



ENERGY STAR Connected Thermostats

Stakeholder Working Meeting Field Savings Metric

April 21, 2017



Attendees

Abigail Daken, EPA

Dan Cronin, EPA

Doug Frazee, ICF International, for EPA

Dan Baldewicz, ICF International, for EPA

Alan Meier, LBNL

Marco Pritoni, LBNL

Brock Glasgo, Carnegie Mellon

Ethan Goldman, VEIC

Nick Lange, VEIC

Michael Blasnik, Nest Labs

Frank David, Carrier

Jing Li, Carrier

Brent Huchuck, Ecobee

Wade Ferkey, AprilAire

Michael Siemann, Whisker Labs

Wendell Miyaji, Comverge

Laurie Sobczak, Comverge

Alex Bosenberg, NEMA

Ed Pike, Energy Solutions, for CA IOUs

Ulysses Grundler, Ecofactor

Karl Muntchnik, IRCO (Trane)

Roy Crawford, IRCO (Trane)

Kurt Mease, Lux Products

John Sartain, Emerson

Charles Kim, SoCalEdison

Henry Liu, PG&E

Jia Huang, PG&E

Essie Snell, eSource

Theresa Weston, DuPont

Michael Fournier, Hydro Quebec

Grant Hatamosa, Zen Ecosystems

Diane Jakobs, Rheem

Ethan Rogers, ACEEE

Phillip Kelsven, BPA

Paul Doppel, Mitsubishi Electric

Brian Rigg, JCI

Theresa Gillette, JCI

Shawn Hern, JCI



Agenda

- Review of 2017 metric improvement priorities and work plans
- In depth discussion of multiple thermostats per home, and zoned systems

2017 Metric improvement priorities

- During February meeting, identified a variety of possible improvements, and polled attendees about their priority

Topic	First priority (# of people)	Second priority (# of people)	Weighted sum
Weather normalization	1	3	2.5
Modulating equipment	0	6	3
Multi stage equipment	1	4	3
Regional temperature baselines	10	0	10
Multi-thermostat homes	4	3	5.5
Handling missing data	2	1	2.5

Big Picture I

Topic	Priority	Status
Weather normalization	6	TBD
Modulating equipment	4	Discussed Mar 24, 2017
Multi-stage equipment	3	Discussed Mar 24, 2017
Regional temperature baselines	1	Offline discussion (CMU project - long term)
Multi-thermostat homes	2	Today
Handling missing data	5	TBD



Big Picture II

Metric improvements meta-questions

- Which effects create the largest distortions – are there small studies or easy tests out there to guide us?
- How accurate do we need to be for this standard? What inequity, from a policy perspective, is the inaccuracy driving?



Problem Statement

- Current metric assumes single-zone, single-stage, single-thermostat HVAC systems
- Alternative systems exist to “zone” a house
 - Multiple traditional “central systems” (usually large houses, one each floor)
 - Mini-split AC/HPs
 - Baseboard heaters
 - Zoned radiant systems (using hot water)
- No clear path to address these has been identified



Features of these systems

Type	Service	CT compatibility	Multi-stage/Modulating
Multiple central systems	Heating, Cooling	CT compatible	A few
Single central system with zone dampers	Heating, cooling	CT compatible, multiple thermostats	A few
Mini-split/multi-split AC/HP	Heat pumps, some cooling only	Proprietary remote control, some compatible with CT	Majority/All
Baseboard Heaters	Heating	Local control, usually line voltage (e.g. not compatible with low voltage CTs)	Some (most in some territories)
Zoned radiant systems	Heating, Cooling (some)	?	?

Mini-splits/multi-splits may be combined with radiant or electric baseboard heat.



Zoned central forced air or radiant systems

- Thermostats don't necessarily know that there is another entity (zone controller) making decisions about calling for heating and cooling
- May make heating and cooling run times misleading, because the amount of heat/cool going to any particular zone (= thermostat) may not be consistent, depending on which other zones are calling for conditioning, especially for systems with single stage equipment and/or fixed speed or fixed torque fans
- When air is not being used in a zone, it may be dumped
- How common are these (<10%)?
 - May be reports in California



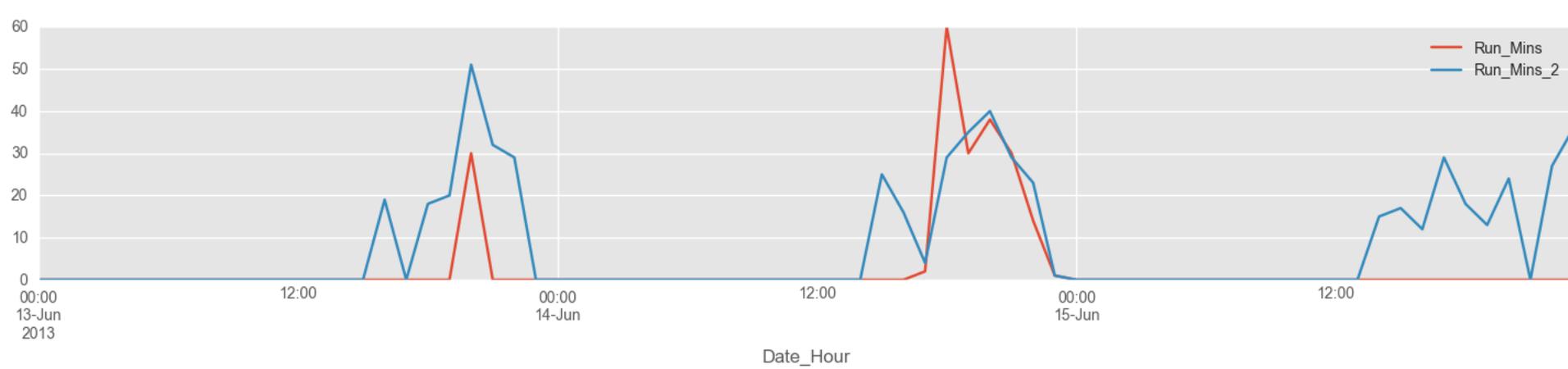
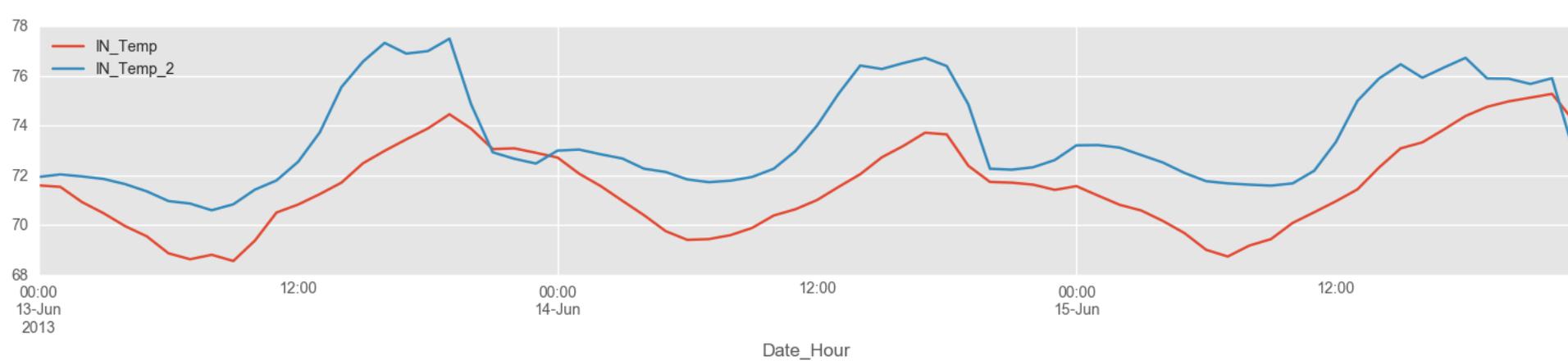
1 - Houses with multiple “central systems” (e.g. 2 + Furnaces or ACs)

Framing Questions

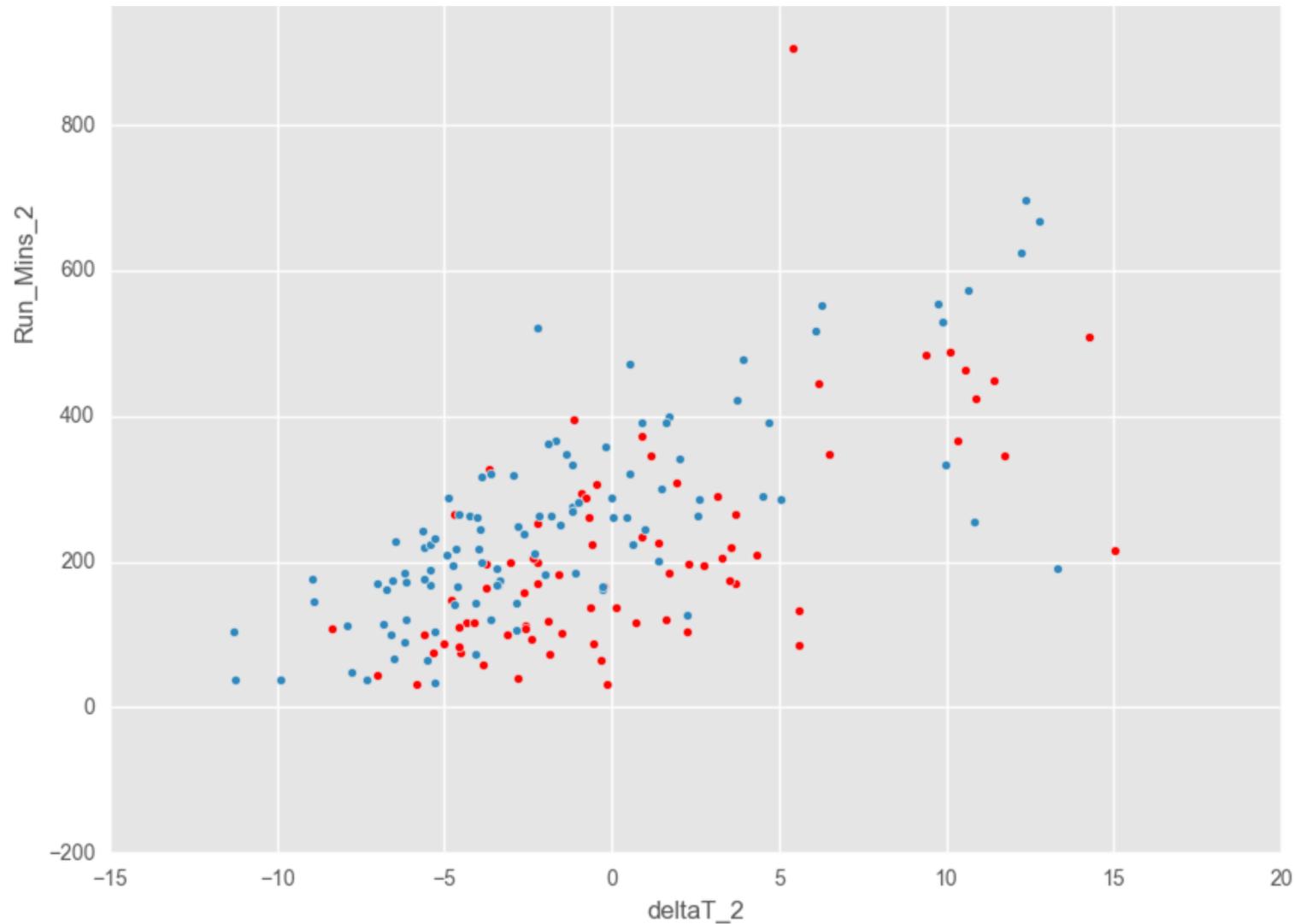
- How many homes with CTs have more than one CT (30%?) ? Does it vary with house size?
- Can each partner clearly identify these thermostats/houses ?
- How is the metric score impacted by these thermostats (picking a single thermostat to represent the whole house) ?
 - Physical (heat) interaction between zones impacts indoor temp and runtime.
 - Should delta T consider adjacent zones ?
 - Quality of fit?
 - Should we “average” multiple thermostats in that house and create a virtual home thermostat ?
 - Should these homes be removed from the pool of candidate thermostats for the metric ?



Multiple thermostats - an example (summer, CA)



Multiple thermostats - an example (summer, CA)





1 - Houses with multiple “central systems” (e.g. 2 + Furnaces or ACs) discussion

- Does drive with size – one system per floor is common for large homes. Can’t control temperature in whole house with one system if there are varying solar gains across even a single story home. Also a common problem for urban row houses.
- Tends to occur in cooling dominated climates. In heating dominated climates, is cooling even needed? If not, can use zonal baseboard or radiant heating – simpler system if cooling not needed.
- Ductless splits also being used to supplement comfort in home with single ducted system. Common in additions, but not exclusive to additions.
- Claim: More common in retrofit than in new homes – designed right in new homes. Counterclaim: more common in new homes than in retrofits (half the Nest thermostats in homes built after 2010 are in multiple thermostat homes; for homes built before 1980, only 20% of thermostats are in homes with more than one.) Bias about the types of systems used – particularly radiant systems? Not notably: 90% of customers are forced air.
- Nest: self-reported house size for 2 thermostat homes 50% larger than for those with one stat. Rare to see a single system in a 3k or 3.5k sq. ft. house, or for 2 story homes in hot climates
- Summary: should expect more and more multiple thermostat homes in the future



1 - Houses with multiple “central systems” (e.g. 2 + Furnaces or ACs) discussion

- Can vendors clearly identify homes with more than one stat? Looks like usually. Can you determine this w/o customer info? Nest: vast majority of customers set up accounts, and we know. (Though some will have multiple CTs from different vendors.) Ecobee: agree. Some odd cases, such as elderly parents with kids controlling thermostat.
- When there are more than one t’stat in a home, how many do they have?
 - Nest can serve up to 20 in a home – people complained about 10!
 - Nest: 80% of homes have one, 15% have 2, 3% have 3, just over 1% have more than 3
 - Lux: As high as 12 – heating only, large home w/radiant
 - Lux: vast majority have 1, and % drops severely after 3 per home (upstairs/downstairs common). About 90% forced air systems
 - Whisker Labs: 76% of homes have 1 thermostat, 24% have multiple thermostats; are starting to collect data about whether homes have additional, non-connected t’stat.
 - Ecofactor: no exact numbers, but similar to above



1 - Houses with multiple “central systems” (e.g. 2 + Furnaces or ACs) discussion

- Effect on metric scores?
 - Nest: Sample subdivided by which homes are multi-thermostat homes: in heating, twice as likely to be screened out, affecting sample average (30% of t-stats in sample). Also thermostats with others in home scored worse on average in heating, but mattered little in national average. Even those that passed screening had worse fits. In cooling, the effects is smaller – no difference in quality of fit, very little difference in results either.
- Any thoughts about why? It’s complicated – many different drivers.
 - If one system per floor, there might be something with occupancy controls and setback... upstairs (bedrooms) tend to be unoccupied more.
 - Zones interact differently in heating than in cooling. Loss from 1st floor in heating is a benefit for 2nd floor.
 - Additional effect in summer: heat gain from sun may drive more than ΔT
 - Also in cooling, may just run at capacity on the upper floor
 - Driven by ΔT being larger in heating?
 - Depends on how air communicated between floors.



1 - Houses with multiple “central systems” (e.g. 2 + Furnaces or ACs) discussion

- Ultimately, does this come down to a question about how to treat them?
- Does ignoring it produce a policy problem? If the scores are pretty much the same, can we leave it alone?
 - Number of thermostats per differs between CT devices using Connected Savings
- Emerson: multi-thermostat homes will tend to have more occupants, because they’re larger. Correlation is challenged: any one have data? May be true up to a certain size, but what size. Check RECS, or census.
- Do homes with more occupants tend to have less savings available? Or more? May be driven by occupant age: young children and retired people tend to be home all day. Also true for lower income homes.
- Emerson: Also harder to set back with pets. Tending not to go in and out of the house as much when in a setback conditions.
- More occupants = more electricity consumption in Seattle.
- Any special considerations for homes with a single central system and zone dampers?
 - Do not know from data that we have this case? True, though can guess.
 - Likely to make results more noisy?



2 - Mini-split AC/HPs

Framing Questions

- Most are also modulating/multi-stage
- Need to take into account the discussion from last meeting
 - VRF (ductless) with single outdoor unit may be even more complex, because need to allocate a portion of the condenser energy use to multiple zones
- How many homes have these ?
 - Are they compatible with 3rd party CTs?
 - How is capacity modulation controlled by 3rd party CTs ?
- Are these systems operated only when needed (occupancy-driven) ?
 - Is constant setpoint a fair baseline ?
- What is the path forward ?



2 - Mini-split AC/HPs discussion

- Anyone on that makes these? Rheem – some.
- Modulating: can't use run time as a proxy for energy use.
- Mini- and multi-split: people use much more as “I need it now” rather than to keep a room at a particular temperature. Current metric doesn't really account for units that are off a lot.
 - Rheem: yes, for sunrooms and similar additions
 - JCI: depends on the application; more likely in US to use a central zone system, as we are used to using energy w/o thought.
- Some of the problem is because the device's behavior is invisible when it is switched off. What would be impact on the metric be?
- How far are we from being able to include these installations in the metric, given all the various issues with them?



3 - Baseboard heaters (120 V)

Framing Questions

- These were excluded from the metric after discussion with stakeholders, however there is a path to include them
- Have local controllers, usually non networked
- Zoned and modulating capacity
- What is the path forward ?



3 - Baseboard heaters (120 V) discussion



4 – Zoned Radiant Systems

Framing Questions

- High temperature (radiators) and low temperature
- Have local controllers ?
- Zoned and modulating capacity (flow)
- What is the path forward ?



4 – Zoned Radiant Systems discussion



Contacts for various work streams

- **Regional temperature baselines:**
Brock Glasgo, 513-519-1008, bglasgo@Andrew.cmu.edu
- **Multi thermostat homes/zoning:**
Alan Meier, 510-486-4740, akmeier@lbl.gov
Dan Baldewicz, 518-452-6426, dan.baldewicz@icf.com
- **Staged/variable capacity systems:**
Abi Daken, 202-343-9375, daken.abigail@epa.gov
- **Incomplete data:**
Any volunteers to be a central point of contact?
- Everything else, including the specification:
Abi Daken, 202-343-9375, daken.abigail@epa.gov or
Dan Baldewicz, 518-452-6426, dan.baldewicz@icf.com



Next Metrics Meeting

- May TBD



Recap: ENERGY STAR Connected Thermostats

- Connected Thermostats Version 1.0 is available for certification:
 - [Eligibility Criteria for Version 1.0.](#)
 - [Method to Demonstrate Field Savings.](#)
 - [Random Number Seeds for Savings Method.](#)



Recap: Software

- Current Software is Thermostat Module V1.1.1:
 - Packages on PyPI:
<https://pypi.python.org/pypi/thermostat/1.1.1>
 - Pip install thermostat
 - Source Code on GitHub:
<https://github.com/EPAENERGYSTAR/epathermostat>
 - Documentation on ReadTheDocs:
<http://epathermostat.readthedocs.io/en/latest/>



Open discussion



Contact Information

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Backup slides – only post in deck if we discuss them



Regional temperature baselines

- Rated as the highest priority
- Has the potential to recognize a wider range of savings strategies
- Meta questions: do we know how big a difference this could make? Definitely has the potential to drive inequities between CT products.
- A path to address this has been identified
 - Carnegie Mellon University researchers are interested in this as a research problem
 - Proposed as a two year project
 - Regular updates and discussions of the work will occur in these metrics meetings, but the bulk of the work will happen outside this group



Homes with multiple thermostats

- Rated as the second priority; closely related to zoning
- Meta questions: Many homes with CTs have multiples (1/3?); some systems inherently zoned; but not clear how inappropriate the current metric will be
- No clear path to address this has been identified
 - Focus the April metrics meeting on this topic?
 - If so, would be helpful to have some better definition of the problem (e.g. includes fully zoned?), and possible paths to gauge its urgency and address it, identified for the April meeting
 - Are a subset of stakeholders interested in working on this topic, to make progress outside of these monthly meetings?



Multi stage and modulating equipment

- Two topics tied for third priority
- Meta questions: Clear that metric as it currently exists is not usable for these systems; also clearly drives inequity, by limiting participation of OEM CTs designed for modulating equipment
- Not a lot of stakeholders indicated they could put time and/or resources into this topic, however outreach to HVAC OEMs has been fruitful
- These topics are the focus of this meeting
- Is this one topic or two?
 - Last meeting there was some discussion that separate strategies may be needed for the two
- To be continued later in this meeting...



Additional metric improvements

- Not a lot of interest in weather normalization.
 - Not clear how much lack of normalization matters or whether it produces any inequity.
 - Simple ideas to check how much difference it makes: Simulation, check consistency of metric scores year to year
- Additional thought to handling missing data was also a fairly low priority
 - A couple people felt strongly about this topic: you are encouraged to bring proposals to the group for consideration