

Innovative Low-Energy Occupant-Responsive HVAC Controls and Systems

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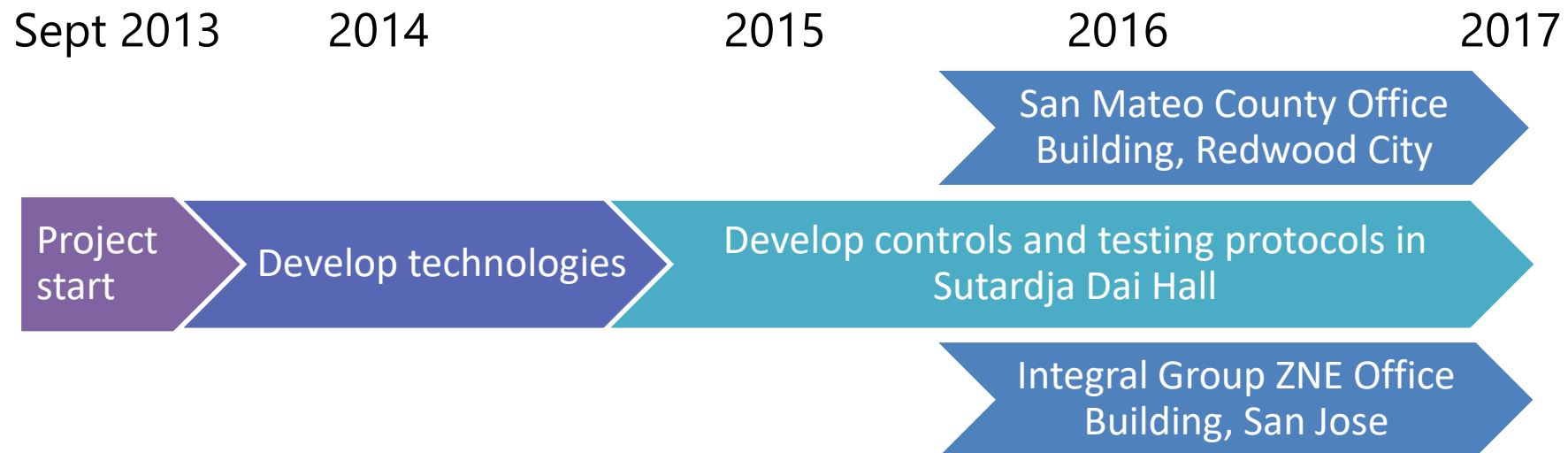
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Project overview

- 3 ½ year project: started September 2013; ended March 2017
- Funding: \$1.6M from CEC/PIER; \$175K match funding from CBE
- Research team: UC Berkeley: CBE, CIEE, EECS
Taylor Engineering, TRC Energy Services

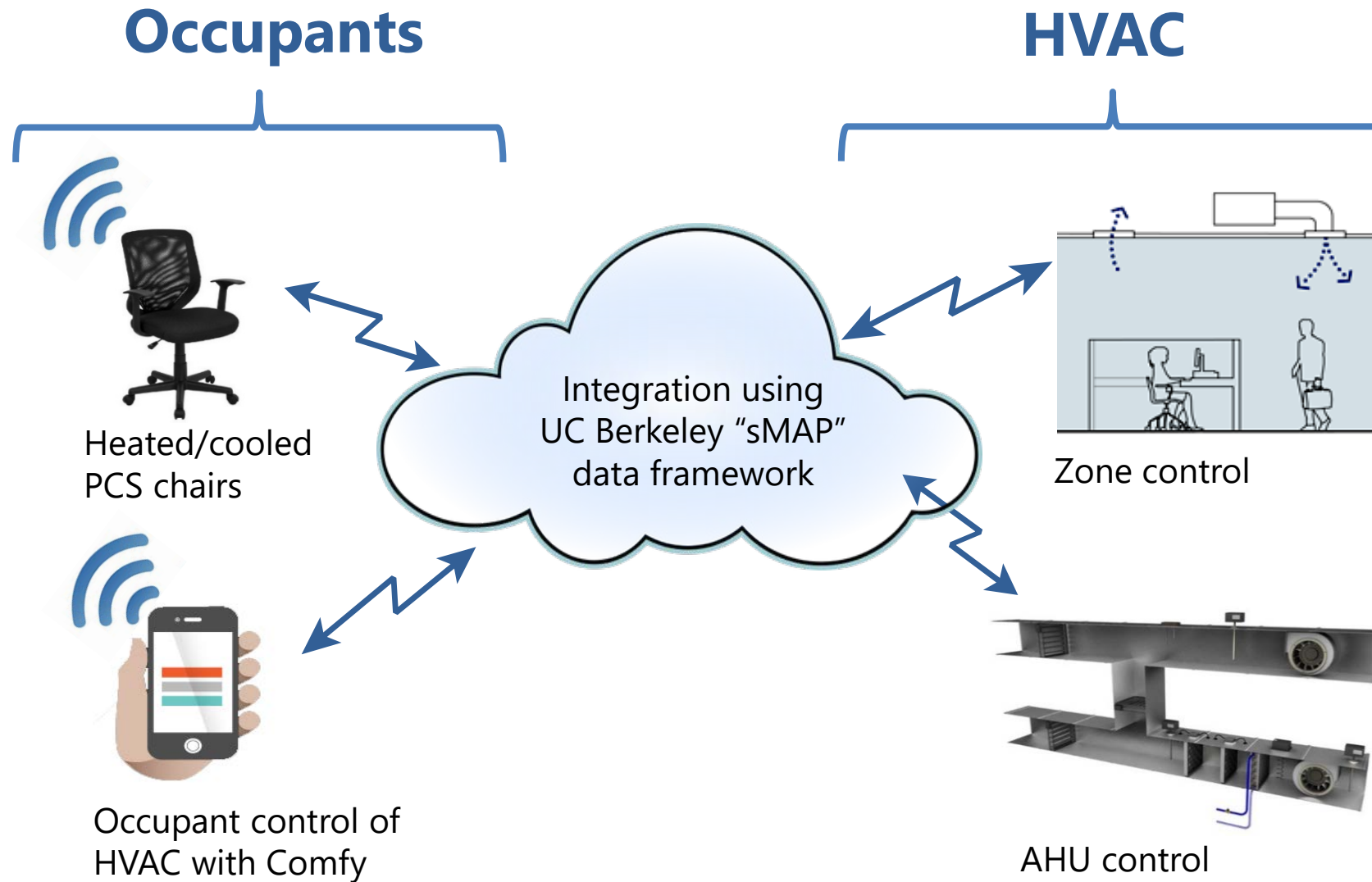
<http://www.cbe.berkeley.edu/research/occupant-responsive-hvac.htm>



Can we give occupants
control over their own
comfort *and* save energy



Integration of innovative technologies



Target areas for Changing the Rules

1. Measurement and actuation
2. Personal comfort systems
3. Occupant vote-based HVAC controls
4. Zone control
5. Air handling unit control
6. Codes and standards

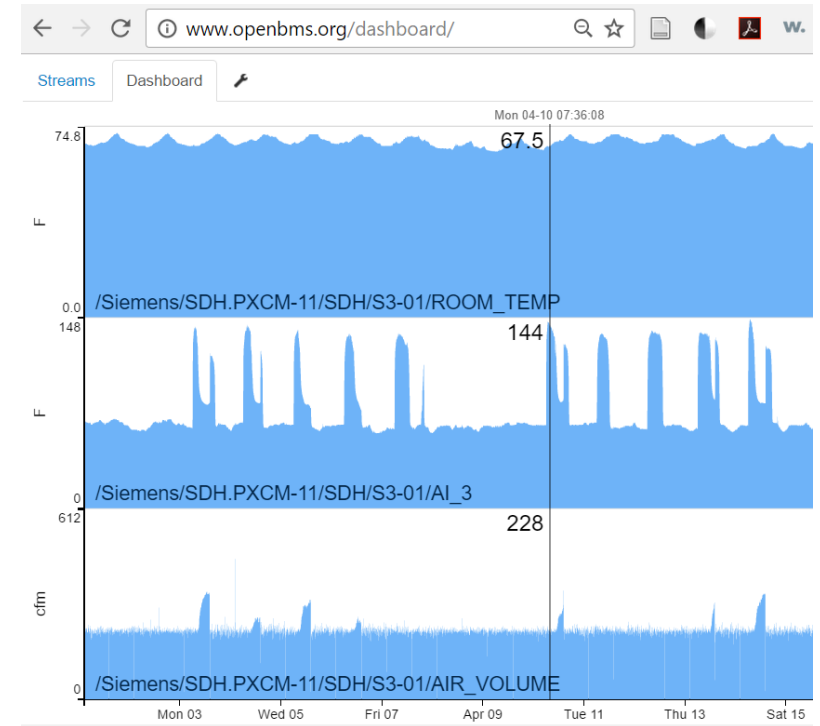


Sutardja Dai Hall (SDH), UC Berkeley
Source: Hathaway Dinwiddie

Changing the Rules:
Measurement
and actuation

Measurement and actuation: sMAP

- Use the Simple Measurement and Actuation Profile (sMAP) software
- Developed at the UC Berkeley Electrical Engineering and Computer Science Department
- Easily deployed in both new and existing buildings
- Allows actuation over BACnet *independently* from the BMS software
- Take a look: www.openbms.org/dashboard

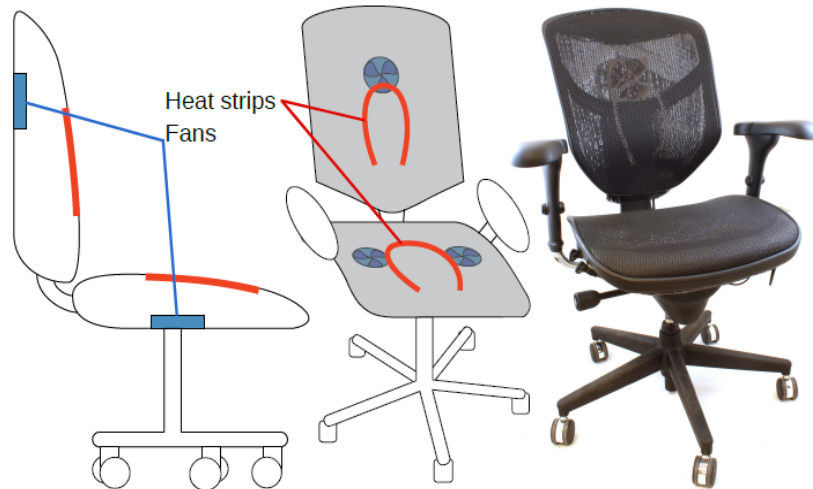


sMAP allows rapid access and visualization of data from different sources

Changing the Rules:
Personal comfort systems

CBE personal comfort chair

- Heated and cooled chair
- Provides individual control
- Saves energy by allowing wider HVAC temperature setpoints
- 50 chairs completed
- Temperature, humidity, occupancy & usage data collected and communicated wirelessly to sMAP server



Field studies using PCS chairs

Sites

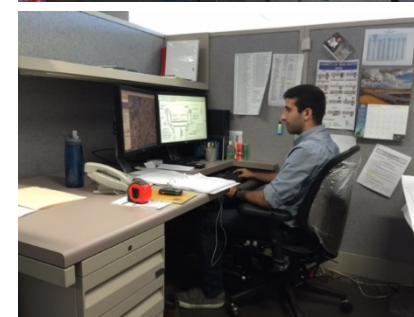
- Sutardja Dai Hall (SDH), UC Berkeley (Jul-Oct 2015)
- San Mateo County (SMC), Redwood City (Apr-Oct 2016)

Field deployment of digital PCS chairs

- 15 participants @ SDH (8 females, 7 males)
- 40 participants @ SMC (21 females, 19 males)
- Chair data: 4.8M entries @ 1-min intervals

Measurements of chair users

- Occupant surveys – over 95% acceptability
- Indoor environmental conditions
- PCS chair usage

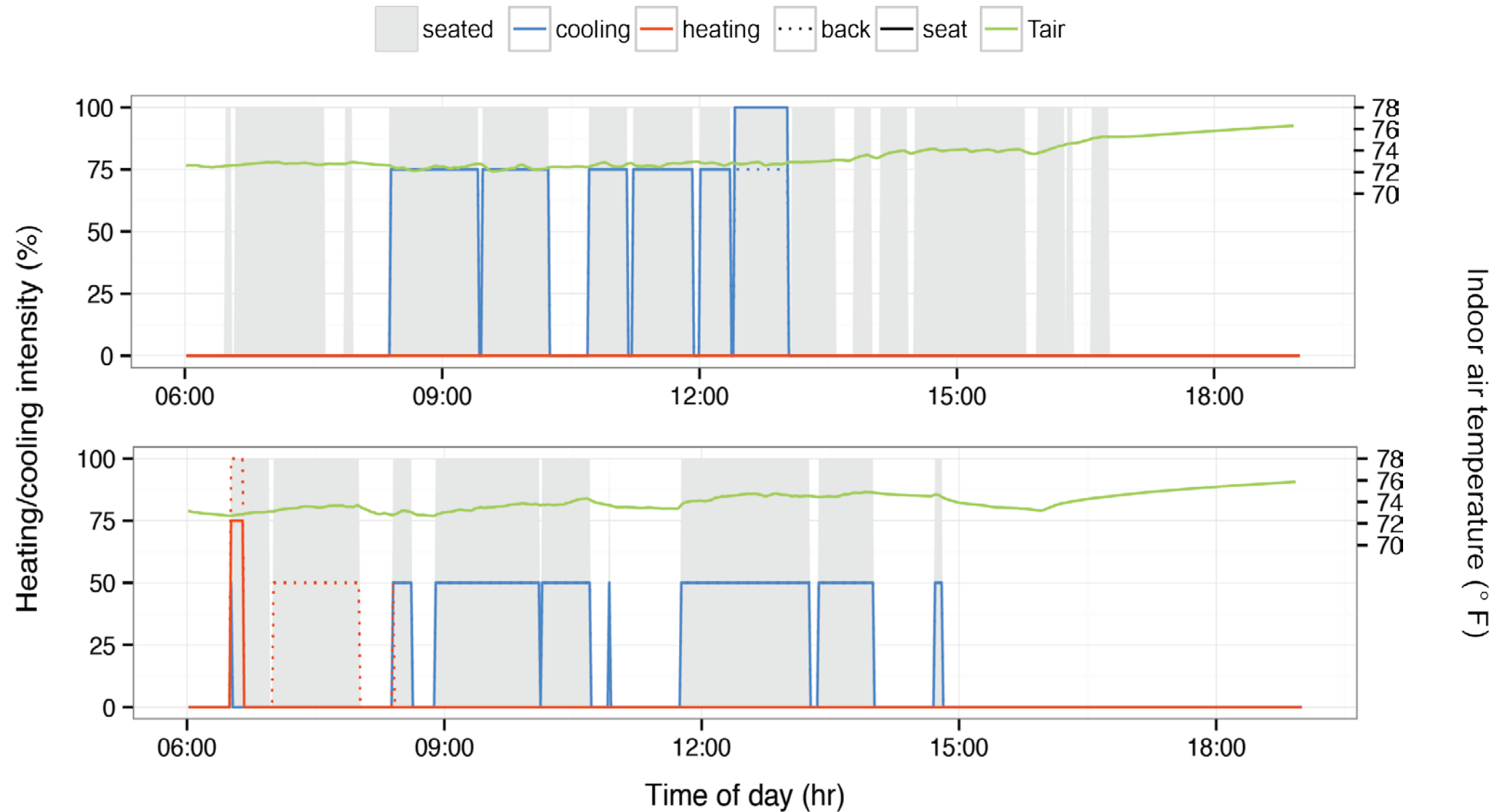


SMC 5th floor: Deployed chairs



● PCS chair

PCS chair study: 2 chairs in same VAV zone



Changing the Rules:
Occupant vote-based
HVAC controls

Occupant vote-based HVAC control: Comfy

Background

- Comfy, commercially available product from start-up company of former UC Berkeley students (Elec. Eng. & Computer Science, CBE)
- Occupants make comfort requests
- Integrates with HVAC controls

Results from San Mateo County

- Started with zone temperature float range of 70-74°F
- Expanded in steps to 69-76°F with no reduction in comfort satisfaction
- Response to Comfy was positive
- Building renewed agreement

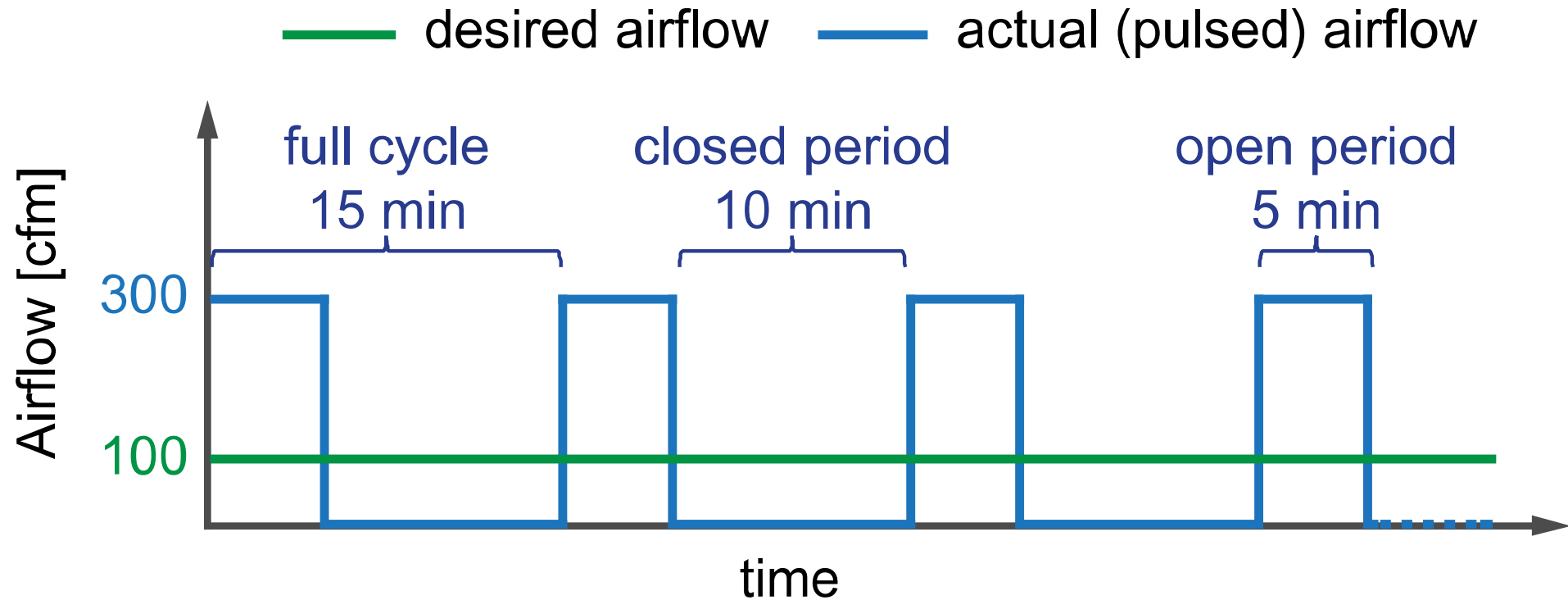


Comfy on a mobile device
Image: Comfy

Changing the Rules: Zone control

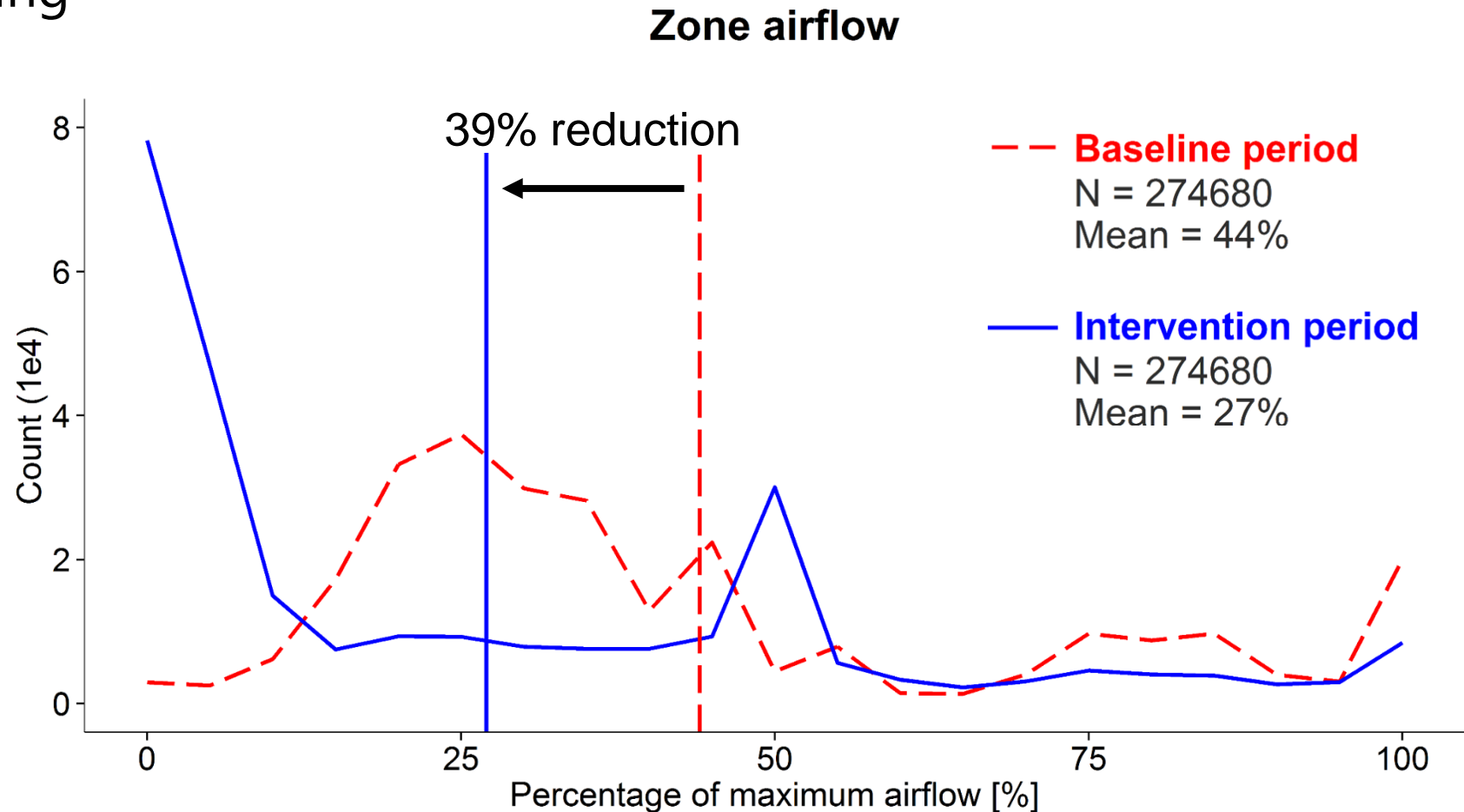
Time-averaged ventilation (TAV) principle

TAV controls the average airflow of a zone to the ventilation rate required by code



Results: TAV intervention field study

TAV does not reduce the amount of fresh outside air entering the building



Changing the Rules:
Air handling unit
control

AHU control

What's the optimal supply air temperature?

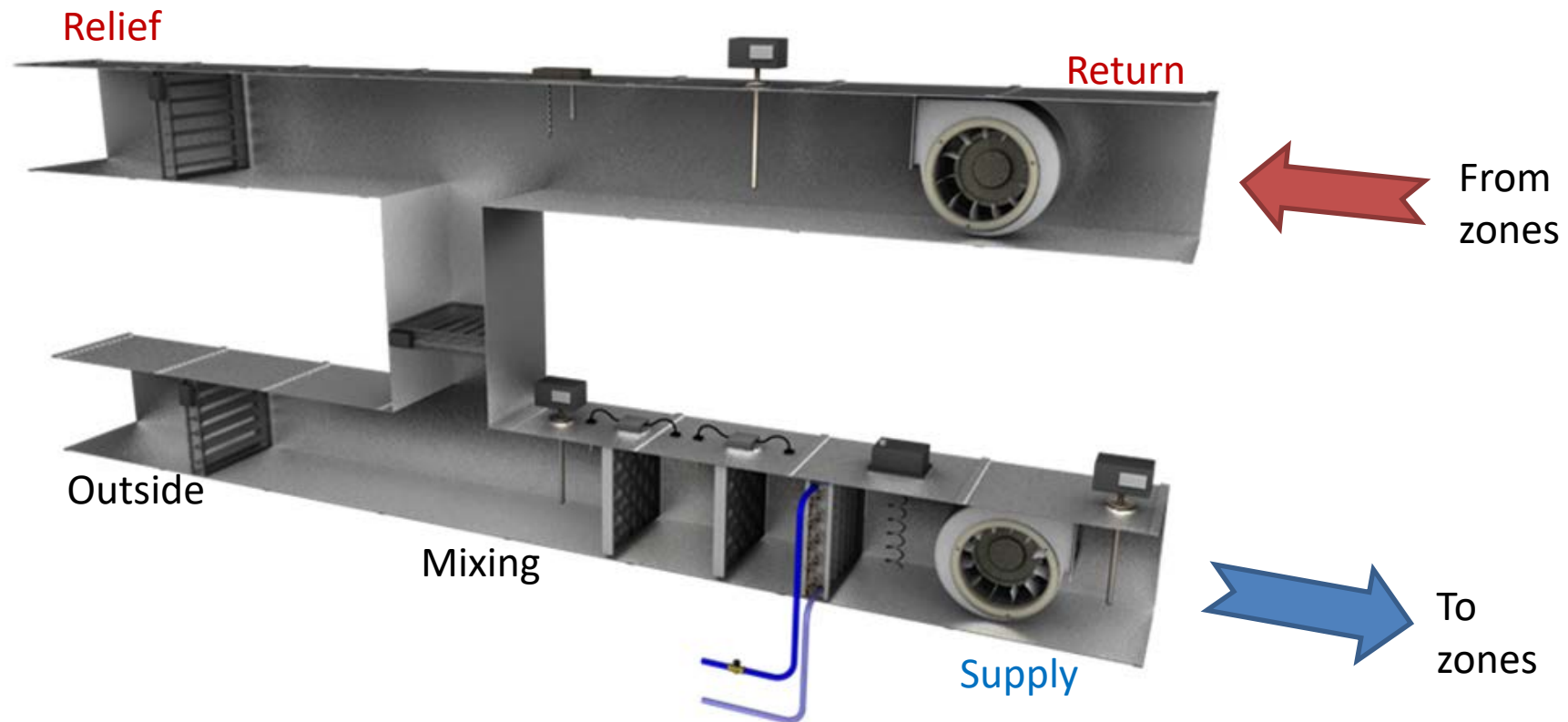
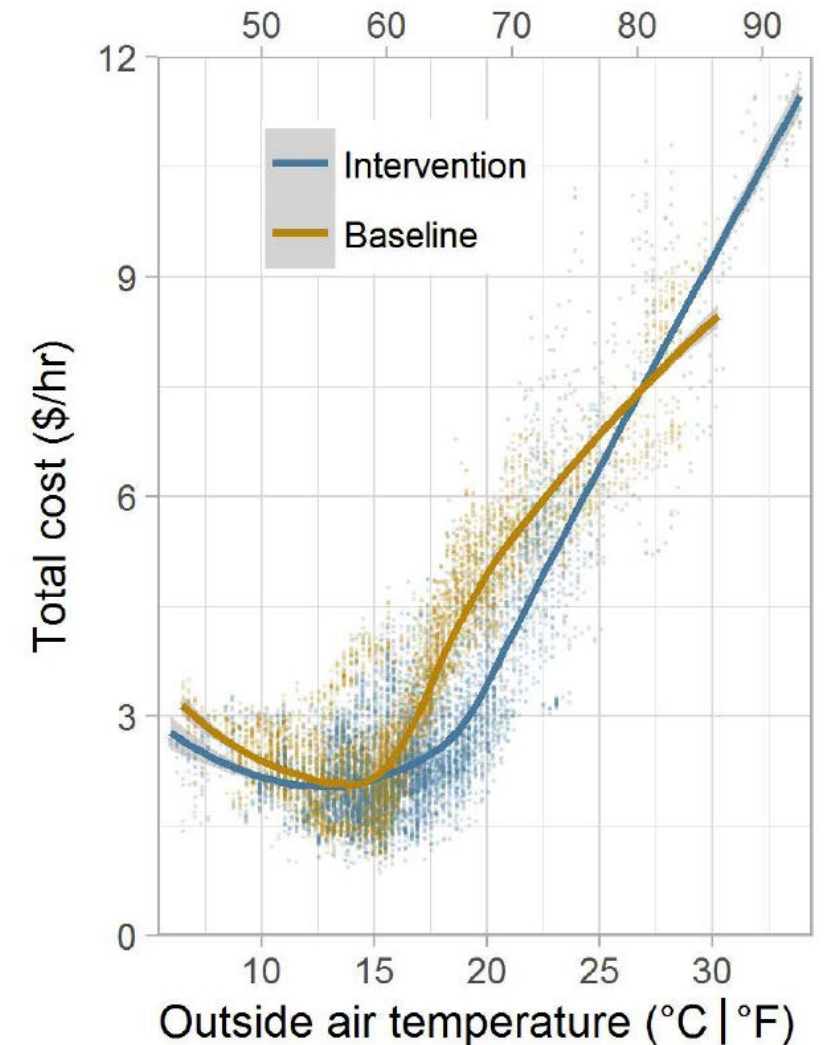


Image: QA Graphics

AHU control: New SAT optimal cost reset

How is this new approach different from current best practice?

- Finds a building specific optimum, based on minimizing the combined costs of chilled water, fan, and reheat energy, subject to comfort constraints
- Fault tolerant
- Uses sMAP - independent from BMS software
- Intervention study in SDH showed reduction in total HVAC energy costs of 29%
- Sequences are available for use



Changing the rules:
Codes & standards

Beneficial outcomes for codes and standards

- ASHRAE Guideline 36P (to be published later in 2017)
 - Added TAV to draft Guideline
 - Considering adding cost-based SAT reset
- ASHRAE Standard 55
 - Added benefits of increased air motion
 - Added dynamic clothing model
- Title 24
 - Consider allowing different temperature setpoints when equivalent comfort is demonstrated
 - Consider adoption of new VAV control strategies in ASHRAE Guideline 36P
- Title 20
 - Consider new methods of test for PCS devices (heaters, fans, etc.)

Q&A

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Please take a moment to fill out the feedback form.

Final report will be posted on CBE website after review is finalized

