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

2016 Building Technologies Office Peer Review





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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
- Secure Builder and Manufacturer Interest; July 31, 2016

Budget:

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

- DOE: \$<mark>263,729</mark>
- Cost Share: \$155,696

Total Project \$:

- DOE: \$<mark>600,085</mark>
- Cost Share: \$220,845

Key Partners:

Best Practices Research Alliance	

Project Outcomes:

- A simplified air delivery system for lowload 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:

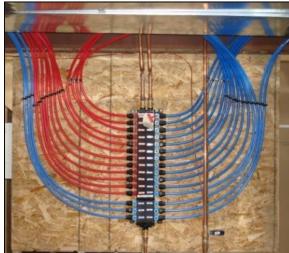
- <u>Market</u>: new construction low-load homes
- <u>Audience</u>: Home builders, HVAC contractors and system designers, HVAC equipment manufacturers and component suppliers, and material suppliers

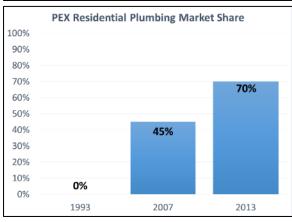




Impact of Project:

- 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



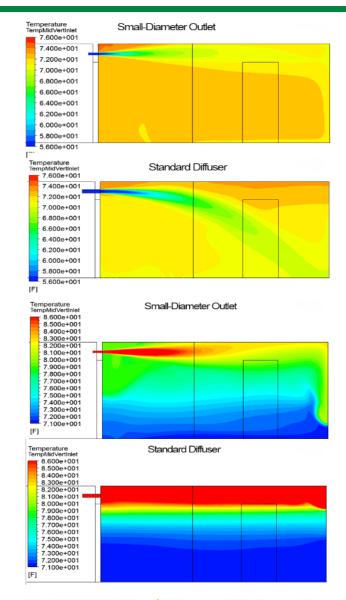




Purpose and Objectives

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





Purpose and Objectives

Objectives	Activities / Partners	Outputs	Short Term Outcome	Mid-Term Outcome	Long Term Outcome	
Demonstrate & integrate energy efficient technologies & practices in	Competitive R&D funding focused on demo, testing & validation by Building America & national lab researchers in field homes	Space conditioning, water heating & IAQ focused Building America upgrade packages & techniques for existing & new homes across climates	Innovator building professionals equipped with validated energy saving solutions for integrating highly energy efficient tech or practices	Leading building professionals improve or construct high performance homes above model energy codes	The building industry regularly constructs high	
representative homes	Resources development with national labs for building prof. & service providers	Guidance for energy savings beyond recent building energy codes & industry standards for stakeholders	Industry standard orgs. & voluntary programs	Industry standard orgs adopt technical specs to accelerate new tech & practices in building energy	performance homes that are ready for renewable energy systems	
Prove energy saving solutions & programmatic	Support business model demo to upgrade or construct high perf. homes with market partners across climates	Best practice online Better Buildings & Buildings America Solution Centers Demonstrated home upgrades	equipped with validated technical specs & guidelines to make homes highly efficient	codes Energy efficiency programs facilitate market demand for	or significantly improves the energy efficiency of existing	
designs on a national scale with market	Outreach to stakeholders on a national scale to increase	& new construction in HPwES & ZER Homes	Energy efficiency programs & building professionals have access	energy efficiency & foster markets that value energy efficiency	homes across climates.	
partners	adoption of energy efficiency solutions in common transactions. Tool development & demo of the value of energy efficiency in the market with market	Peer sharing via Better Building Residential Network Targeted campaigns to propel	to resources & model business practices to increase scale of energy	Building professionals install proven energy saving solutions in the broader	Homeowners are motivated to invest in more energy efficient	
Accelerate market adoption by increasing understanding of		adoption of low cost home upgrade improvements Home Energy Score tool	efficiency investments Wide array of industry stakeholders & building	market Industry stakeholders widely promote value of energy	homes spurred by increased value in the	
effective energy saving solutions	partners Educational support to promote quality workforce	Building science curriculum, student competitions & workforce development	professionals aware of strategies to increase energy efficiency	efficiency in products, services, & typical market transactions with homeowners	residential market.	
60% savings	s in new homes demo'd millio	ed in 1 Market Partnership n existing <u>90% of homes</u> es & 50K 5% savings thru inc new homes measures with part	conditioning single famil	e energy used for space g & water heating in y homes by 40% by 2010 levels	Reduce avg. EUI in all bldgs. 30% by 2030	
			U.S. D	Energy	y Efficiency & vable Energy	

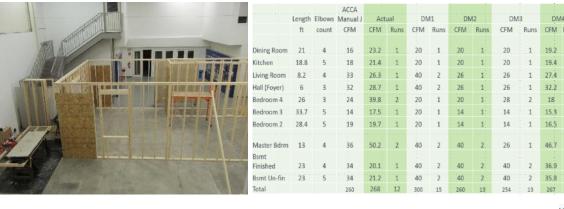
Approach

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







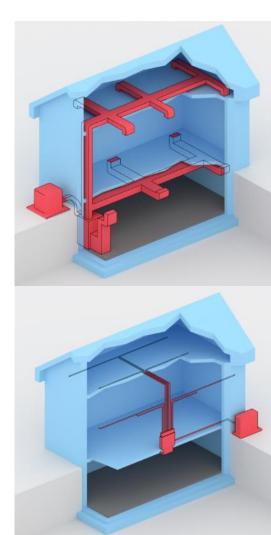




Approach

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

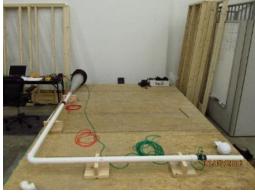


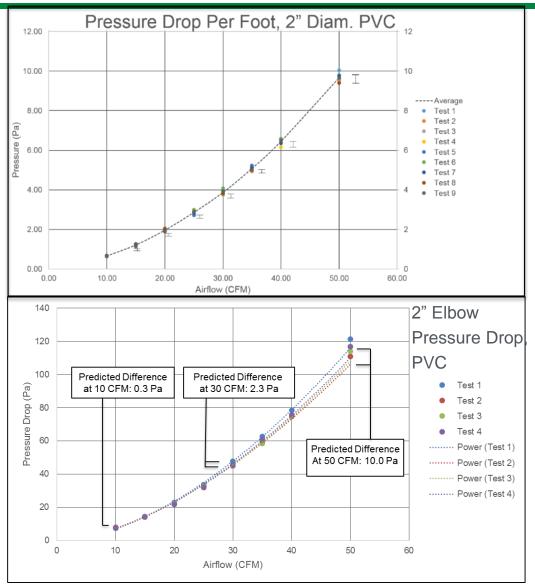


Accomplishments:

 Characterized pressure/ airflow relationships through Lab Testing.









Accomplishments:

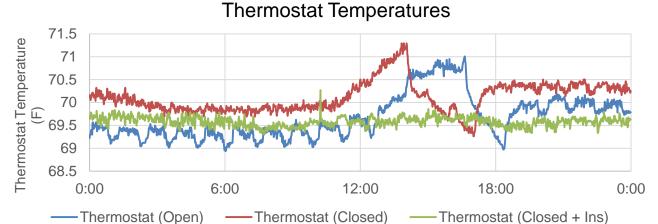
- Modeling
 - Creating a detailed multi-zone
 Energy Plus model simulating the duct system using Energy Plus airflow network objects
 - Evaluate comfort performance of Plug-n-Play duct system
 - Compare performance of Plug-nplay ducts against traditional systems
 - Evaluate range of application for Plug-n-Play ducts
 - Test design methodology
- Several builders, manufacturers and material suppliers have expressed interest in the system and collaboration
- 11 to demonstrate / develop



Accomplishments:

 Field Data collection is underway showing performance results

 Several draft Design Methodologies are being evaluated.



	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



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

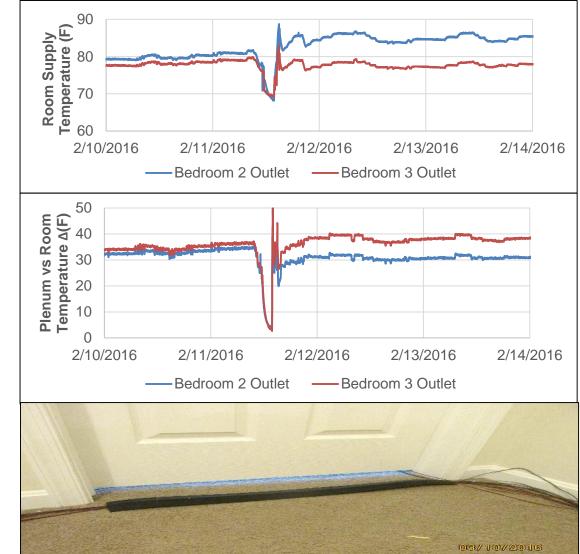




Awards/Recognition: None

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 Or 51% of total budget utilized through February 2016

Additional Funding: None.

Budget History										
Aug. 1, 2015– FY 2015 (past)			2016 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

Project Schedule	-	-	-		-	-	-		-			
Project Start: August 1, 2015 Completed Work												
Projected End: July 31, 2016		Active Task (in progress work)										
		Milestone/Deliverable (Originally Planned)										
		Milestone/Deliverable (Actual)										
		Milestone/Deliverable (Scheduled)										
		Sche	duled	Proje	ct Sta	rt / En	d					
		FY2	2015			FY2	2016			FY2	2017	
Task	Q1 (Oct-Dec)	Q2 (Jan-Mar)	Q3 (Apr-Jun)	Q4 (Jul-Sep)	Q1 (Oct-Dec)	Q2 (Jan-Mar)	Q3 (Apr-Jun)	Q4 (Jul-Sep)	Q1 (Oct-Dec)	Q2 (Jan-Mar)	Q3 (Apr-Jun)	Q4 (Jul-Sep)
Current/Future Work												
Q2 Milestone: Conduct Lab Tests						\bullet						
Q3 Milestone: Complete Cost Analysis				startup								
Q4 Milestone: Performance Simulation Analysis												
Q4 Milestone: Propose Design Methodology to				in project								
Standards Groups				L S								
Q4 Milestone: Secure Manufacturer Interest												
Q4 Milestone: Secure Builder Interest				Delay								
Q4 Deliverable: Final Report												

