Case Study #4 Timber Frame

SUMMARY: This profile features a timber frame house (Figure 1) built as a “spec” house by a team of three contractor-builders. Outside the timber framed walls, they built a 38x89 mm (2x4 in.) wall, insulated with mineral wool batts and a 300 mm (12 in.) Larsen truss with low density spray foam insulation. The house has baseboard electric heat with a propane fireplace. It includes a separate suite above the garage to provide extra rental income to offset the costs of building SuperGreen. The suite was rented before the house was sold.


Figure 1: SuperGreen House, Whitehorse, Yukon

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.

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.

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

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

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.

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.

Figure 2: Setting timber structure

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

Building Envelope:

- Walls (Figure 4): 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).

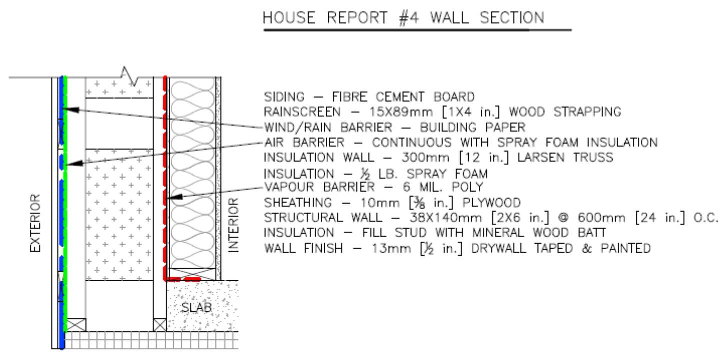


Figure 3: Wall section

- 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.

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 5) - 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 4: Drain water heat recovery

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.

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.

Figure 5: Timber structure

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.


Figure 6: Interior view

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:

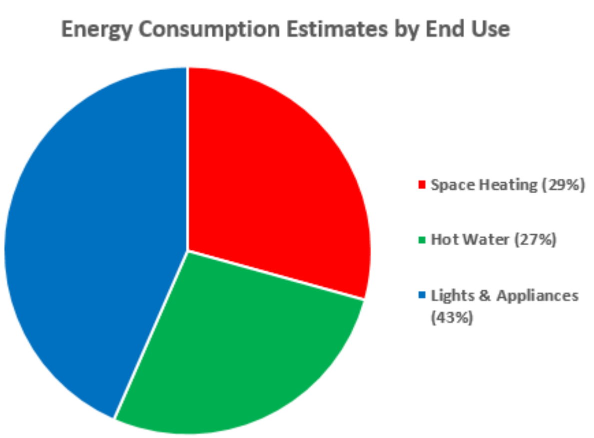
- Control systems: Outside motion sensor.
- Lighting: Compact fluorescent lamps (CFL) and some light-emitting diode (LED) lamps.
- Appliances: All appliances are Energy Star® rated.
- Other features include: Each room has its own thermostat, can be replaced with programmable thermostats in the future.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

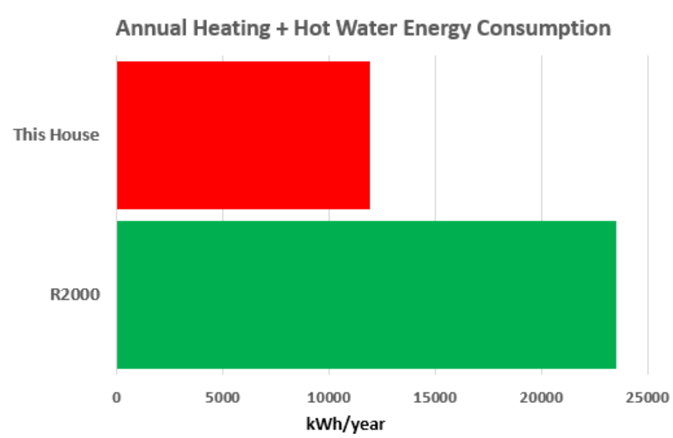
Energy Consumption Performance:

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





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)
Slab heated area	81 m^2 (874 ft^2)
Total liveable heated area	112 m^2 (1,208 ft^2)
Building footprint	93 m^2 (1000 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

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