Wood Fibre Prefabricated Exterior Energy Retrofits

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HSS DESIGN BUILD
SUSTAINABLE & PASSIVE HOMES

1 Detailed background of existing building

1.1 Site

The site is a pie-shaped lot at the end of Larch Place, off Larch Avenue, backing onto Policeman's Creek Boardwalk and the Canmore Golf and Country Club. The neighborhood is known for coarse river formed soils and a high-water table causing moisture issues in crawlspaces.

1.2 Building overview

The project building is a modular home measuring 48' 7" long by 24' 8" oriented north/south. It was delivered to site in two halves measuring 48' 7" long by 12' 4" wide and placed on a partially conditioned concrete foundation in 1979. The building remained largely unchanged and received only basic maintenance and no upgrades until the PEER was completed in the spring of 2025. Canmore is located in climate zone 7A and designated as part of the Cold Climate Zone by the Passive House Institute.

1.2.1 Original construction

1.2.1.1 Foundation

The exterior of the building sits on a concrete stem wall foundation creating a roughly 4' deep semi conditioned crawlspace. Three concrete piles down the center of the crawl space support steel columns connected to a steel truss to support the center of the building. The stem wall is lined with EPS insulation for an effective R-value of 9.

Figure 1. Vented crawlspace features a dirt floor, concrete walls covered with Styrofoam and plywood, steel structural elements, heating system ductwork, and the sewer drain system.

1.2.1.2 Wall Assembly

The original exterior walls of the building are standard 2" by 4" wall construction of exterior cladding, tar paper, 1/2" plywood sheathing, 2" by 4" studs with fiberglass batt insulation in the cavities, 3 mm polyethylene, and 1/4" wood paneling. One unusual feature of the wall assembly is the horizontal strapping embedded into the studs to support the wood paneling which sandwiches the 3mm polyethylene.

Figure 2. 2" by 4" stud wall construction with 1" by 4" notched in above polyurethane vapour barrier. Aluminium windows had poor energy performance and leaked air.

1.2.1.3 Roof assembly

As the building was constructed in two halves meeting along the peak of the roof, the attic is composed of two truss systems supported by the center wall of the building. The roof assembly is also standard for the time it was constructed with Asphalt shingles, tar paper, and ½" plywood over a vented attic. The attic had 6" to 8" of cellulose insulation, 3mm polyethylene, 1/2" fibre board, and wood paneling or painted roof panels.

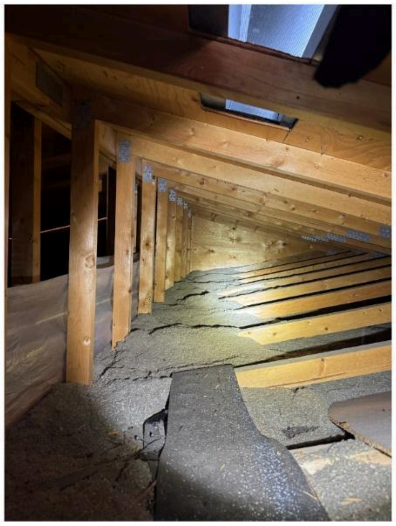


Figure 3. Standard attic build up with minimal insulation. Leaks were repaired and blow-in wood fibre to be added.

1.2.1.4 Heating

The heating system consisted of a forced air natural gas furnace operating at 80 percent efficiency. Air was delivered through ductwork below the floor in the semi conditioned crawl space. There was a hole cut in the ductwork in the crawlspace to maintain enough heat in the crawlspace to prevent it from freezing.

1.2.1.5 Cooling

The building contained no cooling system aside from openable windows and fresh air intake vents in some bedrooms.

1.2.1.6 Fresh air

There was no mechanical fresh air supply system for the building. The only source of fresh air was openable windows in most rooms and openable fresh air intake vents located in some bedrooms.

1.2.2 Occupant comfort issues

The previous owners were not available to complete an occupant survey to identify occupant comfort issues. But, given the construction of the building and the appliances in it, it is likely there were significant comfort issues associated with drafts, cold floors, and poor air quality at a minimum.

1.3 Building performance

1.3.1 Airtightness

An EnerGuide Evaluation was completed as part of the renovation which includes a blower door test before and after the renovation. The building achieved an air leakage of 8.54 ACH50 before the renovation. Air leakage was occurring at many locations in the building including windows, doors, the fireplace, power outlets, attic penetrations, the furnace and floor penetrations to the crawlspace. While there were significant leaks in many components of the building, there were significant leaks into the crawlspace with the furnace penetration being the largest and the duct work also being a significant source of leakage.

1.3.2 EnerGuide performance

The EnerGuide model predicted the existing building would use 126 Gigajoules (GJ) of energy each year compared to 69 GJ for a typical new house and predicted the building could use just 42 GJ if extensive improvements were completed.

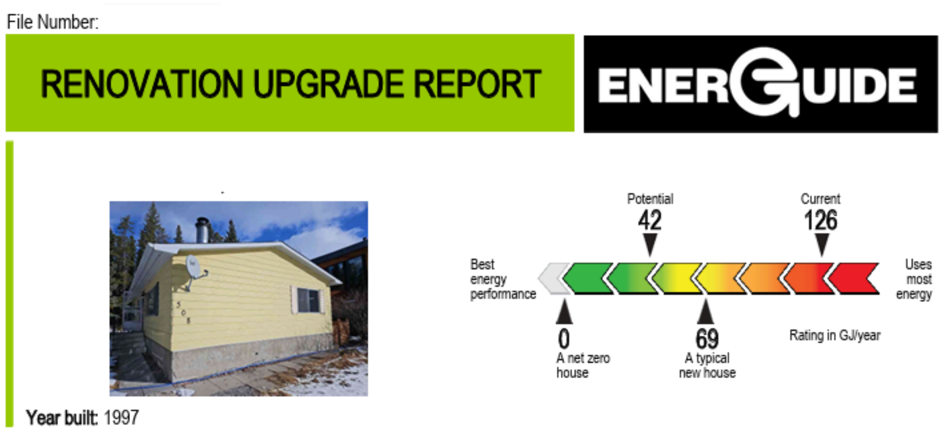


Figure 4. As part of the EnerGuide evaluation a renovation upgrade report is produced which recommends energy saving upgrades as well as this graphic displaying the current and potential energy performance of the building.

Unsurprisingly, the EnerGuide Evaluation determined that space heating is the predominant energy use in the building. The evaluation identified Windows, air leakage, the main walls, and the attic as the largest sources accounting for 34 percent, 25 percent, 20 percent, and 9 percent of heat loss respectively.

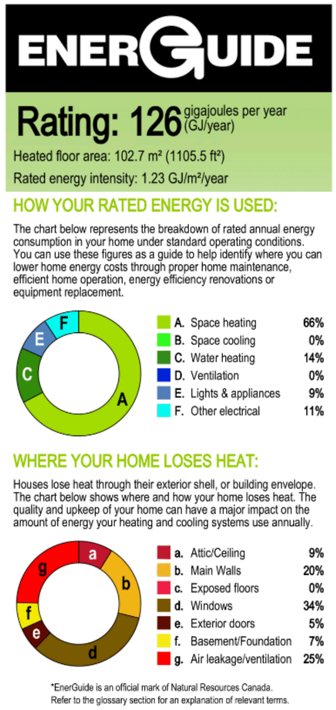


Figure 5. As part of the EnerGuide evaluation the homeowner information sheet contains details of the buildings construction as well as this graphic which shows how much energy the building uses annually, what most of that energy is used for and where heat is lost.

1.3.3 Energy use intensity/Thermal Energy Demand Intensity/Others

The EnerGuide report determined the building had an Energy Use Intensity (EUI) of 341.67kWh(1.23GJ)/m^2/year

1.4 Major deficiencies

Structurally, the building was sound. No significant water damage or rot was found when the building was stripped to the exterior sheathing as part of the retrofit. There was a small amount of rot found in the sheathing covering the rim joist, likely due to air leakage in that location, it was replaced and the seams were taped as part of the retrofit.

As is common in older modular buildings, the sheathing was stapled to the framing. There was some concern about the shear strength of that assembly with the addition of the PEER panels, so nails were added every 12 inches on intermediate supports, and every 6 inches on panel edges to provide adequate shear strength.

The most significant deficiency was the poorly performing windows. This was most clearly demonstrated by the extent of heat loss attributed to them in the EnerGuide evaluation.This was due in part to the low insulating properties of the aluminum frames and glazing, as well as significant air leakage observed during the blower door test. This issue was resolved when the windows were replaced as part of the PEER retrofit.

Air leakage was also a significant deficiency and the second largest source of heat loss. This was due to leaky windows, doors, walls, and significant leakage into the semi conditioned crawl space. Some of this was addressed as part of the PEER through window and door replacement, taping seams on existing sheathing, and the installation of blown in wood fibre. However much of the air leakage was through the interior floor into the semi conditioned and ventilated crawl space. While the homeowner addressed many of these problems, there were enough remaining at the end of the project to result in a higher than desirable blower door score. However, if air leakage in the crawlspace is addressed in the future, the building would achieve a good

blower door test and the homeowner does intend to do this work in the future.

Finally, the 2" by 4" exterior wall assembly, although performing as expected and not unusual for its time, had far too little insulation for this climate and modern expectations for energy performance. This problem was fully addressed by the PEER.

1.5 Overall building suitability for PEER

The building was particularly suitable to be a PEER project. The foundation and existing structure were solid with only minor repairs and reinforcement needed. In part because the building was modular and designed to be transported to the site, it has a simple form, which simplified panel design and installation. Finally, because the building had received only the most basic maintenance and repairs historically, many building components had reached the end of their service life and needed replacing anyway.

2 Project goals/targets

2.1 Additional dwelling unit (ADU)

The owner wished to add a workshop and an additional one-bedroom unit to the existing three-bedroom dwelling on the lot. For this reason, an attached structure was designed for construction shortly after completion of the PEER retrofit. The final ADU design consisted of a two-storey structure attached to the existing building along the full length of the north wall.

2.2 Energy Targets

Upon purchasing the property, the owner wished to complete a Deep Energy Retrofit and an interior renovation at the same time as the ADU was being completed. They wanted to dramatically reduce the energy use of the building with the goal of being net zero ready for the future.

2.3 Thermal performance

Thermal performance goals were dictated by the desire to achieve net zero ready building performance, as well as budgetary constraints. A panel system with a R value of 33 and energy star rated windows were selected to meet these goals.

2.4 Embodied carbon

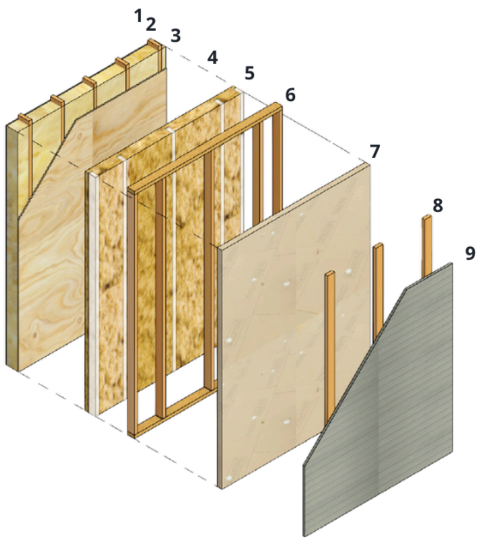
Building construction projects emit large amounts of carbon through the manufacture and transport of materials, as well as through the construction process itself - collectively referred to as embodied carbon. It may take decades of improved operational efficiency to compensate for the embodied carbon of a project. Retrofits can produce similar energy performance to new construction but with as much as 75 percent less embodied carbon. Using wood fibre insulation further reduces embodied carbon because it sequesters carbon during tree growth, which is then stored within the material. Carbon is emitted during production of mineral, glass, and fossil fuel based insulations. Solutions like this are important to meet the challenge of the climate crisis.

Part of the project was funded by grants from Smart Sustainable Resilient Infrastructure Association (SSRIA) and the Investments in Forest Industry Transformation (IFIT) program. The SSRIA funding aims at accelerating the adoption of low carbon solutions for buildings of all types, The IFIT funding aims to create a more competitive, resilient, and environmentally sustainable forestry sector. These grants fit well with HSS Design Build's mission, values, and preference for bio-based materials. As a result, a PEER system using two types of wood fibre insulation was developed. It improves energy performance and stores carbon in the panel walls.

3 Interventions

3.1 Prefabricated Exterior Panel

The prefabricated panels are made of 2" by 6" studs on 24" centers followed by 3.15" tongue & groove rigid wood fibre insulation outboard, followed by vertical 2" by 4" strapping. The panel was fixed to the building with a 1.5" gap between the existing sheathing, and the back of the panel. This gap as well as the stud cavity was filled with dense pack blow-in wood fibre insulation on site. Horizontal siding was attached to the strapping with bugscreen at the top and bottom, creating a vented rainscreen that helps the wall assembly dry.



Exisiting

1 Interior finish

2 6mm poly

3 Strucututal framing and cavity insulation

4 Sheathing

Wood Fibre PEER

5 Blown in wood fibre

6 2" by 6" stud

7 Rigid wood fibre board

8 2" by 4" Strapping

9 Siding

Figure 6. The build up of a wood fibre based prefabricated exterior energy retrofit panel. 1 to 4 is the existing structure which will be stripped down to the sheathing. 6 to 8 is prefabricated off site and lifted into place on the exterior of the building.5 and

3.2 Windows

Northstar, series 1000, triple glazed, Low E, Argon filled, flanged windows fitted to the exterior of the PEER panel. R values ranged from 3.9 to 5.4. High quality glue and tape was used to tie windows to the WRB on the exterior and the 6mm poly air/vapour barrier on the inside.

Figure 7. The interior of the window is connected to the existing polyethylene air/vapour barrier with high quality tapes. The exterior of the window is connected to the weather resistive barrier with high quality tapes.

3.3 Doors

Two new standard quality doors with polystyrene cores were installed at the same position as the originals, centered within the existing 2” by 4” stud wall. High quality tapes were used to seal the wall as the existing sheathing and to the air/vapour barrier on the interior.

Figure 8. Doors are connected to the Air/vapor barrier on the inside and the weather resistive barrier on the outside using high quality tapes.

3.4 Attic

An additional R-17 of blown in wood fibre was added to the attic bringing the total R value up to R-44.4. If space permitted, we would have added more but this allowed us to maintain adequate ventilation and was a significant improvement.

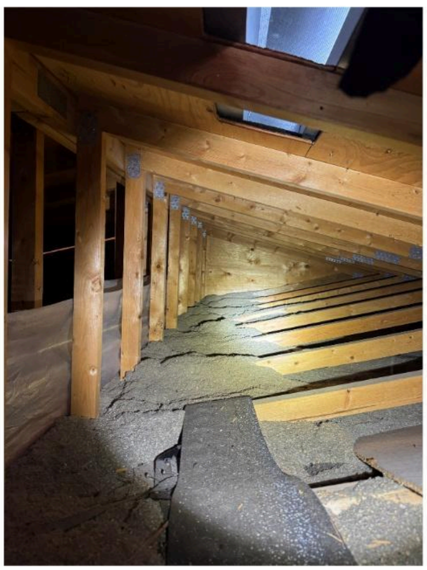


Figure 9. Leaks in the air/vapour barrier were repaired and wood fibre was blown into the attic making sure to maintain ventilation.

3.5 Additional Dwelling Unit

The community of Canmore is struggling to accommodate a growing population and significant demand for more housing, while minimizing the expansion of the community footprint into wildlife corridors. ADU's are a tool that the municipality is using to increase densification in older residential neighborhoods, without removing existing buildings or drastically changing the community.

While the foundation for the ADU was laid during the retrofit, it is largely out of scope for this case study. What is relevant is that the existing building and the ADU will share a wall, for that reason one wall of the building was left unimproved. No additional insulation was added, and an old window was left, this affected the results of the EnerGuide Evaluation, but the ADU has since been completed, and the wall is now retrofitted.

Figure 10. The PEER panel installation is completed except for siding, the foundation for the ADU is poured, the untouched wall was addressed when the ADU was completed.

4 PEER

The goal of PEER is to reduce the cost of retrofitting existing buildings by leveraging the latest technology and prefabrication. Executing a PEER project requires significant expertise to complete. First the building must be scanned and an accurate digital model developed. From this, panels can be designed to fit over the existing building. Panels can then be fabricated off site, stored, transported to site, and installed. On-site finishing is mostly done from the outside of the building.

4.1 Digital Capture

For this project a handheld scanner was used to collect a point cloud of the existing structure. This technology was more affordable to hire but produced less accurate results. Due to the simplicity of the building shape, it was believed that this level of accuracy would be sufficient. Once completed, it was found that the point cloud was not accurate enough, and some manual measurements were taken to confirm the location of important features, such as window rough openings. In future projects, total station 360 degree scanner technology was used. This technology produced highly accurate point clouds and we will be using them moving forward. Some manual measurements may still be needed to confirm window locations. Using the point cloud and the manual measurements, an accurate digital model of the building was completed using Revit.

4.2 Panel design

A catalogue of details was developed for window connections, door connections, panel to panel connections, and foundation connections. Once the general panel design was completed The Revit model was imported to Cadwork which was used to design the panels for the project. Cadwork was also used to produce construction drawings to be used in the prefabrication of the panels.

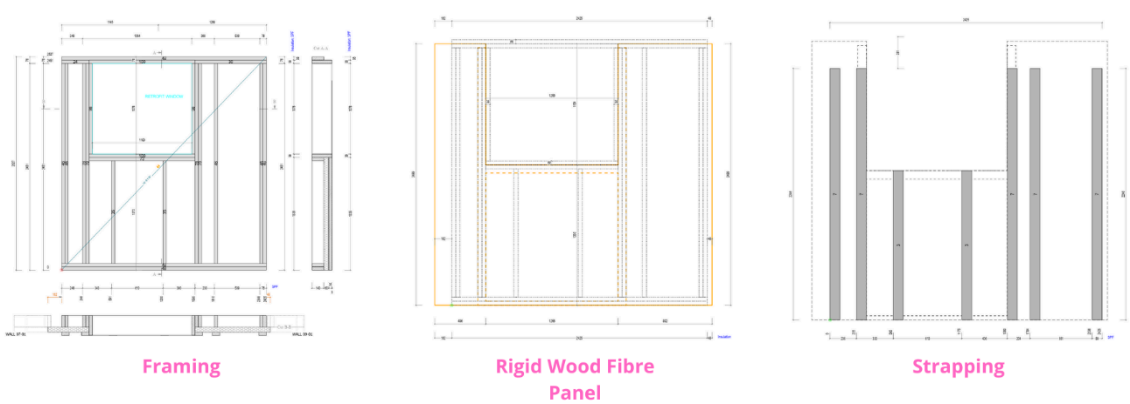


Figure 11. Examples of 3 types of construction drawings created to guide the prefabrication of the PEER panels.

4.3 Panel Fabrication

4.3.1 Facility commissioning

For this project a temporary outdoor prefabrication facility was set up that allowed for an efficient, assembly line workflow. Key features of the prefabrication facility are:

1. Laydown and storage for raw materials including dimensional lumber up to 16 feet long and pallets of rigid wood fibre panels.
2. A cutting station with a chop saw where dimensional lumber can be cut to length and labeled.
3. A cutting station with a table saw for where rigid wood fibre panels can be cut and installed directly.
4. Storage for cut and labeled dimensional lumber.
5. A framing table larger than the largest panel by 2 feet in either direction with a rigid, raised square in one corner that dimensional lumber can be fixed to during construction.
6. Method - such as crane, forklift, or rollers - to move completed panels from the framing table to storage or a trailer.
7. A space for panels to be stored and loaded onto the trailer for delivery to site.

4.3.2 Cutting dimensional lumber

A cut list was generated from Cadworks, showing the required length of each piece in every panel along with an identification number. At the chop saw cutting station, a staff member would cut each piece to size, label it with its identification number, and then stack it next to the framing table for assembly.

4.3.3 Assembling panels

The Cardworks drawings guide the layout of the framing, the rigid wood fibre panels, and the strapping. These guide the assembly of each panel. On the framing table, starting from the corner with the square, the framing members can be laid out, marked up, assembled, and fixed to the square. Rigid wood fibre panels can be cut on the table saw and fixed to the framing, finally strapping can be placed on top of the wood fibre and secured to the framing.

4.4 Transporting panels

Because the panels were stacked flat on the trailer, panel height was limited to ensure the trailer complied with road regulations. We placed a significant amount of dunnage between each panel to transfer the weight to the trailer without damaging the rigid wood fibre. Panels need to be stacked on the trailer in the opposite order you intend to install them to prevent handling them twice. It is beneficial to sketch out exactly how the panels are going to stack on the trailer so that there is a spot for little panels and overhangs are within road regulations.

4.5 Building Preparation

We remove the existing siding and water resistive barrier to reveal the sheathing. The top of the panel sits well below the soffit, so the soffit can remain on for panel install but it does have to come off eventually. Strips of plywood were then installed adjacent to the existing insulation-stop to maintain attic ventilation.

Our system depends on the existing interior 6mm poly for an air/vapour barrier, but we do what we can to improve it. On this project we taped all the seams on the existing sheathing as well as any penetrations through the sheathing. The support ledger was fixed to the concrete foundation by drilling holes and chemically bonding 3/8 thread rod to the concrete.

The existing 80% efficient furnace was replaced with a 95% efficient condensing furnace. The chimney was removed, the shingles and attic air/vapour barrier patched, and new pipes were run out the side of the building. A heat recovery ventilator was installed and tied into existing duct work.

As the building was unoccupied and the work was being done in the summer, we were able to remove the windows before installing panels. One additional window was added. We were also able to disconnect the gas and electric service for several days while we placed the panels and reattached them afterwards.

4.6 Panel installation

All the panels for the project fit on a single trailer. We positioned a rotating telehandler so that all panels could be lifted from the trailer and installed from a single location.All the panels for the project fit on one trailer. We were able to spot a rotating telehandler such that all panels could be lifted from the trailer and placed from one spot. Measure and mark out the location of each panel on the support ledger, this includes marking where the panel is meant to end and the distance out from the existing sheathing. When placing panels with window rough openings, double check they line up accurately with existing rough openings. If the rough openings don't line up close enough for interior window finishes to be installed, shift the panel left or right. The rigid wood fibre boards can be trimmed with a skill saw if needed and a small gap between panels can be filled with spray foam and or taped. This was our first time doing this and we installed all the panels in a couple days, our next PEER went faster, and if we were to do a similar again, we would easily place panels in a day.

The panels were only connected to the structure at the top and at the bottom of the panel to minimize thermal bridging. The panel was fixed to the ledger at the bottom using screws, and at the top using an angle bracket.

Figure 12. The steel ledger was fixed to the concrete foundation; the ledger was screwed to the PEER panel through pre-drilled holes. The top of the panel was fixed to the existing structure using angle brackets. Plywood and framing were attached to the roof truss.

The panel was designed so that there was space between the top of the panel and the roof truss. Framing was added to the bottom of the overhanging roof truss, to allow rigid wood fiber insulation to be installed, enclosing the space from the top of the panel up to the truss.

We installed strips of cardboard from the stud to the existing sheathing around the edge of each panel. This prevented the blown-in wood fiber from moving between panels during installation. It also allowed us to monitor the amount of wood fiber in each panel and ensure the proper density.

4.7 Blow-In Wood Fibre Installation

Wood fibre was blown in on site filling the 5.5” stud cavity as well as the 1.5” gap between the panel and the existing sheathing. Blow-in fibre must be densely packed into the wall cavities to prevent settling; for that reason, the machine needs to be set up accordingly. The number of bags required for each panel should be calculated, and the number of bags used should be tracked to determine that the installed density is appropriate. The strips of cardboard installed between panels helps to do this accurately. 4” holes were drilled in each 24” stud cavity and 2” and 1.5” hoses were inserted all the way to the bottom of the cavity. Because the panels stand off the wall and wood fibre can move between cavities during install, hoses were inserted in 3 or 4 cavities ahead of the one being filled. When a cavity is filled that hose comes out and is reinserted further down the panel.

The space between the top of the panel and the Attic needs to be filled separately as you move across. We installed blocking to break this space into ~10’ sections that could be filled individually. We marked the location of the blocking on the rigid wood fibre. To patch the holes the rigid wood fibre around the hole must be glued and high-quality tape applied over the hole.

Figure 13. *Holes are drilled through the rigid wood fibre panel into each cavity and into the space above each panel. Hoses are inserted in 3 or 4 cavities ahead of the one being filled. As each cavity is filled the hose is leap frogged ahead and the panel is filled with dense packed wood fibre. Afterwards a glue and a tape are applied to seal up the holes.*

4.8 Finishing

MDF window returns and trim were installed on the interior of the windows by the client. Horizontal siding was installed by a subcontractor.

5 Building Performance

This project included a robust monitoring and verification plan with significant data collection. Sensors were deployed throughout the wall system to collect durability data associated with wood fibre and moisture management. Indoor air quality sensors were also deployed to quantify variables pertaining to human comfort and human health. Weather monitoring sensors and electrical energy use sensors will be used to calculate real world energy performance.

After a one-year collection period, data will be analyzed and added to the section below to produce a robust data set to learn from.

5.1 Occupant Comfort

TBD

5.2 Durability

One of the advantages of wood fibre-based insulations is its ability to absorb, distribute moisture and ultimately dry out. While this quality is understood and recognized as an important component of durability in parts of the world where wood fibre is commonly used, there is less comfort in the North American market. With that in mind, sensors were deployed throughout the wall system recording temperature, relative humidity, and wood moisture equivalent. Sensors were positioned at traditionally weak locations such as corners, rim joist, below windows and at various depths within the assembly.

Data collection will occur for a full year after which the data will be analyzed, and this section will be updated. This detailed data set should support the argument for the wider deployment of wood fibre in North America.

5.3 Airtightness

The blower door test completed as part of the EnerGuide home evaluation before the retrofit began, achieved 8.54 ACH50. Significant sources of leakage were the fireplace, the furnace ductwork (connected to a semi conditioned crawlspace), electrical outlets, penetrations to the crawlspace and attic (especially associated with the furnace).

Improvements included replacing the old furnace with a condensing furnace, removing the existing fireplace and sealing penetrations, improving vapour barrier at electrical plugs, filling some penetrations into the crawlspace, taping seams on the external sheathing, and installing new windows and doors.

While these interventions improved air tightness it is important to note that very little was done to address the leaky crawlspace as part of the intervention. At the time of the final blower door test there were large connections between the living space and the crawlspace and we achieved a blower door test of 6 ACH50. During this blower door test a smoke stick inspection was completed, all the improvements made to the living space and the attic leaked very little. There were, however, large leaks into the crawlspace that accounted for most of the air leakage. If these leaks are addressed in the future as part of a crawlspace intervention, we would expect a much better blower door test.

5.4 Energy Performance

5.4.1 Measured Energy Performance

TBD

5.4.2 EnerGuide Performance

This project had an EnerGuide Evaluation completed before and after providing a good opportunity to measure the performance of the intervention in an apple to apples, albeit modeled rather than real world scenario. The Rated Energy intensity of the building was reduced from 1.23 GJ/m^2/year to 0.65 GJ/m^2/year

Water heating, electrical, and lights and appliances were not part of the intervention, ventilation was added but uses very little energy. Natural gas use, which was used only for space heating, was reduced from 81 GJ/year to 22 GJ/year. Heat loss from windows was reduced from 27.5 GJ/year to 4.2 GJ/year, air leakage from 20.25 GJ/year to 7.7 GJ/year, main walls from 16.2 GJ/year to

3.3 GJ/year, attic from 7.3 GJ/year 2.6 GJ/year, foundation from 5.7 GJ/year to 3.3 GJ/year, and doors from 4 GJ/year to 1 GJ/year.

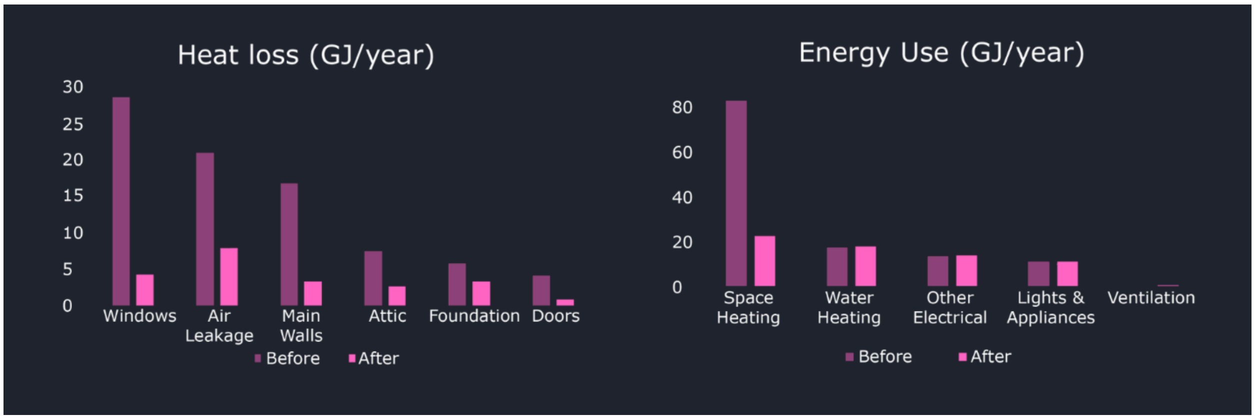


Figure 14. A comparison of the heat loss and energy use data from the EnerGuide Evaluations completed before and after the retrofit.

Total energy use was reduced from 126 GJ/year to 67 GJ/year. Green House Gas emissions were reduced from 11.6 tonnes/year to 8.4 tonnes per year. Space heating went from 66 percent to 34 percent of total energy use.

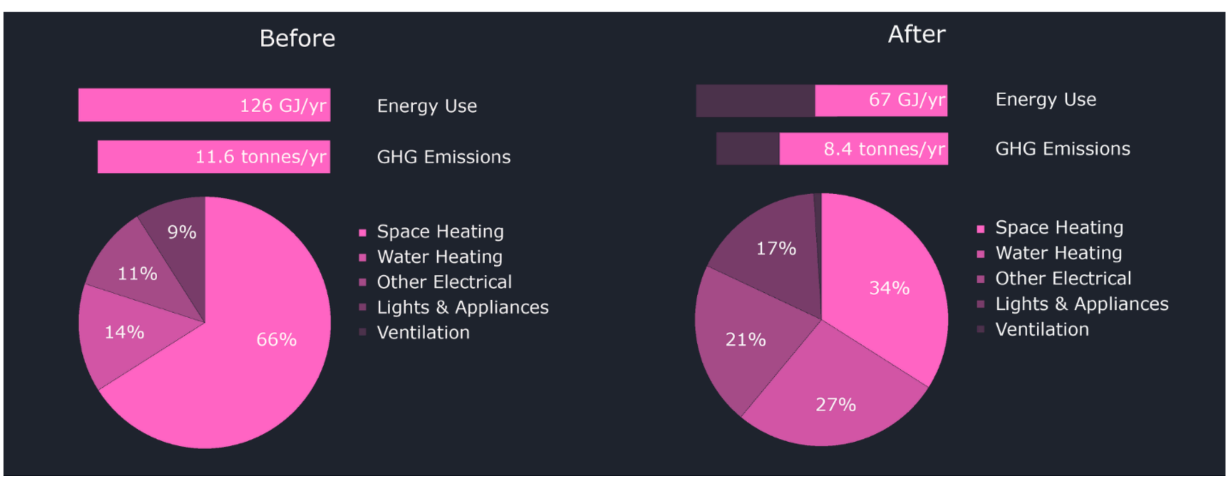


Figure 15. A more detailed comparison of the energy use data as well as greenhouse gas emissions from the EnerGuide Evaluations completed before and after the retrofit.

6 Lessons Learned

6.1 Successes

6.1.1 Windows

Installation went well. We like to install flangeless windows near the center of the wall and over insulate them for improved energy performance, but budgetary constraints pushed us to a standard window detail. This was more affordable, went quickly, and was airtight. In the future we would leave the strapping off around the window so it could be taped to the wood fibre rather than the strapping. We experimented with fitting the entire interior of the window with plywood and with using small mending plates, the mending plates worked better with the MDF window returns providing the backing for the blow in wood fibre.

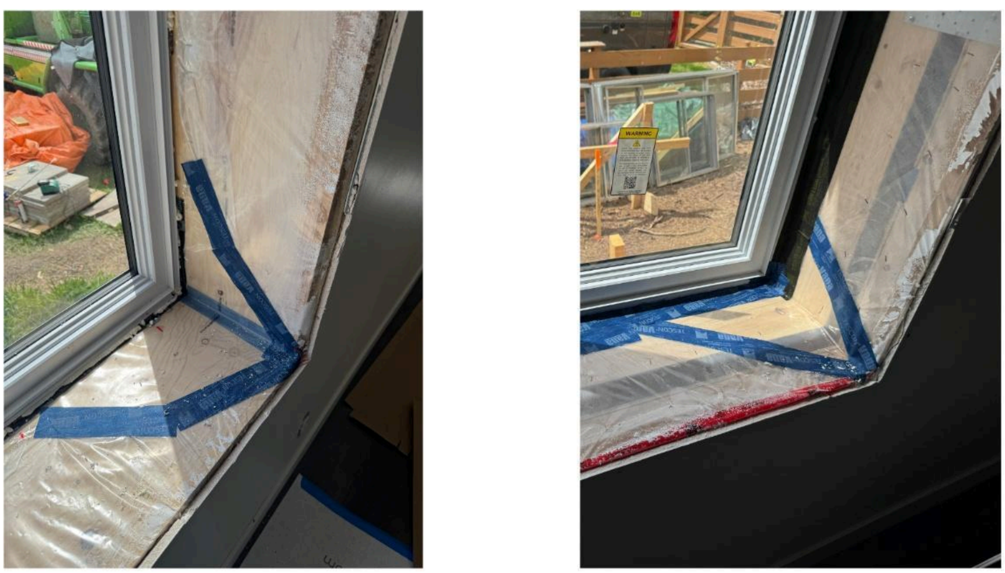


Figure 16. Two different strategies for window interiors. One featured plywood, while the other featured metal mending plates. The mending plates were quicker and just as effective.

6.1.2 Walls

The panels fit together well, and window rough openings lined up accurately. Wall insulation was improved from R-12 to R-47, acoustics would also be dramatically improved because of the wood fibre in the walls.

6.1.3 Attic

The attic insulation was improved from R-27.4 to R-44.4 by adding blown in wood fibre. This work was completed in a day without a major roof intervention. Air/vapour barrier leaks, primarily the hole left after the removal of the chimney, were sealed. The existing attic eave ventilation system was maintained. While more extensive interventions would yield better results this was affordable and effective.

6.1.4 Foundation

The above ground portion of the foundation insulation was improved from R-9 to R-49 while the below ground portion remained at R-9. The scope of this task was reduced, originally, the below ground portion of the foundation was going to be improved as well. Despite that, a significant amount of energy savings was achieved with minimal cost.

6.2 Challenges

6.2.1 3D scanning

Phone based and handheld scanners don't seem to be accurate enough for even simple building shapes. 360-degree total stations are much more accurate. Although they are expensive to purchase, we were able to rent one by the day, were trained how to use it in less than an hour, and easily scanned a couple buildings in a single day. We have also begun scanning interiors of buildings to be used for any interior renovation work.

6.2.2 Steel ledger

We have changed the ledger design since completing this project. The steel design was difficult to install and required a subcontractor to build it; it was also high in embodied carbon. After consulting a structural engineer, we developed a gusseted wood design that was light, could be built in house with over-the-counter parts, and was easier to install. It also had much less embodied carbon.

Figure 17. The new ledger design (left) featuring treated wood and over the counter hardware is better than the steel one (right) used on this project. It was cheaper, easier, and has lower embodied carbon.

6.2.3 Crawlspace

The main weakness of the project is the air leakage associated with the crawlspace. Air leakage has become the largest source of heat loss in the retrofitted building. The crawlspace was excluded from the project for several reasons and although we knew it was going to be a source of air leakage, the extent of the leakage was greater than anticipated. Interpolating from the smoke stick test, roughly 80 percent of the air leakage on the building was occurring through the crawlspace. The lesson here is to expect significant air leakage from projects involving a vented crawlspace and it should be addressed as part of the retrofit.. On the bright side the crawlspace can be improved in the future without redoing any of the completed work and the owner does intend to do this.

6.2.4 Roles and responsibilities

The homeowner was completing an interior renovation at the same time as we were completing the exterior retrofit. While this mostly worked well, things occasionally slipped past both of us. In the future we would more clearly define who is in charge of what to minimize these miscommunications.

Conclusion

The project was a success. The energy performance according to EnerGuide Evaluations completed before and after the intervention of the building was significantly improved. Data collected over the next year will produce more accurate results. While we are still collecting data, we are confident that occupant comfort was significantly improved, and the indoor air quality of the building was significantly improved. Finally, the embodied carbon of the project was reduced by using wood fibre materials that sequester carbon rather than emitting it. It is likely that in the future the crawl space will be improved, and a solar PV array may be added further reducing carbon emissions.

Total energy use was reduced from 126 GJ per year to 67 GJ per year and GHG emissions were reduced from 11.6 tonnes to 8.4 tonnes per year. Energy used for space heating was reduced from 81 GJ per year to 22 GJ per year. There was a dramatic reduction in heat loss via windows, air leakage, and main walls as well as significant reductions in heat loss from the attic, the foundation, and doors.

Although we do not have good data on indoor air quality and occupant comfort before the intervention, both would have been poor. Improvements in airtightness combined with the addition of a heat recovery ventilator would improve the air quality and the ability to manage air quality in the building.

Occupant comfort throughout the building but particularly near exterior walls and windows will be significantly better. Wood fibre insulation and triple pane windows are both effective at reducing noise and would further improve occupant comfort.

Finally, this intervention was extremely effective at addressing environmental concerns such as embodied carbon, waste, and human health associated with the built environment. Retrofits emit up to 75 percent less carbon than new construction and can achieve similar performance to high performance new construction. This project goes a step further by featuring wood-based insulations that sequester carbon within the building resulting in a building with low operational and extremely embodied carbon. Wood based materials are compostable, where other materials such as foams will ultimately end up in landfill and will persist there for generations to come. Finally, wood fibre does not emit any harmful gases when installing it in buildings, living in those buildings, or in the event of a fire. These benefits are realized by the whole community.