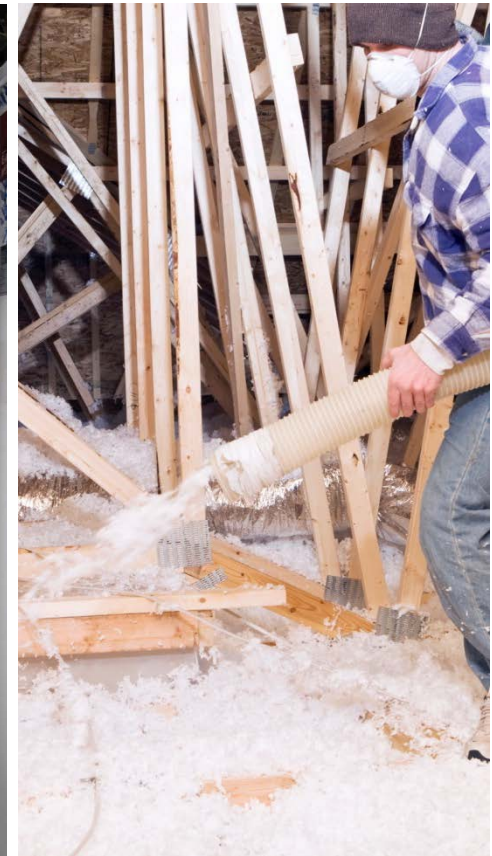


Aug 10, 2016

U.S. DEPARTMENT OF  
**ENERGY**

Energy Efficiency &  
Renewable Energy



# Building America Research: Part 1 - Update and Outlook

**Eric Werling**  
Building America Program Director  
Building Technologies Office



# Some Housekeeping Items

## Two Options for Audio (select audio mode):

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<http://energy.gov/eere/buildings/building-america-meetings#current>

# Agenda

- ✓ Welcome and Introductory Remarks
- ✓ Overview of Building America ([buildingamerica.gov](http://buildingamerica.gov))
  - Linh Truong: National Renewable Energy Laboratory
- ✓ Presentation
  - Eric Werling, U.S. Department of Energy
  - Lena Burkett, U.S. Department of Energy, ORISE Fellow
- ✓ Questions and Answers
- ✓ Closing Remarks

# Building America's Top 3 Building Science Challenges for High Performance Homes:



Solutions for New and Existing Homes with ...

## 1. Moisture Managed High-R Envelopes

- **Less Likely to Get/Stay Wet**

High performance homes with increased insulation, reduced infiltration, reduced risk of condensation, & adequate drying potential inside building assemblies

## 2. Optimized Low-Load Comfort Solutions

- **Effectively Manage Airflow & Indoor RH for Comfort**

High efficiency comfort systems for homes with low thermal loads, including optimal efficiency, managed air flow and RH control at all part load conditions

## 3. Smarter Indoor Air Quality Solutions

- **Control Fresh Air Supply & Contaminant Removal**

Added tightness with improved source control, dilution, and high efficiency filtration, with little or no energy penalty



# U.S. DOE Building America Research to Market Plan



# Research-to-Market Plan and Technology-to-Market Roadmaps

- Published in late 2015
- Developed to guide Building America's Research, Development, and Deployment activities
- Fill critical research and information gaps
- Enable rapid market adoption of technologies and best practices for high performance homes
- Cost-effective solutions that are practical and profitable for builders and home improvement contractors
- Sets specific program objectives over the coming years



# 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:

- Standard Practice as endpoints
- Manage risks to minimize problems of adoption
- Address optimal performance & cost-effectiveness
- Solutions must be practical & profitable for builders and home improvement contractors

## KEY:

Research & Development

Market Engagement

Codes & Standards

DOE lead

Industry lead



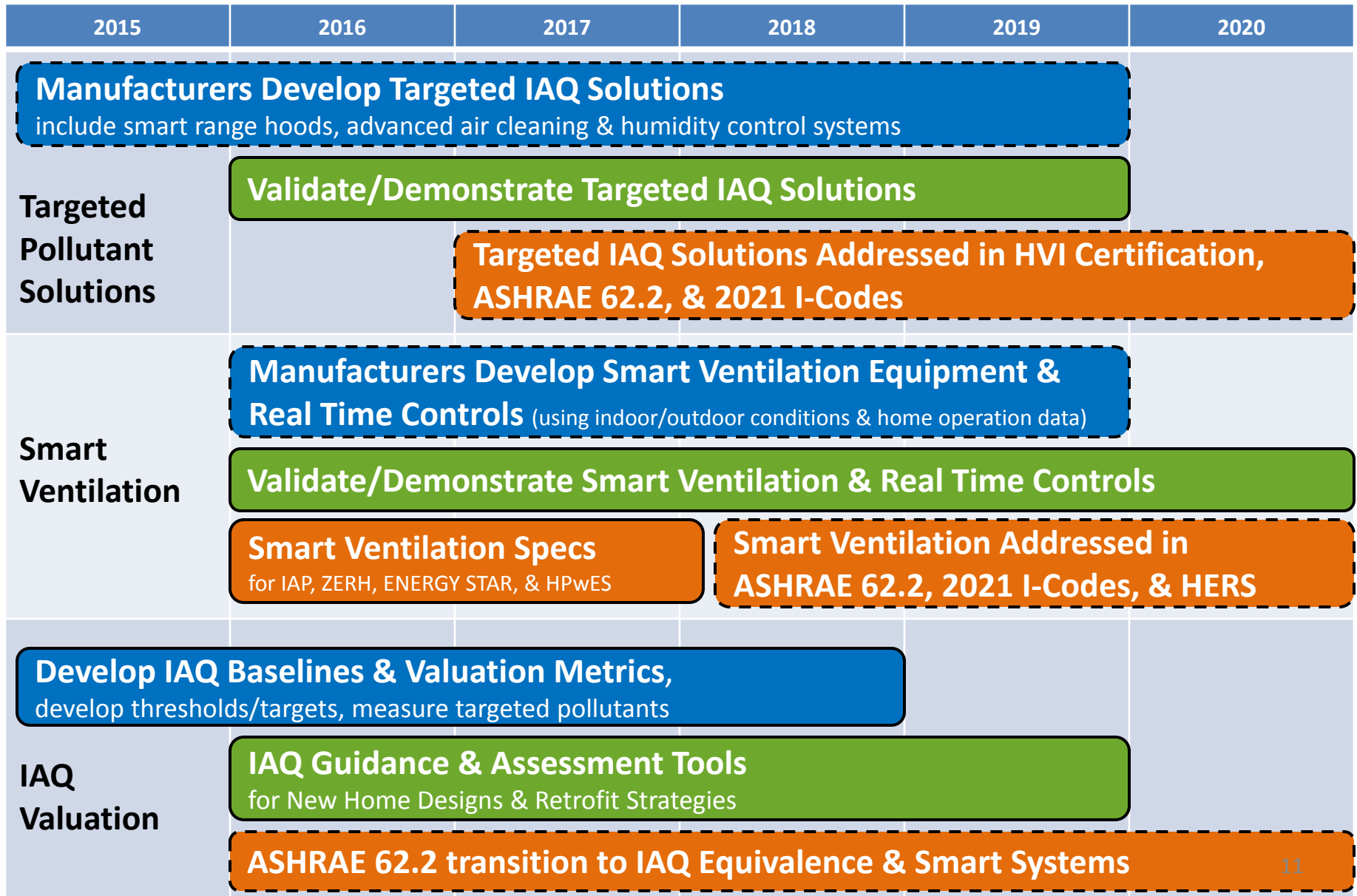
# A. High Performance Moisture Managed Envelopes

	2015	2016	2017	2018	2019	2020
<b>Moisture Risk Management</b>		<b>Moisture Managed Guidance/Tools &amp; Best Practice Specs for priority High-R Envelope Systems in each climate</b>				
	<b>Lab and Field Moisture Risk Assessment of priority High-R Assemblies &amp; Materials</b>					
	<b>Moisture Risk Assessment &amp; Modeling Standards (e.g., ASHRAE 160)</b>					
<b>High Performance Envelope Solutions</b>	<b>Validate/Demonstrate High Performance Envelope Specs in Real World Test Homes</b>					
		<b>Specs in Voluntary Program Standards</b> (ZERH, Energy Star & HPwES)		<b>Moisture Managed High-R Envelopes addressed in 2021 IECC and IRC</b>		

# B. Optimal Comfort Systems for Low-Load Homes

	2015	2016	2017	2018	2019	2020
<b>System Design</b>	<b>Develop System Design Procedures/Tools &amp; Comfort Metrics/Criteria for Low-Load Homes</b> Address whole-house humidity & distribution				<b>I-Codes Adopt Low-Load Design and Performance Standards</b>	
	<b>Validate/Demonstrate Comfort System Solutions in Low-Load Homes using Comfort Metrics/Criteria</b>					
				<b>Best Practice Guidance/Training/Tools on System Design, Installation/Commissioning, &amp; Maintenance</b>		
				<b>System Design Standards Address Comfort Criteria in Low-Load Homes (e.g., ACCA, ASHRAE)</b>		
<b>Smart Systems &amp; Equipment</b>	<b>Assess Load Profiles/Market Demand for Low-Load Homes</b>		<b>Manufacturers Develop Low-Load HVAC and Dehumidification</b> for whole house comfort. Address design & installation issues			
	<b>Manufacturers Develop Automated FDD &amp; Optimization Controls</b> Address equipment & distribution/comfort performance, learning & wireless sensors/controls					
				<b>FDD, Sensors/Controls, Metrics &amp; Performance Validation Standards (e.g., ACCA, ASTM)</b>		
				<b>Validate/Demonstrate Smart HVAC &amp; Advanced Dehumidification Systems</b>		
				<b>Best Practice Guidance on Automated Smart HVAC Operation, Controls, &amp; Maintenance</b>		

# C. Optimal Ventilation & IAQ Solutions



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# Current Building America Projects: High Performance Moisture Managed Envelopes

# Innovative, Affordable, High-Performance, Moisture-Managed Building Enclosure System

## Team and Partners

### University of Minnesota

w/ MonoPath, Urban Homeworks, Twin Cities Habitat for Humanity, Thrive, Building Knowledge, Simply Green, Huber, Unico

## Topic Area

### High-Performance Moisture Managed Envelopes (2016)

- Innovative building enclosure system that outperforms conventional wood-frame construction for energy and durability, yet costs less and can be built faster.
- Optimized whole building system that can deliver 50% energy savings (compared to typical 2010 new home).
- Building system delivered by a single enclosure contractor ensuring better QA/QC and faster dry-in.
- Test and compare this solid panel wall system with high performance wood-frame wall system for performance, constructability, and cost.
- Current target market is affordable housing.



**Success Metrics: Design, build, and monitor 20+ affordable homes to demonstrate and verify >25% enclosure energy savings (above IECC 2009) with performance targets of <1 ACH @50 Pa, improved moisture durability, and lower cost than wood-frame walls with comparable thermal performance.**



# High Performance Building Envelope Assemblies

Team and Partners	Topic Area
<b>Home Innovation Research Labs, Inc.</b> w/ ACC, NAHB, FPL, VSI, Dow, SIPA, APA, IBHS, DuPont	High Performance Moisture Managed Envelopes (2015)



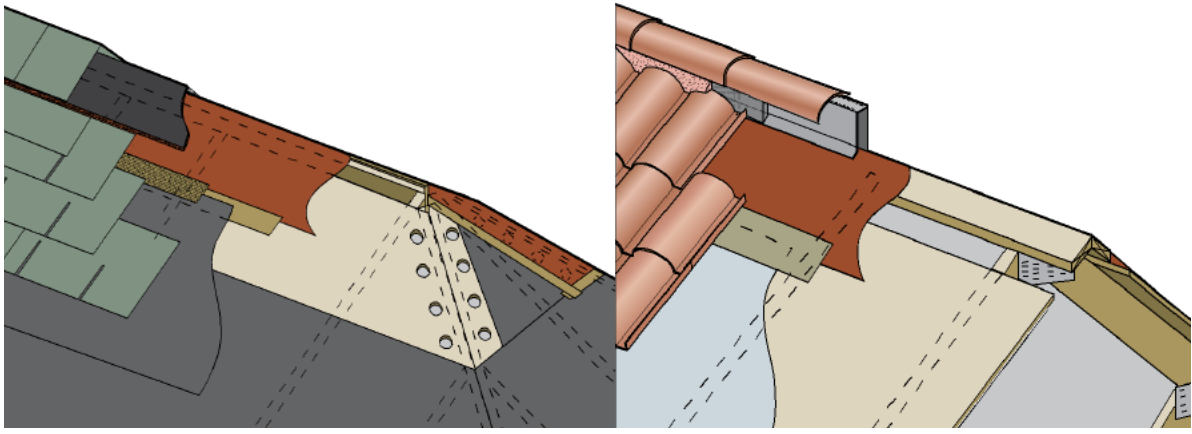
- **Moisture Performance of High-R Wall Systems:** Study moisture performance in high-R walls (>R-20) in 20 occupied high performance homes across different climate zones.
- **Extended Plate and Beam Wall System:** Study the constructability and structural/moisture performance of high-R walls with rigid foam insulation behind the WSP, in the pocket resulting from wall plates one dimension wider than studs.
- **Attic Retrofits Using Nail-Base Insulated Panels:** Study the constructability, energy and moisture performance of an innovative retrofit approach using nail-base insulated panels installed above the existing roof deck.

**Success Metrics: Measured and modeled performance of high-R walls and design guidance for all climates. Efficient, durable wall assembly to meet and exceed new IECC targets. HVAC energy savings of 10% or more for sealed attics and cathedral ceilings.**

# Monitoring of Unvented Roofs with Diffusion Vents and Interior Vapor Control in a Cold Climate

Team and Partners	Topic Area
<b>Building Science Corporation</b> w/ DuPont, Owens Corning, Cosella-Dörken, K. Hovnanian Homes	High Performance Moisture Managed Envelopes (2016)

- Interior vapor control membrane on attics with fibrous insulation.
- Enables affordable insulation solution for attics, bringing the HVAC equipment into the conditioned space.
- New Construction Field Test
- Existing Manufactured Housing Field Test/ Demonstration
- Up to 3 winters of data

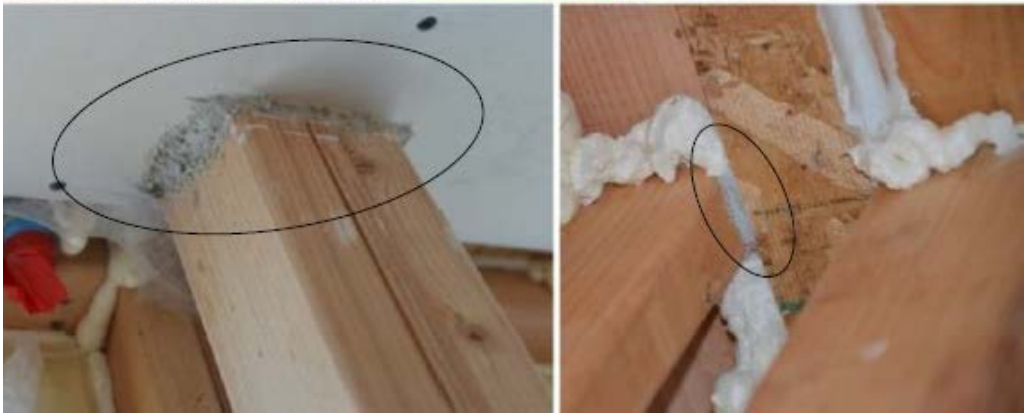


**Success Metrics: Assessment & validation of unvented roof construction detail to enable moisture managed fibrous insulation solutions in cold climates, achieving code & above code performance (R-49) at up to 80% material cost reduction, and saving >10% in HVAC energy use.**

# Aerosol Sealing in New Construction

Team and Partners	Topic Area
<b>Center for Energy and Environment</b> w/ UC Davis WCEC, Building Knowledge, Aeroseal LLC, UMN Cold Climate Housing Program	High Performance Moisture Managed Envelopes (2016)

- Aerosol sealing method (a successful duct sealing solution) applied to whole house envelope sealing.
- Sealant particles dispersed in pressurized house during construction, sealing gaps and cracks in envelope, within a few hours.
- Real time feedback of leakage
- Project will develop the optimal integration of this technology into production homebuilders' practices.



**Success Metrics: 20-home study optimizes integration of aerosol envelope sealing in production building process to radically improve QC and significantly reduce labor cost compared to traditional air sealing.**

# Structural Support of Windows in Walls with Continuous Insulation

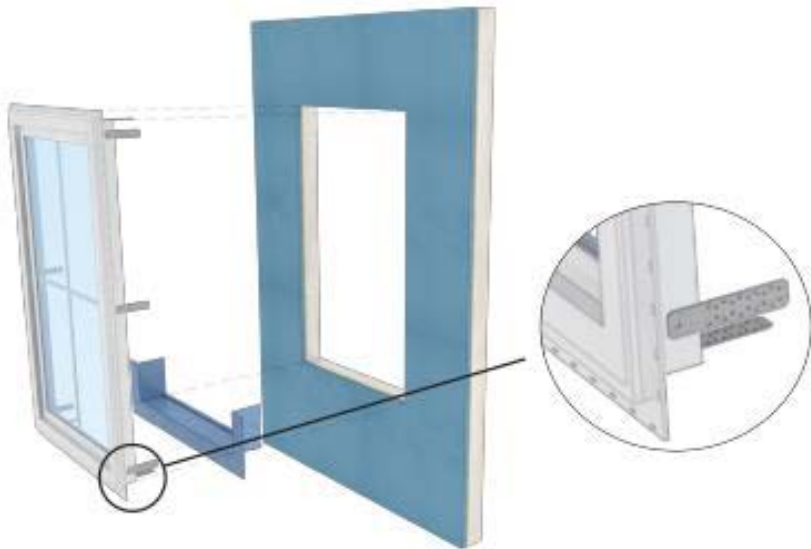
## Team and Partners

### Home Innovation Research Labs, Inc.

w/ American Chemistry Council and American Architectural Manufacturers Association

## Topic Area

High Performance Moisture Managed Envelopes (2016)



- Research is needed to identify code compliant solutions for window installation in walls with continuous insulation (CI)
- The study will evaluate the structural performance of walls with windows of varying shapes and sizes, insulation thicknesses and installation methods.

**Success Metrics:** Structural performance validation of window installation methods for walls with continuous insulation will provide data & justification for additional methods to be included in industry (AAMA) guidance & IRC code provisions. Results will enable increased use of continuous insulation, which is highly effective at raising overall R-value, eliminating thermal bridging, and mitigating moisture issues.

# Physics-based Interval Data Models to Automate and Scale Home Energy Performance Evaluations

## Team and Partners

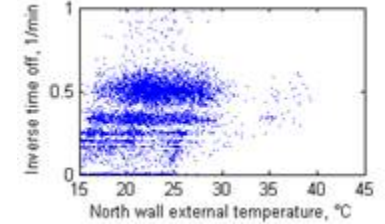
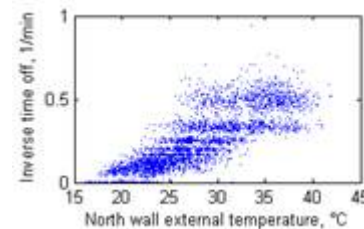
**Fraunhofer USA, Inc.**

w/ Eversource, National Grid, Holyoke Gas & Electric

## Topic Area

Performance Measurement  
(2016)

Develop a highly scalable tool that automatically and remotely analyzes communicating thermostat (CT) and interval meter data to identify household-specific retrofit opportunities to reduce heating energy consumption, quantify expected retrofit energy savings, and validate post-retrofit energy performance.



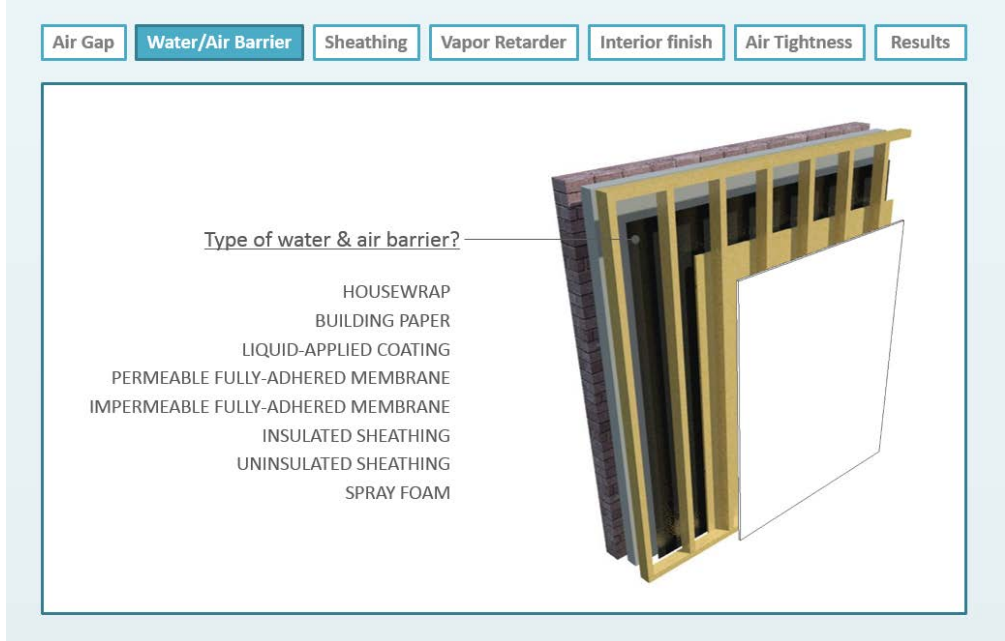
**Success Metrics: Develop & validate approach that correctly identifies households with the target retrofit opportunities with 1) at least 75% classification accuracy and 2) +/-25% accuracy in predicting retrofit energy savings, to significantly increase the uptake of the target retrofit measures while reducing program recruitment costs per retrofit project. Success metrics include doubling the rate of onsite energy audits in partner utility programs for the target households identified by the tool.**




# Moisture Managed Wall Expert System

National Lab	Topic Area
<b>Oak Ridge National Laboratory</b>	High Performance Moisture Managed Envelopes

- Decision support tool for builders and designers
- Provides expert advice on building envelope system performance from industry's best researchers and building scientists
- Evaluates and compares moisture durability for a wide range of walls
- Presents guidance on proper methods to mitigate risk
- Promotes better-informed and decisions higher confidence regarding high performance wall assemblies





# Current Building America Projects: Optimal Comfort Systems for Low-Load Homes

# Variable Capacity Comfort Systems for Low Load Homes

Team and Partners	Topic Area
<b>University of Central Florida</b> <b>Florida Solar Energy Center</b>	Optimized Comfort Systems for Low-Load Homes (2015)

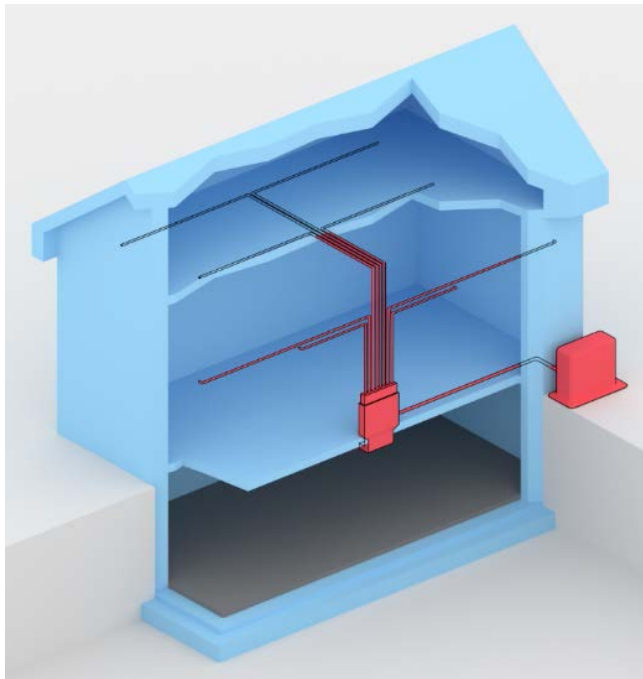


- Validate system approaches for energy efficient management of temperature and relative humidity in low load homes in humid climates.
- Lab test of inverter driven heat pump with small duct high velocity distribution.
- Field tests of ducted mini-split and ductless multi-splits.
- Potential for better RH control via ability to vary compressor speed, refrigerant flow, and coil air flow.
- Field and lab tests to demonstrate smart ventilation control strategies to minimize energy and moisture risks by optimizing delivery of ventilation using real time measurements of risk factors.

**Success Metrics: 5-10% space conditioning energy savings in current DOE Zero Energy Ready Homes while maintaining or enhancing comfort and indoor air quality.**

# A “Plug-n-Play” Air Delivery System for Low Load Homes & Evaluation of a Residential Thermal Comfort Rating Method

Team and Partners	Topic Area
<b>IBACOS</b>	Optimized Comfort Systems for Low-Load Homes (2015)



- A simplified small-diameter residential air delivery system as a solution to the air distribution and comfort delivery issues in low-load production-built homes. The system is assembled in a homerun arrangement from a kit of parts with a limited number of components.
- Evaluating need for, and feasibility of, a Thermal Comfort Rating Method (TCRM) to allow builders and homeowners to make value-based decisions about thermal comfort. TCRM is a scaled metric of whole-house comfort delivery, that quantifies a home’s ability to provide thermal comfort under varying conditions and demands.

**Success Metrics: System easily integrated within the home’s conditioned space, installed with less error and waste, and offers predictable performance to help provide comfort in low-load homes.**

# Integrated Design: A High Performance Solution for Affordable Housing

Team and Partners	Topic Area
<b>The Levy Partnership, Inc.</b>	Envelope, Comfort, and IAQ (2015)

- Develop a high performance Integrated Design for affordable housing (Habitat for Humanity and factory-built)
- Combine a high performance enclosure, ductless mini-split heat pump, transfer fans and ventilation
- Monitor 3 test homes, occupied and unoccupied, for 1 year+
- TRNSYS/CONTAM and BEopt models calibrated to field data

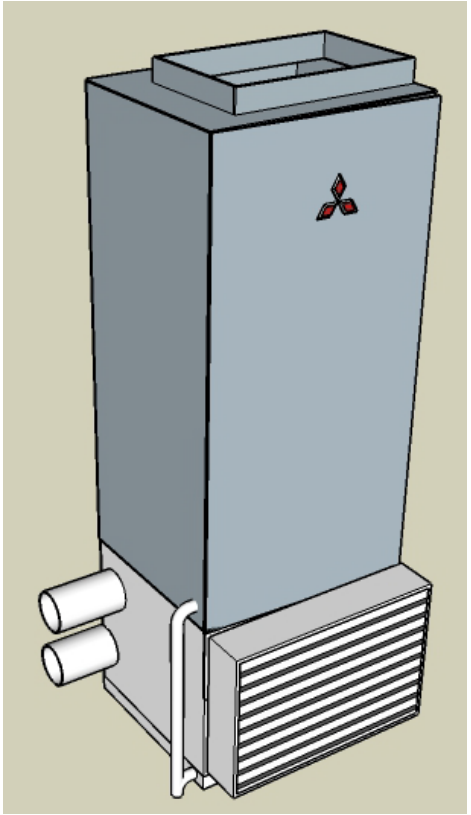


**Success Metrics: Reduce space conditioning energy use by 50% relative to IECC 2009 in Habitat and factory built homes in mixed-humid and cold climates**



# Ventilation Integrated Comfort System (VICS)

Team and Partners	Topic Area
<b>Steven Winter Associates, Inc.</b> w/ Mitsubishi	Optimal Comfort Systems and Optimal Ventilation & IAQ Solutions (2016)

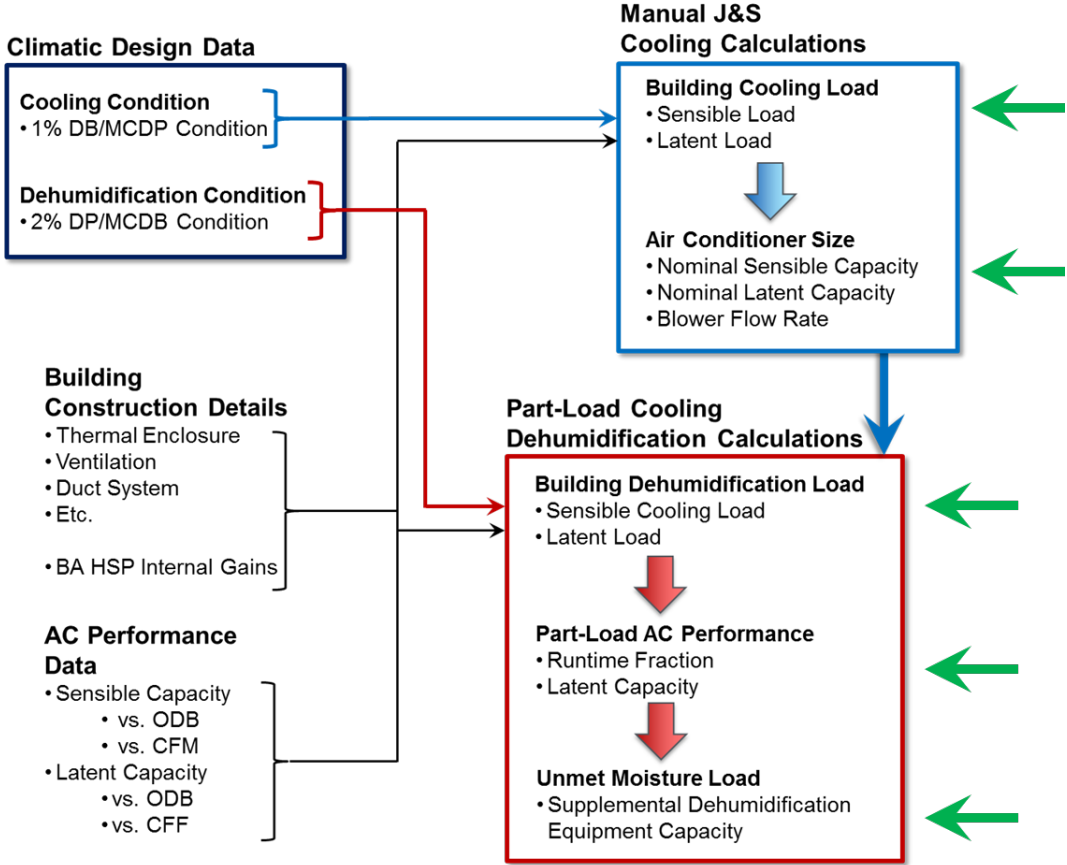


- Development of integrated ERV and heat pump
- Variable speed fans for low energy and high controllability
- Test and demonstrate in unoccupied and occupied homes
- Lower cost and higher performance than typical practice of Central Fan Integrated Supply (CFIS) ventilation

**Success Metrics: Develop, validate, & demonstrate VICS, to reduce up-front cost \$1,000-\$2,000 and save 400-800 kWh/year, compared to separately installed standard ducted ventilation & HAC systems. Enables balanced ventilation, better IAQ, & RH control in tight homes at lower cost.**

# Dehumidification Design and Sizing Procedures

National Lab	Topic Area
<p><b>National Renewable Energy Laboratory</b></p>	<p>Optimized Comfort Systems for Low-Load Homes</p>

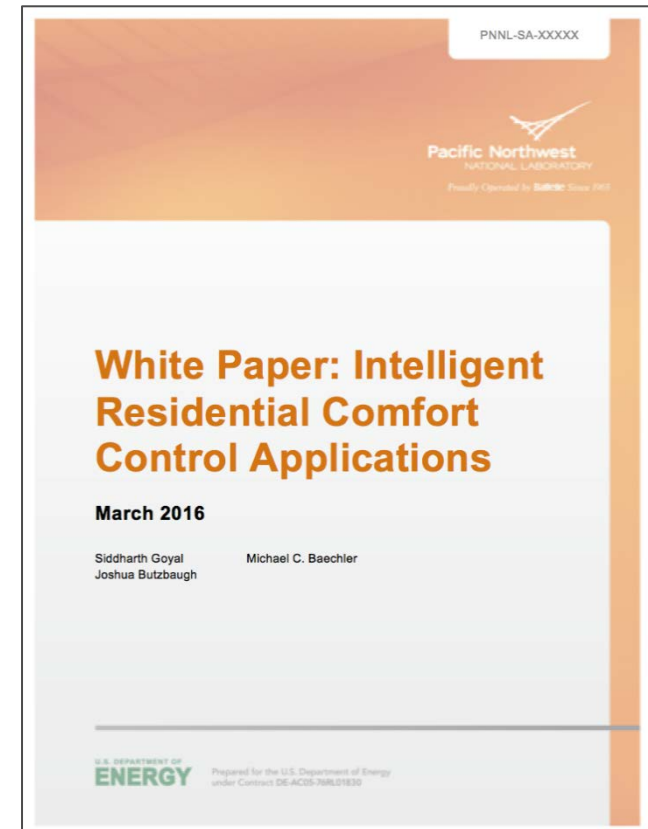



- Parametric analysis comparing procedure to EnergyPlus annual simulations
  - 3 constructions, 10 cities
- Smaller dehumidifiers than “expected”
- Dehumidifiers met the load 94% of the time
- With an RH setpoint of 55%, indoor RH never exceed 60%

# Framework for “Smart” HVAC Applications

National Lab	Topic Area
<b>Pacific Northwest National Laboratory</b>	Optimized Comfort Systems for Low-Load Homes

- Characterize the state of the art in intelligent residential comfort control applications:
  - Sensors and controls technology
  - HVAC commissioning and maintenance technology
- Assess technology gaps and market needs
- Establish framework for coordination between emerging technology and market deployment programs





# Current Building America Projects: Optimal Ventilation & IAQ Solutions

# Performance-Based IAQ and Optimized Ventilation

Team and Partners	Topic Area
<p><b>Southface Energy Institute</b></p> <p>w/ Underwriters Laboratory, Beazer Homes, Illinois Sustainable Technology Center, Venmar, Kerley Family Homes</p>	<p>Optimal Ventilation &amp; IAQ Solutions (2016)</p>

- Develop assessment protocol incorporating low-cost IAQ sensors: PM<sub>2.5</sub>, CO<sub>2</sub>, O<sub>3</sub>, formaldehyde, and radon sensors
- Benchmark IAQ metrics in new and existing homes
- Smart ERV field tests in real-world homes to evaluate impact on IAQ and energy consumption
- Pilot LBNL-developed IAQ Score in test homes



**Success Metrics: Develop & validate a performance-based protocol for assessing indoor air quality (IAQ) in homes and inexpensive smart ERV solution that can achieve average annual HVAC energy cost savings of approximately \$100 compared to central fan integrated supply systems, and ~50% reduction of ventilation related latent loads compared to supply or exhaust strategies. Goal is to overcome builder reluctance to air-tightness & ventilation strategies, to enable energy savings from tight construction in hot/humid climates, while reducing IAQ risks and improving comfort.**

# Energy Savings with Acceptable IAQ through Improved Air Flow Control

Team and Partners	Topic Area
<b>Gas Technology Institute</b>	Optimal Ventilation & IAQ Solutions (2015)

- This project will develop an integrated assessment that will manage HVAC, infiltration, and ventilation airflows for energy savings.
- Field tests of 20 control homes and 20 treatment homes, conducted in cooperation with field practitioners.
- Multiple IAQ measurements including CO2, radon, formaldehyde, humidity
- Guidance for delivering residential retrofits including both good IAQ and maximum energy savings.



**Success Metrics: Reduce the ventilation energy used to assure acceptable IAQ in existing residential homes by 30% using a systems approach to controlling the three contributing air streams: ventilation, infiltration, and duct system losses.**



# Development of the Industry's First Smart Range Hood

Team and Partners	Topic Area
<b>Newport Partners</b> w/ Broan-NuTone	Optimal Ventilation & IAQ Solutions (2016)

- Kitchens are the primary source of the most harmful pollutants generated in the home.
- Kitchen range hoods are seldom used and can be ineffective.
- Develop a Smart Range Hood that senses pollutants, with automatic operation.
- Improve residential IAQ, extend lives, and save billions of dollars in health-related costs annually.

**Success Metrics: “Smart” range hood developed & validated that is very quiet ( $\leq 1$  sone), up to 5 times more efficient than ENERGY STAR, and near 100% capture efficiency, at a target price point competitive with the intermediate market. Enables tighter homes, ZERH specs, & better IAQ by addressing major indoor pollutant source.**



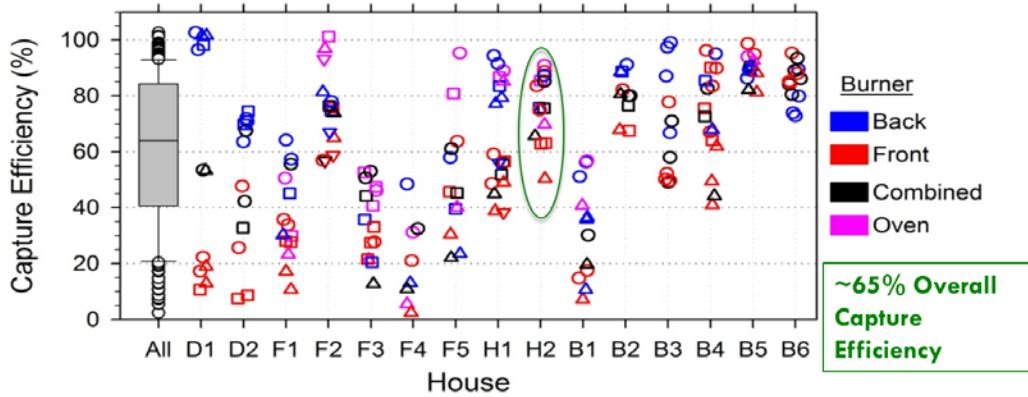
# ASTM Range Hood Test Method

National Lab	Topic Area
Lawrence Berkeley National Lab	Optimal Ventilation & IAQ Solutions



- Capture Efficiency: fraction of emitted pollutants removed by hood
- Variety of devices testing in lab and in homes
- Wall-mount, downdraft, and island

$$CE = \frac{C_{exhaust} - C_{chamber}}{C_{exhaust} - C_{ambient}}$$



# IAQ Score Development

National Lab	Topic Area
<b>Lawrence Berkeley National Lab</b>	Optimal Ventilation & IAQ Solutions (2016)

- A “score” like a HERS rating for IAQ
  - Asset rating: house characteristics & diagnostics
  - Combine health (DALYs) + moisture + odor into single score
- Include system design
  - Filtration, automatic range hoods, smart ventilation control
- Include diagnostics
  - Measure air flows, test alarm systems
- Include construction materials
- Enables credit for a better home
- Collaboration with RESNET, EPA & many others



# Building America Teams' Topic Area Coverage



Improvement RD&D Projects

# What's Next?

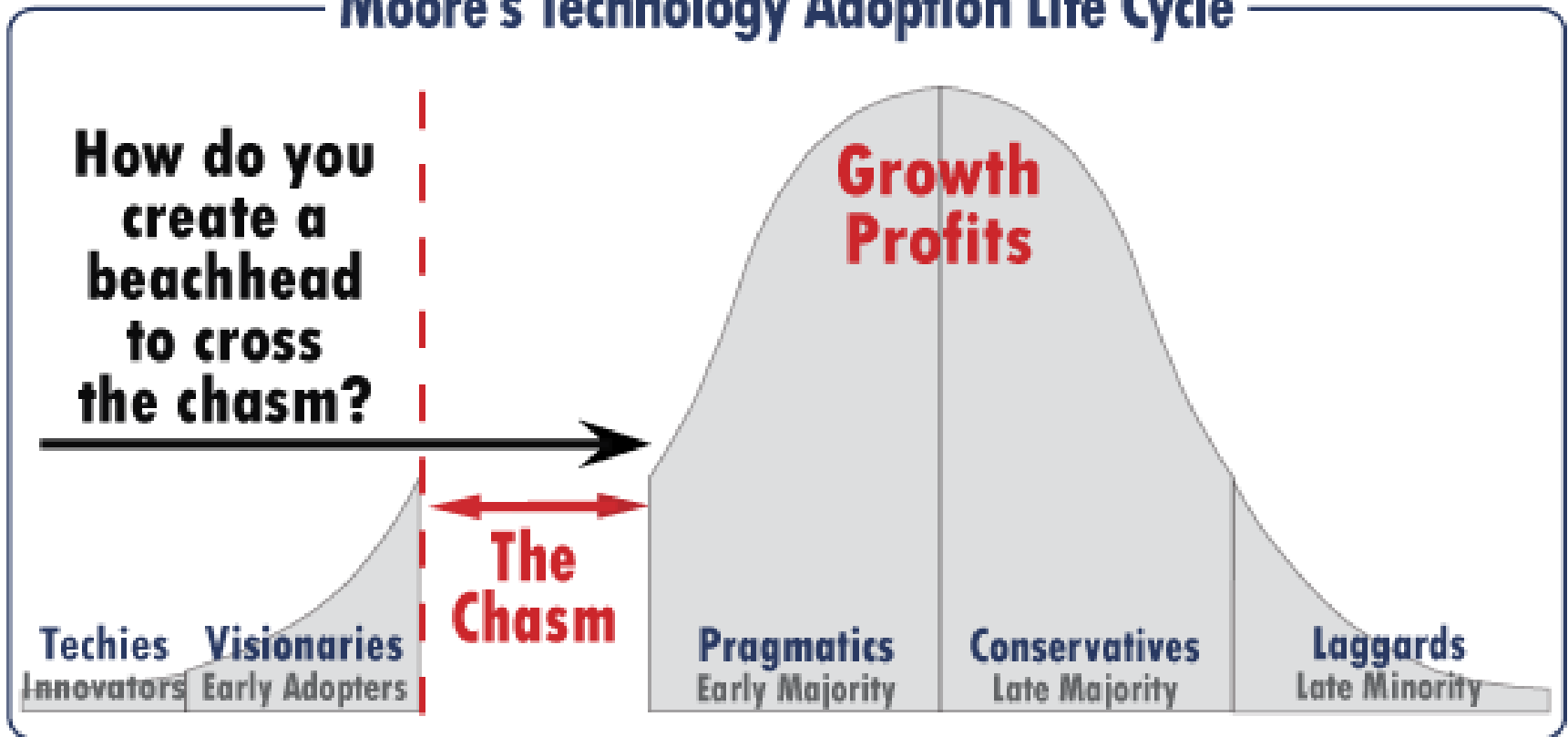
- **Remaining Roadmap Gaps** (Technology, Tools, & Standards)
- Adapt the Roadmaps to **Existing Homes**



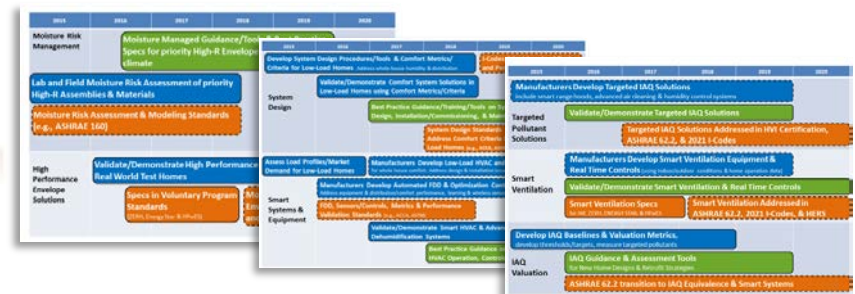


# Remaining Gaps? (preventing wide adoption of high performance homes)

## Moore's Technology Adoption Life Cycle



Sources "Crossing the Chasm". Geoffrey Moore, Collins Business Essentials, 2006





# A. High Performance Moisture Managed Envelopes

	2015	2016	2017	2018	2019	2020
<b>Moisture Risk Management</b>		<b>Moisture Managed Guidance/Tools &amp; Best Practice Specs for priority High-R Envelope Systems in each climate</b>				
	<b>Lab and Field Moisture Risk Assessment of priority High-R Assemblies &amp; Materials</b>					
	<b>Moisture Risk Assessment &amp; Modeling Standards (e.g., ASHRAE 160)</b>					
<b>High Performance Envelope Solutions</b>	<b>Validate/Demonstrate High Performance Envelope Specs in Real World Test Homes</b>					
		<b>Specs in Voluntary Program Standards</b> (ZERH, Energy Star & HPwES)		<b>Moisture Managed High-R Envelopes addressed in 2021 IECC and IRC</b>		

# A. High Performance Moisture Managed Envelopes



## Remaining Roadmap Objectives for...

### New Construction:

- *Lab & field measurements of moisture risks in real world conditions*
- *Validate high-performance envelope systems*

### Existing Homes:

- *Scalable envelope upgrades through home improvement transactions*
- *Transaction specific expert guidance*

# B. Optimal Comfort Systems for Low-Load Homes

	2015	2016	2017	2018	2019	2020
System Design	Develop System Design Procedures/Tools & Comfort Metrics/Criteria for Low-Load Homes <small>Address whole-house humidity &amp; distribution</small>				I-Codes Adopt Low-Load Design and Performance Standards	
	Validate/Demonstrate Comfort System Solutions in Low-Load Homes using Comfort Metrics/Criteria					
	Best Practice Guidance/Training/Tools on System Design, Installation/Commissioning, & Maintenance					
					System Design Standards Address Comfort Criteria in Low-Load Homes (e.g., ACCA, ASHRAE)	
Smart Systems & Equipment	Assess Load Profiles/Market Demand for Low-Load Homes		Manufacturers Develop Low-Load HVAC and Dehumidification <small>for whole house comfort. Address design &amp; installation issues</small>			
	Manufacturers Develop Automated FDD & Optimization Controls <small>Address equipment &amp; distribution/comfort performance, learning &amp; wireless sensors/controls</small>					
	FDD, Sensors/Controls, Metrics & Performance Validation Standards (e.g., ACCA, ASTM)					
	Validate/Demonstrate Smart HVAC & Advanced Dehumidification Systems					
					Best Practice Guidance on Automated Smart HVAC Operation, Controls, & Maintenance	

## B. Optimal Comfort Systems for Low-Load Homes



### Remaining Roadmap Objectives for...

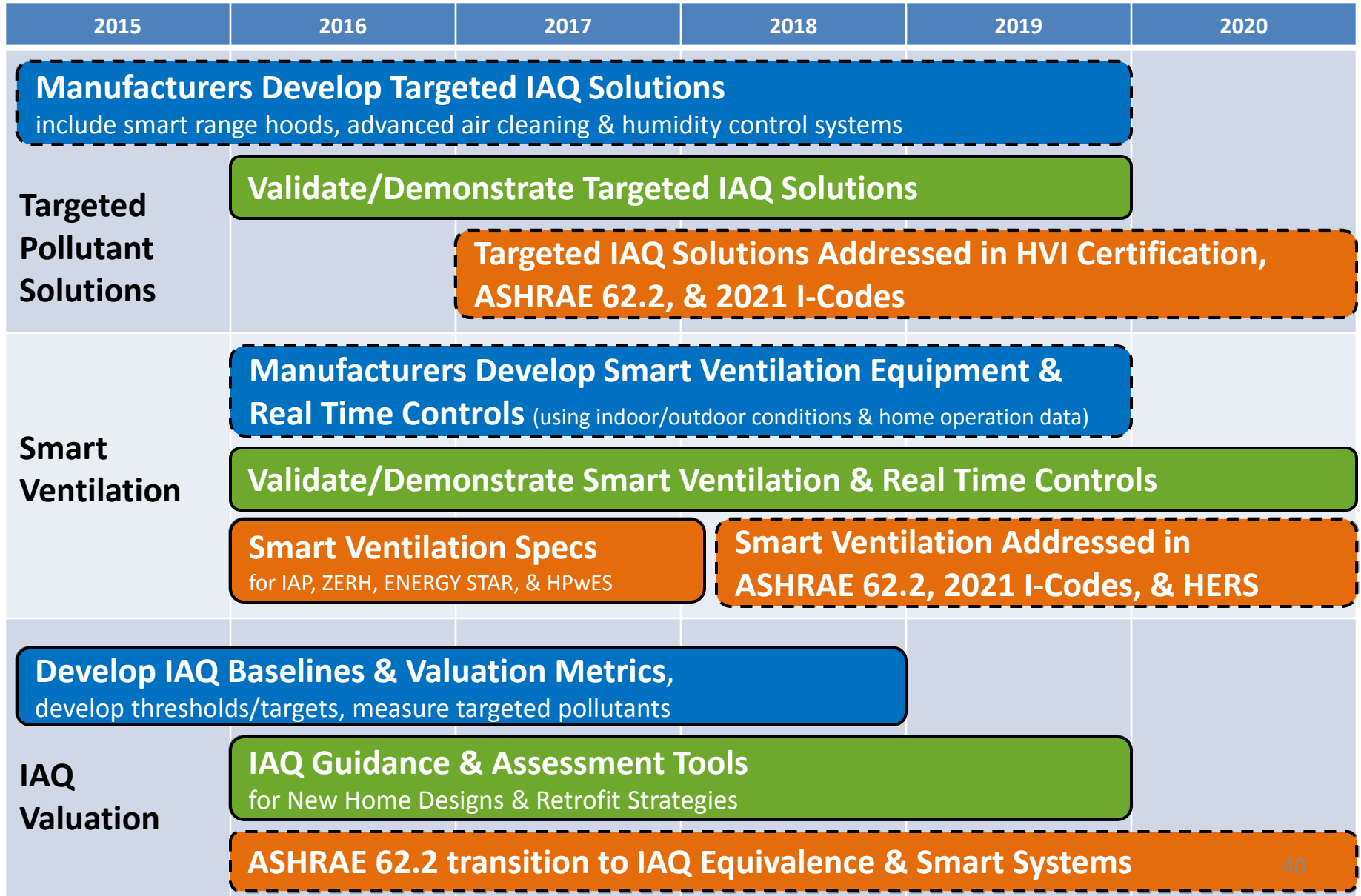
#### New Construction:

- *Affordable low-load HVAC & dehumidification solutions*
- *Smart systems (automated FDD, optimization, connected, learning)*
- *Distribution/comfort performance solutions*

#### Existing Homes:

- *Quantify benefits that could be achieved by correcting design/installation faults*
- *Better commissioning tools (cheaper, faster, more accurate)*
- *Scalable distribution system upgrades*
- *HVAC repair/replacement transaction-specific expert guidance*

# C. Optimal Ventilation & IAQ Solutions



## C. Optimal Ventilation & IAQ Solutions



### Remaining Roadmap Objectives for...

#### New Construction:

- *Develop IAQ baseline for modern homes (pollutant levels & system issues)*
- *Targeted pollutant solutions*
- *Smart ventilation systems (occupancy-based control, system optimization, connected, learning)*

#### Existing Homes:

- *Targeted pollutant solutions, adapted to high impact transactions*
- *Smart ventilation systems, adapted to high impact transactions*
- *Transaction-specific expert guidance*



## **Building America Research: Part 2 - What Makes a Successful Project?**

Date: Wednesday, Aug 17th

Time: 3:00 PM - 4:30 PM ET

The webinar will use projects funded in fiscal years 2015 and 2016 to show clear examples of projects that make good business sense as a DOE/Building America investment. The webinar will cover direct connections to the Building America Research-to-Market Plan and associated Technology-to-Market Roadmaps, sound research questions, success metrics, and market transformation plans.

# Building America

## Building America Website:

- Program information
- Top Innovations
- Climate-specific case studies
- *Building America Update* newsletter
- Building America Solution Center
- Publications Library



[www.buildingamerica.gov](http://www.buildingamerica.gov)

# Building America

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# Upcoming Webinars

## Building America Research: Part 2 - What Makes a Successful Project?

Time: Aug. 17, 2016, 3 p.m. ET

## Partnering for Improved Building Science Education

Time: Aug. 24, 2016, 3 p.m. ET



Thank You!

PDF copies of the presentations in this webinar are available at:

<http://energy.gov/eere/buildings/building-america-meetings#current>

Visit: *www.buildingamerica.gov*

