Energy, carbon, and resiliency - Getting your home ready for the future, today.

Patric Langevin, M. Arch – Glebe resident and building science professional

Why are we having this conversation?

"Scientists estimate that, each day, our added emissions trap the heat equivalent of four hundred thousand Hiroshima-sized bombs"

That is the equivalent of 4.6 Hiroshima-sized bombs every second. Most of that heat is going into the oceans.

Bill McKiben, article in the New Yorker, April 27th 2018
https://www.newyorker.com/science/elements/hiroshima-kyoto-and-the-bombs-of-climate-change

Summary of Future Climate in Canada's Capital Region

What to expect*	2030s	2050s	2080s
Temperature			
Average temperature	↑ 1.8°C	↑ 3.2°C	↑ 5.3°C
Very hot days (above 30°C)	2.5 times more	4 times more	6.5 times more
Very cold days (below -10°C)	20% less	35% less	65% less
Seasons			
Winters shorter by	4 weeks	5 weeks	8 weeks
Springs earlier by	2 weeks	2 weeks	4 weeks
Winter freeze-thaw	↑ 15%	↑ 35%	↑ 55%
Precipitation			
Fall-winter-spring precipitation	↑ 5%	↑ 8%	↑ 12%
Intense precipitation	↑ 5%	↑ 15%	↑ 20%
Snowfall	↓ 10%	↓ 20%	↓ 45%
Extreme Events			
	Possible increases in freezing rain		
	Warming favours conditions conducive to storms, wildfires		

More certainty ↓ Less certainty

** For high emission Scenario RCP 8.5*

More certainty → Less certainty

June 2020, NCC & City of Ottawa report, Climate Projections for the National Capital Region.

Presentation Outline

1. Why do a deep energy / carbon retrofit?
2. Set your objectives.
3. Consider what is possible.
4. Establish a game plan and timeline.
5. Estimate the costs.

Presentation Format

- Presented in the form of a case study.
- Energy, carbon and resiliency considerations scaled to:

<u>32 Ella Street (my home)</u>

- Typical 1750 ft2 single family detached home
- Built 1902 (121 years old)
- 2.5 storeys, brick home, small rear addition
- Rubble foundation

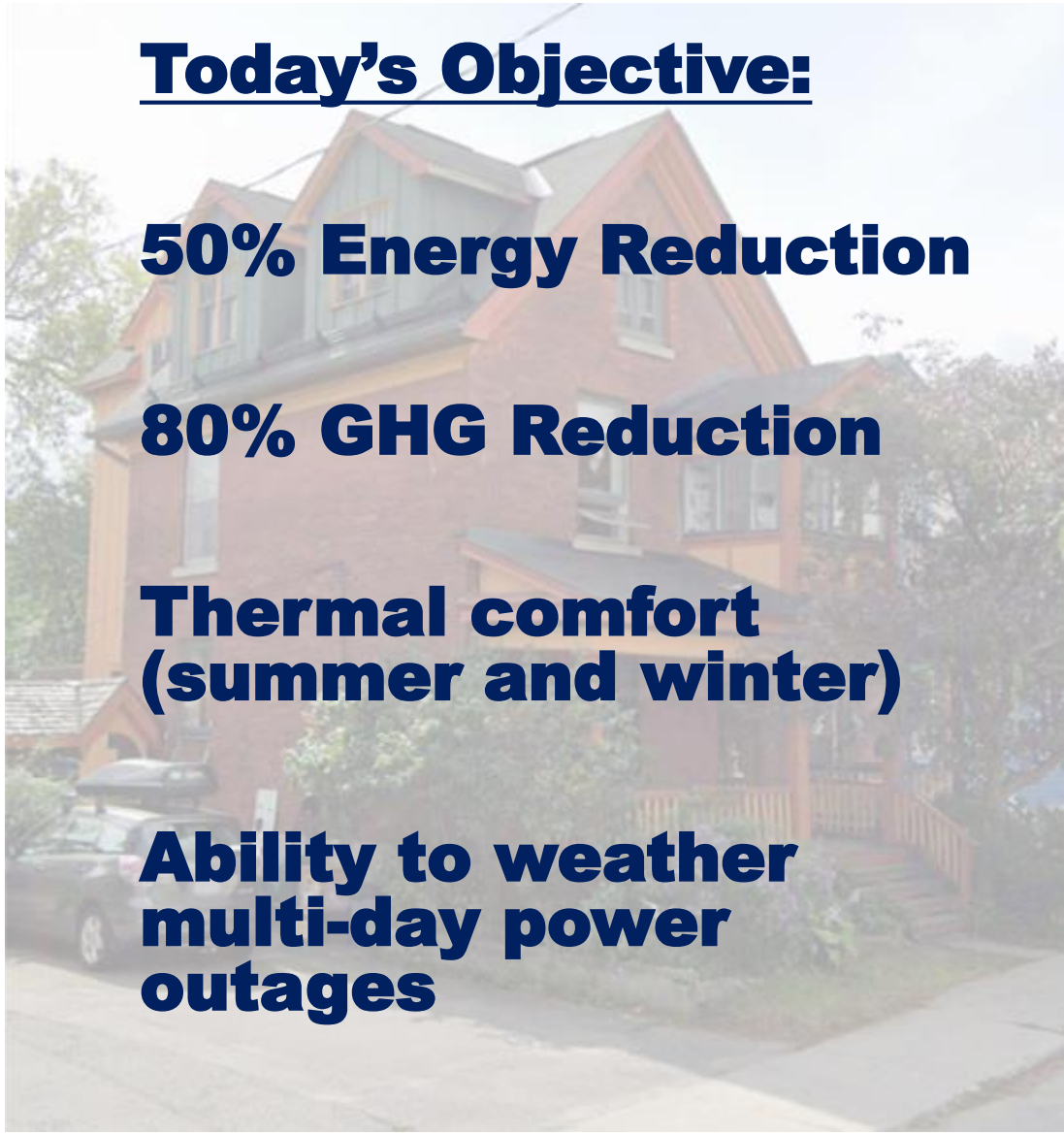
Upgrades to date: cellulose in cavities, insulated basement, some window upgrades, condensing natural gas furnace, 5.2 kW PV array.

1 – Why do a deep energy, carbon or resiliency retrofit?

- Reduce environmental impact
- Reduce energy bills
- Improve thermal comfort
- Aesthetics
- Indoor air quality
- To correct building science issues
- Improve resilience to extreme weather
- Improve survivability in the event of power outages
- Others?

2 – Set your objectives

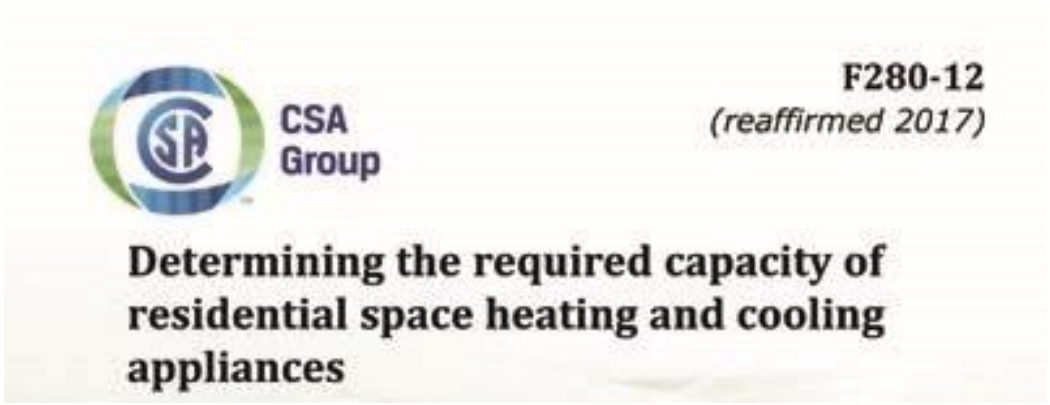
1. Home comfort?
2. Energy cost reduction?
3. Environmental impact?
4. Safety in the event of climate risks?



2 – Set your objectives

To start you will need…

1. An **energy evaluation** to help you set your targets
2. Your home's **heating and cooling loads**. New tools are coming online to help!
3. In a perfect world… a **duct flow test** to help better size HVAC equipment.



Blower door test underway at 32 Ella Street

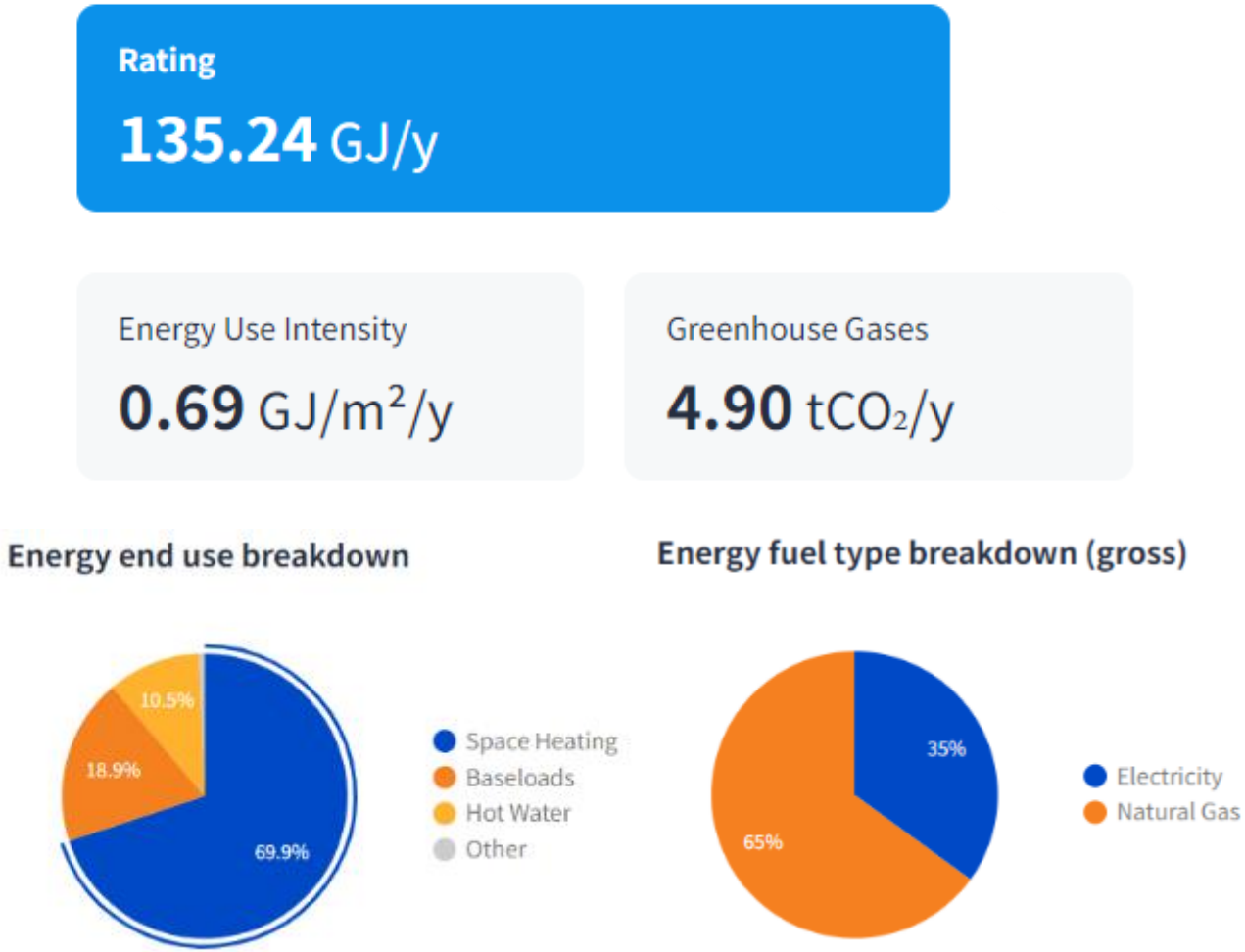
Duct flow test underway at 32 Ella Street

3 – Consider what is possible

Energy evaluation of 32 Ella Street:

House Components	Existing Home
ENVELOPE	
Cathedral / Vault / Flat	R40 batt
Above Grade Walls / Garage Wall	R3.4/in blown cellulose
Foundation Wall	None
Windows & Sliding Glass Doors	Double glazed (U-val=2.16, SHGC=0.35)
Doors	Solid wood (R2.2)
Airtightness	10.0 ACH
HVAC	
Principle Ventilation	None
Space Heating	95.0% AFUE furnace
Cooling & Heat Pumps	None
Domestic Water Heater	0.83 EF electric conventional tank
Drain Water Heat Recovery	None

Energy evaluation helps you determine where you are and your targets.



4 – Consider what is possible

32 Ella Street targets:

Rating

135.24 GJ/y

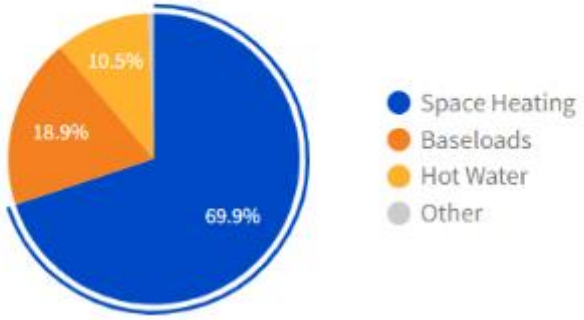
Energy Use Intensity

0.69 GJ/m²/y

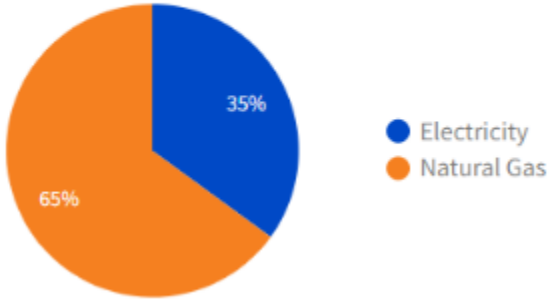
Greenhouse Gases

4.90 tCO_2/y

Energy end use breakdown



Energy fuel type breakdown (gross)

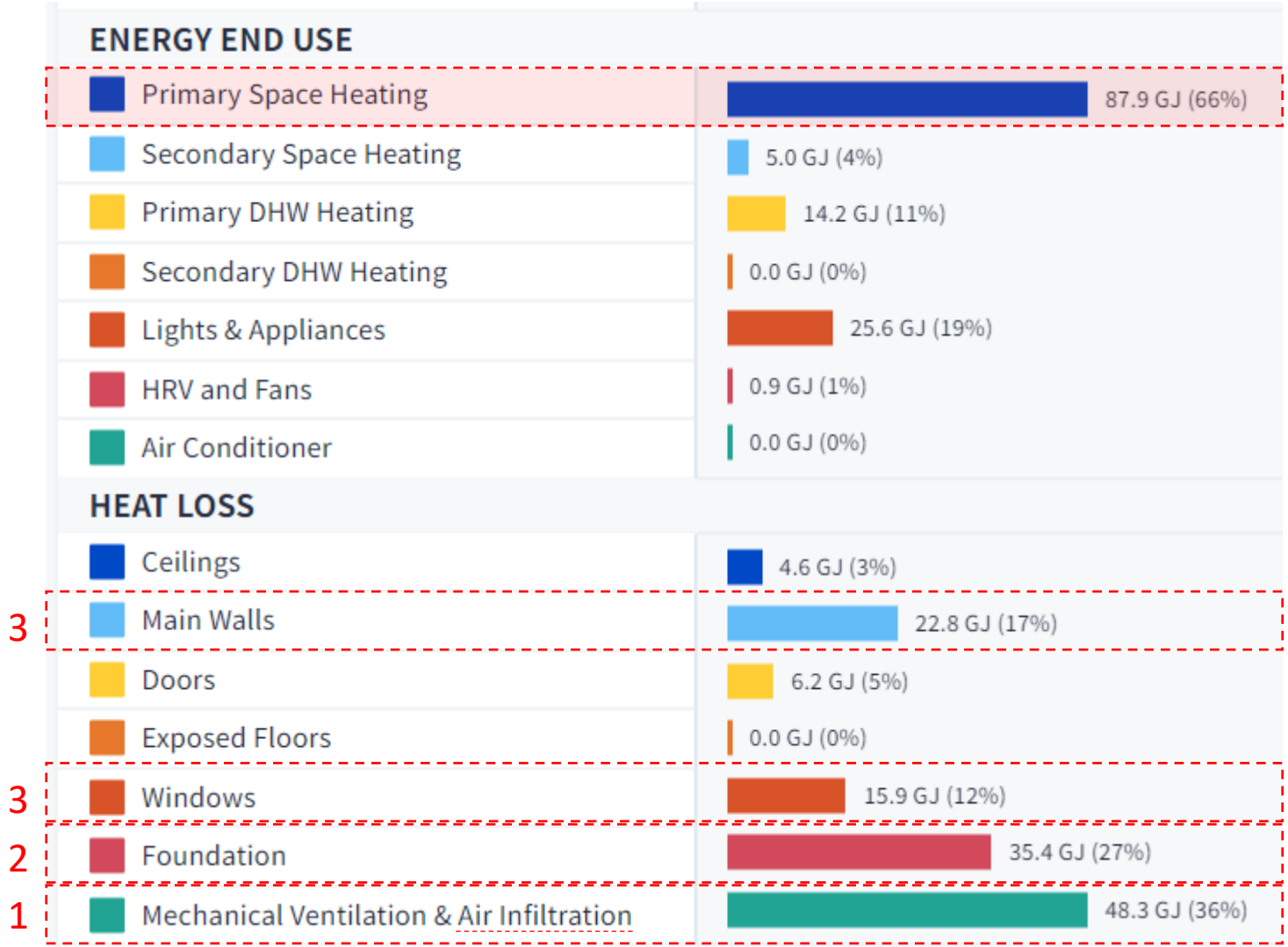


ENERGY TARGET = 68 GJs

GHG TARGET = 0.98 tCO_2/y

3 – Consider what is possible

- Consider the building envelope first!
- Reducing heat loss improves comfort and conserves energy and operating cost
- What are my main loads?
- Where should I put the priority?



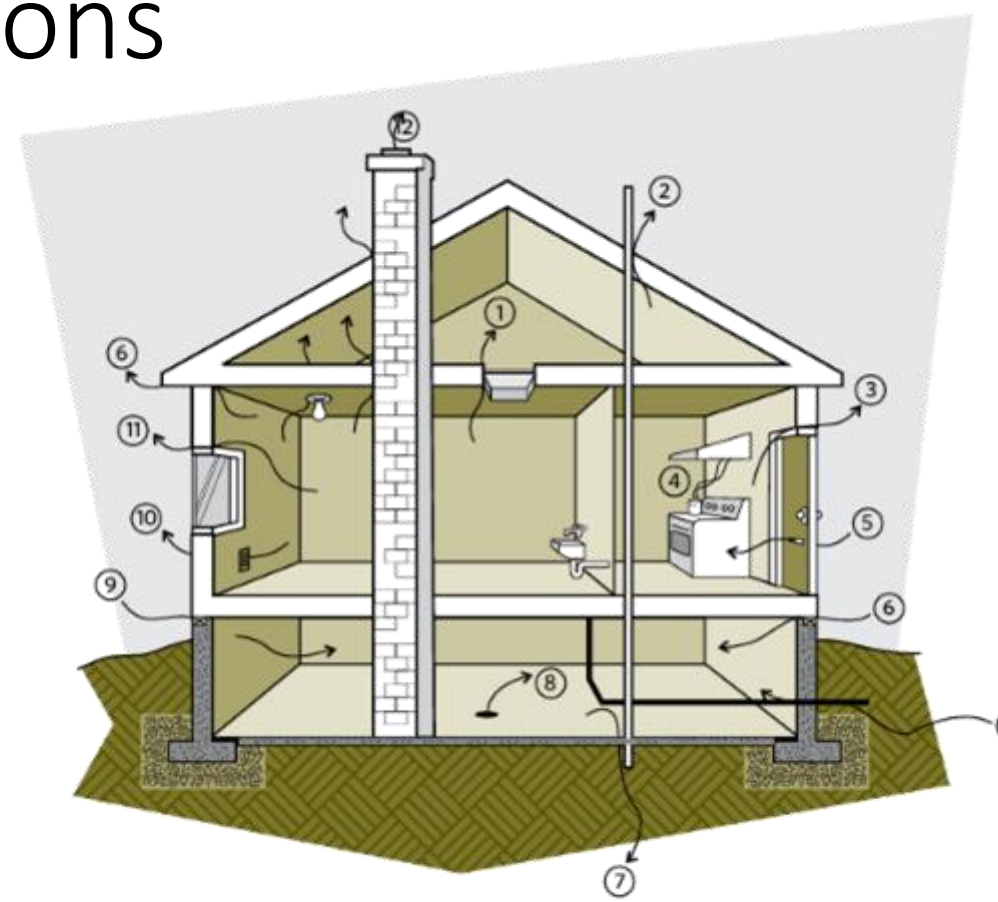
3a – Envelope considerations

Air Infiltration:

- Current Air change rate is 10.
- Can we do better? How?
- What will be the impact?

Reducing air leakage from 10 ACH50 to 4 ACH50 provides a saving of:

17.3 GJ or 25% of our target reductions!



Where to look

Key locations to check for leaks

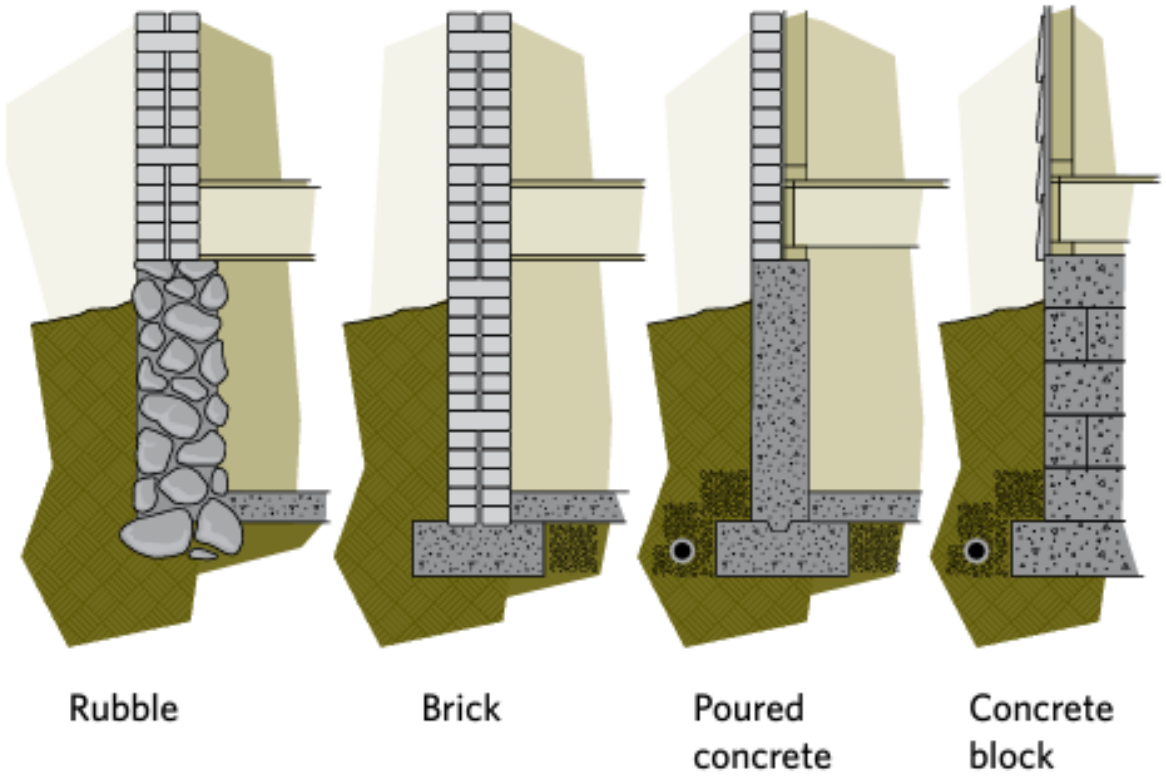
1. attic hatch
2. ceiling penetrations into the attic
3. door
4. exhaust vent
5. mail slot
6. sill and header
7. service entry
8. floor drain
9. foundation crack
10. electrical outlet
11. window
12. chimney

Keeping the Heat In, Natural Resources Canada: https://natural-resources.canada.ca/sites/www.nrcan.gc.ca/files/energy/pdf/housing/Keeping%20the%20Heat%20In_e%20.pdf

3a – Envelope considerations

Foundation:

- Currently the basement is un-insulated
- Conduct some analysis with your energy advisor to determine how much insulation to add.
- Assess the type and condition of your foundation.
- Work with an experienced foundation contractor to do the work.



Keeping the Heat In, Natural Resources Canada:
https://natural-resources.canada.ca/sites/www.nrcan.gc.ca/files/energy/pdf/housing/Keeping%20the%20Heat%20In_e%20.pdf

3a – Envelope considerations

What we did to our home:

- Insulation was added from the inside.
- R-25 effective was added as follows:
  - 2” Faced EPS Insulation with seams taped
  - 2x6 wall with R-22 batts
  - selective vapour membrane
  - ½” drywall

For this home, adding R-25 (effective) thermal resistance provides a saving of:

24 GJ or 35% of our target reductions!

Rigid insulation foamed into the joist cavity

R-22 Mineral wool batt insulation and selective vapour membrane

3a – Envelope considerations

Main Walls and Windows:

- Currently the above grade walls have an effective R-value of 13.7 (a new home in Ontario is typically R-17 to 21, a NZE home is R-24 to R-30)
- Can we add insulation to these walls? Can we change the windows?
- What would be the impact?

3a – Envelope considerations

Main Walls and Windows:

- Removal of exterior cladding is not feasible for cost and/or aesthetic reasons.
- Windows can be updated to triple glazed. *Important! Comfort and indoor air quality improvements result from this upgrade*

Replacing the old windows with new triple glazed windows would save:

4 GJ or 6% of our target reductions

Recently installed triple glazed window

MOLD AND MOISTURE ACCUMULATION DUE TO CONDENSATION

Recently installed double glazed window

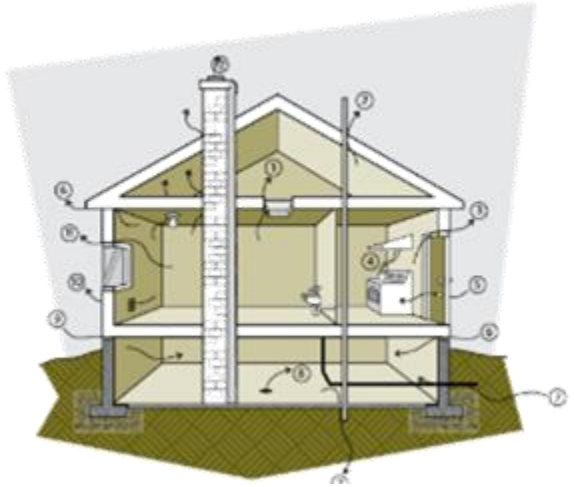
3a – Envelope considerations

- Savings threshold for envelope upgrades before considering Heat Pumps:
  - Reduced Air Leakage = 17 GJs
  - Insulate Foundation = 24 GJs
  - Replace windows = 4 GJs

Potential Energy Savings = 45 GJs (66% of our target savings!)

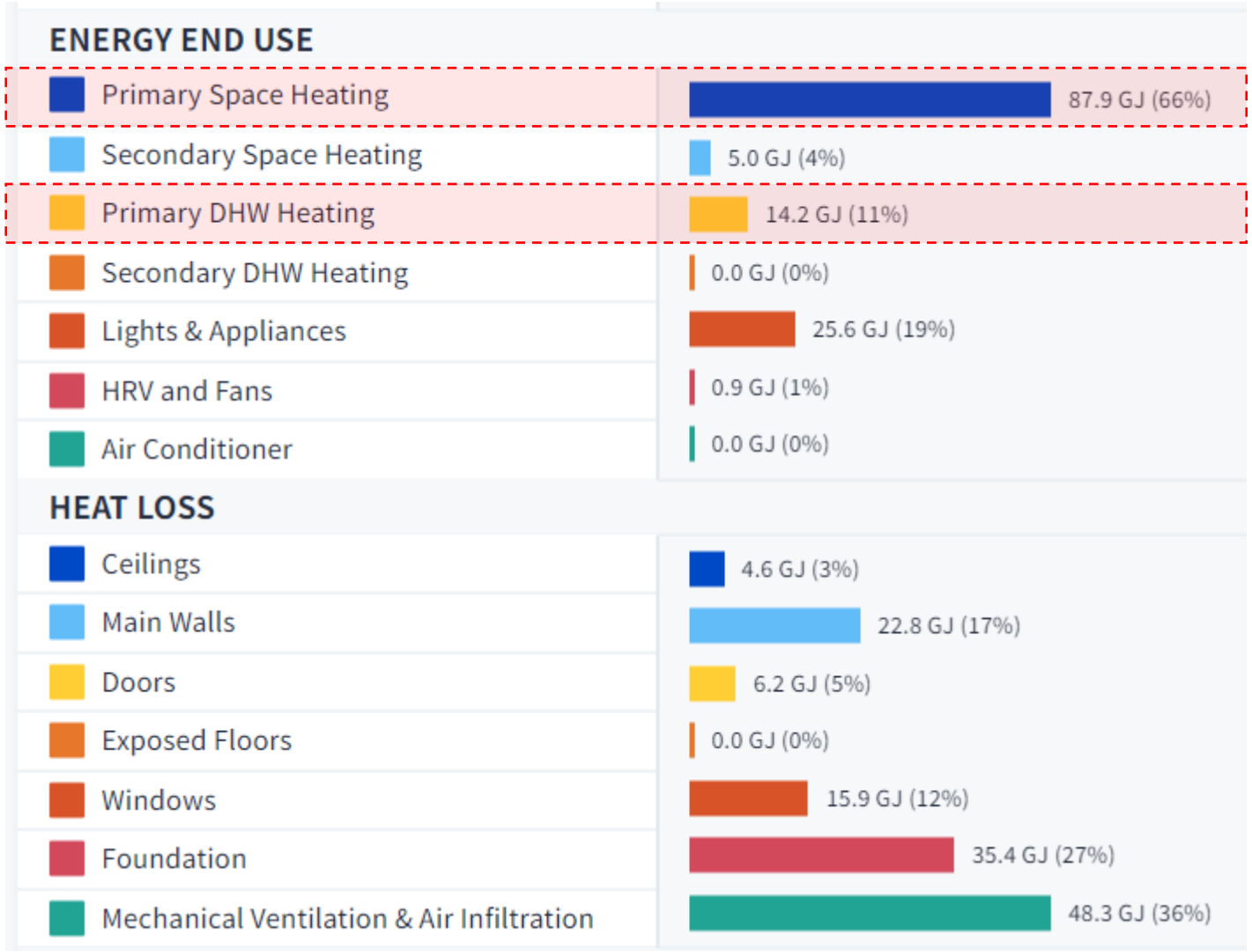
(33% of overall energy savings)

If no other measures, annual energy bill reduction of ~$400 & 40% GHG reduction (2 Tons)



3b – HVAC and DHW Systems

- What can be achieved with heat pumps?



3b – HVAC and DHW Systems

12000 Btu/h = 1 Ton heating

- CSA F280-12 result before upgrades:

Heat Loss/Gain Summary

Design Heat Loss		Design Heat Gain (Sensible + Latent)	
68796 Btu/h	5.7 Tons of heating	**23335** Btu/h	2 Tons of cooling

- CSA F280-12 result after upgrades:

Heat Loss/Gain Summary

Design Heat Loss		Design Heat Gain (Sensible + Latent)	
47470 Btu/h	4 Tons of heating	**17432** Btu/h	1.5 Tons of cooling

31% reduction in heating equipment size

3b – HVAC and DHW Systems

Duct Flow Test Results:

900cfm @ 0.6 inches static pressure

Most heat pumps require 400 CFM per Ton of heating.

Result: 2 to 2.5 Ton inverter driven cold climate heat pump that can modulate to a minimum of 1.5 Tons.

System options:

1 - All electric:

2.5 Ton Cold Climate Heat Pump +

2 Ton (7kW) supplemental heating coil

2 - Hybrid heating system:

2.5 Ton Cold Climate Heat Pump +

96% AFUE existing modulating NG Furnace

3b – HVAC and DHW Systems

System 1 – What to look for in a fully electric system:

- Capacity and COP at low temperature. (Greener homes spec -> COP ≥ 1.8 & Capacity maintenance ≥ 70% at -15 °C)
- Packaged system with a fully modulating air handler.
- System where supplemental heat and the heat pump can operate together to meet 100% of the load.

3b – HVAC and DHW Systems

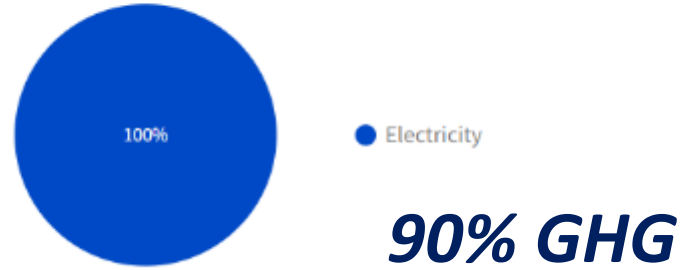
System 1 – What is the impact of a fully electric system:

- Adding a right sized heat pump and moderate electric resistance supplemental heat allows us to save ***24 GJs of energy.***

- This brings the overall energy consumption of the house down to ***66 GJs, 3 GJ lower than the target.***

- ***51% Energy Savings***

Emissions breakdown (gross)



90% GHG SAVINGS

Emissions	
Electricity	0.44 tCO_2
Natural Gas	0 tCO_2

3b – HVAC and DHW Systems

System 2 – What to look for in an Electric and NG (Dual Energy) system:

- Capacity and COP at low temperature. (Greener homes spec -> COP ≥ 1.8 & Capacity maintenance ≥ 70% at -15 °C)
- Packaged system with integrated controls.
- Where not integrated look for HP that has interior compatible electric furnace for when furnace needs to be replaced.
- Controls that allow the HP to operate down to coldest temperature before switchover. (maximize HP operation to reduce GHGs)

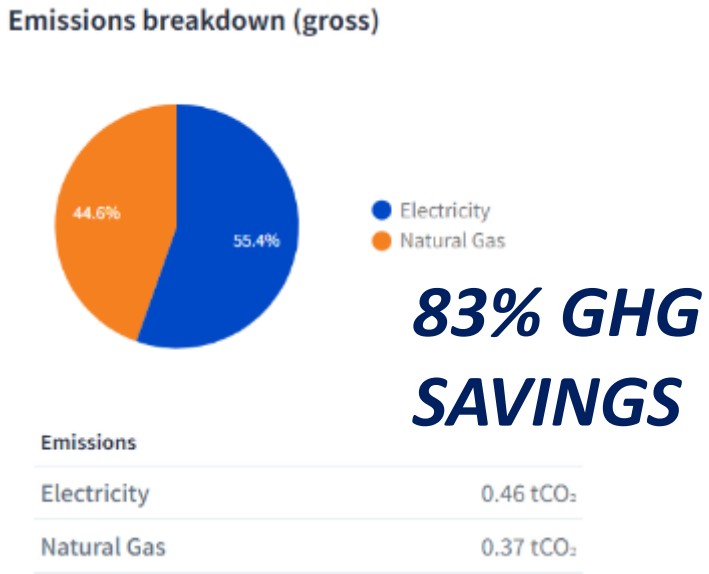
3b – HVAC and DHW Systems

System 2 – What the impact of an Electric and NG (Dual Energy) system:

- Adding a “good” heat pump allows us to save an additional ***17 GJs of energy*****.**

- This brings the overall energy consumption of the house down to ***73 GJs, 5 GJ short of the target.***

- ***46% Energy Savings***

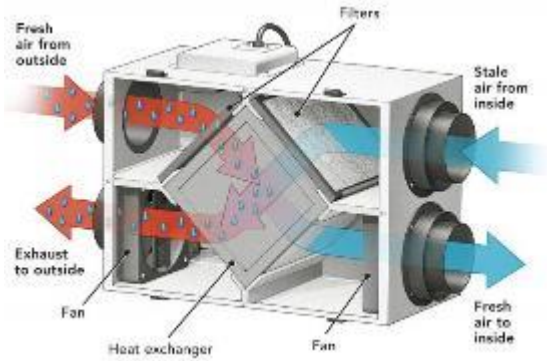


83% GHG SAVINGS

3c – Other Considerations

- Electrical panel limitations
- Resilience/Operation in the event of power outages

3c – Electrical panel limitations



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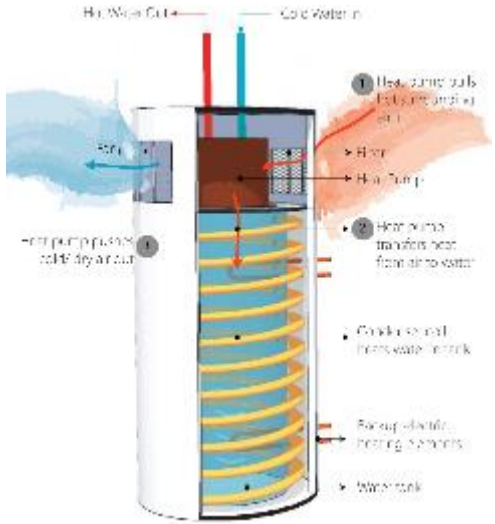

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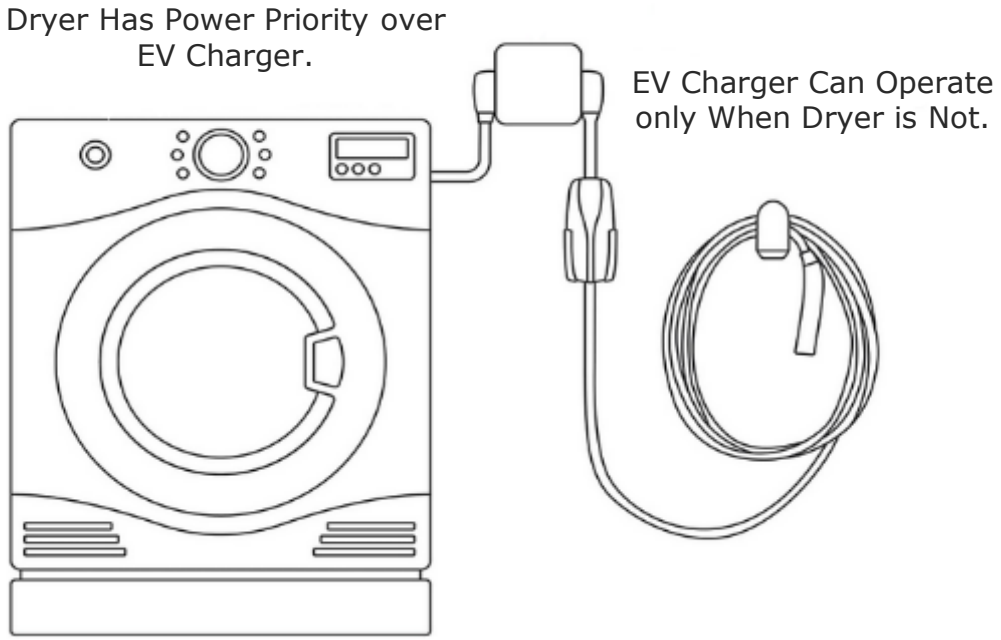
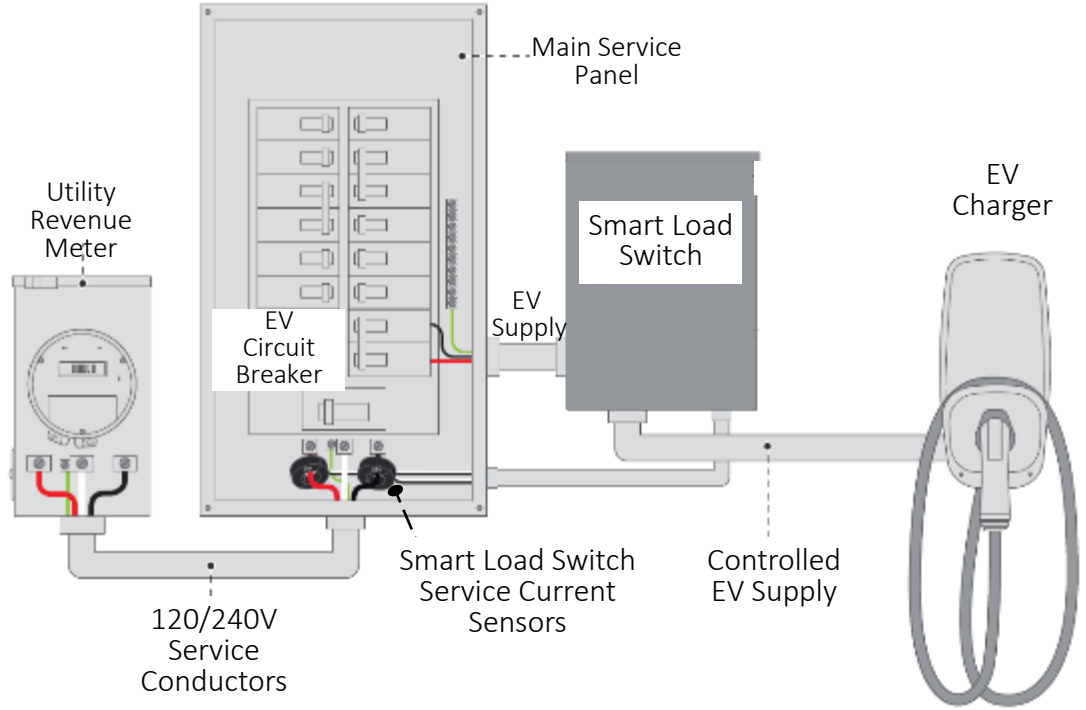
- Higher continuous load demand.
- Existing 100A or 125A services need upgrading (CEC Section 8)

3c - Load Limiting (Splitters and switches)

Plug-in Smart Splitter on 240VAC Outlet



Smart Load Switch on 240VAC Outlet



3c - What about battery storage?

- Currently regulatory barriers exist in the CEC for installing batteries in the enclosure of the home (1 hour fire separation required).
- Current systems like the Tesla Powerwall can provide backup power, but they still have limited capacity (13.5 kW).
- Cost is still high for battery systems (~$20K installed).
- When tied to solar PV they can provide extended coverage.
- Electric vehicles able to power the home may hold promise and may be coming soon.

Chris Taschuk is the proud owner of Saskatchewan's first Tesla Powerwall. (Submitted by Chris Taschuk)

4 – Establish a game plan and timeline

An ***integrated design process*** brings key parties together to develop a comprehensive plan that everyone buys into. You will need a team:

- **A very knowledgeable Energy Advisor**, preferably one 3rd party qualified to deliver Net-Zero Energy Homes and Renovations (CHBA or Passive House), or CACEA Master EA Certified
- **Your renovation contractor** someone you trust and who *"gets"* what you want to do
- **Your HVAC contractor** someone who knows heat pumps, and isn't actively trying to talk you out of a heat pump install
- **Your electrician** or **electrical design expert** who knows the CEC and is willing to go to bat for you with the ESA when it comes to load sharing and load control devices
- **PV consultant** (if going down this path)

6 – Estimate the costs

Air sealing: some air sealing as part of window and basement upgrades, targeted air sealing, budget: $3K to 5K

Basement: $11K in 2018, ~$15-20K today

Windows: $25 to $30K

Heat Pump: Add to furnace - $12K

Replace heating system - $20K

Unknowns: Service upgrade? $2K to $4K

$64K Dual Energy Option

$72K All Electric Option

Key Takeaways…

1. Set your objective.
2. Tackle the envelope first, work with your EA to confirm impact:
   a. Basement
   b. Air tightness
   c. Windows
3. Size the heat pump to your duct work. Adjust the ducts if feasible to allow a larger heat pump.
4. Consider renewable energy and storage

Thank you!