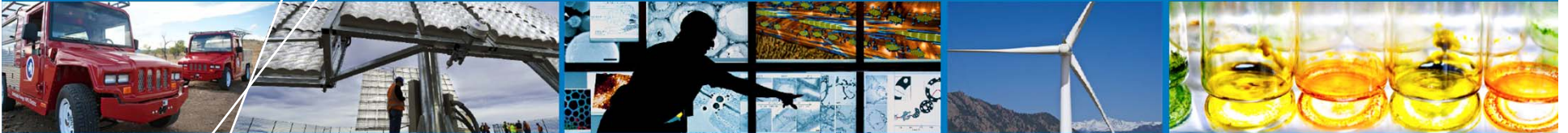


Indoor Temperature and Humidity Data Collection and Analysis



Chuck Booten, NREL

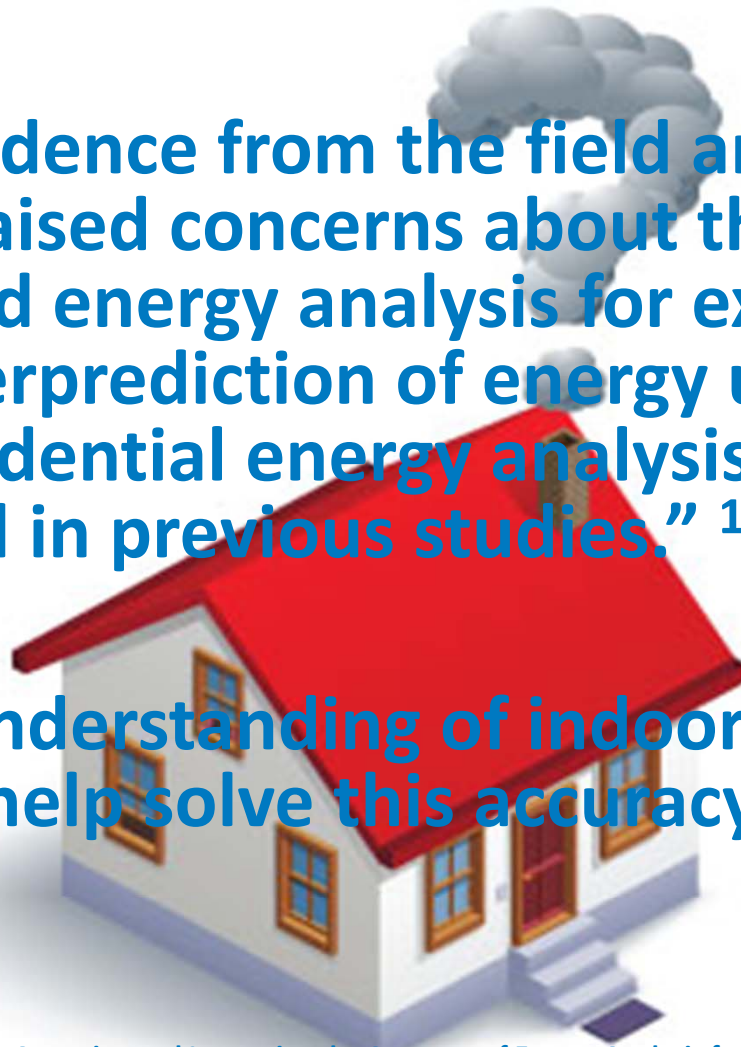
Paul Norton, NERD

Cheryn Metzger, NREL

Why do we care about indoor Temp/RH?

“Anecdotal evidence from the field and controlled studies have raised concerns about the accuracy of software-based energy analysis for existing homes. Overprediction of energy use and savings by residential energy analysis methods has been observed in previous studies.”¹

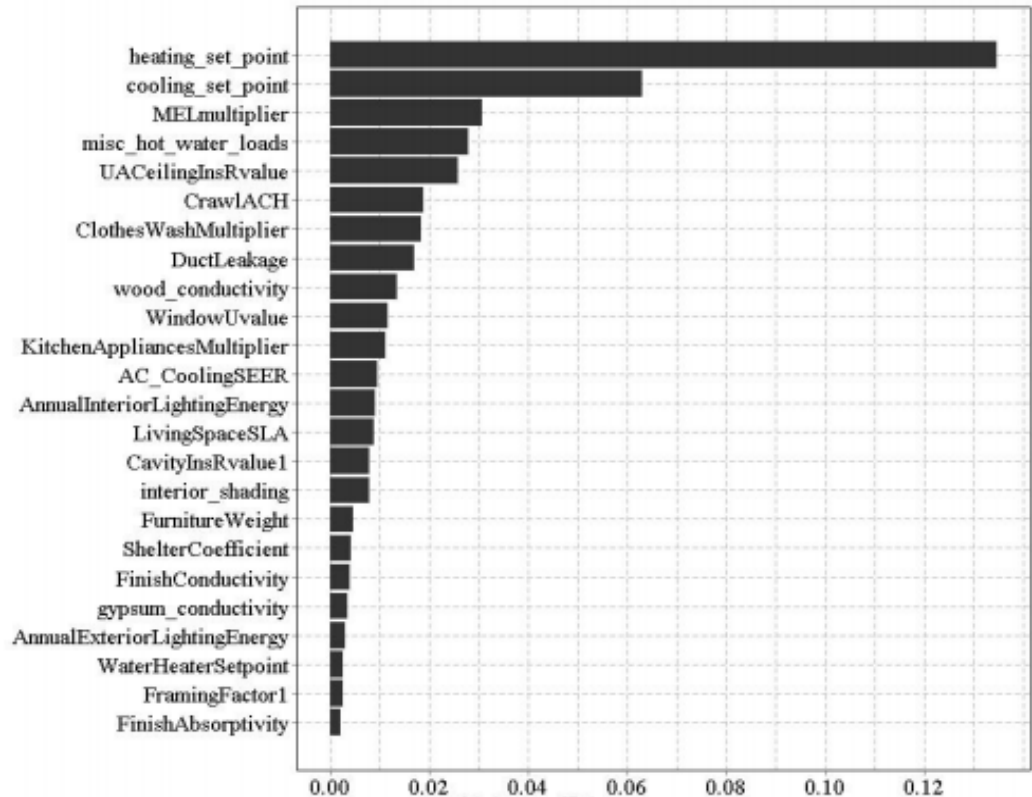
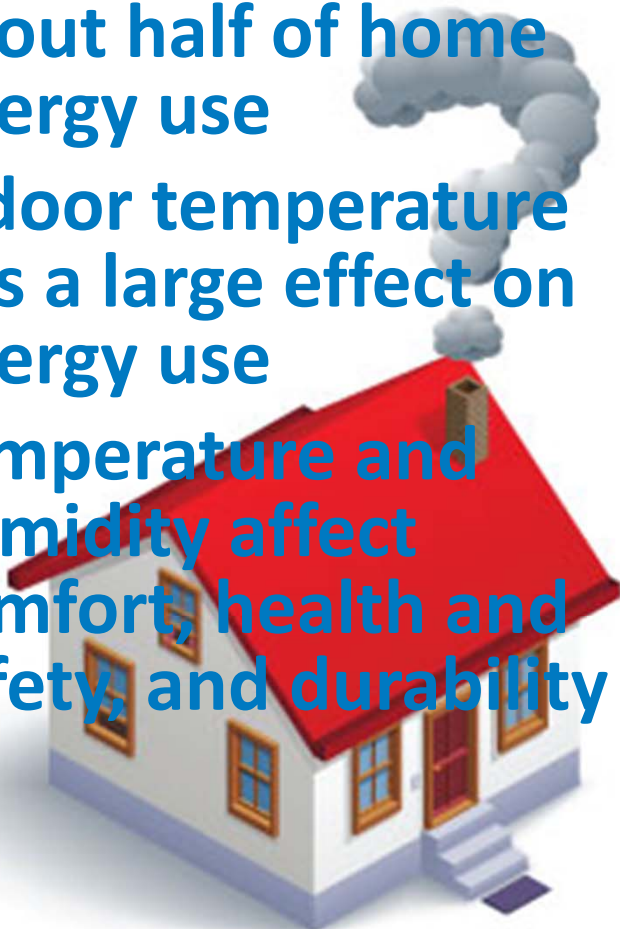
Can a better understanding of indoor temperature and humidity help solve this accuracy issue?



1. Polly, B.; Kruis, N.; Roberts, D. (2011). Assessing and Improving the Accuracy of Energy Analysis for Residential Buildings. 41 pp.; NREL Report No. TP-5500-50865; DOE/GO-102011-3243. <http://www.nrel.gov/docs/fy11osti/50865.pdf>

Why do we care about indoor Temp/RH?

- Space conditioning can account for about half of home energy use
- Indoor temperature has a large effect on energy use
- Temperature and humidity affect comfort, health and safety, and durability



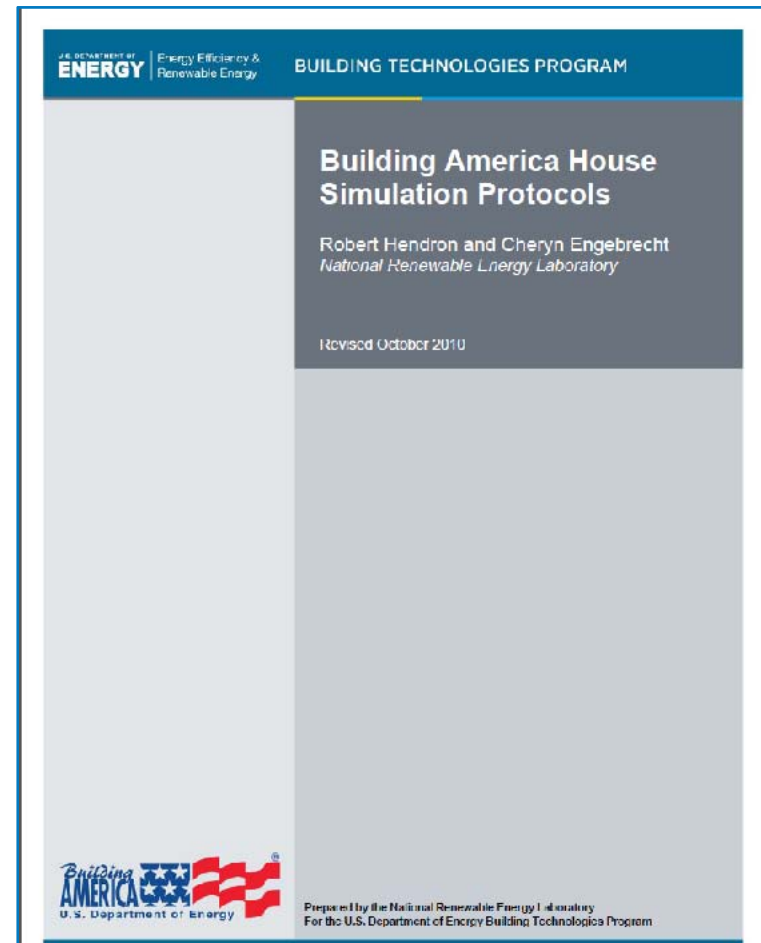
Influence of various inputs on simulated energy use for a particular house

BA House Simulation Protocol

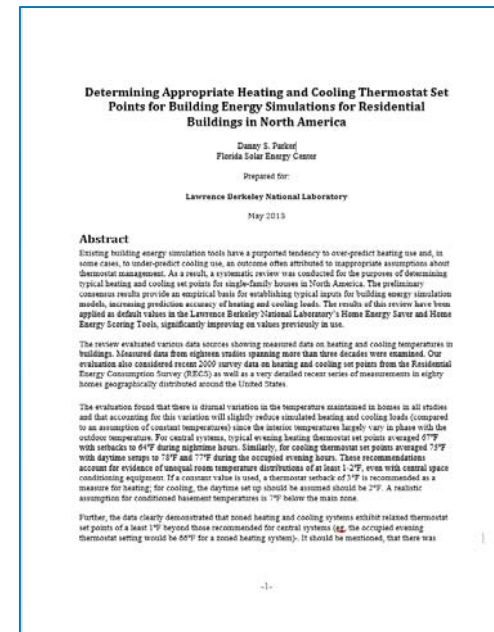
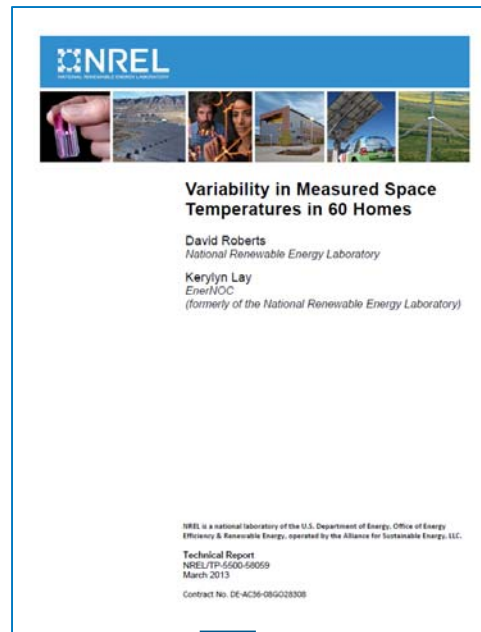
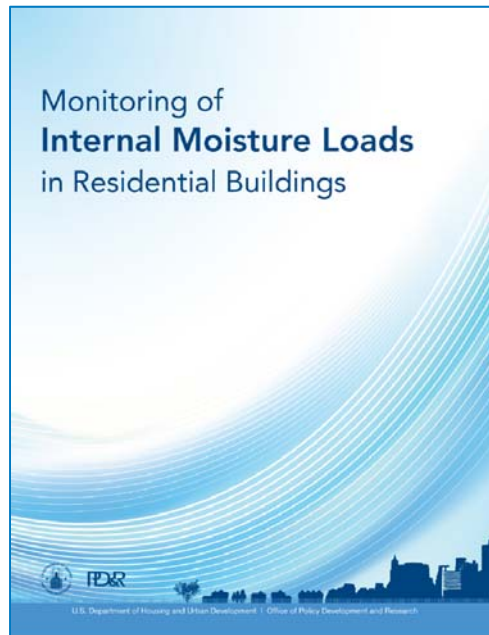
Set point for cooling:
76°F with no setup period

Set point for heating:
71°F with no setback period

(These were based on based on
ASHRAE Standard 55-2004 and the
Residential Energy Consumption
Survey (RECS) of 2005)



Some initial studies raised concerns




What data is needed?

- Hourly T&RH measurements in the living room and all bedrooms
- Outdoor T&RH
- Runtime of space conditioning equipment
- Ideally one year of data.
 - *A minimum* of two weeks of data near the peak of the heating or cooling season

These measurements are often done with stand-alone battery powered loggers (such as HOBOS) provided by NREL. NREL may also be able to provide installation assistance.

Temp and Humidity Measurement Protocol

- **Who is it for?**
 - Anyone collecting temp/RH data in houses (utility programs, researchers, etc.)
- **What does it do?**
 - Guides people through a best practice method for gathering useful T/RH data
- **Why is standardization needed?**
 - Statistical analysis for understanding the important drivers of T/RH distribution requires lots of similarly formatted data
- **How does data get used?**
 - Improved simulation models and inputs



The Building America Indoor Temperature and Humidity Measurement Protocol


Cheryn Engebrecht Metzger
National Renewable Energy Laboratory

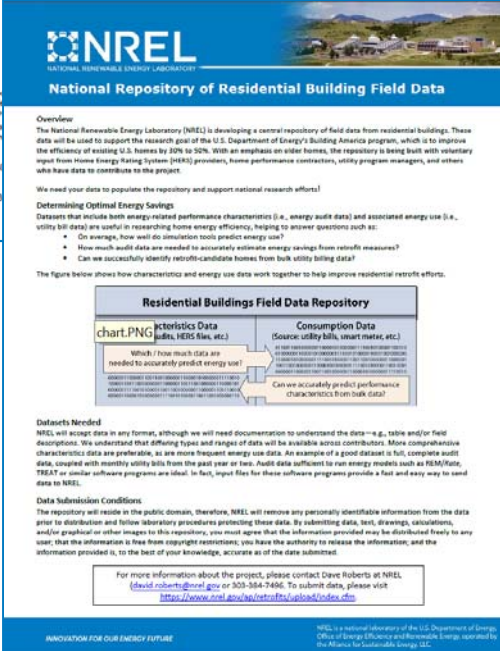
Paul Norton
Norton Energy Research & Development

NREL is a national laboratory of the U.S. Department of Energy, operated by the Alliance for Sustainable Energy, LLC.

This report is available at <https://www.nrel.gov/pdfs/TP-5500-6104.pdf>

Technical Report
NREL/TP-5500-6104
February 2014
Contract No. DE-AC35-09OR21400





NREL
NATIONAL RENEWABLE ENERGY LABORATORY

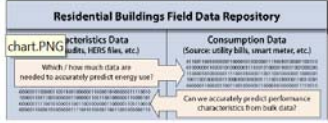
National Repository of Residential Building Field Data

Overview
The National Renewable Energy Laboratory (NREL) is developing a central repository of field data from residential buildings. These data will be used to support the research goal of the U.S. Department of Energy's Building America program, which is to improve the efficiency of existing U.S. homes by 30% to 50%. With an emphasis on older homes, the repository is being built with voluntary input from Home Energy Rating Systems (HERS) providers, home performance contractors, utility program managers, and others who have data to contribute to the project.

We need your data to populate the repository and support national research efforts!

Determining Optimal Energy Savings
Datasets that include both energy-related performance characteristics (i.e., energy audit data) and associated energy use (i.e., utility bill data) are useful in researching home energy efficiency, helping to answer questions such as:
• On average, how well do simulation tools predict energy use?
• How much audit data are needed to accurately estimate energy savings from retrofit measures?
• Can we successfully identify retrofit-candidate homes from bulk utility billing data?

The figure below shows how characteristic and energy use data work together to help improve residential retrofit efforts.



Residential Buildings Field Data Repository

chart.PNG **Characteristics Data** (e.g., HERS flow, etc.) **Consumption Data** (Source: utility bills, smart meter, etc.)

Which/how much data are needed to accurately predict energy use?

Can we accurately predict performance characteristics from bulk data?

Datasets Needed
NREL will accept data in any format, although we will need documentation to understand the data (e.g., table and/or field descriptions). We understand that differing types and ranges of data will be available across contributors. More comprehensive characteristics data are preferable, as are more frequent energy use data. An example of a good dataset is a full, complete audit data, coupled with monthly utility bills from the past year or two. Audit data sufficient to run energy models such as RESNETs, TREAT or similar software programs are ideal. In fact, input files for these software programs provide a fast and easy way to send data to NREL.

Data Submission Conditions
The repository will reside in the public domain, therefore, NREL will remove any personally identifiable information from the data prior to distribution and follow laboratory procedures protecting these data. By submitting data, test, drawings, calculations, and/or graphical or other images to this repository, you must agree that the information provided may be distributed freely to any user, that the information is free from copyright restrictions, you have the authority to release the information, and the information provided is, to the best of your knowledge, accurate as of the date submitted.

For more information about the project, please contact Dave Roberts at NREL (dave.roberts@nrel.gov or 303-584-7496). To submit data, please visit <https://www.nrel.gov/building/retrofit/upload/index.htm>

AN INITIATIVE FOR OUR ENERGY FUTURE

NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.

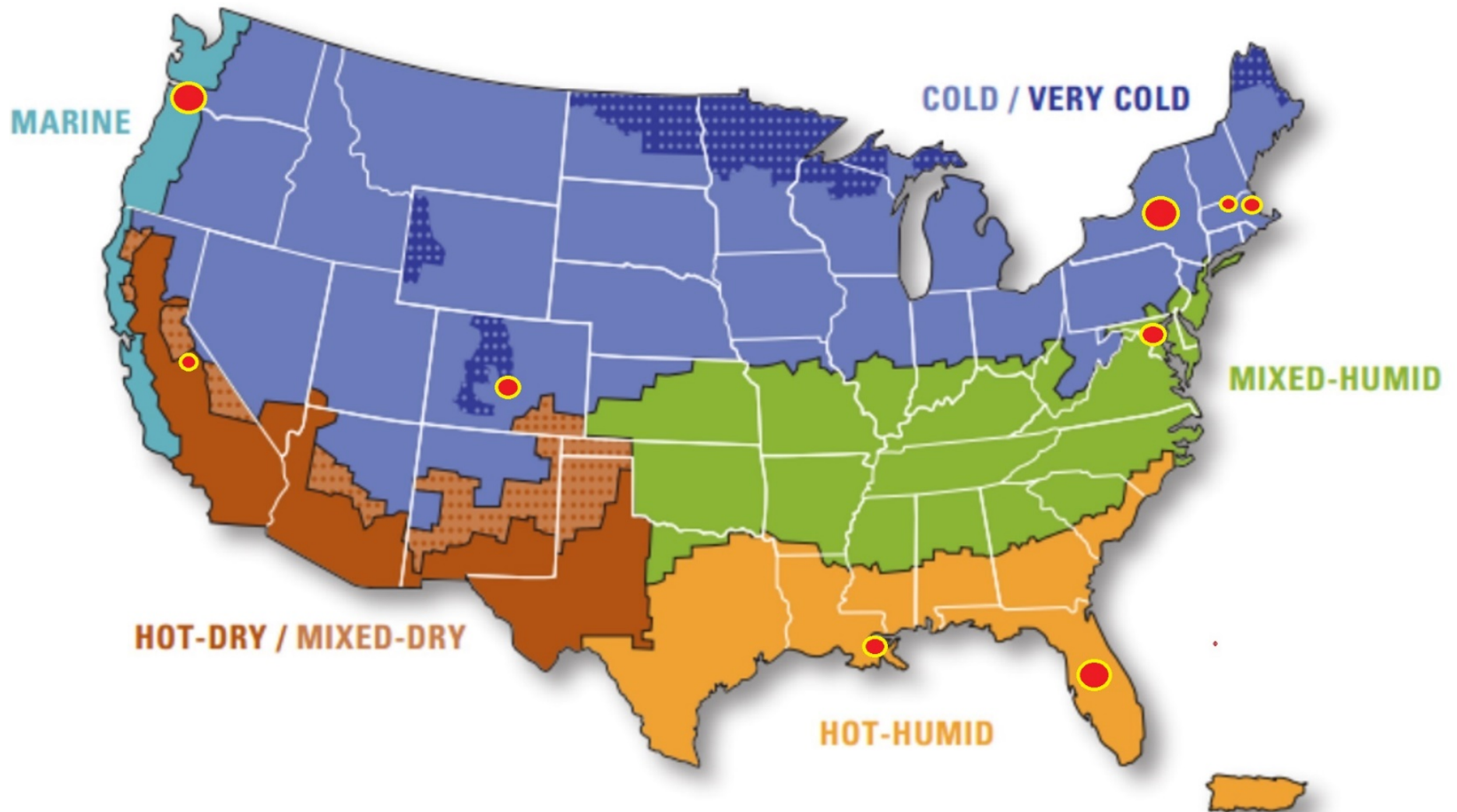
Current Project Scope

- **Implement Protocol**
- **We expect to collect data on over 350 homes of different types in a variety of climates**
- **Data collection will continue through 2015.**
- **The BA Home Simulation Protocols will be updated as needed.**

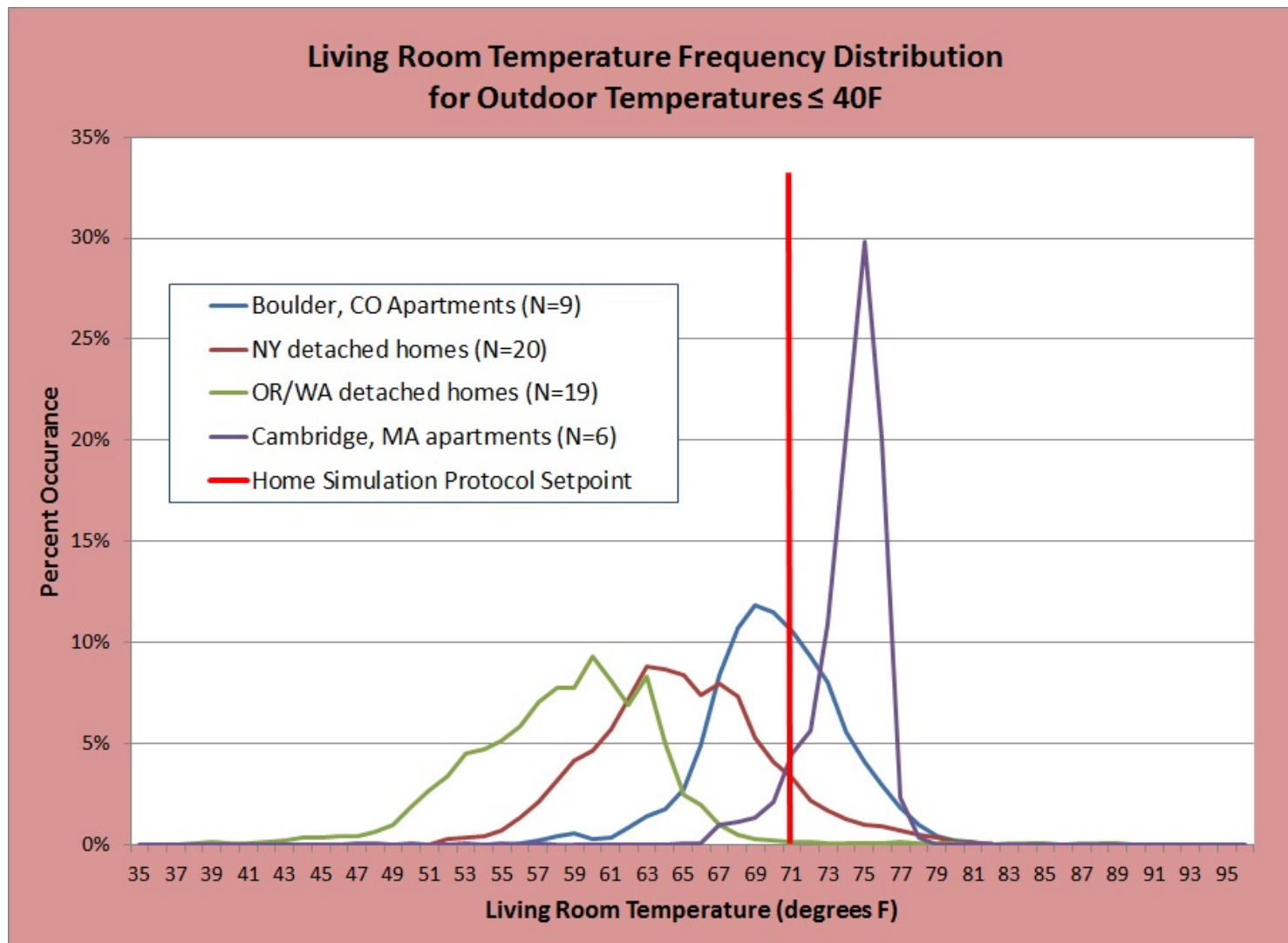
Current Data Distribution

Location	Number of homes	Type of Homes	BA Climate Zone
New York	20	single family detached	Cold
Florida	20	single family detached	Hot-Humid
Oregon	20	single family detached	Marine
Greenbelt, MD	10	Apartments	Mixed-Humid
Boulder, CO	1	single family detached	Cold
Boulder, CO	9	Apartments	Cold
New Orleans, LA	8	single family detached	Hot-Humid
New Orleans, LA	2	single family detached	Hot-Humid
Cambridge, MA	11	Apartments	Cold
Devins, MA	10	single family detached	Cold
Fresno, CA	5	single family detached	Hot-Dry
Denver, CO	5	single family detached	Cold
Anticipated additions for 2014			
TBD	50	Apartments	Hot-Dry or Hot-Humid
TBD	20	Apartments	Cold
All Homes	191		

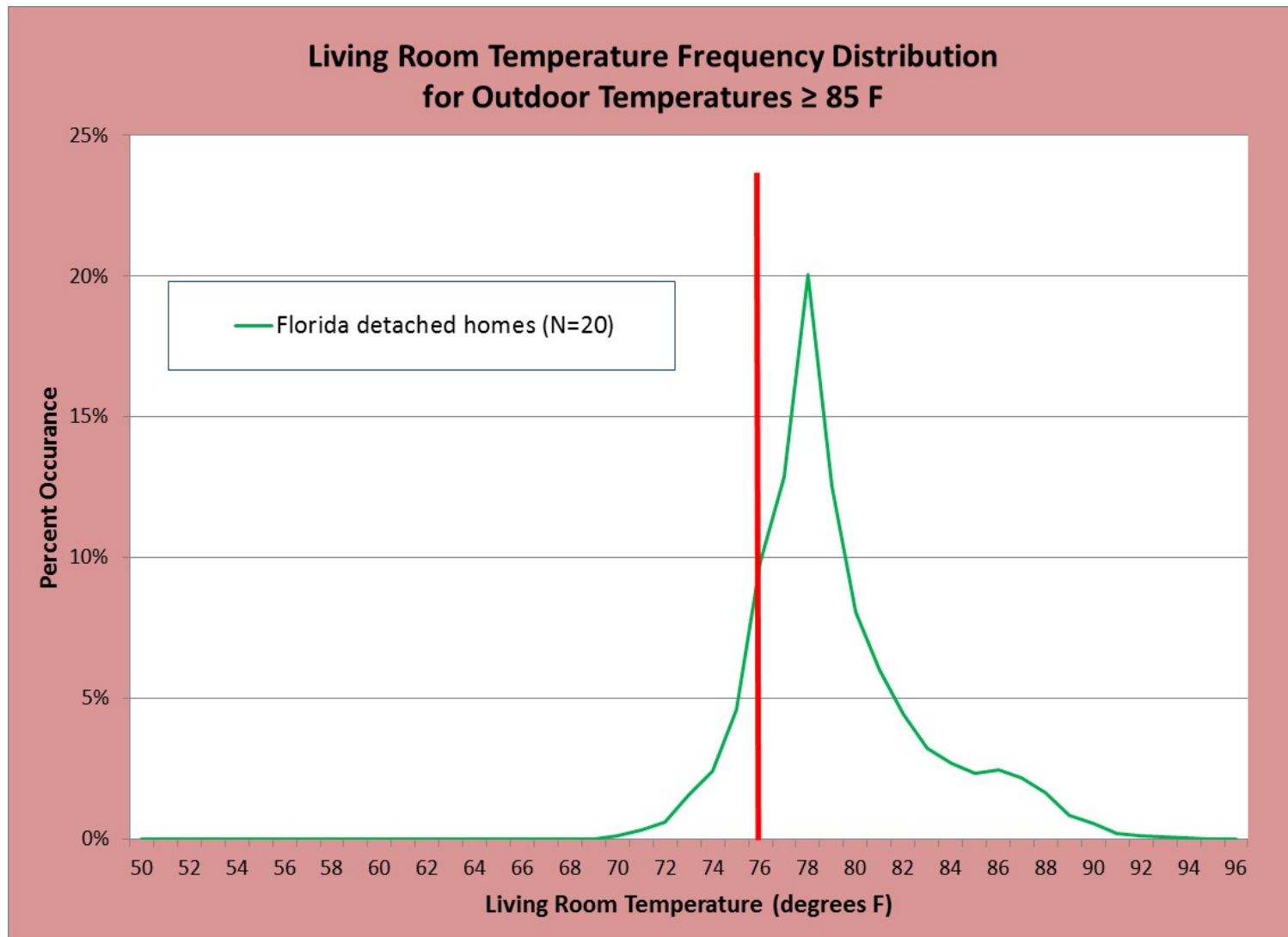
Current Data Distribution



Indoor Temperatures During Heating

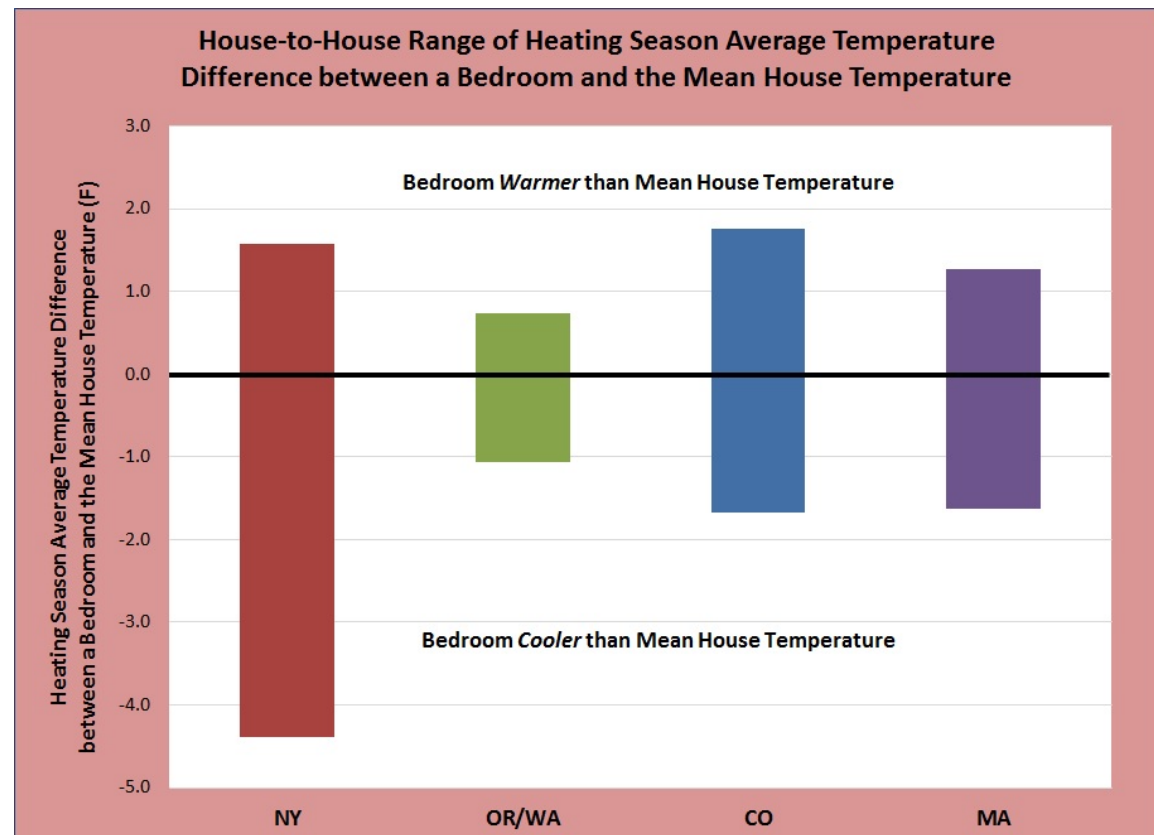


Indoor Temperatures During Cooling

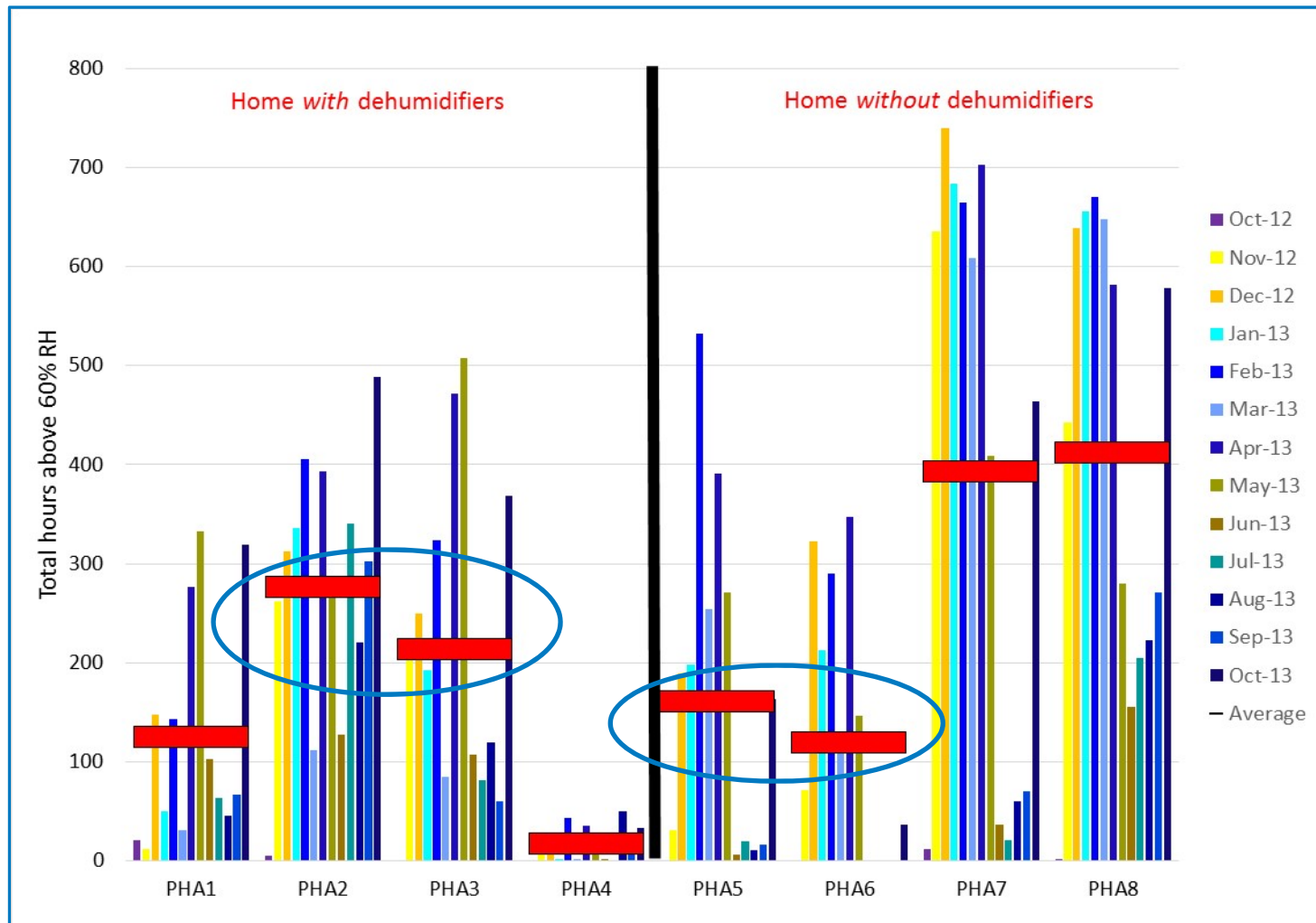


Temperature distributions within homes

- Within houses variations are +/- X deg F on average
- Some rooms warmer, some colder



RH Variability - New Orleans Example



Source: Kerrigan, P., and Norton, P., 2013. Evaluation of the Performance of Houses with and without Supplemental Dehumidification in a Hot-Humid Climate

What caused the variability?

	PHA1	PHA2	PHA3	PHA4	BDC1	BDC2
Occupancy (# of people)	1*	1 or 2**	4	4	1	1
Hours above 60% RH	Average	High	High	Low	Low	Low
Humidity Ratio	Average	Low	High	High	Average	Low
Indoor Temperature	Average	Low	Average	High	High	Low
Master Bath Fan	Average	Low	Low	High	High	Low
Hall Bath Fan	Average	Low	Low	High	Low	Low
Dehumidifier Electricity	Low	High	Low	High	Average	Low
Heat Pump Electricity	Average	High	High	High	Low	Low
DHW Electricity	Average	Low	High	High	Low	Low
Cooking Electricity	High	Average	High	Low	Low	Low
Clothes Dryer Electricity	Average	Low	High	High	Low	Low

Source: Kerrigan, P., and Norton, P., 2013. Evaluation of the Performance of Houses with and without Supplemental Dehumidification in a Hot-Humid Climate

Initial Data Trends

- **Significant variability in indoor temperature and humidity – we need more data**
 - Project-to-project, House-to-house, Room-to-room, and hour of day.
- **Most of the initial data lack space conditioning equipment runtime data – we need more data**
- **Early data may indicate HSP heating setpoint is too high, but we need more data.**

.....Oh, and did we mention..... we need more data!

More data!

- **NREL wants to collaborate**
- **If you have data already, we want to include it in this study**
- **Expand the scope of the existing data...**
 - Older homes
 - Warmer climates
 - More single family detached homes

Further analysis

A photograph of a brown dog, possibly a Weimaraner, digging in the sand on a beach. The dog is seen from the side, with its tail raised and curved. In the background, another dog is visible running on the sand. The ocean waves are visible in the distance under a blue sky.

- Time of day variations (set-up and set-back)
- House to house and intra-house variations
- Regressions to determine important variables
 - Region/climate
 - Age
 - Size
 - Fuel type
 - Cooling season (previously all heating)
 - Number of floors
 - Foundation type

Contact

Chuck Booten

Chuck.Booten@nrel.gov

303-275-3167