



Construction in Arctic Climates

Robbin Garber-Slaght, PE



COLD CLIMATE HOUSING RESEARCH CENTER

CCHRC

Arctic Challenges

Arctic Communities are very remote:

- There are summer barges but most of the year the area is fly in only
- Shipping can be up to 50% of the cost of materials



Arctic Challenges

Permafrost

- Soils that have been below 0°C for at least 2 years
- Provides a solid foundation, unless it thaws
- Warming temperatures are speeding up thaw
- Surface changes exacerbate thaw



Arctic Challenges

Aging infrastructure

- The Alaska oil pipeline is 20 years beyond its service life
- Much of the infrastructure in Alaska was built around the same time as the pipeline



Arctic Challenges

Extreme Cold Climate

- The ASHRAE design temperature is -40°C and colder
- Utqiagvik, Alaska (Barrow) has $10,930^{\circ}\text{C}$ ($19,674^{\circ}\text{F}$) heating degree days



Alaska: a Case Study

Remote Logistics

Fly in supplies

Lack of onsite heavy machinery

No temporary housing

Fairbanks

Basic Package Weight: 20 pounds Dimensions: 10" x 8" x 5"

Shipper	Delivery Time	Price	Price/lb.
ShipToAlaska	Air Freight	\$44.50	
FedEx	2nd Day Air: 2-3 days	\$101.40	\$5.07
FedEx	Ground: 4-7 days	\$56.87	\$2.84
DHL	2nd Day Air: 2-3 days	\$71.10	\$3.56
UPS	2nd Day Air: 2-3 days	\$72.27	\$3.61
UPS	Ground: 4-7 days	\$54.61	\$2.73



Photos by CCHRC

Building on Permafrost

If it's frozen, keep it frozen



UNITED FACILITIES CENTER (UFC)

FOUNDATIONS FOR STRUCTURES:
ARCTIC AND SUBARCTIC
CONSTRUCTION



UFC 3-130-04



Photos by K. Bjella, CRREL

Living with Thawing Permafrost

Infrastructure on permafrost needs constant maintenance

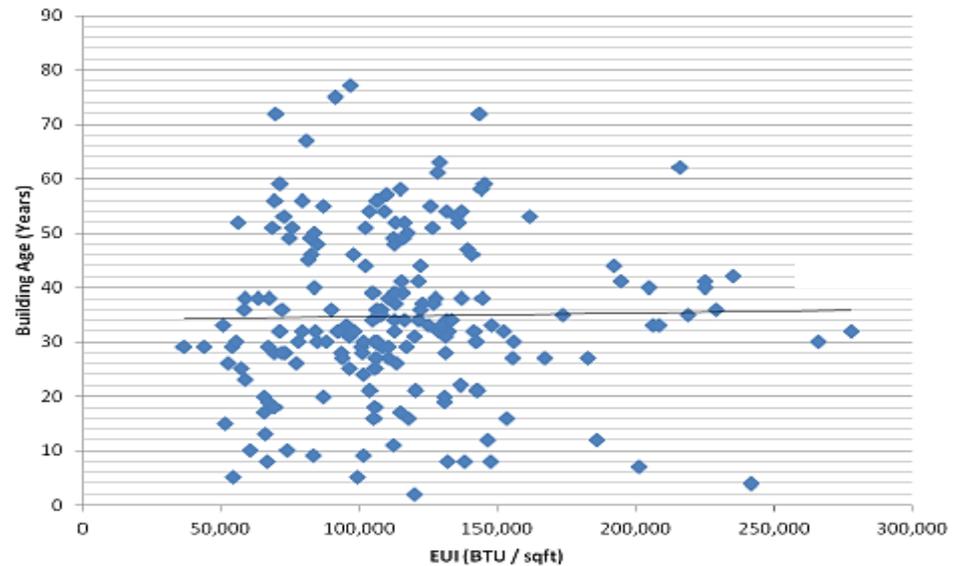


Aging Infrastructure

Alaska's bridges are on average 35 years old

51% of homes in Alaska were built in the 1970s and 80s

Fairbanks, Alaska has one of the oldest and the newest operating coal fired power plants in the nation

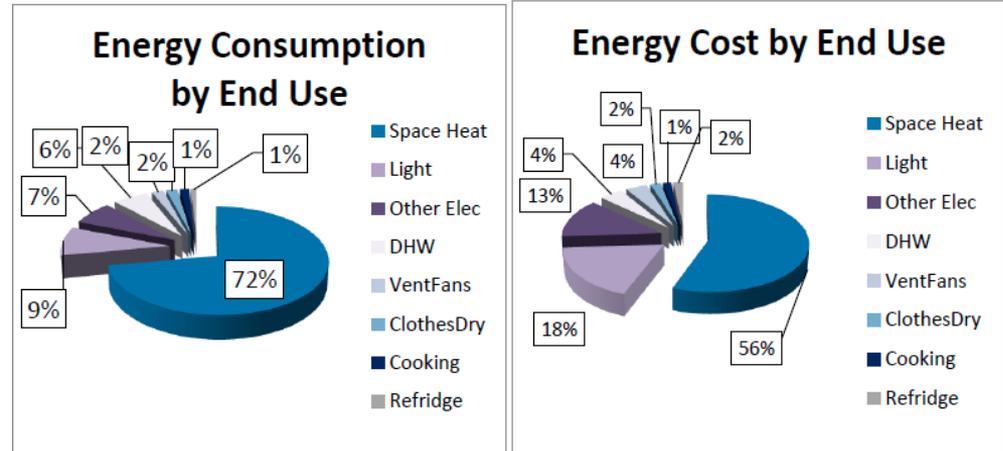


Living in Extreme Cold

Space heating is the single greatest energy cost for buildings in Alaska

Alaska's EUI is close to double the EUI for the rest of the US

Source: Alaska Housing Finance Corporation, 2014
https://www.alaska.edu/files/facilities/public_facilities_whitepaper_102212.pdf



Building Type	Energy use intensity (thousand Btu/square foot in buildings)	
	US	Alaska
Education	68.8	106.2
Health care	172.7	217.3
Office	77.8	124.8
Public assembly	86.3	144.3
Public order and safety	92.2	160.0
Warehouse and storage	34.1	130.5

Building Envelopes for Extreme Cold

Thick thermal envelope

Minimal air leakage

Pay attention to building science

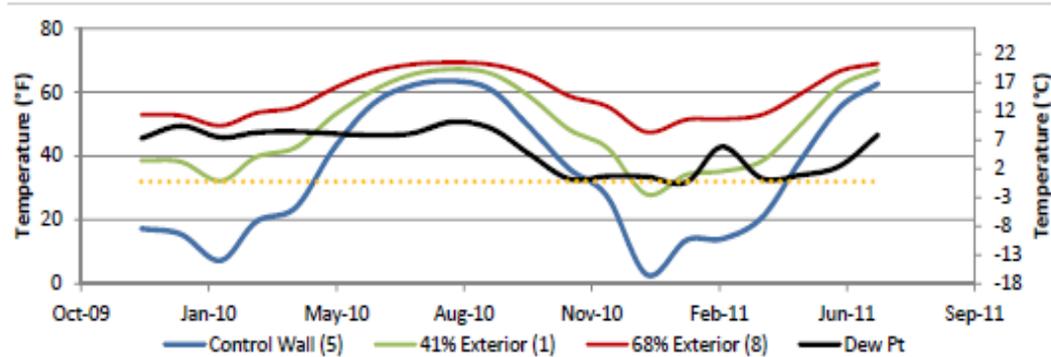
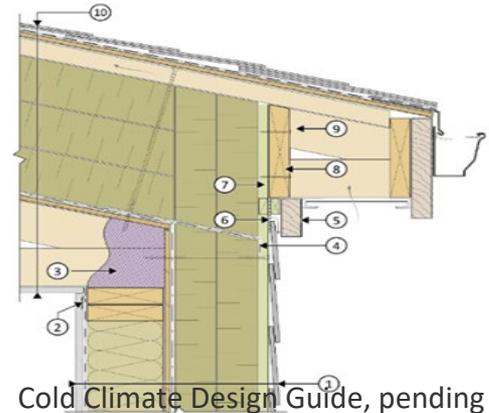


Photo by E. Leffel, Alaska Thermal Imaging



Cold Climate Design Guide, pending





Thank you for listening



www.nrel.gov

robbin.garberslaght@nrel.gov



COLD CLIMATE HOUSING RESEARCH CENTER

CCHRC

This work was authored in part by the National Renewable Energy Laboratory, operated by Alliance for Sustainable Energy, LLC, for the U.S. Department of Energy (DOE) under Contract No. DE-AC36-08GO28308. Funding provided from US Army Program 633734T1500, Military Engineering Technology Demonstration. The views expressed in the article do not necessarily represent the views of the DOE or the U.S. Government. The U.S. Government retains and the publisher, by accepting the article for publication, acknowledges that the U.S. Government retains a nonexclusive, paid-up, irrevocable, worldwide license to publish or reproduce the published form of this work, or allow others to do so, for U.S. Government purposes.

