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Consumers Guide

HEATING, REFRIGERATION and AIR CONDITIONING INSTITUTE of CANADA

Heat Pumps

Consumer's Guide to Heat Pumps

When it comes to heating homes in Canada, the use of a heat pump is probably one of the best kept secrets. Widely used in Europe and Asia, a heat pump draws heat from the air or from the earth and transfers it into the home. While at first thought one might think there is little heat available from these sources in the dead of winter, the reality is that a modern heat pump system can draw enough heat to keep the average home warm even on the coldest day of winter and with little need for backup heating. This is because heat pumps do not rely on an energy forms, such as natural gas or oil, to provide heat. Given that, they can be tremendously energy efficient and economical to operate.

There are two basic categories of heat pumps – those that draw heat from the ground or water and those that draw heat from the air.

How do they Work?

An air-to-air heat pump looks and operates similar to an air conditioner. It does this by taking heat from the outside air, which is extracted via a refrigeration cycle, and distributing it through ductwork into the home just like a conventional furnace. Likewise, a ground source or geoexchange heat pump draws heat from the earth or a body of water and releases it into the home, also through heating ducts.

The operation of a heat pump is, in many ways, similar to your household refrigerator. If you put your hand behind your refrigerator while it is operating, the back of the refrigerator will be quite warm. This is because the unit's refrigeration compressor extracts heat from inside the refrigerator. In its simplest form, a heat pump pulls heat from the air, the ground or from a body of water and discards that heat into your home.

Most heat pumps have some form of backup heat for extra cold days when they cannot provide enough heat for the home, usually in the form of electric heating. Today's heat pumps can provide 75 percent of a home's heating needs. Additionally, the majority of heat pumps can reverse in the summer to provide cooling.

The problem, in Canada, is that the heating load is much higher than the cooling load. Therefore, while it would be possible to size a heat pump large enough to cover the home's entire heating requirements, it would be oversized for cooling. Of course, in regions where air conditioning isn't needed, this issue does not arise.

Air-to-Air Heat Pumps

Traditionally air-to-air heat pumps have been used in areas with warmer climates, such as the West Coast, because their heating capacity drops off substantially when outside temperatures drop below zero degrees.

However, this is no longer the case. Advanced technological development has allowed some state-of-the-art air source heat pumps to provide more than enough heat to keep a modern well insulated home comfortable at temperatures well below zero degrees Celsius, before the backup heat kicks in. As a result, heat pumps are now being used as far north as the Northwest Territories.

Developed in Asia and often referred to as "ductless mini-split" heat pumps, these new heat pumps use "inverter" compressor technology to pump 49 C (120 F) air, and at much lower outdoor temperatures than the conventional heat pump which pumps air at 36 C (98 F). Inverter technology is able to vary the output of the heat pump to match the needs of the home. This technology operates by using programmable "smart" controls which run almost continuously to maintain the home at a constant temperature; unlike conventional heat pumps which provide full output to bring a home up to the required temperature which when reached shuts down until the temperature drops enough to trigger the thermostat or electronic control to

turn on again. Unlike a conventional heat pump which distributes heated or cooled air through ducts, the ductless units distribute heated and cooled air through wall mounted free-air delivery units. There can be multiple units in a home.

Like an air conditioner, a heat pump consists of an indoor and an outdoor unit. Air source heat pumps can be either "add-on," "all-electric" or "bi-valent." Typically, they are powered by electricity, although there are a few natural gas fired heat pumps on the market.

Add-on heat pumps, as the name suggests, are designed to be used with another source of supplementary heat such as a gas, oil, propane or electric furnace.

Whereas an all-electric heat pump is self contained, with electric heating built-in. Developed in Canada, bi-valent heat pumps use a gas or propane fired burner to increase the temperature of the air entering the outdoor coil, allowing the unit to operate at colder temperatures.

Another relatively rare type of heat pump is the air-to-water heat pump. These are used in homes that use hot water (hydronic) heating. They extract heat from the air and transfer it into the water used for heating the home through radiators or in-floor heating.

Energy efficiency

Air-to-air heat pumps are rated for heating efficiency using a heating seasonal performance factor (HSPF) and cooling efficiency which is rated using a seasonal energy efficiency ratio (SEER). Efficiencies have improved enormously in recent years, as today's minimum heating efficiency is 6.7 HSPF and minimum cooling efficiency is 13 SEER. However, units are available with heating efficiencies up to 9 HSPF and cooling efficiencies up to 24.5 SEER.

The Heating, Refrigeration and Air Conditioning Institute of Canada in collaboration with Natural Resources Canada have developed an EnerGuide rating system for furnaces, central air conditioners and air-to-air heat pumps which will help homeowners compare the energy-efficiency of different models and brands available for sale in Canada. All a consumer has to do is look for the EnerGuide rating scale in the manufacturer's brochure.

Cooling in Summer

As noted previously, during the summer heat pumps operates in reverse, becoming air conditioners by removing heat and humidity from inside the home and rejecting it outside. This is one of the things that made even the older less efficient heat pumps attractive. For a modest premium above an air conditioner, a heat pump can provide cooling and also substantially reduce the heating bill by providing enough heat to keep the home comfortable during the fall, early winter and late winter into spring.

Defrosting the System

Like your refrigerator, an air-to-air heat pump must have a defrost cycle. When the outdoor temperature falls to near or below freezing, moisture in the air can freeze on the coil inside the outdoor unit. This reduces the ability of the unit to extract heat from the surrounding air and must be removed. There are two methods commonly used to shift the heat pump into defrost mode: "demand frost" and "time-temperature defrost."

Demand frost is generally the most efficient because it defrosts the heat pump only when required, whereas time temperature defrost initiates the defrost mode at regular timed intervals regardless of whether the heat pump is frosted up.

Ground source heat pumps

As mentioned previously, ground source or geoexchange heat pumps take heat from the ground or a body of water in the winter, which is then used to heat a home, and in the summer reverse the process by removing heat from the home and "rejecting" it into the ground or water. Ground source heat pumps are also referred to as earth-energy systems (EES's).

Despite the marked improvement in air-to-air heat pumps in recent years, ground source heat pumps tend to be more efficient because the underground temperature of the Earth tends to be more stable.

A ground source system should be able to cover about 75 percent of a home's heating needs, thus substantially reducing dependence on fossil fuels or electricity. In fact, ground source systems should pay for themselves in the form of saved energy costs within three to 10 years.

Like air-to-air heat pumps, they use forced air, hot water or electric heat as a backup. This is typically required only on the coldest days of the year.

Many ground source heat pumps are self-contained and include a blower, compressor, heat exchanger and condenser coil in one cabinet. However "split systems" which allow the heating/cooling coil to be added to the existing furnace, granted that the original furnace is retained for backup heating, are also available.

The total cost of installing a geothermal system varies depending on the site, but it typically runs about double the cost of installing a conventional furnace or boiler with air conditioning.

Installation considerations

Ground source heating/cooling is an area that requires specialized knowledge and equipment. As a result, the contractors that design and install these systems tend to specialize in geothermal installations.

In Canada, residential and commercial systems must be sized and installed according to minimum standards as set out in the Canadian Standards Association (CSA) C448 Standard for the Installation of Earth Energy Systems.

One of the most critical steps in installing a ground source system is to size and install the "ground loop" – piping in the ground. There are basically three types of piping systems which are commonly used: an open system, loop system and direct expansion (DX) geothermal system. An open system operates by drawing water into the heat pump from a body of water and then returning it to that body of water. Such systems are typically used when lakes, rivers or even wells are nearby.

More common is the closed loop system in which the heat pump circulates the heating/cooling fluid – usually an antifreeze mixture – through a continuous loop of piping buried in the ground. Heat is drawn from the ground and transferred to the heat pump through the heating/cooling fluid.

The length of the underground loop along with the ground conditions determines the heating and cooling capacity the system.

In new construction, the loop often runs horizontally below the frost line. In retrofits to existing homes, geothermal loops are more often installed vertically to minimize damage to landscaping and/or driveways. For a single-family home, installations have been done even in city neighbourhoods by drilling four holes up to 100 metres deep.

Getting the loop length correct is critical; if the loop is undersized it will not be able to produce as much heat as required which will result in the system operating on backup heat more often than it should.

The third type of system, which is becoming much more common, is the direct expansion geothermal system whereby refrigerant is circulated through the ground loop.

Ground source cooling

Like the air-to-air heat pump, cooling with a ground source heat pump is basically the same as the heating cycle, but in reverse. The direction of the refrigerant flow is reversed in the heat pump so that heat is transferred from the home back into the ground or lake.

Unlike air-to-air units, ground source heat pumps do not require a defrost cycle because the ground or water temperature is much more stable. As well, because most types of ground source heat pumps are located inside, they don't have the same issues with frost.

Adding hot water

It is relatively easy to use a ground source heat pump to create hot water for the home, in addition to heating, by adding a secondary heat exchanger which is sometimes referred to as a "desuperheater" to the system. The secondary heat exchanger operates by extracting heat from the refrigerant in the system after it leaves the heat pump's compressor. Water from the home's hot water heater is pumped through a coil in the heat pump so that some of the heat can be conserved before it dissipates. In both the cooling and heating modes there is always heat available as long as the heat pump is not working at full capacity to fulfill the home's heating needs.

Operating a Heat Pump

For the homeowner, operating a heat pump is similar to operating a furnace. The thermostat or programmable electronic control is set at a comfortable level, 20 C is a good starting point, and adjusted up or down until the homeowner finds their preferred comfort level. Once established, it is left there. If there is a setting for the fan, generally leaving it in the "auto" mode will result in the best performance.

Additionally, the ductless mini-split systems often comes with a remote control so that room occupants can easily adjust the system if needed.

Compared to a furnace, the homeowner will notice that heat pumps tend to run longer because their heat output is lower. However, today's high efficiency electric motors keep electricity consumption to a minimum.

Maintenance is similar to a furnace as homeowners need to check and replace filters periodically. As with a conventional furnace, a contractor should be called in once a year to do an annual maintenance check-up on the system.

Choosing a contractor

Prior to installation, choosing the right contractor is a critical step. As noted, heat pumps require specialized knowledge for both correct design and installation. A good contractor will make a detailed analysis of your home. They will talk to you about your needs, your concerns with the previous system and make recommendations for the correct type of heat pump for your home.

While getting several quotes is a wise strategy, it is important to ensure that those quotes are equivalent. Ask for a written quote that details the equipment that the contractor intends to install, warranties and safe disposal of the old equipment. A lower bid may mean substandard equipment which could impact your comfort and efficiency needs or, even worse, it may indicate a lack of practical training and experience in installing heat pumps.

Consider consulting a member contractor of the Heating, Refrigeration and Air Conditioning Institute of Canada (HRAI). HRAI Contractors Division members are required to carry relevant trade and municipal licensing, liability insurance, workers' compensation and must adhere to a code of ethics that includes developing and maintaining an understanding of proper equipment selection. For more information, visit www.hrai.ca and click on "contractors." The "Contractor Locator" on this site will help you find pre-screened contractors in your area.