

ONTARIO ENERGY BOARD

EB-2020-0293

IN THE MATTER OF the *Ontario Energy Board Act*, 1998, S. O. 1998, c. 15, Schedule B;

AND IN THE MATTER OF an application for leave to construct natural gas pipeline and associated facilities in the City of Ottawa.

Environmental Defence Compendium – Volume 1

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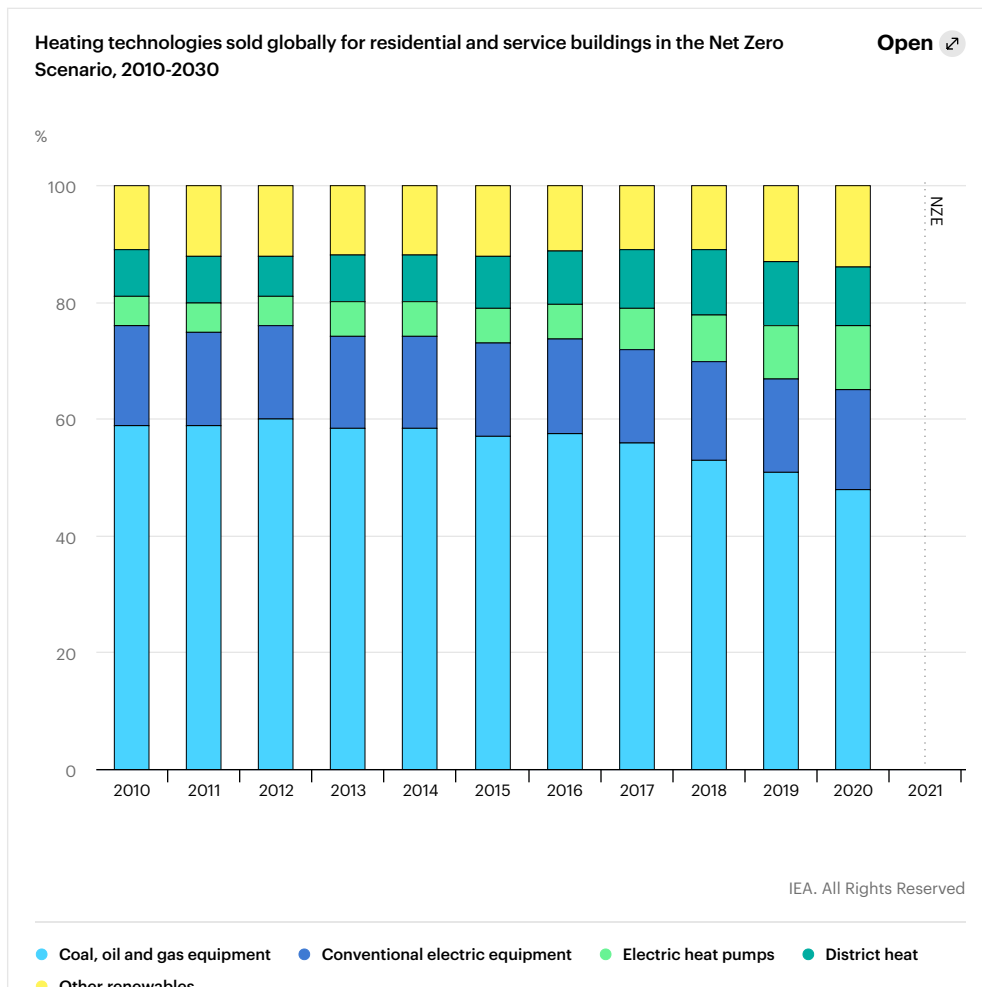
1. International Energy Agency, *Heating Analysis*
2. Natural Resources Canada, *Heating and Cooling With a Heat Pump*
3. Materials re Electric Thermal Storage
4. Regulation 1412-2021
5. EB-2016-0201, OEB Staff Paper, p. 43



In this report

After years of slow but steady decline, the share of coal, oil and natural gas boilers in global heating equipment sales

Nevertheless, in the Net Zero Emissions by 2050 Scenario, the share of heat pumps, low-carbon district heating and



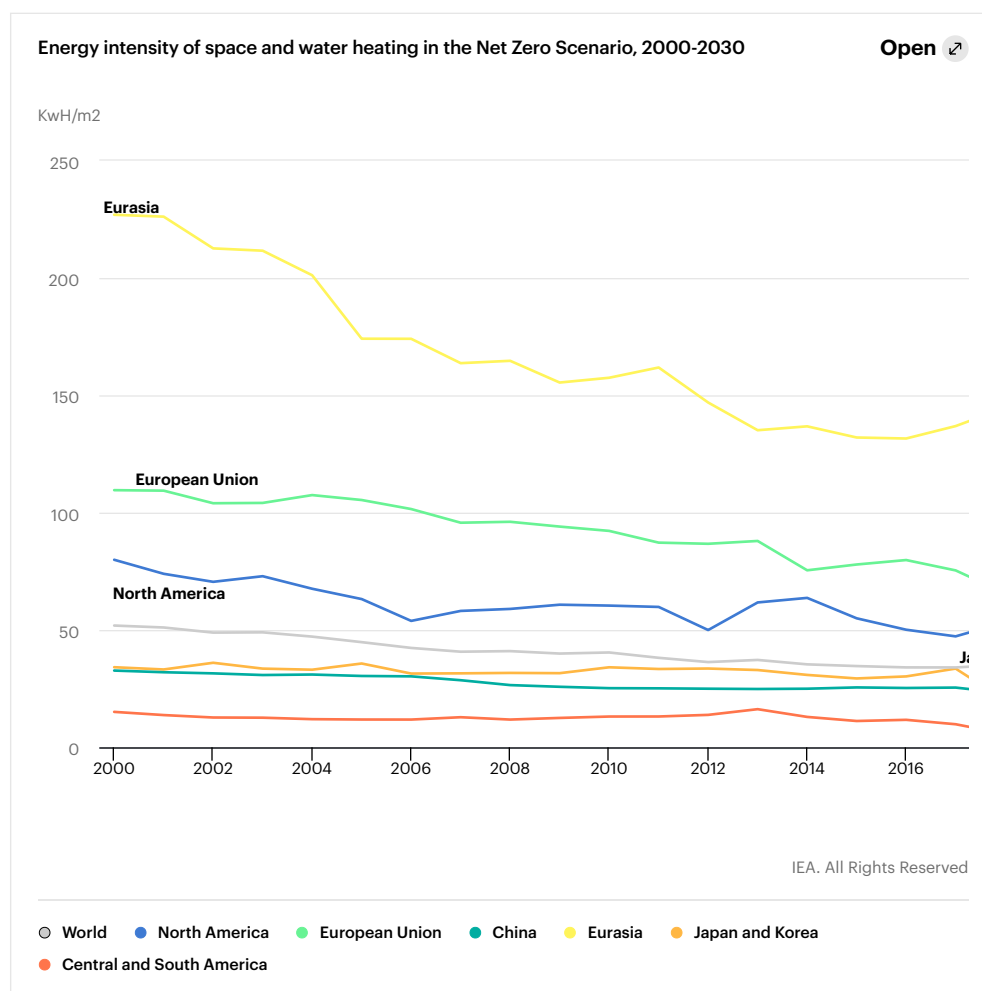
Tracking progress

Energy efficiency progress falls short of necessary savings

Energy use for space and water heating has remained stable since 2010, with heating energy intensities (i.e. final energy use per m²) decreasing by only 2% per year since 2010 – just enough to offset no more than floor area growth.

Most reductions in heating energy intensity have resulted from stricter building energy codes that have improved the energy performance of new constructions and reduced space heating demand, particularly in Canada, China, the European Union, Russia and the United States.

Meanwhile, shifts to heat pumps, which are typically 3-4 times more efficient than fossil fuel boilers, contributed to the average efficiency of heat provision rising from under 95% in 2010 to 120% in 2020.



Inefficient and fossil fuel-based equipment are finally being phased out

The dominance of fossil fuel-based heaters and water heaters is weakening, with their market share recently having fallen to less than 50%. Despite this positive development, however, new fossil fuel boilers and furnaces still jeopardise the achievement of net zero

emissions goals, as they are locking in additional CO₂ emissions that will be released during future operations (boiler manufacturers claim a product lifetime of 1520 years). The build-up of long-lived, hard-to-retrofit heating equipment must therefore cease as soon as possible, with fossil fuel-based heating solutions completely phased out by 2025 to achieve alignment with the Net Zero Emissions by 2050 Scenario.

The gradual replacement of conventional oil and gas boilers by condensing units (with efficiencies typically 90-95%) over the past decade has reduced boiler emissions by 10%. It is well insufficient to meet the Net Zero target.

Progress towards banning fossil fuel boilers is uneven across regions. Norway, Sweden and Finland have already forbidden oil boiler sales for the past decade, and some US states (e.g. [California](#)) and cities (e.g. [Seattle](#)) are also making higher-efficiency equipment the new norm by prohibiting the installation of fossil fuel boilers in new buildings. The United Kingdom is likely to follow suit with the release of its Heat and Building Strategy paper, and in many other countries, including, [France](#), Ireland and Austria, oil boilers will be banned in new buildings by 2025 or earlier.

The Net Zero Emissions by 2050 Scenario calls for a drastic shift to clean energy technologies

To be in line with the Net Zero Scenario, the share of clean energy technologies such as heat pumps, solar thermal heating, low-carbon district energy systems and biomass boilers, needs to exceed 80% of new heating equipment sales by 2030.

Alongside building envelope improvements, deployment of these low-carbon high-efficiency heating technologies would help reduce average global heating energy intensity by around 4% annually in the next decade. The combined effects of efficiency improvements, fuel-shifting and power sector decarbonisation would reduce buildings' heating-related emissions by over 50% by 2030.

Heat pumps are the fastest-spreading heating technology in the Net Zero Emissions by 2050 Scenario

180 million heat pumps in heating mode were in operation 2020, up from under 100 million in 2010. However, most of this growth is from higher sales of reversible units that can also provide air conditioning, which reflects rising cooling demand. Overall, heat pumps still meet no more than 7% of global heating needs in buildings. To be in line with the Net Zero Scenario, however, 600 million heat pumps need to provide 20% of global heat demand for buildings by 2030.

Fortunately, the future looks increasingly bright for heat pumps and renewable heating. Sales continued to grow in 2020 in most heating markets, owing to several fiscal and regulatory policies. For instance, through its Clean Winter Heating Programme, China laid out a plan for [“2+26” key cities and districts](#) to achieve clean heating services for 90% of demand by 2019 and 100% by 2021. Meanwhile, heat pump sales have continued to accelerate in Europe, where installations jumped by more than 7% in 2020 relative to 2019. On the other side of the Atlantic, [British Columbia's](#) low-interest loan for shifting from fossil fuel boilers to heat pumps, [California's](#) new building energy code establishing electric heat pumps as the baseline technology, and [Massachusetts's](#) minimum performance level requirement for new buildings are all strengthening the heat pump market, particularly for new buildings.

Buildings need to reap the benefits of multiple renewable energy sources

Global total installed [solar thermal heat capacity](#) expanded from 230 GW_{th} in 2010 to ~500 GW_{th} in 2020. By comparison, installed solar PV accounts for 710 GW_{elec} and wind



capacity for 740 GW_{elec}.

Twenty-two countries, mostly in the Caribbean, the Middle East and sub-Saharan Africa, included using solar energy as part of their sustainable energy actions for heating and cooling in buildings. While 90% of the installed solar thermal systems are used for water heating in single- and multi-family homes, their application is beginning to broaden to industrial and district energy systems.

Another use of solar heat from PVT technology (solar panels coupling PV and thermal heat production) is now emerging, as installed capacity reaches 710 MW_{th} and 230 MW_{elec}, more than half of which is in Europe (including 39% of the global total in France).

Globally, however, solar thermal technology met less than 3% of space and water heating demand in 2020. This falls short of the double-digit average annual growth needed by 2030 under the Net Zero Emissions by 2050 Scenario to meet 5% of buildings sector heat demand. As solar systems are already cost-competitive with very low-level fossil fuel-based heat in many places, awareness-raising and capacity-building will be keys to deployment.

The use of modern and efficient bioenergy for heat in buildings also remains off track, with little uptake of high-efficiency biomass boilers and stoves outside of Europe and North America, where policy support is available.

District energy system decarbonisation and expansion are needed

District heating systems meet less than 10% of heat demand in buildings globally, but this share is much higher in countries such as China (~15%), Russia (~45%) and Denmark (~50%). The number of new connections overall has increased 3.5% per year since 2010, owing particularly to China's extensive network.

Significant effort is still needed to reduce the carbon intensity of district heating, which has remained relatively constant across the globe in recent years. China's reliance on coal makes heat production particularly carbon-intensive, releasing around 350 gCO₂/kWh. Greater policy attention to air pollution in China (e.g. through the recovery of excess industrial heat) promises to reduce the energy and carbon intensity of district heating.

The share of renewable energy sources in European district energy systems increased in recent years, for example in Denmark, Finland, France, Latvia and Lithuania. The carbon intensity of district heat production is typically 150 to 300 gCO₂/kWh, and decarbonisation efforts currently focus on existing networks and on developing fourth- and fifth-generation low-temperature networks. These highly efficient networks allow for greater integration of renewable energy sources and locally available waste heat.

The solar district heating market is dynamic, and in addition to Denmark, several other countries in Europe and Asia are promoting system development. Synergies with solar power systems are also being explored, including for instance [in the UK](#).

Cities and districts are in a position to lead the energy transition, often setting more ambitious targets than their national counterparts, as district energy networks provide the infrastructure for greater energy security and renewable energy integration.

Hydrogen-based solutions are being explored

Hydrogen is scarcely used in the global buildings sector, although low-carbon hydrogen-based solutions are being tested. A number of challenges, including efficiency losses relative to other low-carbon alternatives, safety considerations, the cost of grid retrofits, and zero-carbon hydrogen production capacity still need to be investigated.

In Japan, the number of ENE-FARM hydrogen-ready fuel cells deployed annually remains steady, with a cumulative 350 000 units installed at the end of March 2021.

In Europe, the ene.field demonstration, launched in 2012, has installed more than 1 000 small stationary fuel-cell systems for residential and commercial buildings in ten countries.

Another project is the H21 demonstration in the United Kingdom, which will demonstrate the potential for direct hydrogen use to reduce the carbon intensity of heat demand using steam methane reformers with CCS.

The Sustainable Gas Institute of Imperial College London develops analyses to improve understanding of the role of gas in future low-carbon energy systems. In addition, the UK Hy4Heat project, which is also evaluating hydrogen potential for heating and covers all stages from appliance certification and quality standards to demonstration, is set to be launched in the second quarter of 2020.

Government-supported hydrogen-blending demonstration projects injecting low-carbon hydrogen into a local gas network are emerging in several cities, including Dunkirk (France) and Adelaide (Australia). The first injections, using a 6% hydrogen blend (by volume), were realised in June 2018, and further blends of up to 20% will be tested, depending on the price of renewable electricity.

Recommended actions

Governments play a key role in setting long-term market signals to direct industry and investor decisions towards sustainable equipment for buildings. On a global scale, fuel-pricing strategies (including taxes and subsidies) need to ensure market equality for all technologies; removing subsidies for fossil fuels is a first step.

In addition, many countries could build upon ongoing efforts to implement CO₂-based taxes. This could be done in Europe through the energy taxation directive, and the EU ETS could be adjusted to cover fossil fuels used in heating systems of less than 20 MW. Germany's scheme in particular covers all heat suppliers and distributors, with a fixed carbon price until 2025 and an auction-based price evaluation post-2025.

Ambitious commitments related to end-use equipment efficiency (e.g. MEPS), emissions (e.g. mandating a share of renewable energy in primary energy use for heat production for buildings) and flexibility (e.g. using smart-readiness labels and incentivising heat storage in water tanks and district energy networks) can take advantage of the synergies gained by using sustainable heating products to achieve multiple climate goals.

Make better use of traditional yet effective policy tools

At the very least, governments everywhere need to implement and update MEPS for heating equipment to steer markets towards clean-energy technologies. These could be technology-neutral (e.g. performance-based) to encourage product innovation and industry competitiveness.

As energy efficiency savings will generate long-term system cost reductions, governments could also promote clean-energy technologies by offering public subsidies for low-income households that may find it difficult to afford them.

For instance, Canada aims for the energy performance of all space heating technologies to be greater than 100%, but it has not specified which technology or fuel should be used to meet this goal.

Countries can also expand and improve labelling schemes for heating equipment (e.g. through energy labels) to increase consumer awareness of energy technology choices.

Informational tools could make use of the increasing quantity of building energy data available through digitalisation, as long as the underlying data management frameworks address data privacy and cyber-related issues.

In addition, governments could work together to improve monitoring, verification and enforcement of heating technologies, and collaborate with industry and trade associations to ensure proper equipment installation and maintenance.

As cities are at the heart of the decarbonisation challenge, effective multi-level governance, including vertical integration and horizontal co-operation with various stakeholders, is required to ensure the alignment of local and national policies. District heating and cooling in particular should be an integral part of building renovation strategies in urban environments.

Dare to implement ambitious and innovative policies

Standards and labelling work best when they are part of a wider market transformation strategy. For example, rebates and procurement policies can be employed at different points of the value chain to support energy-efficient technology deployment.

Regulators can also set performance standards or targets that are more stringent than the minimum lifecycle cost (which is common practice) and apply more ambitious requirements, including technology-forcing standards that could stimulate further innovation of clean energy solutions for heating.

To put heating in line with the Net Zero Emissions by 2050 Scenario, policies should set ambitious targets, followed by rigorous performance standards to introduce a larger proportion of high-efficiency low-carbon equipment into the market alongside the phase-out of fossil fuel boilers and furnaces. This is especially important given the long lifespans of many heating technologies (for example, some gas boiler installations are guaranteed for 25 years).

Policies, including innovative business models proposed by energy service companies, need to address the upfront costs of clean, energy-efficient products. Innovative instruments also include guarantees of origin for renewables-based heat as a source of additional revenue for operators.

National and regional accounting rules also strongly influence the attractiveness of energy service delivery models, so allowing companies to record buildings sector assets off their balance sheets could significantly reduce their net debt.

Resources and links

The HPT TCP is a non-profit organisation that aims to accelerate the implementation of heat pump technologies, including for air conditioning and refrigeration, especially when they can reduce energy consumption and increase the use of renewal energy sources for the benefit of the environment.

IEA Heat Pumping Technologies Technology Collaboration Programme [▶](#)

Acknowledgements

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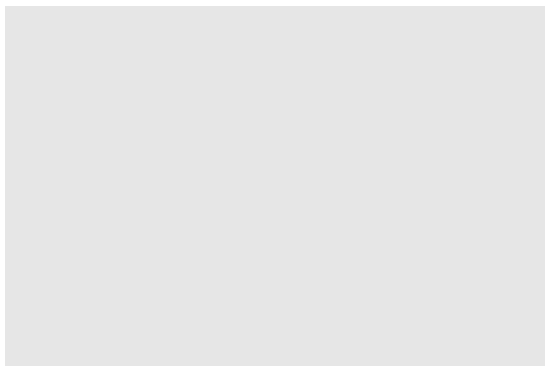


By Thibaut Abergel and Chiara Delmastro
13 December 2020

Flagship report

Net Zero by 2050

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Heating and Cooling With a Heat Pump

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Introduction

If you are exploring options to heat and cool your home or reduce your energy bills, you might want to consider a heat pump system. Heat pumps are a proven and reliable technology in Canada, capable of providing year-round comfort control for your home by supplying heat in the winter, cooling in the summer, and in some cases, heating hot water for your home.

Heat pumps can be an excellent choice in a variety of applications, and for both new homes and retrofits of existing heating and cooling systems. They are also an option when replacing existing air conditioning systems, as the incremental cost to move from a cooling-only system to a heat pump is often quite low. Given the wealth of different system types and options, it can often be difficult to determine if a heat pump is the right option for your home.

If you are considering a heat pump, you likely have a number of questions, including:

- What types of heat pumps are available?
- How much of my annual heating and cooling needs can a heat pump provide?
- What size of heat pump do I need for my home and application?
- How much do heat pumps cost compared with other systems, and how much could I save on my energy bill?
- Will I need to make additional modifications to my home?
- How much servicing will the system require?

This booklet provides important facts on heat pumps to help you be more informed, supporting you to make the right choice for your home. Using these questions as a guide, this booklet describes the most common types of heat pumps, and discusses the factors involved in choosing, installing, operating, and maintaining a heat pump.

Intended Audience

This booklet is intended for homeowners looking for background information on heat pump technologies in order to support informed decision making regarding system selection and integration, operation and maintenance. The information provided here is general, and specific details may vary depending on your installation and system type. This booklet should not replace working with a contractor or energy advisor, who will ensure that your installation meets your needs and desired objectives.

A Note on Energy Management in the Home

Heat pumps are very efficient heating and cooling systems and can significantly reduce your energy costs. In thinking of the home as a system, it is recommended that heat losses from your home be minimized from areas such as air leakage (through cracks, holes), poorly insulated walls, ceilings, windows and doors.

Tackling these issues first can allow you to use a smaller heat pump size, thereby reducing heat pump equipment costs and allowing your system to operate more efficiently.

A number of publications explaining how to do this are available from Natural Resources Canada.

What Is a Heat Pump, and How Does It Work?

Heat pumps are a proven technology that have been used for decades, both in Canada and globally, to efficiently provide heating, cooling, and in some cases, hot water to buildings. In fact, it is likely that you interact with heat pump technology on a daily basis: refrigerators and air conditioners operate using the same principles and technology. This section presents the basics of how a heat pump works, and introduces different system types.

Heat Pump Basic Concepts

A heat pump is an electrically driven device that extracts heat from a low temperature place (a **source**), and delivers it to a higher temperature place (a **sink**).

To understand this process, think about a bicycle ride over a hill: No effort is required to go from the top of the hill to the bottom, as the bike and rider will move naturally from a high place to a lower one. However, going up the hill requires a lot more work, as the bike is moving against the natural direction of motion.

In a similar manner, heat naturally flows from places with higher temperature to locations with lower temperatures (e.g., in the winter, heat from inside the building is lost to the outside). A heat pump uses additional electrical energy to counter the natural flow of heat, and *pump* the energy available in a colder place to a warmer one.

So how does a heat pump heat or cool your home? As energy is extracted from a **source**, the temperature of the source is reduced. If the home is used as the source, thermal energy will be removed, *cooling* this space. This is how a heat pump operates in cooling mode, and is the same principle used by air conditioners and refrigerators. Similarly, as energy is added to a **sink**, its temperature increases. If the home is used as a sink, thermal energy will be added, heating the space. A heat pump is fully reversible, meaning that it can both heat and cool your home, providing year-round comfort.

Sources and Sinks for Heat Pumps

Selecting the source and sink for your heat pump system goes a long way in determining the performance, capital costs and operating costs of your system. This section provides a brief overview of common sources and sinks for residential applications in Canada.

Sources: Two sources of thermal energy are most commonly used for heating homes with heat pumps in Canada:

- **Air-Source:** The heat pump draws heat from the outside air during the heating season and rejects heat outside during the summer cooling season.

It may be surprising to know that even when outdoor temperatures are cold, a good deal of energy is still available that can be extracted and delivered to the building. For example, the heat content of air at -18°C equates to 85% of the heat contained at 21°C . This allows the heat pump to provide a good deal of heating, even during colder weather.

Air-source systems are the most common on the Canadian market, with over 700,000 installed units across Canada.

This type of system is discussed in more detail in the *Air-Source Heat Pumps* section.

- **Ground-Source:** A ground-source heat pump uses the earth, ground water, or both as the source of heat in the winter, and as a reservoir to reject heat removed from the home in the summer.

These heat pumps are less common than air-source units, but are becoming more widely used in all provinces of Canada. Their primary advantage is that they are not subject to extreme temperature fluctuations, using the ground as a constant temperature source, resulting in the most energy efficient type of heat pump system.

This type of system is discussed in more detail in the *Ground-Source Heat Pumps* section.

Sinks: Two sinks for thermal energy are most commonly used for heating homes with heat pumps in Canada:

- Indoor air is heated by the heat pump. This can be done through:
 - A centrally ducted system or
 - A ductless indoor unit, such as a wall mounted unit.
- Water inside the building is heated. This water can then be used to serve terminal systems like radiators, a radiant floor, or fan coil units via a hydronic system.

An Introduction to Heat Pump Efficiency

Furnaces and boilers provide space heating by adding heat to the air through the combustion of a fuel such as natural gas or heating oil. While efficiencies have continually improved, they still remain below 100%, meaning that not all the available energy from combustion is used to heat the air.

Heat pumps operate on a different principle. The electricity input into the heat pump is used to *transfer* thermal energy between two locations. This allows the heat pump to operate more efficiently, with typical efficiencies well over 100%, i.e. *more* thermal energy is produced than the amount of electric energy used to pump it.

It is important to note that the efficiency of the heat pump depends greatly on the temperatures of the **source** and **sink**. Just like a steeper hill requires more effort to climb on a bike, greater temperature differences between the source and sink of the heat pump require it to work harder, and can reduce efficiency. Determining the right size of heat pump to maximize seasonal efficiencies is critical. These aspects are discussed in more detail in the *Air-Source Heat Pumps* and *Ground-Source Heat Pumps* sections.

Efficiency Terminology

A variety of efficiency metrics are used in manufacturer catalogues, which can make understanding system performance somewhat confusing for a first time buyer. Below is a breakdown of some commonly used efficiency terms:

Steady-State Metrics: These measures describe heat pump efficiency in a ‘steady-state,’ i.e., without real-life fluctuations in season and temperature. As such, their value can change significantly as source and sink temperatures, and other operational parameters, change. Steady state metrics include:

Coefficient of Performance (COP): The COP is a ratio between the rate at which the heat pump transfers thermal energy (in kW), and the amount of electrical power required to do the pumping (in kW). For example, if a heat pump used 1kW of electrical energy to transfer 3 kW of heat, the COP would be 3.

Energy Efficiency Ratio (EER): The EER is similar to the COP, and describes the steady-state cooling efficiency of a heat pump. It is determined by dividing the cooling capacity of the heat pump in Btu/h by the electrical energy input in Watts (W) at a specific temperature. EER is strictly associated with describing the steady-state cooling efficiency, unlike COP which can be used to express the efficiency of a heat pump in heating as well as cooling.

Seasonal Performance Metrics: These measures are designed to give a better estimate of performance over a heating or cooling season, by incorporating “real life” variations in temperatures across the season.

Seasonal metrics include:

Heating Seasonal Performance Factor (HSPF): HSPF is a ratio of how much energy the heat pump delivers to the building over the full heating season (in Btu), to the total energy (in Watthours) it uses over the same period.

Weather data characteristics of long-term climate conditions are used to represent the heating season in calculating the HSPF. However, this calculation is typically limited to a single region, and may not fully represent performance across Canada. Some manufacturers can provide an HSPF for another climate region upon request; however typically HSPFs are reported for Region 4, representing climates similar to the Midwestern US. Region 5 would cover most of the southern half of the provinces in Canada, from the B.C interior through New Brunswick ¹.

Seasonal Energy Efficiency Ratio (SEER): SEER measures the cooling efficiency of the heat pump over the entire cooling season. It is determined by dividing the total cooling provided over the cooling season (in Btu) by the total energy used by the heat pump during that time (in Watt-hours). The SEER is based on a climate with an average summer temperature of 28°C.

Important Terminology for Heat Pump Systems

Here are some common terms you may come across while investigating heat pumps.

Heat Pump System Components

The **refrigerant** is the fluid that circulates through the heat pump, alternately absorbing, transporting and releasing heat. Depending on its location, the fluid may be liquid, gaseous, or a gas/vapour mixture

The **reversing valve** controls the direction of flow of the refrigerant in the heat pump and changes the heat pump from heating to cooling mode or vice versa.

A **coil** is a loop, or loops, of tubing where heat transfer between the source/sink and refrigerant takes place. The tubing may have fins to increase the surface area available for heat exchange.

The **evaporator** is a coil in which the refrigerant absorbs heat from its surroundings and boils to become a low-temperature vapour. As the refrigerant passes from the reversing valve to the compressor, the accumulator collects any excess liquid that did not vaporize into a gas. Not all heat pumps, however, have an accumulator.

The **compressor** squeezes the molecules of the refrigerant gas together, increasing the temperature of the refrigerant. This device helps to transfer thermal energy between the source and sink.

The **condenser** is a coil in which the refrigerant gives off heat to its surroundings and becomes a liquid.

The **expansion** device lowers the pressure created by the compressor. This causes the temperature to drop, and the refrigerant becomes a low-temperature vapour/liquid mixture.

The **outdoor unit** is where heat is transferred to/from the outdoor air in an air-source heat pump. This unit generally contains a heat exchanger coil, the compressor, and the expansion valve. It looks and operates in the same manner as the outdoor portion of an air-conditioner.

The **indoor coil** is where heat is transferred to/from indoor air in certain types of air-source heat pumps. Generally, the indoor unit contains a heat exchanger coil, and may also include an additional fan to circulate heated or cooled air to the occupied space.

The **plenum**, only seen in ducted installations, is part of the air distribution network. The plenum is an air compartment that forms part of the system for distributing heated or cooled air through the house. It is generally a large compartment immediately above or around the heat exchanger.

Other Terms

Units of measurement for capacity, or power use:

A Btu/h, or British thermal unit per hour, is a unit used to measure the heat output of a heating system. One Btu is the amount of heat energy given off by a typical birthday candle. If this heat energy were released over the course of one hour, it would be the equivalent of one Btu/h.

A **kW**, or **kilowatt**, is equal to 1000 watts. This is the amount of power required by ten 100-watt light bulbs.

A **ton** is a measure of heat pump capacity. It is equivalent to 3.5 kW or 12 000 Btu/h.

Air-Source Heat Pumps

Air-source heat pumps use the outdoor air as a source of thermal energy in heating mode, and as a sink to reject energy when in cooling mode. These types of systems can generally be classified into two categories:

Air-Air Heat Pumps. These units heat or cool the air inside your home, and represent the vast majority of air-source heat pump integrations in Canada. They can be further classified according to the type of installation:

- **Ducted:** The indoor coil of the heat pump is located in a duct. Air is heated or cooled by passing over the coil, before being distributed via the ductwork to different locations in the home.
- **Ductless:** The indoor coil of the heat pump is located in an indoor unit. These indoor units are generally located on the floor or wall of an occupied space, and heat or cool the air in that space directly. Among these units, you may see the terms mini- and multi-split:
 - **Mini-Split:** A single indoor unit is located inside the home, served by a single outdoor unit.
 - **Multi-Split:** Multiple indoor units are located in the home, and are served by a single outdoor unit.

Air-air systems are more efficient when the temperature difference between inside and outside is smaller. Because of this, air-air heat pumps generally try to optimize their efficiency by providing a higher volume of warm air, and heating that air to a lower temperature (normally between 25 and 45°C). This contrasts with furnace systems, which deliver a smaller volume of air, but heat that air to higher temperatures (between 55°C and 60°C). If you are switching to a heat pump from a furnace, you may notice this when you begin using your new heat pump.

Air-Water Heat Pumps: Less common in Canada, air-water heat pumps heat or cool water, and are used in homes with hydronic (water-based) distribution systems such as low temperature radiators, radiant floors, or fan coil units. In heating mode, the heat pump provides thermal energy to the hydronic system. This process is reversed in cooling mode, and thermal energy is extracted from the hydronic system and rejected to the outdoor air.

Operating temperatures in the hydronic system are critical when evaluating air-water heat pumps. Air-water heat pumps operate more efficiently when heating the water to lower temperatures, i.e., below 45 to 50°C, and as such are a better match for radiant floors or fan coil systems. Care should be taken if considering their use with high temperature radiators that require water temperatures above 60°C, as these temperatures generally exceed the limits of most residential heat pumps.

Major Benefits of Air-Source Heat Pumps

Installing an air-source heat pump can offer you a number of benefits. This section explores how air-source heat pumps can benefit your household energy footprint.

Efficiency

The major benefit of using an air-source heat pump is the high efficiency it can provide in heating compared to typical systems like furnaces, boilers and electric baseboards. At 8°C, the coefficient of performance (COP) of air-source heat pumps typically ranges from between 2.0 and 5.4. This means that, for units with a COP of 5, 5 kilowatt hours (kWh) of heat are transferred for every kWh of electricity supplied to the heat pump. As the outdoor air temperature drops, COPs are lower, as the heat pump must work across a greater temperature difference between the indoor and outdoor space. At -8°C, COPs can range from 1.1 to 3.7.

On a seasonal basis, the heating seasonal performance factor (HSPF) of market available units can vary from 7.1 to 13.2 (Region V). It is important to note that these HSPF estimates are for an area with a climate similar to Ottawa. Actual savings are highly dependant on the location of your heat pump installation.

Energy Savings

The higher efficiency of the heat pump can translate into significant energy use reductions. Actual savings in your house will depend on a number of factors, including your local climate, efficiency of your current system, size and type of heat pump, and the control strategy. Many online calculators are available to provide a quick estimation of how much energy savings you can expect for your particular application. NRCan's ASHP-Eval tool is freely available and could be used by installers and mechanical designers to help advise on your situation.

How Does an Air-Source Heat Pump Work?

An air-source heat pump has three cycles:

- The Heating Cycle:
Providing thermal energy to the building
- The Cooling Cycle:
Removing

Adapting heat pumps to our Canadian climate



thermal
energy from
the building

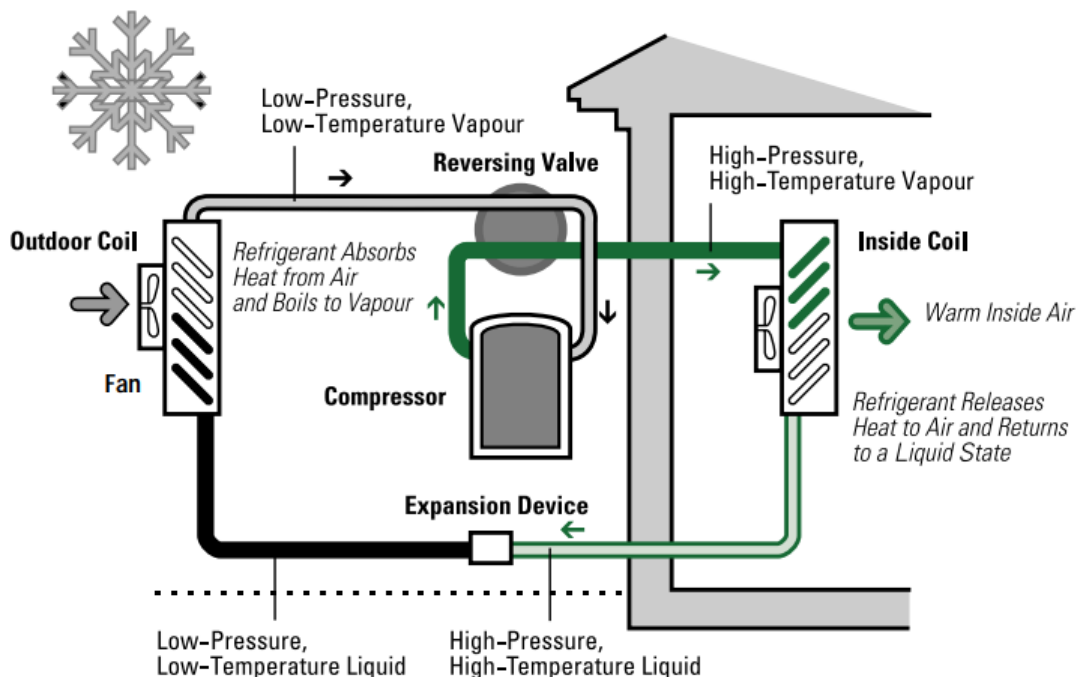
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- The Defrost Cycle: Removing frost build-up on outdoor coils

The Heating Cycle

During the heating cycle, heat is taken from outdoor air and "pumped" indoors.

- First, the liquid refrigerant passes through the expansion device, changing to a low-pressure liquid/vapour mixture. It then goes to the outdoor coil, which acts as the evaporator coil. The liquid refrigerant absorbs heat from the outdoor air and boils, becoming a low-temperature vapour.
- This vapour passes through the reversing valve to the accumulator, which collects any remaining liquid before the vapour enters the compressor. The vapour is then compressed, reducing its volume and causing it to heat up.
- Finally, the reversing valve sends the gas, which is now hot, to the indoor coil, which is the condenser. The heat from the hot gas is transferred to the indoor air, causing the refrigerant to condense into a liquid. This liquid returns to the expansion device and the cycle is repeated. The indoor coil is located in the ductwork, close to the furnace.



The ability of the heat pump to transfer heat from the outside air to the house depends on the outdoor temperature. As this temperature drops, the ability of the heat pump to absorb heat also drops. For many air-source heat pump installations, this means that there is a temperature (called the thermal balance point) when the heat pump's heating capacity is equal to the heat loss of the house. Below this outdoor ambient temperature, the heat pump can supply only part of the heat required to keep the living space comfortable, and supplementary heat is required.

It is important to note that the vast majority of air-source heat pumps have a minimum operating temperature, below which they are unable to operate. For newer models, this can range from between -15°C to -25°C . Below this temperature, a supplemental system must be used to provide heating to the building.

The Cooling Cycle

The cycle described above is reversed to cool the house during the summer. The unit takes heat out of the indoor air and rejects it outside.

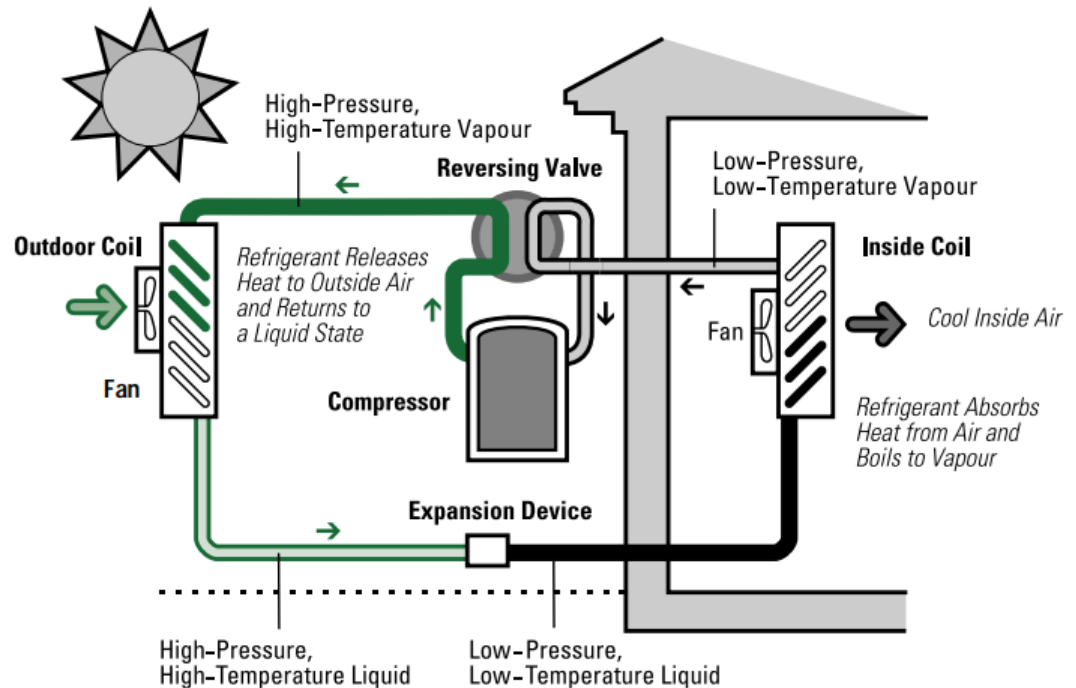
- As in the heating cycle, the liquid refrigerant passes through the expansion device, changing to a low-pressure liquid/vapour

mixture. It then goes to the indoor coil, which acts as the evaporator. The liquid refrigerant absorbs heat from the indoor air and boils, becoming a low-temperature vapour.

- This vapour passes through the reversing valve to the accumulator, which collects any remaining liquid, and then to the compressor. The vapour is then compressed, reducing its volume and causing it to heat up.
- Finally, the gas, which is now hot, passes through the reversing valve to the outdoor coil, which acts as the condenser. The heat from the hot gas is transferred to the outdoor air, causing the refrigerant to condense into a liquid. This liquid returns to the expansion device, and the cycle is repeated.

During the cooling cycle, the heat pump also dehumidifies the indoor air. Moisture in the air passing over the indoor coil condenses on the coil's surface and is collected in a pan at the bottom of the coil. A condensate drain connects this pan to the house drain.

The Defrost Cycle



If the outdoor temperature falls to near or below freezing when the heat pump is operating in the heating mode, moisture in the air passing over the outside coil will condense and freeze on it. The amount of frost buildup depends on the outdoor temperature and the amount of moisture in the air.

This frost buildup decreases the efficiency of the coil by reducing its ability to transfer heat to the refrigerant. At some point, the frost must be removed. To do this, the heat pump switches into defrost mode. The most common approach is:

- First, the reversing valve switches the device to the cooling mode. This sends hot gas to the outdoor coil to melt the frost. At the same time the outdoor fan, which normally blows cold air over the coil, is shut off in order to reduce the amount of heat needed to melt the frost.
- While this is happening, the heat pump is cooling the air in the ductwork. The heating system would normally warm this air as it is distributed throughout the house.

One of two methods is used to determine when the unit goes into defrost mode:

- Demand-frost controls monitor airflow, refrigerant pressure, air or coil temperature and pressure differential across the outdoor coil to detect frost accumulation.
- Time-temperature defrost is started and ended by a pre-set interval timer or a temperature sensor located on the outside coil. The cycle can be initiated every 30, 60 or 90 minutes, depending on the climate and the design of the system.

Unnecessary defrost cycles reduce the seasonal performance of the heat pump. As a result, the demand-frost method is generally more efficient since it starts the defrost cycle only when it is required.

Supplementary Heat Sources

Since air-source heat pumps have a minimum outdoor operating temperature (between -15°C to -25°C) and reduced heating capacity at very cold temperatures, it is important to consider a **supplemental heating source** for air-source heat pump operations. Supplementary heating may also be required when the heat pump is defrosting. Different options are available:

- **All Electric:** In this configuration, heat pump operations are supplemented with electric resistance elements located in the ductwork or with electric baseboards. These resistance elements are less efficient than the heat pump, but their ability to provide heating is independent of outdoor temperature.
- **Hybrid System:** In a hybrid system, the air-source heat pump uses a supplemental system such as a furnace or boiler. This option can be used in new installations, and is also a good option where a heat pump is added to an existing system, for example, when a heat pump is installed as a replacement for a central air-conditioner.

See the final section of this booklet, *Related Equipment*, for more information on systems that use supplementary heating sources. There, you can find discussion of options for how to program your system to transition between heat pump use and supplementary heat source use.

Energy Efficiency Considerations

To support understanding of this section, refer to the earlier section called *An introduction to Heat Pump Efficiency* for an explanation of what HSPFs and SEERs represent.

In Canada, energy efficiency regulations prescribe a minimum seasonal efficiency in heating and cooling that must be achieved for the product to be sold in the Canadian market. In addition to these regulations, your province or territory may have more stringent requirements.

Minimum performance for Canada as a whole, and typical ranges for market-available products, are summarized below for heating and cooling. It is important to also check to see whether any additional regulations are in place in your region before selecting your system.

Cooling Seasonal Performance, SEER:

- Minimum SEER (Canada): 14
- Range, SEER in Market Available Products: 14 to 42

Heating Seasonal Performance, HSPF

- Minimum HSPF (Canada): 7.1 (for Region V)
- Range, HSPF in Market Available Products: 7.1 to 13.2 (for Region V)

Note: HSPF factors are provided for AHRI Climate Zone V, which has a similar climate to Ottawa. Actual seasonal efficiencies may vary depending on your region. A new performance standard that aims to better represent performance of these systems in Canadian regions is currently under development.

The actual SEER or HSPF values depend on a variety of factors primarily related to heat pump design. Current performance has evolved significantly over the last 15 years, driven by new developments in compressor technology, heat exchanger design, and improved refrigerant flow and control.

Single Speed and Variable Speed Heat Pumps

Of particular importance when considering efficiency is the role of new compressor designs in improving seasonal performance. Typically, units operating at the minimum prescribed SEER and HSPF are characterized by **single speed** heat pumps. **Variable speed** air-source heat pumps are now available that are designed to vary the capacity of the system to more closely match the heating/cooling demand of the house at a given moment. This helps to maintain peak efficiency at all times, including during milder conditions when there is lower-demand on the system.

More recently, air-source heat pumps that are better adapted to operating in the cold Canadian climate have been introduced to the market. These systems, often called **cold climate heat pumps**, combine variable capacity compressors with improved heat exchanger designs and controls to maximize heating capacity at colder air temperatures, while maintaining high efficiencies during milder conditions. These types of systems typically have higher SEER and HSPF values, with some systems reaching SEERs up to 42, and HSPFs approaching 13.

Certification, Standards, and Rating Scales

The Canadian Standards Association (CSA) currently verifies all heat pumps for electrical safety. A performance standard specifies tests and test conditions at which heat pump heating and cooling capacities and efficiency are determined. The performance testing standards for air-source heat pumps are CSA C656, which (as of 2014) has been harmonised with ANSI/AHRI 210/240-2008, Performance Rating of Unitary Air-Conditioning & Air-Source Heat Pump Equipment. It also replaces CAN/CSA-C273.3-M91, Performance Standard for Split-System Central Air-Conditioners and Heat Pumps.

Sizing Considerations

To appropriately size your heat pump system, it is important to understand the heating and cooling needs for your home. It is recommended that a heating and cooling professional be retained to undertake the required calculations. Heating and cooling loads should be determined by using a recognized sizing method such as CSA F280-12, "Determining the Required Capacity of Residential Space Heating and Cooling Appliances."

The sizing of your heat pump system should be done according to your climate, heating and cooling building loads, and the objectives of your installation (e.g., maximizing heating energy savings vs. displacing an existing system during certain periods of the year). To help with this process, NRCan has developed an *Air-Source Heat Pump Sizing and Selection Guide*. This guide, along with a companion software tool, is intended for energy advisors and mechanical designers, and is freely available to provide guidance on appropriate sizing.

If a heat pump is undersized, you will notice that the supplemental heating system will be used more frequently. While an undersized system will still operate efficiently, you may not get the anticipated energy savings due to a high use of a supplemental heating system.

Likewise, if a heat pump is oversized, the desired energy savings may not be realized due to inefficient operation during milder conditions. While the supplemental heating system operates less frequently, under warmer ambient conditions, the heat pump produces too much heat and the unit cycles on and off leading to discomfort, wear on the heat pump, and stand-by electric power draw. It is therefore important to have a good understanding of your heating load and what the heat pump operating characteristics are to achieve optimal energy savings.

Other Selection Criteria

Apart from sizing, several additional performance factors should be considered:

- **HSPF:** Select a unit with as high an HSPF as practical. For units with comparable HSPF ratings, check their steady-state ratings at -8.3°C , the low temperature rating. The unit with the higher value will be the most efficient one in most regions of Canada.
- **Defrost:** Select a unit with demand-defrost control. This minimizes defrost cycles, which reduces supplementary and heat pump energy use.
- **Sound Rating:** Sound is measured in units called decibels (dB). The lower the value, the lower the sound power emitted by the outdoor unit. The higher the decibel level, the louder the noise. Most heat pumps have a sound rating of 76 dB or lower.

Installation Considerations

Air-source heat pumps should be installed by a qualified contractor. Consult a local heating and cooling professional to size, install, and maintain your equipment to ensure efficient and reliable operations. If you are looking to implement a heat pump to replace or supplement your central furnace, you should be aware that heat pumps generally operate at higher airflows than furnace systems. Depending on the size of your new heat pump, some modifications may be needed to your ductwork to avoid added noise and fan energy use. Your contractor will be able to give you guidance on your specific case.

The cost of installing an air-source heat pump depends on the type of system, your design objectives, and any existing heating equipment and ductwork in your home. In some cases, additional modifications to the ductwork or electrical services may be required to support your new heat pump installation.

Operation Considerations

You should note several important things when operating your heat pump:

- **Optimize Heat Pump and Supplemental System Set-points.** If you have an electric supplemental system (e.g., baseboards or resistance elements in duct), be sure to use a lower temperature set-point for your supplemental system. This will help to maximize the amount of heating the heat pump provides to your home, lowering your energy use and utility bills. A set-point of 2°C to 3°C below the heat pump heating temperature set-point is recommended. Consult your installation contractor on the optimal set-point for your system.
- **Set Up for an Efficient Defrost.** You can reduce energy use by having your system set up to turn off the indoor fan during defrost cycles. This can be performed by your installer. However, it is important to note that defrost may take a little longer with this set up.
- **Minimize Temperature Setbacks.** Heat pumps have a slower response than furnace systems, so they have more difficulty responding to deep temperature setbacks. Moderated setbacks of not more than 2°C should be employed or a “smart” thermostat that switches the system

on early, in anticipation of a recovery from setback, should be used. Again, consult your installation contractor on the optimal setback temperature for your system.

- **Optimize Your Airflow Direction.** If you have a wall mounted indoor unit, consider adjusting the airflow direction to maximize your comfort. Most manufacturers recommend directing airflow downwards when heating, and towards occupants when in cooling.
- **Optimize fan settings.** Also, be sure to adjust fan settings to maximize comfort. To maximize the heat delivered of the heat pump, it is recommended to set the fan speed to high or 'Auto'. Under cooling, to also improve dehumidification, the 'low' fan speed is recommended.

Maintenance Considerations

Proper maintenance is critical to ensure your heat pump operates efficiently, reliably, and has a long service life. You should have a qualified contractor do annual maintenance on your unit to ensure everything is in good working order.

Aside from annual maintenance, there are a few simple things you can do to ensure reliable and efficient operations. Be sure to change or clean your air filter every 3 months, as clogged filters will decrease airflow and reduce the efficiency of your system. Also, be sure that vents and air registers in your home are not blocked by furniture or carpeting, as inadequate airflow to or from your unit can shorten equipment lifespans and reduce efficiency of the system.

Operating Costs

The energy savings from installing a heat pump can help to reduce your monthly energy bills. Achieving a reduction in your energy bills greatly depends on the price of electricity in relation to other fuels such as natural gas or heating oil, and, in retrofit applications, what type of system is being replaced.

Heat pumps in general come at a higher cost compared to other systems such as furnaces or electric baseboards due the number of components in the system. In some regions and cases, this added cost can be recouped in a relatively short time period through the utility cost savings. However, in other regions, varying utility rates can extend this period. It is important to work with your contractor or energy advisor to get an estimate of the economics of heat pumps in your area, and the potential savings you can achieve.

Life Expectancy and Warranties

Air-source heat pumps have a service life of between 15 and 20 years. The compressor is the critical component of the system.

Most heat pumps are covered by a one-year warranty on parts and labour, and an additional five-to ten-year warranty on the compressor (for parts only). However, warranties vary between manufacturers, so check the fine print.

Ground-Source Heat Pumps

Ground-source heat pumps use the earth or ground water as a source of thermal energy in heating mode, and as a sink to reject energy when in cooling mode. These types of systems contain two key components:

- **Ground Heat Exchanger:** This is the heat exchanger used to add or remove thermal energy from the earth or ground. Various heat exchanger configurations are possible, and are explained later in this section.
- **Heat Pump:** Instead of air, ground-source heat pumps use a fluid flowing through the ground heat exchanger as their source (in heating) or sink (in cooling).

On the building side, both air and hydronic (water) systems are possible. Operating temperatures on the building side are very important in hydronic applications. Heat pumps operate more efficiently when heating at lower temperatures of below 45 to 50°C, making them a better match for radiant floors or fan coil systems. Care should be taken if considering their use with high temperature radiators that require water temperatures above 60°C, as these temperatures generally exceed the limits of most residential heat pumps.

Depending on how the heat pump and ground heat exchanger interact, two different system classifications are possible:

- **Secondary Loop:** A liquid (ground water or anti-freeze) is used in the ground heat exchanger. The thermal energy transferred from the ground to the liquid is delivered to the heat pump via a heat exchanger.
- **Direct Expansion (DX):** A refrigerant is used as the fluid in the ground heat exchanger. The thermal energy extracted by the refrigerant from the ground is used directly by the heat pump - no additional heat exchanger is needed.
In these systems, the ground heat exchanger is a part of the heat pump itself, acting as the evaporator in heating mode and condenser in cooling mode.

Ground-source heat pumps can serve a suite of comfort needs in your home, including:

- **Heating only:** The heat pump is used only in heating. This can include both space heating and hot water production.
- **Heating with “active cooling”:** The heat pump is used in both heating and cooling
- **Heating with “passive cooling”:** The heat pump is used in heating, and bypassed in cooling. In cooling, fluid from the building is cooled directly in the ground heat exchanger.

Heating and “active cooling” operations are described in the following section.

Major Benefits of Ground-Source Heat Pump Systems

Efficiency

In Canada, where air temperatures can go below -30°C , ground-source systems are able to operate more efficiently because they take advantage of warmer and more stable ground temperatures. Typical water temperatures entering the ground-source heat pump are generally above 0°C , yielding a COP of around 3 for most systems during the coldest winter months.

Energy Savings

Ground-source systems will reduce your heating and cooling costs substantially. Heating energy cost savings compared with electric furnaces are around 65%.

On average, a well designed ground-source system will yield savings that are about 10-20% more than would be provided by a best in class, cold climate air-source heat pump sized to cover most of the building heating load. This is due to the fact that underground temperatures are higher in winter than air temperatures. As a result, a ground-source heat pump can provide more heat over the course of the winter than an air-source heat pump.

Actual energy savings will vary depending on the local climate, the efficiency of the existing heating system, the costs of fuel and electricity, the size of the heat pump installed, borefield configuration and the seasonal energy balance, and the heat pump efficiency performance at CSA rating conditions.

How Does a Ground-Source System Work?

Ground-source heat pumps consist of two main parts: A ground heat exchanger, and a heat pump. Unlike air-source heat pumps, where one heat exchanger is located outside, in ground-source systems, the heat pump unit is located inside the home.

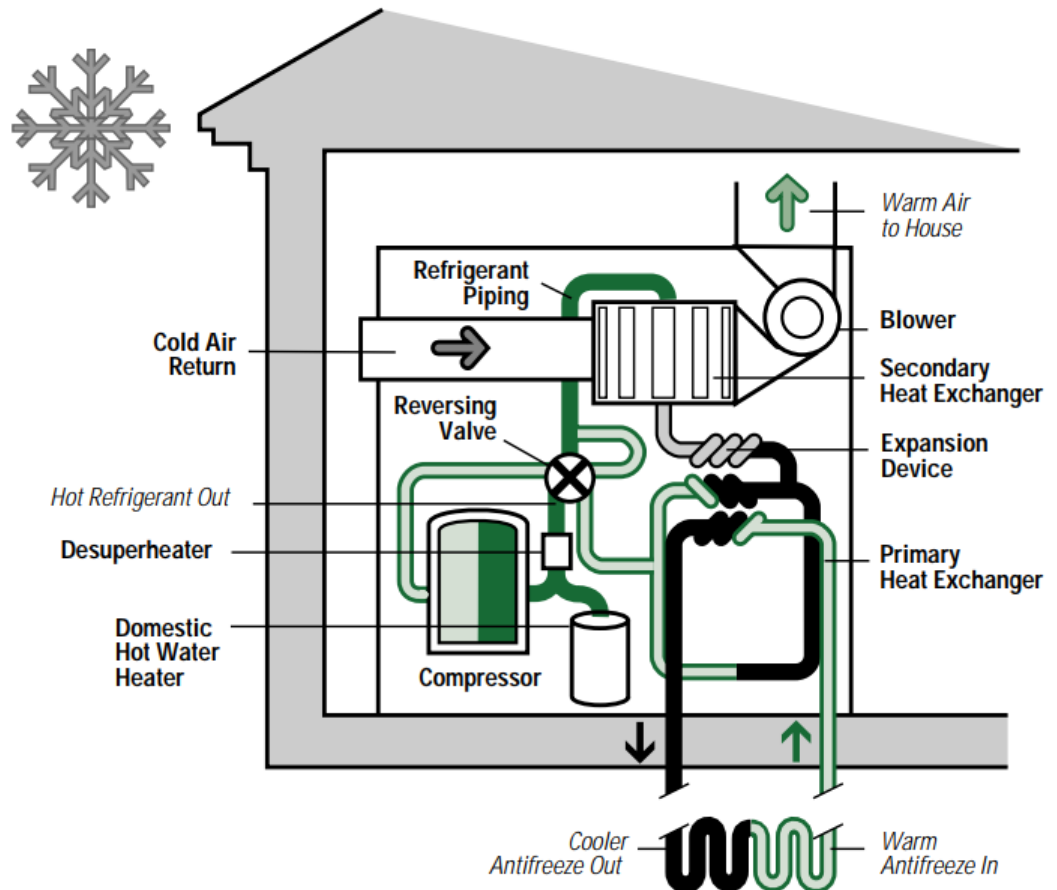
Ground heat exchanger designs can be classified as either:

- **Closed Loop:** Closed-loop systems collect heat from the ground by means of a continuous loop of piping buried underground. An antifreeze solution (or refrigerant in the case of a DX ground-source system), which has been chilled by the heat pump's refrigeration system to several degrees colder than the outside soil, circulates through the piping and absorbs heat from the soil.
Common piping arrangements in closed loop systems include horizontal, vertical, diagonal and pond/lake ground systems (these arrangements are discussed below, under *Design Considerations*).
- **Open Loop:** Open systems take advantage of the heat retained in an underground body of water. The water is drawn up through a well directly to the heat exchanger, where its heat is extracted. The water is then discharged either to an above-ground body of water, such as a stream or pond, or back to the same underground water body through a separate well.

The selection of outdoor piping system depends on the climate, soil conditions, available land, local installation costs at the site as well as municipal and provincial regulations. For instance, open loop systems are permitted in Ontario, but are not permitted in Quebec. Some municipalities have banned DX systems because the municipal water source is the aquifer.

The Heating Cycle

In the heating cycle, the ground water, the antifreeze mixture or the refrigerant (which has circulated through the underground piping system and picked up heat from the soil) is brought back to the heat pump unit inside the house. In ground water or antifreeze mixture systems, it then passes through the refrigerant-



filled primary heat exchanger. In DX systems, the refrigerant enters the compressor directly, with no intermediate heat exchanger.

The heat is transferred to the refrigerant, which boils to become a low-temperature vapour. In an open system, the ground water is then pumped back out and discharged into a pond or down a well. In a closed-loop system, the antifreeze mixture or refrigerant is pumped back out to the underground piping system to be heated again.

The reversing valve directs the refrigerant vapour to the compressor. The vapour is then compressed, which reduces its volume and causes it to heat up.

Finally, the reversing valve directs the now-hot gas to the condenser coil, where it gives up its heat to the air or hydronic system to heat the home. Having given up its heat, the refrigerant passes through the expansion device, where its temperature and pressure are dropped further before it returns to the first heat exchanger, or to the ground in a DX system, to begin the cycle again.

The Cooling Cycle

The “active cooling” cycle is basically the reverse of the heating cycle. The direction of the refrigerant flow is changed by the reversing valve. The refrigerant picks up heat from the house air and transfers it directly, in DX systems, or to the ground water or antifreeze mixture. The heat is then pumped outside, into a water body or return well (in an open system) or into the underground piping (in a closed-loop system). Some of this excess heat can be used to preheat domestic hot water.

Unlike air-source heat pumps, ground-source systems do not require a defrost cycle. Temperatures underground are much more stable than air temperatures, and the heat pump unit itself is located inside; therefore, the problems with frost do not arise.

Parts of the System

Ground-source heat pump systems have three main components: the heat pump unit itself, the liquid heat exchange medium (open system or closed loop), and a distribution system (either air-based or hydronic) that distributes the thermal energy from the heat pump to the building.

Ground-source heat pumps are designed in different ways. For air-based systems, self-contained units combine the blower, compressor, heat exchanger, and condenser coil in a single cabinet. Split systems allow the coil to be added to a forced-air furnace, and use the existing blower and furnace. For hydronic systems, both the source and sink heat exchangers and compressor are in a single cabinet.

Energy Efficiency Considerations

As with air-source heat pumps, ground-source heat pump systems are available in a range of different efficiencies. See the earlier section called *An introduction to Heat Pump Efficiency* for an explanation of what COPs and EERs represent. Ranges of COPs and EERs for market available units are provided below.

Ground water or Open-Loop Applications

Heating

- Minimum Heating COP: 3.6
- Range, Heating COP in Market Available Products: 3.8 to 5.0

Cooling

- Minimum EER: 16.2
- Range, EER in Market Available Products: 19.1 to 27.5

Closed Loop Applications

Heating

- Minimum Heating COP: 3.1
- Range, Heating COP in Market Available Products: 3.2 to 4.2

Cooling

- Minimum EER: 13.4
- Range, EER in Market Available Products: 14.6 to 20.4

The minimum efficiency for each type is regulated at the federal level as well as in some provincial jurisdictions. There has been a dramatic improvement in the efficiency of ground-source systems. The same developments in compressors, motors and controls that are available to air-source heat pump manufacturers are resulting in higher levels of efficiency for ground-source systems.

Lower-end systems typically employ two stage compressors, relatively standard size refrigerant-to-air heat exchangers, and oversized enhanced-surface refrigerant-to-water heat exchangers. Units in the high efficiency range tend to use multi-or variable speed compressors, variable speed indoor fans, or both. Find an explanation of *single speed and variable speed heat pumps in the Air-Source Heat Pump* section.

Certification, Standards, and Rating Scales

The Canadian Standards Association (CSA) currently verifies all heat pumps for electrical safety. A performance standard specifies tests and test conditions at which heat pump heating and cooling capacities and efficiency are determined. The performance testing standards for ground-source systems are CSA C13256 (for secondary loop systems) and CSA C748 (for DX systems).

Sizing Considerations

It is important that the ground heat exchanger be well matched to the heat pump capacity. Systems that are not balanced and unable to replenish the energy drawn from the borefield will continuously perform worse over time until the heat pump can no longer extract heat.

As with air-source heat pump systems, it is generally not a good idea to size a ground-source system to provide all of the heat required by a house. For cost-effectiveness, the system should generally be sized to cover the majority of the household's annual heating energy requirement. The occasional peak heating load during severe weather conditions can be met by a supplementary heating system.

Systems are now available with variable speed fans and compressors. This type of system can meet all cooling loads and most heating loads on low speed, with high speed required only for high heating loads. Find an explanation of *single speed and variable speed heat pumps* in the *Air-Source Heat Pump* section.

A variety of sizes of systems are available to suit the Canadian climate. Residential units range in rated size (closed loop cooling) of 1.8 kW to 21.1 kW (6 000 to 72 000 Btu/h), and include domestic hot water (DHW) options.

Design Considerations

Unlike air-source heat pumps, ground-source heat pumps require a ground heat exchanger to collect and dissipate heat underground.

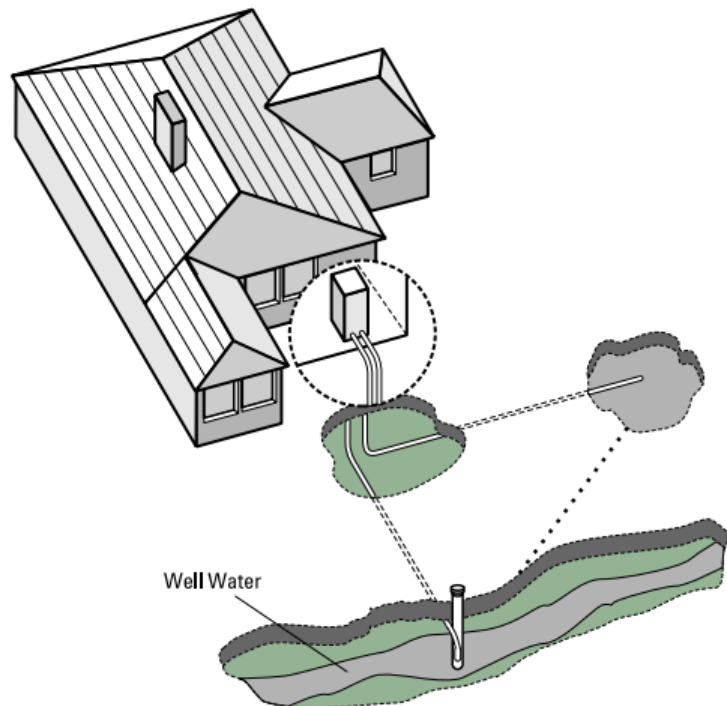
Open Loop Systems

An open system uses ground water from a conventional well as a heat source. The ground water is pumped to a heat exchanger, where thermal energy is extracted and used as a source for the heat pump. The ground water exiting the heat exchanger is then reinjected into the aquifer.

Another way to release the used water is through a rejection well, which is a second well that returns the water to the ground. A rejection well must have enough capacity to dispose of all the water passed through the heat pump, and should be installed by a qualified well driller.

If you have an extra existing well, your heat pump contractor should have a well driller ensure that it is suitable for use as a rejection well. Regardless of the approach used, the system should be designed to prevent any environmental damage. The heat pump simply removes or adds heat to the water; no pollutants are added. The only change in the water returned to the environment is a slight increase or decrease in temperature. It is important to check with local authorities to understand any regulations or rules regarding open loop systems in your area.

The size of the heat pump unit and the manufacturer's specifications will determine the amount of water that is needed for an open system. The water requirement for a specific model of heat pump is usually expressed in litres per second (L/s) and is listed in the specifications for that unit. A heat pump of 10-kW (34 000-Btu/h) capacity will use 0.45 to 0.75 L/s while operating.



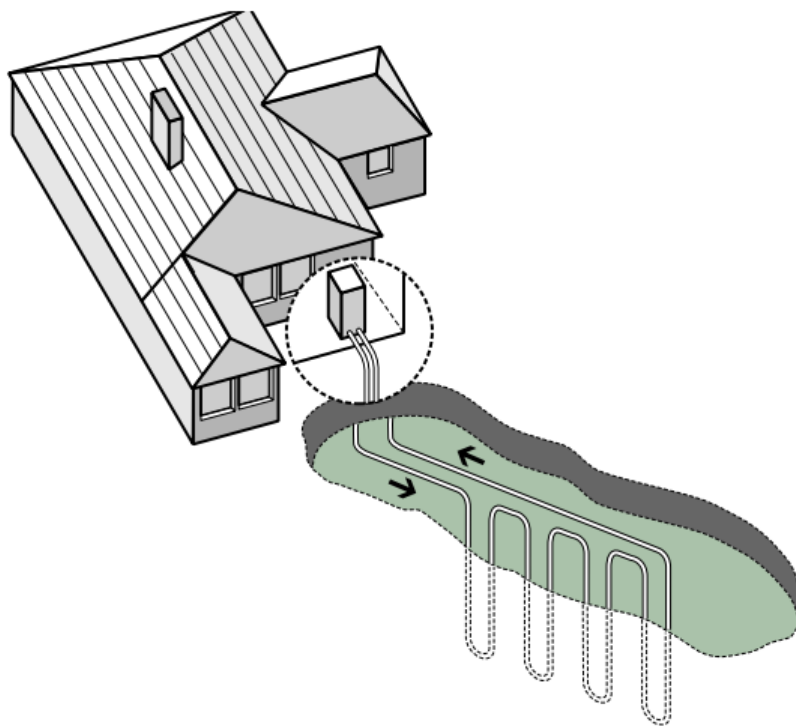
Your well and pump combination should be large enough to supply the water needed by the heat pump in addition to your domestic water requirements. You may need to enlarge your pressure tank or modify your plumbing to supply adequate water to the heat pump.

Poor water quality can cause serious problems in open systems. You should not use water from a spring, pond, river or lake as a source for your heat pump system. Particles and other matter can clog a heat pump system and make it inoperable in a short period of time. You should also have your water tested for acidity, hardness and iron content before installing a heat pump. Your contractor or equipment manufacturer can tell you what level of water quality is acceptable and under what circumstances special heat-exchanger materials may be required.

Installation of an open system is often subject to local zoning laws or licensing requirements. Check with local authorities to determine if restrictions apply in your area.

Closed-Loop Systems

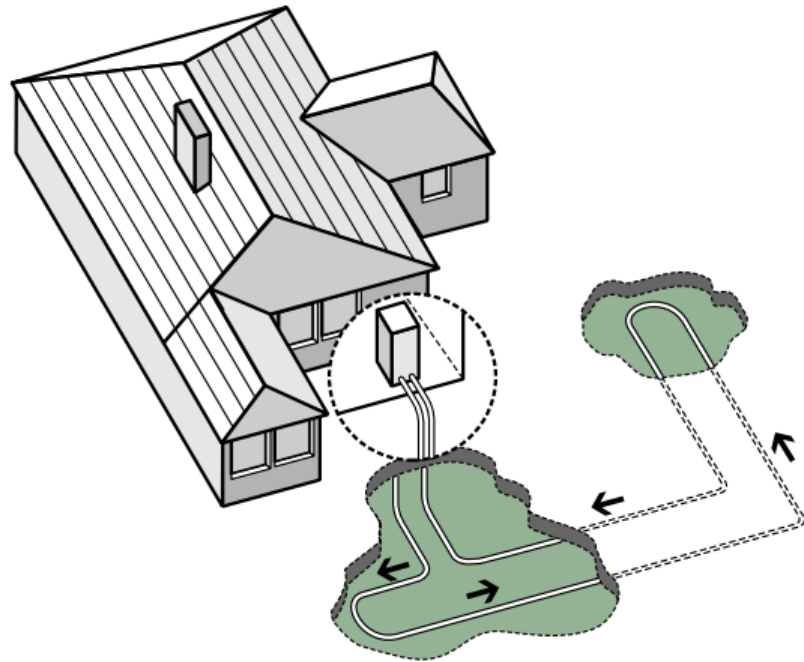
A closed-loop system draws heat from the ground itself, using a continuous loop of buried plastic pipe. Copper tubing is used in the case of DX systems. The pipe is connected to the indoor heat pump to form a sealed underground loop through which an antifreeze solution or refrigerant is circulated. While an open system drains water from a well, a closed-loop system recirculates the antifreeze solution in the pressurized pipe.



The pipe is placed in one of three types of arrangements:

- **Vertical:** A vertical closed-loop arrangement is an appropriate choice for most suburban homes, where lot space is restricted. Piping is inserted into bored holes that are 150 mm (6 in.) in diameter, to a depth of 45 to 150 m (150 to 500 ft.), depending on soil conditions and the size of the system. U-shaped loops of pipe are inserted in the holes. DX systems can have smaller diameter holes, which can lower drilling costs.

- **Diagonal (angled):** A diagonal (angled) closed-loop arrangement is similar to a vertical closed-loop arrangement; however the boreholes are angled. This type of arrangement is used where space is very limited and access is limited to one point of entry.



- **Horizontal:** The horizontal arrangement is more common in rural areas, where properties are larger. The pipe is placed in trenches normally 1.0 to 1.8 m (3 to 6 ft.) deep,

depending on the number of pipes in a trench. Generally, 120 to 180 m (400 to 600 ft.) of pipe is required per ton of heat pump capacity. For example, a well-insulated, 185 m² (2000 sq. ft.) home would usually need a three-ton system, requiring 360 to 540 m (1200 to 1800 ft.) of pipe.

The most common horizontal heat exchanger design is two pipes placed side-by-side in the same trench. Other horizontal loop designs use four or six pipes in each trench, if land area is limited. Another design sometimes used where area is limited is a "spiral" – which describes its shape.

Regardless of the arrangement you choose, all piping for antifreeze solution systems must be at least series 100 polyethylene or polybutylene with thermally fused joints (as opposed to barbed fittings, clamps or glued joints), to ensure leak-free connections for the life of the piping. Properly installed, these pipes will last anywhere from 25 to 75 years. They are unaffected by chemicals found in soil and have good heat-conducting properties. The antifreeze solution must be acceptable to local environmental officials. DX systems use refrigeration-grade copper tubing.

Neither vertical nor horizontal loops have an adverse impact on the landscape as long as the vertical boreholes and trenches are properly backfilled and tamped (packed down firmly).

Horizontal loop installations use trenches anywhere from 150 to 600 mm (6 to 24 in.) wide. This leaves bare areas that can be restored with grass seed or sod. Vertical loops require little space and result in less lawn damage.

It is important that horizontal and vertical loops be installed by a qualified contractor. Plastic piping must be thermally fused, and there must be good earth-to-pipe contact to ensure good heat transfer, such as that achieved by Tremie-grouting of boreholes. The latter is particularly important

for vertical heat-exchanger systems. Improper installation may result in poorer heat pump performance.

Installation Considerations

As with air-source heat pump systems, ground-source heat pumps must be designed and installed by qualified contractors. Consult a local heat pump contractor to design, install and service your equipment to ensure efficient and reliable operation. Also, be sure that all manufacturers' instructions are followed carefully. All installations should meet the requirements of CSA C448 Series 16, an installation standard set by the Canadian Standards Association.

The total installed cost of ground-source systems varies according to site-specific conditions. Installation costs vary depending on the type of ground collector and the equipment specifications. The incremental cost of such a system can be recovered through energy cost savings over a period as low as 5 years. Payback period is dependent on a variety of factors such as soil conditions, heating and cooling loads, the complexity of HVAC retrofits, local utility rates, and the heating fuel source being replaced. Check with your electric utility to assess the benefits of investing in a ground-source system. Sometimes a low-cost financing plan or incentive is offered for approved installations. It is important to work with your contractor or energy advisor to get an estimate of the economics of heat pumps in your area, and the potential savings you can achieve.

Operation Considerations

You should note several important things when operating your heat pump:

- **Optimize Heat Pump and Supplemental System Set-points.** If you have an electric supplemental system (e.g., baseboards or resistance elements in duct), be sure to use a lower temperature set-point for your supplemental system. This will help to maximize the amount of heating the heat pump provides to your home, lowering your energy use and utility bills. A set-point of 2°C to 3°C below the heat pump heating temperature set-point is recommended. Consult your installation contractor on the optimal set-point for your system.
- **Minimize Temperature Setbacks.** Heat pumps have a slower response than furnace systems, so they have more difficulty responding to deep temperature setbacks. Moderated setbacks of not more than 2°C should be employed or a “smart” thermostat that switches the system on early, in anticipation of a recovery from setback, should be used. Again, consult your installation contractor on the optimal setback temperature for your system.

Maintenance Considerations

You should have a qualified contractor perform annual maintenance once per year to ensure your system remains efficient and reliable.

If you have an air-based distribution system, you can also support more efficient operations by replacing or cleaning your filter every 3 months. You should also ensure that your air vents and registers are not blocked by any furniture, carpeting or other items that would impede airflow.

Operating Costs

The operating costs of a ground-source system are usually considerably lower than those of other heating systems, because of the savings in fuel. Qualified heat pump installers should be able to give you information on how much electricity a particular ground-source system would use.

Relative savings will depend on whether you are currently using electricity, oil or natural gas, and on the relative costs of different energy sources in your area. By running a heat pump, you will use less gas or oil, but more electricity. If you live in an area where electricity is expensive, your operating costs may be higher.

Life Expectancy and Warranties

Ground-source heat pumps generally have a life expectancy of about 20 to 25 years. This is higher than for air-source heat pumps because the compressor has less thermal and mechanical stress, and is protected from the environment. The lifespan of the ground loop itself approaches 75 years.

Most ground-source heat pump units are covered by a one-year warranty on parts and labour, and some manufacturers offer extended warranty programs. However, warranties vary between manufacturers, so be sure to check the fine print.

Related Equipment

Upgrading the Electrical Service

Generally speaking, it is not necessary to upgrade the electrical service when installing an air-source add-on heat pump. However, the age of the service and the total electrical load of the house may make it necessary to upgrade.

A 200 ampere electrical service is normally required for the installation of either an all-electric air-source heat pump or a ground-source heat pump. If transitioning from a natural gas or fuel oil based heating system, it may be necessary to upgrade your electrical panel.

Supplementary Heating Systems

Air-Source Heat Pump Systems

Air-source heat pumps have a minimum outdoor operating temperature, and may lose some of their ability to heat at very cold temperatures. Because of this, most air-source installations require a supplementary heating source to maintain indoor temperatures during the coldest days. Supplementary heating may also be required when the heat pump is defrosting.

Most air-source systems shut off at one of three temperatures, which can be set by your installation contractor:

- **Thermal Balance Point:** The temperature below which the heat pump does not have enough capacity to meet the heating needs of the building on its own.
- **Economic Balance Point:** The temperature below which the ratio of electricity to a supplemental fuel (e.g., natural gas) means that using the supplementary system is more cost effective.
- **Cut-Off Temperature:** The minimum operating temperature for the heat pump.

Most supplementary systems can be classed into two categories:

- **Hybrid Systems:** In a hybrid system, the air-source heat pump uses a supplemental system such as a furnace or boiler. This option can be used in new installations, and is also a good option where a heat pump is added to an existing system, for example, when a heat pump is installed as a replacement for a central air-conditioner.
These types of systems support switching between heat pump and supplementary operations according to the thermal or economic balance point.
These systems cannot be run simultaneously with the heat pump – either the heat pump operates or the gas/oil furnace operates.
- **All Electric Systems:** In this configuration, heat pump operations are supplemented with electric resistance elements located in the ductwork or with electric baseboards.
These systems can be run simultaneously with the heat pump, and can therefore be used in balance point or cut-off temperature control strategies.

An outdoor temperature sensor shuts the heat pump off when the temperature falls below the pre-set limit. Below this temperature, only the supplementary heating system operates. The sensor is usually set to shut off at the temperature corresponding to the economic balance point, or at the outdoor temperature below which it is cheaper to heat with the supplementary heating system instead of the heat pump.

Ground-Source Heat Pump Systems

Ground-source systems continue to operate regardless of the outdoor temperature, and as such are not subject to the same sort of operating restrictions. The supplementary heating system only provides heat that is beyond the rated capacity of the ground-source unit.

Thermostats

Conventional Thermostats

Most ducted residential single-speed heat pump systems are installed with a "**two-stage heat/one-stage cool**" indoor thermostat. Stage one calls for heat from the heat pump if the temperature falls below the pre-set level. Stage two calls for heat from the supplementary heating

system if the indoor temperature continues to fall below the desired temperature. Ductless residential air-source heat pumps are typically installed with a single stage heating/cooling thermostat or in many instances a built in thermostat set by a remote that comes with the unit.

The most common type of thermostat used is the "**set and forget**" type. The installer consults with you prior to setting the desired temperature. Once this is done, you can forget about the thermostat; it will automatically switch the system from heating to cooling mode or vice versa.

There are two types of outdoor thermostats used with these systems. The first type controls the operation of the electric resistance supplementary heating system. This is the same type of thermostat that is used with an electric furnace. It turns on various stages of heaters as the outdoor temperature drops progressively lower. This ensures that the correct amount of supplementary heat is provided in response to outdoor conditions, which maximizes efficiency and saves you money. The second type simply shuts off the air-source heat pump when the outdoor temperature falls below a specified level.

Thermostat setbacks may not yield the same kind of benefits with heat pump systems as with more conventional heating systems. Depending upon the amount of the setback and temperature drop, the heat pump may not be able to supply all of the heat required to bring the temperature back up to the desired level on short notice. This may mean that the supplementary heating system operates until the heat pump "catches up." This will reduce the savings that you might have expected to achieve by installing the heat pump. See discussion in previous sections on minimizing temperature setbacks.

Programmable Thermostats

Programmable heat pump thermostats are available today from most heat pump manufacturers and their representatives. Unlike conventional thermostats, these thermostats achieve savings from temperature setback during unoccupied periods, or overnight. Although this is accomplished in different ways by different manufacturers, the heat pump brings the house back to the desired temperature level with or without minimal supplementary heating. For those accustomed to thermostat setback and programmable thermostats, this may be a worthwhile investment. Other features available with some of these electronic thermostats include the following:

- Programmable control to allow for user selection of automatic heat pump or fan-only operation, by time of day and day of the week.
- Improved temperature control, as compared to conventional thermostats.
- No need for outdoor thermostats, as the electronic thermostat calls for supplementary heat only when needed.
- No need for an outdoor thermostat control on add-on heat pumps.

Savings from programmable thermostats are highly dependant on the type and sizing of your heat pump system. For variable speed systems, setbacks may allow the system to operate at a lower speed, reducing wear on the compressor and helping to increase system efficiency.

Heat Distribution Systems

Heat pump systems generally supply a greater volume of airflow at lower temperature compared to furnace systems. As such, it is very important to examine the supply airflow of your system, and how it may compare to the airflow capacity of your existing ducts. If the heat pump airflow exceeds the capacity of your existing ducting, you may have noise issues or increased fan energy use.

New heat pump systems should be designed according to established practice. If the installation is a retrofit, the existing duct system should be carefully examined to ensure that it is adequate.

Footnotes

- 1 The Region 5 HSPF is most reflective of heat pump performance in the Ottawa region. Actual HSPFs may be lower in regions with increased heating degree days. While many colder Canadian regions are still classified under Region 5, the HSPF value provided may not fully reflect actual system performance.

Date modified:

2021-02-11

COMFORT PLUS

Forced Air Furnace



Off-Peak Heating

The Steffes Comfort Plus Forced Air furnace (4100 series) is a type of Electric Thermal Storage (ETS) system which utilizes low-cost, off-peak electricity to provide economical and comfortable heating.

ETS systems convert electricity to heat during off-peak hours and store that heat in specially designed ceramic bricks located inside the unit. Off-peak hours are times during the day or night when the demand for electricity is lower. Because electricity is plentiful, the power company can offer substantial discounts on electricity rates allowing consumers to capture significant savings in their energy bills.

Find Out More at:
www.steffes.com/comfortplusforcedair

Applications and Operation

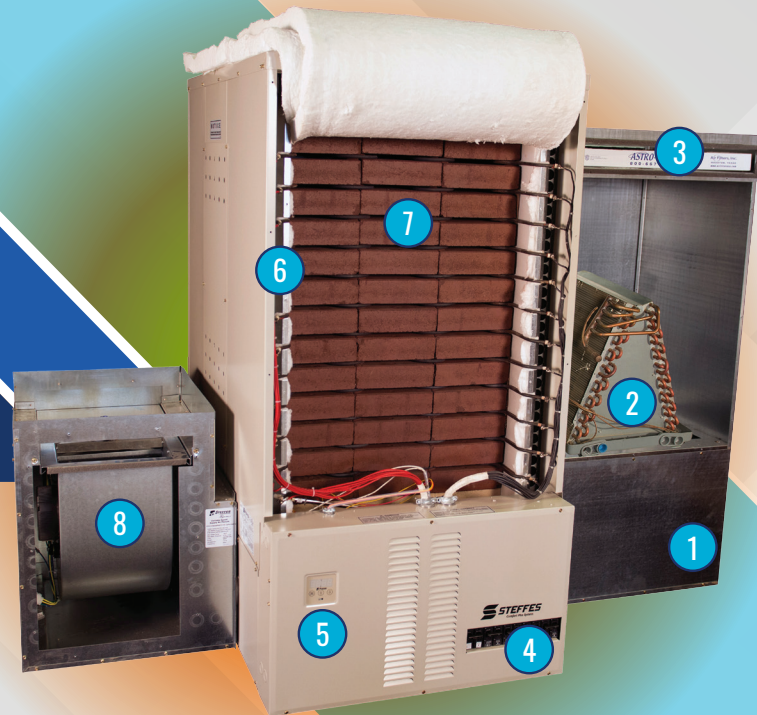
The Comfort Plus Forced Air furnace can be installed as a standalone furnace or as a supplement to other heating systems, such as a heat pump. While heat pumps are known for providing efficient low-cost heating and cooling, they require supplemental heat during colder temperatures. When demand for heat is greater than a heat pumps capacity, the Comfort Plus Forced Air furnace adds the precise amount of its stored off-peak heat as needed to ensure constant comfort while still allowing full optimization of the heat pumps efficiency.

Operation is completely automatic. A sensor monitors outdoor temperature to regulate the amount of heat stored in the bricks. The room thermostat is set to control heat delivery so the desired comfort level can be maintained using the safe, clean, reliable and economical stored off-peak heat.



Components

1. Return air plenum (separately ordered or installer supplied)
2. AC or heat pump coil (must be installer supplied, if applicable)
3. Air filter
4. Built-in circuit breakers for power disconnect
5. Programmable microprocessor based control panel and digital display
6. Electric heating elements
7. High density heat storage bricks
8. Supply air plenum with 1/2 HP or 3/4 HP variable speed blower



1kW = 3412 BTU/hr 1kWh = 3412 BTU

U.S. Pat #5086493 • Canada Pat #2059158

5-year limited manufacturer's warranty

SPECIFICATIONS For standard 240V units. 208V, 277V, and 347V configurations also available. Contact factory for technical specifications.

MODEL	4120			4130		4140	
Charging Input	14.0 kW	19.2 kW	24.8 kW	28.8 kW	37.2 kW	38.4 kW	45.6 kW
Element Current Draw	59 amps	80 amps	104 amps	120 amps	155 amps	160 amps	190 amps
Circuits Required Elements Blower/Control	1-20 amp 2-30 amp	1-30 amp 2-40 amp	1-40 amp 2-50 amp	4-40 amp	4-50 amp	4-50 amp	4-60 amp
	1-15 amp (7 amps maximum load)						
	Unit is factory-configured with multiple-line voltage, single-phase circuit connections. If single feed to the element and blowers/controls circuits is desired, an optional single-feed kit is available. Phase-balancing is recommended when making connections in 3-phase applications.						
Storage Capacity	120 kWh (409,440 BTU)			180 kWh (614,160 BTU)		240 kWh (818,880 BTU)	
	The size and heating ability of the system required for an application is dependent on the heat loss of the area and the power company's off-peak hours. Refer to the Maximum Maintainable Heat Loss for heating abilities in specific charge strategies.						
Approximate Installed Weight	2,267 lbs			3,139 lbs		3,991 lbs	
	Contact a building contractor or architect if you have structural weight concerns of the installation surface selected. Adhere to all national and local electrical and building code placement requirements for electric heating appliances.						
Unit Dimensions - W x D x H w/o Ducting w/ Factory-Built Ducting (1/2 HP) w/ Factory-Built Ducting (3/4 HP)	29.2" x 47.4" x 46.6"			29.2" x 47.4" x 57.6"		29.2" x 47.4" x 68.6"	
	77.6" x 47.4" x 46.6"			77.6" x 47.4" x 57.6"		77.6" x 47.4" x 68.6"	
	82.1" x 47.4" x 46.6"			82.1" x 47.4" x 57.6"		82.1" x 47.4" x 68.6"	
	There are required installation clearances to account for. Contact the factory for information.						
Duct Openings Supply Air Outlet (1/2 HP) Supply Air Outlet (3/4 HP) Return Air Inlet	18" x 22.6" (in factory-built plenum) 22.5" x 22.6" (in factory-built plenum) 10.5" x 22.3" (in unit) or 26.2" x 22.25" (if using a factory-built plenum)						
	26" x 22" x 31"						
Maximum Coil Dimensions (W x D x H)	The factory-built return air plenum is configured for housing an indoor coil. Dimensions listed are that of the inner coil area in this plenum. For larger coils, field provisions to the plenum are necessary or it will need to be supplied by the installer.						
Supply Air Delivery (Field Selectable) 1/2 HP Variable Speed CFM ratings 3/4 HP Variable Speed CFM ratings	1000, 1200, 1400, 1600 1200, 1400, 1600, 2000						
Heating Ability Based on Charge Time (BTU/hr) 8 Consecutive Charge Hours 12 Consecutive Charge Hours 6/4/6/8 Charge Strategy	20,414	27,996	34,175	41,994	49,212	55,992	65,615
	30,621	41,994	45,566	62,991	65,615	83,988	87,487
	30,621	41,994	54,242	62,991	81,363	83,988	99,735
	The size and heating ability of the system required for an application is dependent on the heat loss of the area and the power company's off-peak hours. If the unit is not installed within the heated area, heat lost statically must be taken into account. Contact a local Steffes dealer or power company for assistance in selecting an appropriately sized system for your specific charge strategy. The 6/4/6/8 strategy listed is 8 hours off-peak at night plus 4 hours off-peak mid-day. (The heating ability figures listed have a heat use allowance factored in for sizing purposes. Average BTU/hr delivery rate is the listed value multiplied by .78 heat use factor.)						

Manufacturer reserves the right to discontinue or change at any time, specifications or designs, without notice or incurring obligations.

3050 HWY 22 N | Dickinson, ND 58601 | 701-483-5400 | www.steffes.com | offpeak@steffes.com



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Types of ETS

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TYPES OF ETS

There are three main types of ETS systems, though all function basically the same way—they store heat while power rates are discounted, and release the heat as needed. The main types of ETS are standalone room units, whole-home central heating units, and hydronic (hot water) in-floor units. All three types can qualify for time-of-day rates with us and are great options when switching from oil.

Room unit systems

This type of ETS is the simplest to add to an existing home and any existing heating system. A standalone cabinet, you simply find a convenient place to locate it in your room, and have it hard-wired by an electrician. Cabinets vary in size, but they're generally only about 10" to 12" deep, so they integrate well into most homes' decor. The cabinet is loaded with a bank of ceramic bricks that heat up via the electric heating element that runs between them. A room unit works well as an add-on to any existing system and several room units are ideal when converting from oil.

ETS central heating

A central heating ETS replaces your existing furnace - this is an ideal solution when looking to cleaner home heating systems. These ETS systems come in both forced air and hydronic versions, so if your current home heat is distributed by forced air (through ductwork) or hot water (through radiators), there's an ETS upgrade for you. As with a room unit, the ETS furnace is filled with ceramic bricks that are heated in off-peak hours, so the heat can be released when needed. In the case of hydronic systems, the heat from the bricks is transferred via heat exchanger to water or glycol, which is then circulated through the home's existing radiators.

In-floor radiant

The big difference with in-floor radiant ETS systems is that rather than using ceramic bricks to store the heat, it uses the concrete slab of the floor itself. In this system, water is heated during off-peak hours, and pumped through the home's concrete floor(s). The concrete absorbs and holds this heat, releasing it slowly throughout the day. If your home currently has concrete in-floor heating, especially in a basement space, this could be a good option for you.

ETS/heat pump combination

A [heat pump](#) is a wonderful way to increase your home's heating efficiency. Combine your heat pump with an ETS, and you can boost your savings even more. With this setup, when your heat pump calls for additional heat from a backup source (on winter's coldest days), your ETS can kick in, releasing heat that you bought at a lower rate.

For homes with a heat pump, room unit ETSs are also a common way to heat a finished basement space. This way, a heat pump head doesn't have to be installed in the basement.

[ETS contractors](#)

[Time-of-day rate](#)

[Financing your ETS](#)



QUESTIONS?

Call us at [1-800-428-6774](tel:1-800-428-6774) outside of HRM, weekdays 8 a.m. to 8 p.m.



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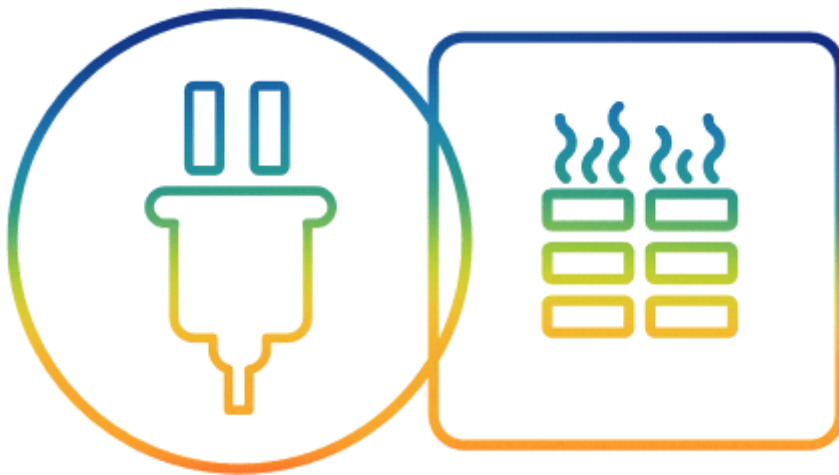
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Need to replace your central heating system?



Opt for central heating with electric thermal storage and receive \$10,000 in financial assistance from Hydro-Québec

About

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A winning choice for its financial, technical and environmental benefits

Financial benefits

Hydro-Québec will provide \$10,000 of financial assistance for the purchase and installation of a central heating ETS system. This financial assistance fully covers the additional cost of installing an ETS system as opposed to a regular system. The ETS system therefore ends up being less expensive.

Receive an additional \$1,500 financial assistance if you install an ENERGY STAR® heat pump at the same time as an Electric Thermal Storage system.

In addition, if you take the further step of signing up for Rate Fle D, the registration period for which is from April 1 to November 20 each year, then you could save approximately \$100 to \$200, if not more, every year on your electricity bill in comparison with the base rate (Rate D).

Technical benefits

- Simple, proven technology that's easy to maintain
- Quieter than a dual-energy or fuel-oil system
- Can be used with a heat pump

- No overheating in the area where the device is located, despite the high temperature of the thermal mass
- Easy connection to existing ventilation ducts (requires only slightly more space than a standard electric heating system)

Environmental benefits

A central heating ETS system is 100% electric. Since it replaces equipment that runs on fossil fuels, it protects the environment and reduces your greenhouse gas emissions, as electricity generated in Québec is 99% clean and renewable.

Flex D dynamic pricing: a further advantage

If you choose to install a central heating ETS system, we recommend signing up for Hydro Québec's new dynamic rate, Flex D, the registration period for which is from April 1 to November 20 each year. That could lead to major savings on your bill.

During winter:

Outside peak demand events, the price of electricity is below the base rate, which could mean considerable savings for you.

During peak demand events, electricity is billed at a higher rate (50¢/kWh). Since your central heating ETS system automatically turns off its heating

elements during these short periods, your overall electricity demand will be

greatly reduced.

The rest of the year:

Rate D (the base rate) will apply.

All about Rate Flex D (<https://www.hydroquebec.com/residential/customer-space/rates/rate-flex-d.html>).

21. Section 64 is replaced by the following:

“64. A borrower who receives financial assistance in the form of a bursary for each year of allocation during which he or she pursues a course of undergraduate studies at the university level leading to a degree, completes the studies within the number of sessions and years of study stipulated by the educational institution for completing the program as structured by the educational institution, and obtains official certification thereof is entitled, on application to the Minister and up to the amount established pursuant to sections 54 and 55, to a 15% reduction on the value of the guaranteed loans contracted to complete the program and, if applicable, on the value of the following guaranteed loans:

(1) loans contracted during his or her college studies in a course of studies leading to a diploma of college studies if he or she receives financial assistance in the form of a bursary for each year of allocation, completes the studies within the number of sessions and years of study stipulated by the educational institution for completing the program as structured by the educational institution, and obtains official certification thereof;

(2) loans contracted during his or her master’s or doctoral studies if he or she receives financial assistance in the form of a bursary, completes the studies within the number of sessions and years of study stipulated by the educational institution for completing the program as structured by the educational institution, and obtains official certification thereof.”

22. Section 74 is amended by replacing “\$260” and “\$129” in the second paragraph by “\$263” and “\$131”, respectively.

23. Section 74.2 is amended by inserting the following at the end:

“, and, for the 2021-2022 year of allocation, any income earned by the student through employment with an organization mentioned in the third paragraph of Schedule I.”.

24. Section 82 is amended by replacing “\$3,119” and “\$2,336” in the third paragraph by “\$3,158” and “\$2,365”, respectively.

25. Section 86 is amended

(1) by replacing, respectively, the amounts provided for in subparagraphs 1 to 3 of the first paragraph by the following amounts:

(1) “\$2.34”;

(2) “\$3.49”;

(3) “\$130.60”;

(2) by replacing “\$11.54” in the second paragraph by “\$11.69”.

26. Section 87.1 is amended by replacing “\$395” by “\$400”.

27. Section 94 is amended by replacing “less than 3 years” in the first paragraph by “5 years or less”.

28. Schedule I is amended by replacing the portion before subparagraph 1 of the third paragraph by the following:

“For the purposes of subparagraph 1 of the first paragraph, for the 2020-2021 year of allocation, employment income earned by the student during the period beginning on 13 March 2020 and ending on 31 August 2020 and, for the 2021-2022 year of allocation, employment income earned by the student during the period beginning on 1 January 2021 and ending on 31 May 2021, while employed with any of the following bodies is not taken into account:”.

29. This Regulation applies from the 2021-2022 year of allocation.

30. This Regulation comes into force on the fifteenth day following the date of its publication in the *Gazette officielle du Québec*.

105354

Gouvernement du Québec

O.C. 1412-2021, 3 November 2021

Act respecting the Ministère du Développement durable, de l’Environnement et des Parcs (chapter M-30.001)

Environment Quality Act (chapter Q-2)

Oil-fired heating appliances

Regulation respecting oil-fired heating appliances

WHEREAS, under subparagraph 1 of the first paragraph of section 95.1 of the Environment Quality Act (chapter Q-2), the Government may make regulations to classify contaminants and sources of contamination;

WHEREAS, under subparagraph 3 of the first paragraph of section 95.1 of the Act, the Government may make regulations to prohibit, limit and control sources of contamination and the release into the environment of any class of contaminants for all or part of the territory of Québec;

WHEREAS, under subparagraph 7 of the first paragraph of section 95.1 of the Act, the Government may make regulations to define environmental protection and quality standards for all or part of the territory of Québec;

WHEREAS, under subparagraph 21 of the first paragraph of section 95.1 of the Act, the Government may make regulations to prescribe the reports, documents and information that must be provided to the Minister by any person or municipality carrying on an activity governed by the Act or the regulations, determine their form and content and the conditions governing their preservation and sending;

WHEREAS, under subparagraph 29 of the first paragraph of section 95.1 of the Act, the Government may make regulations to prescribe any measure aimed at promoting the reduction of greenhouse gas emissions and require that climate change impact mitigation and adaptation measures be put in place;

WHEREAS, under section 115.27 of the Act, the Government may, in a regulation made under the Act, in particular specify that a failure to comply with the regulation may give rise to a monetary administrative penalty, and set forth the amounts;

WHEREAS, under the first paragraph of section 115.34 of the Act, the Government may in particular determine the regulatory provisions made under the Act whose contravention constitutes an offence and renders the offender liable to a fine the minimum and maximum amounts of which are set by the Government;

WHEREAS, under section 124.1 of the Act, no provision of a regulation, the coming into force of which is later than 9 November 1978, likely to affect the immovables comprised in a reserved area or in an agricultural zone established in accordance with the Act respecting the preservation of agricultural land and agricultural activities (chapter P-41.1) applies to that area or zone unless the regulation provides it expressly;

WHEREAS, under paragraph 8.1 of section 15.4 of the Act respecting the Ministère du Développement durable, de l'Environnement et des Parcs (chapter M-30.001), any other sum provided for by law or by a government regulation is credited to the Electrification and Climate Change Fund;

WHEREAS, in accordance with sections 10 and 11 of the Regulations Act (chapter R-18.1), a draft Regulation respecting oil heaters was published in Part 2 of the *Gazette officielle du Québec* of 21 April 2021 with a notice that it could be made by the Government on the expiry of 45 days following that publication;

WHEREAS it is expedient to make the Regulation with amendments;

IT IS ORDERED, therefore, on the recommendation of the Minister of the Environment and the Fight Against Climate Change:

THAT the Regulation respecting oil-fired heating appliances, attached to this Order in Council, be made.

YVES OUELLET
Clerk of the Conseil exécutif

Regulation respecting oil-fired heating appliances

Act respecting the Ministère du Développement durable, de l'Environnement et des Parcs (chapter M-30.001, s. 15.4, par. 8.1)

Environment Quality Act (chapter Q-2, s. 95.1, 1st par., subpars. 1, 3, 7, 21 and 29, ss. 115.27, 115.34 and 124.1)

DIVISION I OBJECT AND SCOPE

1. The objective of this Regulation is to reduce man-made greenhouse gas emissions attributable to domestic heating by gradually prohibiting the installation and repair of certain space and water heaters powered by certain forms of energy.

2. For the purposes of this Regulation, “residential building” means any building that meets the following requirements:

- (1) the building area is not more than 600 m²;
- (2) the building height is not more than 3 storeys;
- (3) the major occupancy of the building is Group C – Housing and it houses only dwellings.

A building is qualified as a residential building in accordance with the National Building Code of Canada 2015 (NRCC 56190) and the Code national du bâtiment

- Canada 2015 (CNRC 56190F), second printing, published by the National Research Council of Canada and prepared by the Canadian Commission on Building and Fire Codes. Subsequent amendments to those documents by that organization do not apply, except errata.

In addition, for the purposes of this Regulation,

(1) “existing residential building” means any residential building for which a building permit was issued before 31 December 2021 by the local municipality having jurisdiction in the territory in which the construction took place;

(2) “new residential building” means any residential building for which a building permit was issued on or after 31 December 2021 by the local municipality having jurisdiction in the territory in which the construction took place;

(3) “boiler” means pressure equipment equipped with a direct power source used to heat a heat-carrying liquid or transform it into steam;

(4) “water heater” means a pressure vessel equipped with a direct energy source in which water destined for exterior use is heated to a temperature of 99°C or less and to a pressure of 1,100 kPa or less. The heat source and control devices are an integral part of the water heater;

(5) “furnace” means a heating appliance that distributes heated air through a system integrated into a building;

(6) “Minister” means the Minister responsible for the administration of the Environment Quality Act (chapter Q-2).

3. Where this Regulation applies, it covers every immovable, including immovables in a reserved area and an agricultural zone established under the Act respecting the preservation of agricultural land and agricultural activities (chapter P-41.1).

DIVISION II PROHIBITIONS

4. This Division applies, to the extent provided for in that Division, to any residential building connected to a municipal or private electric power system governed by the Act respecting municipal and private electric power systems (chapter S-41), to the electric power system of the Coopérative régionale d’électricité de Saint-Jean-Baptiste de Rouville governed by the Act respecting the Coopérative

régionale d’électricité de Saint-Jean-Baptiste de Rouville and repealing the Act to promote rural electrification by means of electricity cooperatives (1986, chapter 21), or to the Hydro-Québec electric power distribution system when carrying on electric power transmission activities, except for residential buildings connected to an independent electric power distribution system.

5. As of 31 December 2021, it is prohibited to install, or have installed, boilers, furnaces and water heaters powered in whole or in part by oil in new residential buildings.

6. As of 31 December 2023, it is prohibited to install, or have installed, boilers, furnaces and water heaters powered in whole or in part by oil in existing residential buildings.

As of that same date, it is also prohibited to install, or have installed, boilers, furnaces and water heaters powered in whole or in part by fossil fuel for the purpose of replacing appliances powered in whole or in part by oil in existing residential buildings.

7. As of 31 December 2023, it is prohibited to repair, or have repaired, boilers, furnaces and water heaters powered in whole or in part by oil in existing residential buildings in the case of

(1) boilers and furnaces installed over 20 years before; and

(2) water heaters installed over 10 years before.

For the purposes of this Regulation, “repairs” means any work done on an appliance referred to in the first paragraph in order to refurbish it, except

(1) maintenance under Annex L of the most recent version of CSA Standard B139, Installation Code for Oil-Burning Equipment, published by the CSA Group;

(2) the repair or replacement of a motor of the appliance or a mobile component activated by that motor;

(3) the repair or replacement of an electronic or electrical component related to the operation and safety controls of the appliance.

Despite subparagraph 1 of the second paragraph, the repair and replacement of an appliance’s combustion chamber or heat exchanger are prohibited.

Nothing in this section prevents anyone from taking the measures necessary to stop the release of contaminants.

DIVISION III DECLARATION

8. Any person who installs, in a residential building, a boiler, furnace or water heater powered in whole or in part by oil, or a boiler, furnace or water heater powered in whole or in part by fossil fuel for the purpose of replacing appliances powered in whole or in part by oil, must, within 30 working days after the installation, send electronically to the Minister a declaration containing

- (1) their name, address and telephone number;
- (2) if applicable, the number of the licence issued to them under the Building Act (chapter B-1.1);
- (3) in respect of each appliance installed,
 - (a) the name, address and telephone number of the owner of the building where the appliance is located;
 - (b) the address of the building where the appliance is located;
 - (c) the date of installation;
 - (d) the type, brand and model; and
 - (e) the date of manufacture or serial number; and
- (4) a description of the procedure followed when removing the tank that supplied fuel to the appliance that was replaced, if applicable.

9. Any person who replaces, in a residential building, a boiler, furnace or water heater powered in whole or in part by oil with an appliance powered by a different form of energy must, within 30 working days after the replacement, send electronically to the Minister a declaration containing

- (1) their name, address and telephone number;
- (2) if applicable, the number of the licence issued to them under the Building Act (chapter B-1.1);
- (3) in respect of each appliance installed to replace another appliance powered in whole or in part by oil,
 - (a) the name, address and telephone number of the owner of the building where the appliance is located;
 - (b) the address of the building where the appliance is located;

(c) the date of installation; and

(d) the type and form of energy powering the appliance; and

(4) a description of the procedure followed when removing the tank that supplied fuel to the appliance that was replaced, if applicable.

DIVISION IV PENALTIES

§I. Monetary administrative penalties

10. A monetary administrative penalty of \$350 in the case of a natural person and \$1,500 in other cases may be imposed on any person who fails to send to the Minister a declaration containing the information prescribed or to comply with the time or terms and conditions of transmission, in contravention of section 8 or 9.

11. A monetary administrative penalty of \$1,500 in the case of a natural person and \$7,500 in other cases may be imposed on any person who

(1) installs, or has installed, in a new residential building, a boiler, furnace or water heater powered in whole or in part by oil, in contravention of section 5;

(2) installs, or has installed, in an existing residential building, a boiler, furnace or water heater powered in whole or in part by fossil fuel, in contravention of section 6;

(3) repairs, or has repaired, a boiler, furnace or water heater powered in whole or in part by oil, in contravention of section 7.

§II. Penal sanctions

12. Every person who contravenes section 8 or 9 is liable to a fine of \$2,000 to \$100,000 in the case of a natural person or \$6,000 to \$600,000 in other cases.

13. Every person who contravenes section 5, 6 or 7 is liable, in the case of a natural person, to a fine of \$8,000 to \$500,000 or, despite article 231 of the Code of Penal Procedure (chapter C-25.1), to a maximum term of imprisonment of 18 months, or to both the fine and imprisonment, or, in other cases, to a fine of \$24,000 to \$3,000,000.

§III. Common provision

14. The amounts from the imposition of monetary administrative penalties and from the fines paid pursuant to this Regulation are credited to the Electrification and Climate Change Fund established under section 15.1 of the Act respecting the Ministère du Développement durable, de l'Environnement et des Parcs (chapter M-30.001).

DIVISION V
FINAL

15. This Regulation comes into force on 31 December 2021.

105355



Ontario
Energy
Board | Commission
de l'énergie
de l'Ontario

February 28, 2019

Staff Research Paper:

Examination of Alternative Price Designs for the
Recovery of Global Adjustment Costs from Class B
Consumers in Ontario

EB-2016-0201

any given hour, the supply-shaped prototype distributes the costs for each technology individually based on the generation and GA cost contribution of that technology. While total generation in any given hour is strongly correlated with Ontario demand, the cost impact will not necessarily follow. The wide range of GA costs per unit of generation for different technologies as well as the intermittency of renewable generation (in the Supply – All variant) are primary drivers of this outcome.

For example, in Figure 33, the contribution to price is plotted for each hour over a 3-day high-demand period in the Supply – All variant alongside the Ontario demand during this period. In this illustration, although solar generation makes up a relatively small portion of the overall supply mix, solar costs have a strong influence on the supply-shaped price due to the fact that the proportion of solar costs in the total GA is higher than the proportion of solar generation in the supply mix and the fact that these costs are confined to the hours in which solar generators actually generate. As a result of these dynamics, the supply-shaped price is correlated to demand but not as strongly or directly as in the demand-shaped pricing prototype. The result is that lower relative prices are offered during high demand periods and higher relative prices are offered during low demand periods (compare price in high-demand hours 20 and 68 in Figure 33 with prices in lower-demand hours 13 and 62 respectively). This incentive for consumers to consume more during some periods of high demand leads to a positive consumer benefit.

Figure 33: Hourly price of the Supply - All variant of the supply-shaped pricing prototype over a three-day high-demand period.

