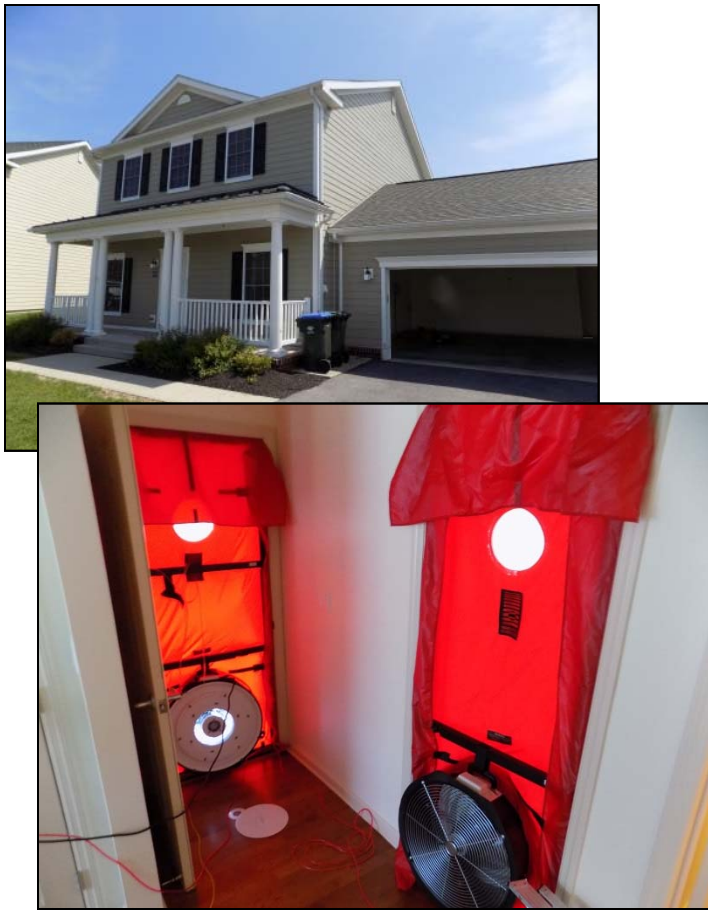
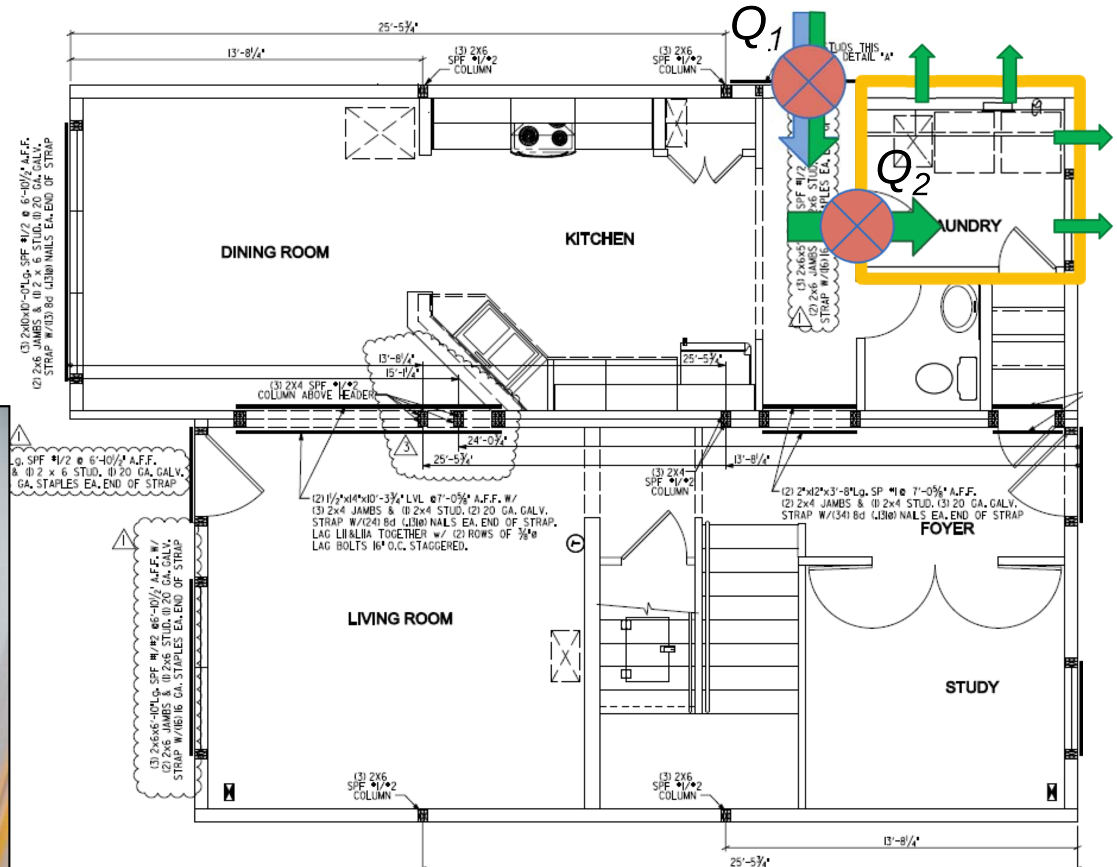
Probabilistic Analysis of the Performance of Air Barrier Systems

2017 Building Technologies Office Peer Review





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

Simon Pallin, PhD, pallinsb@ornl.gov
Oak Ridge National Laboratory

Project Summary

Timeline:

Start date: October 1, 2014

Planned end date: September 30, 2017

Key Milestones

1. Investigate critical construction details for air tightness in 7 to 10 homes with different air barrier systems; 06/30/17
2. Provide a report or journal paper that summarizes the work; 09/30/17

Budget:

Total Project $ to Date:

- DOE: $165k / year
- Cost Share: N/A

Total Project $:

- DOE: $495k
- Cost Share: N/A

Key Partners:

N/A	

Funding:

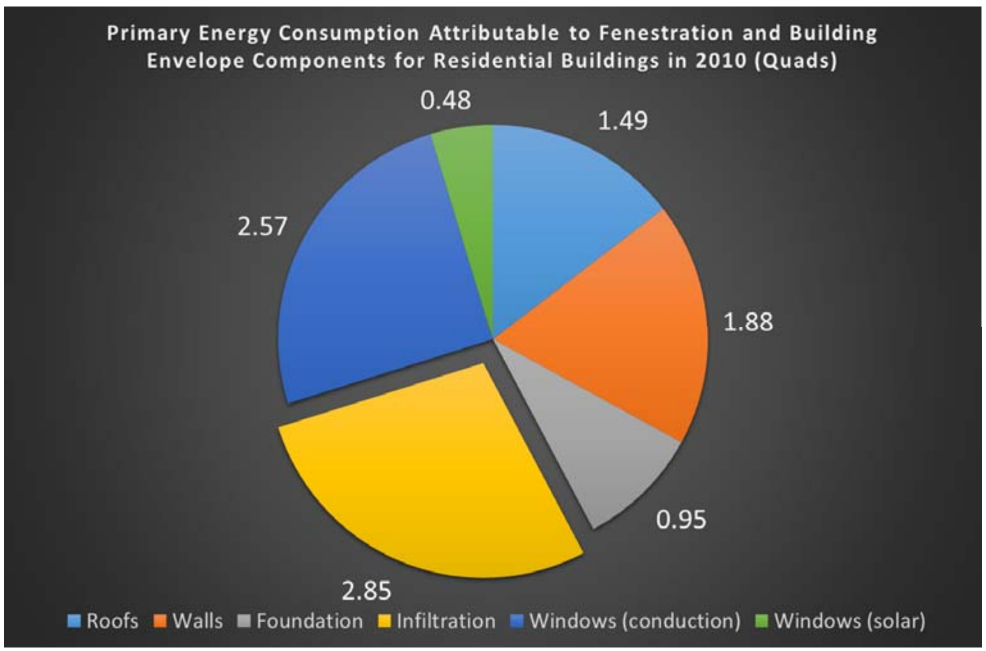
This project is funded using Building Envelope Core Funding.

Project Outcome:

As part of BTO's ET focus (accelerate the development of more energy-efficient technologies for the buildings sector to meet cut building energy use by 45% by 2030), the purpose of this project is to help the construction industry select air barrier technologies that are cost-efficient in terms of performance and durability.

Purpose and Objectives

Problem Statement: Air leakage in buildings is responsible for about **3 Quads** of energy use per year in residential buildings. **Traditional air barrier systems** could limit to only reduce a small portion of the energy loss from infiltration due to installation difficulties, thus requiring a lot of detailing to assemble properly. It's therefore relevant to investigate the performance and ease of installation of **novel air barrier systems** and evaluate against commonly used systems to study the long-term benefits in energy performance and determine if existing air barrier systems can help the building industry to meet **BTO Energy Targets** by 2025.



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Purpose and Objectives

Problem Statement:

Technology Description	Target Sector(s)	2025 Cost Target[1]	2025 Performance Target
Highest Priority R&D Areas			
Highly insulating windows	Commercial and Residential Sectors	Residential sector: Projected installed cost premium ≤$6/ft² compared to the 2010 standard base of windows Commercial sector: Projected installed cost premium ≤$3/ft² compared to the 2010 standard base of windows	Residential sector: R-10 windows with V_T>0.6. Commercial sector: R-7 windows with V_T >0.4. Highly insulating windows must be at comparable thickness and weight to the currently installed window base to enable retrofits.
Building envelope material	Commercial and Residential Sectors	Projected installed cost premium ≤$0.25/ft², including insulation material and associated labor, assuming an R-12/in performance to enable a payback period less than 10 years.	≥R-12/in building envelope thermal insulation material that can be added to walls to retrofit existing buildings and can also be applicable to other portions of the building enclosure (e.g., reduce the impact of thermal bridging between building components). The material must meet durability requirements and minimize occupant disturbance.
Air-sealing technologies (systems-level approach)	Commercial and Residential Sectors	Projected installed cost premium of ≤$0.5/ft² finished floor (25% of current average costs, including mechanical ventilation costs).	A system capable of concurrently regulating heat, air, and moisture flow to achieve the following performance specifications: Residential sector: <1 ACH50 Commercial sector: <0.25 CFM75/ft² (5-sided envelope)

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Purpose and Objectives

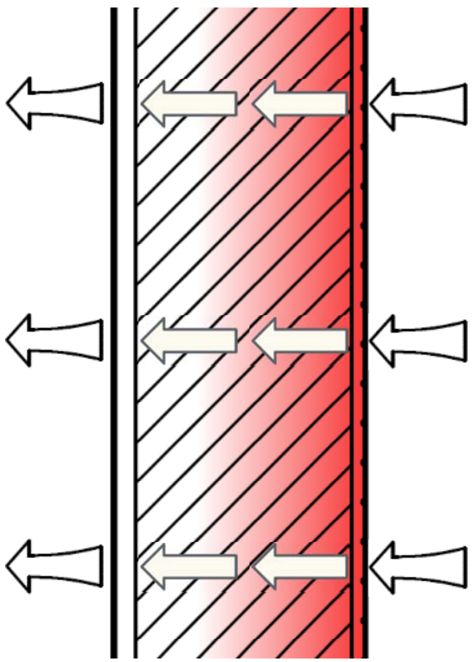
Target Market and Audience: Mainly new residential buildings but also existing buildings in which retrofits involves replacing/improving the air barrier.

Impact of Project: Provide performance charts of different air barrier systems and emphasize key issues of installation to reduce energy losses in homes due to air leakage:

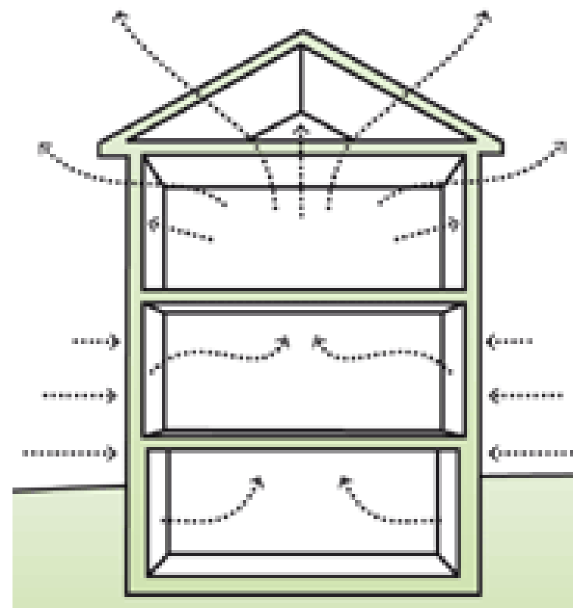
1. Compile measurements data and make available to public. (short-term)
2. Provide industry with guidance on which air barrier system will be most likely to perform as promised. (mid-term)
3. Increase industry awareness of durable and well performing air barrier installation. (long-term)

Approach

How do we evaluate the performance of an air barrier?



Component Level ➔ cfm50/ft^2



Whole House Level ➔ ACH50

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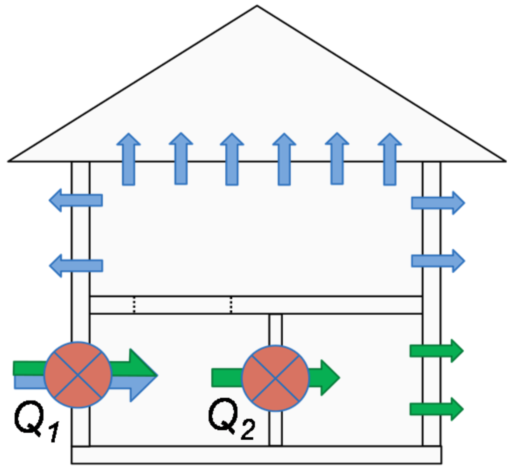
Approach

Guarded Blower Door Test



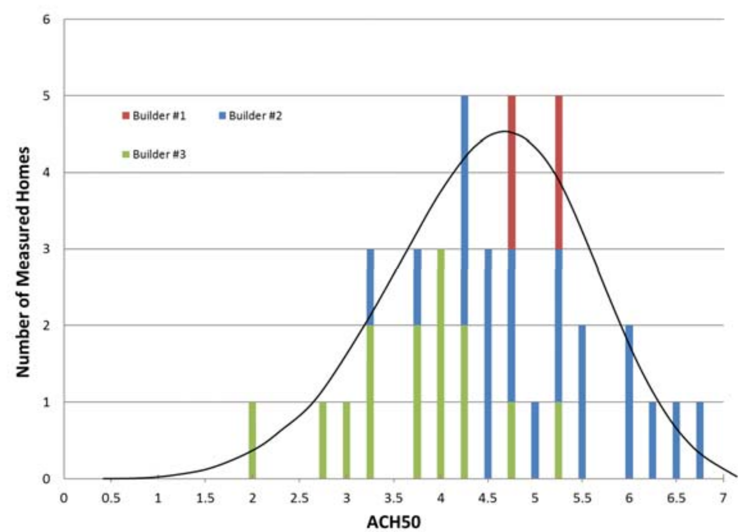
Air leakage of walls: $Q_{walls} = Q_1 - Q_2$

This procedure allows to test the air tightness of walls by deliberately neutralize the pressure difference over the ceiling and floor planes. Basically, there is one major blower between the house and the outside (Blower #1). Then there is at least one additional blower which is set up to eliminate the pressure gradient over the ceiling plane and/or the floor (Blower #2).

Approach

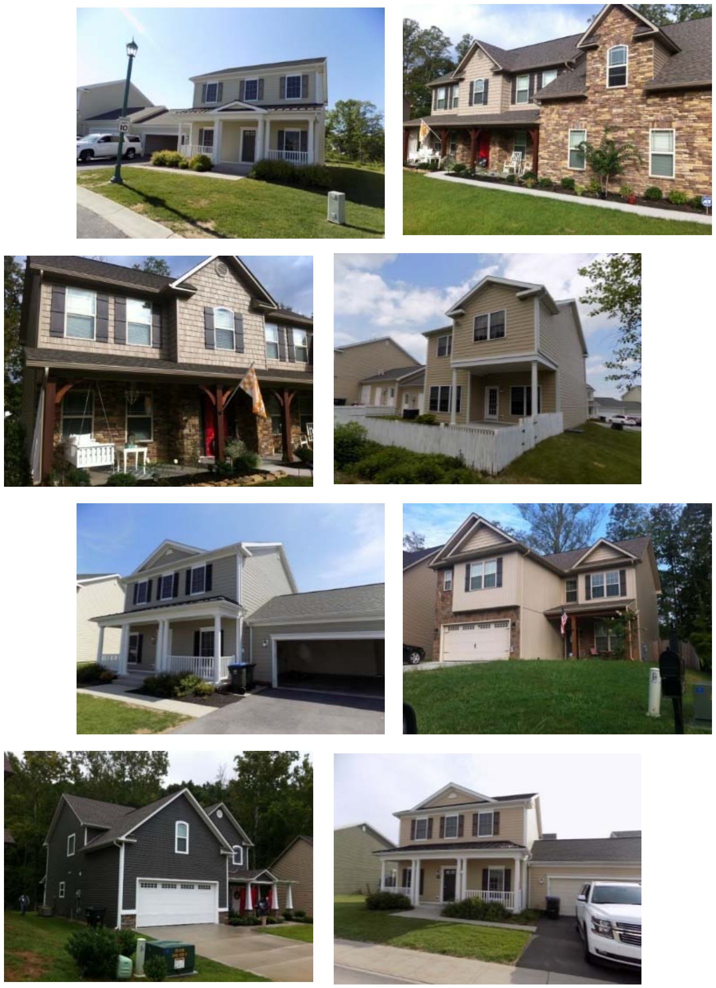
Key Issues: Help the construction industry select air barrier technologies that have, in a cost-efficient and durable manner, the greatest potential to decrease energy losses due to air leakage.

Distinctive Characteristics: Present probabilistic performance charts for commonly used and novel air barrier systems with respect to energy efficiency and costs to enable a faster adoption rate for well performing air barrier systems.

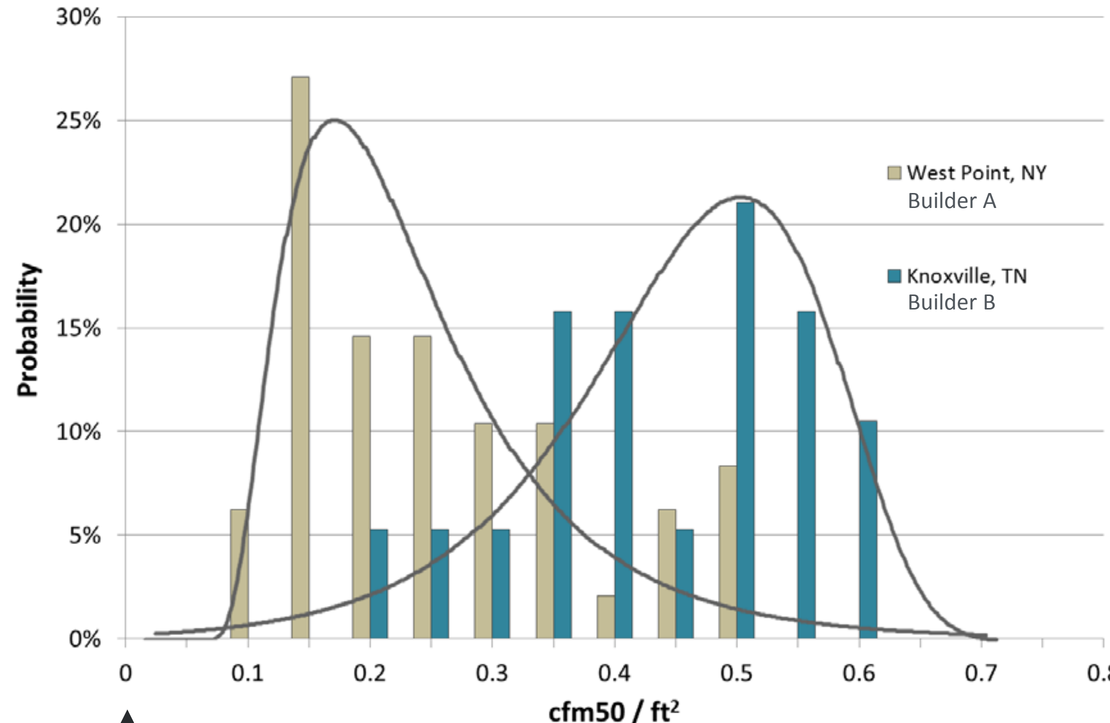


Progress and Accomplishments

Accomplishments: FY15



23 homes built with traditional house wrap



Claimed maximum air leakage of 0.001 cfm75/ft^2 for wall assembly by one manufacturer.

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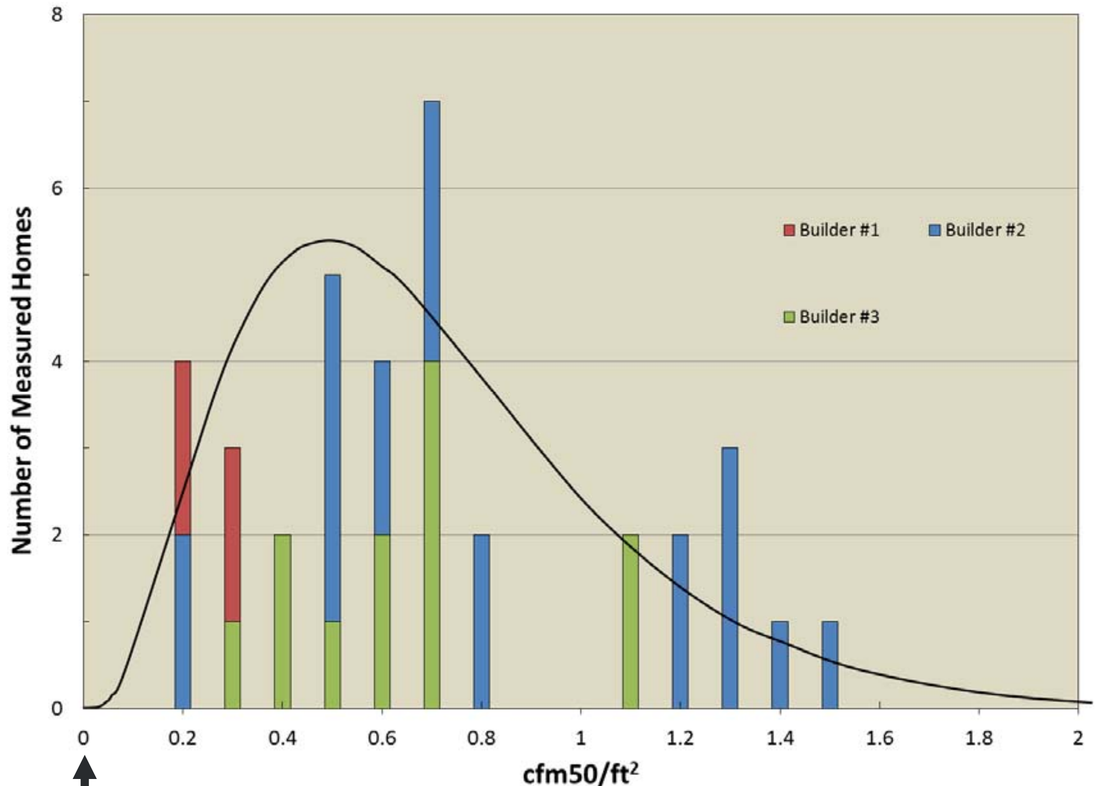
Progress and Accomplishments

Accomplishments: FY16

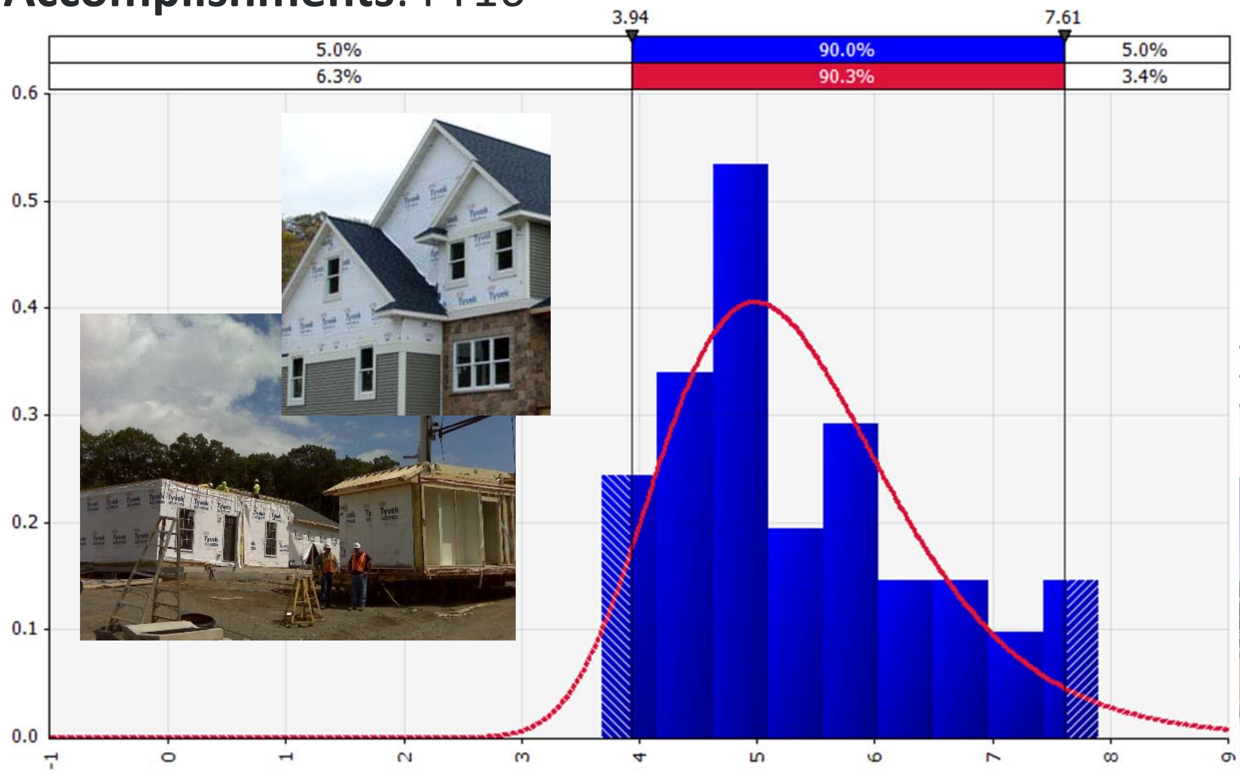
20 homes built with non-insulating sheathing

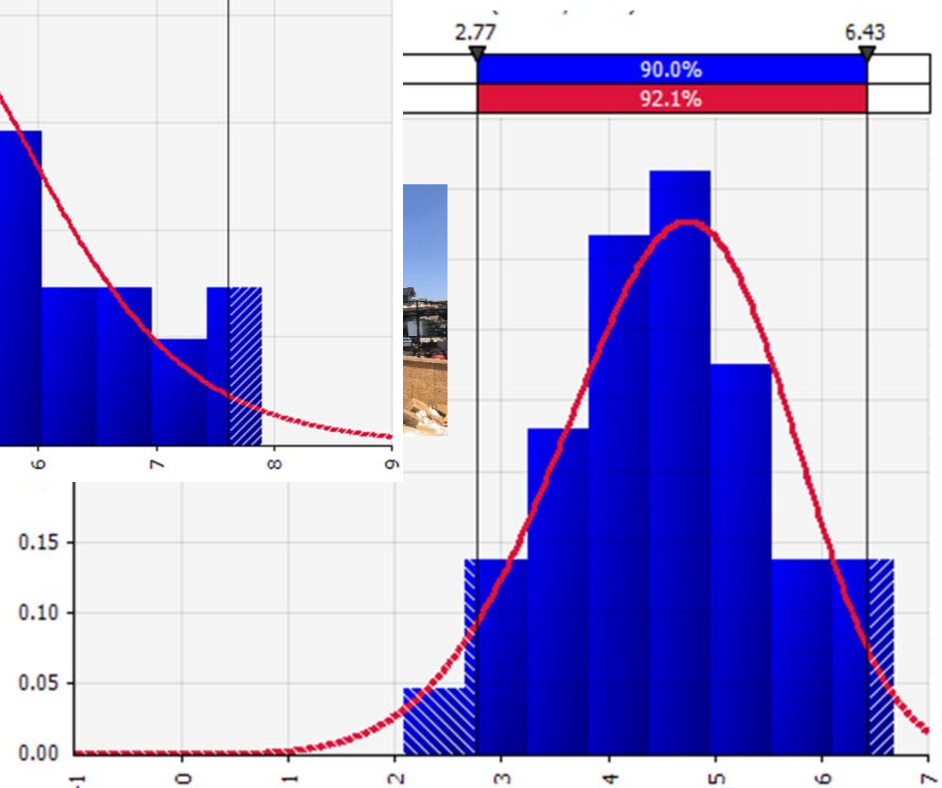


Claimed maximum air leakage of 0.0072 $cfm75/ft^2$ for wall assembly byone manufacturer

Progress and Accomplishments

Accomplishments: FY16





ACH50	5%	95%
House Wrap	3.94	7.61
Non-Insulating Sheathing	2.77	6.43

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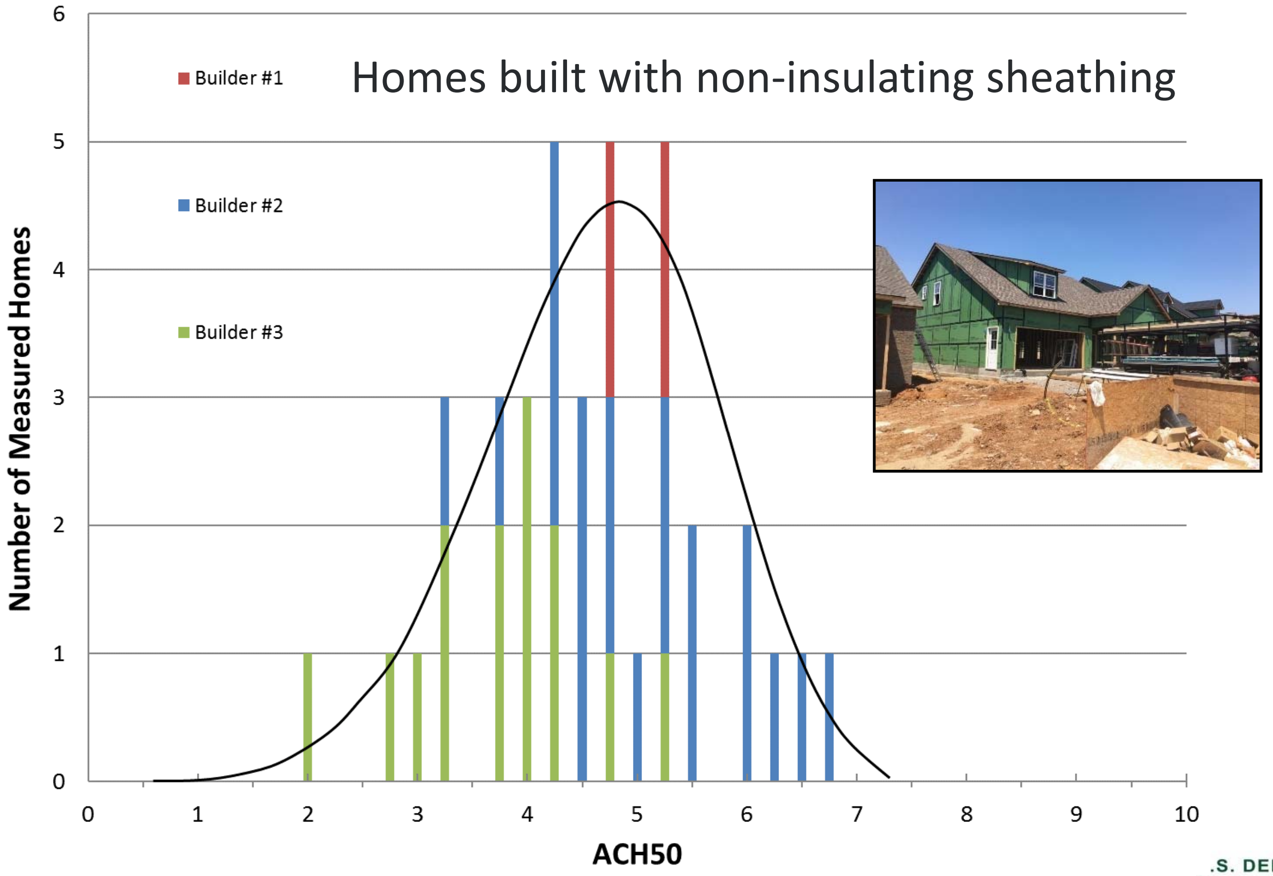
Progress and Accomplishments

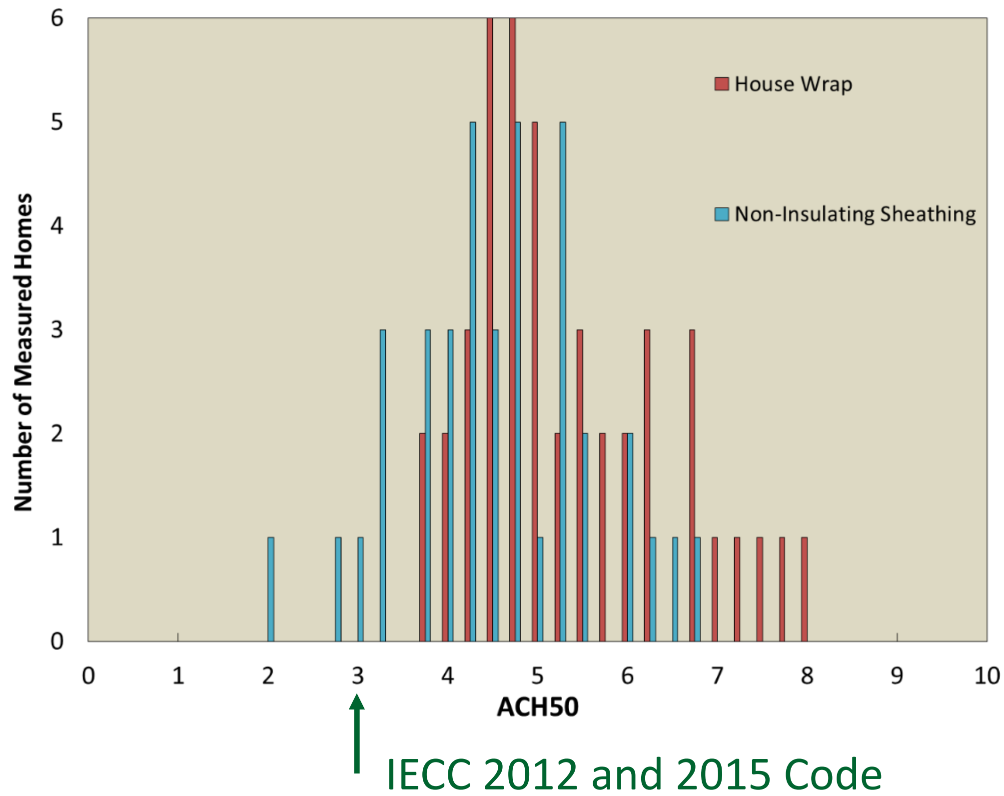
Market impact and lessons learned:
There is great variation in the installation quality of both air barrier systems. More durable systems less sensitive to installation are needed. Or, can builders improve installation quality if they are made aware of critical construction details?



Progress and Accomplishments

Market impact and lessons learned:

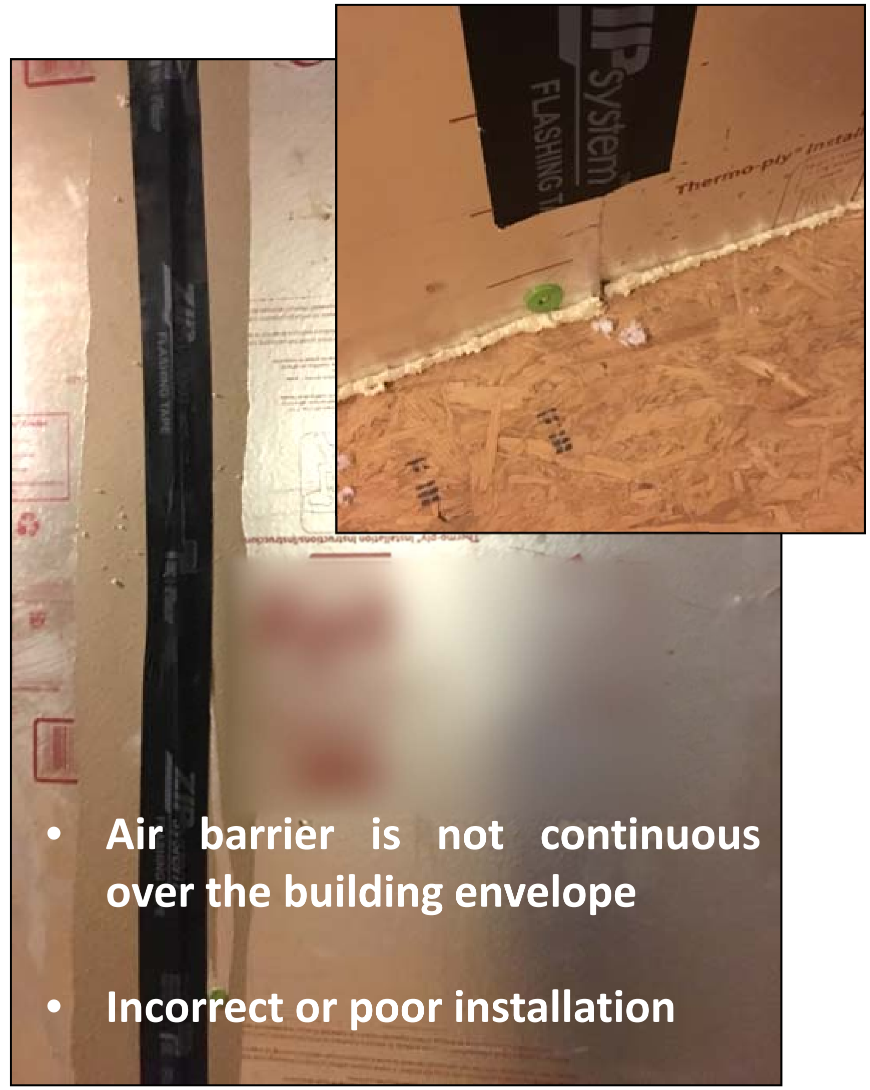
As seen in the field data from this study, the airtightness of buildings can vary with a factor of **three.** The spread in performance can be significantly by more successfully install air barriers. A reduction in energy losses due to air leakage can be estimated to about 40-60% if the tested buildings have an ACH50 of less than 3 (IECC 2012). **But can we reach ACH50 below 1 with current air barrier systems?**



This project helps the industry to better appreciate the importance of air barrier installation quality, critical construction details and give guidance on appropriate installation procedures.

Progress and Accomplishments

Market impact and lessons learned:



- Air barrier is not continuous over the building envelope
- Incorrect or poor installation

Project Integration and Collaboration

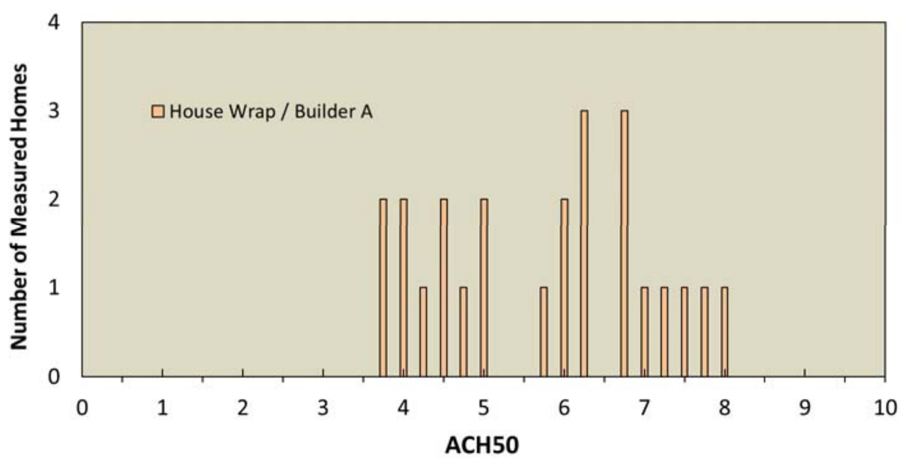
Project Integration: ORNL has collaborated with manufactures of non-insulated sheathing to identify homes available for field test. Results are shared with manufacturer.

Partners, Subcontractors, and Collaborators: Manufacturer of non-insulated sheathing systems.

Communications: Results have been presented in a paper entitled Air Tightness of Common Wall Assemblies and its Effect on R-value at ASTM Symposium on Advances in Hygrothermal Performance of Building Envelopes: Materials, Systems and Simulations in Orlando, FL in October, 2016.

Next Steps and Future Plans

Next Steps and Future Plans: Follow work plan for FY17 and identify where the weak spots are for different air barrier systems in terms of achieving a satisfactory performance.



Factors that influence airtightness

- Construction design
- Floor area / Volume
- Penetration / Installations
- Material properties
- Workmanship

REFERENCE SLIDES

Project Budget

Project Budget: 165k / years
Variances: None
Cost to Date: About 2-3 % of FY17 funding
Additional Funding: None

Budget History					
October 1st 2014 – FY 2016 (past)		FY 2017 – September 30th 2017 (current)		FY 2018 (planned)	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
165k / year	0	165k	0	0	0

Project Plan and Schedule

	◆	Milestone/Deliverable (Actual)										
	FY2015				FY2014				FY2015			
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)
Past Work												
Collect air leakage data on residential buildings where the air barrier type is identified.		◆	◆									
Summarize the work in a report				◆								
Identify potential test homes.					◆							
Test the airtightness of walls in 3 to 5 homes.						◆						
Test the airtightness of walls in 3 to 5 homes.							◆					
Test the airtightness of walls in 3 homes.								◆				
Current/Future Work												
Analyze of the cost-effectiveness the statistical significance of FY15 and FY16 field data of the different air barrier systems.										◆		
Investigate critical construction details for air tightness in 3 to 5 7 to 10 homes with different air barrier systems.											◆	
Provide a report or journal paper that summarizes the work.												◆