Proving Nest Savings

Nest Learning Thermostat™ Pilot Project at Franklin PUD

Emerging Technologies Showcase

June 30, 2016
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Proving Nest Savings

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Todd Blackman – Franklin PUD
Phillip Kelsven – BPA

Emerging Technologies Showcase
June 30, 2016
NEST Learning Thermostat Pilot

• Introduction & Background – Robert
• Pilot Test Implementation – Todd
• Energy Savings Analysis – Phillip
• Next Steps – All
Communicating vs Smart Thermostats?

Residential Communicating Thermostat (CT):

- Thermostat that controls HVAC equipment to regulate the indoor air temperature.
- Internet connection (typically Wi-Fi).
- A CT includes the thermostat with associated firmware as well as a service component supported by hardware, software, and staffing outside of the home.

(definition by Consortium for Energy Efficiency)

Communicating Thermostat ≠ Smart Thermostat
Smart Thermostat - Highlights

• Saves energy (annualized basis)
• Utilizes advanced algorithms for advanced HVAC control and behavior response
• Uses weather data to enhance HVAC operation
• Utilizes occupancy awareness
General Information:
Founded 1934
Energized 1947
Service area 435 square miles
Population of service area approx. 69,000
Number of customers 24,800
Number of employees 100
Energy services staff 4
• **Goal**: Evaluate the Nest Learning Thermostat’s ability to control Residential Air Source Heat Pump (ASHP) operation and realize electricity savings. Pilot field study began in Summer 2013;

• By August 2014 176 Nest thermostats were installed in homes. Analysis presented today

• Submetering in 13 Homes presented in an ACEEE Paper
Pilot Project Implementation

• Why? — Utilities need a thermostat-only rebate to capture more savings from existing HVAC systems and systems installed outside of utility programs.

• How? — With BPA engineering and data support & program management support.

• Selection of participating homes — Database of our biggest HVAC vendor to find homes that had heat pumps and furnaces installed outside of the utility rebate program.
Pilot Project Implementation

- **FPUD/BPA offer to customer** — Estimated a potential savings based on established commissioning and controls savings. BPA and utility funded free professional installations.

- **Installation of Nest thermostats** — Program management vendor (CLEAResult) selected local installer and conducted training. Thermostats installed with efficient settings and a NEST web access username and password accessible to program managers.
Pilot Project Implementation

• Participant Support — Installer provided customer with pilot information letter, including NEST online and phone help resources. Franklin PUD was listed as last resort to ensure program satisfaction – this proved be very important as some participants later became frustrated with the NEST support system.

• Surveys — Mailed out hard copies to all participants with a Survey Monkey online option. Most came back in hard copy form, many without return address information! Both contrary to our expectations.
Pilot Project Implementation

• Lessons Learned
  ➢ Make the return address on the survey mandatory.
  ➢ Not everyone who signed up for the free thermostat were technology friendly or even remotely technology tolerant!
  ➢ Router issues included homes where Wi-Fi is installed and administered by adult children of seniors who have no knowledge of the system.
  ➢ All NEST features did not work in all homes – if the thermostat was not in a traffic area, the AWAY mode could signal false occupancy conditions and cause comfort issues.
Franklin PUD Survey Results

- Surveys were mailed out to all Participants
- Hard copies with link to online survey tool
- Most surveys came back in hard copy and were manually entered into online survey tool
Satisfaction

<table>
<thead>
<tr>
<th>Category</th>
<th>Pilot</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unsatisfied</td>
<td>2%</td>
<td>1%</td>
</tr>
<tr>
<td>Neutral</td>
<td>10%</td>
<td>9%</td>
</tr>
<tr>
<td>Somewhat Satisfied</td>
<td>17%</td>
<td>24%</td>
</tr>
<tr>
<td>Completely Satisfied</td>
<td>68%</td>
<td>65%</td>
</tr>
<tr>
<td>Don't Know</td>
<td>2%</td>
<td>0%</td>
</tr>
</tbody>
</table>
Recommend to Others?

<table>
<thead>
<tr>
<th>Percentage of Participants</th>
<th>Completely Unlikely</th>
<th>Somewhat Unlikely</th>
<th>Neutral</th>
<th>Somewhat Likely</th>
<th>Completely Likely</th>
<th>Don't Know</th>
</tr>
</thead>
<tbody>
<tr>
<td>11%</td>
<td>5%</td>
<td>8%</td>
<td>23%</td>
<td>52%</td>
<td>1%</td>
<td>1%</td>
</tr>
<tr>
<td>(Completely Unlikely)</td>
<td>(Somewhat Unlikely)</td>
<td>(Neutral)</td>
<td>(Somewhat Likely)</td>
<td>(Completely Likely)</td>
<td>(Don't Know)</td>
<td></td>
</tr>
</tbody>
</table>
Issues and Complications

Percentage of Participants

- Too Cold: 10%
- Too Warm: 7%
- Can't Make Adjustments: 12%
- Wi-Fi Issues: 14%
Comfort

Percentage of Participants

- Much Less: 3%
- Somewhat Less: 5%
- About Same: 31%
- Somewhat More: 32%
- Much More: 29%
Did Occupant Set Back Previous Tstat?

58% Yes
35% No
7% Don't Know
Changes to Home in Occupancy, Construction, etc.

- No changes: 85%
- Changes: 15%

Percentage of Participants
Is the Nest Worth $250?

- Yes: 58% Nest worth $250, 65% Non-energy features worth it.
- No: 35% Nest worth $250, 20% Non-energy features worth it.
- Don't Know: 8% Nest worth $250, 15% Non-energy features worth it.
Savings Assessment

• Savings are estimated using three different models
  • Variable Base Degree Day (VBDD) pre – post NAC regression model
  • Fixed effects regression model
  • ECAM+ change point model
<table>
<thead>
<tr>
<th>Sample Size</th>
<th>Avg. Gross Savings</th>
<th>% Total Usage</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>VBDD (&gt;= .70 r-squared)</strong></td>
<td>97</td>
<td>1,103 kWh</td>
</tr>
<tr>
<td><strong>ECAM+ (&gt;= .70 r-squared)</strong></td>
<td>71</td>
<td>1,474 kWh</td>
</tr>
<tr>
<td><strong>Fixed Effects</strong></td>
<td>167</td>
<td>970 kWh</td>
</tr>
</tbody>
</table>
Gross Savings (VBDD)
• Franklin PUD provided billing data on 40 customers who have received rebates on heat pumps or duct sealing in heat pump homes

• Average reduction of 262 kWh

• Unstable sample due to small sample size
• Net savings can only be assessed in the VBDD model

• Net Savings = 1,103 (gross) – 262 (comparison group savings) = 840 kWh
• It is useful to analyze savings by home characteristics to assess whether Nest is more effective in certain types of homes
Savings by Home Characteristics

Average Savings - kWh

- Built < 1980
- Built >= 1980
- Size < 1850 sqft
- Size >= 1850 sqft
- 1 Level
- 2 Levels
- Programmable Tstat
- Non-Programmable Tstat
- Strip Heat Control
- No Strip Heat Control
- Strip heat not on in 1st stage
- Heat Pump < 11 years Old
- Heat Pump >= 11 years Old
- kW strip heat <= 15
- kW strip heat > 15
- Heat Pump <= 3 Tons
- Heat Pump > 3 Tons

- 698 kWh
- 1611 kWh
- 1361 kWh
- 870 kWh
- 1201 kWh
- 1285 kWh
- 1428 kWh
- 1433 kWh
- 1554 kWh
- 728 kWh
- 749 kWh
- 741 kWh

Average Savings - kWh

- 0
- 200
- 400
- 600
- 800
- 1000
- 1200
- 1400
- 1600
- 1800
Savings by Year Built

![Graph showing savings by year built with kWh on the y-axis and year built on the x-axis. The graph includes points representing total savings and a fitted line.](image-url)
Savings by Home Size
Savings by Pre-Consumption

![Graph showing savings by pre-consumption with kWh on the y-axis and pre-consumption on the x-axis. The graph includes a fitted line and data points indicating total savings.](image)
Analysis of Nest Data

- Nest provided anonymous data on 145 homes
- BPA provided subgroups on which to analyze participant data
- Analysis of settings by savings quartile
Heat Pump Balance Settings - Nest Data

Percentage of Participants

- **Auto Away**: 82%
- **Max Comfort**: 20%
- **Max Savings**: 64%
- **Balanced**: 5%
- **Heat Pump Balance Not Enabled**: 11%
Auto Away Settings – Nest Data

Percentage of Participants

- < -327 kWh savings: 71%
- -327 to 996 kWh savings: 100%
- 996 to 2059 kWh savings: 88%
- > 2059 kWh savings: 78%

Savings categories:
- < -327 kWh savings
- -327 to 996 kWh savings
- 996 to 2059 kWh savings
- > 2059 kWh savings
Savings by HP Balance Setting – Nest Data

- Max Comfort: 25%<br>
  - < -327 kWh savings: 20%
  - -327 - 996 kWh savings: 16%
  - 996-2059 kWh savings: 13%
  - >2059 kWh savings: 0%

- Max Savings: 75%<br>
  - < -327 kWh savings: 46%
  - -327 - 996 kWh savings: 64%
  - 996-2059 kWh savings: 17%
  - >2059 kWh savings: 0%

- Balanced: 17%<br>
  - < -327 kWh savings: 0%
  - -327 - 996 kWh savings: 0%
  - 996-2059 kWh savings: 0%
  - >2059 kWh savings: 13%

- Off: 20%<br>
  - < -327 kWh savings: 13%
  - -327 - 996 kWh savings: 5%
  - 996-2059 kWh savings: 13%
  - >2059 kWh savings: 0%
Savings by Temperature Setting – Nest Data

- Avg. Heating Temp
- Avg. Cooling Temp

<table>
<thead>
<tr>
<th>Temperature (F)</th>
<th>&lt; -327 kWh savings</th>
<th>-327 to 996 kWh savings</th>
<th>996 to 2059 kWh savings</th>
<th>&gt; 2059 kWh Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avg. Heating Temp</td>
<td>69.93</td>
<td>69.18</td>
<td>68.26</td>
<td>70.14</td>
</tr>
<tr>
<td>Avg. Cooling Temp</td>
<td>73.51</td>
<td>74.29</td>
<td>75.44</td>
<td>74.15</td>
</tr>
</tbody>
</table>

Savings:
- < -327 kWh savings
- -327 to 996 kWh savings
- 996 to 2059 kWh savings
- > 2059 kWh Savings
Savings by Set Back Delta – Nest Data

 Degrees (F)

< -327 kWh savings
-327 to 996 kWh savings
996 to 2059 kWh savings
> 2059 kWh Savings

Avg. Heating Setback Degrees
Avg. Cooling Setback Degrees
Savings by Run Time – Nest Data

-327 kWh savings: 536.5 hours
-327 to 996 kWh savings: 402.8 hours
996 to 2059 kWh savings: 417.1 hours
> 2059 kWh Savings: 522.3 hours

Heating Hours
Cooling Hours
ACEEE Paper

- ACEEE paper will focus on the sub-meter data of 8 homes
- Find run time reductions controlling for weather
- Puzzling differences in heat pump cycles from pre to post Nest
## ACEEE Paper Preview

<table>
<thead>
<tr>
<th>Site</th>
<th>Avg. cycle pre-run time (minutes)</th>
<th>Avg. cycle post-run time (minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>9.30</td>
<td>31.58</td>
</tr>
<tr>
<td>2</td>
<td>17.46</td>
<td>54.52</td>
</tr>
<tr>
<td>3</td>
<td>17.86</td>
<td>38.81</td>
</tr>
<tr>
<td>4</td>
<td>14.61</td>
<td>20.25</td>
</tr>
<tr>
<td>5</td>
<td>14.23</td>
<td>54.84</td>
</tr>
<tr>
<td>6</td>
<td>11.60</td>
<td>11.44</td>
</tr>
<tr>
<td>7</td>
<td>16.54</td>
<td>30.50</td>
</tr>
<tr>
<td>8</td>
<td>9.21</td>
<td>14.20</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td><strong>13.63</strong></td>
<td><strong>29.76</strong></td>
</tr>
</tbody>
</table>
Next Steps

• Evaluation Report – July 2016
• Advocate for true SMART thermostat definition, CT not good enough
• BPA Qualified unit energy savings measure
• NW Council Regional Technical Forum unit energy savings measure
• Franklin PUD measure
• Future thermostat work
  • Evaluate other HVAC savings
  • Evaluate additional Smart Thermostats
Contact Information

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Thank you for attending!

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