AN INFORMATION SURVIVAL KIT
FOR THE PROSPECTIVE
GEOTHERMAL HEAT PUMP OWNER

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INTRODUCTION

The fact that you are considering a geothermal (or ground-source) heat pump system, places you among the best informed and most innovative homeowners in the country. Geothermal heat pumps (GHPs), although not a new technology, remain a small (but growing) player in the residential heating/cooling sector. Although somewhat higher in first cost, this technology can, in the right application, quickly repay this cost premium through savings in energy costs.

Despite all the positive publicity on GHPs, they are not for everyone. Like any other heating and cooling system, GHPs tend to fit well in certain circumstances and poorly in others. Familiarizing yourself with the factors that effect the feasibility of GHPs will assist you in making an informed decision as to their suitability for your home.

It is the intention of this package to provide that information and to address some of the commonly asked questions regarding the technology. Please feel free to contact us if you have questions not covered in this package.

TERMINOLOGY

One of the major hurdles for this technology is reaching a consensus as to what it will be called. A great many names have been used in the past with confusion resulting for the public and the industry. The following figures outline the major residential system types and the various names used for each.

Three terms are in use to describe the technology in general: geothermal heat pump (GHP), geoexchange (GX) and ground-source heat pump (GSHP). The first two are typically used by individuals in marketing and government, and GSHP by engineering and technical types. The terms appearing in bold (Figure 1) will be the ones used throughout this text.

Ground-coupled systems have been widely used since the mid-1980s. Currently, horizontal systems constitute about half of the installations, vertical 35%, and pond and "other" approximately 15% (Kavanaugh, 1995).

Groundwater systems have been used for somewhat longer time than ground-coupled systems, and have been popular since the early 1970s.

One system type not shown in the figure is the standing column system, an alternative type of open loop system. In this system, water is pumped from a well, passed through the heat pump and returned to the same well. These systems have been widely used in New England and were developed for areas in which the well will not produce enough water for a conventional open-loop system. Sometimes a small flow of water must be “bled” off to waste to keep the well temperature from getting too high or low.

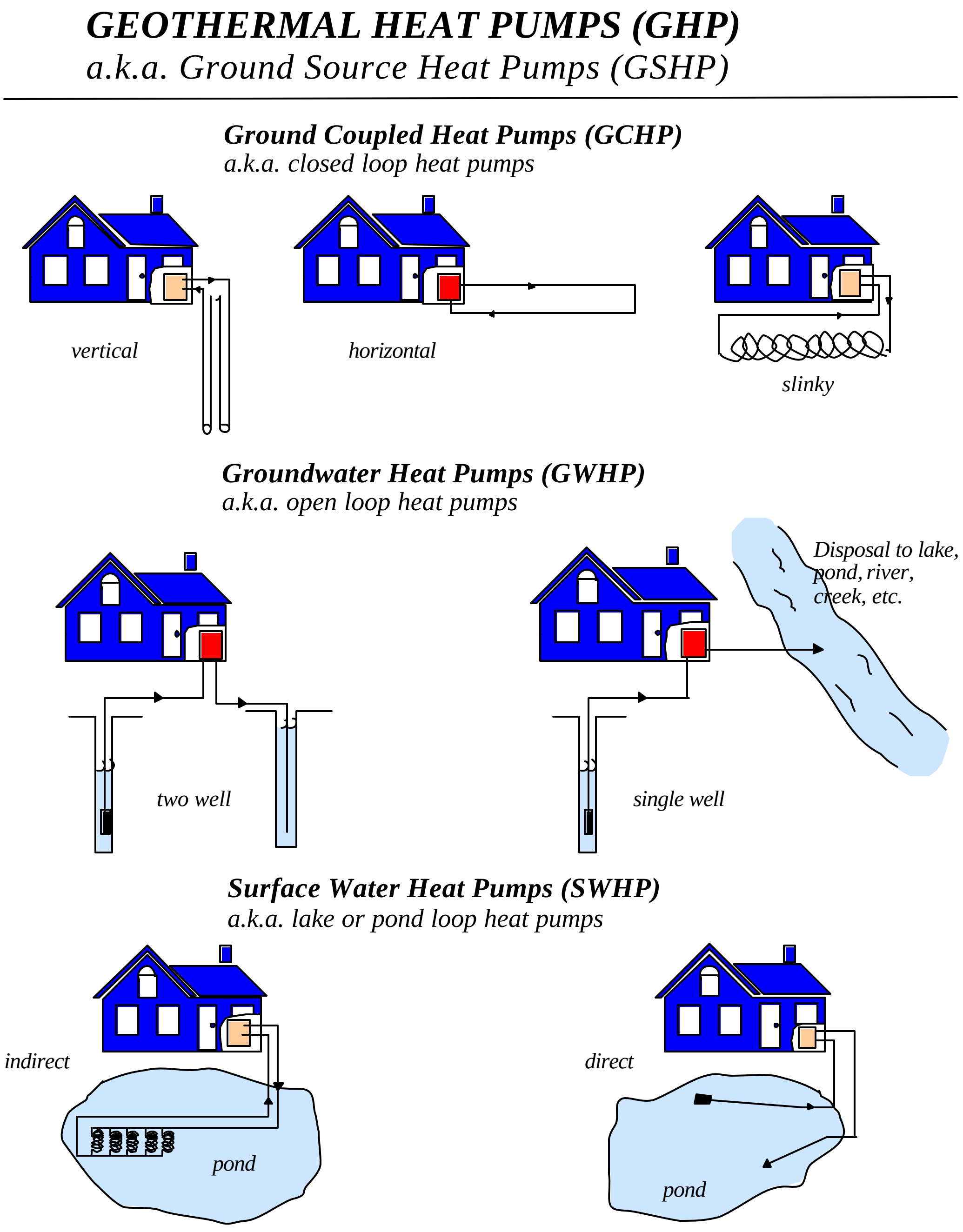

Figure 1.

HEAT PUMPS - FUNDAMENTALS

Heat naturally flows "downhill," from higher to lower temperatures. A heat pump is a machine which causes the heat to flow in a direction opposite to its natural tendency or "uphill" in terms of temperature. Because work must be done (energy consumed) to accomplish this, the name heat "pump" is used to describe the device.

In reality, a heat pump is nothing more than an refrigeration unit. Any refrigeration device (window air conditioner, refrigerator, freezer, etc.) moves heat from a space (to keep it cool) and discharges that heat at higher temperatures. The only difference between a heat pump and a refrigeration unit is the desired effect--cooling for the refrigeration unit and heating for the heat pump. A second distinguishing factor of many heat pumps is that they are reversible and can provide either heating or cooling to the space.

One of the most important characteristics of heat pumps, particularly in the context of home heating/cooling, is that the efficiency of the unit and the energy required to operate it are directly related to the temperatures between which it operates. In heat pump terminology, the difference between the temperature where the heat is absorbed (the "source") and the temperature where the heat is delivered (the "sink") is called the "lift." The larger the lift, the greater the power input required by the heat pump. This is important because it forms the basis for the efficiency advantage of the geothermal heat pumps over air-source heat pumps. An air-source heat pump, must remove heat from cold outside air in the winter and deliver heat to hot outside air in the summer. In contrast, the GHP retrieves heat from relatively warm soil (or groundwater) in the winter and delivers heat to the same relatively cool soil (or groundwater) in the summer.

As a result, geothermal heat pump, regardless of the season is always pumping the heat over a shorter temperature distance than the air-source heat pump. This leads to higher efficiency and lower energy use.

EQUIPMENT

The foundation of any GHP system is the heat pump unit itself. The most commonly used unit in these systems is the single package water-to-air heat pump. All of the components are contained in a single enclosure, about the size of a small gas furnace.

The unit includes a refrigerant-to-water heat exchanger, refrigerant piping and control value, compressor, air coil (heats in winter; cools and dehumidifies in summer), fan and controls (Figure 2).

The single package design is a major advantage over the so-called "split" system used for air-source heat pumps (ASHP). The lack of an outside unit reduces the amount of refrigerant required and the potential for leaks--a major enhancement to reliability.

Virtually all GHP units use refrigerant R-22, an HCFC. R-22 is considered a transition refrigerant and has a ODP (ozone depletion value) of 0.05--only 5% of the most damaging refrigerants R-11 and R-12. This refrigerant is not scheduled for phase out until 2030.

Domestic hot water heating capability can be added to most equipment. The components are installed in the cabinet by some manufacturers and supplied as a small add-on cabinet by others. The domestic hot water heating components consist of a refrigerant-to-water heat exchanger and a small circulating pump. Field installed piping connects this unit to your domestic hot water heater.

High efficiency equipment generally contains a high efficiency compressor, larger air coil, higher efficiency fan motor, and sometimes, a larger refrigerant-to-water heat exchanger.

Manufacturers also offer split systems, water-to-water heat pumps, multi-speed compressors, dual compressor, and rooftop versions of this equipment to suit various applications.

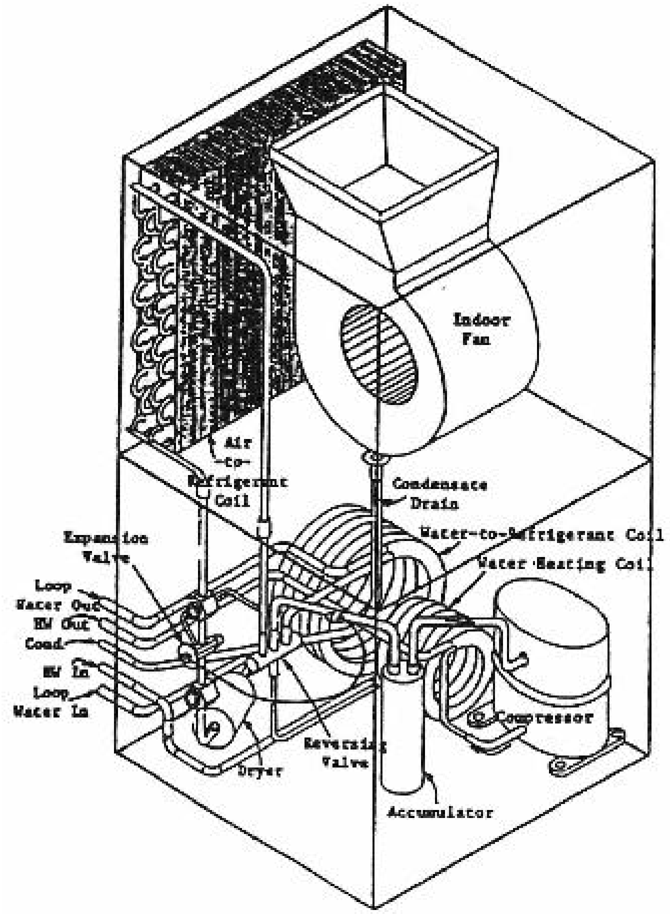

Figure 2. Vertical water-to-air heat pump (Kavanaugh, 1991).

PERFORMANCE RATINGS

One of the most confusing aspects of geothermal heat pump technology is equipment ratings. These heating and cooling performance values are useful for comparing units of the same type (i.e., ASHP to ASHP or

GHP to GHP). Unfortunately, the ratings used for different types of equipment (furnaces, ASHP, GHP) are not generally consistent making comparisons difficult. As a result, it is useful to know what the ratings values include and what they don't.

All heat pumps are rated by the Air Conditioning and Refrigerant Institute (ARI). Results are published every six months in the *Directory of Certified Applied Air Conditioning Products (for GHPs)* and the *Directory of Certified Unitary Products (for ASHPs).*

For water-source heat pumps (the type of heat pump used in all GHP systems), cooling performance is defined by an index called EER (Energy Efficiency Ratio). This is the cooling affect produced by the unit (in Btu/hr) divided by the electrical input (in watts) resulting in units of Btu/wattChr.

Heating performance is defined by the index called COP (Coefficient Of Performance). This is the heating affect produced by the unit (in Btu/hr) divided by the energy equivalent of the electrical input (in Btu/hr) resulting in a dimensionless (no units) value. For both COP and EER, the larger the numerical value, the less electricity required to operate it.

Both the COP and EER values for groundwater heat pumps are single point (valid only at the specific test conditions used in the rating) values only. This in contrast to the seasonal values (HSPF and SEER) published for air-source equipment. COP and EER are not the same as, or valid for use in comparison to, SEER and HSPF.

GHP Ratings

The ratings format for heat pump units used in these systems was recently changed. Up until June 2000, ratings were published under two different headings: ARI 325 (open loop or groundwater heat pumps) and ARI 330 (closed loop or ground-coupled heat pumps). Since much of the older manufacturers literature with the older ratings information included in it is still in circulation, the 325/330 rating system will be reviewed here. ARI 325 was intended for residential groundwater heat pump systems. Performance (EER and COP) was published at two water temperatures: 70^o and 50^oF. A pumping penalty (to reflect the power required by a well pump to supply water to the heat pump) was added to all units rated under ARI 325.

ARI 330 was intended for closed loop or ground-coupled GHPs and was based upon entering water temperature of 77^o in the cooling mode and 32^o in the heating mode. One of the limitations of this rating was that the temperatures used were reflective of a northern climate. Southern installations would see higher temperatures entering the heat pump and thus, have better winter and poorer summer performance than indicated. A much smaller pumping penalty (reflective of the power required by the small ground loop pump) was added to all units under ARI 330.

As of January 2000, the ARI 325 and 330 ratings were replaced with a single ISO 13256-1 rating system. Under the new system, performance values (EER and COP) are provided at different temperatures to reflect performance in different system types. The ratings are divided in to three parts: WLHP, GWHP and GLHP of which the most useful for GSHP systems is the GLHP values. This information can be used to compare the products of one manufacturer to another for either open or closed loop systems. Like the older ARI 330 rating, the units are tested for performance at entering water temperatures of 32°F in the heating mode and 77°F in the cooling mode. The major difference in the newer ISO rating is that the pumping penalties (used in the older ARI ratings)along with penalties for fan power (external to the unit) have been removed. This has had the result of raising the performance values compared to the older rating ARI system. Where an average unit in the old rating system may have had a 13.0 EER in cooling, under the ISO rating this same unit might show a 14.0 or 14.5 rating.

The ratings values (COP and EER) should be thought of as relative numbers. That is they are intended for the comparison of one manufacturer's products to another's. They DO NOT reflect actual performance in any installation.

ASHP Ratings

The major difference between ratings for ASHPs and GHPs is that the air source values are seasonal. They are intended to reflect the total heating or cooling output for the season divided by the total electrical input for the season. These ratings (HSPF - heating, SEER - cooling) cannot be directly compared to the GHP EER and COP numbers.

ASHPs are rated under ARI 210/240. In order to simplify the process, a number of assumptions are made regarding operation of the heat pump. The rating is based on a moderate climate (Washington, DC) and as a result, is not reflective of either very cold or very warm areas of the country.

Furnaces

Furnaces are rated by an index known as AFUE or annual fuel utilization efficiency. This is intended to reflect the annual heat energy supplied divided by the energy content of the fuel consumed to supply that heat. The major drawback is that the electricity required to operate the fan in the furnace (and the combustion air fan if so equipped) is not included in the rating.

FREQUENTLY ASKED QUESTIONS

1. What does it cost to install?

The best way to begin this answer is to say that it will cost more than a conventional system. How much more depends on where you live and which GHP system you use.

For ground-coupled systems (both horizontal and vertical), cost varies with the number of available contractors. Where the technology is not well established, the lack of competition results in higher prices. Open loop systems, because they do not require specialized contractors are less affected by this problem.

Much of the following information is taken from a recent study of GHP costs done by Dr. Steve Kavanaugh and others at the University of Alabama for the Tennessee Valley Authority entitled "*Cost Containment for Ground-Source Heat Pumps*." (This report is available as a separate publication from the Geo-Heat Center.) This report addressed only ground-coupled systems. Groundwater (GW) system values were added by the author of this publication. Costs shown are based on a national survey and costs in your area may vary.

Figure 3 shows the cost of the ground loop portion of the system. For groundwater systems, the costs shown include the cost of a larger well pump, tank, piping to and from the house, and a 50' disposal well. For ground-coupled systems, the costs include the trenching or boring, pipe installation and headers up to the home. This could be considered the "outside" the home costs for the system.

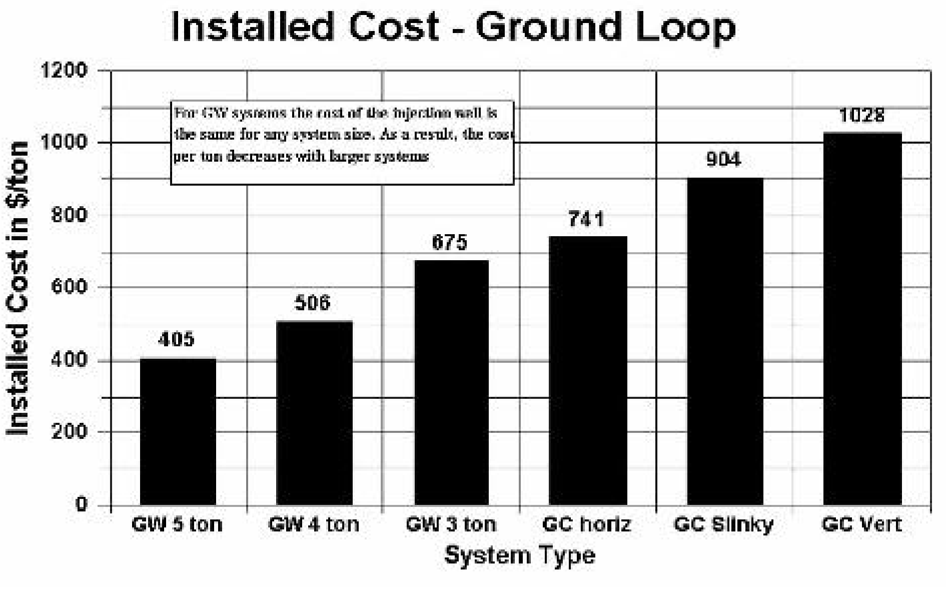

Figure 3.

Figure 4 shows the "inside" the home costs which includes: the heat pump unit, circulating pump, distribution piping, ductwork and incidental mechanical and electrical items.

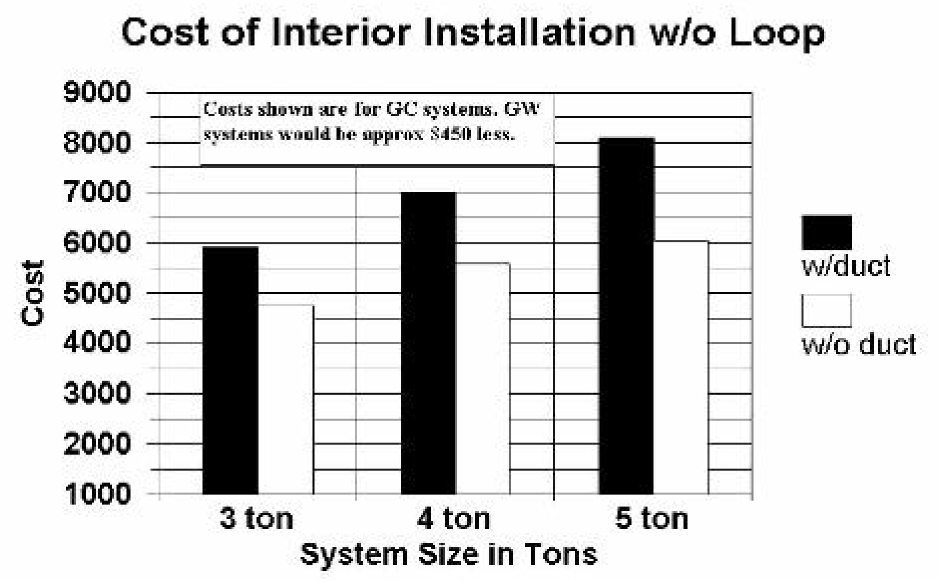

Figure 4.

Figure 5 indicates the cost for the heat pump unit only for the range of sizes normally found in residences.

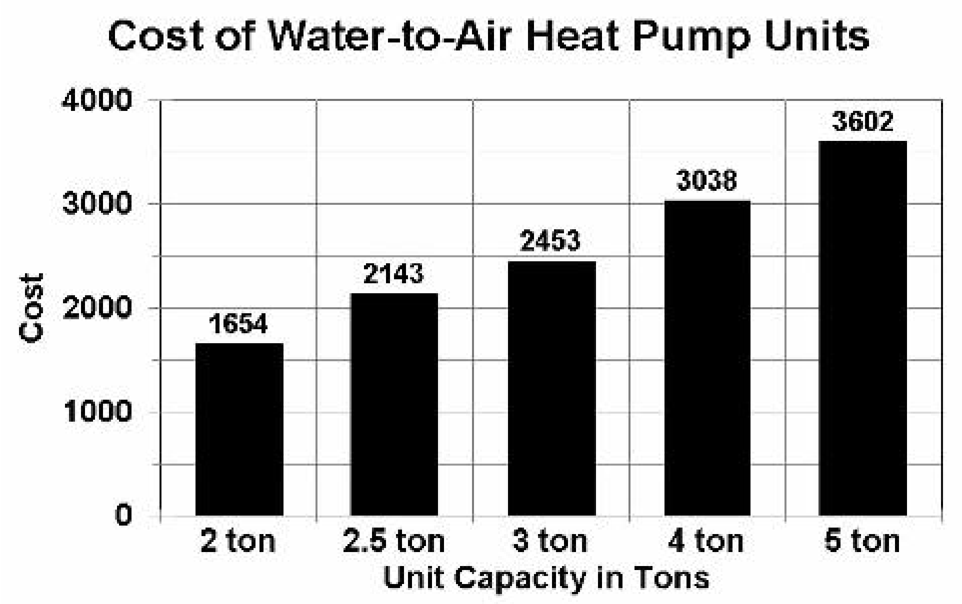

Figure 5.

Figure 6 compares the total costs associated with six different systems for 3-ton capacity. Costs shown include: units, ductwork, all associated components and the ground loop.

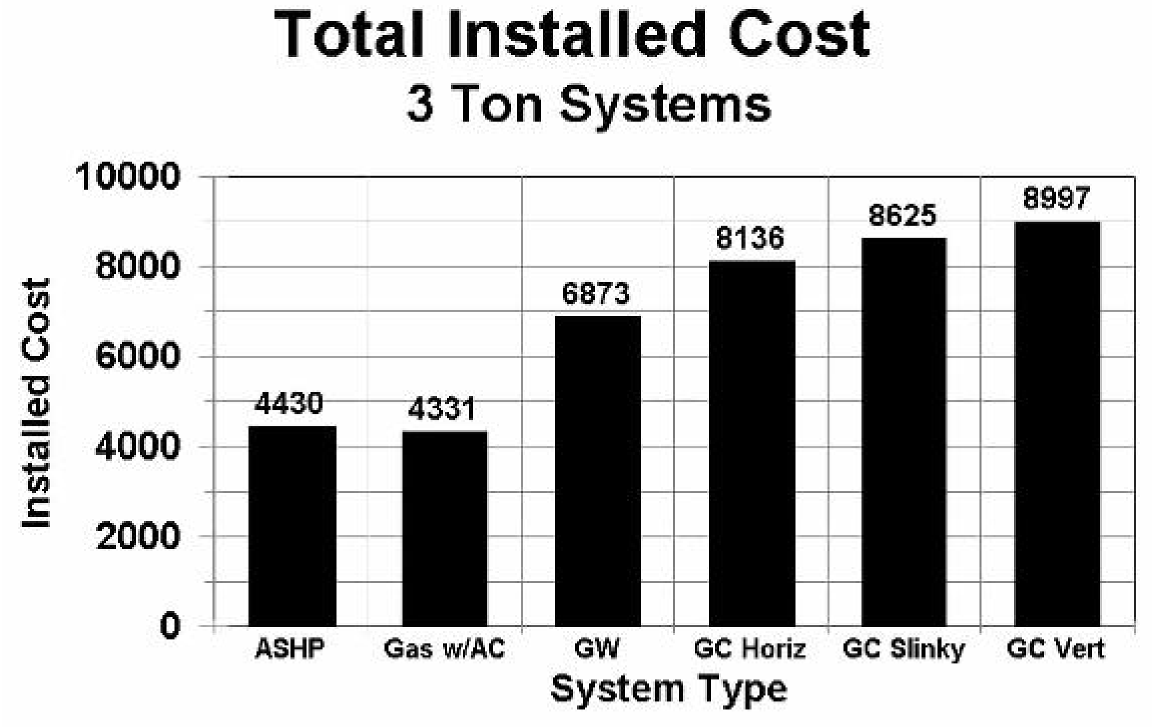

Figure 6.

2. How does the cost of heating with a GSHP compare to other heating methods?

This has a great deal to do with your local rates for electricity and other fuels. The comparison involves the efficiency of the device, the type of fuel used and the cost of that fuel.

Commonly used heating fuels have the following approximate heating content:

Fuel oil	- 138,000 Btu/gal
Propane	- 90,000 Btu/gal
Natural gas	- 100,000 Btu/therm (1,000 Btu/ft^3)
Electricity	- 3,413 Btu/kWh

A common index of the cost of heat is "dollars per 1,000,000 Btu of useful heat." In order to calculate useful heat (heat actually delivered to the house), it's necessary to adjust for the efficiency of the heating device and the cost of the fuel. The following equations can be used for this purpose:

Fuel oil

$$\frac{7.25 x \$/gallon}{efficiency}$$

Efficiency
Old - .65
New std. - .78
Moderate - .84
High - .92

Propane

$$\frac{11.1 x \$/gallon}{efficiency}$$

Natural gas

$$\frac{10.0 x \$/therm}{efficiency}$$

Electric
resistance

$$293 x \$/kWh$$

ASHP

$$\frac{293 x \$/kWh}{COP}$$

COP
Warm climate - 2.5
Cold climate - 1.8

GHP

$$\frac{293 x \$/kWh}{COP}$$

COP
Warm climate - 3.9
Cold climate - 3.1

As an example, let's look at a location in a moderately cold climate when the fuel costs are as follows:

Electricity, $0.07/kWh; fuel oil, $1.05/gal; propane, $1.20/gal; and natural gas, $0.60/therm. This would result in the following useful heat costs:

	$ per Million Btu
Fuel oil	9.06
Propane	15.86
Natural gas	7.14
Electric resistance	20.51
ASHP	9.54 (2.15 COP)
GHP	5.86 (3.5 COP)

Obviously, it is necessary to know the total amount of heat required for the year to calculate annual savings. The above values, however, provide an indication of the percentage savings to be expected from a GHP system compared to other options for heating.

Savings are also generated during domestic hot water heating and cooling. These will be small compared to the heating savings in all but southern climates. See the next question for some examples.

3. How much will it save?

As mentioned in the above question, this depends upon the particulars of your case and for an exact answer requires a sophisticated computer simulation. To provide a guide, the following data was developed (Kavanaugh, 1992a; Kavanaugh, 1992b) for three U.S. locations with widely differing climates. The values shown are annual kWh consumption for the different system types.

Atlanta, GA

	kWh Cooling	kWh Heating	kWh DHW	kWh Total
ASHP	3,409	7,396	4,120	14,925
ASHP (variable speed)	2,499	5,540	4,120	12,159
GHP (std. eff.)	2,599	4,236	2,620	9,455
GHP (high eff.)	2,079	3,510	2,509	8,098

Spokane, WA

	kWh Cooling	kWh Heating	kWh DHW	kWh Total
ASHP	773	11,475	4,120	16,458
ASHP (variable speed)	435	9,295	4,120	13,850
GHP (std. eff.)	451	5,562	3,150	9,163

Portland, OR

	kWh Cooling	kWh Heating	kWh DHW	kWh Total
ASHP	513	6,666	4,120	11,299
ASHP (variable speed)	285	4,706	4,120	9,111
GHP (std. eff.)	337	3,549	3,468	7,354

These figures are based on newly constructed homes conforming to local energy efficiency standards (which are much more stringent in the northwest portion of the country). GHPs are assumed to be equipped with desuperheaters for hot water heating. The balance of the water heating is by electric water heaters.

Additional savings information is available from the sources listed on page 22. The U.S. EPA report, "Space Conditioning: The Next Frontier" by L'Ecuyer and others (EPA 430-R93-004) also contains savings information.

4. How much of the job can I do myself?

Very little. The performance of a ground-coupled heat pump system is determined by the quality of the installation. Assuring that proper backfilling is done around the pipe, fusing of the polyethylene piping, flushing the system and purging air from it, all require skills, tools and equipment only available to properly trained contractors. Ground loops are not do-it-yourself projects.

5. What about domestic hot water heating?

Most GHP units can be equipped (optionally) with a device called a desuperheater to partially heat domestic hot water (DHW). In the summer, this device uses some of the "waste" heat from the air conditioning to heat hot water. As a result, during the cooling season, this heat is free. In the winter, some of the capacity of the heat pump is diverted from space heating to heat domestic hot water. It is important to understand, however, that the heat pump only produces domestic hot water when it is running for either space heating or cooling purposes. As a result, only a portion of the annual domestic hot water heating needs are met by the desuperheater.

The percentage of annual DHW heating needs met depends upon the run time of the heat pump and DHW use patterns in the home. The largest savings occur in applications where the heat pump runs a large number of hours (particularly in the cooling mode) and where alternative water heating is by electric resistance.

For an average family size (3.5 persons), with a 3-ton heat pump, the annual savings on domestic hot water would be in the range of 25% (colder climates) to 35% (warmer climates), or about $100 - $150 per year at $0.08/kWh. Since desuperheater capacity is directly related to heat pump capacity, the savings from a 4- or 5-ton system would be greater than the 3-ton savings cited above.

6. Should I use vertical, horizontal or open loop?

This is a tough question to answer. Let's look first at whether to go open loop or closed loop.

Open loop systems are best applied in situations where the house is, or will be, served by its own water well. A slightly larger well pump is installed to provide for the water required by the heat pump. A major consideration is the disposal of the water. Existing systems have used ponds, lakes, rivers, irrigation ditches, and return (or injection) wells. Surface disposal is obviously the least expensive option; but, even if a disposal well is required, the capital cost is likely to be much less than the cost of a closed loop ground coupling. Water quality is also an important issue. Since the water is used directly in the heat pump, the issue of corrosion and/or scaling can be a problem. If the water is hard (>100 ppm) or contains hydrogen sulphide (rotten egg smell), a closed loop system would be a better choice. If the water is of good quality and the house is to be served by a well for domestic water, serious consideration should be given to the open loop approach. Contractors will often suggest a cupronickel heat exchanger as a way to address water quality problems in open loop systems. It is a rare occasion when this is an effective strategy. Cupronickel is effective for salt water applications. For most of the commonly encountered water quality problems (carbonate scale, iron or hydrogen sulphide), cupronickel construction is of little if any value.

See the costs section of this report for capital costs for the open loop system.

If the system is to be a closed loop design, the choice between vertical and horizontal system is sometimes a difficult one to grapple with. The major advantage of the vertical design is that it places the loop in a much more thermally stable zone. Soil at 100 ft is not subject to the same temperature fluctuations as soil at a 4 or 5 ft depth. As a result, the vertical design offers the potential of supplying the heat pump warmer water in winter and cooler water in summer.

Contractor availability will be the dominant factor in determining which type of ground coupling is used for many projects. In most areas of the country, the availability of contractors is still very limited. As a result, if the local contractors only install horizontal systems, that is what you get.

The thermal advantages of the vertical over the horizontal are less of a factor in moderate climates. The more extreme the climate, either in heating or cooling, the greater the advantage of the vertical system.

See the cost section for a discussion of system costs.

7. Who makes the best equipment?

This is a lot like asking who makes the best car. All major manufacturers produce quality products and what is "under the hood" on most products is surprisingly similar.

One way to compare equipment is by the rated performance. This information is published periodically in the ARI (Air Conditioning Refrigeration Institute) Directory. The following tables list the heating (COP) and cooling (EER) performance data from the most recent directory.

This information addresses only the standard packaged single speed (or single compressor) units of the manufacturers. Many produce other types of equipment of both higher and lower performance. The units listed here are the most widely used models. Additional details on ratings appear in the beginning of this document.

From January 1, 2001 - June 30, 2001 ARI Directory package heat pump units only (WBAHP)

2-speed unit ratings shown in high speed

COOLING	**2**	**3**	**3.5**	**4**	**5**	
Addison VGY/HGY	15.1	14.9	14.3	14.9	14.1	
Bard GSV/WPV	17.5	17.5	16.5	13.4	12.5	
Carrier RVR/RVS	13.3	14.7	15	14.3	14.1	
Carrier RHS/RVS	17.1	16.4	16	16.4	14.6	
Carrier Weathermaker GT-X		17.3	16	17.3	15.8	
Climate Master Genesis GR	13.3	14.7	15	14.3	14.1	
Clmt Mstr Genesis Ultra GSV	17.1	16.4	16	16.4	14.6	
Clmt Mstr Ultra 2 stg VT		17.3	16	17.3	15.8	
Cmnd Aire GSUF___A	16.1	15.5	14.4	14.4	14.8	
Cmnd Aire GSUF___B	17.4	17	15.5	16.2	15.7	
Cmnd Aire GSHC___A	17.8	15.7	13.4	14.3	12.9	
Cmnd Aire GSHC___B	19.1	16.2	13.7	16	13.8	
ECONAR DualTek GC/GH/GV	15.4	14.6	14.2	13	13.1	
ECONAR Dual Circuit Q				14.8	13.3	
FHP Energy Miser EM	15.5	15.3	13.6	13.4	14	
FHP Enviro Miser CV		17.4	15.3	16.4	15	
FHP Multi Step GO				16.3	14.5	
FHP geothermal GT	16.1	16.1	15	13.4	14	
Heat Controller Comfort Aire HG	15.1	14.5	14.3	14.9	14.1	
Hydro Delta Hydro Heat Ext Rng	14.4	15	15	15.2	14.5	
Hydro Delta Hydro Heat MT			15.4		13.2	
Mammoth hydrobank	14	14	14	14	14.5	
McQuay	14.1	13.4	13.4	13	12.6	
Millbrook Hydron Module	13.5	13.6	13	13.1	13	
TETCO Inc	14.1	14.5	14.5	13.5	13.3	
TRANE GEVA/GEHA	13.8	14.5	13.4	13.7	13.8	
TRANE See Cmnd Aire						
Waterfurnace Norhtern Ldr.	17.2	14.8				
Waterfurnace Premier	18.9	16.9	18	17	16.1	
Waterfurnace Premier 2 speed				14.8	13.4	
HEATING	**2**	**3**	**3.5**	**4**	**5**	
Addison VGY/HGY	3.3	3.5	3.4	3.5	3.2	
Bard GSV/WPV	3.5	3.5	3.1	3.1	2.7	
Carrier RVR/RVS	3.3	3.4	3.4	3.3	3.2	
Carrier RHS/RVS	3.6	3.4	3.7	3.7	3.6	
Carrier Weathermaker GT-X		3.7	3.7	4	3.3	
Climate Master Genesis GR	3.3	3.4	3.4	3.3	3.2	
Clmt Mstr Genesis Ultra GSV	3.6	3.4	3.7	3.7	3.6	
Clmt Mstr Ultra 2 stg VT		3.7	3.7	4	3.3	
Cmnd Aire GSUF___A	3	3.1	3	2.9	3	
Cmnd Aire GSUF___B	3.1	3.2	3.1	3.2	3.1	

Cmnd Aire GSHC___A	3.1	3.2	3.2	3.1	2.8	
Cmnd Aire GSHC___B	3.3	3.2	3.2	3.3	2.8	
ECONAR DualTek GC/GH/GV	3.6	3.3	3.2	3.1	3.3	
ECONAR Dual Circuit Q				3.4	3.2	
FHP Energy Miser EM	3.5	3.4	3.2	3.4	3.2	
FHP Enviro Miser CV		3.4	3.2	3.4	3.2	
FHP Multi Step GO				3.7	3.4	
FHP geothermal GT	3.5	3.4	3.5	3.2	3.2	
Heat Controller Comfort Aire HG	3.3	3.4	3.4	3.5	3.2	
Hydro Delta Hydro Heat Ext Rng	3.2	3.4	3.4	3.6	3.6	
Hydro Delta Hydro Heat MT			3.4		3.2	
Mammoth hydrobank	3.2	3.1	3.2	3.4	3.2	
McQuay	3	2.9	2.9	3	2.8	
Millbrook Hydron Module	3.2	3.3	3.3	3.3	3.3	
TETCO Inc	3.3	3.3	3.1	3.1	3.1	
TRANE GEVA/GEHA	3.3	3.3	3.1	3.1	3.1	
TRANE See Cmnd Aire						
Waterfurnace Norhtern Ldr.	3.2	2.9				
Waterfurnace Premier	3.8	3.7	3.7	3.7	3.5	
Waterfurnace Premier 2 speed				3.3	3.2	

8. How do I find a contractor?

Selection of a contractor for a geothermal heat pump system is very important, particularly for ground-coupled systems. There are several places to look for information.

Local utilities often have promotional and/or certification programs for both ASHP and GHP contractors. The utility may maintain a list of approved contractors to which they can refer you.

Manufacturers (see list below) of heat pump equipment can direct you to a dealer/contractor in your area. The International Ground Source Heat Pump Association (IGSHPA) maintains a list of contractors on their web site on the internet (http://www.igshpa.okstate.edu). The list is organized by state.

The search for a groundwater system contractor is somewhat simpler. In this case, most general heating and air conditioning contractors can handle the installation without any special training. It is necessary for him to coordinate with the well pump contractor to assure that an adequately sized well pump and tank are installed.

9. Who makes the heat pump units?

Addison/Weatherking
7050 Overland Road
Orlando, FL 32810
Ph: (407) 292-4400
Fax: (407) 290-1329
www.addison-hvac.com

Aqua Cal
2737 24th Street North
St. Petersburg, FL 33713
Ph: (813) 823-5642
Fax: (813) 821-7471

Bard Manufacturing
P.O. Box 607
Bryan, OH 43506
Ph: (419) 636-1194
www.bardhvac.com

Carrier
Carrier Parkway
P.O. Box 4804
Syracuse, NY 13221
Ph: (315) 432-7383
www.carrier.com

Climate Master
7300 S.W. 44th Street
P.O. Box 25788
Oklahoma City, OK 73125
Ph: (405) 745-6000
Fax: (405) 745-3629
www.climatemaster.com

Econar Energy Systems
  Corp.
19230 Evans Street
Elk River, MN 55330
Ph: (612) 241-3110
Ph: 1-800 4-ECONAR
Fax: (612) 241-3111
www.econar.com

FHP Manufacturing
Div. Leigh Products, Inc.
601 N.W. 65th Court
Ft. Lauderdale, FL 33309
Ph: (305) 776-5471
Fax: (305) 776-5529
www.fhp-mfg.com

Heat Exchanger, Inc.
P.O. Box 790
Skokie, IL 60076
Ph: (312) 679-0300

HydroDelta Corp.
10205 Gravois
St. Louis, MO 63123
Ph: (314) 849-5550
Fax: (314) 849-8410

Hydro Temp
Hwy 67 South
P.O. Box 566
Pocahantas, AR 72455
Ph: (501) 892-8343
Ph: 1-800 382-3113
Fax: (501) 892-8323
www.hydro-temp.com

Mammoth
101 West 82nd Street
Chaska, MN 55318
Ph: (612) 361-2644
Fax: (612) 361-2700
www.mammoth.com

Marvair
P.O. Box 400
Cordele, GA 31015
Ph: (912) 273-3636

Millbrook Industries
Hydronic Division
RR #3, Box 265
Mitchell, SD 57301
Ph: (605) 995-0241
Fax: (605) 996-9186

Snyder General
P.O. Box 1551
Minneapolis, MN 55440
Ph: (612) 553-5330

Thermal Energy Transfer
  Corporation
1290 U.S. 42 North
Delaware, OH 43015
Ph: 1-800 363-5002
Fax: (614) 363-0450

Trane/Command-Aire Corp.
P.O. Box 7916
Waco, TX 76714
Ph: (817) 840-5329
Fax: (817) 840-2221
www.commandaire.com

WaterFurnace International
9000 Conservation Way
Ft. Wayne, IN 46809
Ph: (219) 478-5667
Ph: 1-800 222-5667
Fax: (219) 747-2828
www.waterfurnace.com

Walen
Department 1
P.O. Box 1390
Easton, MD 21601
Ph: (301) 822-9200

10. What do I look for in a contractor?

CERTIFICATION and EXPERIENCE! The contractor should be certified by the International Ground Source Heat Pump Association (IGSHPA) and should have demonstrated experience in installing GHP systems. Don't be afraid to ask to see proof of certification and to ask the location of previous installations.

11. Can GHP systems be used in conjunction with hot water space heating?

Yes and no. Heat pumps are available from several manufacturers that produce hot and chilled water rather than hot and cold air. These units can be connected to some types of hot water heating equipment. The limitation in the heating mode is temperature. Conventional hot water radiators and base-board type elements are designed to operate at temperatures of 160°F and above (older systems as high as 200°F). Unitary heat pumps are limited to producing supply water temperatures of less than 120°F. As a result, on a retrofit basis (a home with existing hot water radiator or baseboard), the prospects are not favorable.

The best hot water system to connect to a GHP are radiant floor (or hydronic radiant slab) systems. This design, in which plastic tubing is installed in the floor slab as it is poured, operate at water temperatures typically much lower than radiator type systems. In order to minimize the required water temperature, the home should be well insulated and use minimal floor coverings. This type of system is more complex, in terms of equipment and controls than a standard water-to-air system and requires careful design.

In general, complete space cooling cannot be accomplished with a floor system since condensation would occur on the floor surface. As a result, this system generally must be coupled with some sort of fan coil unit to provide cooling and dehumidification.

12. Can snow melting be done?

Snow melting can be accomplished with GHPs; but, there are serious cost impacts on the residential side.

Due to the nature of snow melting, a separate system must be installed to serve the load. This is due to its requirement for the circulation of an antifreeze fluid through the system, instead of the warm air supplied by water-to-air heat pumps. Beyond this, since the requirement for snow melting coincides with the need for space heating, additional ground loop must be installed to serve the snow melting system.

Although GHPs produce heat less expensively than most other systems, because of the substantial quantities of heat required by snow melting systems, the annual cost remains high. The high energy cost is a result of the way snow melt systems are operated. Most systems are allowed to "idle" at a low heat output during the winter season. This allows the paved surface to quickly come up to temperature when snow fall occurs. The energy consumed by this idling operation, because of the number of hours over an entire season, is substantial. Because of the thermal mass of the paved surface, simply turning the system on when snow fall occurs results in a long time lag (several hours to one day) between start up and snow melting. This results in incomplete snow removal and a "corduroy" effect on the surface.

The high energy cost is compounded by the need for high water temperatures to produce the necessary output required for adequate snow melting. These temperatures, in areas where heavy snow occurs, are far in excess of what would be produced by available unitary heat pump equipment.

The following evaluation of a snow melt system for a residence in Michigan points out some of the limitations.

> "In your area, a snow melting system would be designed for an output of about 165 Btu/hr per square foot, under melting conditions. For a 12 ft wide 100 ft long driveway, this would amount to 198,000 Btu/hr or the equivalent of about a 20-ton heat pump. This is about six times the size heat pump required for the average house.
>
> For snow melting conditions below 30°F and wind speeds above 5 mph, required water temperatures in the snow melt loop are in excess of 130°F. This is higher than the average heat pump can produce.
>
> Because the snow melting system requires the circulation of hot water, a water-to-water heat pump is required. Most homes with a geothermal heat pump use a water-to-air heat pump.
>
> Snow melting requires a substantial amount of energy on an annual basis. In your area, a residential system would consume about 133,000 Btu/yr per square foot of driveway. Supplying this from a geothermal heat pump, at a COP of 3.5, would require an electrical input of 11 kWh/sq ft of driveway. For a driveway of 1200 sq ft (100 ft x 12 ft), this would be about 13,200 kWh/yr or $924 per year at $0.07/kWh."

Snow melting has been successfully incorporated into some commercial GHP systems serving gas stations/convenience store operations. The advantage here is that the store contains a great deal of refrigeration equipment which continually produces waste heat used for the snow melting system.

The moral of the story is that snow melting can be done with GHPs if money is no object. For most folks though, it's much more economical to hire the neighborhood kid to shovel the driveway.

13. Can I heat my pool?

Pools can be heated with a GHP and in very warm climates, this makes a good match with a space conditioning GCHP. In cooling dominated climates, the space conditioning heat pump rejects much more heat to the ground than it absorbs from the ground. As a result, there is the potential for a gradual increase in ground temperature to occur over a period of years, where a ground-coupled system is used. Removing this excess heat and delivering it to a swimming pool reduces (or eliminates) the problem.

Pool heating will require a separate heat pump for the pool. Beyond this, the heating capacity of the heat pump will likely be less than that of a typical gas-fired heater in the same application. This is a result of the fact that heat pumps cost about five times what gas-fired pool heaters do per unit of heating capacity. The smaller heat pump would not affect the ability to maintain pool temperature, but would result in a longer time required to bring the pool temperature from cold up to usable temperatures at the beginning of the season.

The pool heating unit would be of the water-to-water type rather than the water-to-air design used for home heating and air conditioning. The impact of the pool heating upon required loop length would depend upon the size of the pool and the amount of the year it is in operation.

14. I currently have a propane (or oil or gas) furnace and I am thinking about changing to a GHP. What should I be aware of?

First of all, there will be a major difference in the air temperature from the supply registers. Heat pumps, regardless of the type, produce lower temperature air than fossil fuel furnaces. Air-source heat pumps produce the coolest air 90°F to 95°F. GHPs produce air of 95°F to 103°F, a small but very noticeable improvement.

Another issue is the ductwork. If the house was not originally equipped for air conditioning, the ductwork may be undersized for the heat pump. Both central air conditioning and heat pumps require more air flow than fossil fuel furnaces. Be sure to have your contractor evaluate this issue. Undersized ductwork results in noise and lower system efficiency.

15. Are there any substantial improvements in efficiency on the horizon?

There are always improvements to be made in mechanical devices like heat pumps. This is not a reason to put off the installation of a GHP system, however. Most of the substantial efficiency gains have been made over the past 10 years. Remaining improvements will likely be small in comparison to what has been achieved. As an example, the average performance of five manufacturer's equipment found in the 1987 and current ARI Directories has shown an average of 41% improvement in EER and 27% improvement in COP.

As discussed in the ratings section of this document, the recent changes in the ratings system for water-to-air heat pumps has resulted in a rise in the EER and COP ratings values. In general this is not the result of a general improvement in the equipment itself but rather modifications to the ratings system that improve the numbers.

16. I am planning a large home. Should I use one large unit or two smaller ones?

There are several reasons why it may be advisable to use two smaller units than one large one. The use of two or more small units is referred to in the HVAC trade as "zoning." Generally a separate zone is established if one or more of the following criteria apply: the area has a specific use distinct from the rest of the home (mother-in-law's apartment), the area is maintained at a distinct temperature (basement), a separate level of the home (2nd floor bedrooms).

An additional reason for using two systems is that the equipment of many manufacturers falls off in performance above four tons. As a result, the use of two 3-ton units is likely to yield a higher performance than a single 6- or 7-ton unit. This performance difference, however, is not sufficient to justify the additional cost of the 2-system design.

17. Is the system's antifreeze a potential environmental problem?

In residential applications, the commonly used antifreeze solutions pose little to no environmental hazard. Each state regulates the types of antifreeze materials used in GHP systems. The most commonly used ones are propylene glycol, and methanol. Propylene glycol is a non-toxic fluid which poses no hazards to the environment, humans or animals, and in fact, is used in food processing refrigeration.

Methanol (or alcohol) is potentially flammable, but not in the concentrations used in GHP systems. It is similar to the antifreeze solution used in windshield washer systems.

18. I have heard of a system where air is circulated through large diameter pipes buried in the soil and then supplied to the building for heating purposes. Is this possible?

Anything is possible. It's just that some things work better than others. Due to limitations in heat transfer and equipment, this is one of those ideas that doesn't work too well. The following is an excerpt from a response we recently sent to a farmer in Minnesota. He had 42°F soil and wanted to heat some new barns.

> "In order to transfer heat from a source (like the soil) to a fluid (like air), two things are necessary: a temperature difference and some surface area across which the heat will be transferred (the pipe). Because a temperature difference is required to drive the heat out of the soil, across the pipe and into the air, the temperature of the air leaving the buried pipe will always be less than the temperature of the soil. The closer you try to get the leaving air temperature to the soil temperature, the more pipe (surface area) it takes. For argument, let's figure that a 10°F difference is required (close to what ground-source heat pumps are designed for). This means that the air exiting the pipe will be 32°F in the coldest part of the year. In order for this air to deliver heat to the building to be heated, a temperature difference between the air exiting the pipe and the air in the space is required. The smaller this temperature difference is, the more air that must be circulated to meet the heating load. The problem is that these two temperature

> differences, combined with the temperature of the soil result in the ability to maintain only very low temperatures in the "heated" buildings. If we used another 10°F temperature difference between the space and the pipe exit air, this would result in the ability to maintain only 22°F maximum in the space. The above assumes that the soil would remain at the undisturbed temperature of 42°F minimum. This would not be the case since the removal of heat would cause the decline in the soil temperature, thus reducing the temperatures used above.
>
> This type of system has some real possibilities in the cooling season; but, as you can see, it's pretty limited in the heating season."

The soil is an excellent heat source; but, it requires a heat pump in the system to "amplify" the heat to usable levels for normal space heating.

19. Where can I go for more information?

Geo-Heat Center
3201 Campus Drive
Klamath Falls OR 97601
541-885-1750
http://geoheat.oit.edu

International Ground Source Heat Pump Association (IGSHPA)
470 Cordell South
Stillwater, OK 74078-8018
Ph: 1-800 626-GSHP
http://www.igshpa.okstate.edu

Geothermal Heat Pump Consortium Inc.
701 Pennsylvania Avenue NW
Washington, DC 20004-2696
Ph: 202-508-5500
Fax: 202-508-5222
http://www.ghpc.org

National Rural Electric Corporative
Research Division
1800 Massachusetts Avenue NW
Washington, DC 20032
Ph: 202-857-9775
http://www.webplus.net/nreca/homepage.htm1

Electric Power Research Institute
P.O. Box 10412
Palo Alto, CA 94303
Ph: 415-855-2810
http://www.epri.com/information/aboutEPRI.htm1

Your local electric utility

Your state energy office

20. I am an engineer, where can I go to find more detailed information for large commercial applications?

ASHRAE is the primary source of design information for HVAC systems in commercial buildings. Through it's website you can access the ASHRAE bookstore where you will find design manuals, special publications and the semi-annual Transactions which contains the most current technical papers on the technology.

Please take the time to visit the Geo-Heat Center's website (http://geoheat.oit.edu)where the "Outside the Loop" section contains a wealth of information for the commercial system designer including back issues of the designers newsletter, site characterization information, manufacturer's and services vendor lists.

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Kavanaugh, S. K., 1992b. "Demand and Energy Study of High Efficiency Heating and Cooling Equipment in Georgia." Geo-Heat Center Quarterly Bulletin, Vol. 14, No. 1, Oregon Institute of Technology, Geo-Heat Center, Klamath Falls, OR.

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