

## Community Engagement Webinar: Heat Pump Evaluations

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*CAP Webinar*

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# Outline

- Introductions
- Goals for today
- What is a heat pump?
- Look at data and experience from actual retrofits
  1. Centrally-ducted cold-climate ASHPs (ccASHPs)
  2. Hybrid heating retrofits

\*Disclaimer: We do research. We're a third-party and have no products or services to sell you.





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- Buildings
- Renewables
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# Goals for Today

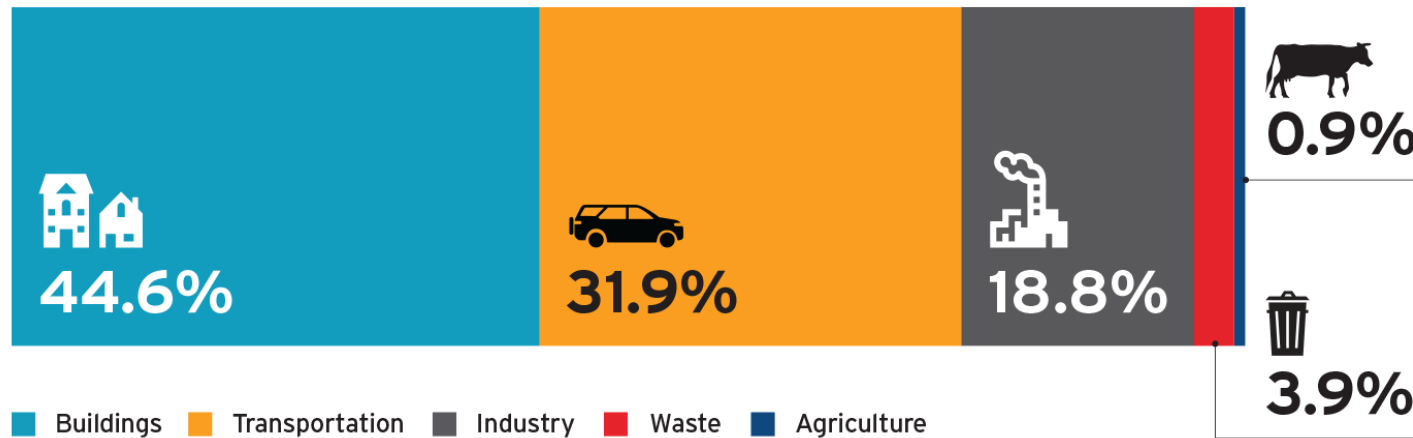
- Demonstrate the following:
  - ✓ 1. They work in our climate and (generally) perform near expectations in terms of energy savings
  - ✓ 2. There are heat pump options for every home
  - ✓ 3. There are both budget option and high-performance options
  - ✓ 4. They can pay for themselves
  - ✓ 5. Homeowners are satisfied with their heat pumps

# What is a heat pump?

A general introduction and some background

Learn more at [smarterhomeheating.ca](http://smarterhomeheating.ca)

# Carbon Emissions In GTHA

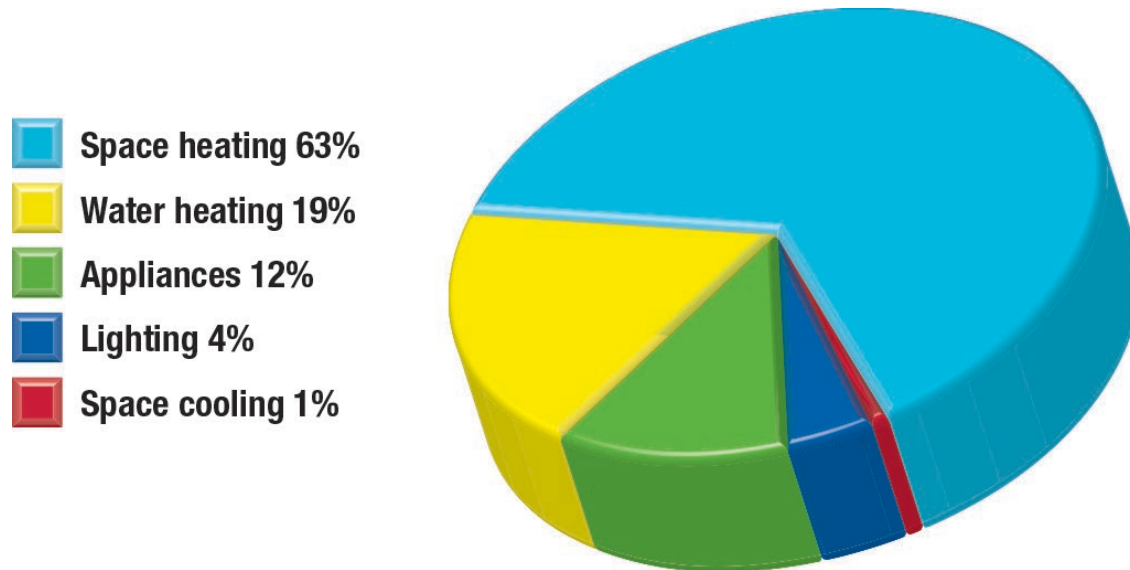


\*The Atmospheric Fund. <https://taf.ca/gtha-carbon-emissions/>

- Majority of GTHA carbon emissions are from buildings
- City of Toronto targeting net-zero carbon by 2040 to address the climate emergency
- Requires urgent deep energy upgrades for every building and home

# Carbon Emissions In Homes

Home ENERGY Use Breakdown

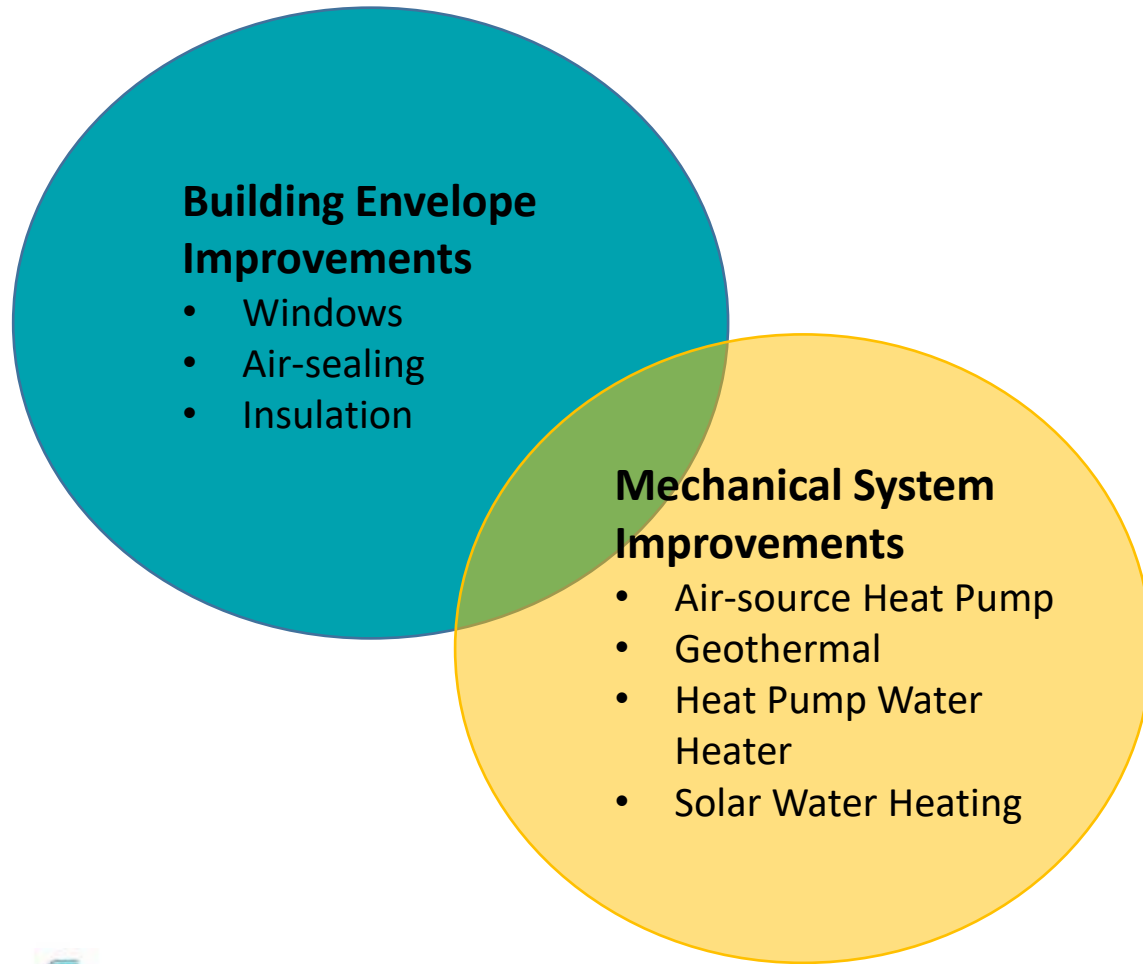


\*Natural Resources Canada. <https://www.nrcan.gc.ca/energy/publications/19030>

- Electricity is currently low-carbon
- Space and water heating (>80%)
- Large majority of heating is from carbon-intensive natural gas (i.e. methane gas)
- **Issue: Need to reduce the gas used for space and water heating in homes**
- Needs to be cost-effective for homeowners
- Heat pumps offer an alternative to conventional systems



# Reducing Carbon In Homes

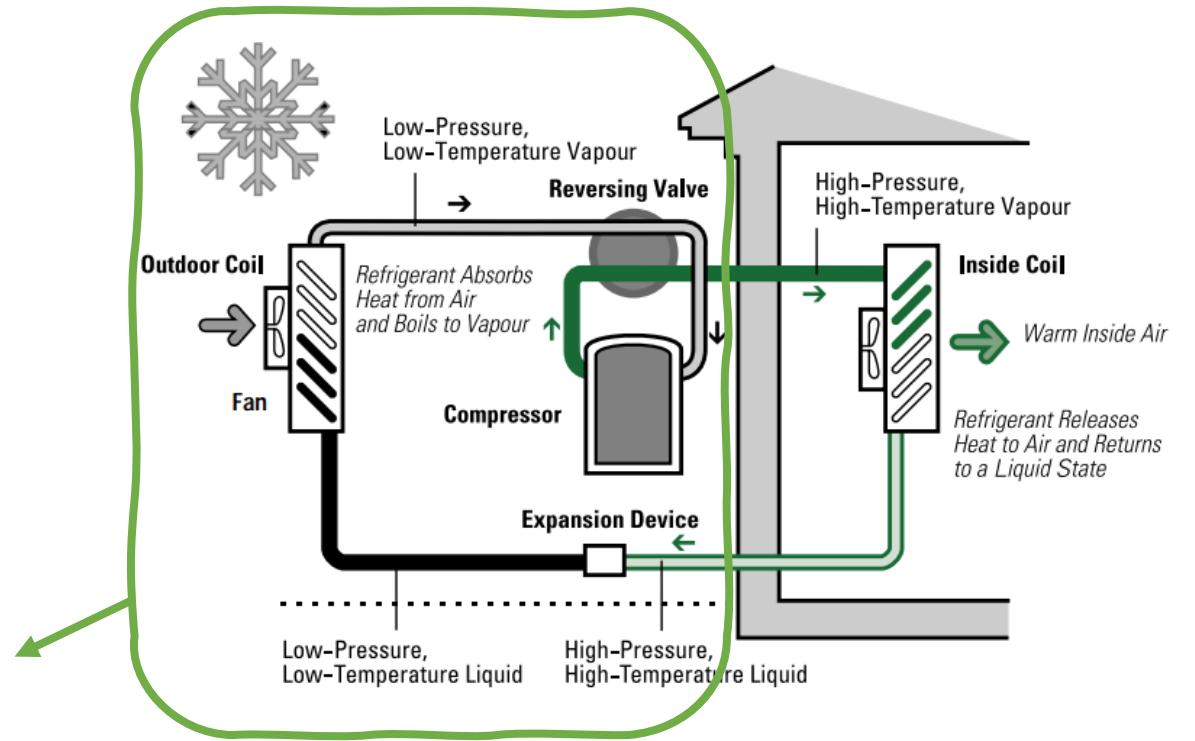


- Three approaches (not mutually exclusive):
  - Building Envelope
  - Mechanical System
  - (Behavioural/Control)
- “Low-hanging fruit” envelope upgrades always recommended:
  - Air-sealing
  - Sufficient attic insulation
  - Window replacements (end-of-life or for comfort)
- Best technical solution: EnerPHit-level retrofits with low embodied-carbon materials
  - Excellent idea; cost can be a barrier



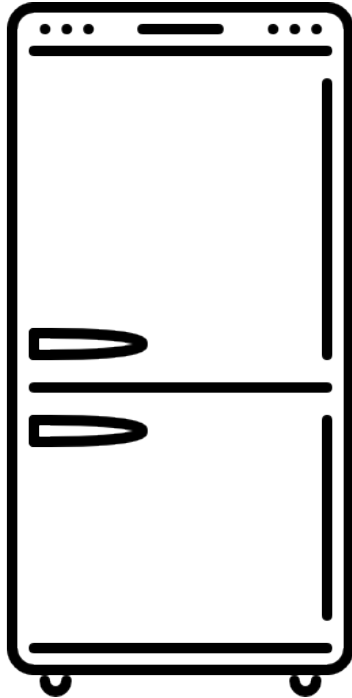
# ASHP Components

- ASHPs use same components as A/C but with some advancements
- Look similar (or the exact same) to A/C
- Typically involves a split refrigerant circuit connecting outdoor unit and indoor fan coil or air handler
- It's really just an air-conditioner that can go "in reverse" to also provide heating



\*Photo Credit: NRCan

# It's Not Magic...



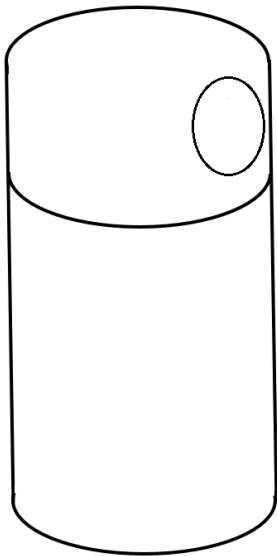
\*Icons from Freepik via flaticon.com

- It's just refrigeration!
- Think of a fridge
- It removes heat energy from inside and rejects it to the room
- Same principle as an ASHP
- Heat is removed from somewhere cold and rejected to somewhere warmer
- For ASHPs, this works even in very cold conditions

# Types of Heat Pump

- There are a variety of heat pump options

Heat Pump Water Heaters



Ground-source Heat Pumps  
(i.e. Geothermal)



Air-Source Heat Pumps



# Types of ASHPs

- Options that do not need existing ductwork or hydronic (i.e. boiler) heating distribution systems

## 1. Ductless Mini-split



\*Photo Credit: Mitsubishi Electric

## 2. Ductless Multi-split

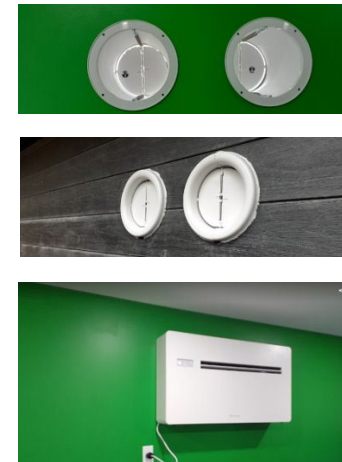


## 3. Ducted Mini-split



\*Photo Credit: Imery & Co

## 4. Monobloc



## 5. Window ASHP



\*Photo Credit: Gradient



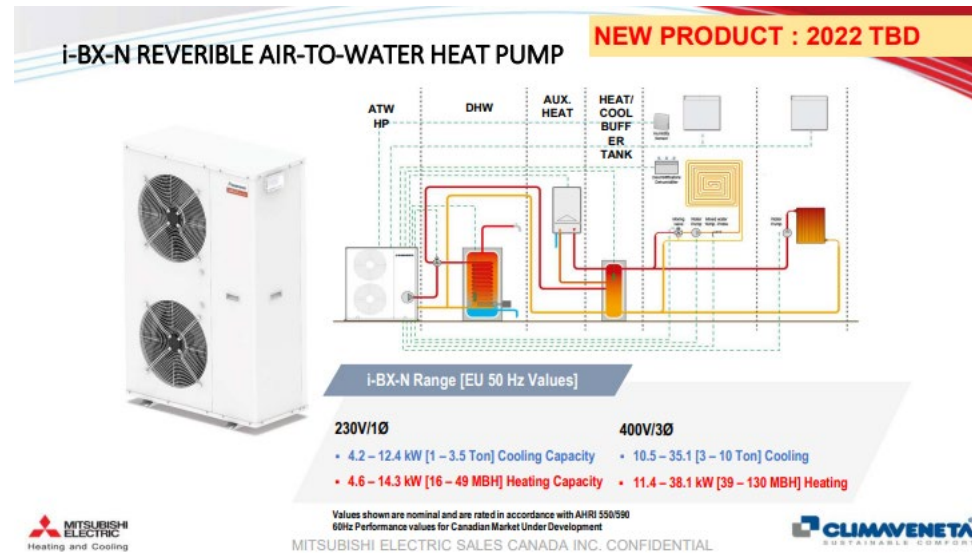
# Types of ASHPs

- Options that utilize existing ductwork or hydronic (i.e. boiler) heating distribution systems

## 5. Centrally-Ducted



## 6. Air-to-water

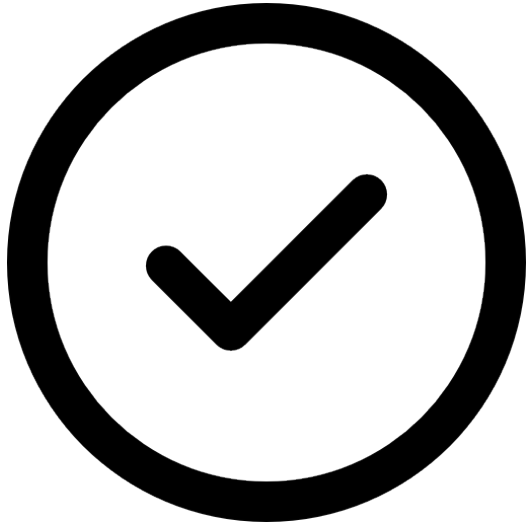


## 7. Hybrid



\*Photo Credit: Mitsubishi Electric

# Check Point



1. Buildings (including homes) are a major source of carbon because of the fossil fuels (primarily gas) used for space and water heating
2. Broadscale deployment of heat pumps is inevitable to approach climate targets
3. Heat pumps consume a lower-carbon fuel and are much more efficient
4. They are just air-conditioners that “go in reverse”
5. There are many different types and there are options suitable for every homeowner

\*Image Credit: Freepik at flaticon.com

**Visit [smarterhomeheating.ca](https://www.smarterhomeheating.ca) for more!**

# Central Cold-climate ASHPs

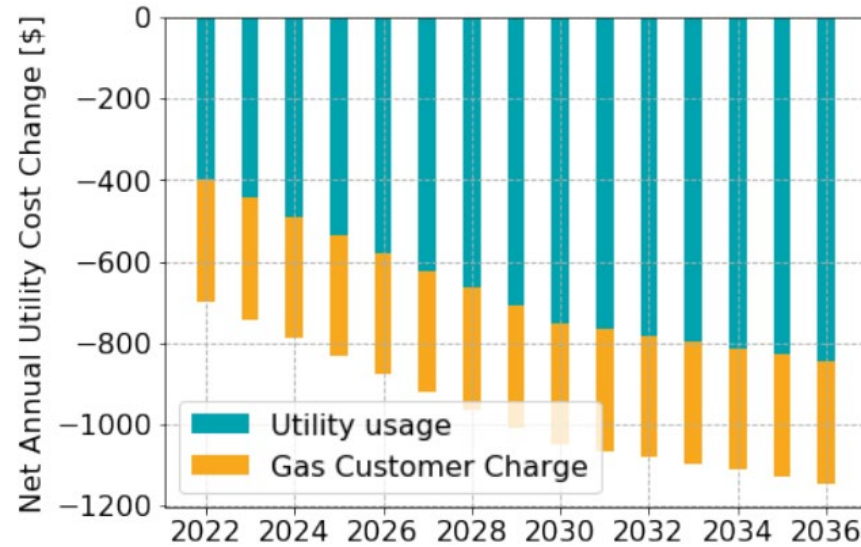


- Evaluated pre- and post-retrofit utility bills in two Toronto century homes
- Pre- Greener Homes Grant and Loan Programs
- Both used premium cold-climate ASHP equipment
- Complete all-electric replacement of gas furnace-A/C system
- In one case, conversion of hot water to heat pump as well
- Central ASHPs cost approx. \$20k (+ \$3.5k to \$6.3 electrical service upgrade)
- Electrifying hot water approx. \$6k; Additional costs for mini-split as well (approx. \$8k); Ancillaries
- Note: **Cost varies** with home and equipment!

Visit [smarterhomeheating.ca](https://www.smarterhomeheating.ca) for more!



# Central ccASHPs: Savings



\*Gas customer charge saving only achieved if home is taken entirely off gas. In some homes, gas may also be used for the stove, fireplace, dryer, etc. The challenge of fully-electrifying therefore varies significantly home-to-home.

- High **uncertainty** with estimating lifetime savings
- Generally, the system is expected to pay for itself with current gas rates and current programs
- Good results in older homes. Best results are achieved in newer homes

**Visit [smarterhomeheating.ca](http://smarterhomeheating.ca) for more!**



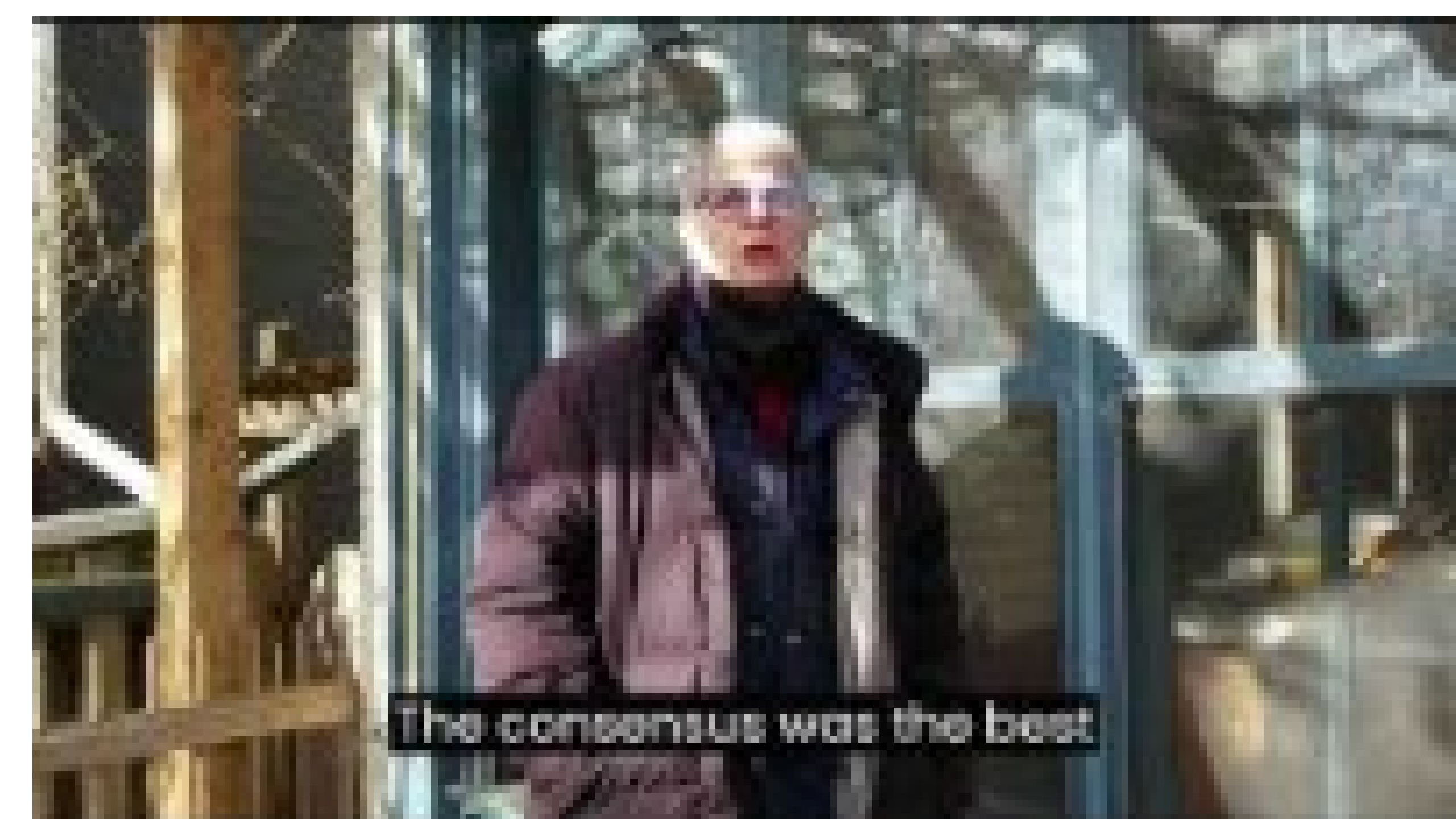
# Central ccASHPs: Feedback

"The **machine works well**. The heat is constant. The noise level inside the house is generally less than with my old gas furnace, but there is a bit of a rumble from the side wall of the kitchen when the heat pump begins its work. My anxiety on running costs was finally allayed by the bills over an entire year. The heat pump, running on electricity, cost virtually the same to run as my old gas furnace and electrical central air conditioner." \*This was for Winter 2020/2021; for Winter 2022/2023, has rates have drastically increased and a substantial savings is expected



"The duct-based heat pump is meeting our heating and cooling needs for the basement, first and second floor, and the ductless heat pump is meeting our needs for the third floor. Generally speaking, **thermal comfort has significantly improved**. Temperatures now remain relatively consistent year-round. Conversely, our two-stage natural gas furnace resulted in more significant temperature fluctuations in the heating months."



A woman with short blonde hair, wearing a purple quilted jacket over a black turtleneck, stands in a doorway. The background shows a room with wooden paneling and a window. The image has a slightly grainy, low-resolution quality.

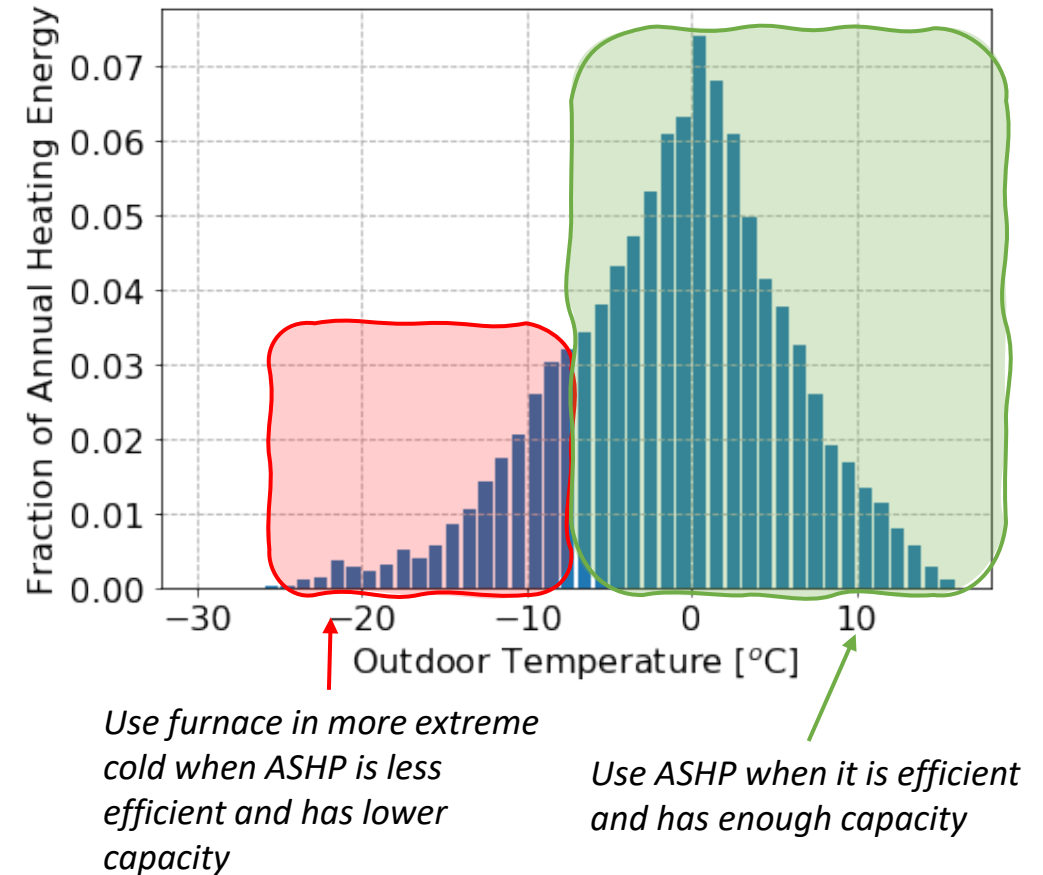
The consensus was the best

# Hybrid Heating

- There are scenarios where homeowners might be interested in other ASHP options
  - Home has newer furnace
  - Homeowner wants/needs lower upfront costs
  - Ductwork is undersized
  - Electrical is constrained
  - Need an emergency system replacement
- Another option is a hybrid heating system which utilizes both gas furnace and ASHP
- ASHP does all of the cooling (replacing the A/C) and most of the heating
- Can use existing furnace

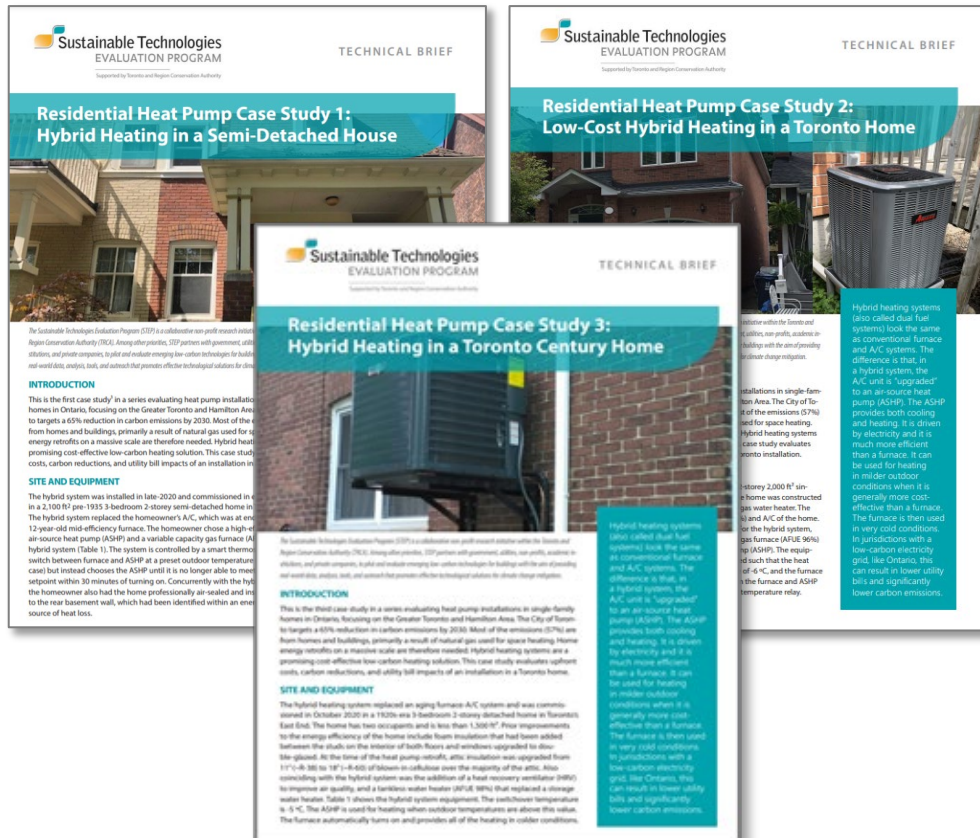
# Hybrid Heating: Background

- Can have lower upfront costs than fully electric but maintains many benefits
- ASHP used for heating in milder conditions and furnace used in extreme cold
- In Southern Ontario, most heating energy is actually in milder temps
- Extreme cold is rare
- Even possible to use existing furnace only as an air-handler





# Hybrid Heating: Case Studies



- Evaluated pre- and post- utility bills of 3 retrofits
- Installed costs for furnace & ASHP were \$8 to \$10k (but can be up to \$12k)
- Single- and two-stage heat pumps (no inverters)
- Inverter-driven options are available
- As low as \$1k more than furnace-A/C
- Reduced gas consumption by 51 to 75%
- Energy savings was near expectations based on equipment ratings

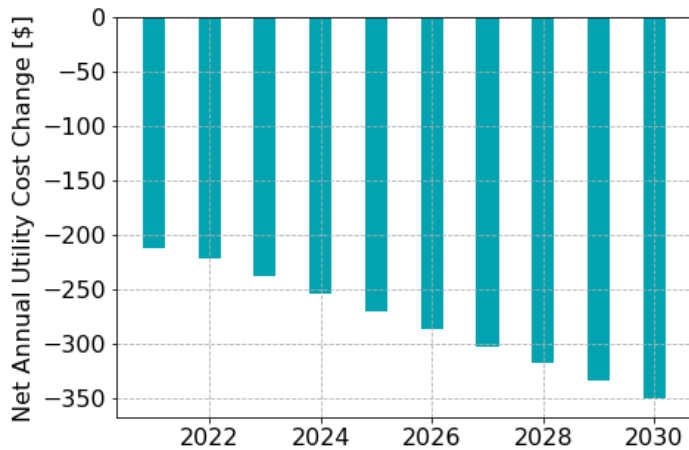
Visit [smarterhomeheating.ca](http://smarterhomeheating.ca) for more!

# Hybrid Heating: Savings

- Updating case studies for current utility rates and factoring in carbon pricing to 2030
- Simple payback vs. gas furnace (without any rebates) could be several years
- MUCH better against propane or oil

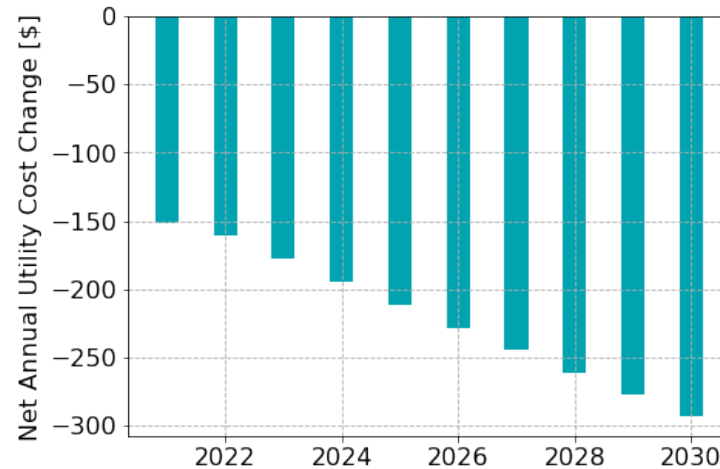
## Case Study 1

Gas reduction for heating: 51%



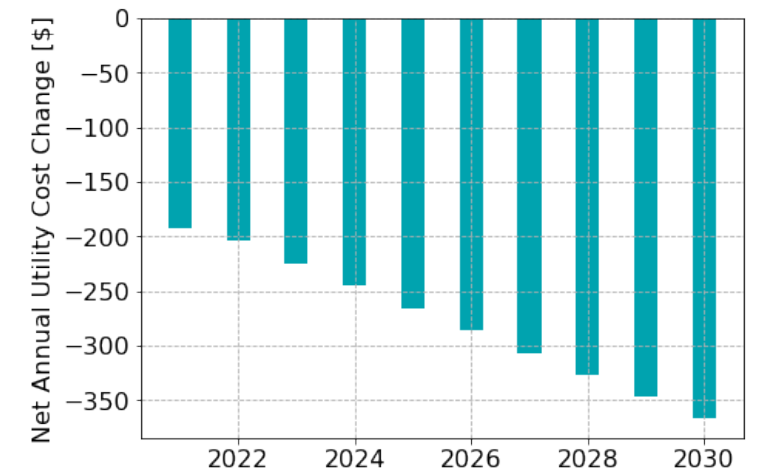
## Case Study 2

Gas reduction for heating: 74%



## Case Study 3

Gas reduction for heating: 65%



# Hybrid Heating: Feedback

“We looked for and found a contractor with significant experience in heat pump installations, and were **happy with their work**. Our house is actually **more comfortable** now than when we used the natural gas furnace exclusively.”



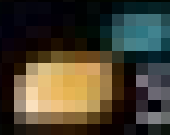
“It costs more to heat my house in the dead of winter but less in the shoulder months – resulting in a slight **overall savings** in energy bills. It [also] works great as an air conditioner.”



“The circulation in the house is actually **very quiet**, no noisier than it was before... In fact, when the fan is on low speed I have to check the vents to see if it is actually working. [Sounds] like an air conditioner [outside].”



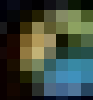
Learn more at [smarterhomeheating.ca](http://smarterhomeheating.ca)  
or [smarterhomeheating.com](http://smarterhomeheating.com)



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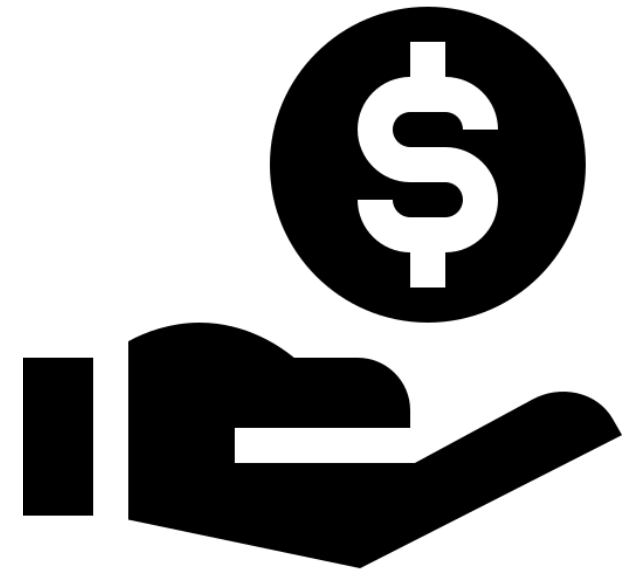


# Hybrid Heating: Final Things to Note

- ASHP costs vary greatly – both budget options and high-performance options are available
- Different controls option can optimize for lowest cost or lowest carbon
- Enbridge currently running a 100-home rebate pilot in London (all systems are installed)
- 1000-home rebate coming soon (London, Peterborough, St. Catharines and Sault St. Marie)
- If you're in Peel (Mississauga, Brampton or Caledon) there is a \$2k (limited) incentive right now: [trca.ca/conservation/sustainable-neighbourhoods/heat-pump-incentive/](https://trca.ca/conservation/sustainable-neighbourhoods/heat-pump-incentive/)
- Federal grants also cover some high-performance hybrid systems

# Key Policies: Rebates

- Rebate programs for heat pumps in small-scale residential are increasing
- Federal Greener Homes Grant provides \$5,000 for high-performance ASHPs (Enbridge HER+ \$6,500)
- Oil to Heat Pump Affordability Grant, up to \$5,000, more details soon
- City of Toronto providing up to \$2,500 rebate
- TRCA - Peel Hybrid ASHP Incentive supported by Climate Action Fund, \$2000 incentive, \*must keep existing furnace
- Enbridge pilot rebate \$3,000 to \$4,500 for smart hybrid ASHP systems (in London, Peterborough, Sault Ste Marie, and St. Catharines)
- Durham Region offering performance-based rebates



\*Image Credit: Freepik at flaticon.com

# Key Policies: No-interest Loans

- 0%-interest loans for energy efficiency upgrades available federally
- Canada Greener Homes Loan
- 0%-interest loans (i) spread the cost out over the system lifetime while you are also getting savings and (ii) make an ASHP cheaper

<https://www.nrcan.gc.ca/energy-efficiency/homes/canada-greener-homes-initiative/canada-greener-homes-loan/24286>

## Time Value of Money Example

Due to inflation and the ability to make a return on investments, future cash flow have a lower value than present cashflows.

**Example:** What's the difference in value between paying \$1,000 today vs. \$1,000 in even payments over 10 years at no-interest (\$100 per year)? Assume discount rate of 5%.

$$PV = \frac{\$100}{(1.05)^1} + \frac{\$100}{(1.05)^2} + \dots + \frac{\$100}{(1.05)^{10}} = \mathbf{\$772}$$

Paying \$1,000 over 15 years at no-interest is equivalent to paying \$772 today assuming a discount rate of 5%.

# Price Check: Utility Rates



$$\frac{\text{Utility Rate}}{\text{Fuel Energy Content} \times \text{Efficiency}} = \text{Cost for Heat}$$

- NG Furnace at current residential rates:  $\frac{0.558 \text{ \$/m}^3}{10.6 \text{ kWh}_t/\text{m}^3 \times 0.95} = \mathbf{0.055 \text{ \$/kWh}_t}$
- High-efficiency ASHP at current rates:  $\frac{0.122 \text{ \$/kWh}}{1 \text{ kWh}_t/\text{kWh} \times 2.8} = \mathbf{0.044 \text{ \$/kWh}_t}$
- Standard-efficiency ASHP:  $\frac{0.122 \text{ \$/kWh}}{1 \text{ kWh}_t/\text{kWh} \times 2.5} = \mathbf{0.049 \text{ \$/kWh}_t}$
- ASHPs can be significantly cheaper (up to 20%) to operate at current rates
- Financials are even stronger for oil & propane
- Proposed ultra-low nighttime rates of 2.5 cents coming May 1, 2023
- Carbon pricing will increase



# Goals for Today Revisited

- ✓ 1. Yes, ASHPs work in our climate and (generally) perform near expectations in terms of energy savings
  - ✓ 2. There are heat pump options for every home
  - ✓ 3. There are both budget options and high-performance options
  - ✓ 4. They can pay for themselves
  - ✓ 5. Homeowners are satisfied with their heat pumps
- If you remember one thing: **No longer makes sense to install A/C; at least choose a heat pump**
  - Learn more at [sustainabletechnologies.ca](http://sustainabletechnologies.ca)

# Thank You – Visit [smarterhomeheating.ca](http://smarterhomeheating.ca) for more!

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## Thanks to Homeowners:

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Blair Scorgie

## Project Funders and Partners:



\*The contents of this presentation do not necessarily represent the policies of supporting agencies. Mention of trade names, vendors, and commercial products does not constitute an endorsement of those products or services.



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# Other topics to reference

# Ductless ASHPs



- Rental townhomes in Brantford
- Heated with electric baseboards
- No central cooling
- 2- and 3-bedroom units



Figure 1. Example layout of a 3-bedroom rowhouse within the complex.



# Ductless ASHPs: Retrofit Overview

- Retrofitted 4 townhomes with ductless multi-split ASHPs
- Refrigerant lines on the building exterior (non-invasive)
- Annual savings approx. **\$850**
- Approx. upfront costs \$14,000 (no rebate)
- With Federal Loan and Grant we expect **net cost savings overall**
- Annual loan repayment  $\approx$  annual savings
- Note energy savings was good but lower than expected due to different factors



# Refrigerants

- Most common residential refrigerant (in Canada) for A/C and heat pumps is R410a
- Global Warming Potential (GWP) of 2,088
- Canada will be moving to R32 in future (675 GWP) – common in Europe and Asia
- Sticking point in Canada is flammability
- High GWP refrigerants have a risk but generally **not talking about using more of them**
- Same amount of refrigerant as before but now doing heating as well as cooling
- A catastrophic loss of refrigerant charge equivalent (approximately) to about 2 years of carbon reduction when ASHP is offsetting gas

# Ductless ASHPs: Feedback

“ ...it was quiet. **You didn’t even know it was on**, it’s like, ‘Are you sure that’s on?’” -Unit 2 Tenant

Q. “How happy are you that you received the heat pump retrofit?”  
“ A. “**Very happy.**” -Unit 4 Tenant

Q. “ Did you find that the heat pump had any issues providing sufficient heat to keep your unit comfortable? For example, in December we had that really bad cold snap. It was like down to -20o C.” A. “**It did more than enough.** Like I said I didn’t even have to turn the fan all the way up.” -Unit 2 Tenant

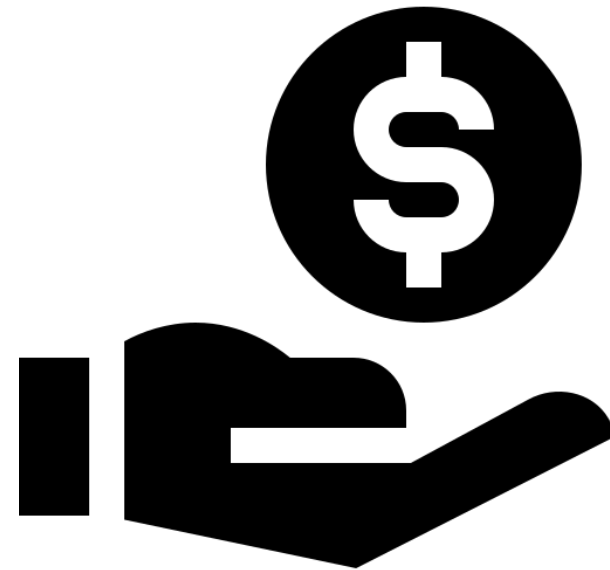
“ ... you would definitely see the savings in the long run. Honestly, who wouldn’t want to convert from those [baseboard] heaters to something **far better**, right?”  
-Unit 1 Tenant

- Occupant feedback very positive
- Easy to use
- Simple install
- Kept comfortable temperatures
- Clean-looking
- Quiet
- Bill savings
- Now have cooling

# Proposed Ultra-low Overnight Electrical rates

- Effective May 1, 2023
- 2.5 cents per kilowatt-hour (kWh)

Price Period	Hours Applicable (Prevailing Time)	Price
<b>On-Peak</b>	Weekdays: 4pm-9pm	Equal to 10 times Low Overnight price
<b>Mid-Peak</b>	Weekdays: 7am-4pm and 9pm-11pm	Equal to standard TOU Mid-Peak price
<b>Weekend Off-Peak</b>	Weekends and Statutory Holidays: 7am-11pm	Equal to standard TOU Off-Peak price
<b>Low Overnight</b>	Every day: 11pm-7am	Calculated so that the OETOU recovers the forecasted average supply cost (RPA)



\*Image Credit: Freepik at flaticon.com



# Links

- Canada greener homes grant

<https://www.nrcan.gc.ca/energy-efficiency/homes/canada-greener-homes-initiative/canada-greener-homes-grant/canada-greener-homes-grant/23441>

- Canada greener homes loan

<https://www.nrcan.gc.ca/energy-efficiency/homes/canada-greener-homes-initiative/canada-greener-homes-loan/24286>

- Enbridge Home Efficiency Rebate Plus

<https://www.enbridgegas.com/residential/rebates-energy-conservation/home-efficiency-rebate-plus>

- Toronto Home Energy Loan Program

<https://www.toronto.ca/services-payments/water-environment/environmental-grants-incentives/home-energy-loan-program-help/>