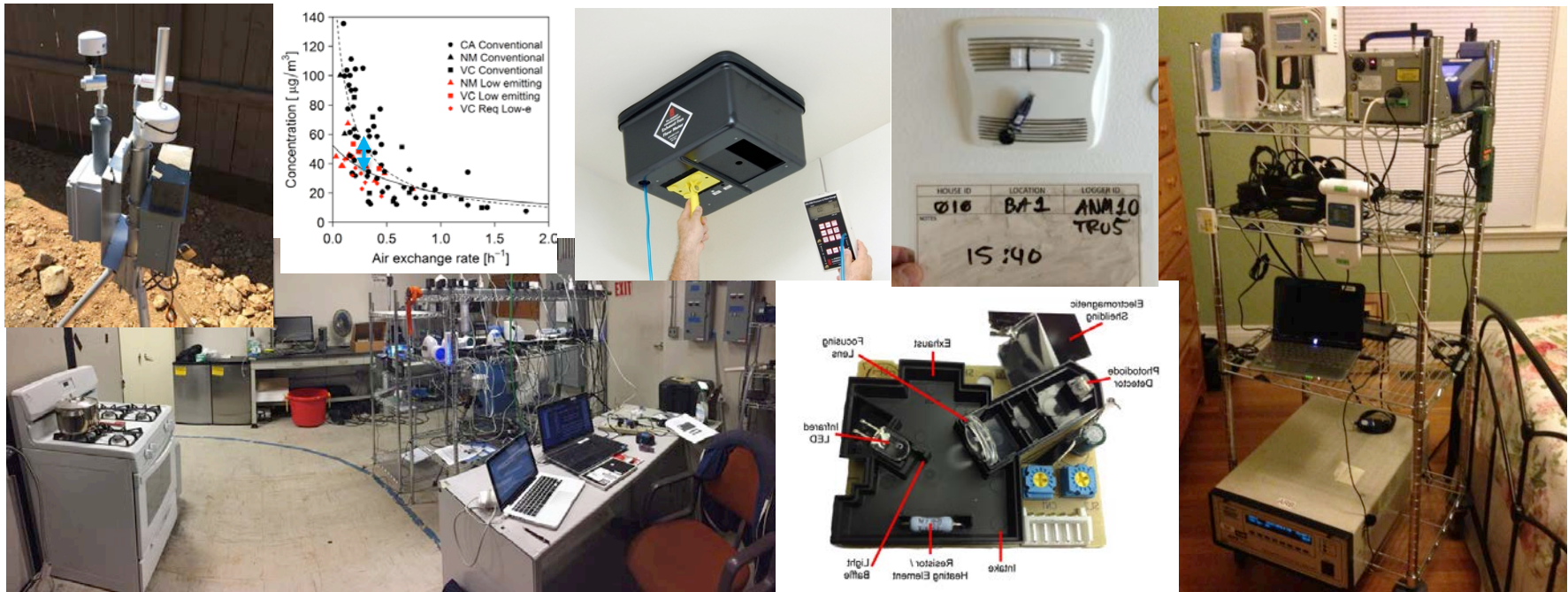


# Healthy Efficient Homes



Lawrence Berkeley National Laboratory

Dr. Iain Walker

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# Project Summary

## Timeline:

Start date: FY16

Planned end date: FY18

## Key Milestones

1. Progress report on New Home IAQ Study (09/18)
2. Report on Pilot testing of IAQ Valuation Metric (09/18)
3. Memo on Developing Smart Ventilation Strategies for High Performance Homes (12/18)

## Budget:

### **Total Project \$ to Date:**

- DOE: \$3.8m
- Cost Share: \$4.6

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- DOE: \$3.8 m
- Cost Share: \$4.6 m

## Key Partners:

ASHRAE	Air Infil. & Ventilation Ctr
ASTM	Cal Air Resources Board
EPA	Cal Energy Commission
HUD	Home Ventilating Inst.
RESNET	GTI, PG&E, SoCalGas
Aereco	Dwyer

## Project Outcome:

This project will produce innovative technologies, industry guidance and codes and standards that ensure good indoor air quality (IAQ) in homes. This will remove barriers concerning IAQ while reducing the energy cost of IAQ, and allow the building industry to achieve the 40% energy savings in existing homes and 60% reductions in new homes targeted in the MYPP.

# Team



Dr. Iain Walker is the PI for this project.

- Codes and standards integration
- Smart ventilation development
- IAQ metrics
- Incoming chair of the national residential building ventilation standard (ASHRAE 62.2) and leads the RESNET Equipment subcommittee developing home energy rating standards.



Dr. Brett Singer is the co-PI for this project.

- New Home IAQ Study
- Expert on Indoor Air Quality measurements and related health effects and has more than 20 years experience leading IAQ field measurement research.



Dr. Rengie Chan

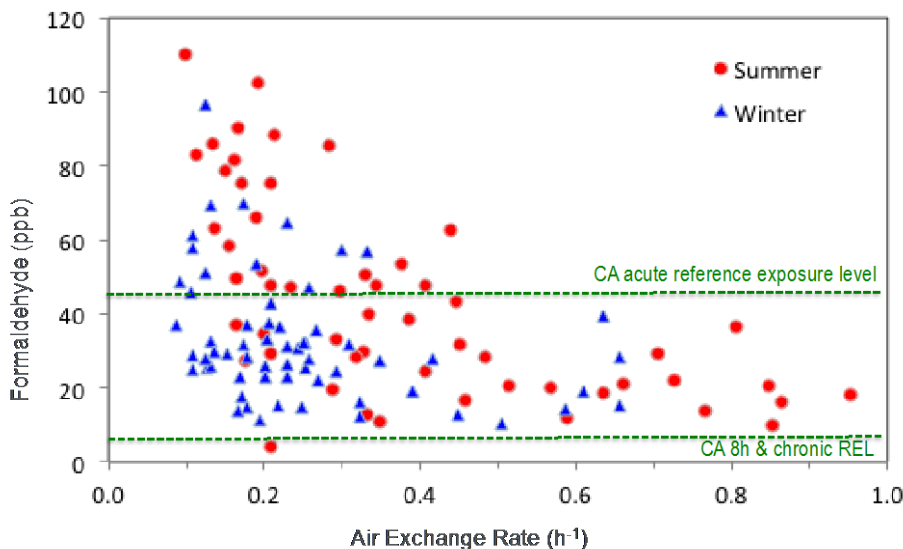
- Field IAQ measurement
- - Created building performance database
- - Analysis of IAQ data to inform policy



Mr. Brennan Less

- Field measurements
- Simulations
- Smart ventilation strategies

# Challenge



\*Offermann, California Energy Commission Report CEC-500-2009-085

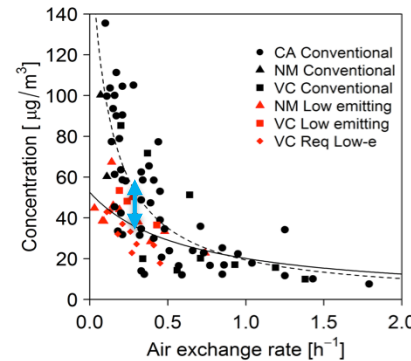
## Problem Definition:

- Concerns about indoor air quality and moisture problems are a market barrier for airtight energy efficient homes
- Pollutants are elevated above healthy levels in homes without adequate ventilation

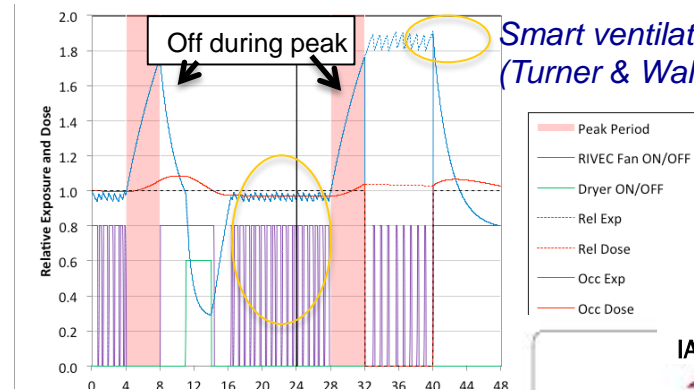
- The buildings industry has a poor track record of working this area and the industry needs, and is asking for, guidance supported by research & demonstrations.
- Public interest research by DOE/RBI is needed to move forward.
- Successfully addressing IAQ issues is essential to achieve the RBI goals of high performance homes that 40% energy savings in existing homes and 60% reductions in new homes targeted in the MYPP.

# Approach – Key Issues from Building America Roadmap

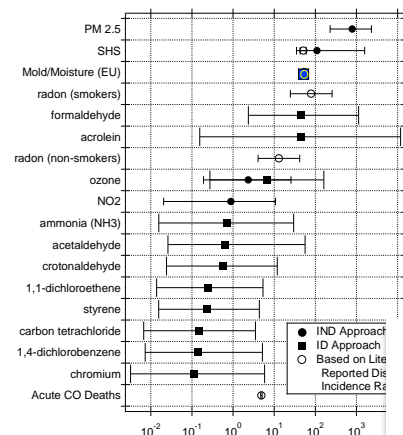
- **Targeted pollutant solutions:** source reduction & task ventilation to reduce general dilution ventilation.
- **Smart ventilation technologies** that reduce energy and peak loads. Sensors and controls to integrate all ventilation equipment for optimal energy and IAQ.
- **IAQ valuation methods** to standardize assessment, prioritize measures and inform buyers of high performance homes.



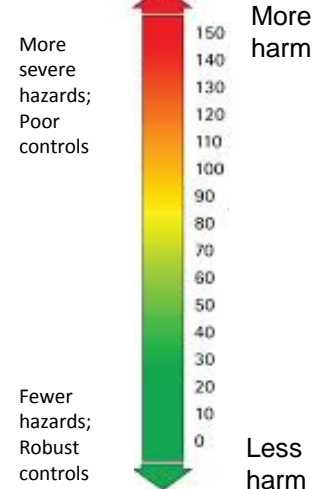
*Formaldehyde 42% lower in homes built with low emitting materials (Hult et al. 2014)*



*Smart ventilation savings (Turner & Walker, 2013)*



IAQ Index



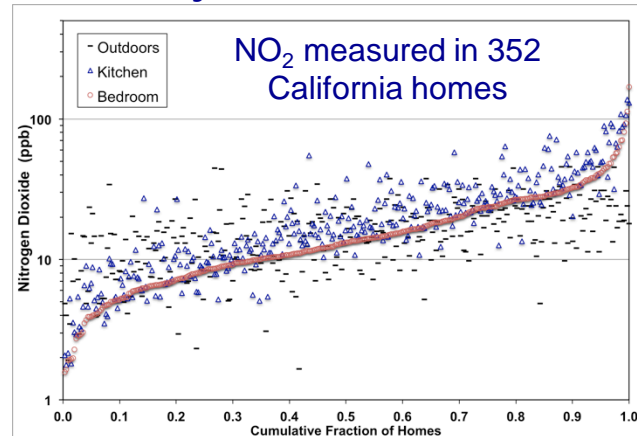


# Approach – R&D Methods to provide good IAQ at minimum energy use

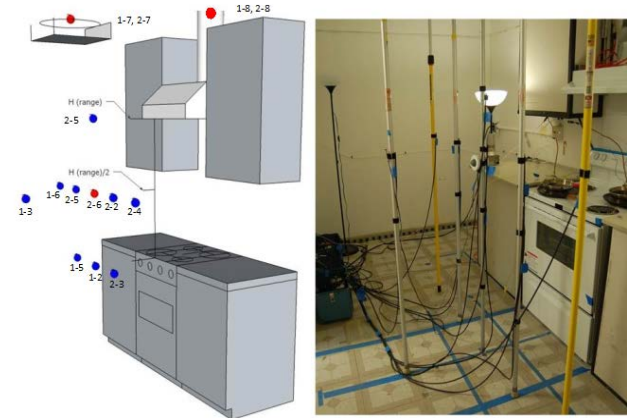
## Laboratory experiments



## Surveys and data collection



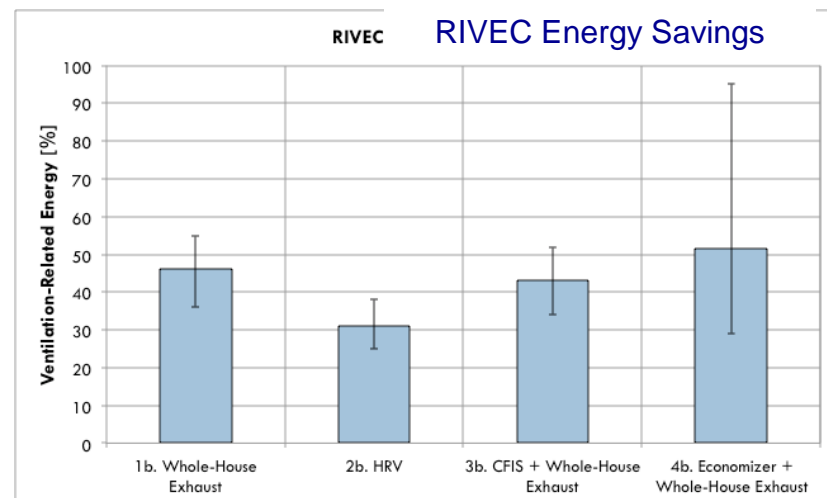
## Test method development



## Controlled experiments in homes



## Analysis & Simulations



# Impact

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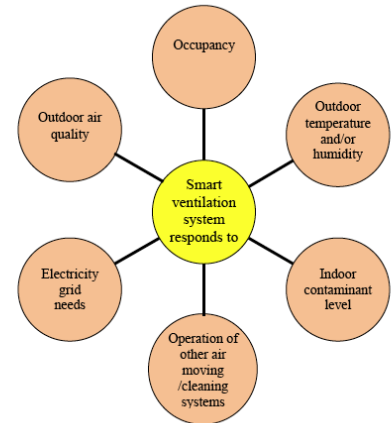
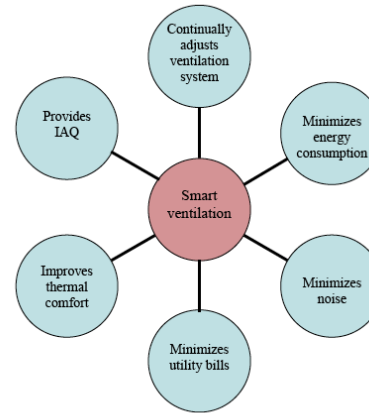
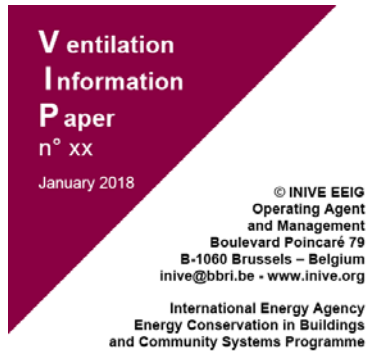
## Industry engagement

- New industry consensus standards: RESNET 380 (diagnostics) & ASTM E3087(Range Hood capture efficiency)
- Updating and improving existing standards: RESNET 301, ASHRAE 62.2, & ASTM
- Changes to building codes, e.g., kitchen/whole house ventilation and air leakage issues California Title 24
- Five peer-reviewed journal articles + 17 conference papers
- More than 60 Workshops/invited talks/papers at industry conferences

# Impact

## Smart ventilation technologies

- Created international definition of Smart Ventilation (with AIVC)



- New strategies to:
  - Reduce ventilation-related energy use by 40% - about 15-20% of total house HVAC energy
  - Reduce peak power requirements by 1-2kW
  - Maintain or improve IAQ (relative exposure)
  - Reduce time above 65% RH (moisture control for high performance homes)
  - Maximize energy savings for occupancy-based controls



# Impact

## National IAQ Study in New Homes

- CEC Co-sponsored project in CA has informed the development of the Building America New Home IAQ project in other climates

## Kitchen ventilation

- Industry demand for ratings based on LBNL work (led to ASTM test method)
- Galvanized national and international awareness/interest: HVI, Broan, Texas A&M, TNO, University of Nottingham
- *Add range hood capture efficiency performance to ASHRAE 62.2, Title 24, IndoorAir plus, weatherization*

## New IAQ metrics

- *Industry demand for the ability to rate homes for IAQ due to LBNL score development*
- *Become standard part of home assessment – collaboration with RESNET*

## Sensors & Controls

- Consumer-grade sensors not quite ready to control ventilation systems
  - Better sensors now being used by some manufacturers
  - *Led to Building America developing evaluation test method*

# Progress – Test Method Development

Project is in final year of three year cycle. New cycle start FY19.

- New Standard: Diagnostics for home energy ratings (RESNET 380)
- Increased flexibility in ASHRAE 62.2, enabling smart ventilation innovations. Now Working on ASHRAE IAQ Position Document.
- Revisions for multi-family in ASHRAE 62.2 and RESNET to be published later in FY18
- Finalized Range Hood Test Method



ANSI/ASHRAE Standard 62.2-2013  
(Supersedes ANSI/ASHRAE Standard 62.2-2010)  
Includes ANSI/ASHRAE addenda listed in Appendix C

**Ventilation and  
Acceptable  
Indoor Air Quality  
in Low-Rise  
Residential Buildings**

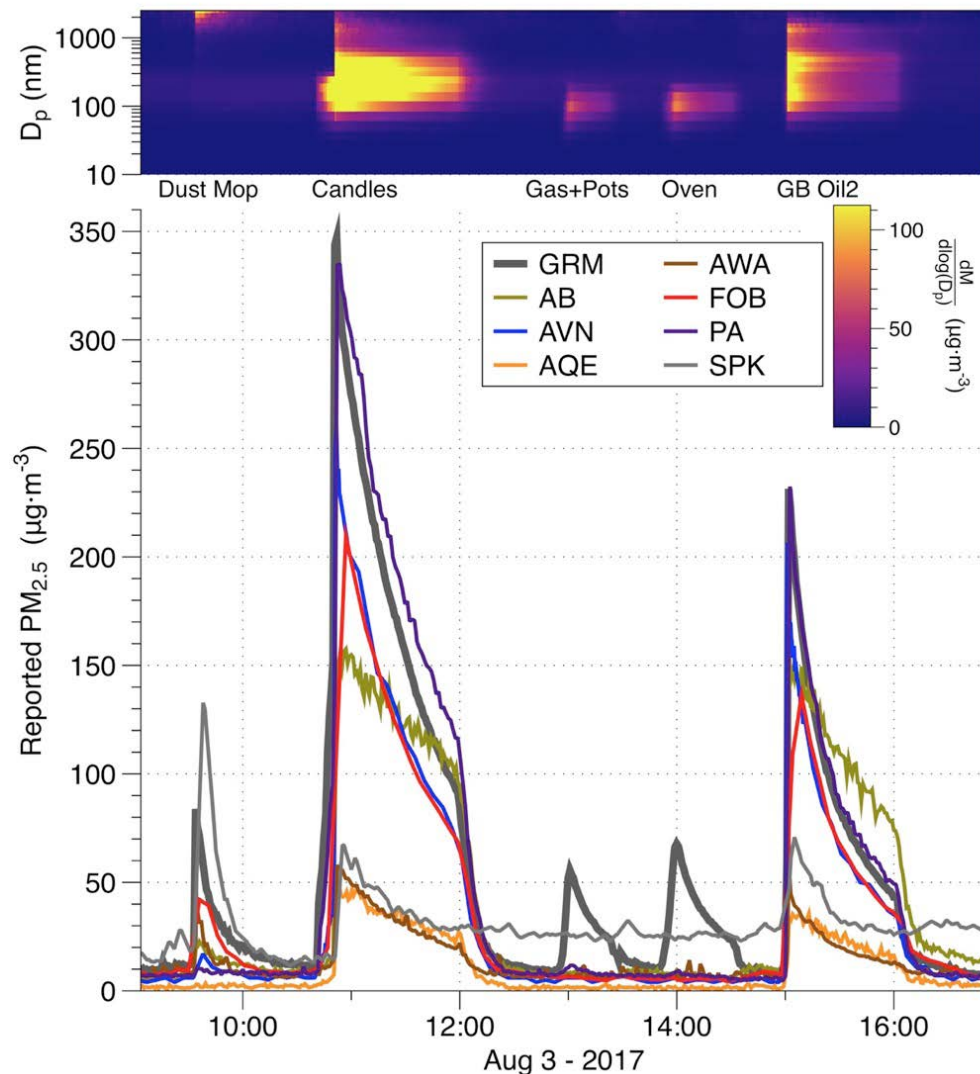
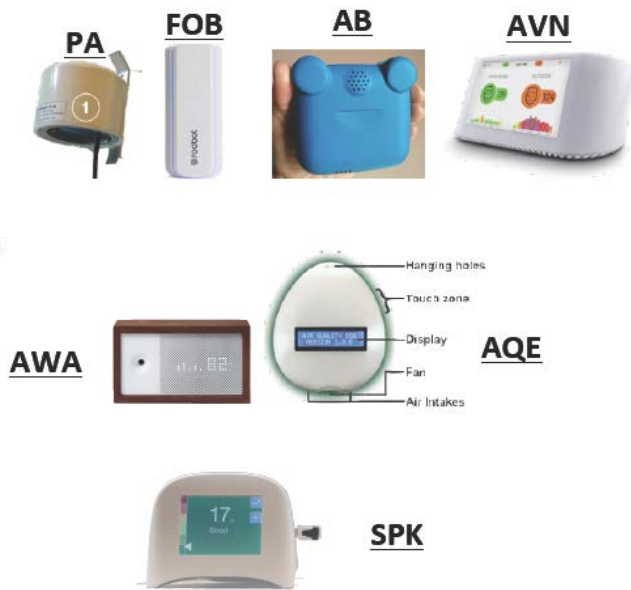


Designation: E3087 – 17

**Standard Test Method for  
Measuring Capture Efficiency of Domestic Range Hoods<sup>1</sup>**

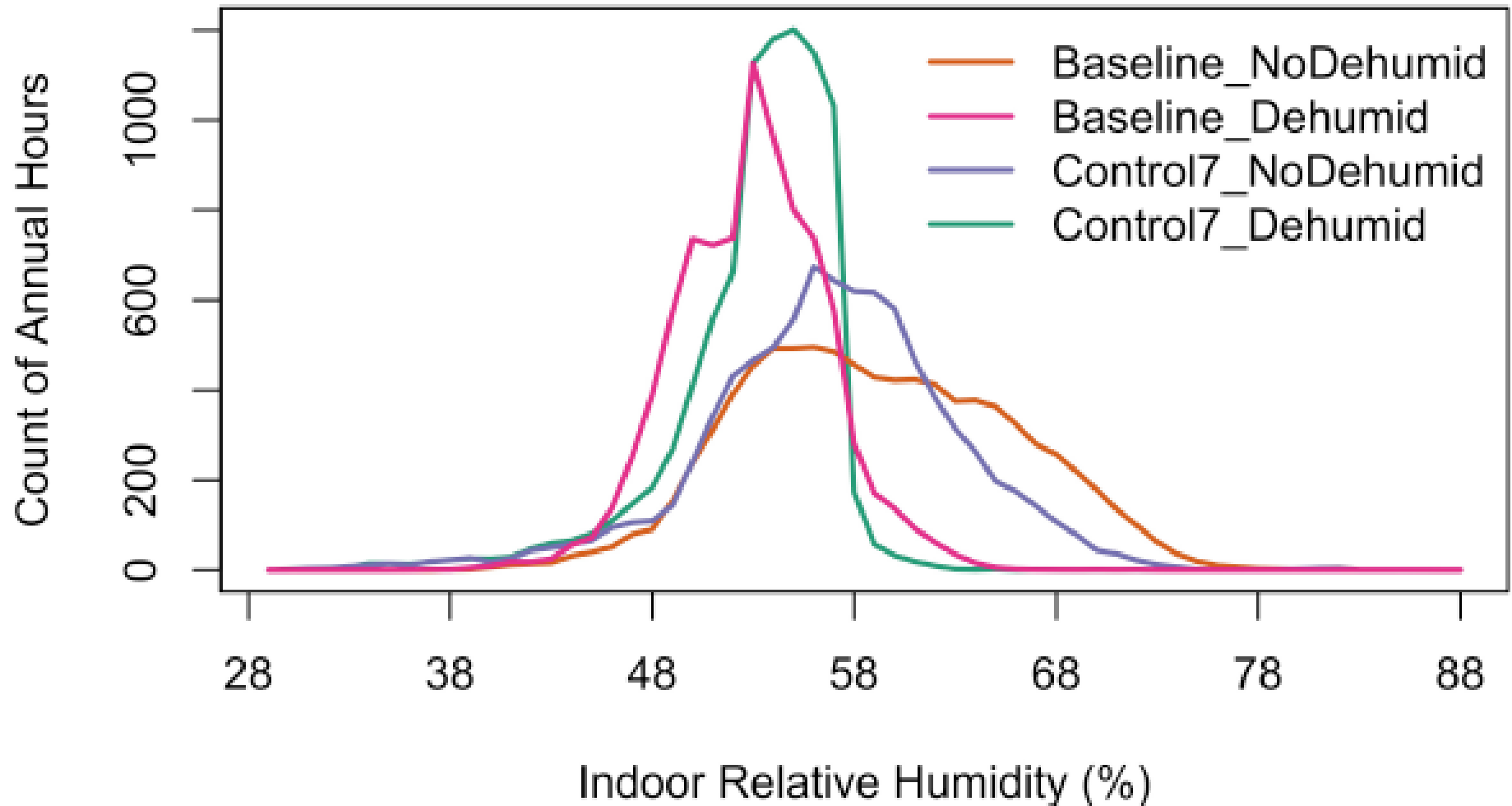
# Progress – Lab Study of IAQ monitors

- Four consumer monitors detected most sources
- Two consumer monitors detected many sources but not quantitatively
- One monitor was not informative



# Progress: Smart Ventilation - Simulations of Humidity Control

- Shift ventilation based on measured humidity & cooling system operation
- Improves Dehumidifier performance



# Progress: Field study - Baseline Home IAQ

- Completed CEC co-funded study
- Inspired Building America: LBNL designed new home study for other climates
- To be used in development of IAQ standards, monitors, & controls
- Key results:
  - 50% more ventilation flow than minimum requirement (ASHRAE 62.2)
  - Contaminants at acceptable levels
  - Poor labeling leads to non-operation (more than half turned off)

	Mean	Standard
Formaldehyde (ppb)	26	7 OEHHA 40 Canada 80 WHO
PM2.5 ( $\mu\text{g}/\text{m}^3$ )	5.6	12
NO <sub>2</sub> (ppb)	3.8	53
CO <sub>2</sub> (ppm)	625	1000
CO <sub>2</sub> bedroom (ppm)	725	1000



# Stakeholder Engagement

## Industry

**BROAN**  
**NuTone**

**AERECO** air on demand

**QUFRESH**

**AirKing**  
Ventilation Products

**Panasonic**

**MITSUBISHI  
ELECTRIC**  
COOLING & HEATING

## Standards



**CALIFORNIA  
ENERGY COMMISSION**



**ASTM  
INTERNATIONAL**



**RESNET**  
RESIDENTIAL ENERGY SERVICES NETWORK



## Utilities and Related



**gti**  
GAS  
TECHNOLOGY  
INSTITUTE

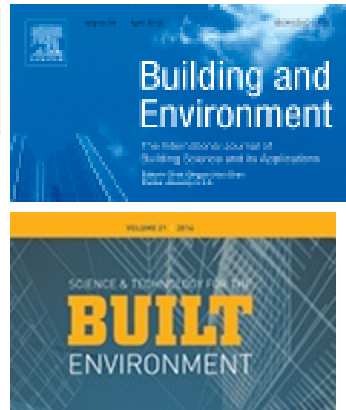


### Leadership roles:

- **ASHRAE:** Lead ASHRAE Residential Ventilation Standard 62.2, develop ASHRAE IAQ Position document
- **RESNET:** Lead Equipment Subcommittee and serve on Standards Development committee and HVAC diagnostics committee
- **ASTM:** Lead standards development for Range Hoods, Air Leakage testing
- **HVI:** technical support to add CE to range hoods
- **AIVC:** International definition of smart ventilation, kitchen ventilation, ensuring tight homes have good IAQ

# Stakeholder Engagement

## Scientific Journals



## Practitioner Journals



## Presentations to Industry & Practitioners



EEBA™



Home  
Performance  
Coalition



International  
Society of  
Indoor Air Quality  
and Climate



Air Infiltration and Ventilation Centre

12<sup>TH</sup> REHVA WORLD CONGRESS



# Remaining Project Work

## Next Steps:

- Develop and evaluate Beta version of IAQ scoring tool
- Continue to develop smart ventilation algorithms
  - Investigate multi zone/multi-family approaches
  - Support industry to incorporate into equipment
- New home IAQ study conducted by competitively selected teams
- Get Range Hood CE Test into ASHRAE 62.2 and HVI listings

## Future Plans:

- Metrics, test methods for automatic and recirculating range hoods.
- Tech support to get smart ventilation recognized in codes/standards/energy calculations
- Smart homes – develop and evaluate sensors to enable good IAQ with greater energy savings + grid interaction

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# Thank You

LBNL

Dr. Iain Walker, Scientist

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# REFERENCE SLIDES



# Project Budget

**Project Budget:** : \$1.2m FY18

**Variances:** No variances from planned budget

**Cost to Date:** \$2.6m

**Additional Funding:**

EPA/HUD support for HEH Program \$300K/y

CEC: Healthy Efficient New Gas Homes (FY15–FY18): \$1.25m

CEC: Smart Ventilation in Advanced California Homes (FY16–FY19): \$1.5 m

CEC: Effective Kitchen Ventilation in Zero Net Energy Homes (FY18-FY20): \$1m

Aereco: Smart Ventilation in Advanced California Homes (FY16–FY19): \$300k

Dwyer: Advanced Flow Hood Performance Verification (FY18): \$100k

## Budget History

FY16– FY 2017 (past)		FY 2018 (current)		FY 2019 – FY21 (planned)	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
\$2.6m	\$3.1m	\$1.2m	\$1.5m	\$4.5m	\$3m

# Project Plan and Schedule

- Project original initiation: 10/2016
- Project planned completion: 09/2018
- Schedule and Milestones:
  - 4/31/18 Status update on Industry Standard Technical Support
  - 9/15/2018 Memo on Pilot testing of IAQ Valuation Score
  - 9/30/18 Progress report on New Home IAQ Study
  - 12/15/18 Memo on Developing Smart Ventilation Strategies for High Performance Homes
- Go/no-go decision /: IAQ field data from BA teams 8/13/2018
- Current and future work: develop IAQ score, study IAQ sensors, develop smart ventilation control strategies, compile baseline IAQ data

Project Schedule												
Project Start: FY16	Completed Work											
Projected End: FY18	Active Task (in progress work)											
	◆ Milestone/Deliverable (Originally Planned)											
	◆ Milestone/Deliverable (Actual)											
	FY2016				FY2017				FY2018			
Task	Q1 (Oct-Dec)	Q2 (Jan-Mar)	Q3 (Apr-Jun)	Q4 (Jul-Sep)	Q1 (Oct-Dec)	Q2 (Jan-Mar)	Q3 (Apr-Jun)	Q4 (Jul-Sep)	Q1 (Oct-Dec)	Q2 (Jan-Mar)	Q3 (Apr-Jun)	Q4 (Jul-Sep)
Scientific guidance & technical support to BA program and stakeholders; national IAQ study	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
C&SI: ASTM range hood method, RESNET 380, ASHRAE 62.2, CA T24, etc.		◆		◆			◆	◆			◆	◆
Smart ventilation: temp control, occupancy control, aux fan credits, eval low-cost monitors				◆				◆				◆
Filtration and air cleaning: Add PM to housing population model; emissions database						◆						
Kitchen vent: develop tests for wall mt, island, downdraft, auto, recirculating hoods				◆		◆		◆				
IAQ valuation / IAQ score / health cost analysis tools				◆				◆				◆
Technical support to Building America teams (FOA awardees)				◆				◆			◆	