IESO Demand & Conservation Planning Technical Paper: Space Heating

Insights on space heating electrification and its implications on Ontario electricity system planning

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1. Executive Summary

As the operator and planner of Ontario's electricity system, one of the IESO's main roles in the electricity sector is to plan and prepare for future needs. A significant function of this work is demand forecasting, which projects demand into the future based on available information and data. Forward-looking analyses of this nature naturally come with uncertainties, owing to anticipated developments that have not yet happened, or may not necessarily occur at all.

With electricity demand in Ontario forecast to increase by 75 per cent by 2050, the IESO anticipates growth at great speed and scale, driven in large part by electrification, and specific commercial and industrial sector development. To ensure electricity procurements and energy policy are aligned with system needs, it's crucial that the IESO enhances its understanding of the underlying factors of this growth to minimize forecast uncertainties and optimize value to the system over the long-term planning horizon.

Looking ahead, the aggregated assessment of these inherent uncertainties with new load development will inform an Ontario demand growth margin, a new forecasting measure to provide a stable growth signal for the province to manage the uncertainty over the next few years, while also providing clarity for electricity planning purposes. In the meantime, the IESO has published a series of technical research papers that examine underlying trends in specific sectors or use cases that will drive demand growth in the long term.

This technical paper takes a deeper look at the electrification of space heating, namely through the adoption of heat pumps, and provides insight on what would be required to fully electrify Ontario's space heating needs and their implications on power system planning. Some of the challenges in forecasting the long-term adoption and load profiles of heat pumps include inconsistent, unavailable and/or unusable data on heat pump uptake and operation; variability of backup heating systems' designs and operation; unclear replacement path for the commercial and industrial sectors; government policies; and ongoing changes to the Ontario Building Code. This analysis then concludes with an outline of actions the IESO is taking to address some of the uncertainties under discussion, including leveraging opportunities to collect more data to better inform and model forecasting scenarios around the adoption and operation of heat pumps.

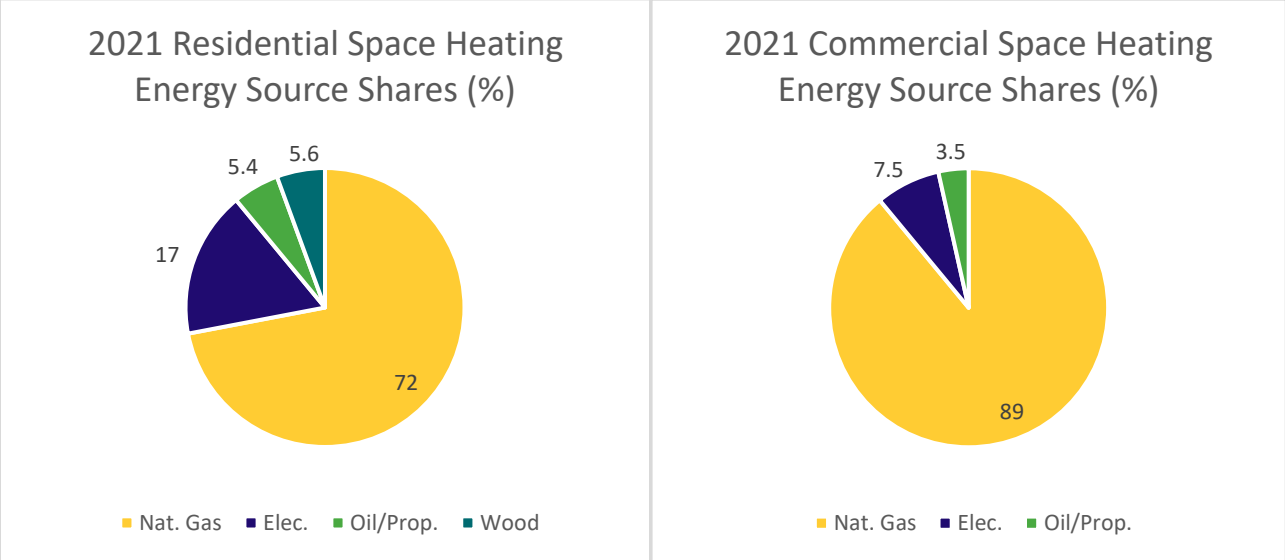
This paper was drafted prior to the repeal of the federal carbon tax, which may slow heat pump adoption rates.

2. Introduction

The purpose of this technical paper is to provide insight on electrifying Ontario's space heating needs and its implications on power system planning.

In Ontario, space heating systems are dominated by fossil fuel sources. Natural gas represents 72%[1] and 89%[2] of space heating energy source shares for residential households and commercial facilities, respectively.

Figure 1. Space Heating Energy Source Shares



Given that space heating energy use represents approximately 60% of the total energy use for both residential and commercial sector, electrifying this end-use will greatly add to electricity demand in Ontario, leading to increasing needs for electricity generation, transmission, and distribution systems expansion.

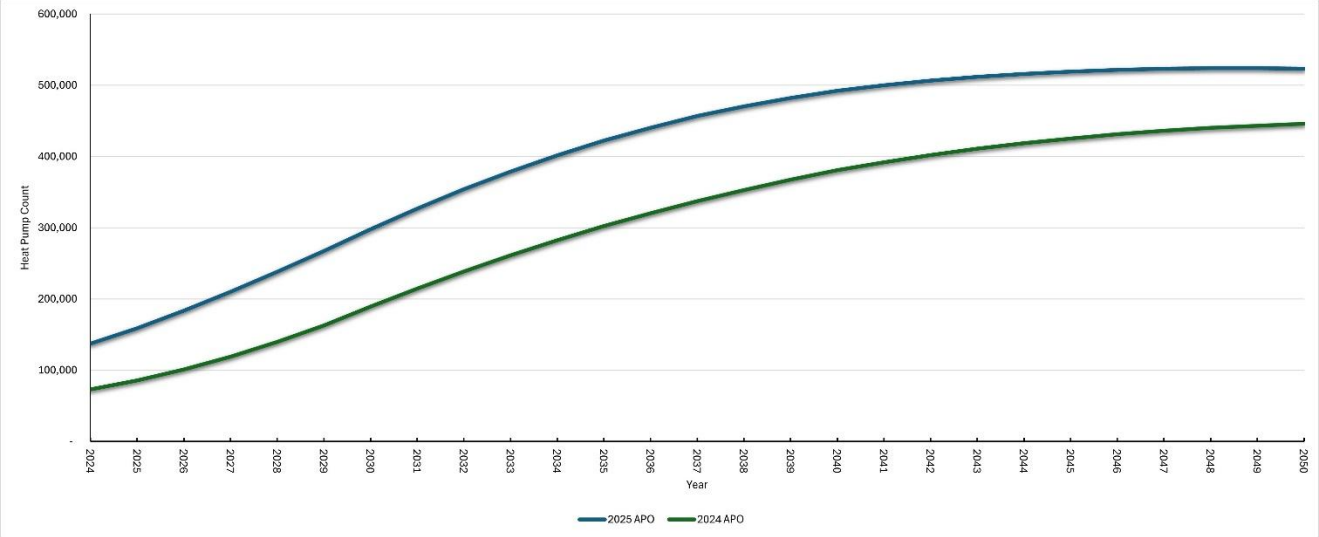
The main space heating technology for electrification will be the heat pump. Heat pumps are more energy efficient and use less electricity to heat homes when compared with electrical resistance heating. Heat pumps simply transfer available heat energy from one source (air source, water source, ground source) to inside the home. They can also function in reverse operation in the summer and provide cooling for the home. Depending on the heat pump's heating capacity, heating system design and the location of the home, a backup heating system (electric resistance heating, fossil fuel fired heating, wood fired heating) may be required. Heat pumps are also expected to emit less greenhouse gases when compared to fossil fuel fired heating systems.

In the 2024 Annual Planning Outlook (APO), approximately 445,000 heat pumps were projected for 2050, which represents 5.5% of all households. This growth was driven by the Toronto Green

[1] https://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/showTable.cfm?type=CP&sector=res&juris=on&year=2021&rn=5&page=0
[2] https://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/showTable.cfm?type=CP&sector=com&juris=on&year=2021&rn=24&page=0

Standard (TGS), a municipal green building standard for new construction with mandatory minimum thermal energy demand intensity and greenhouse gas emission intensity that may require the use of heat pumps to meet. The 2025 APO projects 523,000 heat pumps by 2050, which represents approximately 7.6% of all households. For the 2025 APO, heat pump growth is driven by: residential new construction in the city of Toronto required by the Toronto Green Standard; and customer preferences which are based on operating costs and voluntary decarbonization. Since space heating is typically more economical (lower upfront cost) with natural gas, it is expected that majority of households will still choose natural gas fired heating systems unless government policies require otherwise.

Figure 2. Heat Pump Projection 2024 APO vs 2025 APO



For contrast, the demand forecast produced for the 2022 Pathways to Decarbonization report, which considered a high electrification scenario, forecasted 6.25 million heat pump units by 2050. This represents the maximum potential for heat pump adoption assuming every household to be electrically heated via heat pump and does not undertake a cost-optimization exercise comparing different decarbonization options on the demand side.

Even though heat pumps are expected to consume less energy than electric resistive heating there are many aspects of its implementation that make it difficult to assess the impact to the electricity system.

3. Uncertainties

The following are factors contributing to uncertainties for forecasting heat pump consumption in the long-term demand forecast.

3.1 Heat Pump Adoption

3.1.1 For the residential sector

1. Uncertainty on the number of heat pumps currently installed, based on currently available data.
2. Lack of available heat pump uptake data from NRCAN's Greener Homes Program.
3. Lack of publicly available data representing the breakdown of heat pump types installed. (regular heat pump vs cold climate heat pumps, air sources vs air to water vs ground source).
4. The emergence of ground source heat pumps as an energy service. There are several companies (Enbridge Sustain, Enwave, Subterra, Diverso Energy and Creative Energy) offering to install / maintain / operate geothermal ground loops with no upfront costs and a monthly service fee to residential and commercial customers. Their portfolio is small, currently focused on new construction but will expand to include retrofits of existing buildings as well.

3.1.2 For the commercial/industrial sector

While Statcan and NRCAN publish data on heat pump adoption in the residential sector, data is not available on the commercial or industrial sector.

3.2 Heat pump operation

3.2.1 Load profiles

1. There's uncertainty on the applicability of IESO's current heat pump load profiles since they rely on American data that may have different temperature, building mix, and occupancy assumptions as compared to Ontario data.
2. There's a lack of Ontario specific heat pump load profiles due to limited data availability.

3.2.2 Backup heating operation

There's uncertainty on the backup heating system's size, fuel source and how it is controlled; all of which will affect the system's electricity consumption. For example, the backup heating system can be an electric source or a fossil fuel source, it can be designed to substitute or supplement the heat pump system and depending on the heating capacity of the heat pump the backup system can operate based on vastly different outdoor air temperatures. Due to the variability of the backup heating system's design and operation it creates uncertainties in forecasting its electricity consumption. It is assumed that the heat pump meets 100% of heating needs without backup, due to the limitations of the current forecasting tool.

3.3 Unclear replacement path

3.3.1 Commercial/Industrial sector

For large commercial or industrial facilities that are heated with complicated fossil fuel heating systems, there is no direct heat pump replacement that can provide the same temperature output without significant redesign of the existing heating system.

3.4 Government Policies

3.4.1 Fuel Prices / Carbon tax

Carbon pricing and fuel prices[3] could impact consumer decisions on whether to electrify space heating. Accordingly, the impact of space heating on electricity demand could vary depending on whether and when consumers decide to fuel switch in order to avoid carbon costs.

3.4.2 Codes & Standards

The Ontario Building Code (OBC) was updated in April 2024; however, the energy performance in the updated OBC remains unchanged. Several municipalities have implemented green building standards which sets minimum energy performance and greenhouse gas emissions requirements for new construction. However, except for the Toronto Green Standard, none have plans to implement mandatory performance requirements that may require heat pumps.

[3] https://www.ieso.ca/-/media/Files/IESO/Document-Library/planning-forecasts/apo/Mar2024/Fuel-Cost.xlsx

3.4.3 Grants & Incentives

The federal government announced to renew the Greener Homes Program with $903.5 million in funding in the 2024 Budget. However, participation data from the Greener Homes program for heat pump uptake is not available.

3.4.4 Pilot programs

There are several pilot programs studying heat pump operation.

Pilot Name	Organization	Results
Pumping Energy Savings Phase II: Demonstration and Scale-up Strategy	Toronto Atmospheric Fund / IESO Grid Innovation Fund	The heat pumps were sub metered but the profiles were not suitable as many HP appear to be oversized (short cycling). The existing baseboards were not sub-metered, so their operations were unknown.
Hydro One Networks, Inc. Air-Source Heat Pump Advantage Pilot Evaluation	Hydro One / IESO	120 heat pumps installed. No sub-metering of the heat pump consumption. Savings were analysed through billing data.
London Residential Smart Hybrid Heating Pilot	London Hydro / Enbridge	105 hybrid heat pump system with gas furnaces were installed in London, Ontario. Only 8 homes were selected for Measurement &Verification (M&V). Both electricity and gas consumption were sub-metered. Results were promising as the hybrid heat pump demonstrated utility cost savings (avg. $165 per year), carbon emissions reduction (avg. 40%) and peak demand savings (avg. 2%). It would be useful to see the sub- metered electricity consumption data, to investigate if a load profile could be developed

The provincial government established the Electrification and Energy Transition Panel (EETP) that released the Ontario's Clean Energy Opportunity report in December 2023. The report recommends that IESO and Enbridge coordinate in bulk planning and regional planning activities as customers look to switch from fossil fuel sources to non-fossil fuel sources to meet their needs. The report also

recommends coordination between natural gas and electricity demand side management (DSM) programs to optimize savings. Currently, the IESO and Enbridge has already begun sharing some data and assumptions in demand forecasts; IESO's Save On Energy programs and Enbridge have collaborated in several DSM program deliveries to streamline the application process.

The provincial government has released *Ontario's Affordable Energy Future: The Pressing Case for More Power* which outlines the government's vision for the energy sector. It highlights that integrated planning and coordination between IESO, electricity and natural gas utilities will be required.

4. Conclusion and Takeaways

4.1 Conclusion

The following steps have been taken by the IESO to address some of the uncertainties of forecasting heat pump demand:

1. As more customers look to electrify their space heating needs, the grid will become more sensitive to temperature changes in the winter. A new long-term demand forecasting tool is currently being developed with the ability to analyze the impacts of climate change on weather sensitive end-uses such as heating, cooling and refrigeration. The new tool will come with new load profiles; and for weather sensitive loads, the load shape can be altered based on weather inputs. Specifically for heat pumps, the new tool can also estimate the electricity use of the back-up heating resource. The new forecasting tool will allow the IESO to more accurately predict the future electricity demands from heat pumps and other weather sensitive loads.
2. On-going Enbridge collaboration
   The IESO is working with Enbridge to get access to the metered data from the London Residential Smart Hybrid Heating pilot. The metered consumption data will provide valuable insight on the operation of a hybrid system such as the developing new load profiles and predicting gas / electric switch-over operation.

   The IESO is also working with Resource Innovation consultants in collaboration with Enbridge to develop a new comprehensive heat pump model and tool. The new heat pump model and tool include additional weather files accounting for 12 major population centers in each IESO zone, all base case fuel types (electric, oil, propane and natural gas) and different heat pump technologies (air source, ground source, and hybrid) with either gas or electric back-up heating systems. The collaborative work with Enbridge will harmonize heat pump savings from DSM programs and improve the overall long-term forecast.
3. The IESO has also introduced new heat pump incentives through the Save on Energy program for homeowners with an existing electric primary heating system. The new offerings are part of the 2025-2036 Electricity Demand Management Framework administered by the IESO to provide $10.9 billion of funding over 12 years to help residential and business electricity customers manage their electricity consumptions and costs. The new incentive programs will provide the IESO with greater insights into heat pump adoption numbers and when the programs get evaluated it may provide sub-metered data that can be used to inform new load profiles.

4. The IESO is planning to undertake a behavioural and pricing sensitives study to refine heat pump adoption scenarios in residential dwellings. The study will provide insights into the barrier and motivations, and the degree to which cost factors into consumers decision to adopt heat pump as a primary heating system. The study will also help the IESO predict the effect of DSM rebates on consumer decisions to adopt heat pumps.

5. With the release of *Ontario's Affordable Energy Future: The Pressing Case for More Power*, the IESO expects further collaboration and coordination with electricity and natural gas utilities; the sharing of data and assumptions would greatly improve the electricity demand forecast from space heating needs.

4.2 Takeaways

With space heating energy use representing approximately 60% of the total energy use for both residential and commercial sector, electrifying this end-use will prove quite challenging for power system planners. Heat pumps are identified as the main space heating technology used in electrification.

Heat pumps are expected to consume less energy than the traditional resistive electric heating systems, but the following factors have been identified to contribute to forecast uncertainties in the long-term demand forecast:

1. Heat pump adoption
2. Variability in heat pump operation
3. Unclear replacement path
4. Government policies

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