ENERGY STAR®
Residential Climate Controls (RCCS) Workshop
Field Savings Metrics

San Francisco Hilton Financial District – Embarcadero Room

November 19, 2014

Agenda – morning

9:00 – 9:30AM	– Introduction and Goals for the Workshop Abi Daken, U.S. EPA
9:30 – 10:30AM	– Stakeholder Presentations Opower, Nest, BPA
10:30 – 10:45AM	– Break
10:45 – 11:45AM	– Stakeholder Panel Session Jack Callahan BPA | Michael Blasnik, Nest Nick Payton, Opower
11:45 – 1:00PM	– Lunch (on your own)

Agenda – afternoon

1:00 – 2:30PM	– ENERGY STAR Climate Controls – Abigail Daken, U.S. EPA | Alan Meier, LBNL | Doug Frazee, ICF International
2:30 – 2:45PM	– Break
2:45 – 3:30PM	– Breakout Group Activity – Pareto Chart
3:30 – 4:15PM	– Breakout Group Presentations
4:15 – 4:45PM	– Closing – Next Steps and Ways to Help Abigail Daken, U.S. EPA

Agenda

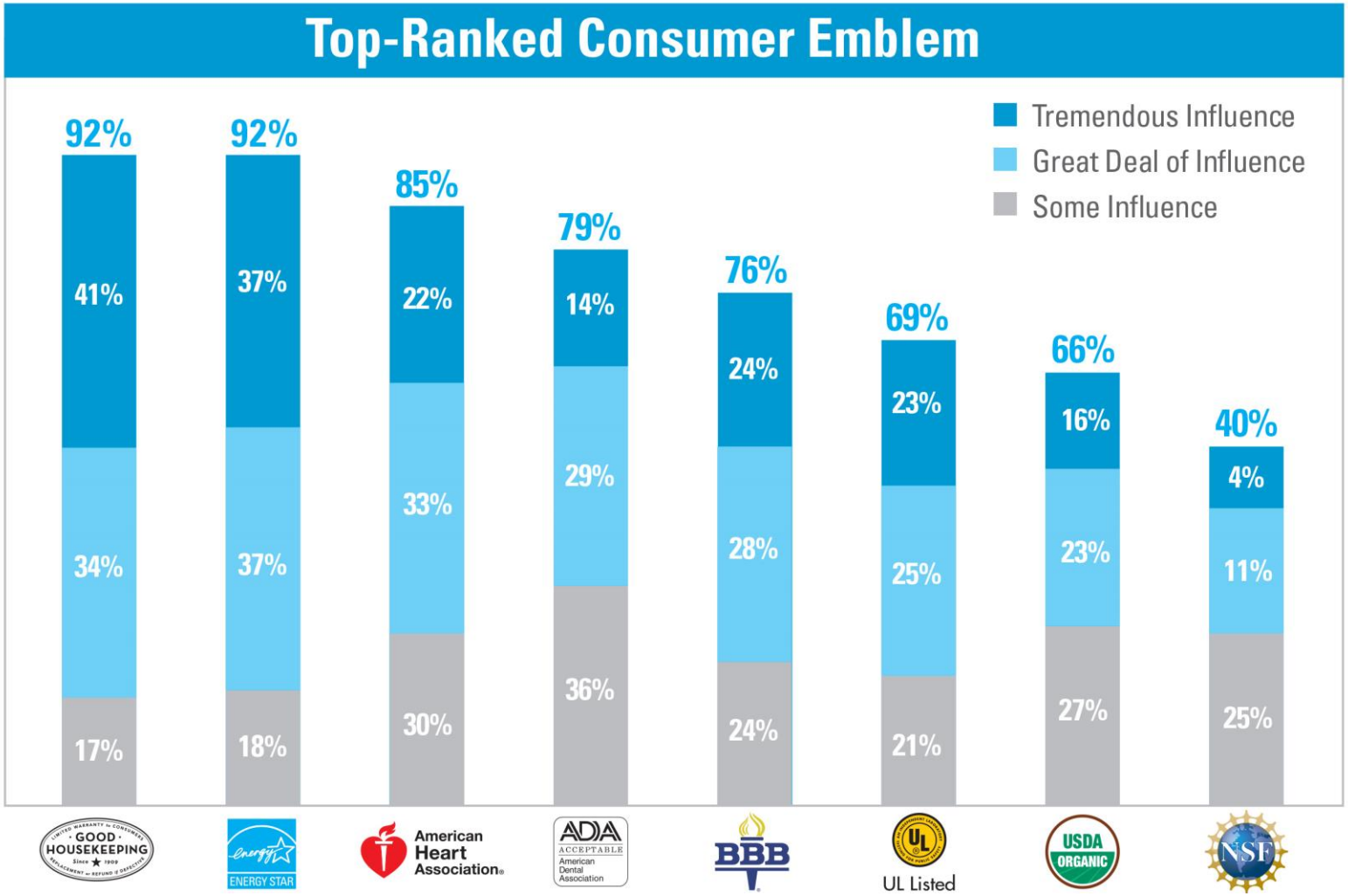
9:00 – 9:30AM – Introduction and Goals for the Workshop
Abi Daken, U.S. EPA

For more than 20 years, EPA's ENERGY STAR program has identified

the most energy efficient products, buildings, plants, and new homes –

all based on the latest government-backed standards and a rigorous third-party certification process.

TARGET AUDIENCES



Note: Audience surveyed 94% female, 35+ age bracket

Source: Fairfield Research, July 2011

ENERGY STAR TODAY

Brand Preference & Loyalty

Of the **87% of households** that recognize the ENERGY STAR label

75% recalled purchasing an ENERGY STAR-labeled product in the past year

73% said the label influenced at least one of their purchase decisions very much or somewhat

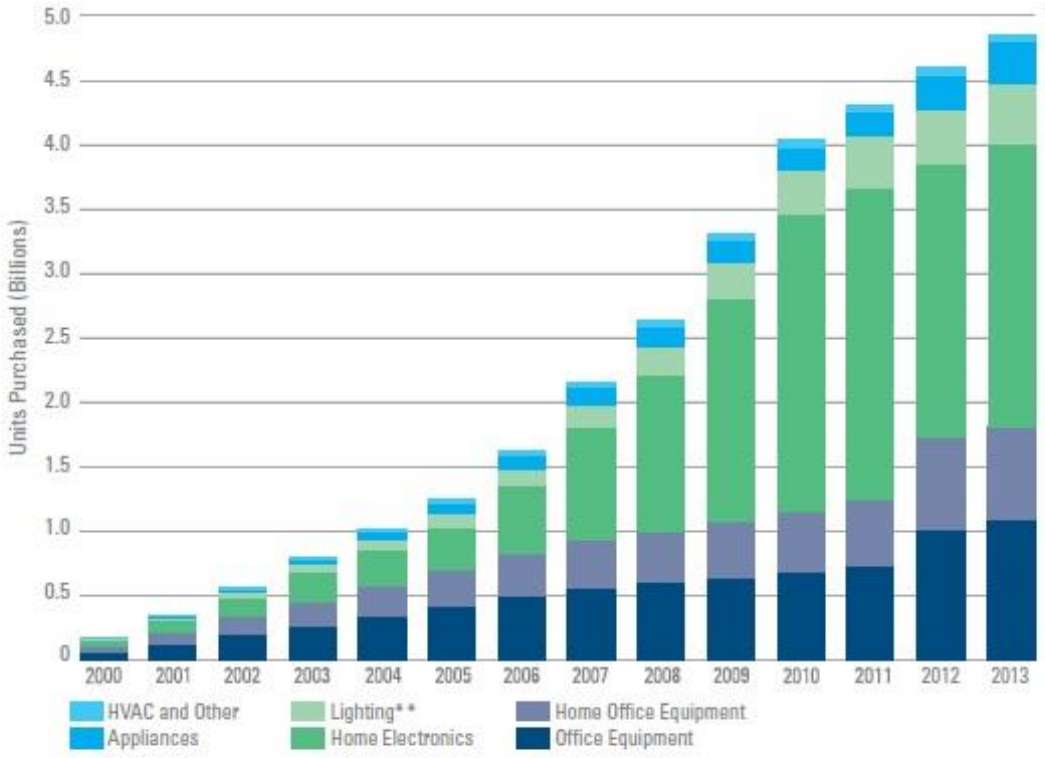
75% were likely to recommend ENERGY STAR-labeled products to a friend

30% were extremely likely to recommend ENERGY STAR

Source: National CEE Household Survey 2012


Every single day,
consumers choose
ENERGY STAR
products more than
800,000 times

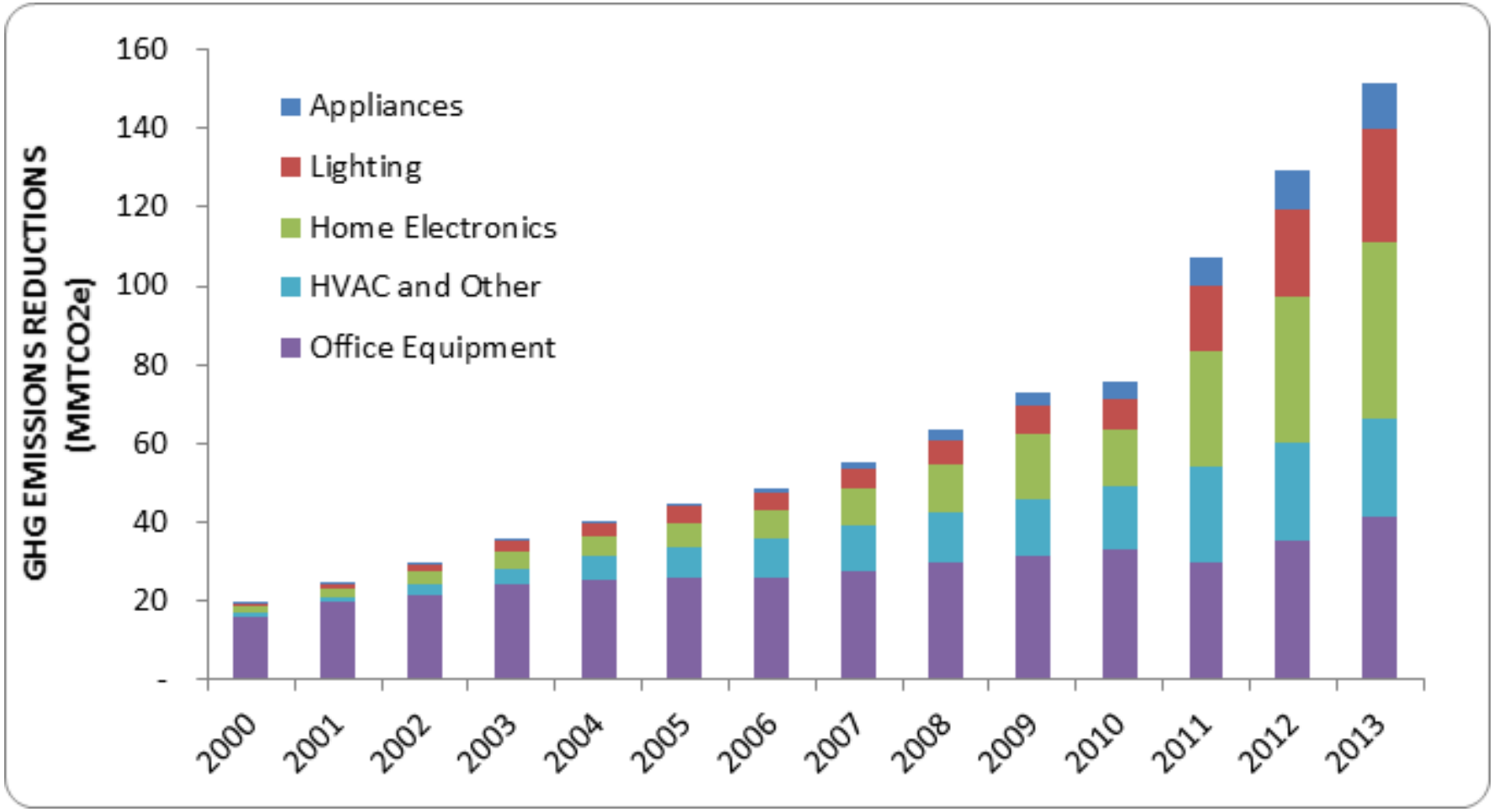
Fig. 2. More than 4.8 Billion ENERGY STAR Certified Products Purchased Since the Program Began*



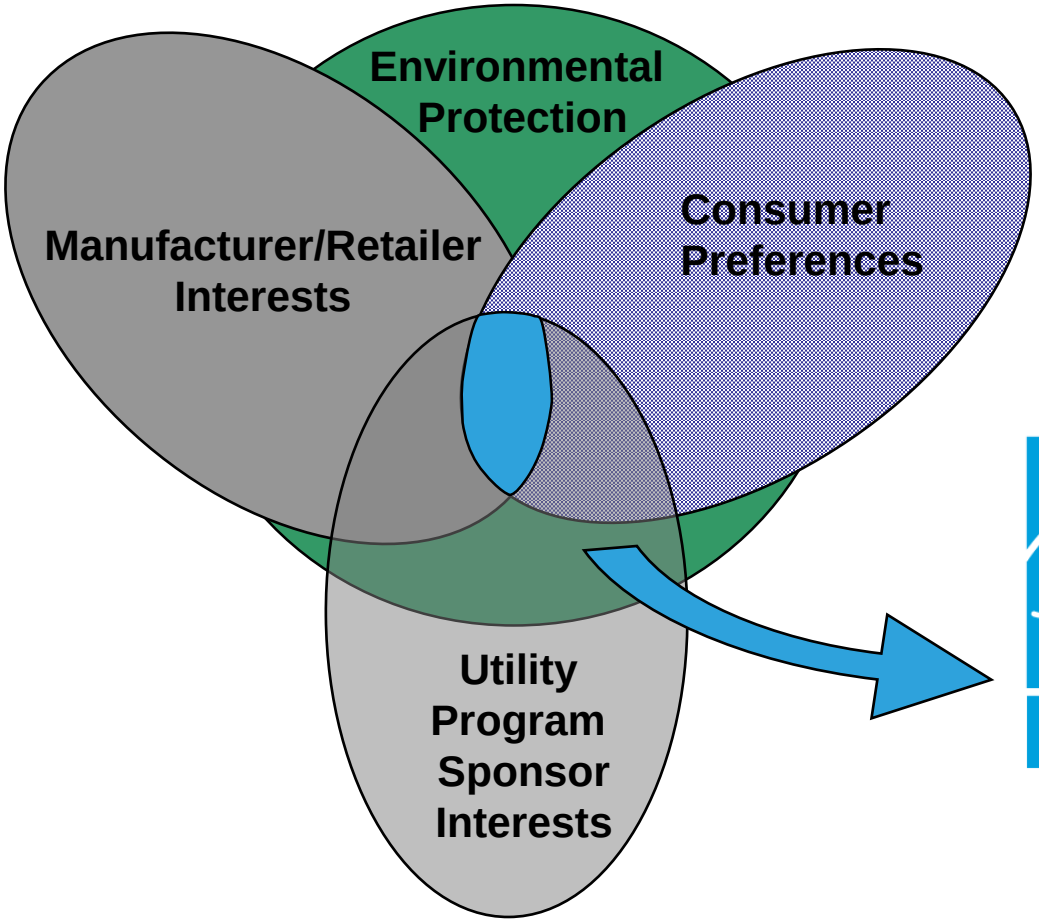
** Program began in 1992.*

*** Lighting category does not include purchases of light bulbs.*

Annual Greenhouse Gas Emissions Avoided



ENERGY STAR's Focus



- Cost-effective
- No Sacrifice in Performance
- Government backed

Consumer is Key

ENERGY STAR Guiding Principles

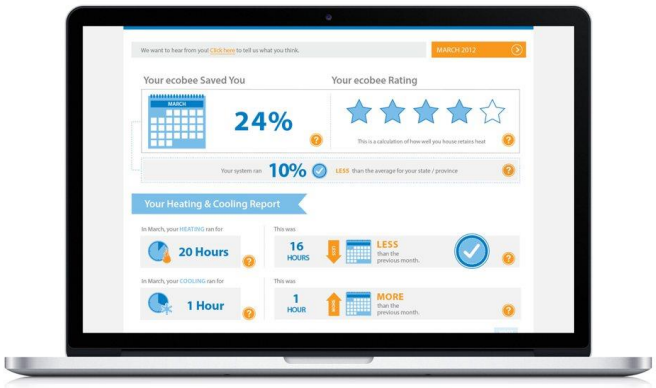
1. Significant energy savings
2. Product performance maintained or enhanced
3. Purchasers can recover investment in increased efficiency within a reasonable time period
4. Efficiency achieved through one or more technologies; products can be broadly available
5. Energy consumption can be measured and verified with testing
6. Label provides meaningful differentiation

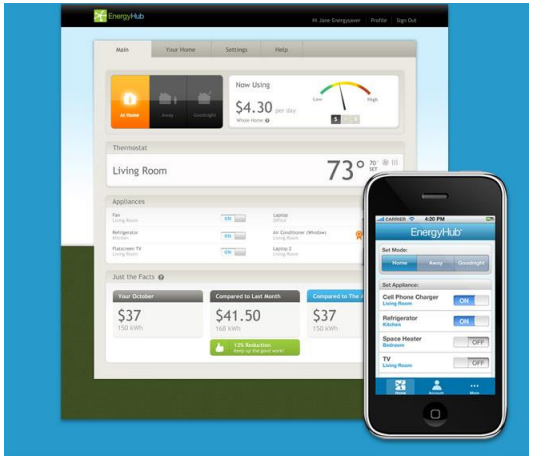
Timeline

- Dec 2009 – ENERGY STAR PT program sunset
- Feb 2010 – ENERGY STAR climate controls specification development
- June 2014 – Consideration of field savings approach
- November 5, 2014 – RCCS Metric Framework and Comparison
- November 19, 2014…

Introduction – A New Approach

- Large potential savings
- New product types & business models emerge
- Measuring RCCS savings being done today, but…
  - no standard methodology
  - savings claims vary widely



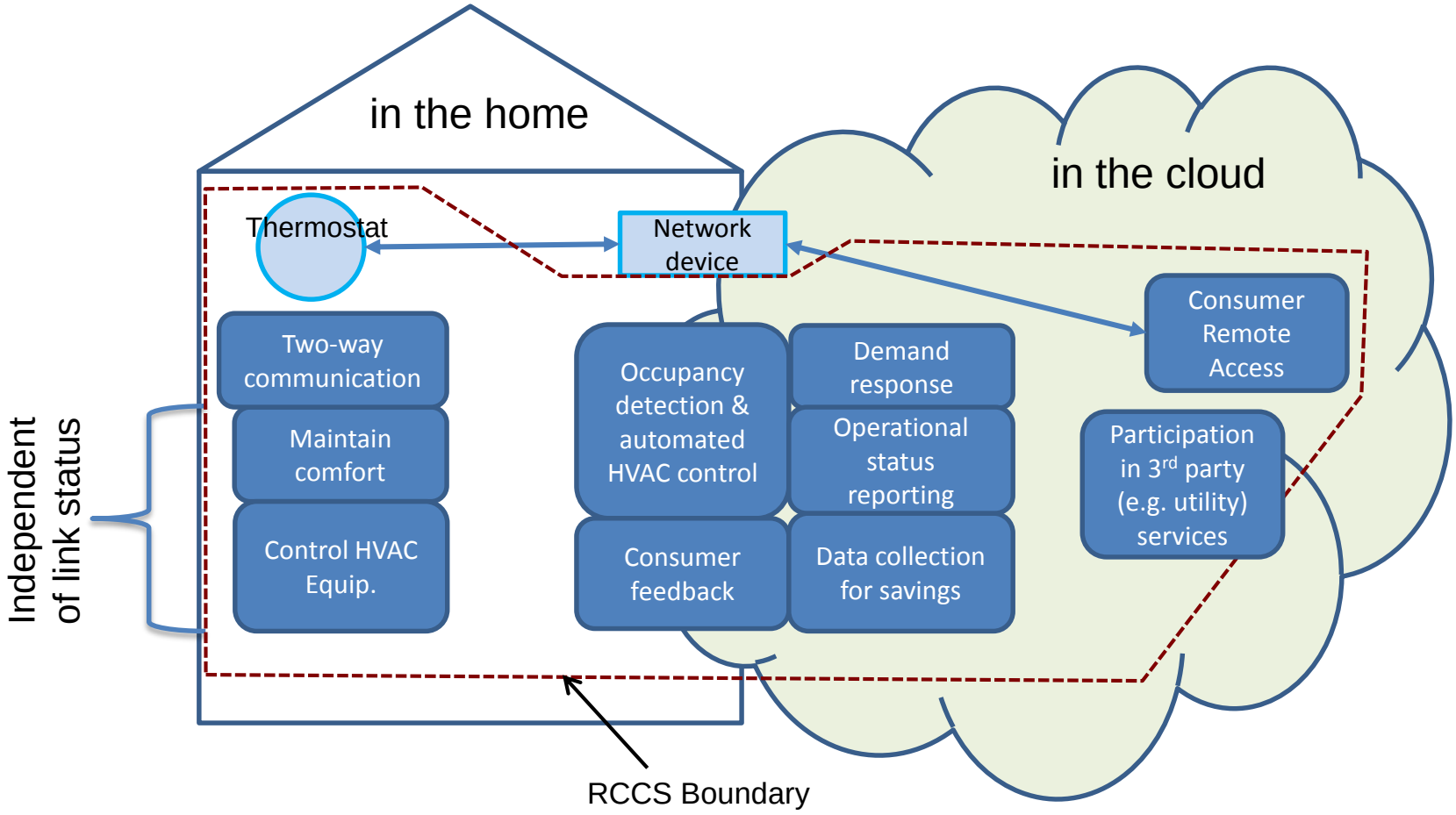


The Promise of Residential Climate Control Systems

- (thermostats) Control Half of your home's energy bill
- 14% savings 26% savings 22% savings
- Saved an average of 11.3% of AC-related energy
- customers in the US saved an average of 23% on their heating and cooling costs

- Utility Not Required: xxxxx Saves 6% on Summer Electricity Bills
- $100 annual savings for consumers
- Saving consumers 10 – 15%
- 4kW Demand Savings per Home
- 9000+ MWh in Energy Savings

Blend of local hardware and cloud services provides RCCS capabilities



Program Outline

- Recognition for RCCSs that save energy in the field
- Service Provider is the ENERGY STAR partner
- To earn the ENERGY STAR:
  - RCCS criteria that enables savings
  - Periodic reporting of savings

Draft test method

Providers run test, submit data

Anonymized data published

Comments published and private

Specification process: Drafts, comments, finalize

EPA recognizes certification bodies (CBs)

Providers submit data to CBs

CBs recognize products

Providers label products

Providers submit annual shipments to EPA

CBs conduct annual 10% verification testing

Same principles, some differences

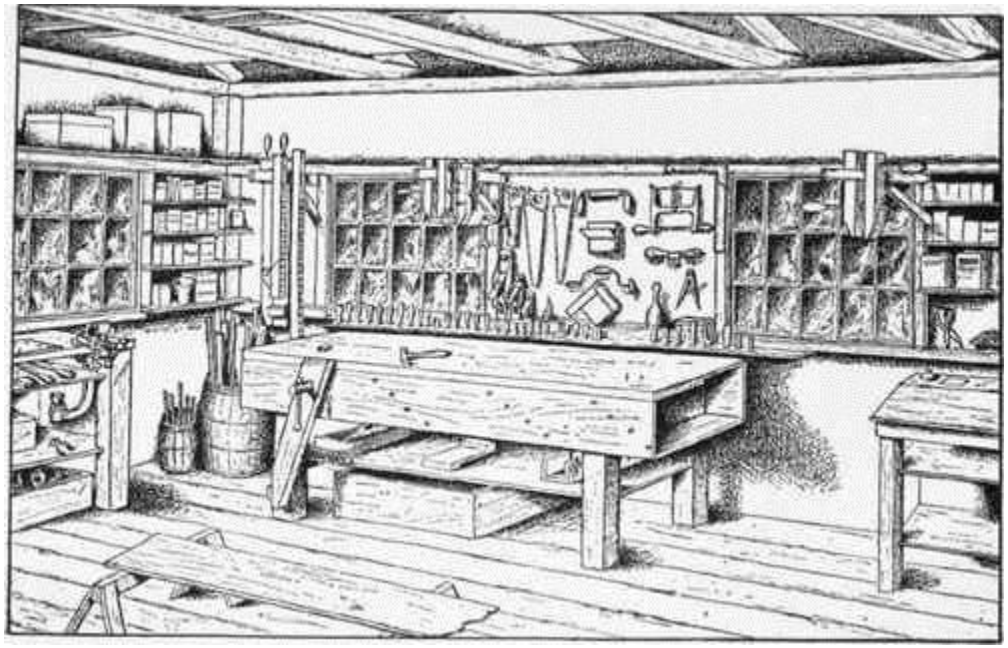
- Product includes service component
- Partner is service provider
- ~~Annual shipments~~ → Periodic field data
  - Calculate program emissions reductions
  - Serve as energy savings data for QPL

Step 1: Metric

- Ranks RCCSs based on field savings
- Uses data from RCCS or publically available
- Preserves consumer privacy
- Protects proprietary information
- Practical to calculate

Goals for Today

information exchange



creativity

collaboration

Today is metrics day

Program issues parking lot

(Actually, Mt. Baker parking lot.)

Agenda

9:30 – 10:30AM – Stakeholder Presentations
Opower, Nest, BPA

"Lessons Learned in Thermostat Program Evaluation and Implementation" - Nick Payton, Opower

Agenda

9:30 – 10:30AM – Stakeholder Presentations
Opower, Nest, BPA

Proposed Metrics for the Energy Star Climate Controls Program - Michael Blasnik, Nest Labs

Agenda

9:30 – 10:30AM – Stakeholder Presentations
Opower, Nest, BPA

A Temperature/Runtime M&V Approach for Smart Thermostats Using Daily Averages - Jack Callahan, Bonneville Power Admin.

Agenda

10:30 – 10:45AM – Break

Agenda

Stakeholder Panel Session

Jack Callahan BPA | Michael Blasnik, Nest

Nick Payton, OPOWER

Agenda

11:45 – 1:00PM – Lunch (on your own)

Agenda

1:00 – 2:30PM – ENERGY STAR Climate Controls –
Potential Field Savings Metrics
Abigail Daken, U.S. EPA | Alan Meier, LBNL |
Doug Frazee, ICF International

Savings Degree-Hours: A Potential Metric for Assessing Effectiveness of RCCS

Alan Meier
Lawrence Berkeley National Laboratory

Definition of Savings Degree-Hours (SDH)

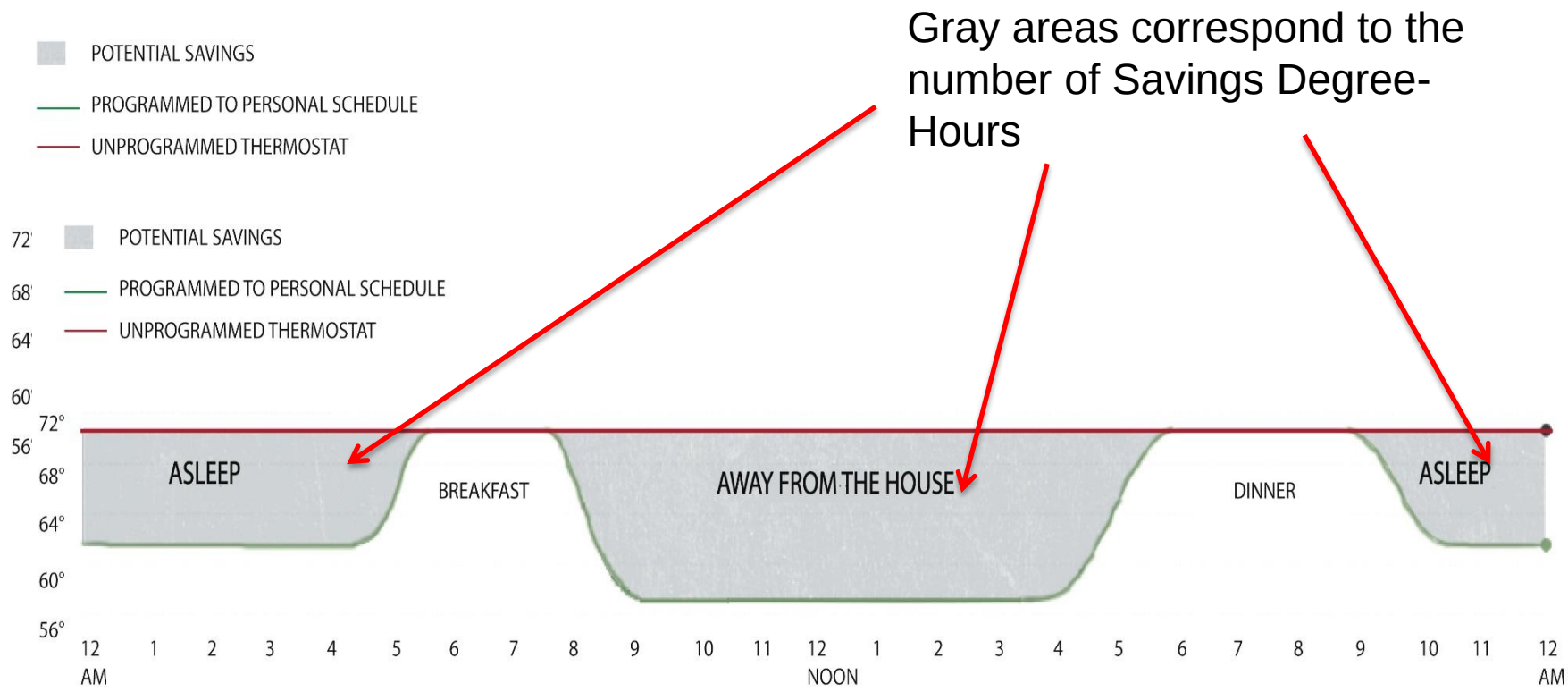
The savings degree-hours metric measures the extent and duration to which the indoor temperature deviates from a reference temperature.

$$SDH = \sum_{each\ heating\ hour} (T_{ref} - T_{obs})$$

$$T_{ref} = reference\ thermostat\ setting$$

$$T_{obs} = observed\ thermostat\ setting$$

SDH = "Area Under the Curve"



Source: Nest thermostat nest.com (2013). Nest Thermostat. Saving energy with Auto-Schedule.

Heating and Cooling SDH Calculations

The calculation of SDH differs slightly for heating and cooling conditions.

For Heating Hours:

$$SDH_h = \sum_{\text{all heating hours}} (T_{refh} - T_{obs})$$

For Cooling Hours:

$$SDH_c = \sum_{\text{all cooling hours}} (T_{obs} - T_{refc})$$

Where,

T_{refh} = reference temperature for heating

T_{obs} = observed indoor temperature

T_{refc} = reference temperature for cooling

Examples of SDH Calculation

Example 1: For heating, 5 Savings Degree-Hours would be accumulated when the RCCS lowered the indoor temperature to 65° from for one hour (assuming a 70° reference temperature)

Example 2: A programmable thermostat: 100 days of night setback from 72°F → 65°F for 8 hours

$SDH_{heating}$ = 100 days x 8 hours x 72-65 = 5600*

Notes:

- A larger number of SDH indicates a more successful RCCS control strategy
- Typical values for annual heating SDH will be ~ 5000 – 10,000
- An RCCS needs to achieve more than 5600 SDH to outperform an ordinary programmable thermostat (in this example)

* This calculation assumes indoor temperature moves instantaneously from one setpoint to another

Discussion of Savings Degree-Hour Metric

- The “Savings Degree-Hour” (SDH) metric measures the extent to which the RCCS reduces HVAC consumption by shifting indoor temperatures closer to outdoor.
  - A superior algorithm/strategy will “extract” more SDHs from a home (without sacrificing comfort)
- Drawbacks of SDH include:
  - Not clear how SDH performs in mild climates
  - Choice of reference temperatures may affect ranking
  - SDH captures savings only from temperature changes (not the savings from use of an economizer or avoiding use of a heat pump’s resistance back-up heat)
  - Service providers may operate a home’s HVAC inefficiently so as to minimize recovery times (and maximize SDH)
  - There is no direct translation of SDH into energy use
  - Consumers will find the concept difficult to understand

Possible Responsibilities of the Service Provider with SDH

A service provider would:

- Define the relevant population (equipment type, software version, other?)
- Perform specified filters to remove homes with incomplete data and other problems
- Calculate the SDH for each home
  - May be able to use the same reference temperatures for all homes (no home-specific normalizations required)
- Report to ENERGY STAR CB the average SDH for customer base
  - Heating
  - Cooling
  - Total
  - Other relevant temperature/setpoint data (to improve RCCS program)

Run Time-Based Metrics for Climate Control System Energy Savings

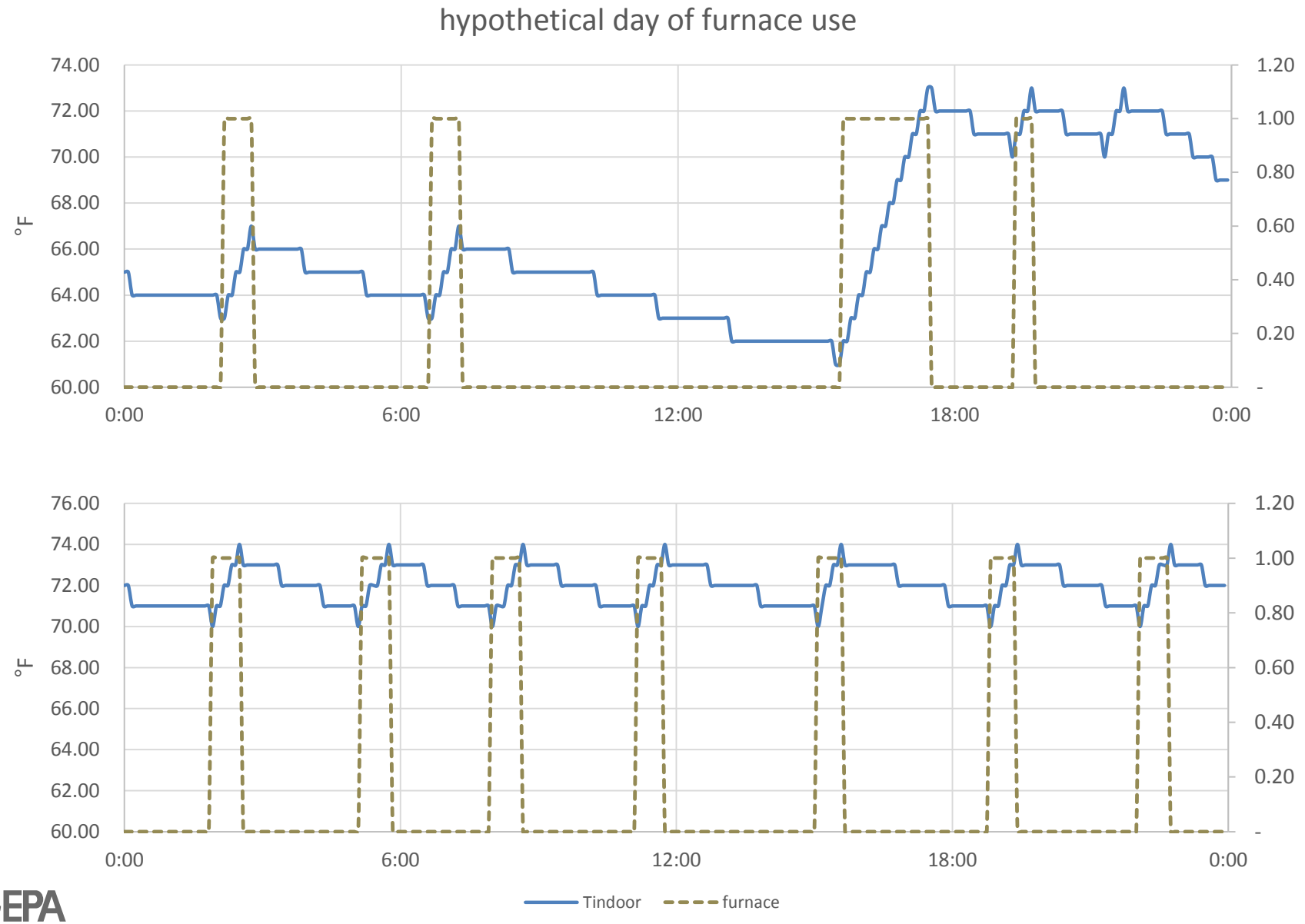
Abigail Daken
Environmental Protection Agency

Definition of run time

The run time metric adds up hours that highly consumptive heating and cooling equipment is operating:

$$RT_{furnace} = \sum_{past\ 12\ months} time\ furnace\ is\ on$$

$$RT_{CAC} = \sum_{past\ 12\ months} time\ compressor\ is\ on$$


hypothetical day of furnace use
°F
74.00
72.00
70.00
68.00
66.00
64.00
62.00
60.00
1.20
1.00
0.80
0.60
0.40
0.20
-
0:00
6:00
12:00
18:00
0:00
°F
76.00
74.00
72.00
70.00
68.00
66.00
64.00
62.00
60.00
1.20
1.00
0.80
0.60
0.40
0.20
-
0:00
6:00
12:00
18:00
0:00
Tindoor
furnace

Discussion of run time as a metric

- Less run time means less energy used
- Measures every strategy RCCS could use to reduce run time (for single speed systems)
- Can be developed for different fuel types
- Primary drawback of run time is identifying a baseline
  - Baseline for an individual home is how much HVAC would have run
  - Utility data suggests could estimate from assumed set temperatures without RCCS
  - Then, can estimate percent run time savings for each home

Possible different approach for run time metric baseline: population average

- Develop average baseline runtime based on
  - RECS data?
  - Estimates of HDD and CDD?
- Similar to EPA strategy for national savings of other products
- Could use regional baselines to improve estimate

Possible Responsibilities of the Service Provider with run time metric similar to that for SDH

A service provider would:

- Define the relevant population (equipment type, software version, other?)
- Perform specified filters to remove homes with incomplete data and other problems
- Calculate the run time for each home
  - Possibly calculate per home baseline and % RT reduction
- Report to ENERGY STAR CB the average metric for customer base for
  - Heating (gas, electric)
  - Cooling
  - Other relevant temperature/setpoint data (to improve RCCS program)

A note about staged systems

- Small but increasing number of installed systems – eventually need to accommodate
- Can get RT_{stage1}, RT_{stage2}, etc.
- Multistage systems complicate baseline as well

Agenda

2:30 – 3:00PM – ENERGY STAR Team Q&A
Abigail Daken, EPA
Alan Meier, LBNL
Doug Frazee, ICF International

Agenda

2:30 – 2:45PM – Break

Agenda

3:45 – 3:15PM – Breakout Group Activity – Pareto Chart

Pareto Chart Explanation & Exercise

- Pareto analysis is used to determine the optimal course of action when multiple approaches are viable.
- Goal: Leverage your expertise to determine the best savings metric with different HVAC setups in breakout groups. Though this is subjective, the purpose is to spur dialogue.
- Metrics to consider: **(1)** Run time metric with per-home baseline based on 90%/10% set points (as per Nest paper) and a per-home analysis of run time vs. delta T (Hybrid run time) and **(2)** Temperature-based metric with compressor utilization percentage reported for heat pumps:
  - Ranking: Accuracy of potential to rank homes with a particular type of HVAC system.
  - Ease: Difficultly of calculating metric. (In all cases assuming data is communicated machine to machine and calculation is automatic)
  - Broadness: Captures savings from all likely savings strategies
  - Savings: Ease and accuracy of estimating national savings
  - Finish: Anticipated ease of dealing with remaining issues (which we will somehow need to solve if we are to use it)

Pareto Chart Example – Favorite TV Show (Illustrative Example)

In each column, assign a numerical value 1-5. **5 is the best.**

	Attributes		
TV Dramas	Writing	Acting	Direction
Breaking Bad	3	2	1
Madmen	5	1	2
The Walking Dead	4	5	5
The Sopranos	2	3	4
House of Cards	1	4	3

Pareto Chart Exercise

- Groups are assigned 1-4
- Meet with your group and assign a numerical value (1-5) to each of the following considerations in each column. **5 is the best option.**

	Run-Time Metric					SDH Metric				
HVAC type	Ranking	Ease	Broadness	Savings	Finish	Ranking	Ease	Broadness	Savings	Finish
Single stage/fixed capacity (no aux heat)										
Single stage HP w/Aux heat										
Multi-stage										
Variable capacity										
Dual-fuel										
Zoned										

Pareto Chart Exercise – Group 1 Results

- Groups are assigned 1-3
- Meet with your group and assign a numerical value (1-5) to each of the following considerations. **5 is the best option.**

	Hybrid Run-Time Metric					SDH Metric					
HVAC type	Ranking	Ease	Broadness	Savings	Finish	Ranking	Ease	Broadness	Savings	Finish	Accuracy
Single stage/fixed capacity (no aux heat)	4	4	4	4		3	5	1	1	4	2
Single stage HP w/Aux heat	4	3	4	4		1	5	1	1	4	2
Multi-stage	4	3	4	4		3	5	1	1	4	2
Variable capacity						4	5	1	1	4	2
Dual-fuel	4	4	4	4		1	5	1	1	4	2
Zoned						1	5	1	1	4	2

Pareto Chart Exercise – Group 2 Results

- Groups are assigned 1-3
- Meet with your group and assign a numerical value (1-5) to each of the following considerations. **5 is the best option.**

	Run-Time Metric					SDH Metric				
HVAC type	Ranking	Ease	Broadness	Savings	Finish	Ranking	Ease	Broadness	Savings	Finish
Single stage/fixed capacity (no aux heat)	4	4				4	4			
Single stage HP w/Aux heat	2	4				1	4			
Multi-stage	4	4				4	4			
Variable capacity	1	4				4	4			
Dual-fuel	1.5	4				4	4			
Zoned	1	4				2	4			

Pareto Chart Exercise – Group 3 Results

- Groups are assigned 1-3
- Meet with your group and assign a numerical value (1-5) to each of the following considerations. **5 is the best option.**

	Run-Time Metric					SDH Metric				
HVAC type	Ranking	Ease	Broadness	Savings	Finish	Ranking	Ease	Broadness	Savings	Finish
Single stage/fixed capacity (no aux heat)	5	3	4	5	2	3	4	3	3	3
Single stage HP w/Aux heat	4	3	4	5	2	2	3	3	3	2
Multi-stage										
Variable capacity										
Dual-fuel										
Zoned										

Agenda

3:15 – 4:00PM – Breakout Group Presentations

Agenda

4:00 – 4:30PM – Closing – Next Steps and Ways to Help
Abigail Daken, U.S. EPA

Wrapping up

- Three immediate work streams require stakeholder involvement
- How long will this all take anyway?
- Open mic for programmatic issues we've parked

Develop candidate metric(s) – need DATA!

- Time sequence data for a few individual homes for metric development
  - HVAC status, set temperature, outdoor temperature, indoor temperature; whatever thermostat knows about equipment type identified (e.g. this is wired as a furnace); climate
  - ICF collects data, person analyzing has no idea which vendor data comes from
- EPA expect to be in close communication with stakeholders during metric development.

Parallel work stream: data validity rules

- Summary reported metrics would include data from nearly 100% of connected fielded units
- There will be units that cannot be included
  - Spotty connectivity leads to incomplete data
  - Major renovations, natural disasters, etc.
  - Others?
- Minimum criteria for data set?
  - Minimum number of units
  - Geographical spread of units
  - Other demographics?

Third work stream: explicit privacy agreement

- Stakeholders anticipate consumer privacy concerns
- Mitigate with explicit statement of shared principles
  - Privacy protections
  - Data ownership?
  - Proprietary data

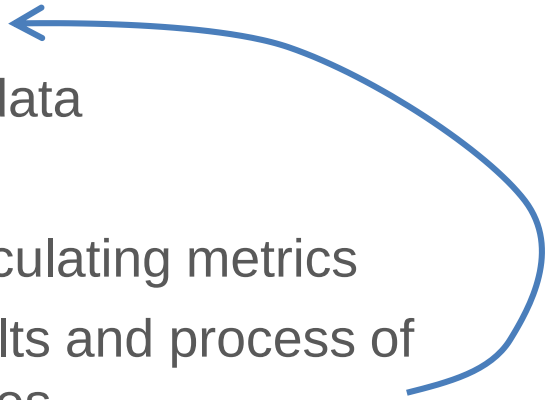
The big picture

Spring 2015: three work streams lead to candidate metrics & processes

Test run metrics on large data sets

- Providers run metrics on their actual data
- Masked results shared
- Providers comment on process of calculating metrics

Use results and stakeholder reaction to results and process of calculations to improve metric(s) and practices



- GOAL: Metrics and data validity finalized end of 2015
- 2016: develop program policies
- Mid-late 2016?: first RCCSs can qualify


OPEN MIC
PROGRAM ISSUES