ENERGY STAR Connected Thermostats

CT Metrics Stakeholder Meeting Slides

May 12, 2020
Attendees

Abigail Daken, EPA
Abhishek Jathar, ICF for EPA
Alan Meier, LBNL
Leo Rainer, LBNL
Eric Floehr, Intellovations
Craig Maloney, Intellovations
Michael Blasnik, Google/Nest
Jing Li, Carrier
Jason Thomas, Carrier
Brian Rigg, JCI
Theresa Gillette, JCI
Rohit Uдавант, JCI
Diane Jakobs, Rheem
Carson Burrus, Rheem
Chris Puranen, Rheem
Glen Okita, EcoFactor
John Sartain, Emerson

Eric Ko, Emerson
Albert Chung, Emerson
James Jackson, Emerson
Mike Lubliner, Wash State U
Charles Kim, SCE
Michael Fournier, Hydro Quebec
Dan Fredman, VEIC
Robert Weber, BPA
Phillip Kelsven, BPA
Casey Klock, AprilAire
Wade Ferkey, AprilAire
Ulysses Grundler, Trane
Jeff Stewart, Trane
Mike Caneja, Bosch
Sarathy Palaykar, Bosch
Brenda Ryan, UL
Mike Clapper, UL

Alex Boesenberg, NEMA
Ethan Goldman
Jon Koliner, Apex Analytics
Michael Siemann, Resideo
Aniruddh Roy, Goodman/Daikin
Dan Baldewicz, Energy Solutions for CA IOUs
Frank David, Carrier
Agenda

• National vs Regional for RHU2
• Software updates
• Checking resubmission data based on long term trends
• EPA and NEEA test data updates
• Thermostat V2.0 changes review
• Update on communicating controllers work
### RHU2: National vs. Regional

<table>
<thead>
<tr>
<th>Vendor</th>
<th>All</th>
<th>Mixed Humid</th>
<th>Very Cold</th>
<th>All</th>
<th>Mixed Humid</th>
<th>Very Cold</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>30-40F n</td>
<td>30-40F ub</td>
<td>30-40F n2</td>
<td>30-40F ub3</td>
<td>30-40F n4</td>
<td>30-40F ub5</td>
</tr>
<tr>
<td>Apple</td>
<td>642</td>
<td>0.129</td>
<td>196</td>
<td>0.123</td>
<td>191</td>
<td>0.119</td>
</tr>
<tr>
<td>Pear</td>
<td>556</td>
<td>0.149</td>
<td>166</td>
<td>0.149</td>
<td>110</td>
<td>0.151</td>
</tr>
<tr>
<td>Grape</td>
<td>130</td>
<td>0.018</td>
<td>0</td>
<td>0.000</td>
<td>1</td>
<td>0.302</td>
</tr>
<tr>
<td>Cherry</td>
<td>451</td>
<td>0.09</td>
<td>174</td>
<td>0.081</td>
<td>135</td>
<td>0.086</td>
</tr>
</tbody>
</table>

- Proceeding with National as there’s no advantage/data trends associated with Regional.
Software Updates

• RHU2
  – 15F wide temperature bins added to the software
  – Proceeding with national oversampled data
• Output Files
  – Split output files into metrics file and other: Work in progress
• Additional Support
  – Python 3.8: Added and Tested with EPAThermostat 2.0
• V2.0 Github: https://github.com/EPAENERGYSTAR/epathermostat/tree/feature/epathermostat_2.0
Update: Discussions with Northwest Energy Efficiency Alliance (NEEA) on field data

- EPA is looking for contributions to a thermostat test data set
- NEEA is conducting an energy savings evaluation of connected thermostats
- Covers four states (WA, OR, ID, MT), two climate zones (Marine and Very-cold/Cold)
- 9 utilities, 4 thermostat vendors, 40 -100 anonymized thermostats/vendor
- Data collected:
  - Pre and post-installation energy use
  - Post-installation thermostat data
- Benefits to sharing data: No added burden on vendors
- Drawbacks: only for Northwest region (little cooling)
- EPA invites other (or same) vendors to contribute data from other regions
Discussion:

• Note that this is a potential connection: vendors don’t panic if this is news to you!
• Note: hourly data, in the input format for ENERGY STAR software
• NEEA is asking to know which data come from the same vendors; EPA would like that too.
• Google can do one full random sample from all 5 climate zones
  – Noted that are already providing for Illinois and for NEEA project
  – Do not think they can just open-source the data set even if anonymous; said “maybe” if de-identified by vendor as well, preserving which data sets come from same vendor
• Resideo similar to Google
• Question whether ecobee’s Donate Your Data set is equivalent, because it’s not a random sample; though for software testing may not matter
  – Can this be tested by comparing results from the opt-in set and a fully random sample
  – LBL can produce DYD ENERGY STAR results, ICF can compare to ecobee resubmitted data
• Clarification that for the next stage, vendors will provide non-anonymized NEEA metric results that can be correlated with before-after meter data for households that have consented
Discussion:

• Fascinating aside: would be great to know if any RBSA participants subsequently installed CTs, because then there would be before-after indoor temperature data

• Another aside: effect of COVID-19
• One vendor said that there was nothing that jumped out at them (during a shoulder season), though the number of thermostats in permanent hold has increased a couple %
• Dramatic change in “auto-away” modes – differences between geographies not as dramatic as the difference in political decisions, possibly partly because those with smart thermostats aren’t the same as the general population
• Ethan Goldman mentioned that there is a national group trying to understand program savings in the era of COVID-19, and any data that could inform that would be welcome
  – Example, OpenTable anonymized reservation volume could be used
• Can thermostat data tell us anything about who is sick?
• **Contact Ethan Goldman if you are interested.**
Impact of COVID-19 on thermostats:

• One vendor said that there was nothing that jumped out at them (during a shoulder season), though the number of thermostats in permanent hold has increased a couple %

• Dramatic change in “auto-away” modes – differences between geographies not as dramatic as the difference in political decisions, possibly partly because those with smart thermostats aren’t the same as the general population

• Ethan Goldman mentioned that there is a national group trying to understand program savings in the era of COVID-19, and any data that could inform that would be welcome
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• Contact Ethan Goldman if you are interested.
Checking Resubmission Data

- Do vendors currently do any data checking before resubmission?
- Some proposed checks:
  - Sanity / range checks
  - Inter-vendor comparisons – compare to other vendors in same submission
  - Data trends – compare to previous submissions
  - Inter-vendor trends – compare to other vendors in previous submissions
A Few Sanity / Range Checks

- Low N (< 50)
- Large fraction filtered (> 20%)
- Mean out of expected range
- High coefficient of variation
- Heat pump data:
  - Fraction of systems that are heat pump
  - Ratio of aux to emergency runtime
Inter-Vendor Comparisons

- Example: Runtime from 13 vendor submissions in February 2020

![Runtime graphs showing different conditions and vendor performance](image-url)
Data Trends

- Example: Drop in Heating Comfort Temperature for one vendor’s January 2018 submission
Inter-Vendor Trends

- Example: Heating runtime (hours); small and large disparities
Discussion: Checking Resubmission Data

• Anyone check data before submitting?
  – Always take a look at the data, but have to submit it no matter what. Submit promptly, but analyze later. Have seen very significant differences between runs and between software versions in how much weather data is available.

• Why is that? NCDC FTP server occasionally down or under maintenance. (Use zip 3 or zip 4 for mapping?)

• Also would be great if zip code tabulation data problem was solved. Should use closest ZTCA number.

• Tries to be graceful, but could probably be improved. (Intellovations/ICF action item)

• Useful to track comfort temperatures, indoor and outdoor temperatures, and setback (difference between average and comfort temperatures drives metric results). Also take the degrees of savings for each device and plot against average degrees setback – should be fairly constant for a given climate. If it’s different for one submission, might mean that a different metric score is explained by different weather.
Discussion: Checking Resubmission Data

• Anyone look at hours of “away”?
  – Yes, informally

• Might also be good to look at differences in products within a product families. Google sees some small differences between products, because the user population is slightly different. (comfort temperature is systematically different)

• Another vendor anecdotally is seeing some difference in setpoint and how they operate between newer and older models

• Speculation: learning trend for people who have had the thermostats for a while? Hard to separate from early adopter vs. someone who just got one with a house they moved into.

• Also seen a trend by what year people bought the thermostat – early buyers a little more efficient, separate from the more slight trend over time for people to save more if they’ve owned a thermostat longer
Thermostat Software Version 2 Changes (Review)

- Moving to all hourly data (365 -> 8760 rows)
- Adding ability to handle multiple-speed equipment:
  - Add columns for stage 1, stage 2, and equivalent full load run time
  - If relative capacities not known then software will assume 0.65

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Stage 1 runtime</th>
<th>Stage 2 runtime</th>
<th>Equivalent full load runtime</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single-stage</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Two-stage with known relative capacity</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Two-stage with unknown relative capacity</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Variable capacity</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>
## V2 Metadata File

<table>
<thead>
<tr>
<th>Name</th>
<th>Data Format</th>
<th>Units</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>thermostat_id</td>
<td>string</td>
<td>N/A</td>
<td>A uniquely identifying marker for the thermostat.</td>
</tr>
<tr>
<td>heating_type</td>
<td>enum</td>
<td>N/A</td>
<td>The type of heating equipment.</td>
</tr>
<tr>
<td>heat_stage</td>
<td>enum</td>
<td>N/A</td>
<td>How the heating equipment is staged.</td>
</tr>
<tr>
<td>cooling_type</td>
<td>enum</td>
<td>N/A</td>
<td>The type of cooling equipment.</td>
</tr>
<tr>
<td>cool_stage</td>
<td>enum</td>
<td>N/A</td>
<td>How the cooling equipment is staged.</td>
</tr>
<tr>
<td>zipcode</td>
<td>string, 5 digits</td>
<td>N/A</td>
<td>The ZIP code in which the thermostat is installed.</td>
</tr>
<tr>
<td>utc_offset</td>
<td>string</td>
<td>N/A</td>
<td>The UTC offset of the times in the corresponding interval data CSV (e.g., -0700)</td>
</tr>
<tr>
<td>interval_data_filename</td>
<td>string</td>
<td>N/A</td>
<td>The filename of the interval data file corresponding to this thermostat. Should be specified relative to the location of the metadata file.</td>
</tr>
</tbody>
</table>

- **Expand equipment_type**
- **Drop utc_offset**
## V2 Metadata Enumerations

<table>
<thead>
<tr>
<th>Name</th>
<th>Enumeration</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>heat_type</td>
<td>non_heat_pump</td>
<td>Non heat pump heating (gas or oil furnace, electric resistance)</td>
</tr>
<tr>
<td></td>
<td>heat_pump_electric_backup</td>
<td>Heat pump with electric resistance heat (strip heat)</td>
</tr>
<tr>
<td></td>
<td>heat_pump_no_electric_backup</td>
<td>Heat pump without electric resistance heat</td>
</tr>
<tr>
<td></td>
<td>heat_pump_dual_fuel</td>
<td>Dual fuel heat pump (e.g. gas or oil fired)</td>
</tr>
<tr>
<td></td>
<td>other</td>
<td>Multi-zone, ?</td>
</tr>
<tr>
<td></td>
<td>none</td>
<td>No central heating system</td>
</tr>
<tr>
<td>heat_stage</td>
<td>single_stage</td>
<td>Single capacity furnace or single stage compressor</td>
</tr>
<tr>
<td></td>
<td>two_stage</td>
<td>Dual capacity furnace or dual stage compressor</td>
</tr>
<tr>
<td></td>
<td>modulating</td>
<td>Modulating or variable capacity unit</td>
</tr>
<tr>
<td>cool_type</td>
<td>central</td>
<td>Central AC</td>
</tr>
<tr>
<td></td>
<td>heat_pump</td>
<td>Heat pump</td>
</tr>
<tr>
<td></td>
<td>other</td>
<td>Mini-split, evaporative cooler, ?</td>
</tr>
<tr>
<td></td>
<td>none</td>
<td>No central cooling system</td>
</tr>
<tr>
<td>cool_stage</td>
<td>single_speed</td>
<td>Single stage compressor</td>
</tr>
<tr>
<td></td>
<td>two_speed</td>
<td>Dual stage compressor</td>
</tr>
<tr>
<td></td>
<td>modulating</td>
<td>Modulating or variable capacity compressor</td>
</tr>
</tbody>
</table>

Add heat_pump to cool_type
# V2 Interval Data File

<table>
<thead>
<tr>
<th>Name</th>
<th>Data Format</th>
<th>Units</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>datetime</td>
<td>YYYY-MM-DD HH:MM:SS</td>
<td>ISO-8601</td>
<td>UTC date and time of this hourly interval.</td>
</tr>
<tr>
<td>cool_runtime_stg1</td>
<td>decimal or integer</td>
<td>minutes</td>
<td>Runtime of cooling equipment (all units)</td>
</tr>
<tr>
<td>cool_runtime_stg2</td>
<td>decimal or integer</td>
<td>minutes</td>
<td>Runtime of cooling equipment second stage (two-stage units only).</td>
</tr>
<tr>
<td>cool_equiv_runtime</td>
<td>decimal or integer</td>
<td>minutes</td>
<td>Full load equivalent runtime of cooling equipment (multi-stage units only).</td>
</tr>
<tr>
<td>heat_runtime_stg1</td>
<td>decimal or integer</td>
<td>minutes</td>
<td>Runtime of heating equipment (all units)</td>
</tr>
<tr>
<td>heat_runtime_stg2</td>
<td>decimal or integer</td>
<td>minutes</td>
<td>Runtime of heating equipment second stage (two-stage units only).</td>
</tr>
<tr>
<td>heat_equiv_runtime</td>
<td>decimal or integer</td>
<td>minutes</td>
<td>Full load equivalent runtime of heating equipment (multi-stage units only).</td>
</tr>
</tbody>
</table>

- **datetime now UTC**
- **Stage 1 is now runtime for all units**
- **Stage 1 is now runtime for all units**
Discussion: Version 2.0 Review

- The rest of the interval data file IS still there, it’s just that we didn’t reproduce it.
- Since we don’t use setpoint temperatures anywhere in the software or report it in the statistics file, should we get rid of it? Since everyone will need to re-write their data translators anyway? **EPA action item: will consider and get back to group next time**
- Will this be required for February 2021 resubmission? Not required, requested as additional data, to test the software. Not expected to be ready for the July resubmission.
Update on Communicating controllers

- No major updates since 4/17 meeting
- AHRI planned to submit proposal May 12; unclear is schedule is delayed
- EPA team continues to think more about possible metrics for top savings mechanisms
- EPA team is considering recognition of systems (controls + HVAC) as an alternative; no conclusions yet