

# Municipalities Leading the Way to a Low-Energy Building Future

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## ABSTRACT

*What happens when a municipality becomes the owner and builder for an innovative low-energy project? Marken Projects joined forces with a small group of motivated individuals from the City of Fort St. John's in northern British Columbia to build a passivhaus that would serve as a demonstration project for future developments in the city. This project is not only one of the first completed passivhaus projects in British Columbia, but at 56 degrees north latitude, it is the most northern in Canada, matched only by one in Finland. It serves as an example of the important role that municipalities can play in introducing new ways of building and new technologies. It has been used as a demonstration to teach builders and homeowners about passivhaus and low-energy building design. The City will be able to communicate lessons learned and best practices observed through constructing and monitoring the project themselves, and by validating technologies not typically used in Fort St. John. They have already succeeded in breaking down local pre-conceptions about energy efficient homes during the construction process. By taking on the role of General Contractors, they faced challenges that lead to increased costs and longer construction timelines but the practical knowledge they gained from building the project themselves outweighed these challenges. Upon completion of the home in the autumn of 2014, it will eventually be sold at market value making this a break-even project for the City. They will retain ownership for three years following completion in order to complete the building commissioning, monitor its energy performance and hold open houses for the community to experience this house and learn more about it. This type of leadership role by a municipality can go a long way towards changing the way building happens.*

## INTRODUCTION

Marken Projects Design Studio joined forces with a small group of motivated individuals from the City of Fort St. John in northern British Columbia in 2011 to build a passivhaus that would serve as a demonstration project for future developments in the city. This project is not only among the first completed passivhaus projects in British Columbia, but at 56 degrees north latitude, it is the most northern in Canada, matched only by one in Finland. There were many reasons that the City of Fort St. John's took on the challenge of becoming owner/builder of their own passivhaus project. Many municipalities in British Columbia are reluctant to consider such an endeavour. Three long years since its inception, the house is finally near completion. But whether after all of our efforts, The City can declare the project a success, is still undecided. They have set extremely high expectations for themselves before they are ready to do so. In this paper we discuss the motivation and challenges in making this project happen; we describe the project and the future plans for leveraging it to change local building practices. This project serves as an example of the important role that municipalities can play in introducing new ways of building and new technologies.

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## PROJECT INCEPTION

Fort St. John is a city of about 18,000 residents in northeastern British Columbia. It is a unique community that is experiencing tremendous growth driven by development in the energy sector, particularly in the unconventional natural gas sector. The City's slogan is *The Energetic City*, referring to energy derived from the region's natural resource exploration and to a tangible mantra for the attitude of the residents. Boasting one of the highest birth rates in the province and an average age of 31 years, many young families move to Fort St. John as they see within it great opportunities to build a solid financial future for their families while also enjoying a great quality of life.

Living in the heart of the province's energy sector (natural gas, hydroelectricity, wind farms, coal, geothermal) the environmental impacts of how energy is extracted from natural resources is a stark reality for Fort St. John. They are part of the region in the province that produces the greatest proportion of energy for export per capita thereby affording others a high quality lifestyle. From this "backyard" vantage point, they can clearly understand the importance of minimizing the environmental impacts of energy extraction by looking to better ways of generating energy. In British Columbia, there are many communities with resource extraction based economies. The residents of these communities are often perceived as having little interest in environmental issues. In fact, with an abundance of resources and the natural beauty surrounding these communities, it is not difficult to understand why environmental concerns such as energy conservation are not a priority for residents. Fort St. John stands out as a very progressive community that takes stewardship of the environment seriously. Over the past 7 years, they have aimed to become an environmental leader in the Peace River region through the use of pervasive sustainable and environmental best practices. Their approach is to prioritize conservation as one of the easiest and best sources of energy. If a rural, northern community with an extraction-based economy can show this type of environmental leadership, there is hardly an excuse for others not to follow in their footsteps. Their projects have been numerous:

- They partnered with BC Hydro to hire one of BC's first Energy Managers, making energy a strategic focus of the community.
- They developed a Community Energy and Emissions Plan (CEEP) to improve energy efficiency, reduce greenhouse gas emissions and foster green energy solutions in the community.
- They have developed a Carbon Neutral Plan for taking action on reducing emissions from municipal operations.
- They have significantly reduced water use in the community through metering and toilet change-out incentive programs.
- They have launched innovative projects such as the micro-hydro project that will use wastewater to generate power to sell back to the utility company – protecting the environment while using a liability as an asset.

The turning point that led to the inception of the passivhaus stemmed from a proposal from BC Hydro (a provincial electric utility) to build a third hydro dam on the Peace River. The dam, referred to as Site C, will be located 7 km from the downtown center. The City is working to protect their community from the negative impacts of this dam. The dam will flood thousands of acres of arable land that could be producing food for the community. Once flooded, this land will be lost forever. The dam would not be necessary if all homes in Fort St. John were constructed to the passivhaus standard. This harsh reality motivated the City to take action to demonstrate extreme energy conservation.

## APPROACH

The passivhaus concept was promoted by the City's Energy Manager and supported by the entire organization including City Council and senior management. The passivhaus project was perceived as an opportunity to:

- Demonstrate that building a home that consumes approximately 80-90% less heating and cooling energy than a typical code-built house is possible in Fort St. John.
- Demonstrate to local builders that highly energy efficient homes can be built at comparable prices per finished square

foot as homes built to building code standards in Fort St. John.

- Demonstrate different building techniques and innovative products and technologies.
- Build a net-zero energy ready building in accordance with their Carbon Neutral Plan.

### Budget Problems

Funding for the passivhaus was approved through the City's budget process in 2012. The passivhaus was part of the Capital budget and was funded through industrial taxation. The house will eventually be sold at market-value and this money will go back into the Capital budget reserve. In this way, the project was envisioned as a break-even project for Fort St. John. The initial construction budget was \$300,000. It was naïve to assume that the project could be constructed for this amount, especially when new houses in Fort St. John cost around \$500,000. Lack of experience in this type of project led to poor budgeting resulting in having to go back to Council on two occasions for additional funds; this created tension within the working group and some negative backlash from the community. A major unexpected factor that increased costs was that the City had to assume the role of general contractor.

### Disinterest in the Building Community

The City did not begin the passivhaus project with the intention of becoming the builder. After the design and construction documents were completed, they issued a call for tenders, but received only one respondent. The construction market is so busy in Fort St. John that there were not many builders interested in taking on the challenge of building something new. Fort St. John is a rapidly growing community with limited development resources. Local developers are struggling to provide for a rapidly expanding market. They are conservative in their construction practices and choose to maintain the standard construction practices and building styles that have worked well for them in the past. There is no need for developers to take risks with new techniques and products in this market. This fueled the desire of the City to demonstrate to builders that passivhaus construction is feasible in northern B.C. and that offering this kind of construction could be a competitive advantage over time, as the province becomes even more proactive on climate change. This is what led the City to take on the role of general contractor, which has resulted in many challenges that have slowed down the construction of the house and increased costs. As the price of housing escalates, the push for change will likely come from the end consumer who is looking for affordability, not only in the initial price of the house but in the ongoing operating costs. It is the City's objective to educate the consumer who will then seek a change in construction style from the local builders.

### OUTCOMES

The Fort St. John passivhaus is a 2000 sqft 2-1/2 storey home with 3 bedrooms, 2.5 bathrooms and 1 flex room. The house is designed to be universally accessible. Construction of the house broke ground in January 2013. The Prefabricated thermal envelope panels traveled 700km north from the factory in Williams Lake, BC to arrive onsite in March. The panels were erected in 10 days. Following this, the windows were installed and the thermal envelope was taped and sealed in the spring of 2013. The thermal envelope is described in **Table 1**.



**Figure 1** (a) Prefabricated thermal panels arriving on site. (b) Erection of the panels was complete within 10 days.

After this, the construction progress suffered from long delays, first due to the need to procure more funds from City Council; then due to heavy workloads of staff. The project also suffered from staff turnover and attrition, which is very typical

in a northern community. Once the construction momentum fell off track, it was very difficult to convince busy subtrades to complete the remaining work. The drywall was not completed until early spring of the following year.

Thermal Envelope	Thickness	Assembly	Effective R-Val
Walls	18.75 in.	11-7/8" TJI prefabricated wall system paired with a 2X4 Service Wall	56
Roof	21.25 in.	16" TJI prefabricated roof system 2X3 service ceiling	70
Floor	16 in.	ICF perimeter, backfilled, 12" XPS R52, 4" concrete top slab on grade	52
Windows	-	Optiwin A12Wood Windows (aluminum exterior and wood interior)	8
Doors	-	Euroline triple paned entry doors with thermal inserts and exterior cladding	8

**Table 1:** Thermal envelope: wood construction with cellulose insulation and ROXUL batt insulation in the service walls; SIGA tapes and membranes were used to achieve airtightness

The mechanical system consists of a direct-ducted ventilation system with heat recovery (HRV) and a combination of electric resistance heating (baseboards) and point source air conditioning (air source heat pumps) for backup heating and cooling. Domestic hot water is provided by a hybrid electric heat pump. This system will consume about 90% less energy than a typical code built house due to an extremely energy efficient building envelope. The heating/cooling cost for the year is estimated to be \$200-\$400, which amounts to annual savings of approximately \$1000-\$1800 when compared to a house built to provincial building code standards in this climate. The house is net-zero energy ready, meaning that it is an ultra-efficient building that can be adapted to net-zero energy at a later date through implementation of renewable energy technologies on site. A 2.82kWp solar photovoltaic (PV) system installed on the roof will produce about 3500 kWhr/year (~25-30% of the homes total energy requirements). The remaining southern portion of the roof is prewired with electrical junction boxes for future PV expansion. Energy monitoring equipment is installed with an on-line analytics subscription for monitoring.



**Figure 2** (a) Heat recovery ventilator installed in upper level closet. (b) Outdoor installation of air source heat pumps.

This home is 100% electric, utilizing provincial hydro-electric power. Using air-source heat pumps in the house with backup electric baseboards installed throughout, the house will emit 0.05 tonnes of GHGs per year — over a 99% reduction in tonnes of GHGs relative to a typical single-family detached dwelling. A single-family detached dwelling emits around 10 tonnes of CO<sub>2</sub> per year, on average. An airtightness level of 0.6 Air Changes per Hour @ 50pa or below is anticipated (pending blower door test). By comparison, an average home built in the 2000s in Canada would be at 3-4 ACH@50pa.

The final construction cost has not been tabulated, as the project is not yet completed. The City has approved a total of \$580,000 for construction. Thus far, the cost of the house remains on par with the cost to build a new home in Fort St. John. With the value of the land included, the cost is \$350 per square foot, similar to newly constructed homes in Fort St. John. Typical new build prices in Fort St. Johns range from \$330-\$380 per finished square foot.

**Performance Ratings.** Pre-certification as a passivhaus was achieved through PHIUS. The house also achieves a preliminary Energuide Rating of 90, is certifiable as LEED Platinum (should dual certification be sought) and is Net-zero Energy Ready.



**Figure 3** (a) Exterior view from the northeast. (b) Exterior view from the southeast.

## INFERENCES AND CONCLUSION

In spite of the delays due to budget issues and lack of experience as general contractors, the execution of the passivhaus has been excellent. It has been constructed exactly as designed. Upon completion of the home in the autumn of 2014, the City will retain ownership for 3 years in order to complete the building commissioning, monitor its energy performance and hold open houses for the community to experience this house and learn more about it. During this time the home will be rented as temporary housing for staff recruited to work for the City. Having an employee live in the home will allow flexibility in arranging for tours, demonstrations, etc. The house will be rented to a family to ensure the City is gathering real-time data that reflects the intent of the demonstration: a single-family residence. It will eventually be sold at market-value making this a break-even project for the City. But even though the City may be able to recover all of their costs, the money is not an indicator of the success of this project. The knowledge gained by the City cannot simply remain with them. A rigorous education and marketing plan is currently in development to ensure that the passivhaus does not become a stand-alone project. The City needs to ensure that they are not simply describing and demonstrating *what* a passivhaus is to the community of Fort St. John, but that they are able to sell the community on their vision for *why* they did it. If they are successful, then this small single-family residence can mark the beginning of a new building movement in Fort St. John. The education and marketing plan includes:

- Utilizing the house as a laboratory whereby builders and the public can see how the house actually performs.
- Providing tours, workshops and training opportunities for the public to understand the simple construction concepts around the passivhaus and how they can be replicated in the community.
- A Construction Manual and that can be provided to other builders.
- Web updates of energy consumption on the City's website.
- A Home Owner's manual

For the City, the markers of success include (1) verification that the final cost of construction is the same or similar as a typical single-family home in Fort St. John, (2) confirming that the performance of the house meets the anticipated energy conservation levels, (3) the uptake by private developers that initiate new projects to the passivhaus standard and finally (4) motivating community members to prioritize energy conservation in the design and construction of their homes. Success for the City of Fort St. John may ultimately mean that energy expansion projects such as the proposed Site C hydroelectric dam will not be necessary.

During construction, the project has been used as a demonstration to teach the local building community about passivhaus construction and low-energy building design. There have already been small signs of success in breaking down local pre-

conceptions about energy efficient homes. The subtrades on-site expressed that they saw the value in ideas such as a service wall and prefabrication. One contractor has even decided to build his own passivhaus for his family. Smaller builders preferred the prefabricated building techniques since they could be erected quickly and were more manageable for smaller crews. This removes some of the construction risk associated with the high cost of labour in the region and the extremely short construction season, making it possible for them to compete with bigger construction companies. A City Building Inspector that took the lead as the General Contractor saw the benefit of becoming a Certified Energy Advisor (CEA) to help facilitate future lower energy building projects in the region. When he completes his training, he will be the first CEA in Fort St. John. As 1 of only 3 city building inspectors, this type of training will offer him great insight into evaluating and influencing the energy performance of construction in Fort St. John.

The City employees that are involved in completing the house since the thermal envelope was sealed have reported exceptional indoor comfort and consistent indoor temperatures even without the HRV commissioned. There has been no need for any additional heating for workers onsite throughout the winter of 2014 at outdoor temperatures well below 0 degrees Celsius. During the hottest days of the summer of 2014, the house maintained a comfortable temperature; the geometry of the roof overhangs provided adequate shading from the summer sun to prevent overheating. The indoor environment is also reported to be remarkably quiet.

In this Northern region of the province, access to building materials and products are limited, inflating costs. Some design ideas that were great from an architectural perspective were not so good from a cost and construction perspective. This incongruity should have been considered at the design stage to mitigate cost escalation. For example, labour costs are so high that a significant amount of money could have been saved by simplifying the roof construction using a truss system over a prefabricated flat roof panel rather than framing a cold roof over a vaulted thermal roof panel. Another example was the extremely high costs of procuring a crane on-site. This has implications on the cost benefits of using prefabricated panels. All of these lessons will be passed on to local builders in a construction manual.

As the project nears completion, the City's Energy Manager and visionary behind this project has said goodbye to Fort St. John and moved on to another position in Alberta. This has been a loss for the City but he leaves behind the groundwork for a bright passivhaus future. This type of municipal leadership that we were fortunate to witness can go a long way towards changing the type of building that happens in our communities. Instead of writing green building guidelines and bylaws, the City of Fort St. John chose the more difficult path of implementing an actual project. We will continue to watch with interest to see what the project impacts will be in the future and whether the City of Fort St. John is able to leverage their efforts in creating this small house to have a larger impact on transforming the local building community.

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