



# **ENERGY STAR Connected Thermostats**

## **Stakeholder Working Meeting Variable and Staged Capacity Systems in the ENERGY STAR Field Savings Metric**

June 5, 2017



## Attendees

Abigail Daken, EPA  
Dan Baldewicz, ICF International, for EPA  
Marco Pritoni, LBNL  
Michael Blasnik, Nest Labs  
Jing Li, Carrier  
Bob Peitz, Carrier  
Karl Mutchnik, IRCO  
Ray Rite, IRCO  
Claire Miziolek, NEEP  
Brian Rigg, JCI  
Theresa Gillette, JCI



## Agenda

- Review of March 2017 discussion
  - Consensus items – check for changes
  - Open questions
  - Proposals brought up
- In depth discussion of variable and staged capacity systems



## Metric improvements meta-questions

- Two meta-questions that may be useful to ask for each of these topics came up at the February meeting
- **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?**



## March 2017 metrics meeting

- Extensive discussion of staged and variable capacity systems
- Over-arching question remains, can the efficiency of the equipment be separated from the contribution of the system controller?
  - Stated in general that the control strategy that means more time in lower capacity stage will save energy
  - More difficult to distinguish equipment and controller efficiency for inherently zoned equipment?



## March 2017 metrics meeting – consensed items

- We do not need a separate way to deal with A/C and HP than furnaces and boilers
  - It was noted and agreed that the efficiency difference between heat pump compressor operation and resistance heat is far larger than between capacity stages
- Can't count on thermostats knowing the relative capacity or actual energy use of variable capacity equipment
  - For two stage A/C, heat pumps and furnaces, a default relative capacity would probably work. Not relevant for boilers.
- 2 & 3 stage systems correct sizing; 5 stage & variable capacity systems follow load.
- For purposes of a metric, do not need to know absolute power draw, just relative draw of the stages



## Consensed Items Discussion

- Any disagreement? One question: what about difference in outside conditions? Maintaining a set point during the day may save energy b/c more run time happens when it is cooler.
  - Ray Rite is taking an action item to estimate savings available (% energy savings)
  - Could be addressed with simulation modeling
  - Not clear will be a real effect with the outdoor temperature variation of an actual core cooling day
  - NREL report with estimate: report #TP-5500-56354 Improved Modeling of Residential Air Conditioners and Heat Pumps for Energy Calculations (2013)  
<http://www.nrel.gov/docs/fy13osti/56354.pdf>



## March 2017 metrics meeting – items discussed but not agreed to

- Disagreement about whether lower capacity actually offers higher efficiency for centrally ducted compressor systems
  - Likely we do not need to resolve this question to move forward
- Do we treat staged equipment differently than variable capacity?



## Current questions discussion

- Do we need to resolve relative efficiency of stages?
  - Not if we have actual relative power draw (estimated?); will vary from site to site
  - No one feels it is critical **CONSENSUS**
- Is relative power draw sufficient? **CONSENSUS - YES**
  - If there are two units in the house, the combined dynamics will depend on relative capacity.
  - Trying to deal with multiple systems/controllers in the home separately – keep alert to make sure that we have a way of trying to not include those homes through whatever measure we end up with for



## Do we treat staged equipment differently than variable capacity?

- 2 stage equipment is easier to address because could come up with a reasonable default of relative power draw
- If we could do that for other systems, we could build a metric
- Even with proprietary system controllers, it seemed from March discussion that we couldn't count on knowing the relative power draw for each minute of run time. We \*could\* make it a requirement – w/in reach if available on the inverter, for newly designed products but maybe not for existing products. Would need to agree on how to define relative power (e.g. conditions)



## Do we treat staged equipment differently than variable capacity?

- (Communicating controller means digital comms between controller and controlled equipment)
- Of new systems, what proportion are communicating?
  - Many systems are designed to work with either type of controller, but ultimately better than 50% for variable and 5 stage
  - Overall, low percentage – single digit perhaps, and variable by manufacturer
  - Ask AHRI for industry wide numbers
  - This is as designed, not sales – no guarantee that sales of communicating HVAC and communicating controllers are going to the same installations



## Do we treat staged equipment differently than variable capacity?

- Two stage equipment idea:
  - Assume default relative stage capacity unless installer inputs different info
  - Base weighting of run time on relative capacity
- Could we do something similar for 3 stage?
  - Idea: survey 3-stage equipment and see how consistent stage sizing is across products and manufacturers
  - 3 stage may be rare
  - **Action item: EPA can do research project**



## 2 stage idea

- Can come up with daily run time as a weighted sum of run time in each stage
- Using that in the metric would successfully capture savings from a more conserving schedule, but would not capture savings from avoiding use of higher stage
- How to capture savings from avoiding higher stages?
  - Alternative baseline – how stages would have been controlled. More sophisticated statistical analysis might show
  - What would happen if we modeled the two stages separately?
  - Probably could model what run time would be if you only had the high capacity stages
  - Brings us right back to the question of whether lower capacity stages are indeed more efficient.
  - If the two stages are the same efficiency, do you actually get savings from encouraging use of the lower capacity stage?
  - Gas furnaces and compressor driven systems are different here, though the lower stage on a furnace has significantly lower electrical draw as long as it has ECM motor.
- Would it be useful and interesting to pursue capturing t'stat settings savings through this proposed 2 stage approach? Generally, **YES, with caveat that still concerned about relative efficiency. Also recommend looking at relative run time in each stage, to look for stark differences.**
- **Action item – Michael will do a surface scan for references around the delivered efficiency of stages and share with group.**



## 2 stage idea

- To pursue this plan, we need default number for relative capacity of the two stages.
  - Michael: Stage 1 is 70% of total capacity for air conditioners/HPs and 65% of total capacity for gas furnaces (this is informal and old).
  - NREL report used default of 72% capacity for 2<sup>nd</sup> stage capacity for AC and HP
  - Action item – Abi will ask AHRI if they want to contribute a better answer
- Who would be willing to help test software and see what answers we get?
  - Michael will take a look at doing this with the current software
  - Ray will also give a shot at evaluating the software when it exists.
- Who would be willing to just produce a few plots of 1<sup>st</sup> and 2<sup>nd</sup> stage run time vs. indoor-outdoor temperature difference for various homes?
  - Michael will look into it
  - Jing will look into it as well
- Action item – Abi will see if AHRI has indeed developed, and is willing to share, a generalized relationship between demand and energy use for inverter-driven systems



## How often should we meet?

- When will people be ready to report on actions?
  - 2 weeks is too soon
  - 4 weeks – 4<sup>th</sup> of July? Later that week or early the following.



## Review of action items

- Abi/Dan:
  - send Doodle for meeting time end of week of July 3, or early following week
  - Start looking at three stage systems, try to come up with relative capacity of stages
- Abi:
  - AHRI: We plan to use a default relative capacity for low stage of 72% for AC and HP, 65% for furnaces. Please let us know if you have better estimates.
  - Check for existence of general relationship between cooling and/or heating demand and energy use for ductless systems
- Michael:
  - Surface scan for references on the relative efficiency of stages for staged equipment
  - Try using weighted run time with 2 stage systems with the current software, and also look at relative run time in each stage (do we need to break this down by demand bins or anything?)
  - Try plotting stage 1 and stage 2 run time of 2 stage systems against demand ( $\Delta T$ )
- Jing:
  - Try plotting stage 1 and stage 2 run time of 2 stage systems against demand ( $\Delta T$ )
- Ray:
  - Work with EPA to use weighted run time on 2 stage systems with current software, and look at relative run time in each stage (with Dan's assistance)