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

2016 Building Technologies Office Peer Review

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

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Project Summary

Timeline:

Start date: August 1, 2015 (new project)

Planned end date: July 31, 2016

Key Milestones

1. Conduct Lab Tests; March 31, 2016
2. Propose Design Guidelines; July 31, 2016
3. Secure Builder and Manufacturer Interest; July 31, 2016

Budget:

Total Project $ to Date: (thru Feb. 2016)

- DOE: $263,729
- Cost Share: $155,696

Total Project $:

- DOE: $600,085
- Cost Share: $220,845

Key Partners:

Best Practices Research Alliance	

Project Outcomes:

- A simplified air delivery system for low-load homes with predictable performance from a manifold arrangement of small diameter ducts
- A straightforward, intuitive design method and companion guidance documents
- Justification and suggested language for needed code and standard changes
- Written commitment from at least one manufacturer partner to pursue product development and at least one builder partner to demonstrate the technology based on the project's findings

Purpose and Objectives

Problem Statement:

- The residential HVAC market faces market challenges with low-load homes and HVAC systems
- Heating and cooling to each space is not optimally delivered from smaller-capacity equipment
- Traditional duct systems have a host of problems
- The issues can inhibit low-load homes from achieving broader high-performance goals, including comfort

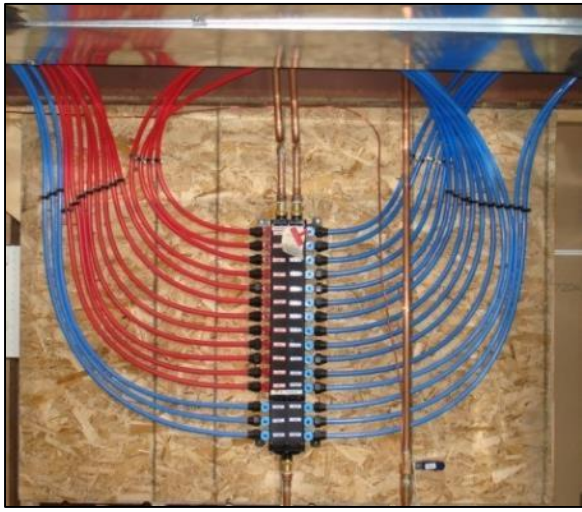
Target Market and Audience:

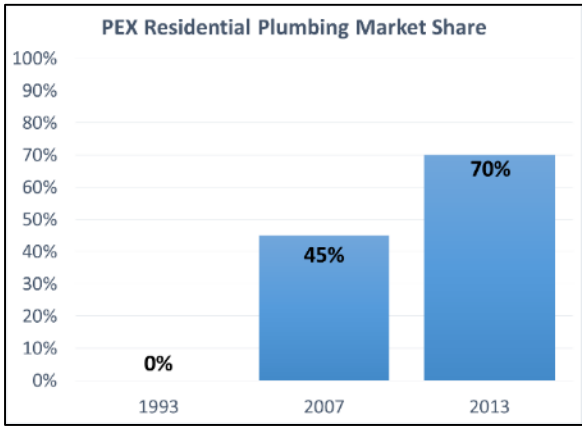
- Market: new construction low-load homes
- Audience: Home builders, HVAC contractors and system designers, HVAC equipment manufacturers and component suppliers, and material suppliers

Purpose and Objectives

Impact of Project:

- The Plug-n-Play duct system could revolutionize ducted air distribution systems in the way manifolded PEX piping systems impacted plumbing distribution.
  - PEX costs 25% - 45% less, installed
  - Rapid claim to majority market share
- Plug-n-Play potential for significant cost savings vs. conventional systems, with performance benefits
  - More discrete room-by-room zoning opportunities
  - Improved comfort - energy is effectively used
  - Ease of design and installation
  - Alternative to current small-diameter systems on the market
- 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
- Lower costs yield wider / deeper market penetration

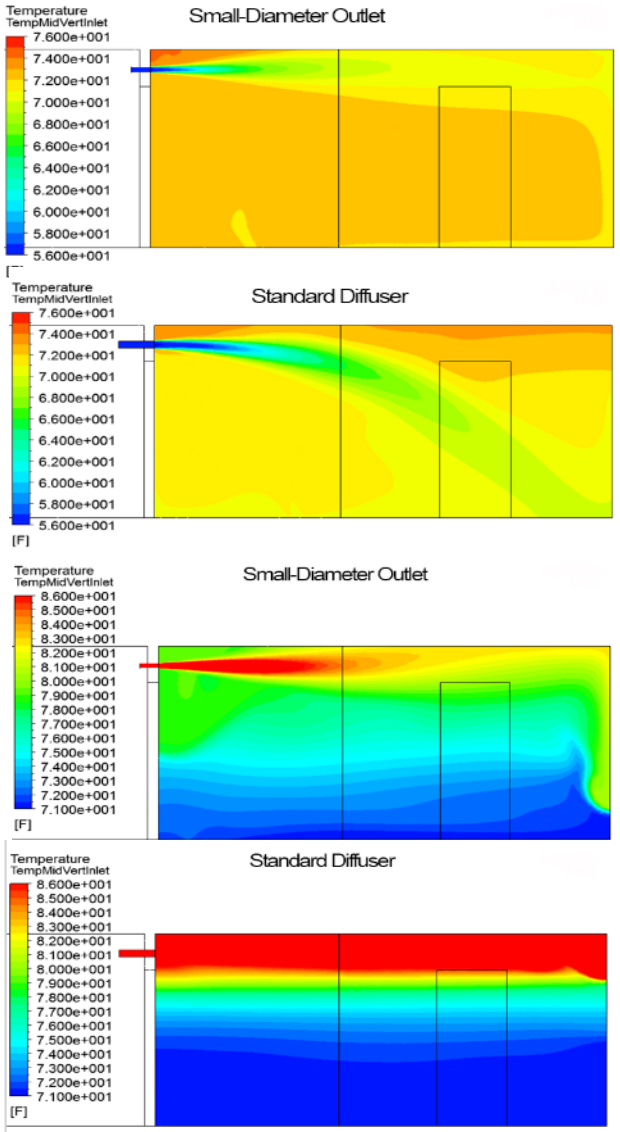




Purpose and Objectives

Project Outputs:

- Characterized the pressure and airflow relationships for plastic small diameter rigid ducts and fittings
- Characterized the installed performance of the Plug-n-Play system
- Compared performance to traditional air distribution system approaches
- Defined range of application for the system in terms of home size, load, load density, and climate
- Analyzed cost and installation impacts
- Developed installation guidance
- Developed design methodology
- Secured interest from a builder and manufacturer



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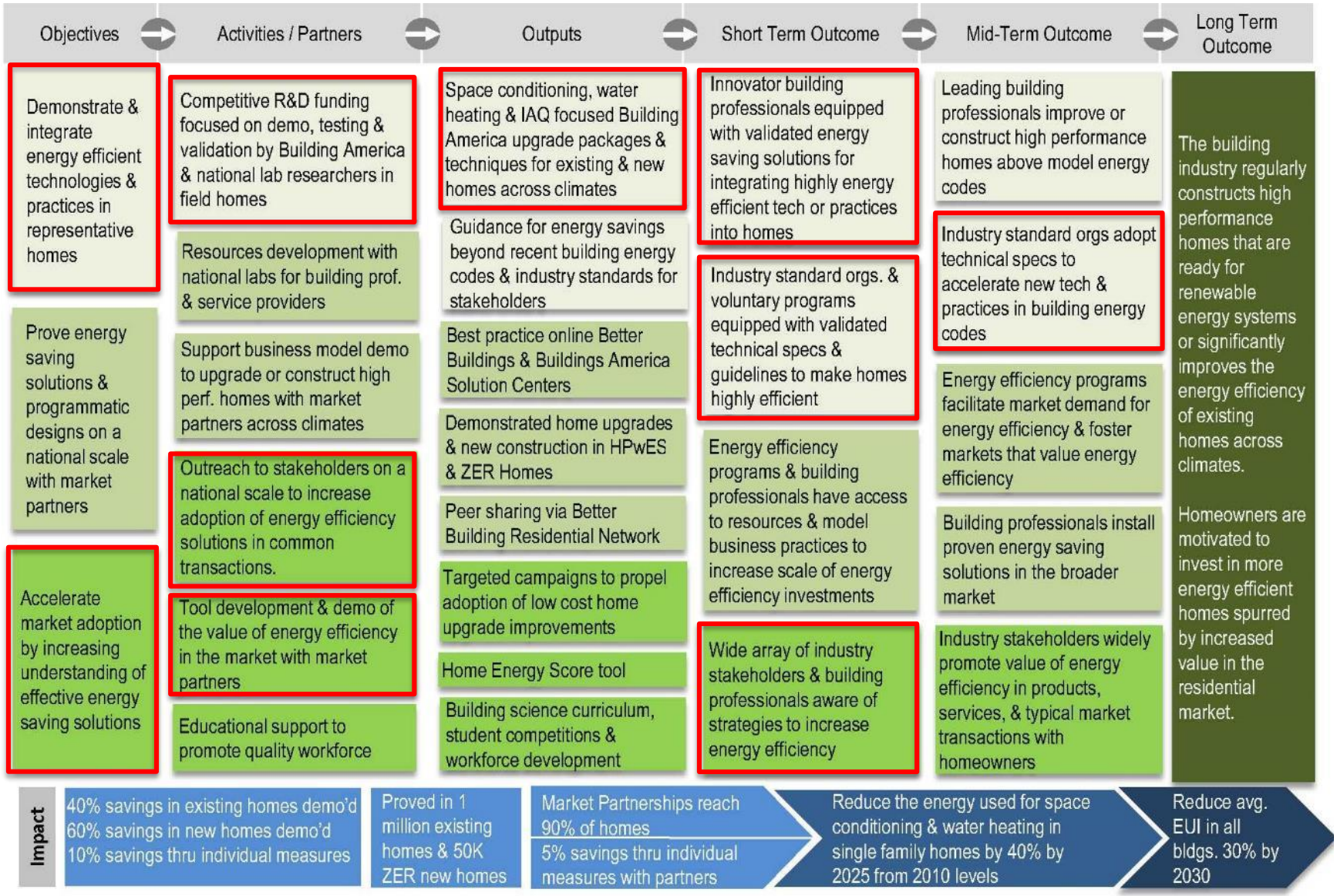
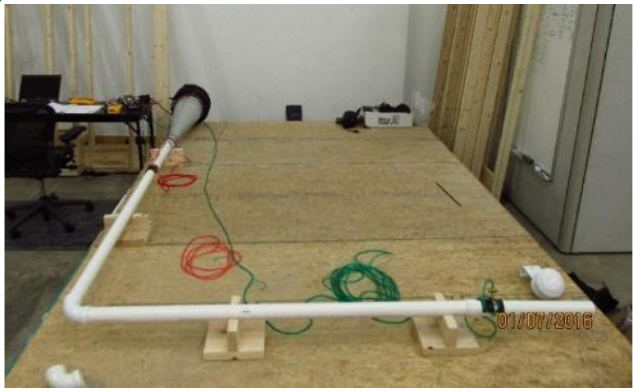
Purpose and Objectives



Approach

Approach:

- Test pressure and airflow relationships for 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 mock-up
- Develop a simple design methodology

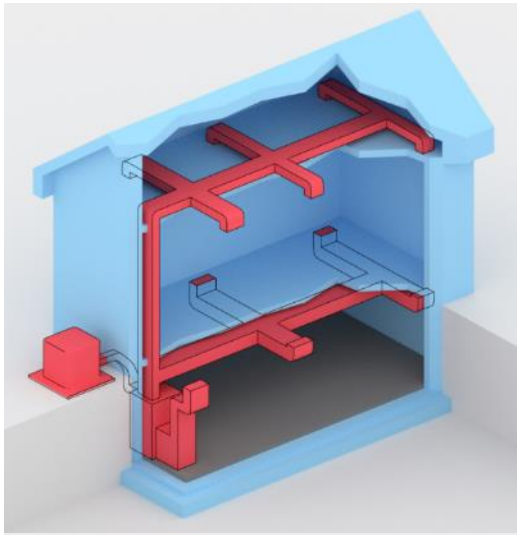


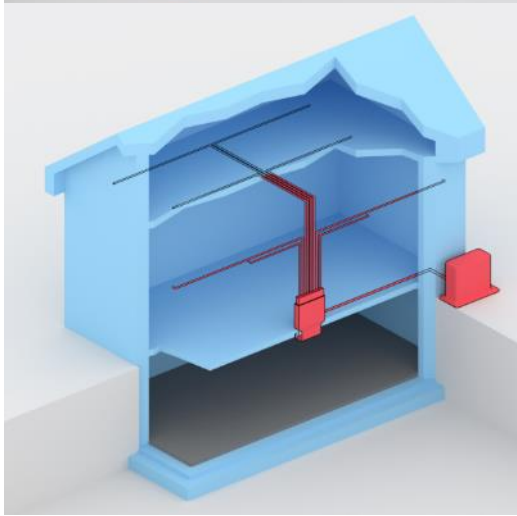
	Length	Elbows	ACCA Manual J	Actual		DM1		DM2		DM3		DM4	
	ft	count	CFM	CFM	Runs	CFM	Runs	CFM	Runs	CFM	Runs	CFM	Runs
Dining Room	21	4	16	23.2	1	20	1	20	1	20	1	19.2	1
Kitchen	18.8	5	18	21.4	1	20	1	20	1	20	1	19.4	1
Living Room	8.2	4	33	26.3	1	40	2	26	1	26	1	27.4	1
Hall (Foyer)	6	3	32	28.7	1	40	2	26	1	26	1	32.2	1
Bedroom 4	26	3	24	39.8	2	20	1	20	1	28	2	18	1
Bedroom 3	33.7	5	14	17.5	1	20	1	14	1	14	1	15.3	1
Bedroom 2	28.4	5	19	19.7	1	20	1	14	1	14	1	16.5	1
Master Bdrm	13	4	36	50.2	2	40	2	40	2	26	1	46.7	2
Bsmt Finished	23	4	34	20.1	1	40	2	40	2	40	2	36.9	2
Bsmt Un-fin	23	5	34	21.2	1	40	2	40	2	40	2	35.8	2
Total			260	268	12	300	15	260	13	254	13	267	13

Approach

Key Issues:

- Duct systems are often not designed to have all runs accessible for maintenance, dampering
- Duct design, layout and installation suffer from shortfall of available skilled labor
- Traditional duct systems are often
  - Oversized for low loads
  - leaky, requiring secondary sealing
  - routed though unconditioned space
  - not well-integrated into home
  - dirt collectors
- Comfort and performance suffers
- Plastic ducts are not presently accepted by the industry





Approach

Distinctive Characteristics:

- A home-run manifold of small diameter ducts to work with small-capacity equipment to deliver predictable performance for low-load homes
- Intended to use off-the-shelf products as a kit-of-parts to install a simplified duct system with less error / waste than conventional systems
- Conventionally-skilled tradespersons and home designers will have a quick, efficient and credible method for designing an air delivery system that responds to the unique qualities of low-load homes and emerging comfort systems, providing reliable design results

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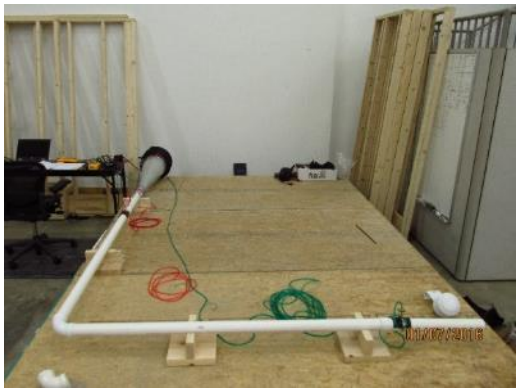
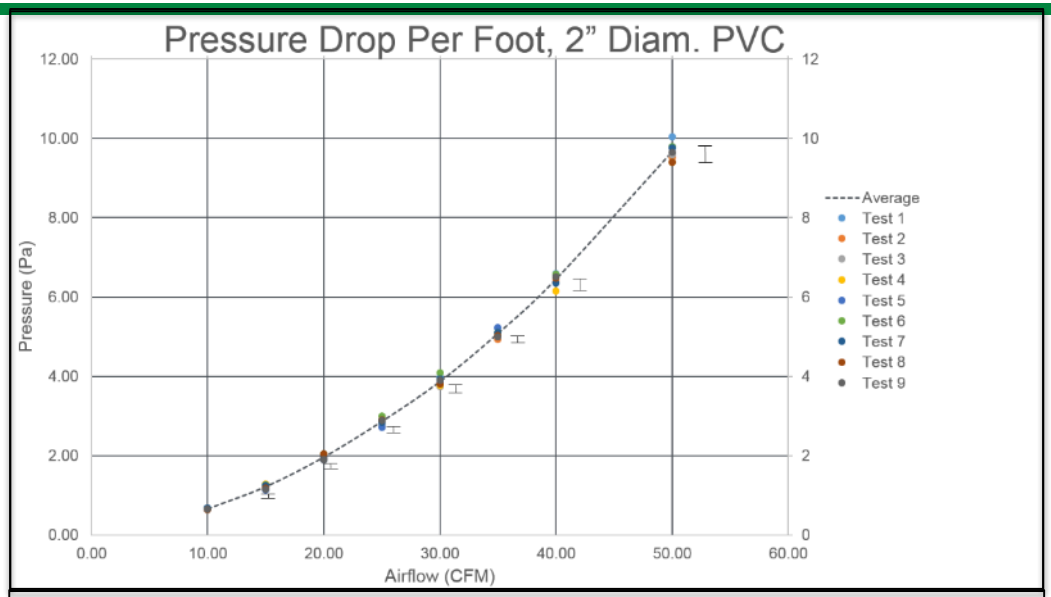
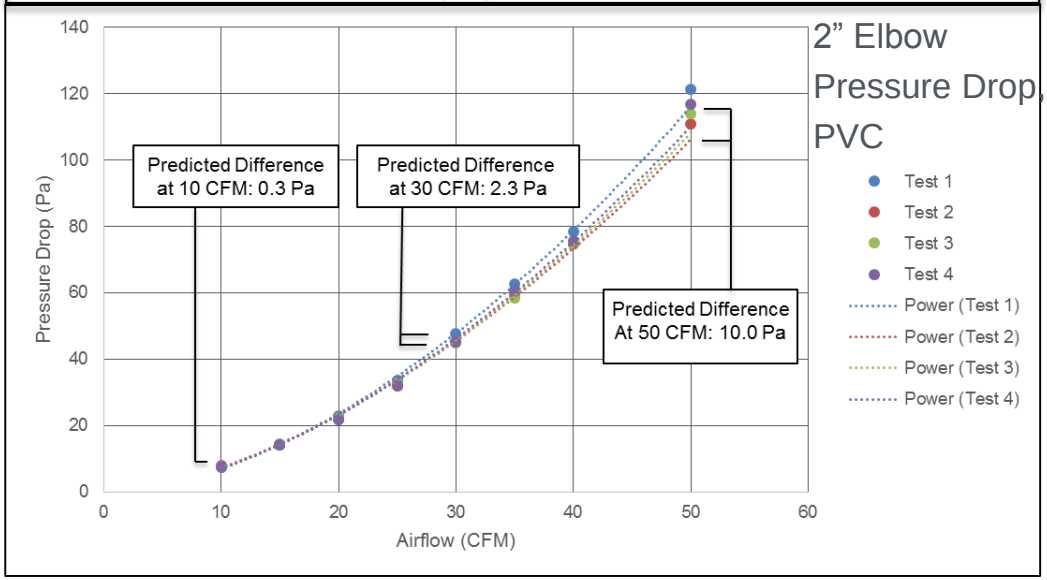
Progress and Accomplishments

Accomplishments:

- Characterized pressure/ airflow relationships through Lab Testing.



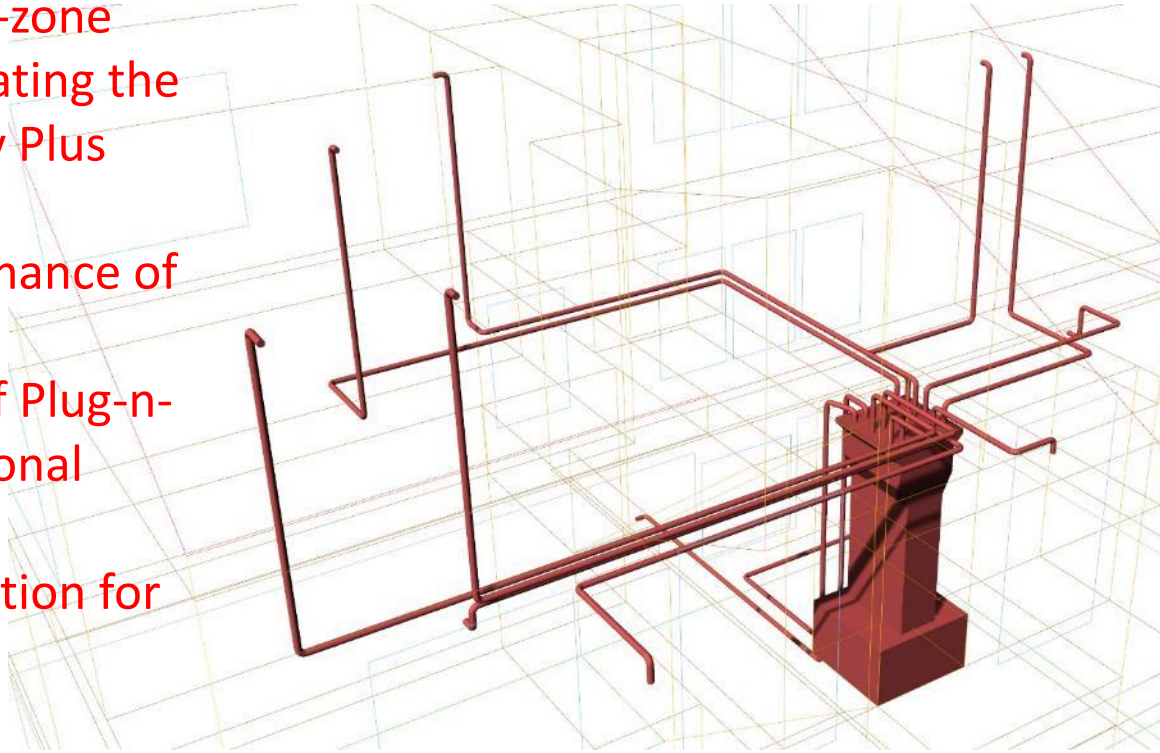




Progress and Accomplishments

Accomplishments:

- Modeling
  - Creating a detailed multi-zone Energy Plus model simulating the duct system using Energy Plus airflow network objects
  - Evaluate comfort performance of Plug-n-Play duct system
  - Compare performance of Plug-n-play ducts against traditional systems
  - Evaluate range of application for Plug-n-Play ducts
  - Test design methodology

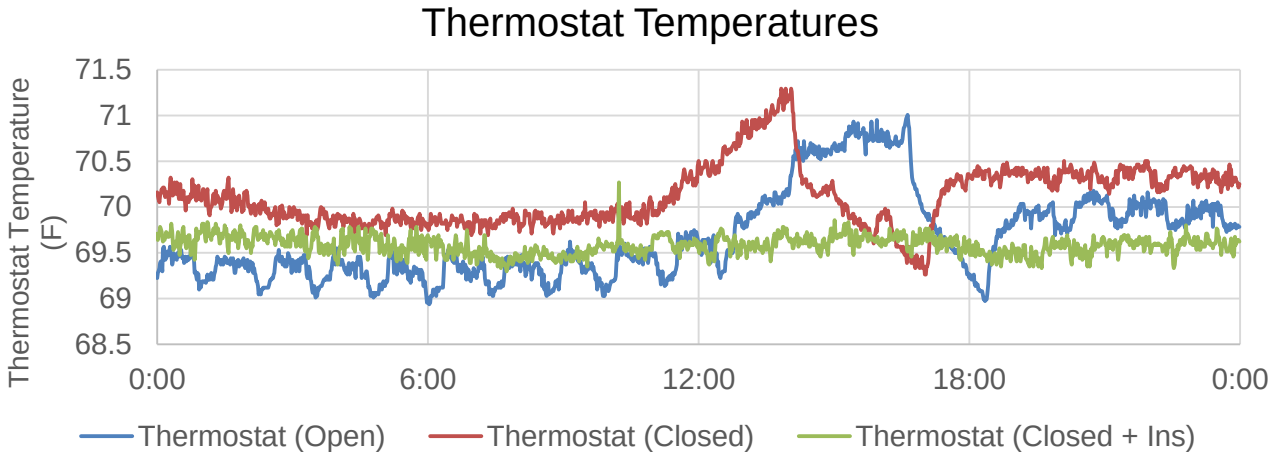


- Several builders, manufacturers and material suppliers have expressed interest in the system and collaboration to demonstrate / develop

Progress and Accomplishments

Accomplishments:

- Field Data collection is underway showing performance results



- Several draft Design Methodologies are being evaluated.

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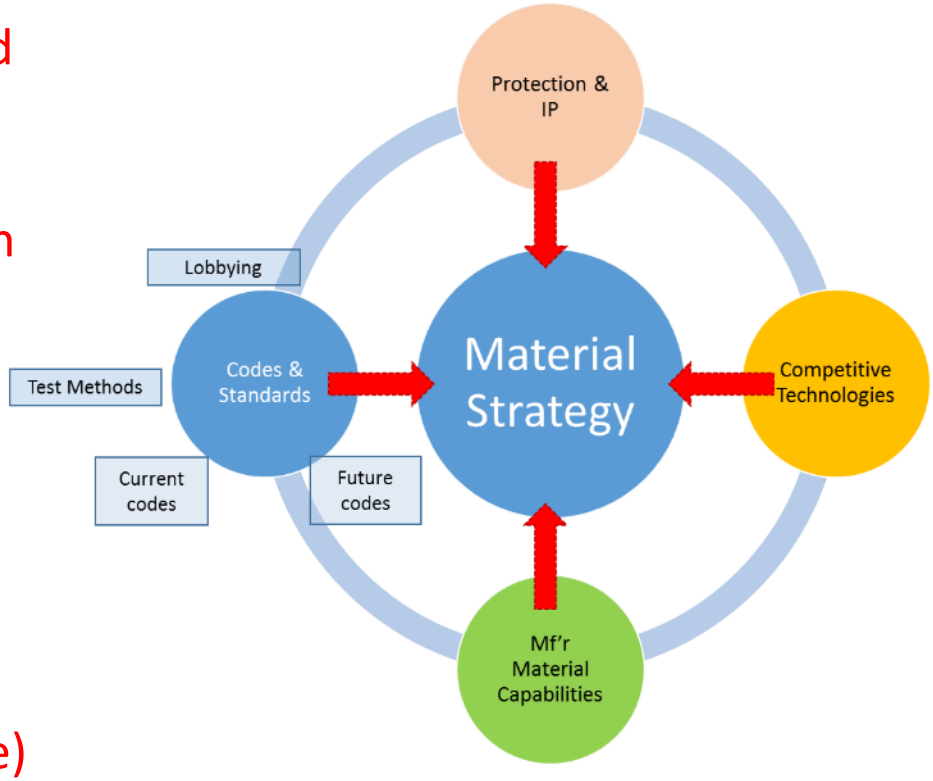
Progress and Accomplishments

Market Impact:

- Multiple builders, manufacturers, and material suppliers have expressed interest
- Dissemination of knowledge has been though Alliance venues
- Design methodology work is accelerated
- To ensure / accelerate impacts:
  - Investigating semi-rigid materials to ease installation
  - Defining the preferred material properties (mass, friction, R-value) to deliver comfort
  - Modeling activities to determine market impact range
  - Engaging code community
- Actual impacts forthcoming

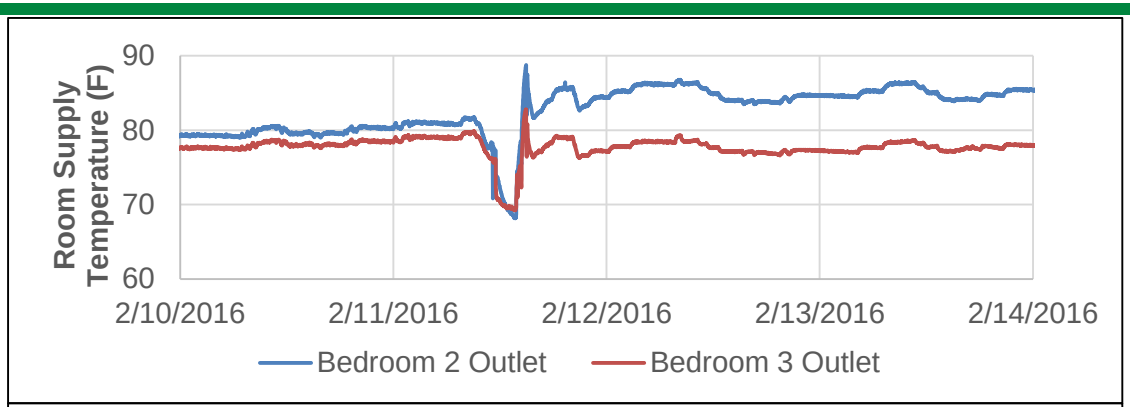


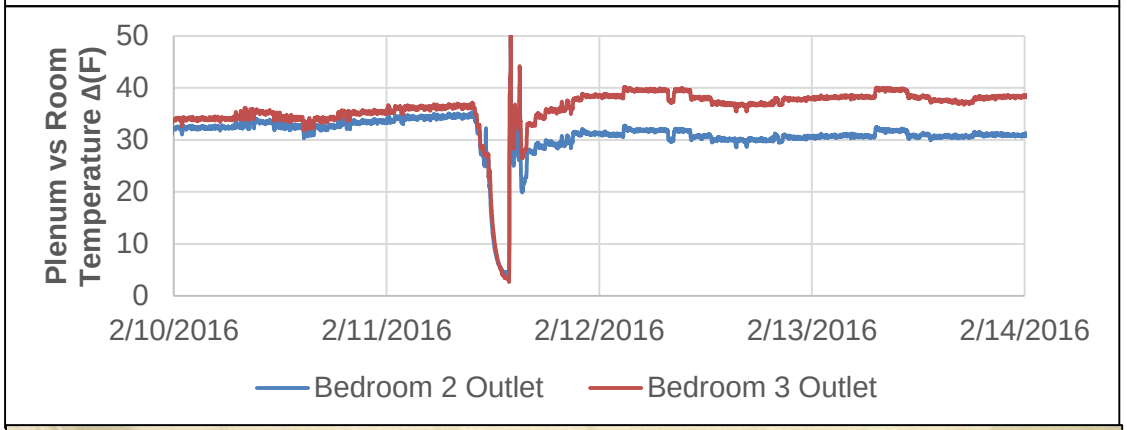
Progress and Accomplishments

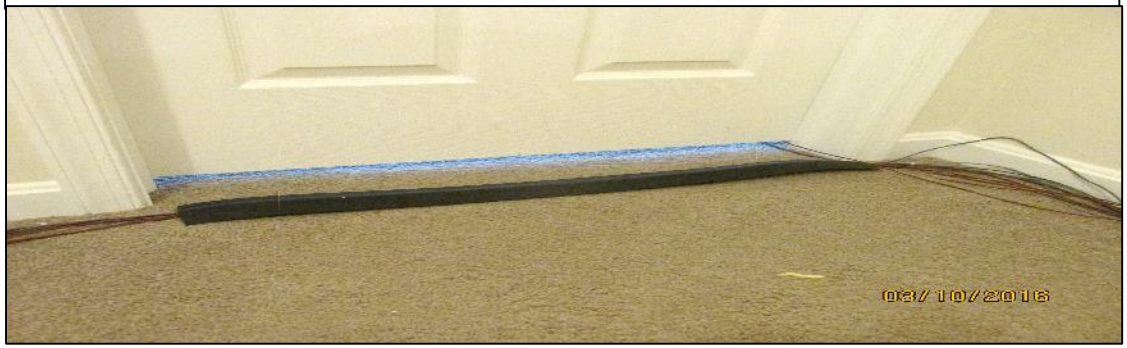
Awards/Recognition: None

Lessons Learned:

- Several installation challenges encountered, even with 2-2.5-in. diam. ducts
- Conditioned energy lost in "transit" through uninsulated ducts greatly impacts room supply air temperature
- A reasonable door undercut provides sufficient return air path with reduced airflow volumes
- Zone dampers are beneficial







Project Integration and Collaboration

Project Integration:

Innovation Pathway

- Model for collaboration to discover, define, demonstrate and deliver innovative solutions with economic and stakeholder value

Partners, Subcontractors, and Collaborators:

Best Practices Research Alliance (a.k.a. "Alliance")

- 75+ homebuilder members
- Represent 200,000 housing units annually
- A dozen innovative building industry product suppliers and manufacturers
- Collaborative homebuilding solutions
- Multi-venue feedback loop

Three alternative material manufacturers have been engaged toward material and product development

Project Integration and Collaboration

Communications:

Best Practices Research Alliance

- Tech Summit and Annual Meeting
- Webinar, Surveys, Builder forums

ASHRAE

- Annual Meeting
- Winter Meeting
- Committee activities

RESNET

- Annual Conference

Pennsylvania Housing Research Center

- Housing Day
- 3rd Biennial Res. Design & Construction Conf.

Next Steps and Future Plans

Next Steps:

- Utilize modeling to compare simulated performance of Plug-N-Play system to conventional duct systems and evaluate application ranges, i.e. size of home, climate; load density
- Perform a time and motion study to compare installation costs and issues of this system against those for conventional systems
- Pursue Builder and Manufacturer willing to demonstration / development

Future Intentions:

- Develop companion components: dampers, plenum/manifold, diffusers

REFERENCE SLIDES

Project Budget

Project Budget: $820,930: $600,085 Federal + $220,845 Cost Share

Variances: To date there have been no variances from the original planned budget

Cost to Date: $263,729 or 44% of Federal Funding utilized through February 2016
$419,425 0r 51% of total budget utilized through February 2016

Additional Funding: None.

Budget History					
Aug. 1, 2015– FY 2015 (past)		FY 2016 (to date)		FY 2016 – Jul. 31, 2016 (planned)	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
$10,142	$78,867	$253,588	$76,829	$336,356	$65,149

Project Plan and Schedule