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Building America U.S. Department of Energy

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Score with Indoor Air Quality

September 28, 2016

Moderator:
Linh Truong– National Renewable Energy Laboratory

Panelist:
Brett Singer – Lawrence Berkeley National Laboratory

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Agenda

- ✓Welcome and Introductory Remarks
- ✓Overview of Building America (buildingamerica.gov)
  - ➢ Linh Truong - National Renewable Energy Laboratory
- ✓Presentation
  - ➢ Brett Singer - Lawrence Berkeley National Laboratory
- ✓Questions and Answers
- ✓Closing Remarks
- ✓Survey

Building America

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www.buildingamerica.gov

Brett Singer, Staff Scientist and Group Leader of Indoor Environmental Impacts Division, Lawrence Berkeley National Laboratory

Brett C. Singer, Ph.D., is staff scientist and group leader of Indoor Environment in the Energy Analysis and Environmental Impacts Division of Lawrence Berkeley National Laboratory (LBNL). He is also a Principal Investigator in the Whole Building Systems Group in the Building Technologies and Urban Systems Division. The recent focus of Dr. Singer's work has been indoor environmental quality and risk reduction in high performance homes, with the goal of accelerating adoption of IAQ, comfort, durability and sustainability measures into new homes and retrofits of existing homes. He holds a Ph.D. in Civil & Environmental Engineering from the University of California, Berkeley.

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Building America Research: Score with Indoor Air Quality

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Building America Webinar
28-Sep-2016

Outline

- Connection to Building America Roadmap
- IAQ score development
- Baseline field study
- Questions

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Building America Integrated Roadmaps

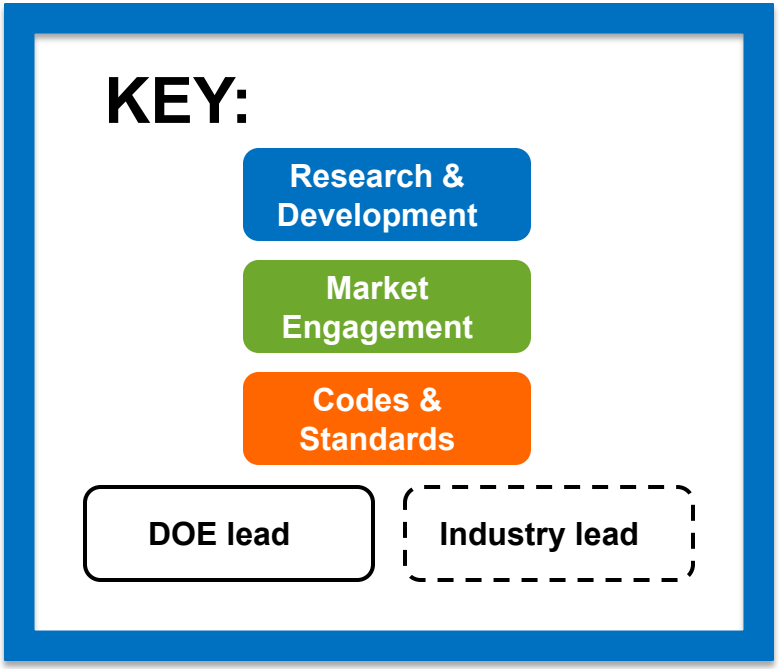
A. High Performance, Moisture Managed Envelope Systems

B. Optimal Comfort Systems for Low Load Homes

C. Optimal Ventilation Systems and IAQ Solutions for Low Load Homes

Overall Roadmap Objectives:

- Best Practice -> Standard Practice
- Manage risks to adoption
- Address optimal performance & cost-effectiveness
- Solutions must be practical & profitable



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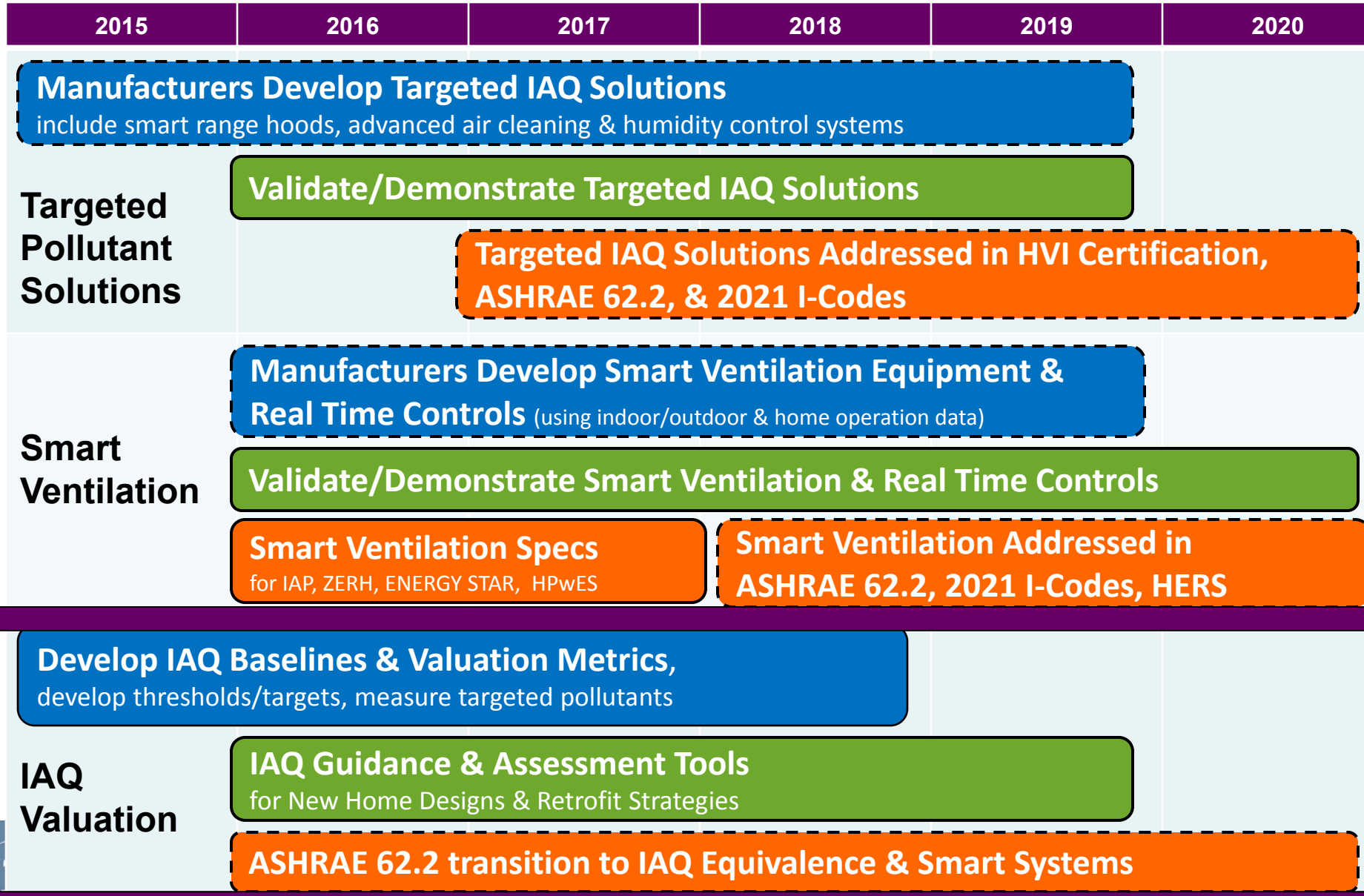
C. Optimal Ventilation & IAQ Solutions



Vision for the IAQ Score

It is an **Asset Rating**

- Rates the home, not the people in it.
- How well is the home designed and built to provide IAQ?
- Rate features based on effectiveness, usability, robustness.

It can be applied to almost all homes

- Existing and newly constructed
- Single detached & attached
- Multifamily units with dedicated systems

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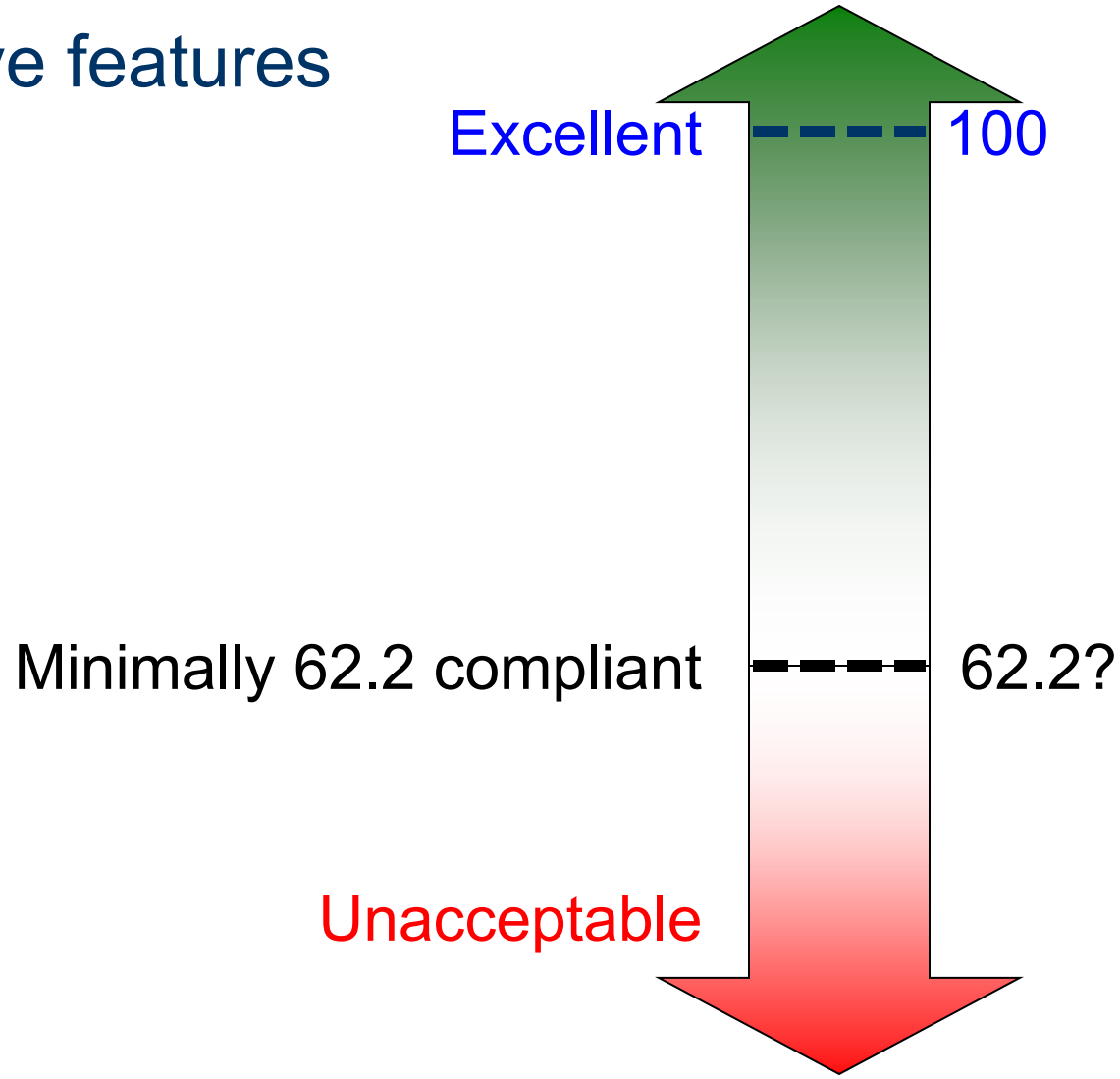
Scale and Scoring

+ points for protective features

– points for hazards



Component Scores

Acute & Chronic Health Hazards

$PM_{2.5}$

Radon

Formaldehyde

Acrolein

NO_2

…

Satisfaction & Odor

Toilets

Inter-apartment transport

Cooking

Nearby outdoor sources

…

Moisture Hazards

Unvented baths

Drainage issues

Dampness

Mold

…

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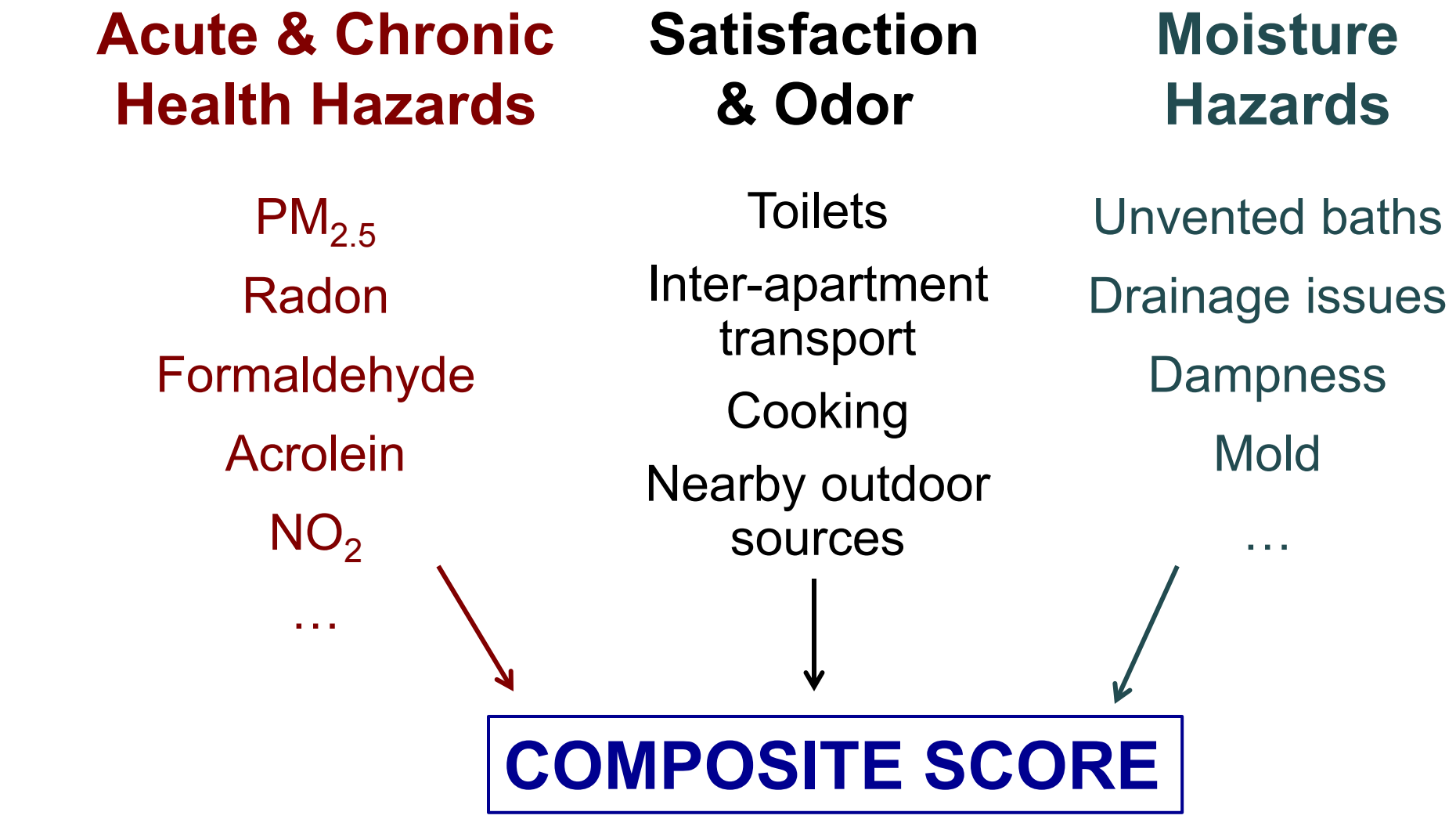
Component Scores



Component Scores

Acute & Chronic Health Hazards

Concentrations

⇩

Exposure & intake

⇩

Disease incidence

+

Cost per incidence

⇩

Disability Adjusted Life Years

Satisfaction & Odor

Need to quantify harm

Moisture Hazards

Need to quantify risk, then harm

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Disability Adjusted Life Years

$$DALY = YLL + YLD$$

YLL = Years lost to premature death

YLD = Equivalent years lost to disability

DALY valued at $50,000 - $160,000

Exposure ***➔ Intake*** x $\frac{\Delta \text{ Disease}}{\Delta \text{ Intake}}$ x $\frac{\Delta \text{ DALYs}}{\Delta \text{ Disease}}$ ⇨ ***DALYs per pollutant***

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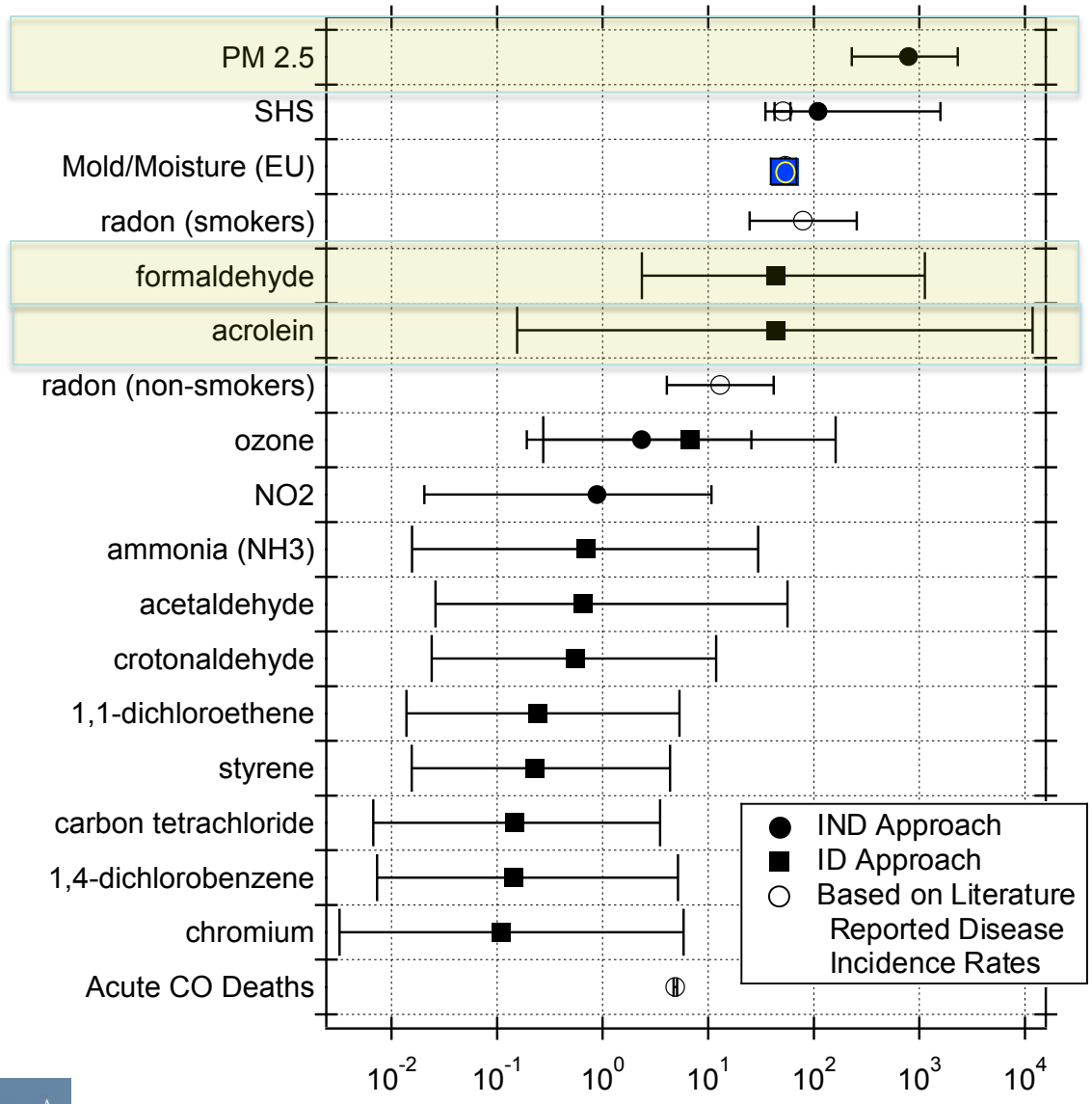
Logue et al., Environmental Health Perspectives, 2012

Disability Adjusted Life Years



PRIORITIES

$PM_{2.5}$
Formaldehyde
Acrolein
Mold / Moisture
Radon

DALYs per year per 100K people

Logue et al., EHP 2012

Input from Expert Workshop

- No mandatory features to generate a score
- No measurements required
- Much larger credits for verified equipment performance
- Outdoor air quality is relevant
- Credits for contaminant control including dehumidification
- Penalize any hazard that would remain after occupants

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Example Features and Hazards

Example Features	Health	Satisfaction	Moisture
Low-VOC materials & finishes	+	+	
Full-bath ventilation	+?	+	+
Kitchen ventilation	+	+	+
Leaky ducts in crawlspace		–	–
Sealed 4” filter box on HAC system	+		
Unvented fireplace	–		–
Ducted HRV, filtered supply air to BRs	+		
Apartment with low cfm/sf measured		+	+?
High outdoor air pollution	–		

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Features characteristics are important

Characteristic	Value
Ducting for kitchen exhaust ventilation	+
Presence of kitchen exhaust fan	+
Kitchen exhaust is range hood	+
Hood has measured flow >100 cfm	+
Hood has rated high capture efficiency	++
Hood <2 sone at >200 cfm	+
Hood interlocked with cooktop or sensor activated	++

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Inconsistent use of kitchen exhaust

Data from Cal. IAQ study; likely biased high

Self-reported usage	Number	Percent
Most times (>75%) when cooktop or oven used	44	13%
Most times when cooktop used, but not oven	39	11%
About half the time	45	13%
Infrequently, only when needed	**113**	**32%**
Never	35	10%
No exhaust fan	73	21%

Mullen et al. LBNL-5970E

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Kitchen exhaust use in Cal. IAQ study:

Reasons for using exhaust system	Number	Percent of 241 users
Remove smoke	111	46%
Remove odors	75	31%
Remove steam / moisture	38	16%
Remove heat	11	5%
Other reasons	5	2%
No reason selected	80	33%

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Mullen et al. LBNL-5970E

Kitchen exhaust use in Cal. IAQ study:

Reasons for NOT using exhaust system	Number	% of 193 using <50% of time
Not needed	92	48%
Too noisy	40	21%
Don't think about it	31	16%
Doesn't work	19	10%
Open window instead	17	9%
Other reasons	7	<4%
Wastes energy	3	<2%
No reason selected or don't know	23	12%

Mullen et al. LBNL-5970E

Development of IAQ Score V1

- Initial score will rely heavily on expert assessment
- Build from reference elements
  - Develop scores for core set of features
  - Other features scored in relation to the reference core
  - Enables all three components to be on same scoring basis
- Target is beta version for pilot testing in Q2 of 2017

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Issues

- Should pollutant measurements be considered if available?
  - Formaldehyde the most suitable
- Any credit for documentation, maintenance schedules, etc?
- What to include under hazards?
  - Radon, tobacco contamination, mold or dampness
- Should correlate with actual IAQ in homes

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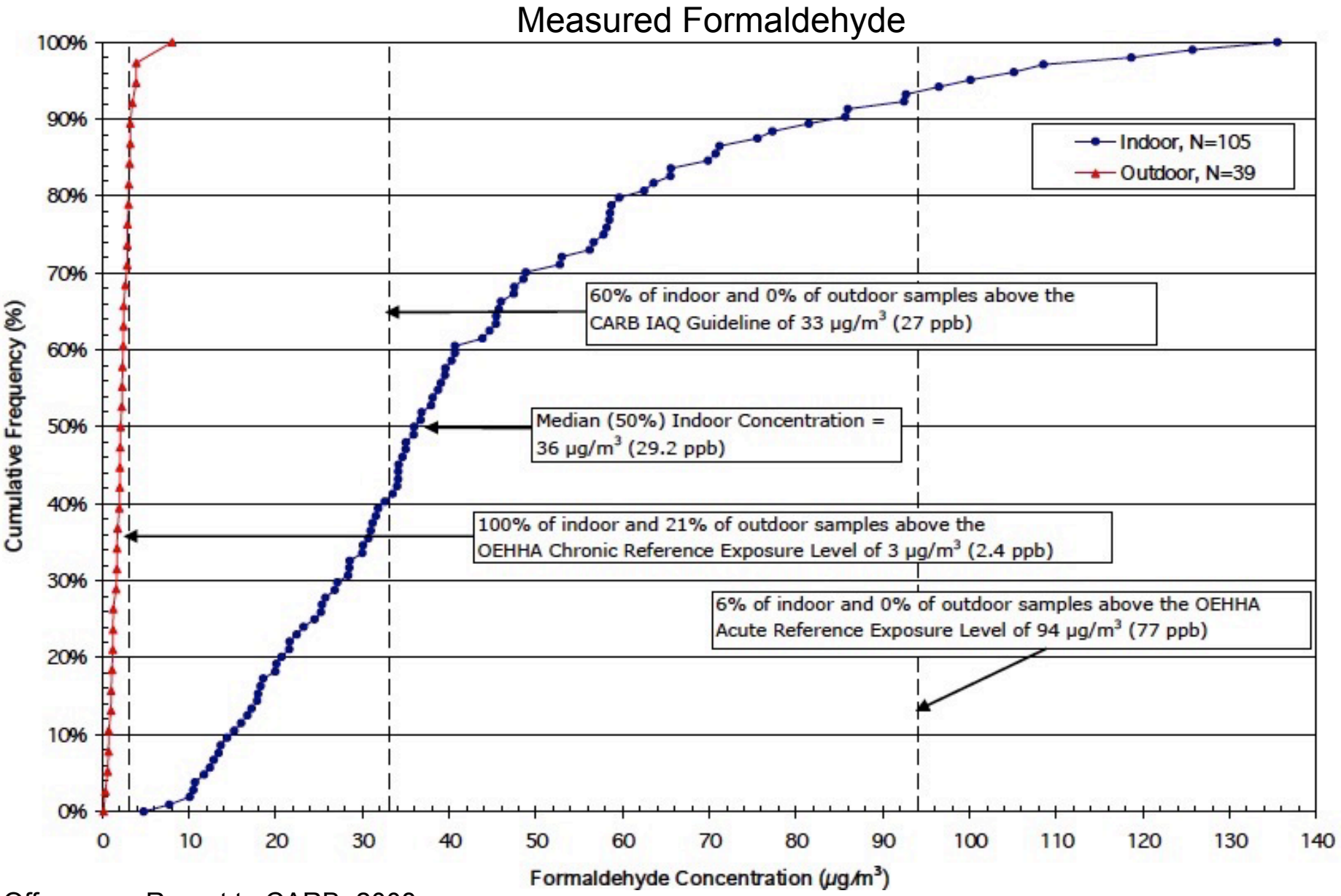
National Baseline IAQ Study - Rationale

- Homes being built with tighter envelopes throughout US
- Consensus on need for ventilation; discord on details
- Limited data on ventilation equipment and practices
- Ongoing debates about various provisions of 62.2
  - Dwelling unit rates too high / too low
  - Value of distributed supply ventilation
  - Importance of design: balanced, supply, exhaust ventilation
  - Does kitchen need rapid extraction?

High formaldehyde in Cal. homes built 2002-2005



Offermann, Report to CARB, 2008

Few studies of ventilation equipment

- Florida, 2015
  - Investigation of the Effectiveness and Failure Rates of Whole-House Mechanical Ventilation Systems in Florida
  - Florida Solar Energy Center, 2015, FSEC-CR-2002-15
- Pacific Northwest, 2015
  - Pacific Northwest Residential Ventilation Effectiveness Study
  - Eklund et al. WSU report to NEEA, #E15-015, 2015
- California, 2012
  - Measuring Residential Ventilation System Airflows: Part 2 – Field Evaluation of Airflow Meter Devices and System Flow Verification
  - Stratton et al. LBNL-5982E

Florida (2015 Report)

- 2014 code requires MV for homes with ≤5 ACH50
- 21-home field study
- Confusion between ventilation and HAC
- Only 12/21 capable of operating
- Only 14% with airflows near design and two turned off

-> **Only 1 operating with design 3/21**

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Pacific Northwest (2015 Report)

- 29 homes in Washington, 1-3 ACH50. Not typical homes!
- State code has required MV since 1990
- Wide variations in understanding about ventilation systems
- Focus was on effectiveness of different system designs
- As found, 10 had airflows below standard; but mostly due to timer settings. All had enough capacity and all operating.

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Ongoing New Home Study in California

- Follow up to Cal. New Home Study (Offermann 2008 report)
- Goal: evaluate MV required in 2008 code to protect IAQ
- Online survey
  - 3000 responses, mostly SoCal Gas customer
  - Single-family / townhouse / duplex, built in 2002 or later
- Field study
  - Characterize MV equipment
  - Measure airflows
  - Monitor equipment use & IAQ parameters over 1 week

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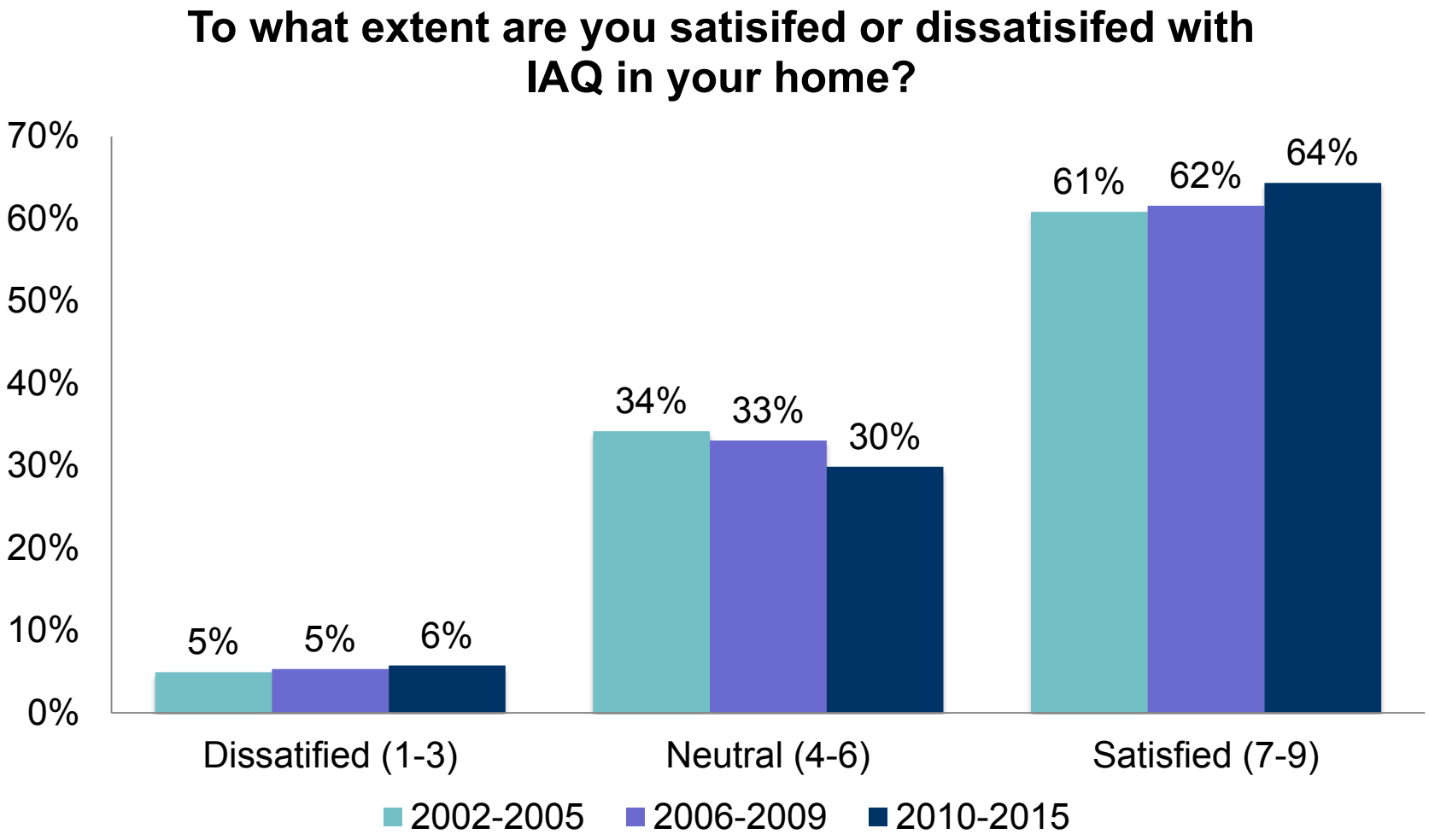
California Survey Results



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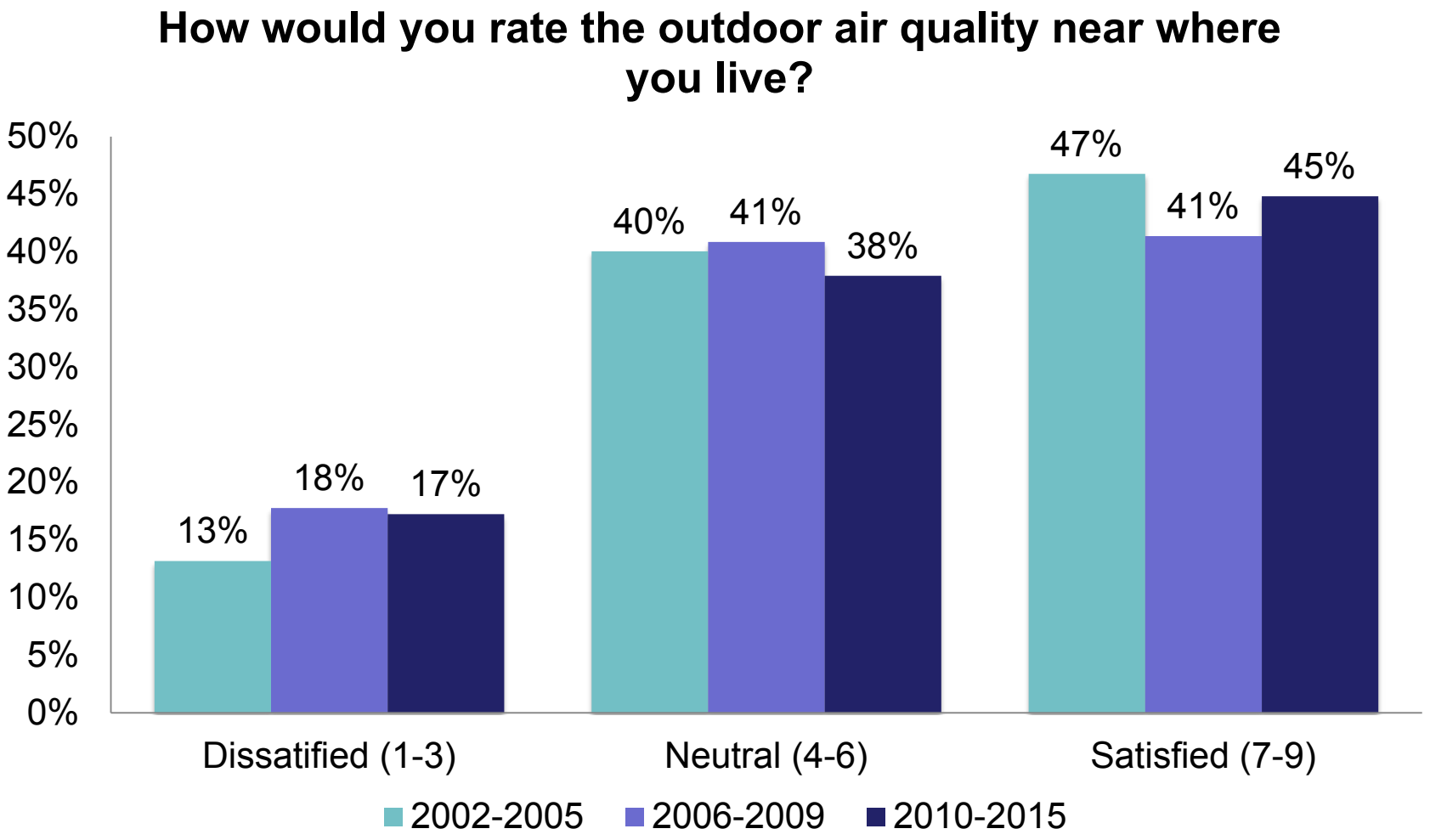
California Survey Results



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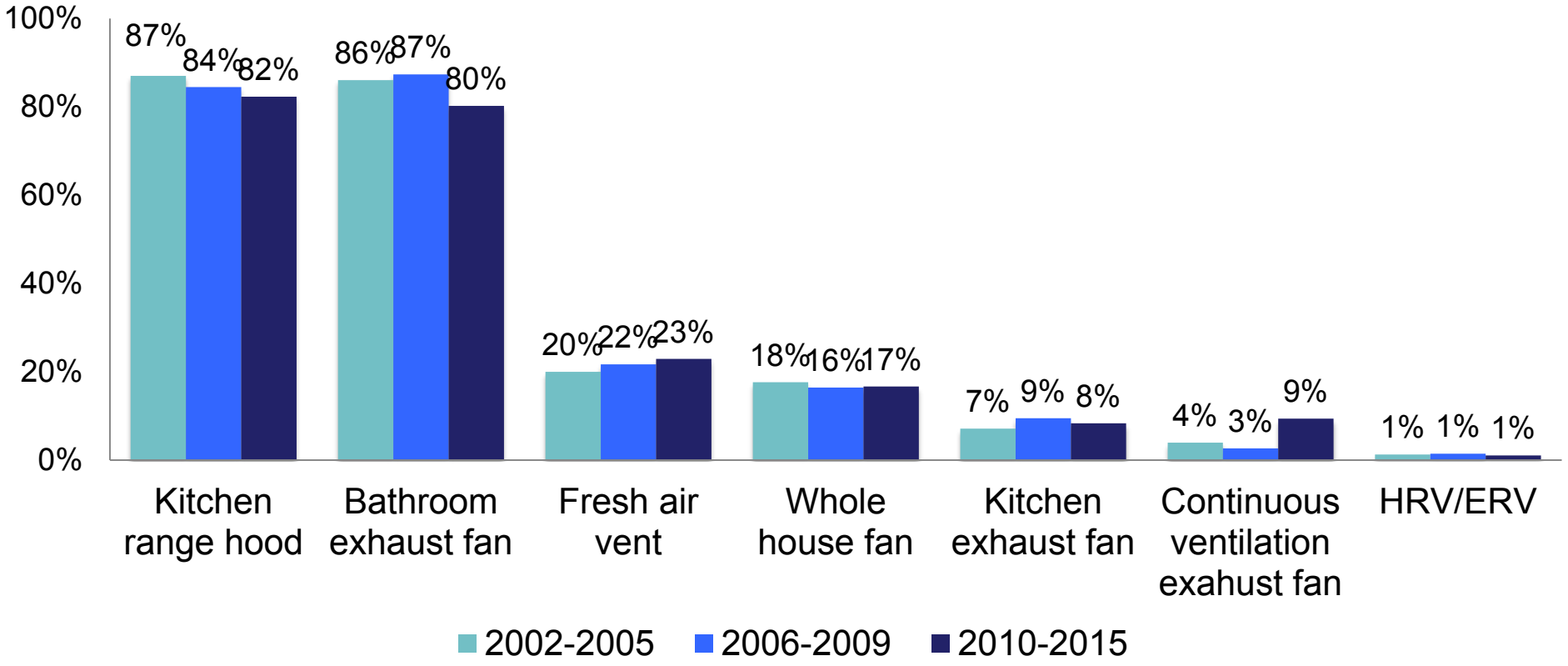
What mechanical ventilation is in your home (California)?



National Baseline IAQ Study - GOALS

Collect data on pollutant, airflow, building and HVAC systems in recent construction occupied homes in varied climates.

Inform standards and technology development to protect IAQ as new homes are built to more stringent efficiency standards.

Compare 62.2 compliant homes to non-62.2.

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Baseline IAQ Study - OBJECTIVES

1. Measure humidity, air pollutants, and ventilation eqt use; track activities that impact emissions and removal.
2. Characterize mechanical ventilation designs; measure performance; explore regional variations.
3. Investigate associations of humidity and contaminant levels with control measures including 62.2-compliant ventilation, envelope air tightness, commissioning, and filtration.

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Study Elements

- Review and compilation of existing information
- Survey
- Data collection in homes
  - Characterization
  - Commissioning
  - Usage
  - Performance in use
- Model after study in California with similar aim – to determine if Title 24 ventilation standards are effective

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Pollutants measurements

Time-resolved

- $PM_{2.5}$ (light scattering)
- CO_2, T, RH
- Ozone, NO_2, CO (sensors)
- T/RH in master bath

Time-integrated

- NO_X and NO_2
- Formaldehyde & acetaldehyde
- Speciated VOCs
- Radon?

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System Diagnostics & Monitoring

- Envelope air leakage and duct leakage (deltaQ)
- Exhaust fans (bath, kitchen, laundry room)
- Clothes dryer vent
- Range hood
- Outside air supply
- Window and patio door use?

Building America Planned 3-Year FOA Schedule (subject to appropriations)

	FY2015				FY2016				FY2017				FY2018				FY2019			
Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
NREL contract down select (FY15 bridge-funding)	$ High-R																			
	$ Comfort																			
	$ IAQ																			
	FOA15			FY15 FOA Award #1																
				FY15 FOA Award #2, etc.																
					FOA16			FY16 FOA Award #1												
								FY16 FOA Award #2												
								FY16 FOA Award #3, etc.												
									FOA17			FY17 FOA Award #1								
												FY17 FOA Award #2								
												FY17 FOA Award #3, etc.								

Notes:

1. All FOA's are fully funded up front
2. No. of awards each year will depend on award negotiations and budget.

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Questions?

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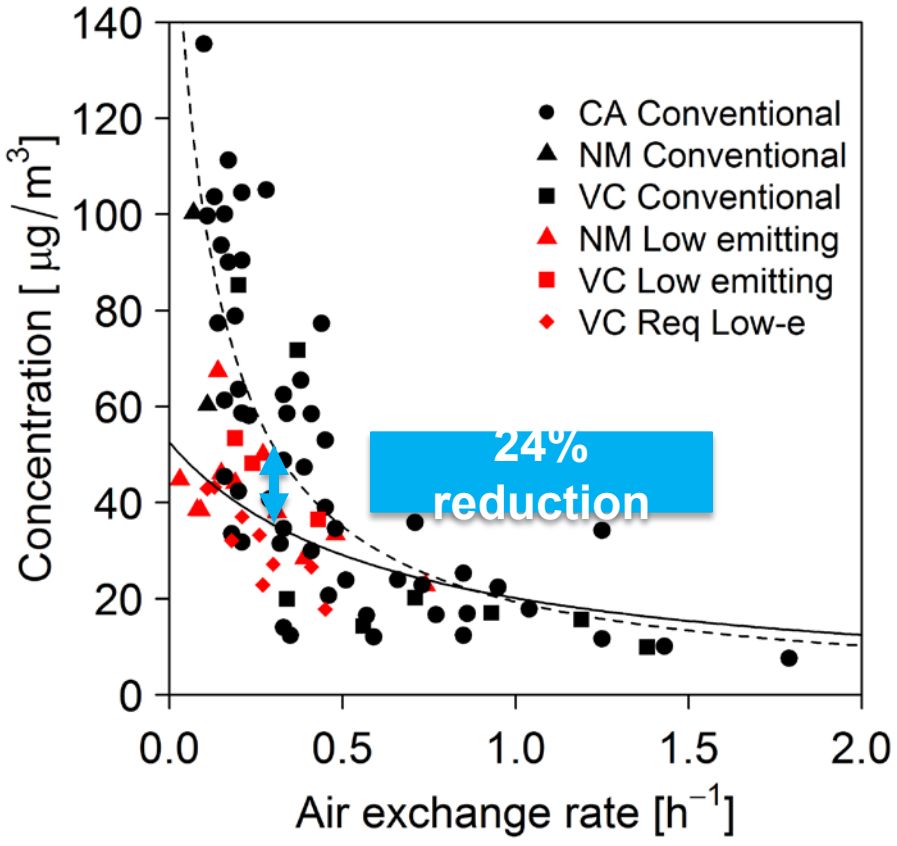
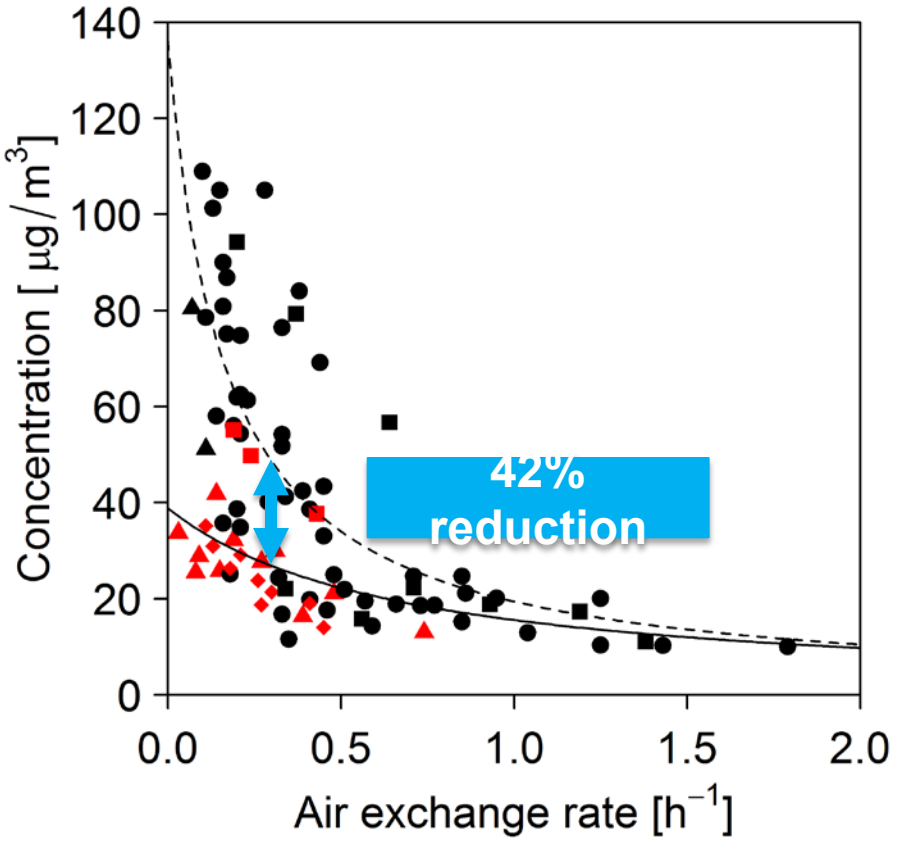
Homes with low-emitting materials have lower formaldehyde concentrations

Unadjusted



Adjusted for T, RH, house age



Hult et al., 2015

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