adapt energy advising

2740/42 Fifth St Passive House aka “Urban Green”

Project Documentation

1 Abstract

New residential duplex, constructed in 2017, in Victoria, BC (Canada)

1.1 Data of building / Gebäudedaten

Year of construction/ Baujahr	2017	**Space heating / Heizwärmebedarf**	**15 kWh/(m²a)**
U-value external wall/ U-Wert Außenwand	0.135 – 0.156 W/(m²K)		
U-value basement ceiling/ U-Wert Kellerdecke	0.128 W/(m²K)	**Primary Energy Renewable (PER) / Erneuerbare Primärenergie (PER)**	58 kWh/(m²a)
U-value roof/ U-Wert Dach	0.110 W/(m²K)	**Generation of renewable energy / Erzeugung erneuerb. Energie**	0 kWh/(m²a)
U-value window/ U-Wert Fenster	0.79 W/(m²K)	**Non-renewable Primary Energy (PE) / Nicht erneuerbare Primärenergie (PE)**	130 kWh/(m²a)
Heat recovery/ Wärmerückgewinnung	77 %	Pressure test n_{50} / Drucktest n_{50}	0.3 h-1
Special features/ Besonderheiten	Heat recovery from all shower drain water, permeable concrete paved surfaces		

1.2 Brief Description

This building is a front/back style residential duplex, with each unit consisting of two storeys. The front unit is 118 sqm, the rear is 126 sqm, and they are essentially a mirror image of each other. The owners built this building for their own use. They chose a duplex because it was permitted in the local Zoning, and the current market conditions make income-generating properties more feasible for young urban professionals near the City centre.

After seeing the Austria House in Whistler during the 2010 Olympics, the owners were interested in the Passive House principles, but were wary about assembling a building in another region and shipping it for assembly. They wanted to build to a high standard of energy efficiency while utilizing local and traditional construction practices as much as possible, rather than doing something that was new and unfamiliar for everyone involved.

The Passive House principles were all adopted: high levels of insulation, air-tight construction, high-performance windows and doors, a heat-recovery ventilation system, elimination of thermal bridging through well-designed building assembly details, and proper building orientation to make use of solar gains and shading. The building stretches its length from East to West, enabling notable solar gains from it’s Southern exposure.

1.3 Responsible project participants / Verantwortliche Projektbeteiligte

Architect/ Entwurfsverfasser	Cascadia Architects http://cascadiaarchitects.ca/
Implementation planning/ Ausführungsplanung	Adapt Energy Advising, Cascadia Architects, Interactive Construction https://www.adaptenergyadvising.com/ http://cascadiaarchitects.ca/ https://www.interactiveconstruction.ca/
Building systems/ Haustechnik	Adapt Energy Advising, Cascadia Architects, Interactive Construction https://www.adaptenergyadvising.com/ http://cascadiaarchitects.ca/ https://www.interactiveconstruction.ca/
Structural engineering/ Baustatik	Hoel Engineering http://www.hoel.bc.ca/
Building physics/ Bauphysik	Cascadia Architects http://cascadiaarchitects.ca/
Passive House project planning/ Passivhaus-Projektierung	Adapt Energy Advising https://www.adaptenergyadvising.com/
Construction management/ Bauleitung	Interactive Construction https://www.interactiveconstruction.ca/

Certifying body/ Zertifizierungsstelle	Andrew Peel http://www.peelpassivehouse.ca/		
Certification ID/ Zertifizierungs ID	17774-17775_APC_PH_20180313_AP	Project-ID (www.passivehouse-database.org) Projekt-ID (www.passivehouse-database .org)	5717

Author of project documentation / Verfasser der Gebäude-Dokumentation	Reed Cassidy Adapt Energy Advising
Date, Signature/ Datum, Unterschrift	29 April 2018

2 Exterior Views

View from North West; front door entry in recessed area.

View from South West**;** large South windows shown, as well as front yard.

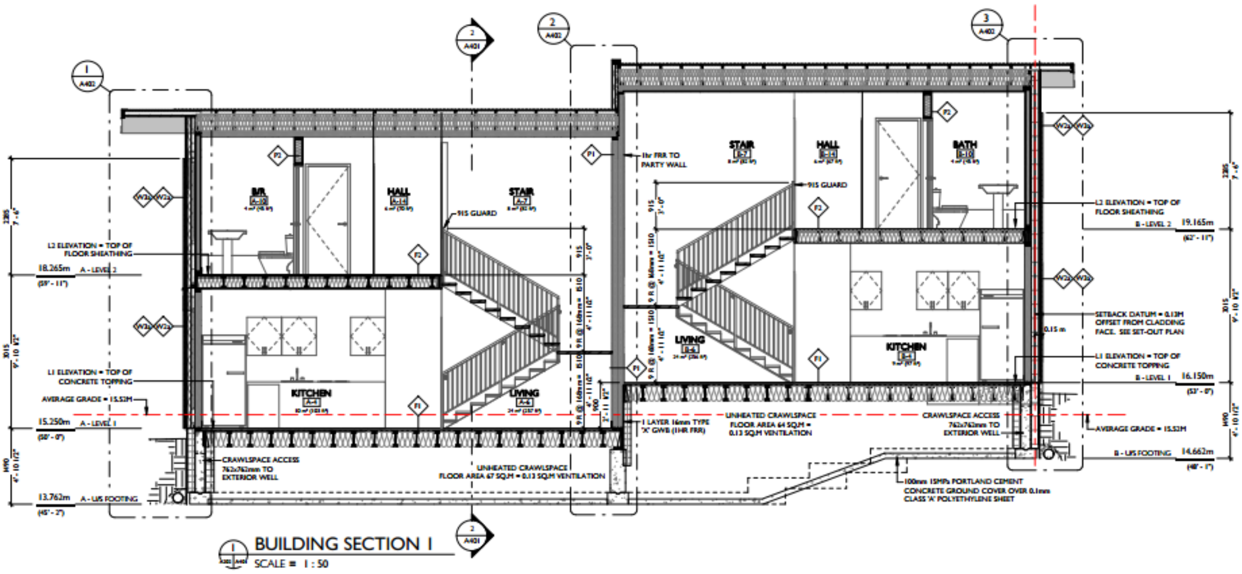
South West; building shading element highlighted. Pervious concrete used for all paved surfaces.

West unit interior; open concept living area on main floors.

East unit kithcen; re-used demolitioned building's subfloor for kitchen trim.

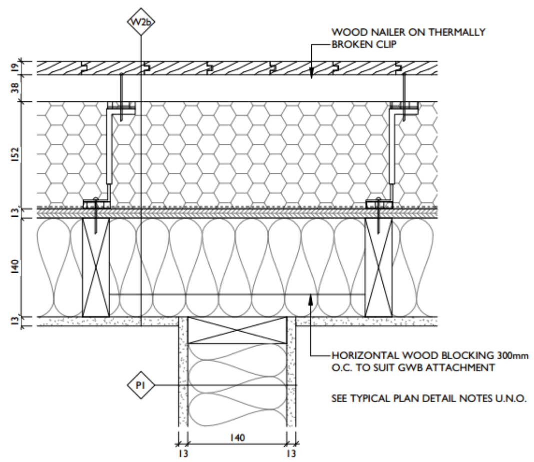
East unit master ensuite bathroom; electronic heated floors controlled by smart unit provide majority of active heating system.

3 Cross-Section



Cross-section running East to West.

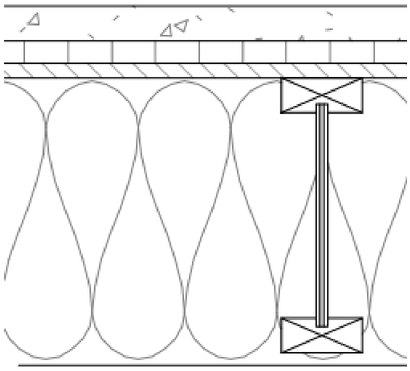
Exterior wall insulation (6“ Roxul CavityRock) eliminates most thermal bridging at assembly junctions, especially around fenestration units where the insulation laps over the window-to-wall and door-to-wall junctions.



Exterior wall assembly, horizontal section.

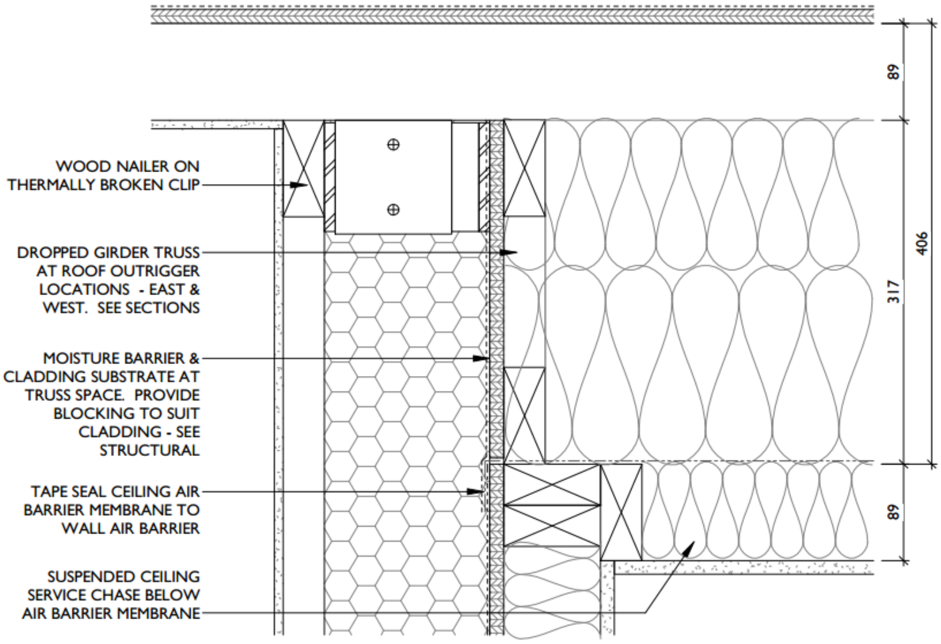
Additional insulation added to the foundation wall exterior minimizes thermal bridging at the main-floor to foundation wall junction. This particular thermal bridge required consideration, because it‘s the geatest linear distance of any in the building.

1“ XPS insulation was added on top of the subfloor beneath the concrete skim-coat to improve the RSI value of the crawlspace ceiling, as well as to minimize thermal bridging from the floor joists. Also, the heavily insulated crawlspace creates a buffered area for the thermal floor assembly above, which has the added benefit of keeping the concrete floors warmer to the touch.



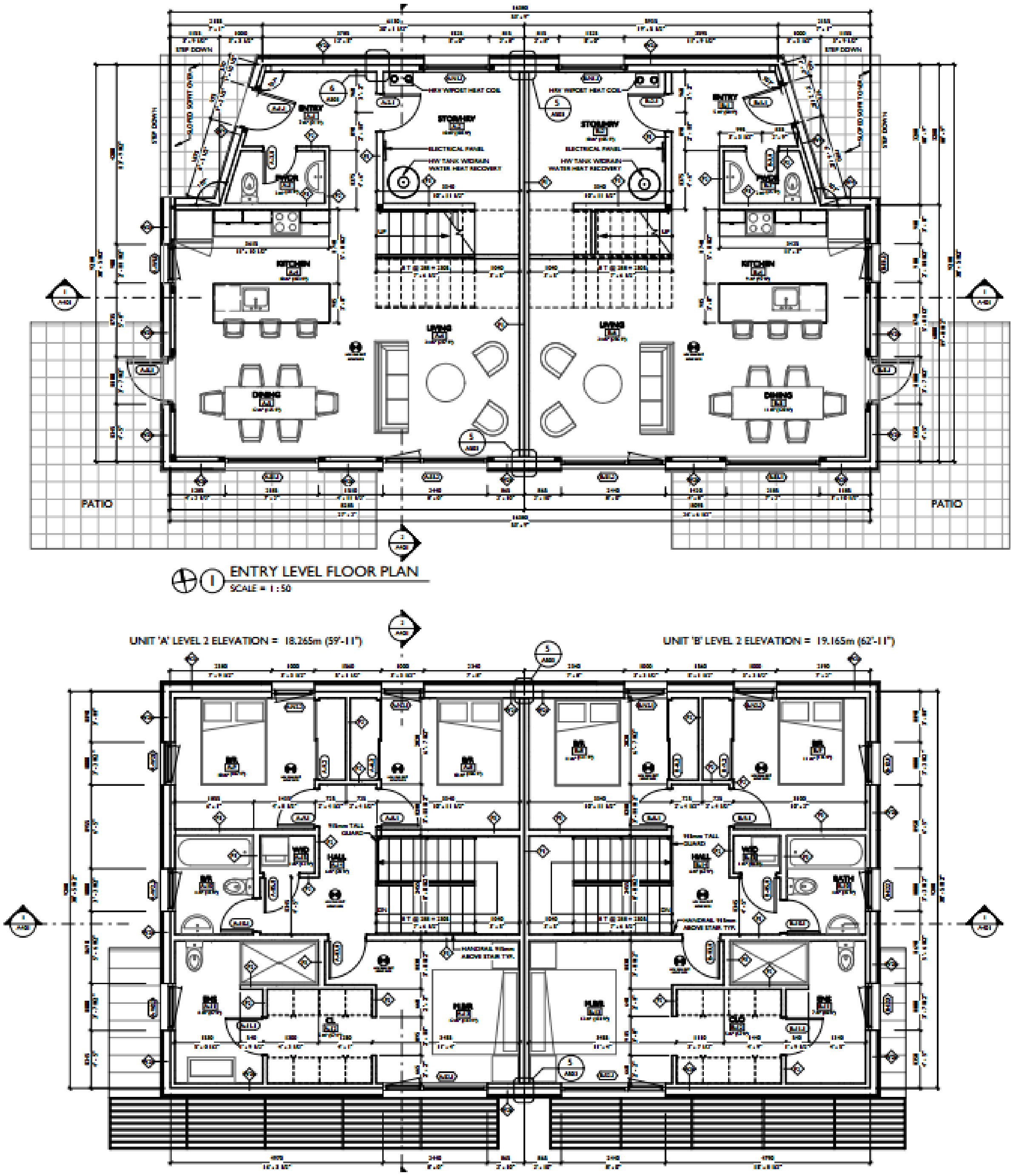
Main floor assembly, crawlspace ceiling.

A dropped 2x4 ceiling below the roof trusses enables a more continuous roof air barrier, as well as reducing thermal bridging from the roof trusses.

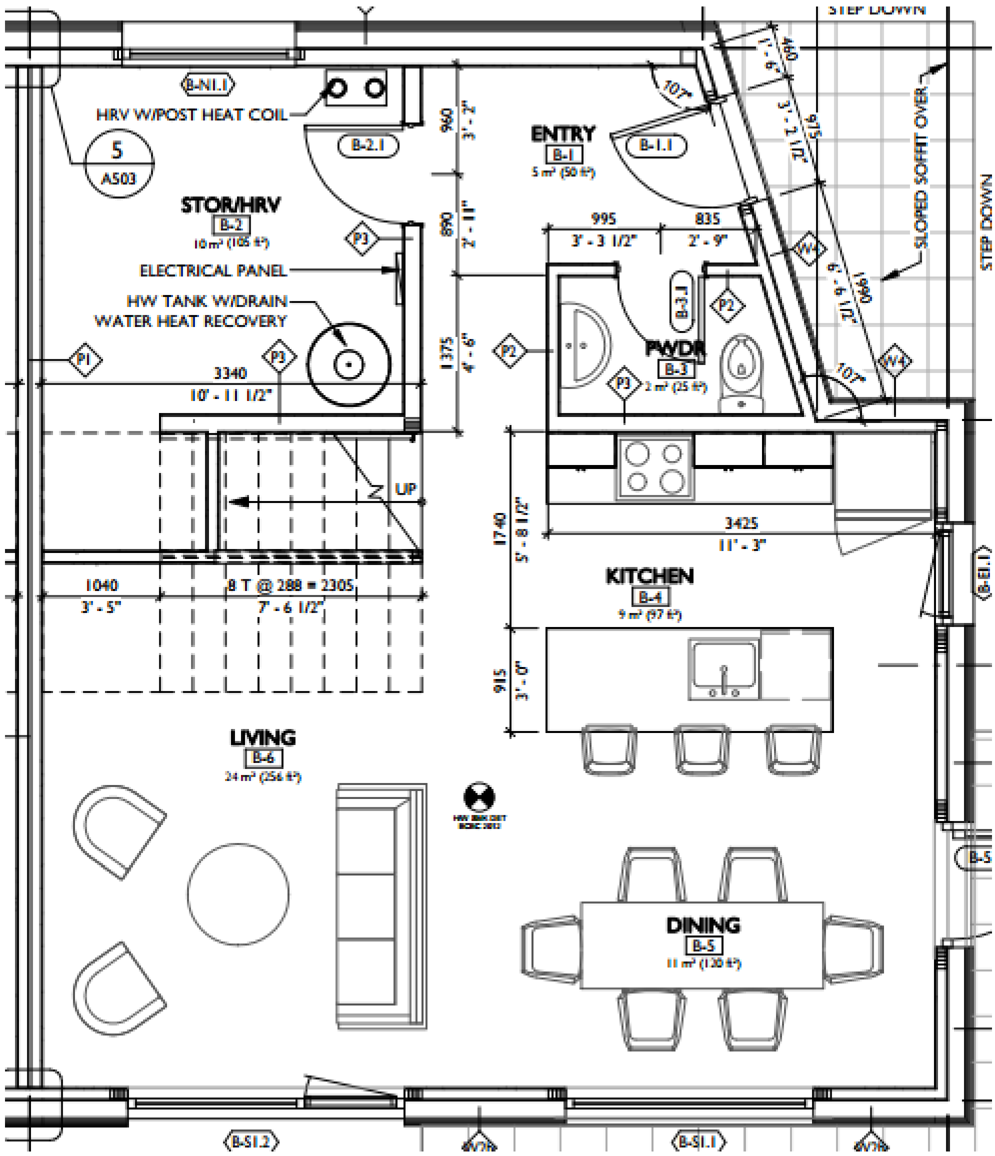


Top of wall at roof.

4 Floor Plans



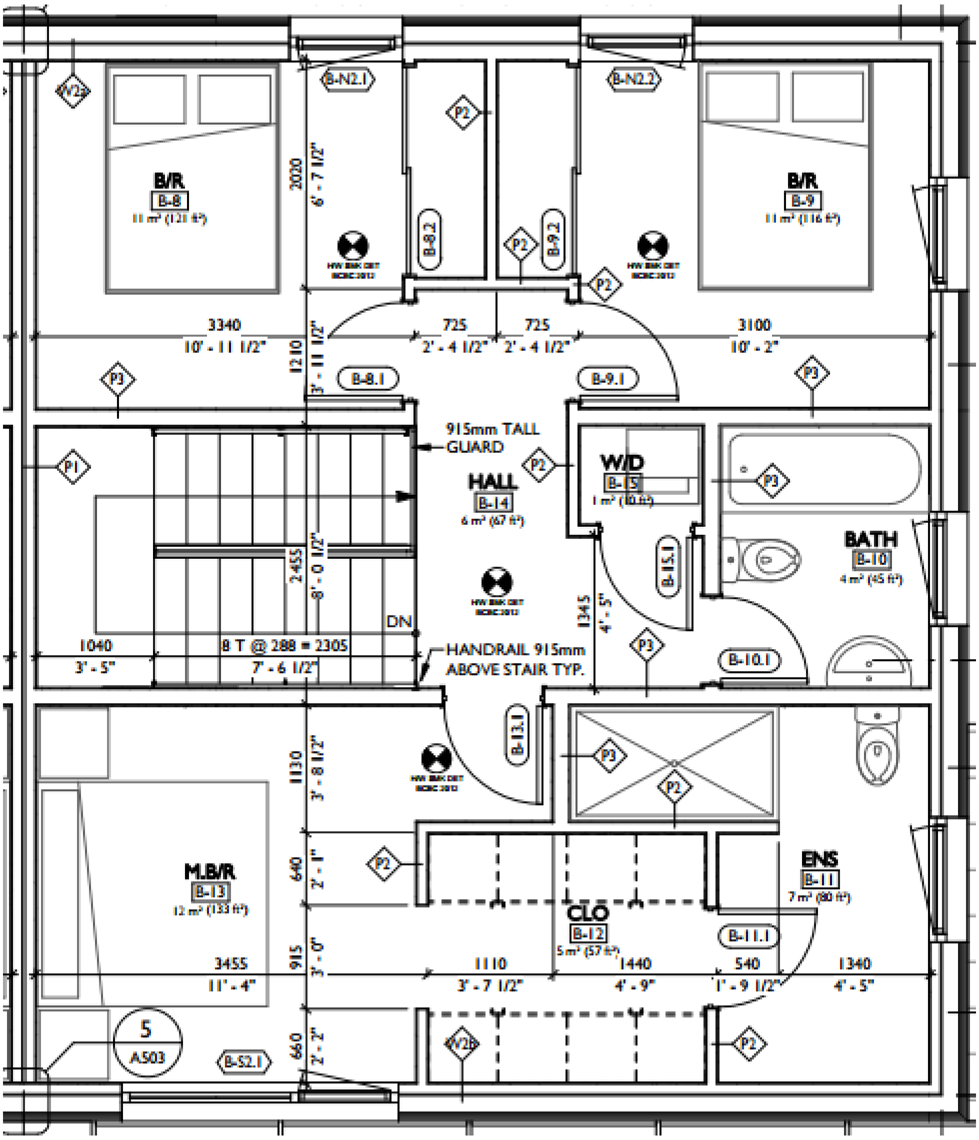
First and second storey floor plans.



West unit first storey.

An open concept living area maximizes the open interior feeling of space, which is typical for modern construction in this area.

A large storage / service room is located on main floor, as no attached garage was implemented. The domestic water heater and shower water heat re-capture system are located here, as well as the HRV.



West unit second storey.

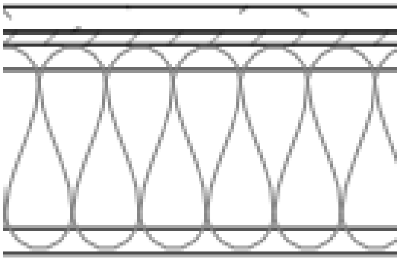
Three bedrooms, two bathrooms, and laundry facilites located on the second floor. A ductless condensing clothes dryer is provided in each unit.

5 Building Construction Details

5.1.1. Floor Assembly – Crawlspace Ceiling

U-Value: 0.128 W/(m2*K)

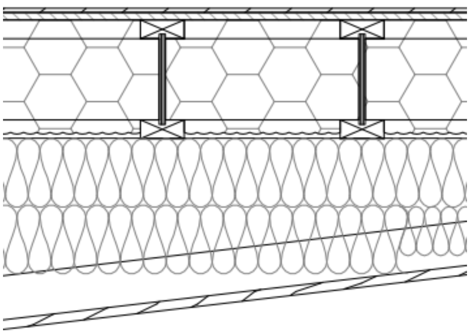
38 mm concrete top coat
25 mm XPS insulation
19 mm plywood sheathing
300 mm TJI @ 400 mm floor joists
R40 batt insulation



5.1.2. Floor Assembly – Covered Entry

U-Value: 0.128 W/(m2*K)

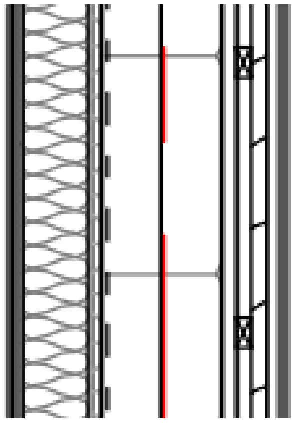
13 mm wood flooring
19 mm plywood sheathing
300 mm TJI @ 400 mm floor joists
R40 batt insulation
R20 batt insulation dropped assembly



5.3.1. Wall Assembly

U-Value: 0.156 W/(m2*K)

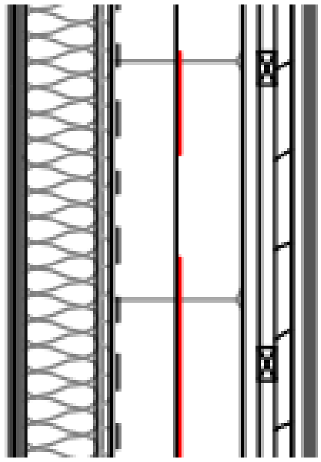
13 mm gypsum board
R14 Batt insulation
38 mm x 89 mm @ 400 mm wood studs
13 mm plywood sheathing
Siga Majvest weather barrier
150 mm Roxul CavityRock insulation w/ z-grit clips
38 mm x 89 mm horizontal strapping
19 mm cedar siding



5.3.2. Wall Assembly – North Wall

U-Value: 0.135 W/(m2*K)

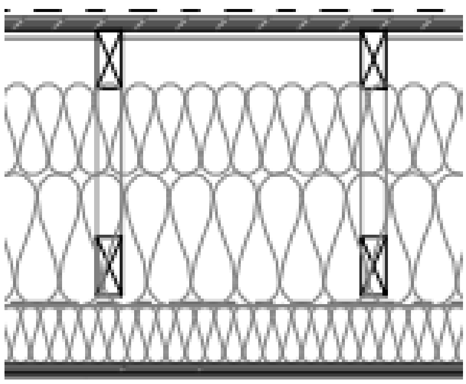
13 mm gypsum board
R14 Batt insulation
38 mm x 140 mm @ 400 mm studs
13 mm plywood sheathing
Siga Majvest weather barrier
150 mm Roxul CavityRock insulation, w/ z-grit clips
38 mm x 89 mm horizontal strapping
19 mm cedar siding



5.4 Roof Assembly

U-Value: 0.110 W/(m2*K)

13 mm gypsum board
38 mm x 89 mm @ 400 mm drop ceiling joists
R14 batt insulation
13 mm OSB sheathing
406 mm @ 400 mm trusses
2 layer R28 batt insulation
13 mm plywood sheathing
Torch-on roofing membrane



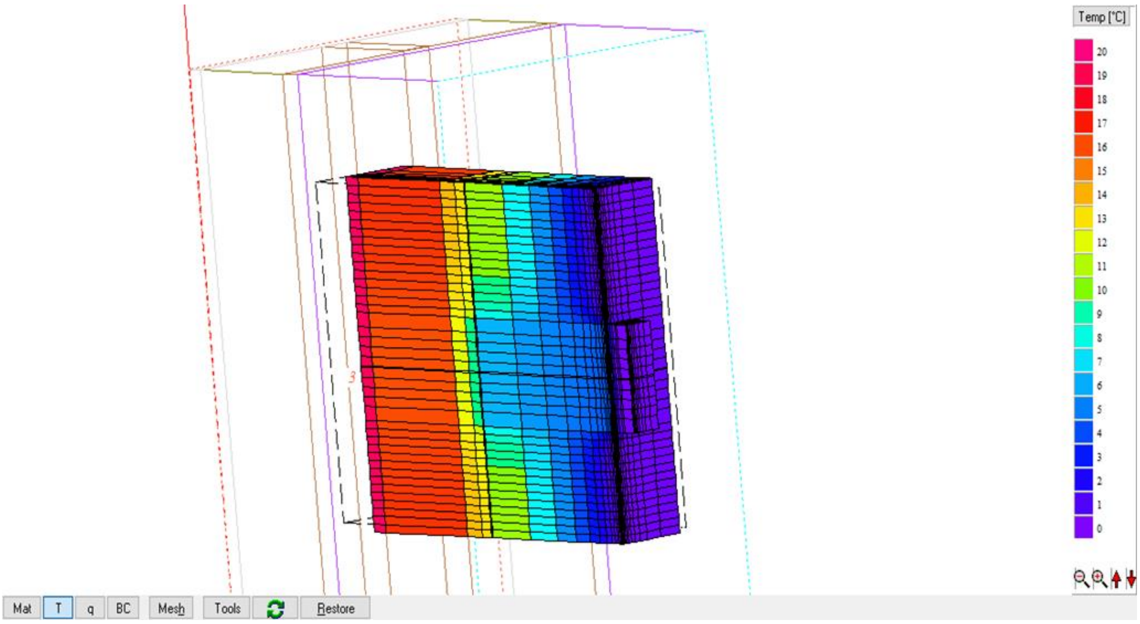
One roof, two floor, and two wall assemblies were used in this project. The desire was to install as much exterior insulation as possible, which was achievable in most of the assemblies.

The local jurisdiction allowed 6” of exterior wall assembly projection into required setbacks, which didn’t have great benefit for this project due to the ample lot size, but was a nice option to have.

5.4 Thermal Bridge Details

5.4.1. Z-grit Clips

The steel z-grit clips used to contain the exterior Roxul insulation required 3D modelling. The resulting Chi-value was 0.007 W/(m2*k).



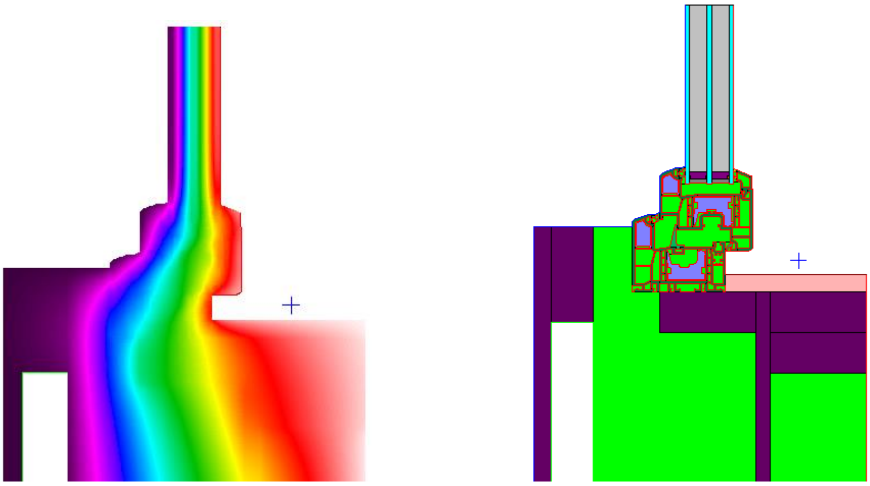
Heat 3D model

Z-grit clips and insulation. The clips proved easy to install, and didn't create any air leakage during testing. They are a sturdy base for the cedar & cement fibreboard cladding.

5.4.2. Window Junctions

Sills for floor to ceiling windows and doors received notches in the concrete, which were framed with plywood and filled with XPS insulation. This prevented the fenestration units from being framed onto concrete foundations, thus minimizing Psi-values.

All window & door headers & jambs were overlapped with exterior insulation. 2D THERM modelling was done, and yielded a Psi-value of 0.006 W/(m2*K).

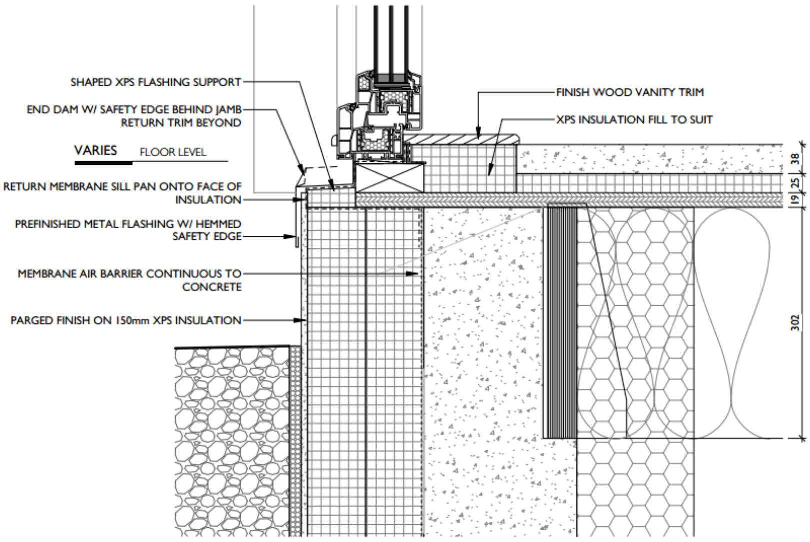


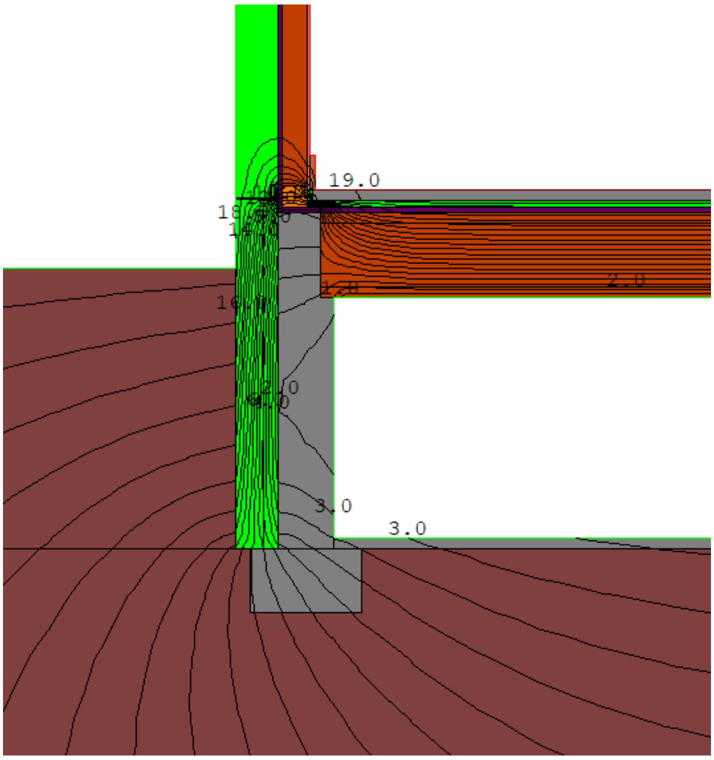
THERM models for window jambs.

West unit dining room window, pre cladding. Framing around windows protected insulation and provided support from metal window trim.

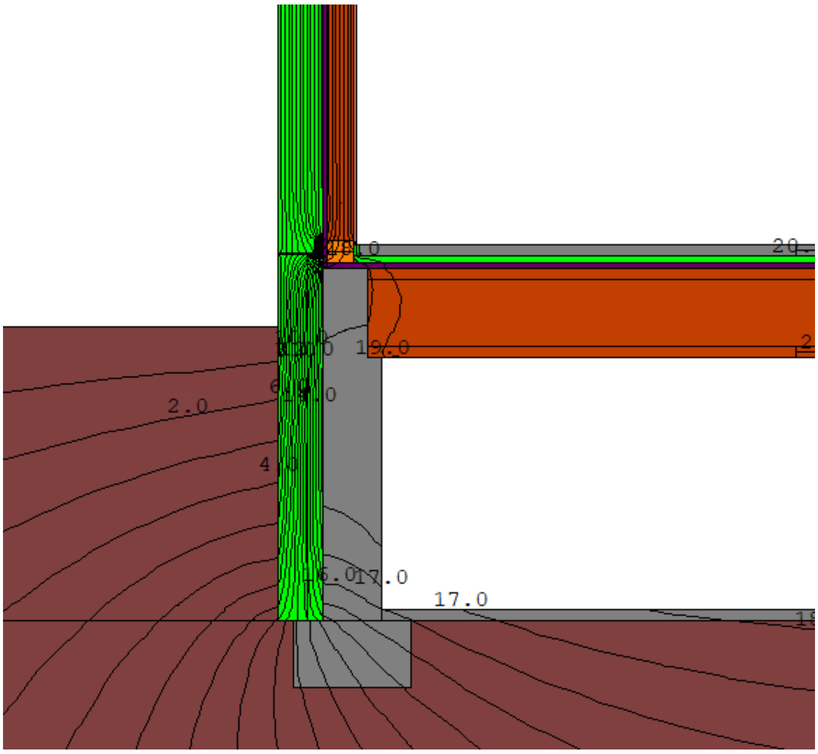
5.4.3. First floor to Foundation Wall

Two THERM models were done to determine the heat loss through this junction.





THERM model for heat loss to basement. Psi-Value: 0.073 W/(m2*K)



THERM model heat heat loss to exterior. Psi-Value: -0.032 W/(m2*K)

6 Windows

Victoria, BC is located in climate zone 4 (warm-temperate). This has Victoria seeing relatively mild winters and summers.

Euroline windows were used for all window and doors except for the front doors. They are triple-pane, insulated vinyl-frame windows, and PHI certified components. The solar factor (g) selected was high in order to make the most of the beneficial exposure, and wasn't of too much concern regarding heat loss.

East unit living room window. All window swing and tilt inward.

Window sill rough framing at foundation buck assembly.

4700 Series ThermoPlus Thermal Performance Chart

Tilt and Turn Window

U Frame (U_f) W/m²•K	Frame Height mm	Ψ (psi) W/m•K	Glass	U Value COG W/m²•K	Solar Factor (g) COG
0.77	115	0.033	4 180-16 argon-4 Clear-16 argon-4 180	0.63	0.55

Picture Window

U Frame (U_f) W/m²•K	Frame Height mm	Ψ (psi) W/m•K	Glass	U Value COG W/m²•K	Solar Factor (g) COG
0.75	72	0.033	4 180-16 argon-4 Clear-16 argon-4 180	0.63	0.55

Door

U Frame (U_f) W/m²•K	Frame Height mm	Ψ (psi) W/m•K	Glass	U Value COG W/m²•K	Solar Factor (g) COG
0.78	142	0.033	4 180-16 argon-4 Clear-16 argon-4 180	0.63	0.55

Euroline product performance chart.

The windows were installed in exterior sub-frames to better align the units in the plane of insulation. The exterior insulation was also wrapped over the frames to minimize thermal bridging.

West unit master bderoom window. Window sits a few inches proud of wall.

7 Doors

Optiwin Entrada doors were used for entry doors. They are triple-pane, insulated wood fram doors, and are PHI certified components. They were chosen for this location due to their flush door sill, and their elegant feel and appearance. The cost of Optiwin products limited them to the one appliction for this project.

The doors were all installed at walk-out elevation, in order to avoid installing decks with their assocated thermal bridges.

1.2 Doorsystem general values inclusive fitting (massiv wall with insulation infront)							
Profile	width of Profile		U_{Frame} - Value		ψ_{Spacer} - Value		$f_{Rsi\,0,25}$ Factor
bottom	181	mm	0,808	W/(m²K)	0,0347	W/(mK)	0,797
side	179	mm	0,808	W/(m²K)	-0,0012	W/(mK)	0,799
top	179	mm	1,095	W/(m²K)	-0,0012	W/(mK)	0,799
french profile	-	mm	-	W/(m²K)	-	W/(mK)	-
U_w	0,70			W/(m²K)	Calculation with insulation panel according EN ISO 10077 . Doordimensions 1100 mm x 2200 mm.The here given Uw fitted value is depending on the doordimensions 1100 mm x 2200 mm.		
ψ fitting	0,005			W/(mK)			
$U_{w\,fitted}$	0,72			W/(m²K)			

Optiwin product performance chart.

East unit fornt door opened.

East unit front door.

8 Airtightness

8.1 Methods and Photos

The air barrier approach was selected based on owner preference. The primary system incorporates wood products, as they‘re easy to manage accidental penetrations, and they were already being used in most of the construction assemblies. Also, plywood‘s vapour permeability qualities make it a desirable choice for this coastal climate.

The plywood subfloor of the first floor (above the unheated crawlspace) runs continuously under the exterior wall plates, which enables it to be taped to the plywood wall sheathing. All joints and penetrations were sealed with Siga tape.

Bathroom floor; penetrations and plywood joints sealed.

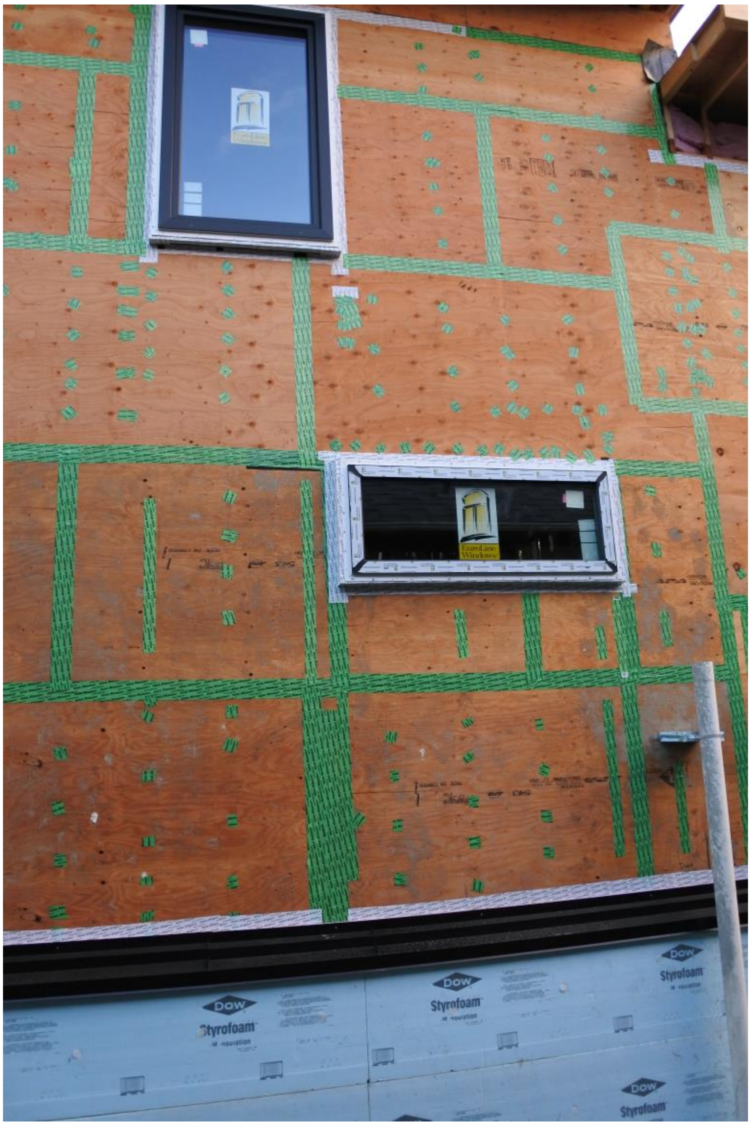
Service room floor; penetrations ad plywood joints sealed.

The plywood wall sheathing saw all joints and penetrations sealed with Siga tape. The plywood subfloor and the OSB roof system air barrier (shown later) were sealed to the wall sheathing with Siga tape.

Wall sheathing sealing. Taped and sealed.

Second floor overhang air barrier installed.

The windows were installed in an exterior subframe, with all connections between sheathing, subframe, and window frame being sealed with Siga tape.



Windows installed and air barrier system installed.

When the weather barrier was contemplated, Siga Majvest was selected. It was a good product to work with on site, as it wasn’t prone to tearing. In addition, it’s vapour permeability are higher than typical local products such as Tyvek, which make it a good choice for coastal BC climates.

Once installed, it’s joints and penetrations were also sealed to help improve the wall air barrier system.

Weather barrier membrane, installed and sealed.

Windows sealed to Siga weather barrier.

The underside of the roof trusses saw a layer of OSB, with all joints and penetrations sealed. The OSB runs continuously under the roof trusses and on top of th ewall plates, eneabling it to be sealed to the wall sheathing. To maintain air barrier continuity (and incorporate additional thermal barrier conuitiy as well), a dropped ceiling was installed to house all services and electrical equipment. This reduced the roof air barrier penetrations to one plumbing vent and two wire penetrations in each unit.

Roof assembly air barrier and dropped ceiling.

8.2 Final Blower Door Testing Results

The completed building achieved the following results:

	n50		
	East Unit (Front)	West Unit (Rear)	Average for Building
Combined Results	0.34	0.34	**0.34**
Pressurization	0.3256	0.2243	
Depressurization	0.3446	0.3415	

9 Ventilation

A Passive House certified ventilation unit was specified in each unit.

Ventilation unit:	Zehnder Comfoair 350
Whole system efficiency (PHPP):	77%
Electrical efficiency:	0.29 Wh/m3

Each unit uses Zehnder ComfoTube ducting, and a manifold. This system was easy to install, which was completed by the owner and the carpenters. It was favoured by the owners because it didn't require the contracting of a sheet metal installer for duct work, rather the ducts were fed through the building to each room as directed by the manufacturer's design team.

West unit HRV.

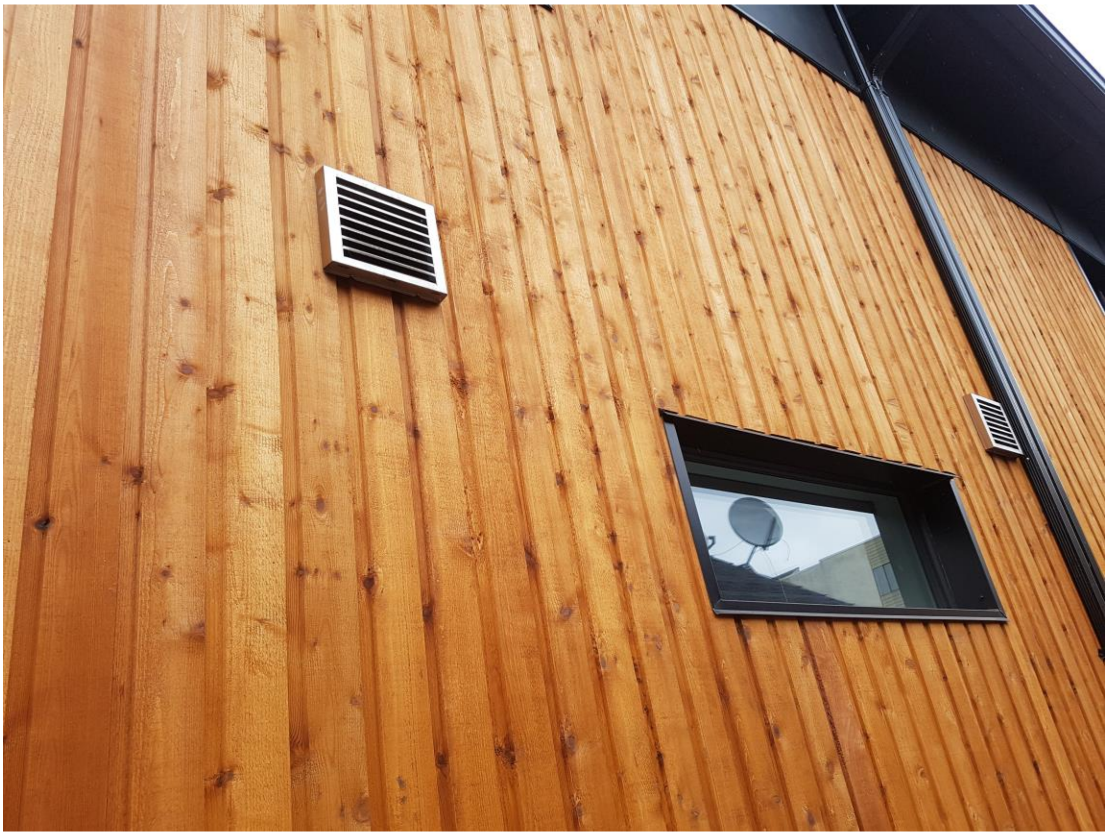
East unit HRV.

West unit upper bathroom ducting and room connection.

The ventilation control units are locted in the hallway between the entry foyer and the the kitchen.

Zehnder Comfo Controller.

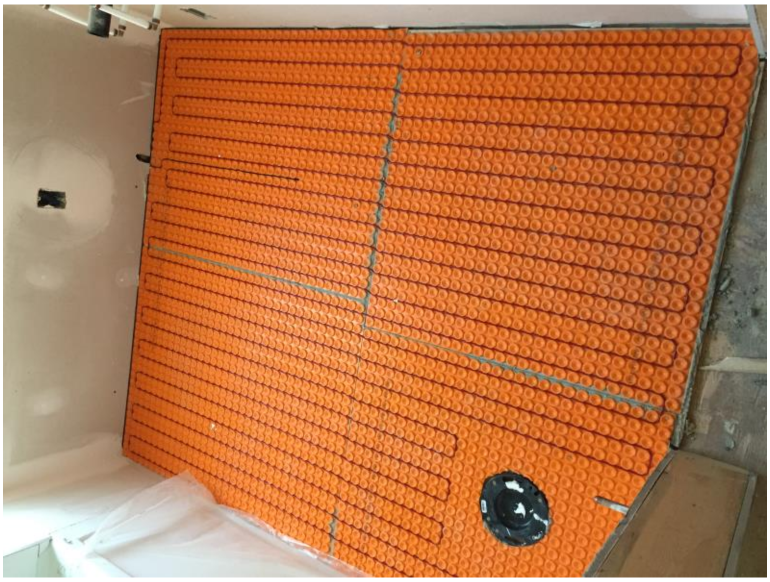
The service room was designed to be on the North side, so the HRV supply and exhaust ducts would have better summer time cooling effectiveness.



Supply and exhaust openings in building exterior wall. North side.

10 Heating

Due to the low heating load enabled by Passive House buildings, combined with the source of all local electricity being from hydro-electric dams, the owners selected electrical resistance for the active heating source. In addition, electricity was the chosen fuel source because the owners plan to install a photovoltaic array in the future, which will offset heating energy consumed.



Upper floor bathroom electrically heated floors. Typical to all upper floor bathrooms.

Smart control devices installed to individually control each heated bathroom floor.

West unit master bathroom tiled floor (heating cables beneath).

East unit living room wall mounted convection heater.

11 Domestic Hot Water

Domestic hot water is supplied to each unit by an electrically powered residential storage tank. Rheem Marathon tanks were selected for their reliability and lifetime warranty, as well as thier high level of tank insulation.

Electricity was chosen as a fuel source because the owners plan to install a photovoltaic array in the future.

To supplement the water heater, each tank is connected to a heat recapture system that is plumbed from the shower drains. A Dutch Solar Systems model 800 was chosen, as it was a product recognized by PHI. This was an easy addition to incorporate, as the building was being built new and the plumbing could be installed as desired.

These systems are also an easy way to make energy gains without any complex systems or components.

12 PHPP Verification Sheet

Passive House Verification

Building:	Blake | Cassidy Passive House
Street:	2740/42 Fifth Street
Postcode/City:	V8T 4B2 Victoria
Province/Country:	BC CA-Canada
Building type:	Duplex Residence
Climate data set:	CA0025a-Victoria
Climate zone:	4: Warm-temperate — Altitude of location: 15.25 m
Home owner / Client:	Aneesa Blake and Reed Cassidy
Street:	2740 Fifth Street
Postcode/City:	V8T 4B2 Victoria
Province/Country:	BC

Architecture:	Cascadia Architects Inc.	**Mechanical system:**	
Street:	1060 Meares Street	Street:	
Postcode/City:	Victoria V8V 3J6	Postcode/City:	
Province/Country:	BC CA-Canada	Province/Country:	
Energy consultancy:		**Certification:**	
Street:		Street:	
Postcode/City:		Postcode/City:	
Province/Country:		Province/Country:	

Year of construction:	2016	Interior temperature winter [°C]:	20.0	Interior temp. summer [°C]:	25.0
No. of dwelling units:	2	Internal heat gains (IHG) heating case [W/m²]:	2.5	IHG cooling case [W/m²]:	2.6
No. of occupants:	5.4	Specific capacity [Wh/K per m² TFA]:	60	Mechanical cooling:	

Specific building characteristics with reference to the treated floor area

					Criteria	Alternative criteria	Fullfilled?[2]
	Treated floor area	m²	243.7				
Space heating	Heating demand	kWh/(m²a)	15	≤	15	-	yes
	Heating load	W/m²	11	≤	-	10	
Space cooling	Cooling & dehum. demand	kWh/(m²a)	-	≤	-	-	-
	Cooling load	W/m²	-	≤	-	-	
	Frequency of overheating (> 25 °C)	%	0	≤	10		yes
	Frequency excessively high humidity (> 12 g/kg)	%	0	≤	20		yes
Airtightness	Pressurization test result n_{50}	1/h	0.3	≤	0.6		yes
Non-renewable Primary Energy (PE)	PE demand	kWh/(m²a)	130	≤	-		-
Primary Energy Renewable (PER)	PER demand	kWh/(m²a)	58	≤	60	60	yes
	Generation of renewable energy	kWh/(m²a)	0	≥	-	-	

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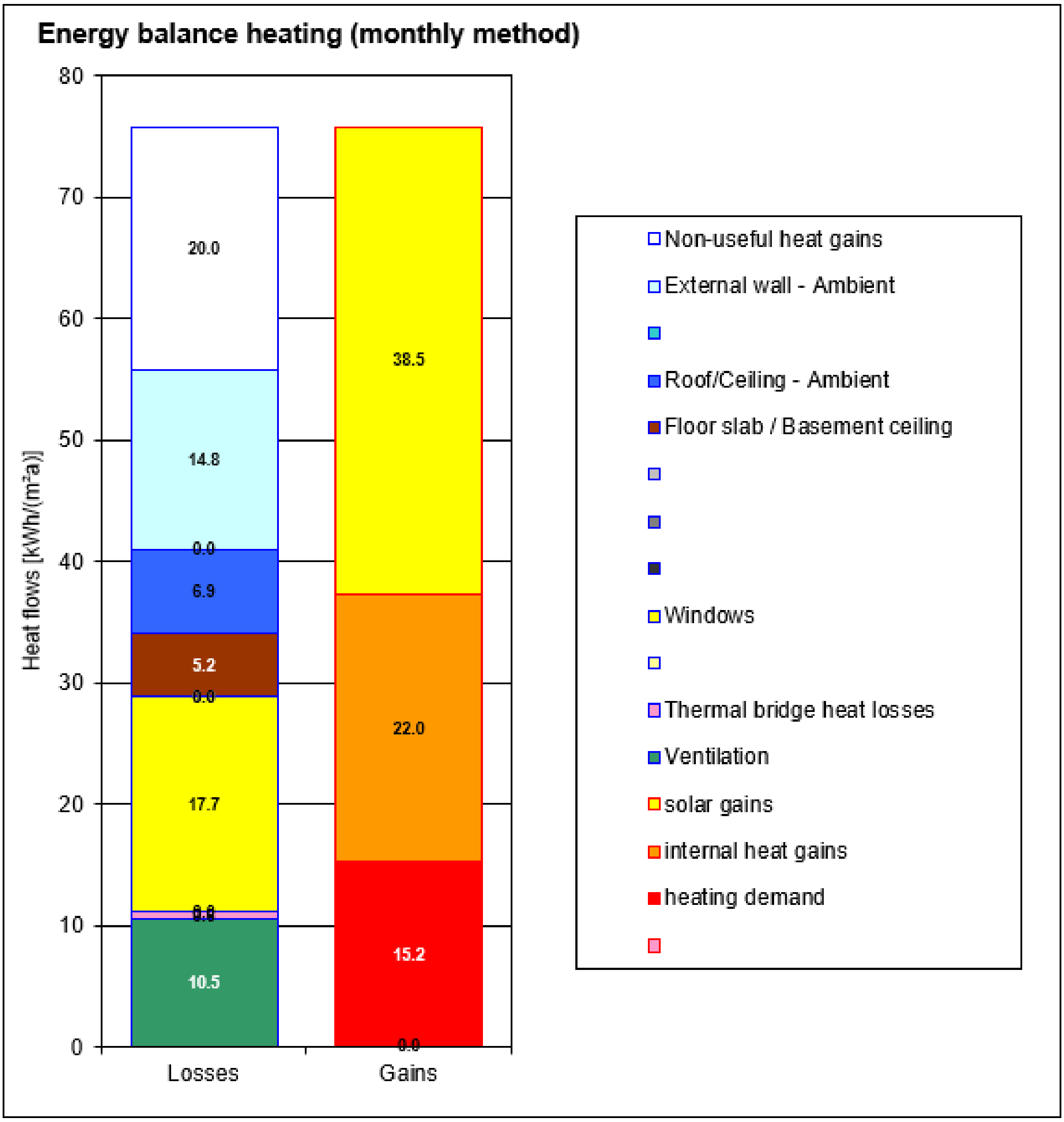
PHPP Verification Sheet



Heating energy balance calculated using PHPP

Window solar gains more than doubled energy losses, which eneabled the building to have more windows on the Northern face and improve natural lighting.

Thermal bridge losses were kept low, which is plausible for relatively less complicated new small residential buildings.

Ventilation losses were high, due to longer than desired interior supply & exhaust duct lengths.

13 User Experience and Actual Consumption

This building has been occupied by the owners (East side) and the same tenants (West side) for the first year of it's operation.

In this region, all of the electricity is provided by BC Hydro. BC Hydro creates electricity using hydro-electric dams. During the first year of operation, the following data was obtained for the total energy consumption (all electricity).

BILLING PERIOD	EAST UNIT ENERGY USED (kWh)	WEST UNIT ENERGY USED (kWh)
Mar 21, 2017 – May 24, 2017	1087	
Apr 1, 2017 – May 24, 2017		1114
May 25, 2017 – July 24, 2017	906	1277
July 25, 2017 – Sept 22, 2017	952	1052
Sept 23, 2017 – Nov 23, 2017	1051	1459
Nov 24, 2017 – Jan 23, 2018	1833	1730
Jan 24, 2018 – Mar 23, 2018	1549	
Jan 24, 2018 – Mar 31, 2018		1809
TOTAL ANNUAL ENERGY CONSUMPTION	**7378**	**8441**

Total energy used during first year: 64.86 kWh/m2*a (15,819 kWh/a)
PHPP Non-Renewable Primary Energy (PE): 129.9 kWh/m2*a (31,684 kWh/a)
PHPP Primary Energy Renewable (PER): 58.4 kWh/m2*a (14,244 kWh/a)

For comparison, the 1970's era single-family dwelling with secondary suite to the North of this home was using approximately 3 x as much electricity during the mid-winter months. This sample home heated exclusively with baseboard heaters.

The West unit experiences higher interior temperatures in the summer months than the East unit, as the heat from setting sun radiates through the windows. The interior temprature rarely breaks 25 Celsuis, thanks to the HRV operation in bypass mode and the summer nighttime ventilation as shown in the PHPP. The owners are contemplating installing exterior blinds on the upper floor West windows to improve interior comfort.

Upon move-in, during the first few days of living in a Passive House building, the owners became immediately aware of the interior comfort. Exterior noise is minimal. Interior air is always fresh. Odors don't linger for very long. Interior surfaces during the winter time are notably warm, compared to a typical home. The owners prefer their home to staying in hotels, as their Passive House home is far more comfortable.

14 Cost Considerations

For reference, here is some building criteria:

- 244 sqm (approx. 3050 sqft) floor area, 2 storey, unheated crawlspace, wood-framed construction
- Permeable concrete driveway & patios
- 24 total fenestration units, 2 water heaters, 2 HRV systems
- 2 dwelling units; entire building contains 6 bedrooms, 4 bathrooms, 2 powder rooms, 2 kitchens, 2 living & dining rooms, 2 laundry areas, 2 service rooms

The total construction costs were as follows:

	Cost	Cost Per SqFt (w/ tax)	Cost Per SqFt (w/out tax)
Hard Costs	$716,831	$239	$228
Soft Costs	$207,787	$69	$66
Grand Total*	$924,618	$308	$293

* Excluding property cost, interest fees and property tax

To get an idea of costs required to achieve Passive House certifiation, we analyzed the wall assembly. This seemed like a good analysis, because wall assemblies are commonly compared in this region. It was assumed that a regular building will receive:

- Gypsum wall board
- Lumber framing
- Batt insulation
- Plywood sheathing
- Tyvek weather barrier
- Rainscreen strapping
- Cladding

Assuming the aforementioned traditional wall assembly, we've calculated the added cost of:

- Upgrading from Tyvek to Majvest
- Taping plywood joints and penetrations with Siga tape
- Taping Majvest joints and penetrations with Siga tape
- Installing ACS clips
- Installing Roxul CavityRock
- Installing external framing to support cladding

Given these cost analysis parameters:

- The added cost for the Passive House exterior wall system was $10.50 / sqft.
- The added cost to the overall construction cost for the project was $39,000, or 4.2% of the grand total.

It was estimated that the total added cost to build to Passive House standards was approximately 18% above Building Code minimum.