ENERGY STAR Connected Thermostats

Stakeholder Working Meeting

April 26, 2019

Attendees

Abigail Daken, EPA
Dan Baldewicz, ICF for EPA
Alan Meier, LBNL
Leo Rainer, LBNL
Michael Blasnik, Google/Nest
Jing Li, Carrier
Tai Tran, Carrier
Brian Rigg, JCI
Kurt Mease, LUX (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
Ed Pike, Energy Solutions for CA IOUs
Nick Lange, VEIC
Dan Fredman, VEIC
Rober Weber, BPA
Phillip Kelsven, BPA
Casey Klock, AprilAire
Behrooz Karimi, IRCO/Trane
Ulysses Grundler, IRCO/Trane
Mike Caneja, Bosch
Brenda Ryan UL
Mike Clapper – UL
Philip Kelseven - BPA

Agenda

- Software Updates (30-45 min)
  - Resistance Heating Utilization
  - General
- Metrics Discussion (Remainder)
  - LBNL: Leo Rainer, Alan Meier
- Wrap Up and Next Steps

Resistance Heating Recap

- Resistance Heating Utilization addresses loophole: Heat pump products can reduce heating runtime, increase setbacks via resistance heating

- Previous RHU Data provided some insight, but
  - Significant outliers, few thermostats in some bins
  - Weighting issues (low runtime bins)
  - Software changes to make calculation more useful

- Working towards Version 2 Connected Thermostats Spec
  - Development effort kicks off in Q4 2019
  - May be able to differentiate products by quality of resistance heat management

Software – RHU Changes (Summary)

- Updates based on stakeholder feedback from previous 2 metrics meetings and additional calls.

- **Additional Data:**
  - Duty cycle information for Aux, Emerg., Comp.
  - Larger temperature bins, in addition to original bins
  - Additional quantiles for each bin
- **Additional Calculation:**
  - RHU2: 30 hours runtime minimum per bin
- **Additional Outlier Filtering:**
  - Based on 1.5* IQR (Interquartile range)

Software – RHU Changes – Data

- More quantiles (characterize extreme values, distributions):
  - Add Tails: q1, q2.5; q98.5, q99
  - Add q(5)'s: q5,q15, … ,q85, q95
  - Applies to all data w/quantiles in output file

- Additional wider temperature bins for RHU (to address lower counts in some bins):
  - Bins: <10, 10-20, …, 40-50, 50-60
  - Original Bins: 00-05, 05-10, … , 50-55, 55-60

- Add Duty Cycles fields, by temperature bins and overall:
  - Aux Duty Cycle (Aux RT / Total heat RT)
  - Emergency Duty Cycle (Emerg. RT / Total heat RT)
  - Compressor Duty Cycle (Comp. RT / Total heat RT)

Software – RHU Changes – Calculation

- Additional calculation: RHU2
- Reduce influence of installations operating far from their design temperature
- Do not include installations in average RHU2 for bin unless they have minimum annual heating run time (any heating) in that bin
  - Example: installation with 2 hours total heating run time in all the hours in the year that its T_{out} is in a given bin
  - Exclude from avg RHU for CT product in that bin, b/c heating equipment was not designed for that T_{out}
  - Minimum run time parameter currently 30 hours; updateable

Software – RHU Changes – Outlier Filtering

- Reduce influence of installations with broken heat pumps
- Applied to RHU2, not to RHU
- Returns filtered and unfiltered results
- First calculate RHU2 using all data
- For each bin, installations > q50 + 1.5 * IQR and/or < q50 – 1.5 IQR eliminated (IQR from unfiltered results)
- Filtered results: statistics calculated on remaining items
- IQR parameter currently 1.5; updateable

RHU software changes Discussion

- Why would you want to see how much of heating run time is emergency aux and compressor? What does it give that RTU doesn't? Knowing the # hours of run time out of total hours, not total heating hours, would be more diagnostic of installations that have a problem.
- Emergency heat? When compressor isn't running. Aux heat is when compressor is running. Should be rarely used, particularly by the thermostat.
- Outlier filtering. May get more data filtered out in warm bins, b/c if 75% of installations not using aux heat at all, ANY aux heat use is an outlier and will be filtered out. In colder bins with wider variation, you might have the opposite problem, that you fail to eliminate much at all. Another option would be symmetrical trimming – top and bottom 5% of data, for instance. Another option would be z-score (variance).

Software – General

- Weather Data Retrieval Updated to
  - EEWeather 0.3.13 and,
  - EEMeter 2.5.2
  - Improves number of thermostats with valid weather station data obtained.

- Pipenv support
  - Goal to make running software more seamless

LBNL - Metrics

- Current savings metrics have several issues
  - Current metrics: heating % run time reduction, cooling % run time reduction
  - Because of baseline, only recognize savings from temperature setback
    - Not from more energy conserving home/awake T_{set}
    - Not from more intelligent HVAC control, e.g. limiting high cooling stage, suggesting opening windows
  - Runtime as a proxy for energy use → only valid for installations with single stage heating & cooling
- Consider additional metrics, or modification to current metric, to address these issues

LBNL - Metrics

- Pure temperature metric – should we try to program that up?
  - Not as simple as it sounds
  - How would we deal with float, and time when the heating and cooling systems are just off
- Another possibility is to use temperatures from the field, but apply them to a few region-specific building simulation models. This would remove the

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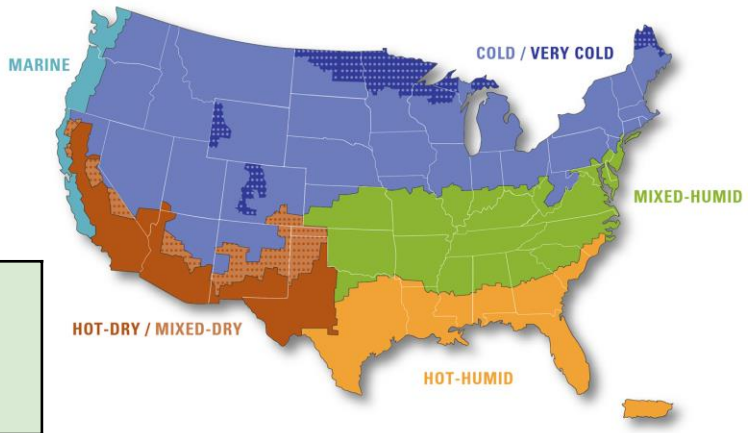
Leo Rainer and Alan Meier, LBNL

Data Set

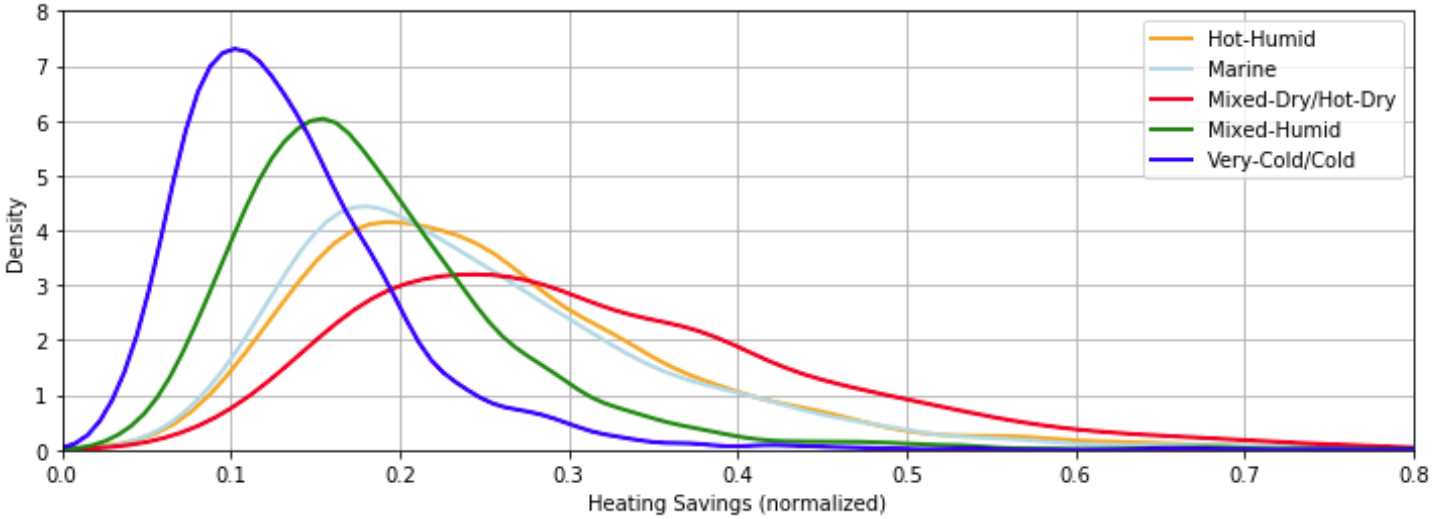
- Non-representative sample from one vendor (self selected)
- 10,685 thermostats
- Period: August 2017 - August 2018
- Parameters generated using version 1.5.0 of the EPA thermostat package

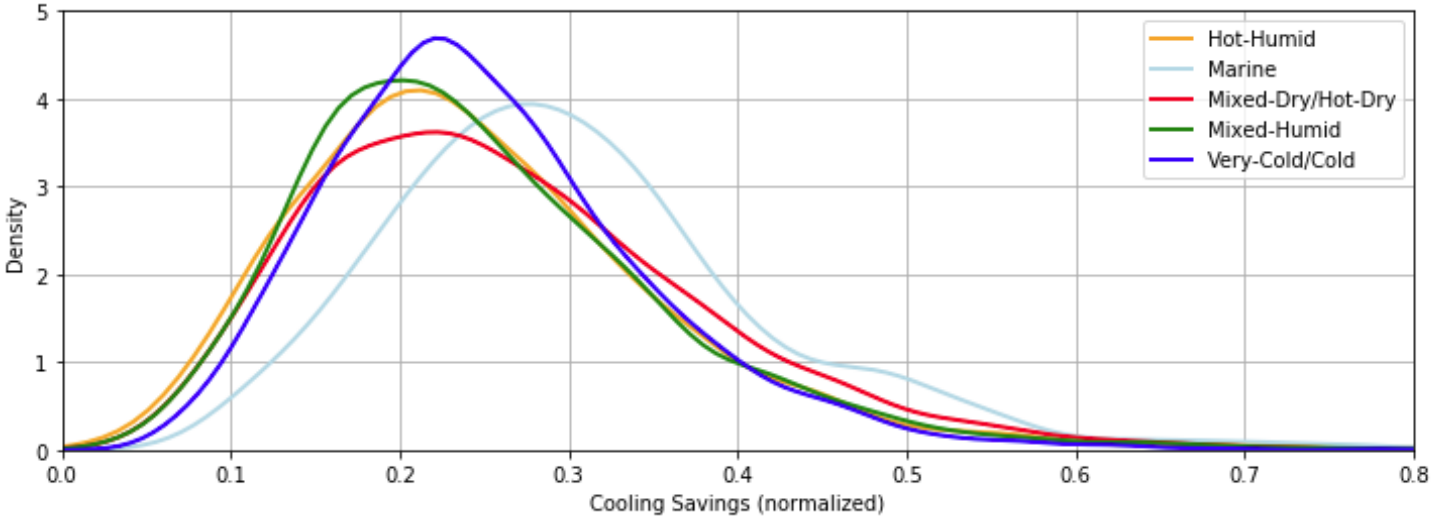
Climate Zone Weighting



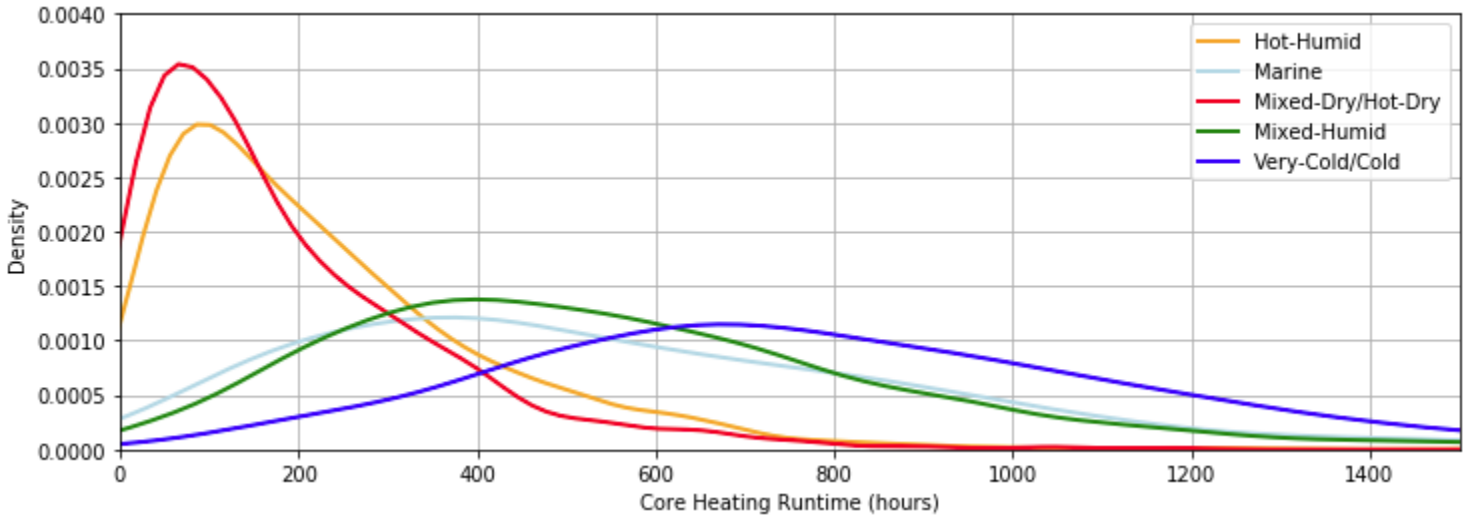
Climate Zone	Heating Weight	Cooling Weight
Very-Cold/Cold	**0.549**	0.096
Mixed-Humid	**0.312**	**0.340**
Mixed-Dry/Hot-Dry	0.054	**0.144**
Hot-Humid	0.049	**0.420**
Marine	0.036	0.000

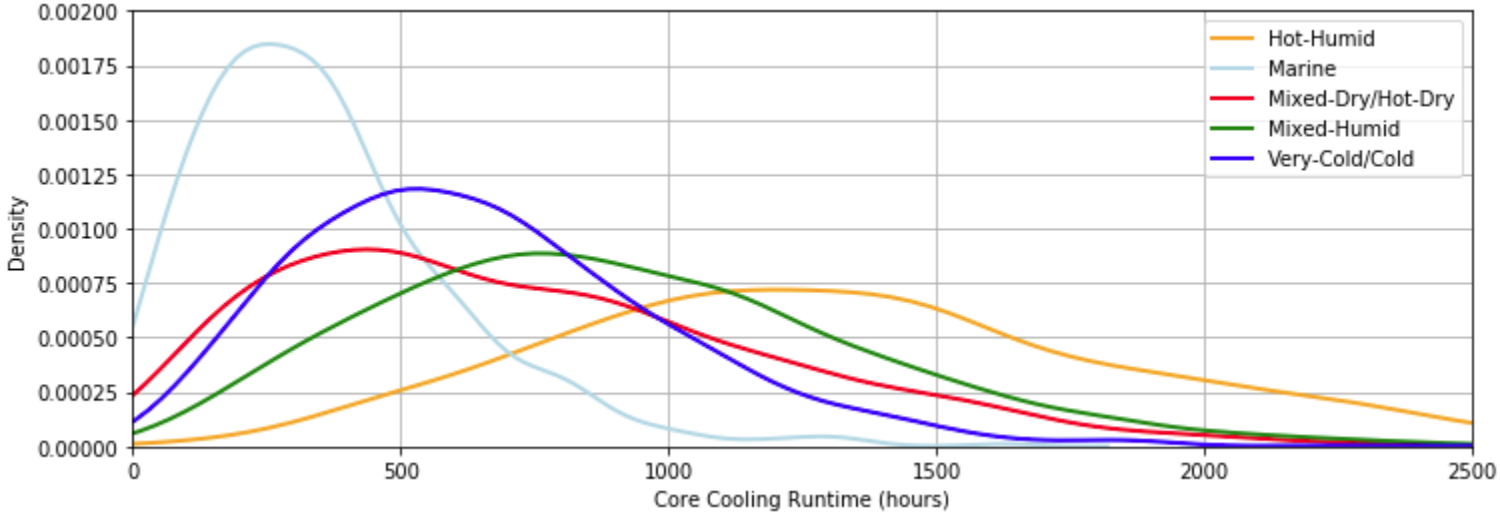
Normalized Savings Distribution by CZ



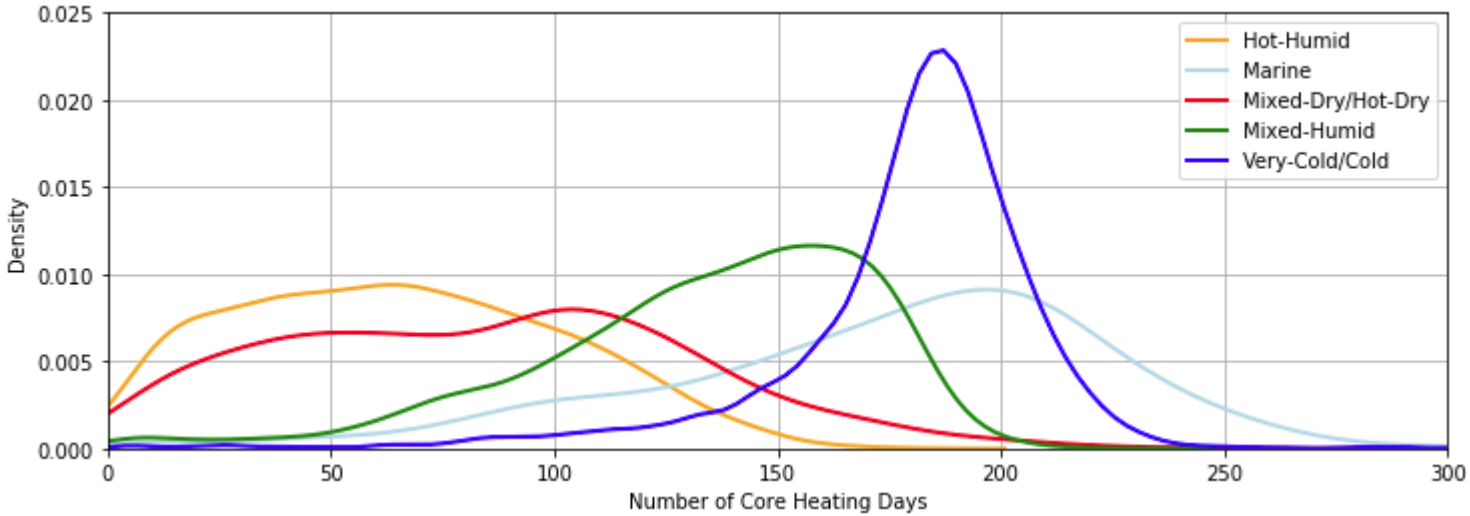


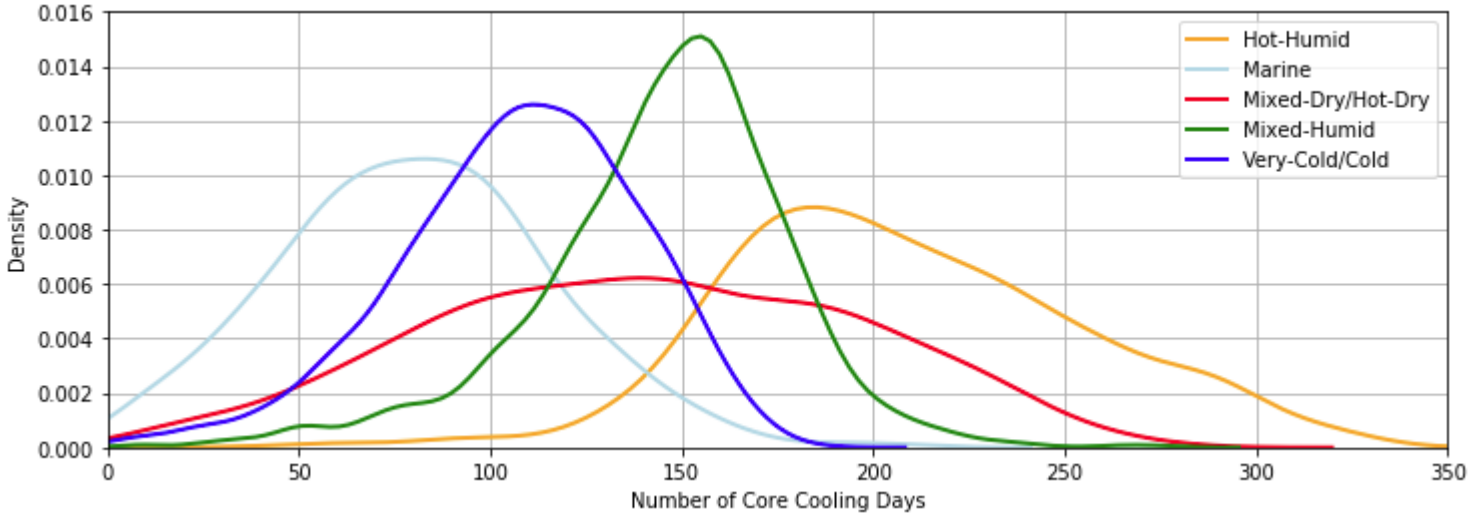
Core Runtime Distribution by CZ



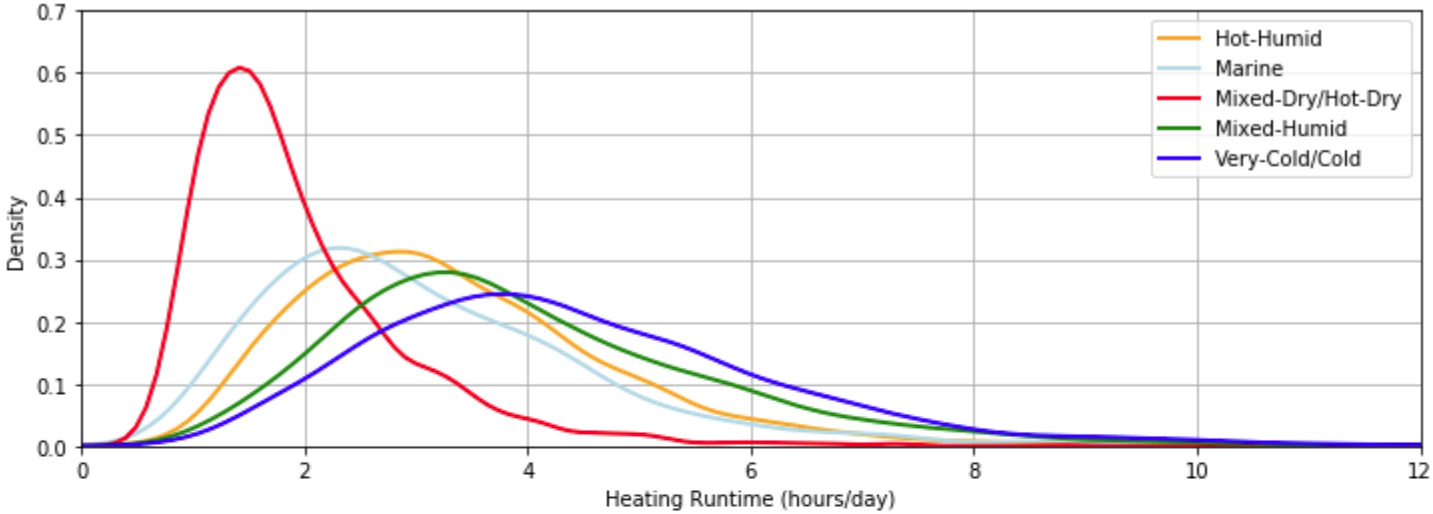


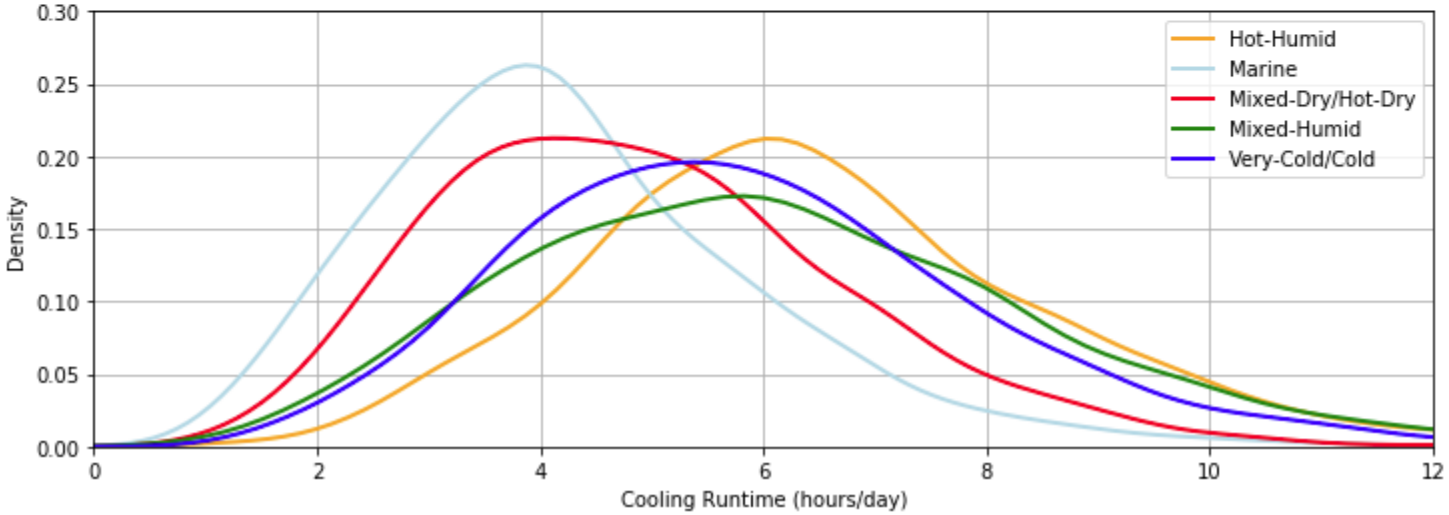
Distribution of Total Core Days by CZ



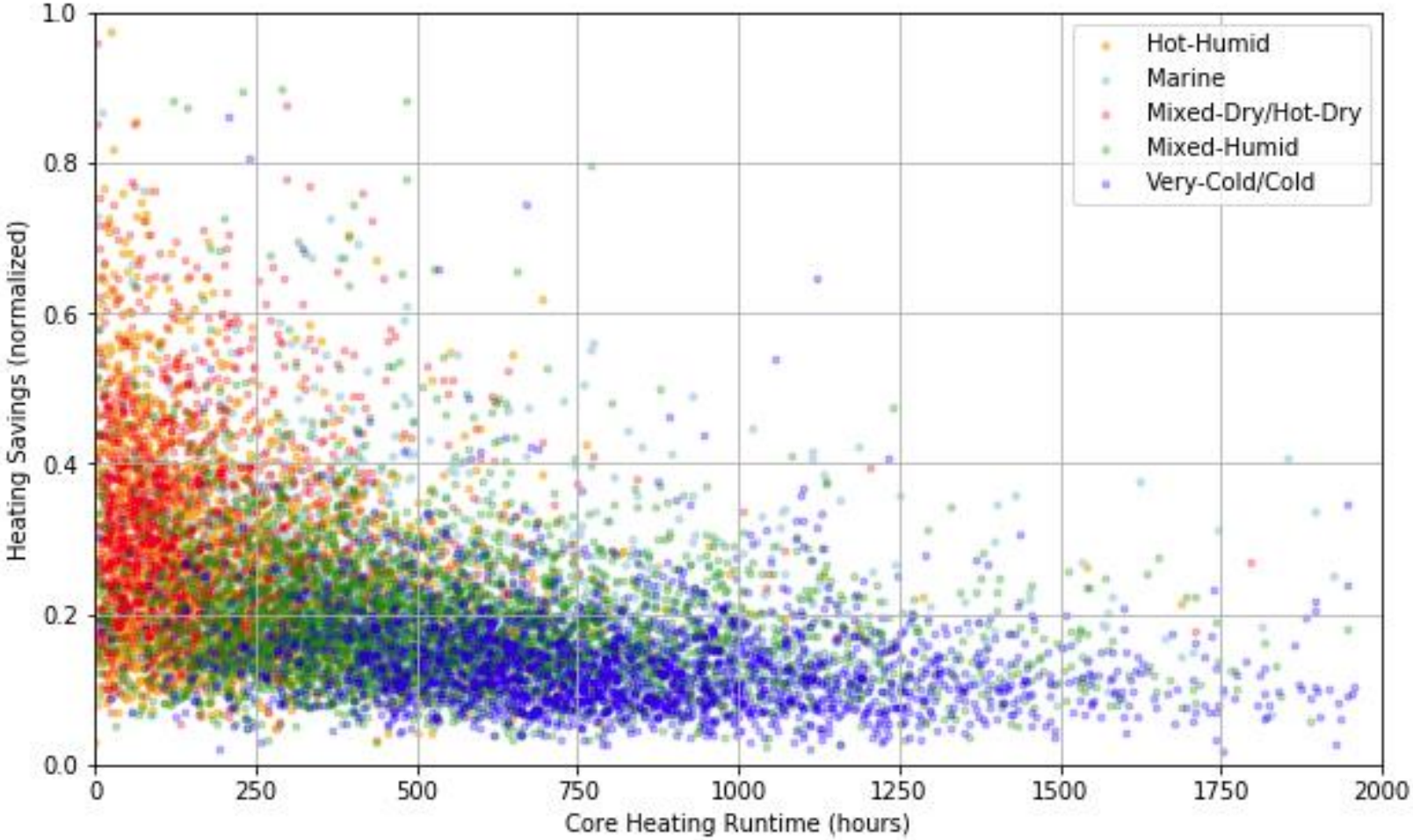


Distribution of Runtime per Core Day by CZ

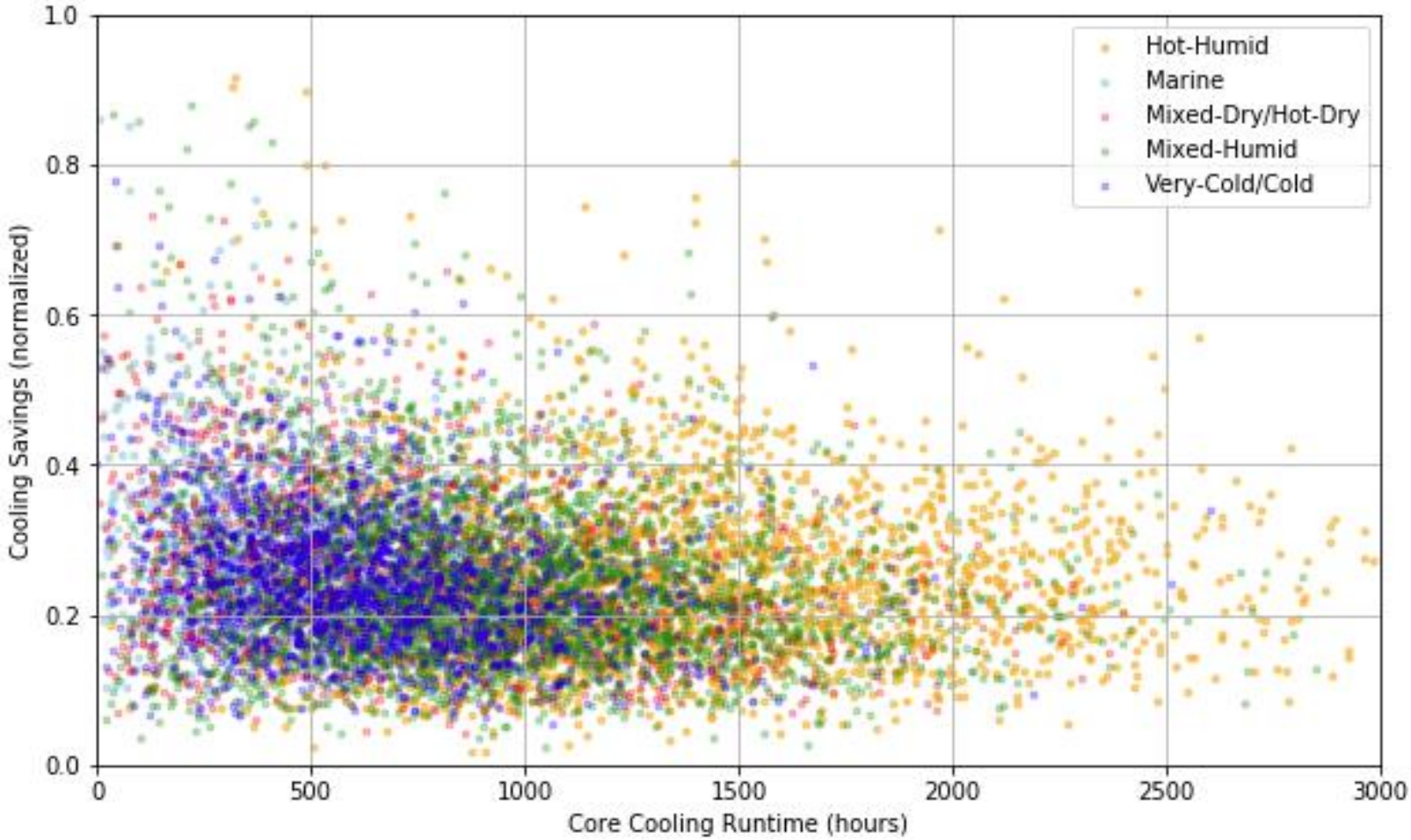




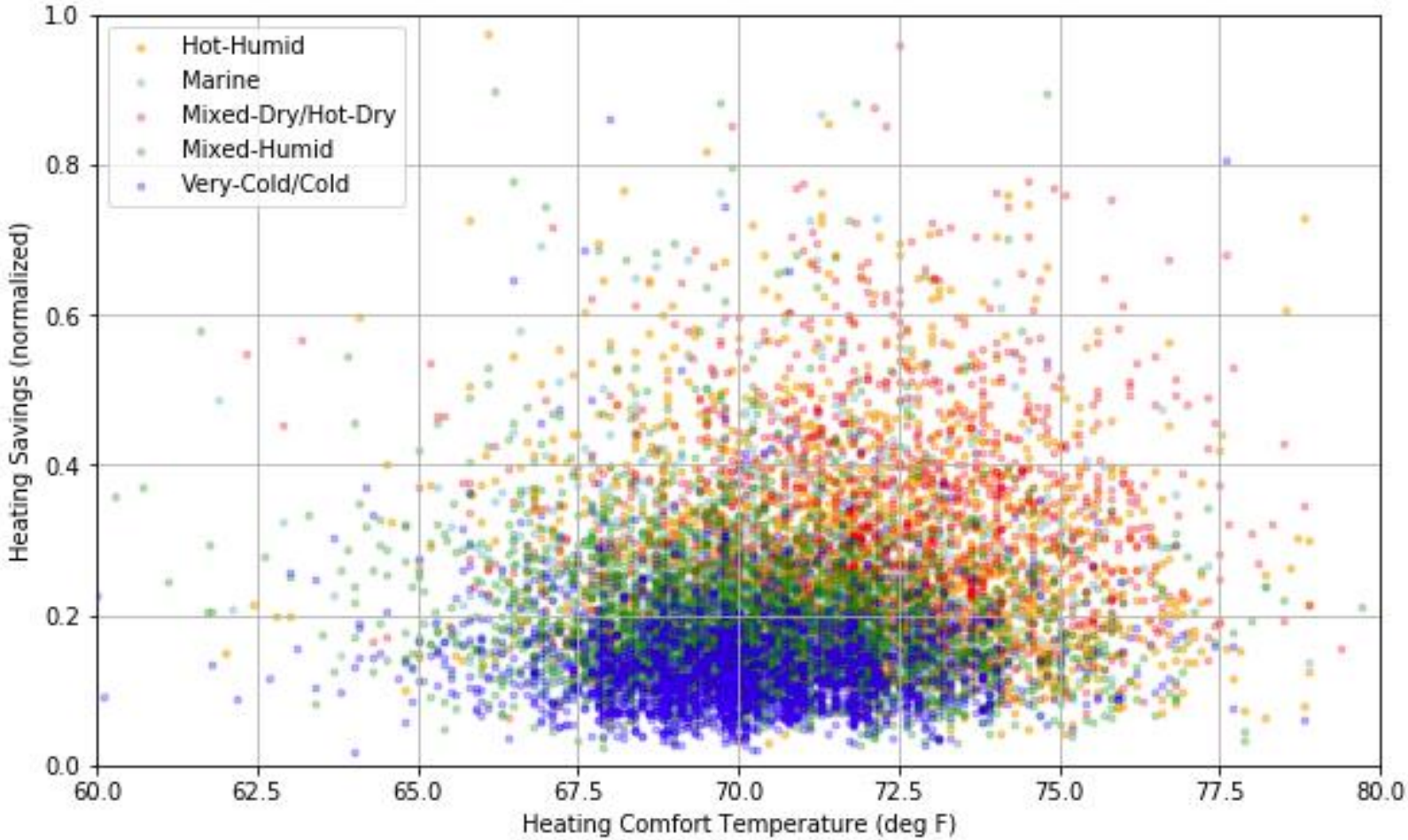
Heating Savings vs Core Heating Runtime by CZ



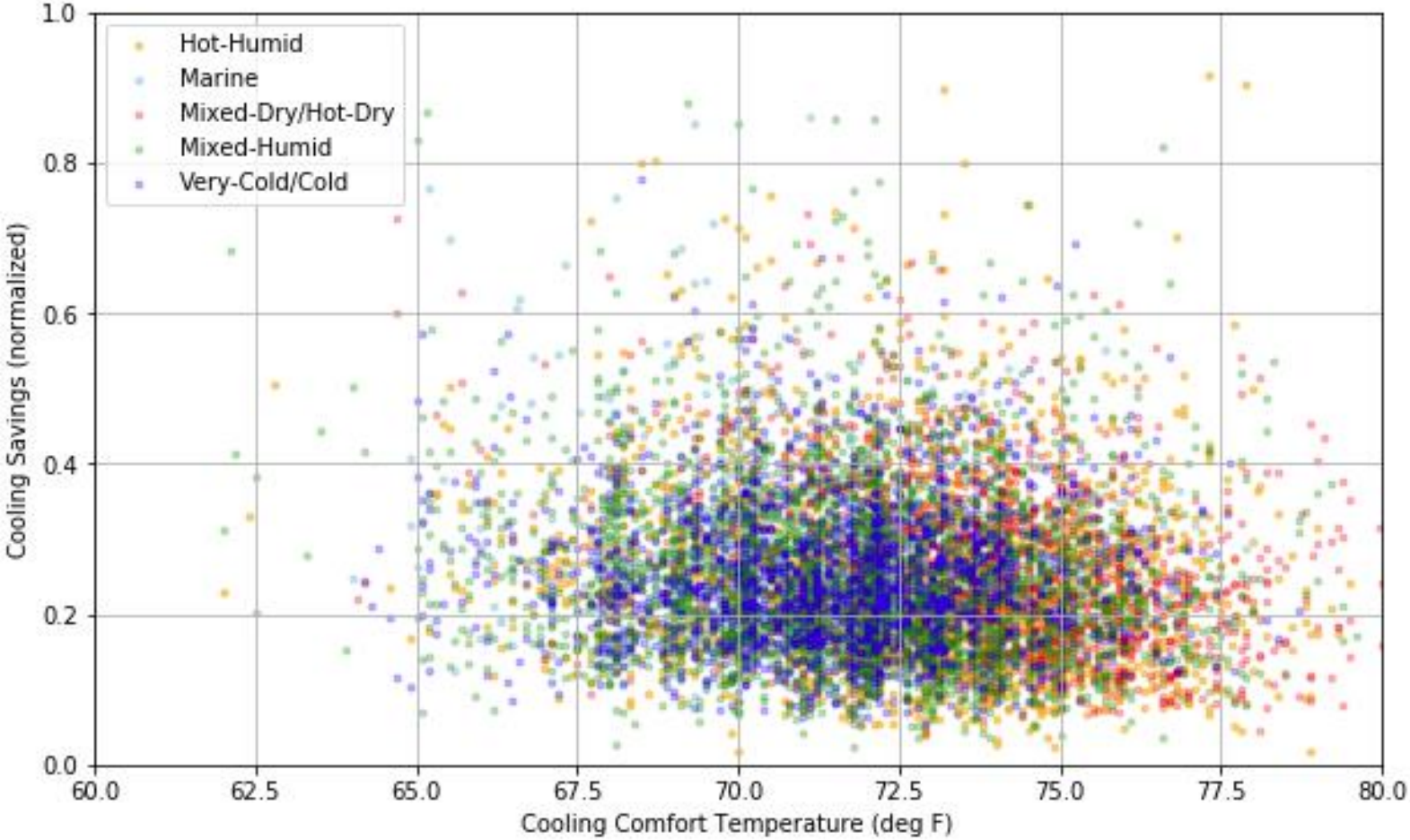
Cooling Savings vs Core Cooling Runtime by CZ



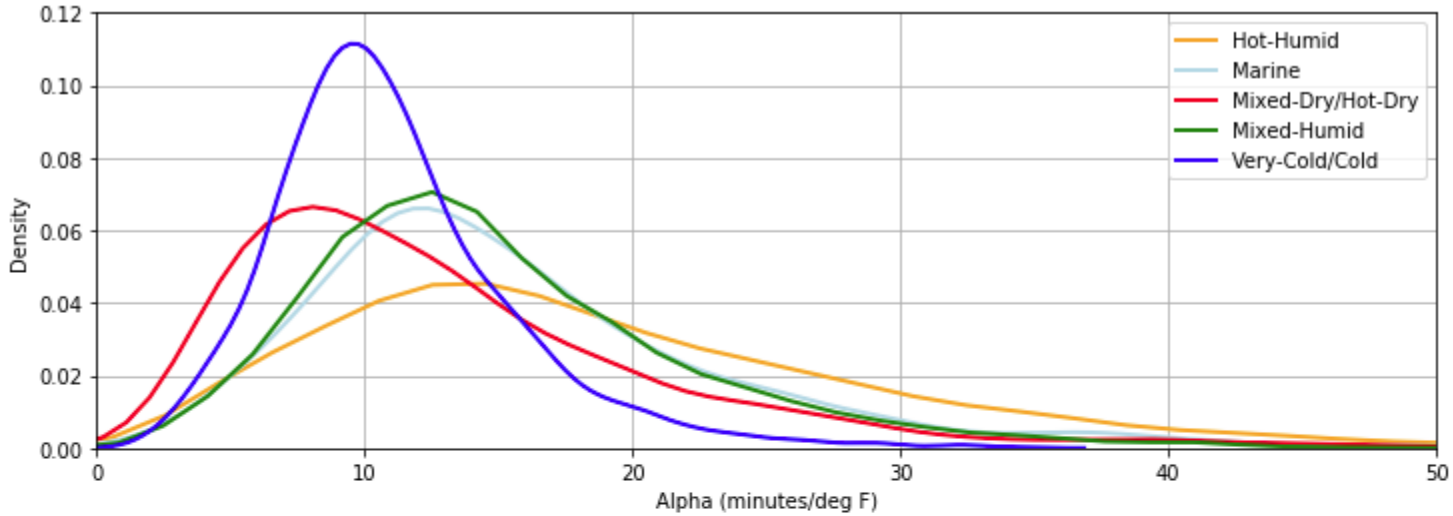
Heating Savings vs Heating Comfort Temp by CZ

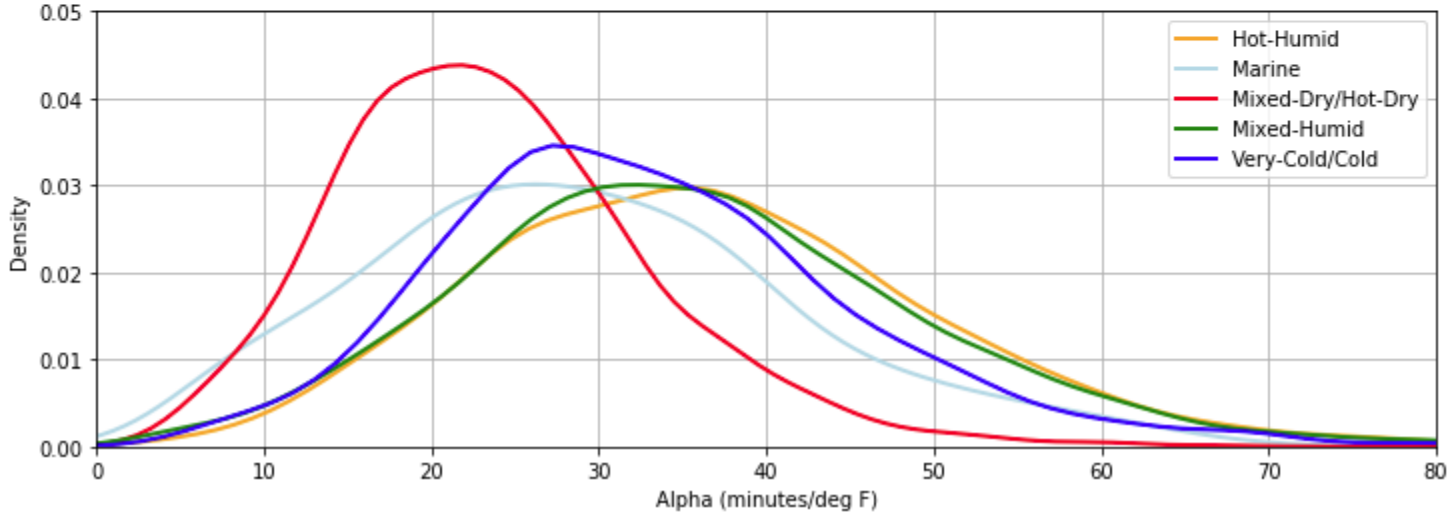


Cooling Savings vs Cooling Comfort Temp by CZ

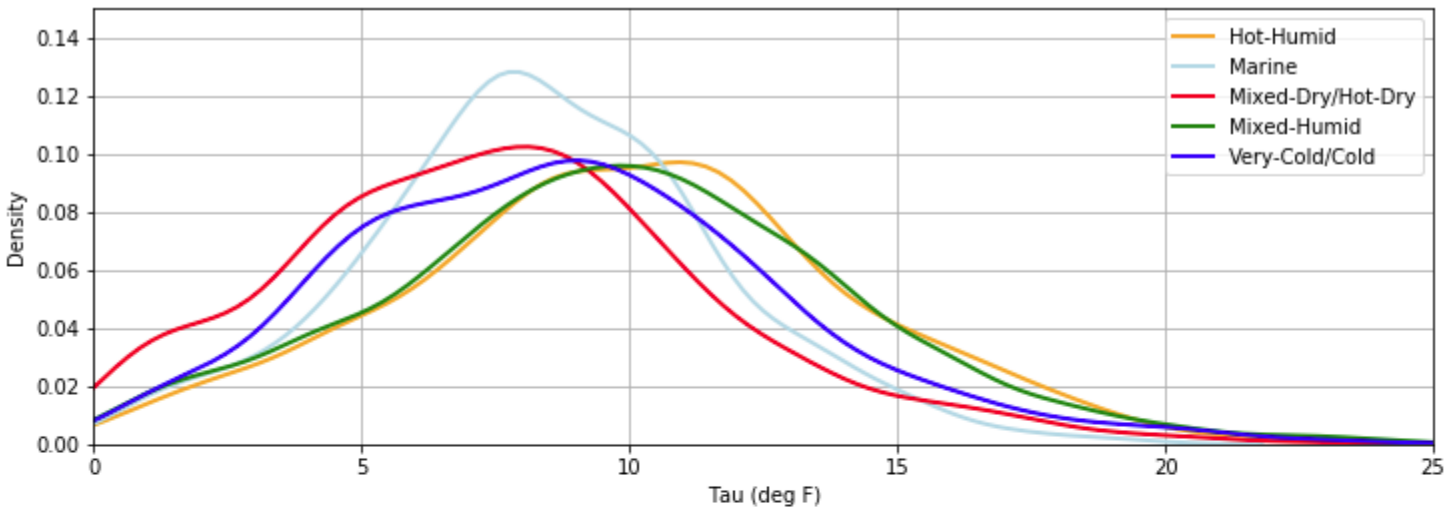


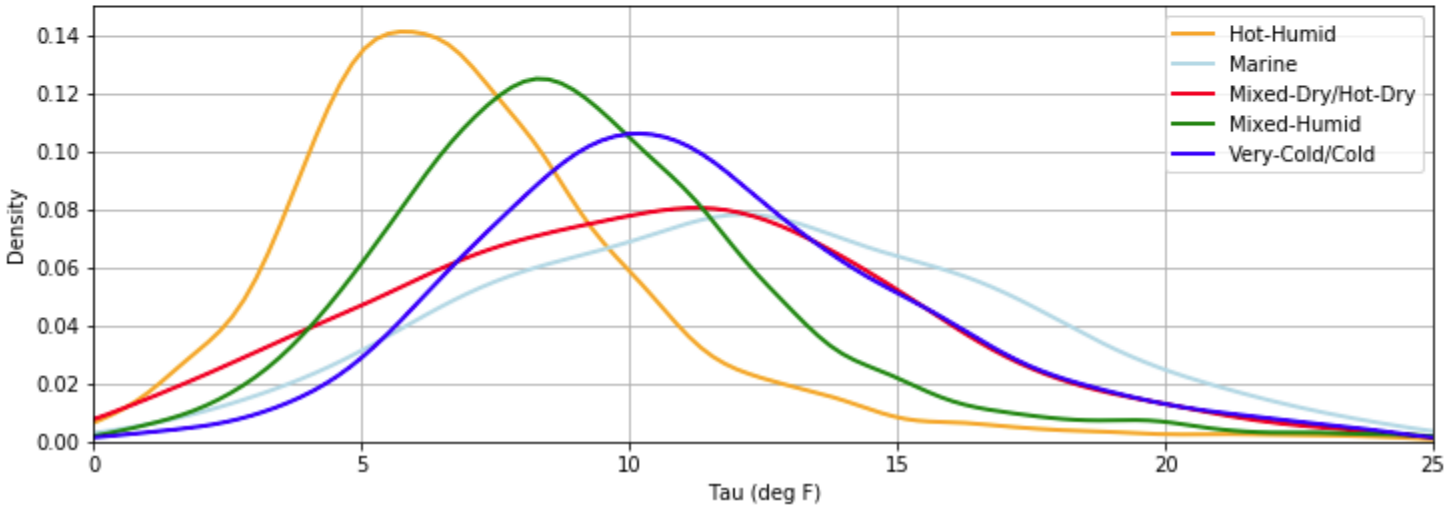
Distribution of Regression Slope (alpha) by CZ



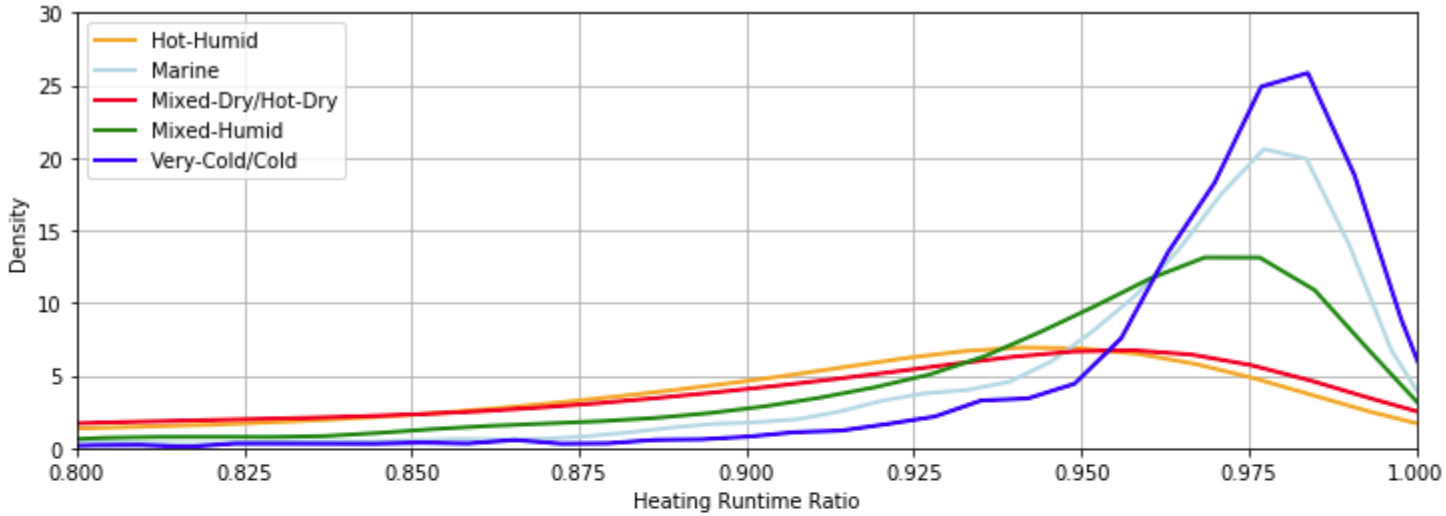


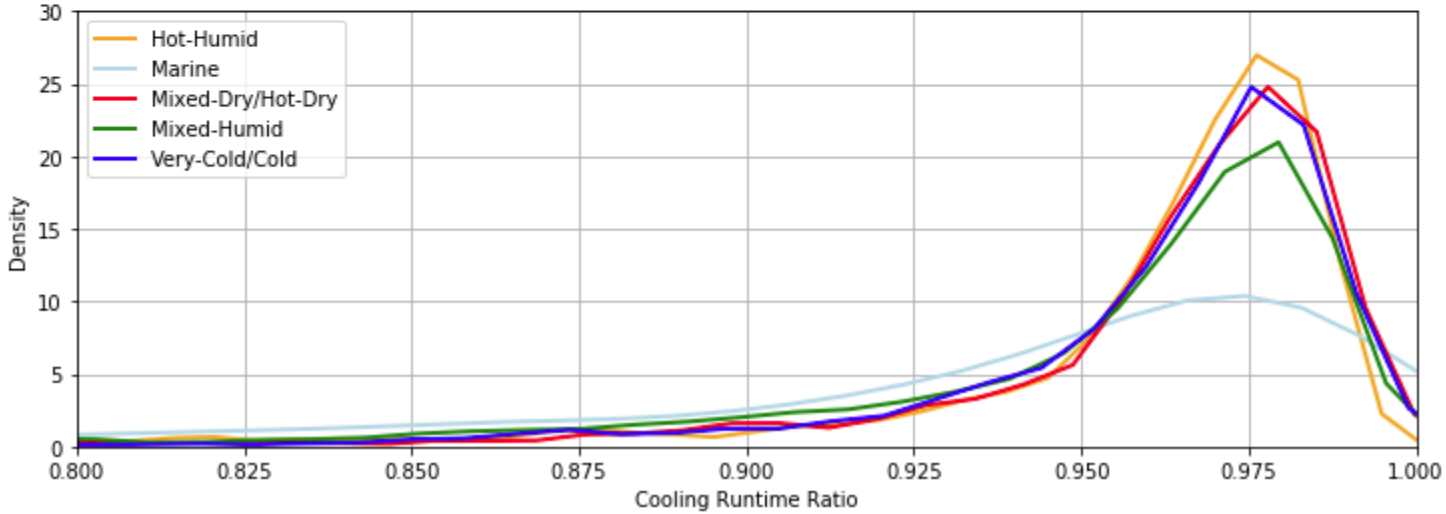
Distribution of Regression Intercept (tau) by CZ





Distribution of Runtime Ratio (core/total) by CZ





Metrics Discussion

- How does the software treat installations with 100 hours of core cooling run time vs. 1000 hours? It treats them all equally (aside from the climate weighting), but comparing based on percent run time reduction is meant to isolate the effect of the thermostat product, somewhat.
- Issue of controllers for staged and variable capacity units: continuing to have no path for them also shuts platforms connecting to them out of SHEMS recognition
- Different factors that effect savings metrics – particularly moving comfort temperature, which saves energy but gives a worse score on the EERGY STAR metric
- RBSA data set: detailed indoor temperature data correlated with a whole bunch of information about the home. Homes with “connected thermostats” (as per auditors) have almost 2 degrees higher average indoor temperature. Haven’t checked if there is an explanatory factor that could cause both. 11 homes out of 257 homes had connected thermostats (we think that was 2015)
- 0.5% reduction in savings score (and Tau) from one year to another based solely on weather

Metrics Discussion

- Demographic data for smart thermostats – definitely differ from smart thermostats to non-smart thermostat (Michigan dataset), and likely between thermostat vendors
- Difference in comfort temperature from product to product probably partly a function of who is choosing each product, and partly a function of the algorithms the vendor is applying
- Is it worth thinking about programming up a temperature-only metric?
  - Original proposal was “savings degree hours”: accumulate difference between indoor temperatures and an arbitrary base temperature, multiplies by hours
  - Has a bit of a problem with float, and when heating/cooling system is off
  - Converting this to energy savings is challenging – maybe simulations would help?
  - This proposal can be found in 2014 documents, back when we were calling this “climate controls”

https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Climate%20Controls%20Metrics%20Framework%20and%20Comparison_0.pdf

https://www.energystar.gov/sites/default/files/11.9.14ENERGY%20STAR%20Climate%20Controls%20Metrics%20Workshop%20Slides.pdf

Wrap up and Next Steps

- Action Items:
  - Plots showing effect of different outlier filters for RHU2 calculation
  - Update regional baseline table based on average of comfort temperature data from vendors, but thoughtfully
  - Phillip Kelsven: present on feature-based effort in NW on future call? EPA and BPA to discuss
  - All: please take very short survey
  - LBNL to work with vendors to get similar data plots as the ones presented today
- Next Steps
  - EPA to inform metrics stakeholders when new software version is ready to try
  - Re-run heat pump only sample with new software
  - Results presented at next metrics meeting (early June?)