Building Envelope Systems Research

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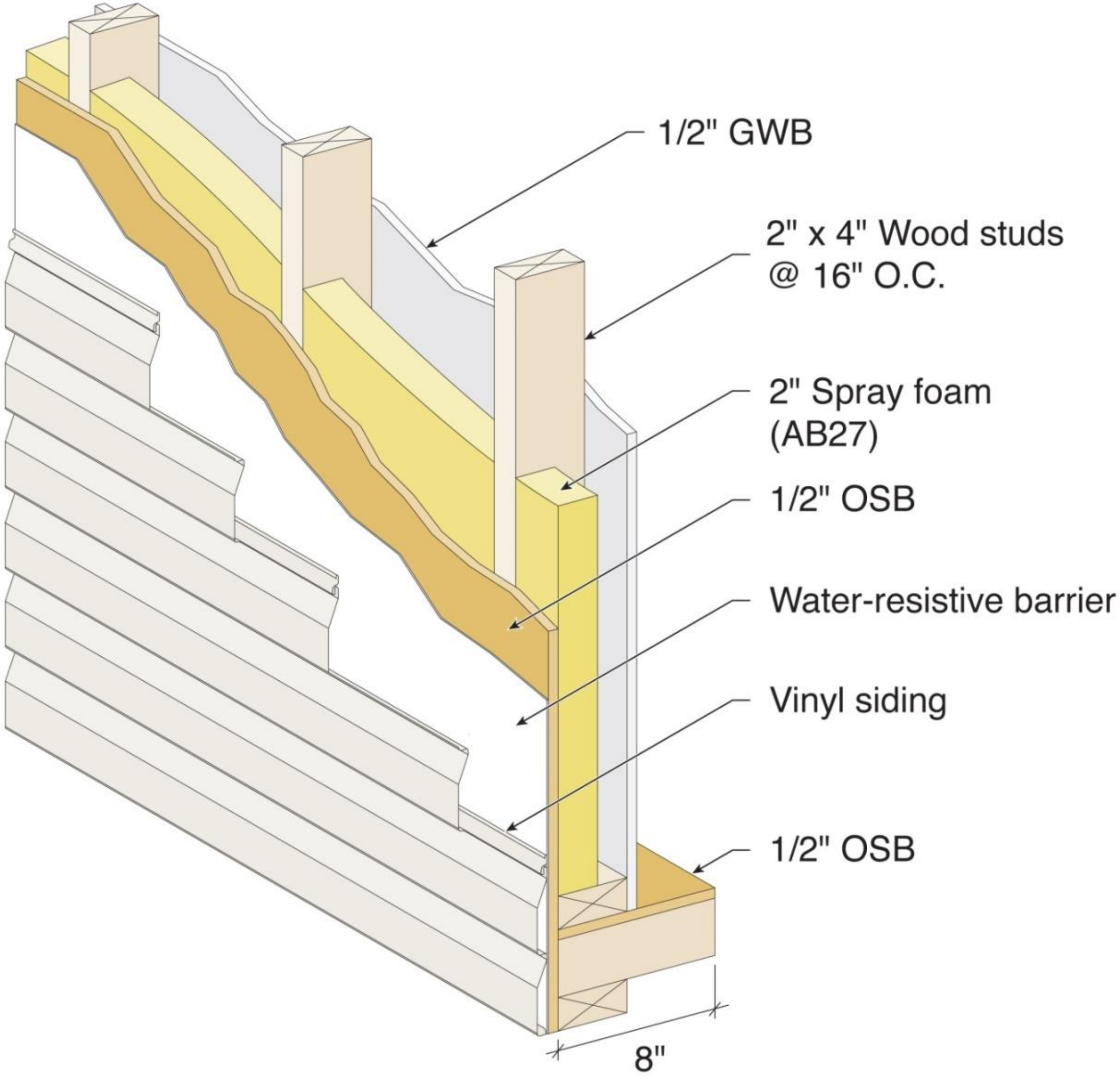
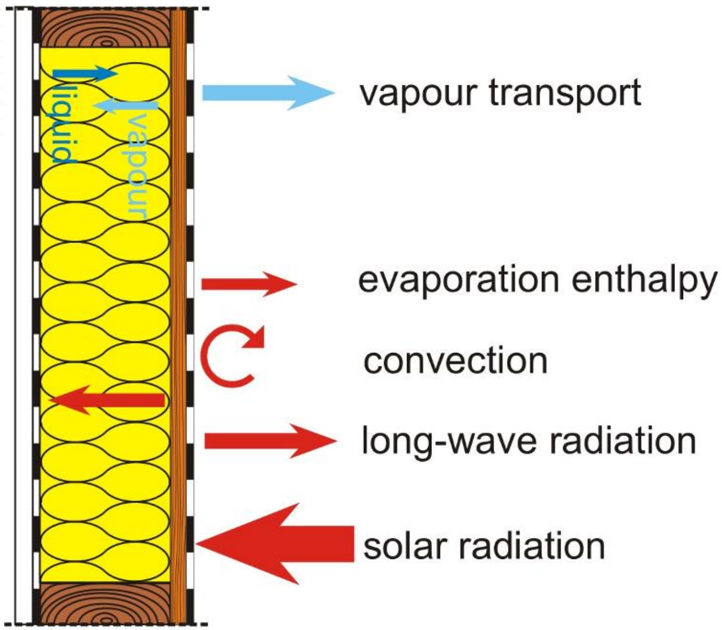
Presented to:
DOE Building Envelope and Windows Workshop

The Building Envelope is a COMPLEX and INTEGRATED SYSTEM

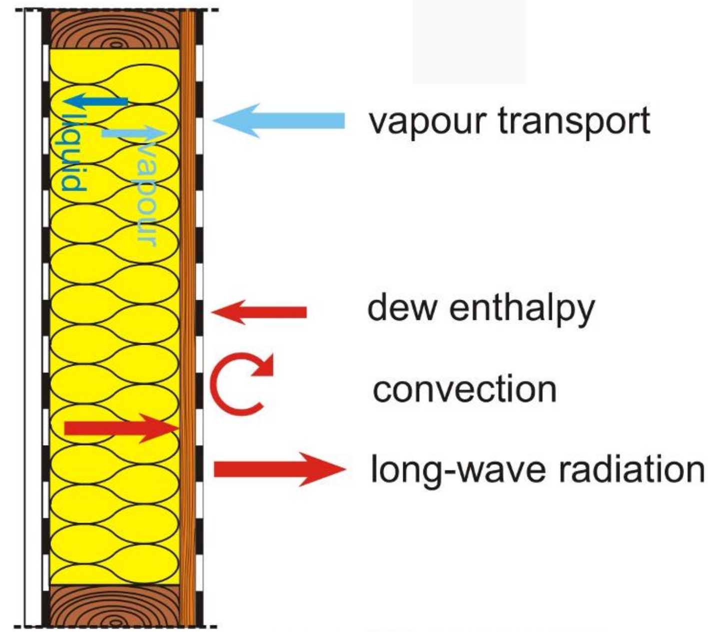


A Complex System with Complex Processes

During the day…..



At night…..



A COMPLEX SYSTEM in a COMPLEX ENVIRONMENT

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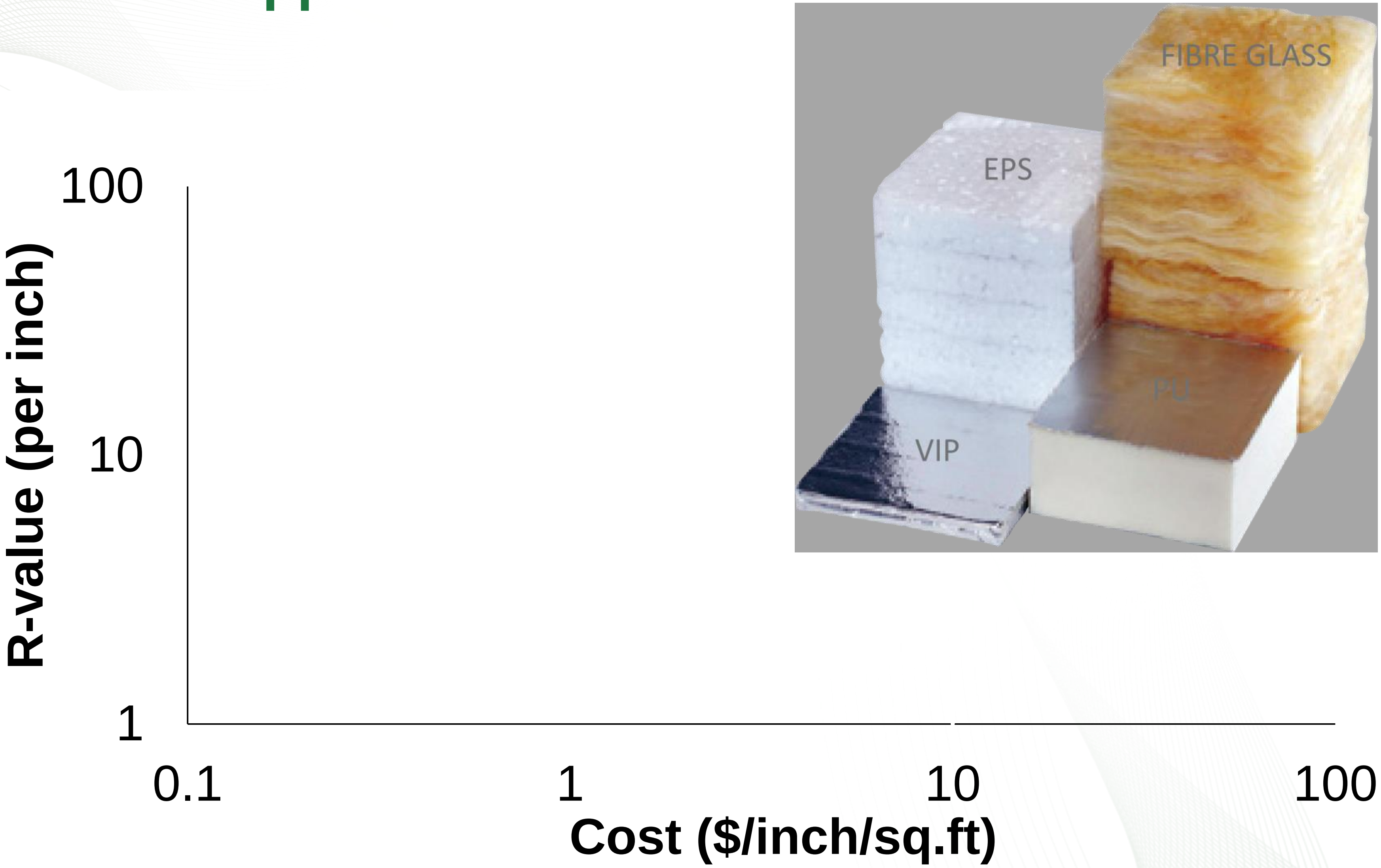
Building Component Requirements

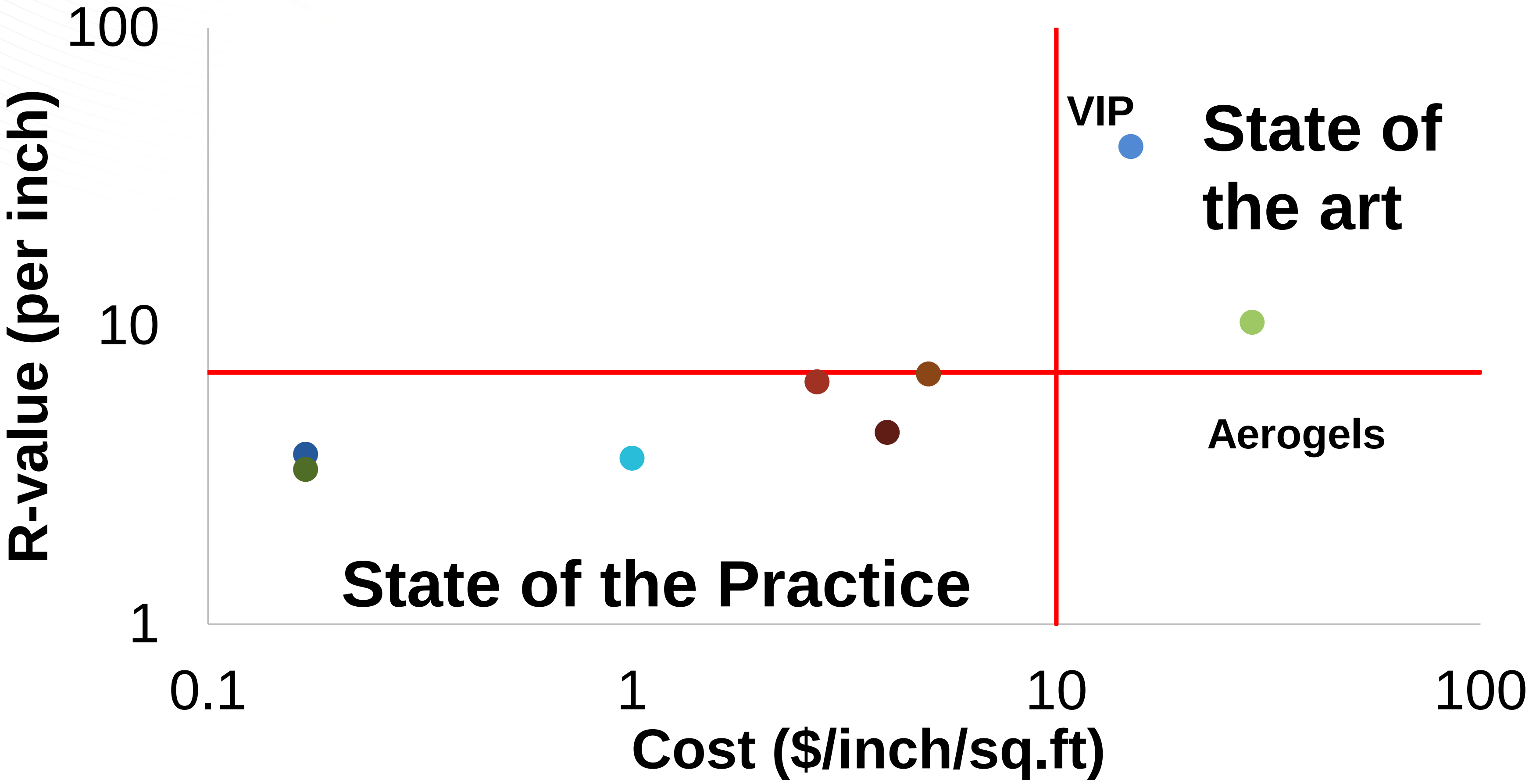
- Many Climates and Extremes
  - Temperature, UV, Wind, Freeze/ Thaw, Moisture, Mold, Fire, Structure, Toxicity, Human Safety
- New vs Retrofit
- Many Building Types
  - Many different designs (parameter mixes)
- Strong Interactions
- Highly Cost Sensitive

Technical Challenges and Current Research

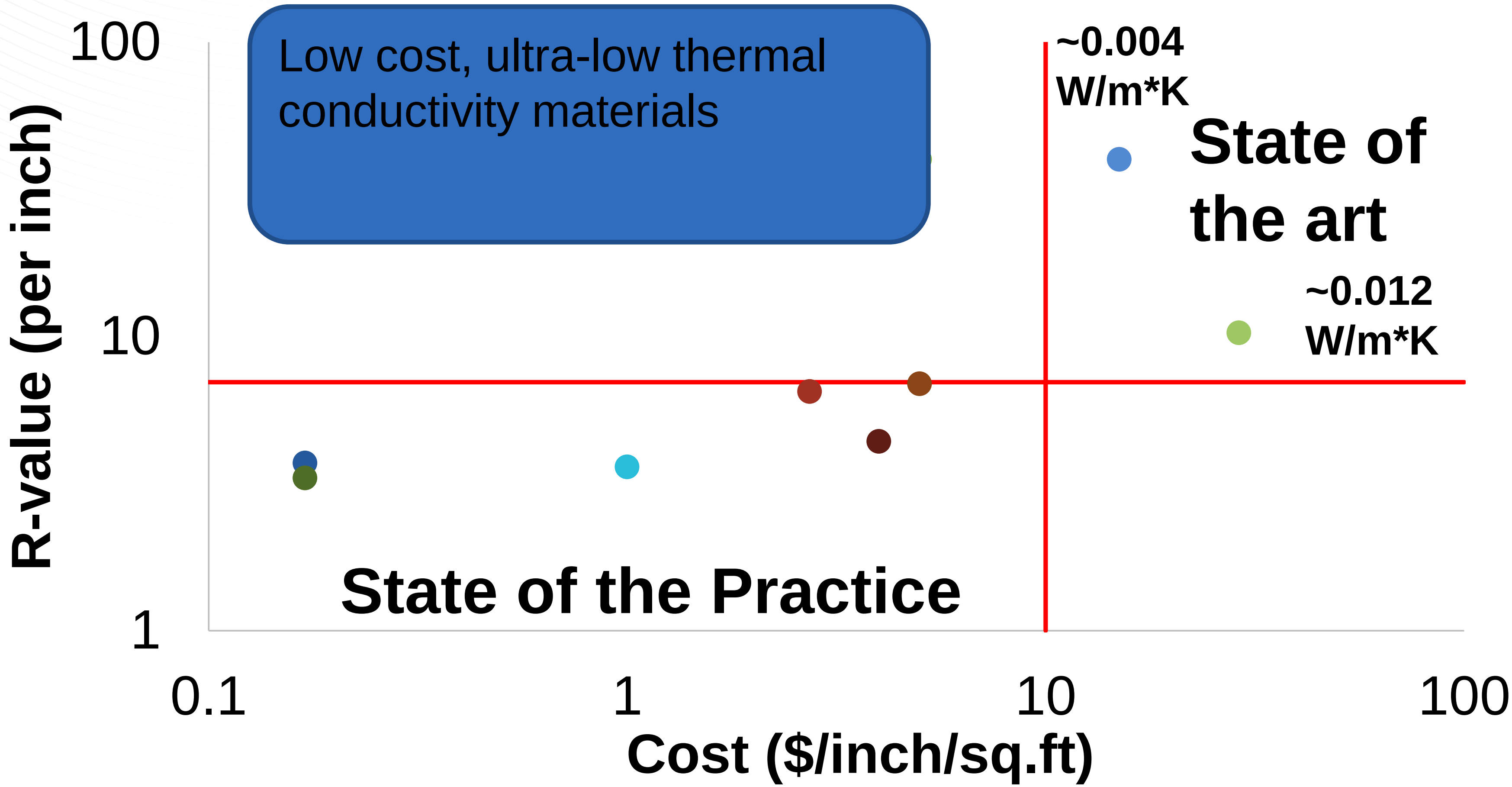
Insulation materials for building envelopes – Innovation opportunities



Insulation materials for building envelopes – Innovation opportunities



Insulation materials for building envelopes – Innovation opportunities

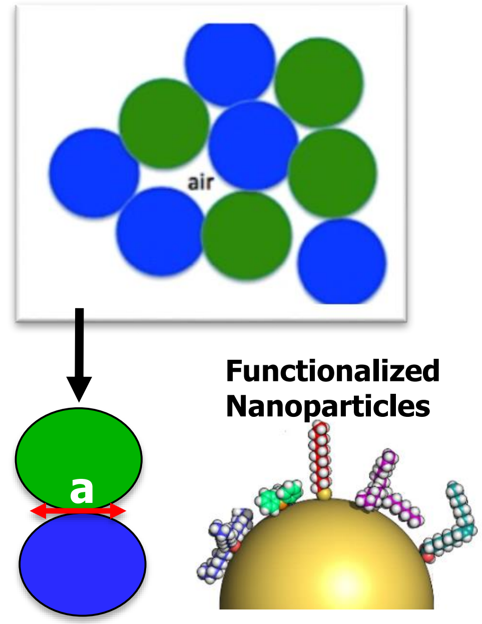


Robust Super Insulation at a Competitive Price

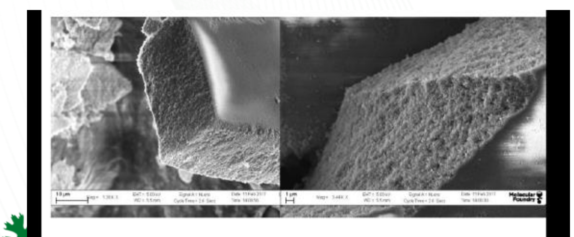
Technology Summary

LBNL is developing a novel insulation using nanoscale phonon engineering to optimize surface energy, particle size, and acoustic property mismatch to achieve R-12/inch.

- R/inch value at least 2 – 4 times higher than conventional insulation
- Almost an order-of-magnitude lower cost vs. aerogel and VIPs
- Increased mechanical robustness and flexibility vs. aerogel and VIPs



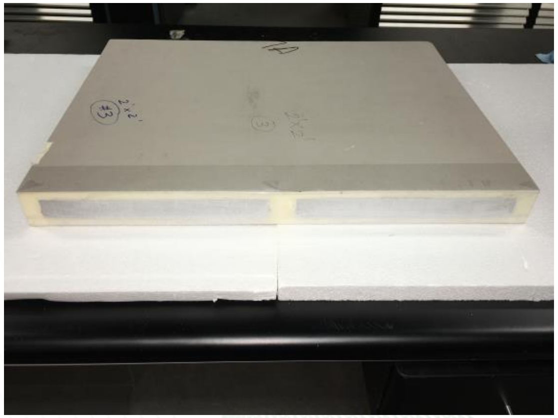
- Particle-particle constriction limits inter-particle phonon transport
- Reduced surface energy and mismatched vibrational spectra further reduce phonon transmission



Modified Atmosphere Insulation Composite Boards

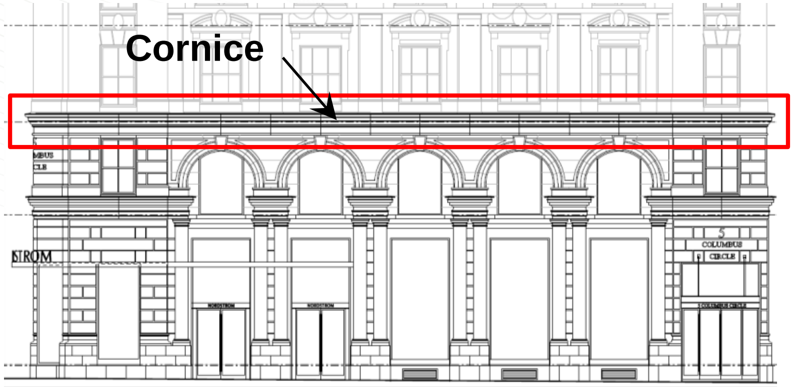
- ORNL/NanoPore/Firestone collaboration: new composite foam-MAI insulation board
- Combination of Modified Atmosphere Insulation (MAI) panels, a low-cost alternative to vacuum insulation, and polyisocyanurate
- Two applications: wall sheathing and commercial roof retrofits
- Second prototype achieved R11.4-R11.9/inch (goal is R-12/inch)
- Energy savings potential of 1,319 TBtu



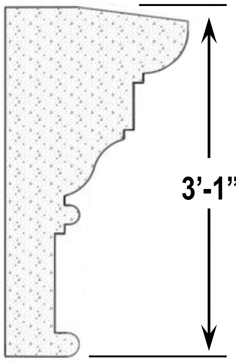


New concretes, composites, and processes for next generation precast envelopes

Building Elevation



Cornice Cross Section



Current Assembly Process

Can We Manage the Heat Differently?

- **The building envelope is not spatially and temporally invariant.**
- **Why do we manage heat that way?**

Thermal Management Using Anisotropy

Reducing Unwanted Heat Flows Through Building Envelopes

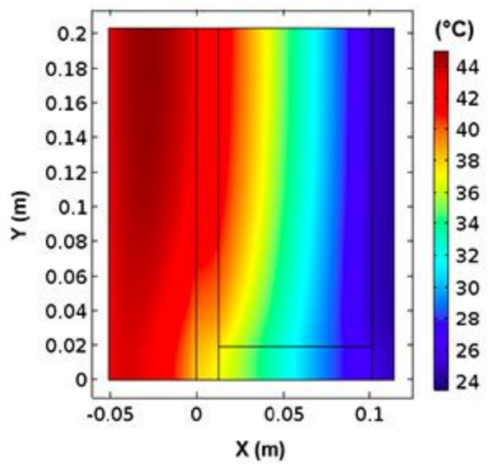
ORNL is investigating directional heat dissipation using anisotropy for reducing unwanted heat flows through the building envelope.

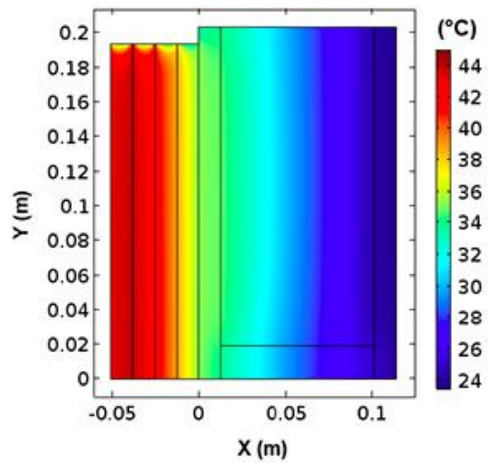
Anisotropic Materials and Composites

Anisotropic composites can be created by alternate layering of isotropic materials, with differing overall thermal conductivities (k) along different axes.

Simulations Show Potential for Reducing Unwanted Heat Gains

Calculations showed annual reductions of 9-69% in internal heat gains through a west-facing wall compared to the isotropic exterior insulation case





Calculated temperature distribution in the wall section with exterior insulation (left) vs. anisotropic composite and heat sink (right)

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Envisioning a truly integrated dynamic system

Can Multifunctional Materials Enable New Integrated Solutions?

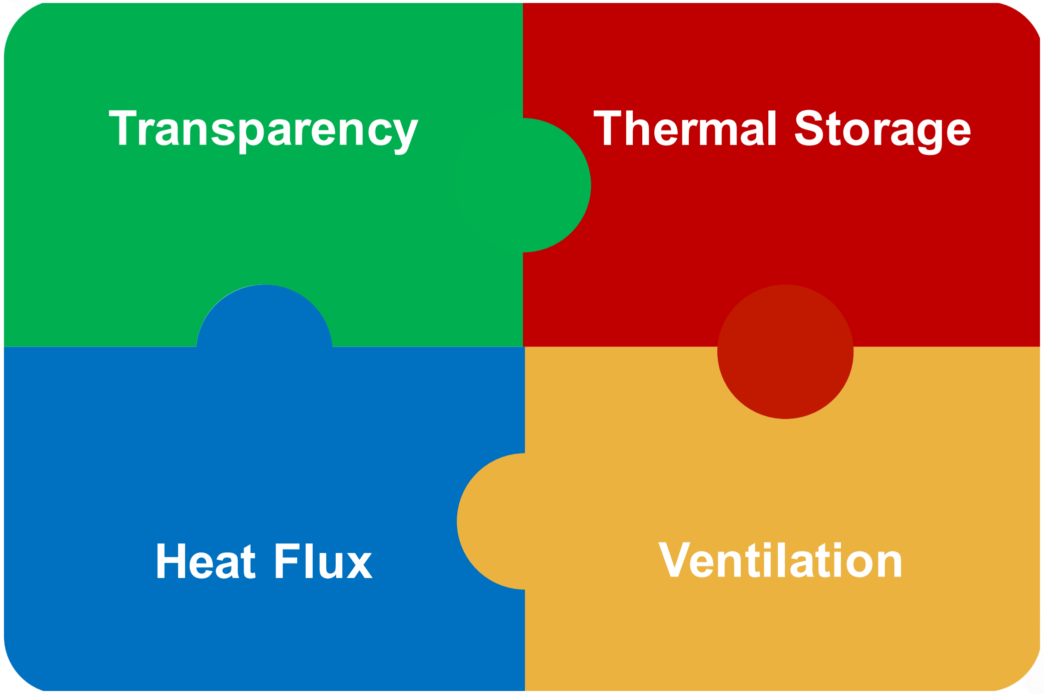


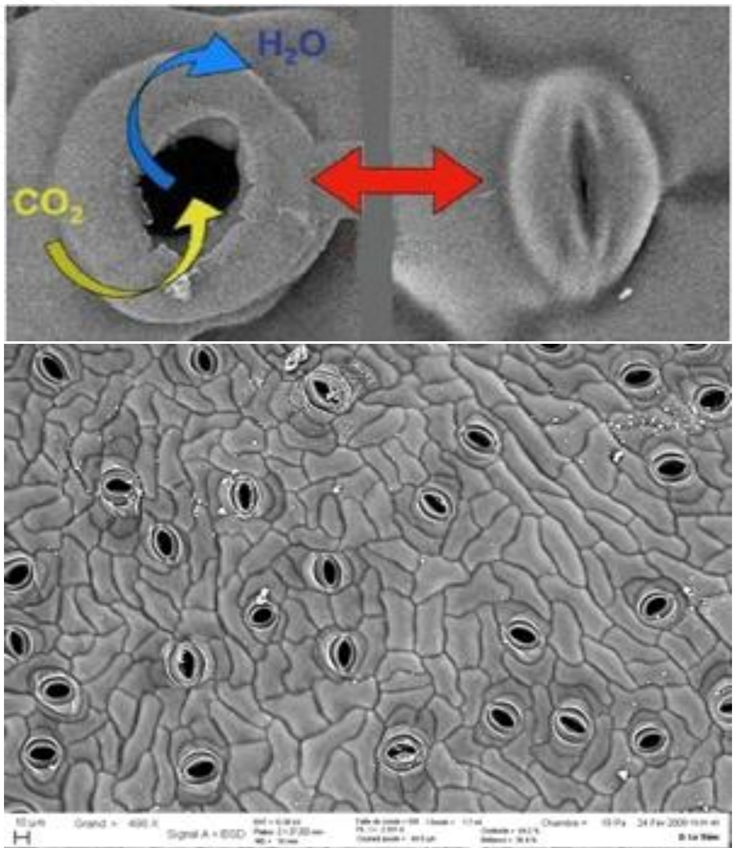
Image source: Fadl Saadi, “Smarter Structures: Synchronizing Building Envelope Technologies”

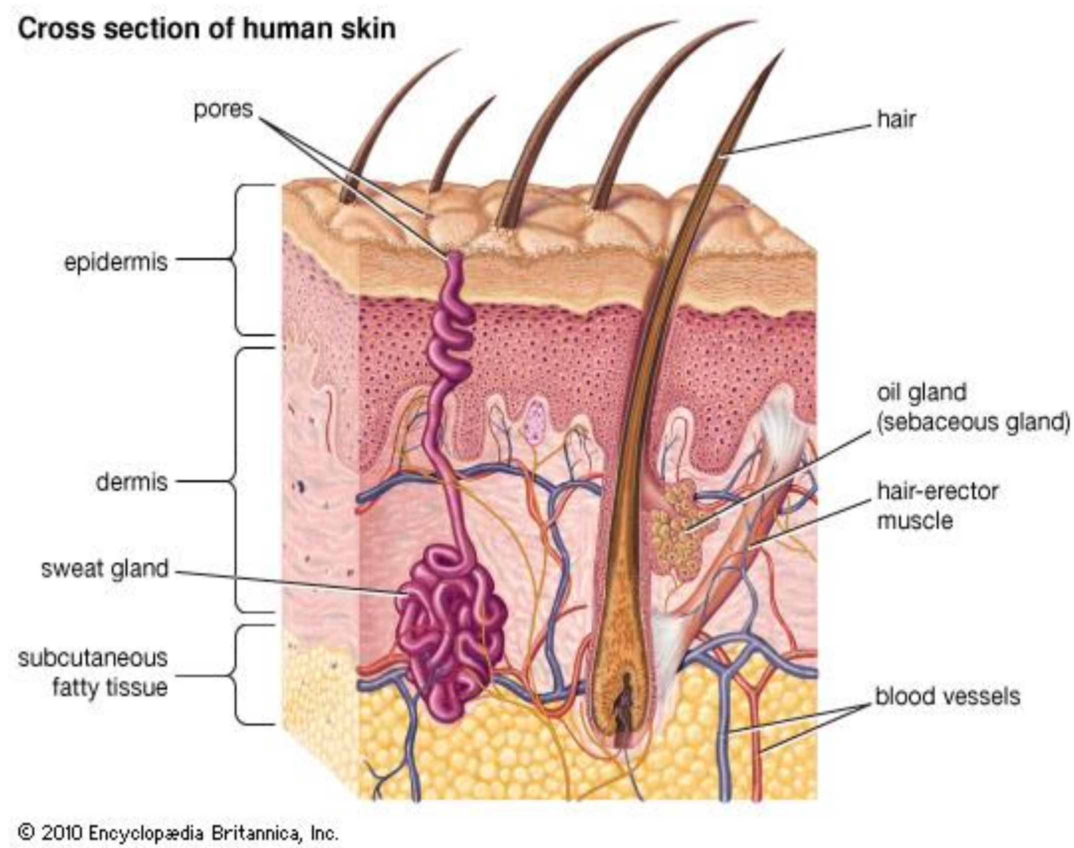
Multifunctional Materials Development

A multifunctional material requires a new design methodology in which **system-level performance is emphasized over the optimization of individual functions.**

Optimizing system-level performance involves optimization **methodologies that are not commonly used in materials science.**

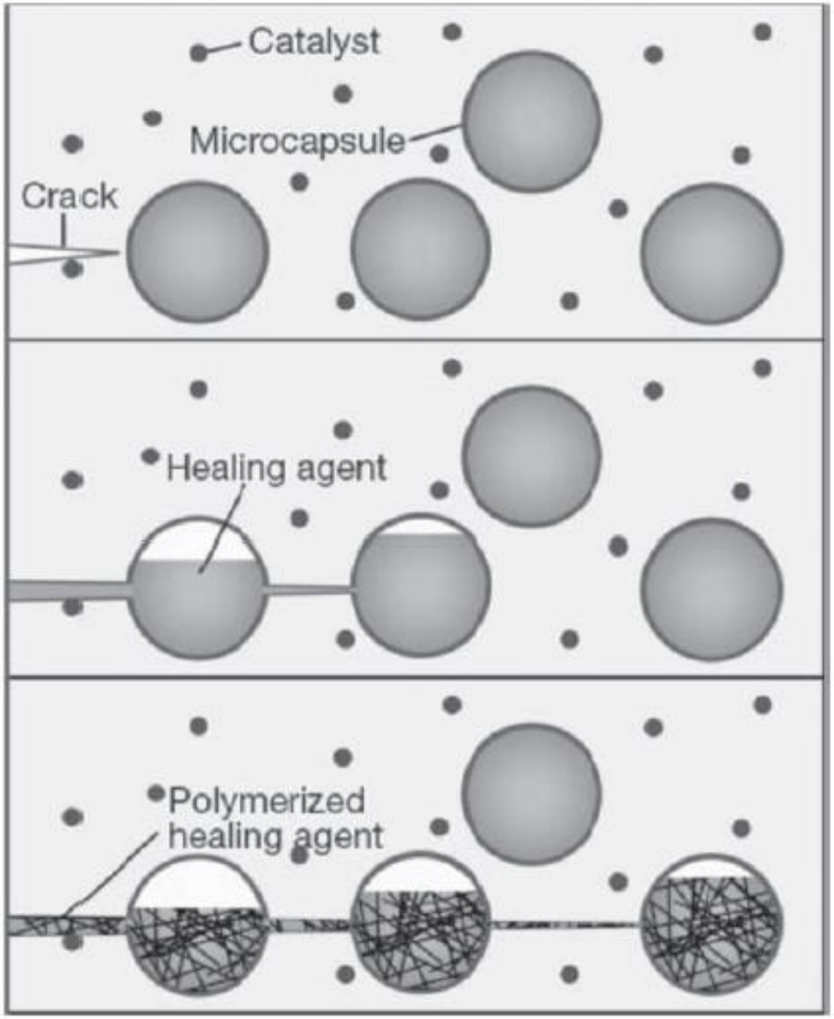
The Original Multifunctional Materials…Evolved…





http://www6.nancy.inra.fr/eef_eng/Pages-Personnelles/Didier-Le-Thiec

Self Healing Materials



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Responsive to damage/failure event.

Anticipated that the original functionality can be restored.

Metals, ceramics, concrete, and polymers.

Thank You

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