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Integrated Wall Retrofit Solutions for Existing Masonry Construction for Commercial Buildings

W14

Amy Wylie & Andre Desjarlais

9-30-2015

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Course Description

The Integrated Wall Retrofit Project aims at identifying best-practice recommendations for an energy-efficient, cost-effective retrofit solution for the interior of existing masonry walls for commercial buildings.

The best practice recommendations identified will be based on evaluation against critical parameters, simulation results, laboratory tests as well as field data collection.

The target market identified is climate zones 4 & 5.

Learning Objectives

At the end of this course, participants will be able to:

1. Review air, thermal and moisture performance impacts for a number of integrated retrofit packages.
2. Identify best-practice recommendation for an energy efficient, cost-effective retrofit on the interior of existing masonry wall system.
3. Review and validate the simulation analysis against laboratory test results performed for thermal performance and air leakage analysis.
4. Analyze potential energy savings achievable through an integrated energy efficient retrofit.

Agenda

- **Project Background & Description**

  - Amy Wylie, Covestro LLC (previously Bayer MaterialScience LLC)

- **Expert Review & Modeling/laboratory Results**

  - Andre Desjarlais, Oak Ridge National Laboratory (ORNL)

- **Building Retrofit & Path Forward**

  - Amy Wylie, Covestro LLC (previously Bayer MaterialScience LLC)

Consortium for Building Energy Innovation (CBEI)

The Consortium, funded by Department of Energy (DOE), is a partnership of 14 member organizations with Pennsylvania State University as the Project Lead.

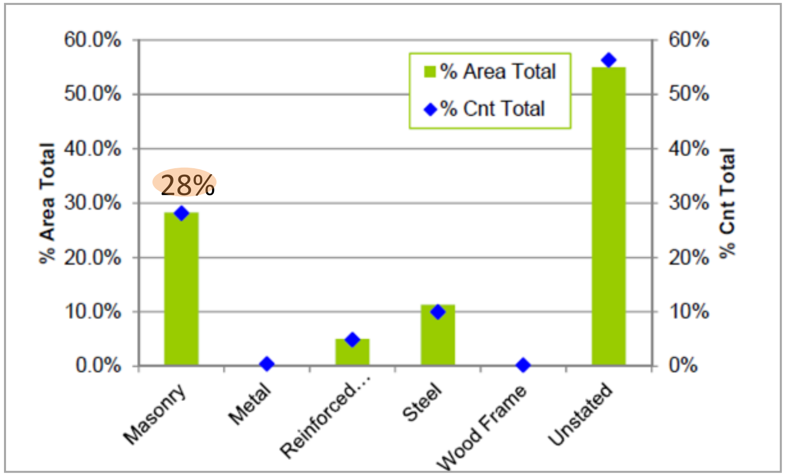
Consortium Goal:

Develop and deploy market-tested pathways to achieve 50% energy reduction in existing SMSCB by 2030.

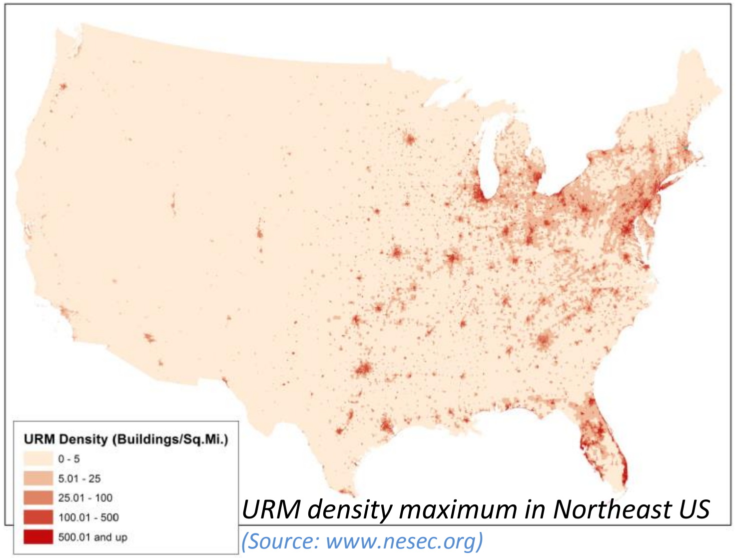
Market Opportunity

- Older buildings with brick walls are common in many northern US cities. Most of these old masonry walls are rarely insulated.
- These buildings with uninsulated masonry walls offer a good potential to achieve energy efficiency through improved envelope performance.

COSTAR Analysis



Masonry construction for existing office buildings in the ten county region around Philadelphia (Source: COSTAR, 2011)



URM density maximum in Northeast US (Source: www.nesec.org)

- Adding insulation to masonry walls on the interior side in cold climates can cause performance and durability problems requiring effective analysis.

Project Background

Old masonry building in Navy yard, Philadelphia.

- Retrofit required for the interior of the masonry wall.
- Recommendations provided based on energy modeling.

Learning:

- Several months required to generate accurate baseline model and integrated design. Owner satisfied, but would not normally do this.
- Owner decided not to pursue the proposed retrofit due to a change in business strategy.

Uncertainty in enclosure retrofits of SMSCB's led the team to seek a risk free environment to test wall assemblies and speed up adoption.

Project Summary

Objective:

Develop package of wall retrofit solutions that exceeds ASHRAE 90.1 2010 requirements with a payback of 10-15 years. Package will be suitable for masonry construction small/med sized commercial buildings and is presently demonstrated on the ORNL Flexible Research Platform (FRP).

Target Market:

Pre-1980's commercial buildings with masonry construction in climate zones 4 & 5 which require insulation on the interior of the existing masonry façade.

Project Summary

Metric for Identifying Best Practice Recommendations:

- Exceed ASHRAE 90.1 2010 performance.
- Payback period ranging 10-15 years.

Project Deliverables:

- An extensive evaluation matrix comparing the performance of retrofit scenarios against 6 critical evaluation parameters.
- Detailed report highlighting performance of the demonstrated wall constructions that will include expert review, simulated results, and field-data.
- Guidelines for best practice recommendations.

Project Partners

CBEI CONSORTIUM for BUILDING ENERGY INNOVATION

covestro

OAK RIDGE National Laboratory

Market partners:

CARLISLE CONSTRUCTION MATERIALS

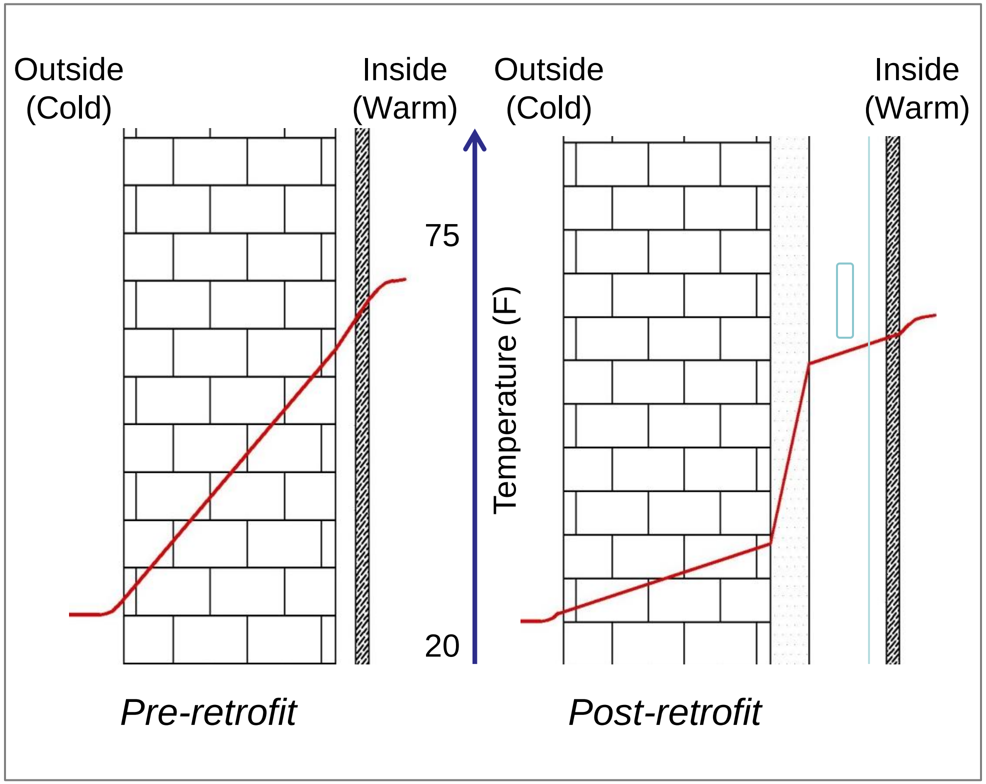
air barrier abaa association of america

Technical Advisory Group (TAG):

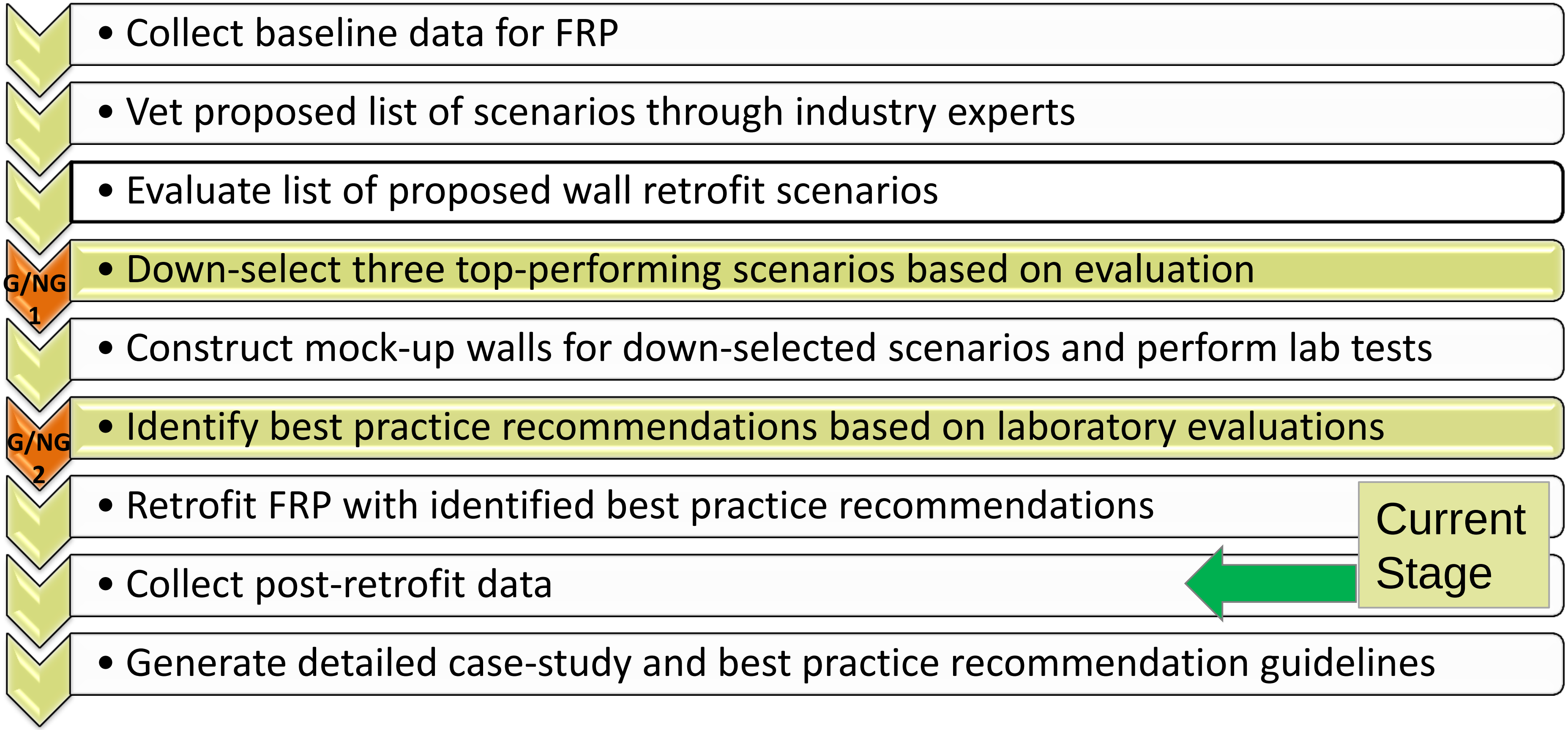
- Brian Stroik: The Boldt Company.
- Fiona Aldous: Wiss, Janney, Elstner Associates, Inc.
- Pat Conway: International Masonry Institute.

Project Need

- To identify an effective integrated retrofit package for the interior of masonry wall construction that addresses:
    - Air-tightness for the assembly
    - Thermal performance
    - Moisture management/durability
- To validate evaluation and laboratory results against field data.



Project Plan



- Collect baseline data for FRP
- Vet proposed list of scenarios through industry experts
- Evaluate list of proposed wall retrofit scenarios

G/NG 1

- Down-select three top-performing scenarios based on evaluation
- Construct mock-up walls for down-selected scenarios and perform lab tests

G/NG 2

- Identify best practice recommendations based on laboratory evaluations
- Retrofit FRP with identified best practice recommendations
- Collect post-retrofit data

Current Stage

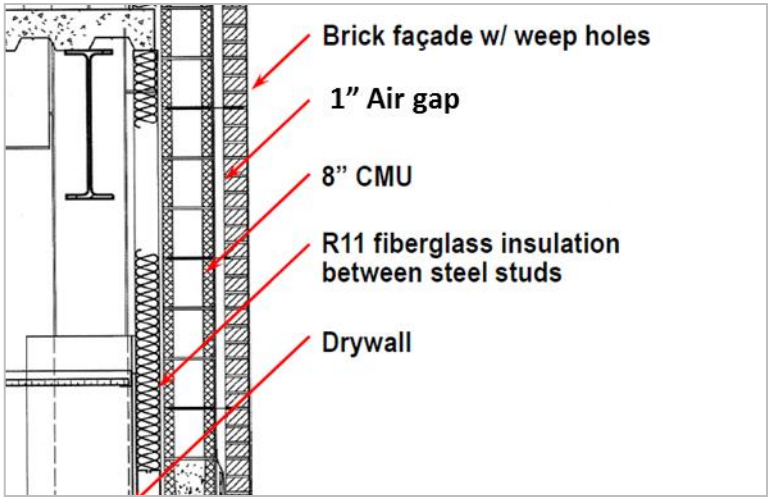
- Generate detailed case-study and best practice recommendation guidelines

Project timeline:

Start date: June 2013; End date: April 2016

Flexible Research Platform (FRP)

Baseline building for demonstrating best practice recommendation



Baseline envelope to represent wall systems typical of older masonry buildings in the ten county region around Philadelphia

Two-story Flexible Research Platform at ORNL

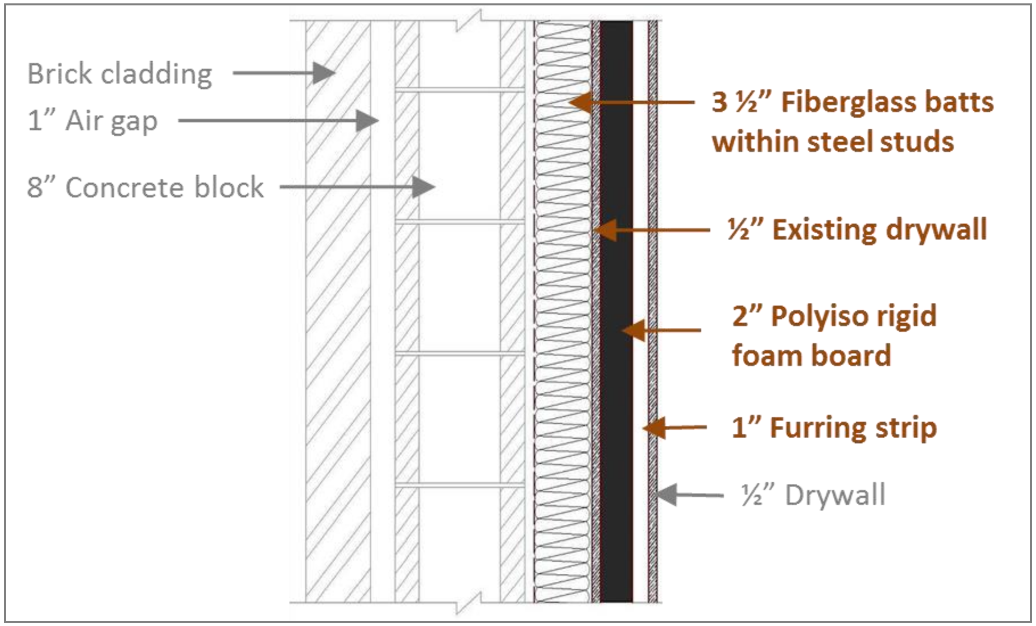
- The baseline envelope system built to represent the wall systems of majority of the pre-1980s buildings in the Philadelphia region based on analysis of CBECS and COSTAR data.

- Two-story structure with a footprint of 40’ x 40’.

- Building is multi-zoned allowing for the simultaneous evaluation of up to six retrofit options.

Initial Proposed Scenarios

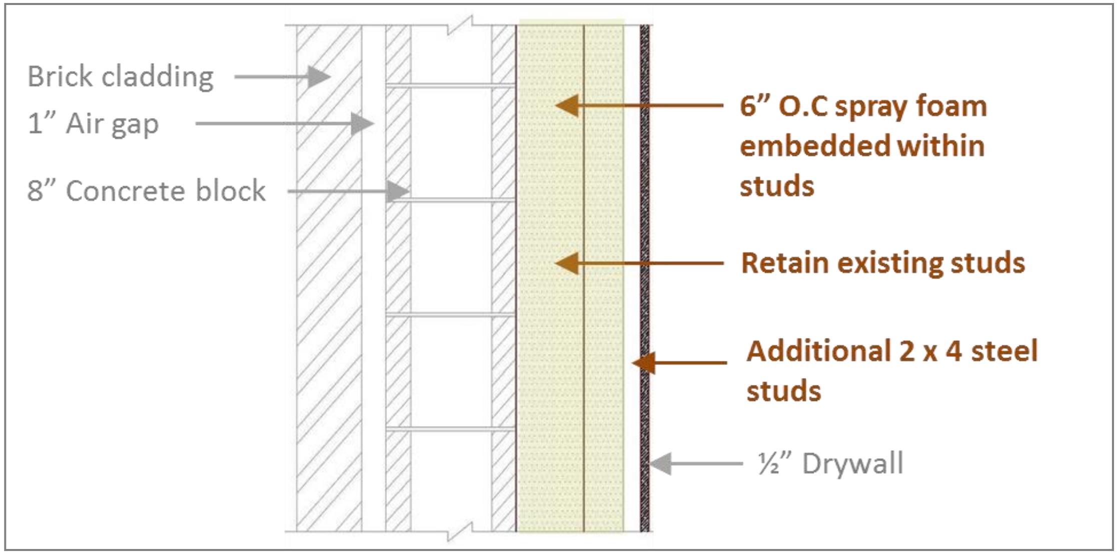
A. Retain the existing wall (studs+existing insulation+existing drywall)



1. Rigid foam board insulation with taped joints installed over existing insulation

Initial Proposed Scenarios

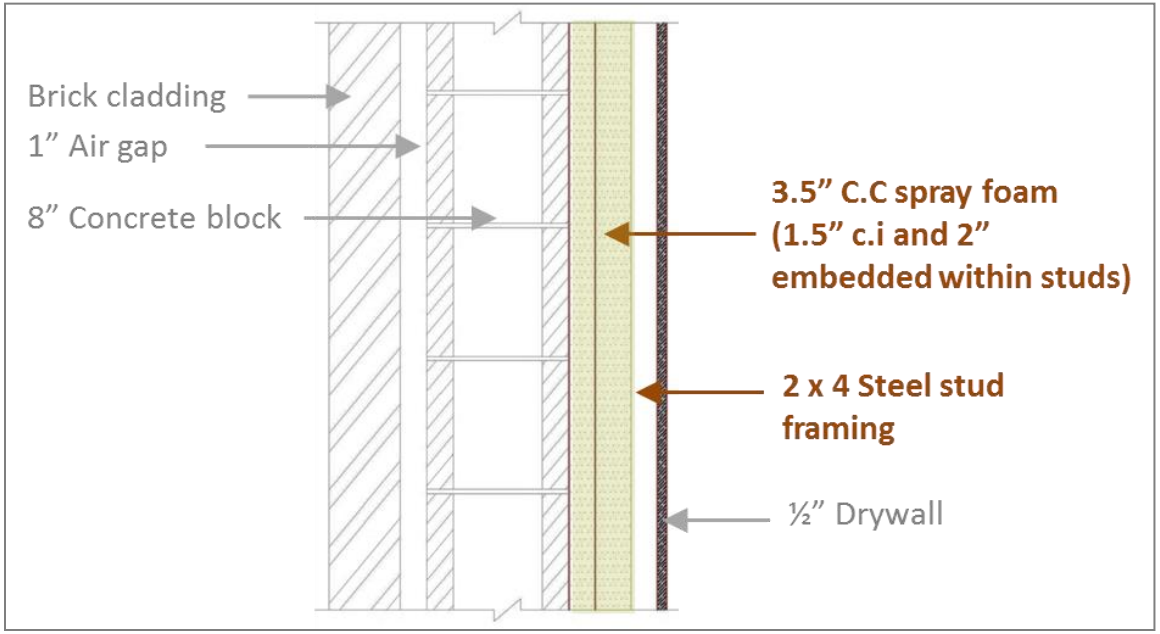
B. <u>Retain the studs but remove existing insulation and existing drywall</u>



2. Open-cell spray foam insulation installed within existing studs

Initial Proposed Scenarios

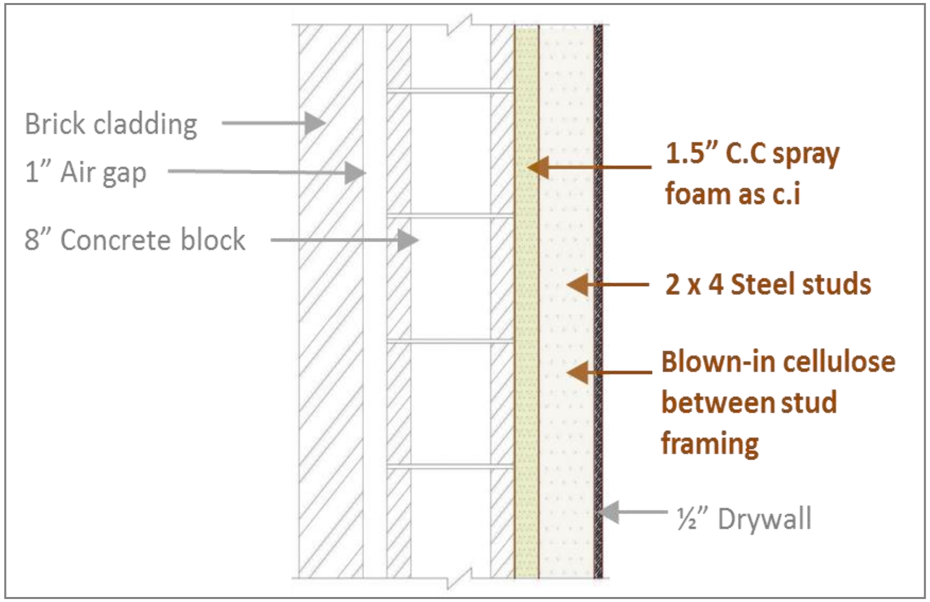
C. <u>Remove existing insulation and steel studs</u>



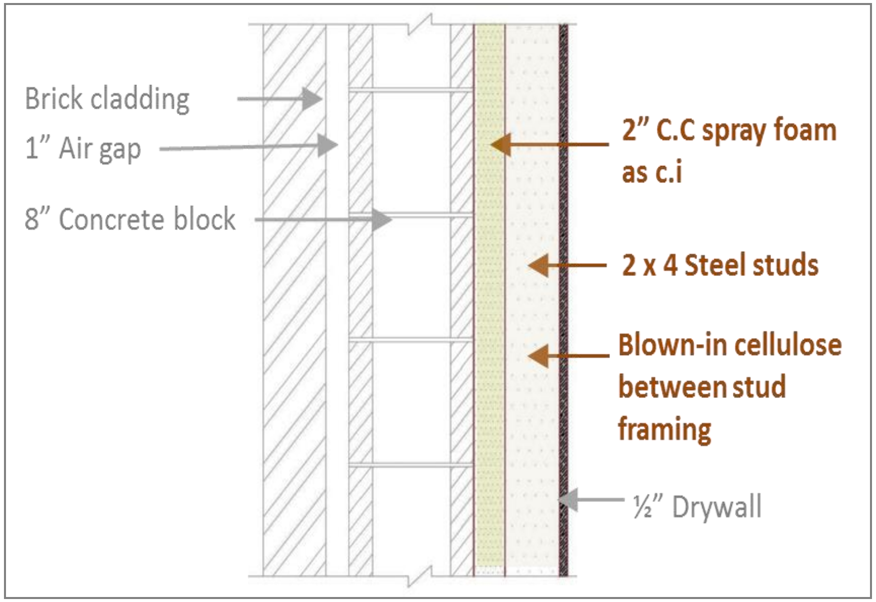
3. Closed-cell SPF insulation

Initial Proposed Scenarios

C. Remove existing insulation and steel studs



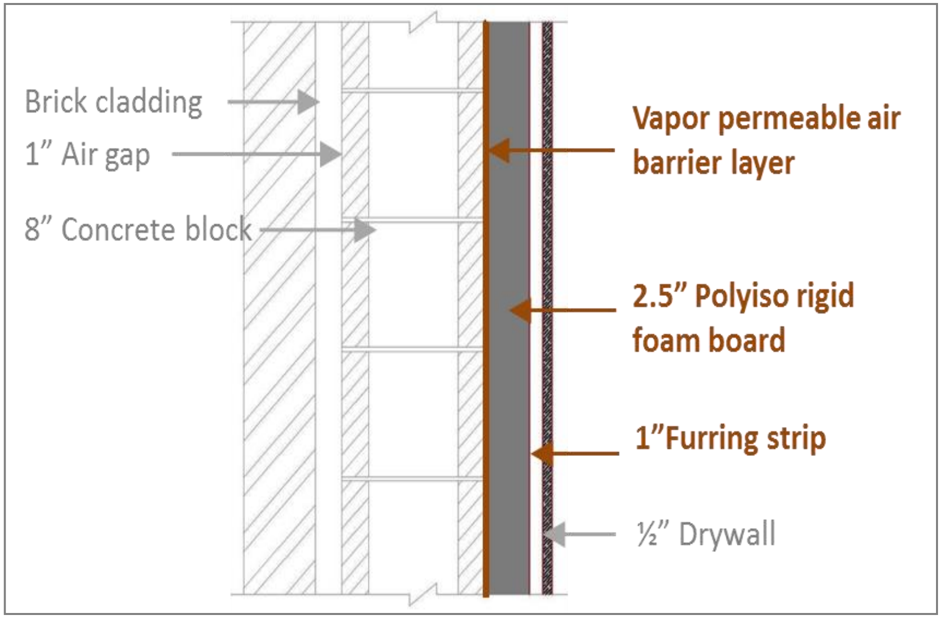
4. Hybrid insulation with 1.5" c.c SPF and blown-cellulose



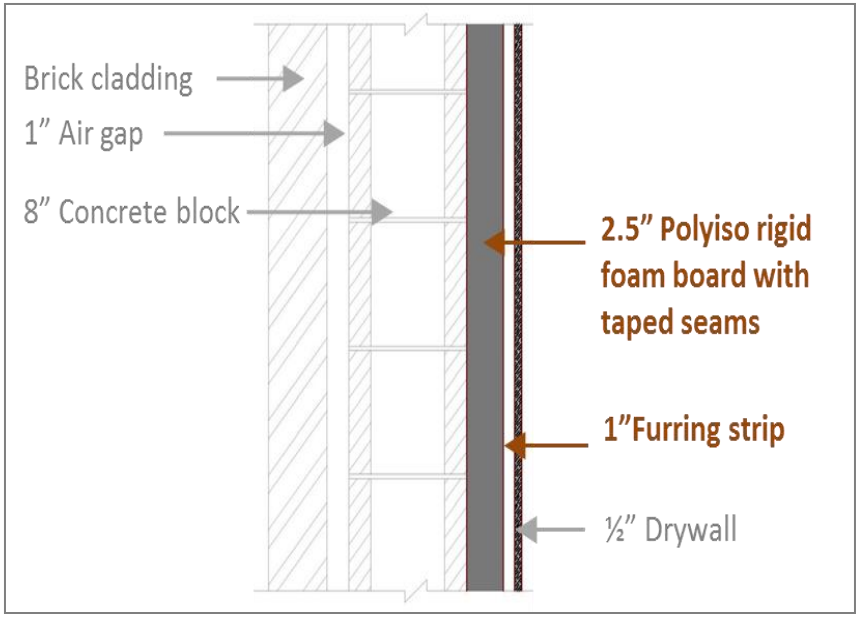
5. Hybrid insulation with 2" c.c SPF and blown-cellulose

Initial Proposed Scenarios

C. Remove existing insulation and steel studs



6. Rigid board insulation installed with a separate a/b layer



7. Rigid board insulation installed w/o separate a/b layer, but with taped seams, and sealed junctions and penetrations

Expert Review & Modeling/laboratory Results

Andre Desjarlais, Oak Ridge National Laboratory

Industry Expert Review

Occurred August 7th 2014 in Westford, MA

Objectives:

- Get input from industry experts on proposed retrofit scenarios and need for additions.
- Acquire input on proposed critical evaluation parameters and weighted percentages.

Participants:

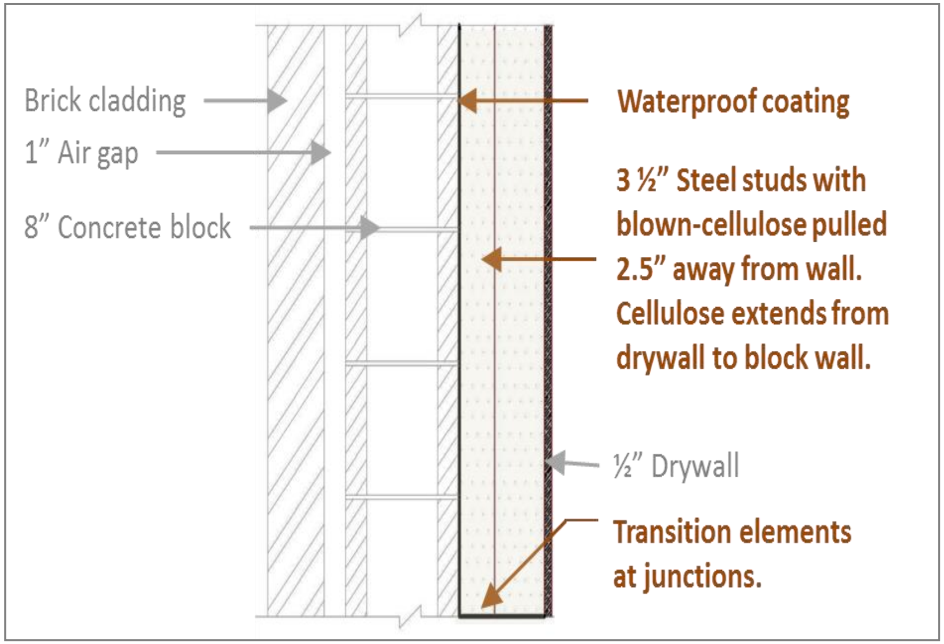
Name		Affiliation	Building Retrofit Market Perspective
A.	**Pat Conway**	International Masonry Institute	Construction Services
	Jay H. Crandell	Applied Residential Engineering Services (ARES)	Building Science
	Joe Lstiburek	Building Science Corporation	Building Science
	Brian Stroik	The Boldt Company	Construction Services
B.	**Valerie Patrick (Facilitator)**	Fulcrum Connection LLC	Consortium for Building Energy Innovation
	Tim Wagner	United Technologies Research Center	Consortium for Building Energy Innovation
C.	**Chad Burhman**	Carlisle Construction Materials	Insulation Materials and Architecture
	Laverne Dalgleish	Air Barrier Association of America	Air Barrier
	Andre Desjarlais	Oak Ridge National Laboratory	Consortium for Building Energy Innovation
	Mike Ducharme	Carlisle Construction Materials	Roofing System Provider
	Jim Lambach	Covestro LLC (formerly Bayer MaterialScience LLC)	Construction Raw Materials Supplier
	Jeff Lear	Covestro LLC (formerly Bayer MaterialScience LLC)	Consortium for Building Energy Innovation
	MacGregor Pierce	Hunter Panels LLC	Construction Parts Supplier
	Amy Wylie	Covestro LLC (formerly Bayer MaterialScience LLC)	Consortium for Building Energy Innovation

Industry Expert Review

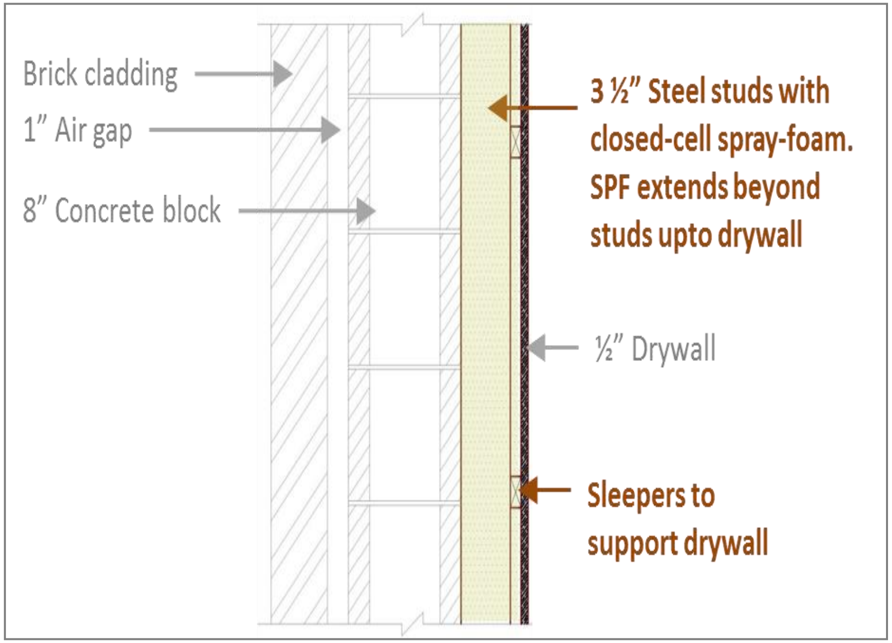
Recommendations and inputs:

- Categorize proposed scenarios as:
  1. A. Retain the existing wall (studs + existing insulation + existing drywall) – cost-effective alternative.
  2. B. Retain the studs but remove existing insulation and existing drywall.
  3. C. Remove existing insulation as well as steel studs.
- Identify good, better and best recommendations.
- Help identify critical evaluation parameters and weighting factors for each parameter.

Scenarios Added



1. Blown-cellulose insulation, existing steel studs and batt insulation torn down



2. Closed-cell spray foam insulation installed within existing studs

Initial Evaluation

Evaluate 9 proposed retrofit scenarios against 6 critical parameters identified by industry experts. Generate evaluation matrix ranking scenarios based on performance.

Scenario No.	Proposed Retrofit Assemblies
A.	**Retain existing wall (w/ existing insulation)**
1	Rigid board over existing insulation (2”)
B.	**Retain existing studs (w/o existing insulation)**
2	Open-cell spray foam within existing stud (6”)
3	Closed-cell spray foam within existing stud (5")
C.	**Remove existing insulation and Studs**
4	Blown-cellulose (6”)
5	Closed-cell spray foam (3.5")
6	Hybrid Spray foam (2")
7	Hybrid Spray foam (1.5")
8	Rigid board w a/b (2.5")
9	Rigid board w/o a/b (2.5”)

Critical evaluation parameters

(with weighting factors) identified by industry experts:

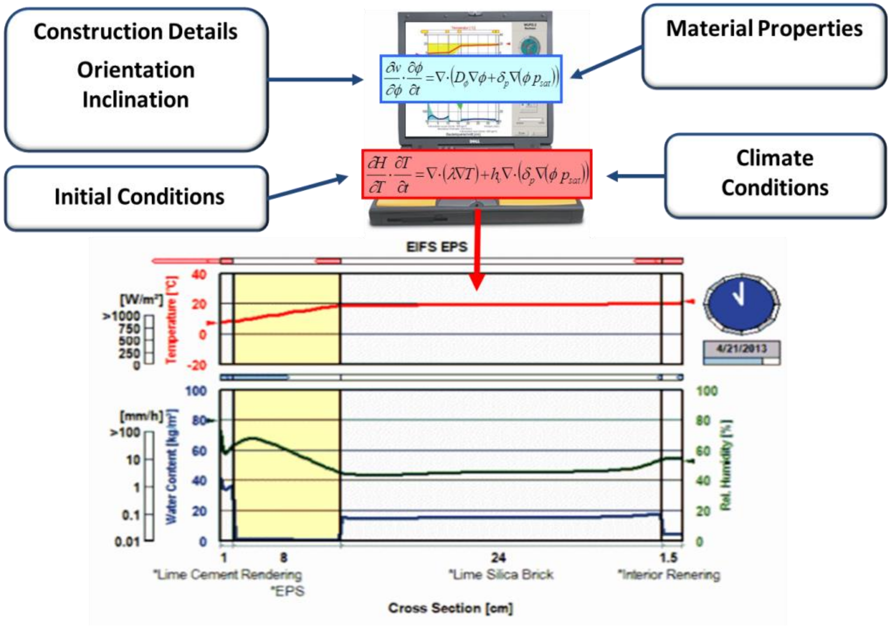
- Cost-effectiveness – 35%
- Moisture management/durability – 20%
- Thermal performance – 18%
- Air leakage – 12%
- Disruptiveness/constructability – 9%
- Indoor air quality – 6%

Result: Down-select three top-performing retrofit scenarios based on evaluation matrix.

Evaluation Parameters Analysis

Data collection sources:

- Cost-effectiveness: Cost data from contractor
- Moisture management/durability: WUFI modeling
- Thermal performance: THERM modeling
- Air leakage: Data from ABAA
- Disruptiveness/constructability: Industry assumptions
- Indoor air quality: WUFI modeling



Construction Details

Orientation

Inclination

Initial Conditions

Material Properties

Climate Conditions

$$\frac{\partial w}{\partial \phi}\cdot\frac{\partial \phi}{\partial t}=\nabla\cdot\left(D_\phi\nabla\phi+\delta_p\nabla(\phi\, p_{sat})\right)$$

$$\frac{\partial H}{\partial T}\cdot\frac{\partial T}{\partial t}=\nabla\cdot(\lambda\nabla T)+h_v\nabla\cdot\left(\delta_p\nabla(\phi\, p_{sat})\right)$$

WUFI simulation screenshot – simulations conducted to determine moisture management and mold probability

Evaluation Parameters Analysis

- For objective evaluation, all data values under different evaluation parameters are normalized to range between 0 to 1.

- The normalized data values for each scenario are then applied with the respective weighted percentages for each evaluation criteria.

- Final ranking matrix combines the weighted percentages for all criteria and provides the total weighted percentage for each scenario.

Evaluation Matrix – Cost-Effectiveness

No.	Scenarios	Insulation type and thickness	Cost ($/sq.ft)	Ranking
	A. Retain Existing Wall			
1	**Rigid board over existing insulation**	**2" Rigid foam board**	**4.35**	**1st**
	B. Retain Existing Studs			
2	**Open-cell spray foam**	**6" o.c spray foam**	**8.75**	**5th**
3	**Closed-cell spray foam within existing stud (5")**	**4.5" c.c spray foam**	**8.65**	**4th**
	C. Remove Existing Wall Completely			
4	Blown-cellulose	6.0"	9.75	
5	Closed-cell spray foam (3.5")	3.5"	9.40	
6	Hybrid Spray foam (2")	2" c.c SPF + 3.5" cellulose	10.10	
7	Hybrid Spray foam (1.5")	1.5" c.c SPF + 3.5" cellulose	9.00	
8	**Rigid board w a/b (2.5")**	**2.5"**	**8.05**	**3rd**
9	**Rigid board w/o a/b**	**2.5"**	**6.55**	**2nd**

Cost data for all scenarios provided by Brian Stroik

Evaluation Matrix – Thermal Performance

No.	Scenarios	Insulation type and thickness	Thermal Performance		Ranking
			R-value	U-value (1/R)	
	A. Retain Existing Wall				
1	**Rigid board over existing insulation** ★	**2" Rigid foam board**	**25.50** ★	**0.039**	**1st**
	B. Retain Existing Studs				
2	Open-cell spray foam	6" o.c spray foam	19.20	0.052	
3	Closed-cell spray foam within existing stud (5")	4.5" c.c spray foam	15.20	0.066	
	C. Remove Existing Wall Completely				
4	**Blown-cellulose**	**6.0"**	**22.10**	**0.045**	**3rd**
5	**Closed-cell spray foam (3.5**	**3.5"**	**22.10**	**0.045**	**3rd**
6	**Hybrid Spray foam (2")**	**2" c.c SPF + 3.5" cellulose**	**25.00**	**0.040**	**2nd**
7	**Hybrid Spray foam (1.5")**	**1.5" c.c SPF + 3.5" cellulos**	**22.00**	**0.045**	**4th**
8	Rigid board w a/b (2.5")	2.5"	20.80	0.048	
9	Rigid board w/o a/b	2.5"	20.80	0.048	

Thermal performance for all proposed scenarios analyzed based on THERM software simulation

★ *Assuming existing insulation is in perfect condition*

Evaluation Matrix – Air Leakage

No.	Scenarios	Insulation type and thickness with a/b material	Air Leakage (l/s.sq.m) @75Pa	Ranking
			Air Leakage Rate	
	A. Retain Existing Wall			
1	Rigid board over existing insulation	2" Rigid foam board with taped seams	0.039	Good
	B. Retain Existing Studs			
2	Open-cell spray foam	6" o.c spray foam with taped drywall	0.038	Good
3	**Closed-cell spray foam within existing stud (5")**	**4.5" c.c spray foam**	**0.009**	**Better**
	C. Remove Existing Wall Completely			
4	**Blown-cellulose**	**6.0" blown-cellulose with a separate fluid applied membrane for air-tightness**	**0.001**	**Best**
5	**Closed-cell spray foam (3.5"**	**3.5" c.cSPF**	**0.009**	**Better**
6	**Hybrid Spray foam (2")**	**2" c.c SPF + 3.5" cellulose**	**0.009**	**Better**
7	**Hybrid Spray foam (1.5")**	**1.5" c.c SPF + 3.5" cellulose**	**0.009**	**Better**
8	**Rigid board w a/b (2.5")**	**2.5" rigid board with separate fluid applied membrane for air-tightness**	**0.001**	**Best**
9	Rigid board w/o a/b	2.5" rigid board with taped seams	0.039	Good

Air leakage data for proposed scenarios obtained from information on ABAA website for air leakage rate for different building assemblies

Evaluation Matrix – Moisture Management

No.	Scenarios	Insulation type and thickness	Moisture Management	Ranking
			Condensation	
	A. Retain Existing Wall			
1	Rigid board over existing insulation	2" Rigid foam board	No	
	B. Retain Existing Studs			
2	Open-cell spray foam	6" o.c spray foam	No	
3	Closed-cell spray foam within existing stud (5")	4.5" c.c spray foam	No	
	C. Remove Existing Wall Completely			
4	Blown-cellulose	6.0"	Yes	**Poor**
5	Closed-cell spray foam (3.5")	3.5"	No	
6	Hybrid Spray foam (2")	2" c.c SPF + 3.5" cellulose	No	
7	Hybrid Spray foam (1.5")	1.5" c.c SPF + 3.5" cellulose	No	
8	Rigid board w a/b (2.5")	2.5"	No	
9	Rigid board w/o a/b	2.5"	No	

Moisture performance for the proposed scenarios analyzed based on potential for condensation between insulation and concrete block masonry. WUFI simulation utilized to analyze probability of condenstion.

Evaluation Matrix – Disruptiveness

No.	Scenarios	Insulation type and thickness	Disruptiveness			Ranking
			Space requires to be vacated	Penalty for space to be unoccupied	Interior Space taken up for retrofit (in inches)	
	A. Retain Existing Wall					
1	**Rigid board over existing insulation**	**2" Rigid foam board**	**Yes**	**0 Days**	**7.5**	**2nd**
	B. Retain Existing Studs					
2	Open-cell spray foam	6" o.c spray foam	Yes	1 Day	8.5	
3	**Closed-cell spray foam within existing stud (5")**	**4.5" c.c spray foam**	**Yes**	**1 Day**	**5.0**	**3rd**
	C. Remove Existing Wall Completely					
4	Blown-cellulose	6.0"	Yes	1 Day	6.5	
5	**Closed-cell spray foam (3.5")**	**3.5"**	**Yes**	**1 Day**	**6.0**	**4th**
6	Hybrid Spray foam (2")	2" c.c SPF + 3.5" cellulose	Yes	1 Day	6.5	
7	Hybrid Spray foam (1.5")	1.5" c.c SPF + 3.5" cellulose	Yes	1 Day	6.0	
8	**Rigid board w a/b (2.5")**	**2.5"**	**Yes**	**0 Days**	**4.0**	**1st**
9	**Rigid board w/o a/b**	**2.5"**	**Yes**	**0 Days**	**4.0**	**1st**

Evaluation Matrix – Indoor Air Quality

No.	**Scenarios**	**Insulation type and thickness**	**Indoor Air Quality** **Mold Probability**	**Ranking**
	A. Retain Existing Wall			
1	Rigid board over existing insulation	2" Rigid foam board	No	**Good**
	B. Retain Existing Studs			
2	Open-cell spray foam	6" o.c spray foam	No	**Good**
3	Closed-cell spray foam within existing stud (5")	4.5" c.c spray foam	No	**Good**
	C. Remove Existing Wall Completely			
4	Blown-cellulose	6.0"	No	**Good**
5	Closed-cell spray foam (3.5")	3.5"	No	**Good**
6	Hybrid Spray foam (2")	2" c.c SPF + 3.5" cellulose	No	**Good**
7	Hybrid Spray foam (1.5")	1.5" c.c SPF + 3.5" cellulose	No	**Good**
8	Rigid board w a/b (2.5")	2.5"	No	**Good**
9	Rigid board w/o a/b	2.5"	No	**Good**

WUFI simulation analysis used to predict mold probability to quantify Indoor Air Quality

Evaluation Matrix – Final Evaluation Matrix

No.	Scenarios	Insulation type and thickness	Ranking
1	**Rigid board over existing insulation**	**2" Rigid foam board**	**1st**
8	**Rigid board w a/b (2.5")**	**2.5"**	**2nd**
9	**Rigid board w/o a/b**	**2.5"**	**3rd**
7	**Hybrid Spray foam (1.5")**	**1.5" c.c SPF + 3.5" cellulose**	**4th**
5	**Closed-cell spray foam (3.5")**	**3.5"**	**5th**
2	Open-cell spray foam	6" o.c spray foam	6th
6	Hybrid Spray foam (2")	2" c.c SPF + 3.5" cellulose	7th
3	Closed-cell spray foam within existing stud (5")	4.5" c.c spray foam	8th
4	Blown-cellulose	6.0"	9th

Final Down-Selected Scenarios

Ranking	Scenarios:
1.	**Retain existing wall; install polyiso rigid board with taped seams on existing wall** ✓
2.	**Demolish existing wall; install polyiso rigid board with a separate air barrier layer** ✓
3.	Demolish existing wall; install polyiso rigid board with taped seams (no separate air barrier) ✗
4.	Demolish existing wall; install hybrid insulation solution with 1.5” c.c SPF and blown-cellulose ✗
5.	**Demolish existing wall; install 3.5” closed cell SPF with 1.5” c.i.** ✓

- Good Solution; however, may not be applicable for all applications.
- Will require physical inspection of existing conditions.

- Almost similar assemblies with only difference being presence of a separate a/b layer.
- Evaluate the best of the two scenarios.

- Two scenarios were very similar in terms of overall performance.
- Scenario 5 chosen over 4.
- More practical/on-site issues for Scenario 4 with two different insulation types/trades.

**The down-selected scenarios meet the first Go/No Go metric:
To exceed ASHRAE 90.1 2010 performance.**

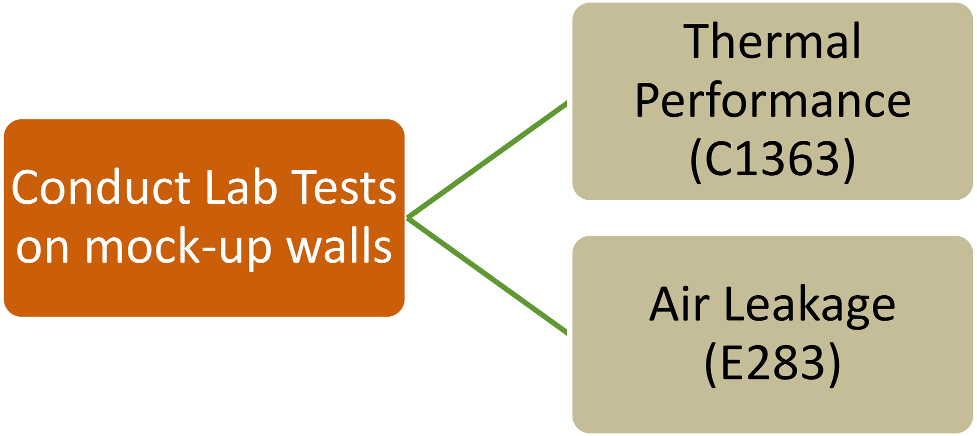
Go/No-Go Metric – Initial Evaluation

Metric	**1. ASHRAE 90.1 2010 requirements (mass walls)**			**2. Payback period**	
Criteria	Climate Zone 4	max U-value - 0.104	Meets criteria	Between 10 - 15 years	Meets criteria
	Climate Zone 5	max U-value - 0.090			
Scenarios					
	Scenario 1	U - 0.0392	✓	✓	✓
	Scenario 2	U - 0.0481	✓	✓ *	✓ *
	Scenario 3	U - 0.0455	✓	✓	✓

* Pricing based on Chicago area and previous experience is estimated pricing tends to be high. Potential for Scenario 2 to also meet criteria.

Laboratory Evaluation

Laboratory test stage: Construct mock-up walls for the down-selected scenarios as a result of initial evaluation and conduct lab tests.



Conduct Lab Tests on mock-up walls

Thermal Performance (C1363)

Air Leakage (E283)

Lab test results:

Down-selected two top-performing retrofit scenarios to demonstrate on FRP:

1. Most cost-effective solution: Retain existing wall; install 2” polyiso rigid board with taped seams on existing wall.

2. Most energy-efficient solution: Install 3.5” closed cell SPF with 1.5” continuous insulation on the concrete block wall.

Laboratory test result: Down-selected the most cost-effective and the most-energy efficient scenarios for demonstration on the FRP.

Laboratory Test

ASTM C1363 Hot Box Test Apparatus at ORNL

ASTM E283/E2357 Air Leakage Test Apparatus at ORNL

Thermal Performance Results

Thermal performance (ASTM C1363) test results			
	ASHRAE 90.1 2010 requirements (mass walls)		
Criteria	Climate Zone 4	max U-value - 0.104	Meets the criteria
	Climate Zone 5	max U-value - 0.090	
Scenarios			
①	Retain existing insulation + 2” PIR boards with taped seams	U - 0.048	✓
②	Demolish existing insulation + 2.5” PIR board with a/b	U – 0.056	✓
③	Demolish existing insulation + 3.5’ c.c SPF	U – 0.046	✓

Air Leakage Analysis Results

Air leakage test results (ASTM E283)			
Scenario	**Air leakage for building assembly**	**ASHRAE compliance option**	**Air Leakage for whole building**
Criteria		**By material** **By assembly**	(Air leakage rate adjusted to better represent old masonry buildings)
Baseline	2.7 L/ s.m^2		8 L/s.m^2 (NCMA, 2011; Emmerich et Persily, 2005; PNNL, 2009)
① Retain existing wall + 2" PIR rigid board with taped seams	1.8 L/s.m^2 (0.0005 L/s.m^2)	✓ by material**	Determine whole building air leakage for retrofit scenarios when demonstrated on Flexible Research Platform at ORNL
② Demolish existing wall + 2.5" PIR rigid board with a separate a/b layer	0.28 L/s.m^2*** (0.001 L/s.m^2)	✓ by material**	
③ Demolish existing wall + 3.5" cc SPF	0.015 L/s.m^2	✓ by assembly*	

*ASHRAE 90.1 2010 air barrier installation compliance by assembly requires air leakage < 0.2 L/s.m^2.

** ASHRAE 90.1 2010 air barrier installation compliance by material requires material with air permeability < 0.02 L/s.m^2.

***Adhesive accompanying the air barrier membrane (to ensure effective adherence) was not used in this scenario in order to facilitate easy removal of the membrane from the mock-up wall frame for future testing.

Energy Savings and Payback Period

Scenario (R-value of assembly)	Baseline 8 L/s.m^2 and existing insulation (R10)			Baseline 8 L/s.m^2 and no existing insulation		
	Total HVAC energy savings	Payback period	Cost/sq.ft	Total HVAC energy savings	Payback period	Cost/ sq.ft
① Retain existing ins. + 2" PIR rigid board with taped seams (R-20.7)	30%	14 yrs	$4.35	-	-	-
② Demolish existing ins. + 2.5" PIR rigid board with a separate a/b layer (R-17.6)	25%	29 yrs	$8.05	31%	17 yrs	$6.05
③ Demolish existing ins. + 3.5" cc SPF (R-21.6)	36%	25 yrs	$9.40	41%	16 yrs	$7.40

- For baseline with no existing insulation, demolition of existing insulation was not needed so the cost of demolition was eliminated from the cost/ft^2 for each scenario.

Laboratory Test Performance Summary

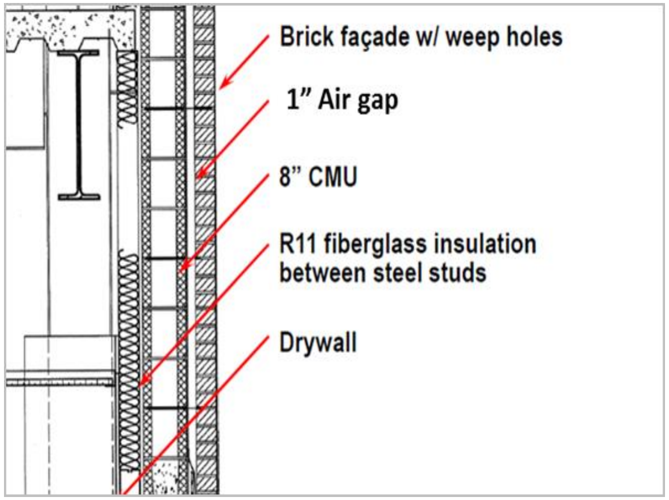
Metric	ASHRAE 90.1 2010 thermal requirements (mass walls)			ASHRAE 90.1 2010 air leakage compliance	Payback period	
Criteria	Climate Zone 4	max U-value - 0.104	Meets criteria	By material	Between 10 - 15 years	
	Climate Zone 5	max U-value - 0.090		By assembly		
Scenario					Baseline with no existing insulation	Baseline with existing insulation
	1	U - 0.048	✓	✓ by material	N/A	**14**
	2	U – 0.056	✓	✓ by material	**17**	**29**
	3	U – 0.046	✓	✓ by assembly	**16**	**25**

Team & TAG Recommendation: Scenario 1 and 3 chosen for demonstration on Flexible Research Platform at ORNL.

Building Retrofit & Path Forward

Amy Wylie, Covestro LLC

Flexible Research Platform (FRP)



Intent: Represent a typical pre-1980s commercial building with masonry construction (Air leakage 8L/s.m^2).

Retrofit zones:

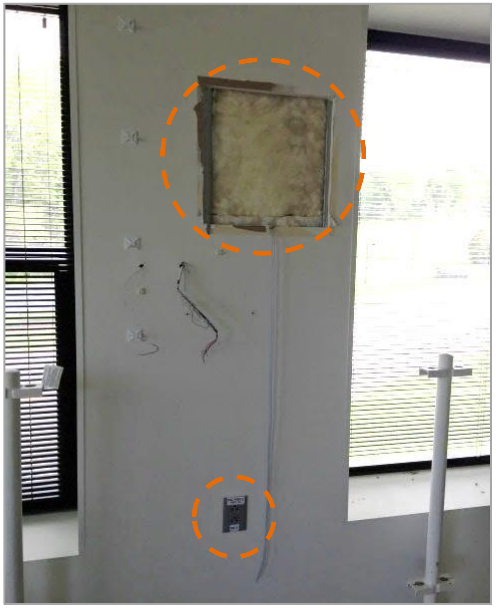
- 2-story building divided into 8 zones.
- 2 retrofit scenarios to be demonstrated in 2 individual zones.
  - North-west zone on 1st floor – Spray foam retrofit.
  - North-west zone on 2nd floor – Rigid polyiso board retrofit over existing wall.

Retrofit Scenario 1:
Rigid PUR board with taped seams over existing wall

Demonstrated: North-west zone on 2nd floor.

Issues:

- Existing electrical receptacles needed to be pulled out.
- Difficult to judge the position of existing cables and wires in the wall while installing the new insulation.
- Existing equipment close to the wall poses difficulty in terms of space for installing additional insulation.
- Need to extend the window frame to cover the additional insulation thickness.



Cutouts in existing wall needed to move electrical receptacles

Extended window frame over additional insulation thickness

Retrofit Scenario 2:

Closed cell SPF application on concrete block wall

Demonstrated: North-west zone on 1st floor.

Issues:

- Labor needed to tear down existing insulation, existing drywall, pull down the steel studs and offset them 1.5” from the wall.
- Need to extend the window frame to cover the additional insulation thickness.

Tear down of existing batts insulation and drywall can be labor intensive.

Extended window frame over additional insulation thickness

Next Steps

- Collect field data for the retrofit solutions demonstrated on the FRP.
- Evaluate field data against initial evaluation results and lab test results.
- Generate a detailed report highlighting performance for the identified best practice recommendation.
- Generate best practice guidelines and disseminate to the industry.
- Execute commercialization plan.

Commercialization/ Dissemination Plan

- Utilize regional and annual conferences through industry associations to disseminate findings to the construction industry.
    - RCI International Convention and Trade Show 2016 – Abstract selected.
      Session: Monday, 3/14/2016; 2:15-3:45pm and 4:00-5:30pm.
- Utilize deployment channels (such as marketing and technical bulletins or regional and national trainings) available through market partners:
    - Air Barrier Association of America (ABAA) – Will submit an abstract for 2016 ABAA Conference and Trade Show.

Commercialization/ Dissemination Plan

- Publish project findings through journal articles as well as through education sections on association websites, such as:
    - American Institute of Architects – Best Practices section
    - Construction Specifications Institute – Webinars
    - Spray Polyurethane Foam Alliance – Technical section: Success stories
    - Polyisocyanurate Insulation Manufacturers Association – Technical Bulletins: Commercial Walls
    - Building Enclosure Council – National Institute of Building Sciences: Resources: Reports and Guidelines
    - Building Research Information Knowledgebase (BRIK) – Research type: Systems

- Potentially organize education webinars through industry association programs to disseminate project results.

Thank You

The following statements apply to all slides in this presentation:

Savings vary. Find out why in the seller's fact sheet on R-values. Higher R-values mean greater insulating power. Actual savings may vary depending on type of home, weather conditions, occupant lifestyle, energy prices and other factors. No specific guaranty or warranty of energy or costs savings is being given and all such guaranties or warranties are expressly disclaimed.

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Any Questions?

This concludes The American Institute of Architects Continuing Education Systems Course

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