

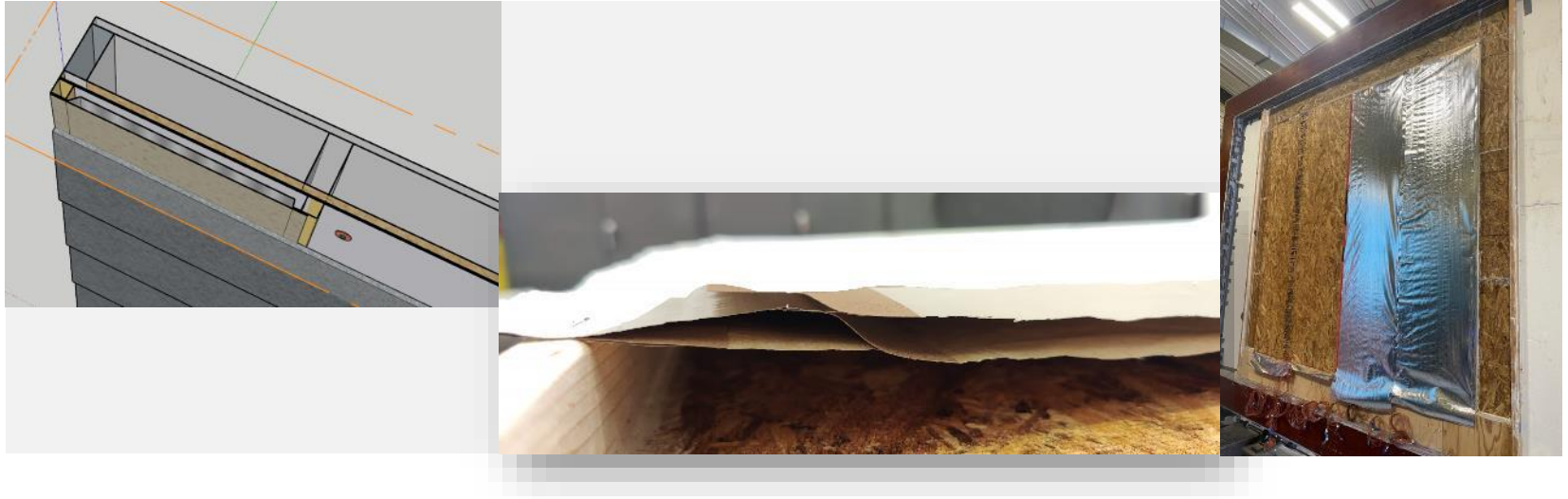
2024 PROJECT PEER REVIEW

U.S. DEPARTMENT OF ENERGY
BUILDING TECHNOLOGIES OFFICE

BTO Peer Review: Multilayer Foil as Exterior Insulation



Multilayer Foil as Exterior Insulation



Oak Ridge National Laboratory (ORNL)
PI Mikael Salonvaara, Senior R&D Staff
salonvaaramh@ornl.gov
WBS 03.01.03.12.29

Project Summary

OBJECTIVE, OUTCOME, & IMPACT

Develop an easy-to-install, low-cost exterior insulation system using multilayer reflective foils for new and retrofit construction. The product can serve as insulation and an air-water barrier in one step. Achieve a minimum of R-5 performance to reduce heating and cooling energy use, especially for low-income households and manufactured homes.



TEAM & PARTNERS

Mikael Salonvaara, ORNL
Emishaw Iffa, ORNL
Gunnar Johnson, ORNL
Hevar Palani, University of Illinois, intern

Wes Hall, Reflectix Inc.

STATS

Performance Period: 10/01/2023–09/30/2025
DOE Budget: \$300K, Cost Share: \$ - K
Milestone 1: Performance verified in lab, R-5+
Milestone 2: Prototypes designed with installation
Milestone 3: Field performance meets R-5+



Problem

- Technical problem
 - Traditional exterior insulation solutions are expensive, require professional installation, and are difficult to apply on rough surfaces
- Market gap
 - Low-income households struggle to afford energy-efficient retrofits, leading to high energy bills and poor comfort
- Target audience
 - Retrofit market (re-siding) for low-income homes and manufactured homes



Alignment and Impact

DOE goal alignment



- The project directly supports DOE's goal of reducing building emissions by enabling low-cost, DIY insulation retrofits
- Reduce building-envelope heat losses and improve water-air tightness to lower energy use and peak demand in existing and new homes



Greenhouse gas
emissions reductions

Potential impact



- Reduce cost by 10%–30% compared with traditional insulation and make retrofits accessible to more households, especially in disadvantaged communities
- Boost the use of exterior insulation in manufactured home plants
- Alleviate the lack of skilled labor in construction by do-it-yourself actions



Energy
justice



Alignment and Impact Equity and Inclusion

- Impact on low-income households
 - This project specifically targets affordable energy-efficiency solutions for low-income families and disadvantaged communities
- Broader adoption
 - By reducing cost and complexity, the solution is expected to help close the energy equity gap



Approach Reflective Insulation Products

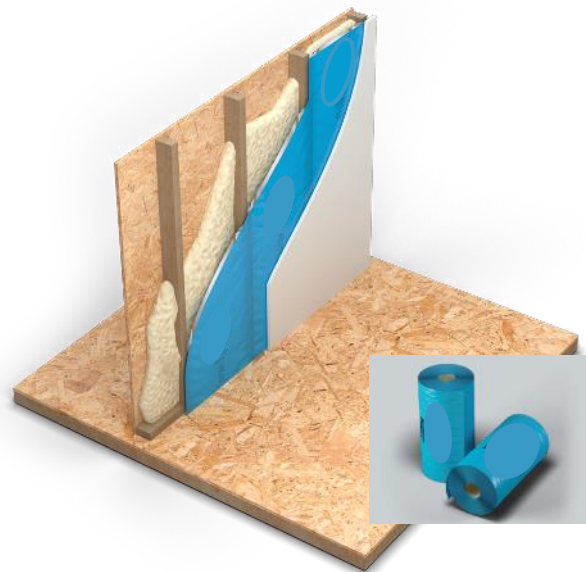
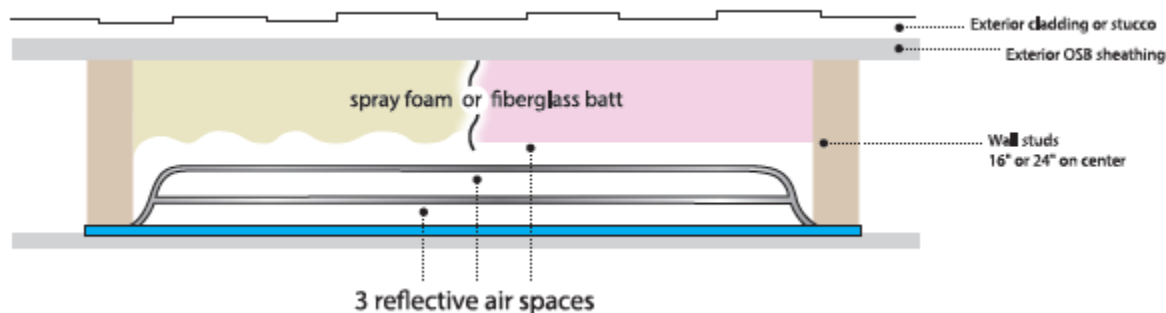
- Multilayer radiant barrier systems
 - R-4.1 @ $\frac{3}{4}$ " cavity (two cavities)
 - R-6.5 @ $1\frac{1}{2}$ " (three cavities)
 - R-7.1 @ $1\frac{5}{8}$ " (three cavities)
- Bubble wrap products (single, double)
 - R-3.7 @ $\frac{3}{4}$ " cavity
 - R-7.0 @ $1\frac{1}{2}$ " cavity





Approach Existing Multifoil Reflective Insulations

- Example: Application with closed-cell spray foam
- To avoid overspray, spray foam does not fill the cavity
- Application on walls on indoor side





Approach System Design

• Design features

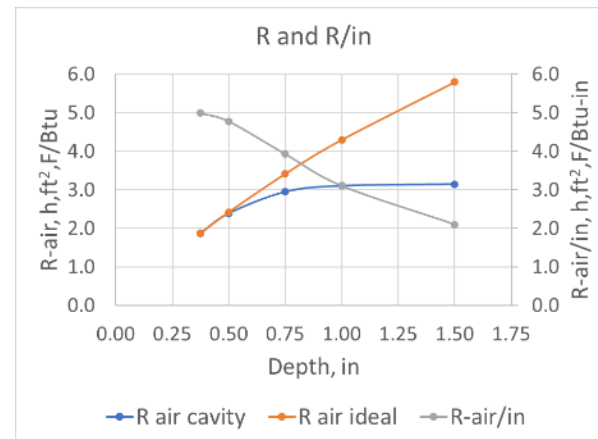
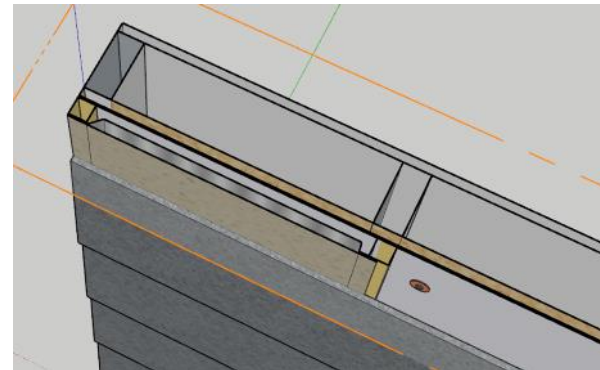
- **Low cost:** Air as insulator
- **Thickness:** Add insulation during re-siding with minimal thickness increase ($\leq 1.5"$)
- **Drainage** by air gap for moisture performance

• Key factors

- Emissivity of the foils (≤ 0.05) and proper cavity depth ($\leq 0.5"$) to minimize convection

• Do-it-yourself focus

- Easy installation with simple tools like staples; no need for professional contractors





Approach Prototyping and Testing

- Test existing products and design new prototypes
 - Air cavities created using expanders or dividers
- Testing
 - Heat flow meter and hot-box testing to confirm R-5+ performance in $\leq 1.5''$ thickness
 - Weather exposure testing to assess durability and dynamic performance
- Time and effort study
 - Evaluate ease of installation and readiness for do-it-yourself installers



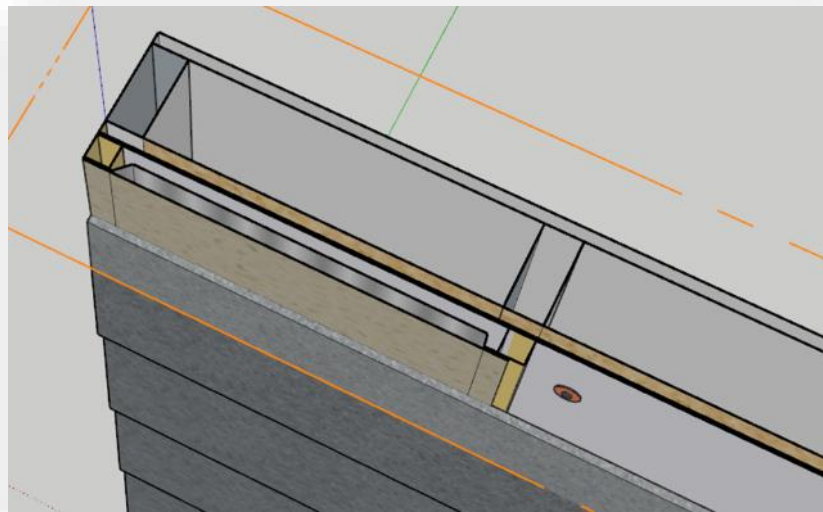
Approach Market Barriers and Commercialization

- **Market barriers**
 - High material costs and labor shortages make traditional retrofits inaccessible to many
- **Mitigation**
 - The system reduces material costs by 50% compared with traditional insulation and simplifies installation



Approach New Application on Exterior of Walls

- During re-siding, add furring strips or similar material to create an air gap
 - Limit thickness to 0.75"–1.5" to avoid extended jams
- Install reflective insulation on furring strips by stapling
- Ensure the continuity of insulation to provide air-water resistance
- Provide all-in-one installation kits with instructions from the hardware store





Progress Radiant Barrier Material Testing

- Tested radiant barrier material products for prototype development
 - An emissivity of 0.50 was found instead of the claimed 0.03–0.04 in many products
 - Product with test reports performed as claimed
- The reflective insulation and radiant barrier market is plagued by unverified products
 - Misleading claims with no test reports
 - Overpromising performance





Progress Laboratory Testing

Completed milestones

- Hot-box testing for manually made product R-6.0 (1.5", heat flow horizontal)
- Thermal resistance in heat flow meter R-5.5 (1.5", heat flow up, three-cavity product) for a commercial product
- Hot-box test is ongoing for the three-cavity commercial product





Progress Testing and Validation

- Ongoing tests
 - Real-world exposure testing for dynamic performance evaluation
 - Simulated impact of air leakage on the thermal resistance
 - Evaluation of impact on moisture performance of walls
- Lessons learned
 - Emissivity and air-gap management are critical for maximizing performance
 - Must design how to verify installation success



Future Work Economic Impact and Cost

- Cost breakdown
 - Reflective insulation costs \$0.50/ft², whereas foam insulation costs \$1.00/ft²
 - Evaluate cost of accessories
 - Time and effort study for labor costs
- Potential savings
 - The insulation offers significant energy savings for homeowners, especially in manufactured homes, with a quick payback period



Future Work Optimization and Scaling

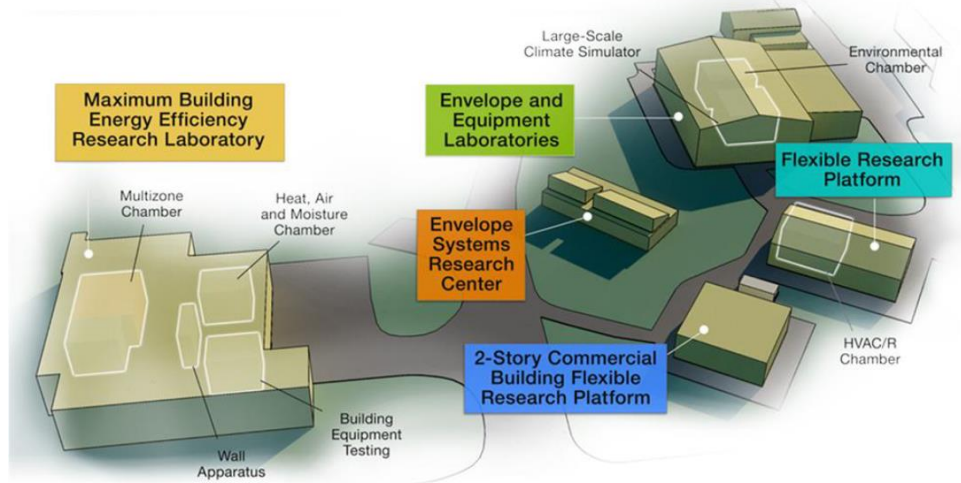
- Next steps
 - Design details for penetrations and connections
 - Reduce installation time and costs further
 - Validate performance in various climates
 - Prepare for broader commercialization
- Plans for 2025
 - Develop partnerships with manufacturers
 - Conduct additional field tests
 - Finalize installation guide

Thank you

Oak Ridge National Laboratory

Mikael Salonvaara, Senior R&D Staff
(865) 341-0022 / salonvaaramh@ornl.gov

WBS 03.01.03.12.29



The **Building Technologies Research and Integration Center (BTRIC)** at ORNL has supported DOE BTO since 1993. BTRIC is comprised of more than 60,000 square feet of lab facilities conducting RD&D to develop affordable, efficient, and resilient buildings while reducing their greenhouse gas emissions 65% by 2035 and 90% by 2050.

Scientific and Economic Results

139 publications in FY24
140+ industry partners
60+ university partners
16 R&D 100 awards
64 active CRADAs

***BTRIC is a
DOE-Designated
National User Facility***

Reference Slides





Project Execution

	FY2024				FY2025			
Planned budget	\$100K				\$200K			
Spent budget								
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Past Work								
Q1 Milestone: Product selection. Design wall assemblies.		◆						
Q2 Milestone: Hot box testing provides R5+.			◆					
Current/Future Work								
Q1 Milestone: Testing exposed to natural weather.						◆		
Q2 Milestone: Time and motion study of installation.							◆	
Q3 Milestone: Optimize design and installation.								◆
Q4 Milestone: Seasonal R-value meets 5+ without moisture issues.								◆

- Project started slow due to material and equipment availability.



Team ORNL and Reflectix Inc.



**Mikael
Salonvaara**

PI, Senior R&D Staff
Project management,
overall design



**Emishaw
Iffa**

R&D Staff
Simulations



**Hevar
Palani**

Intern
Testing and
assembly



**Gunnar
Johnson**

Associate Technician
Assembly installations,
testing



Wes Hall

Reflectix Inc.