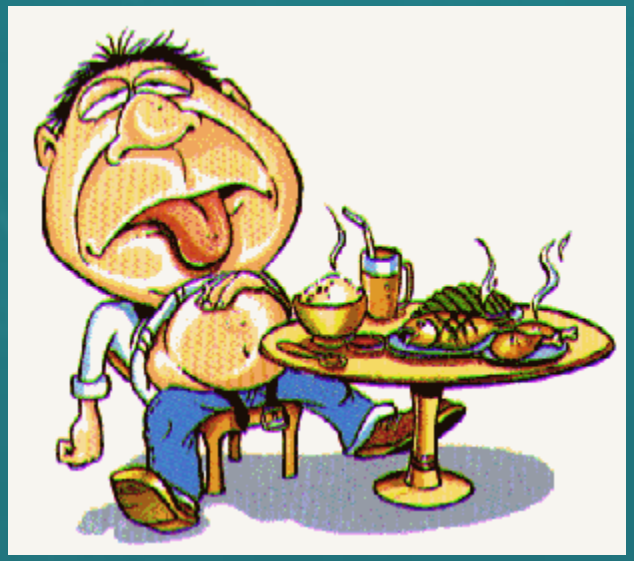
Smart Thermostats: Paving the Way for Smart EM&V

Claire Miziolek, NEEP
Joe Loper, Itron
Abigail Daiken, US Environmental Protection Agency
Richard Counihan, Nest Labs
Nkechi Ogbue, ecobee

ENERGYSAVVY

Setting the Scene

- Control technologies, such as smart thermostats, are the next frontier of efficiency programs



- Introducing the Cast of Characters

The Evaluator

Joe Loper

Nkechi Ogbue
Manager, Regulatory Affairs
nkechio@ecobee.com

Rick Counihan: The Policy Guy
rcounihan@nestlabs.com

The Federal Bureaucrat…

"I'm from the government and I'm here to help."

Abigail Daken,
ENERGY STAR HVAC Product Manager

Claire Miziolek, NEEP
The "*REEO*"

Mission

Accelerate energy efficiency as an essential part of demand-side solutions that enable a sustainable regional energy system

Vision

That the region embraces next generation energy efficiency as a core strategy to meet energy needs in a carbon-constrained world

Approach

Overcome barriers and transform markets through *Collaboration, Education, and Enterprise*

Mission Driven, here to connect the dots and advance the region

Act I: The Technology Promise and the Evaluators' Dilemma

In Pursuit of a Smart Thermostat Protocol

NEEP EM&V Forum Spring Meeting

Joe Loper

April 27th, 2017

SCATTERED LITERATURE

Baseline T-Stat	Cooling Savings % (n)		Heating Savings % (n)	
	kWh	Summer Peak kW	kWh	Btu
Programmable				
Programmed	1 (2)			6 (3)
Manual	15 (2)	16 (1)	12 (1)	12 (3)
Unknown	8 (5)	13 (1)		3 (5)
DLC		3 (1)		

Can I Get an Evaluation from the Crowd?

Our business objective is:

To have a meaningful impact on our customers lives and the environment.

How do we do it?

By making it effortless for everyone to be energy efficient at home.

National Grid 2011 Wi-Fi Programmable Controllable Thermostat Pilot Program Evaluation

nationalgrid

16%

Average cooling use

8% to 10%

Average gas/heating use

Evaluation Context and Parameters	
Objective	• EE – Assessed annual gas and cooling season savings
Evaluator	• The Cadmus Group
Region/Location	• MA and RI
Equipment Type	• Natural Gas Furnace • Central AC
Evaluation Method(s)	• Heating – Billing Analysis • Electric – Site-level data capture paired with ecobee trend data
Savings Reached – Cooling and Electric	• Average of 16% estimated cooling season energy usage
Savings Reached – Heating	• Average of 8% to 10% annual pre-installation gas usage (depending on the thermostat type replaced)

2014 SDG&E PTR Rebate and SCTD Impact Evaluation

0.66 kW

Ex post average individual participant event hour load reduction

0.66 kW

Ex ante average individual participant event hour load reduction in the 1-in-10 weather scenario

0.48 kW

Ex ante average individual participant event hour load reduction in the 1-in-2 weather scenario

Both ex post and ex ante results reflect customers dually enrolled in the Small Customer Technology Deployment (SCTD) and Peak Time Rebate (PTR) Programs and the 4 summer season events

Evaluation Context and Parameters	
Objective	• Peak demand reduction: • Ex post and ex ante evaluation of enabling technology and ADR
Evaluator	• Itron
Region/Location	• CA
Equipment Type	• Central AC
Evaluation Method(s)	•Ex Post – Comparison Group Matching •Ex Ante – Compares ex post regression model results with other data sources
Ex Post Peak Demand Reduction – Dually Enrolled SCTD Customers	•0.66 kW: Ave. individual participant event hour load reduction •0.77 MW: Ave. aggregate load reduction
Ex Ante Peak Demand Reduction – Dually Enrolled SCTD Customers	•0.66 kW: Ave. participant event hr load reduction (in the 1-in-10 weather scenario; based on 2014) •0. 48 kW: Ave. participant event hr load reduction (in the 1-in-2 weather scenario; based on temperate weather patterns)

ecobee Internal Study: 2015 Runtime Savings Estimates

23%

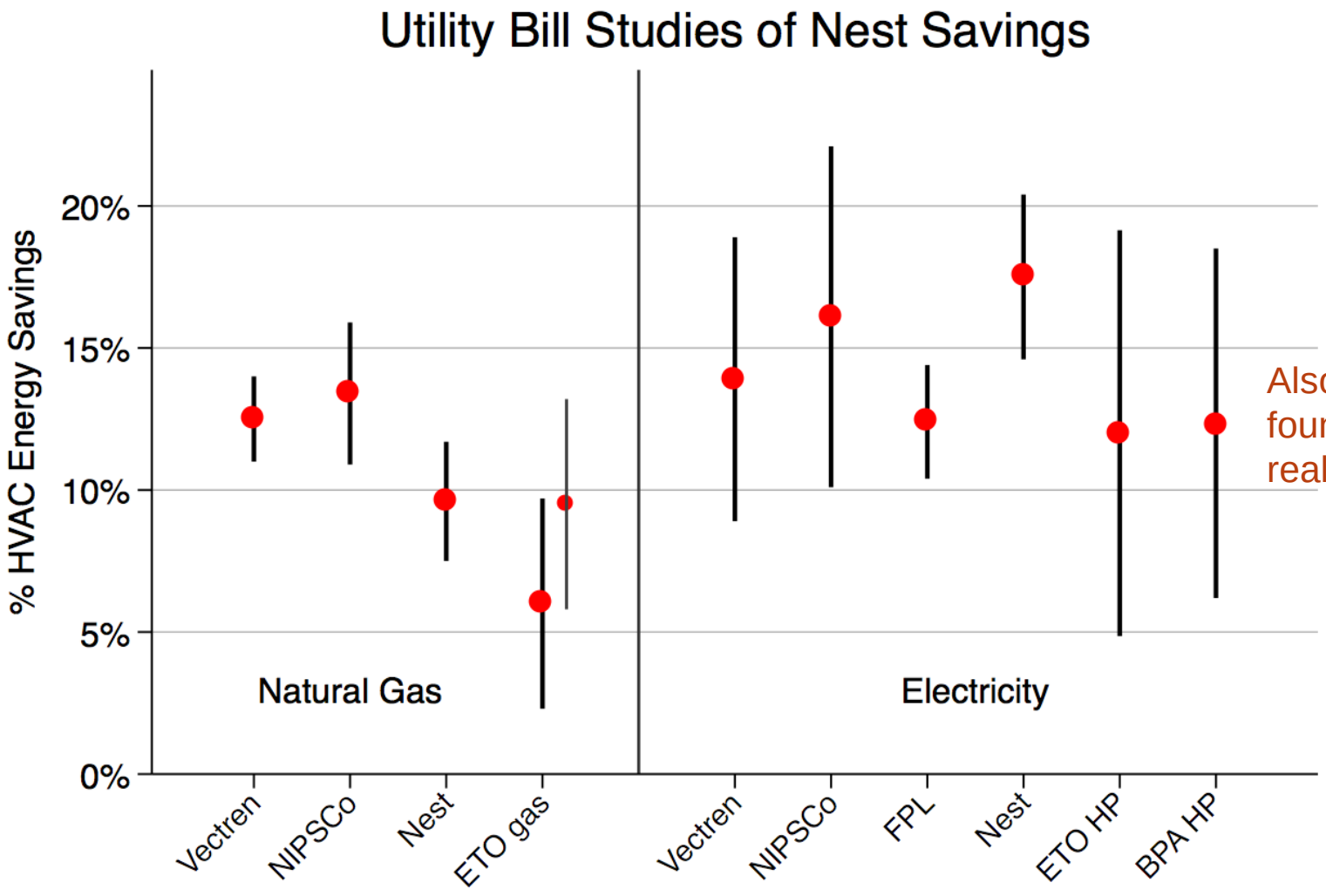
Average cooling system run time savings

22%

Average heating system run time savings

Note: Run time model used compared to a 72˚F hold

Evaluation Context and Parameters	
Objective	• EE - ecobee 2015 follow-up evaluation of North American install base heating and cooling run time savings
Evaluator	• Internal: ecobee
Region/Location	• Install base across North America, including sub-set of ecobee3 consumer population specifically
Equipment Type	• Various
Evaluation Method(s)	• Results reflect terabytes of data from hundreds of thousands of registered residential ecobee thermostat owners • Calculates run times based on the relationship between equipment runtime and the outdoor and indoor temperature set point differential • Run time model is then compared to a 72˚F set point that is held at all times
Savings Reached – Cooling	• Ave. of 23% run time savings
Savings Reached – Heating	• Ave. of 22% run time savings



Also: multiple studies found that customers really like them!

note: only includes publicly available Pre/Post Utility Bill Studies using standard M&V methods

Independent Study #1: Energy Trust of Oregon

Heating electric savings

- Electricity Savings: **12% of heating** use, 781 kWh/yr
- Savings attributed to strip heat control (Heat Pump Balance)

12%

Customer satisfaction

- **High satisfaction: 89%**
- Improved Comfort: 66%
- Non-Energy Benefits: 34% say worth the cost even without energy savings

89%

n = 185 heat pump customers, independent evaluation by Apex Analytics

Independent Study #2: NIPSCo Indiana

13%

Heating savings

Natural Gas Savings: **13.4% of heating use**, 106 th/yr

16%

Cooling savings

Electricity Savings: **16.1% of cooling** use, 388 kWh/yr

n = 400, independent evaluation by Cadmus

Standard programmable thermostat group savings: 7.8% heating, 15% cooling

MAJOR SAVINGS VARIABLES

- Functionality
  - e.g., 2-way communication with HVAC, 2-way ISP communication with resident, remote control with smart phone, programmability, optimization using sensors, geo-fencing, etc.
- Program design
  - e.g., shelf rebates, direct install, user training, related measures, DLC, etc.
- Baselines
  - e.g., manual, programmed, active DLC, unknown, etc.
- HVAC type
  - e.g., HP, CAC w/furnace, other?
- Manufacturer? A function of functionality?

WHERE WE LANDED

- Long list of Required Functionality
  - Anticipating adoption of EPA certification requirement in future
- Baseline Assumptions
  - Retrofit – assumes RUL = EUL = oo
  - May add
    - Early Replacement – would assume RUL< EUL
    - Time of Sale - would reduce incremental costs and savings
      - If programmable % of sales > % of stock
- Simple Algorithm
  - % savings x heating/cooling consumption
- % savings
  - Field test or EPA minimum field test for certification
  - 6% heating, 7% cooling

WHERE WE LANDED (CONT'D)

- Heating/cooling consumption
  - Shelf rebates or HVAC system unknown
  - HVAC not replaced
  - HVAC replaced
  - CAC w/ central furnace, ASHP
- EUL = 7.5
  - Versus 3 and 11 (CA Work Papers), 5 (RTF), 10 (WI), 11 (AR)
- Incremental Cost
  - Retrofit -- Full cost $225 including labor
  - Time of Sale
  - Ballpark based on studies and web search

Help!

Manufacturers please get ENERGY STAR certification.

Program administrators please require it (eventually).

NEEP please help us all.

Act II: A Data-Based Approach

ENERGY STAR = Energy Efficiency

ENERGY STAR has become synonymous with energy efficiency.

The Service and its Energy Use

- Fundamental service: HVAC systems control for comfort
  - Use the least energy to do so, by the way
  - And make it convenient
- ***L a r g e*** savings potential
- How to measure delivered efficiency?

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  - Lab test

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  - Rely on features (programmability)

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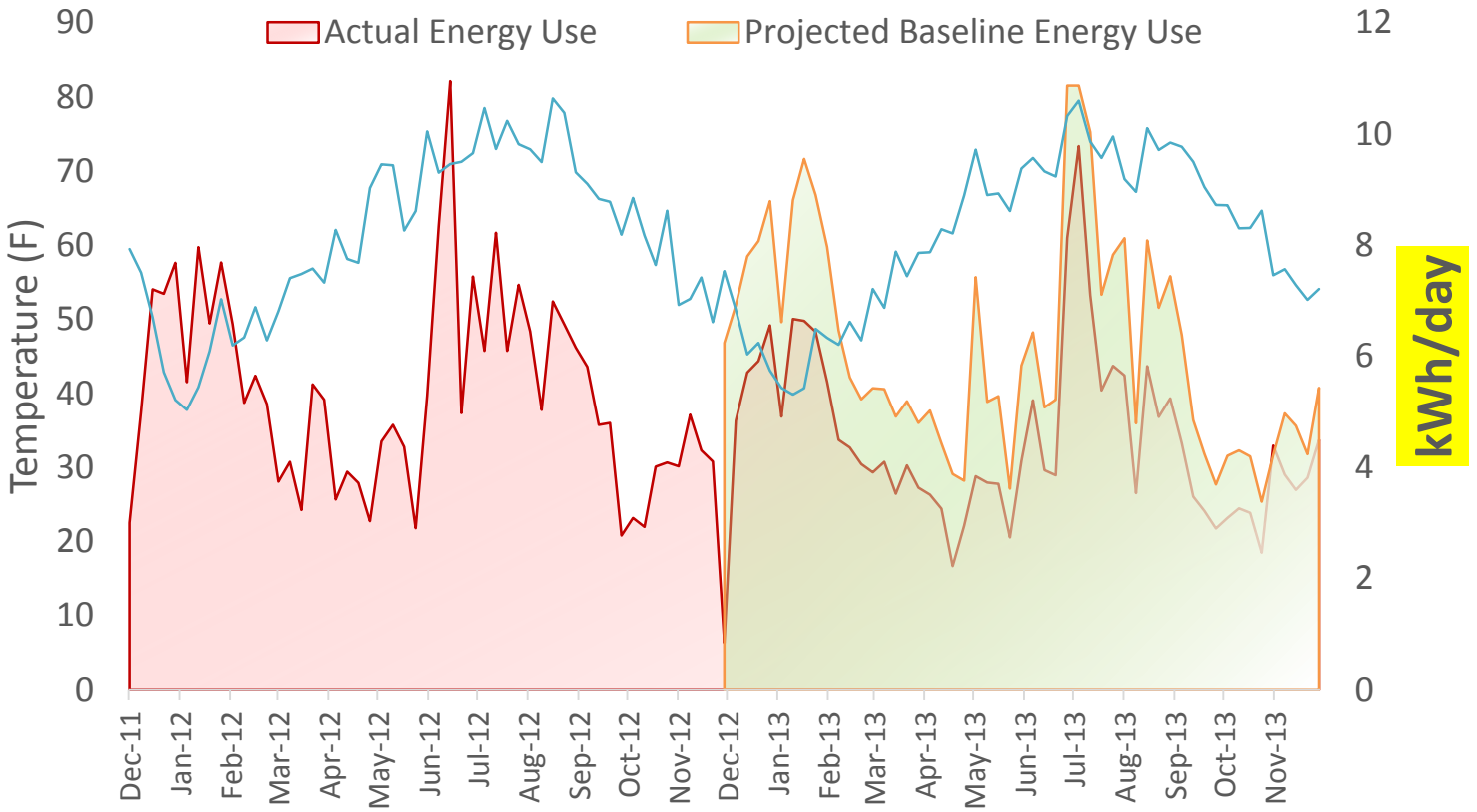
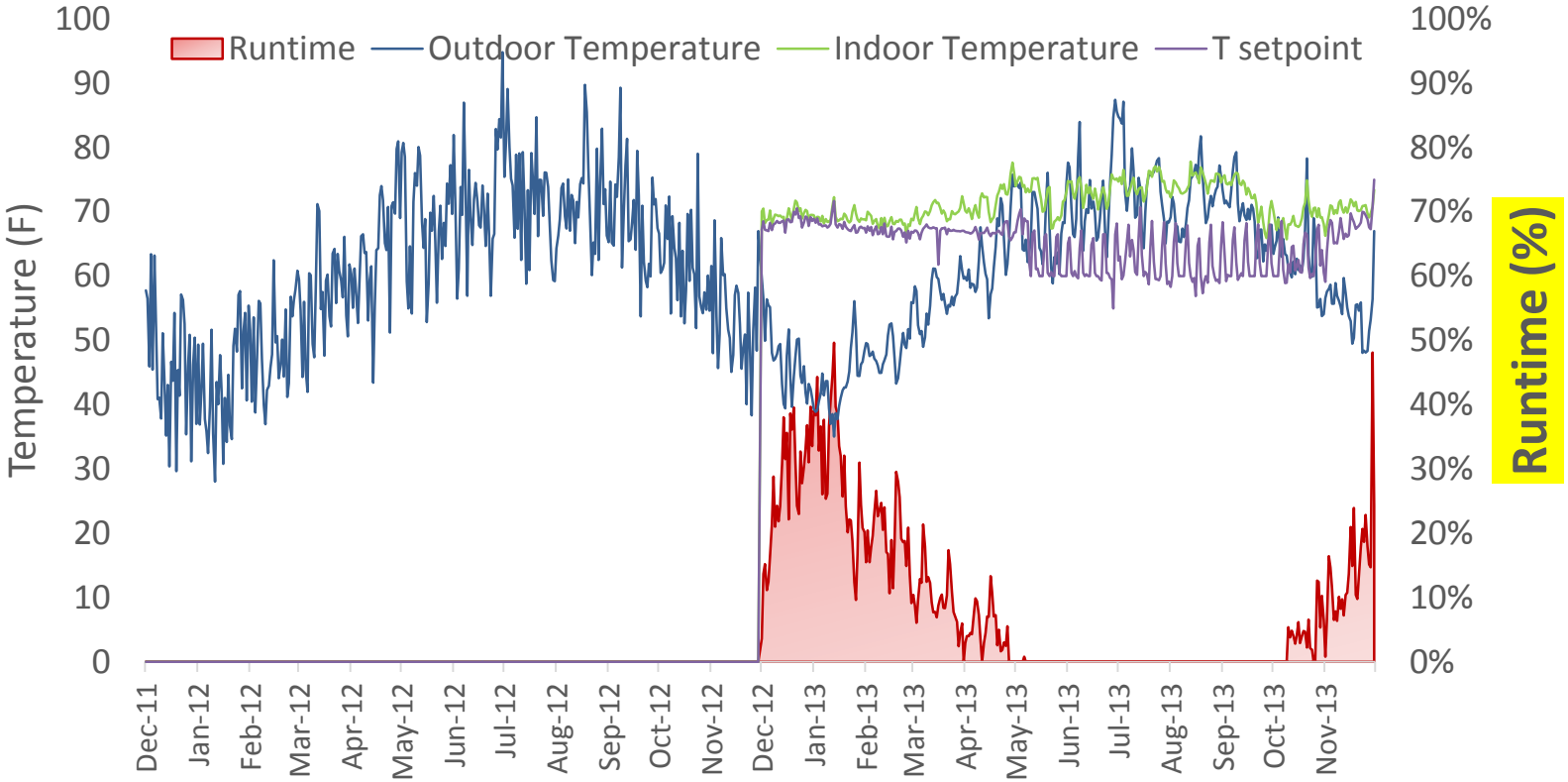
  - ~~Lab test~~
  - ~~Rely on features (programmability)~~
  - **Providers now HAVE DATA reflecting user choices and interactions!**

M&V: Meter Data Before + After Measure



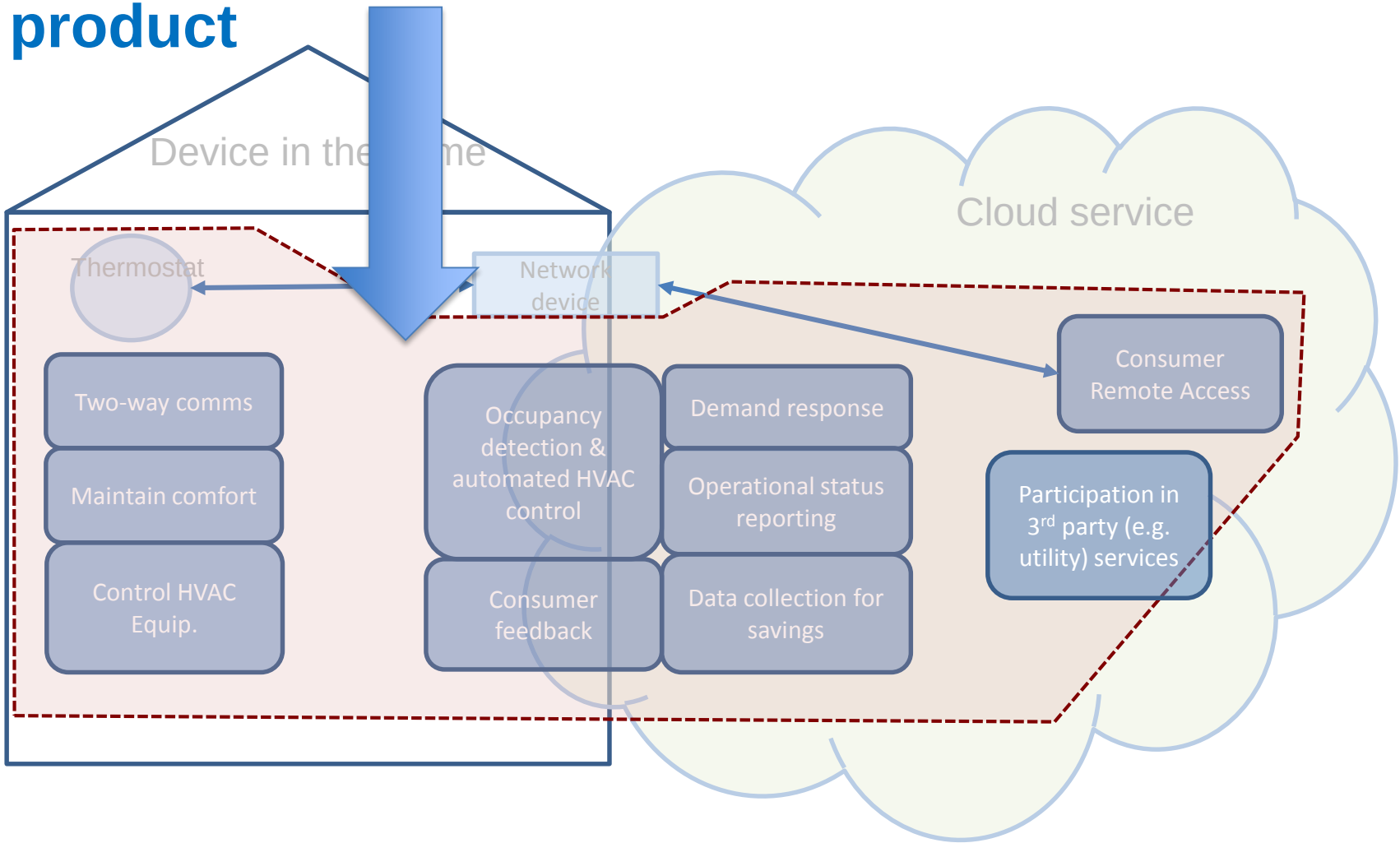
- But kWh/day data includes everything, not just heating and cooling
- Therefore also includes a lot of noise

CT Data: Only After Installation

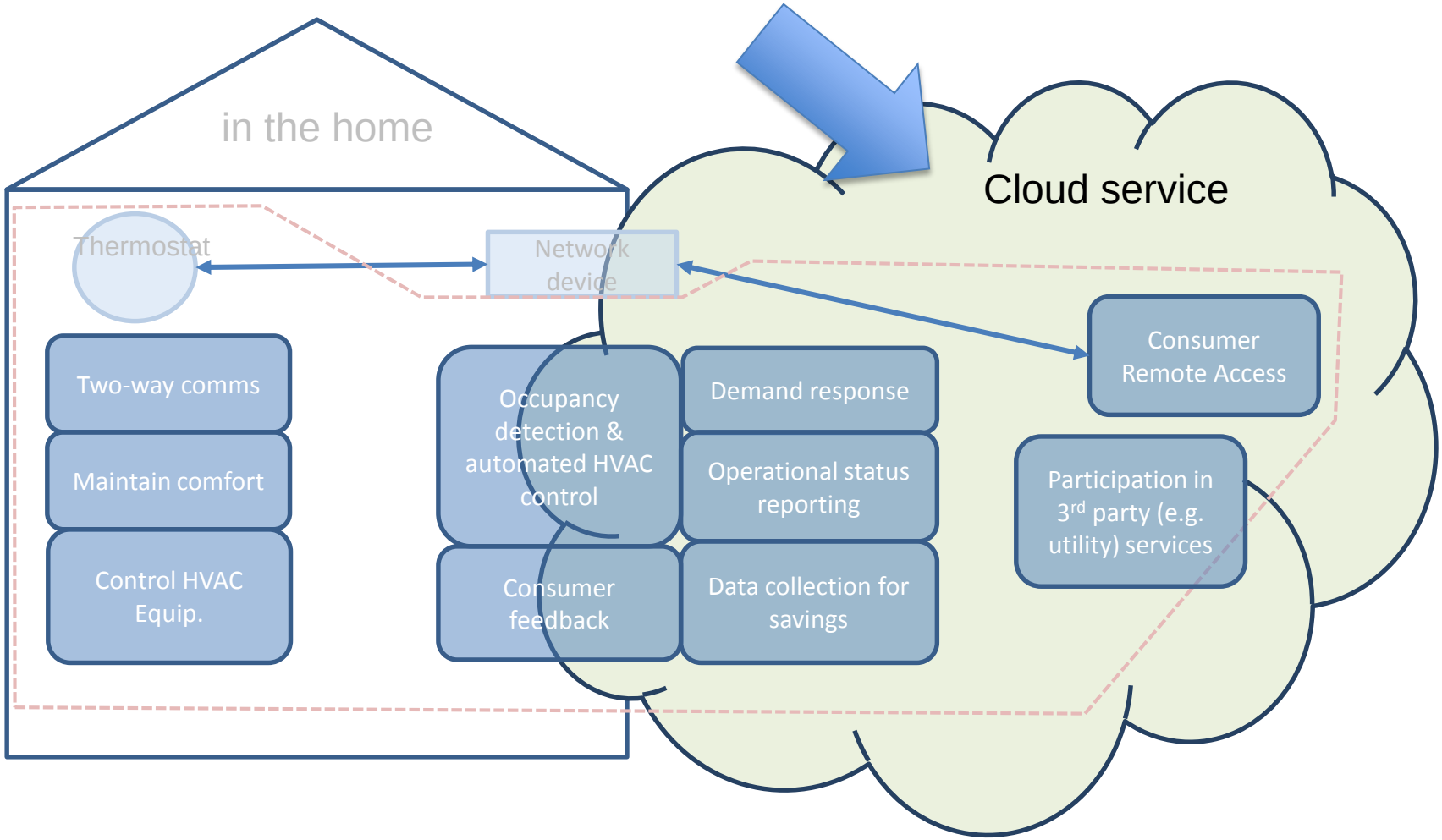


- Runtime is only heating and cooling, no other energy uses
- Wider variety and denser data provide more info

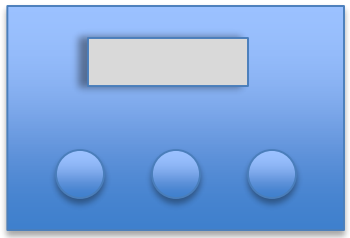
Hardware + Service is the ENERGY STAR product



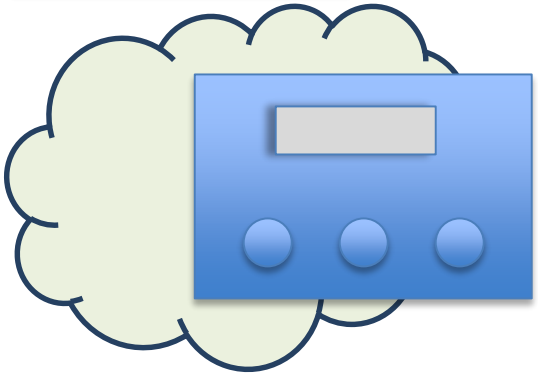
Service Provider is the ENERGY STAR Partner



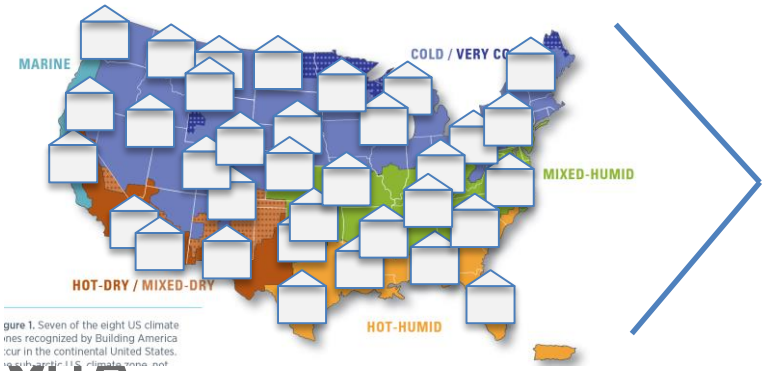
Earning the ENERGY STAR



1. Thermostat device passes basic tests



2. Thermostat product demonstrates basic capability

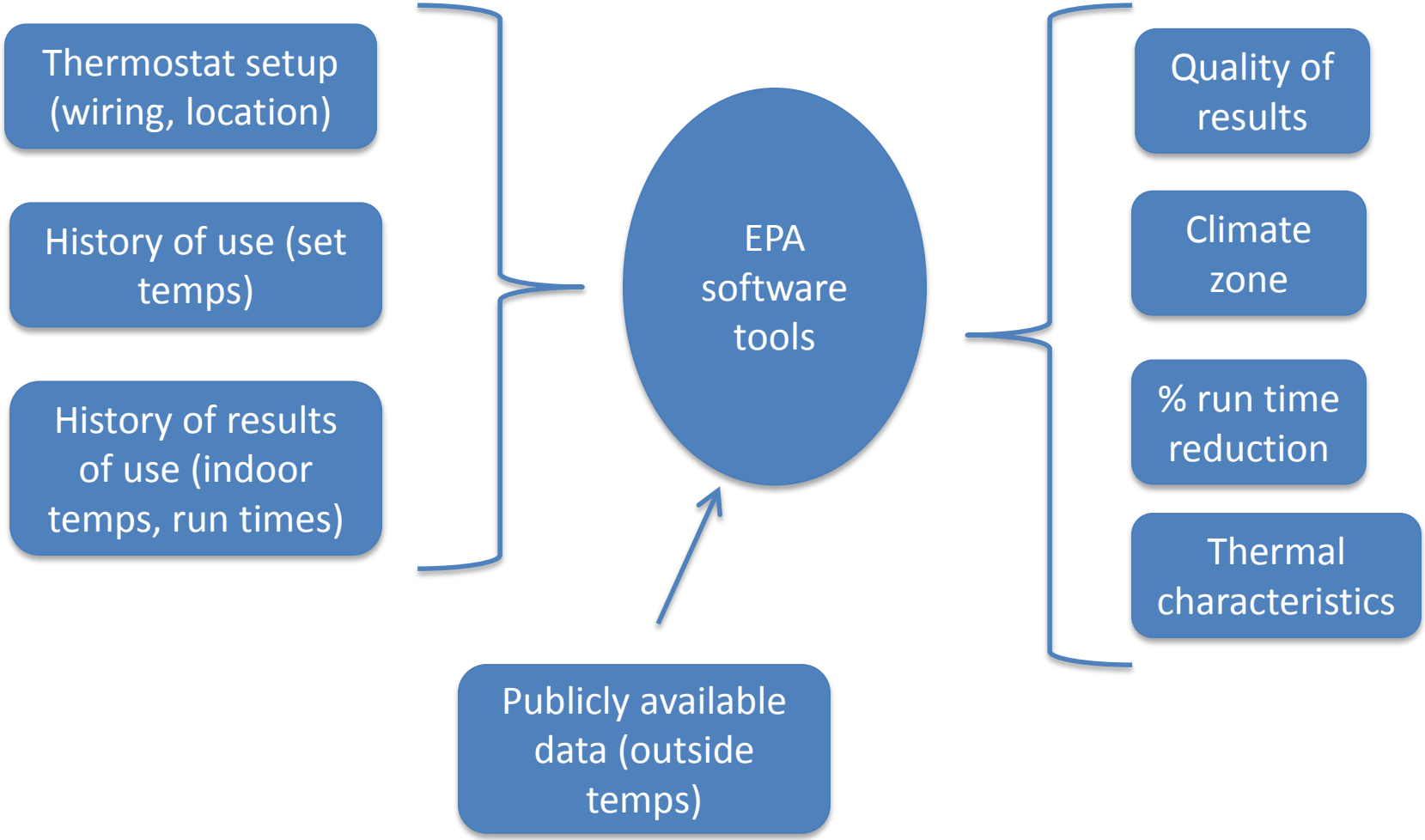


Heating savings

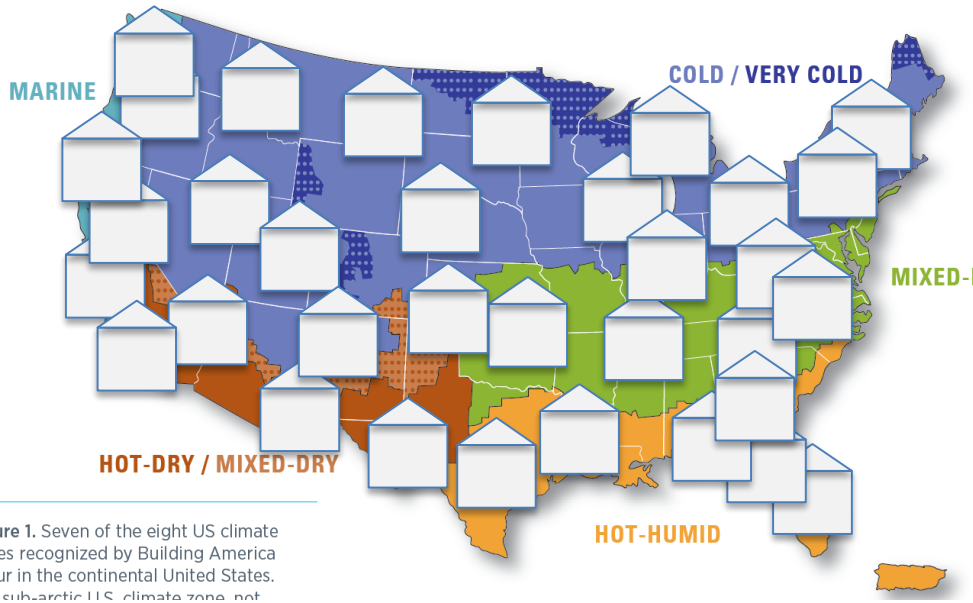
Cooling savings

3. Demonstrate field savings using EPA software tools to analyze and aggregate data from hundreds of US homes

Metric For Each Home



For Sample of Hundreds of Homes



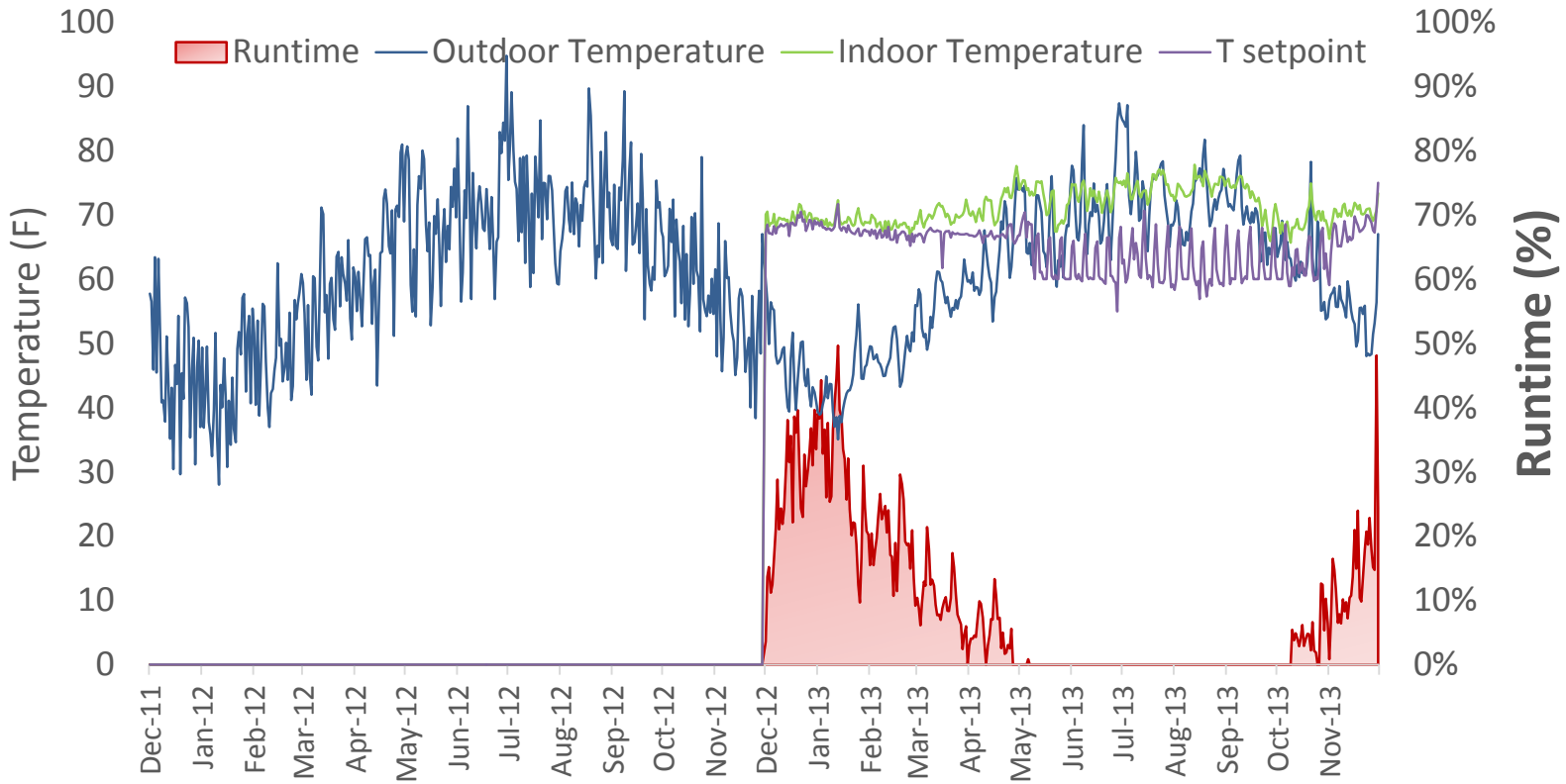
gure 1. Seven of the eight US climate
nes recognized by Building America
:cur in the continental United States.
ıe sub-arctic U.S. climate zone, not

- Cold/Very Cold
- Marine savings
- Mixed Humid
- Hot Dry/Mixed Dry
- Hot Humid savings

Weighted average National savings

Statistical information: deciles, standard error of the mean, etc.

All about that Bass …. Baseline, that is



All about that Bass …. Baseline, that is

- Currently: Comfort temperature from indoor temp history, captures setback only
- Possible in the future: Regional indoor temperature, could captures setback and better comfort temperature
- Only a baseline of run time would capture savings from less run time without changing temperature, e.g. shading, night flushing, etc.

Implications of Field Savings Criteria

- Ensures that a large group of **users will on average save a large amount of energy** (because of the lower 95% bound of average heating and cooling savings).
- Also ensures that the distribution isn't bimodal, with a few giant savers and a lot of losers. **At least 80% of users will see substantial savings** (because of the 20th percentile requirement).
- The metric scores may over- or under-predict savings in a particular utility service territory
  - Only account for setback savings (other savings have been demonstrated by some products)
  - Savings compared to a comfort temperature baseline (known to be not entirely realistic)
  - The average metric savings scores required (**10% in cooling, 8% in heating**) are similar to the savings quoted for smart thermostats in utility pilot M&V studies.

Advantages of proposed approach

- Not HOW energy savings are achieved, just WHETHER they are
- Level playing field
  - Accommodates wide variety of products
  - Can credit savings achieved through services
  - Wide scope for innovation, including behavioral

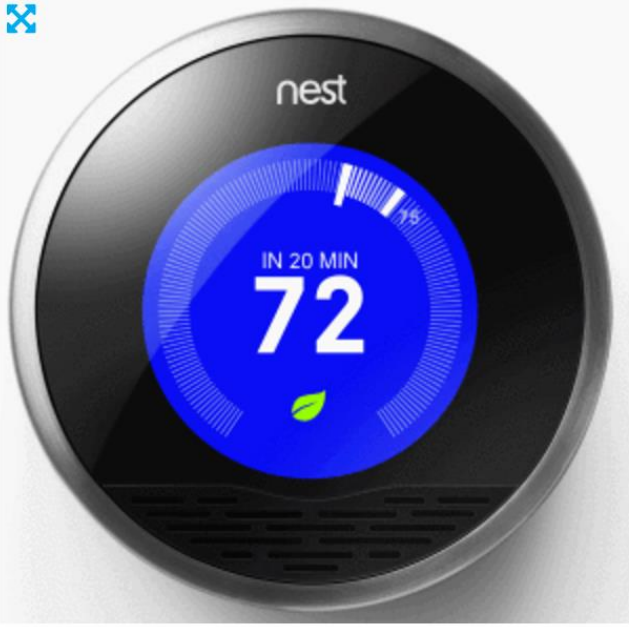
From the Chorus?

BUILDER

NEST EARNS FIRST EPA ENERGY STAR CERTIFICATION FOR A SMART THERMOSTAT

The Nest Learning Thermostat saves 10-12% in heating and 10-15% in cooling, translating to more than $100 in savings for homeowners per year.

By Lauren Shanesy



The Nest Leanring Thermostat from Nest Labs

The Nest Learning Thermostat, a smart thermostat that uses artificial intelligence technology to learn consumer preferences and make energy-efficient decisions about heating and cooling a home, is the first smart thermostat to receive an EPA ENERGY STAR certification.

The testing showed that the system saves 10-12% in heating and 10-15% in cooling, saving homeowners an average of $131 to $145 per year on energy costs. The thermostat currently retails for $249, which means the thermostat can pay for itself in

ecobee Views and Involvement on the ENERGY STAR CT Specification and Process

- ecobee began working with the EPA on the Version 1.0 Method to Demonstrate Field Savings in 2014
  - With other stakeholders, we provided feedback and inputs into the various specification drafts and what is now the current metric
- Metric strengths:
  - Introduced a consistent and formalized process that multiple stakeholders are comfortable with
  - Methodology can translate at the state and regional level
- Metric limitations:
  - It does not work as a thermostat ranking and should only be viewed for the minimum level of savings achieved
  - Self-baselining approach may dampen savings of consumers with more efficient behavior before the new CT is installed

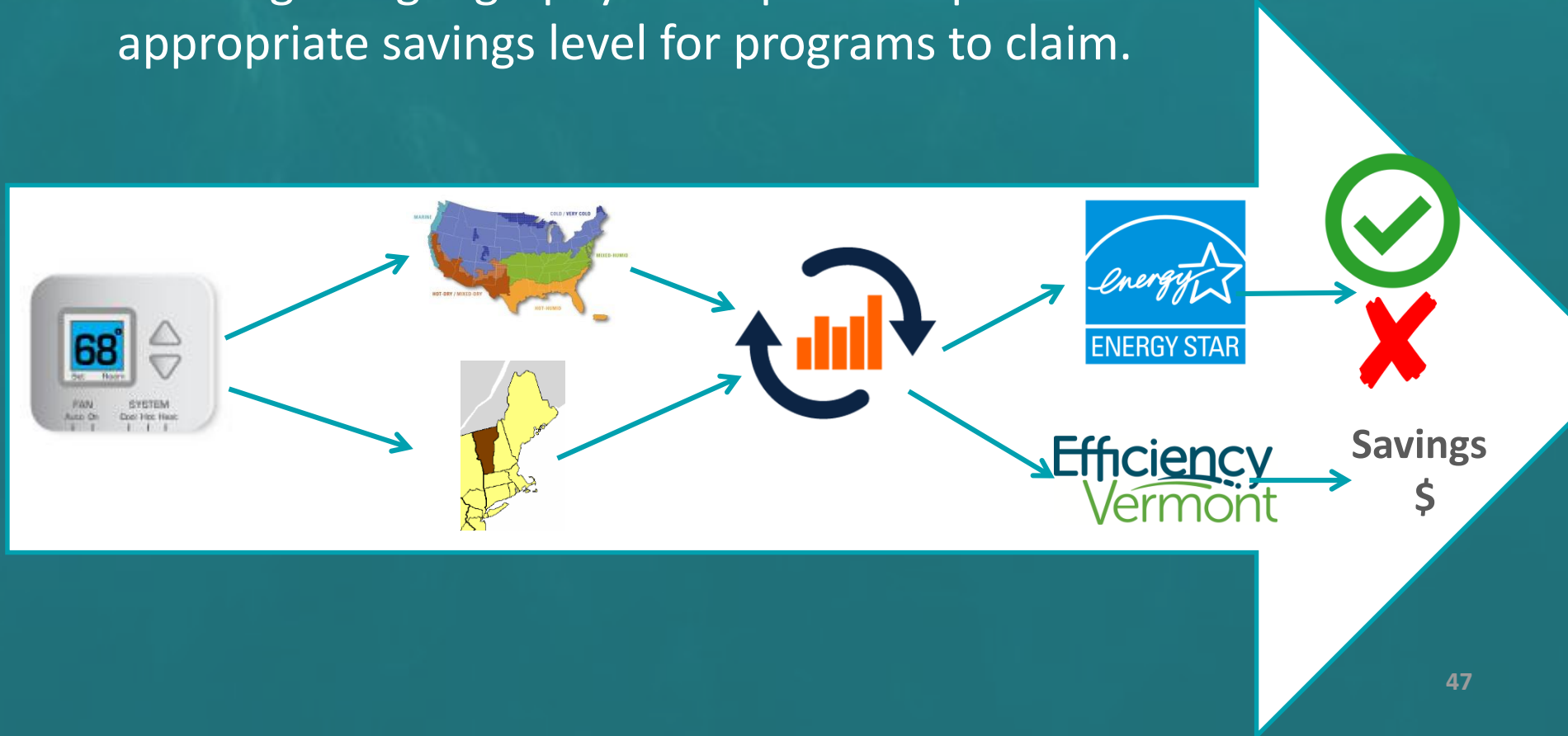
Filling some Gaps: NEEP's Claiming Savings from Smart Thermostat Guidance Document

What We've Established thus far…

- We know there is savings to be had from Smart Thermostats
- BUT as a control technology, it's not "efficient"
- ENERGY STAR's specification identifies the top performers, but does not given you enough to claim savings
- NEEP's forthcoming document walks through how to do this

In one sentence (and a flow-chart)…

- Using ENERGY STAR's methodology and metric tool, programs negotiate with manufacturers to run the field data from a given geography with specific inputs to determine an appropriate savings level for programs to claim.



Step-by-Step Process

- **Step 0**: Programs establish the minimum criteria of "ENERGY STAR Certified" in their smart thermostat promotions
- **Step 1**: Smart thermostat manufacturers certify their products to the ENERGY STAR Specification
- **Step 2**: Program administrators amend contracts* with manufacturers to include a provision for calculating savings.
- **Step 3**: Program-specified data is run through the ENERGY STAR metric to produce a score; that score summary is provided to the program or a 3rd party for analysis
- **Step 4**: Programs and evaluators use the score to determine the appropriate level of savings to claim.

Many considerations and decision to be made

- What is your jurisdiction? (State? Region? Utility territory?)
- What assumptions are you making about the HVAC usage in your jurisdiction?
- What all will you do with this data?
  - Only for claiming savings, or other uses?
- Document in final round of edits, available in next few days here: http://www.neep.org/claiming-savings-smart-thermostats-guidance-document

Act III: Conclusion

NEEP's Parting Thoughts

- More controls are in our future
  - Commercial lighting controls already working into programs
- Data driven approaches for control devices are needed and possible
- Let us not be afraid…together, we can be successful

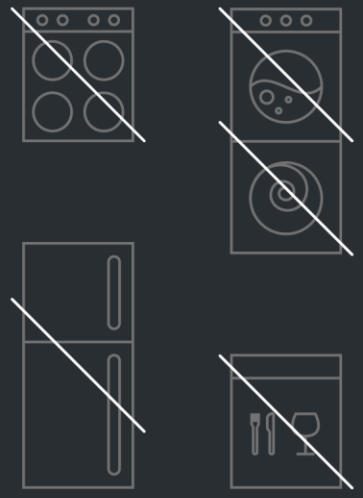
Conclusion: Suggestions for States and Utilities

- Start with Energy Star rating as the benchmark for what qualifies for your program.
- Use the EPA threshold levels for Energy Star rating, 8% savings on heating, 10% savings on cooling for your initial value of savings.
- This can be confirmed for your geography by manufacturers running the EPA protocol for your zip codes to make sure that your area is not significantly different than national averages.
- After a year or two, you can adjust the savings values for your geography by running a pre- and post- analysis using meter data on an appropriate sample of participants if you deem that necessary.

Doing more with less

1 year's energy savings from ecobee =

getting rid of all major appliances **and still getting the chores done**



ecobee owners have an impact

10 ecobee owners
savings
=
1 home's worth
of energy removed
from the grid

Help!

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Program administrators please require it (eventually).

NEEP please help us all.

Question and Discussion