EAST VANCOUVER SINGLE-FAMILY PASSIVE HOUSE

CASE STUDY

Building a comfortable, quiet, and healthy home was a priority for the owners of this single-family residence in Vancouver's Riley Park Neighborhood. Through the pursuit of the international Passive House design standard, this house is estimated to reduce its energy consumption by 75% compared to an equivalent conventional house in Lower Mainland, BC.

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PREPARED BY

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THE UNIVERSITY OF BRITISH COLUMBIA

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PROJECT OVERVIEW

INCREASED INSULATION
allows the exterior wall of this house to achieve R49, more than twice as effective as a house built to current code requirements - **page 04**

THERMAL BRIDGING
was avoided with a simple building shape and careful engineering - **page 04**

EFFICIENT FENESTRATION
certified by Passive House Institute offers exceptional thermal performance, through solar heat gains, and minimal thermal losses - **page 04**

AIRTIGHTNESS
of 0.54 ACH @ 50Pa was achieved by placing the airtight layer on the interior of the wall, any punctures from cladding installation was avoided - **page 04**

PARTIALLY PREFABRICATED
Structural Insulated Panels (SIPs) reduced construction waste, improved thermal performance, and simplified the airtightness process - **page 04**

EFFICIENT APPLIANCES
like the Energy Star washer and ventless dryer used contribute to the house's energy demand reduction - **page 05**

This case study reviews some of the key features and lessons learned in this single-family Passive House.

A HEAT PUMP
provides both hot water and space heating, significantly reducing carbon emissions. Sanden CO_2 water heater is five times more efficient than traditional choices - **page 05**

MINIMAL HEATING
is required and is distributed through in-floor radiant heating only in the basement floor and upper-floor kitchen - **page 05**

A HEAT RECOVERY VENTILATION
(Zhender ComfoAir 550) system with 84% efficiency brings in filtered fresh air while minimizing energy use - **page 05**

PASSIVE COOLING STRATEGIES
were used through overhang shading, cross ventilation and stack effect through windows and the skylight. - **page 05**

With construction costs comparable to a conventional custom-built house, this building has achieved a 70% reduction in annual energy costs.

GENERAL OVERVIEW

This single-family house is located on a standard lot in a residential neighborhood in East Vancouver. The house was built to the Passive House standard in response to the owners' commitment to minimizing their environmental footprint and their interest in a comfortable, healthy, and quiet house.

Project Overview

Building Type	Single-Family Residence
Climate Zone	4: Cool-Temperate
Location	Riley Park, Vancouver
Gross Floor Area **Treated Floor Area**	247 m^2 / 2,659 ft^2 206 m^2 / 2,217 ft^2
Building Height	9.9 m / 32.5 ft
Number of Floors/Suites	2 storeys + basement / 2 suites
Project Completion Date	October 2018

Project Team

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

Lanefab Design/Build

Project Context

In response to global climate change concerns, the City of Vancouver developed 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 icnrementally move toward net-zero energy ready buildings by 2032.

The City of Vancouver catalyzes early adopters of its future targets by incentivising the pursuit of Passive House projects through zoning relaxations. These relaxations include additional building height, depth, site coverage, and a thick wall exclusion to accommodate thicker insulated assemblies.

This single-family house is an early adopter of Passive House in Vancouver, which is approximately equivalent to Step 5 of the BC Energy Step Code. This case study was developed using the information collected through the NearZero Research Program, sponsored by the City of Vancouver.

Design Highlights

The house includes a main residence with three bedrooms and a two-bedroom basement suite. The main focus throughout the design process was on achieving Passive House certification.

To be mindful of the impacts of early design decisions on the building's energy performance, the team used the DesignPH plugin for SketchUp. DesignPH provides preliminary and simplified energy performance estimates for early design iterations.

Solar panels were incorporated in the original design, but due to budget priorities, they are planned for future implementtion. In addition to high energy performance, an underground 800-gallon water tank designed to capture the roof's rainwater runoff will be used for landscape irrigation.

Project Costs

As the Lanefab's first Passive House project, this house costs approximately 5-8% more than a non-Passive House equivalent project. The team expects the cost of future projects to reduce as they gain more experience, and industry and regulatory systems advance.

The house is predicted to have about 70% less annual operation energy costs compared to an equivalent house built to the BC Building Code.

HIGH-PERFORMANCE ENVELOPE

The goal of Passive House Standard is to dramatically lower space heating and cooling needs. This is achieved by using an envelope with thick insulation layers, minimal thermal bridges, a continuous airtight layer, and Passive House certified fenestration.

Envelope

The project used prefabricated Structural Insulated Panels (SIPs), which consist of Oriented Strand Boards (OSB) sandwiching Expanded Polystyrene (EPS) insulation, typically with dimensional lumber every 48". Using SIP panels is not a common practice in Vancouver, however, it is Lanefab's signature construction method in most of their projects. SIPs have stronger structural characteristics, higher airtightness, better thermal resistance, faster framing time, and less construction waste as compared to an equivalent traditional stick-frame building. To achieve the Passive House performance, the usual SIP wall thickness was increased to 8 1/4". Additionally, the service wall cavity was filled with batt insulation. The extra cost for the additional insulation used was not significant relative to the total project cost.

Puro Passiv windows and CAL Doors, which are triple-glazed and Passive House certified are used. The only exception is the roof hatch, for which a locally produced double-glazed Dayliter Skylight was used, as the high-performing envelope allowed enough buffer to use a lower performing and significantly more cost-effective alternative.

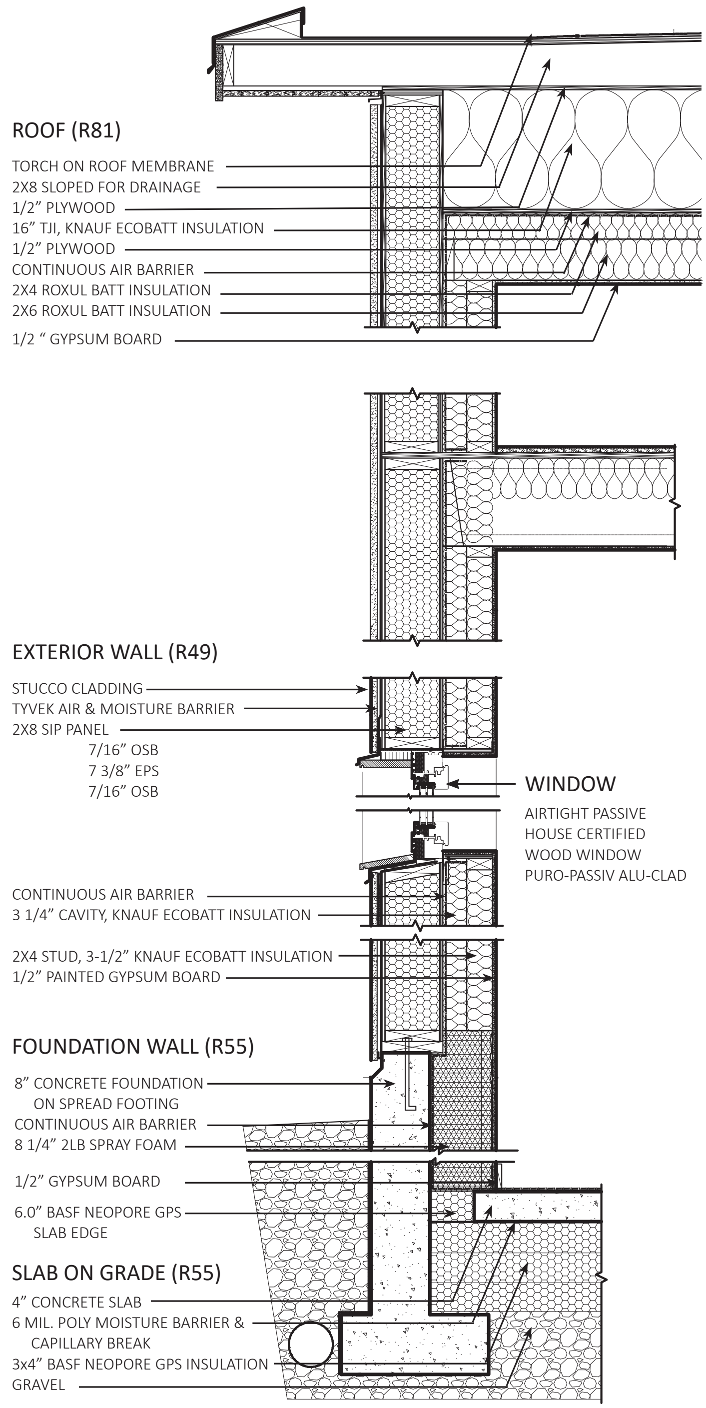
Spanning stair and floor beams from wall to wall proved to be a cost effective solution for reducing thermal bridging by eliminating the need for internal footings in the middle of a slab. Additionally, by calculating the minimum allowable bearing to the wall, the beams were cut short and capped with insulation to eliminate point thermal bridging through the external wall.

Thermal Performance of Exterior Components (Lanefab Design/Build)

Envelope Component	Thickness (cm/inch)	Average U-Value (W/m²K)
Exterior Wall	39 / 15.5	0.116 (R49)
Basement Wall	43 / 17	0.103 (R55)
Basement Floor	41 / 16	0.103 (R55)
Roof	66 /26	0.070 (R81)
Exterior Windows	-	Glazing: 0.56 Framing: 0.79
Exterior Doors	-	Glazing : 0.56 Framing: 1.18
Roof Hatch	-	Glazing: 2.2 Framing: 7.5

Airtightness

The interior SIPs' sheathing is used as the air barrier and is taped on the inside for airtightness. Placing the air barrier on the inside provided flexibility in puncturing the exterior face for affixing elements such as steel outriggers and heavy cladding. Service walls and dropped ceilings allowed the building services to be installated without penetrating the air barrier.



Wall Section (Lanefab Design/Build)
A thick insulation layer with no thermal bridges, continuous airtight layer, and Passive House certified windows contributed to achieving a high-performance envelope.

ENERGY EFFICIENCY STRATEGIES

In addition to minimizing the heating and cooling loads, this Passive House building minimizes other energy needs by using efficient appliances, lighting, and heat recovery ventilation. These solutions not only reduce energy use, but also provide a comfortable indoor temperature and high indoor air quality.

Passive House Performance Characteristics

			Passive House		Building Performance
Parameter	**Characteristic**	**Unit**	**Criteria**	**Alternative**	
Airtightness	Air change rate per hour	ACH @ 50Pa	≤ 0.6	-	0.54
Space heating	Annual demand	kWh /m²a	≤ 15	-	14.2
	Heating load	W/m²		≤ 10	13
Space cooling	Annual demand	kWh /m²a	≤ 15	-	0.4
	Cooling load	W/m²	-	≤ 10	0
	Frequency of overheating	% (> 25˚ C)	≤ 10	-	0
Primary energy requirements	Non-renewable (PE)	kWh/m²a	≤ 120	-	91
	Renewable (PER)	kWh/m²a	-	≤ 60	40

Heating & Cooling

The south-facing windows provide significant solar heat gains, more than a third of the building's heating needs. A sunken patio was designed on the south side to allow more solar access for the basement. An existing coniferous tree in poor health was removed to increase the solar heat gains from the south.

The heating and domestic hot water supply are combined and provided through an electric Sanden CO_2 heat pump. The heating is zoned via a variable speed pump and distributed through in-floor radiant hydronic heating throughout the basement, kitchen and bathroom floors on the main and second floor. To increase comfort in future projects, more heating will be provided at the large, north-facing windows, where heating loads are the greatest.

Additionally, the hot water tank size can be increased or a mini electric hot water backup may be added to ensure the hot water supply is sufficient for both heating and domestic hot water usage in the coldest days of the year.

High solar heat gain glazing on the south side successfully reduced space heating needs in winter. However, to reduce the risk of summer overheating, passive cooling was used through deep overhang shadings on the windows, shading fins, cross ventilation, and stack effect through windows and roof-hatch skylight.

Ventilation

The house utilizes a central Zehnder ComfoAir 550 Heat Recovery Ventilation unit with 84% efficiency based on the HRV's Passive House certification.

Further, ventilation heat losses were reduced by eliminating the need for make-up air in the case of direct exhaust hood fans and dryers. With an electric induction cooktop, a recirculating charcoal filter hood fan was sufficient. The Blomberg Front Load WM77120 clothes dryer eliminated the need for vents. The high-performance Whirpool heat pump washer also contributed to energy use reductions.

Passive House Highlights

- The relaxations provided by the City of Vancouver made it feasible to pursue Passive House certification. However, the negotiation and approval process prolonged the permitting process. As Passive House becomes more common with the City of Vancouver, permit processing times should be reduced.
- The project team engaged with the Passive House certifier early in the design process to identify and address issues that affect the feasibility of Passive House certification.
- Having design and construction team members with Passive House training ensured proper consideration of key Passive House requirements.
- As a first experience with Passive House for the design/build consultant, achieving airtightness proved to be time consuming and challenging. However, as the team gains experiences and the market matures, the process will inevitably become more streamlined.

GLOSSARY

Key terms, definitions, and abbreviations used in this case study arranged alphabetically

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.

Heat Pump
A mechanical device that transfers thermal energy in the opposite direction of natural heat transfer by absorbing heat from a cold space and releasing it to a warmer reservoir. Heat pumps are used for space heating and cooling and heating domestic hot water.

Heat Recovery Ventilator (HRV)
A mechanical energy recovery system which recovers heat from the exhaust air to pre-heat the filtered incoming fresh air stream. This reduces the energy required to bring outside air up to ambient room temperature.

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.

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 an energy modelling tool 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).

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

R-value
The capacity of an insulating material to resist heat flow. The higher the R-value, the greater the insulating power.

Structural Insulated Panels (SIPs)
An engineered sandwich panel, typically consisting of a rigid insulation sandwiched between two layers of structural board (such as OSB sheathing). SIPs combine several components of conventional building, such as studs and joists, insulation, vapor barrier and air barrier. They can be used for many different applications, such as exterior wall, roof, floor and foundation systems.

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.

Vancouver Zero Emission Building Plan
A phased plan that establishes specific targets and actions to achieve zero emissions in all new buildings in Vancouver by 2030.

NOTES

EAST VANCOUVER
SINGLE-FAMILY PASSIVE HOUSE

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https://zebx.org/resources/#case-studies

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