VANCOUVER POINT GREY HIGH-PERFORMANCE LANEWAY HOUSE

CASE STUDY

Using a highly efficient envelope and heat recovery system, this small laneway house exceeded the energy performance requirements of Vancouver Building Bylaw. A theoretical analysis showed that with the same wall thickness, the performance can be significantly improved to almost meet the Passive House standards.

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PREPARED BY

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PROJECT OVERVIEW

INCREASED INSULATION

allows the exterior walls of this house to achieve R36, about 1.5 times more effective than a house built to current code requirements - **page 04**

EFFICIENT FENESTRATION

reduces heating demand through increasing solar heat gains, and reducing thermal losses - **page 04**

AIRTIGHTNESS

is improved by an airtight layer placed on the inside of the exterior wall with a service cavity on the inside, to minimize any puncturing of the airtight layer - **page 04**

PARTIALLY PREFABRICATED

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

A HEAT PUMP

(Rheem Ecohybrid WH50GM air-source heat pump) provides both hot water and space heating - **page 04**

A HEAT RECOVERY VENTILATION

(Venmar Kubix) system with 70% efficiency brings in filtered fresh air while reducing energy losses - **page 04**

PASSIVE COOLING

The house uses passive cooling strategies through overhang shading, cross ventilation and stack effect through windows and the skylight - **page 04**

RENEWABLE ENERGY

supporting infrastructure is incorporated in the design to allow for future addition of renewable energy technologies - **page 04**

A hypothetical analysis showed this high-performance laneway house can reduce its energy demand by more than 50% through further improvements in the efficiency of the envelope, heating and ventilation systems - page 05.

This case study reviews some of the key features and lessons learned from this high-performance laneway house.

GENERAL OVERVIEW

This house was built using partial prefabrication, which is the signature construction method of the design/build team. By using Structural Insulated Panels (SIPs), they reduced construction waste, improved the envelope thermal performance, and simplified the airtightness process.

Project Overview

Building Type	Single-Family Laneway Residence
Climate Zone	4: Cool-Temperate
Location	Point Grey, Vancouver
Gross Floor Area **Treated Floor Area**	74 m² / 797 ft² 54 m² / 581 ft²
Building Height	6.6 m / 21.6 ft
Number of Floors	1.5 storeys
Project Completion Date	April 2017

Project Team

Project Owner	Private Homeowner
Architect	Lanefab Design/Build
Structural Engineer	Deer Lake Engineering Inc.
Mechanical Engineer	Apple Mechanical
Builder	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 incrementally move toward net-zero energy ready buildings by 2032.

This small two-bedroom, one-bathroom residence was built in the rear lot of an existing single-family house in Vancouver's Point Grey neighborhood. The energy performance of this laneway house exceeds the City of Vancouver's prescriptive requirements for single-family houses, which was in place at the time this project was developed.

This study summarizes the solutions implemented in this project to improve it's energy performance, and presents the results of a theoretical analysis conducted by the project design team in which they explored the feasibility of designing this laneway house with total treated floor area of 54 m² to the Passive House standard - which is comparable to Step 5 of BC Energy Step Code. The results show the feasibility as well as challenges for small buildings like this to achieve the new near-zero energy and emission goals.


Lanefab Design/Build

ENERGY EFFICIENCY STRATEGIES

This building was designed to reduce energy-use by increasing insulation and airtightness, using heat recovery ventilation, high-performance windows and doors, and energy efficient lighting and appliances. These solutions are based on Passive House principles, but implemented to work with the City of Vancouver's zoning limitations for this small laneway house.

Envelope

SIPs were used in the wall and roof as they provide higher thermal performance compared to equivalent traditional stick-frame walls.

The interior of Oriented Strand Board (OSB) sheathing of the SIPs act as the airtight layer, with taping the sheathing seams. Placing the airtight layer on the interior and adding an interior 2x4 service cavity reduced puncturing of the airtight layer.

Thermal Performance of Exterior Components (Lanefab Design/Build)

Envelope Component	Thickness (cm/inch)	Average U-Value (W/m²K)
Exterior Wall	33 / 13	0.158 (R36)
Foundation Wall	33 / 13	0.217 (R26)
Floor Slab	33 / 13	0.169 (R33)
Roof	27 /10.6	0.118 (R48)
Exterior Windows	-	Glazing: 0.56 / Framing: 1.10
Exterior Doors	-	Glazing: 0.56 / Framing: 1.16

Heating & Cooling

A Rheem Eco-Hybrid WH50GM air-source heat pump provides both space heating and domestic hot water. The heating is distributed through in-floor electric radiant heating and the domestic water is heated through a conventional tank.

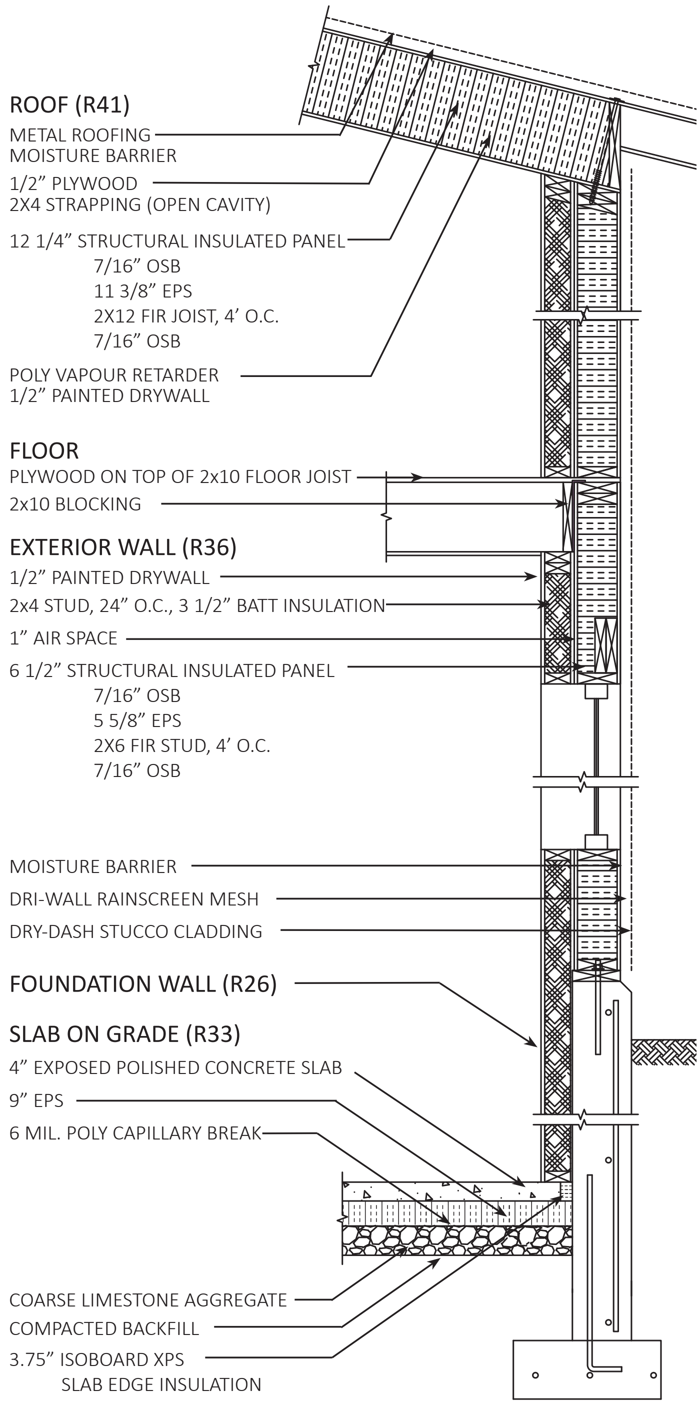
The house uses passive cooling strategies through overhang shading and cross ventilation, and makes use of stack effect through windows and the skylight. The stack effect is air movement into and out of a building resulting from differences between indoor-outdoor air pressures and temperatures.

Ventilation

This laneway house uses a Venmar Kubix Heating Recovery Ventilation (HRV) system with an efficiency of 70%. Ventilated air is distributed through a Plenum duct, a distribution box attached directly to the supply outlet of the HRV. Additional ventilation is provided through the electric kitchen range fan and dryer exhaust fan.

Renewable Energy

Appropriate infrastructure for the future addition of sustainable energy technologies was considered. This includes wiring and piping for future installation of solar panels and a charging station for electric vehicles.



Wall Section (Lanefab Design/Build)
A highly insulated and airtight envelope, with minimal thermal bridges, reduced the heating demand.

PASSIVE HOUSE UPGRADE STUDY

A theoretical study was conducted to assess the feasibility of meeting Passive House requirements for this laneway house. The performance can be significantly improved, but due to small size and restrictions on area and height, achieving Passive House requirements proved to be challenging.

As-built baseline compared to theoretical upgrades and passive house criteria.

Parameter	Characteristic	Unit	Passive House Criteria	Passive House Alternative	As-built	Theoretical Upgrade
Airtightness	Air change rate per hour	ACH @ 50Pa	≤ 0.6	-	2.0	0.6
Space heating	Annual demand	kWh /m²a	≤ 15	-	59	15.3
	Heating load	W/m²		≤ 10	30	13
Space cooling	Annual demand	kWh /m²a	≤ 15	-	-	-
	Cooling load	W/m²	-	≤ 10	-	-
	Frequency of overheating	% (25° C)	≤ 10	-	1.4	11
Primary energy requirements	Non-renewable (PE)	kWh/m²a	≤ 120	-	280	135
	Renewable (PER)	kWh/m²a	-	≤ 60	144	61.7

Upgrades

Without changing the overall design of the house or the wall thickness, the following improvements were modelled in the Passive House Planning Package (PHPP):

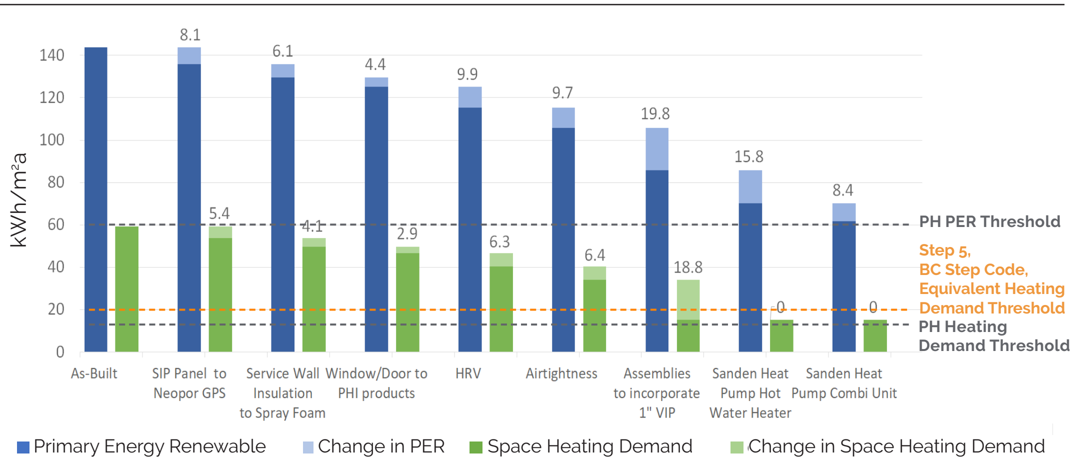
1. Replacing Expanded Polystyrene (~ R22.5) in SIP panels with Neopor Graphite Polystyrene (~ R28) rigid foam insulation.
2. Replacing batt insulation (~ R10.5) and 1" air space with 2 lb spray foam (~ R27).
3. Upgrading fenestration to PH certified products.
4. Upgrading HRV to a PH-certified product.
5. Adding Vacuum Insulation Panels (VIP) in wall assemblies.
6. Improving airtightness to 0.6 ACH.
7. Using a more efficient heat pump water heater.
8. Upgrading to a combined system, delivering both hot water and space conditioning.

Results

The final results came very close, but did not quite meet Passive House standard requirements. This is despite the increase in thermal resistance of the exterior wall from R36 to about R100. Whereas a comparable Passive House wall has an R-value of about 50. However, the improved house met the BC Step Code, Step 5 heating demand requirements.

This highlights the difficulty of acheiving Passive House requirements in smaller and specially laneway houses due to:

- Higher heat loss because of high form factor (surface to floor area ratio). This laneway house's form factor is 4.83, whereas a typical single-family Passive House is around 3.
- Higher air change rates occur due to a smaller volume of air in the building.
- Lower solar heat gain as the building is located in the back alley, with lots of shading from neighbouring objects.



Cumulative improvements in heating and energy demand of the house, resulting from theoretical upgrades (Based on analysis conducted by Lanefab Design/Build)

Upgrading to Passive House may be unrealistic for small houses, given the need for very thick walls. However, efficient and cost-effective mechanical and envelope systems can significantly reduce the overall energy use in small houses without achieving Passive House requirements. For this 50 m² laneway house, the total PER is ~7,800 kWh/year. This is significantly less than a house of the same size built to BC Building Code, which uses ~11,000 kWh/year. It is even comparable to a Passive House that is four times larger, which has a PER of ~8,000 kWh/year.

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.

Expanded Polystyrene (EPS)
A rigid and low-density insulating foam.

Form Factor
The form factor is the ratio of external surface area to internal treated floor area used in the Passive House standard to assess the efficiency of a building form.

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, 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.

Oriented Strand Board (OSB)
A type of engineered wood, formed by adding adhesives and then compressing layers of wood strands in specific orientations.

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).

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.

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.

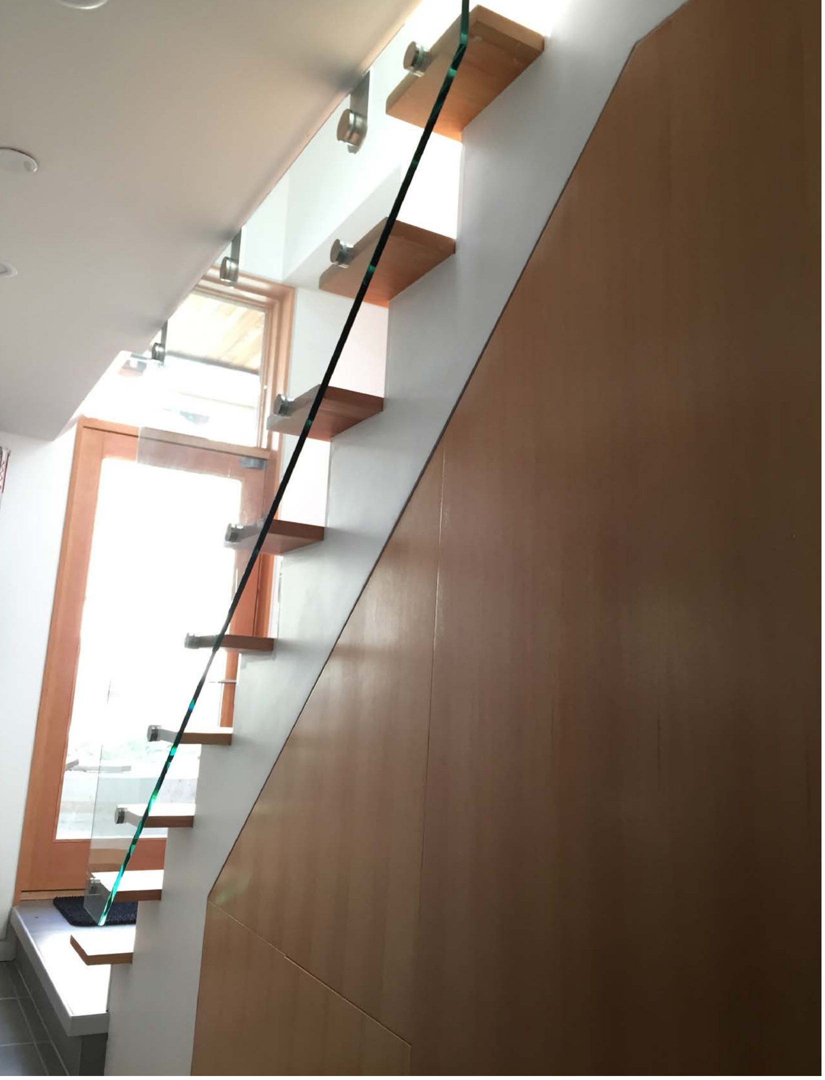
Structural Insulated Panel (SIP)
An engineered sandwich panel, typically consisting of a rigid insulation sandwiched between two layers of structural board (such as OSB sheathing). SIPs combine several components of conventional building, such as studs and joists, insulation, vapor barrier and air barrier. 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. Lower U-Value indicates more energy efficient surfaces. It is the inverse of the R-value.

Vacuum Insulation Panels (VIP)
A highly insulative panel made of a gas-tight enclosure surrounding a rigid insulative core, from which the air has been evacuated. VIPs provide better insulation performance than conventional insulation materials.

Vancouver Building Bylaw (VBBL)
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.

NOTES



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HIGH-PERFORMANCE LANEWAY HOUSE

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