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Retrofitting to Net Zero:

Part 1: Knowing the Landscape

Let's Talk Green Economy Workshop Series

January – March, 2020

What is EnviroCentre?

EnviroCentre:
Your local 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

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

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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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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 background
- Comparing rating systems
- Easy retrofits

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Part 1: Starting the Process

What is Net Zero?

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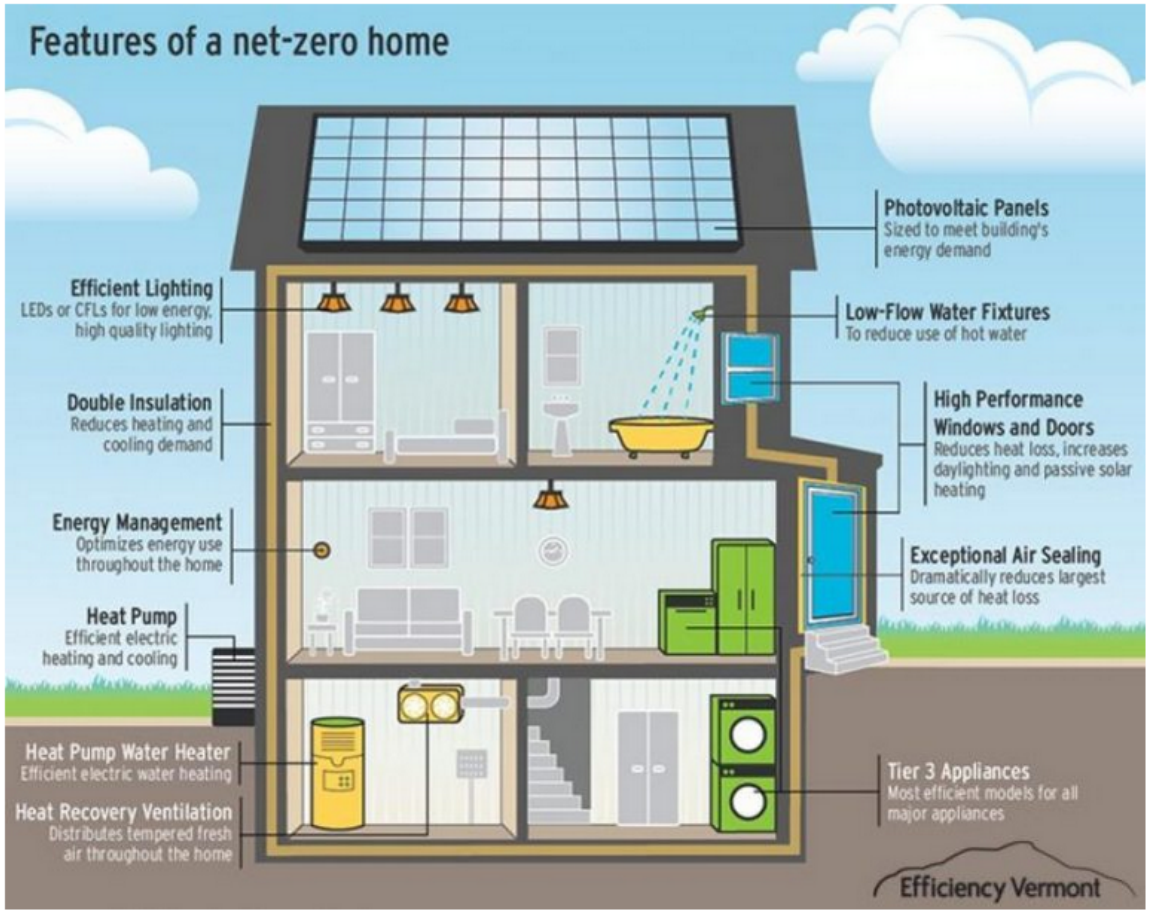
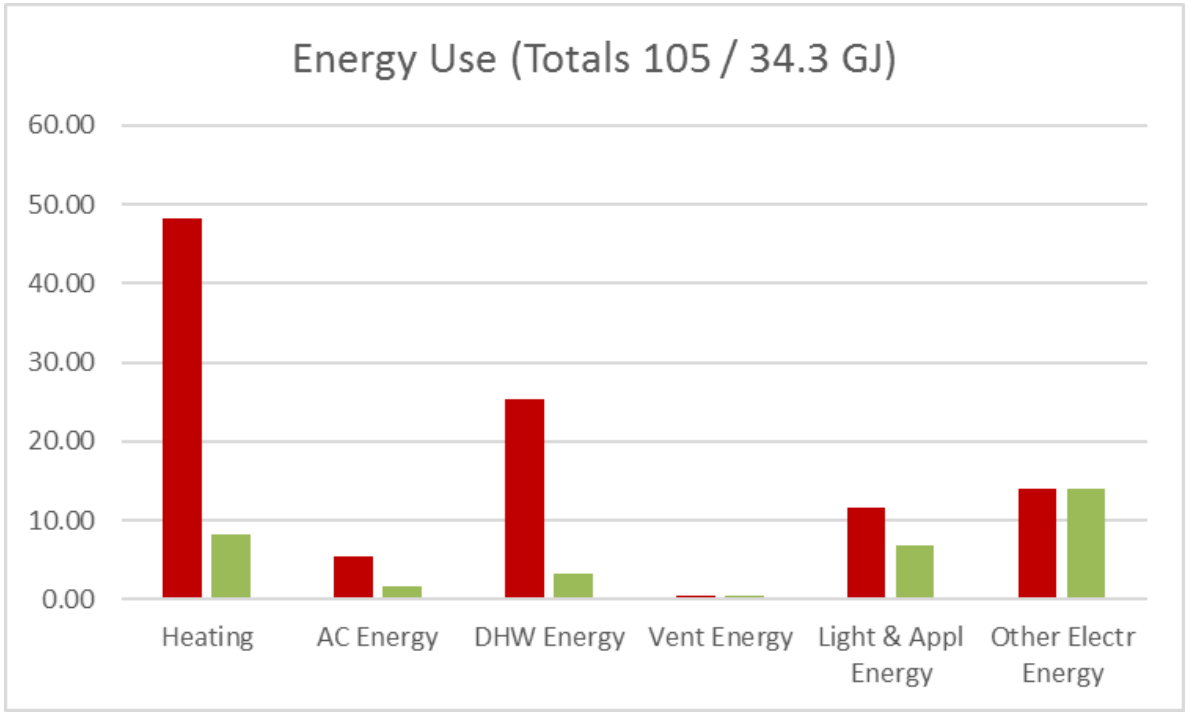
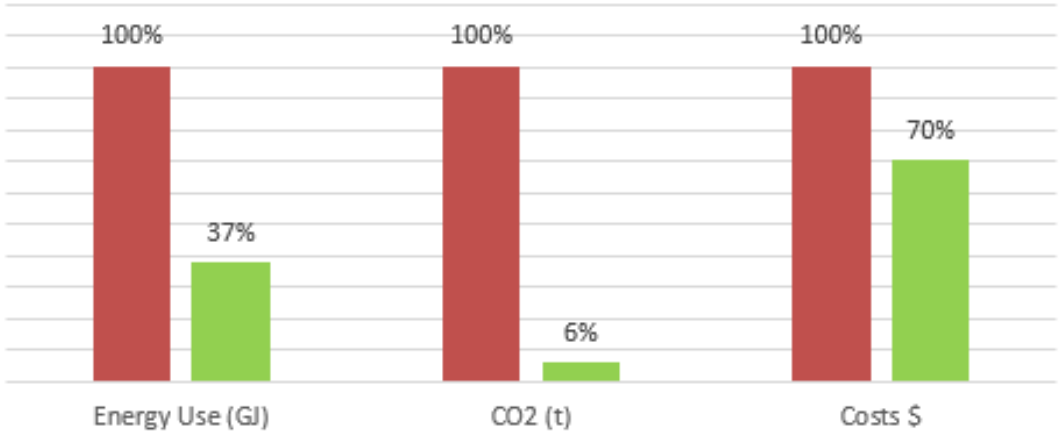
Yearly household energy = Yearly energy generated onsite



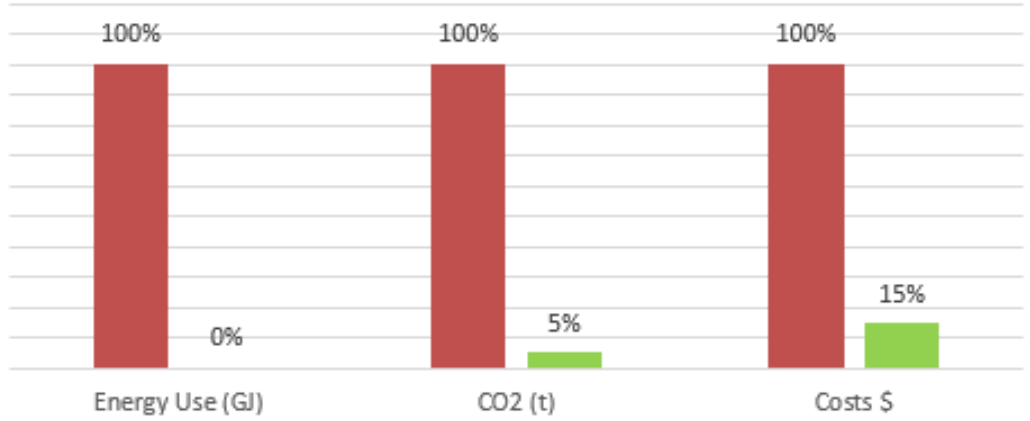


Net Zero retrofit savings

- Lower energy consumption (65-100%)
- Electricity generation offsetting consumption
- Carbon reductions of up to 95%



Net-Zero Ready: Conservation Upgrades Only



Net-Zero: Including Solar Panel Production

Net Zero example

Net Zero Energy Retrofit on 1980s row house, as follows:

1. Mid-efficiency gas furnace to ASHP & electric furnace
2. Standard gas DHW to HP water heater & DWHR
3. Air leakage reduced from 4.6 to 1.5 ACH50
4. Lighting and appliance upgrades
5. All windows replaced with triple-pane fiberglass
6. 500 sq.ft. of solar panels installed to match reduced usage

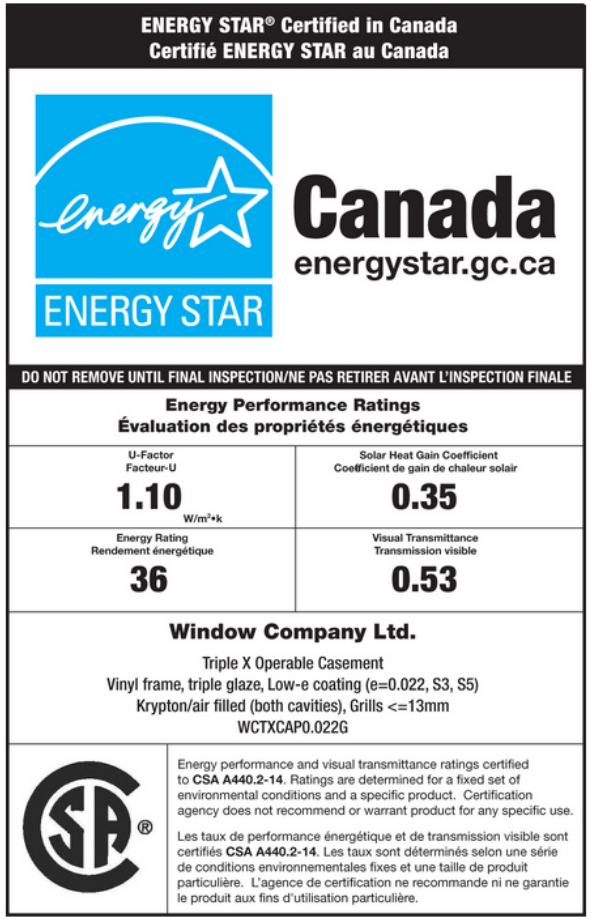
Moving toward Net Zero

How?

1. **Lower heating/cooling demand**
2. **Ultra-efficient heating**
3. **Electricity generation on site**

Toward Net Zero:
lower heating/cooling demand

- Plenty of insulation
- Low air leakage target (1.5 ACH50)
- Advanced windows



Providing ventilation

- 1.5 ACH50 translates to very low natural ventilation rates
- The answer is **Fresh Air Machines**: HRV or ERV equipment

Net Zero:
low heating/cooling needs

- Heating: only 36000 btu/hr heating for a 2000 sf home

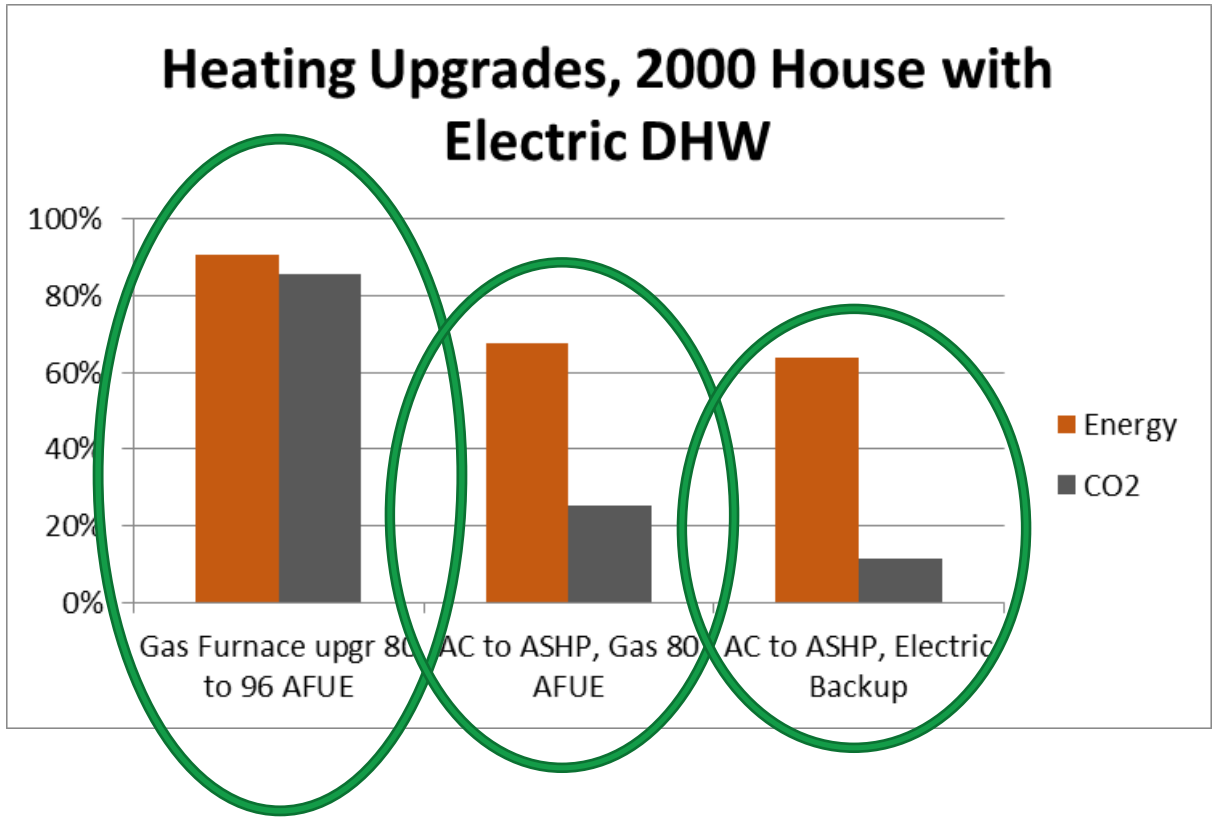
- Cooling is also necessary for:
  - ambient temperature above 26°C for extended periods
  - high interior energy use
  - high occupancy load (100 W per person)
  - excessive solar gain

- ASHPs are a good choice for this application

Toward Net Zero:
Heating upgrades

If you have an electric water heater,

- Upgrading gas heating efficiency gets only 10% energy reduction, 15% drop in CO_2
- Upgrading AC to operational ASHP can get 33% energy, 75% drop in CO_2 (orig. furnace)
- Removing gas entirely and replacing with heat pump gets 35% energy, 90% CO_2



Toward Net Zero:
Electricity Generation

- Rooftop available for PV tells you the maximum energy use you can offset
- 500 sq.ft. of South-facing: ~35 GJ yearly
- 10 kW net metering limit (Ottawa) means **45 GJ** is max production
- Wind not generally available in Eastern Ontario

Toward Net Zero:
The balance

- **45 GJ** max electricity production means:
- **45 GJ** max house rating on the ERS scale
- House details need to be modeled in HOT2000 to match this level

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Certified Energy Advisor

- Creates models based on plans
- Figures out the energy balance
- Recommends cost-effective solutions
- Performs blower testing and site inspections
- Provides the Net Zero label

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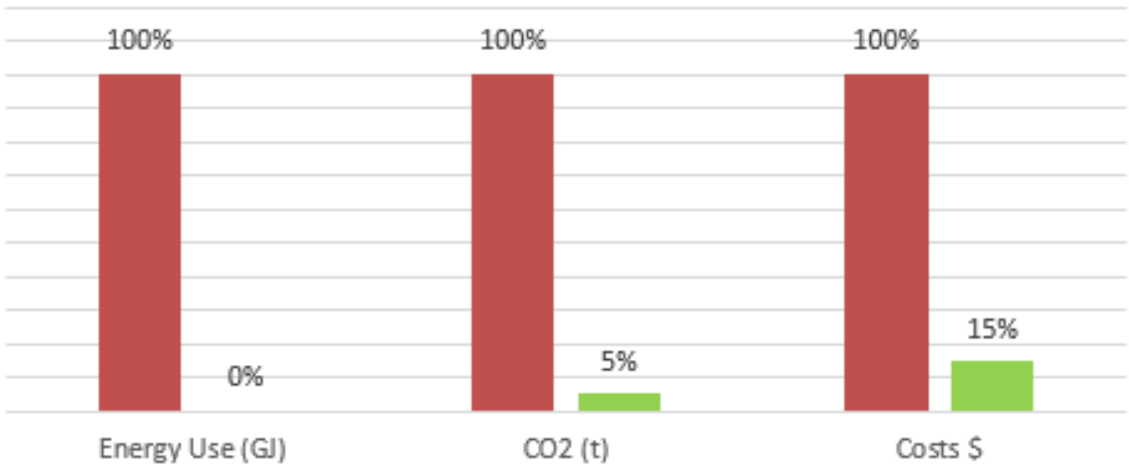
Process vetted by CHBA

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

Results

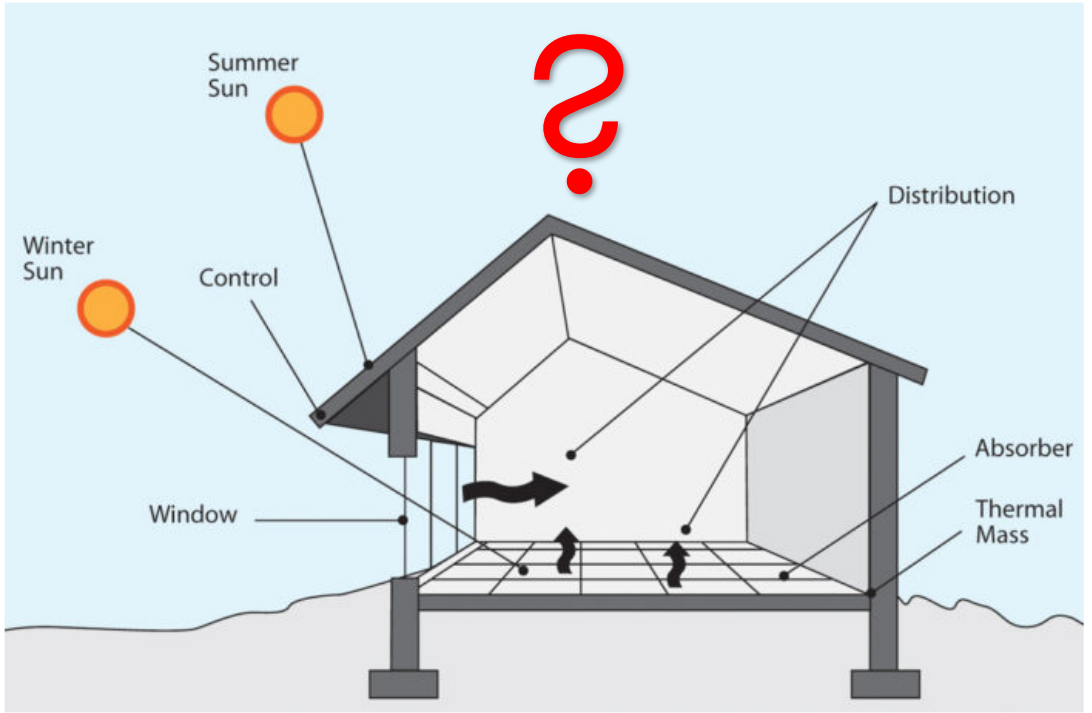
- Outstanding comfort
- Tiny carbon footprint
- Very low operating costs



Net Zero Considerations

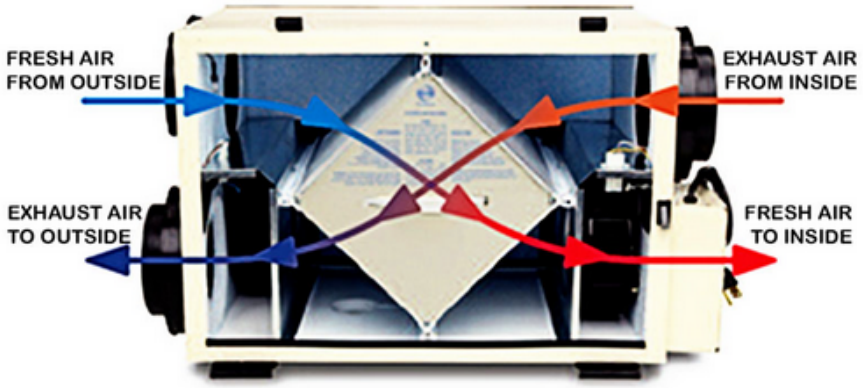
Solar Gain

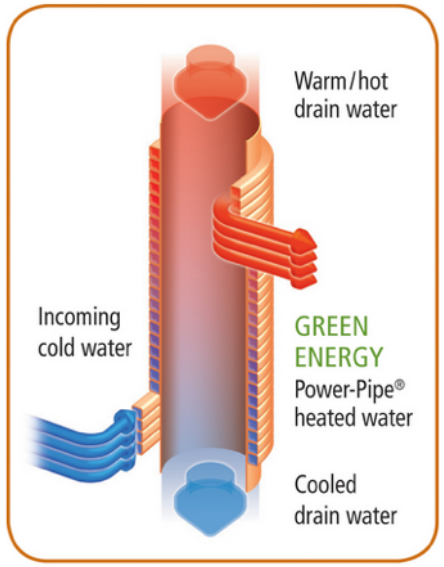
- Can contribute up to 50% of heating
- Too little: heating system consumes more energy
- Too much: summertime overheating (cooling is necessary)
- Good solar design:
    - Strategic window sizing and placement
    - Overhangs for summer shading
    - Film treatment for East and West windows
    - Landscaping and deciduous trees can help
- **Superinsulation** usually better than passive solar
- For well-insulated houses, PV is a better way to collect solar energy



Green Energy Times

Vital Equipment: Heat Exchangers





- Transfer heat energy from one flow to another flow
- The flows do not touch one another
- Used in furnaces, boilers and automobiles (radiators)
- Are the basis of HRV, ERV and DWHR
- HRV/ERV takes heat from exhaust to fresh air (75%)
- DWHR unit: heat from drain to DHW inlet water (60%)

Vital Equipment: Heat Pumps

- "Pump" energy from one place to another
- Both heating and cooling

- **Air-source (ASHP)**: COP of 1.5 to 3.5, cost ~$10K
- 50% energy, 95% less CO2 than natural gas
- Operating costs now similar
- Now effective in colder climates like Ottawa
- **Ground or water source (GSHP, WSHP)**: COP of 3 to 5.5, but cost ~$25K

- **Heat Pump Water Heaters**: heat your water

Residential PV Economics

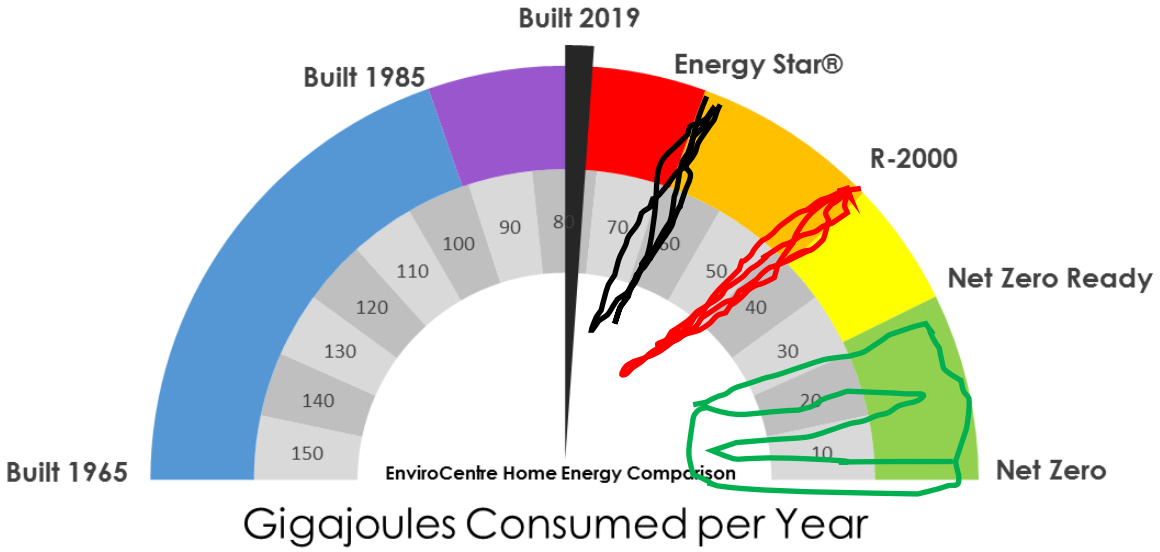
- Typical available roof is 500 ft²
- 10,000 kWh per year in Ottawa
  https://www.nrcan.gc.ca/18366
- Will support ~35 GJ energy consumption
- about $20,000 retail for this size system
- ARR = 7%

Why Net Zero?

Client demand in 2019

4 of top 10 “must-haves” are energy-related

- Walk-in closets
- **Energy-efficient appliances**
- **High-efficiency windows**
- **Overall energy-efficient home**
- Kitchen island
- Open-concept kitchen
- Linen closets
- **HRV/ERV Air Exchange**
- Large windows
- Two-car garage



Reduction in energy use beyond code:

- **Net Zero** 65-100% better than code, compared to
  - 20% for **ESNH**
  - 50% for **R2000**
  - 60-80% for **Passive House**

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Exceptional value, greater comfort & environmentally responsible

- Operating costs same or lower than code house
- Better heat distribution and ventilation
- 65 to 100% less energy use
- More than 90% reduction in GHGs

Cost neutrality when considering lifetime operating costs

- Only 5-10% added costs
- 65% reduction in energy consumption
- Electricity bill: fixed costs only
- Closing the gas account saves fixed costs ($285/yr)
- Safer home: lower insurance costs
- Lower operating costs mean lower risk for mortgage lenders

Net Zero Background

2006: NRCan and CMHC

CMHC Equilibrium Sustainable Housing Demonstration Initiative 2006 – 2012

- 12 completed houses including Minto's Inspiration
- 11 monitored for actual energy performance
  - All less than 50 GJ
  - 7 less than 25 GJ
  - 3 less than 5 GJ (effectively Net Zero)

Echo Haven — Calgary, AB

2013: NRCan

R-2000 Net Zero Energy Pilot 2013 - 2016

- 23 net zero energy homes built by 6 builders in 3 provinces
- 5 Homes built in Kanata by Minto (Arcadia II shown)
- All houses certified R-2000 and labelled with a zero gigajoule rating under ERS Version 15
- Technologies limited to pre-engineered products and systems

Canadian Home Builders' Association

2015-2016: Net Zero Pilot Phase

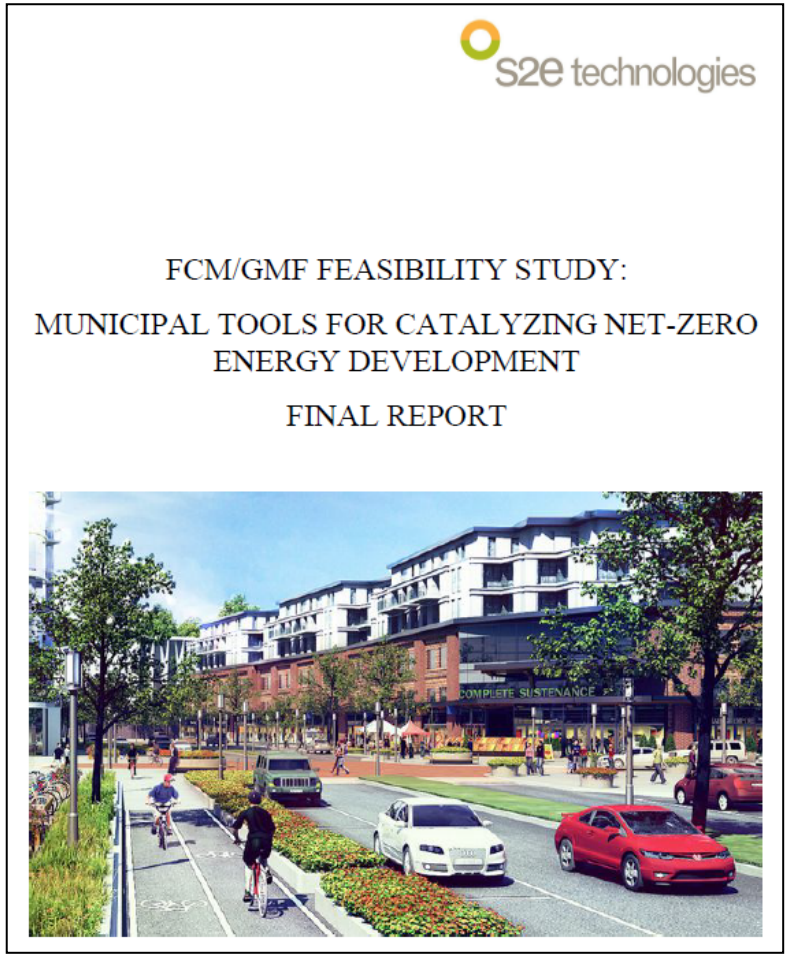
2017: CHBA Home Labelling Program

- **Net Zero** and **Net Zero Ready** labels
- Performance based
- 33+ builders in 7 provinces
- Ontario: 3 labels in 2017, 43 in 2018, now more than 265 across Canada
- CHBA now expanding to renovated homes and mid-rise MURBs

2019: FCM Study

Municipal Tools for Catalyzing Net-Zero Energy Development

- 40 cities surveyed
- 8 sites evaluated
- Design and technology strategies
- Proposed incentives



Global Perspectives on Net Zero

- Widespread research on Net Zero in many countries
- USA: 5000 homes built since 2013
- California: All new homes must now (2020) have at least 2 kW of PV installed
- City of Copenhagen: Net Zero GHGs by 2025 (already 44% reductions since 2005)
- Canada: 30% below 2005 levels by 2030
- Net Zero GHGs by 2050: Denmark, Norway, UK, Canada

Building a plan

Qualification Status

CHBA Net Zero builder requirements

Membership

- Builders and renovators must be a member of the CHBA

Training

- Successfully complete the Net Zero Building Science Training – at least one staff person

License

- Become an EnerGuide (ERS) registered builder with NRCan before starting the home

Registration

- After the first Net Zero/Ready Home is labelled, you can register

Building the right skills

CHBA Net Zero builder training

CHBA has developed:

- **Building Science Training**
- Energy Advisor Training
- **Sales Training**

Training can be taken through qualified SOs including EnviroCentre

- delivered by qualified Trainers

- https://www.chba.ca/CHBA/HousingCanada/Net_Zero_Energy_Program/NZE_Qualified_Training/CHBA/Housing_in_Canada/Net_Zero_Energy_Program/NZE_Qualified_Training.aspx?hkey=2a540759-ed12-40f1-b43b-4c7806ef2679

Getting the timing right

Get Net Zero consultation early in the design stage

- A qualified Energy Advisor should have a seat at the design table
- Expert insight from the building science perspective
- Energy modeling
  - Takes in all the effects of each energy use
  - Is your best guide to upgrade impacts
- Ventilation and comfort need to be carefully considered
- Helps decide on the type of heating system that best fits the energy picture

The Net Zero Retrofit plan will affect

Foundations

Walls and Windows

Attic

HVAC systems

Along the way

On-site with the Energy Advisor

The **Energy Advisor** can provide:

- Feedback on the modeled effect of changes
- Pre-drywall blower testing
- Confirmation that the build meets technical requirements and is on track to qualify

CHBA Net Zero label

Builder/Renovator:

- is responsible for complying with the Builder/Renovator Agreement and meeting all program requirements
- is responsible for ensuring that their homes meet the Program Technical Requirements
- must provide attestation to CHBA that all program requirements have been met
- works with the EA and SO to get ERS and Net Zero/Ready labels for the home

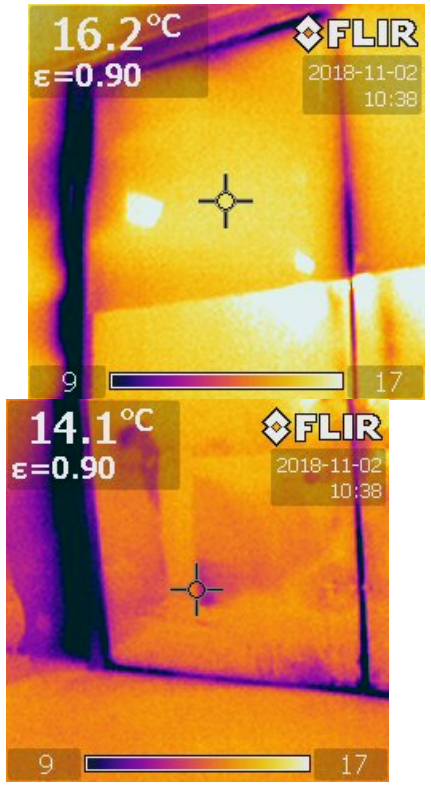
Easy Energy Efficiency Upgrades

Poorly insulated ceilings

Could reduce heating by 10%

- **Attics:**
  - ✓ Airseal first, based on blower / IR testing.
  - ✓ Insulate: blown cellulose is very economical.
- **Flat roofs or cathedral ceilings:**
  - ✓ Custom approach based on the situation.
- **Added benefits:**
  - ✓ reduced leaks, smaller icicles, lower maintenance costs.

Uncontrolled air leakage



Reductions of 10% or more:

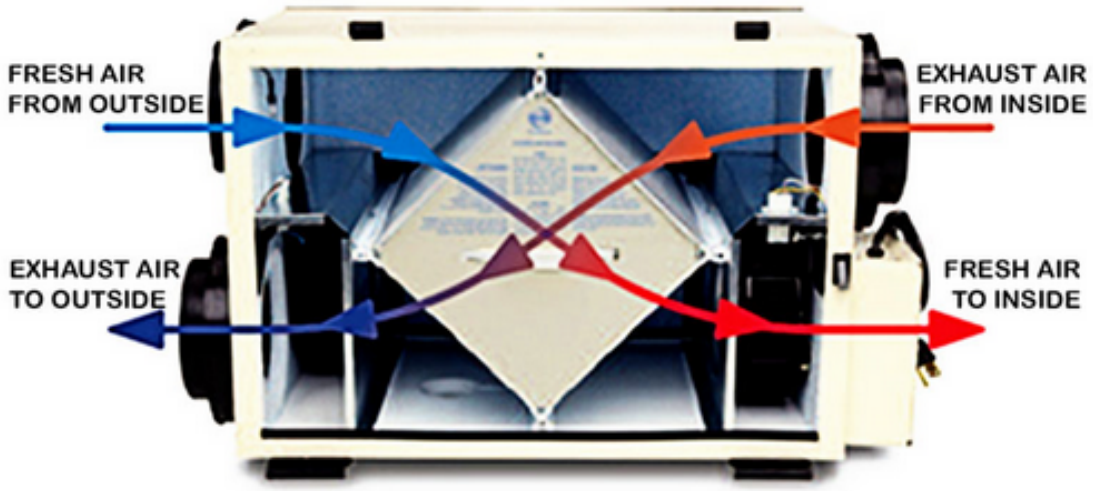
- Air Leakage Testing will tell you where and how much (e.g. EnviroCentre)
- Airseal gaps, cracks and openings
- Weatherstrip doors and windows
- Added benefits:
  - ✓ comfort, humidity control, health and safety (garages)

Any equipment producing heat or cold

Lots of energy use
=
Lots of opportunities for savings

- Air conditioner: Upgrade to air source heat pump
- Water heater: Upgrade to Heat Pump Water Heater
- Gas Furnaces or Boilers: Maintenance only – avoid "Lock-in"
- Refrigerators and freezers: Upgrade

Heat recovery from exhaust air



HRV or ERV - Fresh Air Machines recapture up to 75% of energy from exhaust

- **Heat Recovery Ventilator:** fresh air preheated for free
- **ERV:** preheated air with humidity regulation

- Low electrical consumption, but need regular cleaning maintenance

Heat recovery from drainwater

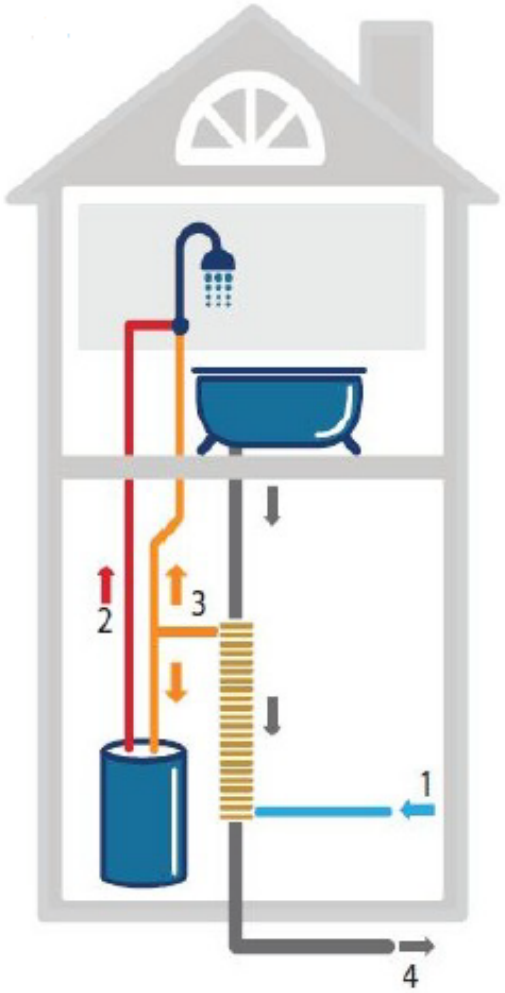


Image: ThermoDrain

DWHR – Hot water energy booster recaptures up to 60% of energy from drainwater (mainly showers)

- Drain Water Heat Recovery units have no moving parts, no maintenance
- Water coming into the water heater is preheated for free!
- Installed by plumber

Deeper Energy Efficiency Upgrades

Deeper Retrofits
(more details in Part 2)

Empty wall cavities:
- Filling with cellulose saves up to 20% on heating

Exterior Wall Insulation:
- Board Insulation under new cladding also saves up to 20%, but more expensive

Foundation:
- Savings up to 20% for interior or exterior insulation. Can be cost-effective, but requires expert advice.

Windows:
- Upgrading is usually necessary to reach Net Zero

Solar Energy:
- Big capital cost, but high returns
- Net metering to offset your entire annual electricity usage
- Site assessment is necessary

De-mystifying ”Green” Certifications

Rating systems comparison

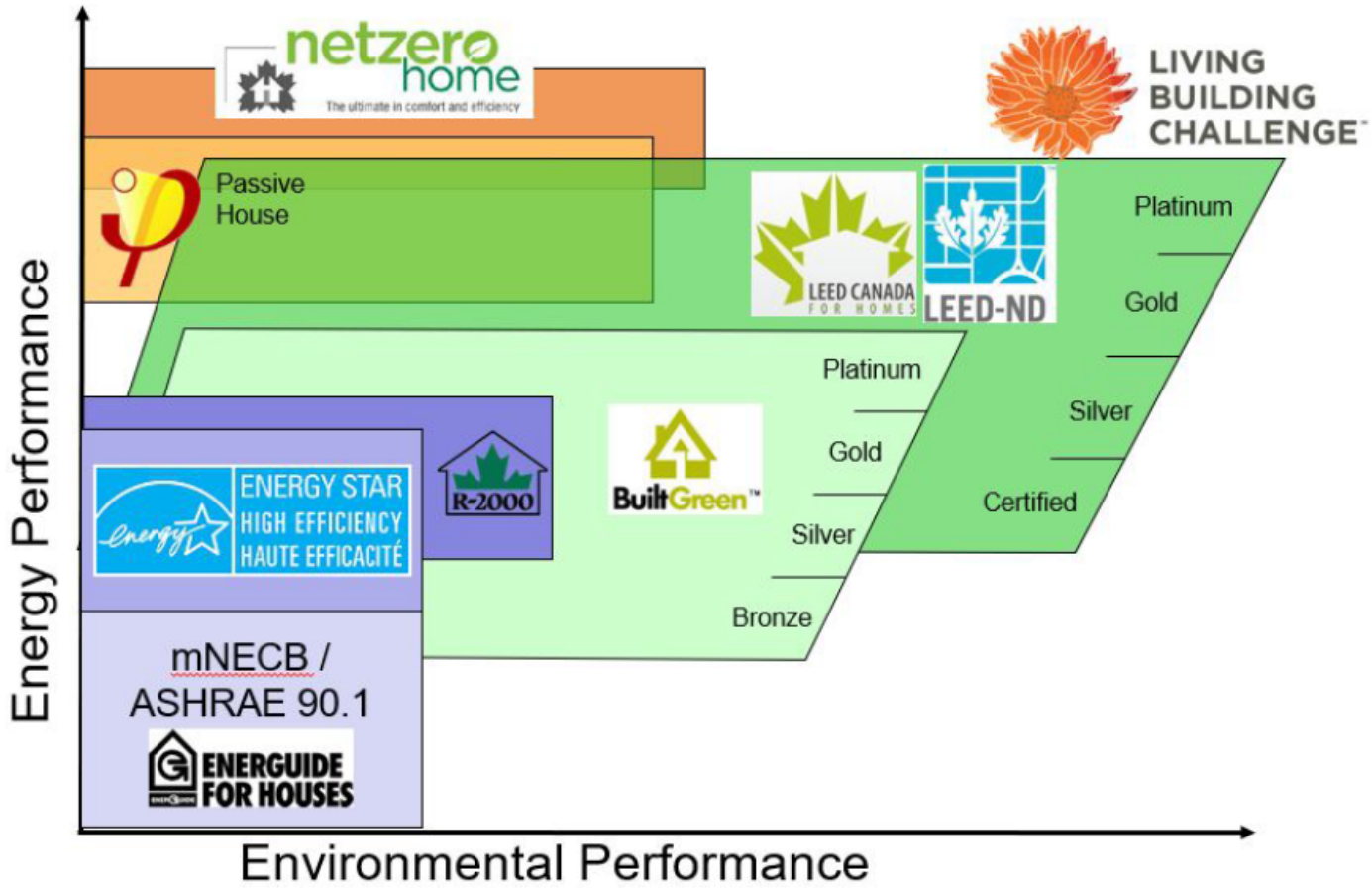


Figure 4-1: Overview of Canadian Green Housing Programs

Certifications

Natural Resources Canada (NRCan)

ENERGY STAR

Currently in transition in Ontario, but within the next year the following will apply:

- Software: New ERS (GJ rating)
- Energy: 20% better than code
- Performance or Prescriptive streams
- Construction: minimums based on effective, not nominal R
- Air leakage: ACH50 at most 2.5 / 3.0 for detached / attached
- Equipment: “shall comply with Canada’s Energy Efficiency Regulations.”
- 8,680 in Ontario last year

Certifications

Natural Resources Canada (NRCan)

R-2000

- Last updated 2012, continues to use the old 0-100 system software
- Energy: 50% better than code
- Performance only – each house modeled, inspected and tested
- Construction: minimums based on code, also environmental requirements
- Air leakage: ACH50 at most 1.5
- Equipment: minimums for HVAC, HRV must be balanced
- Extensive builder and advisor training necessary
- Only 3 in Ontario 2018; 7 in 2017

Certifications

PASSIVEHOUSE CANADA

Passive House and EnerPHit – PHI

- Very low energy, not necessarily with solar generation
- Primarily for new builds, but can also be retrofits

PASSIVE HOUSE INSTITUTE US (PHIUS)

- Similar but different passive house standards
- In some ways more suited to Ottawa climate zone
- Pre-certified or certified projects in 37 states and provinces

Certifications

Canadian Green Building Council (CaGBC)

- Zero Carbon Building Standard: Performance stream also applies to retrofits - $1500 base fee

Canada Green Building Council
Every Building Greener

Requirements of the Standard

	ZCB- Performance (existing buildings)
Demonstrate Zero Carbon Balance	✓
Provide Zero Carbon Transition Plan*	Every 5 years
Install Minimum 5% Onsite Renewable Energy	No requirement
Achieve Thermal Energy Demand Intensity Target	No requirement
Report Energy Use Intensity	✓
Report Peak Demand	✓
Report Embodied Carbon	✓
	* where fuels other than zero emissions biofuels are used onsite

The Benefits of Net-Zero

Better homes

- **Comfort:** More constant, less drafty
- **Costs:** Operating and maintenance
- **Resilience:** Less affected by weather
- **Health:** Air quality

Better business

- Business reputation
- Buyer and Employee retention
- Operational knowledge and planning

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Better city

- Climate Action
- Public Health
- Resilience
- Green Economy
- $ stay in town

What Part 2 will cover:

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

Thank You!

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