

# Energy Savings and Thermal Comfort in a Zero Energy Office Building with Fans in Singapore

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CENTER FOR THE BUILT ENVIRONMENT

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How can we reduce **cooling energy**  
while improving **thermal comfort**?



Photo by Swapnil Bapat on Unsplash

# Fans vs. air conditioning

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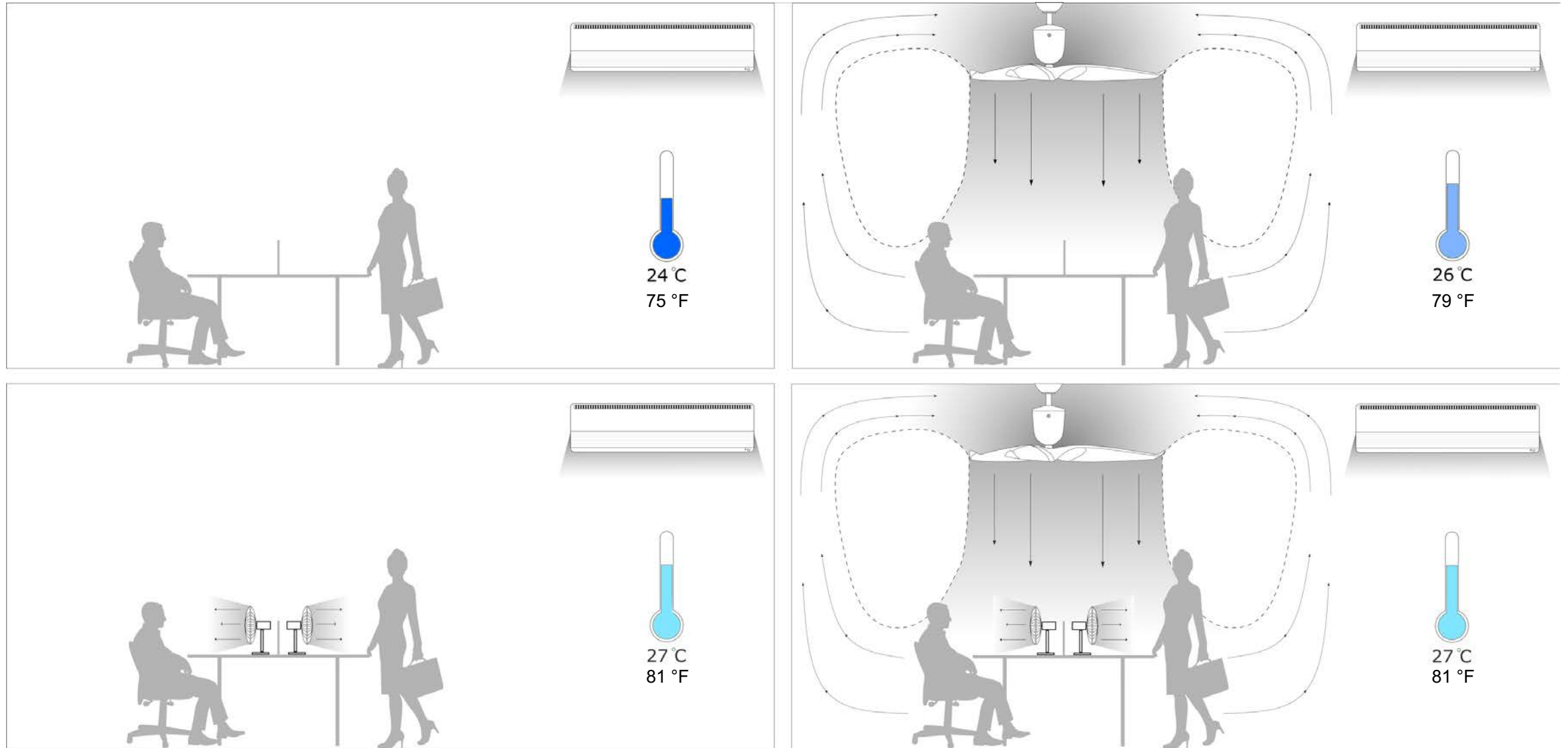
500 – 1500 W  
Thousands \$



2-100 W  
Hundreds \$



# Fans and air conditioning



# Building and Construction Authority Zero Energy Plus Building Office

## Objective

- Quantify the effect of increased temperature setpoints and air movement on energy use and thermal comfort in an occupied building

## Approach

- Retrofit building of ZEB+ office
- 11-week study in an office

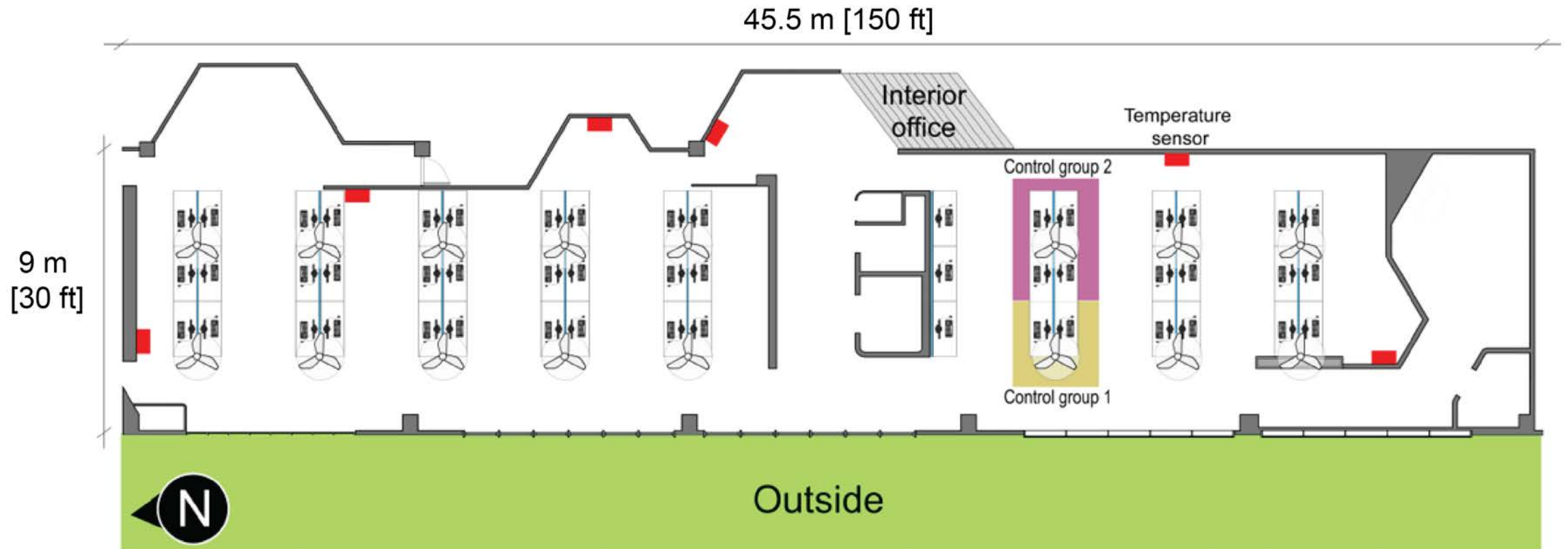
## Funding

- National Research Foundation, Singapore
- Building and Construction Authority
- Dyson and Aeratron



Building and Construction Authority Singapore  
Zero Energy Plus Building Office

# Method: Plan view of Zero Energy Plus Building office



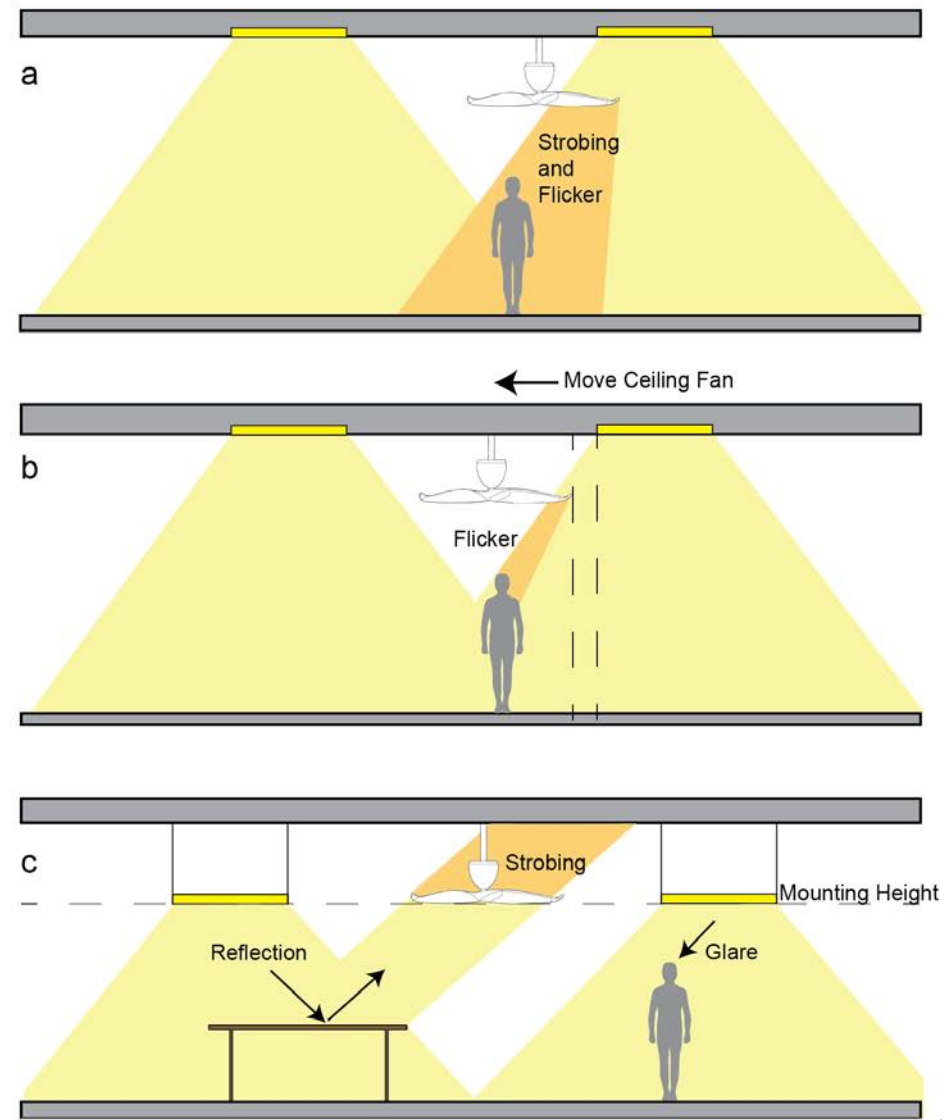
Office plan layout with 51 workstations, and location of wall mounted environmental sensors and ceiling fan control groups. The ceiling fan control groups are highlighted for one workstation row only, but the same control grouping applied to every workstation rows.







# Strobing and flickering



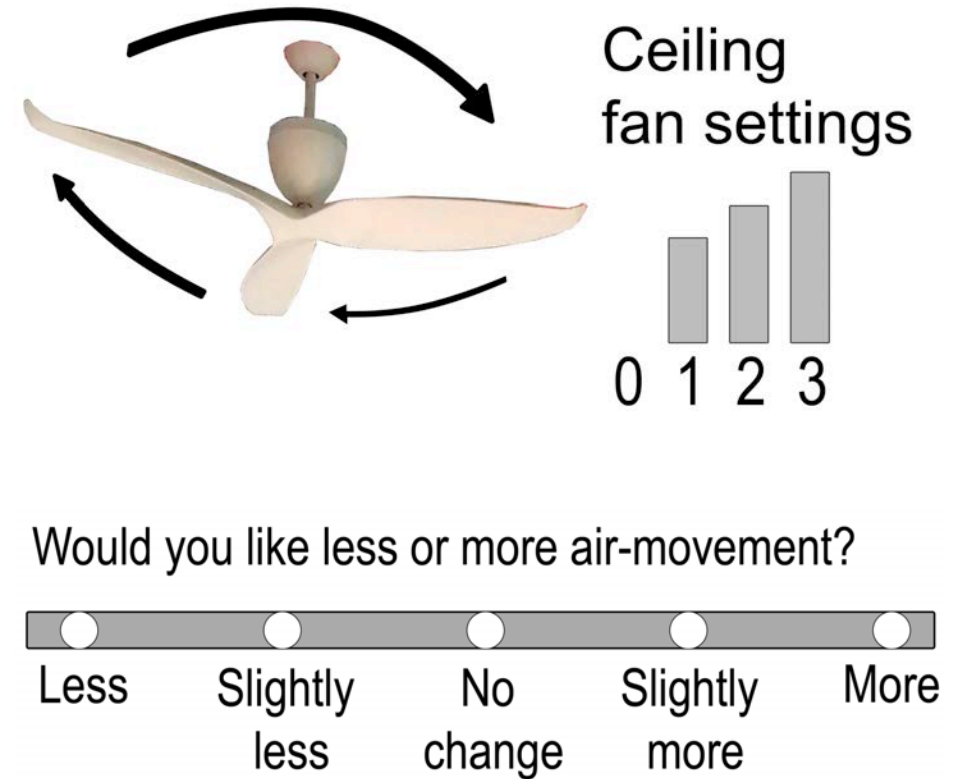






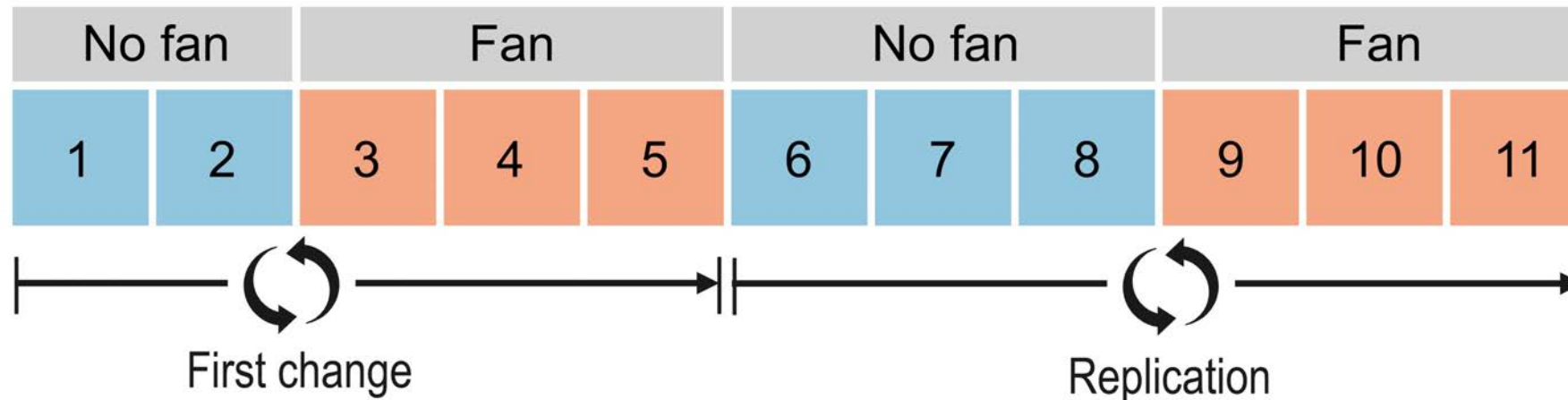
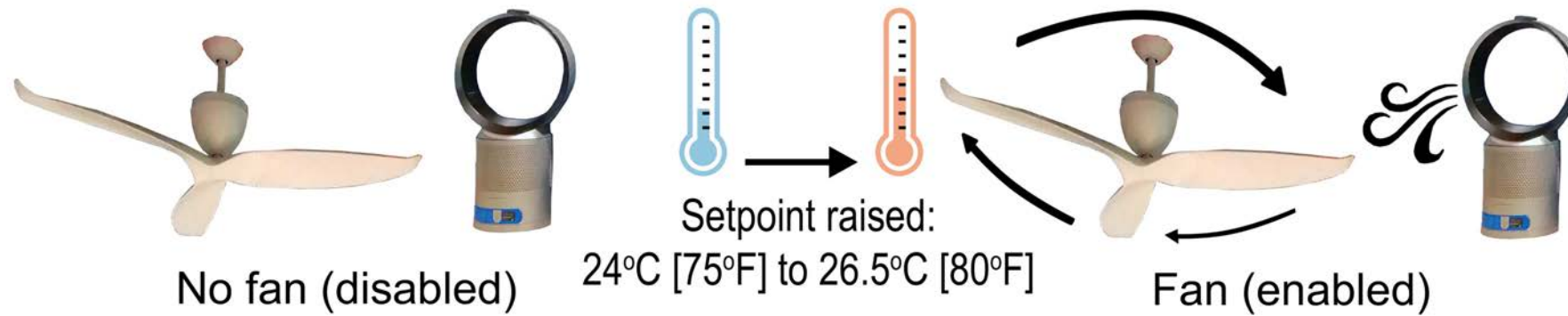
# Ceiling fans control

- App-based input using a scale ranging from: Less to More air movement
- If conflicting feedback are received the system will try to minimize dissatisfaction
- Fans can be controlled at three speed levels





# Method: No fan vs. Fan



# Results: Thermal satisfaction and preference

Right now, how satisfied are you?

 Dissatisfied       Neither satisfied  
nor dissatisfied       Satisfied



## Thermal satisfaction

- Slight reduction in thermal dissatisfaction
- Dissatisfaction rate already low (7%)

# Results: Thermal satisfaction and preference

Right now, how satisfied are you?

■ Dissatisfied      ■ Neither satisfied nor dissatisfied      ■ Satisfied

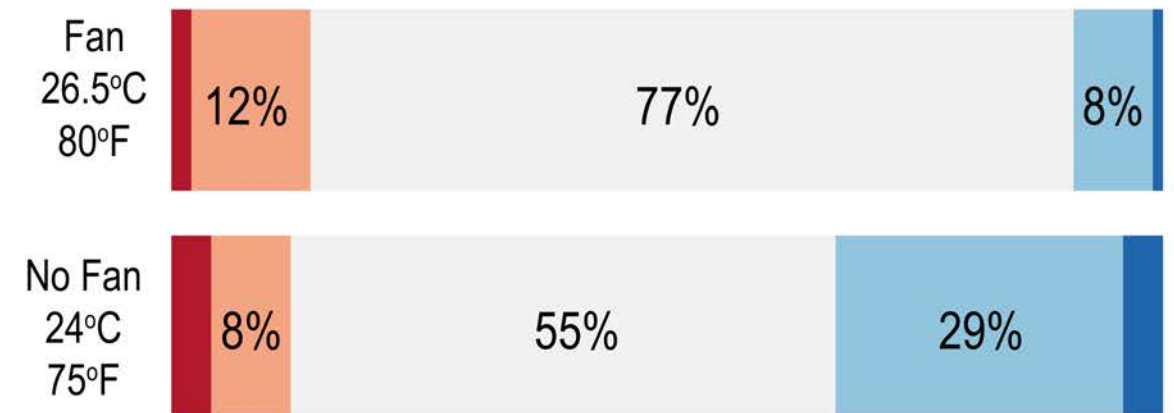


## Thermal satisfaction

- Slight reduction in thermal dissatisfaction
- Dissatisfaction rate already low (7%)

Right now, would you prefer to be...

■ Cooler      ■ Slightly cooler      ■ No change      ■ Slightly warmer      ■ Warmer

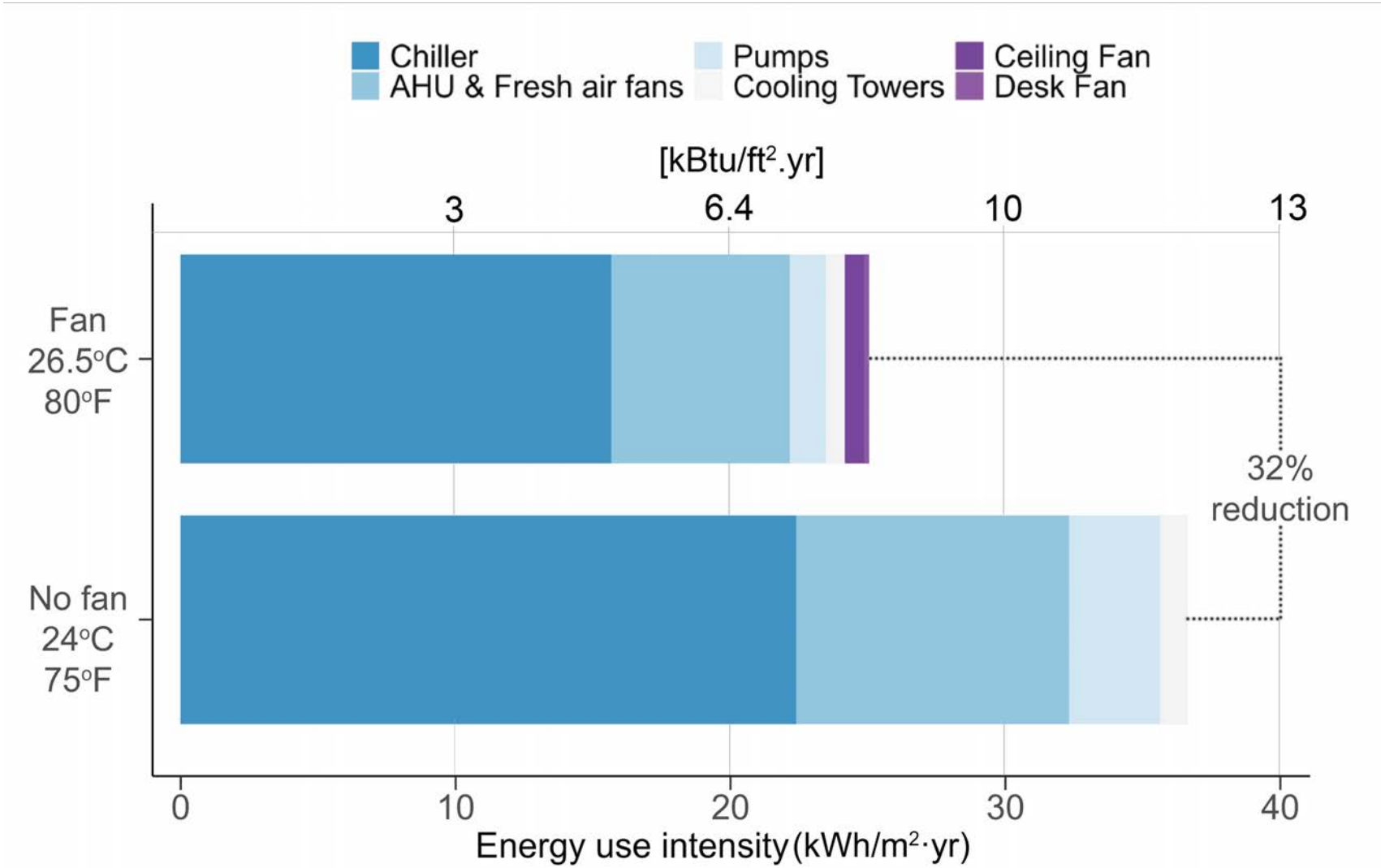


## Thermal preference

- More occupants preferred “No change”
- Reduced overcooling from 33% to 9%



# Results: Energy savings



# Fans for cooling people guidebook

*cbe-berkeley.gitbook.io/fans-guidebook*




What are the benefits of fans?



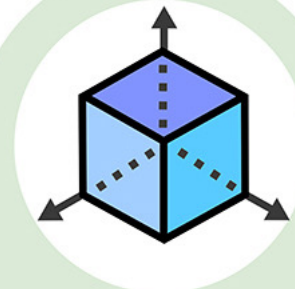
How can I integrate fans with an AC system?



How can I select the right type of fan?



How can I install and operate the fans?



What design tools and standards are available?

# Next steps: Cooling for People Guidebook



Design goals and fan selection

Ceiling fan integration with HVAC system

Managing occupants' expectations with fans

Design tools

Codes and standards

## FULL GUIDEBOOK

Benefits of using fans

Elevated air speed and thermal comfort

Ceiling fans

Other fan types

## Design goals and fan selection

Ceiling fan installation and integration with HVAC system

Conventional HVAC vs. ceiling fans integrated HVAC

additional personal control to further improve occupants' local thermal comfort at whenever it is necessary (e.g., at transient condition or near the window).

### Design examples with ceiling fans

**Uniformity:**  
Ceiling fan without occupant control at multi-occupancy space



**Variability:**  
Ceiling fan with occupant control at multi-occupancy space



**Personal control:**  
Ceiling fan for personal usage in single office



**Targeted:**  
Stronger air movement at locations that require special thermal needs



**Mixed design intent:**  
Uniformity achieves by ceiling fans (macro background air movement)  
Personal control achieves by portable fans (micro environment air movement)



### Design examples with other fan types



**Uniformity:**  
Wall mounted fans or bladeless ceiling fans to produce uniform air movement in small rooms



**Variability & Personal control:**  
Occupants are free to choose any personal fan types (i.e., desk, pedestal, tower fans) with variable air speed and distribution

and

they are free to relocate the fan distance based on personal preference



**Targeted:**  
Wall mounted fans to generate targeted air speed for subjects who seat near the windows

Figure 33. Fans selection examples based on different design intents.



# Q&A

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<https://cbe-berkeley.gitbook.io/fans-guidebook>