Heat Pumps

September 2005

Better By Nature

Consumers Guide – A Home Heating & cooling option

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If you are considering heating and cooling options for your home or looking for ways to reduce your energy bills, you should consider a heat pump. Despite its name, heat pumps are unique appliances that provide both cooling in the summer and heating in the winter. Heat pumps are not new; the first unit came off the production line more than three decades ago.

WHAT IS A HEAT PUMP?

In size and appearance, a heat pump looks like a central air conditioner. A heat pump takes the place of both furnace (with a supplementary heating system) and central air conditioning equipment with a single heating-cooling system. This appliance can pump heat into the home in the winter and pump heat out of the home in the summer. Heat pumps are typically operated electrically. However, a limited number of gas-fired heat pumps are available in Canada. Some types can also provide supplementary hot water heating.

TYPES OF HEAT PUMPS

There are two main types of heat pumps: air-source and ground source (also referred to as an earth-energy system). The only difference between the two types is the place or 'source' to where heat is either taken from or moved to, in the heat pump operation (for example, the air or the ground). You should consult with your contractor to determine which type of heat pump would best meet your needs.

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HOW DOES IT WORK?

Heat pumps transfer heat from natural heat sources in the surroundings, such as the air, ground or water to the home. In cooling, a heat pump transfers heat in the opposite direction, from home to the surrounding air, ground or water.

ENERGY EFFICIENCY

Choosing a heat pump not only provides the desired space cooling, it is also an effective way to reduce heating energy costs. In addition, choosing a high-efficiency heat pump over a lower-efficiency heat pump can save you even more money and energy.
Selecting an energy-efficient heat pump is now made easy. EnerGuide has developed a rating system for heating and cooling equipment called the EnerGuide Rating System. The rating for the cooling mode, found on the back of manufacturers brochures, is designed to help you make an informed choice when buying a heat pump. We recommend that you refer to the Heating Seasonal Performance Factor (HSPF) for the heating mode found in manufacturers' brochures.

The Energy efficiency of heat pumps is measured on three different scales depending on the type of unit. The coefficient of performance (COP) measures heating (winter) efficiency at a specific condition and the typical scale ranges from 2.5 to 4.0. The heating seasonal performance factor (HSPF) measures heating (winter) efficiency over the heating season and the typical scale ranges from 5.9 to 8.8. The seasonal energy efficiency ratio (SEER) measures cooling (summer) efficiency and the typical scale ranges from 10 to 16. Air source heat pumps are rated in COP and EER. In each case, the higher the number, the more energy efficient the heat pump.

ENERGY STAR

ENERGY STAR is an international symbol that stands for high energy efficiency. It is designed to help consumers quickly identify products that save energy.

Heating and cooling accounts for nearly half of the energy you use in your home. And because your heating and cooling equipment lasts more than 10 years, the choice you make today to add or replace a system will affect your utility bills and your wallet for years to come. Using less energy also helps conserve our precious non-renewable natural resources and will also produce fewer emissions, including carbon dioxide (CO_2), that contribute to climate change.

ENERGY STAR designated heating and cooling equipment, when properly designed and installed, can save consumers 15 percent or more on heating and cooling bills each year, depending on where you live and how much you pay for your energy source. Either way, energy savings will often pay for themselves over the life of the equipment.

An ENERGY STAR qualified air-to-air heat pump has the following requirements:

- Must have a seasonal energy efficiency ratio (SEER) of 12 or more
- and a heating seasonal performance factor (HSPF) of 7 or more.

Manufacturers place the ENERGY STAR logo on those models that have demonstrated they meet or exceed the ENERGY STAR energy-efficiency criteria. Today, most leading manufacturers of home heating and cooling equipment are producing high-efficiency systems that qualify for the ENERGY STAR logo.

Usually, you can locate the ENERGY STAR logo on the back of the manufacturers' brochures, beside the EnerGuide rating box. Use the EnerGuide rating to determine the SEER and HSPF ratings and locate the ENERGY STAR logo to ensure you have the most efficient product available.

When looking for a high efficiency air-to-air heat pump a homeowner

should also consider an ENERGY STAR **programmable thermostat.** These thermostats have four daily settings, weekend/day settings, and other energy comfort features. They automatically adjust the temperature to the comfort setting you choose: lowering it while you are away at work and raising it for when you are at home with flexibility for weekend use.

You may be able to reduce your heating costs up to 50 per cent if you convert an electric furnace to an all-electric air-source heat pump. Your actual savings will vary depending on factors such as local climate, the efficiency of your current heating system, the cost of fuel and electricity, and the size and HSPF of the heat pump installed.

More advanced designs of air-source heat pumps are able to provide domestic water heating. Such systems are called 'integrated' units because heating of domestic water has been integrated with a house space-conditioning system. Hot water heating can be provided with high-efficiency in this way. Water heating bills can be reduced by 25 to 50 per cent.

SUPPLEMENTARY HEATING SYSTEMS

Because the performance of some types of heat pump decreases during the colder portions of Canadian winters (there is less natural heat from the heat pump to source), most heat pump installations have a supplementary heating system (also referred to as a back-up or auxiliary heat). This may be a gas or oil furnace or an electric heater installed in the system.

DETERMINING THE PROPER SIZE HEAT PUMP

It is most important that the heat pump (and supplementary heating where required) for your home is the proper size to provide enough heat on the coldest winter night and enough cooling on the hottest summer day. To accomplish this, your installing contractor should perform a "heat loss/heat gain" calculation for your home. Be sure to request this as a part of your purchase process.

MAINTENANCE

Like any piece of mechanical equipment, heat pumps require regular maintenance. To ensure that your heat pump operates efficiently and has a long life, it is recommended that you have a qualified contractor do an annual inspection of your unit. The best time to service your unit is at the end of the cooling season, prior to the start of the next heating season.

You can do some of the simple maintenance yourself, but you may also want to have a competent service contractor do an annual inspection of your unit.

- *Filter and coil* maintenance has a dramatic impact on system performance and service life. Dirty filters, coils, and fans reduce airflow through the system. This reduces system performance, and can lead to compressor damage if it continues for extended periods of time.
- Filters should be inspected monthly and cleaned or replaced as required by the manufacturer's instructions. The coils should be vacuumed or brushed clean at regular intervals as indicated in the manufacturer's instruction booklet. The outdoor coil may be cleaned using a garden hose.

ENVIRONMENTALLY BENEFICIAL

Heat pumps benefit the environment by using the heat in the surrounding air, water and ground to warm your home. Even in the winter, the outside air, water and ground still contains heat, which can be used to heat your house. The sun continually replenishes these heat sources; therefore, the extracted heat is renewable energy as compared to heat that must be produced from fuels or electricity.

CERTIFICATION AND STANDARDS

All heat pumps must be certified for safety and performance by a government recognized certification agency. The Canadian Standards Association (CSA), the Air Conditioning & Refrigeration Institute (ARI) and United Laboratories Canada (ULC) currently verify heat pumps for electrical safety and efficiency. Look for the certification marks of these organizations on the unit or in the product literature.

AIR SOURCE HEAT PUMPS

Air source heat pumps draw heat from the outside air during the heating season and 'dump' heat outside during the summer cooling season.

There are two types of air-source heat pumps. The most common is the *air-*

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to-air heat pump. It extracts heat from the air and transfers it to either inside or outside your home, depending on the season.

The other type is the *air-to-water* heat pump, which is used in homes with hydronic heat distribution systems. During the heating season, the heat pump takes heat from the outside air and transfers it to the water in the hydronic distribution system. If cooling is provided, the process is reversed during the summer: the heat pump extracts heat from the water in the home's distribution system and 'pumps' it outside to cool the house. These systems are still quite rare, and many don't provide cooling; therefore, most of the following discussion focuses on air-to-air systems.

More recently, ductless minisplit heat pumps have been introduced to the Canadian market. They are ideal for retrofit to homes with hydronic or electric-resistance baseboard heating. They are wall-mounted, free air delivery units which can be installed in individual rooms of a house. Up to three separate indoor wall-mounted units can be served by one outdoor section.

Air-source heat pumps can be either *add-on, all-electric, or bi-valent*. Add-on heat pumps are designed to be used with another source of supplementary heat, such as an oil, gas or electric furnace. All-electric air-source heat pumps come equipped with their own supplementary heating system in the form of electric-resistance heaters. Bi-valent heat pumps are a special type, developed in Canada that use a gas or propane-fired burner to increase the temperature of the air entering the outdoor coil. This allows these units to operate at lower outdoor temperatures.

Air-source heat pumps are also used in some home ventilation systems to recover heat from outgoing stale air and transfer it to incoming fresh air or to the domestic hot water.

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 dumps it outside.

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 build-up depends on the outdoor temperature and the amount of moisture in the air. This frost build-up 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 will switch into the defrost mode. One of two methods is used to determine when the unit goes into defrost mode.

Demand-frost controls monitor air flow, refrigerant pressure, air or coil temperature, and pressure differential across the outdoor coil to detect frost accumulation on the outdoor coil.

Time-temperature defrost is started and ended by a preset 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.

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INSTALLATION CONSIDERATIONS

- For any natural gas, oil, or wood furnace, the heat pump coil should be installed on the warm (downstream) side of the furnace.
- If a heat pump is added to an electric furnace, the heat pump coil can usually be placed on the cold (upstream) side of the furnace for greatest efficiency.
- The outdoor unit should be protected from high winds, which may reduce efficiency by causing defrost problems. At the same time, it should be placed so that outdoor air is not recirculated over the coil.
- To prevent snow from blocking airflow over the coil and to permit defrost water drainage, the unit should be placed on a stand that raises it 30 to 60 cm (12 to 24 in.) above the ground. The stand should be anchored to a concrete pad, which in turn should sit on a bed of gravel to enhance drainage. Alternatively, the unit might be mounted from the wall of the house on a suitably constructed frame.
- It may be advisable to locate the heat pump outside the drip-line of the house (the area where water drips off the roof) to prevent ice and water from falling on it, which could reduce airflow or cause fan or motor damage.
- Ductwork must be installed in homes that don't have an existing air distribution system. Heat pump systems generally require larger duct sizes than other central heating systems, so existing ducting may have to be modified.
- The cost of installing an air-source heat pump varies depending on the type of system and the existing heating equipment. Costs will be higher if the ductwork has to be modified or if you need to upgrade your electrical service to deal with the increased electrical load.

OPERATION CONSIDERATIONS

The indoor thermostat should be set at the desired comfort temperature (20 degrees C) and not readjusted.

Continuous indoor fan operation can degrade heat pump performance unless a high-efficiency variable-speed fan motor is used. Operate the system on the 'auto' fan setting on the thermostat.

Heat pumps have longer operating times than conventional furnaces because their heating capacity is considerably lower.

GROUND SOURCE HEAT PUMPS (EARTH-ENERGY SYSTEMS

A ground source heat pump uses the earth or ground water or both as a source of heat in the winter, and as the 'sink' for heat removed from the home in the summer. For this reason, ground source heat pump systems have come to be known as earth-energy systems (EESs). Heat is removed from the earth through a liquid, such as ground water or an antifreeze solution, upgraded by the heat pump, and transferred to indoor air. During summer months, the process is reversed: heat is extracted from indoor air and transferred to the earth through the ground water or antifreeze solution. A direct-expansion (DX) earth energy system uses refrigerant in the ground heat exchanger, instead of an antifreeze solution.

Earth-energy systems are available for use with both forced-air and hydronic heating systems.

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HOW THEY WORK

Geothermal heating and cooling systems (also called earth-energy systems, ground source heat pumps or GeoExchange SM systems) are heat pumps that collect and transfer heat from the earth through a series of fluid-filled, buried pipes running to a building, where the heat is then concentrated for inside use. Ground source heat pumps do not create heat through combustion --- they simply move heat from one place to another.

Heat pumps also operate in reverse to cool a home by transferring the heat out of the house, where the cooler ground absorbs the excess heat. The system is appealing because a single system can be used for both heating and cooling, thus eliminating the need for separate furnace and air conditioning systems.

Ground source heat pumps offer a different kind of heating. Unlike conventional forced-air furnaces, geothermal units offer a steady heat.

INSTALLATION CONSIDERATIONS

As with air-source heat pump systems, EESs 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 C445, an installation standard set by the Canadian Standards Association.

The total installed cost of earth-energy systems varies according to site-specific conditions, but can be up to twice the cost of a gas, electric or oil furnace with add-on air conditioning. The total installed costs of open or ground water EESs can be less; the extra cost is due to ground collectors, whether they are open or closed loop. Ductwork must be installed in homes without an existing air distribution system. The difficulty of installing ductwork will vary, and should be assessed by a contractor.

BENEFITS OF EARTH-ENERGY SYSTEMS

Energy savings

Earth-energy systems will reduce your heating and cooling costs substantially. Energy-cost savings compared with electric furnaces are around 65 per cent.

On average, an EES will yield savings that are about 40 per cent more than would be provided by an air-source heat pump. This is due to the fact that underground temperatures are higher in winter than air temperatures. As a result, an EES 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, and its coefficient of performance at CSA rating conditions.

Domestic Hot Water Heating

EESs also provide savings in domestic hot water costs. Some have a desuperheater that uses some of the heat collected to preheat hot water; newer designs can automatically switch over to heat hot water on demand. These features can reduce your water heating bill by 25 to 50 per cent.

Maintenance

EESs require little maintenance on your part. Required maintenance should be carried out by a competent service contractor, who should inspect your unit once a year.

- As with air-source heat pumps, *filter* and *coil* maintenance has a dramatic impact on system performance and service life. A dirty filter, coil, or fan can reduce air flow through the system. This will reduce system performance and can lead to compressor damage if it continues for extended periods of time.

Operating Costs

The operating costs of an earth-energy 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 that a particular earth-energy system would use.

However, the 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.

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.

Conventional Thermostats

Most residential 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 preset level. Stage two calls for heat from the supplementary heating system if the indoor temperature continues to fall below the desired temperature.

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 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 setback 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.

Electronic 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 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.

Setback savings of 10 per cent are possible, with one setback period of eight hours each day in most Canadian locations. Two such periods per day can result in savings of 15 to 20 per cent.