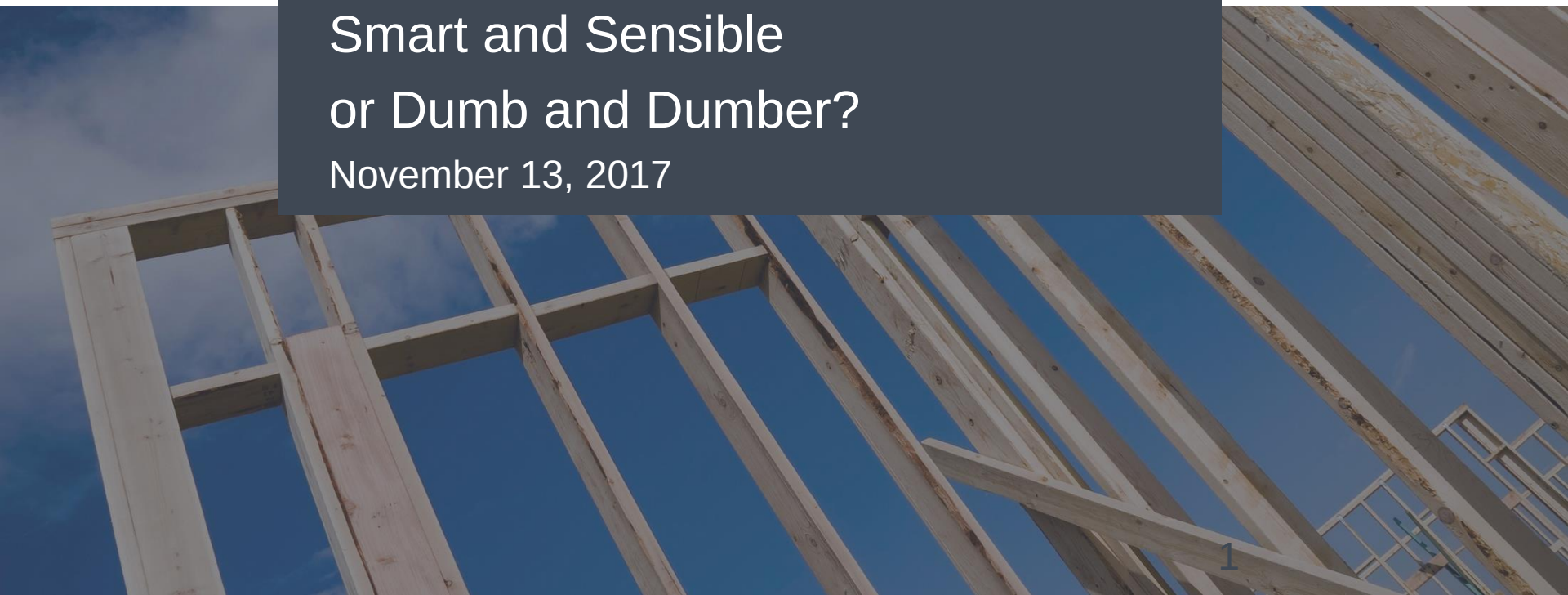
BetterBuiltNW

Connected Thermostats

Smart and Sensible

or Dumb and Dumber?

November 13, 2017



Housekeeping

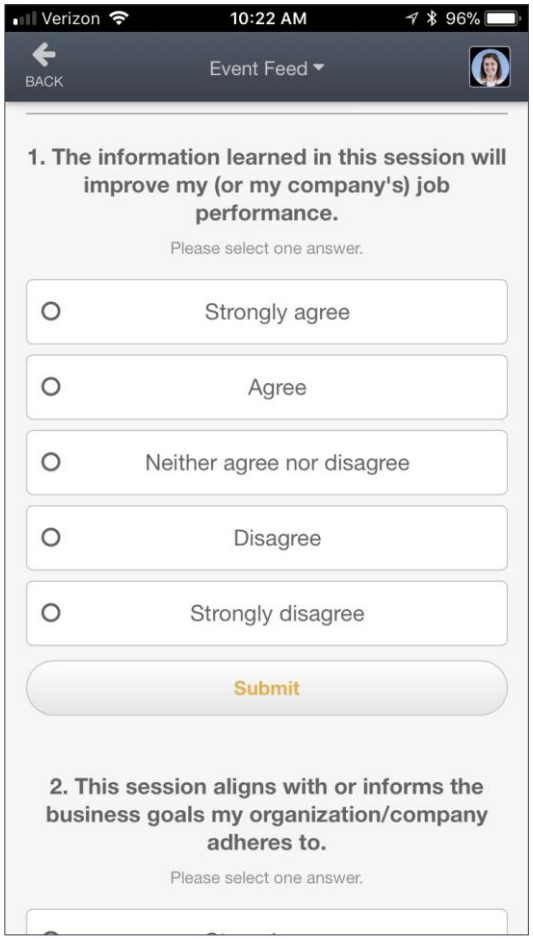
Welcome

- Safety
- Bathrooms
- Cell phones

Session Survey Instructions

At the end of each session, you will be given 5 minutes to complete the session survey.

1. Open the “HEF2017” app
2. Navigate to “Agenda” and select the session
3. Scroll down to “Session Feedback”
4. For each question, select answer and hit “Submit”
5. Show completed survey to BetterBuiltNW rep to earn points
6. Prizes awarded Friday to the top point earners
   - See “Challenge” section in the app for activities
7. Assistance available at the BetterBuiltNW table



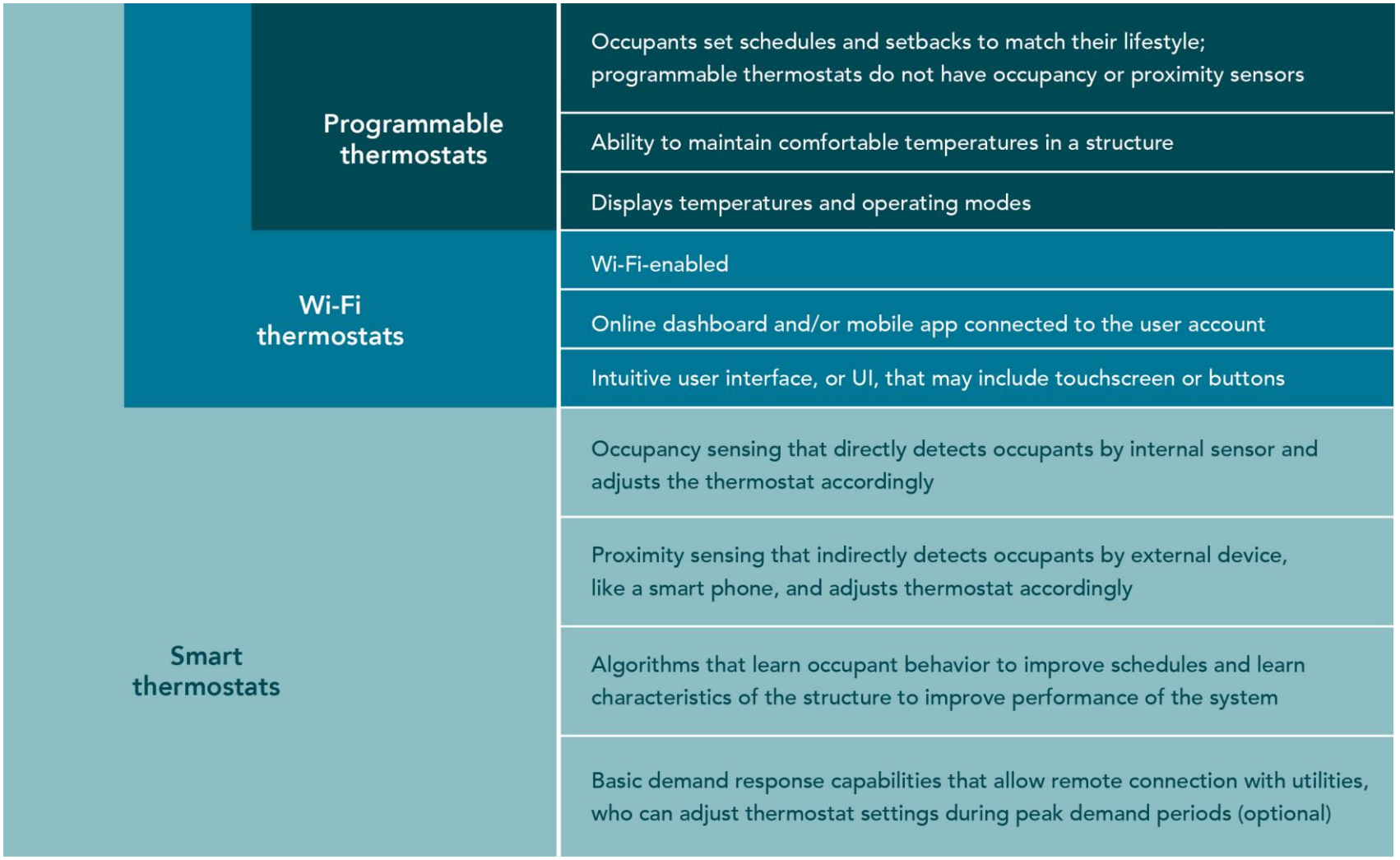
About This Session

- Few answers
- Lots of questions
- …and some advice

Thermostat Groups

- All Thermostats
  - Non Programmable
    - Digital
    - Non digital
  - Programmable
    - Setbacks engaged
    - Used as switch
  - Learning, Internet connected
    - Are you home?
    - Remote Control
    - Cool Stuff
    - Black box stuff

What are Smart Thermostats?



ENERGY STAR Smart Thermostat

- Must have certain features
- Must have some evidence of actual change in set points
- Must somehow have the ENERGY STAR logo

ENERGY STAR Smart Thermostat

Required to:

- Work as a basic thermostat in the absence of connectivity
- Give user feedback about the energy consequences of their settings
- Provide information about HVAC energy use
- Provide the ability to set a schedule
- Provide the ability to work with utility programs to prevent brownouts and blackouts
    - Preserve consumers' ability to override these grid requests

ENERGY STAR Smart Thermostat

Performance Requirements

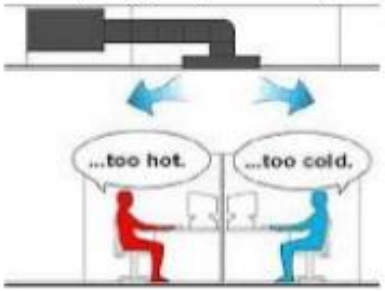
Parameter	Performance Requirement
Static temperature accuracy	≤ ±2.0 ºF
Network standby average power consumption	≤ 3.0 W average
Time to enter network standby after user interaction (on device, remote or occupancy detection)	≤ 5.0 minutes

Thermostats Can Be Smart and Not Save Energy

Definition

TANRI ABENG UNIVERSITY

Thermal comfort is the condition of mind that expresses satisfaction with the thermal environment and is assessed by subjective evaluation (ANSI/ASHRAE Standard 55).Thermal environment is those characteristics of the environment which affects a person's heat loss. In terms of bodily sensations, thermal comfort is a sensation of hot, warm, slightly warmer, neutral, slightly cooler, cool and cold.



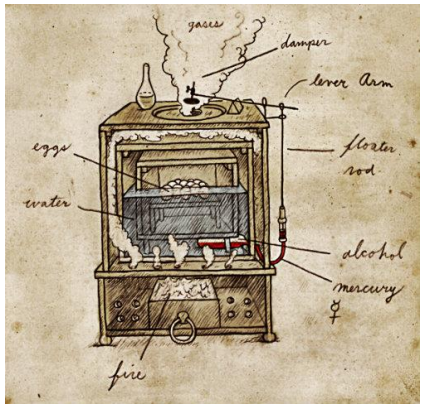
Comfort
(could increase energy use)

Convenience

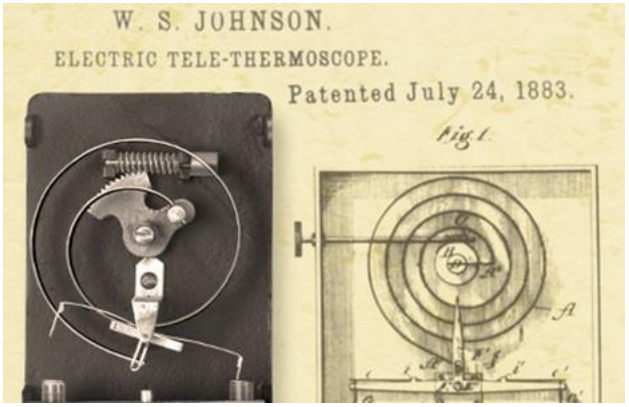
Peace of mind

A Short History of the Thermostat: Hardware to Software

Cornellis Drebbel
1592

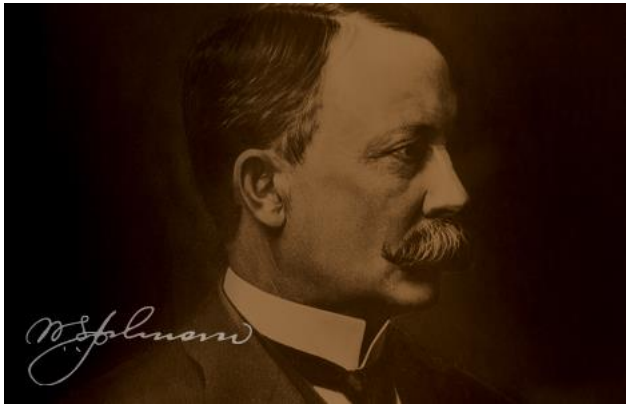


The “magic oven”



Albert M. Butz

1885 the “damper Flapper”



Warren Johnson

More Recent History

1st Programmable Thermostat
1906

The Chronotherm II Adaptive intelligent Recovery

Ecobee
2007

1953
T—87

Vision Pro

Smart Thermostats are Not A Commodity

- Term *commodity* is specifically used to describe a class of goods for which there is demand, but which is supplied without qualitative differentiation across a market.

Smart Thermostats: Key Differences

- User interface
- Motion sensor
- Ability to control other devices
- Demand response capabilities
- Report capabilities
- Behavioral prodding
- Control algorithm
- Data sharing
- Geo-fencing
- App reliant
- Design appeal

Pilots: Yes, Smart Thermostats Can Save Energy

Completed Pilots

Energy Trust of Oregon

- DI Nest t-stats for 200 homes with heat pumps and 200 control homes
- Installed by Pilot staff

Installation Method: Installed by CLEAResult staff

Issues Faced: Bricked product: Close calls on customer service

Franklin PUD

- 176 homes, small control group
- Installed by HVAC contractors

Installation method: Installed by 3rd party HVAC contractor

Issues faced: Contractor training hurdles

Energy Trust of Oregon

- Gas heated homes
- DIY/Self-install, with Geo Fencing

Savings From The ETO Heat Pump Pilot

Table 15. Nest weather-normalized annual electric savings by home construction type.

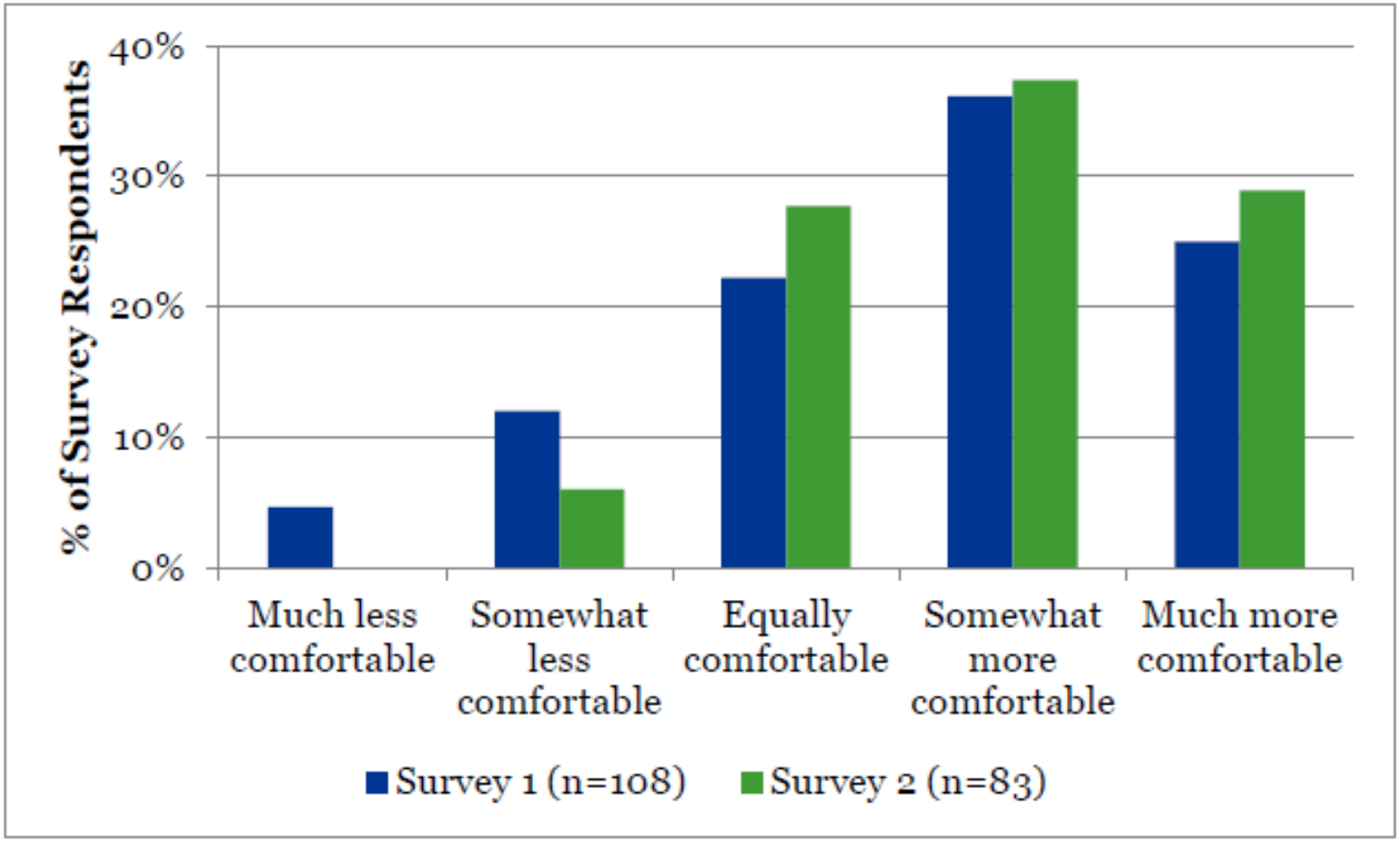
Construction Type	Participant N / Comparison N	Annual Savings (90% CI)	Std. Err.	p-value	Annual Usage	% Savings (90% CI)	Realization Rate
Manufactured	21 / 54	1,172 (470, 1874)	388	0.013	13,521	8.7% (3.5, 13.9)	140%
Site-built	92 / 157	669 (105, 1232)	311	0.057	17,532	3.8% (0.6, 7.0)	80%

Construction Type	Annual Usage
Manufactured	13,521
Site-built	17,532

Data and Graphics From Energy Trust of Oregon and Apex Analytics

Increased Comfort

Figure 24. Comfort of home temperature compared to pre-Nest thermostat period



Data and Graphics From Energy Trust of Oregon and Apex Analytics

What Were They Programmed To Do?

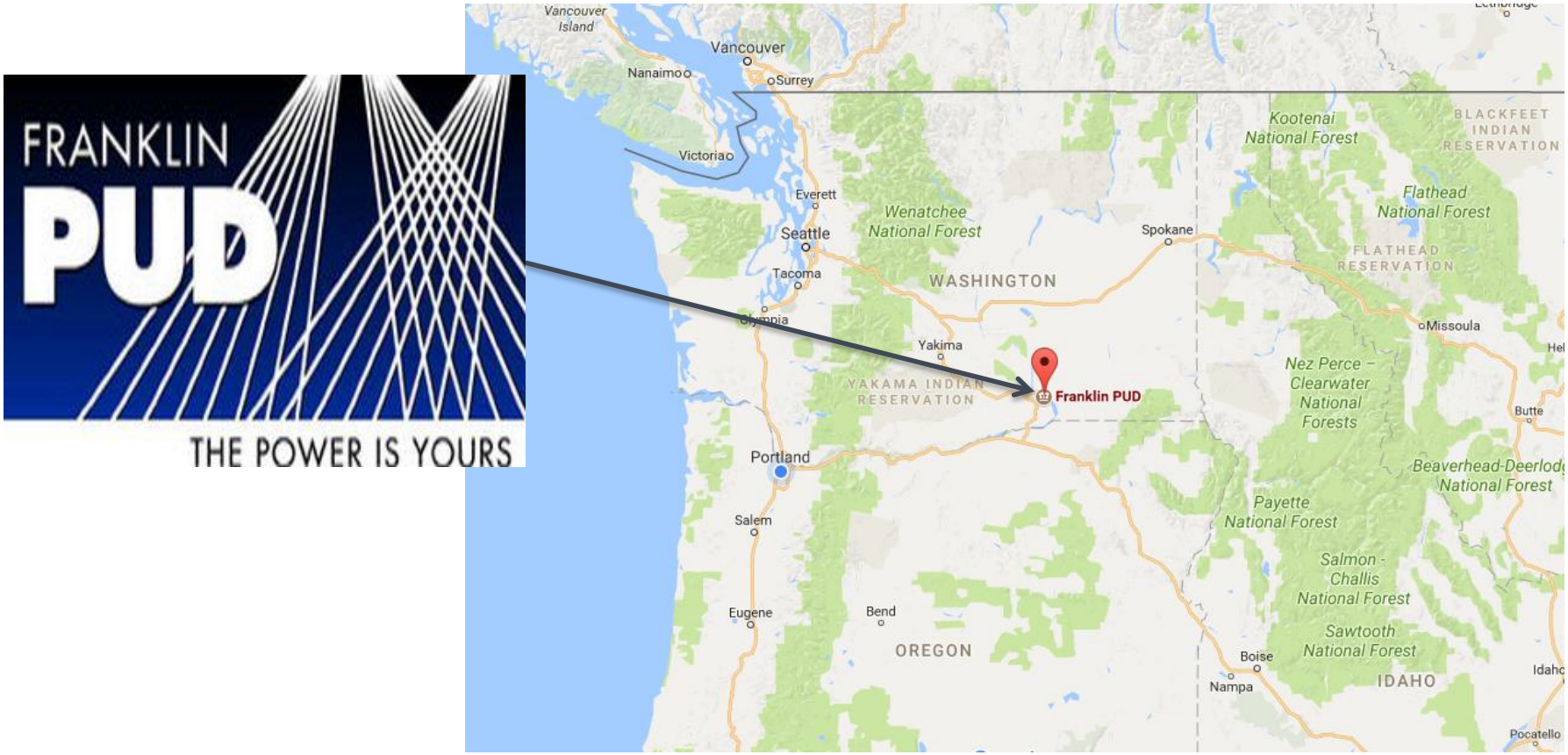
Table 22. Nest weather-normalized annual electric savings by prior thermostat type (Comparison N=211).

Prior Thermostat Type	Participant N	Annual Savings (90% CI)	Std. Err.	p-value	Annual Usage	% Savings (90% CI)	Realization Rate
Not programmable	28	423 (-384, 1230)	445	0.365	14,656	2.9% (-2.6, 8.4)	51%
Programmable	82	1,151 (621, 1681)	293	0.003	17,619	6.5% (3.5, 9.5)	138%

Prior Thermostat Type	% Savings (90% CI)
Non programmable	2.9% (-2.6, 8.4)
Programmable	6.5% (3.5, 9.5)

Data and Graphics From Energy Trust of Oregon and Apex Analytics

Franklin PUD Project



The Answer is…..

N	Total Annual Savings (kWh)	95% Lower C.I.	95% Upper C.I.	R-Squared Criteria	Pre Install Consumption	% Total Savings
167	885	381	1388	All	21804	4.06%
130	824	314	1333	>= .50	21016	3.92%
115	959	419	1498	>= .60	20930	4.58%
97	1103	599	1607	>= .70	21110	5.23%

Data from Phillip Kelsven, Franklin PUD and Robert Weber, BPA

Findings on the Energy Trust of Oregon DIY Gas Furnace Pilot

Thermostat	Annual Therm Savings	SE	90% Conf. Interval	p-value
Nest	34	11	13, 55	0.018*
Lyric	-29	14	-55, -3	0.071*

Thermostat	% Savings	% Heating Savings	Annual Therm Usage	Heating Therm Usage	% Heating Usage
Nest	4.5%	6.0%	761	566	74%
Lyric	-3.7%	-4.9%	784	596	76%

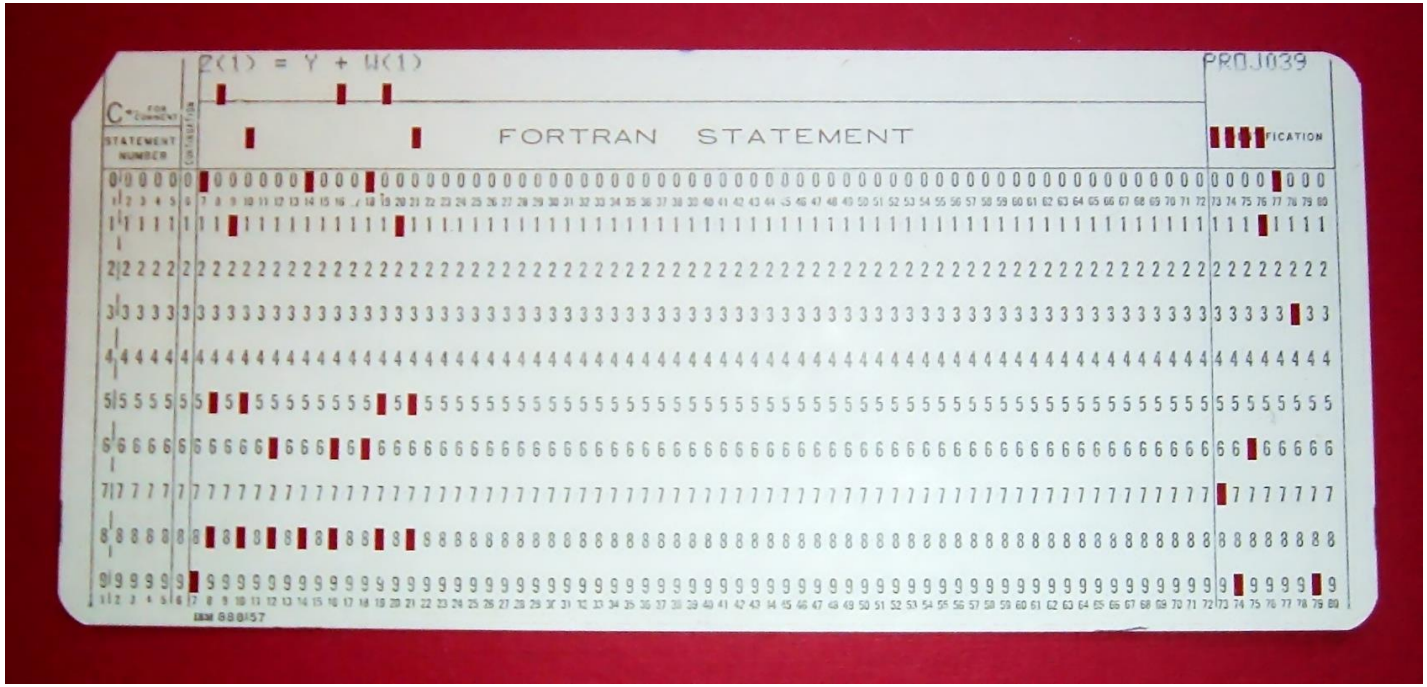
Data and Graphics From Energy Trust of Oregon and Apex Analytics

Considerations For Selecting the Best Fit Smart Thermostat

Avoid Homeowner Confusion and Call Backs

User Interface

- User Interface are like jokes; if you have to explain them, they aren't any good



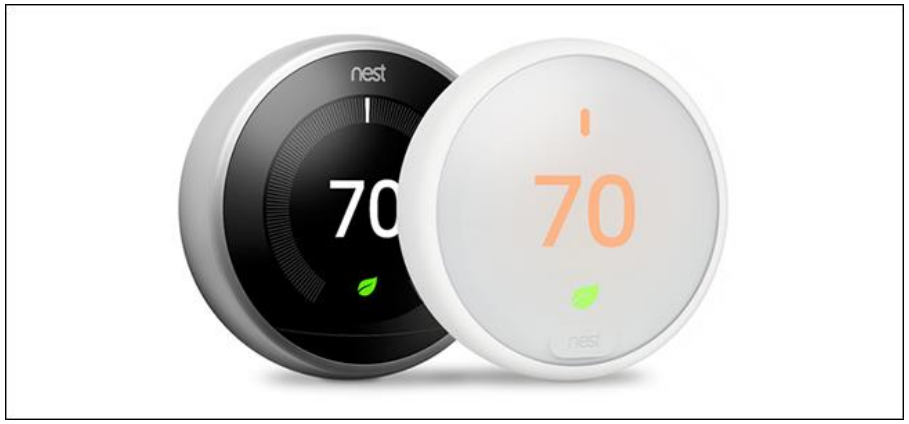
Proprietary Thermostats

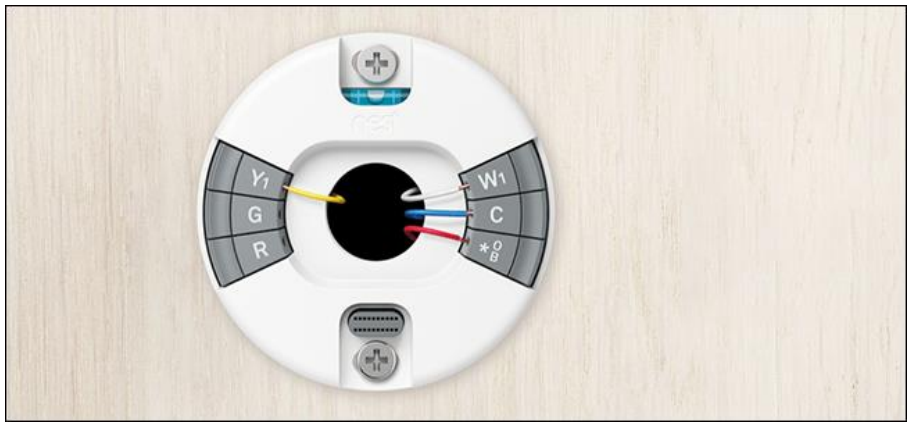
- High End HVAC Systems Usually Need a Proprietary Thermostat To Have Full Functionality
- Modulating Gas Furnaces
- Variable Refrigerant Heat Pumps and Air Conditioners

Smart Thermostats and Ductless Heat Pumps

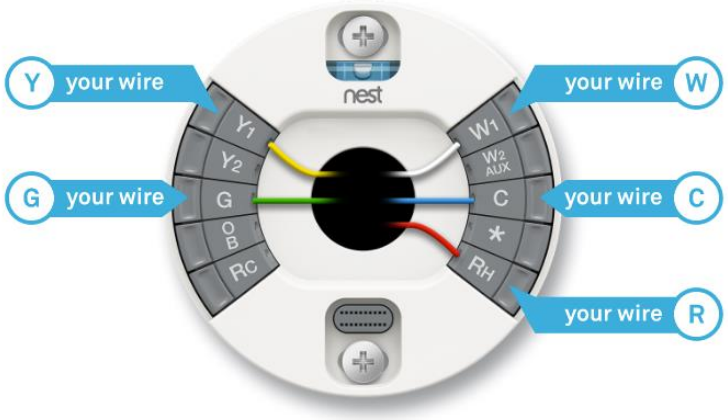
- DHPs already have smart algorithms. It may not be a good idea to layer another set on top.
- If available, use the manufacturers Wi-Fi thermostat.

Nest 3 vs. Nest E





- Same basic features
- The “E” only has 6 wire terminals limiting equipment types and HVAC accessories



Whose Job is it?

Connected thermostats require someone to connect them to the homeowners Wi-Fi:

- The homeowner
- The Builder
- The HVAC Technician
- The Rater/Verifier

Compatibility With Other Smart Stuff

Can the system grow?

- Security
- Smoke and Carbon Monoxide detectors
- Alexa or other hubs
- Home Kit – works with Nest
- Smart Fans, smart doggie doors, etc.

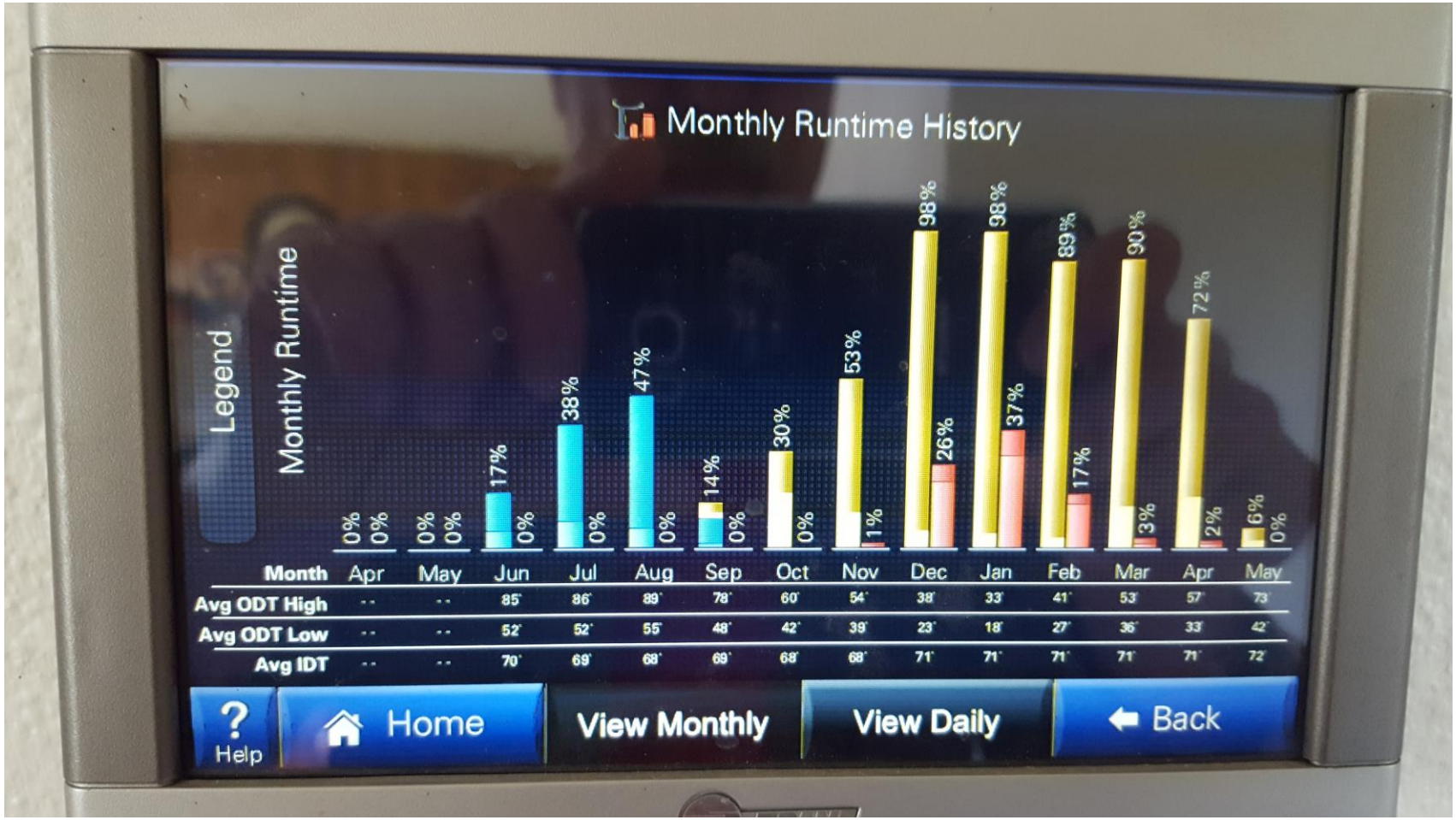
Energy Reports: Built in Data Logging

So much data, who has access?

- The builder?
- The verifier?
- The owner?
- The HVAC contractor?

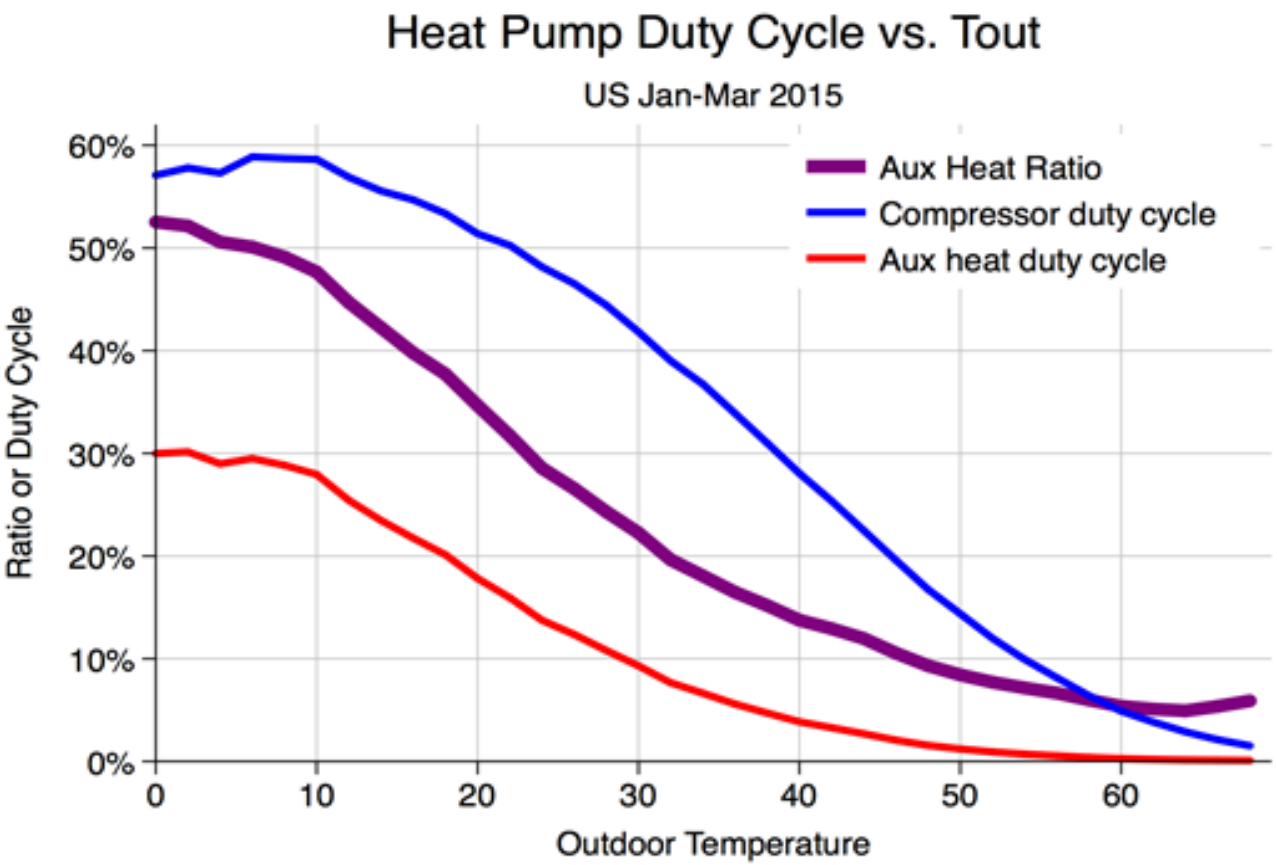
Remote Monitoring and Service Alerts

Can be Viewed Remotely or On Site



Remote Quality Control and Data Logging

What's Next: Smart T-stat as QC



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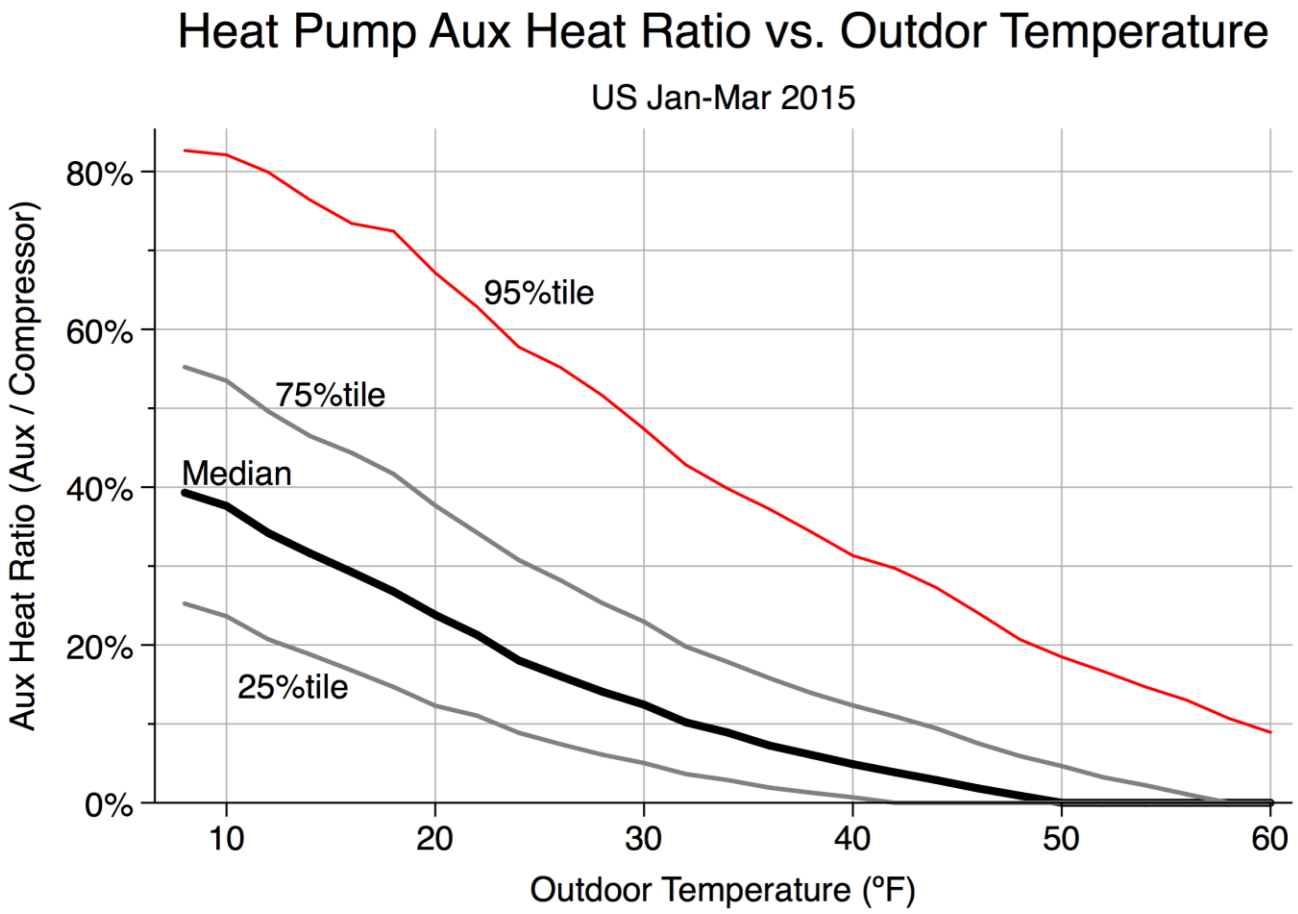

What was found

Site ID	City	Year Built	Sq. ft.	MH Type	Tonnage	Annual kWh in pre-period	Strip Heat Ratio
683853	Bend	1996	1400	Double-wide	2	10452	49%
683890	Bend	1997	1400	Double-wide	2	19685	14%
677995	Bend	1997	1620	Double-wide	2.5	23871	9%
139287	Oregon City	1991	1292	Double-wide	2	15114	7%
25106	Oregon City	1991	1080	Double-wide	2	18094	5%
690344	Terrebonne	1997	1296	Double-wide	2	13630	4%
689461	Bend	1997	1200	Double-wide	2	16089	3%
543542	Oregon City	1995	1800	Double-wide	3	13377	2%
497998	Oregon City	1995	1290	Double-wide	2	11861	2%
325913	Bend	1988	1980	Double-wide	3	17161	2%
690383	Oregon City	1996	1296	Double-wide	2	7230	1%
689451	Bend	1995	1810	Double-wide	3	Not found	1%
583813	Oregon City	1987	1296	Double-wide	2	17410	0%
562026	Oregon City	1990	1568	Double-wide	2.5	10711	0%
520339	Portland	2014	1500	Double-wide	2.5	13310	0%
467510	Bend	1997	1400	Single-wide	2	23871	0%
231255	Oregon City	1990	1400	Double-wide	2.5	12601	0%
467251	Bend	1997	1400	Double-wide	2.5	13761	0%
683842	Oregon City	2013	1917	Double-wide	3	14744	0%

[1] Annual kWh in pre-period is metered use reported to the utility.

What We Found

Site ID	Aux Heat Ratio	Delta Capacity	% Below or Above	Thermostat Settings	ACH at 50Pa	Duct Leakage CFM	Reasons for high aux heat ratio
1173489	0	2114	9%	Strip heat locked out at 35F.	6.8	62	
1156226	0	-6009	-20%	Max Savings	19.4	550	
231255	0	-3272	-11%	Max Savings	7.2	138	
562026	0	-5961	-20%	Max Savings	5.1	707	
1171519	4	54	0%	Max Savings	10.0	274	
139287	7	-5427	-23%	Max comfort	10.3	238	Set to Max Comfort, 23% low on capacity
1138572	9	-11966	-40%	Max comfort -	5.4	250	Set to Max Comfort, Very low capacity
1156212	14	-1709	-7%	Max Savings	10.4	225	Homeowner used deep set backs
1156132	49	3721	16%	Locked out compressor at 35F	9.0	176	Locked out compressor

Preliminary Conclusions

- All thermostats can cause control problems
  - But connected thermostats can find them!

- Maybe by comparing run times and using connected thermostats “problem” homes or systems can be found

Our Best Advice

- Choose a compatible thermostat for your HVAC system
- Decide who will commission the thermostat
- User friendly is better
- Ask the owner for data access
- Educate the homeowner

Evaluations Matter: Both Teams Have the Same Features

Thank You

Bruce Manclark

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