RESEARCH REPORT

Super-Insulated Housing in Yukon

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Documentation of Super-Insulated Housing in Yukon

INTRODUCTION

Since 2007 Yukon Housing Corporation (YHC) has built 224 super-insulated public housing units, with another 300 market units built across the Territory by the private sector. However there has been little to no follow-up on the performance of these houses.

Anecdotal information suggested that these houses were neither difficult nor expensive to build, but have far superior energy efficiency and comfort compared to standard construction. This study was undertaken to document the design and construction of super-insulated (SuperGreen[1]) housing within the Yukon and provide information on their performance, return on investment (where possible), and lessons learned by builder participants.

METHODOLOGY

Builder and Project Identification

Canada Mortgage and Housing Corporation (CMHC) provided funding to the Yukon Government's Energy Solutions Centre (ESC) (YG's Energy Branch) to compile a list of home builders that have constructed super-insulated houses that qualify as SuperGreen or meet a minimum EnerGuide rating of 85. Yukon Housing Corporation was consulted to help identify qualified home builders within the Territory while ESC consulted with territorial and regional home builder associations, water, fuel and electricity utilities, and local housing authorities to identify any other appropriate home builders.

Information Gathering and Phone Survey

Based on the suggested list of builders and projects, ESC contacted the identified home builders to solicit participants for this project and schedule interviews. Participants also provided written permission for ESC to collect technical information on home construction including data on energy performance, construction approaches, sustainable practices and technologies used, project size (number of storeys, heated floor area), tenure (owned and rental), geographical location and likelihood of accessible information.

Homeowners (or occupants) of identified units were also contacted to collect information on their experience with super-insulated housing through an interview. Written permission was also sought to have a home audit completed by a registered Energy Advisor to establish an EnerGuide rating. This permission included the photographing of the exterior and key sustainable features.

Case study candidates were prioritized based on the completeness of information on the home and the willingness of both the home builder and homeowner/occupant to participate in the study. A prioritized list of 10 case studies was approved by ESC and CMHC.

1 SuperGreen represents a Yukon Housing Corporation standard for residential construction that requires buildings to meet an EnerGuide rating of 85 or better.

Interview

Through the interview process, ESC solicited (or arranged to solicit) information on super-insulated design and construction details from the builders. This included: as-built plans, specifications for the structure, envelope, space heating, domestic hot water, ventilation, lighting and appliances, modelling results, EnerGuide for Home rating results, construction documents such as inspection reports, photographs, and air tightness testing results.

ESC also recorded available cost information, builder perceptions on the design and construction of super-insulated houses (lessons learned and knowledge gained, homeowner contact information, and potential leads on other super-insulated projects that might be considered for inclusion in the study).

Site Visits

ESC coordinated with a photographer and a Natural Resources Canada (NRCan) listed energy adviser to undertake a site visit for additional data collection.

Reporting

Each case study includes (where available):

- Overview of the construction of the house (type, number of storeys, heated floor area, structure, envelope, space heating, domestic hot water, ventilation, lighting, appliances, renewable energy systems, water systems)
- Energy efficiency features
- Renewable energy features
- Indoor environment features
- Environmental/Resource conservation features
- Affordability considerations (e.g.; construction costs, operating costs)
- Lessons-learned
- Technical Summary
- Project Team
- Photographs of key features
- ERS rating information, airtightness testing results, utility bills

FINDINGS

In most cases the super-insulated houses were built by builders for the primary residents who wanted to reduce operating and maintenance costs through increased energy efficiency. These builders either had previous experience building high-efficiency single-family homes in the North or received technical support from YHC and ESC to build their homes. All houses achieved an as designed EnerGuide rating between 85 and 87 with one achieving a 90 due to inclusion of Solar PV. Air change rates ranged from 1.3 to 0.4 ach and projected energy use ranged from 73 kWh/m^2 to 208 kWh/m^2. Houses were typically 2 Storey detached units ranging in size from 89 m^2 (960 ft^2) (duplex unit) to 427 m^2 (4,600 ft^2) with either a finished basement, crawlspace, or slab on grade foundation. Two houses utilized timber frame construction, while another was constructed from Structural Insulated panels (SIPs).

Most of the designs focused on deep wall construction – including double wall or Larsen wall-truss system, insulation choices included spray foam, mineral wool, EPS foam billets, or fibreglass batt with R values ranging from R36-R56.

Windows selection was evenly split between triple or quadruple-glazed, Argon filled Low-e with insulated vinyl frames. Ceiling insulation values ranged from R52 to R100 while foundation slabs ranged from R21 to R40.

Electric baseboard heating is used in almost every case as it is considered inexpensive to install, and cost effective. Also, simple electric baseboard heaters have much reduced regular maintenance and servicing costs as compared to furnaces and boilers. Some builders also opted for propane fireplaces or wood stoves for ambiance and back-up. One house utilized a cold climate heat pump while another chose a high efficiency propane combination system for space and domestic water heating with in-floor radiant heat. One house was constructed with Solar PV panels while two others were designed to be solar-ready.

LESSONS LEARNED

With the exception of one modular system the houses were built on site as "one off" designs. Accordingly, they took longer to build and cost more than conventionally built tract houses, but the modestly higher costs of wall construction are at least partially offset by the reduced size and complexity of the mechanical system.

While different approaches were used for achieving an EGH 85 or higher these houses perform as a package that includes increased R values in the walls, floor, and ceiling, triple or Quad glazed windows, and optimized space heating and ventilation systems that work together under harsh conditions.

Extra time may be needed for constructing additional wall framing however, it can provide for a tight durable and energy efficient house. In some cases additional time was required as this was the first time builders were trying out new construction techniques or systems.

Local contractors, builders, and inspectors may not be versed in certain technologies which may add to construction timelines. It is important to ensure that all trades and sub-trades are on board and that good communication exists so that everyone understands the process.

Quadruple pane windows can be heavy to install but provided additional noise reduction from the outside which was seen as a valuable investment in noisier locations. Insulated concrete forms (ICF) were considered a better option than preserved wood foundations but were often not chosen as they were too costly for the budget. Double door combinations must be designed so as to permit adequate ventilation for pressure relief.

It is recommended that design plans be run through the NRCan EGH Rating System early in the process in order to better understand optimal pathways to achieving energy efficiency goals.

Most of the home builders believe that the long-term savings of a SuperGreen home can offset the initial incremental cost of construction; however, the higher up-front cost can be a mortgage limitation for people who might be considering SuperGreen. Lots of contractors know how to achieve higher R-values but felt that clients tend to want to keep the initial cost as low as possible. To address this issue a rebate of up to $10,000 has recently been introduced and is available through the Energy Solutions Centre's Good Energy Rebate Program.

Table 1. Summary of Case Studies

Case study	1	2	3	4	5	6	7	8	9	10
Floor area	357m^2 3,846 ft^2	427 m^2 4,600 ft^2	112 m^2 1,200 ft^2	167 m^2 1,800 ft^2 + 48 m^2 520 ft^2	223 m^2 2,400 ft^2	204 m^2 2,195 ft^2 + 80.4 m^2 865 ft^2	214 m^2 2,300 ft^2	89 m^2 960 ft^2 each unit	130 m^2 1,400 ft^2 each unit	183 m^2 1,974 ft^2 Total liveable area
Dwelling type	2 storey detached	2 storey detached	2 storey detached	2 storey + loft	Detached bungalow	2 storey detached + suite	2 storey detached	2 storey duplex	2 storey triplex	Triplex – 2 single storey and 1- 2 storey
Basement type	Finished basement	Finished basement	Heated crawlspace	Slab on grade	Finished basement	Partially Finished	Crawlspace	Unfinished basement	Crawlspace	Slab on grade
Attached garage	heated	heated	no	heated	no	no	no	no	no	no
Wall	R36	R40	R44		R36	R43	R51.5	R52	R56	
Ceiling	R65	R70	R54	R80	R70	R70	R52	R100	R80	R100
Foundation walls	R21	R38	R40					R39		R20
Windows (Ar filled, low-e)	Triple Glazed	Triple Glazed	Quad Glazed, special insulated frames	Quad Glazed	Triple Glazed	Triple Glazed	Quad Glazed	Triple Glazed	Quad Glazed	Quad Glazed, (not on South side)
Space heating system	Cold climate heat pump e coil on furnace fan as backup	High efficiency propane combo system for space and DHW Infloor radiant	Electric baseboard, with wood backup	Electric baseboard, propane fireplace (solar ready)	Electric baseboard	Electric baseboard	Wood with electric baseboard as back-up	Electric baseboard, in slab radiant heat in basement for thermal storage (solar ready chases)	Electric baseboard	Electric baseboard (solar PV)
EnerGuide rating	87	86	85	87	85	85	85	87	87	86 no solar 90 solar
ACH50	1.3 ach	0.4 ach	0.9 ach	0.4 ach	0.56 ach	0.7 ach	1 ach	0.62 ach	1.1 ach	0.8 ach
Equivalent leakage area @-10Pa	405 cm^2 62.7 in^2	131 cm^2 20 in^2	128 cm^2 19.76 in^2	65.8 cm^2 10.2 in^2	125 cm^2 19.4 in^2	216 cm^2 33.5 in^2	277 cm^2 43 in^2	59 cm^2 9.2 in^2	136.1 cm^2 21.1 in^2	141 cm^2 21.9 in^2
Projected energy consumption	23,636 kWh/yr	31,314 ekWh/yr*	19,714 kWh/yr	20,656 kWh/yr	24,460 kWh/yr	29,423 kWh/yr	25,936 kWh/yr	16,644 kWh/yr	17,726 kWh/yr	19,604 kWh/yr
Space heating energy input	28GJ 7735kWh	67GJ 18,647 kWh	18GJ 5087 kWh	21GJ 5938 kWh	35GJ 9632 kWh	58GJ 16,142 kWh	40GJ 11,051 kWh	6GJ 1793 kWh	9GJ 2592 kWh	12GJ 3373 kWh
Design heat loss	14 kW	17 kW	6 kW	7.5 kW	8.5 kW	15.5 kW	10.5 kW	4.5 kW	5.5 kW	6.5 kW

*ekWh is equivalent kWh determined by showing the energy content of the fuel plus electrical energy.

CONCLUSIONS

The design and construction of super-insulated, properly ventilated, energy efficient housing can provide greater comfort and indoor air quality, reduce greenhouse gas emissions, prevent moisture and mould problems, and of course, lower the heating bills. The following 10 case studies present a number of approaches to achieving energy efficient housing that are neither onerously expensive nor difficult to build. As with all new approaches, planning is essential and the Yukon Housing Corporation and Energy Solutions Centre can provide technical information and assistance to builders considering SuperGreen construction.

SuperGreen Homes in the Yukon

Case Study #1 Wann Road

Summary: *This profile features a house built by a local mechanical contractor for himself. He chose a factory-built house (Figure 1) with higher performance wall system due to a compressed building timeline. He added an additional 38x89 mm (2x4 in.) inner framing to the exterior walls for plumbing and electrical. He also installed a dual-stage cold-climate heat pump.*

WHY SUPERGREEN[1]?

Builder, Occupant Comments

This homeowner had built his previous house about three years before this new house. He didn't want to pay for increasing energy costs and looked at the long-term payoff of going SuperGreen. His focus was on higher insulation levels and also on the mechanical systems, because he wanted to use an air-source heat pump and needed the house heating requirements to be low enough to match his heat pump's heating capacity to make it work.

Location

This SuperGreen house is located on a rural lot in the Porter Creek area of Whitehorse, Yukon.

Figure 1: Factory Built SuperGreen House, Whitehorse, Yukon

Designer-Builder Team

The homeowner acted as his own general contractor and designer. He bought a prefabricated Pacific Homes house with a 'SmartWall®' package. He added interior framing and insulation and applied his knowledge to develop the mechanical systems design and ducting layout. His tradespeople had not worked together as a team before this, but they recommended each other. Nobody other than himself provided drawings. He didn't do any special up-front work with the trades, but they had lots of ongoing discussions to address next steps as they went.

Type of House

This is a detached, moderate-sized, two-story house with a finished basement. It has a total living area of 357 m² (3,846 ft²). There is a heated attached garage.

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[1] SuperGreen is a Yukon Housing Corporation standard of energy efficient house construction.

TECHNICAL DETAILS

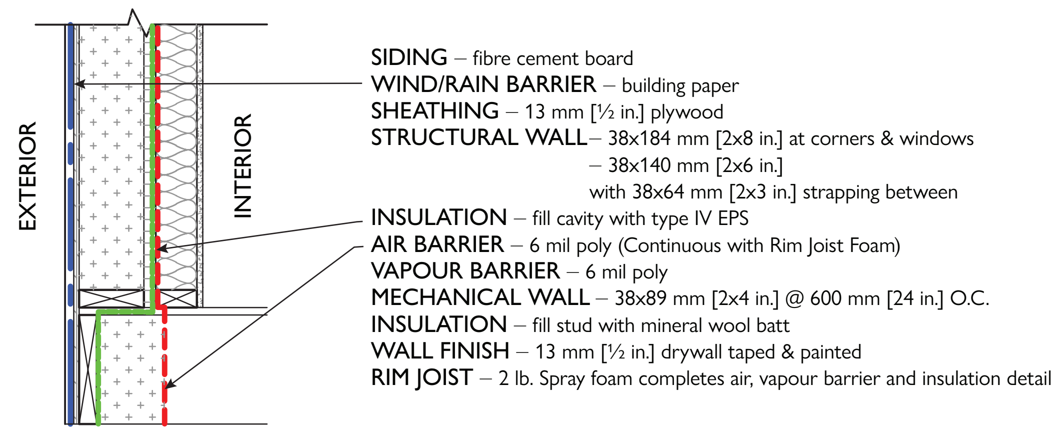


Figure 2: Wall section

Building Envelope

- **Walls (Figure 2):** 38x184 mm (2x8 in.) insulated with expanded polystyrene (EPS), interior 38x89 mm (2x4 in.) framing insulated with mineral wool. Effective RSI 6.3 (R36).
- **Ceilings:** High heel trusses, vented attic with effective RSI 11.4 (R65), blown fibreglass.
- **Foundation:** 38x184 (2x8 in.) preserved wood foundation (PWF) with fibreglass insulation effective RSI 3.4 (R21).
- **Foundation floor:** 5 cm (2 in.) of type IV EPS.
- **Windows:** Fixed and casement triple glazed, argon-filled, low-e coating.
- **Doors:** Fibreglass, polyurethane foam-filled.

Mechanical Systems

- **Space heating:** Dual stage cold-climate air-source heat pump (HSPF 9.4) (Figure 3) with an electric coil in the furnace fan unit as back-up. The air distribution is zoned so each floor has its own thermostat. A propane fireplace was also installed.
- **Ventilation:** Fully ducted Lennox HRV3-195 dual core heat-recovery ventilator (HRV) 78% SRE at -25°C (13°F) balanced at 59 L/s (125 cfm) high speed and 42 L/s (90 cfm) low speed.
- **Hot water:** Electric conserver tank.

Figure 3: Heat pump

Lessons Learned

If he was doing it again, he might design the house a bit smaller and use different windows, but he likes the wall system. It makes for a tight strong house. He estimates that the extra interior wall framing (Figure 4) added about 25% extra to the construction timeline. The only other SuperGreen wall system he's had experience with was a spray foam wall.

He would build the foundation walls and floor about the same, but put more insulation into them. He was very happy with the ceiling insulation as he felt it was a good thermal value for the cost.

Next time, he would go with quadruple pane windows from a local manufacturer. He found the ones he installed don't seal very well.

Figure 4: Framing

He chose an air source heat pump because he felt it is a more efficient and cost-effective way to heat with electricity and offers the option of air-conditioning in the summer months as well. The zoned air distribution system allowed him to set the heat on each floor independently. He reports that the heat pump system is "super cheap to operate".

He considered solar hot water and photovoltaic (PV) systems but deemed it too expensive for his budget.

In the owner's perspective, the house took much longer to build and cost much more than a conventional house. He has done the math and concluded that there will not be a payback from energy savings on his extra insulation investment over the 25 year duration of his mortgage. On the other hand, according to his math, the cold climate air source heat pump does pay off.

He thinks that in general, most people don't want to put extra money up front. They want the most house they can get for the least cost. "The houses in some of the new subdivisions are all alike, built for people who don't care much about energy efficiency and feel that they can't afford to go green."

Since he built his house, his cousin has decided to build a SuperGreen home as well.

Other Energy Efficiency and Sustainability Features

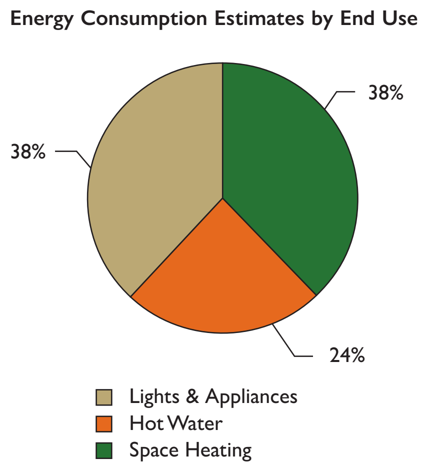
- **Control systems:** No setback thermostat; the owner likes to keep the indoor temperature constant.
- **Lighting:** Light-emitting diodes (LED) lamps, compact florescent lamps (CFL), motion and light sensors outside and a timer for the light in the garage.
- **Appliances:** All appliances are Energy Star® rated.

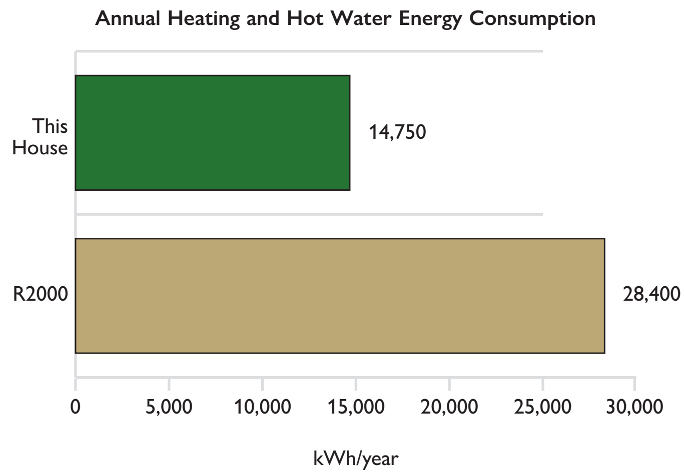
Energy Consumption Performance

An EnerGuide rating is a measure of a home's energy performance. EnerGuide has been in place since the mid 1990's. It makes use of actual house parameters like insulation values, mechanical equipment efficiencies and air tightness in a computer energy simulation (Hot 2000) using standardised occupant conditions for plug in loads, hot water use and thermostat settings. The figure below shows the energy breakdown of this house.

The R2000 program has been in place since the 1980's and has been the benchmark for energy efficient new housing in Canada. That benchmark has been upgraded recently, but for reference this house has been compared to the old familiar standard where a house deemed to be efficient gets an 80 or better on the EnerGuide scale.

ENERGUIDE RATING: 87





Project latitude	60.5°N
Annual heating degree day zone	>6000HDD°C
Mean January temperature	-16.2°C (2.8°F)
January heating design temperature	-41°C (-43°F)
Heating system design heat load	14 kW (47,768 BTU/h)
Main floor(s) heated area	211 m^2 (2,2718 ft^2)
Finished basement heated area	114 m^2 (1,225 ft^2)
Total liveable heated area	325 m^2 (3,496 ft^2)
Building footprint	131 m^2 (1,411 ft^2)
Window area	41 m^2 (443 ft^2)
% of windows facing south	64%
Air leakage rate @ -50 Pa (as operated)	1.3 ach
Equivalent leakage area (hole size) @ -10 Pa (as operated)	405 cm^2 (62.7 in^2)
Annual energy use per m^2	73 kWh/m^2
Projected total annual energy usage	23,636 kWh/yr
Actual performance as it compares to occupant utility bills	Projected load is similar to actual over 2-year period of occupancy

SuperGreen Homes in the Yukon

Case Study #2 Bellingham Court

Summary: *This profile features a house which a local contractor built for himself (Figure 1). A key feature of the house was the double stud exterior wall system that incorporated a 51 mm (2 in.) layer of type IV expanded polystyrene (EPS) foam, between a 38x140 mm (2x6 in.) structural wall and a 38x89 mm (2x4 in.) inner wall. He also utilized a high-efficiency propane "combo" system to provide space heating and domestic hot water.*

WHY SUPERGREEN[1]?

Builder, Occupant Comments

This contractor-homebuilder has built more than 10 high efficiency single-family houses in the past 10 years. All of these homes have similar wall style and R-values. His clients usually find him, though he has built spec homes in the past.

The featured house in this profile is his own. He wanted to build SuperGreen for himself because of the energy efficiency, the livability of the home and the lower cost to operate and heat it. At the time this case study was prepared, he had lived in this SuperGreen home for a month. He had moved from an older home in Whitehorse.

Figure 1: SuperGreen House, Whitehorse, Yukon

He had a local draftsperson draw up the design. They didn't need to do a lot of research, because energy-efficient construction is "pretty much common knowledge these days". They focused on insulation, the heating system, and products like energy efficient light emitting diode (LED) lights that also have a higher life expectancy.

His philosophy is that you can spend money on heating fuel or on high R-value insulation levels and he thinks people are enerally aware of the tradeoffs between building envelope vs. heating costs. However they may not want to spend the money to super-insulate a house up front.

[1] SuperGreen is a Yukon Housing Corporation standard of energy efficient house construction.

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Location

This SuperGreen house is located in the Whistlebend subdivision, Whitehorse, Yukon.

Designer-Builder Team

The trades on this house worked as a team, they are efficient and they know how to work together. Generally they discuss details with the clients and mark their decisions on the walls. This seems to work out.

Type of House

This is a large 427 m^2 (4,600 ft^2), two-storey detached home with a finished basement and a heated attached garage.

TECHNICAL DETAILS

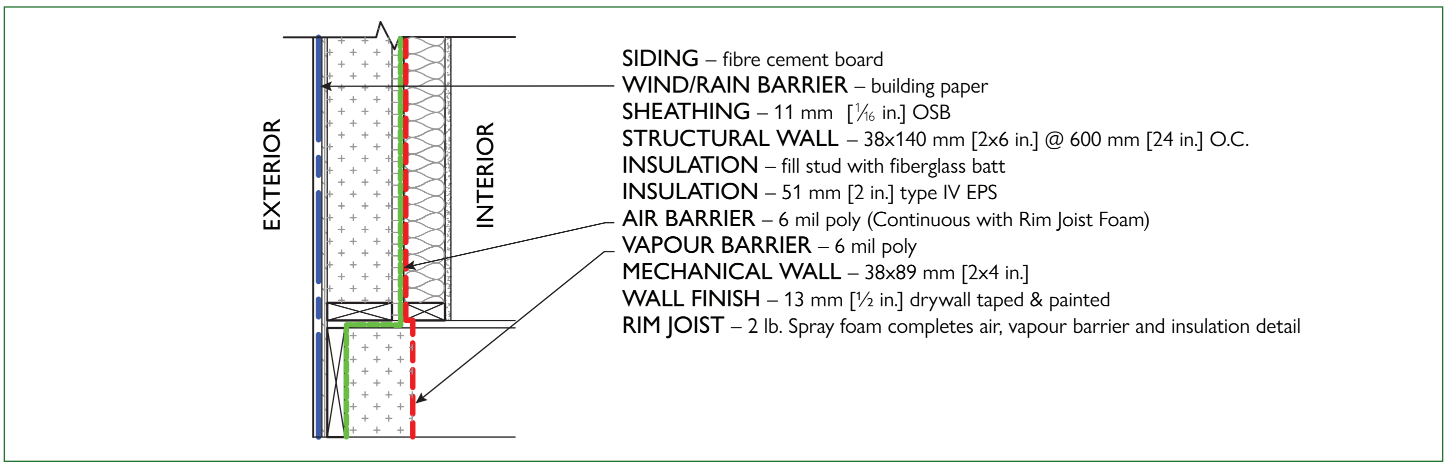


Figure 2: Wall section

Building Envelope

- **Walls (Figure 2):** 38x140 mm (2x6 in.) fibreglass batt filled wall, 51 mm (2 in.) of type IV EPS foam board in between, and a 38x89 mm (2x4 in.) fibreglass filled wall inside. Total effective RSI 7 (R40).
- **Ceiling:** High heel trusses, vented attic, blown cellulose. Total effective RSI 12 (R70).
- **Foundation (Figure 3):** Preserved wood, 38x184 mm (2x8 in.) wall, poly vapor barrier, with 38x89 mm (2x4 in.) wall on the inside. Fibreglass batt insulation. Total effective RSI 6.7 (R38).

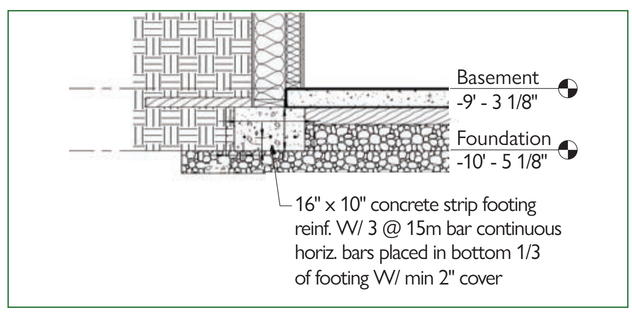


Figure 3: Foundation section

- **Foundation floor (Figure 3):** 100 mm (4 in.) EPS type IV foam below the concrete slab. Total: RSI 3.5 (R20).
- **Windows:** Vinyl, fixed and casement style, triple glazed, argon-filled, low-e coated.
- **Doors:** 3 steel polyurethane foam filled insulated doors, 1 fibreglass insulated main door.

Mechanical Systems

- **Space heating:** Primary: Navien America 91% efficient propane boiler (CSA P.9-11 compliant), in-floor hydronic radiant system.
- **Ventilation:** Fully ducted Vanee 1001 heat-recovery ventilator (HRV), 67% SRE at -25°C (13°F), balanced at 66 L/s (140 cfm) high speed and 41 L/s (87 cfm) low speed.
- **Hot water:** Instantaneous hot water supplied by propane-fired boiler.

Lessons Learned

If he was building again, he would design a smaller house. This house is too big for his personal needs.

He didn't use the EnerGuide Rating System (ERS) as he didn't learn about it until too late. Next time he would involve people who know how to run the plans through the ERS earlier in the process in order to better understand optimal pathways to achieving his energy efficiency goals.

Finding the sources of air-leakage were the greatest challenges. He described how he just wandered around the house, locating and repairing them. "It's just a time-consuming process." He also has experience with a double-wall system, which is his least-favourite. In his opinion, the wall system used on this house is the best available as it eliminates thermal bridging.

Figure 4: Windows

He likes the strength of the 38x184 mm (2x8 in.) foundation wall below grade, but would have chosen insulated concrete forms (ICF) over the preserved wood foundation had his budget permitted.

For the ceiling, the builder feels blown cellulose is a good, cost-effective product and you achieve a high RSI-value.

He had always wanted to try a boiler and is pretty happy with it. Also, propane is a cleaner product than oil with less environmental risks related to storage and use. He would never choose electric heat due to cost of operation.

Neither the window products (Figure 4) he purchased (chosen because they offer coloured frames) nor the customer service of the company he purchased them from met his expectations. For future projects, he would choose locally manufactured windows, which are now available with painted frames.

Although he believes that the long-term savings of a SuperGreen house will offset the initial incremental cost of construction, he also believes that higher up-front cost can be a mortgage limitation for people who might be considering SuperGreen. He knows that lots of contractors know how to achieve higher R-values but clients tend to want to keep the initial cost as low as possible.

Other Energy Efficiency and Sustainability Features

- **Lighting:** About 60% of the fixtures use light-emitting diode (LED) lamps, the rest incandescent.
- All appliances are Energy Star® rated (stove top is propane, oven is electric).

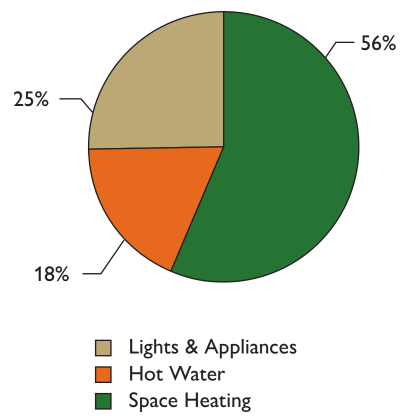
House Energy Consumption Performance

An EnerGuide rating is a measure of a home's energy performance. EnerGuide has been in place since the mid 1990's. It makes use of actual house parameters like insulation values, mechanical equipment efficiencies and air tightness in a computer energy simulation (Hot 2000) using standardised occupant conditions for plug in loads, hot water use and thermostat settings. The figure below shows the energy breakdown of this house.

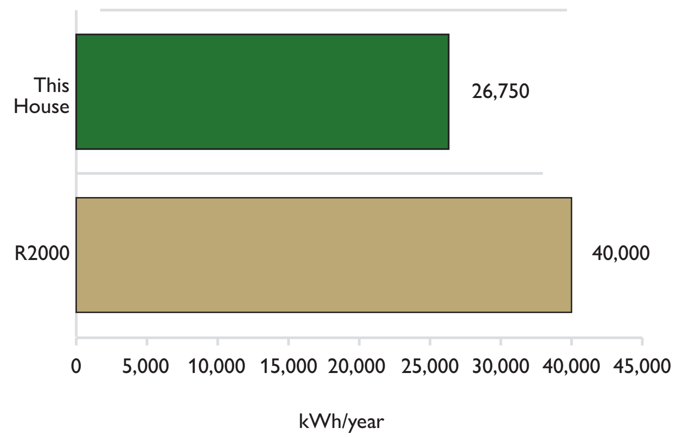
The R2000 program has been in place since the 1980's and has been the benchmark for energy efficient new housing in Canada. That benchmark has been upgraded recently, but for reference this house has been compared to the old familiar standard where a house deemed to be efficient gets an 80 or better on the EnerGuide scale.

ENERGUIDE RATING: 86

Energy Consumption Estimates by End Use



Annual Heating and Hot Water Energy Consumption



Project latitude	60.5°N
Annual heating degree day zone	>6000HDD°C
Mean January temperature	-16.2°C (2.8°F)
January heating design temperature	-41°C (-43°F)
Heating system design heat load	17 kW (58,006 BTU/h)
Main floor(s) heated area	269 m^2 (2,872 ft^2)
Finished basement heated area	135 m^2 (1,452 ft^2)
Total Liveable Area	404 m^2 (4,324 ft^2)
Building footprint	198 m^2 (2,134 ft^2)
Window area	38 m^2 (412 ft^2)
% of windows facing south	31%
Air leakage rate @ -50 Pa (as operated)	0.4 ach
Equivalent leakage area (hole size) @ -10 Pa (as operated)	131 cm^2 (20 in^2)
Annual energy usage per m^2	78 kWh/m^2
Projected total annual energy usage	31,314 ekWh/yr* (10,028 kWh/yr + 2,998 L propane/yr)
Actual performance as it compares to occupant utility bills	Data not available - House occupied less than 1 year at time of publication

**ekWh is equivalent kWh determined by showing the energy content of the fuel plus electrical energy. Propane has an energy content of 7.1 kWh/L*

SuperGreen Homes in the Yukon

Case Study #3 War Eagle Way

Summary: *This profile features a house which a local contractor built for himself (Figure 1). He framed up a 8x140 mm (2x6 in.) structural wall with minimal framing and filled it with high density spray foam. He then installed 25 mm (1 in.) of rigid polyisocyanurate foam board insulation with a foil facer on both sides and an inner 38x89 mm (2x4 in.) wall with mineral wool insulation. This house has conventional electric space heating with wood back-up.*

WHY SUPERGREEN[1]?

Builder, Occupant Comments

For this small house design, this owner-builder used mainly Yukon Housing information, articles from 'Fine Homebuilding' magazine on northern homes and his own thought process to narrow down his design to a system with the most insulation for the least amount of space. Because he is also a contractor, he is constantly surrounded by energy-efficient construction so it didn't require much extra research. For this house, he focused on orientation, wall structure, windows and insulation.

As a wood-burner, he knew how little cordwood would be needed to heat a SuperGreen house. He is conscious about not wanting to depend on sources of heat other than wood, which he can get by himself. It's not all about cost, it's about burning a fuel that you're familiar with, so you can be in tune with the heat source.

Figure 1: SuperGreen House, Whitehorse, Yukon

He and one building partner have worked together for about 25 years. They have lots of experience building houses in the north. He wanted to build a home for himself that would last for 100 years, by trying to get away from materials that can break down. For example, in the case of sheet polyethylene air and vapour barriers, you have rely on how well they are installed for them to work properly. But for spray-applied foam insulation systems, you can get an air and vapour barrier in one application.

In the 1980's, vapour barriers were a big issue, but there wasn't enough attention to how it was sealed. It's a process of evolution. Over the years, we began putting more insulation in houses. Many builders didn't want to seal the vapour barrier for fear of making the house too tight. Some of these homes are showing mold now, so the importance of sealing and good ventilation is becoming clear. The problem with batt insulation is that it isn't effective if air is moving through it because the air and vapour barrier hasn't been sealed perfectly. With solid foam walls there is far less of an issue. Now we can apply different layers of foam to get a solid air and vapour barrier.

[1] SuperGreen is a Yukon Housing Corporation standard of energy efficient house construction.

Canada

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Location

This SuperGreen house is located in a country residential area of Whitehorse, Yukon.

Designer-Builder Team

The building team included the builder, his long-time work partner and the same trades team that they work with on all their houses. They discuss the project as needed, but the trades don't need too much explanation, as their practices have evolved as a team over the years.

The insulation subcontractor is a spray foam company. In the past, there were a few issues with sprayers who previously didn't need to be as precise, but now they have to spray the foam with accuracy and perfection.

Type of House

The house is a small 112 m^2 (1200 ft^2) two-storey detached timber frame hybrid on a heated crawlspace. It has no attached heated garage and no secondary suite.

TECHNICAL DETAILS

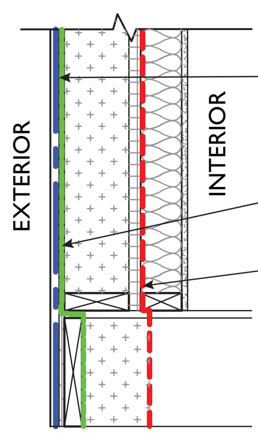


Figure 2: Wall section

Building Envelope

- **Walls (Figure 2):** Combination of high density wall system, 38x140 mm (2x6 in.) structural wall with intermediate 38x89 mm (2x4 in.) studs. High-density spray foam insulation filled the outer cavity followed by another 25 mm (1 in.) layer of rigid polyisocyanurate foam board insulation with a foil facer on both sides, then mineral wool insulation was installed in the inner 38x89 mm (2x4) wall. The builder feels this is the highest RSI (R) value in the least amount of space. Effective RSI 7.7 (R44).

Figure 3: Interior detail

- **Ceilings:** "Hot roof" design - 250 mm (10 in.) of high-density foam insulation. Effective RSI 9.5 (R54).
- **Foundation:** Crawlspace on ICF (insulated concrete form) blocks, filled with concrete and added more foam on the outside - 200 mm (8 in.) of high-density foam Effective RSI 7 (R40), so minimal heat loss.
- **Foundation floor:** Insulated with 75 mm (3 in.) high-density EPS topped with 75 mm (3 in.) 2 lb spray foam Effective RSI 5.3 (R30).
- **Windows:** Vinyl, fixed and casement style, quad-glazed with insulated vinyl frames throughout (locally manufactured).
- **Doors:** Owner-built wood doors – foam filled, double system or air barrier.

Figure 4: Kitchen

Mechanical Systems

- **Space heating:** Electric baseboard, wood cook-stove back-up because that is what the owner is familiar with. Electric baseboards were chosen for low-cost and simplicity.
- **Ventilation:** Fully ducted Eneready 2000 Diamond E heat-recovery ventilator (HRV) 70% SRE at -25°C (13°F) balanced at 47 L/s (100 cfm) High speed and 24 L/s (50 cfm) low speed.
- **Hot water:** Electric conserver tank.
- Rain water is collected for the garden.

Lessons Learned

This builder has been perfecting his design over the years and would use a similar design in future homes (Figure 4), though he admits he's always looking for little ways to sneak in another layer of insulation.

For the foundation walls, the ICF was a little pricier than framing but he would do it again if the customer could afford it.

If the house wasn't so well insulated he would still heat with wood, but would have to install more electric baseboards. They have to control the wood stove so that they are not getting too hot, which is a nice problem! They may need to get a brick oven to store the heat overnight.

He did not use the EnerGuide rating system. In his opinion the recommendations can be misleading. He knows he's a bit stubborn that way. He feels that systems are designed by people who only work on the computer rather than experiencing it by themselves on a ladder at the actual work place, which can just make things more confusing.

Other Energy Efficiency and Sustainability Features

- **Lighting:** Mixed of halogen lamps, light-emitting diode (LED) lamps and some compact fluorescent lamps (CFL). Since the house is very well insulated, the heat produced by the lights contributes to the heating too, so the builder did not necessarily use the most energy efficient technologies.
- **Appliances:** All appliances are Energy Star® rated. He also has a secondary wood cook stove (Figure 5).
- **Other features include:** Orientation – how the house is positioned to capture passive solar heat gains, location of the wood stove is very important together with trying to keep house more open to get even heat everywhere.

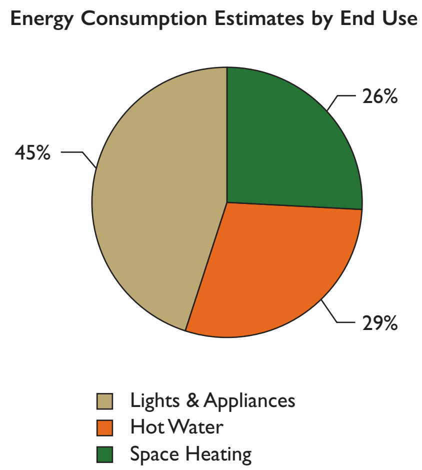
Figure 5: Wood cook stove

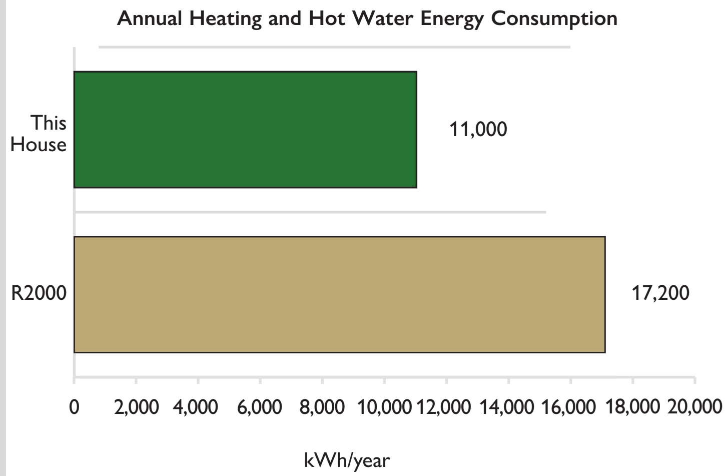
Energy Consumption Performance

An EnerGuide rating is a measure of a home's energy performance. EnerGuide has been in place since the mid 1990's. It makes use of actual house parameters like insulation values, mechanical equipment efficiencies and air tightness in a computer energy simulation (Hot 2000) using standardised occupant conditions for plug in loads, hot water use and thermostat settings. The figure below shows the energy breakdown of this house.

The R2000 program has been in place since the 1980's and has been the benchmark for energy efficient new housing in Canada. That benchmark has been upgraded recently, but for reference this house has been compared to the old familiar standard where a house deemed to be efficient gets an 80 or better on the EnerGuide scale.

ENERGUIDE RATING: 85





Project latitude	60.5°N
Annual heating degree day zone	>6000HDD°C
Mean January temperature	-16.2°C (2.8°F)
January heating design temperature	-41°C (-43°F)
Heating system design heat load	6 kW (20,472 BTU/h)
Main floor(s) heated area	95 m^2 (1,022 ft^2)
Finished basement heated area	58.5 m^2 (630 ft^2)
Total liveable heated area	95 m^2 (1,022 ft^2)
Building footprint	77 m^2 (830 ft^2)
Window area	19.8 m^2 (152 ft^2)
% of windows facing south	37%
Air leakage rate @ -50 Pa (as operated)	0.9 ach
Equivalent leakage area (hole size) @ -10 Pa (as operated)	128 cm^2 (19.76 in^2)
Annual energy use per m^2	208 kWh/m^2
Projected total annual energy usage	19,714 kWh/yr
Actual performance as it compares to occupant utility bills	Data not available - House occupied less than 1 year at time of publication

SuperGreen Homes in the Yukon

Case Study #4 Timber Frame

Summary: *This profile features a house which a local contractor built for himself (Figure 1). A key feature of the house was the double stud exterior wall system that incorporated a 51 mm (2 in.) layer of type IV expanded polystyrene (EPS) foam, between a 38x140 mm (2x6 in.) structural wall and a 38x89 mm (2x4 in.) inner wall. He also utilized a high-efficiency propane "combo" system to provide space heating and domestic hot water.*

WHY SUPERGREEN[1]?

Builder, Occupant Comments

One of the team members had an idea after seeing the success of a LEED Canada for Homes certified duplex in the area. He approached the other two partners, both of whom he had worked with before. They successfully applied for a premium lot in a land lottery. Once the lot was selected and purchased, they began designing a timber frame structure to suit their particular location. After numerous designs and re-designs, the team settled on a blueprint and sent the drawings to an engineering firm for further modifications and subsequent approval of the timber frame design.

The team read a lot, looking for new technologies. They talked with people from Yukon Housing and the Energy Solutions Centre. They looked at other builders' resources and researched the energy evaluations of other houses. They talked with other builders. They looked for what worked and what didn't. They collaborated to design an efficient but simple timber framed wall system. They focussed on insulation. People were interested in what they were doing so by the time they put up the timbers – they had buyers.

Figure 1: SuperGreen House, Whitehorse, Yukon

One of the builders considers himself to be an environmentalist. He feels many houses are wasting energy and he wants to be a small part of the solution to the global warming issue. Building SuperGreen is his solution. The second builder was looking at ways to reduce his ecological footprint by reducing the resources used over the lifetime of a house. The third builder works for Yukon Housing. Through work and his own research he became a promoter of the SuperGreen approach.

[1] SuperGreen is a Yukon Housing Corporation standard of energy efficient house construction.

They agree that there are benefits in fuel savings, living comfort and consistent temperature, but the biggest benefit is the quietness of living in a SuperGreen home. "You just don't hear things outside because it's so quiet due to the insulation and air sealing. Even though it's close to the airport, you hardly hear the planes. You can't put a price on that."

Location

This SuperGreen house is located in an infill area of the Takhini North subdivision, Whitehorse, Yukon.

Designer-Builder Team

The team bought the lot in September and worked on the design through the winter. It was based largely on resources compiled by Yukon Housing Corporation. They had a target EnerGuide Rating, so they worked with the depth of insulation in the walls and roof until they met their goal. One of the builders then took the lead and made very detailed design drawings for the layout of the timber frame to make it all work (Figure 2). In April, they started clearing the lot.

Figure 2: Setting timber structure

The team continually discussed next steps and timelines, when different portions of the house should be completed, safety discussions and updates of what needed to get accomplished each day. They took the drawings to their trades for discussion about details such as the location of lighting in the timber frame, location of the ductwork, plumbing and hot water tank. Trades came in to apply the siding and another group did the roofing. They did most of the concrete work themselves.

The design incurred a few changes along the way. The footprint stayed the same, but they modified the roof system on top of the garage. They had discussions on siding issues and the location of interior walls. Building the house took longer than expected, mostly because they spent more time on the design and somewhat because of being SuperGreen. In the end, construction went mainly according to plan. They agree that the more detail that gets on paper before the project starts, the fewer problems are encountered during construction.

Their design lends itself well to a SuperGreen house. The timber framing is all on the inside and the exterior walls are built outside of the structure (Figure 3). After considerable debate, the team chose low density spray foam insulation for the walls. For the ceiling, they sprayed a layer of high density foam because it has a high insulation value and contributes to the vapour barrier. This was followed by a layer of blown-in cellulose.

The team made use of the EnerGuide Rating System (ERS) software which helped them finalize certain decisions. For example, they chose to go with thicker insulation under the floor slab. The ERS results showed that a big part of the heat loss was through the foundation, so they sprayed 5 inches of high-density foam down before pouring the slab. They also foamed outside the slab before placing the timbers.

The team has done the calculations and understands the long-term benefits of SuperGreen houses. Heating costs are significantly lower, while the life expectancy of the house, if it's ventilated properly, is much longer. As well, people who live in SuperGreen houses not only save on their energy bills but they are living in a quieter, more comfortable house which will make re-sale easier.

Type of House

This is a modest-sized detached 167 m^2 (1800 ft^2) home including two storeys and a loft. The house is slab on grade. It includes a heated garage with the same thickness of the walls as the rest of the building. There is a separate 48 m^2 (520 ft^2) rental income suite above the garage.

TECHNICAL DETAILS

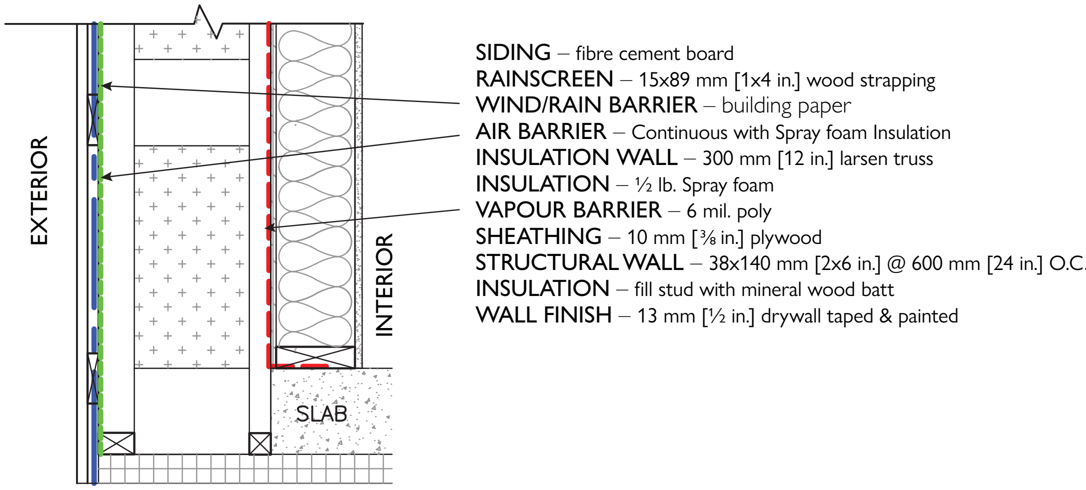


Figure 3: Wall section

Building Envelope

- **Walls (Figure 3):** Timber frame structure, 38x89 mm (2x4 in.) wall, sheathed, wrapped on the outside in vapour barrier with a 300 mm (12 in.) deep Larsen truss on the outside of that with exterior air barrier system.
- **Ceilings:** Combination of 61 cm (24 in.) deep Larsen truss cathedral ceiling with a small amount of venting above the insulation and high heel truss vented attic. Insulation: 76 mm (3 in.) high-density spray foam with 530 mm (21 in.) cellulose above. The ceiling is RSI 14 (R80).
- **Slab on grade foundation:** 127 mm (5 in.) of high density spray-foam directly on the ground under the concrete slab. (Only 76 mm (3 in.) high density foam under the garage slab).
- **Windows:** Fixed and casement style, quad-glazed, argon-filled low-e throughout (locally manufactured).
- **Doors:** Metal polyurethane insulated steel doors. Double doors (inner and outer) except for the front door.

Figure 4: Drain water heat recovery

Mechanical Systems

- **Heating:** Primary: Electric baseboards. Secondary: Propane fireplace.
- **Ventilation:** Fully ducted Venmar EKO 1.5 heat-recovery ventilator (HRV) 64% SRE at -25°C (13°F) balanced at 59 L/s (124 cfm) high speed and 29 L/s (62 cfm) low speed.
- **Hot water:** Electric hot water tanks with drain water heat recovery units (Figure 4) – one in the house and one for the rental suite.
- **Renewable energy system:** The wiring is in place for solar electricity, giving a renewable energy option for the future.

Figure 5: Timber structure

Lessons Learned

Building the timber frame wall system and the Larsen trusses added a lot of time to construction.The advantages of this building system were somewhat compromised by the onset of winter. The team altered insulation from cellulose to low-density foam because of cold weather and timeframe considerations and used cold weather spray foam that allowed application at lower temperatures.

Although they started the project in April, it was August before the timber frame was completed. This was what they expected and it was the only time constraint. If they were doing this again, they would start timber framing earlier, even if it meant building sections in a shop to make the project go more quickly on-site.

Figure 6: Interior view

This builder team worked to get all the trades on board. They had up-front discussions to make sure everybody knew each other. They scheduled regular meetings with the main timber frame builder to ensure that the trades understood what they had to do. They provided the information and the trades figured out how to do their part. The HRV system was installed by one of the builders with guidance from local experts.

As one builder noted "There are always a few changes along the way, but as long as it's not compromising the overall objectives, it's okay." In retrospect, they could have involved the sub-trades sooner, but overall they are very happy with the project.

One of the timber frame builders had used a similar wall system in the past and the design seemed to lend itself well to a timber frame structure (Figure 6). The team manufactured the trusses themselves. The trusses didn't need to support any of the floor systems so they used less lumber. He would consider using this system again but only for a small project and only if it was a timber frame or retrofit.

Instead, he would likely build a double wall. For the double wall, he would use a 38x140 mm (2x6 in.) structural wall on outside and 38x89 mm (2x4 in.) wall on the inside, with fibrefill or spray-in insulation. He prefers Energy Shield foam-boards to separate the walls and batt insulation (fibreglass or mineral wool in the wall cavities.

The other timber frame builder would use the same wall system again, but he would build the two walls together and put them up as one. Or he might investigate a slightly different wall system, perhaps a framed 38x89 mm (2x4 in.) wall, then the vapour barrier, then sheath it then build a second 38x89 mm (2x4 in.) wall on the outside, spacing the walls apart with plywood. The inside wall should be the load bearing structural wall. With the vapour barrier applied to the outside, the number of seams is minimized. Also, the poly is protected by the wall so any plumbing or electric work can be done inside without risk of penetration. The outer wall doesn't have to be load bearing. With the Larsen truss, the wall can be made any depth.

In this case, the house is slab on grade with high density spray foam insulation under the slab. It is easy to work with, can be walked on in 15 minutes, covers the ground completely with no cracks or seams and the concrete can be poured on top of it. The high density foam is more expensive but it fits the ground contours perfectly and gives the best quality of moisture and soil gas barrier. Also they saved money on labour because it was faster.

In the ceiling, the high density spray foam helps to ensure a good air and vapour barrier and they liked the cellulose because it's recycled newspaper. The process they used had a major drawback though when it came to insulating from the outside. They found it was time consuming and frustrating doing outside insulation. If they were doing it again, they would consider building with regular trusses and blown-in insulation after the roof was on.

For the windows they chose locally manufactured quadruple-glazed units. This helped them meet their target EnerGuide rating and the cost was not much higher than for triple. Having a local supplier is easier in case of mistakes, and shipping would have added extra cost. There were concerns about the windows having un-insulated frames, but they decided to use them, partly because the windows in the house were mostly quite small.

In order to reduce air loss and add insulation value, they installed double doors (inner and outer) except for the main entry. They found these were harder to use – opening and closing one door and then the other. As well, the pressure builds up between the two doors so after one door is closed, it's hard to close the other. For this reason, they installed only a single front door.

They installed electric baseboards for primary heat because it's the most cost effective, has no moving parts, it doesn't require on-site use of a fossil fuel and it's much easier to install wiring than ducting. It's inexpensive and simple to operate, it's efficient and it responds quickly to changes in needs. There is an HRV for air exchange, so they didn't need a forced-air system. Also, it would have been hard to find a small enough furnace. There is nearly enough heat generated from lighting and other occupancy-related sources to keep the house warm. The fireplace is solely for back-up. Next time they would like to try an electric thermal storage (ETS) system to take advantage of times of better availability of renewable energy on Yukon's isolated electrical grid.

They installed halogen and compact fluorescent lamps (CFL), with a few light emitting diode (LED) lamps. For their clients, they advise LED's as the best choice. They are better because they come on to full brightness instantly, last a long time and the price is coming down. In the long run, they are less expensive and have less environmental impact. They didn't invest in any electronic control devices because of the extra cost and, at the time, concerns about reliability. They also wanted to keep the house simple and not include complicated controls.

The house is beautiful, but the next time, they might build a simpler design. The timber frame adds to the cost. They would like to try building a medium-sized affordable energy efficient home and focus more on air leakage through walls and windows.

The City inspectors were happy to see people building this way, they are keen on it. The City of Whitehorse has some of the best energy standards all across Canada. This house and the building team have influenced others to build SuperGreen. They have promoted the practice at Contractor Breakfasts. They haven't met anybody who has built SuperGreen who is not very happy they took that step.

Other Energy Efficiency and Sustainability Features

- **Control systems:** Outside motion sensor.
- **Lighting:** Compact fluorescent lamps (CFL) and some light-emitting diode (LED) lamps.
- **Appliances:** All appliances are Energy Star® rated.
- **Other features include:** Each room has its own thermostat, can be replaced with programmable thermostats in the future.
- The concrete slab is stained to provide the finished floor.
- Drain water heat recovery on the shower drains.

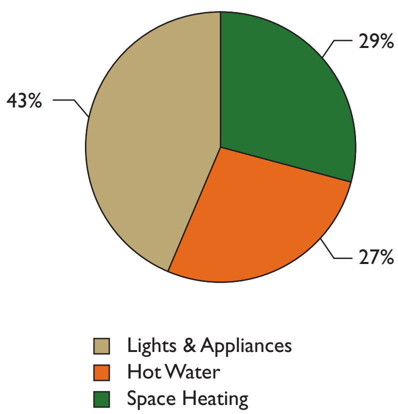
Energy Consumption Performance

An EnerGuide rating is a measure of a home's energy performance. EnerGuide has been in place since the mid 1990's. It makes use of actual house parameters like insulation values, mechanical equipment efficiencies and air tightness in a computer energy simulation (Hot 2000) using standardised occupant conditions for plug in loads, hot water use and thermostat settings. The figure below shows the energy breakdown of this house.

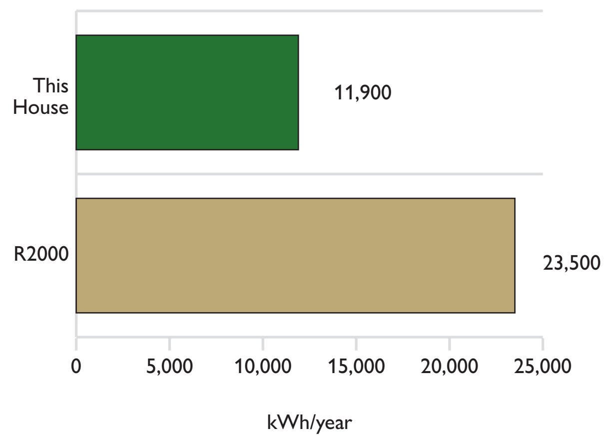
The R2000 program has been in place since the 1980's and has been the benchmark for energy efficient new housing in Canada. That benchmark has been upgraded recently, but for reference this house has been compared to the old familiar standard where a house deemed to be efficient gets an 80 or better on the EnerGuide scale.

ENERGUIDE RATING: 87

Energy Consumption Estimates by End Use



Annual Heating and Hot Water Energy Consumption



Project latitude	60.5°N
Annual heating degree day zone	>6000HDD°C
Mean January temperature	-16.2°C (2.8°F)
January heating design temperature	-41°C (-43°F)
Heating system design heat load	7.5 kW (25,590 BTU/h)
Main floor(s) heated area	112 m^2 (1,208 ft^2)
Finished basement heated area	81 m^2 (874 ft^2)
Total liveable heated area	112 m^2 (1,208 ft^2)
Building footprint	93 m^2 (1,000 ft^2)
Window area	10.8 m^2 (116 ft^2)
% of windows facing south	24%
Air leakage rate @ -50 Pa (as operated)	0.4 ach
Equivalent leakage area (hole size) @ -10 Pa (as operated)	65.8 cm^2 (10.2 in^2)
Annual energy use per m^2	184 kWh/m^2
Projected total annual energy usage	20,656 kWh/yr
Actual performance as it compares to occupant utility bills	Data not available - House occupied less than 1 year at time of publication

SuperGreen Homes in the Yukon

Case Study #5 Carpiquet Road

Summary: *This profile features a house built by a builder for his son (Figure 1). He framed the house with a 38x89 mm (2x4 in.) wall, then filled the wall cavity with expanded polystyrene (EPS) foam billets. He then installed another 5 cm (2 in.) layer of EPS, then a 38x89 mm (2x4 in.) inner wall insulated with mineral wool insulation. The simple design of his house made air-sealing easy. The house is heated with electric baseboards.*

WHY SUPERGREEN[1]?

Builder, Occupant Comments

This builder explains his reasons for going SuperGreen simply. "It's a lot of work to build a house, so I might as well just do it right and save as much money and energy in the heating as we can." He focused on increased insulation and good windows.

He used Yukon Housing Corporation's technical support to see what was new and then spent a bit of time on the internet to come up with his own design. He did the plumbing himself and hired an electrician and a tile setter, both of whom he would recommend. He prepared all the drawings and told them what he wanted, then they had discussions as needed about how each part would work.

He didn't run the design through the EnerGuide Rating system, though he did rely somewhat upon advice from an energy specialist. He's happy with how the process worked and would use this design again.

Figure 1: SuperGreen House, Whitehorse, Yukon

He feels that it's less costly to build SuperGreen when you account for the long term fuel savings compared to the extra cost of additional insulation, but he points out that he's referring to the way he approached SuperGreen, not necessarily the way others approach it.

1 SuperGreen is a Yukon Housing Corporation standard of energy efficient house construction.

Canada

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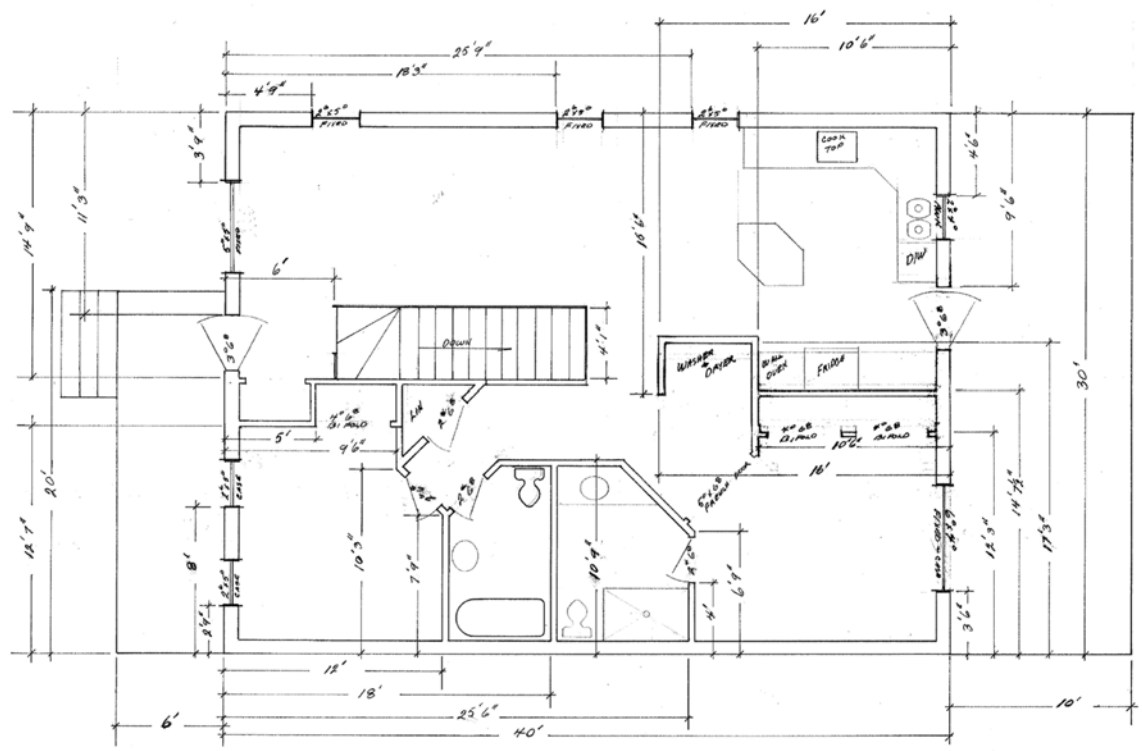

Figure 2: Main floor plan

Location

This SuperGreen house is on an infill lot located in the Takhini North subdivision, Whitehorse, Yukon.

Designer-Builder Team

He did some upfront work with the construction team to effectively incorporate SuperGreen building processes.

Type of House

This house is a modest-sized detached bungalow of 223 m^2 (2400 ft^2) which includes the finished basement. It has no attached garage and no rental suite (Figure 2).

TECHNICAL DETAILS

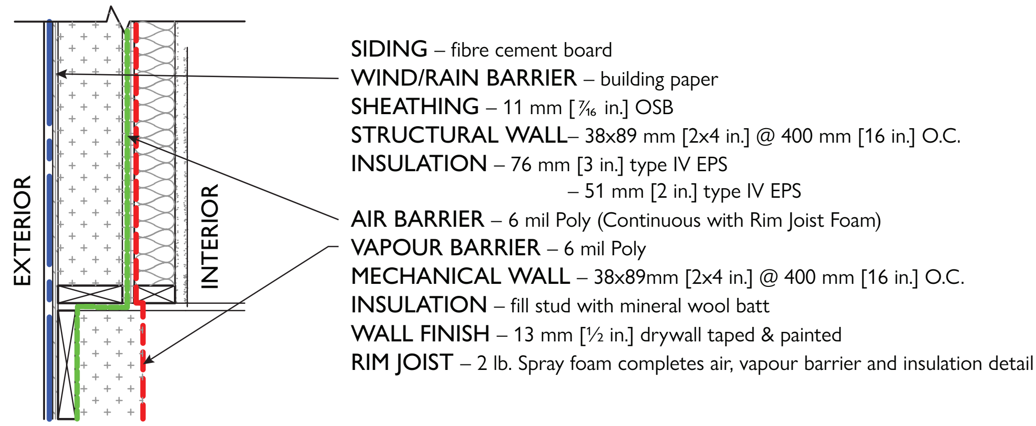

Figure 3: Wall section

Building Envelope

- **Walls (Figure 3):** Framed with 38x89 mm (2x4 in.) filled with type IV EPS foam plus a continuous layer of type IV EPS foam and air-vapour barrier followed by an additional 38 x 89 mm (2x4 in.) wall with mineral wool insulation. Effective RSI 6.3 (R36).
- **Ceilings:** High heel trusses, vented attic, fibreglass insulation. Total RSI 12.3 (R70).
- **Foundation:** Walk-out basement (half), walls are the same as the main floor except the outer framing is 38x140 (2x6 in.).
- **Foundation floor:** Treated wood floor joists with type IV EPS between.
- **Windows**: Fixed and casement style, triple-glazed, argon-filled low-e throughout (shipped from Alberta).
- **Doors:** Metal, polyurethane foam-filled.

Mechanical Systems

- **Space heating:** Electric baseboard.
- **Ventilation:** Fully ducted Eneready Diamond E heat-recovery ventilator (HRV) 70% SRE at -25°C (13°F) balanced at 54 L/s (114 cfm) high speed and 24 L/s (50 cfm) low speed.
- **Hot water**: Electric conserver tank.

Lessons Learned

The design was very straightforward and there were no particular hurdles or challenges because he had the plans in place and knew what needed to be done.

He planned the walls so they would be quick to put up, well insulated and not allow any moisture to get into the wall and cause mold. This system was easy to build and made for a very tight sealed house without a lot of fussing about it. He had seen other super-insulated wall systems go up and he wanted to try to make his process simpler.

First, he built a 38x140 mm (2x6 in.) structural wall in the wood basement. The wall stud spaces were filled with EPS foam billets. On the inside of that, he placed 5 cm (2 in.) of EPS foam and put the air-vapour barrier on the inside of that. He then built a 38x89 mm (2x4 in.) wall inside the air-vapour barrier fo the plumbing and wiring. He filled that cavity with RSI 2.5 (R14) mineral wool batts. The main floor walls were constructed the same way only he reduced the structural wall to use 38x89 mm (2x4 in.) studs.

He purchased windows from Alberta because of the 25 year guarantee. The doors were locally purchased. (Figure 4)

For the ceiling, once the poly was in place on the inside of the trusses, he added 38x64 mm (2x3 in.) strapping which he filled with RSI 1.4 (R 8) fibreglass batt insulation. He then hauled fibreglass batts into the attic space and placed them himself. He didn't enjoy this part but he doesn't trust blown-in insulation.

Insulating the foundation floor was simple also and he would do that system again.

He chose electric heat because it's 100% efficient (one kW of electricity equals 1 kW of heat), it was inexpensive to install and it requires little or no maintenance.

Figure 4: Window and exterior door

Other Energy Efficiency and Sustainability Features

- **Control systems:** Setback thermostat.
- **Lighting:** All light-emitting diodes (LED) lamps, with motion sensors outside under eaves, in the back, front and side of house.
- **Appliances:** All appliances are Energy Star® rated.

Energy Consumption Performance

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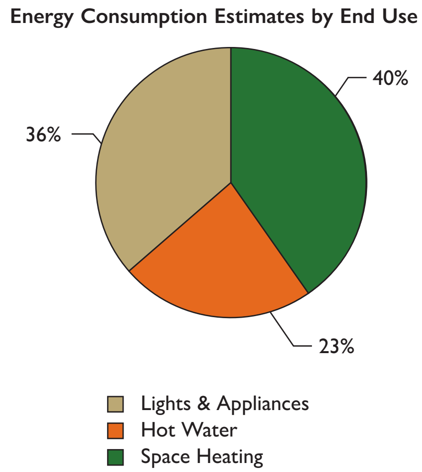
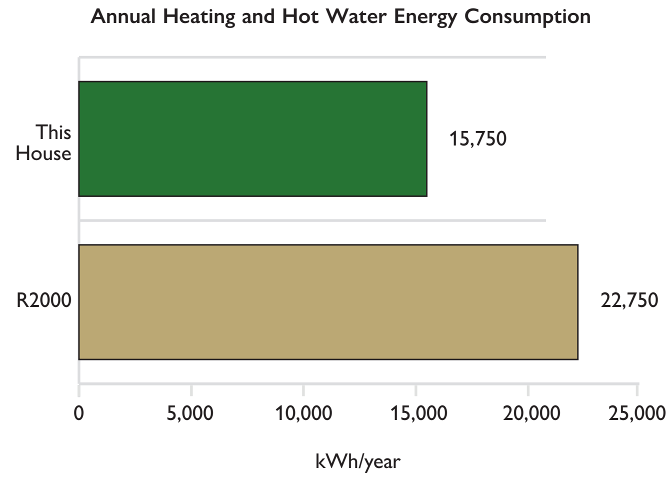
ENERGUIDE RATING: 85





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January heating design temperature	-41°C (-43°F)
Heating system design heat load	8.5 kW (29,003 BTU/h)
Main floor(s) heated area	99 m^2 (1,064 ft^2)
Finished basement heated area	99 m^2 (1,064 ft^2)
Total liveable heated area	198 m^2 (2,128 ft^2)
Building footprint	112 m^2 (1,200 ft^2)
Window area	17 m^2 (183 ft^2)
% of windows facing south	7%
Air leakage rate @ -50 Pa (as operated)	0.56 ach
Equivalent leakage area (hole size) @ -10 Pa (as operated)	125 cm^2 (19.4 in^2)
Annual energy use per m^2	124 kWh/m^2
Projected total annual energy usage	24,460 kWh/yr
Actual performance as it compares to occupant utility bills	Data not available - House occupied less than 1 year at time of publication

SuperGreen Homes in the Yukon

Case Study #6 Aksala Drive

Summary: *This profile features a house (Figure 1) designed by a homeowner-architect and built by her brother, a local builder. The walls are framed with 38x89 mm (2x4 in.) with an exterior insulation system comprised of 150 mm (6 in.) of rigid type IV expanded polystyrene (EPS) foam. The house is heated with electric baseboards.*

WHY SUPERGREEN[1]?

Builder, Occupant Comments

The designer and her partner, both architects, had previously owned a SuperGreen condo. They wanted to experiment with their own house to see what they could achieve in terms of long-term cost savings and trying to reduce their reliance on fossil fuels. Her brother, a local builder, was willing to try something new and seized the opportunity to build SuperGreen.

In designing the house, they used their own knowledge as architects as well as information from the Cold Climate Housing Research Center (CCHRC) in Fairbanks, Alaska. The design focuses on increased levels of wall Insulation and high quality windows. A local energy expert assisted with mechanical system design.

Figure 1: SuperGreen House, Whitehorse, Yukon

Location

This SuperGreen house is located in the Whistlebend subdivision, Whitehorse, Yukon.

Designer-Builder Team

They did most of the drawings themselves, except the ventilation plans which changed during the course of construction. The builder did a lot of extra research to make sure all the systems would work.

This was the first time their trades had worked together on a SuperGreen house, but they recommended each other. The homeowner-designer team were on-site most of the time every day during construction and between themselves and the builder, they didn't give anybody much room to stray from the plan. Their coordination approach was very "hands-on" and the tradespeople had to stick to what they provided. They had a lot of family members working on this house which helped keep costs down.

[1] SuperGreen is a Yukon Housing Corporation standard of energy efficient house construction.

Type of House

This detached house is a modest size at a total of 204 m^2 (2195 ft^2), including finished and unfinished space. It has an additional 80.4 m^2 (865 ft^2) rental income suite, included to help offset the mortgage. It has no attached garage. The suite has a main floor and finished basement, while the main living area is two-storey with an unfinished basement.

TECHNICAL DETAILS

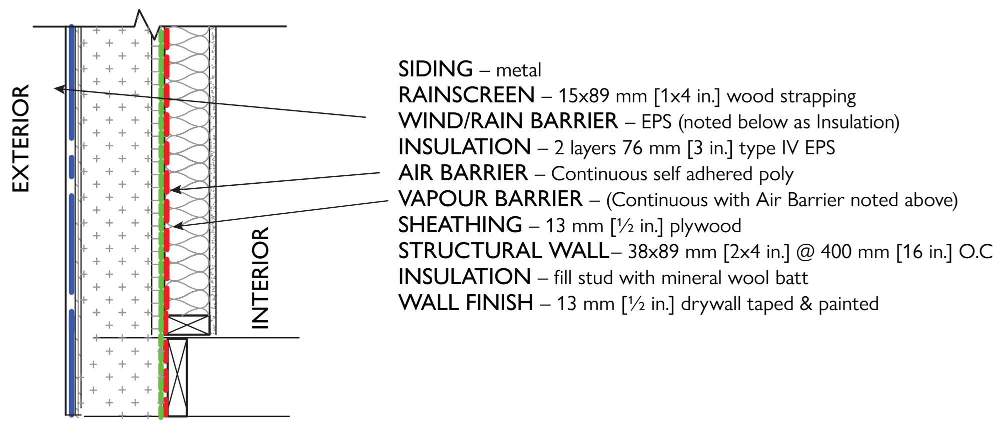


Figure 3: Wall section

Building Envelope

- **Walls (Figure 2):** 38x89 mm (2x4 in.) wall with fibreglass batt insulation, exterior plywood sheathing with the air-vapor barrier on outside, then 6 inches of expanded polystyrene (EPS) insulation, weather barrier, wood strapping and siding. Effective RSI 7.6. (R43).
- **Ceilings:** High heel trusses, vented attic with RSI 12.3 (R70), blown-in cellulose.
- **Foundation:** Full basement, 38x184 mm (2x8 in.) preserved wood foundation (PWF), with 10 mm (4 in.) of type IV EPS, blue skin stick-on foundation protection.
- **Foundation floor:** 10 mm (4 in.) type IV EPS HS40 foam insulation, poly air vapour barrier, 38x140 mm (2x6 in.) PWF wood sleepers, 1.3 mm (0.5 in) plywood floor sheathing.
- **Windows:** Fixed and casement style vinyl, triple-glazed, argon-filled low-e throughout (locally manufactured).
- **Doors:** Metal polyurethane foam-filled with a double pane window.

Mechanical Systems

- **Space heating:** Electric baseboard, planning to add a propane fireplace for ambiance and back-up.
- **Ventilation:** Separate fully ducted Venmar EKO 1.5 ECM heat-recovery ventilator (HRV) 64% SRE at -25°C (13°F) balanced at 61 L/s (130 cfm) high speed with 31 L/s (65 cfm) low speed for the main house and 42L/s (90 cfm) high speed with 21 L/s (45 cfm) low speed for the suite.
- **Hot water:** Separate electric conserver hot water tanks for each space.
- **Renewable energy system:** It won't be difficult to add solar photovoltaic (PV) to the house which is something they would like to do in the next 5 years.

Lessons Learned

For the walls, the builder wanted to experiment with a wall system from CCHRC and to try something different than what other local builders were doing. The construction took a bit longer than expected due to the unforeseen lengthy installation time of the 150 mm (6 in.) of rigid insulation. This resulted in multiple passes around the building assembly that weren't anticipated to complete the layers of the wall.

There were a couple of difficulties working with the foam, both cutting through the thickness of it which added time and also, it was difficult to find the studs through the insulation so the builder missed them every once in a while.

There were no problems with the trades and the polyethylene air-vapour barrier, though they were not used to seeing the poly on the exterior of the sheathing. The structural engineer recommended against putting too many holes in the 38x89 mm (2x4 in.) walls, which in some cases was not respected by the trades.

If they were doing another house, they would stick with their final wall assembly. They would also design deeper roof trusses to accommodate more insulation, to bring it up to RSI 17.6 (R100). The builder would like to try a "hot roof" design.

Figure 3: Exterior view from the living room

The foundation walls worked out well and were really easy to build. The builder found it easier to work with the foam in a below grade situation. For the floor, they wish they had added more insulation, either spray foam or fibreglass batts.

They worked with a local EnerGuide Rating system (ERS) specialist who ran the final design through the EnerGuide program, but they would have preferred to work with the program before they started planning, to run different wall options through the program to see if another system would have been better (lower cost).

Initially, the inspector didn't understand the location of the air and vapour barrier, but once the wall system was explained everything was fine.

They chose electric heat because it was cheap to install and because there is so much insulation, they anticipate the house shouldn't need much electricity to heat. In retrospect, they would have liked to consider other heating systems such as heat pumps which are more efficient, but they didn't want a furnace.

Since they built their house, her mother, who was building a new home, has also decided to build SuperGreen. She decided that having lower utility bills and a more efficient home was worth it.

The builder feels that generally, people are worried about getting in trouble if they build something wrong, so they stick with what they know. He agrees that the up-front cost of SuperGreen is a bit higher but most of the effort goes into insulation and taking care of vapour-barrier continuity.

He would like to see more contractor breakfasts so builders know they aren't the only ones out there, and more incentives for renewable and energy-efficiency.

Other Energy Efficiency and Sustainability Features

- **Control systems:** Motion and light sensors outside. Wireless thermostats on their baseboards which they hope to figure out how to control with their smartphones.
- **Lighting:** 50% light-emitting diode (LED) lamps (over time they will change the rest over to LED) and some halogen lamps.
- **Appliances:** All appliances are Energy Star® rated. They have a gas range with electric oven.
- **Other features include:** Most windows are located on the south and west sides for solar gain.

Energy Consumption Performance

An EnerGuide rating is a measure of a home's energy performance. EnerGuide has been in place since the mid 1990's. It makes use of actual house parameters like insulation values, mechanical equipment efficiencies and air tightness in a computer energy simulation (Hot 2000) using standardised occupant conditions for plug in loads, hot water use and thermostat settings. The figure below shows the energy breakdown of this house.

The R2000 program has been in place since the 1980's and has been the benchmark for energy efficient new housing in Canada. That benchmark has been upgraded recently, but for reference this house has been compared to the old familiar standard where a house deemed to be efficient gets an 80 or better on the EnerGuide scale.

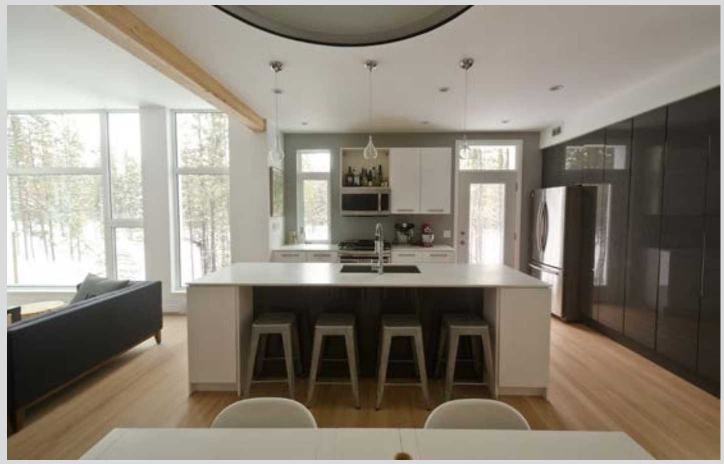
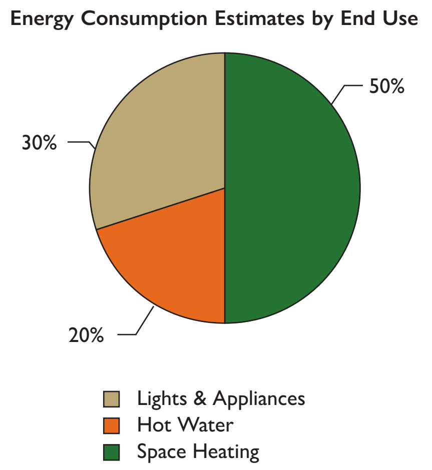
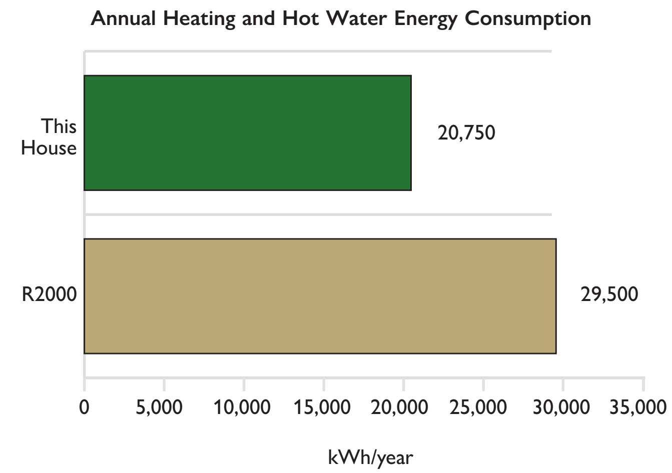


Figure 4: Kitchen

ENERGUIDE RATING: 85





Project latitude	60.5°N
Annual heating degree day zone	>6000HDD°C
Mean January temperature	-16.2°C (2.8°F)
January heating design temperature	-41°C (-43°F)
Heating system design heat load	15.5 kW (52,888) BTU/h)
Main floor(s) heated area	171 m^2 (1,840 ft^2)
Finished basement heated area	103 m^2 (1,104 ft^2)
Total liveable heated area	274 m^2 (1,944 ft^2)
Building footprint	124 m^2 (1,337 ft^2)
Window area	46 m^2 (496 ft^2)
% of windows facing south	41%
Air leakage rate @ -50 Pa (as operated)	0.7 ach
Equivalent leakage area (hole size) @ -10 Pa (as operated)	216 cm^2 (33.5 in^2)
Annual energy use per m^2	107 kWh/m^2
Projected total annual energy usage	29,423 kWh/yr
Actual performance as it compares to occupant utility bills	Data not available - House occupied less than 1 year at time of publication

SuperGreen Homes in the Yukon

Case Study #7 Takhini Hot Springs Road

Summary: *This profile features a house built by a homeowner using high efficiency structural insulated panels (SIPs). This house (Figure 1) is a simple design built 15 km outside of Whitehorse City limits off the Takhini Hotsprings Road. The homeowner chose to build a high-efficiency home, despite the fact that he was not bound by the City's thermal performance bylaws. This house is heated with wood with conventional electric heat as a back-up.*

WHY SUPERGREEN[1]?

Builder, Occupant Comments

The homeowner took the Yukon Housing Corporation (YHC) Homeowner/ Builder Self-Help Course which included one lecture on super energy-efficient construction techniques. He was in the process of designing a "retirement home", so his key criteria were minimizing operating and maintenance costs and minimizing the complexity of running it. SIPs (Figure 2) were more economical for overall cost of installation and have less materials waste. He wanted to build green, but affordable green.

He and his wife would have liked to incorporate renewable energy technologies into the house, but they weren't ready to install any until they were more proven cost effective. Instead they focussed on insulation and air-tightness and a compact design. He used SIPs, and added more insulation to this wall system, quad windows and a double exterior door system and maximized his glazing for solar gain.

For resources, he used information from the YHC course, local energy specialists and consultants, the local window manufacturers, the company who fabricated the SIPs, a building inspector, a civil engineer, a building designer and a carpenter.

Figure 1: SuperGreen House, Whitehorse, Yukon

Figure 2: SIPs assembly

[1] SuperGreen is a Yukon Housing Corporation standard of energy efficient house construction.

Canada

CMHC SCHL

Location

This SuperGreen house is located in an agricultural area off the Takhini Hotsprings Road near Whitehorse, Yukon.

Designer-Builder Team

He and his wife came up with the design and drew up the plans which they gave to the SIPs company who prepared the engineered drawings. They started by contracting a friend who is a carpenter. Together they learned how to assemble the prefabricated SIPs walls and roof based on details from the manufacturer. An example of this is using heavy duty tie down straps to pull sections together for an airtight seal. They were open to experimenting, problem solving and thinking through the details together. The owner and his carpenter completed the majority of the trades work calling upon specific expertise as necessary.

They designed and built the house so they could manage it themselves and so they could control the cost. He was building it primarily for them to live in. They did not run the design through the EnerGuide rating program. They found the building inspector very supportive and helpful with any issues that came up.

Figure 3: SIPs assembly

He suggests that contactors, tradespeople and individual homeowners would benefit from education on SuperGreen (SIPs in particular) education and incentive programs are good promotional tools.

He notes that because heating is very expensive, it's worthwhile to spend extra money up front especially in relatively low cost items like insulation and air tightness.

Type of House

This is a modest-sized detached two-storey house with a 2 m (6.6 ft.) crawlspace and a living area of approximately 214 m^2 (2300 ft^2). It has no attached garage but does have an attached woodshed and has no rental suite. The crawlspace includes 88 m^2 (952 ft^2) for storage and utilities (hot water tank, HRV).

TECHNICAL DETAILS

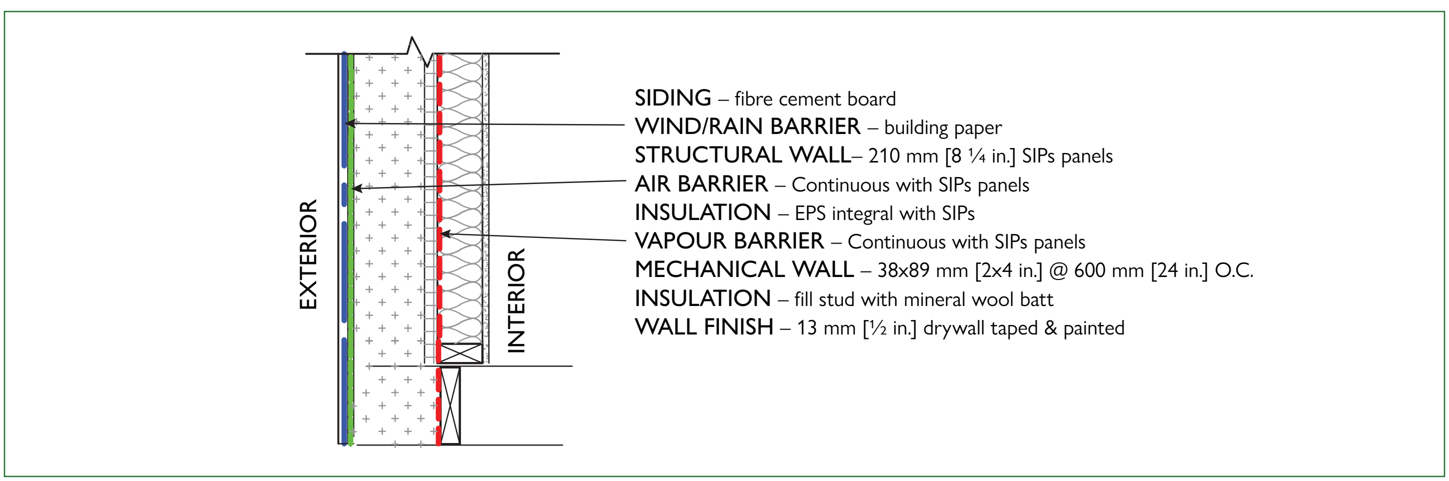


Figure 4: Wall section

Building Envelope

- **Walls (Figure 4):** 21 mm (8 ¼ in.) SIPs RSI 6.4 (R36) with a 38x89 mm (2x4 in.) interior wall against the SIPs insulated with fibreglass batts. Effective RSI 9 (R51.5).
- **Ceilings:** Hot roof cathedral ceiling 300 mm (12 in.) SIPs, Effective RSI 9.2 (R52) insulation.
- **Foundation:** Crawlspace preserved wood foundation (PWF) with staggered double studs on a concrete strip-footing. The sections of the main floor walls that are below ground are built the same as the crawlspace.
- **Foundation floor:** Type IV expanded polystyrene (EPS) and 6 mil poly covered with washed pea gravel.
- **Windows:** Fixed and casement style, quadruple-glazed, argon-filled low-e throughout (locally manufactured).
- **Doors**: Polyurethane foam filled metal doors with glass and locally manufactured double exterior door system.

Mechanical Systems

- **Space heating:** Primary: EPA wood stoves (large one for main heating, smaller one in living area when required). Secondary: Electric baseboards.
- **Ventilation:** Fully ducted Vanee 1001 heat-recovery ventilator (HRV) 67% SRE at -25°C (13°F) balanced at 66 L/s (140 cfm) high speed and 35 L/s (75 cfm) low speed.
- **Hot water:** Electric conserver hot water tank.

Lessons Learned

He chose the wall system for energy efficiency and ease of construction. Though he has no experience with other energy efficient wall systems, he was happy with the house design and with the SIPs. They found that builders/ contractors don't want to build with SIPs because they're not experienced with them and it's not profitable for them because the fabrication and materials purchase occurs elsewhere. For himself as the homeowner, he found SIPs were fast to put up.

Similarly with the site built foundation walls he would use this system again. It was relatively inexpensive and easy to build.

They used fibreglass batt insulation for the foundation walls because of cost, but the alternative would have been spray foam insulation.

Figure 5: Quad windows

He chose quad windows (Figure 5) because they are the most energy efficient. They increased R value by more than 45% compared to triple glazed with coatings for only a 25% increase in cost. He would use quad windows again, but he admits they were very heavy to install. The added bonus is the better sound barrier to outside noise.

For his main entry door he chose a solid single door in combination with an arctic entry. He chose to keep the doors solid and place quad windows adjacent to the doors to let in the light, rather than putting glass in the door.

The other entries use a double door system which is working well, though he thought there might be a frosting issue between two doors but there is no evidence of this so far. The esthetic and convenience trade off was creating the air lock. They found that the thickness of the wall at 330 mm (13 in.) was perfect for this double door system. When you put the two doors together and close them it squeezes the air out. This keeps the inner door warmer.

In a future vaulted ceiling (Figure 6), he would insulate the same way. It was effective and inexpensive and relieved lot of ventilation problems that can occur in an attic. With SIPs he didn't have to apply a vapour barrier because the SIPs are both an air and vapour barrier, but installed one anyhow just to be sure.

For the heating system, he made decisions based primarily on the low capital cost of electric baseboards and wood stoves (Figure 7). Wood is also plentiful and low cost in his area. Baseboards are the least expensive to install, and wood stoves are inexpensive to operate. He keeps the baseboards at a minimum 10 degrees Celsius, he notes they seldom come on.

He wanted to allow natural convection of hot air, so he left the chimney chase open to allow heat to go up to the first floor. He brings the wood through a 'wood bin' like in the old days when they delivered coal. The bin is connected to the wood shed and filled from the outside. He put considerable thought into wood storage and accessibility so he could eliminate the need to carry the wood through the house. He expects to use between 3 and 3 ½ cords of wood per year.

Building a SuperGreen home influenced his choice of heating systems because he believes that using primary wood heat maximizes heating cost efficiency. In the future he plans to explore some different heating system options such as an air source air heat pump as a way of using electric heat more efficiently.

Figure 6: Vaulted ceiling

Figure 7: Wood stove

Other Energy Efficiency and Sustainability Features

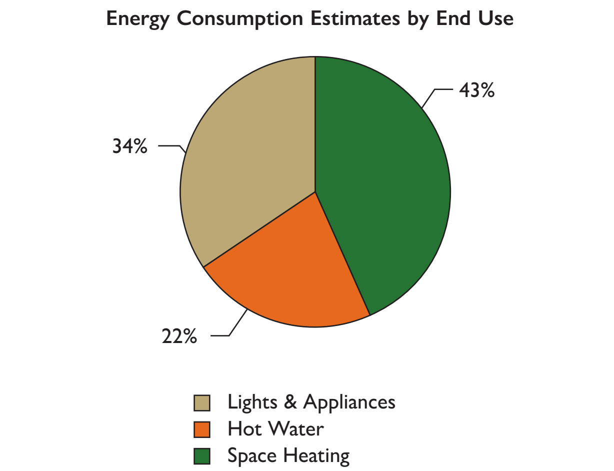
- **Lighting:** Mostly light-emitting diode (LED) lamps and some compact fluorescent lamps.
- **Appliances:** All appliances are Energy Star® rated.
- **Other features include:** Four rainwater collection barrels for gardens, induction cook stove, a simple high efficiency bath fan air circulation system to move heated air from the wood stove to other rooms; and a stairway ceiling fan to move heat around. They collected their untreated waste construction wood and use it for kindling.

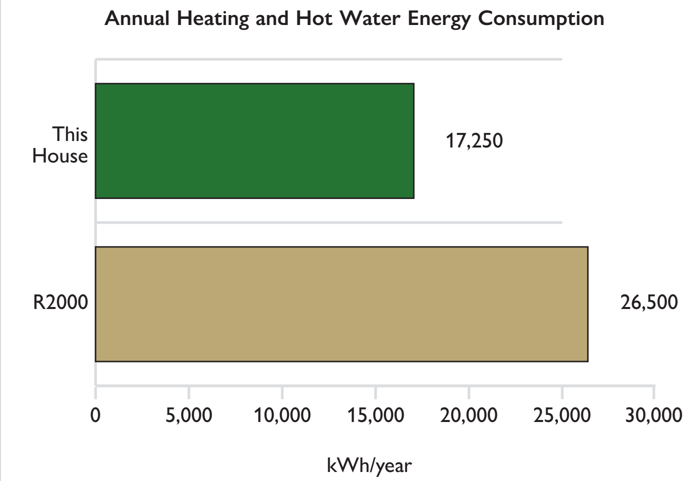
Energy Consumption Performance

An EnerGuide rating is a measure of a home's energy performance. EnerGuide has been in place since the mid 1990's. It makes use of actual house parameters like insulation values, mechanical equipment efficiencies and air tightness in a computer energy simulation (Hot 2000) using standardised occupant conditions for plug in loads, hot water use and thermostat settings. he figure below shows the energy breakdown of this house.

The R2000 program has been in place since the 1980's and has been the benchmark for energy efficient new housing in Canada. That benchmark has been upgraded recently, but for reference this house has been compared to the old familiar standard where a house deemed to be efficient gets an 80 or better on the EnerGuide scale.

ENERGUIDE RATING: 85





Project latitude	60.5°N
Annual heating degree day zone	>6000HDD°C
Mean January temperature	-16.2°C (2.8°F)
January heating design temperature	-41°C (-43°F)
Heating system design heat load	10.5 kW (35,827 BTU/h)
Main floor(s) heated area	185 m^2 (1,988 ft^2)
Finished basement heated area	88 m^2 (952 ft^2)
Total liveable heated area	185 m^2 (1,988 ft^2)
Building footprint	100 m^2 (1,080 ft^2)
Window area	31.8 m^2 (342 ft^2)
% of windows facing south	61%
Air leakage rate @ -50 Pa (as operated)	1 ach
Equivalent leakage area (hole size) @ -10 Pa (as operated)	277 cm^2 (43 in^2)
Annual energy use per m^2	140 kWh/m^2
Projected total annual energy usage	25,936 kWh/yr
Actual performance as it compares to occupant utility bills	Data not available - House occupied less than 1 year at time of publication

SuperGreen Homes in the Yukon

Case Study #8 Nijmegan Road

Summary: *This profile features a duplex (Figure 1) built by a contractor-designer who incorporated old, simple, high-quality ideas with SuperGreen energy-efficiency. This is the first Leadership in Energy and Environmental Design (LEED) Canada for Homes certified project in Yukon. The wall design is a 38x89 mm (2x4 in.) double stud wall filled with low-density spray foam insulation. The house has electric heat, but also incorporates thermal storage in the basement floor to reduce electrical peaks on the grid.*

WHY SUPERGREEN[1]?

Builder, Occupant Comments

The designer-builder attended a talk on a SuperGreen house which Yukon Housing Corporation (YHC) built in Watson Lake. He was taken by the comment that "there is nothing simpler to do". Building for sustainability and reducing the risk to fluctuating energy costs inspired his decision to build high-efficiency.

This is a two-storey duplex with a basement, no heated attached garage and no secondary suite. It was built as an investment and to showcase the energy efficiency.

Figure 1: SuperGreen House, Whitehorse, Yukon

Location

This SuperGreen house is located in the infill neighbourhood of Takhini North, Whitehorse, Yukon.

Designer-Builder Team

The design approach was based on YHC's design and included lots of insulation. A small-construction contractor agreed to take on the project. The contractor had no previous experience in building SuperGreen, but was willing to be innovative and try new things.

The tradespeople who worked on this house had worked on other houses as a team. They worked well together under the jobsite supervision and coordination of the owner-builder. None of the trades prepared drawings in advance, but there was an initial team meeting to kick off the project and identify potential problems. Since the design was based on YHC's SuperGreen, they did not use the EnerGuide Rating program to evaluate building options. While the EnerGuide program results were not used to model different "what-if" scenarios, the design was used in the EnerGuide modelling to achieve a LEED certification for the house.

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[1] SuperGreen is a Yukon Housing Corporation standard of energy efficient house construction.

Canada

CMHC SCHL

Type of House

This house is 2-storey side by side duplex constructed on a full unfinished basement. Each side is 89 m^2 (960 ft^2). The project was built as a spec home and it has been awarded LEED Canada for Homes Gold certification.

TECHNICAL DETAILS

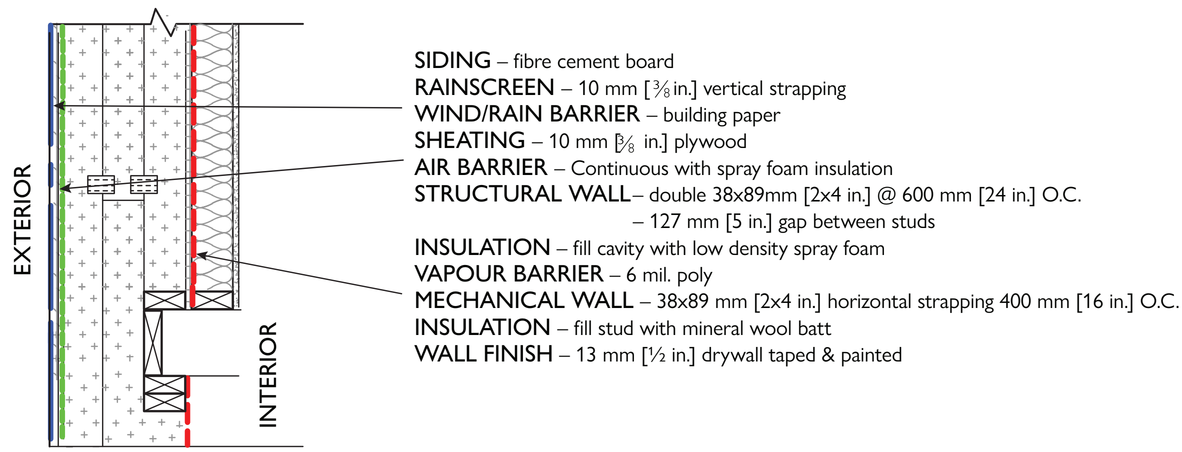


Figure 2: Wall section

Building Envelope

- **Walls (Figure 2):** Double 38x89 mm (2x4 in.) stud truss type wall. The cavity was filled with low-density foam insulation, with the poly air-vapour barrier on the inside of this double wall. They added an additional interior 38x89 mm (2x4 in.) wall insulated with mineral wool for mechanical/electrical services. Effective RSI 9.2 (R52).
- **Ceilings:** Vented attic, high heel trusses, RSI 17.6 (R100), cellulose.
- **Foundation:** Insulated concrete form (ICF) foundation RSI 6.9 (R39).
- **Foundation floor:** 6 inches of type IV expanded polystyrene foam (HS40) RSI 5.3 (R30) under concrete slab.
- **Windows:** Vinyl, fixed and casement style, triple-glazed, argon-filled, low-e on all windows (locally manufactured).
- **Doors:** Metal polyurethane foam-filled double door arctic-combo system.

Figure 3: Hot water

Mechanical Systems

- **Space heating:** Electric baseboard, in-slab radiant heat in basement for thermal storage. Electric baseboards were chosen for low-cost and simplicity. A high-performance house doesn't consume much energy, so no need for an expensive heating system. As well, it's considered to be "green" energy when hydro-electricity is available.
- **Ventilation:** Fully ducted Venmar EKO 1.5 ECM heat- recovery ventilator (HRV) 64% SRE at -25°C (13°F) balanced at 57 L/s (120 cfm) high speed and 28 L/s (60 cfm) low speed.
- **Hot water:** Electric conserver tank with drain water heat recovery on main drain line (Figure 3).

- **Renewable energy system:** Provisions were made for solar photovoltaic (PV) and solar hot water, but systems are not installed at this time. This included installing chases from the attic to the basement for solar hot water lines plus pre-wiring from the attic to the electrical panel area for future solar PV. The long-axis of the house is East-West with the roof slope oriented south to facilitate the installation of solar PV or thermal panels.

Lessons Learned

If he was doing it again, the owner-builder would fine-tune the wall system to speed up construction and "constructability". He would use taller floor joists and better plan where the ductwork was going in advance to reduce bulkheads from dropped ductwork in the ceiling.

The builder prefers the approach of insulating from the inside to allow a better plan for the connections between walls and ceilings.

Another challenge was convincing the plumber not to make an attic access hole in the air-vapour barrier. In the end, it is the general contractor who has to fix the leaks.

Next time, this builder would use the same design (ICF) for the foundation walls – resilient, strong, fast, easy to work on (Figure 4). They would also use the same method for the floor. As well, they were very happy with using blown cellulose for ceiling insulation. It is inexpensive to install and effective.

Locally manufactured windows were chosen for availability, performance and price, but they have un-insulated vinyl frames at this time unless they are insulated as a special request.

Figure 4: ICF detail

Other Energy Efficiency and Sustainability Features

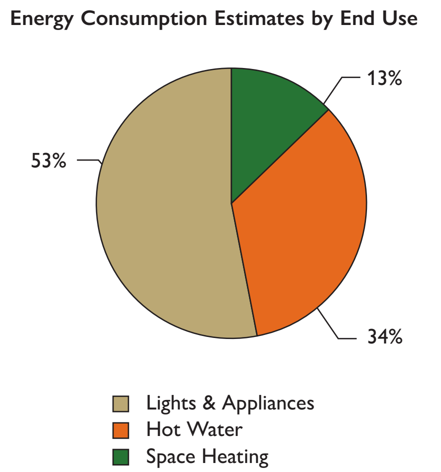
- **Control systems:** Programmable setback thermostats in each room.
- **Lighting:** Combination of compact fluorescent lamps (CFL), light-emitting diode (LED), incandescent and halogen lamps. Some motion-sensors in closets.
- **Appliances:** All appliances are Energy Star® rated.
- Indoor environment features include hard surface floors (easily cleaned so better air quality due to less dirt & dust) and good climate control (walls are very well-insulated, so the house maintains a more constant temperature and is therefore very comfortable).
- Purposeful low-waste building practices – careful sorting and re-use facilitated by using only 38x89 mm (2x4 in.) dimensional lumber for the walls rather than several sizes.

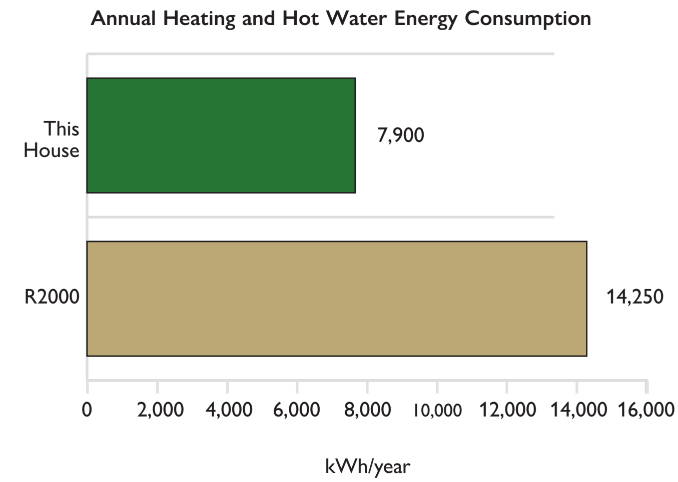
Energy Consumption Performance

An EnerGuide rating is a measure of a home's energy performance. EnerGuide has been in place since the mid 1990's. It makes use of actual house parameters like insulation values, mechanical equipment efficiencies and air tightness in a computer energy simulation (Hot 2000) using standardised occupant conditions for plug in loads, hot water use and thermostat settings. The figure below shows the energy breakdown of this house.

The R2000 program has been in place since the 1980's and has been the benchmark for energy efficient new housing in Canada. That benchmark has been upgraded recently, but for reference this house has been compared to the old familiar standard where a house deemed to be efficient gets an 80 or better on the EnerGuide scale.

ENERGUIDE RATING: 85





Project latitude	60.5°N
Annual heating degree day zone	>6000HDD°C
Mean January temperature	-16.2°C (2.8°F)
January heating design temperature	-41°C (-43°F)
Heating system design heat load	4.5 kW (15,354 BTU/h)
Main floor(s) heated area	74 m^2 (792 ft^2)
Finished basement heated area	37 m^2 (396 ft^2)
Total liveable heated area	111 m^2 (1,188 ft^2)
Building footprint	45 m^2 (480 ft^2)
Window area	12.4 m^2 (134 ft^2)
% of windows facing south	29%
Air leakage rate @ -50 Pa (as operated)	0.62 ach
Equivalent leakage area (hole size) @ -10 Pa (as operated)	59 cm^2 (9.2 in^2)
Annual energy use per m^2	150 kWh/m^2
Projected total annual energy usage	16,644 kWh/yr
Actual performance as it compares to occupant utility bills	20% less annual energy was used over 2-year period than predicted due to occupant lifestyle (both sides show same trend)

SuperGreen Homes in the Yukon

Case Study #9 Phoenix Rising

Summary: *This profile features the first of Habitat for Humanity's (HFH) SuperGreen houses built in the Yukon. They began constructing this triplex after Yukon Housing Corporation (YHC) built their first SuperGreen houses. HFH is a non-profit organization that builds houses for families in need, who are not eligible for a conventional mortgage.The family must have lived in the Yukon for one year.*

On the site of an ex-drug house, the process of building this home – aptly named "Phoenix Rising" – was meant to put some positive energy back into the property.

In addition to employing local tradespeople, Phoenix Rising incorporated labour that benefitted many aspects of the community. Yukon College carpentry, plumbing and electrical classes also gained hands-on experience with SuperGreen construction techniques. Whitehorse Corrections Centre contributed work crews. As well as the regular volunteers, the would-be owners invested sweat equity into their future home.

This house has a truss wall where the exterior is a non-bearing 38x70 mm (2x3 in.) the interior framing of the trus is a structural 38x89 mm (2x4 in.).

The cavity is filled with dense packed cellulose insulation. This house is heated with conventional electric baseboard to simplify maintenance costs.

WHY SUPERGREEN[1]?

Builder, Occupant Comments

The primary builder-designer, who also runs the carpentry program at Yukon College, has always been interested in energy efficiency. Phoenix Rising was a champion project for the carpentry program, providing students with a chance to work alongside and learn about YHC and HFH.

The design focused on the building envelope, insulation and windows. Using publications from the Canadian Wood Council, the wall system was developed under the guidance of YHC who was extensively involved in the project.

Figure 1: SuperGreen House, Whitehorse, Yukon

[1] SuperGreen is a Yukon Housing Corporation standard of energy efficient house construction.

The builder-designer thinks that increased costs and the need for more training of trades is a limiting factor to broader adoption of SuperGreen. Phoenix Rising did a lot of advertising about the project, presenting the public with straightforward easily understood cost-benefit analysis.

Location

This SuperGreen house is in an urban residential area on Wheeler Street in downtown Whitehorse, Yukon.

Designer-Builder Team

While several people with plenty of experience in designing and building houses were part of the project team, this project did not have a designer per se. They had a technical committee – consisting of a team of skilled people both paid and unpaid including YHC, Whitehorse Bylaw, contractors and the Energy Solutions Centre to provide feedback and recommendations on the house components. Final decisions rested with HFH's Board of Directors.

Yukon College carpentry program instructor fulfilled the role of site supervisor while the building was being clad to weather. This included coordinating all of the trades, specialists, carpentry students and volunteers, who were coming in to help throughout the project as needed. Most of the people who worked on this house had not worked together before. However, in keeping with the practice of Yukon College carpentry program, they all met regularly to discuss any issues and next steps.

Paid tradespeople were provided with drawings of the house and expected to show plans of where wiring and plumbing would go for Yukon College students to install.

Type of House

This is a modest two-storey triplex on a 1.2 m (4 ft.) crawlspace with each unit having 130 m^2 (1400 ft^2) of living area. There are no additional suites.

TECHNICAL DETAILS

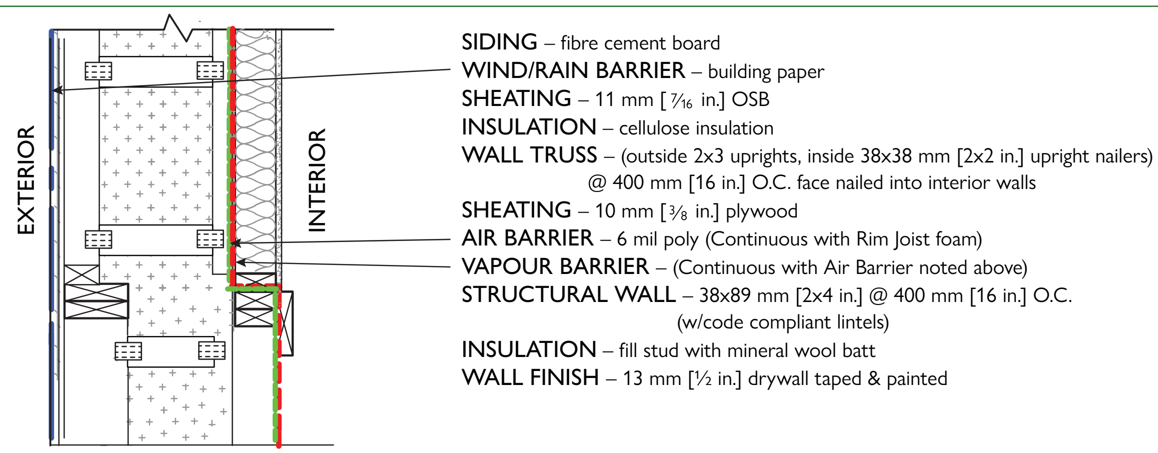


Figure 2: Wall section

Building Envelope

- **Walls (Figure 2):** Hybrid custom Larsen truss, 360 mm (14 in.) stand-off on the outside of a 38x89 mm (2x4 in.) inner frame wall. Effective RSI 9.9 (R56).
- **Ceilings:** High heel trusses, vented attic with blown cellulose RSI 14 (R80).
- **Foundation:** Foundation walls similar to main floor but used preserved wood below grade.
- **Foundation floor:** 2 inch layer of type IV expanded polystyrene (EPS) RSI 1.8 (R10) on the ground.
- **Windows**: Fixed and casement style, quadruple-glazed, argon-filled, low-e throughout (locally manufactured).
- **Doors:** Double-door system - two exterior polyurethane insulated doors - one interior to the wall, one exterior to the wall.

Mechanical Systems

- **Space heating:** Electric baseboard, chosen for economy.
- **Ventilation (Unit A):** Fully ducted Eneready 2000 Diamond E heat-recovery ventilator (HRV) 70% SRE at -25°C (13°F) balanced at 57 L/s (120 cfm) high speed and 24 L/s (50 cfm) low speed.
- **Hot water:** Electric conserver tank.
- **Renewable energy system:** Passive solar gain only.

Lessons Learned

The design took a few false starts to get on track. After some initial floundering the project was reassigned to Yukon College carpentry program and YHC who embraced the opportunity to work together to build a SuperGreen home for HFH. Still, the main hurdle for this project was that there wasn't a proper designer on the team. This created many problems, particularly with integrating mechanical systems, electrical and plumbing (Figure 3).

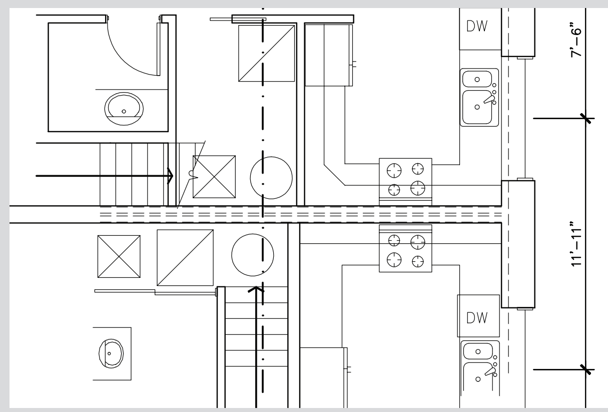


Figure 3: Mechanical systems, electrical and plumbing

The electrical, plumbing and HRV were all installed by the college trades classes so knowing exactly what to do at the outset was paramount.

Finishing of the house was taken on by another group and not all the details were known by all the groups involved. The project survived numerous challenges along the way, partially due to the nature and timing of the project, coordinating professional tradespeople and institutional involvement in the process. They obtained variances from local authorities to allow the building to encroach on the property boundaries.

Throughout construction, YHC ran EnerGuide models and the team incorporated changes based on the results for economics and other considerations.

They chose a Larsen wall-truss system (Figure 4) in order to completely wrap the building in a solid layer of cellulose insulation with no thermal bridging. However, while the builder liked the idea of it on a very simple box shaped building, if they were doing it again, he thinks the stand-off wall was perhaps a bit too deep and overall success depends upon the cellulose applicator's experience.

Figure 4: Larsen wall-truss system

The cellulose settled in the wall leaving a gap at the top, so the walls had to be topped up during construction. Due to uncertainty with future cellulose settling, and the way HFH builds their houses - particularly using volunteer labour – this wall system is no longer used. Construction took somewhat more time than standard, partly due to the number and variety of experience of the people working on it.

For the foundation walls, the preserved wood truss walls were difficult to design to support lateral soil pressure. They wouldn't choose this foundation wall system again and would use insulated concrete forms (ICF) if the project could afford it. They were satisfied with the ceiling system and would do it the same way again. They chose electric heat because it is inexpensive to install, and cost efficient in a super insulated house.

The main builder (college carpentry instructor) has experience with different wall systems, but he has no favourite – it depends on the context. His own home has just 38x140 mm (2x6 in.) walls, but he regrets not building a thicker wall. He has a friend who attempted to build a SuperGreen house, influenced by Phoenix Rising, but it went very badly due to lack of builder understanding of the wall system.

The double door combination of two exterior doors (one interior one exterior) needed to be refined to allow a vented lite in one door for pressure relief. The extra thick wall assembly is also believed to put the doors too far apart and have too much space between causing moisture issues (freezing locks).

Other Energy Efficiency and Sustainability Features

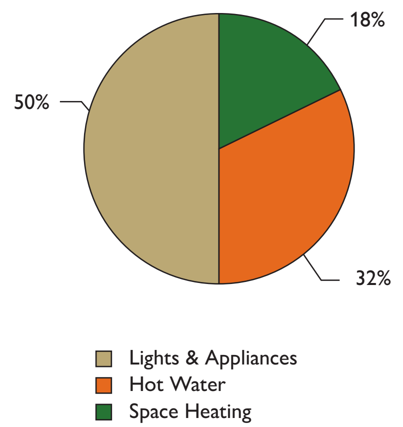
- **Appliances:** All appliances are Energy Star® rated.
- **Other features include:** Drain water heat recovery on drain line. This triplex received the first production quadruple-pane windows from the local manufacturer.

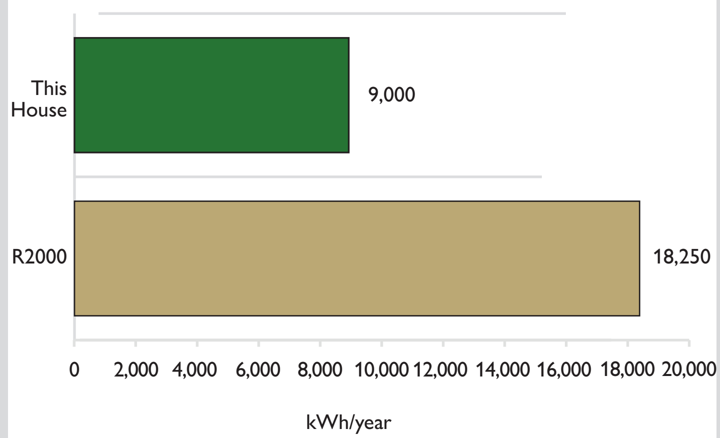
Energy Consumption Performance (Unit A)

An EnerGuide rating is a measure of a home's energy performance. EnerGuide has been in place since the mid 1990's. It makes use of actual house parameters like insulation values, mechanical equipment efficiencies and air tightness in a computer energy simulation (Hot 2000) using standardised occupant conditions for plug in loads, hot water use and thermostat settings. The figure below shows the energy breakdown of this house.

The R2000 program has been in place since the 1980's and has been the benchmark for energy efficient new housing in Canada. That benchmark has been upgraded recently, but for reference this house has been compared to the old familiar standard where a house deemed to be efficient gets an 80 or better on the EnerGuide scale.

ENERGUIDE RATING: 87





Project latitude	60.5°N
Annual heating degree day zone	>6000HDD°C
Mean January temperature	-16.2°C (2.8°F)
January heating design temperature	-41°C (-43°oF)
Heating system design heat load	5.5 kW (18,766 BTU/h)
Main floor(s) heated area	130 m^2 (1,404 ft^2)
Finished basement heated area	65 m^2 (702 ft^2)
Total liveable heated area	130 m^2 (1,404 ft^2)
Building footprint	217.7 m^2 (2,344 ft^2)
Window area	21.2 m^2 (228 ft^2)
% of windows facing south	38%
Air leakage rate @ -50 Pa (as operated)	1.1 ach
Equivalent leakage area (hole size) @ -10 Pa (as operated)	136.1 cm^2 (21.1 in^2)
Annual energy use per m^2	136 kWh/m
Projected total annual energy usage	17,726 kWh/yr
Actual performance as it compares to occupant utility bills	2% below projected averaged over a 4-year period

SuperGreen Homes in the Yukon

Case Study #10 Kų Kàtthe Ä́ą

Summary: *This profile features a triplex in the Takhini River subdivision built by Habitat for Humanity Yukon (HFHY) in partnership with the Champagne and Aishihik First Nations (CAFN).*

The design involved building external structural walls spaced away from a second mechanical service wall on the inside. The cavity was filled with mineral wool insulation and 2 lb. spray foam insulation. This system enabled high insulation values and allowed as much volunteer labour as possible without concern for the impact on air/vapour barrier detailing. The triplex is heated with electric baseboards to simplify maintenance costs.

WHY SUPERGREEN[1]?

Builder, Occupant Comments

HFHY has committed to building SuperGreen to provide affordable living for their clients. CAFN advocates for environmental conservation by utilizing energy-efficient building techniques and technologies that promote sustainability. This partnership was based on achieving common goals.

One objective of CAFN's Leadership is to promote self-reliance through home ownership and trades-related training. This SuperGreen house, named *Kų Kàtthe Ä́ą*, meaning "First House", was a collaborative project bringing together many different organizations.

The Chief of CAFN strongly supported the collaboration, saying "This project is based on the traditional values of our people who used to help each other survive. That kind of co-operation is a value that has been eroded over the years, and I think *Kų Kàtthe Ä́ą* will help to bring it back."

Figure 1: SuperGreen House, Whitehorse, Yukon

[1] SuperGreen is a Yukon Housing Corporation standard of energy efficient house construction.

Canada

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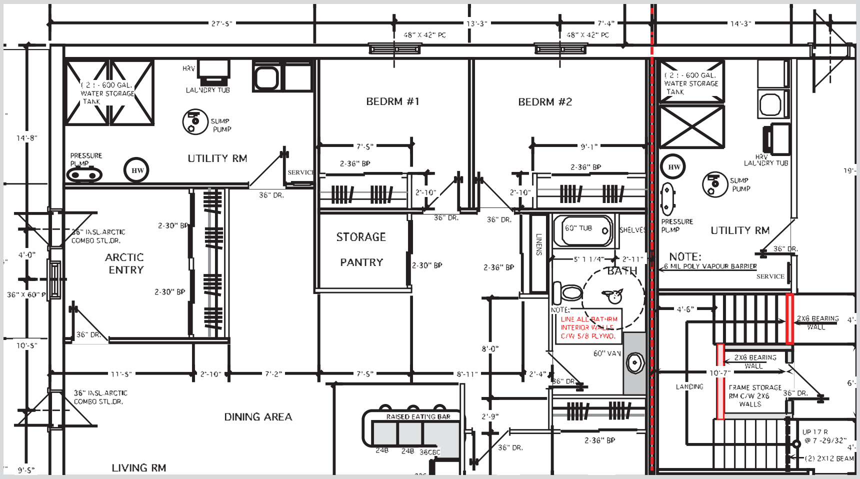


Figure 2: Main floor plan

Location

This SuperGreen house is located in the Takhini River Subdivision 50 km east of Whitehorse, Yukon.

Designer-Builder Team

Through their experience building several SuperGreen houses, HFHY has established a building committee, with includes SuperGreen building specialists and experts in various fields of high-efficiency products and technologies. Their goal is to achieve a minimum EnerGuide Rating of 86 on each project.

The actual construction of this triplex was a highly collaborative and volunteer-based undertaking. Over the course of construction, volunteers on the site included CAFN citizens, staff and leadership, chiefs from other Yukon First Nations, HFHY's Executive Director, President and Board members, several representatives of HFH's national Global Village Director and Aboriginal Housing Program National Manager, Yukon Government MLA's, members of the RCMP, Yukon College, Yukon Housing Corporation and Canada Mortgage and Housing Corporation.

During one especially productive week of construction, National Assembly of First Nations Chief and other First Nation Dignitaries along with the HFH National Leadership Team came to Whitehorse to swing hammers at *Kų Kàtthe Ä'ą*. Canada's Governor General also contributed volunteer labour to the building.

Tradespeople on the site were provided with a full set of plans to guide their work. They were also charged with the responsibility of coordinating the work and managing the volunteers on a continuous basis.

Type of House

Kų Kàtthe Ä'ą is a triplex consisting of two 3-bedroom single storey units on either side of a 4-bedroom, 2-story unit. Unlike a typical town-house or condo, the entryways for the end units are located on the sides of the building to offer maximum privacy.

The house incorporates many accommodating features that allow the home to be easily adapted for life's changing needs. This includes wider halls and doorways and wheel-chair turning areas in the bathroom and kitchen. In the middle unit, extra large closets allow room to install a lift if needed in the future. There is ample "flex" space on the main floor to build an additional bedroom. The homes are built as a slab on grade.

TECHNICAL DETAILS

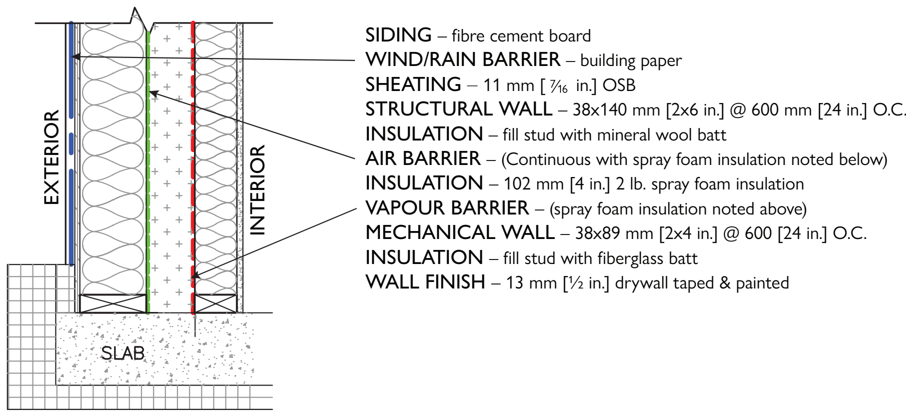


Figure 3: Wall section

Building Envelope

- **Walls (Figure 3):** Structural 38x140 mm (2x6 in.) walls with mineral wool insulation, spaced 100 mm (4 in.) away from a second internal 38x89 mm (2x4 in.) wall, also insulated with mineral wool. The space between the walls is filled with 2 lb spray foam insulation.
- **Ceilings:** High heel trusses with RSI 17.6 (R100) cellulose.
- **Foundation:** Slab on grade with RSI 3.5 (R20) foam insulation underneath.
- **Windows:** Fixed and casement style vinyl, quad glazing, argon-filled, low-e (no low-e on south side to maximize solar gain), locally manufactured.
- **Doors:** Metal polyurethane insulated double (inner and outer) door system, locally manufactured.

Figure 4: Interior view

Mechanical Systems

- **Space heating:** Electric baseboard.
- **Ventilation:** Fully ducted Venmar EKO 1.5 heat-recovery ventilator (HRV) 64% SRE at -25°C (13°F) balanced at 57 L/s (120 cfm) high speed and 28 L/s (60 cfm) low speed.
- **Hot water:** Electric conserver tanks.
- **Renewable energy system:** 14 kW grid-connected solar photovoltaic (PV) system distributed over the 3 units.

Lessons Learned

The wall system used in this building is simple enough to allow a high amount of volunteer involvement in the construction and it has a high insulation value. For these reasons, HFHY has adopted it as their new wall system of choice. To reduce the number of different dimensions and types of materials on site they ordered only mineral wool insulation, and only as thick batts. When thinner insulation was needed for the inner wall they were able to split them with a bread knife. This process worked quite well and simplified the ordering of materials.

Figure 5: Exterior view

The double door system works well in this wall system with very few frost issues.

The decision to install simple electric baseboard heaters eliminates regular maintenance and servicing costs associated with furnaces and boilers.

The lot allowed for sitting the wall of building with the most glazing directly south to maximize passive solar gains. To encourage solar heat gains, the windows on the south side do not have a low-e coating.

The solar array is located on the rooftops of the triplex. The roofs are intentionally asymmetric and face north and south to optimize the slope of the array for solar collection without unintentionally adding wind or snow loading to the structures.

ATCO Electric Yukon contributed financially to the installation of the 14 kW solar PV system. The executive director of HFHY arranged the donation of the solar modules from a company in Ontario. Another Ontario manufacturer provided a discount on the string inverters.

Other Energy Efficiency and Sustainability Features

- **Lighting:** Lighting is compact fluorescent lamps (CFL).
- **Appliances:** All appliances are Energy Star® rated.
- **Other features include:** Grid-connected solar array with string inverters that can provide some electricity in the event of regional power outages.

House Energy Consumption Performance

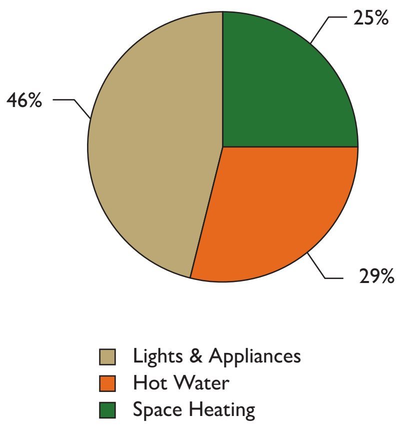
An EnerGuide rating is a measure of a home's energy performance. EnerGuide has been in place since the mid 1990's. It makes use of actual house parameters like insulation values, mechanical equipment efficiencies and air tightness in a computer energy simulation (Hot 2000) using standardised occupant conditions for plug in loads, hot water use and thermostat settings. The figure below shows the energy breakdown of this house.

The R2000 program has been in place since the 1980's and has been the benchmark for energy efficient new housing in Canada. That benchmark has been upgraded recently, but for reference this house has been compared to the old familiar standard where a house deemed to be efficient gets an 80 or better on the EnerGuide scale.

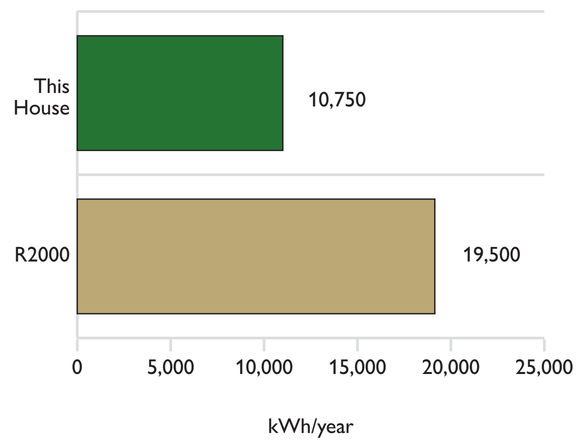
ENERGUIDE RATING: 86

without solar PV array (90 including the solar PV array)
(All data below shows without array)

Energy Consumption Estimates by End Use



Annual Heating and Hot Water Energy Consumption



Project latitude	60.5°N
Annual heating degree day zone	>6000HDD°C
Mean January temperature	-16.2°C (2.8°F)
January heating design temperature	-41°C (-43°F)
Heating system design heat load	6.5 kW (22,179 BTU/h)
Main floor(s) heated area	183 m² (1,974 ft²)
Finished basement heated area	183 m² (1,974 ft²)
Total liveable heated area	196 m² (2,112 ft²)
Building footprint	12.9 m² (139 ft²)
Window area	55%
% of windows facing south	0.8 ach
Air leakage rate @ -50 Pa (as operated)	141 cm² (21.9 in²)
Equivalent leakage area (hole size) @ -10 Pa (as operated)	107 kWh/m²
Annual energy use per m²	19,604 kWh/yr
Projected total annual energy usage	Data not available - House occupied less than 1 year at time of publication
Actual performance as it compares to occupant utility bills	2% below projected averaged over a 4-year period

CMHC Project Manager: Catherine Soroczan
Consultant: Energy Solutions Centre

Housing Research at CMHC

Under Part IX of the ***National Housing Act,*** the Government of Canada provides funds to CMHC to conduct research into the social, economic and technical aspects of housing and related fields, and to undertake the publishing and distribution of the results of this research.

This Case Study is one of a series intended to inform you of the nature and scope of CMHC's research.

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