Final Savings Estimates and Key Learnings from a Behavioral Messaging Thermostat Trial

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How do we get a thermostat programmed with efficient setpoints… and stay that way?

The challenges facing programmable thermostats are well known:

- **Nobody programs them**
- **Difficult to program and even to use**
- **Always set on hold**
- **Used like a manual thermostat**

If the program is never initialized or if the program doesn't run, potential benefits of an efficient program can't be realized

PG&E has piloted a new thermostat that seeks to solve some of these problems

PG&E partnered with Opower and Honeywell to test a programmable thermostat system that encourages customers to maintain efficient programmed setpoints

Interaction with the thermostat using a smart phone app enables:

- **Control of HVAC system from any location where smart phone receives data**
- **Normative messaging to encourage the user to set or maintain efficient setpoints or to discourage using an inefficient setpoint**

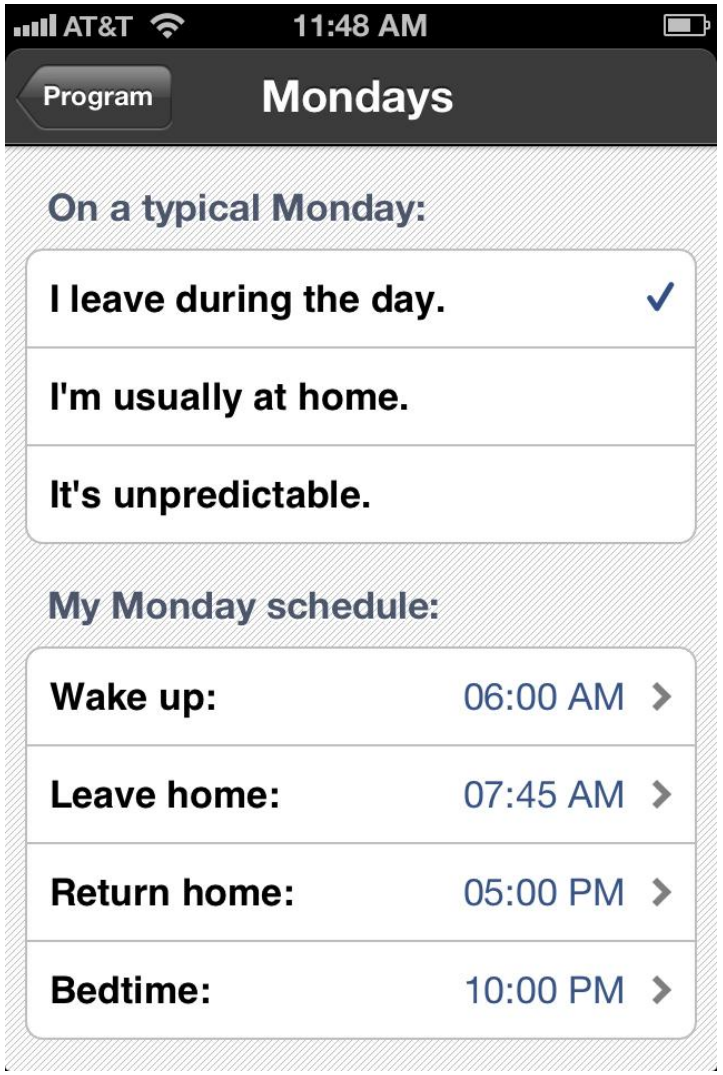
Internet-enabled thermostat wall unit facilitates remote control

Honeywell touchscreen thermostat connects to the customer's Wi-Fi router and a suite of web-enabled user interfaces:

- Web portal
- Tablet app
- Smart phone app

Enhanced interface allows for flexible programming:

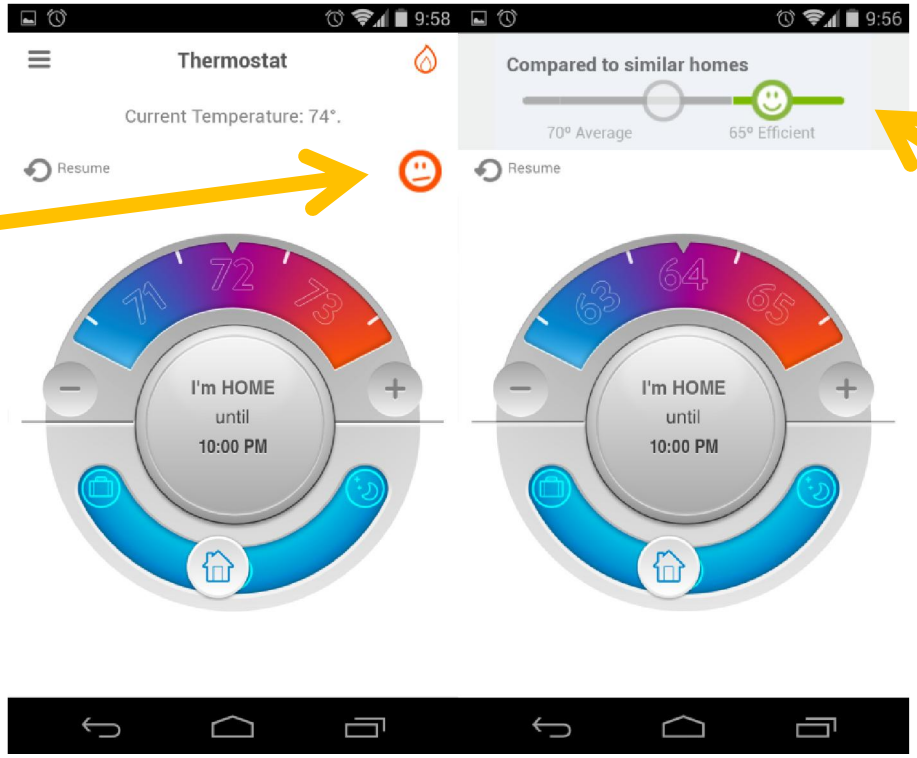
- Typical occupancy habits by day of week
- Timing of occupancy
- Desired temperature settings

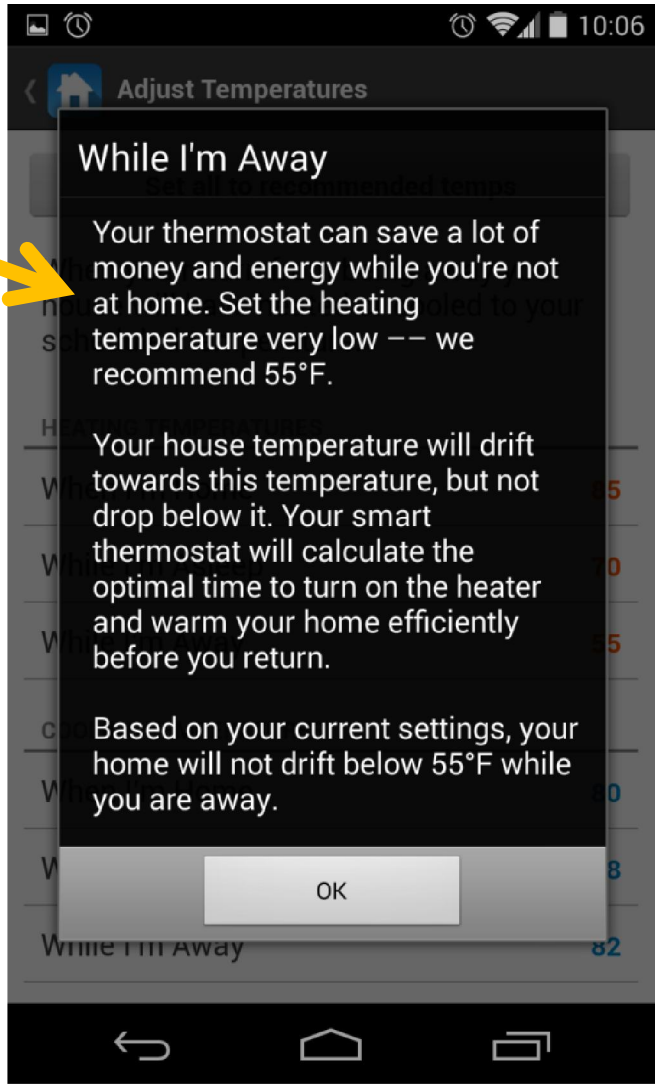


Normative messaging provides the nudges to set and stay at efficient setpoints

Opower designed feedback to appear:

- **When programming setpoints**
- **When looking at current setpoints**
- **When changing setpoints**





Key goal of the pilot was to measure the effect of the thermostat on energy consumption

Pilot stakeholders invested in implementing the pilot as a randomized control trial (RCT) to avoid self-selection bias

Recruitment through retail intercept:

- **Malls, festivals, and farmers' markets**
- **Must have a smart phone and high-speed internet service at home**
- **Onsite survey to screen for eligibility and to determine initial thermostat program**
- **Randomized assignment to treatment and control**
- **Control customers entered into a drawing for an iPad**

Recruitment occurred in two waves:

- **East Bay/northern Central Valley and southern Central Valley**

PG&E implemented the RCT July 2012 through February 2014

Northern cluster installations: July 2012 – October 2012

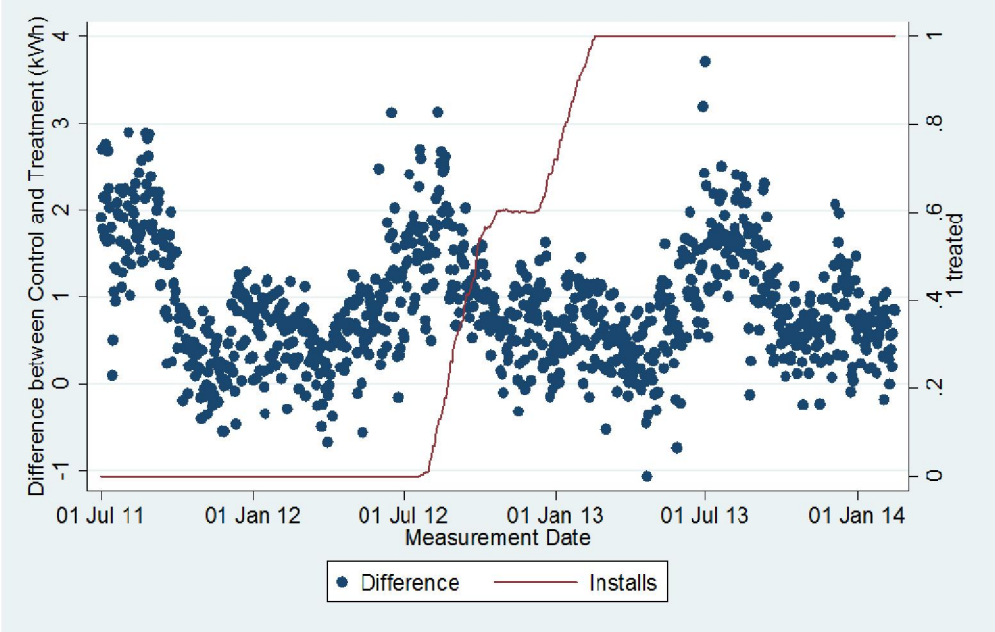
Southern cluster installations: December 2012 – February 2013

- **693 participants recruited, 505 successfully installed by Honeywell**
- **Original Z-wave thermostat was replaced by Wi-Fi thermostat in summer 2013 (423 of 505)**
- **Thermostats were mostly (70%) installed in single-story homes, 3.5 bedrooms, 2.3 adults, and 1.1 children per home on average**

Sample size and implementation challenges may have gotten the best of this RCT

- The control group was found to use more electricity than the treatment group going all the way back to July 2011
- Control group consistently uses even more electricity than treatment group during summer months

Daily Differences in Average Electricity Consumption (Control minus Treatment)



No significant energy savings were found

Energy savings were estimated with a panel regression:

- **Included fixed effects and time effects, with errors clustered at the customer level**
- **Additional terms that estimated the effect of winter and summer weather on usage, both with and without an interaction on treatment status, were also used**

Effect-on-treated: positive values are savings, negative values are dis-savings

Absolute Daily Impact (kWh)	Percent Impact	Standard Error	95% Conf. Lower Bound	95% Conf. Upper Bound
0.25	1.0%	1.1%	-1.3%	3.2%

Absolute Daily Impact (therms)	Percent Impact	Standard Error	95% Conf. Lower Bound	95% Conf. Upper Bound
-0.03	-2.0%	0.9%	-3.7%	-0.3%

Other key objective was to gain insights into customer preferences and attitudes towards enabling technology

Two surveys were administered to treatment customers online

- **November 2012/March 2013 and February 2014**
- **Completion rates of 52%/40% and 48%**

Respondents described the app in positive terms: as easy to use, convenient, simple and user-friendly and a majority strongly agree that:

- **They would recommend the system to a friend**
- **The app provides value beyond the thermostat wall unit**
- **The app is fun to use**
- **The app is easy to use**

The system was both used and useful:

- **About half of respondents change their programmed setpoints and times less than once a month**
- **More than half of respondents change current setpoint at least a few days a week**

The survey provided a number of leads for improving the product concept

- **Normative messaging is designed to nudge but few respondents felt nudged:**
  1. **I can't be changed:** ""As much as they are informative, they aren't enough to convince me to change my routine." (most cited)
  2. **Leave me alone:** "The messages become annoying, as if there is no setting (other than OFF) that will make the program happy!"
  3. **Sometimes I listen:** "Helpful. They at least keep you aware of what others are doing around you and sometimes you'll dial it down a notch." (least cited)
- **Messaging aside, system functionality still faces challenges:**
  - **Without good product education, smarts can be perceived as "dumb" – some customers aren't used to what it's like when the system does the most efficient thing (i.e., heats up the house to temperature BY wake-up time not starting AT wake-up time)**
  - **Challenges using logins and maintaining wi-fi connectivity**

Challenges/issues to consider

- **Need a sample size sufficient to conclusively identify impact**
  - What's the expected impact? 1/3 of manufacturer estimate??
- **How to avoid negative customer experience? (don't deny?)**
- **How to get these things on walls?**
  - Direct installation is costly and time-consuming; self-install has breakage
- **Randomization does not always result in equivalent groups**
- **Will you have customer-level thermostat operating data?**
  - If not, you rely only on noisy household billing data
- **It's hard to gain insight into "how" the savings are achieved**
  - What were they doing before? Did they let this one be "Smart"?
- **How to balance a manageable trial with the need to generalize?**

Plan your sample to match your expected effect (with buffer!)

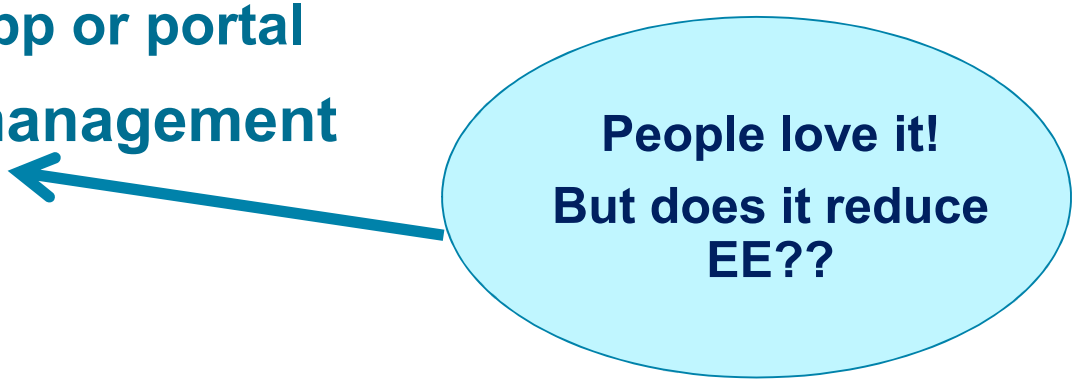
If a technology saves at least:	Confidence interval needed to exclude zero	Necessary Sample Size
2%	1	9,604
3%	2	2,389
4%	3	1,065
5%	4	599
6%	5	384
7%	6	267

Evaluation Considerations

- **Challenge of an accurate baseline**
  - How do we get reliable detailed thermostat data for pre-treatment or control households??
    - HVAC submetering? Self-report? ~~Pick permanent setpoint?~~
- **Adjust the null hypothesis?**
  - ~~Typical "savings are zero"~~
  - "Savings are at least x%" ??
    - If need 6% to run cost-effective program, could set null at that threshold
- **How to separate EE from Take Back?**
  - Evidence that some people use smarter t-stat to make their home more comfortable, → increased consumption

Dangerous to assume Smart = EE?

- Intuitive scheduling/learning
  - occupancy sensors, geofencing, manual settings/adjustments
- Consumer feedback
  - Messaging to maintain efficient setpoint, set a “vacation schedule”, etc.
- Optimization to achieve desired comfort setting more efficiently
  - pre-cooling or heating; setpoint smoothing
- Intuitive schedule and setpoint programming
  - through smartphone app or portal
- Remote operation and management



Next steps

- **PG&E 2015 energy efficiency smart-thermostat scaled field placement/technology assessment:**
  - Experimental design to assess EE savings in PG&E climate zones
  - Household billing analysis and thermostat-specific data

- **Key research questions:**
  - What are the savings? (or, Are they at least x%?)
  - How are those savings achieved?
    - More efficient set points? Set back where they didn't used to set back? Did they allow it to optimize/be smart?
      - Do convenience functions affect efficiency?

Thank You

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