

**FINAL REPORT
COACH HOUSE PROJECT
GROUP 12**

Submitted To:
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ARCC2202 A
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1.0 MOTIVATIONS

1.1 Project Vision

Aging in a space that feels like home rather than only a place to live is a desire shared by many, yet finding housing that supports independence, comfort, and connection can be challenging. Our project addresses these needs by designing an accessory dwelling unit that provides a safe and welcoming home for elderly relatives, in-laws, or individuals with mobility challenges. Beyond functionality, our goal was to create a space that balances accessibility, affordability, and sustainability while integrating seamlessly into the existing property. This granny suite is seen as nearby, with accessible space that provides reassurance while remaining separate from the main home, preserving a sense of independence. Our goal was to demonstrate how a compact home can achieve net-zero performance, remain practical for everyday living, and show thoughtful, purposeful architecture.

1.2 Site Context and Selection

A part of our initial design process involved selecting the site location. We chose 19 Bren-Maur Road in Ottawa, a suburban property that offered great opportunities (see Figure 1).

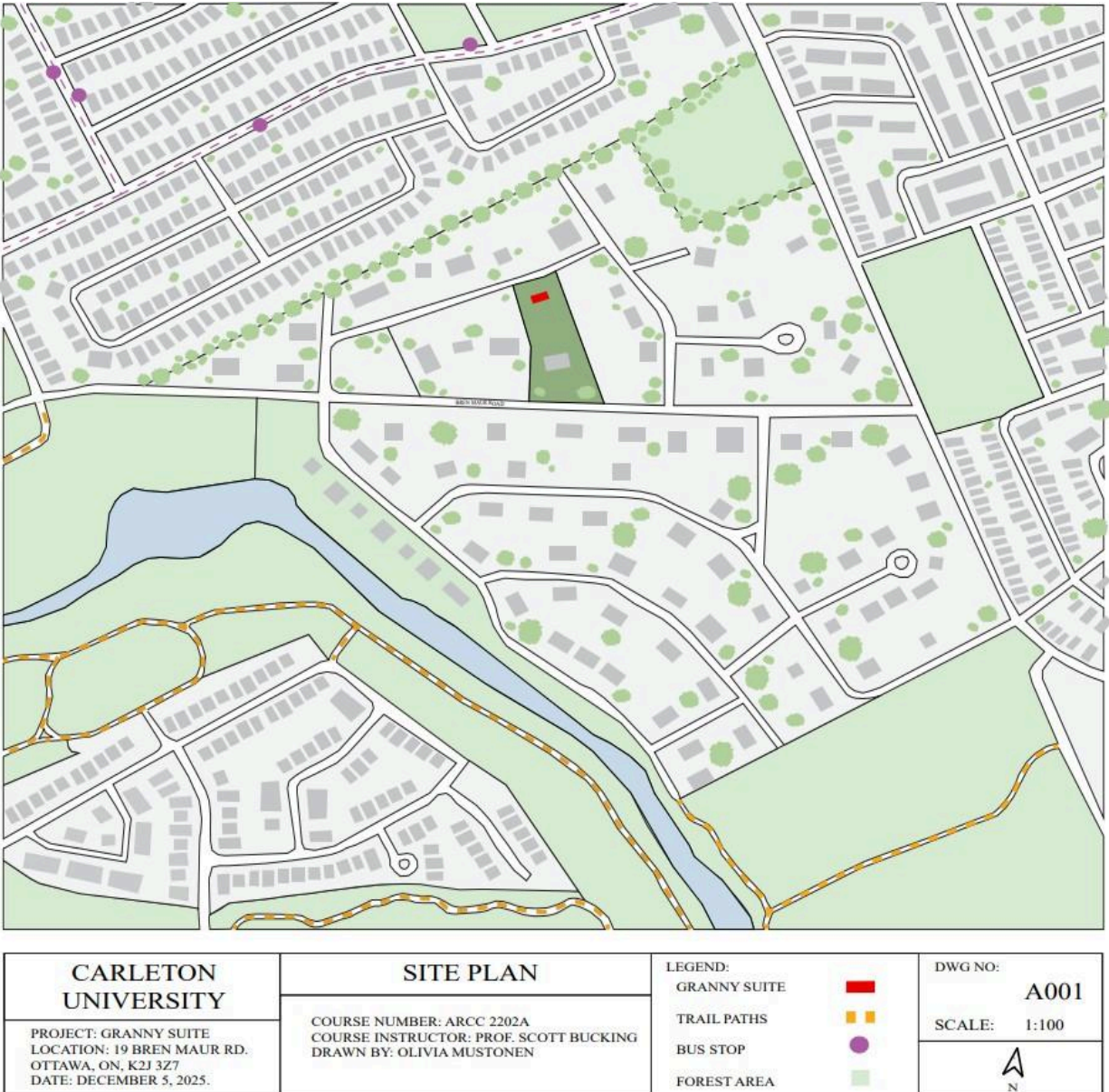


Figure 1. Site analysis of Hearts Desire and the location of the Granny Suite at 19 Bren-Maur Road, Ottawa, ON

The neighbourhood has low traffic noise and natural privacy provided by surrounding vegetation, making it a comfortable and quiet setting for a granny suite. Situated near the Jock River, walking trails, and green spaces, the property also remains close to amenities and public transit. Sun patterns allowed us to orient our house for maximum passive solar gain. A mostly level landscape simplified construction, while the soil throughout the area provided good stability and drainage. The site’s orientation, surrounding vegetation, and proximity to transit and community amenities made it appealing (see Figure 2). Still, it also required careful consideration of solar exposure, accessibility, and integration with the existing landscape.

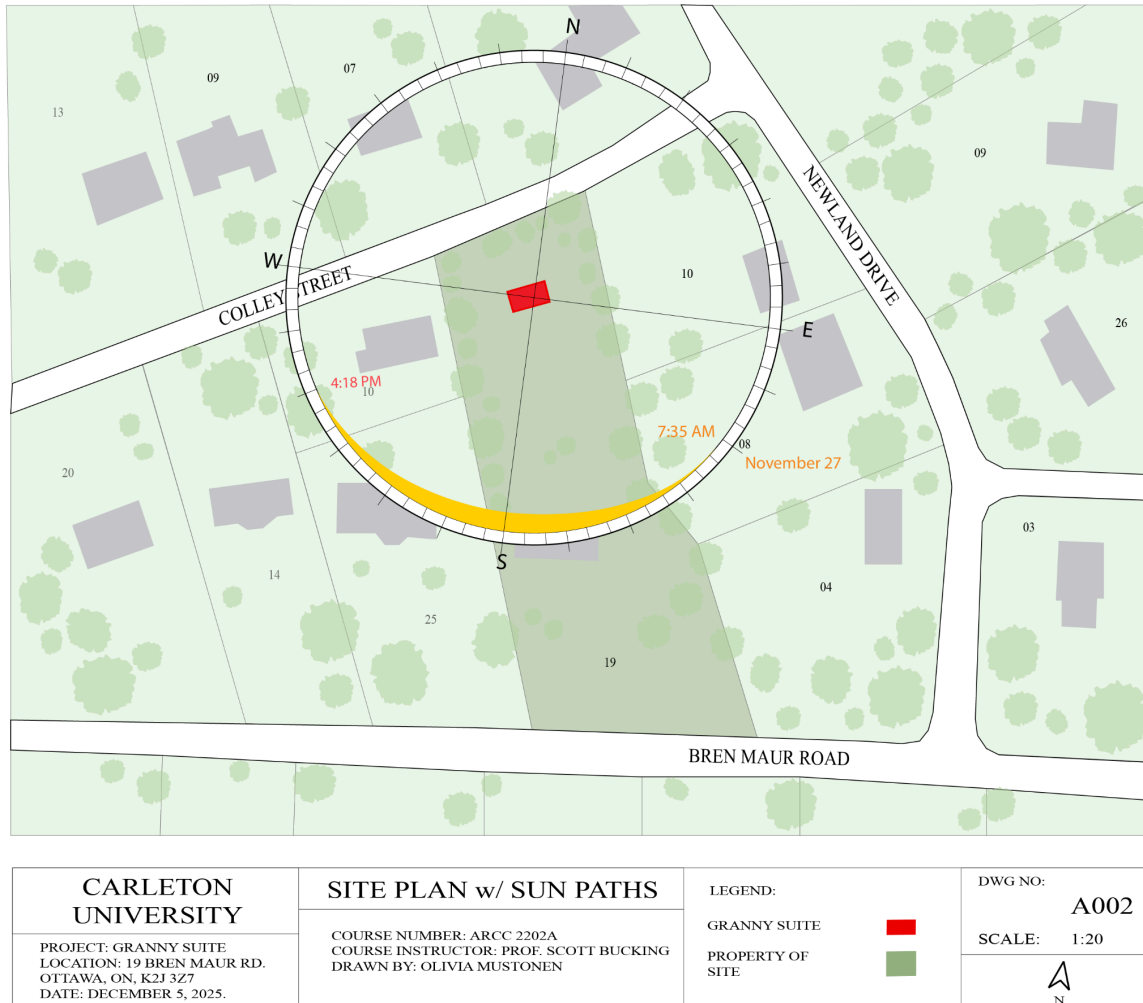


Figure 2. Site plan of the property at 19 Bren-Maur Road, Ottawa, ON

As a group, we spent about a week debating the home's placement. Some members prioritized maximizing solar gain for sustainability, while others emphasized privacy and integration concerns. Accessibility concerns also shaped the discussion, as we wanted smooth transitions and easy access to outdoor spaces. Ultimately, the decision to place the granny suite in its current location reflects our motivation to maximize solar gain while balancing occupant comfort (see Figure 3). This arrangement showed how important it was to us that the granny suite not be seen as just a building dropped onto a lot, but as a carefully considered addition that responds to Ottawa's climate, the property's layout, and the needs of its occupants.

1.3 Challenges and Opportunities

Throughout the development of our tiny home design, we have encountered a range of challenges that have shaped our approach to design choices. These early challenges have provided us with opportunities to think critically about space, accessibility, orientation and sustainability.

1.3.1 Spatial Design Challenges

One of the most significant challenges has been working within the limited space of the tiny home. Balancing livability and efficiency with limited room required careful consideration of design elements. Due to our project's function as a granny suite, accessibility has heavily influenced our decisions around layout and stories. Before establishing the house's function, we experimented with configurations that did not fully consider accessibility or practicality. Once the design's purpose became clear, we realized how small the available space was and that every element placed within it must be intentional. This realization helped refine our priorities, distinguishing between daily essentials and luxuries.

1.3.2 Orientation and Solar Optimization

Early models positioned the building lengthwise, but we later adjusted the layout so that the longer façade faced south, increasing solar gain. Initially, the design emphasized how sunlight would interact with the roof rather than how it would illuminate the interior. In that setup, sunlight reached mostly the shorter side of the home, limiting natural light. After modifying the building's placement, sunlight now travels across the entire interior, allowing for maximum use of daylight throughout the day.

1.3.3 Balancing Architectural and Engineering Perspectives

We also came across the need to balance perspectives between the architectural and engineering aspects of the design. Our team includes members who approach the project from different fields, some more focused on technical precision, others on spatial creativity and user experience. These contrasting ways of thinking and skill sets became one of our greatest strengths. Through multiple iterations and discussions, we found a balance between the two perspectives, resulting in a design that is both practical and creative.

1.3.4 Group Organization and Decision-Making

With so many moving parts, it was initially challenging to assign clear responsibilities. At times, our ideas were ambitious, which made it harder to focus on immediate tasks. Regular check-ins and shared documents helped maintain consistency and keep everyone aligned. These methods highlighted our ability to use collaborative communication to overcome design disagreements and make decisions as a team.

1.4 Affordability and Sustainability

Affordability and sustainability were central to our design process, ensuring the granny suite remained accessible to families while meeting everyday financial needs. The team chose prefabricated construction to reduce overall building costs. Assembling panels off-site and installing them quickly reduces labor costs and waste, making the granny suite more financially accessible. Foundation options such as crawlspaces and basements were considered. Still, the choice of a slab-on-grade foundation was ultimately made, as it minimizes excavation costs, increases precision, and eliminates the need for stairs to support the aging occupants. At the

same time, it reduces embodied carbon compared to deeper foundations. Advanced wood framing was chosen for its efficiency. This framing technique reduces lumber costs while still meeting structural requirements and also reduces heat loss, improving energy performance. Triple-glazed windows and high-performance insulation minimize heating and cooling costs over time, ensuring that utility bills remain affordable for occupants. Material reuse, such as recycled concrete aggregate, reduces foundation costs and embodied carbon, proving how affordability and sustainability support each other. Affordability throughout our project informed our choices, ensuring the granny suite could be a realistic option for any family in Ottawa. Sustainability was the natural extension of those choices, ensuring that cost-saving features came with a lower environmental impact and more comfort for occupants.

1.5 Structural Approach

For the structural system, we selected an insulated slab-on-grade foundation, advanced wood framing, and a simple gable roof. These choices were motivated by affordability, accessibility, and climate in Ottawa, providing a straightforward and durable structure for the granny suite.

1.6 Sustainability Features

The sustainability features chosen for our granny suite design include overhangs, strategic orientation of the home, multiple skylights, an electric cold-climate heat pump, recycled concrete aggregate for the foundation, high-performance envelope materials such as ZIP-R sheathing, dense-pack cellulose insulation, and triple-glazed windows, as well as solar PV sheeting integrated into the roof. Together, these selections reflect our motivation to design a dwelling that aligns with net-zero goals and supports long-term environmental responsibility.

2.0 SUSTAINABILITY

This section describes some of the sustainable features and sources of the tiny home, its function, and how it works.

2.1 Sustainability Features

The solar panel gable roof overhangs at 13° to provide summer shading while collecting solar energy. Since the sun lowers in the winter in the Northern Hemisphere, overhangs optimize the amount of sunlight entering the home, naturally heating it. Plus, it protects against the weather by diverting rainwater away from the home's foundations, preventing potential water damage and erosion.

For natural heating from sunlight, the home's orientation is essential. The windows and sliding glass doors face south, letting in more natural light than the others during the day. In addition, a skylight brings daylight into the living room. The placement of the windows also takes advantage of the sun's path. For example, the bedroom has windows on the east and the south walls. The east window captures the sunrise for early risers, while the south window helps warm

the room. At night, sunlight is limited, but the skylight provides a pleasant view, supporting both sustainability and comfort. (Skylight placement is shown in Figure 3 as a dotted rectangle.)

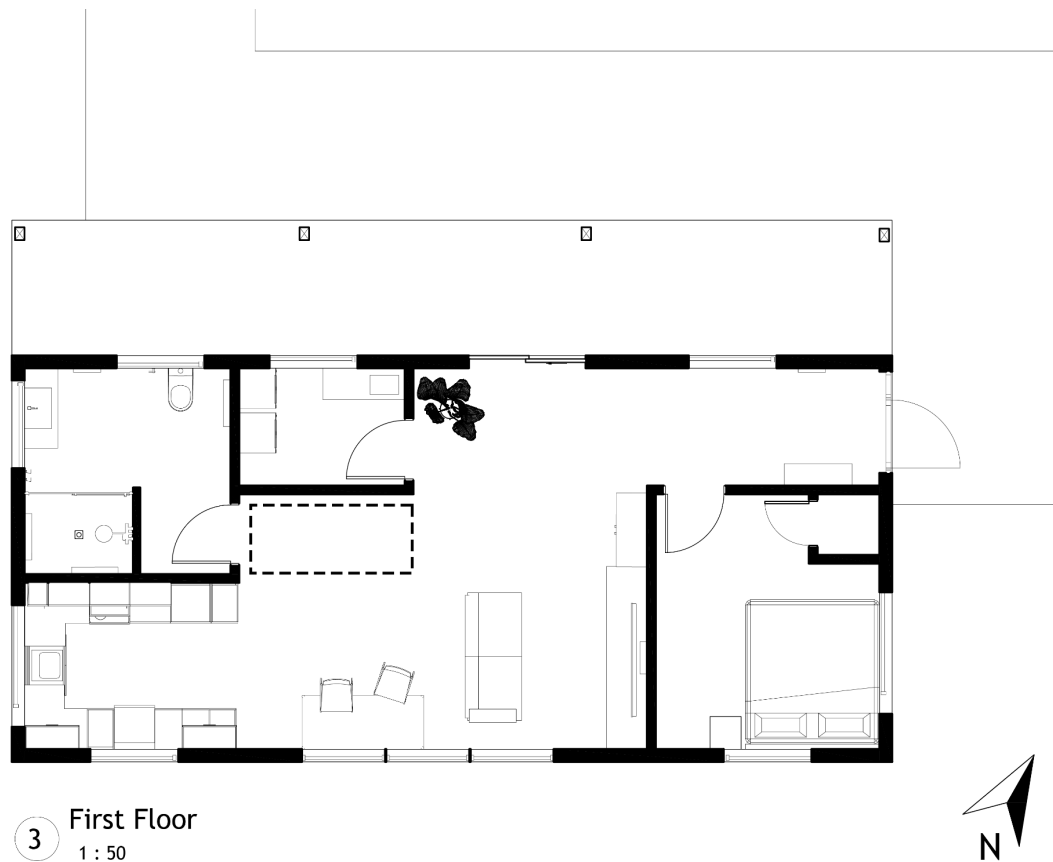


Figure 3. Skylight Placement for Tiny House on Revit Floor Plan

For electrical efficiency, the mini-split heat pump is ideal, as it uses hot or cold refrigerant directly indoors through heads or cassettes. Air moves across its heating and cooling coils, allowing several rooms to be cooled or heated independently. Thus, the team chose an electric cold-climate heat pump as the mini-split type. It is a more sustainable alternative to a gas furnace. Heat pumps are more energy-efficient, environmentally friendly, and safe. The team also considered the heat pump's coefficient of performance, comparing the energy it produces with the energy generated by the solar panels. To reduce heat loss, the home uses sufficient insulation, including ZIP-R sheathing, wrapping, and spray-foam insulation, to lower the U-value of the above-grade surfaces.

For the foundation, the team selected recycled concrete aggregate as a more sustainable option than conventional concrete. According to the Canada Centre for Mineral and Energy Technology, satisfactory concrete can be prepared with recycled concrete aggregate. Though this material is somewhat lower than concrete made with reference aggregate, mix proportions can compensate for this. Its durability is comparable. Using recycled concrete aggregate helps reduce environmental impact and conserve resources by reusing discarded concrete, thus lowering the carbon footprint. The team also understands that concrete quality affects foundation quality, so

we chose to rely on PCL Construction and GIATEC for their experience and research on recycled concrete.

2.2 The Home's Renewable Energy Source

The home's only renewable energy source is solar, which has generated sufficient energy to power the building, much less a 13m by 6m house with skylights installed in the roof. With the sun path, the home collects optimal sunlight due to its position and roof angle. The team chose rigid solar panels over flexible PV sheeting due to their resistance to extreme weather conditions, longer lifespans, and higher efficiency (18%-22%)¹. Although this type is more expensive and more complex to install, the long-term benefits offset the construction costs.

3.0 TECHNOLOGY

This section summarizes the project's structural approach, implemented technologies, material choices, energy consumption calculations and potential renewable energy generation.

3.1 Structural Approach

This section outlines key structural decisions for the coach house, including the foundation, framing strategy, roof form and overall load path.

With multiple options for foundations, basements, crawlspaces and slab-on-grade foundations were considered. However, after reviewing accessibility and cost factors, we found that a basement or crawlspace would introduce stairs and other accessibility issues for aging occupants, so an insulated slab-on-grade foundation was selected. Because the coach house is only one story, this foundation type is acceptable.² The system uses a 4" reinforced concrete slab, combining concrete's high compressive strength with steel's tensile resistance.³ The slab sits on a layer of compacted sand and gravel, which helps distribute loads evenly throughout the soil and reduces the risk of settlement, irregular stress distribution or failure. To address Ottawa's deep frost line, the design includes frost-protection wings (1.2m x 1.5m) paired with a geotextile membrane and XPS insulation to stabilize soil temperatures around the slab since the foundation does not go below the frost line.⁴ Although they have many good characteristics, slab-on-grade foundations have some drawbacks. They limit the ability to run mechanical systems beneath the floor, are difficult to modify after construction, and require high-quality moisture control to avoid long-term durability issues, especially with Ottawa's severe freeze-thaw conditions. Regardless, this foundation system creates a low, step-free entry that supports aging parents and reduces construction complexity and cost.

¹Brian, n/a. "Flexible Vs. Rigid Double-Glass Solar Panels: Which One Is Your Best Choice?"

² Bucking, Scott. Foundations. Lecture 02B, ARCC 2202A, Carleton University, Fall 2025, slides 41.

³ Bucking, Scott. Concrete and Steel. Lecture 08, ARCC 2202A, Carleton University, Ottawa, ON, Fall 2025.

⁴ Bucking, Scott. Foundations. Lecture 02B, ARCC 2202A, Carleton University, Fall 2025, slides 41-43.

The structural system uses advanced wood framing, as shown in Figure 4. This method reduces redundant studs, aligns framing members to transfer loads efficiently, and minimizes thermal bridging. Walls are framed with 2 x 6 studs 24” apart to use less material, incorporate more insulation, and reduce thermal bridging by using two-stud corners. These strategies minimize lumber use and increase insulation depth but require more precision, and may be unfamiliar to contractors who are more familiar with conventional framing practices.⁵



Figure 4. Comparison of Traditional vs. Advanced Wood Framing Layouts⁶

The structure uses a simple gable roof, with slopes of approximately 16° on the south-facing side, and 12.5° on the north-facing side and overhangs for water runoff.⁷ This two-sided geometry formed a ridge running along the length of the building, providing good drainage on both sides. The steeper slope on the south side improves solar access and snow shedding. Despite having many good characteristics, gable roofs have increased exposure to wind and uplift, which is not ideal in earthquake zones like Ottawa.⁸

The coach house follows a simple load path with applied load flowing from the roof to the rafters to the walls, around window headers to the foundation, and finally landing in the soil.⁹ Although this is a nice, simple arrangement, if the underlying soil is not uniformly compacted or has variable moisture content, the slab-on-grade system can become prone to localized settlement.

⁵ Bucking, Scott. Light Framing. Lecture 04, ARCC 2202A, Carleton University, Fall 2025.

⁶ Joseph Patrick, “What Are Advanced Framing Techniques?,” *Lamont Bros. Learning Center*, October 29, 2021, <https://www.lamontbros.com/learning-center/what-are-advanced-framing-techniques>.

⁷ Bucking, Scott. Light Framing. Lecture 04, ARCC 2202A, Carleton University, Fall 2025, slide 71, 74.

⁸ Bucking, Scott. Introduction to Structures. Lecture 02A, ARCC, 2202A, Carleton University, Fall 2025, slide 47.

⁹ Bucking, Scott. Introduction to Structures. Lecture 02A, ARCC 2202A, Carleton University, Fall 2025, slide 43.

Overall, the chosen structural approach provides a durable, energy-efficient and climate-appropriate solution for a small, one-story dwelling.

3.2 Material Selection

This subsection outlines the key materials used in the coach house and summarizes the floor, foundation, wall, roof, and window assemblies.

3.2.1 Floor and Foundation Detail

The slab-on-grade floor assembly provides both structural stability and strong thermal performance. At the base, there is a layer of screened and washed gravel with crushed stone to create drainage and prevent moisture from moving upward into the slab. Above this, there is 4” of type III extruded XPS rigid insulation rated at R-5 per inch, leading to a total of R-20.¹⁰ XPS was selected for its moisture and mould resistance and high compressive strength, despite its high cost.¹¹ A layer of compacted sand sits above the insulation layer to level the base and distribute loads evenly. The 25 MPa reinforced concrete slab serves as the main structural surface due to its high strength properties. The floor assembly is finished with wood floor joists, subflooring and a laminated finish, creating a durable, wheelchair-accessible surface. There are frost wings around the perimeter, topped with a geotextile membrane to provide adequate soil filtration, reinforcement, and drainage, helping prevent erosion and increase stability in frost-susceptible and earthquake-prone zones.¹² On top of the membrane, there is a 4” XPS insulation layer to help maintain soil temperatures in Ottawa’s cold climate.

3.2.2 Wall Detail

The coach house has a high-performance wall assembly consisting of drywall interior finish, a polyethylene vapour, 5.5” of dense-pack cellulose insulation, 1.5” of extruded XPS rigid insulation, ZIP-R sheathing, and horizontal Dolly Varden siding. The group chose cellulose for its low embodied energy, fire resistance and some air-sealing qualities. However, dense-packed cellulose cannot get wet and may settle over time, requiring maintenance.¹³ With an insulation between R-3.0 and R-3.7 per inch, the 5.5” cavity produces between R-16.5 and R-20.35 (averaging to R-18.5).¹⁴ Additionally, the team decided on XPS for its moisture and mould resistance, long-term durability and high thermal performance despite its high cost and low fire resistance.¹⁵ The 1.5” of extruded XPS insulation provides an additional R-5 per inch, with a

¹⁰ Bucking, Scott. Enclosures. Lecture 06, ARCC 2202A, Carleton University, Fall 2025, slide 41.

¹¹ *Bioclima*. “Everything You Need to Know About Extruded Polystyrene (XPS).” Accessed November 29, 2025. <https://bioclima.gr/en/news/everything-you-need-know-about-extruded-polystyrene-xps>.

¹² Bucking, Scott. Foundations. Lecture 02B, ARCC 2202A, Carleton University, Fall 2025, slide 45.

¹³ Bucking, Scott. Enclosures. Lecture 06, ARCC 2202A, Carleton University, Fall 2025, slide 40.

¹⁴ Bucking, Scott. Enclosures. Lecture 06, ARCC 2202A, Carleton University, Fall 2025, slide 41.

¹⁵ *Bioclima*. “Everything You Need to Know About Extruded Polystyrene (XPS).” Accessed November 29, 2025. <https://bioclima.gr/en/news/everything-you-need-know-about-extruded-polystyrene-xps>.

total additional value of R-7.5.¹⁶ Together, the wall achieves an effective R-value of about R-26, exceeding the required R-19 performance standard. A vapour barrier is installed on the warm side of the wall to prevent interior humidity from migrating into the insulation, where it could condense in winter. Regular ZIP-R sheathing without insulation provides both continuous insulation and an air and water-resistant barrier, improving the dwelling's airtightness and minimizing thermal bridging across studs.

3.2.3 Roof Detail

The roof assembly uses a compact cathedral-ceiling configuration consisting of ½” gypsum ceiling, a polyethylene vapour barrier, 9.25” of dense-pack cellulose insulation between 2x10 rafters, 1.5” of insulated ZIP-R sheathing, and architectural asphalt shingles. The thermal performance is similar to that in the wall assembly, providing approximately R-28 to R-34 across the full cavity, with the same advantages and limitations discussed in Section 3.2.2. The 2” Zip-R sheathing adds R-9.6 of continuous insulation while also functioning as the air and water resistive barrier, reducing thermal bridging across rafters and improving airtightness, although it does cost more than other, more traditional sheathing.¹⁷ The exterior shingle layer provides weather protection and adds a negligible R-value. Altogether, the assembly achieves a roof insulation level of approximately R-41, exceeding typical Ontario climate requirements of R-31. Atop the roof assembly are thirty 400W monocrystalline solar panels, which are highly efficient for maximized energy production. However, they have high sensitivity to temperature changes and a notably low temperature coefficient, which can significantly reduce the energy output.¹⁸

3.2.4 Windows

High-performance thermally broken and triple-glazed windows are used in the design of the sliding patio door, windows and skylight for many reasons. The glazing material uses three layers of clear glass with low emissivity coatings, which improves thermal performance by reducing the amount of infrared and ultraviolet light that passes through; however, it slightly lowers visible light transmittance, as shown in Figure 5.¹⁹ Three air chambers slow conduction far more effectively than double glazing, improving winter comfort, although more layers increase cost and weight. The krypton gas fill provides superior insulation in small cavities, outperforming other options, but it is more expensive and can lose effectiveness if the seal fails.²⁰

¹⁶ Bucking, Scott. Enclosures. Lecture 06, ARCC 2202A, Carleton University, Fall 2025, slide 41.

¹⁷ ZIP System, *ZIP System R-Sheathing Product Data Sheet* (Ringsend / Huber Engineered Woods, 2021), accessed November 29, 2025,

https://www.ringsend.com/media/product-files/file/Product-Data-Sheet-Wall-R-sheathing_2021-03-09-152617.pdf.

¹⁸ SOLARKIT, *What's the Difference Between Monocrystalline and Polycrystalline Solar Panels?* (April 14, 2025), accessed November 29, 2025,

<https://shop.solar-kit.eu/en/blog/post/what-is-the-difference-between-monocrystalline-and-polycrystalline-solar-panels>.

¹⁹ Bucking, Scott. Enclosures. Lecture 06, ARCC 2202A, Carleton University, Fall 2025, slide 26.

²⁰ Bucking, Scott. Enclosures. Lecture 06, ARCC 2202A, Carleton University, Fall 2025, slide 25.

Edge spacers and the insulated frame reduce the risk of heat loss and condensation around the edges of the frame. Finally, the airtightness of the sealed glazing unit minimizes infiltration and improves energy performance, but high airtightness requires long-lasting seals, which could degrade over time. Together, these factors give triple-glazed windows some of the lowest U-values possible, around U-0.2, and a low solar heat gain coefficient of around 0.3.²¹ Although triple-glazed assemblies significantly offer excellent insulation, their overall performance depends on the window-to-wall ratio (WWR). This design uses a WWR of 15.15%, which provides ample daylight while minimizing thermal losses in Ottawa's cold climate. Glazing is concentrated on the south, east and west facades to maximize daylight and passive solar gains, while minimizing window area on the north side to reduce winter heat losses and drafts. This strategic distribution ensures that the benefits of the high-performing triple-glazed windows are maximized without introducing unnecessary thermal penalties.

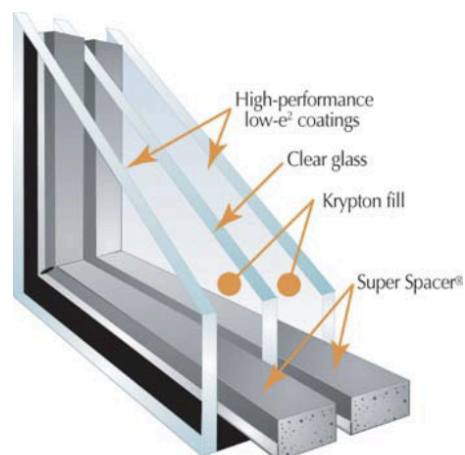


Figure 5. Triple Pane Window Design

3.2.5 Heating, Cooling, and Ventilation

A heat pump was selected because they are typically 300-1200% efficient in cold climates by moving heat instead of generating it.²² A Mitsubishi Hyper-Heat mini-split heat pump was selected and is shown in Figure 6. The design calculations use the standard residential rule of 5–10 W/ft², which yields 4195W. This heat pump provides 5275W, making it appropriately sized for the dwelling. Unfortunately, it performs poorly in colder climates, so the dwelling must rely on its passive design as well. It is also used for cooling, and since the building has strong passive design strategies, it makes the cooling load well under 5275W, meaning the unit meets standards; however, humidity is weaker than other options like central AC.²³

²¹ Bucking, Scott. Enclosures. Lecture 06, ARCC 2202A, Carleton University, Fall 2025, slide 24.

²² Bucking, Scott. Mechanical and Climate Change. Lecture 09, ARCC 2202A, Carleton University, Fall 2025, slide 20.

²³ Mitsubishi Electric Sales Canada Inc., SB_MSZ-FH18NA2 & MUZ-FH18NAH2 Submittal Data, PDF, accessed November 29, 2025, https://www.mitsubishitechinfo.ca/sites/default/files/SB_MSZ-FH18NA2_MUZ-FH18NAH2_202403.pdf.



Figure 6. Mitsubishi Hyper-Heat Mini-Split Heat Pump²⁴

Since modern buildings are airtight, new construction requires a 0.3 ACH mechanical ventilation system, which correlates to 34.5+ CFM to maintain indoor air quality.²⁵ The coach house’s ventilation system utilized a minimum of 0.6 ACH, which correlates to 69+ CFM for improved comfort. The Panasonic Intelli-Balance 100 ERV, shown in Figure 7, provides an adjustable 50–100 CFM and transfers up to 80% of heat between incoming and outgoing air, consistent with heat-recovery requirements. The downsides are that it needs regular maintenance and requires more installation space.²⁶



Figure 7. Panasonic Intelli-Balance 100 Adjustable 50-100 CFM ERV²⁷

Together, this combination of heating, cooling and ventilation will provide a good balance of year-round comfort, air quality and energy efficiency.

²⁴ Mitsubishi Electric Sales Canada Inc., *Submittal Data*.

²⁵ Bucking, Scott. Mechanical and Climate Change. Lecture 09, ARCC 2202A, Carleton University, Fall 2025, slide 34.

²⁶ Panasonic, *Intelli-Balance 100 Balanced Air Solution (ERV) FV-10VEC2 – Product Page*, accessed November 30, 2025, <https://splashes.com/products/panasonic-intelli-balance-50-100-cfm-balanced-air-solution-erv-cold-climate-fv10vec2>.

²⁷ Panasonic, *Intelli-Balance 100 ERV*.

3.2.6 Design Overview

Table 1 summarizes the project’s envelope, mechanical, and renewable-energy values, comparing code minimums from the Ontario Building Code and National Building Code, with the proposed upgraded performance used in the design.

Table 1. Overview of Proposed Envelope Performance, Mechanical Systems, and Renewable Energy Design

Category	Reference ^{28, 29}	Proposed	Description
Wall Insulation ^{30, 31}	R-19	R-26	Dense-pack cellulose + 1.5” XPS rigid insulation
Ceiling Insulation ^{32, 33, 34}	R-31	R-41	9.25” dense-pack cellulose in 2×10 rafters + 2” ZIP-R insulated sheathing
Concrete Under-Slab + Frost Protection Wing Insulation	R-10 (heated slab)	R-20	4” Type III extruded XPS rigid foam insulation
WWR	<17% WWR → very good energy consumption	15.15%	Window-to-Wall Ratio
SFR ³⁵	<5%	3.2%	Skylight-to-Floor Ratio
Heating ³⁶	Must be able to maintain 22 °C in winter temperatures. 5-10 W/ft ² = 5W/ft ² *839 ft ² = 4195 W	18000 BTU = 5275W	Mitsubishi Hyper-Heat mini-split heat pump

²⁸ Ontario Ministry of Municipal Affairs, *Supplementary Standard SB-12: Energy Efficiency for Housing* (Toronto: Queen’s Printer for Ontario, 2016, updated July 7).

²⁹ National Research Council of Canada, *National Building Code of Canada* (Ottawa: National Research Council, 2015/2020).

³⁰ Bucking, Scott. Enclosures. Lecture 06, ARCC 2202A, Carleton University, Ottawa, ON, Fall 2025.

³¹ MateriauxDL, “FOAMULAR® C-200 Extruded Polystyrene Rigid Insulation.” Owens Corning, Accessed November 1, 2025, [FOAMULAR® C-200 Extruded Polystyrene Rigid Insulation](#)

³² “All Things Gypsum: Using Gypsum Board as a Thermal Barrier,” *Woodworking Network*, accessed November 2, 2025, <https://www.wconline.com/articles/85469-all-things-gypsum-using-gypsum-board-as-a-thermal-barrier/>.

³³ National Association of Home Builders. “TechAlert: ZIP System vs. HomeWrap.” NAHB International Builders’ Show Press Kit. Accessed November 1, 2025, [ZIP System® vs. HomeWrap® - An Unbiased Look at the Leading WRB Systems Provided by Industry Expert, Quality Built, LLC](#)

³⁴ Rugged Coatings. “Understanding R-Value in Roofing Systems.” Accessed November 2, 2025. <https://ruggedcoatings.com/understanding-r-value-in-roofing-systems/>.

³⁵ U.S. Department of Energy, “Skylights,” *Energy Saver*, accessed November 28, 2025, <https://www.energy.gov/energysaver/skylights>.

³⁶ Mitsubishi Electric Sales Canada Inc., *Submittal Data*.

Cooling	Max 5000W		
Ventilation	0.3 ACH = 16.3 L/s = 34.5 CFM	0.6 ACH + = 32.6 L/s + = 69+ CFM	Panasonic Intelli-Balance 100 (FV-10VEC2) Adjustable 50-100 CFM Energy Recovery Ventilator (ERV) ³⁷
Solar Panel	≈ 265W ³⁸	400W ³⁹	Trina Solar TSM-DE09.05

3.3 Energy Consumption and Renewable Energy Generation

This section evaluates the home’s total annual energy demand and compares it to the electricity generated by the proposed renewable energy system.

3.3.1 Household Thermal Behaviour

Table 2 presents the calculated heating, cooling, and operational energy requirements of the home using the ClimaPlus Climate Box simulation.

Table 2. Energy Consumption Calculations Using ClimaPlus Climate Box⁴⁰

Climabox Dimensions	Width = 6m Length = 13m Height = 3.56m [Interpolation= $\frac{[(0.5)(3.5m + 4.0m)(1.5m)] + [(0.5)(4.0m + 3.0m)(4.5m)]}{1.5m + 4.5m}$]
Window to Wall Ratio (WWR)	Orientation = Input Value (Calculated Value) North = 10% (9.11%) South = 20% (20.67%) West = 20% (16.88%) East = 20% (19.88%)
Construction	Roof (R-42, U-0.024) → (U-0.11) Best Wall (R-31.75 , U-0.0315) → (U-0.13) Best Floor (slab on grade) → Slab on grade Glazing (U-0.8 → U-0.15) → (U - 1.5) Double Low-E Low-Solar-Gain
Exposed Thermal Mass	Medium (floor)
Infiltration	Regular (0.6 ACH)
Peak Internal Gain	Medium
Natural Ventilation	Operable Windows (wind & buoyancy)
Conditioning System	Heating: Ground source heat pump heating (best of the options)

³⁷ Panasonic, *Intelli-Balance 100 ERV*.

³⁸ “4 kW Solar System,” Understand Solar, accessed November 29, 2025, <https://understandsolarsolar.com/4kw-solar-system/>.

³⁹ “Trina Solar Panels – 400W Monocrystalline Silicon,” Kabair Parts, accessed November 29, 2025, <https://www.kabairparts.com/product-page/trina-solar-panels-400w-monocrystalline-silicon>.

⁴⁰ “Climabox,” ClimaPlusBeta, accessed November 29, 2025, <https://climaplusbeta.com/Climabox>.

	Cooling: Direct Expansion Cooling
Emissions	Electricity: 0.275 kg CO ₂ e/kWh Gas: 0
Total Energy Consumption *Including heating, cooling, lighting, plug loads, and envelope performance	77 kWh/m ² .a = (77 kWh/m ² a)(78m ²) = 6006 kWh/a

3.3.2 Appliance and Water Heater Energy Consumption

Table 3 summarizes the monthly and annual electricity use from appliances and domestic hot water, based on typical load profiles.

Table 3. Total Appliance and Water Heater Energy Consumption⁴¹

Appliance	Average Monthly Usage (kWh)
Computer	45
Printer	45
Refrigerator-Freezer	44
Dishwasher	18
Microwave	11
Coffee Maker	10
Clothes Washer	13
Clothes Dryer	37
Electric Oven	23
Flat-Panel TV	21
Cable TV Set-Top Box	17
Electric Water Heater (2 ppl)	410
Total kWh Appliance Usage	284
Total kWh added from electric water heater usage	410
Total monthly kWh usage	694
Total Annual kWh usage	8328

⁴¹ Pacific Power, “Energy Usage Calculator,” accessed November 30, 2025, <https://www.pacificpower.net/savings-energy-choices/home/energy-usage-calculator.html>.

3.3.3 Energy Overview

Table 4 compares the home's total annual electricity consumption with the renewable energy system's output to determine whether the design operates in surplus or deficit.

Table 4. Renewable Energy Balance Summary

Renewable Energy Source	Description of System Including Specs
Energy Used (Climaplus + Appliances)	(6006 + 8328)kWh/a = 14334 kWh/a
Energy Produced	13,800 kWh/a
Energy Deficit	534 kWh/a
The system produces slightly less energy than the home requires, resulting in a small annual deficit of 534 kWh. This shortfall can be supplied by the electrical grid during periods of low solar production, ensuring the continuous operation of appliances and heating/cooling systems. The deficit can also be minimized through efficiency upgrades.	

4.0 REVIT MODEL

This section summarizes the project's development in Revit, an AutoDesk-developed software for Building Information Modelling (BIM).

4.1 Design Accomplishments

Throughout the design process, Revit enabled the team to construct a comprehensive architectural model integrating structural and interior components. The Revit team was able to develop the foundation design and further the structural elements with clarity. This allowed everyone to visualize how the footings, walls, and slabs interact as a cohesive system. The software also facilitated a deeper understanding of interior assemblies by examining the layered construction of the walls, floors, and roof systems and how each contributes to the complete building envelope as a whole. Additionally, Revit's topography and landscape tools allowed the team to include contextual elements, enhancing the realism and completeness of the model. The program also supported the development of the interior layout, further developing the visualization of the suite's interior dynamic.

4.2 Limitations

With this experience, Revit presents several creative limitations that constrained the design workflow. A significant challenge was creating custom families or importing detailed elements, such as the foundation, windows, and doors, from external sources. In addition, Revit's rendering capabilities, while useful for basic visualization, were difficult to control to achieve high-quality outputs. This was an obstacle because no group member had prior Revit experience, leaving the team with minimal expertise in lighting, materials, or rendering settings. Although Revit is a

powerful tool for BIM, it can limit some creative exploration and visualization without additional software or advanced user expertise.

4.3 Details of Revit Model

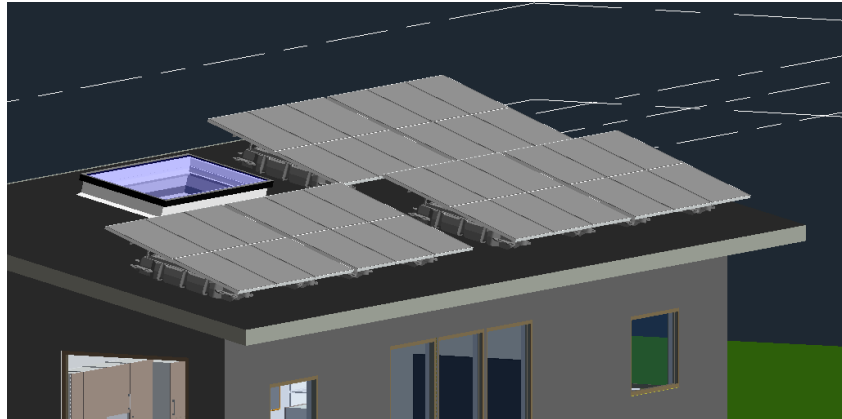


Figure 8. Screenshot of Revit File showing imported solar panel family

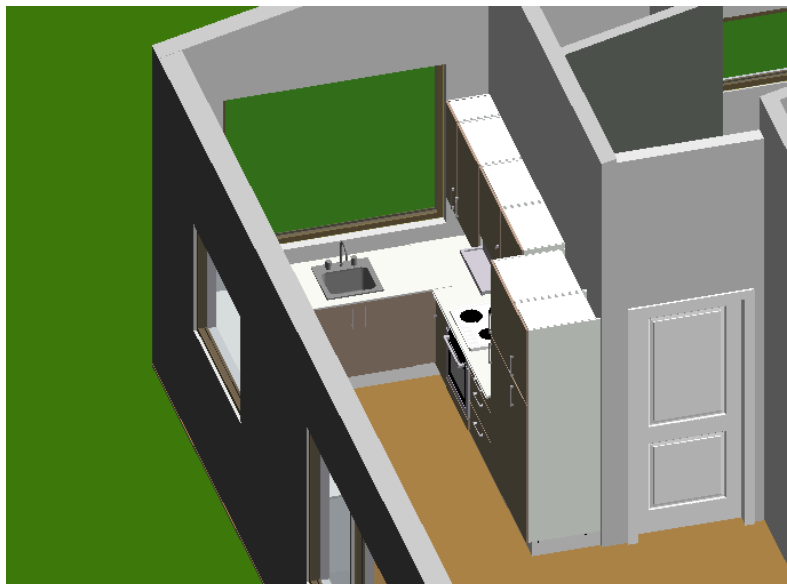


Figure 9. Screenshot of Revit File showing imported kitchen family

4.4 Preliminary Sketches

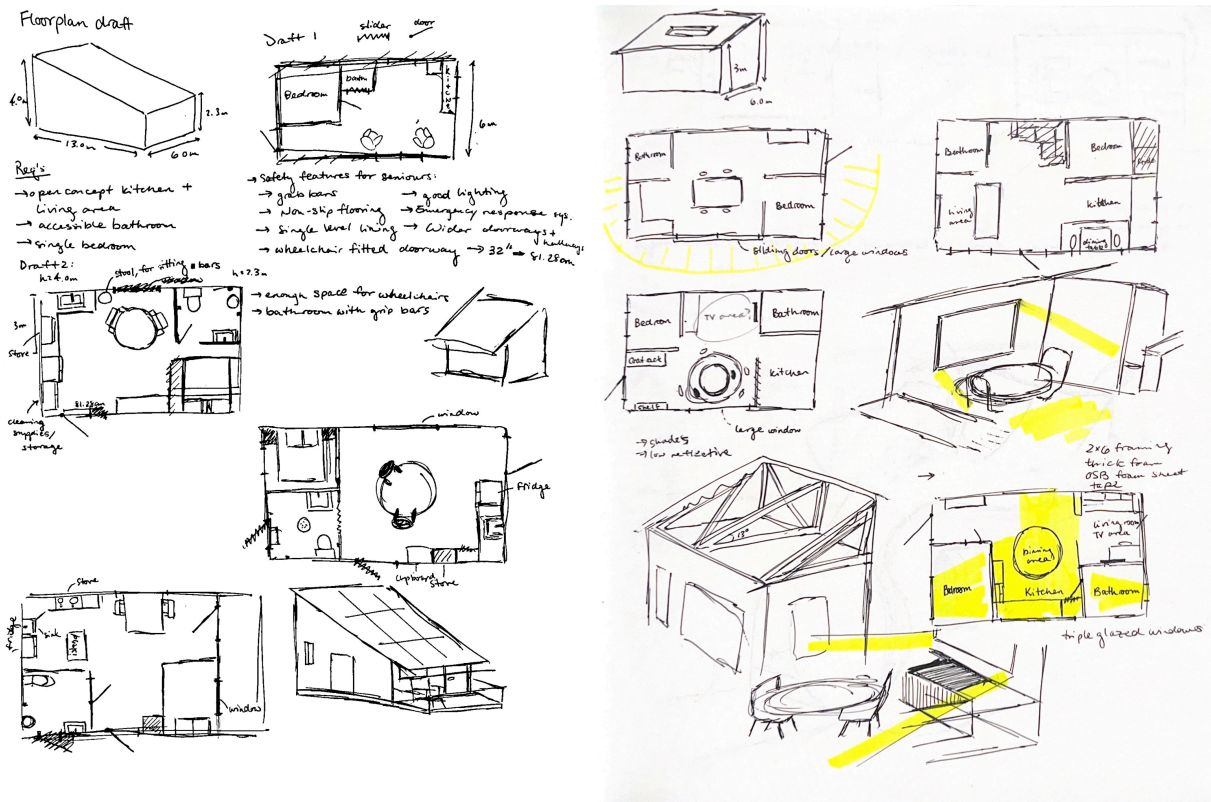
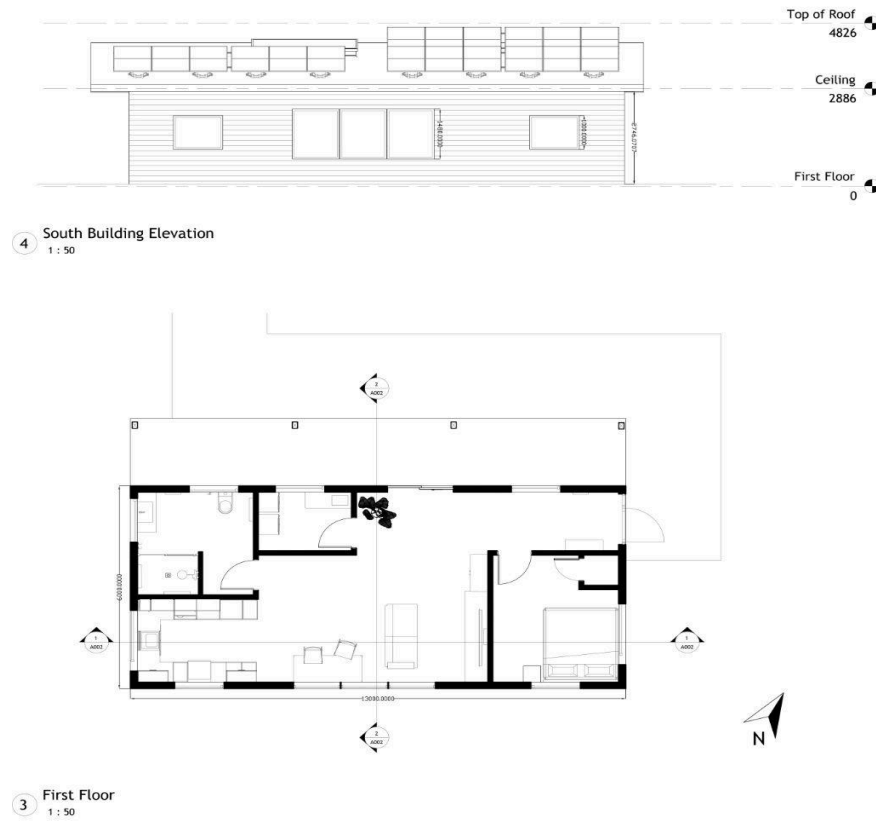


Figure 10. Preliminary Sketches of Tiny House, including Floor Plans, Frame, and Natural Lighting

5.0 DRAWINGS AND RENDERING

This section shows the project's plans, sections, elevations, and perspective views of both the interior and exterior, using AutoCAD, Revit, and Twinmotion.




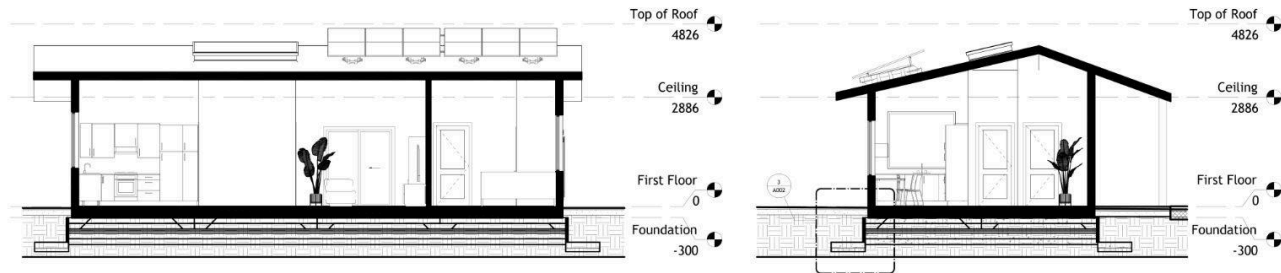
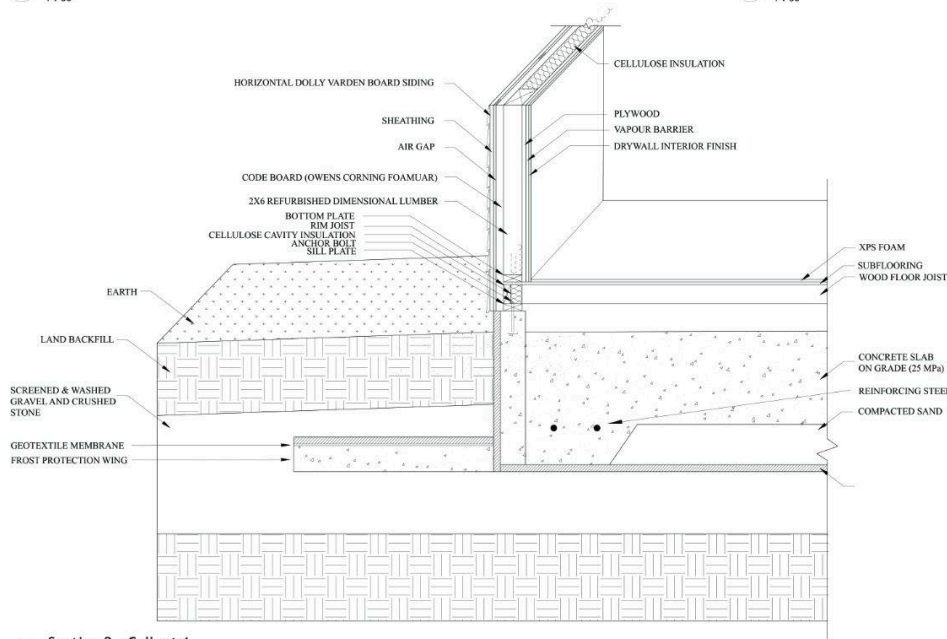
 Carleton University	
Location: 19 Bren Maur Rd. Ottawa ON, K2J 3Z7	
Course:	Prof. Scott Bucking
ARCC2202A	
Tiny Home	
Plan and Elevation	
Date:	05 December, 2025
Drawn by:	Olivia Mustonen, Cara Li, Alexander Sheppard
A001	
Scale:	1:50

Figure 11. First Floor Plan of the Granny Suite



1 Section 1
1 : 50

2 Section 2
1 : 50



3 Section 2 - Callout 1
1 : 5

 Carleton University	
Location:	19 Bren Maur Rd. Ottawa ON, K2J 3Z7
Course Instructor:	Prof. Scott Bucking
ARCC2202A	
Tiny Home	
Sections and Detail	
Date:	05 December, 2025
Drawn by:	Olivia Mustonen, Cara Li, Alexander Sheppard
A002	
Scale:	As Indicated

Figure 12. Building and Wall/Foundation Section of the Granny Suite

5.4 Exterior Renders



① North Elevation



② East Elevation



③ South Elevation



④ West Elevation


 Carleton University	
Location: 19 Bren Maur Rd. Ottawa ON, K2J 3Z7	
Course Instructor: Prof. Scott Bucking	
ARCC2202A	
Tiny Home	
Rendered Elevations	
Date	05 December, 2025
Completed by	Olivia Mustonen
A003	
Scale	1:50

Figure 13. Rendered Elevations of the Granny Suite



1 Exterior Northeast Perspective 1



2 Exterior Northwest Perspective 2



3 Exterior Roof Perspective 3



Location: 19 Bren Maur Rd.
Ottawa ON, K2J 3Z7

Course Instructor: Prof. Scott Bucking

ARCC2202A

Tiny Home

Rendered Exterior Perspectives

Date 05 December, 2025

Completed by
Olivia Mustonen

A004

Scale 1:50

Figure 14. Rendered Perspectives of the Exterior

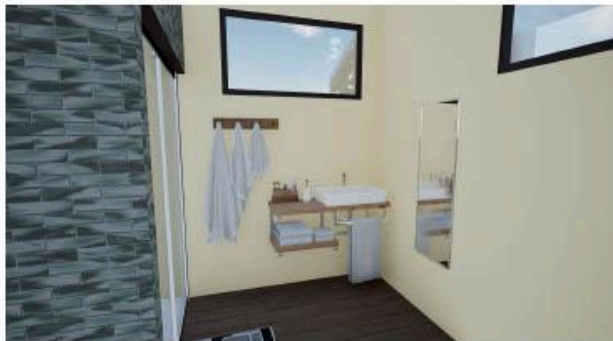
5.5 Interior Renders



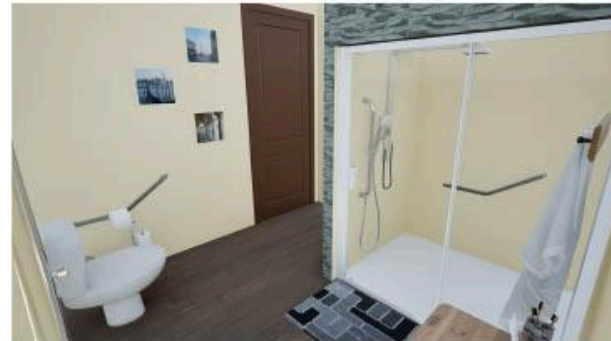
1 Interior Perspective of Main Entrance



2 Interior Perspective of Bedroom



3 Interior Perspective of Bathroom 1



4 Interior Perspective of Bathroom 2



Carleton
University

Location: 19 Bren Maur Rd.
Ottawa ON, K2J 3Z7

Course Instructor: Prof. Scott Bucking

ARCC2202A

Tiny Home

Interior Rendered Perspectives

Date 05 December, 2025

Completed by
Olivia Mustonen

A005

Scale N.T.S

Figure 15. Rendered Bedroom and Bathroom



1 Interior Perspective of Dining Area



2 Interior Perspective of Kitchen 1



3 Interior Perspective of Kitchen 2



4 Interior Perspective of Kitchen 3



Location: 19 Bren Maur Rd.
Ottawa ON, K2J 3Z7

Course: Prof. Scott Bucking
Instructor:

ARCC2202A

Tiny Home

Interior Rendered
Perspectives

Date 05 December, 2025

Completed by
Olivia Mustonen

A006

Scale N.T.S

Figure 16. Rendered Dining and Kitchen Area



1 Interior Perspective of Living Area



2 Interior Perspective of Dining and Kitchen Area



Location: 19 Bren Maur Rd.
Ottawa ON, K2J 3Z7

Course Instructor: Prof. Scott Bucking

ARCC2202A

Tiny Home

Interior Rendered Perspectives

Date 05 December, 2025

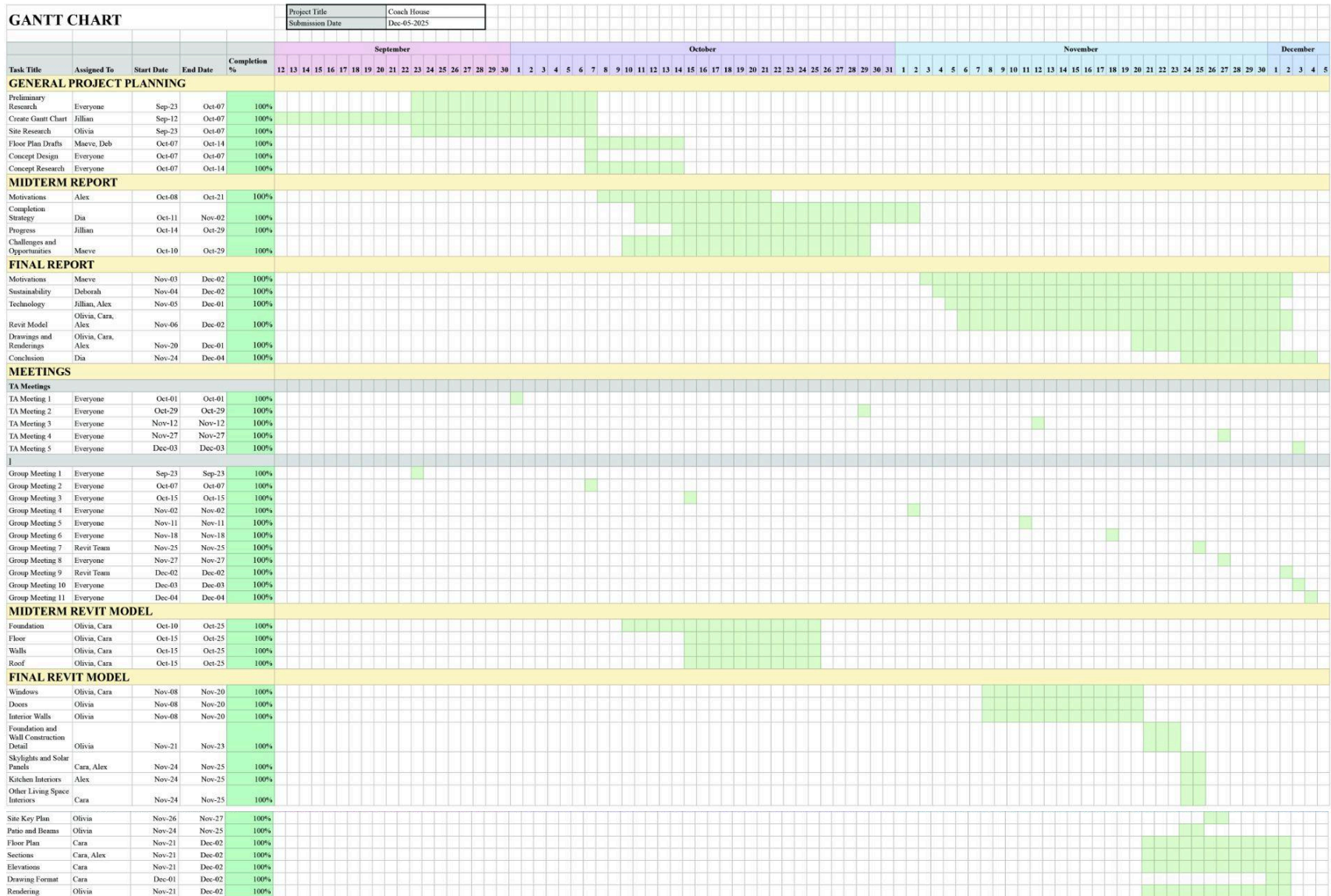
Completed by
Olivia Mustonen

A007

Scale N.T.S

Figure 17. Rendered Living Area and Dining with Human Scale

6.0 GANTT CHART



7.0 CONCLUSIONS AND FINAL THOUGHTS

Over the course of our Coach House Project, our team learned to integrate technical study, sustainable design, and digital modelling into a comprehensive approach. Learning Revit for the first time was a steep learning curve for the entire team. As we progressed through the project, our team got more comfortable with the various tools, capabilities, and workflows required to produce a highly detailed 3D model. If we were required to undertake this project again, we would want to spend additional time exploring alternative assemblies, mechanical layouts, and energy-efficient options to continue improving the design. We believe we could have leveraged Revit's advanced capabilities even further, such as creating completely customized families, conducting sun studies, and performing energy analyses to improve the efficiency of future versions of the design.

Our team felt that using a digital workflow to complete the Coach House Project was far more organized and accurate than drawing it all by hand, especially for analyzing how the different components (walls, foundations, roof, etc.) and systems interconnect. However, we were also aware that working digitally limits our ability to think creatively while requiring much more technical problem-solving. Each member of our team gained an understanding of how the three disciplines (architecture, environment, and structure) are interconnected and how they impact the final product. Throughout the drafting and modelling process, Olivia enhanced her skills in CAD, BIM, and rendering. Based on her prior coursework, Deborah applied the building codes she studied to R-values, fenestration, and passive strategies. Jillian gained a better understanding of how the section of materials and the building envelope impact energy use, which is directly connected to the concepts she was studying in her Architecture and the Environment class. Maeve was able to see the relationship between affordability and sustainability as part of supporting a user-centred design strategy. Cara learned about construction assemblies and how buildings are actually put together. Alex appreciated the high degree of coordination required to design large-scale projects. Dia understood the benefits of translating conceptual ideas from her studio classes into technical assemblies that make up the building, thus closing the gap between what she wanted to achieve through design and the science of building.

In general, the Coach House Project provided us with a practical, scientifically based approach to housing design. While our strategies evolved over the course of the project, we ultimately produced a simple, sustainable design that was supported by solid passive design, efficient materials, and a simple structural system. The constraints of accessibility, affordability, and net-zero aspirations created an opportunity for us to design a house that was both functional and environmentally responsible. If we were to undertake this project again, we would maintain the same collaborative structure we used, as it fostered efficient teamwork and enabled us to leverage each other's diverse skill sets. Overall, the project has shown us that thoughtful design can result in a compact, comfortable and resilient home for those who live there.

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Appendix A – Technology Calculations

This Appendix provides all necessary calculations for Section 3.0 Technology in Table 5 below.

Table 5. Technology Calculations

Category	Location	Calculations	Total
Conditioned Floor Area	Floor 1	$A_{\text{total}} = A_{\text{Rectangle}}$ $= (\text{Length})(\text{Width})$ $= (13.0\text{m})(6.0\text{m})$ $= 78.0 \text{ m}^2$	78.0 m ²
Exposed Surface Area	South Facing Wall	$A_{\text{total}} = A_{\text{Rectangle}}$ $= (\text{Length})(\text{Height})$ $= (13.0\text{m})(3.0\text{m})$ $= 39.0\text{m}^2$	39.0m ²
	North Facing Wall	$A_{\text{total}} = A_{\text{Rectangle}}$ $= (\text{Length})(\text{Height})$ $= (13.0\text{m})(4.5\text{m})$ $= 58.5\text{m}^2$	58.5m ²
	East & West Facing Wall (ea.)	$A_{\text{total}} = A_{\text{Rectangle1}} + A_{\text{Rectangle2}} + A_{\text{triangle2}} + A_{\text{triangle1}}$ $= (W_{R1})(H_{R1}) + (W_{R2})(H_{R2}) + 0.5[(W_{T1})(H_{T1}) + (W_{T2})(H_{T2})]$ $= (1.5\text{m})(3.5\text{m}) + (4.5\text{m})(3.0\text{m}) + 0.5[(1.5\text{m})(0.5\text{m}) + (4.5\text{m})(1.0\text{m})]$ $= 5.25\text{m}^2 + 13.5\text{m}^2 + 0.375\text{m}^2 + 2.25\text{m}^2$ $= 21.375 \text{ m}^2$	21.38m ²
	Roof	$A_{\text{total}} = A_{\text{Rectangle1}} + A_{\text{Rectangle2}}$ $= (\text{Length}_{R1})(\text{Width}_{R1}) + (\text{Length}_{R2})(\text{Width}_{R2})$ $= (13.0\text{m})(1.8\text{m}) + (13.0\text{m})(4.6\text{m})$ $= 23.4\text{m}^2 + 59.8\text{m}^2$ $= 83.2\text{m}^2$	83.2m ²
WWR	South (Sample)	$WWR = \frac{\text{Total Window Area}}{\text{Exposed Surface Area}} \times 100\%$ $= \frac{[2(1.0\text{m} \times 1.3\text{m}) + 3(1.23\text{m} \times 1.48\text{m})]}{39.0\text{m}^2} \times 100\%$ $= \frac{[8.0612\text{m}^2]}{39.0\text{m}^2} \times 100\%$ $= 20.67\%$	20.67%
	North	$WWR = \frac{[(1.73\text{m} \times 2.03\text{m}) + 2(0.7\text{m} \times 1.3\text{m})]}{58.5\text{m}^2} \times 100\%$ $= \frac{[5.3319\text{m}^2]}{58.5\text{m}^2} \times 100\%$ $= 9.11\%$	9.11%
	East	$WWR = \frac{(1.5\text{m} \times 1.8\text{m}) + (0.7\text{m} \times 1.5\text{m}) + (2.0\text{m} \times 0.25\text{m})}{21.38\text{m}^2} \times 100\%$	19.88%

		$= \frac{[4.25m^2]}{21.38m^2} \times 100\%$ $= 19.88 \%$		
	West	$WWR = \frac{(0.7m \times 1.3m) + (1.5m \times 1.8m)}{21.38m^2} \times 100\%$ $= \frac{[3.61m^2]}{21.38m^2} \times 100\%$ $= 16.88 \%$	16.88%	
	Total	$WWR = \frac{(8.0612 + 5.3319 + 4.25 + 3.61)m^2}{(39.0 + 58.5 + 21.38 + 21.38)m^2} \times 100\%$ $= 15.15 \%$	15.15%	
Skylight-to-Floor Ratio	–	$SFR = \frac{Skylight Area}{Floor Area} \times 100\%$ $= \frac{[(1.0m \times 2.5m)]}{78.0m^2} \times 100\%$ $= 3.2\%$	3.2%	
PV ⁴²	Roof	General Info <ul style="list-style-type: none"> • Dimensions: 1.754m x 1.096m • Panel Area: 1.92m² 	–	
		Number of Panels *Roof area is reduced to account for the skylight *Panels will only be placed on the South side; North will not get sufficient sun exposure.	$N = \frac{Roof Area}{Panel Area}$ $= \frac{58 m^2}{1.92 m^2}$ $= 30.21$	30
		Power Output (400W Panels) * Assuming Perfect Fit	$kW = \frac{N \times 400W}{1000}$ $= \frac{30 \times 400W}{1000}$ $= 12.0 kW$	12.0 kW
		Electricity Produced * Annual kWh value was interpolated using lecture 5 values for the slope of the south-facing roof ⁴³	$E = 12.0 kW \times 1150 kWh/kW$ $= 13800 kWh$	13800 kWh

⁴² “Trina Solar Panels – 400W Monocrystalline Silicon,” Kabairfivethe Parts, accessed November 29, 2025, <https://www.kabairparts.com/product-page/trina-solar-panels-400w-monocrystalline-silicon>.

⁴³ Scott Bucking, Solar Radiation and Site Planning, Lecture 05, ARCC 2202A, Carleton University, Ottawa, ON, Fall 2025.