

Move air, then cool it: low-carbon comfort with air movement

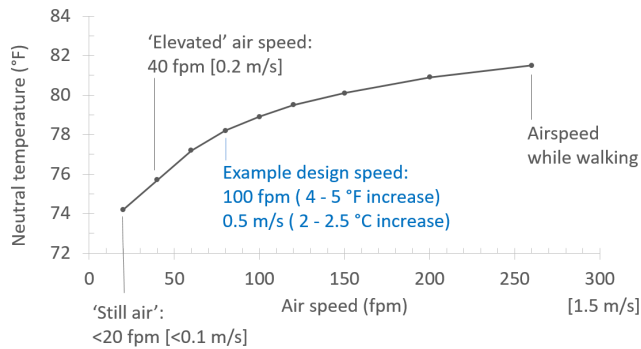
Dana Miller, Center for the Built Environment, UC Berkeley

Why design with air movement?

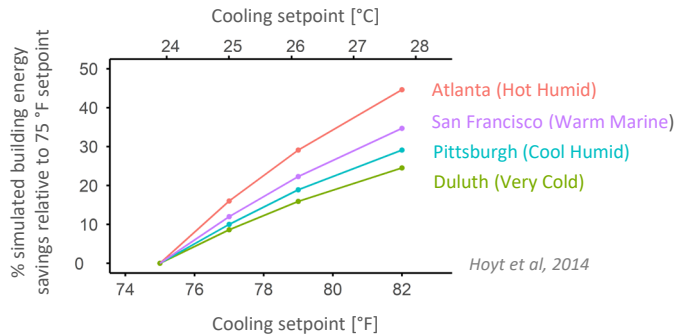
- Improve occupant comfort
- Save energy and operating costs
- Downsize or remove HVAC equipment and ductwork
- Affordability

How can air movement help save energy?

1. Fans enable comfort at higher temperatures



2. Higher air conditioner setpoints save energy



3. Modern fans now more efficient + effective

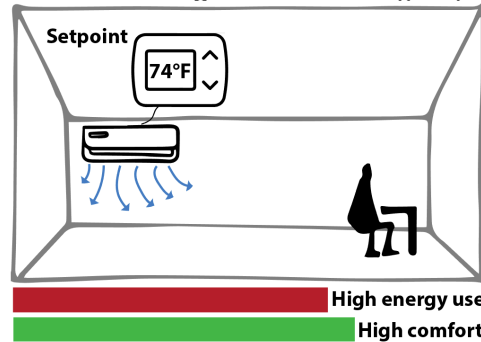
Improvements in motors and blade design mean quiet, durable fans with DC motors use <math>< 10 \text{ W}</math> at medium speeds.



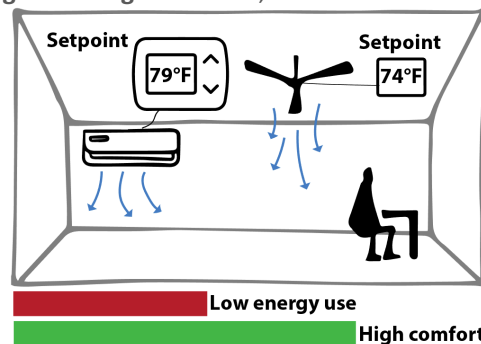
Why fans plus air conditioning?

- Meet high cooling loads flexibly and resiliently
- Coordinate for savings - fans must reduce air conditioning runtime and/or loads to save energy.

Conventional cooling – air conditioning only



Staged cooling – fans first, then air conditioning



What have been barriers to wider use?

- **Regulatory** – previous building code limits
- **Technical** – need for better design guidance + tools
- **Cultural** – image of solely using air conditioning as more modern, healthy, comfortable choice.



Most US homes have at least one ceiling fan (RECS 2015), and fans are widely used in tropical climates, but they are sometimes perceived as obsolete with air conditioning, instead of a complementary technology and a modern choice.

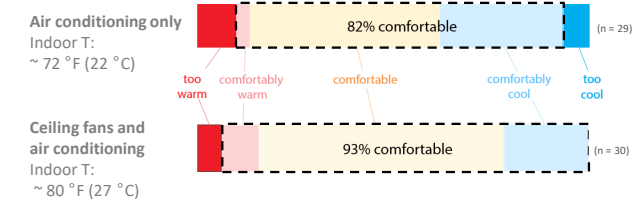
Case studies: energy savings with comfort

Corporate office, Singapore (Lipczynska et al 2014)

- Before: air conditioned at 23 °C (73 °F)
- With ceiling fans: air conditioned at 26 °C (79 °F)
 - ~30% energy savings
 - Improved comfort and self-reported productivity

Office + community space, Stockton, CA

- One of four sites in ongoing 2+ year technology demonstration project
- With ceiling fans:
 - ~50% energy savings
 - Comparable occupant comfort



Want more air movement for cooling?

- **Try it** - use a desk fan for personal comfort control
- **Design with it** - new engineering standards for desk and ceiling fans, and new design tools + design guide
- **Integrate it** - stage controls with air conditioning
- **Research it** – ongoing demonstration projects
- **Manufacture it** - more and better options, especially for commercial sector



Research team

Center for the Built Environment: Gail Brager, Paul Raftery, Hui Zhang, Therese Pepper, Elaina Present, Ed Arens, Stefano Schiavon.
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 Association for Energy Affordability: Andy Brooks, Sebastian Cohn, Mitch Greene.
 Big Ass Fans: Jay Fizer, Christian Taber, Justin Risner, Pete Maley.

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Recent examples of design with air movement

Ceiling fans combined with with air conditioning



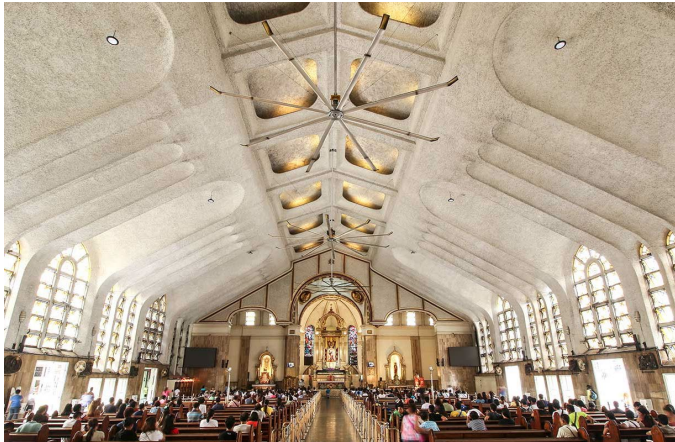
DPR Construction, Phoenix AZ, 2011. Photo: DPR
Net-zero energy operation. Fans cool first, then run together with air conditioning above 78°F (25.6 °C)

Bosch Singapore cafeteria, 2017. Photo: Bosch
Fans cool first, then run together with air conditioning above 79°F (26 °C).

University of Nebraska Recreation Center, Lincoln, NE. Photo: HOK

Commonwealth Club, San Francisco, CA, 2017. Photo: LMS Architects

Ceiling fans only



Quiapo Church, Manila, Philippines. Photo: Big Ass Fans



Rocky Mountain Institute, Basalt, CO. Photo: Steve Griffen
Architects: ZGA Architects, MEP: PGA Engineering



Kampung Admiralty, Singapore. Architects: WOHA
Photo: World Architecture Festival / WOHA

USB-powered (DC motor) low power desk fans

For personal comfort control, and can also be used to enable raising air conditioning cooling setpoint.

