Heat Pumps Q&A

What is a heat pump?

- an electrically-powered mechanical device that transfers heat from the energy contained in the outside air or the ground to the interior of the home

- they usually provide a more efficient way to use the hydro resources than electric resistance heating because for each kilowatt-hour of electricity that is used to transfer heat, up to four, or even more kilowatt hours of heat energy may be delivered to the house

Two main kinds of heat pumps are used for space heating:

- **air-source** heat pumps transfer heat energy from the outside air to the house
- **ground-source** heat pumps transfer heat energy from the ground to the house. There are two kinds of ground-source heat pumps:
    - *open loop systems* transfer heat from water in wells or in ponds, then the used water is discharged to a stream, pond, ditch, drainage tile, river or lake
    - *closed loop systems* transfer heat from the soil using a continuous loop of buried pipe. While an open system drains water

Understanding COPs

The ratio of heat energy output to electrical energy input is called the coefficient of performance, or COP. For example if your heat pump delivers 3.4 kilowatt-hours of heat to your home for every kilowatt-hour of electricity that it takes to run the heat pump, then your heat pump's COP is 3.4.

The COP of air-source heat pumps varies much more than is the case for ground-source heat pumps because the temperature of air varies much more than the temperature of the ground. For example, while air temperature in the Yukon can easily vary by 60°C annually, a 7-winter study of ground temperatures in the Whitehorse area showed ground temperatures varying by at most only 14°C over the winter, at approximately 3 metres below surface, with the maximum temperature being about 9°C and the minimum being about -6°C.

As a result, ground-source heat pump COPs remain fairly constant within a range of 2.5 to 3.8.

For air-source heat pumps, the COP varies with the outside air temperature. For example at 10°C the COP for a typical conventional air-source heat pump could be about 3.3. At -8.3°C, the COP for the same heat pump could be 2.3 and at -15°C, the COP could be 1. Cold climate air-source heat pumps have higher COPs than do conventional air-source heat pumps for a given outside temperature.

Keep in mind that for both air-source and ground-source heat pumps, the actual COPs measured in the field are rarely as high as the manufacturers' claimed COPs. However, the COPs can still be valuable for comparing the relative performance of different heat pumps.

from a well, a closed loop system circulates its heat transfer solution in pressurized pipe.

How well do heat pumps work in the Yukon's climate?

There are not very many heat pumps installed in the Yukon at this time, however experience from across Canada and colder regions of the U.S.A. leads to the following assumptions:

- **ground-source** heat pumps that are well-designed and installed should work well in the Yukon because ground temperatures remain relatively warm throughout the winter compared to air temperatures

- **air-source** heat pumps' ability to extract heat from the air diminishes as the outdoor air temperature decreases. Current research results show that only heat pumps with a COP of 2 or more at -18°C should be considered for the Yukon. Longer hours of heat pump operation may impact on reliability and compressor life. Installation of properly sized start up and running capacitors on a heat pump compressor motor will improve the operation of the heat pump and help to extend the compressor motor life.

Heat Pump Characterization Study

(for air-source heat pumps in the Yukon)

The Heat Pump Characterization Study gives an overview of air-source heat pump topics relevant to the Yukon, such as:

- recent technology developments including different types of air-source heat pumps, scroll compressors and air-source heat pumps on heat recovery ventilators
- economic estimates of the cost of heating with air-source heat pumps in the Yukon compared to heating with oil and electric heat
- a recommended sizing approach for air-source heat pumps in cold climates
- recommended efficiency specifications for the Yukon
- other topics specific to cold climates.

This March 2010 study was prepared for the Energy Solutions Centre by Caneta Research Inc. Copies are available at the Energy Solutions Centre or at the following web address: http://www.esc.gov.yk.ca/pdf/yukon_airsource_heatpump_mar_2010.pdf

How much do heat pump systems cost to install and maintain in the Yukon?

- **Residential-scale air-source** heat pumps range from approximately $8,000 to $15,000 for materials and installation

    - the cost varies based on the type and size of heat pump (cold climate heat pumps tend to be more expensive because there are fewer of them

manufactured and they are more complex machines having either variable speed compressors, two-stage compressors, or the ability to operate at higher pressures than regular heat pumps). A reasonable approach to choosing the right sized air-source heat pump is to select one with a heating capacity at -18°C of 25 to 35% of the home's design heating load. A heat pump of this size would supply approximately 60 to 75% of the annual heating load.

- air-source heat pumps tend to be most economic when the existing heating cost is over $4,000 per year.
- at current electricity and heating prices in the Yukon, an air-source heat pump will usually have a payback of under six years, if the cost of installation is less than three times the annual heating cost. This could change as energy prices change.

- **Residential-scale ground-source** heat pumps range can from $25,000 to $70,000 for materials and installation for typical homes.
  - the cost varies based on the size of the heat transfer loop, whether the system is installed at the time of house construction or added later, and whether or not a soil thermal recharge system (a system to add heat to the ground in the summer), such as a solar thermal system is installed.

- **Back-up heating systems** are necessary with air-source heat pumps and highly recommended for ground-source heat pumps, so the cost of the back-up heating system may need to be considered. Note that a back-up heating system is recommended for any home in the Yukon in order to provide extra heat during the coldest weather while allowing the primary heating system to be sized to operate efficiently for most of the heating season. In the Yukon, oversizing of heating systems so that they can meet all of the home's heating requirements, even during

The Impact of Heat Pump Use on the Yukon's Electrical Supply

If every Yukon home switched to heating with a heat pump, we could have to increase our renewable generation capacity by as much as 50%, in order to meet our electrical requirements without increasing the use of the utility's diesel generators.

On the other hand, there is the possibility that if enough Yukoners used heat pump systems in synchronicity with the demand cycle of the grid then we could make better use of our existing hydro resources. In other words, if homeowners used their heat pumps during the milder parts of the winter, the shoulder seasons and the summer and then switched to their back up heating systems during the coldest parts of the winter, this would have the dual benefits of better optimizing the use of our hydro resources and reducing the Yukon's total fossil fuel consumption.

Of course, matching individual homeowners' heat pump usage to hydro supply could be a complex task for the electrical utilities and would involve specific demand side management policies and technologies.

the coldest weather, has been a problem that can lead to heating systems working inefficiently most of the heating season.

Who is qualified to install and maintain heat pump systems?

- Anyone trained and certified by a heat pump manufacturer is qualified and would receive technical support from the manufacturer.

- Qualified heat pump installers should be accredited by regional associations such as the Manitoba Geothermal Energy Alliance or the B.C. GeoExchange Coalition, or national and international organizations such as the International Ground Source Heat Pump Association (IGSHPA) or the Canadian GeoExchange Coalition (CGC). However, keep in mind that the training courses for installers provided by the IGSHPA and the CGC are only a few days in length and do not, on their own, qualify a company to size and install a system. The company should also have staff with appropriate trades' backgrounds.

Are heat pumps the best heating choice for my home?

There are **three steps** that the Energy Solutions Centre recommends you take whenever you consider a new heating system:

- **Step 1**. Reduce your home's heating requirements by sealing, insulating and ventilating efficiently. To help with this step you can have a home energy evaluation done to direct your energy retrofitting efforts towards the most cost-effective projects. The staff at Yukon Housing can help you find a qualified home energy evaluator.

- **Step 2**. Have a heat loss calculation done on your home after you complete the retrofitting so that you know how much heat any heating system will need to provide to your home. Proper sizing of the equipment is crucial to its efficient operation, and can save you money immediately by ensuring that your equipment is not oversized. Energy evaluators can provide this calculation for you as part of a post-retrofit energy evaluation.

- **Step 3**. Finally, when comparing the costs of heating systems, compare the total cost of the heating systems over their lifetimes. The total cost equals the initial purchase and installation price plus the system's life-long operation, fuel and maintenance costs adjusted for interest on the money that is spent. Remember that the economic costs are only a part of the price picture. There are also different environmental, social and health costs associated with different heating systems. The staff at the Energy Solutions Centre can help you identify and explore the values of these non-economic costs.