REPORT

Peak Time Savings Direct Load Control Pilot

Measurement & Verification Report

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Prepared for
ComEd

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1 Executive Summary

Beginning in fall 2014, Commonwealth Edison Company (ComEd) customers could enroll in a new demand response (DR) program called Peak Time Savings (PTS). PTS is available to all residential customers with smart meters. Under the PTS program, consumers can receive bill credits if they reduce their electricity demand during PTS Event Hours, which were expected to occur on hot summer afternoons between 11 AM and 7 PM. Customers are notified the day of a curtailment event, typically early in the morning but no later than 30 minutes prior to the start of the event period. Credits are based on the difference between a customer's electricity use during PTS Event Hours and a customer's baseline load (CBL) for those same hours. The credit equals $1.00 for each kWh reduced. Approximately 58,000 customers were enrolled in the PTS program for the summer of 2015.

An important issue that arose during the regulatory proceeding leading up to authorization of the PTS program was whether ComEd should offer consumers enabling technology, either for free or on a subsidized basis, that would automate reductions in air conditioning (AC) use during PTS Event Hours. The Illinois Commerce Commission (ICC) concluded during that proceeding that there was insufficient evidence to make a decision about enabling technology and directed ComEd to design and implement a Direct Load Control (DLC) pilot to determine whether offering certain enabling technology in conjunction with the PTS program would be cost effective. This report was a requirement of the DLC pilot established by the ICC.

ComEd's PTS/DLC pilot program was implemented during the summer of 2015. The purpose of the pilot is to determine whether offering enabling technology increased PTS enrollment rates, whether the offer of technology increased customer satisfaction, whether the presence of enabling technology increased the load reductions for PTS participants, and whether the incremental benefits of the technology offset its costs.

1.1 Pilot Design

The PTS/DLC pilot segmented residential customers with smart meters into two groups consisting of single family and multifamily customers. Single family customers with smart meters were randomly divided into three groups. One group received an offer to enroll in the PTS program with no enabling technology, a second group was offered an AC switch, and a third group was offered a programmable communicating thermostat (PCT). Customers included in the pilot program are the customers that accepted the PTS program enrollment offer, have central AC, and enrolled in the PTS/DLC pilot program. Installation of the AC switch and the thermostat was free to participants and there was no cost to customers for the AC switch. ComEd offered three PCT options that had different functionality and different costs to participants. Customers were given an instant rebate of $100, resulting in one option being free; a second option with greater functionality had a cost to participants of $60; and the third option with even more functionality cost $145. 83% of customers chose the free option, 15% of customers chose the $60 option, and only 2% of customers selected the $145 option.

Multifamily customers with smart meters were randomly divided into two groups. PTS was marketed to one group with no offer of technology and the second group received the offer of a plug-in load control device for window AC. Customers included in the pilot program are the customers that accepted the PTS program enrollment offer, have window AC, and enrolled in

the PTS DLC pilot program. Participants who had more than one window AC received multiple devices. Initially, professional installation and customer education were offered to all those accepting the plug in device but arranging for installation became problematic. In the interest of time, devices were mailed to customers who were asked to plug them in and initiate connection to the internet, which is how device communication for load control was conducted.

Table 1-1 summarizes the treatment groups included in the pilot and also indicates the number of participants that were enrolled and, where pertinent, had the enabling technology successfully installed.

Table 1-1: Treatment Groups for DLC Pilot

Customer Segment	Group	Enrollment Offer / Enabling Technology Offer
Single Family Customers with Central AC	Group 1	**Single Family Customers (SF) with Central AC and PTS Only:** Customers enrolled in PTS without the offer of enabling technology who receive event notification by phone, text message, or email (973 customers)
	Group 2	**SF with PTS + Central AC Cycling Switch:** Customers who enrolled in PTS and accepted the offer of an AC load control device and had the device successfully installed – the device cycles at 50% (up to 15 min every half hour) during PTS Event Hours, using an adaptive algorithm (710 customers)
	Group 3	**SF with PTS and Central AC + Wi-Fi-enabled PCT:** Customers who enrolled in PTS and accepted the offer of and had successful installation of a PCT that reduces operation of central AC during PTS events. The PCT was operated as a cycling device during PTS Event Hours, rather than using temperature setback as a way of reducing usage. (270 customers)
Multifamily Customers with Window AC	Group 4	**Multifamily Customers (MF) with Window AC and PTS Only:** Customers that enrolled in PTS and that were not offered an enabling technology and who receive notification via phone, text message, or email (628 customers)
	Group 5	**MF with PTS + Plug-in Wi-Fi outlet with remote thermostat for Window AC units:** Customers that enrolled in PTS and were offered a plug-in device to reduce operation of window AC during PTS Event Hours (92 customers)

To estimate load impacts for each of the five groups summarized in Table 1-1, participants in each group were divided randomly into two sub-groups (A and B) except for Group 2, which was

divided into three sub-groups (A, B and C). For each PTS event, either Sub-Group A or Sub-Group B was notified of an event and, for those with technology, had their AC cycled. The other group was not notified and did not have their AC cycled. The A and B groups had an equal number of events during which they were notified and cycled. Load impacts during PTS Event Hours were calculated as the difference in load between the notified/cycled group and the group that was not notified/cycled. This is referred to as a randomized control trial (RCT) research design and ensures that the estimated impacts are unbiased by selection effects and are caused by the treatment being studied. The difference between Sub-Groups A and B equals the total impact of the enabling technology plus reductions due to behavior changes that customers might make, such as shifting laundry or dishwashing to hours outside the event period. Sub-Group 2C was called for all events. A comparison between Sub-Group 2C load and load for Sub-Group 2A or 2B, whichever was notified/controlled for an event, measures the incremental effect of the enabling technology over and above any behavioral changes that customers might make to curtail usage.

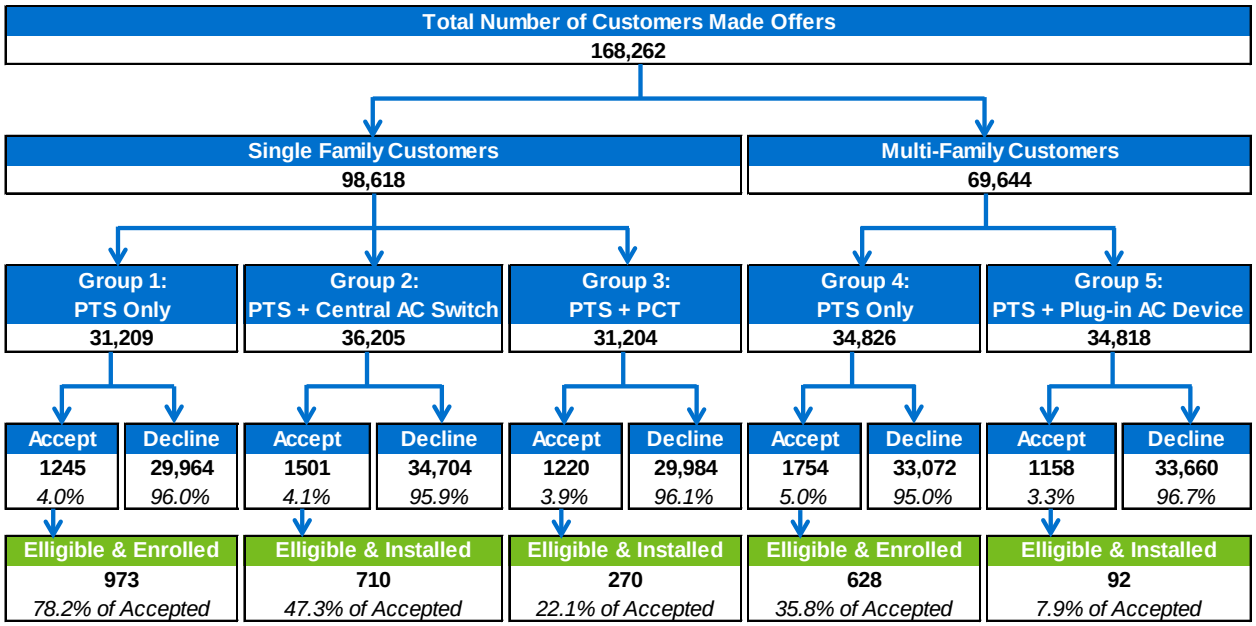
1.2 Customer Enrollment

Figure 1-1 summarizes the number of offers made and the acceptance rate for each of the five treatment groups included in the pilot. Across the five groups, the average acceptance rate was 4.1%. Customer offer acceptance is defined as any customer, regardless of actual pilot eligibility, who received an offer and responded to ComEd expressing interest in participating in the pilot. Pilot enrollment is defined as a customer who met the eligibility criteria for the pilot; completed the pilot registration process; installed the enabling technology device, if applicable; and was assigned to a treatment group. There is a significant difference between acceptance and enrollment rates. Customers accepting the offers were included in the determination of acceptance rates even if it was later determined that they were not eligible for the pilot, which required ownership of either central or window AC, depending on the groups, and whether or not those who were offered the technology wanted it.

A comparison of acceptance rates across the treatment groups indicates the extent to which the offer of free or subsidized technology impacted enrollment in the PTS program. Ultimately, the offer of an enabling technology did not increase acceptance rates for any of the treatment groups. There was no difference in overall acceptance rates with or without technology for single family customers, regardless of whether the offer was an AC switch or a PCT. For multifamily customers, the offer of technology actually resulted in a lower overall acceptance rate of 3.3% compared to an acceptance rate of 5% from the customers offered PTS without any enabling technology. The 1.7% difference is highly statistically significant based of a two sample test for differences in proportions[1].

[1] The resulting 95% confidence interval for customers offered PTS without any enabling technology is 5% +/- 0.2%; the 95% confidence interval for customers offered PTR with enabling technology is 3.3% +/- 0.18%.

Figure 1-1: Summary of Offer Acceptance Rates



1.3 Load Impacts

Over the course of the summer of 2015, six events were called, with the first event held on July 23 and the last one held on September 2. Figure 1-2 summarizes the hours when each event occurred and shows which groups were called for each event. The hours from 1 to 3 PM were common across all 6 events. 5 of the 6 events included the hour from noon to 1 PM and 3 of the 6 events included the hour from 3 to 4 PM. The variation in hours resulted in 4 of 6 events being 3 hours long and the other 2 events being 4 hours long. All customers, regardless of installed technology, received event notifications via their channel of preference – any combination of email, text, or phone – the day of the event, typically around 10 AM.

Figure 1-2: Summary of Event Dates, Sub-Group, and Dispatch Hours

Event Date	Sub-Group	Hours	Hour Ending			
			13	14	15	16
7/23/2015	A + C	12pm-4pm				
8/13/2015	A + C	12pm-3pm				
9/1/2015	A + C	12pm-3pm				
7/24/2015	B + C	12pm-4pm				
7/31/2015	B + C	1pm-4pm				
9/2/2015	B + C	12pm-3pm				

Table 1-2 summarizes the average load reductions obtained across the six events for each treatment. Both single and multifamily customers with no enabling technology reduced loads on average by roughly 9%. However, loads, and therefore load reductions, were more than three times larger for single family customers than for multifamily customers. The load impacts reflect customers that have central AC in the case of the single family segment and window AC for the multifamily segment. As such, they may not be representative of the impacts that are obtained by the general PTS participant outside the pilot, because some of the PTS participants have central and/or window AC and some do not.[2]

The load reduction for Group 2, unfortunately, does not reflect the impact of the AC switch. A failure occurred where none of the installed switches acted upon the receipt of the load control signal. Surprising, there was still a 7% load reduction from customers who took action outside of the AC switch to achieve load reductions through other means. This impact is similar in magnitude to the non-technology enabled group, indicating that customers who opted into the AC switch enabling technology don't provide larger impacts than those who didn't elect to install the enabling technology.

The load reduction for Group 3, which had a PCT that cycled the central AC, had an average load reduction of almost 24% and an absolute load reduction of 0.51 kW per participant, which is more than 3 times larger than Group 2 and about 2.8 times larger than Group 1. Groups 1, 2 and 3 may have different selection effects associated with program enrollment, because Group 1 was not offered a control device and Groups 2 and 3 were offered different types of devices, with Group 3 requiring replacement of an existing thermostat. A comparison of the loads of the three groups on hot summer days when events did not occur shows that, during the hours when events are typically called, loads for the three groups were quite similar. Outside the typical event hours, loads for Group 3 were higher in the late afternoon and evening hours. Given the similarity in loads across the three groups, it is safe to assume that the majority of the difference in load reductions between Groups 1 and 2 and Group 3 is due to the enabling technology. Put another way, it is reasonable to assume that the enabling technology, whether a switch or a PCT, increases load reductions by 2.5 to 3 times compared with single family customers with central AC that do not have the enabling technology.

Table 1-2: Average Load Reduction per Customer across All Event Hours

Customer Segment	Treatment Group	Load w/o DR (kW)	Load w/ DR (kW)	Impact (kW)	Impact (%)
Single Family Customers w/ central AC	1: PTS Only	2.060	1.877	0.183	8.9%
	2: PTS + AC Switch	2.155	2.004	0.151	7.0%
	3: PTS + PCT	2.135	1.625	0.511	23.9%
Multifamily Customers w/ Window AC	4: PTS Only	0.604	0.552	0.052	8.6%
	5: PTS + Plug-in AC Device	0.752	0.602	0.150	20.0%

[2] The load impacts of all PTS program participants for the summer 2015 are being analyzed and will be included in an evaluation report submitted to the ICC by September 1, 2016.

In percentage terms, the average load reduction for multifamily customers with window AC, i.e., Group 4, is similar to single family customers with central AC, i.e., Group 1, but is quite small, 0.05 kW per participant. Adding plug-in load control devices nearly triples the absolute load reduction and more than doubles it in percentage terms.

1.4 Cost Effectiveness Analysis

Table 1-3 summarizes the cost-effectiveness results for various DLC technology options and compares them to DLC eligible customers without technology. Nexant's analysis indicates that DLC technology options are not currently cost-effective to offer to PTS customers based on current costs, benefits, demand reductions, and recruitment practices.

Table 1-3: Cost-effectiveness of Customer-technology Combinations

Cost-effectiveness Perspective	Metric	Per Household 15 Year NPV			
		Marginal Benefits	Marginal Cost	Net Benefits	Benefit/Cost Ratio
Total Resource Cost Test	Single Family PTS only w/ AC	$78.09	$37.17	$40.92	2.10
	Single Family PTS w/ AC + AC switch	$219.65	$239.21	($19.56)	0.92
	Single Family PTS w/ AC + Thermostat	$219.65	$470.65	($251.00)	0.47
	MF PTS only w/ Room AC	$22.01	$37.17	($15.16)	0.59
	MF PTS + Room AC modlet - self-install	$65.60	$539.77	($474.17)	0.12
	MF PTS + Room AC modlet - professional install	$65.60	$653.04	($587.44)	0.10
Utility Cost Test	Single Family PTS only w/ AC	$78.09	$52.88	$25.20	1.48
	Single Family PTS w/ AC + AC switch	$219.65	$283.42	($63.77)	0.78
	Single Family PTS w/ AC + Thermostat	$219.65	$514.86	($295.21)	0.43
	MF PTS only w/ Room AC	$22.01	$41.60	($19.59)	0.53
	MF PTS + Room AC modlet - self-install	$65.60	$552.98	($487.38)	0.12
	MF PTS + Room AC modlet - professional install	$65.60	$666.24	($600.64)	0.10

2 Overview of Pilot Design and Implementation

ComEd's PTS program is an opt-in program for customers with smart meters who take service under Rider PTR – Peak Time Rebate (Rider PTR). Under the PTS program, participating residential customers receive bill credits for reductions in electricity use during PTS Event Hours, which typically occur on hot summer afternoons between 11 AM and 7 PM. Participants are notified the day of a curtailment event, typically early in the morning but no later than 30 minutes prior to the event period. Electricity usage reductions are measured by comparing actual usage during a curtailment period to estimated usage determined using a customer baseline load (CBL) methodology. The credit equals $1.00 per kWh for each kWh reduced during the curtailment period. The credits provided to PTS customers are fully funded through ComEd's bidding of PTS resources into the capacity and energy markets of PJM International, L.L.C. (PJM), with the vast majority of compensation coming from PJM's capacity market.

On February 21, 2013, the Commission entered an Interim Order in Docket No. 12-0484 (Interim Order) directing ComEd to investigate through a pilot whether load control (DLC) technology should be provided to all qualifying PTR participants to automate load reductions during PTS events. Specifically, the Commission order asked that the pilot be designed to answer the following questions:

(1) how much energy is curtailed with or without DLC technology;
(2) how much demand response ComEd is able to bid into PJM with or without DLC technology;
(3) how much revenue would be received from PJM with or without DLC technology;
(4) what would the level of customer satisfaction be with or without DLC technology; and
(5) what would the cost of PTS be with or without DLC technology.

This report documents the design and evaluation of the pilot, which was conducted during the summer of 2015. The remainder of this section discusses the pilot design and implementation process. Section 3 documents the customer acceptance rates for each treatment and answers the question of whether the offer of enabling technology increases customer enrollment. It also provides a brief summary of a satisfaction survey that was done by another firm. Section 4 presents peak-period load impacts for PTS participants with and without enabling technology and Section 5 addresses the issue of whether it is cost effective to offer enabling technology to PTS participants.

2.1 Pilot Design

As discussed above, the primary objectives of the PTS DLC pilot are to determine whether offering enabling technology increased PTS enrollment rates, whether the presence of enabling technology increased load reductions for PTS participants, whether the incremental benefits of the technology offset its costs, and whether the offer of technology increased customer satisfaction.

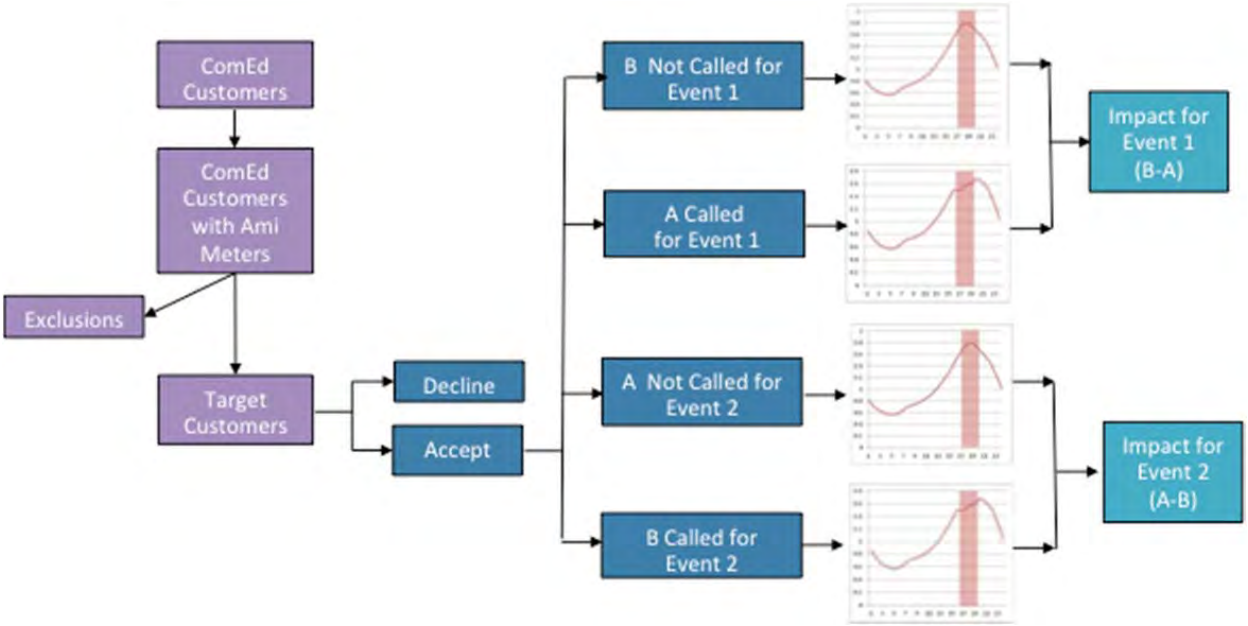
Determining whether the offer of technology impacts acceptance rates is relatively straightforward. For a single technology, this objective can be met by randomly placing all customers with smart meters in two groups and marketing the PTS program to one group with no offer of technology and the other with the offer of technology and comparing the acceptance

rates for the two groups. This comparison can be made for the two groups as a whole and also for the subset of customers in each group that have AC and are eligible to receive the technology, because not all customers have AC.

Designing a pilot to estimate the incremental load impact associated with load control technology is more challenging. A minimum objective for any pilot is internal validity. An internally valid load impact estimate in the context of the DLC pilot is one for which there is no plausible explanation for any observed difference in usage for PTS participants who are and are not provided with enabling technology other than the equipment itself. Comparing loads for individual customers before and after they enroll in the program is not valid because there are many reasons besides enrollment that might cause changes in load over time, such as differences in weather or economic conditions. Comparing load for customers who accept the technology offer with those that turn it down or who are not offered the technology is not valid because those who accept it may have different load patterns prior to enrolling from those who don't. For example, those who accept the load control technology might have lower AC usage than those who don't. If so, estimating load impacts by comparing loads for participants with and without the technology could produce a biased estimate because of these self-selection effects.

RCT designs are designed to ensure that treatment and control customers are identical in every way except for the fact that one group is exposed to the treatment and the other is not. For many treatments of interest in the electricity industry, such as time of use rates and energy efficiency measures, once a customer enrolls, the treatment is in effect all the time. In these cases, an RCT design requires recruiting customers and then denying or delaying the treatment to half of those who agree to enroll. When a treatment of interest is not in effect on all event days, as is the case for PTS participants with or without load control technology, it is possible to use an RCT design without denying enrollment to anyone. This is done by randomly assigning enrolled PTS customers to two groups and alternating event days across the groups. We refer to this as an event-based RCT design and it is the approach that was used in the PTS/DLC pilot. Figure 2-1: Event-based RCT Design & Evaluation provides an illustrative overview of the design and evaluation of a generic event- based RCT.

Figure 2-1: Event-based RCT Design & Evaluation



The PTS/DLC pilot segmented residential customers with smart meters in two groups consisting of single family and multifamily customers. Roughly 65% of ComEd's residential population is comprised of single family customers and about 87% of these customers have central AC. Single family customers with smart meters were randomly divided into three groups. One group received an offer to enroll in the PTS program with no enabling technology, a second group was offered an AC switch, and a third group was offered a PCT. Installation of the AC switch and the PCT was free to participants and there was no cost to customers for the AC switch. ComEd offered three PCT options that had different functionality and different costs to participants – a $100 instant rebate was given to customers, resulting in one option being free; a second option with greater functionality had a cost to participants of $60; and the third option had even more functionality and a cost of $145. 83% of customers chose the free option, 15% of customers chose the $60 option, and only 2% of customers selected the $145 option.

The multifamily customer segment was divided into two groups. PTS was marketed to one group with no offer of technology and the second group received the offer of a plug-in load control device for window AC. More than half of all multi-family dwellings have window AC units. Participants who had more than one window AC could receive multiple devices. Initially, professional installation and customer education was offered to all those accepting the technology but arranging for installation became problematic. In the interest of time, devices were mailed to customers who were asked to plug them in and initiate connection to the internet, which is how device communication for load control was conducted.

Table 2-1 summarizes the five treatment groups included in the pilot.

Table 2-1: Treatment Groups for DLC Pilot

Customer Segment	Group	Enrollment Offer / Enabling Technology Offer
Single Family Customers with Central AC	Group 1	**Single Family Customers (SF) with Central AC and PTS Only:** Customers enrolled in PTS without the offer of enabling technology who receive event notification by phone, text message, or email.
	Group 2	**SF with PTS + Central AC Cycling Switch:** Customers who enrolled in PTS and accepted the offer of an AC load control device and had the device successfully installed – the device cycles at 50% (up to 15 min every half hour) during PTS Event Hours, using an adaptive algorithm.
	Group 3	**SF with PTS and Central AC + Wi-Fi-enabled PCT:** Customers who enrolled in PTS and accepted the offer of and had successful installation of a PCT that reduces operation of central AC during PTS events. The PCT was operated as a cycling device during PTS Event Hours, rather than using temperature setback as a way of reducing usage. Customers could choose from among three PCT offers with varying functionality and prices. The lowest cost PCT was free to customers and the prices for the other two were $60 and $145. Most customers took the free PCT.
Multifamily Customers with Window AC	Group 4	**Multifamily Customers (MF) with Window AC and PTS Only:** Customers that enrolled in PTS and that were not offered an enabling technology and who receive notification via phone, text message, or email
	Group 5	**MF with PTS + Plug-in Wi-Fi outlet with remote thermostat for Window AC units:** Customers that enrolled in PTS and were offered a plug-in device to reduce operation of window AC during PTS Event Hours

To estimate load impacts for each of the five groups summarized in Table 2-1, participants in each group were divided randomly into two groups (A and B) except for Group 2, which was divided into three sub-groups (A, B and C). For each PTS event, either Sub-Group A or Sub-Group B was notified of an event and, for those with technology, had their AC cycled. The other group was not notified and did not have their AC cycled. The Sub-Groups A and B had an equal number of events during which they were notified and cycled. Load impacts during PTS Event Hours were calculated as the difference in load between the notified/cycled sub-group and the sub-group that was not notified/cycled. This is referred to as a RCT research design and ensures that the estimated impacts are unbiased by selection effects and are caused by the treatment being studied. The difference between Sub-Groups A and B equals the total impact of the enabling technology plus reductions due to behavior changes that customers might make,

such as shifting laundry or dishwashing to hours outside the event period. Sub-Group 2C was called for all events. A comparison between Sub-Group 2C load and load for Sub-Group 2A or 2B, whichever was notified/controlled for an event, measures the incremental effect of the enabling technology over and above any behavioral changes that customers might make to curtail usage.

Figure 2-2 and Figure 2-3 provide a schematic overview of the pilot design and evaluation approach for the single and multifamily segments.

Figure 2-2: Pilot Design for Single Family Central AC

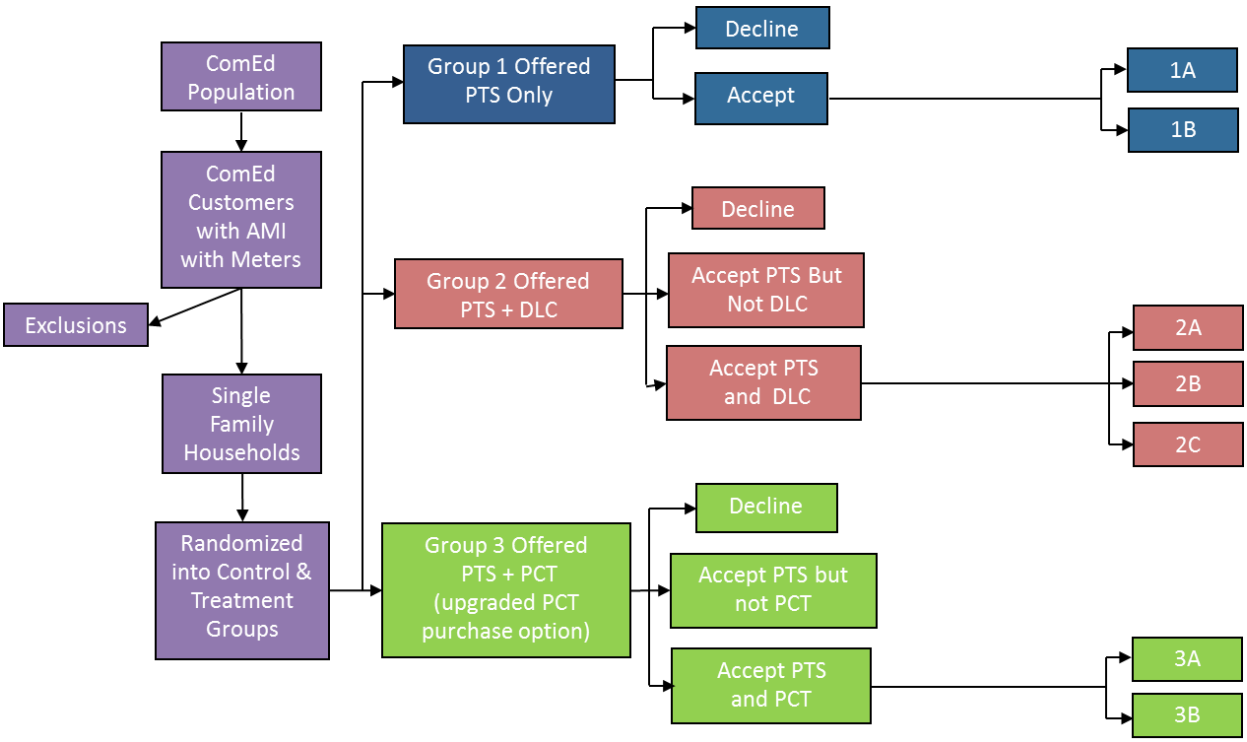
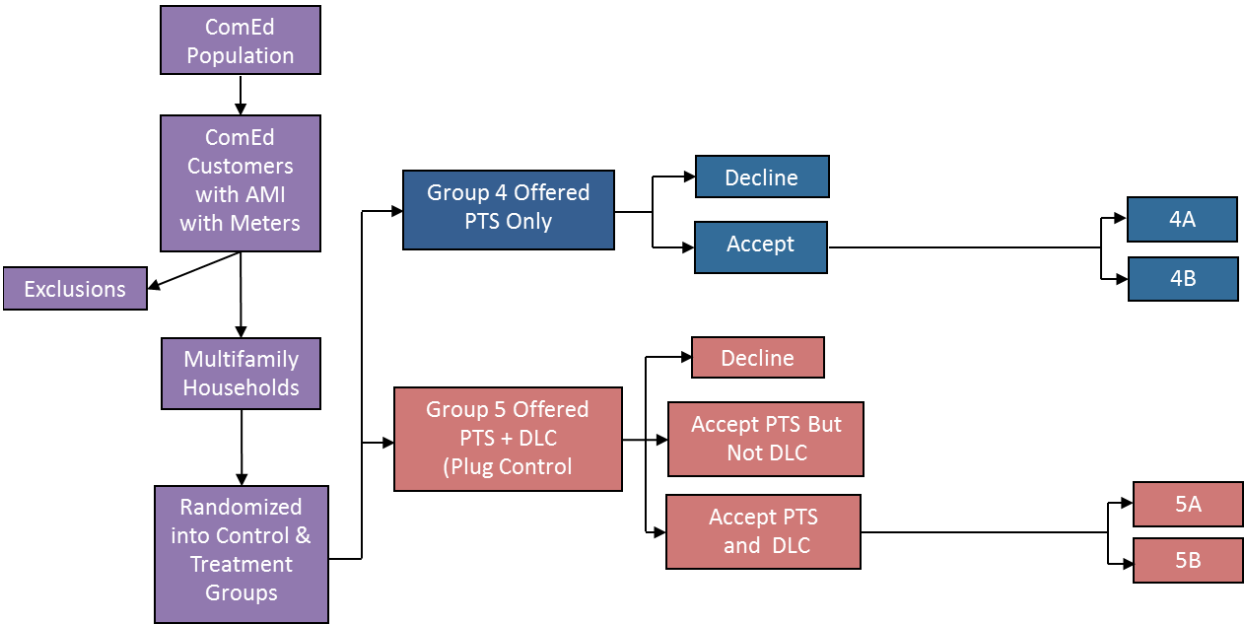


Figure 2-3: Pilot Design for Multifamily Window AC



The initial pilot design targeted an enrollment of 500 customers in each of the 11 treatment groups spanning the segments, technologies and A/B/C sub-groups. ComEd used direct mail as the primary marketing channel and employed multiple waves of marketing. A more detailed discussion of the marketing effort is contained in Section 2.2.1. For various reasons that are explained more fully in subsequent sections, actual enrollment fell well short of the goal. Table 2-2 summarizes the number of enrolled customers with installed technology (for appropriate treatment cells). It should be noted that many more customers accepted the offer than were ultimately enrolled. The biggest cause of the difference between acceptance and enrollment was lack of eligibility. This was especially true in the multifamily sector, where many respondents did not have window AC and/or a Wi-Fi connection that could be used. There were also a number of installation failures on site. Finally, it should be noted that all customers counted in Table 2-2, including in the PTS only cells, have central AC for single family customers and window AC for multifamily customers.

Table 2-2: Summary of Final Enrollment in Each Test Cell

Customer Segment	Group	Enrollment Offer / Enabling Technology Offer	Event Sub-Groups		
			Sub-Group A	Sub-Group B	Sub-Group C
Single Family Customers with Central AC	Group 1	Peak Time Savings + None	471	502	
	Group 2	Peak Time Savings + Device for Central AC	234	211	265
	Group 3	Peak Time Savings + PCT (Honeywell)	135	135	
Multifamily Customers with Window AC	Group 4	Peak Time Savings + None	310	318	
	Group 5	Peak Time Savings + Plug-in AC Device (ThinkEco Smart AC Kit)	44	48	

2.2 Pilot Implementation

This section summarizes the marketing procedures used to recruit customers, provides more detail about the technologies offered, and discusses some of the implementation challenges that arose during the pilot.

2.2.1 Summary of Marketing Materials

Participants were recruited into the PTS/DLC pilot primarily through direct mail. All potential participants received recruitment letters, brochures and back-up materials providing program information such as PTS Event Hours, when and how PTS periods are announced, eligibility criteria and the offer code and website for the respective treatment group, how to enroll, and incentives. Different groups were directed to different websites as enrollment was managed by different outside contractors. Figure 2-4 through Figure 2-7 contain examples of some of the key marketing material. Additional examples are contained in Appendix A.

Figure 2-4: Example of Recruitment Letter

Account Number: 285 632 115

ComEd
An Exelon Company

Sample A. Sample
1234 Main Street
Apt. 123
Your Town, IL 12345-6789

LOOK WHAT YOUR HOME'S SMART METE CAN DO FOR YOU

INTRODUCING THE PEAK TIME SAVINGS PROGRAM

Earn during the hottest days of summer.

Dear Sample A. Sample:

Because a smart meter has been installed at your home, you are eligible to enroll in ComEd's new Peak Time Savings program that pays you back for using less electricity. ComEd will credit your electric bill when you reduce your electricity use during Peak Time Savings Hours.

- ComEd will announce Peak Time Savings Hours on days when electricity is most in demand – as early as 9 a.m. or at least 30 minutes prior to the start. Peak Time Savings Hours will typically occur for a few hours between 11 a.m. and 7 p.m. on three to five days during the summer.
- Reduce your electricity use during Peak Time Savings Hours and you'll earn a credit which will appear on your electric bill as actual dollars off the total amount due.
- Enrollment is now open for the 2015 summer season. There's no cost to enroll and no penalty if you enroll and don't participate.

To enroll simply visit ComEd.com/EarnCredits and enter offer code Peak2 or call 844-275-2500. You'll earn a credit on your bill plus save on energy costs.

Sincerely,

Val Jensen, senior vice president, Customer Operations

P.S. See the enclosed Optional Technology insert for a more convenient way to automatically save during Peak Time Savings Hours.

ENROLL TODAY. There's no cost to enroll and no penalty if you enroll and don't participate.

REDUCE your electricity use during Peak Time Savings Hours.

EARN a credit which will appear on your electric bill as actual dollars off the total amount.

ENROLL NOW in Peak Time Savings for the 2015 season.

ONLINE
Visit ComEd.com/EarnCredits
Offer code: Peak2

PHONE
Call 844-275-2500

HAVE YOUR ACCOUNT NUMBER HANDY.
285 632 115

ComEd. An Exelon Company powering lives

© Commonwealth Edison Company, 2014

Figure 2-5: Example of Technology Insert

PEAK TIME SAVINGS OPTIONAL TECHNOLOGY

NEVER MISS A SAVINGS OPPORTUNITY

Save conveniently and automatically with optional technology.

ComEd. An Exelon Company powering lives

PEAK TIME SAVINGS + TECHNOLOGY

A more convenient way to save energy.

If you live in a single-family home with a working central air conditioner and Wi-Fi, you can take advantage of an additional Peak Time Savings opportunity.

- During Peak Time Savings Hours, ComEd will wirelessly adjust your air conditioner through a Wi-Fi-enabled thermostat device.
- A Honeywell programmable thermostat will be provided and installed by an authorized ComEd contractor at no cost to you. Ask about a thermostat upgrade option when you enroll.
- ComEd will send a signal to the thermostat to raise the temperature by a few degrees when Peak Time Savings Hours occur so you never miss a savings opportunity. You can choose to run the fan on your air conditioner to continue to circulate cool air.
- If you choose not to participate on that day, you can override the ComEd signal by simply changing the setting on your thermostat. You can always participate next time. You are always in control.

Enroll today and arrange for your free installation.

ComEd.com/PeakCredit | 844-275-2500

IPCT

Figure 2-6: Example of Recruitment Brochure

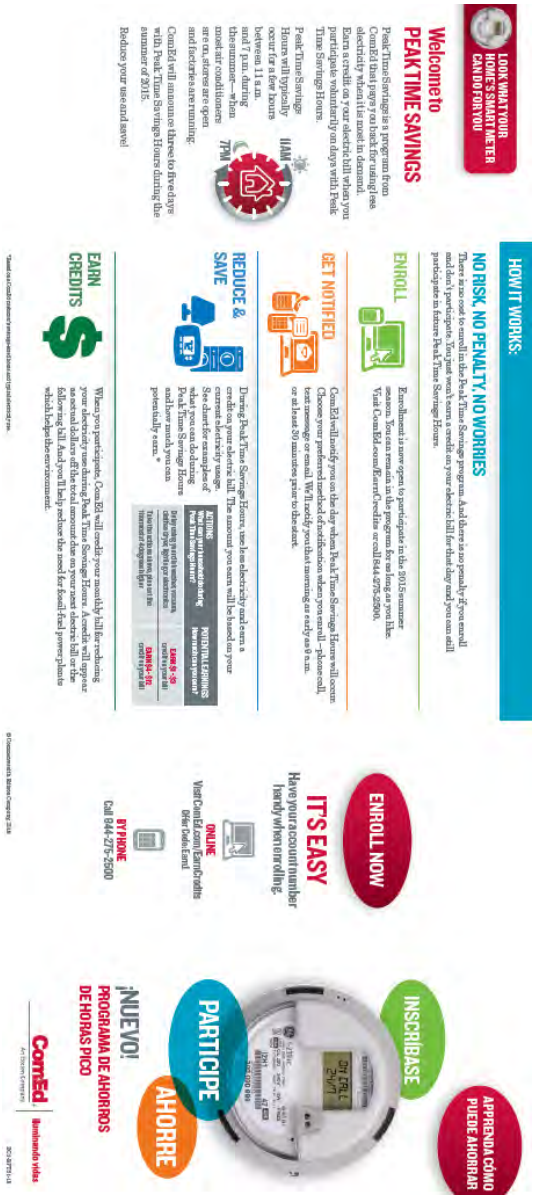
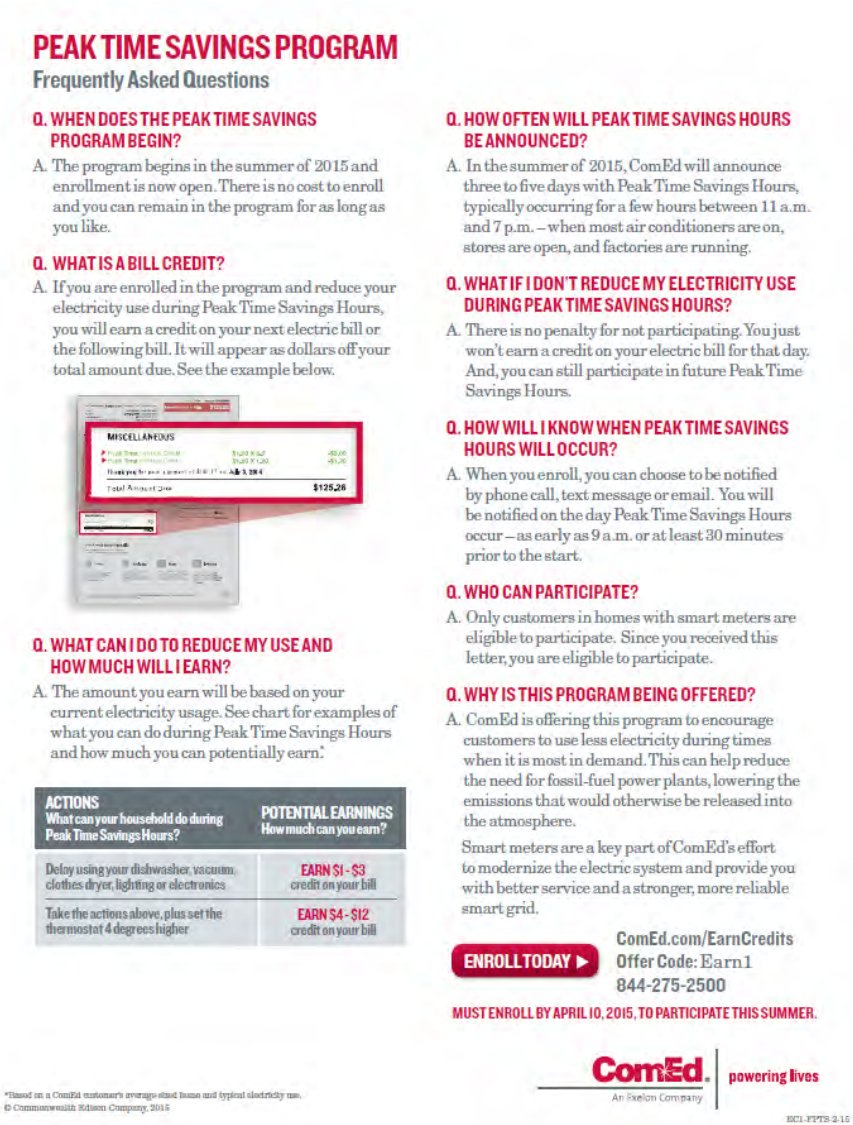


Figure 2-7: Example of FAQ



PEAK TIME SAVINGS PROGRAM

Frequently Asked Questions

Q. WHEN DOES THE PEAK TIME SAVINGS PROGRAM BEGIN?

A. The program begins in the summer of 2015 and enrollment is now open. There is no cost to enroll and you can remain in the program for as long as you like.

Q. WHAT IS A BILL CREDIT?

A. If you are enrolled in the program and reduce your electricity use during Peak Time Savings Hours, you will earn a credit on your next electric bill or the following bill. It will appear as dollars off your total amount due. See the example below.

MISCELLANEOUS

Total Amount due $125.26

Q. WHAT CAN I DO TO REDUCE MY USE AND HOW MUCH WILL I EARN?

A. The amount you earn will be based on your current electricity usage. See chart for examples of what you can do during Peak Time Savings Hours and how much you can potentially earn.*

ACTIONS What can your household do during Peak Time Savings Hours?	POTENTIAL EARNINGS How much can you earn?
Delay using your dishwasher, vacuum, clothes dryer, lighting or electronics	EARN $1 - $3 credit on your bill
Take the actions above, plus set the thermostat 4 degrees higher	EARN $4 - $12 credit on your bill

*Based on a ComEd customer's average-sized home and typical electricity use.
© Commonwealth Edison Company, 2015

Q. HOW OFTEN WILL PEAK TIME SAVINGS HOURS BE ANNOUNCED?

A. In the summer of 2015, ComEd will announce three to five days with Peak Time Savings Hours, typically occurring for a few hours between 11 a.m. and 7 p.m. – when most air conditioners are on, stores are open, and factories are running.

Q. WHAT IF I DON'T REDUCE MY ELECTRICITY USE DURING PEAK TIME SAVINGS HOURS?

A. There is no penalty for not participating. You just won't earn a credit on your electric bill for that day. And, you can still participate in future Peak Time Savings Hours.

Q. HOW WILL I KNOW WHEN PEAK TIME SAVINGS HOURS WILL OCCUR?

A. When you enroll, you can choose to be notified by phone call, text message or email. You will be notified on the day Peak Time Savings Hours occur – as early as 9 a.m. or at least 30 minutes prior to the start.

Q. WHO CAN PARTICIPATE?

A. Only customers in homes with smart meters are eligible to participate. Since you received this letter, you are eligible to participate.

Q. WHY IS THIS PROGRAM BEING OFFERED?

A. ComEd is offering this program to encourage customers to use less electricity during times when it is most in demand. This can help reduce the need for fossil-fuel power plants, lowering the emissions that would otherwise be released into the atmosphere.

Smart meters are a key part of ComEd's effort to modernize the electric system and provide you with better service and a stronger, more reliable smart grid.

ENROLL TODAY ▶ ComEd.com/EarnCredits
Offer Code: Earn1
844-275-2500

MUST ENROLL BY APRIL 10, 2015, TO PARTICIPATE THIS SUMMER.

ComEd. An Exelon Company | powering lives

EC1-FPTS-2-15

Table 2-3 summarizes the schedule of the marketing waves. The original marketing plan called for sending 50,000 direct mail pieces; 10,000 to each of the five treatment groups. Ultimately, ComEd ended up sending approximately 165,000 direct mail pieces after noticing lower than expected acceptance rates in waves one and two. Seven marketing waves were completed via direct mail. Wave seven was a re-mail for customers from Groups 2-5 who didn't initially respond. Due to low acceptance rates, additional email marketing campaigns were also used to supplement the direct mail campaign for Groups 3, 4, and 5—marketing waves eight and nine. Wave eight targeted multifamily customers via email to encourage enrollment in the pilot. Wave nine specifically targeted potential participants from Group 3 who had not yet created an Opower account; or who had created an Opower account, but not yet completed all of the necessary steps in the Opower portal to receive the PCT.

Table 2-3: DLC Pilot Marketing Wave Schedule

Production Schedule			
Wave	**Date**	**Treatment Group**	**Type**
1	10/22/2014 – 10/24/2014 12/8/2014	1,2,4,5 3	Direct Mail
2	11/10/2014 – 11/12/2014 1/5/2015	1,2,4,5 3	Direct Mail
3	1/19/2015 – 1/21/2015	1-5	Direct Mail
4	1/19/2015 – 1/21/2015	1-5	Direct Mail
5	2/18/2015 – 2/20/2015	1-5	Direct Mail
6	3/02/2015 – 3/04/2015	1-5	Direct Mail
7	3/27/2015 – 3/30/2015	2-5	Direct Mail
8	4/23/2015	4 & 5	Email
9	4/23/2015 – 4/28/2015	3	Email

2.2.2 Overview of Technologies Deployed

Three main technologies were deployed during the pilot.

Single Family Central AC Device (Group 2)

A single family central AC device is a device that is connected directly to the central AC unit. The device is able to connect directly to ComEd's paging network. Once the device is connected to the paging network, during PTS curtailment events, the device will receive a signal from the utility and the AC unit will be controlled. The devices were programmed to cycle the AC off for 50% of the time during an event.

Customers are able to over-ride the direct control process.

Figure 2-8: Comverge Central AC Switch

Single Family PCT (Group 3)

A PCT automates the heating, ventilation, and AC (HVAC) equipment. Customers can program the PCT to heat and cool to specific temperatures at specific times of the day. The PCT connects to the Internet through a Wi-Fi connection and can receive signals from the utility or customer to raise or lower temperature during curtailment events. The PCTs were programmed to effectively cycle the AC off for 50% of the time during events to provide load reductions similar to the AC switches listed above. Customers were offered three PCT options; one free version, and two upgraded devices at an additional cost.

Honeywell FocusPro- 228 customers (83%) opted for the free version: A Wi-Fi enabled 7-Day PCT; allowing customers to choose 7-day (with separate programming for each day) or non-programmable settings; automatically change from heating to cooling; and allows for remote access from anywhere using a computer, tablet, or smartphone.

Figure 2-9: Honeywell FocusPro

Figure 2-10: Honeywell VisionPro

Honeywell VisionPro- 42 customers (15%) selected the first upgrade option at an additional cost of $60- including additional features such as a touchscreen with a large, easy to read display and a helpful filter change reminder based on actual system runtime.

Honeywell Smart 9000- 4 customers (2%) selected the second upgrade option at an additional cost of $145- with additional features including an easy-to-read customizable color touchscreen, the ability to view the humidity in the home, and a feature to improve air circulation to help regulate the temperature throughout the home.

Figure 2-11: Honeywell Smart 9000

Multifamily Plug-in AC Control Device (Group 5)

The ThinkEco smartAC Kit is a plug-in window AC control device that is placed between the wall outlet and the Plug-in AC unit. With the smartAC kit, customers can set a personalized schedule or control it with a smartphone. The smartAC kit also comes with a thermostat remote sensor, which senses the room temperature and will control the A/C to maintain a comfortable home. The device connects to the Internet via Wi-Fi, 3G, or a gateway. Once the device is connected to the Internet, during PTS curtailment events, the window AC unit will receive a signal from the utility and will be controlled. Customers are able to over-ride the direct control process.

Figure 2-12: ThinkEco smartAC Kit

2.2.3 Installation Challenges and Success Rates

Treatment Groups 2, 3, and 5 each had installations completed by professionals; Group 5 also had the option for a self-installation kit. After a customer expressed interest in the technology offer either online or via the telephone, the installer would contact the customer to gather additional eligibility information and to schedule an installation appointment, as appropriate.

Group 2, the group accepting the AC switch, had the highest equipment installation rate, at 50% of eligible customers who accepted the offer. The primary reason for installations not being completed was customers changing their mind, representing 67% of the incomplete installations. Only about 9% of the incomplete installations were due to technical issues such as an incompatible AC system. A key reason why installation success was high for customers who didn't change their mind was that in many cases installers did not need to go inside the home to complete the installation and in many instances could complete job without having an appointment or the homeowner being home.

Group 3, the PCT group, exhibited the lowest installation completion rate of those accepting the initial offer at 25%. However, it should be noted that the installation data wasn't tracked at a level of detail that allowed for the separation of those customers who didn't have central AC and were thus ineligible to participate in the pilot, versus those who initially accepted the offer and ultimately decided they didn't want the technology. Groups 1 and 2 both had approximately 20%

of the customers without central AC who accepted the offer. If this assumption is applied to Group 3 customers, the number of eligible customers can be reduced to 846, resulting in a higher installation success rate of 32%. Reviewing the actual data, only 3% of the incomplete installations were due to technical issues and 26% were directly attributable to customers changing their minds, leaving nearly 70% of the incomplete installation to those who weren't eligible, or those who changed their minds. When applying the 20% no central AC assumption similarly to above, 5% of installation failures are attributable to technical issues and 95% of the incomplete installations are due to customers ultimately changing their minds. Technical installation issues were classified as a technical turndown, however no further details were provided in the installation data.

Treatment Group 5 had an installation rate of approximately 35% of eligible customers who accepted the offer. However, the 35% installation rate reflects an underlying combination of self-installation and professional installation, each with very different success rates. Some customers were offered professional installation in order to ensure that at least some devices were properly installed for the pilot in case there was a low rate of self-installation. Professional installation completion rates were approximately 79%. Conversely, self-installation rates were only 26%, meaning only one out of every four devices that were shipped to customers was installed. This is fundamentally different from the other treatment groups because, if the other groups have an incomplete installation, the cost of the device is not lost. With Group 5, any customers who were mailed a device for self-installation and never installed it added significantly to program cost without producing any benefits. 90% of the incomplete installations were due to customers changing their mind, or not self-installing the device. Only 10% of the incomplete device installations were due to technical issues. Of these, 8 customers didn't have Wi-Fi, 2 had incompatible window AC units or safety issues, and 7 had issues with their router or hotspot connecting to the device.

Table 2-4 summarizes the installation success rates for each treatment group, and separates out the incomplete installations between those driven by customers changing their mind versus technical installation issues. Ultimately, customers changing their mind about installing the technology far outnumbered any technical installation issues.

Table 2-4: Summary of Installation Success Rates by Treatment Group

Customer Segment	Group	Enrollment Offer / Enabling Technology Offer	Installations Completed		Accepted & Eligible	Reasons for Incomplete Installation					
						Technical Issue		Changed Mind		Unknown	
			Count	%		Count	%	Count	%	Count	%
Single Family Customers with Central AC	Group 2	Peak Time Savings + Device for Central AC	445	50%	897	42	9%	301	67%	109	24%
	Group 3	Peak Time Savings + PCT (Honeywell)	270	25%	1090	28	3%	217	26%	575*	70%
Multifamily Customers with Window AC	Group 5	Peak Time Savings + Plug-in AC Device (ThinkEco Smart AC Kit)	92	35%	264	17	10%	155	90%	0	0%

* Includes mix of ineligible customers (no central AC) and customers who changed their mind; data was not tracked at a level to differentiate

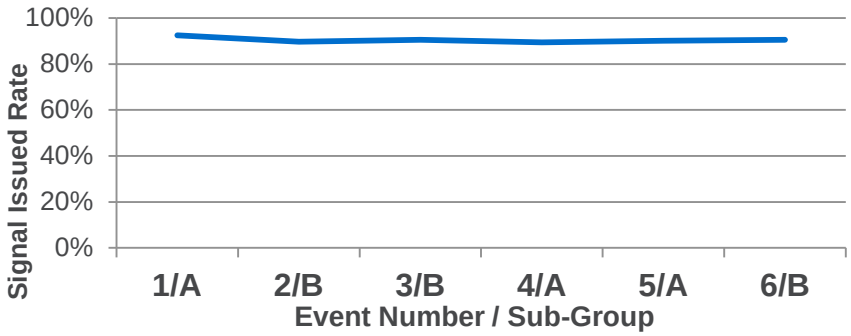
2.2.4 Technical Difficulties and Other Unanticipated Barriers

A number of technical difficulties and unanticipated barriers arose during the pilot. By far the most significant problem arose for Group 2, Sub-Groups A and B. At the end of the pilot, when examining the load data on event days, Nexant discovered that the estimated load impacts for Group 2 were very similar, indeed a bit lower, than for Group 1, which had no enabling technology, and significantly lower than for Group 3, which had PCTs. Upon further investigation by ComEd, it was discovered that none of the AC switches worked for any of the events. In order to guard against such an event, ComEd had set up a test device in the lab, and this device worked correctly during event hours. Unfortunately, the devices in the field did not work. As discussed in Section 4, this prevented estimation of load impacts for single family customers with AC switches.

Both PCTs and plug-in devices for window AC units required a connection to the internet in order to receive event activation signals. During the installation process, each device was required to be registered with the back-office systems, which allowed for an installation confirmation. Device activation success rates for each event were calculated based on the known base of installed devices. The average event completion rates varied significantly by device, with approximately 81% of PCTs completing the average event and 68% of the plug-in devices participating in the average event. Slightly different metrics were tracked for each device type, resulting in some differences in how device performance is reported below. The participation and completion rates were impacted by network connectivity issues and customer overrides during events. Factors contributing to the ultimate completion rates for each device are discussed below.

Figure 2-13 shows the percent of PCTs that were issued an event signal by event. The trend is generally constant across the event season, holding at approximately 90%. The reason why only 90% of the devices with confirmed installations were issued event signals isn't known. It may be that some customers dropped out of the program and un-registered their device from the back-end system before or during the event season. Of the 90% of devices that were issued event signals, 90% of those devices communicated back to confirm receipt of the event signal. This further drop of 10% is attributable to customers with network connectivity issues or customers that intentionally disconnected or blocked their devices from communicating with the back-end system; effectively overriding the events.

Figure 2-13: Percent of PCTs Issued Signal by Event



PCT signal issued rates tend to be constant across the season, and the majority of PCTs tend to either be issued signals for all events (87%), or none (7%) as illustrated in Figure 2-14. Nearly all of the communication failures appear to be tied to devices that did not communicate for any of the events after the initial device installation and networking configuration – in other words, devices that lost their network connection after installation, before the first event, and never got it back.

Figure 2-14: Number of Event Signals Issued per PCT

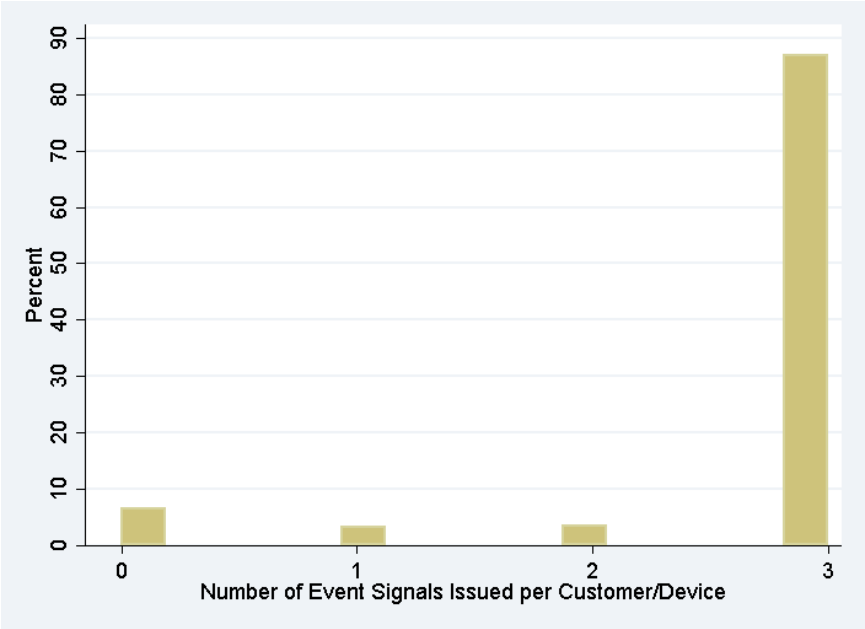


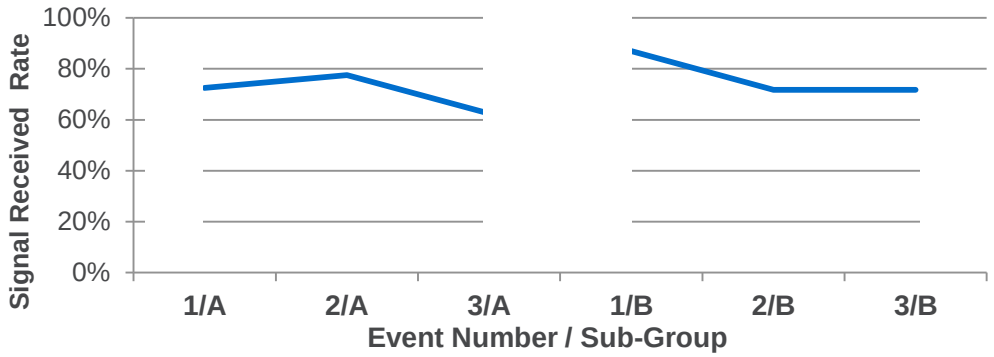
Table 2-5 provides a summary of PCT activation rates by event and for the average event. The key takeaway from this table is that very few customers opted out of events if the event signal was received. In fact, the event completion rate once a PCT received the signal was 99%. Given this high realization rate once a signal is received, it is likely worth further exploration to learn more about the factors that contributed to the 90% signal issued and received rates. If these problems could be overcome, average load impacts would improve.

Table 2-5: PCT Activation Rates by Event

Event Date	Tech Ready (Installed) [1]	Event Signal Issued [2]	Event Signal Received [3]	Event Completed Confirmation [4]	Opt Out	Issued % [2]/[1]	Received % [3]/[2]	Completed % [4]/[1]	Realization Comp/Rec [4]/[3]
7/23/2015	132	122	104	100	0	92.4%	85.2%	75.8%	96.2%
7/24/2015	126	113	109	109	0	89.7%	96.5%	86.5%	100.0%
7/31/2015	126	114	98	97	1	90.5%	86.0%	77.0%	99.0%
8/13/2015	132	118	106	106	0	89.4%	89.8%	80.3%	100.0%
9/1/2015	132	119	111	110	1	90.2%	93.3%	83.3%	99.1%
9/2/2015	127	115	106	106	0	90.6%	92.2%	83.5%	100.0%
Avg. Event	**129.2**	**116.8**	**105.7**	**104.7**	**0.3**	**90.5%**	**90.5%**	**81.0%**	**99.0%**

Figure 2-15 shows the percent of plug-in devices from Group 5 receiving an event signal by event. On average, 74% of the devices received a signal. However, when the signal reception rates are observed sequentially for each sub-group, a slight declining trend across the event season emerges. It isn't clear if the reception rate level and trend is technical, due to network connectivity issues, or behavioral, and a result of customers disconnecting the devices. Further investigation may help to provide insights as to drivers for this trend. If the decline is behaviorally driven, additional customer encouragement may help increase participation rates.

Figure 2-15: Percent of ThinkEco Devices Receiving Event Signal by Event / Sub-Group



ThinkEco plug-in window AC devices exhibit more variation in the number of activations per customer compared to PCTs. Figure 2-16 shows that only about 43% of the devices received event signals for all three events. A visual analysis of the signal reception by event in Figure 2-17 shows a wide variety of participation patterns from devices receiving less than three event signals. It does not appear that there is any sort of general trend of customers disconnecting devices after the first event as there are multiple instances of devices receiving signals for the first and third event. As observed in Table 2-6, the primary factor underlying event signal success, and ultimately event participation, is whether the thermostat is online for the event. At this time, it is unknown if the reasons for some devices being offline is technical or behavioral. Table 2-6 also shows that nearly 92% of plug-in device customers started the event —the device indicated it participated in at least some of the event—if the initial signal was received. This indicates some customers are likely opting out of the event by either disconnecting or bypassing the device rather than opting out via the conventional opt-out channels. Given the conventional opt-outs are relatively low, and more than 90% of devices receiving the signal are starting the events, the primary areas of interest for improving program performance should be focused on better understanding why some of the devices aren't online during the events. If customers are simply unplugging the devices and it is due to customer behavior, perhaps additional customer outreach can help to improve the performance.

Figure 2-16: Number of Event Signals Received per Plug-In Device

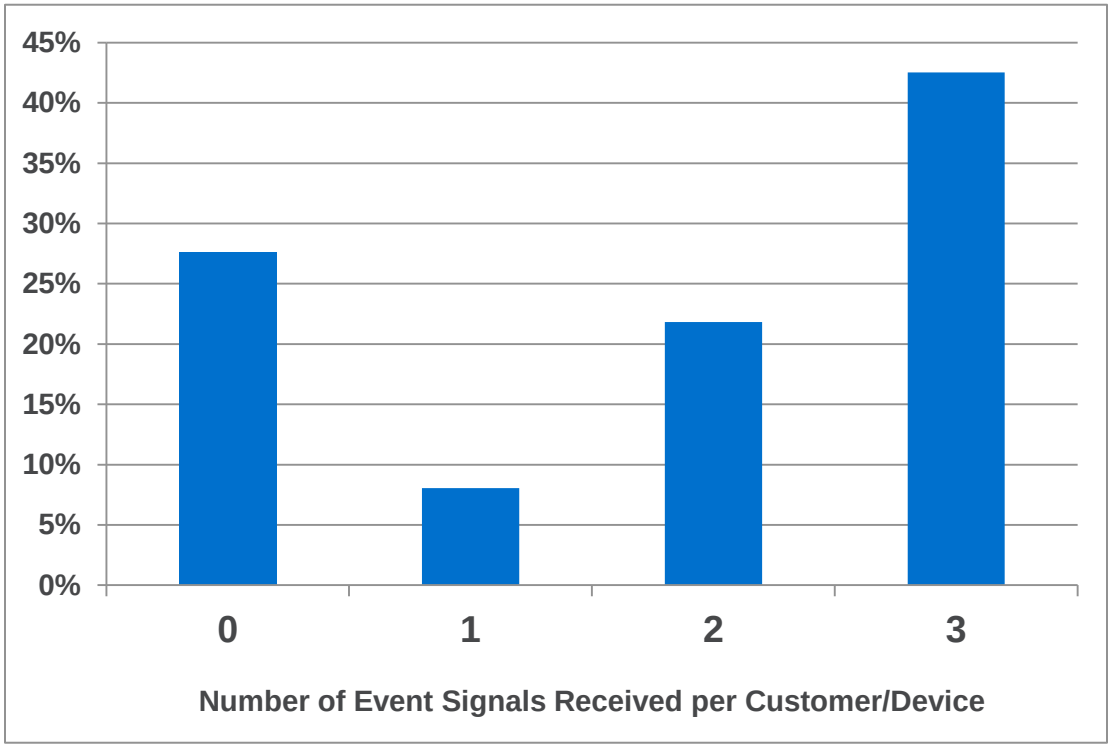


Figure 2-17: Device Event Signal Reception by Event

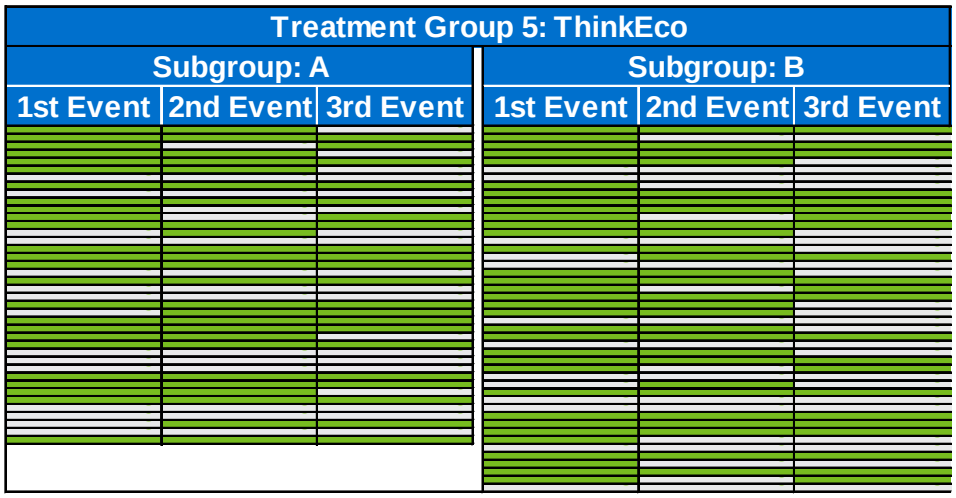


Table 2-6: Plug-In Device Activation Rates per Event

Event Date	Tech Ready (Installed) [1]	Thermostats Online [2]	Device Rec'd Signal [3]	Event Participated Confirmation [4]	Opt Out	Rec'd % [3]/[1]	Participated % [4]/[1]	Realization Part/Rec [4]/[3]
7/23/2015	40	29	29	24	3	72.5%	60.0%	82.8%
7/24/2015	46	41	40	31	2	87.0%	67.4%	77.5%
7/31/2015	46	33	33	32	2	71.7%	69.6%	97.0%
8/13/2015	40	32	31	30	0	77.5%	75.0%	96.8%
9/1/2015	40	26	25	25	1	62.5%	62.5%	100.0%
9/2/2015	46	33	33	33	3	71.7%	71.7%	100.0%
Avg. Event	**43.0**	**32.3**	**31.8**	**29.2**	**1.8**	**74.0%**	**67.8%**	**91.6%**

2.3 Event Summary

Over the course of the summer, six events were called, with the first on July 23 and the last on September 2. Each of the Sub-Groups A and B experienced three events, however the sequencing did not alternate between Sub-Group A and B for every other event. The first two events were A and then B; however, the next pair of events were B as the treatment group, then A. The final pair of events reverted back to A being called, followed by B. Sub-Group C from Group 2 experienced all six events. The hours from 1 to 3 PM were common across all 6 events; 5 of the 6 events included the hour from noon to 1 PM; and 3 of the 6 events included the hour from 3 to 4 PM. The variation in hours resulted in 4 of 6 events being 3 hours long, and the other 2 events were 4 hours long. All customers, regardless of installed technology, received event notifications via their channel of preference – any combination of email, text, or phone – the day of the event, typically around 10 AM.

Table 2-7: Summary of Event Dates, Sub-Group, and Dispatch Hours

Event Date	Sub-Group	Hours	Hour Ending			
			13	14	15	16
7/23/2015	A + C	12pm-4pm				
8/13/2015	A + C	12pm-3pm				
9/1/2015	A + C	12pm-3pm				
7/24/2015	B + C	12pm-4pm				
7/31/2015	B + C	1pm-4pm				
9/2/2015	B + C	12pm-3pm				

3 Customer Acceptance

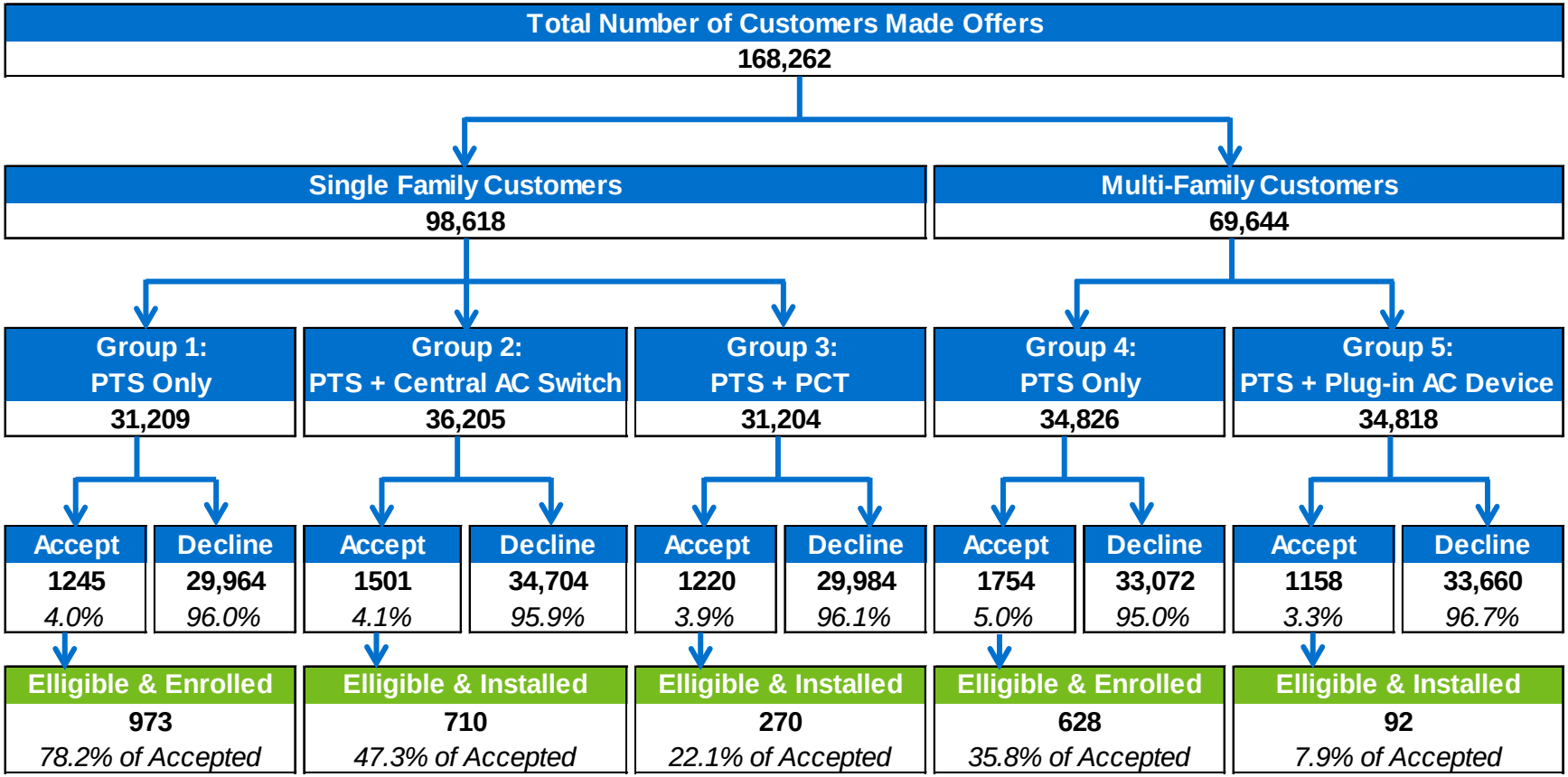
The customer recruitment effort yielded a 4.1% overall acceptance rate on-average across the treatment groups. Figure 3-1 summarizes the acceptance rates for each of the five treatment groups, and includes the number of offers made in total, by customer segment, and ultimately for each treatment group.

A comparison of enrollment rates in the PTS program across the groups indicates the extent to which the offer of free or subsidized technology impacted enrollment in the PTS program. The relevant comparison for answering the question, "Does the offer of technology increase PTS enrollment?" for single family home customers is between the acceptance rate for customers recruited for Group 1 with the acceptance rate for customers recruited for Group 2 and Group 3, including those who accept PTS and DLC, those who accept PTS but decline DLC and those who accept both but for whom the equipment could not successfully be installed. Comparing Group 1 acceptance rates with the acceptance rate for those that have the DLC equipment successfully installed could understate the influence of the offer of technology on customer enrollment. A similar comparison can be made for the multifamily home customers when comparing the acceptance rates between Group 4 and Group 5; again, focusing on the overall acceptance rate and not the number of customers who actually installed the technology.

The offer of an enabling technology didn't increase customer acceptance rates for any of the treatment groups. There was no difference in overall acceptance rates with or without technology for single family customers. For multifamily customers, the offer of technology actually resulted in a lower overall acceptance rate of 3.3% compared to an acceptance rate of 5% for customers offered PTS without any technology.

Overall, more than 168,000 customers received offers. The 4% average customer acceptance rate includes all customers who accepted the offer, regardless of eligibility or whether they ultimately installed the technology. The final counts of customers who installed devices, if applicable, and who were ultimately enrolled are included at the bottom of Figure 3-1. The final eligible and enrolled or installed numbers reflect the challenges associated with moving a customer from expressing interest to ultimately taking action to complete the enrollment process and installing a device. This final enrollment rate varied quite significantly by treatment group. It should be noted that not having AC, or the right type of AC, for a specific treatment group was a significant factor in reducing the number of pilot-eligible customers in several treatment groups. Approximately 20% of single family homes accepting the initial offer were ineligible due to not having central AC; additionally 50% of multifamily customers initially accepting the offer were ineligible due to not having window AC. Generally, customers who accepted the offer and weren't eligible for the pilot, or didn't complete the installation, were enrolled in the general PTS program. Each treatment group is described in further detail in the remainder of this Section.

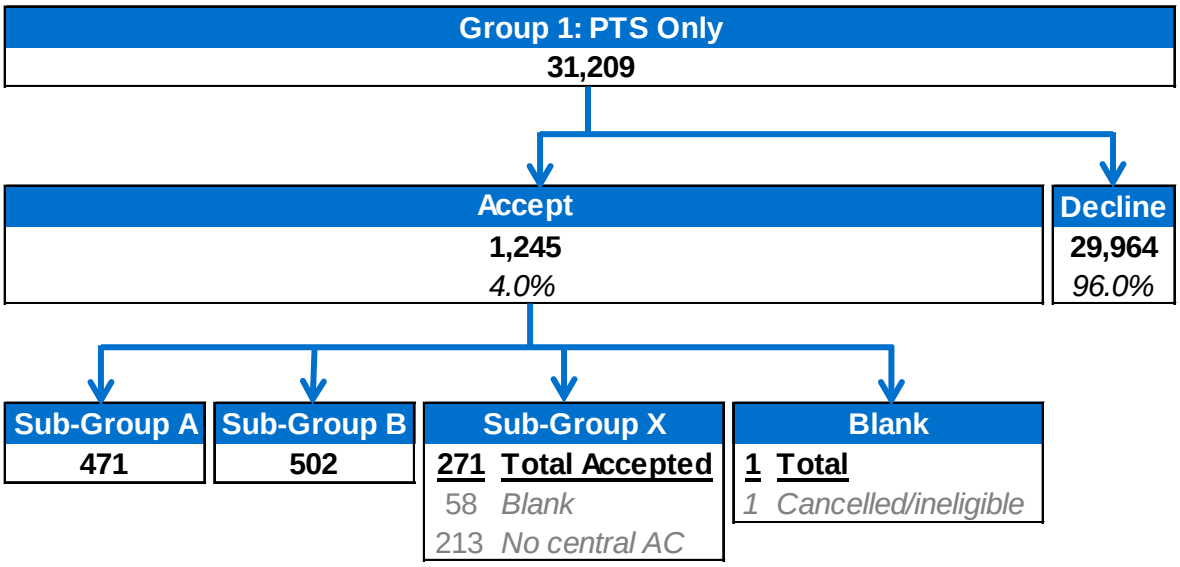
Figure 3-1: Summary of Offer Acceptance Rates



3.1 Treatment Group 1

Figure 3-2 summarizes the customer acceptance and ultimate enrollment rates for Group 1—single family homes that did not receive the offer of enabling technology. The overall acceptance rate was 4%, which is nearly identical to the 4.1% average across all treatments. 31,209 customers were recruited in order to obtain an initial acceptance group of 1,245. Customers accepting the offer were then assigned to Sub-Group A or B if they met the pilot participation criteria of having central AC and weren't planning to move during the summer of 2015. Those not assigned to Sub-Group A or B due to eligibility reasons were assigned to Sub-Group X, which essentially meant they were part of the broader PTS program and not considered an active treatment group for the pilot. Of the customers not eligible for the pilot, 79% was due to not having central AC. The specific reasons for the remaining customers not being eligible was not recorded in the enrollment datasets provided for the analysis.

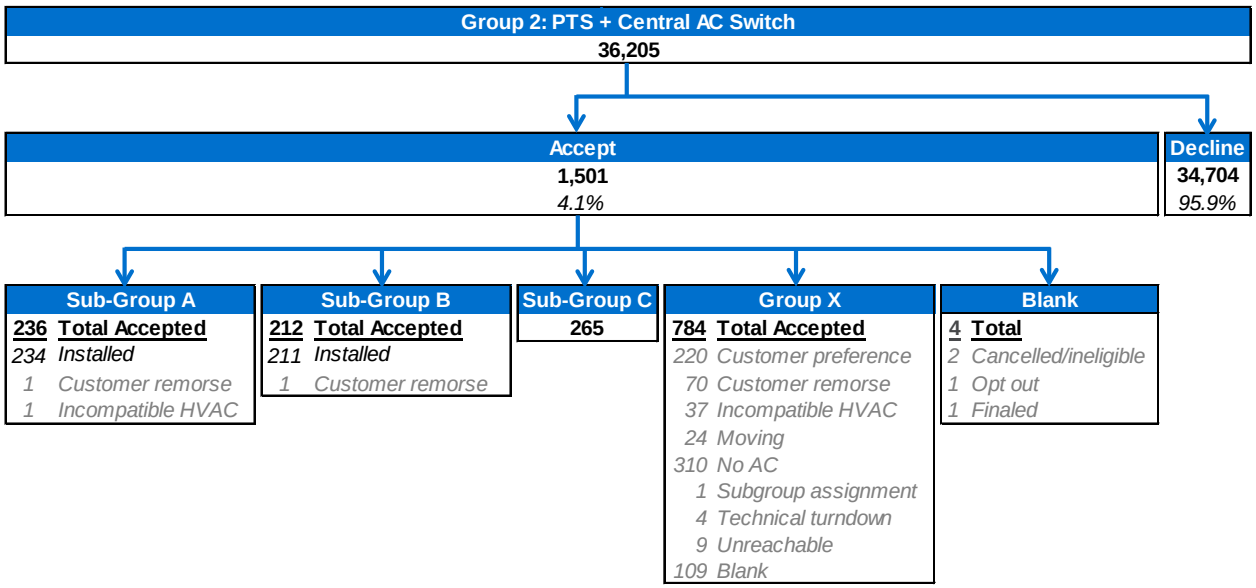
Figure 3-2: Customer Acceptance Rates for Treatment Group 1



3.2 Treatment Group 2

Figure 3-3 summarizes the customer acceptance and enrollment rates for Group 2, single family customers who were offered an AC switch that would cycle their AC during event hours. The overall acceptance rate was 4.1%. 36,205 customers were recruited in order to yield an initial acceptance group of 1,501. Customers accepting the offer were then randomly assigned to Sub-Group A, B, or C if they met the pilot participation criteria of having central AC and weren't planning to move during the summer of 2015. Customers assigned to Sub-Group A or B were contacted to schedule installation of the AC switch. Customers assigned to Sub-Group C were held as a control group and not contacted to install switches; but were notified of the events. The objective of creating Sub-Group C was to facilitate the calculation of the incremental impact of the switch technology, controlling for the potential self-selection bias associated with those customers who accepted the technology offer. Those not assigned to Sub-Group A, B, or C due to eligibility reasons were assigned to Sub-Group X. Of the customers not assigned to a treatment group, 40% were due to not having central AC. For those initially assigned to Sub-Group A or B, an additional 37% changed their mind about wanting technology and were removed from the primary treatment groups. Customers who had technical issues for device installation were also moved to Sub-Group X and essentially removed from the pilot. Additional detail regarding device installation success rates was provided in Section 2.2.3.

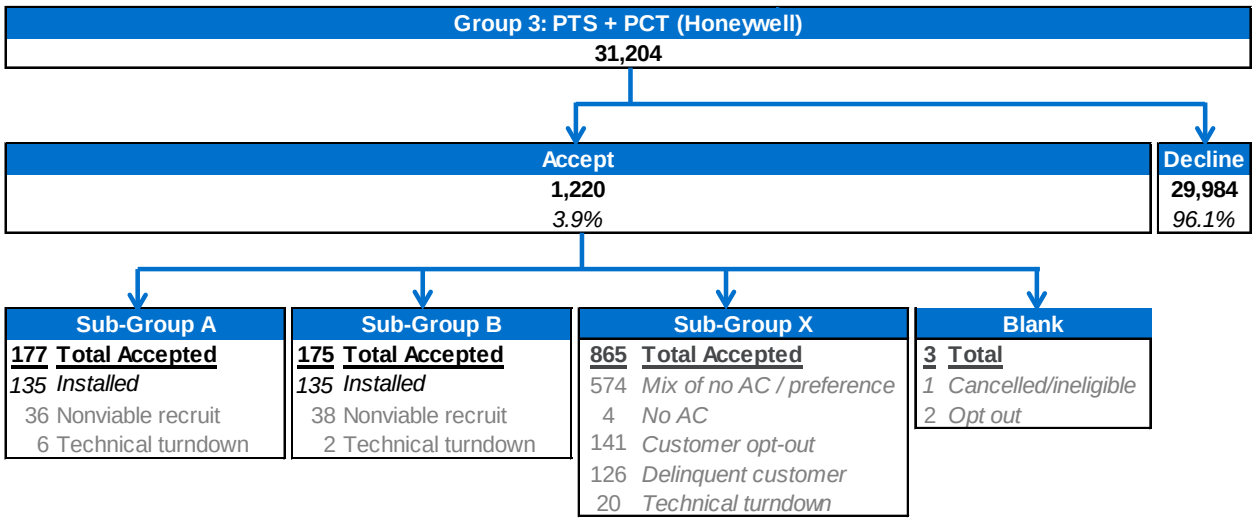
Figure 3-3: Customer Acceptance Rates for Treatment Group 2 AC Switch



3.3 Treatment Group 3

Figure 3-4 summarizes the customer acceptance and enrollment rates for Group 3, customers in single family homes who received the offer of a PCT. The overall acceptance rate was 3.9%, which was nearly identical to the general acceptance rate across all treatments. 31,204 customers were recruited in order to yield an initial acceptance group of 1,501. Customers accepting the offer were randomly assigned to Sub-Group A or B if they met the pilot participation criteria of having central AC, had Wi-Fi, and weren't planning to move. Customers assigned to Sub-Group A or B were contacted to schedule installation of the PCT, with 80% of the eligible customers electing to install a PCT. Customers were given a choice of three thermostat options at the time of the installation. Customers were given a $100 instant rebate, resulting in one being free, another with more functionality costing customers $60 and a third costing $145. 83% of customers chose the free option, 15% of customers chose the $60 option, and only 2% of customers selected the $145 option. Those not assigned to Sub-Group A or B due to eligibility reasons were assigned to Sub-Group X. Of the customers not assigned to a treatment group, 66% resulted from not having central AC or from deciding they didn't want a PCT after all. The specific breakdown for customers not having central AC versus changing their minds was not recorded in the enrollment datasets provided for the analysis. Additional details regarding device installation success rates are discussed in Section 2.2.3.

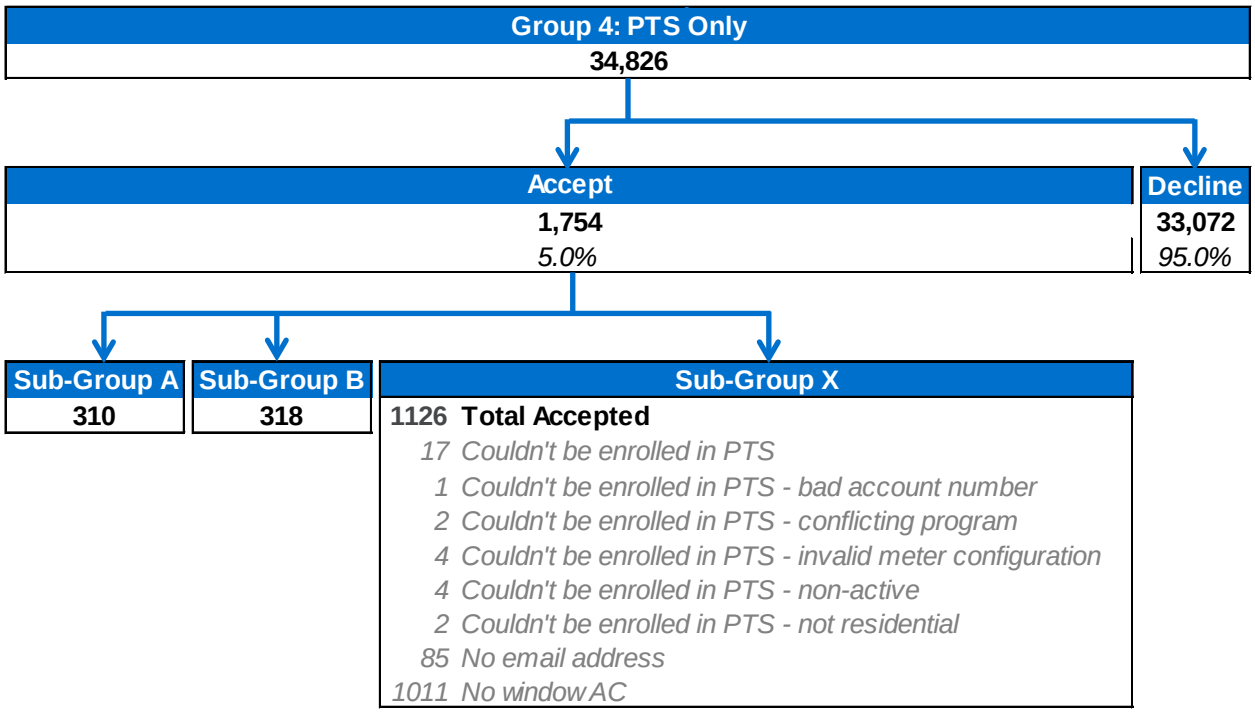
Figure 3-4: Customer Acceptance Rates for Treatment Group 3



3.4 Treatment Group 4

Figure 3-5 summarizes the customer acceptance and enrollment rates for Group 4, multifamily customers who did not receive an offer of enabling technology. The overall acceptance rate for customers receiving offers was 5%, which was higher than the average acceptance rate across the pilot of 4.1%. This is also in sharp contrast with the Group 5 multifamily customers who were offered technology and exhibited an acceptance rate of only 3.3%. Based on this acceptance data, it appears that not offering technology increases the acceptance rate for multifamily customers by 50% relative to similar multifamily customers who were offered technology. 34,826 customers were recruited in order to yield an initial acceptance group of 1,754. Customers accepting the offer were then assigned to Sub-Group A or B if they met the pilot participation criteria of having window AC and weren't planning to move. Those not assigned to Sub-Group A or B due to eligibility reasons were assigned to Sub-Group X. Of the customers not eligible for the pilot, 90% were due to not having window AC. The reasons for the remaining customers not being eligible for the pilot were generally due to customers not completing the PTS program enrollment process for a variety of issues as noted under Sub-Group X in Figure 3-5.

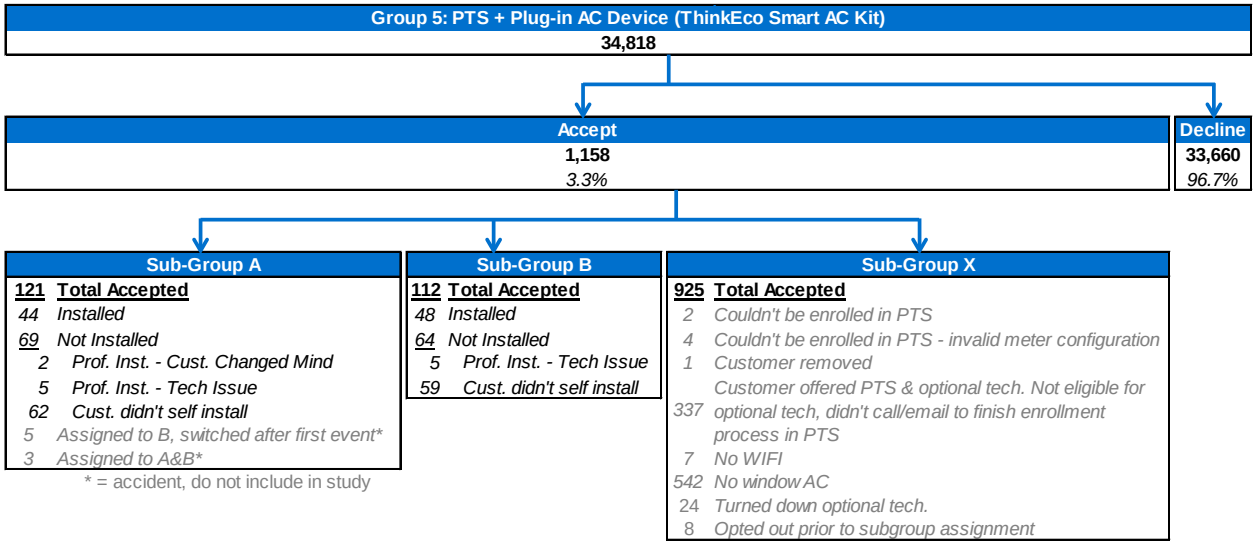
Figure 3-5: Customer Acceptance Rates for Treatment Group 4



3.5 Treatment Group 5

Figure 3-6 summarizes the customer acceptance and enrollment rates for Group 5, multifamily customers who were offered a ThinkEco smartAC plug-in window AC device. The overall acceptance rate for customers receiving offers was 3.3%, which was lower than the general acceptance rate and significantly lower than the acceptance rate of 5% for multifamily customers who were not offered technology. Ultimately, 34,818 customers were recruited in order to obtain an initial acceptance group of 1,158. Customers accepting the offer were randomly assigned to Sub-Group A or B if they met the pilot participation criteria of having window AC, had Wi-Fi, and weren't planning to move during the operational window of the pilot. Customers assigned to Sub-Group A or B were either mailed self-installation kits or contacted to schedule professional installation of the device. Those not assigned to Sub-Group A or B due to eligibility reasons were assigned to Sub-Group X. Of the customers not assigned to a treatment group, 59% were due to not having window AC; an additional 36% of customers never completed the enrollment process. 26% who were mailed devices for self-installation actually installed the device, and 79% of professional installations were completed. The key takeaway from this group is that 64% of eligible customers accepting the initial offer never installed a device. This resulted in less than 0.3% of all recruited customers actually installing a device. Additional details regarding device installation success rates are discussed in Section 2.2.3.

Figure 3-6: Customer Acceptance Rates for Treatment Group 5



3.6 Summary of Participant Survey

ComEd contracted with MarketStrategies, Inc. (MSI) to conduct a survey among pilot participants to obtain quantitative information on a variety of questions of interest, including:[3]

- Participant satisfaction with ComEd overall and with the PTS program between those with and without technology;
- Overall incentives received from the program, including satisfaction with the magnitude of the PTS incentives received for each event;
- Satisfaction with the enrollment process and, for those with technology, satisfaction with scheduling and installation of the equipment;
- The role of technology in deciding to participate in PTS;
- Ease of use of the technology;
- The PTS event process (pre- and post-event communications);
- Understanding customers' knowledge about participating in events;
- Understanding customers' typical energy using behavior and energy-efficiency behavior;
- Determining if customers took actions to save energy during PTS hours and understanding the motivations for taking action;
- Assessing the impact of household characteristics; and
- Assessing the likelihood to participate in PTS events again in 2016.

The telephone survey was conducted from October 23 to November 16, 2015. MSI successfully completed 339 surveys. This response rate of roughly 14% was obtained after making up to six attempts to reach each participant (including calling at different times of day and evening), sending pre-notification letters about the research and paying $25 for each completed survey. Response rates varied from a low of roughly 11% for the central AC control group to a high of approximately 18% for the central AC PCT treatment group and the window AC control group.

3.6.1 Customer Satisfaction, Awareness, and Perceptions

ComEd's Peak Time Savings DLC pilot program was well received by participating customers, showing generally high overall satisfaction as well as likelihood to participate in PTS events in 2016 and to recommend the program to family and friends. Overall, roughly nine in ten (DLC technology, 93%; Control, 88%) participants report being satisfied with the PTS program, i.e., participants rated 6-7 or 8-10 in a 0 to 10 scale (6-10). However, customers with DLC technology were significantly more likely than the Control group, i.e., customers without DLC technology, to rate their satisfaction at the top end of the scale (82% vs. 71% customers rated 8-10 in a 0 - 10 scale (8-10)). Participants in both control and technology groups show the highest satisfaction with ComEd (DLC technology, 81%; Control, 81%, (8-10)).

Considering specific aspects of the PTS program, customers in both groups show the highest satisfaction (8-10) with ease of the enrollment process (DLC technology, 87%; Control, 88%), with notifications sent the day after PTS events to communicate energy saved /credit on the

[3] This section is based on MarketStrategies, Inc. *ComEd Peak Time Savings - DLC Topline Report,* November 24, 2015.

customer's electric bill (DLC technology, 84%; Control, 80%), event notification (DLC technology, 82%; Control, 73%), and mailed reminders and information from ComEd (DLC technology, 70%; Control, 72%). Roughly 70% of participants said they were satisfied (6-10) with the amount they saved on their bill during PTS events and 49% said they were very satisfied (8-10).

Program aspects specific to those with DLC technology were also rated highly by a majority of customers. PCT participants were significantly more satisfied than AC switch participants with the professionalism of the installing technician (98% vs. 84%, (6-10)) and the timeliness of the technician (97% vs. 86%, (6-10)).

Nearly three in four (73%) customers said they would be likely (6-10) to recommend the program to family and friends. However, those with DLC technology show a significantly higher likelihood than the Control group (86% vs. 75%, ((8-10)). Nearly all participants (DLC technology, 95%; Control, 94%) said they are likely (6-10) to participate in future events.

3.6.2 PTS Event Notification

Overall opinions of the PTS events were positive as indicated by overall program satisfaction, awareness, and participation in the events. Roughly four in ten (DLC technology, 39%; Control, 45%) correctly recalled three PTS events occurring over the course of the summer.

Nearly four in ten in the central AC switch group (38%) and roughly half of those in the central AC PCT (53%) and the window AC plug-in (48%) groups believe ComEd wirelessly adjusted their AC during the events. A majority said they did not override ComEd's control during these events.

Customers without DLC technology were significantly more likely to take action to save energy during the event than those with technology (82% vs. 61%), indicating a reliance on the technology to "save" among DLC participants. However, those with technology showed slightly higher recall for receiving a credit (DLC technology, 88%; Control, 82%) and on average believed that they saved more during the events ($4.38 vs. $3.69). Further, recall for average savings was greater among all central AC groups when compared to window AC groups. This aligns with actual event savings where central AC groups earned larger credits, on average, than window AC groups.

The biggest motivator to take action during PTS hours is financial. When asked to state in their own words the most important reason for taking actions, roughly two in three said "saving money." "Saving energy" was a distant second.

Additionally, nine in ten respondents indicated that reducing energy usage to save money (87%) and receiving a credit on their electric bill (85%) were very large factors (8-10) for participating in PTS hours. Conserving as much energy as possible and helping protect the environment followed, with 79% rating this as a very large factor (8-10) for taking action during PTS hours. The least influential factor was the GE smart appliance contest with 29% rating this as a very large factor (8-10). The largest barrier to taking action centered on being unable to take action due to being away from home (DLC technology, 54%; Control, 59%).

Notifications sent after the events were recalled by most and found to be clear and easy to understand. Recall of the post-event notification was high for both groups, though slightly higher among the Control group (86%) compared to those with DLC technology (79%).

Overall, more than eight in ten (DLC technology, 89%; Control, 82%) strongly agree that the amount of the bill credit on the post-event notification was clearly communicated and easy to understand. However, those with DLC technology were much more likely than the Control group to feel the amount of information was “just right” (70% vs. 57%).

3.6.3 Impact on Smart Meter Awareness and Value Perceptions

A strong majority of participants were aware that they have a smart meter at their household. However, customers with DLC technology showed significantly higher awareness than those in the Control group (88% vs. 77%). Customers in the window AC groups were less likely to be aware of their smart meter than all central AC groups.

The PTS program had a positive impact on the value customers place on their smart meter. Of those aware of their smart meter, roughly six in ten feel having a smart meter is valuable to them (6-10), with those with DLC technology showing a slightly higher value (DLC technology, 65%; Control, 58%, non-significant). Further, customers in the Control group (19%) were significantly more likely than those with DLC technology (9%) to find little or no value of smart meter (0 to 4 in a 10 point scale).

While the PTS DLC program had a positive impact on the value of smart meters for both groups, those with DLC technology were significantly more likely than those in the Control group to say the program has made their smart meter more valuable (60% vs. 48%).

4 Load Impacts

One of the primary objectives of the PTS/DLC pilot was to estimate the load reduction during event hours for each treatment group and to estimate the incremental load impact of enabling technology over and above what consumers would do in the absence of load control. This section summarizes the estimate load impacts for each treatment group.

4.1 Load Impact Estimation Methodology

As discussed previously, the pilot was designed and implemented as a RCT, which makes the impact estimation straightforward. For each event, either Sub-Group A or Sub-Group B was notified and had a signal sent to the installed technology, while the other group is neither notified or signaled. A simple difference in loads between the two groups provides an estimate of the load impact of the treatment being tested for that event. Below is a list of the load impact estimates that can be produced from the experiment:

- Group 1, difference in load between Sub-Groups A and B for each event: Estimates the total load impact of PTS without technology for single family participants with central AC.
- Group 2, difference in load between Sub-Groups A and B: Estimates the total load impact of PTS plus AC switches for single family participants with central AC.
- Group 2, difference in load between Sub-Groups A and C or between Sub-Groups B and C: Estimates the incremental load impact of AC switches over and above the behavioral changes made by single family participants who accepted AC switches. As mentioned previously, due to a technical malfunction, it was not possible to directly estimate this impact.
- Group 3, difference in load between Sub-Groups A and B: Estimates the total load impact of PTS plus a PCT for single family participants with central AC.
- Group 4, difference in load between Sub-Groups A and B: Estimates the total load impact of PTS without technology for multifamily customers with window AC.
- Group 5, difference in load between Sub-Groups A and B: Estimates the total load impact of PTS plus the ThinkEco Smart AC Kit for multifamily participants with window AC.

All of the above comparisons except one (discussed below) are devoid of selection effects, since the differencing analysis is done for subsets of each group that are randomly assigned to treatment and control conditions after enrollment. Given the relatively small sample sizes in each cell, there could be differences in load between Sub-Groups A and B on non-event days that would bias the impact estimates due to random sampling variation. These differences will cancel out for the average event as long as an even number of events is called across the summer. For any individual event, the estimated impact might be inaccurate using a simple difference calculation due to random differences in the Sub-Groups A and B. As such, we used a difference-in-differences calculation for event-specific estimates. This approach subtracts any difference in load during the peak period on non-event days that have similar weather conditions to event days from the difference on the event day. To further improve statistical precision, this calculation was done using a fixed-effects regression methodology, which reduces the standard errors of the estimates.

Load impacts for single and multifamily customers are quite different due primarily to differences in the level and pattern of electricity use between the two customer segments as seen in Figure 4-1and Figure 4-2, which show average loads for each group on non-event days with weather conditions similar to event days. Single family customers have much higher loads than multifamily customers at all times of the day and have loads that peak in late afternoon. Multifamily customers have a relatively flat load shape, peak during evening hours, and are quite small compared to single family customers.

There appears to be a small selection bias in Group 3 relative to Groups 1 and 2. Group 2 customers exhibit higher load in the late afternoon and evening. As discussed later, it is important to note that the majority of the difference between Group 3 and the other two single family groups occurs after the average event window from 12 to 4 PM. During those hours, the loads across all single family customer treatment groups are very similar.

There also appears to be some selection bias between customers who accepted and ultimately installed a plug-in window AC device relative to those who were not offered a load control device. Group 5 customers with the load control device only accepted the PTS only offer, with those customers accepting the device exhibiting higher load during all hours.

Figure 4-1: Hourly Average Demand for Single Family Customers with Central AC on Event-Like Days

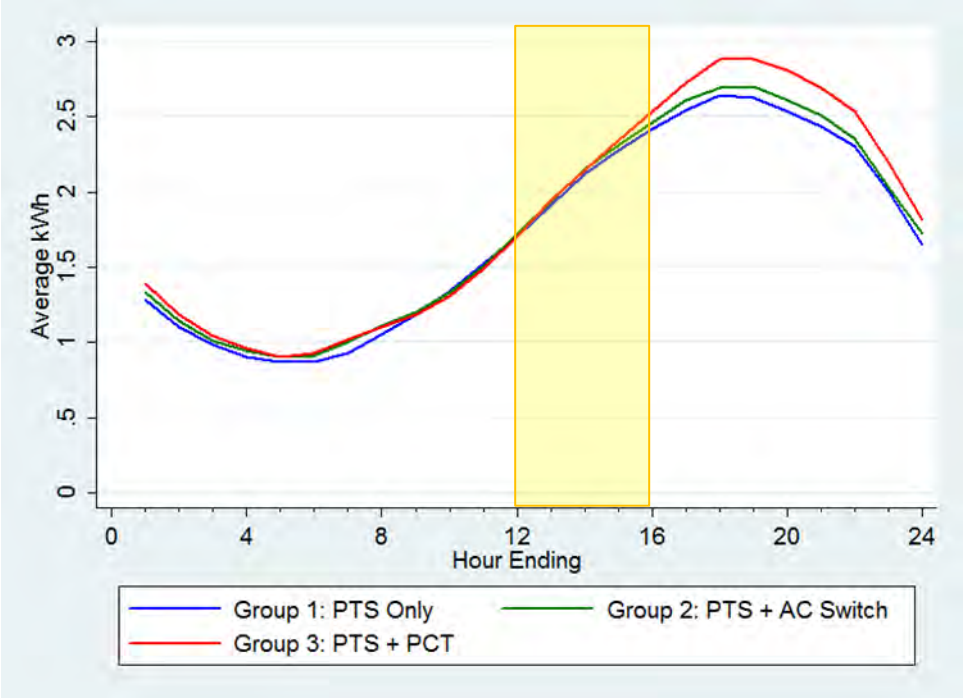
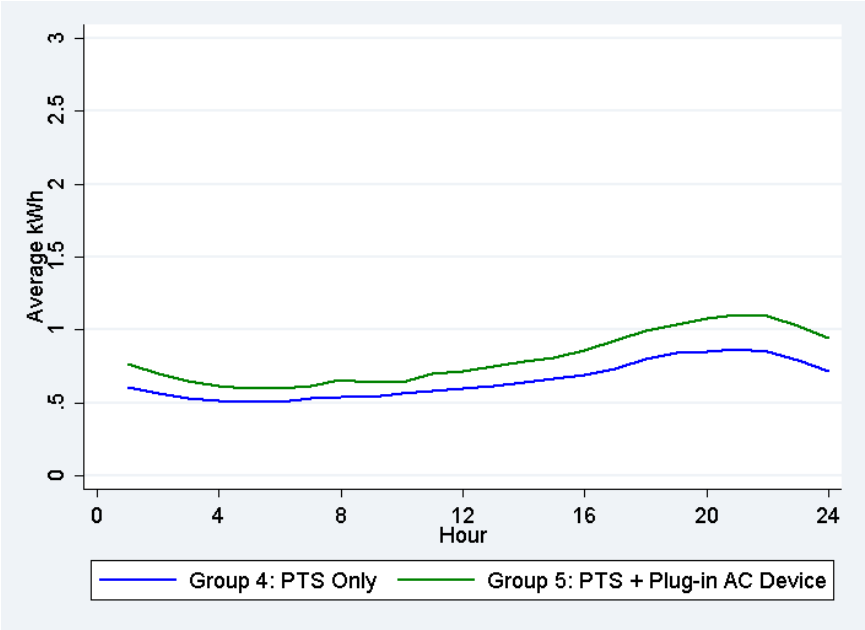


Figure 4-2: Hourly Average Demand for Multifamily Customers with Window AC on Event-Like Days



4.2 Summary of Estimated Load Impacts

Table 4-1 summarizes the estimated load impacts for each treatment group. Customers with DLC devices had much higher impacts than those without devices – but average impacts without technology were also significant. Single family customers exhibited the largest impacts in absolute terms; however the impacts are comparable to the multifamily customers when compared in percentage terms. When comparing PTS only impacts between single family and multifamily customers, single family customers provided average hourly load impacts of 0.18 kW (8.9%) whereas multifamily customers provided impacts about one third the size in absolute terms, at 0.05 kW (8.6%).

Table 4-1: Average Load Reduction per Customer Across All Event Hours

Customer Segment	Treatment Group	Load w/o DR (kW)	Load w/ DR (kW)	Impact (kW)	Impact (%)
Single Family Customers w/ Central AC	1: PTS Only	2.060	1.877	0.183	8.9%
	2: PTS + AC Switch	2.155	2.004	0.151	7.0%
	3: PTS + PCT	2.135	1.625	0.511	23.9%
Multifamily Customers w/ Window AC	4: PTS Only	0.604	0.552	0.052	8.6%
	5: PTS + Plug-in AC Device	0.752	0.602	0.150	20.0%

Impacts for single family customers with PCTs were about three times larger than impacts from multifamily customers with plug-in devices at 0.51 kW and 0.15 kW, respectively. In percentage terms, the impacts are much closer at 24% for PCTs and 20% for plug-in devices. It should be noted these load impacts are for all customers with installed devices, regardless of device

activation for a specific event—which did vary. Based on the average device activation rates in Table 2-5 and Table 2-6 of 91% and 74% for PCTs and plug-in devices, average load impacts for activated devices can be calculated at 26% for PCTs and 27% for plug-in devices.

Impacts from Group 2 only reflect the behavioral component of the program, as the AC switches didn't function properly. More specifically, Group 2 impacts represent load reductions from customers who were expecting their AC to be cycled, when it actually wasn't. The slightly lower impacts from Treatment Group 2 relative to Treatment Group 1 are consistent with a hypothesis that customers might have responded less because they were expecting their AC to be managed for them. The PCTs from Treatment Group 3 were programmed to operate similarly to the AC switches in Treatment Group 2 (e.g., they were cycled in the same way, not subjected to temperature adjustments), so it is reasonable to infer the load impacts for Treatment Group 2 would have been similar to Treatment Group 3 had the switches worked.

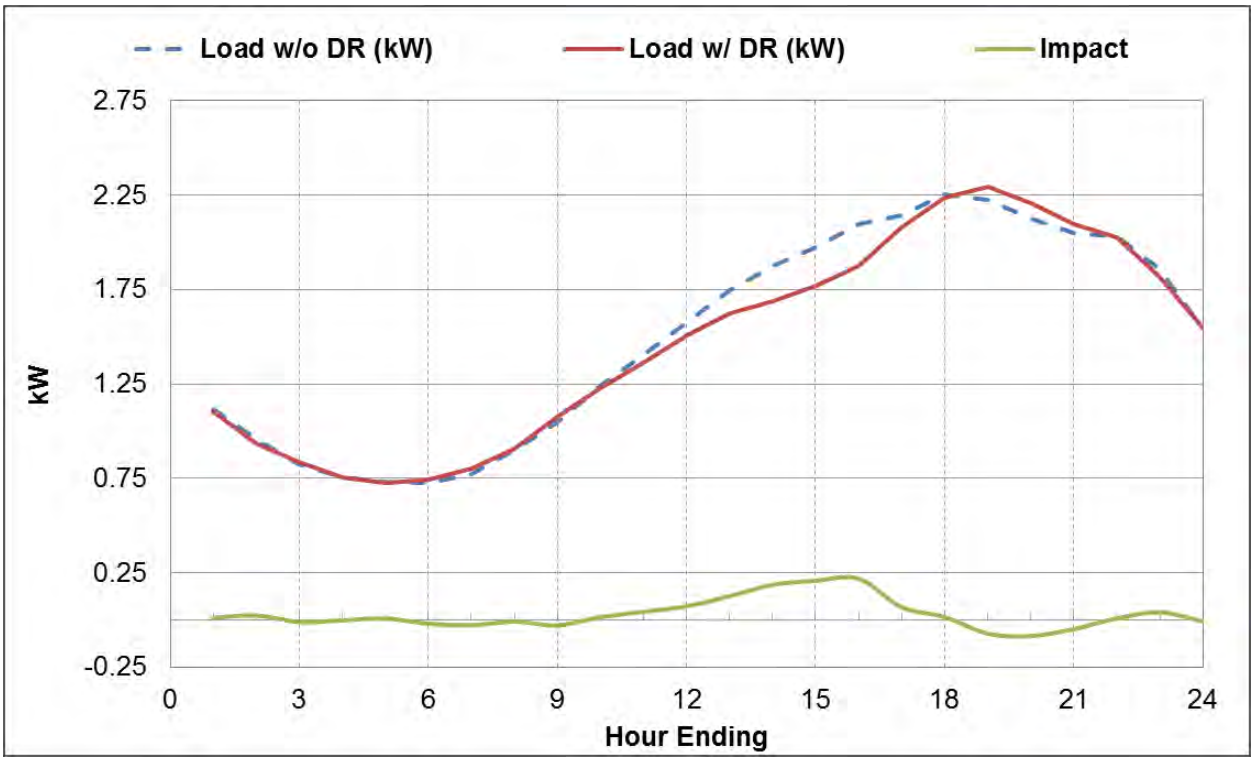
One of the objectives of the pilot was to estimate the incremental impact attributable to the enabling technology, when controlling for potential selection bias from customers willing to install the technology. The switch failures prevented this from being calculated directly. However, it is possible to infer the incremental impact of enabling technology based on the observed load impacts from the other treatment groups when considering the similarities in customer load shapes during event hours on event like days as observed in Figure 4-1. Assuming the AC switches would have resulted in similar load impacts to the PCTs at 0.51 kW (24%), and PTS impacts without technology are within the range of 0.15 kW (7%) to 0.18 kW (9%), the incremental impact of technology can be estimated at between 0.33 kW (15%) and 0.36 kW (17%). This indicates the incremental impact from enabling technology is roughly 2.5 to 3 times the size of the impact from PTS only. While a direct calculation as initially intended would have been ideal, this estimation provides a reasonable basis to support the hypothesis that enabling technology does in fact provide a significant incremental load impact well above what could be attributable to selection bias. This topic will be addressed at a greater level of detail in Section 4.4.

4.3 Treatment Group 1

Figure 4-3 shows the average load with DR, load without DR (reference load), and load impact for Group 1 customers that reduce load through behavior changes in response to the PTS incentive. During typical event hours (12 PM to 4 PM), the average reference load was around 2.06 kW. The average load with DR during event hours was around 1.87 kW. This resulted in an average load reduction of 0.183 kW per customer, representing an 8.9% reduction relative to the reference load. On an hourly basis, impacts were relatively low in the first event hour (0.126 kW) and peak at 0.218 kW from 3 PM to 4 PM. Load reductions continued for at least one hour following the completion of the official event window; at two hours following the event the observed load with DR was similar to the reference load. In the third, fourth, and fifth hours following the event the load with DR was slightly higher than the reference load, indicating that there was some minor snapback[4] after the event.

[4] Snapback is defined as when customer energy use increases relative to the reference load after an event ends. This is typically driven by increased cooling load to restore preferred temperatures after an event, or deferred use of appliances.

Figure 4-3: Average Hourly Load Impact per Customer- Treatment Group 1

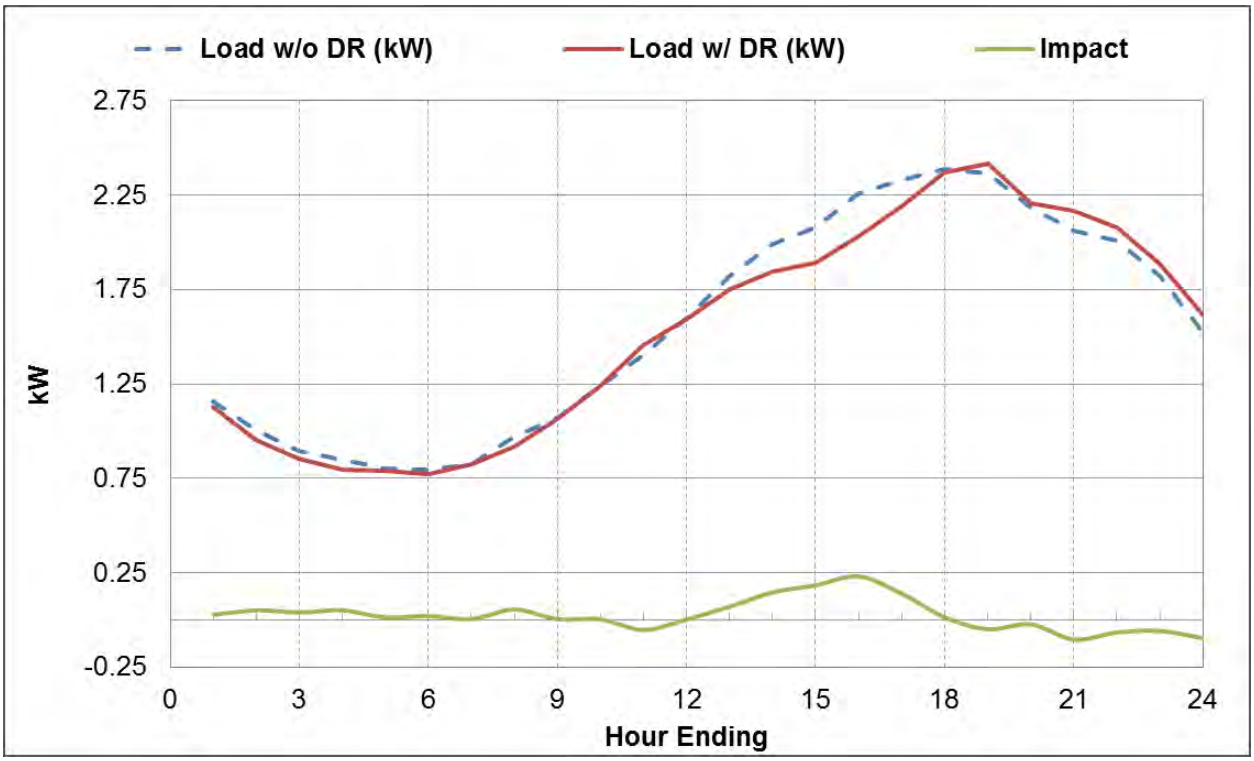


4.4 Treatment Group 2

Figure 4-4 shows the average load with DR, load without DR (reference load), and load impact for Group 2 customers who accepted load control switches on their AC. As previously discussed, the switches were not operational during the events due to installation errors. During typical event hours (12 PM to 4 PM), the average reference load was around 2.15 kW. The average load with DR during event hours was around 2.00 kW. This resulted in an average load reduction of 0.151 kW per customer, representing a 7.0% reduction relative to the reference load. On an hourly basis, impacts were relatively low in the first event hour (0.070 kW) and peak at 0.231 kW from 3 PM to 4 PM. Load reductions continued for one hour following the completion of the official event window; at two hours following the event the observed load with DR was similar to the reference load; exhibiting little to no snapback.

The impacts from Treatment Group 2 are interesting because customers thought their AC was being cycled when it wasn't. This provides a unique look at the behavioral portion of a load impact from a customer who chose the technology and expected it to reduce AC use during event hours. When comparing impacts with Group 1 who were PTS only, without enabling technology—or the expectation of enabling technology— the impacts were actually slightly smaller from Treatment Group 2. While the differences in impacts between the two groups aren't statistically significant given the small sample sizes, it does provide supporting evidence to reject the hypothesis that customers who accepted the technology offer would provide larger impacts on their own, and that technology didn't provide any incremental load impact once selection bias was eliminated.

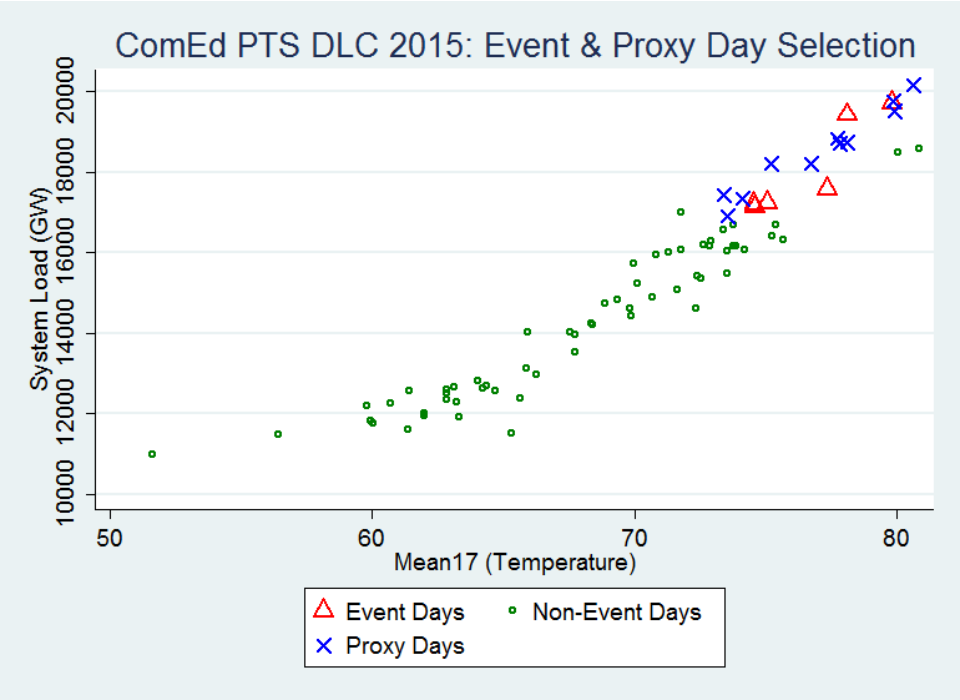
Figure 4-4: Average Hourly Load Impact per Customer- Treatment Group 2



As noted earlier in Section 4, one of the objectives of the pilot was to estimate the incremental impact attributable to the enabling technology, when controlling for potential selection bias from customers willing to install the technology. The switch issues prevented this from being calculated directly. However, it is possible to infer the incremental impact of enabling technology based on the observed load impacts from the other treatment groups when considering the similarities in customer load shapes during event hours on event like days as was seen previously in Figure 4-1, which shows the average hourly load on days with similar temperature and system load conditions as event days.

Figure 4-5 shows how the event-like days used in the load calculation in Figure 4-1 were determined. A propensity score matching algorithm was used to identify proxy days based on finding the closest match to an event day based on system load, temperature, and other factors such as the month and day of the week. In the figure, event days are identified as red triangles, and the event like or proxy event days selected by the model are identified as blue X's. Other non-event days are identified are identified as green circles.

Figure 4-5: Proxy Event Day Selection



When evaluating the load profiles for each of the single family customer treatment groups in Figure 4-1, there are clearly selection effects evident in the load profile of the customers who ultimately installed a PCT. However, most of the variation from the other two treatment groups occurs after the typical event window, highlighted in yellow. In fact, three of the six events actually ended at 3 PM, when there is virtually no difference in load between the three treatment groups. This similarity in load during typical event hours on event like days is the first step towards inferring the incremental load reduction provided by technology based on the available data from the pilot.

The next step requires an assumption regarding the similarity of load impacts between what should have happened with the AC switches and what was observed with the PCTs. The AC switches for Treatment Group 2 were designed to provide a 50% cycling response when they received the event signal. In order to allow for a comparison between the AC switches for the pilot, the PCTs were essentially programmed like a switch and also set to provide 50% cycling to the AC rather than use a simple temperature setback of a few degrees as is sometimes done with PCT. Given that both the AC switch and PCT were programmed to provide 50% cycling, and the customer load during event hours on event like days are similar across the treatment groups; it is reasonable to assume the load reductions from Group 2 would have been similar to the load reductions from Group 3 had the AC switches operated correctly.

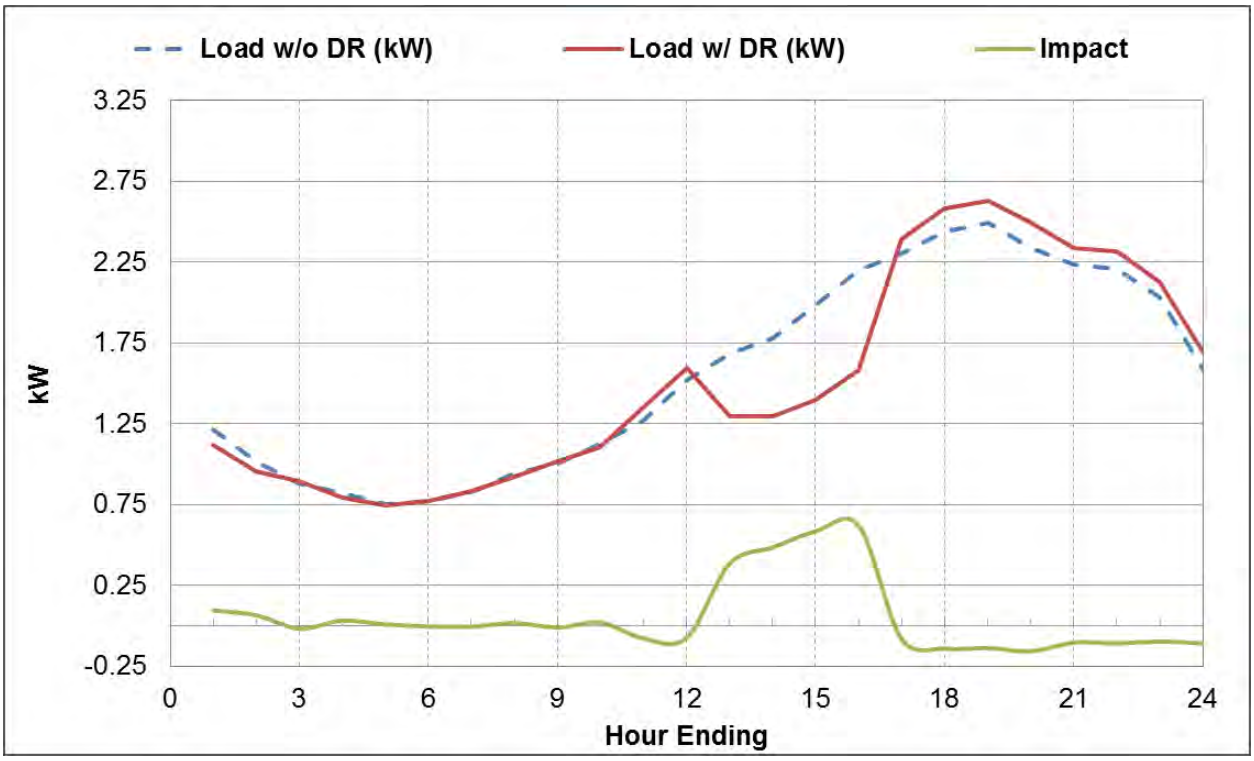
Assuming the AC switches would have resulted in similar load impacts to the PCTs at 0.51 kW (24%), and PTS only impacts without technology are within the range of 0.15 kW (7%) from customers who weren't offered enabling technology to 0.18 kW (9%) from customers who accepted and installed enabling technology; the incremental impact of technology can be estimated at between 0.33 kW (15%) and 0.36 kW (17%). This indicates the incremental impact

from enabling technology is roughly twice the size of the impact from PTS only. While a direct calculation as initially intended would have been ideal, this estimation provides a reasonable basis to support the hypothesis that enabling technology does in fact provide a significant incremental load impact well above what could be attributable to self-selection bias.

4.5 Treatment Group 3

Figure 4-6 shows the average load with DR, load without DR (reference load), and load impact for single family customers with PCTs. During typical event hours (12 PM to 4 PM), the average reference load was around 2.135 kW. The average load with DR during event hours was around 1.625 kW. This resulted in an average load reduction of 0.511 kW per customer, representing a 23.9% reduction relative to the reference load. On an hourly basis, impacts were slightly lower in the first event hour (0.385 kW) and peak at 0.621 kW from 3 PM to 4 PM. Load increased relative to the reference load in the hours following the event for the rest of evening. The average load increase in the 4 hours following the event was 0.129 kW; a 6% increase compared to the reference load. The observed post-event snapback is typical for a DLC program of this nature.

Figure 4-6: Average Hourly Load Impact per Customer- Treatment Group 3

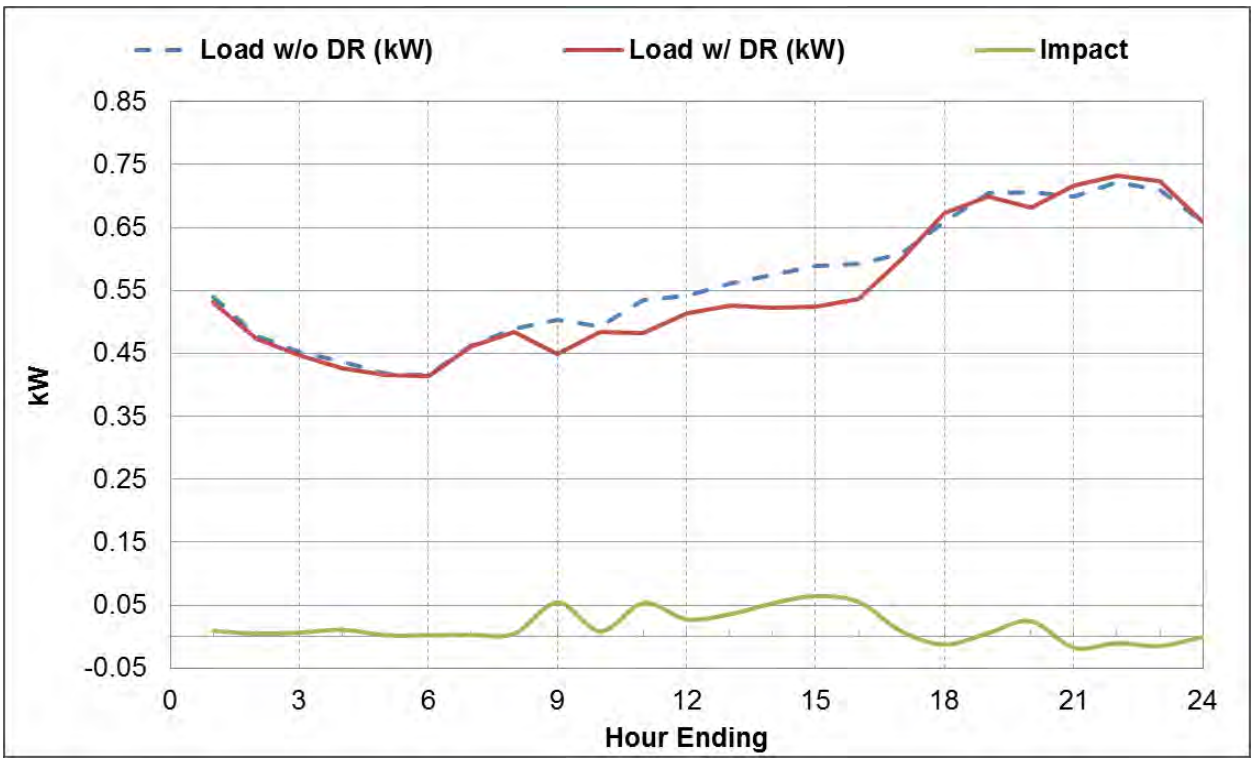


4.6 Treatment Group 4

Figure 4-7 shows the average load with DR, load without DR (reference load), and load impact for multifamily customers with window AC but who were not offered a control device. During typical event hours (12 PM to 4 PM), the average reference load was around 0.604 kW. The average load with DR during event hours was around 0.552 kW. This resulted in an average load reduction of 0.052 kW per customer, representing an 8.6% reduction relative to the

reference load. On an hourly basis, impacts were relatively low in the first event hour (0.036 kW) and peak at 0.064 kW from 2 PM to 3 PM. Load with DR returned to a similar level as the reference load in the hour following the event, and remained similar to the reference load for the rest of the day, exhibiting no snapback after the event. The apparent load reduction prior to the event window is likely due to random customer energy usage variation, as the multifamily customers exhibited significant variation in hourly energy usage, particularly in percentage terms. This is largely attributable to the lower overall energy usage levels of multifamily customers relative to single family customers. At this scale, a single appliance turning on or off significantly affects the customer's load shape.

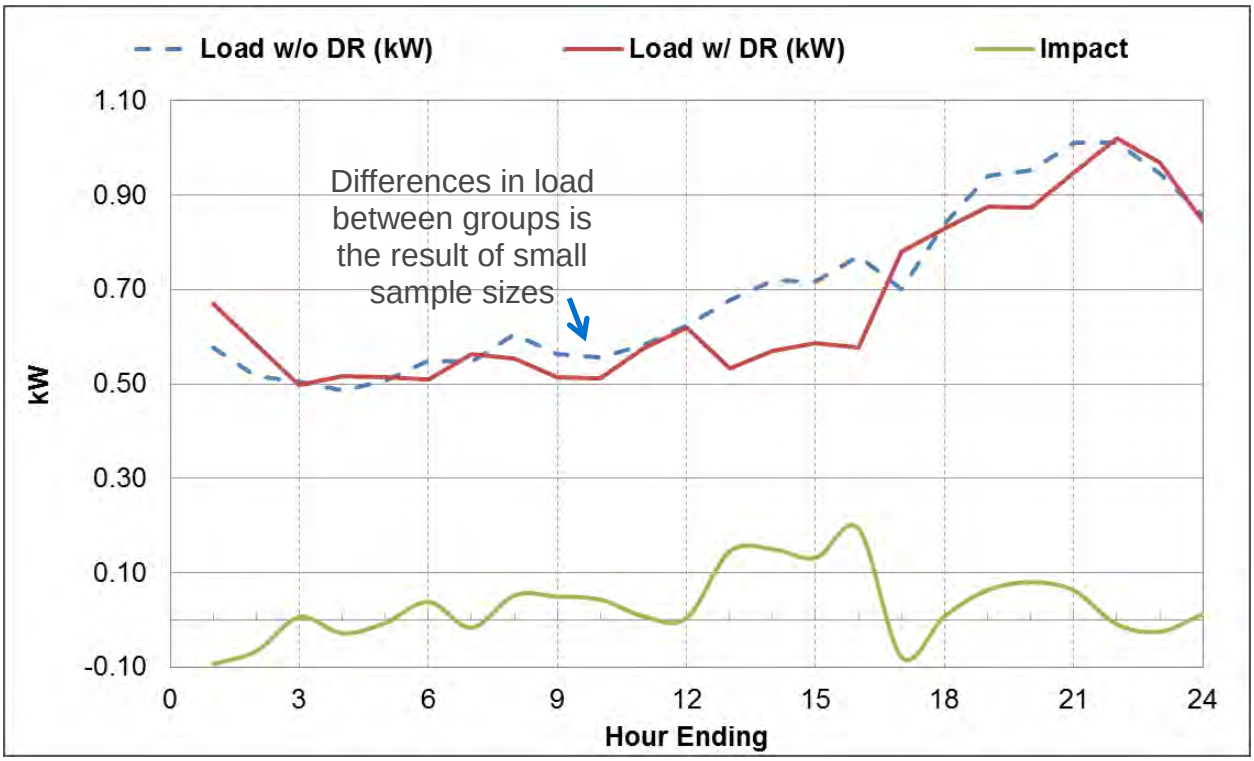
Figure 4-7: Average Hourly Load Impact per Customer- Treatment Group 4



4.7 Treatment Group 5

Figure 4-8 shows the average load with DR, load without DR (reference load), and load impact for multifamily customers with an installed plug-in device in each hour of the average event day. During typical event hours (12 PM to 4 PM), the average reference load was around 0.752 kW. The average load with DR during event hours was around 0.602 kW. This resulted in an average load reduction of 0.150 kW per customer, representing a 20.0% reduction relative to the reference load. On an hourly basis, impacts were generally consistent from hour to hour and peaked at 0.193 kW from 3 PM to 4 PM. Load increased relative to the reference load by 0.078 kW, 11.8% of the reference load, in the hour following the event, but there was no indication of snapback beyond that first post-event hour.

Figure 4-8: Average Hourly Load Impact per Customer- Treatment Group 5



4.8 Load Impacts for Average Event by Hour

Table 4-2 provides load impacts for the average event by hour for each of the treatment groups. Uncertainty adjusted impacts are provided in addition to the point estimates for the load impacts noted in the earlier sections. The uncertainty adjusted impacts help provide context to the effect of relatively small sample sizes on the load impact calculations. Based on overlap between the uncertainty adjusted impacts of Groups 1 and 2, there is not a statistically significant difference in load impacts between customers on PTS only and customers who were effectively on PTS only due to the AC switch failures but opted in to the enabling technology treatment. The lower bound at the 10th percentile for the PTS with PCT treatment group impact was 0.457, and the upper bound at the 90th percentile of the PTS only treatment group impact was 0.206 kW. This indicates there is a difference in load impacts of at least 0.25 kW that can be associated with enabling technology based on the assumptions developed in Section 4.4. Given this evidence, there is very little room to question the existence of incremental impact associated with DLC technologies when accounting for customer selection bias.

Table 4-2: Load Impacts for the Average Event by Hour

Customer Segment	Treatment Group	Hour Ending	Load w/o DR (kW)	Load w/ DR (kW)	Impact (kW)	Impact (%)	Avg. Temp. (°F)	Uncertainty-adjusted Impact - Percentiles				
								10th	30th	50th	70th	90th
Single Family Customer w/ Central AC	1: PTS Only	13	1.833	1.707	0.126	6.9%	85.0	0.099	0.115	0.126	0.137	0.153
		14	2.029	1.843	0.186	9.2%	85.2	0.160	0.175	0.186	0.197	0.213
		15	2.184	1.977	0.208	9.5%	84.7	0.179	0.196	0.208	0.220	0.237
		16	2.244	2.026	0.218	9.7%	83.4	0.183	0.204	0.218	0.233	0.254
		Avg. Hourly	***2.060***	***1.877***	***0.183***	***8.9%***	***84.7***	***0.159***	***0.173***	***0.183***	***0.192***	***0.206***
	2: PTS + AC Switch	13	1.899	1.829	0.070	3.7%	85.0	0.028	0.053	0.070	0.087	0.111
		14	2.131	1.985	0.146	6.9%	85.1	0.103	0.128	0.146	0.164	0.190
		15	2.300	2.117	0.184	8.0%	84.6	0.140	0.166	0.184	0.202	0.227
		16	2.345	2.114	0.231	9.8%	83.3	0.176	0.208	0.231	0.253	0.285
		Avg. Hourly	***2.155***	***2.004***	***0.151***	***7.0%***	***84.7***	***0.115***	***0.136***	***0.151***	***0.166***	***0.187***
	3: PTS + PCT	13	1.886	1.501	0.385	20.4%	85.0	0.331	0.363	0.385	0.407	0.438
		14	2.078	1.593	0.485	23.3%	85.1	0.427	0.461	0.485	0.509	0.543
		15	2.286	1.701	0.585	25.6%	84.6	0.524	0.560	0.585	0.609	0.645
		16	2.362	1.741	0.621	26.3%	83.3	0.552	0.593	0.621	0.649	0.690
		Avg. Hourly	***2.135***	***1.625***	***0.511***	***23.9%***	***84.7***	***0.457***	***0.489***	***0.511***	***0.533***	***0.564***
Multifamily Customer w/ Window AC	4: PTS Only	13	0.571	0.536	0.036	6.2%	85.0	0.018	0.028	0.036	0.043	0.053
		14	0.605	0.552	0.053	8.8%	85.2	0.036	0.046	0.053	0.060	0.070
		15	0.625	0.561	0.064	10.3%	84.7	0.047	0.057	0.064	0.072	0.082
		16	0.617	0.562	0.055	8.9%	83.4	0.031	0.045	0.055	0.065	0.079
		Avg. Hourly	***0.604***	***0.552***	***0.052***	***8.6%***	***84.7***	***0.038***	***0.046***	***0.052***	***0.058***	***0.067***
	5: PTS + Plug-in AC Device	13	0.702	0.557	0.145	20.7%	85.0	0.091	0.123	0.145	0.167	0.199
		14	0.746	0.596	0.150	20.1%	85.2	0.107	0.132	0.150	0.168	0.194
		15	0.774	0.642	0.132	17.0%	84.7	0.080	0.111	0.132	0.152	0.183
		16	0.799	0.606	0.193	24.2%	83.4	0.138	0.170	0.193	0.216	0.248
		Avg. Hourly	***0.752***	***0.602***	***0.150***	***20.0%***	***84.7***	***0.108***	***0.133***	***0.150***	***0.168***	***0.193***

5 Cost Effectiveness Analysis

Cost-effectiveness analysis is critical for comparing different resource options and for optimizing investment decisions. It allows for comparisons across resource options and provides a basis for prioritizing investments. A key goal of cost-effectiveness analysis is to provide factual insights, make tradeoffs transparent, improve the planning process, and help maximize value.

This section assesses the cost-effectiveness of including DLC in the PTS program based on the pilot findings. Inherently, this type of analysis is not a full assessment of the cost-effectiveness of the PTS program or of potential improvements to that program if improvements were identified and implemented.

The analysis here focuses on two main research questions:

- Are the various customer-technology options cost-effective? In other words, do the benefits of additional demand reduction outweigh the costs of recruiting customers, offering them utility provided technology (if applicable), and continuing operations? The analysis focuses on whether the marginal unit pays for itself and does not factor in overhead fixed costs, which are not linked to the number of participants. The results inform whether it is cost-effective to offer customers DLC technology, assuming no changes in the program or targeting practices.
- What are the key drivers of cost-effectiveness? Can cost-effectiveness of DLC options be improved by modifying how the program is designed, implemented, and targeted?

Cost-effectiveness analysis is generally applied on a forward looking basis to investments that typically have large upfront costs but have benefits that accrue over multiple years. While policies and programs can lead to winners and losers, cost-effectiveness focuses on the broader question of whether the overall policy is beneficial. The two most common perspectives applied are known as the total resource cost test (TRC) and the program administrator cost test (PAC), also known as the utility cost test (UCT).

The TRC test answers the question of whether the average utility customer is better off overall. This perspective essentially measures whether customers as a whole group benefit from the program (both participants and non-participants), and therefore considers incentive payments as a transfer from one group (non-participants) to another (participants). As such, incentive payments are not considered costs that burden the cost-effectiveness of the program under the TRC test. The TRC test is generally the primary basis for policy decisions.

The PAC test answers the question of whether the overall program is self-funded, or whether funds are needed to implement the program (i.e., whether the costs of the program, including incentive payments, are paid for by the benefits of the program). The main difference between the two perspectives is how customer incentives are accounted for. Under the TRC test, incentive payments are considered a transfer between customers, and thus are not included as costs in the assessment. Under the PAC perspective, incentive payments need to be accounted for as part of the operating expenses and thus are considered a cost.

5.1 Customer-Technology Combinations Analyzed

The cost-effectiveness analysis was implemented for six distinct customer-technology combinations that correspond to the DLC pilot results:

1. **Single family customers with central AC but no enabling technology (SF PTS only).** Demand reductions for this group were directly measured and purely behavioral.
2. **Single family customers with central AC and AC switches (SF PTS + AC Switch).** For reasons described in Section 2.2.4, demand reductions observed from customers with PCTs were used. Because both technologies work on the same principle (AC cycling, rather than adjusting thermostat set points), it was assumed that the load impacts would be comparable for these technologies.
3. **Single family customers with central AC and PCT (SF PTS + PCT).** Demand reductions for this group were directly measured.
4. **Multifamily residences with window AC but no enabling technology (MF PTS only).** Demand reductions for this group were directly measured and purely behavioral.
5. **Multifamily residences that self-install window AC control devices.** The difference between customers who install devices on their own and those who do so with professional assistance is that installation costs are avoided.
6. **Multifamily residences with professional installation window air conditioner control devices.** These customers have installation costs associated with them.

By design, PTS customers and the respective control groups included in the analysis either had central AC or window AC.

5.2 Cost and Benefit Inputs

Table 5-1 summarizes the main inputs into the cost-effectiveness analysis for each of the six customer-technology combinations. Table 5-2 summarizes the avoided generation capacity costs, the most tangible benefit of demand response programs. This analysis did not include energy or T&D-related benefits, since there are so few event hours in a given year that these benefits are negligible. The avoided generation capacity costs provide the bulk of the benefits, and are the focus of this assessment.

This analysis used a 15 year analysis period, with the program starting in 2017. The results are expressed in terms of 2015 dollars.

Table 5-1: Cost Effectiveness Inputs

Category	Metric	Single Family PTS only	Single Family PTS + AC switch	Single Family PTS + Thermostat	MF PTS only	MF PTS + Window AC modlet - self-install	MF PTS + Window AC modlet - professional install
General inputs	Discount rate	7.05%					
	Inflation rate	1.90%					
	Analysis period	15					
Installed devices per enrollee		0	1.2	1.2	0	1.86	1.86
Annual attrition (includes turnover and opt-outs)		7.50%	7.50%	7.50%	7.50%	7.50%	7.50%
One-time costs per enrollee	Acquisition recruitment	$11.55	$11.55	$11.55	$11.55	$11.55	$11.55
	Utility equipment[1]	$0.00	$88.56	$155.23	$0.00	$384.02	$384.02
	Installation	$0.00	$106.30	$152.50	$0.00	$0.00	$125.00
	Total	$11.55	$206.41	$319.28	$11.55	$395.57	$520.57
Annual recurring costs per enrollee	Reminder mailings	$0.83	$0.83	$0.83	$0.83	$0.83	$0.83
	Notification, analytics, and settlement calculations	$3.25	$3.25	$3.25	$3.25	$3.25	$3.25
	Customer device support	$0.00	$4.00	$4.00	$0.00	$4.00	$4.00
	Device software licensing	$0.00	$0.00	$20.00	$0.00	$20.00	$20.00
	Total	$4.08	$8.08	$28.08	$4.08	$28.08	$28.08
Load Impacts per enrollee	Demand reduction (kW)	0.18	0.52	0.52	0.05	0.16	0.16
	Annual event hours	12	12	12	12	12	12
	Incentive payments ($/kWh)	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00

[1] Equipment costs reflect the average number of devices per enrollee

Table 5-2: Avoided Generation Capacity Costs

Year	$/MW-day
2015	$136.00
2016	$59.37
2017	$120.00
2018	$200.21
2019	$192.48
2020	$201.47
2021	$208.92
2022	$217.21
2023	$225.69
2024	$227.89
2025	$238.07
2026*	$242.59
2027*	$247.20
2028*	$251.90
2029*	$256.69
2030*	$261.56
2031*	$266.53
2032*	$271.60

*Beyond 2025, values are extrapolated using a 1.9% annual inflation rate