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

Grant Award #: EPC-16-013
Background

Multifamily new construction is a growing proportion of California residential market

<table>
<thead>
<tr>
<th>Year</th>
<th>Single-Family</th>
<th>Multi-Family</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007</td>
<td>68,409</td>
<td>44,625</td>
<td>113,034</td>
</tr>
<tr>
<td>2008</td>
<td>33,050</td>
<td>31,912</td>
<td>64,962</td>
</tr>
<tr>
<td>2009</td>
<td>25,454</td>
<td>10,967</td>
<td>36,421</td>
</tr>
<tr>
<td>2010</td>
<td>25,526</td>
<td>19,236</td>
<td>44,762</td>
</tr>
<tr>
<td>2011</td>
<td>21,641</td>
<td>25,702</td>
<td>47,343</td>
</tr>
<tr>
<td>2012</td>
<td>27,560</td>
<td>31,665</td>
<td>59,225</td>
</tr>
<tr>
<td>2013</td>
<td>36,991</td>
<td>48,481</td>
<td>85,472</td>
</tr>
<tr>
<td>2014</td>
<td>37,089</td>
<td>48,755</td>
<td>85,844</td>
</tr>
<tr>
<td>2015</td>
<td>44,896</td>
<td>53,337</td>
<td>98,233</td>
</tr>
<tr>
<td>2016 (Proj.)</td>
<td>42,540</td>
<td>64,399</td>
<td>106,939</td>
</tr>
</tbody>
</table>
Multifamily occupants are more racially diverse and a large proportion are renters. Utility bills are a greater proportion of annual budgets.

Source: 2010 United States Census
EPIC Fan project overview

Objectives

- Demonstrate the potential of automatically-controlled, learning ceiling fans and thermostats to provide energy efficiency and improved comfort
- Identify and address market barriers to wider acceptance and adoption
- Develop standard rating methods, a design guide, and energy code language to facilitate widespread adoption

Funding: $1,888,683 + $315,926 match
Duration: 1 October 2016 - 30 March 2020
Project Team

California Energy Commission
Adel Suleiman, CAM

Center for the Built Environment, UC Berkeley
Prof. Gail Brager (PI), Therese Peffer, Paul Raftery, Hui Zhang, Elaina Present

TRC Solutions
Gwelen Paliaga, David Douglass-Jaimes, Abhijeet Pande

Ass’n for Energy Affordability
Andy Brooks

Match funds:
Big Ass Solutions
Thomas Lesser, Christian Taber
Fans save energy—right?

Fact: Ceiling fans provide comfort at 5-8°F higher temperatures than the conventional range during the cooling season.

Assumptions:
- Clothing: long sleeve shirt, long pants, under shirt (clo = 0.65)
- Metabolic Rate: Typical office (met = 1.3)
- Relative humidity: 50%
A Decade of Ceiling Fans in Commercial Buildings

2006
Flying Blind
• ’98 FSEC data
• No guidance on 3 heights

2008-2009
ASHRAE 55
• CBE Paper “people want more air movement”
• Improve comfort calculation
• Average 3 heights

2012
Data driven design & products
• Full Scale Testing
• Classroom fan
• BMS integration

2014-2016
Market Transformation
• ASHRAE Test standard (216)
• DOE rulemaking
• CEC study: Smart Integrated Fans
• GSA Green Proving Ground

Slide credit: Gwelen Paliaga, TRC
Questions

- How can Smart Fans + Smart thermostats improve comfort and savings?
- How does one coordinate the fan with the HVAC system to maximize comfort with energy savings?
- How wide of a fan?
- Where to place in room?
- How low to hang from ceiling?
- Where is expected “cooled” zone?
- How can these fans save energy for the disadvantaged households for whom energy costs are a large part of income?
Methods

Laboratory testing
- Configuration optimization
- Comfort performance index

Field demonstrations in multifamily housing
- Common spaces
- Dwelling units

Technology transfer
- Evaluation of benefits
- Outreach to address barriers
- ASHRAE TC 216 design tool
- Codes and standards

Berea College’s “Deep Green” residence hall. Photo: Big Ass Solutions
EPIC Fan project overview

**Task 1: General Project Tasks**

**Task 2: Laboratory Testing**
- Study 1: Scale Configuration Optimization
- Study 2: ASHRAE 216 - Design Tool
- Study 3: Comfort Performance Index

**Task 3: Multifamily Common Space Demonstration**
- 18 Multifamily Common Spaces

**Task 4: Multifamily Dwelling Unit Demonstration**
- 6 Multifamily Dwelling Units

**Task 5: Technology Readiness**
- Market Factors
- Case Studies
- Barriers

**Task 7: Technology Knowledge Transfer**
- Design Tool
- Design Guide
- Codes & Standards
- Outreach & Publications

**Task 6: Evaluation**
- Benefits
Timeline of Project

Start:
Oct 2016
End: Mar 2020

Task 2 Laboratory Setting
Task 2.1 Scale Configuration Optimization
Task 2.2 ASHRAE 216 Design Tool
Task 2.3: Comfort Performance Index

Task 3 Multifamily Common Area and Fitness Room—Site Demonstration
Site 1 Interim report
Site 2 Interim report
Site 3 Interim report
Report

Task 4 Multifamily Dwelling Unit—Site Demonstration
Site 1 Interim report
Site 2 Interim report
Site 3 Interim report
Report

Task 5 Technology Readiness
Task 5.1 Case Study of Ceiling Fan Automation
Task 5.2 Technology Readiness Report

Task 6: Evaluation of Project

Task 7: Technology/Knowledge Transfer Activities
Project Innovation and Advantages

• **Emergent Technology Solution:**
  – Higher level of energy-comfort optimization by controlling ceiling fans based on occupancy and temperature, and adjusting thermostat settings to optimize for both energy and comfort.

• **Low Operating Cost and User Requirement:**
  – Energy savings and high user comfort with an easy interface that requires very little understanding of controls (unlike most programmable thermostats currently on the market).
  – From the customer’s perspective the solution will ‘just work’ without the need for manual interventions once installed.

• **Low Upfront Cost:**
  – Compared to other types of HVAC retrofits, ceiling fan and thermostat technologies are relatively low-cost options. Appropriately trained contractors or do-it-yourself installers can install these products easily.

• **Range of Applications:**
  – The integrated solution offers a scalable energy retrofit concept that is demand-response ready and applicable to both residential and commercial buildings.

• **Focus on demonstrations in disadvantaged areas:**
  – This project offers direct monetary and quality-of-life benefits to low-income multifamily households, whose energy costs make up a higher proportion of household expenses than the average California resident.