Analysis of Geothermal Heat Pump Manufacturers Survey Data

by Peter Holihan[1]

Introduction

The Energy Information Administration (EIA) collected information on shipments of geothermal heat pumps, often called ground source or geoexchange systems, for the first time in 1997. This information is based on data filed on the EIA's Form EIA-902, "Annual Geothermal Heat Pump Manufacturers Survey." In addition to discussing geothermal heat pump shipment data, this article describes how geothermal heat pumps work, system economics, and provides two case studies, including the Department of Energy's role in geothermal heat pump development.

Geothermal Heat Pump Survey Results

Results of the 1997 and 1998 EIA surveys of geothermal heat pump manufacturers showed a total of 128,745 geothermal heat pumps, or an average of almost 32,200 units annually were shipped during the period 1994 through 1997.[2] Over 37,000 units were shipped in 1997, more than in any other year (Table 1). Data from the survey indicate that for the period 1994 through 1997, ARI-330 and ARI-325 model types[3] accounted for over three-fourths of total shipments (55 percent and 25 percent, respectively).

The survey was initiated in 1997 to track the recent market penetration of geothermal heat pumps. The rise in shipments during the mid 1990's is due in part to educational efforts of utilities and groups such as the Geothermal Heat Pump Consortium and the International Ground Source Heat Pump Association. Several utilities have been effective in promoting the use of heat pumps through low interest loans, extended warranties, utility bill guarantees, or rebate programs.

The data for 1997 show that 43 percent of geothermal heat pumps were shipped to the South, followed by 28 percent to the Midwest, and 16 percent to the Northeast (Table 2). Eleven percent were shipped to the West, while 2 percent were exported.[4]

The 37,156 units shipped in 1997 had a total rated capacity equal to 139,764 tons (Table 3) or an average 3.8 tons per unit. ARI-320 units tend on average to be smallest at 3.1 tons per unit, followed by ARI-325 and ARI-330 units at almost 4 tons per unit. Non-ARI rated units are largest on average, at 5 tons per unit.

Table 1. Geothermal Heat Pump Shipments by Model Type 1994-1997
(Number of Units)

Model Type	1994	1995	1996	1997
ARI-320	R5,390	R4,851	R4,318	R7,494
ARI-325	5,924	8,615	7,603	9,724
ARI-330	16,023	18,185	18,094	18,611
Non-ARI Rated	757	838	991	1,327
Total	**R28,094**	**R32,489**	**R31,006**	**R37,156**

R = Revised.
Source: Energy Information Administration, Form EIA-902 "Annual Geothermal Heat Pump Manufacturers Survey."

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[2] The 1997 survey was the first EIA geothermal heat pump survey. It collected data for the years 1994 through 1996.

[3] See "Classification of Heat Pumps," for a description of heat pump types as classified by the Air-Conditioning and Refrigeration Institute (ARI).

[4] Because the EIA-902 survey includes only domestic manufacturers, the survey does not provide information on geothermal heat pumps imported from foreign manufacturers.

Table 2. Geothermal Heat Pump Shipments by Exports, Census Region, and Model Type, 1997
(Number of Units)

Exports and Census Region	Model Type				Total
	ARI-320	ARI-325	ARI-330	Non-ARI Rated	
Exports	R298	101	437	64	R900
Midwest	R589	2,717	6,780	492	R10,578
Northeast	R1,786	1,512	2,593	93	R5,984
South	R4,329	4,015	6,828	613	R15,785
West	R492	1,379	1,973	65	R3,909
Total	**R7,494**	**9,724**	**18,611**	**1,327**	**R37,156**

R = Revised.
Note: The Midwest census region consists of Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin. The Northeast census region consists of Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont. The South census region consists of Alabama, Arkansas, Delaware, District of Columbia, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia, and West Virginia. The West census region consists of Alaska, Arizona, California, Colorado, Hawaii, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming.
Source: Energy Information Administration, Form EIA-902 "Annual Geothermal Heat Pump Manufacturers Survey."

Table 3. Capacity of Geothermal Heat Pump Shipments by Model Type, 1994-1997
(Total Rated Capacity in Tons)

Model Type	1994	1995	1996	1997
ARI-320	R14,248	R11,003	R15,798	R22,916
ARI-325	29,003	39,672	28,705	37,049
ARI-330	63,101	74,253	64,114	73,137
Non-ARI Rated	2,879	3,935	5,091	6,662
Total	**R109,231**	**R128,863**	**R113,708**	**R139,764**

R = Revised.
Source: Energy Information Administration, Form EIA-902 "Annual Geothermal Heat Pump Manufacturers Survey."

Table 4. Geothermal Heat Pump Shipments by Customer Type and Model Type, 1997
(Number of Units)

Customer Type	ARI-320	ARI-325	ARI-330	Non-ARI Rated	Total
Exporter	RW	RW	RW	RW	R325
Wholesale Distributor	R2,758	8,226	9,091	307	R20,382
Retail Distributor	RW	W	0	R46	R473
Installer	R3,471	1,071	8,820	791	R14,153
End-User	R35	RW	W	W	657
Others	RW	W	W	W	R1,166
Total	**R7,494**	**9,724**	**18,611**	**1,327**	**R37,156**

R = Revised.
W = Data withheld to avoid disclosure of proprietary company data.
Source: Energy Information Administration, Form EIA-902 "Annual Geothermal Heat Pump Manufacturers Survey."

The EIA surveys about 40 manufacturers of geothermal heat pumps. However, the five largest geothermal heat pump manufacturers account for 84 percent of heat pumps shipped; the 10 largest manufacturers account for 98 percent. Generally, geothermal heat pumps are shipped by manufacturers to either wholesale distributors or directly to installers (Table 4). (Installers also purchase heat pumps from wholesale distributors.) Few heat pumps are shipped directly to the end-user; instead, the end-user purchases from the installer, or possibly a retail distributor. The installer coordinates installation services, involving subcontractors as necessary. For instance, a contractor is needed to install the earth connection, which allows the earth to be used as a heat source or heat sink. Then, a heating, ventilation, and air conditioning (HVAC) contractor, which may or may not be the same, installs the geothermal heat pump.[5]

Technical Discussion of Heat Pumps

General Description

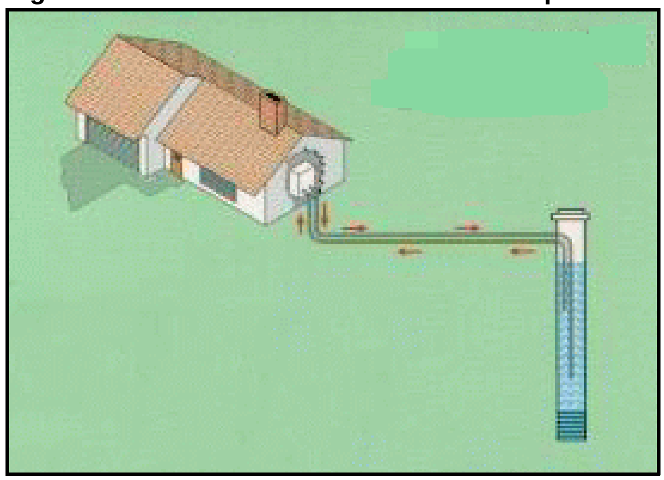
A heat pump is a machine that transfers heat both to and from a source by employing a refrigeration cycle. Although heat normally flows from higher to lower temperatures, a heat pump reverses that flow and acts as a "pump" to move the heat. Therefore, a heat pump can be used both for space heating in the winter and for cooling (air conditioning) in the summer. In the refrigeration cycle, a refrigerant (known as the "working fluid") is compressed (as a liquid) then expanded (as a vapor) to absorb and remove heat. The heat pump transfers heat to a space to be heated during the winter period and by reversing the operation, extracts (absorbs) heat from the same space to be cooled during the summer period.

The most common type of heat pump for domestic use, referred to as a "conventional" heat pump, is the air-to-air (air source) system in which heat is taken from air (heat source) at one location and transferred to air (heat sink) at another location. In the winter, a heat pump takes heat from outside air and via a working fluid transports the heat to inside the home. When the outside air temperature drops below 25-30 degree Fahrenheit, the air source heat pump uses electric resistance heat. In the summer, the heat pump reverses the process, removing heat from the home and transporting it to outside air, cooling the home in the process.

Geothermal Heat Pump Description

A geothermal heat pump (Figure 1) is a heat pump that draws heat from or removes heat to the ground or ground water, instead of air. In the winter, a geothermal heat pump transfers heat from the ground or ground water to provide space heating. In the summer, the heat transfer process is reversed; the ground or groundwater absorbs heat from the living or working space and cools the air. A geothermal heat pump benefits from nearly constant ground and ground water temperatures over most of the "temperate" climate zone found in the continental United States, regardless of outside air temperatures. These temperatures are higher on average than winter air temperatures and lower on average than summer temperatures. The heat pump does not have to work as hard to extract heat from or move heat to the ground or groundwater at a moderate temperature as from the cold air in winter or to the hot air in summer. The energy efficiency of a geothermal system is thus higher than that of a conventional heat pump. Many geothermal systems are also more efficient than fossil-fuel furnaces. As with any heat pump, the actual pump used in a geothermal system is powered by electricity.

Figure 1. Ground-Water Source Heat Pump



Source: Geothermal Heat Pump Consortium.

A geothermal heat pump can also provide hot water at greatly reduced costs using a device called a "desuperheater" that transfers excess heat from the heat pump's compressor to a hot water tank. In the summer, hot water is provided free; in the winter, water heating costs are cut approximately in half. Depending on the location, geothermal heat pumps can reduce energy consumption and, correspondingly, emissions by more than 20 percent compared to high-efficiency outside air heat pumps. Although residential geothermal heat pumps are generally more expensive to install than outside air heat pumps, they can reduce energy consumption, lower energy bills and emissions of carbon and other air pollutants, and operate without need of a backup heat source over a very wide range of climates. For commercial buildings, geothermal heat pump systems are very competitive with boilers, chillers, and cooling towers.

[5] Geothermal heat pump systems are still sufficiently rare that geothermal loop and HVAC contractors must be specially trained to install such systems. Currently, a new home or building owner interested in geothermal heat pumps can find qualified installers by contacting the local electric utility.

Classification of Heat Pumps

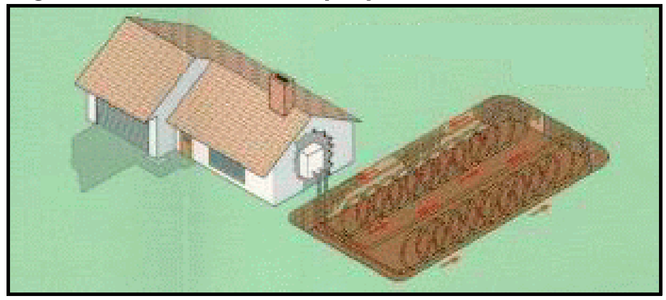
The EIA-902 Survey, "Annual Geothermal Heat Pump Manufacturers Survey," tracks shipments of the following three main types of geothermal heat pumps, as classified by the Air-Conditioning & Refrigeration Institute (ARI), and the much smaller shipped volume of non-ARI rated systems. A brief description of the three ARI-classified systems are:

ARI-320—Water-Source Heat Pumps (WSHP)—These systems are designed to be installed in commercial buildings. In some applications (not considered a geothermal system) a central cooling tower and boiler supplies cooled or heated water, respectively, to heat pumps installed in series. The heat pumps remove building heat to cooled water during the cooling season and, during the heating season, receives heat from boiler water.[6]

ARI-325—Ground Water-Source Heat Pumps (GWHP)—The GWHP is an open-loop system where ground water is drawn from an aquifer or other natural body of water into piping. At the heat pump, heat is drawn from or dumped to the water through a heat exchanger to the refrigerant in the heat pump. The heated or cooled water returns to its source (Figure 1).

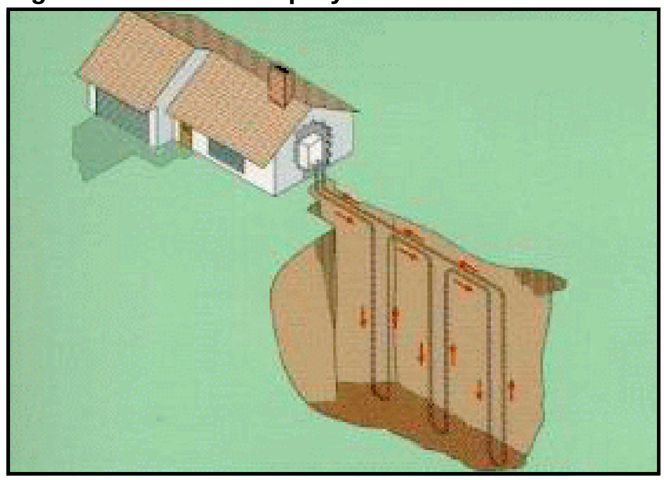
ARI-330—Ground Source Closed-Loop Heat Pumps (GSHP)—A water or water/antifreeze solution flows continuously through a closed loop of pipe buried underground. Ground heat is absorbed into or rejected from the solution flowing in the closed loop. At the heat pump, heat is drawn from or dumped to the closed loop solution via heat transfer through a heat exchanger, which then passes heat to or removes heat from the refrigerant in the heat pump. Depending on the type and area of land, systems can either be installed horizontally or vertically[7] (Figure 2 and Figure 3).

Figure 2. Horizontal Loop System



Source: Geothermal Heat Pump Consortium.

Figure 3. Vertical Loop System



Source: Geothermal Heat Pump Consortium.

Geothermal Heat Pump System Economics

Almost 70 percent of the nation's electrical energy is consumed in residential and commercial buildings,[8] including electric power used in space heating and cooling and water heating. By decreasing the amount of energy used for these services, the Nation has a major energy-saving opportunity. According to a 1993 report by the Environmental Protection Agency (EPA), geothermal heat pumps were the most energy efficient and cost effective space conditioning systems then available.[9] The EPA report found that energy efficiency translates to reduced emissions, and the emissions that are released occur at electric power plants, where emissions are monitored and controlled. The cost effectiveness of a geothermal heat pump system is highly dependent on a number of variables including installed cost of different systems, interest rates, and geographic location

[6] Not all ARI-320 units are connected to geothermal (ground/ground water) heat sources; many ARI-320 units use water from other sources than the ground (e.g., boiler/cooling tower configurations). The survey data includes only those ARI-320 units installed in a geothermal application. EIA is conducting research to determine how accurate manufacturers are in reporting the number of units used in geothermal applications.

[7] Geothermal units can be rated by the manufacturer for combined applications as ARI-325 and ARI-330. EIA is conducting research to determine how accurate the manufacturers are in reporting the application as either an ARI-325 or ARI-330 for these units.

[8] Energy Information Administration, *Annual Energy Review 1997*, DOE/EIA-0384(98) (Washington, DC, July 1998).

[9] Environmental Protection Agency, "Space Conditioning: The Next Frontier," report 430-R-93-004, April 1993.

which impact climate, soil conditions, land availability, and fuel availability and cost. However, there are both barriers to and factors for increased market penetration of geothermal heat pumps.

Barriers to Geothermal Heat Pumps

Geothermal heat pump systems generally have a higher initial (capital) cost than alternative heating and cooling systems. Based on the estimated yearly energy and maintenance cost savings, the payback period can vary from 2 to 10 years. The primary difference between the cost of a geothermal heat pump system and a conventional air source heat pump system is the investment in a ground loop for heat collection and rejection that is required for a geothermal system. The ground loop cost is the premium paid to get a system that will operate year round without backup support. In contrast, air source heat pumps lose efficiency in providing heat when outside temperatures drop below 20 to 30ºF, and switch to a higher operating cost electric resistance back-up heating system. Making a geothermal system cost-effective, relative to a conventional air source heat pump, depends upon generating annual energy cost savings that are high enough to pay for the additional cost of the ground loop in a relatively short time.[10] Other barriers to market penetration include lack of consumer information and both the difficulty in adopting new building standards and the public's reluctance to utilize new technologies.

Factors Favoring Geothermal Heat Pumps

Factors that have improved market penetration of geothermal heat pumps include rebates and low interest loans offered by electric utilities. Some electric utilities see geothermal heat pumps as a way to improve load factors in mortgage positive cash flow. In particular, they want to attract owners of new homes toward electricity rather than gas. By offering the home owner a rebate, which reduces the first-year capital cost of the heat pump system, such utilities improve the purchase economics of a geothermal heat pump relative to alternatives. Alternatively, a low interest rate loan offered for geothermal heat pumps increases their attractiveness by lowering future year costs relative to those of other heating/cooling systems (assuming the owner finances the purchase of a heating/cooling system). Also, advertising and information campaigns by the proponents of geothermal systems on their energy efficiency and economic benefits compared to alternative systems have boosted public awareness.

Fort Polk Case Study

In 1996, the world's largest installation of geothermal heat pumps was completed at the U.S. Army's Fort Polk military base in Leesville, Louisiana. The heat pumps replaced 3,243 air-source heat pumps and 760 central air conditioning/natural gas forced air furnace systems for 4,003 housing units. The housing units were apartments, townhouses, and duplexes built between 1972 and 1988. Unit floor space ranged from 900 to 1,400 square feet. The geothermal heat pump configuration implemented at Fort Polk is a closed-loop, vertical-borehole ground heat exchanger system. Each heat pump has its own ground heat exchanger of the vertical U-tube type of polyethylene pipe. Over 8,000 borehole heat exchangers were drilled. Each borehole has a 4-inch diameter and a depth of 100 to 450 feet.

An investment of $19 million was made to install the geothermal heat pumps. The expected benefit of this investment is reduced energy and maintenance costs. The energy savings portion of the savings is based on the higher energy efficiency of the geothermal heat pump system compared to the heating and cooling systems being replaced. The energy efficiency of cooling systems is measured in terms of an Energy Efficiency Rating (EER), equal to the Btus of cooling produced by the system per watt of electricity consumed, averaged over an annual basis, while the heating efficiency is measured in terms of the coefficient of performance (COP). At Fort Polk, the replaced older heating systems had EERs of 7 to 8 while the geothermal heat pumps have EERs of 15.4.[11]

The Fort Polk geothermal heat pump systems are owned and operated by an energy service company (ESCO). Such companies typically install and own energy systems, whether they be energy efficiency upgrades or energy management systems in buildings or heating and cooling systems such as the geothermal heat pumps. The end user pays the ESCO a percentage of the energy

[10] For municipally owned buildings that have low-interest loans to finance the installation, the payback period would be shorter than for a conventionally financed building.

[11] It is worth noting that new conventional cooling systems have a much higher EER rating than the displaced Fort Polk units. EIA assumes that new conventional cooling systems have an EER of between 10.0 and 17.7. See EIA's report, *Assumptions to the Annual Energy Outlook 1999*, located at http://www.eia.doe.gov/oiaf/assum99/introduction.html. Due to the nature of the buildings retrofitted at Ft. Polk, the EIA's residential demand assumptions provide the most appropriate comparison.

and maintenance cost savings the consumer sees when a more energy efficient system is installed. The payments enable the ESCO to recover its capital investment, cover the cost of financing the investment, cover system operation and maintenance expenses, and earn a profit. In the case of Fort Polk, 77.5 percent of the total savings goes to the ESCO while the U.S. Department of Defense (DOD) keeps 22.5 percent.

The geothermal heat pumps have enabled Fort Polk users to realize energy savings and to decrease peak demand for electricity relative to the systems the heat pumps replaced. Oak Ridge National Laboratory (ORNL) conducted an independent evaluation before, during, and after the replacements with sponsorship by the DOD and DOE's Office of Utility Technologies. The findings indicate that geothermal heat pump systems, in combination with other energy replacement measures, have reduced annual whole-community electrical consumption by 33 percent (26 million kilowatthours), natural gas consumption for space heating and water heating by 100 percent, summer peak electrical demand by 43 percent (7.5 megawatts), and improved load factor from 52 percent to 62 percent.[12]

Evaluating the Economics of Geothermal Heat Pump Systems

A method to evaluate the economics of a geothermal heat pump system versus an oil heat/electric air conditioning system on a comparable basis is to calculate a project's "net present value." Net present value[13] is the total cost in real (the year the investment is initially made) dollars to the purchaser of an investment over the life of that investment. The net present value is calculated using the initial capital investment of the system, a series of future payments (annual operating cost), income (rebates, revenue) over the life of the investment, and a discount rate.[14]

Table 5. Capital and Operating Cost Data
(1996 Dollars)

HVAC System	Capital Investment: Installed Cost EIA	Capital Investment: Installed Cost GHPC	Capital Investment: Utility Rebate	Capital Investment: Net Cost	Annual Costs: Heating	Annual Costs: Cooling	Annual Costs: Water Heating	Annual Costs: Domestic Energy	Annual Costs: Total Operating
Geothermal Heat Pump	15,000	19,283	2,971	16,312	978	189	243	537	1,947
Oil-fired Furnace & Electric Air Conditioning	10,000	16,200	0	16,200	1,162	236	207	572	2,142

Notes: This table is for a specific home in Connecticut and may not be indicative of other homes or homes in other regions of the country. The geoexchange equipment and ductwork cost was $10,541 and the ground loop $8,742. The oil-fired furnace and electric central air conditioning system was estimated at $16,200.

Sources: Energy Information Administration (EIA), Office of Integrated Analysis and Forecasting. "Energy Crafted Homes in Connecticut, 1998," Table 1, Geothermal Heat Pump Consortium, Inc. (GHPC).

[12] For a copy of the report, "The Evaluation of a 4000-Home Geothermal Heat Pump Retrofit at Fort Polk, Louisiana: Final Report," contact Patrick Hughes at (423) 574-9329, or, email at hughespj1@ornl.gov.

[13] Net present value is derived using the following formula: $NPV = \sum_{j=1}^{n} \frac{values_j}{(1-rate)^j}$ where n is the number of cash flows in the list of values. In this example, n, which represents the number of annual operating cost payments over a 20-year operating life, is equal to 20. The"values" are the annual operating costs; the initial (first year) operating costs is given in the table. The subsequent values for the remainder of the operating life are multiplied by the annualized escalator factor for either distillate fuel oil or electricity for New England in the residential sector.

[14] The "discount rate" attempts to place the expenditure of funds over a long time period on a same-year basis. Usually, expenditures or benefits over time are "discounted" back to the time period when the initial capital investment was made. The rate at which expenditures or benefits are discounted is determined by many factors. To place current and future costs and benefits on a financially comparable basis in a strict sense, one discounts by the expected rate of inflation to place future payments/expenditures on a comparable valuation basis. There are other factors which influence the choice of discount rate, however. Uncertainty, due either to market factors (e.g., the certainty of knowing future prices) or inexperience with new technology, can cause a potential investor to require a high discount rate (i.e., the value of future benefits or costs drops quickly as time progresses).

The following example analyzes the economics of a geothermal heat pump system versus an oil heat/ electric air conditioning system for a new home in the Northeast, specifically Connecticut. Oil-fired heating is common in this region; therefore, it is considered the basis for comparison. Relevant capital and operating cost data for the two systems in a new home are summarized in Table 5. Note that without the utility rebate, a capital cost premium is paid for the geothermal heat pump system. Note also that the initial investment is greater but the operating cost is lower for the geothermal heat pump system than for the alternative oil-fired furnace/electric air conditioning system. The operating cost of the oil-fired furnace/electric air conditioning system will increase faster in real dollars over time as the real dollar cost of oil fuel increases. Thus, the real dollar operating cost savings for a geothermal heat pump system will grow larger over time if real oil prices continue to rise.

How quickly the savings of the geothermal heat pump system grow over time is a function of the discount rate. A discount rate in its simplest terms is the cost (interest rate) of money. However, for evaluating energy efficiency investments, economic literature refers to an "implicit discount rate" or "hurdle rate." The concept of a hurdle rate, uses a empirically-based rate which is required to stimulate actual purchases, that is, the rate implicitly used by consumers. These rates are often much higher than would be expected if financial considerations alone were their source.

Among the reasons often cited for relatively high apparent discount rates for consumer energy efficiency choices are the following:

- uncertainty about future energy prices and thus about the returns from an energy investment
- uncertainty about future technologies and their cost—current investment becomes locked in and may limit future options
- lack, or high cost, of good information on efficiency and savings
- additional costs of adopting a system that may be difficult to observe or quantify
- tenure expected to be shorter than life of investment, causing some gains for energy efficiency investments to be lost to the new purchaser
- urgent replacement of a failed system, which limits the time to plan, evaluate, and install a comparatively complex and unfamiliar system
- hesitancy to replace the current working system, especially with an unknown system,
- attributes other than energy efficiency that may be important to consumers
- limited availability of funds to be able to invest in any of the options under consideration
- renter/owner incentive differences
- incentives offered by builders to minimize construction costs of housing.

From Table 5 data, a net present value for each investment can be calculated. The assumptions on which this calculation will be based are that (1) both systems have a 20-year operating life, (2) the annualized maintenance is approximately equal for both systems, (3) the real annualized escalation of distillate fuel oil price for New England in the residential sector is 0.33 percent,[15] (4) the real annualized escalation of electricity price for New England in the residential sector is -0.79 percent,[16] and (5) the long-term real (implicit) discount rate is 20 percent, typical for risk-averse residential buyers looking for short payback on investment.[17]

Given these assumptions, using GHPC data for the installed cost, the net present value cost for the geothermal heat pump system, without the rebate, is about $28,440; the net present value for the alternative, oil-fired furnace/electric air conditioning, is about $26,700. (The utility rebate for the geothermal heat pump system brings the net present value down to $25,460.) Without the utility rebate, at a 20-percent discount rate, a consumer would not purchase the geothermal heat pump system on purely an economic basis. Under the assumptions used, the break-even rate where consumers would be indifferent between systems (when the two systems have an equal net present value) is approximately 8 percent. At any discount rate greater than 8 percent, the consumer would choose the geothermal heat pump.

[15] Energy Information Administration, *Supplement to the Annual Energy Outlook 1998*, Table 11. See website location ftp://ftp.eia.doe.gov/pub/forecasting/aeo98/sup98tables/.

[16] *Ibid.*

[17] Energy Information Administration, *Annual Energy Outlook 1998*, DOE/EIA 0383(98) (Washington, DC, December 1997), p. 22. See website location http://www.eia.doe.gov/oiaf/aeo98/homepage.html.

Based on EIA data for installed cost, the discount rate at which the consumer is indifferent is between 2 and 3 percent.

It is important not to generalize the above results. One reason is that the economic feasibility of using geothermal heat pumps varies substantially between small- and large-scale applications (e.g., residential versus commercial). Also, the capital costs of the two HVAC systems compared here are based upon a single house in a private sector pilot geothermal heat pump program. EIA's National Energy Modeling System, used to develop energy forecasts through 2020, uses average regional cost and performance factors in assessing technology choices, and may well provide results which differ from those shown in this analysis.[18]

Recent Department of Energy Participation

In 1994, the U.S. Department of Energy (DOE), working closely with the Environmental Protection Agency (EPA), Edison Electric Institute, Electric Power Research Institute, International Ground Source Heat Pump Association, National Rural Electric Cooperative Association, utility sector, and geothermal associations and manufacturers helped to create the Geothermal Heat Pump Consortium (GHPC). The GHPC launched the National Earth Comfort Program, designed to foster the development of a fast-growing, self-sustaining, national GHP industry infrastructure. The DOE has also supported research and development activities through the DOE's national laboratories and industry associations. In partnership with the GHPC, the DOE's Office of Geothermal Technologies seeks to increase annual installations of GHP systems to about 400,000 by 2005 and reach about 2 million total installed by that same year. The GHPC estimates that 400,000 geothermal heat pumps are being used today for heating and cooling throughout the United States in residential, commercial, and government buildings.

The Energy Policy Act of 1992 requires the Federal government to become more energy efficient. President Clinton, by Executive Order 12902, reinforced the law by mandating a 30-percent reduction in energy use by Federal agencies by 2005, compared to a 1985 baseline. Fort Polk, Louisiana, the world's largest installation of geothermal heat pumps for residential housing, almost met the mandated energy savings with only the installation of its GHP system. By exceeding the 30-percent reduction mandate in family housing, which represented about 40 percent of base energy consumption, Fort Polk can reach its overall savings mandate by taking a few other energy saving measures.[19]

The Fort Polk project was a joint effort of the Army and an energy service company (ESCO) under an energy savings performance contract (ESPC). ESCOs provide the expertise and financing to develop, build, and maintain energy-efficiency projects for customers. Under energy savings performance contracting the goal is to renew energy consuming systems using private investment, and realize energy and maintenance cost savings that are shared between the customer and the ESCO. In performance contracting, ESCOs take on a much wider spectrum of responsibilities and risks than is common in conventional contracting.

The results at Fort Polk created the momentum to establish ESPC's in the Federal sector. The DOE Federal Energy Management Program (FEMP) has implemented National Geothermal Heat Pump "Super-ESPCs" to streamline the procurement process and encourage federal sites to consider the potential energy and cost savings of GHP-centered ESPCs. Federal agencies can now contract with ESCOs who have been competitively selected and pre-approved by FEMP to develop GHP-centered energy-efficient projects at federal sites anywhere in the United States under the Super-ESPC.

[18] *Ibid.*

[19] See the "Fort Polk Case Study" presented in this paper for additional information on the installation.