TNHA Resilient Housing

for the North Slope of Alaska

The arctic is warming at nearly twice the rate of the rest of the planet, causing coastal erosion, permafrost melt, and many ecological changes. Communities in Alaska are feeling the impacts through intensifying storms, unstable tundra, and crumbling infrastructure.

“We’re on the front line of the battle right here,” says Claude Garoutte, project manager with Tagiugmiullu Nunamiullu Housing Authority (TNHA) on Alaska’s North Slope. “We have to adjust and change to deal with global warming and carbon. We’re doing our part with incorporating R-60 walls, LEDs, heat exchangers, solar, and other innovative techniques.”

The North Slope has an extreme arctic climate. The regional hub of Barrow, located on the Arctic Ocean, has 20,000 annual heating degree days (a measure of heating demand based on temperature), twice as many as Anchorage and more than three times that of Chicago. To meet this demand, the average North Slope home uses 30% more energy than the average Alaska house. “I was using about 300 gallons of heating oil a month,” says Barrow resident George Tagarook.

Water pools under a house in Point Lay, as wood pilings conduct heat to the ground during the summer and thaw frozen soil. This process can cause subsidence of up to 5 feet for homes on the North Slope.

The new design has a post-on-pad foundation that isolates the heated building envelope from the frozen ground.

One in five homes in the region is overcrowded (seven times the national average), according to the 2014 Alaska Housing Assessment. The arctic environment and climate change have also exacerbated structural and indoor air quality issues in the housing stock.

TNHA is tackling all these challenges with a sustainable new housing design that can adapt to the changing arctic. The housing authority and the people of the North Slope have been working with the Cold Climate Housing Research Center (CCHRC) for years to design a house that fits the climate, culture, and economy of the region, starting with a prototype house in Anaktuvuk Pass in 2008. “TNHA is a leader in improving housing and its adaptability to climate change,” says Jack Hebert of CCHRC.

The new design is a super-insulated house that slashes fuel use and incorporates innovative features such as an adjustable, portable foundation to respond to unstable ground, solar hot water collection, and integrated heating and ventilation.

One of the most visible impacts of climate change in North Slope communities is subsidence. As ice-rich permafrost thaws, the surface of the ground begins to deform. This can lead to ground shrinking away beneath buildings or even major sinkholes. “Most of the villages are in imminent threat. The permafrost has receded 4-6 feet in about nine

CCHRC
Cold Climate Housing Research Center

years. We often have to put cross-bracing on them because the houses are shaking and leaning now," says Garoutte.

Most homes in the North Slope rest on wood pilings driven into the ground, which accelerate permafrost thaw by conducting heat into the frozen ground. As the permafrost thaws, the ground around it settles. "It's Mother Nature, you can't always fight against it," Tagarook says. He has an old house in Kaktovik that needs to be re-leveled. "It's cracking up and tipping sideways."

The prototype has a post-on-pad foundation that rests atop the ground, isolating the house from the soil and preventing heat from affecting the permafrost. With the threat of permafrost melt and growing storm surges, the house was designed to be easily relocated if needed. The foundation has sliding steel posts attached to the pads that can be adjusted up to 8 feet in height as the tundra moves and beams can that act as skids to be towed to a new location. "It's pretty neat. You can either adjust the house to whatever height you want or tow the house back to a level spot," Tagarook says.

Indoor air quality is also a challenge in the severe cold, as humid indoor air tries to escape through the building envelope and condenses on cold surfaces inside the wall, leading to mold and rot. In fact, 35% of homes on the North Slope are airtight and lack adequate ventilation. "There are 9-year-old houses in Point Lay that are structurally unsound because of the subsidence of the foundations and lack of ventilation. We've spent up to $73,000 on a renovation because they turned off the HRV and the house is moldy. Electricity is expensive and homeowners often can't see the need for the HRV until it is almost too late," Garoutte says.

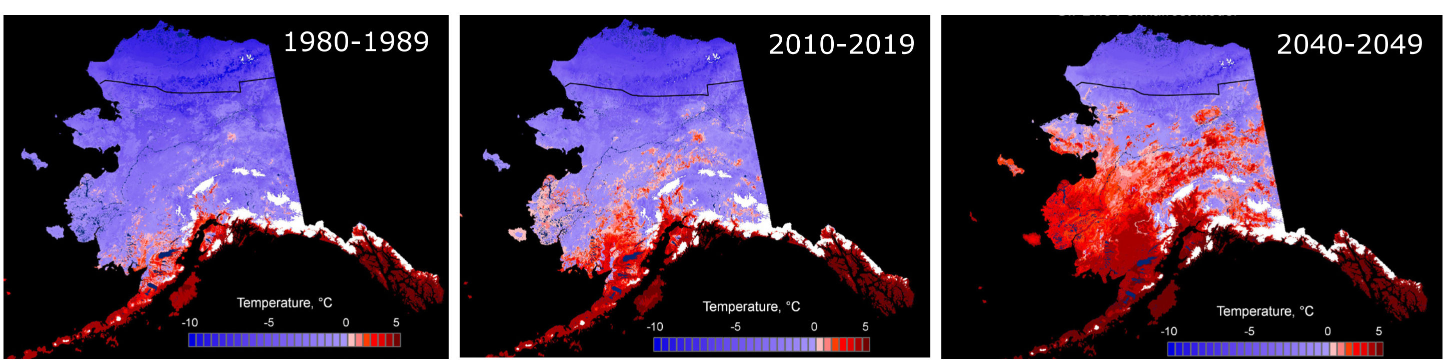
Loss of shore-fast sea ice and thawing of frozen ground along coastlines results in greater erosion, especially during severe storms. Erosion rates can exceed 50 feet per year and may eventually force some coastal communities to relocate.

Climate Change in Alaska

Both air and ground temperatures in the North Slope are projected to continue warming over the next century. The maps below show historical and predicted changes for permafrost at 1 meter depth, with light pink indicating the temperature at which ground thaws. While Southwest Alaska faces the most dramatic changes, the temperature in the North Slope (within the black boundary) also approaches the melting point. While much of the ground is expected to remain below freezing, the active layer–the top layer of soil that melts in the summer and freezes in the winter–is projected to penetrate deeper. A UAF report estimates the active layer will get 30-40% deeper by the end of this century in the Nationa Petroleum Reserve-Alaska, a northcentral portion of the North Slope[1].

Warming permafrost and a growing active layer present challenges for ecosystems as well as building roads, houses, and infrastructure.

1 Source: *NPR-A Climate Change Analysis. An Assessment of Climate Change Variables in the National Petroleum Reserve in Alaska.* Scenarios Network for Alaska & Arctic Planning (SNAP) University of Alaska Fairbanks.

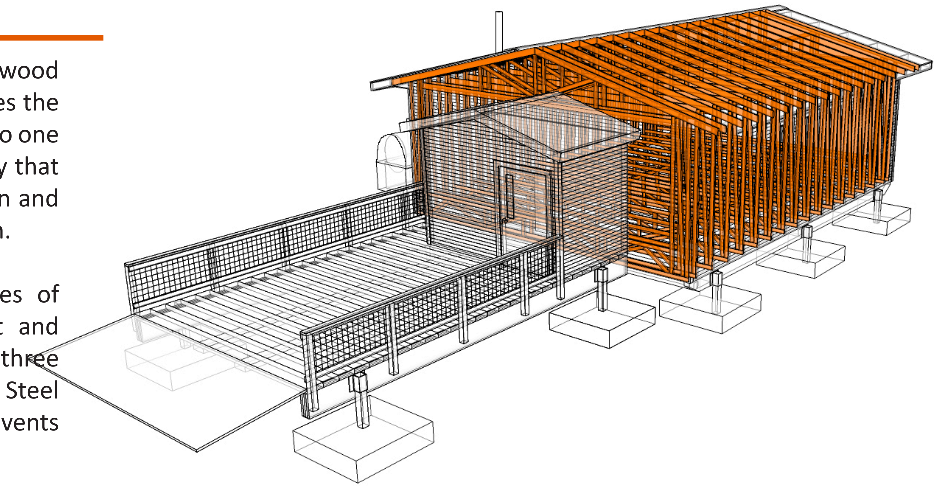


Mean Annual Soil Temperatures at 1 meter depth. These maps use data from the University of Alaska Fairbanks Scenarios Network for Alaska & Arctic Planning and the UAF Geophysical Institute Permafrost Lab to show past and future projected changes to permafrost in Alaska.

Integrated Truss

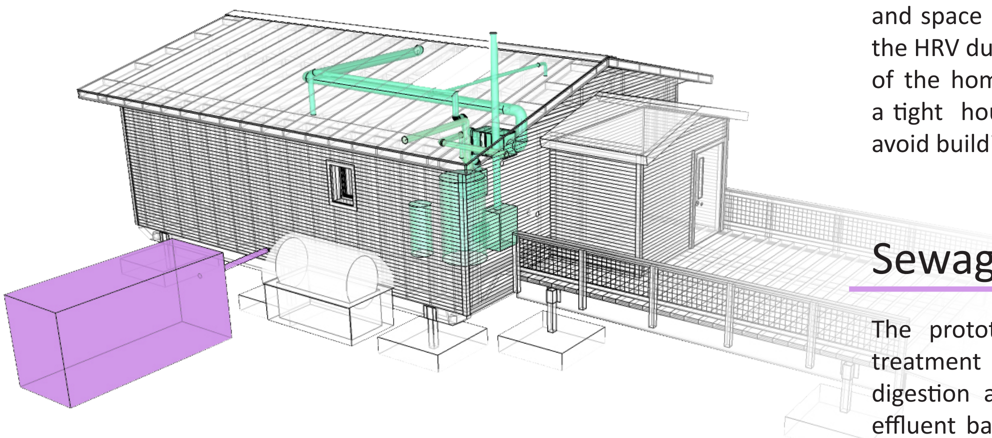
The house is framed with an integrated wood truss, a single prefabricated unit that combines the exterior walls, floor joists, and roof framing into one structural assembly. This creates a thick cavity that allows ample space for high R-value insulation and speeds up the process of framing construction.

The entire envelope is filled with 10 inches of polyurethane spray foam, which is airtight and moisture resistant, for an R-60 envelope (three times higher than a conventional 2x6 wall). Steel siding provides shear strength and prevents moisture from infiltrating the building.



Integrated Heating & Ventilation

A Toyotomi boiler provides both domestic hot water and space heating to the home. The heater is tied into the HRV ducting to distribute fresh, warm air to all areas of the home. Mechanical ventilation is critical in such a tight house to ensure healthy indoor air quality and avoid building problems caused by excess humidity.



Sewage Treatment Plant

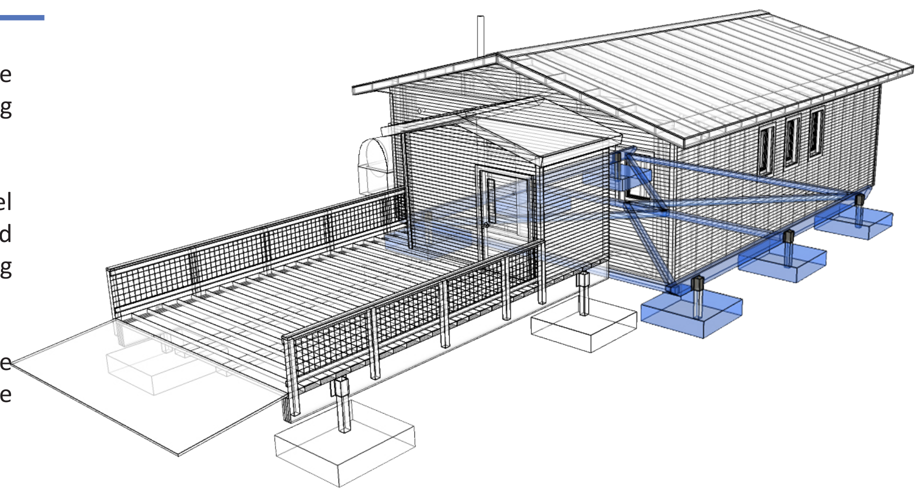
The prototype homes use a self-contained sewage treatment plant that sterilizes waste through aerobic digestion and ultraviolet light before discharging the effluent back to the ground. The $30,000 systems use minimal electricity and do not disrupt the ground.

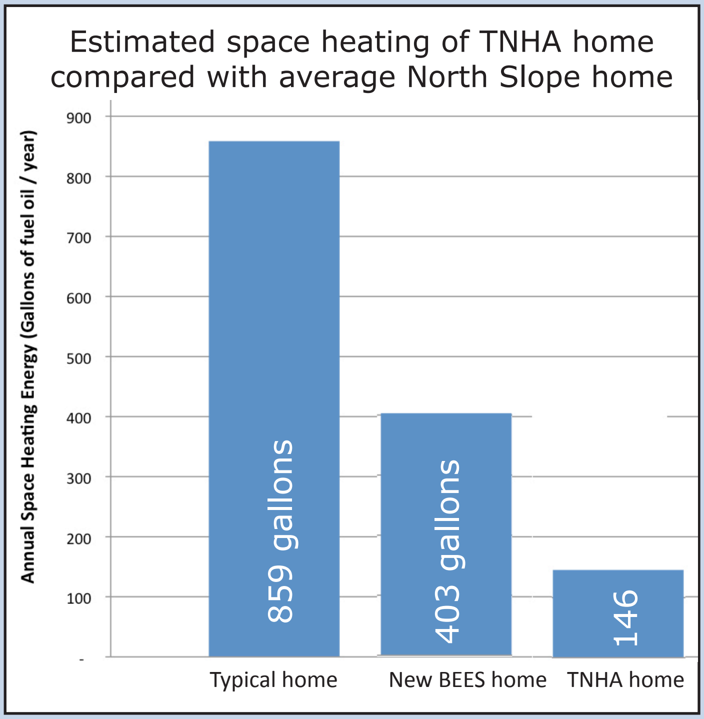
Skiddable Foundation

The post-on-pad foundation isolates the house from the ground and prevents heat from leaking into the soil and affecting permafrost.

The foundation is adjustable, with sliding steel posts attached to the pads that can move up and down, so it can respond to seasonal or lasting permafrost thaw.

The beams are designed as skids. If the house needs to be moved, it can be lowered to the ground and towed to a new location.





The TNHA home is modeled to use less than 150 gallons of heating oil a year for space heating, less than half as much as a new energy efficient home in the village of Point Lay and 80% less than the average home in the region.

In the new design, fresh ventilation air is injected into the distribution system whenever the heat is turned on to ensure the house receives adequate ventilation.

The homes also use solar energy for water heating, with three solar thermal collectors tied to an 80-gallon water tank. The collectors heat the water to a certain temperature (based on how sunny it is), and the boiler boosts it to the final temperature needed for showering and other uses. While solar can be a challenge at northern latitudes because of the extreme angle of the sun, the systems are performing well even on overcast days, according to TNHA Executive Director Daryl Kooley.

City sewage treatment systems in the North Slope often consist of water lines running through above-ground insulated pipes to open sewage lagoons. Not only are these systems prone to catastrophic failure, but it can cost more than $400,000 to hook up a single house to water and sewer because of the difficult ground conditions. The prototype homes use a self-contained sewage treatment plant that sterilizes waste, a more affordable and environmentally friendly option in this environment.

TNHA is building a total of 24 prototypes in three villages this year. "We're hoping to alleviate the overcrowding and get the funding to build 100 houses," Kooley says.

For more information on TNHA's sustainable housing design, contact Claude Garoutte at 907-852-7169

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