National Institute of Building Sciences Provider #G168

BEST4 Conference
Nibsbest4 • April 13-15, 2015

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Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

Learning Objectives

Participants will :

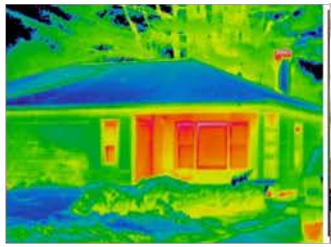
1. Learn how to link the performance of individual building enclosure components in a holistic framework to achieve high-performance buildings.

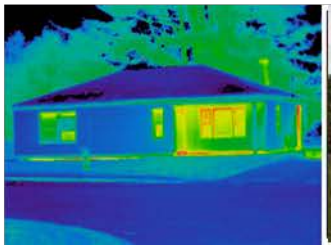
2. Explore, through built case studies, how building envelope design determines overall energy conservation and sustainability capabilities

3. Learn innovative practices for avoiding heat loss as well as moisture and air infiltration in enclosure design for healthy new and existing buildings.

4. Understand the role of building enclosure commissioning in the design, construction, and operation and maintenance of commercial facilities.

Field Test Data from Retrofit of a Small Residential House Using EISF Technology


John Edgar*, Ali Fallahi**, Alliston Watts**, Jan Kosny**, Tom Remmele*, Linda Jeng***

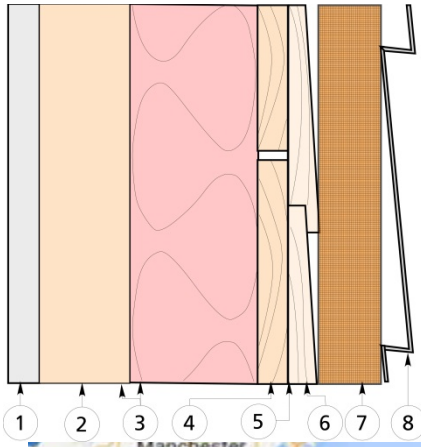
*STO Corporation, **Fraunhofer CSE, ***Dow Chemical

Kansas City, Apr. 13-15, 2015

Energy Retrofit of Single Family Dwelling in Brunswick, ME

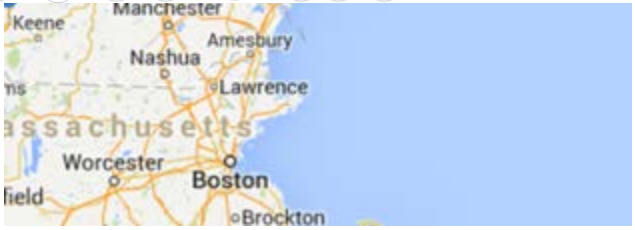
- **Objectives**
  - Verify hygrothermal performance with instrumentation and modeling
  - Provide direct comparison of energy consumption before and after restoration
  - Demonstrate constructability of an insulated wall system with XPS insulation
  - Provide functional and aesthetically attractive finished product

Pre-Restoration



Wall Assembly Components (as-built):

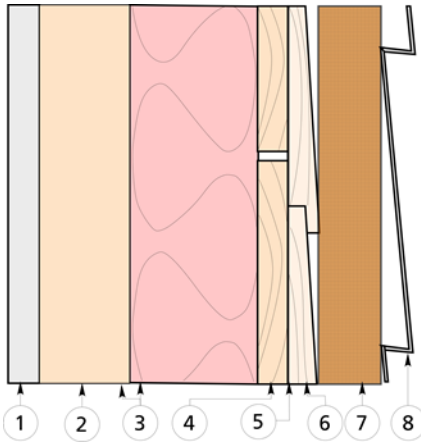
1. Gypsum wall board (painted)
2. Nominal 2x4 wood framing
3. R 8.2 fiberglass batt insulation with 1-1/2-inch air space between batt and interior wall board.
4. Wood plank sheathing
5. Asphalt-saturated paper or felt
6. Wood lap siding
7. Foil-faced polyisocyanurate insulation
8. Vinyl siding



Restoration Start-Up

Restoration System

Existing Wall Construction



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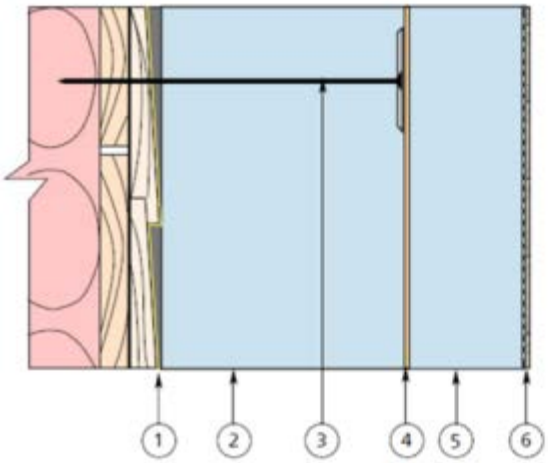
4. Wood plank sheathing
5. Asphalt-saturated paper or felt
6. Wood lap siding
7. Foil-faced polyisocyanurate insulation
8. Vinyl siding

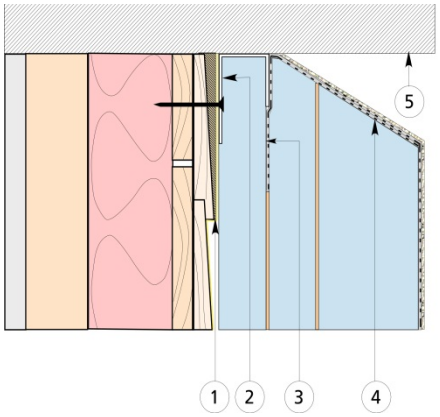
New Wall Construction



EIFS Retrofit Wall Assembly Components (typical wall areas)

1. Waterproof air-barrier coating with joint treatment
2. 4-inch (102 mm) XPS Insulation
3. EIFS faster with washer
4. Polyurethane spray foam adhesive
5. 2-inch (51 mm) XPS Insulation
6. EIFS base coat, reinforcing mesh and finish

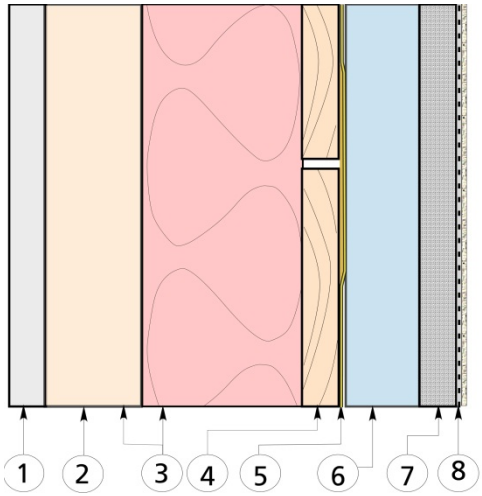
Detail at Soffit



Soffit Detail

1. Waterproof air-barrier coating
2. Starter track fastened through shim.
3. Backwrap to first layer of XPS
4. Backwrap onto bevel
5. Soffit

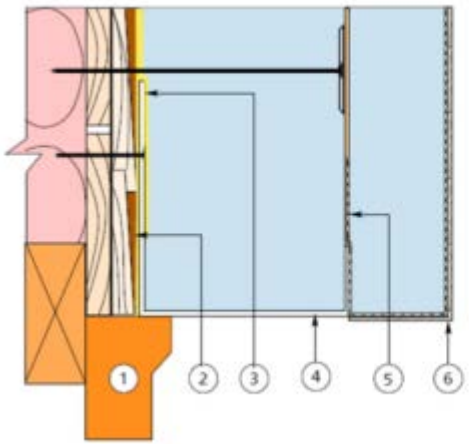
Detail at Front Entrance



Entrance Alcove Retrofit
Wall Assembly Components

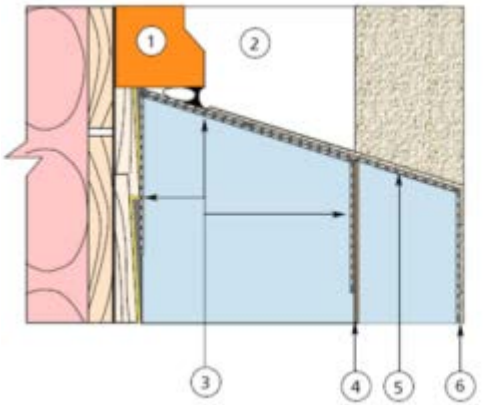
1. Gypsum wall board (painted)
2. Nominal 2x4 wood framing
3. R 8.2 fiberglass batt insulation with 1-1/2 inch air space between batt and interior wall board
4. Wood plank sheathing
5. Waterproof air-barrier coating with joint treatment between planks
6. 1-inch (25 mm) XPS Insulation
7. 5/8-inch (16 mm) cement board
8. EIFS base coat, reinforcing mesh and finish

Detail at Windows



EIFS Retrofit Wall
Window Head and Jambs
(head shown)

1. Window molding
2. Shim coated with AMB coating
3. Lap AMB over starter track leg
4. PVC starter track
5. Back wrap outside layer of XPS
6. EIFS base coat, reinforcing mesh and finish



EIFS Retrofit Wall Assembl
Window Sill

1. Window molding
2. Jamb covered with PVC track
3. Pre-back wrap applied to layer of XPS
4. Polyurethane spray foam adhesive
5. Reinforced base coat lap over pre-back wrap
6. EIFS finish

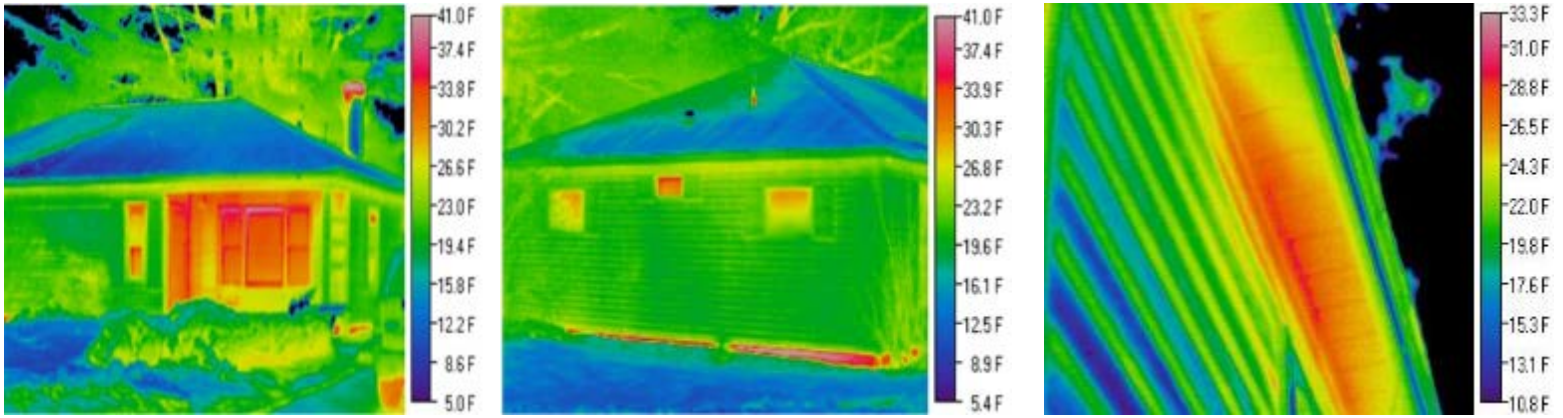
Restoration Summary

Blower Door Test

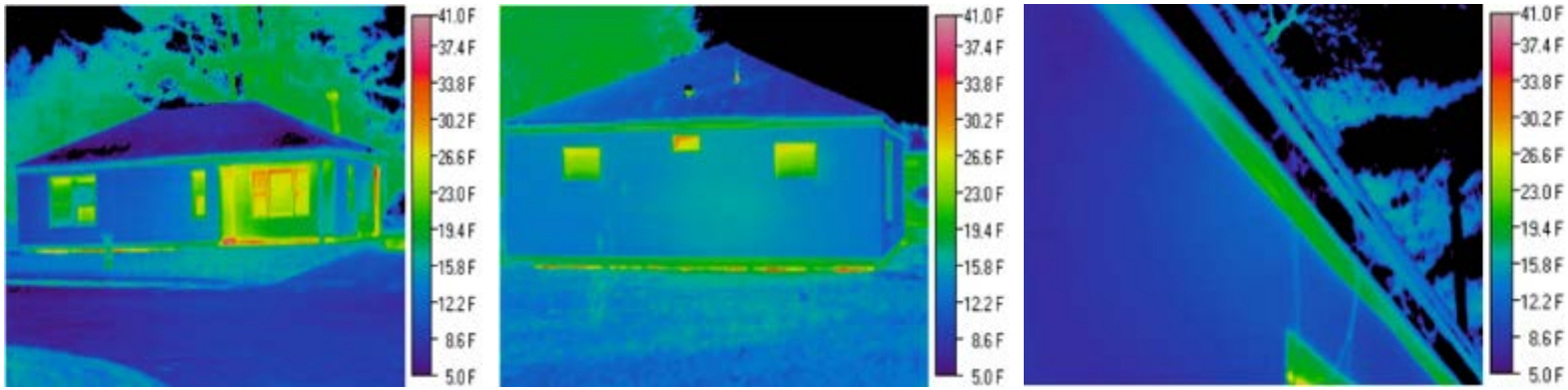
13% air tightness improvement

	Pre-Retrofit	Post-Retrofit
Airflow @50 Pa (cfm)	1583	1375
ACH50	8.09	7.02
Canadian EqLA@10 (in^2)	175.0	157.87
LBL ELA@4Pa (in^2)	98.0	89.4

Thermal Imaging

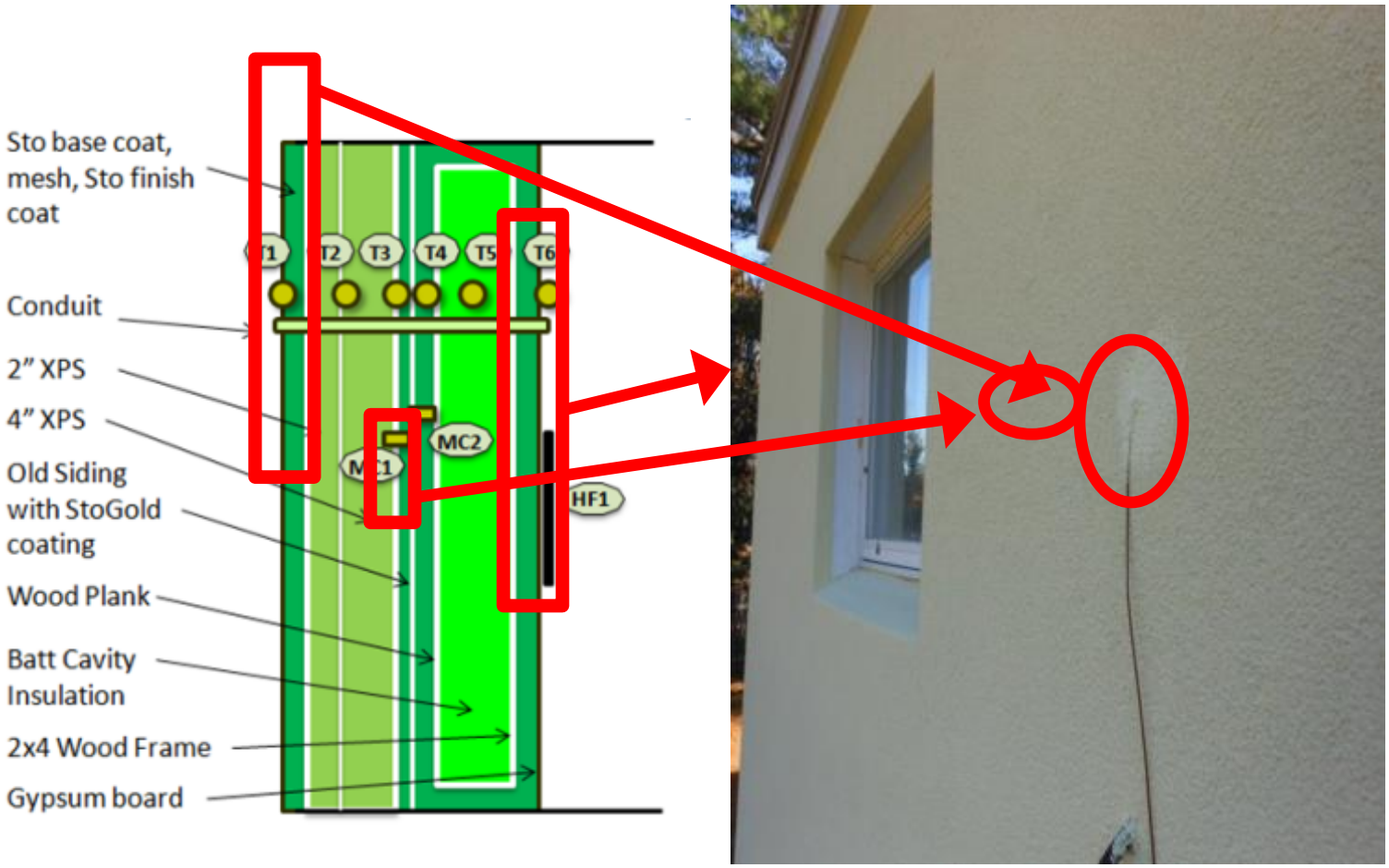


Before Retrofit

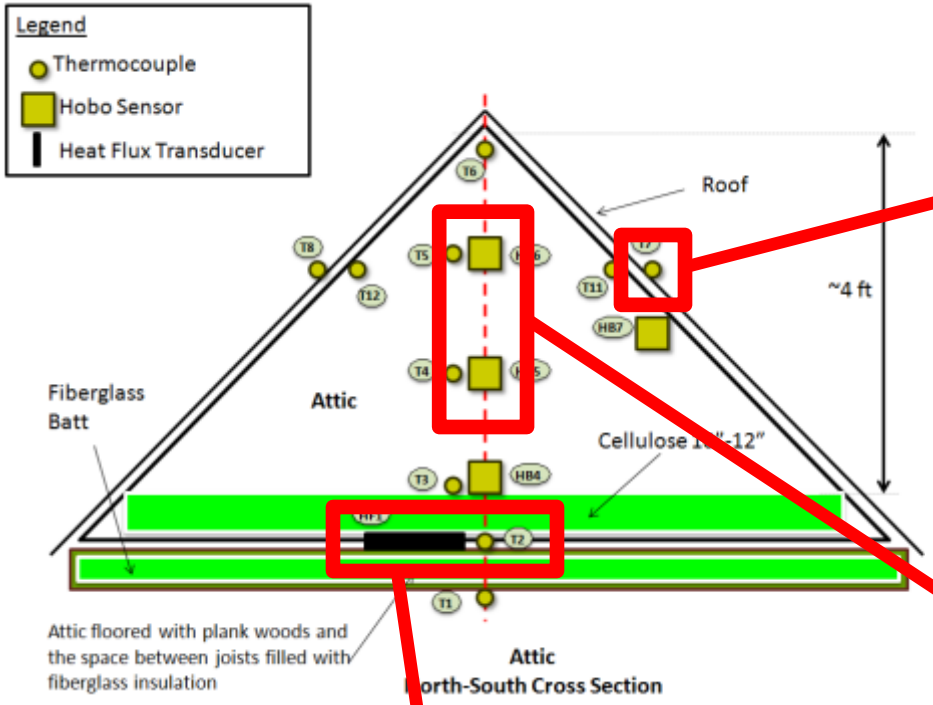


After Retrofit

Wall Instrumentation



Attic Instrumentation



Data Acquisition

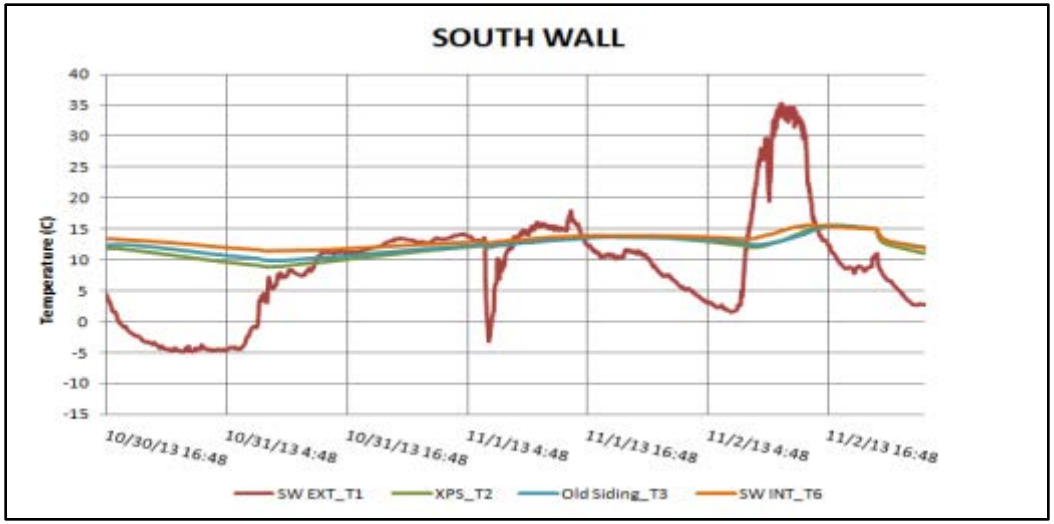
Pyranometer

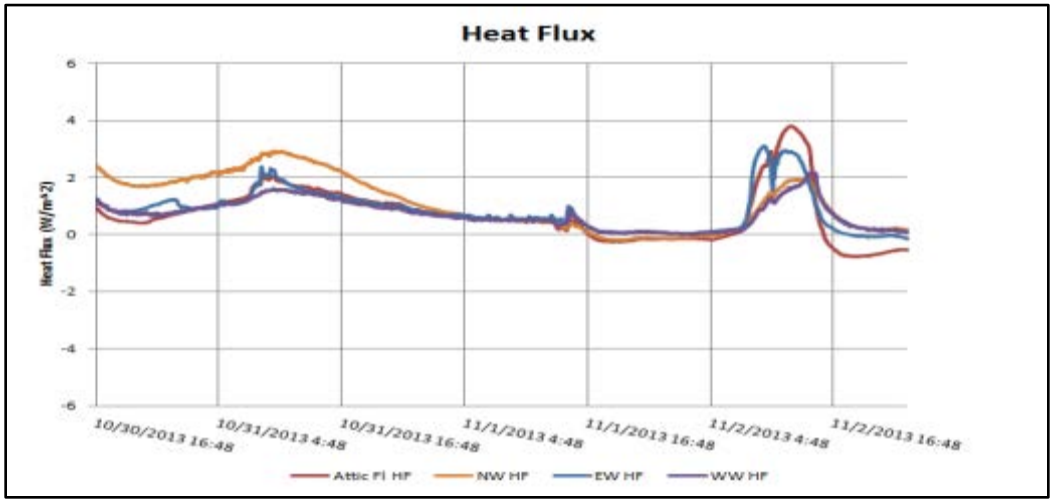
Heat Flow Meter

Weather Station

Data Acquisition Device

Field Test Results



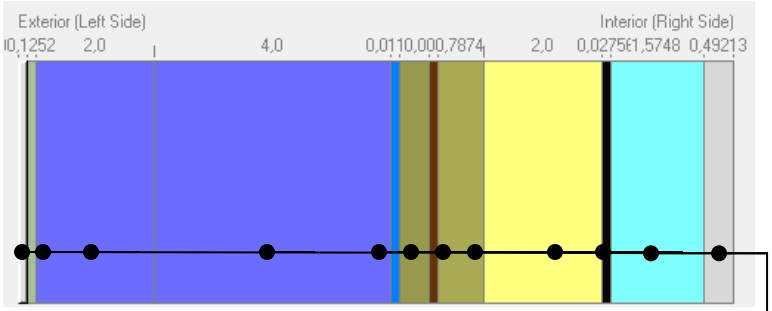


Hygrothermal Model

- Developed WUFI model to assess the risk of moisture accumulation in the wall assembly under actual climatic conditions at the site of the test house

- Boundary conditions from customized *.WAC and *.KLI climate files, generated based on the collected weather data from interior and exterior of the Brunswick test house

- WUFI modeled moisture contents first compared and verification against measured data, then the model ran for all ASHRAE climate zones

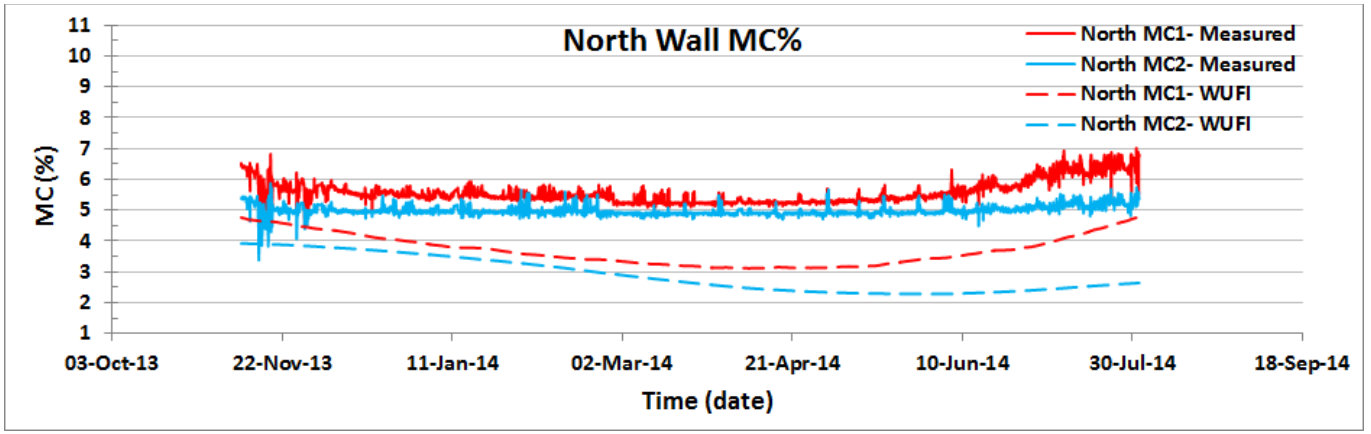


Exterior
- EIFS reinforcing mesh and finish
- EIFS base coat
- 2-inch XPS insulation
- Polyurethane spray foam adhesive
- 4-inch XPS insulation
- Water-proof air barrier
- Wood lap siding
- Asphalt saturated paper
- 2-inch Fiberglass batt insulation with vapor barrier in 2x4 wood framing
- 1.5-inch air gap
- Gypsum board

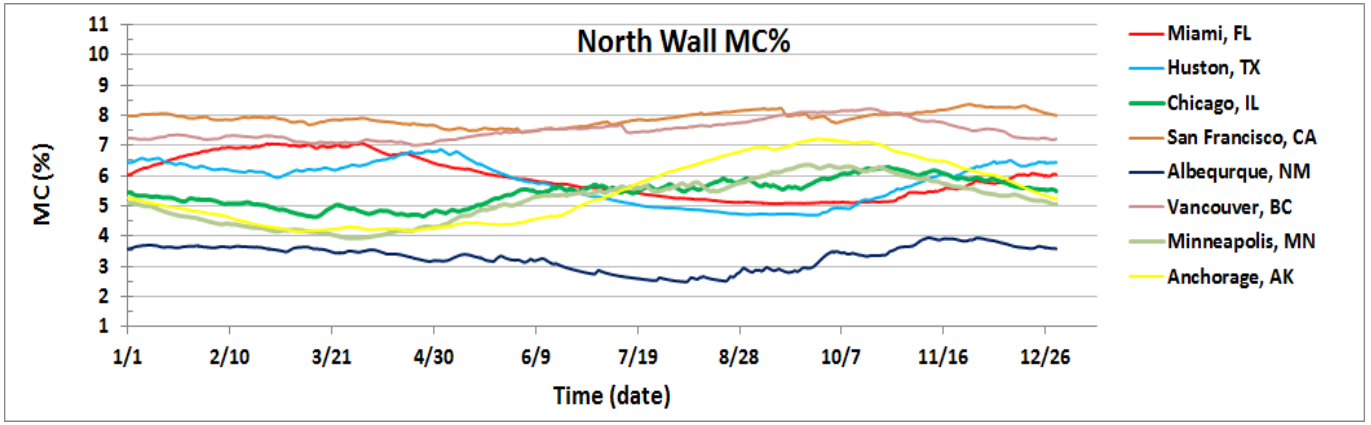
Interior

Modeled Wall Section

Hygrothermal Model



Comparison of Modeled MC against Measured MC



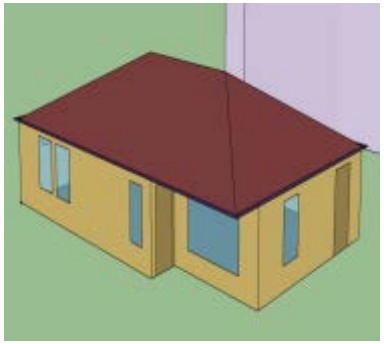
Comparison of Modeled MC of a Typical Occupied Single-Family House at Different ASHRAE Climates

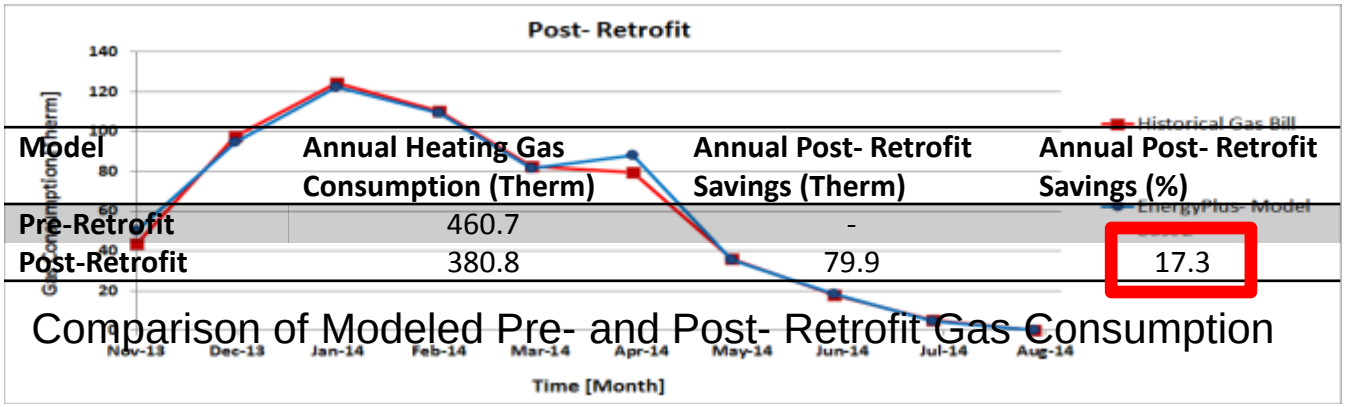
Energy Model

- Developed EnergyPlus model to compare the energy consumption between pre- and post-retrofit stages

- A two-thermal zone model with boundary conditions from climate files generated based on the measured data from interior and exterior of the Brunswick test house

- EnergyPlus model was calibrated against historical utility bills; then the calibrated model used for predicting energy consumption at different retrofit scenarios and different ASHRAE climates



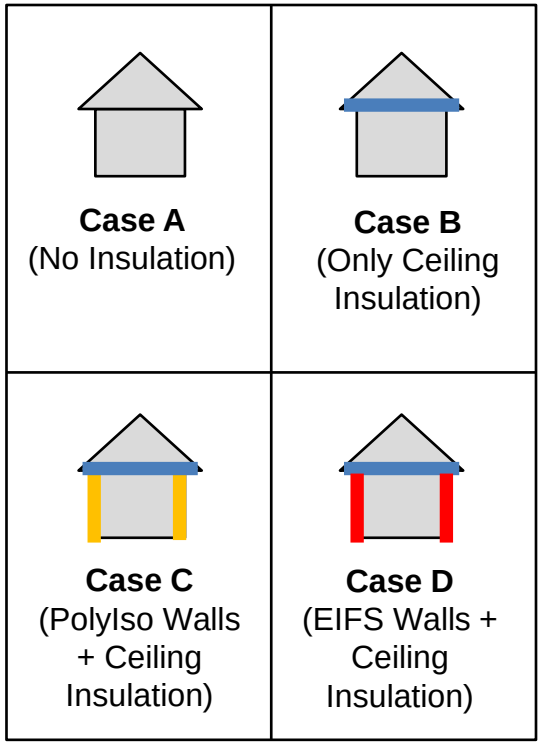


Model	Annual Heating Gas Consumption (Therm)	Annual Post- Retrofit Savings (Therm)	Annual Post- Retrofit Savings (%)
Pre-Retrofit	460.7	-	
Post-Retrofit	380.8	79.9	17.3

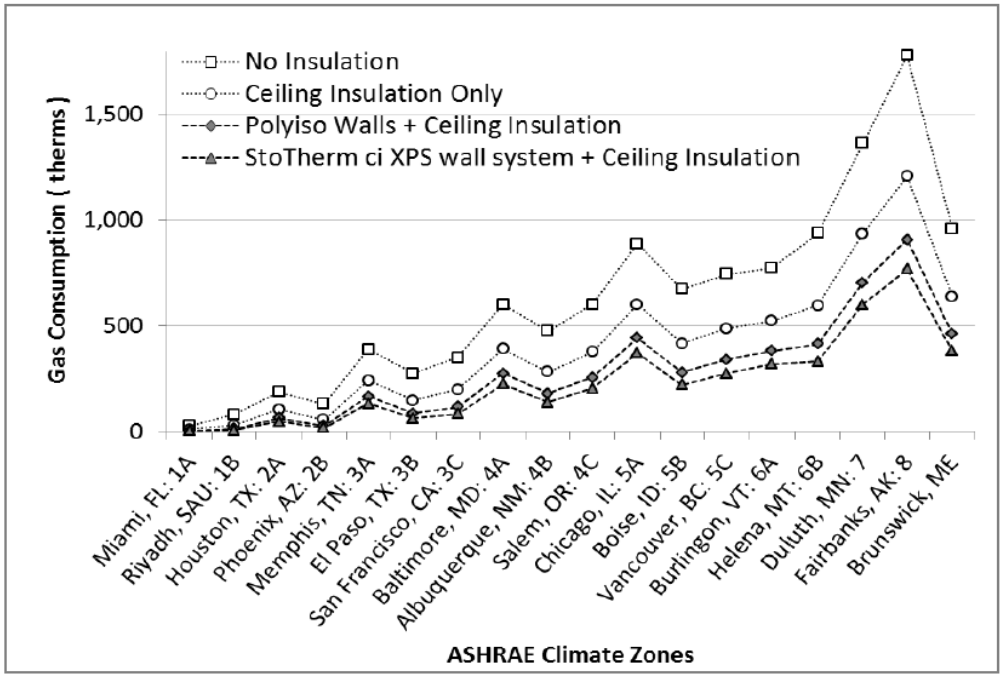
Comparison of Modeled Pre- and Post- Retrofit Gas Consumption

Comparison of Modeled Gas Consumption against Historical Gas Bill

Energy Model



Modeled Retrofit Scenarios



Comparison of Heating Energy Savings for Different Retrofit Scenarios at Different ASHRAE Climates

Conclusion

- Based on WUFI modeling results and the measurements, the risk of moisture accumulation in the retrofitted continuous XPS insulated wall system in the Brunswick test house is low and remains below 7.5%. At different ASHRAE climate regions, the risk of moisture accumulation does not exceed 9% and stays below the 20% safety threshold.

- Based on calibrated EnergyPlus results when the pre-retrofit wall (R-12.3 wall) is retrofitted to continuous XPS insulated wall system (R-38.3 wall), approximately 17% gas consumption savings can be achieved annually. This saving is equivalent to a gas consumption reduction of approximately 80 therms/year.

- Molded EnergyPlus results of different Brunswick test retrofit scenarios shows that replacing the 0.5” Polyiso insulation with 6” of XPS in the continuous insulation wall system improves heating energy performance from 51 to 139 therms/year savings in very cold climate zones and from 2 to 32 therms/year savings in hot ASHRAE climate zones.

- Molded EnergyPlus results of different Brunswick test retrofit scenarios shows that adding the continuously insulated XPS wall system to an uninsulated wall improves heating energy performance considerably from 143 to 438 therms/year savings in very cold climate zones and from 7 to 115 therms/year savings in hot ASHRAE climate zones.