Integrating Smart Ceiling Fans and Communicating Thermostats to Provide Energy-Efficient Comfort

Air movement, such as through ceiling fans, can provide cooling comfort while using only a tiny fraction of the energy required by HVAC systems. Modern, highly efficient ceiling fans use as much power as an LED light bulb, and many have onboard temperature and occupancy sensors for automatic operation based on indoor conditions. These devices can offset an increase in indoor air temperature as much as eight degrees F, providing improved comfort over a wider range of temperatures while also reducing a building's total HVAC energy by an average of 5-7% per degree F increase.

This project demonstrated the integration of smart ceiling fans and communicating thermostats in affordable multifamily housing and mixed-use buildings in California's Central Valley. Overall, the field demonstrations resulted in 39% measured compressor energy savings during the cooling season. Energy savings varied widely by site, with savings as high as 71% and median savings of 15%. All commercial spaces with regular occupancy schedules showed energy savings, even before normalizing for warmer outdoor temperatures in following years. The largest site saved over $6,000 in cooling energy costs over the cooling season — a considerable amount for an affordable housing facility manager. The team also used full-scale laboratory tests to develop an advanced online design tool and design guide, and they created a plan to improve codes and standards that would advance wider adoption of this strategy.

KEY OUTCOMES

- Demonstrated 39% compressor energy savings during cooling season. The median energy savings across all 13 compressors was 15%.
- Assuming a modest 15% market penetration of this approach in California, over the next 15 years this will yield annual savings of 736 GWh, $125M, and 537M lbs. of CO2 emissions.
- The team launched an online ceiling fan design tool (shown above) to facilitate design with ceiling fans and to accelerate their adoption in a wide range of buildings.
- Demonstrated ceiling fans as resiliency tools: During an unplanned AC failure at a test site, the ceiling fans maintained comfort during several summer months.

PROJECT OVERVIEW

CEC EPIC Solicitation

Reducing Costs for Communities and Businesses Through Integrated Demand-Side Management and Zero Net Energy Demonstrations (GFO-15-308)

Proposal Name

Integrating Smart Ceiling Fans and Communicating Thermostats to Provide Energy-Efficient Comfort

Project Dates

August 2016 – March 2020

Lead Scientists and PIs

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Industry Team Members

TRC Energy Services
Association for Energy Affordability
Big Ass Fans

RESULTING PUBLICATIONS (ABRIDGED)

Parkinson, T., P. Raftery, and E. Present, 2020. Spatial uniformity of thermal comfort from ceiling fans blowing upwards. *Proceedings ASHRAE 2020 Winter Conference*, Orlando, FL, February.

Chen W., H. Zhang, E. Arens, M. Luo, Z. Wang, L. Jin, J. Liua, F. Bauman, P. Raftery, 2020. Ceiling-fan-integrated air conditioning: Airflow and temperature characteristics of a sidewall-supply jet interacting with a ceiling fan. *Building and Environment*, Volume 171, March.

He, Y., W. Chen, Z. Wang, and H. Zhang, 2019**.** Review of fan-use rates in field studies and their effects on thermal comfort, energy conservation, and human productivity. *Energy and Buildings.* Vol. 194, July.

Present, E., P. Raftery, G. Brager and L. T. Graham, 2019. Ceiling fans in commercial buildings: In situ airspeeds & practitioner experience. *Building and Environment*, 147, Jan.

Raftery, P., J. Fizer, C. Wenhua, Y. He, H. Zhang, E. Arens, S. Schiavon and G. Paliaga, 2019. Ceiling fans: Predicting indoor air speeds based on full scale laboratory measurements. *Building and Environment,* May.

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