THE GEOTHERMAL CONCEPT

A HOMEOWNER'S GUIDE TO GEOTHERMAL HEATING AND COOLING COMFORT SYSTEMS

CLIMATEMASTER® GEOTHERMAL HEATING AND COOLING

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The Global Leader

For more than 50 years ClimateMaster has serviced the needs of the commercial and residential construction industry worldwide with the most comprehensive line of water-source and geothermal heat pumps available anywhere.

ClimateMaster's state of the art facilities in Oklahoma City, Okla., reflects the company's commitment to its customers, employees and products. The company stresses quality in its modern 610,000 square foot facilities through extensive quality control programs.

A total commitment to excellence is why ClimateMaster is the world's leader in design and manufacture of water-source and geothermal heat pumps. We build quality heat pumps for life... the life of buildings and the people who use them.

Visit us at climatemaster.com to learn more about geothermal heating and cooling systems.

ClimateMaster®
Geothermal Heating & Cooling

Homeowners across North America are searching for better ways to get more out of their energy dollar. Many have found that the geothermal heat pump can help. Geothermal energy not only costs less to operate than any other heating and cooling system, but it also helps preserve our natural resources and lessens our dependency on fossil fuels.

This brochure has been developed as a guide to introduce you to geothermal technology. Using a question and answer format, we've tried to provide you with the most popular topics that have been requested by consumers.

Table of Contents:

What is a Geothermal Heat Pump and how does it work?

Q: What is a geothermal heat pump?

A: A geothermal or "ground-source" heat pump is an electrically powered device that uses the natural heat storage ability of the earth and / or the earth's groundwater to heat and cool your home or business.

Q: How does it work?

A: Like any type of heat pump, it simply moves heat energy from one place to another. Your refrigerator works using the same scientific principle. (See "How is a geothermal heat pump like a refrigerator?" on page 5.) By using refrigeration, the geothermal heat pump removes heat energy stored in the earth and / or the earth's groundwater and transfers it to the home.

Q: How is heat transferred between the earth and the home?

A: The earth has the ability to absorb and store heat energy. To use that stored energy, heat is extracted from the earth through a liquid medium (water or an antifreeze solution) and is pumped to the heat pump heat exchanger. There, the heat is used to heat your home. In summer the process is reversed and indoor heat is extracted from your home and transferred to the earth through the liquid.

Q: You mentioned heating and cooling. Does it do both?

A: One of the things that makes a heat pump so versatile is its ability to be a heating and cooling system in one. You can change from one mode to another with a simple flick of a switch on your indoor thermostat. Plus, a geothermal heat pump can assist in heating hot water year-round.

Tranquility® 30 Vertical Geothermal Heat Pump with EarthPure® Zero Ozone Depletion Refrigerant

Q: Do I need separate ground loops for heating and cooling?

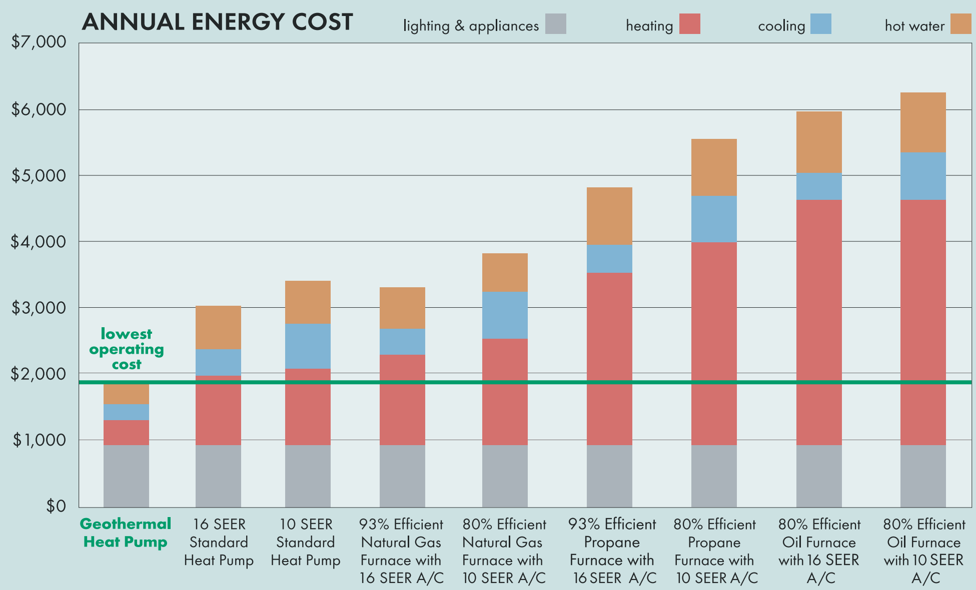
A: No. The same loop works for both. All that happens when changing from heating to cooling, or vise versa, is that the flow of heat is reversed inside the unit.

Q: What types of loops are available?

A: There are two main types: open and closed. Both of these loops will be addressed later in the brochure.

Q: Does the underground pipe system really work?

A: The buried pipe, or "ground loop", is the biggest technical advancement in heat pump technology to date. The idea to bury pipe in the ground to gather heat energy began in the 1940s. But it's only been in the last twenty-five years that new heat pump designs and improved pipe materials have been combined to make geothermal heat pumps the most efficient heating and cooling systems available.



Calculations are based upon current utility costs for a typical home in the U.S. Midwest.
Visit climatemaster.com to use our online energy calculator or contact a dealer for your detailed savings estimate.

How is a geothermal heat pump like a refrigerator?

Like a refrigerator, a geothermal heat pump simply transfers heat from one place to another. When a refrigerator is operating, heat is being carried away from the inside food storage area to the outside, your kitchen. Therefore, cooling is not being added to the inside; heat is being taken out.

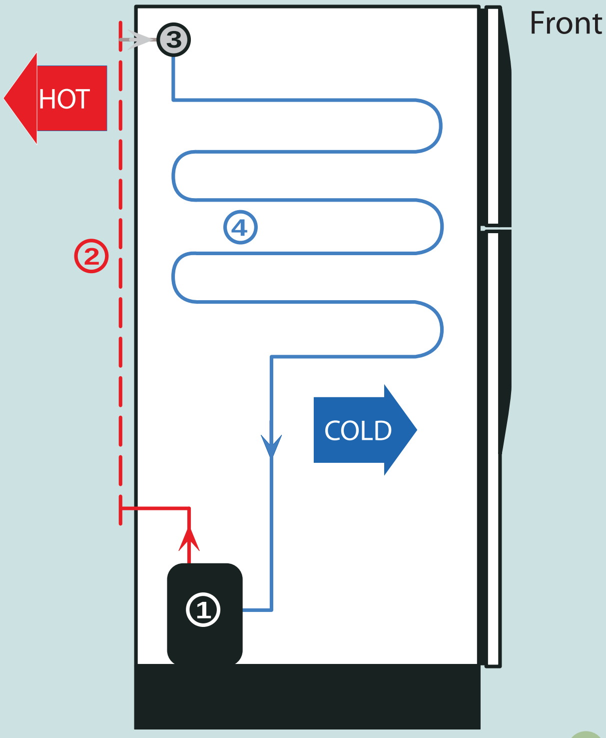
To understand the operation of a geothermal heat pump, it helps to understand how a refrigerator works. A refrigerator uses a refrigeration circuit with four main components, a compressor (1), a condenser (2), an expansion device (3), and an evaporator (4). Refrigerant (sometimes referred to by the brand name Freon) is pumped through the circuit to transfer heat from the inside of the refrigerator to the outside.

The compressor (1) is the pump. It also pressurizes the refrigerant gas. Since temperature and pressure are directly related, as the pressure increases, the temperature increases. The high temperature / high pressure gas flows from the compressor to the condenser (2). The cooler air in the kitchen (relative to the temperature of the refrigerant, 150 to 180°F [65 to 85°C]) causes the refrigerant to condense into a liquid. When two surfaces at different temperatures touch (or are very near–separated only by tubing), the hotter surface cools and the cooler surface warms. This is a law of physics called the second law of thermodynamics. The condenser therefore releases heat to the kitchen.

The next step in the process involves the expansion device (3). The expansion device is a small orifice that the refrigerant is forced through. The small hole creates a pressure differential between the two sides of the device. Think of an expansion device like a dam on a river with a hole in the dam. The water leaking through the hole is at a low pressure on the downstream side; the water on the other side (being held back by the dam) is at a high pressure. Once again, the pressure / temperature relationship (lower pressure / lower temperature) creates a cold, low pressure liquid refrigerant that gets fed to the evaporator (4).

As warm air inside the refrigerator (relative to the very cold temperature of the refrigerant) passes through the evaporator coil (4), the hotter surface (air inside the refrigerator) gets cooler and the cooler surface (refrigerant in the evaporator (4) tubing) gets warmer. The liquid refrigerant evaporates back into gas form, and the cycle starts over again as the refrigerant enters the compressor (1). The evaporator therefore absorbs heat from the inside of the refrigerator, which keeps the food cold.

An air conditioner or refrigerator transfers heat in only one direction. A heat pump can transfer heat in two directions, thereby heating or cooling the space. Most heat pumps heat or cool the air. Some heat pumps heat or chill water. An additional component, a reversing valve, is added to a heat pump, which allows the refrigerant to change direction, allowing the space that was being cooled to be heated.



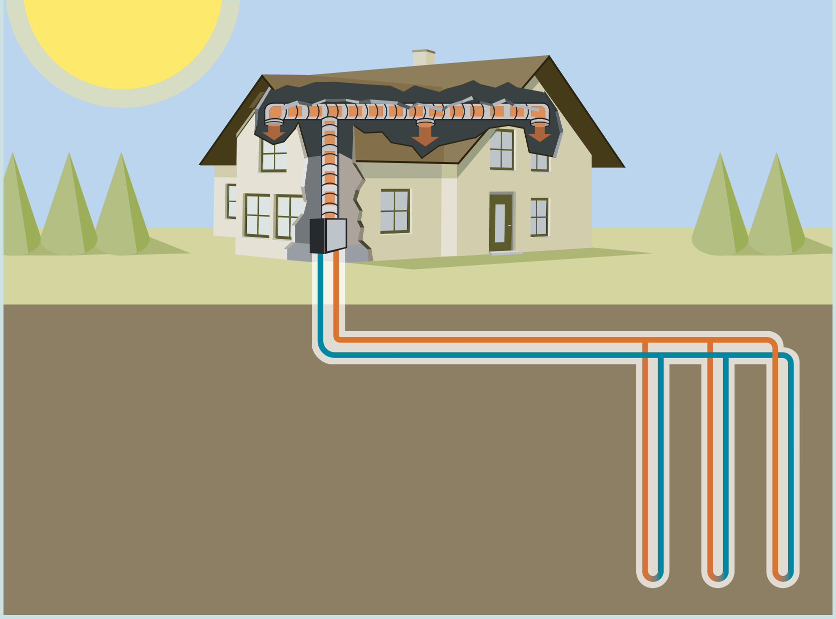
A geothermal heat pump has a compressor, a condenser, an expansion device, and an evaporator like a refrigerator, but also includes a reversing valve to allow both heating and cooling. The big difference between a refrigerator or traditional air conditioner and a geothermal heat pump is the way heat is transferred. A geothermal heat pump transfers heat between the refrigerant circuit and the ground instead of between the refrigerant circuit and the air. The ground is a much milder heat source, since the temperature changes very little over the course of the year. The outside air temperature, however, varies significantly over the year, making a geothermal heat pump much more energy efficient than a traditional air conditioner or heat pump. A geothermal heat pump compressor also operates at lower pressures because of the milder heat source / heat sink (the ground), helping provide longer life expectancies.

A geothermal heat pump is a like a refrigerator in many ways. Simple refrigerator technology coupled with the stable temperature of the Earth provides quiet, reliable, and energy efficient heating and cooling systems for today's discerning homeowners.

Geothermal heat pumps: closed-loop systems

Q: What is a closed-loop system?

A: The term “closed-loop” is used to describe a geothermal heat pump system that uses a continuous loop of special buried plastic pipe as a heat exchanger. The pipe is connected to the indoor heat pump to form a sealed, underground loop through which water or an antifreeze solution—depending on where you live—is circulated. Unlike an open-loop system that consumes water from a well, a closed-loop system recirculates its heat transferring solution in pressurized pipe.


An example of a vertical loop installation

Q: Where can this loop be located?

A: That depends on land availability and terrain. Closed-loops are trenched horizontally in yards adjacent to the home if the yard is large enough. Or, for smaller yards, the loops can be installed vertically using a drill rig, much like a water well installation.

Q: How deep and long will my horizontal trenches be?

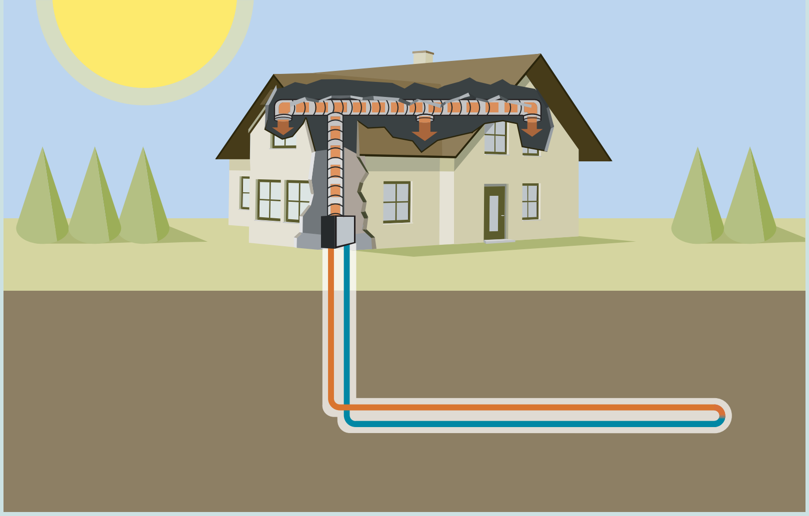
A: Trenches are normally four to six feet deep [1.2–1.8 meters]. One of the advantages of a horizontal loop system is being able to lay the trenches according to the shape of the land. As a rule of thumb, 125–300 feet of trench are required per ton of heat pump capacity [11–27 meters per kW of capacity].

Q: How many pipes are in a trench?

A: Anywhere from 1 to 6 pipes per trench may be used, depending upon the optimal design for the yard. More pipe per trench shortens the total amount of trench required.

Q: What if I don’t have enough room for a horizontal loop?

A: Closed-loop systems can also be vertical. Holes are bored to about 150–300 feet per ton of heat pump capacity [13–27 meters per kW of capacity]. U-shaped loops of pipe are inserted in the holes. The holes are then back-filled with a sealing solution (grouting material).


An example of a horizontal loop installation

Q: How long will the loop pipe last?

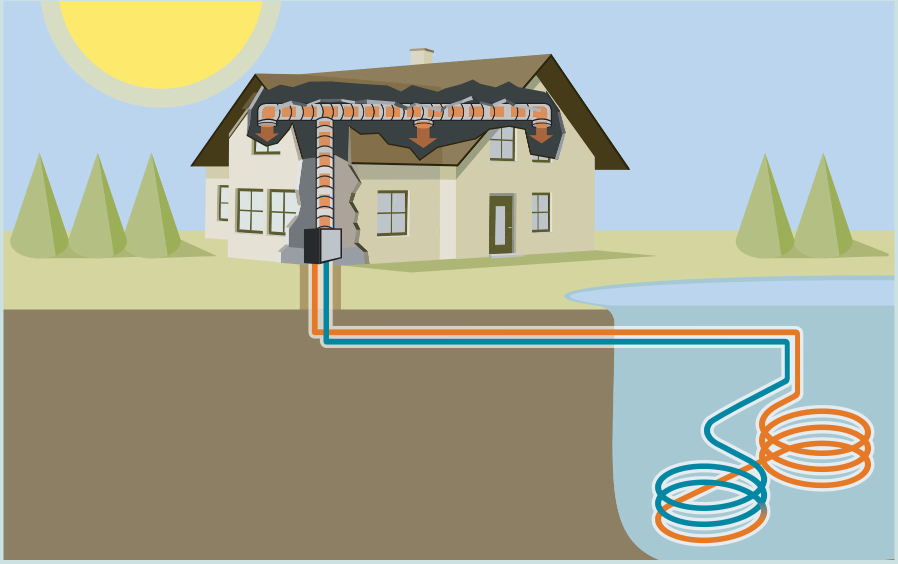
A: Closed-loop systems should only be installed using the appropriate high-density polyethylene pipe. Properly installed, these pipes will last over 50 years. They are inert to chemicals normally found in soil and have good heat conducting properties. PVC pipe should not be used under any circumstances.

Q: Can I install an earth loop myself?

A: It’s not recommended. In addition to thermal fusion of the pipe, good pipe-to-soil contact is very important for successful loop operation. Nonprofessional installations may result in less than optimum heat pump performance.

Q: How are the buried pipe sections of the loop joined?

A: The only acceptable method to connect pipe sections is by thermal fusion. Pipe connections are heated and fused together to form a joint stronger than the original pipe. Mechanical joining of underground pipe for an earth loop is never an accepted practice. The use of barbed fittings, clamps and glued joints is certain to result in loop failure due to leaks.


An example of a pond loop installation

Q: Will an earth loop affect my lawn or landscape?

A: No. Research has proven that loops have no adverse effect on grass, trees or shrubs. Most horizontal loop installations use trenches about 3 feet [1 meter] or less wide. This, of course, will leave temporary bare areas that can be restored with grass seed or sod. Vertical loops require little space and result in minimal lawn damage.

Q: Can I reclaim heat from my septic system disposal field?

A: No. Depending upon your geographic location, an earth loop will reach temperatures below freezing during extreme conditions and may freeze your septic system. Such usage is banned in many areas.

Q: If the loop falls below freezing, will it hurt the system?

A: No. The antifreeze solution used in loops that operate at low temperatures will keep it from freezing down to about 15°F [-9°C] fluid temperature. In the U.S. and Canada, three types of antifreeze solution are acceptable: propylene glycol, methyl alcohol, and ethyl alcohol. Some states / provinces may require one type over another.

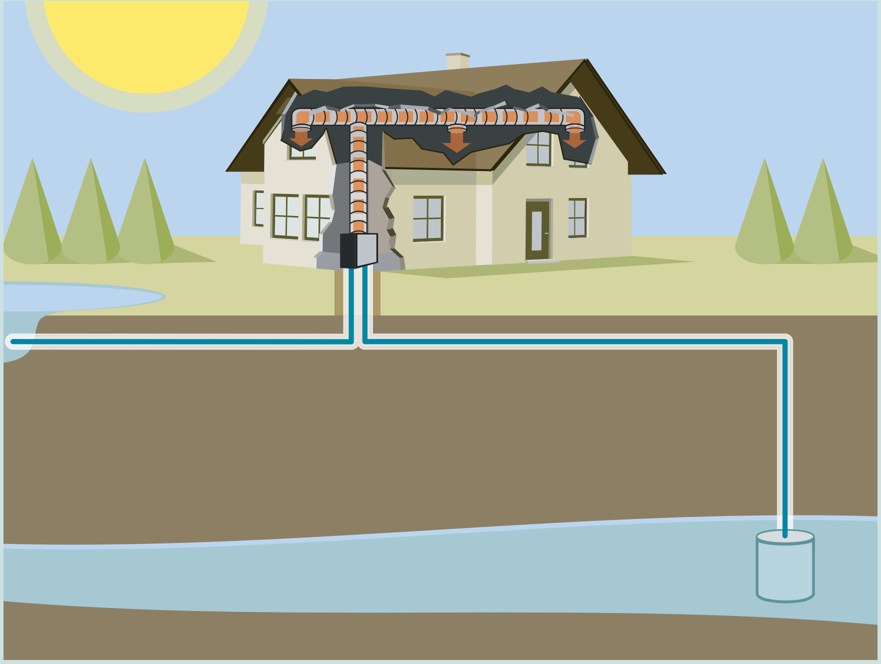
Q: I have a pond near my home. Can I put a loop in it?

A: Yes, if it's deep enough and large enough. A minimum of 8–10 feet [2.5–3 meters] in depth at its lowest level during the year is needed for a pond to be considered. In pond loops, polyethylene pipe must be used. Generally, a minimum of 1 / 2 acre [0.2 hectare] pond is required to provide adequate surface area for heat transfer.

Geothermal heat pumps: open-loop systems

Q: What is an open-loop system?

A: The term "Open-Loop" is commonly used to describe a geothermal heat pump system that uses groundwater from a conventional well as a heat source in winter and a heat sink in summer. The groundwater is pumped through the heat pump where heat is extracted (in winter) or rejected (in summer) then the water is disposed of in an appropriate manner. Since groundwater is a relatively constant temperature year-round, it is an excellent heat source / heat sink.



An example of a groundwater installation

Q: What do I do with the discharge water?

A: There are a number of ways to dispose of water after it has passed through the heat pump. The open discharge method is the easiest and least expensive. Open discharge simply involves releasing the water into a stream, river, lake, pond, ditch or drainage tile. Obviously, one of these alternatives must be readily available and must possess the capacity to accept the amount of water used by the heat pump before open discharge is feasible.

A second means of water discharge is the return well. A return well is a second well bore that returns the water to the ground aquifer. A return well must have enough capacity to dispose of the water passed through the heat pump. A new return well should be installed by a qualified well driller. Likewise, a professional should test the capacity of an existing well before it is used as a return.

Q: How much groundwater does an open-loop system need?

A: Geothermal heat pumps used in open-loop systems need differing amounts of water depending on the size of the unit. The water requirement of a specific model is usually expressed in gallons per minute (l / s) and is listed in the specifications for that unit. Your heating and cooling contractor should be able to provide this information. Generally, the average system will use 6-10 G.P.M. [0.4–0.6 l / s] while operating. An extremely cold day might result in a usage of 6,000–10,000 gallons [23,000–38,000 liters] of water.

Your well and pump combination should be large enough to supply the water needed by the heat pump in addition to your domestic water requirements. You will probably need to enlarge your pressure tank or modify your plumbing to supply adequate water to the heat pump.

Q: What problems can be caused by poor water quality?

A: Poor water quality can cause serious problems in open-loop systems. Your water should be tested for hardness, acidity and iron content before a heat pump is installed. Your contractor can tell you what level of water quality is acceptable.

Mineral deposits can build up inside the heat pump's heat exchanger. Sometimes a periodic cleaning with a mild acid solution is all that's needed to remove the build-up.

Impurities, particularly iron, can eventually clog a return well. If your water has a high iron content you should be sure that the discharge water is not aerated before it's injected into a return well.

Geothermal heat pumps: open-loop systems continued

Finally, you should opt against using water from a spring, pond, lake or river as a source for your heat pump system unless it's proven to be free of excessive particles and organic matter. They can clog a heat pump system and make it inoperable in a short time.

If water quality is a concern, a closed-loop system should be used.

Q: Does an open-loop system cause environmental damage?

A: No. They are pollution free. The heat pump merely removes heat from or adds heat to the water. No pollutants are added whatsoever. The only change in the water returned to the environment is a slight increase or decrease in temperature.

Q: Are there any laws that apply to open-loop installations?

A: In some localities, all or parts of the installation may be subject to local ordinances, codes, covenants or licensing requirements. Check with local authorities to determine if any restrictions apply in your area.

Geothermal heat pumps: parts of the system

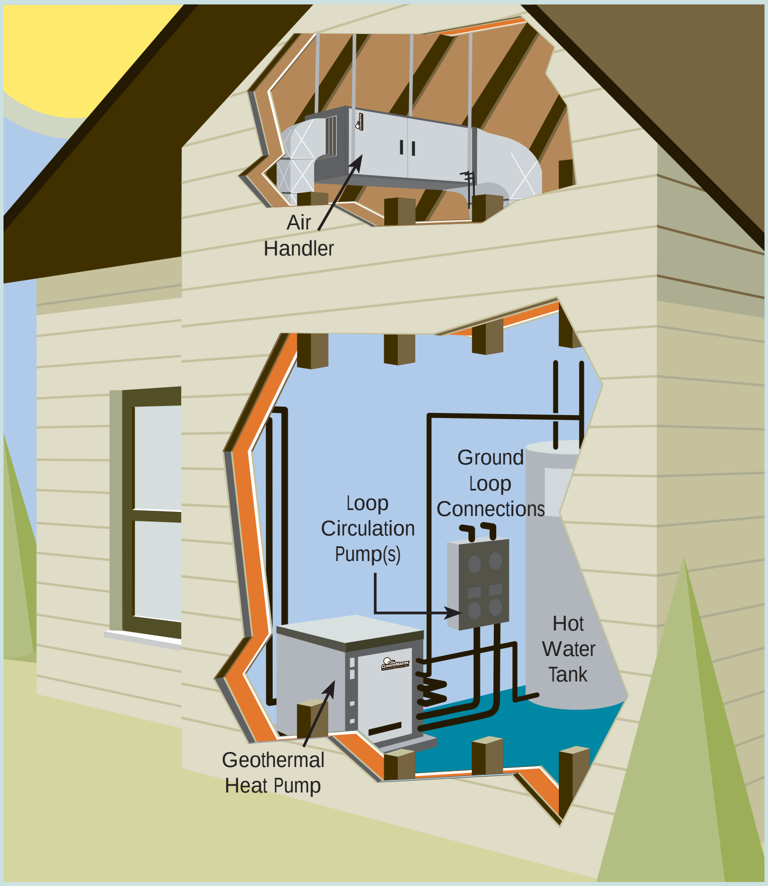
Q: What are the components of a geothermal heat pump system?

A: The three main parts are the heat pump unit, the liquid heat exchange medium (open or closed loop), and the air delivery system (ductwork).

Q: Are all geothermal heat pumps alike?

A: No. There are different kinds of geothermal heat pumps designed for specific applications. Many geothermal heat pumps, for example, are intended for use only with higher temperature ground water encountered in open-loop systems. Others will operate at entering water temperatures as low as 20°F [-7°C] which is required for closed-loop systems.

Geothermal heat pumps can also differ in the way they are designed. Self-contained units combine the blower, compressor, water heat exchanger and air coil in a single cabinet. Split systems allow the coil to be added to a forced-air furnace and utilize the existing blower.



An example of an indoor split unit installation with an electric furnace in attic

Q: Is a geothermal heat pump difficult to install?

A: Most units are easy to install, especially when they are replacing another forced-air system. They can be installed in areas unsuitable for fossil fuel furnaces because there is no combustion, thus, no need to vent exhaust gases.

Ductwork must be installed in homes that don't have an existing air distribution system. The difficulty of installing ductwork will vary and should be assessed by a contractor.

Q: Will I have to add insulation to my home if I install one of these systems?

A: Geothermal heat pumps will reduce your heating and cooling costs regardless of how well your home is insulated. However, insulating and weatherizing are key factors in realizing the most savings from any type of heating and cooling system.

Q: Can a geothermal heat pump also heat water for my home?

A: Yes. Using what's called a Hot Water Generator (HWG), some types of geothermal heat pumps can save you up to 50 percent on your water heating bill by pre-heating tank water. The HWG is a factory-installed option.

Q: Can a geothermal heat pump be added to my fossil fuel (Gas, oil, propane) furnace?

A: Split systems can easily be added to existing furnaces for those wishing to have a dual-fuel system. Use the heat pump as the main heating source and a furnace as a supplement in extremely cold weather if additional heat is needed.

Q: I have ductwork, but will it work with this system?

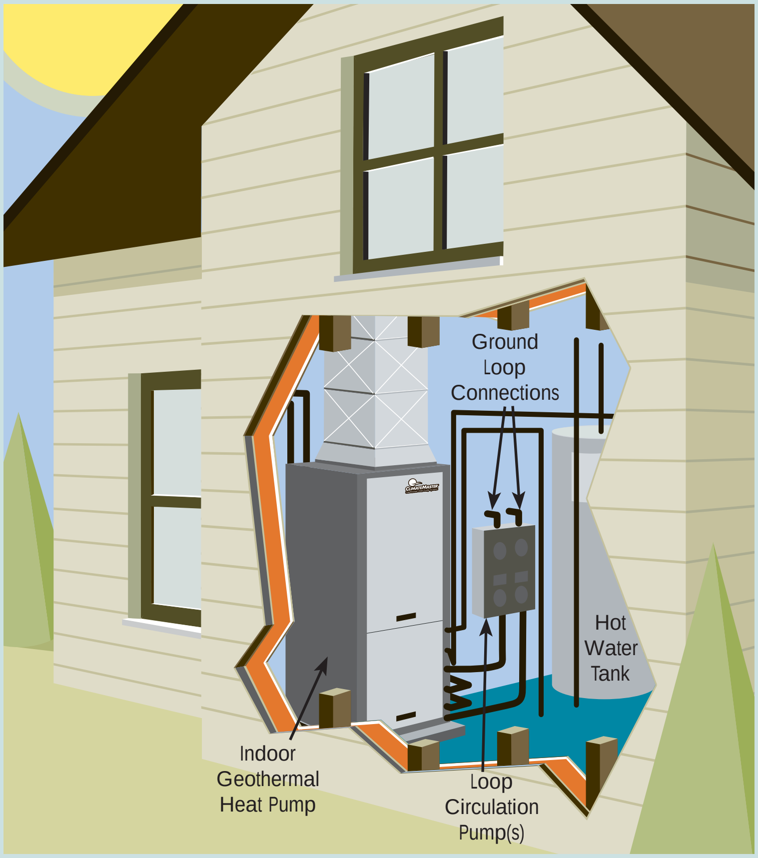
A: In all probability, yes. Your installing contractor should be able to determine ductwork requirements and any minor modifications, if any are needed.

Q: Do I need to increase the size of my electric service?

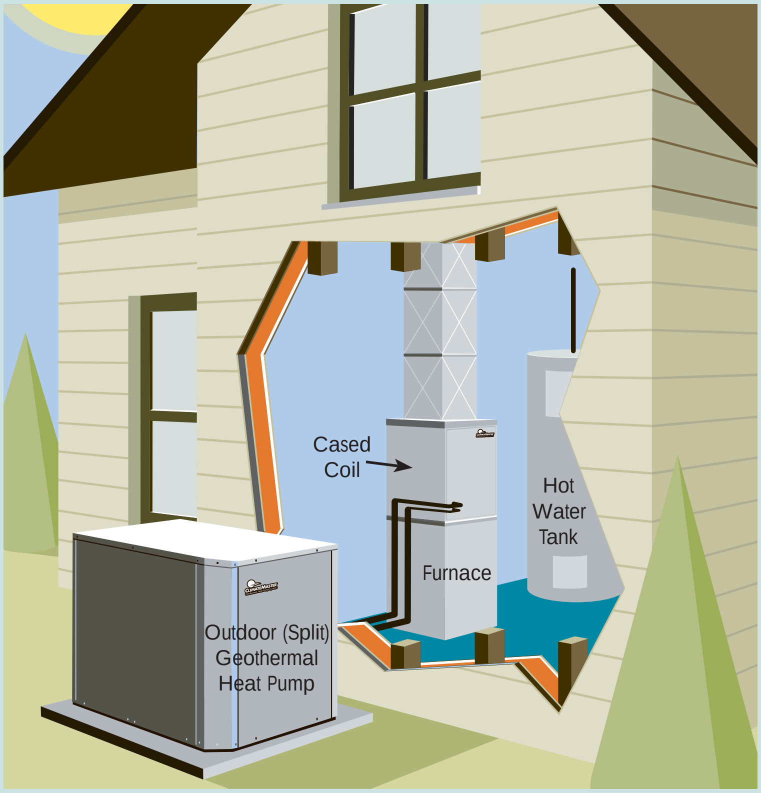
A: Geothermal heat pumps don't use large amounts of resistance heat, so your existing service may be adequate. Generally, a 200-amp service will have enough capacity, and smaller amp services may be large enough in some cases. Your electric utility or contractor can determine your service needs.

Q: Should I buy a heat pump large enough to heat my home with no supplemental heat?

A: Your contractor should provide a heating and cooling load calculation (Heat Loss / Heat Gain) to guide your equipment selection. Geothermal heat pumps are sized to meet all your cooling requirements. Depending on your heating needs, a geothermal heat pump will supply 80–100 percent



An example of a packaged upflow unit installation



An example of an outdoor dual fuel split unit installation matched with a cased coil of your designed heating load. Sizing the heat pump to handle your entire heating needs may result in slightly lower heating costs, but the savings may not offset the added cost of the larger heat pump unit. Also, some oversized units can cause dehumidification problems during the cooling mode, resulting in a loss of summer comfort.

Other types of installations:

- Horizontal
- Vertical downflow
- Water-to-water (radiant floor heating)

Geothermal heat pumps: the major benefits

Q: How efficient is a geothermal heat pump?

A: Geothermal heat pumps are 3.5–5 times as efficient as the most efficient fossil fuel furnace. Instead of burning a combustible fuel to make heat, they simply move heat that already exists. By doing so, they provide 3.5–5 units of energy for every unit used to power the heat-pump system.

Q: What does a system like this cost?

A: A system for the typical home will cost more than if you bought a separate forced-air furnace and central air conditioning system. But you wouldn't be comparing "apples to apples". To get an accurate comparison of costs you need to consider the following:

- Payback, or how long it takes to recover the difference in costs between the two systems using energy savings. Payback for most geothermal heat pump systems runs three to five years.
- Energy efficiency of the two systems. To get an accurate picture, make sure efficiency claims are substantiated. Your lifestyle and how well your home is insulated affect how economical a system will be.
- Total operating savings from heating, cooling and domestic hot water must be combined to get an accurate picture of total energy savings.
- Energy costs and availability, both present and future.
- Maintenance costs and system reliability.
- System lifespan.
- ClimateMaster GeoDesigner software can calculate annual operating costs for geothermal systems and compare to other technologies.

Q: What about comfort?

A: In winter, a geothermal heat pump system moves warm air (90°–105°F) [32°–41°C] throughout your home via a standard duct network. Typically, a very even comfort level is found throughout the home. This is because the warm air is moved in slightly higher volumes and, therefore, saturates the home with warmth more evenly. This even helps out hot or cold spots and eliminates the hot air blasts common with fossil fuel furnaces.

In summer, cool, dehumidified air is dispersed through the same duct network.

It's also a great comfort to know that you've reduced your energy consumption while using an inexhaustible energy source—the earth.

Geothermal heat pumps: the major benefits continued

Q: Which system is best, open- or closed-loop?

A: The net results in operating cost and efficiency are virtually the same. Which system to choose depends mainly on whether you have an adequate groundwater supply and means of disposal. If you do, an open loop can be used very effectively. If not, either a horizontal or vertical closed-loop system is your best choice.

Over a period of years, a closed-loop system will require less maintenance because it's sealed and pressurized, eliminating the possible build-up of minerals or iron deposits.

Geothermal heat pumps: Questions you should ask about a new heating and cooling system

Regardless of the type of heating and cooling system you may be considering for your home or business, there are specific questions you should ask the dealer / installer. These questions deal with finding out the actual efficiency of the system, any operating limitations it may have, and the bottom line of operating costs. The answers here are meant as a guide for what you should try to find out with your questions.

Q: What is the Btuh [kW] size of the geothermal heat pump or furnace that's being proposed?

A: Heating systems are designed to provide specific amounts of heat energy per hour. The term "Btuh" [kW] refers to how much heat can be produced by the unit. Before you can know what size system you'll need, you must have a heat loss / heat gain calculation done on your home. From that, an accurate determination can be made on the size of the heating / cooling system. Many fossil fuel furnaces are substantially oversized for home heating requirements, resulting in increased operating costs.

Q: Is the efficiency rating actual or just a manufacturer's average?

A: All types of heating and cooling systems have a rated efficiency. Fossil fuel furnaces have a percentage efficiency rating. Natural gas, propane and fuel oil furnaces have efficiency ratings based on laboratory conditions. To get an accurate installed efficiency rating, factors such as flue gas heat losses, cycling losses caused by oversizing, blower fan electrical usage, etc., must be included.

Air conditioners are normally rated in SEER (Seasonal Energy Efficiency Ratio). SEER and EER (Energy Efficiency Ratio) cannot be directly compared without the use of software.

Geothermal heat pumps, as well as all other types of heat pumps, have efficiencies rated according to their Coefficient of Performance or COP for heating and EER for cooling. It's a scientific way of determining how much energy the system produces versus how much it uses.

Most geothermal heat pumps systems have COPs of 3.5–5.0. That means for every one unit of energy used to power the system, 3.5 to 5 units are supplied as heat. Whereas a fossil fuel furnace may be 80–90 percent efficient, a geothermal heat pump is about 450 percent efficient. Some geothermal heat pump manufacturers and electric utilities use software to accurately determine the operating efficiency of a system for your home. Software like ClimateMaster GeoDesigner allows comparisons in dollars to avoid the confusion of the various rating systems.

Q: Will the minimum entering water temperature have an effect on which heat pump I buy?

A: Yes. If you have an open-loop system, your entering water temperatures (EWTs) may range from the 70s°F [20s°C] in the southern United States to the 40s°F [single digits, °C] in Canada. All heat pumps can handle temperatures in the moderate to warm ranges. A closed-loop system, on the other hand, may encounter EWTs below freezing. Not all ground-source heat pumps will operate at those low temperatures. It's important for you to know what EWTs your heat pump will handle.

Geothermal heat pumps: Questions continued

Q: Are the dealer and loop installers qualified?

A: Don't be afraid to ask for references from dealers. A reputable dealer won't hesitate to give you names and numbers to call to confirm his capabilities. The same applies to the loop installer.

Q: Will open- or closed-loop be best for you?

A: That depends on several factors, as stated earlier. A dealer should be willing to install what's best for you, not for him.

Q: Will the loop joints be heat fused?

A: The only acceptable method for joining buried sections of the special pipe used for closed loop systems is heat fusion. Any other method will eventually result in the failure of the loop.

Q: How long is the payback period for a ground-source heat pump system?

A: To figure this accurately, you must know how much per year you'll save in energy costs with a ground-source system, and the difference between it and a traditional heating system and central air conditioner. As an example: if you'll save $700 per year with a ground-source system and the costs difference is $2,000, your payback would be less than three years.

Q: If a home has ceiling cable heat or baseboard heat, do air ducts need to be installed in my home?

A: Not always. It may be desirable to install ground-source heat pump room units. For some small homes, one room unit would provide most of the heating and cooling needs. Ceiling cable or baseboard units could then be used for supplemental heat.

Q: Can I use a heat pump for radiant floor heating (warm floors)?

A: Yes. Water-to-Water heat pumps heat water instead of air. The principle is the same as far as loop piping is concerned. Warm water is circulated through the floor to heat the home.

Q: If I want to know more about geothermal heat pumps, whom should I contact?

A: Visiting climatemaster.com, or speaking with the dealer that provided this brochure can provide you with a wealth of additional information about geothermal heat pumps.

One of the many resources provided at climatemaster.com is a distributor locator to find the nearest ClimateMaster distributor. Your ClimateMaster distributor can put you in touch with qualified installers in your area. Also, your local electric utility can provide you with more information. Go to climatemaster.com to find a ClimateMaster dealer near you.

Glossary:

Closed-loop heat pump system: A heat pump system that uses a loop of buried plastic pipe as a heat exchanger. Loops can be horizontal or vertical.

COP (Coefficient of Performance): The ratio of heating provided by a heat pump (or other refrigeration machine) to the energy consumed by the system under designated operating conditions. The higher the COP, the more efficient the system.

Compressor: The central part of a heat pump system. The compressor increases the pressure and temperature of the refrigerant and simultaneously reduces the volume while causing the refrigerant to move through the system.

Cycling losses: The actual efficiency of a heating or cooling system is reduced due to start-up and shut-down losses. Over sizing a heating or cooling system increases cycling losses.

EER (Energy Efficiency Ratio): The ratio of cooling provided by a heat pump (or other refrigeration machine) to the energy consumed by the system under designated operating conditions. The higher the EER, the more efficient the system.

Fossil fuel: Any of several types of combustible fuels formed from the decomposition of organic matter. Examples are natural gas, propane, fuel oil, and coal.

Geothermal heat pump: A heat pump that uses the earth as a heat source and heat sink.

Heat exchanger: A device designed to transfer heat between two physically separated fluids or mediums of different temperatures.

Heat pump: A mechanical device used for heating and cooling which operates by moving heat from one location to another. Heat pumps can extract heat from air, water, or the earth. They are classified as either air-source or ground-source (geothermal) units.

Heat sink: The medium—air, water or earth—which receives heat rejected from a heat pump.

Heat source: The medium—air, water or earth—from which heat is extracted by a heat pump.

Hot Water Generator: A device for recovering superheat from the compressor discharge gas of a heat pump or central air conditioner for use in heating or preheating potable water.

Open-loop heat pump system: A heat pump system that uses groundwater from a well. The water is returned to the environment.

Payback: A method of calculating how long it will take to recover the difference in costs of two different heating and cooling systems by using the energy and maintenance cost savings from the more efficient system.

Supplemental heating: A heating system used during extremely cold weather when additional heat is needed to moderate indoor temperatures. May be in the form of electric resistance or fossil fuel.

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