

## Applications of Heat Pumps in Alaska

A recent report published by the Alaska Center for Energy and Power and the Cold Climate Housing Research Center indicate that there are 49 reported residential and six commercial installations of heat pumps — both ground-source and water-source (seawater) — throughout the state, with the majority being horizontal systems. Most reported an operating efficiency in the normal ranges and high customer satisfaction. Proper design coupled with professional installation is a big predictor of success with these systems. However, only 13 installers and very few designers and drilling professionals have been identified in Alaska.

Preliminary economic analysis shows that GSHPs are economically successful in areas where the cost of electricity, which runs the pump, is low and the cost of fuel is high. The most successful installations are in Southeast Alaska, where hydropower plants typically keep electric costs lower than average, but where heating oil costs are high. In Anchorage, which benefits from the relatively low cost of natural gas, or a remote village like Bethel, with high electric costs, GSHPs cannot compete with traditional heating systems.



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# Case Study: Alaska SeaLife Center

The Alaska SeaLife Center is Alaska's only public aquarium, located on the shores of Resurrection Bay. With recent escalations in heating oil costs, the SeaLife Center is motivated to reduce its monthly operational expenses by considering heat production methods that are more cost effective than direct use of heating oil. In addition, the SeaLife Center is interested in reducing its current production of greenhouse gas (CO<sub>2</sub>) as part of the greater mission to preserve and protect the fragile marine environment of Alaska.



Heat pump units installed and ready for connections. Photo courtesy of Randy Stouffer, ASLC



To accomplish these goals, the SeaLife Center is installing two GSHPs that use seawater under the Emerging Energy Technology Grant program, funded by the Denali Commission and the State of Alaska Renewable Energy Fund program. Although it has been successfully deployed in Europe, this innovative process of removing latent heat from seawater and using it to heat buildings is an emerging technology in Alaska. The seawater heat pump required for this process is not an "off-the-shelf" or conventional heat pump. While conventional heat pumps typically lift heat from water sources at 45° to 55°F, seawater heat pumps lift heat from lower temperatures, requiring more innovative compressor technology.

This project is scheduled to be completed by June 2011 and has a total project budget of approximately \$850,000. An initial feasibility study showed that two heat pump units could supply about 38% of the total heating load for the SeaLife Center and have a payback period of 10 years.

For more information about heat pumps in Alaska, please contact Jason Meyer, Alaska Center for Energy and Power, 907-272-1520, or [jason.meyer@alaska.edu](mailto:jason.meyer@alaska.edu).



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## Ground Source Heat Pumps in Alaska



Technicians prepare to install "slinky coils," a type of horizontal closed-loop system, at Weller Elementary School in Fairbanks. Photo courtesy CCHRC



Weller Elementary School, Fairbanks. Photo courtesy CCHRC

Heat pump technology is used widely in the Lower 48 and around the globe; however, there are limited installations in cold climates. While little is known about the effectiveness of this technology in Alaska, given the high heating costs statewide it is worth investigating to determine if it makes technical and economic sense.

### What is a heat pump?

A heat pump is a device that forces the movement of heat from a low-temperature substance to a higher-temperature medium. A ground-source heat pump (GSHP) transfers energy to and from a ground or water source to provide heating and/or cooling. The GSHP is considered a partially renewable energy technology because, while it accesses solar and geothermal energy, it requires electricity to operate. A heat pump is considered a fully renewable technology only if the generation source of electricity is also derived from a renewable resource.

The GSHP is a mature technology with widespread implementation across the United States for space heating and cooling, but it is currently an uncommon method of space heating in Alaska. However, there have been several high-profile installations in Alaska recently, indicating a broader interest in exploring this alternative space heating method.



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## How a GSHP works

A GSHP system is typically composed of three parts:

1. Ground loop — tubing filled with a circulating fluid that passes through a ground or water source to accept the energy.
2. Heat pump — the mechanical system that allows for the extraction of energy from the ground loop fluid.
3. Heat distribution system — the system that distributes heat throughout the home or building.

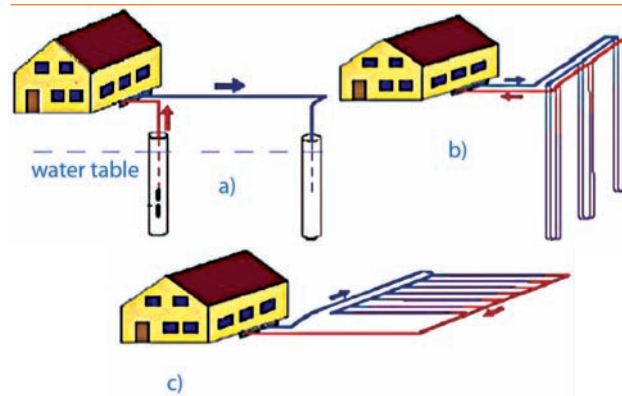
In cold climates, heat flows from a low-temperature source (approximately 32° to 45°F), such as water or soil, to a lower-temperature refrigerant fluid via a ground heat exchanger (15° to 30°F). This heat transfer causes the refrigerant to evaporate. The gaseous refrigerant is then compressed by the heat pump, forcing the temperature and pressure to increase to a useful range. The high-temperature gas passes through a condenser to transfer its heat to the heat distribution system. This heat extraction causes the refrigerant to return to a liquid. The refrigerant then passes through an expansion valve, where it is further cooled by depressurization, allowing the cycle to repeat.

### Can a heat pump work in cold climates like Alaska?

The process may seem counterintuitive based on the common notion that soil or water at a temperature below 32°F cannot provide useful energy or serve to heat a structure. However, material contains energy until it reaches absolute zero at -460°F. So, for a given material at 32°F energy can still be extracted if there is a sufficient temperature difference between the ground and the heat pump refrigerant. Care must be taken to ensure that the pump is accurately sized, designed and operated so that it does not freeze the ground as it pumps heat into the facility.

**Did you know?** A residential refrigerator is a heat pump! The refrigerator moves heat inside the unit to the outside by the same process outlined above. In this instance, the interior space of the refrigerator is the heat source. This process can be scaled and configured to provide sufficient heating or cooling for a variety of applications.

### Ground-loop configurations for heat sources a) open-loop borehole, b) closed-loop vertical, c) closed-loop horizontal (Omer, 2006)



There are several configurations possible for closed-loop systems; the two most common are vertical borehole loops and horizontal loops. Horizontal ground loops are typically installed from 6 to 12 feet below the ground surface, depending on the local frost depth and the water table. The pipe can be laid in trenches or pits in a linear pattern, or coiled in “slinky” loops that create overlapping layers. Lake loops are cheaper to install and require shorter overall piping lengths, but they may require permits from regulatory agencies.

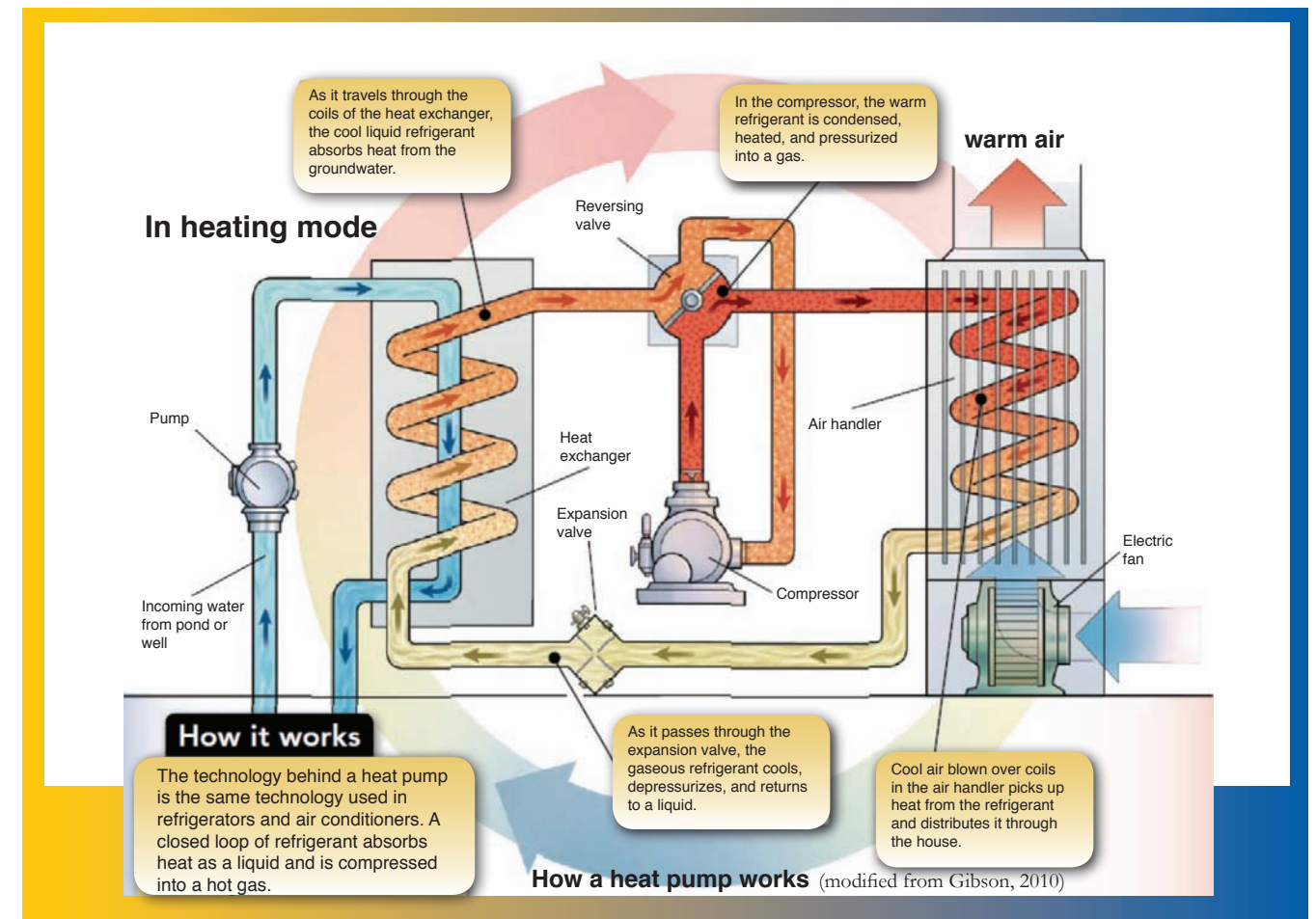
## Heat Sources and Systems

The source of heat for a heat pump depends on local resources and climatic conditions. Typically, the choice is between ground, water or air.

### Ground-Source Heat Pumps

**Open-Loop System.** Water from a surface water source (ocean, lake, river) or groundwater is pumped through the heat exchanger and then discharged to the same or a different water body. These systems can be cheaper than closed-loop systems because there is less work involved in installation. They can also have a comparable or higher efficiency than a closed-loop system. However, local codes and regulations regarding groundwater discharge must be met. Consistency of the water supply in terms of quantity and quality are crucial to ensure uninterrupted heat pump operation and long service life. In cold climates they are further limited because freezing temperatures can make the source unavailable or cause pipes to freeze.

For more information: [www.uaf.edu/acep](http://www.uaf.edu/acep)



**Closed-Loop System.** This system is made from a pipe loop located in the ground or a water body. A fluid with a low freezing temperature, such as a glycol-water solution, is circulated in this loop. These systems are more costly than open-loop types because they require expensive excavation or drilling. However, they are the most common systems because they don't have the limitations of open-loop systems mentioned above. Closed-loop systems reduce the risk of freeze-up and are virtually maintenance free. However, these loops are more susceptible to damage and have a potential to contaminate water bodies if they release the fluid from the loop.

### Air-Source Heat Pumps

These heat pump units are relatively simple, cheap and easy to install. However, air-source heat pumps commonly have lower efficiencies than ground-source or water-source heat pumps in cold climates due to the low

air temperatures during heating demand. There are also some serious technical limitations that reduce efficiency, such as icing of the heat exchanger, which requires defrosting, and operation in snowy conditions.



The Alaska Center for Energy and Power and the Cold Climate Housing Research Center have recently completed a comprehensive report investigating the viability of GSHPs in cold climates and the current installations in Alaska. *Ground-Source Heat Pumps in Cold Climates* was published in May 2011 and can be found online at [www.uaf.edu/files/acep/Ground-Source-Heat-Pumps-in-Cold-Climates.pdf](http://www.uaf.edu/files/acep/Ground-Source-Heat-Pumps-in-Cold-Climates.pdf).