An Analysis of the Financial and Climate Benefits of

Electrifying Ontario's Gas-Heated Homes

by Installing Air-Source Heat Pumps

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Aug 02 2022

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Acknowledgments

The consultant wishes to acknowledge the technical assistance provided by the members of the Ontario Clean Air Alliance Research's Heat Pump Advisory Committee:

Keith Burrows | The Atmospheric Fund

Kent Elson | Elson Advocacy

Evan Ferrari | eMerge

Brendan Haley | Efficiency Canada

Jeff Hunter | Evolved Thermal Energy

Gillian Lind | Hydro One

Peter Love | Love Energy Consultants

Martin Luymes | Heating, Refrigeration and Air Conditioning Institute of Canada

Evelyn Lundhild | Independent Electricity System Operator

Kai Millyard | Green Communities Association

Michael Parkes | Ontario Energy Board

Sonny Pirrotta | Panasonic

Ralph Torrie | Corporate Knights

Eve Wyatt | Pocket Change Project and Ontario Clean Air Alliance

The Committee members are not responsible for the report's recommendations or any errors that may remain.

Ontario Clean Air Alliance Research gratefully acknowledges the generous financial support that it has received for this report from: Echo Foundation, Green Sanderson Family Foundation, Ivey Foundation, Mike Brigham Foundation and Taylor Irwin Family Foundation at the Toronto Foundation.

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Introduction

Ontario homeowners are increasingly concerned about rising costs of living and are also looking for ways to play a role in addressing climate change. Heat pumps for space heating and cooling and for water heating are ideal solutions. Indeed, heat pumps are emerging as the recommended climate solution for residential buildings, and they can also save a homeowner thousands of dollars over the equipment's lifetimes when compared to heating systems that use methane (a.k.a., natural) gas. It is time to consider heat pumps to replace aging space and water heating equipment.

This report models the utility bill savings and greenhouse gas savings that are possible for homes that transition to heat pump systems when their gas furnace is at its end of life. **The spreadsheet model used in this analysis is available for download on the Ontario Clean Air Alliance website. Users can change the modeling assumptions and inputs such as the heating loads, heating system efficiencies, installation dates, and they can also model the impacts for select Ontario cities.**

Heat pumps are emerging as the recommended climate solution for residential buildings, and they can also save a homeowner thousands of dollars

What are heat pumps?

Heat pumps are mechanical systems that move heat. Refrigerators and air conditioners are heat pumps that work in one direction to keep an area cool. Heat pumps for heating and cooling are reversible, that is they can replace a furnace by moving heat into a home in winter and replace a central air conditioner by moving heat out of a home in summer. Modern cold climate heat pumps can supply all of the heat needed by a home even in cold climates and in older homes and they can also improve comfort: they are far more efficient and better able to extract heat from cold temperatures than previous generations of heat pumps.

Moving heat is more efficient than generating heat. A gas furnace has a maximum theoretical efficiency of 100% because it cannot generate more heat energy than the energy contained in the fuel. A heat pump on the other hand, can move several units of heat energy with one unit of electrical energy and can achieve average efficiencies of 300% or more[1].

Heat pumps are a mature technology that are ever improving. Heat pumps have been in use for over a century and have proven to be highly reliable. Yet just as cars and phones have evolved significantly in recent decades, so too have heat pumps. Heat pumps are, and continue to become, more efficient, better suited to cold climates, quieter, and more affordable[i]. Modern cold climate heat pump systems with built-in backup resistance heaters are capable of efficiently providing all of the heat required to keep a home comfortable even in Ontario's climate[2].

There are many types of electric heat pumps. For example, electric heat pumps can exchange heat with the outside air (air source heat pump: ASHP) or the ground (ground source heat pump: GSHP). There are heat pump systems that can replace any existing heating and cooling system, whether it is centrally ducted forced air, radiant floor heat, or even baseboard heat. Water heaters also come in highly efficient electric heat pump forms (HPWHs). While this work focuses on ASHPs designed to replace a centrally ducted furnace in Ontario's climate and HPWHs to supply hot water for domestic use, GSHPs and multi-split systems that do not require ductwork are also excellent options.

A furnace has a maximum theoretical efficiency of

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[1] Heat pump average seasonal efficiencies include all of the energy used by the heat pump over the heating season, including built-in electric resistance backup heaters for very cold days. This analysis uses a more conservative 270% efficiency.

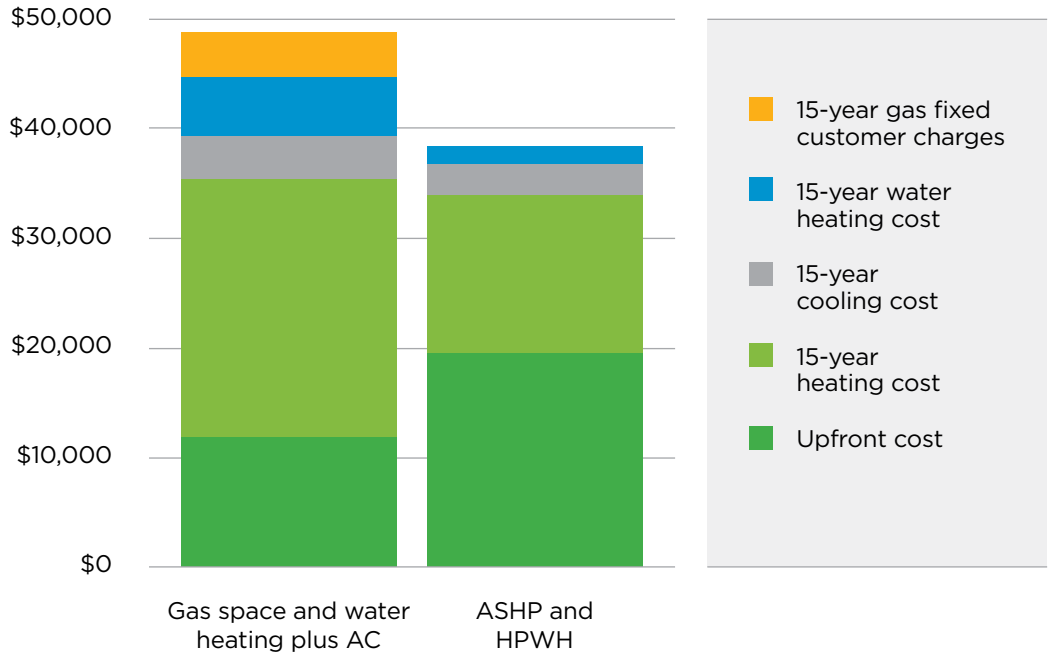
[2] Backup resistance heaters can be used to top up the heat provided by the heat pump when it struggles to extract enough heat from very cold outside air and is also used during defrost cycles. Cold climate heat pumps are often rated to provide full heating down to -20°C to -30°C, but performance will vary by system and installation.

Electric heat pumps save money

The economic landscape is increasingly favourable for heat pumps for a number of reasons. First, heat pumps have become considerably more efficient and can now heat homes in the coldest climates. Second, the rising federal carbon tax will put continued upward pressure on fossil fuel energy bills[3]. Third, the federal Greener Homes Grant currently offers up to $5,000 rebates and interest-free loans for qualified electric heat pump systems. Fourth, methane gas prices have risen dramatically in recent times.[ii]

Figure 1 shows how an average Toronto home that is looking to replace a failing gas furnace in 2022 will see an estimated $10,320 in lifetime total savings (capital plus energy) if they choose to fully electrify their home with heat pump systems for space and water heating instead of installing a replacement gas furnace (conventional system)[4]. Although some homes may need to electrify stoves and other gas-burning appliances before disconnecting from the gas supply, these investments have the benefit of improving indoor air quality, eliminating the risk of carbon monoxide poisoning and saving the monthly gas fixed charges ($22-$23/month).

Figure 1 | **Lifetime costs for a Toronto home**



Heat pumps have become considerably more efficient and can now heat homes in the coldest climates

[3] Our analysis uses the July 2022 Ontario Energy Board approved residential prices for gas and electricity and the Government of Canada's schedule to raise the carbon tax to $170 per tonne by 2030.

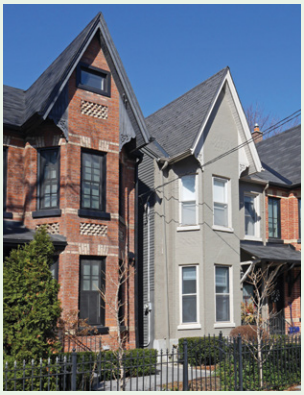
[4] The upfront costs for the conventional system include the cost of replacing the furnace, air conditioner and water heater to similar models over the 15-year lifespan of the furnace system. The upfront cost for the heat pump system includes the cost of the ASHP, HPWH and upgrading the electrical panel minus the $5,000 Greener Homes Grant and assumes that the home can disconnect from the gas supply and save the gas fixed customer charges.

The optimal time to invest in a heat pump is when a home's equipment is near the end of its life. Buying a replacement gas system could lock a homeowner into 15 years of high prices and unnecessary carbon pollution. While the upfront cost of the heat pumps for space and water heating is greater than that of conventional gas equipment (see *Table 1*), a home will begin to save money immediately on the utility bills. An average Toronto home with a Greener Homes Grant for heat pump equipment will see an 8-year payback period, and a 12-year payback without the grant.

Even greater savings are possible when cost-effective energy efficiency upgrades to the building envelope are performed because total heating costs are reduced and smaller heating and cooling systems can be used. Although much of the upfront cost of a heat pump comes from the labour costs of installation, larger 5 ton systems can be 20% more expensive than the average sized 3 ton system modeled here.

Table 1 | Upfront costs for the conventional and heat pump systems used in this analysis

	Conventional systems		Heat pump systems	
	Equipment	**Upfront installed cost**	**Equipment**	**Upfront installed cost**
Heating	Gas furnace (95% efficiency)	$5,000	ASHP (SCOP 2.7)	$19,000
Cooling	Air conditioner (SEER 13)	$5,000	ASHP (SEER 18)	
Hot water	Gas water heater (67% efficiency)	$2,000	HPWH (EF 3.75)	$3,750
Other costs	NA	NA	Electrical panel upgrade Greener Homes grant	$2,000 -$5000
Total		$12,000		$19,750



An average Toronto home with a Greener Homes Grant for heat pump equipment will see an 8-year payback period

Electric heat pumps reduce greenhouse gases

Canada's commitment to achieving net zero greenhouse gases by mid-century[iii] means that homes will ultimately be required to shift away from using fossil fuels such as methane gas for space and water heating. Most organizations that have studied the alternatives recommend shifting to electric heat pump systems for space and water heating. Those organizations include the Intergovernmental Panel on Climate Change (IPCC)[iv], the International Energy Agency (IEA)[v], and also countless municipalities in their climate action plans. A great example is the City of Toronto's TransformTO climate action strategy that notes "All suitable (retrofit) packages include fuel switching to electric heat pumps."[vi]

Heating our homes and businesses with methane gas creates huge amounts of carbon emissions. This accounted for almost 19% of Ontario's total greenhouse gas emissions in 2013 (latest provincial inventory year). Electric heat pumps can reduce these carbon emissions for space heating and cooling plus water heating by 35% for the average home in the short term even though much of the additional electricity needed for these systems would be generated with fossil fuels[5]. More importantly, when the grid is decarbonized, heat pumps will provide a 100% reduction in carbon emissions from space and water heating. For the average home, a switch from gas to heat pumps powered with zero-carbon electricity will reduce greenhouse gas pollution by 4.7 tonnes per year. This is equivalent to taking 1.4 fuel-burning cars off the road. According to The Atmospheric Fund, the total life cycle emissions of methane gas (including emissions from drilling, extraction and transportation) are 1.92 times greater than the emissions from burning the gas in Ontario[vii]. Therefore, the total annual greenhouse gas reduction benefit from replacing gas space and water heating with a heat pump could be equivalent to taking 2.8 fuel-burning cars off the road. This is a key benefit to heat pumps. The federal government is taking action to achieve a net zero electricity supply by 2035[viii] and 33 Ontario municipalities have called for the province to phase-out gas-fired electricity generation[ix]. Heat pumps offer major carbon reductions in the short term as well as complete carbon elimination in the medium term.

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[5] Based on the natural gas generation forecast by IESO in 2021.

Benefits under different scenarios

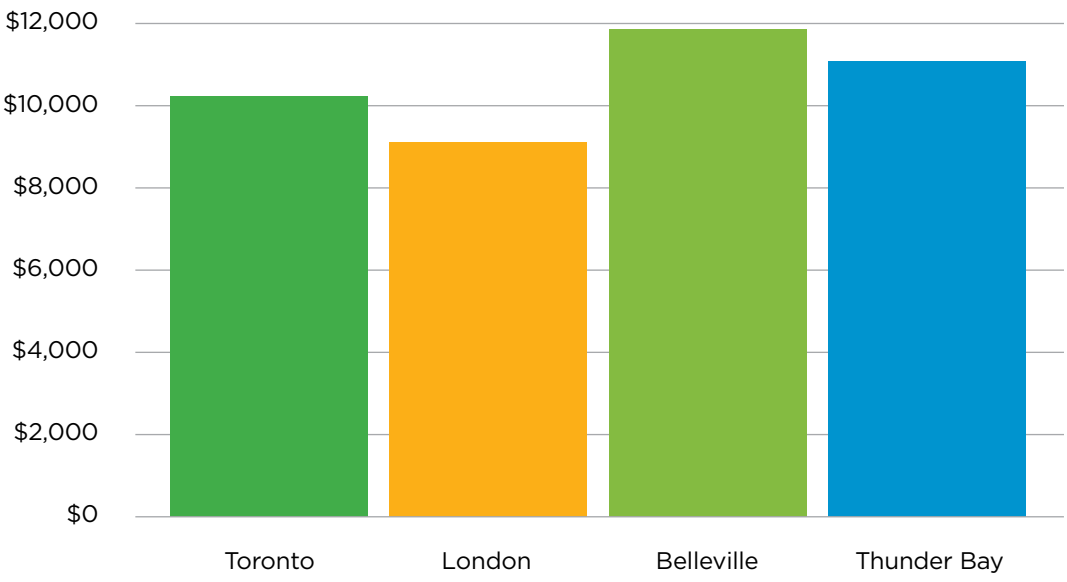
The above analysis is based on an average Toronto home that installs both a heat pump for space conditioning and a heat pump for water heating at the same time. We have extended this analysis to look at other scenarios shown in figures 2 and 3. In all scenarios, homeowners save a great deal. Unless otherwise stated, lifetime savings assumes the homeowner avoids paying monthly charges for fixed gas customer charges that pay for gas distribution pipelines, and uses the ($5,000) Greener Homes Grant to offset the upfront cost of the heat pump systems.

Savings modeled in this report for Toronto are representative of saving expectations across the province

Location

Electricity and methane gas prices vary across the province. *Figure 2* shows the lifetime savings for full electrification relative to conventional gas systems in different cities representing the four major Enbridge Gas rate areas in Ontario[6]. It is clear that the savings modeled in this report for Toronto are representative of saving expectations across the province.

Figure 2 | Lifetime savings for an average home in different Ontario cities



Home types

The lifetime savings will vary by home based on its rate of heat loss. Older homes tend to have less insulation and are leakier than newer homes that have been built to higher building standards. While an average gas-heated

[6] All of these cities are found in climate zone V and will therefore have similar heat pump performances. The same heating and cooling loads were applied to homes across the province.

home in Toronto will save $10,320 over its lifetime by fully electrifying with heat pumps, an average home built before 1946 will save significantly more ($14,060[7]) and an average home built since 1984 will save less ($8,225). The savings in older homes are greater because their heating requirements are higher.

Installation choices

A homeowner may not choose to replace both their space and water heating systems at the same time. If an end of life furnace is replaced with an ASHP, but the homeowner continues to use a gas water heater, the 15-year savings will total $4,493. These savings are significantly less because the homeowner would continue to pay the monthly gas fixed charges that pay for gas distribution pipelines, and add an estimated $4,499 to the lifetime cost.

Alternatively, a homeowner may opt to install a conventional electric tank water heater instead of a heat pump water heater because of lower upfront cost, a preference for conventional equipment, or other considerations. The resulting lifetime savings amount to $7,554.

Methane gas rates

Current gas and electricity prices (July 2022) were used in this analysis. However, electric heat pump systems are cost-effective even at much lower methane gas prices. On a lifetime cost basis with upfront costs included, fully electrifying the average Toronto home with heat pumps is still more cost-effective than traditional gas systems for space and water heating paired with an air conditioner if gas commodity prices are assumed to be as much as 88% lower than today's levels. This is mainly because fully electrifying will also save the high cost of delivering gas to the home through gas pipelines, save carbon costs, and save both heating and cooling costs through more efficient equipment.

Carbon costs

In this analysis, the price of carbon rises by $15/yr until it reaches $170 per tonne in 2030 as outlined by the federal government. After 2030, we assumed that the price of carbon remains steady at $170 per tonne. This is a conservative assumption. Ontario's Independent Electricity System Operator is planning to assume annual increases in the price of carbon of $15 per tonne until 2035 in its decarbonization pathways study[x]. If the carbon price continues to rise by $15 per year until 2035, the lifetime savings for an average Toronto home choosing to fully electrify their home will amount to $11,927 instead of $10,320.

[7] Assumes 20% higher upfront cost for a larger cold climate heat pump system.

Installation date

Lifetime savings increase over time largely due to the increased carbon costs, but a homeowner whose furnace is approaching its end of life now is still better off switching to heat pumps. A 2025 installation date for heat pumps for space and water heating gives a lifetime savings of $12,007 compared to conventional systems.

New gas communities

The Government of Ontario is supporting the expansion of Enbridge's system to bring methane gas to communities that do not currently have gas service (e.g., Selwyn). The cost of expanding the gas system to serve new communities is being paid for by a $12 a year surcharge on the gas rates of Enbridge's 3.6 million existing residential customers and by a $0.23 per cubic metre surcharge on the rates of the gas customers in the new gas communities. These potential new customers would be wise to opt for electric heat pumps for space and water heating instead, as the average lifetime savings relative to conventional gas systems amount to $20,014.

In gas expansion communities, average lifetime savings relative to conventional gas systems amount to

$20,014

Figure 3 | Lifetime savings from space and water heating electrification scenarios

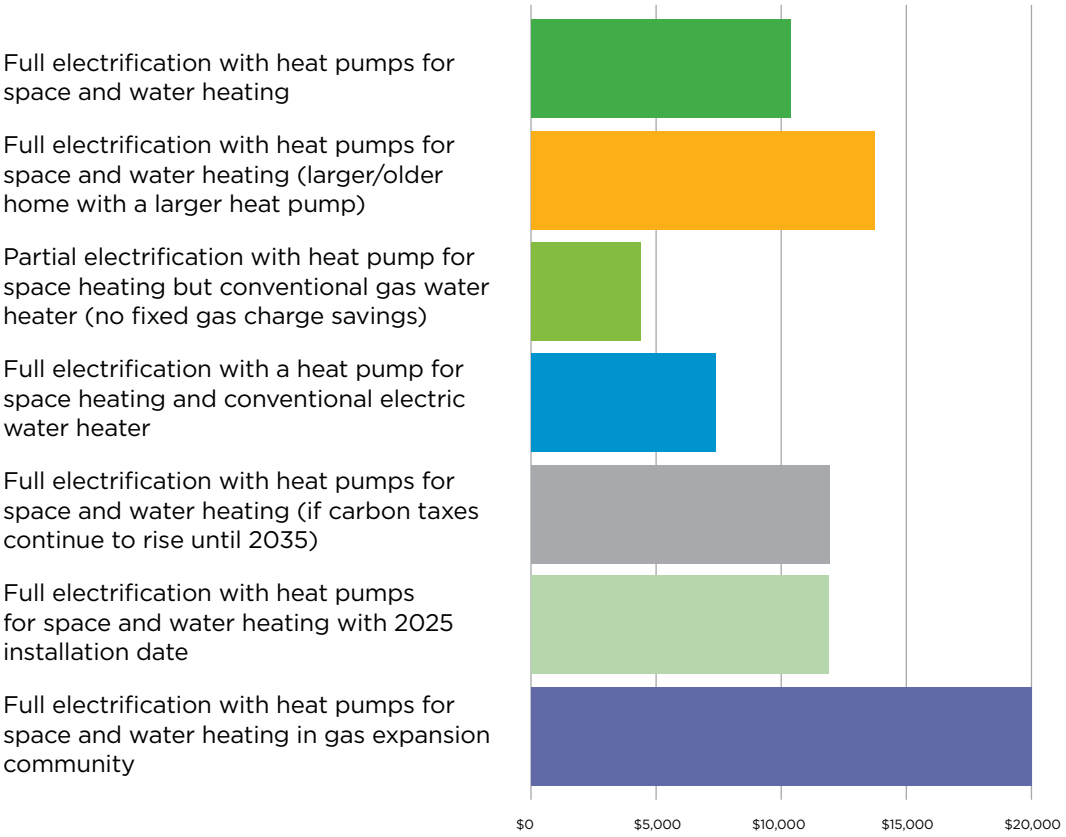


Figure 3 note: (1) Savings based on an average Toronto home unless otherwise stated, (2) assumed installation date in 2022 [savings increase as the carbon tax increases until 2030], (3) full electrification refers to a home being able to disconnect from the gas supply system, (4) all scenarios assume receipt of the $5,000 Greener Homes Grant.

Homeowners under all modeled conditions save money by shifting to electric heat pumps when their furnace is at the end of its life. Furthermore, these lifetime savings are significant and can compensate for other factors that might reduce the cost-competitiveness of electric heat pumps: different home heating requirements, different utility rates, higher upfront costs for heat pumps, and other factors.

Homeowners under all modeled conditions save money by shifting to electric heat pumps when their furnace is at the end of its life

Further considerations

A homeowner considering switching to electric heat pumps to save money and to make meaningful contributions to addressing the climate crisis will benefit from planning that switch in advance. For older homes, investing in energy efficiency upgrades and air sealing can save on heating and cooling costs from day one while reducing the size of heat pump ultimately needed to heat and cool a home. Shifting other equipment, such as stoves, barbeques, fireplaces and driers[8] off methane gas makes it easier to disconnect from the gas pipeline system when the heat pumps are installed thereby saving hundreds of dollars a year by avoiding Enbridge's fixed monthly customer charges. Those fixed charges cover gas distribution pipelines across the province that you no longer need to pay for. Upgrading an electrical panel is a good forward-thinking investment to accommodate a future heat pump and EV charger and may be more cost effective when arranged in advance rather than an urgent upgrade when a furnace dies (the average cost of upgrading an electrical panel is included in the upfront cost of an air source heat pump in this analysis).

As with all major purchases, it is advisable to get multiple quotes and evaluate the economic implications given all factors in a home before investing in heat pumps. While many in the HVAC industry offer cold climate air source heat pumps and heat pump water heaters, there are also many who remain ignorant of the capabilities of modern units and their cost-effectiveness, so it is wise to shop around.

Some homeowners may be concerned about the global warming potential of leaked refrigerants used in air conditioning and heat pump systems. Yet the climate change impact of such leaks are less than the impacts of behind the meter methane leaks in homes that use methane gas[xi]. This concern is also expected to decrease with time as better low global warming potential refrigerants are phased in due to the Kigali Agreement to the Montreal Protocol.

Finally, it is worth asking insurance providers if insurance premiums can be lowered when the electrified home is disconnected from the gas supply.

[8] Electric heat pump driers are now commercially available, and growing evidence of the health hazards of cooking with gas is also driving appliance electrification.

Conclusions

Homeowners in Ontario's existing gas communities can realize an average $10,320 in lifetime savings by switching to electric heat pumps for space and water heating when their gas furnace reaches the end of life. An average homeowner in a new gas community can save $20,014 by installing a heat pump instead of a gas furnace and water heater. Modern air source heat pumps for space heating and cooling plus heat pump water heaters can have average efficiencies of 300% or more and have proven to be reliable even in Ontario's colder climates. Their performance and upfront costs are expected to improve over time as the technology continues to evolve and economies of scale are realized. A switch to all electric heat pumps also reduces the home's greenhouse gas pollution from space heating and cooling plus water heating by 35% with Ontario's current grid mix and by 100% once we achieve a zero-carbon electricity grid.

Homeowners in Ontario can realize an average

$10,320

in lifetime savings by switching to electric heat pumps when their gas furnace reaches the end of life

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Notes

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THE ONTARIO CLEAN AIR ALLIANCE, established in 1997, successfully led the campaign to phase-out dirty coal power in Ontario. We are now working to move our province towards a 100% renewable energy future.

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