Preliminary results from field evaluation of programmable thermostats:

Does usability matter for energy savings?


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Fraunhofer CSE – Applied R&D and Technology Commercialization

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- Focus on building technologies, solar photovoltaics (PV), and technology commercialization
  - Confidential co-development programs
  - Third-party technology validation
  - Technology commercialization assistance for early-stage cleantech companies
  - Targeted research initiatives to promote the profitability and technical leadership of U.S. industry

Building Energy Efficiency

Photovoltaic Module Technology

Technology Commercialization

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Building Energy Efficiency Group – Focus Areas and Capabilities

Core Focus Areas:

- Building Enclosures
- Residential Energy Management

Cross-Cutting Capabilities

- Energy Modeling
- Field Monitoring and Evaluation
- Technology Assessment and Energy Consumption Characterization

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Overview

- Thermostats and saving energy
- Usability of programmable thermostats
- Fraunhofer project to evaluate how thermostat usability affects energy-saving behavior
- Our results in the context of behavior change model

Thermostats & Energy Saving

Programmable thermostats have large energy savings potential:

- Heating and cooling comprise 42% of total source residential energy
- Rule of thumb: 3% reduction in energy use for each degree of reduction in setpoint temperature
- Most U.S. households own either a programmable (37%) or manual (48%) thermostat (if they know what that means)

Source: DOE/EIA.

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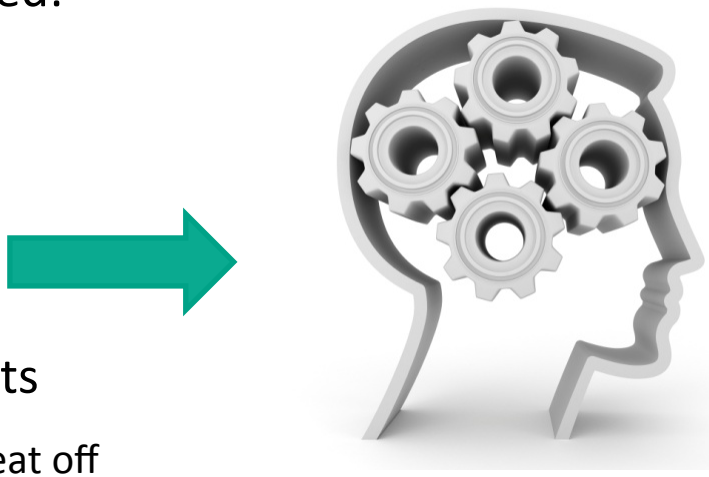
Thermostats & Energy Saving

Thermostat effectiveness depends on home occupant behavior:

- Programming for energy savings is complicated:
  - Weekday/weekend, 7-day, vacation
  - Small fonts/buttons, abbreviations
  - Confusing symbols and lights



- Misconceptions about energy and thermostats
  - Heating all the time is more efficient than turning heat off
  - Thermostat is simply an on/off switch
  - Thermostat is a dimmer switch for heat

Source: A. Meier et al. (2011)

Thermostats & Energy Saving

Energy savings due to programmable thermostats:

- Programmable thermostats **save** energy
  - 6% and 3.6% savings in a billing analysis of 7,000 and 25,000 households, respectively
  - 9% savings in a survey of 2,300 respondents

- Programmable thermostats **do not** save energy
  - No significant savings in billing and survey analysis of 299 households
  - No savings and/or some increases

Sources: RLW Analytics (2007), Michaud et al. (2009), Tachibana (2009), Nevius & Pigg (1999), Cross & Judd (1996), Conner (2001), Parker 2000)

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Current focus: Thermostat usability

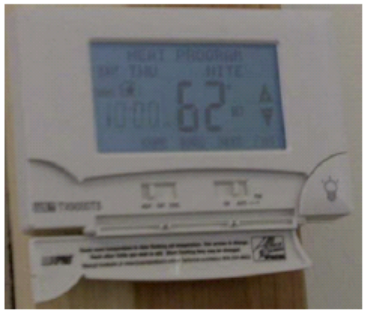
Development of new specifications for EnergyStar:

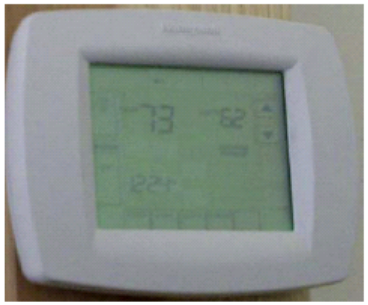
- Main assumption:
  - Improved usability will facilitate energy saving behavior
- Main questions:
  - How to measure usability of programmable thermostats?
  - How usability affects use and adoption of thermostat energy saving features?

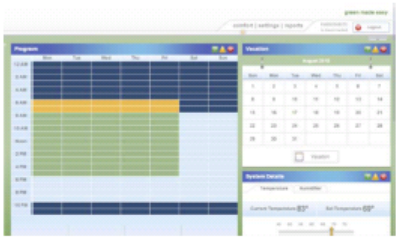
Current focus: Thermostat usability

Usability tests at LBNL (A.Meier et al.):

- 5 thermostat interfaces
- 31 participants
- 2 intefaces per person
- 6 tasks for each test
- 372 videos







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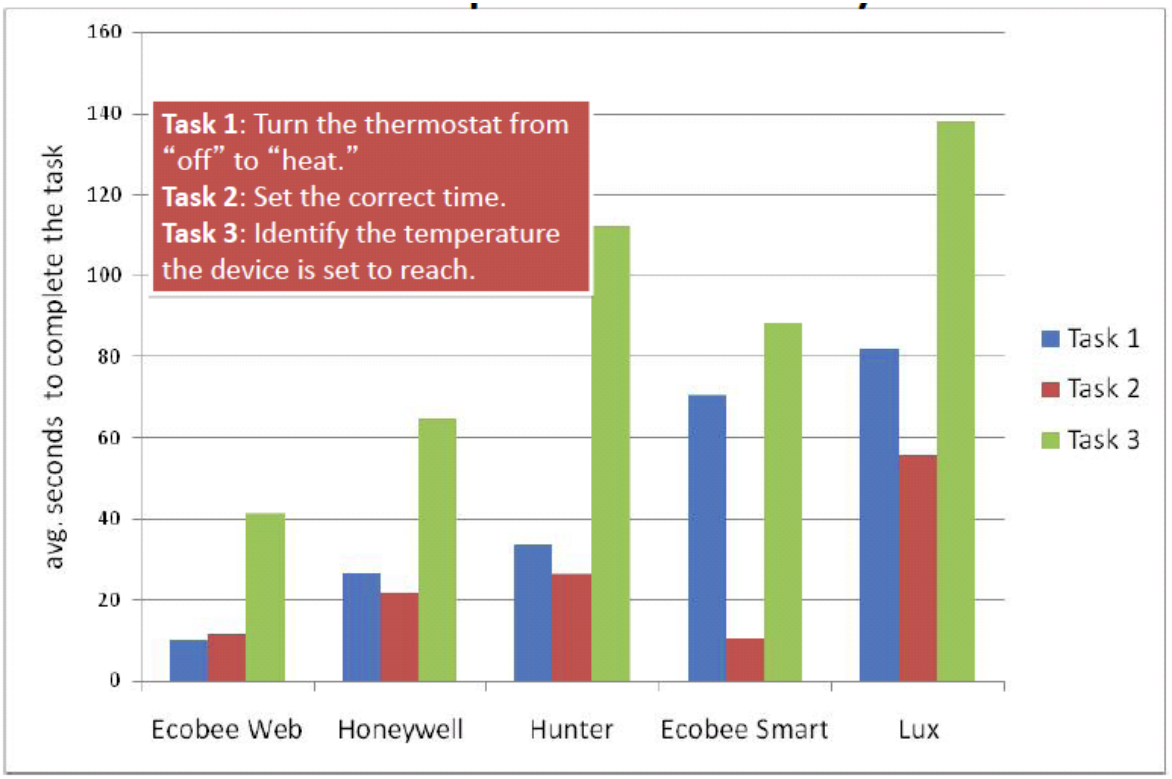
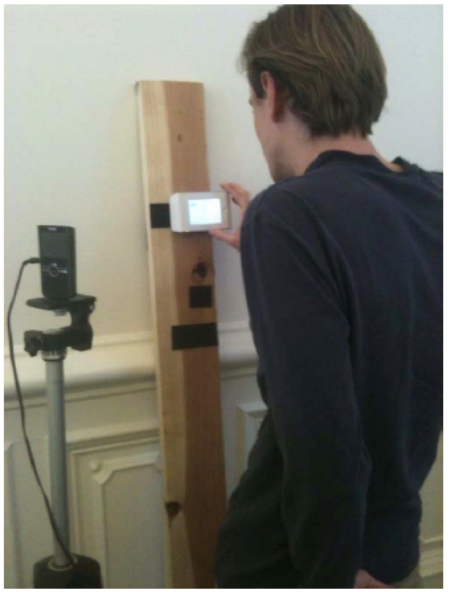
Current focus: Thermostat usability

Usability tests at LBNL (A.Meier et al.):





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Current focus: Thermostat usability

Findings from usability tests at LBNL (A.Meier et al.):

- Touchscreen interface performed better than button interface
- Best-performing thermostat requires internet (WiFi) and computer
- Second best is Honeywell VisionPro

Does usability facilitate energy saving behavior?

U.S. Department of Energy (DOE), Building America project

- Field Evaluation Study
- Research question:

Are people with a high-usability thermostat more likely to use energy-saving settings?

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- Multifamily affordable housing building in Revere, MA
- Weatherization in entire building
  - Furnace/AC replacement, insulation and air-sealing of the back wall in the utility closet
- Opt-out recruitment
- 83 out of 92 households participated in the study
- 63 valid datasets

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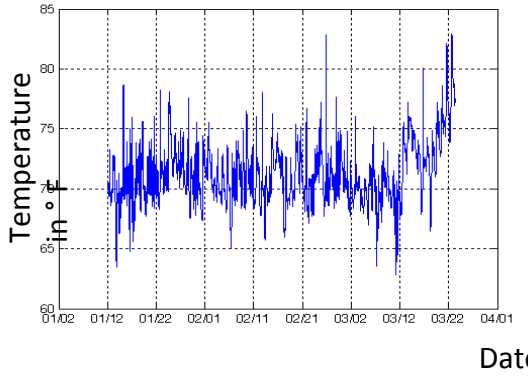
- Touch screen (high-usability) thermostats
- Button interface (low-usability thermostats)
- Non-intrusive sensors to measure
  - Temperature
  - Humidity
  - Furnace on/off state
- Questionnaire data
- Gas meter readings
- Weather data (Boston)



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Two thermostat groups

- “high usability” touch screen

  VisionPro 8000 (VP)

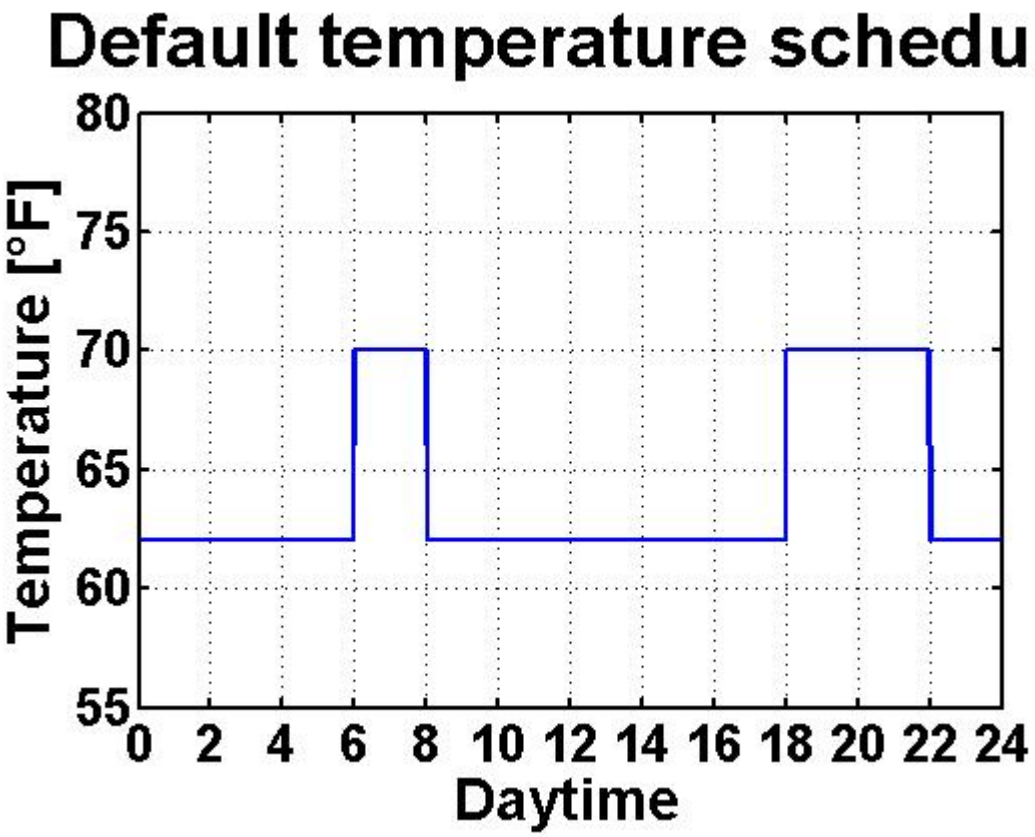
$118

- “low usability” button interface

  Basic Programmable (BA)

$17

Same default settings



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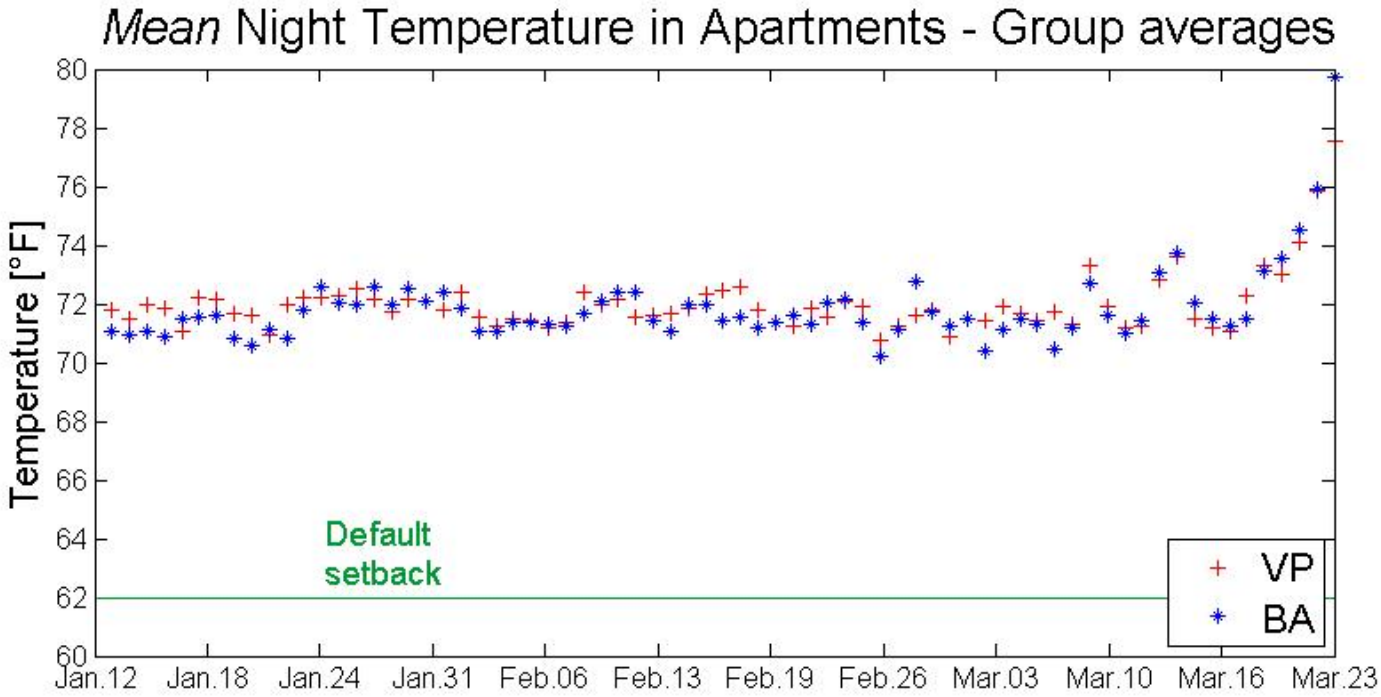
Results: Night temp – setback or not?



T_{mean}	BA	VP
Mean [°F]	71.8	72.0
Std. dev. [°F]	1.3	1.0

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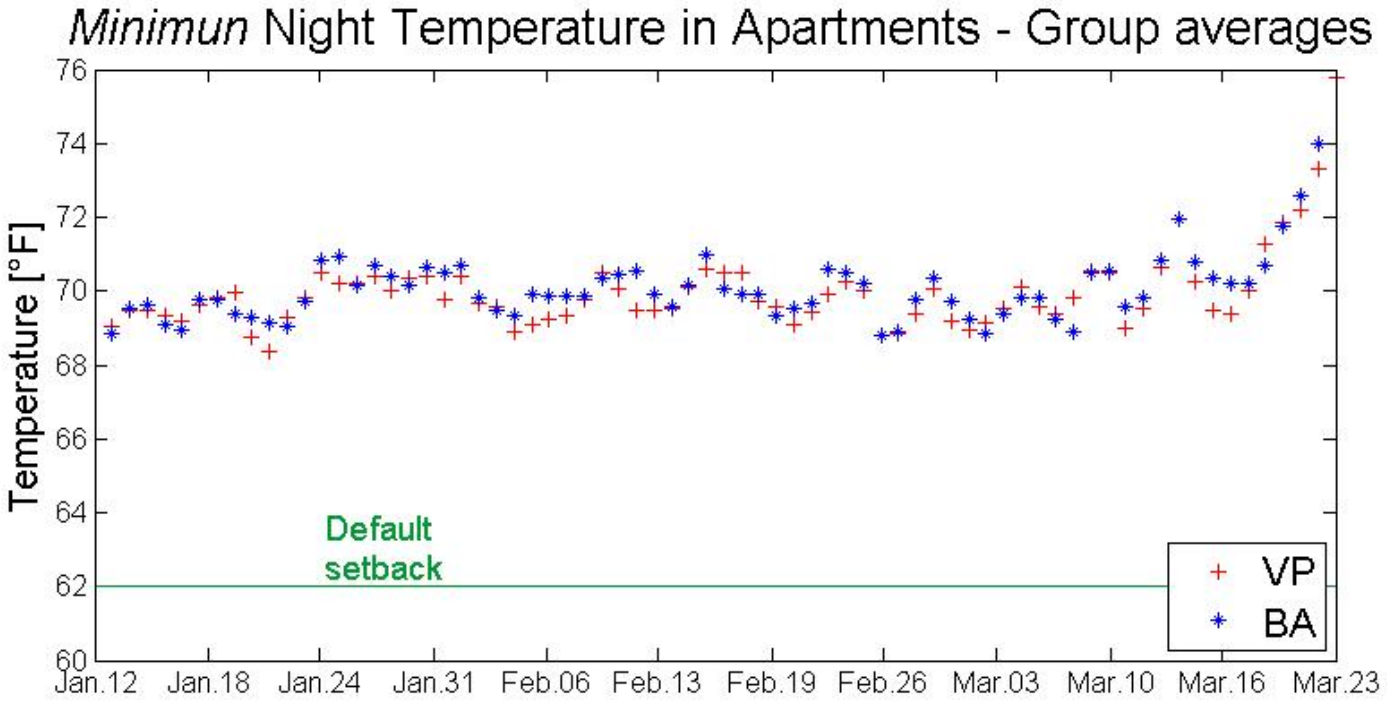
Results: Night temp – setback or not?



T_{min}	BA	VP
Mean [°F]	70.1	69.9
Std. dev. [°F]	1.3	1.1

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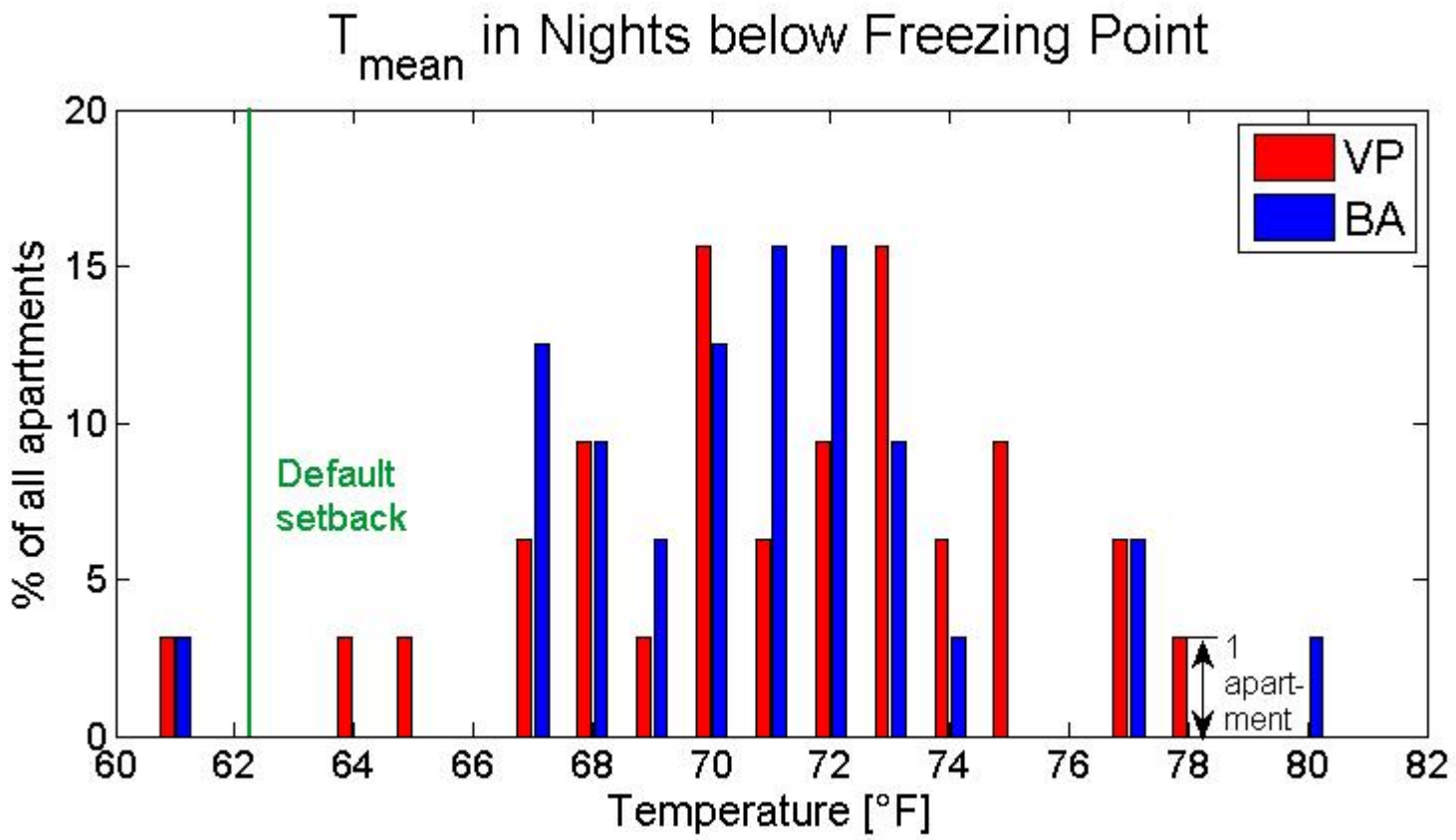
Results: Coldest nights

- Only nights when temperature fell below freezing 32°F (22 nights after January 12)
- Calculated average temperature for each apartment between midnight and 4AM
- Averaged for 22 cold nights

Results: Coldest nights



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Results: Coldest nights

- Average night temperature across 22 cold nights:

	BA	VP
Tmean (°F)	71.6	71.2
Std.dev. (°F)	3.6	3.8

- Average evening temperature 8-10PM:

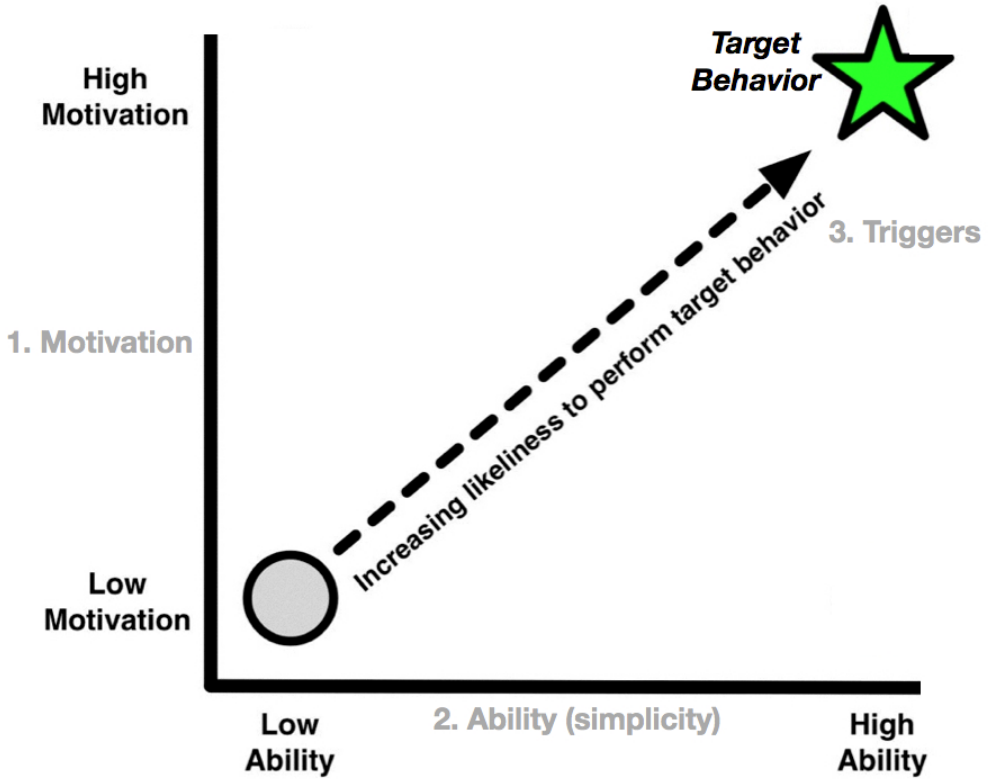
	BA	VP
Tmean (°F)	72.4	72.4
Std.dev. (°F)	3.8	3.6

To be released this summer and fall

- Percentage of households in each condition that used
  - daytime setbacks
  - Some program (default or not)
  - Overrides of default setting and the temp preferred
  - Permanent “Hold” function and for how long
- Relationship between self-report and sensor-based data
- Satisfaction with thermostats

What does it all mean?

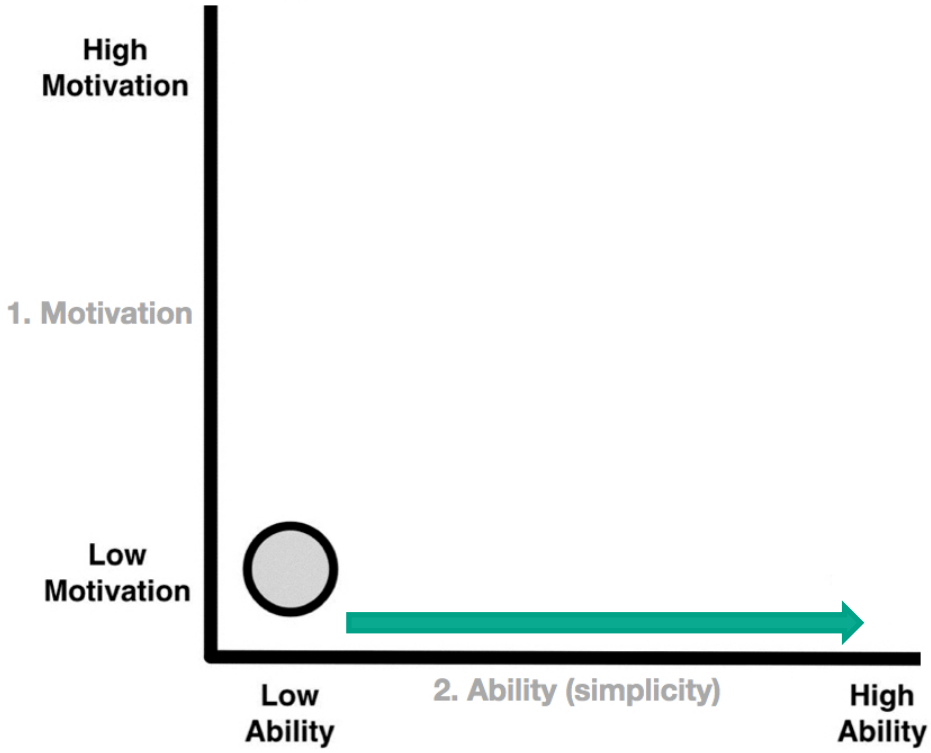
- Factors underlying Behavior Change:
  - Ability
  - Trigger
  - Motivation



Persuasive'09, April 26-29, Claremont, California, USA.

Thermostat behavior change: ability is not enough…

- Three main factors:
  - Ability
  - ~~Trigger~~
  - ~~Motivation~~



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Preliminary Conclusions

- Are people with a high-usability thermostat more likely to use energy-saving settings?
  - Not, unless they are motivated and „triggered“
- What do we do next?
  - Work on the missing components: motivation & triggers
  - Have technology replace motivation and triggers