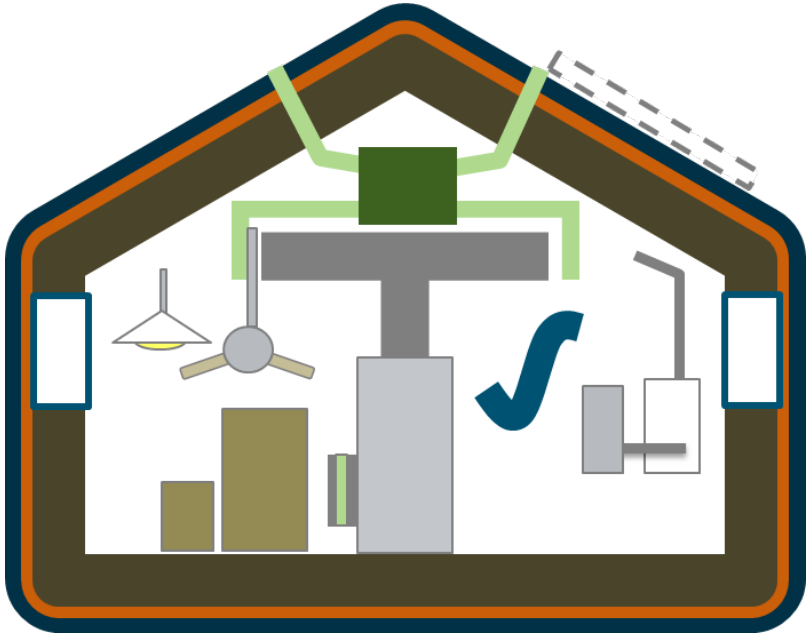
Building America Building Science Advisor (BSA)

2017 Building Technologies Office Peer Review



Enabling improved homes for Americans that **cut bills in half**, improve **health/comfort**, and increase **jobs/profits** for housing industry based on **better home performance/value.**

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

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Oak Ridge National Laboratory

Project Summary

Timeline:

Start date: 4/1/2015

Planned end date: 9/30/2018

Key Milestones

1. Rollout improved BSA; 06/30/17
2. Expand BSA to all U.S. CZs; 9/30/17

Budget:

Total Project $ to Date:

- DOE: $560,000
- Cost Share: $0

Total Project $:

- DOE: $900,000
- Cost Share: $0

Key Partners:

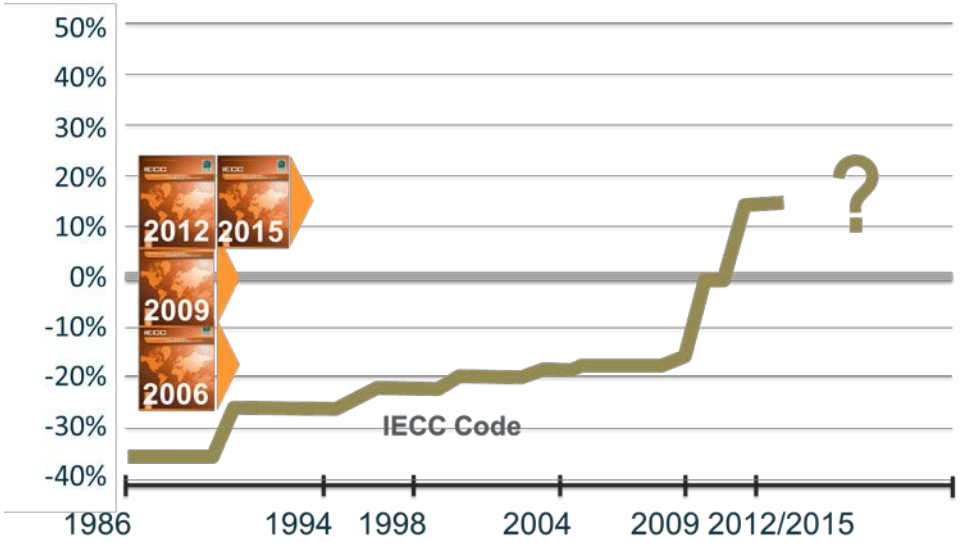
Home Innovation Research Laboratory	Forest Product Laboratory
Building America Teams	ARES Consulting
RDH Building Science	Building Science Corporation

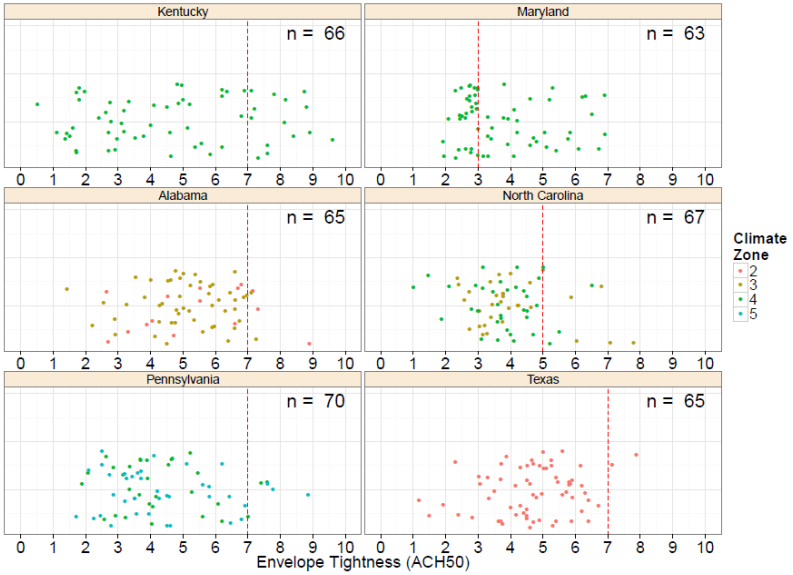
Project Outcome:

A web tool that provides building professionals with guidance to minimize moisture related risks in low energy, high performance homes that can reduce the **energy use intensity of new single-family homes by at least 60%.** Based on the knowledge of the industry's best researchers and building scientists, this tool will enable users to make informed decisions needed to minimize risks and confidently construct homes that are so energy efficient that all or most annual energy consumption can be offset by renewable energy.

Purpose and Objectives

Modern building envelopes have evolved

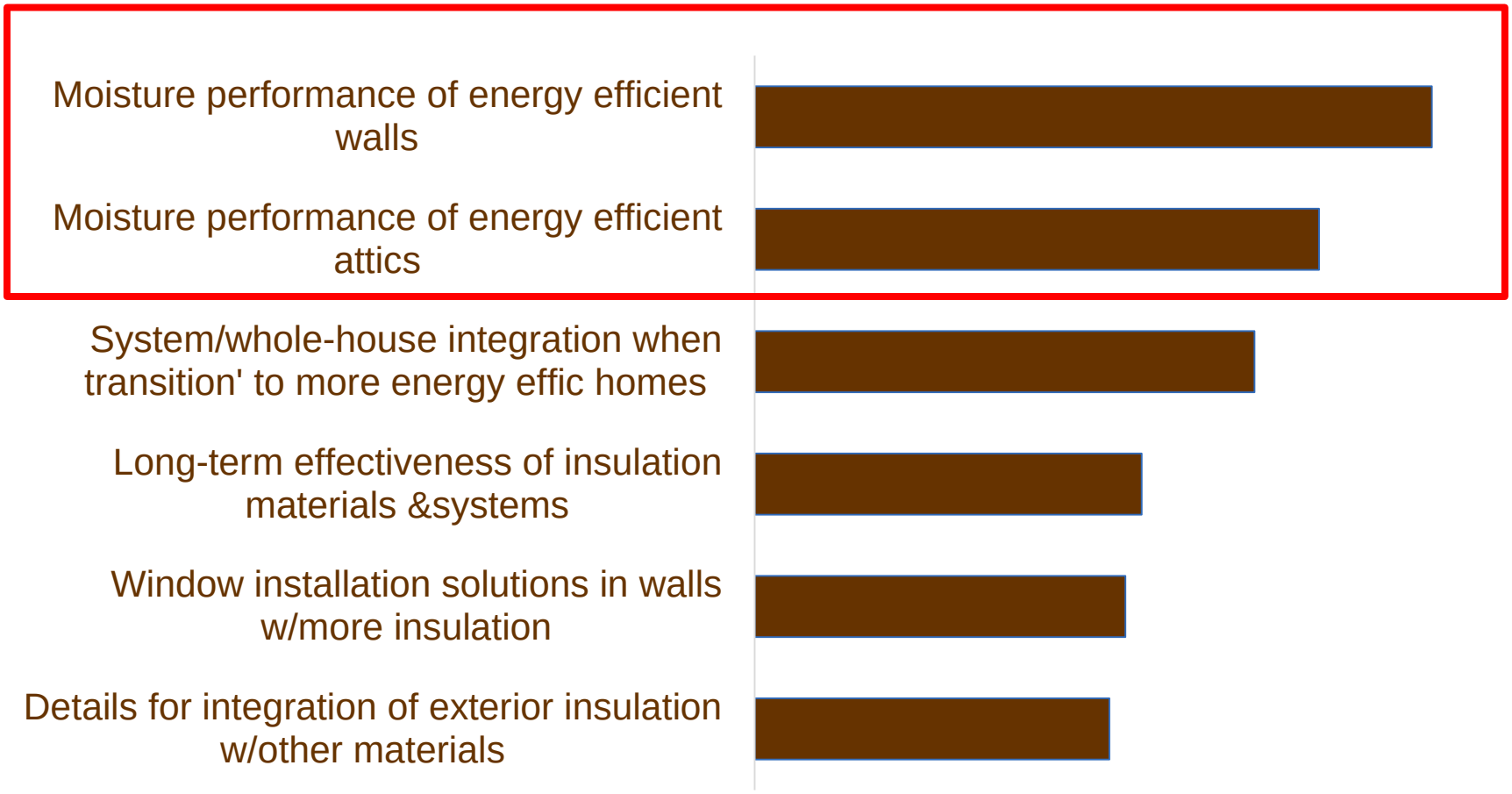




Problem Statement: As building envelope assemblies continue to evolve, they become less tolerant of design and installation flaws. Consequently, there is market uncertainty regarding the moisture risk of high-performing envelope systems, which in turn **hinders adoption**. Unfortunately, builders, architects, and other building professionals **lack access to credible guidance** on **durable**, **energy-efficient** wall assemblies to mitigate risks. This knowledge gap must be addressed to achieve residential EUI reduction targets.

Purpose and Objectives

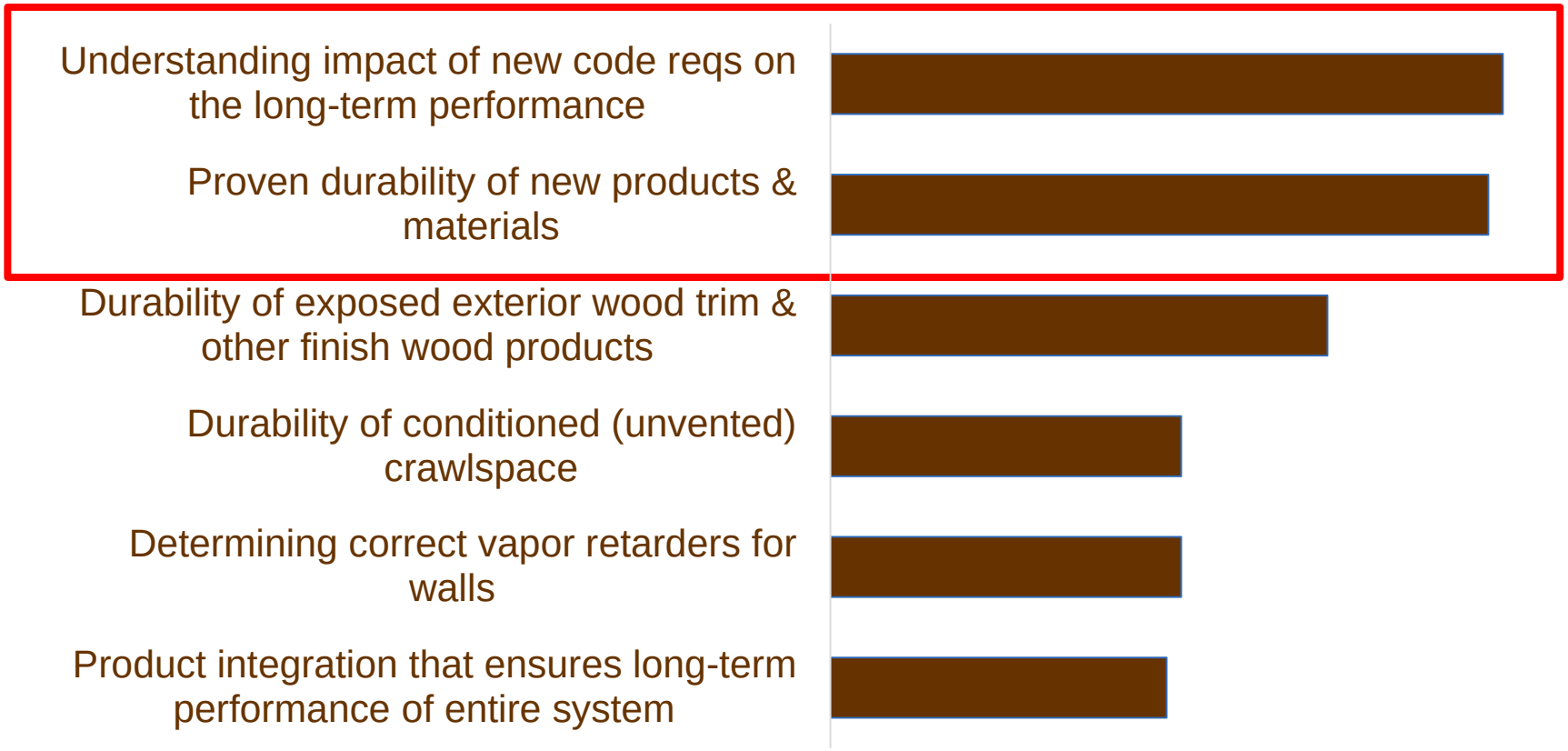
Builder Survey: Top Challenges in Energy Efficiency



Source: Home Innovation Research Laboratory

Purpose and Objectives

Builder Survey: Top Challenges in Energy Efficiency



Source: Home Innovation Research Laboratory

Project Summary

Target Market and Audience: Target market is new residential construction, which in 2014 was approximately 1 million new housing units. The audience is residential builders, architects, manufacturers, and raters.

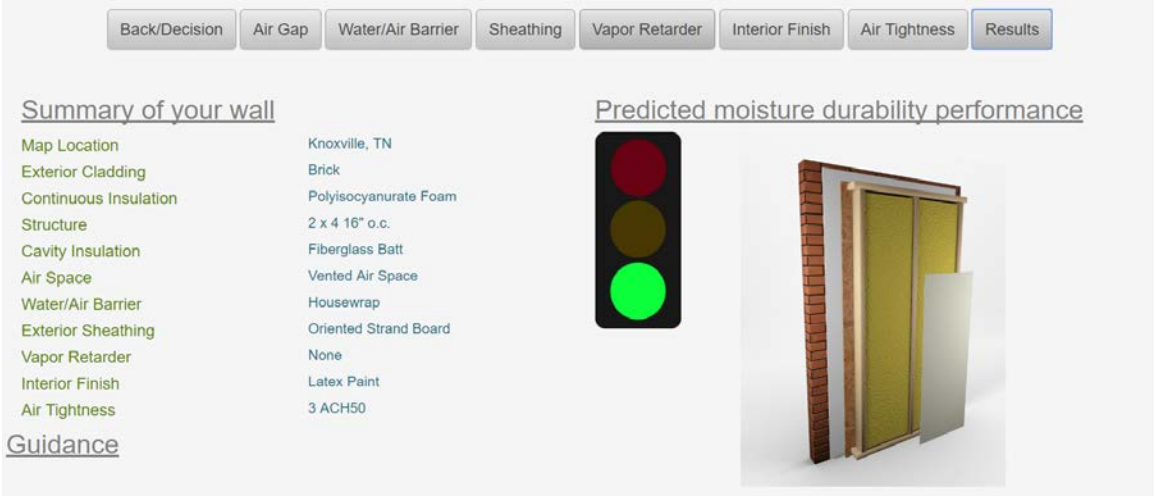
Impact of Project:

1. As stated in the Building America Research-to-Market Plan, high-R building envelope assemblies in new and existing homes can decrease energy use by about 2.75 quads per year.

2. Project outcome is a web based tool that provides guidance to minimize moisture related risks in low energy, high performance homes that can reduce the energy use intensity of new single-family homes by at least 60%.
3. Near and Intermediate outcomes: Web based tool will be used as a moisture management reference and learning tool for leading ***building professionals to improve or construct high performance homes above model energy codes***.
4. Long term outcomes: Tool will continually be updated with moisture management guidance for new materials and envelope assemblies. All real or perceived risks in high performance building envelopes will be addressed by the BSA.

Approach

Approach: Give every building professional access to the knowledge of the industry's best researchers and **building** scientists.



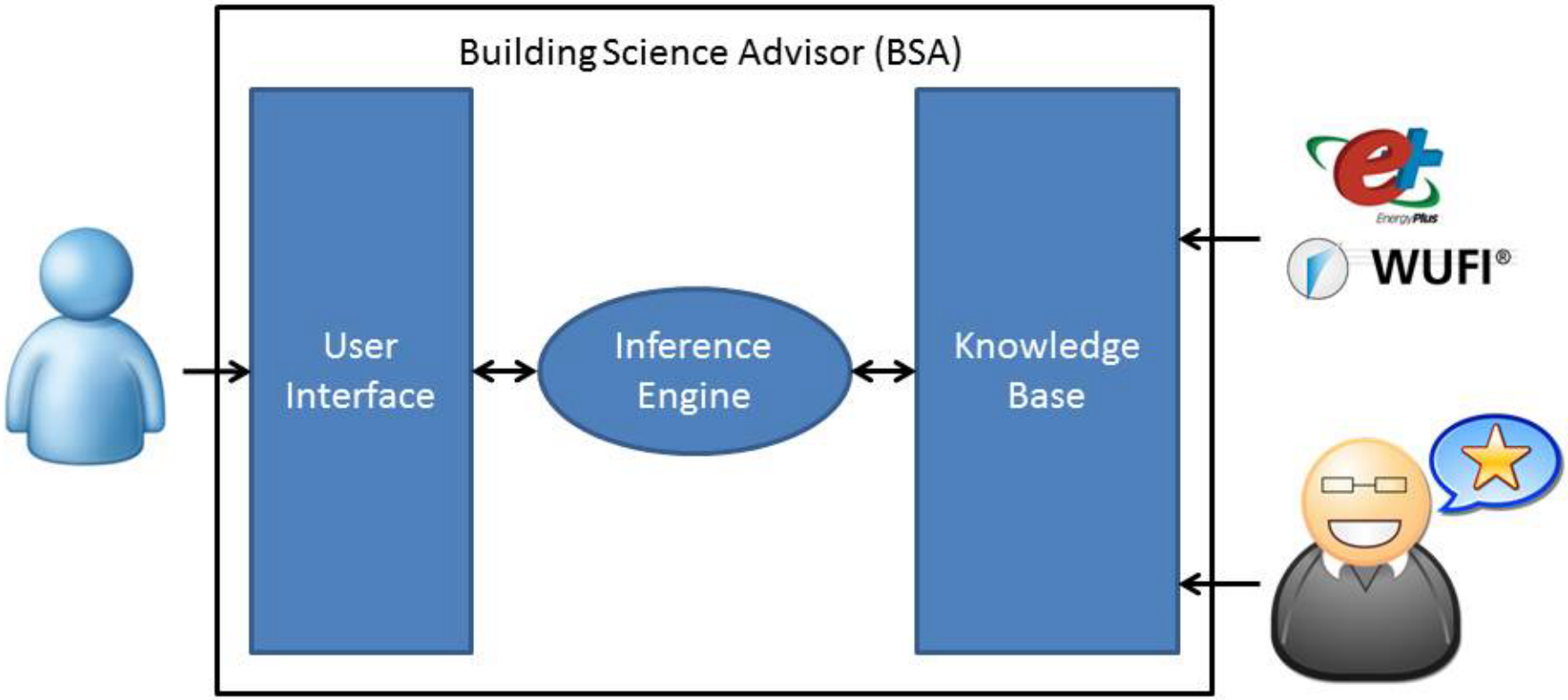
Key Issues:

1. Distilling expert knowledge into an expert system framework
2. Designing probabilistic hygrothermal simulations
3. Validating hygrothermal simulations

Distinctive Characteristics:

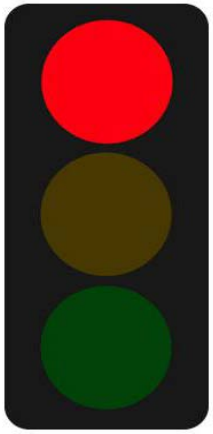
1. First application of an expert system for moisture management in buildings.
2. Articulates guidance for durable wall systems based on expert consensus and empirically validated hygrothermal modeling and simulation.

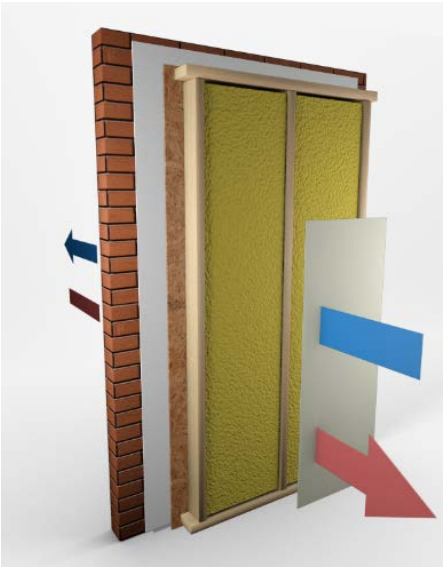
Approach


Building Science Advisor (BSA)
User Interface
Inference Engine
Knowledge Base
WUFI®

Approach: Inputs into Knowledge Base

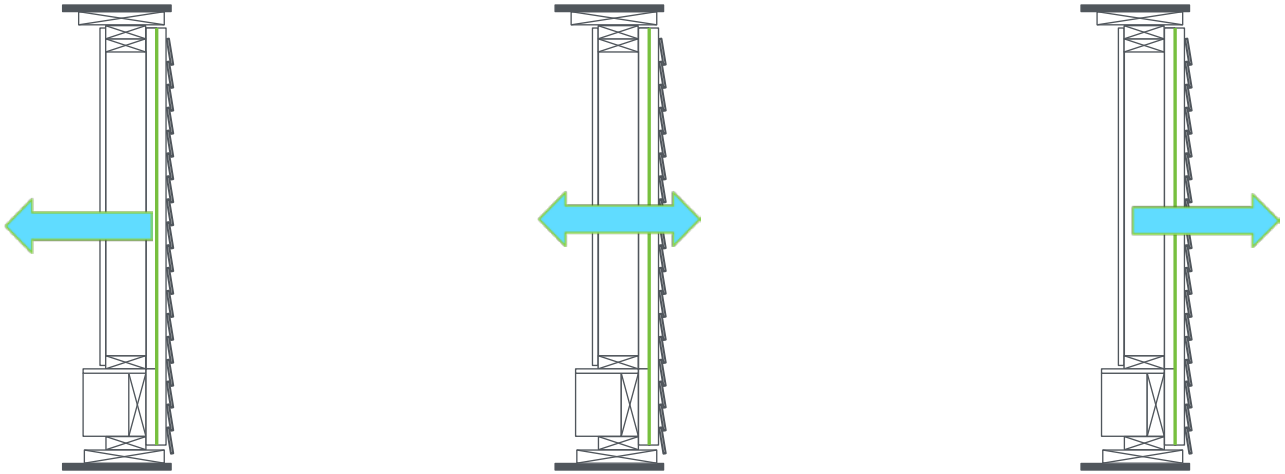
- Knowledge - coded as if/then statements called rules
  - e.g. **if** cladding is moisture absorptive and there is no air gap for ventilation, **then** the wall is considered moisture risky
- Sources
  - Expert Knowledge
    - Expert meetings
    - Historical performance of common walls
    - Building code
  - Hygrothermal Simulations
    - Access durability of walls not captured in expert knowledge set
    - Validate expert knowledge





Approach: Knowledge Base Inputs –Summarized as Expert Knowledge (Guiding Principles)

	Moisture Management Strategy		
	Drying to interior	Drying to both interior and exterior	Drying to exterior
	- Interior material permeance > 10 - External material permeance < 1	- Interior material permeance > 10 - External material permeance > 10	- Interior material permeance < 1 - External material permeance > 10
Cold / Very Cold	a		
Marine			
Hot Dry / Mixed Dry			
Mixed Humid		b	
Hot Humid		b	
	a. Higher risk can occur in a *Very Cold* climate, and with high indoor humidity levels.		
	b. Evaluation assumes indoor climate to be conditioned during summer months		
	Does not consider IRC Code Table R702.7.1		



Approach: Inputs into Knowledge Base – Empirically Validated Hygrothermal Simulations

Probabilistic Indoor Conditions

EnergyPlus

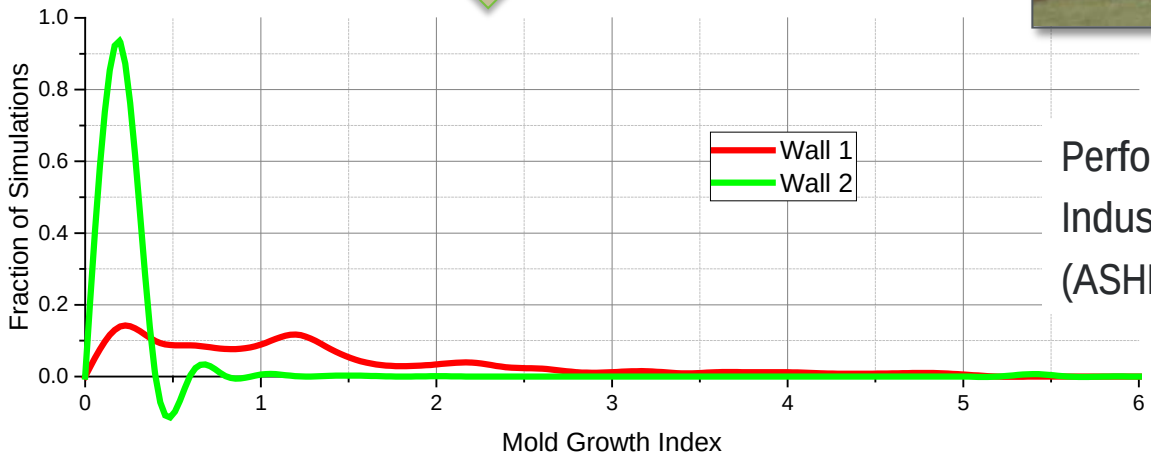
Moisture Durability Simulations

WUFI®

Empirical Validation

ORNL Environmental Chambers

Collaboration with HIRL Field Tests



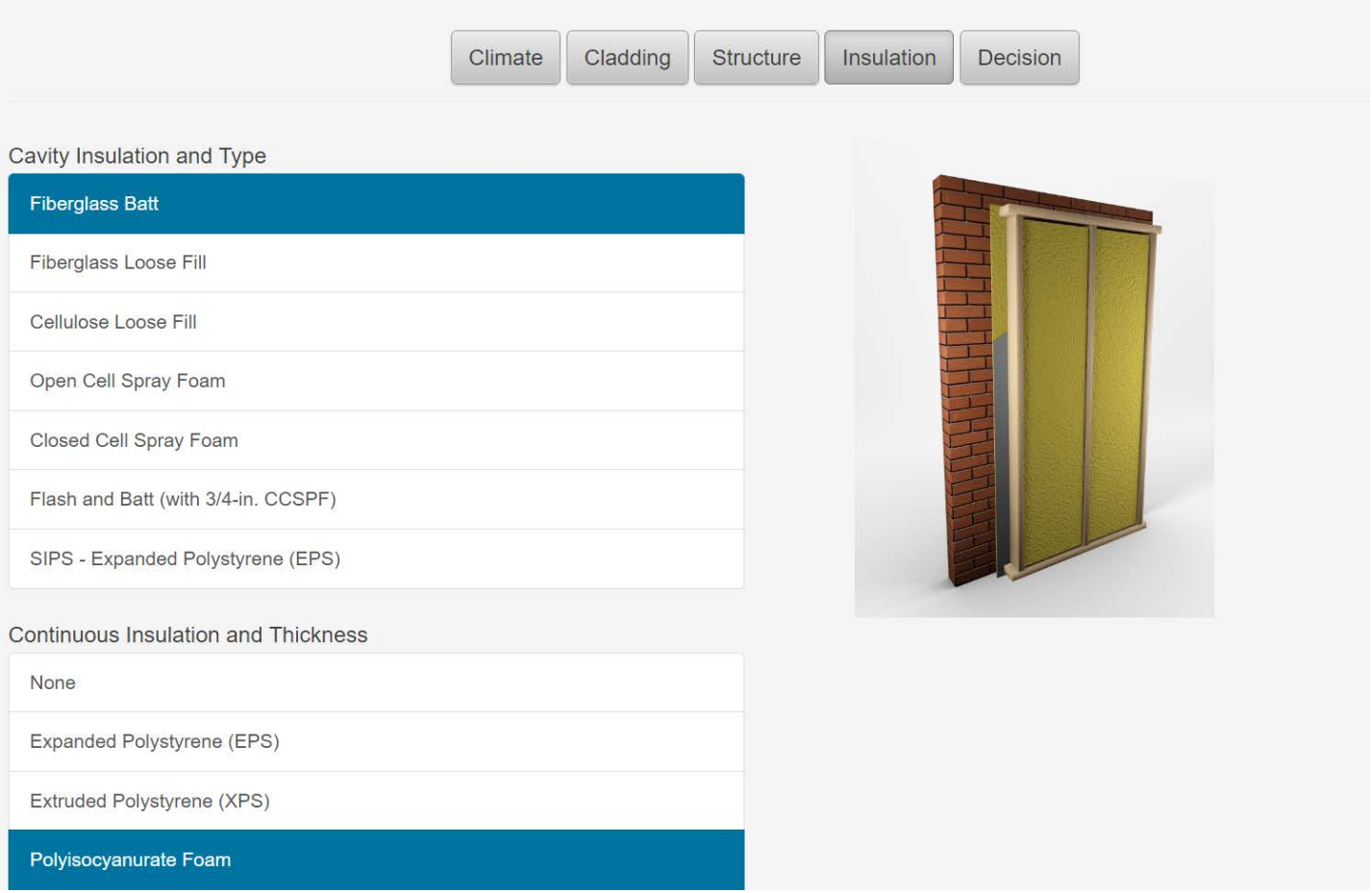
Performance Indicator: Mold Growth Index

Industry recognized indicator of durability risk (ASHRAE Standard 160)

Progress and Accomplishments

Accomplishments:

- Alpha version of web tool has been completed with initial set of expert knowledge.



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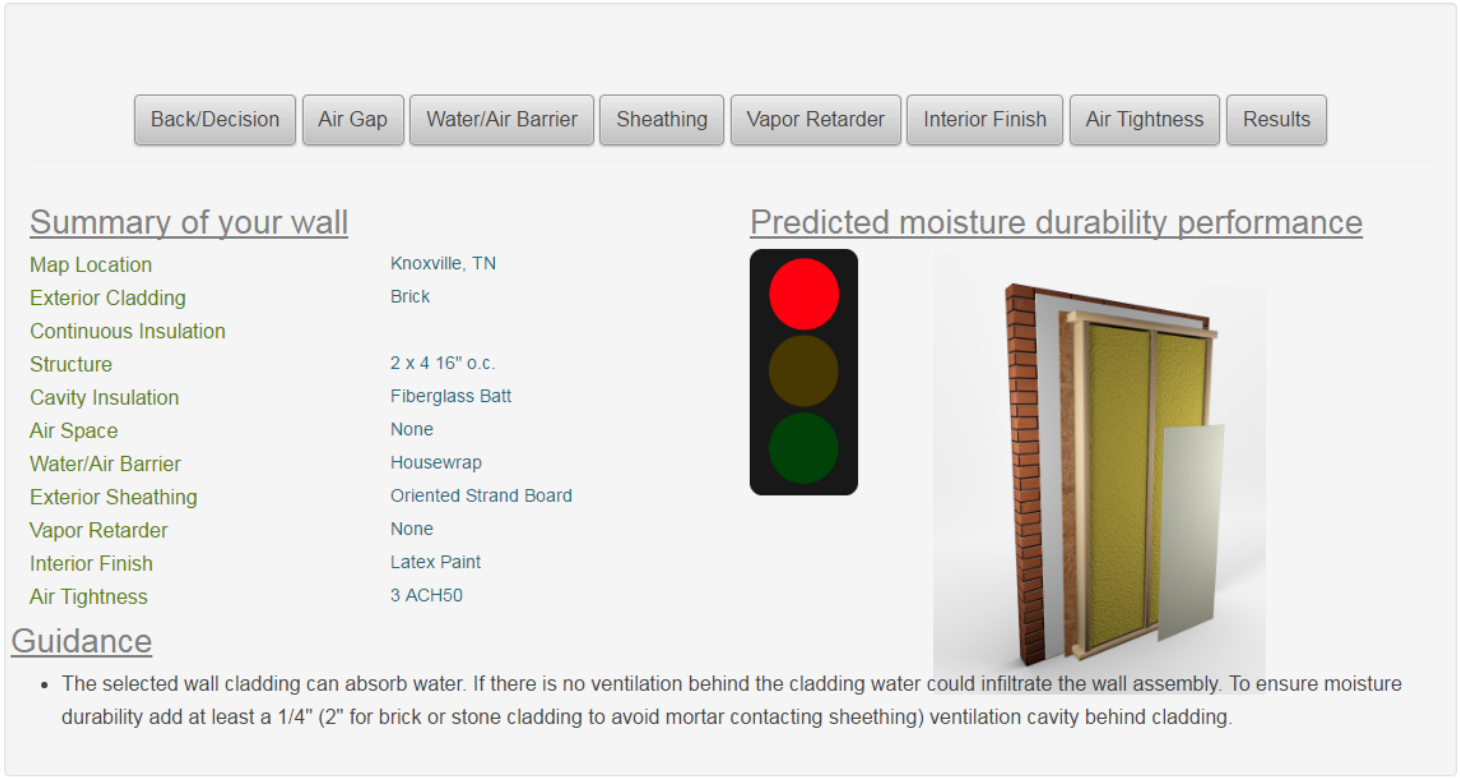

Progress and Accomplishments

Market Impact: High-R building envelope assemblies in new and existing homes can decrease energy use by about 2.75 quads per year[1].

1. Builders, raters, and building science consultants have been engaged in the development of this tool, particularly through presentations and follow on discussions at key conferences (e.g. EEBA and RESNET). These stakeholders have agreed to evaluate a "soft rollout" of the beta version to provide feedback to ensure maximum impact.
2. Feedback from key stakeholders regarding the impetus for the BSA and the development have been positive.

Awards/Recognition: None

Project Integration and Collaboration

Communications:

EEBA, October 6-8, 2015, Denver, CO.

1. *Building America Roadmap: Moisture Managed High-R Assemblies*, André Desjarlais

EEBA, September 27-29, 2016, Dallas, TX.

2. *Building Science Advisor,* Roderick Jackson

RESNET.

3. *High Performance, Moisture Managed Envelope Systems for the Masses*, Eric Werling

ASTM Symposium on Advances in Hygrothermal Performance of Building Envelopes, October 26-27,2016, Orlando, FL.

4. Simulations of Indoor Moisture Generation in U.S. Homes, Philip Boudreaux

Buildings XIII Conference, December 4-8, 2016, Clearwater, FL.

5. Coming Soon: DOE's New Building Science Advisor, a Web-based Design Tool to Help Manage Moisture Risks in Walls, Eric Werling

6. Protocol to evaluate the moisture durability of energy-efficient walls, Philip Boudreaux

7. Simulating air leakage in walls and roofs using indoor and outdoor boundary conditions, Simon Pallin

Project Integration and Collaboration

Project Integration: Collaborating with moisture durability experts to gather knowledge to add to BSA. BSA will bring the moisture durability of different wall assemblies to builders.

Partners, Subcontractors, and Collaborators: Moisture durability experts:

- **Bailey Brown, RDH Building Science Inc.**
- **Lena Burkett, U.S. Department of Energy**
- **Jay Crandell, ARES Consulting**
- **André Desjarlais, ORNL**
- **Samuel Glass, FPL**
- **Roderick Jackson, ORNL**
- **Vladimir Kochkin, HIRL**
- **Joseph Lstiburek, BSC**
- **Simon Pallin, ORNL**
- **Sam Rashkin, U.S. Department of Energy**
- **Chris Schumacher, BSC**
- **Eric Werling, U.S. Department of Energy**

Next Steps and Future Plans:

- Continued development of the alpha version for a soft rollout.
- Soft rollout will be beta tested by key stakeholders (e.g. building scientists, builders, raters, manufacturers) whom have volunteered to provide feedback.
- Tool will be continuously updated with moisture management guidance for new materials and envelope assemblies.

REFERENCE SLIDES

Project Budget

Project Budget: Project budget to date: $560,000.00 (FY16&FY17)
Variances: None
Cost to Date: $305,426.00
Additional Funding: None

Budget History					
4/1/2015 – FY 2016 (past)		FY 2017 (current)		FY 2018 – 9/30/2018 (planned)	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
$168,000	0	$392,000	0	$340,000	0

Project Plan and Schedule

- Project Start date: 4/1/2015
- Planned end date: 9/30/2018
- Gain industry consensus on the risk protocol – **Completed 3/30/2016**
- Roll out improved version of BSA with enhanced search features released with additional attributes identified by users of the beta version - 06/30/2017
- Expand BSA to include expert guidelines for walls for all U.S. climate zones - 09/30/2017