THE EARTH-COUPLED OR GEOTHERMAL HEAT PUMP AIR CONDITIONING SYSTEM

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ABSTRACT

As utility costs have risen despite political campaign promises and energy conserving measures implemented by the utility companies such as alternative fuel use (coal and nuclear), co-generation, etc., homeowners have begun to search for effective methods of reducing their electricity bills. In some cases homeowners are faced with utility bills That are approaching the cost of their mortgage payments. For those with fixed incomes, such as the elderly or those looking forward to retirement in the near future, this has become an alarming reality. Virtually every homeowner would like to reduce his utility bill but the question is, what items should he address in order to have a significant impact on his electricity costs? According to Houston Lighting & Power Company, 50% of an electricity bill can be attributed to the air conditioning system, and another 15-20% to the hot water heating system (7). Therefore, to dramatically reduce utility costs one should look first at these two "energy gulpers" and next at proper home insulation, window coverings, etc. (5). The other electrical appliances in the home use relatively minor amounts of electricity compared to the air conditioning and hot water heating system. This paper will describe the geothermal heat pump and the desuperheater as the latest developments in energy efficient air conditioning and water heating.

INTRODUCTION

Homebuyers today have many options to choose from. Often the type or style of the whirlpool bath seems to get more attention than the energy-consuming devices in the home. Since the air conditioner and water heater consume approximately two-thirds of the electricity used in a typical month, the energy efficiency of these two appliances is an important factor in the purchase decision. Over the last 40 years central air conditioning has evolved from oscillating fans, to window units, to split-system air conditioning systems with either gas or electric furnaces (7). Up until the last four or five years there was little consideration given by either manufacturers, contractors or homeowners to the efficiency of their heating and cooling system. However, the Arab oil embargo changed that situation dramatically. Utility bills began to skyrocket. In fact in the last eleven years the average annual rate of increase from Houston Lighting and Power has been seventeen percent. Now high efficiency air conditioning systems are being actively promoted by the utilities and the air conditioning contractors. During the past few years heat pumps have gained in popularity due to heavy promotion from the electric utility companies. This is due to the utility companies desire to use some of their extra capacity in the winter time as well as reduce the bills of customers who have electric resistance heat as their heating source (7).

"A heat pump operates like a standard electrically driven air conditioner in the summer, collecting heat from the air in the home and expelling it outside. In winter the process is reversed so that the heat pump collects heat from the outdoor air to warm the air inside the house" (10). The heat pump can do this because heat exists in air. Even cold winter air contains heat. On very cold days most heat pumps will have to rely on supplemental resistance heaters to provide sufficient heating for the space. The efficiency of the heat pump is very good relative to a fossil fuel furnance or resistance heat since the heat pump collects heat that already exists in the outdoor air by means of its refrigeration cycle. This means that the heat pump supplies from 1½ to 2½ times more energy as heat than it consumes in energy as electricity, depending on the efficiency of the unit and the geographic location. The problem with heat pumps, as most people know them, is that they depend on the outside air temperature to move the heat into or out of the house. This means that the colder it gets outside, the less efficient the heat pump becomes. Also, as temperatures rise in the summer the heat pump becomes less efficient in removing heat from indoor air and rejecting it to outdoor air.

THE EARTH-COUPLED OR GEOTHERMAL HEAT PUMP

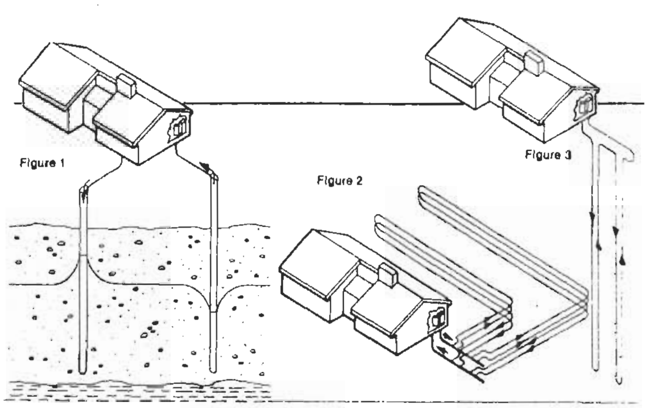
What if there were a source of heat that was at a relative constant temperature of 55°-75° F.? Then the system could operate in a very efficient range. Systems that have been developed to utilize these constant temperatures are called "earth-coupled" or "geothermal heat pumps". These systems still use the basic heat pump design of moving heat from one source to another but also take advantage of the relatively constant earth temperature. Generally at depths of about 30 to 50 feet the earth remains at a constant temperature, reflecting the average air temperature of the area (6). In south Texas this will vary between 69°-74° F., which is an almost perfect operating condition for efficient operation of the earth-coupled heat pump. Across the United States the earth and water temperatures at depths of 30-60 feet have been plotted in graphs by the water well industry. These temperatures vary from 40° F. along our northern boundary to about 75° F. in southern Florida. These temperatures fall within an earth-coupled heat pump's efficient operating limits.

HISTORY

These systems were first developed 25 years ago by Swedish engineers in response to Sweden's increasing dependence upon foreign imports of oil and coal. The earth-coupled heat pump was designed, tested, and now, after hundreds of thousands of installations, has become the standard installation of this country. Shortly after the Swedes developed this technology, Canada followed suit for similiar reasons. About 12 years ago Dr. Jim Bose, of Oklahoma State University, became interested in the earth-coupled heat pump. He requested, and received a federal grant to research the applicability of this design in the U.S. Since then both Bose and Dr. Harry Braud of Louisianna State University have developed sufficient research, testing, and mathematical models to predict the length of pipe, type of pipe, and diameter of pipe to be used to properly couple with a geothermal heat pump. Presently there are plans for a study at Texas A & M University, to be initiated this summer, by Professor Bill Aldred of the Agriculture Engineering Department. He plans to develop a mathematical model of the heat transfer characteristics in an earth-coupled system. Professor Aldred will be utilizing a three ton geothermal heat pump connected to a vertical parallel loop system. The system's heat transfer will be monitored by 99 thermistors installed at various locations throughout the earth loop (11).

TYPES OF SYSTEMS

There are two basic types of earth-coupled systems currently used in the U.S.: Open loop, and closed loop, horizontal or vertical. (figure 1, 2, & 3).



OPEN LOOP SYSTEM

The open loop system uses groundwater as a heat source/sink (figure 1). Water is pumped from a well and flows through a heat exchanger, then is discharged back to the environment.

Discharge well. There are a variety of discharge systems to dispose of the water. A recharge well can be constructed, allowing the water to reenter the groundwater for use later. Recharge wells will have different characteristics depending on the geological conditions and water quality. In many places unlimited quantities of water can be injected into formations, but in areas where the static water level is high it may be necessary to discharge the water at a different depth. The supply well should be a minimum of 50 feet from the discharge well to prevent heat from building up in the system (9). Shallow tile fields, septic type systems or drains all allow the water to be returned to the ground, thus replenishing the groundwater supply. Water can also be discharged into lakes, streams or rivers and even storm sewers. All of these methods are subject to local and state approval so that the groundwater is not polluted. The only change that occurs is that the groundwater temperature has been slightly altered.

The typical open system uses 2½ to 3 gallons per minute (gpm) per ton of cooling capacity and produces a temperature change of 10 to 12 degrees in the groundwater. If an adequate well is already available on the property, only slight modifications to the water system and a method to dispose of the water are needed. If a home has a water supply from another source, such as a water utility, a well must be drilled and a complete water supply and disposal system installed. Costs for the open system can vary depending upon whether a water system is already available, and the type of disposal method chosen.

Open loop systems are not without their problems. Some areas of the U.S. cannot utilize these systems. The primary problem has been finding an adequate amount of water to meet the needs of the home and the heat pump. In rural areas, a well capable of producing 20 to 30 gpm is needed to meet the heat pump needs and peak domestic water needs of the household. Farm households need even more water.

The second most serious problem is water quality. Water may be found in sufficient quantity but may contain chemicals (such as calcium and iron) that tend to foul the system by depositing a scale or sludge on the heat exchanger. Wells, pumps, and water systems will then need periodic maintenance to keep them free from this scale, adding to the cost of operating the system (9). However, much of this maintenance of the unit's heat exchanger has been eliminated by the development of a new cuprous-nickel alloy that inhibits the development of scale.

Cuprous-nickel alloy. The cuprous-nickel alloy expands and/or contracts very rapidly as it is heated or cooled. The expansion or contraction tends to break off any mineral deposits that are trying to build up on the heat exchanger and the flowing water simply flushes them out of the system. This alloy is very popular for use in offshore drilling rigs as it is very resistant to corrosion, even by salt water. The geothermal heat pump has become a very common method of heating and cooling boats and other types of seagoing vessels for this reason.

CLOSED LOOP SYSTEM

Many or all of these problems are solved by the closed loop system. A closed loop system circulates a liquid through a length of buried pipe to capture the heat in the soil, and returns the warmed liquid to the heat exchanger to be cooled and recirculated over and over again. No groundwater is used. Nothing is pumped out of or recharged back into the ground. The system is fully sealed. This system has been available in the U.S. since the

1970's, but has become popular only during the past five or six years as utility costs have continued to rise.

There are two types of closed loop systems: a horizontally laid pipe, and a vertically installed pipe. Horizontal systems (figure 2) are installed in a wide range of patterns and methods, the simplest design being the single pipe loop. A pipe (usually 1 1/4 inch polybutylene or polyethylene plastic) is installed in a trench three to four feet below ground. The length and pattern of the pipe layout varies depending upon soil conditions, local climate, heat pump design, and available land area. Eleven hundred to two thousand feet of trench and pipe for a single pipe system is typical for a three-ton system. By installing two or more pipes in the same trench total trench length can be shortened somewhat (3). The design and layout of these systems should be left to the professional.

The vertical closed loop (figure 3) is somewhat simpler to design and can be used in areas where closely spaced homes are built. A vertical closed loop uses approximately 150 feet of borehole per ton. A three-ton unit, then, will use a total of 450 feet of borehold (or 900 feet of pipe) in a typical installation (4).

A typical vertical loop system is installed in drilled boreholes and usually is separated into several loops (i.e., several 150 foot boreholes) using 3/4 inch polyethylene or polybutylene pipe with watertight butt-fused joints used throughout the system. This type of joining system ensures longevity and protection from any leaks.

Type of pipe. The polyethylene or polybutylene pipe was selected for this application due to its heat transfer rates and its resistance to environmental stress cracking. The pipe is designed to withstand 800 pounds per square inch (psi) pressure and, in fact, operates at 20-30 psi (6). It is the same pipe commonly used by utility companies for the transmission of natural gas. The typical warranty of the pipe is 50 years. The two leading manufacturers of the pipe resin are Phillips Petroleum and Shell Chemical. Many other types of materials have been tested by Bose and Braud. All have been rejected, due to cost effectiveness or lack of reliability in this application. Currently, PVC (Polyvinylchloride) pipe is being used in some installations due to the cost and the water well drillers' lengthy experience with this type of pipe, but there is grave concern in the industry as to the ability of this pipe to stand up under the earth's environmental stress. All current research points toward the polyethylene or polybutylene pipe as being in the best long term interest of the consumer.

Once installed in the ground, the loops are pressure-tested, then filled with water or a solution of either calcium chloride or a food grade glycol. The latter two reduce the chance of ice crystals forming within the loop as the fluid passes through the heat exchanger (6). In the south Texas area this is not necessary as the earth temperature never reaches 32° F. even very near the earth surface. However, if the homeowner should vacate his house during a period of extended freezing weather, then either the system should be left operating at a lower temperature or drained just as any water system should be, to prevent rupture and subsequent water damage.

SYSTEM EFFICIENCY

Why are closed loop systems so efficient? The entering water temperature through the heat exchanger remains nearly constant and, because it is using a constant temperature, the heat pump can be designed for maximum efficiency. Because the water quality is controlled, no scaling or fouling which might reduce the efficiency of the system occurs within the heat exchanger.

Currently about the most efficient conventional cooling unit has a seasonal energy efficiency ratio (S.E.E.R.) of 10, meaning that the unit is capable of producing 10 B.T.U.'s (British Thermal Units) of cooling effect for every watt of energy it consumes. However, the rating point for S.E.E.R. of air source units is an outside air temperature of 82° F. This means that at temperatures exceeding 82° F. the air source system will experience a decrease in efficiency. Since the earth-coupled heat pump has an average energy efficiency ratio (E.E.R.) of 13 it is at least 30% more efficient for cooling than the air source unit with an S.E.E.R. of 10. Earth-coupled heat pumps are not rated with an S.E.E.R. due to the fact that they use relatively constant temperature water. This further enhances their attractiveness, as the units stay at peak efficiency even when it becomes extremely hot outside.

For the earth-coupled heat pump the heating efficiency is almost twice that of the next best device, the conventional air source heat pump. This standard heat pump will generally average a coefficient of performance (C.O.P.) of 2.1, whereas, for the earth-coupled heat pump it is approximately 4.0. This means the earth-coupled heat pump will produce 4 watts of energy for every watt of energy it consumes, whereas, the standard heat pump will produce only 2.1. Furthermore, as the outdoor air gets colder the efficiency of the air source heat pump drops off significantly, whereas, the earth-coupled heat pump continues to perform at peak efficiency since its heat source is well water or water circulated through the ground loop. Water has a specific heat much greater than that of many other substances and, therefore, can store or release far more heat for a given rise or fall in temperature.

Evidence to show the true cost effectiveness of these systems was recently demonstrated by tests conducted by the National Association of Home Builders Research Foundation and monitored for the Department of Housing and Urban Development on a test house built in Maryland with many energy saving devices installed. The Energy Efficient Residence-2 (EER-2) provided answers that will help guide builders in the future as they consider what features to build into their homes. The EER-2 house was occupied in October, 1981, by a family of four and was closely monitored for a year to evaluate the effectiveness of the special energy conserving features. According to the test results the most cost effective feature in the home was the earth-coupled heat pump. Savings in cooling and heating costs indicated less than a three year payback on the premium cost associated with the system, or in other words, a 33% return on investment (13).

Further proof of the economics of the earth-coupled heat pump has been documented by operating results from a New York utility company. The Boston Edison Impact 2000 House is delivering three times more energy as heat than is consumed in electricity by its compressor and pumps. The earth-coupled heat pump system was selected for the air conditioning system for this utility company's show home to display the latest energy conserving features available in a home. Boston Edison has been conducting field tests for over three years on a number of homes in the area and has become convinced of the significant energy reductions available through the application of the earth-coupled heat pump (8).

Locally over 500 of these systems have been installed in the last two years in the greater Houston area. Results range from a homeowner in a small home (2100 sq. ft.) who replaced her old gas furnace and split system air conditioner and is now saving more than 50% on her utility bills; to the retired engineer (class of '51 Texas A & M), in Bellaire, Texas, who put in a system 22 years ago and today will tell you that for the last several years his monthly utility bills have been $100 lower than his neighbor's bills. The homeowner in the first case, had a 3½ ton vertical ground loop system installed, and the retired engineer, had a shallow water well drilled to supply water for his system. The water is used to sprinkle his lawn after being circulated through his five ton geothermal heat pump.

DESUPERHEATER

Another significant feature of most earth-coupled systems is that because they are self-contained units located inside the house, "desuperheaters" can be added to produce domestic hot water. A desuperheater is an additional heat exchanger in the flow line to extract some of the heat from the refrigerant. The hot gas then enters the condensor for complete condensation. This hot gas can be used to produce domestic hot water very economically (2). Some systems are designed to supply all the domestic hot water needs of the household while others produce hot water only while the unit is running. The desuperheater is a relatively inexpensive addition to the system since most manufacturers of earth-coupled systems usually provide them as an accessory to their basic unit. The additional cost to the consumer is in the range of $600.00-$800.00, which is far below the least expensive solar water heating system currently available at $4,000.00 or more. Savings in water heating costs of 70-80% are quite common with this system. For a family of four in Houston, Texas, this would mean $400.00-$500.00 in annual savings at today's utility rates. The desuperheater can operate whether the unit is in the cooling or heating mode and will easily provide 140° F. water. Typically 140° F. water is sufficient for all domestic use. The water heater is not eliminated from the house as it becomes a back-up source of heat for hot water should the air conditioning system be turned off during the spring and fall seasons.

ADVANTAGES AND DISADVANTAGES OF OWNING AN EARTH-COUPLED HEAT PUMP

ADVANTAGES

1. Two-thirds of the energy used comes indirectly from the sun which is a renewable, non-polluting energy source.
2. An earth-coupled heat pump can be applied practically anywhere for residential, commercial and industrial heating/cooling systems.
3. There is no noisy, bulky outdoor condensing equipment required.
4. No back-up supplemental heating equipment is necessary.
5. An earth-coupled heat pump is a relatively simple machine requiring little if any maintenance.
6. An earth-coupled heat pump system has the lowest operating cost of any space heating or cooling system.
7. F.H.A. will generally appraise a home with this system at a higher value.
8. No open flame is necessary, as is required on gas furnaces.

DISADVANTAGES

1. Initial investment for a water supply or loop system. It should be noted that a packaged earth-coupled heat pump system and ductwork (equipment installed indoors) costs approximately the same as other fossil fueled equipment with central air conditioning. Typically, a water supply system or loop will cost an additional $600.00-$1,000.00 per ton of cooling capacity.
2. Coordination of trades can be a problem during installation as two or more additional contractors are involved (well driller-trenching-plumbing). The ideal situation is to have someone responsible for the entire outside installation, stubbing the two loop or water supply lines into the house (outside turnkey operation).
3. Public education. Many consumers are distrustful of heat pumps due to past bad experiences with air-to-air heat pumps. Consumers need to be made aware of the fact that a geothermal unit does not have a defrost cycle and that the compressor sits inside. These two facts contribute to a much longer compressor life (19 years vs. 7 years, according to ASHRAE). Most consumers are not aware that geothermal units have been in use, primarily in the South, for over 25 years. Prior to 1980, most geothermal heat pumps were used in commercial applications. In 1984 construction began on the tallest office building in the West. This building will employ the use of two thousand geothermal heat pumps. However, these units will utilize boilers and fluid coolers to offset the water temperature changes in the water loops as the units both heat and cool the structure. These types of systems were also utilized by A.I.A. award winning League City Intermediate School and the Cypress Fairbanks Medical Center Hospital. Another factor is that most urbanites obtain their water from municipal water systems. Most people are afraid to get involved in a new technology.

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FINANCIAL CONSIDERATIONS

FIRST COST

In rural areas where the water well is large enough to handle both the domestic needs of the house and the geothermal heat pump, there is almost no premium first cost associated with the product. But in many cases either a pair of water wells or a ground loop will be required. This means an additional cost of $600.00-$1,000.00 per ton of cooling capacity required for the house. So for a typical house requiring four tons of cooling a premium cost as high as $4,000.00 might result. At first glance, this certainly seems prohibitive, but let us analyze this cost in terms of payback, return on investment, life cycle cost and cash flow (4).

PAYBACK

The investment of $4,000.00 is paid back in approximately 3 years. After that the investment becomes an annuity as the savings increase with each increase in the utility companies' rates. Over a period of 20 years (the expected life of this system) these savings could exceed $40,000.00 if utility rates continue to increase at the same rate as they have for the last several years.

RETURN ON INVESTMENT

The investment of $4,000.00 has an annual rate of return of 25-35% since the annual savings with this system over some highly efficient conventional systems vary between $1,000.00 to $1,300.00 (2). Compared to a typical certificate of deposit paying about 10%, this is a two or three times better return on investment. Unlike the interest earned on a C.D. the savings are not taxable.

LIFE CYCLE COST

The total cost over the twenty year life of the earth-coupled system is dramatically lower than a typical air-to-air system as shown in Table 1. This is calculated at today's utility rates which means that as rates increase the savings increase as well. Graph 1 shows the effect of an annual utility rate increase of 15 percent and an operating life of ten years. The assumptions made include a four ton earth-coupled heat pump system with a 13.0 E.E.R. and a 3.7 C.O.P. versus a conventional air-source system with an 8.5 S.E.E.R. using an electric furnace for heat. Savings in water heating by using the desuperheater were estimated to be 80% of the typical cost of $50.00 per month for a family of four in the Houston area. Maintenance savings of $240.00 per year for the nine year period were estimated by local Houston air conditioning contractors. These are typical costs associated with semi-annual condenser coil cleanings and condensor fan motor replacements every 4th year. Replacement savings were estimated to be the replacement of the outdoor condensing unit prior to the eleventh year. Total savings amounted to $34,013.00 in ten years or $252.44 per month. All calculations were made using local weather data for Houston, Texas, and the typical system operating hours, provided by Houston Lighting & Power and the Department of Energy. A Sharp computer model 2L-5400 was used to calculate the operating costs of the standard system and then to determine the actual savings with the more efficient system.

Table 1: COST COMPARISON

COST OF INSTALLATION (4 ton unit)

Air-to-Air Heat Pump	Open Loop Heat Pump	Closed Loop Heat Pump
$3,000.00	$4,500.00[1]	$7,000.00

OPERATION SAVINGS USING A EARTH-COUPLED GEOTHERMAL HEAT PUMP

$1,228.00/Year at 9 Cents/kwh

PAYBACK

Open loop heat pump versus air-to-air heat pump: 1.2 years

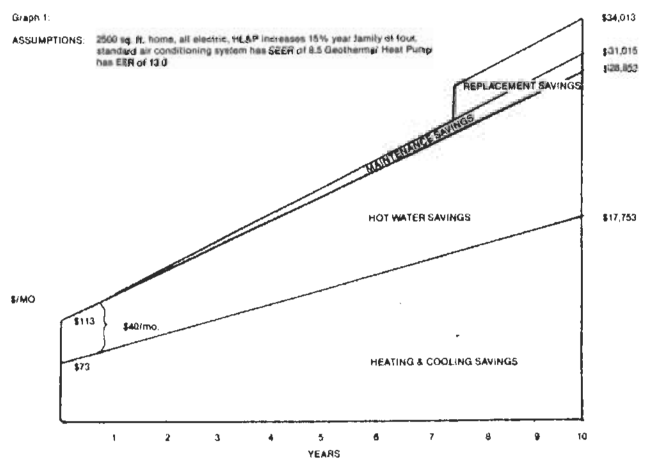
Closed loop heat pump versus air-to-air heat pump: 3 years

TOTAL COST OVER 20-YEAR LIFE[2]

Air-to-Air (8-10 year life)	Open Loop[3] (18-20 year life)	Closed Loop (18-20 year life)
$48,240.00	$24,680.00	$23,900.00

[1] Supply well already exists on property but injection well has to be drilled.
[2] Operation at 9 cents/kwh over life of system.
[3] Slightly more maintenance on open loop system due to injection well.

OPERATING SAVINGS FOR A GEOTHERMAL HEAT PUMP



CASH FLOW

The mortgage increase of $4,000.00 will result in a $43.00 per month increase in the mortgage payment, whereas, the savings in utilities average over $102.00 per month. Therefore, there is an immediate positive cash flow of over $59.00 per month. This savings is also after tax savings which means its real worth needs to be increased by the tax bracket of the homeowner. Furthermore, the savings will increase as the utility rates increase, whereas, the fixed cost of the mortgage does not increase. So the gap between the two grows greater with time, much to the benefit of the homeowner.

TAX CREDITS

The following is taken from the Congressional Record:
GEOTHERMAL TAX LEGISLATION
Background and need

In its report on the Energy Tax Act of 1978 (Public Law 950618), the Senate Finance Committee stated that the purposes of the legislation were to "induce consumers of oil and gas to conserve energy and convert to alternative energy sources". To meet this goal, the Energy Tax Act provided major tax incentives for the production of energy from such resources as geothermal, solar, wind, and biomass. These incentives-mostly in the form of tax credits, deductions, and allowances-have generated unprecendented interest in developing alternative energy projects.

However, regulations issued in 1981 by the I.R.S. have drastically limited the application of the alternative energy incentives enacted in 1978 and reaffirmed and expanded by the Crude Oil Windfall Profits Tax Act of 1980 (Public Law 96-223). With regard to geothermal energy, four specific limitations imposed by the I.R.S. appear to run contrary to Congressional intent:

Only water of a temperature of 122° F...or greater is considered "geothermal energy," even though the Energy Tax Act itself contains no temperature threshold. As a result, homeowners or businesses with water cooler than 122° F. cannot qualify for the residential or business energy investment credits.

A homeowner who installs a geothermal system to heat his residence cannot qualify for the residential energy credit unless 100 percent of the energy in the system is supplied by geothermal sources. Geothermal energy systems often include peaking equipment fueled by oil, gas, or coal. This peaking equipment typically provides less than 20 percent of the total annual energy load, since it is only used on the coldest days of the year. But, such peaking equipment would disqualify the system.

A business that installs geothermal equipment cannot qualify for the energy investment credit if the geothermal fluids are mixed with energy from another source. Geothermal resources may not, in some instances, be hot enough to fully satisfy an industrial process heat requirement. However, by adding a few degrees to the heat supplied from the geothermal source, it will often be possible to displace a large fraction of the conventional fuel consumed in the plant. Under the I.R.S. limitation, if a geothermal system requires even a minimal addition of non-geothermal heat, then the entire system becomes ineligible for the energy tax credit.

A company building an electric power plant using geothermal and energy from another alternative energy resource, such as biomass, can take the geothermal credit on the equipment run solely on geothermal energy and the biomass credit on the equipment fueled exclusively by wood. But, those components of the plant using both geothermal and biomass energy cannot qualify for either credit (12).

Therefore, the residential credit of 40 percent of the first $10,000.00 of qualifying expenditures for devices using renewable energy is not allowable in the case of water source heat pumps. Bills have been introduced in both the House of Representatives and the Senate for the last two years but none have made it out of committee for a final vote. Apparently the current budget deficit precludes the popularity of providing relief to the nation's homeowners faced with enormous utility bills.

UTILITY COMPANY REBATES

Oil prices have dropped significantly in the past few years yet utility rates continue to climb. However, the projected population growth rate of Texas dictates that the utility companies build new and larger power plants. The financing and construction costs of these facilities must be offset by rate increases. The only viable alternative for the utility company is to encourage homeowners to conserve energy. Furthermore, the electric utility company has the additional problem of having to provide plants capable of handling peak summer loads which then have far too great a capacity in the winter months. Thus they would like to flatten their load requirement by having more customers use electricity to heat their homes in the winter in lieu of natural gas. To encourage conservation most utility companies are offering rebates to either new or existing homeowners who install high efficiency heat pumps. These rebates range from $200.00 per ton of cooling for units with an S.E.E.R. of 13 in Austin to $600.00 per unit for heat pumps with a 10 plus E.E.R. in Houston. Also, in Austin, the utility company provides another $100.00 rebate if a desuperheater is installed in the system. Since most geothermal heat pumps exceed 11 E.E.R. they more than qualify for these rebates. For example a homeowner in Houston could qualify for a $1,200.00 rebate by simply having two two-ton geothermal heat pumps installed in his home. This rebate would significantly offset the premium first cost of the ground loop system.

SUMMARY

When the cost of energy was low any type of air conditioning system was a blessed relief from the humidity and heat of the Texas sun. Now due to rising costs of utilities homeowners need to recognize the important financial aspects of choosing the best air conditioning and hot water heating system available. The first cost of the air conditioning and water heating systems may be important. But certainly the operating costs, life expectancy of the system, cash flow, and utility company rebates available should be considered in order to make the wisest possible decision. If all of the financial considerations are explored fully, the "state-of-the-art" for a residential air conditioning and water heating system appears to be the earth-coupled geothermal heat pump.

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