OG&E SMART STUDY TOGETHER IMPACT RESULTS

Interim Report – Summer 2010

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Global Energy Partners Project Manager
C Williamson

Global Energy Partners
An EnerNOC Company

EXECUTIVE SUMMARY

The primary goal of OG&E's Smart Study TOGETHER is to assess the impact of multiple levels of enabling technology combined with different dynamic pricing rates on a customer's energy consumption. To achieve this goal and enable effective and efficient targeting, a randomized sample of approximately 2,816 residential participant and control group customers and 465 small business (general service) participant customers in the area of Norman, OK was selected in the spring and early summer of 2010. The ultimate goal is to determine if the demand reductions achieved through a combination of price response programs, in-home technology, and energy awareness will allow OG&E to delay capital investments in incremental generation resources. Specifically, the goal is for the eventual full deployment of the program, which includes customer participation in Price Response programs enabled by Smart Meter technology, to have the effect of reducing peak demand to the extent that OG&E can avoid building a new 165 MW peaking unit in 2015 and a second 165 MW peaking unit in 2016.

This interim report focuses on the residential study results for the summer of 2010. Because of the limited number of small business customers in Norman and the challenges around recruiting enough participants, the small business results are to be considered more anecdotal in nature.

Residential customers were offered two rates as part of the Smart Study TOGETHER project. Based on their random assignment, participants were offered either a Time-of-Use rate with a Critical Price option (TOU-CP) or a Variable Peak Pricing rate with a Critical Price option (VPP-CP). Customers in the control group were left on their existing standard rates.   OG&E is testing four technology options, including a web portal, an in-home display (IHD), a programmable communicating thermostat (PCT), and a combination of all three.

A randomized study design was implemented with participant and control groups to estimate the load reduction associated with each of the eight rate-technology combinations. The design was expanded to give secondary information about load reduction for three age and three income demographic segments. Customers were then recruited to participate in the study, and data were collected over the summer of 2010. 2,516 customers were included in the analysis.

This report provides summary information about the results of the study, with load reductions in tabular and graphical form accompanied by comments. Some results by age and income are included in this report as well. More complete results are included in the Appendices. Highlights of the findings include:

- In general, the automated response of the PCT and All Three groups reduce load more than the information provided through the IHD and Web Portal. However, the IHD and Web Portal load reductions are more constant throughout the peak period, whereas the PCT and All Three groups tend to have a load reduction spike at the beginning, and savings that decay later in the period.

- The TOU-CP shows significant load reductions for all technology groups on both non-event weekdays and the weekday event.

- The VPP-CP rate shows load reductions that correspond to the price level on weekdays – there is statistically significant load reduction on days when prices are standard, medium, and high, and the load reduction increases as the price increases.

- The one weekend event was on a late summer day, and as a result, the savings were smaller but still statistically significant for several of the rate/technology combinations.

- The one weekday event was on a mild day as well. The kW savings for the TOU-CP were comparable to the average weekday, but because the load was lower, the percentage

savings were higher. The behavior of the VPP-CP customers was similar to their behavior on a high-priced day, but with less load reduction since the load for the day was lower because of the temperature.

- The PCT groups often show more savings that the All Three group, but this is likely due to the fact that the PCT group included only those with central AC, and the All Three group included customers both with and without central AC.

- In several cases, the All Three group showed both overall load reductions throughout the day and further reductions in the peak period. This suggests that the information technologies (IHD and Web) are prompting behavioral changes in addition to the automated response of the PCT.

Findings related to the Age segments include:

- The Family age segment has the highest average baseline usage, and generally has higher load reductions, particularly for the PCT and All Three groups.

- In several cases, the Mature and Young groups showed better load response than the Family group to the information provided by the IHD.

- The PCT and All Three groups generally had higher savings for each of the age segments, consistent with the trend for the combined population.

Findings related to the Income segments include:

- The High income segment has the highest average baseline usage, and generally has higher load reductions.

- The Low income segment shows higher percentage savings in many cases, and in some cases higher kW savings than the higher-consuming Middle and High income segments. This may be a result of Low income customers being more price sensitive and taking more actions to reduce load.

- The PCT and All Three groups in the Low income segment appear to have load reductions throughout the day, including several hours before the event.   Since these are off-peak periods, this is not price response, but may be due to the PCTs replacing manual thermostats, then being used to reduce load when the home is unoccupied. It could also be due to higher energy awareness.

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BACKGROUND

1.1 GOALS OF THE STUDY

The primary goal of OG&E's Smart Study TOGETHER is to assess the impact of multiple levels of enabling technology combined with different dynamic pricing rates on a customer's energy consumption. To achieve this goal and enable effective and efficient targeting, a randomized sample of approximately 2,816 residential participant and control group customers and 465 small business (general service) participant customers in the area of Norman, OK was selected in the spring and early summer of 2010. The ultimate goal is to determine if the demand reductions achieved through a combination of price response programs, in-home technology, and energy awareness will allow OG&E to delay capital investments in incremental generation resources. Specifically, the goal is for the eventual full deployment of the program, which includes customer participation in Price Response programs enabled by Smart Meter technology, to have the effect of reducing peak demand to the extent that OG&E can avoid building a new 165 MW peaking unit in 2015 and a second 165 MW peaking unit in 2016. These numbers are based on achieving a 20% customer Price Response participation rate and an average peak demand reduction of 1.3 kW per participating residential customer.

The experiment is to determine the load reduction enabled by smart grid/smart metering resulting from various combinations of dynamic rates and enabling technologies. OG&E is testing two rates, a time-of-use critical peak price (TOU-CP) and a variable peak price (VPP-CP) (for both residential and small commercial), and four technology options, including web portal, in-home display (IHD), programmable communicating thermostat (PCT), and a combination of all three. While estimating the average on-peak period load reduction is the most important goal of the study, we also plan to estimate how much load has shifted to the off-peak period, and if there is an overall reduction in energy consumption.

This report focuses on the residential study results for the summer of 2010. Because of the limited number of small business customers in Norman and the challenges around recruiting enough participants, the small business results for the first summer are to be considered more anecdotal in nature.

1.2 GUIDING PRINCIPLES

OG&E established ten guiding principles for the study. These principles were used throughout the planning, design, implementation, and analysis for the program.

- Demand Response (DR) results will be obtained through customer empowerment.

- OG&E will not utilize any direct control of customer equipment or appliances.

- Customers will be provided time differentiated pricing and be allowed to choose their balance of cost versus comfort.

- Pricing (rates) will reflect true market prices minimizing any subsidies within or across customer rate classes.

- It is anticipated that all future customer participation will be voluntary, thus participation in this research will also be voluntary.

- Enabling technology will be provided to customers at no cost.

- Customers will be encouraged to remain on the program for the entire length of the study and incentives may be required.

- A control group will be utilized to eliminate the impact of weather, economic conditions, fuel prices, and other non-controllable variables.

- The number of customers participating in both the study and the control group must be large enough to provide statistically significant results which can be applied to OG&E's entire customer base.

- The sample will reflect the demographic makeup of OG&E's customer population.

1.3   RATE OPTIONS

Residential customers were offered two rates as part of the Smart Study TOGETHER project. Based on their random assignment, participants were offered either a Time-of-Use rate with a Critical Price option (TOU-CP) or a Variable Peak Pricing rate with a Critical Price option (VPP-CP). Customers in the control group were left on their existing standard rates.

1.3.1   Time-of-Use with Critical Pricing

The TOU-CP uses the existing Residential and General Service TOU rates as the respective base rate. The TOU-CP will also include a Critical Price, or Price Overcall Provision which can be utilized when OG&E requires a reduction in total system load. With a minimum of two hours notice, a price overcall can be issued to raise the price level to the critical price. A price overcall may occur at any time during the year. The price overcall time period will not be less than two hours nor will it exceed 8 hours in length. Table 1-1 shows the prices for the TOU-CP rate.

Table 1-1   TOU-CP Prices

Price Level	TOU-CP Price	Estimated Days at each price level
Off-peak	4.2¢ per kWh	35
On-Peak	23¢ per kWh	85
Critical	46.0¢ per kWh	2

1.3.2   Variable Peak Pricing

The VPP-CP was designed using the existing Residential TOU rate as a base rate. The peak period price in the TOU rate is replaced with a variable price signal sent to participating customers. A single price will apply to the entire five-hour window each weekday. There are four defined price levels – Low, Standard, Medium and High – to simplify communications of price level. The prices assigned to each price level are based on the underlying Standard and TOU tariffs. Low prices, at 4.5¢ per kWh, are similar to Off-peak energy prices, Standard prices equate to the standard tariff summer season tail-block price, and Medium and High prices reflect the peak period energy prices.

The VPP-CP will also include a Critical Price, or Price Overcall Provision which can be utilized when OG&E requires a reduction in total system load. With a minimum of two hours notice, a price overcall can be issued to raise the price level to the critical price, which for VPP-CP is the same as the high price. A price overcall may occur at any time during the year. The price overcall time period will not be less than two hours nor will it exceed 8 hours in length.

The Day-Ahead On-Peak Prices for VPP-CP are communicated to the customer by 5:00 PM on the day prior to the applicable day. On-Peak Hours are from June 1 through September 30, beginning each day at 2:00 PM and ending at 7:00 PM, local time, excluding Saturdays, Sundays, Independence Day (as observed) and Labor Day. Off-Peak hours are defined as all hours that are not On-Peak hours. Table 1-2 shows the prices for the VPP-CP rate.

Table 1-2   VPP-CP Prices

Price Level	VPP-CP Price	Estimated Days at each price level
Low and off-peak	4.5¢ per kWh	50
Standard	11.3¢ per kWh	37
Medium	23.0¢ per kWh	23
High	46.0¢ per kWh	10
Critical	46.0¢ per kWh	2

1.4   TECHNOLOGY OPTIONS

OG&E is testing four technology options:

- Web portal

- In-home display (IHD)

- Programmable communicating thermostat (PCT)

- Combination of all three.

To determine the most appropriate equipment for each technology, OG&E turned to the focus groups they conducted along with GE during May 2008. Customers felt that Smart Grid enabled tools gave them more control over their consumption and costs. They also felt having more information allowed them to make better choices. Customers were more interested in an in-home device over a PCT, but expressed concern over the costs. Consumers also expressed interest in having online access to their consumption so they could more actively manage their consumption. Because the costs and benefits associated with each technology vary, OG&E decided to include each equipment configuration in the Study. Furthermore, because cost was more than twice as important to consumers as any other attribute, OG&E will also be providing the equipment at no cost to the customer.

Customers that choose to participate in Smart Study TOGETHER will randomly be assigned to one of the above technology configurations or to the control group.

1.5   SYSTEM LOAD CHARACTERISTICS

Because the pilot targets system peak reduction, it is important to consider the nature of the OG&E system load. The 2010 OG&E system peak of 6,171 MW occurred at the hour ending 5:00 PM on August 4. This summer system peak is much higher than the winter peak of 4,642 MW, which occurred on January 8 at the hour ending 8:00 AM.

Figure 4-1 below shows the system load shape for the 2010 system peak day. Note that the system load during the peak period is fairly flat. The system load during each of the other four on-peak period hours is greater than 96% of the actual peak, and the hour before the peak is within 1% of the actual peak. This means that reducing just the specific hour of the system peak will not significantly reduce OG&E's capacity requirements – load must be reduced in all of the peak hours.

OG&E System Peak Day - August 4, 2010
Peak of 6,171 MW at 17:00
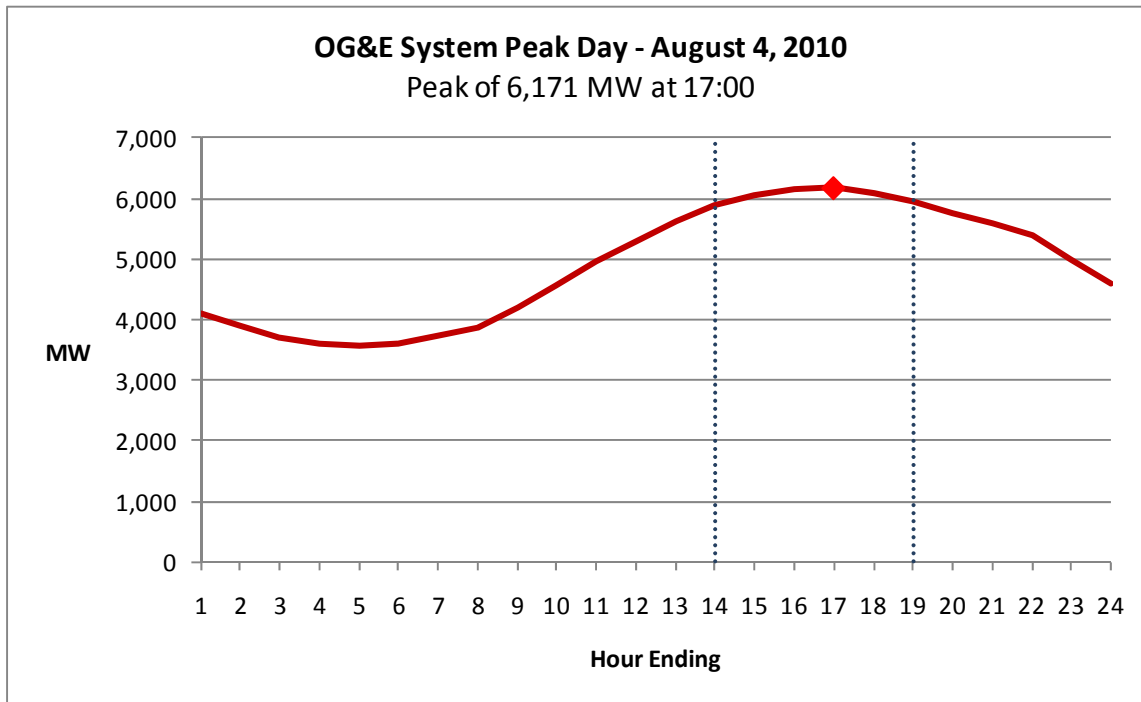
Figure 1-1 *System Load on the summer peak day, August 4, 2010*

Also important is the number of hours throughout the year that the system load is at or near the system peak. The best way to examine the nature of the relative magnitude of the system load throughout the year is a load duration curve. A load duration curve is a graph showing the system load for all 8,760 hours of the year, sorted from highest to lowest. Figure 1-2 shows a load duration curve for OG&E. Because the load duration curve drops off relatively quickly, load reduction in a few hours each year can reduce the capacity needs of the system significantly. In fact, the load exceeds 92% of the peak for fewer than 1% of the hours in the year.

OG&E 2010 Load Duration Curve
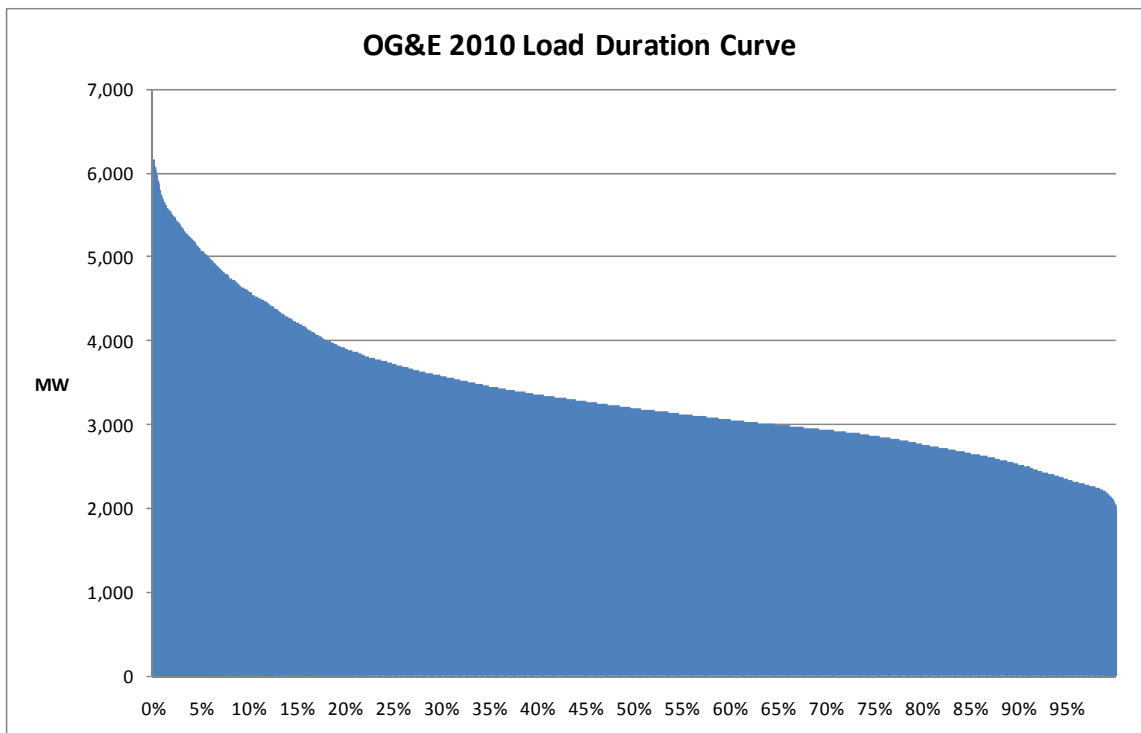
Figure 1-2 *System Load Duration Curve for OG&E for 2010*

The nature of the OG&E system load is such that a technology-enabled pricing offering of the types offered in this pilot has the potential to reduce system capacity requirements significantly, potentially enough to eliminate the need for the two peaking units described above.

EXPERIMENTAL DESIGN

2.1 STUDY DESIGN

For the Residential study, we collected interval data using smart meters from a sample of customers in Norman to estimate the load reduction resulting from various combinations of dynamic rates and enabling technologies. The two rates and four technology options described above result in eight combinations (referred to as treatments), with a separate sample of participating customers needed for each. For the analysis, we also need a control group of customers who are as similar as possible to those in each of the treatment (rate-technology combination) groups. We estimate the load reduction by comparing the load for the customers with each rate-technology combination with the load for customers in the control group. We make this comparison for several different day types, including average weekend days, average weekdays, event days, and average days for the various price levels for the VPP-CP rate. In addition to a direct comparison, we intend to use a statistical regression model, which will quantify the variability from all other known sources (appliances, building size, etc.) and remove that from the estimate of load impact. It will also allow us to estimate the load impact for different temperatures, which we expect will vary, and different appliance mixes. However, the analysis for this report is based on a direct comparison of loads.

One important consideration was how to assign customers to the different rate-technology options and the control group. Because OG&E is planning to offer dynamic rates on a voluntary basis, it was most appropriate to recruit customers to volunteer to participate. However, since OG&E needs to determine the best option for rate and technology implementation, it was appropriate to randomize the assignment of customers to the 8 treatment cells. This allows for direct and unbiased comparison of the rate-technology options. If customers were given a choice, then the results for, say, the IHD group would not apply to all customers, but only to those customers who would choose an IHD when the program is implemented. Also, it was critical to assign customers who volunteer randomly to the control group as well. This may seem strange, but the control group should include customers who are as much "like" those in the treatment groups as possible. It was made clear to these customers that they were not on the rate, and would not receive any technology. Because the control group was to be compared with all eight of the treatment groups separately, we decided to double its sample size to improve the precision of all estimates.

Two of the technologies, PCT and Web Portal, require specific customer qualifications. If a customer does not have central AC, they cannot be assigned to PCT. If a customer does not have internet access, they cannot be assigned to Web Portal. Because of this, all customers assigned to either of these groups were also given a secondary random assignment. During the initial contact, if a customer assigned to PCT reported that they did not have a central AC, then they were given their secondary assignment. If a customer assigned to Web Portal reported that they did not have internet access, then they were given their secondary assignment. This was asked before they were offered anything, so the customers never knew if they were receiving their original assignment or their secondary assignment. We considered the same approach for the All Three technology group, but chose not to implement it. If in an eventual system-wide rollout, all three technologies were offered to all customers, there would be a mix of customers with and without central AC and with and without internet access. In those cases, the customers would receive those technologies which they qualified for, so we decided to emulate that with the study. So the load reductions for the All Three category reflect a mix of customers, most of which have all three, but some of which have only two, or in some cases, only one of the three. But this reflects what we would expect in a future rollout.

2.2   DEMOGRAPHICS

The residential sample design includes additional layers, based on customer demographics of two types. Estimating the load impacts for each rate-technology combination is still the primary goal, but we also wanted to get a sense of how the impacts vary across three life stage demographic groups (Family, Mature, and Young) and three income demographic groups (High, Middle, and Low), based on PRIZM codes.   Including the demographics will help OG&E better understand what types of customers provide the most load reduction, and will help determine marketing approaches for future recruiting efforts. The sample design estimates the top level (rate-technology group) at one precision, and the life stage and income groups with less precision. But the design is nested, so the layers build up to the top level, giving us the best estimate for the rate-technology groups.

2.3   RANDOMIZATION

In order to implement a randomized design, all eligible customers were randomly preassigned to either one of the treatment groups or the control group. This was done before recruiting started, so that then when customers called in or went online to join the study, the assignment was already determined. In order to optimize survey data collection and ensure consistent data, each interested customer first responded to a survey, and then was either told what their preassigned rate technology combination was, or if they were in the control group, they were told that they were not eligible to participate this year. As a result, we had survey data for all customers, both participant and control.

The sample design called for 10% of the sample in each of the eight rate-technology cells, and 20% in the control group.   In the randomization process, we assigned slightly more customers (10.5%) in each rate-technology group, and slightly fewer (16%) in the control group. This was done because we expected that some participants would not be able to participate because of equipment incompatibility, which would not happen with the control group.

2.4   LACK OF PRETREATMENT DATA

Because the meters were installed in the spring and early summer of 2010, the analysis of summer 2010 did not allow for the use of any pretreatment data. In a designed statistical experiment of this type, having data for both before the rate and technology start and after they are in place allows adjustment of the results for any pre-treatment differences between the participant and control groups. This was not possible with this study, since there was not interval data available for the study customers before the smart meters were installed.   This made the randomized assignments to treatment and control even more important, since randomization is an effective way to ensure that pretreatment differences are minimized and groups of customers are similar.

IMPLEMENTATION

3.1 RECRUITING

Recruiting started early in 2010, with the target of recruiting 2,400 customers evenly distributed across the eight treatment groups, as shown in Table 3-1 below. This table reflects the rate-technology options that were used for recruiting, and all the customers that were recruited.

Table 3-1   Smart Study TOGETHER 2010 Recruiting As Designed

	Control	TOU-CP	VPP-CP	Total
Control	480	-	-	480
Web Portal	-	240	240	480
IHD	-	240	240	480
PCT	-	240	240	480
All Three	-	240	240	480
Total	**480**	**960**	**960**	**2,400**

With the recruiting complete as of June 30, 2010, there were 2,667 residential customers recruited for the study.

3.2 RERANDOMIZATION

The sample design called for consistent sample sizes across all cells, both at the rate-technology level, and at the demographic level. Because different types of customers signed up at different rates, because there was random variation in how many signed up, and because there were more customers who were disqualified based on some equipment considerations, certain of the cells filled up more quickly than others. We capped the cells to avoid oversubscribing customers, resulting in some customers that wanted to participate not being included in the study. These customers were told that they would be eligible to participate the next summer. For certain cases where some cells filled up more quickly than others for the same demographic segment, we changed the random preassignments for customers *who had not yet contacted OG&E* from the cell that was full to others that were not. Because we did this only for those who had not yet tried to sign up, the randomized design was retained, but we were able to fill up more of the cells.

In the end, we did not fill all the cells to the target levels. The load shapes for those cells with fewer customers were not as precisely estimated as those with larger samples, but we did get a sufficient sample in each for valid statistical analysis.

3.3 DIFFERENCES BETWEEN ASSIGNMENTS AND ACTUAL INSTALLATIONS

As described above, customers were randomly preassigned to either the control group or to one of the eight rate-technology groups. These assignments determined the enabling technology or technologies that participants would receive, which would then be used to distinguish treatment cohorts during the analysis. Customers in the control group were not to receive any enabling technologies. Treatment group customers, on the other hand, would receive what was designated by their primary assignment, or if they did not qualify for that, then by their secondary assignment. Most of the time, installed technologies matched assigned technologies.

In addition, for all customers in the control group, technology installations were handled properly. That is, no control group customers received enabling technologies. This section describes a few instances where the installed technologies for some participants did not match the assigned technologies and explains what was done as a result.

After we randomized the technology assignments, Comverge handled the recruiting and installation. As the installations were occurring, OG&E tracked the customer installation status based on the assigned rate and technology groups. At the end of the summer, we examined the database containing variables indicating whether access to the Web Portal was provided and indicating the number of IHD and PCT devices installed. We used these variables to determine the actual installed technologies. Unfortunately, neither the information about whether the primary assignment or the secondary assignment was used, nor the qualifying questions about internet access and central AC which drove the decision of which assignment was used were not retained in the database. This would have provided insight into how customers responded to the qualifying questions, enabling us to make better technology group classifications when installed technologies did not match assigned technologies.

Examining the data, we realized that not all installations had occurred as planned. All installations should have only been for one or for all three of the technologies, except for control group customers who received none. Most customers either received their primary or secondary assignments, but some customers received something other than what should have been installed. Some customers, for example, had two technologies installed, which, based on the technology assignments, should not have occurred, except in special circumstances for customers in the All Three group. For example, customers assigned to the All Three group who did not have central AC could only have had Web Portal access and an IHD installed while customers without internet access could only have had an IHD and PCT installed. Because we wanted to include all records that were valid, we checked to see if there were possible, logical reasons for having these unusual technology combinations, and when there were, the corresponding customers were included in the analysis. For instance, we would have classified customers fitting the two cases just described into the All Three group. This is appropriate, because the field staff would not have been able to install a PCT without central AC, and because Web Portal access was not possible without internet access. Survey data indicated whether a customer had a central AC but not whether they had internet access.

In other cases we used our best judgment to categorize customers, often making inferences regarding internet access based on the actual installations since internet access information was absent from the survey data. Interestingly, we found that some customers received no technologies even though they were assigned to one of the eight rate-technology groups. These customers were placed into a separate "Rate Only" group. We believed that the majority of the Rate Only group customers were those who agreed to participate, but for whom OG&E was unable to set up an appointment to install equipment (either IHD or PCT). This group was excluded from the analysis, because they did not have any enabling technology, and because their self-selected nature meant that they were not matched to the control group.

We made an effort to keep as many customers in the analysis as possible, based on the assumption that the differences between assigned and installed technologies were random installation errors and that there were no systematic reasons that customers did not receive the technology they were supposed to have received. As a result, we decided that there was more value to using the customers "as installed" in those cases where the installation did not match their original assignment, as long as they fit into one of the four technology groups. Further detail regarding technology group categorization can be found in the Appendix A.

Table 3-2 below, which excludes the control group customers, displays technology assignments as well as the actual installed technologies for all customers with interval data used in the analysis.

Table 3-2   Smart Study TOGETHER 2010 Assigned versus Actual

	Assigned Technology				
Actual Technology	**Web Portal**	**IHD**	**PCT**	**All Three**	**Total**
Web Portal	519	0	2	37	558
IHD	1	480	17	0	498
PCT	1	0	430	0	431
All Three	5	0	0	475	480
Total	**526**	**480**	**449**	**512**	**1,967**

3.4   EXCLUDED PARTICIPANTS

It was not possible to include every participant we had interval data for in the analysis. Two main reasons prevented customers from being used. The first was related to technology group classification. As discussed above, customers in the Rate Only group were excluded from the analysis. In addition, customers that we were unable to place into a technology group were also excluded. This was only the case when customers received their primary assignment but also received an additional enabling technology. The motivation behind excluding these customers was that, if we were to place them into the technology group associated with their primary assignment, their usage would be subject to the effects of that technology while also being subject to the effects associated with the additional enabling technology, thus biasing the results. Further detail regarding technology group classification can be found in Appendix A.

The second reason we excluded customers had to do with erroneous usage data, with the focus being on exceptionally high values. We got the indication that the data contained inaccuracies when, in some cases, average load shapes looked abnormal, with immense spikes during various hours of the day. In order to look for these inaccurate values we identified customers with daily mean usage values much higher than average. We were able to edit values for two customers since they had very few erroneous values and, as a result, were able to include these customers in the analysis. In these cases, we replaced the erroneous values with the average of the valid values on either side of them. We were unable to edit the data for five other customers, however, and had to exclude them. These customers had too many erroneous values on too many days for it to have been feasible for us to edit their data.

One additional, but important and perhaps obvious, point is that customers for whom we had no interval data were not included in the analysis. The original database included 2,816 customers, but not all of them had interval data.

3.5   SAMPLE SIZES USED FOR ANALYSIS

Using the actual technology assignments as described above, Table 3-3 shows the number of customers in each rate-technology group that were used in the analysis. The distribution of participants across rate categories for each technology group is roughly equivalent and is what we would expect based on the randomization of the preassignments.

Table 3-3   Smart Study TOGETHER 2010 Sample Sizes Used

	Control	**TOU-CP**	**VPP-CP**	**Total**
Control	549	-	-	549
Web Portal	-	282	276	558
IHD	-	249	249	498

PCT	-	218	213	431
All Three	-	246	234	480
Total	**549**	**995**	**972**	**2,516**

3.6   PCT AND CENTRAL AIR CONDITIONING CONSIDERATIONS

The programmable communicating thermostat requires specific customer qualifications. A customer home must have central air conditioning in order to receive a PCT. Consequently, we can assume that anyone with a PCT has central AC. Given that the PCT group consists of customers with central AC only, a comparable control group is used. Direct load comparisons and savings estimates for the PCT group are calculated with a control group of customers with central AC. All load shapes, savings shapes, consumption and savings estimates, and segmented age and income graphs in this report will reflect this when referring to the PCT group.

RESULTS

Using the interval data collected for customers in the study, along with the actual assignments described above, the savings for each day type were estimated as follows. We first calculated the average hourly load for each day type for each customer. Since these were based on actual measured data for the days, these were not statistical estimates and so had no uncertainty associated with them. Then for each rate-technology combination and for the control group, we calculated an average day type load shape for each demographic combination segment (age and income), and then weighted those segments based on the OG&E service territory proportions in each segment.   This adjusted the relative representation of the different demographic segments to correspond to OG&E's service territory instead of to the roughly equivalent sample sizes from the sample design. We also calculated the associated variances and 90% confidence intervals for these estimates. The participant and control group load shapes in the graphs in this section are the result of these calculations.

We then calculated the savings as the difference between the control group load and the participant group load for each day type, for each rate-technology combination.   We used the variances of the load shape estimates to calculate the 90% confidence intervals for the savings as well.

4.1   OVERALL RESULTS BY RATE AND TECHNOLOGY

This section presents the results for the entire rate-technology group, including all demographic segments. As described above, the demographic segments are weighted to reflect the overall mix of customers in OG&E's service territory.

4.1.1   Average Non-Event Day Impacts

We start with the impacts on non-event days. Table 4-1 below shows, for on-peak and off-peak times, the kWh baseline consumption (from the control group), the associated kWh and percentage change in consumption, as well as the overall kWh change for each day type and each rate-technology combination. Note that, on a given day type, baseline consumption is different for the PCT group than it is for the other technology groups. This is as a result of the PCT group control group being comprised of customers with central AC only. Note that throughout the report, we present consumption reductions as negative numbers, and increases as positive numbers. However, we report demand in terms of reductions, so that a positive reduction means less energy consumed. Also note that there is no on-peak period on weekends, so all consumption is reported as off-peak.

Table 4-1   Non-Event Day Average Customer Consumption and Savings

	On-Peak Consumption			Off-Peak Consumption			Overall
	Baseline	**Change**	**Percent**	**Baseline**	**Change**	**Percent**	**Change**
TOU-CP Weekend Non-Event							
Web Only				56.05	-0.29	-0.51%	-0.29
IHD Only				56.05	-3.88	-6.93%	-3.88
PCT Only				56.50	-0.36	-0.63%	-0.36
All Three				56.05	-1.42	-2.52%	-1.42

TOU-CP Weekday Non-Event							
Web Only	14.89	-1.49	-10.03%	36.18	0.41	1.15%	-1.08
IHD Only	14.89	-2.51	-16.84%	36.18	-1.81	-5.00%	-4.32
PCT Only	15.03	-4.41	-29.37%	36.64	1.25	3.42%	-3.16
All Three	14.89	-3.83	-25.73%	36.18	0.07	0.20%	-3.76
VPP-CP Weekend							
Web Only				56.05	-1.03	-1.83%	-1.03
IHD Only				56.05	-1.42	-2.53%	-1.42
PCT Only				56.50	0.74	1.31%	0.74
All Three				56.05	-0.74	-1.32%	-0.74
VPP-CP Low Weekday							
Web Only	11.26	-1.60	-14.23%	29.55	-2.69	-9.10%	-4.29
IHD Only	11.26	-1.46	-12.94%	29.55	-3.05	-10.32%	-4.51
PCT Only	11.50	-1.71	-14.85%	30.26	-2.70	-8.92%	-4.41
All Three	11.26	-1.48	-13.15%	29.55	-3.47	-11.75%	-4.95
VPP-CP Standard Weekday							
Web Only	14.09	-1.01	-7.15%	33.85	0.68	2.01%	-0.33
IHD Only	14.09	-0.90	-6.37%	33.85	-0.05	-0.16%	-0.95
PCT Only	14.21	-3.41	-23.97%	34.26	1.86	5.43%	-1.55
All Three	14.09	-2.84	-20.18%	33.85	0.21	0.63%	-2.63
VPP-CP Medium Weekday							
Web Only	17.13	-1.36	-7.92%	41.04	1.46	3.55%	0.10
IHD Only	17.13	-1.41	-8.25%	41.04	0.58	1.41%	-0.84
PCT Only	17.24	-5.41	-31.41%	41.34	3.66	8.85%	-1.76
All Three	17.13	-4.39	-25.63%	41.04	1.67	4.07%	-2.72
VPP-CP High Weekday							
Web Only	18.37	-2.15	-11.72%	44.38	0.43	0.97%	-1.72
IHD Only	18.37	-2.02	-10.99%	44.38	0.50	1.14%	-1.51
PCT Only	18.41	-6.43	-34.95%	44.52	3.74	8.39%	-2.70
All Three	18.37	-5.20	-28.29%	44.38	2.21	4.98%	-2.99

Table 4-2 below shows average on-peak kW savings for each day type and each rate-technology combination, as well as the kW savings at the single hour that shows the maximum reduction. This is usually in the first hour of the period for the PCT and All Three groups, when the load reduction due to the PCT is maximized. For the Web and IHD, the maximum demand tends to occur later in the on-peak period.

We include on-peak demand reductions on the weekend days as well, even though the entire weekend days are off peak. We report this because there is some consistency in customer

behavior across all days, resulting in weekend day demand reductions during what would be the usual on-peak hours on a weekday.

Table 4-2   Non-Event Day Average Customer Demand

	Average On-Peak Demand			Demand at Maximum Reduction		
	Baseline	**Reduction**	**Percent**	**Baseline**	**Reduction**	**Percent**
TOU-CP Weekend Non-Event						
Web Only	3.35	0.06	1.78%	3.36	0.13	4.00%
IHD Only	3.35	0.29	8.72%	3.36	0.37	11.05%
PCT Only	3.37	0.09	2.62%	3.38	0.16	4.62%
All Three	3.35	0.12	3.72%	3.36	0.19	5.74%
TOU-CP Weekday Non-Event						
Web Only	2.98	0.30	10.03%	3.03	0.33	10.90%
IHD Only	2.98	0.50	16.84%	2.83	0.54	19.15%
PCT Only	3.01	0.88	29.37%	2.64	1.25	47.30%
All Three	2.98	0.77	25.73%	2.63	1.10	42.07%
VPP-CP Weekend						
Web Only	3.35	0.10	3.03%	3.19	0.18	5.61%
IHD Only	3.35	0.06	1.91%	3.36	0.14	4.25%
PCT Only	3.37	0.01	0.38%	3.22	0.10	3.11%
All Three	3.35	0.05	1.55%	3.36	0.10	2.87%
VPP-CP Low Weekday						
Web Only	2.25	0.32	14.23%	2.49	0.35	14.12%
IHD Only	2.25	0.29	12.94%	2.49	0.33	13.09%
PCT Only	2.30	0.34	14.85%	2.35	0.41	17.54%
All Three	2.25	0.30	13.15%	2.09	0.34	16.21%
VPP-CP Standard Weekday						
Web Only	2.82	0.20	7.15%	2.88	0.24	8.22%
IHD Only	2.82	0.18	6.37%	2.88	0.20	6.91%
PCT Only	2.84	0.68	23.97%	2.45	1.11	45.34%
All Three	2.82	0.57	20.18%	2.44	0.93	38.20%
VPP-CP Medium Weekday						
Web Only	3.43	0.27	7.92%	3.29	0.31	9.40%

IHD Only	3.43	0.28	8.25%	3.64	0.30	8.26%
PCT Only	3.45	1.08	31.41%	3.08	1.68	54.65%
All Three	3.43	0.88	25.63%	3.08	1.38	44.94%
VPP-CP High Weekday						
Web Only	3.67	0.43	11.72%	3.37	0.51	15.03%
IHD Only	3.67	0.40	10.99%	3.56	0.47	13.11%
PCT Only	3.68	1.29	34.95%	3.37	1.96	58.21%
All Three	3.67	1.04	28.29%	3.37	1.63	48.34%

The OG&E system peak nearly always occurs at 5:00 PM on a summer weekday. Table 4-3 below shows kW savings at 5:00 PM for each weekday day type and each rate-technology combination, as well as the kW savings for August 4 at 5:00 PM, the date and time of the actual system peak. August 4 was a VPP high-priced weekday, so that is the only VPP-CP day type with the August 4 load reduction.

Table 4-3   Non-Event Day Average Customer Demand at the time of the System Peak

	Demand Reduction at 5:00 PM			System Peak Day - August 4, 2010		
	Baseline	**Reduction**	**Percent**	**Baseline**	**Reduction**	**Percent**
TOU-CP Weekday Non-Event						
Web Only	3.03	0.33	10.90%	4.03	0.31	7.78%
IHD Only	3.03	0.54	17.73%	4.03	0.64	15.96%
PCT Only	3.06	0.90	29.60%	4.01	1.08	26.89%
All Three	3.03	0.80	26.47%	4.03	0.90	22.36%
VPP-CP Low Weekday						
Web Only	2.30	0.35	15.17%			
IHD Only	2.30	0.29	12.62%			
PCT Only	2.35	0.41	17.54%			
All Three	2.30	0.30	13.24%			
VPP-CP Standard Weekday						
Web Only	2.88	0.24	8.22%			
IHD Only	2.88	0.20	6.91%			
PCT Only	2.89	0.67	23.06%			
All Three	2.88	0.54	18.73%			
VPP-CP Medium Weekday						
Web Only	3.48	0.28	8.11%			

IHD Only	3.48	0.28	8.04%			
PCT Only	3.51	1.04	29.60%			
All Three	3.48	0.81	23.33%			
VPP-CP High Weekday						
Web Only	3.71	0.45	12.11%	4.03	0.34	8.52%
IHD Only	3.71	0.40	10.73%	4.03	0.33	8.27%
PCT Only	3.71	1.21	32.73%	4.01	1.23	30.55%
All Three	3.71	0.96	25.89%	4.03	1.09	27.09%

For the TOU-CP group, there is very little change on weekend days, with only the IHD group showing a statistically significant difference during a few afternoon hours. The load reductions during the weekdays, however, are all statistically significant, with the PCT and All Three groups showing the greatest reduction. Note that for these two groups, the average and peak kW savings are quite different, indicating that the savings are not flat throughout the peak period, which can be seen clearly in the graphs below.

The savings estimates for the VPP-CP group across the different day types reflect both the differences in price effect and the differences in the days at the various price levels. The level of VPP weekday price, be it low, standard, medium, or high, is set based on the forecasted OG&E system load, which is driven primarily by temperature. So higher prices are generally associated with higher system loads. Fortunately, the higher the usage, the higher potential savings, so that as the price goes up, the savings potential increases as well.

The nature of the savings of the VPP-CP rate is similar to the TOU-CP rate, with the PCT and All Three groups saving more than the IHD and Web groups on all but the low-priced days.

One important consideration to keep in mind is that the PCT group includes only those customers with central AC, since that was a requirement of having the PCT. For the All Three group, there were many with central AC, but some without, since that group represents a more diverse population. Because of this, the savings for the PCT group are often slightly higher than the savings for the All Three group. We believe that this is a result of the differences in the mix of customers, and does not reflect a fundamental difference between how customers are responding.

The graphs below show the estimated load shapes for the control group and for each of the rate-technology groups for each day type for each rate. These graphs allow for a comparison of the different groups. We start with the TOU-CP rate group.

Figure 4-1 below shows the load shapes for the TOU-CP rate for an average of the non-event weekend days. On weekend days, the TOU-CP rate appears not to have any real effect on usage. The IHD Only group appears slightly (though not statistically significantly) lower, probably due to the increased awareness IHD customers have of their energy use. Note that prices for the TOU-CP customers are lower on weekends than the standard rate, but this lower price does not result in an increase in energy use.
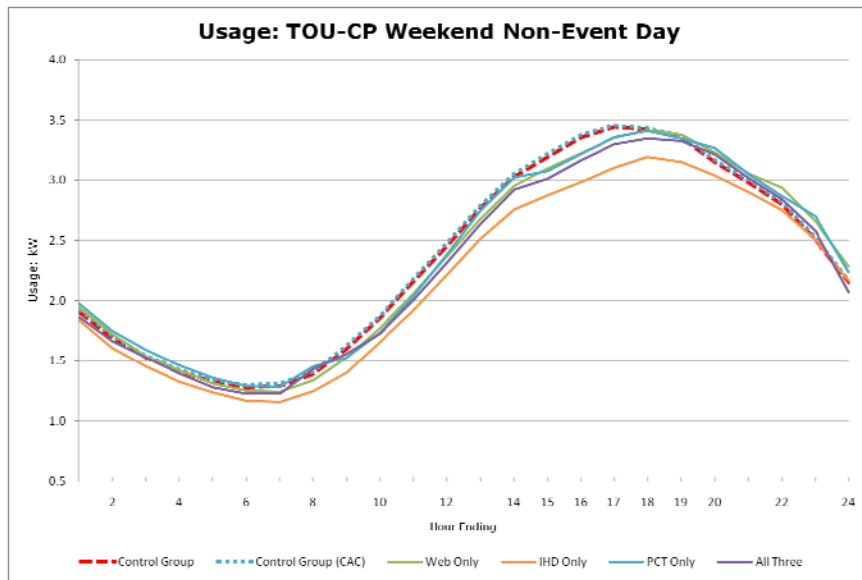
Figure 4-1   TOU-CP weekend non-event day, all rate-technology combinations

Figure 4-2 shows the load shapes for the average non-event weekday. The PCT and All Three groups clearly show a bigger initial savings, when the PCTs raise their setpoints in response to the higher price, but that savings decays after the start of the peak period, since the indoor temperature rises to the new setpoint, and the central AC goes on again. The IHD and Web only groups are fairly similar, with the IHD showing slightly more savings, which may be due to increased awareness of energy use, though it is not statistically significant.
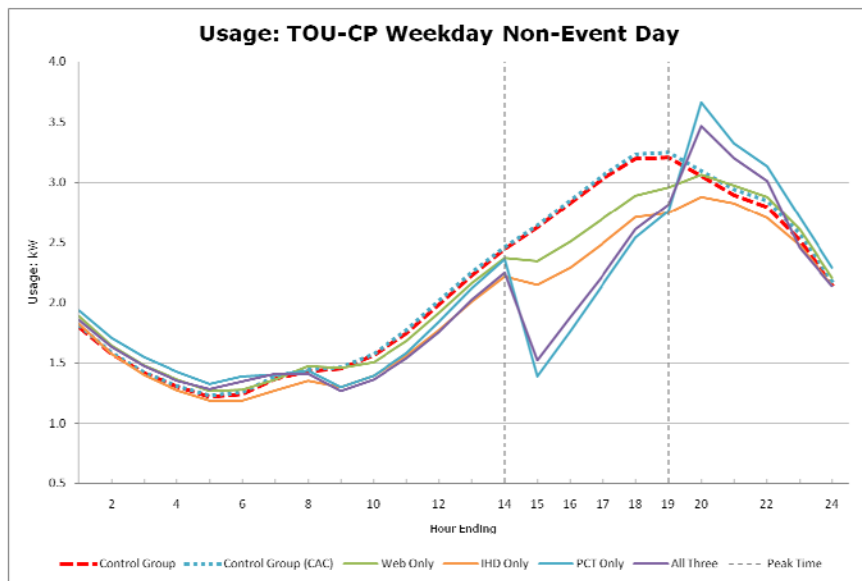
Figure 4-2   TOU-CP weekday non-event day, all rate-technology combinations

Figure 4-3 below shows the load shape for the VPP-CP group for an average weekend day. There are not any significant differences between the load shapes for the control group and any of the rate-technology groups.
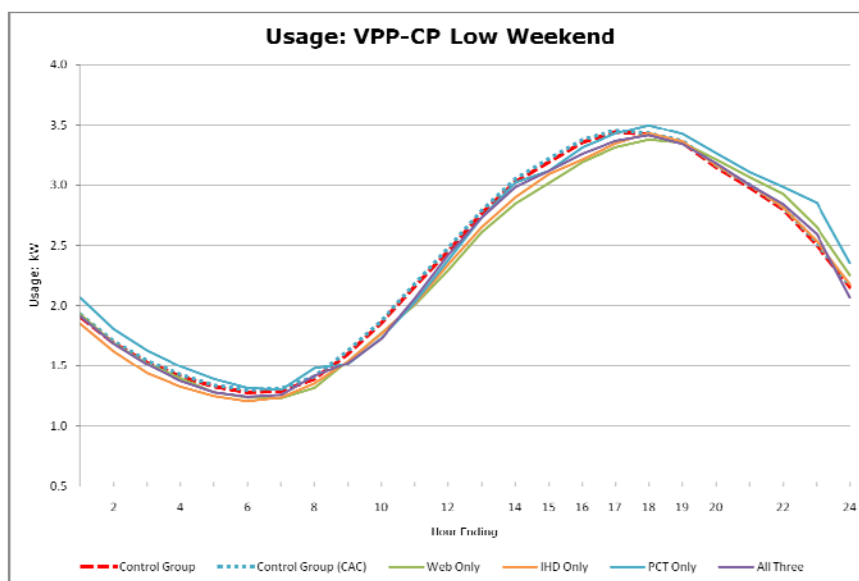
Figure 4-3 *VPP-CP weekend non-event day, low price, all rate-technology combinations*

Figure 4-4 shows the load shapes for the VPP-CP rate on low-priced weekdays. Note that even though the price during the peak period does not change, there appears to be a load reduction for all rate-technology groups both early in the day and to a lesser extent, at the beginning of the peak period. We believe that the early drop is due to increased awareness of energy use combined with PCTs, which customers appear to be using not only to preset price response, but also to program in more conventional ways to lower the setpoint when they are out of the home during the day.
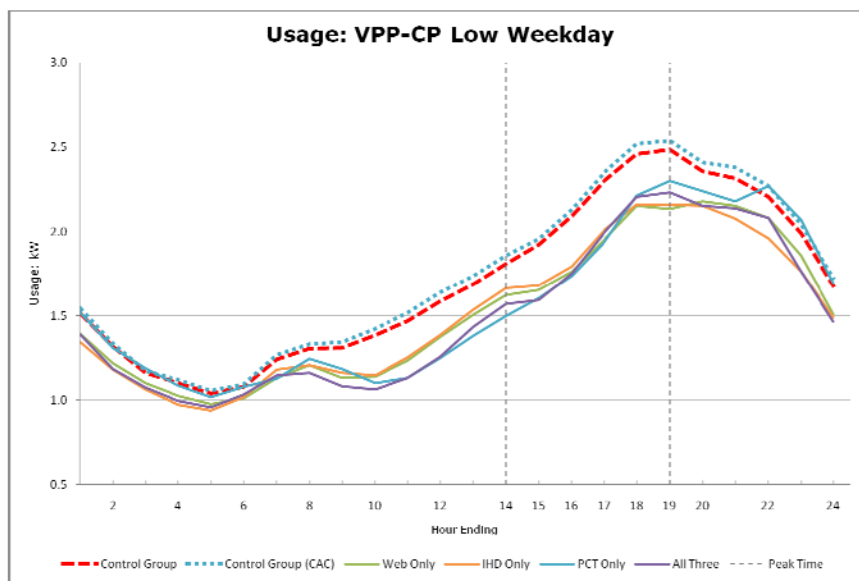
Figure 4-4 *VPP-CP weekday non-event day, low price, all rate-technology combinations*

Figure 4-5 shows the load shapes for the VPP-CP rate on standard-priced weekdays. There is a more significant drop in the loads for the PCT and All Three groups that is in response to the price increase, and a smaller drop in the IHD and Web groups. Note that there is also a sizeable (and statistically significant) "rebound effect" after the event for both the PCT and All Three groups, when the PCTs are reset back to a lower temperature, increasing energy use. For the

PCT group, this effect lingers throughout the night, with slightly higher usage until the early morning hours. There does not appear to be any rebound effect for the IHD and Web groups.
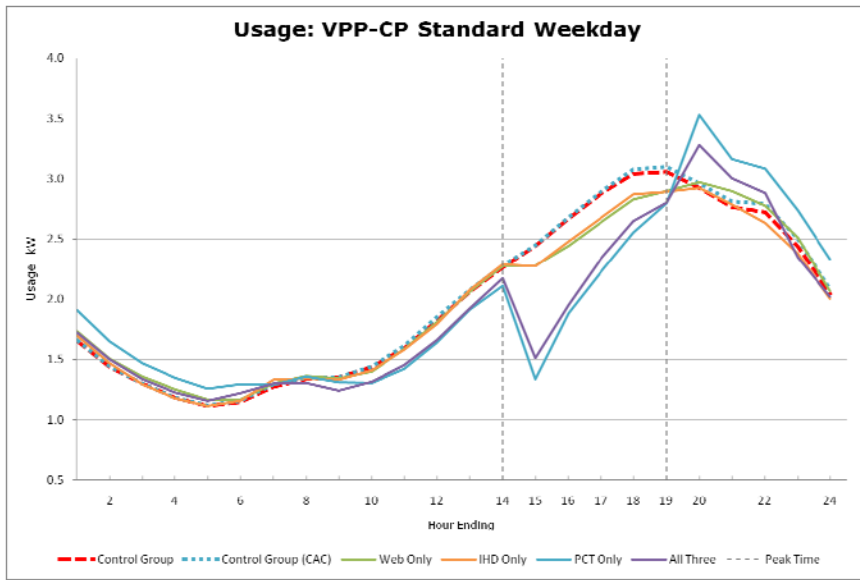
Figure 4-5   *VPP-CP weekday non-event day, standard price, all rate-technology combinations*

Figure 4-6 shows the load shapes for the VPP-CP rate on medium-priced weekdays. The effects are similar to the standard-priced day, but with a slightly higher load, slightly higher savings, and slightly more rebound effect, driven by the combination of the higher temperatures on medium-priced days and the higher price.
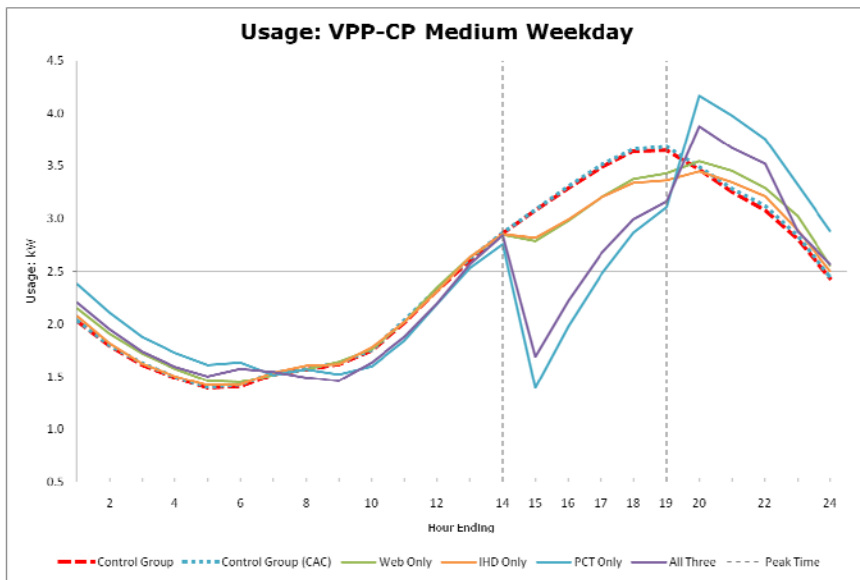
Figure 4-6   *VPP-CP weekday non-event day, medium price, all rate-technology combinations*

Figure 4-7 shows the load shapes for the VPP-CP rate on high-priced weekdays. The patterns of increased savings over the lower prices, peak savings for the PCT and All Three groups early in the event, and a significant rebound effect continue here, with the highest savings of any non-event day for each rate-technology group.
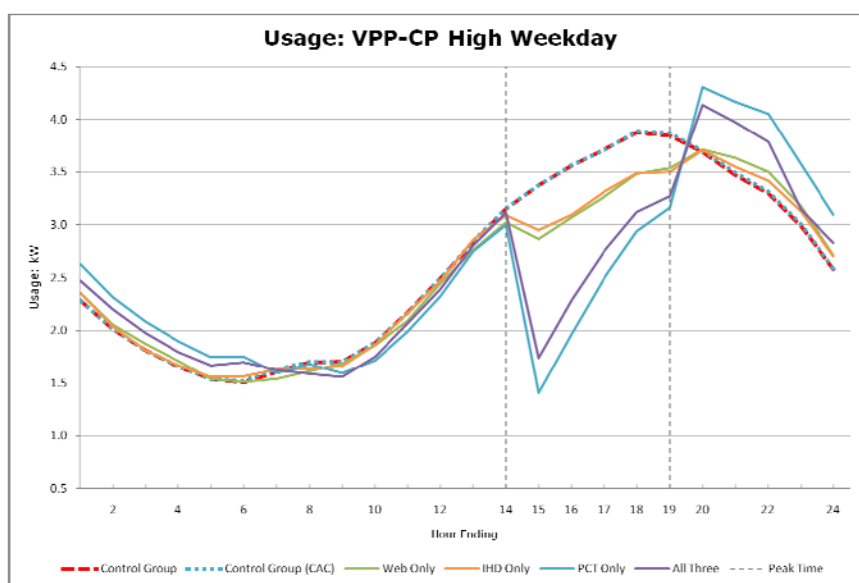
Figure 4-7   *VPP-CP weekday non-event day, high price, all rate-technology combinations*

4.1.2   Event Day Impacts

Table 4-4 below shows, for on-peak and off-peak times, the kWh baseline consumption (from the control group), the associated kWh and percentage change in consumption, as well as the overall kWh change for the September 12 weekend day event for each day type and each rate-technology combination. Table 4-5 below shows average on-peak and maximum on-peak kW savings for each day type and each rate-technology combination for the weekend day event. Note that, on a given day type, baseline consumption is different for the PCT group than it is for the other technology groups. This is as a result of the PCT group control group being comprised of customers with central AC only. This event went from 4:00 pm to 6:00 pm. This was the only weekend day event called, and was on a late summer, early fall weekend day, so the baseline load was low, and the savings potential was minimal.   The time of year, the low load, the lack of savings for PCT, and the small savings overall indicate that there was little or no cooling load during this event. This is also the only case where IHD and Web savings are generally comparable to or higher than the PCT and All Three groups, particularly for the VPP-CP rate. This is likely due to customers more likely being home on a weekend and taking manual actions beyond automated control. However, the savings across the board are small, though they are statistically significant. The savings for the two consecutive hours of the event are also fairly similar, with no big change in the level of savings from hour 17 to hour 18. This is likely due to the lack of cooling load and due to the shorter duration of the event. As noted above, consumption is presented as the net change in energy used, but the demands are presented as reductions.

In this section, on-peak is referring to the time period of the event.

Table 4-4   *Weekend Event Day Average Customer Consumption and Savings*

	On-Peak Consumption			Off-Peak Consumption			Overall
	Baseline	**Change**	**Percent**	**Baseline**	**Change**	**Percent**	**Change**
TOU-CP Weekend Event							
Web Only	5.37	-0.61	-11.28%	36.73	1.59	4.32%	0.98
IHD Only	5.37	-0.97	-18.02%	36.73	-0.48	-1.30%	-1.44

PCT Only	5.33	-0.63	-11.85%	36.50	1.74	4.76%	1.11
All Three	5.37	-0.93	-17.41%	36.73	-0.17	-0.48%	-1.11
VPP-CP Weekend Event							
Web Only	5.37	-0.75	-13.90%	36.73	-1.17	-3.19%	-1.92
IHD Only	5.37	-0.83	-15.43%	36.73	-0.91	-2.49%	-1.74
PCT Only	5.33	-0.14	-2.70%	36.50	1.10	3.01%	0.95
All Three	5.37	-0.18	-3.42%	36.73	-0.31	-0.85%	-0.50

Table 4-5   Weekend Event Day Average Customer Demand

	Average On-Peak Demand			**Demand at Maximum Reduction**		
	Baseline	**Reduction**	**Percent**	**Baseline**	**Reduction**	**Percent**
TOU-CP Weekend Event						
Web Only	2.68	0.30	11.28%	2.79	0.38	13.64%
IHD Only	2.68	0.48	18.02%	2.79	0.49	17.49%
PCT Only	2.67	0.32	11.85%	2.78	0.38	13.78%
All Three	2.68	0.47	17.41%	2.79	0.54	19.24%
VPP-CP Weekend Event						
Web Only	2.68	0.37	13.90%	2.79	0.48	17.31%
IHD Only	2.68	0.41	15.43%	2.79	0.50	17.97%
PCT Only	2.67	0.07	2.70%	2.78	0.10	3.53%
All Three	2.68	0.09	3.42%	2.79	0.17	5.96%

Table 4-6 below shows, for on-peak and off-peak times, the kWh baseline consumption (from the control group), the associated kWh and percentage change in consumption, as well as the overall kWh change for the August 25 weekday event for each day type and each rate-technology combination. Note that, on a given day type, baseline consumption is different for the PCT group than it is for the other technology groups. This is as a result of the PCT group control group being comprised of customers with central AC only. This was the only weekday event called, and was on a relatively mild summer day. As a result, the savings are comparable to the average non-event weekday for TOU-CP and for the average standard and medium price weekday for the VPP-CP. The percentage savings are higher, because of the lower base load.

Table 4-6   Weekday Event Day Average Customer Consumption and Savings

	On-Peak Consumption			**Off-Peak Consumption**			**Overall**
	Baseline	**Change**	**Percent**	**Baseline**	**Change**	**Percent**	**Change**
TOU-CP Weekday Event							
Web Only	10.80	-2.14	-19.80%	25.20	0.97	3.86%	-1.17

IHD Only	10.80	-2.76	-25.58%	25.20	0.40	1.57%	-2.37
PCT Only	10.85	-4.21	-38.80%	25.16	3.16	12.58%	-1.05
All Three	10.80	-3.31	-30.60%	25.20	1.44	5.71%	-1.87
VPP-CP Weekday Event							
Web Only	10.80	-1.57	-14.52%	25.20	0.52	2.08%	-1.04
IHD Only	10.80	-1.45	-13.40%	25.20	-0.20	-0.79%	-1.65
PCT Only	10.85	-3.49	-32.15%	25.16	3.59	14.28%	0.10
All Three	10.80	-3.32	-30.78%	25.20	2.26	8.95%	-1.07

Table 4-7 below shows average on-peak and maximum on-peak kW savings for each day type and each rate-technology combination for the weekday event.   Note that the savings are much more constant across the event, with the average and peak kW reductions very similar. This is probably more due to the relatively mild temperature, rather than the nature of the event, but without other weekday event days to compare this day with, we don't know for sure.

Table 4-7   Weekday Event Day Average Customer Demand

	Average On-Peak Demand			Demand at Maximum Reduction		
	Baseline	**Reduction**	**Percent**	**Baseline**	**Reduction**	**Percent**
TOU-CP Weekday Event						
Web Only	2.16	0.43	19.80%	2.52	0.55	21.83%
IHD Only	2.16	0.55	25.58%	2.52	0.60	23.85%
PCT Only	2.17	0.84	38.80%	2.41	0.90	37.12%
All Three	2.16	0.66	30.60%	1.97	0.71	35.95%
VPP-CP Weekday Event						
Web Only	2.16	0.31	14.52%	1.77	0.38	21.63%
IHD Only	2.16	0.29	13.40%	1.97	0.34	17.30%
PCT Only	2.17	0.70	32.15%	1.99	0.86	43.17%
All Three	2.16	0.66	30.78%	1.97	0.78	39.79%

The OG&E system peak nearly always occurs at 5:00 PM on a summer weekday. Table 4-8 below shows kW savings at 5:00 PM for each rate-technology combination. Since the actual peak day, August 4, was not an event day, we can't include the peak day savings for the weekday event days.

Table 4-8   Weekday Event Day Average Customer Demand at the time of the System Peak

	Demand Reduction at 5:00 PM		
	Baseline	**Reduction**	**Baseline**
TOU-CP Weekday Event Day			

Web Only	2.14	0.34	15.97%
IHD Only	2.14	0.55	25.54%
PCT Only	2.16	0.87	40.08%
All Three	2.14	0.69	32.29%
VPP-CP Weekday Event			
Web Only	2.14	0.28	13.22%
IHD Only	2.14	0.28	13.22%
PCT Only	2.16	0.78	35.98%
All Three	2.14	0.69	31.97%

Figure 4-8 shows the load shapes for the TOU-CP rate on the weekend event day, September 12. All four rate-technology groups showed a statistically-significant reduction in load during this two-hour event. The graph also shows the fairly flat savings, with the rate-technology lines about the same distance from the control group line for the two hours of the event.
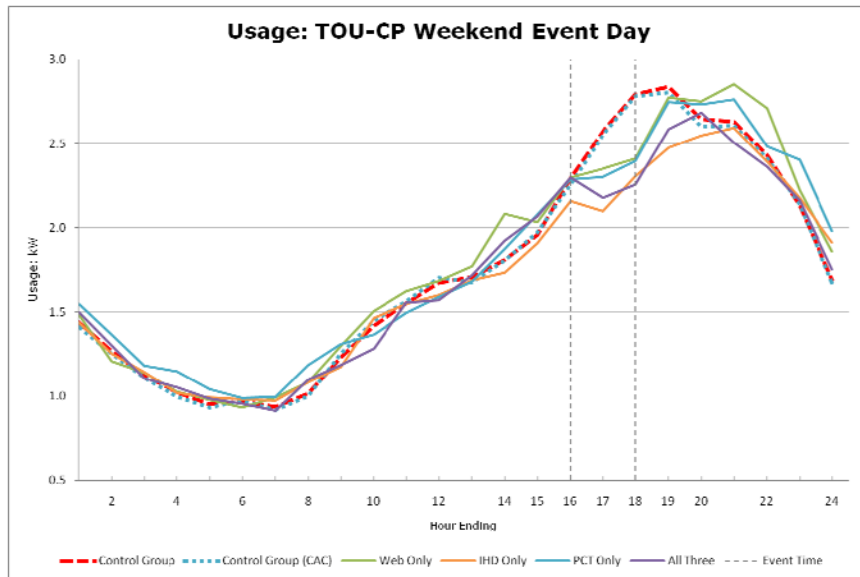
Figure 4-8   *TOU-CP weekend event day, all rate-technology combinations*

Figure 4-9 shows the load shapes for the VPP-CP rate on the weekend event day. The PCT and All Three groups show virtually no response to the event, probably because of the lack of cooling load. The IHD and Web groups do show statistically significant load reductions, with higher savings in the second hour of the event.
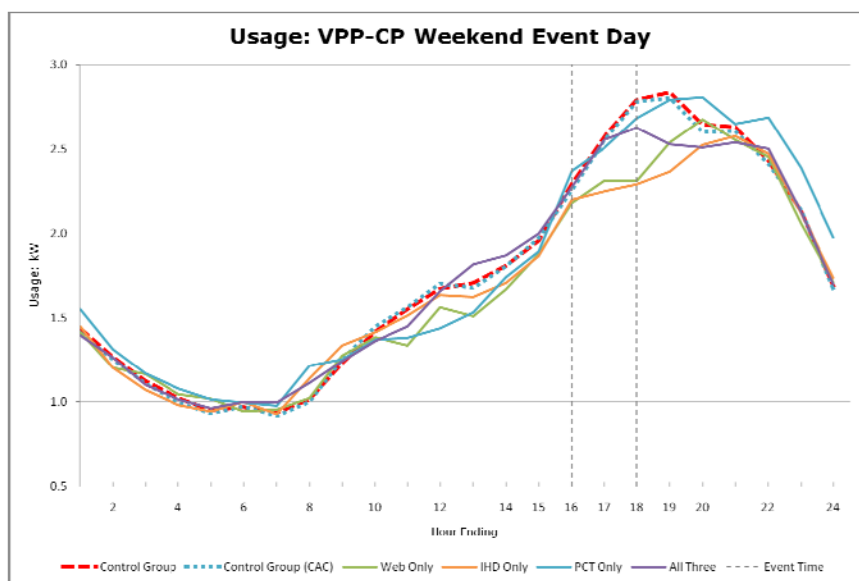
Figure 4-9   VPP-CP weekend event day, all rate-technology combinations

Figure 4-10 shows the load shapes for the TOU-CP rate on the weekday event day. The PCT and All Three groups show slightly higher savings, but also a much higher rebound effect than the IHD and Web groups. All the load reductions for the TOU-CP rate group on the weekday event day are statistically significant.
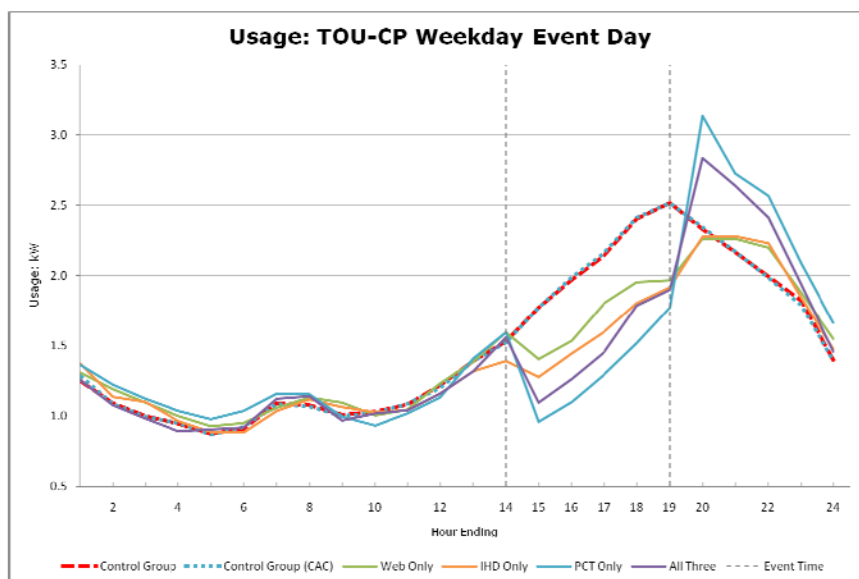
Figure 4-10   TOU-CP weekday event day, all rate-technology combinations

Figure 4-11 shows the load shapes for the VPP-CP rate on the weekday event day. Pattern here is very similar to the TOU-CP on the weekday event shown above, with the PCT and All Three groups show slightly higher savings, but also a much higher rebound effect. All the load reductions for the VPP-CP rate group on the weekday event day are statistically significant.

Figure 4-11   VPP-CP weekday event day, all rate-technology combinations

4.2   RESULTS BY AGE AND BY INCOME

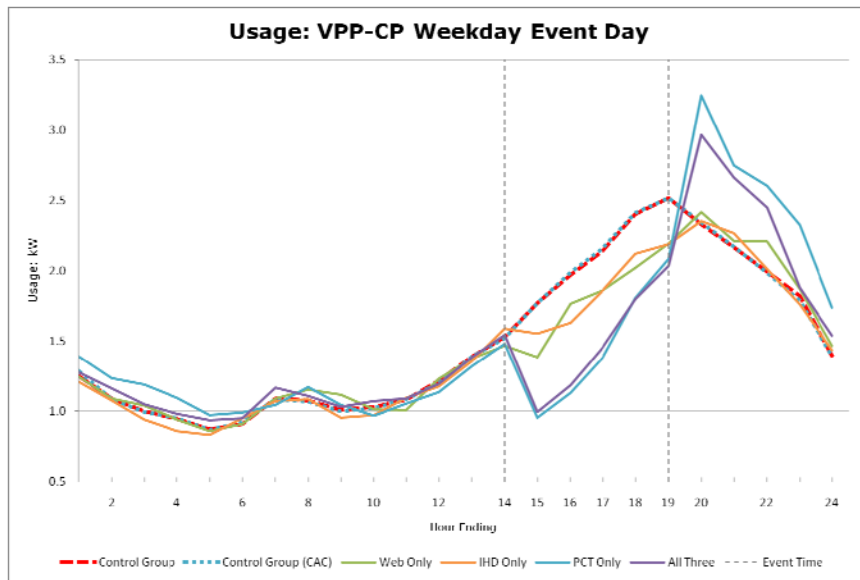Because the design of the study included representation of customers across three age segments and three income segments, we were able to estimate savings for each of the three levels of each demographic category. As with the overall results above, we applied weights the age categories within each income category to reflect the mix of customers in OG&E's service territory. Similarly, we applied weights to the income categories within each age category. The resulting age and income results indicate what the expected load reductions would be if the distribution of the participants within each demographic segment were roughly similar to the distribution of the population within that segment. While it is tempting to look at combinations of age and income, such as young low income participants, this would reduce the sample sizes so much that the results would be somewhat questionable statistically.

With two rates and eleven corresponding day types, as well as four technology options, adding three age segments and three income segments creates a large volume of savings estimates. Because of this, we focus on the impacts for the weekday events for both rates, along with weekdays for TOU-CP and high-price weekdays for VPP-CP. Graphs for all day types are included in the Appendix.

One thing that we should be aware of is that with so many different combinations, random chance may result in apparent indications of effects that may not bear out in a full roll-out. That said, we can glean an idea of how different types of customers may respond to these time-varying rates and technologies by looking across all the results.

4.2.1   Impacts by Age Segment

The customers were split into three age categories, Family, Mature, and Young based on their PRIZM Codes. Each of the rate-technology groups and the control group were split up for analysis, so that each demographic segment was compared with an appropriate control group.

4.2.1.1   Impacts by Age Segment for TOU-CP

Table 4-9 below shows the savings estimates for each age group and each technology for the average non-event weekday for customers on the TOU-CP rate during the on-peak and off-peak periods as well as overall. Table 4-10 below shows average on-peak and maximum on-peak kW savings for each age group and each rate-technology combination for the average non-event weekday for customers on the TOU-CP rate. Note that, by a given age segment, baseline

consumption is different for the PCT group than it is for the other technology groups. This is as a result of the PCT group control group being comprised of customers with central AC only. With the highest baseline usage, the Family segment also has the highest load reduction for the PCT and Web groups, both on a kW and a percentage basis. The Mature has the highest savings for the IHD and All Three groups. Looking across each age segment, the PCT shows the greatest load reduction for the Family group, with the All Three saving the most for the Young and Mature groups. As with the combined results above, this difference could be due in part to the inclusion of customers both with and without central AC in the All Three group, but only those with central AC in the PCT group.

Table 4-9   Average Customer Savings, TOU-CP Weekday Non-Event Day, by Age

	On-Peak Consumption			Off-Peak Consumption			Overall
	Baseline	Change	Percent	Baseline	Change	Percent	Change
Family							
Web Only	18.12	-3.66	-20.19%	44.75	-3.63	-8.10%	-7.28
IHD Only	18.12	-3.18	-17.55%	44.75	-1.25	-2.78%	-4.42
PCT Only	18.46	-7.19	-38.92%	46.24	-5.38	-11.63%	-12.56
All Three	18.12	-3.57	-19.72%	44.75	0.50	1.11%	-3.08
Mature							
Web Only	14.73	-0.68	-4.64%	34.31	1.75	5.11%	1.07
IHD Only	14.73	-3.32	-22.55%	34.31	-3.18	-9.28%	-6.51
PCT Only	14.27	-2.98	-20.92%	32.60	7.20	22.09%	4.22
All Three	14.73	-4.24	-28.78%	34.31	0.41	1.19%	-3.83
Young							
Web Only	12.77	-0.76	-5.93%	31.92	1.97	6.16%	1.21
IHD Only	12.77	-1.23	-9.62%	31.92	-0.85	-2.66%	-2.08
PCT Only	13.34	-3.86	-28.92%	33.81	0.08	0.25%	-3.77
All Three	12.77	-3.62	-28.32%	31.92	-0.56	-1.77%	-4.18

Table 4-10   Average Customer Demand, TOU-CP Weekday Non-Event Day, by Age

	Average On-Peak Demand			Demand at Maximum Reduction		
	Baseline	Reduction	Percent	Baseline	Reduction	Percent
Family						
Web Only	3.62	0.73	20.19%	3.69	0.81	21.87%
IHD Only	3.62	0.64	17.55%	3.69	0.71	19.26%
PCT Only	3.69	1.44	38.92%	3.26	1.81	55.40%
All Three	3.62	0.71	19.72%	3.20	1.15	36.00%
Mature						
Web Only	2.95	0.14	4.64%	3.17	0.18	5.66%

IHD Only	2.95	0.66	22.55%	3.17	0.70	22.09%
PCT Only	2.85	0.60	20.92%	2.52	1.03	40.72%
All Three	2.95	0.85	28.78%	2.62	1.13	42.90%
Young						
Web Only	2.55	0.15	5.93%	2.42	0.23	9.38%
IHD Only	2.55	0.25	9.62%	2.42	0.31	12.64%
PCT Only	2.67	0.77	28.92%	2.32	1.07	46.26%
All Three	2.55	0.72	28.32%	2.22	1.05	47.33%

Figure 4-12 shows the three segment participant load shapes along with their corresponding control group load shapes for the Web group for the TOU-CP rate on a non-event weekday. As with the PCT group, the Family segment appears to be reducing energy use somewhat throughout the entire day as well as during the peak period.
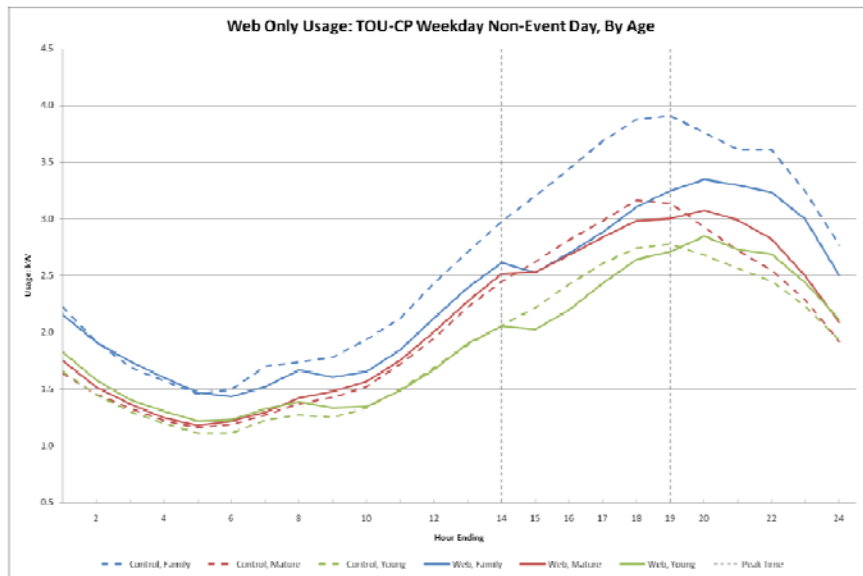
Figure 4-12   TOU-CP weekday non-event day, Web, by age

Figure 4-13 shows the three segment participant load shapes along with their corresponding control group load shapes for the IHD group for the TOU-CP rate on a non-event weekday. In this case, the Mature and Young participant loads are very similar, but the control group loads are quite different, resulting in higher estimated savings for the Mature segment. With an IHD showing the Mature customers their energy use all the time, members of this segment may be taking actions to save energy throughout the day.

Figure 4-13   TOU-CP weekday non-event day, IHD, by age

Figure 4-14 shows the three segment participant load shapes along with their corresponding control group load shapes for the PCT group for the TOU-CP rate on a non-event weekday. Note that while the Family and Mature participant loads are very similar, the control group loads are quite different, resulting in higher estimated savings for the Family segment. It appears that customers in the Family segment may be more likely to use the PCT to set the temperature higher during the entire day, not just during the peak period. This could be because the Mature segment is probably more likely home during the day, whereas homes of those in the Family segment may be unoccupied during the workday.

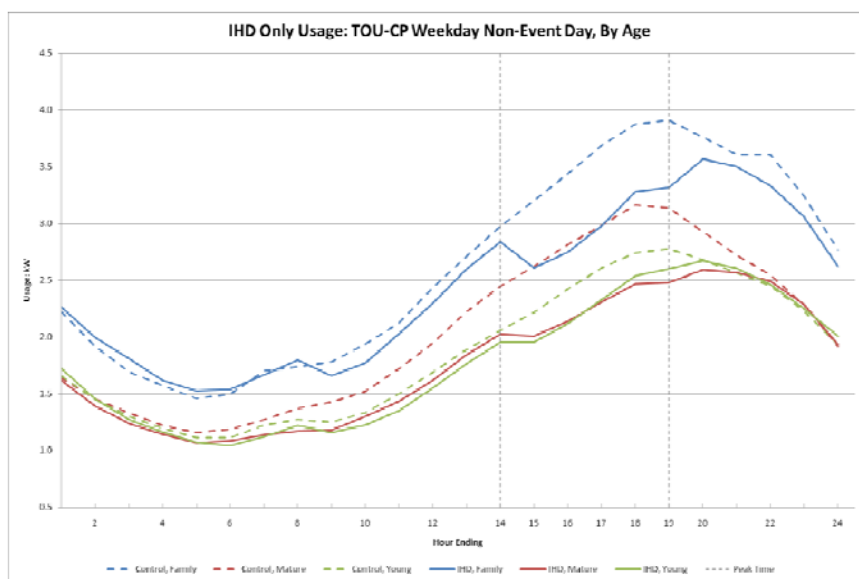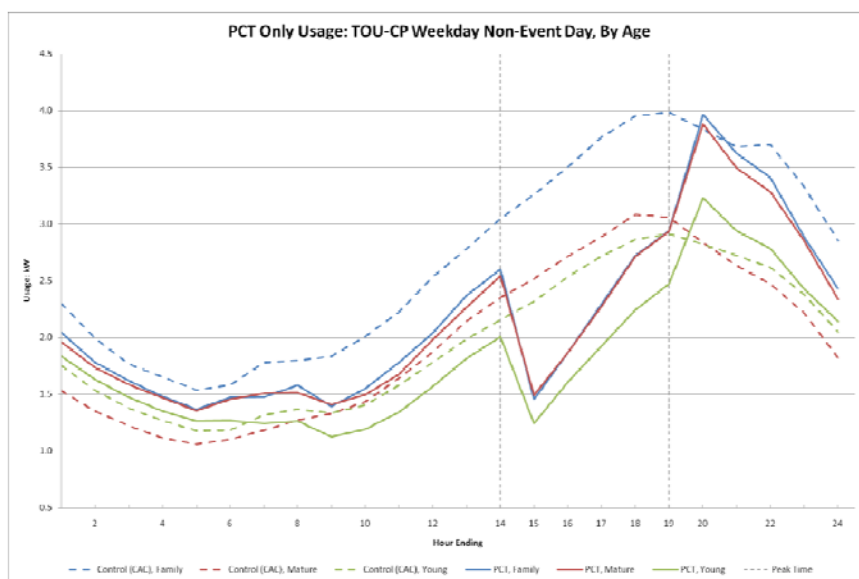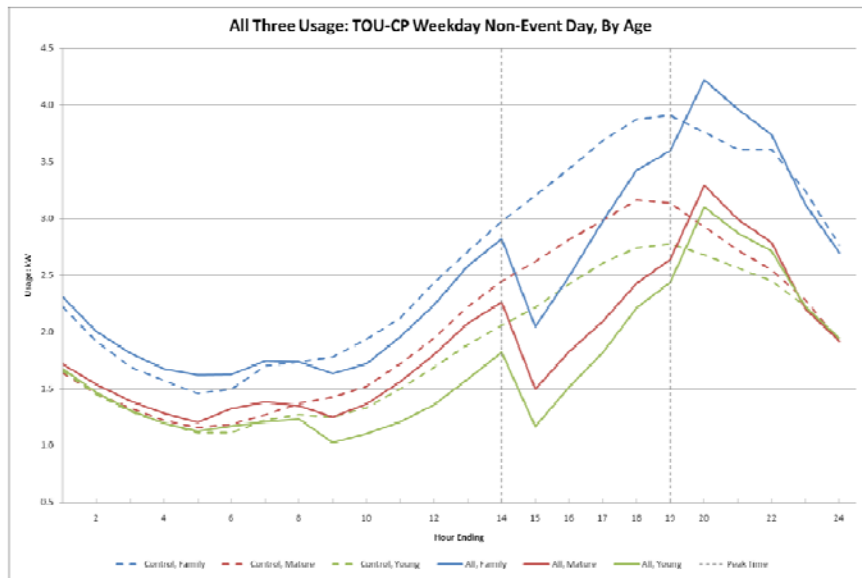**Figure 4-14   TOU-CP weekday non-event day, PCT, by age**

Figure 4-15 shows the three segment participant load shapes along with their corresponding control group load shapes for the All Three group for the TOU-CP rate on a non-event weekday. The three age segments appear to be responding to the technologies in about the same way, reducing energy use somewhat throughout the entire day, but more during the peak period.

Figure 4-15   TOU-CP weekday non-event day, All Three, by age

Table 4-11 below shows the savings estimates for each age group and each technology for the weekday event of August 25 for customers on the TOU-CP rate during the on-peak and off-peak periods as well as overall. Table 4-12 below shows average on-peak and maximum on-peak kW savings for each age group and each rate-technology combination for the weekday event of August 25 for customers on the TOU-CP rate. Note that, by a given age segment, baseline consumption is different for the PCT group than it is for the other technology groups. This is as a result of the PCT group control group being comprised of customers with central AC only. With the highest baseline usage, the Family segment again has the highest load reduction for the PCT and Web groups, both on a kW and a percentage basis. Again, the Mature has the highest savings for the IHD group, but unlike the non-event day, the Young group has the highest savings.

Comparing the non-event and event days for the TOU-CP is useful as well. The Family savings were higher for the non-event weekday (even though the prices were lower), indicating that most of the savings is likely due to cooling load reduction, reinforced by the high PCT savings, as opposed to behavioral changes, since the event day was a mild summer day. The Mature is mixed, with the PCT, IHD, and Web savings higher on the event day, but the All Three savings higher on the non-event day. This is more difficult to interpret, but could be due to reliance on both behavioral and automated responses, which would result in higher savings for the event day, as well as an indication of higher price sensitivity. The Young segment has higher savings for all technologies, which is probably also a combination of both price sensitivity and willingness to undergo behavioral change.

Looking across each age segment, PCT is the highest for the Mature and Family segments, and the All Three group has the highest savings for the Young segment.

Table 4-11   Average Customer Savings, TOU-CP Weekday Event Day, by Age

	On-Peak Consumption			Off-Peak Consumption			Overall
	Baseline	Change	Percent	Baseline	Percent	Change	Change
Family							
Web Only	12.68	-2.81	-22.16%	29.73	1.25	4.21%	-1.56
IHD Only	12.68	-1.90	-15.02%	29.73	3.50	11.77%	1.59

PCT Only	13.00	-5.92	-45.51%	30.56	2.74	8.95%	-3.18
All Three	12.68	-2.36	-18.64%	29.73	4.46	15.01%	2.10
Mature							
Web Only	10.63	-1.95	-18.31%	23.81	0.54	2.25%	-1.41
IHD Only	10.63	-3.82	-35.99%	23.81	-1.48	-6.22%	-5.31
PCT Only	10.18	-3.42	-33.63%	21.67	6.67	30.81%	3.25
All Three	10.63	-2.78	-26.15%	23.81	1.84	7.74%	-0.94
Young							
Web Only	9.64	-1.85	-19.20%	23.36	1.20	5.15%	-0.65
IHD Only	9.64	-2.32	-24.12%	23.36	0.05	0.19%	-2.28
PCT Only	9.99	-3.77	-37.79%	24.79	0.00	0.00%	-3.77
All Three	9.64	-4.49	-46.64%	23.36	-1.12	-4.77%	-5.61

Table 4-12   Average Customer Demand, TOU-CP Weekday Event Day, by Age

	Average On-Peak Demand			Demand at Maximum Reduction		
	Baseline	**Reduction**	**Percent**	**Baseline**	**Reduction**	**Percent**
Family						
Web Only	2.54	0.56	22.16%	2.95	0.71	24.18%
IHD Only	2.54	0.38	15.02%	2.89	0.57	19.82%
PCT Only	2.60	1.18	45.51%	2.91	1.27	43.77%
All Three	2.54	0.47	18.64%	2.51	0.53	21.15%
Mature						
Web Only	2.13	0.39	18.31%	2.47	0.61	24.79%
IHD Only	2.13	0.76	35.99%	2.47	0.85	34.50%
PCT Only	2.04	0.68	33.63%	1.84	0.81	43.84%
All Three	2.13	0.56	26.15%	2.37	0.58	24.62%
Young						
Web Only	1.93	0.37	19.20%	1.63	0.45	27.74%
IHD Only	1.93	0.46	24.12%	1.63	0.50	30.93%
PCT Only	2.00	0.75	37.79%	1.87	0.79	42.23%
All Three	1.93	0.90	46.64%	1.79	1.04	57.90%

Figure 4-16 shows the three segment participant load shapes along with their corresponding control group load shapes for the Web group for the TOU-CP rate on the weekday event day. The three age segments appear to be responding similarly during the event period, with most of

the load reduction probably due to behavioral changes, given the lack of much of a rebound effect for any of the segments.
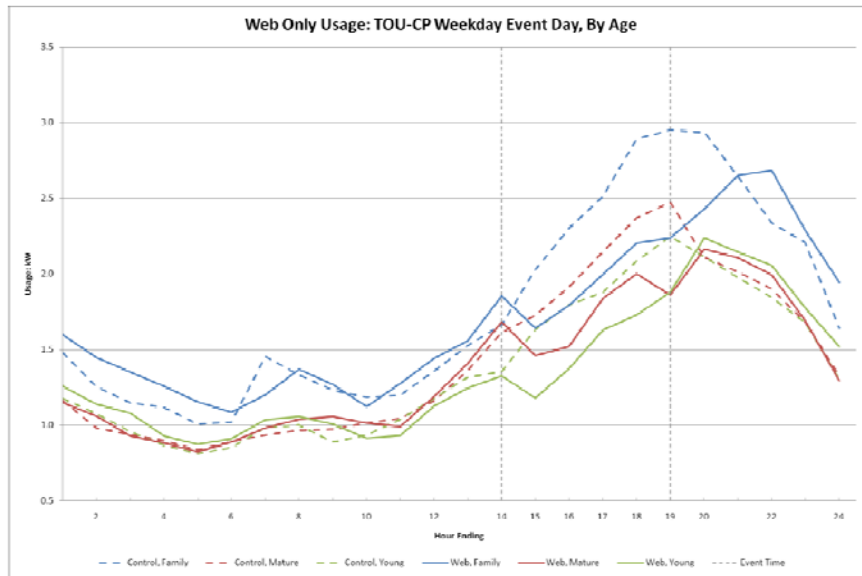
Figure 4-16   TOU-CP weekday event day, Web, by age

Figure 4-17 shows the three segment participant load shapes along with their corresponding control group load shapes for the IHD group for the TOU-CP rate on the weekday event day. In this case, the Mature and Young segment load shapes are fairly similar, with higher estimated savings than the Family segment. This further suggests behavioral changes in response to higher prices.

Figure 4-17   TOU-CP weekday event day, IHD, by age

Figure 4-18 shows the three segment participant load shapes along with their corresponding control group load shapes for the PCT group for the TOU-CP rate on the weekday event day. All segments respond in a similar way, with the Family segment showing the biggest savings and also the most pronounced rebound effect. It appears that customers in the Young segment

reduce their load for the whole day in this case, perhaps changing their behavior in response to the previous day's notice of higher prices.

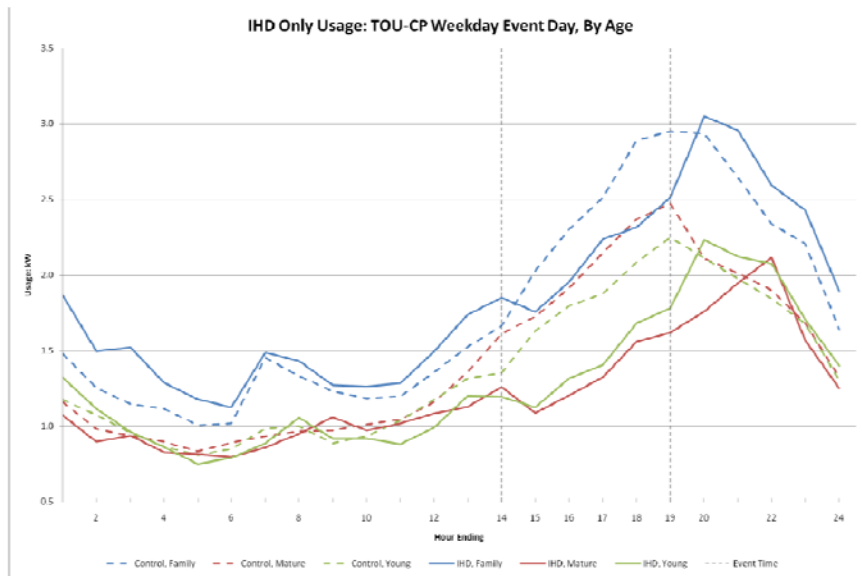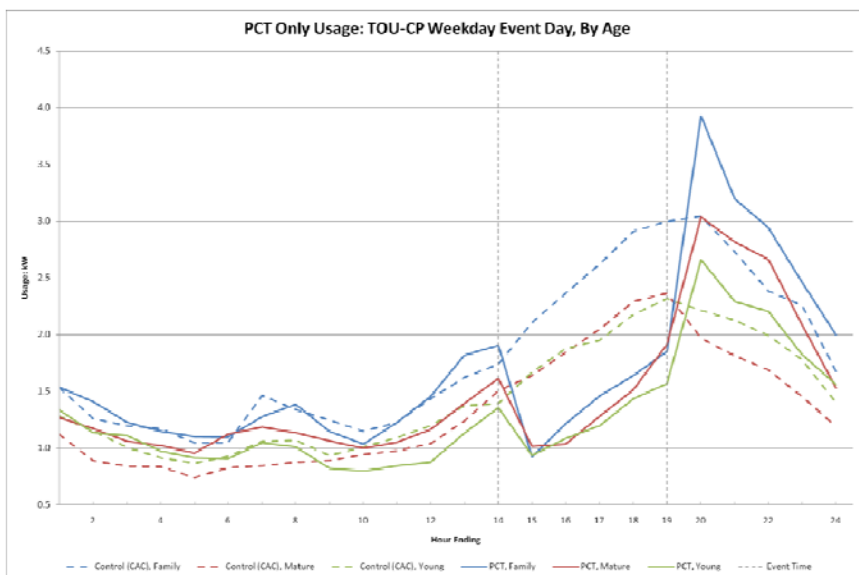*Figure 4-18   TOU-CP weekday event day, PCT, by age*

Figure 4-19 shows the three segment participant load shapes along with their corresponding control group load shapes for the All Three group for the TOU-CP rate on the weekday event day. The Family and Mature segments appear to be responding to the technologies in similar ways, primarily during the event period. However, the Young segment load shape is particularly interesting. There are statistically significant load savings for several hours before the start of the event, probably driven by behavioral changes in response to the day-ahead notification. Then, at the start of the event, the load reduces further, probably driven by the automatic response of the PCT. This may be the clearest illustration of the effect of the combination of the three technologies in the All Three group. All segments also have a significant rebound effect after the end of the event period.

Figure 4-19   TOU-CP weekday event day, All Three, by age

4.2.1.2   Impacts by Age Segment for VPP-CP

Table 4-13 below shows the savings estimates for each age group and each technology for the average high-priced non-event weekday for customers on the VPP-CP rate during the on-peak and off-peak periods as well as overall. Table 4-14 below shows average on-peak and maximum on-peak kW savings for each age group and each rate-technology combination for the average high-priced non-event weekday for customers on the VPP-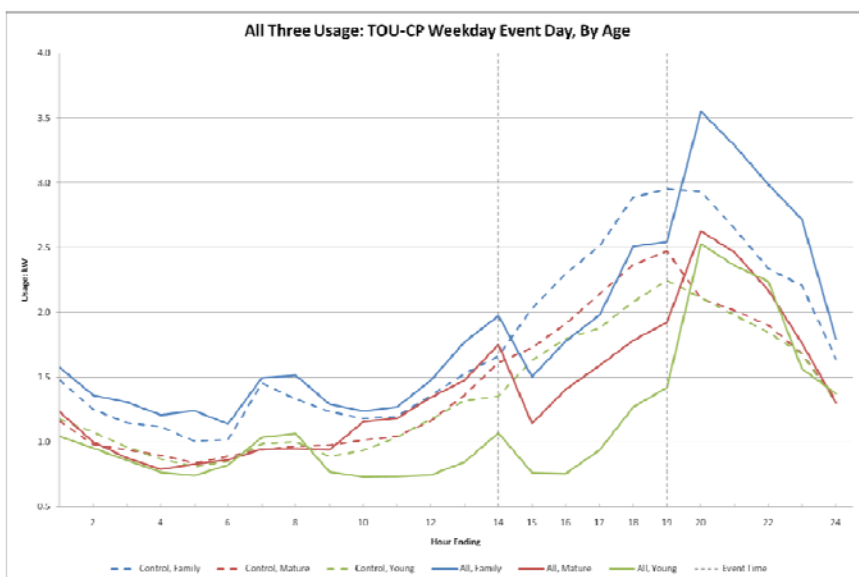CP rate. Note that, by a given age segment, baseline consumption is different for the PCT group than it is for the other technology groups. This is as a result of the PCT group control group being comprised of customers with central AC only. With the highest baseline usage, the Family segment also has the highest kW load reduction for the IHD and Web groups. The Mature has the highest savings for the PCT, and the Young segment has the highest savings for the All Three group.

Looking across each age segment, the PCT shows the greatest load reduction for the Family and Mature segments, with the All Three saving the most for the Young segment.   As with the combined results above, the higher PCT savings could be due in part to the inclusion of customers both with and without central AC in the All Three group, but only those with central AC in the PCT group.

One curious result is that for the Mature segment customers on the VPP-CP rate, those customers in the IHD and Web groups who receive only information (without the automated response of a PCT) do not respond to either the high price of an event or the high-priced weekdays. This is in stark contrast to the Mature customers in the IHD group on the TOU-CP rate, who did respond with significant load reductions on both weekdays and on the event day. This is very difficult to interpret and understand. It could be due to random chance, if this group of mature customers just happened to be less receptive to the information from an IHD for some reason. But it could due also be to some characteristic or reaction to the VPP-CP rate that is not present with the TOU-CP rate. This is conjecture, but it could be something like fatigue from so many price changes – maybe these folks had trouble keeping track of things with prices changing every day. Or maybe there was confusion about the prices. But there does seem to be something different going on here, which may warrant further research.

Table 4-13   Average Customer Savings, VPP-CP High-Priced Weekday, by Age

	On-Peak Consumption			Off-Peak Consumption			Change
	Baseline	Change	Percent	Baseline	Change	Percent	Change
Family							
Web Only	21.41	-3.74	-17.47%	52.09	0.06	0.12%	-3.68
IHD Only	21.41	-3.15	-14.73%	52.09	-2.49	-4.77%	-5.64
PCT Only	21.52	-7.42	-34.51%	53.02	4.38	8.27%	-3.04
All Three	21.41	-5.02	-23.46%	52.09	9.28	17.82%	4.26
Mature							
Web Only	18.66	-0.87	-4.66%	43.76	1.15	2.62%	0.28
IHD Only	18.66	-0.89	-4.77%	43.76	1.36	3.11%	0.47
PCT Only	18.00	-6.81	-37.82%	41.28	2.31	5.59%	-4.50
All Three	18.66	-5.06	-27.11%	43.76	1.33	3.05%	-3.72
Young							
Web Only	15.93	-2.29	-14.39%	39.49	-0.01	-0.04%	-2.31

IHD Only	15.93	-2.33	-14.61%	39.49	1.78	4.51%	-0.54
PCT Only	16.60	-5.36	-32.28%	41.66	4.69	11.25%	-0.67
All Three	15.93	-5.46	-34.28%	39.49	-1.96	-4.96%	-7.42

Table 4-14   Average Customer Demand, VPP-CP High-Priced Weekday, by Age

	Average On-Peak Demand			Demand at Maximum Reduction		
	Baseline	**Reduction**	**Percent**	**Baseline**	**Reduction**	**Percent**
Family						
Web Only	4.28	0.75	17.47%	4.34	0.83	19.17%
IHD Only	4.28	0.63	14.73%	4.17	0.70	16.77%
PCT Only	4.30	1.48	34.51%	4.00	2.46	61.56%
All Three	4.28	1.00	23.46%	3.98	1.81	45.44%
Mature						
Web Only	3.73	0.17	4.66%	3.44	0.32	9.25%
IHD Only	3.73	0.18	4.77%	3.44	0.24	7.03%
PCT Only	3.60	1.36	37.82%	3.30	1.92	58.32%
All Three	3.73	1.01	27.11%	3.44	1.68	48.82%
Young						
Web Only	3.19	0.46	14.39%	3.07	0.53	17.38%
IHD Only	3.19	0.47	14.61%	3.07	0.52	17.08%
PCT Only	3.32	1.07	32.28%	3.00	1.64	54.90%
All Three	3.19	1.09	34.28%	2.88	1.46	50.62%

Figure 4-20 shows the three segment participant load shapes along with their corresponding control group load shapes for the Web group for the VPP-CP rate for high-priced weekdays. The Family and Young segments seem to be reacting similarly, with a fairly continuous load reduction throughout the event.   As with the IHD group, the Mature segment savings are smaller and not statistically significant.
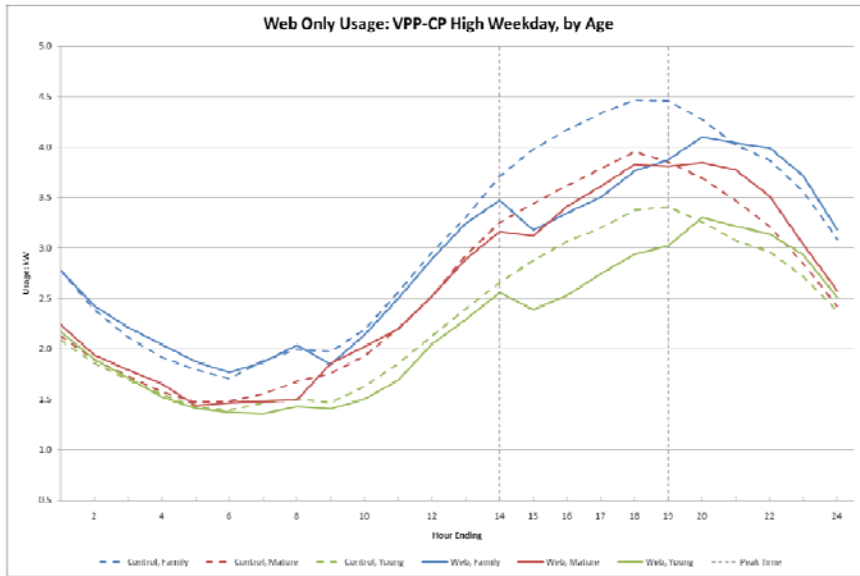
Figure 4-20   VPP-CP high-priced weekday, Web, by age

Figure 4-21 shows the three segment participant load shapes along with their corresponding control group load shapes for the IHD group for the VPP-CP rate for high-priced weekdays. The Family and Young load savings are similar, especially on a percentage basis. However, the Mature load savings is much smaller in this case, in stark contrast to the TOU-CP weekday and event day above, where the Mature segment had the highest savings. We don't have an explanation for this, but it may be due to random variation in customer energy use or characteristics.

Figure 4-21   VPP-CP high-priced weekday, IHD, by age

Figure 4-22 shows the three segment participant load shapes along with their corresponding control group load shapes for the PCT group for the VPP-CP rate for high-priced weekdays. The Family and Young savings are very similar, both having a big drop at the beginning of the event and a large rebound effect after the event. It appears that customers in the Mature segment may be more likely to use the PCT to set the temperature higher during the entire day, not just

during the peak period, resulting in the drop during the pre-event period and a smaller rebound effect. Also note that the Family load is higher over night, possibly as a result of hotter days tending to happen in succession, so the rebound effect continues into the morning of the following day.
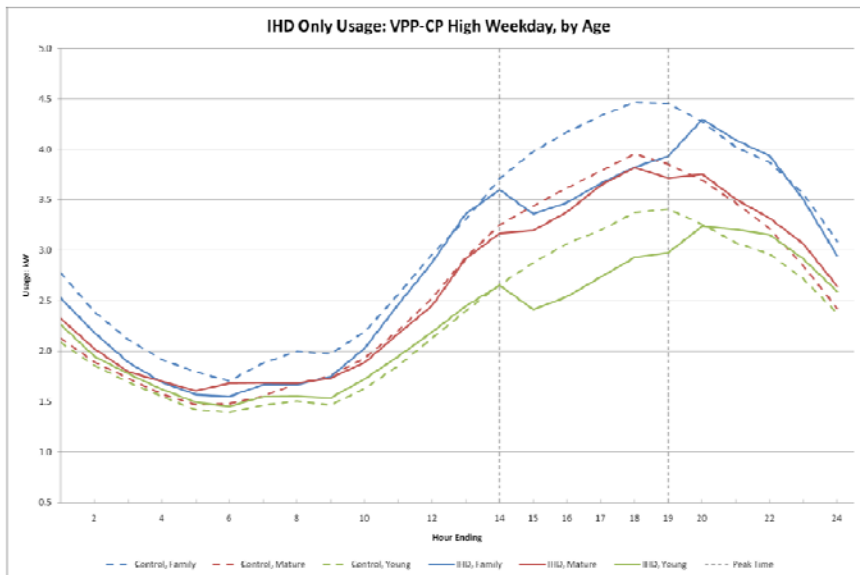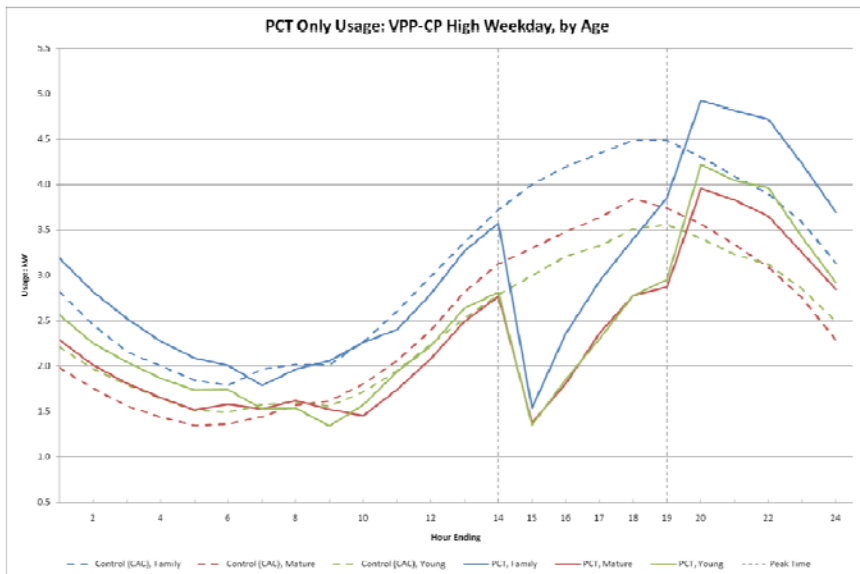

Figure 4-22   *VPP-CP high-priced weekday, PCT, by age*

Figure 4-23 shows the three segment participant load shapes along with their corresponding control group load shapes for the All Three group for the VPP-CP rate for high-priced weekdays. The response here is similar to the PCT group, with all segments showing a strong drop in load at the beginning of the event, and a large rebound effect after the event. In this case, the Young segment shows more reduction leading up to the event, and a smaller rebound effect. Also as with the PCT, the rebound effect for the Family group runs into the next day, resulting in a statistically significant increase in energy use overnight.

Figure 4-23   *VPP-CP high-priced weekday, All Three, by age*

Table 4-15 below shows the savings estimates for each age group and each technology for the weekday event of August 25 for customers on the VPP-CP rate during the on-peak and off-peak periods as well as overall. Table 4-16 below shows average on-peak and maximum on-peak kW savings for each age group and each 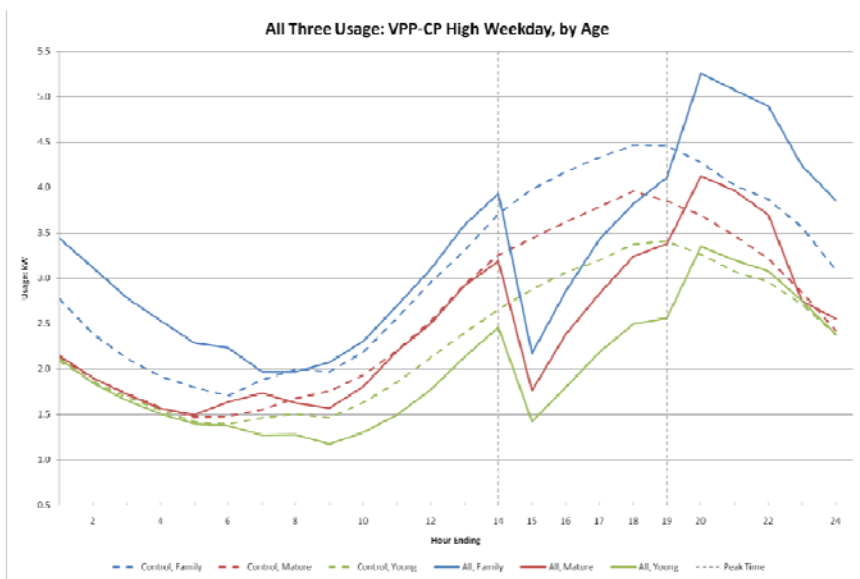rate-technology combination for the weekday event of August 25 for customers on the VPP-CP rate. Note that, by a given age segment, baseline consumption is different for the PCT group than it is for the other technology groups. This is as a result of the PCT group control group being comprised of customers with central AC only. The Family segment has the highest load reduction for the IHD and Web groups. The Mature segment has the highest savings for the PCT and All Three groups. The Young group has lower kW savings, but because it has a lower baseline load, the percentage savings are comparable to the Family segment.

Comparing the non-event and event days for the VPP-CP is useful as well. In all cases, the savings are higher for the high-priced weekday than for the event day. This is probably completely due to the mild weather on the event day, in contrast with the generally warmer high-priced weekdays. However, on a percentage basis, the savings on the event day are slightly higher for the IHD and web groups, probably reflecting the increased savings due to behavioral changes.

Looking across each age segment, PCT has the highest savings for the Mature segment, and the All Three group has the highest savings for the Young and Family segment.

*Table 4-15   Average Customer Savings, VPP-CP Weekday Event Day, by Age*

	On-Peak Consumption			Off-Peak Consumption			Overall
	Baseline	Change	Percent	Baseline	Change	Percent	Change
Family							
Web Only	12.68	-2.53	-19.93%	29.73	1.56	5.26%	-0.97
IHD Only	12.68	-2.20	-17.37%	29.73	-1.03	-3.47%	-3.23
PCT Only	13.00	-3.92	-30.19%	30.56	4.14	13.56%	0.22
All Three	12.68	-3.46	-27.32%	29.73	4.74	15.93%	1.27
Mature							
Web Only	10.63	-0.56	-5.23%	23.81	0.13	0.54%	-0.43
IHD Only	10.63	-0.44	-4.13%	23.81	-0.18	-0.76%	-0.62
PCT Only	10.18	-3.86	-37.94%	21.67	3.45	15.94%	-0.41
All Three	10.63	-3.60	-33.86%	23.81	2.31	9.71%	-1.29
Young							
Web Only	9.64	-1.89	-19.58%	23.36	0.18	0.76%	-1.71
IHD Only	9.64	-1.91	-19.80%	23.36	0.38	1.61%	-1.53
PCT Only	9.99	-2.81	-28.12%	24.79	3.34	13.47%	0.53
All Three	9.64	-2.95	-30.65%	23.36	0.44	1.88%	-2.52

Table 4-16   Average Customer Demand, VPP-CP Weekday Event Day, by Age

	Average On-Peak Demand	Demand at Maximum Reduction

	Baseline	Reduction	Percent	Baseline	Reduction	Percent
Family						
Web Only	2.54	0.51	19.93%	2.95	0.59	20.03%
IHD Only	2.54	0.44	17.37%	2.30	0.58	25.27%
PCT Only	2.60	0.78	30.19%	2.36	1.03	43.45%
All Three	2.54	0.69	27.32%	2.30	0.79	34.44%
Mature						
Web Only	2.13	0.11	5.23%	1.73	0.28	15.98%
IHD Only	2.13	0.09	4.13%	2.47	0.14	5.50%
PCT Only	2.04	0.77	37.94%	1.84	0.87	47.36%
All Three	2.13	0.72	33.86%	2.15	0.78	36.34%
Young						
Web Only	1.93	0.38	19.58%	1.63	0.44	27.27%
IHD Only	1.93	0.38	19.80%	2.08	0.47	22.40%
PCT Only	2.00	0.56	28.12%	1.87	0.73	38.84%
All Three	1.93	0.59	30.65%	1.63	0.81	49.50%

Figure 4-24 below shows the three segment participant load shapes along with their corresponding control group load shapes for the Web group for the VPP-CP rate the weekday event. The Family segment shape drops at the beginning of the event, and slowly comes back up at the end, indicating probable behavioral changes. The Young segment shape does the same thing, but starts earlier in the day. The Mature group does not show any significant response to the event in this case.
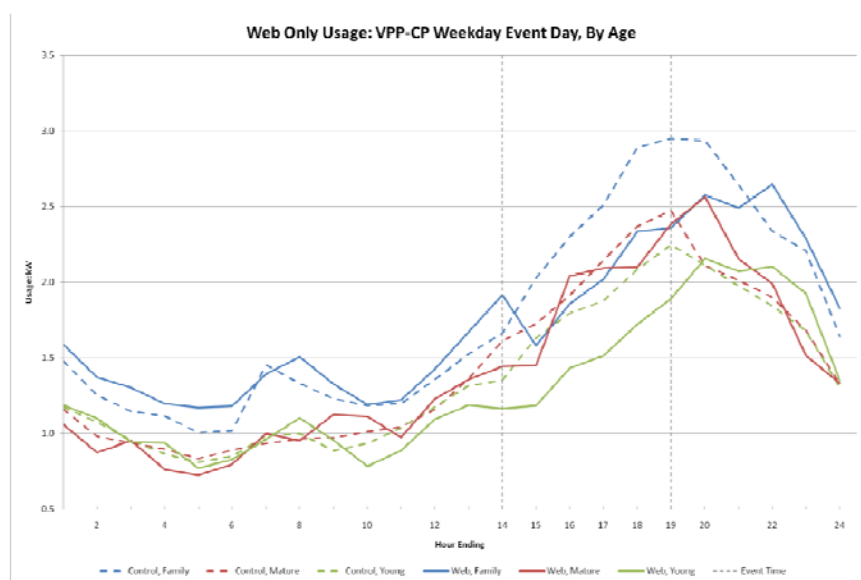
Figure 4-24   VPP-CP weekday event day, Web, by age

Figure 4-25 shows the three segment participant load shapes along with their corresponding control group load shapes for the IHD group for the VPP-CP rate the weekday event. As with the

high-priced day, the Family and Young segments respond similarly with a fairly constant load reduction throughout the event, but the Mature group does not respond.
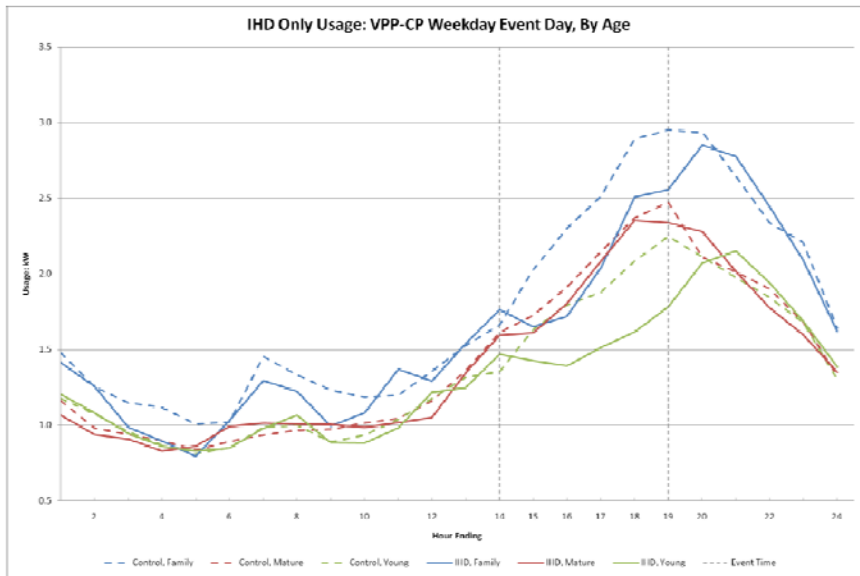

Figure 4-25   VPP-CP weekday event day, IHD, by age

Figure 4-26 shows the three segment participant load shapes along with their corresponding control group load shapes for the PCT group for the VPP-CP rate the weekday event. All segments respond in a similar way, with a significant load drop followed by a rebound effect after the end of the event.
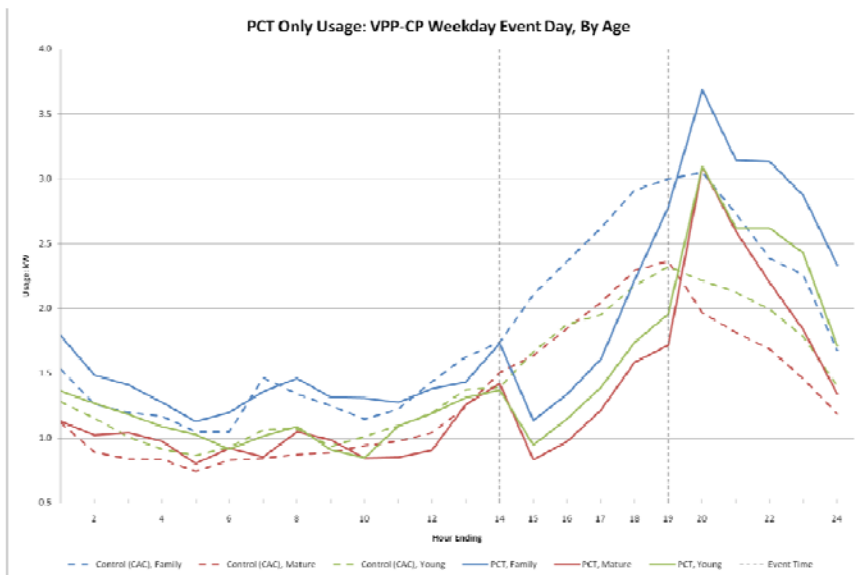
Figure 4-26   VPP-CP weekday event day, PCT, by age

Figure 4-27 shows the three segment participant load shapes along with their corresponding control group load shapes for the All Three group for the VPP-CP rate the weekday event. The Family and Mature segments appear to be responding to the technologies in similar ways, primarily during the event period. However, as with the TOU-CP, the Young segment load shape shows a reduction in energy use for several hours before the start of the event, probably driven by behavioral changes in response to the day-ahead notification. Then, at the start of the event,

the load reduces further, probably driven by the automatic response of the PCT. All segments also have a significant rebound effect after the end of the event period.
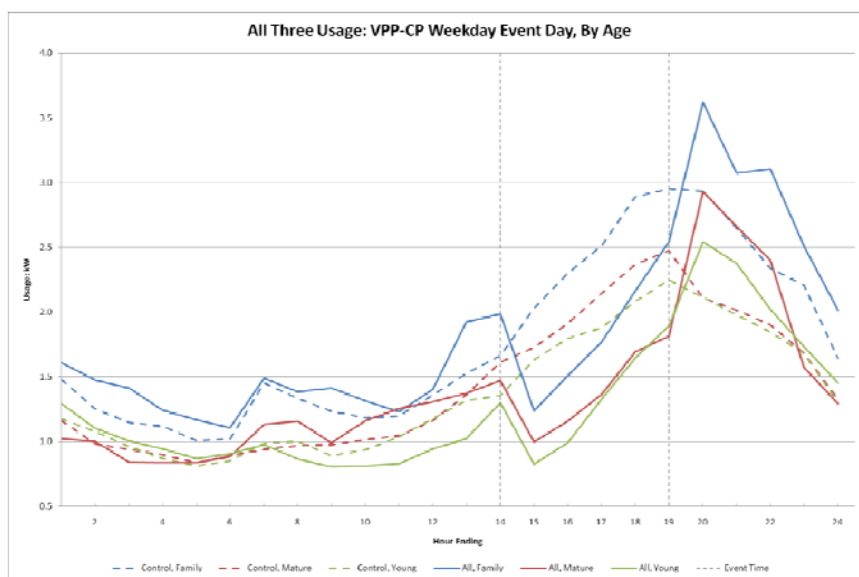
Figure 4-27   VPP-CP weekday event day, All Three, by age

4.2.2   Impacts by Income Segment

The customers were split into three income categories, Low, Middle, and High, based on their PRIZM Codes. Each of the rate-technology groups and the control group were split up for analysis, so that each demographic segment was compared with an appropriate control group.

4.2.2.1 Impacts by Income Segment for TOU-CP

Table 4-17 below shows the savings estimates for each income group and each technology for the average non-event weekday for customers on the TOU-CP rate during the on-peak and off-peak periods as well as overall. Table 4-18 below shows average on-peak and maximum on-peak kW savings for each income group and each rate-technology combination for the average non-event weekday for customers on the TOU-CP rate. Note that, by a given income segment, baseline consumption is different for the PCT group than it is for the other technology groups. This is as a result of the PCT group control group being comprised of customers with central AC only. Even though the Low segment has the lowest baseline usage, they show the largest kW savings for the IHD group, as well as the highest percentage savings for all four groups. With much higher baseline consumption, the High segment does show higher kW savings for the other three technology groups. The Middle segment shows lower percentage savings and lower kW savings for all groups except the All Three group, where the kW savings are slightly higher than the Low segment.

Looking across each income segment for all segments, the PCT and All Three groups show higher savings, most likely due to the automated response of the thermostats. The Web group has the lowest savings, except for the High segment, where the Web savings exceeds the IHD savings. Curiously, the All Three group savings for the Low segment are less than the IHD savings, surprising since the All Three group customers all have an IHD. The difference is not great, so may not be statistically significant, but could also be an indication that customers with PCTs as well as IHDs may assume that the PCT will "take care of things" for them, and may pay less attention to the IHD information.

Table 4-17   Average Customer Savings, TOU-CP Weekday Non-Event Day, by Income

	On-Peak Consumption			Off-Peak Consumption			Overall
	Baseline	Change	Percent	Baseline	Change	Percent	Change
High							
Web Only	18.95	-3.19	-16.85%	46.99	-3.09	-6.57%	-6.28
IHD Only	18.95	-2.08	-10.97%	46.99	-1.12	-2.38%	-3.20
PCT Only	19.12	-4.95	-25.88%	47.51	6.42	13.52%	1.48
All Three	18.95	-5.33	-28.11%	46.99	-1.98	-4.22%	-7.31
Middle							
Web Only	13.98	-0.60	-4.30%	33.24	3.14	9.43%	2.53
IHD Only	13.98	-1.67	-11.94%	33.24	0.24	0.73%	-1.42
PCT Only	13.79	-2.88	-20.86%	33.08	3.69	11.14%	0.81
All Three	13.98	-3.28	-23.50%	33.24	1.73	5.22%	-1.55
Low							
Web Only	12.28	-0.82	-6.71%	29.62	1.06	3.59%	0.24
IHD Only	12.28	-3.57	-29.05%	29.62	-4.10	-13.83%	-7.67
PCT Only	12.66	-5.26	-41.51%	30.55	-5.09	-16.67%	-10.35
All Three	12.28	-3.04	-24.79%	29.62	0.40	1.34%	-2.65

Table 4-18   Average Customer Demand, TOU-CP Weekday Non-Event Day, by Income

	Average On-Peak Demand			Demand at Maximum Reduction		
	Baseline	Reduction	Percent	Baseline	Reduction	Percent
High						
Web Only	3.79	0.64	16.85%	3.60	0.68	18.77%
IHD Only	3.79	0.42	10.97%	3.60	0.50	13.94%
PCT Only	3.82	0.99	25.88%	3.36	1.51	44.97%
All Three	3.79	1.07	28.11%	3.34	1.55	46.34%
Middle						
Web Only	2.80	0.12	4.30%	2.85	0.15	5.14%
IHD Only	2.80	0.33	11.94%	2.66	0.40	15.01%
PCT Only	2.76	0.58	20.86%	2.42	0.96	39.72%
All Three	2.80	0.66	23.50%	2.46	0.99	40.31%
Low						
Web Only	2.46	0.16	6.71%	2.34	0.21	8.84%
IHD Only	2.46	0.71	29.05%	2.63	0.77	29.23%
PCT Only	2.53	1.05	41.51%	2.22	1.27	57.17%

All Three	2.46	0.61	24.79%	2.17	0.83	38.27%

Figure 4-28 shows the three segment participant load shapes along with their corresponding control group load shapes for the Web group for the TOU-CP rate for non-event weekdays. The load responses are similar during the event for the three segments.
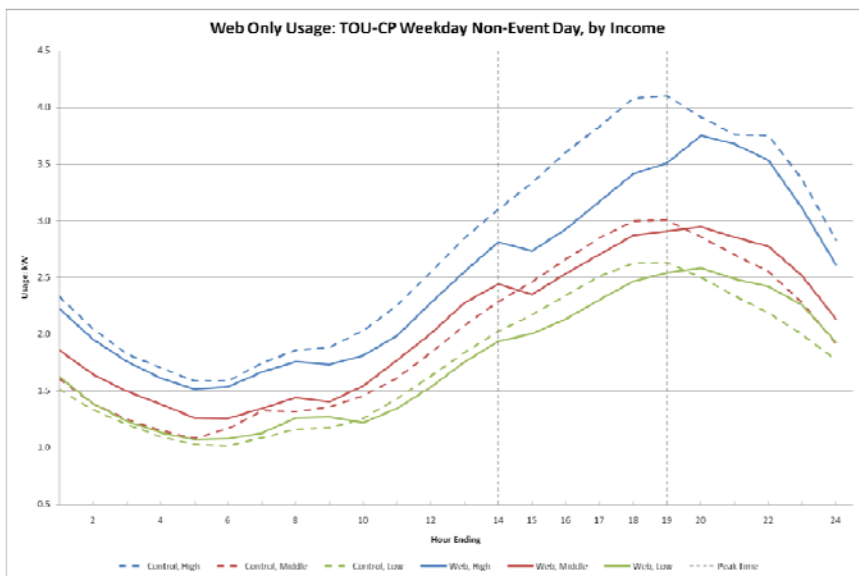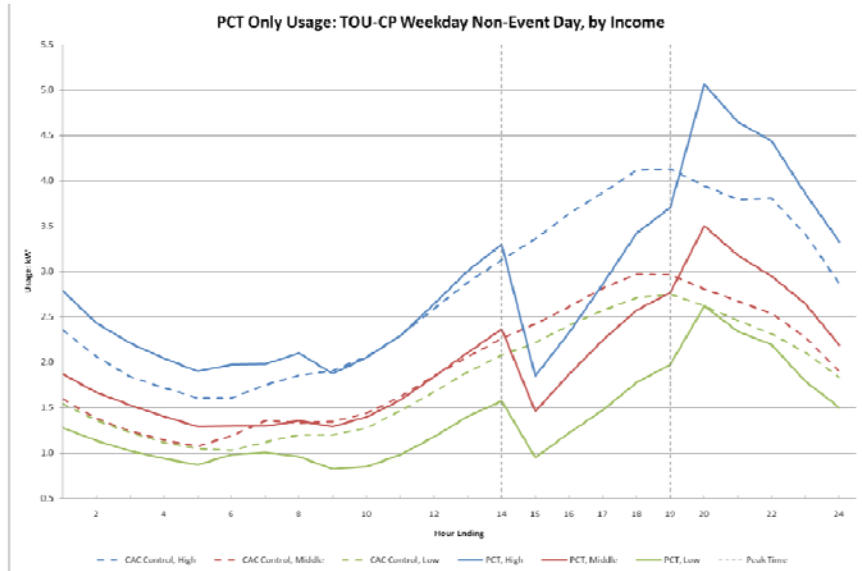

Figure 4-28   ***TOU-CP weekday non-event day, Web, by income***

Figure 4-29 shows the three segment participant load shapes along with their corresponding control group load shapes for the IHD group for the TOU-CP rate for non-event weekdays. In this case, the High and Middle segment load responses are very similar, with a consistent load reduction throughout the event, and no appreciable rebound effect. The Low segment shows a bigger drop both proportionally and in kW, including a significant drop in the hours leading up to the peak period. This could be an indication of higher price sensitivity of the Low segment.
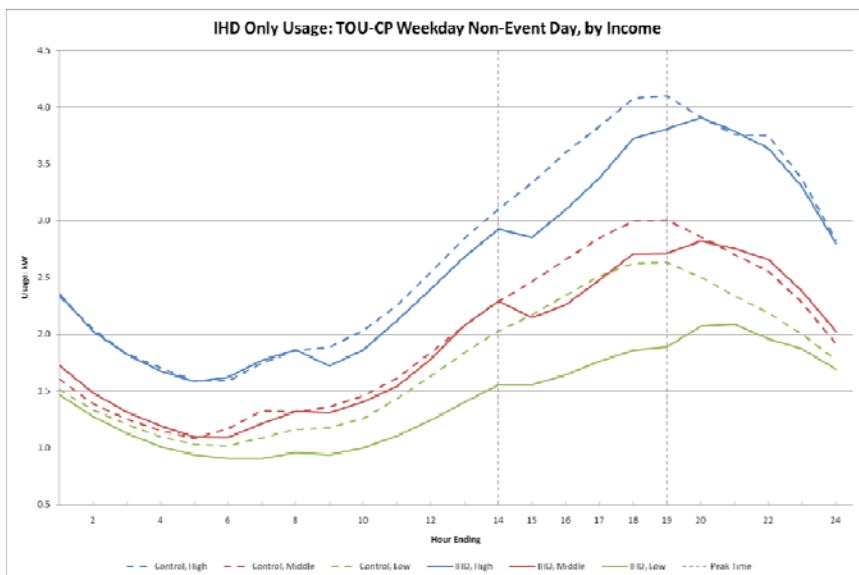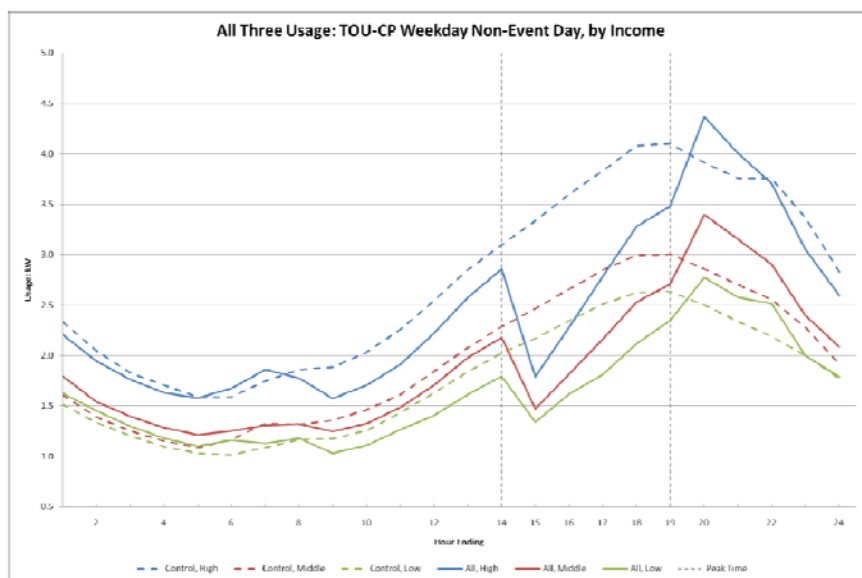

Figure 4-29   ***TOU-CP weekday non-event day, IHD, by income***

Figure 4-30 shows the three segment participant load shapes along with their corresponding control group load shapes for the PCT group for the TOU-CP rate for non-event weekdays. All income segments show a proportional drop in load at the beginning of the event and a sizable rebound effect after the end of the event. The Low segment also shows a pretty dramatic and statistically significant load reduction for several hours leading up to the beginning of the peak period, probably based on customer programming of the PCT. This could be an indication of higher price sensitivity of the Low segment.

Figure 4-30   TOU-CP weekday non-event day, PCT, by income

Figure 4-31 shows the three segment participant load shapes along with their corresponding control group load shapes for the All Three group for the TOU-CP rate for non-event weekdays. The three income segments appear to be responding to the technologies in about the same way, reducing energy use to some extent throughout the entire day, but more during the peak period. This could be an indication of the combination of behavioral changes based on information and the automated response of the PCT.

Figure 4-31   TOU-CP weekday non-event day, All Three, by income

Table 4-19 below shows the savings estimates for each income group and each technology for the weekday event of August 25 for customers on the TOU-CP rate during the on-peak and off-peak periods as well as overall. Table 4-20 below shows average on-peak and maximum on-peak kW savings for each income group and each rate-technology combination for the weekday event of August 25 for customers on the TOU-CP rate. Note that, by a given income segment, baseline consumption is different for the PCT group than it is for the other technology groups. This is as a result of the PCT group control group being comprised of customers with central AC only. Even though the Low segment has the lowest baseline usage, they show the largest kW savings for the IHD group, as well as the highest percentage savings for all but the Web group. This could be further evidence of more price sensitivity for this segment. With much higher baseline consumption, the High segment does show higher kW savings for the other three technology groups. The Middle segment shows lower percentage savings and lower kW savings for all groups. The High segment shows a surprisingly high savings for the Web group, which may be indicative of higher use of and familiarity with the web in general.

Looking across each income segment, the PCT and All Three groups show higher savings for all segments, most likely due to the automated response of the thermostats. The Web group has the lowest savings, except for the High segment, where the Web savings exceeds the IHD savings. As on non-event days, the All Three group savings for the Low segment are less than the IHD savings, surprising since the All Three group customers all have an IHD. The difference may not be statistically significant, but could be an indication that customers with PCTs as well as IHDs may assume that the PCT will "take care of things" for them, and may pay less attention to the IHD information.

Table 4-19   *Average Customer Savings, TOU-CP Weekday Event Day, by Income*

	On-Peak Consumption			Off-Peak Consumption			Overall
	Baseline	Change	Percent	Baseline	Change	Percent	Change
High							
Web Only	13.57	-3.80	-28.03%	32.50	-0.93	-2.88%	-4.74
IHD Only	13.57	-2.60	-19.14%	32.50	1.47	4.53%	-1.12
PCT Only	13.60	-5.04	-37.02%	32.48	7.71	23.74%	2.68
All Three	13.57	-4.45	-32.78%	32.50	1.31	4.02%	-3.14
Middle							
Web Only	10.39	-0.94	-9.07%	22.89	3.87	16.89%	2.93
IHD Only	10.39	-1.17	-11.23%	22.89	1.96	8.56%	0.79
PCT Only	10.55	-3.73	-35.40%	23.05	5.57	24.16%	1.83
All Three	10.39	-2.84	-27.35%	22.89	3.19	13.92%	0.35
Low							
Web Only	8.84	-1.75	-19.79%	21.05	0.14	0.68%	-1.61
IHD Only	8.84	-4.23	-47.88%	21.05	-1.81	-8.58%	-6.04
PCT Only	8.81	-3.92	-44.48%	20.83	-2.63	-12.63%	-6.55
All Three	8.84	-2.74	-30.99%	21.05	0.09	0.41%	-2.66

*Table 4-20   Average Customer Demand, TOU-CP Weekday Event Day, by Income*

	Average On-Peak Demand			Demand at Maximum Reduction		
	Baseline	Reduction	Percent	Baseline	Reduction	Percent
High						
Web Only	2.71	0.76	28.03%	3.09	0.86	27.92%
IHD Only	2.71	0.52	19.14%	3.16	0.64	20.39%
PCT Only	2.72	1.01	37.02%	3.11	1.15	36.99%
All Three	2.71	0.89	32.78%	2.74	1.00	36.40%
Middle						
Web Only	2.08	0.19	9.07%	2.38	0.33	13.93%
IHD Only	2.08	0.23	11.23%	1.84	0.33	17.69%
PCT Only	2.11	0.75	35.40%	1.89	0.91	48.26%
All Three	2.08	0.57	27.35%	1.84	0.68	36.81%
Low						
Web Only	1.77	0.35	19.79%	2.09	0.50	23.70%
IHD Only	1.77	0.85	47.88%	1.93	0.97	50.02%
PCT Only	1.76	0.78	44.48%	1.96	0.90	45.98%
All Three	1.77	0.55	30.99%	1.78	0.63	35.51%

Figure 4-32 shows the three segment participant load shapes along with their corresponding control group load shapes for the Web group for the TOU-CP rate for the weekday event. The three income segments appear to be responding similarly during the event period, with most of the load reduction probably due to behavioral changes, given the lack of much of a rebound effect for any of the segments. The Middle segment shows the smallest load reduction.
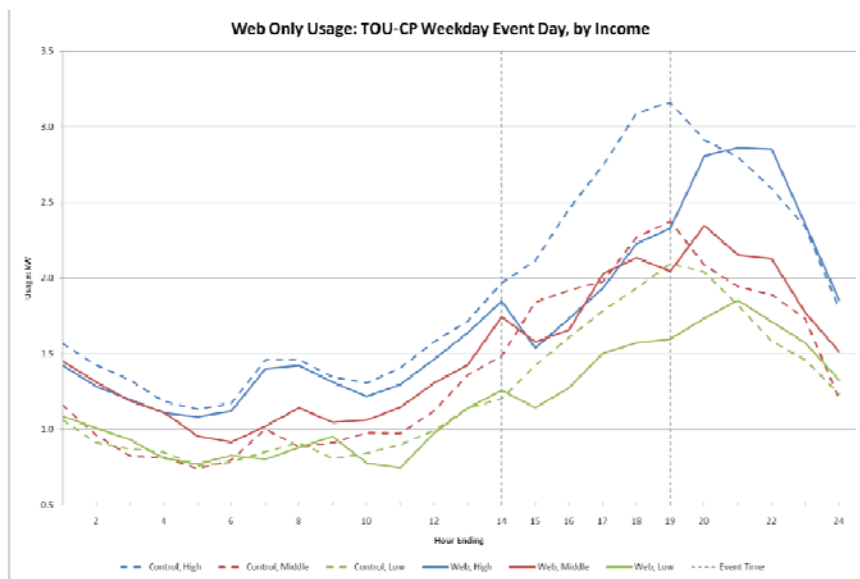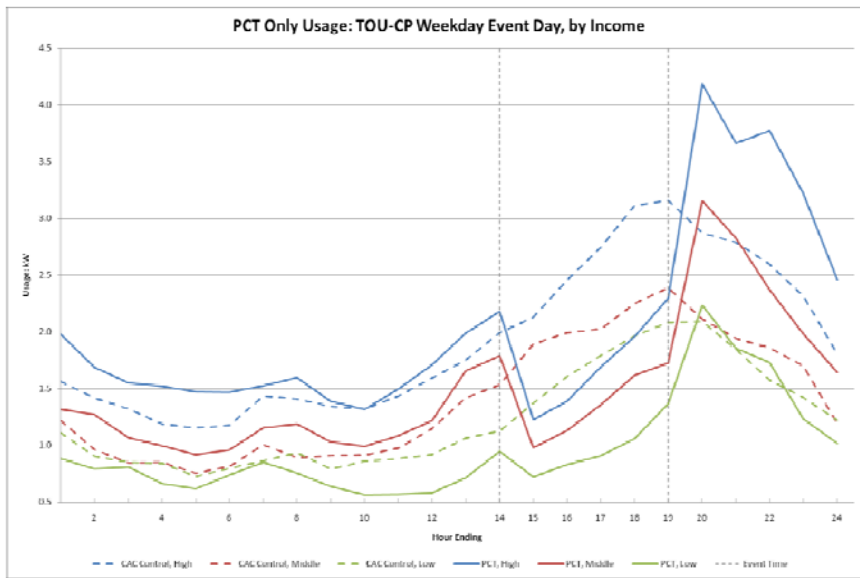

Figure 4-32   TOU-CP weekday event day, Web, by income

Figure 4-33 shows the three segment participant load shapes along with their corresponding control group load shapes for the IHD group for the TOU-CP rate for the weekday event. In this case, the High and Middle segment load responses are very similar, with a consistent load reduction throughout the event, and no appreciable rebound effect, with the High segment showing more savings. The Low segment shows a bigger drop both proportionally and in kW, including a significant drop in the hours leading up to the peak period. This could be an indication of higher price sensitivity of the Low segment.
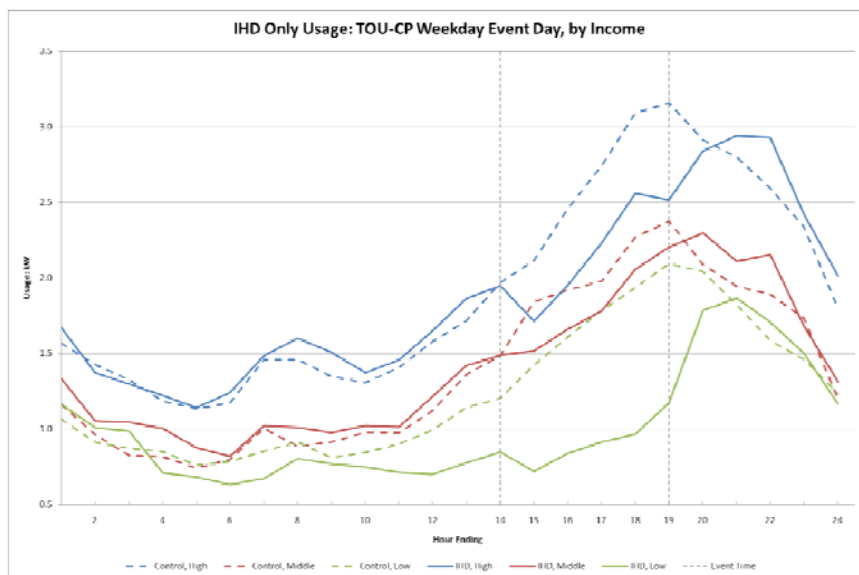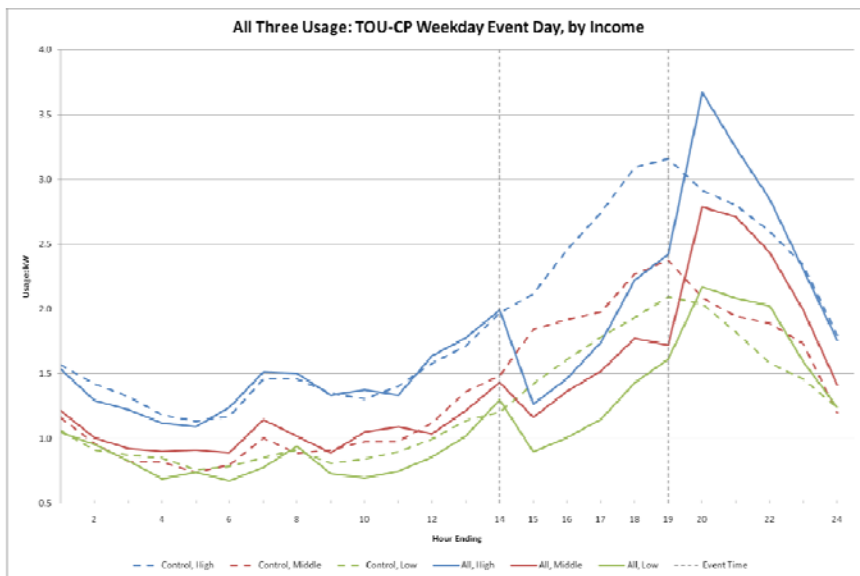

Figure 4-33   TOU-CP weekday event day, IHD, by income

Figure 4-34 shows the three segment participant load shapes along with their corresponding control group load shapes for the PCT group for the TOU-CP rate for the weekday event. All income segments show a proportional drop in load at the beginning of the event and a sizable rebound effect after the end of the event. The Low segment also shows a pretty dramatic and statistically significant load reduction for several hours leading up to the beginning of the peak period, probably based on customer programming of the PCT. This could be an indication of higher price sensitivity of the Low segment. This graph also shows the possibility that customers are pre-cooling, ramping up their central AC before the event starts, suggested by the increase in load just before the start of the event for the Middle and High segments.

Figure 4-34   TOU-CP weekday event day, PCT, by income

Figure 4-35 shows the three segment participant load shapes along with their corresponding control group load shapes for the All Three group for the TOU-CP rate for the weekday event. The three income segments appear to be responding to the technologies in similar ways, with a big load drop at the beginning of the event period, and a sizable rebound after. The Low segment shows less of a rebound.

Figure 4-35   TOU-CP weekday event day, All Three, by income

4.2.2.2 Impacts by Income Segment for VPP-CP

Table 4-21 below shows the savings estimates for each income group and each technology for the average high-priced non-event weekday for customers on the VPP-CP rate during the on-peak and off-peak periods as well as overall. Table 4-22 below shows average on-peak and maximum on-peak kW savings for each income group and each rate-technology combination for the average high-priced non-event weekday for customers on the VPP-CP rate. Note that, by a

given income segment, baseline consumption is different for the PCT group than it is for the other technology groups. This is as a result of the PCT group control group being comprised of customers with central AC only. Even though the Low segment has the lowest baseline usage, the kW savings for the PCT group is about the same as the High segment, and twice the Middle segment. With much higher baseline consumption, the High segment does show the highest kW savings for all technology groups.

Looking across each income segment for all segments, the PCT and All Three groups show higher savings in each segment, most likely due to the automated response of the thermostats. The Web group has the lowest savings for the Middle group, but higher savings than the IHD for the Low segment. This low savings for the IHD group for the Low segment is not statistically significant, and is difficult to interpret, since for the TOU-CP rate, the savings were much higher.

**Table 4-21   Average Customer Savings, VPP-CP High-Priced Weekday, by Income**

	On-Peak Consumption			Off-Peak Consumption			Overall
	Baseline	Change	Percent	Baseline	Change	Percent	Change
High							
Web Only	22.86	-3.08	-13.48%	55.10	-1.02	-1.85%	-4.10
IHD Only	22.86	-3.02	-13.23%	55.10	-1.82	-3.29%	-4.84
PCT Only	22.93	-7.98	-34.83%	55.23	4.95	8.97%	-3.03
All Three	22.86	-8.02	-35.08%	55.10	-0.74	-1.34%	-8.76
Middle							
Web Only	17.45	-1.56	-8.91%	41.98	3.56	8.48%	2.00
IHD Only	17.45	-2.33	-13.37%	41.98	0.86	2.05%	-1.47
PCT Only	17.16	-3.84	-22.36%	41.50	9.59	23.10%	5.75
All Three	17.45	-5.06	-29.01%	41.98	3.60	8.57%	-1.46
Low							
Web Only	15.40	-1.88	-12.20%	37.44	-0.97	-2.60%	-2.85
IHD Only	15.40	-0.92	-5.97%	37.44	2.14	5.71%	1.22
PCT Only	15.68	-7.31	-46.60%	38.11	-2.16	-5.67%	-9.47
All Three	15.40	-2.96	-19.22%	37.44	3.51	9.36%	0.55

Table 4-22   Average Customer Demand, VPP-CP High-Priced Weekday, by Income

	Average On-Peak Demand			Demand at Maximum Reduction		
	Baseline	Reduction	Percent	Baseline	Reduction	Percent
High						
Web Only	4.57	0.62	13.48%	4.42	0.70	15.79%
IHD Only	4.57	0.60	13.23%	4.42	0.63	14.30%
PCT Only	4.59	1.60	34.83%	4.16	2.29	55.05%
All Three	4.57	1.60	35.08%	4.14	2.24	54.12%

Middle						
Web Only	3.49	0.31	8.91%	3.39	0.37	10.82%
IHD Only	3.49	0.47	13.37%	3.39	0.57	16.80%
PCT Only	3.43	0.77	22.36%	3.16	1.62	51.30%
All Three	3.49	1.01	29.01%	3.23	1.61	49.67%
Low						
Web Only	3.08	0.38	12.20%	2.85	0.53	18.46%
IHD Only	3.08	0.18	5.97%	2.98	0.24	8.12%
PCT Only	3.14	1.46	46.60%	2.89	1.97	68.31%
All Three	3.08	0.59	19.22%	2.85	1.14	40.09%

Figure 4-36 shows the three segment participant load shapes along with their corresponding control group load shapes for the Web group for the VPP-CP rate for high-priced weekdays. The three income segments show similar load reduction patterns, with a fairly constant reduction throughout the peak period.
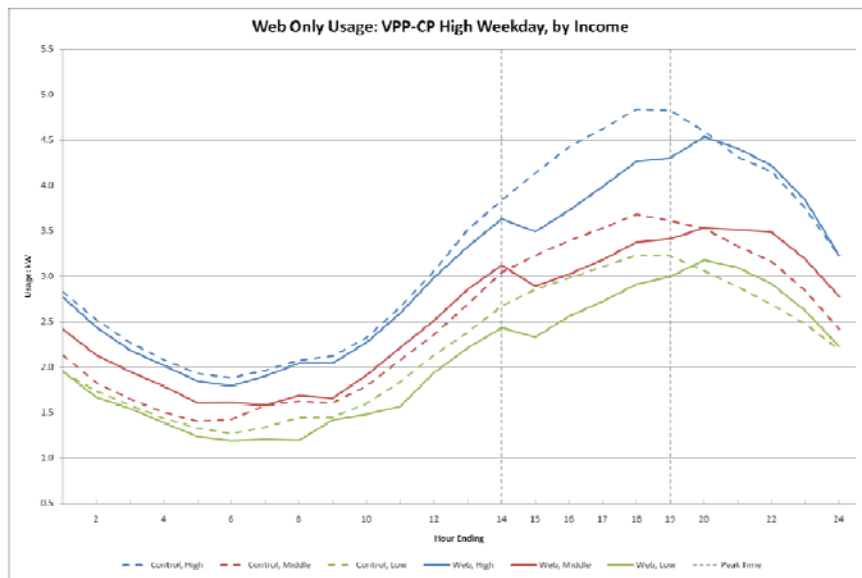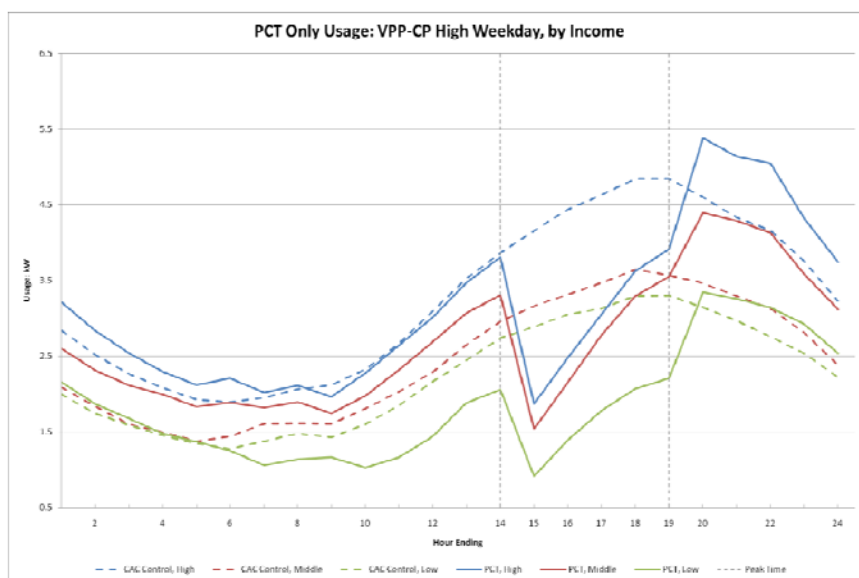

Figure 4-36   VPP-CP high-priced weekday, Web, by income

Figure 4-37 shows the three segment participant load shapes along with their corresponding control group load shapes for the IHD group for the VPP-CP rate for high-priced weekdays. The Middle and High segment Low load savings are similar, showing a consistent load reduction throughout the peak period. Surprisingly, however, the Low segment load savings is much smaller in this case, in contrast to the TOU-CP weekday and event day above. We don't have an explanation for this, but it may be due to random variation in customer energy use or characteristics.
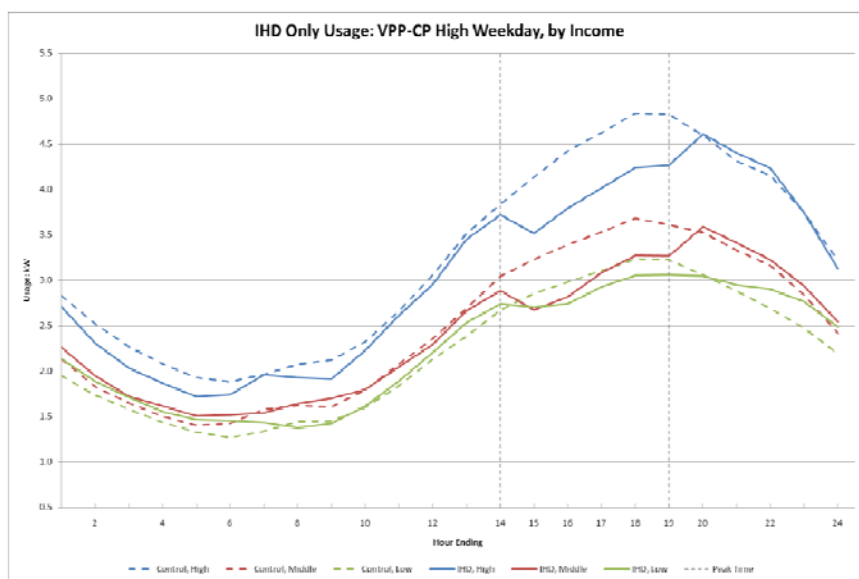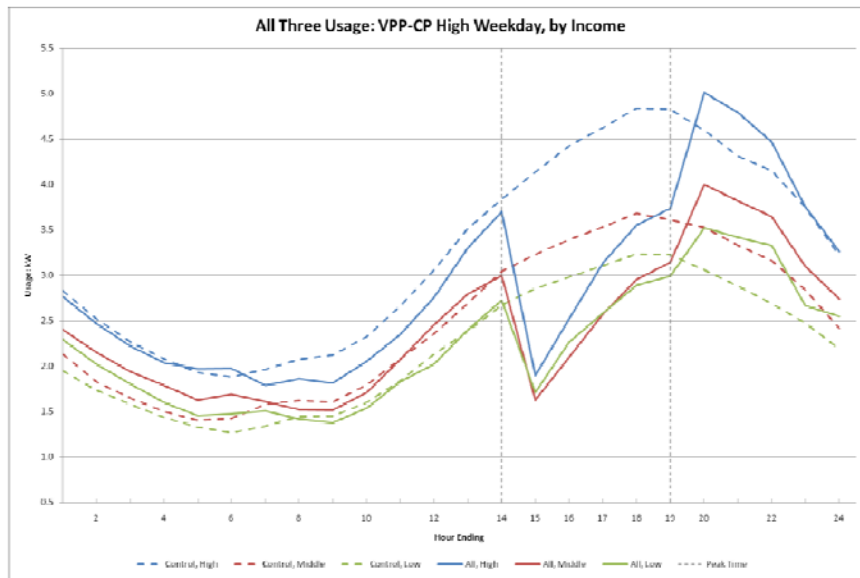
Figure 4-37   VPP-CP high-priced weekday, IHD, by income

Figure 4-38 shows the three segment participant load shapes along with their corresponding control group load shapes for the PCT group for the VPP-CP rate for high-priced weekdays.   All income segments show a proportional drop in load at the beginning of the event and a sizable rebound effect after the end of the event. The Low segment also shows a pretty dramatic and statistically significant load reduction for several hours leading up to the beginning of the peak period, probably based on customer programming of the PCT. This could be an indication of higher price sensitivity of the Low segment.

Figure 4-38   VPP-CP high-priced weekday, PCT, by income

Figure 4-39 shows the three segment participant load shapes along with their corresponding control group load shapes for the All Three group for the VPP-CP rate for high-priced weekdays. The response here is similar to the PCT group, with all segments showing a strong drop in load at the beginning of the event, and a large rebound effect after the event. However, in this case, the Low segment does not show load reduction leading up to the event as it did above.

Figure 4-39 *VPP-CP high-priced weekday, All Three, by income*

Table 4-23 below shows the savings estimates for each income group and each technology for the weekday event of August 25 for customers on the VPP-CP rate during the on-peak and off-peak periods as well as overall. Table 4-24 below shows average on-peak and maximum on-peak kW savings for each income group and each rate-technology combination for the weekday event of August 25 for customers on the VPP-CP rate. Note that, by a given income segment, baseline consumption is different for the PCT group than it is for the other technology groups. This is as a result of the PCT group control group being comprised of customers with central AC only. The results are similar to the high-priced day, but with slightly higher savings in most cases. Given that the event-day price is the same as the high price, this is what we would expect. Again, the Low segment has the greatest kW and percentage savings in the PCT group, with the highest percentage savings of any group or segment at 50%. The All Three group is the highest load reduction for both the Middle and High segments.

Table 4-23 *Average Customer Savings, VPP-CP Weekday Event Day, by Income*

	On-Peak Consumption			Off-Peak Consumption			Overall
	Baseline	Change	Percent	Baseline	Change	Percent	Change
High							
Web Only	13.57	-2.47	-18.19%	32.50	-1.42	-4.38%	-3.89
IHD Only	13.57	-2.57	-18.92%	32.50	-2.48	-7.62%	-5.04
PCT Only	13.60	-3.84	-28.26%	32.48	2.89	8.91%	-0.95
All Three	13.57	-5.03	-37.08%	32.50	-1.07	-3.28%	-6.10
Middle							
Web Only	10.39	-0.95	-9.13%	22.89	3.74	16.35%	2.80
IHD Only	10.39	-1.00	-9.61%	22.89	3.30	14.42%	2.30
PCT Only	10.55	-2.03	-19.29%	23.05	8.42	36.54%	6.39
All Three	10.39	-4.13	-39.74%	22.89	4.16	18.19%	0.04
Low							

Web Only	8.84	-1.34	-15.11%	21.05	-0.54	-2.56%	-1.88
IHD Only	8.84	-0.89	-10.07%	21.05	-1.22	-5.80%	-2.11
PCT Only	8.81	-4.41	-50.00%	20.83	0.14	0.69%	-4.26
All Three	8.84	-1.23	-13.93%	21.05	3.43	16.32%	2.20

Table 4-24   Average Customer Demand, VPP-CP Weekday Event Day, by Income

	Average On-Peak Demand			Demand at Maximum Reduction		
	Baseline	Reduction	Percent	Baseline	Reduction	Percent
High						
Web Only	2.71	0.49	18.19%	3.09	0.70	22.55%
IHD Only	2.71	0.51	18.92%	3.09	0.73	23.53%
PCT Only	2.72	0.77	28.26%	2.46	0.89	36.05%
All Three	2.71	1.01	37.08%	3.09	1.08	34.93%
Middle						
Web Only	2.08	0.19	9.13%	1.84	0.41	22.40%
IHD Only	2.08	0.20	9.61%	1.84	0.47	25.51%
PCT Only	2.11	0.41	19.29%	1.89	0.78	41.34%
All Three	2.08	0.83	39.74%	1.84	1.04	56.71%
Low						
Web Only	1.77	0.27	15.11%	1.42	0.43	30.42%
IHD Only	1.77	0.18	10.07%	1.78	0.33	18.77%
PCT Only	1.76	0.88	50.00%	1.79	1.08	60.45%
All Three	1.77	0.25	13.93%	1.61	0.50	31.15%

Figure 4-40 shows the three segment participant load shapes along with their corresponding control group load shapes for the Web group for the VPP-CP rate the weekday event. The three segments show similar load reduction patterns, with the High segment showing more savings than the other two.
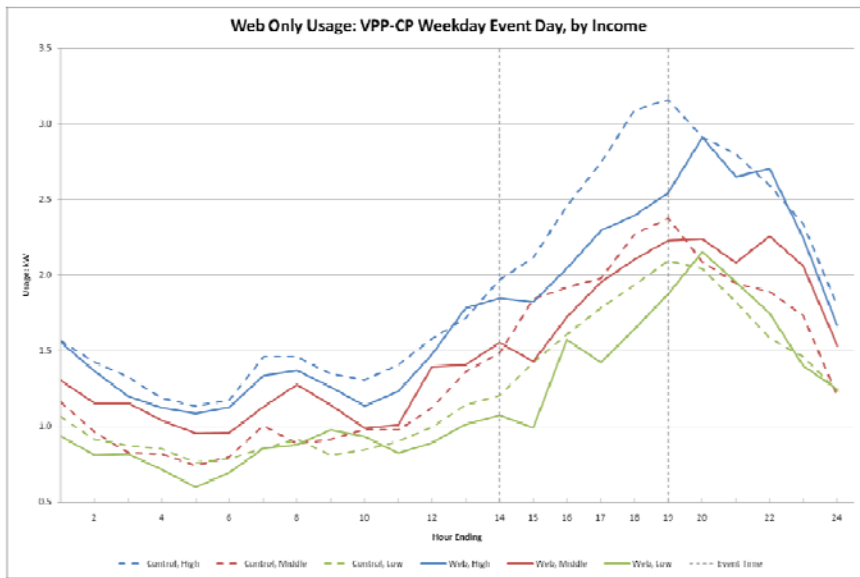
Figure 4-40   VPP-CP weekday event day, Web, by income

Figure 4-41 shows the three segment participant load shapes along with their corresponding control group load shapes for the IHD group. The High segment shows the biggest load reduction, with the Middle and Low segments showing less.
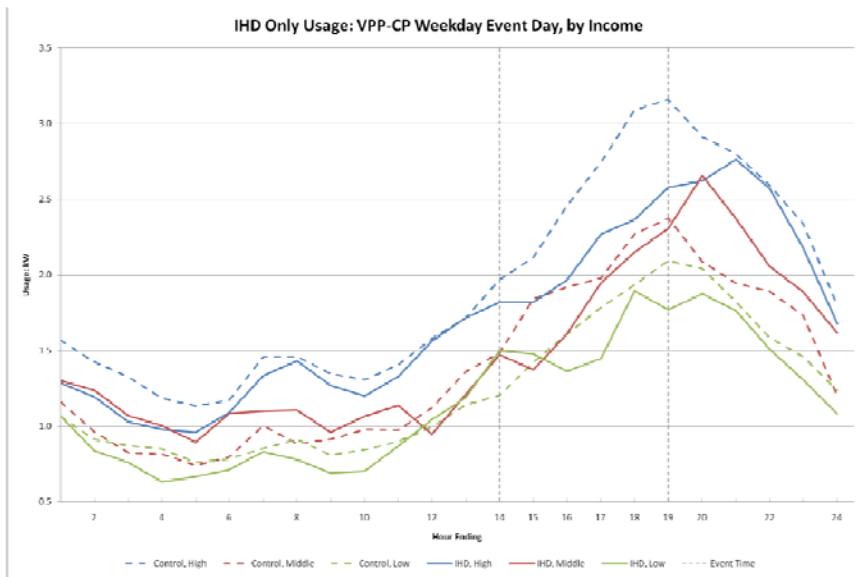

Figure 4-41   VPP-CP weekday event day, IHD, by income

Figure 4-42 shows the three segment participant load shapes along with their corresponding control group load shapes for the PCT group for the VPP-CP rate the weekday event. All segments respond in a similar way, with a significant load drop followed by a rebound effect after the end of the event. The Low segment shows some load reduction in the several hours before the event.
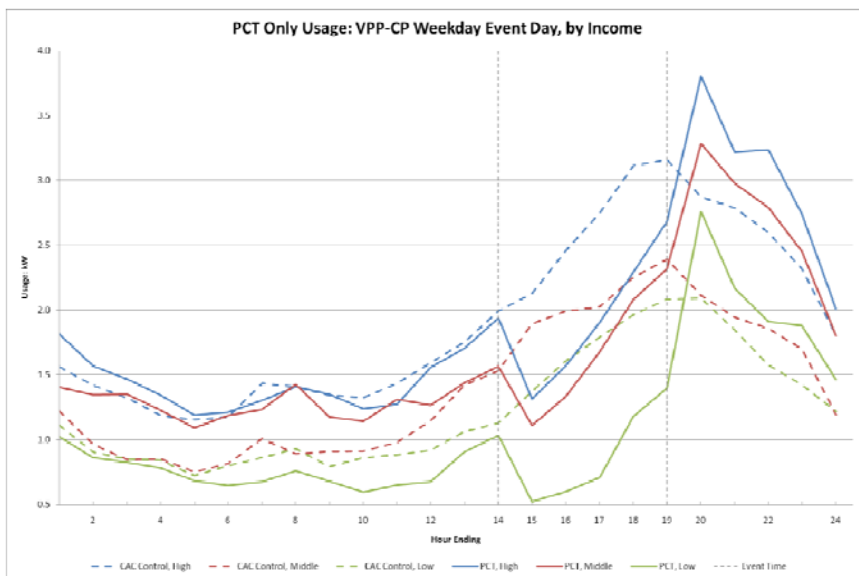

Figure 4-42   VPP-CP weekday event day, PCT, by income

Figure 4-43 shows the three segment participant load shapes along with their corresponding control group load shapes for the All Three group for the VPP-CP rate the weekday event. The three segments show about the same load reduction pattern, but the Low segment has much smaller savings than the other two segments.
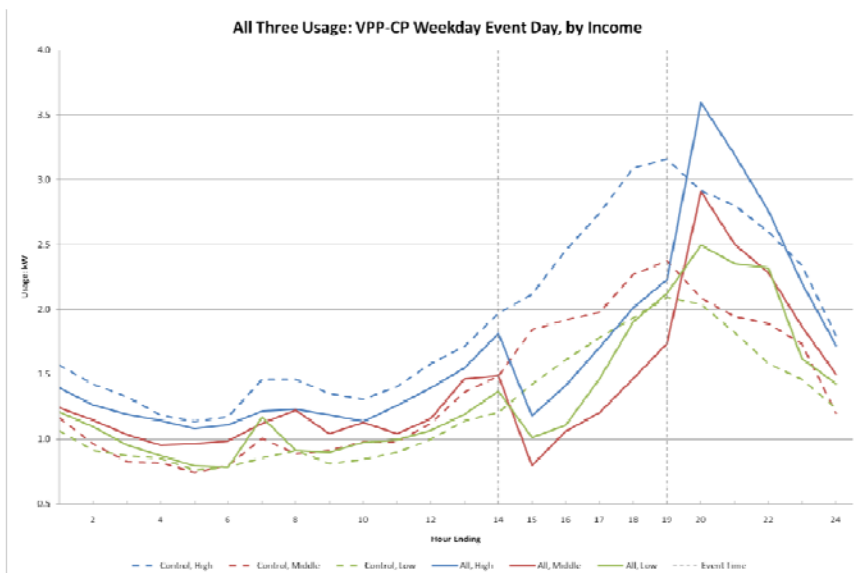

Figure 4-43   VPP-CP weekday event day, All Three, by income

SUMMARY AND RECOMMENDATIONS

5.1 SUMMARY

The specific preliminary results of the Smart Study TOGETHER are listed below.

- In general, the automated response of the PCT and All Three groups reduce load more than the information provided through the IHD and Web Portal. However, the IHD and Web Portal load reductions are more constant throughout the peak period, whereas the PCT and All Three groups tend to have a load reduction spike at the beginning, and savings that decay later in the period. There was also usually a significant rebound effect after the event for the PCT and All Three groups.

- There is very little change in weekend loads for either rate, either up in response to lower prices or down out of habit.

- There is no statistically significant change in loads on low-priced days for VPP-CP customers, but it does appear that some customers are programming their thermostats in conventional ways to reduce energy use while they are away from the home.

- The TOU-CP shows significant load reductions for all technology groups on both non-event weekdays and the weekday event.

- The VPP-CP rate shows load reductions that correspond to the price level on weekdays – there is statistically significant load reduction on days when prices are standard, medium, and high, and the load reduction increases as the price increases.

- The one weekend event was on a late summer day, and as a result, the savings were smaller but still statistically significant for several of the rate/technology combinations. Because there was not much cooling load, the PCT and All Three groups showed less savings, particularly for the VPP-CP.

- The one weekday event was on a mild day as well. The kW savings for the TOU-CP were comparable to the average weekday, but because the load was lower, the percentage savings were higher. The behavior of the VPP-CP customers was similar to their behavior on a high-priced day (not surprising, since the high price is the same as the critical price during an event), but with less load reduction since the load for the day was lower because of the temperature.

- The PCT groups often show more savings that the All Three group, but this is likely due to the fact that the PCT group included only those with central AC, and the All Three group included customers both with and without central AC.

- In several cases, the All Three group showed both overall load reductions throughout the day and further reductions in the peak period. This suggests that the information technologies (IHD and Web) are prompting behavioral changes in addition to the automated response of the PCT.

5.1.1 Age Segment Conclusions

The preliminary results related to the Age segments are summarized below.

- The Family age segment has the highest average baseline usage, and generally has higher load reductions, particularly for the PCT and All Three groups.

- In several cases, the Mature and Young groups showed better load response than the Family group to the information provided by the IHD.

- The Mature customers on the TOU-CP rate seemed to respond to the IHD rather dramatically, but this was not the case for the Mature customers on the VPP-CP rate.

- The PCT and All Three groups generally had higher savings for each of the age segments, consistent with the trend for the combined population.

5.1.2   Income Segment Conclusions

The preliminary results related to the Income segments are summarized below.

- The High income segment has the highest average baseline usage, and generally has higher load reductions.

- The Low income segment shows higher percentage savings in many cases, and in some cases higher kW savings than the generally higher-consuming Middle and High income segments.   This may be a result of Low income customers being more price sensitive and taking more actions to reduce load.

- The PCT and All Three groups in the Low income segment appear to have load reductions throughout the day, including several hours before the event.   Since these are off-peak periods, this is not price response, but may be due to the PCTs replacing manual thermostats, then being used to reduce load when the home is unoccupied. It could also be due to higher energy awareness.

- In some cases, the High income segment shows more load reduction for the Web Portal group, which may be due to easier access to the web or better familiarity.

5.2   RECOMMENDATIONS FOR PHASE II

Going forward, we have the following recommendations for the implementation of Phase II. In some cases, we may modify the analysis of Phase I data to reflect these recommendations.

- In the recruiting, use a more presumptive approach for participants. Once the customer completes the survey, we should describe what they will be getting and set things up based on the assumption that they will be participating – don't ask them if they are still interested.

- Adjust the marketing to reflect the expected recruiting rates by demographic segment. For those demographic segments that were difficult to enroll in the first phase, market to everyone. For those that were filled early, randomly subdivide the population and only market to a subset that is inversely proportional to the recruiting rate from phase I.

- Consider not using the secondary assignments for the PCT and Web Portal groups. If a customer is preassigned to the PCT group and does not have central AC, do not include them in the study. We can put them on the rate and assign them to the Web Portal, but their data will not be analyzed as part of the analysis. This will eliminate a small bias in the other technology groups resulting from the inclusion of slightly more customers without central AC.

- Call more events across a wider variety of days. Develop a plan to call events so that they are called on with a wide range of temperatures.

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