



Innovate, Design, Sustain: EcoHaven

Single-Family Housing | 02.04.2024

Thompson Rivers University | University of British Columbia Okanagan

Project Summary

Innovate, Design, Sustain (IDS) is a multidisciplinary team from UBC Okanagan (UBCO) and Thompson Rivers University (TRU) in British Columbia (BC), Canada. Our mission goes beyond the confines of a single project. We are setting the precedent for sustainable, disaster-resilient, and affordable residential development using a market-ready modular design: EcoHaven.

The 2023 BC wildfire season was the province's most destructive, affecting 48,000 people and 24,000 properties. This devastation emphasizes the urgent need for sustainable and disaster-resilient communities. Amidst a severe housing deficit, that disproportionately impacts people with disabilities, young families, and seniors, EcoHaven offers an affordable, market-ready solution. Featuring an open-concept kitchen and living space, two bedrooms, and two bathrooms, it exceeds code requirements and market expectations for affordability, occupant comfort, and operational efficiency.

In the summer of 2024, EcoHaven will be built near Ashcroft, BC, for a local charity, Honour Ranch, as a live-in caretaker's house. With ambitions to construct ten additional homes next year, this initiative will increase its capacity to support mental health programs for veterans, frontline workers, and members of the Canadian Armed Forces. Using EcoHaven as a case study, IDS and Honour Ranch will prove that sustainable, disaster-resilient homes are affordable and market-ready in BC.

Design Strategy

As the impacts of climate change are felt across British Columbia, we must go beyond emissions reduction and adapt to extreme weather patterns. By addressing the most pressing climate concerns in the region, including wildfires, extreme heat, and flooding, in a highly scalable design, EcoHaven will contribute to resilient communities across Thompson-Okanagan. Modular construction is central to the design strategy, selected for its reproducibility, cost savings, and superior quality. EcoHaven comprises two symmetric modules fabricated in a controlled environment and sized based on the constraints of the major provincial shipping routes. Market-ready components enhance constructability while minimizing cost.

An integrated design process facilitates shared learning between students and industry, promoting innovation. EcoHaven is used as a case study in the development of a multi-criteria decision-making framework to evaluate the trade-offs between sustainability and wildfire resilience. Using the analytical hierarchy process for comparisons, the framework incorporates expert opinions to streamline early design decisions with the intent to reflect decisions promoting sustainable and fire-smart building practices.



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Industry Partners

- Honour House Society (*Design Partner*)
- RJC Engineers
- Project Green Architecture
- Smith + Andersen
- Whole Systems Energy
- Chandos Construction
- Green Construction Research and Training Center



Project Data

Gross Building Area: 1,297.0 ft²

Occupancy: 2-4

Market: Young Families and Professionals, Seniors

Climate Zone: 5

Urban Setting Case Study: Salmon Arm, BC

Heating Degree Days: 3650

Implementation Case Study: Honour Ranch, Ashcroft, BC

Heating Degree Days: 3700

Technical Specifications

Construction Cost: \$236.62/ft²

Energy Performance Salmon Arm:

TEDI: 4.74 kBtu/ft²-year

MEUI: 8.99 kBtu/ft²-year

Utility Cost Before PV: \$368/year

DOE ZERH ERI Before PV: 25

Envelope:

Exterior Walls: R 37.0 Crawlspace: R 54.2

Low-slope Roof: R 43.52 Opaque Door: U 0.18

Windows: U 0.12 / SHGC 0.34

Mechanical Systems:

Air-source Heat Pump: Lennox EL22XPV, 36 kBtu

Heat Pump Water Heater: SANCO2, 43 gal

Greywater Recycling: Hydraloop H300, 80 gal

ERV: Panasonic Intelli-Balance, 50-100 CMF

On-site PV Salmon Arm/Honour Ranch: 27.4/28.4 MBTU/yr

Battery Capacity: 16.37 kBtu or 11.5 hours

British Columbia Source Energy Factor: 1.11

Embodied Carbon: 44 CO₂eq/ft²

Project Highlights

Architecture: EcoHaven features natural elements that integrate architectural interest with function and comfort. South-facing windows maximize passive solar gains in winter, while louvers, exterior shutters, and roof overhangs prevent summer overheating. The interior layout meets the BC accessibility code, the ADA, and SAFR Homes Standard, featuring ramp access and widened circulation for age-in-place living. EcoHaven adapts to the local climate while using modular construction to make sustainable, disaster-resilient communities attainable.

Engineering: Prefabricated modules combined with a steel helical pile foundation can scale across the BC Interior while minimizing material waste and construction time. The vaulted parallel chord truss roof is optimized for material efficiency and structural safety. Open web floor joists easily integrate with mechanical systems. EcoHaven recycles up to 45% of greywater, to address the regions low per-capita water supply. Water sense fixtures and a leak detection system further reduce water consumption and grouping household utilities optimizes the plumbing layout for cost and efficiency.

Envelope: The exterior wall assembly has a 2-hour fire resistance rating and incorporates ASTM Class A1 non-combustible materials. A continuous layer of mineral wool insulation eliminates thermal bridging, increases thermal mass, and protects from the elements. Hempwool cavity insulation balances the embodied and operational carbon, and the unvented, split-insulated flat roof keeps conditioned air inside, reducing reliance on active systems. The Glaser method was used to validate the assemblies, ensuring the dewpoint forms outside of the air and vapor barrier.

Efficiency: Systems thinking, and BIM and energy model interoperability streamlined design iteration. Analysis based on historical climate data and future projections enhances resilience. EcoHaven meets the highest BC Energy Step Code level, making it 80% more energy efficient than the standard home. The Lennox air-source heat pump effectively balances heating and cooling loads, with electric baseboard heating provided as a contingency. The SANCO2 heat-pump water heater uses CO₂ as refrigerant and is 70% more efficient than standard boilers. A backup tankless electric water heater enhances reliability during extreme cold. The smart home hub integrates the Energy Star HVAC systems, appliances, and LED lighting while enabling consumption monitoring.

Grid-Interactivity: At Honour Ranch, the solar array produces 28.4 MBTU yearly and is parallel mounted to reduce structural loads while eliminate roof penetrations. During outages, a lithium-ion battery supports critical systems for 11.5 hours. EcoHaven integrates with BC Hydro's net-metering program, selling surplus power for credits during peak production to offset times of low solar exposure, leveraging BC's 98% clean, renewable energy.

Life-Cycle: EcoHaven minimizes embodied carbon by eliminating structural concrete using timber framing and a steel helical pile foundation. An embodied carbon baseline with common-practice materials, inspired by Vancouver guidelines, was developed on the first iteration of EcoHaven using a cradle-to-grave LCA. Design iteration optimized embodied carbon, cost, and resilience using locally manufactured materials that maximize service life, like steel roofing, and achieves a 38.5% reduction in embodied and operational carbon compared to the modeled baseline.

Health: Window placements were validated by daylight simulations to maximize natural light while reducing glare. The primary lighting layout is designed based on each room's lumen and warmth requirements, creating visual appeal. Strategically placed task lights improve productivity. MERV13 filters, an automatic air purifier, the Intelli-balance energy recovery ventilator, and spot ventilation enhance indoor air quality year-round. Fire-safe acoustic insulation, resilient channels, and magnesium oxide wallboard create a fire and sound barrier between rooms with an STC rating of 45.

Market: EcoHaven is adaptable, functioning in rural settings, as urban infill housing, or for neighborhood expansions in growing communities. The modular design suits climate and market needs across the BC Interior and considers demographics in the target location, Salmon Arm. The modular design addresses regional economic, social, and climate needs, allowing EcoHaven to scale across the Thompson-Okanagan. The purchase price of \$301,283, considering a builder profit of 15%, is affordable for the target market and is under 30% of the household salary of families in the BC Interior.

Community: The destruction from wildfires in the Thompson-Okanagan has worsened the local housing crisis, emphasizing the need for affordability. EcoHaven provides young families and seniors with superior build performance at an attainable price. The age-in-place design promotes occupant well-being and independence, meeting the needs of Honour Ranch and bridging the gap in accessible housing in BC. By implementing EcoHaven at Honour Ranch as a caretaker's house, we will give back to the people who protect our community.

