



# **ENERGY STAR Connected Thermostats**

## **CT Metrics Stakeholder Meeting Slides**

August 10, 2020



## Attendees

Abigail Daken, EPA

Abhishek Jathar, ICF for EPA

Alan Meier, LBNL

Leo Rainer, LBNL

Nick Turman-Bryant, ICF for EPA

Eric Floehr, Intellovations

Craig Maloney, Intellovations

Michael Blasnik, Google/Nest

Kevin Trinh, Ecobee

Joel Jacob, Ecobee

Jing Li, Carrier

Jason Thomas, Carrier

Frank David, Carrier

Brian Rigg, JCI

Theresa Gillette, JCI

Rohit Udavant, 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

John Hughes, Trane

Jeff Stewart, Trane

Mike Caneja, Bosch

Sarathy Palaykar, Bosch

Brenda Ryan, UL

Mike Clapper, UL

Alex Boesenberg, NEMA

Ethan Goldman

Jon Koler, Apex Analytics

Michael Siemann, Resideo

Aniruddh Roy, Goodman/Daikin

Jia Tao, Daikin

Dan Baldewicz, Energy Solutions  
for CA IOUs

Cassidee Kido, Energy Solutions  
for CA IOUs

Dave Winningham, Lennox

Dan Poplawski, Braeburn

Natasha Reid, Mysa

Peter Gifford, Mysa

Vrushali Mendon, Resource  
Refocus



## Agenda

- Follow up on metric topics from June
  - Occupancy states detection
- Software updates
  - Weather station data
  - ZCTAs
- Metrics for Variable Capacity Systems
- Results from July resubmission



## Information on Holds

### Background

- Most homes appear to rely on Hold for a large percentage of operating time
- Vendors implement Hold in different ways

Q1: Can we agree on a definition of Hold?

### Parameters of Hold and their impact on metric

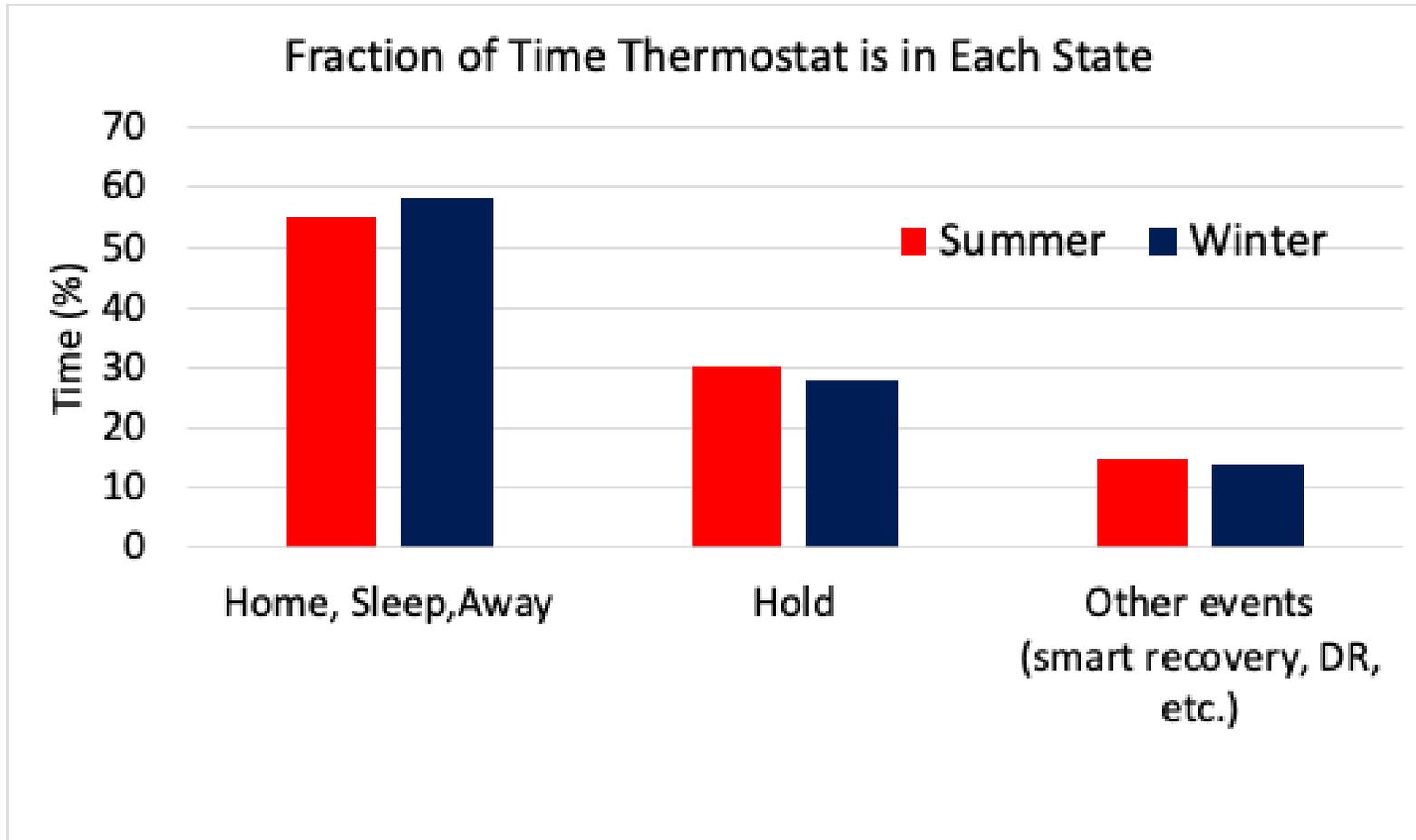
- Existence of Hold
- Elapsed time
- Frequency

Q2: How do Holds affect energy use?

Q3: How do Holds affect the metric? Does this fully capture the effect on energy use?



## Many homes use Hold a significant fraction of time





## Discussion: Holds

- Q1: Definition of “hold” Proposed def: “All scheduled operations are suspended for the period in which the hold takes place, and the temperature set point is not changed.”
  - Add that automations are suspended as well
  - What about demand response? Could be an example of an automation; could be treated differently. Also potentially time of use adjustment.
  - Posit: Demand response is treated differently during holds than other temperature adjustments. No disagreement.
  - What does the automations part means? Narrowly: set point stays where it is (except for demand response) until the hold is canceled. Note that some automations do run, those that don't affect set point.
  - What about 3<sup>rd</sup> party services that alter set points? Some 3<sup>rd</sup> party services operate through a series of short holds, though from the residents' perspectives the set points are changing too, and energy savings may be happening. Not really distinguishable from a customer leaving the t'stat on hold and changing the temp, though that's less likely to be saving energy.
  - Holds can affect accessories and fan speeds, for instance. Do we want to include those?



## Discussion: Holds

- Do not allow holds to control the ventilation system for the thermostat that has that control
  - Note for long terms absence, reducing ventilation to save energy may make sense
- Opened up a can of worms, but at first order: “Set point remains constant (with the exception of adjustments for DR) until the hold is cancelled.”
- Categories/types of holds:
  - “good hold”: long term energy saving set point, as in for vacation (note can be exploited to make a “bad long-term hold”)
  - Some have separate permanent hold (presumably for comfort) and a more efficient vacation hold
  - “bad long-term hold”:
  - “short term hold”: more or less efficient, the impacts are nominal
  - Characterize based on being above (cooling) or below (heating) the comfort temp
  - Small percentage of users control thermostats by using system modes (cool, off, heat) rather than setting a temperature. Old style stats it’s a slider switch; ecobee got complains about having the toggle a menu level down.



## Discussion: Holds

- Q2: How do holds affect energy use? (Anecdotes or other information)
  - Differentiate between 2 different types of hold: eco/away are held forever and save energy. Hundreds of hours a year. Bad hold: override schedule with single setpoint which is less efficient.
  - Is there any way to generalize whether holds are leading to higher or lower energy use? Are people using holds because they don't know how to use some of the energy saving features in the thermostat
  - Back in the day, holds were almost always associated with higher energy use, because use for comfort temp was more common than for vacation. Anyone think this isn't still true? Nope.
  - Vendors can check this, by looking at the impact of the manual hold relative to letting schedules run. You can do that for vacation too. Compare comfort and average temp in both cases to check metric effect.
  - Compare hold to a non-setback thermostat, as opposed to a setback thermostat for which a substantial percentage don't set back. Does that percentage change for a smart thermostat.



## Discussion: Holds

- Q3: How do holds affect the metric? Does this fully capture the effect on energy use?
  - A thermostat on long term hold all the time will have a metric score of zero.
  - Splitting data for 'on hold' and 'not on hold' would help, because the hold temp will affect the comfort temp. If it's a good temp then you would save. Given that we're looking at the 10<sup>th</sup> and 90<sup>th</sup> percentile, we could use a smaller % of time (2.5%?) we would see an effect.



## Software Updates - Weather Station Selection

- ZIP Code Tabulation Areas (ZCTAs)
  - Now only using ZCTAs for locating weather stations
  - ZIP Codes are still supported, but will be translated to ZCTAs
  - Best results are with using ZCTAs rather than relying on code to translate ZIP to ZCTA
- Weather Stations
  - Updated algorithm to discount low-quality weather stations from consideration.
    - Low-quality is defined as any month in the last five years having less than 50% of data
  - Extended maximum weather station distance from 50km to 100km
  - New algorithm will improve chances of finding a weather station with good data



## Equipment Terminology

- Fixed
  - Fixed speed
  - Fixed capacity
  - Single speed
  - Single capacity
  - Single stage
- Variable
  - Variable speed
  - Variable capacity
  - Modulating
- Multiple
  - Two speed
  - Two stage
  - Dual stage
  - Dual capacity
  - Multi speed
  - Multi-stage

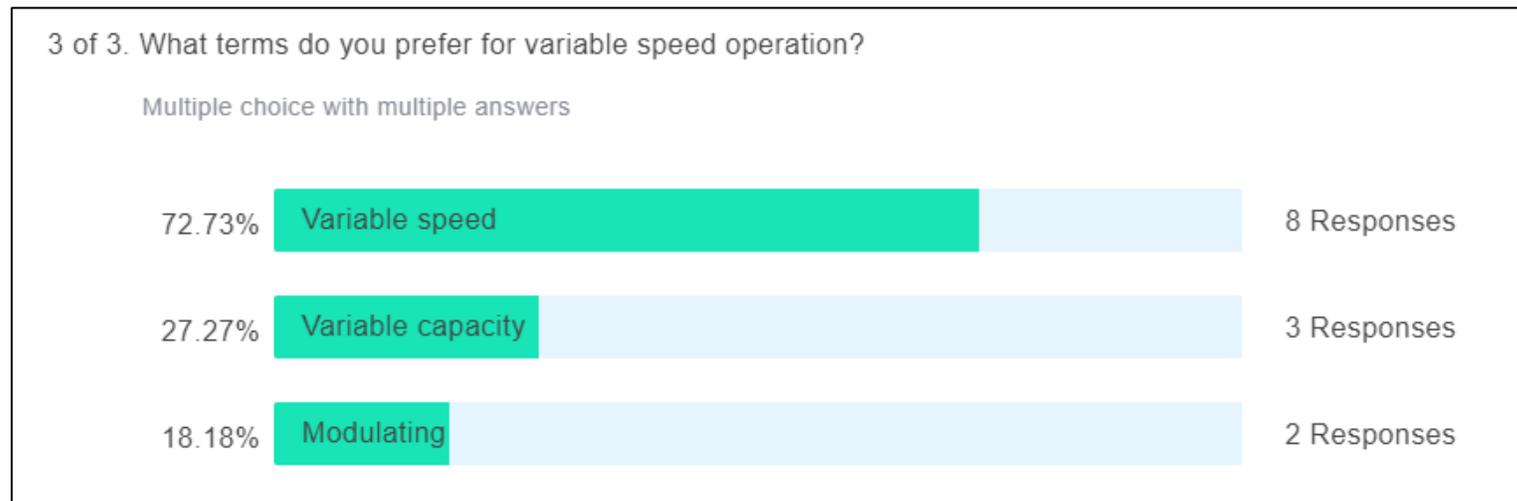
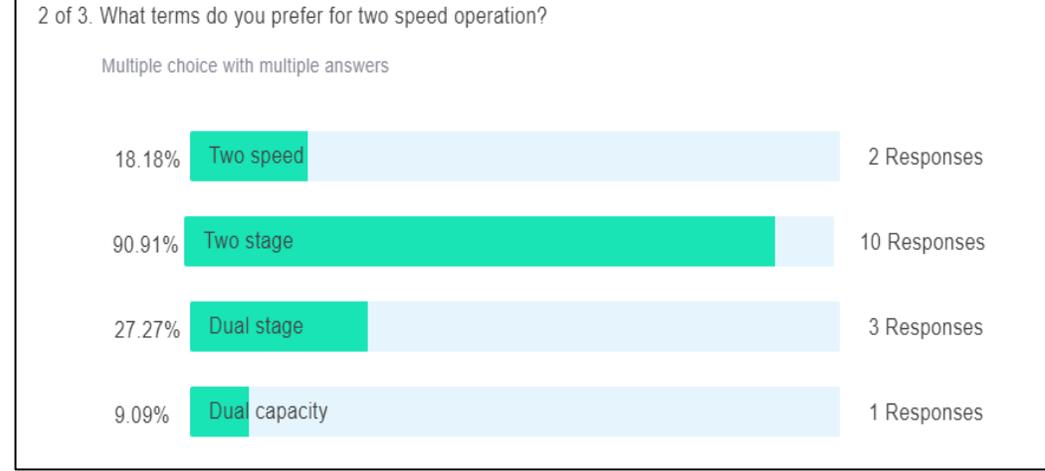
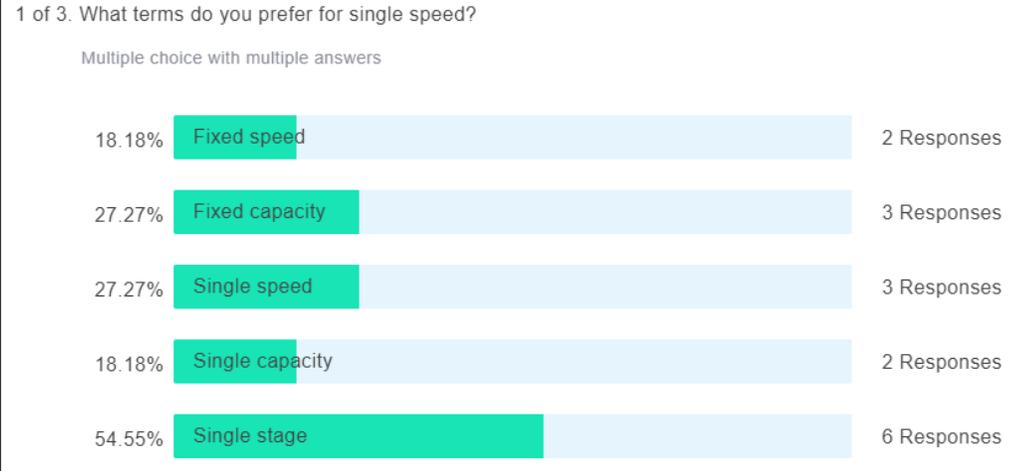


## Discussion: Software Updates

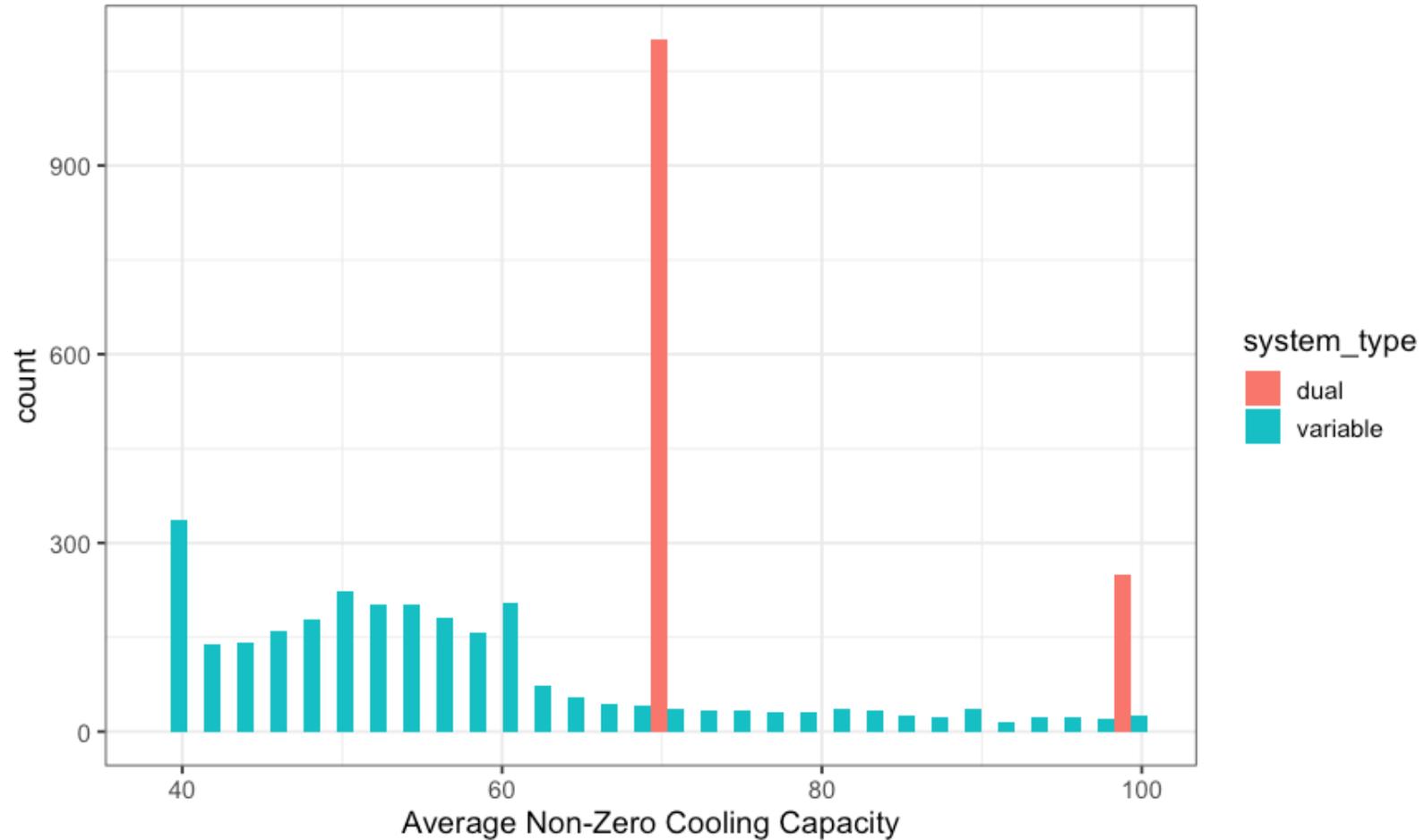
- Is there any documentation about how we're coming to these decisions? So that we can study and comment for next time? Not now, but we'll make some.
- Equipment type terminology polls
  - Fixed capacity: Mostly "single-stage", fairly even for the others.
  - Two Capacities: 91% two stage, 27% dual stage, smaller for others
  - More than two capacities: variable speed 73%, variable capacity
  - DOE (CAC/HP) test procedure uses single speed, dual capacity, and variable speed
  - At least one stakeholder was answering just for CAC/HP; not generally true



## Poll Results

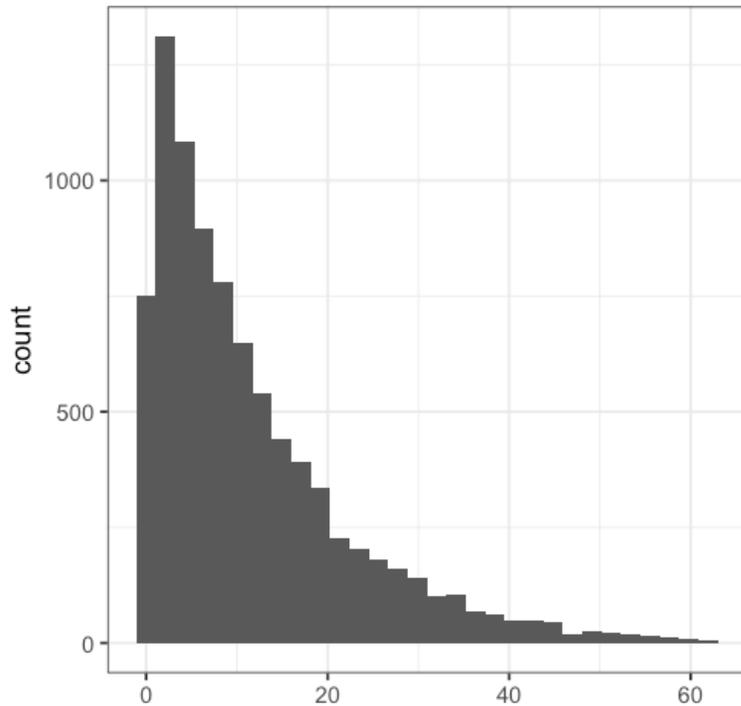


## Questions related to measuring the performance of variable capacity systems

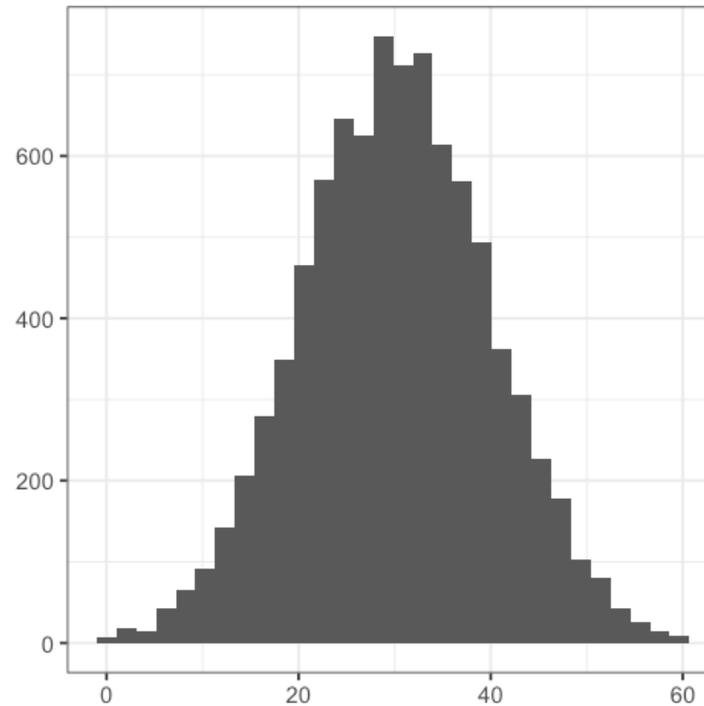


## Which of these three histograms do you think would more likely characterize a variable capacity system's distribution of hourly runtimes?

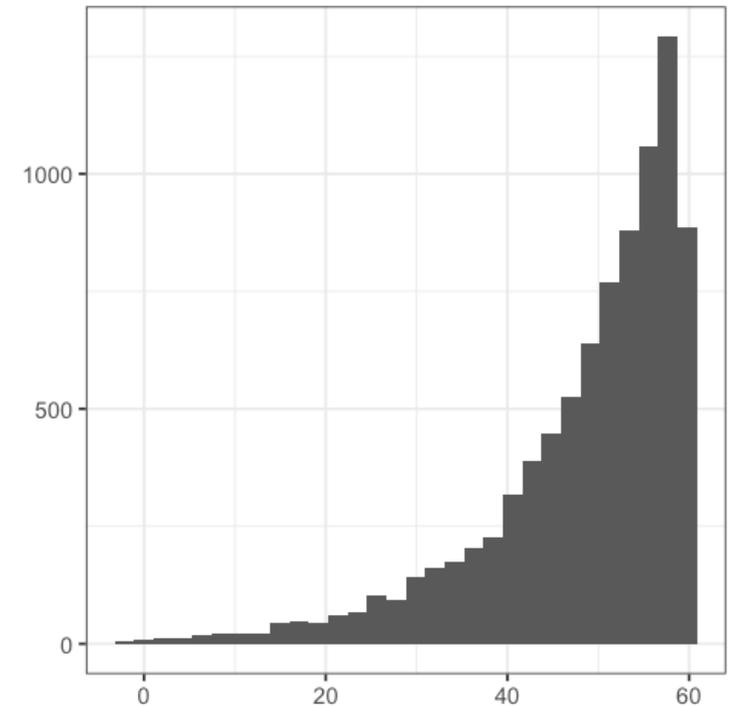
A



B



C



Total Minutes Per Hour When Cooling Capacity is Non-Zero



## Under what conditions would we expect a variable capacity system to run at a steady state?

- If we define Delta-T as the difference between the indoor and outdoor temperatures:
  - We would expect the system to run for long periods at high capacity when Delta-T is greatest
  - We would expect the system to be cycling on an off at low capacity when Delta-T is lowest
  - **How would you quantifiably characterize the middle range when a variable capacity system's efficiency advantage is greatest** (when it can run at a steady state at a lower capacity instead of short cycling)?
  - What Delta-T / capacity-call combinations should we subset from the data to compare relative runtimes or capacity levels (e.g., capacity calls ranging from 0 to 70 with 25<sup>th</sup> to 75<sup>th</sup> percentiles of Delta-T?)



## Do we think it is possible to detect short cycling with data on an hourly time resolution?

- For example, if we have data that gives us the total runtime in minutes and the average cooling demand for that hour, how would we distinguish between a system that has short-cycled 3 times for 30 minutes and a system that ran for 30 minutes at a steady state?
- What would we need to know in order to detect short-cycling?



## Discussion: Variable capacity systems

- What distribution of run times would you expect, particularly compared to a single or dual stage system?
  - Sizing effects this
  - Ecobee: would expect to see something more like C – equipment able to operate at a lower capacity for longer times. Resideo agrees.
- If we saw a distribution more like A, what might account for that?
  - Lubliner: anecdotally, as the HVAC tech embraces variable capacity, gap in skills among installers may contribute. Poorly sized zones or poorly balanced between zones might have this effect.
  - Trane: sizing would definitely effect this. Would expect even for variable capacity that there would be two modes: If load of structure is below min capacity of system, it'll cycle at the minimum capacity like a single stage system. Over the course of the day, as the load increases, you should see a distribution more like C.
  - Daikin: for residential use, the systems aren't a lot more complicated than fixed capacity. Expect C to best represent the distribution of minutes of run time in an hour.

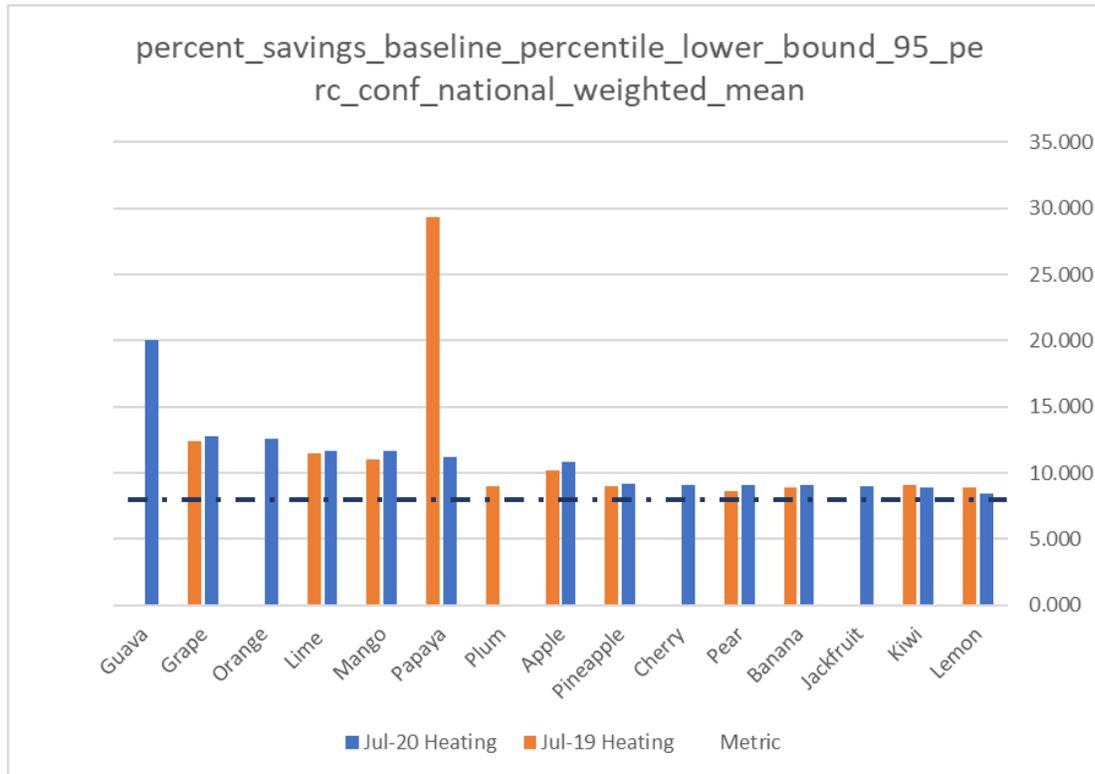


## Discussion: Variable capacity systems

- How to ID times we would expect long run times?
  - Daikin: need to consider home properties as well. For a modern low load home, outdoor temperature may have relatively little influence.
  - Nest: Also depends on how people operate their homes. If you come home and try to recover from setback, you may need full capacity no matter what the outside temperature is. Daikin: in some places, may make energy + comfort sense NOT to set back.
  - More helpful to talk about it by the balance point rather than outside temp.
  - Humidity also is a major issue; and may affect how much run time is needed.
  - Energy Solutions: Long operation at low capacity should have a unique signature, so that could potentially be removed from the data. Could isolate shoulder seasons and compare to summer seasons.



## July 2020 Submission



- 14 datasets received with 5 RHU2 datasets
- Quarantine effects not very evident in the submissions
- All vendors above certification threshold, not likely to be true in February 2021; will not affect certification
- Working with vendors to understand anomalous results.

Type	Metrics	Average -Jul 2019	Average -Jul 2020
Heating	percent_savings_baseline_percentile_q20_national_weighted_mean	7.71	7.10
Cooling	percent_savings_baseline_percentile_q20_national_weighted_mean	9.46	8.60
Heating	percent_savings_baseline_percentile_lower_bound_95_perc_conf_national_weighted_mean	11.65	10.97
Cooling	percent_savings_baseline_percentile_lower_bound_95_perc_conf_national_weighted_mean	14.91	13.90



## Discussion: Resubmission data

- Nest: 75% decline in time spent in occupancy-based away modes, reduced now to more like 50% reduction. Geographic changes by state. Nest customers started saying home before the government told them to. Urban vs rural: urban folks changed their behavior more but were absent more to begin with.
- Nest: connected smoke and CO detectors show that people are cooking more



## New topic: ASHRAE 90.2 reach code for building

- Trying to give credit for energy savings associated with a connected thermostat over a manual setback thermostat.
- Do stakeholders want to be on the committee or advisors to the committee?
- If you are interested, contact Mike