Retrofitting to Net Zero:

Part 2: Getting it Right

Let's Talk Green Economy Workshop Series

January – March, 2020

What is EnviroCentre?

EnviroCentre:
Ottawa Environmental Non-profit

Our mission is to provide people, communities, and organizations in Ottawa with practical solutions to lighten their environmental impact in lasting ways.

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Our work focuses on four main areas

Green Homes

Active Transportation

Green Lifestyles

Green Business

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Energy Services

- Home and MURB Energy Audits
- Business Energy Analysis and Audits
- Business carbon accounting (through Carbon 613)
- Green Audits

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Carbon 613:
EnviroCentre's program for businesses

- Membership based program for Ottawa businesses
- Access to events, resources, discounts
- Comprehensive tools for Carbon analysis and target setting
- Local network of businesses committed to climate action

Carbon 613 by envirocentre

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Who I am

- Greg Furlong, Senior Energy Analyst
- Energy Advisor – NRCan, CHBA Net Zero, ENERGY STAR etc.
- Certified Energy Manager (AEE)
- More than 700 private homes since 2003
- Over 100 MURBs assessed plus a dozen commercial audits
- Co-founder of a successful retail business in Toronto

Our goals today

- Net Zero Details
- Incentives and Deeper Retrofits
- Worked-out Examples

Net Zero Review

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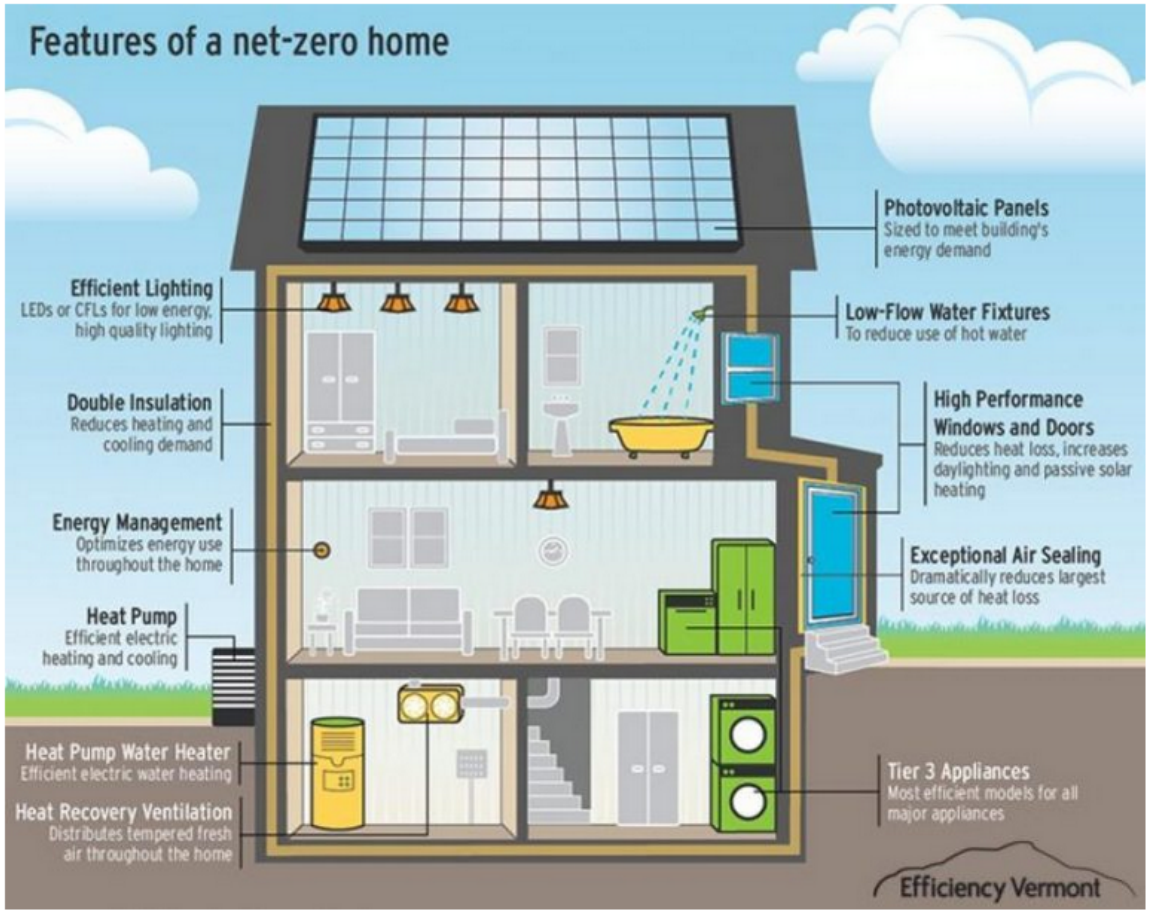
Yearly household energy = Yearly energy generated onsite

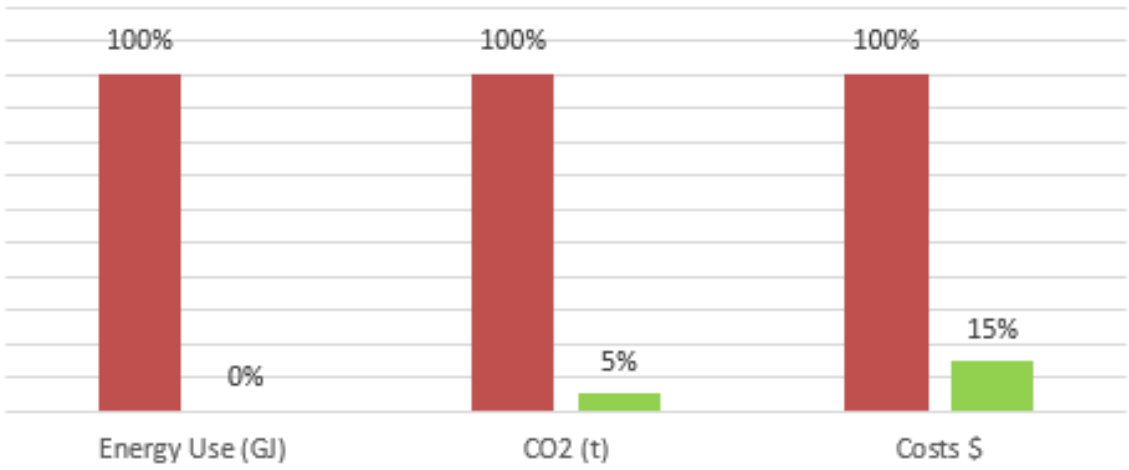


Process vetted by CHBA

Each **Net Zero** and **Net Zero Ready** Home is verified by government-licensed third-party **Service Organizations** and recognized by **CHBA** for its achievement.

Net Zero Results:

- Outstanding comfort
- Very low operating costs
- Tiny carbon footprint



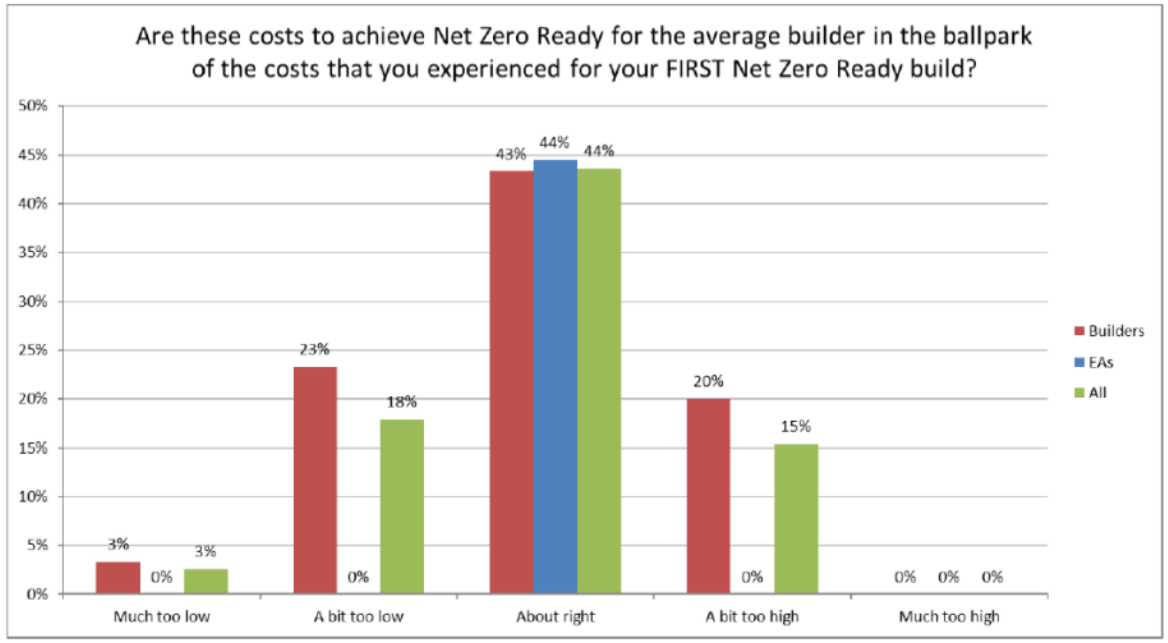
Net Zero Considerations

Part 9 OBC

Houses and MURBs must satisfy the following:

- not greater than 3 storeys
- not greater than 600 m^2 (6458 sq. ft.) footprint
- on permanent foundations, or permanently moored float homes
- where a house consists of a mix of residential and non-residential,
    - Total non-residential floor area is less than residential and no more than 300 m^2
    - Risk category of the non-residential occupancies is acceptable

COSTING



CHBA NET ZERO HOME LABELLING PROGRAM
Summary Report 2020

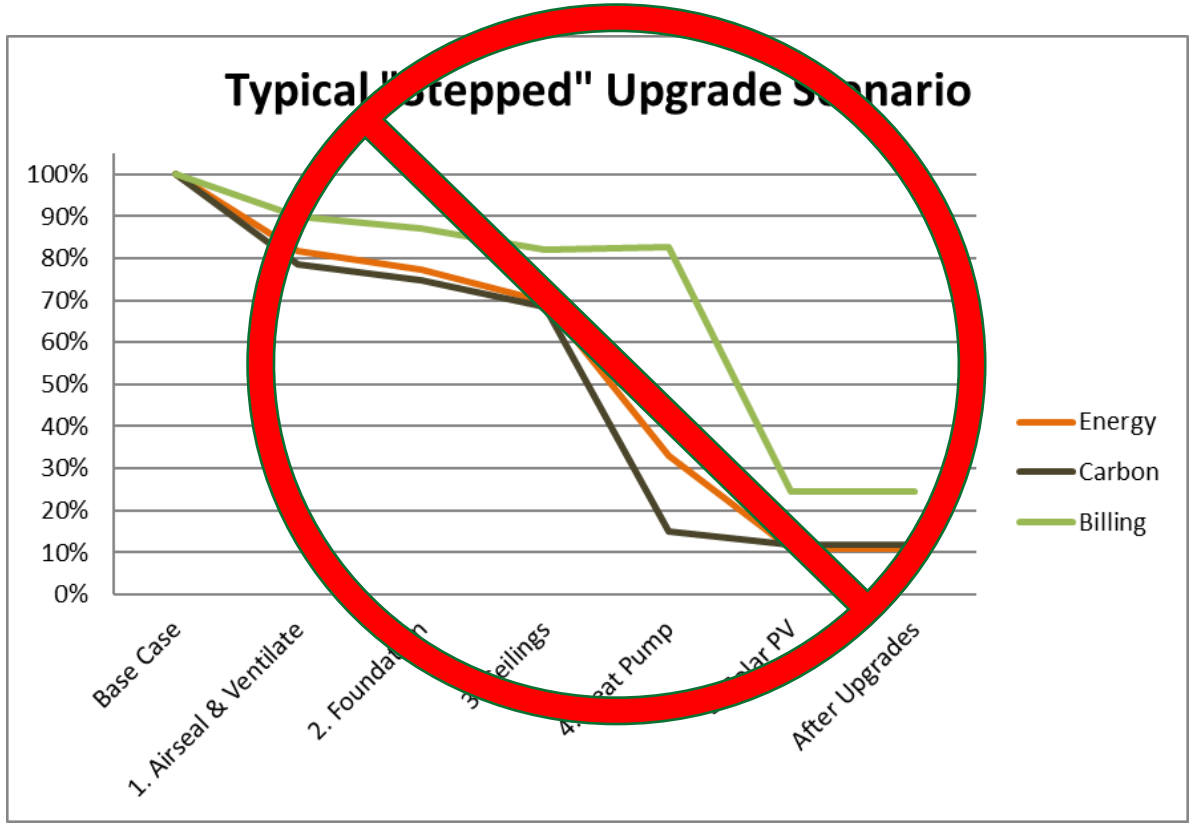
Added Costs for Improved Construction?

CHBA study of the first 47 homes found that for Net Zero Ready:

- +$15.30 / sq.ft. on average
- Only about 9% added costs
- Operating costs reduced by 35%

Cost neutrality when considering lifetime operating costs

- 65% reduction in energy consumption
- Closing the gas account saves fixed costs ($285/yr)
- Safer home: lower insurance costs
- Lower operating costs mean lower risk for mortgage lenders

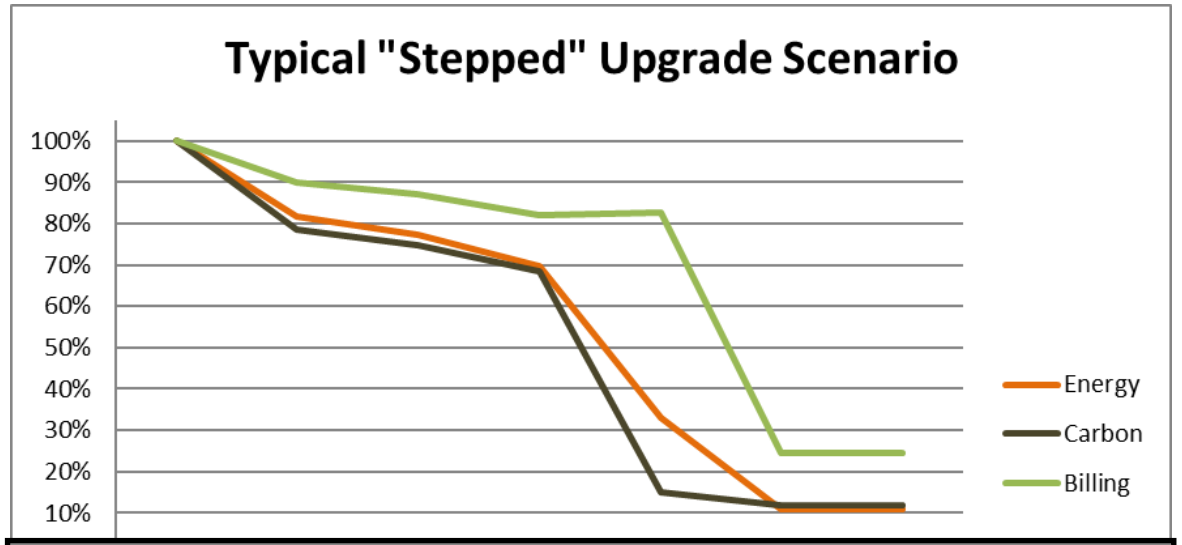


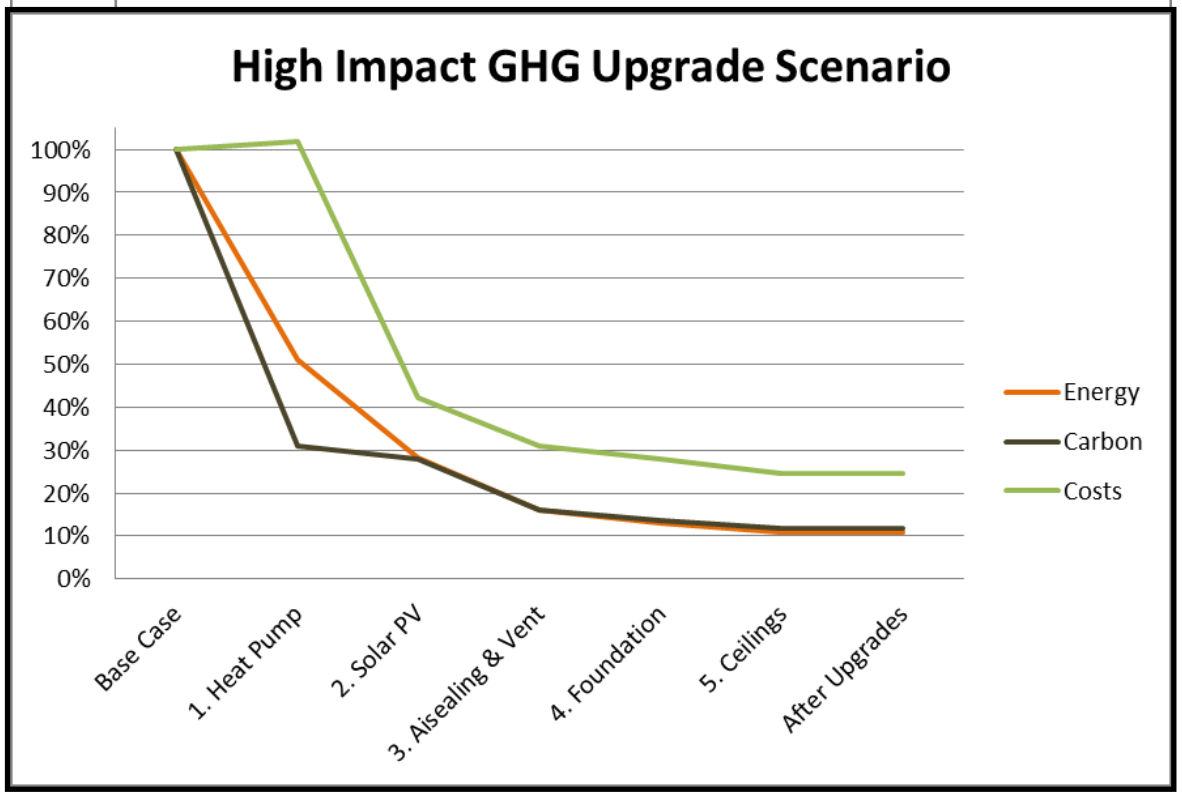
Managing the Project: Stepped Retrofits for Net Zero

Stepped plans start with the most cost-effective upgrades and use savings to pay for other upgrades. Building envelope first!

However, compared to other plans, this results in

1. Smaller Energy savings
2. Smaller Carbon reductions
3. Smaller $ savings





Effective Strategies for Net Zero

Cut to the chase: Start with upgrades that have immediate significant impact on energy use, like ASHP and Solar PV.

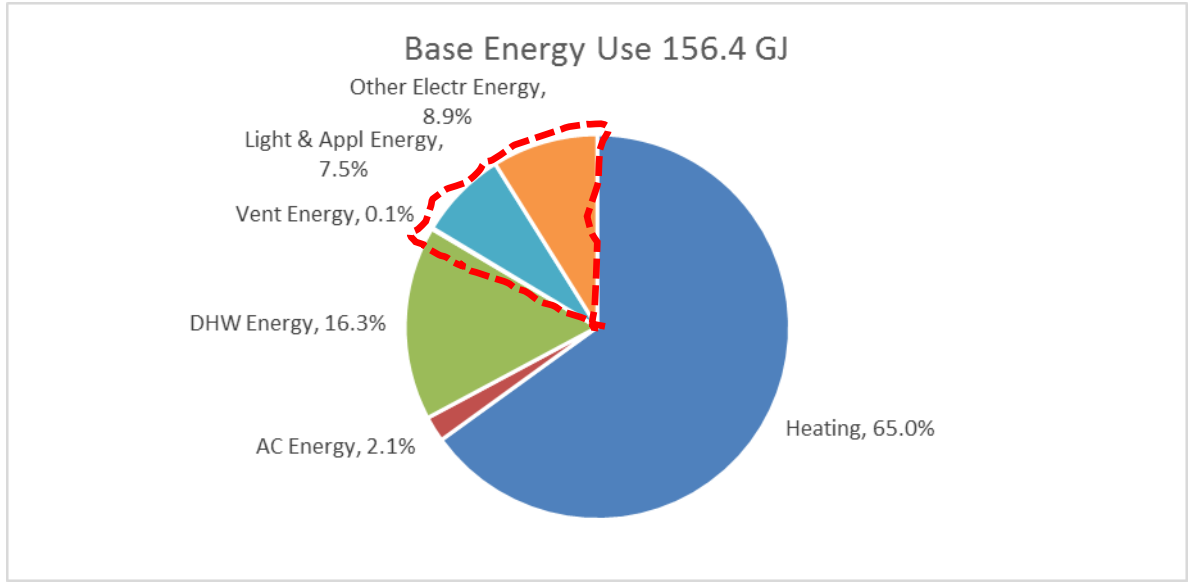
Compared with the stepped plan, this example had

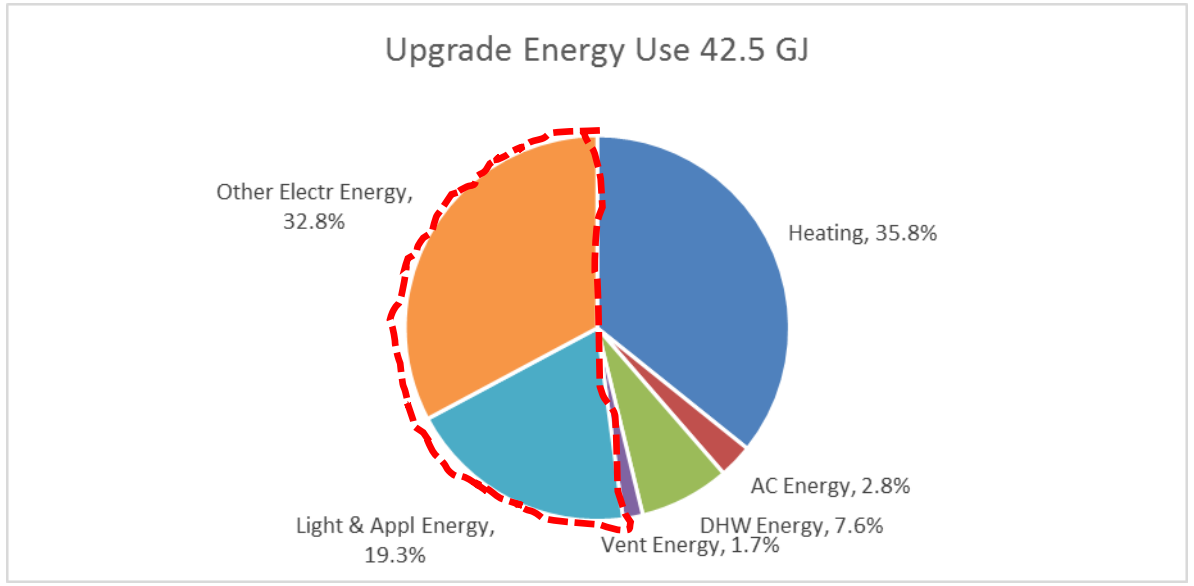
- **56% less energy use - 740 GJ**
- **60% less carbon production – 33 tonnes**
- **38% lower utility costs - $9,700 extra cash**

Total cost of upgrades **was the same** in both cases!

Base Loads

- Energy used within the house
- Older housing: 20% of total
- Net Zero: more than 50%
- Limits further energy reductions
- Requires more solar PV
- Affects summertime AC loads
- HOT2000 allows slight reduction when approaching Net Zero





CHBA Net Zero Renovations Program – Coming Soon

- CHBA currently has a Net Zero Home labelling program for **new homes**
  - Well over 250 homes labelled to date
  - Renos also eligible if they meet the same requirements

- Now working on a Net Zero program for **renovations to existing homes**
  - Renovations program will mirror the existing program

- Note that "Net Zero" is in reference to "**Net Zero Energy**"
  - the home can produce as much energy as it consumes annually

CHBA Net Zero Renovations Program

Timeline:

- **Year 1: Reno Program Development** *June 2019 - March 2020*
  - Finalize Reno Label technical & admin requirements

- **Year 2: Pilot Program** *April 2020 - March 2021*
  - Launch the 1-year pilot for CHBA Renovator Members (10-20 projects)
    - **Spots for participants still available!**
  - CHBA Renovator Manual

- **Year 3: Launch Version 1** *April 2021 - March 2022*
  - Modify Program based on Pilot results
  - Launch Version 1 of the CHBA Net Zero Renovations Label

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CHBA Net Zero Renovations Program

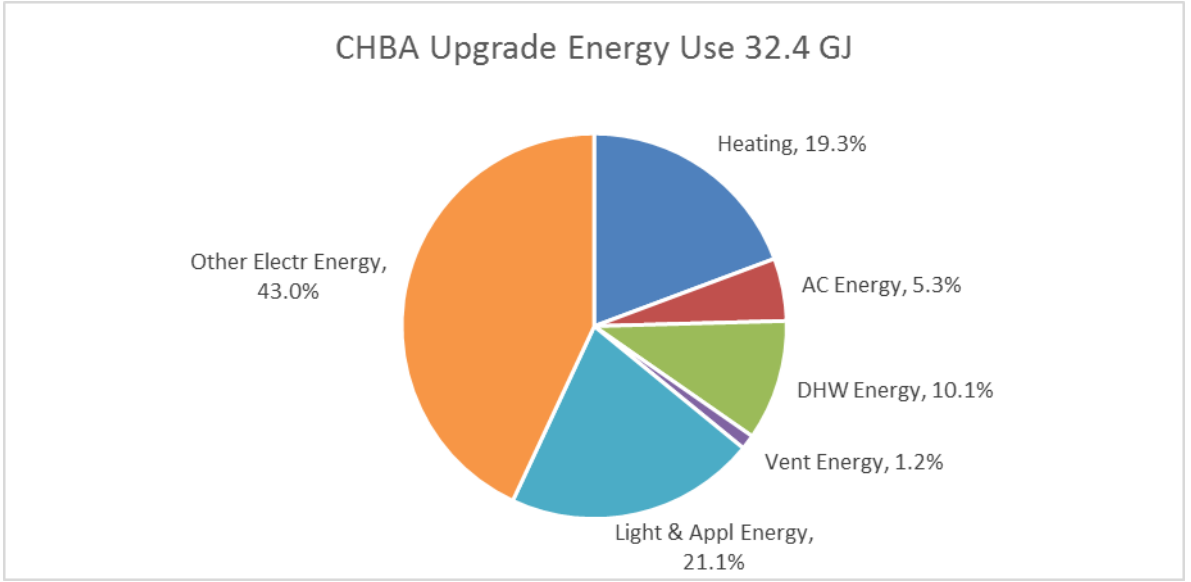
For more information please contact:

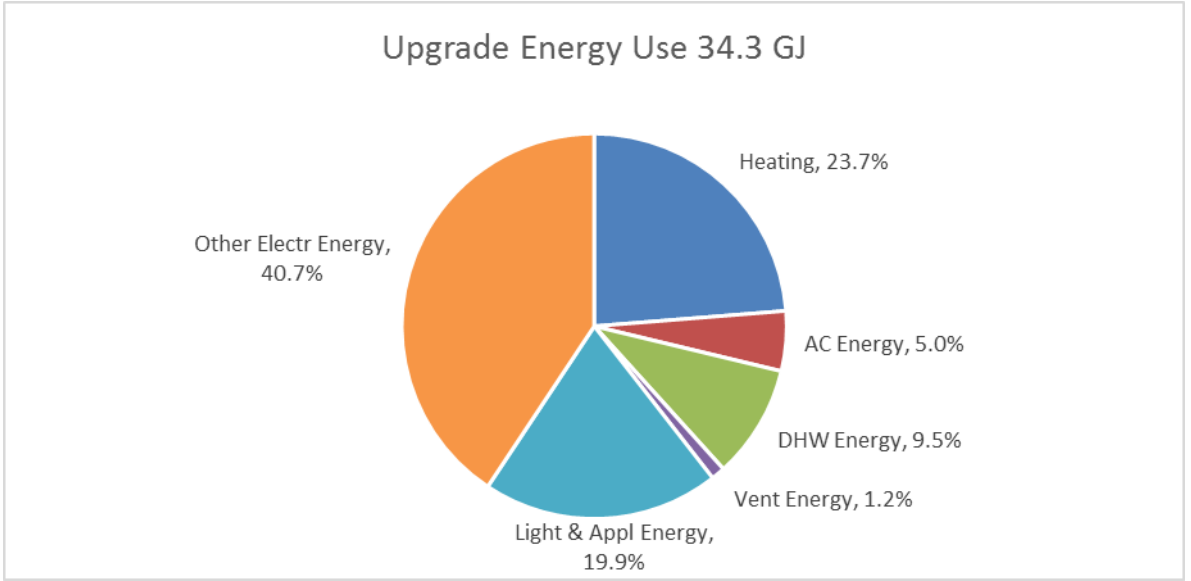
Marie Hanchet
Project Manager,
Net Zero Energy Housing
613.230.3060 x263
marie.hanchet@chba.ca

netzero home
The ultimate in comfort and efficiency

Other Net Zero Retrofits

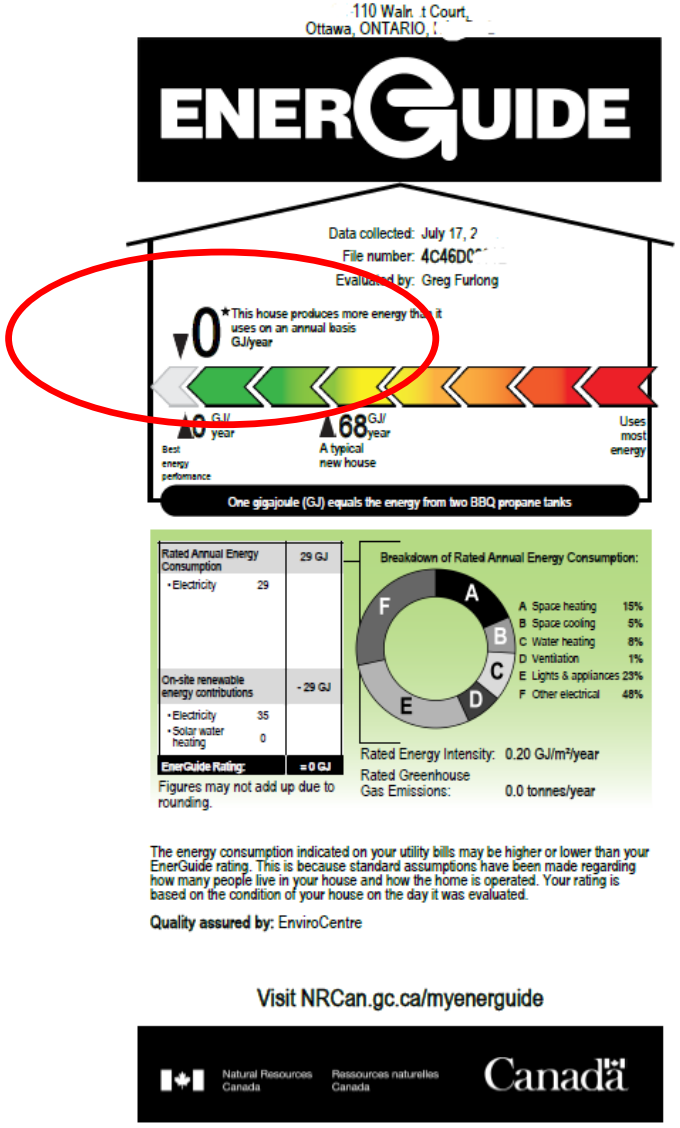
- When retrofit standards won't qualify for CHBA Label – see 80s house upgrade example here
- This unlabeled version does not include upgrades to:
  - External walls
  - Basement slab R5





Other Net Zero Retrofits

- Could still achieve net zero performance, as verified by the NRCan EnerGuide Rating, but:
  - Higher energy use
  - More solar panels necessary
  - Bigger carbon footprint
  - No Net Zero Ready rating
  - No Net Zero label



110 Waln t Court,
Ottawa, ONTARIO,

ENERGUIDE

Data collected: July 17, 2
File number: 4C46D0
Evaluated by: Greg Furlong

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

0 GJ/year Best energy performance

68 GJ/year A typical new house

Uses most energy

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

Rated Annual Energy Consumption		29 GJ
• Electricity	29	
On-site renewable energy contributions		- 29 GJ
• Electricity	35	
• 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	15%
B	Space cooling	5%
C	Water heating	8%
D	Ventilation	1%
E	Lights & appliances	23%
F	Other electrical	48%

Rated Energy Intensity: 0.20 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: EnviroCentre

Visit NRCan.gc.ca/myenerguide

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Available Incentives

Single-Family Housing Retrofits

Limited programs in Ontario, but the following are still active:

- **CMHC Green Home**: up to 25% rebate on mortgage insurance premium
  - https://www.cmhc-schl.gc.ca/en/finance-and-investing/mortgage-loan-insurance/the-resource/energy-efficient-housing-made-more-affordable-with-mortgage-loan-insurance

- **Genworth Energy- Efficient Housing Program**: same as CMHC Green Home
  - http://genworth.ca/en/products/energy-efficient-housing.aspx

- **Enbridge: Home Efficiency Rebate** for residential properties (gas users only, non-MURB)
  - https://enbridgesmartsavings.com/

- **Federal Tax Provision for Clean Energy Equipment:**
  - Classes 43.1 and 43.2 of Schedule II
  - Fully expense your solar energy system and heat recovery equipment
  - CCA rate of 100%

	15% Premium Refund	25% Premium Refund
If pre-retrofit rating is 200 GJ/year or higher***	Decrease by 45 GJ/year	Decrease by 90 GJ/year
If Pre-Retrofit rating is lower than 200 GJ/year	Decrease by 20 GJ/year	Decrease by 45 GJ/year

Multi-Unit Residential Building Retrofits

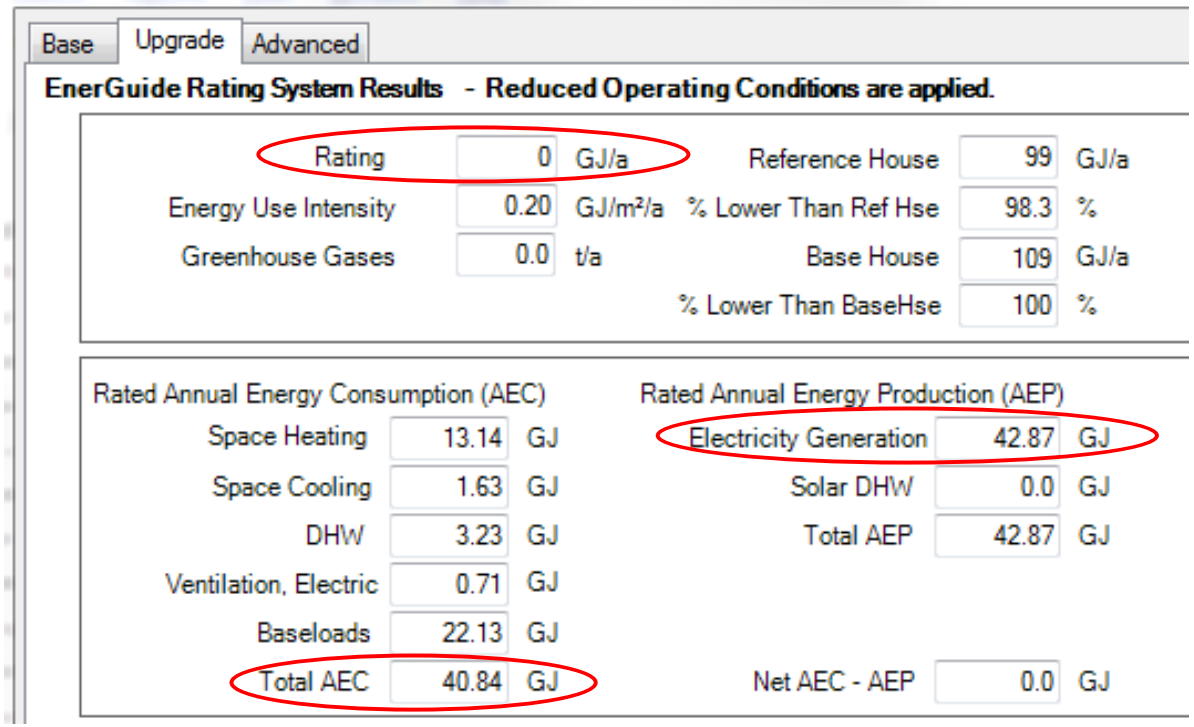
MURBs are eligible for commercial incentives:

- **IESO: SaveONEnergy Retrofit Program**
  - Substantial incentives for electrical savings
  - https://saveonenergy.ca/For-Your-Small-Business
- **Enbridge: Smart Savings** is similar, but for savings that affect gas use
  - For continuing gas users only - beware of Lock-in
  - https://enbridgesmartsavings.com/
- **Federal Tax Provision for Clean Energy Equipment (previous slide)**


Retrofit to
Success

Key elements of a Net Zero retrofit:

- Start the process with an open mind
- Always be considering the energy balance
- Exterior changes may be necessary
- When designing, follow the specifications in the **CHBA Net Zero Home Labelling Program Technical Requirements**
- Consult with the Energy Advisor on anything that affects HVAC or the exterior
- Figure out the heating system last, based on the minimal requirements outlined by the EA
- Choose contractors with training in building science
- Test air leakage before it's too late to fix



Base | Upgrade | Advanced

EnerGuide Rating System Results - Reduced Operating Conditions are applied.

Rating	0	GJ/a	Reference House	99	GJ/a
Energy Use Intensity	0.20	GJ/m²/a	% Lower Than Ref Hse	98.3	%
Greenhouse Gases	0.0	t/a	Base House	109	GJ/a
			% Lower Than BaseHse	100	%

Rated Annual Energy Consumption (AEC)			Rated Annual Energy Production (AEP)		
Space Heating	13.14	GJ	Electricity Generation	42.87	GJ
Space Cooling	1.63	GJ	Solar DHW	0.0	GJ
DHW	3.23	GJ	Total AEP	42.87	GJ
Ventilation, Electric	0.71	GJ			
Baseloads	22.13	GJ			
Total AEC	40.84	GJ	Net AEC - AEP	0.0	GJ

Start the process with an open mind

The best upgrades are not always obvious

- Ventilation and comfort need to be carefully considered
- Energy modeling
  - Takes in the effects of each energy use
  - Gauges the energy balance
  - Is your best guide to upgrade impacts
- Decide on the type of heating system that best fits the energy picture

Consider the energy balance

For Net Zero, all energy use needs to be offset by recovery or generation:

- HVAC (which depends on building envelope)
- Appliances
- Entertainment and other household use
- Lighting

vs:

- What heating or cooling energy can be recaptured and reused?
- How much electricity can you generate on your property?

Consider making exterior changes

Might be the most effective way to upgrade:

- Walls
- Foundation

Consult with the Energy Advisor!

Especially on anything that affects HVAC or the exterior

Figure out the heating system last

Based on the minimum requirements outlined by the Energy Advisor

- Sizing and distribution are important
- Choose appropriate technology for the situation
- Beware manufacturer/installer claims of comfort and efficiency
- In some situations, efficiency gains don't outweigh added costs

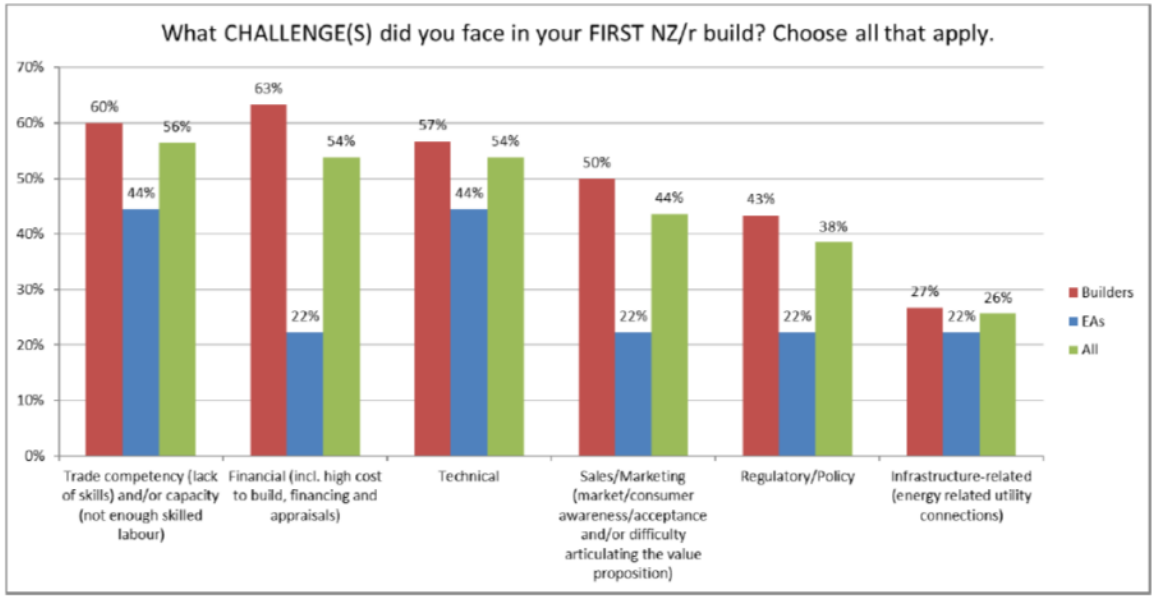
Hire contractors with training in building science

Trained contractors will:

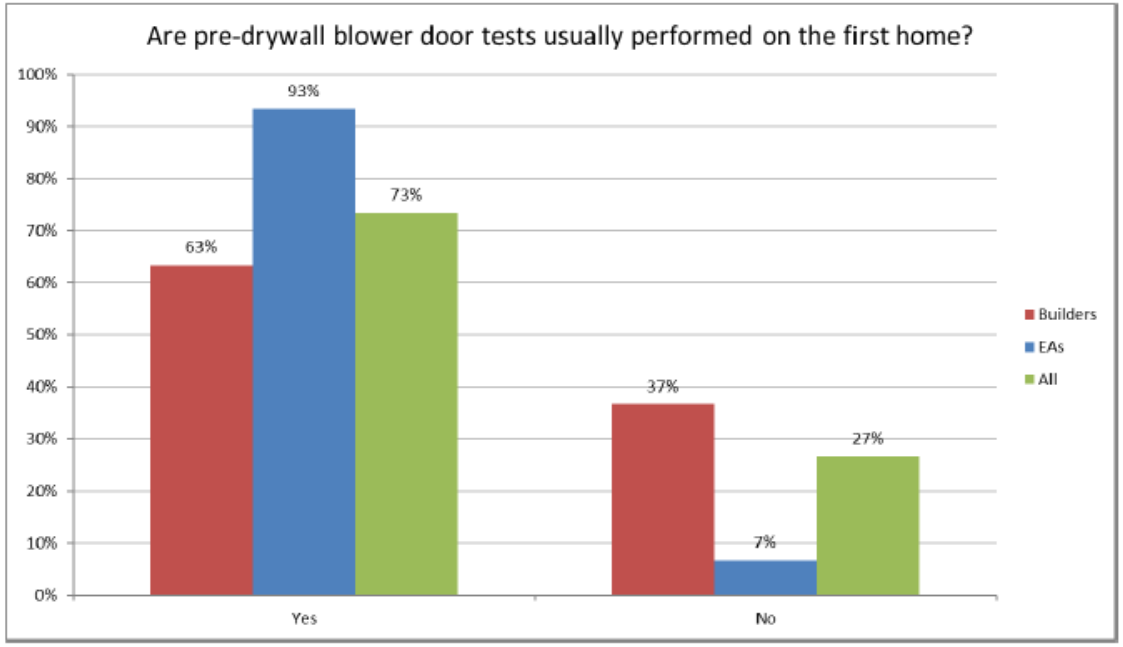
- Understand why you're doing it this way
- Come up with ideas to do it even better

Education was the biggest challenge for most projects in the CHBA study!

CHALLENGES



PRE-DRYWALL BLOWER DOOR TEST



Test air leakage before it's too late to fix

Benefits outweigh the cost:

- Risk of not meeting the target is too high not to do a pre-drywall air test

Installation

Construction materials & techniques

- Additions and other new construction should exceed building code
- Especially in attention to air barrier and insulating value

CHBA Technical Requirements

- **Insulation:** See table at right for Ottawa climate of 4500 HDD
  - Effective, not nominal values

Building Assembly	Heating Degree Days[2]	
	4000-4999	5000-5999
	RSI (R)	
	NBC Climate Zones	
	6	7a
Ceilings below attics	8.67 (49.2)	10.43 (59.2)
Cathedral ceilings and flat roofs	4.67 (26.5)	5.02 (28.5)
Walls above grade[3]	3.08 (17.5)	3.08 (17.5)
Floors over unheated spaces	4.67 (26.5)	5.02 (28.5)
Foundation walls below or in contact with the ground	2.98 (16.9)	3.46 (19.6)
Unheated floors below frost line	0.88 (5.0)	0.88 (5.0)
Unheated floors on ground above frost line[4,5,6]	1.96 (11.1)	1.96 (11.1)
Heated or unheated floors on ground on permafrost[5]	-	-
Heated floors on ground[5]	2.32 (13.2)	2.85 (16.2)
Slabs on grade with integral footing[4,7,8]	1.96 (11.1)	3.72 (21.1)

CHBA Technical Requirements

- **Airtightness:** 1.5 ACH50 (same as R-2000)
  - 2 ACH50 for attached homes

- **Other:**
  - HRV balanced
  - Forced-air Ductwork must be sealed

Building Type	ACH@50Pa	NLA@10 Pa		NLR@50 Pa	
		cm^2/m^2	$in^2/100\ ft^2$	$L/s/m^2$	$cfm50/ft^2$
Attached	2.0	1.00	1.44	0.75	0.15
Detached	1.5	0.70	1.00	--	--

CHBA Technical Requirements

Solar Photovoltaics:

- must calculate production following NRCan's procedures
- area, slope and azimuth dimensions must reflect the specified design

Important Considerations

- Calculate the maximum kWh expected capacity of the array ASAP
- Get a site assessment now!
- Install early for immediate savings

Heating and Cooling

The answer is usually Air Source Heat Pumps

Not specified by CHBA, but well matched to Net Zero

- Handle small heating and cooling loads
- Extremely efficient
- Low cost to operate
- Only uses electricity
- Now effective in colder climates like Ottawa
- Can run with combustion backup heating if desired

Important Considerations

- Install as early as possible – big GHG savings in Ontario even when undersized
- EA and HVAC contractor will provide equipment sizing
- Keep existing heating system as backup until end of life

Insulation – Attics and Other Ceilings

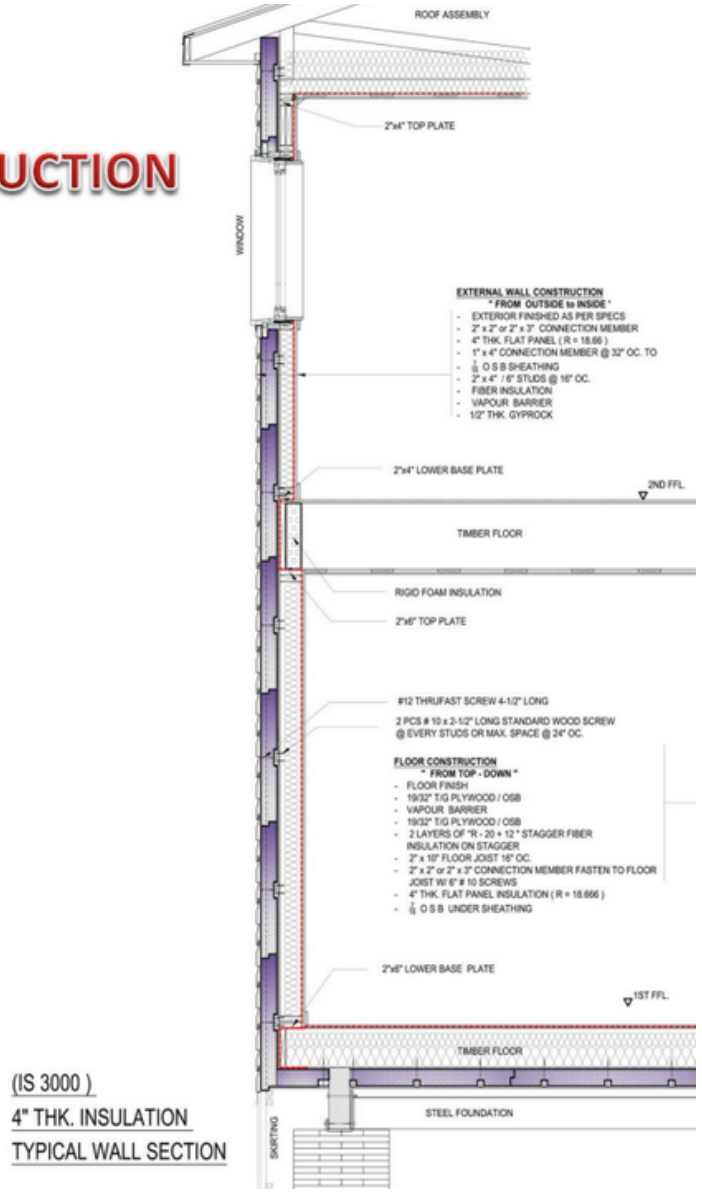
Meeting CHBA Requirement of R49.2 (attics):

- Can usually reach with R60 cellulose (17")
- Vertical space may be a problem

Meeting R26.5 (flat roofs or cathedral ceilings):

- Upgrading by filling cavities with fiber insulation may create problems
- Will probably need to add continuous layer
- Exterior preferred – dew point etc.
- Can be scheduled when reroofing

IS 3000 for RETROFIT & NEW CONSTRUCTION



(IS 3000)
4" THK. INSULATION
TYPICAL WALL SECTION

Insulation – Walls

Meeting CHBA Requirement of R17.5:

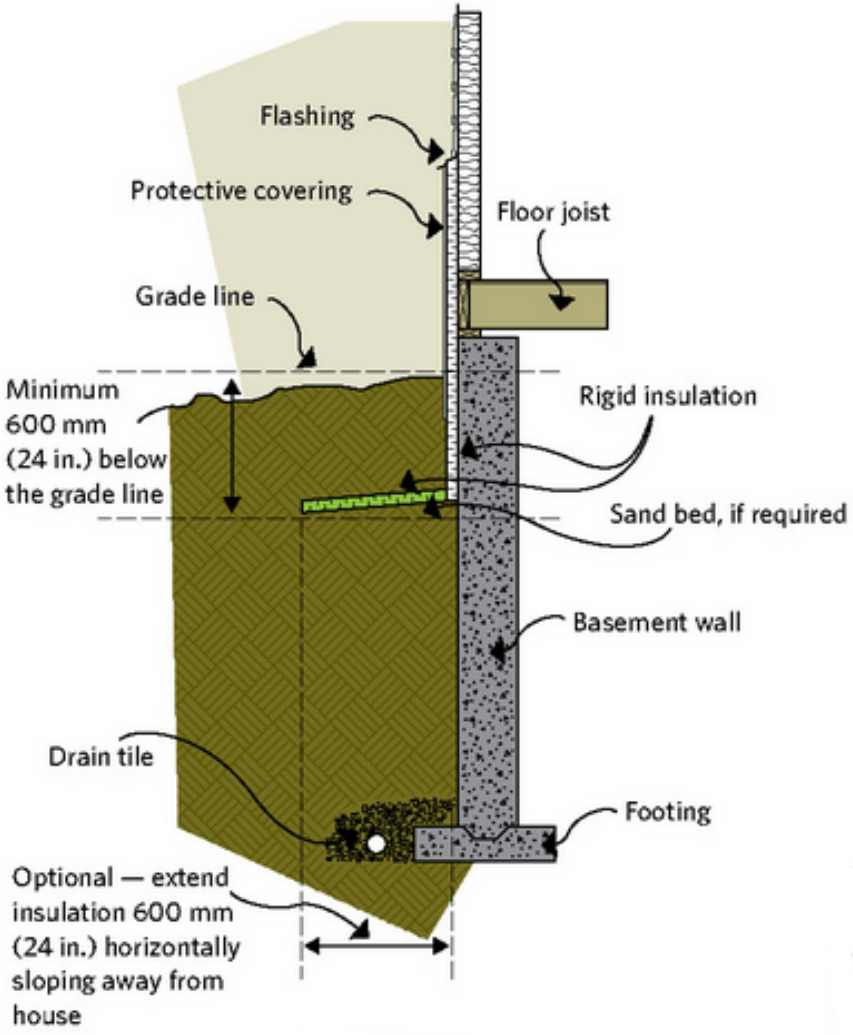
- Need to add continuous layer: at least R6 for 4" walls, R1 for 6" walls
- Insulation R & R is ineffective: thermal bridging
- Exterior preferred – dew point etc.

Materials

- Board insulation, almost any type
- Add continuous air barrier at this time
- Install window upgrades – flashing

Some commercial wall systems available:

- ATLAS www.atlasrwi.com
- Energy Wall http://energywallsystems.com/



Insulation – Foundations

Upgrading requires expert advice

- Any water leakage must be resolved first
- Poured concrete – very stable
- Concrete block – usually OK
- Stone or Rubble – proceed with caution! Exterior insulation is best

Meeting CHBA Requirement of R16.9:

- Possible interior: 2x4 framing with 3" gap, R20 batts
- Exterior board or foam insulation:
  - best energy approach, especially with stone
  - adds about 4" thickness
  - can be continuous with exterior wall insulation
  - Excavation is usually necessary

Skirts could be effective here - but not currently approved by CHBA

CHBA Requirement for basement floor is R5 on the slab

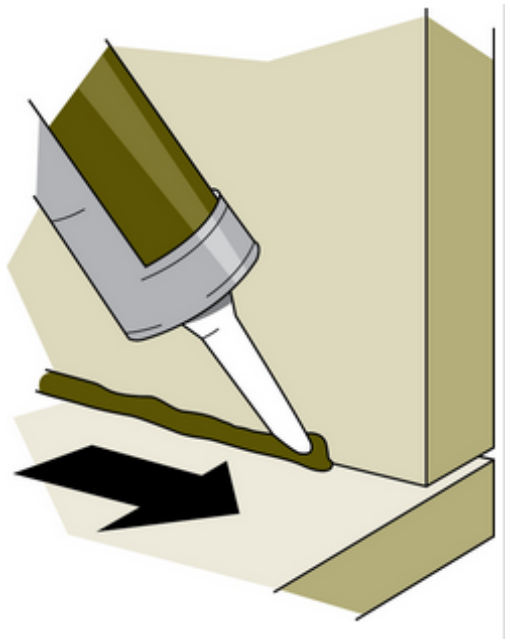
Windows & Doors

Quality:

- CHBA: ENERGY STAR qualified for the climate zone in which they are installed
- Decorative windows need not comply, but must be double glazed and less than 15% of total glazing
- One door (max) need not comply

Window Placement:

- Reduce N facing
- Beware excessive S and W facing



Air leakage

Most older houses are 4 ACH50 or more. Deep reductions are necessary to reach 1.5 ACH50:

- Air Leakage Testing will tell you where and how much (e.g. EnviroCentre)
- Blower door guided sealing also possible
- Classic: side attics, overhanging floors, split walls
- Airseal gaps, cracks and openings
- Weatherstrip doors and windows
- Added benefits:
    - comfort, humidity control, health and safety (garages)

Vapour Transmission

- Moist air gets into cold areas; water condenses
- Best control is by reducing air leakage through the envelope
- Avoid installing board insulation on the warm side of fibre insulation
  - 1/3 – 2/3 rule
- Vapour retarder
  - Only prevents direct vapour diffusion
  - Continuous but can be unsealed
  - Unless also the air barrier!

Number of Bedrooms	Minimum Airflow Rate (at 0 °C)	
	L/s	CFM
1	16	34
2	18	38
3	22	47
4	26	55
5	30	64
>5	As per good practice such as described in CAN/CSA F326-M91 (R2014) "Residential Mechanical Ventilation Systems"	

Ventilation

CHBA Net Zero Requirements:

- Must have a balanced ventilation system with heat recovery
- Capable of meeting the principal ventilation air flow rate
- Installed so that supply and exhaust are balanced within 10% at high speed, with a label attached

HRVs and ERVs serving individual residential units shall be

- certified by the Home Ventilating Institute (HVI), or
- be ENERGY STAR qualified

Hot Water

- CHBA: no restrictions on fuel or type of water heater
- For Net Zero, Heat Pump Water Heaters are necessary
- Should be coupled with longest possible DWHR unit

- Another option for Net Zero is to couple DHW with the main heat pump system
- Common with GSHP systems

Coordinating the process

CHBA Net Zero Builder/Renovator Responsibilities

Builder/Renovator:

- Must have membership, training and license
- is responsible for complying with the Builder/Renovator Agreement
- is responsible for meeting the Technical Requirements
- works with the EA and SO to get ERS and Net Zero/Ready labels for the home

CHBA: Process Summary

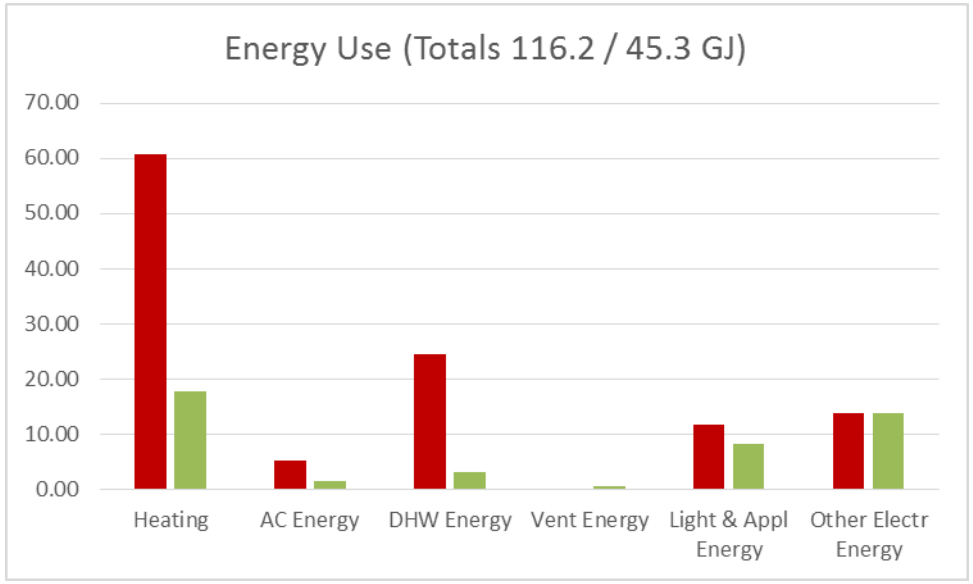
1. Energy Advisor performs baseline energy modeling from plans
2. EA creates revised model of the same home that meets NZ requirements
3. Verifies that the final design meets NZ requirements
4. Builder builds home to meet requirements
5. EA may visit construction site to verify construction and perform intermediate air leakage testing
6. When home is completed, builder schedules final evaluation with EA. (NOTE: Builder will receive labels from SO within 3 weeks of final evaluation.)
7. EA evaluates home per ERS protocol and is responsible for verifying compliance with the Net Zero Home Labelling Program Technical Requirements.

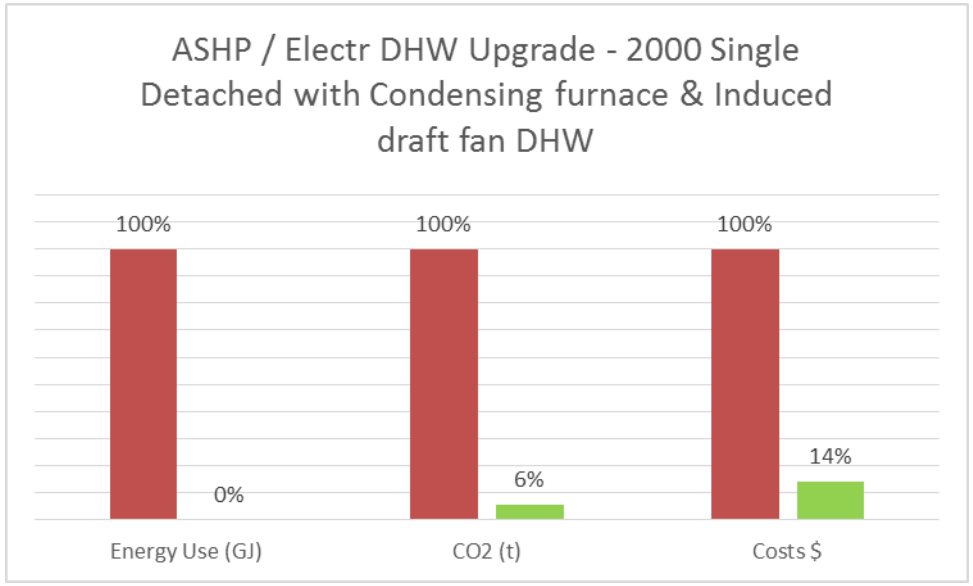
Note: Attestation is required from Builder for components that cannot be verified by the EA

Net Zero Retrofit Examples

Detached House, built in 2000

- 2000 sf on main and 2nd floors
- R32 Attic
- R20 walls with vinyl siding or brick
- R12 foundation with gypsum
- 3.8 ACH50
- Mid efficiency gas furnace, std. DHW, 10 SEER central AC





2000 House - Upgrades

- Attic R60
- All windows upgraded to triple pane fibreglass
- Air leakage 1.5 ACH50
- HRV installed
- ASHP 30,000 Btu with electric backup furnace
- Heat pump water heater with DWHR
- Upgraded fridge and lighting
- 650 sf of solar panels
- ERS Rating 45 GJ

- Note: no added wall or foundation insulation

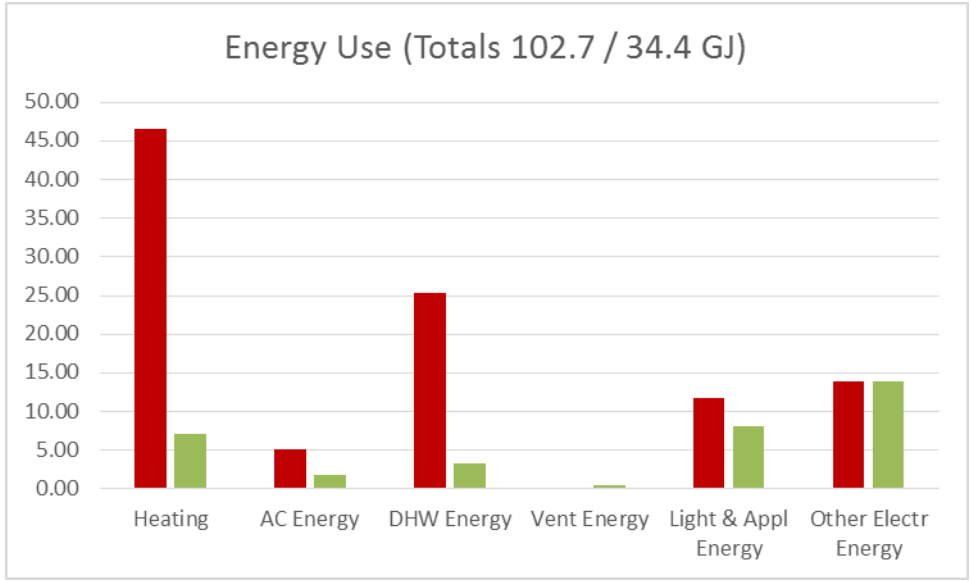
Row House, built in 1982

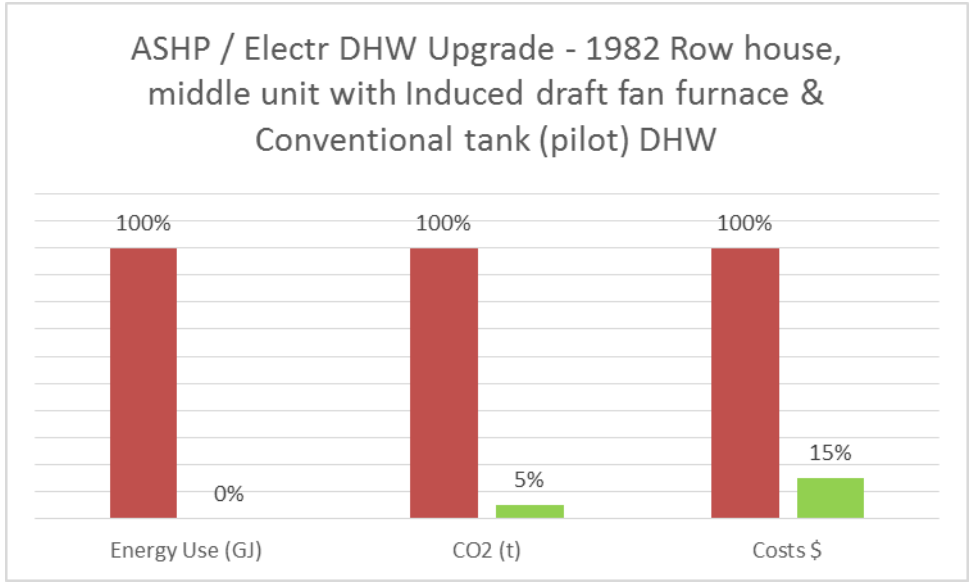
- 1100 sf on main and 2nd floors
- R32 Attic
- R20 walls with wood siding
- R10 foundation – upper half only, with R20 header
- 4.6 ACH50
- Mid efficiency gas furnace, std. DHW, 10 SEER central AC

1982 Row House - Upgrades

- Attic R60
- Foundation R20, header R22
- All windows upgraded to triple pane fibreglass
- Air leakage 1.5 ACH50
- HRV installed
- ASHP 24,000 Btu with electric backup furnace
- Heat pump water heater with DWHR
- Upgraded fridge and lighting
- 500 sf of solar panels
- ERS Rating 34 GJ

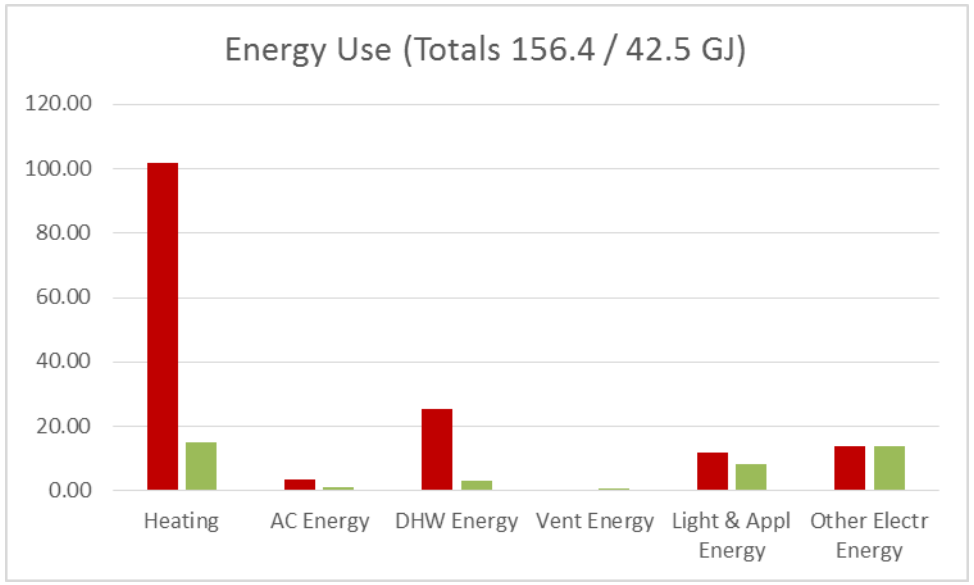
Note: no added wall or slab insulation

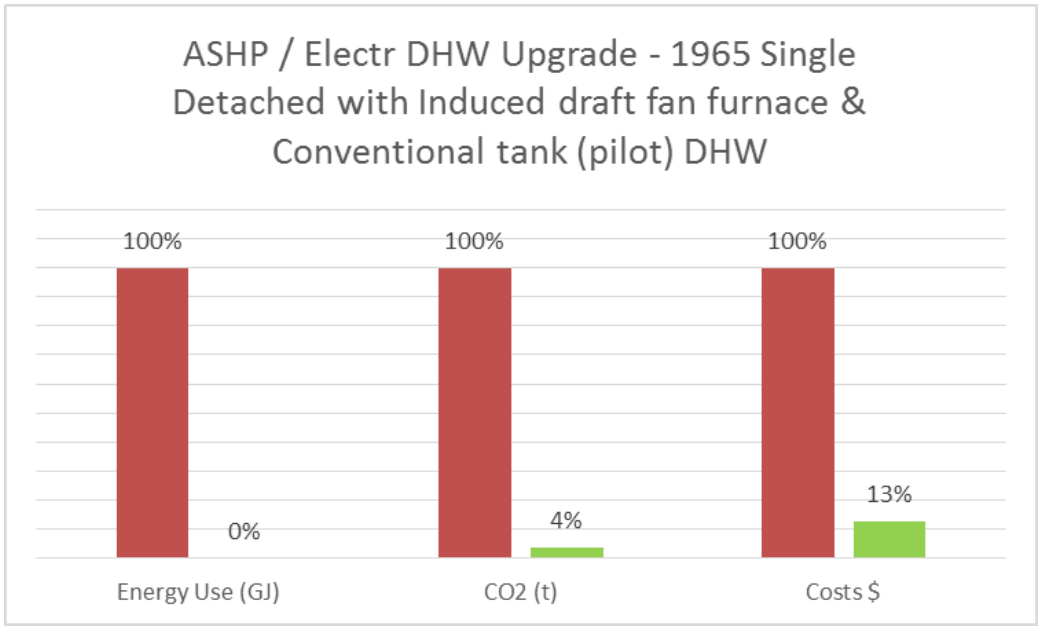




Bungalow, built 1965

- 1500 sf on main floor
- R32 attic
- R8 walls with brick
- Uninsulated basement with R8 header
- 4 ACH50
- Mid efficiency gas furnace, std. DHW, 10 SEER central AC
- ERS rating 155 GJ





1965 Bungalow - Upgrades

- Attic R60
- Foundation R20, header R22, slab R5
- All windows upgraded to triple pane fibreglass
- Air leakage 1.5 ACH50
- HRV installed
- ASHP 24,000 Btu with electric backup furnace
- Heat pump water heater with DWHR
- Upgraded fridge and lighting
- 650 sf of solar panels
- ERS Rating 42 GJ

Note no wall insulation added

Thank You!

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