Geothermal heat pumps: A down-to-earth investment

The dirt under our feet holds clean, "green" power that could potentially save consumers hundreds of dollars annually in heating and cooling costs, cut greenhouse gas emissions and help utilities to manage their loads more efficiently. The geothermal heat pump (GHP)—also called ground-source heat pump or geo-exchange system—is a highly efficient, electric space-conditioning system that extracts heat from its surroundings and moves it to where it is needed.

Although the technology has been in use since the 1940s, the market for it has only recently gained ground, pushed by rising fuel costs and environmental issues. Consumers who are concerned about both—and there are more every day—have discovered that GHPs are a good way to bring sustainability home.

Cost savings and other benefits

According to the U.S. Environmental Protection Agency, geo-exchange systems save homeowners 30 to 70 percent in heating costs, and 20 to 50 percent in cooling costs, compared to conventional systems.

Money isn't the only thing GHPs save. Approximately 70 percent of the energy the system uses is renewable energy from the ground. And, the electricity needed to operate the pump can come from any source, including solar and wind.

Since heat pumps don't burn oil, gas or wood to create heat, they reduce the amount of toxic emissions in the atmosphere. They currently eliminate more than three million tons of carbon dioxide, the equivalent of taking 650,000 automobiles off the road.

A GHP can add considerably to a home's value. Because the system doesn't rely on outside air, it keeps indoor air cleaner and free from pollens, outdoor pollutants, mold spores and other allergens.

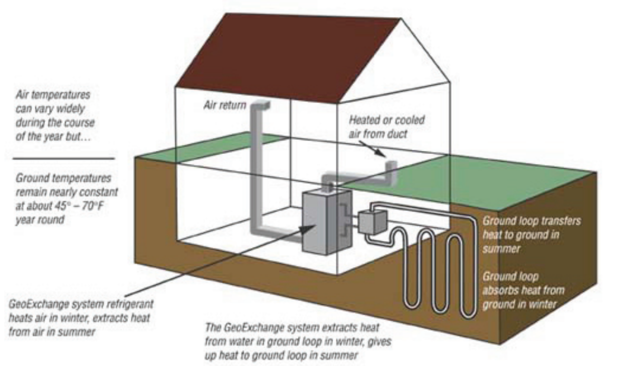
The systems are built to last for decades and require little maintenance. With fewer mechanical components than other HVAC systems, GHPs are quieter to operate. The largest component, the underground piping, is sheltered from the weather and is often guaranteed to last 25 to 50 years. The components inside the house are small and easily accessible for maintenance.

How GeoExchange systems save so much energy

GeoExchange systems rely on the renewable energy of the earth just below the surface for their high efficiency. A water solution flowing through piping buried in the ground absorbs heat from the ground in winter and transfers it to the GeoExchange system inside the building.

There, the heat is concentrated and transferred to air circulating through the interior to provide warmth on the harshest winter days.

In summer, the process is reversed. The system extracts heat from the interior air and transfers it to the ground by way of the ground loop piping.



Artwork courtesy of Geothermal Heat Pump Consortium

Performance standards

For all types of GHPs, heating performance is indicated by the Coefficient of Performance (COP), the ratio of heat provided in Btu per Btu of energy input. Cooling performance is defined by Energy Efficiency Ratio (EER), the ratio of the heat removed (in Btu per hour) to the electricity required (in watts) to run the unit. For both COP and EER, the larger the numerical value, the less electricity required to operate it.

The Energy Star label on a system indicates a heating COP of 2.8 or greater and an EER of 13 or greater. Energy Star-qualified geothermal heat pumps use about 30 percent less energy than a standard heat pump. They are also quieter than conventional systems.

The Air-Conditioning and Refrigeration Institute (ARI), a non-profit organization, rates the performance of residential and small commercial heat pump equipment. Certified equipment carries the ARI seal. Use the ratings only to compare one manufacturer's products to another's. They DO NOT reflect actual performance in any installation.

Heat pump basics

Geothermal home conditioning systems consist of three components:

- A fluid-filled earth connection that transfers heat between the ground and its fluid
- A heat pump to move the heat between the fluid and the air that will condition the building
- A distribution system that delivers the conditioned air to the building

The earth connection is a loop field, buried vertically or horizontally (see sidebar) on the property. The size of the loop field depends on the size of the building to be conditioned. Typically, one loop (400 to 600 feet) has the capacity of one ton or 3.5 kilowatts. An average house will range from three to five tons (10 to 18 kW) of capacity.

The fluid in the loops is usually antifreeze or water, while the pump component uses refrigerant R-22 to exchange heat between the refrigeration cycle and the antifreeze exchange fluid. R-22 is an earth-friendly hydrochlorofluorocarbon (HCFC) with only 5 percent of the ozone depletion value of the most damaging refrigerants R-11 and R-12.

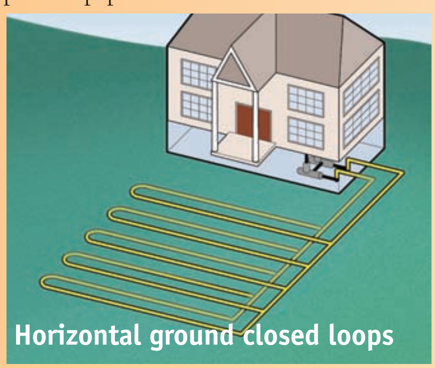
The heat pump, or air handler, is installed in the house, and includes a compressor, air coil, blower and filter. The home's air-delivery ductwork distributes the heated or cooled air through the house, just like conventional heating systems.

A device called a "desuperheater" can be added to most GHP systems to provide household water-heating capability. In the summer cooling period, the heat that is taken from the house is used to heat the water for free. In the winter, water heating costs are reduced by about half.

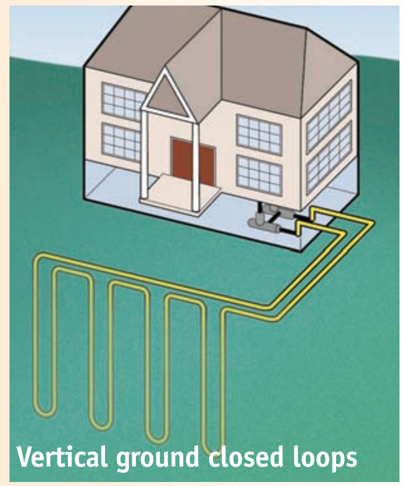
Types of loops: pros and cons

Most loops for residential geoexchange systems are installed either horizontally or vertically in the ground, or submersed in water in a pond or lake. Each type of loop configuration has its own advantages and disadvantages. Your GHP contractor should help you decide which configuration best meets your specific needs.

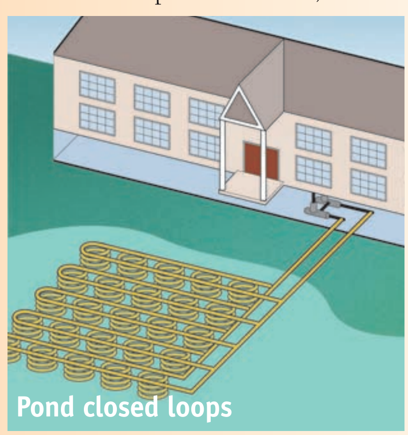
Horizontal ground closed loops are a series of parallel plastic pipes laid in trenches three to six feet below the ground surface, typically 400 to 600 feet long per ton of heating and cooling capacity. These installations are relatively simple—especially if done while a home is under construction—but require a large site and longer lengths of pipe due to seasonal variations in soil temperature.



Vertical ground closed loops are installed in vertical holes 150 to 450 feet deep. Each hole contains a single loop of pipe with a U-bend at the bottom, and a horizontal pipe connects each vertical loop. The heat exchanger is buried deeper than with a horizontal system, so vertical systems are usually more efficient and can get by with less total pipe. Drilling for vertical installations is more expensive than trenching for horizontal loops. However, for smaller sites and hard rock soil, vertical loops may be the only option.



Pond closed loops and open-loop systems may be the most economical option and the easiest to install for homes near a body of surface water, such as a pond or lake. The pond closed-loop consists of long sections of pipe submerged under water. This configuration requires a water level that never drops below six feet. Open-loop systems are the simplest to install, but can only be installed where local codes permit. Always consult local environmental officials when considering an open-loop system.



Artwork courtesy of Geothermal Heat Pump Consortium

What to expect

Beyond the high first costs for installation, simple lack of familiarity with GHP technology is a major stumbling block for many consumers. The more customers understand about GHP technology, the more satisfied they will be with their GHP systems. Below are some of the issues that concern homeowners. The International Ground Source Heat Pump Association (IGSHPA) has a comprehensive list of frequently asked questions at **www.igshpa.okstate.edu/geothermal/faq.htm.**

Lawns: Retrofitting a home with a ground-source heat pump almost always involves digging up a lawn. Horizontal loops require a long, narrow trench, while vertical loops disturb less area. Grass seed or sod can easily restore temporary bare spots. ALWAYS check with your utility for underground cables before digging.

Air distribution: Proper construction of the home's ductwork is essential to efficient operation over the life of the GHP. Ductwork must be sized, insulated and sealed properly so the air gets where it's going at the right temperature.

Speaking of temperature, the output air from a GHP is 90-105 degrees (F), lower than that of forced-air furnaces. However, heat pumps increase comfort by moving warm air at slightly higher volumes, evening out the hot or cold spots common with fossil fuel systems.

Electric bills: Homeowners who replace a gas or fuel-oil furnace with a GHP may be surprised to see their electric bill go up. This is especially true for inadequately-insulated homes, and should be factored into the payback calculation. A well-insulated and -weatherized home is the key to keeping energy bills down with any type of heating and cooling system, GHPs included.

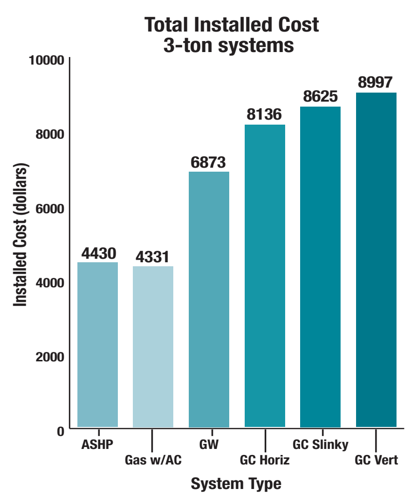
Backup systems: All systems require an emergency backup. Heat pumps can meet all of a home's cooling needs and 80 to 100 percent of the heating requirements. The contractor's economic analysis should dictate what portion of heat the GHP should provide and what portion should come from the auxiliary source. A home's existing fossil fuel or electric heat system can provide the backup.

Insurance coverage: Most homeowner insurance policies automatically cover GHPs. Contact your insurance provider to find out what its policy is. Even if your policy will cover your system, it is best to inform them in writing that you own a new system.

What it costs

There's no getting around it—GHPs are more expensive to install than conventional heating and cooling systems. The payback comes from the system being much less expensive to maintain and operate. The efficiency of a properly-sized and -installed GHP (the amount of energy delivered per unit consumed) is more than twice that of high-efficiency forced-air furnaces.

So how much should a homeowner expect to pay for a GHP, and how long will it take to recoup the investment? On average, a GHP system costs about $2,500 per ton of capacity, or roughly $7,500 for a 3-ton unit (a typical residential size). In comparison, other systems would cost about $4,000 with air conditioning. The cost of drilling or trenching is the most expensive component of the system. Depending on the size and type of GHP, drilling conditions and local labor rates, trenching can run from $1,000 to $3,000 per installed ton, above the cost of the equipment itself.



Source: An Information Survival Kit for the Prospective Geothermal Heat Pump Owner, Kevin Rafferty, P.E., for HeatSpring Energy, March 2008

Savings range from 30 to 60 percent, depending on factors such as climate, the system replaced and local utility rates. The return on investment can vary as widely as two to 10 years, calculated from current energy costs. Remember, the cost of energy stored in the ground doesn't go up.

Special financing options and incentives can reduce the payback period—sometimes considerably. Energy-efficient mortgage loans for energy-saving home improvements may be available through Federal, state or local governments; power providers; and banks or mortgage companies. Manufacturers or power providers may also offer performance contracts, loans to buy energy-saving systems that the customer repays with guaranteed utility savings.

The Database of State Incentives for Renewable Energy (DSIRE) Web site, **www.dsireusa.org/**, has the latest information about incentives. Check with your electric utility to see if they offer any rebates, financing, or special electric rate programs. Be sure the system you're interested in qualifies for available incentives before you make your final purchase.

Proper installation

Installing a GHP is not a do-it-yourself project—backfilling around the pipe, fusing the polyethylene piping, flushing the system and purging air from it require skills, tools and equipment only available to properly-trained contractors. In fact, under-qualified contractors may well be the most common source of performance problems.

Drilling and design are also essential to the GHP system's performance. Mechanical engineers qualified for conventional HVAC design may lack the specific skills needed for designing heat pumps. The Association of Energy Engineers now certifies electrical engineers, and drillers receive certification through the National Groundwater Association.

Currently, training and accreditation standards differ from state to state. In areas where GHP technology has not yet caught on, qualified contractors may charge higher prices. Start your search for accredited installers and certified designers with IGSHPA's business directory, **www.igshpa.okstate.edu/directory/directory.htm.**

Use these guidelines from the Geothermal Heat Pump Consortium, **www.geoexchange.org**, to help evaluate contractors:

- **Go with a pro.** The contractor should follow the installation procedures established by IGSHPA.
- **Check training credentials.** Installers should be accredited by IGSHPA or another recognized institution that trains and certifies contractors. Also, find out if the contractor has been trained by the manufacturer of the equipment you are purchasing. Different systems have different specifications.
- **Get references.** Installing a GHP in Iowa is different than installing one in Utah, so ask for the names of other local customers. Visit or call the references to check their satisfaction firsthand.
- **Expect a home evaluation.** A good contractor will check ducts, insulation and other features to make the best recommendation for your home.
- **Ask questions.** Find out about the contractor's experience installing GHPs and inquire about the recommendations for your home.
- **Get several estimates in writing.** Talk to two or more contractors. Ask for a breakdown between labor and equipment costs, and get clarification for any questions to make sure you are comparing "apples to apples."
- **Get a warranty.** Manufacturers' terms vary. Insist on a performance guarantee that covers the installed system—not just the heat pump itself.
- **Insist on a written contract.** Be sure to include all terms, including costs and start-stop dates.

Resources – Web sites and experts

Geothermal Heat Pump Consortium, **www.geoexchange.org/**

International Ground Source Heat Pump Association, **www.igshpa.okstate.edu**

Geo-Heat Center, Oregon Institute of Technology, **http://geoheat.oit.edu/**

The Office of Energy Efficiency and Renewable Energy Geothermal Technologies Program, **www1.eere.energy.gov/geothermal/heatpumps.html**

The Database of State Incentives for Renewable Energy, **www.dsireusa.org/**

ENERGY STAR, **www.energystar.gov/index.cfm?c=geo_heat.pr_geo_heat_pumps**

Association of Energy Engineers Certification Program, **http://www.aaecenter.org/certification/**

Energy Services
Western Area Power Administration

Energy Services Web site
www.wapa.gov/es

Western's Power Line:
1-800-POWERLN
(1-800-769-3756)

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