Adaptable—Sustainable Housing Solutions for Every Climate

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Adaptable: A High Efficiency Vacuum Insulated Panel Modular Building System

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BACKGROUND / INDUSTRY IMPACT

Remote, predominantly Alaska Native communities—many facing relocation due to climate change—have insufficient, unhealthy, and inefficient housing. Approximately 50% of the materials cost for remote building in the North is transportation. Traditional building practices cannot fill the need, and infrastructure damage from ground subsidence due to permafrost thaw, flooding, and erosion is widespread.

Permafrost subsidence-damaged home in Pt. Lay, AK. Photo from Ben Jones, UAF

Alaska needs a flat pack, kit-of-parts building solution that can be assembled on-site without heavy equipment, specialized labor, or ground preparation. New homes must be expandable and moveable without destruction. A building solution designed to meet the extreme logistical and environmental challenges of remote Alaska would work anywhere.

PROJECT OVERVIEW / OBJECTIVES

- Develop prototypes of a durable composite infill panel-on-structural-frame system that incorporates high-performance and low-volume vacuum-insulated panels (VIPs).
- Evaluate the system's potential as a high-efficiency residential housing solution.

APPROACH & FUTURE WORK

We modified a basic and inexpensive curtain wall glazing/gasket mounting system to attach composite VIP opaque panels to a structural frame and validate a practical design-for-reassembly building system. Panels with finished interior, exterior, and insulation layers mount quickly and easily. The system enables home expansion and repair without destruction, and panels can be upgraded with other technologies (e.g., PVs).

We're now designing Adaptable interoperable interior furnishings and developing a kitted, expandable, integrated foundation/conditioned access floor system.

Research Outcomes

VIPs increase thermal performance and can be replaced without destruction. The limited availability of VIPs currently inhibits widespread use in residential construction, but the Adaptable system would perform well with other, simpler insulation materials.

Our work shows that a design-for-reassembly kit-of-parts building system with standard, over-the-counter materials is feasible. A building system that works in remote Alaska's extreme environments can address the housing insecurity faced by Alaska Native communities and be applicable for other regions. The circular economy in construction is the clearest path to achieving the right to repair.

Prototype Performance

The prototype was evaluated outside of the Cold Climate Housing Research Center's facility in Fairbanks in winter 2022–23. The test hut (12.5' long x 9' wide x 9.5' tall; interior space of 882.5 ft^3 and overall space of 1056.5 ft^3) allows evaluation of representative whole-home performance. Envelope leakage tests found an airtightness of .024 (+/-.003) CFM50 per square foot of enclosure area. Preliminary results show the effective R-value for the whole building envelope of about R-30, and, compensating for the door, non-VIP foam panels, and metal foundation braces shows an effective R-value of the Adaptable wall assembly of R-40 (validating our 3D COMSOL modeling estimate).

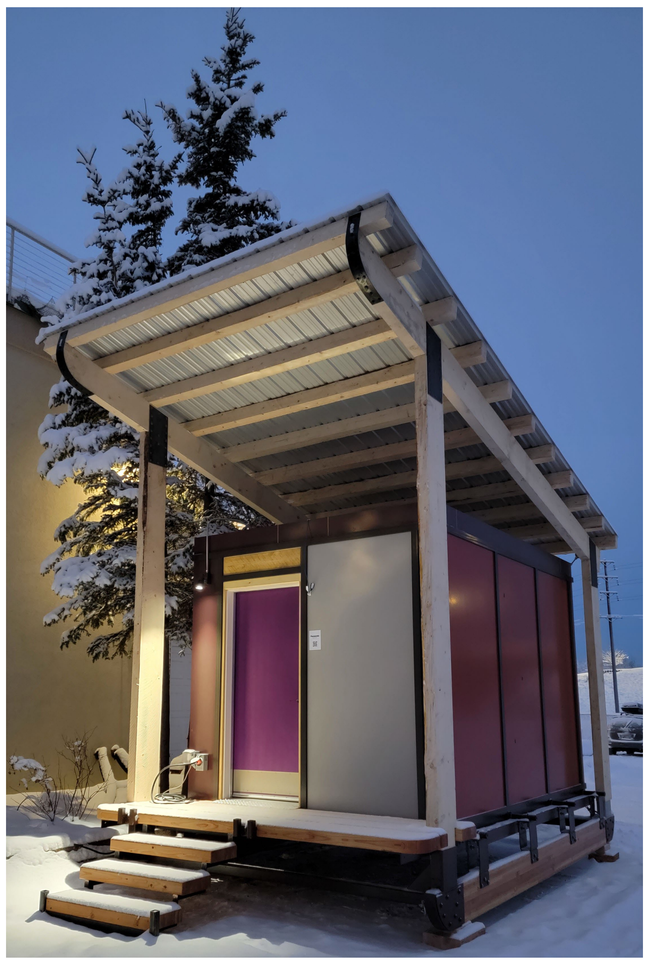

Photo by Ryan Tinsley, NREL

Impact

Adaptable is a housing solution that prioritizes equity, efficiency, and occupant agency by making assembly and repair simple and affordable. It demonstrates a path to the circular economy in construction and a scalable path to equitable decarbonization via efficient and high-quality housing. Decentralized manufacturing can produce standardized components out of a range of materials. It's designed for resilience to climate change: 150 mph wind and 150 lb. snow load in the highest seismic zone while enabling relocation. In forested areas, local logging and mills can produce the main and heaviest components and grow a regional workforce around housing security. Local production would eliminate the carbon-heavy impacts of transporting housing materials to the North. Interoperable prefabricated components allow for a range of home designs, customization, and expandability.

The structural frame is made with standard glulam lumber, each 4' x 8' Adaptable composite panel has four 1-in. thick 2' x 4' fiberglass-core VIPs, and the basic building system provides aesthetics. Photos by Stacey Fritz, NREL

NREL is a national laboratory of the U. S. Department of Energy, Office of Energy Efficiency and Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.

BTO Peer Review
Arlington, VA
April 25-27, 2023
NREL/PO-5600-85552