Residential Decarbonization 2030

How do we motivate the unwilling residential contractor?
OGA CONFERENCE, April 26, 2022
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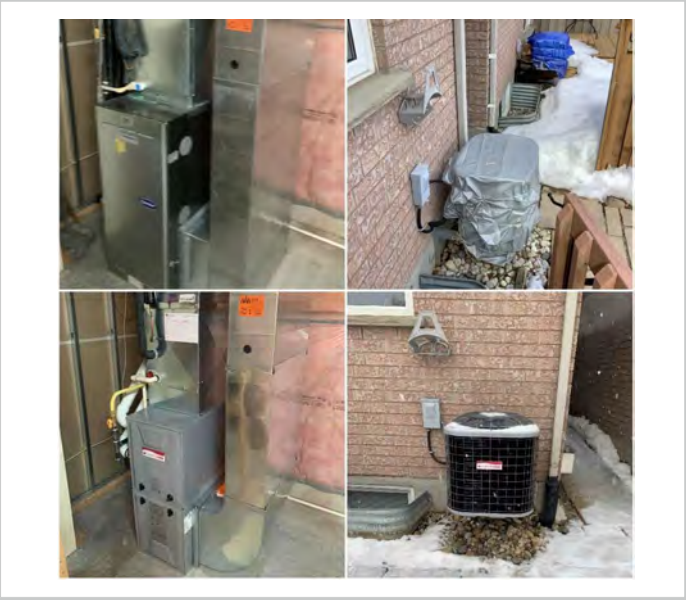
Focusing on retrofit contractors

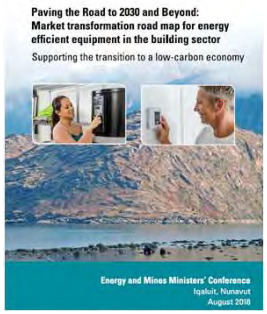
How do we move away from like-for-like replacements?



- This talk will focus on Ontario, the market that I know best.

- We need to move away from a like-for-like replacement (usually a forced air gas furnace and an air conditioner) to something else, but what?

The MTR and the Five As



IDENTIFYING MARKET BARRIERS Market transformation scorecards developed for each technology based on the five A's				
Availability Does the technology exist?	**Accessibility** Does the market have access to the technology?	**Awareness** Does the market know about the technology?	**Affordability** Is the technology affordable?	**Acceptance** Is the form, fit and function of the technology acceptable?

1.1 The Pan-Canadian Framework on Clean Growth and Climate Change (PCF) outlines the commitments of the federal, provincial and territorial governments (Governments) to reduce greenhouse gas (GHG) emissions and promote clean, low-carbon economic growth for Canadians. Accelerating the development and mainstream adoption of clean and more energy efficient technologies is a key component to achieving these goals for Canadians.

In 2018 the Market Transformation Roadmap for Energy Efficiency Equipment in the Building Sector identified five general barrier to market adoption

Availability – Is the technology fully commercialized and available in Canada?

Accessibility – Is there sufficient product choice in the market, and does the current performance testing align with the product functionality and capabilities?

Awareness – Are contractors, building owners, designers, and engineering firms familiar with the benefits of the technology and do they have the expertise to design, install and service them? Have they been convinced of the merits of the technology?

Affordability – Do high upfront costs, installation and/or maintenance costs deter market demand?

Acceptance – Are the form, fit, and function of the technology well accepted or is it deemed too risky by end users?

2018

Technology	Availability *Does the technology exist?*	Accessibility *Does the market have access to the technology?*	Awareness *Does the market know about the technology?*	Affordability *Is the technology affordable?*	Acceptance *Is the form fit and function of the technology acceptable?*
Ground-source heat pumps	🟢	🟢	🟢	🔴	🔴
Cold climate air-source heat pumps	🟡	🟡	🟡	🟡	🟡
Gas heat pumps	🟡	🔴	🔴	🔴	🔴

2021

Technology	Availability *Does the technology exist?*	Accessibility *Does the market have access to the technology?*	Awareness *Does the market know about the technology?*	Affordability *Is the technology affordable?*	Acceptance *Is the form fit and function of the technology acceptable?*
Ground-source heat pumps	🟢	🟡	🟡	🔴	🔴
Cold climate air-source heat pumps	🟢	🟡	🔴	🔴	🟡
Gas heat pumps	🟡	🔴	🔴	🔴	🔴
Hybrid gas electric ASHP systems	🟢	🟢	🟡	🟡	🟡

In 2018 and again in 2021 the Space Heating Experts Team looked at the technologies that are “most likely” to help achieve the goal of improving energy efficiency and graded them on a scale of green for “go”, the barrier has been over come, yellow is “Caution/Somewhat”, the barrier has been partially over come, and red is “Barrier Still Present”, the barrier still exists and is preventing adoption.

The major change in 2021 was the addition in of Hybrid Gas-Electric ASHP systems to the list. In retrofit applications in areas with natural gas service this approach answers many of the concerns that homeowners and contractors have. One challenge is that the Greener Homes Grant incentivized the wrong systems, something that I will come back.

COVID throws a wrench into the plans…

Demand surges as people are forced to spend more time at home…

Factories reduce output due to COVID induced material shortages… The shift production to their “A” products – generally standard efficiency and those using fewer microprocessors.

The Greener Homes Grant adds fuel to the fire by incentivizing equipment that isn’t in the supply chain…

Carbon pricing moves to $50 eTon of CO2 on its way to $170…

Inflation takes off.

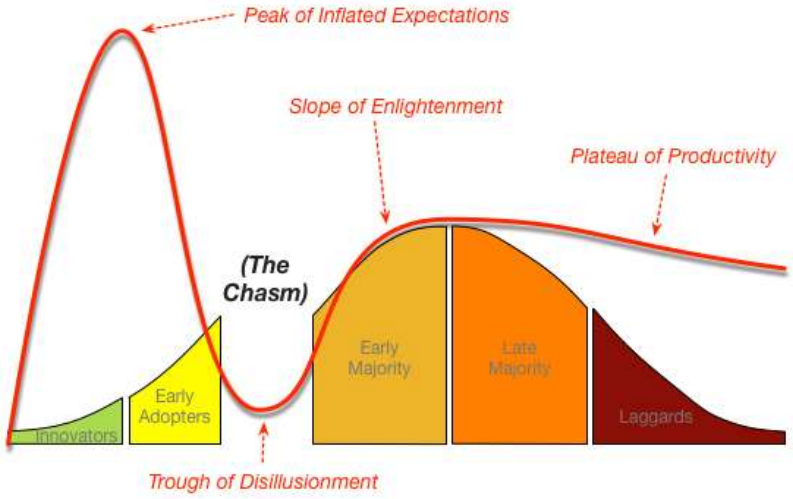
What do we (as a society) want?

- Decarbonization of the residential building sector
- An end to energy poverty
- Quality workmanship
- Good paying jobs

I'm going to suggest that:

- Most consumers have no idea how their house is heated and cooled and don't really care. They care that they are comfortable and that their utility bill isn't more than they've budgeted.
- Most residential retrofit HVAC contractors want to do work that is straight-forward, cookie cutter, and profitable.
- Therefore, the solution that
    - most resembles what consumers already have,
    - is easy for contractors to retrofit,
    - keeps consumer comfortable, and
    - delivers on keeping their utility bills on budget, is going to win for the majority.

- Conversely, what I see in many climate action plans is something,
    - Radical to the consumer – it acts very differently than what they have now,
    - Suffers from a significantly higher upfront cost,
    - Offers incredibly long paybacks and marginal (if any) utility savings today
    - If complicated for the contractor to do at scale profitably today.



https://www.businessprocessincubator.com/content/hope-optimism-and-delusion/

Let's consider that industry – manufacturers have made significant investments in both the status quo and the adoption of new technology, but as Jim Bolger put it to me succinctly, distributors and contractors do not have enough faith in the technology in many cases, don't trust the volatility in the marketplace with "come & go" incentive programs to make the switch & invest to promote geothermal or ASHP in their product offerings or sales efforts.

So, the good news is that for many of the underlying technologies – GSHP, ASHP, ccASHP – the technology is advanced, the products exist but not in the volume needed to support our market without strong and determined signals to the market that we are serious about adoption.

And remember that in retrofit applications we are trying to bolt-on 21st Century goals on to 20th Century homes…

What are the challenges?

Carbon Pricing

- Will the political backlash to higher fuel prices exacerbate energy poverty and interrupt the plan?

Ontario's Wynne says she regrets handling of electricity prices

JUSTIN GIOVANNETTI >
PUBLISHED MAY 29, 2018

This article was published more than 3 years ago. Some information may no longer be current.

Plans can't be made on quicksand, we as an industry need to know that if we invest our resources based on government's plans that they are going to come to fruition. Anyone in the industry longer than 10 years has been the beneficiary and victim of conservation plans that ramp up demand and then collapse it like a house of cards. So, in your zeal to decarbonize don't forget what happened to Kathleen Wynne…

"Facing daily anger over hydro bills, the Liberals announced in March, 2017, that they would cut rates by 25 per cent. The government borrowed billions of dollars to lower bills through the end of the decade. Hydro rates will then rise over the next two or three decades to pay for the borrowing. **The discontent around bills, according to Ms. Wynne, was due to "a real failing of my ability to explain to people that if we had not built the electricity system up, we wouldn't have a reliable electricity grid, it's as simple as that," she said. "We didn't explain that very well and we probably didn't explain it soon enough and act soon enough.""**

What are the challenges?

Workforce Development

- The average age of refrigeration/air conditioning mechanics in Ontario 58 +/-

- Covid reduced the number of new Canadians exacerbating an existing shortage

- It is relatively easy to get a G2 and difficult to get a 313D

We need to show contractors a path to create new residential air conditioning system mechanics (313D).

Just in my group of 30 contractors we identified a need for **112** new 313Ds over the next 5 years, **split 70/30 for growth vs retirement**.

We identified the existing apprenticeship structure as something that is challenging for the average contractor and apprentice to navigate. We created an employer group sponsorship for 313D and 308R with the help of SOY and have now worked with St. Lawrence College to create the Province's first hybrid-delivery program focused solely on 313D.

We also work to collaborate with organizations like Women in HVAC-R Canada to help support more women in the HVAC trades.

What are the challenges?

Most HVAC replacements are emergencies

- Retrofit options need to be in-stock.

- Contractors must be able to make the case for doing something different.

- Most consumers are not interested in paying more up front or over time.

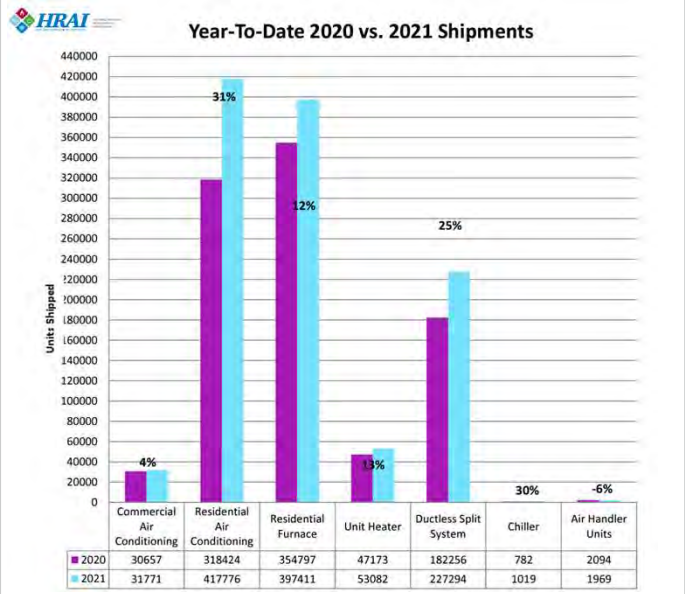
People rest at the Oregon Convention Center cooling station in Oregon, Portland on June 28, 2021, as a heatwave moves over much of the United States.

Kathryn Elsesser | AFP | Getty Images

What are the challenges?

Most HVAC replacements are emergencies

- Every like-for-like replacement or Central AC sold instead of a Central HP, is a 15-year lost opportunity.



- In 2021 there were ~100,000 single-family, townhouses and row-houses built in Canada
- There were almost 400,000 furnaces sold, so we can assume that approximately 300,000 furnaces and a similar number of ACs found their way in to retrofits
- Residential Central HPs are included in the AC number, but we know that the CHP units shipped are a fraction of the cooling-only CAC number.
- In Residential HVAC there are two seasons: How Much? and How Soon? – When we are in “How Soon” season the customer isn’t willing to wait, they will buy what is on the shelf to protect their health, property and sanity.
- What caused that huge increase in 2021 AC sale? The Western Heat Wave.

What are we supposed to do with this?

Customer wants to "get off fossil fuels." Contractor wants to earn a sale and a happy customer.

90-year-old semi, 20' lot, Downtown Toronto

100-amp electrical service, maxed out

Existing mid-efficiency furnace, 60 MBTU/h output, ductwork supports 1100 CFM

43 MBTU/h heat loss, 19 MBTU/h heat gain

Atmospheric DHW located in a spot that the customer would like to use for a shower.

What are the challenges?

Giving Contractors Confidence

- Like-for-like is easy, profitable and (almost) no one ever complains.

- I need easy tools to show my customer what the lifecycle cost is likely to be.

- I don't want to end up on TV because I told my customer they would save money only to be proven wrong.

If an electrification job does not meet a customer's expectations of comfort, cost, or convenience, who in this room is willing to lose their jobs and livelihood?

Who in this room will volunteer to put their reputation, time and resources on the line to educate and inform consumers to generate consumer demand?

Who in this room is willing to take a pay-cut, lost opportunity cost and spend time away from family to go get trained on heat pumps?

Who in the room is willing to make their phone-numbers available to homeowners or have their workplace open for public feedback and google reviews?

Who in this room is encouraging their kids to go to trade school and become HVAC techs to rake in all this new opportunity that electrification is going to bring?

Sustainable Technologies
EVALUATION PROGRAM

TECHNICAL BRIEF

Residential Heat Pump Case Study 1: Hybrid Heating in a Semi-Detached House

The Sustainable Technologies Evaluation Program (STEP) is a collaborative non-profit research initiative within the Toronto and Region Conservation Authority (TRCA). Among other priorities, STEP partners with government, utilities, non-profits, academia institutions, and private companies, to pilot and evaluate emerging low-carbon technologies for buildings with the aim of providing real-world data, analysis, tools, and outreach that promotes effective technological solutions for climate change mitigation.

INTRODUCTION

This is the first case study[1] in a series evaluating heat pump installations in single-family homes in Ontario, focusing on the Greater Toronto and Hamilton Area. The City of Toronto targets a 65% reduction in carbon emissions by 2030. Most of the emissions (57%) are from homes and buildings, primarily a result of natural gas used for space heating. Home energy retrofits on a massive scale are therefore needed. Hybrid heating systems are a promising cost-effective low-carbon heating solution. This case study evaluates upfront costs, carbon reductions, and utility bill impacts of an installation in a Toronto home.

SITE AND EQUIPMENT

The hybrid system was installed in late-2020 and commissioned in early January 2021 in a 2,100 ft² pre–1935 3-bedroom 2-storey semi-detached home in Toronto's East End. The hybrid system replaced the homeowner's A/C, which was at end-of-life, as well as a 12-year-old mid-efficiency furnace. The homeowner chose a high-efficiency two-stage air-source heat pump (ASHP) and a variable capacity gas furnace (AFUE 97%) for the hybrid system (Table 1). The system is controlled by a smart thermostat. It does not switch between furnace and ASHP at a preset outdoor temperature (as is often the case) but instead chooses the ASHP until it is no longer able to meet the thermostat setpoint within 30 minutes of turning on. Concurrently with the hybrid system retrofit, the homeowner also had the home professionally air-sealed and insulation was added to the rear basement wall, which had been identified within an energy audit as a source of heat loss.

Hybrid heating systems (also called dual fuel systems) look the same as conventional furnace and A/C systems. The difference is that, in a hybrid system, the A/C unit is 'upgraded' to an air-source heat pump (ASHP). The ASHP provides both cooling and heating. It is driven by electricity and it is much more efficient than a furnace. It can be used for heating in milder outdoor conditions when it is generally more cost-effective than a furnace. The furnace is then used in very cold conditions. In jurisdictions with a low-carbon electricity grid, like Ontario, this can result in lower utility bills and significantly lower carbon emissions.

Table 2. Utility bill analysis results.

Parameter	Value
Whole-home post-retrofit gas consumption (Sep 2020 to May 2021)	1,050 m³
Whole-home baseline gas consumption	1,772 m³
Total gas reduction	722 m³ (41%)
Whole-home post-retrofit elec. consumption (Sep 2020 to May 2021)	5,946 kWh
Baseline electricity consumption*	3,951 kWh
Electricity increase from hybrid heating system	1,994 kWh
Gas reduction for *space heating*	**51 %**
Net utility cost savings for *space heating***	**$46**
Net carbon savings for *space heating*	**1.4 tonnes**

* There was a large adjustment made for the secondary fridge.
**This is the *total* utility savings for Sept 2020 to June 2021 assuming *current* rates.

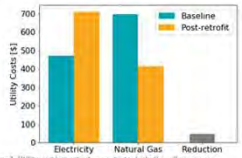


Figure 1. Utility cost impacts at *current* rates including all measures.

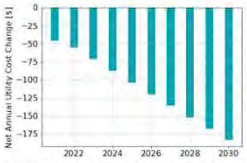


Figure 2. Estimated annual net utility cost changes considering carbon pricing. Electricity rates were assumed to increase at 2%/year from current values. Negative values are savings. Note the savings are from both the ASHP and the increase in efficiency from the previous mid-efficiency furnace. By 2030, approximately $100 of the savings per year should be from the hybrid system alone.

"I've been sweating about climate change for a while now. So, naturally, I felt prompted to put my money where my mouth was when it came to greening my own abode. I decided to set myself the task of making the DEEPEST possible cuts in my carbon emissions for the LEAST amount of money." –Homeowner

Table 1. Equipment schedule for hybrid heating system.

	Equipment
Furnace	**GMVM970603BN** Goodman furnace; Modulating gas valve; 60 kBTU; 97% AFUE; 3 Ton ECM variable-speed blower
ASHP	**GSZC160241** Goodman two-stage heat pump; Up to 17 SEER and 9.5 HSPF (Note: This is a medium-level heating efficiency for an ASHP); 2 Ton

UPFRONT COSTS

A hybrid system including a single- or two-stage ASHP *and* a high-efficiency furnace should cost $8,000 to $12,000 installed (plus tax; not including rebates). At the low end of this spectrum are systems for small-to-medium homes that use a single-stage ASHP. At the higher end are systems for larger homes that include a high-efficiency two-stage ASHP.

Based on review of the installation invoice, the upfront cost for the hybrid system in this case study was near the middle of this spectrum, and was **approximately $3,000 more than conventional furnace-A/C**. Also note that, in many cases, it is possible to achieve lower upfront costs by using a single-stage ASHP or by replacing only the A/C unit with an ASHP that is then used with the *already-existing* furnace.

This communication has been prepared by the Sustainable Technologies Evaluation Program (STEP). STEP gratefully acknowledges the insights shared by homeowner Lisa Feger, Marshall and Hackberg contractor Imperial Energy for this analysis. The contents of this report do not necessarily represent the policies of supporting agencies. Mention of trade names and commercial products does not constitute an endorsement of those products.

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Conservation

TAF Toronto

Region of Peel York Region

Sustainable Technologies EVALUATION PROGRAM

TECHNICAL BRIEF

Residential Heat Pump Case Study 2: Low-Cost Hybrid Heating in a Toronto Home

The Sustainable Technologies Evaluation Program (STEP) is a collaborative non-profit research initiative within the Toronto and Region Conservation Authority (TRCA). Among other priorities, STEP partners with government, utilities, non-profits, academic institutions, and private companies, to pilot and evaluate emerging low-carbon technologies for buildings with the aim of providing real-world data, analysis, tools, and outreach that promotes effective technological solutions for climate change mitigation.

INTRODUCTION

This is the second case study in a series evaluating heat pump installations in single-family homes in Ontario, focusing on the Greater Toronto and Hamilton Area. The City of Toronto targets a 65% reduction in carbon emissions by 2030. Most of the emissions (57%) are from homes and buildings, primarily a result of natural gas used for space heating. Home energy retrofits on a massive scale are therefore needed. Hybrid heating systems are a promising cost-effective low-carbon heating solution. This case study evaluates upfront costs, carbon reductions, and utility bill impacts of a Toronto installation.

SITE AND EQUIPMENT

The hybrid heating system was installed in October 2020 in a 2-storey 2,000 ft² single-family detached home located in The Beaches, Toronto. The home was constructed in 2002 and has four occupants. It uses a tankless on-demand gas water heater. The hybrid heating system replaced the original furnace (AFUE 92%) and A/C of the home. There have been no other recent energy efficiency upgrades. For the hybrid system, the homeowners selected a two-stage high-efficiency natural gas furnace (AFUE 96%) and a relatively low-efficiency single-stage air-source heat pump (ASHP). The equipment schedule is outlined in Table 1. The system was configured such that the heat pump provided all the heating above an outdoor temperature of -6 °C, and the furnace was used exclusively in more extreme cold. Switching between the furnace and ASHP was handled automatically by the thermostat and an outdoor temperature relay.

Hybrid heating systems (also called dual fuel systems) look the same as conventional furnace and A/C systems. The difference is that, in a hybrid system, the A/C unit is "upgraded" to an air-source heat pump (ASHP). The ASHP provides both cooling and heating. It is driven by electricity and it is much more efficient than a furnace. It can be used for heating in milder outdoor conditions when it is generally more cost-effective than a furnace. The furnace is then used in very cold conditions. In jurisdictions with a low-carbon electricity grid, like Ontario, this can result in lower utility bills and significantly lower carbon emissions.

Table 2. Utility bill analysis results.

Parameter	Value
Actual post-retrofit gas consumption (Nov 2020 to June 2021)	457 m^3
Baseline gas consumption	1,517 m^3
Total gas reduction	1,060 m^3 (70%)
Gas reduction from hybrid heating system	830 m^3
Gas reduction from reduced hot water usage	230 m^3
Actual post-retrofit electricity consumption (Nov 2020 to June 2021)	9,029 kWh
Baseline electricity consumption*	5,956 kWh
Electricity increase from hybrid heating system	3,073 kWh
Gas reduction for *space heating* from hybrid system	**74%**
Net utility cost increase for *space heating* from hybrid system**	**$41**
Net carbon savings for *space heating* due to hybrid system	**1.5 tonnes**

* Large correction was made for greater EV usage pre-retrofit.
**This is the *total* utility increase for Nov 2020 to June 2021 assuming *current* rates.

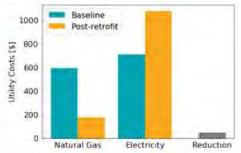

Figure 1. Utility cost impacts including hybrid system *and* hot water reductions.

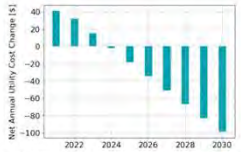

Figure 2. Estimated annual net utility cost changes from the hybrid system considering carbon pricing. Electricity rates were assumed to increase at 2%/year from current values. Positive values are a utility cost increase. Negative values are savings.

"I wanted to significantly reduce our household fossil fuel consumption. My goal was to do this at little to no extra cost in the long term, and demonstrate to others how feasible this is to do today without sacrificing comfort or budget." -Homeowner

Table 1. Equipment schedule for this hybrid system.

	Equipment
Furnace	**GMVC960603BN** Goodman furnace; Two-stage; 60 kBTU; 96% Efficiency; 3 Ton ECM variable speed blower motor
ASHP	**ASZ130301** Amana single-stage heat pump; 8.2 HSPF (Note: This is a low heating efficiency for an ASHP); 13 SEER; 2.5 Ton

UPFRONT COSTS

A hybrid system including a single- or two-stage ASHP *and* a high-efficiency furnace should cost $8,000 to $12,000 installed (plus tax; not including rebates). At the low end of this spectrum are systems for small-to-medium homes that use a single-stage ASHP. At the higher end are systems for larger homes that include a high-efficiency two-stage ASHP.

Based on review of the installation invoice, the upfront cost for the hybrid system in this case study was at the low end of this spectrum, and was **approximately $1,000 more than a conventional furnace-A/C system**. Also note that, in many cases, it is possible to achieve lower upfront costs by replacing only the A/C unit with an ASHP that is then used with the *already-existing* furnace.

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Conservation

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Region of Peel York Region

Sustainable Technologies EVALUATION PROGRAM

TECHNICAL BRIEF

Residential Heat Pump Case Study 3: Hybrid Heating in a Toronto Century Home

The Sustainable Technologies Evaluation Program (STEP) is a collaborative non-profit research initiative within the Toronto and Region Conservation Authority (TRCA). Among other priorities, STEP partners with government, utilities, non-profits, academic institutions, and private companies, to pilot and evaluate emerging low-carbon technologies for buildings with the aim of providing real-world data, analysis, tools, and outreach that promotes effective technological solutions for climate change mitigation.

INTRODUCTION

This is the third case study in a series evaluating heat pump installations in single-family homes in Ontario, focusing on the Greater Toronto and Hamilton Area. The City of Toronto targets a 65% reduction in carbon emissions by 2030. Most of the emissions (57%) are from homes and buildings, primarily a result of natural gas used for space heating. Home energy retrofits on a massive scale are therefore needed. Hybrid heating systems are a promising cost-effective low-carbon heating solution. This case study evaluates upfront costs, carbon reductions, and utility bill impacts of an installation in a Toronto home.

SITE AND EQUIPMENT

The hybrid heating system replaced an aging furnace-A/C system and was commissioned in October 2020 in a 1920s-era 3-bedroom 2-storey detached home in Toronto's East End. The home has two occupants and is less than 1,500 ft². Prior improvements to the energy efficiency of the home include foam insulation that had been added between the studs on the interior of both floors and windows upgraded to double-glazed. At the time of the heat pump retrofit, attic insulation was upgraded from 11" (~R-38) to 18" (~R-60) of blown-in cellulose over the majority of the attic. Also coinciding with the hybrid system was the addition of a heat recovery ventilator (HRV) to improve air quality, and a tankless water heater (AFUE 98%) that replaced a storage water heater. Table 1 shows the hybrid system equipment. The switchover temperature is -5 °C. The ASHP is used for heating when outdoor temperatures are above this value. The furnace automatically turns on and provides all of the heating in colder conditions.

Hybrid heating systems (also called dual fuel systems) look the same as conventional furnace and A/C systems. The difference is that, in a hybrid system, the A/C unit is "upgraded" to an air-source heat pump (ASHP). The ASHP provides both cooling and heating. It is driven by electricity and it is much more efficient than a furnace. It can be used for heating in milder outdoor conditions when it is generally more cost-effective than a furnace. The furnace is then used in very cold conditions. In jurisdictions with a low-carbon electricity grid, like Ontario, this can result in lower utility bills and significantly lower carbon emissions.

Table 2. Utility bill analysis results.

Parameter	Value
Actual post-retrofit gas consumption (Dec 2020 to May 2021)	534 m³
Baseline gas consumption*	1,454 m³
Total gas reduction	920 m³ (63 %)
Gas reduction from hybrid heating system	862 m³
Gas reduction from water heater upgrade	39 m³
Gas reduction from attic insulation upgrade	18 m³
Actual post-retrofit electricity consumption (Dec 2020 to May 2021)	4,760 kWh
Baseline electricity consumption*	1,556 kWh
Electricity increase from hybrid heating system	3,204 kWh
Gas reduction for *space heating* due to hybrid system	**65 %**
Net utility cost increase for *space heating* from hybrid system**	**$64**
Net carbon savings for *space heating* due to hybrid system	**1.6 tonnes**

* There was a small adjustment made for the HRV.
**This is the total utility increase for Dec 2020 to May 2021 assuming *current* rates.

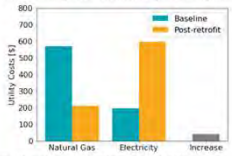


Figure 1. Utility cost impacts at *current* rates including all measures.

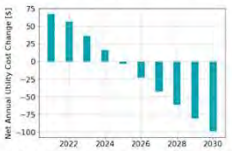


Figure 2. Estimated annual net utility cost changes from the hybrid system considering carbon pricing. Electricity rates were assumed to increase at 2%/year from current values. Positive values are a utility cost increase. Negative values are savings.

"The heat pump behaves differently from the gas furnace. It doesn't recover the temperature as quickly when the temperature is below the target. We used to setback the furnace significantly at night, but found that the heat pump could not get it back to daytime temperature in a reasonable time. We now only set it back 2 degrees. This is just a change that one gets used to."
-Homeowner

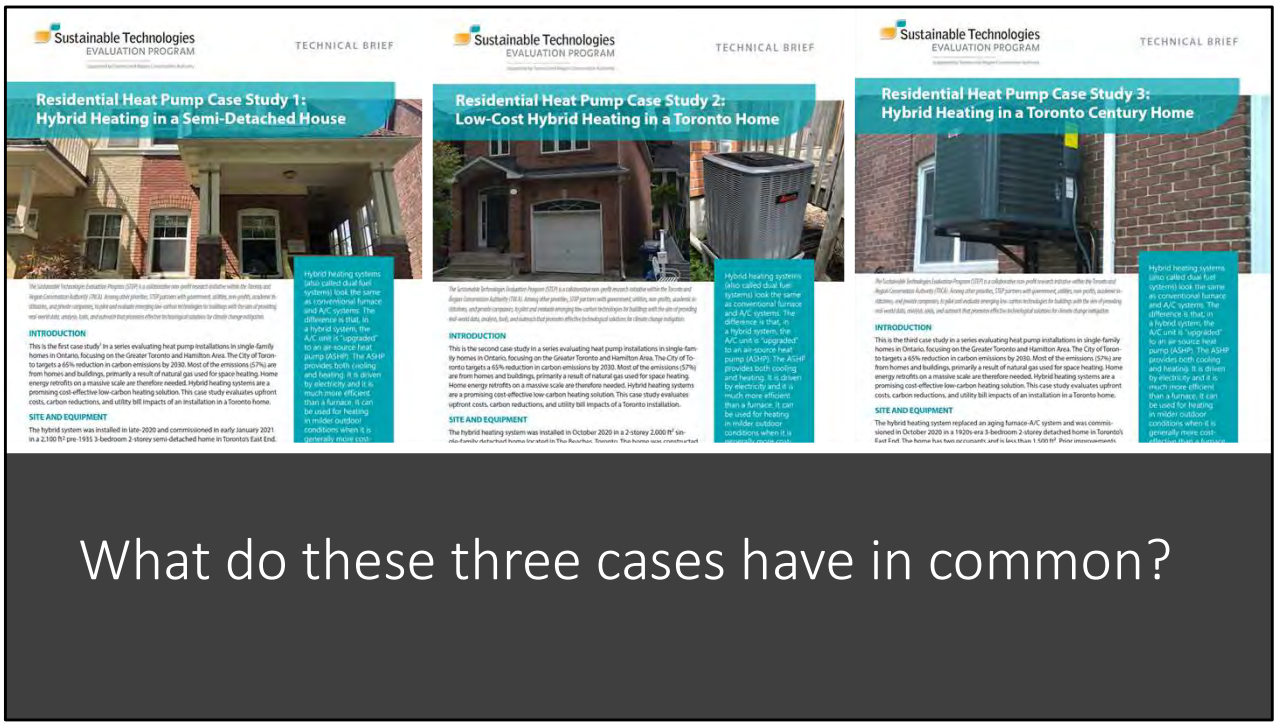
Table 1. Equipment schedule for hybrid heating system.

	Equipment
Furnace	**GMVC960603BN** Goodman Furnace; Two-stage; 60 kBTU; 96% Efficiency; 3 Ton ECM variable speed blower motor
ASHP	**GSZ160241** Goodman single-stage heat pump; Up to 16 SEER and 9.0 HSPF (Note: This is a medium-level heating efficiency for an ASHP); 2 Ton

UPFRONT COSTS

A hybrid system including a single- or two-stage ASHP *and* a high-efficiency furnace should cost $8,000 to $12,000 installed (plus tax; not including rebates). At the low end of this spectrum are systems for small-to-medium homes that use a single-stage ASHP. At the higher end are systems for larger homes that include a high-efficiency two-stage ASHP.

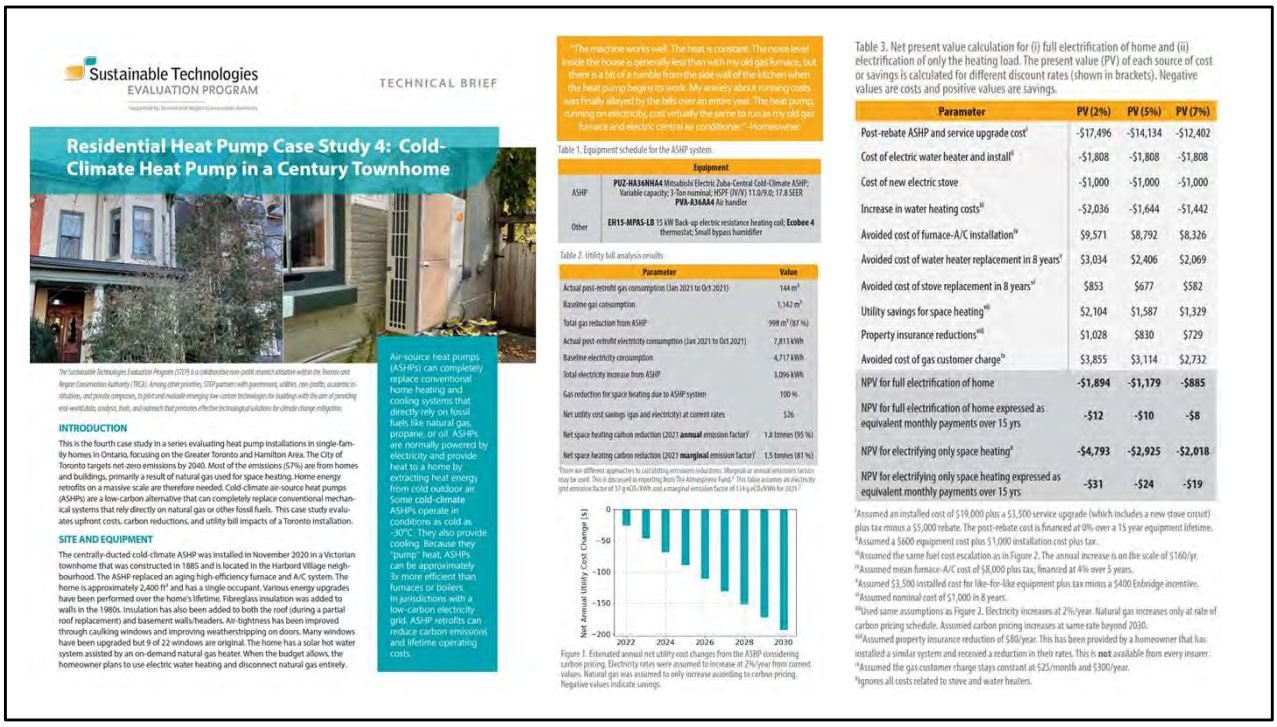
Based on review of the installation invoice, the upfront cost for the hybrid system in this case study was at the low end of this spectrum, and was **approximately $2,000 more than a conventional furnace-A/C system**. Also note that, in many cases, it is possible to achieve lower upfront costs by replacing only the A/C unit with an ASHP that is then used with the *already-existing* furnace.



What do these three cases have in common?

They all:

- Reduced heating system carbon emissions by at least 50%, at least 1.4 tonnes
- They are all retrofits that an HVAC contractor can do today with nominal additional training
- They all will save the homeowner on their utility bills within the next 5 years
- They are all just marginally more expensive than a like-for-like replacement
- AND NONE OF THEM QUALIFY FOR THE GREENER HOMES GRANT!



Sustainable Technologies EVALUATION PROGRAM

TECHNICAL BRIEF

Residential Heat Pump Case Study 4: Cold-Climate Heat Pump in a Century Townhome

INTRODUCTION

This is the fourth case study in a series evaluating heat pump installations in single-family homes in Ontario, focusing on the Greater Toronto and Hamilton Area. The City of Toronto targets net-zero emissions by 2040. Most of the emissions (57%) are from homes and buildings, primarily a result of natural gas used for space heating. Home energy retrofits on a massive scale are therefore needed. Cold-climate air-source heat pumps (ASHPs) are a low-carbon alternative that can completely replace conventional mechanical systems that rely directly on natural gas or other fossil fuels. This case study evaluates upfront costs, carbon reductions, and utility bill impacts of a Toronto installation.

SITE AND EQUIPMENT

The centrally-ducted cold-climate ASHP was installed in November 2020 in a Victorian townhome that was constructed in 1885 and is located in the Harbord Village neighbourhood. The ASHP replaced an aging high-efficiency furnace and A/C system. The home is approximately 2,400 ft² and has a single occupant. Various energy upgrades have been performed over the home's lifetime. Fibreglass insulation was added to walls in the 1980s. Insulation has also been added to both the roof (during a partial roof replacement) and basement walls/headers. Air-tightness has been improved through caulking windows and improving weatherstripping on doors. Many windows have been upgraded but 9 of 22 windows are original. The home has a solar hot water system assisted by an on-demand natural gas heater. When the budget allows, the homeowner plans to use electric water heating and disconnect natural gas entirely.

Air-source heat pumps (ASHPs) can completely replace conventional home heating and cooling systems that directly rely on fossil fuels like natural gas, propane, or oil. ASHPs are normally powered by electricity and provide heat to a home by extracting heat energy from cold outdoor air. Some cold-climate ASHPs operate in conditions as cold as -30°C. They also provide cooling. Because they "pump" heat, ASHPs can be approximately 3x more efficient than furnaces or boilers. In jurisdictions with a low-carbon electricity grid, ASHP retrofits can reduce carbon emissions and lifetime operating costs.

"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 about 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 electric central air conditioner." –Homeowner

Table 1. Equipment schedule for the ASHP system.

	Equipment
ASHP	**PUZ-HA36NHA4** Mitsubishi Electric Zuba-Central Cold-Climate ASHP; Variable capacity; 3-Ton nominal; HSPF (IV/V) 11.0/9.0; 17.8 SEER **PVA-A36AA4** Air handler
Other	**EH15-MPAS-LB** 15 kW Back-up electric resistance heating coil; **Ecobee 4** thermostat; Small bypass humidifier

Table 2. Utility bill analysis results.

Parameter	Value
Actual post-retrofit gas consumption (Jan 2021 to Oct 2021)	144 m³
Baseline gas consumption	1,142 m³
Total gas reduction from ASHP	998 m³ (87 %)
Actual post-retrofit electricity consumption (Jan 2021 to Oct 2021)	7,813 kWh
Baseline electricity consumption	4,717 kWh
Total electricity increase from ASHP	3,096 kWh
Gas reduction for space heating due to ASHP system	100 %
Net utility cost savings (gas and electricity) at current rates	$26
Net space heating carbon reduction (2021 **annual** emission factor)[i]	1.8 tonnes (95 %)
Net space heating carbon reduction (2021 **marginal** emission factor)[i]	1.5 tonnes (81 %)

[i] There are different approaches to calculating emissions reductions. Marginal or annual emissions factors may be used. This is discussed in reporting from The Atmospheric Fund.[7] This table assumes an electricity grid emission factor of 37 g CO_2/kWh and a marginal emission factor of 134 g CO_2/kWh for 2021.[7]

Figure 1. Estimated annual net utility cost changes from the ASHP considering carbon pricing. Electricity rates were assumed to increase at 2%/year from current values. Natural gas was assumed to only increase according to carbon pricing. Negative values indicate savings.

Table 3. Net present value calculation for (i) full electrification of home and (ii) electrification of only the heating load. The present value (PV) of each source of cost or savings is calculated for different discount rates (shown in brackets). Negative values are costs and positive values are savings.

Parameter	PV (2%)	PV (5%)	PV (7%)
Post-rebate ASHP and service upgrade cost[f]	-$17,496	-$14,134	-$12,402
Cost of electric water heater and install[g]	-$1,808	-$1,808	-$1,808
Cost of new electric stove	-$1,000	-$1,000	-$1,000
Increase in water heating costs[iii]	-$2,036	-$1,644	-$1,442
Avoided cost of furnace-A/C installation[iv]	$9,571	$8,792	$8,326
Avoided cost of water heater replacement in 8 years[v]	$3,034	$2,406	$2,069
Avoided cost of stove replacement in 8 years[vi]	$853	$677	$582
Utility savings for space heating[vii]	$2,104	$1,587	$1,329
Property insurance reductions[viii]	$1,028	$830	$729
Avoided cost of gas customer charge[ix]	$3,855	$3,114	$2,732
NPV for full electrification of home	-$1,894	-$1,179	-$885
NPV for full electrification of home expressed as equivalent monthly payments over 15 yrs	-$12	-$10	-$8
NPV for electrifying only space heating[x]	-$4,793	-$2,925	-$2,018
NPV for electrifying only space heating expressed as equivalent monthly payments over 15 yrs	-$31	-$24	-$19

[f] Assumed an installed cost of $19,000 plus a $3,500 service upgrade (which includes a new stove circuit) plus tax minus a $5,000 rebate. The post-rebate cost is financed at 0% over a 15 year equipment lifetime.
[g] Assumed a $600 equipment cost plus $1,000 installation cost plus tax.
[iii] Assumed the same fuel cost escalation as in Figure 2. The annual increase is on the scale of $160/yr.
[iv] Assumed mean furnace-A/C cost of $8,000 plus tax, financed at 4% over 5 years.
[v] Assumed $3,500 installed cost for like-for-like equipment plus tax minus a $400 Enbridge incentive.
[vi] Assumed nominal cost of $1,000 in 8 years.
[vii][viii] Used same assumptions as Figure 2. Electricity increases at 2%/year. Natural gas increases only at rate of carbon pricing schedule. Assumed carbon pricing increases at same rate beyond 2030.
[viii] Assumed property insurance reduction of $80/year. This has been provided by a homeowner that has installed a similar system and received a reduction in their rates. This is **not** available from every insurer.
[ix] Assumed the gas customer charge stays constant at $25/month and $300/year.
[x] Ignores all costs related to stove and water heaters.

"A premium high-performance inverter-driven cold-climate ASHP with electric resistance back-up may currently cost between $19,000 and $25,000 (plus tax; not including rebates) for a single-family home. The cost for this ASHP installation was at the low end of this range."

"There was an additional cost of approximately $3,500 (plus tax) to upgrade the electrical service of the home to 200A to accommodate the increased electricity demand. This also included a new circuit and receptacle for an electric stove that replaced a gas stove at the same time of the ASHP retrofit. Newer homes may not require a service upgrade. A conventional furnace-A/C replacement for a comparable home may cost between $6,000 and $10,000 (plus tax), or possibly more depending on the installer and the home. The additional upfront cost (post-rebate) of a high-performance central cold-climate ASHP system is then several thousand dollars to potentially more than $10,000. While this cost is substantial, the analysis will show that the lifetime operating cost savings can offset much (or nearly all) of the incremental upfront costs."

Figure 3: Proportion of households spending 30 per cent or more of their income on shelter costs, 2006 and 2016

Source: Statistics Canada, Census 2006 and 2016 by Census Division

Table 1: Private occupied dwellings by type in Waterloo Region, 2006-2016

Dwelling type	2006	Per cent of total dwellings	2011	Per cent of total dwellings	2016	Per cent of total dwellings	Absolute change 2011-2016	Per cent change 2011-2016
Single-detached house	101,440	57.0%	109,400	57.1%	113,470	55.7%	4,070	3.7%
Semi-detached house	11,940	6.7%	12,910	6.7%	12,930	6.3%	20	0.2%
Row house	17,860	10.0%	20,240	10.6%	22,635	11.1%	2,395	11.8%
Apartment	46,245	26.0%	48,365	25.2%	54,280	26.6%	5,915	12.2%
Other	510	0.3%	680	0.4%	515	0.3%	-165	-24.3%
Total	**177,995**	**100%**	**191,595**	**100%**	**203,830**	**100%**	**12,235**	**6.4%**

Source: Statistics Canada, Census 2006 to 2016 by Census Division

PLANNING, DEVELOPMENT AND LEGISLATIVE SERVICES – 2016 Census Bulletin #6

Municipal Goals

- 149,000 low rise homes as of 2016 = 29,807 need to be converted to 100% heat pumps by 2030.
- 4267 homes / year
- 2245 new single-family, semi- and row- houses built in WR in 2021

Half of the Region of Waterloo's Residential Decarbonization Goal can be achieved in the RNC sector…

- The easiest house to make carbon-free is a new home
- This "net zero ready home"
  - is a 15-year lost opportunity
  - will never be carbon free by 2030
  - will be harder to ultimately decarbonize if the duct system is designed around a gas furnace's temperature rise

Retrofit contractors often get experience on equipment by servicing it after it is installed by an RNC contractor. Therefore, getting the desired types of systems into new construction helps to

1) meet carbon reduction goals sooner, and

2) helps build **Availability** (by priming the supply chain with predictable volume for RNC projects), **Accessibility** (equipment in the supply chain must meet RNC codes); **Awareness** (retrofit contractors will see the systems work first-hand as they maintain and service them, building awareness); **Affordability** (competition for this work will incentivize OEMs to compete for the work); **Acceptance** (retrofit contractors will become proponents of the technology as they see it work in RNC and will recommend it to their customers.)

How do we turn obstacles into opportunities?

- Articulate a clear path forward so the channel can plan effectively
  - No one wants to invest only to discover that a change in government policy devalues their investment
- Support workforce development and the training of more 313D - Residential Air Conditioning System Technicians
- Collaborate more with Industry and work to prevent unintended

consequences

- Let’s stop creating incentives for products that are not in the supply chain
- Please collaborate more with industry to understand our challenges

- Give contractors the tools to easily demonstrate the cost/benefit of electrification – tools that they can use easily and in the home

- Take a two-step approach – equipment lifecycle means that an AC installed today is a lost opportunity for 15 years! Hybrid systems are an interim step to help get us there.