Dual fuel, dual benefits:

How hybrid heating can cut energy costs and reduce emissions from Ontario homes

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About Clean Prosperity

Clean Prosperity is a Canadian climate policy organization that advocates for pragmatic solutions to grow the low-carbon economy. Learn more at CleanProsperity.ca.

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Abbreviations

COP	coefficient of performance
IESO	Independent Electricity System Operator
kW	kilowatt (1000 watts)
kWh	kilowatt-hour (1000 watt-hours)
MW	megawatt (1,000 kilowatts)
MWh	megawatt-hour (1,000 kilowatt-hours)
OEB	Ontario Energy Board
RNG	renewable natural gas
TWh	terawatt-hour (1,000,000 megawatt-hours)

Executive summary

Home heating is changing, and heat pumps offer a highly efficient alternative to natural gas furnaces. A realistic plan to cut emissions from Ontario households currently heating with natural gas requires household savings and low system-wide costs.

Instead of completely abandoning natural gas in existing homes, hybrid heating systems — which combine electric air-source heat pumps with traditional natural gas heating — offer a practical path to reducing emissions while encouraging cost-effective home heating for many Ontario households. We find that hybrid heating can reduce both operating costs and emissions for many households.

A net-zero future means that Ontario's electricity demand will peak in the winter, not in the summer as it does now. Hybrid heating can reduce the pressures on Ontario's electricity grid compared to widespread adoption of only air-source heat pumps.

We use modelling from Navius Research to compare two extreme scenarios — all Ontario buildings adopting hybrid heating, or all Ontario buildings going fully electric with air-source heat pumps. We find that electricity costs are 20% lower in the all-hybrid heating scenario. This scenario is still consistent with Canada achieving net-zero emissions in 2050.

Hybrid heating can generate significant savings for the Ontario electricity grid if widely adopted, but it comes with an upfront cost to individual end users. The system-wide savings can be used to make hybrid heat pumps cheaper and thus more attractive to end users.

Our preliminary estimates show that widespread deployment of hybrid heating systems can save upwards of $4,700 per household in electricity generation system investment compared to a scenario in which half of Ontario homes have all-electric heating systems in 2050. Consumers should reap some of that benefit of adopting a hybrid heating system through an upfront subsidy.

Instead of completely abandoning natural gas in existing homes, hybrid heating systems — which combine electric air-source heat pumps with traditional natural gas heating — offer a practical path to reducing emissions while encouraging cost-effective home heating for many Ontario households.

Quebec capitalizes on the value of existing natural gas networks by covering up to 80% of the incremental costs of installing hybrid systems in existing homes. Quebec also offers an electricity rate structure designed for hybrid heating. Ontario should adopt a similar model.

An Ontario subsidy for hybrid heating systems should be designed so that heat pumps cost end consumers no more than conventional central air conditioning systems. Other Ontario electricity ratepayers should subsidize hybrid heating system installations, because these systems reduce their electricity rates.

Policy support for heat pump adoption should extend to households who do not outright own their heat pumps. Finally, provincial trades certifications limit the ability of contractors to install heat pumps, particularly when paired with natural gas furnaces. This should be fixed.

Now that the federal fuel charge has been removed, policymakers seeking to decarbonize home heating need to turn their attention to practical, cost-effective alternatives — chief among them, hybrid heating systems with smart in-home controls.

Recommendations

1. Make it easier for Ontario households to adopt hybrid heating systems.

The federal and Ontario governments should subsidize the widespread deployment of hybrid heating systems in Ontario. Governments should subsidize a wide range of heat pumps and support a better design for financing heat pumps as emergency replacements.

Subsidies should make heat pumps as affordable to consumers as air conditioning systems. They should make hybrid heating systems the most appealing option when Ontario consumers replace their air conditioners or gas furnaces.

2. Assess the value of hybrid heating for the Ontario energy system under a competitive market.

The Ministry of Energy should direct the Independent Electricity System Operator (IESO) to estimate the capacity value of hybrid heating systems for optimizing energy demand against peak-period supply cost.

The Ontario government should direct the IESO to provide incentives for any kind of dispatchable capacity flexibility from electric home heating. Wide-scale deployments of these options should emerge from a competitive process, such as capacity markets.

3. Make it possible for Ontario households to get the most value from their hybrid heating systems.

The Ontario government should direct the Ontario Energy Board to consider adopting electricity pricing options designed for hybrid heating — such as the pricing options used in Quebec.

As an early first step, Ontario should make it easy for customers to adopt the ultra-low overnight rate only for winter months, without customers needing to contact their electricity provider to seasonally switch plans.

4. Make it easier for more home heating trades workers to install heat pumps.

Trades workers certified only for residential-level heating and cooling do not get the benefits, such as access to funding or full interprovincial mobility, of being included in the Red Seal Program, which sets common standards for tradespeople across Canada.

Ontario should seek to persuade other provinces to harmonize training for gasfitters and heat pump technicians; and to recognize its Residential Air Conditioning Systems Mechanic trade certification and include it in the Red Seal program.

Introduction

Building operations, including the electricity to service them, account for 18% of Canada's total emissions, with 47% of those emissions coming from the residential sector. Most of these emissions come from burning hydrocarbons for home heating, especially natural gas.

Reducing these emissions is challenging because of the scale of Canada's housing stock. Canada's built environment includes about 10.5 million single-family dwellings, with continuous annual growth. Of those, about five million homes are connected to the natural gas system, most of them in Ontario. Almost half of Canada's residential natural gas consumption is in Ontario.[1]

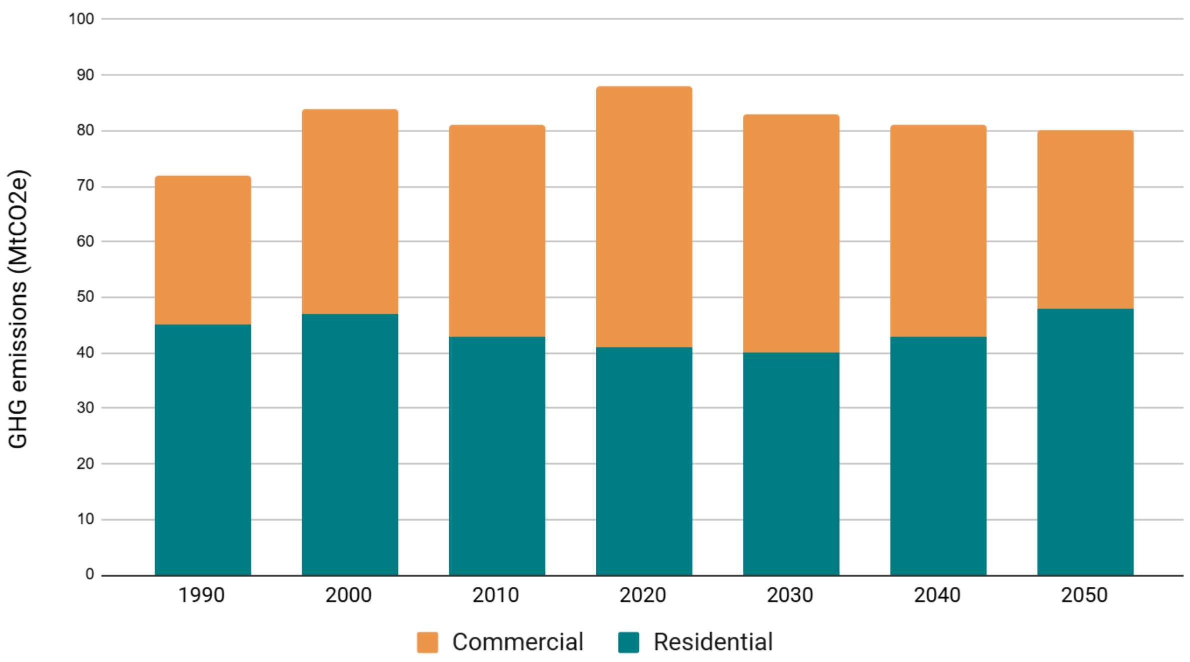
This study proposes ways to reduce both emissions and home heating costs for existing single-family homes connected to the natural gas system. The study is primarily focused on Ontario, Canada's largest consumer of residential natural gas.

From 1990 to 2020, overall emissions from Canadian buildings — residential and commercial — increased by 23% (Figure 1). To understand the future evolution of those emissions, we used Navius Research's integrated gTech-IESD model to model Canada's energy systems between now and 2050 under a set of energy and climate policies and plans that we see as politically stable. This forecast assumes that federal-provincial political dynamics result in the elimination of many of the most stringent policies, such as the oil and gas emissions cap, and that the recently eliminated federal fuel charge is not reinstated.

In such a scenario, emissions from buildings only decrease moderately, with all reductions coming from commercial buildings. Emissions from residential buildings increase by about 15% from 2020 to 2050. Alberta and Ontario account for all the increase in residential building emissions through 2050.

[1] Alberta accounts for about a quarter of residential natural gas consumption, with the balance consumed largely in the three other Western provinces.

Figure 1: Past and forecast emissions from buildings in Canada, 1990-2050.



Source: Forecast for 2030-2050 based on modelling from Navius Research.

The federal fuel charge was intended to incentivize homeowners to switch from natural gas to electric home heating. Following the cancellation of this policy in April 2025, policymakers are looking at new solutions for reducing building emissions. Are there ways to reduce costs to homeowners and reduce emissions, while limiting the amount of public funding required? We will show that there are solutions that can benefit Ontario homeowners (and energy consumers broadly), taxpayers, and the climate.

The promise (and pitfalls) of heat pumps for cost savings and emissions reductions

Compared to natural gas furnaces, heat pumps reduce emissions from home heating and, in certain circumstances, can also reduce energy costs for consumers. Heat pumps are up to five times more energy efficient than gas furnaces, consistently achieving at least double the efficiency of furnaces in nearly all climates.

A major barrier to heat pump adoption has been the significant upfront costs of a heat pump. The cost can range from $3,000 for a standard three-ton centrally ducted heat pump to $15,000 for a heat pump designed to operate in a cold climate — excluding additional installation costs or potential electricity service upgrades. Technologically, heat pumps are very similar to air conditioners, and they offer home cooling as well as heating. The incremental cost of a heat pump over an air conditioning system can range from less than $1,000 to $3,000.[2]

Another barrier to heat pump adoption in Ontario is the fact that many homeowners currently connected to natural gas would not be financially better off by fully adopting non-emitting heating options. This is largely due to the province's climate and prevailing energy prices, and the removal of the federal fuel charge.

In addition, utilities may be hesitant to encourage widespread heat pump adoption because of the considerable pressure this would put on electricity grids. With widespread adoption of all-electric heating, electricity demand would no longer peak in the summer as it does now — Ontario would become a winter-peaking province. This effect would be exacerbated by the fact that heat pump efficiency decreases with external temperatures. If consumers do not have backup natural gas furnaces and rely entirely on electric heating, their total energy consumption on the coldest days of the year is significantly higher than on other days.

In a study of heating electrification at the national level, Peters, Marstokk, and Riehl (2024) find that meeting these new peak demands would require a significant increase in generation, transmission, and distribution capacity — particularly in Ontario and Alberta, if these provinces are to reach net-zero emissions.[3] This increased demand (their scenario forecasts 62% of Ontario's home heating being all-electric in 2050), if not paired with peak load management technologies, would require a significant build-out of the entire electricity supply chain at considerable cost, possibly resulting in higher electricity prices.

Further, as we will show later in the paper using new modelling from Navius, widespread adoption of fully non-emitting home heating sources in a net-zero, lowest economic cost scenario would require new peak capacity electricity supply that, in Ontario, would be most cost-effectively delivered by natural gas-fired generation, partly negating some of the emissions saved by electrifying home heating.

A practical approach to heat pump adoption

Ontario policymakers seeking to reduce building emissions should not ignore these practical problems with the adoption of all-electric heat pump systems. An alternative solution is to promote the widespread adoption of hybrid heating systems — electric heat pumps combined with gas furnaces. This can both reduce overall emissions as much as the widespread adoption of all-electric heat pump

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[2] An estimate from the Building Decarbonization Alliance estimates the average incremental cost at about $2,000.

[3] They find that peak Ontario demand will more than double from 2015 levels by 2050, growing from 23,000 MW to 55,000 MW. Indeed, in subsequent analysis that incorporates the potential grid impacts of a cold winter, peak demand could grow to over 60,000 MW. Provinces with milder weather or that currently have widespread deployment of electric resistance heating will see modest increases in peak demand. Alberta's peak electricity demand quintuples in their net-zero forecast.

systems, reducing the necessary investment in the electricity grid, and reduce costs for homeowners. That is because widespread adoption of all-electric heat pump systems can lead to increased emissions from the electricity sector and foregone electrification elsewhere, relative to the direct emissions that come from hybrid home heating.

Hybrid heating systems use an electric heat pump when that is the most cost-effective option, and switch to a natural gas furnace when external temperatures drop to a level at which the heat pump can no longer operate cost-effectively (See Box 1). Later in this paper, we will look in greater detail at a scenario in which hybrid heating systems are widely adopted in Ontario.

Box 1: Heat pumps and hybrid heating

An air-source heat pump moves heat rather than generating it. In cold weather, it extracts heat from the outside air and moves it indoors to warm a home. In warm weather, it works in reverse, removing heat from inside and releasing it outdoors to cool the space, like a traditional air conditioner.

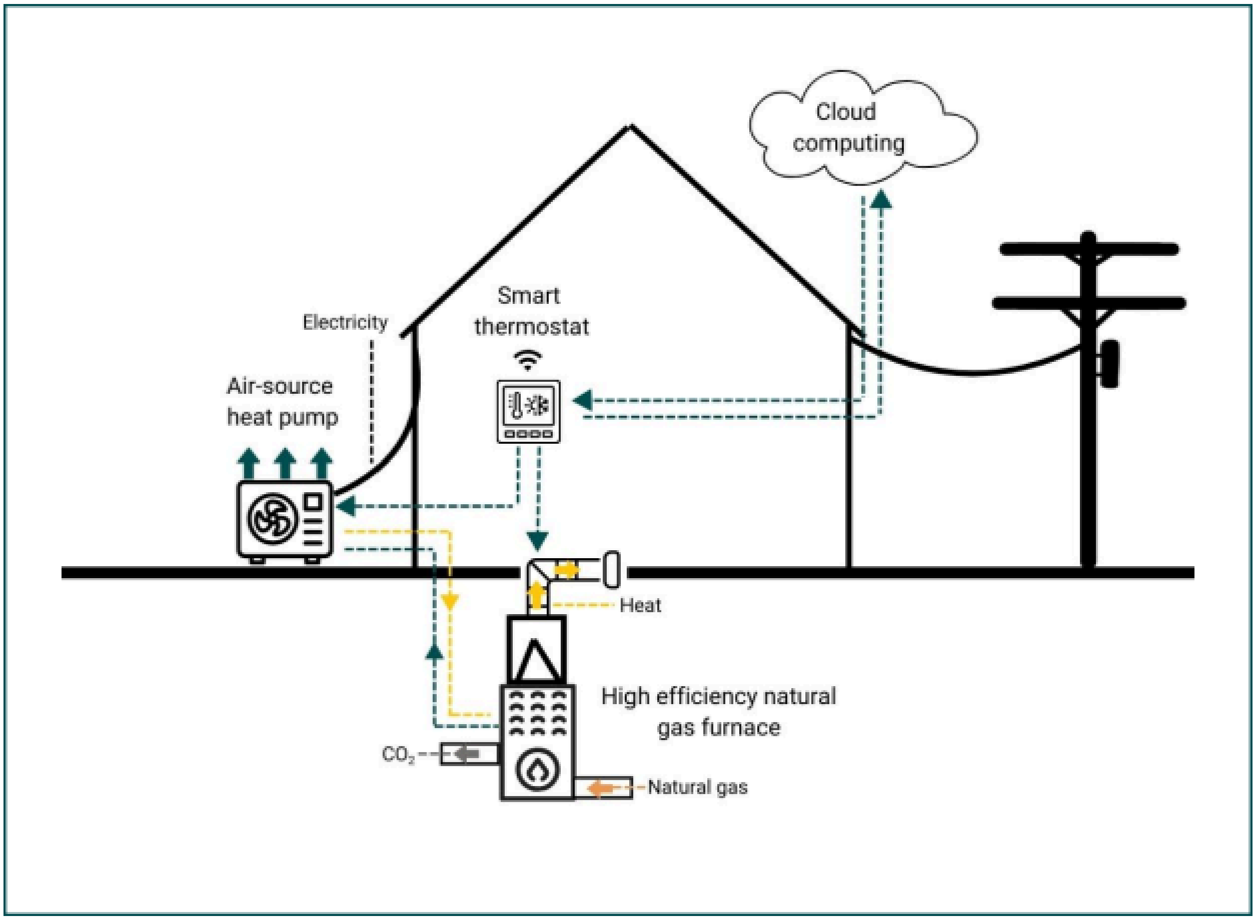
Hybrid heating combines a heat pump with a non-electric backup heating system, typically a natural gas or propane furnace. This setup allows the home to switch between energy sources based on the external temperature. Heat pumps achieve a coefficient of performance (COP) of two to four in moderate temperatures, meaning that they deliver two to four times more heat energy than the electricity they consume, while natural gas furnaces and baseboard heating consistently maintain a COP slightly under one.

Cold-climate air-source heat pumps are designed to maintain a COP above 1.5 at -20°C, often achieving COPs above 2.0 at -15°C, using variable-speed compressors and refrigerants that are optimized for low temperatures. Cold-climate heat pumps often require a higher amperage electrical service compared to standard air-source heat pumps or air conditioning units, so installation can, in some cases, necessitate upgrades to a home's electrical service. In contrast, standard air-source heat pumps are less expensive but typically experience a sharp drop in COP below 0°C, making them inefficient or inadequate for primary heating in cold climates without auxiliary backups, such as electric resistance heaters, or natural gas furnaces.

As temperatures drop, a heat pump's COP declines. In Ontario, this makes natural gas the more cost-effective option in extreme cold temperatures, as the price per kWh equivalent is currently much lower for natural gas than electricity. In homes that have both gas furnaces and heat pumps, most current smart thermostats do little to optimize the transition between heating systems for both comfort and cost savings. However, in-home technology is increasingly becoming available, such as GreenBox, that optimizes home heating operations based on energy prices and temperature.

In homes with natural gas furnaces that also have central air conditioning (over 85% of Ontario homes have air conditioning of some kind; central air conditioning systems are the most common), switching to a hybrid heating system requires no additional major investment, such as adding ducts or mini-split units to individual rooms, to maintain heating home comfort.

Analysis of other kinds of heat pumps, like ground-source heat pumps, are outside the scope of our analysis.



Households with hybrid heating systems using smart thermostats can reduce their heating costs; first, by always taking advantage of the most energy-efficient heating technology, which partly depends on ambient temperature. At moderately cold temperatures, heat pumps provide the most cost-effective home heating. This is because the heat pump will be operating at its highest efficiency at times that coincide with periods in which electricity systems built for servicing peaks at extreme temperatures will have spare capacity, and therefore lower costs. A net-zero future means Ontario's electricity demand will peak in the winter, not the summer. With better designed electricity rates built expressly around the technology switching in hybrid heating technology, as discussed later in the paper, homeowners with hybrid heating systems can save on their heating costs.

The second cost saving we estimate comes from utilizing the existing natural gas distribution infrastructure to offset new investment needed to meet the new winter peaks in electricity demand. These potential system-level savings allow for a market-driven form of support for hybrid heating adoption that can supplement existing government programs and at no cost, or indeed a savings, to other energy consumers.

Provinces should take the lead

Provinces are the right level of government to adopt many of the policies we propose to encourage the optimal changes to home heating. The impact on provincial electricity grids and the overall emissions impact of adoption of heat pumps will vary dramatically by province.

Provinces are also responsible for consumer protection provisions that will be instrumental to successfully increasing the uptake of hybrid heating systems. Easily accessible long-term financing options are key to increasing demand for heat pump installations. The vast majority of air conditioner or heating system replacements happen when equipment fails. Customers often do not have savings accumulated for those failures and cannot receive government-subsidized loans quickly enough to pay for an urgently-needed replacement. Making it as easy as possible for consumers to adopt heat pumps in place of air conditioners and also buy integrated heat pumps to create a hybrid system when they replace their gas furnaces depends on the implementation of policies to address problems like these.

Provinces also hold the powers over skilled worker certifications, including interprovincial certification recognition, which need improvement to ensure a sufficient workforce to install heat pumps.

Deployment of hybrid heating systems focuses on existing Ontario homes

The next section is a home-level analysis of the benefits of hybrid heating systems. We focus on existing single-family homes, in particular those built before improvements to energy efficiency standards in building codes, and that are connected to existing natural gas infrastructure. These home-level results show that now, or when heating and cooling systems need replacement, is the ideal time for homeowners to upgrade outdated heating systems, independent of any planned renovations that would be ideal times to improve their home's energy efficiency standards.[4]

The 2012 update to the Ontario Building Code introduced stricter energy efficiency minimums for new builds that may make a switch to all-electric heating a more viable financial option for the most energy-efficient homes served by natural gas. This paper only looks at energy use in existing homes, particularly those with energy efficiency levels of previous building codes, and doesn't consider how the future build-out of homes with higher efficiency standards will affect decisions about how to manage the usage and potential expansion of natural gas networks (see Harland et al. 2024 for a review of those issues).

A common critique of hybrid heating approaches is that they divert attention and resources away from deep retrofits and full electrification, which may indeed be the ideal long-term solution for decarbonizing homes. We leave analysis of building envelope retrofits to others. We will argue that hybrid heating systems in Ontario offer a scalable and cost-effective way to cut residential emissions by two-thirds using existing infrastructure, one that can be implemented quickly and with little household-level planning.

With the right smart controls, hybrid heating can also reduce strain on the Ontario electricity grid during peak winter demand, and preserve flexibility for future upgrades. Hybrid systems provide a practical pathway that complements Ontario's broader electrification efforts while buying time for grid expansion, distributed energy solutions, workforce training for building envelope retrofits, and deeper efficiency improvements.

[4] The large majority of homes in Ontario were built before 2011. This is particularly important as older buildings are less energy efficient than new builds in Canada, contributing to increased emissions from home energy use. We do not discuss the details of energy-efficiency building envelope retrofits in this report.

Home-level heating emissions reduction options

KEY TAKEAWAYS

- We model the effects of switching from natural gas furnaces to both hybrid and all-electric home heating in two of Ontario's largest cities, Ottawa and Vaughan.
- Hybrid heating systems offer significant emissions reductions and a potential for cost savings. Cost savings are a likely precondition for households to adopt hybrid heating.
- Switching to electric-only home heating systems results in a marginal monthly cost increase to households, even when households fully disconnect from the natural gas system.

Previous studies have done excellent work looking at the cost effectiveness of heat pump adoption at the household level (Miller et al. 2023, and Martin et al. 2024) and at how Canada can reach net-zero emissions while minimizing costs (Harland et al. 2024). What these studies do not do, however, is assess the home heating pathways that align both reductions in emissions and reductions in household costs, particularly without a carbon tax, or the implications of fully electrified heating for the electricity grid (as discussed in the next section).

A model of home heating and retrofit options

A study by the Canadian Climate Institute (2023) shows that in Toronto, heat pumps with gas backups are generally the lowest-cost option for single-family homes under mid-range assumptions, but that some households can be better off with fully electric service. Martin et al. (2024) find that Ontario households in general have less clear outcomes on total energy costs, however the study does not examine the potential for hybrid heating systems.

These studies assume that carbon prices will rise to $170 per tonne by 2030. That assumption about a high consumer-facing carbon price is no longer valid, and affects the economics of heat pump adoption in Ontario. At a carbon price of $50 per tonne, Ferguson and Sager (2022) find that Ontario residents might save money by adopting hybrid heating, but that savings from going fully electric depend on whether customers maintain gas connections, and prevailing and future utility prices.

We explore the economics of heat pump adoption under current, politically stable policy and current energy prices. We analyze potential options from the perspectives of typical Ontario homeowners.

An energy and emissions model of a typical home

We use Natural Resource Canada's HOT2000 energy modelling software for residential buildings to model 20-year-old, 2,700 square-foot single-family homes in Vaughan and Ottawa. These cities are located in two distinct climate zones, representative of Southwestern and Eastern Ontario, respectively. In addition to the HOT2000 model, we also use Volta SNAP software to break out home energy use by the hour to assess various electricity pricing strategies.

We analyze and compare the performance of natural gas heating systems against hybrid heating systems. We also compare the energy efficiency, environmental impact, and cost-effectiveness of each system. See Appendices B, C, and D for assumptions about the energy characteristics of our model home and its heating and cooling systems, and Figure 2 for a rendering.

Our model calculates the energy required to keep the temperature between 21 °C and 25 °C in a home inhabited by an average Ontario family, made up of two adults and one child.

Figure 2: Home modelled in HOT2000

Home heating source scenario results

To assess the emissions reductions and operating cost-effectiveness associated with hybrid and all-electric heating systems, we model three homes in each of Vaughan and Ottawa. The homes are identical except for the following variables:

1. Baseline home: High-efficiency natural gas furnace and gas water heater. There is also a central split air conditioning system.
2. Hybrid home: Heat pump with smart controls, alongside a high-efficiency gas furnace and gas water heater. We look at two ways to set the hybrid heating system: one setting focused on maximizing cost reductions, another on maximizing emissions reductions.
3. All-electric home: Heat pump and electric resistance water heater, and no household gas service.

We assume that the baseline, hybrid, and all-electric homes adopt the ultra-low overnight electricity rate. Under Ontario's ultra-low overnight rate, customers pay 2.8 cents per kilowatt hour (kWh) between 11 pm and 7 am. Rates range from 7.6 cents in the off-peak period during weekends and holidays to 12.2 cents per kWh in mid-peak periods, during weekday mornings, afternoons, and late evenings, up to 28.4 cents per kWh in the on-peak period from 4 pm to 9 pm on weekdays. In the sensitivity analysis (detailed in Appendix D), we look at the implications of different pricing schemes, such as the standard time-of-use rates of 7.6 cents per kWh off-peak, 12.2 cents per kWh mid-peak, and 15.8 cents per kWh on-peak.

We also assume that the hybrid home uses a smart control system to control when different heating systems are running in order to minimize costs.

Hybrid heating systems reduce costs and emissions

Modelling results are consistent across our Vaughan and Ottawa homes. The hybrid home has the potential to have the lowest annual utility costs because of its ability to automatically use the lowest-priced energy source for heating. The fully electric system doesn't allow for taking advantage of price differences to the same extent between peak and off-peak periods. While such systems would potentially allow for intraday time-shifting with smart controls, such as pre-heating homes during off-peak periods, we expect those savings to be minor compared to the ability to shift fuel sources while maintaining constant home comfort, without extensive home retrofits. In addition, time-shifting would give the same advantages to the hybrid home as it would to the home with the all-electric heating system. We don't look at time-shifting in our modelling, but it would reduce the cost difference between the all-electric and hybrid scenarios and the baseline natural gas system.

In addition to time-shifting, all-electric homes can take advantage of off-peak pricing by pre-heating air and water, and with in-home energy storage systems like batteries (e.g. in an electric vehicle) or thermal storage, such as using heat from a hot water tank. The cost savings would depend on the efficiency of the storage system. However, these are more capital-intensive options than smart controls for home space heating, or they may affect home comfort; therefore we do not include them in our assessment here. As discussed later, policy should not preclude alternatives to hybrid heating from winning market share if they turn out to be the lowest cost options to reducing peak electricity demand.

Table 1: Annual utility costs and emissions in Vaughan and Ottawa

Home	Utility cost/year		Operating cost change		House-specific emissions reduction	
	Vaughan	Ottawa	Vaughan	Ottawa	Vaughan	Ottawa
Baseline (Natural gas furnace)	$2,990	$3,165				
Hybrid - cost focused (Heat pump with gas furnace, smart controls)	$2,863	$3,084	-$128	-$81	40%	38%
Hybrid - emissions focused (Heat pump with gas furnace, smart controls)	$3,000	$3,262	+$10	+$97	63%	60%
All-electric (Heat pump only, no gas service)	$3,493	$3,960	+$503	+$795	100%	100%

We look at two potential ways that consumers could set their hybrid heating systems. The first focuses on reducing household operating costs. In this circumstance, households only use their heat pumps during the ultra-low overnight and off-peak price periods.[5] We find that if consumers maximize the advantages of ultra-low overnight pricing using smart controls, the hybrid heating system offers a moderate decrease in operating costs of between 3% and 4% in both Ottawa and Vaughan and a reduction in emissions of between 38% and 40%.

Alternatively, households could set their hybrid heating systems to maximize their emissions reductions. With this setting, households would avoid using their heat pumps during the maximum weekday evening on-peak electricity prices, but would still run their heat pumps during the mid-peak periods during weekday mornings, afternoons, and late evenings. We estimate the emissions reduction with this setting to be about 60% or more in both Vaughan and Ottawa compared to a fully natural-gas powered baseline. In this scenario, the Vaughan household keeps its costs almost the same as with a natural gas furnace (a $10 a year increase), and the Ottawa household sees a modest 3% increase in annual operating costs.[6] The fully electric system, alongside which households also fully eliminate their natural gas usage including their monthly gas connection fee, cuts in-home heating-related emissions entirely but increases homeowners' annual energy costs by between 17% and 25% in Vaughan and Ottawa, respectively.

Sensitivity analysis and comparison to real-world studies

We also conduct a sensitivity analysis to demonstrate how hybrid and all-electric heating systems perform under a range of economic and policy scenarios, relative to a baseline system. The baseline system is a high-efficiency natural gas furnace and gas water heater using time-of-use pricing. Sensitivity analysis shows that hybrid heating systems with price-optimizing smart controls remain a cost-effective option across different electricity rate types, big drops in the price of electricity and even lower natural gas prices. Hybrid heating is also the most affordable option for a Vaughan household given high carbon taxes of $175 per tonne.

Our modelling results are broadly consistent with real-world data from studies of heat pump adoption in other countries (see Appendix A). Our findings are also closely aligned with the results of a pilot of hybrid heating systems with price-optimizing smart controls in London, Ontario, in 2021 (Toronto and Region Conservation Authority 2023). The average home in this pilot saw heating cost savings of 15% and average emissions reductions of 40%. However, these savings also included reduced costs from gas consumption that also included a carbon charge, which over the course of the pilot study added between 12 and 15 cents per cubic metre of natural gas, when the overall cost of natural gas was around 48 cents per cubic metre.

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[5] We also assume that households use their natural gas furnace at all temperatures below -15 °C, regardless of the price of electricity, given the lower efficiency of heat pumps at those temperatures.

[6] Households with hybrid heating that choose to maximize their emissions reductions reduce an additional 1.4 tonnes per year in Vaughan and 1.7 tonnes in Ottawa, relative to households that maximize cost savings. The incremental cost per tonne of emissions reduced is between about $105 and $125 between these two scenarios. There are no savings to households in either circumstance by operating their natural gas furnaces instead of their heat pumps during ultra-low overnight or off-peak hours.

The London pilot, and another similar study in Peel Region suggested two key areas for improvement in hybrid heating systems: (1) improving the ability of households to optimize between cost savings and emissions reductions through less default use of natural gas, via better optimization settings in the thermostat; and (2) increase the sizing of heat pumps to increase the electric heating capacity of the home at ambient temperatures below -5 °C.[7] The larger the heat pump installed in a hybrid heating system, the more of the home's heating needs can be met through electric heating, and the greater the emissions reductions.

Our findings also align with similar modelling by MaRS and Enbridge, which found that hybrid heating systems can reduce emissions by 80%. However, the potential household-level savings depend on the outdoor temperature and electricity prices. At cold temperatures with a large amount of heating demand, the study estimated electricity prices need to be below six cents per kWh to generate savings for customers relative to using natural gas. This highlights the importance of advanced smart controls, which switch between heat sources based on weather and electricity prices, in the deployment of hybrid heating.

Our findings of potential annual operating cost savings with hybrid heating do not consider the capital costs of new equipment. For example, the additional cost of going fully electric includes either the outright purchase or rental of a high-efficiency heat pump and an electric hot water heater, not to mention potential electrical panel upgrades. We will address capital costs in the discussion below.

[7] The real-world results from these pilot studies justify our use of a relatively large heat pump capacity in our model. As we show in Appendix C, our results do not materially change based on the size of the heat pump, which may highlight the difference between model expectations versus real-world performance.

Economy-wide implications of home heating choices

KEY TAKEAWAYS

- Economy-wide models for Ontario show that a significant increase in fully electric home heating creates significant investment pressures to meet peak electricity demand.
- We estimate that widespread adoption of hybrid heating systems can reduce electricity system demand peaks and lower electricity costs for all users, compared to a heavier reliance on all-electric heating.
- Widespread deployment of hybrid heating is both an economical solution for the Ontario electricity grid, and is consistent with a national net-zero scenario.
- Hybrid heating provides a lower-cost option to the electricity system than using natural gas generation to meet peak period demands from scenarios with heavy or full reliance on all-electric heating options. The lower cost of hybrid heating creates an opportunity for utilities to pay households to adopt hybrid heating systems.

To complement our house-level model, we also produce economy-wide modelling of multiple scenarios to provide directional guidance about the impact of different building heating technology choices on emissions reductions and electricity market outcomes.

Modelling future emissions and technology scenarios

We modelled two emissions-reduction scenarios for Canada and Ontario's energy economies using Navius' integrated gTech-IESD model. Each set of results represents possible outcomes based on the macroeconomic dynamics and technological choices associated with specific emissions reduction policies.[8]

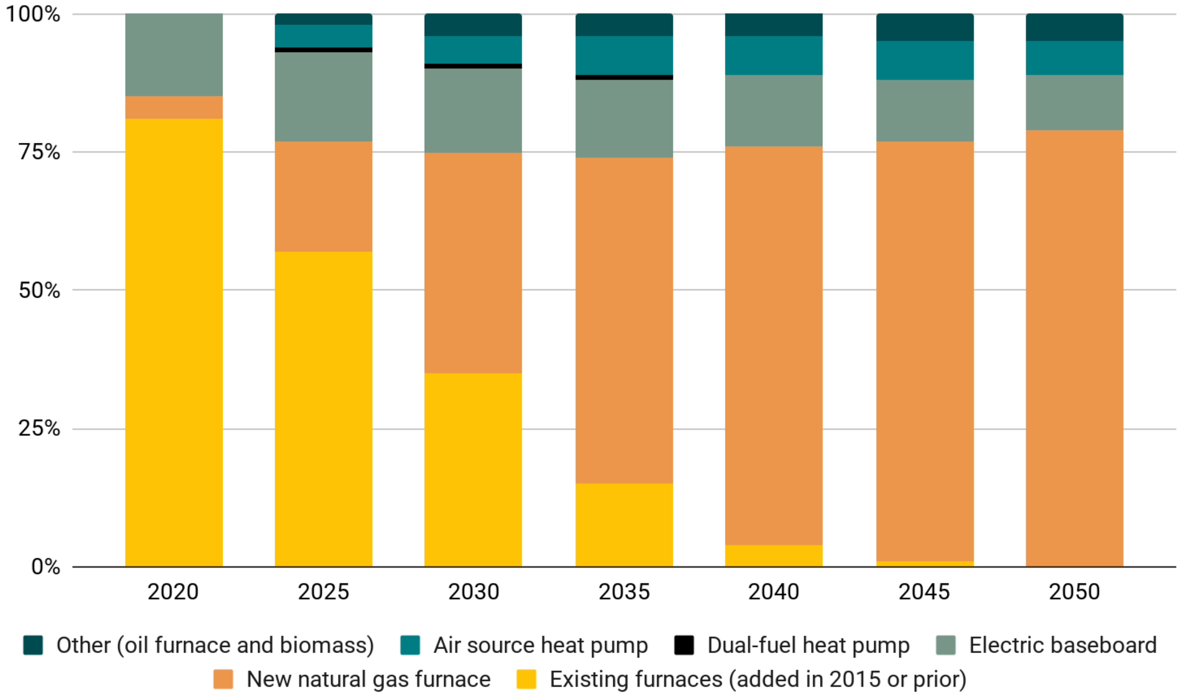
Stable policy: We first modelled what Canada and Ontario's energy systems would look like between now and 2050 under a set of energy and climate policies and plans that we see as politically stable. Most notably, this excludes the now-removed federal fuel charge and federal Clean Fuel Regulations

[8] The scenarios we model here are a combination of new and existing buildings, both residential and commercial. We do not break out new versus existing buildings because the Navius model as currently designed cannot distinguish between a new home or an existing one. We do not expect this to significantly affect the results, because in Ontario the large majority of homes in 2050 will be the existing housing stock as of 2025. The model estimates the behaviour of commercial and residential building operators separately, with slightly different results on new installation choices by commercial operators when they face no technology constraints. When we apply technology constraints in sensitivity analyses, we apply the same constraints on commercial and residential installations.

that affect household-level energy decisions.[9] In this scenario, by 2050 buildings in aggregate will become the second-highest emitting sector in Canada, behind the oil and gas sector.

Despite available incentives, heat pumps represent only 5% of the market share of installed space heating technology in residential buildings in Ontario by 2050 under this scenario (Figure 3). This takes into account both new buildings, and replacement systems, with aging furnaces predominantly being replaced by new natural gas models. Indeed, this scenario shows a decline in heat pump market share relative to current sales of heat pumps. The net result is that 75% of the total housing stock would remain on natural gas furnaces under current policy. In addition, the model finds that households do not choose to adopt hybrid heating, because hybrid heating systems involve the large capital expenses of both a heat pump and a furnace.

Figure 3: Market share of Ontario residential home heating sources under current policy



Source: Modelling by Navius Research

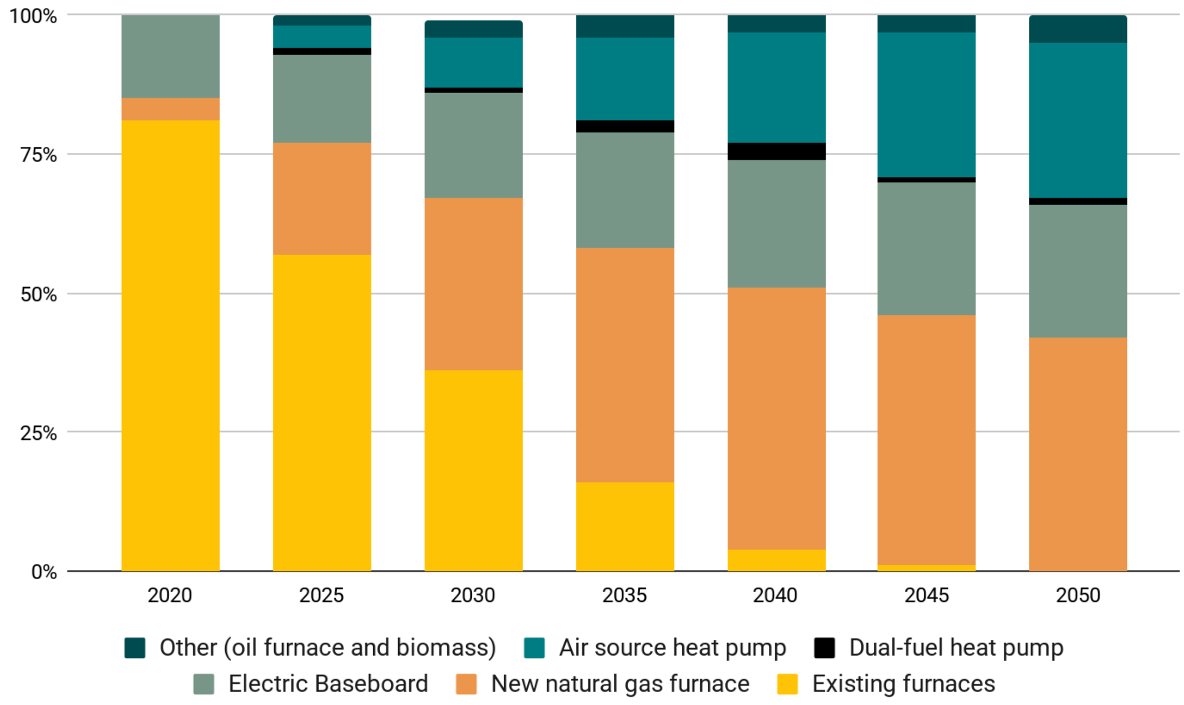
[9] To represent existing policy, we also include Ontario's announced procurement of 6,000 MW of new nuclear generation capacity by 2040, 5,000 MW of renewables (i.e. solar and wind), and an announced procurement of 2,917 MW of grid storage. This scenario also includes the federal government's announced regulations requiring a 75% reduction in methane emissions by 2030. We added a data center sector in Ontario with significant electricity consumption, based on IESO expectations.

A net-zero scenario: Our second scenario models the most cost-effective pathway for Canada to reach net-zero emissions by 2050. We assume that 50 Mt of emissions persist in the economy and are offset by factors such as land-use changes.

We assume that carbon dioxide removal (such as direct air capture) is available, albeit at a high cost of $360 per tonne. Carbon dioxide removal reduces emissions by nearly 150 Mt per year by 2050 in this scenario. This allows for continued production and emissions in sectors with high value to the economy, such as the oil and gas sector, and creates opportunities for other sources of emissions, such as natural gas electricity generation or the continued use of natural gas in home heating, when reducing emissions from these sources is higher cost than further investment in carbon dioxide removal.

Building emissions fall considerably in this pathway, but buildings are still the second-largest source of emissions in Canada in 2050. In a scenario in which Canada as a whole reaches net-zero emissions by 2050, about 50% of Ontario homes have electric heating (see Figure 4). About 40% of new home heating installations and replacements are still natural gas furnaces.

Figure 4: Market share of Ontario residential home heating sources under net-zero pathway



Source: Modelling by Navius Research

Alternative net-zero modelling scenarios

The scenario in Figure 4 (above) represents one potential deployment of home heating technology in Ontario to meet a Canadian net-zero target by 2050. However, there are other potential technological pathways, and changing economy-wide assumptions in the modelling can have broad implications for home heating choices. We examine the Ontario results in a few different scenarios that test the sensitivity of the results to technology choices and model assumptions. In Figure 5 (below), we show the implications of these alternatives, relative to a baseline net-zero scenario, for natural gas generating capacity in Ontario through 2050.

Technology adoption: Our first alternative technology scenario models an extreme case in which hybrid heating systems displace electric baseboard heating, air-source heat pumps, and natural gas furnaces in all new and replacement heating system installations.[10]

Our second alternative technology scenario examines another extreme outcome, in which all new heating systems are cold-climate air-source heat pumps.

Neither scenario in which a single technology has a 100% market share should be taken as realistic. However, their implications for the broader energy sector point to possible outcomes from more gradual roll-outs of the technologies to a level higher than in the baseline scenario, in which neither technology is dominant.

Economy-wide assumptions: In addition, we model these two alternative technology scenarios using varying economy-wide assumptions that affect the path to net zero-emissions in 2050 (see Appendix F for details). Regardless of these assumptions, widespread deployment of hybrid heating remains the most economical option and the need for natural gas-fired electricity generation does not materially change.

Electricity generation capacity and prices

The largest economic difference due to different building-heating technology choices is the effect on the electricity generation sector. A rapid deployment of hybrid heating systems, while Canada also achieves net-zero emissions by 2050, sees retirement of Ontario natural gas electricity-generating facilities beginning in 2030. In contrast, rapid adoption of all-electric heating systems sees a significant increase in natural gas-fired generating capacity. The more modest adoption of all-electric heating systems in our baseline mix sees an increase in gas generation capacity beginning in 2040 (see Figure 5 below).

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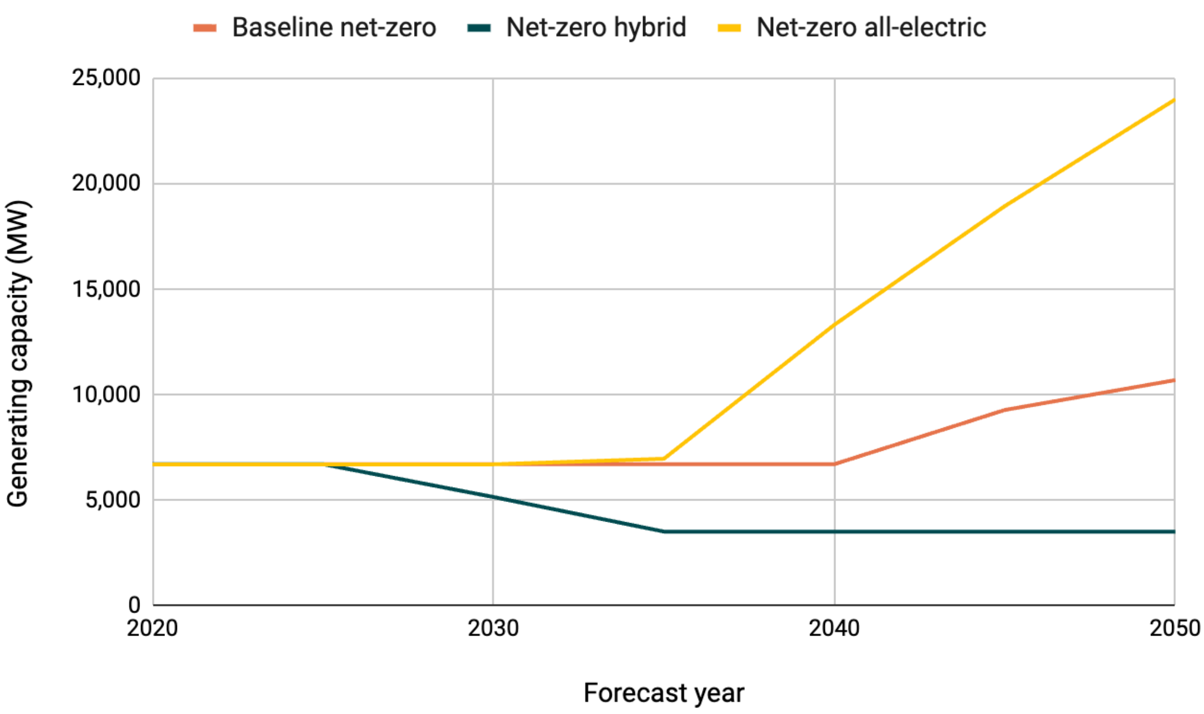
[10] The hybrid heat pump system in this scenario only switches between fuel sources based on COP, not hourly electricity price, unlike in our household-level model.

Figure 5: Ontario natural gas electricity generation capacity in future scenarios



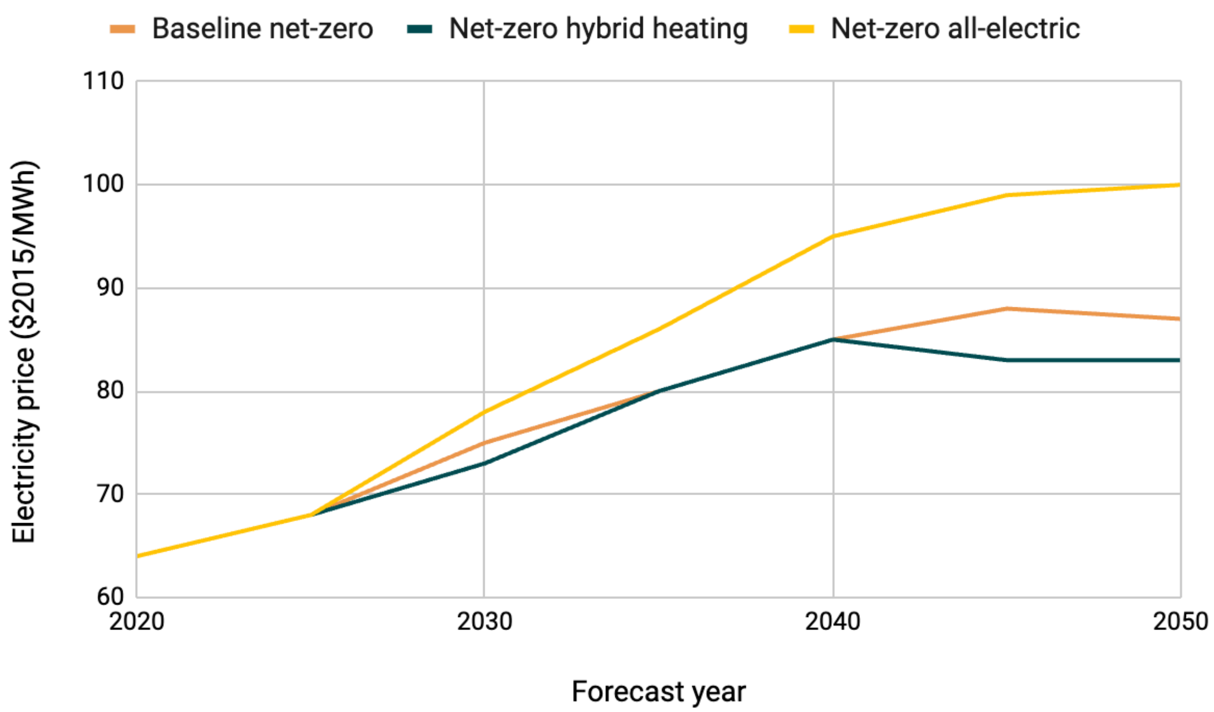
Source: Modelling by Navius Research

Natural gas-fired electricity plants that run for only a small number of hours per year to meet demand peaks are the main difference in electricity supply between scenarios. The model doesn't deploy new nuclear generating capacity to meet peak-period heat pump energy demand, because nuclear power plants are only economical if they have high utilization. Similarly, renewables have relatively low capacity value for serving winter peaks, and require significant increases in energy storage capacity that our modelling finds uneconomical even when we assume low prices for storage. However, during summer demand peaks, air conditioning demand can be met economically with solar power, both at grid scale and behind the meter on rooftops.

Changes in electricity generation capacity affect electricity prices (Figure 6).[11] By 2040, the hybrid heating scenario sees the lowest cost of electricity, slightly lower than the baseline net-zero scenario. By 2050, electricity prices in the hybrid heating scenario are 20% lower than in the scenario with all-electric heating.

[11] We do not compare electricity prices or natural gas generation mixes to the current policy scenario, as other factors such as the deployment of nuclear power create significant variability in electricity markets between these model runs.

Figure 6: Ontario electricity prices under different net-zero scenarios



Source: Modelling by Navius Research

The higher prices in the other net-zero scenarios likely arise from the significantly larger investments in generating and distribution capacity required to meet higher peak demands — but with lower capacity utilization. In our hybrid heating net-zero scenario, the average capacity utilization of electricity generation facilities is 43% in 2050. In contrast, the all-electric scenario only achieves 36% utilization and the net-zero baseline 39%. The cost of this unused capacity is spread across the economy through higher electricity prices.

Compared to the baseline net-zero scenario, electricity prices in the hybrid scenario would be about 4% cheaper, a savings of about $900 million per year based on forecast consumption of 261TWh in 2050. A portion of those savings could be attributed to households that adopt hybrid heating systems, through lower electricity rates at certain times, upfront rebates, or a combination of both, as discussed below.

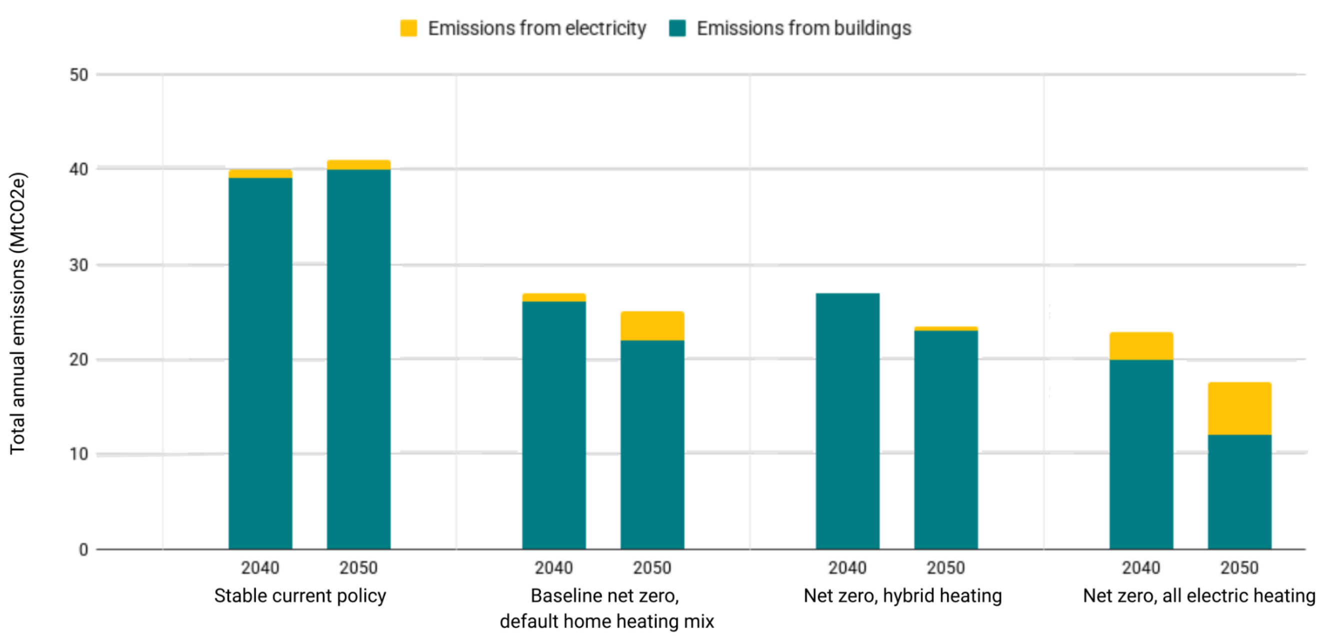
Emissions outcomes

Not only does a greater reliance on hybrid heating reduce the need for investment in the electricity sector, and consequently electricity prices, doing so also reduces Ontario's aggregate emissions from buildings and the electricity sector, compared to the mix of building heating and electricity generation in a baseline Canada-wide net-zero scenario. In addition, greater reliance on hybrid heating systems reduces Canada's need for carbon removal to meet net-zero targets by 5 Mt per year.

Both hybrid and all-electric heating systems use low-emitting, low-cost electricity during periods of moderate winter temperatures. They both utilize the electricity system in the most efficient way during these hours. The main difference between scenarios where each of these systems is dominant lies in how the electricity system generates power and emissions during periods of extreme cold, which will occur regularly, when electricity demand for heating is highest in an all-electric scenario.

One main reason why hybrid heating systems reduce emissions is that natural gas furnaces are about 90% efficient in converting combusted gas into usable heat, while natural gas peaking power plants are only about 40% efficient in generating electricity. The result is that every unit of electricity generated from natural gas for home heating may actually lead to higher overall emissions attributable to heating, relative to natural gas furnaces, if electric heating systems aren't significantly more efficient than furnaces. During the coldest hours of the year, heat pumps lose a considerable amount of their efficiency advantage. Therefore, a significant increase in the deployment of all-electric heating may negate expected emissions reductions, as a consequence of the additional emissions produced by natural gas peaking power plants during periods when heat pumps lose their efficiency advantage and sharply increase their electricity demands (see Figure 7 below).

Figure 7: Combined annual building and electricity emissions in Ontario in 2040 and 2050, stable current policy and net-zero scenarios



Source: Modelling by Navius Research

Figure 7 (above) shows how our modelling results support this hypothesis. In all three net-zero scenarios, combined emissions from buildings and electricity fall, relative to stable current policy. Note that since these are net-zero scenarios, the variability between them is explained by variability in emissions from other sectors of the economy.

Compared to the baseline net-zero scenario (with its mix of heat pumps, resistive heaters, and standalone natural gas furnaces), wide deployment of hybrid heating systems leads to marginally higher building emissions. However, total building and electricity emissions are lower by 2050 in the hybrid heating scenario than in the baseline net-zero scenario.

The logic of the outcomes in the hybrid heating scenario is that during non-peak hours when heat pumps are significantly more efficient and cost-effective than gas furnaces, households will choose to heat their homes with emissions-free energy. They will switch to their furnaces when electricity demand, and prices, are high. This results in reduced emissions from the electricity sector to service peak demand, and reduced emissions from the 40% of customers who would otherwise choose a standalone natural gas furnace, but instead have hybrid heating systems they use in electric mode during non-peak hours. This reduction in emissions from less use of natural gas-fired electricity generation offsets the increase in emissions from buildings that would otherwise switch to fully non-emitting sources at all hours.

Compared to a hybrid heating net-zero scenario, Figure 7 shows that emissions from home heating and the electricity sector are lower with widespread adoption of all-electric heating. But these reductions come at the expense of considerably higher electricity prices as shown in Figure 6. In this net-zero scenario with all-electric heating, there is less decarbonization in other sectors of the economy, because of the greater reduction in building emissions. Recall that all three of the net-zero scenarios have the same total national emissions; the only difference is the source of emissions changes.

Hybrid heating as an alternative energy supply

The above scenarios showcase the difference in Ontario's macroeconomic emissions outcomes from different building heating technology choices. Equally important is identifying the combination of energy supply and demand in the hours of peak demand.

We can estimate the difference in energy supply sources between our stable policy scenario and our baseline net-zero scenario. This allows us to see how energy supply mixes change to meet the new peak electricity demand from electric heating.[12]

[12] We focus on these two scenarios as they are the most plausible; we exclude the illustrative alternative scenarios from the previous section in which all new building heating sources are hybrid heating or all-electric air source heat pumps.

In the net-zero scenario, the increase in building electricity consumption requires a commensurate increase in generating supply, or decreased demand elsewhere in the economy. The most notable increase in electricity supply between the two scenarios is that the net-zero scenario forecasts a considerable increase in the amount of electricity generated from new natural gas power plants that do not use carbon capture and sequestration. In both scenarios, Ontario preserves its existing natural gas-fired electricity generation. In the baseline net-zero scenario, the province adds another 4,000 MW of new natural gas-fired electricity generation to meet peak period demands.[13]

That 4,000 MW of new natural gas capacity would represent the equivalent of four to eight power plants. The permitting process for these new facilities would be extensive and uncertain, which the Navius modelling does not consider. The low-end estimated capital cost of a simple cycle natural gas power plant is $1,250 per kW, resulting in $5 billion in total installed costs, followed by the ongoing operating costs.

Widespread deployment of hybrid heating creates, through the ability of hybrid systems to switch between energy sources, flexible capacity in the electricity system that offers electricity system planners an alternative to procuring this scale of natural gas-fired electricity generation. One way to estimate the value of this flexible capacity is to look at Ontario's capacity market. For the 2025 summer peaking period, the capacity auction clearing price was $332 per MW-day. Presumably, the capacity auction would clear at a similar price should Ontario become a winter peaking province, if Ontario seeks to electrify more building heating.

The capacity market value reflects the ability to provide power to the electrical grid. Homes connected to the Ontario electricity system place an obligation on the electricity system to serve them, and a heat pump adds to that obligation. Home heating systems that can offer flexibility between using natural gas or electricity can provide a capacity buffer to the electricity system during winter demand peaks.

[13] Our modelling also shows a substantial increase in non-emitting capacity to meet peak demand, mainly battery and hydrogen energy storage supplied from non-emitting sources. Combined, they provide peak capacity of a little under 20,000 MW. That level of investment is already a considerable increase, nearly equivalent to Ontario's current hydro-electric and nuclear generating capacity. In addition, industrial users will use less electricity in peak hours in a net-zero scenario compared to their energy use under current policy.

On the 85 coldest weekdays of the year, between December 1st and March 31st — when demand peaks are likely to occur — Ontario homes with hybrid heating systems could offer an aggregate capacity flexibility of 4,000 MW to the grid. Using the summer capacity market values proportional to the amount of availability, that would be worth $113 million per year. The net present value of 15 years of that capacity flexibility would be $1.3 billion, at a discount rate of 4%. That's far less than the $5 billion it would cost to build natural gas peaking power plants to supply an equivalent capacity.

The air-source heat pump in our model home (above) draws a maximum of around 15 kW. Taking this system as representative of an average home with hybrid heating, that 4,000 MW of capacity represents 267,000 homes. Using the capacity market values above, each home provides about $423 in annual capacity saving benefit per year. If these homes had dispatchable flexibility to switch between electric and gas heating, each home provides about $4,700 in capacity market value over 15 years. If half of this amount went to households as an upfront grant (with the other half shared between benefits to all ratepayers and companies that would take responsibility for aggregating the flexible capacity from participating homes), that would cover the incremental difference between the cost of an air conditioning system and a heat pump when customers replace their air conditioners.

This amount requires significant further assessment before policymakers and utilities decide on the optimal capital support for hybrid heating systems, as it depends on factors such as the size of heat pumps, size of homes, capacity market values, the length of time that participating homeowners are contractually obligated to retain natural gas heating, the flexibility of home heating sources, and transmission and distribution savings.[14]

The capacity flexibility offered by hybrid heating also provides an opportunity for utilities to offset electricity system investments as customers electrify their home heating. The aggregate value of these investment savings is comparable to the estimates (above) of the reductions in electricity prices associated with widespread adoption of hybrid heating.

As we will discuss below, the value of this capacity flexibility can be split between all ratepayers, the homeowner adopting the heat pump, and companies aggregating the hybrid homes. Various structures could emerge, such as an upfront capital supplement to homeowners to cover the additional installation costs of a hybrid heating system, along with an annual retention payment to stay enrolled in the demand flexibility program.

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[14] For example, if we assume that our 4,000 MW of additional peak capacity represents homes with an average maximum draw of 10 kW instead of 15 kW, there would be 400,000 homes offering capacity flexibility, and the discounted future value using the same assumptions would be $3,250 per home. Maintaining the assumption that the homes have a maximum draw of 15 kW but shortening their contracts for offering capacity flexibility from 15 years to 10 years, the total discounted value of future capacity payments would be $916 million, which if spread over 267,000 homes would amount to about $3,600 per home in upfront value. The province can better assess this aggregate capacity value with an integrated energy assessment of the natural gas and electricity systems, looking in particular at the potential cost impacts of reduced consumption on the natural gas system.

Policy implications

KEY TAKEAWAYS

- Upfront subsidies for heat pump adoption are a cost-effective approach to reducing emissions from residential buildings. Hybrid heating systems offer unique value to Ontario's energy system to reduce investment needs for energy demand peaks. The high value of hybrid heating can create incentives for markets and private companies to find ways of offsetting the upfront cost of hybrid heating systems.

- In addition, Ontario should look at creating an electricity price option modelled on Quebec's, which bases electricity prices for hybrid heating users on ambient temperature. This is an easy-to-understand proxy for electricity system costs and heat pump performance, and is optimized for hybrid heating savings opportunities. Such a system can lower household bills without consumer involvement if used with smart-home technology. It can better align the price incentives driving customer energy use so consumers use less electricity at times in which the electricity sector faces supply shortages and high costs.

- Ontario should tackle other regulatory barriers to heat pump and hybrid heating adoption. For example, barriers to certification and training for skilled trades constrain the growth of the workforce that will be needed to meet increasing demand for heat pump installations.

Reducing upfront cost and operating costs

Above we estimate the operating costs that consumers will likely face by changing their home heating technology choices. The capital cost of acquiring a new heating system is also of critical importance. This section addresses the policy issues affecting a household's decision to obtain a heat pump.

In Ontario there is a strong case for adopting subsidies that make heat pumps as affordable as air conditioning systems. Over 85% of Ontario homes have air conditioning. As these air conditioners, particularly central air conditioning, reach their ends of life, encouraging consumers to adopt a heat pump in place of a standard air conditioning system offers significant potential to reduce emissions at no incremental cost to consumers in the grant programs we will propose. Programs should aim to make heat pumps the default and lowest-cost choice when consumers need to replace their air conditioning systems. Similarly, when customers face replacement of their furnaces, a hybrid heating system should be readily available and supported by policy.

Current federal financing programs, such as the Canada Greener Homes Loan, which ended as of October 1, 2025, offered federally subsidized loans to address these upfront costs of purchase, but required a home energy audit before consumers can access funding. This made the program ineffective for customers who need to replace their equipment in an emergency. If they couldn't afford the full upfront cost of a new air conditioner or heat pump, these consumers had to rely on other sources of financing to replace their equipment.

Establish heat pump subsidies

Optimal heat pump subsidies vary based on regional climate, prevailing energy prices, grid resilience and emissions, and other factors. Ontario should follow the methodology set out in studies such as Bernard et al. (2024) and Davis (2023) to estimate the optimal value of subsidies that reduce upfront heat pump costs and offer continued support for capital cost financing.

Local investment needs may also influence incentives for heat pump adoption. As Dachis (2024) shows, investment in local electricity distribution infrastructure is likely to be driven by peak capacity needs for heat pumps. Planning for these investments is predicated on fully electrified heating. If instead, local electricity companies could integrate their specific capacity constraints with incentives or enhanced local marketing for hybrid heating adoption, they could optimize the location of hybrid heating adoption and other peak-mitigation tools to reduce the needs for peak capacity investment.

Upfront incentives for hybrid heating systems should be available for both cold-climate heat pumps and standard heat pumps, although it will likely be sensible to offer larger subsidies for the former, not only because of higher unit costs, but also due to the potential requirement for costly upgrades to home electricity systems. For these reasons, in some homes a standard heat pump, as part of a hybrid heating system, may be the most affordable way for the household to reduce its emissions.

Cold-climate heat pumps may require a larger potential electricity draw than standard air-source heat pumps during cold weather. This is because cold-climate heat pumps have higher-capacity compressors and often have auxiliary electric resistance heaters. This larger electricity draw may require costly electrical panel upgrades that, in addition to the cost of the heat pump, may deter some consumers from making the switch. However, under the current Ontario Home Renovation Savings program, standard heat pumps are not eligible for any subsidies, with only cold-climate heat pumps eligible. A grant for a standard heat pump, as part of a hybrid heating system, may be justifiable for consumers not able to make the upgrade to a cold-climate heat pump, albeit at a lower rate, given the more modest energy switching available.

At the same time, cold-climate heat pumps may not be necessary or a cost-effective alternative when paired with natural gas furnaces. Although our modelling uses a cold-climate heat pump, which delivers greater emissions reductions than a standard heat pump model, that may not be the best solution for every household (see Appendix C). The optimal level of subsidies for heat pumps will depend on factors such as heat pump performance, among other factors.

Use utilities and energy services companies to lower upfront costs of heat pumps

The potential benefits that hybrid heating systems provide to other electricity system users justifies some form of subsidy financed by the public and/or ratepayers. There are at least two kinds of potential benefits to others, called externalities, that merit subsidies for capital costs. The first is the capacity flexibility value at times of peak demand that we estimated above.

> There are at least two kinds of potential benefits to others that merit subsidies for capital costs. The first is the capacity flexibility value at times of peak demand. The second potential benefit lies in how much incremental electricity demand heat pumps create in non-peak periods, in which the price that consumers are willing to pay for electric heating is more than the marginal cost of electricity supplied to the grid.

The second potential benefit lies in how much incremental electricity demand heat pumps create in non-peak periods, in which the price that consumers are willing to pay for electric heating is more than the marginal cost of electricity supplied to the grid. Incremental demand in these hours defrays the capital cost of generating capacity, which benefits all consumers through lower prices. The total rates consumers (or taxpayers[15]) pay must finance the system costs.

Ontario electricity generators have two sources of revenue: hourly electricity markets, and a Global Adjustment that is an add-on charge to consumers, to cover the cost of generator contracts, or regulated rates not covered by prices in hourly markets. The OEB sets total rates so that the total hourly prices plus Global Adjustment costs of the system equals the total rate revenues. The overall system operates more cost-effectively when consumers voluntarily utilize more electricity when the system is operating at very low marginal cost. This helps defray the large fixed costs of major investments, such as nuclear power plants, by spreading them over a greater volume of electricity consumption, particularly during off-peak hours, when the marginal cost of generation is lowest. A pricing structure that incentivizes efficient voluntary resource use lowers the overall share of the cost of capital projects not covered by hourly electricity prices, which consumers involuntarily pay, through the Global Adjustment. The higher the share financed through voluntary consumer demand, such as through greater use of heat pump use in off-peak hours, the more efficient the market.

These sources of potential external value present possibilities for reducing or eliminating the upfront cost of heat pump adoption, in excess of the cost of replacing an air conditioning system. The main question becomes which entity is best suited to providing these subsidies.

Governments, through grants: Through 2024, taxpayer-funded federal grants for heat pump adoption have been the primary means of defraying up-front heat pump adoption costs. As the Ontario government provides significant fiscal support for electricity prices, it is already implicitly subsidizing heat pump adoption. Additional electricity demand from heat pumps would increase the fiscal cost of this subsidy to the province, which is now in large part a fixed percentage of consumers' bills. This taxpayer subsidy creates a distributional problem of supporting heat pump users at the expense of non-heat pump users, unlike the proposals we suggest below that are a mutually beneficial form of support.

Direct reductions financed by natural gas customers: The primary program for supporting home retrofits in Ontario has been the Home Efficiency Rebate program, since replaced by the Home Renovation Savings Program under very similar terms and principles. It provided incentives for various home retrofits, including heat pumps (see Appendix A). The Home Efficiency Rebate was the largest part of Enbridge's Demand Side Management program,[16] overseen by the Ontario Energy Board. The OEB allows Enbridge to share the cost of grants across its rate base, because the system as a whole benefits from lower gas usage, therefore lowering natural gas rates for other consumers. We apply a

[15] There are two primary taxpayer-funded support programs for the Ontario electricity system. The first directly reduces the cost of energy contracts, therefore reducing overall system costs that consumers must finance. The second does not change overall system costs or rate revenues from consumers, but reduces the overall final bill as a transfer to consumers.

[16] Across the entire province, Enbridge spent about $50 million on this program in 2019, the most recent year that it reported on the program.

similar logic to hybrid heating systems in making the case for electricity system users to finance capital costs.

Capacity aggregation: The externalities of a hybrid heating system are different from the externalities of carbon emissions. With emissions, there is no naturally occurring market that can value the economic harm. That is why governments introduce carbon markets. However, the external effects of hybrid heating systems are contained within the existing electricity market. This means it is possible to develop a pricing mechanism to monetize the value that hybrid heating systems provide to the grid.

As discussed above, natural gas furnaces paired with heat pumps can provide electricity planners with capacity flexibility that offers an alternative to procuring additional capacity from natural gas electricity generation. These capital savings become a value that can be shared between operators of hybrid heating systems, existing electricity users, and investors in hybrid heating deployment.

The capacity value of natural gas furnaces in homes that could offset peak electricity use should need to compete with other potential sources of flexible capacity. For example, companies that integrate smart home technologies in hot water heaters could reduce their energy use during peak periods. Currently, Ontario customers with smart thermostats can get $75 for signing up to have their thermostats turn off their air conditioners during peak summer hours.

The IESO commissioned a 2022 report on the economic potential of demand-side responses to meet peak energy demand. The report found that a number of achievable demand-side responses could meet future peaks, reducing winter peaks by up to 9%. The largest share of the demand-side reductions that the IESO identified to reduce winter peaks come from heating demand, including options ranging from smart thermostats controlling new heat pumps and baseboard heaters, to hybrid systems. However, that study was predicated on consumer behaviour in response to a $170 per tonne (or higher) carbon tax, leading to a significant increase in the deployment of all-electric heat pumps across Ontario. The IESO should consider reviewing the kinds of demand-side technology consumers are likely to want to adopt without a carbon tax.

Economic literature is beginning to capture the value of energy savings programs that are tied specifically to reducing peak demand. Boomhower and Davis (2020), for example, find that smart heating and cooling systems that can adjust to reduce peak demand have significant electricity market values.

Existing small customers have a right to connect at regulated rates, meaning that electricity planners must assume these heat pumps would draw electricity. Ontario electricity system planners therefore have to anticipate the possibility of widespread heat pump adoption and the implications for the electricity grid, particularly if they have a mandate to create an energy system consistent with Canada's emissions reductions goals. With enough connected heat pumps that offer load-shedding capacity by operating in tandem with a natural gas furnace, a hybrid heating aggregator could bid into capacity markets to offset winter demand peaks. Hybrid heating operators and energy service aggregators could use these revenues to attract customers.

Indeed, Hydro-Québec and Énergir, the main natural gas supplier in the province, have entered into such an arrangement. Hydro-Québec subsidizes the majority of the upfront costs of heat pump installation for natural gas customers who want to switch to hybrid heating (see Box 2). Hydro-Québec subsidizes the cost using revenue from its customers, which actually saves customers money in the long term. That's because the alternative of building more capacity to serve demand peaks created by all-electric heating would end up costing customers more. Énergir will receive up to $400 million cumulatively to cover the partial loss of revenue from 100,000 homes, or $4,000 per home, a similar value to the estimates for Ontario consumers above. Expanding the ability of the IESO to offer measures that use electricity-sector revenues to reduce emissions from natural gas consumers would likely require legislative amendments, but for end consumers would be administered in a similar manner the Quebec model, and how Ontario natural gas consumers subsidize retrofits through the Home Renovation Savings Program.

Box 2: Quebec and B.C. embrace hybrid heating

In July 2021, Hydro-Québec and Énergir initiated a hybrid heating agreement aimed at converting existing natural gas heating systems to hybrid systems, utilizing both electricity and natural gas. Under this arrangement, electricity serves as the primary heating source, with natural gas providing supplementary heat during peak demand periods. This strategy seeks to maximize the use of non-emitting electricity for heating, thereby reducing greenhouse gas emissions, while also alleviating stress on the electrical grid during high-demand times.

The agreement's first phase targets the conversion of approximately 100,000 residential customers (a majority of Énergir's customers) to hybrid heating systems. Subsequent phases aim to extend this initiative to commercial and institutional customers. To encourage participation, the Quebec government and Hydro-Québec offer grants covering up to 80% of conversion costs, with customers agreeing to maintain their connections to the natural gas system for a fixed period. The anticipated outcome is a reduction in natural gas consumption by over 70% among participating customers, contributing significantly to Quebec's climate objectives (see Seguin and Bigouret 2023).

This model offers a potential template for consumers in other provinces, particularly Ontario, where there are nearly 30 times more natural gas customers. However, concerns have been raised that the program has not been integrated into competitive demand-side management programs (Haley, Gaede, and Nippard 2024). Ontario can address this problem by supporting hybrid heating adoption through hybrid heating users selling their flexible capacity into the electricity market. This forces companies offering aggregated capacity services to bid against each other to find the lowest-cost option.

In British Columbia, FortisBC provides a direct rebate of up to $5,000 for the installation of a hybrid heating system. This is more than the rebate of up to $4,000 that BC Hydro provides for the installation of a standalone heat pump. FortisBC justifies offering a higher amount because their program supports the purchase of both a new heat pump and a new furnace, along with smart controls for switching between them, while the BC Hydro program only funds the replacement of an electric heating system with a heat pump.

Effective long-term energy systems planning

The uncertainty of the amount of emissions reductions from transitioning to fully electrified home heating is one reason for the Ontario government to encourage widespread adoption of hybrid systems. An additional reason for adopting hybrid heating systems is that energy systems planners can more easily plan for energy demand growth with incentives for widespread, small-scale change, as opposed to planning large generation projects with long and uncertain lead times, due to permitting requirements. The exact amount that energy demand will grow in the future is highly uncertain. That uncertainty creates risk for energy systems planners, as well as for proponents of individual power facilities, who will want a higher return on investment for taking that risk. That will lead to higher bids for new capacity during IESO procurements. The end result would be higher Global Adjustment costs and eventually higher end consumer prices.

In contrast, expanding the deployment of hybrid heating systems faces minimal permitting and approvals risk. Once an aggregator of hybrid heating systems enters the market, the main variable will be the rate at which it can expand its flexible capacity offering to the grid. That expansion rate, and the factors that influence hybrid heating adoption rates, can be influenced by financial incentives, based on further study by energy systems planners.

The cost-effectiveness of hybrid heating systems hinges on how natural gas system costs are shared. Since customers pay fixed fees for gas connections and usage-based distribution and transmission costs, if the deployment of hybrid heating systems leads to reduced gas system utilization, it could raise per-unit costs. Therefore, the future economics — and ideal adoption rate — of hybrid or fully electric heating will depend on natural gas prices, infrastructure use, and the comparative efficiency of energy sources. Gas system rate design, and the implications for future use and costs if provinces need the full capacity of the gas system only sparingly, will need to be part of joint system planning, but is beyond the scope of what can be covered here.

The significant reduction in natural gas consumption, if hybrid heating expands, will create opportunities for a greater proportion of blended fuel, such as renewable natural gas or hydrogen, to serve a larger share of heating needs without as much supply growth. That will further reduce emissions from home heating while still utilizing the existing natural gas distribution infrastructure, and staying on track for net-zero emissions.

Price incentives for adopting hybrid heating

The modelling we conducted in the previous section shows a possible reduction in costs using existing price structures for Ontario electricity users. Electricity rates geared towards electrified heating can offer customers significant savings.

In Quebec, to implement the capacity sharing deal discussed in Box 2 above, hybrid heating users have the option to choose an electricity rate tailored to their usage. Hydro-Québec refers to it as Rate DT, where the hourly electricity rate is based on temperature. At -15 °C (or -12 °C in some locations), the electricity price increases. During periods of very low temperatures (below -15 °C or -12 °C, depending on the region), Rate DT customers face a price of 28.2 cents per kWh during periods of extreme cold. The rest of the time, Rate DT customers get a price of 4.8 cents per kWh. This is substantially lower than the normal price of electricity for residential customers of 6.7 cents per kWh (10.3 cents per kWh for additional usage beyond 40 kWh a day). An in-home indicator light, which Hydro-Québec provides free of charge, signals when the higher cost goes into effect. Consumers can install smart thermostats that switch to the lowest-cost heating source automatically.

Such a price program will make sense for Ontario when it becomes a winter-peaking province, as electric heating becomes more commonplace. The current Ontario ultra-low overnight rate offers great opportunities for households using heat pumps to heat their homes at night. However, this rate does not reflect the future strains on the electrical grid or encourage using heat pumps when doing so is most efficient.

The current Ontario ultra-low overnight rate has an on-peak price of 28.4 cents per kWh every weekday of the year between 4 pm and 9 pm. During the winter months, a price over 28 cents per kWh would result in households choosing to run their natural gas furnaces during peak price periods, regardless of whether heat pumps are the most efficient option given prevailing weather.

Similarly, a very cold day on a weekend or overnight may be a period of significant electricity strain, [as Alberta experienced] in January 2024. However, the current ultra-low overnight rate wouldn't give customers an incentive to reduce electric heating use.

A simple pricing option available to consumers during the winter that bases prices on outdoor temperatures would save money for consumers, be simple to understand, have no effect on home heating levels if paired with smart home technology, and properly calibrate heat pump versus furnace use to avoid strains on the electrical system. An even simpler interim option is to offer consumers the ability to automatically set their winter electricity pricing plan at the ultra-low overnight rate, but the summer pricing plan at tiered or normal time-of-use prices. Currently, consumers must contact their electricity distributor to switch between pricing plans.

There is an extensive economic literature on the economic benefits of time-varying rates, showing the large economic benefits of high electricity rates at times of peak demand and low prices at other times (Bernard et al., 2024, Emenike et al, 2023). While these monetary benefits are real, the cost has often fallen on households needing to spend time and mental effort on optimizing their energy use. They may switch the time they run appliances, or forgo using electricity altogether. Smarter home technology can assist with this, for example, by allowing for automatic pre-heating of homes during times of low demand, ahead of peaks. Hybrid heating, and electricity rates that incentivize optimal use, expand these choices to consumers further by presenting options for maintaining home comfort at the lowest possible cost in both money and time.

Removing regulatory and other barriers

Directly tackling the consumer cost of a heat pump through subsidies is one key lever for increasing adoption. Governments also have other regulatory levers that can encourage more long-term leasing of heat pumps to reduce upfront costs, create local incentives for heat pump adoption, and increase the pool of installers for heat pumps.

Customer protection

Heat pump providers have begun to offer a leasing model with no upfront cost for installation. These companies have long-term monthly payment plans at interest rates that are sufficient to offer their investors a competitive rate of return. In the case of Enbridge Sustain, these investments in heat pumps are not shared among the entire natural gas rate base, meaning natural gas customers are not exposed to the capital costs and risks (or the income) from Enbridge's heat pump business.

Because hybrid heating offers customers the opportunity to lower their heating costs, the additional monthly cost of a financed heat pump may still see customers paying the same price for heating that they would have with their natural gas furnaces. These forms of financing are common for heat pump providers in the United Kingdom (Miller et al. 2023). This option is not a subsidy for heat pump adoption, merely a more efficient capital financing approach that leverages aggregated borrowing at lower cost compared to household self-financing. Government loan programs should seek to complement this approach.

Any policy discussion about encouraging the financing of heat pumps must recognize that appliance rentals in Ontario have long been a source of political debate about consumer protection. Concerns about predatory business practices, anti-competitive behavior, and the long-term financial burden on consumers have led to government intervention.

Policymakers should review applicable legislation[17] to assess how heat pumps and hybrid heating systems fit into the current framework for customer protection. For example, a subsidy for installing hybrid heating systems that requires long-term connection to the natural gas system will need to consider how to handle the cost to customers who later choose to disconnect from gas services. This will create new obligations on the OEB to deal with the terms of these long-term gas connection contracts. The federal government could assist by directing the Competition Bureau to study the financing options for home heating services and to make recommendations on the lowest-cost

[17] In response to consumer complaints about high-pressure sales tactics and restrictive contracts for water heaters, the Ontario government enacted the Stronger Protection for Ontario Consumers Act in 2013. This legislation introduced several measures to safeguard consumers, such as clearer disclosure requirements and ensuring consumers are fully informed before entering into agreements.

options for consumers that also preserve the incentive for companies to offer financed heat pumps to consumers.

Removing workforce barriers to installation

The above discussion has focused on the capital investments, cost to consumers, and electricity market effects associated with the widespread adoption of hybrid heating systems. Every installation also requires a skilled worker. A key barrier to significantly scaling up heat pump installations in Ontario is a shortage of installers. One estimate finds that reducing emissions from homes to meet Canada's emissions targets will require nearly a quadrupling of the number of refrigeration and air conditioning mechanics (BuildForce Canada 2024).

One major cause of the labour shortage in trades required to install hybrid heating systems is the licensing regimes for technical professionals. Provinces, or bodies with delegated regulatory authority, determine the training requirements for professionals to become fully certified technicians. A heat pump technician requires an air conditioning mechanic licence of some kind, and a gas furnace installer requires a separate gasfitter licence. Licensing regimes present multiple potential barriers:

Unnecessary training requirements: Canadian provinces take various approaches to how much training, either on the job or in-class technical training, an apprentice requires to become certified. These vary across Canada, particularly for refrigeration and air conditioning mechanics. An apprentice requires 7,200 hours of on the job training in most of Canada to become fully certified. Ontario requires 9,000 hours of training and Quebec requires 9,800 hours of training. These requirements add about a year of additional training. As Dachis and Brydon (2013) show, these additional years of training slow down entry into trade workforces.

In addition, provinces also regulate the number of apprentices that a certified refrigeration and air conditioning mechanic can take on. In Western Canada, and some Atlantic provinces, each certified Refrigeration and Air Conditioning Mechanic can train at least two apprentices at any given time. However, in Ontario, a certified Refrigeration and Air Conditioning System Mechanic can only train one apprentice at a time. In Quebec, an apprentice must work with two certified Refrigeration Mechanics to qualify for certification. As Dachis and Brydon (2013) show, these limitations can significantly reduce the available labour force in a sector.

Certification and migration barriers: Canadian provinces have adopted the Red Seal Program to set common standards for skilled trades, including apprenticeships. When a province adopts a Red Seal designation for a trade, they agree to allow technicians certified in that trade elsewhere in Canada to work in the province without writing a provincial examination by that province's certification body. Most workers licensed as Refrigeration and Air Conditioning Mechanics are able to move from province-to-province easily.

Ontario's training system is unique compared to most of Canada because it has a lower training requirement (4,500 hours) for in-home air conditioning/heat pump system installation certification.

This lowers the barrier for within-Ontario training opportunities. However, because Ontario and Manitoba are the only provinces that certify this trade, it isn't eligible for the Red Seal designation. This excludes prospective apprentices from federal funding or loan programs that are often limited to Red Seal trades. If other provinces recognized this trade, it would open more opportunities for heat pump technicians.

There are many thousands of certified Gasfitters in Ontario, substantially more than the number of certified Refrigeration and Air Conditioning Mechanics. Ontario does not participate in the Red Seal certification for Gasfitters. This certification does not permit them to install heat pumps, though many do so anyway. That limitation means that many installation or repair companies might send untrained people, or might need to send multiple trained people to install a hybrid heating system that involves replacing a furnace, even when a single installer might be capable of doing the work.

Those trained only as natural gas furnace technicians face great uncertainty in their future employment outlooks. Uncertainty about the future of natural gas furnaces will also deter potential entrants to the field. An option for harmonized cross-training, and financial support for training, can improve the future job prospects for current gas technicians and may mean that more heat pump installers can emerge from the existing pool of gasfitters (HRAI 2025). Better training can also ensure that hybrid heating systems are installed with optimal settings, such as the temperature at which the heat pump switches over to the gas furnace.

Recommendations

1. **Make it easier for Ontario households to adopt hybrid heating systems.** The federal and Ontario governments should subsidize the widespread deployment of hybrid heating systems in Ontario. Governments should subsidize a wide range of heat pumps and support a better design for financing heat pumps as emergency replacements.

    a. The Ontario Energy for Generations plan explicitly supports hybrid heating. This is an excellent start. To better execute on this plan, the Ontario government should offer subsidies for standard and cold-climate heat pumps to make them as affordable to consumers as air conditioning systems. Support for standard heat pumps can ensure that customers who would require electrical panel upgrades to install a cold-climate heat pump are able to adopt hybrid heating without a significant upgrade cost. Further, hybrid heating allows households to install heat pumps that do not need to fully heat homes in the coldest of temperatures.

    b. The federal and Ontario governments should design supports that make installing a hybrid heating system the most appealing option when Ontario consumers replace their air conditioners or gas furnaces. Government programs should recognize that these replacements are often emergencies, and that consumers don't have time to complete lengthy application processes. The federal loan program requiring an energy audit and a lengthy approval is ineffective in these circumstances. Rather than limiting access to those who can afford to purchase a heat pump in an emergency, government support should be delivered through utility and energy-service companies, regardless of whether the customer owns the heat pump unit.

2. **Assess the value of hybrid heating for the Ontario energy system under a competitive market.** Ontario's energy system is planned in silos, with separate assessments of the value of electricity and natural gas systems. As announced in Energy for Generations, the Ontario Ministry of Energy will be uniting electricity, natural gas, hydrogen, biofuels, and other energy sources into one integrated plan that will power people's lives and the Ontario economy.

    a. The analysis of the capacity value of hybrid heating in this paper is only a starting point in understanding its system value. The Ontario government should direct the IESO to conduct its own estimate of the capacity value of hybrid systems for optimizing energy demand against peak-period supply cost, covering generation and delivery cost savings across natural gas and electricity users.

    b. The Ontario government should direct the IESO to provide incentives for any kind of dispatchable capacity flexibility from electric home heating. The most cost-effective means should win the most support from energy users, and indeed multiple approaches could be combined. Perhaps that will include hybrid heating. There could also be other approaches that can offer value to the grid. With this value to the market in hand, different system aggregators can grow their customer bases with incentives to adopt flexible heating. The provincial government should support pilot programs for technologies that support dispatchable capacity flexibility from home heating, to help identify which are most cost-effective. Wide-scale deployments of these options should emerge from a competitive process, such as capacity markets.

3. **Make it possible for Ontario households to get the most value from their hybrid heating systems.** Our analysis indicates that with smart controls optimized to take advantage of the cheapest energy source, hybrid heating is likely the lowest cost form of home heating for many Ontario households. The Ontario government should enact policies that support this cost savings.

    a. The Ontario government should direct the Ontario Energy Board to study, and consider adopting, Quebec-style electricity pricing options designed for hybrid heating. An initial step could be a pilot program that looks at Ontario consumers with hybrid heating already installed, to assess the household-level cost savings and value to the energy grid of Quebec-style pricing. Similarly, Ontario should make it easy to adopt the ultra-low overnight rate only for winter months without customers needing to contact their electricity provider.

    b. The federal and Ontario governments should include smart thermostats in their upfront support for hybrid heating adoption. That support should have a requirement that smart thermostats be able to optimize both emissions and operating costs for consumers by switching between electricity and natural gas.

4. **Make it easier for more home heating trades workers to install heat pumps.** Better training of home heating trades workers can encourage them to make installing hybrid heating or heat pump systems the default option when the existing technology in a home stops working. Ontario should seek to persuade other provinces to rethink how they regulate training and professional certification for heat pump and natural gas installers. They should encourage harmonized training for gasfitters and heat pump technicians. Ontario should seek to persuade other provinces to recognize its Residential Air Conditioning Systems Mechanic trade certification and include it in the Red Seal program so that apprentices have better access to Red Seal-related programs. Provinces should remove barriers to interprovincial migration when trades workers are able to demonstrate equivalent training.

Conclusion

For the dual purposes of reducing emissions and maintaining or improving affordability for consumers, Ontario should support the widespread deployment of residential hybrid heating systems. By leveraging off-peak, low-emissions electricity for heat pump operation and switching to natural gas during periods of peak electricity demand, homeowners can reduce their emissions while minimizing their electricity costs. By shaving electricity demand peaks, the province can reduce its investments in generating capacity. Policymakers should embrace hybrid heating and institute policy changes that best enable its wide adoption.

Appendix A: Current building decarbonization policy incentives and literature review of international heat pump programs

The existing federal and provincial policy framework to promote building emissions reductions in Ontario revolves around loans to finance retrofits along with current provincial as well as past and proposed federal grant programs.

Federal programs

The 2024 Canada Green Buildings Strategy featured a number of mainly granting programs for retrofits to reduce building emissions. The Canada Greener Homes Grant was the most ambitious federal policy on this front, and as of July 2025 396,732 households have completed retrofits and received a grant, with another 60,742 applications still being processed. The program is now closed to new applicants. The Greener Homes Grant gave up to $5,000 in direct grants for home retrofits including heat pumps, plus $600 in subsidies for home energy audits. Eligible homeowners could use these grants to reduce the upfront cost of purchasing a heat pump, but could not utilize these programs if they rented or leased the heat pump.

In addition to these grants, the federal government offered the Canada Greener Homes Loan program until October 1, 2025. This program provided between $5,000 and $40,000 in interest-free loans with a repayment term of 10 years. The 2024 federal budget indicated that a total of $6.7 billion had been paid out through these loan and grant programs. An additional $600 million was added to the loan program in the federal government's 2024 Fall Economic Statement. As of July 2025, $1.77 billion in grants have been issued through the Greener Homes Grant program, meaning that the majority of the funding has been in the form of loans.

The federal government has announced that a Canada Greener Homes Affordability Program (CGHAP) will be launched in 2025 to provide low-income households with no-cost home retrofits. However, as of September 2025, few details have been announced for broad national roll-out, besides the initial launch of the program in Manitoba. In Manitoba the program offers free heat pumps to low- and middle-income homeowners and renters.

In 2022 the federal government announced the Oil to Heat Pump Affordability program, a household grant of up to $10,000 for low-to-median income homeowners to transition away from oil-fueled heating systems. Eligible upgrades include electrical and mechanical heating system work, oil tank removal, outdoor piping for ground-source heat pumps, and electric water heaters. As of July 2025, the program has installed over 20,000 new heat pumps, 75% of them in Atlantic Canada, where about a quarter of homes use oil for heating — the highest prevalence of any region in Canada.

Provincial and municipal programs

The Ontario government launched a new program in January 2025 for energy efficiency upgrades in homes and small businesses. The Home Renovations Saving program builds on previous programs delivered only via the natural gas system. With recent amendments to the Electricity Act, the IESO is also now party to energy efficiency measures that use electricity to reduce emissions, but only from oil or propane. The Home Renovations Saving program offers a significant rebate on eligible upgrades, including new windows, doors, insulation, smart thermostats, heat pumps, and solar energy installations.

Table A1: Rebates offered under Ontario's Home Renovation Savings program

System	Estimated upgrade costs (not including installation)	Home Renovation Savings program rebate
Roof/attic Insulation	$2,800	Up to $1,500
Wall insulation	$4,500	Up to $3,600
Windows	Double pane $900, triple pane $1350 (per window)	$100 per window
Cold-climate heat pump	$7,000	$500 per ton. Up to $2,000 for cold-climate air-source heat pump Free cold-climate heat pump for low income homes powered by electricity (under the Energy Affordability Program)

Other provinces, such as Quebec, B.C., and Manitoba, as well as select municipalities in Alberta and Ontario, have adopted programs to assist homeowners in financing energy-efficiency upgrades (including heating and cooling systems).

Studies of heat pump adoption

Interpreting international studies of heat pump adoption must include recognizing the difference in local factors. Davis (2023) looks at the determinants of U.S. household adoption of heat pumps and finds adoption is higher in warmer climates (e.g. the U.S. South) and in regions with lower electricity prices. In contrast, colder regions and areas with high electricity costs have lower adoption rates. Similarly, Anderson and Kirkpatrick (2024) find that heat pump conversions are primarily influenced by energy costs rather than demographic characteristics, such as income.

International studies are useful for understanding the effect of policy choices and rate design on consumer behaviour. Shen et al. (2022) find that upfront rebates of between US$300 and US$450 for heat pump adoption in North Carolina increase uptake by 13%, much more than cutting the borrowing rate for loans by more than half. A recent study on heat pump adoption in the U.K. (Bernard et al. 2024) suggests that heat pump users widely adopt smart thermostats and automation settings to shift energy use in response to time-of-use pricing, indicating strong potential for technology-specific pricing, pending future research. Financially, Bernard et al. (2024) estimate the 2023 U.K. heat pump subsidy generates £1.24 in societal benefits for every £1 in net government costs. Using flat electricity prices, heat pump running costs are slightly higher than gas boilers due to electricity prices. As of mid-2024, heat pump users faced an estimated £190 in additional annual costs, though disconnecting from the gas grid could reduce this difference to around £83 per year as they reduce fixed charges on their bill (albeit at the risk of needing to replace other household equipment that uses natural gas). However, once customers switch to time-of-use pricing, switching to a heat pump saves them approximately 18% on their energy bills.

Appendix B: Model home specifications

Tables A2 and A3 summarize the specifications of the modelled home used for analysis. The model is based on a single-family home located in Vaughan and Ottawa, Ontario. The model home's thermal efficiency values are adjusted for building code minimums prior to 2012 (Table A3). We use weather data from the nearest international airports in both cities.

Table A2: Input specifications for model home

Characteristic	Value
Type	Single family detached
Plan shape	Square — 7 corners
Storeys	2
Front orientation	North
Above grade floor area (m^2)	252
Below grade floor area (m^2) (unconditioned space)	142
Rooms	5 bedrooms, 4 bathrooms, 1 utility room, 1 kitchen, 1 living room, 1 dining room
Highest ceiling (m)	2.46
Ceiling type	Attic/gable
Foundation type	Basement
Air change rate	2.5 ACH @50 Pa
Indoor temperatures	Main floor temperature: 21 °C and cooling set point to 25 °C. Night heating set to 18 °C
Base home heating system	Natural gas condensing furnace (90% efficiency)

	Conventional natural gas hot water tank (151.4 L)
Base home cooling system	Central Split AC (SEER 14)

Table A3: Minimum thermal efficiency of home components, per Ontario building code prior to 2012

Location	Vaughan	Ottawa
NECB climate zone	5	6
Heating degree days	3800	4500
Roof/attic insulation (ft^2 °F h/BTU and m^2K/W)	R30 / RSI 5.46	R30 / RSI 5.46
Wall insulation (ft^2 °F h/BTU and m^2K/W)	R17 / RSI 3.01	R17 / RSI 3.01
Floor insulation (above unconditioned space) (ft^2 °F h/BTU and m^2K/W)	R30 / RSI 5.46	R30 / RSI 5.46
Window/doors performance (20 windows)	U 2.2 / RSI 0.45	U 2.2 / RSI 0.45
Basement walls (ft^2 °F h/BTU and m^2K/W)	R8 / RSI 1.41	R8 / RSI 1.41

Appendix C: Heat pump comparison data

The sizing calculations for the heat pumps used in our model homes are based on Natural Resources Canada's Air-Source Heat Pump Sizing and Selection Guide (2020).

Base model Vaughan home loads from Volta SNAP

Design heat loss at -18.3 °C (-0.4 °F): 52,764 BTU/h
Design cooling for July at 31.5 °C: 20,244 BTU/h
Annual heating: 83.09 GJ
Annual cooling: 5.04 GJ

Target cooling capacity range = 80% to 125% of design cooling load
= 0.8 x 20,244 BTU/h to 1.25 x 20,244 BTU/h
= 16,195 BTU/h to 25,305 BTU/h

Target heating capacity at 17 °F = design heating load x 43 / (60 - design temp)
= 52,764 BTU/h x 43 / (60-0.4)
= 37,564 BTU/h

Peak load = target heating capacity since we are optimizing for winter peaking loads.

Heat pump sizing estimations

3 ton = 36,000 BTU/h
4 ton = 48,000 BTU/h
5 ton = 60,000 BTU/h

By using the estimations above and the target heating capacity, the heat pump needs to be at least a 3.0 ton unit. To account for the results from real-world pilot studies in which real-life household heating demand is more than what models such as the Volta SNAP model calculate, and to not undersize the heat pump for the size of the model home, we chose to use a 3.5 ton heat pump in our model.

In addition, Table A4 provides a summary of various cold-climate heat pumps sourced from the NEEP database, evaluated using the Vaughan-based model home to confirm the appropriately sized heating unit. We conducted a test to determine the correct heat pump size and cutoff temperature for the home. After looking at the performance of various heat pumps and using the Natural Resources Canada guide cited above, we assume a cutoff temperature of -15 °C, where the heating system switches from the electric heat pump to the natural gas furnace, as this is the temperature at which the heating capacity, based on the lower efficiency, falls to the point of not being able to heat the home (see Figure A1 below).

For emissions from the natural gas furnace, we assume an emission factor of 1.932 kg CO_2e per cubic metre of natural gas.

We produce total cost estimates for these hybrid heating systems using two scenarios: one in which there is no price-optimizing software, and another in which there is price optimizing software (Table A4). For our price optimizing scenario, we use an hourly model of the home over the course of the entire year. The switchover point is a cutoff temperature of -15 °C, or when the electricity price in our ultra-low overnight rate is at on-peak prices for our emissions-focused scenario, which is the basis of comparison for Table A4.

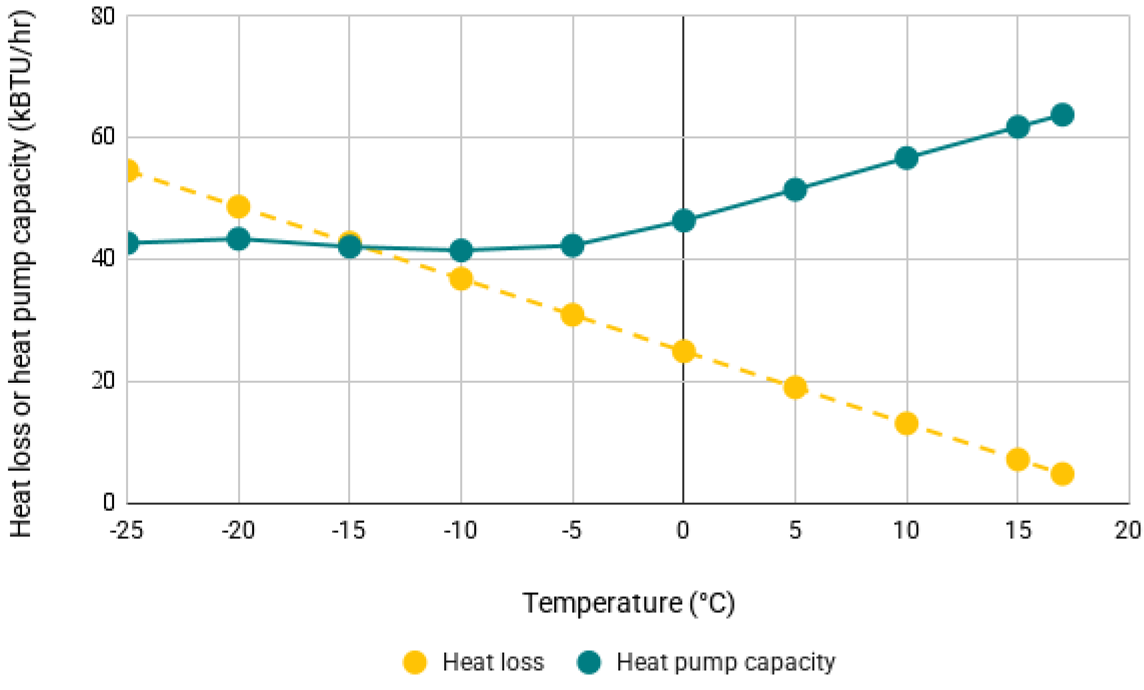
Table A4: Cold-climate heat pump analysis with hybrid heating

Heat Pump Characteristics				**No price-optimizing controls (-15 °C cut-off)**			**Price-optimizing controls (-15 °C and on-peak price cut-off)**		
Name	**HSPF**	**SEER**	**Size**	**Electricity price ULO ($)**	**Natural gas price ($)**	**Total price ($)**	**Electricity price ULO ($)**	**Natural gas price ($)**	**Total price ($)**
CARRIER Infinity 20 VS Heat Pump	9	18.5	4 ton , heating 45000 BTU/h	$2,401	$740	**$3,141**	$2,127	$846	**$2,973**
CARRIER Infinity 21 VS Cold Climate Heat Pump	11	20	4.5 ton , heating 52000 BTU/h	$2,397	$740	**$3,137**	$2,139	$834	**$2,973**
Custom Comfort - cold climate	9.2	16.4	5 ton, 60000 BTU/h	$2,385	$740	**$3,126**	$2,137	$834	**$2,971**
RHEEM - 1.5 ton	7.2	10	1.5 ton, 12800 BTU/h	$1,993	$1,065	**$3,058**	$1,838	$1,159	**$2,998**
Panasonic CU series	7.9	10	3 ton, 36000 BTU/h	$2,526	$745	**$3,271**	$2,251	$839	**$3,090**

RHEEM 3.5 ton	8	12	3.5 ton, 42,000 BTU/h	$2,520	$741	**$3,261**	$2,243	$834	**$3,077**

The total utility costs for the heat pumps modelled are very similar, and in some cases, the larger units appeared to have slightly lower operating costs when used with price-optimizing software. However, we chose the 3.5 ton RHEEM heat pump for the unit in the calculations in the body of the paper based on the detailed load calculations. Figure A1 (below) shows the heat pump coefficient of performance we assume at various temperature levels. For the all-electric heating system, we assume that the heat pump runs to temperatures up -25 °C, at which point it switches to electric-resistance backup heating.

Figure A1: Performance of a 3.5 ton cold-climate air-source heat pump at varying temperatures



Limitations of heat pump sizing simulation

While the selected heat pump may operate below -15 °C or perform above its rated capacity at that temperature, we chose a -15 °C cutoff for modelling purposes based on the NRCan heat pump sizing toolkit cited above, as well as assessment of the unit's heating performance curve. This provides a standardized and conservative estimate that aligns with typical hybrid system design practice. It is important to note that in practice, the dynamic balance point, the temperature at which the heat pump can no longer meet the full heating load, can vary depending on factors such as house performance, homeowner activity, local climate, and utility rates. Using a restricted cutoff provides more accurate and controllable simulation results, as recommended by both the HOT2000 and Volta SNAP software packages.

Appendix D: Modelling methodology

We upload our HOT2000 model to Volta SNAP, a software tool developed by Volta Research. Volta SNAP streamlines energy assessments for existing low-rise residential buildings by providing an hourly breakdown of the home's energy use.

1. Heating system inputs are adjusted in Volta SNAP for each scenario.
    - Baseline: High-efficiency natural gas furnace and gas hot water heater
    - Hybrid: Heat pump alongside high-efficiency gas furnace and gas hot water heater
    - All-electric: Heat pump and electric water heater, and the household cancels gas service

2. While HOT2000 has limitations in modelling heat pump COP variation, Volta SNAP enhances accuracy by aligning hourly electricity usage with real-world heat pump performance curves. Volta SNAP accurately calculates the hourly electricity usage over a full year.

Using the hourly electricity usage breakdown, we calculate the energy usage for both electricity and natural gas. The calculations vary for each model home scenario.

Table A5: Volta SNAP outputs used in calculation of electricity and natural gas usage in the model homes

	Electricity	**Natural gas**
Baseline	Hourly electrical load kWh (includes base loads, ventilation, cooling)	**Natural gas used (m^3)** = Total hourly heating load in Watts produced by the Volta SNAP model, converted to the energy-equivalent quantity of natural gas, and adjusted for the efficiency of the furnace. + Domestic hot water gas usage
Hybrid	Hourly electrical load kWh (includes base loads, ventilation, cooling, heating from heat pump)	If hourly heating kWh = 0 and total heating load is more than 0 kWh, natural gas furnace is on. **Natural gas used (m^3)** = Total hourly heating load in watts — when the gas furnace is on — produced by the Volta SNAP model, converted

		to the energy-equivalent quantity of natural gas, and adjusted for the efficiency of the furnace. + Domestic hot water gas usage
All-electric	Hourly electrical load kWh (includes base loads, ventilation, cooling, heating, domestic hot water)	

HOT2000 and Volta SNAP have water usage assumptions, specified in Table A6 (below).

Table A6: Hot water usage and inputs in the model homes

Hot water temperature	55 °C
Other daily consumption per occupant	2.292 L
Bathroom faucets	Faucet flow: standard - 8.3 L/min Faucet use: 1.33 L per occupant per day
Shower	Temperature: warm (41 °C) Flow: standard - 9.5 L/min Average duration: 6.5 L/min Showers per week per occupant: 5.2
Dishwasher	Cycles per occupant per week: 1.37 Rated water consumption per cycle: 19 L Rated annual energy consumption: 260 kWh
Clothes washer	Cycles per occupant per week: 1.9 Rated water consumption per cycle: 54 L Rated annual energy consumption: 197 kWh

Table A7: Vaughan model home loads breakdown, full year

	Base loads (kWh)	Ventilation (kWh)	Hot water (gas m^3 / electric kWh)	Heating (gas m^3)	Heating (kWh)	Cooling (kWh)	Total electricity (kWh)	Total natural gas (m^3)
Baseline	6,552.40	35.95	682.07 m^3	2,219.59		1,211.94	7,800.29	2,901.66
Hybrid (low emissions)	6,552.40	35.95	698.98 m3	378.08	7,314.51	1,000.62	14,903.48	1,077.06
All-electric	7,117.40	35.95	4,627.74 kWh		9,138.54	1,001.05	21,920.68	

Table A8: Ottawa model home loads breakdown, full year

	Base loads (kWh)	Ventilation (kWh)	Hot water (gas m^3 / electric kWh)	Heating (gas m^3)	Heating (kWh)	Cooling (kWh)	Total electricity (kWh)	Total natural gas (m^3)
Baseline	6,552.40	35.95	702.21 m^3	2,729.92		1,019.48	7,607.83	3,432.12
Hybrid (low emissions)	6,552.40	35.95	698.98 m^3	721.42	8,323.90	1,001.05	15,913.31	1,420.40
All-electric	7,117.40	35.95	4,749.55 kWh		12,573.26	843.80	25,319.92	

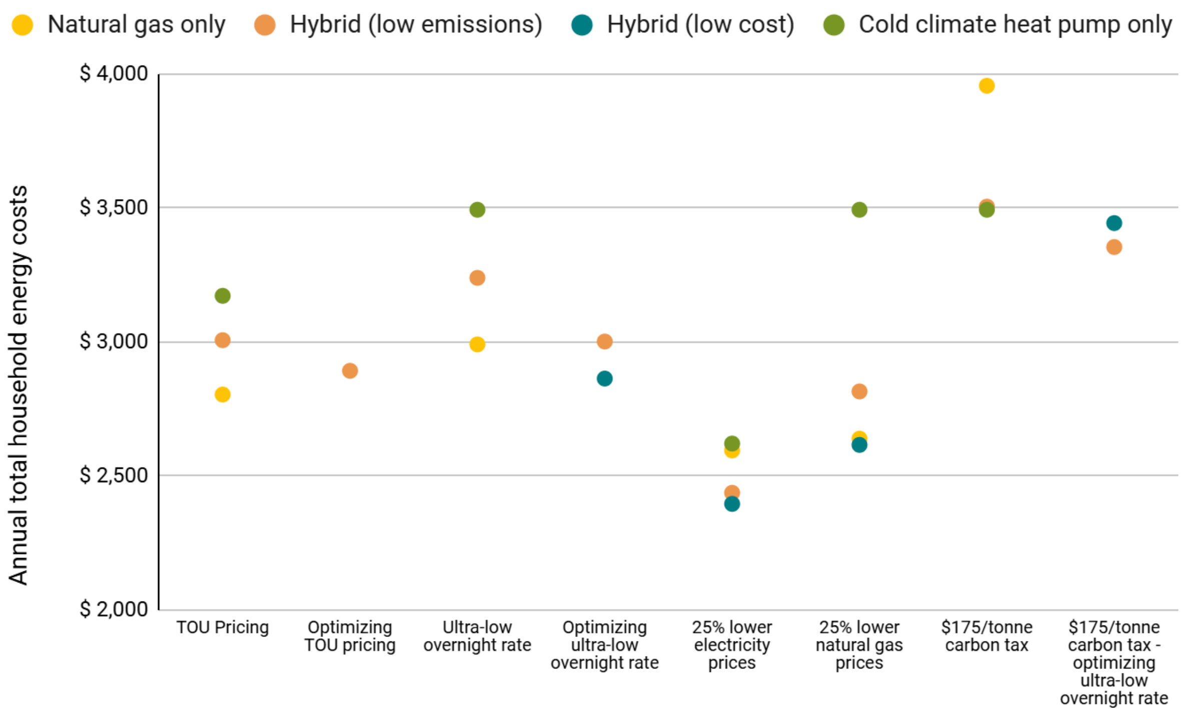
Sensitivity analysis

The results of our sensitivity analysis are shown in Figure A2 (below). We find that under standard time-of-use pricing, a typical Vaughan home sees about a $200 higher operating cost if they adopt a hybrid heating system compared to a fully natural gas furnace. A hybrid system using time-of-use pricing, without price-optimizing thermostat controls, has prices about $200 higher than a standard natural gas system. In this scenario, the household reduces emissions by 69%. Our Vaughan household that adopts smart controls with a hybrid system, and switches to natural gas in the coldest hours and at peak prices, sees total utility operating costs increase by about $90 per year, while reducing emissions by 55%. A fully electric heating system adds about $220 more in annual energy costs, relative to a fully natural gas system, when operating on time-of-use pricing. This assumes that the all-electric household does not have time-optimizing smart controls that pre-heats the home ahead of peak periods or optimizes the operation of the hot water tank — with smart controls, consumers may not see such a large spike in costs.

As we show in the paper, the full value of using price-optimizing smart controls comes from a price program with significantly different hourly prices: the ultra-low overnight rate. When hybrid heating customers use the ultra-low overnight rate and switch from heat pump to gas heating when the ambient temperature is -15 °C or below, but without any form of price optimizing smart controls, they do not see savings using the ultra-low overnight rate relative to a home on the same electricity plan using natural gas furnaces. However, when hybrid heating customers can optimize their heating supply choice based on the hourly cost of electricity, and only avoid using their heat pump during the top peak hours priced at 28.4 cents per kWh (as in our emissions-focused scenario), they see costs about equal ($10 more per year) to the baseline natural gas heating system.

If customers adopt a lower-cost mix of natural gas and electricity in which they also do not use electricity when it is at the mid-peak price, they see savings of around $120.[18] Without smart controls that modify the level of heating in a home or the timing of hot water heating, an all-electric home faces $500 in additional operating costs under a hybrid heating system, relative to the natural gas-only home.

Figure A2: Sensitivity analysis of home heating costs



Both a fully electric system and a hybrid system have lower operating costs if electricity prices decline. It would take about a 25% reduction in electricity prices for an all-electric system to begin to be cost-comparable to a natural gas system, assuming no other price optimization. Regardless, the hybrid systems still offer lower operating costs. If natural gas prices were to fall 25%, the hybrid

[18] In addition, although not shown in Figure A2, if customers were to switch their electricity pricing plan to traditional time-of-use during the summer, but kept their ultra-low-overnight rate during the summer with smart controls, their overall utility costs fall relative to a natural gas-only home on time-of-use pricing.

heating system optimized for lowest costs and the baseline natural gas furnace would see similar operating costs.

Adding a $175/tonne carbon tax makes the standard natural gas furnace a much more expensive option than both a fully electric system or a hybrid heating system.[19] At $175/tonne, an all-electric system, without any smart controls for hot water or space heating, has a comparable cost to a hybrid system that also does not have any smart controls. However, when we account for the hybrid heating system's ability to optimize fuel sources with smart controls, both configurations of the hybrid system have lower equivalent operating costs to an all-electric heating system in a scenario with a $175/tonne carbon tax.

[19] Although not shown in the graph, we estimate that a natural gas-only home has equivalent operating costs to an all-electric home once carbon prices exceed $100 per tonne.

Appendix E: Utility cost data

Tiered utility pricing for Vaughan and Ottawa simulations is based on Ontario Energy Board pricing. We base electric utility pricing for Vaughan and Ottawa on rates from Alectra Utilities and Hydro Ottawa respectively. Natural gas pricing for both locations are from Enbridge Gas. The total sales tax (HST) is not included for electricity as there is a provincial rebate for that portion, but we do include HST for natural gas. We take the most recent Enbridge residential rates from their July 2025 OEB-approved rates. We base the gas supply charge on the headline rate, and exclude cost adjustment meant to reflect the difference between past forecasts of gas costs and actual amounts that Enbridge collects based on past forecasting errors. This amount is consistent with the winter average natural gas supply price over the last five years. We assume an average volumetric delivery component of $0.13 per cubic metre.

Table A9: Residential time-of-use electricity price for Alectra and Hydro Ottawa

	Cost
Off-peak usage: weekdays 7 p.m. – 7 a.m., weekends and holidays all day	$0.076/kWh
Mid-peak usage: weekdays 11 a.m. – 5 p.m.	$0.122/kWh
On-peak usage: weekdays 7 a.m. – 11 a.m. and 5 p.m. – 7 p.m.	$0.158/kWh
Base delivery charge	$34.35/month for Alectra; $34.51/month for Hydro Ottawa
Transmission charge	$0.0177/kWh for Alectra; $0.0198/kWh for Hydro Ottawa
Regulatory fixed charge	$0.26/month
Regulatory variable charge	$0.00615/kWh

Table A10: Residential ultra-low overnight (ULO) electricity price for Alectra and Hydro Ottawa

	Cost
On-peak usage: weekdays 4 p.m. – 9 p.m.	$0.284/kWh
Mid-peak usage: weekdays 7 a.m. – 4 p.m., and 9 p.m. - 11 p.m.	$0.122/kWh
Weekend off-peak usage: 7 a.m. – 11 p.m.	$0.076/kWh
Ultra-low overnight usage: Every day 11 p.m. – 7 a.m.	$0.028/kWh
Base delivery charge	$34.35/month for Alectra; $34.51/month for Hydro Ottawa
Transmission charge	$0.0177/kWh for Alectra; $0.0198/kWh for Hydro Ottawa
Regulatory fixed charge	$0.26/month
Regulatory variable charge	$0.00615/kWh

Table A11: Ontario residential natural gas price for Enbridge Gas

	Cost	**Cost**
Delivery	$0.13/m^3	$3.49/GJ
Gas supply charge	$0.13/m^3	$3.49/GJ
Transportation to Enbridge	$0.058/m^3	$1.55/GJ
Base customer charge	$26.78/month	$26.78/month

Appendix F: Modelling scenarios of different technology costs

Lower energy storage costs: Our primary results are based on current (2020) upfront costs for one hour of lithium-ion battery storage at $294/kW power cost and $922/kWh storage cost (in 2015 dollars). The cost of lithium-ion storage declines in future years with increased adoption of lithium-ion batteries up to an assumed cost floor of $92/kW power and $159/kWh storage upfront costs. We also modelled the effect of lower-cost energy storage, assuming a faster declining capital cost rate that can drop to a lower minimum cost floor of $72/kW power and $105/kWh storage costs, as that may provide an option for reduced natural gas electricity generation. This scenario also models hydrogen storage capital costs with a current upfront cost of $1,969/kW charging cost (electrolyzer) and $2,029/kW discharging cost (fuel cell). With increased adoption, upfront costs decline up to an assumed price floor of $573/kW charging cost and $464/kW discharging cost in the baseline scenario. Under the lower storage cost scenario, we assume a faster declining capital cost rate that can drop to a lower minimum cost floor of $515/kW charging and $45/kW discharging cost.

With lower storage costs, the model deploys an additional 3,500 MW of hydrogen storage, on top of about 17,000 MW of lithium battery storage and 3,000 MW of hydrogen storage for Ontario peak hour usage in the baseline scenario. We find that relative to the baseline building heating choices in a net-zero scenario which has a mix of heating technology, lower storage costs can reduce the need for natural gas generation in peak hours by a few thousand MW in 2035. By 2050, increased storage capacity only reduces peak natural gas generating capacity by approximately 1,000 MW. Therefore, lower storage costs do not materially change the conclusion.

All scenarios assume that the capital cost of a combined-cycle gas turbine is $1,223 per kW and a single-cycle turbine is $1,086 per kW. Solar PV capital costs are forecast to fall from a cost of $1,570 per kW in 2020 to a future cost of $730/kW by 2050.

We do not examine the potential effect of other peak-reducing technologies, such as in-home batteries, thermal storage with water heaters (for example), or utility-controlled charging of electric vehicles. As discussed further in the paper, provinces should create technology neutral market mechanisms that allow all these technology options to compete to provide the lowest cost reductions to peak demand.

Natural gas death spiral: Hybrid heating will reduce the volume of natural gas used. Therefore its viability depends on the balance between gas system utilization and the relative efficiency of energy types. The future cost of maintaining the natural gas system can determine the ideal rollout rate of hybrid and fully electric heating systems. Our analysis also included a scenario in which the cost of natural gas incorporates this potential dynamic — where gas companies obtain approval to collect more per customer — which may in turn reduce the viability of hybrid heating systems. However, we found little effect on natural gas prices in Ontario by including the possibility that reduced demand increases the rate at which people defect from the natural gas system. This non-result should not be a surprise, because hybrid systems maintain the customer base and the fixed monthly costs, independent of fuel use, may be sufficient to cover existing system maintenance. Indeed, the widespread rollout of hybrid systems incorporates a doubling in the price for natural gas services between 2025 and 2050 in Ontario.

Rising natural gas prices are driven by higher production costs under net-zero policies. A high carbon price on the production sector will push upstream natural gas companies to adopt costlier abatement measures — such as electrifying compression systems and strengthening methane management to make Canadian natural gas production consistent with a net-zero future.

There is also greater blending of renewable natural gas and hydrogen into the natural gas supply. The additional costs of blending are passed through in the natural gas service price. Our modelling assumes that Canada reaches net-zero emissions, but that the United States does not. Consequently, Canada won't export renewable natural gas (RNG), derived from waste methane, but can import RNG from the U.S. Blending RNG reduces the carbon intensity of natural gas, thereby lowering the implicit carbon price associated with it. If the U.S. competes with Canada for RNG, the cost of blended natural gas in Canada could rise. This increase would stem from either reduced RNG blending and higher carbon costs or greater reliance on pricier second-generation RNG. Ultimately, this potential natural gas price hike could diminish or even eliminate the savings from lower electricity prices expected with hybrid heating. Our model results in the widespread hybrid heating scenario indicate RNG representing 7% of the natural gas blend, with hydrogen at 2% percent in Ontario.

Assuming no direct air capture: The continued use of many emitting technologies often relies on carbon removal (specifically, direct air capture) technology being available to offset any emissions for Canada to meet a net-zero goal. We test a scenario in which there is no direct air capture, although carbon capture and bio-energy with carbon capture would be available, albeit at high costs. In scenarios without carbon removal, more natural gas-fired electricity generation utilizes carbon capture and sequestration. The relative differences between our technology sensitivity tests in terms of the outcomes for electricity prices stays the same, however. As a result, the availability of direct air capture makes little difference to Ontario home heating technology scenarios.

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