FPL Residential Thermostat Load Control Pilot Project Evaluation

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ABSTRACT

In a 2008-2009 pilot study of 400 participants, Florida Power & Light (FPL) and Applied Energy Group, inc. (AEG) evaluated the technical and economic benefits of a new generation of two-way communicating programmable thermostat technology to enhance FPL's existing switch-based direct load control program, On Call. FPL's On Call program is over twenty years old and is among the largest residential load control programs in the nation. This new technology provided FPL with enhanced capability to monitor and control heating and cooling during system-critical periods. Participants had remote internet access to thermostats for programming to save energy and to monitor the temperature of their homes, and to override FPL curtailments.

The unique capabilities of the thermostats to monitor and record key statistics facilitated the analysis of heat/cool performance, demand and energy impacts and effects of programming. These statistics included actual hourly runtime minutes, average hourly ambient temperature, mode (on-program or on-hold) and current full programming (7-day, four-period setpoints), which enabled accurate segmentation of customers into manual vs. programming segments and percentage of participants who used programming.

Most notably, results included the conclusions that 1) day-setback programmers produced both 25% higher demands and higher curtailment impacts than non-setback or manual mode users in both summer and winter; and 2) programmers used 12% more energy than non-programmers, counter to the traditionally held benefits of programmable thermostats. Indoor temperature data, gathered at the thermostat, provided new insight into a key reason for higher energy use among programmers.

FPL concluded that the thermostat approach enhanced the appeal of the On Call program based on strong initial customer interest, few overrides and solid long-term customer satisfaction.

Background

On June 15, 2007, FPL petitioned the Florida Public Service Commission for permission to conduct a Residential Thermostat Load Control Pilot Project. A typical barrier to customer acceptance of utility load control programs is the reluctance of customers to surrender control of heating and air conditioning appliances. Consequently, FPL proposed to evaluate whether the benefits of the On Call Program could be expanded through a new generation of communication and control technologies that put residential customers in charge of decisions that could lower energy costs, while allowing customers to override FPL interruption of their heating and air conditioning appliances. The Commission approved FPL's request on August 14, 2007.

This paper summarizes the results of the pilot project, which provided 400 participants with a free Internet-ready programmable thermostat as an alternative to On Call's most popular option; central air conditioning and heating cycle bill credits totaling $31 per year. Pilot participants also had the option of overriding FPL's interruption of their central AC and heat via

phone or Internet. Participants' accessibility to the Internet also provided them the option of remote access to their thermostat for programming to save energy and to monitor the temperature of their homes.

FPL's pilot gathered the data essential to estimating and evaluating the technical and economic merits of the thermostat approach, including 1) potential customer participation, including potential for current On Call customers to "switch" to the thermostat option; 2) impact of programming on energy use; 3) demand impacts net of customer overrides; and 4) overall satisfaction and dropout rates and reason for dropouts. The sample of 400 was considered sufficient to cost-effectively achieve the statistical objectives[1] of the pilot study in these areas.

Technical/Economic Evaluation

Potential Participation

FPL found that offering the programmable thermostat option increased the On Call's appeal, and about 2% of current On Call participants could be expected to "switch" to the thermostat option.

Response rates to direct mail solicitation were used to estimate initial customer interest and future potential for participation. Pilot direct mail solicitations used the same look, feel and savings promise[2] that FPL employs when selling the On Call program, allowing the results of pilot solicitations to be compared to On Call's response rate for the same time period.

Solicitation 1 tested the thermostat options' effect on the appeal of On Call. FPL offered 10,000 On Call-eligible customers a choice of receiving a free Internet-ready programmable thermostat or the On Call credit option. FPL observed a 16% increase in the response rate compared to the On Call baseline. Fifty nine percent of respondents selected the On Call credit option and 41% selected the thermostat option. A statistical test shows total response rate is significantly greater than On Call's baseline, indicating that a thermostat option increases On Call's appeal.[3]

Solicitation 2 tested the potential for current On Call participants to "switch" to the thermostat option, potentially impacting cost-effectiveness. FPL offered 1,000 On Call participants the thermostat in lieu of air conditioning and heating bill credits. All 1,000 were currently receiving $31 in annual air conditioning and heating cycle credits, and 2.2% decided to switch.

Impact of Programming on Energy Use

Fifty six percent of participants programmed their thermostats. Programmers used 12% more annual cooling energy than non programmers, and this increase results from higher overnight duty cycles associated with lower indoor thermostat setpoints.

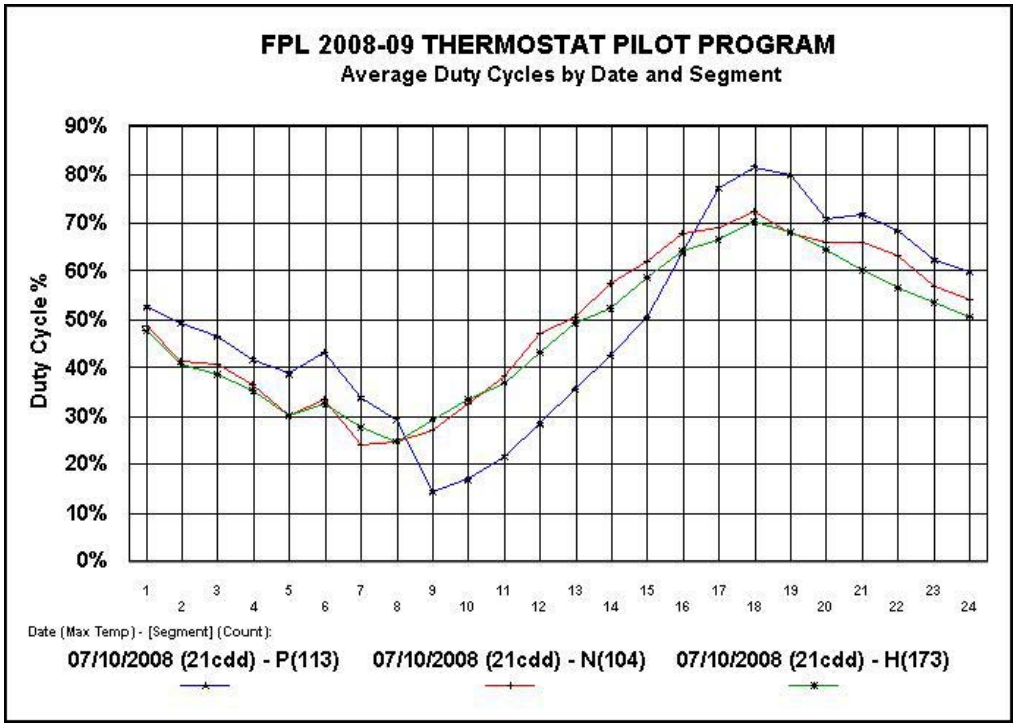
FPL encouraged participants to use their thermostat's programming features by providing information on how to program on three occasions: 1) by brochure at the time of installation, 2) by email following installation and 3) by email in spring 2008. Ongoing programming support was available by calling a toll-free number posted on the thermostat and at the program website.

By July 2008, data retrieved from the thermostats showed that programming patterns had stabilized, with 56% of thermostats programmed. Participants fell into three analytic segments: non-programmers (H), programmers who used at least two degrees of daytime setback (P), and programmers who do not use daytime setback of at least two degrees (N).

Table 1 – Programming Segmentation

Programming Segmentation on July 9, 2008	Number of homes in segment	Percent of total participants
H: Non-programmers. Thermostat on "Hold"	176	44%
P: Program, use day setback 2 or more degrees	117	29%
N: Program, but do not use day setback of at least two degrees	106	27%
	399	**100%**

Figure 1 – Duty Cycle Profiles of Segments



Thermostats programmed with day setbacks of at least 2 degrees produced a distinct load shape. While load profiles for segments H and N are similar, the profile of segment P shows that thermostats programmed with 2+ degrees of day setback have duty cycles which are lower during the day setback period, but higher during the 4-5pm peak and overnight. Segment P's peak duty cycles also resulted in 25% greater kW reduction during control events, compared to the non-programming segment H.

FPL studied the energy impacts of a variety of programming behaviors by comparing non-programmers (segment H) to programmers (segments P and N). Energy impacts from programming were evaluated utilizing an annualized statistical regression. The regression

modeled daily runtime as a function of cooling degree days, with r-squared values generally in the 90% range and t-stats strongly significant for each programming segment. For non-programmer (segment H) and programmer (P&N) segments, the confidence levels around the annual runtime and kWh estimates were approximately +/- 12%.

This analysis found that programmers used 12.4% more cooling energy than the non-programming segment H. Indoor temperature data shows why: programmers maintained lower average indoor temperatures than non programmers. Figure 2 shows that while the indoor temperatures of day setback programmers (P) are 1 degree warmer than non-programmers (H) for eight hour day setback period, they are 1 or more degrees cooler for the remaining 16 hours a day - more than offsetting any energy savings from their day setback. Non-day setback programming segment N maintained temperatures which were cooler than the non-programming segment at all times, easily explaining why this programming segment used more cooling energy than the non-programming group.

Figure 2 – Indoor Temperature by Segment

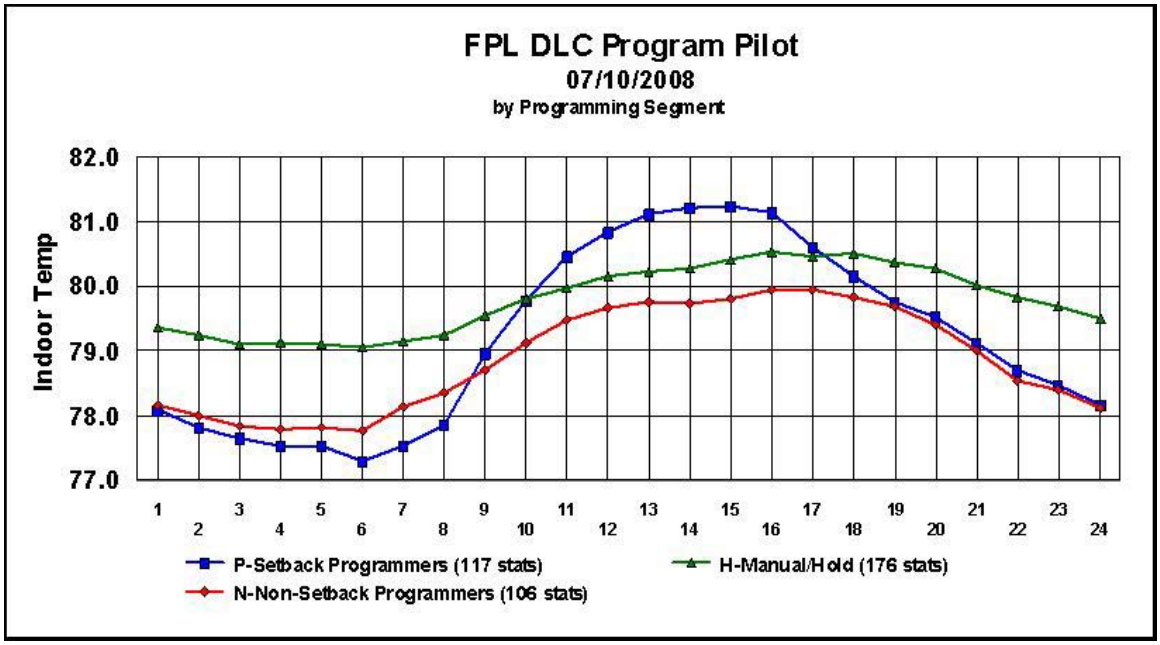


Table 2 – Annual Cooling Energy Use by Segment

Programming segment	Annual cooling hours	Annual cooling kWh	Annual difference vs. H
All Participants	2,019	7,824	n/a
H: Non-Programmers	1,980	7,346	n/a
P: Day Setback Programmers	2,251	8,352	14%
N: Non-Day Setback Programmers	2,197	8,153	11%
P + N: All Programmers	2,226	8,257	12.4%

Such findings are not unprecedented. The EPA Energy Star program cites other evidence that programmable thermostats do not result in reliable energy savings and can result in increased energy use. As a result, Energy Star suspended its labeling of programmable thermostats on December 31, 2009. In May 2009 the EPA notified programmable thermostat manufacturers that "EPA has been unable to confirm any improvements in terms of the savings delivered by programmable thermostats and has no credible basis for continuing to extend the current Energy Star specification."[4]

Demand Impacts Net of Customer Overrides

Because the element of overrides is new, and can reduce the demand under utility control, FPL tested customer override behavior. Impact reduction from customer overrides averaged less than 1%.

On average, less than 1% of participants used their option to override FPL control. Participants did not show any sensitivity to being controlled frequently; 5 times in 59 days in 2008, or on consecutive days. Customers appeared most sensitive during the single winter event when overrides totaled 2.28%.

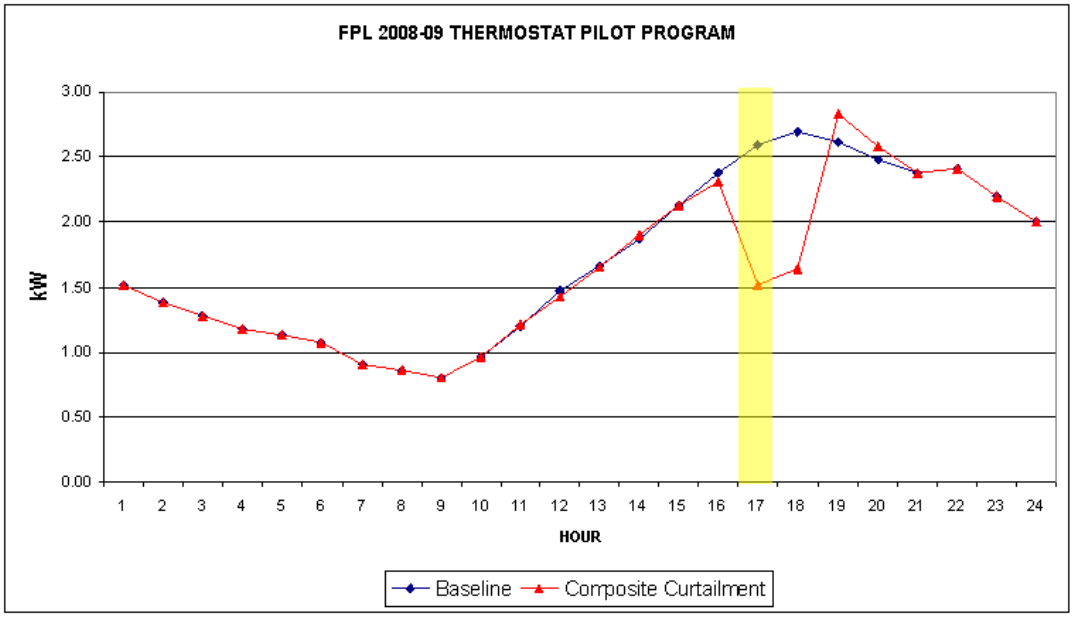
Table 3 - Override Rate by Event Type

Event type	Number of events in average	Average cumulative override rate
All events: 8 summer and 1 winter	9	0.96%
Typical summer peak days, 50% cycle	4	1.07%
Peak hour overrides for typical summer peak days, 50% cycle	4	0.18%
Winter, 50% cycle	1	2.28%

Four summer load control events were most typical of summer control events. The average result from these four events was a peak hour load reduction of 1.079 kW per thermostat, at the meter, net of overrides.[5] A composite load curve of these four events is shown in Figure 3 compared to a baseline load curve of non-curtailment days with comparable weather.

Figure 3 shows the composite results of four typical summer control events. An average reduction of 1.079 kW per thermostat was achieved at the meter during FPL's 4-5pm peak hour. Average energy payback of 15% occurs after two hours of control at the 50% cycle level.

Figure 3 – Summer Curtailment Impacts

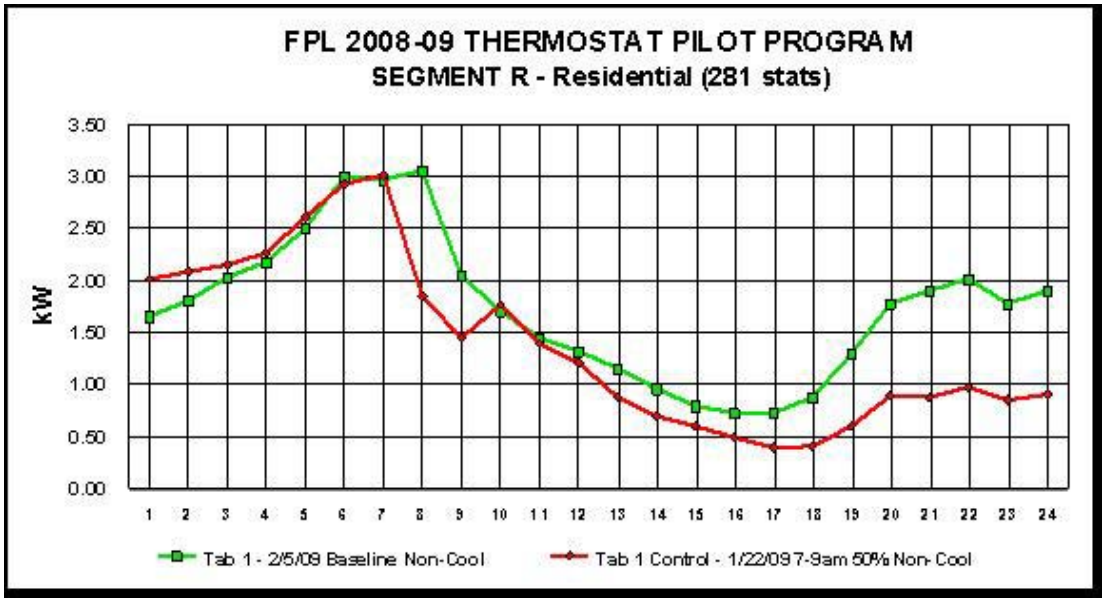


The pilot's 1.079 kW per appliance impact results from one house type (single family detached) and one geographic location (Broward County). To estimate impacts at FPL's system level, the 1.079 kW per appliance impact was adjusted for geography, house type using ratios from FPL's On Call program and the marginal impact of 2% "switching" from On Call. The resulting FPL system-level impact of 0.93 kW per participant at the meter is higher than On Call's typical 0.71 kW.[6]

Only one opportunity to test winter impacts in the target temperature range of 36 to 45 degrees occurred during the pilot period, with an actual temperature of 41 degrees. The result of this event was a peak hour load reduction of 0.63 kW per appliance, at the meter, net of overrides. As with the summer impacts, this winter impact was adjusted for geography and house type using ratios from FPL's On Call program and the marginal impact of 2% "switching" from On Call. The resulting FPL system-level impact of 0.61 kW per participant at the meter was lower than On Call's typical 0.67 kW[7], although based on only one event.

The 1.21 kW impact shown in Figure 4 is reduced by 50% because half of participants' heaters were off or not in heating mode during the winter event.

Figure 4 – Winter Curtailment Impact – Heated Units Only



Satisfaction

FPL tracked overall satisfaction at two points; in June 2008, prior to any load control events and again in June 2009 after nine load control events. FPL also tracked dropout rates and reasons for dropouts, retention at pilot completion, as well as customer support rates.

As shown in Table 4, overall satisfaction with the thermostat program did not change over the course of the pilot, with seven out of ten participants providing "very satisfied" ratings. Three out of four participants would "definitely" recommend the program to a friend. Among program features consistently ranked as most important was the feature "Helps Save on Electric Bill".

Table 4 – Participant Satisfaction

	June 2008 (before events)	June 2009 (after 9 events)	Test of statistical difference (t-test, 90% confidence)
Overall satisfaction with thermostat program, "Very satisfied"	71% 59 responses	68% 60 responses	No difference
Would "definitely" recommend program to a friend.	79% 63 responses	73% 62 responses	No difference

FPL tracked dropout rates, reasons for dropouts as well as retention at pilot completion. Nineteen participants (4.75%) dropped out of the pilot before completion. The majority (3%) dropped out prior to the first load control event.

– 9 cited problems with their air conditioner
– 6 thermostat compatibility issues with new air conditioners
– 2 thought their electric bills were higher

– 1 misunderstood available functionality
– 1 curtailment related

At the conclusion of the pilot, customers were notified by mail and given the choice to keep the FPL thermostat without Internet access after August 13, 2009 or to have their original thermostat reinstalled at no charge. Over half (56%) of participants responded and 90% chose to keep their FPL thermostat. Participants were also offered FPL's On Call program, and 33% of respondents requested additional information about On Call.

FPL tracked the pilot's telephone and contractor support rates and found that the thermostat-based pilot required significantly more support than FPL's current switch-based On Call program. From May 2008 to May 2009, 38% of thermostat participants called and 10% of participants required a contractor visit, exclusive of curtailment events. These non-curtailment support rates are significantly higher than On Call's 5.5% call support rate and 2.6% contractor support rate.

Cost-Effectiveness

At the end of the test period, FPL performed a cost-effectiveness analysis using the Florida Commission-approved Participant test, RIM test and TRC test. FPL utilizes enhanced versions of the latter tests, E-RIM and E-TRC, which account for environmental impacts of the measure.

A measure passes an individual test when its benefit-cost ratio is greater than 1.0. Using verified kW and kWh impacts from the pilot, and projected program costs, FPL calculated the following values:

1. Participant Test: Infinite (pass)
2. E-TRC: 0.90 (fail)
3. E-RIM: 0.96 (fail)

Cost-effectiveness tests therefore indicated that the program marginally failed the TRC and RIM tests.

Summary

- FPL found that offering the programmable thermostat option increases On Call's appeal, and about 2% of current On Call participants could be expected to "switch" to the thermostat option.
- 56% of participants programmed their thermostats. Programming did not save cooling energy in south Florida. Programmers used 12% more annual cooling energy than non programmers.
- Impact reduction from customer overrides averaged less than 1%.
- Thermostat summer peak hour reduction, net of overrides, averaged 0.93 kW per participant at the meter.
- Thermostat winter peak hour reduction, net of overrides, averaged 0.61 kW per participant at the meter.

- Overall satisfaction was consistently rated "very satisfied" by over 68% of participants over the course of the pilot.
- 4.75% of participants dropped out, with only one citing curtailments as the reason.
- Thermostat-based load control requires significantly more customer support than FPL's switch-based On Call program.

Conclusions

Thermostat-based load control has the potential to help reduce peak demand. The ability to save energy (kWh) by programming, however, has not been successfully demonstrated. In fact, pilot participants who programmed their thermostats used 12% more annual cooling energy than non programmers. Participants in FPL's thermostat pilot placed great importance on its ability to help save on their electric bill. The gap between the ability to save energy and consumer expectations presents a significant challenge to any future program utilizing programmable thermostats. FPL remains open to the use of thermostats as demand response devices. In light of the issue of increased energy use, FPL is not seeking continuance of the Residential Thermostat Load Control Pilot, nor is it seeking to add a thermostat option to its On Call program at this time.

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[1] A sample of 400 from the approximately 900,000 potential qualifying residential central a/c owners in the service area was designed to render statistically accurate results within +/- 5% precision at the 95% confidence level for aggregate levels of participation, programming use, and use of Internet features; each segment (programmers and non-programmers) was expected to include approximately 200 participants, which would produce precision of +/- 7% at 95% confidence level. The sample also produced duty cycle (% on) estimates within +/-5% at 95% confidence level during peak afternoon hours.

[2] The savings promise of up to "$100 a year" can result from On Call bill credits for or initial estimates of energy

[3] Difference between two independent proportions (t-test) has a 95.36% probability of significant difference.

[4] EPA letter to programmable thermostat manufacturers and other stakeholders, May 22, 2009. http://www.energystar.gov/ia/partners/prod_development/revisions/downloads/thermostats/Spec_Suspension_Memo_KeyDates.pdf

[5] Runtime data was converted to duty cycles (percent on-time) and then applied to a maximum load draw estimate of 3.71 kW per thermostat determined from single-family detached homes in FPL's On Call program at the time of the Pilot study

[6] 2007 On Call program evaluation

[7] 2007 On Call program evaluation