“Promoting and advancing the development of healthy, durable, and sustainable shelter for Alaskans and other Circumpolar people.”
YOUR FRIENDLY NEIGHBORHOOD CUTTING-EDGE BUILDING SCIENCE RESEARCH CENTER
WHAT DOES SUSTAINABLE SHELTER LOOK LIKE?
UNSUSTAINABLE SHELTER
UNSUSTAINABLE SHELTER
SOME THINGS WE ARE DISCOVERING,
SOME THINGS WE ARE REMEMBERING

AS WE MOVE EVER FORWARD
DESIGNING FOR DIVERSITY

PROTOTYPES

FOUNDATION

WALL TYPES

BUILDING FORM
The most successful Arctic animals don't have to eat more fuel to keep warm in the winter. Instead, they put their energy into high-quality fur and fat to maintain their body temperature.

RETAINING heat, not PRODUCING heat, is the most important part of an animal's survival.

SO WHY DO WE MAKE HOUSES WITH THIN SKIN AND THINK THAT FEEDING THEM MORE HEATING OIL WILL MAKE THEM WARM ENOUGH IN THE ARCTIC?

ENVELOPE DESIGN
INTELLIGENT SUPPLY, REDUCED DEMAND

**367 gallons**

**ANNUAL HEATING**

**Energy Breakdown**

<table>
<thead>
<tr>
<th></th>
<th>million BTUs</th>
<th>gallons of Fuel Oil #1 equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>48.5</td>
<td>367</td>
</tr>
<tr>
<td>Space</td>
<td>44.8</td>
<td>339</td>
</tr>
<tr>
<td>domestic hot water</td>
<td>3.7</td>
<td>28</td>
</tr>
</tbody>
</table>

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>electric</td>
<td>9,392 kWh</td>
<td>(699/month)</td>
</tr>
<tr>
<td>water</td>
<td>19,700 gallons</td>
<td>(1,642/month)</td>
</tr>
</tbody>
</table>

**Space Heating** 17k BTU Diesel heater in-line with HRV (primary) | forced air distribution | pellet stove (secondary)

**Domestic Hot Water** Electric

**Ventilation** HRV (Heat Recovery Ventilator)

**Walls** REMOTE R-51

**Foundation** Polyurethane Foam Raft R-60

**NW: Birch House**

[Image of Birch House diagram]
INTELLIGENT SUPPLY, REDUCED DEMAND

**SE: Willow House**

### 366 gallons*

**ANNUAL HEATING**

Energy Breakdown

<table>
<thead>
<tr>
<th></th>
<th>million BTUs</th>
<th>gallons of Fuel Oil#1 equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Space &amp;DHW</td>
<td>48.3</td>
<td>366</td>
</tr>
<tr>
<td>Solar offset</td>
<td>5.5</td>
<td>42</td>
</tr>
<tr>
<td>Propane Boiler</td>
<td>42.8</td>
<td>324</td>
</tr>
<tr>
<td>electric</td>
<td>4,272 kWh</td>
<td>(356/month)</td>
</tr>
<tr>
<td>water</td>
<td>15,400 gallons</td>
<td>(1,283/month)</td>
</tr>
</tbody>
</table>

¹ Amount contributed by solar

**Combined Space Heating & Domestic Hot Water** 3 solar thermal collectors | propane boiler | radiant floor distribution

**Ventilation**  HRV

**Walls**  REMOTE R-51

**Foundation**  driven steel pilings | R-60 polyurethane floor insulation
Because heating and ventilation behavior. The west houses, for example, experienced issues with overheating. Therefore the difference in energy use can be attributed to other factors, such as heating system efficiency.

Each house had roughly the same heating load. Comparison between Village homes owned the land.

Construction costs were competitive with energy as the average new energy efficient home of the same square foot for heating and domestic hot water (or about 1,600-square-foot house), predicted to use approximately 250 gallons of fuel oil for a year, and the Southwest home used almost twice that. This points out the need for an improved second year to optimize the efficiency of both heating and ventilation.

Electric load was reduced by the design, lighting, and appliances of the home. For example, large second-story windows on each house maximize passive daylighting and LED lights and Energy Star appliances also save energy. Given that college students tend to work long hours and use lots of electronics, electric use in Alaska of 7,788 kilowatt-hours (kWh). The first-year data both answers and poses additional research questions. For example, the homes were buildout will test new innovations in building science Sustainable Village, designing a community center, and twiced that. This points out the need for an improved energy efficiency standards set by home energy efficiency standards set by the number and length of showers, amount of appliance use.

The system, extra heat work long hours and use lots of electronics, electric use in Alaska of 7,788 kilowatt-hours (kWh). The first-year data both answers and poses additional research questions. For example, the homes were buildout will test new innovations in building science Sustainable Village, designing a community center, and twiced that. This points out the need for an improved energy efficiency standards set by home energy efficiency standards set by the number and length of showers, amount of appliance use.

The average house in Fairbanks uses 76,400 BTU/gallon heating oil of fuel oil for a 920 gallons of fuel oil for a number of fuel oil for a 920 gallons of fuel oil for a
Survey of Indoor Air Quality
University of Alaska Fairbanks Sustainable Village

by Martin Kotol
Visiting PhD student from the Danish Technical University

Ventilation:
The ventilation unit is a Zehnder ComfoAir 350 EXP Luxe. The unit has a counterflow heat exchanger and is the only unit in the Sustainable Village that does not have a recirculation mode, which means it provides constant air exchange with outside air. The occupants can choose from four fan speeds ("Absent", 1, 2, and 3) or automatic regime. There is also a booster switch in the bathroom. The ventilation layout is shown in Figure 6.

As a protection against freezing, the unit is equipped with an 800 Watt (W) electrical preheater for the cold air, which activates when the outside temperature drops below 15°F (‐9.5°C). In the event that the preheater cannot sufficiently protect the core against freezing, the controller can start reducing the supply air flow while maintaining the exhaust air flow, which will help to reduce the risk of freezing.
In the Southwest house, an experimental cooling system was used to lower the temperature underneath the homes. A small in-line fan was installed in an empty pipe running through the raft foundation, which circulated cold winter air through the foam. The fan was turned on on February 9, 2013 to test its effect on ground temperature. It was turned off at the end of March when daily temperatures began to rise above freezing. No effect on ground temperature was recorded.

The foundation fan will be used again during the winter of 2013–2014. Researchers will see whether the cooling system can achieve cooler ground temperatures over a longer period of time.
THE SUSTAINABLE VILLAGE AT UAF
PHASED DEVELOPMENT PLAN

DEEP GREEN COTTAGES
LOWEST DENSITY

DUPLEX HOUSING
MID-LEVEL DENSITY

MULTI-UNIT HOUSING
HIGHEST DENSITY

4 BEDROOM HOMES

ACCESS CORRIDOR
WATER LINE
ELECTRIC SERVICE
PARKING
EXISTING TRAILS
PROPOSED TRAILS
AND BOADRWALKS

CIRCULATION/
SERVICE RUN

PEDESTRIAN PATHS TO CAMPUS

COMMUNITY CENTER

2012
COMPLETED
PROTOTYPES

2013/14
COMMUNITY
CENTER

2014-2030
CLUSTERED
HOUSING

FAIRBANKS STREET

GEIST ROAD

HARPER BUILDING

PLAZA

GARDEN

PARKING

4 BEDROOM HOMES

See full document here.
HUMAN BEHAVIOR

We forget the human element at our peril

The University of Alaska Fairbanks Sustainable Village is a living laboratory for students and researchers to learn about energy efficient design and construction and other facets of sustainable living in the north. The project is a partnership between the Cold Climate Housing Research Center (CCHRC) and UAF to develop new building and energy technologies and include students in the creation of sustainable housing. It started with four homes in 2012 and will grow with more homes and community spaces in coming years.

Students worked with CCHRC to design the four, 1,600-square-foot homes, each with a large south-facing second-floor deck, shed-style roof, and big solar windows. Each has a super-insulated building envelope (R-50–60) with a unique combination of wall assembly, foundation, and heating and ventilation systems. The goal was to test how different strategies could improve the energy efficiency and lower the cost of conventional construction.

Three homes use the REMOTE wall developed by CCHRC with 5.5 inches of batt insulation in the wall cavity and 8 inches of rigid foam outside the sheathing. The southwest home has 5.5 inches of batt insulation on the inside wall and a 12-inch standoff wall filled with densely packed cellulose insulation. The ventilated roofs contain 20 inches of cellulose and a continuous 2-inch air gap underneath the roof deck to keep the roof cold and dry.

The Village is built on permafrost, a common phenomenon throughout Alaska. There are two types of foundations designed for permafrost–a standard piling foundation that elevates the home off the ground and an innovative foam raft foundation that rests directly on the ground. CCHRC is studying how the raft foundation affects soil temperature, as an economical alternative to pilings.

Several types of heating systems were incorporated–solar hydronic, biomass, and conventional sources like propane and diesel. Two homes use the BrHEAThe System, an integrated heating and ventilation system with a small diesel heater that injects heat into the HRV (heat recovery ventilator) supply air. CCHRC developed the BrHEAThe System to ensure healthy indoor air quality in tight, energy efficient homes by tying together heating with fresh air supply. Local and recycled materials were incorporated, with steel pipe for pilings recycled from the North Slope, steel siding reclaimed from historic gold mines in Fairbanks, and wood from site clearing chipped up to build walkways. Minimal site disturbance was emphasized during and after construction to preserve the natural environment.

CCHRC worked with students to monitor the homes' performance for the first year of occupancy–including fuel use, water use, electricity use, indoor air quality, and ground temperature. This report presents and discusses the data collected at the four homes from September 2012 to September 2013.

FIRST YEAR PERFORMANCE

Northeast house at the UAF Sustainable Village.

Sustainable Village residents for the Fall 2013 semester. Students must show an interest in living a sustainable, low-impact lifestyle to live in the homes.
temperature with a significant drop in sleep quality at temperatures above 75.2°F (24°C) (Humphreys, 1979).

The average temperature in all bedrooms was within the 64.4–77.9°F (18–25.5°C) range suggested by the Harbin study (Wang et al., 2003) to satisfy 80% of occupants. However, according to interviews with the occupants, the large temperature swings leading to occasional overheating in Spruce house have caused some discomfort (more details can be found in the section on the Spruce House HRV).

In order to compensate for the high temperatures, the occupants started closing the air terminals and even opening windows as shown on Figure 12.

Figure 12. Frost formation above the window was created by the vapor escaping from the open window in the Spruce house.

Analysis of the night-time temperatures (10 p.m. – 8 a.m.) showed that the Spruce house bedrooms exceeded 75.2°F (24°C) for significant periods of time (see Figure 13).
THE INTEGRATED TRUSS
ATMAUTLUAK PROTOTYPE
FRAMED IN A SINGLE DAY
TRUSS A PROFILE
NOT TO SCALE
DESIGNED BY OTHERS

TRUSS B PROFILE
NOT TO SCALE
DESIGNED BY OTHERS

ARCTIC ENTRIES THAT WORK
KEEPING THE GROUND FROM MOVING
SUSTAINABLE DESIGN IS NOT ALL BUILDING SCIENCE
We’ve structured our grid so that for the next two generations, our children will be forced to locate their homes based entirely on where they can defecate. I think as humans, we are capable of more than that.

-Pond Inlet Resident
SUSTAINABLE SANITATION
UNDERSTANDING EQUIPMENT, UNDERSTANDING PLACE
UNDERSTANDING CULTURE, UNDERSTANDING THE USE OF SPACE
UNDERSTANDING DISTRIBUTION CAPACITY
UNDERSTANDING WIND
BUCKLAND PROTOTYPE
BUCKLAND PROTOTYPE
One Fire, Two Uses

BUCKLAND PROTOTYPE

MECHANICAL SYSTEM DIAGRAM

June 2013

Closed Glycol Loops

Supply

Return

Supply

Return

SINK
FAUCET
SHOWER
WASHER

CIRCULATING PUMP
DISASTER RESPONSE: GALENA
WALL TYPES

Integrated Truss
**INSULATION:** SPRAY FOAM or CELLULOSE
**Description:** Prefabricated whole-house truss
**Assembly:** Basic wood frame construction
**Materials:** Prefabricated super-structure, standard materials otherwise
**Logistics:** Transportable by road or barge—Air transport may be possible depending on design.
**Construction:** Year round possible (potentially limited by use of spray foam)

**Cost Factors**
**Increased costs:** Long shipping distances | logistic size
**Decreased costs:** Road system builds | multiple units (economy of scale)

**Benefits of design:** Rapid construction time, less labor required

REMOTE Wall
**INSULATION:** Rigid Foam
**Description:** Residential Exterior Membrane Outside Insulation Technique
**Assembly:** Traditional framing and flashing techniques; Pressure equalized rain screen
**Materials:** Standard
**Logistics:** Standard Wood/Steel framing travels well | transport of bulky rigid foam can prove costly over long distances
**Construction:** Year round possible

**Cost Factors**
**Increased costs:** Fly in only site (as rigid foam is bulky)
**Decreased costs:** Road system builds | Decreased O&M costs for occupants

**Benefits of design:** Very tight and well-insulated thermal envelope

Quinhagak Wall
**INSULATION:** SPRAY FOAM or CELLULOSE
**Description:** Polyurethane Air/Water tight Design
**Assembly:** Complex framing, good water management in wet climates
**Materials:** Galvanized steel structure
**Logistics:** Light and compact materials package = many shipping options
**Construction:** Sensitive to seasons

**Cost Factors**
**Increased costs:** Specialized construction equip needed
**Decreased costs:** Multiple units (economy of scale), components are weight optimized for easy air cargo shipping

**Benefits of design:** Very tight and well-insulated thermal envelope

Standard Framed Wall
**INSULATION:** Fiberglass or Fiberglass batts or Blown-in Cellulose
**Assembly:** Traditional framing and flashing techniques
**Materials:** Wood or steel may be used

**Cost Factors**
**Increased costs:** Extremely remote locations | high energy costs
**Decreased costs:** Well established techniques shorten labor learning curve

**Benefits of design:** Quick assembly with standard labor crews

Runway length is a primary factor in determining payload capacity

HERCULES: Payload: ~48,000 lbs
Minimum runway length: 3,000 ft

DC-6: Payload: ~28,000 lbs
Minimum runway length: 3,500 ft

CASA 212: Payload: ~5,000 lbs
Minimum runway length: 1,000 ft

Not ideal for construction in winter

May be EXPENSIVE TO HEAT in rural areas with high energy costs without additional insulation and/or alternative heating source
DISASTER RESPONSE
DISASTER RESPONSE
THANK YOU, AND COME VISIT

Aaron Cooke aaron@cchrc.org

www.cchrc.org (907) 457-3454