



Geothermal Heat Pumps 101

As energy costs continue to rise and pollution concerns continue to be a hot topic, a geothermal system could be a solution.

A geothermal heat pump uses the earth as either a heat source, when operating in heating mode, or a heat sink, when operating in cooling mode. It uses the ground's available heat in the winter and puts heat back into the ground in the summer. It transfers heat, while a conventional furnace or boiler produces heat.

Geothermal systems operate based on the stability of underground temperatures; the ground a few feet below surface has a very stable temperature throughout the year, depending upon the location's annual climate. Geothermal heat pumps, or "geo-exchange" and "ground-source heat pumps," can be used in almost any region, but should be distinguished from geothermal heating. Geothermal heating is used in areas where exceptionally high underground temperatures, such as hot springs and steam vents are used to heat indoor spaces without the use of a heat pump.

The most common use of geothermal heat pumps focuses on the use of water to exchange heat with the ground, often referred to as "water-source geothermal heat pumps" or "water loop geothermal heat pumps."

In a single loop system, the copper tubing refrigerant loop actually leaves the heat pump appliance

cabinet and goes out of the house, underground to directly exchange heat with the ground before returning to the appliance, hence the name "direct exchange" (DX).

In a double loop system, the refrigerant loop exchanges heat with a secondary loop made of plastic pipe containing water and anti-freeze. After leaving the heat exchanger, the plastic pipe leaves the appliance cabinet, and goes out of the house, and underground before returning, so the water exchanges heat with the ground. This is known as a water-source system. Secondary loops are popular for ground use because they are not pressurized, so cheap plastic tubing can be used, and because they reduce the amount of expensive refrigerant required.

Components

Geothermal systems require three primary components: a length of buried tubing on the property, a liquid pump pack and a water-source heat pump. The tubing can be installed horizontally as a loop field or vertically as a series of long U-shapes (see page 16-C). The purpose of the tubing is to transfer heat to and from the ground. Typically, one loop (400 to 600 feet) has the capacity of one ton or 3.5 kilowatts (kW). An average house will range from three to five tons (10 to 18 kW) of capacity.

The second component is a liquid pump pack, which sends the water

through the tubing and the water-source heat pump, which is the last component that replaces the existing furnace or boiler. This is where the heat from the tubing is transferred for heating the structure. An example of a heat pump is a refrigerator; heat is removed from the refrigerator's compartments and transferred to the outside.

Common Systems

Closed Loop Systems - The most common system is a closed loop, which circulates the fluid through the pipes in the loop fields and does not pull in water from a water source. In a closed loop system, there is no direct interaction between the fluid and the earth, only heat transfer across the pipe. There are three types of closed loop systems – vertical, horizontal and pond.

A vertical closed loop system is composed of pipes that run vertically in the ground. A horizontal closed loop field is composed of pipes that run horizontally in the ground. A closed pond loop is not as common, but is becoming increasingly popular. If the site has an adequate body of water, this may be the lowest cost option.

Open Loop Systems - In contrast to the closed loop systems, an open loop system pulls water directly from a well, lake, or pond. Water is pumped from one of these sources

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Bluestem's New Employees & Summer Interns

Bluestem West

Travis Blackwood

was hired as an apprentice lineman at Bluestem West recently. He is a native of our area and grew up on a farm near Clay Center. He graduated from the Pratt Community College's Electric Power and Distribution Program. His hobbies as he explains are pretty much anything that has to do with the outdoors.

Ben Easterburg is an apprentice lineman at Bluestem West. He is a 2006 graduate of Manhattan Area Technical College's (MATC) Electric Power and Distribution Program. In his spare time, he enjoys the outdoors, especially golf, carpentry and riding ATV's.

Gary Gonser has joined Bluestem West as a journeyman lineman. Originally from Clay Center, he graduated from Clay County Community High School in 1981. He has been working for Kayton Electric Contractors for the past 13 years as a lineman. His No. 1 hobby is riding motorcycles.

Kane Kramer was hired as an apprentice lineman at Bluestem West. He is originally from Longord and graduated from Clay County Community High School in 2007. Kramer has recently completed his education at Pratt Community College's Electric Power and Distribution Program. He has one brother, Cody, 24, and a sister Cassity, 18. His father is a farmer and his mother is a homemaker. Kramer's hobbies are hunting, fishing and just being outdoors.

Trent Broxterman, summer intern at Bluestem West, was born in Topeka and was raised in Axtell. He graduated from Axtell High School in 2006 and began classes at MATC's Electric Power and Distribution Program in 2008. He will graduate in December from the electric power and distribution program. Broxterman began working for Bluestem during the 2007 ice storm and continued on as a summer intern. His hobbies are hunting, fishing and working on cars.

Jeff Crawford, from Minneapolis, is a summer intern at Bluestem West. He graduated from Minneapolis High School in 2006 and from MATC's Building and Trades Program. Crawford is currently pursuing his major in MATC's Electric Power and Distribution Program and will graduate in the fall. In his spare time, he enjoys anything



New linemen at BEC West (from left) are Kane Kramer, apprentice; Gary Gonser, journeyman; Ben Easterburg, apprentice; and Travis Blackwood, apprentice. BEC Summer Interns (from right) are Jeff Crawford, Trent Broxterman and Ryan Thomas.



New Apprentice linemen at BEC East (from left) are J.R. Hynek, David Burton and Kyle Hooten. BEC Summer Interns are (from right) are Jesse Hatfield and Luke Brazzle.

to do with the outdoors, including fishing and hunting.

Ryan Thomas is a summer intern at Bluestem West this year. He grew up north of Clay Center and is the son of Larry and Susan Thomas. He graduated from Clay County Community High School in 2008 and will attend MATC's Electric Power and Distribution Program in 2009. When he isn't working, he enjoys being outdoors, fishing and hunting.

Bluestem East

David Burton is an apprentice lineman at Bluestem East. He is the son of Ralph and Kimm Burton of Frankfort. He graduated from Frankfort High School and MATC's Electric Power and Distribution Program in 2006. Prior to BEC, he worked for Watts Electrical

Contractors. His hobbies include fishing, hunting and also enjoys farming.

Kyle Hooten is an apprentice lineman at Bluestem East is the son of Roger Hooten of Wamego. He graduated from Wamego High School and later from MATC's Electric Power and Distribution Program in 2007. Hooten's hobbies include hunting, fishing and spending time with his family.

J.R. Hynek, was hired as an apprentice lineman at Bluestem East. He is from Wamego and graduated from Wamego High School. After high school he went to work for Kayton Electric line contractors in Holdrege, Neb. His hobbies include hunting, fishing and anything that involves water sports.

Luke Brazzle is a summer intern at Bluestem East. He is the son of Jim and Sandy Brazzle of Wamego. He graduated from Wamego High School in 2004. Brazzle attended Hutchinson Community College where he received an associate degree in fire science. He then fought fires in the western U.S. for two years. Brazzle is currently enrolled at MATC in the Electric Power and Distribution Program. His hobbies are hunting, fishing and trapping.

Jesse Hatfield has joined Bluestem East as a summer intern. He is the son of Tim and Lori Hatfield of Wamego. He graduated from Wamego High School and is currently enrolled in MATC's Electric Power and Distribution Program. Some of his hobbies include riding motor cycles and shooting guns.

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into the heat pump, where heat is either extracted or added. The water is then pumped back into a second well or body of water.

There are three general types of systems. First water can be pumped from a vertical water well and returned to a nearby pond. Second, water can be pumped from a body of water and returned to the same body of water. Third, water can be pumped from a vertical well and then returned to another discharge well located a minimum of 50 feet from the supply well.

While thermal contamination (where the ground temperature is affected by the operation of the system) is possible with any geothermal system, with proper design, planning, and installation any loop configuration can work very well for a long time. Deep lake water cooling uses a similar process with an open loop for air conditioning and cooling. Open loop systems using ground water are usually much more efficient than closed systems because they exchange heat with water at ground temperature. Closed loop systems, in comparison, have to make do with the inefficient heat-transfer between the water flowing through the tubing and the ground temperature.

One of the benefits of an open loop system is that, for most configurations and depending on the local environment, ground water is at a

constant temperature of about 50°F. In closed loop systems the temperature of the water coming in from the loop is often within 10°F of the temperature of the water entering the loop this shows how little heat was exchanged. The constant ground water temperatures significantly improve heat pump efficiency.

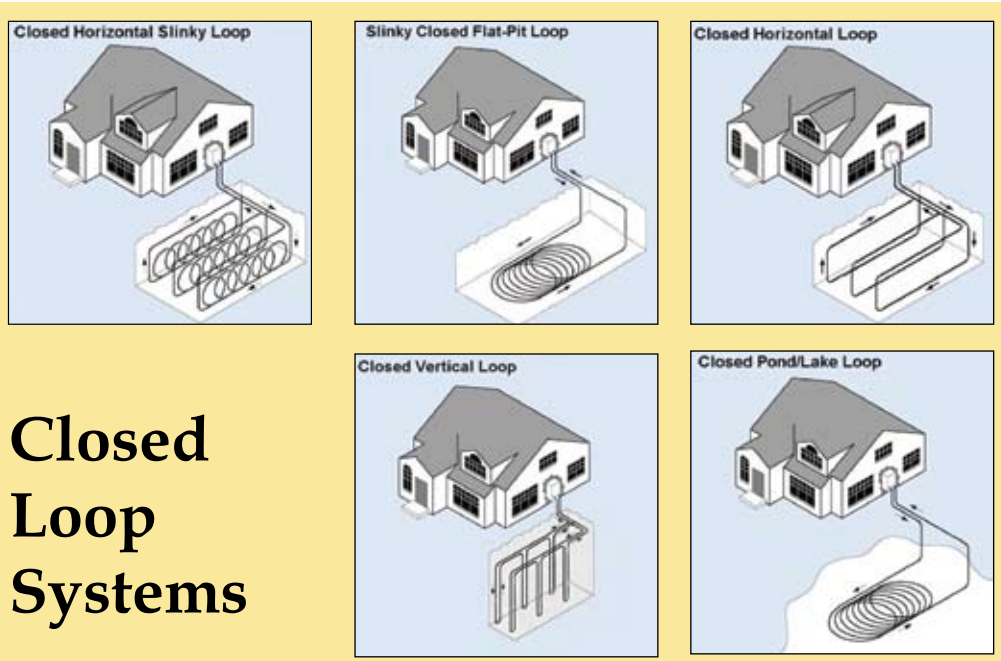
Pump and Dump Water Wells and Surface Water - This type of system uses well or surface body water as the heat exchange fluid that circulates directly through the geothermal system. These systems are recommended to have a filter installed in line and checked periodically for cleaning. Once water has circulated through the system, it returns to discharge well or surface discharge. This option is practical

only where there is an adequate supply of relatively clean water, and all local codes and regulations regarding groundwater discharge are met.

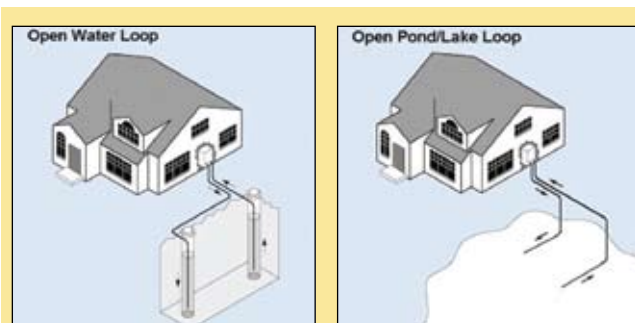
Benefits of Geothermal
Minimizes Electricity Use - Geothermal systems transfer heat to and from the ground with minimal use of electricity. Bluestem offers special rates and rebates to customers who install geothermal. Electrical plants have the largest loads during summer months and much of their capacity sits idle during winter months.

Geothermal systems allow the electric companies to use more of their facility during the winter months. Geothermal systems also reduce peak usage during the summer due to the increased efficiency of heat pumps. This allows electric companies to avoid costly construction of new power plants.

Environmentally Friendly - Geothermal systems are environmentally friendly. They are a renewable energy source, non-polluting, and are recognized as one of the most efficient heating and cooling systems on



Closed Loop Systems



Open Loop Systems

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the market. The U.S. Environmental Protection Agency (EPA) has called geothermal the most energy-efficient, environmentally clean, and cost-effective space conditioning systems available. Geothermal systems do not use fossil fuels for heating the house and eliminate threats caused by combustion, like carbon monoxide poisoning. The fluids used in loop fields are designed to be biodegradable, non-toxic, non-corrosive and have properties that will minimize pumping power needed.

Longevity - The life span of the system is longer than conventional heating and cooling systems. Most loop fields have a warranty for 25 to 50 years and are expected to last 50 to 200 years.

Efficiency - Geothermal heat pumps are especially well matched to under floor heating systems which do not require extremely high temperatures, unlike wall-mounted radiators. Thus they are ideal for offices. Using large surfaces such as floors instead of radiators distributes the heat more uniformly and allows for a lower temperature heat transfer fluid.

The Earth below the frost line remains at a relatively constant temperature year round. This temperature equates roughly to the average annual air-temperature of the chosen location, so is usually 45 to 70°F depending on location. Because this temperature remains constant, geothermal heat pumps perform with far greater efficiency and in a far larger range of extreme temperatures than conventional air conditioners and furnaces, and even air-source heat pumps.

A particular advantage is that they can use electricity to heat spaces and water much more efficiently than an electric heater. This allows buildings to be heated with renewable energy without transporting and burning biomass on site, producing biogas for use in gas furnaces or relying solely upon solar heating.

Did You Know?

The current use of geothermal heat pump technology has resulted in the following emissions reductions:

- Elimination of more than 5.8 million metric tons of CO₂ annually
- Elimination of more than 1.6 million metric tons of carbon equivalent annually

These 1 million installations have also resulted in the following energy consumption reductions:

- Annual savings of nearly 8,000 GWh
- Annual savings of nearly 40 trillion Btus of fossil fuels
- Reduced electricity demand by more than 2.6 GW

The impact of the current use of geothermal heat pumps is equivalent to:

- Taking close to 1,295,000 cars off the road
- Planting more than 385 million trees
- Reducing U.S. reliance on imported fuels by 21.5 million barrels of crude oil per year.

A Great Investment - Geothermal heat pump technology is a Natural Building technique. It is also a practical heating and cooling solution that can pay for itself within a few years of installation. Today there are more than 1 million geothermal heat pump installations in the U.S.

Costs & Savings

The initial cost of installing a geothermal system can be two to three times that of a conventional heating system in most residential applications, new construction or existing. In retrofits, the cost of installation is affected by the size of living area, the home's age, insulation characteristics, the geology of the area, and location of the home/property.

For new construction, proper duct system design and mechanical air exchange should be considered in initial system cost. These systems can save the average family hundreds (sometimes thousands) of dollars per year, reducing the average heating/cooling costs by 30-70 percent per household.

Heat Pump Heating & Air Conditioning - For heating, a geothermal heat pump removes the heat

from the fluid in the Earth connection, concentrates it, and then transfers it to the building. For cooling, the process is reversed.

Heat Distribution - Conventional ductwork is generally used to distribute heated or cooled air from the geothermal heat pump throughout the building.

Residential Hot Water - In addition to space conditioning, geothermal heat pumps can be used to provide domestic hot water when the system is operating. Many residential systems are now equipped with desuperheaters that transfer excess heat from the geothermal heat pump's compressor to the house's hot water tank.

A desuperheater provides no hot water during the spring and fall when the geothermal heat pump system is not operating, however because the geothermal heat pump is so much more efficient than other means of water heating, manufacturers are beginning to offer "full demand" systems that use a separate heat exchanger to meet all of a household's hot water needs. These units cost-effectively provide hot water as quickly as any competing system.