ORNL Building Envelopes FY12 Program

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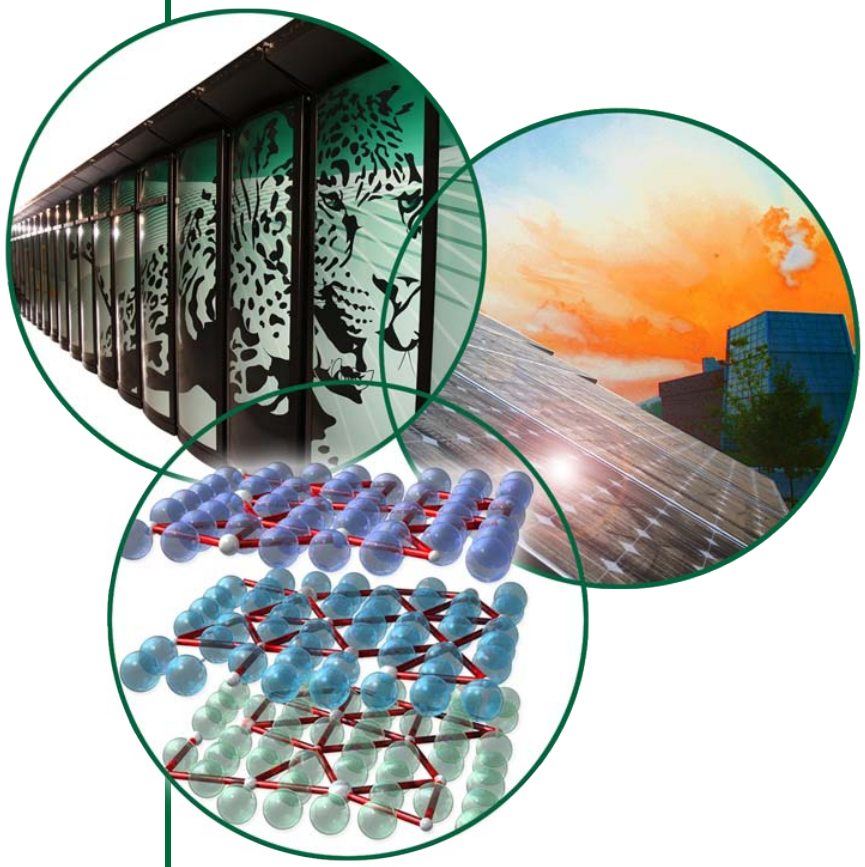
26 June 2012



U.S. DEPARTMENT OF ENERGY

OAK RIDGE NATIONAL LABORATORY

MANAGED BY UT-BATTELLE FOR THE DEPARTMENT OF ENERGY

Envelope R&D in Four Areas

- Roofs and Attics
- Cool Roofs
- Vacuum Insulation Panels
- Advanced Insulations
  - Insulation Research
  - Air Barriers
  - PCMs
  - Foundations

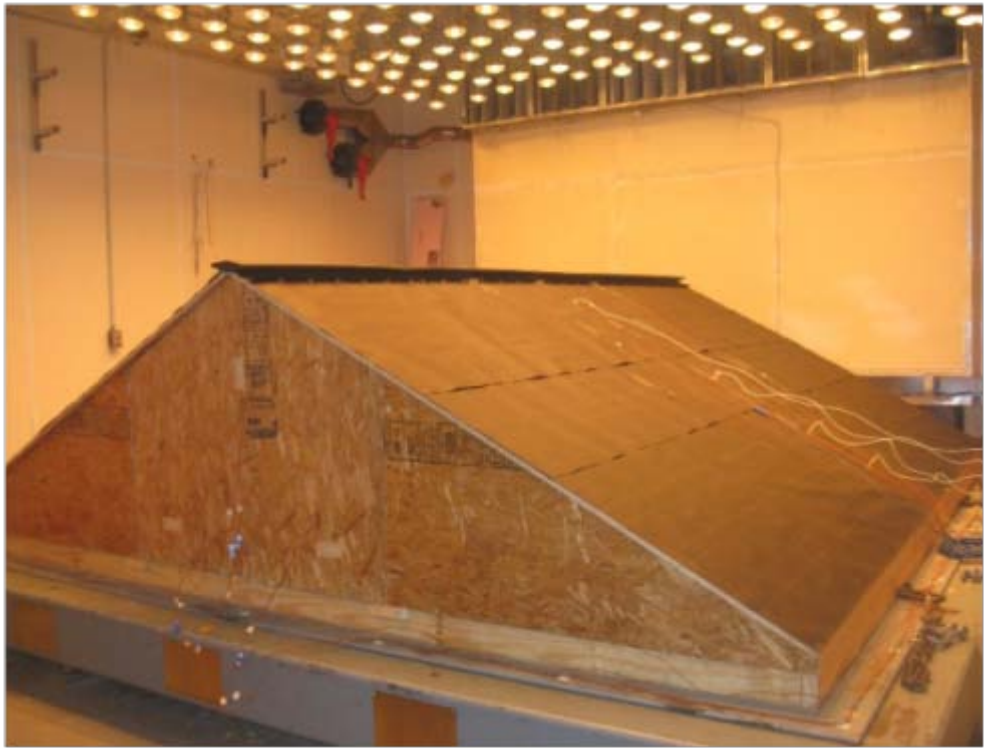
Natural Exposure Test Facilities

Attic Systems Deliverables

- Radiant Barriers for Retrofit Applications
- Establish benchmarks for the seven attics under study in Charleston, SC based on field measures collected at the NET facility
- Develop prototype attic assemblies systems including cool asphalt shingles, ventilation, and energy harvesting that supports developments at 3M. Sign CRADA.
- Finalize partnerships with private sector companies to undertake a full scale demonstration of a roof retrofit project
- Complete hygrothermal modeling of the proposed attic retrofit

Performance Evaluation of Attic RB Systems Using LSCS

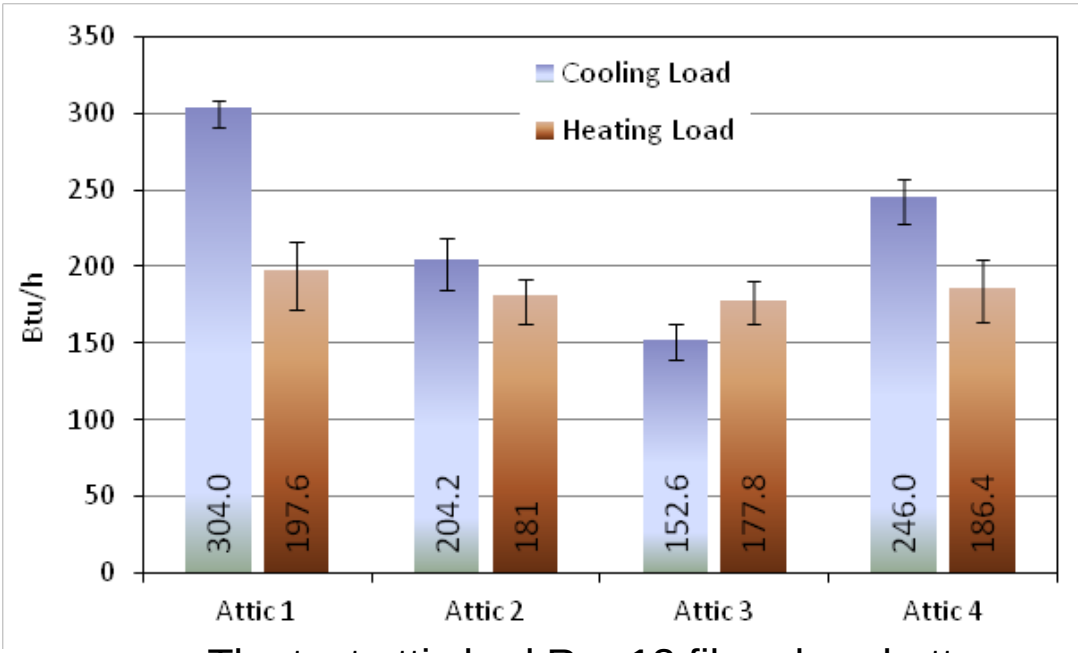
Attic 1	Oriented Strand Board (OSB) without radiant barrier (RB), $\varepsilon = 0.89$
Attic 2	OSB with perforated foil faced RB, $\varepsilon = 0.03$
Attic 3	RB stapled to rafters, $\varepsilon = 0.02$
Attic 4	Spray applied low-e paint on roof deck and rafters, $\varepsilon = 0.23$



Performance Evaluation of Attic RB Systems Using LSCS

- Cooling load through attic 2, 3, and 4 was 33%, 50%, and 19% lower compared to the load from attic 1 during summer daytime conditions

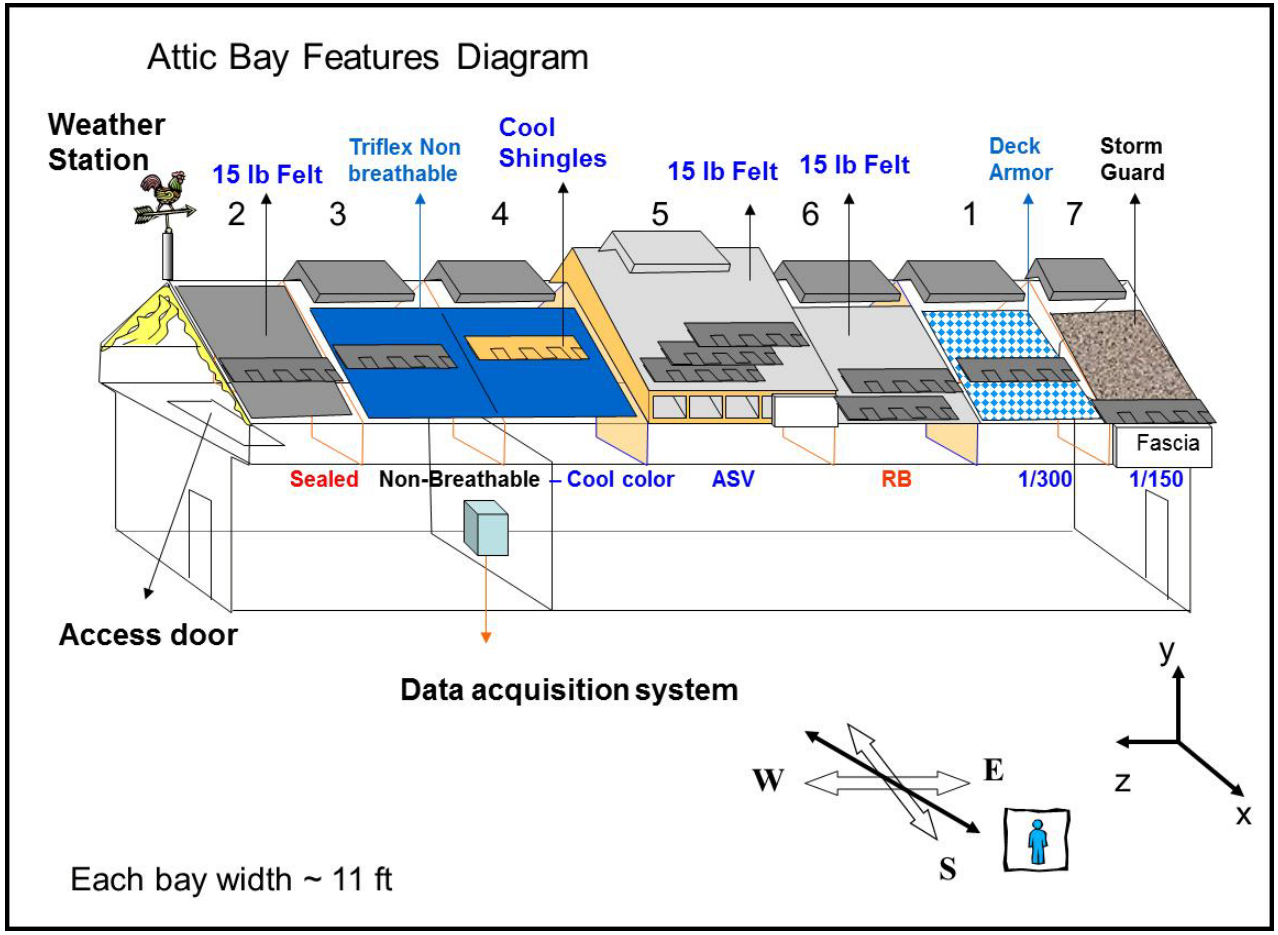
- During winter conditions, a 6 to 10% reduction in heat loss through the ceiling was observed, but the result was not statistically significant at 95% confidence.



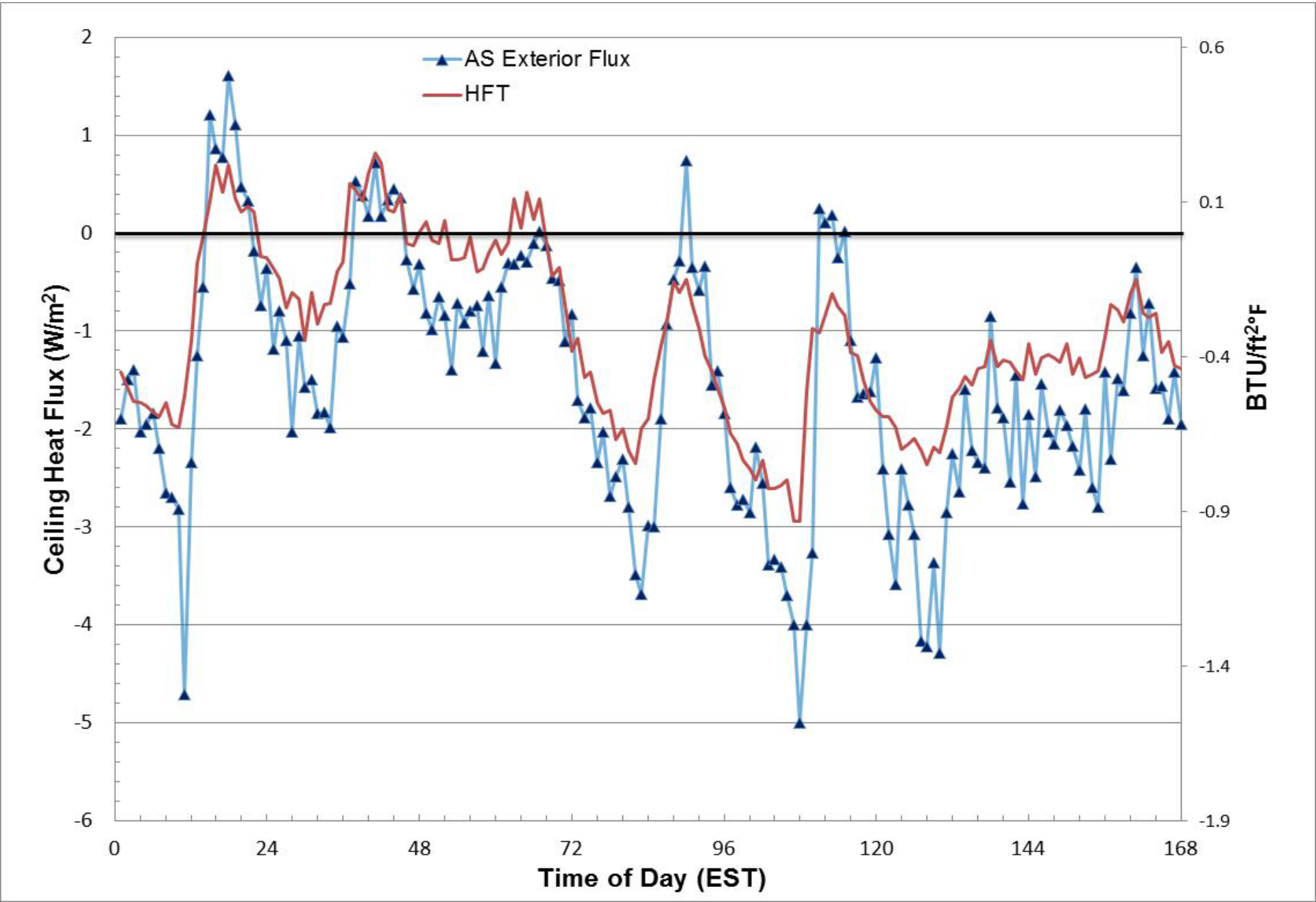
- The test attic had R_{US} 13 fiberglass batt insulation on the floor
- Summer daytime condition: climate chamber air temperature 100°F, roof exterior surface temperature 140°F
- Winter Night condition: climate chamber air temperature 32°F

NET Facility Charleston, SC

Attic Cavity	Acronym
Attic 01	CTRL (16 Perm)
Attic 02	SLD (8 Perm)
Attic 03	NB (0.04 Perm)
Attic 04	CC (0.04 Perm)
Attic 05	ASV (8 Perm)
Attic 06	RB (8 Perm)
Attic 07	FF (0.10 Perm)



Winter Ceiling Heat Flux



Condensation Potential Least for ASV Roof and Attic

Charleston Field Data Jan through March 2011

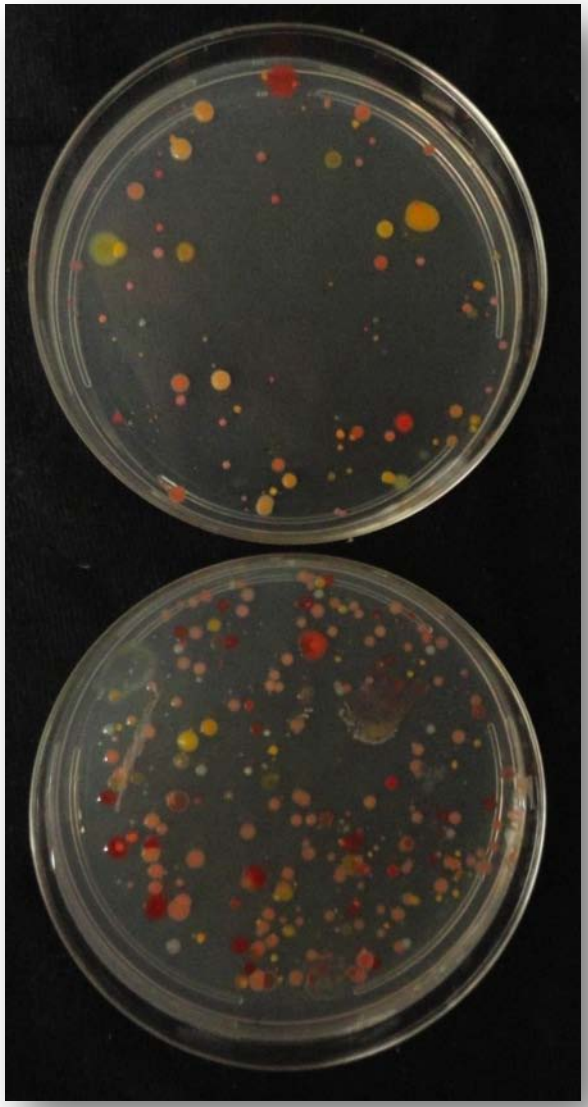
Attic	Hours $T_{sheath}<T_{dp}$ (2015 total)	% Time for Condensation on Sheathing	Hours $T_{joist}<T_{dp}$ (2015 total)	% Time for Condensation on Joist
03 – Low perm	110	5.5%	72	3.6%
04 – Irr Shingle	103	5.1%	62	3.1%
01 - CTRL	102	5.1%	48	2.4%
06 - RB	83	4.1%	26	1.3%
07 – 1:150	75	3.7%	32	1.6%
05 - ASV	20	1.0%	10	0.5%

Cool Roofs Deliverables

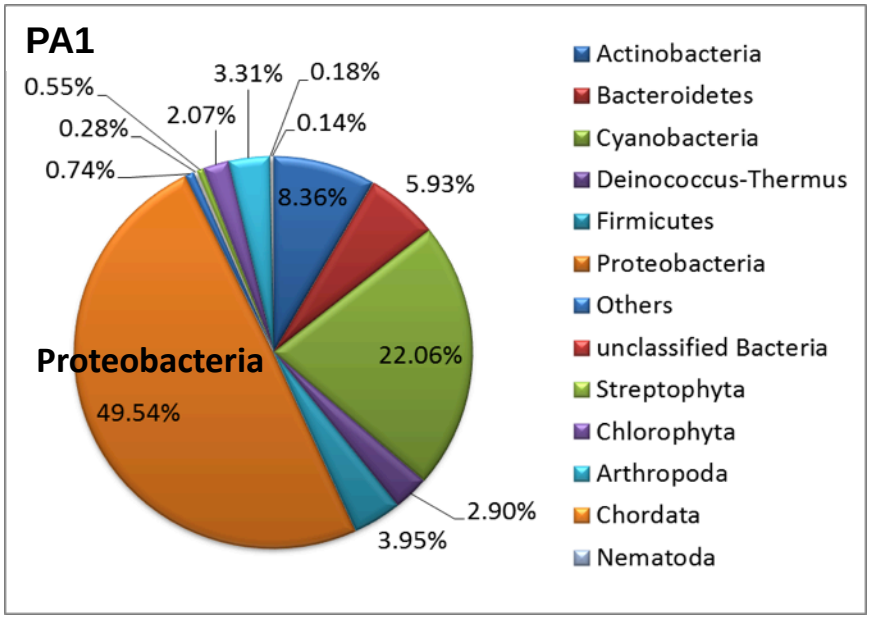
CRADA signed with Owens Corning to jointly develop cool shingles
First family of experiments has been started using accelerated protocol (Dow CRADA)

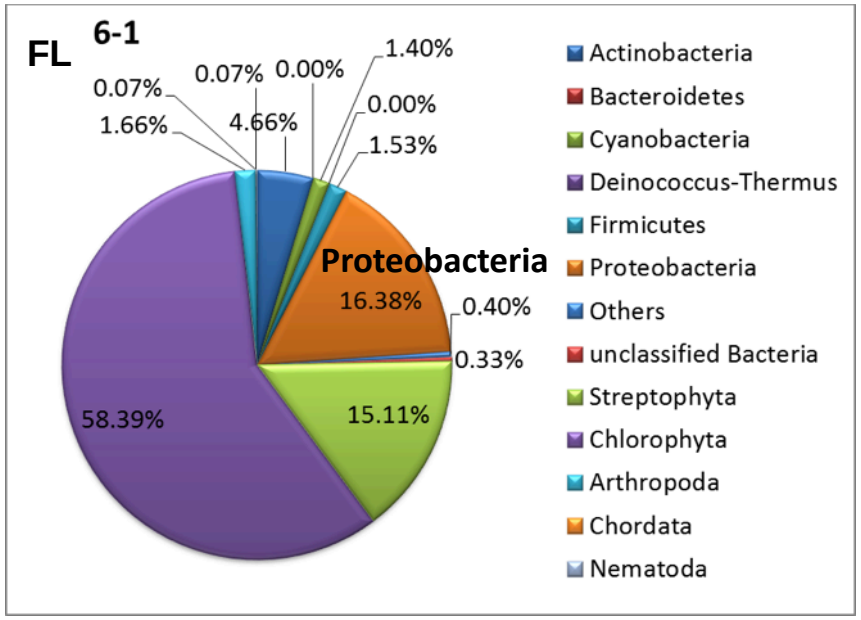
Research Plan

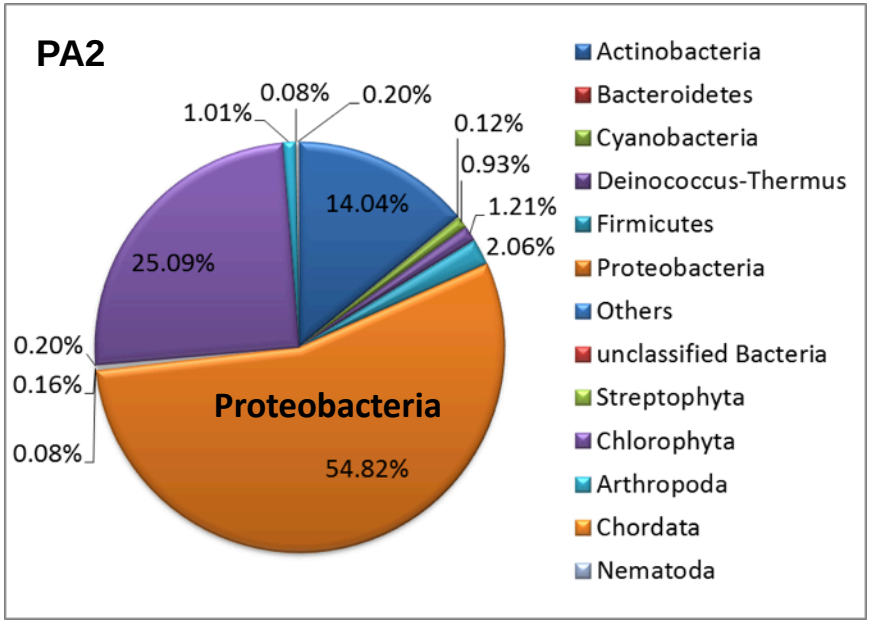
- Characterization microbial community on roof samples weathered in different climatic regions of the US
- Develop “microbial “cocktail to inoculate roof materials
- Design accelerated testing apparatus; verification method
- Establish accelerated testing protocol under laboratory-controlled climatic conditions

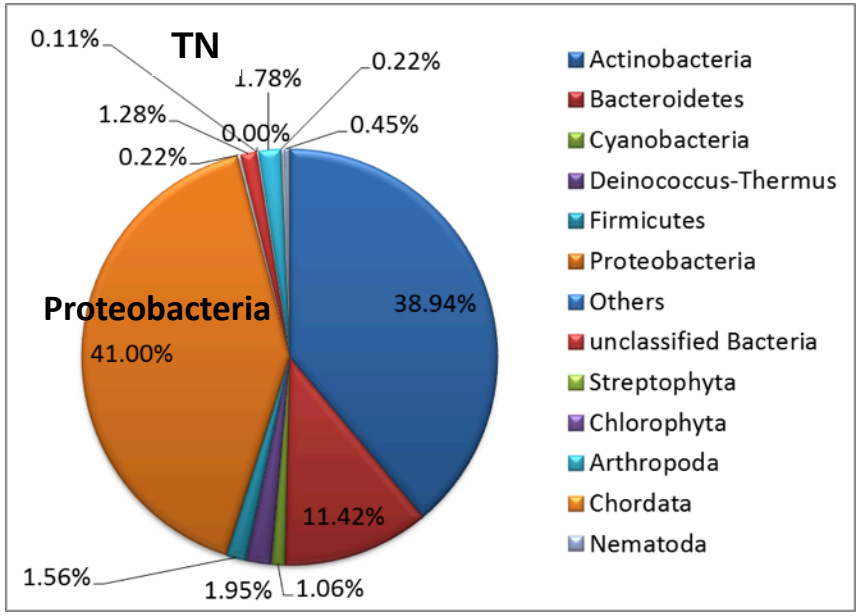


Differences in Microbial Communities (bacterial and eukaryotic sequences detected)

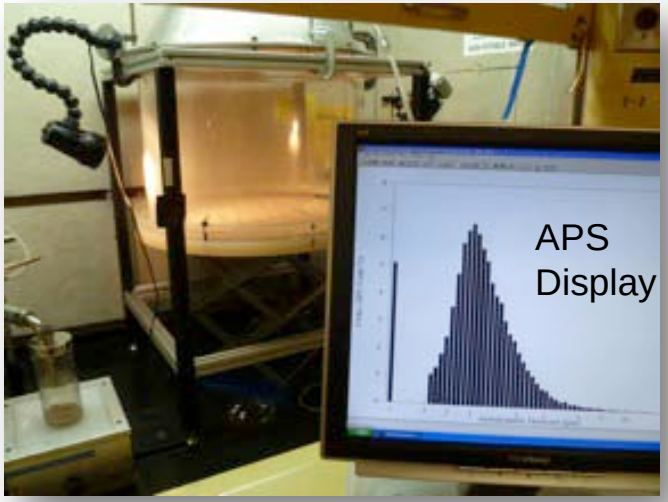








Accelerated Soiling Apparatus



Clean Simulated

- Chamber built for accommodating a sample up to 15” in dia. or multiple samples of smaller area
- Real-time monitoring capability for particle loading
- Design for loading dry and or wet contaminants

Transfer Ambient Exposure Method to Equivalent (faster) Laboratory Testing

- Temperature control
- Humidity control
- Dew formation
- Whole spectrum solar irradiation (# of Sun)
- Weather cycle programmable

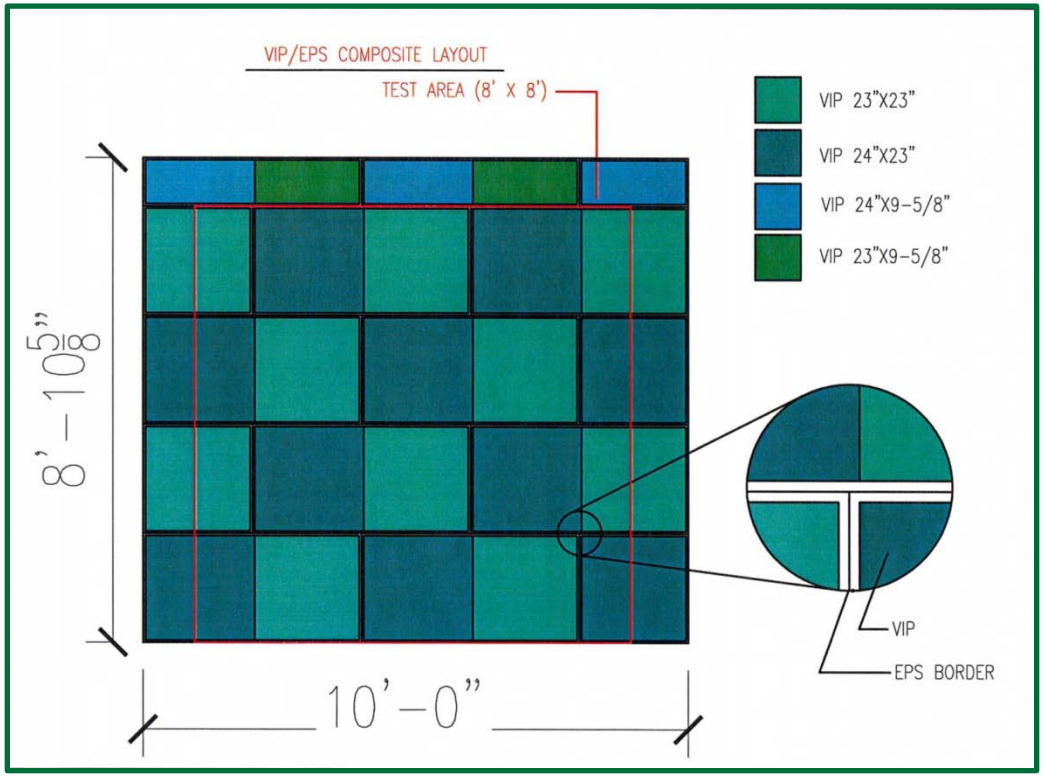
Vacuum Insulation Panel Deliverable

Draft report on test results for retrofit wall

- Related work: Updating ASTM material and test standard
- Related work: Updating ASHRAE handbook materials

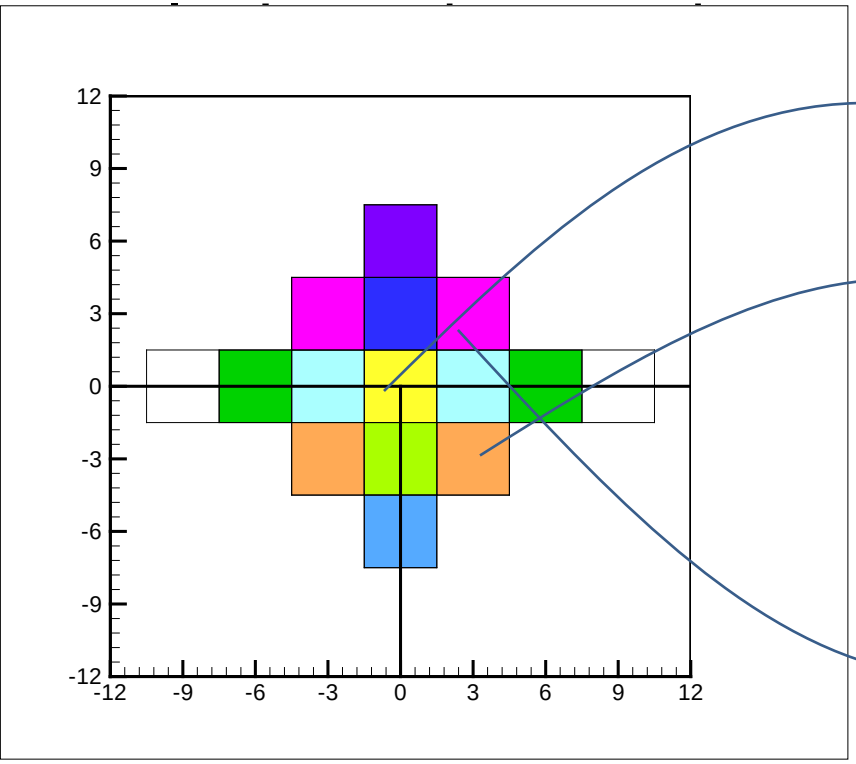
High R Wall Panel with Vacuum Insulated Panels

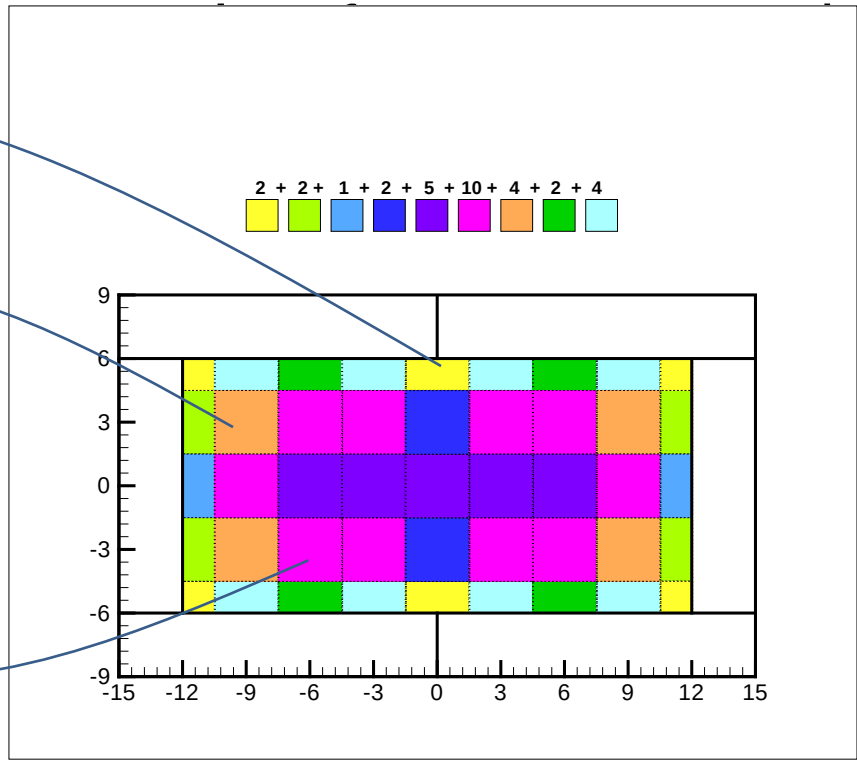
- EIFs with 2’ x 4’ sections filled with butted ~2’ x 2’ butted VIPs
- 1” EPS surrounds and protects VIPs on all sides (3” total thick)
- Metal stud wall



Two Analysis Approaches (30 transducer HFMA)

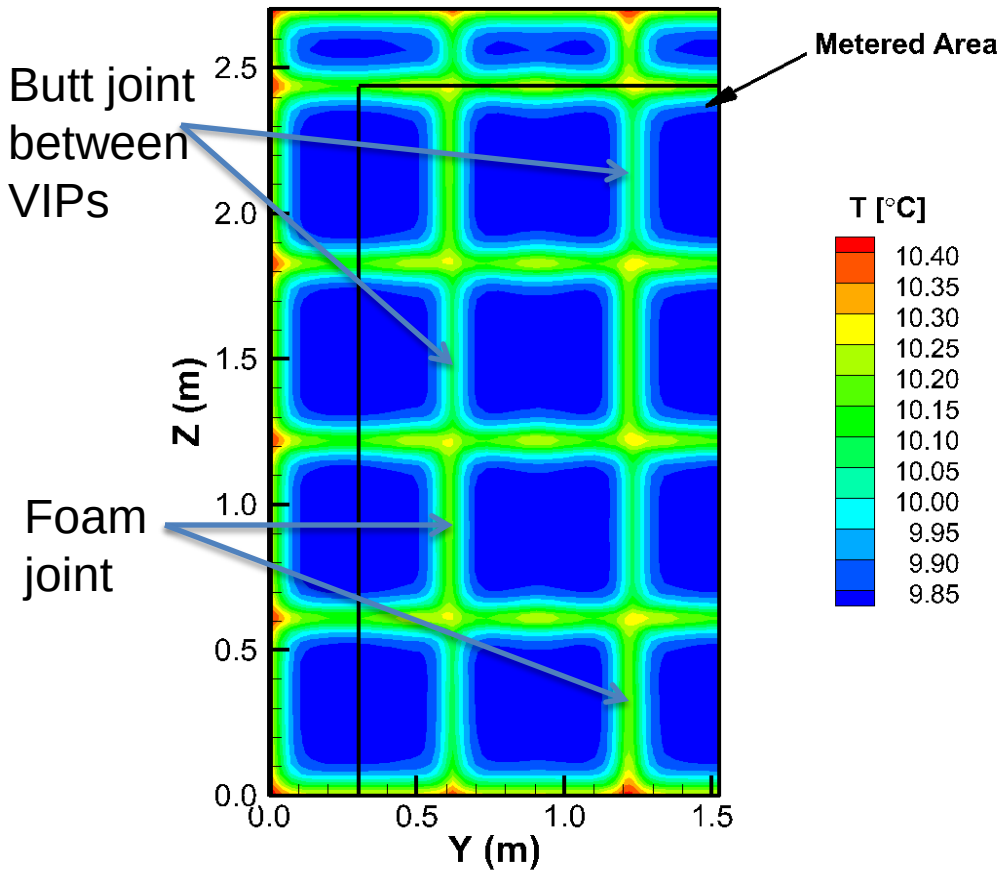
- Map measured heat flux relative to VIP edges – new to this project

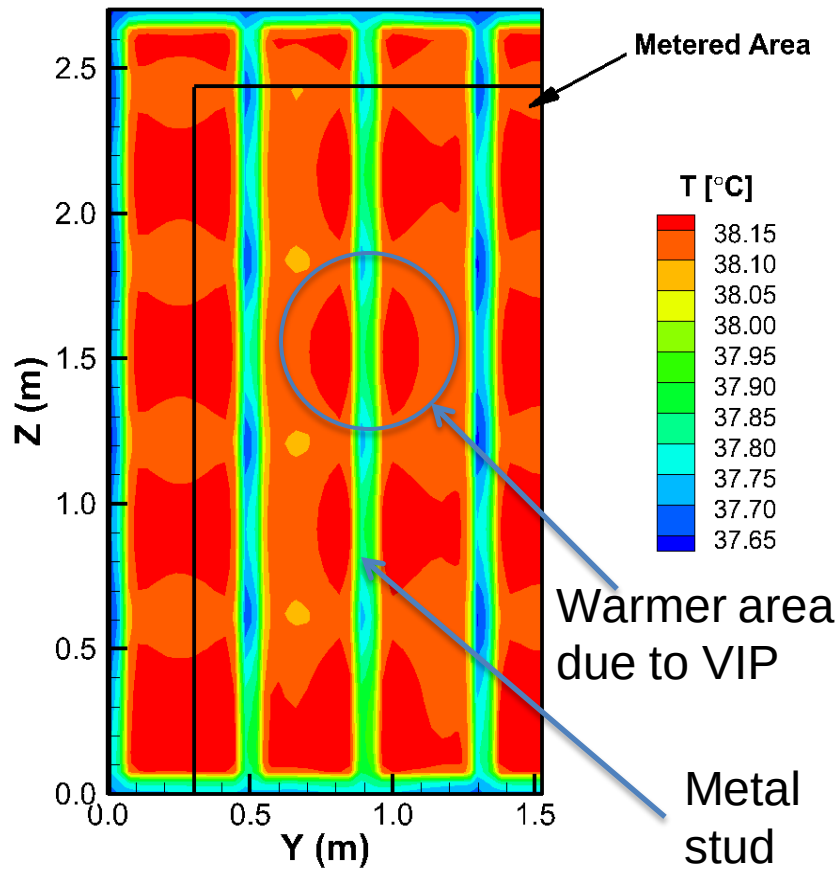




Two Analysis Approaches (30 transducer HFMA)

- Use measured heat fluxes to solve for VIP center and edge thermal conductivity; Apply values to finite difference wall model
- Model R 35.7, experiment R 31.3



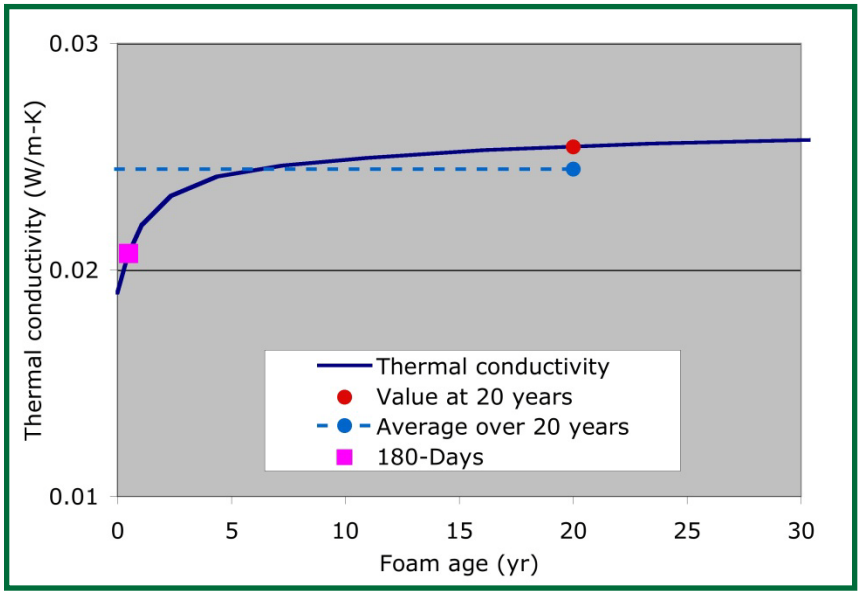


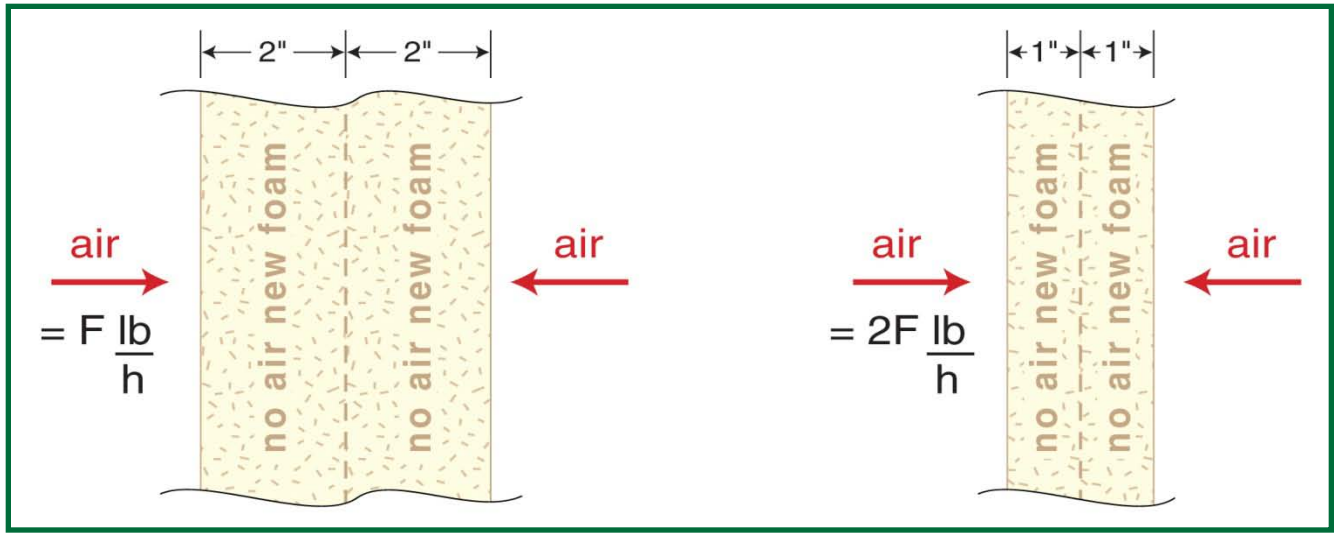
Advanced Insulation Deliverables

- *Insulations:* Draft report on accelerated aging ruggedness test for foam insulation

Lifetime performance: Which R-value should you use for a product that ages?

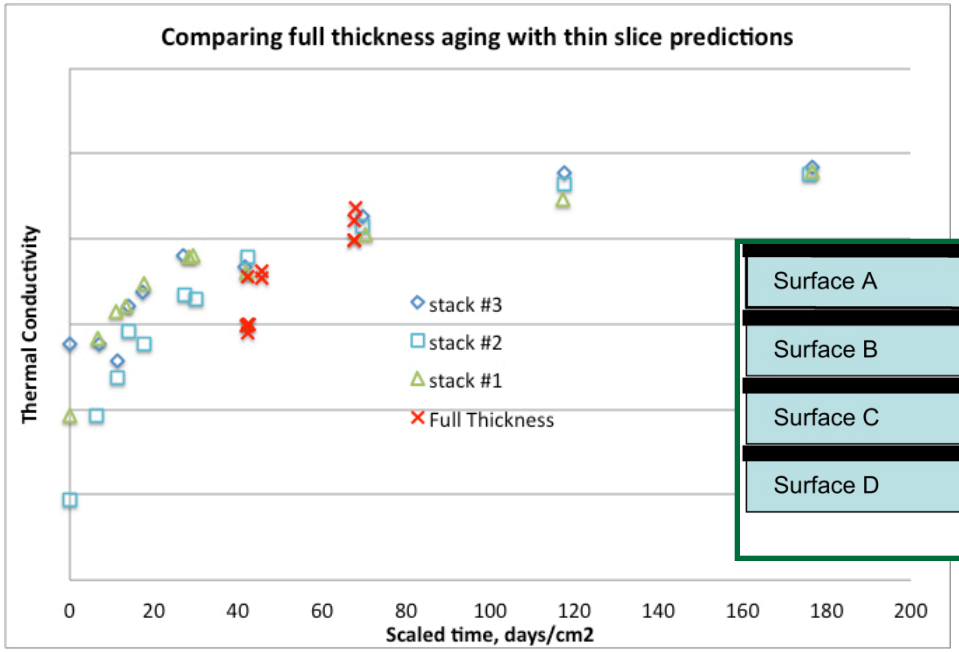
- R-value claims not believed, retarding market for highly effective insulation
- Developing new blowing agents
- Accelerated aging required

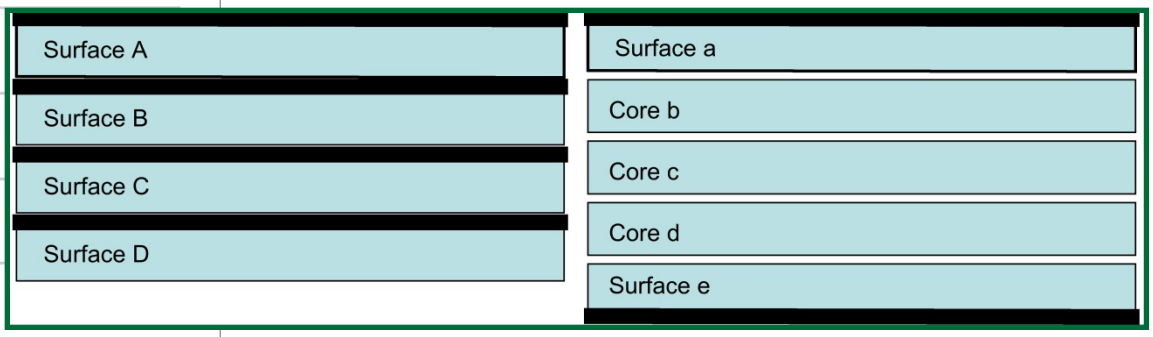




Testing the test method

- Does theory work for ‘real’ products?
- 2006 - 2012 Four manufacturers, eight products
  - Comparing predictions to 5 year lab aging
  - Learning which test parameters work best for each product



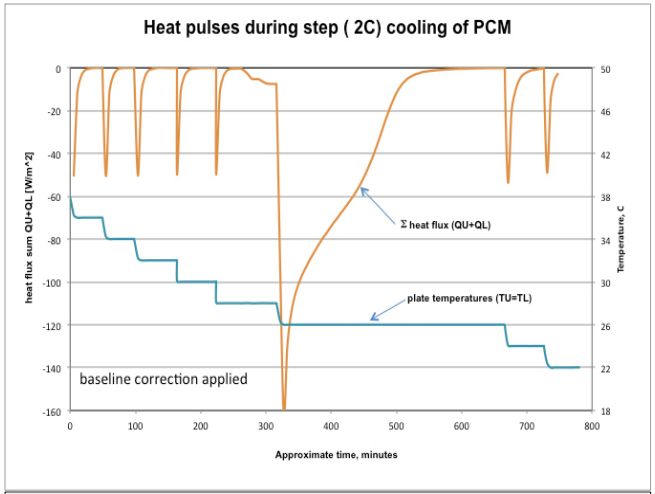


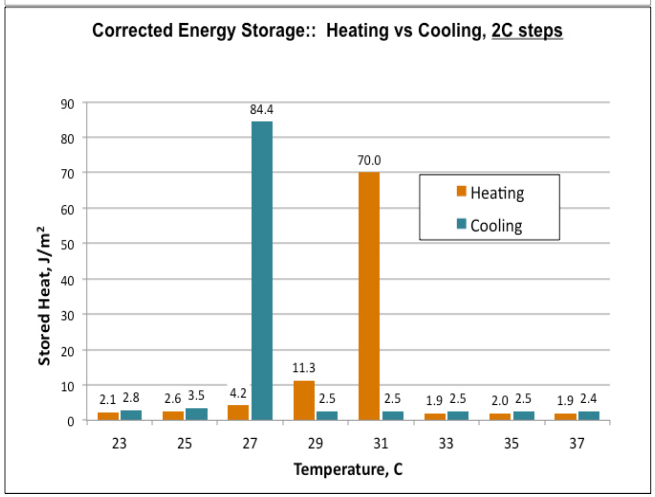
PCM Deliverables

- *PCMs:* Draft PCM test procedure submitted for first ASTM ballot
- *PCMs:* Draft report on building envelope influences on PCM performance (complete)

Dynamic Test Method Development to Support PCMs

- ASTM Task Groups - First meeting Fall 2010
  - Draft 3 discussed October 2011
  - *Ballot will follow April 2012 task group review*
- New protocols for instrument control
- Papers:
  - 30th and 31st International Thermal Conductivity Conference, 2009 and 2011; Building Simulation Conference, 2011; Building Envelope Conference XI, 2010
- IEA and ISO Task Groups





Air Barrier Deliverables

- *Air Barriers:* Complete a CRADA agreement with the Air Barrier Association of America.
- *Air Barriers:* Interim report summarizing results from ABAA Phase 2.

New York State Energy Research & Development Authority

Phase 2 at Syracuse NET Facility

- Monitor 3 panels per air barrier type
  - Level 1 < 0.02 L/(s.m^2) (material)
  - Level 2 ~ 0.2 L/(s.m^2) (assembly)
  - Level 3 ~ 1 L/(s.m^2) (enclosure)
- Simulated imperfections
- Evaluating 8 air barrier types

Interior

Spray-applied foam

Mechanically fastened

Non-insulating board stock

Insulating board stock

Sealers w/ backup structure

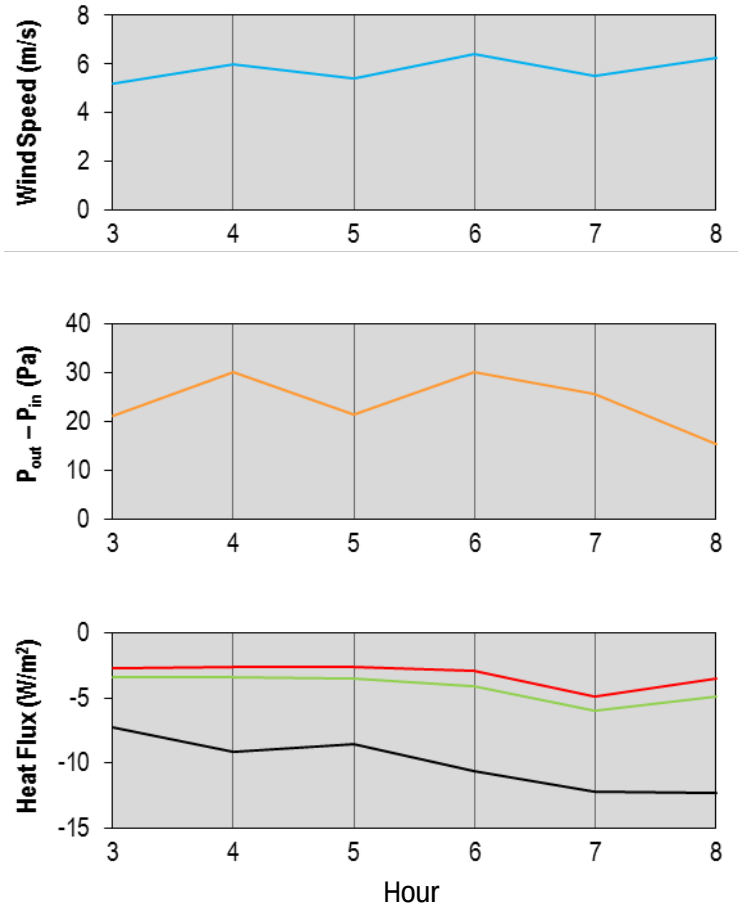
Self-adhered

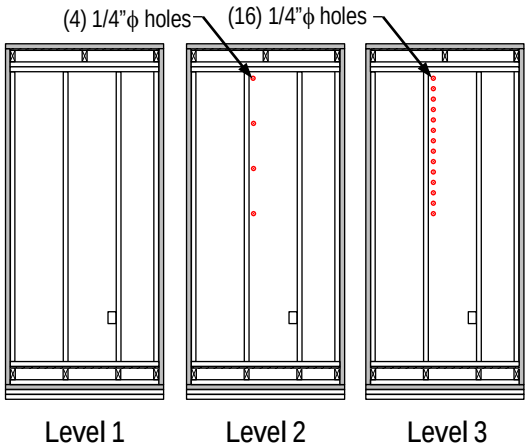
Fluid-applied non-foaming

- Data collection started on October 2012

Phase 2: Preliminary Results

November 6, 2011

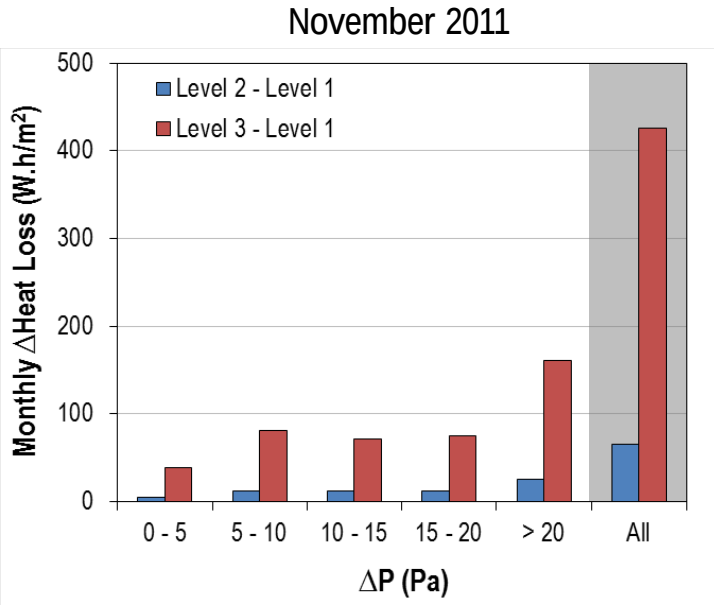


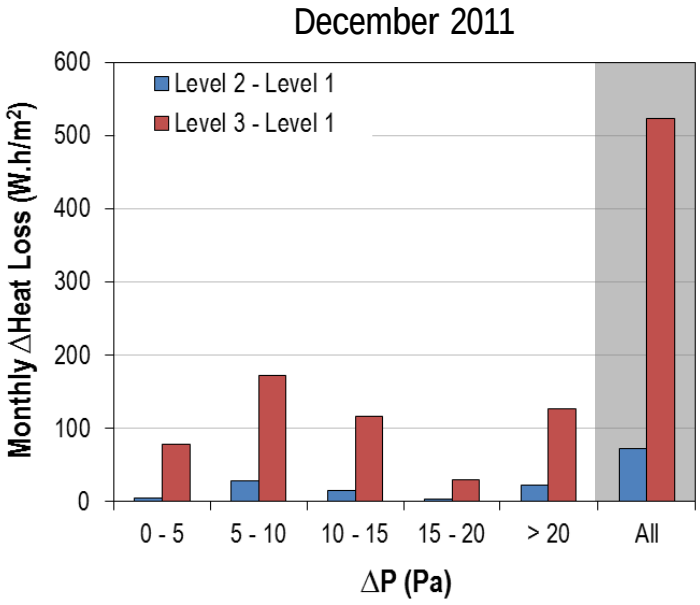


	Air Leakage [L/(s.m^2)] at ΔP = 21.3 Pa	Avg Heat Flux (W/m^2)
Level 1	< 0.02	-3.2
Level 2	~ 0.11	-4.2
Level 3	~ 0.33	-10

Phase 2: Preliminary Results

Quantify effectiveness of different air barriers technologies with field data

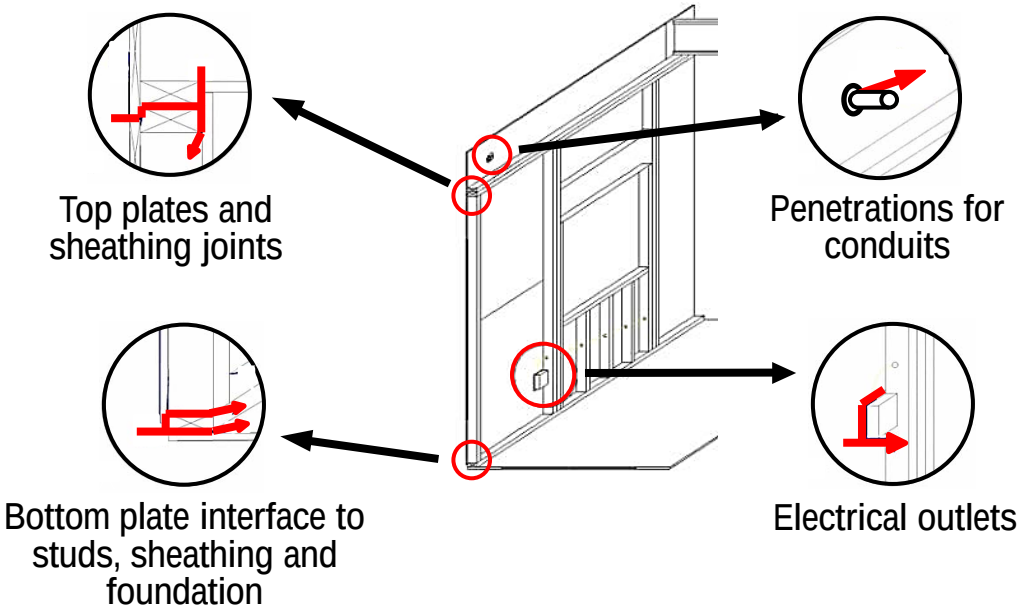




	Monthly Heat Loss (W.h/m^2)		
Air leakage @ 75 Pa [L/(s.m^2)]	Level 1 (< 0.02)	Level 2 ≅ 0.21	Level 3 ≅ 0.72
November 2011	564	629	990
December 2011	983	1057	1506

Sub-Assembly Tests

- Use ASTM E 2357 to characterize major air leakage paths in walls
- Assess methods to seal significant sources of leakage
- Data to define precision of apparatus scheduled for July



Foundation and Moisture Control Deliverables

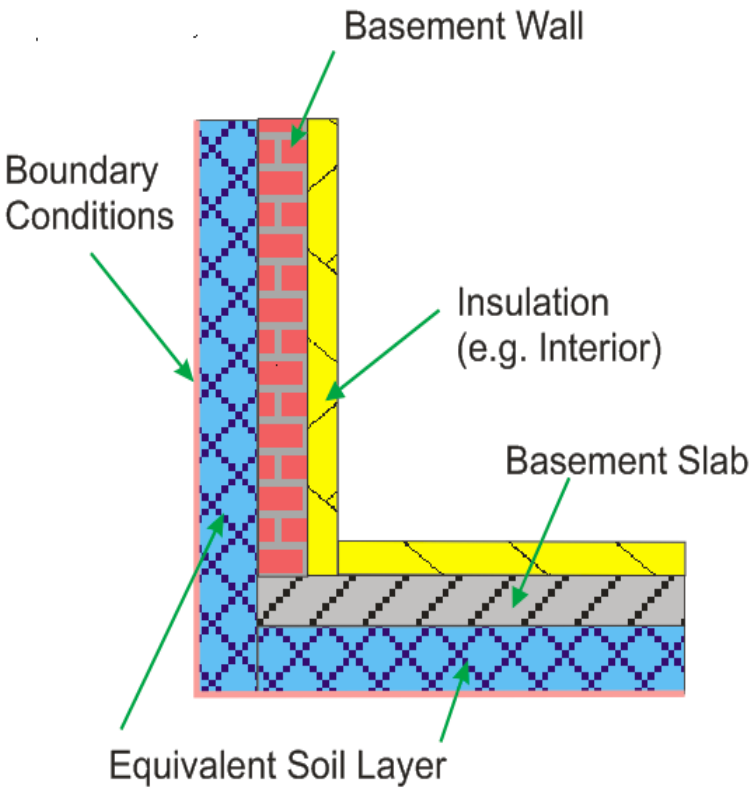
- *Foundation:* Draft report on foundation insulation test results
- *Foundation:* Joint ORNL/UMinn draft report on modeling of foundation systems

University of Minnesota

Fraunhofer IBP

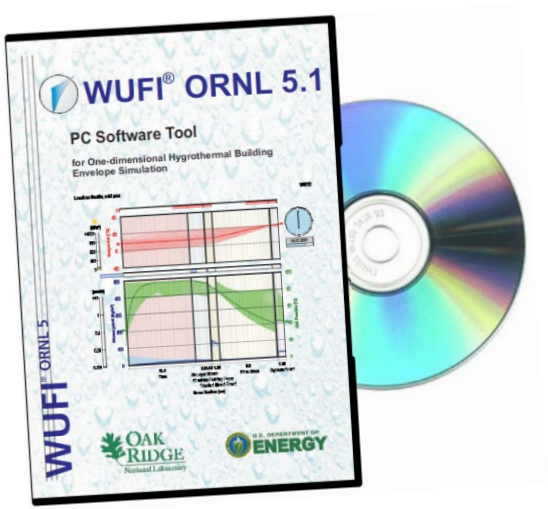
Durability of Foundation Insulation Systems

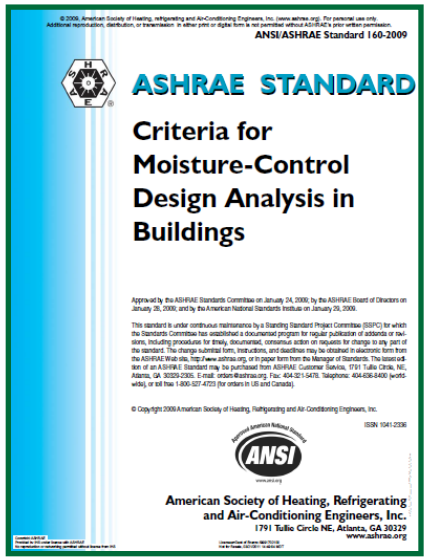
- Modeling dependent on soil properties, transfer coefficients and climate data (radiation , precipitation)
- External measurement data required
  → Univ. of Minnesota
- Knowledge about soil mechanics required
  → Univ. of Tennessee

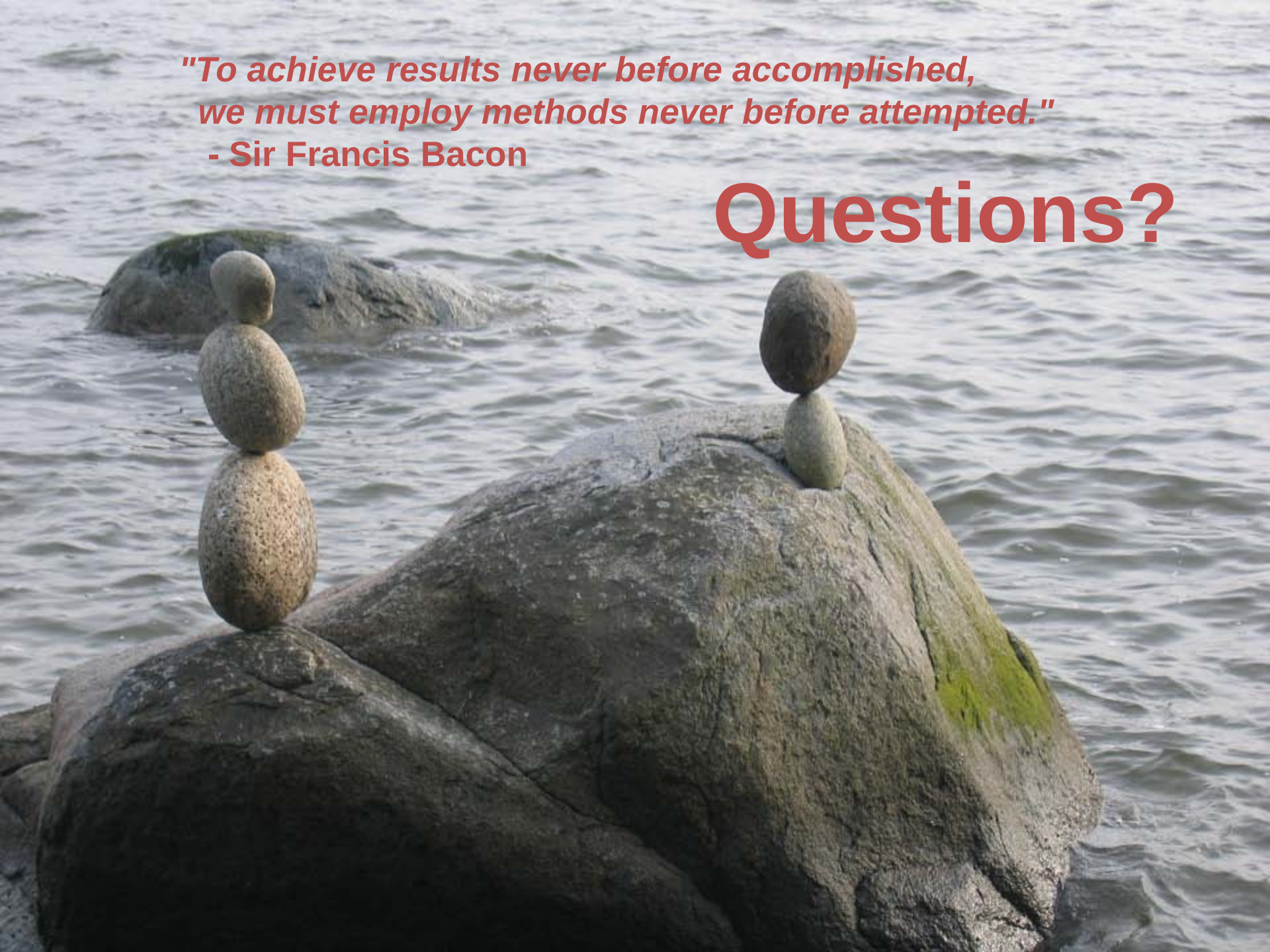


WUFI-ORNL Software Enhancements

- Ventilated cladding model
- Radiation balance model on exterior surfaces
- Additional North American materials
- New weather files from ASHRAE TRP 1325
- Minor changes…..






"To achieve results never before accomplished,
we must employ methods never before attempted."
- Sir Francis Bacon
Questions?