ENERGY STAR Connected Thermostats

Stakeholder Working Meeting

November 22, 2019

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
Brian Rigg, JCI
Theresa Gillette, JCI
Kurt Mease, JCI
Diane Jakobs, Rheem
Carson Burrus, Rheem
Chris Puranen, Rheem
Glen Okita, EcoFactor
Brent Huchuk, ecobee
John Sartain, Emerson
James Jackson, Emerson
Mike Lubliner, Washington State U
Charles Kim, SCE
Michael Fournier, Hydro Quebec
Dan Fredman, VEIC
Robert Weber, BPA
Phillip Kelsven, BPA
Casey Klock, AprilAire
Ulysses Grundler, IRCO/Trane
Jeff Stewart, IRCO/Trane
Mike Caneja, Bosch
Sarathy Palaykar, Bosch
Brenda Ryan, UL
Mike Clapper, UL
Alex Boesenberg, NEMA
Ethan Goldman, Recurve
Jon Koliner, Apex Analytics
Michael Siemann, Resideo
Aniruddh Roy, Goodman/Daikin

Agenda

- Introduction with Abhishek
- RHU: Straw man proposal for metric and sampling
- Additional Metrics: Illinois Method
- Adding Installation Types:
  1. Variable capacity fossil fuel and electric resistance
  2. Variable capacity compressor based

Abhishek Jathar, MSE, EIT (FE)

- Energy and Sustainability Engineer, ICF
- Abhishek.Jathar@icf.com

- Master of Science - Electrical Engineering, Power and Energy Systems at Arizona State University.
- Experience – Smart Grids, Power System Protection, Load modelling, Renewable Energy and Electric Vehicles.

RHU: Where were we again?

- Resistance heat utilization (RHU) is a measure of how well thermostats avoid use of resistance heat backup for heat pumps

$$RHU = \frac{resistance\ heat\ run\ time}{total\ heating\ run\ time}$$

- Calculated for homes with a heat pump and resistance back (per tstat wiring); calculated daily, average over year w/in outdoor temp bin (e.g. 30F - 35F)
- Roll up average over all installations with time in a given temp bin
- RHU2: Two improvements exclude some installations from the average
  - < 30 hours in bin (conditions heating system is not designed for)
  - Run time in top 5th percentile w/in bin (malfunctioning heat pump)
- July 2019 data collection included these changes, additional percentiles, and larger temperature bins

RHU: Straw man proposal for metric and sampling

- Previous meetings: shared RHU2 results, discussed need for additional sampling of heat pumps for reasonable results
- As a **starting place for discussion**, EPA proposes:
  - Heat pumps only sample of installation w/minimum 50 installations nationwide used only to determine RHU required with periodic data submission
  - Separate sample to determine heating and cooling percent run time reduction may randomly include some heat pump installations as it does now
  - Metric for RHU: RHU in temperature bin 30F-45F upper 95th confidence limit of the mean ≤ 0.2
- Discussion
  - Need to specify enough installations in the 30-45F temperature bin?
  - National vs. in particular regions? Could we do better than 20% at that bin in colder regions? Or do that well in a colder bin?

Data from July 2019 Submission (2 sets used V1.5, had no RHU2 data)

	30-40F n	30-40F ub	40-45F n	40-45F ub
mango	160	0.086	188	0.100
papaya	48	0.202	53	0.164
pear	63	0.089	72	0.078
pineapple	107	0.122	91	0.145
plum	5	0.799	5	0.846
apple	58	0.138	71	0.115
grape	7	0.119	11	0.061
lemon	25	0.505	32	0.485
lime	100	0.160	107	0.147

Discussion: RHU

- Geographic dispersion? Yeah, several issues. Compressor will be larger compared to heating loads in warmer climates, because they are sized for cooling in every climate. Resistance heat is typically larger in colder places.
- Alternate approach: requirements per regions? Not all regions have significant # of heat pump installations. Do just cold+mixed humid, and everything else? At least 50 from mixed humid and 50 from everything else? Assumes that you learn more about heat pump control in mixed humid climate zone, which is probably true. Cold might push us to figure out how it's really working.
- Opinions on concentrating on 30-45F range? Generally no objections.
- 15F wide temperature bin? Could be good to look at the average outdoor temp this was based on as well. Or look at three 5F bins separately, maybe with different levels.
- Still concerned about dealing with outliers, very high RHU indicating problem with system. Maybe better to look at the median performance? Are there user settings that could cause that to happen? (e.g. compressor lockout temp, the way you set the flipped behavior, etc. Comfort setting may also effect this – which contractors would like.)

Discussion: RHU

- Can we get at it by defining outliers as installations with a lot of compressor use but also resistance heat use? Yes, that helps. Though it wouldn't distinguish products that are better at avoiding aux heat use for recovery. If compressor is running 60% of the time, a lot of aux heat makes sense. If you're only running it 30% of the time but all of it was with aux, that's not good control. Use an outlier threshold – if lots of compressor runtime, no need to include it in the average.
- Track recovery separately? Sounds like a lot of trouble.
- Note to figure out whether average outdoor temperature is daily or hourly. The meaning of compressor run time is different depending on it. Cursory look implies daily? Looks like EVERYTHING is daily. (Because we only had daily data for heating RT, presumably).
- ER use in bin compared to compressor run time in entire day? **Or just exclude days with >X (50%? 70%?) compressor run time in the day in the bin average for the installation.**

Discussion: RHU

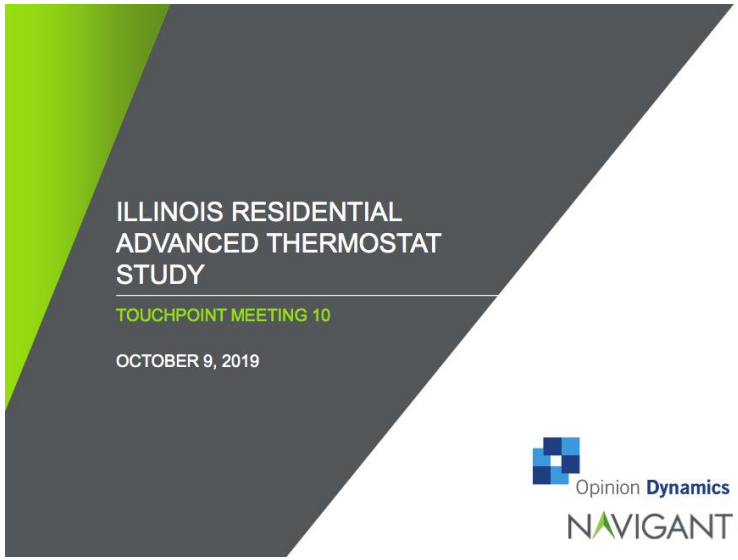
- ER times off time for the day: if there's 0% off time in the day, the ER minutes don't count; if there was heat running only 50% of the time, then you'd get half weighting. If heat running very little, it would be heavily weighted. Avoids making extra decision? Naaah.

Proposed Adjustment of Energy Star Method for Use in Evaluation

ENERGY STAR CT Stakeholder Meeting
November 22, 2019
Alan Meier and Leo Rainer, LBNL

Illinois Residential Advanced Thermostat Study

- Proposed adjustments to address two key questions:
  - Adjusting *Baseline Comfort Temperatures* to account for free heating and cooling
  - Adjusting for *Setback Behavior*

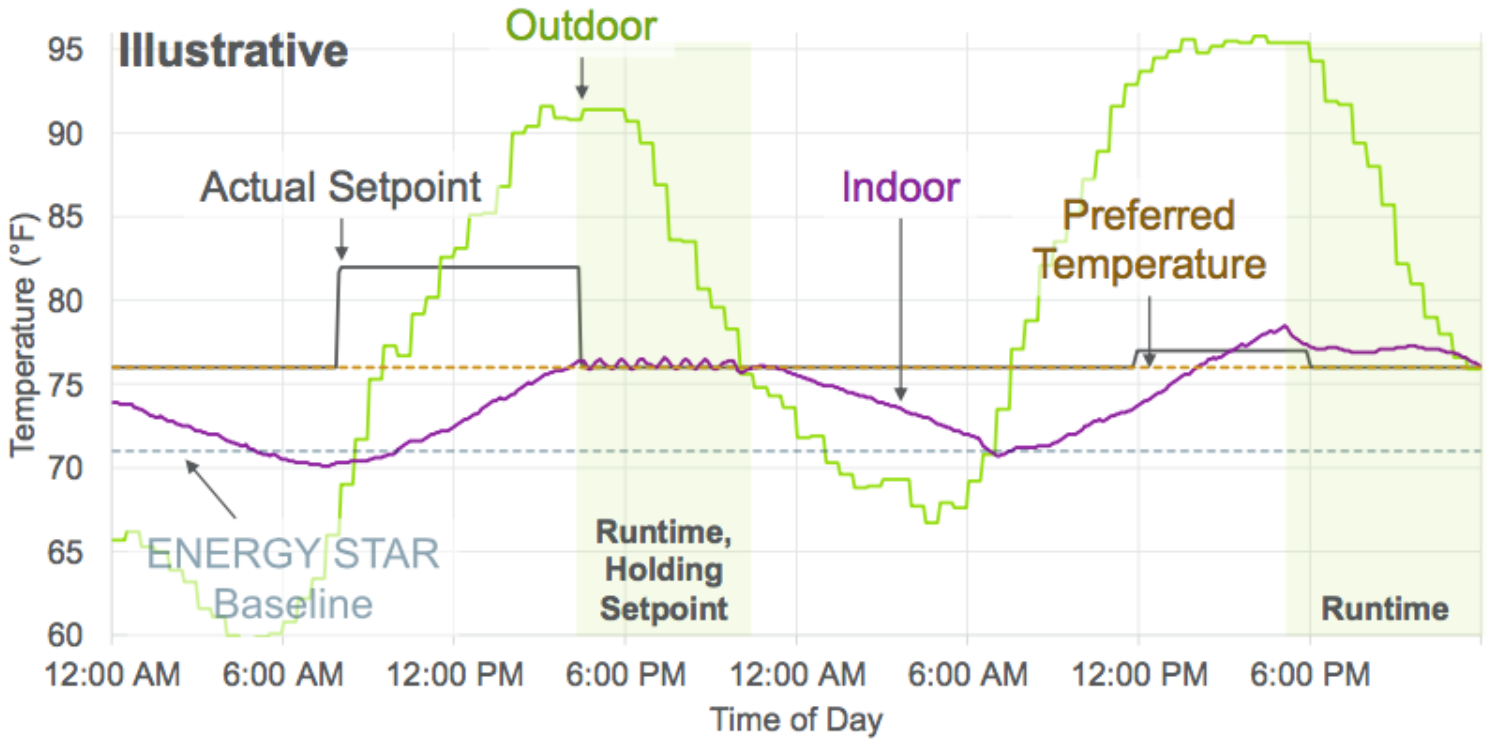


Adjustment of Baseline Comfort Temperatures

- Include only hours with runtime (reduce free cooling or free heating)
- Include only hours where indoor temperature is within 1°F of setpoint (steady state)
- Select the preferred comfort temperature based on the 10^{th} percentile of temperature for cooling
- Select the preferred comfort temperature based on the 90^{th} percentile of temperature for heating

ILLUSTRATIVE EXAMPLE

The preferred comfort temperatures would be selected from hours where the system is holding the setpoint.



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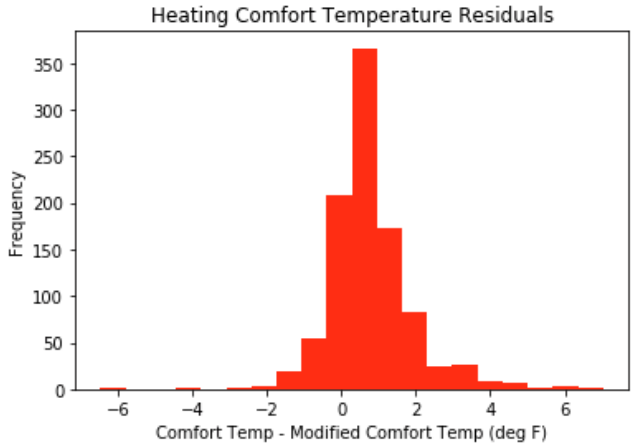
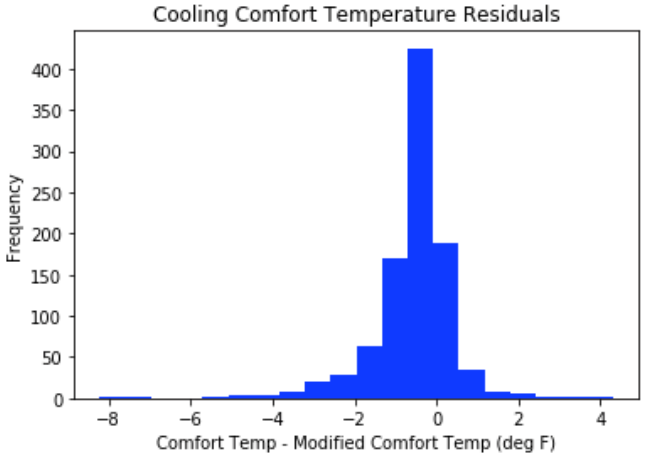
Differences between Comfort Temperature and Modified Comfort Temperature

Climate Zone	Heating Difference* (°F)	Cooling Difference* (°F)
Hot-Humid	0.9	-0.3
Marine	0.7	-1.3
Mixed-dry / Hot-dry	1.2	-1.0
Mixed-humid	0.6	-0.4
Very-cold / Cold	0.6	-0.7

- Comfort temperature – Modified comfort temperature





Discussion: Illinois method

- Report cites NEEA method, which used fixed indoor temp, but then switched to using comfort temp without addressing why. Yes, still a self-referential baseline, same issues.
- Why still 10th percentile if you're only looking at these constrained times. Across days 10th percentile still makes sense.
- Also proposed changing the average temperature too, by averaging the minimum (in cooling) of the comfort temp and the indoor temp, averaging over the core cooling days, and using that as the baseline temperature.
- Is a half degree or a degree enough to make a difference in the heating or cooling savings? Yes, definitely.
- One vendor's calculation with thermostats in Illinois in cooling reduced savings by about 1/5.
- **Not clear that it will make a big difference – Navigant will be trying with real data – stay in touch and do nothing for now.**

Adding installation types: Variable capacity fossil fuel and electric resistance

- Importantly, for these types, efficiency doesn't change much with capacity
- Hypothesize energy use proportional to the sum over intervals of the relative capacity in each time interval times the length of the interval
- Use "equivalent full load run time" (ERT) in place of run time
- A couple notes:
  - Current data may include staged and variable capacity units wired as fixed capacity – bad data, so adding those controlled appropriately is improvement
  - Default relative capacity for staged units used for installations where the thermostat/controller doesn't know the relative capacity
- Discussion topics:
  - Yes or no?
  - Proposal: add to code for 2 stage and allow for stakeholders to do outside of code for other system types.
  - How short a time interval is needed?
  - Similar strategy for zoning?
  - Lost information: use of lower capacity modes. Does is matter?

Discussion: Variable and staged fossil fuel installations

- Generally a good idea? **No objections.**
- Do we have a data set where we can look at the time scale for capacity change? To get at the needed granularity we would need.
- Doesn't matter a lot what relative capacity you use because it won't effect savings, though it may effect linearity.
- One vendor notes that low single digits of installations are wired for control of 2-stage heating (this vendor has mostly DIY installs). Another vendor found 15% for model that is generally contractor installed, 7% for a model that is often DIY installed.

Adding installation types: Variable capacity compressor based

- Generally proprietary controllers, currently none certified, though some control enough fixed capacity systems
- Have not been able to establish that ERT is proportional to energy use and not easily related to indoor – outdoor temperature difference.
- Contemplating a completely different way of evaluating performance. Outline:
  - Confirm that controller brings equipment to lower capacity states using controls verification test (CVT) as in ASRAC work for VRF systems (more info to follow)
  - Collect field data showing relative time in lower capacity states, e.g. ERT vs. total RT? Ideas for this metric welcome.
- Process from here:
  - Convene specific meeting about this in December or January (probably with AHRI)
  - Develop specific proposal, test method(s), field data analysis/aggregation as needed
  - Aim to include in spec revision (2020)

Description of Controls Verification Test (CVT)

- CVT for commercial VRF system controllers; modify for residential
- Set up with controlled unit in psychometric chamber as for usual SEER test
- “Indoor” chamber temp starts >> set point; verify unit at full capacity
- Ramp indoor temp down slowly
- As chamber approaches set temp verify control ramps capacity down
- As indoor temp continues to ramp down, control will get to minimum capacity and start cycling at minimum capacity
- When indoor temp below the set point verify unit turns off
- Achieved relative capacities must make sense with manufacturer test points for cooling efficiency test
- Please hold discussion on the specifics of the test until we have more details; discussion on general approach welcome

Discussion: Variable and staged compressor-based installations

- Energy350 is looking into controller/equipment interactions, intending to install systems in employee homes for the winter – will hook Abi up with this group

Discussion: New business?

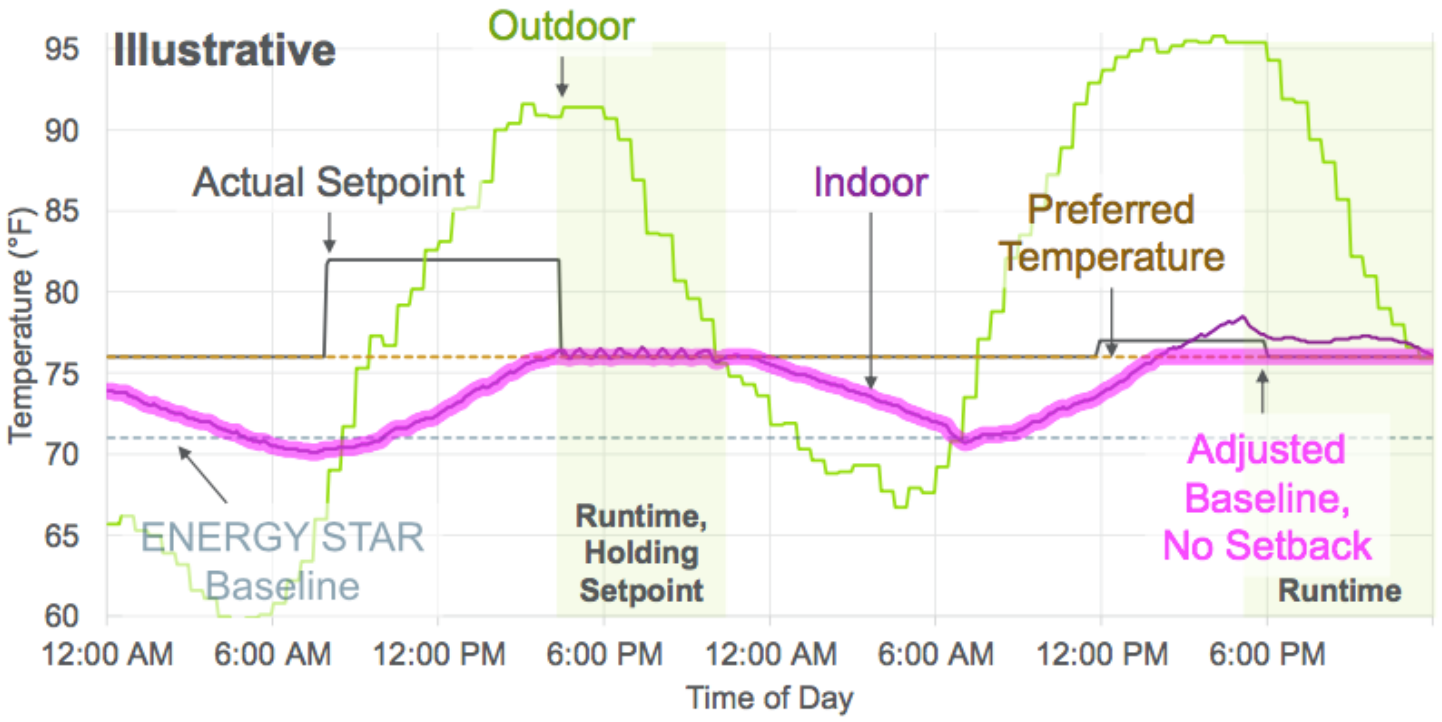
Wrap up and Next Steps

- Action Items:
- Next Steps:

Backup Slides

ILLUSTRATIVE EXAMPLE

Baseline is the minimum of indoor and preferred comfort temperatures, selected from hours where the system is holding the setpoint.



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