University of British Columbia Okanagan
Thompson Rivers University

Attached Housing | 04.04.2023

Innovate, Design, Sustain: River Crossing

Project Summary

Innovate, Design, Sustain is a team of students from diverse backgrounds representing The University of British Columbia Okanagan and Thompson Rivers University. Our goal is to improve resiliency, accessibility, and sustainability of residential housing.

The remote Village of Lytton, British Columbia (BC), is one of the longest continuously inhabited areas in North America. Since a wildfire destroyed the town in June 2021, residents have been prevented from returning to their homes. River Crossing offers them an opportunity to rebuild a resilient, efficient, and sustainable community.

River Crossing consists of four custom-designed units with private outdoor space. Families and seniors are a significant percentage of the population of Lytton. Thus, the adaptable layout can accommodate multigenerational family living or allow the homeowner to rent vacant units at market rate. In response to the lack of inclusive housing in Lytton before the fire, River Crossing exhibits a one-bedroom accessible unit, an entrance ramp, and widened doorways on the main floor. The three family units include two bedrooms, a flex room, and an open-concept kitchen, living, and dining area. River Crossing is designed for affordability and ease of maintenance to meet the community's unique needs.

Design Strategy

As the impacts of climate change continue to worsen, residential buildings must adapt to withstand extreme weather. River Crossing demonstrates that it is possible to create a uniformly non-combustible timber building in a high-risk location using market-ready materials. An enclosure-first approach reduces the risk of ignition during a wildfire and improves thermal performance. Prefabricated wall panels, trusses, I-joist floors, and a helical pile foundation reduce construction time, ensuring residents can return home faster.

With environmental impact considered in each decision, River Crossing meets the certification requirements of the DOE ZERH program, BC Step Code 5, and LEED Platinum. The building orientation optimizes passive heating, cooling, and ventilation which is crucial to reduce energy consumption in Lytton's extreme climate. Roof-mounted photovoltaic panels integrate with the local utility using a net-metering connection and produce more energy than River Crossing consumes in one year.

Project Data

- **Location:** Lytton, BC, Canada
- **Climate Zone:** 5
- **Lot Size:** 0.23 acres
- **Custom Units:** 4
- **Building Size:** 4,841 ft^2; 2 storeys
- **Occupancy:** 10 - 16 people
- **Target Market:** Multigenerational families, real-estate investors
- **Construction Cost:** US$197.66/$ft^2$
- **Construction Time:** 6 Months

Technical Specifications

Envelope:

- Wall: R37.9
- Windows: U0.16
- Roof: R50.1
- Crawlspace: R69.2
- Air Changes per Hour: 0.13

Fire Resistance Rating:

- Exterior: 2 hr
- Demising: 1 hr

Energy Performance:

- On-site PV: 25,415 kWh/yr
- TEDI = 2.00 kBtu/(ft^2·year)
- MEUI = 9.50 kBtu/(ft^2·year)
- HERS before PV: 30 to 32
- HERS with PV: -15 to -10

Lifecyle Impact:

- Embodied Carbon: 38 lb CO_2-eq/ft^2
- Carbon Benefit: 60.6 tons

Air-to-Air Heat Pump:

- SEER: 22.5
- Min. Operating Temperature: -22°F

Heat Recovery Ventilator:

- Adjusted SHR at -13°F: 78%
- Filter: MERV13

Air-Source Heat Pump Hot Water Tank:

- COP: 2 to 5

Industry Partners

- RJC Engineers
- Smith + Andersen
- Project Green Architecture

U.S. DEPARTMENT OF ENERGY SOLAR DECATHLON

THE UNIVERSITY OF BRITISH COLUMBIA Okanagan Campus

THOMPSON RIVERS UNIVERSITY

Project Highlights

Architecture: River Crossing is inspired by the buildings that stood before it, ensuring community acceptance. The design is feasible to implement, prioritizing functionality and the requirements of local codes, allowing form to follow. Blue cladding optimizes heat absorption and reflection, reducing temperature fluctuations. The interior design promotes flow and easy circulation between rooms.

Engineering: To overcome the constraints of a remote location, the structural system reduces construction waste and sources all structural materials from local manufacturers. The steel helical pile foundation has an immediate load-carrying capacity after installation, reducing construction time. The air source heat pump hot water tank has a coefficient of performance of up to 5, while the drain water heat recovery system further reduces energy demand. The integrated greywater system sterilizes wastewater and repurposes it for the sanitary system. A remote-controlled Leak Defense System connects to the main water line to monitor appliances and pipes, preventing costly damage.

Market Analysis: River Crossing meets the needs outlined in the Lytton Community Plan by providing 2+ bedroom units, accessible housing, and affordable rentals. A low operational cost and on-site renewable energy generation guarantee a return on the initial investment. The Lytton Homeowner Resilient Rebuild program supports non-combustible residential development and will subsidize the construction cost of River Crossing at US$948,749, including a 5% contingency for variations in schedule and materials.

Durability and Resilience: The non-combustible cladding and insulation reduce ignition risk during a wildfire and provide a 2-hour fire resistance rating for the exterior walls. The Vulcan Vents ensure no stray embers penetrate the envelope, and exterior aluminum shutters protect the windows from cracking due to radiant heat. Decentralized HVAC systems give residents control of their interior climate while reducing the risk of fire spread between units. The durable air-source heat pumps operate in temperatures down to -22˚F, colder than the historical minimum, while backup baseboard heaters and electric fireplaces ensure the building is reliable in extreme weather.

Embodied Environmental Impact: River Crossing promotes circularity by replacing all concrete with forest stewardship council-certified BC timber for a lifecycle carbon benefit of 60.6 tons of CO2. Locally manufactured engineered timber, insulation, helical piles, and roofing further reduce embodied carbon. A cradle-to-grave lifecycle analysis shows that the construction of River Crossing generates 38 pounds of CO_2-eq per square foot, over 70% less than the standard Canadian two-story low-rise.

Integrated Performance: The roof overhangs and balconies provide shading from direct sunlight in the summer and are bypassed by the winter sun to passively heat the space. Matte finishes and flooring eliminate sun glare in the afternoon. The photovoltaic panels lay flush on the south roof, maximizing the size of the array while preventing snow and debris accumulation. The common entry vestibule minimizes heat loss and improves acoustic performance.

Occupant Experience: Accessibility is essential to social sustainability and multigenerational occupancies. River Crossing's accessible unit includes sliding doors, three-foot hinged door clearances, and a five-foot turn radius throughout. Textured flooring adds visual interest while improving the grip of surfaces prone to moisture build-up. Variable height counters and electrical outlets create an inclusive space.

Comfort and Environmental Quality: Residents can control space conditioning based on occupancy using the quad-zone heat pumps, while the built-in de-humidification function and silver ion filters improve air quality. The heat recovery ventilators have air intake vents at least 6 ft from the exhaust, and the MERV13 filters remove up to 98% of particulates, including wildfire smoke. Non-combustible acoustic insulation, flooring underlayment, and electrical box putty pads create an effective sound barrier between units. Acoustic channels in the demising walls and ceilings further reduce sound transmission.

Energy Performance: A continuous layer of exterior thermal insulation with limited interruptions mitigates thermal bridging. Programmable thermostats and motion sensors further reduce HVAC and lighting loads. The units have an average HERS score of 31 and -12.25 before and after renewable energy generation, respectively. Roof-mounted photovoltaic panels produce 25,415 kW/yr and interface with the load management systems to protect Lytton's aging population during extreme temperatures.