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April 24, 2013

VIA OVERNIGHT UPS DELIVERY

Ms. Ann Cole
Division of the Commission Clerk and
Administrative Services
Florida Public Service Commission
Betty Easley Conference Center
2540 Shumard Oak Boulevard, Room 110
Tallahassee, FL 32399-0850

RE: Docket No. 110031-EG; FPL's Annual Report on Residential Service Dynamic Price Response Pilot Rate

Dear Ms. Cole:

Enclosed are an original and five copies of Florida Power & Light Company's ("FPL's) Final Report on its Residential Service Dynamic Price Response Pilot Rate approved by Order No. PSC-11-0257-TRF-EG.

If you have any questions or concerns please feel free to call me.

Sincerely,

Jessica Cano

Jessica A. Cano

Enclosure
cc: Keino Young

Docket No. 110031-EG
Florida Power & Light Co.
Final report: Residential Service Dynamic Price Response Pilot Project

The Residential Service Dynamic Price Response Pilot Project is part of Florida Power & Light Company's ("FPL's") Energy Smart Florida ("ESF") In-Home Technology Project ("Project"). The purpose of the Project is to study the technical feasibility, customer acceptance and energy impacts of emerging smart-grid enabled consumer technologies and dynamic pricing. In part, the Project was designed to help FPL study how smart meter-enabled dynamic pricing combined with real-time energy information and load reduction enablement impact peak load and energy use.

FPL conducted the Project in fulfillment of its commitment to the U.S. Department of Energy ("DOE"), which funded FPL's Energy Smart Florida initiative pursuant to the American Recovery and Reinvestment Act ("ARRA"), which was awarded on March 30, 2010 (DE – OE0000211). The Project and dynamic pricing pilot were part of FPL's Energy Smart Florida smart grid initiative, and were fully funded by the DOE grant.

FPL received approval by the Florida Public Service Commission ("FPSC") of the dynamic pricing pilot on May 24, 2011. As part of the approval, FPL was ordered to provide a final report detailing information such as customer response, attrition, energy usage, cost savings, conservation results, and the experience of participants as reported in interviews and surveys.

FPL's $200 million award was the maximum allowed by DOE under ARRA. Up to $3.1 million of the $200 million award was budgeted for the In-home technology program and dynamic pricing pilot. FPL completed the Project on time and within budget. This final report summarizes the Project and associated dynamic pricing pilot. The Project's full report, as submitted to the DOE, is attached.

Participation by Project Group

Table 1: Planned and actual distribution of Project Participants by Technology and Rate

Technology / Rate	In-Home Displays (IHDs)	Home Energy Controllers (HECs)	HEC and Smart Appliances
Standard Rate RS-1	Group 1 250 planned 226 actual	Group 2 120 planned 111 actual	N/A
Dynamic Price Response Pilot Rate RSDPR-1	N/A	Group 3 120 planned 117 actual	Group 4 10 planned 10 actual

- FPL completed solicitation, enrollment and installations by September 1, 2011, as scheduled.

FPL achieved 93% of the Project participation goal, including 98% of the pilot rate participation goal.

- Planned participation was up to 500 customers, including 130 on pilot rate
- Actual initial participation was 464 customers, including 127 on the pilot rate

- Participating customers were enrolled in one of four Treatment Groups designed to test the effect of a specific "treatment" or new technology and / or rate:
  - **Group 1:** FPL provided 226 customers with in-home displays ("IHDs") providing real-time energy use information. These customers remained on the standard RS-1 residential rate;
  - **Group 2:** FPL provided 111 customers with Home Energy Controllers ("HECs") which allow customers to monitor their home's energy usage and cost, as well as, monitor the energy use of selected appliances or schedule their operation. These customers remained on the standard RS-1 residential rate;
  - **Group 3:** FPL provided 117 customers with HECs that notify customers of dynamic price events and enable selected appliances to respond in a programmatic manner to dynamic price signals. These customers took service pursuant to the Residential Service Dynamic Price Response (RSDPR-1) pilot rate; and
  - **Group 4:** FPL provided 10 customers with HECs as well as one or more Smart Appliances, which can conserve energy and reduce load in innovative ways. These customers took service pursuant to the RSDPR-1 pilot rate. This group is a qualitative technology demonstration, and is not suitable for quantitative analysis due to its small size.
  - **Control Group (not shown):** The Project used a Control group of 379 homes for comparison. Control group homes were on the standard RS-1 rate, and did not receive any of the technologies described above.

Customer Response

Customers were solicited by direct mail, with follow up by outbound phone call and in some cases reminder post cards and email. For Group 3, two direct mail appeals were required. Customer response to solicitations varied by technology group, with response rates declining with the increasing complexity of the offer.

- A total of 600 customers responded to solicitation, an overall response rate of 4.5%
  - Group 1: 7.9%
  - Group 2: 3.8%
  - Group 3: 1.8% after one mailing, which increased to a total of 2.9% after a second mailing
- From the 600 customers who responded to solicitation, 464 were ultimately successfully installed
  - 570 (95%) of respondents met participation qualifications
  - 480 (85%) of qualified respondents elected to enroll
  - 464 (96%) of enrolled respondents were successfully installed
  - The first ten customers to respond to, and qualify for, the pilot rate were also offered one or more smart appliances. All ten accepted, and 33 smart appliances were installed.

- 85% of participants ranked "impact on electric bill" as their primary reason for enrolling.

Attrition

A total of 23 Project participants (5%) dropped out. Participants who dropped out were not replaced. Details of attrition, by Group and main reason, are summarized below:

Attrition: Participant Drop Outs by Reason Given
Counts include participants contacting FPL to drop out and may not reflect all who stopped using the device

Group	Group 1	Group 2	Group 3	Group 4		
Technology / Rate combination	IHD on RS	HEC on RS	HEC on RSDPR	Appliances on RSDPR	Totals	Percent by Reason
Initial participants	226	111	117	10	464	
Bought new air conditioner	-	1	-	-	1	4%
Comfort concern	-	1	-	-	1	4%
CPP event	-	-	1	-	1	4%
Moved	1	2	4	-	7	30%
Technology issues	1	8	4	-	13	57%
Total drop outs (contacted FPL)	**2**	**12**	**9**	**0**	**23**	**100%**
Drop outs as percent of initial	**0.9%**	**10.8%**	**7.7%**	**0%**	**5.0%**	**-**
Average days of participation	**185**	**254**	**205**	**-**	**215**	**-**

- **Group 1**: While IHD users did not need to contact FPL to drop out, as the device can simply be unplugged, two of 226 (0.9%) did contact FPL to drop out. One could not keep the display connected to the meter and the other moved. Periodic communications tests of connectivity between the IHDs and the FPL smart meter indicate that upon completion of the Project in August 31, 2012, approximately 60% of IHDs were no longer in use.
- **Group 2**: Twelve of 111 (10.8%) dropped out, with the majority citing technology issues as their main reason.
- **Group 3**: Nine of 117 (7.7%) dropped out, with main reasons divided equally between moving and technology issues. Only one RSDPR-1 participant dropped out as a result of a dynamic pricing event. Event # 4, held 1/4/12, was a winter morning event and the participant reported that he used space heaters (which are not controlled by the pilot technology) and was not aware of the event until after it had passed. The participant recommended the addition of an audible alarm as a possible technology enhancement to the HEC.
- **Group 4**: None of the 10 smart appliance participants dropped out.

Energy Usage and Conservation Results

Measurement and evaluation was performed by a third-party consultant, The Brattle Group. The Brattle Group's detailed analysis may be found in the attached report.

Annual Energy (kWh) Conservation, excluding Critical Peak Pricing (CPP) event days

- None of the treatments resulted in annual energy conservation which was statistically distinguishable from zero (at 95 percent confidence level).
    - Group 1: decrease of 0.81% (not significant)
    - Group 2: increase of 0.43% (not significant)
    - Group 3: decrease of 2.84% (not significant)
    - Group 4: This group is a qualitative technology demonstration which is not suitable for quantitative analysis due to its small size.

Load (kW) Reductions During CPP Event Days

- From September 2011 to August 2012, FPL conducted 12 CPP events totaling 54 hours. Events were conducted to measure load reduction by HEC and consumer price response under a variety of conditions. Some months had no events and no calendar month had more than two events. Eight were held in summer, two in winter, one each in spring and fall. Winter events were three hours. Most summer events were four hours, and two summer events were eight hours, the maximum allowed under the pilot tariff. One winter event and one summer event coincided with FPL monthly system peak days. The final two events were held on consecutive days.

Summary of CPP events, September 2011 – August 2012

Event #	Season	Date	Start - end times	CPP hours used	Meters targeted	Phone calls during	Truck rolls during	Event related	Note
1	Summer	9/14/2011	3 to 7pm	4	106	2	0	0	
2	Summer	9/29/2011	3 to 7pm	4	125	0	0	0	
3	Fall	10/25/2011	10am to 2pm	4	125	1	0	0	
4	Winter	1/4/2012	6 to 9am	3	125	5	1	1	January 2012 peak
5	Winter	2/13/2012	6 to 9am	3	124	0	0	0	
6	Spring	4/17/2012	4 to 8pm	4	121	0	0	0	
7	Summer	6/4/2012	4 to 8pm	4	120	1	0	0	June 2012 peak
8	Summer	6/29/2012	4 to 8pm	4	120	0	0	0	
9	Summer	7/2/2012	4 to 8pm	4	120	1	0	0	
10	Summer	7/19/2012	Noon to 8pm	8	120	2	0	0	8 hour event
11	Summer	8/1/2012	4 to 8pm	4	120	1	0	0	Day 1 of 2
12	Summer	8/2/2012	Noon to 8pm	8	120	1	0	0	Day 2, 8 hour event
			Total	54	1446	14	1	1	
			% of total meters			0.97%	0.07%	0.07%	

- All 12 CPP events resulted in load reductions which were statistically significant at the 95% confidence level.
  - The average hourly load reduction across all CPP events was 0.42 kW
  - The average reduction during the typical summer system peak hour (4:00-5:00 p.m.) was 0.37 kW
  - The average reduction during the typical winter system peak hour (7:00-8:00 a.m.) was 0.80 kW

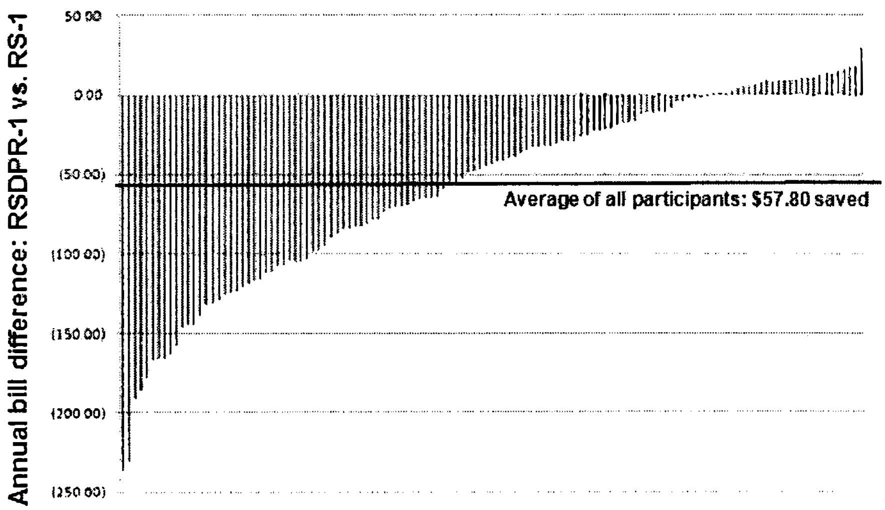
The average load reduction was also significantly higher for the first five non-winter CPP events than the last five non-winter CPP events (0.42 kW vs. 0.30 kW). This diminishing load reduction could not be attributed to weather or to the performance of the smart meter network, and may have resulted from some combination of HAN reliability and customer behavior as the smaller reductions were associated with upward trends in the proportion of HECs appearing unjoined from their smart meter, participants reporting that they noticed CPP events and participants reporting overriding their thermostats during events.

Cost Savings

Since none of the technology treatments resulted in energy (kWh) conservation on non-CPP days which was statistically distinguishable from zero, conservation did not result in cost savings. Most participants in the RSDPR-1 pilot rate did experience annual cost savings as a result of participation in the rate. After an average of twelve bills on RSDPR-1:

- 79% of RSDPR-1 pilot rate participants saved money relative to what they would have paid on FPL's standard rate, RS-1.
- Annual bill impacts (including taxes)
  - o Impacts on bills over the pilot year range from savings of $236 to losses of $30.
  - o Average participant impact was a savings of $57.80.

Seventy nine percent of RSDPR-1 participants paid less than they would have paid on RS-1. Individual impacts ranged from savings of $236 to increases of $30. On average, participants saved $57.80.



Energy Use	Savers	Non-savers
Average kWh per month	1,870 kWh	967 kWh
Average percent of total kWh On Peak	0.75%	0.94%

FPL

- Main Sources of AnnualRSDPR-1 Customer Bill Savings:
  - o CPP Events (14% of total): The RSDPR-1 Pilot Adjustment Factors were designed to be revenue neutral such that the higher priced Conservation Pricing Hours charge would offset the credits provided in the remaining Non-Conservation Pricing Hours if the customer did not curtail usage. Customers could realize savings by curtailing use during the Conservation Pricing Hours.
  - o RSDPR-1 v. RS-1 Rate Structure Differences, Energy Charges (56% of total): Because the RS-1 rate increases by 2 cents per kWh above 1,000 kWh whereas the RSDPR-1 rate increased by 1 cent per kWh above 1,000 kWh. This structural difference created a higher savings potential for participants using more than 1,000 kWh per month. In fact, on average, savers had above average kWh consumption (1,870 kWh per month) whereas non-savers have below average kWh consumption (967 kWh per month).
  - o RSDPR-1 v. RS-1 Rate Structure Differences, Customer Charges (30% of total): The RSDPR-1 pilot rate has a lower monthly Customer Charge of $4.75 compared to RS-1's $5.90. Because the rate for Non-Conservation Pricing Hours was greater than the rate for the first 1,000 kilowatt hours on the standard residential RS-1 rate (but lower than the RS-1 rate for usage greater than 1,000 kilowatt hours), RSDPR-1 participants

were charged a slightly lower Customer Charge to ensure that any low-usage participating customers were held harmless. All participants benefitted from this reduced charge.

FPL notified pilot rate participants of their pilot-to-date savings or losses by letter at the pilot mid-point (April 2012) and upon completion of the pilot. Those letters did not result in any participant inquiries.

Participant Experience

Participants had up to five opportunities to comment on their experience, as summarized in the following table:

Schedule of Participant Surveys

Group	Group 1	Group 2	Group 3	Group 4
Technology / Rate combination	IHD on RS	HEC on RS	HEC on RSDPR	Appliances on RSDPR
Survey type and date				
1. Enrollment and Installation Experience: Feb - Aug 2011	✓	✓	✓	✓
2. Pulse 1: July 2011	✓	✓	-	-
3. In-depth Interviews: November 2011	-	-	-	✓
4. Pulse 2: November 2011	✓	✓	✓	-
5. Pulse 3: May 2012	✓	✓	✓	-
6. Pulse 4: August 2012	✓	✓	✓	-

Key Findings from Customer Surveys

- Participants reported very high satisfaction with the equipment installation experience, with 96% rating satisfaction with Overall Quality of Installation as an 8, 9 or 10 on a scale of 10.
- Overall, participants reported solid satisfaction with the pilot technology and the program. Approximately half of each group reported very good to excellent satisfaction (top 2 options on a 7-point scale). Survey results showed that satisfaction was supported by technology benefits and savings; dissatisfaction stemmed from technology problems and a lack of expected savings. Specific findings from each Group include:
  - **Group 1**: IHDs made a strong first impression, but key measures of benefits, expectations and device use declined significantly in just a few months. Approximately 60% of IHDs appeared to be unplugged by the end of the pilot.
  - **Group 2**: Participants with HECs on the standard rate RS-1 reported higher dissatisfaction than the other groups, were significantly less likely to report saving energy, and were more likely to report abandoning use of their technology than HEC participants on the pilot rate, RSDPR-1.
  - **Group 3**: More participants with HECs on the pilot rate RSDPR-1 reported saving energy than the other groups. Pilot rate participants were accepting of the pilot rate; most agreed they understood how it worked and that the idea made sense. FPL did not receive a single pilot rate-related billing inquiry during the pilot. Pilot rate participants were also accepting of 12 CPP events, and required very little support during the events. The majority of those who noticed events reported that they did not feel inconvenienced and only one participant dropped out of the pilot as the result of a CPP event.
  - **Group 4**: Qualitative findings from in-depth, in-home interviews with Group 4 revealed

that: A dedicated display which makes real-time information available at a glance creates awareness and gives participants a feeling of control and empowerment (i.e. creates an option to act, but not an obligation). The most-used display is the digital cost of current usage, as dollars displayed in digits required no visual or conceptual interpretation. The concept of electrical demand, expressed in kW, was too abstract. When participants glanced at a high number, some act, but most changes are minor, like turning lights off. Only a few acted consistently. About half of smart appliance users noticed CPP events, and none reported they needed to over-ride appliances during events.

Conclusions

The following is a summary of key conclusions which are further discussed in the Executive Summary of the attached full report:

- Overall, FPL concludes that HAN technology, standards and products remain a developmental aspect of smart grid and should continue to be monitored as its reliability, costs and benefits improve. (See full report pages 6, 15, 16 and 24.)
- **Group 1**: FPL concludes that, with current technology, providing near-real time energy feedback with IHDs was technically difficult and while appreciated by participants, did not result in annual energy savings which were statistically distinguishable from zero.
- **Group 2**: FPL concludes that HECs were support-intensive and did not result in annual energy savings which were statistically distinguishable from zero.
- **Groups 3 and 4**: FPL concludes that pilot participants were accepting of dynamic pricing, but that technology improvements are needed to diagnose the causes of varying load reductions over time. HAN technology improvements which provide real-time monitoring of end-to-end connectivity and end-point overrides are needed to provide precise insight into how technical and behavioral factors contribute to HEC-enabled demand response. Such improvements would be essential to future consideration of HEC-enabled demand response.

FPL conducted its In-home Technology Pilot from February 2011 through August 2012. At the conclusion of the pilot, all pilot technology was deactivated or returned to FPL and pilot rate customers were returned to service under FPL's standard RS-1 rate.

DOE funding for the ESF Project provided FPL with a unique opportunity to test and assess the technical feasibility, consumer acceptance and energy impacts of emerging HAN-enabled technologies and dynamic pricing.

Due to the developmental nature of HAN technology and the lack of energy savings found in this pilot, FPL does not intend to pursue a continuation of the pilot or to develop programs based on the concepts or technologies explored in the pilot at this time.

Acknowledgement & Disclaimer

This material is based upon work supported by the Department of Energy under Award Number DE-OE0000211. Disclaimer: This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately

ATTACHMENT

Florida Power & Light
Energy Smart Florida, DE – OE0000211

Element 5
Residential In-home Technology and Dynamic Price Response Pilot
Impact Metric Final Report

Patrick Agnew, Technical Manager ESF Element 5

Florida Power & Light (FPL)
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December 12, 2012

Acknowledgement & Disclaimer

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Table of Contents

1. EXECUTIVE SUMMARY AND CONCLUSIONS

The purpose of the FPL In-home Technology and Dynamic Price Response Pilot was to study the technical feasibility, customer acceptance and energy impacts of emerging smart grid-enabled consumer technologies and dynamic pricing. FPL conducted the pilot in fulfillment of its commitment to the U.S. Department of Energy (DOE), which funded FPL's Energy Smart Florida initiative pursuant to the American Recovery and Reinvestment Act (ARRA) through a grant awarded on March 30, 2010 (DE – OE0000211). The pilot was fully funded by the DOE grant. FPL completed the pilot on time and within budget.

Technical Feasibility

The use of direct or near real-time energy information from the smart meter's Home Area Network (HAN) radio was central to the pilot. The HAN radio can provide near real-time energy feedback that is timely and detailed. However, the accuracy of near real-time feedback is not billing quality as it is transmitted directly and immediately into the home, bypassing the utility validation processes typically applied prior to presenting energy use information to customers.

HAN technology, standards and products are developmental. The HAN communication protocol which was available for pilot use, Smart Energy Protocol 1.0 (SEP 1.0), is non-specific, making interoperability or "plug and play" between smart meters and HAN products difficult to achieve. Technical personnel with HAN skills are scarce and the experience of technology developers and utilities is limited.

FPL's pilot deployed a range of HAN-enabled technologies in four configurations;

- In-home energy displays (IHDs) on FPL's standard residential rate, RS-1
- Home energy controllers (HECs) on the standard RS-1 rate
- Home energy controllers on a pilot dynamic Critical Peak Pricing (CPP) rate, RSDPR-1
- Home energy controllers with one to five smart appliances on the pilot rate RSDPR-1

Pilot technologies were deployed starting with the simplest configuration and progressing to the more complex, allowing personnel to gradually develop HAN skills. In-home energy display installations took approximately 30 minutes. Home energy controller installations were more complex and required two to three hours of skilled technical labor.

Once deployed, home energy controllers were support-intensive: Users of home energy controllers required significantly more support than users of in-home displays and were likely to require support on more than one occasion. Participation in the pilot rate, however, did not increase the use of technical support, as HEC users on the pilot rate were equally likely to call for support as those on the standard rate, RS-1.

The percentage of home energy controller's with intact wireless connections to their smart meters decreased significantly over the course of the pilot in spite of FPL's proactive monitoring and maintenance efforts. Performance of FPL's Advanced Metering Infrastructure network was stable over the course of the pilot and 96.7 percent of targeted meters received CPP events while 96.1 percent confirmed receipt of CPP events.

Customer Acceptance

The customer response to pilot solicitation was good, averaging 4.5 percent. Response rates decreased, and marketing costs increased, with the complexity of the offerings. Eighty one percent of respondents enrolled and eighty five percent of participants ranked "impact on electric bill" as their primary reason for enrolling.

The majority of participants preferred to view their energy use on a dedicated display, in dollars, using the near real-time view "how much I'm using right now." Half or more of the participants reported reducing their energy use since the technology was installed, with most describing saving "a little."

Overall, participants reported solid satisfaction with the pilot technology and the program, with approximately half of each group reporting very good to excellent satisfaction (top 2 options on a 7-point scale). Survey results showed that satisfaction was supported by technology benefits and savings; dissatisfaction stemmed from technology problems and a lack of expected savings.

In-home displays made a strong first impression, but key measures of benefit, expectation and device use declined significantly in just a few months. Sixty percent of in-home displays appeared to be unplugged by the end of the pilot.

Participants with home energy controllers on the standard rate RS-1 reported higher *dissatisfaction* than the other groups, were significantly less likely to report saving energy, and were more likely to report abandoning use of their technology than home energy controller participants on the pilot rate, RSDPR-1.

More participants with home energy controllers on the pilot rate RSDPR-1 reported saving energy than the other groups. Pilot rate participants were accepting of the pilot rate; most agreed they understood how it worked and that the idea made sense. FPL did not receive a single pilot rate-related billing inquiry during the pilot. Pilot rate participants were also accepting of 12 CPP events, and required very little support during the events. The majority of those who noticed events reported that they did not feel inconvenienced and only one participant dropped out of the pilot as the result of a CPP event.

Pilot participants reported adopting energy-conserving behaviors and home improvements. The majority of participants reported changing their energy habits, with the largest majority in the pilot rate group. The home energy controller-equipped groups increased their rate of thermostat programming compared to pre-pilot levels and used more conservative thermostat settings than the in-home display group. "Installing efficient lighting" was the most common home improvement, reported by half or more of each group. FPL found some participation in its energy conservation rebate programs among the Control and treatment groups, with the highest participation in the air conditioning replacement program. There was only one statistically significant difference in conservation program participation among the groups; group T3, home energy controllers on the pilot rate, had higher participation in the ceiling insulation program than the Control group.

Energy Impacts

Pilot measurement and evaluation was performed by The Brattle Group. The external validity of the pilot results only applies to the pilot's southeast Florida geography.

Annual energy (kWh) conservation (excluding CPP days)

- None of the treatments resulted in annual energy conservation which was statistically distinguishable, with 95 percent confidence, from zero.

CPP Impacts

Load (kW) reduction during CPP events:
- All 12 CPP events resulted in load reductions which were statistically significant at the 95% confidence level.
- The average hourly load reduction across all CPP events was 0.42 kW
- The average reduction during the typical summer system peak hour (4-5pm) was 0.37 kW
- The average reduction during the typical winter system peak hour (7-8am) was 0.80 kW

Post-CPP event energy snapback
- Only two of the 12 CPP events showed significant post-event snapback. It was possible that there were additional snapback effects spread over multiple hours after CPP events which the pilot did not have the precision to measure.

Net energy (kWh) conservation on CPP days:
- Three of the 12 CPP event days resulted in statistically significant energy conservation: one of ten non-winter events (3.5%) and both winter events (average of 16.5%).

The average load reduction was also significantly higher for first five non-winter CPP events than the last five non-winter CPP events (0.42 kW vs. 0.3 kW). This diminishing load reduction could not be attributed to weather or to the performance of the AMI network, and may have resulted from some combination of HAN reliability and customer behavior as the smaller reductions were associated with upward trends in the proportion of home energy controllers appearing unjoined from their smart meter, participants reporting that they noticed CPP events and participants reporting overriding their thermostats during events.

CONCLUSIONS

Home Area Network (HAN) Technology

FPL concludes that HAN technology, standards and products remain a developmental aspect of smart grid.

The current SEP 1.0 standard makes interoperability or "plug and play" between HAN products and smart meters very difficult to achieve and compatibility with future smart meter firmware releases difficult to assure. HAN enabled in-home devices, especially home energy controllers, require significant ongoing support. Technical maturation based on the proposed SEP 2.0

standards may result in improved interoperability, network stability and lower support costs. However, the timeline for such maturation remains uncertain. FPL should consider re-evaluating HAN when SEP 2.0 certified products, tested by FPL's smart meter vendor, become available.

In-home Displays (IHD): Direct, or near real-time, energy feedback
FPL concludes that providing near-real time energy feedback was technically difficult and, while appreciated by participants, did not result in annual energy savings which were statistically distinguishable from zero.

All pilot participants were provided near-real time energy use and cost feedback and in IHD equipped group T1, the only treatment was direct feedback. Most T1 participants reported high initial engagement with the IHD, reporting that it helped them to understand their energy use, and motivated them to change their energy habits. Most set their IHD to display the near-real time view "how much I'm using right now" in dollars. The initial period of high engagement was followed by a period of high attrition in IHD use, and half of IHDs appeared to be unplugged in less than a year. In spite of the engagement reported by participants, in-home displays did not result in energy savings. This may be a fundamental finding as technical improvements may not produce a different result.

Home Energy Controllers (HEC): Direct feedback plus appliance-level monitoring or control
FPL concludes that home energy controllers were support-intensive and did not result in annual energy savings which were statistically distinguishable from zero.

HECs provided enhanced direct feedback through graphic displays and added the ability to monitor or control one or more large energy-using appliances. Interviews revealed that HEC users found the controller's simple digital display of the dollar cost of current use more intuitive at a glance than the graphic options. Participants with appliance-level monitoring reported finding the information interesting to know, but difficult to act on. HECs also provided the enhanced ability to schedule the central cooling and heating thermostat through a graphic interface and the presence of this capability resulted in significant increases in thermostat programming. Home energy controllers did not result in energy savings and the lack of anticipated savings negatively affected the experience of some T2 customers.

Dynamic Price Response Enabled by Home Energy Controllers
FPL concludes that pilot participants were accepting of dynamic pricing and technology improvements are needed to diagnose the causes of varying load reductions over time.

Participants were accepting of FPL's pilot rate and the majority of participants reporting that they understood how it works. Participants were also accepting of the 12 CPP events, some up to eight hours in duration, reporting little inconvenience. Participation in the pilot rate did not increase the need for technical or billing support and the pilot rate appears to have created a supportive context for the maintenance-intensive HEC, providing bill savings without adding inconvenience.

Average load reductions during CPP events diminished significantly over time. The pilot technology, however, was not capable of monitoring and measuring the extent to which HAN reliability and customer behavior may have contributed to the diminishing impacts. HAN technology improvements which provide real-time monitoring of end-to-end connectivity and end-point overrides are needed to provide precise insight into how technical and behavioral factors contribute to HEC-enabled demand response. Such improvements may be essential to any future consideration of HEC-enabled demand response.

DOE funding for The Energy Smart Florida In-home Technology and Dynamic Pricing pilot provided FPL with a unique opportunity to test and assess the technical feasibility, consumer acceptance and energy impacts of emerging, HAN-enabled technologies and dynamic pricing. HAN technology remains a developmental aspect of smart grid and should continue to be monitored as its reliability, costs and benefits improve.

2. PILOT BACKGROUND

- *The use of direct, or near real-time, information from the smart meter's home area network (HAN) radio is central to the pilot*

2.1. Technology

FPL smart meters contain two radios:

1. A 900 MHz network interface radio used for utility operations such as obtaining meter readings and,
2. An IEEE 802.15.4, 2.4 GHz, home area network (HAN) radio designed for bi-directional communication with in-home devices. When activated, the HAN radio can communicate near real-time information to a compatible in-home device with which the radio has been paired. The elements of near real-time information can include whole-house power use, energy price, time synchronization and brief text messages.

In order to conduct a true test of HAN technology, communication with in-home devices in FPL's pilot was enabled exclusively by the smart meter's HAN radio. This was done to test in-home capabilities through local, bi-directional communication using the smart meter as the bridge to the utility's back office. In-home devices were not connected to broadband.

2.2. The use of near real-time information from the smart meter's HAN radio was central to the pilot

Users of electricity can potentially receive energy feedback in forms which can be categorically differentiated based on their timeliness, detail and accuracy. The Electric Power Research Institute (EPRI) depicts the typology of energy feedback in Figure 1.[1] Types of feedback fall into two general categories: "indirect" feedback, which is provided after consumption occurs, and "direct" feedback, which is provided in near real-time, or as consumption occurs. Indirect feedback categories range in timeliness and detail, from monthly bills that show total use only, to energy audits that disaggregate monthly use by appliance, to smart meter web sites that display the prior day's use in hourly intervals. Indirect categories typically present billing-quality data, meaning its accuracy has been verified by utility quality checks.

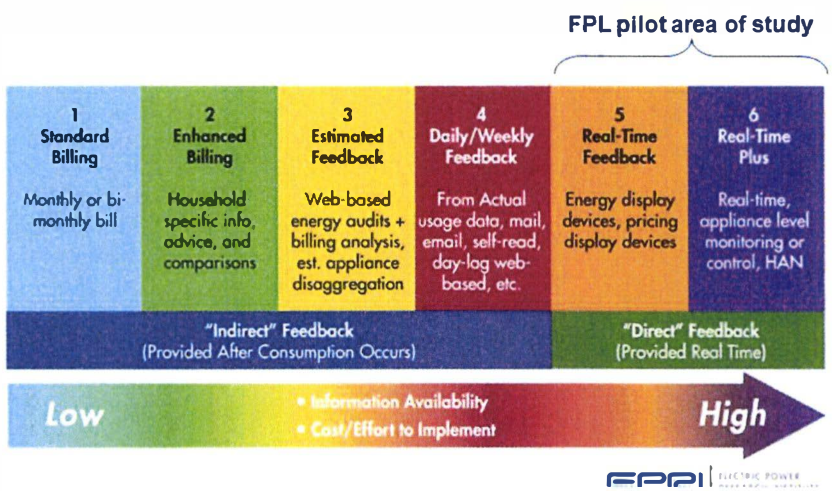


Figure 1: Typology of energy feedback. Copyright EPRI.

"Direct" feedback categories use near real-time information and are the focus of

FPL's pilot. Direct feedback categories include display devices and home energy controllers with appliance level-monitoring or control. Because information provided by direct feedback is available instantly, it bypasses verification by utility quality checks, so its accuracy is not considered billing-quality.

It has been positioned that near real-time feedback has the potential to help consumers become more energy-aware and energy-conserving. However, demonstrations of the effects of near real-time feedback have produced wide-ranging results.[2] Because providing near real-time feedback is technically difficult and costly, more certainty about its benefits is needed. It was the intent of this program, in part, to evaluate this position.

The FPL pilot included the following HAN-enabled in-home devices:

- In-home displays (IHDs)
- Two types of home energy controllers (HECs)
- Programmable communicating thermostats (PCTs) networked with the HECs
- Water heater and pool pump control switches networked with the HECs
- A small population of HECs networked to as many as five smart appliances, including refrigerators, dishwashers, clothes washers, dryers and heat pump water heaters

2.3. Four technology configurations were developed for the pilot

The pilot technologies were distributed to four treatment groups to allow FPL to test and measure the absolute and marginal effects of near real-time feedback, appliance-level monitoring or control and HEC-enabled dynamic price response. Smart appliances were deployed to ten homes as a qualitative study of technical feasibility and customer acceptance.

Table 1: Design of experiment: Pilot treatment groups T1 through T4

FPL pilot technology / rate combinations	In-home Displays (IHD)	Home Energy Controllers (HEC)	HEC and Smart Appliances
Standard Rate: Residential Service RS-1	**Group T1** Near real-time energy feedback	**Group T2** Near real-time energy feedback + appliance-level monitoring or control	na
Pilot Rate: Residential Service Dynamic Price Response RSDPR-1	na	**Group T3** Near real-time energy feedback + appliance-level monitoring or control + HEC-enabled dynamic price response	**Group T4** Near real-time energy feedback + appliance-level monitoring or control + HEC-enabled dynamic price response + smart appliances

2.3.1. Configuration 1: GE in-home display deployed to group T1

Figure 2

Configuration 1 consisted of the GE in-home energy display, which provided:

- Digital display of current whole-house power use and cost (dollars per hour)
- Digital display of cost and amount of energy used (to date) during calendar month, forecasted cost and amount of energy to be used by end of calendar month, and text messages

2.3.2. Configuration 2: Cisco HEC deployed to groups T2, T3

Figure 3

Configuration 2 consisted of the Cisco HEC, which provided:

- Graphic thermostat interface
- Graphic displays of current whole-house power use and cost (dollars per hour), cost and amount of energy used (to-date) during the calendar month, current price level indicated by color codes, text messages, and an energy budget application that tracks actual and forecasted monthly use against a user determined goal
- Appliance-level control of electric water heater and/or pool pump
- When deployed to T3 homes, units provided automated response to CPP events by adjusting thermostat set point and turning off electric water heater and/or pool pump, based on user preferences (user could override thermostat response at thermostat or controller console, and water heater and pool pump response could be overridden at console)

2.3.3. Configuration 3: GE Nucleus^{TM} HEC deployed to groups T2, T3

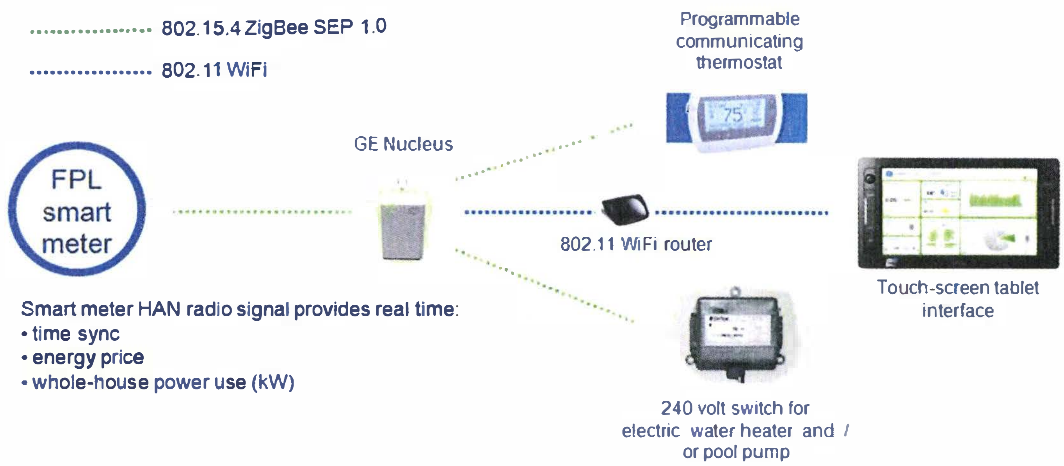


Figure 4

Configuration 3 consisted of the GE Nucleus^{TM} HEC, which provided:

- Graphic thermostat interface
- Graphic displays of current whole-house power use and cost (dollars per hour), cost and amount of energy used (to-date) during the calendar month, current price level indicated by color codes and text messages
- Appliance-level monitoring of energy use by electric water heater and/or pool pump
- When deployed to T3 homes, units provided automated response to CPP events by four-degree thermostat offset and turning off electric water heater and/or pool pump (user could override thermostat response at thermostat or controller console, while water heater and pool pump could not be overridden)

2.3.4. Configuration 4: GE Nucleus^{TM} and smart appliances deployed to group T4

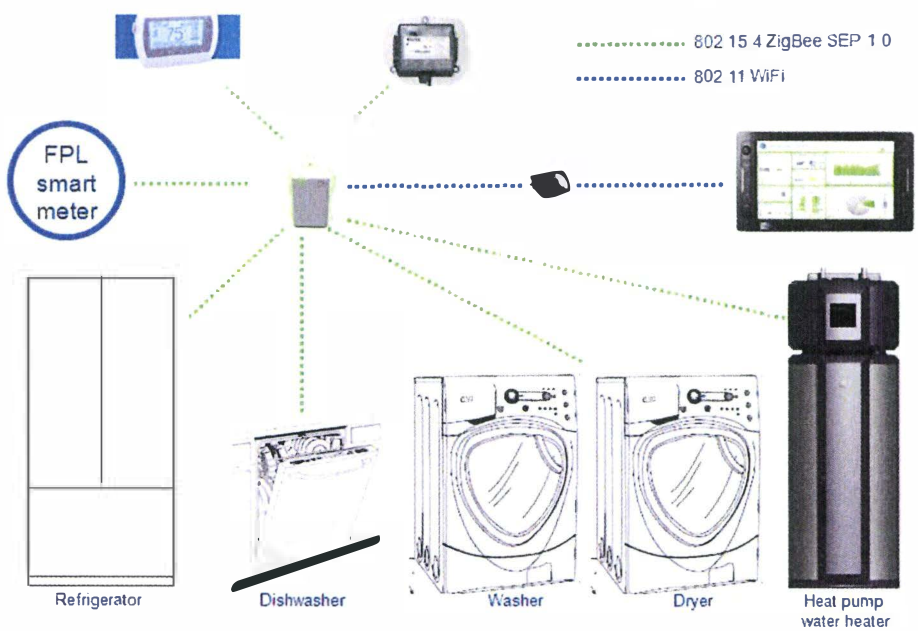


Figure 4

Configuration 4 consisted of the GE Nucleus™ HEC and up to five GE smart appliances, which provided:

- The features of technology Configuration 3
- Appliance-level monitoring of energy use by smart refrigerator, dishwasher, washer and dryer
- Smart appliances respond to CPP events in ways designed to minimize energy use while also minimizing user inconvenience. Appliances respond automatically in two general ways: 1) delaying start until a lower-cost period, or 2) if appliance is mid-cycle when a high price period occurs, reducing its power requirement without interrupting its task. In most cases appliance responses could be overridden by consumers.
- The GE smart appliances used in the FPL pilot featured these manufacturer-specified programmatic responses to CPP events:
    - Refrigerator: Disable several features, such as QuickFreeze, Quick Ice™, and TurboCool™, delay defrost and consumer-safe temperature shifts.
    - Dishwasher: Delay cycle start and disable the heated dry option. These features can be overridden by the customer.
    - Clothes washer: Delay cycle start. Power Saver cycle suggested as the default setting if the consumer has overridden delayed cycle start. These features can be overridden by the customer.
    - Clothes dryer: Delay cycle start. Power Saver cycle is suggested as the default setting if the consumer has overridden delayed cycle Start. If already operating, complete the remaining portion of cycle in Power Saver mode. These features can be overridden by the customer.
    - GeoSpring Hybrid-electric water heater: Use a 550-watt "eHeat" heat pump mode vs. the 4,500-watt resistance element. Enable a lower water temperature set point (e.g., 100 degrees) to minimize cycling.

2.4. Pilot Rate: Residential Service Dynamic Price Response, RSDPR-1

- *During critical peak price (CPP) hours, prices increased by 350 percent to encourage reduction in energy usage*

As part of the Energy Smart Florida in-home technologies program a dynamic pricing pilot was also implemented and tested.

FPL's pilot rate was a two-tier dynamic rate consisting of a base or "all hours" energy charge, and a higher CPP charge that was applicable during times of peak demand, which FPL designated as CPP hours. For marketing purposes, the rate was termed "FPL Smart Price" and CPP hours were termed "Conservation Price Hours." The rate for non-CPP hours was greater than the rate for the first 1,000 kilowatt hours on the standard residential RS-1 rate, but lower than the RS-1 rate for usage greater than 1,000 kilowatt hours, the Pilot Rate had a slightly lower monthly Customer Charge to ensure that any participating low-usage customers were held harmless. Thus, participants purchased electricity at a discount during all hours except CPP hours. These discounted hours would comprise at least 99 percent of the year.

Figure 6: RSDPR-1 pilot rate as disclosed in brochures

Table 1 – Standard Price versus Smart Price

FPL standard price (RS-1) Customer charge: $5.90 per month	FPL Smart Price (RSDPR-1) Customer charge: $4.75 per month	
Cost per kilowatt-hour (kwh):	at least 99% of the time	during Conservation Price Hours (up to 1% of the time)
up to 1,000 kwh 8.714c	8.823c	30.845c
over 1,000 kwh 10.714c	9.823c	31.845c

Prices reflect fuel and non-fuel charges effective June 1, 2011. Taxes and the standard storm charge are not included.

About Table 1: FPL's "customer charge" is the fixed monthly fee for electric service. You also pay for the electricity you consume per kilowatt-hour (kwh). The price per kwh varies, depending on how much energy you use (more or less than 1,000 kwh) during each billing period. FPL Smart Price participants will pay an overall discounted price for electricity 99 percent of the time, including the customer charge plus the cost of electricity per kwh. You will pay a much higher price up to 1percent of the time during CPHs.

Table 2 – Smart Price Discount

Average monthly energy use (kwh)	Annual discount with no Conservation Price Hours
1,000	$0.72
1,500	$54.12
2,000	$107.64
2,500	$161.04

About Table 2: Table 2 shows the annual discount you could realize from FPL Smart Price based on your average monthly energy usage. We'll designate occasional CPHs when energy conservation is needed, and your savings over the year-long pilot will be affected by how you respond during these periods. If you reduce your energy use during CPHs, you will save. If you ignore the CPHs, expect to offset your discount and pay about the same as you do today. If your energy use increases during CPHs, you could pay more. Actual savings will vary, depending on how much energy you use during CPHs.

During CPP hours total prices increased by 350 percent to encourage a reduction in energy usage. By tariff, FPL could designate a critical peak period, and apply the higher CPP charge up to 88 (about one percent) hours a year. Participants were notified at the start of CPP events through the home energy controller, which displayed visual notifications.

The rate was designed to be revenue neutral, consistent with the Florida Public Service Commission (FPSC) policy on time of use rates. Accordingly, if an average customer (based on the ¢/kWh energy average for residential customers) did not reduce usage during CPP events, that customer paid the same amount per kilowatt-hour as he/she would have paid under FPL's standard RS-1 rate. Alternatively, if the customer reduced usage during one or more CPP events, the customer paid less than he/she would have paid under the RS-1 rate.

This two-tier rate design achieved several project objectives. It met the Federal Energy Regulatory Commission (FERC) definition of a dynamic rate[3] and met the DOE's express desire to test some form of real time or critical peak pricing[4]. DOE also expressed a desire to conduct ideal randomized controlled trials with mandatory assignment of technology-rate combinations to avoid self-selection bias[5]. However, FPL believes participation in technology programs and alternative rates should be voluntary. Thus, FPL employed a voluntary (opt-in) pilot design, and its results are representative of a voluntary program. Customers were not offered a choice of treatments and were not aware of the other treatments.

It should be noted that FPL's billing system is not designed to bill dynamic rates. FPL was capable of administering the dynamic pilot rate on a small scale and with manually intensive processes. However, this manual effort had no impact on the project results or findings.

FPL is required to seek FPSC approval of any new rates or tariff sheets, and received FPSC approval for the dynamic pricing pilot and associated RSDPR-1 tariff on May 24, 2011. (Docket No. 110031-EG, Order No. PSC-II-0257-TRF-EG).

3. TECHNICAL FINDINGS

3.1. Development

- *HAN technologies and products are developmental and time-consuming to integrate. Technical personnel with HAN skills are scarce.*
- *Smart Energy Protocol 1.0's non-specific nature made interoperability difficult to achieve.*
- *The level of interoperability that was finally achieved was meter firmware version-specific.*

3.1.1. HAN technologies and products are developmental

Home area network technology is in the developmental stage. Technical personnel with HAN technical skills are scarce and the experience of those individuals is limited. At the time FPL proposed its HAN pilot to the DOE, few equipment providers or utilities had HAN experience outside of test labs. Most of the in-home products used in FPL's pilot were beta versions; first generation and pre-commercial.

The IEEE 802.15.4, 2.4 GHz HAN radio and ZigBee Smart Energy Protocol comprised the de facto industry choice for HAN due to low cost, low-power usage, mesh networking and reach. The initial version of the Smart Energy Protocol, SEP 1.0, had shortcomings. It left many items optional and did not provide a robust, interoperable and forward-compatible communication standard. Since SEP 1.0 was not a mature technical specification, it was subject to variation in implementation by technology developers, and this greatly hindered the ability to achieve interoperability or "plug and play" compatibility between HAN devices, including smart meters.

3.1.2. SEP 1.0's non-specific nature made interoperability difficult to achieve

Because of the developmental state of HAN technology and non-specific nature of SEP 1.0, interoperability, or "plug and play" between smart meters and in-home technologies was very difficult to achieve. Extensive testing and refinement were required to enable FPL smart meters to communicate with in-home devices. In the case of HECs, communication between in-home network components (PCTs, water heater and pool pump control switches, smart appliances) also needed to be tested. The level of interoperability which was finally achieved was meter firmware version-specific. This required FPL to update the meter firmware of potential pilot homes prior to in-home device deployment and prevented FPL from updating the meter firmware of pilot homes during the pilot.

FPL has been an active participant in the development of national interoperability standards across all aspects of Smart Grid technology. Specific to HAN, FPL has supported national groups such as NIST through various Priority Action Plans (PAP's) and UCA OpenSG in the development of consistent energy use cases to develop national interoperability standards. FPL has also been a thought leader in the development of Cyber Security technology and best practices for Smart Grid as utilities must build and retain consumer confidence that any utility provided connection to in-home technology meets all state and federal requirements.

3.1.3. The level of interoperability that was finally achieved was meter firmware version-specific

Working directly with HAN technology provided FPL the opportunity to experience its capabilities and limitations. *A key limitation discovered early on was that the amounts displayed by in-home devices did not match the utility bill.* This was due to several limitations of the SEP 1.0 standard: First, the standard did not support utility billing cycles, so in-home devices displayed usage based on calendar months only. Second, the standard did not support the fixed monthly Customer Charge or the block tariffs (FPL's standard residential rate, RS-1, is an inclining block rate with a lower price for first 1,000 kWh). Finally, in-home devices did not record energy used during periods when they were unplugged or out of communication with the smart meter. FPL considered that pilot participants could reasonably expect to compare the amount displayed by the in-home device to their FPL bill and that any difference could create issues. As a result, FPL included the following disclaimer on printed solicitation materials and reviewed it during the enrollment phone call and installation visit:

> *"The dollars shown on the display are a guide to your energy cost, but will not match your FPL bill. That's because the display tracks energy use by the calendar month, not by your FPL billing cycle (the period of time between meter readings), and does not include taxes and standard fees that are part of your monthly bill."*

3.2. Deployment

Below is the summary of findings from the deployment phase of the program:

- *Deployment progressed from the simplest to most complex configurations.*
- *In-home energy display installations took 30 minutes on average.*
- *Home energy controller installations were complex and took two to three hours.*

3.2.1. Deployment progressed from the simplest to most complex configurations

After extensive lab testing, but prior to deployment to pilot homes, FPL performed test installations in several employee homes. These test deployments provided the opportunity to develop detailed installation procedures, test HAN radio signal propagation and estimate the time required to perform pilot installations. Based on the test installations, FPL decided to deploy to pilot homes in stages, beginning with the simplest device, in-home displays, and progressing to the more complex configurations of home energy controllers and, ultimately, smart appliances. Each stage required more complex network construction and maintenance, and this approach allowed installers to build their networking skills and focus on mastering the installation of one technology at a time.

3.2.2. In-home energy display installations took 30 minutes on average

In-home energy display installation took about 30 minutes. Installation consisted of activating the smart meter HAN radio and establishing a secure, paired connection between the meter and the in-home display. The display needed to be located within the home near enough to the smart meter to receive the HAN radio signal, and display location was typically a compromise of HAN radio signal strength, power plug availability and participant preference.

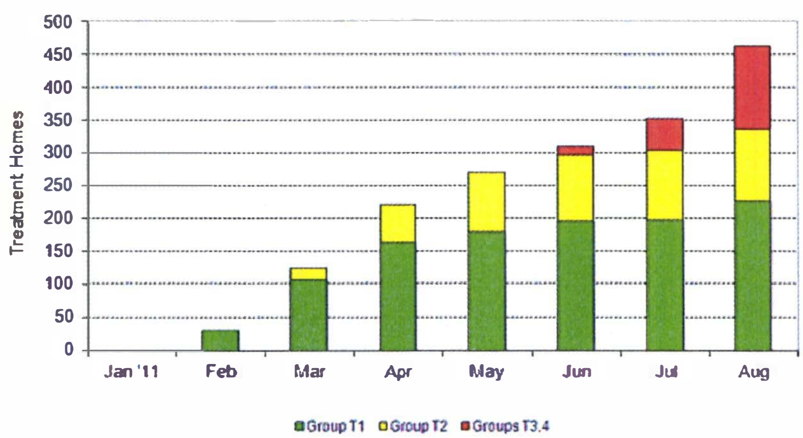
3.2.3. Home energy controller installations were complex, taking two to three hours

Home energy controller installations were complex and time-consuming. Installations took several hours and required installers to possess diverse technical skills: the power wiring skill of an electrician, the control wiring skill of an air conditioning technician and the wireless networking skills of an information technology technician. As with in-home displays, FPL was compelled to locate home energy controllers within the home and near the smart meter to receive the HAN radio signal. Again, the location was a compromise of HAN radio signal strength, power plug availability and participant preference.

In-home energy displays and home energy controllers are emerging technologies and successful installation included taking the time to educate participants in the use of these technologies. Installers provided participants with an orientation in the use of the new technology, including an information kit and refrigerator magnet displaying a toll-free support phone number. Participants enrolled in the pilot rate received supplemental orientation from an FPL residential energy representative to ensure they understood the pilot rate, how the HEC enabled automatic response to CPP events and what to expect during CPP events.

FPL's deployment to 464 homes started February 2011 and was completed on September 1, 2011. Overall, 96 percent of in-home display and home energy controller installations were successful. Less than one percent of installations were abandoned due to inability to establish a connection between the smart meter's HAN radio and the in-home device. Other causes of abandoned installations included incompatibility of the thermostat with the customer's air conditioner and the condition of the home's appliances or wiring.

Figure 7: Deployment timeline



Upon completion of installation, participants were given an opportunity to report their satisfaction with the enrollment and installation process, and 96 percent rated their satisfaction with Overall Quality of Installation as an 8, 9 or 10 on a scale of 10.

At the end of 2011, FPL's deployment of 238 home energy controllers was the largest among DOE Smart Grid Investment Grant (SGIG) recipients and was one of only two deployments of smart appliances.

3.3. Support

- *Home energy controllers were support intensive.*
- *Participation in the pilot rate did not increase the need for technical support.*
- *The percentage of HECs with intact wireless joins to smart meters decayed significantly over the course of the pilot, in spite of FPL's proactive monitoring and maintenance efforts.*

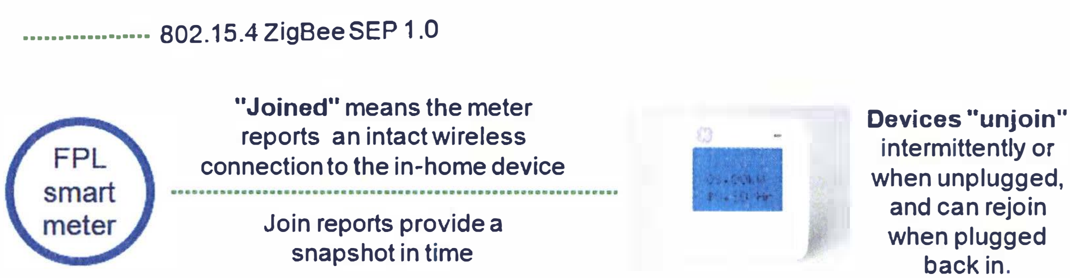
3.3.1. Home energy controllers were support intensive

Post-deployment technical support was provided on both a proactive and reactive basis. Proactive support was based on monitoring the connectivity between the smart meter and in-home technologies. Reactive support was based on response to participant calls to the pilot's toll-free support number.

3.3.2. Proactive Support

HAN technology has limited capability to proactively monitor in-home devices. FPL's monitoring was limited to the state of the wireless connection between the smart meter's HAN radio and the in-home display or controller to which it was directly paired or "joined." FPL could not monitor the connectivity of networked devices downstream from home energy controllers (thermostats, water heater and pool pump switches, smart appliances) and could not monitor the settings or pilot participants' use of home energy controllers or any of its downstream devices.

Figure 8: Illustration of in-home device to smart meter "join"



Because the wireless "join" to the smart meter HAN radio was the in-home device's energy information link, FPL monitored the state of meter-device joins every month. Join monitoring reports provided a snapshot in time. Since HAN devices can unjoin and rejoin intermittently, or simply be unplugged by the user at the time the join snapshot is taken, a device could appear unjoined in one month and appear rejoined the next month.

FPL investigated unjoined devices by calling the participant. Participant cooperation was needed to verify the state of join (by confirming the device was displaying current energy use). If the device was still unjoined at the time of the call, participant cooperation was also needed to rejoin the device to the meter. Given the uncertainty in join monitoring and FPL's desire to avoid inconveniencing participants with unnecessary phone calls, FPL developed analytic categories and an investigation plan based on its confidence in the join analysis and the degree of economic risk to the participant if the in-home device was unjoined from the meter.

FPL's analytic categories were designed to increase the certainty that a device was intermittently or permanently unjoined or unplugged. These categories were:

- Joined last month, still joined this month
- Joined last month, now not joined (to identify newly unjoined devices)
- Not joined last month, now joined (to identify rejoined devices)
- Not joined last month, not joined this month (to identify chronically unjoined devices)

FPL combined these analytic categories with an investigation plan based the degree of economic risk to the participant if the in-home device was, in fact, unjoined from the meter:

- Group T1, in-home displays on the standard RS-1 rate, was monitored only. Displays which are unplugged also appeared unjoined, and join reports primarily provided a proxy for participant attrition in the use of in-home displays.
- Group T2, home energy controllers on the standard RS-1 rate: Participants were called if the HEC appeared unjoined for two consecutive months. This approach was intended to increase the certainty that the device was actually unjoined and to reduce unnecessary participant contact.
- Groups T3 and T4, home energy controllers on RSDPR-1 pilot rate: Participants were called every month the HEC appeared unjoined because an intact join was essential to receiving CPP events. These were the only groups that would be exposed to economic risk from being unjoined.

FPL found that proactively maintaining joins involved attempting to contact an average of about 10 percent of HEC users each month. Depending on the group, half to two-thirds of participants contacted reported their HEC was, in fact, joined to the meter at the time of the call. Some participants did not return FPL's calls and their HECs remained unjoined for several months, contributing to a growing number of unjoined HECs. FPL found proactive join maintenance to be an elusive exercise that both increased over time and often resulted in unnecessary participant contact.

FPL found that the percentage of HECs with intact wireless joins to smart meters decayed significantly over the course of the pilot, in spite of FPL's proactive monitoring and maintenance efforts.

Figure 9: T2 HEC join history

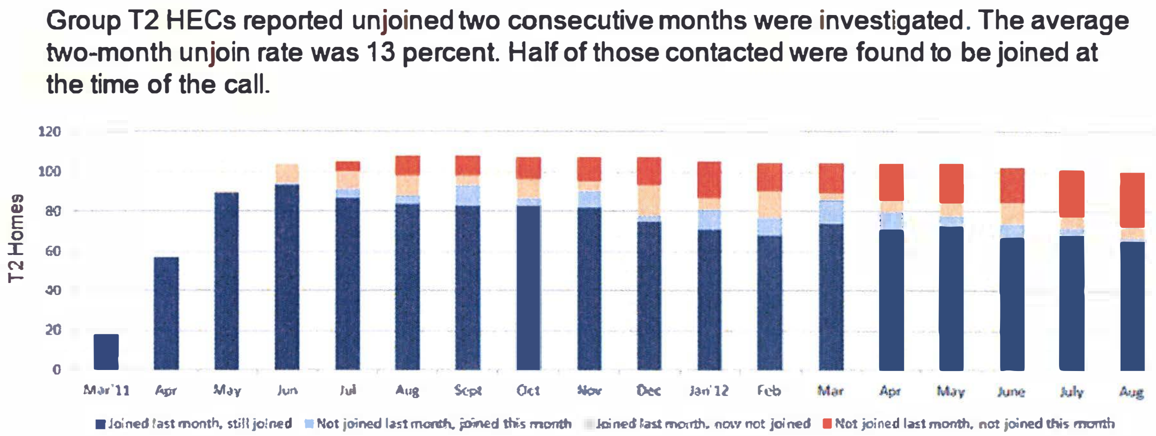
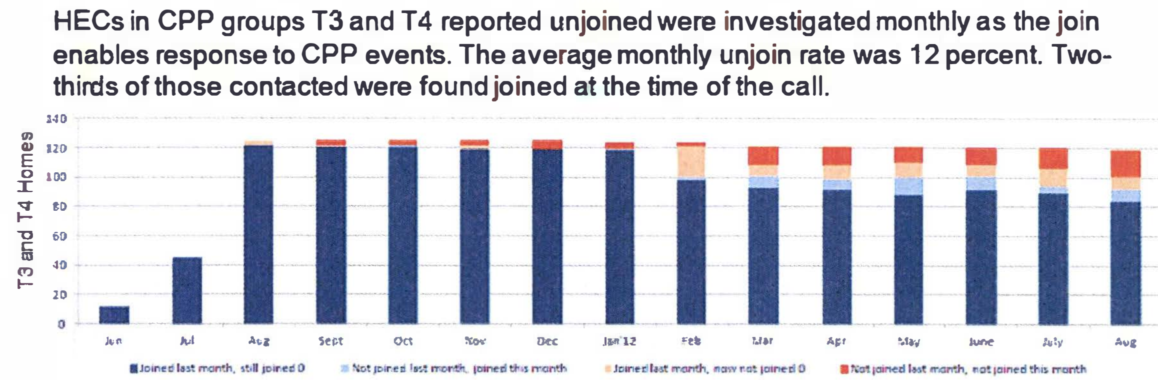


Figure 10: T3 and T4 join history



3.3.3. Reactive Support

Reactive support included responding to participant calls to the pilot's toll-free support number. When responding to calls, technical support personnel first attempted to resolve the inquiry over the phone. If the issue could not be resolved by phone, a support technician visited the home.

Support for in-home displays consisted of reestablishing the wireless join to the smart meter. Loss of join typically resulted from the participant moving the display beyond the range of the meter's HAN radio or a power outage. In some cases, in-home displays simply could not maintain a stable join to the smart meter. On average, less than one percent of in-home display users called per month, and most in-home display support issues were resolved by phone. Twenty six percent of in-home display issues required a technical service visit.

Home energy controllers were much more support-intensive than in-home displays. During the six-month deployment period preceding the pilot measurement year, technical service visits were made to an average of 10 percent of HEC homes per month. However, during this period, technicians were still learning about the complexities of home energy controllers, and support processes were still maturing. During the pilot measurement year, 68 percent of HEC participants needed to call the technical support number. Even with mature support processes, the great majority (81 percent) of HEC issues could not be resolved by phone, resulting in technical service visits to 55 percent of homes in one year. The majority of technical service visits (60 percent) were to restore wireless network connections between in-home components or the join to the smart meter. Home energy controllers are complex wireless networks – even basic pilot installations contained seven radios, including the smart meter's HAN radio. These complex networks were difficult to keep connected and did not always restore themselves following power outages. As one HEC user stated in the August 2012 survey, "*My system lost connection 3 or 4 times in the last few months some due to outages in the area.*"

Table 2: Annual technical support by technology type

Annual Technical Support Summary by Technology Type
Measurement Year: September 2011 - August 2012

Device type	In-home Displays	Home Energy Controllers
Number of device-months	2693	2720
Called the pilot's 1-800 support number	10%	68%
Required Technical Site Visit	2.7%	55%
Percent of calls requiring a Technical Site Visit	26%	81%

Table 3: Details of technical service visits

Truck Rolls 9/1/11-8/31/12	Count	% Total	Network	Hardware
AC maintainance	2	2%		
Defective wiring	4	3%		
Deinstall HEC	12	9%		
Hardware - unclassified	2	2%		2%
Hardware - batteries	1	1%		1%
Hardware - IHD	2	2%		2%
Hardware - radio	3	2%		2%
Hardware - thermostat	12	9%		9%
Hardware - replace tablet	2	2%		2%
Meter change	3	2%		
New AC,reinstall thermostat	1	1%		
Rebuild in-home network	2	2%	2%	
Rejoin to meter's HAN radio	15	12%	12%	
Reset in-home network	48	38%	38%	
Reset network - router	12	9%	9%	
Software	3	2%		
Thermostat configuration	4	3%		
TOTAL	**128**	**100%**	**60%**	**17%**

3.3.4. Detecting Unseen Problems

Proactive support acted on potential problems of which FPL was aware. Reactive support responded to problems noticed by participants. A third category of problems, those unknown by FPL and unnoticed by participants also exists; e.g.; when a HEC downstream device (thermostat, water heater and pool pump control switches, smart appliance) lost its wireless connection to the HEC without the participant noticing. Such a condition is of consequence during CPP events, because such a disconnected device could not receive the event signal and act automatically reduce load. To get a sense of the frequency of such occurrences, two proactive inspections of HEC network connectivity were performed:

- The first inspection was performed on group T4 smart appliance homes in spring 2012, six months after installation. In nine homes visited, technicians observed that 22 percent (2 of 9) thermostats, 33 percent (1 of 3) water heater / pool pump switches and 7 percent (2 of 29) smart appliance communication modules were offline, without participants being aware.

- The second inspection was performed at the end of the pilot in fall 2012. In a sample of homes with intact home area networks (had not been disabled by the customer prior to the technician's arrival), FPL found that 8 percent of thermostats, 33 percent of water heater / pool pump switches and 18 percent of smart appliances were not connected to the home energy controller.

Table 4: Post-pilot inspection of HEC in-home network connectivity

Post-pilot inspection of HEC in-home network connectivity in T2, T3 and T4 homes
Inspections conducted: September - October, 2012

HEC Peripheral Devices Inspected		Percent Connected	Percent Not Connected
Thermostats inspected	49	-	-
Thermostats connected to HEC	45	92%	8%
Water heater / pool pump switches	12	-	-
Switches connected to HEC	8	67%	33%
Smart appliances inspected	11	-	-
Smart appliances connected to HEC	9	82%	18%

Two surveys asked participants to report their need to call the pilot's toll-free support number and their satisfaction with the support provided. Results showed that:

- Users of home energy controllers required significantly more support than users of in-home displays and were likely to require support on more than one occasion.
- The pilot rate did not increase the use of technical support, as HEC users on the pilot rate were just as likely to call for support as those on the standard rate.
- The majority who used the technical support reported high satisfaction with the service provided.

Table 5: Participant-reported use of technical support

Use of 1-800 Technical Support and Satisfaction with Support Provided
<u>Bold</u> indicates 90% confidence in significant change from prior Pulse
(>Tn) indicates 90% confidence in significant difference from Group n in same Pulse

Group	Group T1, IHD on RS		Group T2, HEC on RS		Group T3, HEC on RSDPR	
Survey	Pulse 3	Pulse 4	Pulse 3	Pulse 4	Pulse 3	Pulse 4
Responses collected	May-12	Aug-12	May-12	Aug-12	May-12	Aug-12
Number of respondents	64	55	38	39	47	30
Called the pilot's 1-800 support number	25%	31%	63% (>T1)	77% (>T1)	64% (>T1)	**83%** (>T1)
Called once	not asked	13%	not asked	15%	not asked	33% (>T1,2)
Called on more than one occasion	not asked	18%	not asked	62%(>T1)	not asked	50% (>T1)
Satisfied with support (very or extremely)	63%	59%	71%	53%	70%	68%

3.4. AMI network performance during CPP events

- *96.7 percent of targeted meters received CPP events.*
- *96.1 percent of targeted meters confirmed receipt of CPP events.*
- *Participants served by meters not receiving events were not billed the higher CPP price for that event.*

During CPP events, FPL's advanced metering infrastructure (AMI) conveyed the price event to participant smart meters. Participant meters, in turn, sent a confirmation of receipt to FPL and conveyed the event to participants' home energy controller, which could then act to reduce load and inform the participant of the event. If notification of the event did not reach the meter, neither the home energy controller nor the customer could be aware of, or respond to, the event. In such cases, the participant was not billed at the higher CPP price for that event.

FPL experienced some variation in both the delivery of price events to meters and receipt of confirmation from meters. FPL performed 12 CPP events during the pilot, targeting a total of 1,446 meters. 96.7 percent of targeted meters actually received CPP events, with 96.1 percent confirming receipt. The 0.6 percent difference between meters receiving and meters confirming was determined by investigating the logs of meters failing to confirm receipt, a process that was added following CPP event #6. FPL verified that 16 percent of non-confirming meters actually received the events. Such investigations were manual and time-bound, as they were performed, by necessity, before the CPP event ended. Thus, these investigations may not be feasible in large-scale programs.

Meters confirming reciept of CPP events				
Event #	Date	Meters targeted	Meters confirming	Percent confirming
1	9/14/2011	106	104	98.1%
2	9/29/2011	125	117	93.6%
3	10/25/2011	125	122	97.6%
4	1/4/2012	125	124	99.2%
5	2/13/2012	124	115	92.7%
6	4/17/2012	121	118	97.5%
7	6//4/12	120	118	98.3%
8	6/29/2012	120	115	95.8%
9	7/2/2012	120	118	98.3%
10	7/19/2012	120	113	94.2%
11	8/1/2012	120	112	93.3%
12	8/2/2012	120	113	94.2%
		1446	**1389**	**96.1%**

Table 6: Meters confirming receipt of CPP events

3.5. Summary of Technical Findings

- The use of direct or near real-time energy information from the smart meter's home area network (HAN) radio was central to the pilot.
- Near real-time energy feedback is highly timely and detailed. Its accuracy, however, is not considered billing quality.
- HAN technologies and products are developmental. Technical personnel with HAN skills are scarce. Smart Energy Protocol 1.0's non-specific nature made interoperability difficult to achieve, and the level of interoperability which was finally achieved was meter firmware version-specific.
- FPL's pilot deployed a range of HAN-enabled technologies in four configurations, starting with the simplest and progressing to the more complex.
- In-home energy display installations each took approximately 30 minutes, while home energy controller installations were more complex and required two to three hours of skilled technical labor.
- Home energy controllers were support-intensive: Users of home energy controllers required significantly more support than users of in-home displays and were likely to require support on more than one occasion.
- Participation in the pilot rate did not increase the use of technical support, as HEC users on the pilot rate were just as likely to call for support as those on the standard rate, RS-1.
- The percentage of HECs with intact wireless joins to smart meters decayed significantly over the course of the pilot, in spite of FPL's proactive monitoring and maintenance efforts.
- During CPP events, 96.7 percent of targeted meters received notification of events and 96.1 percent confirmed receipt of events.

4. CUSTOMER ACCEPTANCE

- *Overall satisfaction is supported by technology benefits and savings; dissatisfaction stems from technology problems and a lack of expected savings.*
- *Customers were accepting of the pilot rate and CPP events.*

4.1. Solicitation and Enrollment

- *13,446 customers were solicited, 4.5 percent responded and 81 percent of respondents enrolled.*
- *Overall, the project achieved 93 percent of planned participation.*
- *Participants ranked "impact on electric bill" as their primary reason for enrolling.*

In-home displays, home energy controllers and dynamic electric rates are new and unfamiliar to most consumers so FPL's insights into customer acceptance started with its efforts to recruit pilot participants. While the idea of an in-home energy display was relatively simple, dynamic pricing enabled by a home energy controller was new and complex.

4.1.1. Savings could not be guaranteed

FPL could not guarantee prospective participants that they would save money. In-home displays are unlike energy efficient products such as compact florescent lights, which save energy simply by being installed. Savings for IHD participants depended on participants acting on the near real-time energy feedback presented. Home energy controllers were new products which combined near real-time energy feedback with appliance monitoring or control, and their energy saving impacts were unknown.

FPL anticipated that prospective participants may have savings expectations and desired to provide participants some guidance. FPL provided guidance based on the published finding that consumers who actively use near real-time feedback, such as that provided by an in-home display, can reduce their consumption of electricity on average by about 7 percent.[6]

Group T1 prospects received this savings statement from the solicitation brochure:

How much can I save?
Your electric bills will continue to reflect how much energy you actually use. Any potential savings will depend on the changes you make to your energy habits. Studies have shown that consumers who actively use an energy display and the data it offers can save an average of about 7%.

Group T2 prospects received these savings statements from the solicitation brochure:

Will the technology automatically reduce my electric bills?
No, the device gives you information about your energy use and costs, as well as the ability to control your home's biggest energy user. These features enable you to make choices that could reduce your electricity use and monthly bills. Your bill will reflect how much energy you actually use during the billing cycle, which is the period of time between meter readings.

Will my electric bills be lower or higher?
That will depend on how much electricity you use and whether you make changes to your energy habits. Studies have shown that consumers who actively use an energy display save an average of about 7% on their electricity consumption.

Potential savings in group T3 had the greatest uncertainty as bill changes depended on conservation actions taken both on a day-to-day basis and during CPP events. Due to this uncertainty, FPL did not cite the 7 percent figure used in the savings statements for T1 and T2. Instead, group T3 prospects received this savings statement from the solicitation brochure:

Will my electric bills decrease automatically?
No, your monthly electric bills will reflect how much energy you use and when you use it. Depending on what actions you take, your actual energy cost over the year-long pilot may decrease, increase or stay about the same as they are today.

4.1.2. 13,446 customers were solicited, 4.5 percent responded, 81 percent enrolled

Customers were solicited at random from a pool of 13,446 technically eligible homes. Technical eligibility had both physical and utility account-level requirements. Physical eligibility included single-family homes within the pilot geography served by an active smart meter for at least 12 months. Homes participating in treatments involving home energy controllers were also required to have central air conditioning. Account-level eligibility included: 1) at least 12 continuous months of service at the premise under FPL's standard Residential Service rate (RS-1) and 2) no enrollment in FPL's load management or levelized-billing programs.

A third party randomly assigned eligible customers to the Control group or to be solicited for a treatment, so all eligible customers had equal chances of being solicited for the various treatment groups or assigned to the Control group. Customers who were solicited were not offered a choice of treatments and were not aware of the other treatments. Participation was free and voluntary, and customers were enrolled on a first-come basis. Customers were requested to participate for at least a year, but there were no barriers to exiting, and participants could drop out at any time just by calling a toll-free number.

Customers were solicited by direct mail, with follow-up by outbound phone call, post card or email. While it took considerable follow-up to substantially meet planned participation levels from the sample pool, overall customer response to solicitation was good, averaging 4.5 percent. FPL found that response rates varied by treatment, decreasing as the complexity of the treatments increased:

- Response for the least complex treatment, in-home displays on the standard RS-1 rate, was 7.9 percent.
- Response for home energy controllers on the standard RS-1 rate was 3.8 percent.
- Response for the most complex treatment, home energy controllers on the pilot dynamic rate RSDPR-1, was 1.8 percent after the initial mailing, increasing to 2.9 percent after a duplicate mailing to the same homes.

Table 7: Solicitation and enrollment results

Solicitation and Enrollment Results	Group T1 IHDs on RS-1	Group T2 HECs on RS-1	Group T3 HECs on RSDPR-1	Group T4 Smart Appliances on RSDPR-1	TOTALS
Households solicited	3,592	3,746	6,108		13,446
Total responses	285	141	174		600
Response rate (with duplicate mailing)	7.9%	3.8%	1.8% (2.9%)		4.5%
Cost per response (with duplicate mailing)	$28	$53	$109 ($122)		
Qualified responses	278	131	163		572
% of responses that qualified to enroll	98%	93%	94%		95%
Enrolled	236	116	132		484
% of total responses enrolled	83%	82%	76%		81%
% of qualified responses enrolled	85%	89%	81%		85%
Installations completed	226	111	127		464
Installation success rate	96%	96%	96%		96%
Initial participants	226	111	117	10	464
Planned participation	250	120	120	10	500
% of planned participation achieved	90%	93%	98%	100%	93%

The look, feel and cost of the solicitation mailers were held constant for all groups so the marketing cost per lead was solely a factor of customer response rates. The marketing cost per lead was lowest for in-home displays ($28) and highest for the pilot rate ($109 after the first mailing and $122 after the duplicate mailing).

Customers responded by calling a toll-free number. Customers could ask questions about the program and, if they chose, enroll. On average, 81 percent of total respondents enrolled. Group T1, in-home energy displays on the standard rate, had the highest enrollment rate (83 percent) and group T3, home energy controllers on the pilot rate, had the lowest (76 percent).

Smart appliance group T4 was created from the first ten customers who enrolled in the pilot rate and had a home energy controller successfully installed. Solicitation for the pilot rate did not mention smart appliances, so the appliances were in no way an incentive. Subsequent to successful home energy controller installation, the first ten respondents received an offer of one or more smart appliances, based on the home's ability to receive the appliance(s). All ten accepted, and 33 smart appliances were deployed, as shown below:

Table 8: Smart appliances deployed

Group T4 Smart Appliances Deployed

Totals shown by home and by appliance type

T4 Home	Refrigerator	Washer	Dryer	Dishwasher	Water heater	Total, by home
1	1	-	-	-	-	1
2	1	1	1	1	-	4
3	1	1	1	1	-	4
4	1	1	1	1	-	4
5	1	1	1	1	-	4
6	-	1	1	-	-	2
7	1	-	-	-	-	1
8	1	1	1	1	1	5
9	-	1	1	1	1	4
10	1	1	1	1	-	4
Total, by type	**8**	**8**	**8**	**7**	**2**	**33**

4.1.3. The project achieved 93 percent of planned participation

The project achieved at least 90 percent of planned participation in each treatment group and 93 percent of overall planned participation. Ninety two percent of participants reported completing the enrollment process with one phone call.

Table 9: Planned and actual participation by treatment group

Planned and Actual Participation by Treatment Group	In-home Displays (IHD)	Home Energy Controllers (HEC)	HEC and Smart Appliances
Standard Rate: Residential Service RS-1	**Group T1** 250 planned 226 actual 90% of planned	**Group T2** 120 planned 111 actual 93% of planned	na
Pilot Rate: Residential Service Dynamic Price Response RSDPR-1	na	**Group T3** 120 planned 117 actual 98% of planned	**Group T4** 10 planned 10 actual 100% of planned

4.1.4. 85 percent ranked "impact on electric bill" the primary reason for enrolling

During enrollment, participants were asked a set of DOE-specified questions regarding appliance stock and demographics[7], and an additional question regarding their main reason for enrolling in the pilot. The vast majority (85 percent) ranked "impact on electric bill" as their primary reason for enrolling. "Impact on the environment" and "impact on future energy supplies" were ranked second and third, respectively.

Table 10: Ranked reasons for enrolling

Ranked reasons for enrolling	Percent Ranking
Ranked "impact on electric" bill MOST important	85%
Ranked "impact on the environment" as SECOND most important	66%
Ranked "impact on future energy supplies" as LEAST important	69%

4.2. Participants had up to five opportunities to comment on their pilot experience

Participants had up to five opportunities to comment on their pilot experience: after enrollment and installation, and up to four times during the pilot through a series of "Pulse" surveys. The Pulse survey series was designed to gather quantitative participant feedback on a core set of measures over time and identify areas for more detailed exploration. Most participants took the surveys online, with a few taking them by phone. Groups T1 and T2 were deployed first and took Pulse 1 in July 2011. Group T3 was deployed later and took its first survey, Pulse 2, in November 2011.

Group T4 included just 10 homes and was too small to provide valid quantitative insight through surveys. The majority of participants in T4, however, participated in in-depth interviews in November 2011. The interviews provided detailed qualitative insights into use of energy feedback and smart appliances. Some of these insights were then incorporated into the Pulse 3 survey to determine if they could be quantitatively generalized to other treatment groups.

Table 11: Schedule of participant surveys

Schedule of Participant Surveys

Survey type and date	Group T1	Group T2	Group T3	Group T4
1. Enrollment and Installation Experience: Feb - Aug 2011	✓	✓	✓	✓
2. Pulse 1: July 2011	✓	✓	-	-
3. In-depth Interviews: November 2011	-	-	-	✓
4. Pulse 2: November 2011	✓	✓	✓	-
5. Pulse 3: May 2012	✓	✓	✓	-
6. Pulse 4: August 2012	✓	✓	✓	-

Key Pulse survey measures shared by groups T1, T2 and T3 are discussed first. Group T3 responded to additional questions about the pilot rate and CPP events, and these are discussed in report section 4.3, "The FPL Smart Price Experience."

4.2.1. Summary of Pulse Survey Findings

- *Overall, participants reported solid satisfaction with the pilot technology and the program, with approximately half of each group reporting "very good" to" excellent" satisfaction (top 2 options on a 7-point scale).*
- *Satisfaction is supported by technology benefits and savings; dissatisfaction stems from technology problems and a lack of expected savings.*
- *Half or more survey respondents in all groups reported reducing their energy use since the technology was installed, with most describing saving "a little." Significantly larger percentages of participants in group T3, home energy controllers on the pilot rate, reported reducing their energy use.*
- *The majority of survey respondents in all groups reported using their technology once a week or more throughout the pilot.*
- *The majority of participants preferred to view their energy use on a dedicated display, in dollars, using the near real-time view "how much I'm using right now."*
- *In-home displays made a strong first impression, but key measures of benefit, expectation and device use declined significantly in just a few months. By the end of the pilot, 60 percent of in-home displays appeared to be unplugged.*
- *T3 home energy controller users on the RSDPR-1 pilot rate experienced lower levels of dissatisfaction than T2 HEC users on the standard RS-1 rate, even though the two groups used identical technology and experienced the same need for technical support.*
- *By the end of the pilot, half of each group indicated they would "definitely or very likely" be willing to recommend the program to a friend, with more T2 participants likely to not recommend the program.*

Table 12: Key Pulse survey measures common to groups T1, T2 and T3

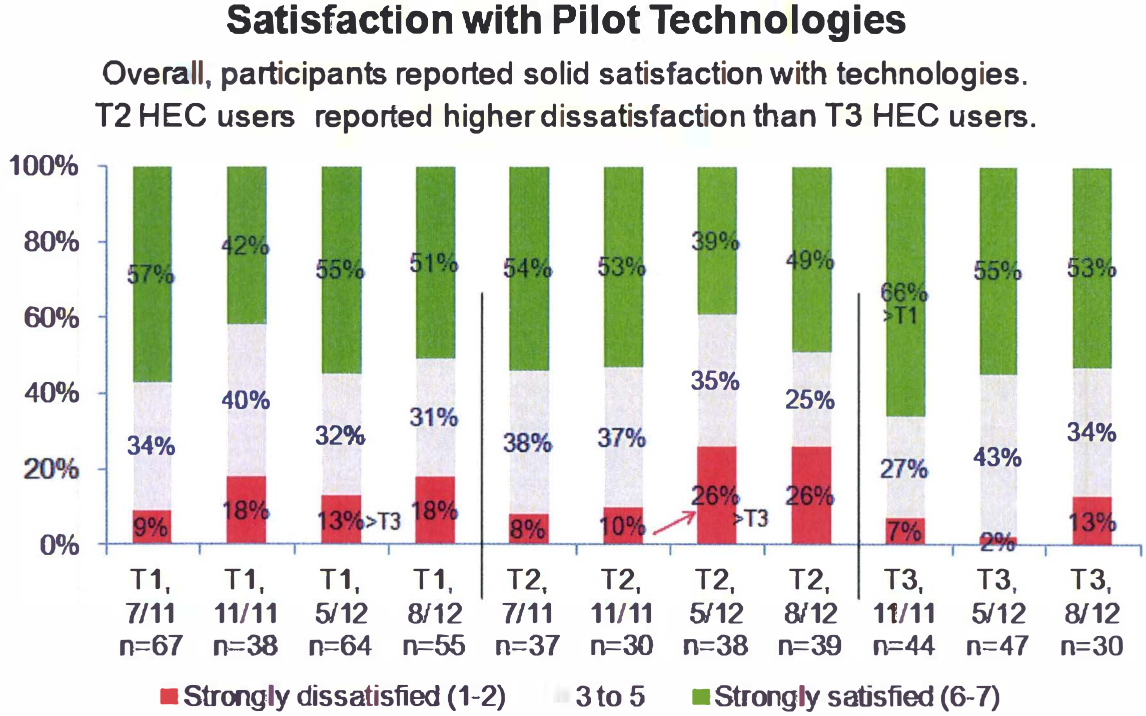
Significant findings summarized in this chart are discussed in throughout the Customer Acceptance section of the report.

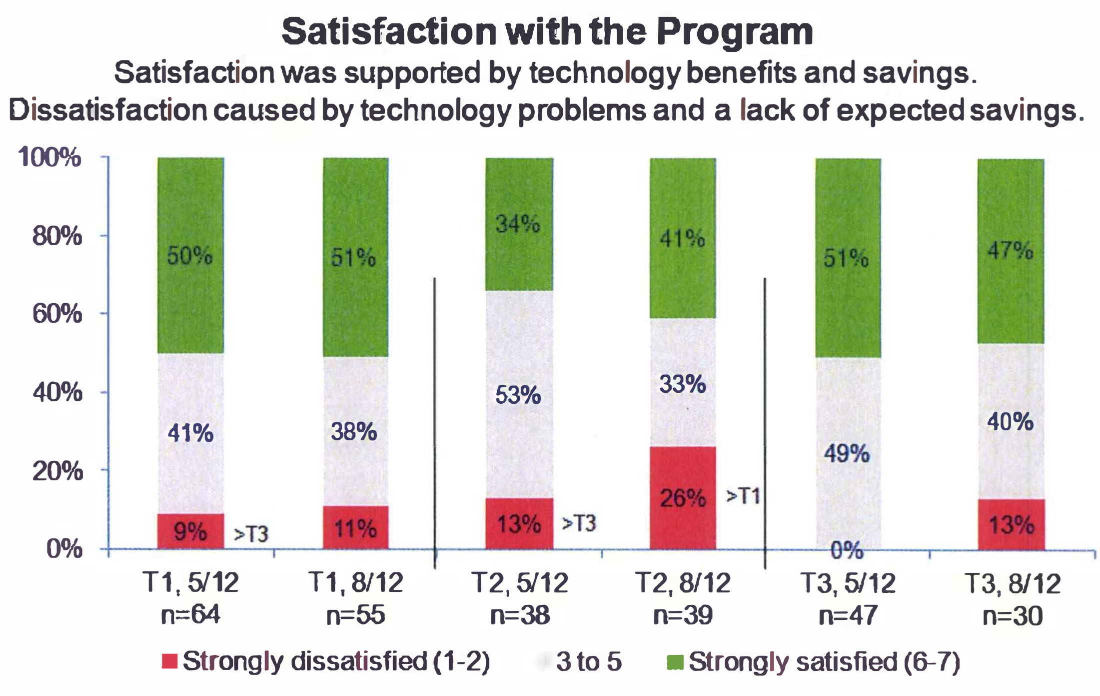
Pulse Surveys: Key Measures Shared by T1, T2 and T3
% indicates percent rating of 6 or 7 on 7-point scale, unless noted otherwise
Bold indicates 90% confidence in significant change from prior Pulse
(>Tn) indicates 90% confidence in significant difference from Group n in same Pulse

	Group T1 IHD on RS-1				Group T2 HEC on RS-1				Group T3 HEC on RSDPR-1		
Survey	Pulse 1	Pulse 2	Pulse 3	Pulse 4	Pulse 1	Pulse 2	Pulse 3	Pulse 4	Pulse 2	Pulse 3 *	Pulse 4
Responses collected	Jul-11	Nov-11	May-12	Aug-12	Jul-11	Nov-11	May-12	Aug-12	Nov-11	May-12	Aug-12
Number of respondents	67	38	64	55	37	30	38	39	44	47	30
Satisfaction with the Pilot Technology (top 2 boxes, 7 point scale)	57%	42%	55%	51%	54%	53%	39%	49%	66%(>T1)	55%	53%
Dissatisfaction with the Pilot Technology (bottom 2 boxes, 7 point scale)	9%	18%	13%(>T3)	18%	8%	10%	**26%**(>T3)	26%	7%	2%	13%
Helps you understand your energy use	72%	**55%**	66%	not asked	86% (>T1)	**60%**	66%	not asked	70%	74%	not asked
May help you save money on electric bill	57%	**39%**	53%	45%	62%	53%	45%	56%	68%(>T1)	64%(>T2)	63%
Frequency of use: Once a week or more	83%	**66%**	67%	62%	92%	89% (>T1)	**68%**	72%	93%(>T1)	83%(>T1)	80% (>T1)
Provides meaningful information	57%	50%	58%	not asked	78%(>T1)	63%	63%	not asked	82%(>T1,2)	68%	not asked
Motivates you to change your energy habits	54%	45%	52%	42%	65%	60%	53%	51%	75%(>T1)	68%(>T1)	67% (>T1)
Have decreased energy use since installed	60%	55%	58%	49%	51%	67%	61%	54%	80%(>T1)	81%(>T1,2)	73% (>T1,2)
Have stopped using the device	9%	18%(>T2,3)	19%(>T3)	24% (>T3)	5%	3%	**16%**(>T3)	21%	0%	4%	10%
Makes you more energy-aware	not asked	not asked	64%	not asked	not asked	not asked	66%	not asked	not asked	77%	not asked
Helps you understand which things in your home are using energy	not asked	not asked	63%	55%	not asked	not asked	53%	56%	not asked	72%(>T2)	60%
Empowers you to control energy use if you choose	not asked	not asked	58%	56%	not asked	not asked	68%	51%	not asked	77%(>T1)	67%
Satisfaction with the Program (top 2 boxes, 7 point scale)	not asked	not asked	50%	51%	not asked	not asked	34%	41%	not asked	51%	47%
Dissatisfaction with the Program (bottom 2 boxes, 7 point scale)	not asked	not asked	9%(>T3)	11%	not asked	not asked	13% (>T3)	26% (>T1)	not asked	0%	13%
Would very likely or definitely recommend program to a friend	not asked	not asked	67%	45%	not asked	not asked	53%	46%	not asked	64%	60%

* In the month prior to Pulse 3, pilot rate participants received a letter stating their pilot to date savings or loss compared to what they would have paid on the standard rate. The savings were only from the difference in rates, and did not reflect day to day conservation.

Figures 10 and 11: Key measures of satisfaction common to groups T1, T2 and T3





4.2.2. Pulse survey 1, July 2011, included groups T1 and T2

- *The attribute "Helps you understand your energy use" received the highest ratings.*
- *Large majorities in T1 and T2 used their technology once a week or more.*

Pulse 1 was taken several months after installing technology and provided a view of the initial reactions to the technology and a baseline for subsequent Pulse surveys.

Helps you understand your energy use was the benefit receiving the highest initial rating by both groups, with T2's score higher than T1. Group T2 also scored *provides meaningful information* higher than T1. There were no differences between the groups on the remaining attributes, with more than half of each group reporting the technology *motivates you to change your energy habits* and that they *have decreased their energy consumption since installed.* Of those reporting a decrease in energy consumption, most described the decrease as "*a little.*"

A large majority of both groups reported using their device once a week or more.

Satisfaction with the technology was equal between the T1 and T2 with just over half reporting high satisfaction (6 or 7 on a 7-point scale) and less than one-tenth reporting dissatisfaction (1 or 2 on a 7-point scale). Less than one-tenth reported they had *stopped using the device.*

Participant comments were not collected in Pulse survey 1.

4.2.3. Pulse survey 2, November 2011, included groups T1, T2 and T3

- *"Helps you understand your energy use," the highest rated attribute in prior survey, declined significantly for both T1 and T2.*
- *T1's weekly use of IHDs dropped significantly, and one-fifth report they stopped using the device, showing significantly higher attrition than HEC groups T2 and T3.*
- *In the first survey of T3, participants scored significantly higher than T1 on nearly every measure and higher than T2 on "provides meaningful information."*
- *Satisfaction of T1 and T2 remained stable.*

Overall, the majority of participants were satisfied with their technology and reported their energy use had decreased "a little." Findings specific to individual groups included:

Among T1 IHD users, key measures of benefit, expectation and device use declined significantly in the four months since Pulse 1. Declines in *helps you understand your energy use*, *may help you save money on your electric bill* and *use once a week or more* reflected a significant reduction in engagement with the IHD. One-fifth reported they had *stopped using the device*, significantly more than HEC groups T2 and T3. This survey provided participants the opportunity to comment on why they had stopped using the device, and the majority of comments related to technology issues; *"I had the repair people here quite a few times. It works for a day or two then quits again. I finally gave up on the thing."*

Among HEC group T2, *helps you understand your energy use,* the group's highest scoring attribute in prior survey, declined significantly. The frequency of T2's HEC use held steady, and there was no change in attrition.

Pulse survey 2 was the first survey of pilot rate group T3, whose technology had been installed for at least two months. T3 scored higher than T1 on nearly every measure and higher than T2 on *provides meaningful information.* Pulse survey 2 was taken after three CPP events, and participant acceptance of CPP events is discussed in section 4.3, "The FPL Smart Price Experience."

4.2.4. In-depth interviews, November 2011, smart appliances group T4

At the same time Pulse survey 2 was taken, in-depth interviews were conducted with group T4. The interviews provided detailed qualitative insights about viewing, and acting on, energy information and about smart appliances. Each two-hour interview was conducted in the participant's home. The interviews produced several observations that were later incorporated into the Pulse survey 3 and were quantitatively tested to see if they could be generalized for other treatment groups. Key observations include:

Observation 1:

- A dedicated display that is always visible (vs. a smart phone, personal computer or iPad/tablet) was the preferred way of viewing energy information. The reason: having real-time information available at a glance created awareness and gave participants a feeling of control and empowerment; i.e. created an option to act, but not an obligation.
- Validation: Pulse survey 3 validated that a dedicated display was the first choice for all groups. When *makes you more energy-aware* was tested as a technology attribute, two-thirds of the participants in every group strongly agreed. When *empowers you to control your energy use if you choose* was tested as a technology attribute, T3 rated it significantly higher than T1, suggesting the attribute may be more relevant in the context of the pilot rate.

Observation 2:

- The dollar cost of current usage, displayed in digits, is the most-used view. The reason: dollars displayed in digits require no interpretation. The concept of electrical demand, expressed in kW, was abstract.
- Validation: Pulse survey 3 validated that, overall, participants preferred to view their energy use in dollars, using the near real-time view *"how much I'm using right now."* The preference for this near real-time view is noteworthy, as it is enabled by the direct feedback capability of the smart meter's HAN radio. This is in contrast to the views *how much I've used so far this month* and *forecast of how much I might use by end of the month,* which are typically provided as indirect feedback via smart meter websites updated with the prior day's usage. Thus, participants preferred to view their energy use with the near real-time "direct" feedback that was central to the pilot.

Table 13: Preferences in viewing home energy use

Preferences in Viewing Home Energy Use: Pulse 3, May 2012
% indicates percent of users reporting view as preference
(>Tn) indicates 90% confidence in significant difference from Group Tn

Group	Group T1	Group T2	Group T3
Technology / Rate combination	IHD on RS	HEC on RS	HEC on RSDPR
Number of respondents	64	38	47
Usually set display in dollars	53%	68%	68%
Usually set display in kilowatt hours	47%	32%	32%
Display used the most: How much I'm using right now	81% (>T3)	74% (>T3)	49%
Display used the most: How much I've used so far this month	17%	26%	45%(>T1,2)
Display used the most: Forecast of how much I might use by end of	2%	0%	6%
How would you prefer to view your home's energy information?			
Dedicated energy display	53%(>T3)	42%	36%
Personal computer	22%	18%	28%
Smart phone	17%	26%	21%
iPad / tablet	8%	13%	15%

Observation 3:

- Colors convey price changes during CPP events. As one participant said, *"I just look for the red."*
- Validation: Pulse survey 3 validated that visual clues were the most effective way for participants to take notice of CPP events, with *see color change on the energy controller* the visual clue used most.

Observation 4:

- Appliance-level information did not lead to changes in behaviors. Appliance-level monitoring made users feel more informed about how each appliance contributed to the whole, but didn't actually change their behaviors based on what they learned.
- Validation: Pulse survey 3 validated that group T3 scored *helps you understand which things in your home are using energy* significantly higher than T2, suggesting the attribute may be more important in the context of the pilot rate, e.g. being informed about which appliances to avoid using during CPP events.

The interviews also contributed to the understanding of participants' attitudes toward acting on energy feedback, in general, and their use of smart appliances during CPP events:

Everyone wanted to save money, but only a few were willing to compromise

The #1 motivation for all participants was to lower their monthly utility bill. However, most did not have a specific goal in mind and did not plan to inconvenience themselves or their family.

Participants valued information because it put them in control

The information provided by the home energy controller educated participants on something about which they had no prior knowledge. Greater awareness gave participants a feeling of control over their household energy usage and related decisions.

Participant behaviors and habits did not significantly change

Interviews indicated that awareness did not always result in action. The home energy controller proved to be helpful in increasing overall awareness, and some participants made small changes in their habits, but overall, the changes were minor and most participants did not consistently alter how they used appliances.

During CPP events, participants tried not to use the smart appliances

A few actively sought out appliances and devices to shut down, whereas the majority of participants would simply postpone using the smart appliances, if it was convenient for them to do so. After three CPP events, about half of the smart appliance users reported noticing events, and none reported the need to over-ride appliances during the events.

4.2.5. Pulse survey 3, May 2012, other findings for groups T1, T2 and T3

- *Comments showed that satisfaction was supported by technology benefits and savings, and dissatisfaction stemmed from technology issues and a lack of expected savings.*
- *Pilot rate group T3 was the most satisfied and T2 the least satisfied, even though these groups used identical technology, made identical use of technical support and reported identical satisfaction with the support they received.*

Prior to the Pulse survey 3, pilot rate group T3 participants were notified by letter of their pilot-to-date dollar savings or loss compared to what they would have paid on FPL's standard electric rate, RS-1. The dollar difference noted in the letter was the rate differential alone, and did not reflect participants' conservation efforts made outside of CPP events. At the time the letters were sent, the net average pilot-to-date rate savings among all participants was 2.1 percent. Ninety percent of participants had an average pilot-to-date savings of $39.98. The 10 percent who were not saving had an average pilot-to-date loss of $2.58. Those with losses were also provided suggested strategies for saving during the remaining CPP events. The letters did not result in any inquiries from participants.

In addition to validating observations from the in-depth interviews, Pulse survey 3 revealed new differences in dissatisfaction among the groups. Overall, the majority of respondents reported they were continuing to use their device once a week or more, and that they had decreased their energy consumption "a little." *Satisfaction with the technology* (6 or 7 on a 7-point scale) remained stable over time and on par across all groups. However, a trend in dissatisfaction (1 or 2 on a 7-point scale) emerged: HEC group T2's *dissatisfaction with the technology* increased significantly in this survey and one-fourth reported they had *stopped using the device,* and *dissatisfaction with the technology* and *the program* were significantly higher among T1 and T2 participants than T3.

Participant comments revealed the reasons for their satisfaction and dissatisfaction. Those who said they were "very satisfied" enjoyed the ability to monitor energy usage and easily regulate the temperature of their home; "*My FPL bill decreased. In addition, I like* *the thermostat regulator that constantly maintain the temperatures at the different times."* Those less satisfied reported issues with their device not working properly and did not see significant savings; *"We have experienced some reliability issues, and I am not convinced it has generated any significant savings."*

Among the HEC-equipped groups, the survey responses of the T3 group on the pilot rate stood in significant contrast to those of T2 on the standard rate. T3 reported higher satisfaction or lower dissatisfaction on nearly every measure. This is noteworthy because these two groups were equipped with identical technology, reported an identical use of technical support and identical satisfaction with the support they received. The only programmatic difference was that T3 participated in the pilot rate.

When offering reasons for satisfaction, T3 participant responses were consistent with other groups. Positive comments emphasized technology benefits and some savings; *"We like how easy it is to operate and program. It has saved us money."* Negative comments emphasized technology issues.

4.2.6. Pulse survey 4, August 2012, groups T1, T2 and T3

Pulse survey 4 was taken in the final days of the pilot. There were no major changes in the themes seen in Pulse survey 3. Group T3 continued to show significant differences in three areas, all consistent with the prior survey:

- The majority of participants in all groups continued to use their technology once a week or more. Frequency of use among T3 participants was significantly higher than T1, consistent with the prior survey.
- Half or more of participants in all groups reported decreasing their energy use since the technology was installed. Significantly more T3 participants reported decreasing energy use than T1 or T2, consistent with the prior survey.
- Significantly more T3 customers reported that the technology motivated them to change their energy use habits, consistent with the prior survey.

Satisfaction with the program and equipment was similar across groups.

- Customers in T2 reported higher dissatisfaction than T1 and T3
- While approximately half of the customers would definitely recommend the program, more T2 customers said they would not recommend it, and the likelihood of recommending the program decreased in T1 from the previous survey.

T3 customers generally liked the idea of the program and how it could help them manage their energy use, but they reported ongoing technology issues; *"I think the program is great. However my unit has stopped working on two separate occasions."*

4.3. The FPL Smart Price experience: acceptance of the pilot rate and 12 CPP events

- *Customers were accepting of the pilot rate; most agreed they understood how the rate worked, and the idea made sense. FPL did not receive a single pilot rate-related billing inquiry during the pilot.*

- *Customers were accepting of 12 CPP events, requiring little support; a total of less than 1 percent called during events. Only one participant dropped out as the result of a CPP event.*
- *HEC users on the pilot rate had lower dissatisfaction than HEC users on the standard rate, and the pilot rate appears to have created a supportive context for the maintenance-intensive HEC, providing savings without adding inconvenience.*

From September 2011 to August 2012, FPL conducted 12 CPP events totaling 54 hours. Events were conducted to measure load reduction by home energy controllers and consumer price response under a variety of conditions. Some months had no events and no calendar month had more than two events. Eight were held in summer, two in winter, one in spring and one in fall. Winter events were three hours. Most summer events were four hours, and two summer events were eight hours, the maximum allowed under the pilot tariff. One winter event and one summer event coincided with FPL monthly system peak days. The final two events were held on consecutive days.

Table 14: Summary of CPP Events

Summary of CPP events, September 2011 – August 2012									
Event #	Season	Date	Start - end times	CPP hours used	Meters targeted	Phone calls during	Truck rolls during	Event related	Note
1	Summer	9/14/2011	3 to 7pm	4	106	2	0	0	
2	Summer	9/29/2011	3 to 7pm	4	125	0	0	0	
3	Fall	10/25/2011	10am to 2pm	4	125	1	0	0	
4	Winter	1/4/2012	6 to 9am	3	125	5	1	1	January 2012 peak
5	Winter	2/13/2012	6 to 9am	3	124	0	0	0	
6	Spring	4/17/2012	4 to 8pm	4	121	0	0	0	
7	Summer	6/4/2012	4 to 8pm	4	120	1	0	0	June 2012 peak
8	Summer	6/29/2012	4 to 8pm	4	120	0	0	0	
9	Summer	7/2/2012	4 to 8pm	4	120	1	0	0	
10	Summer	7/19/2012	Noon to 8pm	8	120	2	0	0	8 hour event
11	Summer	8/1/2012	4 to 8pm	4	120	1	0	0	Day 1 of 2
12	Summer	8/2/2012	Noon to 8pm	8	120	1	0	0	Day 2, 8 hour event
			Total	54	1446	14	1	1	
			% of total meters			0.97%	0.07%	0.07%	

Because participants did not receive advance notice of CPP events and might not be home during events, home energy controllers provided an automated "set and forget" response to events. All home energy controllers included a thermostat and, in 71 percent of T3 homes, central cooling and heating was the only load subject to automatic response. In the remaining homes, the HEC also controlled a water heater and / or pool pump.

As a test of price response, participants could override, at a minimum, the thermostat's automatic response to CPP events in order to balance the cost / comfort equation. The pilot also encouraged participants to take actions to supplement automated responses, such as deferring energy-intensive tasks such as drying clothes until after CPP events. This behavioral aspect was one of the distinguishing features of price response when compared to FPL's direct load control program, On Call. Under On Call, participants may not override utility control of their appliances and do not receive additional compensation if they take supplemental actions to reduce load. Price response participants may override automated responses and are encouraged to take, and rewarded for taking, supplemental actions to reduce load.

Table 15: Loads subject to automated response during CPP events

Loads subject to automated response during CPP events	
Group	Groups T3,4
Technology / Rate combination	HEC on RSDPR
Homes in sample	123
HVAC (cooing and heating cycles)	71%
HVAC + water heater	19%
HVAC + pool pump	7%
HVAC + pool pump + water heater	3%
Total	100%

By design, FPL's home energy controller–enabled price response pilot tested a combination of automated response and participant response. This chain of technical enablement and participant response is illustrated in Figure 13, below.

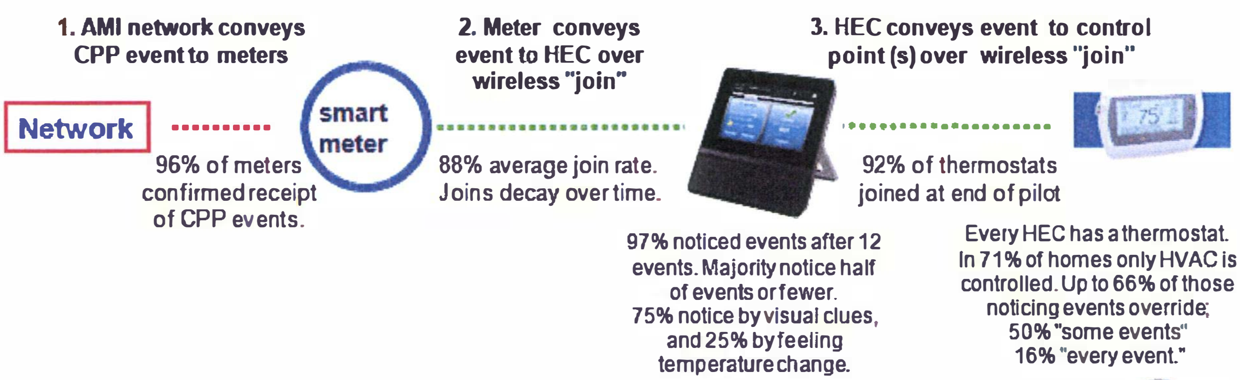
Figure 13: Chain of technical enablement and participant response during CPP events

Home energy controller- enabled price response is a function of technical reliability and participant response, including overrides

1. **FPL's AMI network conveys the CPP event to the participating smart meter**
   FPL receives confirmation of receipt. If the CPP event fails to reach the meter the HEC will not act. In such cases, the customer is not billed for the CPP event.

2. **The smart meter conveys the CPP event to the home energy controller (HEC)**
   The smart meter's HAN radio conveys time sync, text messages, power use and price into the home. The HEC must be "joined" to the HAN radio to receive the event, so joins are monitored and maintained. Most customers notice events by visual clues from the HEC, rather than feeling a temperature change.

3. **The HEC responds automatically, the customer may "balance the cost / comfort equation"**
   The utility cannot monitor inside the home: control points may be unjoined from the HEC or customers may override automated responses , without the utility's knowledge.



FPL

Group T3 participants had three opportunities to respond to Pulse survey questions regarding their experience with the pilot rate and CPP events. The surveys were scheduled so that the number of CPP events doubled between the surveys.

Table 16: Pulse survey measures for pilot rate RSDPR-1, "FPL Smart Price" and CPP events

Pulse survey measures for CPP events and pilot rate, RSDPR-1 "FPL Smart Price"
% indicates percent rating 6 or 7 on 7-point scale, unless otherwise noted (e.g. 3, 4, 5)
Bold indicates 90% confidence in significant change from prior Pulse

Group	Group T3, HEC on RSDPR-1 Dynamic Rate		
Survey	Pulse 2	Pulse 3*	Pulse 4
Responses collected	Nov-11	May-12	Aug-12
Number of respondents	44	47	30
Number CPP events held prior to survey	3	6	12
Noticed Conservation Price Event(s)	68%	66%	**97%**
Notice event because of visual clue from HEC or thermostat	not asked	84%	75%
Notice event by feeling temperature change in house	not asked	16%	24%
Number of events noticed by majority of respondents	not asked	3 or fewer	5 or fewer
Noticed fewer events than I expected	not asked	not asked	27%
Noticed about the number that I expected	not asked	not asked	41%
Noticed more events than I expected	not asked	not asked	7%
Event inconvenience: Don't bother me at all (6 or 7)	30%	39%	45%
Event inconvenience: Neutral (3, 4, 5)	57%	55%	41%
Event inconvenience: Events are inconvenient (1 or 2)	13%	6%	14%
Changed thermostat setting during event to keep from becomming	33%	**55%**	69%
Changed thermostat setting: Every event	not asked	23%	17%
Changed thermostat setting: Some events, but not all	not asked	32%	52%
Never changed thermostat setting during events	not asked	45%	31%
Warmest acceptable thermostat setting during a summer event (average)	not asked	79	not asked
Smart Price rate: I understand the way it works	not asked	68%	not asked
Smart Price rate: The idea makes sense to me	not asked	57%	not asked
Smart Price rate: Is a better deal than the standard electric rate	not asked	55%	not asked
Does technology or price plan help you save more?			
Price plan helps more (6,7)	not asked	26%	27%
Neutral / Balanced (3,4,5)	not asked	59%	60%
Technology helps more (1,2)	not asked	15%	13%

* In the month prior to Pulse 3, pilot rate participants recieved a letter stating their pilot-to-date savings or loss compared to what they would have paid on the standard RS-1 rate. The savings were only from the difference in rates, and did not reflect day to day conservation.

Pulse surveys went into greater depth about participant views on CPP events, attitudes towards events, overriding automated thermostat response, supplemental actions taken to reduce load during events, understanding of the pilot rate and how the home energy controller and pilot rate helped them save.

4.3.1. After 12 CPP events, nearly every participant had noticed events

After three, and again after six CPP events, two-thirds of participants reported noticing CPP events. After 12 events, this proportion increased significantly to 97 percent. Throughout the pilot, the majority of participants noticed half or fewer of the actual number of events. At the end of the pilot, two-thirds of participants reported that the number of CPP events they noticed was less than, or equal to, the number they had expected. Participants usually noticed CPP events from a *visual clue* provided by the home energy controller, rather than *feeling the temperature in the home change*. Visual clues included seeing a color change or text message on the controller console, seeing a light on the thermostat or seeing a change in the thermostat setting. We note that several participants, including the only one to drop out of the pilot due to a CPP event, commented that an audible event alert would be a welcomed technology enhancement. In the final survey, after 12 events, more participants commented that other forms of notification, including text and email, would be appreciated.

4.3.2. The majority of participants did not feel inconvenienced by CPP events

The majority of those who noticed events reported that they did not feel inconvenienced by them, even after 12 events, including two 8-hour events and two consecutive-day events. Nearly half reported that events *don't bother me at all*. This finding was reinforced by FPL's experience in supporting participants during events; participants required very little support - a total of less than one percent called during the pilot's 12 events.

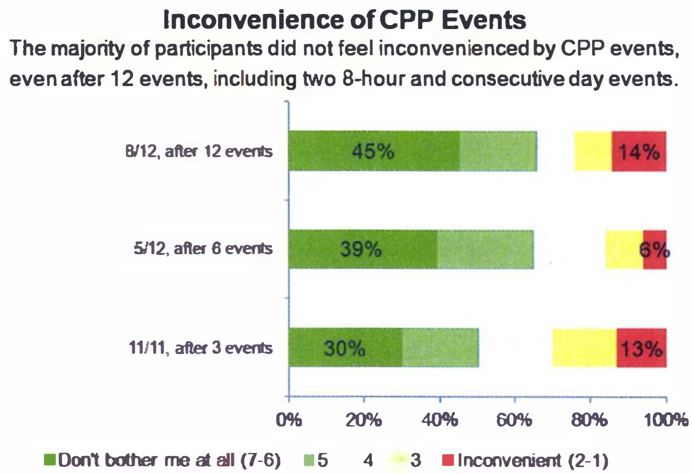


Figure 14: Inconvenience of CPP events

4.3.3. Two-thirds of participants overrode thermostat responses to CPP events

By the end of the pilot, two-thirds of participants reported *changing their thermostat setting during event to keep from becoming uncomfortable*. Most reported overriding *some events, but not all*. A minority reported overriding *every event*. About one-third reported they never changed their thermostat during events.

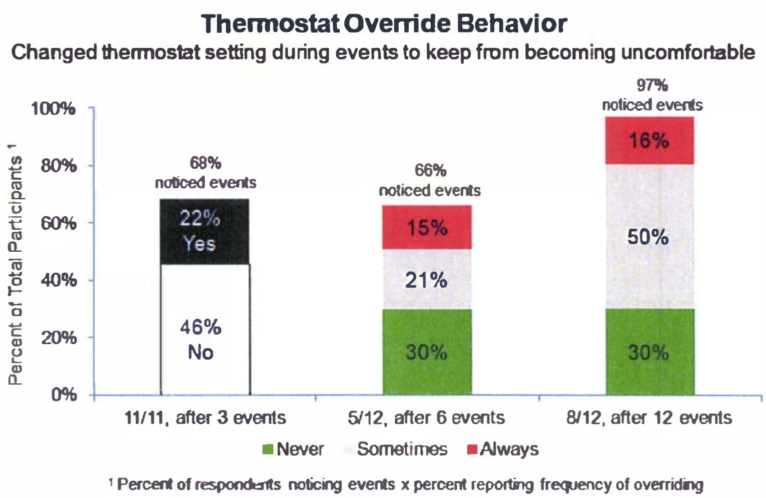


Figure 15: Thermostat Override Behavior

FPL estimates participants used about two degrees Fahrenheit of thermostat conservation while at home during summer CPP events. The estimate is based on participant responses to two questions: 1) the warmest acceptable thermostat setting during a summer CPP event and 2) the usual at-home thermostat setting. The average warmest acceptable setting during a summer CPP event was 79 degrees, was two degrees warmer than T3 participants' average at-home thermostat setting of 77 degrees.

4.3.4. Participants took supplemental conservation actions during CPP events

Participants had the option of taking other conservation actions during CPP events to supplement automated responses from the HEC. Most of those who "noticed events" took some supplemental action. The most common, taken by more than half of the respondents, was delaying their use of laundry appliances until the event ended.

Other Conservation Actions Taken During CPP Events
Source: Pulse 3, May 2012

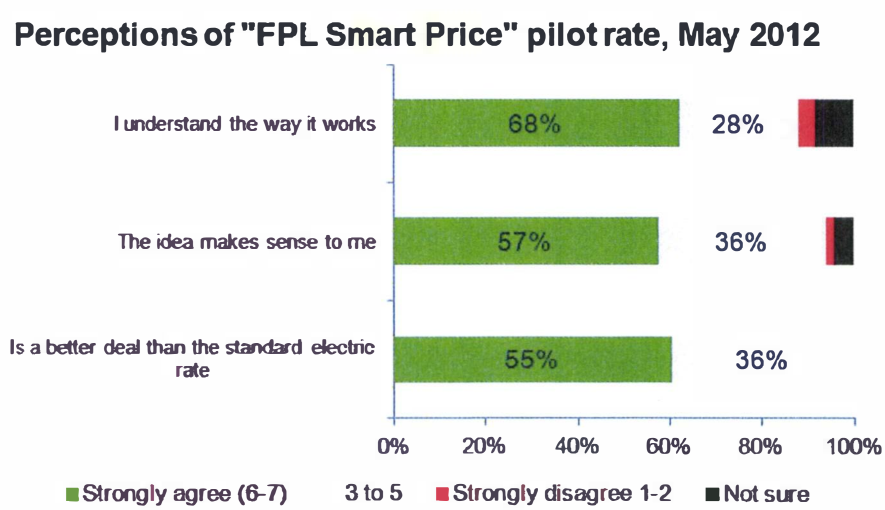
Group	Group T3
Technology / Rate combination	HEC on RSDPR
Survey	Pulse 3, Nov-12
Number of respondents	47
Number of CPP events held prior to survey	6
Laundry appliances	61%
Dishwasher	52%
Lights	39%
Cooking appliances	29%
Fans	29%
TV / Computer / Games	26%
Did not take any actions	13%

Table 17: Supplemental actions taken during CPP events

4.3.5. Most participants had positive perceptions of the pilot CPP rate

When surveyed about the pilot rate in May 2011, after six CPP events and receiving a pilot-to-date savings letter, the majority of pilot rate participants reported they *understand the way it works.* The majority also reported *the idea makes sense to me,* and about half considered the pilot rate *a better deal than the standard electric rate*. These survey findings were reinforced by FPL's pilot operational experience: not one pilot rate-related billing inquiry was received during the pilot.

Figure 16: Perceptions of pilot rate RSDPR-1

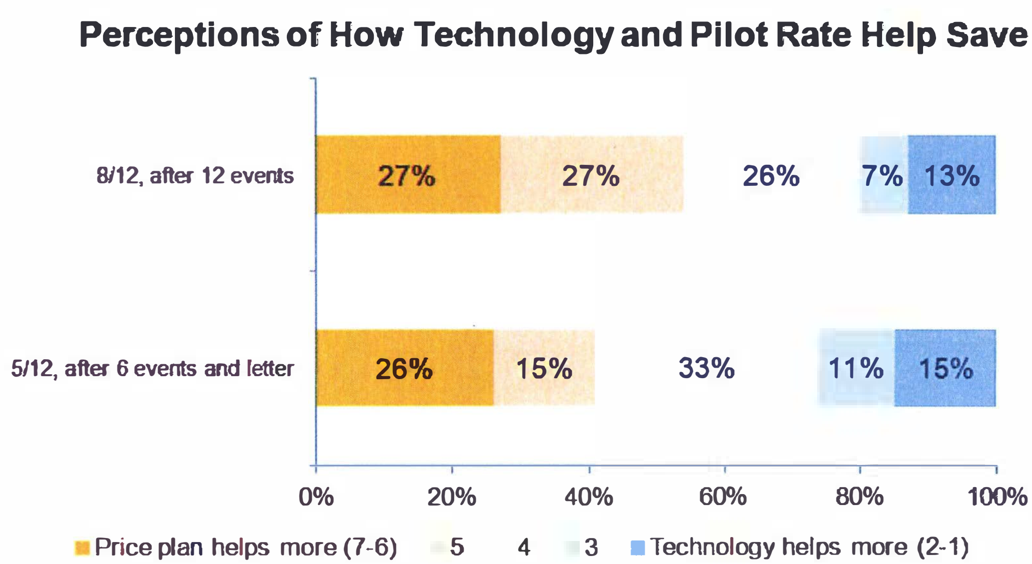


4.3.6. Perceptions of how the technology and pilot rate help to save

Given T3's lower *dissatisfaction* ratings for the pilot technology compared to the identically-equipped T2 group, FPL attempted to discern from participants how the technology and pilot rate were perceived to have contributed to saving. It was evident from survey results that overall satisfaction was supported by technology benefits and savings. In the case of T3 participants, the technology provided the unique savings benefit of automatic "set and forget" response to CPP events. The rate itself also provided savings, as participants received a discount on all energy used outside CPP events.

Participants were asked which helped them to save *more*; the technology or the pilot rate? When asked after six CPP events and a pilot-to-date rate savings letter, participants credited the pilot rate over the technology by 1.6 to 1. By the end of the pilot, participants credited the price plan over the technology by 2.7 to 1. FPL surmised that the pilot rate provided a supportive context for the maintenance-intensive HEC technology; the rate provided a reason to maintain the technology, and a source of savings that did not create additional inconvenience.

Figure 17: Perceptions of how HEC technology and pilot rate RSDPR-1 helped them save



4.4. Participant attrition and retention

FPL's pilot included an "opt-in" design, so participation was voluntary. While customers were requested to participate for at least a year, there were no barriers to exiting, and participants could drop out at any time just by calling a toll-free number. Exiting participants were asked their main reason for dropping out.

Over the course of the pilot, a total of 23 participants (5 percent) contacted FPL to drop out. The majority (57 percent) cited technology issues as their main reason for ending participation early. Participants who dropped out spent an average of 215 days in the program.

Table 18: Participant drop outs by reason given

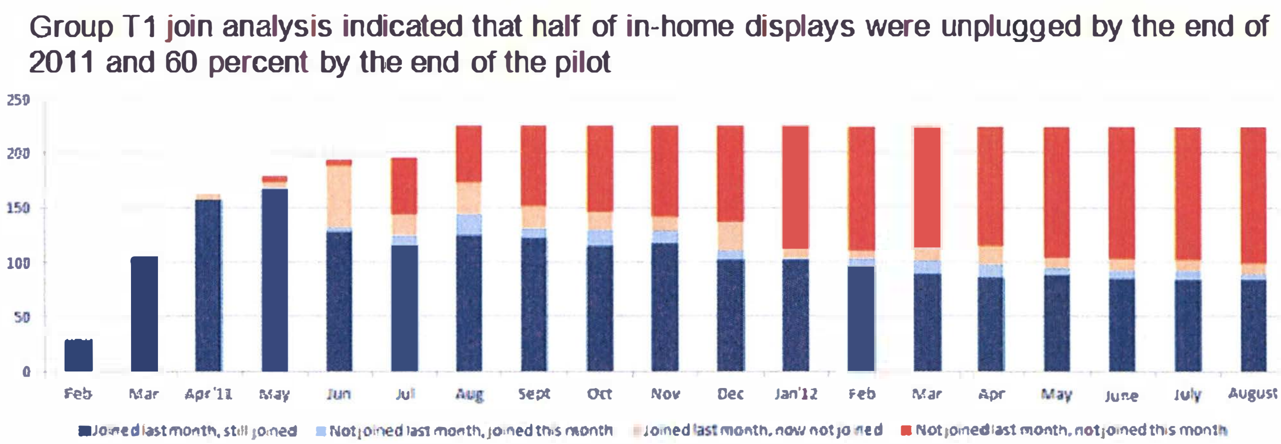
Attrition: Participant Drop Outs by Reason Given
Counts include participants contacting FPL to drop out and may not reflect all who stopped using the device

Group Technology / Rate combination Initial participants	Group T1 IHD on RS 226	Group T2 HEC on RS 111	Group T3 HEC on RSDPR 117	Group T4 Appliances on 10	Totals 464	Percent by Reason
Bought new air conditioner	-	1	-	-	1	4%
Comfort concern	-	1	-	-	1	4%
CPP event	-	-	1	-	1	4%
Moved	1	2	4	-	7	30%
Technology issues	1	8	4	-	13	57%
Total drop outs (contacted FPL)	**2**	**12**	**9**	**0**	**23**	**100%**
Drop outs as percent of initial	**0.9%**	**10.8%**	**7.7%**	**0%**	**5.0%**	**-**
Average days of participation	**185**	**254**	**205**	**-**	**215**	**-**

To drop out, home energy controller users in groups T2, T3 and T4 needed to contact FPL to arrange removal of their HEC thermostat and any water heater / pool pump control switches. Participants in groups T3 and T4 also needed to have their account transitioned from the pilot rate back to FPL's standard RS-1 rate.

While HEC users needed to contact FPL to have their technology removed, group T1 in-home display users did not, as they could simply unplug their device. FPL used the results of monthly "join" reports to help estimate the number of IHD users who had unplugged their device, as an IHD which has been unplugged also unjoins from the meter. Based on join analysis, approximately half of IHD users had unplugged their devices by the end of 2011 and 60 percent by the end of the pilot.

Figure 18: Group T1 In-home display join history served as a proxy for participant attrition



Only one T3 pilot rate participant dropped out as the result of a CPP event. CPP event # 4 was a winter event, held on January 4, 2012 from 6 to 9 a.m. The participant reported that he used space heaters that were not controlled by the home energy controller and that he was not aware of the event until after it had ended. The participant commented that an audible CPP event alert would be a helpful enhancement to the HEC.

None of the T4 smart appliance participants dropped out of the pilot.

4.5. Summary of Customer Acceptance Findings

- **Overall**
  - Customer response to pilot solicitation averaged 4.5 percent. Response rates decreased and marketing costs increased with the complexity of the offerings. Participants ranked "impact on electric bill" as their primary reason for enrolling.
  - The majority of participants preferred to view their energy use on a dedicated display, in dollars, using the near real-time view "how much I'm using right now."
  - Half or more of the participants reported reducing their energy use since the technology was installed, with most describing saving "a little."
  - Survey results showed that satisfaction was supported by technology benefits and savings; dissatisfaction stemmed from technology problems and a lack of expected savings.
  - Participants reported solid satisfaction with the pilot technology and the program, with approximately half of each group reporting very good to excellent satisfaction (top 2 options on a 7-point scale).

- **T1 in-home energy displays on the standard rate RS-1**
  - In-home displays made a strong first impression, but key measures of benefit, expectation and device use declined significantly in just a few months.
  - By the end of the pilot, 60 percent of in-home displays appeared to be unplugged.

- **T2 home energy controllers on the standard rate RS-1**
  - T2 participants reported higher dissatisfaction than T1 and T3, were significantly less likely to report a decrease in their energy use than T3, and were significantly more likely to report abandoning their use of the technology than T3 participants.

- **T3 home energy controllers on the pilot rate RSDPR-1**
  - Significantly more T3 participants reported decreasing their energy use than the T1 or T2 groups.
  - T3 participants were accepting of the pilot rate; most agreed they understood how it worked and that the idea made sense. FPL did not receive a single pilot rate-related billing inquiry during the pilot. More pilot rate participants credited the pilot rate with helping them to save than credited the technology.
  - T3 participants were accepting of 12 CPP events, requiring little support: A total of less than 1 percent called during events. The majority of those who noticed events reported that they did not feel inconvenienced by them, and only one participant dropped out of the pilot as the result of a CPP event.

- T3 home energy controller users on the pilot rate experienced lower levels of *dissatisfaction* than T2 HEC users on the standard rate, even though these groups used identical technology and experienced the same need for technical support. FPL concluded that the pilot rate created a supportive context for the maintenance-intensive HEC, providing both a 1) reason to maintain the HEC and 2) a source of savings without additional inconvenience.

5. PARTICIPANT CONSERVATION HABITS AND HOME IMPROVEMENTS

- *The majority of participants changed their energy habits, with the largest majority in the T3 group.*
- *Thermostat programming increased for T2 and T3 compared to pre-pilot levels, and used more conservative thermostat settings than group T1.*
- *"Installing efficient lighting" was the most common home improvement, reported by half or more of each group.*
- *Group T3 had higher participation in FPL's ceiling insulation rebate program than the Control group*

A combination of Pulse survey and rebate program participation data was used to assess energy conserving habits adopted and home improvements made during the pilot treatment period.

Table 19: Conservation Habits and Home Improvements

Conservation Habits and Home Improvements Adopted as a Result of the Program
Source: Pulse survey 3, May 2012
% indicates percent of users reporting
(>Tn) indicates 90% confidence in significant difference from Group Tn

Group Technology / Rate combination Number of respondents	Group T1 IHD on RS 64	Group T2 HEC on RS 38	Group T3 HEC on RSDPR 47
Have changed their energy habits	67%	63%	89% (>T1,2)
Have made energy-saving home improvements	61%	47%	55%
Energy habits changed			
Changed setting on my thermostat	70%	88% (>T1)	95% (>T1)
More likely to turn off lights when leaving room	86%	100% (>T1)	93%
More likey to turn off fans when leaving room	79%	79%	71%
More likey to turn off TVs, computers, game machines	67%	79%	76%
More likely to clean or replace AC filter regularly	65%	58%	57%
More likely to clean lint filter on dryer	58% (>T2)	38%	52%
More likely to use cold rinse for laundry	33%	46%	43%
More likely to match water level to size of laundry	37%	29%	36%
Reduced hours pool pump runs	26%	42%(>T1)	29%
Not pre-rinse dishes before loading dishwasher	28% (>T2,3)	13%	14%
Changed temperature setting on water heater	14%	21%	12%
Home improvements made			
Installed more efficient lighting	74% (>T2)	50%	77%
Had air conditioner (AC) serviced	31% (>T2)	11%	35%
Replaced AC with more efficient model	28%	22%	12%
Sealed leaks in AC ducts	21%	11%	23%
Added insulation	18% (>T2)	6%	27%

5.1. The majority of participants changed their energy habits

The majority of participants reported they had *changed their energy habits as a result of the program,* with a significantly larger majority in group T3. When surveyed about specific changes in their energy habits, the majority of respondents in all groups reported changing the setting on their thermostat and being more likely to turn off lights, fans and entertainment equipment when leaving the room. About half of the respondents in all groups reported being more likely to clean or change their central air conditioning filter regularly, and to clean the lint filter on their dryer.

5.2. Thermostat programming increased for T2 and T3 compared to pre-pilot levels

The pilot resulted in significant changes in thermostat use among HEC-equipped groups T2 and T3. These groups were more likely to change their thermostat setting and increase their rate of thermostat programming compared to pre-pilot levels. The results suggest these effects were produced by the introduction of the HEC technology. It is important to note that the practice of thermostat programming was neither encouraged nor discouraged in the pilot.

Pulse survey 2 established a pre-pilot thermostat programming baseline by asking group T2 and T3 participants: 1) to describe the type of thermostat (programmable or not programmable) they used prior to the pilot and, 2) if they used a programmable type, whether or not they used the "scheduling feature." The responses were used to estimate the percentage of T2 and T3 homes that had a *programmed* thermostat prior to the pilot. During the pilot, programmable thermostats were installed in all T2 and T3 homes, as part of the home energy controller. Pulse survey 3 asked T2 and T3 participants to describe the new thermostat installed in their home, and the vast majority correctly described their new pilot thermostat as being programmable. An average of three-fourths of the participants also reported using the new thermostats' scheduling feature. While the proportion of participants reporting use of the scheduling feature did not increase significantly over pre-pilot levels, the base of homes equipped with programmable thermostats did, leading to a significant increase in programming over pre-pilot levels in both groups.

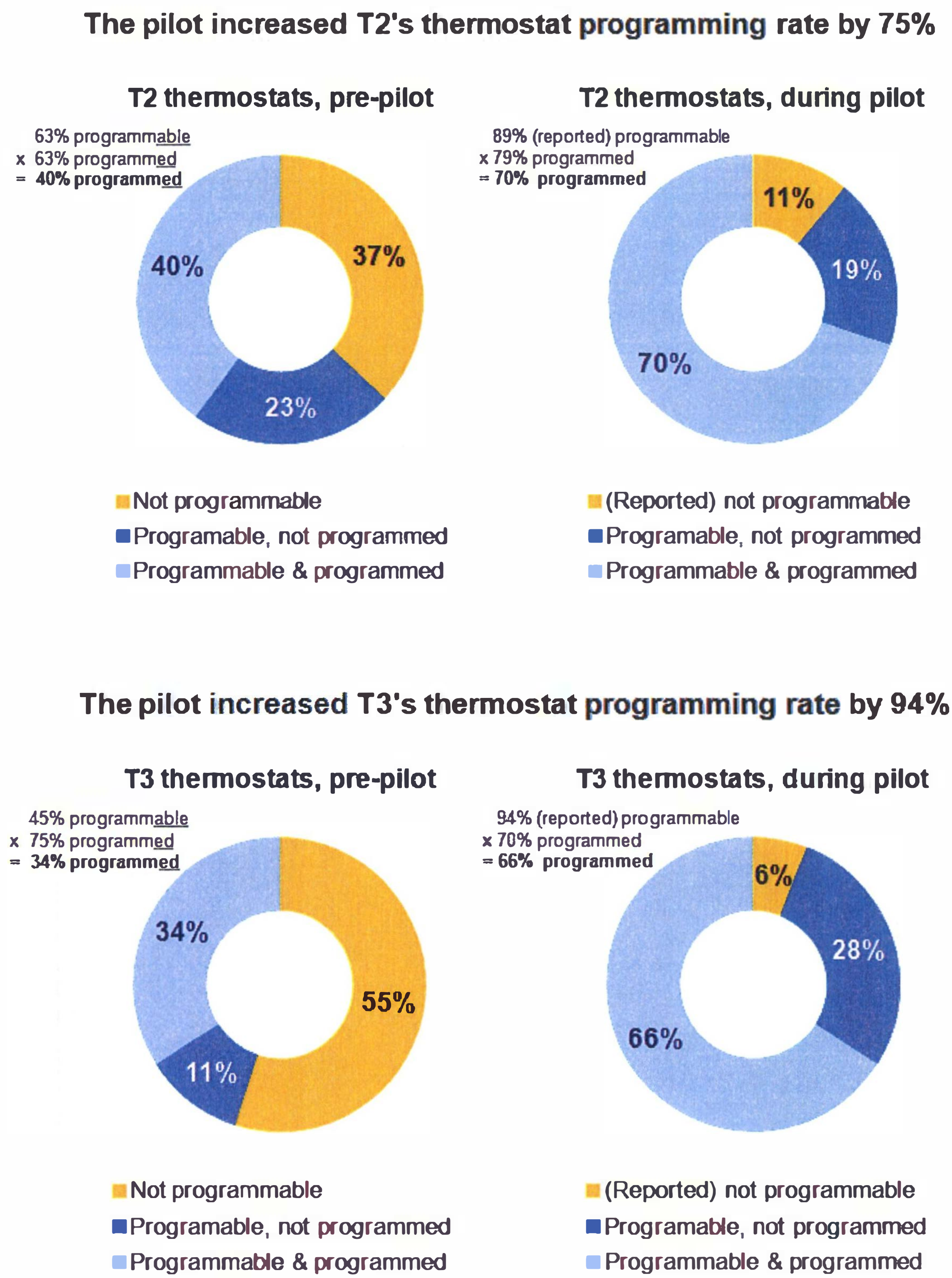
All pilot groups were asked how they set their thermostat when away from home, when returning home and at bed time. The average reported temperatures for T2 and T3 were nearly identical. T1's average settings were lower than T2 and T3; two degrees cooler when away from home during the day and one degree cooler when returning home.

Table 20: Changes in thermostat use as a result of the pilot

Conservation Habits: Thermostats
Sources: Pulse survey 2, November 2011 and Pulse 3, May 2012
% indicates percent of users reporting
(>Tn) Indicates 90% confidence in significant difference from Group Tn

Group	Group T1	Group T2	Group T3
Technology / Rate combination	IHD on RS	HEC on RS	HEC on RSDPR
Number of respondents, Pulse 2	not asked	30	44
a. Had programmable thermostat before the pilot	not asked	63%	45%
b. Used the scheduling feature before the pilot	not asked	63%	75%
a x b = homes with a programmed thermostat before the pilot	na	40%	34%
Number of respondents, Pulse 3	64	38	47
a. Have a programmable thermostat now	52%	89% (>pre pilot, >T1)	94% (>pre pilot,>T1)
b. Use the scheduling feature now	42%	79% (>T1)	70% (>T1)
a x b = homes with a programmed thermostat now	22%	70% (>pre pilot, >T1)	66% (>pre pilot,>T1)
Changed setting on my thermostat as result of program	70%	88% (>T1)	95% (>T1)
Average thermostat setting: When away during the day	78	80	80
Average thermostat setting: When returning home	76	77	77
Average thermostat setting: At bed time	76	77	76

Figure 19: Changes in thermostat programming among HEC-equipped groups T2 and T3



5.3. Installing efficient lighting was the most common home improvement

When asked about energy-saving home improvements, about half of the participants in each group reported making some type of improvement. Installing efficient lighting was the most common home improvement, reported by half or more of each group. Compared to the T2 group, more T1 participants reported installing energy efficient lighting, having the air conditioner serviced and adding insulation.

5.4. Participation in FPL rebate programs

In addition to self-reported Pulse survey data on energy-saving home improvements, FPL checked its residential conservation program database for participation in FPL rebate programs by treatment and control group homes during the pilot. FPL's residential rebate programs include high-efficiency central air conditioning replacement, central air conditioning duct leak repair, and ceiling insulation installation. Among homes completing the pilot, FPL found some participation in each program and the highest participation in the air conditioning replacement program. There was one statistically significant difference among groups; group T3 had higher participation in the ceiling insulation program than the Control group.

Table 21: Participation in FPL rebate programs

Energy-Saving Home Improvements: Participation in FPL Rebate Programs Post-Treatment
Source: FPL Program Database, January 2011 - August 2012
(>Tn) indicates 95% confidence in significant difference from Group Tn

			Number participating in program			Percent participating in program		
Treatment Period	**Group**	**n**	HVAC	Insulation	DUCT	HVAC	Insulation	DUCT
2/2011 - 8/2012	Control (C)	342	12	0	0	3.5%	0%	0%
2/2011 - 8/2012	T1	209	11	2	1	5.3%	1.0%	0.5%
3/2011 - 8/2012	T2	103	7	3	0	6.8%	2.9%	0%
6/2011 - 8/2012	T3	114	4	4	1	3.5%	**3.5%, >C**	0.9%
9/2011 - 8/2012	T4	10	0	0	0	0%	0%	0%
	Total	**778**	**34**	**9**	**2**	**4.4%**	**1.2%**	**0.3%**

The Brattle Group

Energy Smart Florida Pilot - Final Impact Evaluation

05 December 2012

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Prepared for

FPL

6. ENERGY IMPACTS (AS REPORTED BY THE BRATTLE GROUP)

- *The ESF pilot interval data is of very good quality with minimal amounts of data issues.*
- *The treatment and control group are largely comparable to each other.*
- *We do not find any energy conservation effects that are statistically distinguishable from zero.*
- *We find that on critical peak event days T3 customers reduced their average hourly load in the event window by approximately 0.42 kW.*
- *Average hourly load reductions in the event window during winter event days were twice as large as those on non-winter event days (0.71 kW vs. 0.36 kW).*
- *Average hourly load reductions in the event window were significantly larger for the first five non-winter events than the final five (0.42 kW vs. 0.3 kW).*
- *The average reduction in demand during the typical system peak hour was 0.37 kW for summer (4-5 pm) and 0.80 kW for winter (7-8 am).*
- *The reduction in demand during the coincident system peak hour was 0.64 kW for the summer and 0.95 kW for the winter peak.*
- *All of the load shifting reductions and differences are statistically significant at the 95 percent level.*

6.1. INTRODUCTION

FPL conducted the Energy Smart Florida (ESF) pilot to evaluate the effect of different technologies and a Critical Peak Pricing (CPP) rate on the energy using behavior of a sample of its customers. The purpose of the ESF pilot was to measure the impact of these different technologies and the CPP rate on energy conservation and load shifting. The treatment and control group customers were randomly selected in the ESF pilot. Hourly load data was collected on all groups during the pre-treatment and treatment periods. The following treatments were tested:

- T1 customers remained on the standard rate (which featured an inclining block rate design) and were provided with In Home Displays (IHDs)
- T2 customers remained on the standard rate and were provided with Home Energy Controllers (HECs)
- T3 customers were moved to the CPP rate structure and were provided with HECs
    - Unlike the T1 and T2 cells, the thermostats of the T3 customers were programmed to conserve energy during various peak windows on certain event days
    - T3 customers were charged higher prices during the event hours but received a rate discount for all other hours

In this section we discuss the experimental validity of the ESF pilot and measure its effect along two key metrics: energy conservation and load shifting. We undertake this analysis using regression analysis.

It is important to note that the ESF pilot interval data is of very good quality with minimal amount of data issues and that the treatment and control group are largely comparable to each other. Any remaining differences are accounted for within the regression model.

In terms of energy conservation, we find that in the treatment period, excluding critical peak event days: T1 customers decreased their energy usage by 0.81 percent; T2 customers increased their energy usage by 0.43 percent; and T3 customers decreased their energy usage by 2.84 percent. However, we also find that ***none of these results are statistically distinguishable from zero.***

In terms of load shifting, we find that on critical peak event days T3 customers reduced their average load by approximately 0.42 kW during the CPP event. Reductions during winter event days were twice as large as those on non-winter event days (0.71 kW vs. 0.36 kW). We also find that the impact was significantly larger for the first five non-winter events than the final five (0.42 kW vs. 0.3 kW). The average reduction in demand during the typical system peak hour was 0.37 kW for summer and 0.80 kW for winter. Two CPP events occurred concurrently with the coincident summer and winter system peaks. The reduction in demand during the coincident system peak hour was 0.64 kW for the summer and 0.95 kW for the winter peak. All of the above load shifting reductions and differences are statistically significant at the 95 percent level.

The rest of the section proceeds as follows in Section 6.2 we examine the validity of the experimental design by examining how the sample was selected, comparing load shapes between the treatment and control groups and testing for selective attrition by participants. In section 6.3 we discuss our empirical approach and then present the results from our energy conservation and load shifting analysis. In section 6.4 we conclude with a summary of the key findings from our energy impact analysis.

6.2. Validity of Experimental Design

6.2.1. Sample Selection

The sample frame for the ESF pilot was drawn from the population with smart meters in Broward County, Florida. This area was selected because the maturity of FPL's smart meter deployment in the area could provide more pre-treatment data and allowed the evaluation of impacts under weather conditions experienced by many FPL customers. Since the sample frame for the ESF pilot was confined to this region, the external validity of the pilot results only applies to this region. FPL identified the customers who were eligible for participation in the pilot within this population based on technical and utility account-level requirements (These criteria are discussed in Section 4.1 of this report) After the eligibility criteria were applied, 13,446 customers qualified for participation in the pilot. From this number, *The Brattle Group* randomly assigned these customers to the control group or to a group which was to be solicited for one of three treatments. This procedure was designed to ensure that all eligible customers had equal chances of being solicited for the various treatment groups or assigned to the Control group. A third party solicited participation from the customers who were randomly assigned into the treatment group. Customers who were assigned in the treatment group were not offered a choice of treatments and were not aware of the other treatments. Participants had the option of declining participation or affirming participation. They could also exit the pilot at any stage.

6.2.2. Randomization

In order to ensure the internal validity of the ESF pilot results, we first compare the control and treatment groups to assess whether they are balanced. We do this by running three descriptive analyses with the underlying hourly ESF data.

- i- Comparison of typical day load profiles for each month (computed by averaging the load values for control and treatment customers by hour)
- ii- Detailed summary statistics of the load data
- iii- Analysis of survey data (socio-demographic and appliance attributes)

Our typical day load analysis reveals that the load profiles are comparable between treatment and control groups (based on statistical mean comparison tests) during most pre-treatment months. Moreover, the treatment and control group typical day loads have the same shape. However, we also observe that the average usage for the treatment group is slightly larger than the average usage for the control group in all cases. Examination of detailed summary statistics of the load data reveals that the treatment group has more customers with larger loads than the control group. This observation explains the slightly higher average usage values for treatment group for most pre-treatment and treatment months. It is important to note that this finding does not constitute an issue for our statistical analysis as we account for these differences in the regression framework as we later discuss in this report.

We also repeat the typical day load profile analysis at a more aggregate level. For this purpose, we determine the common pre-treatment period for all four ESF treatments as June 2010 through January 2011 and create typical day load profiles for the ESF treatments and the control group by season in Figure 1 and Figure 2. Similar to the monthly comparisons, we find that the treatment and control group load profiles have the same shape. The similarity of the load shapes is essential to ensure the comparability of the treatment and control cells, whereas the differences in levels can be accounted for in the regression model. However, the mean comparison between the control group and the treatment cells presented in Table 1 reveals that the difference between the average hourly usage of the two groups is not statistically significant at a ninety-five percent confidence level.

Figure 1: Comparison of Load Shapes for Winter Months

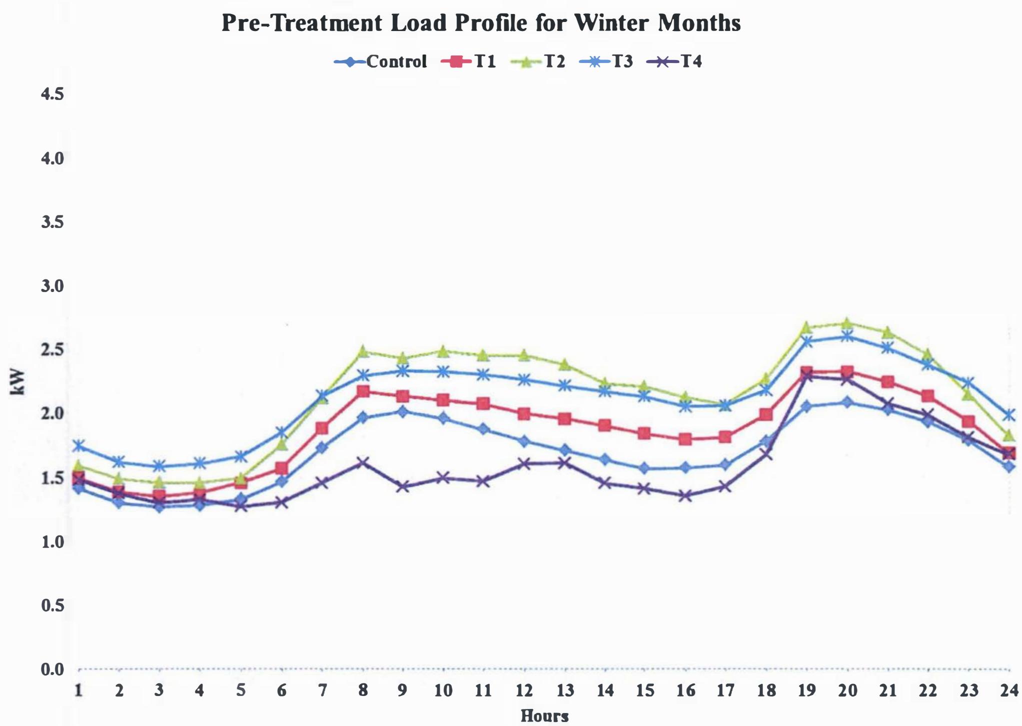


Figure 2: Comparison of Load Shapes for Non-Winter Months

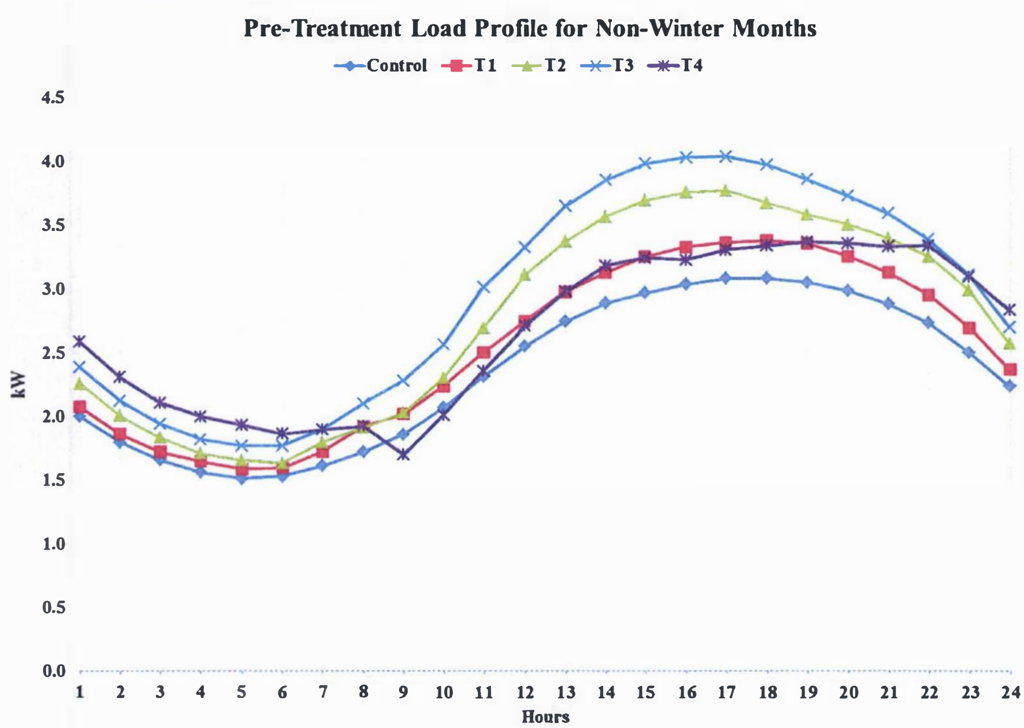


Table 1: Mean Comparison Test for Control and Treatment Groups

Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf. Interval]	
Control	24	2.075	0.085	0.415	1.899	2.250
Treatment	24	2.342	0.105	0.515	2.125	2.560
Combined	48	2.209	0.070	0.482	2.068	2.349
Δ		-0.267	0.135		-0.539	0.005

Δ = mean (Control) - mean (Treatment) — **Pr(|T| > |t|)** =0.0539 — **t** =-1.9787

H0: $\Delta = 0$, HA: $\Delta \neq 0$ — **Outcome**: Do Not Reject H0

In addition to the detailed analysis of the load data to gauge the comparability of the treatment and control groups, we also analyzed the survey data collected for both the treatment and control customers. Analysis of the survey data revealed that the treatment and control groups were comparable to each other on several socio-demographic and appliance attributes, while they differed on several others which are noted below.

The treatment and control groups were found to be comparable for the following attributes:

- Education of the head of the household (44% of the treatment and 38% of the control customers reported associate or bachelor degrees)
- Home ownership (95% of both treatment and control customers own their home)
- Heating type (94% of the treatment and 90% of the control customers have electricity heating)
- Importance of electricity bill for electricity consumption decision (85% of both treatment and control group customers rank the importance of their electricity bills as number 1)
- Importance of environmental concerns for electricity consumption decision (66% of the treatment and 72% of the control group customers rank the importance of environment as number 2)
- Importance of the impact on future energy supplies for electricity consumption decision (69% of the treatment and 73% of the control group customers rank the importance of impact on future energy as number 3)

The treatment and control groups were *not* found to be comparable for the following attributes:

- Annual household income (50% of the treatment customers reported incomes more than $70K, whereas 43% of the control customers reported incomes between $30K and $70K)
- Type of home (100% of the treatment and 97% of the control group customers live in single-family or multi-family homes with less than four units)

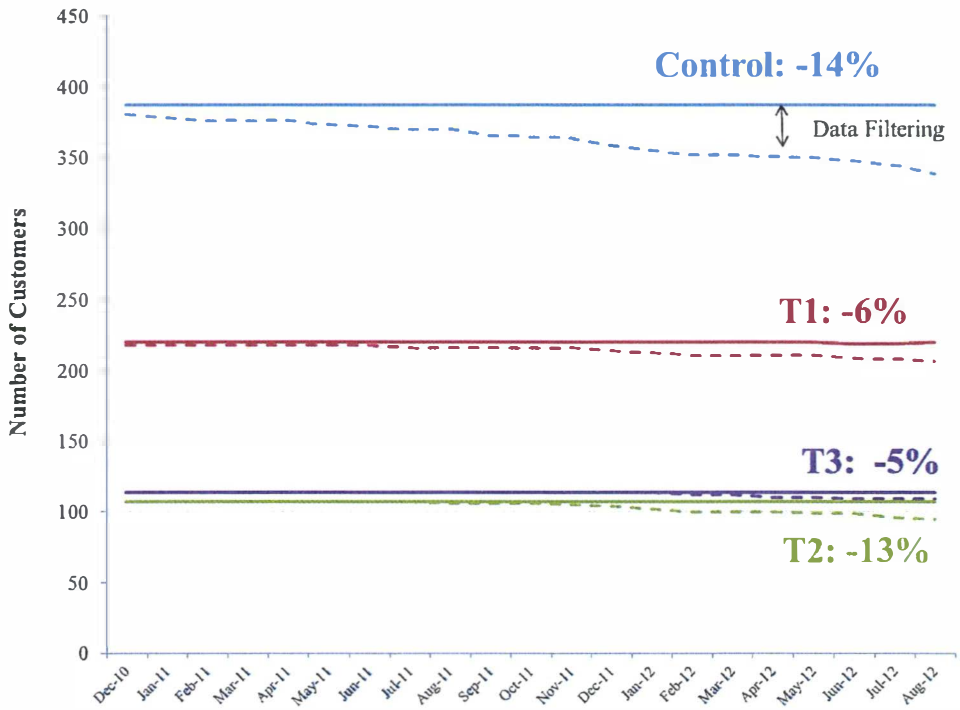
- Number of people in the household (86% of the treatment and 69% of the control customers reported more than 2 people)
- Cooling type (96% of the treatment and 89% of the control group customers have central air conditioning in their homes)
- Swimming pool ownership (41% of the treatment and 29% of the control group customers have a swimming pool)
- Spa/hot tub/whirlpool ownership (41% of the treatment and 27% of the control group customers have spa/hot tub/whirlpool)

Even though the treatment and control group responded differently to several socio-demographic and appliance attributes, they responded similarly to all attitudinal questions. The finding that they have similar preferences towards energy consumption is yet another important assurance that the treatment and control groups are largely balanced. Any remaining difference between these two groups will be accounted for in the regression analysis.

6.2.3. Attrition

During the course of the ESF pilot, some participants left the study. If this attrition was random, then it would not affect the validity of the impact evaluation results. However, if attrition was related to the treatments (selective), then it could pose a risk to the internal validity of the pilot. For example, if all of the large energy users left the treatment group due to higher bills under CPP, then the treatment and control groups would lose their random allocation feature and cease to be comparable. Overall, there was an attrition rate of 10 percent for the entire pilot period. Figure 3 shows attrition across the different treatment groups and control group over time.

Figure 3: Attrition by Treatment Group



We tested whether this attrition was selective based on pre-treatment average energy usage and found that for all of the treatment groups, attrition was random. For the control group, who were unaware of their role in the experiment, lower usage customers were significantly more likely to close their accounts and hence unconsciously leave the experiment than higher usage households. Thus the selective attrition amongst the control group is not problematic and in fact made the control group more similar to the treatment group which had higher usage in the pre-treatment period (this difference was statistically insignificant).

6.3. Our Approach and Results

We utilize regression analysis as our primary impact evaluation approach in this study. Regression analysis is a statistical technique that allows us to account for the impact of many different explanatory variables on one "dependent" variable. By including multiple explanatory variables, we can isolate the pure effect of our variables of interest on the dependent variable. For example, we can isolate the effect of our experimental treatment on energy usage by separately accounting for the confounding effects of changing weather over the same time period. Typically, regression analysis only identifies correlation between variables, however, when we combine it with the ESF experimental design, which randomly assigns customers to a treatment and control group, we can interpret the estimated treatment impacts as reflecting causality and not just correlation.

A randomized controlled experiment, as depicted in Figure 4, represents the gold standard of experimental design and involves random allocation of the customers into the treatment and control cells. In the ESF pilot, the treatment customers were first randomly allocated to the treatment pool, then solicited from this randomly selected group. By randomly selecting into the treatment and control group, we expect that the treatment and control group will be identical in the pre-treatment period i.e. Tpre-Cpre=0. However with smaller samples, some differences between the groups may occur. In Section 6.2.2, we showed that the treatment and control groups had similar load shapes and attitudes, but differed in terms of the level of usage and some appliances. We assume that these differences between the groups are permanent over time and are accounted for by Tpre-Cpre. Our impact measure is thus the difference in electricity usage between the treatment and control group after our experimental intervention (Tpost-Cpost) net of the pre-existing differences between the groups (Tpre-Cpre).

Figure 4: Randomized Controlled Experiment

	Control Group	**Treatment Group**
Before Treatment	Cpre	Tpre
After Treatment	Cpost	Tpost

True Impact Measure = (Tpost-Cpost)-(Tpre-Cpre)

Note: In this figure, Cpre (Tpre) represents the average usage of the control (treatment) group in the pre-treatment period. Similarly, Cpost (Tpost) represents the average usage of the control (treatment) group in the post-treatment period.

We estimate this "difference-in-differences" impact measure using regression analysis. This allows us to increase the precision of our estimates by utilizing individual data (as opposed to just comparing group aggregates) and accounting for factors like fluctuations in weather, individual-specific usage that does not change over time, and so on. We use regression analysis to answer two primary questions:

1) Is there any ***energy conservation*** due to the program treatments?
2) Is there any ***load shifting*** due to program treatments?

Theoretically, we hypothesize that there are several different channels through which our experimental interventions may drive energy conservation, and that at least one of these factors will have an impact on each experimental group.

Experiment Group T1 has IHDs that give the customers feedback over their energy usage. Having better information over their usage patterns may lower the costs of energy conservation behavior, allowing customers to conserve more. For example, if the IHD shows a customer that they use a lot of energy on a Saturday when nobody is home, they may reprogram their thermostat to turn off on Saturdays. In addition to the learning effects of feedback, just having a visual representation of how much energy they are using may motivate customers to conserve.

Experiment Group T2 has HECs that give the same type of feedback as the IHDs and may motivate energy conservation for the same reason. In addition, the HECs allow customers greater control over several of their appliances, which may make it easier to conserve energy.

Finally, Group T3 has the same technology as T2 and has the same motivations to conserve. However, they may be more motivated to conserve since they may have additional awareness of their energy usage because of their exposure to CPP events. In addition, they may conserve during CPP events, because energy usage is not perfectly substitutable between periods i.e. if the customer turns off their air-conditioner during the heat of the day, they cannot make up for that by running the air-conditioner more during the night when it has already cooled off.

For load shifting, we expect that only Treatment Group T3 will be affected, since they are the only group exposed to critical peak prices. We hypothesize several possible reasons that they may reduce load during critical peak periods. Firstly, customers may change their energy usage behaviors in response to the increased price during critical peak periods (if they notice that an event is underway). Secondly, they may reduce load due to the HEC automated control, even without any behavioral change relating to the use of other appliances. The HEC automated control is programmed to raise the thermostat temperature in summer and lower it in winter, turn off the pool pump and turn off the electric water heater. However, customers have the ability to override some, if not all of these automatic features. Finally, customers may decrease load during CPP events due to increased energy awareness induced by the events themselves. However, it is important to note that the critical peak prices will yield a behavior change only if the customers notice that an event is in progress.

6.3.1. Energy Conservation

6.3.1.1. Estimating Equations

We estimate energy conservation impacts at the daily level. Energy usage is measured as the average hourly usage for the day in kWh. Our primary regression equation is laid out in equation 1, below:

$$\begin{aligned} kWh_{it} = \beta_o + \sum_{G=1}^{3} & (\beta_{1G} * TreatCust_{G_i} + \beta_{2G} * TreatPeriod_{G_t} + \beta_{3G} * TreatCust_{G_i} \\ & * TreatPeriod_{G_t}) + \beta_4 * CPPDay_t + \beta_5 * CPPDay_t * TreatCust_{3_i} \\ & + \beta_6 Month_t + \beta_7 * THI_t + \beta_8 * Month_t * THI_t + \beta_9 * DayOfWeek_t + \\ & \beta_{10} * FE_i + \varepsilon_{it} \end{aligned} \tag{1}$$

Where:

$TreatCust_{G_i}$	: Dummy variable indicating that customer i is in treatment group G
$TreatPeriod_{G_t}$	: Dummy indicating the treatment period for treatment group G.
$TreatCust_{G_i} * TreatPeriod_{G_t}$	: Dummy indicating that customer i is in treatment group G and is receiving treatment
$CPPDay_t$	: Dummy indicating that a CPP event occurred on that day
$CPPDay_t * TreatCust_{3_i}$	: Dummy indicating that a CPP event occurred and customer i was in treatment group 3.
$Month_t$	: Month of the year specific effects
THI_t	: Average daily Temperature Humidity Index
$Month_t * THI_t$	: Month of the year specific THI effects
$DayOfWeek_t$	: Day of the week specific effects
FE_i	: Customer specific effect
ε_{it}	: Error term, assumed to be clustered at the individual level

In the regression equation above, our main parameter of interest is β_{3G}. This parameter measures the specific impact of being in the treatment group during the treatment period. Since there are three treatment groups, we actually estimate three parameters: β_{31}, β_{32} and β_{33} for treatment groups T1, T2 and T3, respectively. This is contrasted with being in the control group during the treatment period and netted off against any pre-treatment differences between the treatment and control group. We also account for the effect of CPP event days in general as well as the effect of CPP event days on treatment group T3. *Our energy conservation impact measures exclude any conservation impacts on CPP days, which are analyzed separately* (see Section 6.3.2.2). To increase the precision of our estimates we include a Temperature Humidity Index (THI) and allow its effect on energy usage to vary by month of the year. We also allow for month of the year and day of the week specific effects on energy usage. Finally, we account for fixed differences between customers that do not change over time with a customer specific "fixed effect". We assume that any other differences in daily energy usage that are not accounted for by the above explanatory variables, are random, and that these random shocks are correlated for any individual customer.

6.3.1.2. Results

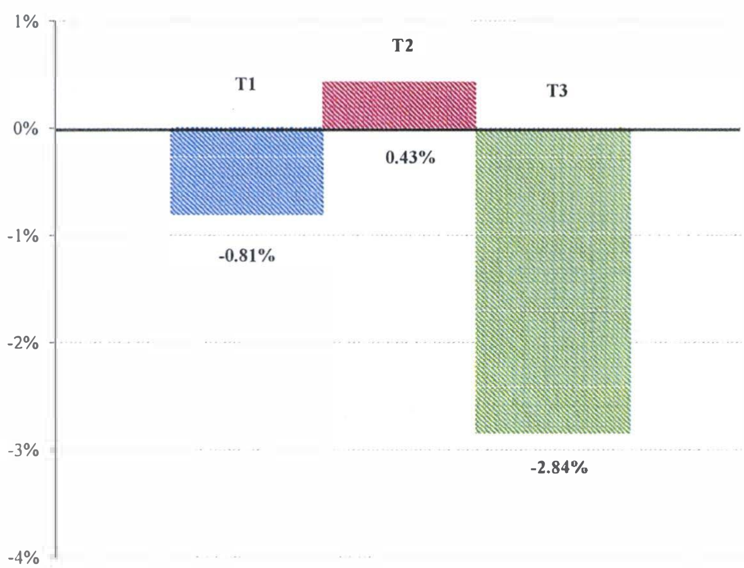
Table 2 shows our average hourly impact in kWh, which corresponds to the parameter β_{3G} from Estimating Equation 1. We divide by the group-specific average hourly load in the treatment period to obtain the percentage impacts.

Table 2: Average Hourly Energy Conservation Impacts

	T1	T2	T3
Average Hourly Impact (kWh/hr)	-0.017	0.01	-0.068
Average Hourly Load (kWh/hr)	2.088	2.34	2.391
% Impact	**-0.81%**	**0.43%**	**-2.84%**

The energy conservation impacts in percentages are shown graphically in Figure 5. The point estimates for T1 and T3 are negative, while that for T2 is positive. *However, none of these estimates are statistically distinguishable from zero*. Put differently, our impact measure is a point estimate of the true impact measure, and based on the precision of our estimates, we can estimate an interval in which this true impact measure lies. Our criterion for selecting interval size is that we would like to be 95% confident that the true impact measure lay within the interval. If this interval is sufficiently far enough away from zero, we can say that our results are statistically distinguishable from zero. However, as is the case above, if this interval overlaps with zero, it means our results are statistically indistinguishable from a zero result.

Figure 5: Average Hourly Energy Conservation Impacts (Percentages)



In addition to the above analysis, we also combined Treatment Groups T2 and T3 together to test whether there was an overall energy conservation impact from the HECs, and Treatment Groups T1, T2 and T3 to test whether there was an overall energy conservation effect from feedback over energy usage. By combining the groups, we increase our sample size and the precision which we can identify treatment effects. However, in both cases, we still did not find a significant energy conservation impact.

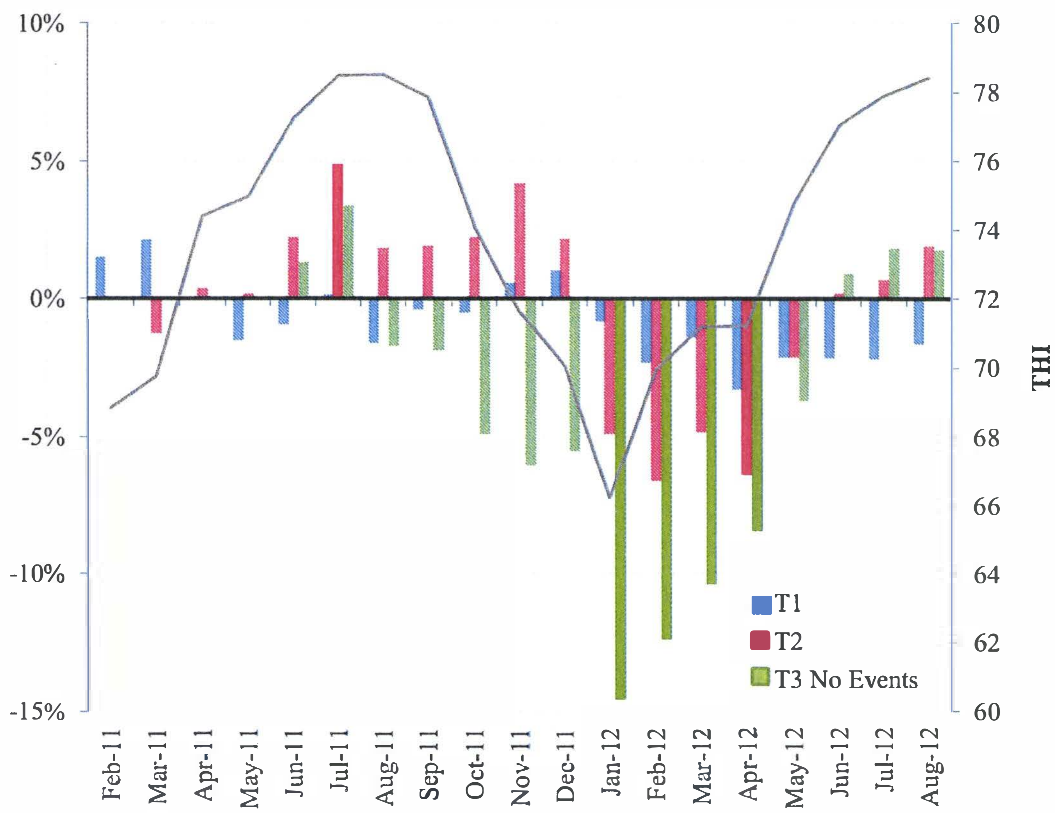
It is still possible that an energy conservation impact exists, but is too small to be statistically identified. Table 3 shows the minimum detectable impact that can be detected based on the precision of our impact estimates. This table can be interpreted as follows: for T1 we will only be able to statistically distinguish a conservation impact from zero if it is greater than 2.68% (at a 95 percent confidence level).

Table 3: Minimum Detectable Impacts.

Treatment Group	Minimum Detectable Conservation Effect
T1	2.68%
T2	3.12%
T3	4.66%
T2 and T3 Combined	3.11%
T1, T2 and T3 Combined	2.39%

Although we find no annual average energy conservation effects, we tested whether there were month-specific conservation effects. These results are shown in Figure 6 for all three treatment groups. The left side y-axis shows energy conservation impact in percentage terms, while the right side y-axis shows the Temperature Humidity Index. Monthly energy conservation impacts are represented by bars, while the temperature humidity index is shown as a grey line. Estimated impacts which are statistically significant from zero are shown as solid color blocks, while shaded blocks represent non-significant results.

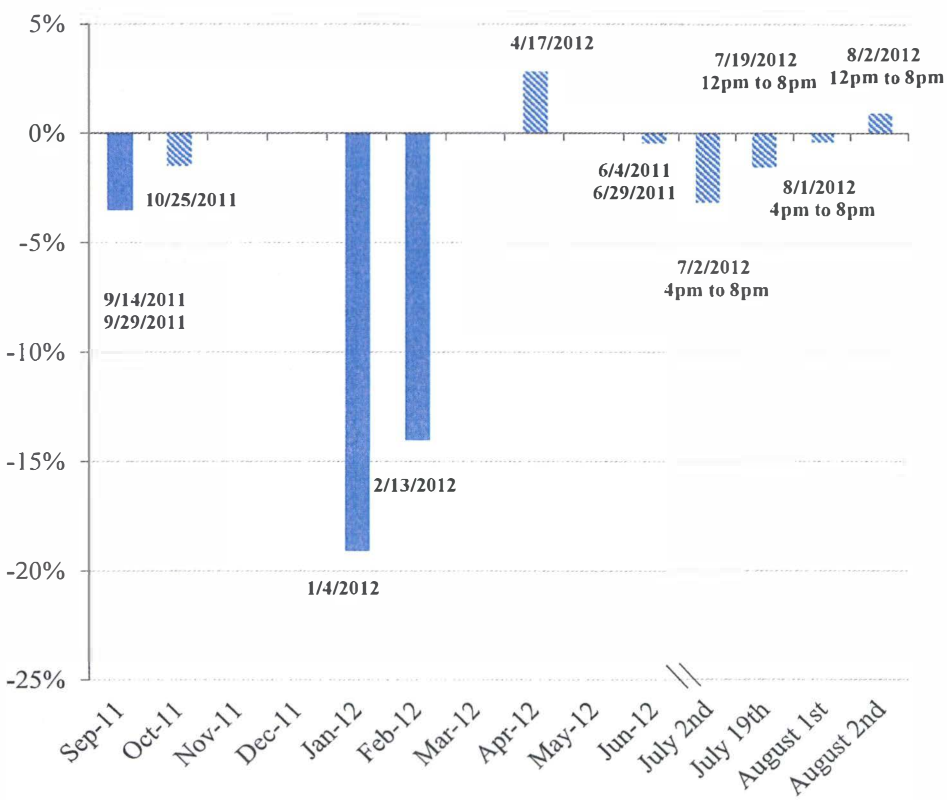
Figure 6: Month-Specific Energy Conservation in Percentages



For T3, we find that there are statistically significant energy conservation effects in January through April, while the months bordering this period are insignificant, but of similar magnitude. We find similarly negative, but smaller effects for T2 in this period, although only the April impact is statistically distinguishable from zero. These energy conservation impacts seem to occur in the winter and spring period, when the temperature humidity index is at its lowest. To test whether there is a relationship between THI and energy conservation we re-estimate equation 1, but allow for energy conservation impacts to vary by THI. We find that at lower THI values there are significant energy conservation impacts for T2 and T3, but they decrease to zero as the THI increases. These impacts are larger for T3 than T2.

Finally we examined energy conservation on CPP event days for T3. These results are shown in Figure 7. Only three events had energy conservation that was significantly different from zero. Two of these three events, occurred in the winter months and also had the largest magnitude.

Figure 7: Energy Conservation on CPP Event Days



To summarize our energy conservation findings, we find no statistically identifiable overall energy conservation impact for any of the treatment groups on an annual basis, although it seems that the HECs did induce some energy conservation during the winter and spring months. There was additional conservation for T3 during 3 out of the 12 CPP event days.

6.3.2. Load Shifting

6.3.2.1. Estimating Equation

We estimate load shifting impacts at the hourly level. Energy usage is measured as the hourly load in kW. We ran hour of the day and event specific regression equations to calculate hour by hour impacts. This shows the impact of an event across a 24 hour window making loading-shifting patterns clear and illustrating any "rebound/snapback" at the end of the event. For practical reasons, we restricted the analysis to a comparison of T3 and the control group. Our primary regression equation is laid out in equation 2, below:

$$kW_{it} = \beta_o + \beta_1 * TreatCust_{3_i} + \beta_2 * TreatPeriod_{3_t} + \beta_3 * TreatCust_{3_i} * TreatPeriod_{3_t} + \beta_4 * CPPDay_t + \beta_5 * CPPDay_t * TreatCust_{3_i} + \beta_6 Month_t + \beta_7 * THI_t + \beta_8 * Month_t * THI_t + \beta_9 * DayOfWeek_t + \beta_{10} * FE_i + \varepsilon_{it} \quad (2)$$

Where:

$TreatCust_{3_i}$	: Dummy variable indicating that customer *i* is in treatment group *3*
$TreatPeriod_{3_t}$	: Dummy indicating the treatment period for treatment group 3.
$TreatCust_{3_i} * TreatPeriod_{3_t}$	: Dummy indicating that customer *i* is in treatment group *3* and is receiving treatment
$CPPDay_t$	: Dummy indicating that a CPP event occurred on that day
$CPPDay_t * TreatCust_{3_i}$	: Dummy indicating that a CPP event occurred and customer *i* was in treatment group 3.
$Month_t$	: Month of the year specific effects
THI_t	: Average daily Temperature Humidity Index
$Month_t * THI_t$	: Month of the year specific THI effects
$DayOfWeek_t$	: Day of the week specific effects
FE_i	: Customer specific effect
ε_{it}	: Error term, assumed to be clustered at the individual level

In the regression equation above, our main parameter of interest is β_5. This is the impact of being in treatment group T3 on a CPP event day for that specific hour. This is contrasted with being in the control group on the CPP day and netted off against any non-CPP day as well as pre-treatment differences between the treatment and control group. To increase the precision of our estimates we include a Temperature Humidity Index (THI) and allow its effect on energy usage to vary by month of the year. We also allow for month of the year and day of the week specific effects on energy usage. Finally, we account for fixed differences between customers that do not change over time with a customer specific "fixed effect". These fixed effects relate to a particular hour of the day. We assume that any other differences in daily energy usage that are not accounted for by the above explanatory variables, are random, and that these random shocks are correlated for any individual customer.

6.3.2.2. Results

To illustrate the load shifting effects graphically, we include Figure 8. The leftmost figures show the T3 and control group load-shapes on an event day compared with the seasonal average. The central column shows the net differences between the event day and the seasonal average for both the treatment and the control groups. Finally the rightmost figures show the difference-in-differences, which is the difference between the seasonally adjusted treatment and control load. *These results illustrate how we move from the load shapes to a difference in difference estimate.* Our regression analysis operates similarly, but with increased precision since it includes additional explanatory variables and uses individual rather than aggregate data. The top row shows a summer event day, while the middle row shows a winter event day. The bottom row shows an eight hour event day. All in all twelve events were called, ten in summer and two in winter. Both winter events were three hours in duration, while six of the summer events lasted for four hours and two for eight hours.

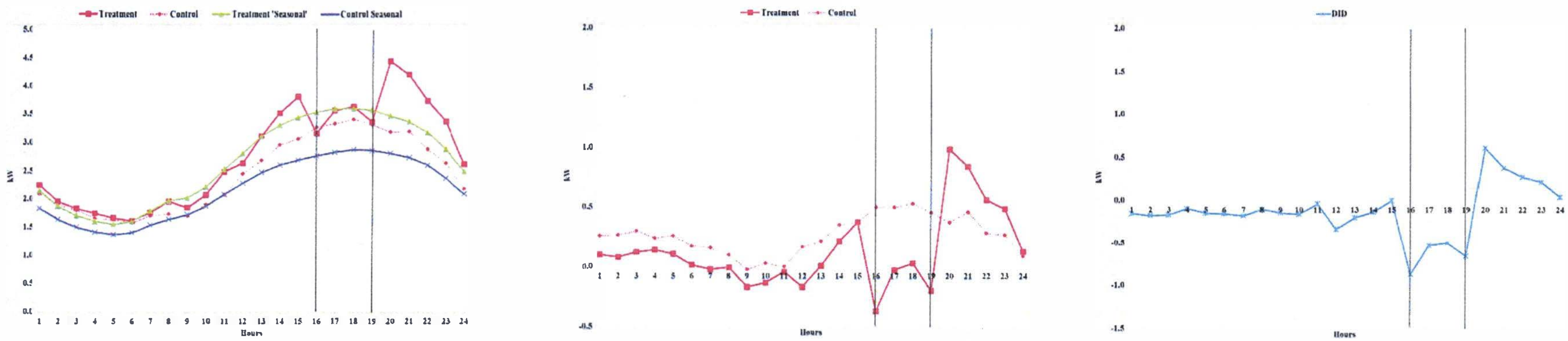
Figure 8: Illustrative Load Shapes

Load Shape for Event Day and Seasonal Average (All Winter / Non-Winter, Non-Holiday, Non-Event Weekday)

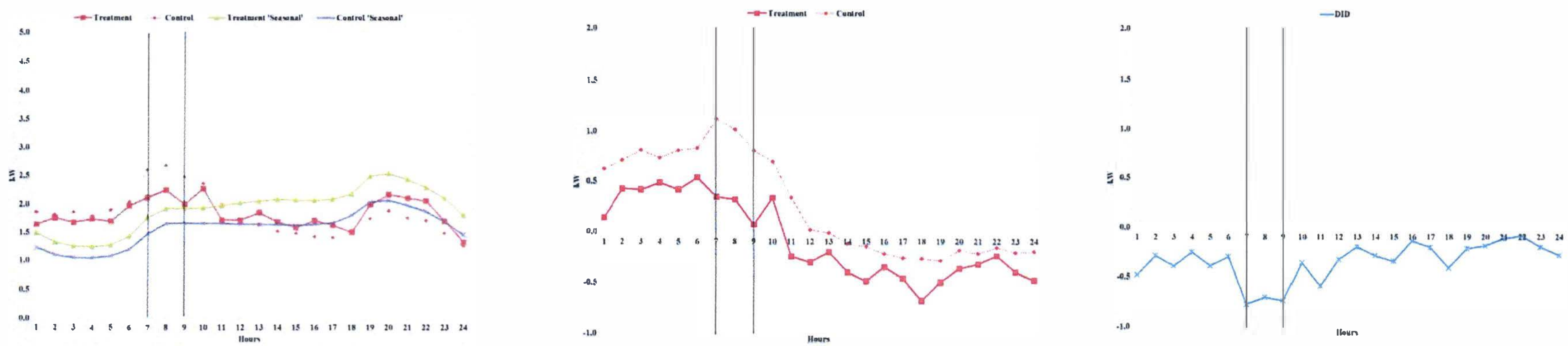
Difference between Event Day Load and Seasonal Average Load

Difference between Treatment And Control Group (After Removing Difference in Seasonal Average Load)

Summer – September 14th Event Day



Winter – February 13th Event Day



8 Hour – August 2nd Event Day

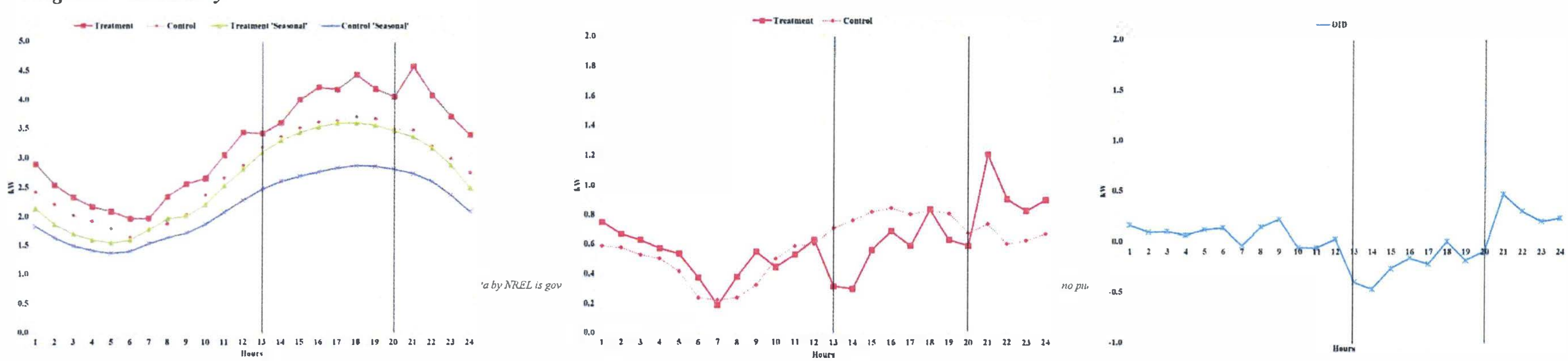
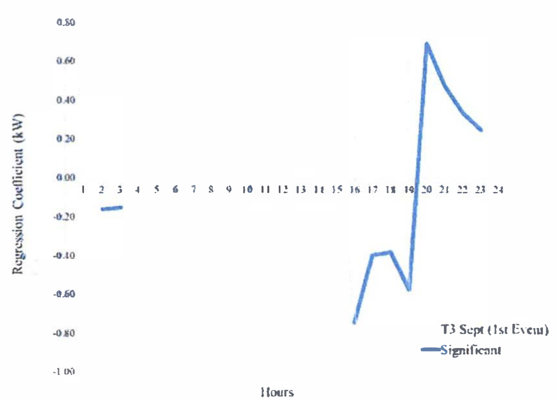


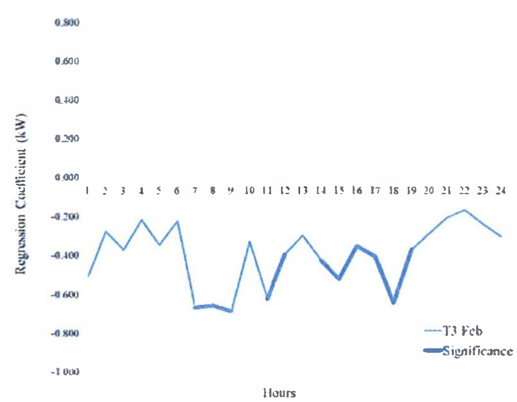
Figure 9 shows our regression results from the same three events illustrated above. The regression results are very similar to the difference-in-differences results shown in Figure but are more precisely identified. The darker blue line shows where impacts are statistically significant (distinguishable from zero).

Figure 9: Illustrative Regression Results

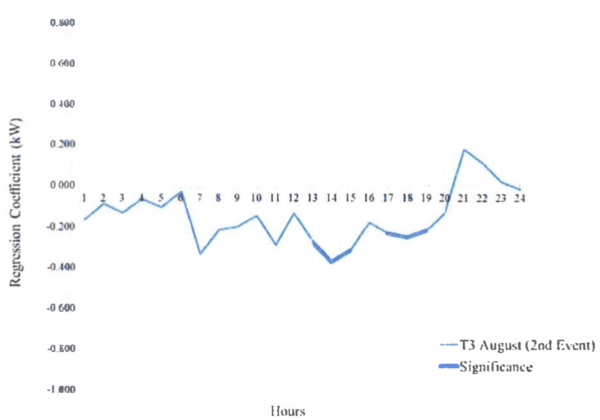
Summer - September 14th Event Day



Winter – February 13th Event Day

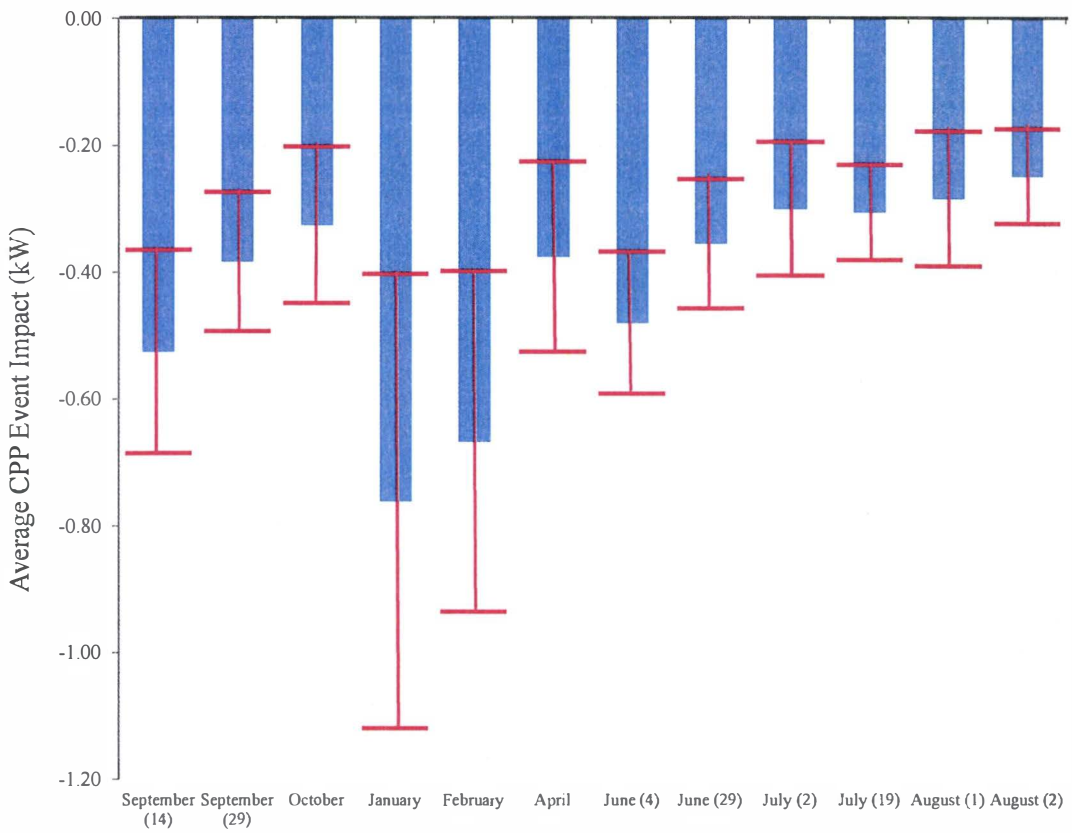


8 Hour – August 2nd Event Day



To obtain the average load impact of each event, we added up all of the impacts during the event window and divided by the number of hours in the event window. This is shown graphically in Figure 10. Even though not all of the hours during the critical peak price event window are significant, the average impact for each event is significantly different from zero. The blue bars show our estimates of the average load impact, while the red bars show the interval between which we are 95% confident that the true impact lies.

Figure 10: Estimated Peak Impacts



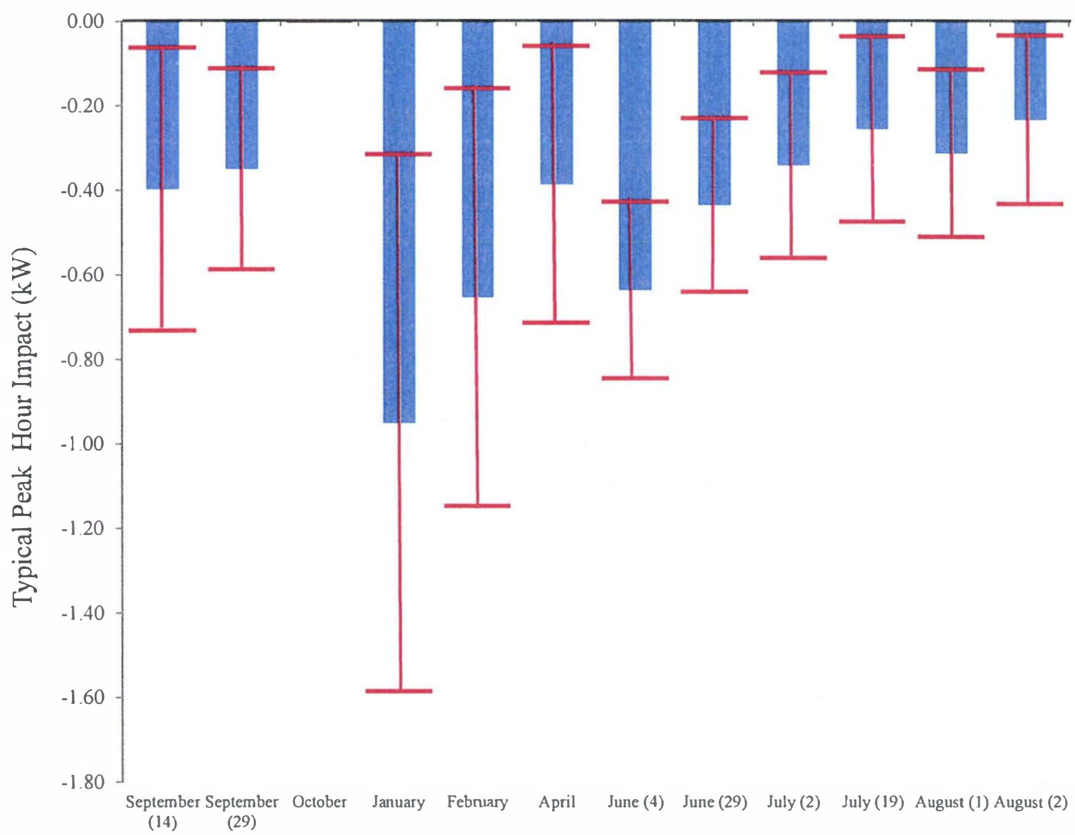
The average load reduction across all events is 0.42 kW, with the average winter reduction (January and February) of 0.71 kW being almost double that of the average non-winter reduction of 0.36 kW. Only two events have statistically significant snapback in the hour following the end of the event. Snapback means that energy usage increases above the non-event baseline as electricity prices return to normal and households make up for lost functionality during the event. This may take the form of making up for cooling (or heating) lost during the event, or deferring the usage of appliances until after an event. Both events with statistically significant feedback occurred in the summer (September 14, 2011 and June 4, 2012). The amount of snapback in the hour following the end of each of these events was 0.69 kW and 0.36 kW respectively.[1] It is possible that there are additional snapback effects spread over multiple hours after the CPP event, and that these are too small to be accurately measured given our sample size. In fact, it seems likely that either additional conservation or snapback effects do exists, since we found statistically significant reductions during the event, but did not find any statistically significant

[1] Snapback is estimated using Estimating Equation 2 in Section 6.3.2.1. This is the same estimating equation used for calculating impacts during CPP events.

increase (snapback) after the event (apart from two events), or any statistically significant reduction (conservation) over the entire event day.

Figure 11 shows the impact of the CPP event during the typical seasonal system peak. The typical summer peak hour is 4-5 pm, while the typical winter peak is 7-8 am. Eleven out of the twelve CPP event windows contained the typical peak hour. The average impact during the daily peak hour was a reduction of 0.45 kW. The average summer reduction during the typical peak hour was 0.37 kW and for winter it was 0.80 kW. Two of the CPP events, June 4, 2012 (4-5pm) and January 4, 2012 (7-8am) occurred coincidentally with the summer and winter system peaks, respectively. The reduction in kW demand coincident with the hour of the summer system peak was 0.64 kW, while for winter it was 0.95 kW. Both reductions were statistically significant.

Figure 11: CPP Impact during Daily System Peak Hour on CPP Event Day (blank means peak hour was outside of event)



Note:

* The typical system peak hour occurs at 4-5 pm in the summer and 7-8 am in the winter

** The September 29 event took place between 10am and 2pm and did not include the typical system peak hour

*** The January 4 and June 4 events were concurrent with the actual coincident system peak hours for winter and summer respectively

Returning Figure 11, it is also clear that the first five non-winter events had a larger average impact than the final five (0.42 kW vs. 0.3 kW). A comparison of means tests, shown in Table 4 shows that the average reduction in load in the last five periods is indeed significantly lower than in the first five.[2] This result is statistically significant at the 95 percent level.

Table 4: Mean Comparison Test of First Five and Final Five Non-Winter Events

Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
0	5	-0.420	0.037	0.082	-0.522	-0.318
1	5	-0.300	0.018	0.041	-0.350	-0.250
Combined	10	-0.360	0.028	0.088	-0.423	-0.297
Δ		-0.120	0.041		-0.215	-0.025
Δ = mean (Control) - mean (Treatment)				**Pr(|T| > |t|)** = 0.0191		t = -2.9277
H0: Δ = 0, HA: Δ ≠ 0				**Outcome**: Reject H0		

We can hypothesize several possible reasons why this may be: (i) weather; (ii) technical reliability decreased over time; (iii) customer propensity to override equipment increased over time due to learning or CPP event fatigue, or (iv) changes in CPP event window timing.

With only 10 events, we cannot conclusively examine what factors caused the reduction in impacts; however the data is suggestive of possible causes.

Figure 12 shows non-winter load impacts plotted as blue bars on the left y-axis, while THI is plotted as a grey line on the right y-axis. The first 5 events are cooler than the last 5, although this difference is not statistically significant in a mean comparison test between both groups of events.

[2] When looking at the typical peak hours of 4-5pm, we did not find any evidence of decay in the last five events. However, since this typical peak hour was varying across the CPP event window and was unknown and possibly meaningless to customers, we choose to focus on the average impact of the entire event.

Figure 12: Non-Winter Event Impacts and THI

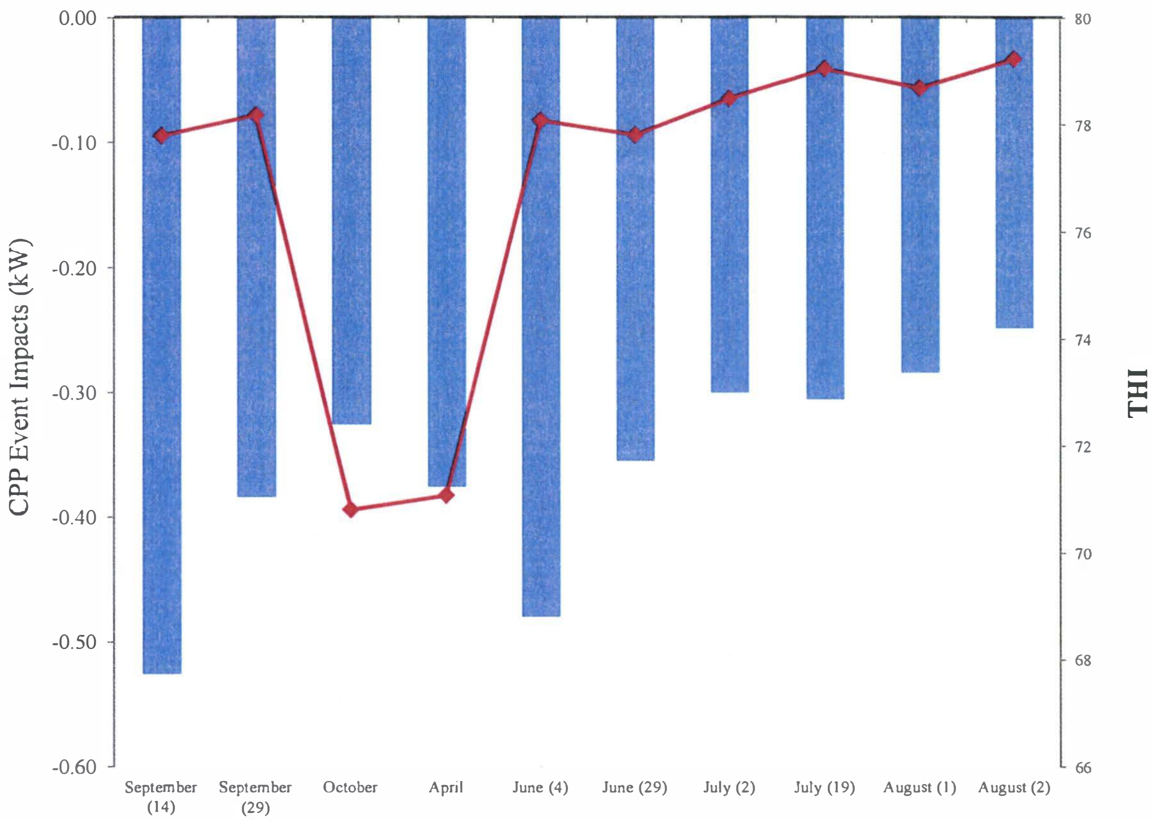


Figure 15 in Section 4.3.3 shows that both the number of customers noticing events and the number of customers overriding the HEC's automatic response increased over time. For the first six events, only 36% of customers reported overriding, while after 12 events, 66% of customers did so. This could indicate learning on the part of customers about how to use the override, or it could represent CPP event fatigue. See Section 4.3.3 for more details on customer override behavior.

Figure 10 in Section 3.3.2 shows the connection between the smart meter and the HEC over time. If the smart meter and the HEC are "joined" it means that there is an intact wireless connection between the two. The join is an instantaneous measure of connectivity and does not tell us whether the connection is momentarily or permanently down. It also only tells us whether the smart-meter is connected to the HEC and not whether the HEC is connected to the thermostat, pool pump and water heater. Nonetheless, it is a rough approximation of technical reliability and it decreases over the experiment period. Figure 13, which was compiled by FPL, shows the comparison between join rates for the first and last five events. A comparison of means test shows that the monthly join rate was significantly higher in the months of the first five than the months of the last five events. Figure 13 additionally shows that the percent of meters confirming receipt of individual CPP events did not change over the same two time periods. This indicates that the performance of the AMI network remained constant, but the Home Area Network (HAN) deteriorated over time. For more details on connectivity between the various HAN components and the performance of the AMI network during CPP events see Sections 3.3 and 3.4.

Figure 13: Technical Reliability of the AMI Meter and the Join with the HEC – Based on FPL Analysis

T3 Technical Reliability
Comparison of first five and last five non-winter CPP events

	Event Months	A. Monthly meter-HEC join rates	A. Averages	Event Dates	B. Percent of meters confirming reciept of CPP event	B. Averages
First five non-winter CPP events	September, 2011	96%	90%	14-Sep	98%	97%
				29-Sep	94%	
	October, 2011	98%		25-Oct	98%	
	April, 2011	82%		17-Apr	98%	
	June, 2011	84%		4-Jun	98%	
Last five non-winter CPP events	June, 2012	84%	80%	29-Jun	96%	95%
	July, 2012	78%		2-Jul	98%	
				19-Jul	94%	
	August, 2012	77%		1-Aug	93%	
				2-Aug	94%	
			Difference significant at 95% confidence			Difference not significant at 95% confidence

Finally, it is possible that the timing of the CPP event windows may have caused differences in the impacts over time. Table 14 in Section 4.3 shows that all of the final five events end at 8 pm, whereas only two of the first five non-winter events end at this later hour. The other three non-winter events end at 7 pm, 7 pm and 2 pm, respectively. It is possible that more people are home at this hour, thereby increasing override behavior. In the hour by hour analysis, only two out the seven events ending at 8pm have statistically significant impacts for the hour from 7 to 8 pm. All other events have statistically significant impacts in the final hour of the event.

To summarize the key findings from the load shifting analysis: (i) the average load reduction across all CPP events is 0.42 kW; (ii) winter impacts (January and February) were almost double that of non-winter impacts (0.71 kW vs.0.36 kW); (iii) the first five non-winter events had a significantly higher load impact than the final five (0.42 kW vs. 0.3 kW). The average reduction in demand during the typical system peak hour was 0.37 kW for summer and 0.80 kW for winter. The reduction in demand during the actual coincident system peak hour was 0.64 kW for the summer and 0.95 kW for the winter peak. All of the load shifting reductions and differences are statistically significant at the 95 percent level.

6.4. Summary of Results Energy Impacts

- **Experimental Validity:**
    - The ESF pilot interval data is of very good quality with minimal amounts of data issues.
    - The treatment and control group are largely comparable to each other.

- **Energy Conservation:**
    - T1 customers decreased their energy usage by 0.81 percent.
    - T2 customers increased their energy usage by 0.43 percent.
    - T3 customers decreased their energy usage by 2.84 percent.
    - None of these results are statistically distinguishable from zero.
    - There is some evidence of conservation in the cooler months for T2 and T3.

- **Load Shifting**
    - The average hourly load reduction in the event window across all CPP events is 0.42 kW.
    - Winter impacts (January and February) were almost double that of non-winter impacts (0.71 kW vs.0.36 kW).
    - The first five non-winter events had a significantly higher average hourly load impact in the event window than the final five (0.42 kW vs. 0.3 kW).
    - The average reduction in demand during the typical system peak hour was 0.37 kW for summer (4-5 pm) and 0.80 kW for winter (7-8 am).
    - The reduction in demand during the actual coincident system peak hour was 0.64 kW for the summer and 0.95 kW for the winter peak.
    - All of the load shifting reductions and differences are statistically significant at the 95 percent level.
    - It is possible that additional snapback or conservation effects exist on CPP days but we do not have the precision to measure.

[1] Electric Power Research Institute (EPRI) product 1016844 "Residential Electricity Use Feedback: A Research Synthesis and Economic Framework", published 2/27/2009. EPRI makes no warrantly or representations, expressed or implied, with respoect to the accuracy, completenes, or usefulness of the information contained in the Material. Additionally, EPRI assumes no liability with respect to the use of, or for damages resulting from the use of the Material.

[2] S. Darby, cited in Faruqui A, et al., The impact of informational feedback on energy consumption: A survey of the experimental evidence, Energy (2009), doi:10.1016/j.energy.2009.07.042. Darby reviewed 21 feedback studies that consider energy savings associated with direct feedback. Amongst those studies, energy savings ranged from 0 to 20 percent, with 15 of those studies falling in the range of 5 to 14 percent.

[3] Federal Energy Regulatory Commission, "A National Assessment of Demand Response Potential" June 2009, page ix, footnote 3.

[4] U.S. Department of Energy, Smart Grid Investment Grant Funding Opportunity Announcement, (DE-FOA-0000058), June 25, 2009, p. 23.

[5] Ibid.

[6] Faruqui A, et al., The impact of informational feedback on energy consumption: A survey of the experimental evidence, Energy (2009), doi:10.1016/j.energy.2009.07.042, pg 1, Abstract. “Our review indicates that the direct feedback provided by IHDs encourages consumers to make more efficient use of energy. We find that consumers who actively use an IHD can reduce their consumption of electricity on average by about 7 percent when prepayment of electricity is not involved.”

[7] DOE Guidebook for ARRA Smart Grid Programs, Metrics and Benefits, December 7, 2009, Appendix D, Table D-4