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 Thermal Performance of EIFS Using Vacuum Insulation Panels

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Wall Deep Energy Retrofit

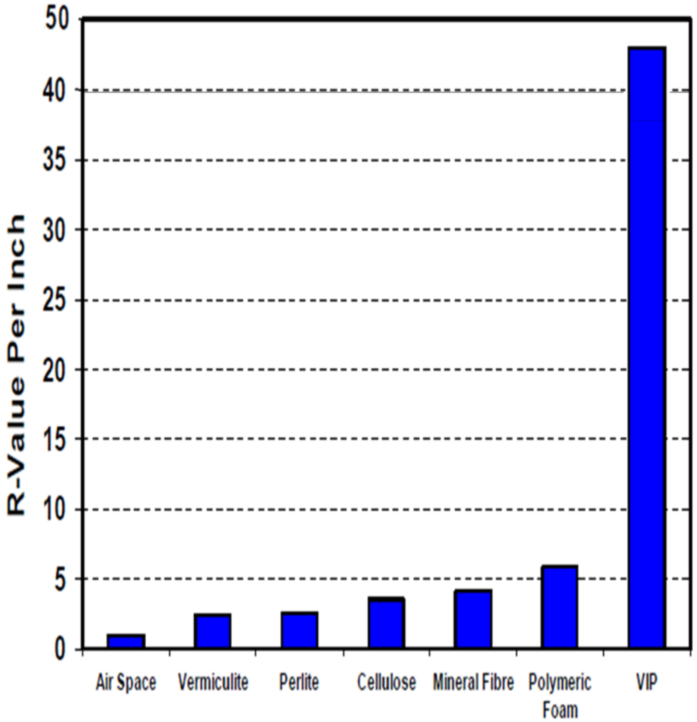
Requires roof extension/detailing

Requires window relocation/detailing

- Sometimes, it is impractical or costly to install thick insulation due to space loss or additional modifications and detailing

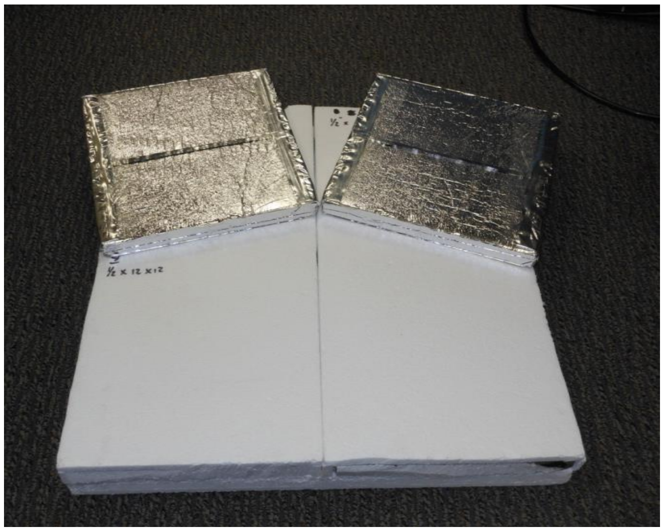
Benefits of Vacuum Insulation Panels (VIPs)

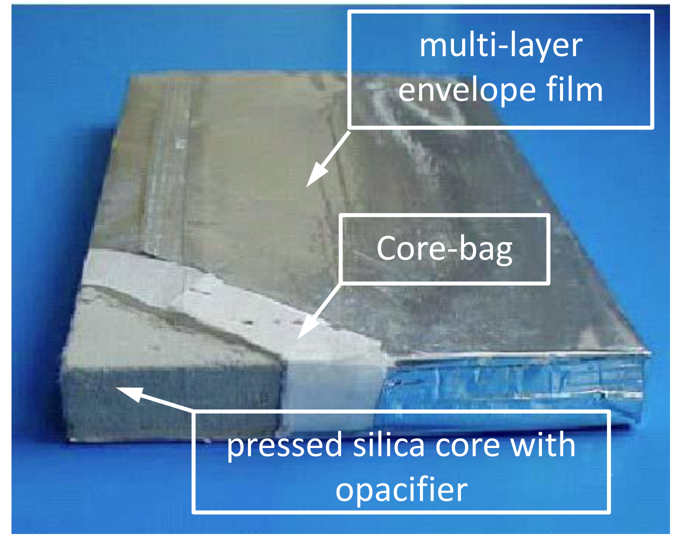
VIPs are 4 to 8 times thinner than convention insulations for the same target R-vale



- Thinner solutions for a given target thermal resistance
- VIP offers one of the highest thermal resistances of any insulation technology

Vacuum Insulation Panel (VIP) Technology

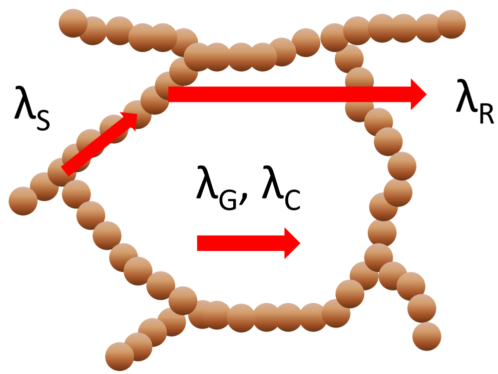




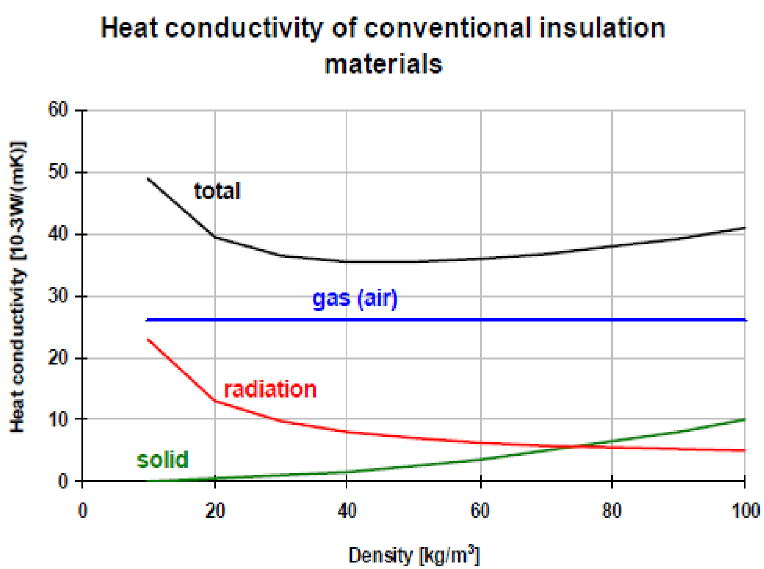
http://www.ecbcs.org/docs/Annex_39_Report_Subtask-A.pdf

- Vacuum Insulation Panel (VIP) consists of a nanoporous core that is evacuated and enclosed in a container that is highly impervious to air and water vapor transmission
- Thermal conductivity as low as 0.004 W/m-K

Heat Transport in Conventional Insulations



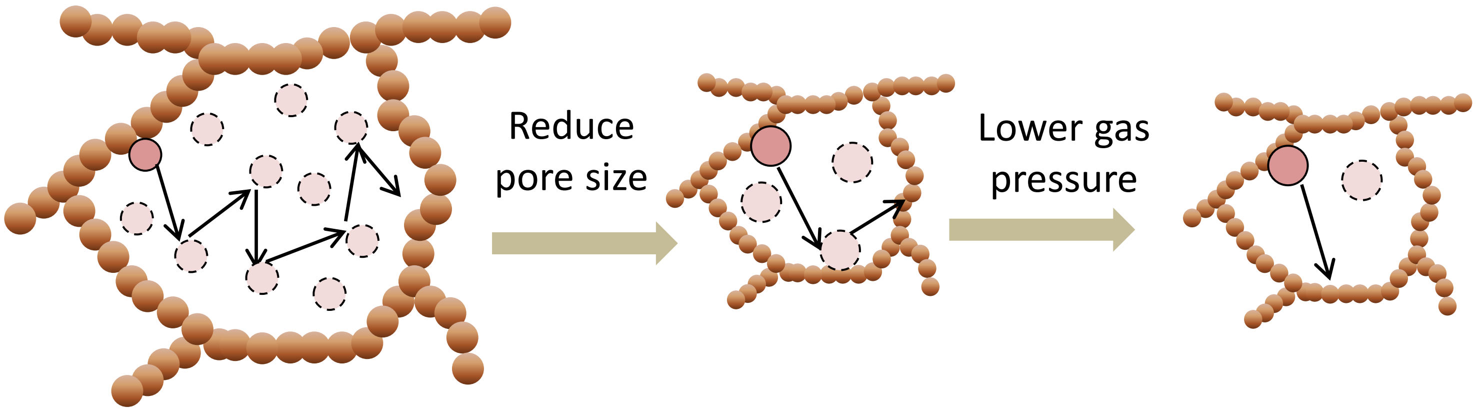
$$\lambda_T = \overbrace{\lambda_S + \lambda_G}^{\text{Conduction}} + \overbrace{\lambda_C}^{\text{Convection}} + \overbrace{\lambda_R}^{\text{Radiation}}$$



- Macroporous media used at atmospheric pressure
- Mineral fiber and polymeric foams
- Porous structure implies only limited number of channel for heat conduction
- Gas conduction dominates the thermal conductivity

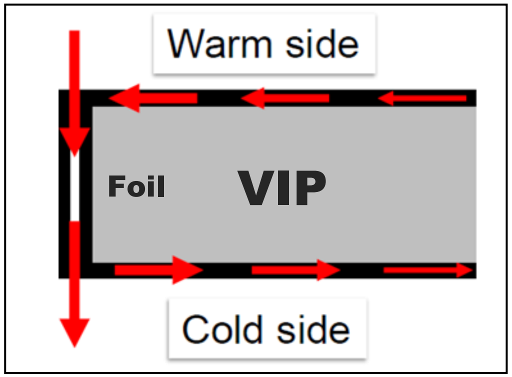
IEA/ECBCS Annex39, VIP Subtask A

Heat Transport in VIPs



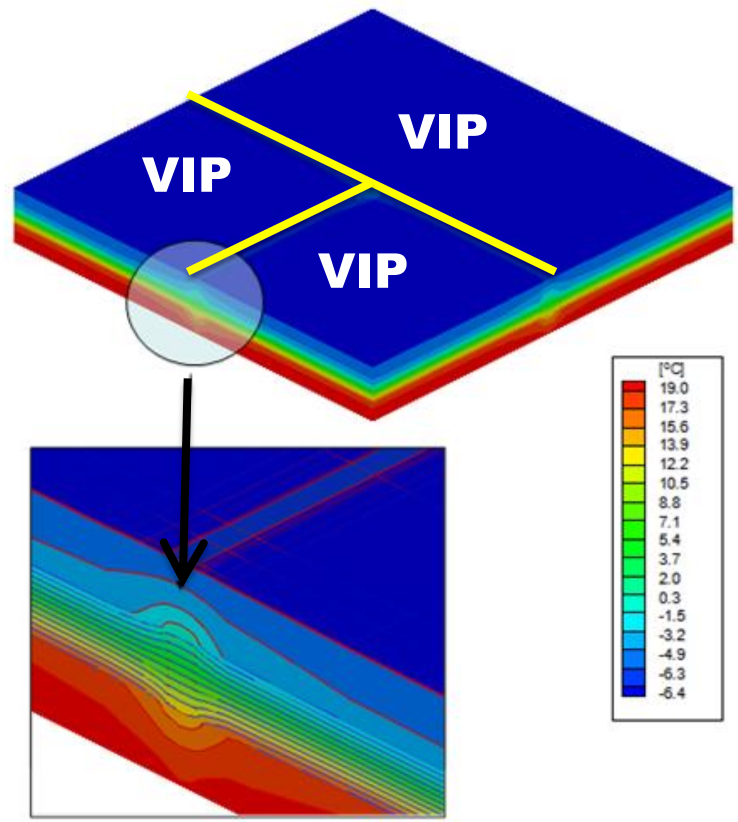
- MFP for air molecules is ~70 nm
- VIP core is made of a nanoporous material
- Typical pore size is ~10-100 nm
- Core is surrounded by a film and evacuated to lower pressures

Vacuum Insulation Panels – Thermal Bridging



VIP Thermal Bridging due to Metallic Foil

IEA/ECBCS Annex39, VIP Subtask A



VIP Thermal Bridging due to Protective Foam- 3D Thermal Model showing heat loss through foam layer

Project Introduction

Project Objective: To assess the field performance of the VIP-based EIFS technology in building retrofit applications.

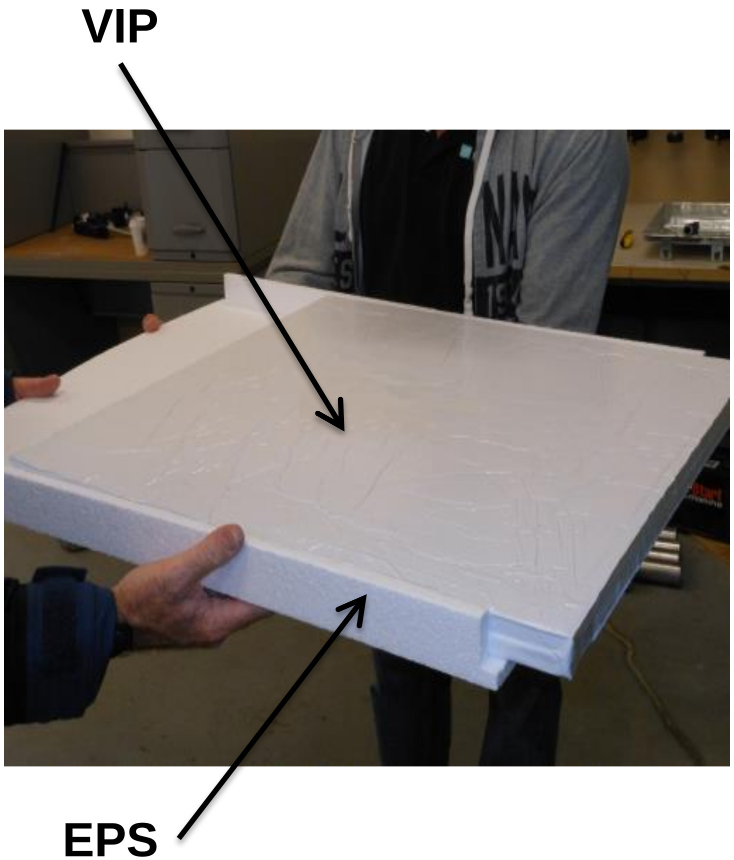
Subtasks:

- Detailed instrumentation for field testing to measure temperature and moisture gradient in the walls
- Performing small scale lab testing of material samples as an input for numerical modeling and hygrothermal analysis
- Evaluate and analyze the collected field test data
- Numerical analysis and energy simulations using EnergyPlus and WUFI to validate and extend performance evaluation


Before Retrofit


After Retrofit

Wall Retrofit -Vacuum Insulation Panels

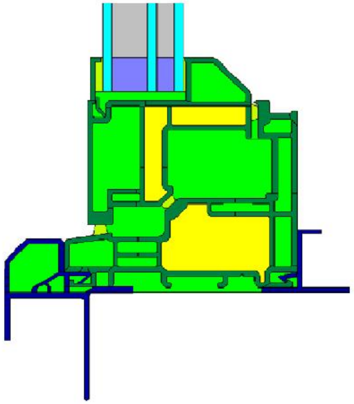


- Two major U.S. building envelope manufacturers carried out the retrofit stage of this study, including VIP manufacturing, foam encapsulating, designing, and installation.

Wall Retrofit – High Performance Windows

Existing poor performing windows

- In addition, a major U.S. window manufacturer donated its high efficient R-5 windows to be installed as a part of the retrofit stage.



High performing R-5 windows after retrofit

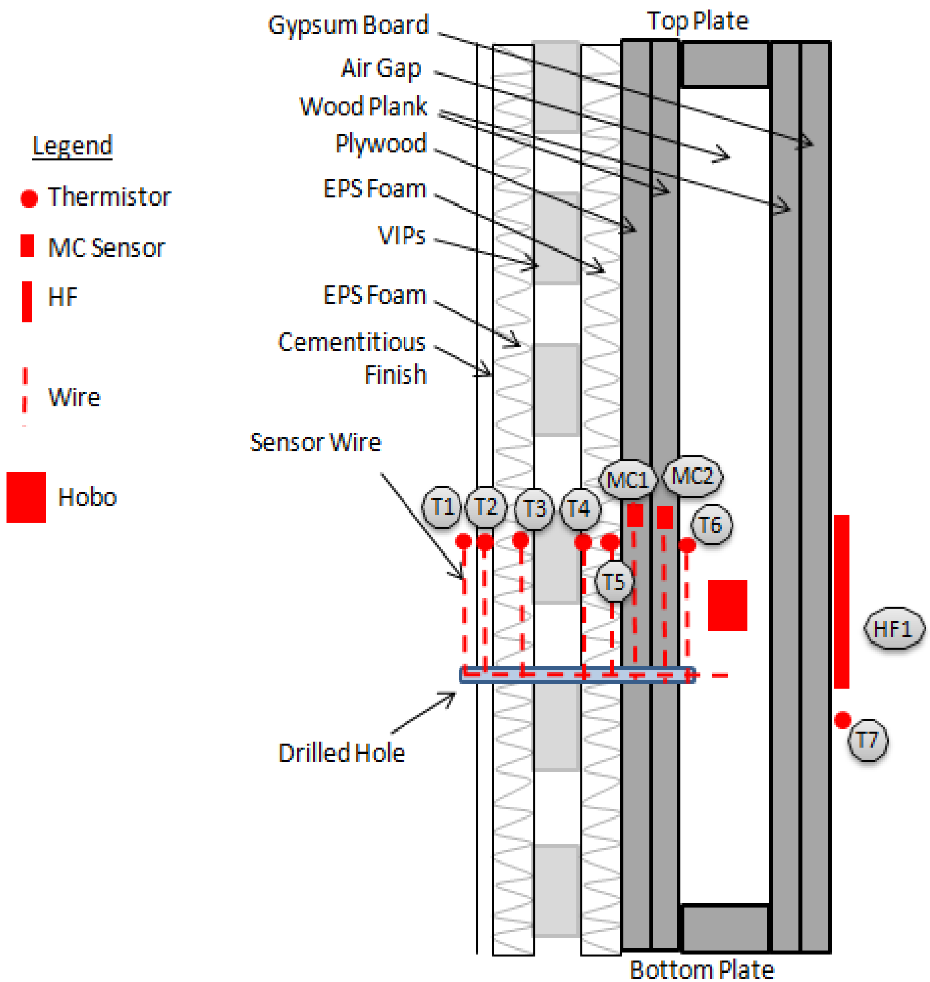
During Wall Retrofit

Wall Retrofit

Before Retrofit

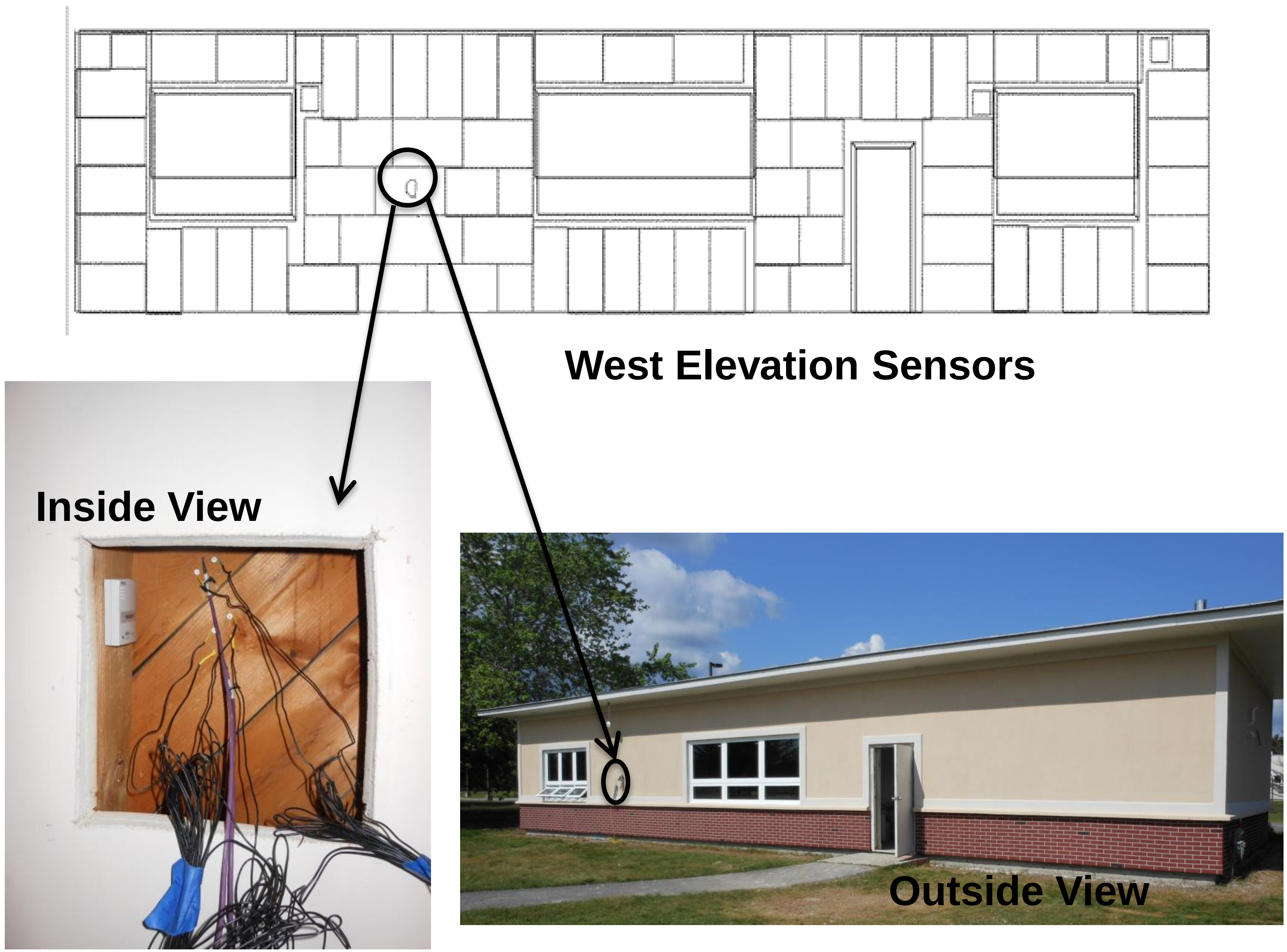
After Retrofit

Wall Sensor Layout

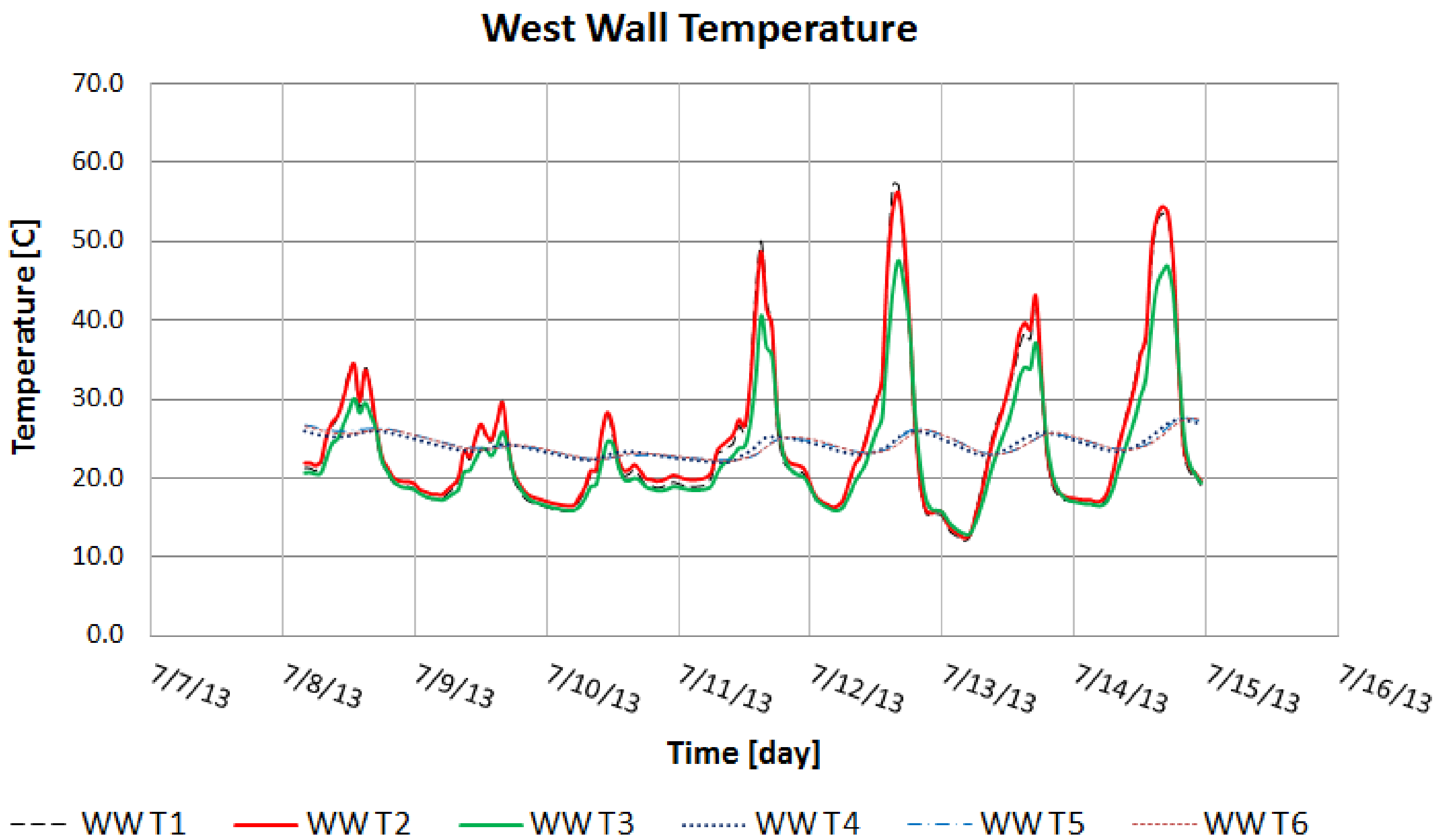


West Wall

Wall Sensor Layout



Field Test Collected Data



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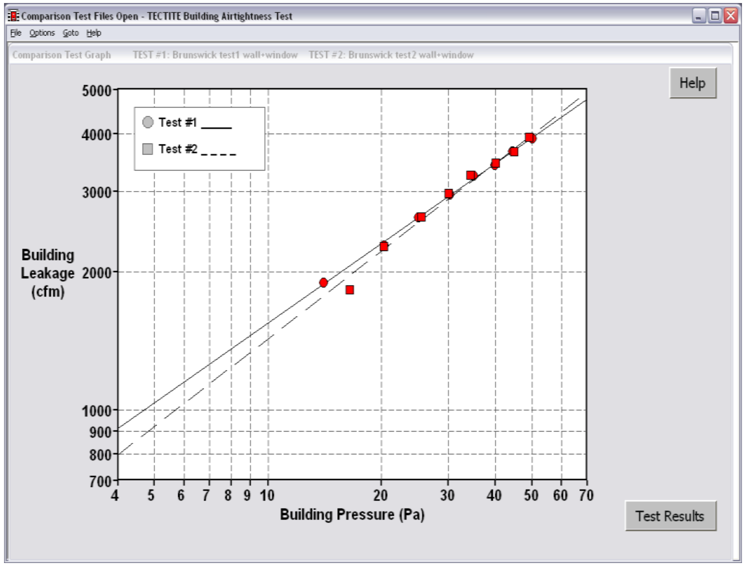
Blower Door Test

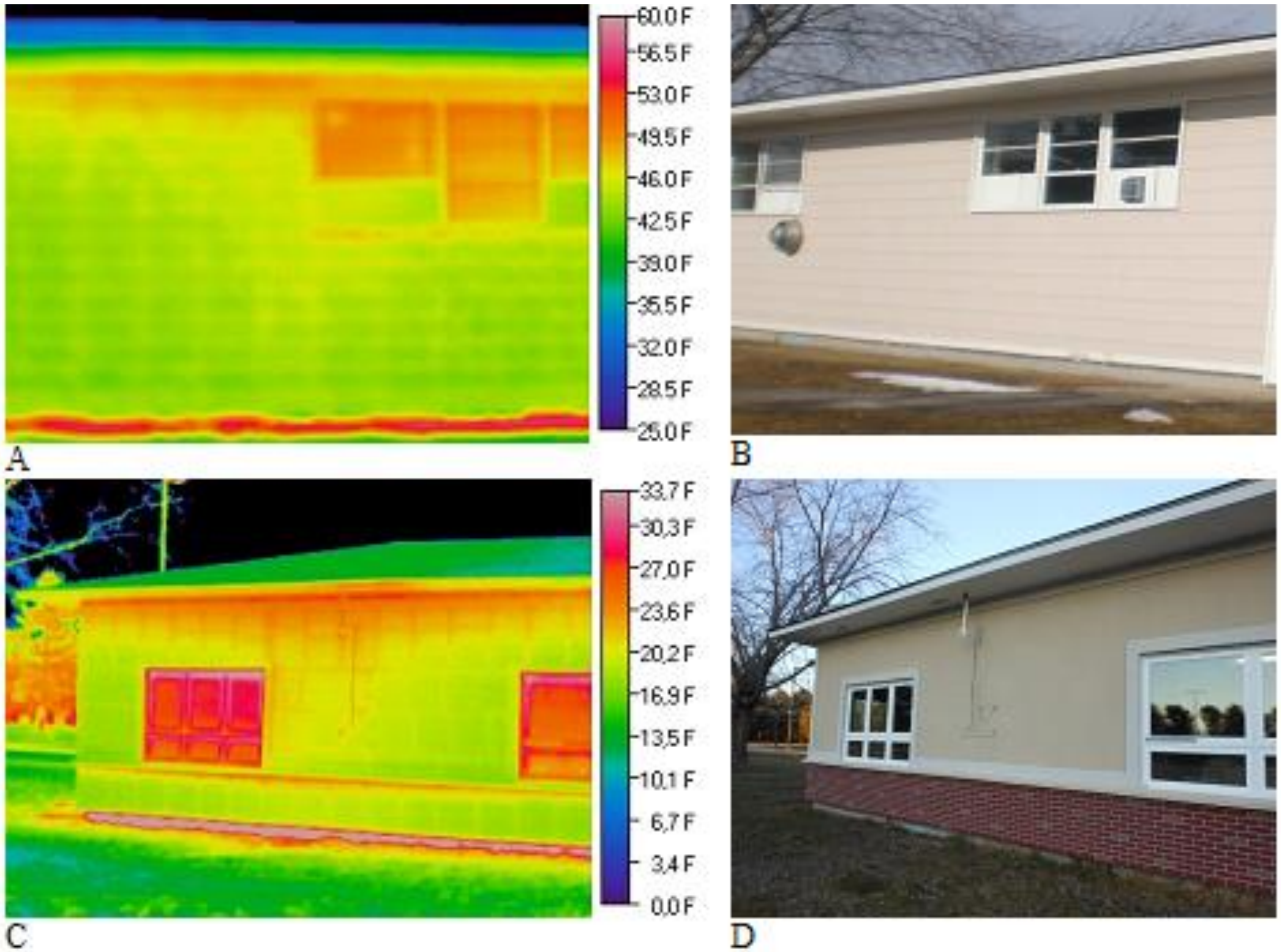


TIME	Without Windows Sealed-off	With Windows Sealed-off	Difference
Pre-Retrofit	11.7 ACH @ 50 Pa	10.90 ACH @ 50 Pa	6%
Post- Retrofit 1	8.15 ACH @ 50 Pa	8.13 ACH @ 50 Pa	0.2%

30% Improved

CONTINUING EDUCATION AIA

Thermography Results

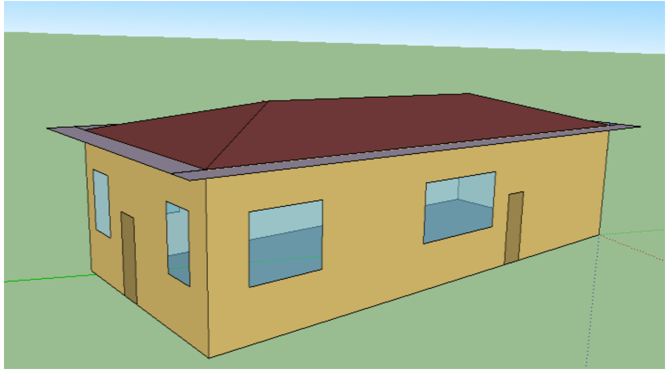


Before

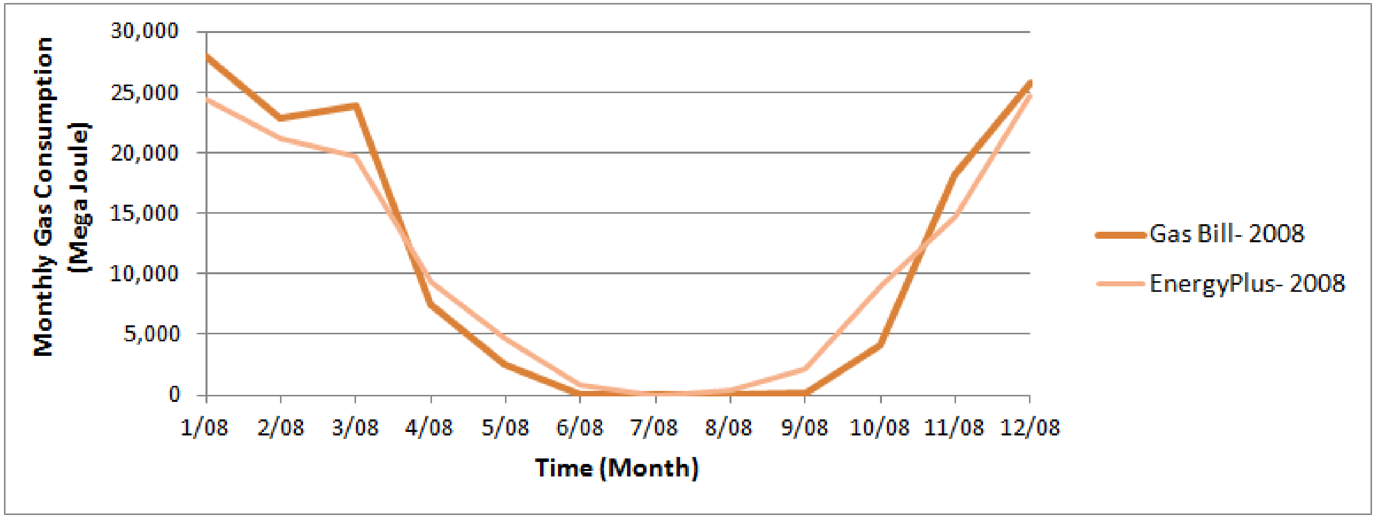
After

Energy Model

- Base-Case EnergyPlus model developed using actual weather conditions at the site of test building in Brunswick, ME
- Base-Case model calibrated against historical utility bills both from pre-retrofit and post-retrofit stages.

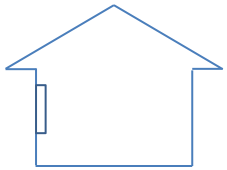


EnergyPlus Model of Test Building



Gas Consumption Calibration

Energy Model Configurations

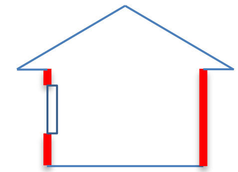


Case A

-Existing walls, R-3.7
-Existing windows, R-1
-Pre-retrofit Infiltration: 11.7 ACH

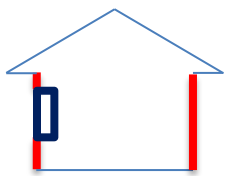
Case B

-Existing walls, R-3.7
-High Efficient R-5 windows
-Pre-retrofit Infiltration: 11.7 ACH



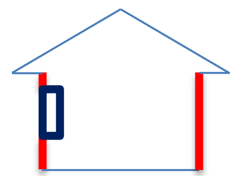
Case C

-VIP walls, R-48.5
-Existing windows, R-1
-Pre-retrofit Infiltration: 8.1 ACH



Case D

-VIP walls, R-48.5
-High Efficient R-5 windows
-Pre-retrofit Infiltration: 8.1 ACH

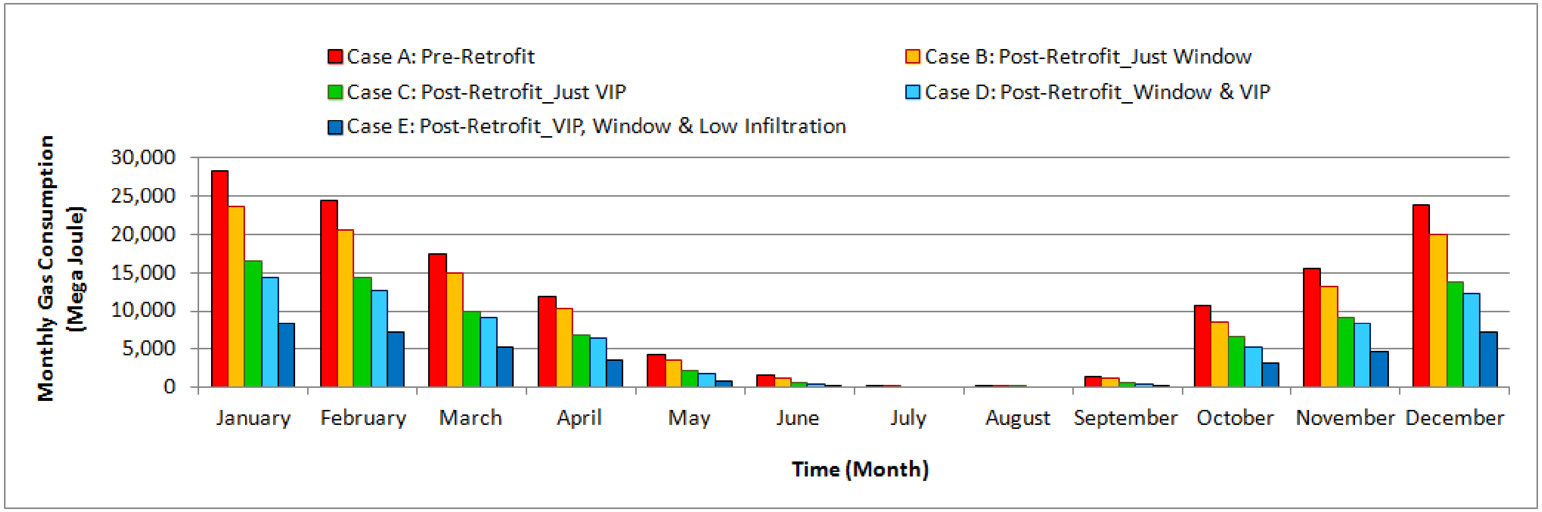


Case E

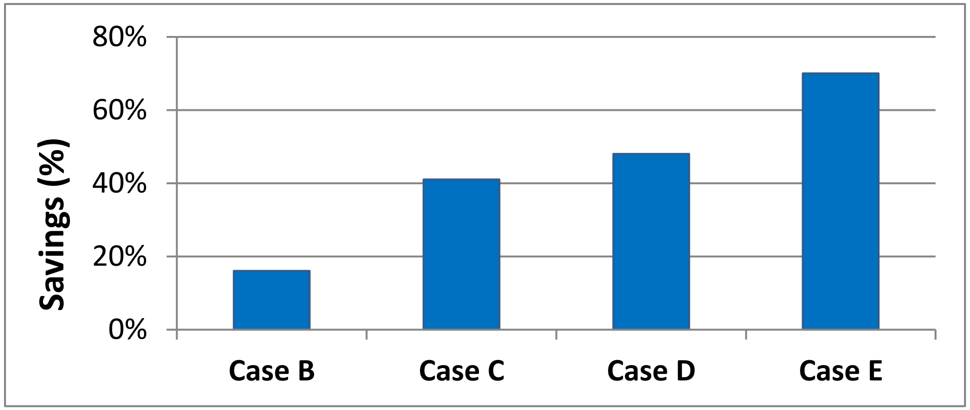
-VIP walls, R-48.5
-High Efficient R-5 windows
-Pre-retrofit Infiltration: 3.5 ACH

Modeled EnergyPlus Configurations

Energy Model Results

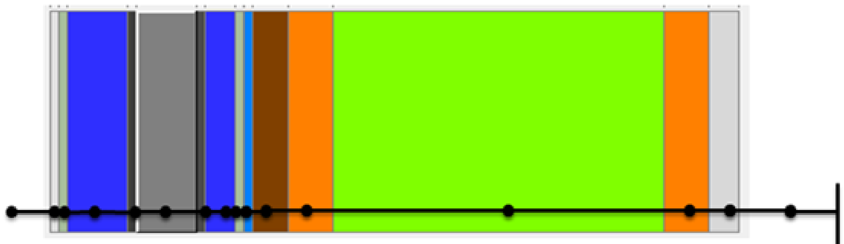


Monthly Gas Consumption



Annual Gas Consumption Savings

Hygrothermal Model

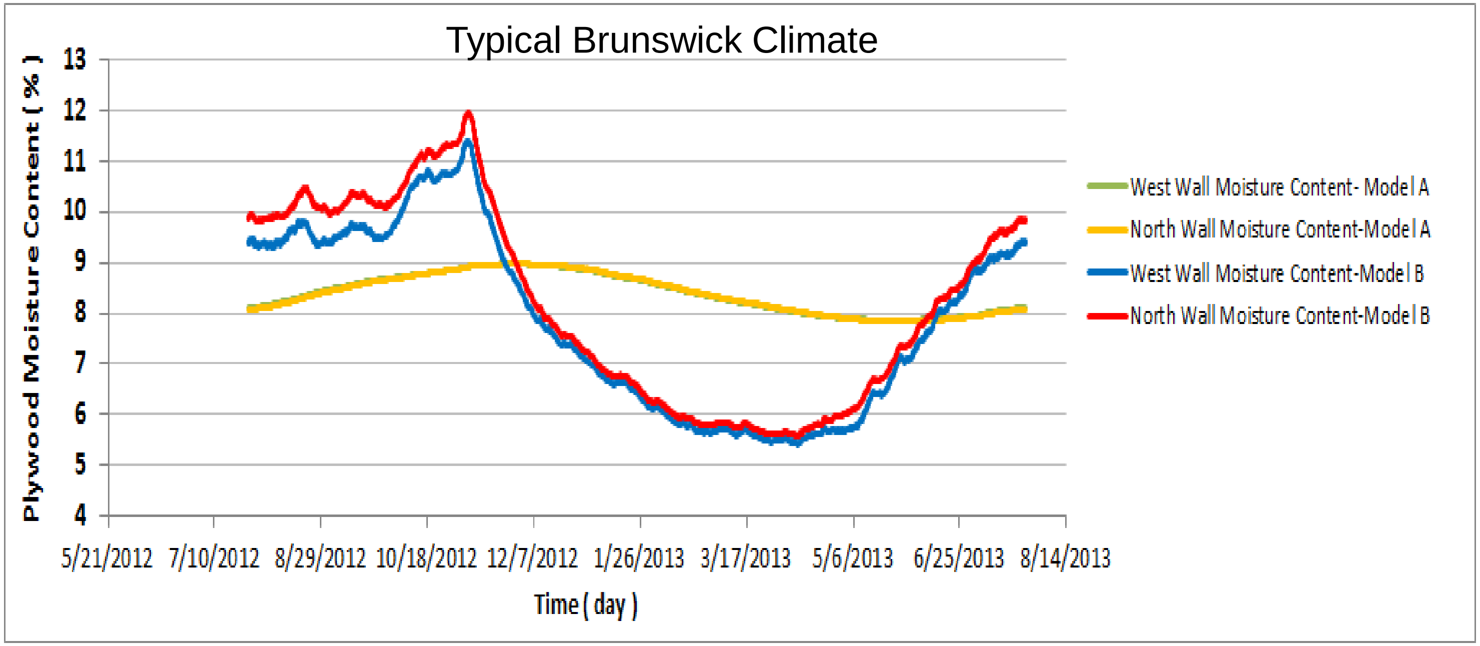


Model A

Interior
1- Gypsum Board (0.5”)
2- Wood Plank (0.75”)
3- 2x6 Air gap (5.5”)
4- Wood Plank (0.75”)
5- Plywood (0.5”)
6- Vapor/air retarder (0.012”)
7- Adhesive (0.125”)
8- EPS (0.5”)
9- Aluminum Foil (0.00047”)
10- Fume Silica VIP Core (1.5”)
11- Aluminum Foil (0.00047”)
12- EPS (1.5”)
13- Cementations Base Coat (0.125”)
14- Acrylic Finish (0.125”)
Exterior

Modeled Wall Section in WUFI

Hygrothermal Model



MC% of West Wall and North Wall below 20% Safety Threshold for Wood Rotting

Conclusion

- Thermographic images taken before and after the renovation clearly show improvement in heat losses after renovation with VIPs.
- Blower door tests performed before and after the renovation show a 30% air tightness improvement after renovation with VIPs.
- Based on WUFI modeling results and the measurements, the risk of moisture accumulation in the VIP-based EIFS of the retrofitted wall in the Brunswick building is low and remain below 12% and don’t reach the critical threshold for wood deteriorations.
- Based on developed energy model of the Brunswick building, annual gas consumption savings of the building retrofitted with high efficient windows is 16% while in combination with other efficiency measures such as VIP-base EIFS and improved airtight building the savings of 48% and 70% are achievable.

Any Questions?