



EAST VANCOUVER SINGLE-FAMILY PASSIVE HOUSE

CASE STUDY

A comfortable, quiet, and healthy home was a priority for the owners of this single-family residence in Vancouver's Riley Park Neighbourhood. Through incorporating the key components of Passive House design, such as a highly insulated envelope, high quality doors and windows, heat recovery systems, and efficient appliances, this house uses an estimated 75% less energy compared to an equivalent conventional house

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PREPARED BY



THE UNIVERSITY
OF BRITISH COLUMBIA

GENERAL OVERVIEW

This newly built single-family home with a basement suite is located on a small lot in a residential neighborhood in East Vancouver. The home was built to the Passive House standard in response owners' commitment to minimizing their environmental footprint.

Project Overview

Building Type	Single-Family Residence
Climate Zone	5
Location	Riley Park, Vancouver
Gross/Treated Floor Area	247 m ² / 206 m ²
Building Height	9.9 m
Number of Floors	2 stories + basement suite
Project completion date	October 2018

Project Team

Project Owner	Private homeowners
Architect	Lanefab Design/Build
Structural Engineer	Deer Lake Engineering Inc.
Builder	Lanefab Design/Build
Mechanical Engineer	Apple Mechanical
PH Consultant	Lanefab Design/Build
PH Certifier	RDH Building Science

Project Context

In response to global climate change concerns, the City of Vancouver released the Zero Emissions Building Plan, which sets a roadmap for making all new buildings zero emissions by 2030. In 2017, the Province of British Columbia enacted the Energy Step Code to incrementally move toward net-zero energy ready buildings by 2032.

As a participant of NearZero.ca initiative that is sponsored by the City of Vancouver, this project is one of the early adopters of zero emission house design and construction technologies in BC.

Planning and Design

The main design focus of this project was achieving the Passive House requirements. To be mindful of the impacts of design decisions on the building energy performance, the design team used DesignPH plugin for SketchUp. DesignPH provides preliminary and simplified energy performance estimates for early design iterations.

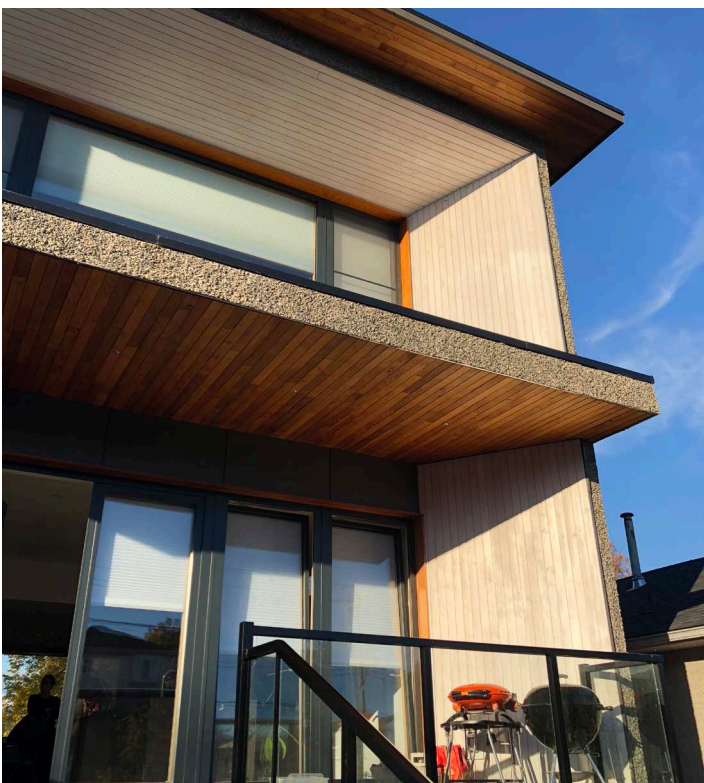
The City of Vancouver's relaxations for single-family homes was significant in enabling this project to be able to pursue and achieve Passive House certification. The relaxations allowed extra depth and height, exclusion of wall thickness from maximum allowable floor area, increased size of the sunken patio, and increased site impermeability.

In addition to high-energy performance, this house also has the green roof and an 800-gallon rainwater tank designed to capture the green roof's water runoff, which can be used for watering the yard in times of water shortage and restriction.

Budget and Financing

As the first Passive House project of design/build team, this house approximately cost 5-8% more than a non-Passive House equivalent project of this team. They expect the cost of future projects to reduce as they gain more experience and the industry and regulatory systems advance.

The building is estimated to have about 60% less annual operation energy cost compared to an equivalent house built to step one of BC Energy Step Code.



ENERGY PERFORMANCE

This house is pursuing Classic Passive House certification. Passive House is an internationally recognized certification program, developed an independent research institute based in Germany. The program is intended to result in buildings with extremely low space heating and cooling needs and consequently lower environmental impacts, as well as a comfortable indoor temperature and air quality.

Envelope

The project used prefabricated Structural Insulated Panels (SIPs), which are Oriented Strand Boards (OSB) sandwiching Expanded Polystyrene (EPS) insulation. Although using SIP panels is not the common practice in Vancouver, it is the signature construction method of the project's design/build team. They use SIP panels because of their strong structural characteristics (e.g. less susceptible to shifting), higher thermal resistance with less thickness compared to traditional wood framing, air tightness, acoustic performance and reducing construction time and costs.

To achieve the Passive House performance they increased the SIP thickness from 2x6 to 2x8 and also filled the service wall cavity with batt insulation to accommodate the insulation thickness required. However, the extra cost for the additional insulation used, was not significant.

All of the windows and exterior doors are Passive House certified triple-glazed units. The one exception is the roof hatch, for which a locally manufactured double-glazed skylight roof hatch was used. This became possible through building a high-performing envelop with enough buffer to use a lower performing and significantly more cost effective alternative.

A cost effective solution used to reduce thermal bridging was spanning stair and floor beams from wall to wall to eliminate the need for internal footings in the middle of a slab. Additionally, by calculating the minimum bearing of each beam to the wall structure, the beams were cut short and capped with insulation in the beam pockets.

Air Tightness

The interior OSB sheathing of the SIP panels are used as the air barrier and are taped on the inside for airtightness. Air barrier on the inside provided more flexibility in using the exterior face for affixing elements such as steel outriggers and claddings. Service walls and dropped ceilings let the trades run all of the building services without penetrating the air barrier.

Heating & Cooling

The south-facing glazing provide solar heat gains provided close to half of the building heating needs. Through the City of Vancouver relaxations, a fairly extensive stepped sunken patio was designed on the south side of basement to allow more solar access. An existing poor condition coniferous tree was removed to increase the solar heat gains from the south.



Lanefab Design/Build uses partially prefabricated framing using SIP panels for the framing of all of their projects.

The heating and domestic hot water supply of the house are combined and provided through a heat pump water heater. The heating is zoned via a variable speed pump and is distributed through in-floor radiant hydronic heating in the basement, and in the kitchen and bathrooms on the main and second floor. The design team suggested that in future projects they may add heating distribution close to the south siding windows for additional comfort. They may also increase the size of hot water tank or add a or mini-electric heating backup to ensure in the coldest days of winter the hot water supply is sufficient for heating and domestic hot water.

Although the high g-value glazing used on the south side, successfully reduced space heating demand in winter, they increased the risk of overheating during summer. To overcome that, passive cooling was used through deep overhang shadings on windows, shading fins, cross ventilation and stack effect through windows and the roof-hatch skylight.

Heat Recovery Ventilation

The house has a central Heating Recovery Ventilation (HRV) unit with 82% efficiency. All of the HRV penetrations from the main floor to basement were through fire-rated floor assemblies.

Primary Energy

The kitchen ranges are electric with recirculating charcoal filter hoods. A ventless heat pump clothes dryer is used which eliminates the need for exhaust vent. Using ductless systems reduced the ventilation need and thus reduced the required make-up air and contributed to the space heating targets. Solar panels were incorporated within the original design, but due to budget shortage, they were excluded during construction.

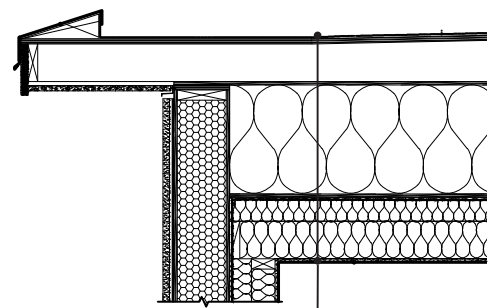
LESSONS LEARNED

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Table: Achieved energy performance compared to Passive House criteria.

Parameter	Characteristic	Unit	Passive House		Building Performance
			Criteria	Alternative	
Air tightness		ACH @ 50Pa	≤ 0.6	-	0.54
Space Heating	Annual demand	kWh /m ² a	≤ 15	-	14.2
	Heating load	W/m ²		≤ 10	13
Space cooling	Annual demand	kWh /m ² a	≤ 15	-	0.4
	Cooling load	W/m ²	-	≤ 10	0
	Frequency of overheating	% (> 25° C)	≤ 10	-	0
Primary energy requirements	Non-renewable (PE)	kWh/m ² a	-	≤ 60	40
	Renewable (PER)	kWh/m ² a	≤ 120	-	91

Wall Section: The wall section displays the thick insulation layer, countinuous airtight layer, and highlyefficient Passive House certified window that are used to build a Passive House envelope



Lessons Learned

The following are the key variations that the project team experience compared to an equivalent project built to the building code requirements:

- The City of Vancouver's relaxations made pursuing Passive House certification more financially feasible. However, negotiating and getting approval for some of the design strategies that were crucial for achieving certification increased the permitting process time. As the City staff gain more experience on Passive House project, the processing time is expected to reduce.
- The project team engaged with the Passive House certifier early in the design process to identify and address issues that affect the feasibility of achieving Passive House certification.
- Having members with Passive House training on the design and trade teams ensured proper consideration of key Passive House aspects.
- As the first experience of the project builder, achieving airtightness requirement was challenging. They had to spend a significant amount of time for airtightness quality control and testing. As the team gain more experience and the product supply market advances, they expect the process to become more streamlined.

ROOF

TORCH ON ROOF MEMBRANE
2X8 RIPPED TO SLOPE FOR DRAINAGE
1/2" PLYWOOD
16" TJI, W/ KNAUF ECOBATT
1/2" PLYWOOD
CONTINUOUS AIR BARRIER
2X4 ROXUL COMFORT BATT INSULATION (R4/INCH)
2X6 ROXUL COMFORT BATT INSULATION (R4/INCH)
1/2" GYPSUM BOARD

EXTERIOR WALL

STUCCO CLADDING
TYVEK A.B./M.B.
2X8 SIP PANEL W/ EPS (R3.6/INCH)
CONTINUOUS AIR BARRIER
3 1/4" KNAUF ECOBATT INSULATION (R14/INCH)
2X4 W/ KNAUF ECOBATT (R14/INCH)
1/2" GYPSUM BOARD

FOUNDATION ASSEMBLY

1/2" GYPSUM BOARD
NOTCHED 2X4 (OR 2X4 ON EDGE)
8 1/4" 2LB SPRAY FOAM
CONTINUOUS AIR BARRIER
8" CONCRETE FOUNDATION ON SPREAD FOOTING
6.0" BASF NEOPENE GPS SLAB EDGE (R4.7/INCH)

WINDOW

AIRTIGHT PASSIVE HOUSE CERTIFIED PURO-PASSIV ALU-CLAD WOOD WINDOW

GLOSSARY

Key terms, definitions, and abbreviations used in this case study.

BC Energy Step Code A voluntary provincial standard that provides an incremental and consistent approach to achieving more energy-efficient buildings that go beyond the requirements of the base BC Building Code.

DesignPH A plugin developed by the Passive House Institute in Germany for SketchUp, a 3D design software used by architects. DesignPH uses an algorithm to automatically analyze the SketchUp 3D models and provide a preliminary energy performance estimates for early design iterations. It also extract primary inputs such as areas, windows, and shading into Passive House Planning Package (PHPP) energy modeling tool.

g-value Solar Factor or Total Solar Factor is a measure of the solar energy transmittance of glazing. A g-value is between zero to one and a value of 1.0 represents full transmittance of radiation..

Heat Recovery Ventilator (HRV) A mechanical energy recovery system which works between two streams of different temperatures. Residual heat from exhaust gas is recovered and effectively transferred to a fresh air stream. Building exhaust air is used as a heat source or heat sink depending on climate conditions, time of year and requirements of the building.

Plenum duct An air-distribution box attached directly to the supply outlet of the HVAC equipment. The ductwork that distributes the heated or cooled air to individual rooms of the house connects to the plenum.

Heat Pump a mechanical device that transfers thermal energy in the opposite direction of spontaneous heat transfer by absorbing heat from a cold space and releasing it to a warmer reservoir.

Passive House an internationally recognized certification program, developed by an independent research institute based in Germany. The program is intended to result in buildings with extremely low space heating and cooling needs and consequently lower environmental impacts, as well as a comfortable indoor temperature and air quality.

Passive House Planning Package (PHPP) PHPP is specifically developed to design Passive House buildings and is based on a combination of several existing, proven and verified calculation methods that are compliant to the European standard for the thermal performance of buildings (EN 832).

Vacuum Insulation Panels (VIP) Commonly used as a retrofit for wood-frame walls.

Form Factor The form factor is the ratio of external surface area by internal treated floor area.

Structural Insulated Panels (SIPs) A sandwich structured composite, consisting of an insulating layer of rigid core sandwiched between two layers of structural board.

Non-renewable Primary Energy (PE) Demand The total energy demand for operation of a building, including heating, cooling, hot water, lighting, and plug loads. To account for energy losses along the generation and supply chain, Passive House Institute (PHI) multiplies the building energy requirement by a PE factor.

Primary Energy Renewable (PER) Demand To account for renewability of different energy sources, PHI developed new factors (PER) to replace PE factors.

Vancouver Building Bylaw Among BC municipalities, the City of Vancouver is uniquely able to adopt its own Building Bylaw. VBBL regulates the design and construction of buildings in the City.

Form Factor The form factor is the ratio of external surface area by internal treated floor area.

U-value A measure of thermal performance or heat transfer through a surface due to conduction and radiation. The lower the U-Value, the more energy efficient the surface is.