Homeowner's Guide to Geothermal Heat Pump Systems

Introduction

This guide is written to offer helpful information for homeowners considering installing a geothermal (often called ground-source) heat pump system to heat and cool their home. In writing this guide, we have tried to synthesize information from a number of sources and provide useful information to assist individuals as they go through the often complex process of considering geothermal, requesting bids, selecting a contractor, having a system installed, and insuring proper performance. While we have attempted to write to the general North American audience, the content is likely biased towards our own experience which is concentrated in the eastern and mostly northeastern US.

The Guide is motivated largely by a recent discussion on LinkedIn GeoExchange forum initiated by Tamar Fox, a homeowner in Minnesota. In an effort to troubleshoot her own system, Ms. Fox has become quite engaged in the industry discussion groups and after years of troubleshooting, posed the question "What is the best way to select a GSHP designer/installer?" The discussion topic elicited over 140 comments from many of the leading experts in the field, clearly indicating that it is an important question without a simple answer. One common element in the advice given is the importance of an educated homeowner. This guide is intended to provide an additional resource that will help educate homeowners on geothermal heat pump systems to facilitate a productive dialogue between homeowners and installers. Our goal is to be informative rather than prescriptive, and we encourage homeowners to consult other valuable resources that may be more pertinent to their geographic location or specific situation.

How Geothermal Heating/Cooling Systems Work

This Guide will refer to geothermal heating/cooling systems as *Geo Systems*. Geo systems extract solar energy from the shallow subsurface using a ground heat exchanger (commonly called a *ground loop*), and concentrate this energy to heat a home. In the cooling season, geo systems reject heat from the home to the ground via the ground loop.

Geo systems can be an excellent choice to heat and cool a home because they offer the potential for long-term low and stable heating and cooling costs, offer unparalleled comfort and reliability, and can dramatically reduce a homeowner's carbon footprint. The reasons

that geo systems are relatively rare in the U.S. are threefold: 1) most Americans don't understand, or are not aware of, geo systems as a viable option; 2) like solar panels and other "green energy" technologies, geo systems can have relatively high upfront costs but available federal tax credits can significantly offset these upfront costs; and 3) geo systems are best suited to well-insulated homes with a tight building envelope.

There are several important distinctions between a geo system and a traditional fossil-fuel based system. The following tables describe these basic differences in cooling and heating mode.

COOLING

Cooling Method	Building Heat is Extracted Via:	Method of Heat Rejection	Heat is Rejected to:
Air Conditioner (air source heat pump)	Heat Pump	Condenser Coil	Hot outdoor air
Geothermal Heat Pump	*Heat Pump*	*Ground Loop*	*Cool ground*

HEATING

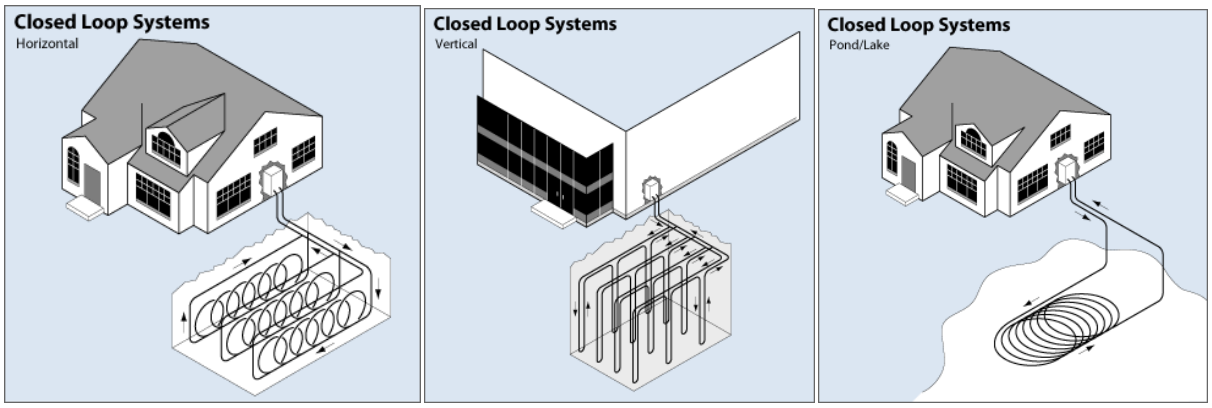
Fuel	Source of Fuel	Fuel Deliver y Method	Thermal Energy Extraction Method
Oil	Non-renewable fossil fuel	Oil Truck	Combustion
Natural Gas	Non-renewable fossil fuel	Pipeline	Combustion
Propane	Non-renewable fossil fuel	Propane Truck	Combustion
Electricity	Renewable Hydro power Nuclear Combustion of fossil fuels (i.e. natural gas, coal) Renewable Solar or Wind	Transmission Wire	Direct Resistance
Geothermal	*Renewable solar energy in shallow subsurface* *and* *Electricity* *(see above for sources of electricity)*	*Ground Loop*	*Heat Pump**

* The higher the efficiency of the geothermal heat pump system, the less electricity required to operate the system.

A geo system consists of four individual components: 1) the ground loop; 2) the heatpump; 3) the distribution system; and 4) system controls. Understanding how these components function will help to select the type of system you want and the best installer for the job.

The Ground Heat Exchanger or Ground Loop

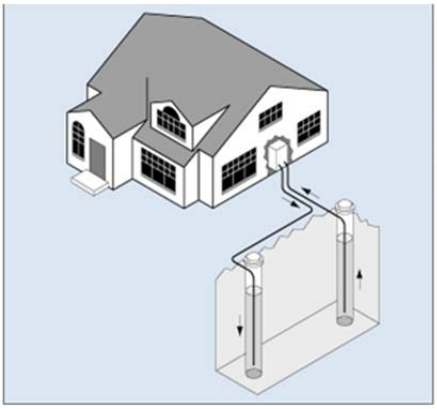
The ground heat exchanger, also commonly called a ground loop, is a pipe or a well that contains fluid in thermal connection with the ground. A **Closed Ground Loop** circulates a dilute mixture of water and refrigerant through underground tubing to extract heat from the ground. The fluid in the tube absorbs heat from the ground and delivers this heat up to the heat pump in the home. In cooling mode, heat from the building is rejected into the fluid, which in turn transfers the heat to the ground as it circulates through the ground loop. Different configurations of closed ground loops are shown below:



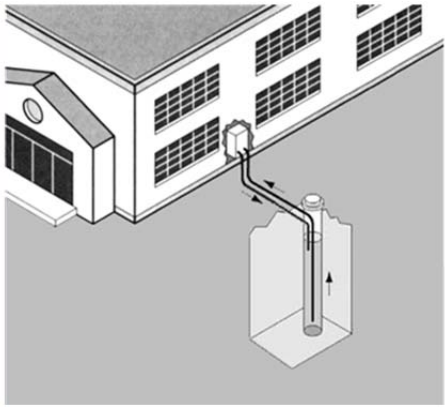
Horizontal Slinky Vertical Pond/Lake Slinky

Open Ground Loops withdraw heat directly from water pumped from a groundwater well or surface water body such as a pond or lake. After passing through the heat exchanger in the heat pump, ground water is returned to the same well (Standing Column Well) or to a different well (Reinjection Well). Because open loop systems do not use antifreeze, it is important that the water temperature not drop below freezing. One approach to help manage entering water temperature (both in heating and cooling mode) is to *bleed* some of the return water and discharge it to another location, drawing in more of the groundwater near the well.

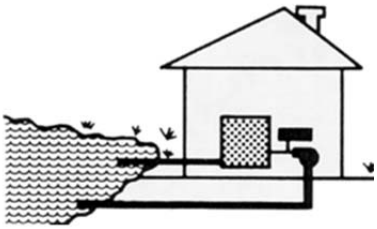
Open pond loops take water from a pond or lake and return it back to the surface water body. Any open loop system that returns water to a *surface water body* will likely require a permit. Also, many states and localities have specific regulations regarding the withdrawal and return of groundwater from wells, and specific permits may be required. Make sure to discuss this possibility with your installer. Different configurations of Open Loop systems are shown below:



Extraction/Rejection Well



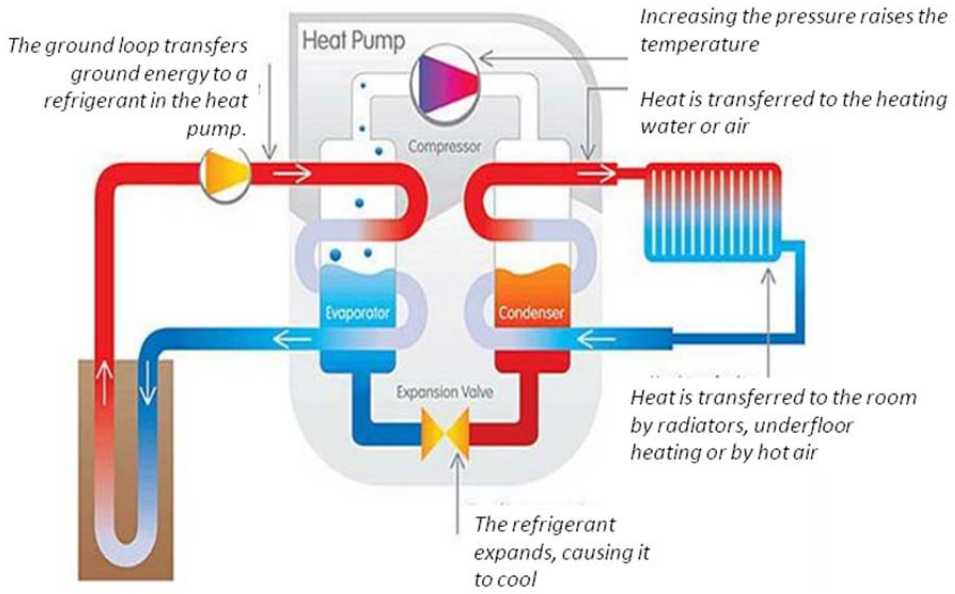
Standing Column Well



Surface Water Loop

The Geothermal Heat Pump

A geothermal heat pump is the equipment that concentrates thermal energy in the circulating fluid into temperatures that are high enough to heat a building. The heat pump uses a refrigeration cycle, just like that used in refrigerators, freezers and air conditioners. As shown below, low to moderate ground temperatures are carried into the heat exchanger in the ground loop fluid. These low to moderate temperatures are passed by a loop of refrigerant in the heat exchanger, causing the refrigerant to vaporize into a low pressure, warm vapor. This vapor is then routed into the compressor where it is pressurized into a



Refrigerant Cycle in Heat Pump

high pressure, hot gas. Air or water flowing past this hot refrigerant vapor picks up heat and then moves into the building to heat the building. Having given up some of its heat, the

now warm high pressure refrigerant gas moves on to the expansion valve where it is allowed to rapidly expand, thereby cooling and returning to its original state, a cold liquid.

From this point, the cycle repeats itself. In cooling mode, this entire cycle is run in reverse, with heat from the building being transferred to the ground loop fluid which in turn rejects the heat to the ground.

Compressor Staging

The geothermal heat pump contains either a single, dual, or variable speed compressor. A single-stage compressor produces a constant amount of heating or cooling. Because single stage systems are designed to meet the maximum load, they tend to be oversized during periods of moderate load, resulting in rapid cycling of the heat pump. Rapid cycling reduces efficiency, creates more wear on the heat pump, and may not result in the desired level of humidity reduction during cooling mode. Dual stage systems help to alleviate this problem as they can operate most of the time at 67% of full capacity (1st stage) and then can increase compression during periods of higher demand (2nd stage). Dual stage systems have longer cycles and provide for improved efficiency and comfort. While a dual stage heat pump is a significant improvement over a single stage heat pump, oversizing a dual stage heat pump can result in similar short cycling and potential problems with humidity control. When a single heat pump is serving multiple zones, similar inefficiencies can result. Because the heat pump needs to be sized for maximum load to all zones, it may be oversized, even in 1st stage, for individual zones. Heat pump staging and efficient delivery of heat to different zones are aspects that can often be managed through proper controls (discussed below). Some of the newest heat pumps have multiple stages that can help to alleviate this problem. The variable speed compressor operates at a wide range of capacities that can be better aligned with the wide range of heating / cooling loads. Variable speed heat pumps, while offering higher efficiencies, do come with a higher price tag. Your installer can help you decide which type of heat pump is right for you.

Auxiliary Electric Heat

A geothermal heat pump is often equipped with an electric heating element that is commonly referred to as the auxiliary heat. The auxiliary heat can serve two separate purposes. First, it can turn on as a 3rd stage of a two stage system when the heat pump at full load is not sufficient to meeting the heating demand. This is common in very cold climates where it might make more economic sense to design a system to meet 90-95% of the maximum demand and use electric heat to meet the remaining 5-10%. Under these conditions, the auxiliary is used in combination with the heat pump and reductions in efficiency are modest. The second purpose of the auxiliary electric heat is to provide a source of emergency back-up heat if the heat pump shuts off. We have found that homeowners can be quite unhappy if an unexpectedly high electric bill is their first clue that their heat pump was not functioning properly. One solution to avoid the surprise on

an electric bill is to include system monitoring that will alert the homeowner when the auxiliary heat is active.

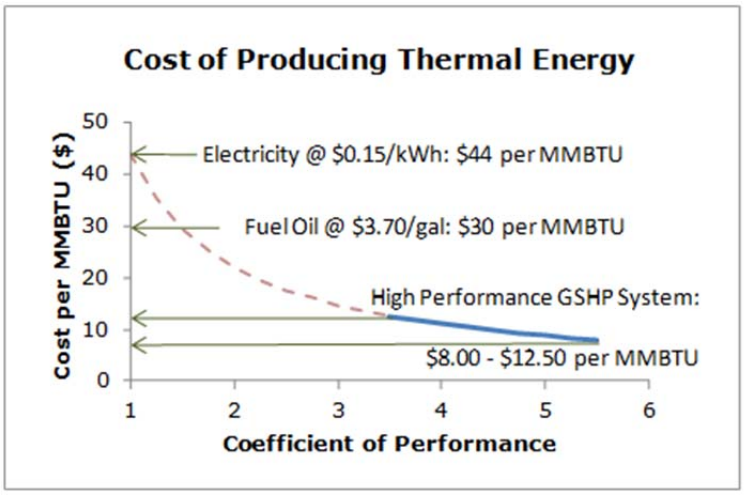
Desuperheater: Hot Water Heating

A desuperheater is a secondary heat exchanger that uses excess heat from the heat pump to preheat water entering the home's hot water tank. The desuperheater only operates when the heat pump is actively heating or cooling the home. In some cases, the desuperheater can provide more than half of a home's domestic hot water. Many installers strongly recommend using an intermediate storage tank (often referred to as a buffer tank) instead of plumbing directly to the domestic hot water tank(s).

Coefficient of Performance

The term Coefficient of Performance (COP) is used to describe both the efficiency of a heat pump and the overall efficiency of a geothermal heat pump system. Manufacturers test their equipment in the lab according to industry standards and report a COP for a range of laboratory operating conditions. These data are commonly referred to as Performance Data. The COP of the installed system takes into account the actual heat pump efficiency (under actual operating conditions) as well as additional electrical loads such as circulating pumps, distribution-side pumps/fans, and auxiliary electric heating. The COP of the entire system may be, and usually is, different than the rated heat pump COP.

As shown in the figure to the right, once the installed COP exceeds approximately 3.5, most of the savings have been achieved and the costs savings associated with increasing the COP from 4 to 5 can be on the order of a few dollars per million BTUs (MMBTU). There is, however, a significant difference in the cost per MMBTU between a COP of 2 and 3.



Geo systems should be installed in homes that are well insulated and have made every reasonable effort to reduce building load. Load reduction can significantly reduce building load, system size, and therefore the cost of installation. Once you begin talking with prospective installers, you should ask your installer what you can expect in terms of actual COP and what measures they take to ensure a high performing system.

The Heating/Cooling Distribution System

The third component of a geo system is the distribution system that is responsible for moving the heat from the heat pump through the home. Air ducting goes with a water-to-

air geothermal heat pump, and a radiant (usually floor) system goes with a water-to-water geothermal heat pump.

Whether you choose/have a forced hot air or radiant system, an efficient distribution system is very important for a high performance geo system. For radiant systems, pipes must be properly sized have proper spacing and have a good thermal connection with the room. For air distribution systems, ducts must be tightly sealed and efficient.

System Controls

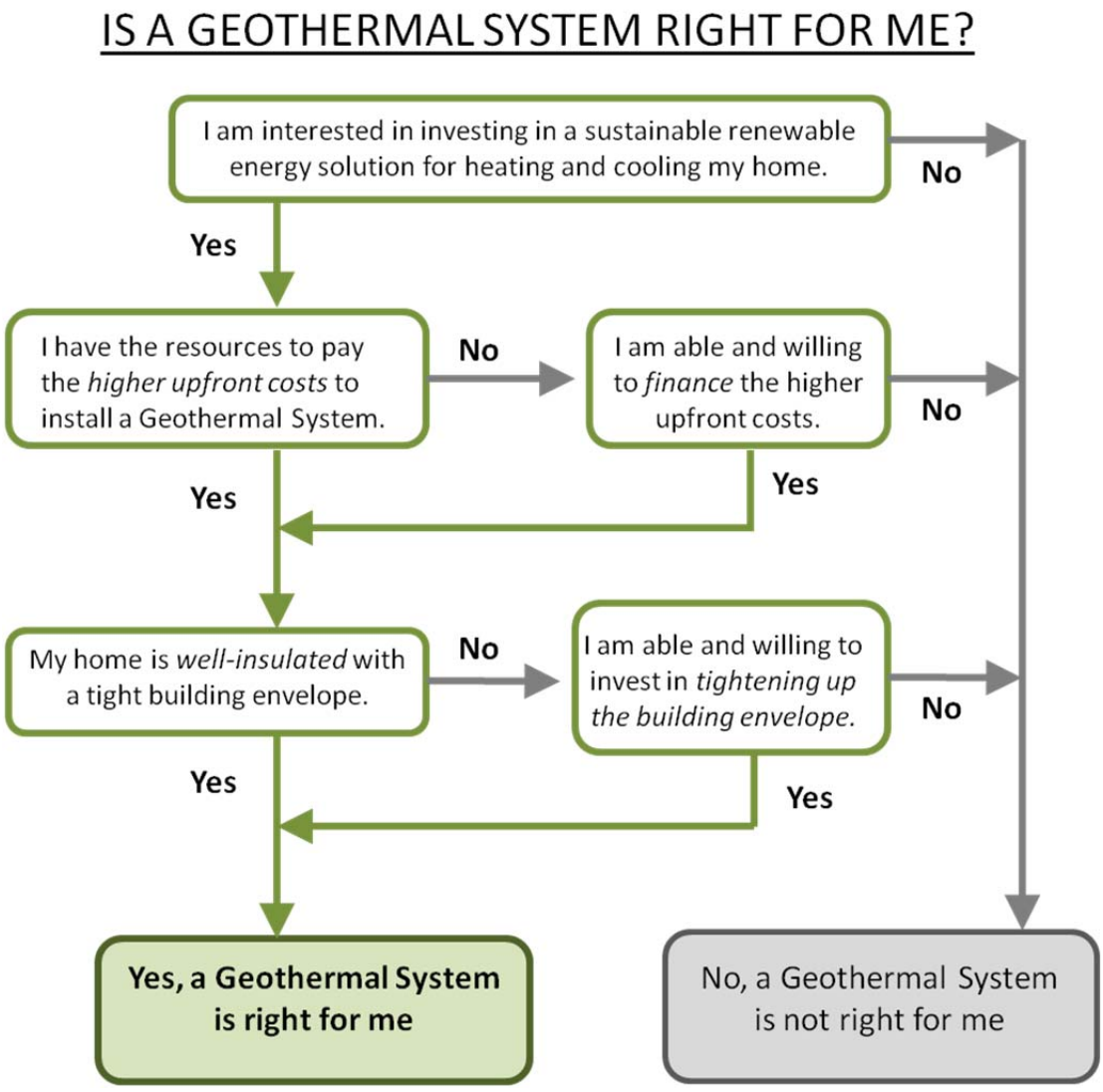
As noted above, optimizing the efficiency of a geothermal heat pump requires careful attention to proper heat pump staging and efficient distribution of heat throughout the home. Most heat pump manufacturers have specific thermostats for their heat pumps, though in many cases it is possible to use other thermostats that have additional features, such as internet access. Most of the common WiFi thermostats (e.g. Ecobee) are compatible with geothermal heat pumps, however be sure that your installer is familiar with your preferred thermostat and that they have been able to use it successfully in other installations.

Is a Geothermal Heating/Cooling System Right for You?

Now that we have covered what a geothermal heat pump system is, the next step is to determine if it is appropriate for your application. Unlike homes heated with oil and propane, geo systems use thermal energy from the ground as their primary "fuel" and electricity to run the heat pump. Given the highly variable price of oil and propane, homes heated with these fossil fuels often have huge fluctuations in their heating bills. Homes heated with a geo system benefit from using renewable thermal energy in the ground and the relatively steady cost of electricity.

Running a heat pump is not carbon-free because of the electricity used to operate the heat pump. However, in parts of the country where electricity is generated with emissions-free energy sources such as hydroelectric, nuclear, and wind, the net carbon emissions associated with the operation of a heat pump are very low. Even in parts of the country that rely more heavily on coal-generated electricity, the net carbon emissions from heat pumps are nearly always considerably less than heating/cooling with natural gas, oil or propane. While geo systems produce a steady stream of comfortable heat, if the home is not well insulated, the geo system or any high efficiency heating/cooling system will be need to be very large or will need to operate well beyond its design capacity. *The main reason we don't recommend installing a geo system in a home that lacks a tight building envelope is that homeowners will likely blame the geo system for their high electricity bills instead of the simple fact that their house is poorly insulated.*

For a well-insulated home, a geo system will cost more to install upfront, but will pay for itself in the long run, especially as fossil fuel costs continue to rise. The higher upfront costs of a geo system stem from the need to install a ground loop (as discussed above). Just as the most highly efficient oil and gas furnaces come at a premium cost, the most efficient heat pumps (those with the highest COP) tend to come at a premium cost as well. However, as will be discussed below, dual stage heat pumps deployed in a thoughtful manner can offer homeowners reliable low-cost heating and cooling for decades to come. Take a look at the flow chart below to see if a geo system is right for you.



If you arrived at the green box and have decided that a geothermal system is right for you, it's time to start looking for an experienced and qualified installer in your area.

Finding and Selecting the Right Geo Installer

Finding the right installer is essential for a geo system. While the process we propose here may seem lengthy, it isn't that much different from the steps one should undertake to install a traditional HVAC system. The four steps we recommend to find a good geo installer is as follows:

1. Create your Long List of potential geo installers by doing some simple research
2. Ask installers on your long list a series of questions to narrow down to a Short List of 3 or 4 installers
3. Request bids from your Short List – ask them a set of specific questions, detailed below, when they conduct the site visit
4. Compare the bids and check references.

Identify Geo Installers in Your Area (Your Long List)

You will first want to identify potential installers within a large radius (potentially 50 miles or more) from your home. There are several resources that can help in creating your "long list" of geothermal system installers:

- Word of Mouth
- Geothermal Professional Organizations
- Geothermal Heat Pump Manufacturers

Word of Mouth

If you know someone locally who has a geothermal system that they are happy with, by all means ask them who installed their system. This can be a great way to get started with your search.

Professional Organizations

Many professional organizations, both nationally and regionally, provide a list of members. While this is one good source, keep in mind that there are many excellent installers who are not members of these organizations. A non-exhaustive list includes:

National Organizations

- Geothermal Exchange Organization (GEO) http://www.geoexchange.org/
  GEO is a professional industry group. While installers on this list are probably good ones, there are many high quality installers not on this list.

- International Ground Source Heat Pump Association (IGSHPA)
  http://www.igshpa.okstate.edu/
  IGSHPA is the leading training organization for closed loop geo system and maintain lists of accredited installers and certified geothermal designers.

Regional Organizations

Some regions of the country have their own regional geoprofessional organizations. Members of these organizations are committed to excellence and furthering their industry, and therefore members of these organizations are likely to offer high quality installations.

- California Geothermal Heat Pump Association
- Colorado GeoEnergy and Heat Pump Association CoGHPA
- Connecticut Geothermal Association
- Geothermal Alliance of Illinois
- Iowa Geothermal Association
- Long Island Geothermal Energy Organization LIGEO
- Minnesota Geothermal Heat Pump Organization
- Michigan Geothermal Professional Association
- New England Geothermal Professional Association (NEGPA)
- Wisconsin Geothermal Association

Manufacturers' Websites

Most heat pump manufacturers maintain a searchable database of installers who are trained on their geothermal heat pump systems. The leading manufacturers of residential geothermal heat pumps in North America include:

- Climatemaster
- WaterFurnace
- ComfortAir
- Bosch
- Enertec (Hydron, GeoComfort and Tetco)
- Geofinity
- Nordic (Canada)
- NextEnergy (Canada)

Narrow Down Your List (Your Short List)

Depending on where you live, you may now have quite a long list. To narrow your list down to the top 3 or 4 that you will request bids from, we suggest you *request the following information from installers*:

Where Did They Get their Training and Certification?

There are many excellent methods for an installer to receive training and certification, both online and in the classroom setting. The most common GSHP training and certification program is offered through the International Ground Source Heat Pump Association (IGSHPA) and consists of two different levels. The Certified Geothermal Designer (CGD) is trained in sophisticated ground loop design often associated with large residential and commercial buildings. A CGD level of training is typically not necessary for a single family residential system. IGSHPA also offers an Accredited Installer (AI) certification that is

geared more towards the complete design and installation of a closed-loop residential GSHP system. There is currently no nationally recognized training program for open loop or standing column well systems, but as explained below, some distributors have extensive experience in this type of installation and offer professional training to their installers. Among others, the following organizations offer excellent training and certification for geo installers:

- IGSHPA offers a variety of training classes at their Oklahoma headquarters
- HeatSpring Learning Institute works with IGSHPA to deliver online training
- GeoConnections Inc Several coauthors of the IGSPHA training manuals have integrated much of the technical material involved in design into a commonly used piece of design software -- LoopLink. Training and certification on the software means that the individual is familiar with the same design methods as the IGSHPA Accredited Installer.
- Water Energy Distributors is a New England distributor that offers classroom and hands-on training in all aspects of geo installations, and are well known for their expertise in standing column well open loop installations.
- Phoenix Energy Supply in upstate New York offers IGSHPA training
- Litchfield Geothermal offers IGSHPA training seminars around the country
- Asheville Geothermal offers IGSHPA training in North Carolina
- The Energy Efficiency Business Coalition (EEBC) offers IGSHPA training in Colorado
- The Geothermal Training Institute in Minnesota offers a wide variety of online and classroom IGSHPA training seminars.

If you expect you will be using a vertical ground loop, also check to see if the driller that your installer uses has individuals on staff who have received the IGSHPA Vertical Loop Installer (VI) training. It is very important to keep in mind that IGSHPA accreditation represents a level of training but does not insure proper installation or a highly efficient geo system.

Other professional credentials that are common in the geothermal industry include: Professional Engineer, Professional Geologist, Architect, and Licensed Driller. While these credentials may add to one's qualifications they are usually not sufficient to design a high performance GSHP system without specific training and experience in GSHP technology.

How Much Experience do they have with Geo Systems?

Ask the installer about their experience installing geothermal heating cooling systems. Ask them questions regarding:

- How many years have they been doing geo installs?
- How many systems have they installed?
- Is their experience in residential or commercial?

- If you are building a new home, make sure they have experience with new installations. Likewise, if you are replacing an existing heating/cooling system with geo, confirm that they have plenty of experience with geo retrofits.

How do they Size the Geo System?

Sizing any HVAC system is very important to achieve optimal performance. The Residential Energy Services Network (RESNET) uses this analogy:

> "You wouldn't buy an 18-wheeler just to drive around town, right? That vehicle wouldn't match the task at hand, and would cost you a lot more money to operate. The same goes for heating and cooling equipment. If your system is larger than necessary, it means that you are paying to operate larger fans and larger compressors. The goal is to buy one that is sized "just right." This can be equated to highway mileage in a vehicle. If it runs steadily, without stopping and starting, it's more affordable to operate…. The Manual J [of a building] is the name for a specific protocol used to determine how much heating/cooling a home needs to stay cool and dry in the summer and warm in the winter. This load calculation process was developed by engineers in the heating and air conditioning industry and has been used for decades to accurately size heating and air-conditioning equipment."

For a geo system, proper sizing is additionally important as the system size will determine the size of the ground loop, which is your investment enabling you to utilize your own energy from the ground.

All geo systems should be properly sized by using either ACCA Manual J or ASHRAE methods, also commonly referred to as load analysis. Either the installer should do the calculation themselves or they should hire someone else to do it. Be sure to get the name and credentials of the individual doing the analysis. Larger homes that have more than a few heat pumps and have higher heating/cooling demands tend to be designed by an architect and may utilize an engineer to design the geothermal HVAC system. In that case, the engineer will perform the load calculations and most likely use either ASHRAE or ACCA Manual J methods. Either type of house, large or small, it is very important for the homeowner to demand that the loads are done using ASHRAE or ACCA Manual J methods by individuals with training and experience in geo systems. For geo systems, calculations should tend to be aggressive with few 'safety factors'.

How do they Size the Ground Loop?

A critically important part of the design is determining the proper size of the ground loop. This may be the single most expensive component of the geo system and proper sizing will be essential to insure proper performance. The ground loop should be sized based on an understanding of the load (determined above), the thermal properties of the ground materials, and materials used in the ground loop construction.

For larger projects, a test well will often be drilled to allow for an onsite thermal conductivity test. For residential systems this is typically not practical, both logistically and financially. Instead, the designer will be relying on estimates of thermal properties based on rock type, obtained through observations, geologic maps, and experience in the area.

What Brand of Heat Pump do they Recommend?

Many installers carry a single heat pump brand, while others offer a variety of brands. Ask the installer why they prefer this brand of heat pump, and ask them what features of these heat pumps will be favorable for your application. Make sure that the heat pump they are recommending is listed in the AHRI database.

How do they Handle Available Tax Credits/Rebates?

The US federal government offers a tax credit of 30% of total installation cost of a geothermal heat pump system, both for new construction and for retrofits. The system must be put into service by December 31, 2016. Several state governments, local governments and electric utilities also offer financial incentives around the installation of geothermal heating systems. The Database of State Incentives for Renewables and Efficiency (DSIRE) provides a comprehensive listing by state of financial incentives. Ask the potential installers how these credits/rebates will be handled. Be sure that you understand how these benefits are incorporated into their bid, particularly for new construction.

Will they Monitor the Geo System's Performance?

Optimal performance from a geo system is achieved when the heat pump equipment is properly sized for the building, the ground loop is properly sized and installed for the heat pump equipment, and the heating/cooling is distributed efficiently through the building (load side). If one or more of these system components is out of balance it can result in other components operating less efficiently. A good monitoring system will tell you if all these systems are operating in balance, and moreover, will alert you and the installer if the system is out of balance and needs an adjustment. In short, a monitoring system can alert you to a potential problem before you are surprised by either a very large electric bill (if your system faults out and goes to auxiliary electric heat) or worse, the system stops working altogether and leaves you without heat or air conditioning. Ask your potential installers what type of monitoring and verification system they plan on using to keep track of the performance of your geo system. If the installer does not intend to use a monitoring system, make sure you ask why and how they intend to keep track of your system's performance.

Do They Offer a Maintenance/Service Contract?

Geo systems generally require only limited maintenance. Because open loop systems feed ground water or surface water directly through the heat exchanger in the heat pump, the groundwater filter on the entering water line will need to be changed periodically. Who

will be responsible for that? And how often will that need to be done? In the case of closed loop systems, the antifreeze should be checked on an annual basis and, if necessary, charged. Also, all forced hot air heating systems need periodic air filter changes. Again, find out who will do that and how often should it be done? If the installer offers a service contract, what is that cost for that contract and what is included?

Request Bids from your Short List Installers: The Site Visit

Once you have narrowed down your list, go ahead and request bids for installing a geo system at your home. Installers will visit your home to prepare their bid. This is your opportunity to have experts evaluate your specific situation and provide you with recommendations on whether a geothermal heat pump is appropriate for your home , given specific information about HVAC distribution, building load, and site geology.

We recommend you ask them to discuss these topics with you during their site visit. While you can expect many installers to discuss these issues with you in general terms, many specifics of the design may not be shown on the bid. In many markets, the design is the installer's competitive advantage that they have honed over years of experience in conditions specific to your geographic location. The effectiveness of their designs will be evidenced through talking to their references, performance data from their other installations, and a service agreement that shows they will stand behind their work.

Also, be aware that during the site visit, you shouldn't expect installers to provide concrete answers to all these questions, but rather be able to discuss them intelligently with you. Installers will determine the answers to these questions during their design process.

- Ground loop: Ask the installer what type of ground loop they recommend. Be sure they inspect your property and identify potential locations for the drilling/excavation equipment, noting overhead powerlines, septic systems, and other potential limitations.
- Heat Pump Equipment: What type of heat pump equipment will they be recommending? Is the heat pump AHRI Certified?
- Heat Distribution System: Will they be recommending forced hot air or radiant heat for your home? Discuss with them the pros and cons of each. If this is a retrofit, what changes will need to be made to your home to accommodate the geo system?
- Pumping Penalty: Ask the installer for an estimate of the pump penalty (i.e. roughly how much electricity is expected to be required to circulate the fluids through the loop).
- Balance Points: What are the outside air temperatures when the heating and air conditioning should come on? At what outside air temperature, should the auxiliary begin to supplement heat pump(s), if applicable?

- Peak Loads: What are the design temperatures for maximum heating and cooling loads, (e.g. 5°F for heating and 90°F for cooling).
- Minimum and Maximum Entering Water Temperatures: Entering water temperature is a large determining factor in the efficiency of the heat pump (similar to the 'octane rating' of gasoline in your car). Heat pumps can operate down to very cold water temperatures (25 °F) but loose efficiency under these conditions. Ask the installer to discuss what he/she expects to see as minimum and maximum entering water temperature during peak load.
- Building Improvements: What improvements might be made to tighten up the building envelope to help to reduce system size and cost of installation? If you (the homeowner) agree to making specific changes, and they base their design on those changes, then it will be your responsibility to make the agreed upon changes.

Choose an Installer

A ground loop is an investment that enables the use of a renewable energy source to heat and cool your home. If properly sized and properly constructed, it can be a significant asset to your home.

If all the bids proposed the same design and the same equipment, evaluating the bids would be simple: compare prices and references, and the choice would be obvious. However, this will likely NOT be the case. In terms of equipment, different contractors may favor different heat pump brands, with different features and prices. One installer might recommend a water-to-air system while another encourages you to go with water-to-water. You might have different recommendations for the ground loop; one contractor may advocate a standing column well due to its lower upfront drilling costs while another may advocate a closed loop design due to its lower pumping penalty and fewer maintenance requirements. Some installers will recommend a longer ground loop (deeper boreholes for vertical designs, longer trenches for horizontal designs) to maintain higher efficiency during peak load. Others may suggest installing a shorter loop length with the occasional use of supplemental electric heat (auxiliary heat) during peak load, thereby reducing installation costs but increasing operating costs. In some areas, it is simply a trade-off between initial installation costs and annual operating costs. However, this tradeoff may be less clear when the building load is dominantly heating or cooling. A shorter ground loop may experience thermal degradation over time (cooling off in a heating dominated climate or warming up in a cooling dominated climate). In the end, there may be many different design options. However, provided that they are all properly designed by experienced geothermal professionals, they should all work as designed and deliver the expected benefits. The final decision will come down to personal preference, cost, and rapport with installer.

To assist you in evaluating the bids and making your final decision, you should review the bids carefully and discuss the following details with your installer:

- Detail specifications of system components: As noted above, the bids should be a detailed as possible (without the installer giving away the actual specifics of their design). At a minimum, the bid should include equipment names, model numbers, the type and length of ground loop to be installed (standing column well, vertical closed loop, horizontal closed loop) and pump sizes.
- An estimate of the pumping penalty: After the heat pump, the next largest power consumer of the geo system is the pump required to circulate the loop fluid. Bear in mind, the smaller the piping/tubing, the more electricity that will be required to move the fluid (higher pump penalty). While smaller diameter tubing will be less expensive, it may end up costing you more in electricity costs in the long run. The pumping penalty (in kilowatts) should be less than 25% of heat pump power consumption listed in the AHRI Performance Data table.
- Manual J: The bid should specify that a Manual J analysis will be conducted. If the contractor does not compute the Manual J themselves, they should provide the name of the individual who performed the analysis.
- Drilling/Excavating Contractor: Detailed information regarding the drilling/excavating contractor should be made available to the customer. Many of these contractors have extensive experience with geo systems, and you will want to make sure your geo installer is working with one of these drillers. Contact the driller/excavator and ask them for a list of references as well. For closed loop systems, be sure they specify that the well will be grouted following IGSPHPA guidelines.
- Electrician: The bid should specify the name of the electrician that will work on the job; the electrician should be well versed in wiring geothermal equipment. Be sure you are aware of any upgrades that may be required to your electrical service.
- PT Ports: Be sure your installer includes in the design special ports to measure the temperature and pressure of the ground loop. These are commonly called P/T ports or Pete's Plugs.
- Tax Credits: While geothermal contractor should be able to confirm the eligibility of the equipment being installed for the Federal Tax Credits, the details in obtaining the tax credits are up to the homeowner and their personal accountant.
- References: Request a list of references, contact them, and ask them about their experience both working with the contractor as well as their experience with the geo system. Did they have a positive experience with the installation process? Did the installation stay within the proposed budget? If not, why not? Has the geo system operated as promised (comfort and reliability)? What methods have they used to verify system operation?
- Maintenance/Service: Details about future servicing of the geothermal system should be specified.

- Warranty: The contractor should be able to provide warranty information at the request of the customer. Can the contractor insure that the system operates to within 10% of manufacturer Performance Data? While this helps to insure that the heat pump equipment is operating within its specifications, and any adjustment or equipment malfunction will be covered, it does not necessarily equate to ensuring that the entire system is operating within 10% of the heat pump COP. Understand the difference between equipment warranty and warranty of system design.

Selection of the winning bid will ultimately come down to your confidence that the installer has the proper training and experience and has provided a detailed design that will deliver the financial and environmental benefits you desire. Their design should take into account the specific characteristics of your home and the ground conditions in which the loop will be installed. The thoroughness of the design process should be clear through their explanations to you of the topics discussed above. References and independent monitoring of existing installations are ways in which they can demonstrate that their specific designs perform as promised.

Select a Method for Monitoring Your New Geo System

Much of the discussion thus far has focused on how to identify the optimal design from the best installers and designers. Your investment in a geo system will enable you to utilize the renewable thermal energy of your property, will pay dividends for years to come, and will increase the property value of your home. However, even the best designs installed by well trained and experienced personnel can experience mechanical problems that require maintenance and repair. If you were to spend $50,000 on a high performance automobile, you probably would not assume that it would just run trouble free for the next decade, but you would be interested in having a dashboard with gauges and diagnostics so that minor issues could be quickly identified and fixed before they became bigger problems.

Until recently, the most common way to monitor the performance of a geo system was to pay close attention to electric bills. Unfortunately, this approach has proven to be ineffective in identifying and correcting problems before they cost you significant amount of money (as evidenced by high electric bill). In addition, it is often very difficult to troubleshoot the cause of the problem because there is no record of when it occurred or under what conditions.

Today, web-based monitoring that has become standard on many solar PV systems is now also available for geothermal heat pump systems. Web-based monitoring allows the homeowner to see how a system is performing in real time, receive email alerts when operating conditions exceed prescribed limits, and compare actual operating conditions with system design parameters. Homeowners and installers can work to together to

integrate monitoring into maintenance contracts so that if problems do arise, the installer can access the data and get a head start identifying the problem before they leave the shop.

When sufficient data points are collected, BTUs produced and kWh consumed can be tracked and provide a basis for computing cost and carbon savings, using local fuel costs and carbon intensities.

Information	Electric Bill	TED 5000	Ecobee	Ecobee-Geo*	GxTracker
Whole House Electricity	✓	✓	✗	✗	✗
GSHP Electricity	✗	✓	✗	✓	✓
Entering Water Temp.	✗	✗	✓	✓	✓
Ground BTUs Produced	✗	✗	✗	✓	✓
Heating & Cooling Degree Days	✗	✗	✓	✓	✓
Savings Relative to Conventional Fuels	✗	✗	✗	✓	✓
Carbon offsets relative to conventional Fuels	✗	✗	✗	✓	✓
Determine Balance Points	✗	✗	✓	✓	✓
Email alerts	✗	✗	✓	✓	✓
Measure Pumping Power	✗	✗	✗	✗	✓
Hot Water Monitoring	✗	✗	✗	✗	✓
Flow metering option	✗	✗	✗	✗	✓

* Hardware and GES app for Ecobee Smart thermostat, expected release Summer 2014

Conclusion

A geo system can be an excellent choice for homeowners looking to install a heating and cooling system that will offer then stable low heating and cooling costs, unparalleled comfort, and often significantly reduce their carbon footprint. We hope you find this information helpful and please send questions and comments to: info@groundenergysupport.com