Net Zero *in Kitsilano*

John Baldwin and Linda Bily

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The Project

This booklet describes the development of a net-zero house in Vancouver's Kitsilano neighbourhood at 3612 POINT GREY ROAD.

We purchased the property in 1994 and lived in the original 2 storey stucco bungalow which was built in 1937. We loved living in the neighbourhood and enjoyed walking to the beach and being situated on a bike lane and near many shops. In 2017 the decision was made to tear down the existing house and build a new one. Like many old houses in Kitsilano the house was poorly insulated, inefficient and moldy from the damp climate. We reasoned that if we sold the property it would be torn down immediately.

Housing is a big contributor to climate change. Therefore it was essential to us that we replace it with a high performance low emission house that would be energy efficient and run with solar panels.

We studied the latest green and sustainable building ideas: zero emissions, net-zero, the use of responsible materials, a healthy indoor environment, embodied carbon footprint, creating a regenerative space, human scaled living and ecology of place. And set forth to incorporate as many of these aspects as we could.

Our key goal was to build a NET ZERO home. We wanted to have many of the features of both Passive and LEED houses without the formal certification. In addition we wanted to emphasize the use of green, natural and eco-friendly materials that are sustainable and minimize the use of harmful chemicals to create a healthy home.

3612 Point Grey Road has a Walk Score of 74 and a Bike Score of 78 and is considered Very Walkable and Very Bikeable. Most errands can be accomplished on foot and biking is convenient for most trips. There are also many nearby public transportation options. It is an ideal place to build a net-zero home. "Drive less. Live more." - something we already loved about Kitsilano.

Project Timeline

2017

September 2017	Began design work with architect

2018

February 2018	Development Permit Application

2019

August 2019	Building Permit Application
October 2019	Development Permit Issued

2020

January 2020	Energy Modelling
February 2020	Began working with Kingdom Builders
May 2020	Building Permit Issued
June 2020	Deconstruction
July 2020	Constructions begins
August 2020	Foundation poured
September 2020	House framed
November 2020	Mechanical & electrical rough in
December 2020	Roof, doors & windows
December 2020	Mid-construction airtightness test

2021

January 2021	Drywall
February 2021	Interior Finishing
April 2021	Solar panels installed
May 2021	Completion

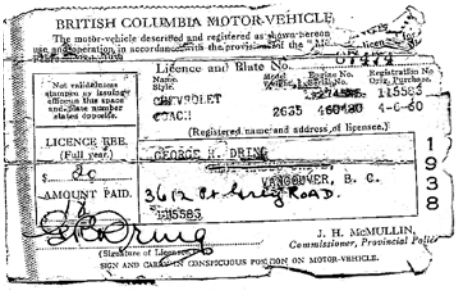
Original House

The project required the demolition and deconstruction of our existing house. We had bought the property in 1994. The original 2 storey stucco bungalow was built in 1937. It was an in-fill house among the surrounding 1920s Craftsman homes typical of Kitsilano. It originally had 1 bedroom upstairs, 1 bedroom on the main floor and an unfinished basement. With several rennovations over the years it eventually had 3 bedrooms, 2 bathrooms and and a finished 2 bedroom basment suite.

Various people had lived in the house over the years. Information from the Vancouver Archives:

1938 George Dring (cashier, travellers insurance)
1940 Henry Hill (Engineer, Bralorne Mines)
1950s Oren and Mary Patton (retired)
1962 Mrs Mary Patton (retired)
1968 D. R. Weems and Paula D'Roxey (musician)
1980s Elizabeth Bremner

An old neighbour remembers when the 20m high spruce tree in the backyard was transferred from a small potted Christmas tree in the 1950s.


BRITISH COLUMBIA MOTOR-VEHICLE

Licence and Plate No. 07474

CHEVROLET 2635 460480 4-6-60 115583

(Registered name and address of licensee.)

GEORGE H. DRING

VANCOUVER, B. C.

36 12 Arbutus Road.

115583

LICENCE FEE (Full year.) $ 2c

AMOUNT PAID.

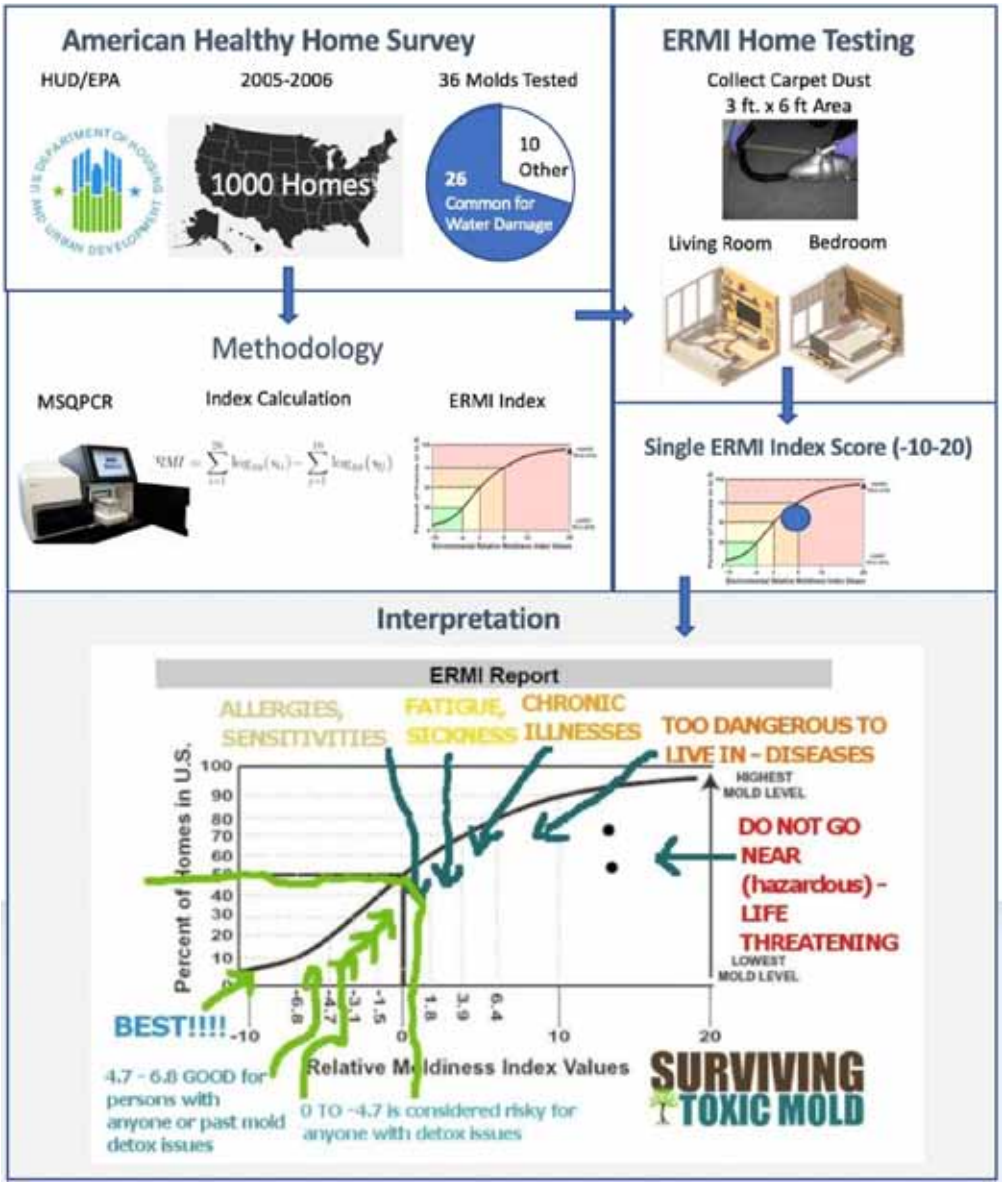
1938

J. H. McMULLIN, Commissioner, Provincial Police

A 1938 motor vehicle license found in the garage.

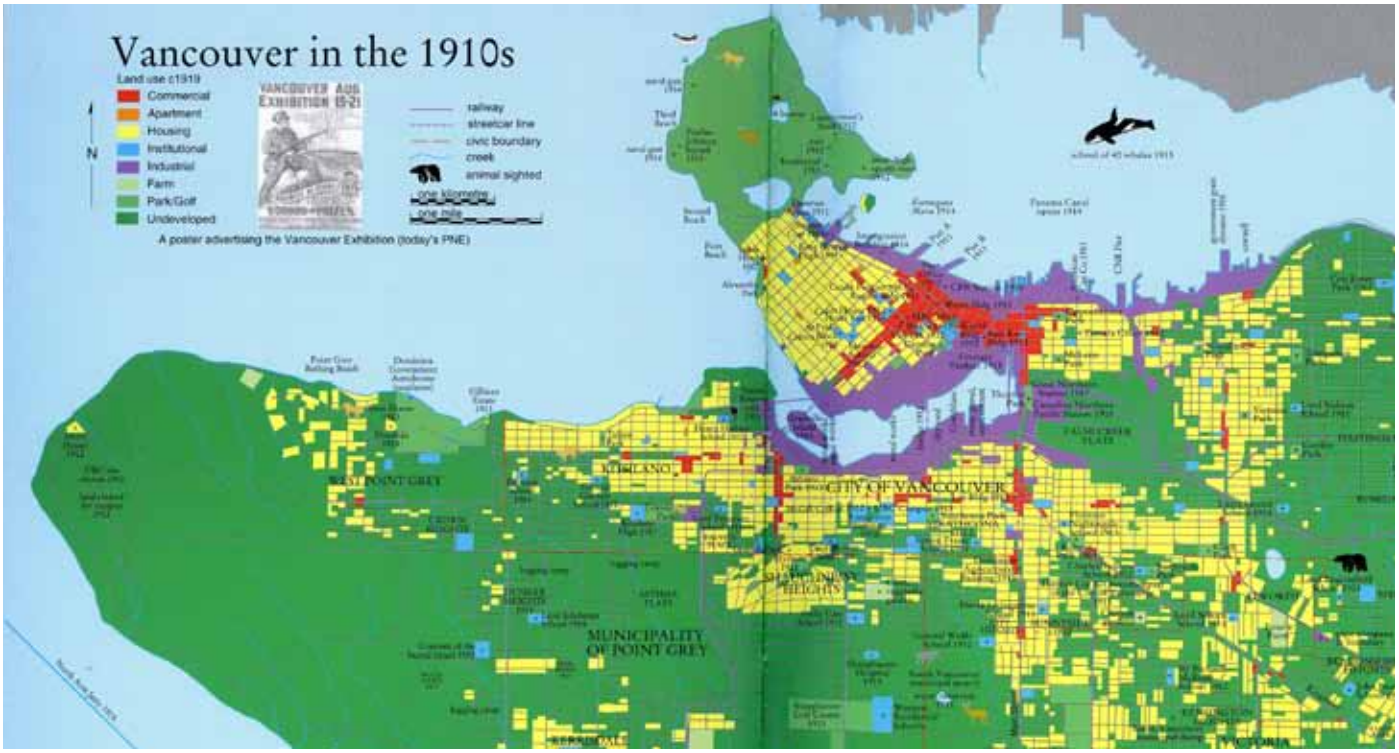
3612 Point Grey Road

In 2016 after living in the house for 24 years we both developed health issues. John developed allergy like symptoms and Linda developed breast cancer and chronic fatigue (CIRS). We had concerns about the interior air quality in the old house, particulary mold. Testing using the ERMI test developed by the EPA placed our house in the 90th percentile for moldy homes (likely quite common in Vancouver). We made the decision to move out and build a new house. We felt the work required to renovate the old house to mitigate these concerns would be substantial and it would be very difficult to upgrade the old house to a high energy performance level.



Mold testing explained.

History

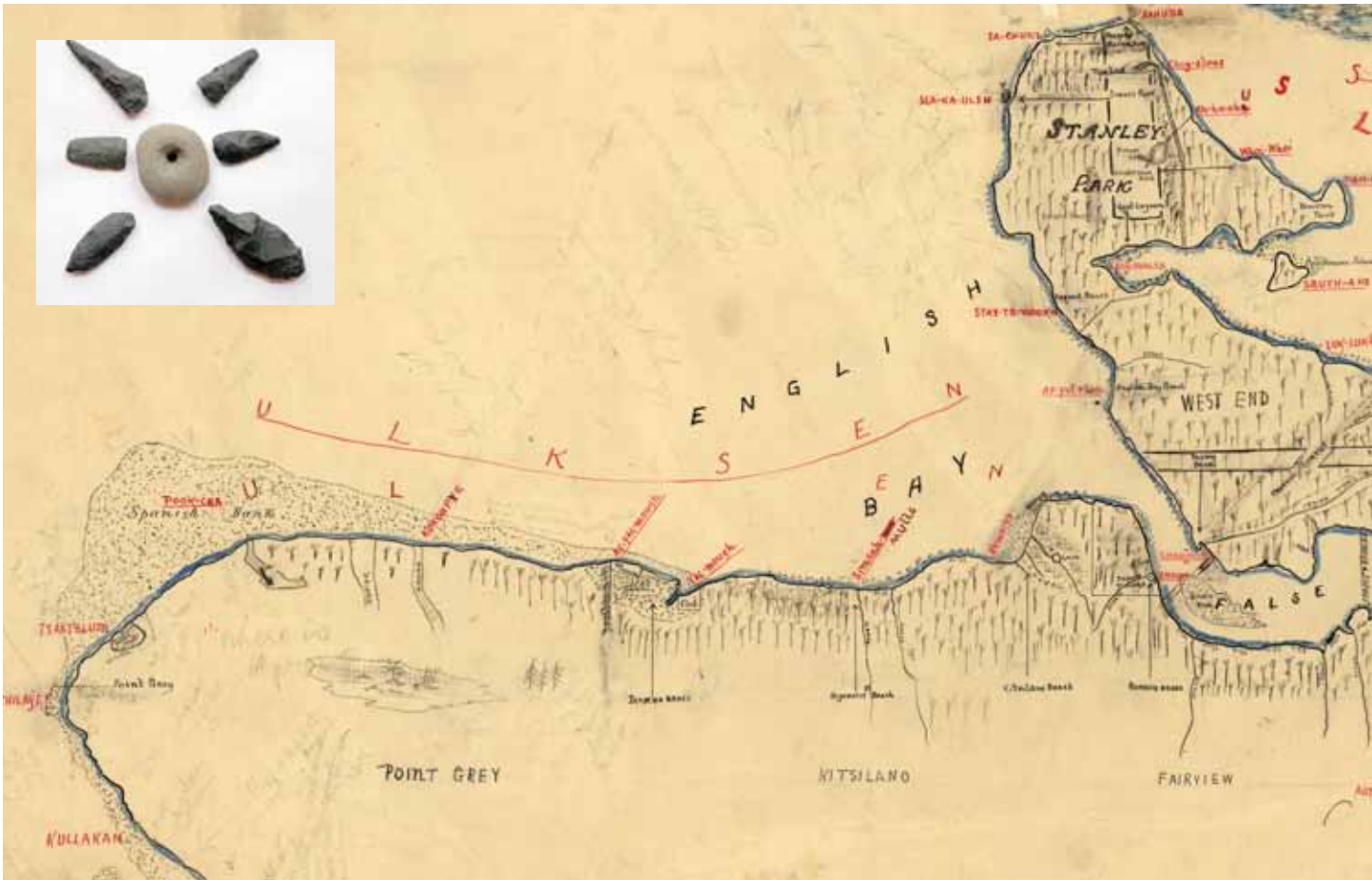


Much of Kitsilano was built in the 1920s as the city expanded out of the dowtown peninsula. What is not commonly known is that people have lived here for thousands of years. Vancouver is built on the traditional territory of the Coast Salish Peoples, including the the xʷməθkʷəyəm (Musqueam), Skwxwú7mesh (Squamish), Stó:lō and Selilwitulh (Tsleil-Waututh) Nations. Nearby villages were located at Jericho Beach and Locarno Beach – just a few blocks away. These villages date back more than 3500 years making them older than ancient Rome. The area was covered by huge trees and criss-crossed with footpaths and salmon streams.

Point Grey, 1883.

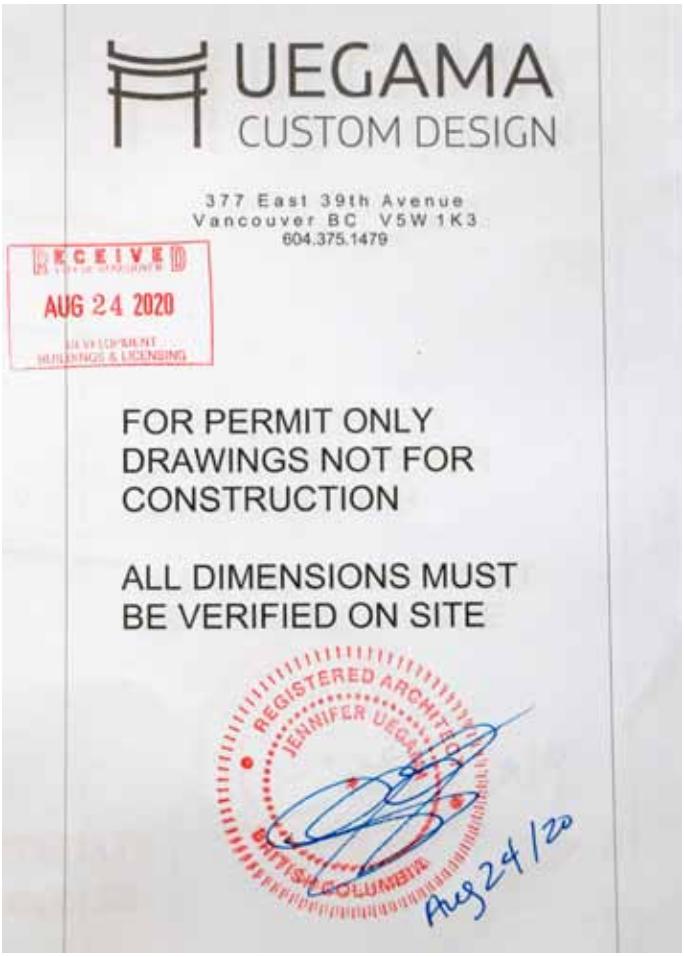
A replica of a dugout canoe contrasts with a freighter at Jericho Beach.

Indian villages and landmarks in Vancouver. Compiled by James Mathews 1932



Design

In September 2017 we began working with our architect, Jen Uegama, to design a new house. The basic idea was a simple semi-passive house that could be energy efficient and run with solar panels. We care deeply about climate change and wanted this house to reflect our commitment to that. At this stage we didn't know any of the details that would be needed to make that happen.



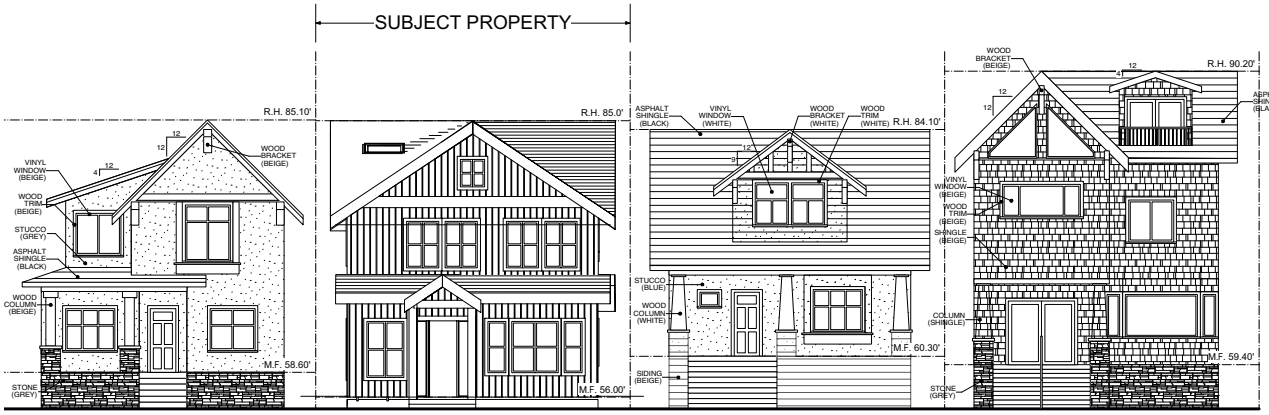
Jen Uegama, Architect

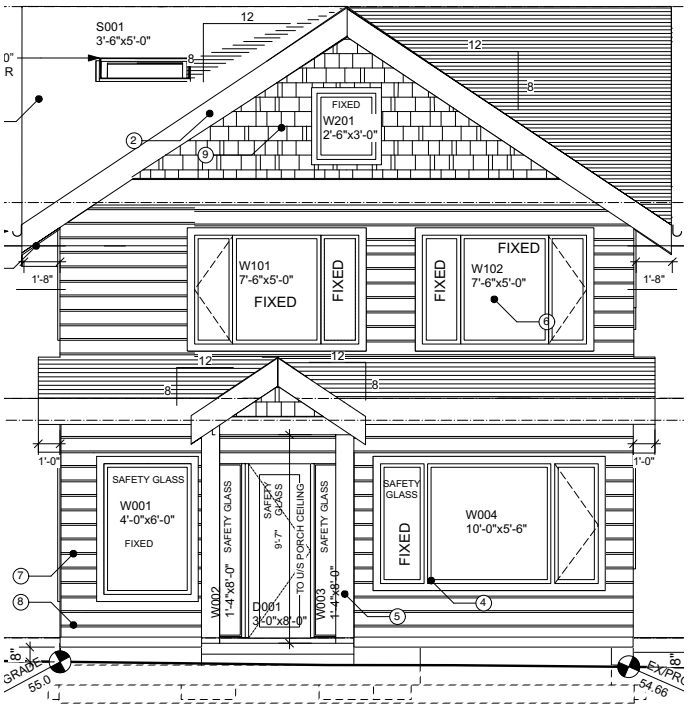
The owners started the design for this house knowing that they wanted to build only what they need – so the compact, efficient 1,600 sq ft plan was developed. The house was also designed to meet the neighbourhood's strict design guidelines for new houses to fit in with neighbouring heritage-style homes. This house will meet Step 5 of the BC Energy Step Code and is also participating in the Near Zero case study program.

From top (roof-top solar panels) to bottom (12" of insulation below the slab) and everywhere in-between, this house has embraced energy-efficient, environmentally responsible materials and equipment.

Jen Uegama

"As a general rule, a simple shape is more materials and energy-efficient."



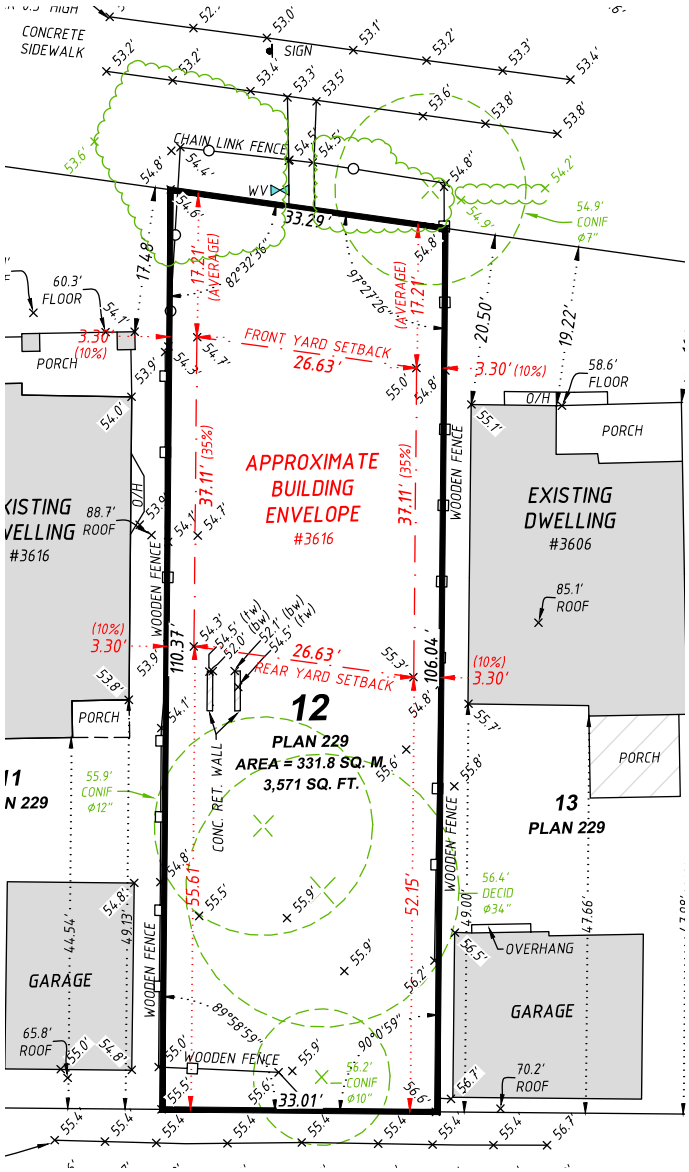


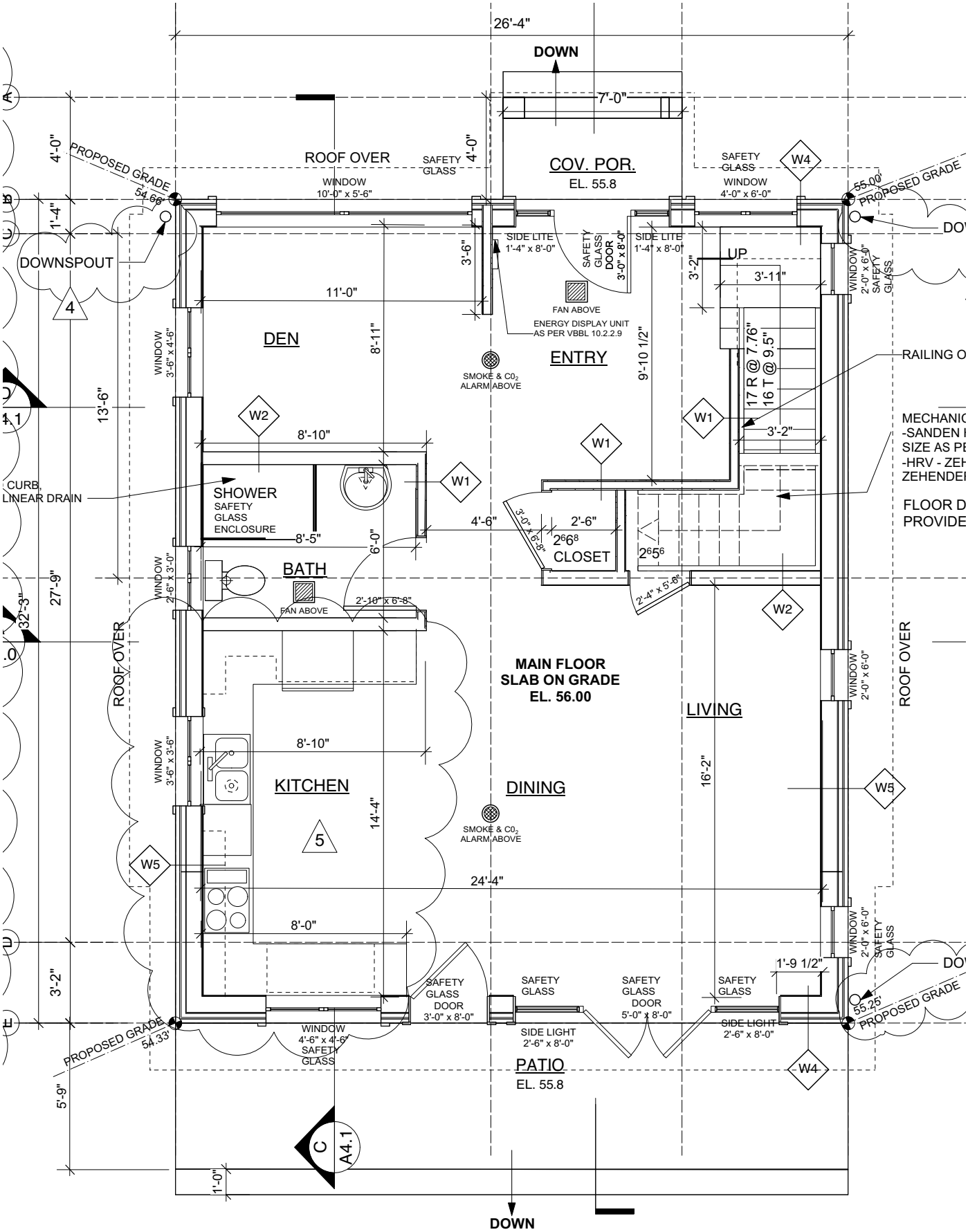
Components of a Net-Zero Home

1. **Insulation** Super-insulated building envelope reduces heat loss and as a result a smaller heating system is needed.
2. **Airtightness** further reduces the size of the heating system and fresh air is provided by mechanical ventilation with heat recovery.
3. **Windows** High-performance, Passive House certified windows reduce energy loss through the weakest points in the wall assemblies.
4. **Efficient Mechanical Systems**, lighting, and appliances, including a Zehnder Q450 HRV all reduce energy consumption.
5. **Solar Energy** Solar panel on-site renewable energy system offsets energy consumed and brings the home to net zero.

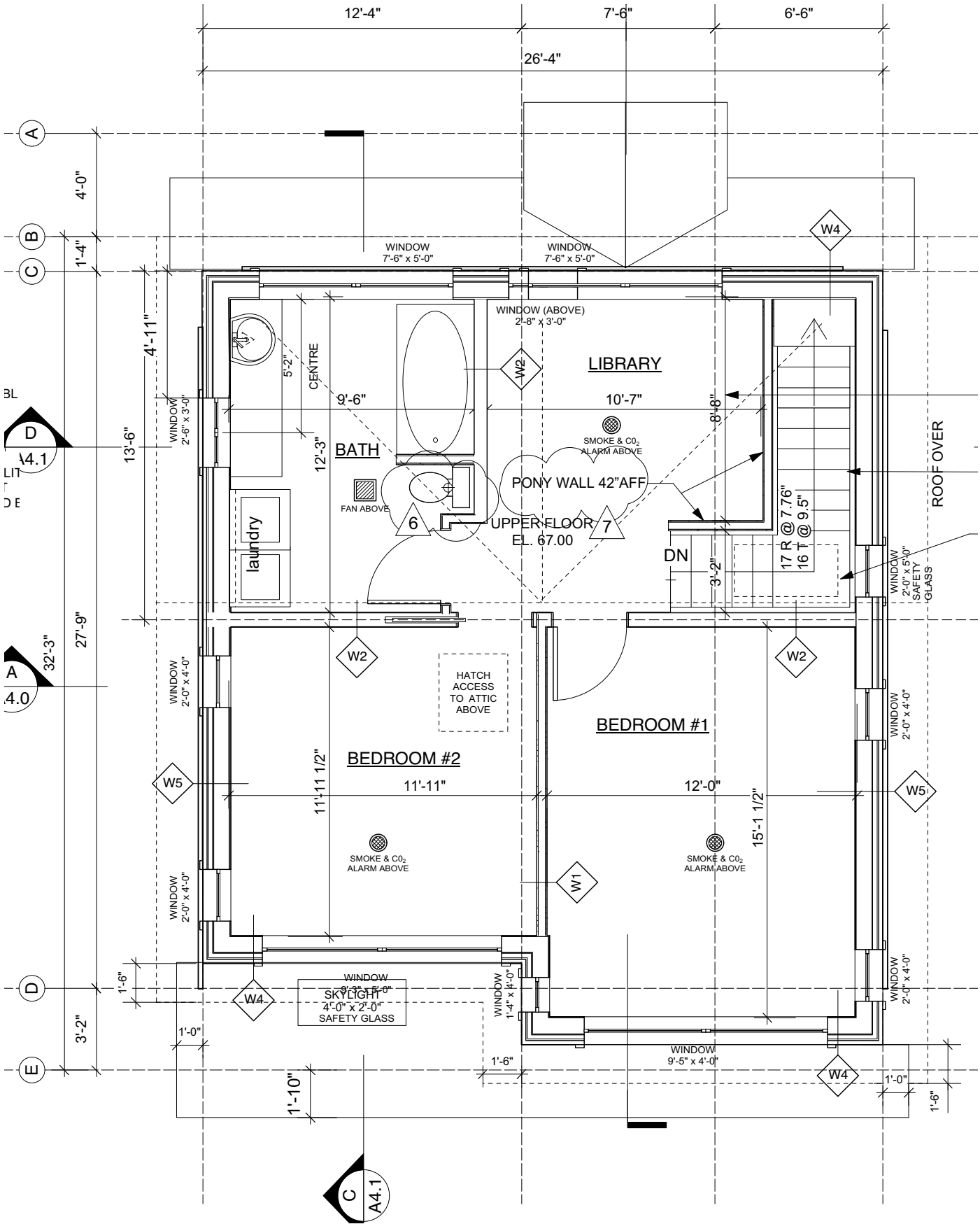
Project Details

- Address: 3612 Point Grey Road
- Zoning: RT-8
- Lot size: 33’ x 106’
- Floor Space: 1597 sq ft (148 sq m)
- Maximum Floor Area: 1785 sq ft
- House Dimensions: 26.3’ x 32.2’
- Height: 29 ft above slab
- Floorplan: 2 floors, 2 bathrooms, 2 bedrooms, office and den (could easily be configured as 3 bedrooms and den for a single family).
- Foundation: slab on grade sitting on 12” EPS insulation
- Design: near passive features, including shape and smaller size
- Wall Assembly: Well insulated split wall
- Windows: triple glazed Cascadia fiberglass windows
- Space heating: Mitsubishi split heat pump heating system
- Domestic hot water: Sanden CO2 heat pump water heater
- Appliances: Samsung ventless heat pump clothes dryer





main floor: 848.7 sq ft



second floor: 748.4 sq ft

Salvage and Deconstruction

After moving to a rental house nearby we began the process of salvaging materials and deconstructing the old house. The city has a strict recycling requirement for older houses.

We started with an ad on Craigslist. Thomas answered the ad and salvaged the kitchen cabinets, doors, deck, electrical plugs, switches, etc. He was able to reinstall these in Princeton and Yak. The furnace was also salvaged and converted to run on propane. We sold all the appliances and most of the furniture on Craigslist. Then we heard about a new company called Unbuilders that does exactly what their name implies. The house was deconstructed and 90% of the materials were salvaged and donated for reuse or recycled. This included dimensional lumber, hardwood flooring, windows, wiring etc appraised at $51,386.00.

unbuilders
Deconstruction Inc.

TRP
The ReUse People
Canada

The main floor kitchen (above) was salvaged and reinstalled in Princeton, BC (below).

Oil Tank

It occured to us that we should check the backyard for an oil tank as many of these old houses have oil tanks that were abandoned. Sure enough a tank was found and Art Graham removed it along with 70 tons of contaminated soil in September 2019.

Arts Speedy Solutions Oil Tank Removal
"Your Lower Mainland Specialists"
www.speedysolutions.ca • info@speedysolutions.ca
#653 – 3381 Cambie Street, Vancouver, BC V5Z 4R3 • Phone: 778 321 1706

Salvaged 83 year old 2″x 6″ dimensional lumber.

Energy Modelling

The more we learned about energy efficient houses, the more we refined our design and raised our goals. We learned a lot from discussions with our friend Bill MacKinnon, Energy Manager at BC Housing. Energy modeling by Barbara Meihuizen (www.domushomeenergy.com) was crucial. By determining actual values for the performance of the proposed house we realized that the goal of net-zero would be possible with an airtight, high efficiency house. Jennifer Johnson, the solar panel expert, was also key in this process. The output of a preliminary design of the solar system set a bench mark that the house would have to meet through increased performance of both the house and its mechanical system.

The energy modelling dictated targets for the wall assemblies, air tightness, windows and mechanical system that would make the house essentially equivalent to a passive house and meet Step 5 of the BC Energy Step Code. Step 5 will require all new construction to be net zero ready and will come into effect in 2032: i.e. in 10 years all new houses will have to meet the same requirements as our house.

Especially crucial in this process was realizing the importance of air tightness required the need for a builder that had experience building an air tight house.

The modelling showed that the proposed house could potentially use up to 90% less energy than a standard house and could essentially be heated with a hair dryer.

Barbara Meihuizen, Energy Advisor.

ENERGY STEPCODE
BUILDING BEYOND THE STANDARD

"We know we're not going to meet long term energy targets building to the current building code minimum. Aiming higher now is like creating a road map for others to follow in the years ahead."
Bill MacKinnon, Energy Manager, BC Housing

Pre-construction Step 5 Compliance Report

D: 9.36.6. ENERGY STEP CODE COMPLIANCE (see BCBC Sentence 2.2.8.3.(3) of Division C)

Rated Energy Consumption (GJ/year): Proposed House 14 Reference House 46 **HDD:** 2,825

Metric	Units	Required	Proposed
Step Code Level	Step 1, 2, 3, 4, or 5	**5**	**5**
Mechanical Energy Use Intensity (MEUI)	kWh/(m²·year)	*25 (max)*	24
ERS Rating % Lower Than EnerGuide Reference House, *where applicable*	%	*n/a (min)*	69.4
Thermal Energy Demand Intensity (TEDI)	kWh/(m²·year)	*15 (max)*	11
Adjusted TEDI	kWh/(m²·year)	*18 (max)*	11
Building Envelope % Better	%	*50 (max)*	0
Airtightness in Air Changes per Hour at 50 Pa differential	ACH @ 50 Pa	*1 (max)*	1
		Step Code Design Requirements Met:	**Yes**

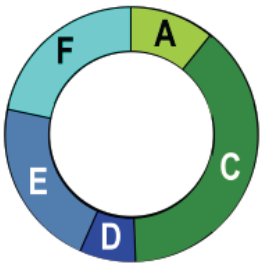
Energy Modelling Results

Hot 2000 modelling predicted the rated annual energy use of the preliminary design as:

Space heating	3.0 GJ/yr
Water heating	10.9 GJ/yr
Ventilation	0.3 GJ/yr
Baseloads	21.57 GJ/yr
Other electrical	13.6 GJ/yr
TOTAL ENERGY USE	34 GJ/yr
RENEWABLE ENERGY GENERATION	37 GJ/yr
NET ANNUAL ENERGY USE	0 GJ/yr

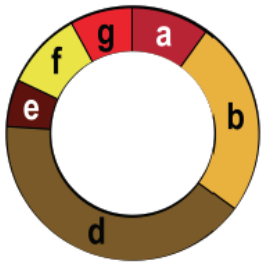
The HOT 2000 energy modelling results for the preliminary design showed that the house could meet its energy consumption with the renewable energy generated by the solar panels. In addition we hoped to improve upon several important factors that were assumed in the HOT 2000 modelling that would lead to even greater energy savings in the final house. We planned to use a Sanden heat pump water heater that would reduce the energy used for water heating by more than 50%. We also hoped that a skilled builder would be able to build the house with a much higher airtightness than the assumed 1.0 air changes per hour.

How Your Rated Energy is Used



A. Space heating	9%
B. Space cooling	0%
C. Water heating	32%
D. Ventilation	1%
E. Lights & appliances	18%
F. Other electrical	40%

Where Your Home Loses Heat



a. Attic/Ceiling	10%
b. Main Walls	25%
c. Exposed floors	0%
d. Windows	41%
e. Exterior doors	6%
f. Basement/Foundation	10%
g. Air leakage/ventilation	8%

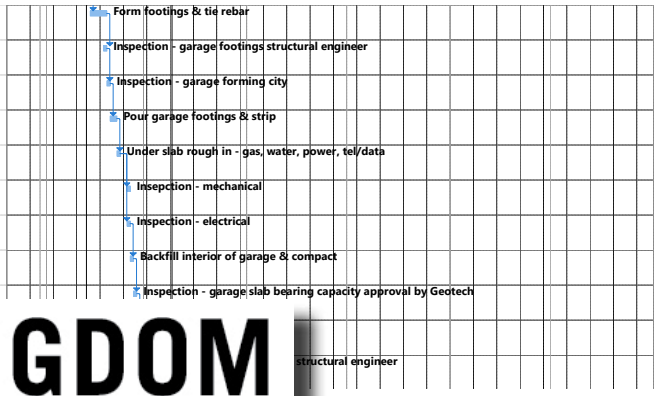
HOT2000
Natural Resources CANADA
Version 11.9

Windows on the south side of the house contribute a significant passive solar gain of 9.1 GJ/yr

Builder

Choosing the right builder was key to the project. The more we learned about energy efficient houses the more we realized that this was a new field not everyone in the construction industry was familiar with. We were referred to Kingdom Builders who had the knowledge and experience to build an energy efficient house. They had built multiple passive houses, were involved with the Near Zero program and came highly recommended by Barbara, our energy advisor, as well as a previous client, Karel Jonker, who had used them to build two passive houses. They are extremely organized, reliable, good with detail, easy to work with and have done an amazing job. They have been a pleasure to work with.

Form footings & tie rebar	3 days	2020-07-16	2020-07-20
Inspection - garage footings structural engineer	*1 day*	*2020-07-20*	*2020-07-20*
Inspection - garage forming city	*1 day*	*2020-07-21*	*2020-07-21*
Pour garage footings & strip	2 days	2020-07-22	2020-07-23
Under slab rough in - gas, water, power, tel/data	1 day	2020-07-24	2020-07-24
Insepction - mechanical	*1 day*	*2020-07-27*	*2020-07-27*
Inspection - electrical	*1 day*	*2020-07-27*	*2020-07-27*
Backfill interior of garage & compact	1 day	2020-07-28	2020-07-28
Inspection - garage slab bearing capacity approval by Geotech	*1 day*	*2020-07-29*	*2020-07-29*
Slab prep for garage			
Inspection - slab forming structural engineer			



KINGDOM BUILDERS

Budget Category				This Request	Over / Under
Site establishment & maintenance					
New home warranty				$ -	$ -
Pre-construction inspections	$ -	$ -	$ -	$ 983.70	$ -	$ 983.70
Site costs	$ 13,340.00	$ -	$ 13,340.00	$ 8,267.19	$ 118.13	-$ 4,954.68
Disposal	$ 6,500.00	$ -	$ 6,500.00	$ 3,565.00	$ 450.00	-$ 2,485.00
Labour site establishment & maintenance	$ 23,400.00	$ -	$ 23,400.00	$ 4,218.00	$ -	-$ 19,182.00
Materials site establishment & maintenance	$ 2,500.00	$ -	$ 2,500.00	$ 1,829.85	$ -	-$ 670.15
Deconstruction					
HAZMAT removal	$ -	$ -	$ -	$ -	$ -	$ -
Demolition	$ -	$ 1,500.00	$ 1,500.00	$ 1,500.00	$ -	$ -
Tree removal	$ -	$ -	$ -	$ -	$ -	$ -

Paul Lilley, Principal & General Manager

Aaron Lavalle, Project Manager

Steve Warrender, Site Lead

The Kingdom Builders crew: Himmat Gill, Steve Warrender, Max Kazakoff and Matt Burns

Foundation

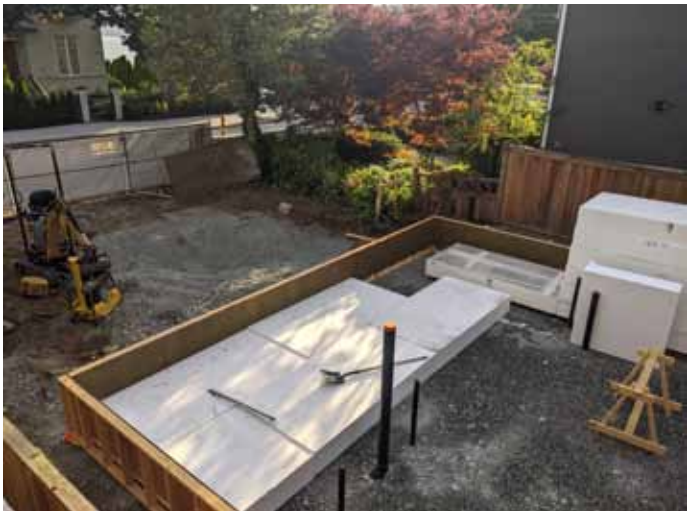
The house is built on a concrete slab on grade. A slab uses considerably less concrete than a basement or crawl space. As concrete has a very high embodied CO_2 footprint, the use of a slab foundation instead of a basement gives a big reduction in the total embodied carbon in the building.

In addition the structural concrete main floor was polished as a finished floor. This makes use of the existing structural foundation to provide the finished floor without using any additional building materials and creates a sustainable low maintenance floor.

The concrete slab was poured in August 2020.

Concrete Slab on Grade R30

- Polished concrete finished floor
- 10″ concrete raft slab, reinforced
- 15 mil poly vapour barrier
- 12″ EPS rigid insulation Geospan
- 6″ min free draining compacted gravel



12″ EPS rigid insulation Geospan.

Steel rebar reinforcing ready for concrete.

"*The price to build a proper wall below grade is always more expensive than the cost to build above grade. It will be cheaper to build an energy efficient and healthy two story house above grade than the same quality house with one level below grade.... the sad reality is that very few basements are actually built properly and most end up moldy. You won't get that with a slab.*"

Mike Reynolds, Ecohome.net

Wall Assembly

A key aspect of the house was the wall assembly, which combines the two most important components of a net zero home: insulation and airtightness. Our friend Marcus Dell, a building envelope engineer (and the D in RDH Building Science), recommended the split wall assembly. Advantages of the split wall assembly compared to other wall assemblies are:

- high performance rating
- relatively straightforward to build
- uses a single plane of airtightness which makes it easier to achieve a high airtightness
- less risk of water deterioration and ingress
- better drying characteristics
- excellent performance against mold and moisture
- uses continuous insulation rather than insulation corrupted by studs
- the air barrier is protected within the wall and is very durable.
- high sustainability rating
- maintains an average relative cost efficiency

The details of the split wall assembly were refined in discussions with Kingdom Builders. It was felt that Cascadia clips were key for ease of construction.

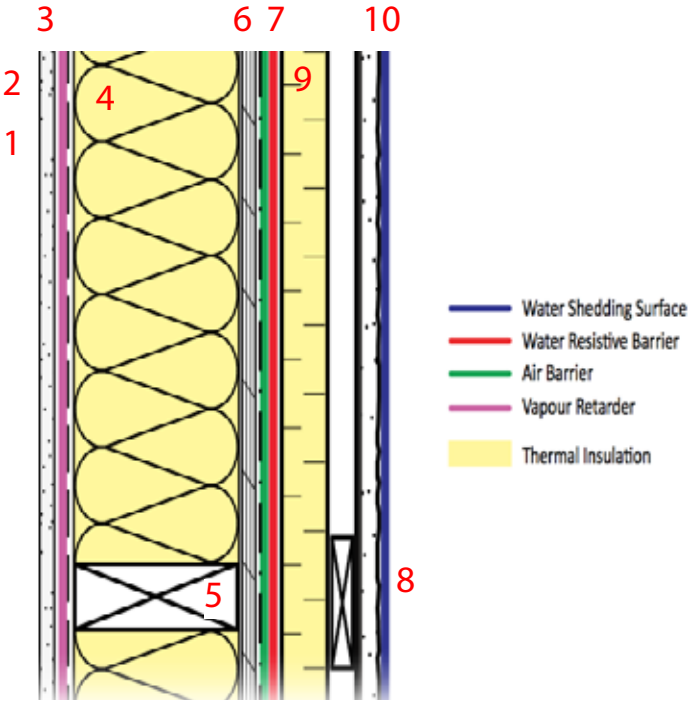
The exterior insulation pushes the dew point exterior of the air barrier, which avoids condensation within the wall and consequently often improves the durability of the assembly. This was a deciding factor in choosing a 2x6 wall with 4" of exterior insulation rather than a 2x8 wall with 2" of exterior insulation.

Marcus Dell, Building Envelope Engineer

Additionally, while not explicitly required by the codes, a relatively more permeable interior vapour barrier consisting of vapour retarder paint was used to permit some amount of inward drying. In general, a vapour permeable exterior insulation in combination with an interior vapour barrier was felt to provide a lower risk wall assembly than an assembly using impermeable exterior insulation.

Split Wall Assembley R32

1. Finish paint - Benjamin Moore Natura
2. Low VOC vapour barrier primer paint
3. ½" Gypsum Wall Board
4. Fiberglass Batt insulation
5. 2x6 studs @ 16" OC
6. ½" exterior plywood
7. Siga Majvest 500 SA air barrier
8. Cascadia 4" clip with z-girt 1" airspace
9. 4" Rigid Comfortboard 80 mineral wool
10. Hardieplank HZ5 horizontal siding



3. ½" Gypsum Wall Board

4. Fiberglass Batt insulation (filling framing cavity)

5. 2x6 studs @ 16" OC

6. ½" exterior plywood

7. Siga Majvest 500 SA air barrier

8. Cascadia 4" clip with z-girt 1" airspace

9. 4" Rigid Comfortboard 80 mineral wool

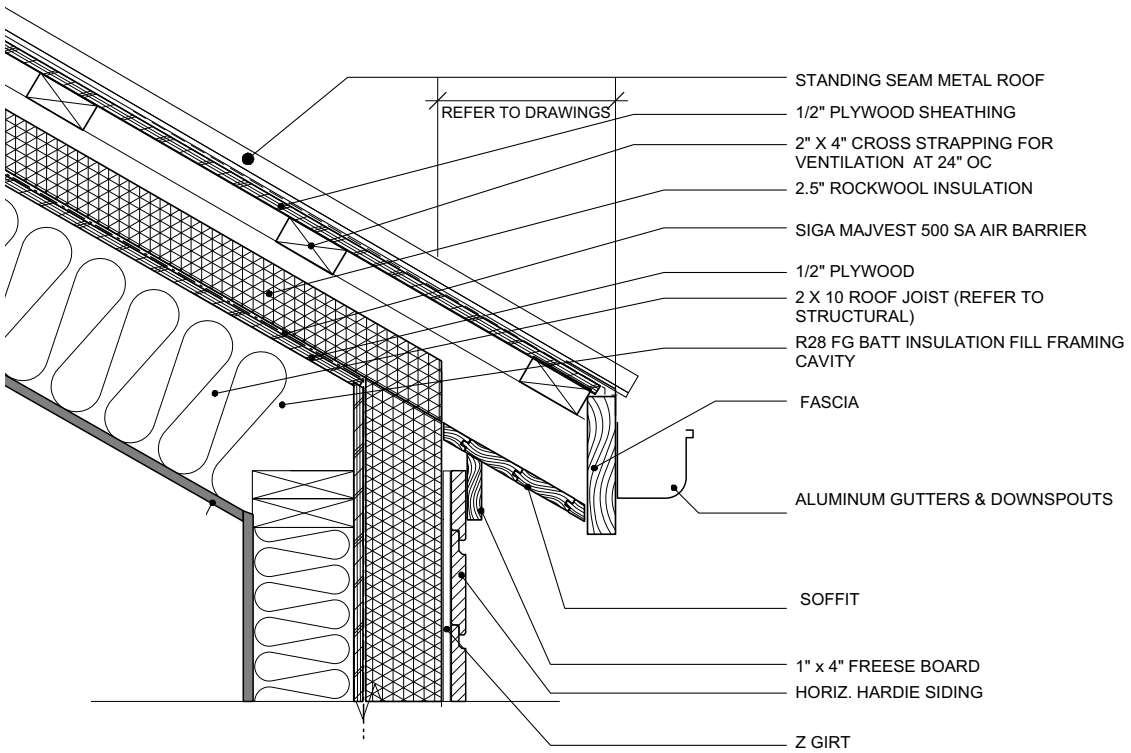
10. Hardiepanel HZ5 siding, non combustible

Framing

The framing was done in September 2020.

The Roof

The roof was framed in October 2020. Insulation and the final metal roof was installed in November 2020, just in time for winter.



Roof Assembly R31

- Prefinished metal roofing
- High temperature peel and stick
- ½" plywood sheathing with glued joints
- 2x4 cross strapping (maintain 2 ½" venting space)
- 2.5" Rockwool insulation between 2x4, 1" air gap between cross strapping and insulation
- 2x4 over framing cantilever over roof edge to create overhang
- Siga Majvest 500 SA air barrier
- ½" plywood
- 2x10 joist
- R-28 FG Batt insulation in framing cavity
- ½ Gypsum Wall Board ceiling
- Vapour barrier primer paint
- Finish coat of paint

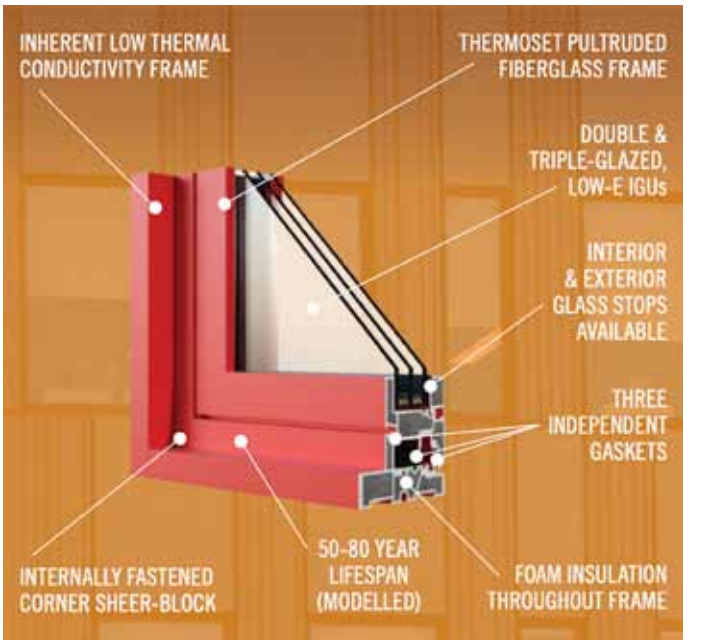
Windows

High performance windows are a game changer when building a net zero home. We chose the Cascadia Universal series triple glazed fiberglass windows. Windows were installed in early December 2020.

Advantages of Fiberglass Windows

- locally made
- low E, Argon filled
- high strength and thermal efficiency
- no VOCs
- Living Building Challenge Red-List free
- less embodied energy than vinyl or aluminum
- not susceptible to decay or insect attack
- low thermal expansion
- low maintenance, 50-80 year lifespan
- Passive House certified
- Energy Star rated

CASCADIA
WINDOWS & DOORS



Cascadia Universal series triple glazed fiberglass window cross-section.

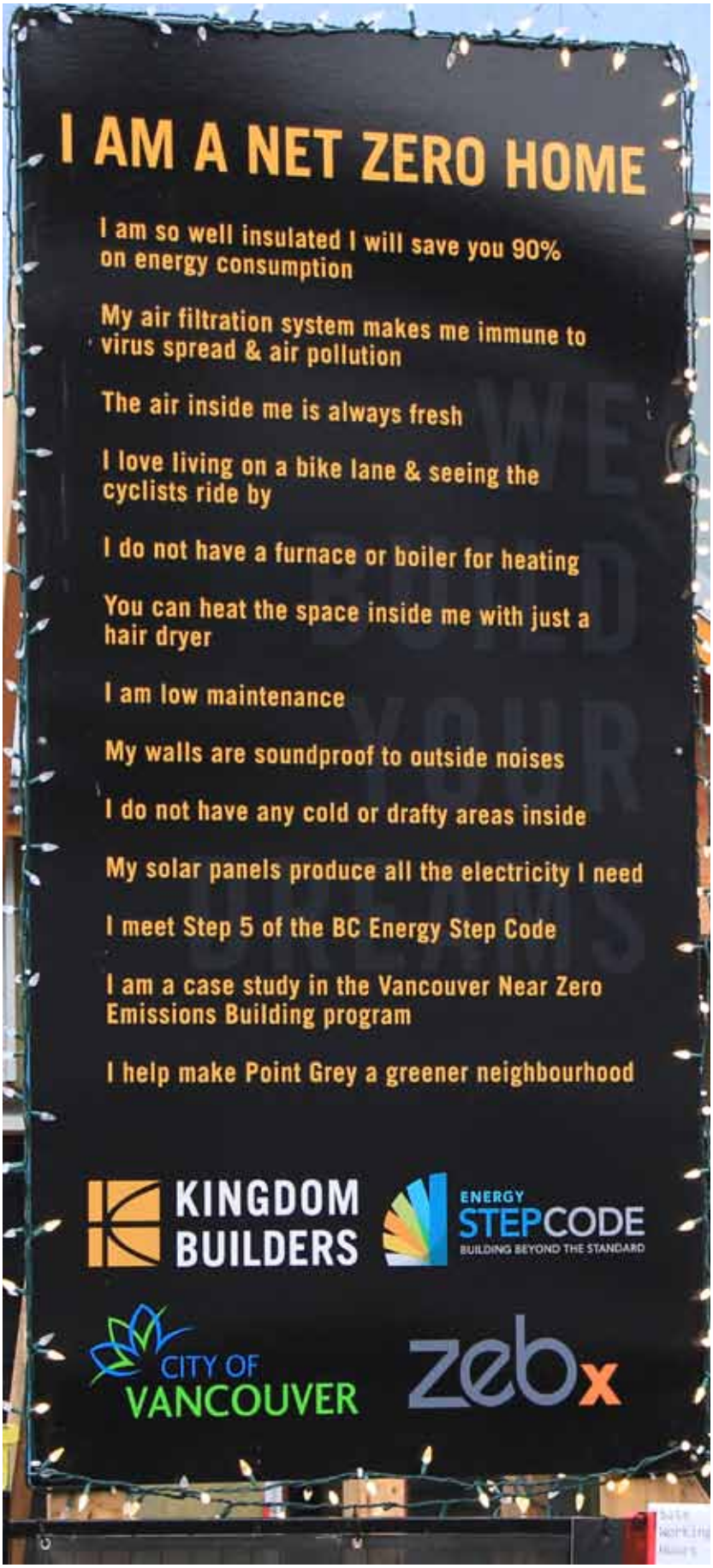
"Spending more on windows and insulation means spending less on the mechanical system."
Mark Bloomfield, kgarch.com


SIGA
Majvest 500 SA


Majvest 500 SA
SIGA

The Sign

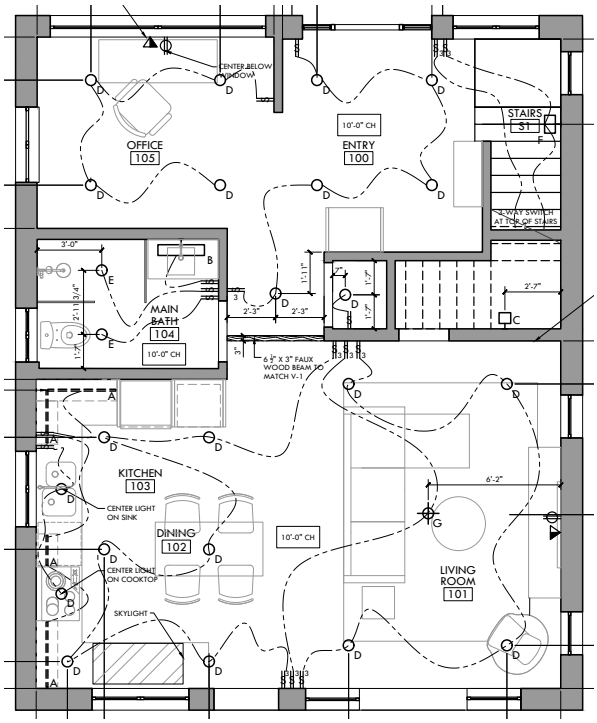
Neighbours were curious and asking questions about the house from the beginning. Aaron Lavalle, from Kingdom Builders, came up with the idea of making a sign to explain the house's design and features to people walking and cycling along Point Grey Road. Many photographs were taken of the sign and it helped educate curious onlookers as they watched an energy efficient house be built in their neighbourhood.



Rough In Electrical and Plumbing

The rough in plumbing and electrical were installed in November 2020 and power was hooked up to the house at the end of the year 2020.

FOWLSTONE ELECTRIC LTD.



Airtightness

"Up to 25% of the energy loss in a building is attributable to air leakage."
Passive Design Toolkit, City of Vancouver

An airtight building envelope is a crucial component of a high performance house. The walls are designed using a split wall assembly. This allows for a robust peel and stick membrane on the exterior plywood sheathing, taped and sealed to ensure continuity which makes it easier to achieve an airtight building. In addition, the peel and stick membrane is protected within the wall and offers a very durable air barrier. The roof assembly was built on top of the membrane to make it easier to ensure the air barrier was not compromised by complex construction details and penetration of the roof rafters. Careful attention is essential during contruction to minimize any perforations in the air barrier. The builders were confident this wall assembly could be used to achieve an airtightness of less than 1.0 Air Changes per Hour to meet the requirements of Step 5.

Blower Door Test

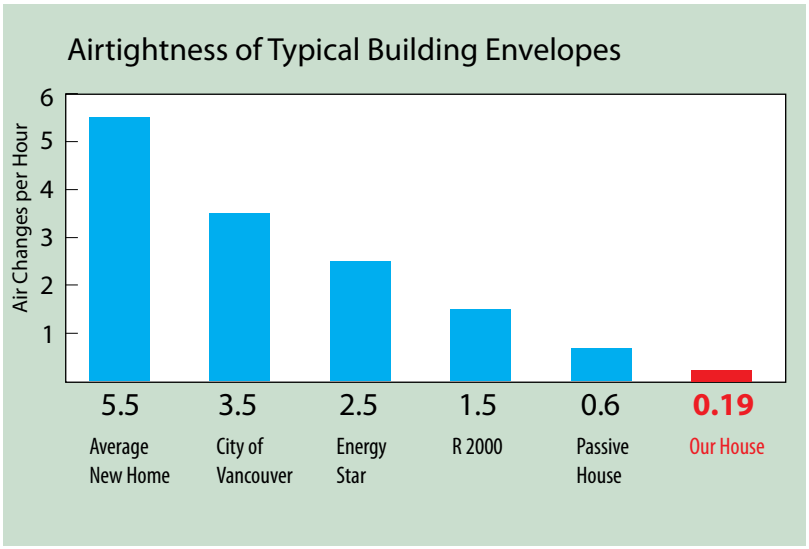
Airtightness is measured with a blower door test. A fan is used to pressurize the house and the air leakage is measured. This is then calibrated with the volume of the house to express the air leakage in terms of Air Changes per Hour (ACH).

A mid-construction blower door test was performed in December 2020. This test is very helpful to assess the airtightness of the air barrier at a time when it is still possible to address any major leaks. As part of the test the house is filled with smoke, which helps to visually assess any air leakages.

The results of the mid-construction blower door test far exceeded the results required for Step 5. The air tightness was measured at 0.22 ACH and placed the airtightness well above that required for a Passive House. This is a reflection of the excellent job done by Kingdom Builders.

The superb airtightness obtained by mid-construction also meant that the finished house would be even more efficient than what the preliminary energy modelling had shown.

The blue Siga Majvest 500 SA permeable membrane is the air barrier.



Steve Warrender patches leaks in the air barrier identified by smoke leaks during the blower door test.

Blower Door Test Results

- Mid-construction ACH = 0.22
- Completed House ACH = 0.19

Barbara Meihuizen, our energy advisor, measures the air leakage during the mid-construction blower door test.

Heat Recovery Ventilator (HRV)

One of the most important systems of a well insulated, airtight house is an HRV, which ensures a constant supply a clean, fresh air and removes old stale air and moisture while recovering most of the heat from the exhausted air. The Zehnder ComfoAir Q450 HRV was chosen and was installed in December 2020. This is basically standard equipment in a passive house. It has a maximum airflow of 203 cfm, a heat recovery rate of 88% and specific electric power of 0.21 Wh/m^3.

As we had both recently recovered from the effects of poor air quality in their old house due to mold, the overall ventilation strategy for the house was especially important. It was important to insure that the total ventilation erred on the large side. Ventilation requirements (eg. Passivhaus Guidelines) typically aim for a minimum of 0.3 ACH (air changes per hour). For this project we wanted a ventilation rate which was slightly higher than that recommended by the BC building code. A comparison to other countries with similar wet maritime climates (eg. Scotland, England, New Zealand) showed that their building codes recommended ventilation rates of about 0.5 ACH and we decided to aim for that. The Zehnder HRV system was designed with a flow of 130 cfm. For comparison the BC Building Code recommends a minimum of 56 cfm.

Kitchen Exhaust

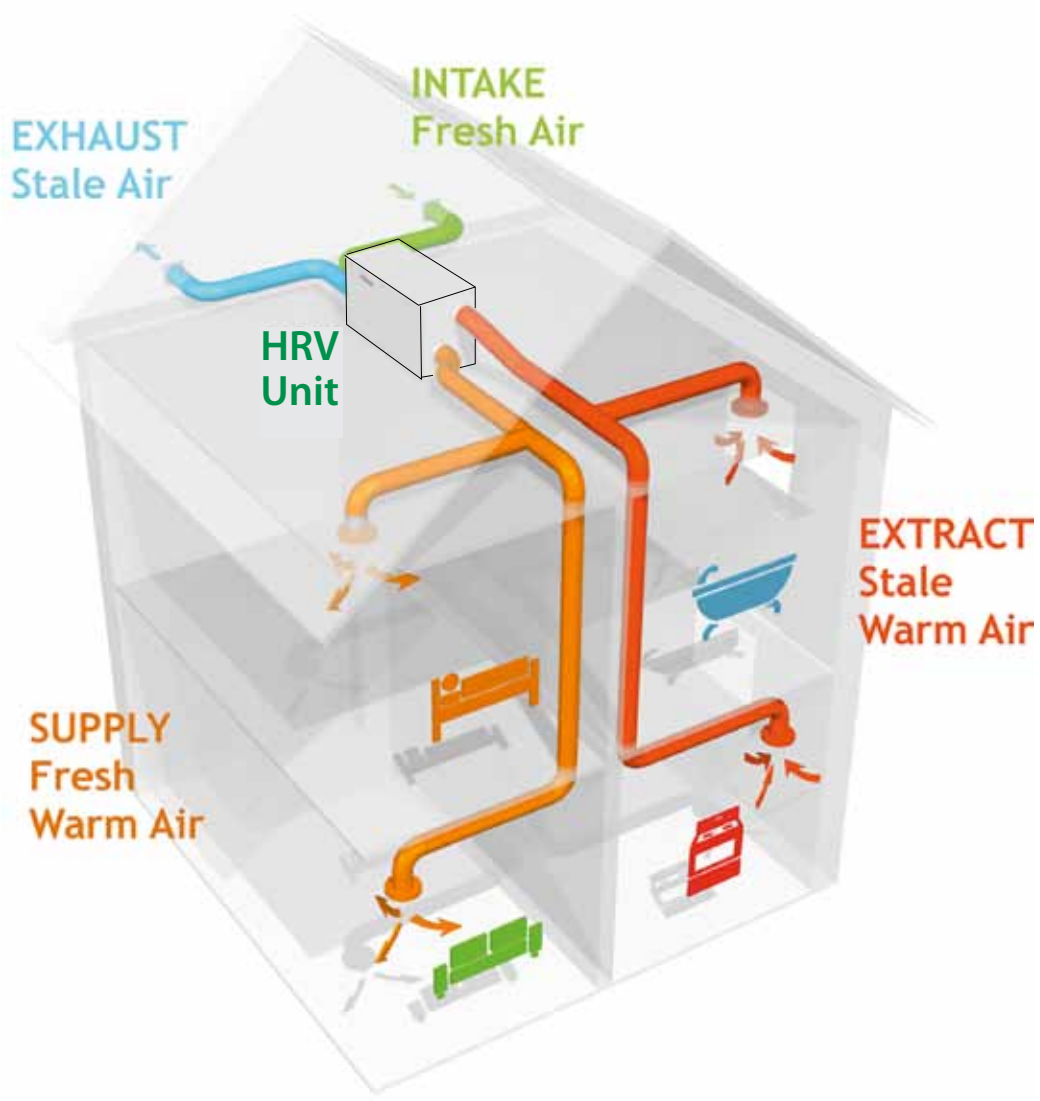
For a high performance Step 5 house a vented range hood is not recommended even though it is required by code. The City of Vancouver has an alternate solutions process whereby the project can apply to use the HRV in combination with a recirculating range hood instead of a vented range hood.

Air Distribution Schedule

Floor	Room	# of Tubes	Air Volume (CFM)	
			Supply	Return
Main Floor	Kitchen Register 1	3		32
Main Floor	Kitchen Register 2	3		31
Main Floor	Bathroom	2		21
Main Floor	Entrance Hallway	1		11
Main Floor	Den	2	21	
Main Floor	Living Rm Register 1	2	26	
Main Floor	Living Rm Register 2	2	26	
Upper Floor	Bathroom	2		21
Upper Floor	Utility Rm	1		4
Upper Floor	M. Bedroom	2	25	
Upper Floor	Bedroom 2	1	11	
Upper Floor	Family Rm/Office	2	21	
Attic	Conditioned Attic	1		10
		24	**130**	**130**

Air Changes/Hour: 0.54

Zehnder ComfoAir Q450 HRV



Air supply ducts from the HRV to the Living Room.

Drywall

Drywall was delivered and installed in January 2021.

Our Architect, Jen Uegama, observes the progress.

City of Vancouver

Vancouver has the lowest per capita greenhouse gas emissions of any major city in North America. To reduce carbon emissions the City of Vancouver has implemented a phased in approach to achieve the greenest building code in North America. Its Greenest City Action Plan sets goals to transition to zero emissions buildings in all new construction by 2030. To achieve this, Vancouver is setting limits on emissions and energy use in new buildings, and will reduce these limits over time in conjunction with the province wide BC Energy Step Code. The Step Code will transition from the present Step 1 to Step 5 in 2032, when Net Zero Energy Ready homes will be the minimum energy performance requirement across the province. Step 5 will be roughly equivalent to a Passive House. Vancouver City Council has also set a target of reducing embodied GHG emissions in new buildings by 40% by 2030.

To facilitate this transition, the city has created a variety of extremely helpful resources and programs including a Zero Emissions Building Exchange (ZEBx), a Green Building Planner and its Near Zero Emissions Building (NZEB) program.

The Near Zero Emissions Building (NZEB) program is an initiative of City of Vancouver to stimulate the use heat pumps for space heating and domestic hot water and catalyze increased NZE building development through research projects and by partially offsetting some design costs related to building a NZE home.

In the middle of our energy modelling our house was accepted as a case study for the Near Zero Emissions Building (NZEB) research project with a grant of $22,500. This stimulated us to further improve our targets for the wall assemblies, air tightness, windows and mechanical system to meet Step 5.

NearZero.ca

Use a Heat Pump in your Step 4, 5 or Passive House project and get up to $22,500!

"Congratulations John, Your application to the Near Zero Emissions Building (NZEB) program has been approved and a compensation amount of $22,500 has been set aside for this project."

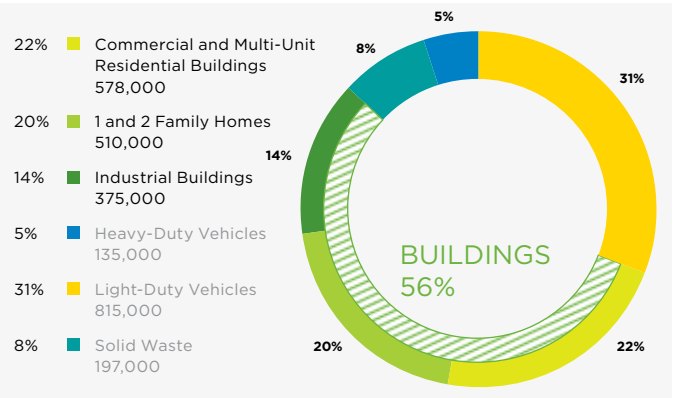
Roberto Pecora May 5, 2020

Chris Higgins (left), Green Building Planner with the City of Vancouver is interviewed on site by Aaron Lavalle (right) of Kingdom Builders.

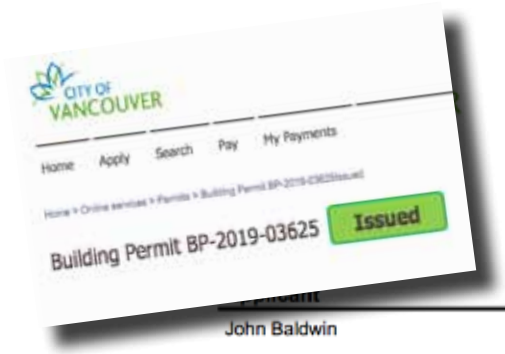
"Moving toward 100% renewable energy is another way that Vancouver is working to become the greenest city in the world."

Mayor Gregor Robertson

VANCOUVER'S 2014 GHG EMISSIONS SOURCES



56% of Vancouver's greenhouse gas emissions are from buildings. (Greenest City Action Plan 2020)

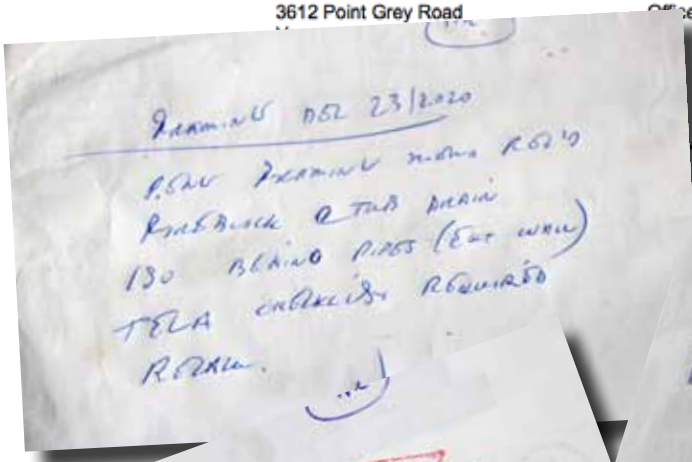


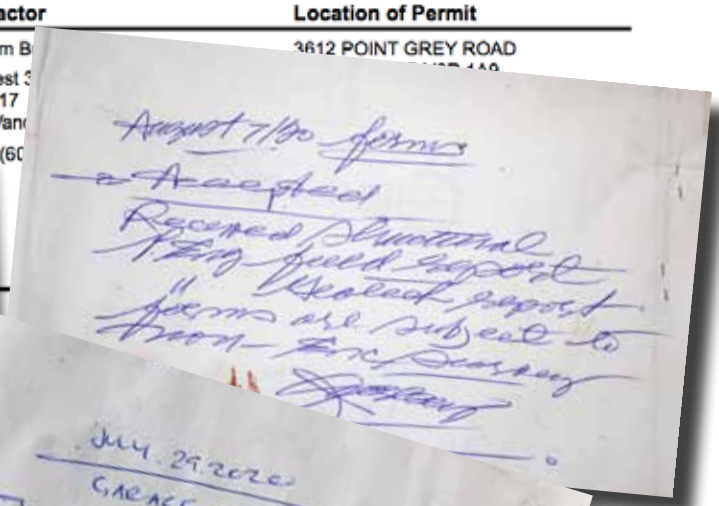
Building Permit

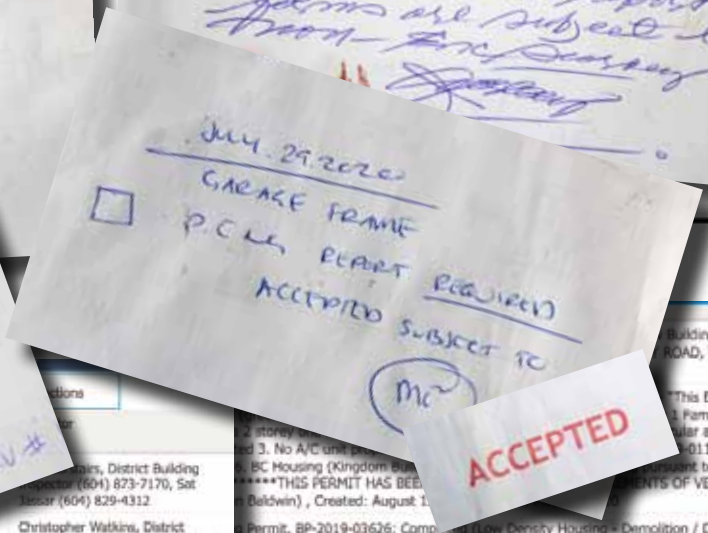
BP-2019-03625
CHANGE NOTICE

Status: Issued

	Contractor	Location of Permit
John Baldwin	Kingdom B	3612 POINT GREY ROAD
Property Owner	949 West 3 Suite 217 North Van	
3612 Point Grey Road		







Inspection Number						
BP-2019-03625-15				Dec 23, 2020	Dec 23, 2020	Christopher Watkins, District Building Inspector (604) 873-7901
BP-2019-03625-09				Oct 13, 2020	Oct 13, 2020	Mike Carstairs, District Building Inspector (604) 873-7170
BP-2019-03625-03				Aug 14, 2020	Aug 14, 2020	Mike Carstairs, District Building Inspector (604) 873-7170
BP-2019-03625-08				Aug 17, 2020	Aug 17, 2020	Mike Carstairs, District Building Inspector (604) 873-7170
BP-2019-03625-05				Aug 6, 2020	Aug 6, 2020	Jamie Hartley, District Building Inspector (604) 873-7968
BP-2019-03625-13				Dec 8, 2020	Dec 8, 2020	Mike Carstairs, District Building Inspector (604) 873-7170
BP-2019-03625-18				Dec 24, 2020	Dec 24, 2020	Christopher Watkins, District Building Inspector (604) 873-7901
BP-2019-03625-06				Aug 7, 2020	Aug 7, 2020	Jamie Hart
BP-2019-03625-01				Jul 20, 2020	Jul 20, 2020	Jenn Good
BP-2019-03625-04	Passed	View COI	1 and 2 FD - Framing	Jul 29, 2020	Jul 29, 2020	Mike Carst
BP-2019-03625-17	Passed	View COI	1 and 2 FD - Insulation and vapor barrier	Jan 5, 2021	Jan 5, 2021	Mike Carst
BP-2019-03625-14	Passed	View COI	Draintile	Dec 8, 2020	Dec 8, 2020	Glen Medw Sprinkler Ir
BP-2019-03625-02	Passed	View COI	Draintile	Jul 27, 2020	Jul 27, 2020	Glen Medw Sprinkler Ir
BP-2019-03625-11	Passed	View COI	Enforcement	Nov 17, 2020	Nov 17, 2020	Mike Carst
BP-2019-03625-10	Passed	View COI	Non-encroachment/Plan Check	Nov 6, 2020	Nov 6, 2020	Mike Carst
BP-2019-03625-12	Passed	View COI	PS - Sheathing	Dec 8, 2020	Dec 8, 2020	Mike Carst

Building a house in Vancouver requires navigating the complex process of permitting and inspections through design and construction. This page shows some of the forms, checklists, applications, permits, and inspections that are required. Once the permits had been obtained by our architect, our site lead, Steve Warrender, took over stick handling a myriad of inspections and building by-laws.

Exterior Finishing

Siding

The exterior of the house was finished with HZ5 Hardieplank Lap Siding. Fire rating rules require the use of fiber cement siding for fire protection on the exterior of the house rather than cedar siding. HZ5® products are made to resist wet, freezing conditions.

Fiber cement siding costs less than wood, doesn't attract pests, and is water resistant to protect against swelling, cracking and buckling. It has exceptional performance and durability, offering moisture and rot resistance and low maintenance.

Soffit

Longboard Soffits made of architectural grade aluminum with a high performance powder coat finish were chosen as a maintenance free alternative to real wood that would compliment the hardieplank siding. Longboard is 100% recyclable, non-combustible, maintenance free, insect-proof, will not rot, peel, warp, or fade, can be used to gain LEED credits and is attractive.

The split wall assembly required careful attention to detail around flashing, trim, corners and windows.

The final coat of exterior paint was done in May 2021.

Longboard Soffits.

Interior Finishing

Sustainable, green, low VOC, and formaldehyde free materials were used for interior finishing. No particle-board or OSB board was used anywhere in the house. Instead real wood was used wherever possible. All finishes are zero or very low VOC. We avoided the use of any chemicals that would affect indoor air quality.

After endless planning and selecting hundreds of details, it was amazing to watch the house be transformed as the interior finishing progressed.

Surface Finishing

Wood Finishing Kunos natural oil sealer 244 , made in Germany, distributed by Livos in Quebec. Zero VOC and biodegradable. This stuff is incredible.

WESTPRO PAINTING

Interior Paint The interior was painted with Benjamin Moore Natura, which is one of the highest recommended zero VOC paints. Natura is certified by the Asthma and Allergy Foundation of America, Cradle to Cradle, Green Seal and qualifies for LEED points.

Trim and Baseboards

Interior window trim, door trim and baseboards are made from solid vertical grain Fir 1" x 4".

Interior Doors

Locally made Trimlite Fir Shaker Panel Interior Doors (#8401).

Stairway Lights

Three art deco wall sconces were salvaged from the old house and were rewired to be used to light the stairway in the new house.

Countertop

Caesarstone Rugged Concrete engineered quartz. Non porous, extremely durable, easy to clean and maintain and very hygienic.

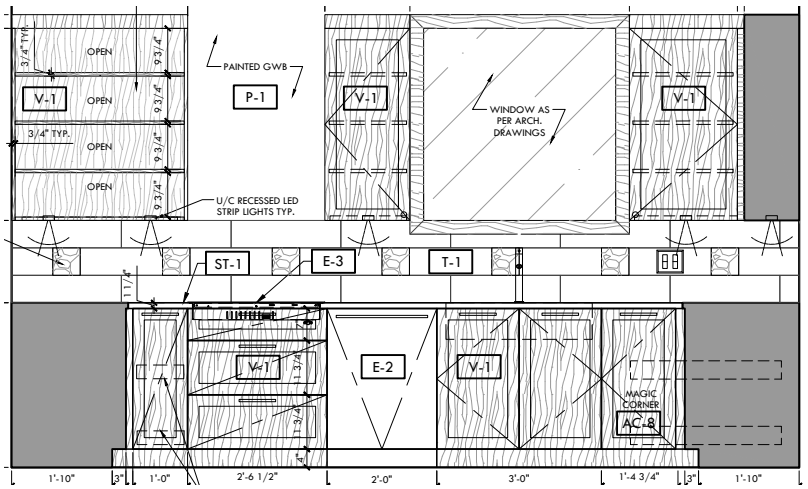
Tile finish on the main floor shower.

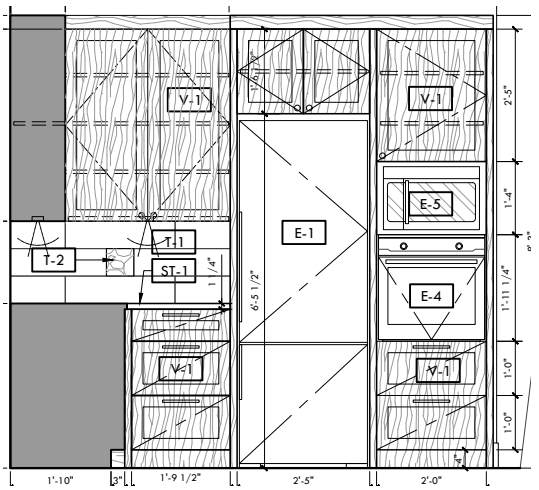
Water Efficiency

Water efficient plumbing fixtures are an important part of reducing hot water and energy use. Designed in California, the High Sierra Half Dome low flow showerhead uses up to 40% less water and is rated as one of the best low flow showerheads.

Cabinets

The cabinets and millwork are made from FSC-certified PureBond Maple Plywood from Columbia Forest Products, which is manufactured in Canada with a soy-based PureBond adhesive that is formaldehyde-free.





After years of staring at drawings it was incredible to watch the cabinets come to life.

Our first view of the finished kitchen.

Flooring

Main Floor The main concrete slab was polished to become the finished floor. This creates a very sustainable and low maintenance floor. The floor was coloured by using special dyes along with the densifiers during the polishing and grinding process.

Upstairs Floor The upstairs floor was finished with Lauzan solid maple flooring, natural series, ambiance collection with titanium finish.

Bathroom Floor Bathroom floors were finished with tile.

Mechanical Systems

It was essential that all the mechanical systems be very energy efficient so that they would not use more energy than will be generated by the solar panels.

Space and water heating are the biggest energy loads in the house and together account for up to 40% of the energy used. Because the house has been designed with a super-insulated building envelope to reduce heat loss a traditional furnace or boiler is not needed. The house could literally be heated with a hair dryer.

The most efficient way to provide heat is to use an air source heat pump. This can provide space heating and hot water.

Heat pumps gain their efficiency by transferring existing heat rather than generating heat. A heat pump uses a small amount of electricity to transfer a large amount of heat and can be up to 4 times more efficient than an electric resistance heater.

The main components of an air source heat pump are:

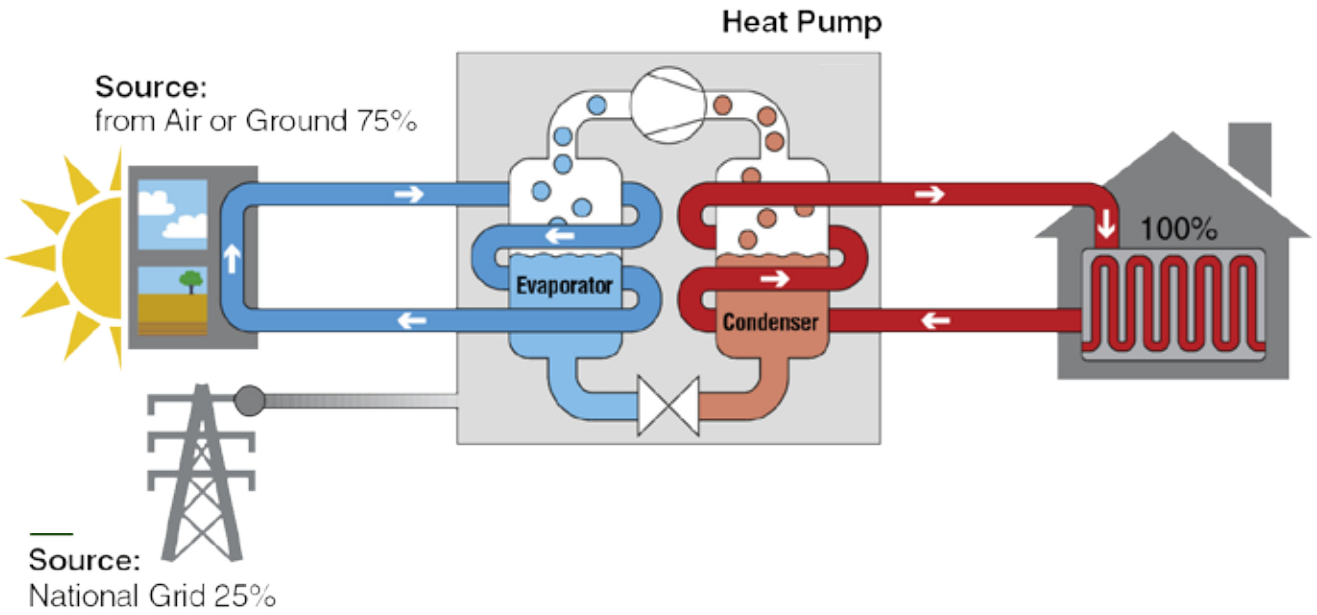
- An outdoor heat exchanger coil, which extracts heat from ambient air.
- An indoor heat exchanger coil, which transfers the heat into an indoor heating system or domestic hot water tank.

A "standard" domestic air source heat pump can extract useful heat down to about −15 °C so is ideally suited to Vancouver's climate.

Hot Water

A Sanden SANCO2 high efficiency heat pump hot water heater 43 Gal system was chosen for its high energy efficiency. The Sanden Heat pump water heater is essentially standard equipment in most Passive houses. The Sanden uses CO_2 as the heat pump refrigerant. CO_2 is a natural refrigerant which is ozone friendly and does not contribute to global warming.

A heat pump hot water heater offers 75% energy savings over an electric resistance water heater.



Heating

A Mitsubishi split heat pump heating system was chosen. A mini split heat pump system consists of a heat pump located outside and 2 wall mounted indoor units to distribute the heat into each level of the house. Through discussions with Derek Aves of One Track Heating we selected the 2 zone wall mount system GL units Model Mxz2c20na

Wall mounted indoor unit to distribute heat.

Mitsubishi exterior heat pump.

Appliances

Energy efficient appliances were used throughout. This was key in helping to reduce electricity consumption so that the goal of net zero energy could be achieved with the use of solar panels.

The most significant appliance is the clothes dryer which uses a lot of energy. Samsung has developed a heat pump clothes dryer that is extremely energy efficient and does not vent waste heat to the outdoors.

- A heat pump dryer passes hot air over your clothes to collect moisture and dry them. This same air then goes through an evaporator, where the moisture is condensed and collected in a water tank.
- Where other dryers simply blow hot air on your clothes, heat pump dryers use a more sophisticated energy-efficient heat exchange system to conserve and reuse the same air (think of it as recycling air).
- Heat pumps only use approximately 50% of the energy used by conventional dryers.
- As their drying air temperature is considerably lower than conventional dryers, heat pumps are less abrasive on your garments.

"Small is beautiful."

Solar Panels

The primary goal of the project was that the house be net-zero. This was accomplished by mounting a system of solar photo voltaic PV modules on the roof. Because solar panels were part of the vision from the very beginning, the roof angle, aspect and width were specifally designed for solar panels. The roof angle is approximately 35 deg. And as many solar panels as possible are mounted across the entire width of the house to take advantage of the unobstructed southern exposure.

Solar Energy System

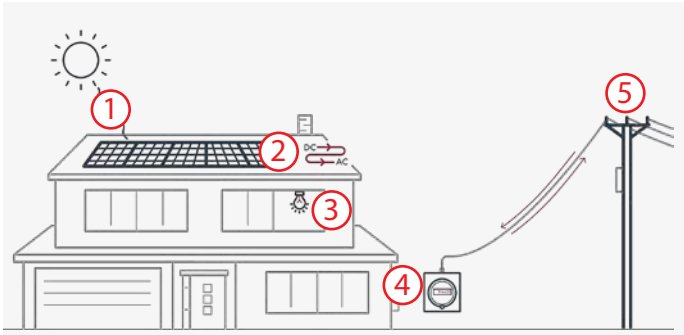
- Number of solar panels: 27
- System size: 9.05 kW
- Predicted solar generation: 10,400 kWh/year
- CO_2 Reduction: 72 tonnes
- Your investment pays back in: 12 years
- Your estimated BC Hydro bill savings over the system's lifetime: $116,000
- Roof orientation: south
- Roof angle : approximately 35 degrees

The solar panels were installed in April 2021. Scaffolding was still in place at the back of the house, which made the installation much easier.

Jennifer Johnson, Solar Connect

"In 2020, the International Energy Agency declared solar power the cheapest source of electricity in history."

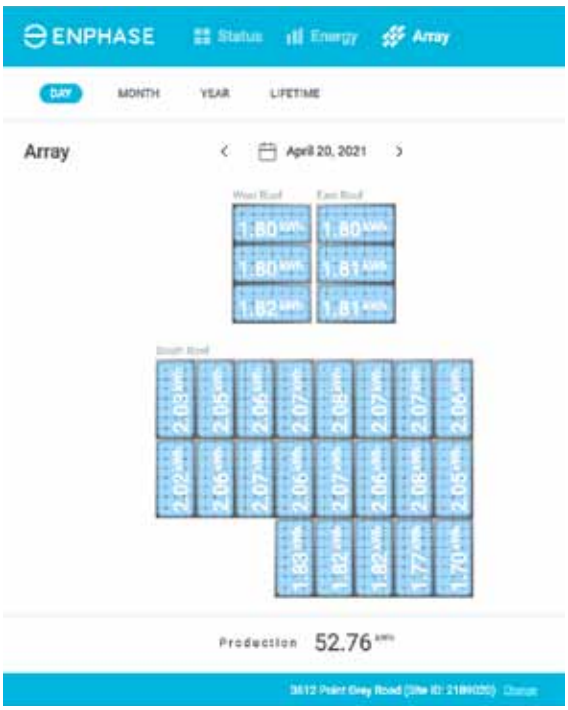
BC Hydro Net Metering



1. Solar panels convert energy from the sun into direct current (DC) electricity.
2. Inverters convert DC electricity into alternating current electricity, which is what a home and the BC Hydro grid uses.
3. The solar PV generation powers the home first, with excess being sent to the grid.
4. Your smart meter measures how much grid electricity has been used by a home and how much excess PV generation has been sent to the grid.
5. Excess solar PV generation is credited on the BC Hydro Bill. Homes with solar energy systems tend to bank credit through the spring and summer and use it up in the fall and winter.

Canadian Solar 335 W PV are manufactured by a Tier 1 industry leading supplier in Canada, and are high quality, durable in all weather conditions, long lasting with excellent performance in low light conditions. Panel size 0.992 m x 1.700 m x 0.035 m.

Six solar panels were mounted on the front west and east facing roofs. These panels will generate approximately 10% less than south facing panels.



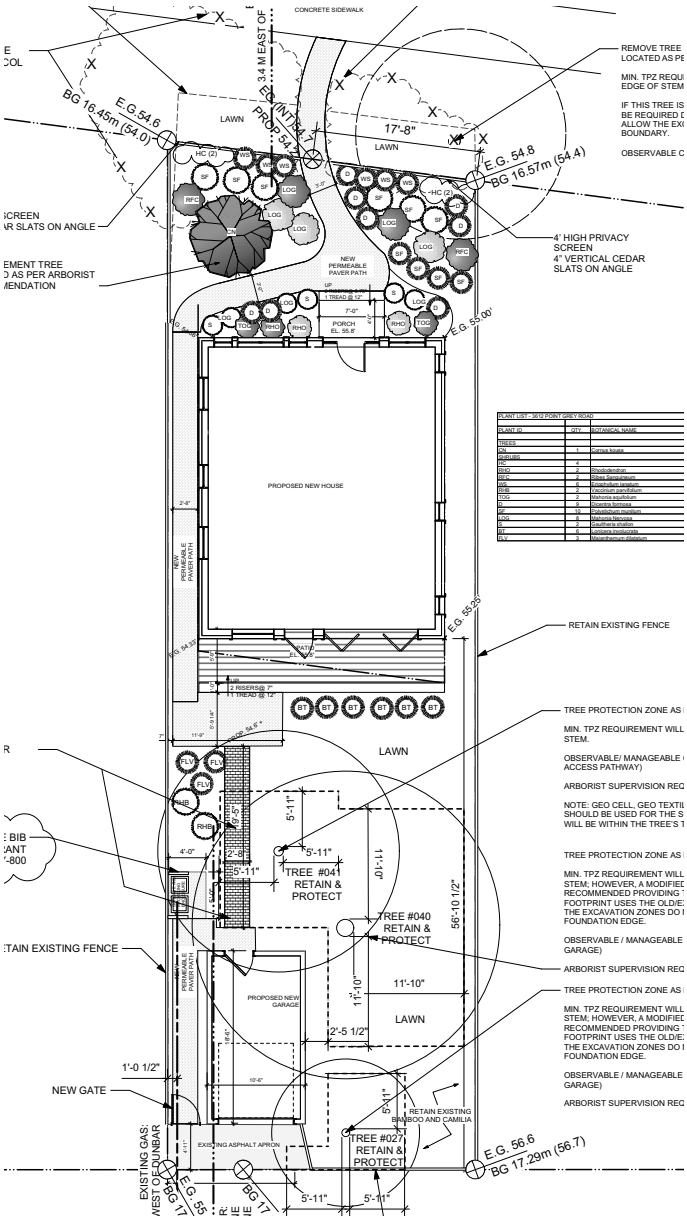
The performance of each panel can be monitored online through Enphase. This screen shot shows the solar energy produced on April 20, 2021.

Landscaping

We chose landscaping that reflects the green nature of the home. City guidelines for green landscaping and bird friendly design were incorporated. We focussed almost entirely on native plants. No irrigation is used and we tried to minimize cement and maintain the permability of the soil.

The main feature of the property is a large spruce in the center of the flat sunny backyard. This creates a private green space in the backyard that has been incorporated into the design by having a large kitchen/living room across the back of the house at ground level that opens onto a backyard patio.

Landscape Plan



Plant List

A visit to the Stanley park native plant demonstration garden helped give us ideas to develop a plant list for the landscape plan. The list included:

- Red Flowering Currant
- Red Huckleberry
- Sword Fern
- Maidenhair Fern
- Salal
- Pacific Bleeding Heart
- False Lily of the Valley
- False Salomom Seal
- Bunchberry Dogwood
- Western Azalea
- Common Snowberry

Mint Landscaping installing sod at the front of the house.

Celtic Stone installing a flagstone patio at the back of the house. The front, side and rear walkways were also constructed of flagstone.

The Finished House


3612

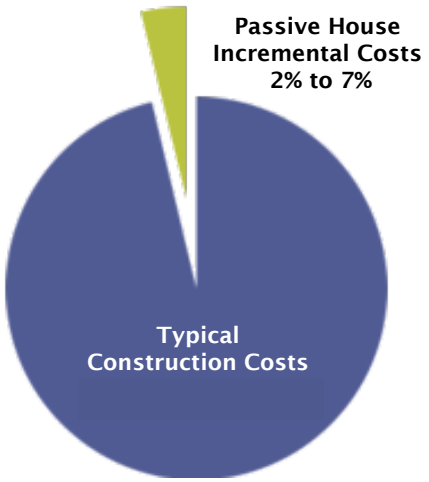
Considering a Net-Zero Home?

"Exceptional energy performance and the ultimate in comfort."
Canadian Home Builders Association

Incremental Costs

One of the most common questions is: What is the overall estimated incremental cost increase to build this project, compared to a code-built equivalent? This is difficult to estimate. Our builder Aaron Lavalle feels that when compared with the latest Vancouver Building By-Law the answer is approximately 5% (not including the solar system).

The passive house windows and doors as well as the high performance wall assemblies (extra material and installation costs) have the biggest impact on the incremental cost. The mini split heating system is likely cheaper than a forced air furnace and associated ducts. It is important to consider that the energy costs to operate the house will be significantly less than a code built house.



A 2016 *Passive House Costing Study* by City of Vancouver estimated that constructing to the Passive House standard has a total construction cost premium of approximately 2% to 7% as compared to Vancouver Building By-Law (VBBL) construction. Building envelope costs are 15% to 20% higher for a Passive House; however, mechanical cost savings of 30% to 40% are realized. Overall annual energy bills are up to 20% to 25% lower in a Passive House standard home than a comparable VBBL house.

Challenges

The field of green buildings is new and evolving rapidly. Though it is an exciting time to be building a net-zero home, there is also a steep learning curve.

The architectural design for a net-zero home needs to be integrated with factors such as the roof design for solar panels; general passive house guidelines for shape and window placement; and type of foundation etc.

A preliminary solar panel design is key for setting a benchmark target for household energy use.

Energy modelling is also key to ensure that wall assemblies, mechanical systems and appliances can all combine to reach net zero for the benchmark target set by the solar panels.

Airtightness is critical and requires considerably more attention from the builder than building a standard house.

Despite the fact that Step 5 houses will be the minimum requirement by 2032, very few builders currently have the necessary knowledge to build to the standard which is needed to achieve a net zero energy efficient building.

It is essential to work with a builder that has training and experience building passive or high performance houses and airtight construction.

Embodied Carbon

Embodied carbon in construction (emissions associated with a building's construction materials) is responsible for approximately 11% of the world's carbon emissions.

Conscientious material choices can significantly reduce this embodied carbon. Concrete in basements has been shown to account for a large fraction of the embodied carbon in a house. We used a slab on grade foundation to significantly reduce this. Extruded polystyrene and most spray foam insulations also have a high global warming potential. Alternative materials have a fraction of this. To insulate the foundation we used expanded polystyrene and to insulate the exterior walls we used mineral wool.

A study of *Embodied Carbon in Passive House Buildings* prepared for ZEBx showed that Passive houses have relatively low embodied carbon and calculated that a house like ours would have on the order of 30 tons of CO_2 equivalent of embodied carbon.

Step 5 Whole House guidelines from the BC Energy Step Code.

Advantages of a Net Zero Home

Environmentally responsible

- energy savings
- zero CO_2 emissions
- lower embodied carbon footprint
- reduced use of resources
- pioneer in sustainability
- water efficiency

Greater comfort, healthier living

- improved indoor air quality
- even temperature distribution
- quiet

Exceptional value

- no monthly energy bills
- durable, low maintenance home
- higher resale value
- protect yourself from rising energy prices
- tax incentives

"The traditional approach, where the architect designs the building shape, orientation and envelope, and then transmits the drawings to the mechanical and electrical engineers for their design, is a sequential approach that misses the rich opportunities for optimizing building performance through a collaborative approach throughout the design process."

Lynn Bellenger, Former President ASHRAE

Net-Zero Certification

"Look Ma, No chimney!"

An Energuide rating of the finished house was done on May 12, 2021. This involved an evaluation of the as-built house and its mechanical systems as well as a final blower door test. The pre-construction energy modelling was then updated with the as built conditions and used to estimate the energy use of the finished house. The predicted energy use of the finished house is slightly lower than the preliminary energy modelling because of the improved airtightness and a better modelling of the efficient hot water heater. The completed house received an energuide rating of 0 GJ/year and was certified as net-zero by City Green Solutions.

Barbara Meihuizen, our energy advisor, takes a fun pose while setting up the final blower door test.

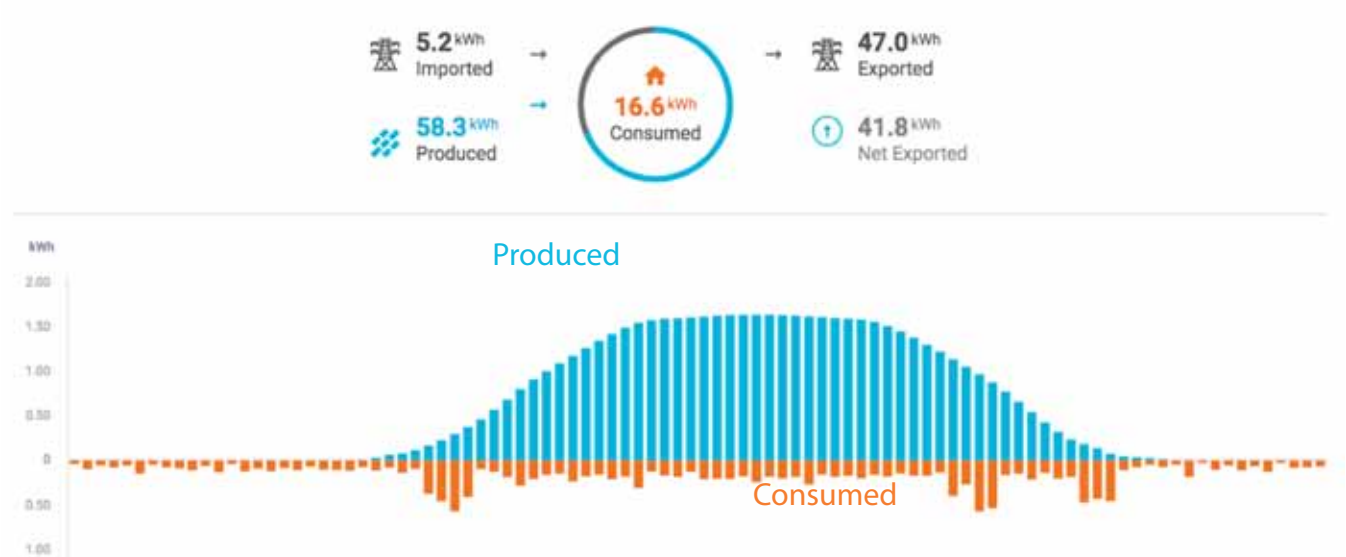
Carbon Offsets

We decided to purchase carbon offests to offset some of the carbon emissions from construction and the embodied carbon used to make the construction materials. As net-zero homes are refined, it is hoped that these two sources of emissions will get lower.

"Our journey to a 100% renewable energy future is just starting, but we're not starting from scratch. We already have the knowledge, skills and technologies to meet our transportation and building energy needs in a renewable way."

Greenest City Action Plan 2020

Energy produced and consumed on June 1, 2021, a typical sunny summer day.



3612 Point Grey Rd,
Vancouver, BRITISH COLUMBIA, V6R 1A9

ENERGUIDE

Data collected: May 12, 2021

File number: **7931N00443**

Evaluated by: Barbara Meihuizen - Domus Home Energy

0 ★This house produces more energy than it uses on an annual basis
GJ/year

0 GJ/year
Best energy performance

73 GJ/year
A typical new house

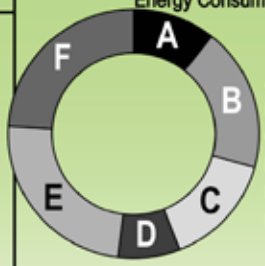
Uses most energy

One gigajoule (GJ) equals the energy from two BBQ propane tanks

Rated Annual Energy Consumption		32 GJ
• Electricity	32	
On-site renewable energy contributions		- 32 GJ
• Electricity	41	
• Solar water heating	0	
EnerGuide Rating:		= 0 GJ

Figures may not add up due to rounding.

Breakdown of Rated Annual Energy Consumption:



A	Space heating	8%
B	Space cooling	14%
C	Water heating	11%
D	Ventilation	5%
E	Lights & appliances	18%
F	Other electrical	44%

Rated Energy Intensity: **0.19 GJ/m²/year**

Rated Greenhouse Gas Emissions: **0.0 tonnes/year**

The energy consumption indicated on your utility bills may be higher or lower than your EnerGuide rating. This is because standard assumptions have been made regarding how many people live in your house and how the home is operated. Your rating is based on the condition of your house on the day it was evaluated.

Quality assured by: City Green Solutions

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Home

Our house passed the final inspection on May 21, 2021 and we were very excited to move into our new home on May 26, 2021.

The house was completed ahead of schedule and on-budget. Building a net zero house has been a fascinating, challenging and rewarding process. We hope this booklet helps inspire others to do the same.

Building inspector Mike Carstairs gives Steve the thumbs up on our final inspection.

Acknowledgements

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Photographs by John Baldwin, Linda Bily, Gary Cleven, Aaron Lavalle, Jon West.

Free pdf copies as well as information on ordering printed copies are available at:
www.johnbaldwin.ca

This booklet describes the development of a net-zero house in Vancouver's Kitsilano neighbourhood.

The purpose of this booklet is to help promote net-zero homes.

Information on ordering printed copies from Blurb.ca, as well as free pdf copies are available at:

www.johnbaldwin.ca