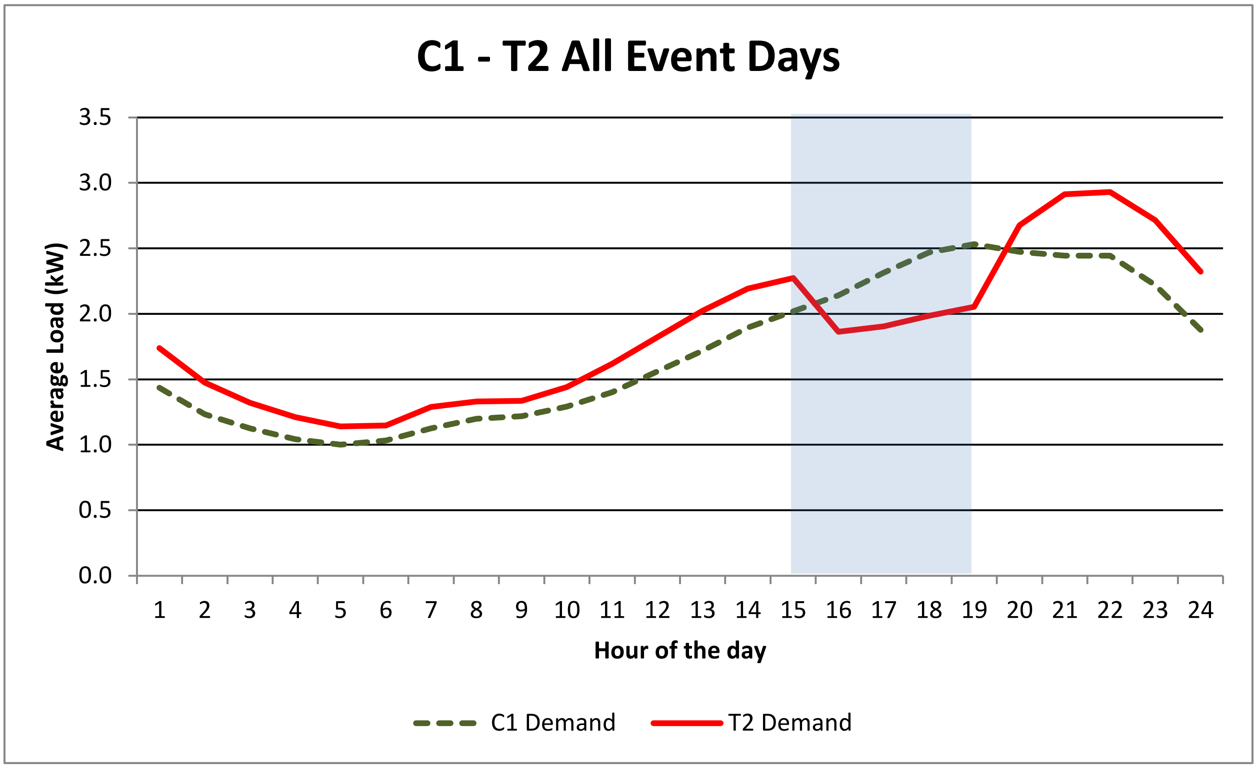


Figure 27: C1-T2 Event Day Load Curves

Figure 27 illustrates the C1 and T2 load curves on an event day. The T2 customers increased their demand leading up to the event at a quicker pace than that of the C1 group. When the event began, the T2 group reduced their demand to levels below C1 and remained below the control group for the duration of the four hour event. This is the only time period during an event day when the T2 group reduced their hourly demands below the C1 group. Once the event concluded, the T2 group increased their demand in the hours known as the payback period, returning to the higher demands they had prior to the event. The graph shows that the difference between the T2 demands and the C1 demands are much larger after the event concluded than it was leading up to the event, which is an indication of a payback period. The T2 group resumed their normal load shape after the event.

Table 23: C2-T3 Average Event Day Demand

C2 - T3 Average Event Day Demand (kW)						
Hour Ending	C2 Demand	T3 Demand	Impact	Impact %	Lower Bound	Upper Bound
1	1.550	1.706	0.156	10.08%	0.093	0.219
2	1.287	1.436	0.148	11.53%	0.094	0.203
3	1.138	1.242	0.105	9.19%	0.057	0.153
4	1.048	1.136	0.088	8.37%	0.043	0.132
5	1.001	1.063	0.062	6.22%	0.021	0.103
6	1.042	1.113	0.071	6.83%	0.029	0.114
7	1.186	1.216	0.031	2.60%	(0.017)	0.079
8*	1.252	1.093	(0.159)	-12.70%	(0.205)	(0.113)
9*	1.265	1.094	(0.171)	-13.53%	(0.220)	(0.123)
10*	1.390	1.136	(0.254)	-18.28%	(0.309)	(0.200)
11*	1.566	1.267	(0.298)	-19.05%	(0.360)	(0.236)
12*	1.793	1.401	(0.393)	-21.89%	(0.461)	(0.324)
13*	2.024	1.635	(0.390)	-19.24%	(0.465)	(0.314)
14*	2.240	1.868	(0.372)	-16.61%	(0.453)	(0.291)
15*	2.364	2.017	(0.347)	-14.67%	(0.430)	(0.264)
16*	2.560	1.394	(1.167)	-45.57%	(1.245)	(1.088)
17*	2.802	1.499	(1.303)	-46.49%	(1.385)	(1.220)
18*	2.977	1.660	(1.317)	-44.24%	(1.401)	(1.233)
19*	3.049	1.764	(1.286)	-42.16%	(1.371)	(1.200)
20*	2.905	2.665	(0.239)	-8.24%	(0.327)	(0.151)
21	2.793	2.799	0.006	0.23%	(0.081)	0.094
22	2.747	2.781	0.034	1.22%	(0.052)	0.119
23	2.499	2.460	(0.039)	-1.56%	(0.120)	0.042
24	2.078	2.424	0.346	16.63%	0.270	0.421
Total Energy (kWh)*	**46.529**	**39.883**	**(6.646)**	**-14.28%**	**(7.773)**	**(5.519)**
Critical Peak Energy (kWh)*	**11.385**	**6.317**	**(5.068)**	**-44.51%**	**(5.367)**	**(4.769)**

Table 23 displays the T3 (customers who received a PCT) load curve compared to the C2 load curve along with the impact analysis for an average event day. It appears that the T3 customers not only reduced their demand during the event period by using 44.5% less energy, but also reduced their total event day energy. The 14.3% load reduction by the T3 group was statistically significant, as is the reduction during the four hour event. Beginning in hour ending (HE) 8, the T3 customers began reducing their demand and carried that reduction through HE 20. Their reduction actually extended an hour after the event ended when compared to the C2 group. The energy consumed by the T3 group compared to the C2 group indicated that the treatment group customers not only shifted their demand to hours when the energy costs are cheaper, but also discovered ways to reduce their overall energy. The reduction in overall energy could have been a result of the customers adjusting the set point on their thermostat. The PCT was designed to adjust the set point only during hours 16-19, but the large reductions beyond the event hours could be a result of manually adjusting the set point outside of the event hours too.

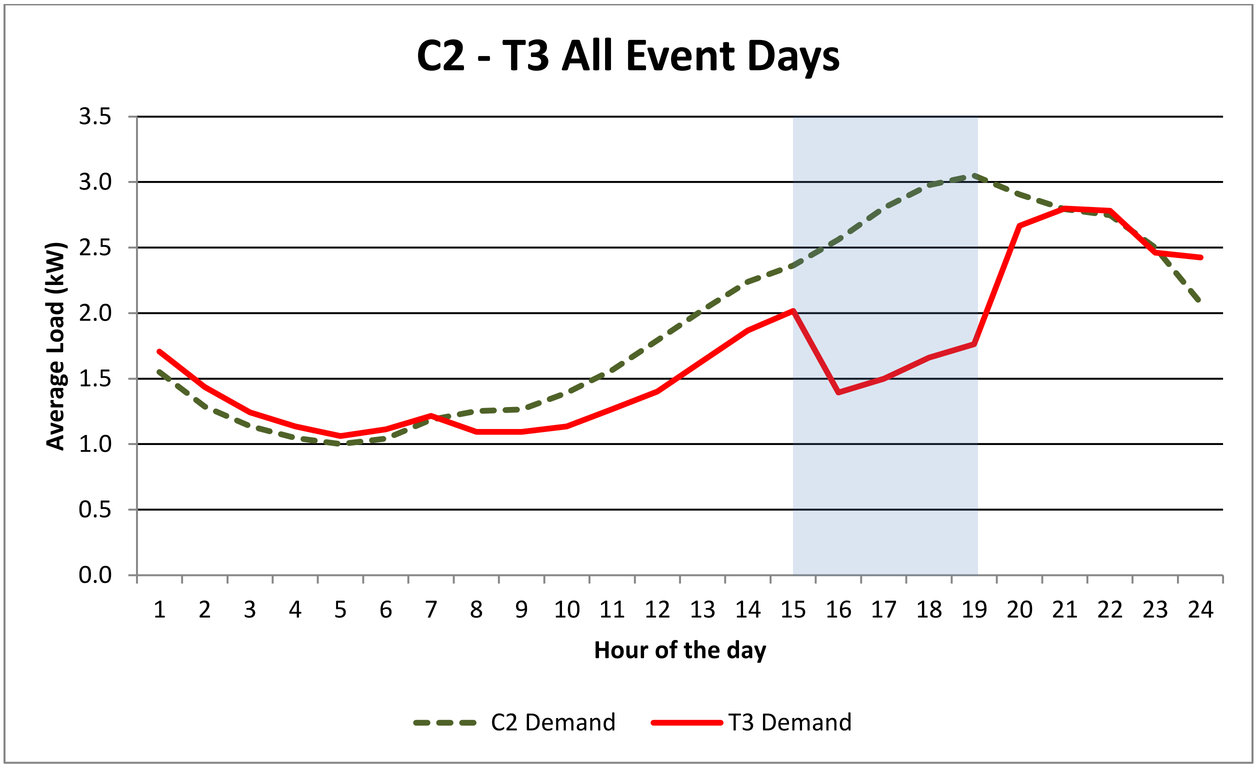


Figure 28: C2-T3 Event Day Load Curves

Figure 28 further illustrates that the T3 customers shifted their load to off peak hours as well as reduced their entire load. Up until HE 7, the T3 group had a higher demand than that of the C2 group. Beginning in HE 10, the T3 group began to increase their demand at a similar rate as the C2 group. When the event began at HE 16, there was a steep drop in demand by the T3 group while the control group continued to increase their demand. After the initial drop in demand by the T3 group, they again began to increase their demand at what appears to be the same rate as the C2 customers. At the conclusion of the event, there was a spike in demand in HE 20 by the T3 group which was to be expected. What was not expected is that the T3 group did not increase their demand to statistically significant levels above the C2 group. Instead, beginning in HE 21, they followed almost the exact demand levels of the control group. It was expected that the T3 group would exceed the demand of the C2 group during the payback period as they resumed energy consuming activities that were avoided during the event.

Table 24: C2-T4 Average Event Day Demand

C2 - T4 Average Event Day Demand (kW)						
Hour Ending	C2 Demand	T4 Demand	Impact	Impact %	Lower Bound	Upper Bound
1	1.550	1.716	0.166	10.71%	0.104	0.228
2	1.287	1.435	0.148	11.47%	0.094	0.201
3	1.138	1.236	0.098	8.59%	0.051	0.145
4	1.048	1.116	0.068	6.51%	0.025	0.112
5	1.001	1.058	0.057	5.71%	0.017	0.097
6	1.042	1.111	0.069	6.66%	0.028	0.111
7	1.186	1.224	0.039	3.25%	(0.008)	0.085
8*	1.252	1.155	(0.096)	-7.70%	(0.141)	(0.052)
9*	1.265	1.091	(0.174)	-13.77%	(0.220)	(0.128)
10*	1.390	1.138	(0.252)	-18.13%	(0.305)	(0.199)
11*	1.566	1.289	(0.277)	-17.67%	(0.338)	(0.216)
12*	1.793	1.491	(0.302)	-16.84%	(0.371)	(0.233)
13*	2.024	1.689	(0.335)	-16.57%	(0.411)	(0.260)
14*	2.240	1.891	(0.349)	-15.59%	(0.430)	(0.269)
15*	2.364	2.065	(0.298)	-12.63%	(0.381)	(0.216)
16*	2.560	1.466	(1.094)	-42.73%	(1.171)	(1.017)
17*	2.802	1.536	(1.266)	-45.18%	(1.346)	(1.186)
18*	2.977	1.695	(1.282)	-43.08%	(1.365)	(1.200)
19*	3.049	1.790	(1.260)	-41.31%	(1.344)	(1.175)
20*	2.905	2.640	(0.265)	-9.11%	(0.353)	(0.176)
21	2.793	2.803	0.011	0.38%	(0.076)	0.098
22	2.747	2.823	0.076	2.78%	(0.008)	0.160
23	2.499	2.466	(0.033)	-1.31%	(0.111)	0.045
24	2.078	2.387	0.309	14.86%	0.234	0.383
Total Energy (kWh)*	**46.529**	**40.245**	**(6.283)**	**-13.50%**	**(7.380)**	**(5.186)**
Critical Peak Energy (kWh)*	**11.385**	**6.487**	**(4.898)**	**-43.02%**	**(5.189)**	**(4.607)**

Table 24 displays the hourly demands for the T4 treatment group (customers who received an IHD and a PCT) and the C2 control group and the event day impact analysis. Much like the T3 group, the T4 group reduced their total energy consumption during the event period as well as the whole day. On average, the T4 customers reduced their load 43% during the event period and 13.5% during the event day. Beginning in HE 8, the T4 customers reduced their demand and carried that reduction through HE 20. Their reduction actually extended an hour after the event ended compared to the C2 group, much like the T3 group.

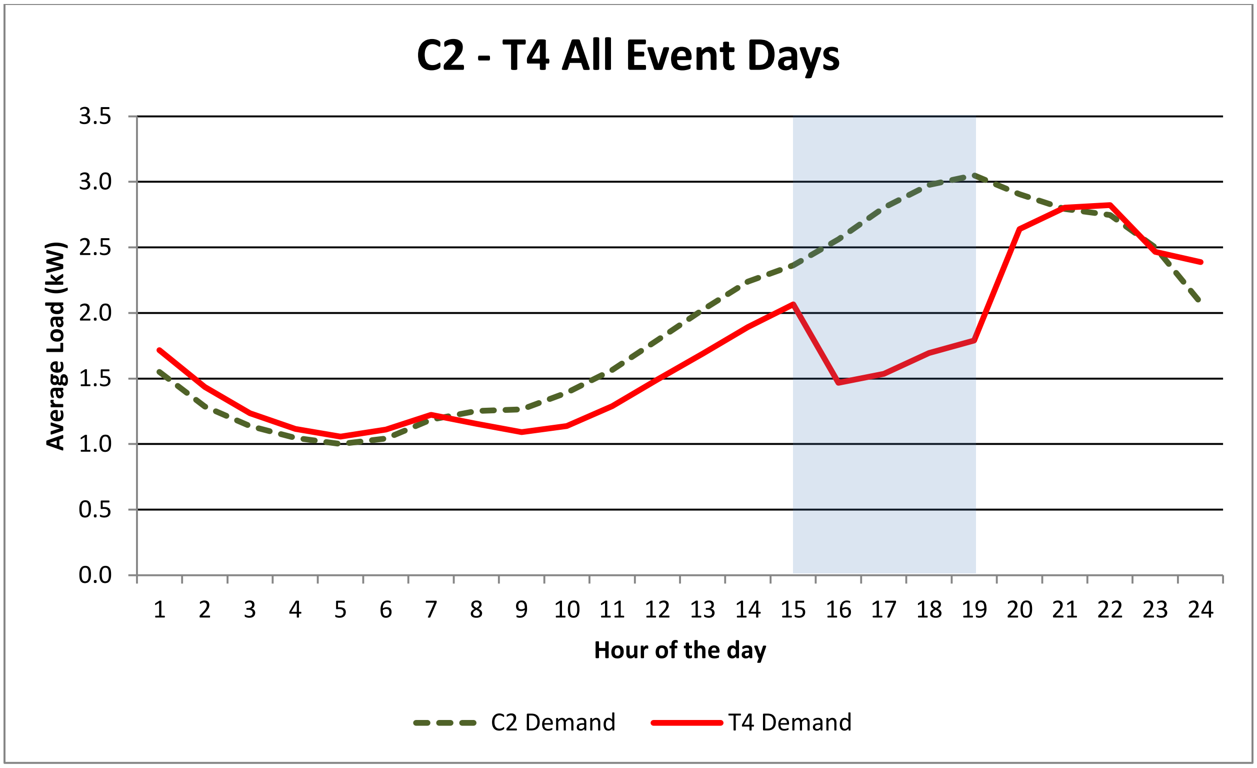


Figure 29: C2-T4 Event Day Load Curves

Figure 29 further illustrates DTE's belief that the T4 customers shifted their load to the off peak hours as well as reduced their entire load on event days. Up until HE 7, the T4 group had a higher demand than that of the C2 group. This happened to be during the off-peak period when energy costs were the lowest for the treatment groups. Beginning in HE 10, the T4 group began to increase their demand at a similar rate as the C2 group. When the event began at HE 16, there was a steep drop in demand by the T4 group while the control group continued to increase their load. After the initial drop in demand by the T4 group, they again began to increase their demand at what looks to be the same rate as the C2 customers. At the conclusion of the event, there was a spike in demand in HE 20 by the T4 group, which was to be expected but they still did not consume more energy than C2. T4 demands slightly exceeded the demands of C2 during HE 21 and 22. It was anticipated that the payback period would be much larger than what actually occurred after the event, perhaps even having T4 experience higher demand levels than the control group. This added to the belief that the T4 customers had learned how to reduce their hourly demand. It should also be noted that the T4 event day load curve was very similar to the T3 event day load curve, indicating a likeness between the two treatment groups. The similar behavior between the T3 and T4 groups could well be attributed to the reliance on the programmable thermostat to shift energy consumption and ultimately reduce it.

6.a.ii. Hot and Cold Weather TOU Days Evaluation Results

Hot and cold weather TOU days are identified previously in Section 5. The analyses shown below for the four treatment groups were performed for the 16 hot weather days and 16 cold weather days only. In the graphs that follow, the shaded light blue region represents peak period, the light orange region represents mid-peak period, and the unshaded region represents the off-peak period.

Table 25: C1 - T1 Average TOU Hot Weather Day Demand (All Hours)

C1 - T1 Average TOU Hot Weather Day Demand (All Hours)						
Hour Ending	C1 Demand	T1 Demand	Impact	Impact %	Lower Bound	Upper Bound
1	1.307	1.464	0.157	12.03%	0.103	0.212
2	1.144	1.271	0.127	11.10%	0.078	0.176
3	1.047	1.130	0.083	7.97%	0.039	0.128
4	0.985	1.057	0.072	7.32%	0.031	0.113
5	0.954	1.017	0.063	6.57%	0.024	0.101
6	0.989	1.056	0.067	6.80%	0.028	0.106
7	1.088	1.123	0.035	3.20%	(0.006)	0.075
8	1.129	1.159	0.030	2.65%	(0.011)	0.070
9	1.144	1.175	0.031	2.72%	(0.013)	0.075
10	1.197	1.220	0.024	1.97%	(0.026)	0.073
11	1.289	1.366	0.076	5.93%	0.020	0.133
12	1.377	1.504	0.128	9.27%	0.066	0.189
13	1.511	1.656	0.146	9.63%	0.078	0.213
14	1.662	1.797	0.135	8.12%	0.062	0.208
15	1.805	1.945	0.141	7.80%	0.063	0.219
16	1.951	2.048	0.097	4.98%	0.017	0.177
17	2.118	2.244	0.126	5.93%	0.041	0.210
18	2.288	2.413	0.124	5.44%	0.037	0.212
19	2.314	2.419	0.105	4.52%	0.019	0.191
20	2.218	2.362	0.144	6.48%	0.059	0.228
21	2.144	2.262	0.118	5.51%	0.037	0.199
22	2.116	2.221	0.105	4.96%	0.027	0.183
23	1.943	2.067	0.124	6.36%	0.051	0.196
24	1.627	1.780	0.153	9.39%	0.090	0.216
Total Energy	**37.293**	**39.738**	**2.446**	**6.56%**	**1.244**	**3.647**
Off Peak	**9.123**	**9.898**	**0.775**	**8.50%**	**0.451**	**1.099**
Mid-Peak	**19.505**	**20.720**	**1.215**	**6.23%**	**0.565**	**1.866**
On-Peak	**8.665**	**9.123**	**0.458**	**5.29%**	**0.141**	**0.775**

Table 25 displays the hourly demands and impact analysis for the T1 customers compared to the C1 customers. When looking at the hourly demands, it appeared that the T1 group did not reduce their energy consumption in reaction to the TOU rate on hot weather days. All hours except HE 7-10 show a statistically significant positive difference from the control group. Despite using a statistically significant amount of more energy during each TOU period, the percentage difference between the control group's energy and the treatment group's energy was larger during the off peak period and the smallest during the on-peak period which indicates there was some load shift. T1 customers have no technology to aid them in reducing their load, but may have used the educational materials to learn about methods to shift their energy use, as can be observed in Figure 30.

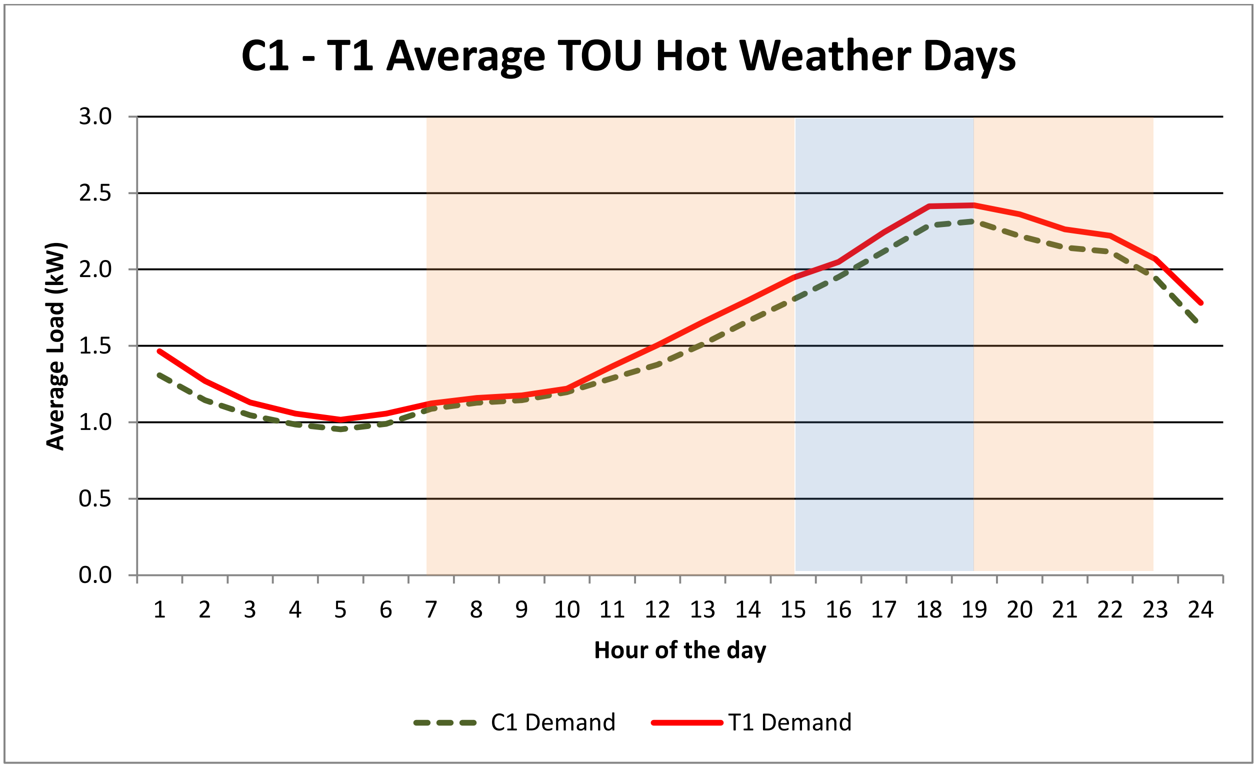


Figure 30: C1 - T1 Average TOU Hot Weather Days

Table 26: C1 - T2 Average TOU Hot Weather Day Demand (All Hours)

C1 - T2 Average TOU Hot Weather Day Demand (All Hours)						
Hour Ending	C1 Demand	T2 Demand	Impact	Impact %	Lower Bound	Upper Bound
1	1.307	1.625	0.318	24.36%	0.264	0.373
2	1.144	1.382	0.239	20.87%	0.190	0.287
3	1.047	1.240	0.193	18.47%	0.149	0.238
4	0.985	1.136	0.151	15.33%	0.110	0.192
5	0.954	1.088	0.134	14.05%	0.095	0.173
6	0.989	1.115	0.126	12.71%	0.087	0.165
7	1.088	1.233	0.145	13.36%	0.105	0.186
8	1.129	1.270	0.141	12.48%	0.100	0.181
9	1.144	1.274	0.130	11.38%	0.086	0.174
10	1.197	1.324	0.127	10.65%	0.078	0.177
11	1.289	1.452	0.163	12.63%	0.106	0.219
12	1.377	1.592	0.215	15.61%	0.153	0.276
13	1.511	1.769	0.258	17.10%	0.191	0.325
14	1.662	1.921	0.259	15.57%	0.186	0.332
15	1.805	2.073	0.269	14.90%	0.191	0.347
16	1.951	2.066	0.115	5.90%	0.035	0.196
17	2.118	2.241	0.123	5.80%	0.038	0.207
18	2.288	2.413	0.124	5.44%	0.037	0.212
19	2.314	2.443	0.129	5.56%	0.043	0.215
20	2.218	2.499	0.280	12.65%	0.196	0.365
21	2.144	2.466	0.322	15.01%	0.241	0.403
22	2.116	2.458	0.342	16.17%	0.264	0.420
23	1.943	2.303	0.359	18.49%	0.287	0.432
24	1.627	1.967	0.340	20.87%	0.277	0.403
Total Energy	**37.293**	**42.376**	**5.083**	**13.63%**	**3.882**	**6.285**
Off Peak	**9.123**	**10.793**	**1.670**	**18.31%**	**1.346**	**1.995**
Mid-Peak	**19.505**	**22.404**	**2.899**	**14.86%**	**2.249**	**3.550**
On-Peak	**8.665**	**9.168**	**0.502**	**5.80%**	**0.185**	**0.820**

Table 26 displays the hourly demands and impact analysis for the T2 customers compared to the C1 customers. By looking at the 5 kWh or 13.6% increase in total energy consumption, it appears that the T2 group did not reduce their energy consumption in reaction to the TOU rate on hot weather days. However, when we look closely at the hourly consumption, we can see that the increase in consumption during the peak period was much lower than during the rest of the day. During this period, the percentage difference between the two loads was 5.8%, which was much smaller than the 18.31% difference during the off peak period and the 14.86% difference during the mid-peak period. This is easily visible in Figure 31. Hence, it can be inferred that customers with the availability of IHDs responded by shifting their energy consumption way from the on-peak period in a limited extent because of the TOU peak rate. All hours show a statistically significant difference from the control group, so it is certainly possible that the increase in energy consumption was a direct result from customers being on the TOU rate.

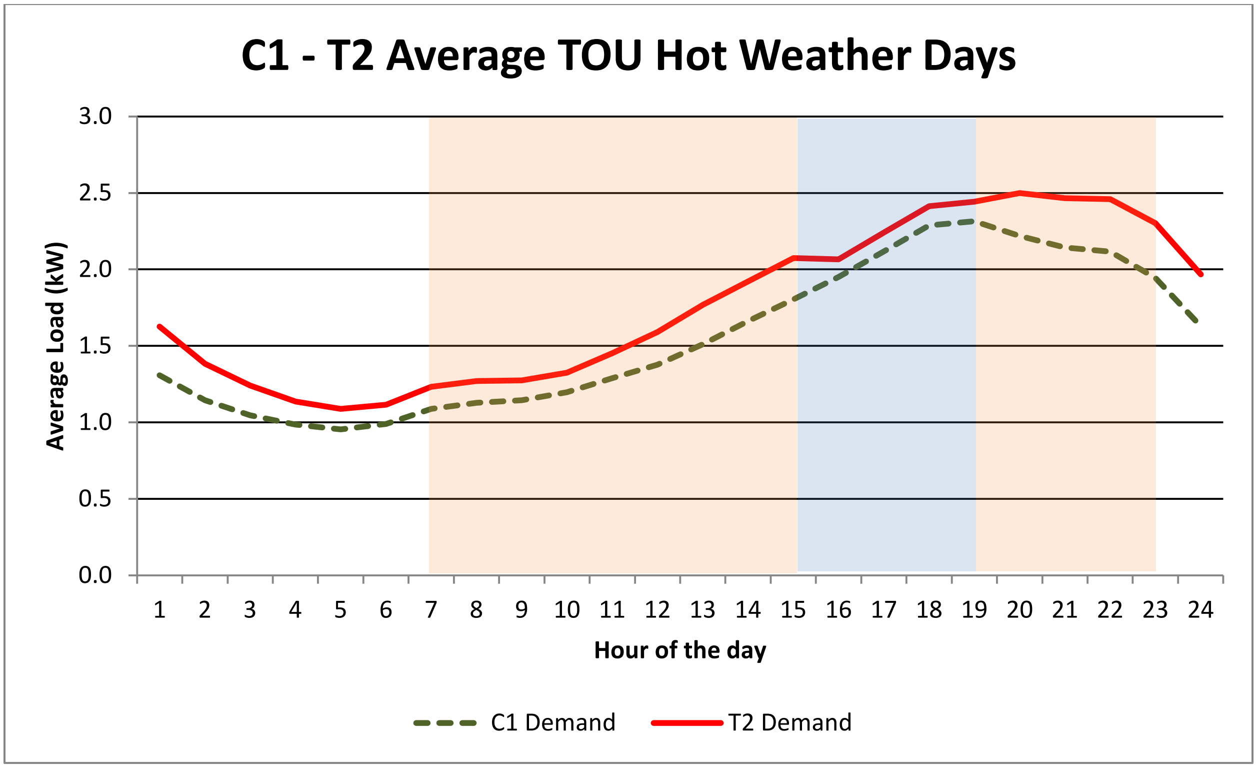


Figure 31: C1 - T2 Average TOU Hot Weather Days

Table 27: C2 - T3 Average TOU Hot Weather Day Demand (All Hours)

C2 - T3 Average TOU Hot Weather Day Demand (All Hours)						
Hour Ending	C2 Demand	T3 Demand	Impact	Impact %	Lower Bound	Upper Bound
1	1.425	1.595	0.171	11.99%	0.116	0.225
2	1.220	1.332	0.112	9.19%	0.063	0.161
3	1.082	1.171	0.089	8.19%	0.044	0.133
4	1.008	1.086	0.078	7.71%	0.037	0.119
5	0.964	1.025	0.061	6.34%	0.023	0.100
6	1.010	1.055	0.046	4.55%	0.007	0.085
7	1.131	1.140	0.009	0.82%	(0.031)	0.050
8*	1.205	1.053	(0.152)	-12.60%	(0.192)	(0.111)
9*	1.207	1.023	(0.184)	-15.23%	(0.228)	(0.140)
10*	1.291	1.040	(0.252)	-19.49%	(0.301)	(0.202)
11*	1.435	1.121	(0.314)	-21.89%	(0.371)	(0.258)
12*	1.598	1.265	(0.333)	-20.82%	(0.394)	(0.271)
13*	1.787	1.418	(0.369)	-20.63%	(0.436)	(0.301)
14*	1.969	1.588	(0.381)	-19.35%	(0.454)	(0.308)
15*	2.135	1.746	(0.389)	-18.21%	(0.467)	(0.311)
16*	2.332	1.648	(0.684)	-29.34%	(0.765)	(0.604)
17*	2.577	1.873	(0.705)	-27.34%	(0.789)	(0.620)
18*	2.773	2.105	(0.668)	-24.09%	(0.755)	(0.581)
19*	2.756	2.093	(0.663)	-24.06%	(0.749)	(0.577)
20*	2.589	2.328	(0.261)	-10.08%	(0.345)	(0.177)
21*	2.470	2.307	(0.164)	-6.63%	(0.245)	(0.083)
22*	2.391	2.282	(0.109)	-4.56%	(0.187)	(0.031)
23*	2.181	1.999	(0.182)	-8.33%	(0.255)	(0.109)
24	1.810	2.034	0.223	12.34%	0.160	0.286
Total Energy*	**42.275**	**37.307**	**(4.968)**	**-11.75%**	**(6.170)**	**(3.767)**
Off Peak	**9.621**	**10.432**	**0.811**	**8.43%**	**0.487**	**1.136**
Mid-Peak*	**22.221**	**19.159**	**(3.061)**	**-13.78%**	**(3.712)**	**(2.411)**
On-Peak*	**10.434**	**7.719**	**(2.715)**	**-26.02%**	**(3.032)**	**(2.397)**

Table 27 displays the hourly demands and impact analysis for the T3 customers compared to the C2 customers. The T3 group reduced their total energy usage by an average of approximately 5 kWh or 11.8% on the hot weather TOU days, as seen in Table 27. These customers began reducing their load beginning in HE 8 and maintained a statistically significant reduction until HE 23 (which included both the mid-peak and peak periods). The reduction in load was lower during the mid-peak period as compared to the on-peak hours, which could mean that customers were pre-cooling their homes using the smart thermostat. T3 customers appear to have shifted their loads from the mid-peak and on-peak periods to the off-peak periods as a result of the TOU rate. The only period that the T3 customers consumed a statistically significant amount of more energy was the off-peak period. The other two periods, mid-peak and on-peak, show a statistically significant reduction in energy consumption, with the largest reduction in consumption coming during the on-peak period when the T3 customers used 26% less energy than their C2 counterparts. The load shifts can be easily seen in Figure 32

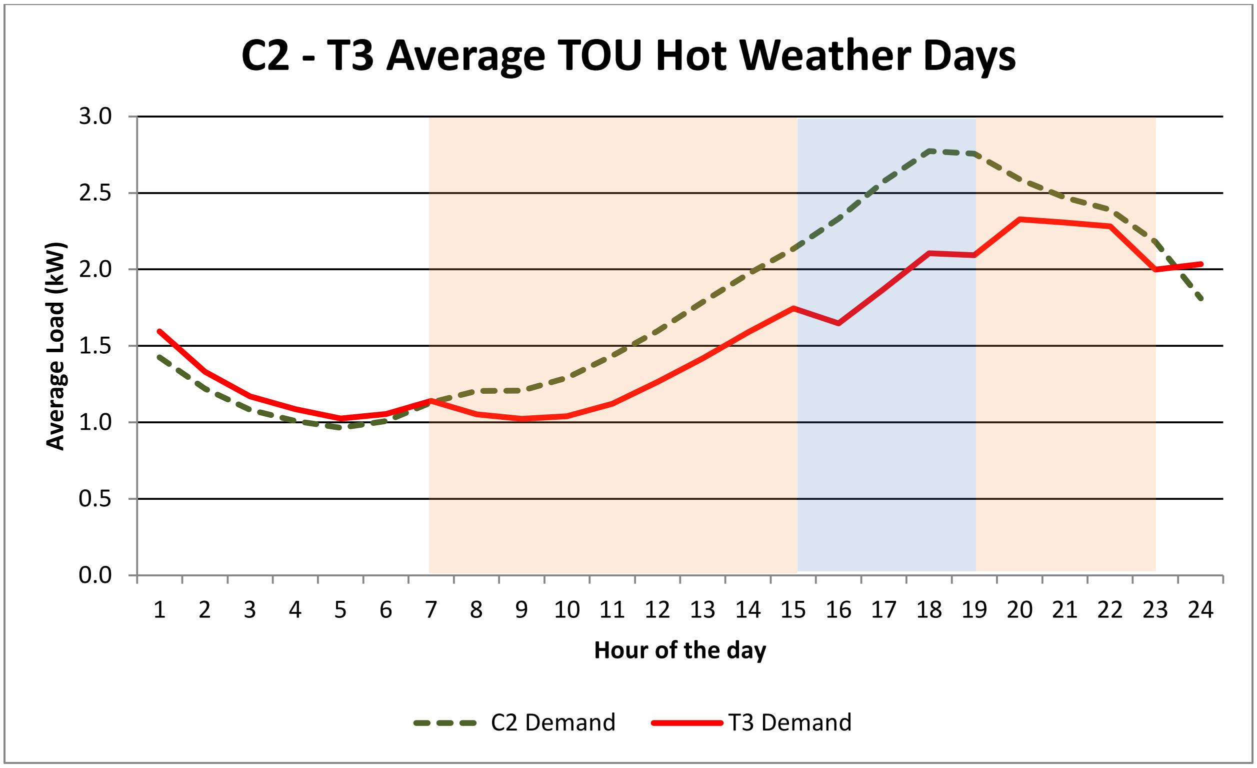


Figure 32: C2 - T3 Average TOU Hot Weather Days

Table 28: C2 - T4 TOU Hot Weather Day Demands (All Hours)

C2 - T4 Average TOU Hot Weather Day Demand (All Hours)						
Hour Ending	C2 Demand	T4 Demand	Impact	Impact %	Lower Bound	Upper Bound
1	1.425	1.614	0.189	13.30%	0.135	0.244
2	1.220	1.361	0.141	11.59%	0.093	0.190
3	1.082	1.177	0.095	8.78%	0.051	0.139
4	1.008	1.068	0.060	5.94%	0.019	0.101
5	0.964	1.011	0.047	4.86%	0.008	0.085
6	1.010	1.054	0.045	4.42%	0.006	0.084
7	1.131	1.179	0.048	4.23%	0.007	0.088
8*	1.205	1.084	(0.121)	-10.02%	(0.161)	(0.080)
9*	1.207	1.040	(0.167)	-13.85%	(0.211)	(0.123)
10*	1.291	1.073	(0.218)	-16.90%	(0.268)	(0.169)
11*	1.435	1.152	(0.283)	-19.75%	(0.340)	(0.227)
12*	1.598	1.263	(0.334)	-20.93%	(0.396)	(0.273)
13*	1.787	1.406	(0.381)	-21.32%	(0.448)	(0.314)
14*	1.969	1.582	(0.387)	-19.66%	(0.460)	(0.314)
15*	2.135	1.743	(0.392)	-18.37%	(0.470)	(0.314)
16*	2.332	1.703	(0.629)	-26.96%	(0.709)	(0.548)
17*	2.577	1.898	(0.679)	-26.36%	(0.764)	(0.595)
18*	2.773	2.111	(0.662)	-23.87%	(0.749)	(0.575)
19*	2.756	2.117	(0.639)	-23.18%	(0.725)	(0.553)
20*	2.589	2.371	(0.217)	-8.39%	(0.302)	(0.133)
21*	2.470	2.345	(0.126)	-5.08%	(0.206)	(0.045)
22	2.391	2.333	(0.058)	-2.42%	(0.136)	0.020
23*	2.181	2.085	(0.096)	-4.40%	(0.169)	(0.023)
24	1.810	2.095	0.284	15.70%	0.221	0.347
Total Energy*	**42.275**	**37.826**	**(4.449)**	**-10.52%**	**(5.650)**	**(3.247)**
Off Peak	**9.621**	**10.547**	**0.926**	**9.62%**	**0.601**	**1.250**
Mid-Peak*	**22.221**	**19.452**	**(2.769)**	**-12.46%**	**(3.420)**	**(2.119)**
On-Peak*	**10.434**	**7.832**	**(2.602)**	**-24.94%**	**(2.919)**	**(2.284)**

Table 28 displays the hourly demands and impact analysis for the T4 customers compared to the C2 customers. The customers in the T4 group reduced their total load by 4.5 kWh or 10.52% during the event day when compared to the C2 control group, as shown in Table 28. A statistically significant reduction in load began during HE 8 and was maintained until HE 21. Like the T3 group customers, the T4 customers used a statistically significant amount of more energy during the off peak period and reduced their load by statistically significant amounts during the mid-peak and on-peak periods. The largest reduction occurred in the on-peak period when the T4 customers used 25% less energy than the

C2 group. Providing that the T3 customers appeared to have the same consumption patterns as the T4 customers, it is believed that the PCT was having the biggest influence on when the customers used energy. The overall reduction in load, however, was slightly less than the T3 group customers, indicating the combination of IHD along with a PCT might not be any more effective than only the PCT.

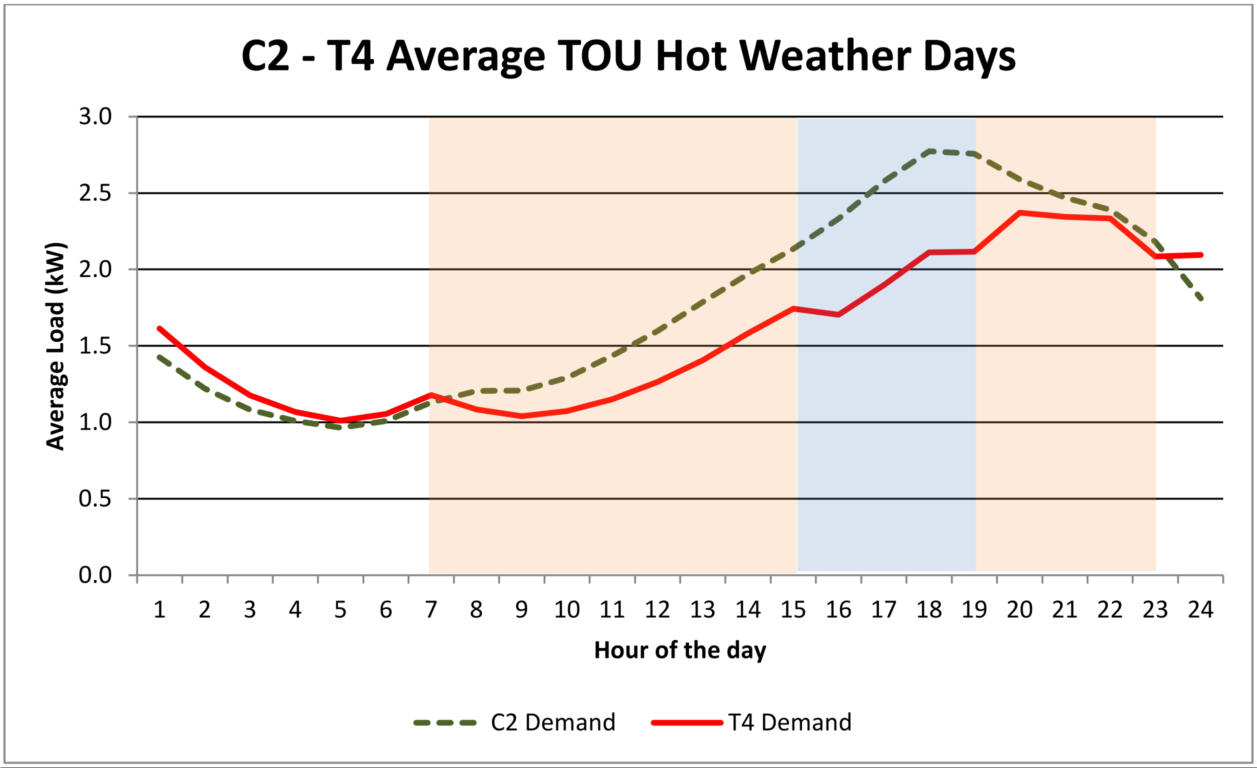


Figure 33: C2 - T4 All TOU Hot Weather Days

Cold Weather TOU Days

Table 29: C1 - T1 Average TOU Cold Weather Day Demand (All Hours)

C1 - T1 Average TOU Cold Weather Day Demand (All Hours)						
Hour Ending	C1 Demand	T1 Demand	Impact	Impact %	Lower Bound	Upper Bound
1	1.037	1.116	0.079	7.60%	0.043	0.114
2	0.981	1.046	0.065	6.59%	0.031	0.098
3	0.937	1.010	0.073	7.78%	0.042	0.104
4	0.941	0.999	0.058	6.16%	0.027	0.089
5	0.967	1.021	0.053	5.52%	0.022	0.085
6	1.079	1.097	0.019	1.73%	(0.014)	0.052
7	1.218	1.259	0.041	3.38%	0.003	0.079
8	1.256	1.324	0.068	5.43%	0.029	0.107
9	1.175	1.243	0.068	5.78%	0.030	0.106
10	1.121	1.195	0.074	6.57%	0.035	0.112
11	1.095	1.191	0.096	8.74%	0.057	0.134
12	1.091	1.177	0.086	7.92%	0.048	0.124
13	1.099	1.164	0.065	5.87%	0.027	0.103
14	1.102	1.148	0.046	4.15%	0.008	0.084
15	1.117	1.171	0.054	4.82%	0.016	0.092
16	1.167	1.200	0.033	2.82%	(0.006)	0.072
17	1.300	1.316	0.016	1.26%	(0.025)	0.058
18	1.573	1.577	0.003	0.22%	(0.045)	0.052
19	1.746	1.772	0.027	1.52%	(0.024)	0.078
20	1.761	1.837	0.077	4.37%	0.025	0.129
21	1.741	1.808	0.066	3.80%	0.015	0.117
22	1.647	1.723	0.076	4.62%	0.026	0.126
23	1.438	1.530	0.092	6.41%	0.047	0.137
24	1.217	1.308	0.091	7.47%	0.051	0.131
Total Energy	**29.808**	**31.233**	**1.425**	**4.78%**	**0.637**	**2.213**
Off Peak	**8.379**	**8.856**	**0.477**	**5.69%**	**0.231**	**0.723**
Mid-Peak	**15.644**	**16.509**	**0.865**	**5.53%**	**0.443**	**1.287**
On-Peak	**5.785**	**5.865**	**0.079**	**1.37%**	**(0.082)**	**0.241**

Table 29 displays the hourly demands and impact analysis for the T1 customers compared to the C1 customers. When looking at the hourly demands, it appears that the T1 group did not reduce their energy consumption in reaction to the TOU rate on cold weather days. The T1 customers with no technology used a statistically significant higher level of energy during the entire day, as also can be observed in Figure 34. However, despite consuming more energy during the day, the percentage difference between the T1 load and the C1 load is smallest during the on-peak period at 1.37% and is not a statistically significant amount. The largest percentage difference was during the off peak period when the treatment group customers used 5.69% more energy than the control group customers. This pattern indicates that the T1 customers shifted their load during the cold days in response to the TOU rate.

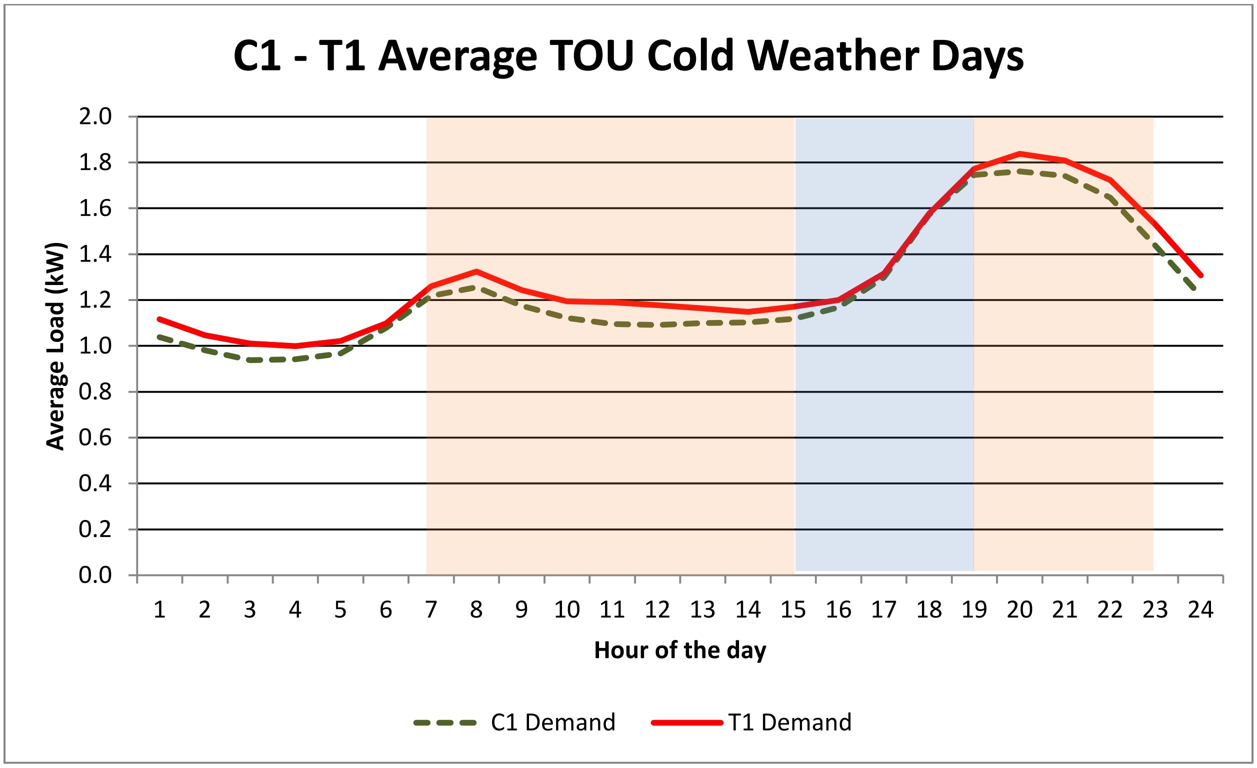


Figure 34: C1 - T1 Average TOU Cold Weather Days

Table 30: C1 - T2 Average TOU Cold Weather Day Demand (All Hours)

C1 - T2 Average TOU Cold Weather Day Demand (All Hours)						
Hour Ending	C1 Demand	T2 Demand	Impact	Impact %	Lower Bound	Upper Bound
1	1.037	1.146	0.109	10.47%	0.073	0.144
2	0.981	1.086	0.104	10.64%	0.071	0.138
3	0.937	1.061	0.124	13.21%	0.093	0.155
4	0.941	1.051	0.110	11.72%	0.079	0.141
5	0.967	1.096	0.128	13.27%	0.097	0.160
6	1.079	1.191	0.112	10.42%	0.079	0.145
7	1.218	1.376	0.158	13.00%	0.121	0.196
8	1.256	1.428	0.172	13.69%	0.133	0.211
9	1.175	1.299	0.124	10.55%	0.086	0.162
10	1.121	1.238	0.117	10.45%	0.079	0.156
11	1.095	1.201	0.106	9.65%	0.067	0.144
12	1.091	1.187	0.096	8.80%	0.058	0.134
13	1.099	1.172	0.073	6.68%	0.035	0.111
14	1.102	1.165	0.063	5.69%	0.025	0.101
15	1.117	1.181	0.063	5.68%	0.025	0.102
16	1.167	1.209	0.042	3.58%	0.003	0.081
17	1.300	1.351	0.052	3.98%	0.011	0.093
18	1.573	1.668	0.094	6.00%	0.046	0.143
19	1.746	1.867	0.121	6.96%	0.070	0.172
20	1.761	1.923	0.163	9.25%	0.111	0.215
21	1.741	1.905	0.163	9.38%	0.112	0.215
22	1.647	1.801	0.154	9.36%	0.104	0.204
23	1.438	1.570	0.133	9.23%	0.088	0.177
24	1.217	1.338	0.122	10.00%	0.081	0.162
Total Energy	**29.808**	**32.496**	**2.688**	**9.02%**	**1.900**	**3.476**
Off Peak	**8.379**	**9.346**	**0.967**	**11.54%**	**0.721**	**1.214**
Mid-Peak	**15.644**	**17.065**	**1.421**	**9.08%**	**0.999**	**1.843**
On-Peak	**5.785**	**6.095**	**0.309**	**5.35%**	**0.148**	**0.471**

Table 30 displays the hourly demands and impact analysis for the T2 customers compared to the C1 customers. By looking at the 2.68 kWh or 9% increase in total energy consumption, it appears that the T2 group did not reduce their energy consumption in reaction to the TOU rate on cold weather days. However, when we look closely at the hourly consumption, we can see that the increase in consumption during the start of the peak period was much lower than during the rest of the day. This is more easily visible in Figure 35. During the on-peak period, the treatment group used 5.4% more energy than the control group, and during the off-peak period, T4 customers used 11.5% more energy than C1 customers. Much like the T1 customers, this pattern appears to indicate that the T2 customers were responding to the TOU rate by shifting their load to the hours with lowest cost.

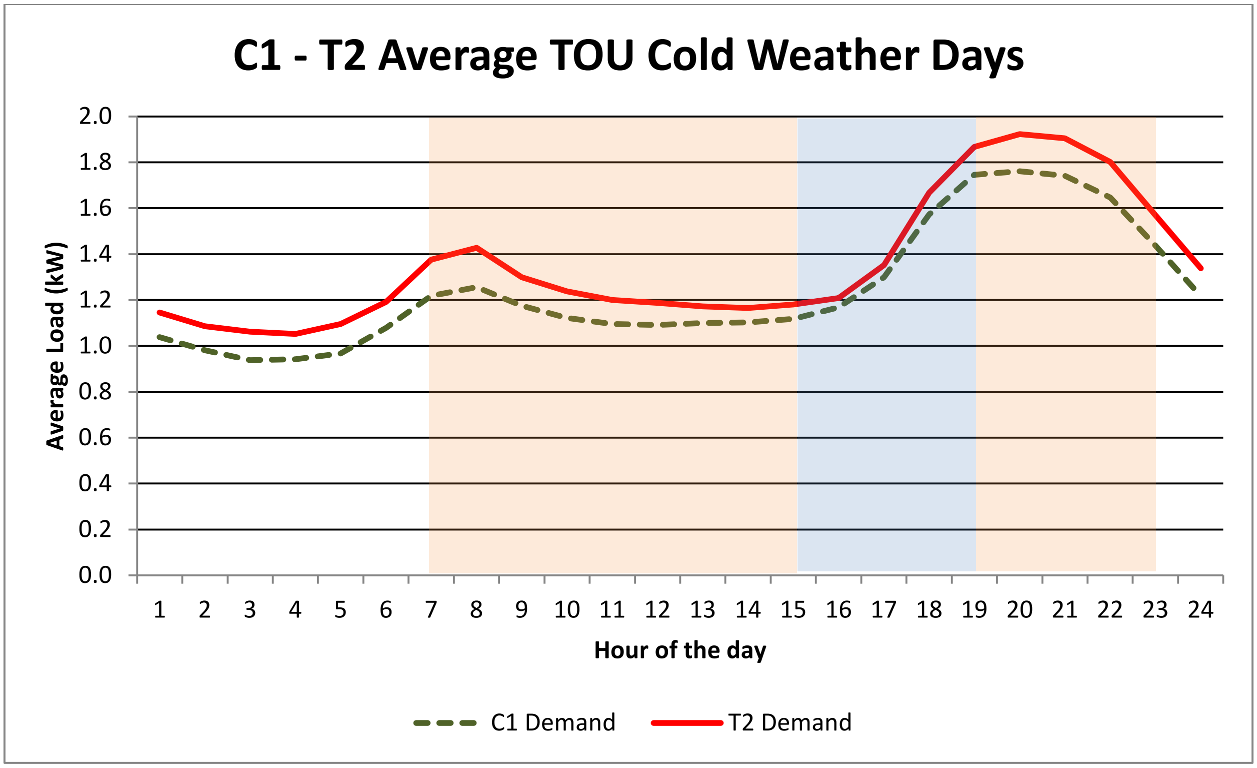


Figure 35: C1 - T2 Average TOU Cold Weather Days

Table 31: C2 - T3 Average TOU Cold Weather Day Demand (All Hours)

C2 - T3 Average TOU Cold Weather Day Demand (All Hours)						
Hour Ending	C2 Demand	T3 Demand	Impact	Impact %	Lower Bound	Upper Bound
1*	1.039	0.956	(0.082)	-7.92%	(0.118)	(0.047)
2*	0.967	0.882	(0.085)	-8.82%	(0.119)	(0.052)
3*	0.945	0.854	(0.091)	-9.67%	(0.123)	(0.060)
4*	0.948	0.863	(0.085)	-8.98%	(0.116)	(0.054)
5*	0.985	0.912	(0.074)	-7.48%	(0.105)	(0.042)
6	1.067	1.042	(0.025)	-2.35%	(0.058)	0.008
7	1.246	1.208	(0.037)	-3.00%	(0.075)	0.000
8*	1.294	1.168	(0.126)	-9.75%	(0.165)	(0.087)
9*	1.208	1.083	(0.125)	-10.32%	(0.163)	(0.086)
10*	1.160	1.037	(0.123)	-10.60%	(0.161)	(0.085)
11*	1.143	1.028	(0.115)	-10.02%	(0.153)	(0.076)
12*	1.131	1.024	(0.107)	-9.44%	(0.145)	(0.069)
13*	1.129	1.020	(0.108)	-9.60%	(0.146)	(0.070)
14*	1.120	1.015	(0.105)	-9.38%	(0.143)	(0.067)
15*	1.138	1.022	(0.115)	-10.15%	(0.154)	(0.077)
16*	1.179	1.056	(0.123)	-10.42%	(0.162)	(0.084)
17*	1.313	1.204	(0.109)	-8.31%	(0.150)	(0.068)
18*	1.622	1.487	(0.135)	-8.31%	(0.183)	(0.087)
19*	1.794	1.625	(0.170)	-9.46%	(0.221)	(0.119)
20*	1.804	1.646	(0.158)	-8.78%	(0.210)	(0.106)
21*	1.779	1.622	(0.157)	-8.82%	(0.208)	(0.106)
22*	1.703	1.526	(0.177)	-10.41%	(0.227)	(0.128)
23*	1.531	1.323	(0.209)	-13.64%	(0.254)	(0.164)
24*	1.258	1.135	(0.123)	-9.81%	(0.164)	(0.083)
Total Energy*	**30.499**	**27.737**	**(2.762)**	**-9.06%**	**(3.550)**	**(1.973)**
Off Peak*	**8.456**	**7.852**	**(0.604)**	**-7.14%**	**(0.851)**	**(0.358)**
Mid-Peak*	**16.135**	**14.510**	**(1.625)**	**-10.07%**	**(2.047)**	**(1.202)**
On-Peak*	**5.908**	**5.372**	**(0.536)**	**-9.07%**	**(0.697)**	**(0.374)**

Table 31 displays the hourly demands and impact analysis for the T3 customers compared to the C2 customers. The T3 group reduced their total energy usage by an average of approximately 2.76 kWh or 9% on the cold weather TOU days, as indicated in Table 31. A statistically significant reduction in load was witnessed throughout the day except during HE 6 and HE 7. The average reduction in load was almost constant in the mid-peak periods and peak period, as can also be seen in Figure 36. The largest reduction by the T3 customers occurred during the mid-peak period (10%) as opposed to the on-peak period (9%) which was unexpected. While all three periods experienced a statistically significant reduction, it was assumed that the load reductions would be the same as the hot summer days with the largest reduction occurring during the on-peak period. The off peak period still had the smallest reduction at 7%, which can be attributed to the low price point. The T3 customers were still shifting their load to periods with lower costs as a result of the TOU rate during the cold weather days.

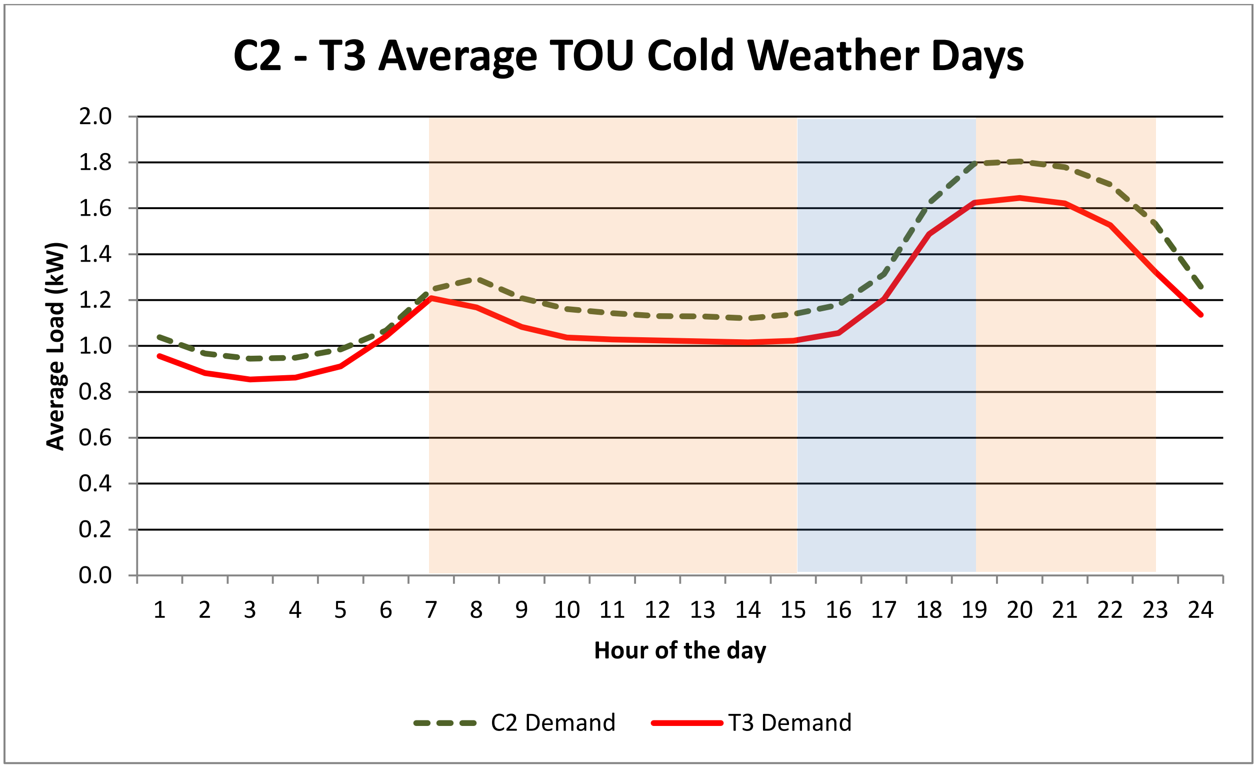


Figure 36: C2 - T3 Average TOU Cold Weather Days

Table 32: C2 - T4 TOU Cold Weather Day Demands (All Hours)

C2 - T4 Average TOU Cold Weather Day Demand (All Hours)						
Hour Ending	C2 Demand	T4 Demand	Impact	Impact %	Lower Bound	Upper Bound
1*	1.039	0.970	(0.069)	-6.63%	(0.104)	(0.033)
2*	0.967	0.906	(0.062)	-6.38%	(0.095)	(0.028)
3*	0.945	0.886	(0.059)	-6.22%	(0.090)	(0.028)
4*	0.948	0.883	(0.065)	-6.81%	(0.096)	(0.033)
5*	0.985	0.946	(0.039)	-3.99%	(0.071)	(0.008)
6	1.067	1.076	0.009	0.82%	(0.024)	0.042
7	1.246	1.238	(0.008)	-0.62%	(0.046)	0.030
8*	1.294	1.207	(0.087)	-6.75%	(0.126)	(0.048)
9*	1.208	1.075	(0.133)	-10.97%	(0.171)	(0.094)
10*	1.160	1.027	(0.133)	-11.48%	(0.172)	(0.095)
11*	1.143	0.996	(0.147)	-12.83%	(0.185)	(0.108)
12*	1.131	0.997	(0.134)	-11.83%	(0.172)	(0.096)
13*	1.129	0.991	(0.138)	-12.22%	(0.176)	(0.100)
14*	1.120	0.987	(0.133)	-11.85%	(0.171)	(0.095)
15*	1.138	1.000	(0.138)	-12.12%	(0.176)	(0.100)
16*	1.179	1.041	(0.138)	-11.73%	(0.177)	(0.099)
17*	1.313	1.174	(0.140)	-10.66%	(0.181)	(0.099)
18*	1.622	1.449	(0.173)	-10.68%	(0.221)	(0.125)
19*	1.794	1.620	(0.174)	-9.70%	(0.225)	(0.123)
20*	1.804	1.656	(0.148)	-8.23%	(0.200)	(0.096)
21*	1.779	1.611	(0.168)	-9.44%	(0.219)	(0.117)
22*	1.703	1.532	(0.171)	-10.03%	(0.220)	(0.121)
23*	1.531	1.315	(0.217)	-14.17%	(0.262)	(0.172)
24*	1.258	1.123	(0.135)	-10.75%	(0.175)	(0.095)
Total Energy*	**30.499**	**27.710**	**(2.789)**	**-9.14%**	**(3.577)**	**(2.000)**
Off Peak*	**8.456**	**8.028**	**(0.428)**	**-5.06%**	**(0.675)**	**(0.182)**
Mid-Peak*	**16.135**	**14.396**	**(1.739)**	**-10.78%**	**(2.161)**	**(1.316)**
On-Peak*	**5.908**	**5.283**	**(0.624)**	**-10.57%**	**(0.786)**	**(0.463)**

Table 32 displays the hourly demands and impact analysis for the T4 customers compared to the C2 customers. The customers in the T4 group reduced their total load by 2.79 kWh or 9.14% during the cold weather TOU days when compared to the C2 control group, as shown in Table 32. A statistically significant reduction in load was witnessed throughout the day except HE 6 and HE 7. As observed in Figure 37, the reduction in load was more significant in the mid-peak periods and peak period as opposed to off-peak periods. Much like the T3 customers, the T4 customers' largest percentage decrease occurred during the mid-peak hours at 10.8%. The smallest decrease in energy reduction when compared to the C2 control group occurred during the off peak period with a reduction of 5%. As was previously stated in the T3 discussion it would be expected that the largest reduction would occur during the on-peak period. However, despite this, it can still be determined that the TOU rate was causing the treatment group customers to shift their load to periods with lower costs during the cold weather days.

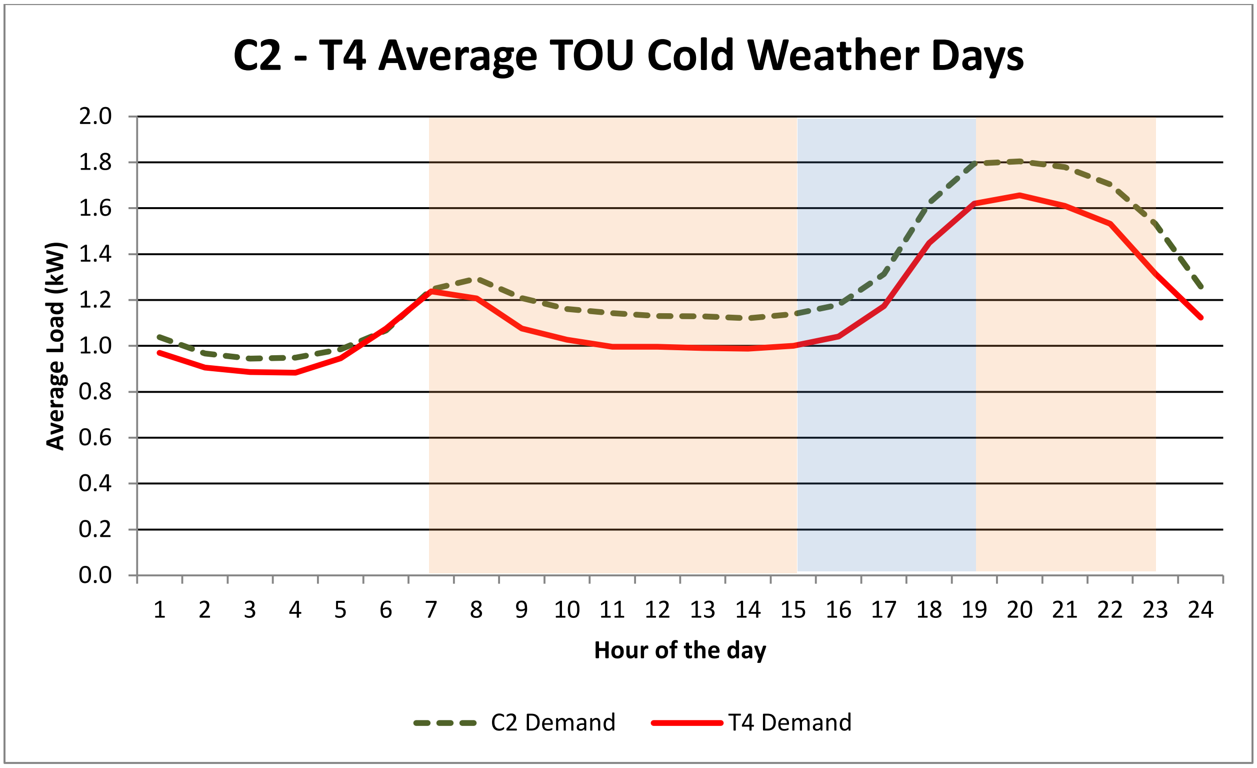


Figure 37: C2 - T4 All TOU Cold Weather Days

6.a.iii. Cohort Event Days Evaluation Results

The CPP event day analysis was further conducted for cohorts based on usage levels, income levels, and presence/absence of central air-conditioning (CAC). Customers in these cohorts were analyzed separately for the various technology combinations as follows:

- Medium usage customer groups (T1_04, T2_04, T3_04, T4_04)
- High usage customer group (T1_05, T2_05, T3_05, T4_05)
- Low income customer groups (T1_06, T2_06, T3_06, T4_06)
- Medium income customer groups (T1_07, T2_07, T3_07, T4_07)
- High income customer groups (T1_08, T2_08, T3_08, T4_08)
- Customers with CAC (T1_09, T2_09)
- Customers without CAC (T1_10, T2_10)

Note: all T3 and T4 (customers with PCTs) had CAC.

Table 33: Average Event Day Demand by Usage Type and Technology

Usage Type	Technology	Peak period consumption (kWh)			Total consumption (kWh)		
		Control	Impact	Impact %	Control	Impact	Impact %
Medium Usage	No Technology	7.751	(1.378)	-17.78%	33.811	(0.992)	-2.93%
	With IHD	7.751	(2.084)	-26.89%	33.811	(0.380)	-1.12%
	With PCT	9.401	(4.025)	-42.81%	37.923	(3.278)	-8.64%
	With IHD and PCT	9.401	(3.709)	-39.45%	37.923	(3.233)	-8.53%
High Usage	No Technology	15.629	(1.741)	-11.14%	67.933	2.654	3.91%
	With IHD	15.629	(2.987)	-19.12%	67.933	2.597	3.82%
	With PCT	16.680	(6.725)	-40.32%	69.231	(8.947)	-12.92%
	With IHD and PCT	16.680	(6.983)	-41.86%	69.231	(7.346)	-10.61%

Table 33 displays the peak period and total consumption and impacts for different cohorts by usage type and technology[11]. The medium usage and high usage groups show a similar trend; that is, customers with no technology showing the least reduction in peak period consumption, with significant improvements in load reductions given the addition of PCTs. For high usage customers, the treatment group customers without technology or with only IHDs, actually increased their total consumption. While all other groups reduced their total event day consumption, some load shifting was occurring, as neither of the total reduction percentages is as high as the peak period reduction percentage. This of course also signifies that the higher event-based pricing was effective.

The PCT-only medium usage group has the highest actual (4 kWh, 3.2 kWh) and percentage (42.8%, 8.6%) peak and total reduction, respectively among all medium usage groups; hence, providing only PCTs could be considered as the most effective way to reduce consumption. The high usage groups with only IHDs also result in a significant 3 kWh peak reduction, though it is less than half of that with PCTs. IHDs with PCTs gave the maximum peak reduction, while only PCTs gave the maximum overall reduction. Further analysis comparing medium and high usage groups by technology is provided below, along with graphs displaying the respective load curves.

[11] See Table 18 for usage parameters

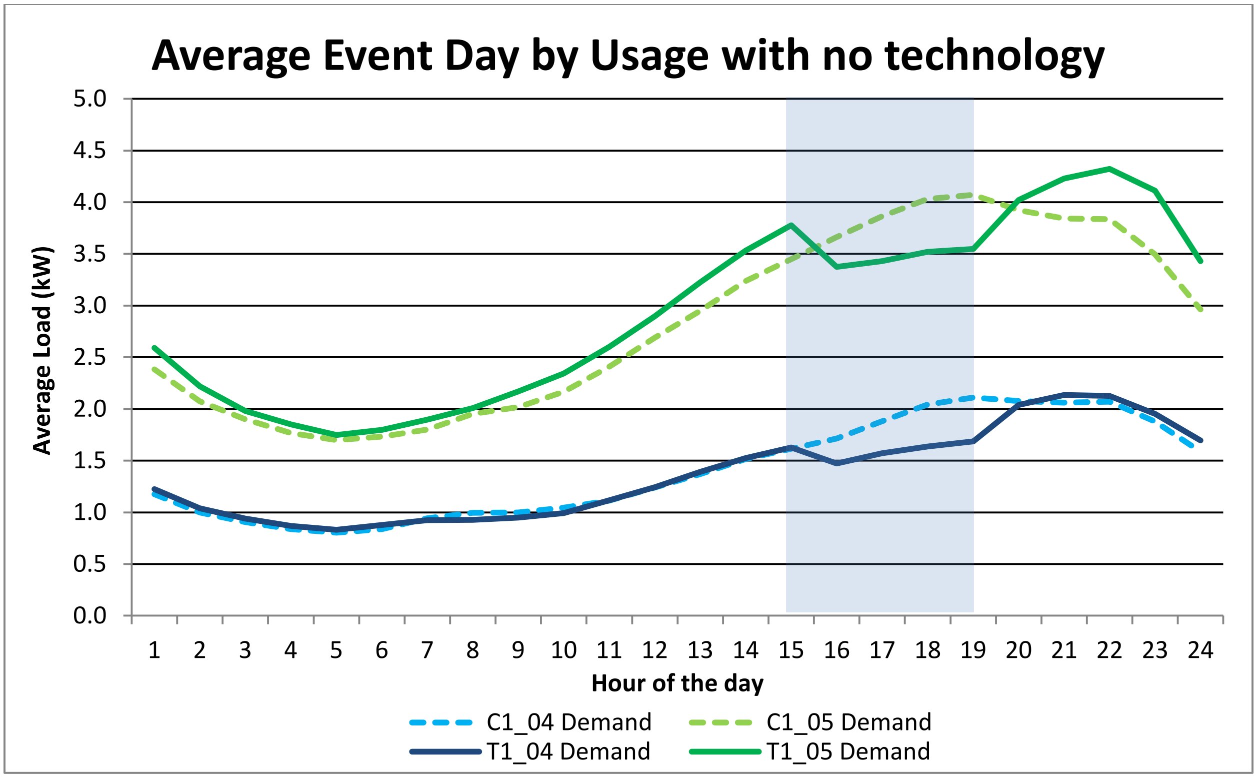


Figure 38: Average Event Day Load Profiles by Usage with no technology

Figure 38 shows the load curves for medium usage (C1_04, T1_04) and high usage (C1_05, T1_05) control and treatment groups, respectively, with no technology. Hourly data and impact analysis can be seen in Appendix F. The medium usage treatment group customers matched the control group for most hours except during the peak event period and HE 20, with a load reduction of 1.38 kWh (17.78%) during the peak period. In contrast, the high usage treatment group customer load profile showed a shift in load from peak periods to the hours just before and after the peak periods; hence, even though they reduced the peak load by 1.74 kWh (11.14%), they actually increased their total load by 2.65 kWh (3.91%). It can be deduced that during CPP event days, high usage customers had more flexibility in shifting their peak load without reducing their overall load; the medium usage customers may not have enjoyed this flexibility, but they still conserved during the CPP event day's peak period.

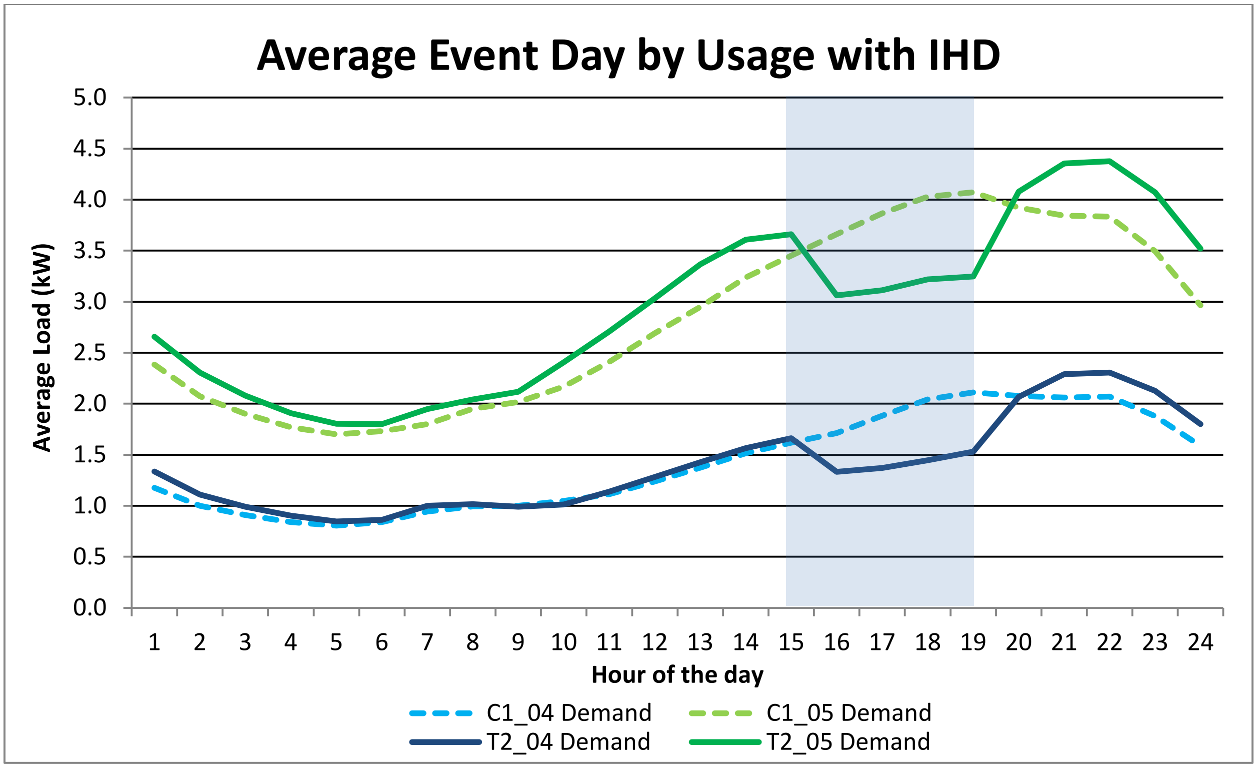


Figure 39: Average Event Day Load Profiles by Usage with IHD

Figure 39 shows the load curves for medium usage (C1_04, T2_04) and high usage (C1_05, T2_05) control and treatment groups, respectively, with IHD. Hourly data and impact analysis can be seen in Appendix F. The medium usage treatment group customers match the control group up until the start of the peak period, after which there was a load reduction of 2.08 kWh (26.89%) during the peak period and then an increase in load till the end of the day. The high usage treatment group customer load profile showed higher consumption all day except during the peak period. A shift in load from peak periods to the hours just before and after the peak periods was also observed; hence, while they reduced the peak load by about 3 kWh (19.12%), they actually increased their total load by 2.6 kWh (3.82%) just as the earlier group did. The presence of IHD increased the level of load reduction for both medium and high usage customers, and it also assisted the medium usage customers in load shifting.

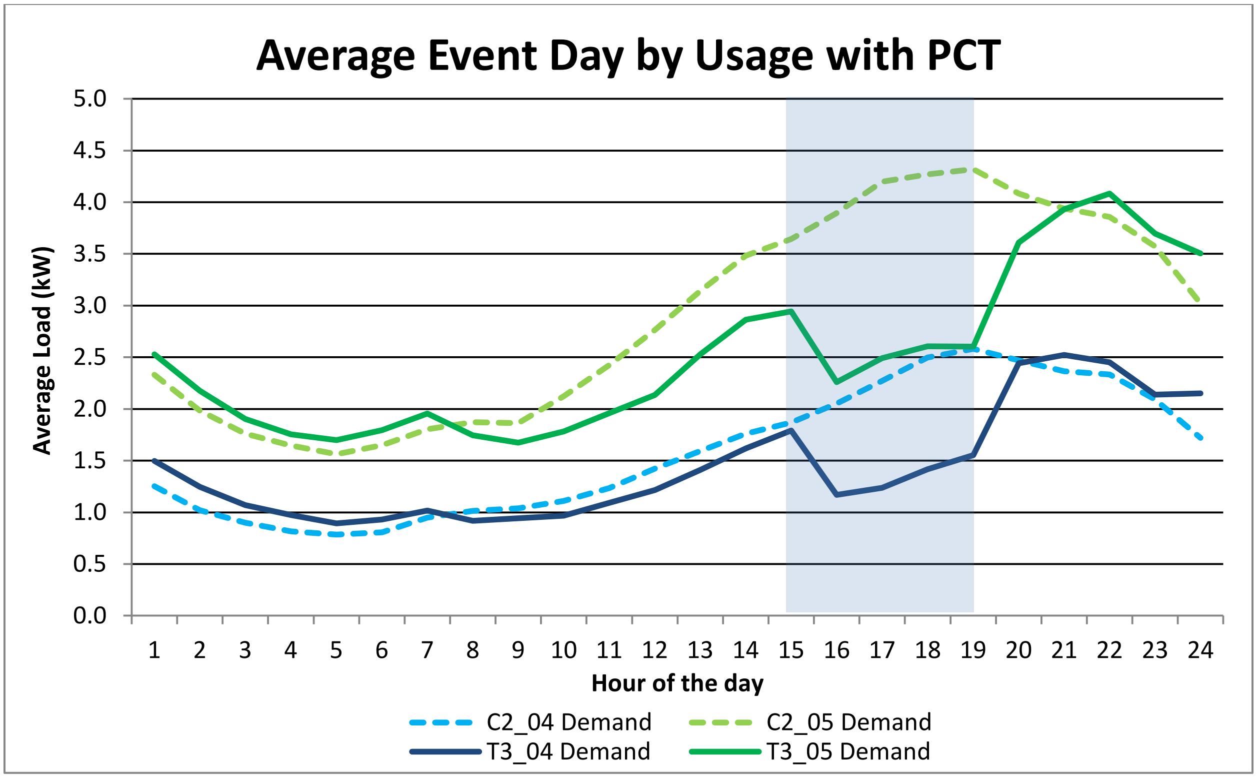


Figure 40: Average Event Day Load Profiles by Usage with PCT

Figure 40 shows the load curves for medium usage (C2_04, T3_04) and high usage (C2_05, T3_05) control and treatment groups, respectively, with PCTs. Hourly data and impact analysis can be seen in Appendix F. The medium usage and high usage treatment group customers both followed a similar load profile pattern with increased loads during the early morning and late night off-peak hours, slight reduction in load during the mid-peak hours and a drastic reduction in load during the CPP event hours. The medium usage treatment group customers followed a conservative TOU pricing load curve that increased load during the off-peak period, a slight decrease in load during the mid-peak period, and high reduction in load during the peak period (4 kWh, 42.81%). The high usage customers also reduced their consumption to a greater extent during the mid-peak period, resulting in higher overall load reduction of 8.95 kWh as against the peak time reduction of 6.73 kWh, which is not seen in the earlier groups. These high usage customers equipped with PCTs did not tend to perform any pre-cooling or increase any other energy consuming activities before the CPP event.

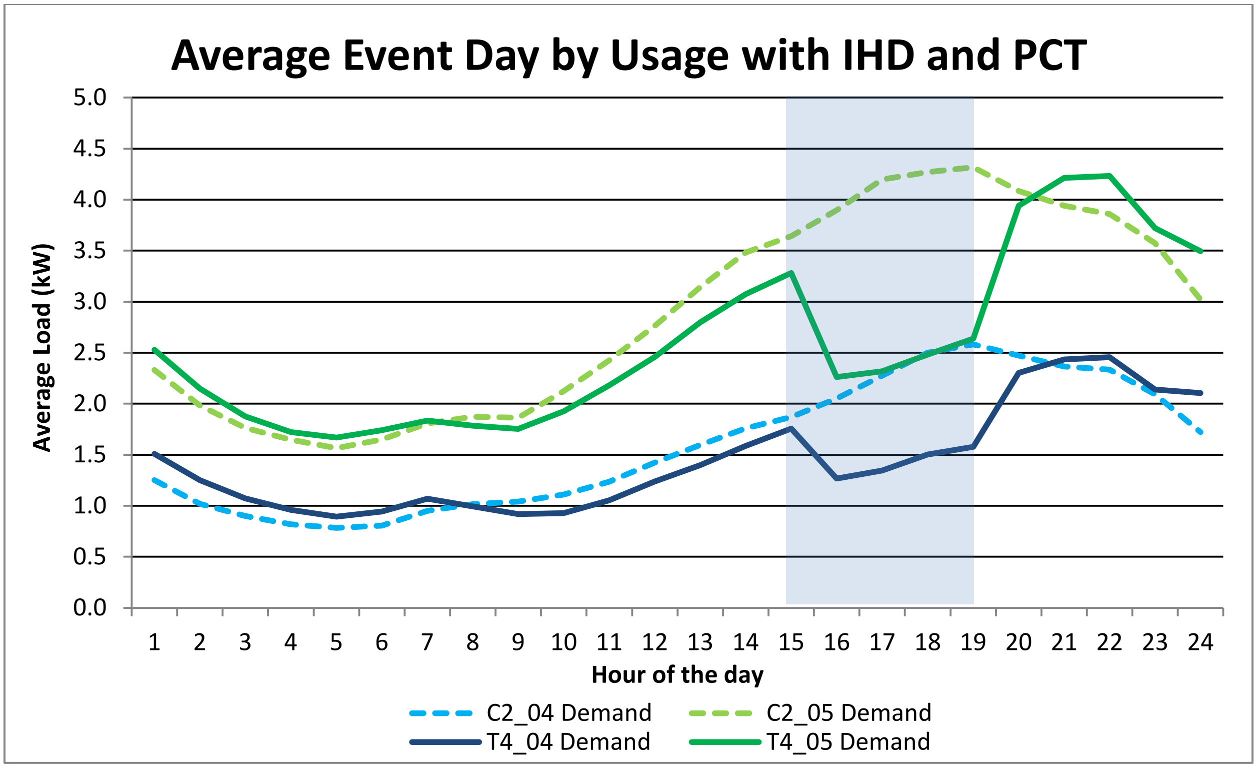


Figure 41: Average Event Day Load Profiles by Usage with IHD and PCT

Figure 41 shows the load curves for medium usage (C2_04, T4_04) and high usage (C2_05, T4_05) control and treatment groups, respectively, with IHDs and PCTs. Hourly data and impact analysis can be seen in Appendix F. The medium usage and high usage treatment group customers both followed a similar load profile pattern, with increased loads during the early morning and late night off-peak hours, a slight reduction in load during the mid-peak hours, and a drastic reduction in load during the event peak hours. Even though equipped with PCTs and IHDs, the medium usage treatment group customers reduced their peak time load by 3.71 kWh (39.45%), which was slightly less than the medium usage customers with only PCTs. The high usage customers showed a slightly better peak reduction of almost 7 kWh (41.86%). The high usage did show some load shifting, which might be due to the presence of IHDs; hence, their overall load reduction is 7.34 kWh. Both medium and high usage customers so equipped did not tend to perform any pre-cooling or increase any energy consuming activities before the CPP event.

Table 34: Average Event Day Demand by Income level and Technology

Income Level	Technology	On -Peak period consumption (kWh)			Total consumption (kWh)		
		Control	Impact	Impact %	Control	Impact	Impact %
Low Income	No Technology	9.003	(1.292)	-14.35%	39.436	(1.882)	-4.77%
	With IHD	9.003	(0.481)	-5.34%	39.436	8.047	20.41%
	With PCT	11.318	(4.989)	-44.08%	47.505	(9.965)	-20.98%
	With IHD and PCT	11.318	(5.280)	-46.65%	47.505	(5.667)	-11.93%
Medium Income	No Technology	7.021	(1.487)	-21.18%	30.747	(1.079)	-3.51%
	With IHD	7.021	(1.354)	-19.29%	30.747	3.597	11.70%
	With PCT	9.381	(4.509)	-48.07%	38.309	(5.179)	-13.52%
	With IHD and PCT	9.381	(3.749)	-39.96%	38.309	(4.921)	-12.84%
High Income	No Technology	10.844	(1.427)	-13.16%	47.101	1.289	2.74%
	With IHD	10.844	(2.672)	-24.64%	47.101	(0.259)	-0.55%
	With PCT	12.291	(5.350)	-43.53%	49.705	(6.060)	-12.19%
	With IHD and PCT	12.291	(5.348)	-43.51%	49.705	(7.564)	-15.22%

Table 34 displays the peak period and total consumption and impacts for different cohorts by income level and technology during the CPP events[12]. All three income level groups reduced their event day peak period loads by at least 5%, but those having PCTs (with or without IHDs) had peak period reductions generally in excess of 40%. The total consumption did not reduce across the board. Three cohorts: Low-income with IHDs (T2_06), medium income with IHDs (T2_07), and high income with no technology (T1_08) increased their overall consumption, as much as 20% (8 kWh) for the low-income with IHD group. Despite the increased usage by low and medium income technology with an IHD, DTE does not conclude that the presence of an IHD caused these customers to increase their usage. This was more than likely caused by some data abnormalities.

Another interesting observation from Table 34 is that the low income control group consumed more energy than the medium income control group. By looking at the makeup of the low income control group vs the medium income control group, the low income group had a higher percentage of customers that fell in the high usage category. While it can't be said with certainty why this occurred, it can be speculated that low income customers do not have the discretionary income to spend on energy efficient products, houses might not be insulated properly, appliances could be older or simply the connection between cost and energy savings has not been recognized.

Among the low-income group, customers with no technology produced larger reductions during the on-peak period results than customers with IHDs. Customers with only PCTs reduced their peak demand by

[12] See Table 18 for income level parameters

almost 5 kWh (or 44%) and overall demand by almost 10 kWh (21%), showing that PCTs might be best way to get significant peak and overall reductions in low-income households.

For medium income, peak reductions were similar for customers without any technology or with IHDs (about 1.4 kWh or 20%). For middle income customers, the best peak and overall were seen for the group with only PCTs (T3_07); the reductions were even higher than those with PCTs and IHDs, showing that the addition of IHD actually did not help middle income customers.

For high income customers with no technology, the percentage reductions were lower than those seen even by low and middle income customers. High income customers tended to react better with the availability of more technology. High income customers have the best peak and overall load reductions with the help of both PCT and IHD, though the PCT-only group also had similarly good peak period reductions. An interesting observation is that peak period and total load for low income and high income customer groups were higher than that of middle income groups in this study. The low income group with PCT's did show significant savings, not only in percentage terms, but also in absolute load reduction values. Further analysis comparing low, medium, and high income groups by technology is provided below along with graphs displaying the respective load curves.

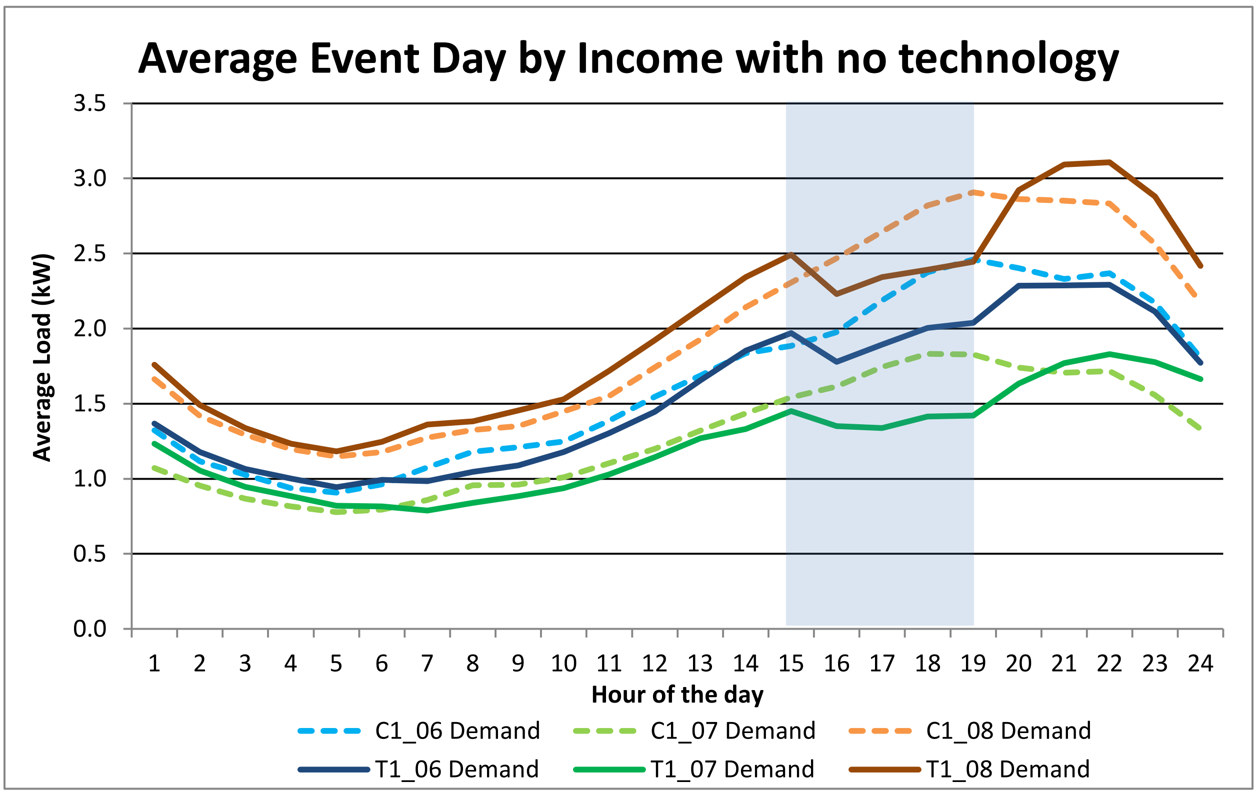


Figure 42: Average Event Day Load Profiles by Income with no technology

Figure 42 shows the load curves for low income (C1_06, T1_06), medium income (C1_07, T1_07), and high income (C1_08, T1_08) control and treatment groups, respectively, with no technology. Hourly data and impact analysis can be seen in Appendix F. The low income customers moderately reduced their usage for a few hours in the morning and then sharply reduced their usage during the peak event hours, thereby having a peak reduction of 1.3 kWh, but an overall total load reduction of 1.9 kWh. The middle income group tends to show a flatter curve by avoiding an increased load during the peak period, as done by its control group, with a slight increase during the after-event off-peak hour; hence, this group achieves a 1.5 kWh peak reduction and a 1.08 kWh total reduction. The high income treatment group customers increased their load throughout the day except for the sharp reduction during the peak period. While they showed a decent peak period reduction of 1.4 kWh, they actually have a slightly higher overall load than their control group (by 1.3 kWh). It can be deduced that middle income customers responded best without the help of any technology.

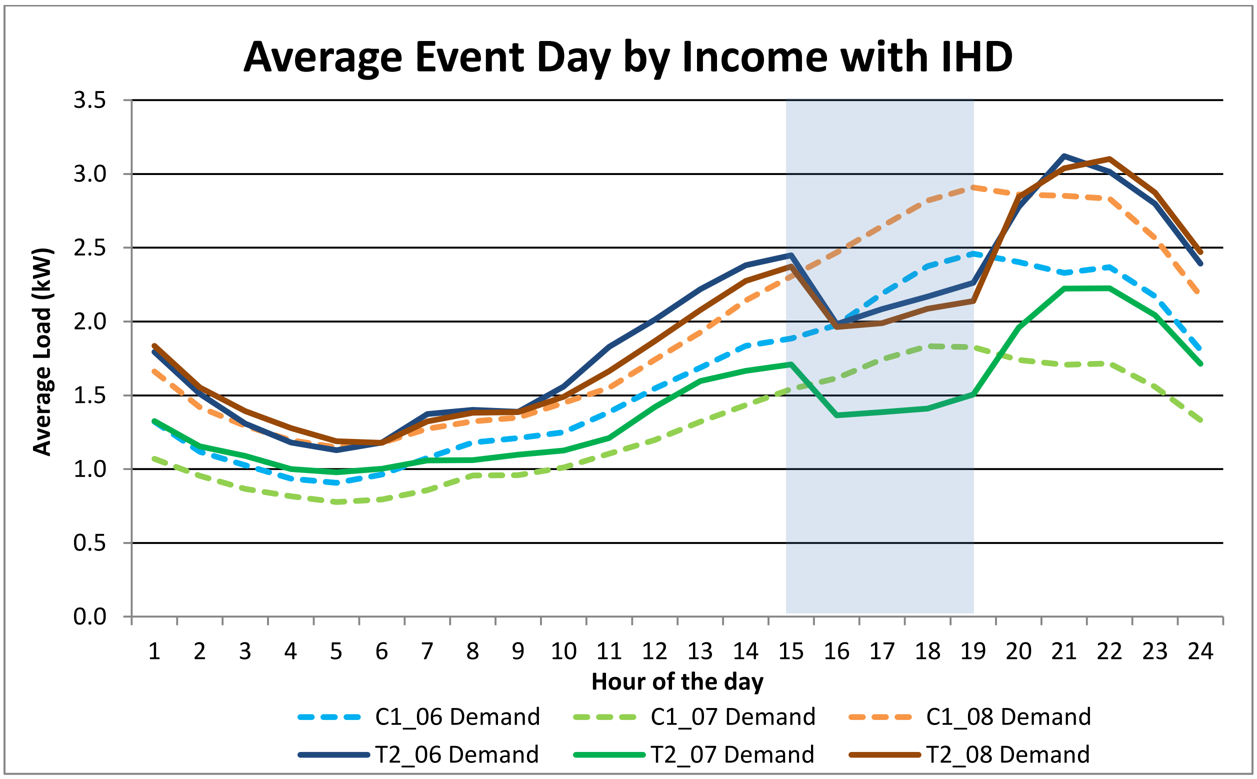


Figure 43: Average Event Day Load Profiles by Income with IHD

Figure 43 shows the load curves for low income (C1_06, T2_06), medium income (C1_07, T2_07), and high income (C1_08, T2_08) control and treatment groups, respectively, with IHDs. Hourly data and impact analysis can be seen in Appendix F. The low income customers show a unique load consumption pattern in which they increased their consumption quite a bit before and after the peak period and only marginally reduced their peak period consumption (by .48 kWh or 5.34%). Hence their overall consumption was 20% (or 8 kWh) higher than their respective control group's consumption. The middle income customers with IHDs showed a higher tendency of shifting loads to non-peak periods from the peak periods; hence, there is an increase in total load by 3.6 kWh (11.7%), even though they reduced the peak period load by 1.35 kWh. The high income treatment group customers increased their load marginally throughout the day, while they reduced their load sharply during the peak period. While they showed a peak period reduction of 2.67 kWh, their overall reduction was only 0.26 kWh. The presence of an IHD did help in shifting load from peak to off-peak periods, allowing for a decent reduction in peak demand and avoiding significant reductions in overall demand, with the exception of the low income group (further analysis would help determine if the control group load for the low income is a good counter-factual load).

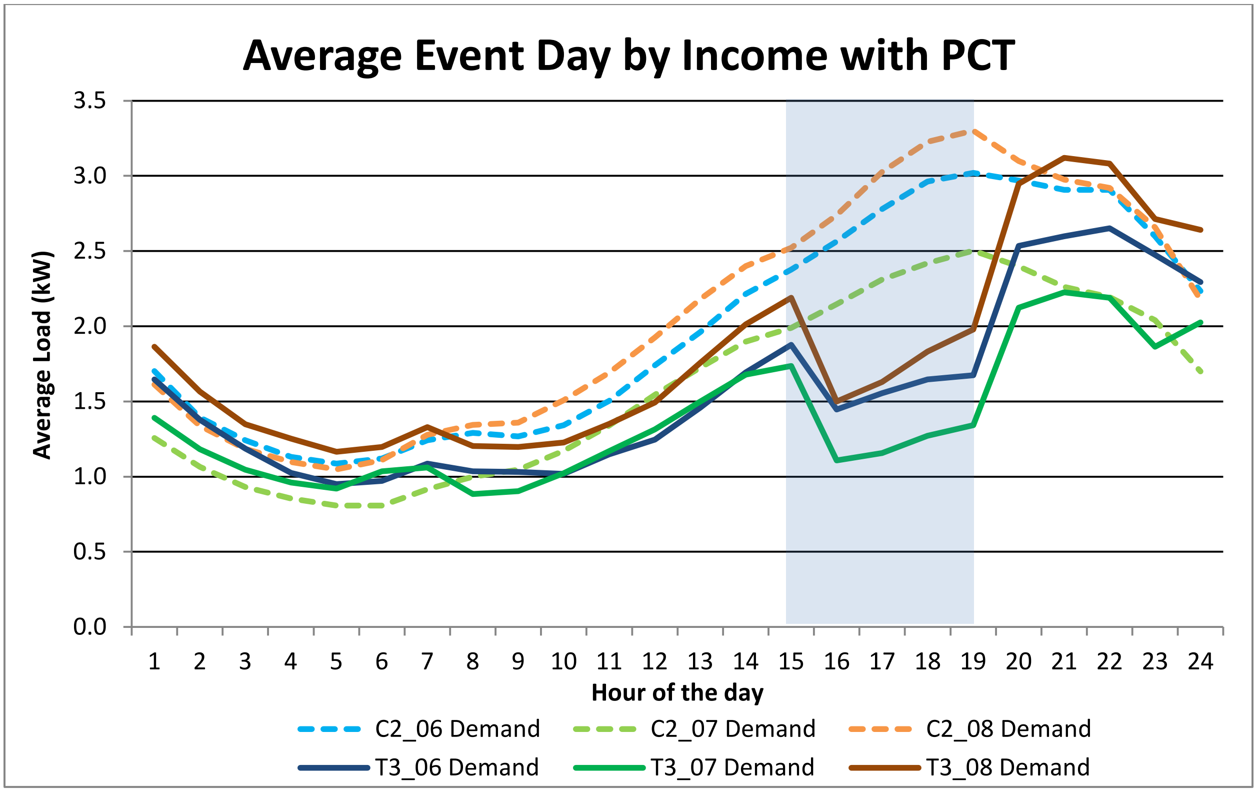


Figure 44: Average Event Day Load Profiles by Income with PCT

Figure 44 shows the load curves for low income (C2_06, T3_06), medium income (C2_07, T3_07) and high income (C2_08, T3_08) control and treatment groups respectively with PCTs. Hourly data and impact analysis can be seen in Appendix F. The low income customers had lower consumption throughout the day with maximum reductions during the peak event hours, which resulted in a peak reduction of almost 5 kWh (44%) and an overall total load reduction of about 10 kWh (21%). The middle and high income groups tended to have slightly higher demands during off-peak hours, but reduced their consumption during the mid-peak and peak periods. The middle income customers produced the maximum percentage (48%, 4.5 kWh) among all income groups with any technology combination. The high income treatment group had the highest actual peak load reductions of 5.35 kWh (43.53%) with a high overall load reduction of 6.06 kWh. As highlighted earlier, all three income level groups responded well with PCTs, though it would be interesting to further study how low income customers manage to reduce their load all day.

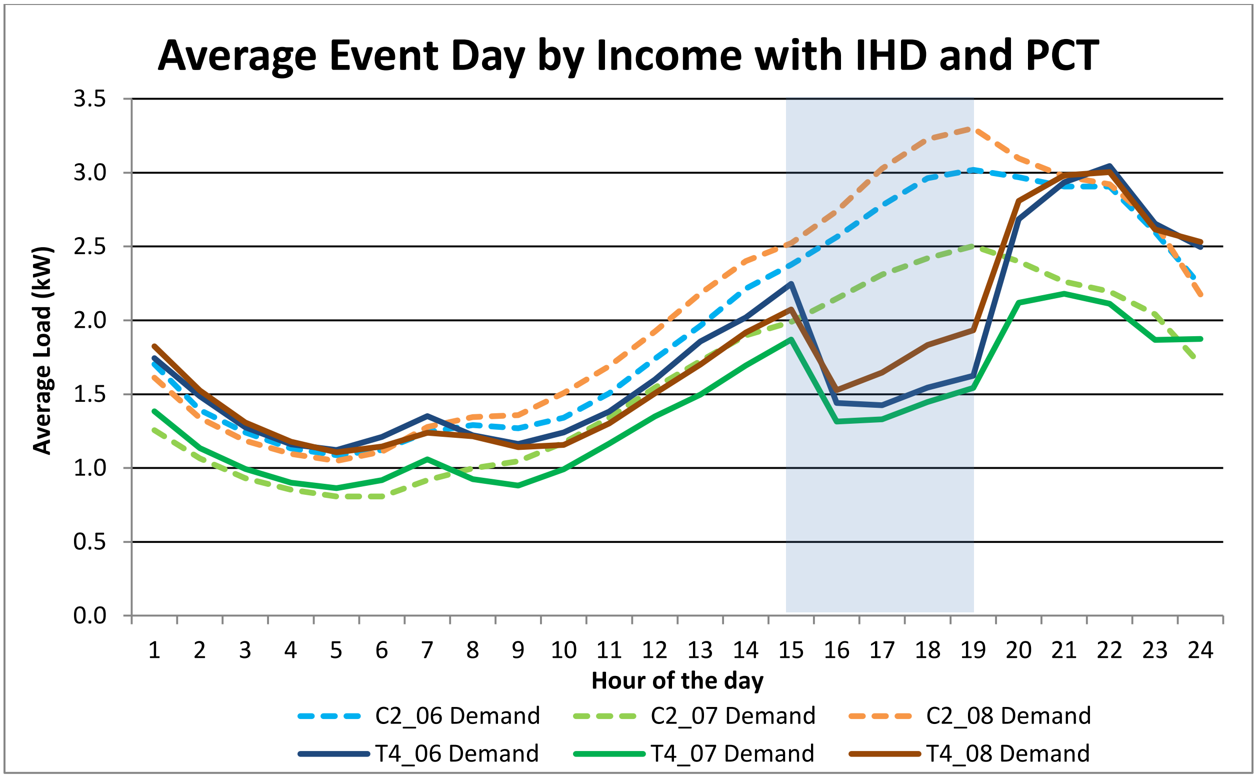


Figure 45: Average Event Day Load Profiles by Income with IHD and PCT

Figure 45 shows the load curves for low income (C2_06, T4_06), medium income (C2_07, T4_07) and high income (C2_08, T4_08) control and treatment groups, respectively, with PCTs. Hourly data and impact analysis can be seen in Appendix F. The low, middle, and high income group customers showed a similar load profile, which can be seen responding to underlying TOU rate structure also. They increased their loads marginally during the off-peak periods, reduced by a considerate amount during the mid-peak periods, and reduced by greater value during the peak event hours. The peak period reductions for the three income groups ranged from 40% to 46%, while the overall load reductions fell between 11% and 15%. The addition of IHDs to PCTs did not seem to increase load reductions by a great deal, and actually produced lower load reduction for the middle income group.

Table 35: Average Event Day Demand by Presence/Absence of CAC and Technology

Central Air-Conditioning	Technology	Peak period consumption (kWh)			Total consumption (kWh)		
		Control	Impact	Impact %	Control	Impact	Impact %
Yes	No Technology	11.170	(2.012)	-18.01%	47.115	(1.363)	-2.89%
	With IHD	11.170	(2.534)	-22.69%	47.115	1.511	3.21%
No	No Technology	5.228	(1.158)	-22.15%	26.644	(0.694)	-2.60%
	With IHD	5.228	(1.127)	-21.56%	26.644	0.956	3.59%

Table 35 displays the peak period and total consumption and impacts for different cohorts based on the presence/absence of CAC and technology. All four treatment groups reduced their event day peak period loads by at least 18% to 23%, but the presence of IHDs did not result in overall load reduction for all the treatment groups. The C1 with central air conditioning control group's consumption (cohort C1_09) was almost the same as the C2 control group's consumption during the on-peak period (11.17 kWh vs. 11.39 kWh) as was expected indicating that the customers that make up these two groups are similar and come from the same population. However, the energy reduction by the T1_09 and T2_09 groups was almost half of the reduction by that the T3 and T4 customers (2.012 kWh and 2.53 kWh to 5.07 kWh and 4.9 kWh). It is believed that the larger reductions experienced by the T3 and T4 customers was a direct result of the PCT that they were provided[13].

[13] It is important to remember that it was a requirement for the customers in the C2, T3 and T4 groups to have central air conditioning whereas this was not a requirement of the C1, T1 and T2 groups. This is why cohorts C1_09, T1_09 and T2_09 are compared to the C2, T3 and T4 groups as the 09 groups had central air conditioning.

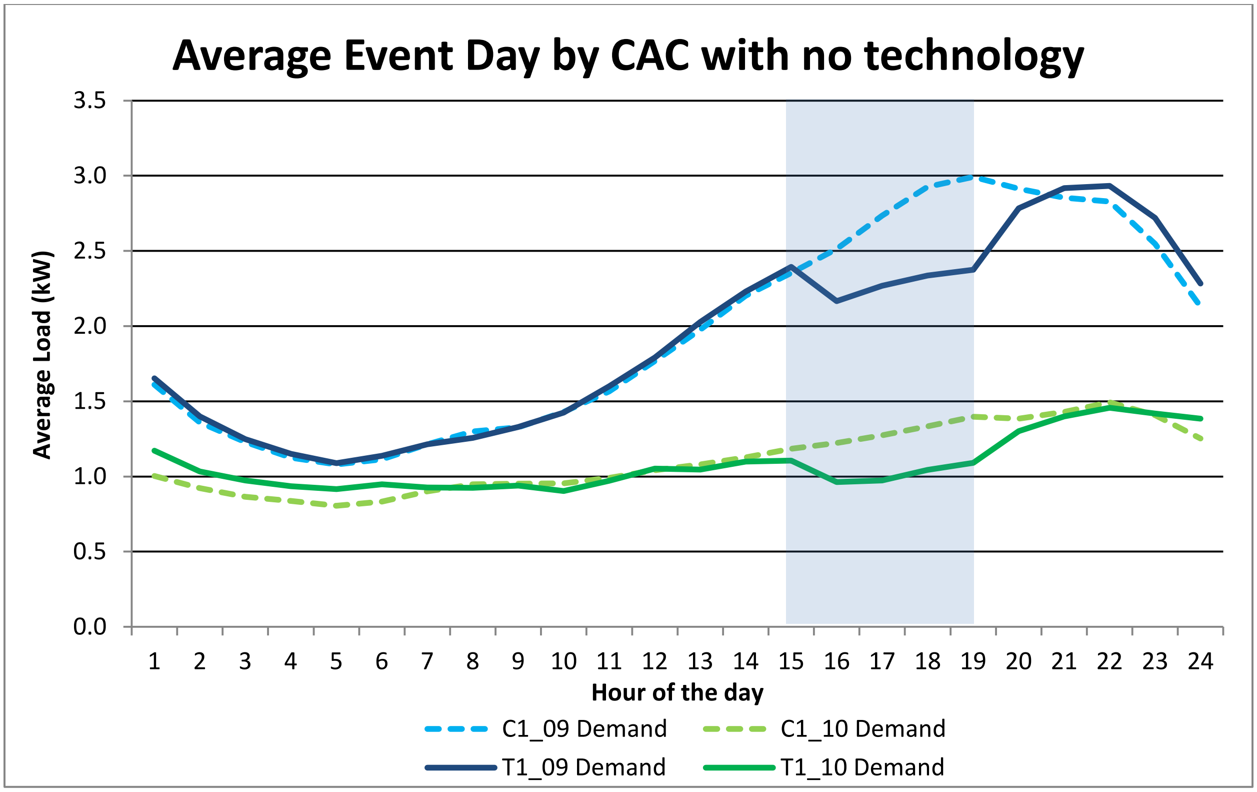


Figure 46: Average Event Day Load Profiles by presence of CAC with no technology

Figure 46 shows the control and treatment group load curves for customers with CAC (C1_09, T1_09) and customers without CAC (C1_10, T1_10), respectively, with no technology. Hourly data and impact analysis can be seen in Appendix F. Customers with CAC had a much higher baseline and a sharper increase in consumption during the evening hours. Hence, these customers had more scope for load reduction, which they exercised during the presence of the high event price in the peak period by bringing their peak loads down by about 2 kWh (or 18%). They tended to marginally increase their load late in the night; hence, their overall load is still reduced by 1.36 kWh. The customers without CAC and any technology had a lower and flatter baseline, but still implemented energy conservation during the event day peak period and hence lowered their peak load by 1.16 kWh (or 22%). This appeared to be in direct contrast of the T3 and T4 customers that seemed to rely heavily on achieving energy conservation through their PCT. It would be interesting to learn what energy conservation behaviors these customers undertook during the events to reduce their load. While they did not have CAC, they obviously found other ways to limit their electricity consumption.

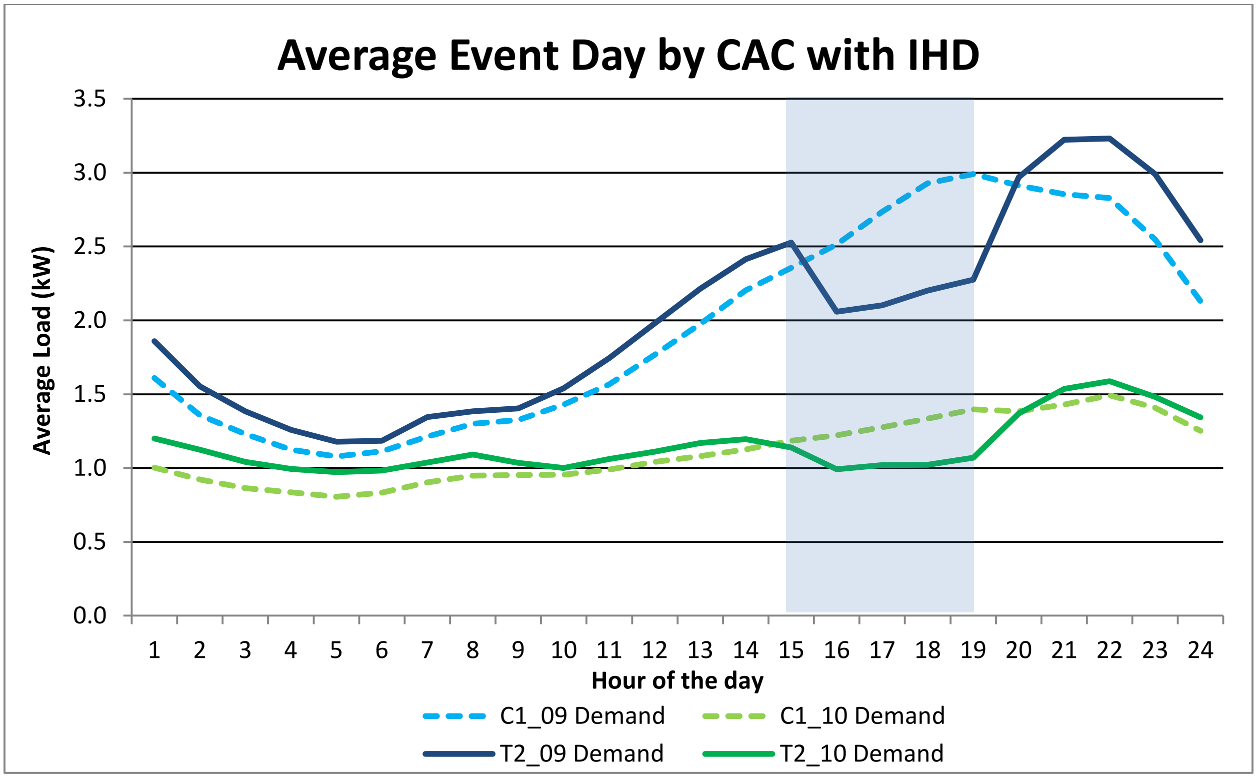


Figure 47: Average Event Day Load Profiles by presence of CAC with IHD

Figure 47 shows the control and treatment group load curves for customers with CAC (C1_09, T2_09) and customers without CAC (C1_10, T2_10), respectively, with IHD. Hourly data and impact analysis can be seen in Appendix F. Again, the customers with CAC had a much higher baseline and a sharper increase in consumption during the evening hours. Since these customers also had an IHD, it can be assumed they noticed the lower price during the off-peak and mid-peak hours and tried to shift their evening loads to those hours and possibly even pre-cool their homes. Hence, they succeeded in reducing the event day peak period load by 2.53 kWh (22.7%), even though the overall event day load increased by 1.51 kWh. The customers without CAC but with IHDs also implemented a significant load shifting to early morning off-peak hours besides the mid-peak hours and hence had an overall increase in load by almost 1 kWh, while their peak period load was reduced by 1.13 kWh.

6.b Process Evaluation Results

Customer recruitment

The recruitment process utilized dual response methods of online and Business Reply (BR) mail for initial interest and qualification; a link to the required baseline demographic survey was subsequently sent to customers who responded by mail. BR was offered on the advice of the direct mail consultant preparing recruiting materials, based on demonstrated past successes with that vehicle. Online was offered as a potential indicator of program participation success. While the BR responses were swift and plentiful, these candidates overwhelmingly failed to take the next step of completing the baseline survey online when they received the follow up email and link.

Since technology was a key component of all but one treatment cell, it was theorized that willingness to qualify online would begin to help weed out the most "technically challenged or insecure." More in-depth customer qualification based on customer comfort with technology was not considered due to the potential impact on customer interest in the program. In other words, there was a perceived risk in asking too many questions about comfort with technology as doing so might lead customers to question whether the process would be too complicated and to then opt not to continue with qualification and enrollment. The limited target population with which to work reinforced this concern.

The recruitment process also was challenged by the variety and incidence of incompatible heating systems in target population homes, including boiler, baseboard, and geothermal systems. As a result, the second mailing was modified to eliminate BR, fine-tune qualification questions to better screen for the desired forced air heating system, and incentivize enrollment with an Entertainment® discount card. As shown in Table 9, this combination of changes resulted in customer response and qualification that nearly equaled the first mailing but yielded better response and qualification rates and over 900 completed enrollments. Enrollment was considered complete when the customer bound Nucleus to the meter and established communication. Many customers started the enrollment process (changed rate) but did not follow up with GE or, if they did get devices, did not bind. Follow-up phone calls, not part of the original process design, were instituted to address this lag, yielding some success. Interestingly, many of these "AWOL" customers remain on the DPP rate to this day, without benefit of the educational tools that the program provides.

AMI and technology installations

At the time recruiting began, AMI deployment had been in process for several years, and nearly 500,000 AMI electric meters with six months of AMI interval data were in place. However, internal screening to eliminate incompatible rates and account characteristics reduced the target population significantly, leading to concern that based on projected response rates, the mail quantity would be insufficient. For example, screening for account effective dates greater than twelve months (to assure customers with 12 month history), and to eliminate interruptible air conditioning, payment plans and arrears greater than thirty days reduced the eligible population by over half. With TAG approval, the six month interval data requirement was relaxed to three months in order to achieve the appropriate mail quantity. This was necessary for a combination of reasons: internal screening was found to reduce the eligible population substantially more than anticipated, and at the time the mail file was being prepared, reducing the interval data requirement was the only way to increase the target audience.

As noted previously, the incidence of meter/Nucleus incompatibility was not anticipated, and became a program enrollment challenge. Approximately 60 meter/Nucleus replacements were done, but they were time consuming as well as ill-timed during the heavy enrollment push. This would pose a significant challenge in a wider scale program.

Information technology vendors

During the course of the pilot, GE pushed several Nucleus software updates to correct both functionality and improve ease of customer use. In addition, in August 2012 Nucleus was adversely impacted by an Adobe Air Update that required many customers to reconfigure their Nucleus clients. Periodic Adobe

Updates continued to “annoy” customers and create concern about their impact on Nucleus. In general, customers were slow to act on software updates, necessitating both DTE and GE outbound communications reminding them to install the updates. Even with gentle reminders, some customers still did not use the latest software version.

Customers expected technology to be set up for them, particularly those with PCTs. GE Factory Service technicians installed the PCTs. Due to the incidence of older heating systems in the enrolling pilot population, GE Factory Service Technicians installed what they characterized as a high volume of “5-wire adapter kits” to adapt the customer’s 4-wire configuration to the PCT’s 5-wire set up, although they did not establish any formal tracking. Many customers expressed disappointment that the technicians not only would not help with software and set up, but were not well informed on the pilot program, generally or specifically. Customers did not appreciate that the factory service technicians were from a different GE organization. In their minds, “GE is GE.” Despite DTE providing program talking points, it was difficult to ensure that a regional factory service organization would utilize a dedicated support team for a project such as this, and that those installers would learn the program specifics.

Customers expected the technology to be mature. Persistent Nucleus performance issues (stuck signals, conflict with Adobe Air, unbinding, etc.), led a number of customers to complain that they entered the pilot with the expectation that the technology would work. The words of one frustrated customer summed it up best: “I did not expect that we would be *Beta testing*.” These issues were especially bothersome to customers because they saw the value of the usage and pricing information that Nucleus provided, “just not all the time.” A larger deployment would require a more mature and mass-market friendly technology.

Finally, the pilot program launched using GE DR1000 version 1.5, GE’s Demand Response system that sent price and Demand Response signals. It also tracked customer interaction with the PCT during events, such as over-ride, reject, etc. The significant proportion of signals that had no event disposition at all made it impossible to evaluate customer response to the event beyond the meter data being collected for load analysis. While GE advised that version 2.0 would address a number of the DTE concerns about the DR features and the deficiency in the participation reports, it was deemed impractical and risky to push an upgrade during the enrollment process (or any other time over the course of the pilot), as it would impact every connected device. Therefore, the pilot was forced to run to completion on version 1.5. A possible contributor to the lack of event participation data was the utilization of “commercial” versions of the GE software, which meant Nucleus data sharing was not automatic. During software installation, customers had to click “yes” or “no” to the pop box that asked if they were willing to share data, subject to use as outlined in GE’s data privacy policy. While DTE repeatedly reminded them to click “yes,” there was no control over customer selection and no reporting on the proportion of pilot participants who agreed to share. The impact of the customer selection is therefore unknown.

Education

A comprehensive Pilot Customer Communications plan was utilized that listed planned eNewsletter and secure pilot portal content by month. From time to time, monthly content was changed in response to customer feedback collected from Contact Center and/or the pilot program email box, and this flexibility served the team well in its effort to provide timely actionable information. DTE's vast Energy Efficiency library was the basis for much of the monthly content. While the basic content was tailored for the specific treatment cells, Focus Groups in fall 2012 indicated that customers did not see it that way and felt it was generic and not pilot-specific. As a result of this input, fundamental changes were made to newsletter length and content. These changes were noticed and appreciated as follow up research indicated, but some customers indicated they wanted information more customized to their own situations. This would not be practical in a large-scale program.

While "click throughs" are a quantifiable measure of readership, Focus Groups also indicated that pilot customers were aware of the monthly eNewsletter, its mid-month delivery, and sometimes the subject lines, but were simply too busy to read it monthly, as they were similarly too busy to read any number of other emails. This suggests that the awareness was higher than the measured click through rate.

Early customer feedback, supported by focus group findings revealed customers were unsure of their cost/savings status on the DPP rate. In July 2013, 13-month savings calculations were run and emailed to each individual customer. These were very well received, but based on the July timing did not include a full year of CPP exposure. Therefore, in January 2014, a calendar 2013 cost/savings report was sent to provide a look back for the entire calendar year, including its eleven CPP events. This cost/savings analysis also was provided to the SmartCurrents contact center, for use if needed in call handling.

Review of the DPP Rate Comparison Calculator stats provided by Aclara revealed that the calculator was not heavily utilized. Unfortunately, this is the only measure of customer utilization of a "pull" channel (meaning that customers had to take a voluntary action to access) for the pilot duration since the web platform changeover in summer 2013.

Post-pilot, the DPP rate remains available to residential customers with an AMI meter, subject to the 5,000 customer cap. Market Research indicated the importance of education for the DPP rate going forward. The thoughtful design and creation of pilot program educational materials yielded a suite of materials that was easily repurposed for use post-pilot. Going forward, all new DPP customers will receive a welcome kit of the best DPP education materials and savings strategies developed over the course of the pilot. All customers on DPP will be reminded each spring about the Critical Peak event feature of the rate, and to call the Contact Center to review and verify their notification preferences. An annual savings report will be provided, giving DPP customers a 12-month look back on their DPP costs compared to what they would have paid on standard residential. This savings report also provides links on tips to employ for continued savings on the rate.

Event dispatch and notification

During the enrollment process, customers were asked to provide up to three preferences for CPP event notification. These customer preferences were stored in the enrollment system, and subsequently transferred to the DTE notifications system that interfaced with the third party Varolii messaging service. Data issues in the transfer file were discovered in the dispatch of the August 2012 event, when approximately one third of participants did not receive the notification. Of the 379 message failures, 37 percent were T1, 25 percent were T2, 19 percent were T3, and 20 percent were T4. The large-scale notifications failure was not evident until the morning of the event. While the event was not cancelled, customers who were clearly identified as “not notified” were proactively advised that a system issue prevented their notifications from generating, and that they would be credited for any Critical Peak Usage. This data issue was resolved in November 2012 and was confirmed again via system testing in May 2013.

Testing in May 2013 also revealed the need to monitor internal processes. To ensure compliance with the 6:00 p.m. day-ahead notice requirement, DTE modified internal processes and oversight to identify any problems as they occurred. An internal stakeholders email was put in place to communicate each planned CPP event across departmental lines. Upon creation of the messages, a system generated email was distributed to internal stakeholders. IT staff monitored internal processes, and advised when the messages left the DTE server and transmitted to Varolii. Overnight, Varolii delivered a detailed report of notifications success and failure. This timing was critical to allow for the possibility that Varolii delivery might fail. In such case, DTE would be ready to notify customers of event cancellation and turn off critical peak pricing in the billing system. Such a wholesale failure did not occur.

Overall, notifications for all 2013 events went out successfully. The few notifications failures seen from event to event were determined to be the result of customers failing to keep preferences current. These were addressed as identified by Varolii message status reports and customer calls, in addition to a general message in the monthly e-newsletter reminding customers to keep preferences up to date. Additionally, the contact center staff was instructed to make notification preference updates a part of every customer call. A small population of customers did neglect to update notification methods in spite of email reminders, and CPP charges incurred; personal letters were mailed to them, indicating the contact method on file and notification failure reason. Notification creation and delivery tracking is shown in Appendix C. This tracking was delivered to the pilot program management. A large-scale, DPP-based demand response program would necessitate providing visibility of individual customer notification success/failure by event in the billing system. This would allow customer representatives to handle customer inquiries about notification delivery and CPP billing.

Overall and with one exception, CPP event dispatch in the GE DR1000 was uneventful, with events starting and ending within a few minutes of the defined parameter. The one exception was Event 2, Monday, June 24, 2013, as noted earlier. While the event did dispatch and start on time, the Critical Peak Price signal and associated PCT temperature off-set stayed in effect all night, leaving customers both extremely uncomfortable and concerned about mounting CPP charges. The glitch was identified by DTE IT and escalated to GE at 7:00 a.m. the following morning. The SmartCurrents team responded quickly to send an eblast acknowledging the stuck signals and assuring customers that billing was not affected. Contact center activity jumped that day, and agents had to assure customers they would not be overcharged for the extended event. The semi-annual web-based satisfaction survey, originally slated to field that same week, was postponed as a result of the stuck signal and the resulting customer angst.

Customer service

Due to the number and variety of treatment cells, or "offers," customers had a variety of paths for customer service calls. Enrollment and routine account transactions were handled by the SmartCurrents contact center, a third party call center service provided by APAC Customer Services, Inc. Customer representatives were already skilled to take DTE Customer Care calls, and were held to the same high standards for call quality. SmartCurrents representatives provided pilot customer care through the duration of the pilot.

During the enrollment phone call, the customer representative gave a brief program overview with description of the DPP rate and asked if there were any questions before starting the enrollment process. The incidence of rate questions was significantly lower than anticipated. After the rate change, customers with technology were transferred to the GE contact center for ordering devices and making appointments for PCT installation if applicable. A process gap was identified when SmartCurrents representatives advised DTE that many transfers to GE went to voice mail. Rather than simply advise the customer to call GE later, the SmartCurrents representatives left a detailed message on the GE order line, with customer name, phone and treatment cell so that GE could make a call back. This small process change allowed for better success initiating and processing GE orders. GE made an additional process improvement by requesting SmartCurrents to also provide the customer mailing address, since the T2 IHD could simply be mailed to the customer, and did not require a scheduling phone call. This freed up GE staff to concentrate on contacting T3 and T4 customers who needed to schedule PCT installations.

The GE order line was disconnected after all enrollment activities had been completed and official observation began in August 2012. A few customers noticed, but only because they were incorrectly calling the order line for tech support. Questions about devices and/or technical support issues continued to be handled by a separate GE Tech support number. However, over time, call volumes and resultant staffing attrition at GE reduced days and hours of operation. Throughout 2013, GE support calls averaged five to seven per week at most, except when a widespread issue was experienced such as the IHD cycling on and off, resulting in a natural spike in call volume. Incoming calls on Saturdays went to voice mail, to be returned later in the day or on Monday morning.

Binding calls continued to be handled by DTE personnel, but as noted earlier, the need for continued binding support was not anticipated and as enrollment concluded, binding hotline staff resources were reallocated. As a result, the persistent but low call volume was handled with a voice mail/call back system through the end of the pilot. These staffing reductions did not go unnoticed by customers, who indicated in the fall 2013 focus groups that they felt active hours for technical support had been reduced over time.

Overall, post-enrollment customer service call volume was lower than anticipated. DTE contact center activity is shown below. Extended recruiting activity can be seen in the 2012 call handling volume. Call volume in 2013 was a drastic 70 percent lower than 2012, and monthly activity averaged about 150 calls per month versus the previous year's 560 average per month.

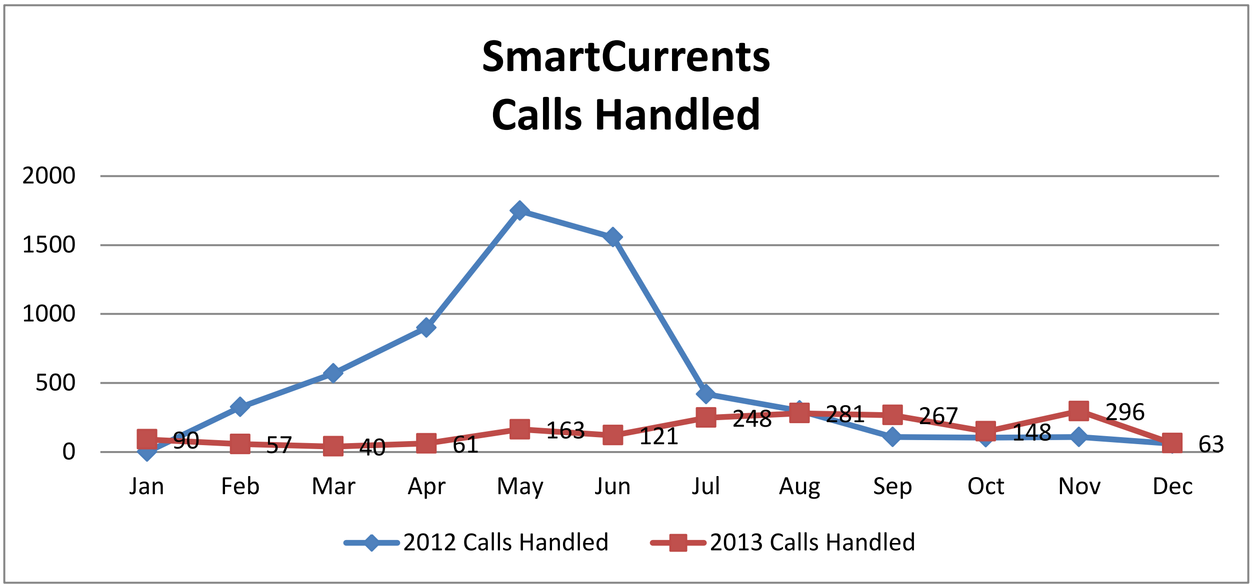


Figure 48: SmartCurrents Call Volumes 2012 - 2013

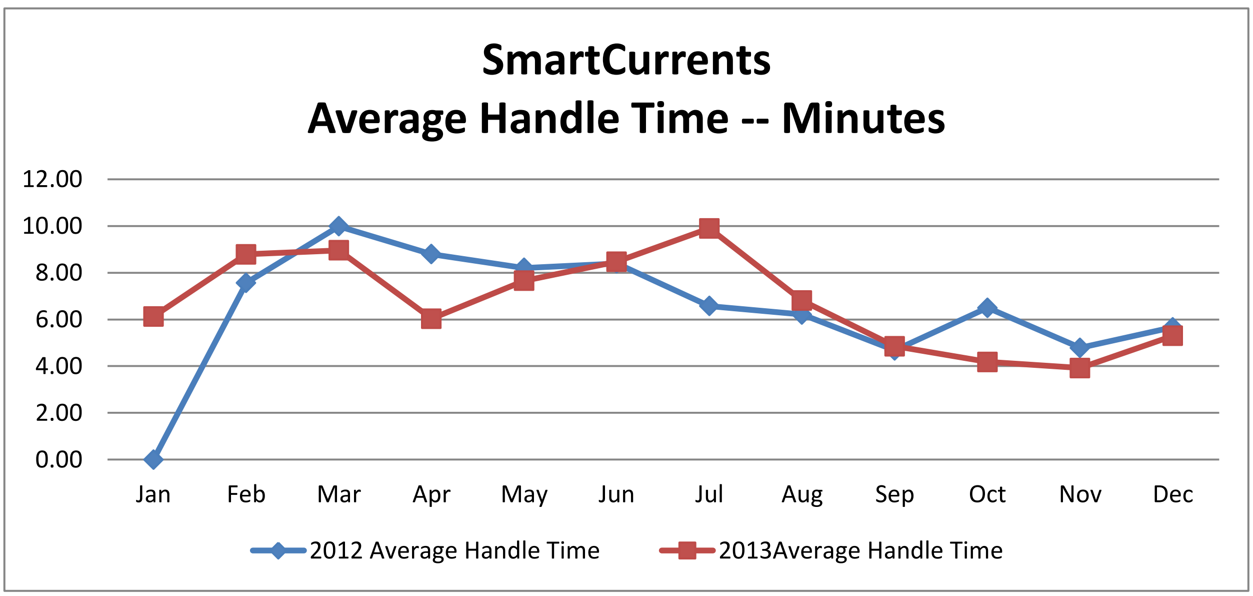


Figure 49: SmartCurrents Average Handle times 2012 - 2013

Notably, call volumes to the SmartCurrents Contact Center fell far short of projections for summer of 2013. Program management had anticipated call volume spikes driven by the planned 10-15 CPP events, a drastic increase from one event in summer 2012. As shown above, the highest call volume month was July 2013, with a total of four CPP events, and three back to back on July 15-17. High bill calls were specifically anticipated, particularly in bill periods that included multiple events, such as July. Over the course of the summer, some billing units had bill periods that included five or six CPP events. However, even with multiple event bills, the anticipated call volumes did not materialize. DTE can only speculate that overall the participants had sufficiently internalized the DPP rate and understood their usage each bill period.

6.c. Additional Results

6.c.i. Segmentation Analysis

Marketing and consumer behavior analysis can yield insightful findings through data interpretation and visualization that may not be possible to see in standard electricity load analyses. Therefore, DTE engaged Market Strategies International (MSI) to perform separate, parallel behavioral analyses to investigate the idea that targeting of programs may be enhanced through improved understanding of how different segments of customers respond to demand response and energy conservation programs in different ways. Toward this end, MSI performed two segmentation analyses: Load-based and Attitude-based.

Load-based Segments. This segmentation approach leveraged new energy usage data, available because the DTE Energy SmartCurrents Pilot project included the deployment of distribution automation (smart circuits) and AMI. Based on these new technologies, actual customer usage data over time periods could be investigated for treatment groups and control groups.

Working in other settings on prior projects, MSI had developed load-based segmentation (LBS) techniques grounded in distinct usage patterns that can be observed by analyzing interval usage data. Segments can be defined by patterns of average hourly usage per day over the course of the year, or seasonally (including extreme hot or cold periods). An energy usage-based segmentation can be developed and applied to households with complete or near-complete longitudinal usage data, yielding distinct usage patterns based on time-of-use, amount of energy use, and responses to Dynamic Peak Pricing event days.

The eight-segment LBS solution graphed in the figure below, (utilizing normalized hourly usage as basis variables for a k-means cluster assignment), was selected for the purpose of this particular load-based segmentation. In the graph, mean usage is displayed on the y-axis as the raw average usage per kilowatt hour. The x-axis shows the 24-hour cycle in a day (summer weekday), in which Hour-0 is 12:00 a.m.; Hour-20 is 8:00 p.m., etc. As can be seen in the graph, there are distinctive usage patterns, particularly during the morning and afternoon hours where there is more separation among the segments.

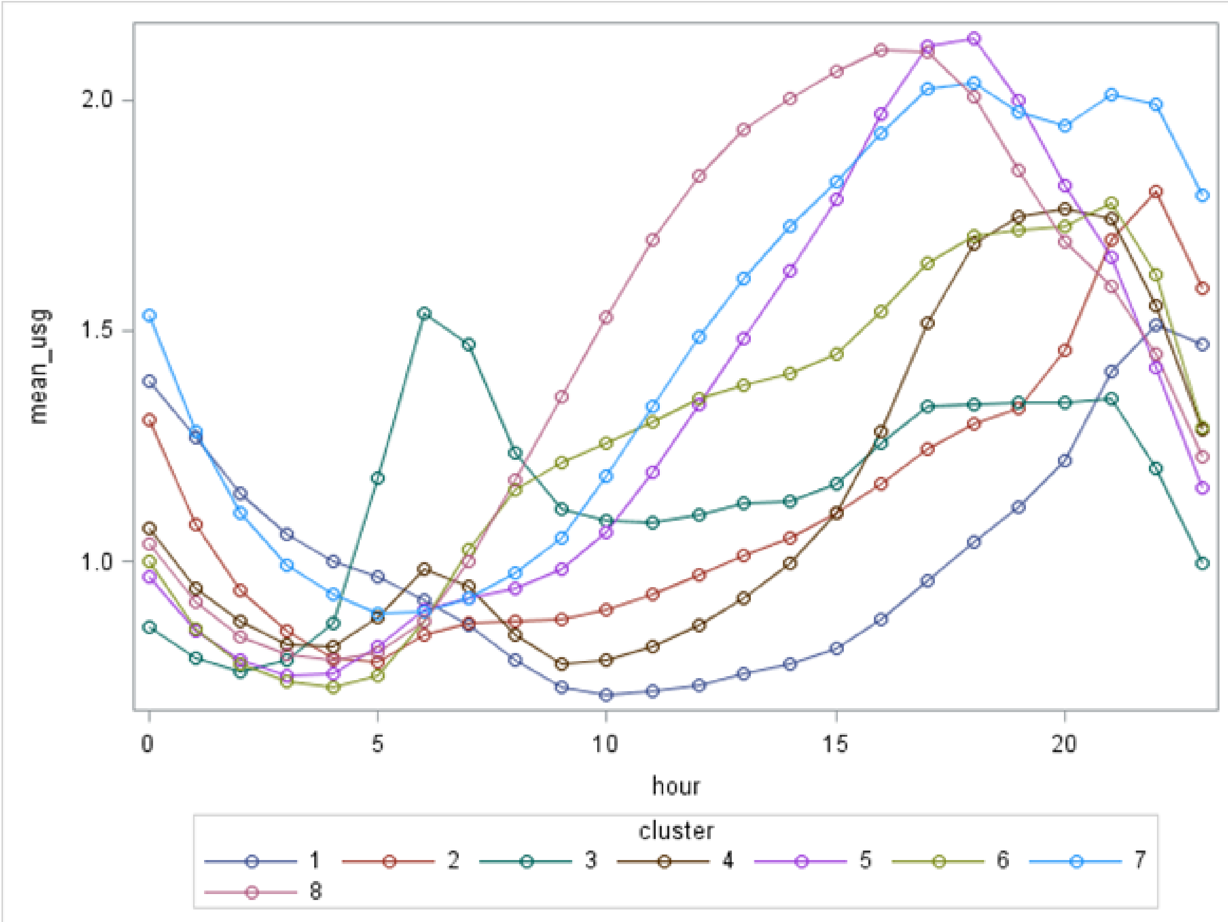


Figure 50: Eight Segment LBS Solution

Extending these techniques and applying them to the DTE Energy SmartCurrents program has created the potential to:

- Analyze and report on the complete set of SmartCurrents treatment and control group data by LBS segment
- Determine how customer behaviors and survey responses during CPP events differ by LBS
- Derive actionable implications for the design and marketing of demand response and other dynamic pricing initiatives

Attitude-based Segments. This segmentation was based on work done in 2009-2010, when MSI partnered with DTE to develop an attitude-based segmentation framework, investigating residential customers' attitudes, behaviors, and experiences with DTE.

The resulting segmentation framework identified seven homogenous groups of individuals who were maximally different from each other group on multiple dimensions, including:

- Attitudes about energy conservation
- Attitudes toward innovation and new product adoption
- Values and lifestyles
- Demographics: Household income as reported by customers
- Behaviors: Energy consumption based on DTE records

Additionally, two scoring tools were developed in order to score all DTE customers into one of the seven segments, based on either: (1) customers' answers to a reduced set of survey items to classify segment membership at a high accuracy, or (2) any available customer database information, where there no survey data were available, classifying customers at a somewhat lower accuracy.

The seven attitude-based segments are:

- **Affluent Greens** – Highest level of income and education, likely to participate in DTE Energy Optimization (EO) programs and use Smart Meters to save energy
- **Energy Indifferent** – Second-highest income, most are married with kids or are "empty nesters", tend not to be early adopters and have an average likelihood to participate in EO programs
- **DIY Conservers** – Moderate income, slightly below average education, most are married with kids or are "empty nesters", have adopted energy efficiency (EE) measures on their own, average likelihood to participate in EO programs
- **Traditionals** – Oldest segment (four in ten are retired), moderate income and lower than average in education, less knowledgeable about EE, least likely to participate in EO programs
- **Greens** – Lower-moderate income, relatively high education, youngest segment, self- identify as environmentalists, likely to participate in DTE EO programs
- **Cash Flow** – Lower income, high unemployment, largest segment in city of Detroit, high percentage of women, average likelihood to participate in DTE EO programs
- **Budget DIY** – Lower income, highest percentage of women, higher unemployment, average level of adoption of EE measures, three in ten live in North-South suburban regions, slightly less likely to participate in DTE EO programs

Therefore, it is possible to:

- Analyze and report on the complete set of SmartCurrents treatment and control group data <u>by attitudinal segment</u>

- Determine how customer behaviors and survey responses during CPP events differ by these segments
- Derive actionable implications for the design and marketing of demand response and other dynamic pricing initiatives

A number of important, tentative conclusions can be drawn from the load-based and attitude-based segmentation analyses. These findings suggest that there are important opportunities to use both types of segmentation to improve the efficacy of dynamic pricing programs.

Considering LBS analysis, for example:

1. Equipping households with education and/or technology has been shown to influence their overall behavior during an event. However, members of LBS 8, LBS 7, and LBS 4 show less usage reduction per household during events. These segments could therefore receive reduced attention when promoting demand response programs, potentially increasing the efficiency of marketing and reducing the cost of technology components that may be included in a program.

2. Similarly, if one wanted to select a small number of households that will deliver the largest per-household impact on energy savings, focusing on selecting LBS 6 and/or LBS 3 would help achieve this objective.

Since segmentation based on interval usage data alone can be effective in identifying underlying groupings within the greater population, load-based segments have the potential to be used for a number of purposes including: DPP participant targeting by segment, assessment of segment size by the complete DTE customer base, targeted education materials for higher energy saving segments, etc.

There are similar marked differences in behavior during events based on attitude-based segment, which could be leveraged in similar fashion:

1. Members of two segments, Budget Do it Yourself (DIY) and Traditionals, show low usage reduction per household during events. It may be prudent to limit the amount of demand response effort and spending directed at these segments.

2. On the other hand, the segments that show the greatest reduction in energy consumption per household during events are Affluent Greens, DIY Conservers, and Greens. There is an opportunity to increase the impact of resources invested in demand response by focusing on these segments.

Analytical methodologies and data descriptions are contained in the MSI report shown in Appendix H.

7. Informational Consumer Behavior Pilot

DTE also ran an informational pilot, with the expectation that the pilot would provide important information about two programs: Pre-pay and Smart Appliances. The statistical significance of this pilot was limited due to: small DOE-approved grant sample sizes, implementation cost (customers were expected to pay the $200 delivery cost as well as tax on the wholesale cost to DTE of the appliances, via IRS form 1099), and a lack of pre-treatment end-use data.

The informational portion of the design still provided insights in and among themselves, especially about program engagement and customer technology acceptance.

Pre-pay

As part of the informational pilot, DTE offered a pre-pay billing option, branded Pay As You Go, for up to 200 customers. Pre-pay billing allowed customers to pre-pay for electric service when they wanted and in the amounts that they wanted, essentially providing a "pay as you go" option. The Pay As You Go option required enrollment in on-line or electronic billing, at least two communication methods, and either the Standard Residential Service (D1) or Dynamic Peak Pricing rate (D1.8). Customers with other rates and/or monthly charges (such as appliance repair) were not recruited.

Balance notifications were customized to individual customer preferences. For instance, notifications could be triggered when remaining balances reached a specified amount (e.g., $20). Customers could receive notifications over multiple channels: email, phone, and/or text.

The Pay As You Go billing option worked as follows:

1. The customer representative enrolled the customer in the program.
2. The customer created a credit on their account by submitting payment to DTE.
3. The customer used electricity, and usage was deducted from account balance on a nightly basis.
4. At customer's selected balance level or when 10 estimated days balance threshold was reached, notification was sent through multiple channels informing the customer of balance.
5. Should balance fall to zero, three day friendly credit started.

System constraints (functionality, ease of use, etc.) delayed recruiting and enrolling customers for Pay As You Go until June 2013. As a result, recruiting was done by targeted phone calls versus mail, and focused on customers with Residential Service, although a small number of customers on DPP were also enrolled. The recruiting phone call described Pay As You Go as "a program designed to fit your needs. You can better manage your energy usage, save energy and ultimately save money. And it's FREE."

To capture the "Voice of the Customer," DTE engaged Consumer Insights (CI) to conduct a series of focus group studies with three objectives among current Pay As You Go customers:

- Understand what the most important "trigger" points are for considering the program.
- Understand areas of the program that may be confusing for customers.

- Understand the type of person who may best fit the profile of whom may be the most interested in the program.

Methodology and Sample

CI held two focus group discussions with 18 Pay as You Go customers. Discussions were 90 to 120 minutes in duration, and were conducted at Cypher Research in Canton, Michigan, on November 21, 2013.

Customers were invited by phone to participate in the upcoming discussions. Respondents were paid $125 for their participation. Participants were age 18 or over and primary utility bill payer and household energy use tracker. The groups included a mix of satisfaction levels with DTE Energy.

Findings

Pay as You Go participants share some psychographic similarities: Customers liked having the sense of control that they felt came from pre-paying their account. Oftentimes with non-DTE Energy bills, they gained some “fail safe” control in the form of paying in advance or padding their account as an insurance policy against an accidental missed payment. Additionally, there was a sense of pride in the fact that they were personally responsible enough to never miss a payment.

Two key perceived benefits of the Pay as You Program included a sense of control and a mechanism for behavior change. The Pay As You Go program allowed some of these customers to have the sense of control they craved by providing them information they didn’t believe was accessible outside of the program: *“You could go on to the DTE Energy website and see what your daily usage is. So I could track it and make some changes in the way that I do things to reduce my bill.”*

Enrollees in the program also felt that they might change their behavior, and that daily or weekly updates would serve as a mechanism for behavior change. By checking their account balance and seeing how it related to their energy usage, customers felt that they would receive a clear cost to behavior relationship and provide motivation for using less energy.

“Ease of use,” in the form of the monthly eBill and alert notifications, was an important aspect for most program enrollees who didn’t want to actively search out information. The electronic notification in the form of a monthly eBill was thought to be a convenient method for customers to check their account balance. *“They would notify me by email when my bill was due and I thought, 'That's cool' because I take my mail and chuck it while I check my email every hour.”* However, some customers didn’t understand why the eBill statement wouldn’t reflect their current balance. Enrollees understood the program to include up-to-the-day updates on their balance and energy usage and felt that the monthly eBill should also be updated at the time of the email blast.

While there wasn't consensus in terms of when customers wanted to receive alerts, they did like the idea of being able to select when they would receive text alerts, whether it was a day away from having a zero balance, a week away, or a couple of weeks.

The focus groups also revealed a few areas of customer confusion. Some respondents could not recall whether they were told that they had to maintain an account balance, and indicated they were confused when they began receiving alerts for dwindling balances. Others felt they didn't understand how the overall idea worked or how it would benefit them. Accessing usage and balance information also proved difficult for some.

In response to concerns voiced in the focus groups, DTE has made several enhancements to help improve the customer experience: improved the online experience by streamlining the process to obtain usage and balance information and providing 12 months history; modified the alert notification process to monitor and track alert timing and frequency in order to gauge effectiveness; and revamped the Welcome Kit with new content and graphics explaining the program in greater detail to help set customer expectations and improve their experience.

Pay As You Go Welcome Kit materials are shown in Appendix D.

Smart Appliances

A subset of customers was specifically targeted to receive "smart" appliances that would react to changing price signals. Customers who received smart appliances also received Nucleus, IHD, and PCT. Three smart appliance treatments were observed: Smart Kitchen (Refrigerator and Dishwasher), Smart Laundry (Front loading washer and dryer), and Smart Suite (Kitchen plus Laundry set).

Targeted appliance customers received invitations similar to those issued to the other treatment cells, modified to include the list of enabling technologies they would receive for a "minimal charge" (delivery fee and tax liability for the wholesale cost of appliances). While 100 customers per smart appliance treatment were envisioned, recruiting was challenged on several fronts. The refrigerator was among the largest on the market, and as such many targeted customers could not accommodate the size. The laundry pair presented its own challenges. The target audience for laundry pair was severely limited because natural gas is the predominant fuel for clothes drying in southeast Michigan. The limited target audience was further constrained by the dryer's specific electrical outlet configuration. Only a handful of customers with non-conforming outlets were willing to pay a contractor to replace the outlet. (Having GE delivery personnel change dryer cords was outside the scope of the contract.) Final enrollment by treatment cell is shown below.

An additional limiting factor was the prospect of being taxed on the wholesale value of the appliances (The $200 delivery charge, however, was not an issue.) The reportable taxable value ranged from $2,206 for the laundry pair to $5,472 for the full suite. Customer reaction to the potential tax liability suggested that even the wholesale value was more than they would want to pay for smart appliances. While price points were not scientifically tested, customer comments in connection with the taxable value in this case suggested they may not be willing to pay a premium for the functionality.

Table 36: Enrollment in Appliance Treatment Cells

Treatment Cell	Description	Enrolled
S1	T4 + Smart Kitchen	21
S2	T4 + Smart Laundry	29
S3	T4 + Smart Suite (Kitchen and Laundry)	14

While sample sizes prevented meaningful meter data analysis, appliance customers were included in every other aspect of the pilot program. They received monthly eNewsletters, access to the Web Portal and its monthly updates customized to their treatment cell, all e-blasts and access to the PLW game. Appliance customers participated in focus groups and periodic surveys.

Anecdotally, in focus group discussions, appliance customers continued to appear "lazier" about behavioral changes than treatment cells with less equipment. In Fall 2013, they indicated they were still relying on the EP (Energy Price – must over-ride to turn appliance on) functions of their GE smart appliances to avoid on-peak run times and still had not made the same number of behavioral changes in the past year as T2-T4 customers. S1-S3 were as aware of DPP rates as T1-T4 participants, but indicated they relied almost entirely on the GE appliances to provide them cost savings over making other changes to equipment or behavior in their homes.

Adding smart appliances from GE typically disengaged customers from actively pursuing other ways to reduce their energy costs—in part because S1-S3 participants knew they were receiving appliances at the point of invitation. In contrast, treatment cell respondents were not guaranteed any equipment at the point of invitation at all, leading to a self-selection process that favored participants more heavily motivated to change behavior in an effort to reduce cost and improve the efficiency of the power grid.

Appliance respondents were much more concerned about the loss of Nucleus connectivity across their thermostat and smart appliances at the conclusion of the pilot than treatment cell respondents; it would not be unexpected to see a greater attrition off DPP from these households than treatment cell households as a result of this heavier reliance on self-correcting appliances.

The Final Web Survey in December 2013 shows there were large gains for nearly every energy-saving behavior assessed over the past year. While the treatment cells displayed significant increases in energy-saving actions over the year, the S1-3 appliance cells retained the highest overall level of action in nearly every category, somewhat contradicting their comments in the focus groups.

Behavior Changes Since Joining SmartCurrents	Total			T1			T2-T4			S1-S3		
(green/red) = sig. higher/lower than respective T1; * = sig. higher/lower than respective T2-T4	12/12 (n=838)	7/13 (n=929)	12/13 (n=860)	12/12 (n=113)	7/13 (n=124)	12/13 (n=113)	12/12 (n=687)	7/13 (n=767)	12/13 (n=704)	12/12 (n=38)	7/13 (n=38)	12/13 (n=43)
Minimize all electricity usage 3pm-7pm	68%	75%↑	78%↑	66%	78%↑	80%↑	67%	74%↑	78%↑	82%	76%	81%
Run washer/dryer on the weekends, avoiding weekdays	53%	55%	60%↑	44%	45%	55%	55%	57%	60%	61%	61%	74%
Run dishwasher 11pm-7am	41%	48%↑	50%↑	33%	37%	50%↑	41%	49%↑	50%↑	58%*	71%*	65%
Set thermostat to raise AC temp 3pm-7pm	40%	50%↑	52%↑	26%	40%↑	44%↑	43%	51%↑	54%↑	42%	66%↑	49%
Better control of "vampire" sources of electric consumption	33%	37%↑	47%↑	29%	37%	48%↑	34%	38%	47%↑	26%	34%	42%
Run dishwasher 7am-3pm OR 7pm-11pm	31%	31%	33%	30%	35%	33%	31%	31%	32%	26%	26%	40%
Switched to CFL/LED bulbs (since joining the program)	31%	40%↑	50%↑	33%	44%↑	51%↑	30%	39%↑	49%↑	32%	50%	58%↑
Run washer/dryer 7am-3pm OR 7pm-11pm	30%	34%	36%↑	28%	35%	36%	29%	32%	35%↑	42%	53%*	44%
Set thermostat to lower AC temp before 3pm to "pre-cool"	21%	27%↑	34%↑	16%	23%	27%↑	22%	27%↑	35%↑	24%	32%	30%
Run washer/dryer 11pm-7am	16%	18%	18%	12%	15%	14%	16%	18%	19%	18%	24%	23%
None	5%	3%↓	2%↓	9%	5%	2%↓	5%	2%↓	2%↓	0%	0%	0%

SmartCurrents Web Study Report — Q14. Since joining SmartCurrents, have you changed any of your behavior when it comes to the electricity consumption in your household? ↑↓ = sig. higher/lower than within group 12/12 — Chart 12

Figure 51: S1-3 Appliance Customers Retained the Highest Level of Action over the Year

A majority of appliance respondents indicated in December 2013 that they had finally started delaying their dishwasher use through automatic delays. As in prior waves of web survey, about a quarter of respondents stated they still have yet to see an "EP" warning on their dishwasher.

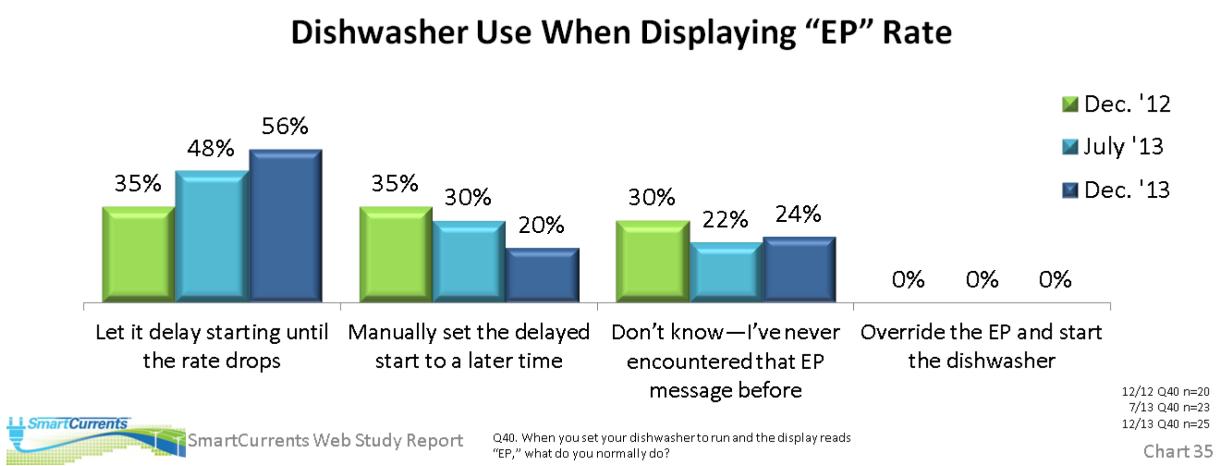


Figure 52: S-Cell Dishwasher Habits

And finally, most S-Level respondents continue to delay (either automatically or manually) their laundry during "EP" rate warnings. As with the dishwashers, a sizable number have never run into the "EP" warning on their washers and dryers, as seen below.

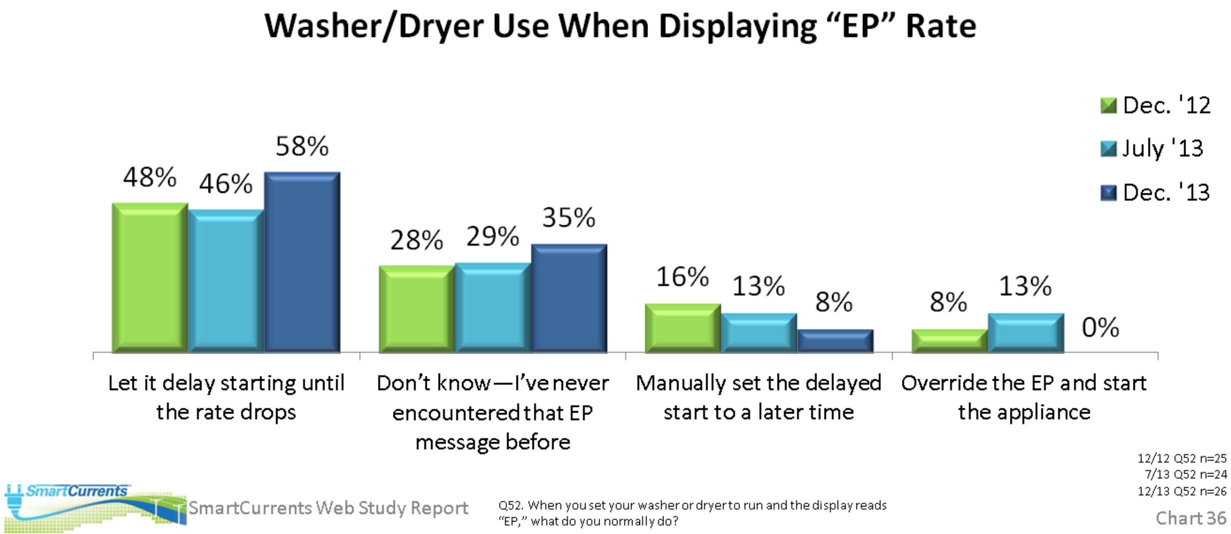


Figure 53: S-Cell Washer/Dryer Habits

Comparing the appliance groups to the other treatment cells, DTE has observed that across all treatment levels, there have been significant increases in stated conservation behaviors over the past year. However, there was relatively little differentiation in self-reported conservation activity between the various levels of participation, which would indicate that education and a minimal technology investment may offer an attractive combination of budget and impact on usage for DTE Energy.

Over the year December 2012 to December 2013, there were relatively few meaningful differences in self-reported energy saving actions between respondents with minimal technology (levels T2, T3, & T4) and those with the larger technology pieces (levels S1, S2, & S3). The final web survey in December 2013 best illustrated this trend, as T2-T4 respondents were as likely as S level respondents to report they engaged in any given action.

Appliance respondents saw the fewest self-reported increases over the past year, but retained their high overall level of action across all categories.

8. Conclusions

Leading up to the pilot program launch, DTE hypothesized that a DPP rate supported only by education (T1) could result in energy conservation and demand response. According to the event day load curve, the T1 group did experience a level of demand response. On an average event day, these customers were able to reduce their load during the four critical peak hours by 1.192 kWh (12.6%) compared to the C1 control group. Unfortunately, T1 customers did not experience any level of energy conservation for daily energy consumption during both the event days and non-event hot and cold weather days. It appears that T1 customers simply shifted some of their load during the critical peak hours to other periods on the event days and maintained their normal load shape on the non-event days. This could be a result of the T1 group forgetting about the TOU rate or not realizing how much energy they were consuming. Both of these issues can potentially be mitigated by providing technology (IHD, PCT) in addition to the rate. Nonetheless, education only seemed to work for reducing energy consumption during a critical peak period for demand response.

On the 11 event days during 2013, T2 customers were able to reduce their load an average of 1.651 kWh (17.5%) during the four hours of the critical event period. However, despite reducing their load during the critical event hours, T2 customers used 3.574 kWh (8.7%) more energy, on average, on an event day compared to the C1 control group. During the non-event hot weather days and cold weather days, T2 customers used 13.6% and 9.0% more energy, respectively, than C1 customers. Hence, T2 customers did not succeed in energy conservation with the help of a DPP rate plus IHD, countering the hypothesis that IHD would provide more rate/energy awareness and hence better energy conservation. This result was surprising considering the fact that customers felt empowered by the presence of an IHD.

With that said, due to concerns over the high usage bias that existed within the T2 group, it might be beneficial for DTE to perform more customer level analysis to determine if and why the C1 group was truly a good counterfactual load.

It was hypothesized that a PCT would achieve the greatest level of demand response. The customers in the T3 and T4 groups received a PCT and seemed to be capable of internalizing the rate to the greatest degree, even though they found the device complex and unintuitive. Not only did these two treatment groups reduce their critical peak demand by the greatest amount on average during events, they were also able to reduce daily energy consumption during the pilot period. During the events, T3 and T4 customers were able to reduce their critical peak load by 44.5% and 43.0%, respectively, when compared to the C2 group. These results provide clear evidence to prove this hypothesis correct.

What was not expected was the positive effect that the PCT would have on energy conservation. It was hypothesized that the greatest level of energy conservation would be achieved by customers who had an IHD. Instead, the customers with only PCTs achieved the greatest level of energy conservation. The T3 customers were able to shed 11.8% of their total load on hot, non-event days. It is also interesting that they used a statistically significant lower amount of energy during the mid-peak and on-peak periods when the energy costs were the highest and a statistically significant higher amount of energy during the off-peak period when the costs were the lowest. This indicates that the T3 customers were able to reduce their total daily energy use and also shift their energy use to the off-peak hours during hot, non-event days with the same characteristics as event days. The T4 customers reduced their load 10.5% on the average hot day when compared to the C2 customers. The T4 customers used less energy during the on-peak and mid-peak hours and used more energy during the off-peak hours indicating they were able to shift their load to the off-peak period in addition reducing their load as a whole during the average hot day. The behavior of these two groups indicates the best way to achieve energy conservation through a TOU rate is to provide the technology needed to accommodate a “set it and forget it” mentality. The difference in energy consumption between these two treatment groups and C2 is not nearly as large during the cold weather days, and the treatment groups’ load curves do not follow the price changing triggers as much as the summer load curve. This reflects that the majority of DTE’s service territory is heated by natural gas, and that the PCT settings have a reduced effect on the overall electric load consumption during cold weather days.

From the analysis discussed in this report, it appears that the IHD had a lesser effect on the consumption behavior of T2 customers, and a non-noticeable effect on that of T4 customers. However, it is not known how the IHDs were used, and the overall impact due to technical issues, therefore, it might be best to perform a post-survey on the customers supplied with IHDs to learn this information. Performing this additional work is beneficial only if there is a belief that the IHD can be an effective tool to influence customer behavior.

DTE has gained in-depth knowledge about the effect that a CPP rate with an underlying TOU rate would have on customers, with and without enabling technologies (IHD, PCT, and the combination). Although the pilot participants were demographically different from DTE’s service territory as a whole, DTE is confident that the results and conclusions drawn from the study can be applied to the entire service area. While the energy reductions may lower when applied to the greater population, the important learning is that given the right combination of equipment, education, and pricing structure, significant influence can be exerted on how and when energy is consumed.