ENERGY STAR Climate Controls Stakeholder Workshop
November 19, 2014
San Francisco, California

An Approach to M&V for Smart Thermostats Using Daily Average Temperature and Run Time

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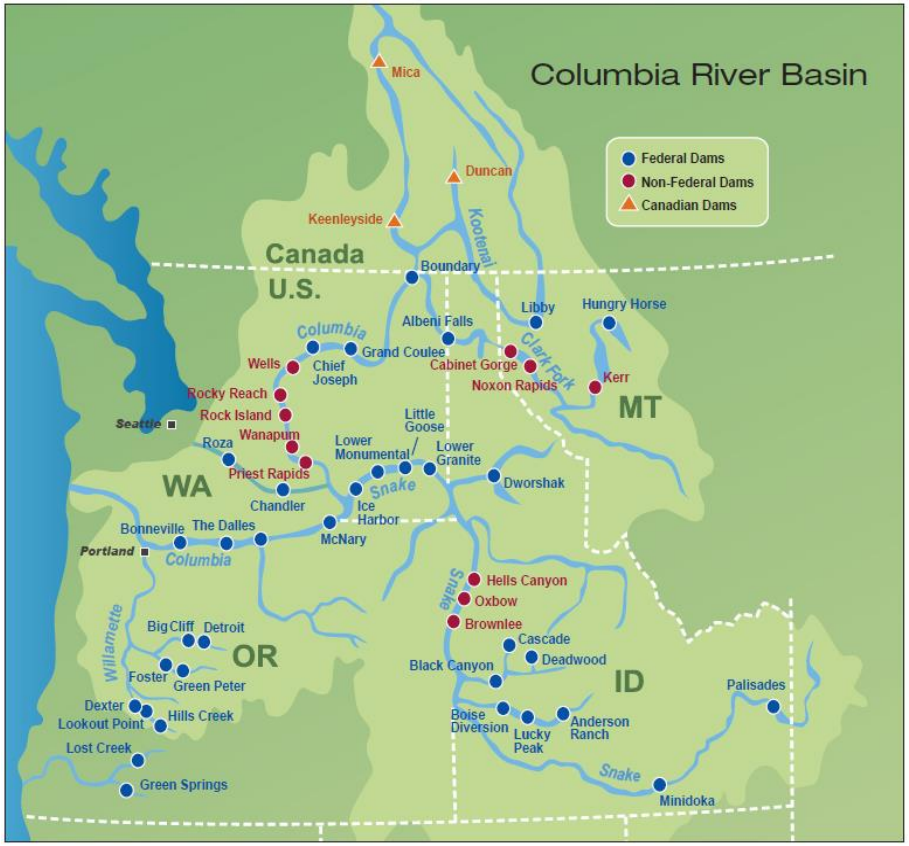
BPA and the Federal Columbia River Power System

- BPA markets electric power to 140+ customers, mostly public utilities
- Wholesale: no direct access to retail utility revenue meters
- BPA acquires cost-effective conservation resources
  - ~$100 million of annual incentives for EE programs
  - “Reliable energy savings”
  - Meets 85% of load growth with conservation resources
  - Limited DR program



Smart and Connected Devices

- Internet-connected
- Data collected and stored by vendor
- Software-based performance
- Rapid product evolution

Smart Thermostats


Photo Courtesy of Energy Hub

Advanced RTU Controls

Photo courtesy of Catalyst

Digital Lighting Controls


Photo courtesy of Digital Lumens

Smart and Connected Thermostats

….vendors promising deeper and more persistent improvements in efficiency than previous thermostats.

Some Claims:

"…save about **20%** on your heating and cooling bill."

"…users saved **24%** on their heating and **21%** on their cooling"

"Save **10 - 15%** more on your heating and cooling."

"…savings of the best WiFi thermostat can range from **$300 to $400 a year**."

Photo Courtesy of Energy Hub

…reliable resource? or not??

Utility Perspective - EE and DR Programs

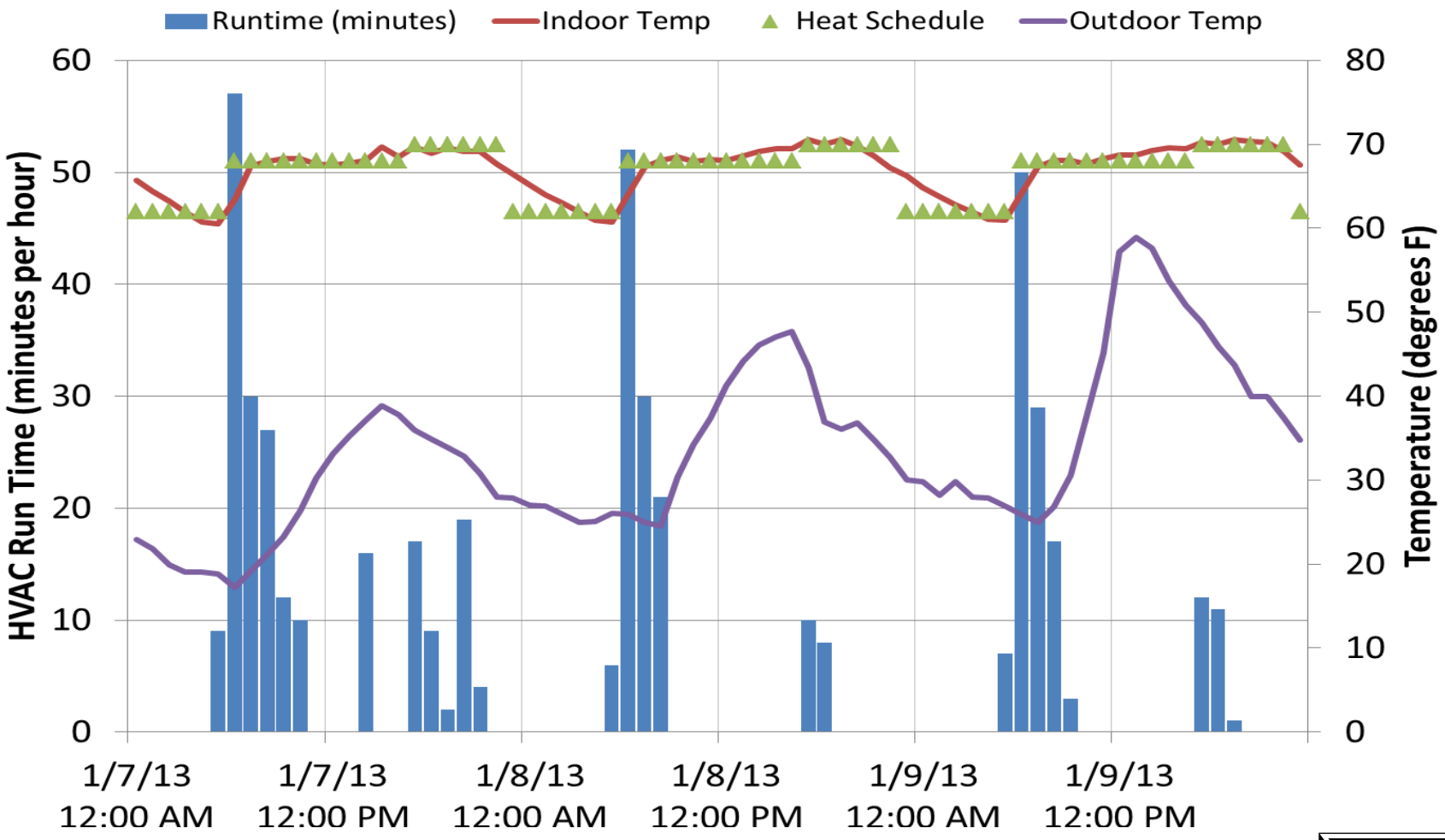
Goals

- Reliable energy savings
  - Quantifiable
  - Persistent
- Responsive demand
  - Measurable
  - Predictable
- Program support (optional)
  - Heat pump & AC diagnosis
  - Home heat loss rate
  - HVAC capacity/sizing

EE Program Needs

- Accurate baseline
- Measure specification
- Third-party validation
- Scalable M&V
  - Low cost measurement
  - Multiple climate zones
  - Multiple products/vendors
  - Adapt to innovation
- Data and device standards

Example Data Set for Single Home



Proposed Approach to M&V Methods

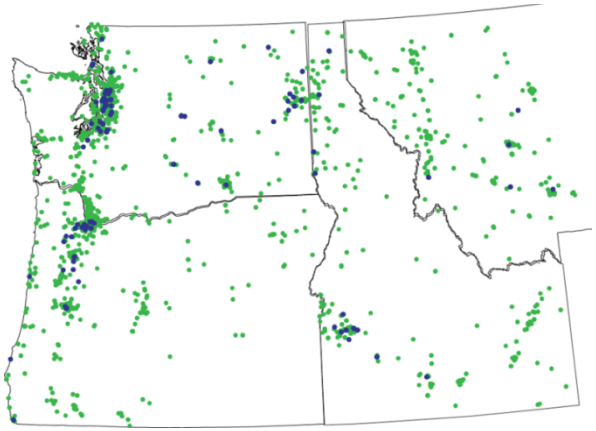
- Unit of analysis is a group of homes (a vendor's customers)
- Collect data from connected thermostats. Report, for each day:
  - Group average indoor temperature
  - Group average outdoor temperature*
  - Group total run time, by mode (R)

  } ΔT
- Isolate deep heating and cooling seasons (ΔT > 12º F in this study)
- Calculate linear regression function: Run time = $f(\Delta T)$
- Establish control group as representative homes from the extensive, 2012 Northwest Residential Building Stock Assessment
- Replace group average indoor temperatures in vendor's data set with average indoor temperature from the control group to estimate run time under baseline conditions (normalized to TMY)

*We use outdoor temperature measurement from the nearest, publically-available weather station

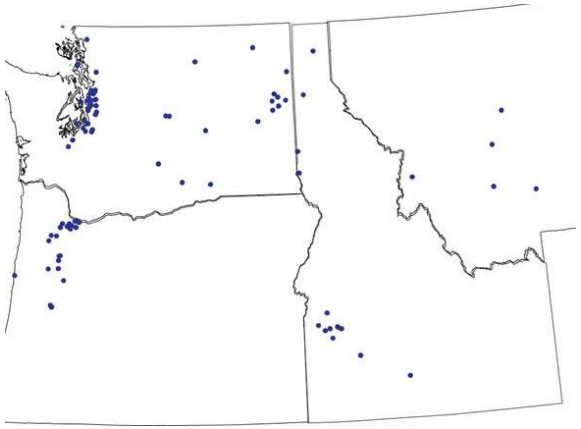
Northwest Residential Building Stock Assessment

- 2012 assessment of residential building characteristics in the Pacific Northwest (RBSA 2012)
- 1,400 total residences surveyed
  - 65% of sites single family
  - 35% manufactured homes & apartments
- 101 homes were selected as representative sample for extensive instrumentation and data collection (including temperature and HVAC energy use)



Source: Residential Building Stock Assessment: Single-Family Characteristics and Energy Use, Baylon, et. al., 2011

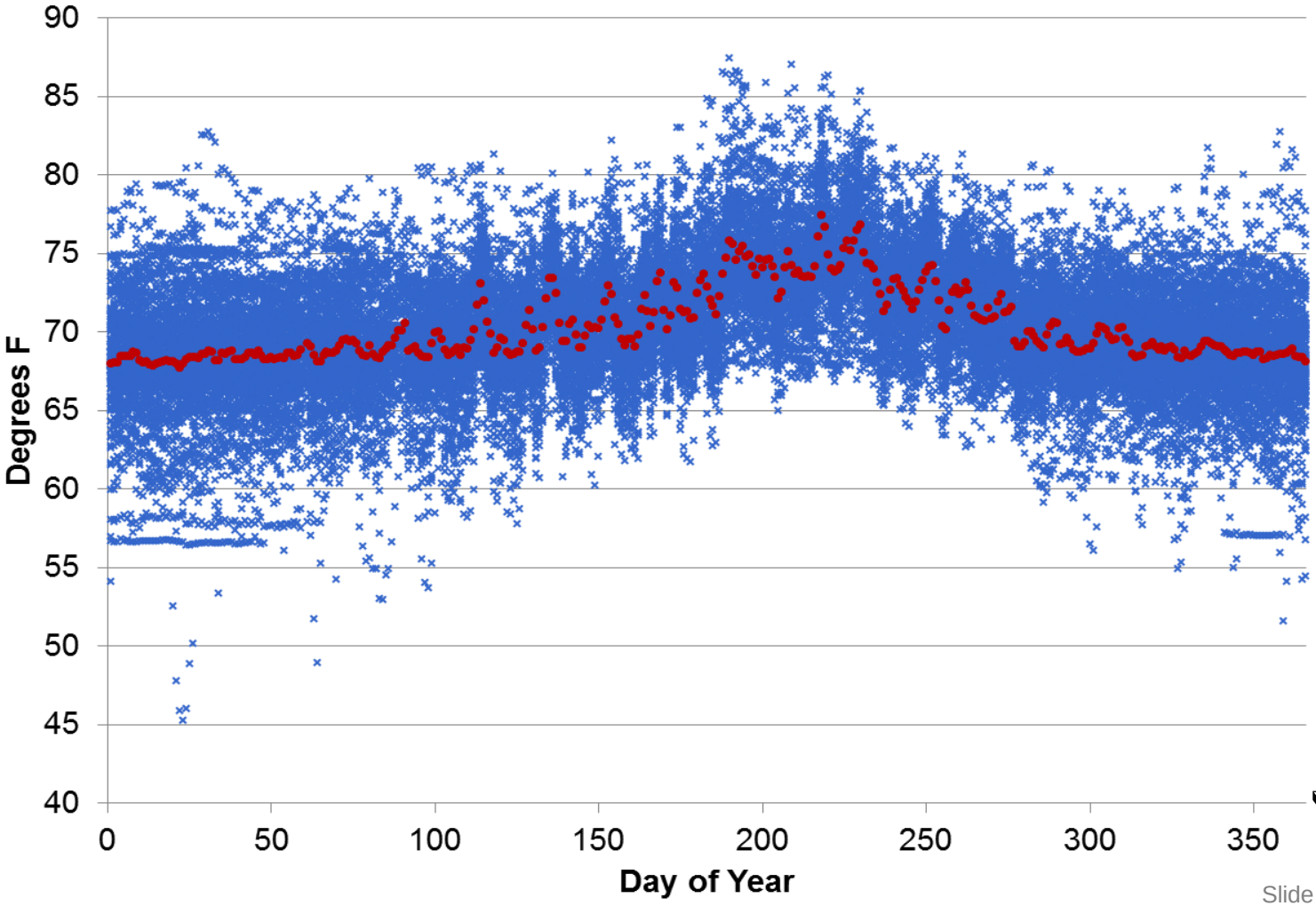
Control Group: RBSA 2012 Homes



- Sample frame: 101 sub-metered homes
  - 19 electric resistance homes
  - 25 heat pump homes
  - 57 natural gas homes
- Two years of data collection
- Whole-home and HVAC energy use at 5-minute intervals
- Run time and natural gas use for furnaces
- Average indoor and outdoor temperatures at 5-minute intervals

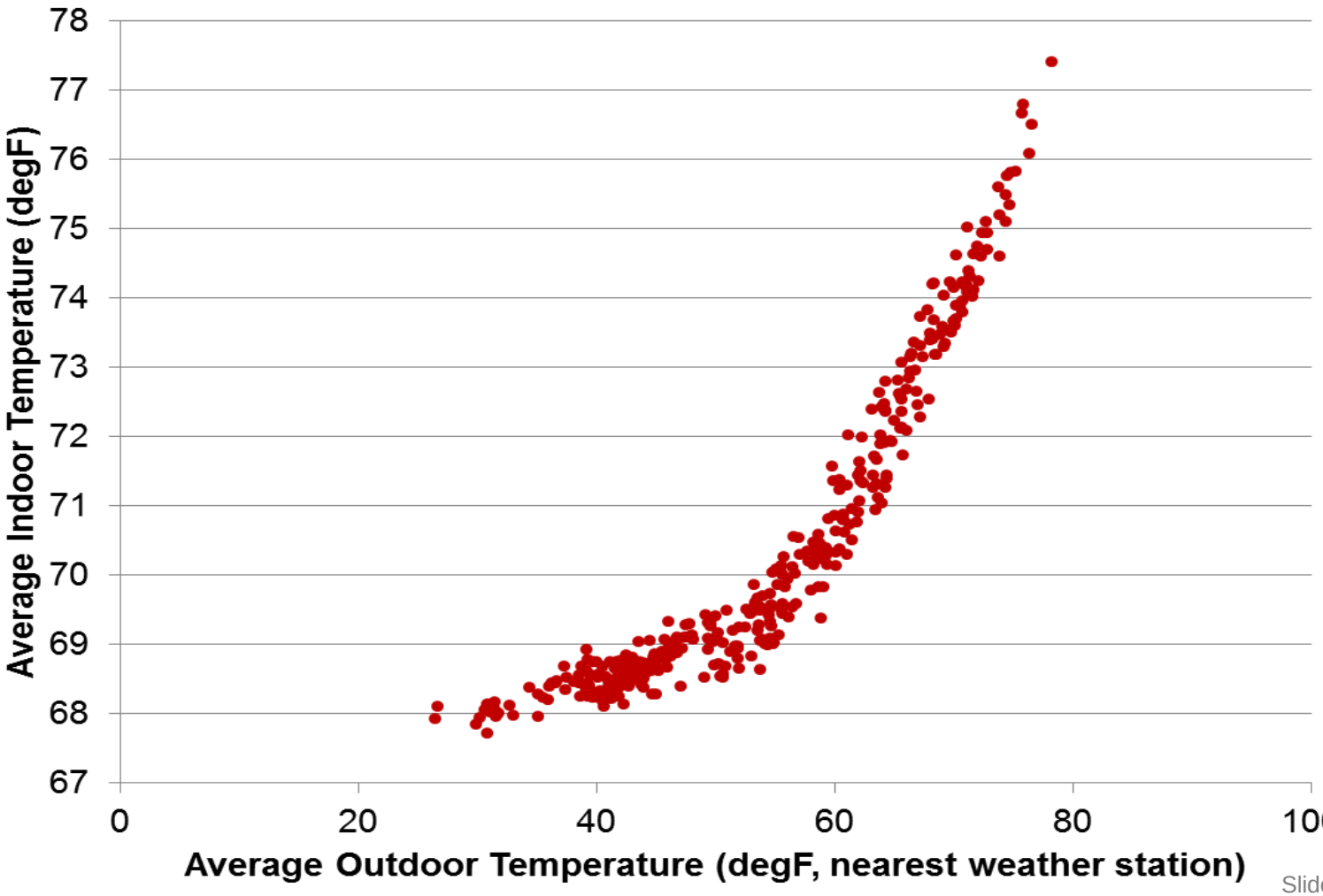
Daily Average Indoor Temperature

(365 days, 101 sub-metered homes, RBSA 2012)



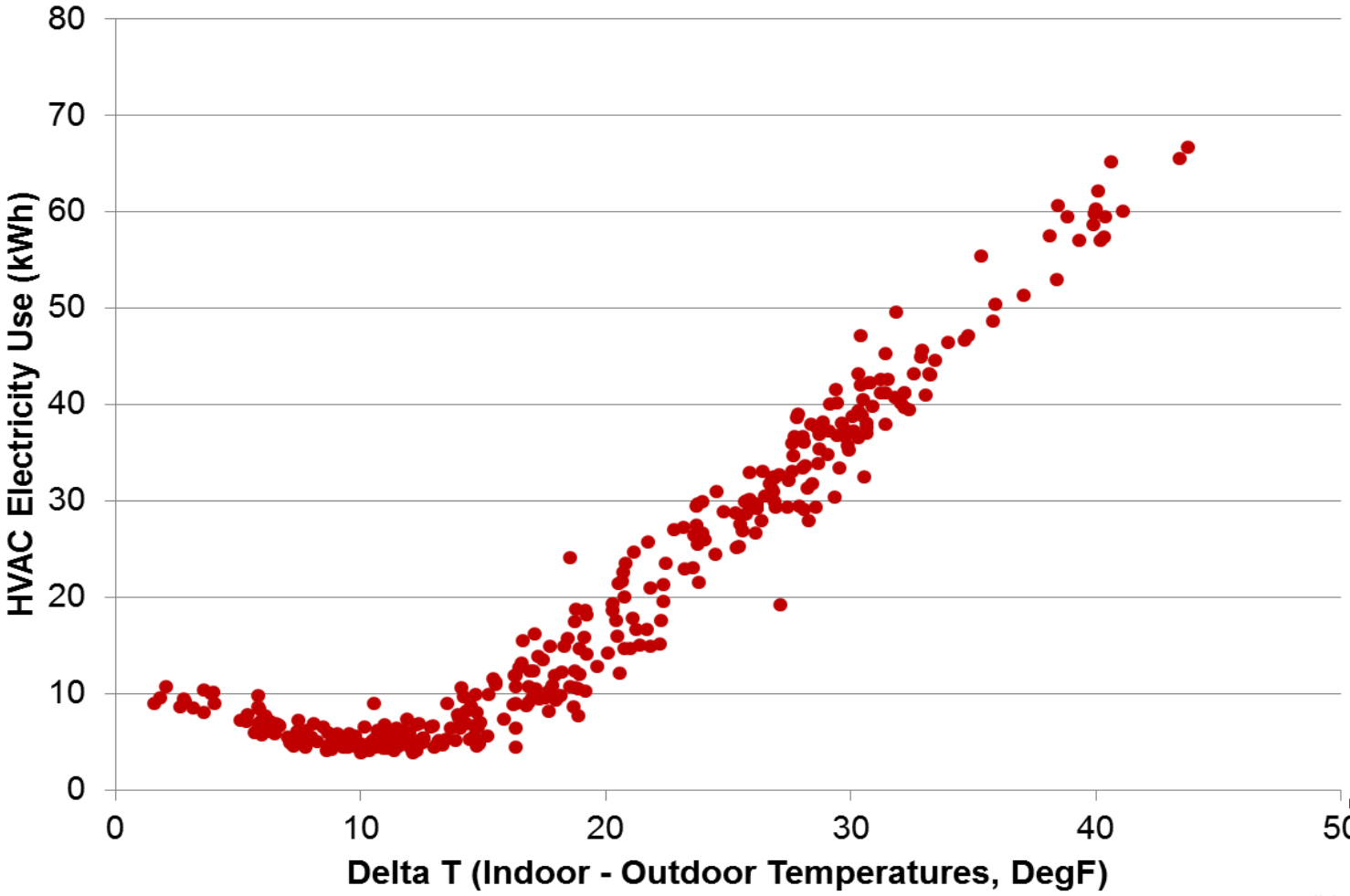
Indoor Temperature vs. Outdoor Temperature

(Daily, group averages, 101 sub-metered homes, RBSA 2012)



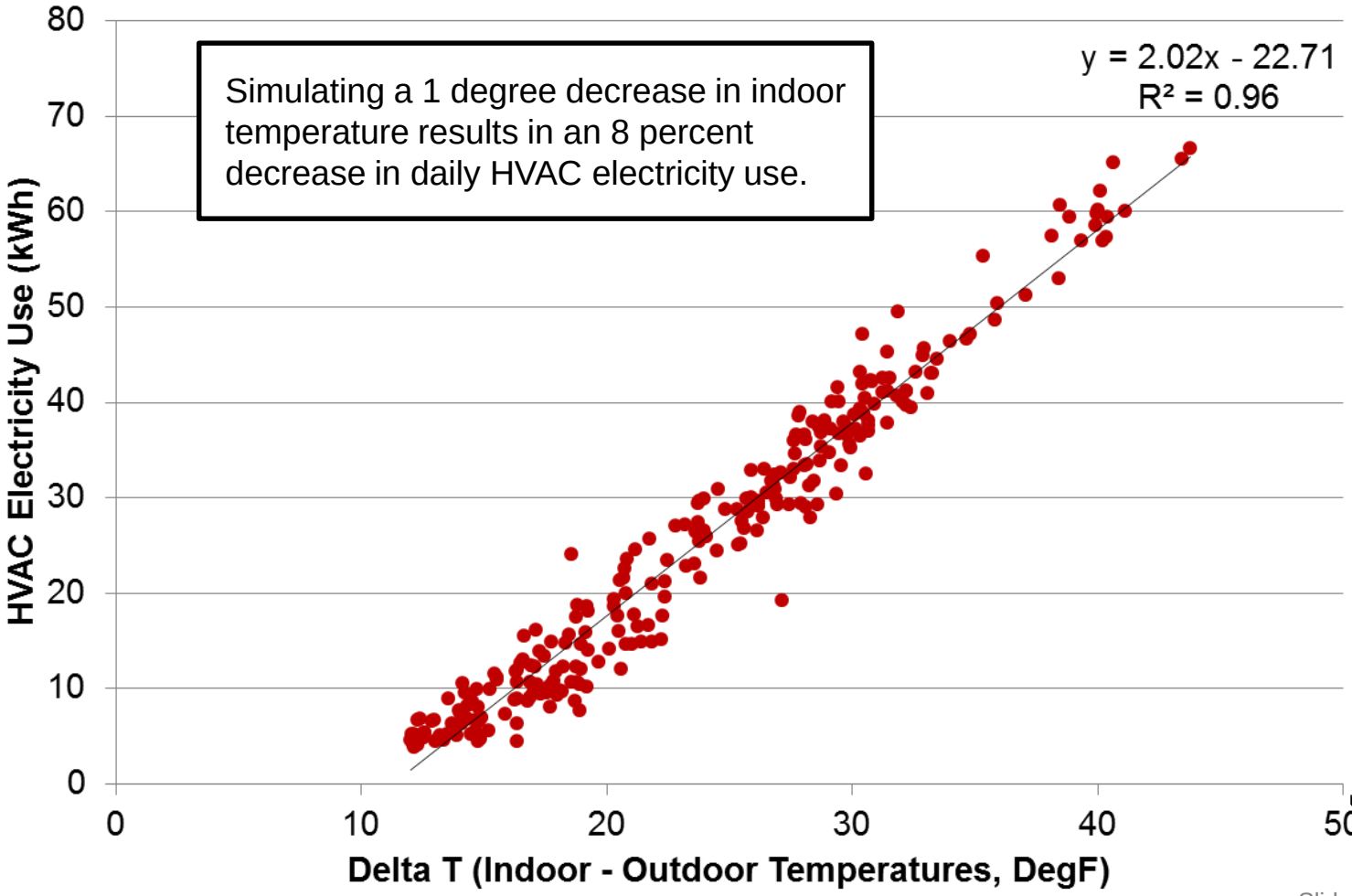
HVAC Electricity Use vs. Delta T

(Daily, group total energy and average temperatures
42 electrically-heated homes, RBSA 2012)



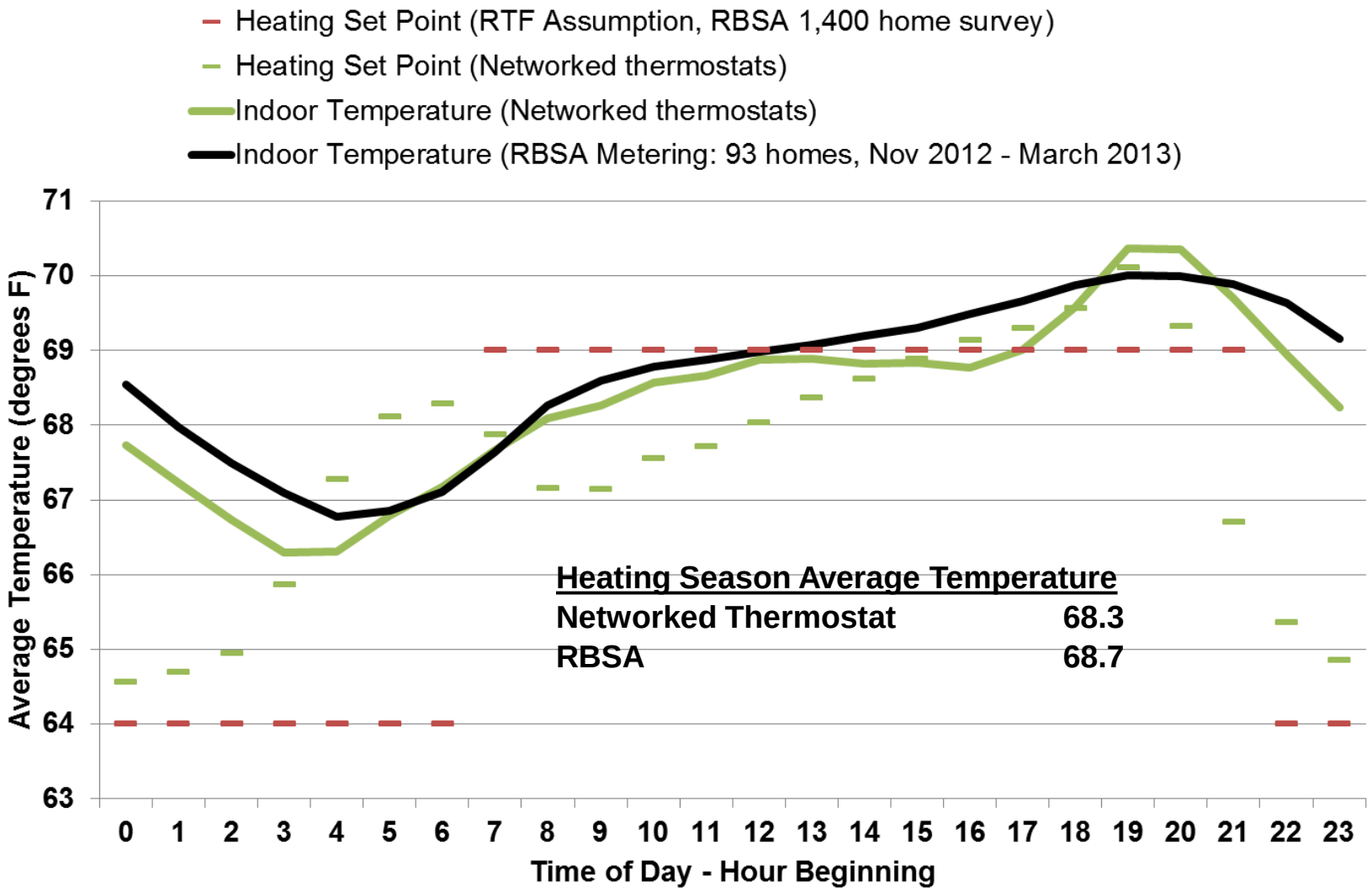
HVAC Electricity Use vs. Delta T > 12ºF

(Daily, group total energy and average temperatures
42 electrically-heated homes, RBSA 2012)



Comparison of Indoor Temperature and Set Points

(Data set comparison, heating season, not weather-normalized)



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