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Building America

Quarterly Team Project Update

August 30, 2016

U.S. Department of Energy
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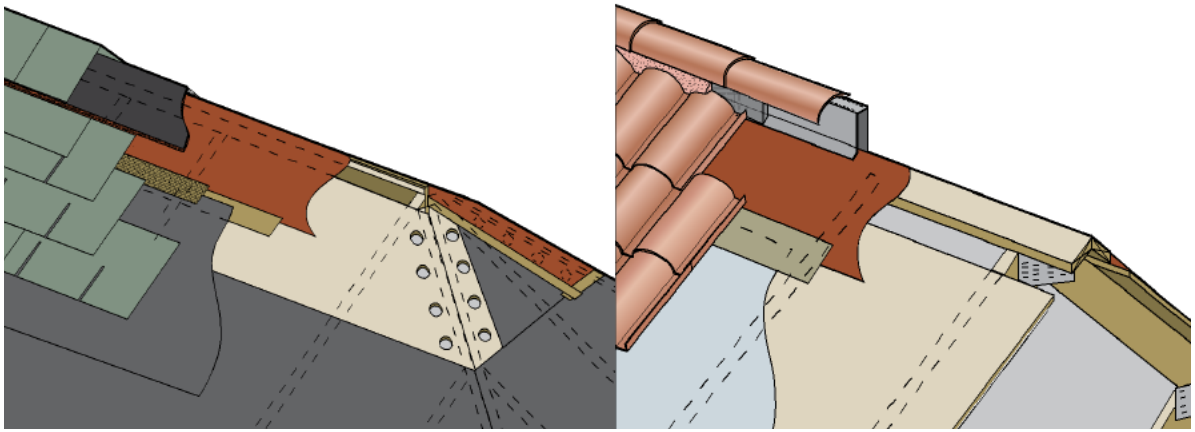
Up Next…

bsc Building Science Corporation

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

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

- Field testing of attics with fibrous insulation at roofline (conditioned attic).
- Enables affordable insulation solution for attics, bringing the HVAC equipment into the conditioned space.
- Testing interior vapor control membranes, vapor diffusion ridge vent
- 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.

Previous Research

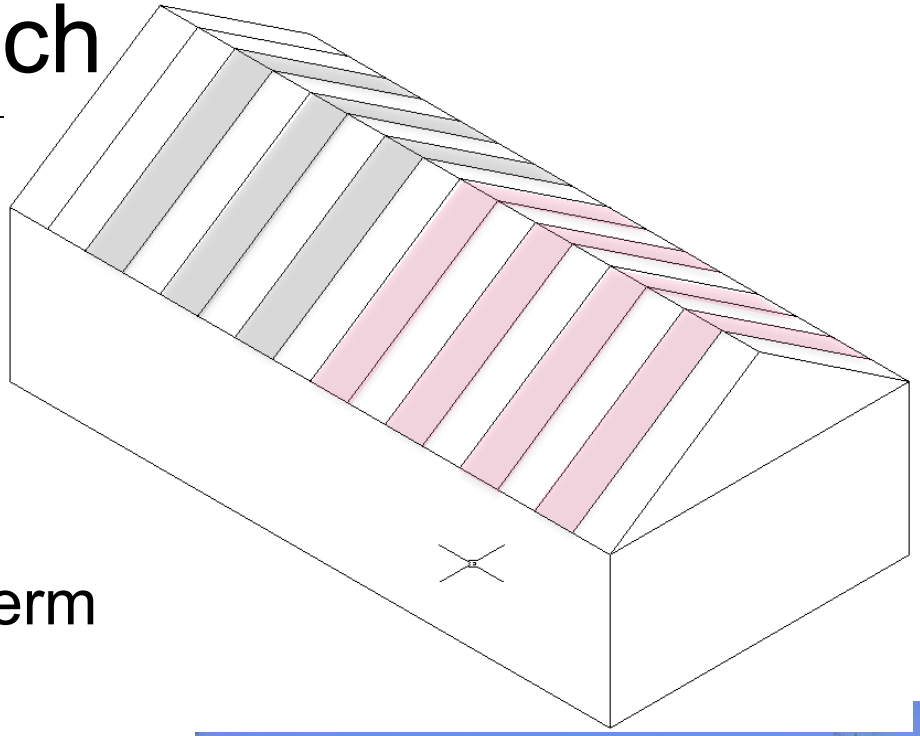
- Chicago (5A):
  - One winter, 50% RH
  - Unvented roofs-high risk
  - Cellulose lower risk than FG batt
- Houston/Orlando (2A):
  - 2 attics, multiple seasons
  - Diffusion vents allow greater drying, avoid moisture problems
- Europe/PassivHaus:
  - Allowing unvented roofs w. variable-perm vapor control, other constraints

Chicago roof disassembly


Houston roof w. diffusion vent

Experimental Approach

- CZ 5A test hut (32'x16')
- Multiple N-S roof bays
- R-49 (14" TJI framing)
- Test variables:
  - Vapor retarder: variable perm vs. fixed perm
  - Diffusion vent at ridge vs. no diffusion vent
  - Fiberglass vs. cellulose
  - "Control" comparison § R806.4 spray foam + fibrous



Experimental Timeline

- Winter 2016-2017
  - "Normal" interior conditions (constant T, ~30% RH)
- Winter 2017-2018
  - Elevated RH (50% constant)
- Winter 2018-2019
  - Add air leakage into rafter bays
- Decommissioning/disassembly

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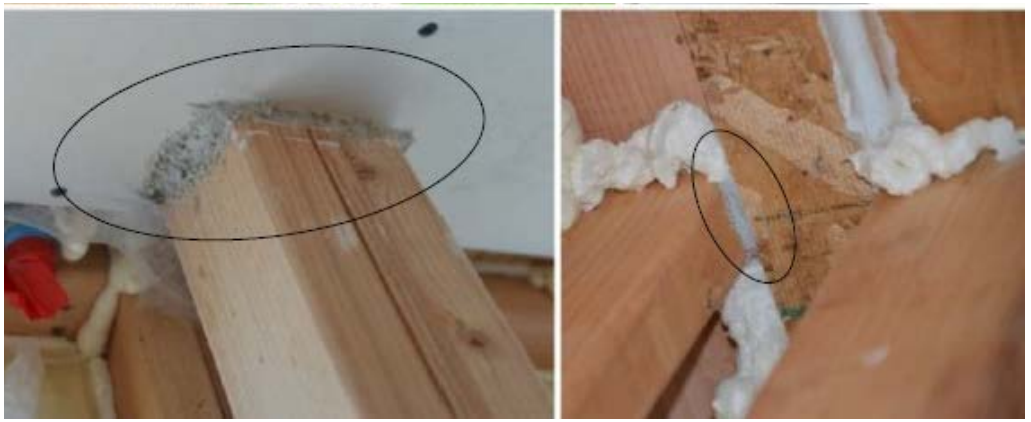
Up Next…

cee
Center for Energy and Environment

Aerosol Sealing in New Construction

Team and Partners	Topic Area
Center for Energy and Environment 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, sealing envelope gaps up to 3/8” wide, within 60 to 90 minutes.
- 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.

Leakage Reduction - CA Single Family

Test #	Floor Area (sf)	Envelope Tightness (CFM50)		Envelope Tightness (ACH50)		Percent Reduction
		Pre	Post	Pre	Post	
1	3,550	5,100	1,936	9.1	3.4	62%
2	2,019	4,603	1,690	13.7	5.0	63%
3	2,324	4,472	676	11.6	1.7	85%
4	3,550	4,758	1,018	8.5	1.8	79%
5	2,324	4,813	969	12.4	2.5	80%
6	2,324	5,095	1,226	13.2	3.2	76%
Avg	**2,682**	**4,807**	**1,253**	**11.4**	**2.9**	**77%**

Minnesota new construction 18 MF units: 67% to 94% reduction, average = 81% (0.7 ACH50)

Center for Energy and Environment

Optimize Sealing Process

- Reduce aerosol sealing labor time by selecting best time during construction process
- Reduce builder costs by eliminating some manual sealing
- 4 builders, iterative process

Test #	Time (pers-hours)			
	Setup	Sealing	Cleanup	Total
1	6.3	1.5	5.0	12.8
2	5.9	1.3	3.4	10.6
3	6.7	1.2	4.2	12.1
4	6.9	1.9*	4.0	12.8
5	3.5	1.4	1.9	6.8
6	4.6	1.3	3.4	9.3
Avg	**5.7**	**1.4**	**3.7**	**10.7**

* - air compressor ran out of fuel causing a pause in the sealing

First Year Timeline

- Project Management and Test Plan
- Builder kick-off meeting
- 1st MN builder
  - Assess houses and demo aerosol sealing
  - Identify 2 approaches and apply to treatment houses
  - Review results with builder and modify approach
- 1st CA and 2nd MN builder

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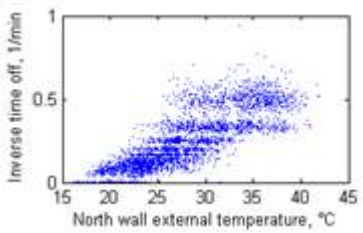
Up Next…

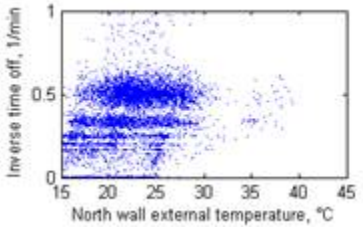
Fraunhofer

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

Team and Partners	Topic Area
Fraunhofer USA, Inc. w/ Eversource, National Grid, Holyoke Gas & Electric	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.

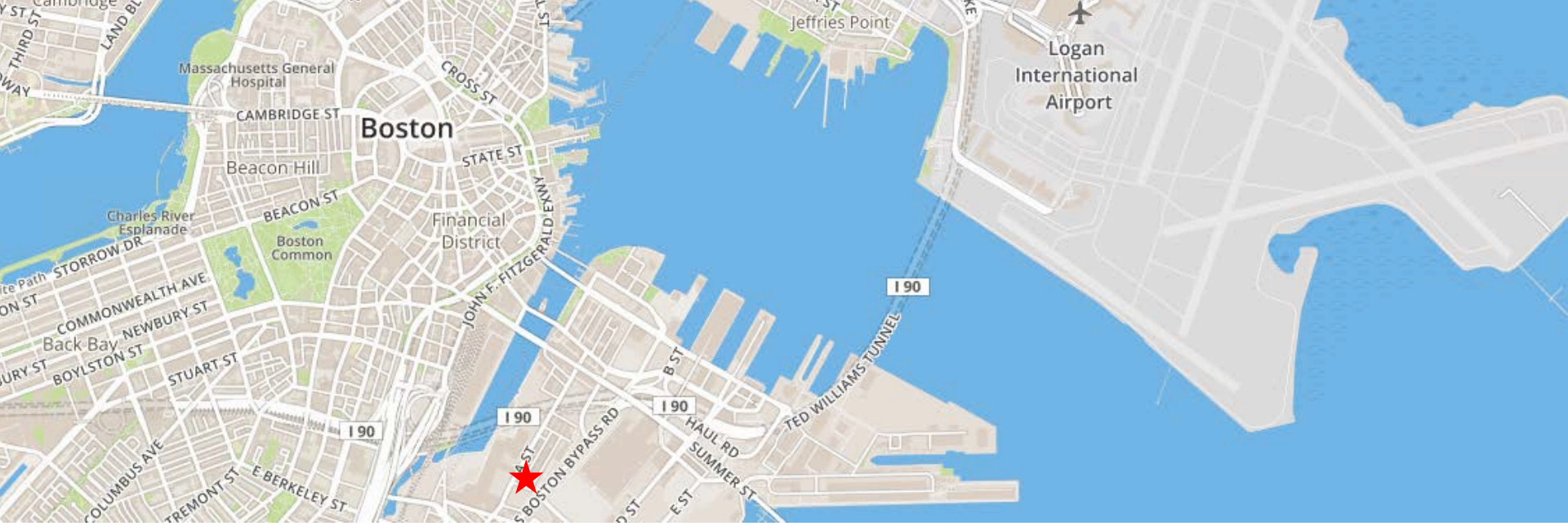
Approach: Algorithms

- Develop coarse-grained lumped (gray-box) models
  - Connect CT data (indoors air temperature and HVAC runtime) with home thermal parameters (R-value, ACH, HVAC efficiency)
- Apply to homes, increasing application complexity over project life
  - From regular gas furnaces to condensing boilers
  - From single-zone to multi-zone homes
- Couple with Machine Learning (ML) (as needed)
  - Use ML to improve modeling accuracy
  - Incorporate interval energy meter data
- Use models
  - Estimate home thermal parameters
  - Characterize home-specific classes of retrofit opportunities (e.g., insulation upgrade)
  - Predict home-specific post-retrofit energy savings

Approach: Experimental

- Existing and new utility data
  - ~80 homes: CT data, detailed home assessments, interval gas and electric meter data
  - Several hundred homes: CT data + home energy evaluations
  - Season 1: pre-retrofit; on-site energy evaluations for ground truth; model refinement
  - Season 2: retrofits in some homes; further model validation
- Randomized Controlled Trials
  - Treatment and Control Groups (~250 homes each)
  - Treatment: receive home-specific retrofit offerings and saving estimations
  - Compare EMC implementation rates
  - Verify saving predictions

- Create:
  - Data Framework and Specifications
  - Best Practices Guide for Scale Up



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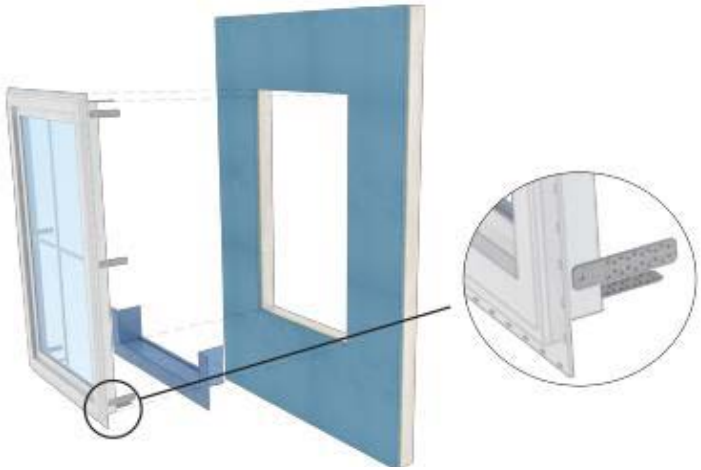
Up Next…

Home Innovation RESEARCH LABS™

Home Innovation RESEARCH LABS

Structural Support of Windows in Walls with Continuous Insulation

Partners	Topic Area
Home Innovation Research Labs, Inc. American Chemistry Council American Architectural Manufacturers Association	Topic 1: High Performance Moisture Managed Envelopes (2016)



- Identify code compliant solutions for window installation in walls with continuous insulation (CI)
- 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.

Home Innovation RESEARCH LABS

Methodology

- Advisory Group
- Inventory of windows configurations and installation practices
- Test protocols
- Performance criteria
- Test matrix
  - ✓Wind pressure
  - ✓Gravity load
- Develop design and installation guidance – AAMA, IRC, installation instructions

Home Innovation RESEARCH LABS

Testing

Home Innovation
RESEARCH LABS

THANK YOU

Home Innovation Research Labs

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Finding Innovation a Home

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Up Next…

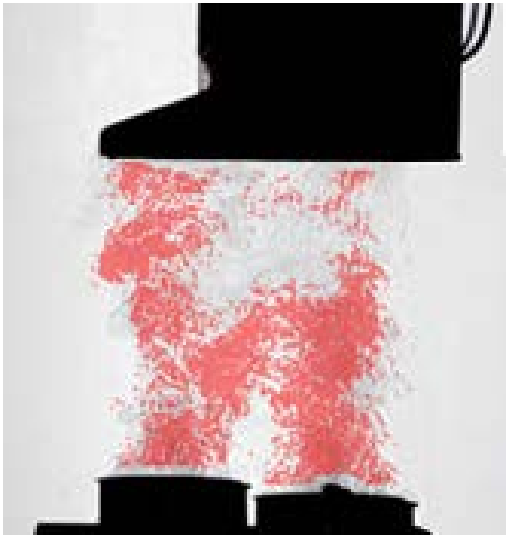
NP

Newport Partners L.L.C.

Development of the Industry's First Smart Range Hood

Team and Partners	Topic Area
Newport Partners 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.



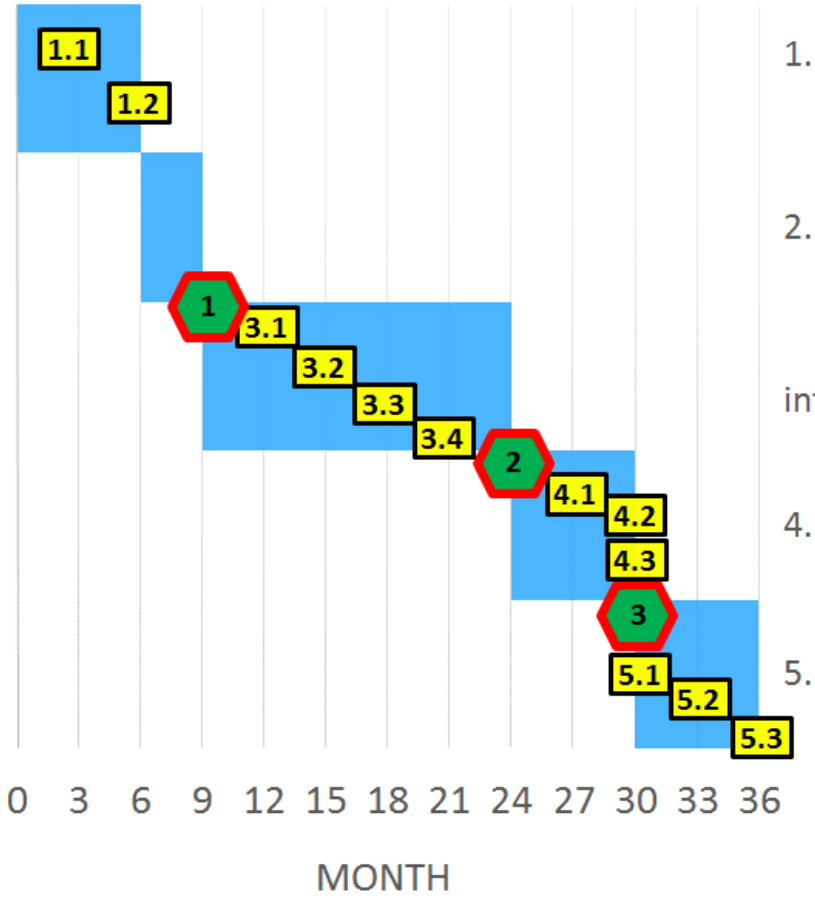
Success Metrics: "Smart" range hood developed & validated that is very quiet (≤ 1 sone), up to 5 times more efficient than ENERGY STAR, and near 100% capture efficiency, at a target price point competitive with the intermediate market. Enables tighter homes, ZERH specs, & better IAQ by addressing major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

Project Workplan

Phase 1: Pre-Prototype

Phase 2: Prototype Development

Phase 3: Lab and Field Testing



TASK

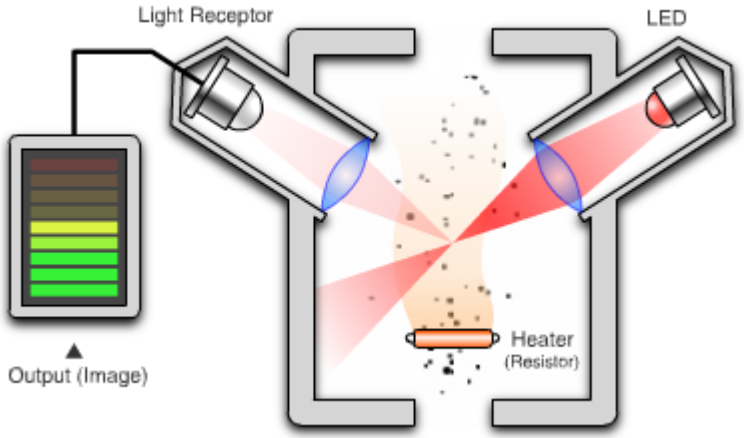
1. Identify criteria specifications for sensors and source sensors
2. Develop control logic
3. Develop prototypes with integrated sensors and controls
4. Conduct lab tests
5. Field-test prototype

Milestone

GO/NO-GO

Task 1: Source Sensors

- Targeted pollutants
- Sensors: accurate, low cost, durable
  - PM2.5, Temperature, RH
  - Others?



Images c/o Shinyei Technology

PM2.5

Acrolein

CO

Formaldehyde

CO_2

H_2O

Temp

NO_2

Contact

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Up Next…

Southface

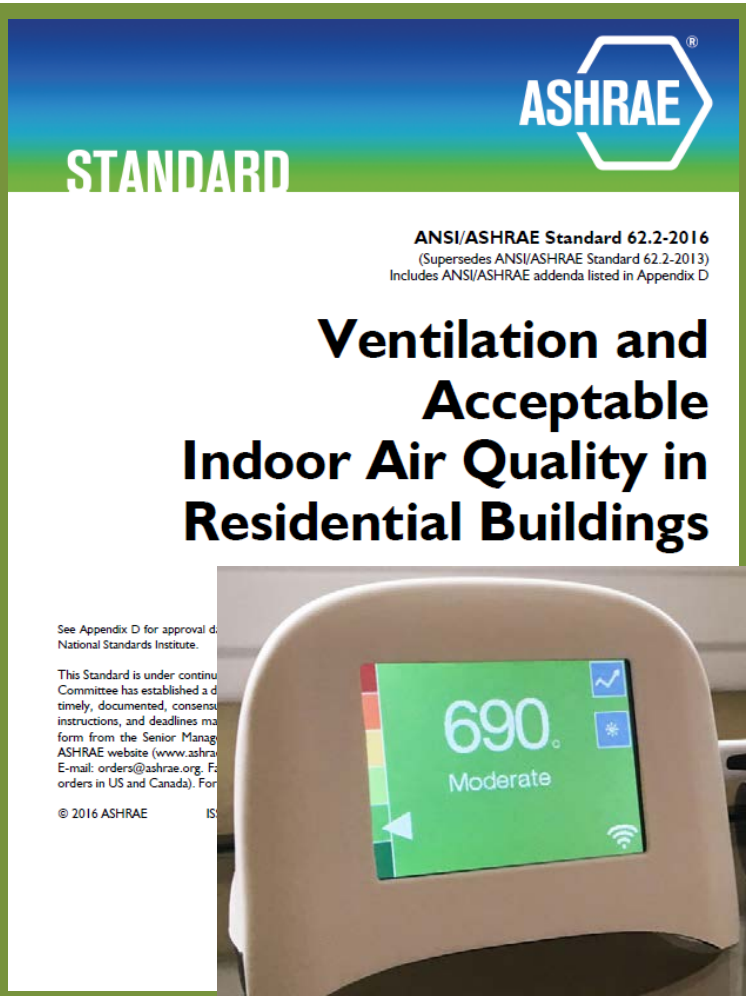
Performance-Based IAQ and Optimized Ventilation

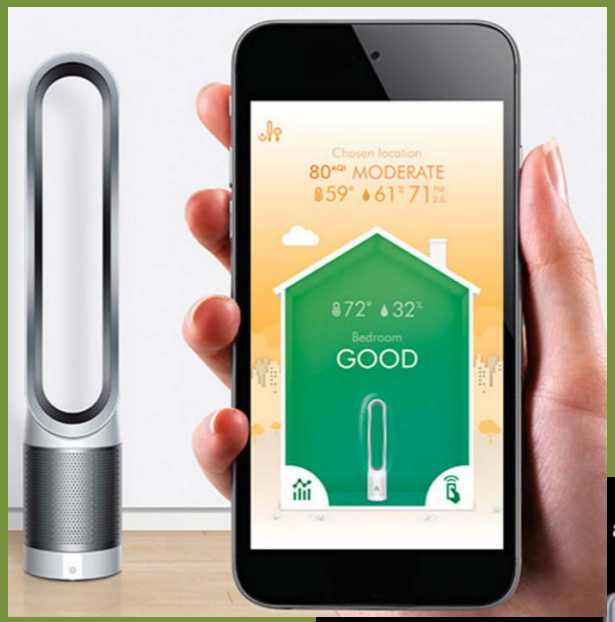
Team and Partners	Topic Area
Southface Energy Institute w/ Underwriters Laboratory, Beazer Homes, Illinois Sustainable Technology Center, Venmar, Kerley Family Homes	Optimal Ventilation & IAQ Solutions (2016)

- Develop assessment protocol incorporating low-cost IAQ sensors: PM2.5, CO_2, O_3, TVOC, 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

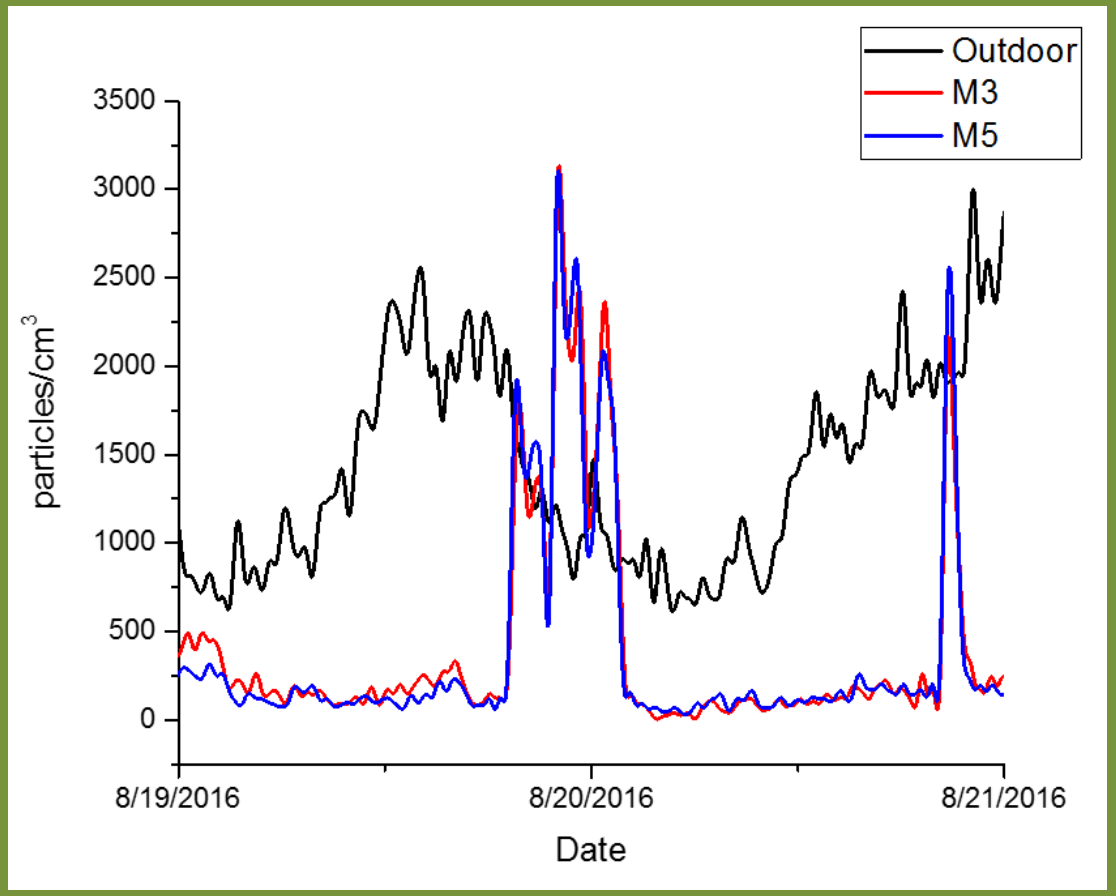
Success Metrics: Develop & validate a performance-based protocol for assessing indoor air quality (IAQ) in homes and inexpensive smart ERV solution that can achieve average annual HVAC energy cost savings of approximately $100 compared to central fan integrated supply systems, and ~50% reduction of ventilation related latent loads compared to supply or exhaust strategies.

What Is "Good" Indoor Air Quality?





Preliminary Data



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Elliott Horner – UL Environment

Venmar – Broan NuTone

Beazer Homes

Kerley Family Homes

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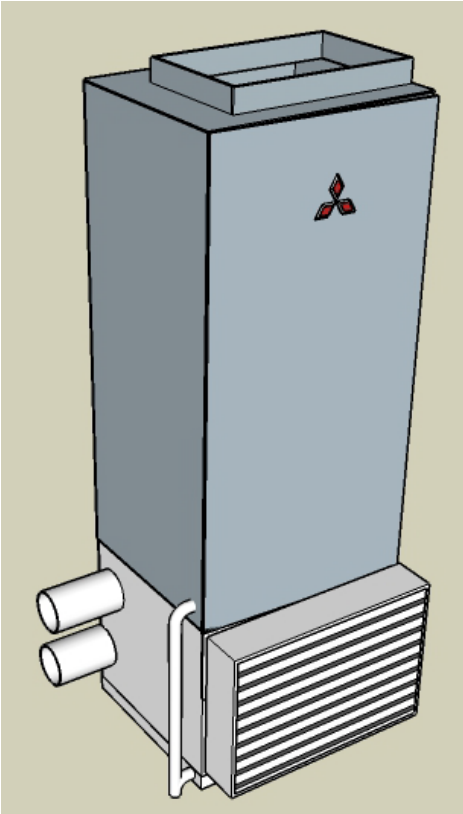
Up Next…

Steven Winter Associates, Inc.

Improving the Built Environment Since 1972

Ventilation Integrated Comfort System (VICS)

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



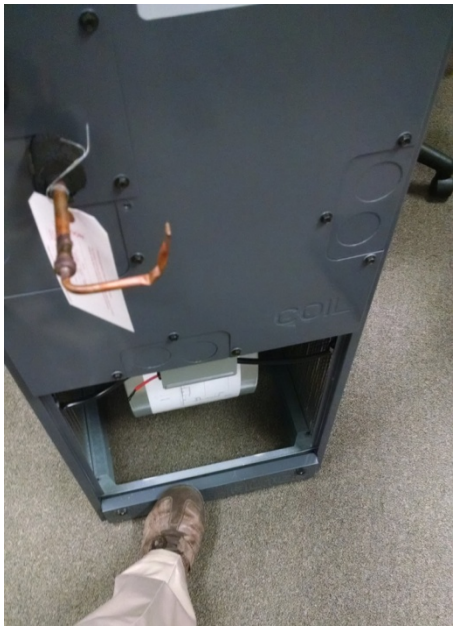
- Development of integrated E/HRV and heat pump
- Variable speed fans for low energy and high controllability
- Test and demonstrate in unoccupied and occupied homes
- Lower cost and better performance than most balanced, heat recovery ventilation options.

Success Metrics: Develop, validate, & demonstrate VICS, to reduce up-front cost $1,000-$2,000 compared to separate E/HRV. Save 400-800 kWh/year compared to exhaust only ventilation. Enables balanced ventilation, better IAQ, & RH control in tight homes at lower cost.

SWA - VICS

Why? Why now?

- Low loads
- Ventilation flow rates more similar to design heating/cooling rates
- Increased availability and performance of small-cap, variable-speed ASHPs
- New Mitsubishi high-static, 1-ton fan coil (0.3”-0.8” w.c.)



Some key features:

- 30-120 CFM outdoor air (adjustable)
- Separate control of supply & exhaust flow rates
- All outdoor air filtered, passed through heat recovery, through ASHP coil (heated/cooled/dehumidified) before distribution
- ERV first, but HRV to come

SWA - VICS

Applications

- Low-load SF homes, ZERH, Passive House, etc.
  - Single ductless ASHP can meet load, but with distribution (esp. cooling) drawbacks
  - Most of these homes have fully ducted E/HRVs
  - Why not combine?

- Moderately efficient apartments
  - Growing demand for unit-by-unit HVAC
  - Tenants responsible for heating/cooling bills
  - Increased compartmentalization and ventilation req's
  - Central ventilation challenging (balancing, fire dampers, maintenance)
  - Individual E/HRV for each apartment often too pricy, space constraints

SWA - VICS

Oversimplified Schedule:

- Design air side, build & test air-side prototype (Y1)
- Connect to outdoor unit, test in unoccupied space (Y2)
- Refine, test second prototype in occupied home likely in DC area (Y3)
- Commercialize and sell thousands!

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Up Next…

UNIVERSITY OF MINNESOTA

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

Team and Partners	Topic Area
NorthernSTAR: University of Minnesota MonoPath, Urban Homeworks, Twin Cities Habitat for Humanity, Thrive, Building Knowledge, Simply Green, Huber, Unico	**Topic 1: High-Performance Moisture-Managed Envelopes**

- **Innovative building enclosure system outperforms conventional wood-frame construction for energy and durability, yet can be built faster and cost less.**
  - Validate with modeling, testing, and monitoring the performance, constructability, and cost.
  - Demonstrate market delivery and acceptance.
- **Innovative building system is delivered by a single enclosure contractor ensuring better QA/QC.**
  - Reduced enclosure errors and/or defects.
  - Quicker dry-in and faster overall construction.
- **Optimized whole building system that delivers Zero Energy Ready Home performance.**
  - Current target market is affordable housing.

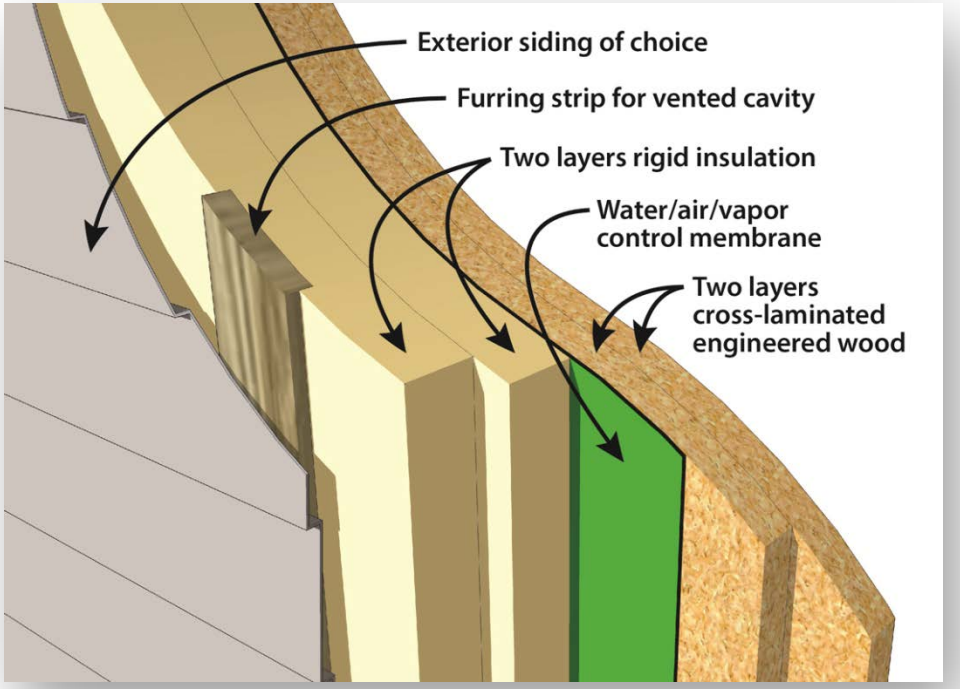
In 2014, seven identical homes were built (shown above). Four prototypes were developed by U of MN in early 2000's.

Success Metrics: Design, build, and monitor 20+ affordable homes to demonstrate and verify enclosure energy savings along with improved airtightness, moisture durability, quality, and lower cost.

Project Core and Guiding Principles:

– Perfect Wall with Exterior Thermal & Moisture Management System (ETMMS)

"In concept the perfect wall has the rainwater control layer, the air control layer, the vapor control layer and the thermal control layer on the exterior of the structure." *from BSI-001 – "The Perfect Wall"*



Benefits of "ETMMS"

- Structure is kept warm and dry
  - long-term enclosure durability
  - minimal thermal stress/movement
  - IAQ and occupant health benefits
- Critical control layers are protected from degradation functions, puncture, etc.
- Control layers are simplified
  - water, air, and vapor control reduced to a single membrane
- Exterior insulation is continuous
  - reduces bridging; better R-value
- Back-ventilated cladding
  - improves cladding durability
  - reduces moisture load on the wall
- Can be used in any climate

NorthernSTAR Innovations:

- Building Technology: Use of the *structural engineered panel* (SEP)
- Building Delivery: Use of a *single enclosure contractor* delivery process

Benefits of Structural Engineered Panel

- Reduces cost of assembling "Perfect Wall"
  - easier to apply control layers
- Simplifies application of exterior insulation
- Less labor, less skill required to build
- Speeds enclosure construction time
  - especially time to secure and dry
- Stronger with enhanced protection from wind loads, flying debris, seismic loads, etc.

Benefits of Single Enclosure Contractor

- Building process developed by MonoPath
  - reduces installation errors
  - speeds overall construction time
  - reduces overall construction cost
- More consistent performance outcomes
  - reliable insulation quality and performance
  - improved moisture management
  - remarkable and repeatable airtightness
    - early prototypes under 1 ACH@50
    - recent homes approaching 0.6 ACH@50Pa




End Day 1: Structure completed

University of Minnesota

- Cold Climate Housing Program
- Center for Sustainable Building Research

Research and Industry Partners

- System Developer: MonoPath
- Builders: Twin Cities Habitat for Humanity, Urban Homeworks, Thrive Home Builders
- Consultants: Building Knowledge, Simply Green
- Suppliers: Huber Engineered Wood, Unico Systems

End Week 1: House dry and secure

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End Month 1: House completed

Up Next…

FLORIDA SOLAR ENERGY CENTER®

A Research Institute of the University of Central Florida

Variable Capacity Comfort Systems for Low Load Homes

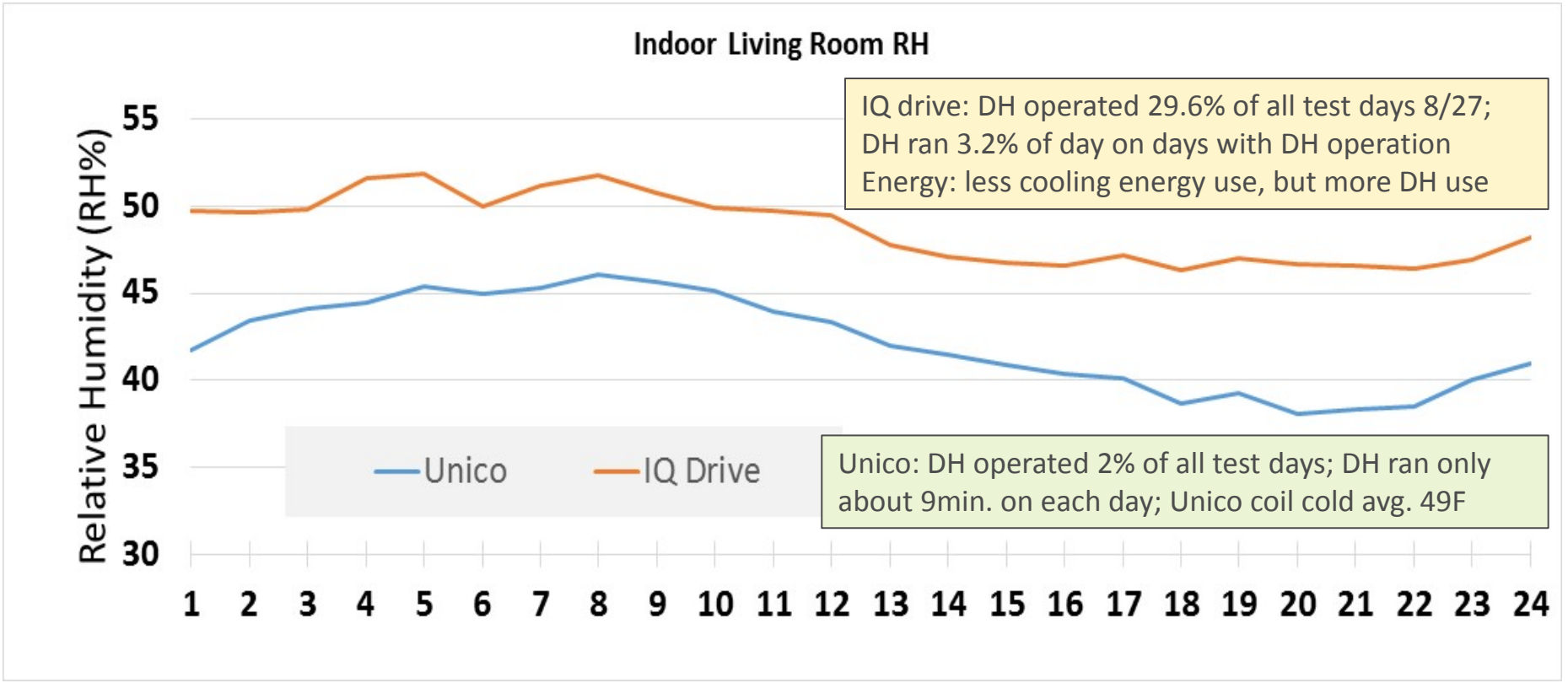
Team and Partners	Topic Area
University of Central Florida **Florida Solar Energy Center**	Optimized Comfort Systems for Low-Load Homes (2015)

- 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.
- Select strategies present opportunities to reduce/eliminate duct losses.
- Investigating distribution of comfort throughout the homes.

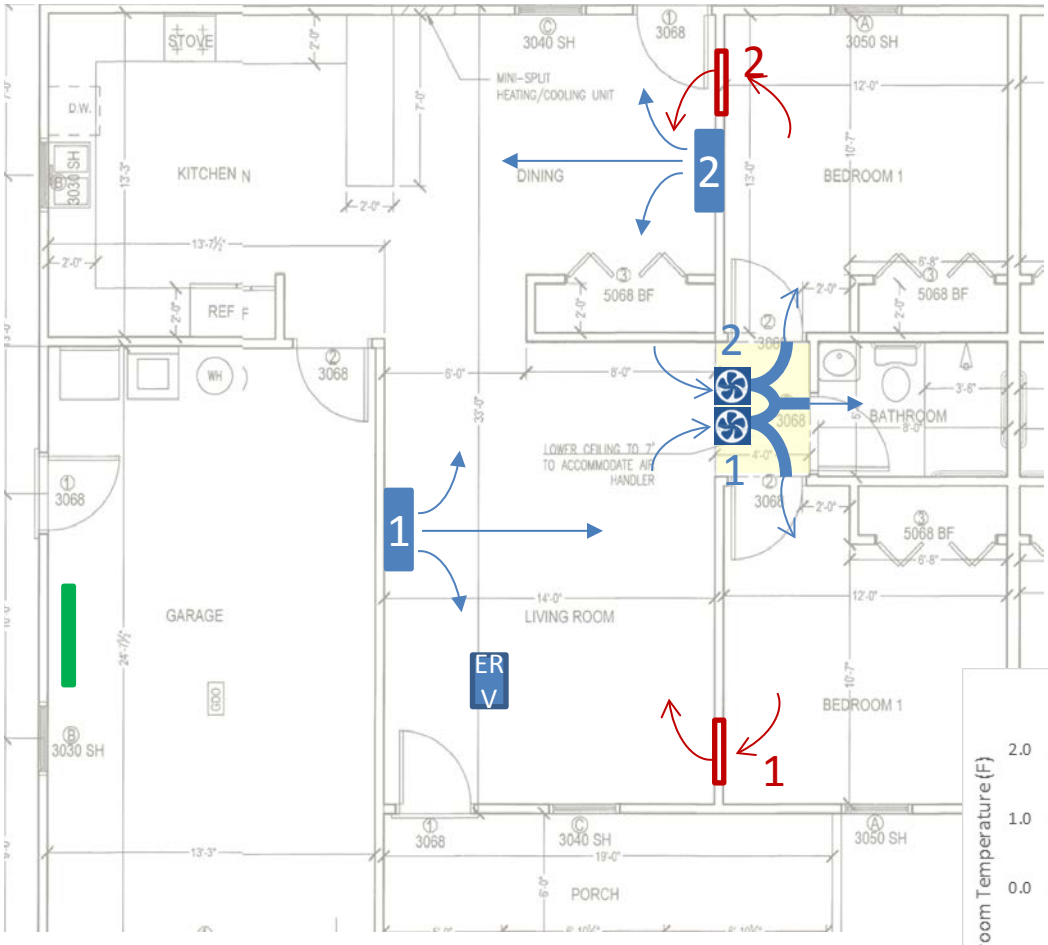
Success Metrics: 5-10% space conditioning energy savings in current DOE Zero Energy Ready Homes while maintaining or enhancing comfort.

Unico Variable Capacity SDHV System – Lab Test

Daily Composite of Indoor RH
Comparison Between Two Different Ducted Variable Capacity Systems



New Smyrna Ductless Multi-Split – Field Test

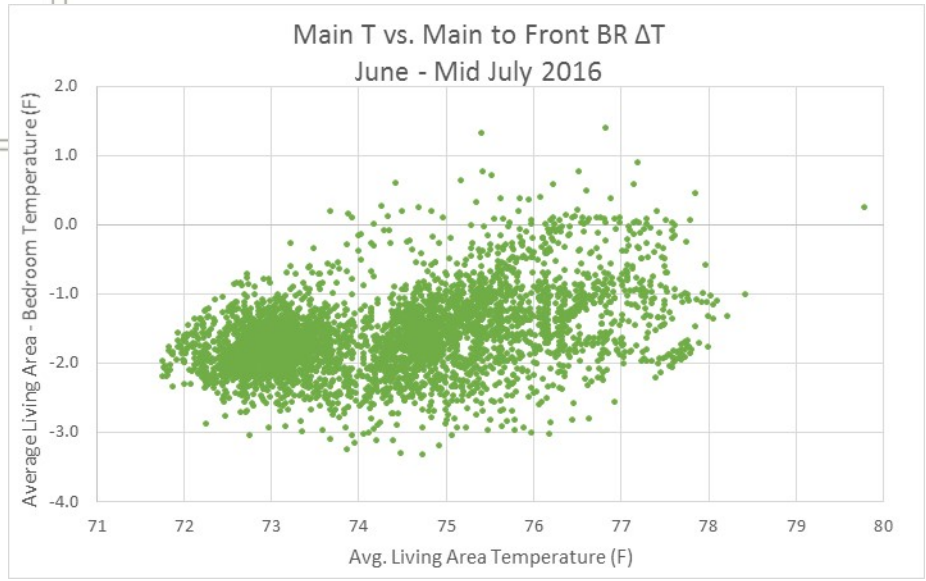


Data Acquisition

T/RH — 4 wireless T/RH sensors

T/RH RA — 6 hard wired T/RH sensors

Campbell Datalogger



Sarasota Ducted Mini-Split – Field Test

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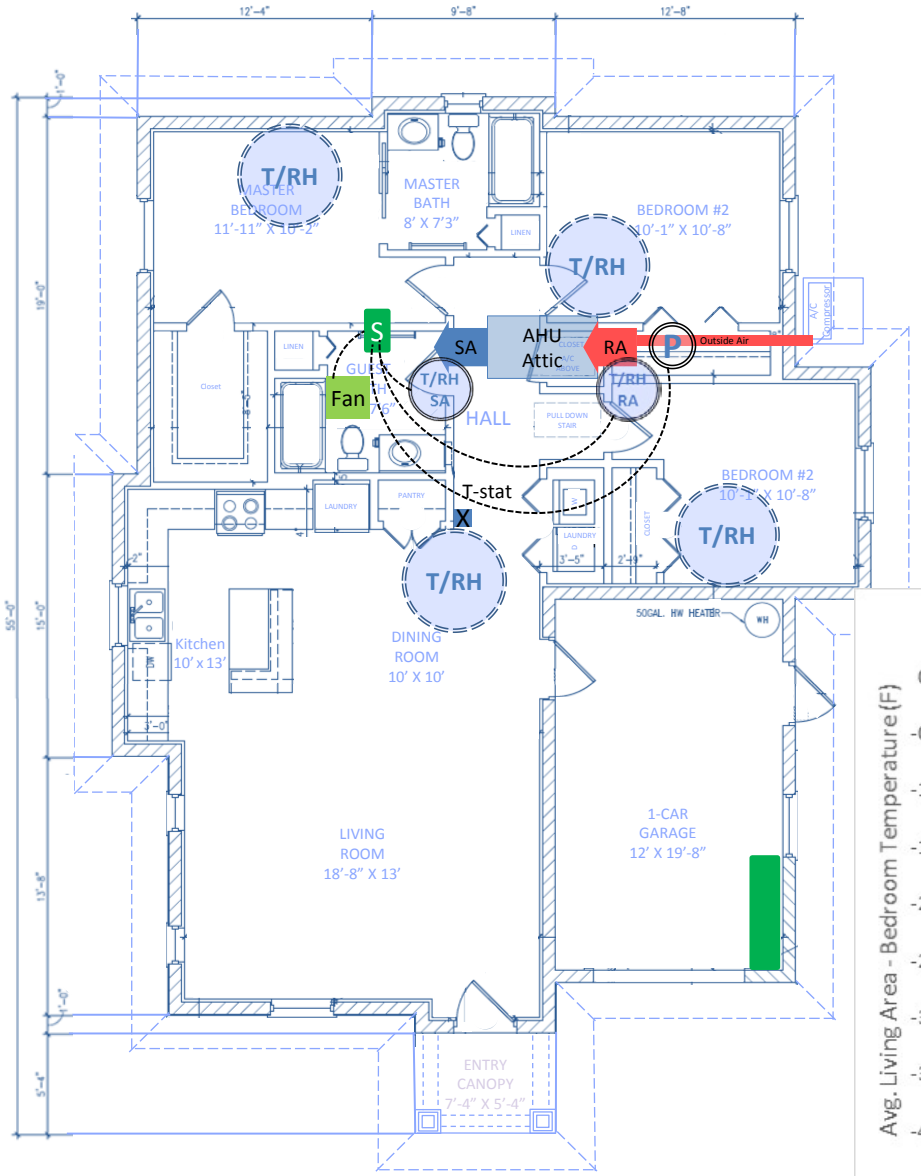


Data Acquisition Elements

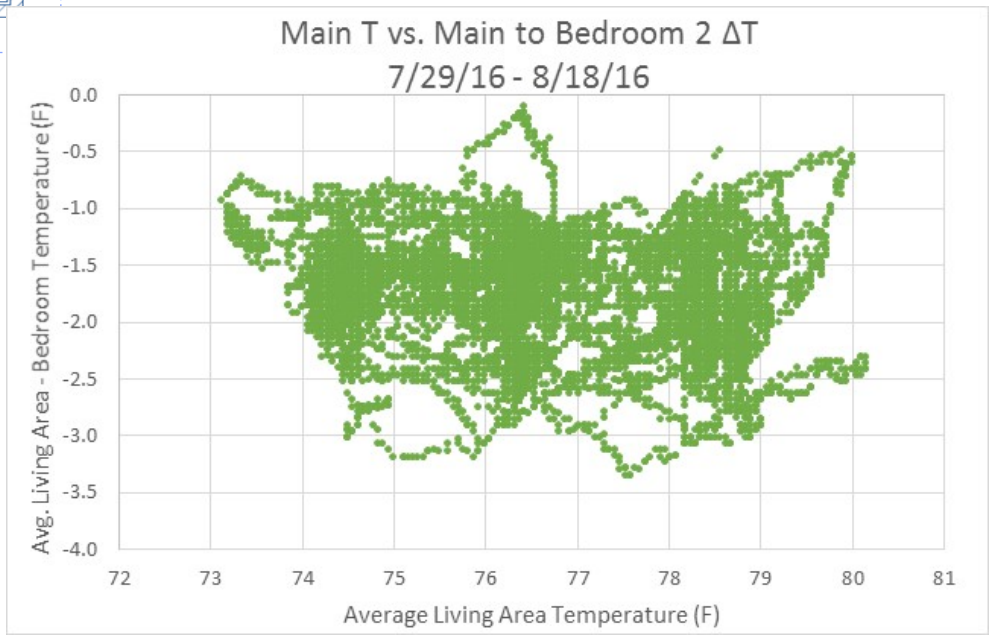
T/RH — 4 wireless T/RH sensors

T/RH — 2 T/RH sensors Wired to "S-Pod"

P — Iris Damper (photos below) and DG3 Manometer (OA Duct Pressure Measurements)

S — Wireless Sitesage "S-pod" T/RH, Exhaust Fan Power, And Iris Damper Pressures

Sitesage Datalogger Receives Wireless Input, Collects CT Data For AHU, Compressor, Whole House Power



Smart Mechanical Ventilation System Control

Team and Partners	Topic Area
University of Central Florida **Florida Solar Energy Center**	Optimal Ventilation and IAQ Solutions (2015)

- Optimize mechanical ventilation in response to variable risk factors.
- Lab test of system controlled by algorithm varying flow real time proportional to outdoor temperature and relative humidity (Florida)
- Field test of system delivering 2 levels of flow in response to 1) outdoor temperature and 2) occupancy (Washington)
- Field test of hybrid supply/exhaust system involving CFIS with variable capacity mini-split.

Success Metrics: 5-10% space conditioning energy savings in current DOE Zero Energy Ready Homes while maintaining IAQ equivalency.

Smart Ventilation Algorithm – Lab Test

- Combines influence of various variables into a single RSS term for every hour

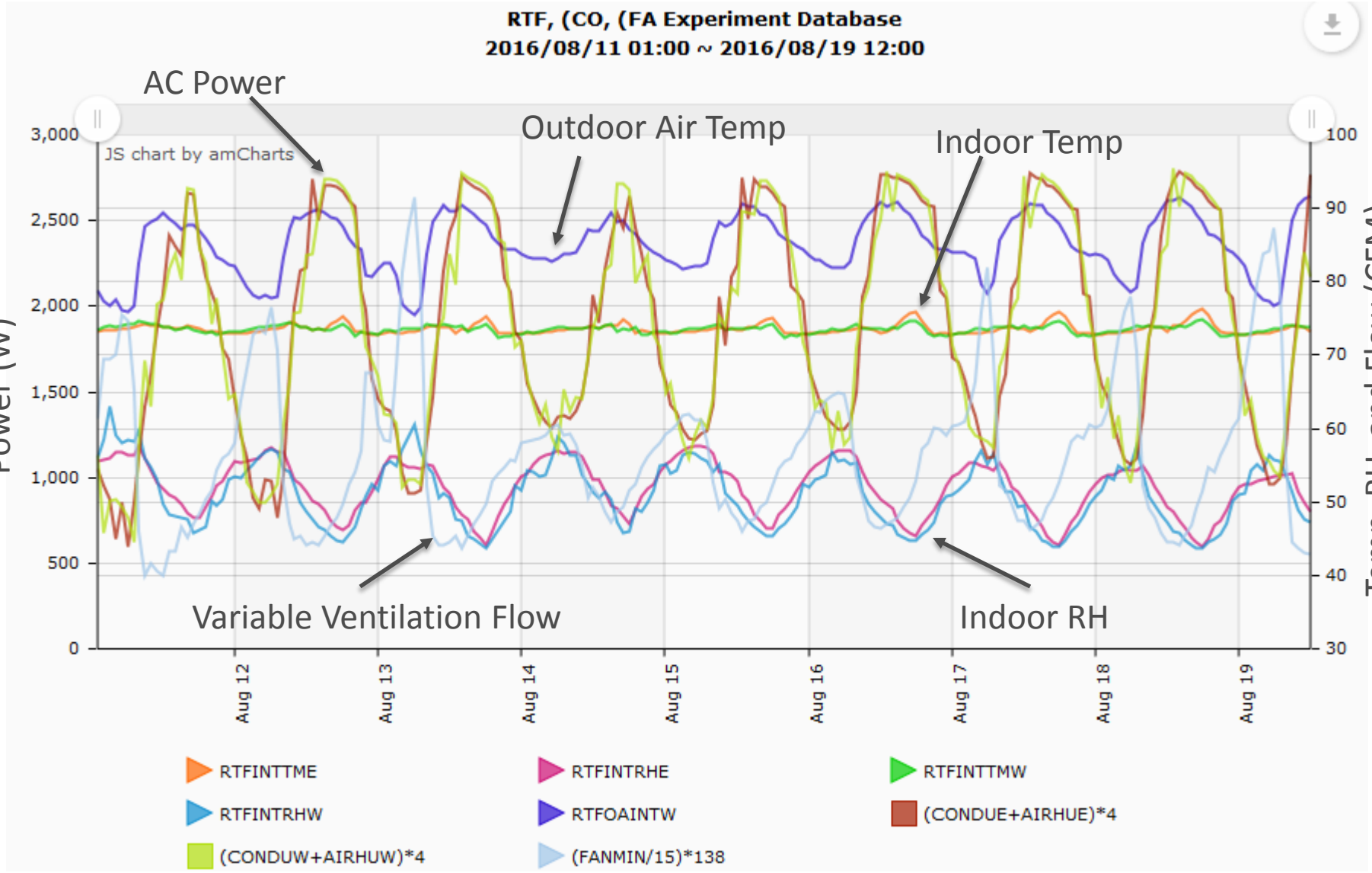
$$RSS = \sqrt{(\Delta T * X_T)^2 + (\Delta W * X_W)^2}$$

- Time weighted RSS becomes a multiplier to adjust ventilation flow (relative exposure)

$$\text{Average } (RSS_1 : RSS_{23}) / RSS_{24}$$

- Enhance potential for savings with seasonal adjustment factors, determined iteratively to ensure relative exposure target achieved.

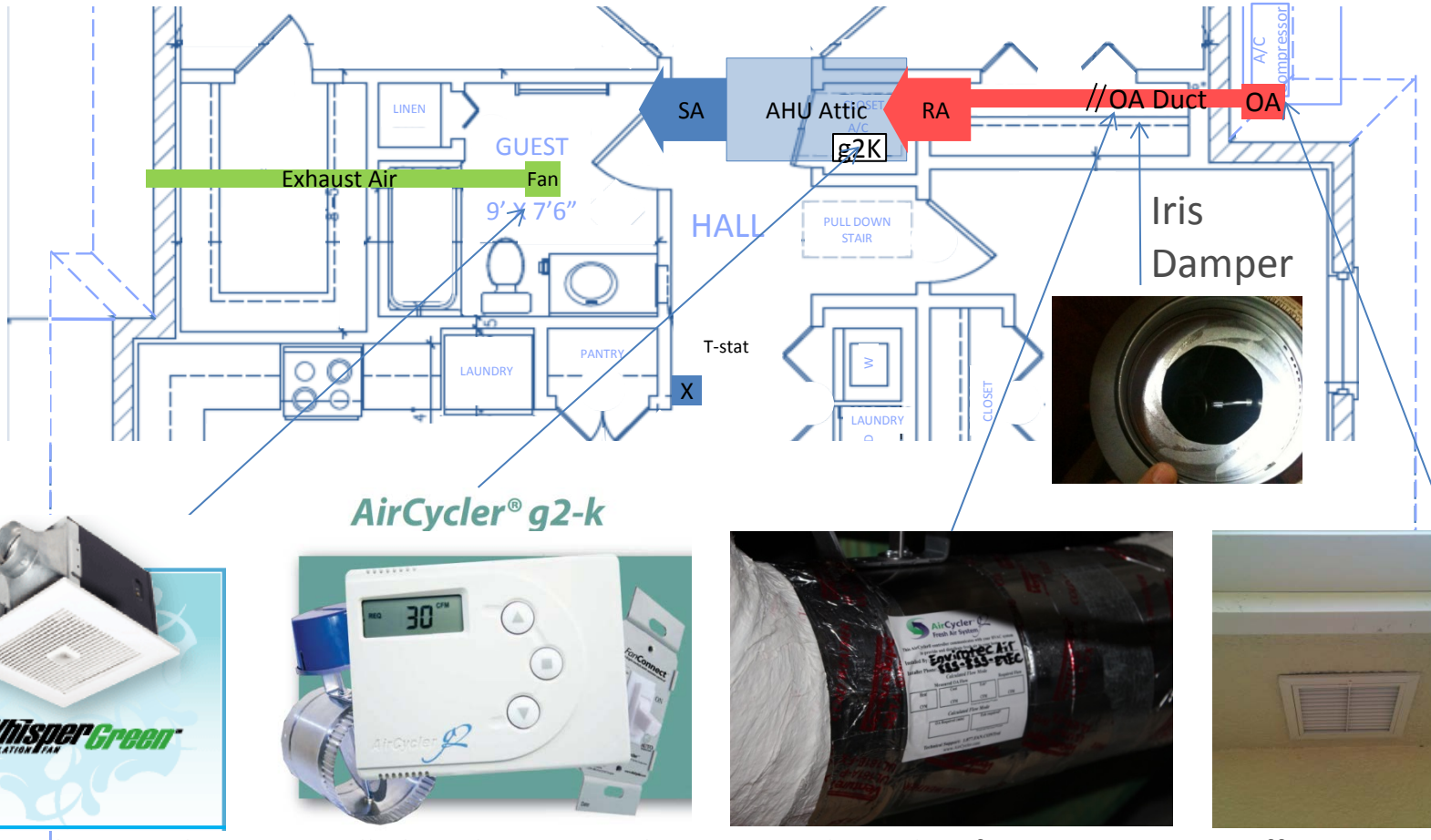
Smart Ventilation Algorithm – Lab Test



Hybrid Supply / Exhaust System – Field Test

Contact
Eric Martin
martin@fsec.ucf.edu
321-638-1450

How does variable nature of supply flow affect achievement of 62.2?



Constant duty-rated Panasonic bath fan connected to AirCycler g2K controller

Installed inside AHU, totals OA flow hourly. Closes electronic damper in OA duct or runs bathroom to match hourly flow to 62.2 target

Outside air duct from OA intake to return plenum with electronic damper (connected to the g2K) and manual override damper

Soffit mounted, filter-back outside air intake.

Up Next…

The Levy Partnership

Integrated Design: A High Performance Solution for Affordable Housing

Team and Partners	Topic Area
The Levy Partnership, Inc.	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

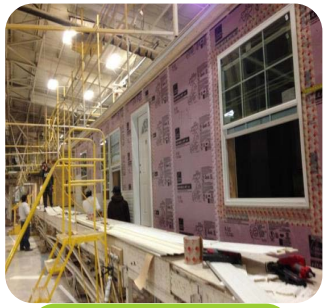
Building America Partnerships for High Performance Housing Innovations

DE-FOA-0001117

Building America TO5

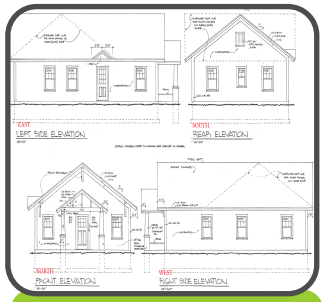
Russellville lab house

- Calibrated BEopt & TRNSYS models
- Redesign and test systems



Eatontown lab house

- Model & design
- Build & install
- Instrument & evaluate
- Recalibrate models



Habitat test homes – Worcester, MA & Havre de Grace, MD

- Build
- Instrument & evaluate

Eatontown

- Occupy
- Evaluate 12 months
- Recalibrate

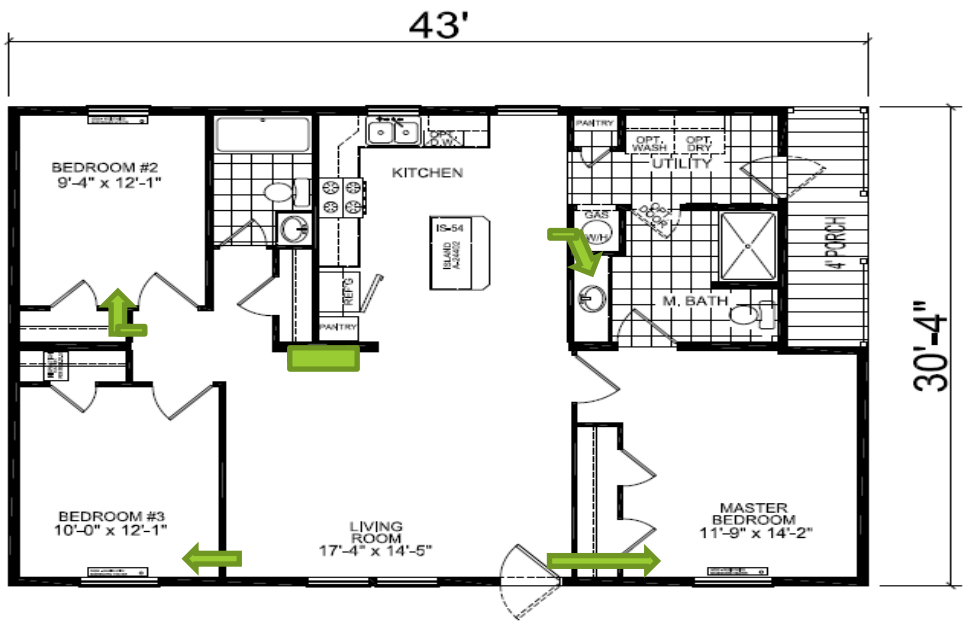
Guidelines

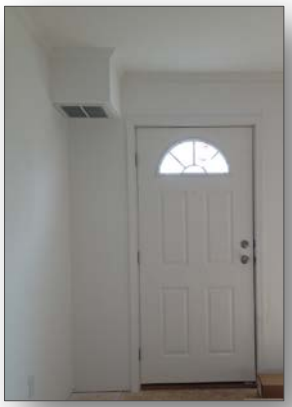
- Habitat & similar
- Factory builders

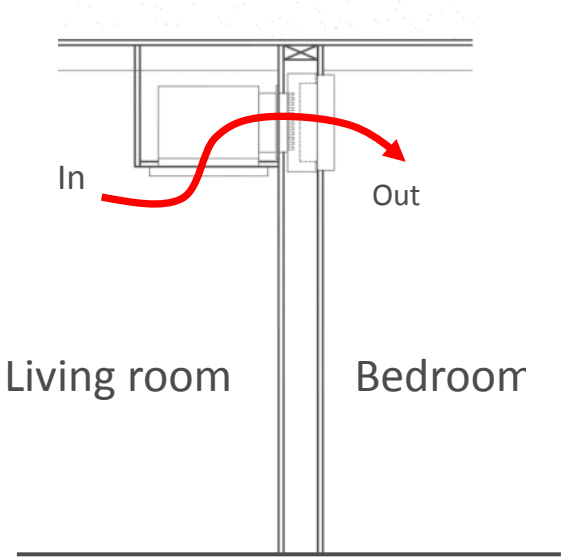
Partners: Habitat for Humanity International, Systems Building Research Alliance, product manufacturers

ARIES Collaborative

Eatontown test house





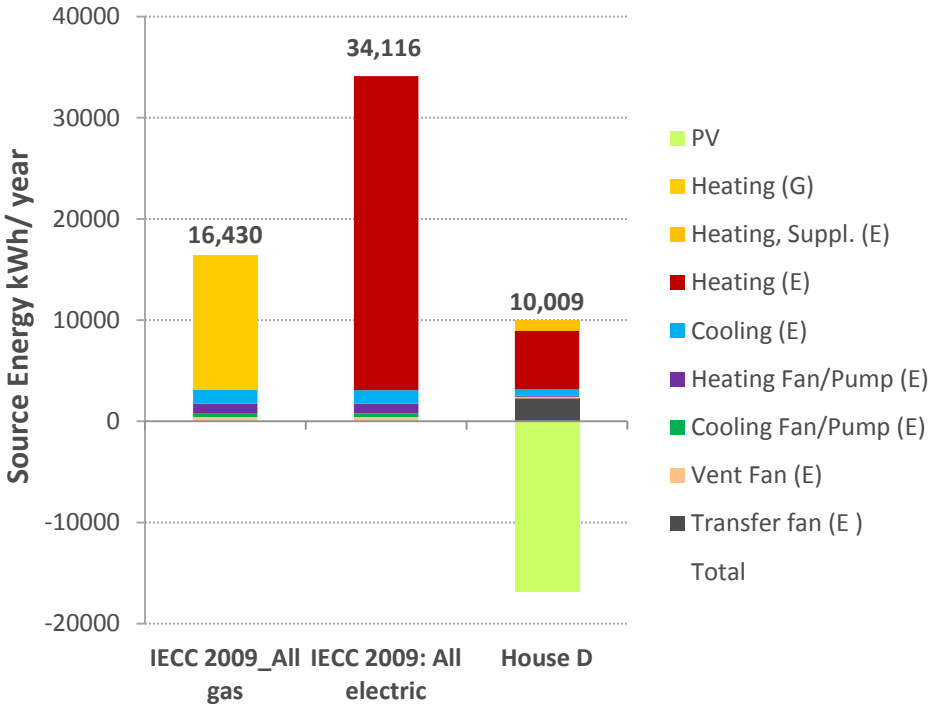


~150 cfm
~2°F delta T
~ 324 Btu/hr
About the same as an open door

ARIES Collaborative

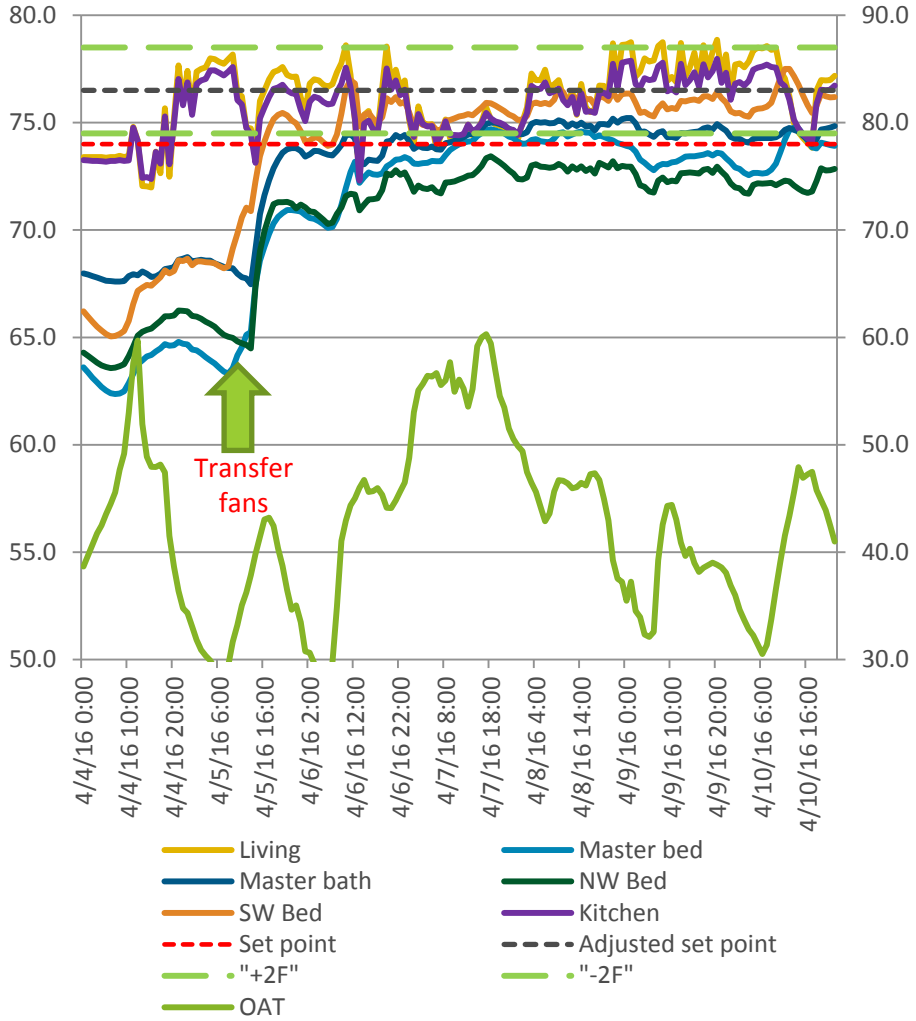
Advanced Residential Integrated Energy Solutions

Model Results Compared to Baseline
Space Conditioning Only



- Enclosure calibrated to field data
- Heat pump using standard BEopt library entry
- Supplemental space heating estimated at 400-500 kWh

ASHRAE 55 and ACCA Manual RS



- Transfer fans increased bedroom temperatures by 7°F
- Greater spread at lower ambient temperatures
- Living room temperature ~4F higher than set point
- All but two rooms within 4F band
- Resistance heat to bring all rooms into compliance

The Levy Partnership, Inc.
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ARIES Collaborative

Up Next…

gti®

GAS TECHNOLOGY INSTITUTE

Energy Savings with Acceptable IAQ through Improved Air Flow Control

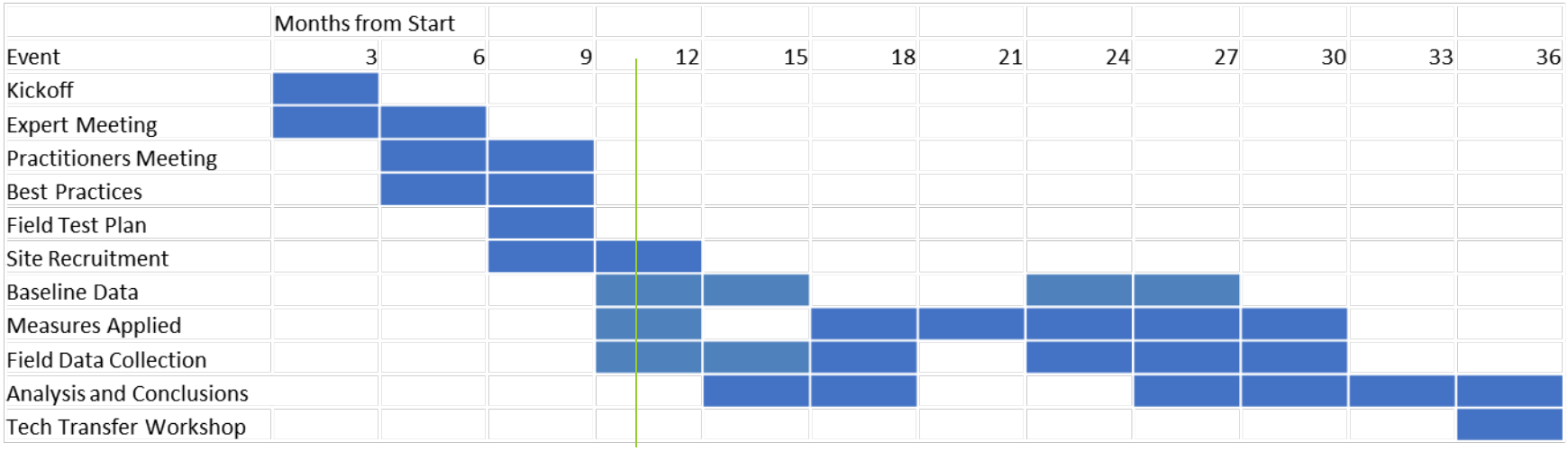
Team and Partners	Topic Area
Gas Technology Institute, University of Illinois, Midwest Energy Efficiency Alliance, Chitwood Energy Management, National Center for Healthy Housing	Optimal Ventilation & IAQ Solutions (2015)

- This project will develop an integrated assessment that will measure the impact of controlled HVAC duct losses, infiltration, and ventilation options on IAQ and 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: Through systematic management of airflows, provide improved energy savings with the same IAQ or improved IAQ with the same energy savings.

Energy Savings and IAQ – Approach and Status

- Expert meeting and field practitioners meeting Q1 2016 - complete
  - Solidify test plan – instruments, houses, data analysis
  - Understand what can be done in the field for air sealing
  - Identify partners and related programs to leverage funds
- Field test plan Q2 2016 – reviewed and being updated; summary to NREL by 09/1/2016
- Go/no go passed; BP2 approved 08/2016
- Field test Q3 2016 – not yet started



Energy Savings and IAQ – Field Test Logistics

Field test

- Work with practitioners in Illinois and Iowa programs
- Test at least 20 treatment, 20 control homes
  - Groups of 5+5
  - Each group in a different season
  - Baseline and control/post-treatment
- Implement different ventilation strategies if possible
- Measure multiple contaminants
  - CO_2, radon, formaldehyde, humidity
  - Some particles measurement with borrowed equipment
- Intervention sequence

Baseline
Post-treatment

Group A - "treatment" with systematic flow treatment
Group B - "control" with business as usual

3-4 week period

	1	2	3	4	5	6	7	8	9	10	11	12
Group 1A												
Group 1B												
Group 2A												
Group 2B												
Group 3A												
Group 3B												
Group 4A												
Group 4B												

Energy Savings and IAQ - Team

PARR
The Partnership for Advanced Residential Retrofit

Larry Brand
Gas Technology Institute

Paul Francisco and Bill Rose
University of Illinois

Mark Milby
Midwest Energy Efficiency Alliance

Rick Chitwood
Chitwood Energy Management

Jonathan Wilson
National Center for Healthy Housing

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Building AMERICA U.S. Department of Energy

Up Next…

Home Innovation RESEARCH LABS™

Home Innovation RESEARCH LABS

Attic Retrofits Using Nail-Base Insulated Panels

Team and Partners	Topic Area
Home Innovation Research Labs, Inc. w/ SIPA, ACC, APA, Dow, DuPont, Owens Corning	High Performance Moisture Managed Building Envelopes

Purpose: Develop and demonstrate a roof/attic energy retrofit solution using retrofit panels for existing homes where traditional attic insulation approaches are not effective or feasible.

Success metrics: HVAC energy savings of at least 10% for sealed attics and cathedral ceilings; improved comfort; and monitored data that confirms acceptable moisture levels.

Home Innovation RESEARCH LABS

Demonstration Site 1: Hot-Humid Climate – St. Simons Island, GA

Site Assessment:

- Construction details/baseline data
- Energy savings: est. 14% heating, 13% cooling
- WUFI analysis: below 9%MC in all cases

Design Specification:

- 6” retrofit panel
- Convert attic from vented to unvented

Home Innovation RESEARCH LABS

Demonstration Site 2: Cold Climate – Ann Arbor, MI

Site Assessment:

- Construction details/baseline data
- Energy savings: est. 20% heating, 14% cooling
- WUFI analysis: below 15%MC in all cases

Design Specification:

- 8” panel main roof, 5” panel addition roof

Home Innovation RESEARCH LABS

Progress:

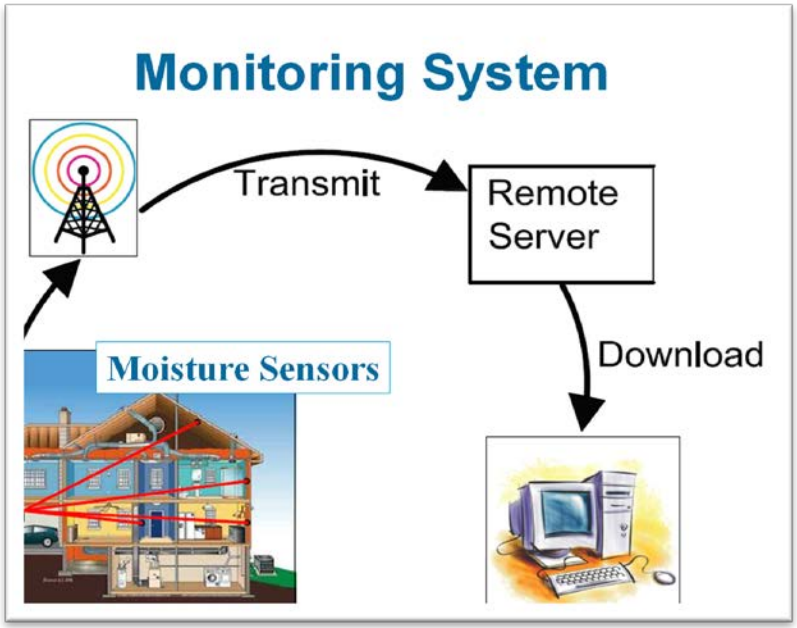
- Established Project Teams
- Conducted site assessments
- Developed design specifications

Next Steps:

- Conduct observational research
- Conduct design reviews and approve final design solutions
- Install retrofit panels and remainder of monitoring sensors

Home Innovation RESEARCH LABS

Moisture Performance of High-R Wall Systems



Team and Partners	Topic Area
Home Innovation w/ American Chemistry Council, NAHB, USDA Forest Products Lab, VSI	High Performance Moisture Managed Building Envelopes

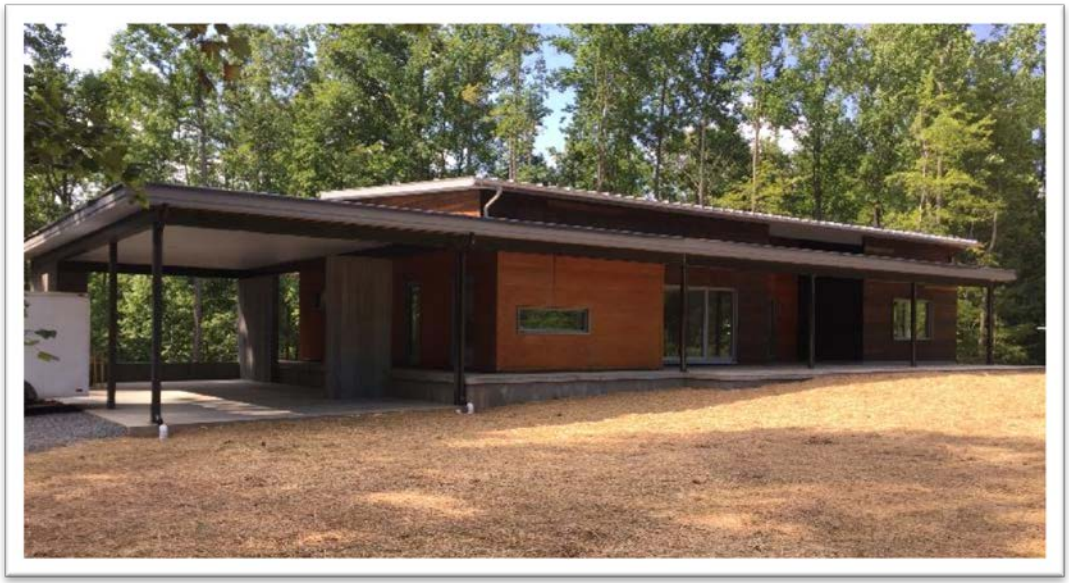
- **Goal:** Study moisture performance of high-R walls (>R-20) in occupied high performance homes across different climate zones. Improve builders' confidence and facilitate transition to high-R walls.
- **Success Metrics:** Measured and modeled performance of high-R walls and design guidance to ensure durability of high performance walls.

Home Innovation RESEARCH LABS

Progress

- Advisory Group is engaged
- A total of over **100 inquiries from builders**
- Sensor and instrumentation packages were shipped to **20 sites** for installation
- **16 homes** have been instrumented

Home Innovation RESEARCH LABS

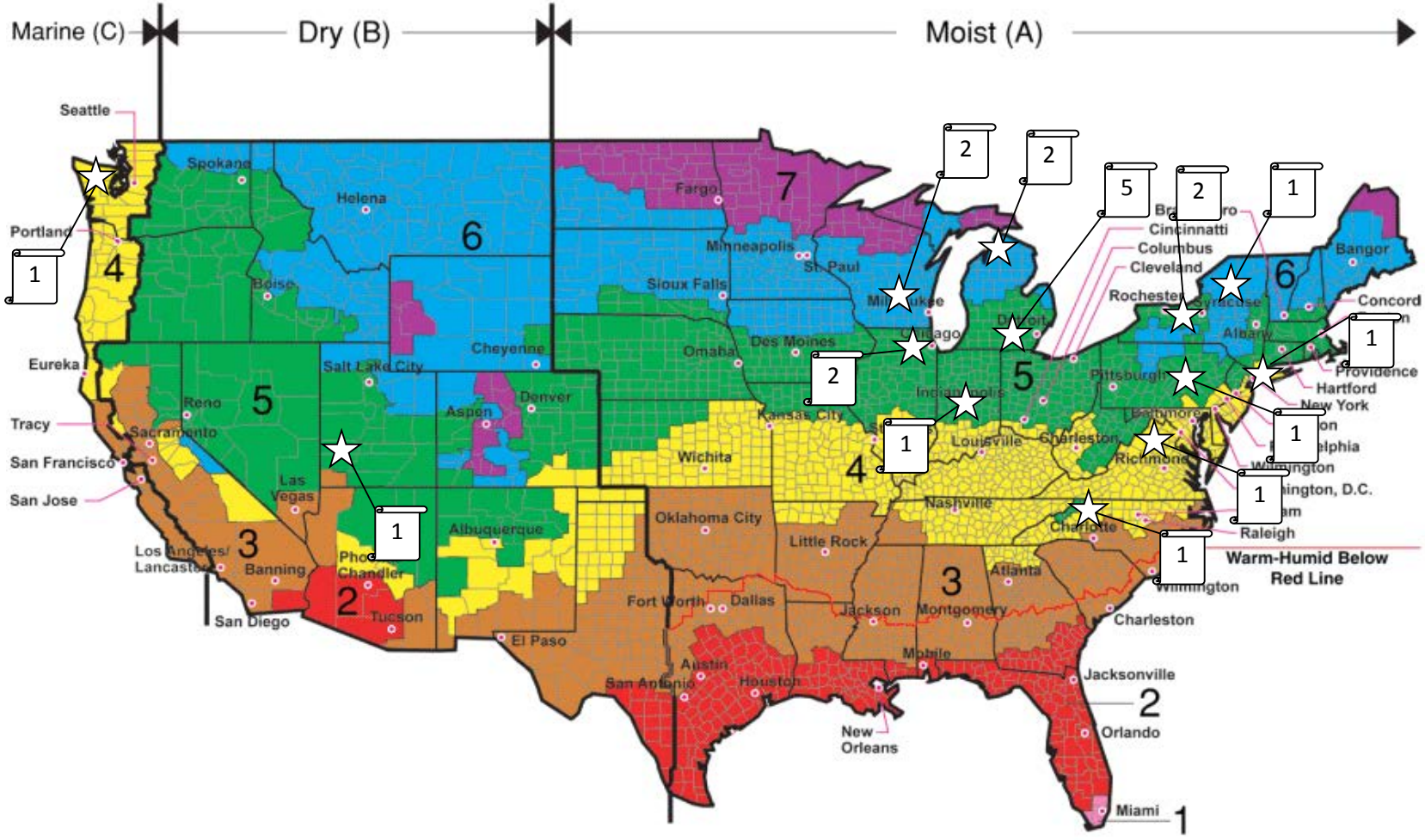


Next Steps

- Complete installation of sensors
- Document house characteristics for each site
- Perform quality check on installation and documentation

Home Innovation RESEARCH LABS

Number of Homes Chosen for Instrumentation by Climate Zones



All of Alaska in Zone 7 except for the following Boroughs in Zone 8: Bethel, Dellingham, Fairbanks, N. Star, Nome North Slope, Northwest Arctic, Southeast Fairbanks, Wade Hampton, and Yukon-Koyukuk

Zone 1 includes: Hawaii, Guam, Puerto Rico, and the Virgin Islands

Home Innovation RESEARCH LABS

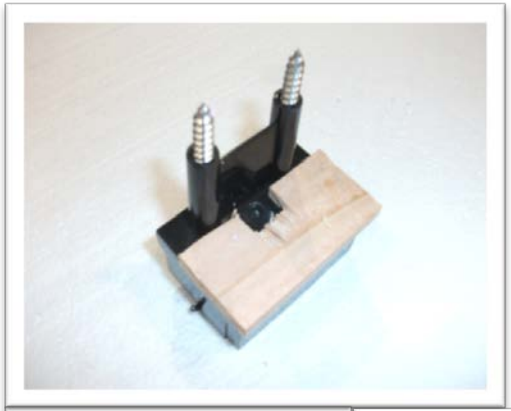
Extended Plate and Beam (EP&B) Wall System

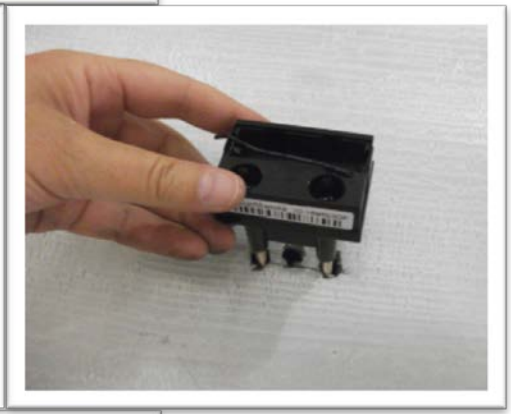
Team and Partners	Topic Area
Home Innovation Research Labs, Inc. w/ American Chemistry Council, Forest Products Laboratory, The Dow Chemical Company Builder Partners: Arn McIntyre Construction, Kevin L. Smith Construction	High Performance Moisture Managed Envelopes (2015)

- **Goal:** Study the constructability and structural/moisture performance of high-R walls with rigid foam insulation interior to the wood structural sheathing
- **Success Metrics:** Efficient, cost-effective, durable wall assembly to meet and exceed new IECC targets

EXTENDED PLATE AND BEAM (EP&B) WALL SYSTEM

Home Innovation RESEARCH LABS





Project Tasks

Structural testing

Moisture Monitoring

Site observation

Construction Guide

Field Tests

Two demonstration houses

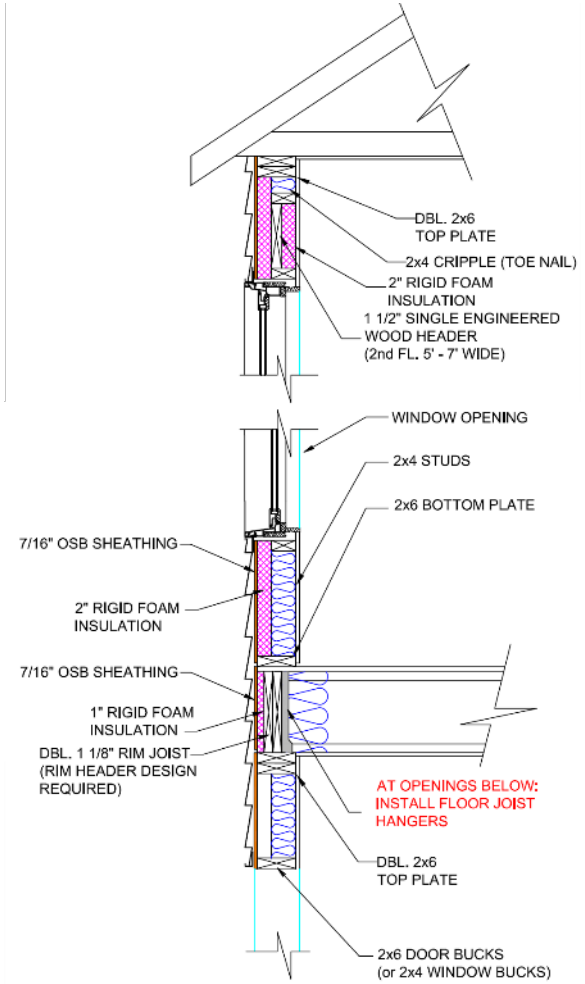
Michigan (CZ 5)

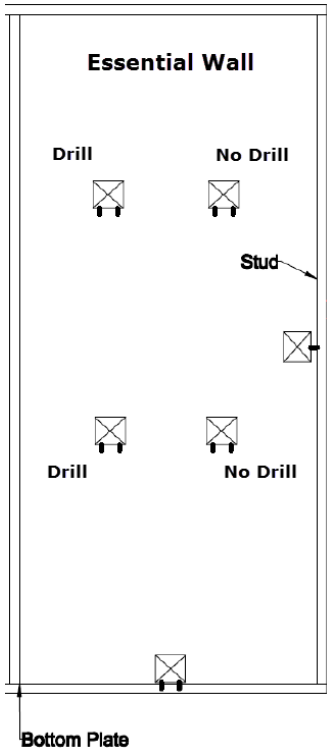
Home Innovation RESEARCH LABS

Site Observation

Home Innovation RESEARCH LABS

Lessons learned, and looking ahead….





- Structural connections
- Moisture Control
- Sensor Placement
- Waste Control
- Assembly efficiencies
- Industry acceptance

Home Innovation
RESEARCH LABS

THANK YOU

Home Innovation Research Labs

HomeInnovation.com

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Finding Innovation a Home

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Building AMERICA U.S. Department of Energy

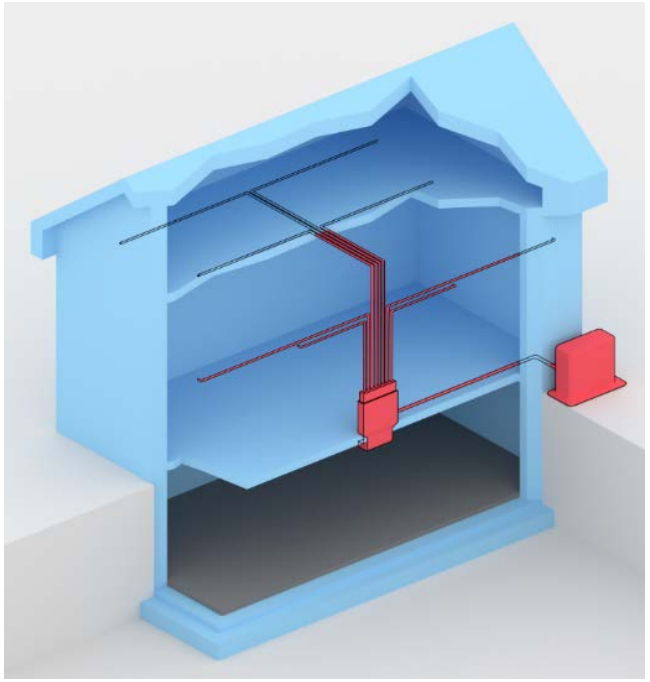
Up Next…

IBACOS®

innovation

A “Plug-n-Play” Air Delivery System for Low Load Homes

Team and Partners	Topic Area
IBACOS with the Housing Innovation Alliance	Optimized Comfort Systems for Low-Load Homes (2015)

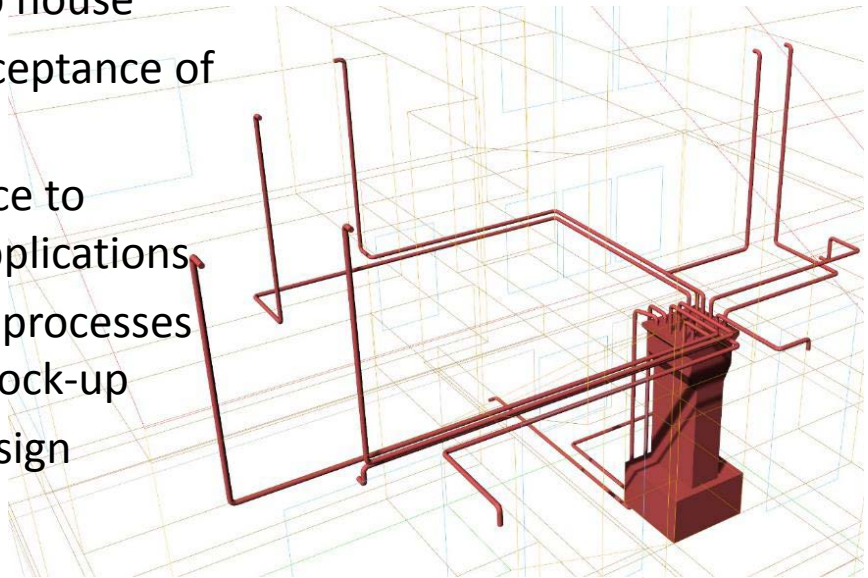


- Project Goal is to develop a simplified small-diameter residential air delivery system as a solution to the air distribution and comfort delivery issues in low-load production-built homes.
- System is assembled in a homerun arrangement from a kit-of-parts with a limited number of components.
- A straight-forward design methodology and companion guidance document accompany the system.
- Demonstrate advantages of the system and garner industry support with secured builder and manufacturer partners.

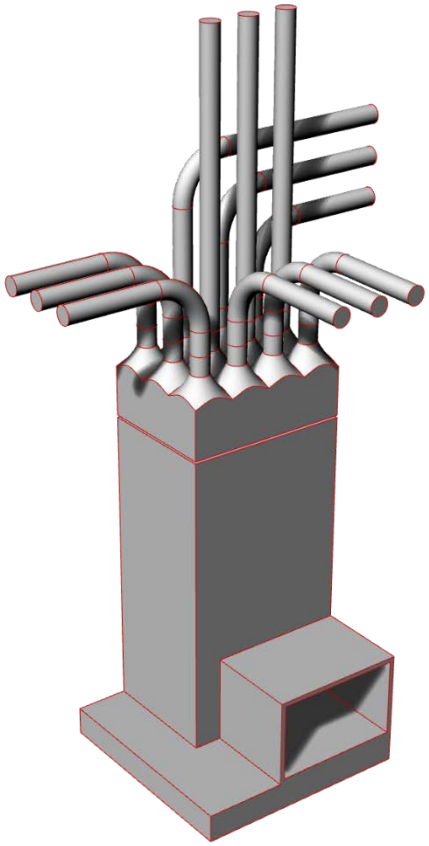
Success Metrics: Duct system is easily integrated within the home’s conditioned space, installed with less cost, error and waste, and offers predictable performance to help deliver comfort in low-load homes.

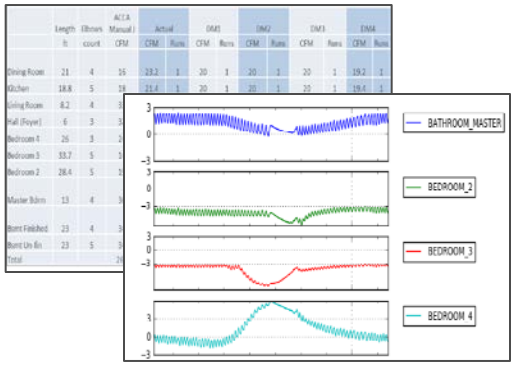
Project Approach

- Roadmap Connection
  - Develop System Design Procedures/Tools & Comfort Metrics/ Criteria for Low-Load Homes
- Key Tasks
  - Industry engagement, solicit support
  - Test pressure, airflow and temperature change characteristics for various straight runs and fittings
  - Install and evaluate a duct system in an unoccupied lab house
  - Push industry for acceptance of plastic ducts
  - Simulate performance to establish range of applications
  - Evaluate installation processes in a wood-framed mock-up
  - Develop a simple design methodology



Progress / Findings / Opportunities

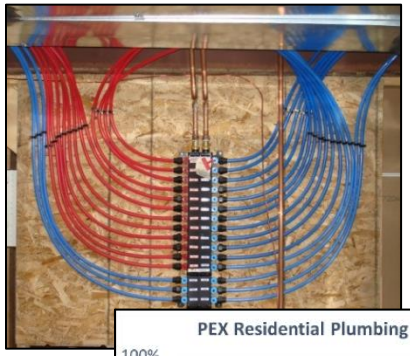


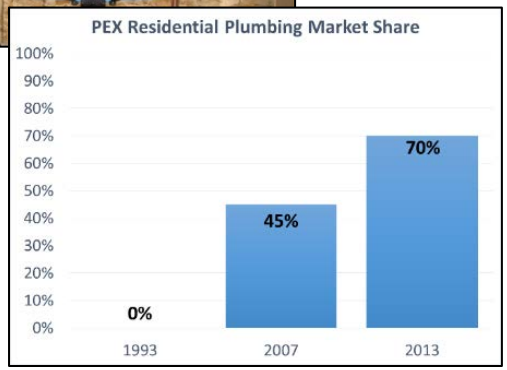


- Significant industry interest demonstrated
- Pressure / airflow relationships established
- Semi-rigid duct shows promise
- Duct temperature loss/gain impact are significant
- Gaps in material / product availability identified
- Code community being engaged
- Draft design methodology being evaluated
- Expertise advanced with residential multizone thermal simulation models and integrated airflow networks
  - Represents a collaboration opportunity within Building America

Vision / Project Contact Information

- Vision
  - Revolutionize ducted air distribution systems similar to the way manifolded crosslinked polyethylene (PEX) piping systems have impacted plumbing distribution
  - Residential ductwork is a $1.2 Billion market annually
    - 10% new constr. market penetration in 5 years
    - 25% penetration in 10 years plus retrofit market





IBACOS®
innovation

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Business Contact:
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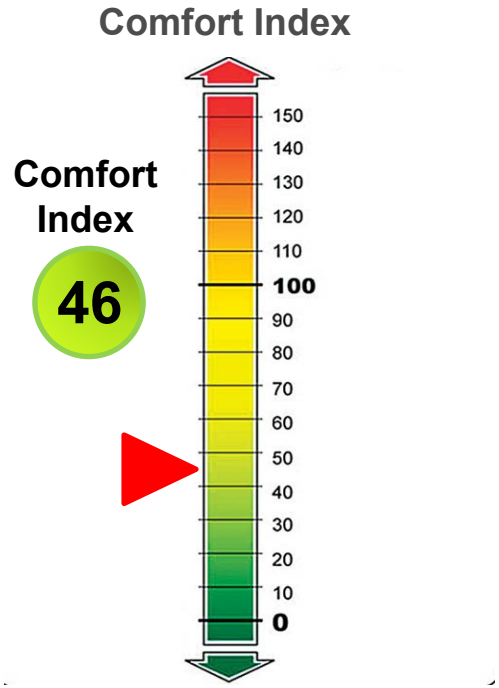
Evaluation of a Residential Thermal Comfort Rating Method

Team and Partners	Topic Area
IBACOS with the Housing Innovation Alliance	Optimized Comfort Systems for Low-Load Homes (2015)



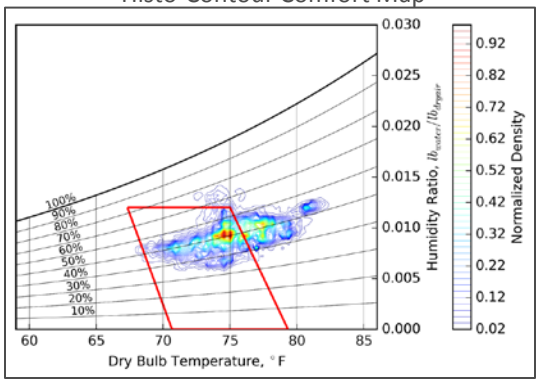
- Evaluate the need for, and feasibility of, a Thermal Comfort Rating Method (TCRM) for the residential sector.
- The TCRM is envisioned as an asset rating system that represents, in simple terms, a home's overall ability to provide thermal comfort to its occupants under varying conditions and demands.
- The metric would give builders and homeowners a tool to make value-based decisions regarding thermal comfort performance in the context of energy efficiency.

Success Metrics: Purpose and value are revealed in having a simplified metric available to the industry to represent comfort delivery in production homes.

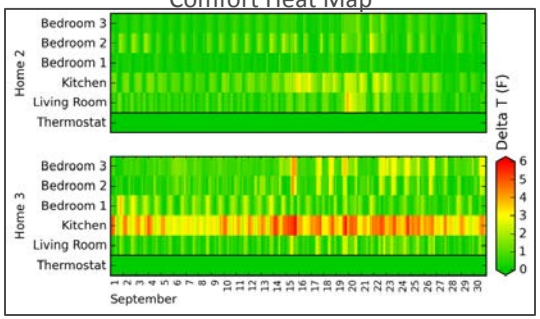
Why? / Key Activities

- Why?
  - Recognized lack of suitable methods to assess comfort in homes
  - IBACOS and other industry experience with discomfort in low-load “high-performance” homes”
- Key Activities
  - Industry engagement
    - Introduce concepts (what, why)
    - Seek stakeholder interest and feedback
    - Enhance concepts
    - Seek collaboration and development partners
  - Establish detailed justification for TCRM development: need, benefit
    - Literature search
    - Review industry trends
    - Identify risk factors for low-load homes
    - Review existing metrics
    - Develop expected use cases
    - Develop the business case for use
  - Develop a vision for a path forward for development
  - Summarize in a white paper

Histo-Contour Comfort Map



Comfort Heat Map

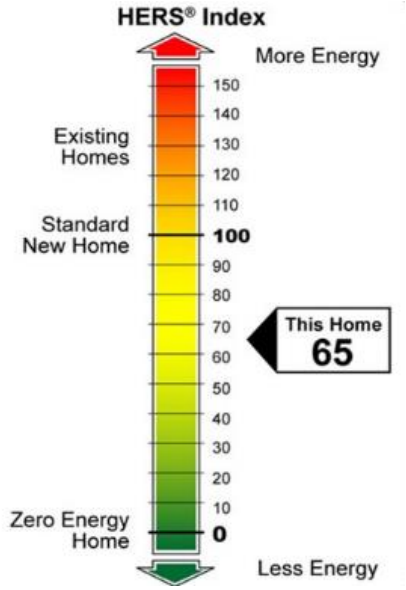


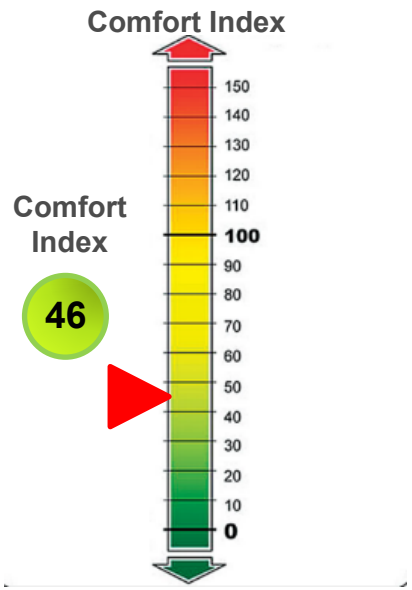
Accomplishments

- Concept development
- Substantial industry engagement
  - Webinars, blogs, feature article, live presentations
  - Builders, manufacturers, utilities, industry design / research professionals
  - ASHRAE, RESNET, ACI, Housing Innovation Alliance
- Interest established from potential collaborators
- Coordination with IAQ metric developers
- Draft white paper being revised

Vision / Project Contact Information

- Vision
  - A comfort performance metric similar to, and able to work with, the Home Energy Rating System (HERS) index for energy efficiency and other developing residential sector asset ratings (IAQ, water efficiency, etc.)
  - Use as a consistent comfort-based metric to evaluate and demonstrate value of concepts in Building America projects.





HERS® Index image courtesy of RESNET (http://www.resnet.us/)

IBACOS®
innovation

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Up Next…

Discussion Topics

What Activities Should Building America Lead in 2017 to Help Industry Adopt High Performance Solutions?

Research & Development

Market Engagement

Codes & Standards

Objectives of the Poll & Discussion:

a) Collect expert input about biggest remaining challenges necessary to meet Building America Roadmap goals (research, guidance, and CSI)

b) Explore industry engagement strategies (Building America facilitated meetings) that will have the most impact on industry adoption of innovations

Building America Facilitated Meeting Poll: Topics

HVAC installation quality assessment and verification
- Auto-tuning HVAC Systems – insensitivity errors
- Fault Detection and Diagnostics - limit performance degradation of HVAC equipment time

Radiant cooling for temperate climates
Practical retrofit strategies for building enclosures
Achieving proper air and water management in retrofit without resetting the windows
Air leakage in town house common wall
Moisture in buildings - common causes and cures
Guidance for proper and safe spray foam for both applicators and occupants
Real world capillary break solutions -- materials, means, and methods
ASHRAE 62.2 Multifamily Working Group - Objectives and Needs
Indoor Air Quality and Ventilation in High Performance Homes
Most important ventilation and IAQ-related questions to seek to answer in a national field study of new homes
Make-up air for tight homes -- when, where, and how?
Humidity control in high performance homes with various ventilation strategies
- Enhanced dehumidification air conditioning
- Including RH control performance in Energy Star HVAC performance certification

Smart mechanical ventilation Smart mechanical ventilation
Defining acceptability and excellence for residential indoor air quality
- Performance based IAQ metrics and technologies
- defining IAQ, IAQ metrics

Addressing kitchen contaminants to maintain IAQ in super-efficient new homes and retrofits
Strategies to enhance builder confidence in high performance homes
Building inspector forum - why buildings fail
Establishing value metrics for high performance and energy efficient construction to bring commonality to decision making by various stakeholders
Defining what "do no harm" means, without fault or simply better than you found it
Shortage of skilled labor in residential construction - a barrier to high performance buildings
Upgrading existing houses - exploring new construction practices through the decades
Multifamily buildings: energy modeling, air tightness testing, other MF issues
Code issues of mid-rise multifamily (falls between ICC residential and commercial code)
Advanced water heating systems and distribution
"Off-grid" home (ZERH, solar PV with batteries, and backup NG generator) in response to fight over net-metering going on across the country
MELs (Appliance, pool pumps, etc.)

Building America Facilitated Meeting Poll: Results

Research & Development

Topics that you feel are most important or have the greatest near-term need in the industry related to **Research & Development**.

TOPIC	Number of Votes (Max 26)
Most important ventilation and IAQ-related questions to seek to answer in a national field study of new homes	9
Smart mechanical ventilation	9
Humidity control in high performance homes with various ventilation strategies	8
HVAC installation quality assessment and verification	7
Multifamily buildings: energy modeling, air tightness testing, other MF issues	7
Practical retrofit strategies for building enclosures	5
Air leakage in town house common wall	4
Defining acceptability and excellence for residential indoor air quality	4
Advanced water heating systems and distribution	4

Building America Facilitated Meeting Poll: Results

Market Engagement

Topics that you feel are most important or have the greatest near-term need in the industry related to **Market Engagement**.

TOPIC	Number of Votes (Max 26)
Shortage of skilled labor in residential construction - a barrier to high performance buildings	11
Strategies to enhance builder confidence in high performance homes	10
Practical retrofit strategies for building enclosures	9
Establishing value metrics for high performance and energy efficient construction to bring commonality to decision making by various stakeholders	7
Building inspector forum - why buildings fail	6
Defining acceptability and excellence for residential indoor air quality	5
HVAC installation quality assessment and verification	4
Guidance for proper and safe spray foam for both applicators and occupants	3

Building America Facilitated Meeting Poll: Results

Codes & Standards

Topics that you feel are most important or have the greatest near-term need in the industry related to **Codes & Standards**.

TOPIC	Number of Votes (Max 25)
HVAC installation quality assessment and verification	13
Code issues of mid-rise multifamily (falls between ICC residential and commercial code)	10
ASHRAE 62.2 Multifamily Working Group - Objectives and Needs	8
Make-up air for tight homes -- when, where, and how?	5
Humidity control in high performance homes with various ventilation strategies	5
Defining acceptability and excellence for residential indoor air quality	5
Air leakage in town house common wall	4
Multifamily buildings: energy modeling, air tightness testing, other MF issues	4

The End… but it's not over.

Continue to submit topic ideas!