



## Top Smart Thermostats for Preference and Usability

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 RESEARCH SOLUTIONS

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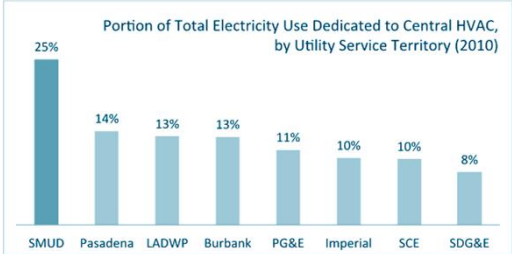


Powering forward. Together.




## Why Thermostats Matter

- Thermostats manage ~25% of annual electricity use at SMUD
- Residential AC is responsible for >30% of SMUD peak



Utility Service Territory	Portion (%)
SMUD	25%
Pasadena	14%
LADWP	13%
Burbank	13%
PG&E	11%
Imperial	10%
SCE	10%
SDG&E	8%

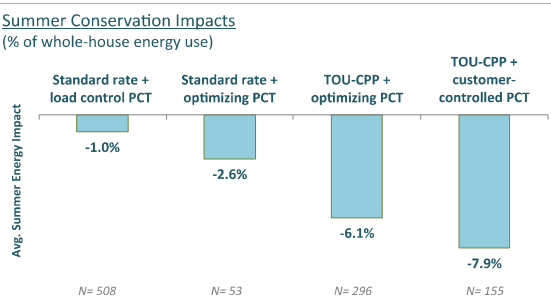
Source: California Energy Commission, 2009



## Why Smart Thermostats Matter


### Summer Conservation Impacts

(% of whole-house energy use)



Rate Structure	Avg. Summer Energy Impact (%)	N
Standard rate + load control PCT	-1.0%	508
Standard rate + optimizing PCT	-2.6%	53
TOU-CPP + optimizing PCT	-6.1%	296
TOU-CPP + customer-controlled PCT	-7.9%	155

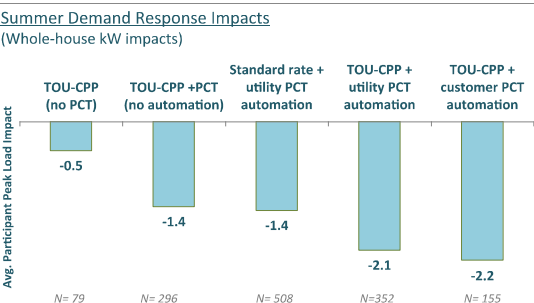
Source: Herter Energy, SMUD's Load Impact Calculator



## Why Smart Thermostats Matter


### Summer Demand Response Impacts

(Whole-house kW impacts)



Rate Structure	Avg. Participant Peak Load Impact (kW)	N
TOU-CPP (no PCT)	-0.5	79
TOU-CPP + PCT (no automation)	-1.4	296
Standard rate + utility PCT automation	-1.4	508
TOU-CPP + utility PCT automation	-2.1	352
TOU-CPP + customer PCT automation	-2.2	155

Source: Herter Energy, SMUD's Load Impact Calculator



## Thermostats Tested (2013)



## Research Questions

- How do thermostats compare in terms of:
  - Efficiency (time-on-task)
  - Preference (of two tested thermostats)
  - Satisfaction (ratings of standard features)
- How do participants rate **advanced features**?

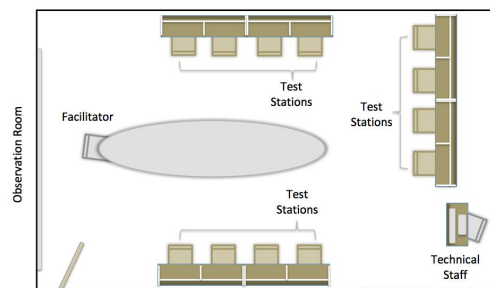


## Methodology

- 12 thermostats tested
  - 10 communicating “smart” thermostats (6 with apps)
  - 2 standard non-communicating thermostats
- Simultaneous multi-user, paired-comparison test
  - 163 participants x 2 units per participant = 326 tests
  - >95% of possible ordered pairs tested
- 90-minute sessions
  - Video recording of thermostat tests
  - Surveys
  - Group discussions



## Laboratory Layout



## Efficiency = Time on Task

The same 7 tasks were performed for each thermostat

- 1 Identify the current indoor temperature
- 2 Set to cool. Identify the current target cooling temperature
- 3 Change the current target cooling temperature to 79
- 4 Identify the scheduled cooling temperature for Saturday at 8 am
- 5 Set to heat. Identify the current target heating temperature
- 6 Change the current target heating temperature to 63
- 7 Identify the scheduled heating temperature for Saturday at 8 am

$$\text{Task Efficiency} = 2s / (1+e^t)$$

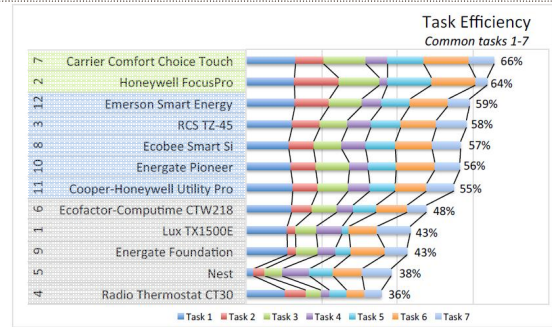
Where

- s = Success = {0 for failed tasks; 1 for completed tasks}
- t = Time-on-Task = time to complete the task, in minutes.

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## Results: Efficiency



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## Preference

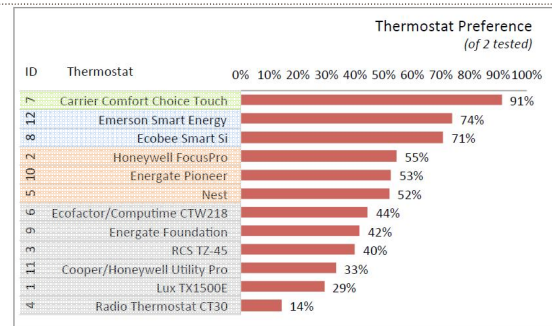
Imagine that the thermostat in your home suddenly dies and your mechanic offers a choice between the thermostats you just reviewed - at the same price. Please circle the thermostat you would choose to have installed.

6 2

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## Results: Preference



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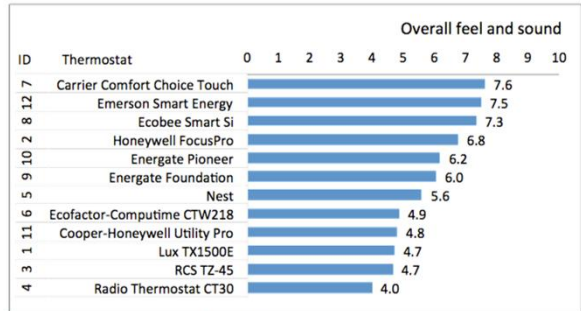


## Satisfaction (with Standard Features)

- 1 Rate EASE OF USE and UNDERSTANDING
  - a Information on the screen
  - b Buttons, dials and switches
  - c Meanings of words and symbols
  - d Menu navigation
  - e Overall ease of use
- 2 Rate how the thermostat FEELS and SOUNDS
  - a Buttons
  - b Touchscreen
  - c Dials
  - d Switches
  - e Overall feel and sound
- 3 Rate how the thermostat LOOKS
  - a Layout of the screen and buttons
  - b Size of the screen
  - c Color(s)
  - d Readability of the smallest text
  - e Overall appearance of the thermostat



## Results: Satisfaction



Statistical significance bounds:  $\pm 2.6$  ( $\alpha=0.01$ )

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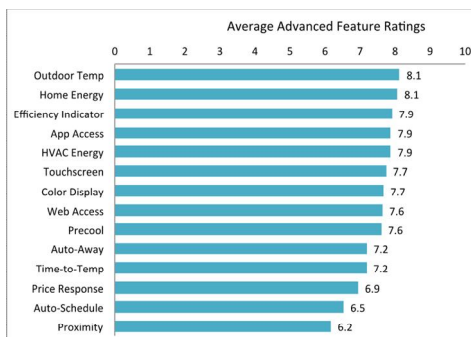
## Regression of Standard Features Ratings on Efficiency and Preference

- Screen**
  - Color display  $\rightarrow$  higher Preference scores
  - Larger screen  $\rightarrow$  higher Efficiency scores
- Feel and Sound**
  - Higher Feel & Sound ratings  $\rightarrow$  higher Preference
- Participant Characteristics**
  - Youth  $\rightarrow$  higher Efficiency scores
  - Home owners  $\rightarrow$  higher Efficiency scores
- Smart Phone App**
  - Not significant in predicting efficiency or preference
  - Rated higher by younger users
- Appearance**
  - Not significant
- Number of Buttons**
  - Not significant

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## Perceived Usefulness of Potential Advanced Features



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## Top Ranking Smart Thermostats 2013

### 1. Carrier Comfort Choice Touch



### 1. Emerson Smart Energy



### 1. Ecobee Smart Si



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## Thermostats being Tested (2015)



ecobee3



Honeywell Lyric



Honeywell RTH9320WF



Emerson Sensi



Venstar ColorTouch



Trane XL824



Lux GEO



Carrier Cor



Nest 3rd generation



Schneider Wiser Air



American Standard AZone950



Allure Eversense



## U.S. Department of Energy Disclaimer

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## Questions?

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