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Net-zero Energy Building Speakers Series

Wildsight Kimberley/Cranbrook

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What is Net-zero Energy Building?

Wikipedia:

A zero-energy building, also known as a zero net energy (ZNE) building, net-zero energy building (NZEB), or net zero building, is a building with zero net energy consumption, meaning the total amount of energy used by the building on an annual basis is roughly equal to the amount of renewable energy created on the site, or in other definitions by renewable energy sources elsewhere.

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In 2014, US Department of Energy (DOE) contracted with National Institute of Building Sciences to establish definitions, associated nomenclature and measurement guidelines for zero energy buildings with the goal of achieving widespread adoption and use by the industry

NET

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- “Net” is necessary to be accurate in accounting for energy usage.
- “Net” is necessary to safeguard potential legal implications.
- DOE Zero Energy ready Home program received feedback and concluded the term “net” was confusing to consumers.

The project team considers the following and adopt Zero Energy

- “Net” does not add substantive meaning to the name, since the definition fully describes how to account for delivered and exported energy.
- Simplicity, consistency and to accentuate the core objective
- Recognized Net Zero Energy (NZE) and Zero Net Energy (ZNE) are in wide use and convey the same meaning as Zero Energy

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On 16 September 2015, US DOE publish the document called “A Common Definition for Zero Energy Buildings:

an energy-efficient building where, on a source energy basis, the actual annual delivered energy is less than or equal to the on-site renewable exported energy.”

http://energy.gov/sites/prod/files/2015/09/f26/bto_common_definition_zero_energy_buildings_093015.pdf

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Net Zero Energy READY

Necessary to have a two-tiers system:

- Allow the industry smoother and easier transition from existing energy efficient practice to Net Zero
- More market adaptable, at least at present moment and near future.
- Provide the opportunity for future upgrade to NZE when the price of PV drop (OR electrical rate inflate)

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Definition of NZEr

Need a clear and rigorous definition – how ready is ready?

CHBA Net Zero Energy Labelling program:

NZEr is same as NZE but just without the renewable system installed at the moment

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Net Zero Energy Ready

Designed, modelled, and constructed to the same standards and performance of a NZE Building

—

PV

Install PV

Net Zero Energy

An energy efficient building with on-site renewable exported energy

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Environment

Economical benefits

Durable

Why?

Safer

Healthier

It is the direct way to achieve carbon neutral buildings

NZE is the future

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Global Long-term Benefits

- Lower environmental impact
- Lower operating and maintenance costs
- Better resiliency to power outage and natural disasters
- Improved energy security

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Benefits to Home Owners

- Durable: building science, quality control, longer life, safer
- Healthier: better indoor air quality, more comfortable
- Efficient: energy savings, environment

Canadian Home Builders' Association

2015 CHBA Home Buyer Preference Study

Top 10 "Must Have" Home Features

1. Walk-in closets
2. *Energy efficient appliances*
3. *Overall energy efficient home*
4. *High-efficiency windows*
5. Kitchen islands
6. Linen closets
7. Open concept kitchens
8. Large windows
9. 2-car garage
10. Walk-in pantry

Buy the full survey results online at chba.ca/buyersurvey

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When?

NOW

For all new buildings

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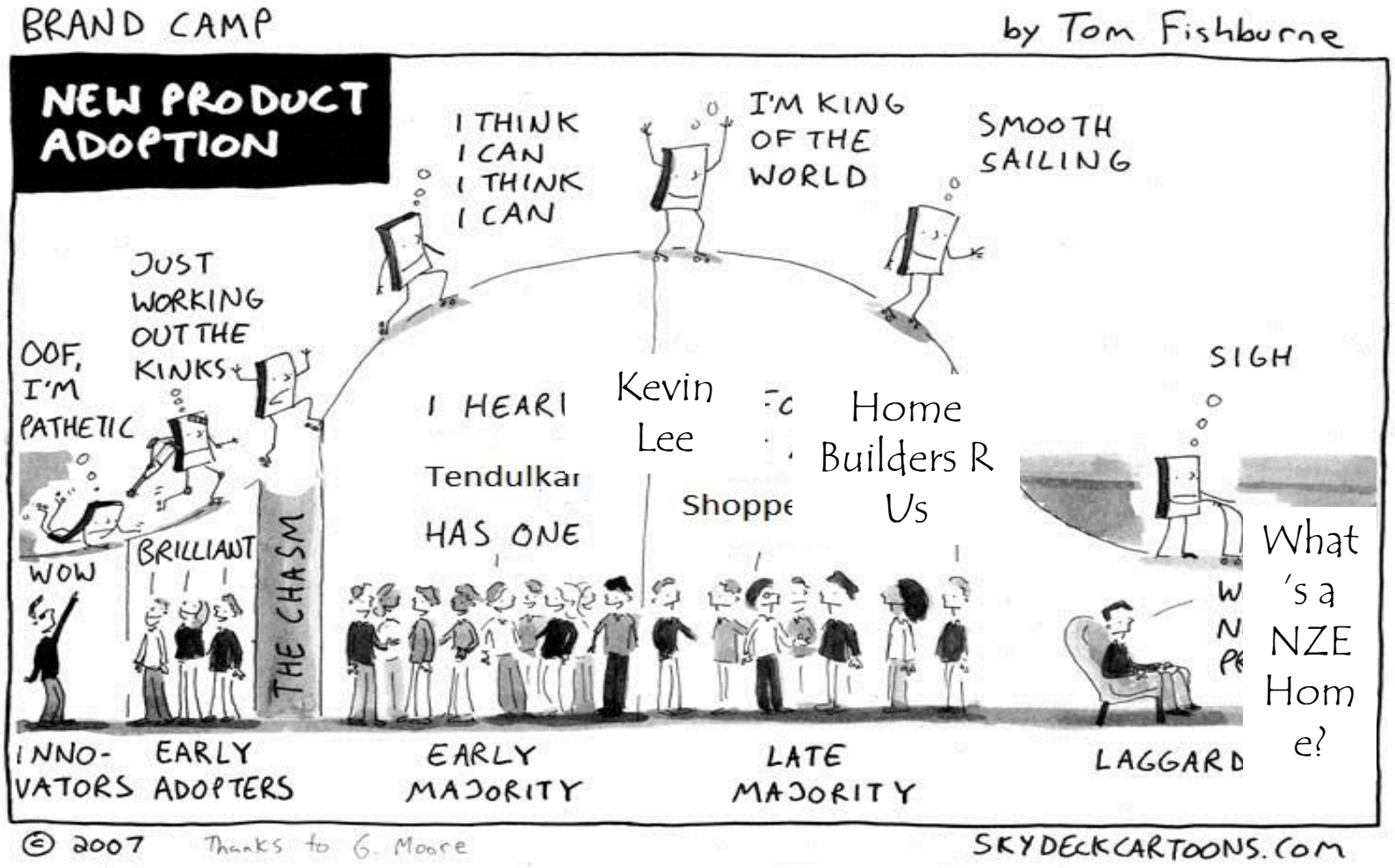
Net Zero Energy Housing is economically market feasible

Minimal or no increase in operation cost of NZEr house

- Additional mortgage payment for the energy upgrade can be fully or mainly offset by the saving in energy bills

We have a strong business case!

NZE Housing is in early adopters stage and facing the Chasm



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How?

Reduce energy demand

Conserve energy:

Building envelope, mechanical system, occupation loads

+

Produce renewable energy

Solar Panels

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Building Envelope is Important!

- Lower initial cost
- Higher return in cost-benefit
- Improve the overall quality of the building
- Upgrade the indoor living environment

MUST HAVE MININIUM REQUIREMENTS

Case Study - Zen House

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A tailored-designed and custom-built 2 ½ storeys single family home - finished floor area 3942 sq. ft. plus 740 sq. ft. heated crawl space

Building Envelope and Systems

Foundation:

3” TYPE 2 EPS RIGID INSULATION BOARD

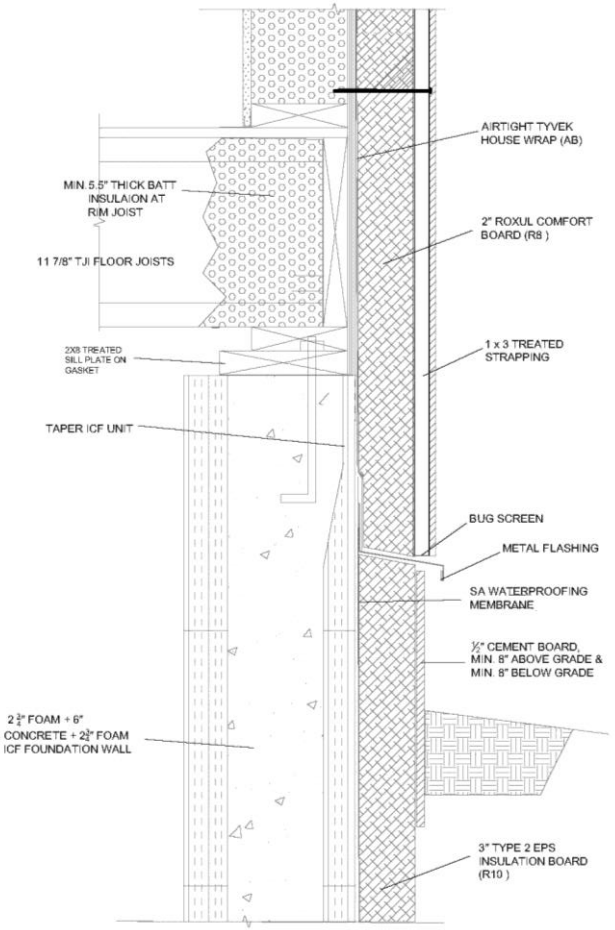
SA WATERPROOFING MEMBRANE (AB)

6” CONCRETE IN INSULATED CONCRETE FORM, ICF

½” DRYWALL

LOW-PERMEANCE LOW-VOC WATER-BASED PAINT, <30 ng/(Pa.s.m^2) (VB)

EFFECTIVE R-VALUE = 30.5



TYPICAL ABOVE GRADE FOUNDATION WALL SECTION

Base Slab

FLOOR FINISHING

4” THICK CONCRETE SLAB

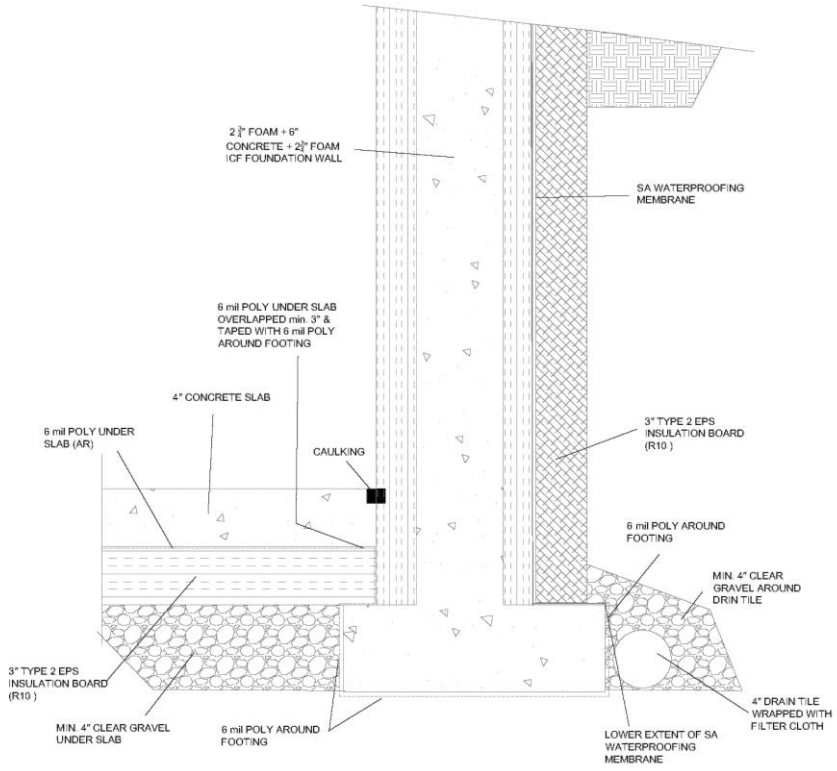
SEALED 6 mil POLY (AB & VB)

3” TYPE 2 EPS RIGID INSULATION BOARD

MIN. 4” GRAVEL

COMPACTED SOIL BASE

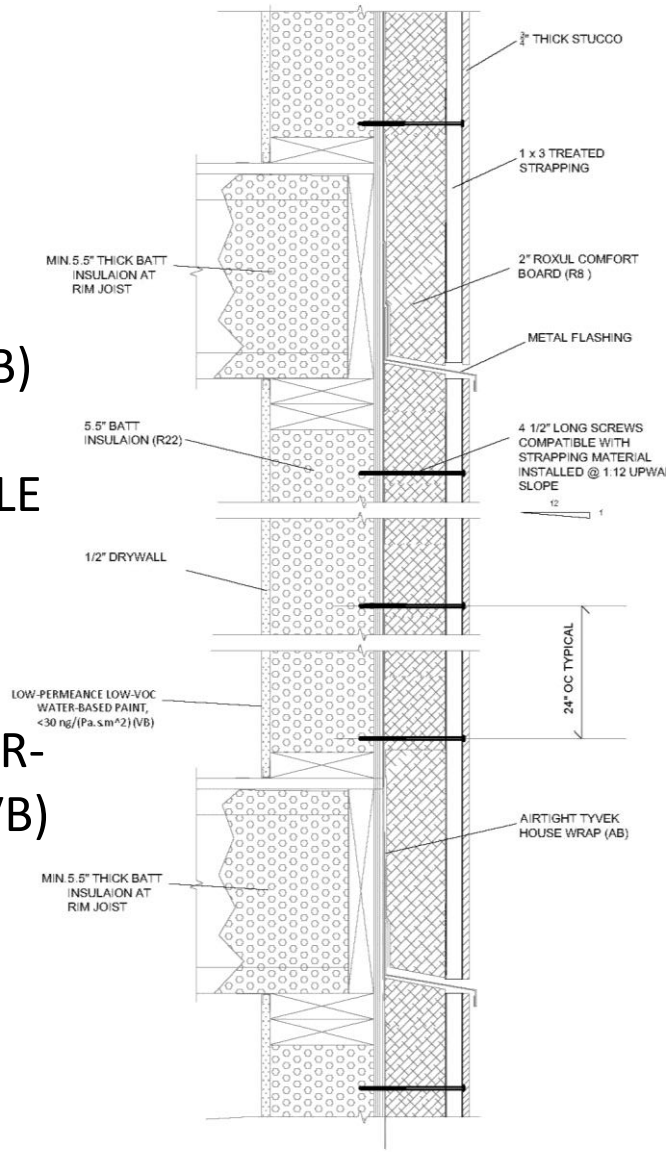
EFFECTIVE R-VALUE = 12.0



TYPICAL FOUNDATION WALL SECTION

Wall assembly:

- ¾”ISTUCCO
- ¾”AIR SPACE
- 1X3 TREATED STRAPPING
- 2” R8 ROXUL COMFORT BOARD
- AIR-TIGHT TYVEK HOUSE WRAP (AB)
- ½”PLYWOOD WALL SHEATHING
- 2X6 STUDS @24” O.C. WITH DOUBLE TOP PLATE AND 2 STUDS CORNER
- 5.5” R22 BATT INSULATION
- ½”5DRYWALL
- LOW-PERMEANCE LOW-VOC WATER-BASED PAINT, <30 ng/(Pa.s.m^2) (VB)
- EFFECTIVE R-VALUE = 25.7



TYPICAL WALL SECTION
(VERTICAL VIEW)

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Ceiling/Roof:

ROOF WITH FLAT CEILING

- ASPHALT SHINGLE ROOFING TILES
- ROOFING MEMBRANE
- ½”OROOF SHEATHING
- ENGINEERING TRUSSES @ 24” O.C.
- 14” BLOWN CELLOUSE INSULATION R42
- SEALED & GASKETED 5/8” FIRE RATED AIR-TIGHT DRYWALL (AB)
- LOW-PERMEANCE LOW-VOC WATER-BASED PAINT, <30 ng/(Pa.s.m^2) (VB)
- EFFECTIVE R-VALUE = 51

ROOF WITH VAULTED CEILING

- ASPHALT SHINGLE ROOFING TILES
- ROOFING MEMBRANE
- ½”OROOF SHEATHING
- 2X4 STRAPPING @ 16” O.C.
- 11 7/8” TJI JOISTS
- 12” R40 BATT INSULATION
- SEALED & GASKETED 5/8” FIRE RATED AIR-TIGHT DRYWALL (AB)
- LOW-PERMEANCE LOW-VOC WATER-BASED PAINT, <30 ng/(Pa.s.m^2) (VB)
- EFFECTIVE R-VALUE = 37

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Windows and Doors

FIXED, AWNING, CASEMENT WINDOWS OR FRENCH DOORS

VINYL FRAME

TRIPLE GLAZING

LOW-E COATING

ARGON GAS INFILL

INSULATED SPACER

Heating and cooling

- High efficiency cold climate air source heat pump (Mitsubishi Zuba-Central, heating HSPF 9.4, cooling EER 12.0 SEER 15.00)
- Forced air system
- Two zones control (one for basement and the other for main and upper floors) to better control the room temperatures at different thermal conditions.

Air Filter

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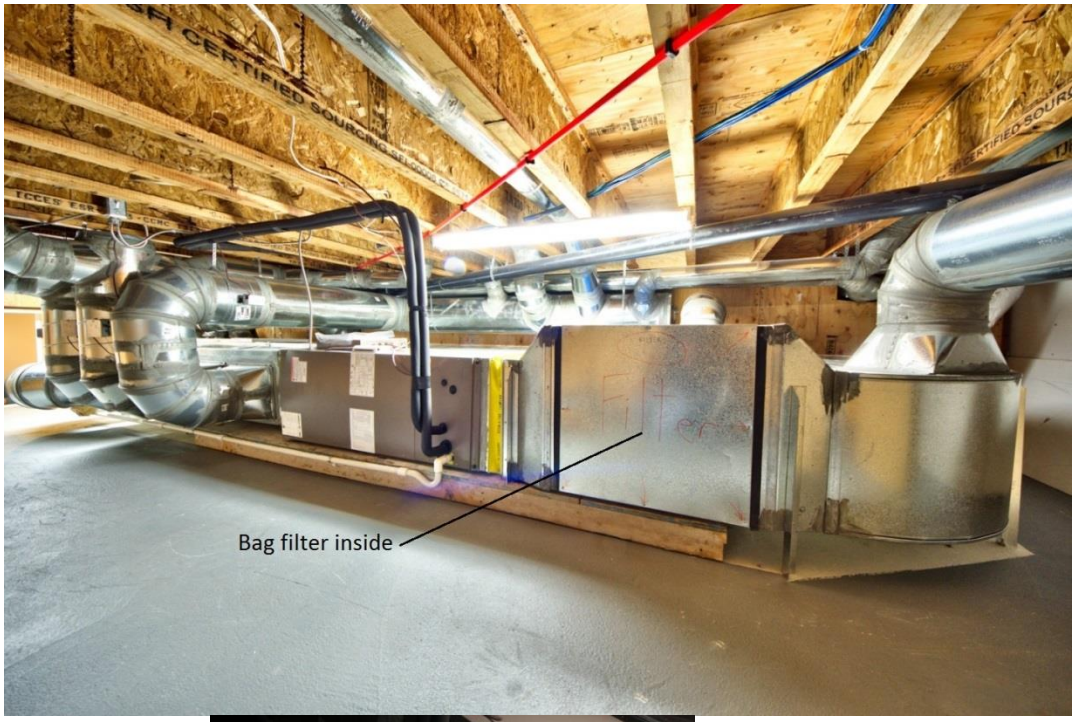
A MERV 13 bag filter is installed in the HVAC duct system - see the metal box holding the bag filter at the return side of air handler.

Air handler fan will run continuously to circulate air inside the house while passing air through the filter to achieve the best air quality.



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Hot Water

High efficiency gas water boiler with indirect tank (IBC VFC 45–225, 95% AFUE)

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Ventilation

- Eneready 2000 HRV
- Whisper Power grills with PoshTime zone switches at all bathrooms
- HRV supply integrated with the heating supply ducts.
- HRV exhaust in dedicated HRV exhaust ducts
- All HRV ducts were tested on site before drywall to ensure air-tightness.

Lighting

- 70% of lighting fixtures in LED light
- 20% of lighting fixtures in CFL
- Motion-sensor control for exterior lights

Appliances and other electrical equipment

All new home electric appliances, including fridge, dishwasher, range, hood fan, washer and dryer in are Energy Star rating.

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Cost-Benefit Study of Energy Conservation Measures (ECM)

2 broader approaches

Provide higher insulation and better air-tightness of the building to reduce heat loss, reducing the energy required to keep the building in a livable condition

Increase the efficiency of mechanical systems, lighting and home appliances, so they use less energy to perform their functions.

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These two broader approaches can be carried out through 9 Energy Conservation Measures (ECM)

1. Increase insulation of the foundation wall
2. Increase insulation of base slab
3. Increase insulation to above grade exterior wall
4. Increase insulation of roof
5. Upgrade windows and doors
6. Improve air-tightness of the house
7. Upgrade the efficiency of heating and cooling system
8. Upgrade the efficiency of domestic hot water system
9. Use higher efficient lighting and home appliances

ECM #1

Location: Foundation wall

Baseline construction: 8” concrete wall plus 2x4 R12 furring wall inside

Upgrade: Use ICF wall and add 3” EPS insulation on outside face of wall

Annual energy saving: 2626.87 kWh
(based on HOT2000 energy model result)

Additional cost: $4,494.31
(based on contractor’s construction cost records)

ECM #2

Location: Foundation base slab

Baseline construction: 2’ wide 3” EPS insulation under slab along foundation walls

Upgrade: 3” EPS insulation under whole base slab

Annual energy saving: 471.12 kWh

Additional cost: $1,240.00

Note: many municipalities have required insulation under whole base slab if radiant floor heating is installed. In this case, this is not an ECM

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ECM #3

Location: Exterior wall above grade

Baseline construction: 2x6 R22 wall

Upgrade: Add 2” mineral wool semi-rigid insulation board on outside of exterior walls.

Annual energy saving: 4004.65 kWh

Additional cost: $13,070.77

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ECM #4

Location: Roof

Baseline construction: R40 for both sflat and sloping ceiling roofs

Upgrade: No upgrade is adopted in Zen House due to high cost

Annual energy saving: 0 kWh

Additional cost: $0

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ECM #5

Location: All windows

Baseline construction: Double glazing, clear glass, air infill, vinyl frame

Upgrade: triple glazing, low-e coating, argon gas infill, insulated spacer, vinyl frame

Annual energy saving: 2164.88 kWh

Additional cost: $2,500.00

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ECM #6

Location: Building envelope

Baseline construction: normal air-tight construction, ACH = 4.55 ACH @ 50 Pa

Upgrade: high performance air-tight construction, ACH = 0.9 ACH @ 50Pa (actual air test result of ZEN House)

Annual energy saving: 6950.49 kWh

Additional cost: $3,539.44

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ECM #7

Location: Heating System

Baseline equipment: high efficient (90%) condensing gas furnace

Upgrade: cold climate air source heat pump, heating HSPF 9.4, cooling, EER 12.0, SEER 15.00

Annual energy saving: 20047.49 kWh

Additional cost: $5,400.00

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ECM #8

Location: Domestic hot water system

Baseline equipment: medium efficient gas hot water tank

Upgrade: condensing high efficient (90%) hot water boiler

Annual energy saving: 2183.10 kWh

Additional cost: $2,471.00

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ECM #9

Location: Lighting and appliances

Baseline equipment: normal lighting and appliances

Upgrade: 70% LED lighting, 20% CFL lighting, energy star appliances and water saving plumbing fixtures

Annual energy saving: 3626.24 kWh

Additional cost: $1,000.00

ECM Cost-benefit Analysis - Initial Cost

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ECM	Additional cost	Annual energy saved (kWh)	cost to save 1 kWh
ICF plus 3” EPS to foundation wall	$4,494.31	2626.87	$1.71
3" EPS under base slab	$1,240.00	471.12	$2.63
2" exterior Roxul to exterior wall	$13,070.77	4004.65	$3.26
Roof insulation from R40 to R50	NA	NA	NA
Windows - Triple glazing	$2,500.00	2164.88	$1.15
Air-tightness - to R2000 standard	$3,539.44	6950.49	$0.51
Cold weather air source heat pump	$5,400.00	20047.49	$0.27
High efficient hot water tank	$2,471.00	2183.10	$1.13
Energy efficient lighting & appliances	$1,000.00	3626.24	$0.28

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ECM has different service life

Future electricity rate forecast based on BC Hydro 2011 IRP Technical Advisory Committee, Integrated Resource Plan, Long-Term Rate Forecast

2010 BC Hydro Residential Rate, Tier 1: $0.067

Assumed inflation 2.1%

Use Equivalent-Annual-Annuity Approach

ECM Cost-benefit Analysis – Service Life

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ECM	Service life	IRR	Equivalent-Annual-Annuity (cents)
ICF plus 3” EPS to foundation wall	50	5%	5.35
3" EPS under base slab	50	3%	2.42
2" exterior Roxul to exterior wall	50	2%	0.41
Roof insulation from R40 to R50	50	NA	NA
Windows - Triple glazing	30	6%	3.29
Air-tightness - to R2000 standard	40	15%	7.66
Cold weather air source heat pump	25	27%	6.56
High efficient hot water tank	25	5%	2.18
Energy efficient lighting & appliances	10	23%	4.01

Annual Green House Gas Emission (tonne): 6.686 *(11.688)*

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ECM	Service life	GHG Reduction in Service Life	Additional cost	Add. Cost to save 1 tonne GHG
ICF plus 3” EPS to foundation wall	50	24.60	$4,494.31	$182.70
3" EPS under base slab	50	4.45	$1,240.00	$278.65
2" exterior Roxul to exterior wall	50	37.50	$13,070.77	$348.55
Roof insulation from R40 to R50	50	NA	NA	NA
Windows - Triple glazing	30	12.18	$2,500.00	$205.25
Air-tightness - to R2000 standard	40	40.28	$3,539.44	$87.87
Cold weather air source heat pump	25	23.68	$5,400.00	$228.09
High efficient hot water tank	25	9.78	$2,471.00	$252.79
Energy efficient lighting & appliances	10	15.98	$1,000.00	$62.58

Energy Performance of Zen House

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Site Energy in Heating Mode Only

Estimated Annual Space Heating Energy Consumption (kWh): 3043.05
(27969.07)

Ventilator Electrical Consumption: Heating Hours (kWh): 1322.78
(512.04)

Estimated Annual DHW Heating Energy Consumption (kWh): 3327.21
(7800.57)

ESTIMATED ANNUAL SPACE + DHW ENERGY CONSUMPTION (kWh):
7693.04 *(36281.68)* LESS 79%

Eneguide Rating: **88**

Note: Figures in bracket are Baseline House results

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Annual Estimated Energy Consumption by Devices

Site Energy in Heating Mode Only

kWh	Heating	A/C	HRV + fan	DHW	Appliance	Total
Baseline	27489.09	0.00	1005.52	7800.64	8759.86	45055.12
Zen House	2933.63	0.00	1920.19	3327.22	6838.20	15019.25
Zen House to baseline percentage	11%	0%	191%	43%	78%	33%

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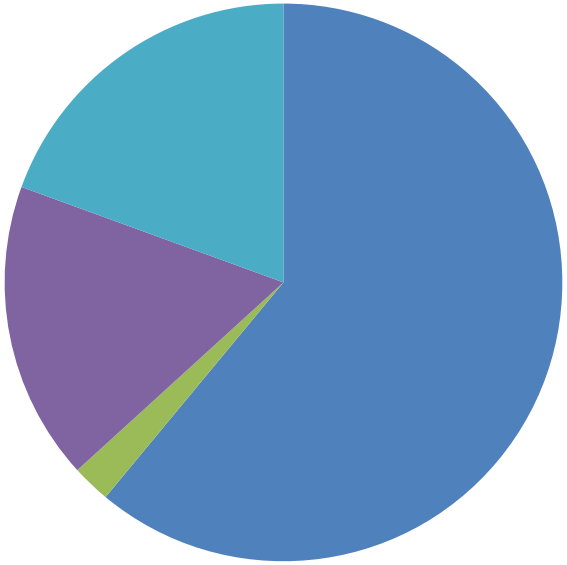
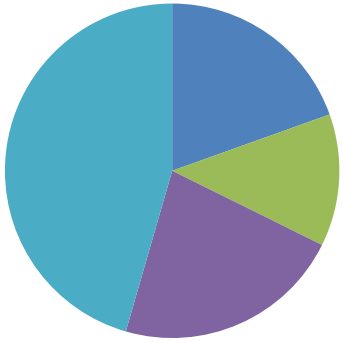
Baseline



- Heating
- A/C
- HRV + fan
- DHW
- Appliance

Zen House



Occupant Behaviour - Biggest Load!

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Estimated Annual Fuel Consumption Costs

Site Energy in Heating Mode Only

	Electricity	Gas	Total	Saving	Saving in Percentage
Baseline	$796.83	$1,240.49	$2,037.32		
Zen House	$935.16	$265.82	$1,200.98	$836.34	41%

Occupation Loads

Include:

- Lighting
- Major appliances
- Plug loads (miscellaneous equipment)

Design Parameters of Occupation Loads

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Recent R2000 Net Zero Energy Housing Pilot Program allows further reduction:

Lighting Load to 1kWh/day (if over 80% of the lighting fixtures are LED or CF),
Appliance Load to the actual energy consumption certified under Energy Star Program.
No reduction of the Others Load and the Exterior Load is allowed

Reduced to

Possible reduced to
16.7 kWh/Day, i.e. 6096 kWh/year

Buildup the Miscellaneous Equipment Loads

Proposed LBC single family home at Vancouver
3388 W42nd Avenue Vancouver
Appliance Load Calculation
04-Jan-16

Miscellaneous Equipments Consumption

Room / Space	Appliance	Est. Wattage	Usage Increment	Usage Period	Active Usage (hr/y)	Active Consumption	Standby Wattage	Standby Usage (hr/y)	Standby Consumptio	Total Consumption	
	Elevator										
Basement											
Mechanical Room	Central Vacuum	1400	1	hr/week	52.0	72.8	0	8708.0	0.0	72.8	
Laundry	Iron	1100	55	mins/week	48.0	52.8	0	8712.0	0.0	52.8	
	Washing Machine 1										
	Dryer 1										
	Washing Machine 2										
	Dryer 2										
Gym	Excerise Machine 1	100	5	hr/week	260.0	26.0		8500.0	0.0	26.0	
	Excerise Machine 2	100	5	hr/week	260.0	26.0		8500.0	0.0	26.0	
	TV	150	1	hrs/day	730.0	109.5	6.4	8030.0	51.4	160.9	
Spa	Portable Spa Machine	1000	5	hr/week	260.0	260.0		8500.0	0.0	260.0	
	TV	150	1	hrs/day	730.0	109.5	6.4	8030.0	51.4	160.9	
	Steam Generator	9000	2	hr/month	24.0	216.0		8736.0	0.0	216.0	
	Sauna Heater	9000	2	hr/month	24.0	216.0		8736.0	0.0	216.0	
Bathroom	Towel Warmer	150	1.5	hr/day	547.5	82.1		8212.5	0.0	82.1	Sierra
Main Floor											
Main Kitchen	Induction Cooktop 1										
	Range Hood	259	60	mins/day	365.0	94.5	2.8	8395.0	23.5	118.0	Venma
	Fridge										
	Wine Steller						0.0	8760.0	0.0	0.0	
	Dishwasher										
	Oven 1										
	Steamer	500	3	hr/week	156.0	78.0		8604.0	0.0	78.0	
	Garburator										
	Rice Cooker	200	13	hr/week	676.0	135.2	0	8084.0	0.0	135.2	
	Food Processor	350	2	hr/week	104.0	36.4	0	8656.0	0.0	36.4	Cuisina
	TV	150	2	hrs/day	730.0	109.5	6.4	8030.0	51.4	160.9	
	Microwave	1000	13	mins/day	79.0	79.0	2.8	8681.0	24.3	103.3	
	Toaster	1100	6	mins/day	37.0	40.7	0	8723.0	0.0	40.7	
	Instant Hot Water	0	0	mins/day	0.0	0.0	18	8760.0	157.7	157.7	
Kitchen	Induction Cooktop 2										
	Range Hood	259	1	hr/week	52.0	13.5	2.8	8708.0	24.4	37.9	Venma
	Oven 2										
	Garburator										
Powder Room	Towel Warmer	150	1.5	hr/day	547.5	82.1		8212.5	0.0	82.1	
Entry Hallway	Doorbel	0	0		0.0	0.0	5	8760.0	43.8	43.8	
Parents Ensuite	Towel Warmer	150	1.5	hr/day	547.5	82.1		8212.5	0.0	82.1	
Meeting Room	*Computer CPU*	68	5	hr/day	1825.0	124.1	1.2	6935.0	8.3	132.4	
	Monitor	84	5	hr/day	1825.0	153.3	2	6935.0	13.9	167.2	
	Laser Printer	250	1	hr/week	52.0	13.0	4.2	8708.0	36.6	49.6	
	Telephone	4.5	24	hr/day	8760.0	39.4	2.2	0.0	0.0	39.4	
	Router/DSL/Cable/Modem	6	5	hr/day	1825.0	11.0	2	6935.0	13.9	24.8	
	Laptop Charger	0	0		0.0	0.0	4.5	8760.0	39.4	39.4	
	Mobile Phone Charger	5	3	hr/day	1095.0	5.5	0.1	7665.0	0.8	6.2	
	TV	150	1	hrs/day	365.0	54.8	6.4	8395.0	53.7	108.5	
Tea Counter	Small Dishwasher	1400	3	hrs/week	156.0	218.4	0	8604.0	0.0	218.4	
	Kettle	2000	45	mins/day	273.8	547.5	0	8486.3	0.0	547.5	
Garage	Garage Door	400	8	min/day	48.7	19.5	2.8	8711.3	24.4	43.9	
	Electric Car Station										

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An Important and Useful Equipment

Energy information display

- Occupiers aware of their energy consumption
- A useful tool to change occupiers' energy consuming behaviour
- Allow the designer/builder to review/evaluate the design assumption of the building
- Allow the developer to monitor the actual energy performance.

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Renewable Energy System

Among other building elements, it maybe the biggest challenge for achieving NZE:

- Higher initial cost
- Lower Cost-Benefit return
- Required big area
- Restricted orientation
- Visual impact on building appearance

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Design consideration of Photovoltaic

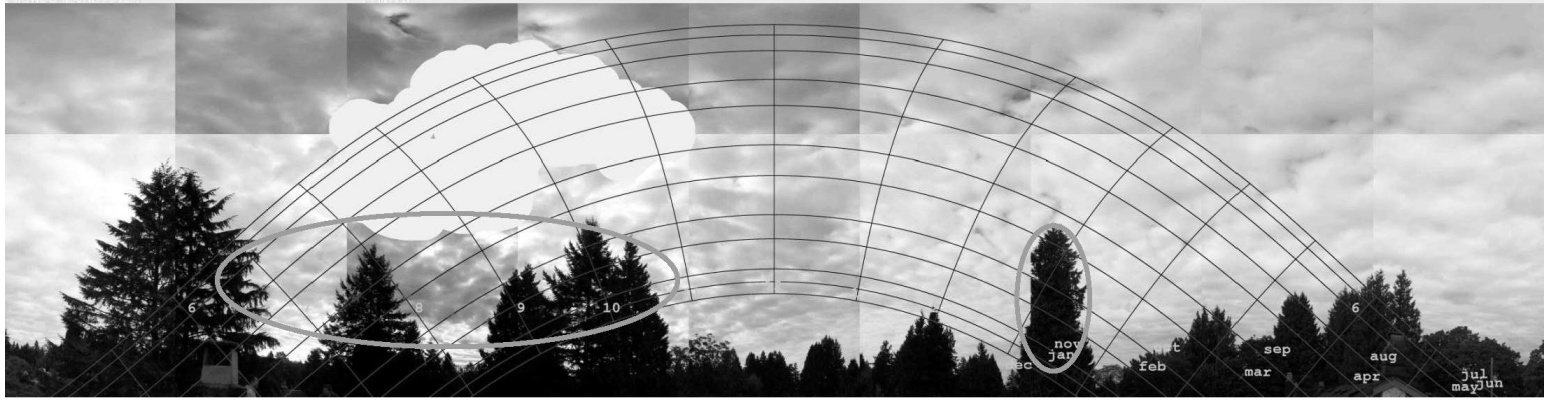
Shading

- By surrounding environment, e.g. trees
- By other part of the building, e.g. dormer

Site 2 – West Upper Roof

Location	Latitude	Longitude	Elevation	Declination
VANCOUVER, BC, CAN	49.2 °	-123.2 °	3 m	17.6 °

Month	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Ave.
Light Shaded %	25.8	24.3	10.9	3.5	3.9	5.4	4.2	3.1	6.3	17.0	28.0	30.3	13.5
Sunlight/Day (Hours)	1.39	2.65	3.45	5.2	5.58	5.42	6.21	5.71	5.06	2.69	1.65	1.29	3.86
Available Sunlight (Hours)	1.03	2.01	3.08	5.02	5.36	5.13	5.95	5.53	4.74	2.24	1.18	0.9	3.52
Shading Factor	0.91												



Shading factor = 0.9. Approximately 10% of annual harvest would be lost to shading due mostly to aforementioned trees impacting morning and late afternoon solar harvests Oct through Mar. Trees to the SE have slightly less impact than at site 1 as they clear the winter horizon by 10:30 AM.

Presently the site scores at the low end of “Very Good”, however tree growth will increase shading impact with time.

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PV efficiency

- The efficiency of PV module keep on improving in recent years.
- Presently,

  commercial standard products: 15%

  commercial high efficient products: 20%
- IEA's roadmap (2014) recommends increase module efficiencies to 24% (sc-Si), 19% (mc-Si) by 2017

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Cost of PV module

- Cost of PV module keep on dropping in last decade
- US NREL estimates PV cost drop to $2.5 per 1 Wp installed in 10 years time but will then be stable – because of constant labour, design and approval costs

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Some examples of NZE and NZEr houses in Lower Mainland

Harmony House – one of the 12 national EQuilibrium projects

Past 3 years BC Hydro bills indicate its performance very close to net zero.

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Vancouver Net Zero Energy Ready House

EnerGuide rating: 88

Total energy consumption reduction: 75%

Zen House

Insightful

A high performance house with EnerGuide rating of 88 - save about 75% of total energy

Design Energy performance

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		Harmony House	Vancouver NZEr Home	Zen House	Proposed NZE Townhome
Finished floor area	m^2	438	224	336	121
Heating + a/c	kWh/yr	3242	1150	3304	1098
Total energy consumption	kWh/yr	14987	15117	17734	7747
Heating + a/c per floor area	kWh/m^2.yr	7.40	5.14	9.02	9.09
Total energy per floor area	kWh/m^2.yr	34.22	67.49	47.38	64.17

Actual Energy Consumption of Harmony House (NZE)

based on BC Hydro bills

Design annual energy consumption: 14987 kWh

	# days	Incoming meter	Outgoing meter	Net	Annual electricity charge
Dec 6, 2011 to Nov 19, 2012	345	10896	11109	-213	-$14.35
Nov 20, 2012 to Dec 3, 2013	375	12459	11243	1216	$45.54
Dec 4, 2013 to Jan 20, 2015	409	14326	11165	3161	$129.76

Actual Energy Consumption of NZEr homes (based on BC Hydro & Fortis BC bills

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		Vancouver NZEr Home	Zen House
Design annual energy consumption	kWh	15117	17734
1st year electricity	kWh	10620	7542
1st year natural gas	GJ	*5.04*	31.7
1st year energy consumption	kWh	12020	16347
2nd year electricity	kWh	9315	-
2nd year natural gas	GJ	*5.04*	-
2nd year energy consumption	kWh	10715	-

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Q & A