CLEAResult®

Are you smarter than your smart stat?

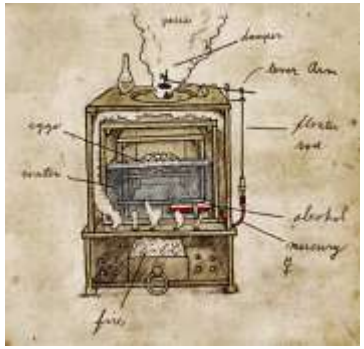
Smart learning thermostat experience

Bruce Manclark

We change the way people use energy™

A short history of the thermostat
Hardware to Software

noun
a device that automatically regulates temperature, or that activates a device when the temperature reaches a certain point

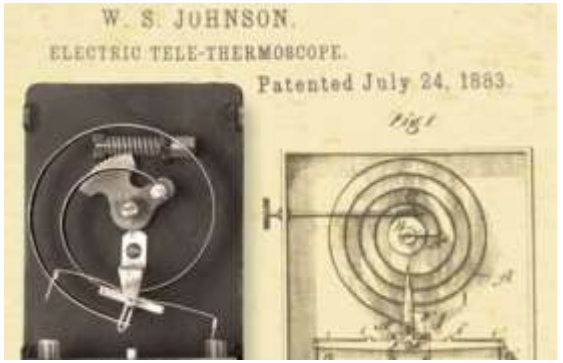


The “magic oven”

Cornellis Drebbel
1592

1885 the “damper Flapper”

Albert M. Butz



Warren Johnson

CLEAResult®

A short history of the thermostat

1906
First programmable thermostat

1953
Henry Drewfuss' Honeywell T87 thermostat

The Chronotherm II adaptive intelligent recovery

Honeywell's VisionPRO

2007
Ecobee

CLEAResult®

Completed pilots

Energy Trust of Oregon

- DI Nest t-stats for 200 homes with heat pumps and 200 control homes
- Installed by CLEAResult staff
- Issues faced: bricked product; close calls on customer service

FRANKLIN PUD
THE POWER IS YOURS

Franklin PUD

- 176 homes (small control group)
- Installed by third-party HVAC contractor
- Issues faced: contractor training hurdles

Energy Trust of Oregon

- DIY comparison on gas-heated homes
- Installed by homeowner
- Issues faced: fewer than expected. Geo-fencing set up

A smart thermostat is not a commodity

The term *commodity* describes a class of goods for which there is demand, but which is supplied without qualitative differentiation across a market.

Smart thermostats vs. commodities

Key differences:

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

Energy Trust of Oregon Heat Pump Pilot

- 200 homes recruited from home audit database
- Installed by CLEAResult
- Connected to Wi-Fi
- Programmed to Max Savings in Balance Point mode
- Learned what the term “bricked” meant

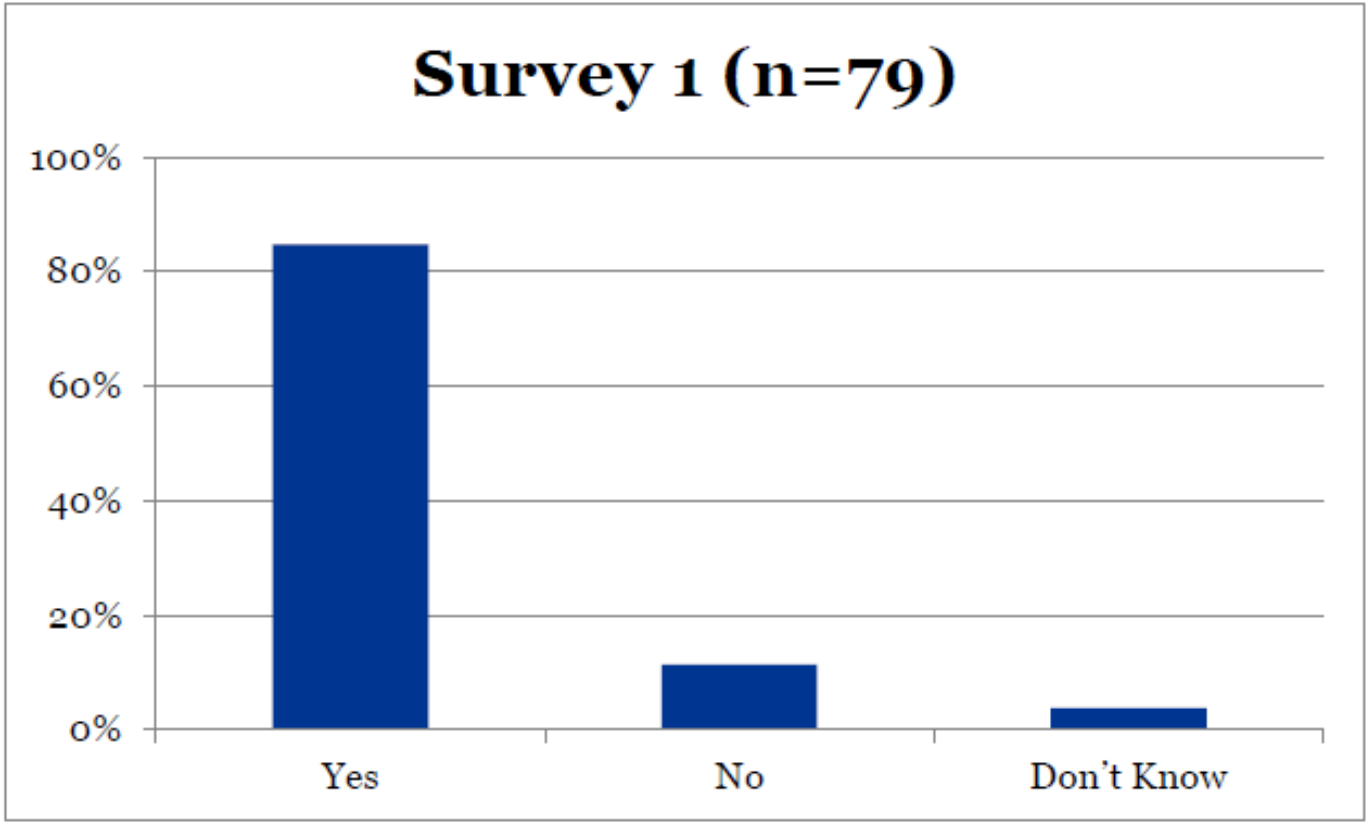
The savings are…

Nest weather-normalized annual 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%

Existing thermostats

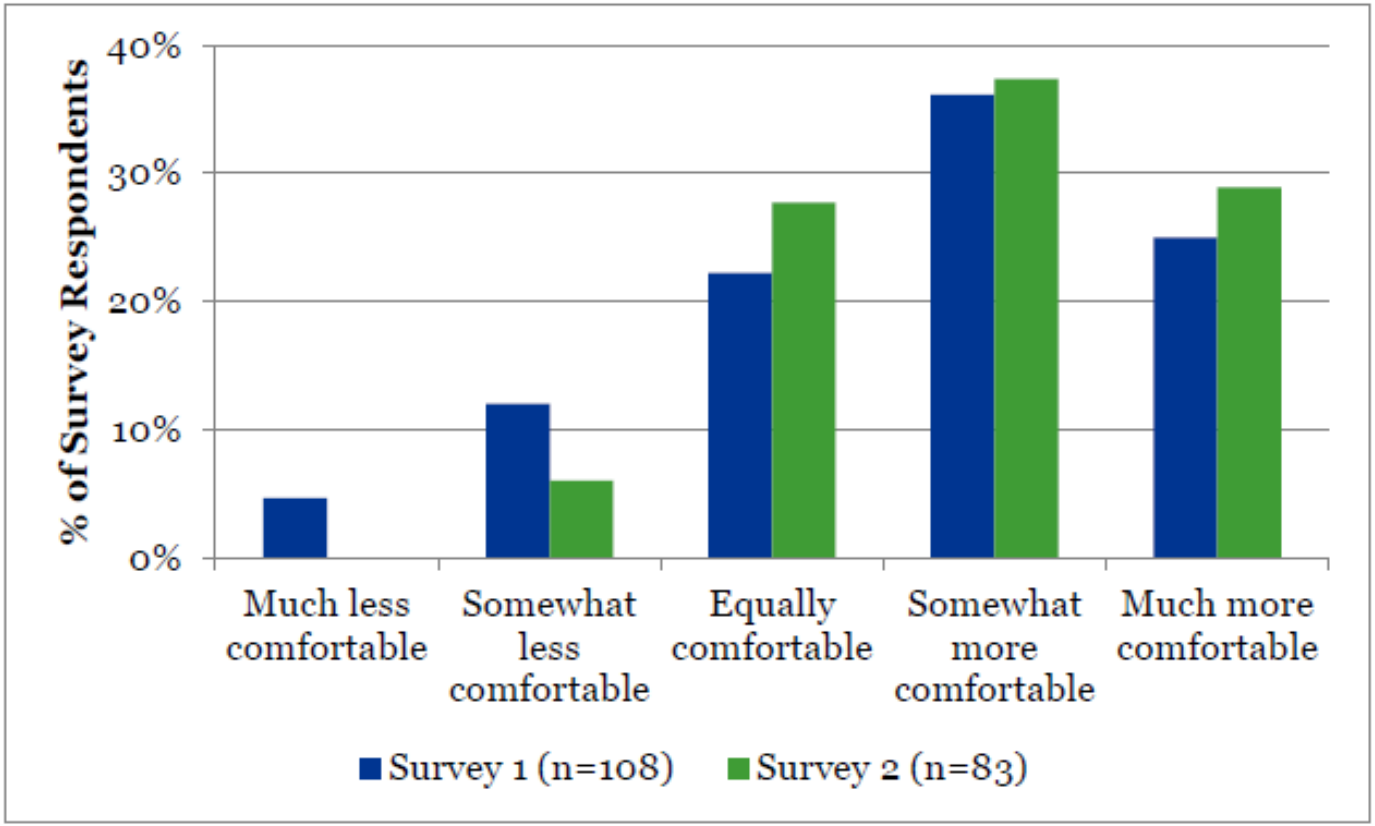
Was previous programmable thermostat actually programmed?



Data and graphics from Energy Trust of Oregon and Apex Analytics

Increased comfort

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?

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%

Data and graphics from Energy Trust of Oregon and Apex Analytics

Targeting high users might be a great idea

Nest weather-normalized annual electric savings by annual electricity usage

Electricity Usage Category	Participant N / Comparison N	Annual Savings (90% CI)	Std. Err.	p-value	Annual Usage	% Savings (90% CI)	Realization Rate
Less than 13,000 kWh	32 / 79	-60 (-619, 498)	308	0.848	10,022	-0.6% (-6.2, 5.0)	-7%
13,000 to 18,000 kWh	46 / 62	267 (-330, 864)	329	0.437	15,125	1.8% (-2.2, 5.7)	32%
18,000+ kWh	34 / 53	1,984 (678, 3289)	720	0.020	24,233	8.2% (2.8, 13.6)	237%

Data and graphics from Energy Trust of Oregon and Apex Analytics

Franklin PUD project

FRANKLIN PUD

THE POWER IS YOURS

Franklin PUD project

- Installed by local contractor
- Participants were a mix of heat pump customers known to Franklin PUD and customers of the installing contractors
- CLEAResult used online QC to ensure that the units were placed in Max Savings Heat Pump Balance mode
- Smallish (40 homes) used for control group

PRISM model analysis

N	Total annual savings (kWh)	95% lower C.I.	95% upper C.I.	R-Squared criteria	Pre-install consumption	% Total savings
167	885	381	1,388	All	21,804	4.06%
130	824	314	1,333	>= .50	21,016	3.92%
115	959	419	1,498	>= .60	20,930	4.58%
97	1103	599	1,607	>= .70	21,110	5.23%

Data from Phillip Kelsven and Robert Weber. BPA

Random effects models

Model specification	Annual kWh savings
1. Pure fixed effects with year built	970
2. Random with HDD random effect, with year built	884
3. Random without HDD random effect, with year built	965
4. Random with HDD random effect, no year built	955
5. Random without HDD random effect, no year built	969
6. Random with square feet random effect, with year built	971

Data from Phillip Kelsven and Robert Weber. BPA

Findings on the Nest/Lyric DIY gas furnace pilot

Billing analysis

Analyzed monthly gas billing data

- Nest and Lyric participants analyzed separately
- Compared pre- to post-change in gas use between treatment and comparison homes
- Used regression models to estimate impact of thermostats on gas use while controlling for weather
- Final savings weather normalized and annualized

Three different comparisons were made to reduce potential biases

- All qualified customers vs. randomized comparison group (Intention-to-treat analysis using local average treatment effect)
- Pilot participants vs. randomized comparison group
- Pilot participants vs. matched comparison group

Subgroup analyzed to see if savings varied between groups.

Installation rates

Participation phase	Nest	Lyric	Total
Number of thermostats purchased	220	195	415
Returned/defective/shipping problem	8	24	32
Total thermostats installed	**212**	**171**	**383**
Percent of thermostats installed	**96%**	**88%**	**92%**

Reason for return	Nest	Lyric	Total
Customer complaints	0	5	5
Installation problem – thermostat functions	1	6	7
Installation problem – defective thermostat	1	7	8
Post-installation problem – thermostat failed	3	3	6
Post-installation problem – unknown	2	1	3
Shipping problem	1	2	3
Total returned	**8**	**24**	**32**
Percent returned	**4%**	**12%**	**8%**

Data and graphics from Energy Trust of Oregon and Apex Analytics

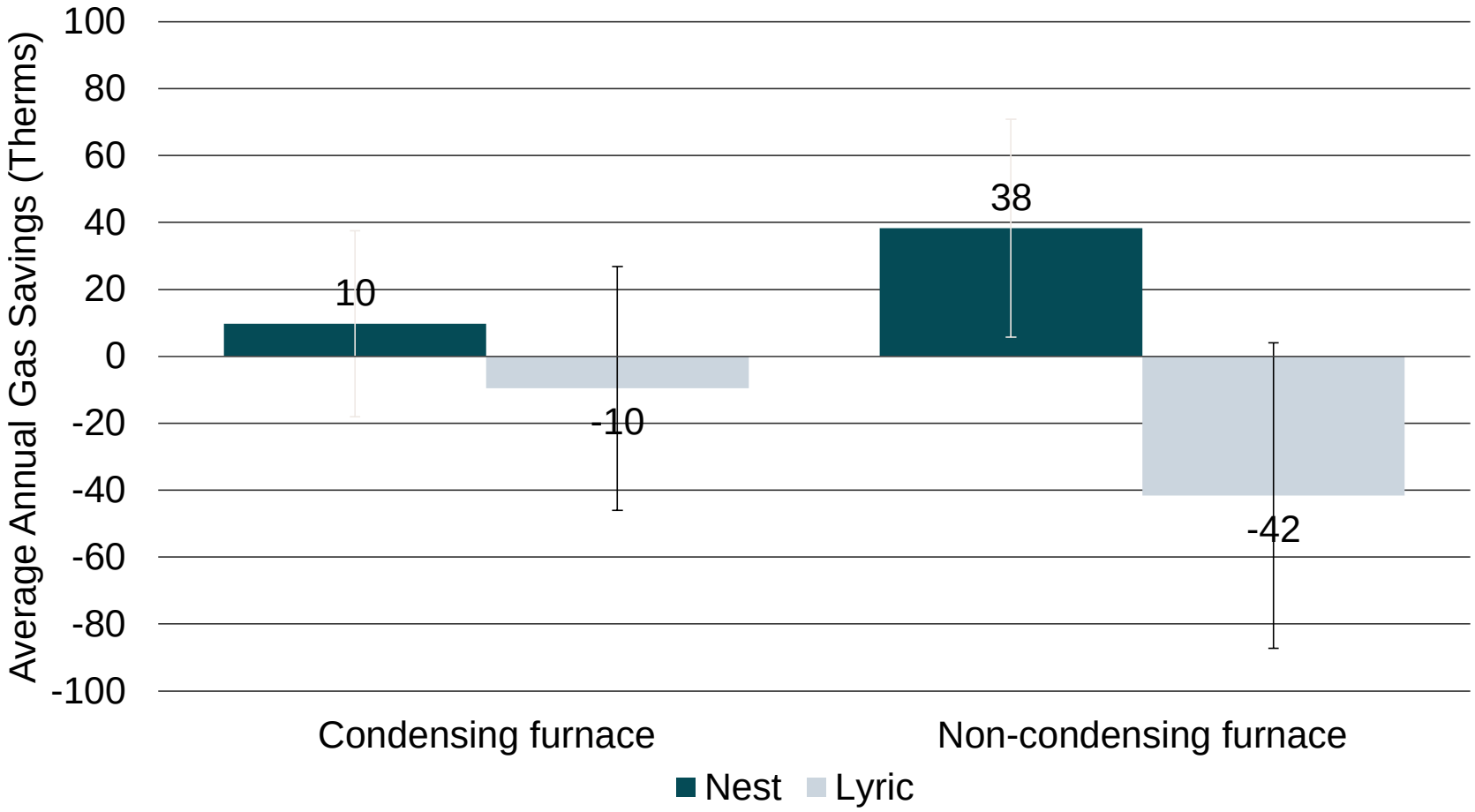
Results

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

Savings by furnace type



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Lessons learned

1. Quality control at some level is needed.

2. Technical support, while not always perfect, is improving.

3. Design/user interface matters.

4. High-end HVAC systems may have propriety t-stats. Third-party t-stats will not work or offer all the features that propriety t-stat does.

More lessons

5. Two-wire configurations only work with some t-stats.

6. Record the serial number or Mac address if you want data from manufacturer.

7. Never assume everything is going well in a pilot.

8. Talk early to the manufacturer, as data sharing might be easier than you think.

9. Smart devices may do dumb things.
   It’s the age of the algorithm. Not a commodity

