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

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Building America

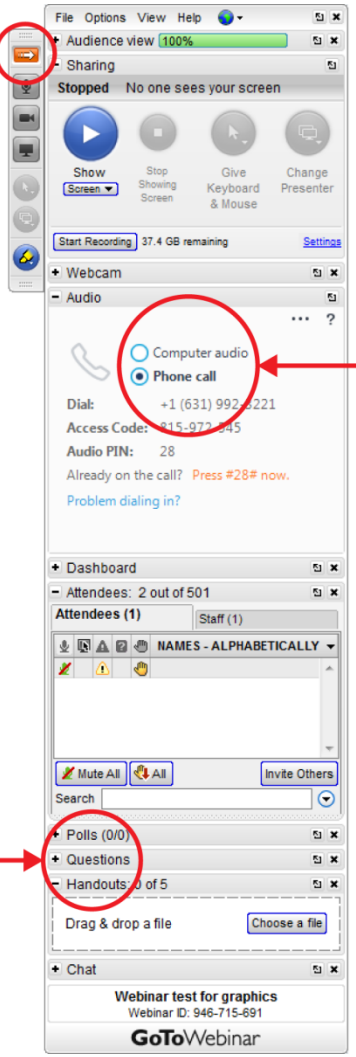
Quarterly Team Project Update

November 15, 2016

U.S. Department of Energy
Eric Werling
Lena Burkett

National Renewable Energy Laboratory
Stacey Rothgeb

Open and close your control panel



2 Audio Options:
Use telephone to dial into the call

OR

Use your computer's microphone & speakers ("VoIP")*

**If you are using the Mic and Speakers (VoIP) option, please make sure your computer has a microphone and it is enabled.*

Submit text questions

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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 and system flow, 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.
- Energy measurements and multiple IAQ measurements including CO2, radon, formaldehyde, humidity
- Guidance for delivering residential retrofits including both good IAQ and 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.

Field Test Plan Logistics

Contractor identifies home as a "treatment" home candidate based on initial diagnostics, recruits and enrolls home

↓

Contractor identifies suitable "control" home, recruits and enrolls home

↓

Visit for instrumentation installation scheduled, conducted (ASAP following recruitment)

↓

Baseline measurements recorded 3-4 weeks

↓

Interventions completed (ASAP following baseline)

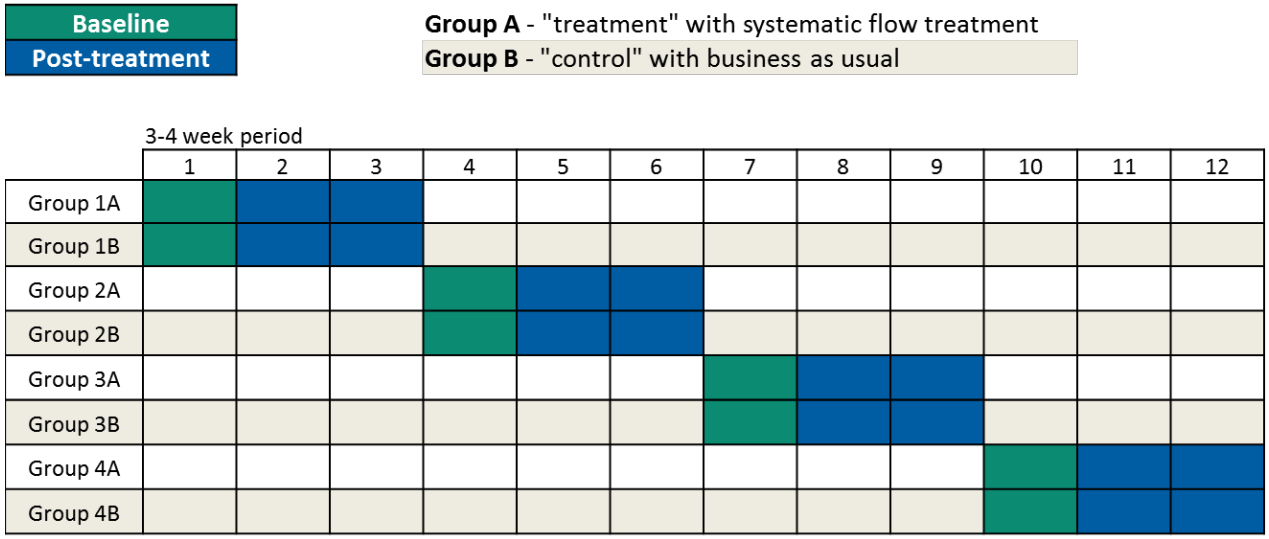
↓

Post-intervention measurements recorded 3-4 weeks; homes with supply and exhaust measured an additional 3-4 weeks (ASAP following interventions)

Site Visits

Anticipated Site Visits:

- V1 – Audit/Qualify (partner)
- V2 – Install Instruments for Baseline Sampling (team)
  - V2+1 Wk – Return HCHO and Radon samples
- V3 – Treatment or Control Measures (partner)
  - V3+1 Wk – Return HCHO and Radon samples
- V4 – Removal (team)



Field Test Plan – Criteria for airflow management measures (abbreviated)

Issue	Diagnostic	IAQ samples	Standard intervention	Enhanced intervention	Soft target	Hard target
Air leakage	Blower door	All	Contractor choice	Depends on initial airtightness and opportunities	< 6.5 ACH50	Within 10% of soft target
Foundation to soil	Visual	Rn, T/RH	none	Sealed sump pumps, ground covers over bare dirt, large cracks sealed	--	--
Garage to house leakage	Zonal Pressure Diagnostics	CO (provisional)	Contractor choice	Air sealing between garage and house	--	50% reduction or 30 sq in. maximum leakage area, whichever is tighter
Foundation to outside leakage	Zonal Pressure Diagnostics	PM2.5 (provisional)	Contractor choice	Air sealing between foundation and outside	Leakage area of foundation to outside should be less than leakage area of attic to outside	--
Duct leakage in foundation or garage spaces	Duct Pressurization, Delta-Q if Duct Pressurization not possible	Same as foundation and garage	none	Seal supply leaks to outside, return leaks in foundation space or garage	20% total duct leakage	10% total duct leakage or 6% leakage to outside

Up Next…

FLORIDA SOLAR ENERGY CENTER®

A Research Institute of the University of Central Florida

Variable Capacity Comfort Systems for Low Load Homes

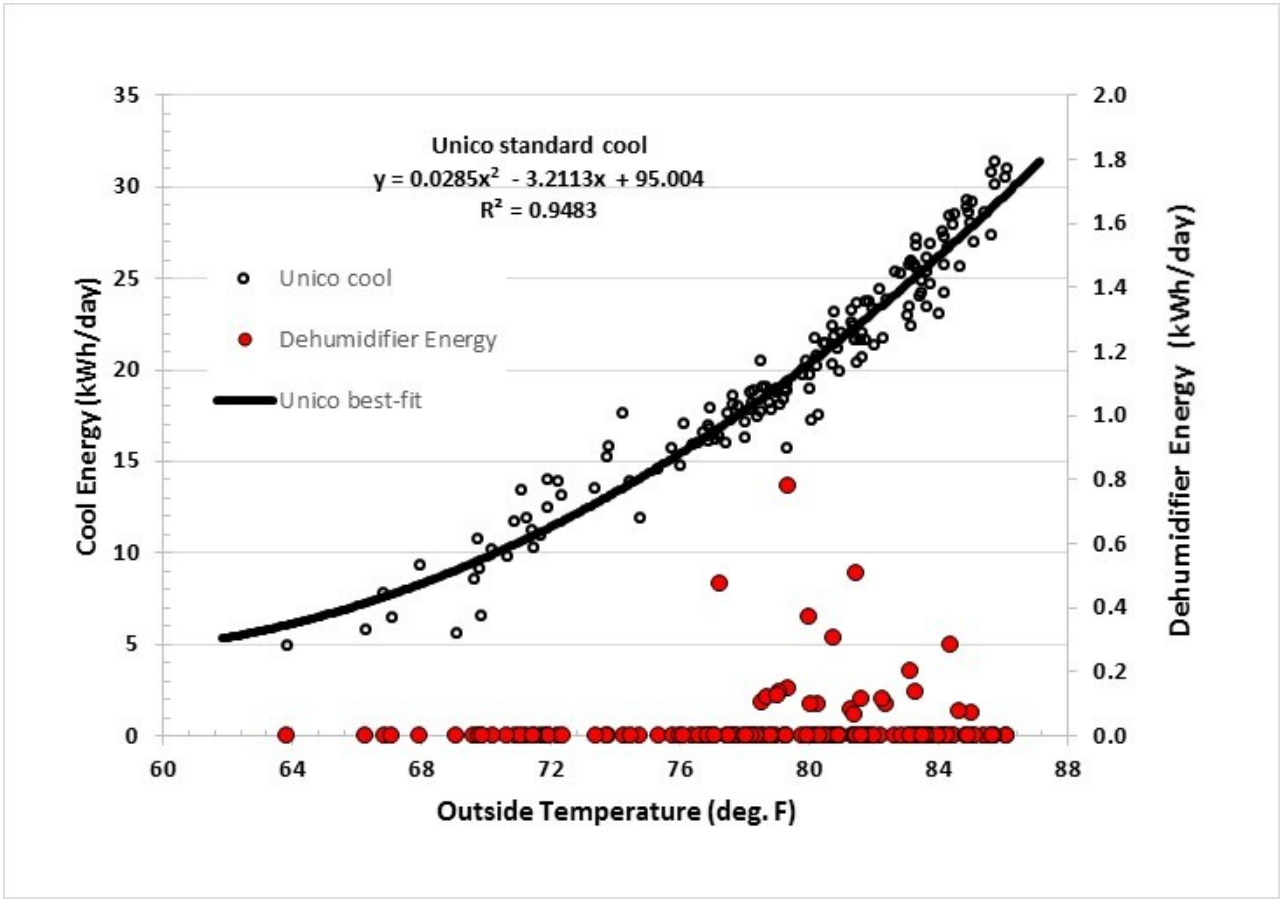
Team and Partners	Topic Area
University of Central Florida **Florida Solar Energy Center**	Optimized Comfort Systems for Low-Load Homes (2015)

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

- 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.

Unico Variable Capacity SDHV System – Lab Test

Latest Results from Unico SDHV Variable Capacity System- Standard Cooling Mode



Some DH operation has occurred recently.
DH operation has been minimal @ (RH<60%)
4.5 DH hours / total 3552 hrs =0.12%

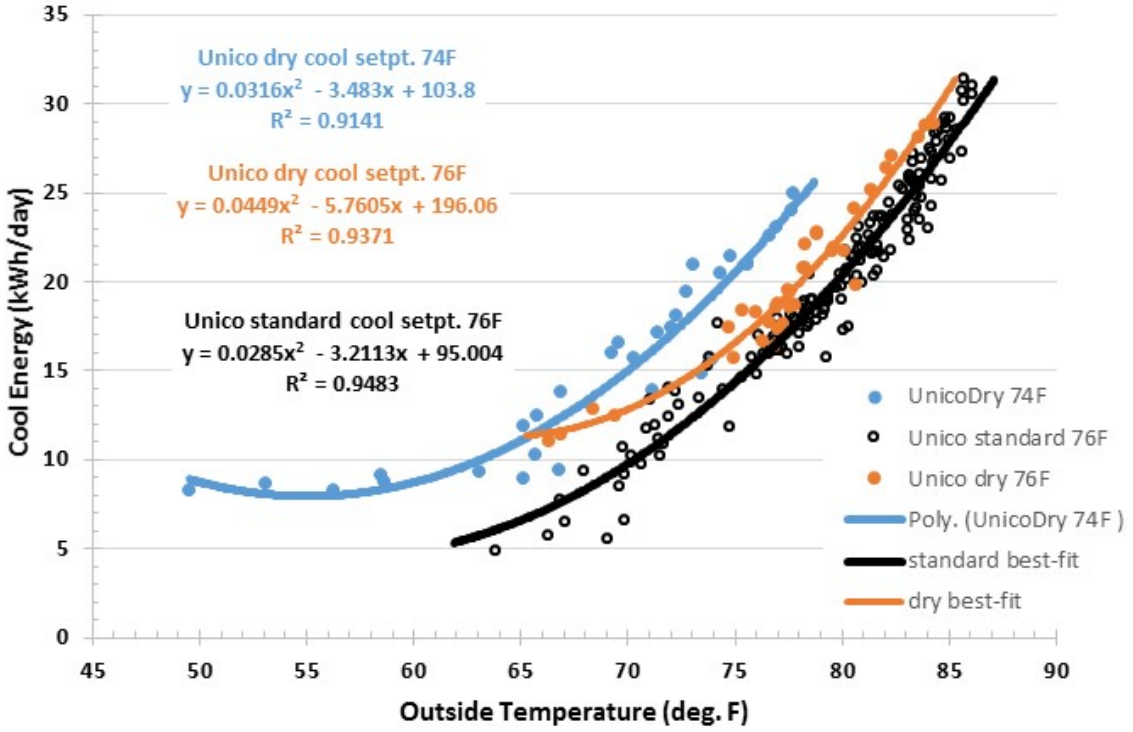
Good thermal distribution.

Only 16W power stand-by (AHU+Compressor); aprox. 6 times less than prev. tested VC system.

Dry cooling mode has required no DH runtime.

Unico Variable Capacity SDHV System – Lab Test

Latest Results from Unico SDHV Variable Capacity System- Standard & Dry Cooling Mode



At 81F
Dry mode = 24.1 kWh/day
Standard=18.6 kWh/day
Dry uses 23% more energy at same out temperature.

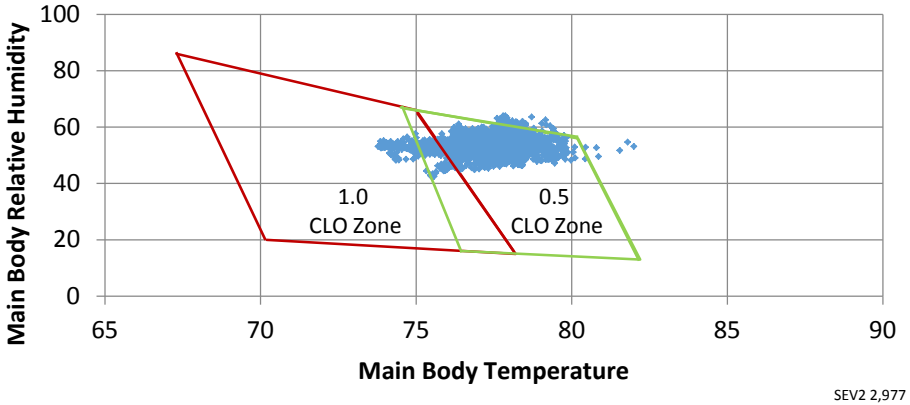
BUT- Dry mode is not needed for entire day; just from early-late am

Continuing to collect dry mode data during low load period Nov.-Dec. 2016

Ductless Multi-Split / Ducted Mini-Split – Field Test

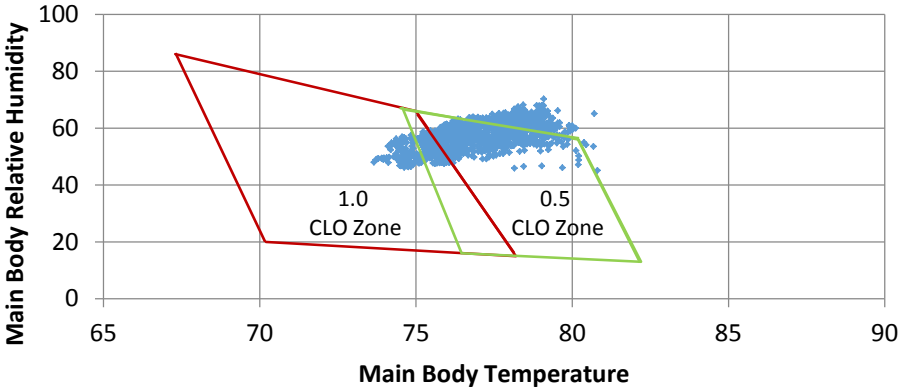
Contact
Eric Martin
martin@fsec.ucf.edu
321-638-1450

Ductless Multi-split, July Conditions (>60% RH = 3.2%)



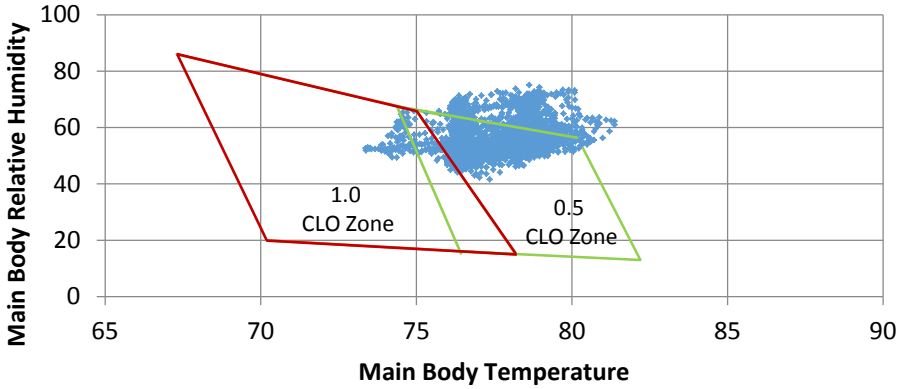
SEV2 2,977

Ductless Multi-split, Oct. Conditions (>60% RH = 38.3%)



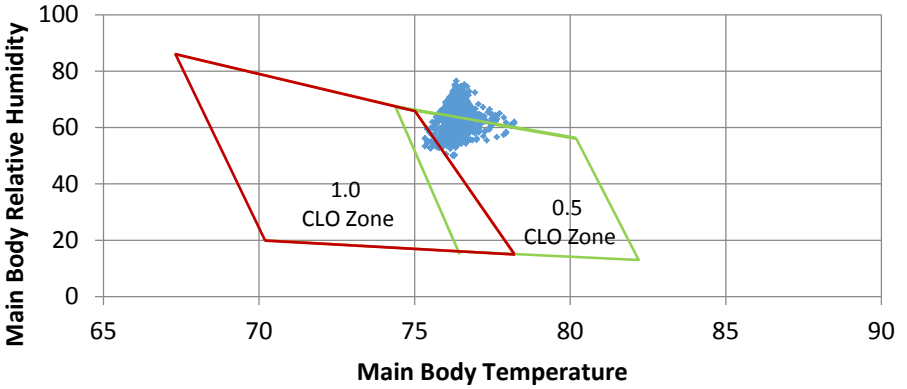
SEV2 1,784

Ducted Mini-split, July Conditions (>60% RH = 25.5%)



MSE 2,976

Ducted Mini-split, Oct. Conditions (>60% RH = 89.9%)



MSE 2,591

Smart Mechanical Ventilation System Control

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

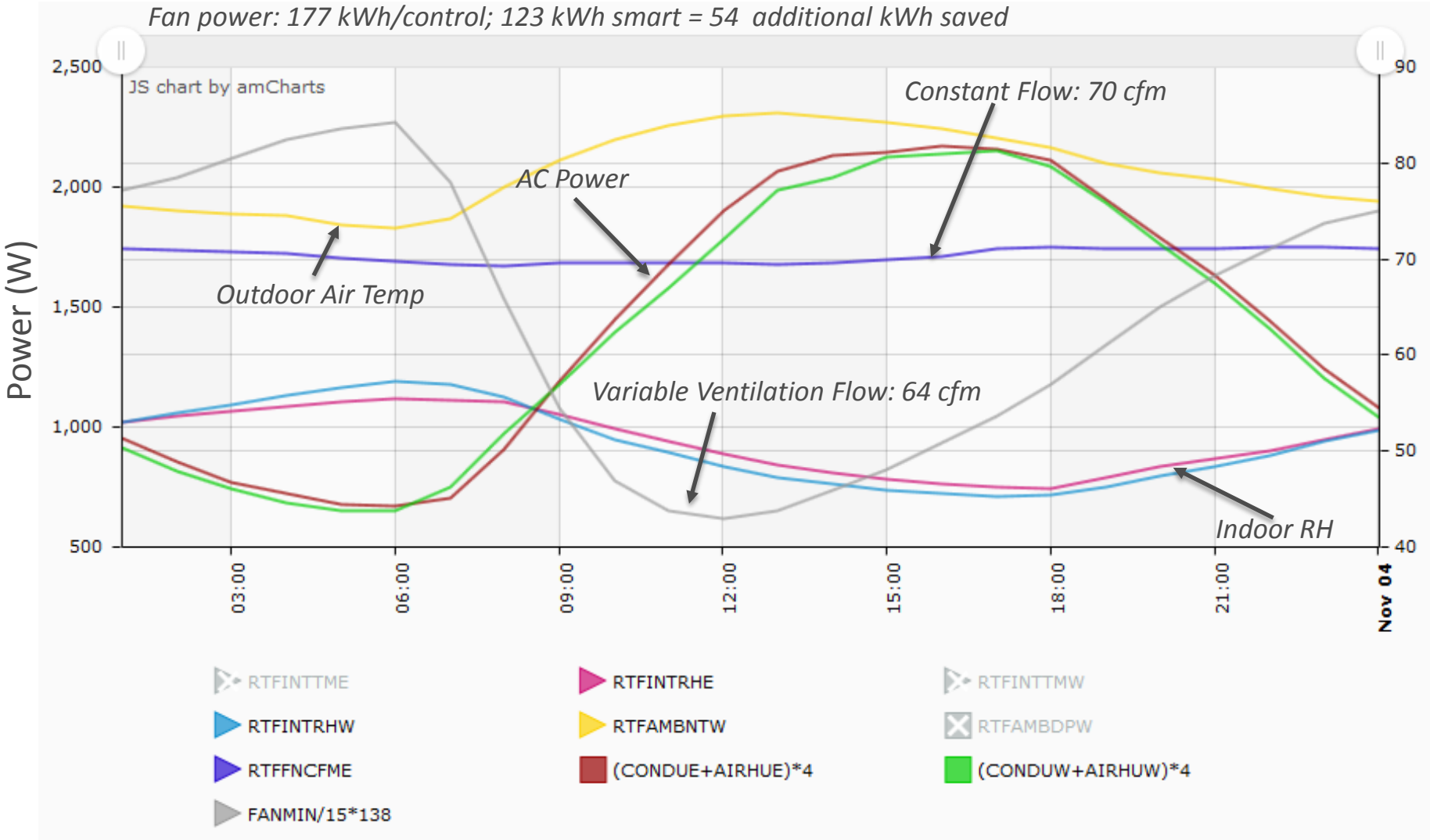
- Optimize mechanical ventilation in response to variable risk factors.
- Lab test of system controlled by algorithm varying flow real time proportional to outdoor temperature and relative humidity (Florida)
- Field test of system delivering 2 levels of flow in response to 1) outdoor temperature and 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: Full Scale Test, Performance May – Oct 2016

2.3% reduction to cooling (149 kWh); slightly lower interior humidity

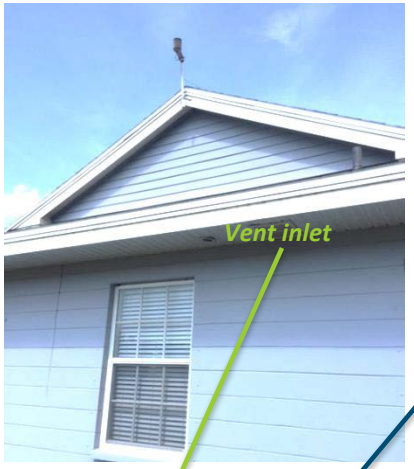
Fan power: 177 kWh/control; 123 kWh smart = 54 additional kWh saved

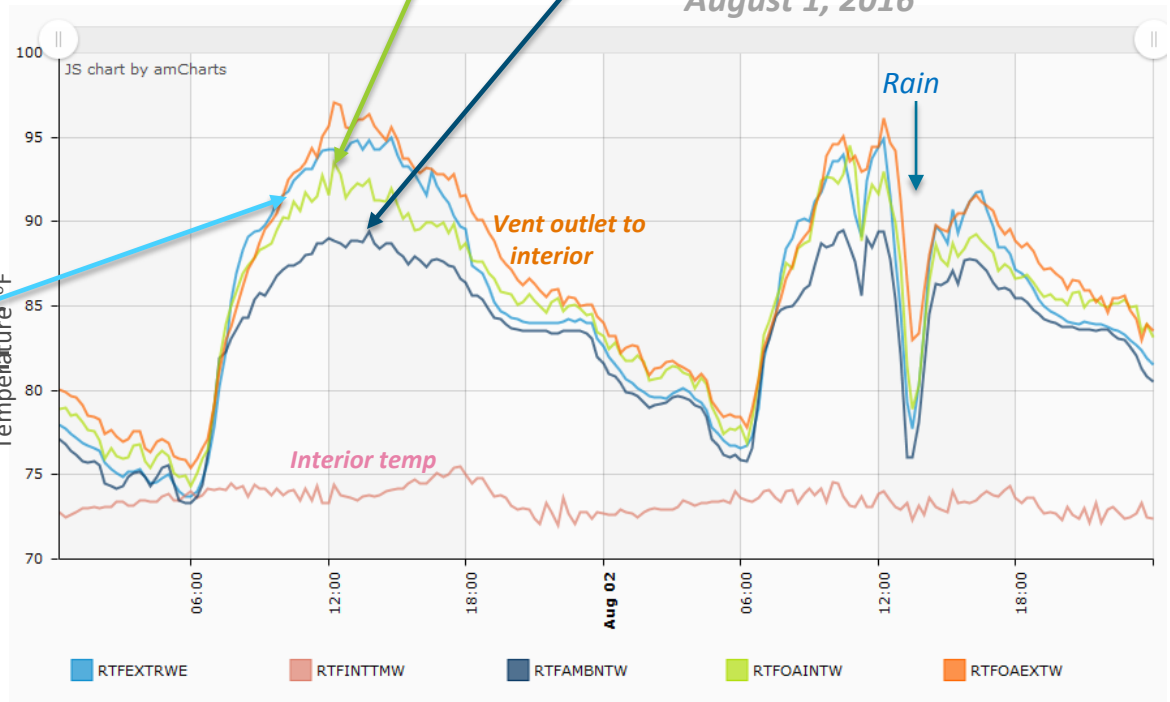


Laboratory Test of Smart Ventilation: Air temperature varies around building

Lessons Learned, outdoor control temperature

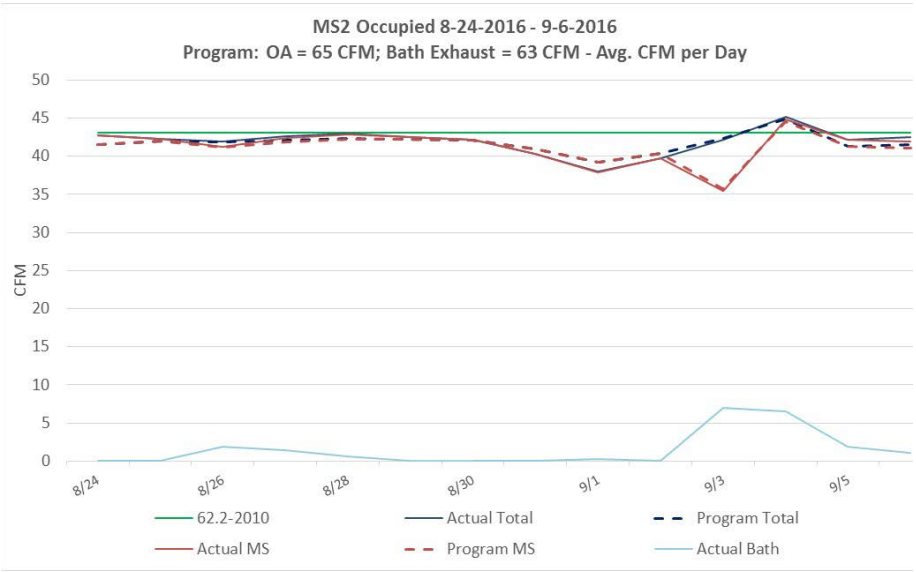
- Potential to use broadband weather to drive Smart Vent, but…
- Air temperature in summer at 15 ft height 3-4 ºF lower than air temperature at soffit inlet
- Increase not coming from attic; evidence of wall related heat
- Air temperature is higher near ground and varies with time of day
- Impact fan heat (60 W @ 138 cfm)
- Ideal s tdoor target 60 º

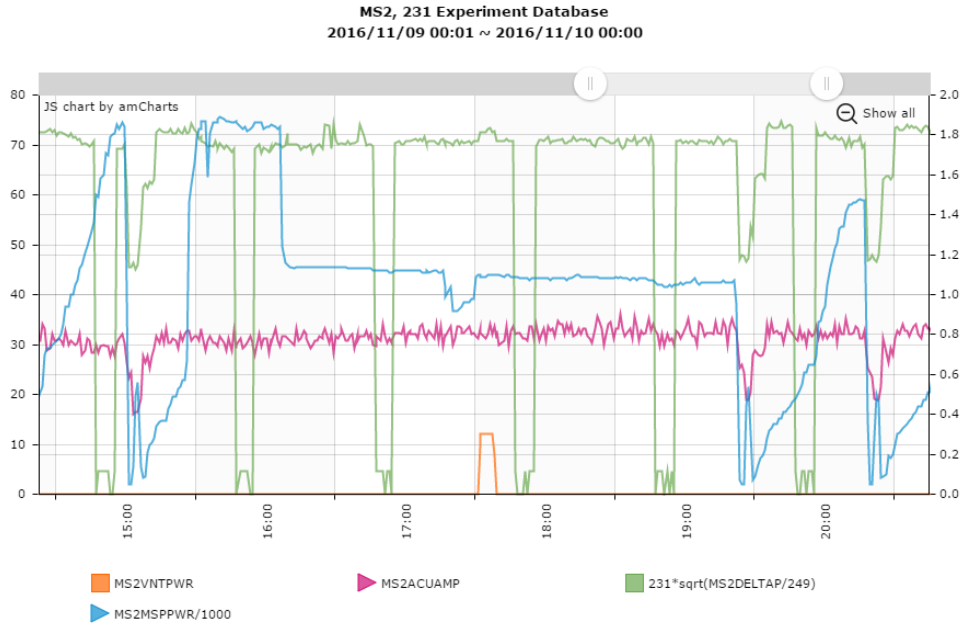


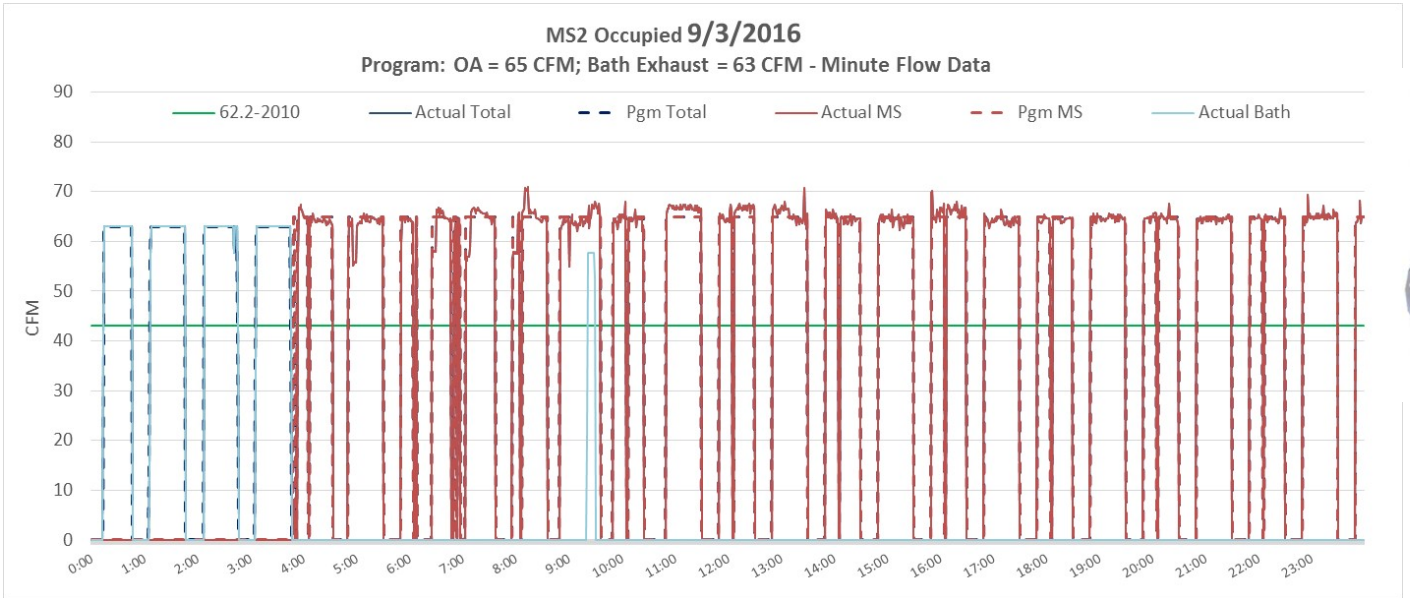


Hybrid Supply / Exhaust System – Field Test

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







AirCycler® g2-k

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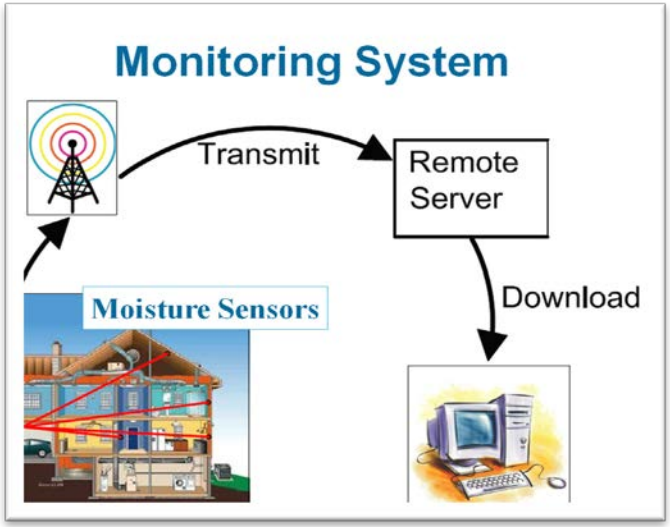
Up Next…

Home Innovation RESEARCH LABS™

Moisture Performance of High-R Wall Systems

Team and Partners	Topic Area
Home Innovation Research Labs w/ American Chemistry Council, NAHB, USDA Forest Products Lab, VSI	High Performance Moisture Managed Building Envelopes (2015)



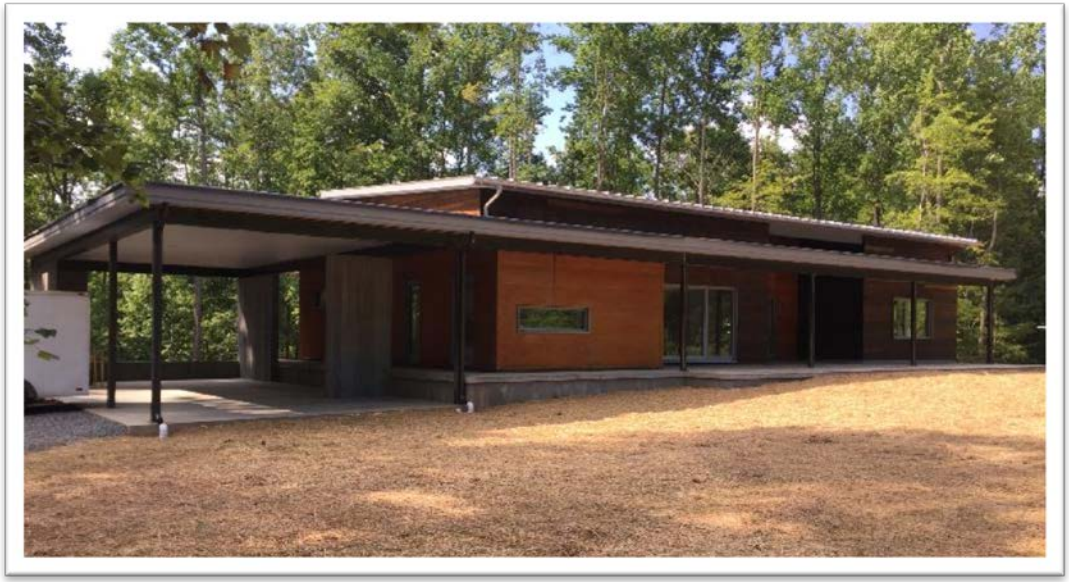
Goal: Study moisture performance of high-R walls (>R-20) in occupied high performance homes across different climate zones. Improve builders' confidence and facilitate transition to high-R walls.

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

- Finalized Wall List sent to Advisory group
- Sensor and instrumentation packages were shipped to **22 sites** for installation
- **18 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
- Preliminary WUFI Simulation

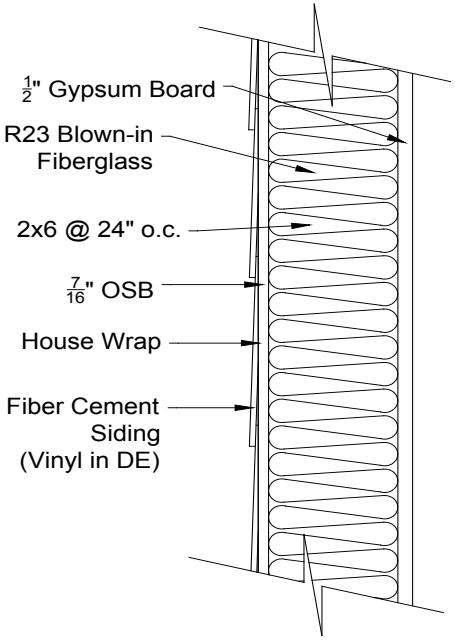
Home Innovation RESEARCH LABS

Wall Attributes

Cladding
Vinyl Siding
Fiber cement
Wood siding
Brick veneer
Stucco

WRB
Housewrap
Zip system
Membrane
Grade D house wrap
Self-adhered membrane

Exterior Insulation
XPS
EPS
PIC
Mineral Wood



Type of Sheathing
OSB
Plywood
Zip system

Cavity Insulation
Cellulose
Fiberglass Batt
Blown-in fiberglass
Flash & Batt
Open cell spray foam

Interior vapor retarder
Kraft paper
Poly
Smart vapor retarder
Class III rated paint

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

Home Innovation RESEARCH LABS



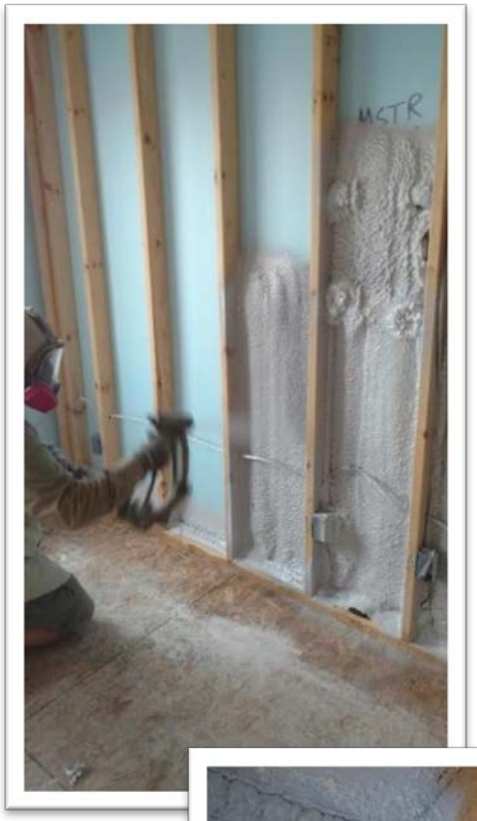


Houses complete…

Two 1200 sf houses in
Grand Rapids, Michigan

Partner Builder:
Arn McIntyre

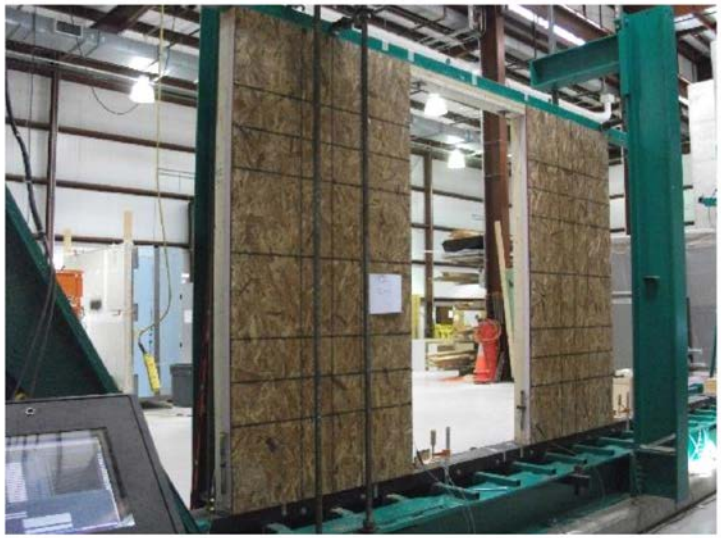
Home Innovation RESEARCH LABS



Wall components

OSB sheathing, Tyvek house wrap and vinyl siding
2x4/2x6 EP&B Framing
2 in. XPS
1 in. flash coat ccSPF
JM Spider cavity fill
Occasional bays with KFB for comparison

Home Innovation RESEARCH LABS



Project Tasks:

Structural Testing

Moisture Monitoring

Constructability Analysis

Construction Guide

Building Code Proposals

Next Step…

Panelized Project

Attic Retrofits Using Nail-Base Insulated Panels

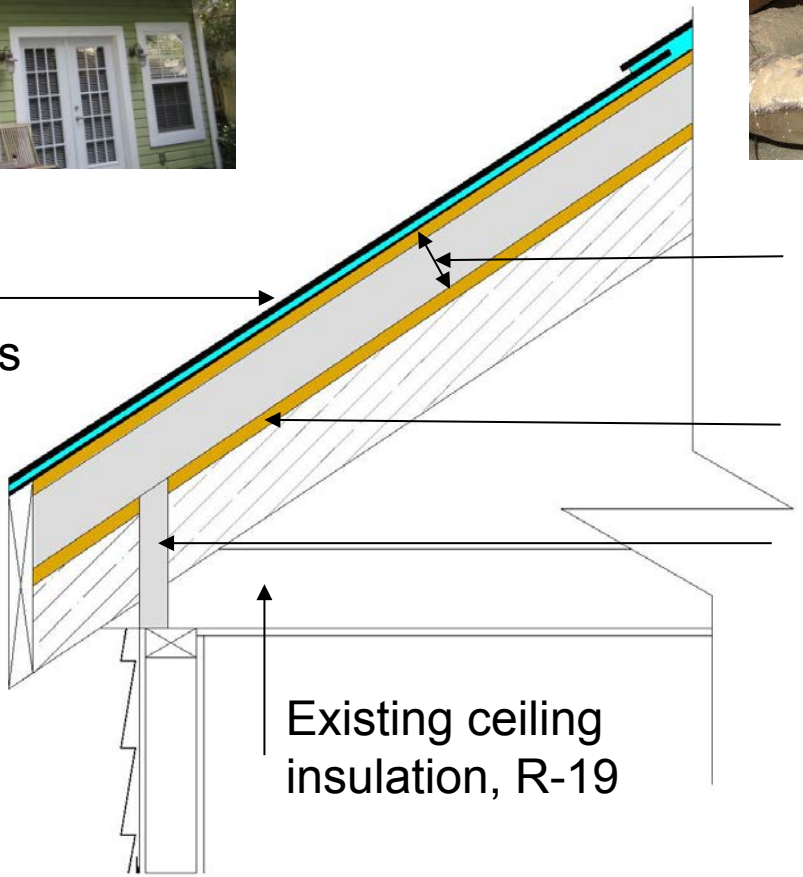
Team and Partners	Topic Area
Home Innovation Research Labs, Inc. w/ SIPA, ACC, APA, Dow, DuPont, Owens Corning	High Performance Moisture Managed Building Envelopes (2015)

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: Heating and cooling energy savings of at least 10%; improved comfort; monitored data that confirms acceptable moisture levels.

Home Innovation RESEARCH LABS

Design Solution: Hot-Humid Climate - St. Simons Island, GA



Roofing: asphalt shingles and ridge vent over vent mat over #15 felt

Retrofit Panel, R-25: 5.5” Neopor® EPS core

Existing roof deck

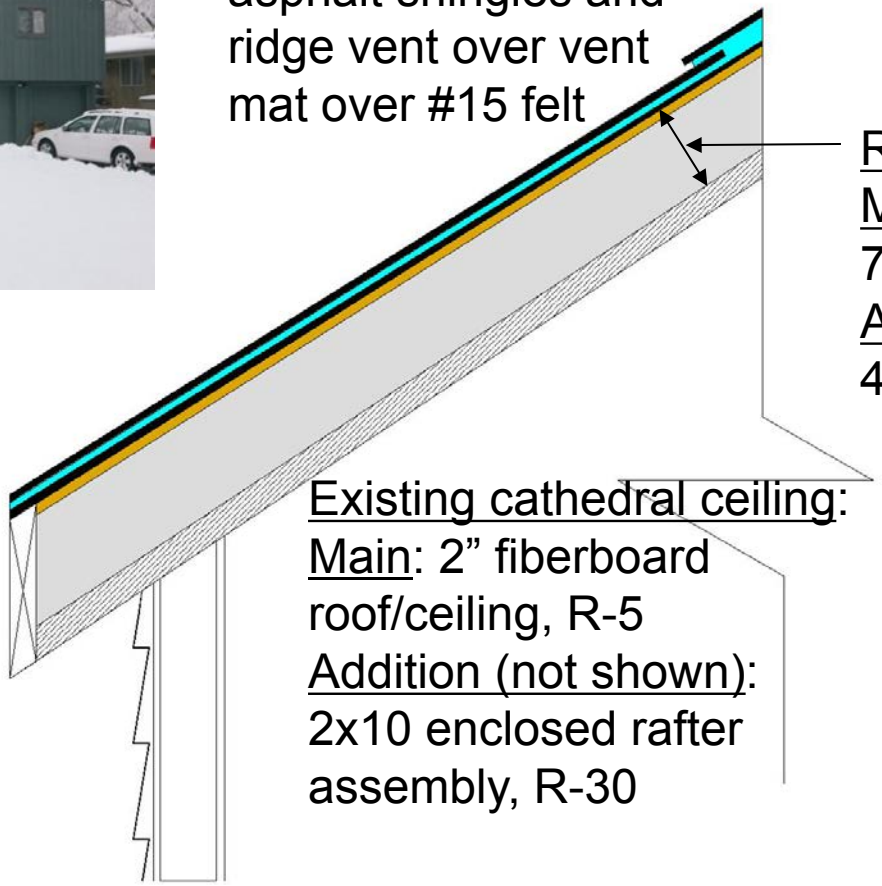
Eave Insulation, R-11: Foil-faced PIC, 2”

Existing ceiling insulation, R-19

Gable Insulation, R-24: (not shown) 2” PIC over 3” Neopor® EPS

Home Innovation RESEARCH LABS

Design Solution: Cold Climate – Ann Arbor, MI



Roofing:
asphalt shingles and ridge vent over vent mat over #15 felt

Retrofit Panel:
Main Roof: R-34, 7.5” Neopor® core
Addition Roof: R-20, 4.5” Neopor® core

Existing cathedral ceiling:
Main: 2” fiberboard roof/ceiling, R-5
Addition (not shown): 2x10 enclosed rafter assembly, R-30

Home Innovation RESEARCH LABS

Observational Research:

Purpose: Assess the constructability of the ventilation mat that is intended to allow outward drying from an unvented roof assembly and reduce shingle T.

Results:

- Overall takeaway was favorable
- Gap maintained at full thickness
- Shingles looked normal (not wavy)

Progress since last quarter:

- Interim Report
- Observational Research
- Design review webinar
- Final design solutions

Next Step: Installations

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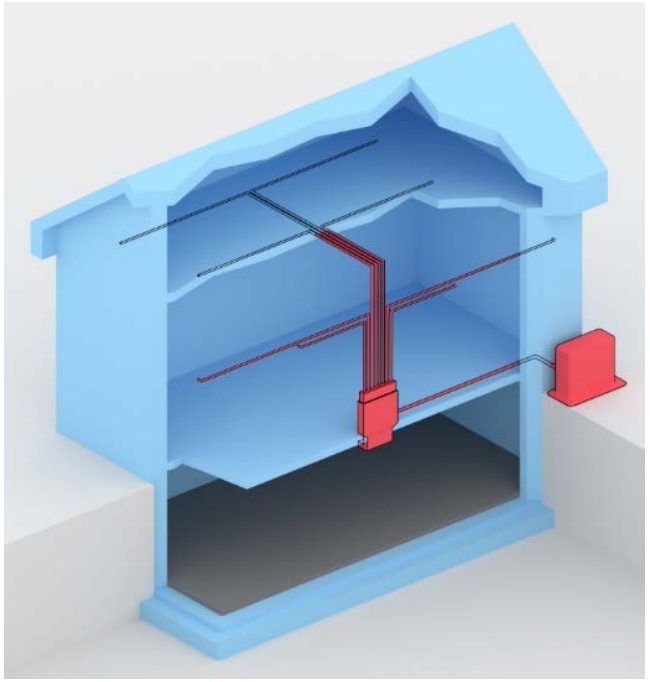
Up Next…

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.

Design Method

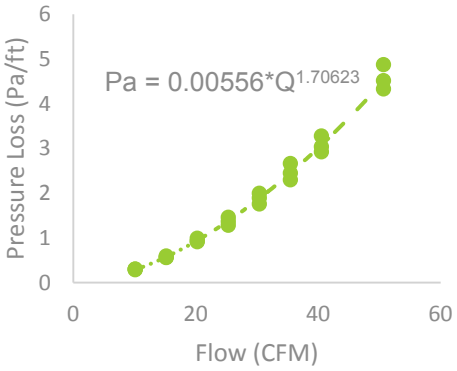
- Vision
  - Can a simple, home run single duct size design approach provide comfort in low load homes (>2009 IECC)
- Several design methods being tested
  - Start with standard ACCA design tools
  - Utilize streamlined 'Manual D' tool
  - Coefficients calculated from lab measurements
  - Determine need for temperature loss compensation

House	4	Lab House
Code	2	IECC 2012
Climate	5	
Nominal CFM	66	(based on 20' L, 60 Pa)
Total CFM	-	
Available Pressure	0.35	in. wc. (from manual S)
Inlet Temp.	120	
Ambient Temp.	75	
Heating factor	0.0231	
Cooling factor	0.0268	

Summary Rollup

#	Room	Heating BTU	Cooling BTU	CFM	Len	Elb	Ducts DM1	DM2	DM3	DM4
1	Breakfast	2519	705	58	18.8	5	1	1	1	2
2	Dining	1749	976	40	21	4	1	1	1	1
3	Family	3267	991	75	8.2	4	1	1	1	1
4	Foyer	2653	510	61	6	3	1	1	1	1
5	Bedroom 2	1983	839	46	28.4	5	1	1	1	2
6	Bedroom 3	1249	2303	62	33.7	5	1	1	2	3
7	Bedroom 4	2808	1829	65	28.8	6	1	1	2	3
8	Master Bedroom	3033	1229	70	13	4	1	1	1	2
9	Master Bathroom	1018	229	24	15	4	1	1	1	1
10	Hall	813	268	19	15	5	1	1	1	1
11	Unfinished Basement	3143	350	73	23	5	1	1	2	2
12	Finished Basement	4015	304	93	23	4	1	2	2	3
13										
14										
15										
16										
		28250	10533			Tot:	12	13	16	22

Select Material
3.0" Thermaflex



$$CFM = \frac{Pa^{\left(\frac{1}{n}\right)}}{C * L}$$

Range of Applicability

- Identify range of loads for typical builder homes at different code levels, and climate zones
- Determine maximum total house load each PnP variant can serve
- Understand tradeoff between total number of ducts, available static pressure, and temperature change.
- **2.5” ductwork can condition a typical 2500 sq. ft. house built to 2012 code.**

	Assuming 0.35" ASP			H Factor	C Factor
				0.0231	0.0268
Diameter	**Flow**	**# Ducts**	**Total CFM**	**Total BTU**	
2	26	16	416	18000	15500
2.5	39	16	624	27000	23300
3	66	16	1056	45600	39300

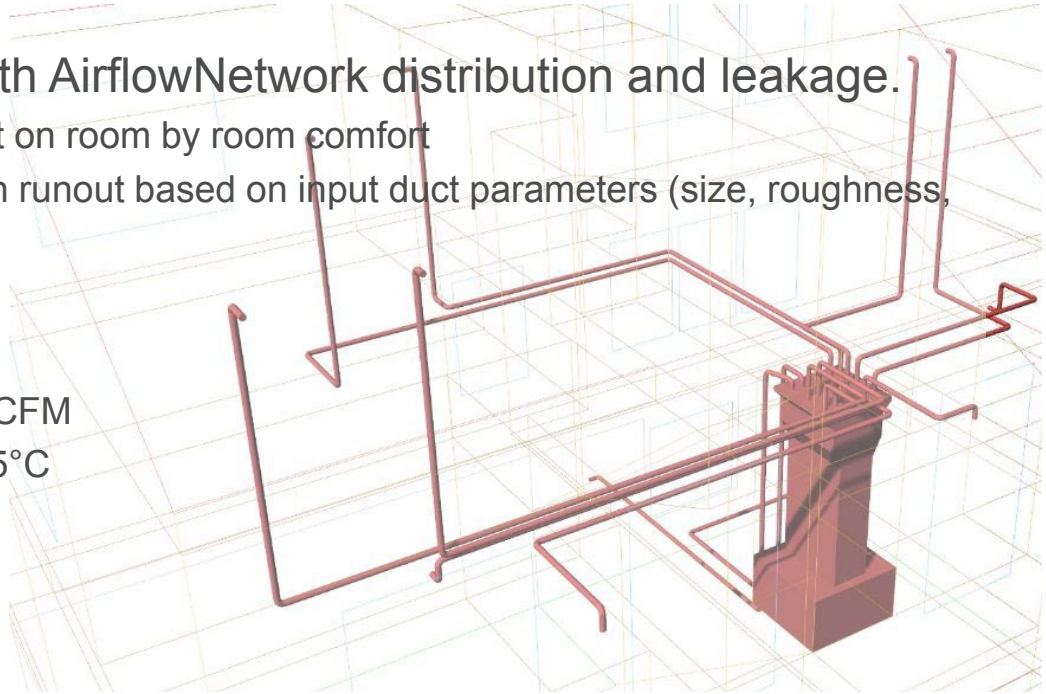
Assuming 0.35" ASP | Heating dT 40 | Cooling dT 30

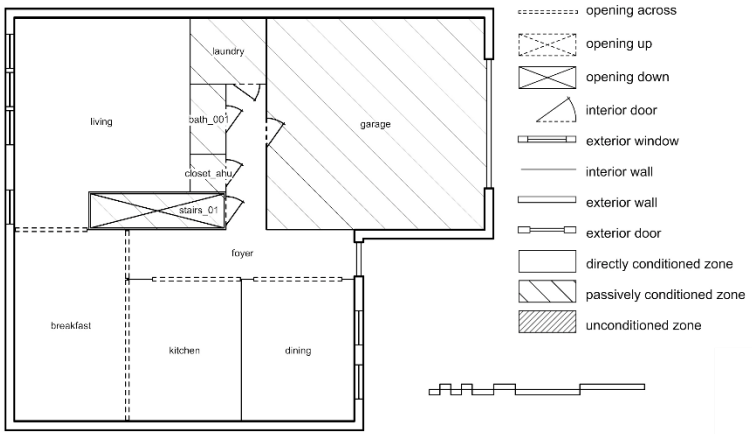
Highest cooling load orientation | Lowest cooling load orientation

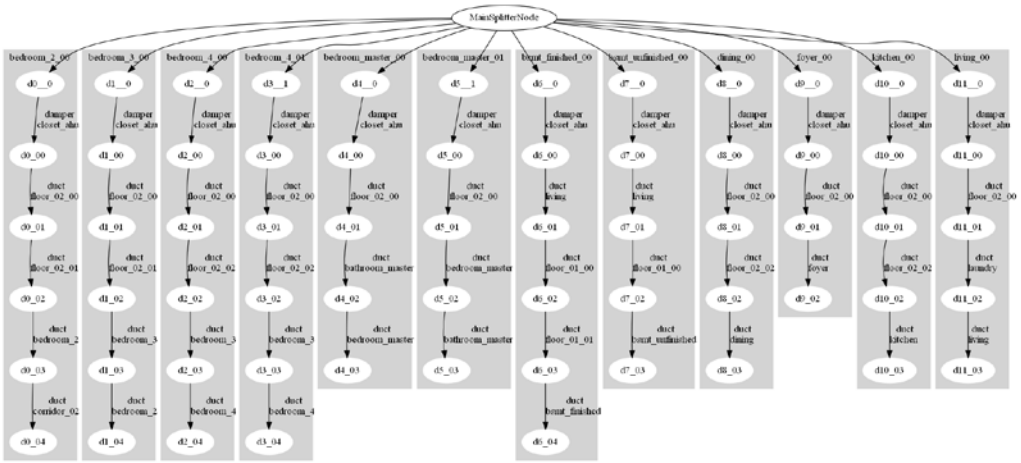
	House 1						House 2						House 3						House 4						House 5					
	Sees						Newtown Mid						Pulte House						Lab House						Imagine					
	876						1124						2252						3168						4157					
	CZ2		CZ3		CZ5		CZ2		CZ3		CZ5		CZ2		CZ3		CZ5		CZ2		CZ3		CZ5		CZ2		CZ3		CZ5	
	2009	2012	2009	2012	2009	2012	2009	2012	2009	2012	2009	2012	2009	2012	2009	2012	2009	2012	2009	2012	2009	2012	2009	2012	2009	2012	2009	2012	2009	2012
Heating	12280	8095	12474	9083	14200	10964	10487	6064	9674	6428	13133	10139	20618	12837	19130	13559	27491	22552	27253	17010	23879	16996	34739	28250	42608	27952	41559	28066	56440	46416
Cooling	13922	10361	11477	9681	10397	9412	14846	11527	14594	9696	12471	11744	21709	16811	20580	16072	17782	16894	18207	13359	20286	14804	11687	10533	43232	33423	42427	28997	26148	22339
2" H																														
2" C																														
2.5" H																														
2.5" C																														
3" H																														
3" C																														

Multi-zone model

- EnergyPlus multizone model with AirflowNetwork distribution and leakage.
  - Simulate air delivery system's impact on room by room comfort
  - AFN determines airflow through each runout based on input duct parameters (size, roughness, dynamic loss, leakage, and U value)
  - Thermostatically controlled
- Prediction accuracy
  - Duct airflow is predicted within +/- 1 CFM
  - Supply outlet air temperature within 5°C







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Up Next…

The Levy Partnership

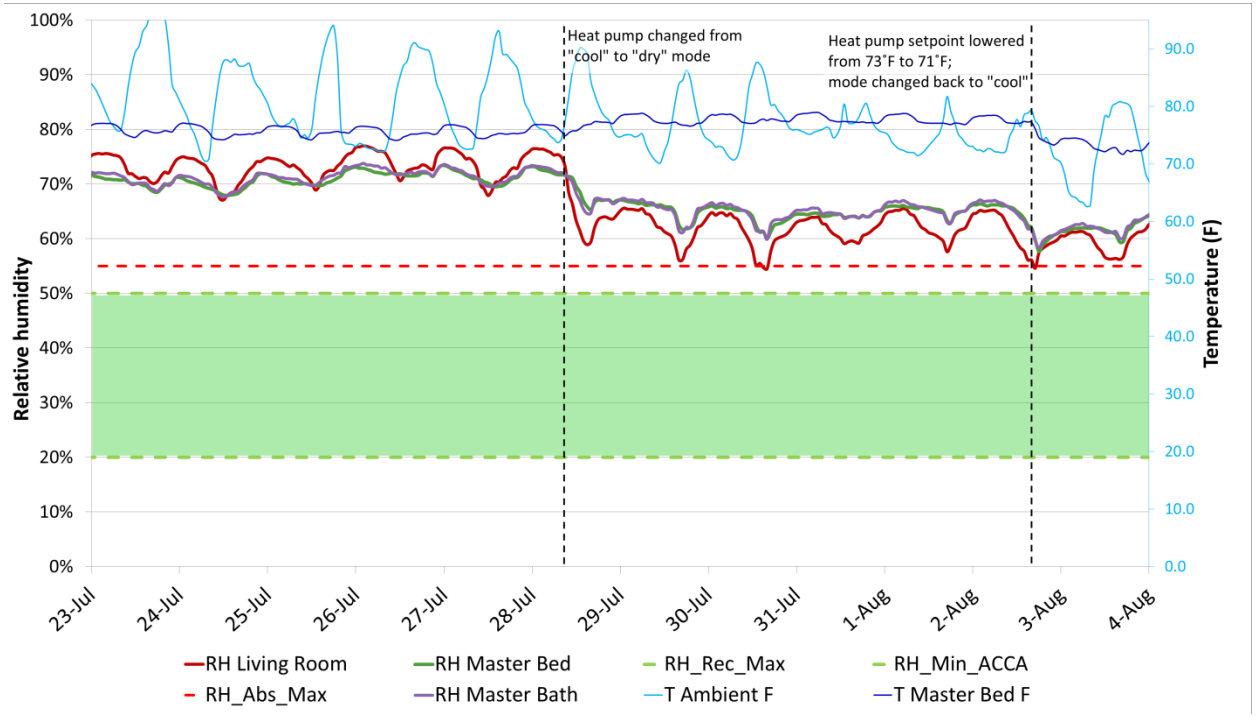
Integrated Design: A High Performance Solution for Affordable Housing

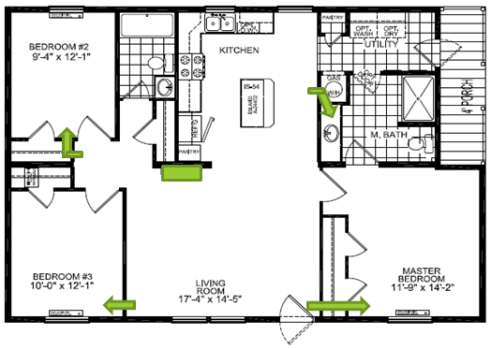
Team and Partners	Topic Area
The Levy Partnership, Inc.	Envelope, Comfort, and IAQ (2015)

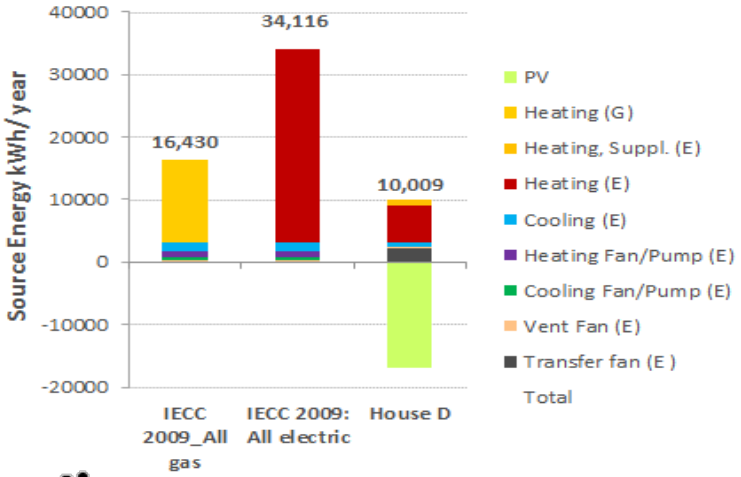
- Develop a high performance Integrated Design for affordable housing (Habitat for Humanity and factory-built)
- Combine a high performance enclosure, ductless mini-split heat pump, transfer fans and ventilation
- Monitor 3 test homes, occupied and unoccupied, for 1 year+
- TRNSYS and BEopt models calibrated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

Compliance with Comfort Criteria: ACCA Manual RS, ASHRAE 55







- Temperatures mostly in compliance
- Relative Humidity exceeded ACCA for large portions of cooling period
- “Dry” mode reduced RH, but temperature increased
- Reducing setpoint helps…but too cool
- Stand-alone dehumidifier uses too much energy

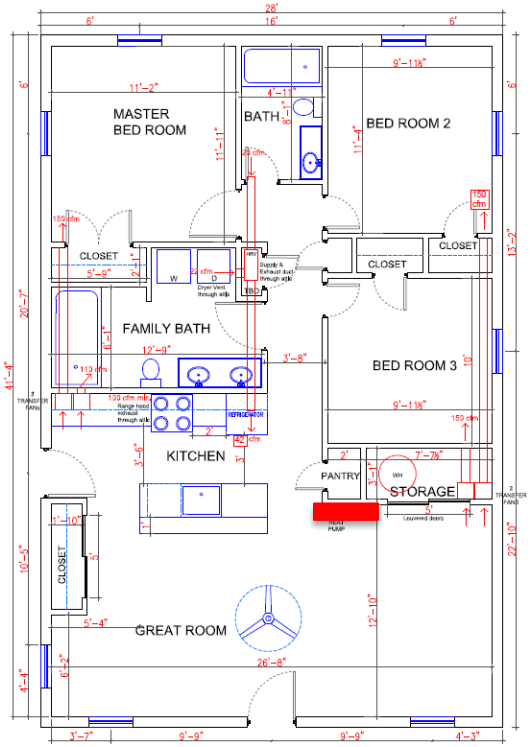
Options:

- Split-coil heat pump (Daiken Quaternity, etc.)
- Multi-zone heat pump (large unit to meet high loads; small unit running continuously at max speed)
- Smaller heat pump that runs more

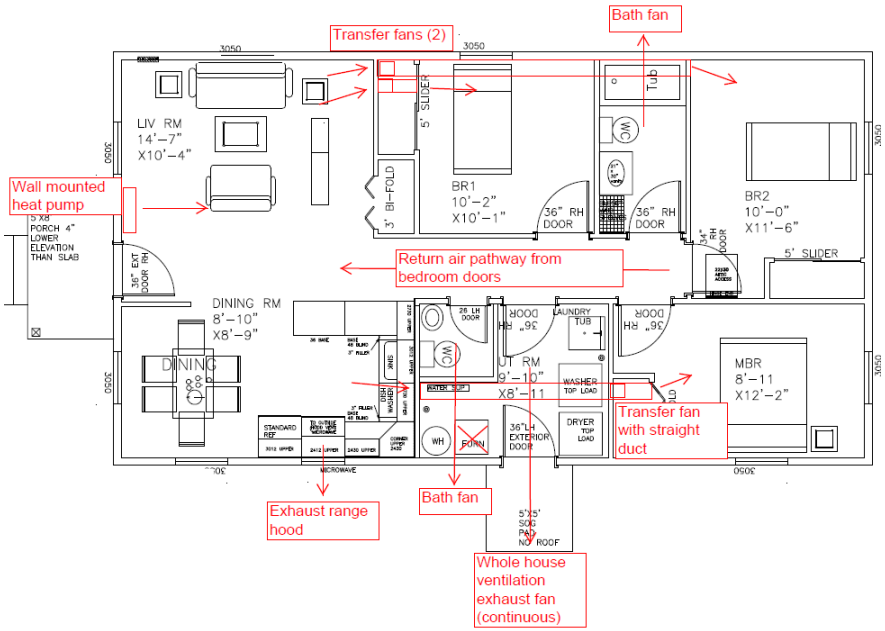
Note that ASHRAE 62.1-2010 and -2013 state that RH should be at or below 65%

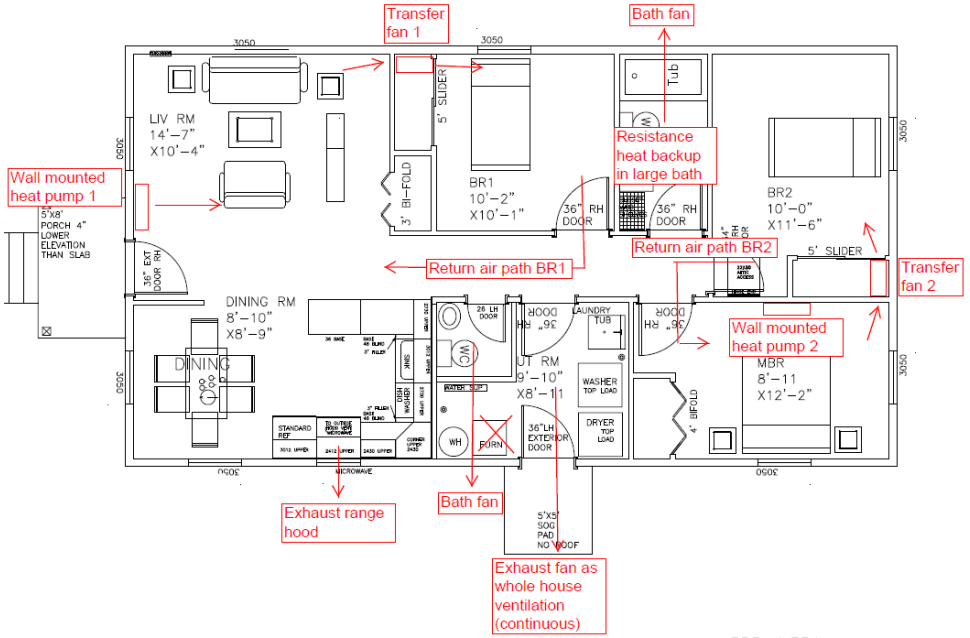
ARIES Collaborative

- New Habitat Houses
- Complete construction spring 2017
- Occupied monitoring for 1 year



Worcester





Susquehanna

ARIES Collaborative

Advanced Residential Integrated Energy Solutions

DOE Institutional Review Board

- New emphasis at DOE on IRB process impacts BA research
- If collecting data from occupied homes, or otherwise involving "human subjects" team may have to go through this process
- IRB comment:
  - "If participating in the research is a condition of receiving a home then the research would be considered coercive and would be un-approvable. The populations receiving these houses would be considered vulnerable and at a greater risk for undue influence. If after the home is awarded, the participants are approached and agree to participate …, that would be acceptable."

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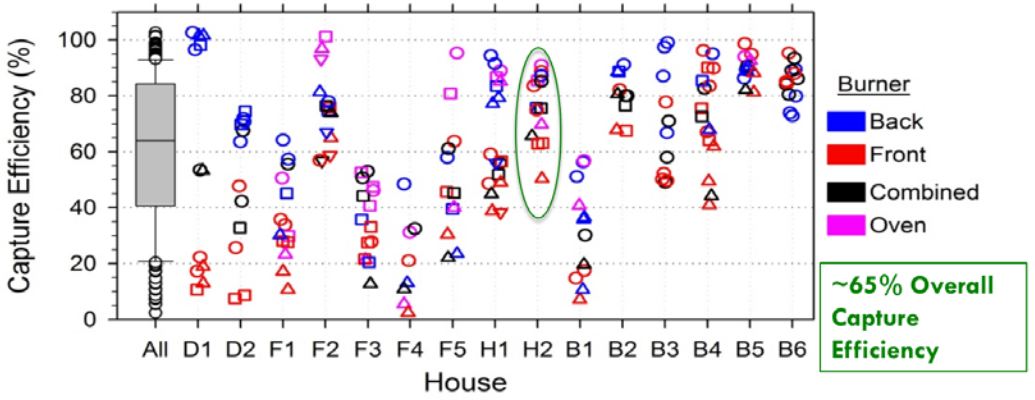
Up Next…

BERKELEY LAB

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
- Hood automation
- Recirculating hoods

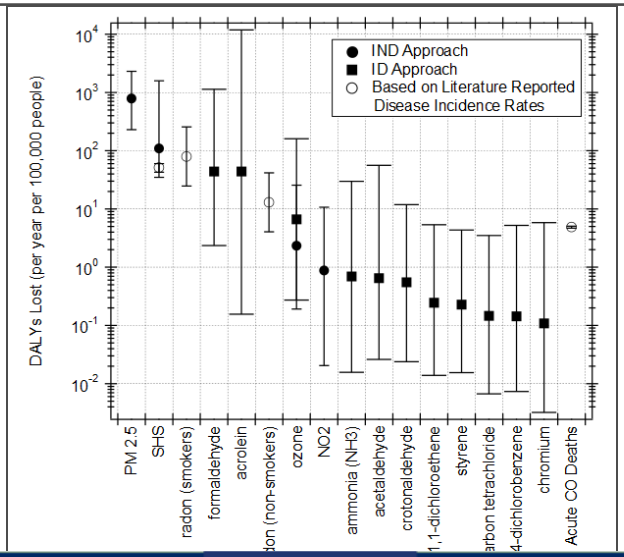


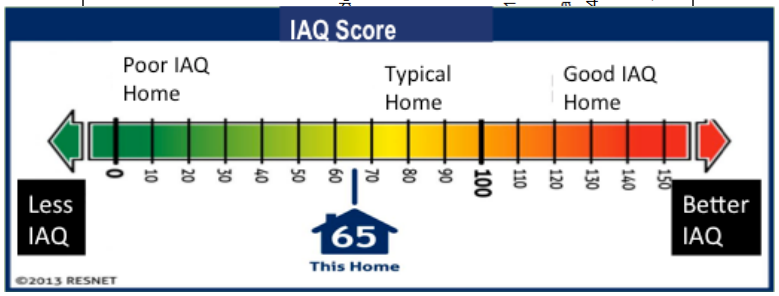
Success Metrics: ASTM Test Method adopted by ASHRAE 62.2, CEC T24, EnergyStar, etc.

IAQ Score Development

National Lab	Topic Area
Lawrence Berkeley National Lab	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
- Input from health experts + practitioners





Success Metrics: Prototype IAQ score ready for use by industry

Codes and Standards

National Lab	Topic Area
Lawrence Berkeley National Lab	Optimal Ventilation & IAQ Solutions (2016)

ASHRAE 62.2: add technical improvements
- Options for filtration
- Natural infiltration superposition
- Zoned systems
- Multifamily requirements

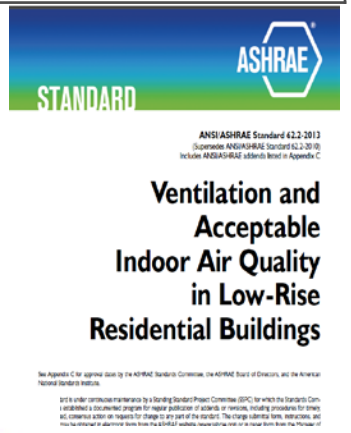
RESNET 380:
- Change other RESNET standards to incorporate 380
- Revise 380 for improved clarity

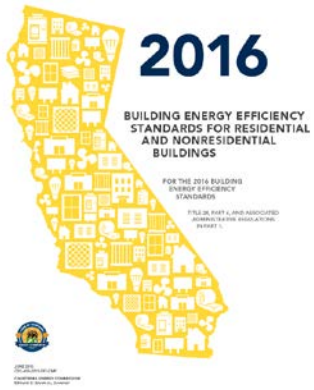
New RESNET HVAC Quality Installation Requirements

ASTM:
- Publish new Range Hood Capture Efficiency Standard

CEC T24 :

- Support ventilation requirements for Net Zero Energy Code





Success Metrics: Publication of new and revised standards

Smart Ventilation I – Occupancy

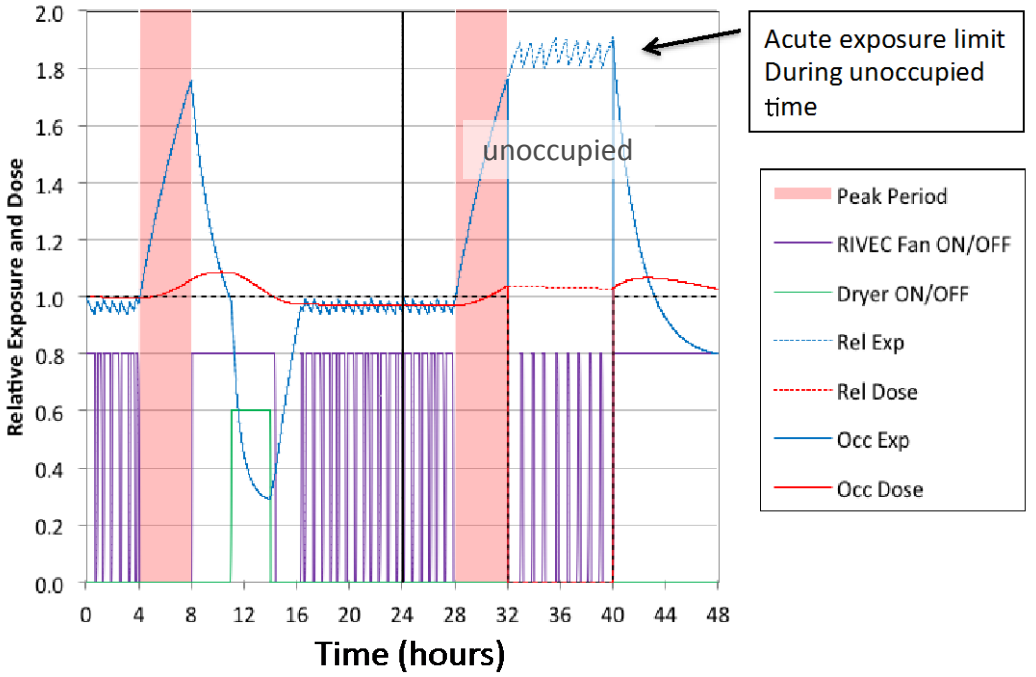
National Lab	Topic Area
Lawrence Berkeley National Lab	Optimal Ventilation & IAQ Solutions (2016)

Ventilation systems to incorporate occupancy

- Ventilate less when no occupants
- Control peak to avoid acute exposure

Implementation

- Timers – just like a programmable thermostat
- Sensors – more flexibility but more error. No current systems will work.



Success Metrics: Guidance on energy savings and implementation of occupant controls

Smart Ventilation II – IAQ Sensors

National Lab	Topic Area
Lawrence Berkeley National Lab	Optimal Ventilation & IAQ Solutions (2016)

Innovations in sensors

- Are they any good? Accuracy, durability, reliability
- Are they measuring the right things?
  - PM, Nox, Formaldehyde, Acrolein, T, RH, Benzine, Ethanol?
- Can we use them as diagnostic tools?
- Can we use them as ventilation controllers?

Need laboratory testing …

Success Metrics: Guidance on use of Low-Cost IAQ sensors

Smart Ventilation III – IAQ Sensors – prelim data

National Lab	Topic Area
Lawrence Berkeley National Lab	Optimal Ventilation & IAQ Solutions (2016)

We want:

- PM2.5, NO2, Formaldehyde, Acrolein, T, RH,+ couple of specific VOCs, e.g., benzine

We get:

- Some of these…

Device	Price	Temp	RH	CO_2	VOC	$PM_{2.5}$	PM_{10}	CO	Ozone	NO_2
Birdi (NA)	$119	●	●	●	●	●				
Koto Air Cubes	$139	●	●	●						
Netatmo	$149	●	●	●						
Speck	$149	●				●				
Airmentor	$183	●	●	●	●	●	●	●		
Awair	$199	●	●	●	●	●	●			
BlueAir-Aware	$199	●	●	●	●	●	●			
Foobot	$199	●	●	●	●	●		●		
Air Quality Egg	$280	●	●			●	●	●	●	
Dylos-DC 1100	$290					●	●			
uHoo (NA)	$299	●	●	●	●	●		●	●	

Device	Price	Temp	RH	CO_2	VOC	$PM_{2.5}$	PM_{10}	CO	Ozone	NO_2
Birdi (NA)	$119	●	●	●	●	●				
Koto Air Cubes	$139	●	●	●						
Netatmo	$149	●	●	●						
Speck	$149	●				●				
Airmentor	$183	●	●	●	●	●	●	●		
Awair	$199	●	●	●	●	●	●			
BlueAir-Aware	$199	●	●	●	●	●	●			
Foobot	$199	●	●	●	●	●		●		
Air Quality Egg	$280	●	●			●	●	●	●	
Dylos-DC 1100	$290					●	●			
uHoo (NA)	$299	●	●	●	●	●		●	●	

● Yes ● Somewhat ● No ● Not clear from product literature

And not always in the right range

Success Metrics: Guidance on use of Low-Cost IAQ sensors

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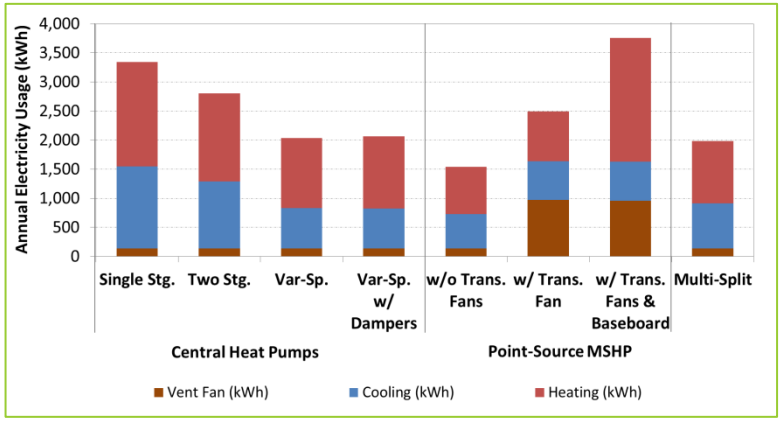
Up Next…

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Minimizing Comfort Risks in Low-Load Homes

National Lab	Topic Area
National Renewable Energy Laboratory	Optimized Comfort Systems for Low-Load Homes



Improved Moisture Modeling in Low-Load Homes

In collaboration w/ ORNL, assess the sensitivity latent and sensible gains have on comfort and recommended system sizing in low-load homes

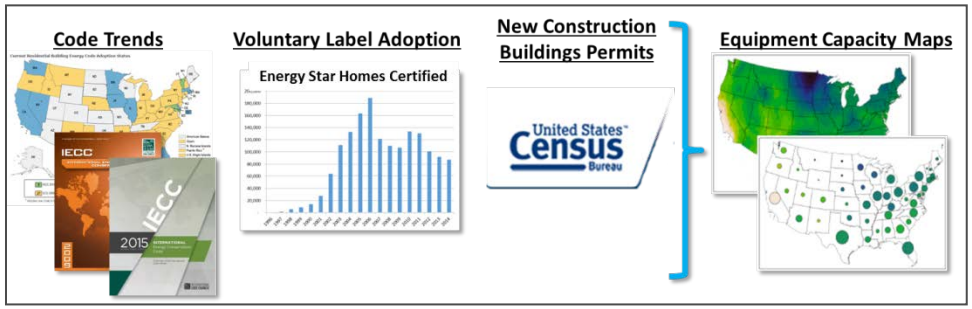
Low-Load Home Zoning Best Practices

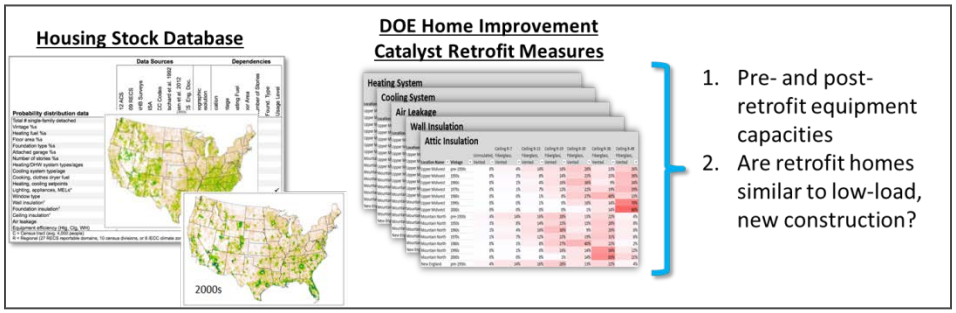
Investigate performance and cost tradeoffs of various equipment types to achieve uniform temperature distribution in low-load homes.

Success Metrics: Sufficient guidance available to ensure comfort in low load homes.

HVAC Market Characterization for Low-Load Homes

National Lab	Topic Area
National Renewable Energy Laboratory	Optimized Comfort Systems for Low-Load Homes





Construction and Market Projections for Low-Load Homes

- Forecast the market penetration and equipment needs for new construction and post deep-energy retrofit low-load homes

Success Metrics: Provide justification to HVAC manufacturers to produce equipment optimally designed for low-load homes.

PV-Assisted HPWH

National Lab	Topic Area
National Renewable Energy Laboratory	Integrated Renewables

Prototype PV Heat Pump Water Heater

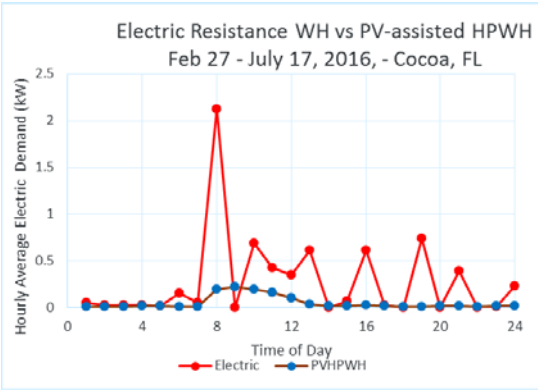
Canadian Solar 310 Watt modules

ABB (Power-One) Microinverter

GE GeoSpring 50 gal HPWH

Testing at FSEC Hot Water Systems Laboratory

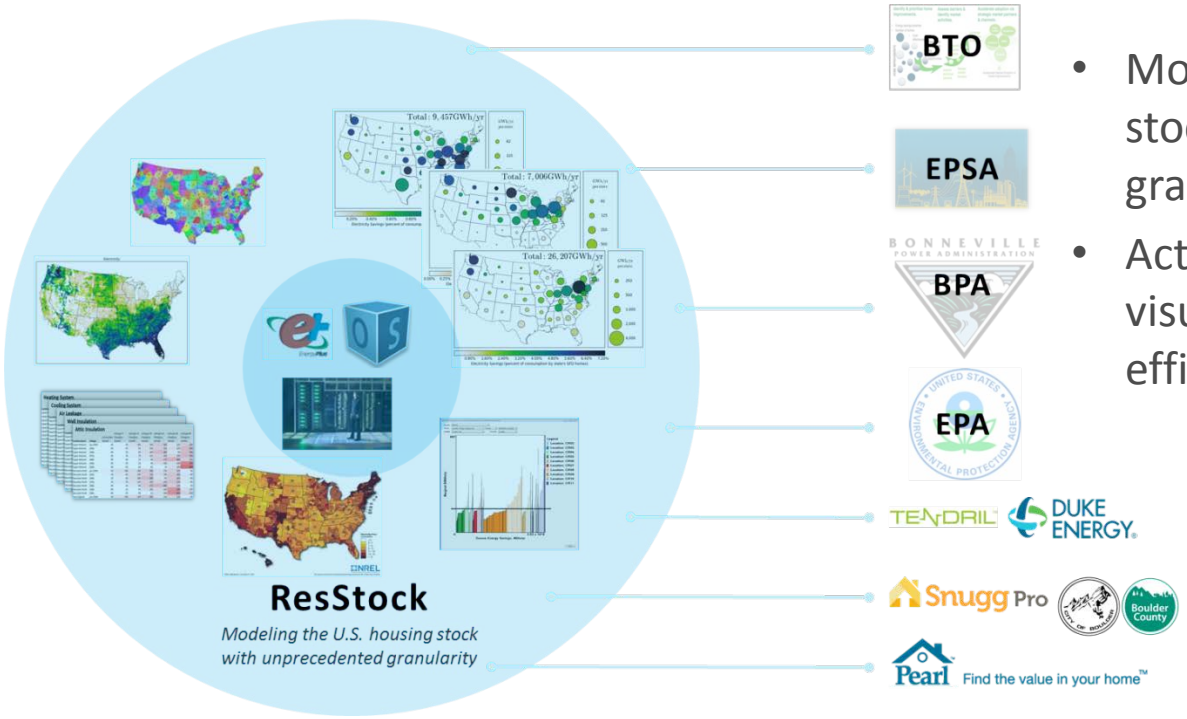
- Findings
  - 0.8 Quads potential savings
  - 100% self-consumption of PV
  - $1,200 incremental cost
  - 50-70% savings over resistance
  - Total system COPs of 5-7



Success Metrics: Proof of concept of cost-effective solar storage solution.

ResStock – Quantifying Energy Efficiency Potential in US Housing Stock

National Lab	Topic Area
National Renewable Energy Laboratory	Tools & Analysis

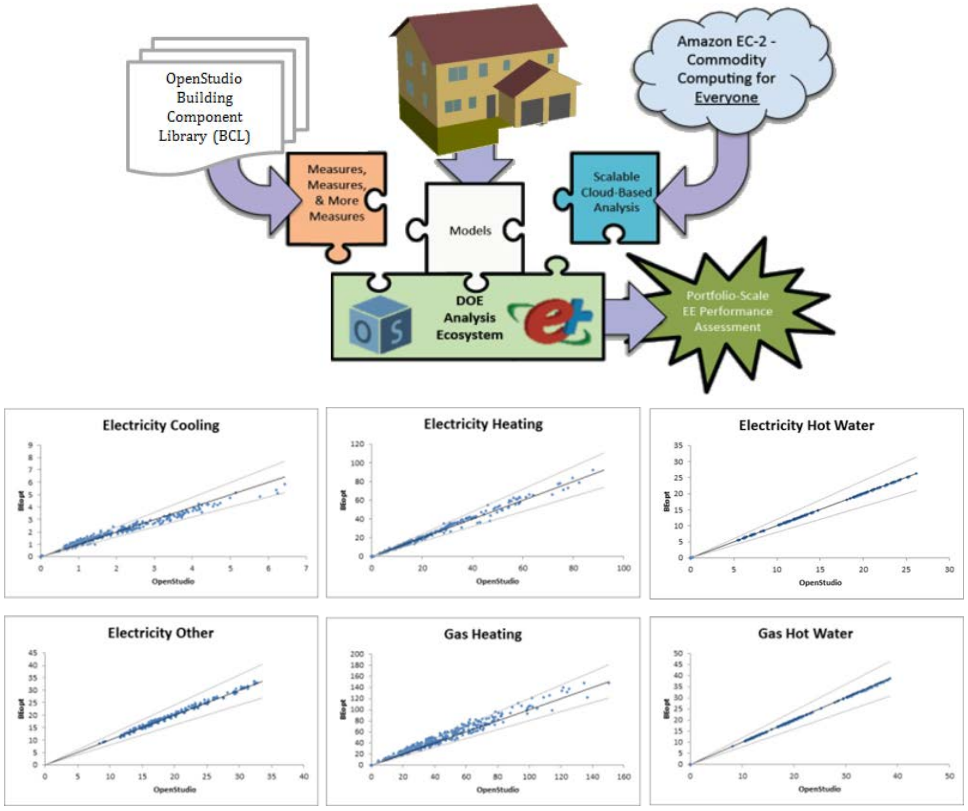


- Model the entire U.S. housing stock with unprecedented granularity
- Actionable analyses and visualizations of U.S. energy efficiency potential

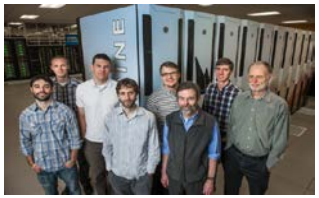
Success Metrics: Driving and optimizing EE investments at scale

Residential Modeling Capabilities in OpenStudio/EnergyPlus

National Lab	Topic Area
National Renewable Energy Laboratory	Tools & Analysis



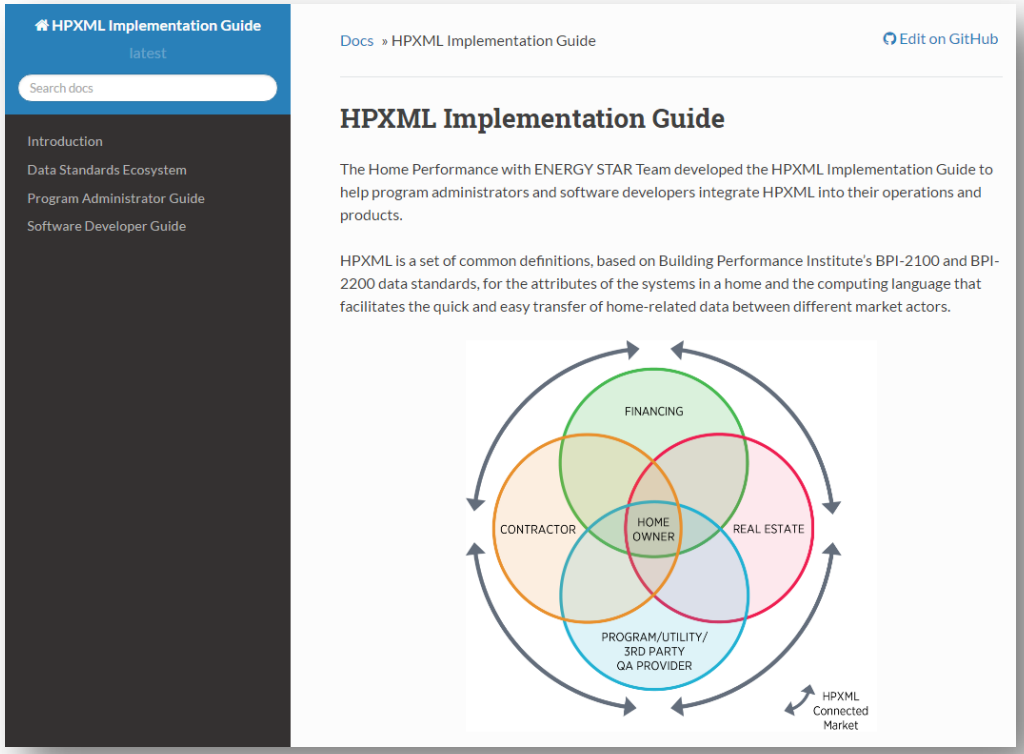
- EnergyPlus
  - Foundation heat transfer model
  - Airflow Network enhancements
  - HVAC system flexibility/capability for single-zone models
  - Speed up HPWH model
- OpenStudio
  - Wrap new E+ capabilities
  - Complete testing



Success Metrics: Achieve parity with BEopt technologies

Better Buildings Data Accelerator - HPXML

National Lab	Topic Area
National Renewable Energy Laboratory	Tools & Analysis



- Develop a data dictionary for HPXML that is linked to the schema and other data dictionaries such as BEDES and RESO
- Develop HPXML import capability to SEED to support residential data collection and aggregation

Success Metrics: EE upgrades accelerated as a result of reduced data management costs

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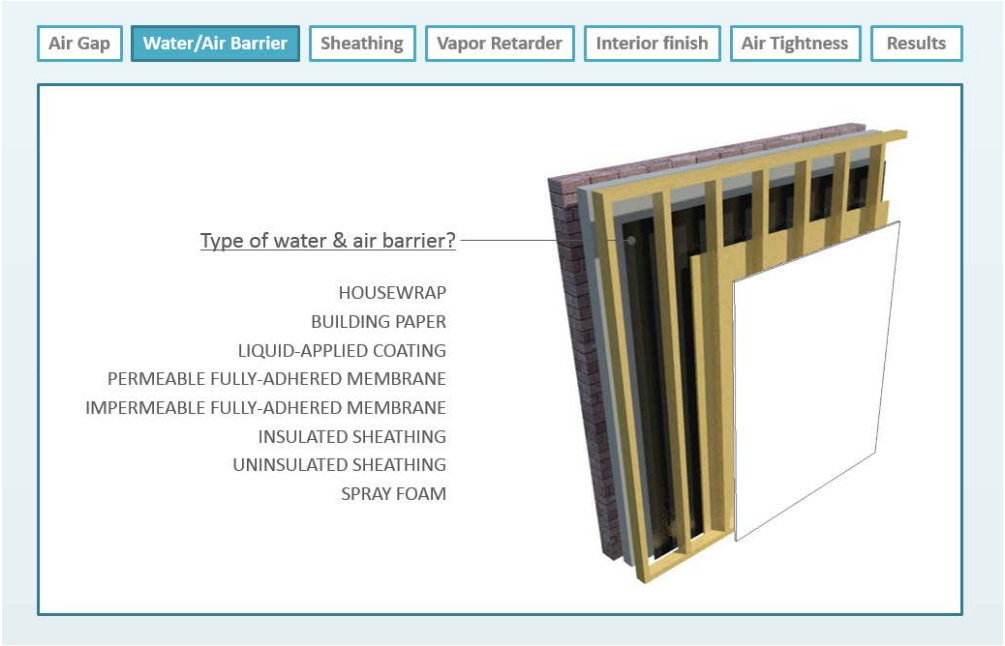
Up Next…

OAK RIDGE National Laboratory

Moisture Managed Wall Expert System

National Lab	Topic Area
Oak Ridge National Laboratory	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



Success Metrics: Moisture durability assessments that are used by the construction industry

why?

- Due to more insulation and overall airtightness in modern building envelopes, they do not dry out as easily; therefore, there are increased risks due to unmanaged moisture
- Predicting moisture durability performance of high-*R* envelope assemblies is complex
- Different envelope assemblies will perform differently depending on climate
- A practical means to vet assemblies for moisture durability is needed

Building Science Advisor: Preliminary Output

Back/Decision | Air Gap | Water/Air Barrier | Sheathing | Vapor Retarder | Interior Finish | Air Tightness | Results

Summary of your wall

Map Location	Fort Worth, TX
Exterior Cladding	Vinyl Siding
Structure	2 x 4 16" o.c.
Cavity Insulation	Fiberglass Batt
Continuous Insulation	None
Air Space	Vented Air Space
Water/Air Barrier	Housewrap
Exterior Sheathing	Oriented Strand Board
Vapor Retarder	None
Interior Finish	Latex Paint
Air Tightness	5 ACH50

Predicted moisture durability performance

For "yellow" and "green" please use guidance table for optimized performance.

Guidance

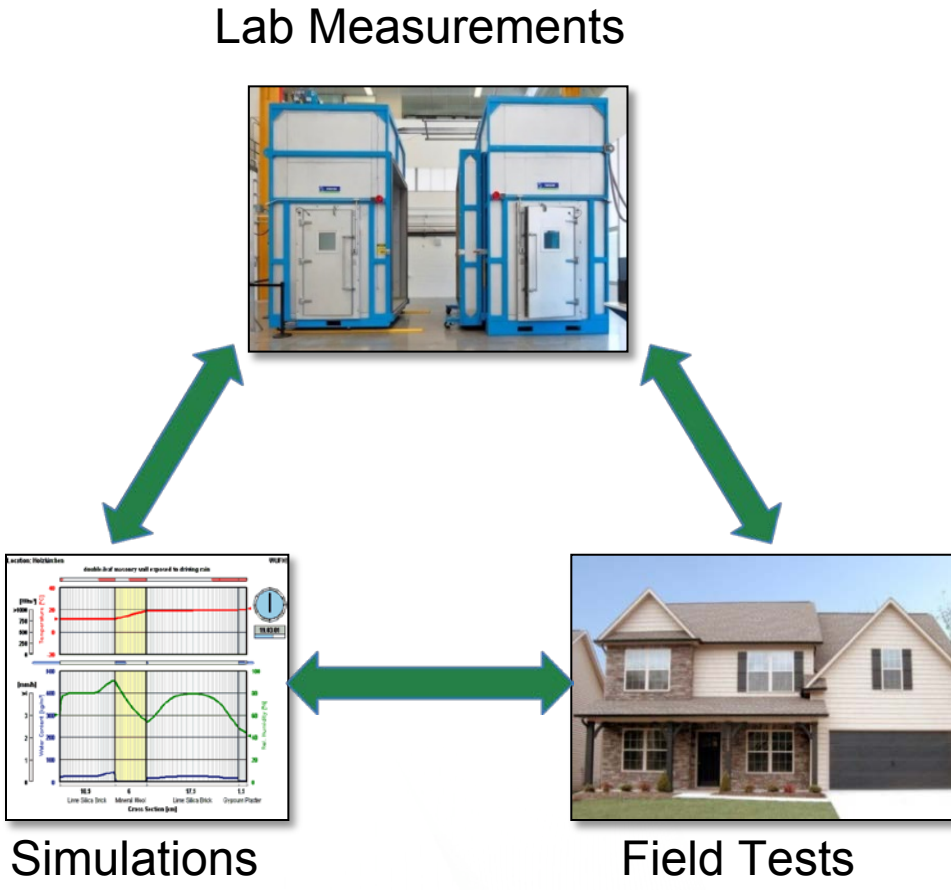
- The wall design protects the inside from rain water, both directly and indirectly through cladding or wicking.
- The wall design is airtight, thus low air leakage is expected that could carry water vapor to the inside of the wall.
- The wall design avoids condensation and can dry to the inside, outside or both.

Moisture managed, high performance envelope systems analysis

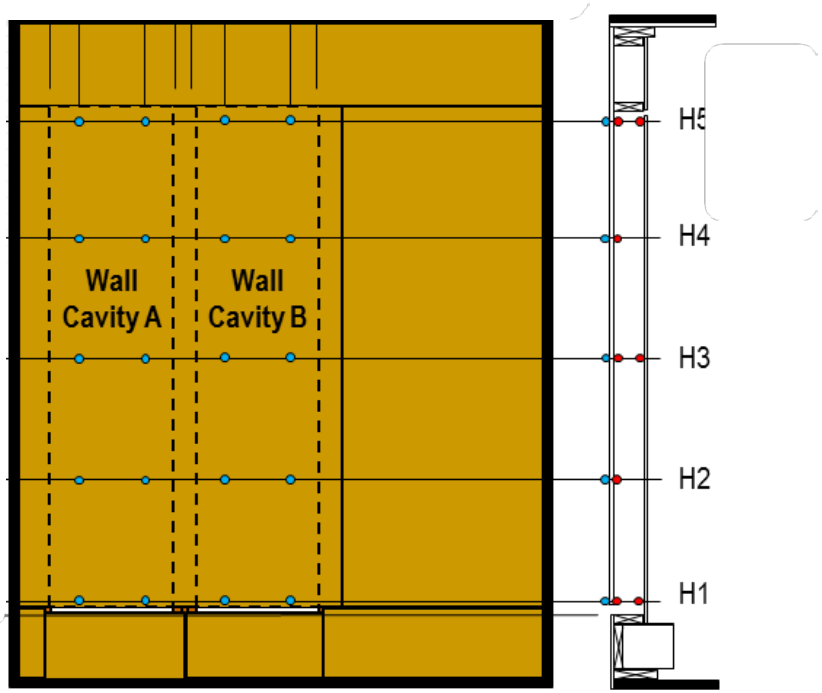
To minimize moisture risks, hygrothermal performance must be assessed under many different conditions, (e.g. varying material properties, workmanship, indoor conditions, and the outdoor environment)

ORNL will leverage limited field evaluations (conducted by Building America teams) with targeted lab chamber tests, to validate probabilistic simulation models.

ORNL will complement the field evaluations (used to validate simulation models) with controlled laboratory tests conducted in the ORNL HAM (Heat, Air, and Moisture) chamber

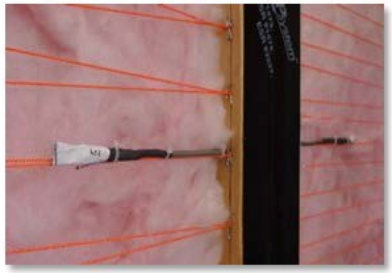


Validation with laboratory measurements



Elevation of test wall Cross-section

- Temperature
- Temperature and relative humidity

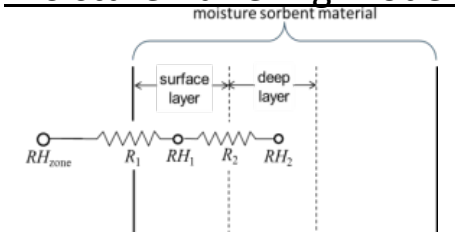


Sensitivity Analysis of Humidity in Low-Load Homes

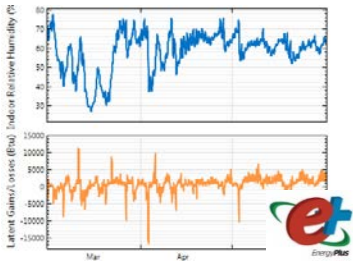
National Labs	Topic Area
Oak Ridge National Laboratory **National Renewable Energy Laboratory**	Optimized Comfort Systems for Low-Load Homes

- Evaluate the sensitivity of indoor humidity to:
  - Equipment sizing
  - Equipment airflow
  - Blower-off delay
  - Moisture loads
  - Moisture buffering
- Use a probabilistic approach to explore the full range of conditions that impact relative humidity.
- Future BA R&D and mitigation strategies will be based on targeting the factors that have the highest impact on comfort in low load homes.

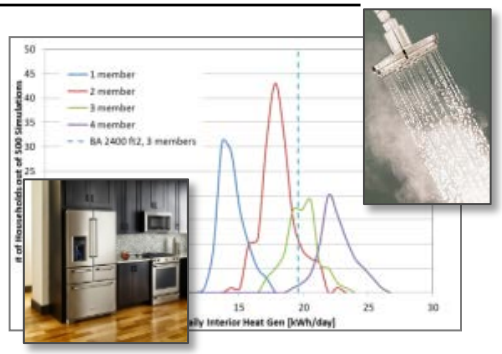
Moisture Buffering Model



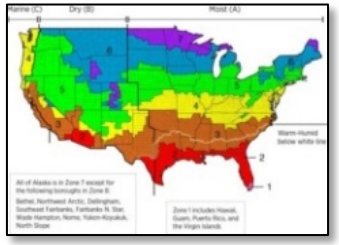
Annual Simulations



Internal moisture loads



U.S. Climate Regions



Success Metrics: Relative impact of internal loads, equipment sizing, and equipment setup on relative humidity in low load homes.

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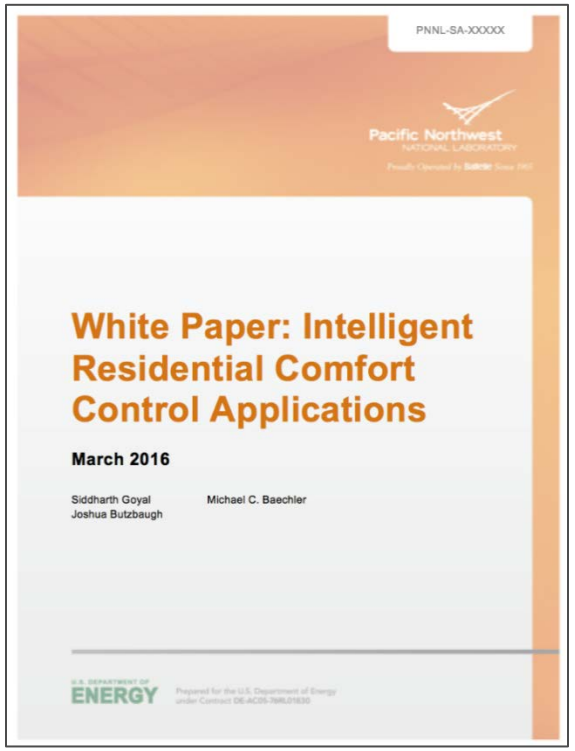
Up Next…

Pacific Northwest
NATIONAL LABORATORY

Framework for "Smart" HVAC Applications

National Lab	Topic Area
Pacific Northwest National Laboratory	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



Success Metrics: Assessed technology and market needs

Accelerated Window Attachment Market Transformation

National Lab	Topic Area
Pacific Northwest National Laboratory	High Performance Building Envelope Assemblies and Systems

- Facilitate market transformation of energy-efficient window attachments
  - Attachment Energy Rating Council (AERC) participation
  - Assisting ENERGY STAR to launch framework for label on storm windows
- PNNL Lab Home testing of dynamic control of cellular shading devices
- Partnering Organizations: BPA, NEEA, Hunter Douglas, Larson Manufacturing, Quanta Technologies, Birch Point Consulting and Efficiency Solutions

Success Metrics: ENERGY STAR label, more product sales, utility acceptance

Building America Solution Center

National Lab	Topic Area
Pacific Northwest National Laboratory	Prove Savings at Scale

- **Develop a new home improvement navigation tool that will link existing home content to remodeling projects and proper sequencing**
- Design and launch additional features to be primary public facing tool for Building America publications
- Ensure content is current with partner program requirements
- Particular focus on outreach in FY17

- Average of over 35,000 page views/month in FY16 (doubled since FY13)

Success Metrics: Number of guides, number of users, number of page views

Accelerated Market Adoption of Heat Pump Water Heaters

National Lab	Topic Area
Pacific Northwest National Laboratory	Prove Savings at Scale

- Increase market penetration of HPWHs
- Coordinate with ORNL
- Identify successful regional deployment programs and help replicate nationally
- Target partnerships with REEOs, utilities, production home builders, etc.
- Investigate retailer, installer and manufacturer involvement in national initiative
- Develop HPWH Deployment Plan

Success Metrics: Number of successful projects identified, strategic partnerships

Building Science Education

National Lab	Topic Area
Pacific Northwest National Laboratory	Accelerate Market Adoption

- Improve building workforce
- Outreach focused on content development for the Building Science Education Solution Center (BSESC)
- Maintain current partnerships, develop new partnerships with higher education institutions and private industry
- Partner with CBI/NIBS BB Workforce Guidelines to develop cohesive strategy

Success Metrics: Number of modules added to BSESC, partner reach

Codes and Standards Integration

National Lab	Topic Area
Pacific Northwest National Laboratory	Accelerate Market Adoption

- Assist Building America research teams with code barrier issues and code proposals
  - Remove code and standard barriers that hinder innovations
- Develop specific guidance for code officials and builders
- Educate code officials and builders on expectations for compliance (31 code briefs available on BASC)
- Partnering organizations:
  - Building America research teams
  - Regional Energy Efficiency Alliances

Success Metrics: Code barriers overcome, code briefs developed, code proposals assisted, trainings provided

Up Next…

Outreach and Promotion

Telling Your Story

Promote Your Amazing Work

- Seize the opportunities
  - Research Publications
  - Project Highlights
  - Project Partnerships
  - Conferences, Meetings, and Industry Events

Leverage All Communication Channels

Complementing Your Efforts

- DOE/EERE
  - Social Media
- Building Technologies Office
  - Weekly newsletter
- Building America
  - Website
  - Webinars
  - Monthly Newsletter
- Industry Media Partners


ENERGY.GOV
Office of Energy Efficiency & Renewable Energy

Building America Program

Building America Update: Partnerships and Innovation Focus of Latest Funding Opportunity

Welcome to the Building America Update, a monthly newsletter.

Partnerships and Innovation Focus of Latest Funding Opportunity

To move the industry toward higher efficiency and more innovation, the Department of Energy (DOE) Building Technologies Office (BTO) released a Funding Opportunity Announcement (FOA), Building America Industry Partnerships for High Performance Housing Innovation – 2017, on Nov. 3, 2016.

We are looking for more project teams that can accelerate energy performance improvements in residential buildings using an integrated building systems approach to achieve peak energy

Building America U.S. Department of Energy

This Month's Residential Successes

- Solar Water Heating in Multifamily Buildings-Greenfield, Massachusetts
- BrightBuilt Home, Modular Zero

Maximize Building America Brand

- **Use the logo**
  - Add it to presentation templates
  - Add it to your report covers
  - Share it with guidance
- **Take (good) photos**
- **Send us your stories**

Up Next…

Existing Homes Roadmap Discussion

Existing Homes: Envelope

What are the top 3 transactions with most potential for improving envelopes in existing homes?

Existing Homes: Envelope

Which type of envelope upgrade has the largest remaining technical gap or research need?

- Wall Insulation
- Attic Insulation
- Foundation Insulation
- Air sealing (attic, basement, crawlspace, interior)
- Window Attachments/Window Rehab

Existing Homes: Envelope

Related to envelope upgrades in existing homes, which of these barriers could be addressed by further research?

- Costs
- Moisture issues
- Challenges of finishing
- Disruption to occupants
- Other (explain)

Existing Homes: Wall Insulation

What are the remaining technical gaps and/or research needs related to adding continuous insulation during typical re-siding transaction?

Existing Homes: Wall Insulation

What are the remaining technical gaps and/or research needs related to increasing wall R-value (as a stand-alone EE measure)?

Existing Homes: Attic Insulation

What are the remaining technical gaps and/or research needs related to adding attic/roof insulation during typical re-roofing and/or roof repair transaction?

Existing Homes: Attic Insulation

What are the remaining technical gaps and/or research needs related to increasing attic R-value (as a stand-alone EE measure)?

Existing Homes: Comfort

Which type of comfort/HVAC upgrade has the largest remaining technical gap or research need?

- Existing Heating/Cooling System Equipment Retro-commissioning
- Heating/Cooling System Equipment Replacement
- Distribution improvement
- Smart HVAC sensors and controls
- Other (explain)

Existing Homes: Comfort

Related to comfort/HVAC upgrades in existing homes, which one of these barriers could be best addressed by further research?

- Costs
- Inaccessibility
- Installation quality
- Degraded performance of new equipment due to poor performance of existing system components
- Other (explain)

Existing Homes: Comfort

What are the top 3 transactions with most potential for improving comfort systems in existing homes?

Existing Homes: HVAC

What are the remaining technical gaps and/or research needs related to retro-commissioning existing HVAC equipment during typical service call transaction?

Existing Homes: HVAC

What are the remaining technical gaps and/or research needs related to improving performance of existing components when one piece of equipment is replaced?

(e.g., Outside unit is replaced, while existing evap coil, AHU, furnace, and ducts remain)

Existing Homes: HVAC Distribution

What are the remaining technical gaps and/or research needs related to duct repair and sealing in existing homes?

Existing Homes: Smart HVAC

What are the remaining technical gaps and/or research needs related to incorporating smart HVAC sensors and controls as add-ons to existing equipment or onboard replacement equipment in existing homes?

Existing Homes: IAQ

Which type of IAQ upgrade has the largest remaining technical gap or research need?

- Whole house ventilation
- Spot ventilation (kitchen/bath)
- Filtration upgrade
- Dehumidification
- Other (explain)

Existing Homes: IAQ

What are the top 3 transactions with most potential for improving IAQ in existing homes?

Existing Homes: Ventilation

What are the remaining technical gaps and/or research needs related to improving performance of ventilation during bath/kitchen remodels?

Existing Homes: Filtration

What are the remaining technical gaps and/or research needs related to improving filtration performance during HVAC repair/replacement?

Existing Homes: Dehumidification

What are the remaining technical gaps and/or research needs related to addressing dehumidification in existing homes, either with add-on or integrated equipment?

Existing Homes: Performance Measurement

Which area of performance measurement has the largest remaining technical gap or research need?

- Identifying homes with most potential for energy savings
- Determining EE measure(s) with most potential for energy savings for a given home
- Cost of in-home energy audit
- Validating improved performance
- Other (explain)
-

Existing Homes: Performance Measurement

What are the remaining technical gaps and/or research needs related to performance measurement in existing homes?

Existing Homes: Implementation

What are the barriers to implementation of energy efficiency measures in existing homes?

- Cost to Homeowner
- Intrusion in Occupied Homes
- Technical gaps
- Lack of qualified Home Performance Contractors
- Other (explain)

Existing Homes: Implementation

What is the biggest barrier in applying new construction solutions to existing homes?

- Inaccessibility to problem areas (e.g., ducts in between floors)
- Damage/repair of interior/exterior finishes after EE measure (e.g., patching holes after drill-and-fill)
- Working around dangerous materials present in existing homes (e.g., asbestos, lead paint)
- Working with outdated/unfamiliar materials or building practices in existing homes (e.g., lath and plaster, balloon framing)
- Requires experienced multi-disciplinary contractor

Thank You!

PDF copies of the presentation at:
http://energy.gov/eere/buildings/building-america-meetings

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