ENERGY STAR Connected Thermostats

CT Metrics Stakeholder Meeting Slides

June 18, 2020

Attendees

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Leo Rainer, LBNL
Nick Turman-Bryant, ICF for EPA
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Craig Maloney, Intellovations
Michael Blasnik, Google/Nest
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Jason Thomas, Carrier
Frank David, Carrier
Brian Rigg, JCI
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Carson Burrus, Rheem
Chris Puranen, Rheem
Glen Okita, EcoFactor
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Albert Chung, Emerson
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Charles Kim, SCE
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Casey Klock, AprilAire
Wade Ferkey, AprilAire
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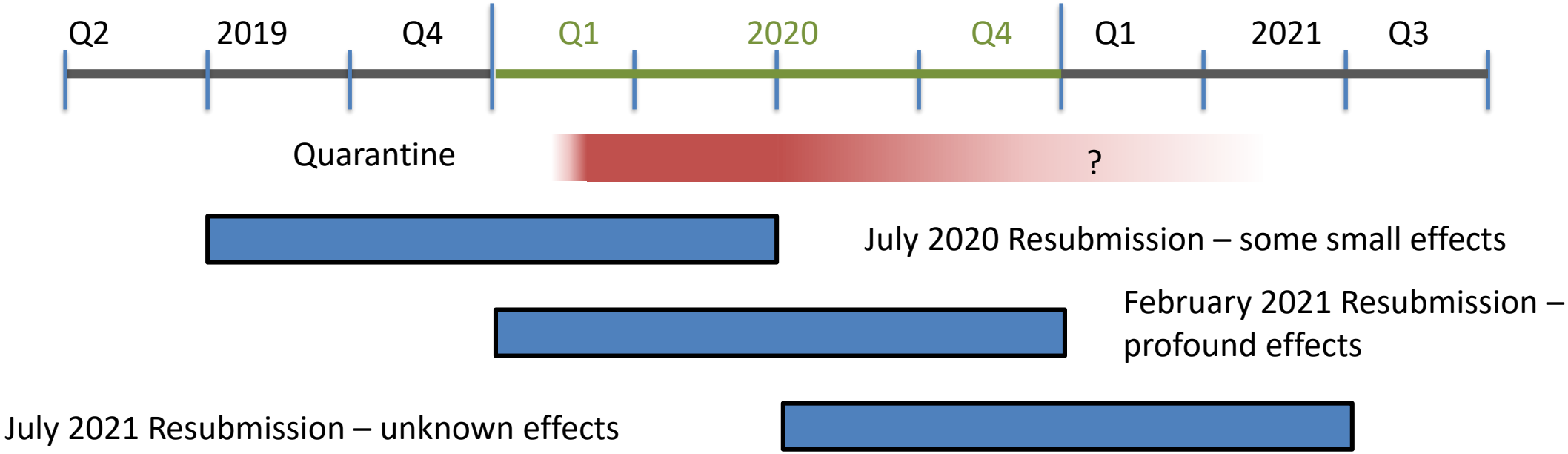
Jeff Stewart, Trane
Mike Caneja, Bosch
Sarathy Palaykar, Bosch
Brenda Ryan, UL
Mike Clapper, UL
Alex Boesenberg, NEMA
Ethan Goldman
Jon Koliner, Apex Analytics
Michael Siemann, Resideo
Aniruddh Roy, Goodman/Daikin
Dan Baldewicz, Energy Solutions for CA IOUs
Dave Winningham, Lennox
Dan Poplawski, Braeburn

Agenda

- A few administrative notes
  - Field data in the COVID-19 ERA
  - Overlapping V1 and V2 software and field data submissions
- Software update
- Tackling the problem with weather station data
- What can we do with occupancy modes (Home, Sleep, Away, etc.)

Smart Thermostat Field Data Resubmissions

- For currently certified products, submit data as usual – it will be interesting to see what the results are
- For new product certifications, contact EPA or ICF



Overlapping V1 and V2 submissions

- July 2020 submission
  - Use software version 1.7.2
  - Feel free to also experiment with 2.x branch, but note it is changing frequently at the moment
- Not ready for parallel submission using V2.x submission, originally anticipated July 2020
  - ensures new software works, etc.
  - Heat pump oversample gives last data before proposing RHU2 levels for specification Version 2.0
- Anticipate February 2021 request for parallel submission with V1.x and V2.x

Software Updates

- Version 1.7.2
  - Most recent software version to be used for July submission
  - Backports the warning message suppression
  - Cleans up the tests and coverage
- Version 2.0
  - Split output files into metrics file and statistics file
    - Metrics file to include 5 metric values
    - Statistics file:
      - Dropped 10 F bins and NOIQFT duty cycles
      - 12 five-degree bins and 1 fifteen-degree bin for RHU1, RHU2, RHU2IQFLT
    - Github: https://github.com/EPAENERGYSTAR/epathermostat/tree/feature/feature/epa_2.0_new_output
  - Dropped setpoint temperature

Matching Thermostat Location to Hourly Weather Data

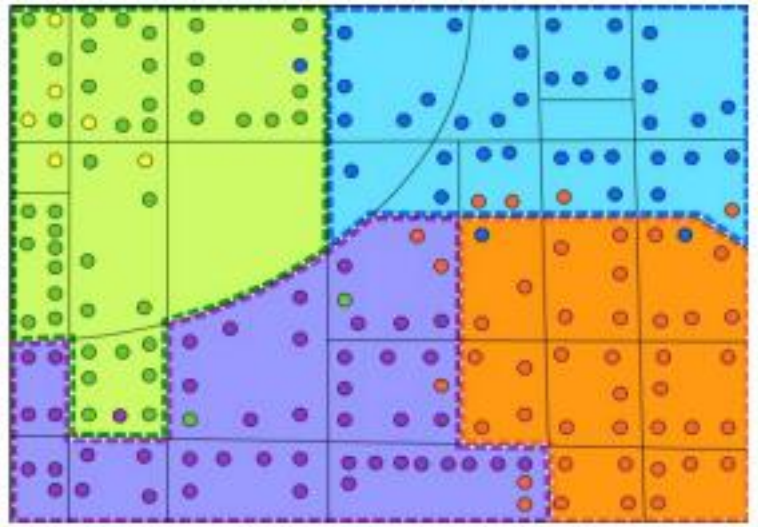
Thermostat Summary Metadata

`zipcode`	string, 5 digits	N/A	The ZIP code in which the thermostat is installed [2].

[2] Will be used for matching with a weather station that provides external dry-bulb temperature data. This temperature data will be used to determine the bounds of the heating and cooling season over which metrics will be computed. For more information on the mapping between ZIP codes and weather stations, please see eemeter.weather.location.

ZIP Code Tabulation Areas (ZCTAs)

- US Postal Service ZIP Codes
  - ~42,000 unique codes
  - A collection of mail delivery routes, not geographic
  - Some can correspond to single buildings or post-offices
- ZCTAs
  - Generalized areal representations of USPS ZIP co
  - Developed by the US Census Bureau
  - ~33,000 unique codes
  - Missing ~9K USPS ZIP codes (20%)



Each dot represents an address and each color represents a different ZIP Code.

Weather File Mapping Failures

- The EPA thermostat code uses the EEweather package to retrieve weather data
- ~2,500 NOAA Integrated Surface Database (ISD) files with current hourly data
- Uses ZCTA to estimate the latitude and longitude of the thermostat
- Uses Lat/Long to find closest ISD file
- Three typical matching errors:
  - **Non-ZCTA code**
  - Weather file too far away
  - Missing data or file

Possible solutions to ZCTA failures

- Require a valid ZCTA (current)
- Find closest valid ZCTA numerically to submitted ZIP code
- Use ZIP code to ZCTA crosswalk
- Add optional latitude and longitude to metadata file

Discussion: Weather Station Data

- Zip code is user entered for one vendor; some vendors have a street address that they derive zip code from; these are intended to be the location of install not the billing zip code.
- Some people avoid giving real info
- Reverse IP discrepancies occur, but not clear which is more representative of actual location
- One vendor: In DR programs, at least 75% are good; for general population better than 50%
- Another vendor: 90-95% accurate
- Another vendor: zip code for account, can refer to multiple thermostats in different locations. No information about the actual location of the thermostats.
- Reverse IP lookup: 60% or so can be within a few miles, 40% nowhere close. Other vendors think that it's a bit better.
- Anyone have an opinion on whether mapping of zip to ZCTA better in software or by vendor? Note that if vendor does it provides possibility to use other info to derive ZCTA.
  - One vendor: If software does it, consistent and easier to maintain.
- Separate issue: some states (e.g. CA) have better mapping to deal with elevation and microclimates. EE weather does have some tools to rank by elevation and a couple other things.

Discussion: Weather Station Data

- Another way to deal with this: if you don't have a good mapping, run with each and see which has the best linear fit.
- But probably doesn't matter, mostly, to the scores
- The simplest way to avoid losing thermostats is to truncate zipcode to 3-4 digits.
- Modified approach would be to know which zip codes tend to present problems (fit issues) based on weather station data. To do this, we'd need to know which thermostats were filtered out for bad weather station data. One person noted that it might be useful to know the zip at which thermostats were kicked out for poor fit.
- Suggestion that the thermostat module output metrics file contain a row for every thermostat in the metadata file (everything in the sample), whether or not it mapped to a weather station or whatever.
  - Any other thoughts about this suggestion?
  - One second, and the idea that it could lead to diagnostics that COULD be in the stats file
  - Extension of something we were already considering
  - Any objections to this suggestion? No.

Discussion: Weather Station Data

- Another topic: for the case where one account has many thermostats, should we just assume (for >5?) are they likely to be scattered over a wide area? Or are we talking about an apartment building?
  - They'll often be a string of businesses scattered across a city, or maybe an apartment complex.
  - So 95% of them should be fine for weather station data
  - Vendor will explore more to see if they can see any problems produced by this in their latest submission
  - Another question: significant number of these are small commercial. Is behavior different from residential? YES. Should we be treating them differently? Results are skewed – more driven by internal gain.
- Another little idea to test how well 3-digit zip codes work: could randomly change last 2 digits of zip codes in the latest input files (metadata file) and see if it has a significant effect
  - Note you might want to randomly select the new zips from the list of ZCTAs, so as to make sure you don't drop different t'stats.

Thermostat States Discussion

Vendors use different terms to describe thermostat states

Taken from operating manuals and websites – illustrative only

	HVAC status	**Occupant activity, e.g. "sleep, away, etc."**	**Schedule override, e.g., - "hold, vacation, demand response"**
ENERGY STAR	none	event	none
Google nest	mode	none	none
ecobee	not known	Comfort setting, climate setting, or activity period	event
Resideo/Honeywell	mode	period	override
Emerson	mode	not known	not known

Question:

Do your thermostats use Home, Sleep, and Away or similar terms to guide users during set-up, programming, or operation?

Question:

Would it be useful to standardize the names of the states?

Think about this in terms of:

- Consumers
- Vendors
- Technical standards committees
- ENERGY STAR
- Energy management systems relying on interoperability

Are *states* important in understanding thermostat performance?

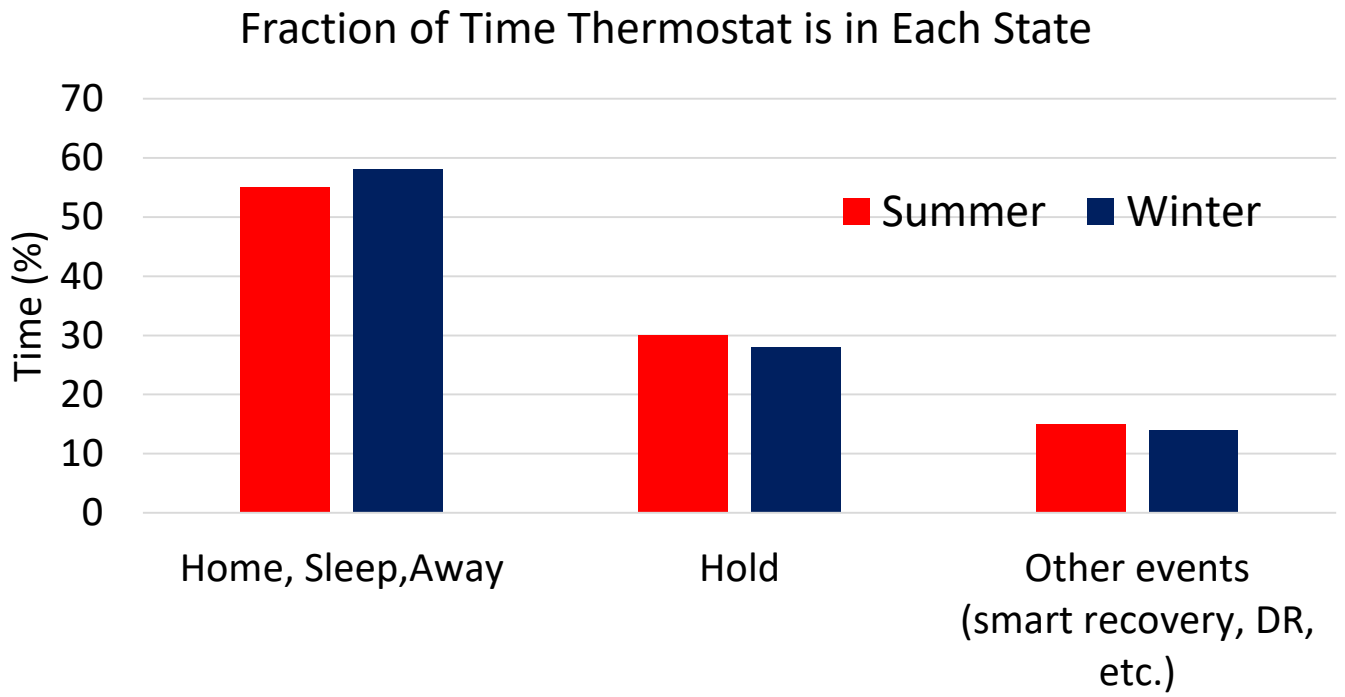
- Thermostat *states* are created to translate consumer preferences into HVAC operation
- A successful, energy-efficient thermostat combines those preferences with a thoughtful user interface, operational algorithms, and sensor inputs to operate the HVAC
- A thermostat is more likely to operate efficiently if it can characterize the most common user preferences with unique states

Mode
Home
Away
Sleep
Eco
Event
Schedule
Scene
Follow Me
Program
Prog
Activity
Hold
Override
Function
Auto
Manual
Option
DR
Config
System
Smart Home
Smart Away

Thermostats are in *Hold* ~30% of the time

- *Hold* and *Sleep* times are roughly equal
- This is probably not the most efficient operation
- Are these thermostats capturing user preferences or are energy savings “left on the table”?

Hypothesis: A lower %*Hold* time implies more efficient operation



Data from a couple hundred thermostats

Question:

In a large, diverse population, will homes with a lower fraction of time in *Hold* use less energy than those with a higher fraction?

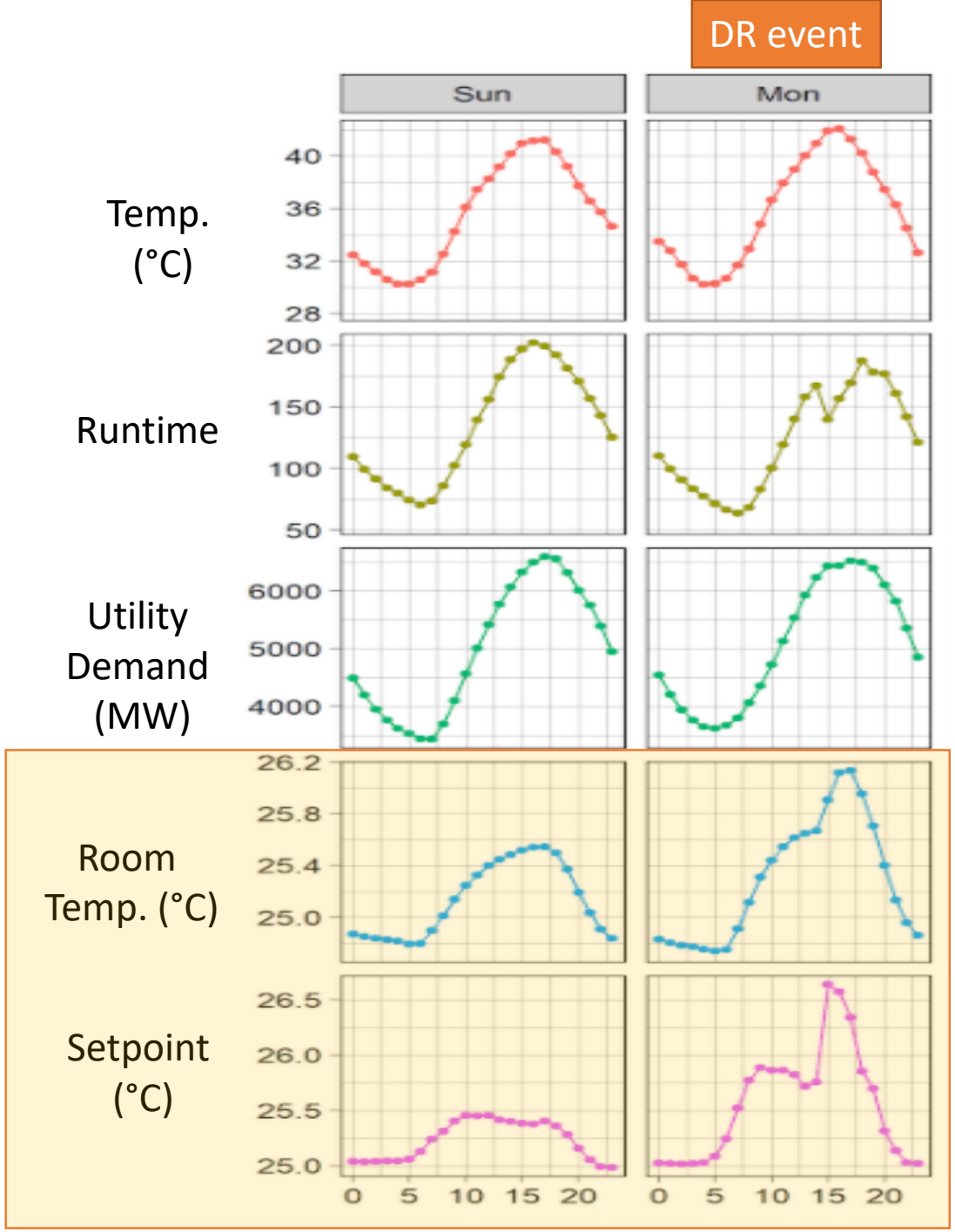
Question:

Do your thermostats have an explicit *Hold* function?

What do users do if there's no *Hold* option?

The Demand Response State

- An increasing number of thermostats participate in DR programs
- Setpoints and indoor temperatures rise during summer DR events
- Should these temperatures be included in calculations of EPA Comfort Temperatures (and, ultimately, the metric)?



Question:

Should EPA include temperatures during DR events in the calculation of comfort temperatures?

Discussion: Thermostat States

- Re first poll: Braeburn and Google don't have a way to answer this question.
  - The gist of what we're trying to do is to see if vendors have a way to nudge users to use them to achieve savings.
  - System defaults to programming, but user can make a supplemental positive choice to use something else (occupancy). Default program is "morning, day, evening, night". "Home awake, home asleep, away" only to pertain when the user has chosen to use occupancy-based control.
  - Resideo uses "home, sleep, away" for both occ and traditional schedule-based control.
  - Does IP come into why different vendors use different control strategies?
  - What mode the system is in may not be recorded in the thermostat data file.

Discussion: Thermostat States

- Second poll: 64% in favor of standardizing, 36% opposed. Anyone want to elaborate?
- Might want to standardize to help users understand; and easier for programs to teach users
- But innovation happens in places outside the standard set of states. Possibly less relevant for HVAC status
- If the states are used to match user preferences to HVAC operation, and standardizing does it better, do we save energy while keeping people comfortable.
- One vendor mentions expressed that standards usually aren't helpful for users, and wouldn't lead to more energy savings
- Having a standard would be helpful for aggregators and maybe for HEMS vendors as well. Currently, vendors have to interpret their states to interact with Alexa, for instance.
- So integration is happening without standards
- Isn't that the spirit of CHIP and the connected home IP process? Maybe.
- Note that occupancy is more complicated than home, away, asleep. Who is home? In which part of house?
- Also, asleep isn't always the same for every device, some would want lag or lead time – example, turn heat down 30 min before bed, turn light off when or after you go to bed.
- Also depends on variety of capability of HVAC products, and the control system capability itself – e.g. preconditioning.

Discussion: Thermostat States

Hypothesis: A lower %*Hold* time implies more efficient operation

- Colorado pilot looking at difference between vendors in hold time and correlate to energy savings.

  https://www.xcelenergy.com/staticfiles/xe-responsive/Company/Rates%20&%20Regulations/Regulatory%20Filings/CO-Smart-Thermostat-Pilot-Evaluation.PDF

  - Would it depend on population – Resideo sees less hold time for populations that participate in DR/EE programs than the general population that just had a contractor install the thermostat.

Poll #3

- Note that types of equipment may effect this too
- Old study found average setpoint for homes on hold for long periods of time was the same as for those on a schedule (not smart thermostats)

  https://slipstreaminc.org/sites/default/files/documents/publications/becc-whitepaper-october-2015-v3.pdf

Discussion: Thermostat States

Poll #5 DR Events, temperature included: 38% Yes, include; 63% No, do not include

- Could apply to both run time and temperature
- But would you be able to exclude them? Vendor may not know
- How many DR events are being called anyway? Traditional utility 10-20 per season (3 hours at a time), a few do every day
- Only matters to comfort temp if it's > 10% of the hours (or may push a more moderate temperature to the 10^{th}/90^{th} percentile
- Are there vendors with a good chunk of their population of users participating in DR programs
- Ecobee: now easier to sign up for DR, may have seen a substantial increase lately
- One vendor confirms that they won't know if the customer, app, 3^{rd} party DR changed the setpoint
- Illinois re-ran E* score and looked at changing comfort temp from 10^{th} to 20^{th} percentile and it made 2.7% metric score difference on scores of about 15%.