



ENERGY STAR Connected Thermostats

Stakeholder Working Meeting

September 26, 2019



Attendees

Abigail Daken, EPA

Dan Cronin, EPA

Dan Baldewicz, ICF for EPA

Alan Meier, LBNL

Leo Rainer, LBNL

Eric Floehr, Intellovations

Craig Maloney, Intellovations

Michael Blasnik, Google/Nest

Jing Li, Carrier

Tai Tran, Carrier

Brian Rigg, 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

Ari Mytelka, Energy Solutions

Dan Fredman, VEIC

Rober Weber, BPA

Phillip Kelsven, BPA

Casey Klock, AprilAire

Behrooz Karimi, IRCO/Trane

Ulysses Grundler, IRCO/Trane

Jeff Stewart, IRCO/Trane

Mike Caneja, Bosch

Brenda Ryan, UL

Mike Clapper, UL

Alex Boesenberg, NEMA

Ethan Goldman, Recurve



How do we regard the current metric?

- Last meeting we discussed several new metrics (as well as the RHU results)
 - General agreement that we need to do something about resistance heat, and constructive ideas as to how
 - Most had little to say about additional metrics
- Today, taking a step back to WHY we might seek additional metrics
- Sent questions ahead of time for you to think about and discuss internally
- Our end goal is to help guide consumers towards energy saving, and to encourage innovative solutions, or at least avoid discouraging them



Poll 1: Current metric fairness/accuracy

- For most products, EPA associates an efficiency metric with each model, in order to give consumers the best information possible, but we accepted that we needn't do that for Version 1 of the CT specification.
- Begs the question: Could EPA publish current metric scores? Do the products with the highest metric scores save the most energy?
- **Poll: Do you think the current metric accurately reflects energy savings from your connected thermostats?**
- Poll results: 57% responding; 63% yes, 38% no (rounding error)
- Discussion
 - Would appreciate seeing metric scores by thermostat make/model for evaluators/programs. One study (IEPEC 2019 compared metric scores to metered savings in individual homes); not great correlation.
 - In absence of more information, have to say no. Cycle time by itself not closely correlated with energy savings. Plus ENERGY STAR metric likely to be not perfect measure of run time reduction.

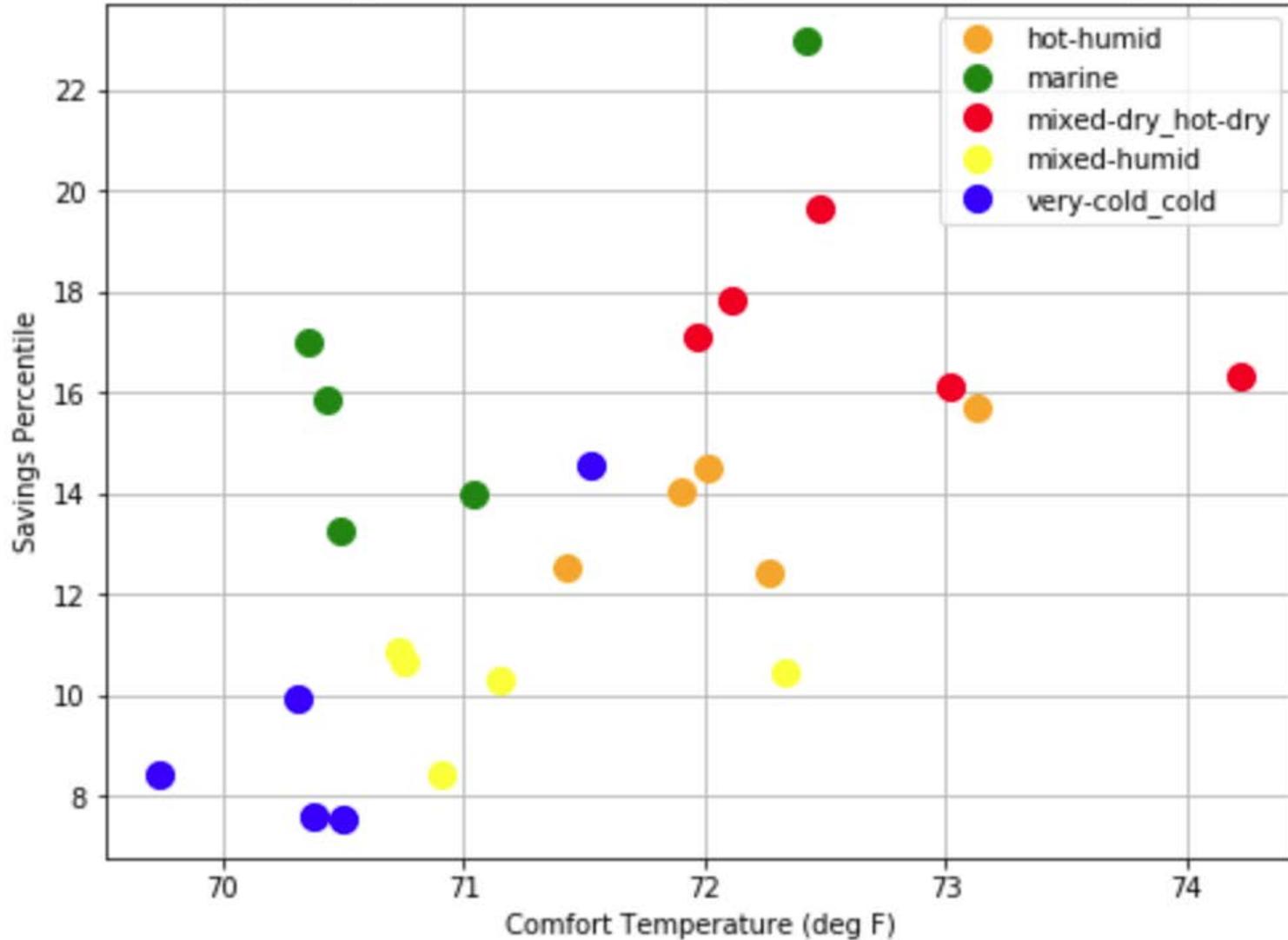


Discussion

- Would never expect correlation from a single home – need a group of homes for any meaningful correlations
- If I was going to rank products by their score, I'd want to know what the average temperature and average comfort temperature was too, because it will show how much opportunity there is in that population of homes.
- SEER for air conditioners is really just a relative measure, not giving absolute savings. However, for a given home, a higher SEER AC will generally use less energy than a lower SEER A/C
- Within a region, is there correlation between comfort temperature and savings?
 - Heating, hard to say: even in very cold/cold just one point that implies correlation
 - Cooling: mix dry/hot dry does seem to show a correlation
- For a given home there's no doubt of the effect; can be seen with natural experiments
- Recast question: Does the current metric rank products accurately? (Yes/Yes with adjustments&additions/No/don't know) Results: 57% voting, yes 0%, yes w/adjustments: 13%, no 13%, don't know 75%

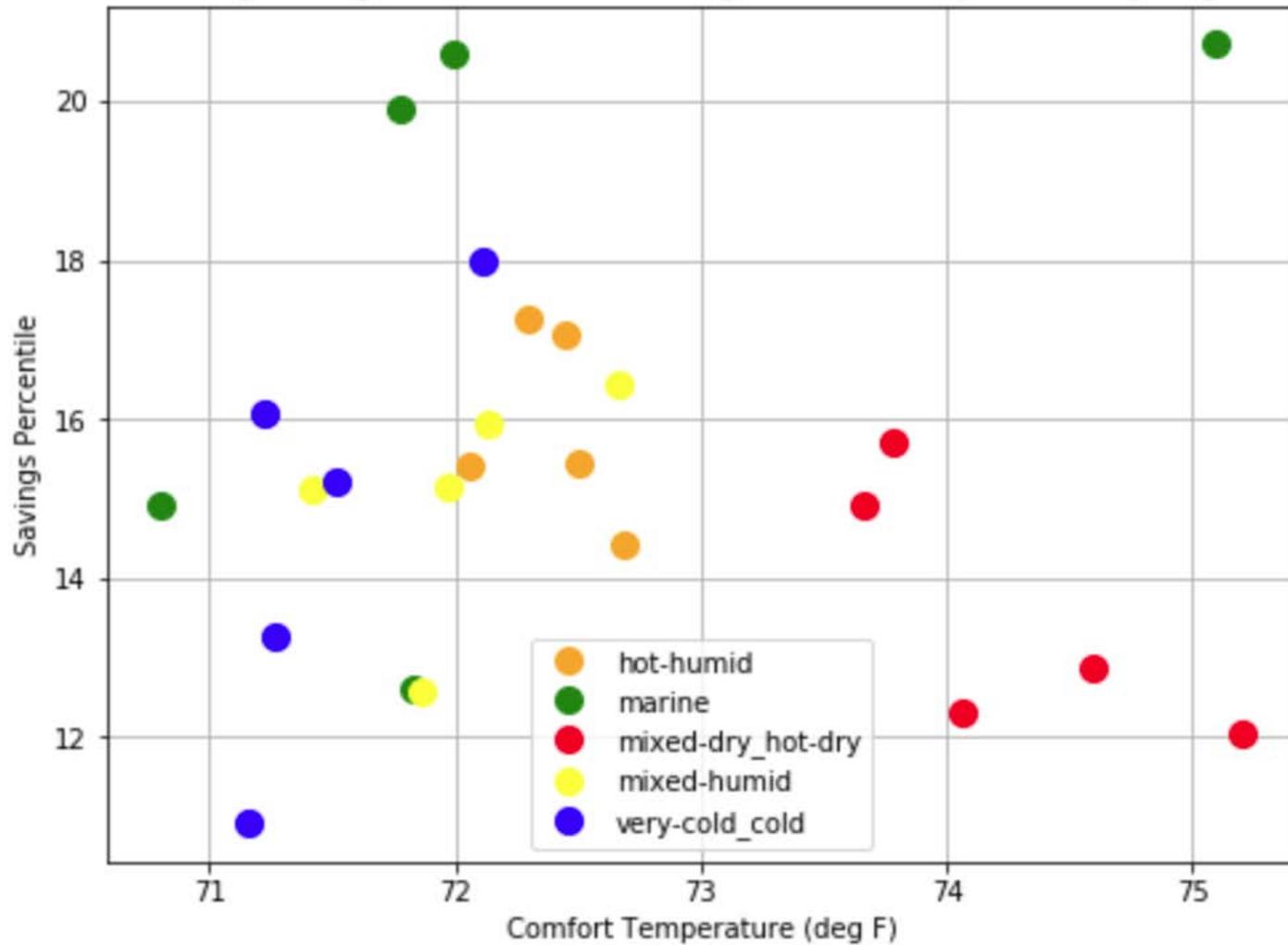


Heating Savings Percentile vs Heating Comfort Temperature by Region





Cooling Savings Percentile vs Cooling Comfort Temperature by Region





Poll 2: Unintended consequences

- We know that some strategies that do save energy actually will decrease the metric score.
- **Poll: Are you avoiding energy savings strategies because of how they will be reflected in the metric score?**
- Poll results: yes: 0%, no: 100%; 36% voting (probably all the providers on the call)
- Discussion
 - Do everything we can to enable energy savings; won't let a metric get in the way.
Goal is system efficiency



Poll 3: Limits of included installations

- In 2016 (and now), most homes have fixed capacity air conditioners and heat pumps, but we expect that to change.
- Meanwhile, there are WiFi thermostat providers that can't participate b/c their products are designed for variable capacity equipment.
- Clarifying comments/questions: can we include 2-stage at least for furnaces/boilers where there is no significant difference in efficiency between stages?
- **Poll: Thinking four years in the future, will more than 20% of your installations not be able to be analyzed under the current metric (i.e. not be single zone fixed capacity)?**
- Poll results: not enough votes to be significant
- Discussion
 - Clearly a trend in the industry, so it's a problem you'll have to solve
 - Simpler for gas furnaces or electric resistance heat, harder to do for compressor heating and cooling systems
 - 3rd party thermostats: not seeing significant trend towards multi-stage systems in heating or cooling



Discussion

- Complicating the picture: some units are wired as single stage and control their staging themselves. Assumed to be more common with 3rd party thermostats. For Nest's population of users, expect at least half of multistage equipment are wired as single. (In a retrofit situation, need to run additional wire to wire as 2-stage)
- May be just throwing out better data by not including those that are 2-stage with run time weighted by relative capacity and summed
- Suggestion to include in sample, collect data, but not (yet) include in stats calculation



Poll 4: ENERGY STAR metric and program savings

- % runtime reduction \neq deemed savings
- Others have argued it can be – EPA agrees that with realistic temperature baseline, decent lower bound
- **Poll: Do you think the current metric is as good as or better than conventional M&V techniques for establishing deemed savings?**
- Poll results: 54% voting; 0% yes, 71% yes with modifications, 29% no
- IF the current metric isn't suitable for this, should we strive to make it so?
- Discussion
 - To make it suitable, would need the metric score for the baseline condition; still have potential biases around the comfort temp, but those are smaller than the biases in the current methods
 - Mostly programs aren't concerned about the demographic differences between those who tend to buy smart thermostats and those who don't
 - If there are systematic demographic differences between the program population and those analyzed for metric score (e.g. in occupancy), that might need to be addressed



Discussion

- Bias in participation groups can be partly accounted for by using future participants
- IEPEC paper also for smart thermostat direct install in low income homes, which is a pretty homogeneous population – showed savings (New Orleans). Interestingly, households w/o WiFi saved more than those with
- Using temperature loggers only, can get a decent estimate of metric score, by calculating the comfort and average temperature (average setback) and multiplying by a factor for % savings in each climate zone. Works well enough for a baseline. Getting even more localized could work too, getting that % savings per setback from nearby smart thermostats
- Problem with accounting for savings from comfort temperatures: the differences between homes may swamp the differences between products, and in fact if the different products have even slightly different demographics of their customers, it may have a substantial effect upon savings.
- Would it be useful to have thermostats report whether its running a schedule
- RBSA shows relationship between comfort temperatures and shell characteristics
- Rate of temperature drift (during non heat/cool hours) is a decent proxy for shell

Alternative Metrics to Evaluate CT Performance (continued)

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



Some Characteristics of a Good Performance Metric

- A clear means of ranking the values (a larger value consistently means more energy savings in the field)
- A benchmark value based on external information (146 is a “good” score)
- A dimension that is easy to relate to (i.e., a temperature or an amount of savings)
- It is closely related to energy
- Strategy neutral (No bias towards a specific energy-saving strategy)
- Stock neutral (No bias towards home or equipment characteristics)
- Technology neutral (Works equally well for furnace, heat pump, variable speed, etc.)

Metric Characteristic Matrix

Metric	Clear Rank	External Benchmark	Relatable Dimension	Strategy Neutral	Equipment Neutral	Envelope Neutral	Technology Neutral	Energy Related
Percent runtime reduction (self-ref)								
Percent runtime reduction (regional)								
Trimmed Temperature (self-ref)								
Trimmed Temperature (regional)								
Delta Temperature (self-ref)								
Delta Temperature (regional)								
Savings Degree Hours (self-ref)								
Savings Degree Hours (regional)								

Trimmed Heating Temperature Metrics

$$\textit{Trimmed Heating Temperature: } \frac{\sum_i \min(T_{i; \text{CORE_HEAT}}, T_{\text{COMFORT_HEAT}})}{N_i}$$

$$\textit{Delta Heating Temperature: } \frac{\sum_i \min(T_{i; \text{CORE_HEAT}}, T_{\text{COMFORT_HEAT}})}{N_i} - T_{\text{COMFORT_HEAT}}$$

$$\textit{Savings Degree Hours: } \sum_i \left(\min(T_{i; \text{CORE_HEAT}}, T_{\text{COMFORT_HEAT}}) - T_{\text{COMFORT_HEAT}} \right)$$

Where:

i is hourly,

N_i is number of hours in core heating days; calculated as $\text{Days}_{\text{CORE_HEAT}} * 24$

$T_{i; \text{CORE_HEAT}}$ is hourly temperature on core heating days

$T_{\text{COMFORT_HEAT}}$ can be either the 90th percentile core comfort temp

or a regional baseline heating comfort temperature

Trimmed Cooling Temperature Metrics

$$\textit{Trimmed Cooling Temperature: } \frac{\sum_i \max(T_{i; \text{CORE_COOL}}, T_{\text{COMFORT_COOL}})}{N_i}$$

$$\textit{Delta Cooling Temperature: } \frac{\sum_i \max(T_{i; \text{CORE_COOL}}, T_{\text{COMFORT_COOL}})}{N_i} - T_{\text{COMFORT_COOL}}$$

$$\textit{Savings Degree Hours: } \sum_i \left(\max(T_{i; \text{CORE_COOL}}, T_{\text{COMFORT_COOL}}) - T_{\text{COMFORT_COOL}} \right)$$

Where:

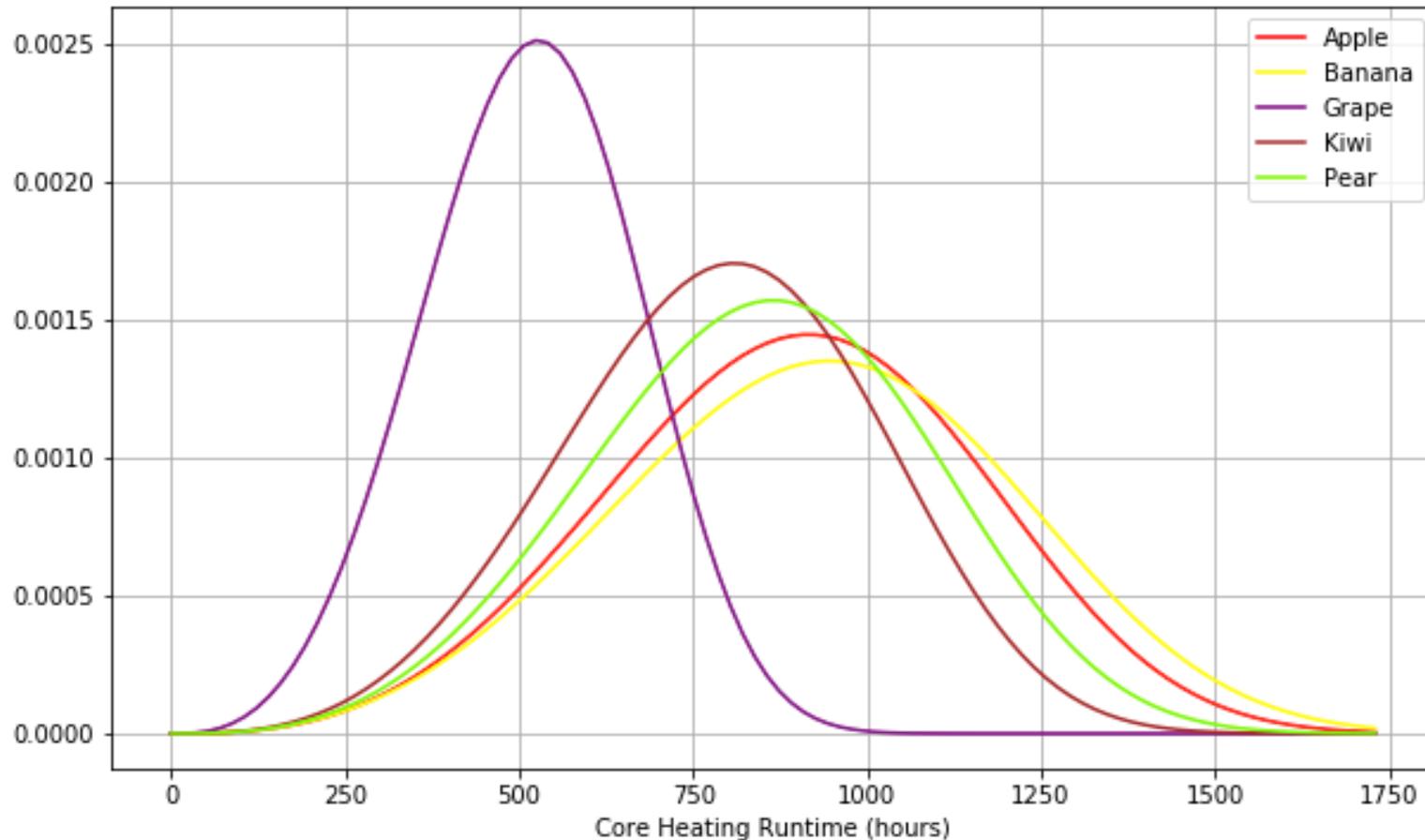
i is hourly,

N_i is number of hours in core cooling days; calculated as $\text{Days}_{\text{CORE_COOL}} * 24$

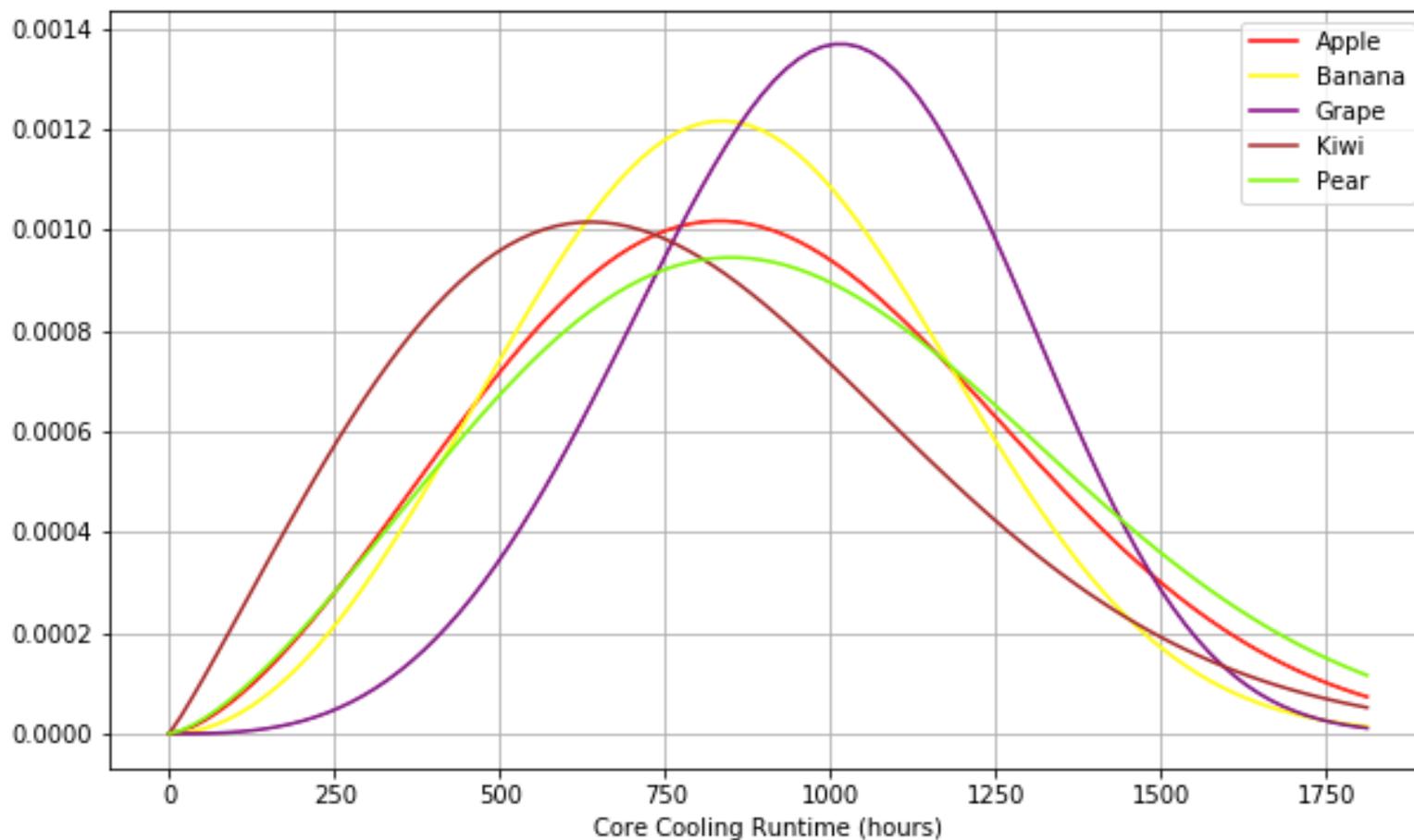
$T_{i; \text{CORE_COOL}}$ is hourly temperature on core cooling days

$T_{\text{COMFORT_COOL}}$ can be either the 10th percentile core comfort temp
or a regional baseline cooling comfort temperature

Heating Runtime Distributions in Very-Cold / Cold



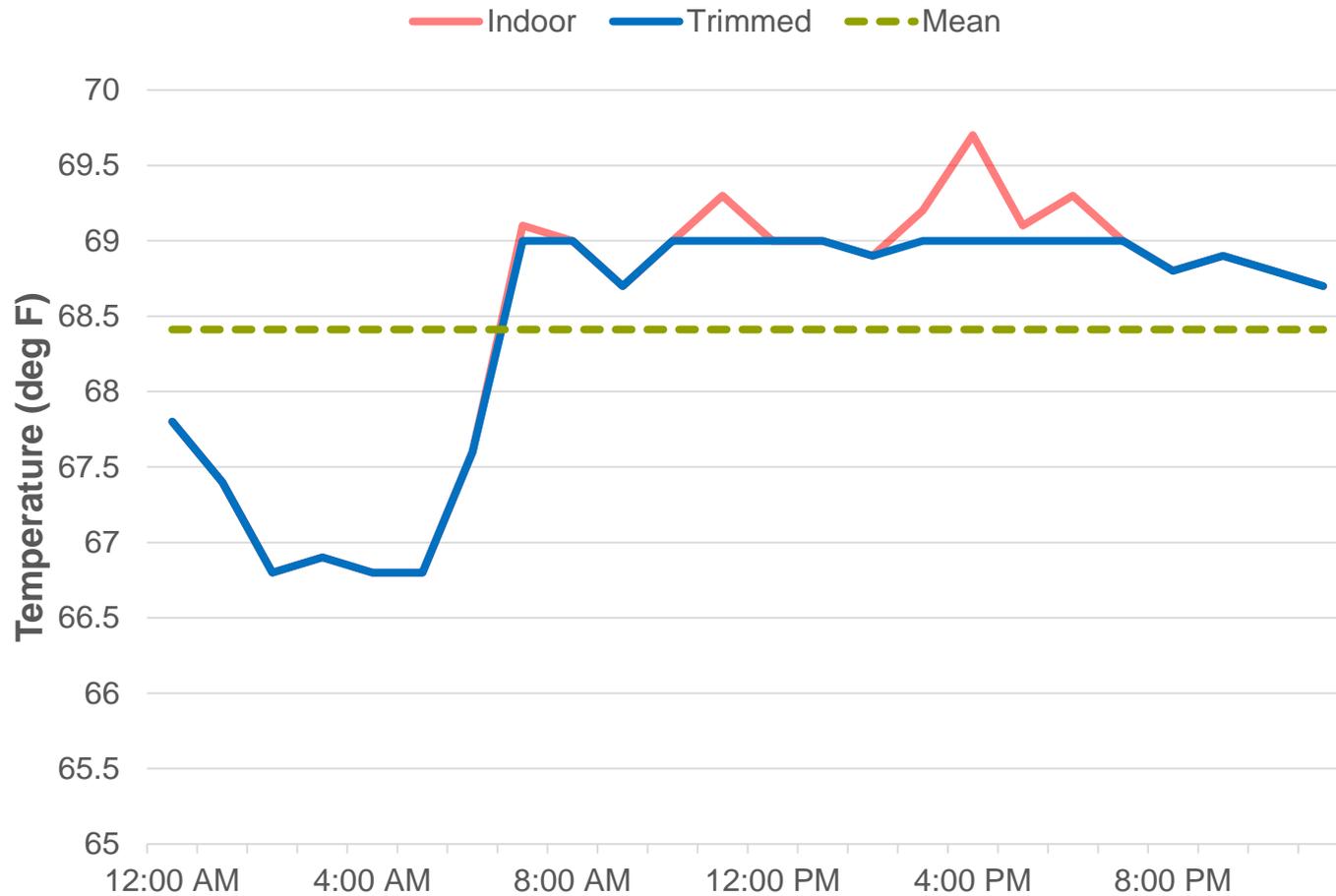
Cooling Runtime Distributions in Mixed-Dry / Hot-Dry



Backup Slides



Trimmed Mean Heating Temperature Example



Total Runtime Metrics

$$\textit{Total Heating Runtime (hours)} = \frac{\sum_D \textit{Daily}_{HEAT_RT} + \sum_i \textit{Hourly}_{EMERGENCY_HEAT_RT}}{60}$$

$$\textit{Total Cooling Runtime (hours)} = \frac{\sum_D \textit{Daily}_{COOL_RT}}{60}$$

Where:

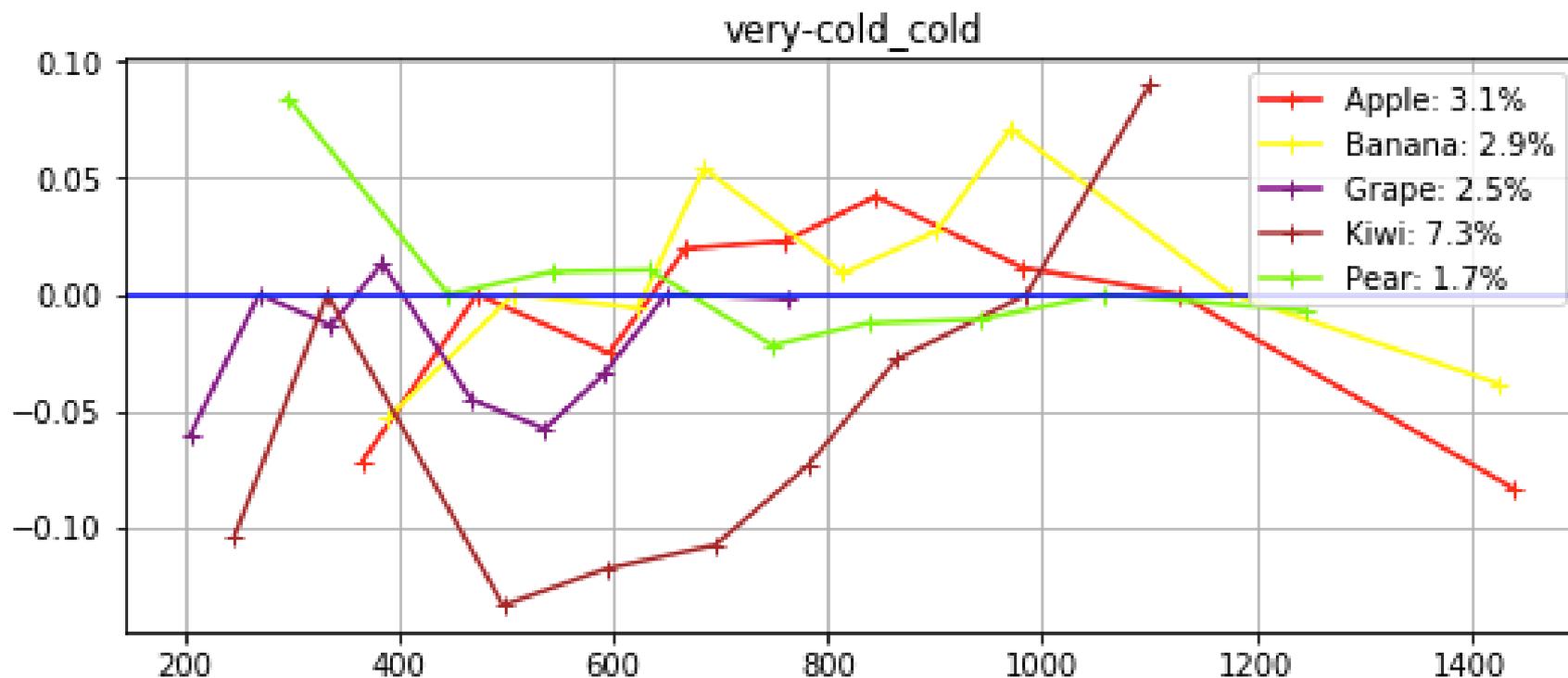
i is hourly; *D* is daily

*Daily*_{HEAT_RT} is the daily heating runtime for the thermostat in minutes

*Daily*_{COOL_RT} is the daily cooling runtime for the thermostat in minutes

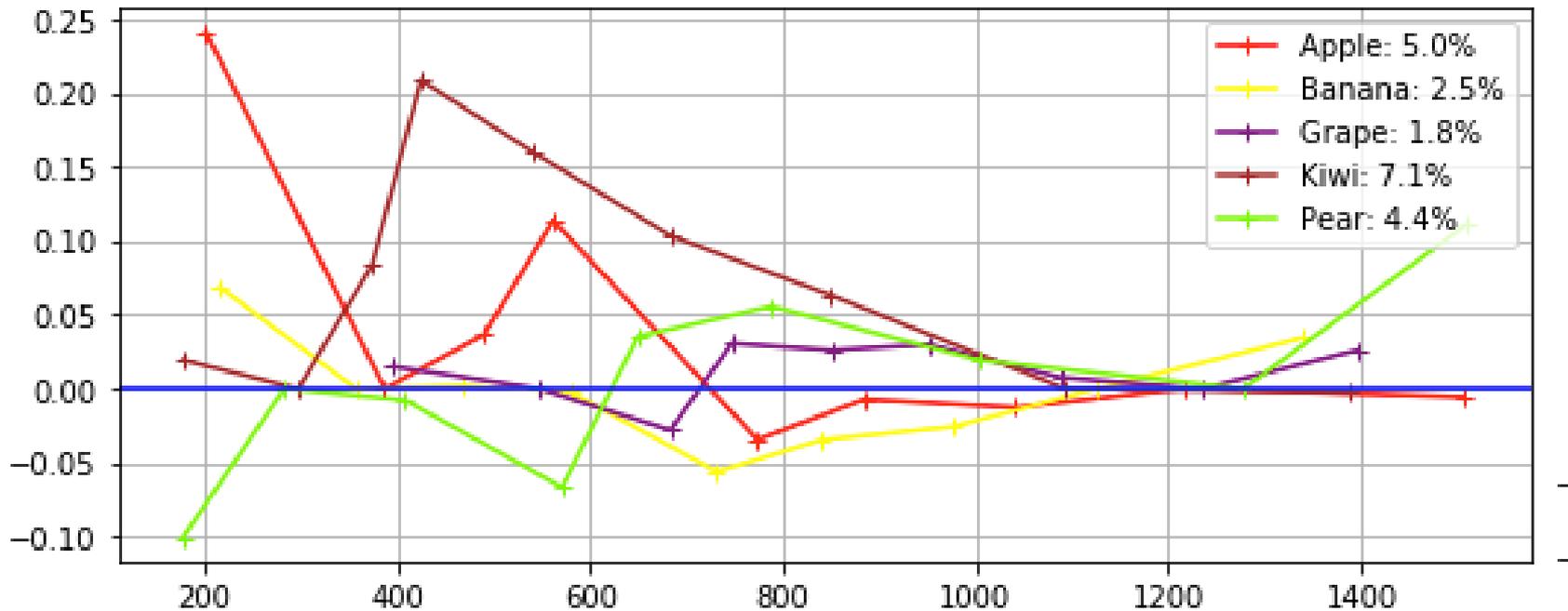
*Hourly*_{EMERGENCY_HEAT_RT} is the hourly emergency heat runtime in minutes (heat pumps only)

Heating Runtime Weibull Distribution Error



Cooling Runtime Weibull Distribution Error

mixed-dry_hot-dry





Backup Slides