

ADVANCED BUILDING SCIENCE WEBINAR SERIES

# Top 5 Building Science & Energy Efficiency Priorities When Renovating Canadian Homes

*What are the critical building science principles?*



**ENBRIDGE GAS PROVINCIAL ADVANCED BUILDING SCIENCE SERIES**

In Partnership with: Enbridge Gas and Building Knowledge Canada

# Top 5 Building Science & Energy Efficiency Priorities When Renovating Canadian Homes

March 10, 2022 1:00-2:30 PM (EST)



**Gord Cooke**  
Building Knowledge Canada



**Toby Smith**  
Building Knowledge Canada



- Gord and Toby would like to acknowledge that they offer specific services

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## **Susan Cudahy**

Enbridge Gas  
Supervisor Strategic Builder Relationships

Susan Cudahy supervises a team across the province of Ontario who specialize in business development within the construction industry.

Fully sponsored and supported by :

## Housekeeping – Rules of Engagement

- Questions please place **ONLY** in **Q&A**
- Be considerate, thoughtful, and respectful in the CHAT 😊.
- The BKC Admin team is on CHAT ready to help with tech concerns or general inquiries.
- Please complete SURVEY MONKEY asap after!
- Links, presentation materials - All will be sent out to attendees following the webinar.



## Agenda

- Intro and Prep 1-1:15
- Guest Speaker and Presentation 1:15-2:00
- Question & Answer + Discussion 2:00-2:30

## TELL US!...(Polls)

Where are you joining us from?

What keeps you busy day-to-day?

ADVANCED BUILDING SCIENCE WEBINAR SERIES

# Top 5 Building Science & Energy Efficiency Priorities When Renovating Canadian Homes

*What are the critical building science principles?*





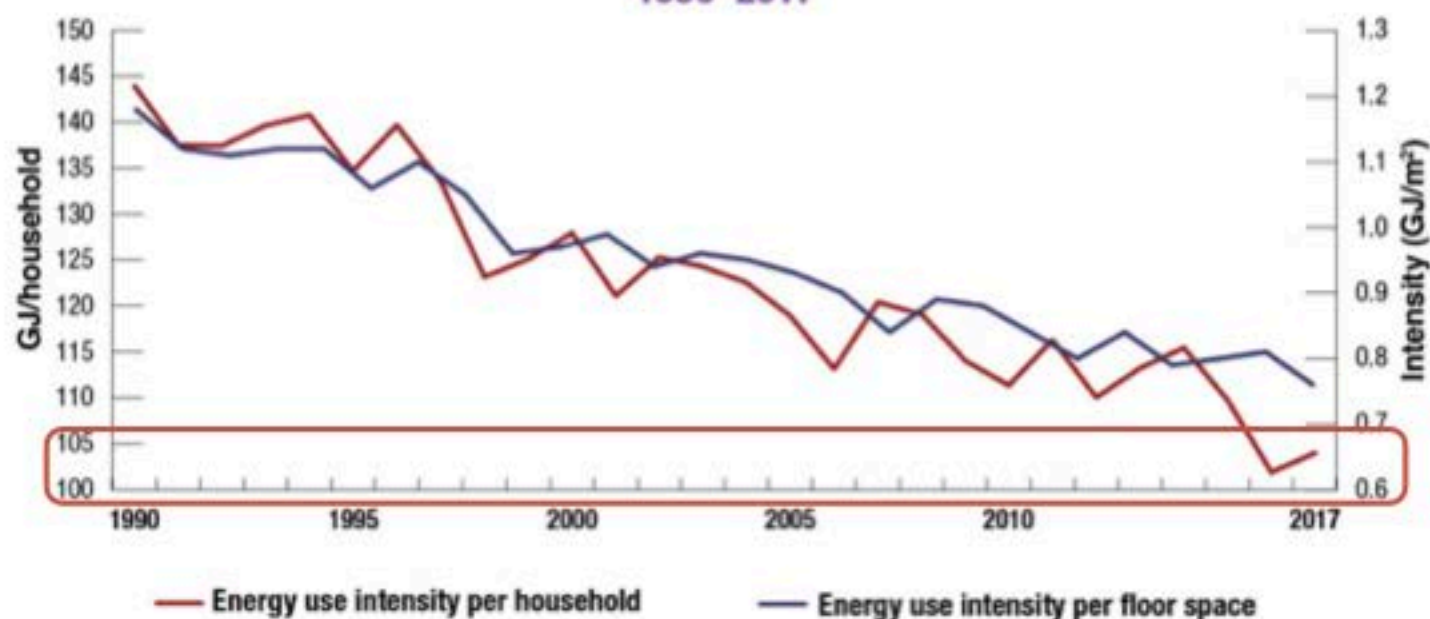
# Agenda

- The urgency of energy efficiency initiatives in existing homes
- What are the common renovation priorities
- The building science imperatives in those renovations
  - ✓ Avoiding risks, optimize opportunities
- 5 priorities that respect the science

# Our Housing Stock

Year Built	Millions
Before 1946	1.6
1946–1960	1.2
1961–1977	2.6
1978–1983	1.6
1984–1995	3.1
1996–2000	1.1
2001–2005	1.3
2006–2010	1.3
2011–2015	1.2
Total	15

Residential energy intensity per household and floor space, 1990–2017

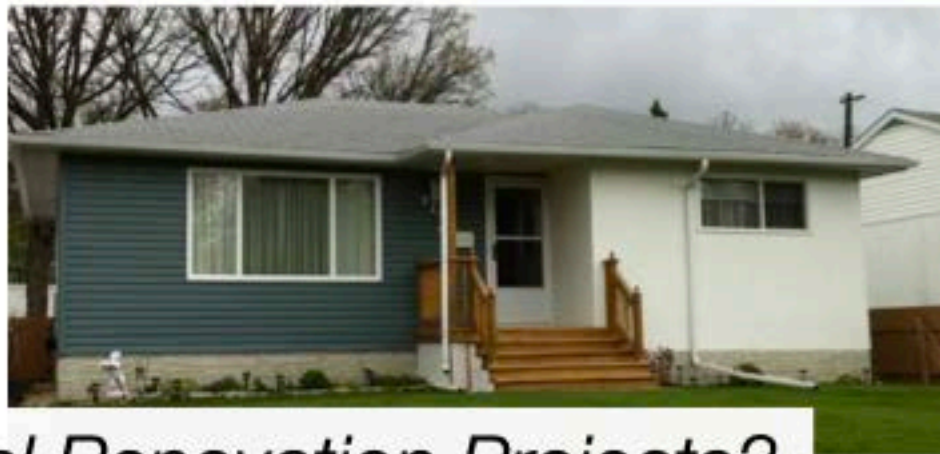


✓ A 28% reduction per household, but still +100 GJ / Household

Before 1946



50's / 60's



*What are the Typical Renovation Projects?*



70's / 80's



90's / 00's



# Renovation Priorities

- Kitchen & bathrooms
- Basement
- New roof
- Windows
- Additions
- Just updating finishes
- HVAC replacements

*What prompts renovations?*

*Which of these should include an energy efficiency upgrade?*

*How do we get to “deep” energy retrofits?*



# What's in a New Net Zero Home

## Enclosure

- R60 - R70 Ceilings
- R25 - R35 Walls
- R25 - R35 Basements
- R10 - R20 Slabs
- Tri-pane windows
- < 1.5 ACH@50 Pa



**+ Solar Panels**

## Mechanicals

- Heat pump
- Efficient back-up
- High efficiency DHW
- High efficiency ERV
- Drain water heat recovery
- LED lights
- ENERGY STAR appliances



# Case Study

## 1959 Two Storey Renewal

- Priorities: Livable basement, fix roof, better windows, mechanical repair/replacement, lower bills
- Would like to incorporate energy efficiency where possible
- Limited budget





# Case Study

## Before and After

	Pre-Reno (Oct 2010)	Post-Reno (Oct 2016)
ACH	5.36	4.72
Electricity (kWh)	13703	8978
Natural Gas (m3)	1567	1820
Total Energy (GJ)	108	100



# A Basement Example

Can you smell this basement right now?



*Is this a candidate for an  
energy improvement?*

## Gut It, Fix Water Issues





Clean It, then Insulate it



New HE furnace & Heat Pump

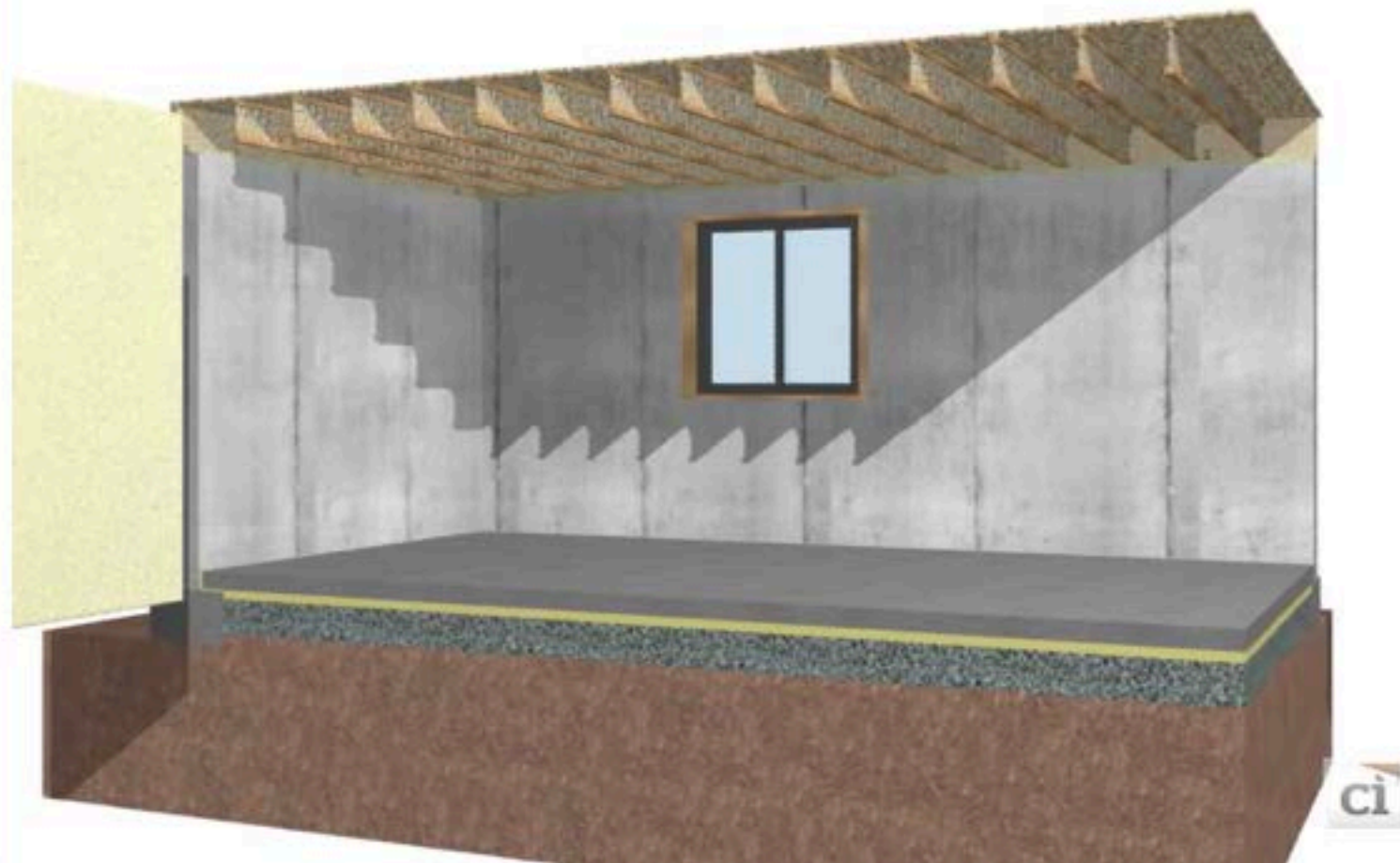
New windows

LED lights

HE water heater



# Proper insulation choices



## Floor Options in Existing Homes

Warmer, dryer,  
healthier





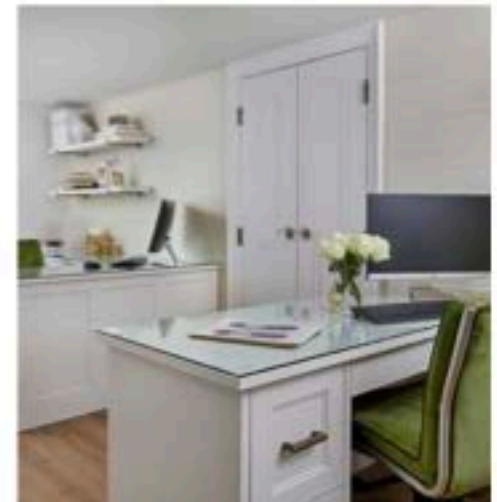
# Opportunities & Benefits

More livable space

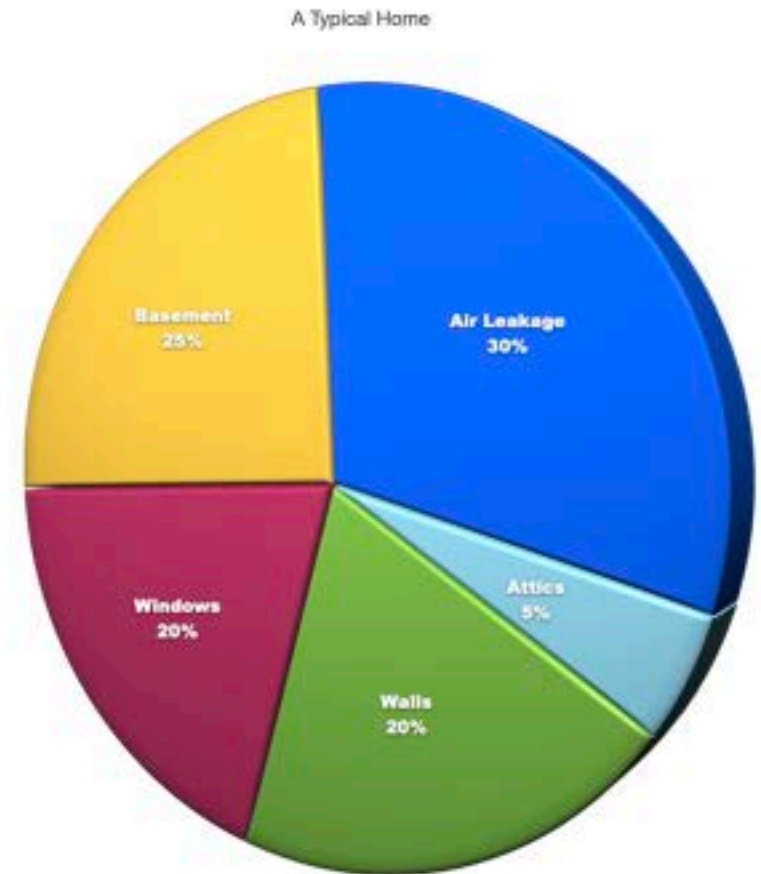
Healthier

Safer

+ 3-10 GJ Energy Reduction

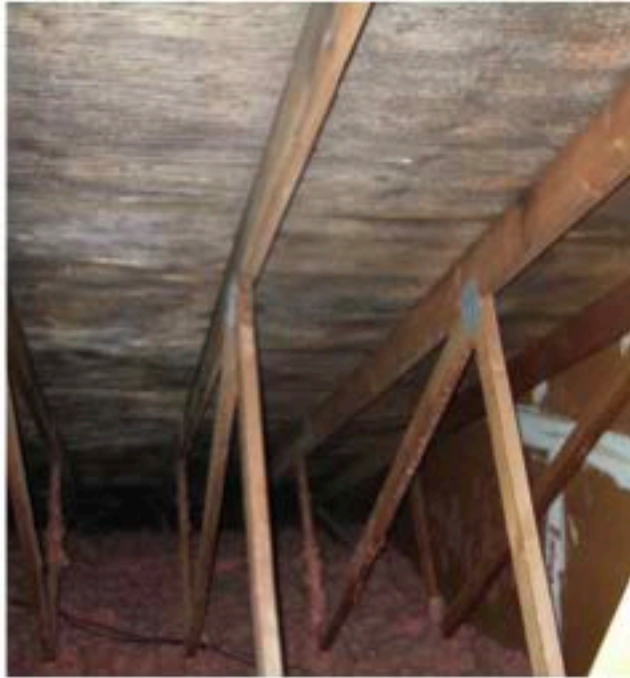


# Air Leakage - on the agenda for 40 years





This is **Air Leakage**



This is **Air Leakage**



This is **Air Leakage**



# Air Tightness Testing – Blower Door

- A critical component in energy audits
- Tested at 50 Pa = 30 kph wind pressure
- Exaggerates leaks to empower effective improvements
- Allows before / after comparisons

***You CAN'T insulate without air sealing***



## Other Benefits of Finding the Leaks



- Knowing where the bugs come in
- Knowing where the dust is coming from
- Knowing where the water is coming from
- Knowing where the noise is coming from
- Knowing how much they are WASTING

**Look for holes to seal in  
EVERY renovation project**

## Air Leakage - big holes



Look for holes to seal in  
**EVERY** renovation project





## HOW TIGHT ???

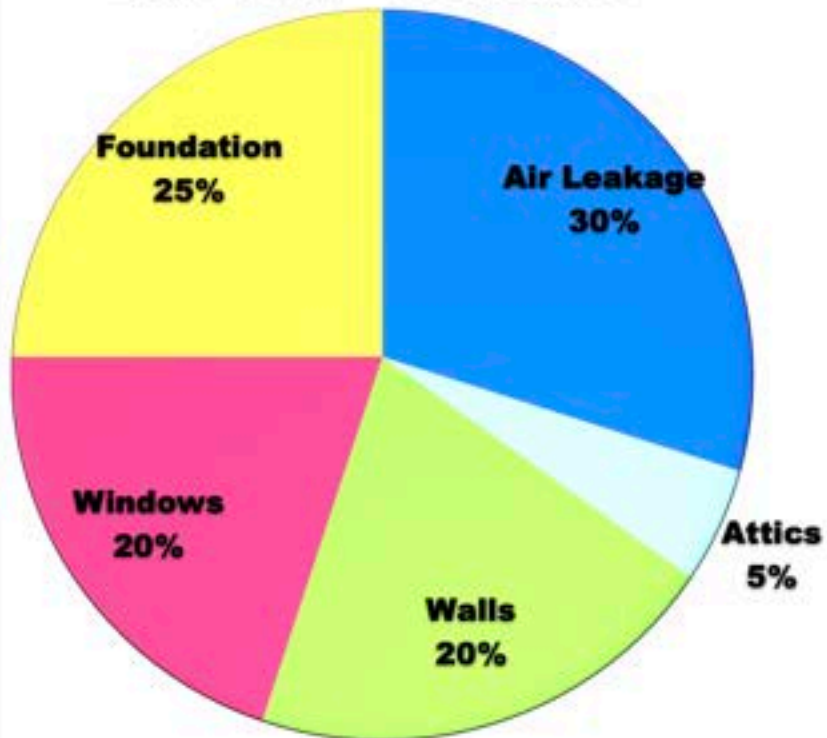
- “Canadian Code” 3.0 ACH@50
- ENERGY STAR 2.5 ACH@50
- R2000 1.5 ACH@50
- Passive House 0.6 ACH@50
- **Net Zero** <1.5

25% Improvement  
= 5 to 10 GJ

Tight Construction -  
Measured as Air Changes per Hour at 50 Pascal pressure

## Energy Impact of air tightness

2015 Code - 3.0 ACH50



The Heat Energy Loss in a 2350 ft<sup>2</sup> Home

ACH50

HOT2000 GJ

3.5

116

3

113.7

2.5

110.6

2

107.6

1.5

104.6

1

101.7

0.5

98.7

0.05

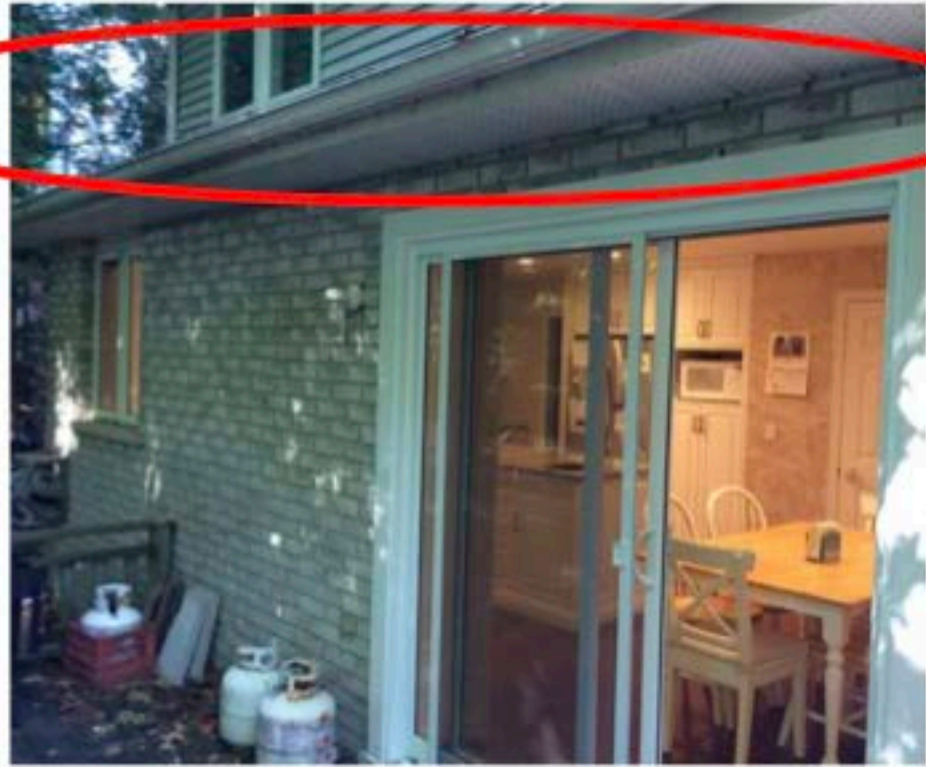
96.3

## A Kitchen Example





## Could There be More To It



Remove the drywall on the exterior wall

## What They Found

- 20 years of mice
- Wasp nests
- An improper electrical connection
- No air barrier
- Ineffective insulation



# The Result



## Energy Opportunities:

- New ENERGY STAR appliances
- LED lights
- Triple Glazed patio door & window

Safer, healthier, more comfortable – no mice



# Lets talk about windows

Do you want more or less?

Are they good from an energy perspective?

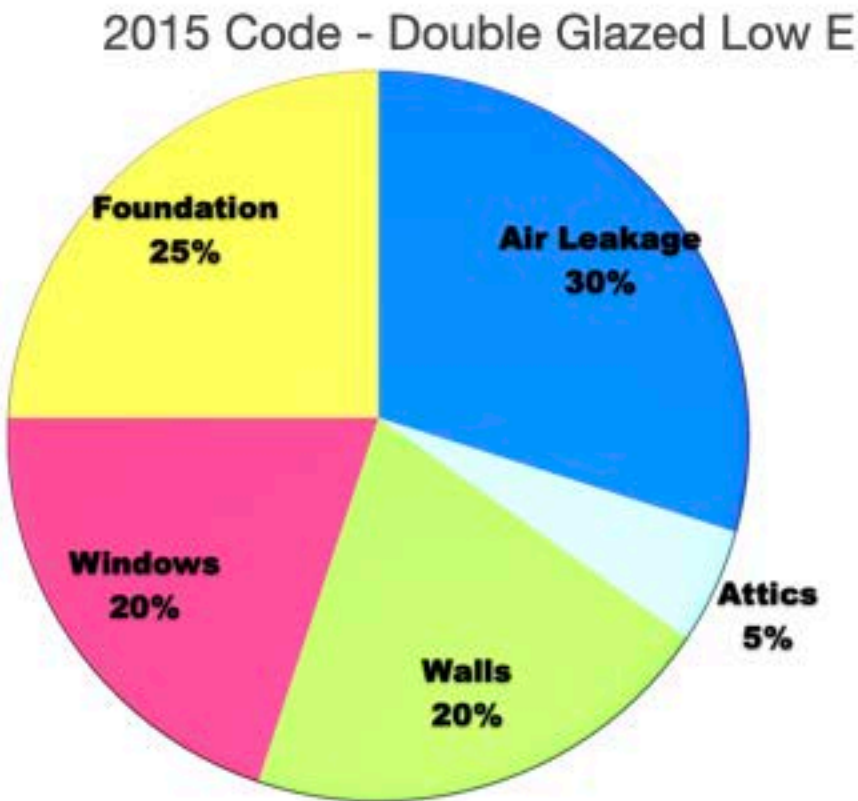
How about comfort?

What about condensation?

Impact on HVAC sizing

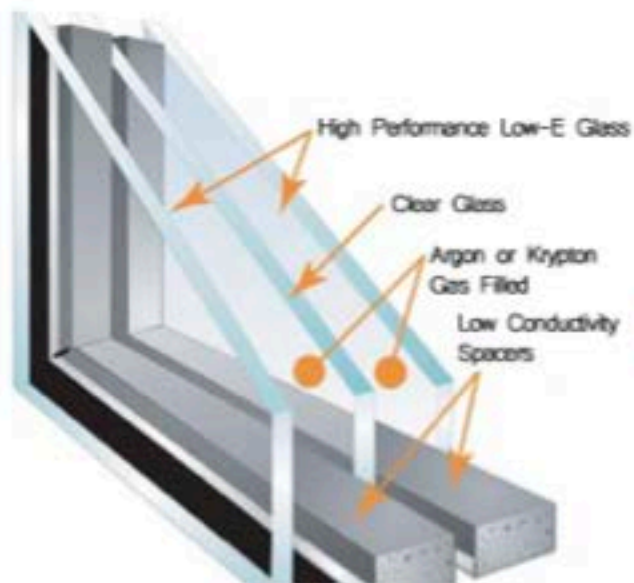


Energy Impact of windows - Halifax, Montreal, Ottawa, Calgary

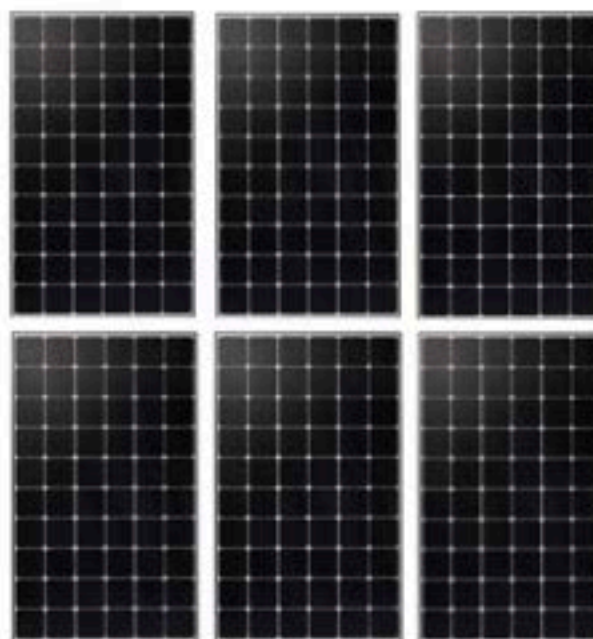


The Heat Energy Loss in a 2350 ft<sup>2</sup> Home

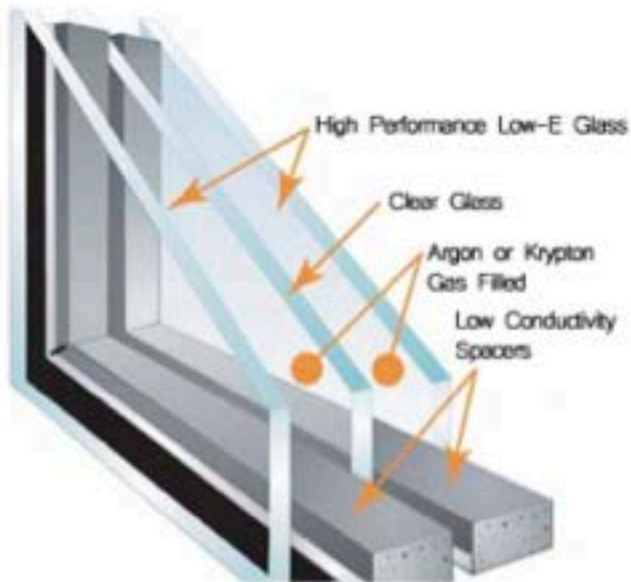
Windows	HOT2000 GJ
DBL / Low E	100.5
TRI / 1- Low E	96.6
TRI / 2-LowE	94.3



=



Triples = 4 - 6 Solar Panels



## Consequences:

Less moisture on surfaces

Allows higher indoor RH - 40%

Impact of solar gain

Manages comfort

Resizing mechanicals

Are there any building science consequences





**Canada**  
energystar.gc.ca

DO NOT REMOVE UNTIL FINAL INSPECTION/NE PAS RETIRER AVANT L'INSPECTION FINALE

**Energy Performance Ratings**  
**Évaluation des propriétés énergétiques**

U-Factor  
Facteur-U

**1.20**

W/m<sup>2</sup>·K

Solar Heat Gain Coefficient  
Coefficient de gain de chaleur solaire

**0.22**

Energy Rating  
Rendement énergétique

**25**

Visual Transmittance  
Transmission visible

**0.40**

**Window Company Ltd.**

Classic Double Hung  
Wood Frame, Metal Clad, Triple Glaze  
Low-e coating (e=0.022, S2, e=0.149, S3)  
Argon/air filled, Grills <=19mm  
WCDHTS2S3G



**Canada**  
energystar.gc.ca

DO NOT REMOVE UNTIL FINAL INSPECTION/NE PAS RETIRER AVANT L'INSPECTION FINALE

**Energy Performance Ratings**  
**Évaluation des propriétés énergétiques**

U-Factor  
Facteur-U

**1.93**

W/m<sup>2</sup>·K

Solar Heat Gain Coefficient  
Coefficient de gain de chaleur solaire

**0.47**

Energy Rating  
Rendement énergétique

**32**

Visual Transmittance  
Transmission visible

**0.42**

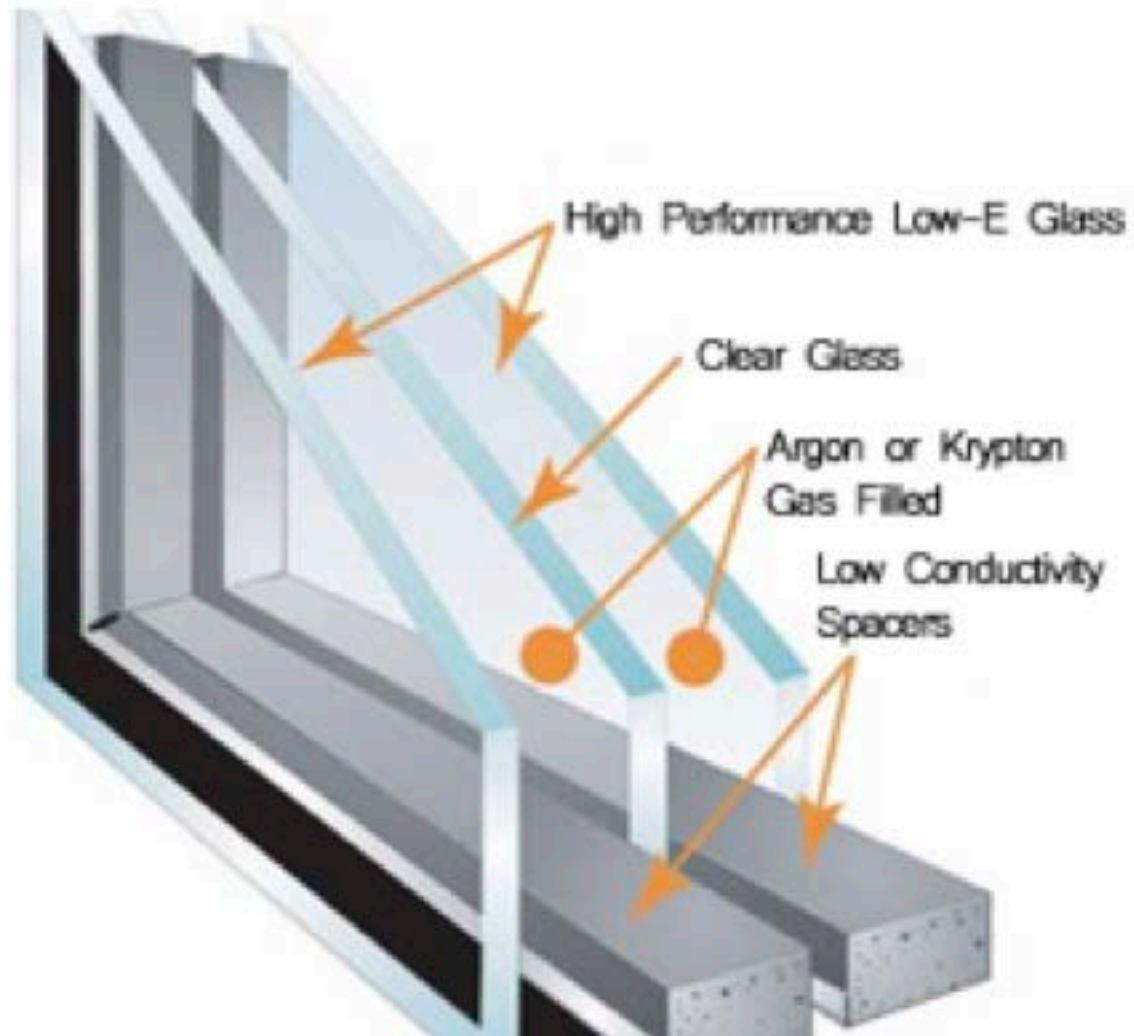
**Window Company Ltd.**

Optimal Sliding Glass Door  
Vinyl frame, Double glaze  
Low-e coating (e=0.022, S3)  
Argon/air filled  
NR9999-9999999-ES

**Windows - make the right choice**  
**It should be triples**

# Good Choices

Less condensation  
Avoid cooling loads  
Better comfort  
Quieter

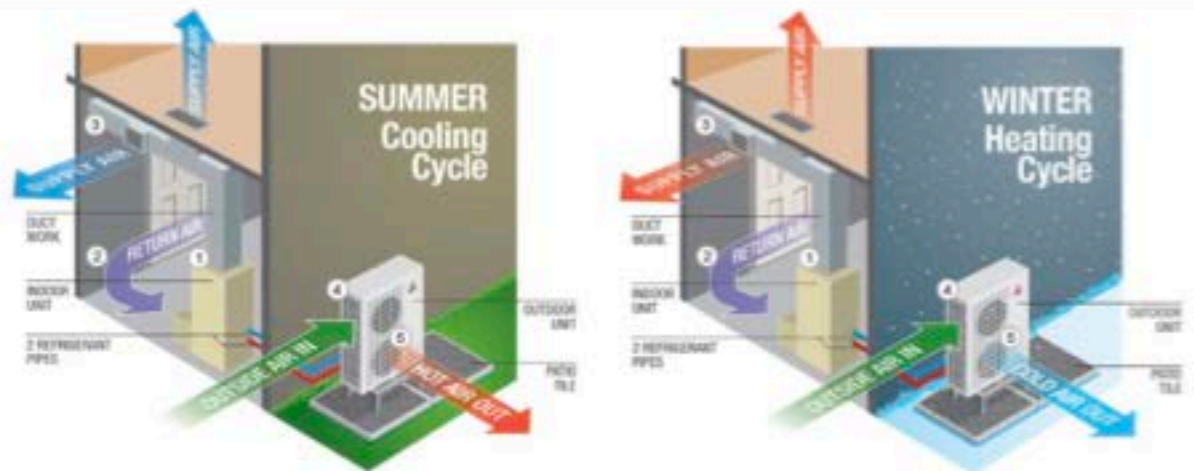


## 4. Mechanical

- Condensing gas furnace to higher efficiency gas furnace may not yield much savings
- For efficiency consider heat pumps
- For cost efficiency consider hybrid gas/heat pump
- Is it time to add balanced ventilation?



# Why Heat Pumps?



**Gas = 95% to 98%**

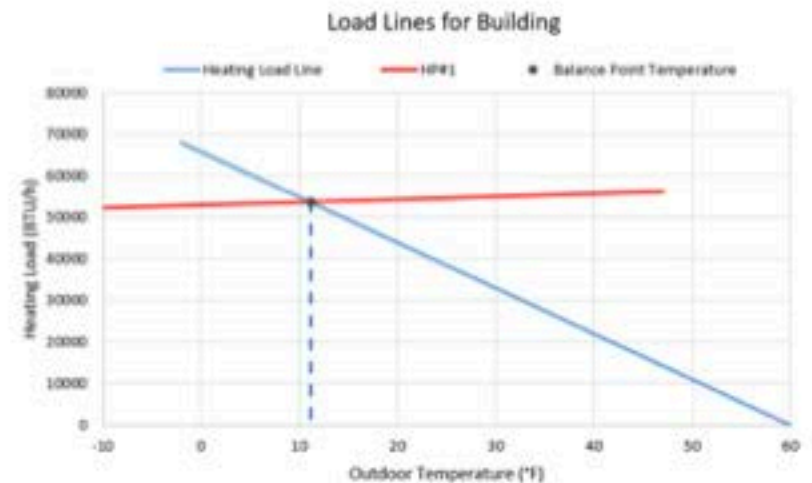
- For every \$1 of energy you buy or make you get \$3 to \$4 worth of heat
- They save about 10 GJs / yr

**300% to 400%**



# Sizing your Heat Pump

- Important to size properly to avoid unnecessary expense and get best performance
- Rule of thumb – size for cooling + 25%
- May require HL/HG calculation – CSA F280
- NRCan has Heat Pump Sizing Tool that can also do savings calculations

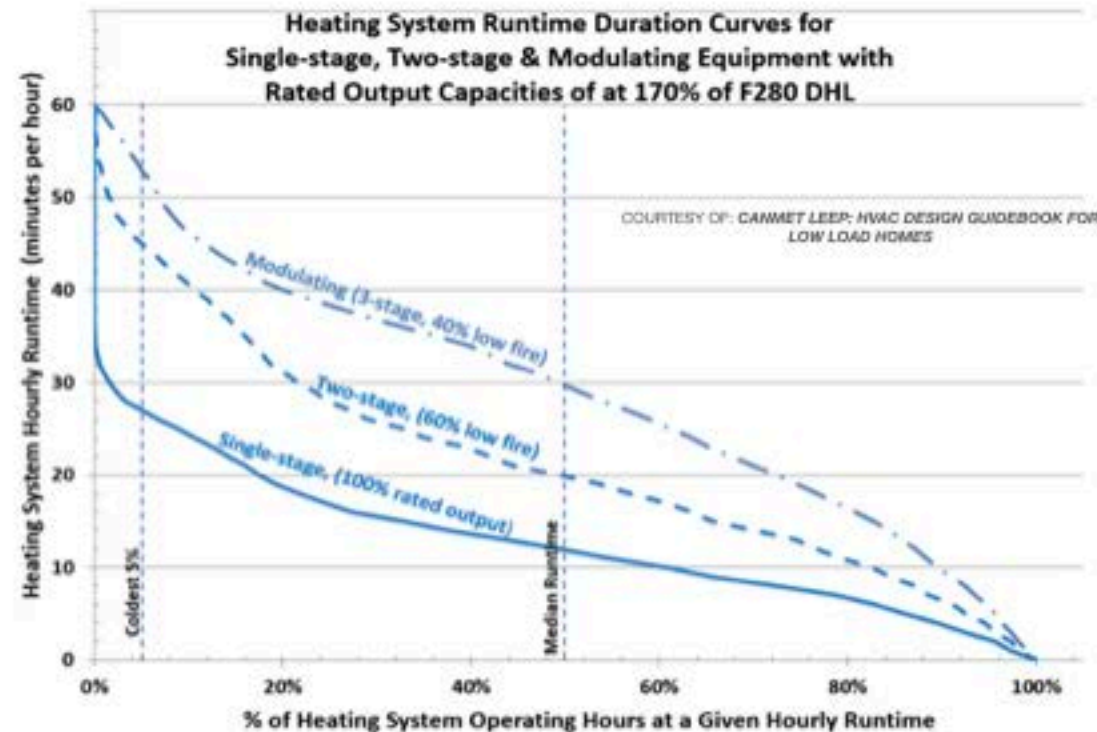


# Heating/Cooling Sizing

Be wary of just swapping equipment for same size

## Without proper sizing...

- Equipment too large: cycling of furnace and/or AC = uncomfortable temperatures and humidity



# Which homes would benefit from heat pumps?

## *Four distinct scenarios for electric heat pumps in Canadian housing:*

### The low-hanging fruit

Switching oil furnaces to heat pumps

- Saves energy, \$ and GHGs across Canada

**5-15 year payback**

(Cost of GHG saved: < \$0 / tonne)

### The toughest nut to crack

Switching gas furnaces to heat pumps

- Saves GHGs, but increases \$ in ON, MB and BC.
- Homeowners are worse off

**No Payback**

(Cost of GHG saved: \$70-300 / tonne)

### The cost-effective alternative

Switching electric baseboards to heat pumps

- Saves energy and \$ across Canada
- Saves GHGs in AB, SK, ON and Atlantic Canada

**5-15 year payback**

(Cost of GHG saved: < \$0 / tonne)

### Unintended consequences

Switching gas furnaces to heat pumps

- Increases GHGs and \$ in AB, SK and NS, due to extensive coal and oil based electricity generation in those provinces

**No Payback, no GHGs saved**

# Heating Costs

- Consider electricity costs more BUT...heat pumps are more efficient

2019	Electricity	Natural Gas	Propane
\$/kWh	\$ 0.150	\$ 0.022	\$ 0.094
\$/MJ	\$ 0.042	\$ 0.006	\$ 0.026
\$/GJ	\$ 41.53	\$ 6.06	\$ 26.19

	ASHP + HPWH	Natural Gas Heat & HW	Propane Heat & HW	Hybrid Heat & Gas HW
Estimated Annual Cost	\$ 2,564	\$ 1,754	\$ 3,122	\$ 2,027



# Deep Energy Retrofit - Toronto

**Location:** Toronto, ON (Leaside)

**Year built:** 2012

**Size:** 3609 square feet

Lower level: 1123 sq. ft

Main floor: 1170 sq. ft

Second floor: 1315 sq. ft

**Energy Renovation date:**

May 2021



## Case Study - Energy Efficiency Upgrades Chosen

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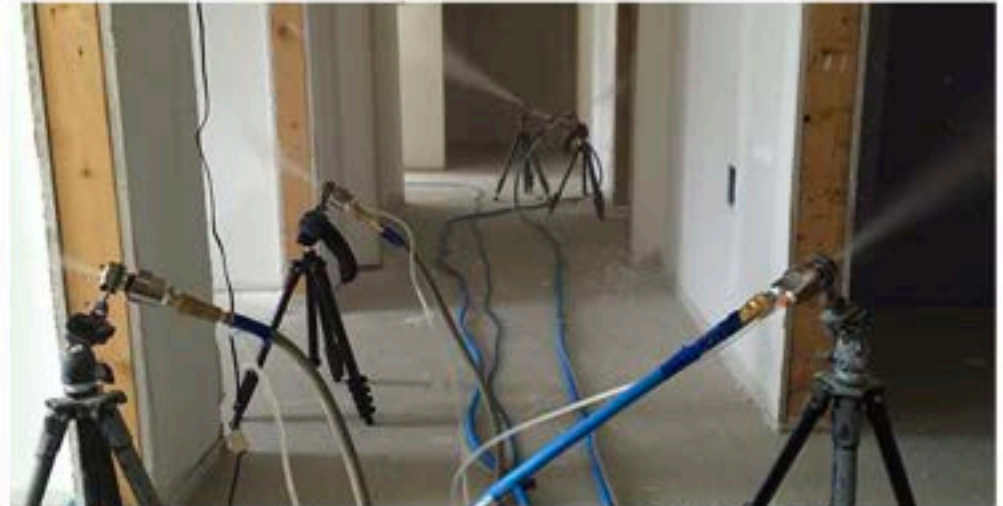
### 1. Address air leakage:

- Air tightness improvements using innovative AeroBarrier technology

### 2. Improve mechanical systems

- Maximize gas furnace efficiency - 99% AFUE
- Implement a "hybrid heating" strategy by including an air source heat pump
- Improved air conditioning performance
- Improved ventilation performance - High efficiency HRV
- Improve domestic hot water heating performance - condensing water heater
  - additional modelling of a heat pump water heater
- Reduced forced air duct leakage to improve comfort control

They used a  
New Technology  
to improve air tightness



**AEROBARRIER**

Breakthrough Evaporative Sealing Technology By Aerosol

**Certificate of Completion**

Evaporative Sealing Performed For:  
ACHS - 800 North 800th Ave  
TOMES  
4870 DOWLING ROAD  
Dewey's Bay, CHANDLER, ARIZONA

**Overall Sealing Results:**

When test started:  
YOUR HOME A/C:

225.0 CFM air leakage, equivalent to a  
61.4 Square Inch Hole or 0.11 Air  
Changes per Hour

At end of 24 hours test stopped and leakage  
measured at 5.00 CFM per hour

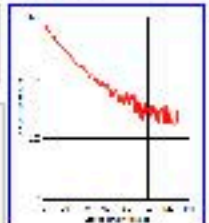
After test finished:

YOUR HOME A/C:

5.00 CFM air leakage, equivalent to a  
0.013 Square Inch Hole or 0.0022 Air  
Changes per Hour

This corresponds to a 97.8% Reduction in  
leakage (air changes).

Note: Evaporative sealing and air change results  
are calculated at standard pressure and 68°F.



Installation of: AEROBARRIER  
Contract Date: 1/15/2014  
Contract Location: Chandler, Arizona  
Technician: [Name Redacted]  
Address: [Address Redacted]

**AEROBARRIER**  
AEROSOL TECHNOLOGY, LLC



# Deep Energy Retrofit - Summary Results

## Modelled Savings

Scenario	Heat Loss BTUs/hr	Annual Space Heating Energy	Annual Space Cooling Energy	Utilities
Original	41,900	62.8 GJ	82.8 GJ	\$2300 + tax
After	32,200	19.4 GJ	35.2 GJ	\$2800 + tax

- A 69% reduction in annual space heating energy use from 4 energy efficiency measures
  - Improve efficiency of furnace from 90% to 99% AFUE
  - Improve HRV performance from 55% to 79% SRE
  - Add an air source heat pump to create a "hybrid heating" strategy
  - Improve air tightness from 3.5 ACH to 2.1 ACH using AeroBarrier air sealing technology
- A 57% reduction in total annual energy use and green house gas emissions for space conditioning and DHW



## Walls - When Residing



Add exterior Insulation



Install a Thorough Weather / Air Barrier

## The History



Nominal  
R-Value

R12

R20

R24

R35

Effective  
R-Value

R10.3

R15

R16

R18.1

# Effective R-value

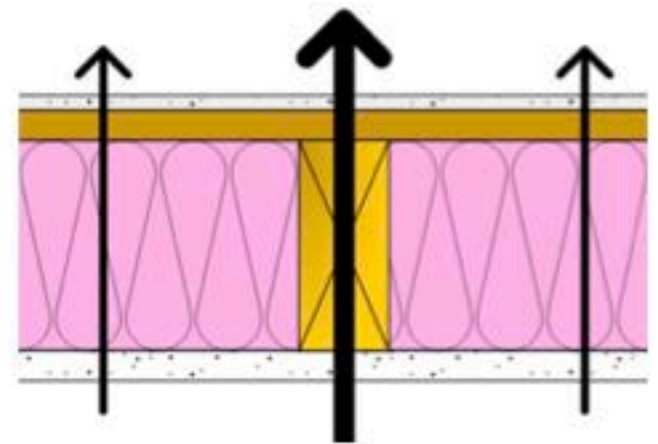
The switch from Nominal to Effective R value is a fundamental change in approach:

- **NOMINAL:** Ignores Thermal Bridging
- **EFFECTIVE:** Accounts for Thermal Bridging

Heat flows more easily through wood studs

2" x 6" stud = R-6

Insulation cavity = R-19+



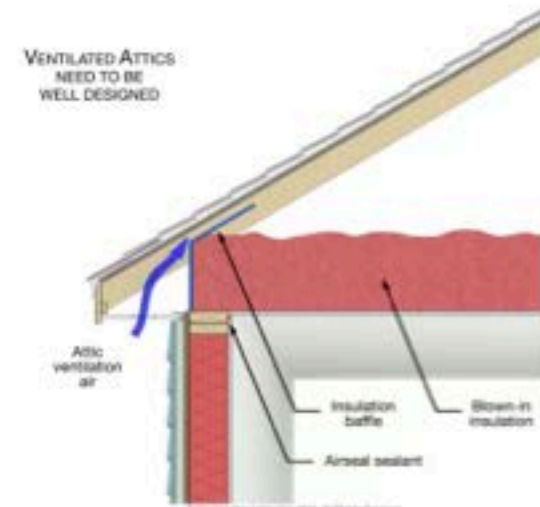
## Adding R10 Improves Performance by 70%

Framing Percentage	R-Value	
	Cavity	Studs
<b>23%</b>		
Outside air film	0.17	0.17
Exterior insulation	<b>10</b>	10
7/16" OSB	0.62	0.62
Cladding/Siding	0.62	0.62
Framing - 2 x 6	n/a	5.83
cavity insulation	<b>19</b>	n/a
½" gypsum	0.45	0.45
Interior air film	0.68	0.68
<b>Sub-Totals</b>	31.54	18.37
<b>Total EFFECTIVE R- Value</b>	<b>25.04</b>	



## 5. Adding to other reno's

- Kitchen reno – Insulate behind walls, ENERGYSTAR appliances
- Bath reno – Consider tankless or water heater upgrade, air sealing, improve ventilation
- Roof replacement – Top up attic, improve attic ventilation, air seal if possible, time to consider solar PV?



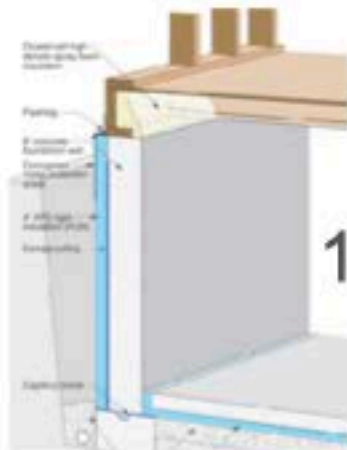
## Evaluating Choices, Alternatives & Options



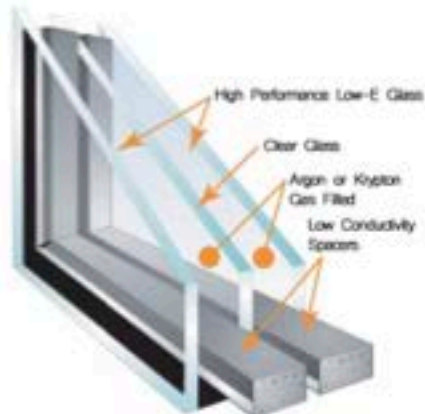
6 GJ



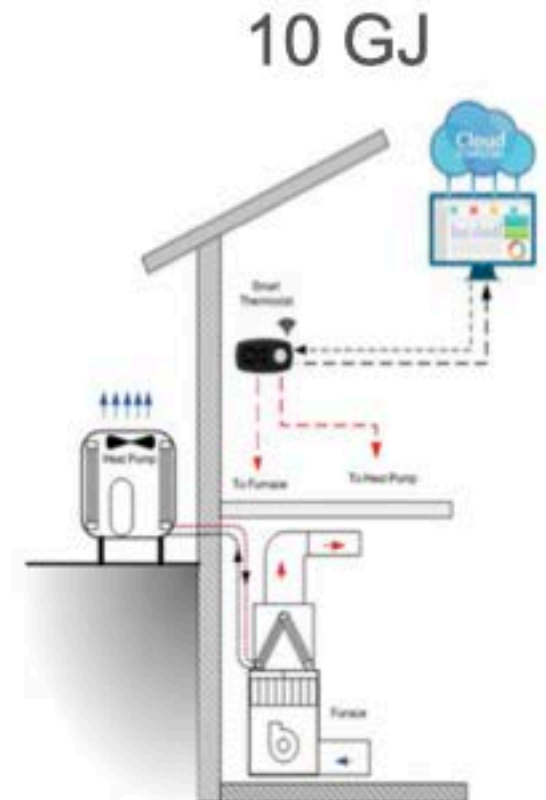
9 GJ



10 GJ



6 GJ



# What's Practical?

## Enclosure

- ✓ R60 - R70 Ceilings
- R25 - R35 Walls
- ? R25 - R35 Basements
- R10 - R20 Slabs
- ✓ Tri-pane windows
- ? < 1.5 ACH@50 Pa



? Solar Panels

## Mechanicals

- ✓ Heat pump
- ✓ Efficient back-up
- ✓ High efficiency DHW
- ✓ High efficiency ERV
- ✓ Drain water heat recovery
- ✓ LED lights
- ✓ ENERGY STAR appliances

## Include in Every project

- An energy assessment
- Air sealing
- More insulation, properly installed
- Repair of moisture issues
- Continuous ventilation
- Assessment of combustion safety



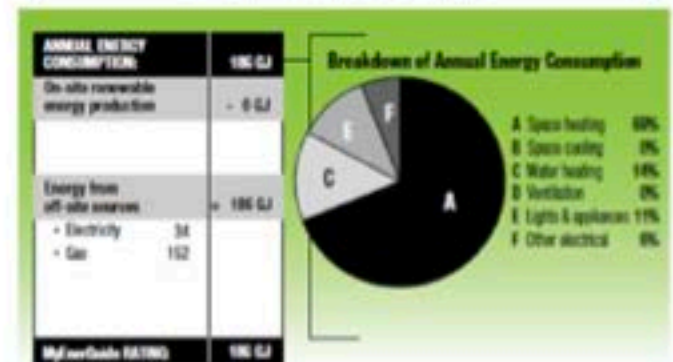
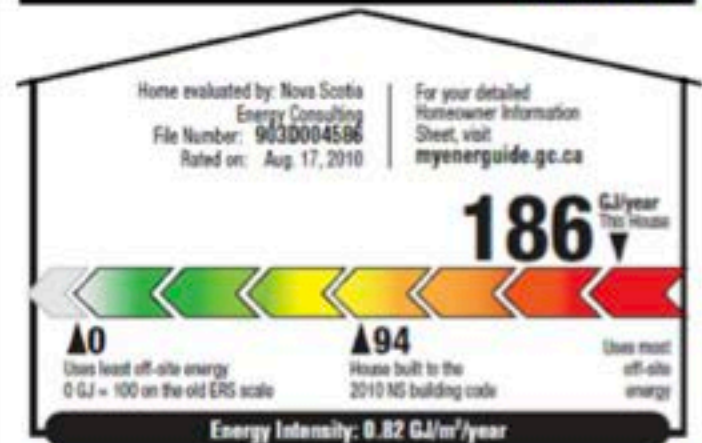


# THE NEW METRIC - GigaJoules

**1 GJ = 278 kWh of energy**

ENERGUIDE Rating includes:

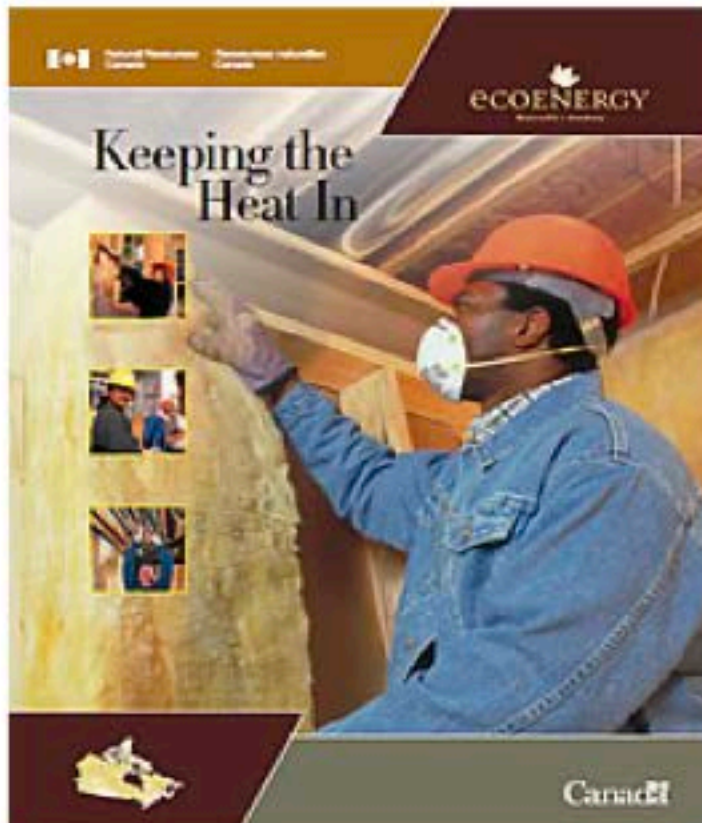
- Energy for heating
- Energy for cooling
- Energy for ventilation
- Energy for normal lights & appliances
- Energy for normal hot water use
- Energy produced by on-site renewables



Annual Greenhouse Gas Emissions: 13 tonnes



# There are Best Practice Guides to Help



## ABOUT YOUR HOUSE

CE 281

### Before You Start an Energy-Efficient Retrofit—The Building Envelope

The building envelope is the outer layer of the building that separates the living space from the outdoor environment, both above and below grade. Many older homes have high heating requirements because of high rates of air leakage and building envelope areas that are not well insulated.

Like any renovation, retrofitting the building envelope requires careful planning. Before you decide to go ahead with the project, it is important to clearly identify the areas that you want to improve. Just as important is a thorough inspection of the existing structure so that any current problems can be estimated.

#### HEALTHY HOUSING™

There are many ways to improve the energy efficiency of the building envelope and make your home healthier for you, the community and the environment. When retrofitting the building envelope, be sure to consider:

- **Occupant health**—minimize control strategies, use of low emissions

materials and products, ventilation for improved indoor air quality.

- **Energy efficiency**—effective air and moisture barriers and insulation, energy-efficient windows and HVAC systems.

- **Resource efficiency**—materials with recycled content, building details that minimize the amount of material used.

- **Environmental responsibility**—durable materials that will last longer and minimize future waste in landfill sites, recycling fixtures to reduce construction waste.

- **Affordability**—a tight, well-insulated building envelope to reduce ongoing operating costs, durable products to reduce future repair and replacement expenses.

#### COMMON SITUATIONS

Many homeowners suffer for years, living in houses that are cold, drafty or have high heating bills, especially on windy days during the heating season. The process of improving

the energy efficiency of the entire building envelope can seem like an overwhelming task. An understanding of the principle that the house functions as a system (see the House as a System section) is critical for anyone undertaking a building envelope retrofit. Prioritizing the different aspects of the work and learning about viable retrofit techniques can help you to work through the many decisions that must be made.

To help you recognize problems and to plan an energy-efficient retrofit, consider these important areas:

- **Assessing the building**—the house may be cold, drafty and expensive to heat. A thorough assessment of the building envelope is critical and will help you to prioritize the different aspects of the work.

- **Structural problems**—there may be structural or water leakage problems. Any existing problems and damage must be repaired as part of the retrofit project.

Canada



CMHC, NRCan, Utilities, Leading Manufacturers  
Enbridge





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A quarterly newsletter you'll want to actually read.

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- ✓ Industry highlights
- ✓ Industry and BKC updates
- ✓ Articles of note
- ✓ Building science events
- ✓ Webinar announcements

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UPCOMING WEBINARS

## 2022 ADVANCED BUILDING SCIENCE WEBINAR SCHEDULE **IS POSTED!**

VISIT <https://buildingknowledge.ca/events/> TO SIGN UP.

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CRITICAL CANADIAN HOME BUILDING SCIENCE PART 1:

### IAQ Details for High Performance Homes

April 14, 2022 1:00-2:30 PM (EST)



Gord Cooke  
Building Knowledge Canada

ENBRIDGE GAS PROVINCIAL ADVANCED BUILDING SCIENCE SERIES  
In Partnership with: Enbridge Gas and Building Knowledge Canada

NEW FOR 2022

### Construction Heat and Appliance Commissioning





May 12, 2022 1:00-2:30 PM (EST)

# Thanks for attending!

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