Project Number: BMV-CO36

# Feasibility Assessment of the Implementation of a Ground Source Heat Pump System in the Merton Community

An Interactive Qualifying Project
Submitted to

The Merton Council and Mr. Robert Harris

And to the Faculty
of the

WORCESTER POLYTECHNIC INSTITUTE

In Partial Fulfilment of the Requirements for the

Degree of Bachelor of Science

By


Alison Lee Aery

Jason Draper Butler

Max Giang

Meghan Elisabeth Smith


February 28, 2003

Approved by :

Professor Bogdan Vernescu, Major Advisor

Professor Jeanine Plummer, Co-Advisor

# Executive Summary

The last half-century has shown the detrimental environmental effects of industrialization on the Earth. Damage to the planet can be seen through deforestation and the depletion of fossil fuels, as well as the presence of harmful pollutants in the soil, water and air. Many of these pollutants are formed by the creation of energy through combustion of fossil fuels. To combat these problems, scientists and engineers have been working to create alternative ways to produce energy. Ground source heat pumps are a means of renewable energy that make use of energy stored underground.

At the same time, there has been a shift in the United Kingdom governmental policy towards improving the quality of living in its communities. Communities have set Decent Homes standards, which dictate the minimum standards that residential buildings must attain. For the Merton community in south London, these standards include having functional and effective heating systems as well as thermally efficient homes. There has also been focus on combating the problem of fuel poverty in the U.K., where households spend more than 10% of their income for heating their homes.

To help improve living conditions, the Merton Council is investigating the possibility of using ground source heat pump technology to provide inexpensive and efficient home heating. The U.K. energy company, Powergen, is offering communities a ground source heat pump package at a significantly reduced price. The Merton Council, in conjunction with Mr. Robert Harris, a private investor and consultant, is looking into implementing the Powergen package in Council-owned properties. To aid the Council, our group investigated the technical feasibility of the ground source heat pump, and the feasibility of implementing it in Merton housing stock.

We also created informational and promotional material that the Council can use in order to educate and inform the community about the ground source heat pump system.

Ground source heat pumps operate on the principle that there is energy held in the Earth that can be tapped into by using the proper equipment. Below the frost line, the ground remains at a fairly constant temperature of around 12°C. This energy can be removed from the ground and pumped into a house to provide heat and hot water.

The ground source heat pump is widely used throughout the United States, Scandinavia, Iceland, and Switzerland. It has been successfully implemented in over 400,000 homes and buildings in the U.S. alone. The heat pump system has several benefits when compared to common heating systems. First, the ground source heat pump provides approximately a 45% reduction in annual energy costs when compared to an oil system, and 68% when compared to electric. The ground source heat pump provides savings over gas systems for houses with high energy consumption. In houses with low energy needs, the costs are comparable to gas heat. Second, the ground source heat pump can reduce polluting emissions up to 72% when compared to other common heating systems. Lastly, in the United States, the heat pump has proved to need minimal maintenance throughout its 30-year lifetime.

To meet our goal of assessing the feasibility of using the ground source heat pump in Merton, we gathered in-depth information about the Powergen heat pump system, and the Council's housing stock. We interviewed multiple system experts: Mr. John Parker of EarthEnergy, who designed the heat pump system being employed by Powergen; Mr. Roger Hitchin, a representative from Building Research Establishments; Mr. Damien Bree, an architect who has designed buildings implementing the heat pump; and Ms. Deborah Bennett, a representative from GeoScience, an engineering firm that works with heat pump systems.

From these interviews we discovered that the heat pump system that Powergen is employing is designed for newly built houses only. The ground source heat pump contains underground piping filled with a heat transfer fluid that removes the heat from the ground. Inside the house, there is the heat pump unit itself, which takes the heat from the piping and uses it to heat the home and provide hot water.

In order to install the underground piping, a drilling rig must drill 60-meter deep holes. The holes must be 5 meters apart from one another, and 2 – 3 meters away from the house and the property lines, so the house must have a large garden to accommodate the piping. The underground piping is filled with the heat transfer fluid, and the holes are sealed up with grout. The drilling and installation of the piping takes about 2 days. The heat pump unit is a small piece of equipment that is installed within the house. The installation of the heat pump and hot water tank takes about two days.

The ground source heat pump package that is offered by Powergen costs £2500 per system. Additional consumer expenses include the cost of drilling and pipe installation, on the order of £2000, and the expense of a plumber installing the connecting piping at £500. This gives a total initial expenditure of £5000 per house.

The Powergen package is intended for newly constructed houses that are designed for the package. They must be less than 100 $m^2$, single story, stand-alone houses, having sufficient room to install the piping. They also must have an under floor heat distribution system and an overall high thermal efficiency. The Merton Council is not allowed to build new housing, and therefore will not be able to construct a house with these design specifications. If a ground source heat pump system were to be implemented in Council-owned housing, it would need to be retrofitted into an existing house. Although Powergen does not recommend this type of installation, it is possible by bringing the house up to the standards and requirements set by Powergen for installation.

The Council currently owns 7000 residences, with only 2180 being stand alone or terraced housing. Although these residences would be the possible locations of a retrofit, the current housing stock is in a state of disrepair. In order to bring the houses up to the thermal efficiency standards required for the ground source heat pump, the windows would need to be replaced with double glazed windows, and exterior insulation would have to be placed on the brick exterior walls. In addition, most of the Council's housing has gas heating systems with radiator distribution. These would need to be replaced with radiant under floor heating distribution systems. These major renovations would be highly disruptive requiring residents of the houses to be moved out during construction. In addition, these repairs will incur considerable expenses that the Council does not have sufficient funds for.

The expenses incurred by installing the ground source heat pump system, or completing the needed retrofitting renovations, can be offset by various sources of funding. The Carbon Trust, set up by the U.K. government, provides rebates when environmentally friendly technology is used in place of a highly $CO_2$ emitting system. This can range from around £500 for replacing a gas heating system to £1500 for replacing an electric system. Additional financial support for the project can be received from the Clear Skies Fund. This fund provides grants for the development of alternative energy systems, including the ground source heat pump. Individuals can receive up to £5000 and communities can apply for up to £100,000. This money could be used by the Merton Council to fund their renovations and heat pump implementation in Council properties.

In the European green energy market, the most effective promotional campaigns for renewable energy systems have focused heavily on consumer education. The marketing campaigns raise the potential consumers' awareness about the energy system, thereby addressing their concerns and alleviating anxiety about a previously unfamiliar system. Successful promotional tactics for alternative energy have also been focused on economic benefits. In addition, showing governmental support for the technology has helped further renewable energy sources in the European utility market.

To determine the Merton community's receptiveness of the ground source heat pump, as well as find out what concerns they had with the possibility of having an alternative energy system installed in their homes, we surveyed various community members. They were highly receptive to the possibility of having a ground source heat pump. Seventy nine percent of surveyed residents said that they wanted to purchase environmentally friendly products. Ninety three percent said they would like to have an environmentally friendly heating system in their home if it saved them money, and 85% still said they would like the heating system if costs were similar to their current heating system. There appears to be very strong community support for a project such as the ground source heat pump in Merton. In addition, the community was surveyed to find out their concerns pertaining to a new environmentally friendly heating system. The majority of the community was concerned with maintenance, reliability, safety, and long-term effectiveness.

In our development of the promotional and educational material, we made sure to respond to the community's concerns about the system. We highlighted the economic and environmental benefits of the system. At the same time, we provided information about the technology and operation of the ground source heat pump. We created a tri-fold pamphlet with brief information on all of these topics, and created a brochure with more in-depth information about the ground source heat pump. A public presentation was also developed and given on February 26th, 2003. This presentation was videotaped, transferred onto a CD and will be placed on the Merton website along with the other written documents, so that it can be accessed by the community.

Due to the major expense that would be incurred through trying to install the ground source heat pump system in the current Council-owned housing stock, we recommend that the Merton Council not attempt to implement the program. Installing the system would only be advisable if they could receive significant funds from outside sources such as the Clear Skies Fund. Instead, we recommend that the Council work with Registered Social Landlords, Housing Associations, and private landlords in the Merton community to encourage them to build new housing that will implement the ground source heat pump system. By encouraging these groups to make use of the Powergen heat pump package, Merton will still be making strides to reduce fuel poverty and increase the standard of living amongst its residents. At the same time, Merton will be setting precedence in the London community for reducing fossil fuel consumption and harmful carbon dioxide emissions.

# Abstract

This project explored the technical feasibility of implementing ground source heat pump systems to supply heat and hot water in the London area, as well as the viability of implementation in the Merton Council housing stock and community. We determined that the Merton Council should not implement the system, due to both technical and financial limitations. However, the Council should use the promotional material that we produced to educate housing associations and private consumers, encouraging them to consider using the heat pump system.

# Table of Contents

# List of Tables

# List of Figures

# 1 Introduction

Since the mid twentieth century, there has been an increased awareness about the effects of industrialization on the modern world. Concerns about fossil fuel consumption, deforestation, and harmful emissions that perpetuate the greenhouse effect have risen. Part of the concern was the discovery of a small hole in the earth's protective ozone layer above Antarctica created by over use of certain technologies (Natural Environment Research Council, 2002). The potential repercussions of decisions about fuel and chemical use, including increased UVA/UVB radiation, global warming and the loss of many natural resources, brought environmental concerns to the forefront and concern for the earth began to take centre stage.

As concerns for the environment became a larger priority, people began looking for ways to stop or at least slow down the damaging effects of industrialization. Following this lead, researchers began investigating possible environmental alternatives to fossil fuel consumption and pollutant-emissive production processes. Many of the problems with the environment were due to the methods that were being used to produce energy. Solutions that were developed consisted of exploring various types of renewable energy sources as opposed to burning different fuels. A well-known heating source that makes use of renewable energy is the use of photovoltaic energy through solar panels. The panels are used to convert the solar energy into electricity. Another alternative method of generating power is wind. This is usually done in bulk, using many windmills together in what is called a wind farm to generate electricity that supplies homes and businesses. Prior to this project, this has been a main source of renewable energy for Powergen, an energy company that has twelve wind farms producing electricity to power in excess of 50,000 households in the United Kingdom (Powergen, 2003a). A third method of energy generation that has been used for centuries is harnessing the power of rivers by the use of dams.  A less well-known method is to use the heat from the ground.  This is called geothermal energy and is made possible because of the earth's warm core and the ability of the ground to insulate and store the solar energy it collects near the surface.  All of these alternative energy sources have proven to be useful, but they must be accepted as viable alternatives to the environmentally damaging use of fossil fuels, thereby allowing individuals to meet their energy needs in a more ecologically friendly manner.

In an effort to address environmental needs and concerns, the Merton Council in south London is investigating the feasibility of implementing technology that can provide an energy alternative that is environmentally friendly, as well as being an inexpensive means of heating homes.  The Council wants to implement a new, green method of heating that also improves the value and quality of their community's dwellings.  To help solve problems such as fuel poverty, the Council is looking at a geothermal heat pump system that incorporates energy saving and environmentally friendly technology.  Its main component is a ground source heat pump system used to provide the energy needed to heat the building as well as provide hot water.  One of the aims of Merton's regeneration strategy is to incorporate future technologies, such as the ground source heat pump, in the Merton area, taking steps towards creating a cleaner, greener community.  The Council is working with Mr. Robert Harris, a private developer currently working with ground source heat pumps, to help explore this technology.  Further information about the Merton Council and Mr. Harris can be found in Appendix A.

Although there are many systems that have been implemented in the United States, the use of a geothermal method is not widely known as a viable option for heating in the United Kingdom.  Systems in the United States are mainly installed in large buildings or complexes, such as schools, and implemented in new, expensive homes. However, these systems are not usually presented as an option for the average homeowner.

Our main goal was to compare this ground source heat pump with the current traditional heating systems to determine if there are concrete reasons for switching to geothermal energy. It was important for us to confirm the feasibility of installation of the ground source heat pump system from multiple standpoints. Without the proper climate, ground conditions, and willingness of clients to fund the installation of the system, it would not be advantageous to integrate the geothermal heat pump system in homes, businesses, government buildings, or other institutions.

We interviewed several experts in the field of geothermal energy and ground source heat pumps to learn about the specifics of the system, and the differences between the systems in the United States and United Kingdom. This method provided us with information about the feasibility of installing the heat pump, as well as the economic and environmental benefits of this system. We used surveys to gain an understanding of the community's attitude towards our system. We created an educational brochure, tri-fold pamphlet, and a presentation to educate consumers and the Council about the systems technical feasibility, installation requirements, use and maintenance considerations, and economic and financial aspects.

In our background chapter we explained the workings of the technology associated with the ground source heat pump as well as information about the Merton community. The methodology explains the research strategies that we used and the relevance of our gathered data. We also explained the final results of our research and recommendations for the Merton Council, which includes our promotional material and our final presentation at the conclusion of our project work in the United Kingdom.

# 2 Background

The total supply of the world's energy reserves are diminishing. The strong dependence on the use of fossil fuels currently satisfies only 84% of the energy demand worldwide and will not be able to continue fulfilling this demand indefinitely (Brus & Golob, 1993, 10). Many countries have begun planning ways to reduce the consumption of limited fuel sources. Before the implementation of the heat pump system can occur, a meteorological, economic and social understanding of the Borough of Merton must be developed. We examined common heating systems in order to compare and contrast them with geothermal energy. This information was then applied to develop an educational program which was used to present an efficient ground source heating system to the Merton Council and community.

## 2.1 Merton

The potential feasibility of a ground source heat pump system relies heavily on the location where it will be installed. When a potential site is located and specified, it cannot be assumed that the location will be an acceptable area where the system will work well. Research to obtain background information was conducted to determine if the Borough of Merton suited the necessary specifications of the heat pump before the project could be carried out. The weather, economy, population, and the different types of housing stock within Merton and specifically the Council's properties were carefully examined.

### 2.1.1 Weather

An issue of great concern is the weather conditions in the Borough of Merton, since it is the desired area of implementation. This includes temperature, cloud coverage, precipitation and the chance of flooding. Although changes in climate may continue to occur, it is possible to gain a basic overall impression of these variables. This is important to determine a general time during the year for optimal installation, and determine the weather conditions that may affect the system's performance.

#### 2.1.1.1 Temperature

In recent years, temperatures in Merton have been fairly moderate, with temperatures averaging from 3°C in January to around 17°C in July (The Weather Channel Enterprises, 2002). This relatively warm temperature above the surface allows effective use of the heat pump system because the ground will be warmer, and it will be able to extract more heat from the ground using the geothermal component of the system. Past files of recorded temperatures and research completed by the U.K. Climate Impacts Programme have shown that average monthly temperatures are rising. Moreover, they claim that average temperatures will continue to rise due to the urban heat island effect. London is densely populated and the large amounts of heat emitted from buildings slowly contributes to an elevation in temperature (Livingstone, 2002). It is predicted that in the year 2080, the Borough of Merton and the city of London will have "extreme temperatures comparable with those of the present-day New York City" (Livingstone, 2002). This change in temperature from a variance of 14 degrees to a variance of 24 degrees will inevitably have a large impact on the environment and how people live. This would mean that the warmest yearly temperature would now be increased to about 27°C. This elevation in temperature would require an increase in the estimated amount of cooling necessary to work and live comfortably inside, of approximately 20% by the year 2080 (Livingstone, 2002). This predicted temperature change and increased pressures on the heating/cooling system presents a large increase in the potential market for alternative means of residential and commercial heating and cooling, because current systems will become very expensive to use due to the limited supply of fuel sources.

### 2.1.1.2 Precipitation

Because the heat pump system involves underground installation, precipitation amounts are of great importance. If there is too much rain, the installation of underground piping may be difficult or restricted to certain months of the year. The United Kingdom weather stations report daily summaries of the weather to surrounding stations, which are known as "climatic observations" (Met Office, 2002a). The data show that within the past six years rainfall can vary greatly, however a pattern can still be determined. By referring to Table 2.1, the rainfall from May to July seems to be drier than other months of the year with rainfall averaging 67 mm per month. Rainfall then becomes heavier until it reaches a maximum average in October of 125 mm for the month. The months following October then become slightly drier and the basic cycle is repeated (Met Office, 2002b).

**Table 2.1**
**Average Monthly Rainfall (in inches) in England and Wales**
(Source: England & Wales Rainfall Chart, 2002)

| Year | Jan (1) | Feb (2) | March (3) | April (4) | May (5) | June (6) | July (7) | Aug. (8) | Sept. (9) | Oct. (10) | Nov. (11) | Dec. (12) | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1997 | 13.8 | 116.6 | 30.7 | 24.2 | 72.9 | 123.8 | 47.3 | 91.9 | 35.0 | 66.7 | 113.5 | 105.0 | 70.1 |
| 1998 | 116.0 | 22.7 | 96.5 | 121.8 | 32.5 | 124.3 | 58.5 | 50.2 | 92.3 | 161.1 | 83.9 | 90.9 | 87.6 |
| 1999 | 133.9 | 51.3 | 70.9 | 74.9 | 57.6 | 82.0 | 24.1 | 103.0 | 119.0 | 81.9 | 64.2 | 151.1 | 84.5 |
| 2000 | 54.5 | 96.1 | 38.0 | 132.5 | 83.8 | 47.6 | 61.3 | 66.4 | 121.5 | 180.1 | 174.8 | 136.6 | 99.4 |
| 2001 | 72.7 | 93.2 | 88.7 | 95.0 | 41.9 | 40.6 | 71.9 | 84.7 | 80.2 | 131.4 | 67.3 | 43.9 | 76.0 |
| 2002 | 94 | 129.1 | 49.3 | 53.5 | 91.5 | 54.5 | 82.3 | 67.2 | 34.9 | 134.3 | 150.2 | 131.4 | 89.3 |
| | | | | | | | | | | | | | |
| Average | 80.8 | 84.8 | 62.4 | 83.7 | 63.4 | 78.8 | 57.6 | 77.2 | 80.5 | 125.9 | 100.74 | 105.5 | 84.5 |

Although there is considerable precipitation year round, there are parts of the season that seem to be drier, thereby presenting a possible timeframe in which the underground installation of the system may be completed if precipitation began to interfere with the project.

#### 2.1.1.3 Flooding

Among the many variables that need to be researched to install a geothermal heating system, flooding is undeniably important. If the ground becomes too waterlogged, potential issues with the installation or operation of the underground piping may occur. The London area and all its boroughs are greatly exposed to potential damage from flooding. The torrential rain on August 7, 2002 caused London to be severely disrupted as heavy rains accumulated at one inch every half hour (London Climate Change Partnership, 2002). The recent occurrence of unusually heavy rainfall over the past decade in the London area raises the concern that flooding is becoming a problem. This flooding will mainly cause a problem in the installation process, which requires heaving equipment and digging where ground conditions are vital to success or failure.

#### 2.1.1.4 Cloud Cover

As part of the proposed heat pump system may involve the use of solar energy, the amount of cloud coverage in the Merton area is of great importance. Significant cloud coverage (London Climate Change Partnership, 2002) can impede solar panel effectiveness and cause potential difficulties in providing sufficient energy for the entire heat pump system.

The weather stations in the United Kingdom report a mixture of hourly snapshot observations of weather known as “synoptic observations” (London Climate Change Partnership, 2002). Data centres such as the Hadley Centre, located in Bracknell, Berkshire, have data up to 100 years old that is readily available to the public by using climate models to simulate climate variability (Hadley Centre, 2002, 4). These observations provide measurements based on synoptic observations as well as information that allow us to investigate the cloud cover in the area. “Changes in the level of ‘cloudiness’ modify the emitted infrared radiation from the sun and directly affect the amount of energy absorbed by possible solar collectors" (Hadley Centre, 2002, 1). Cloud coverage can cause the radiation from the sun to be emitted by either a short-wave cooling effect, or a long-wave (greenhouse) heating effect; depending on the cloud's height, type, particle size distribution and phase (Hadley Centre, 2002, 1). Information on cloud coverage is valuable in testing the efficiency of possible implementation of solar panels in Merton.

### 2.1.2 Economics of Area

By finding out financial information about the residents of Merton, we determined if the introduction of new products are likely to succeed in the community. From a financial viewpoint, Merton has a diverse class of people who live within the four districts of Wimbledon, Merton, Mitcham, and Morden. Each district is somewhat segregated and decreases in order of economic class. The residents of Wimbledon tend to have salaries that are £10,000 higher than the other two districts (Merton Council, 2002a, 15). They also are more likely to own their own homes. Merton and Mitcham residents are typically middle class with moderate salaries of about £27,000 and are more likely to own or rent a flat. Morden tends to have residents with the lowest salaries of the four districts whom probably rent low income or local authority flats (Merton Council, 2002a, 15). A Housing Needs Survey conducted in 1999 related the incomes of the people of Merton to the type of homes they owned or rented. In this survey it was found that on average the salaries of homeowners were £33,654, while salaries of tenants who rent privately were £21,467. The salaries of local authority tenants were found to be only £4,608. The average income per person in Merton was approximately £22,961. Based on yearly Housing Needs Updates conducted in Merton the local earnings per person have increased 9.3% per year since

1999. As of May 2001, the average household income had increased to £27,500 (Merton Council, 2002a, 15).

Despite the wide range of income, the percentage of unemployed persons remains low, and has only increased slightly from 2.7% in May 2001 to 3.7% in March 2002 (Merton Council, 2002a, 15). This percentage (3.7%) is equal to that of the average unemployment in the outer sections of London, and slightly larger than the 3.5% of people unemployed in central London (Merton Council, 2002a, 15). The low unemployment rate shows the borough of Merton to be a financially stable community that will be a good test location for the ground source heat pump system.

### 2.1.3 Municipal and Communal Population of Merton

To effectively market the geothermal heat pump system we found information about the citizens of the borough of Merton to whom our group is targeting. The current population of Merton is approximately 190,000 people and 26% of the current population is of a minority ethnic background (Merton Council, 2002a, 15). The total population is expected to increase to 209,000 by the year 2016 (Merton Council, 2002b, 6). The London Research Centre predicted that the average household size will decrease from 2.39 persons to 2.34 persons by the same year. Although this may seem like a small change it means that about 3680 people are expected to be living alone by 2016 (Merton Council, 2002a, 15).

#### 2.1.3.1 Residential Population

Merton is classified as primarily a residential area. Out of the present population of the Borough, more than 130,000 people have jobs outside of Merton. The majority of the community owns a place of residence (Merton Council, 2002a, 24). The high residential aspect is strongly related to the Borough's close proximity to the city of London. There are not many commercial or governmental buildings or organizations because these resources are readily available to the community within the nearby cities. The fact that the area is largely residential was a main consideration to the successful integration of the heat pump system into the community, as it will provide many potential customers with the option of implementing the design in their own homes.

#### 2.1.3.2 Commercial Population

Businesses are becoming more prevalent in the Merton area and continue to increase in number as years pass. Currently, there are over 7,500 businesses located in Merton that provide approximately 50,000 jobs to the surrounding community (Merton Council, 2002c). A partial list of businesses currently located in Merton includes cable television providers, charities, charity shops, electric companies, equipment and services for disabled and elderly people, fax services, gas companies, legal services, photography booths, photocopying services, clothing and convenience stores, telephone, typing, and water services (Merton Council, 2002d). Although our group's marketing strategy was mainly presented to the Council, homeowners and business establishments may also be potential consumers of the heat pump system.

### 2.1.4 Housing Stock

As the proposed heat pump system is designed for new-build residences, a thorough understanding of the housing stock in that area is important to help determine if the system can be installed in Merton housing. By understanding the housing conditions in the area our group was able to assess the types of homes that are available as well as what kinds of home expenses the average resident experiences.

The three different types of landlords are the Council, Registered Social Landlords (RSL's) and private landlords. The Council owns approximately 7,000 residences that are mainly rented as low-income housing. RSL's own many properties and work with the Council to help fill the housing needs of the community and meet regulations as well as return a profit for themselves as an organization (Merton Council, 2002b, 10). Private landlords rent their property and/or buildings to obtain a profit (Merton Council, 2002b, 10).

After examining the current prices needed to rent a flat or purchase a house in Merton, it appears that the prices are becoming harder for residents to afford. Although expendable income is increasing, the average price of housing is increasing at a higher rate. In the private sector, one to three bedroom flats range from £200 to over £350 per week. Council housing imposes significantly lower rates ranging from £60 to £70 per week. The RSL sector shows similar rates to that of Council housing of under £100 per week for up to a four bedroom flat (Merton Council, 2002b, 10). The average housing price for the first quarter of 2002 in Merton was £217,000 (Merton Council, 2002b, 6), which was more than £50,000 more than the London housing cost average (Merton Council, 2002a, 16). Aside from 57% of the Merton population being unable to buy or rent a place of residence privately, the status of the stock available to let is a prevalent issue.

Many of the estates and various properties owned by the Council are approaching half a century in age and may have not seen any significant upkeep since they were built (Merton Council, 2002b, 11-12). There are many standards that must be met, which include the decent homes standard, the fuel poverty level, and the Best Value performance (Merton Council, 2002b, 12). An estimated 95% of private sector homes suffer from disrepair, which affects rates of energy efficiency, and require approximately £4,000 worth of repair per property (Merton Council, 2002a, 23). It was found that 8,000 private sector homes are unfit to be lived in, and it would cost about £32 million to complete the desired renovations. It was established through an annual Housing Needs Update that "9.7% of all households and 20.2% of Local Authority households house people who are living in overcrowded conditions (Merton Council, 2002a, 23)."

One plan to improve the conditions of flats within Merton is to effectively utilize the Major Repairs Allowance (MRA) organization. The MRA was introduced in April 2001 to improve ongoing maintenance. The MRA funds can be used to maintain conditions of buildings, but not completely restore old buildings to modern-day standards. The restoration of Council property has been estimated to require an additional £5 million. Another possible solution to improving housing conditions is to allocate a portion of the Capital Programme budget within Merton to improve the Standard Assessment Procedure (SAP) ratings, which measures standards of living (Kahle, 2002). Budgeting a specific amount of funds to help the conditions of Merton will allow for effective home improvements, such as providing more insulation, repairing heating systems to run more efficiently and repairing walls and windows to retain heat. Currently, the allotted yearly budget is £76,000. It is necessary to obtain a more substantial amount to improve housing conditions if standards are to be raised.

It was important to know the conditions of the housing stock of this community because it showed us exactly how the potential consumers are living now. Knowing their specific standards of living helped us to tailor the marketing scheme to target all of the sub-populations in Merton.

## 2.2 Common Heating Systems

One major attraction of traditional heating systems is that they are familiar. Their ability to provide heat has proven to be effective. For many people this familiarity and comfort with a heating system is an important characteristic in their choice of heating means. For example, gas is the most used residential system installed today in the United States (Consumer Research Magazine, 2000, 24-25). It is important, however, to look at the facts that make these traditional heating systems different from each other, so that they can be compared and contrasted with the geothermal heating system that has been proposed by the Merton Council.

### 2.2.1 Gas, Oil, Coal, and Electricity

Heating systems powered by fossil fuels are still the main source of energy in the world. The energy released from fossil fuels and nuclear fuels meets about 84% of the world's energy needs (Brus & Golob, 1993, 9). In 1990, the total amount of energy consumed worldwide from non-renewable energy sources was equivalent to energy released from burning approximately 7.5 billion metric tons of oil (Brus & Golob, 1993, 9). The most frequently used fuel is oil when considered in all of its applications such as residential, commercial and industrial processes. Considering that the majority of transportation in the U.S. uses oil-based products, it becomes clear that the use of fossil fuels is prevalent.

Although the use of oil is widespread, coal is far more bountiful in the natural environment. Coal is the most abundant non-renewable energy source totalling roughly 1.6 trillion metric tons worldwide in 1990, which is about six times the amount of total usable oil reserves (Brus & Golob, 1993, 9). Even though it is more abundant, the combustion of coal does not release as much energy as oil. The combustion of 1 ton of hard coal, such as anthracite or bituminous coal, yields 2/3 the amount of energy in one ton of oil. Even though coal is the least expensive of the fossil fuels, which is one of the reasons it is used so frequently in industry, it may not be the ideal energy choice for domestic use because it requires large quantities to obtain considerable amounts of energy (Brus & Golob, 1993, 9).

A third non-renewable energy source is natural gas. The energy content of natural gas reserves is comparable to that of oil, but the majority of the gas reserves are located in a few select countries. Natural gas is not used as frequently as other methods because when it is burned it only releases about one-thousandth the amount of energy as compared to the same volume of crude oil. In addition, gas is difficult to transport in large quantities (Brus & Golob, 1993, 9-10).

Natural gas, oil, and electric are the three most common household heating systems. Burning wood and solar energy are used to a lesser degree. A study conducted in 1993 by the Energy Information Agency showed that over half of the households in the United States were using natural gas for home heating, while a quarter used electric, 11% used oil, and another 10% used an alternative method (Home Heating Fuels, 1995). These alternative methods included wood, solar, geothermal and other types of heating that make up too small of a portion of the total to be mentioned separately.

Many of the popular systems are successful because they are very efficient. Efficiency shows how much of the fuel is actually being changed into heating energy. Electric heat can be 100% efficient while gas and oil both can be around 60% efficient (Consumer Research Magazine, 2000, 24-25). The high efficiency of electric heating results from the fact that all of the electrical energy is changed into thermal energy. With oil and gas there is some waste so the energy conversion is not perfect.

Knowing the most popular common heating systems and how they work allowed us to develop insight into the reasons that consumers would choose one system over the others. This was helpful in determining where geothermal systems fit in the distribution of all heating systems in the total home owning population.

### 2.2.2 Economic Costs

The economics are perhaps the most important facts to learn about the existing common heating systems. Cost is very often the most influential factor in many decisions. It is important to understand every expense that is involved with all heating systems so that they can be compared and contrasted with the ground source heating system to find which benefits to target in the marketing campaign.

There are two categories of systems that people currently use in their homes and businesses for providing heat and hot water. The first consists of using fossil fuels such as gas or oil to provide for the building and in the second, electricity is used to provide heat and hot water for the building. In either instance, the fossil fuel or electricity must be paid for each time that the systems are used. The initial installation costs of these systems are in the range of approximately £3800 for forced air to £5150 for oil-fired heat. Electric resistance, also known as electric baseboard, resides in the middle at about £4450.

Aside from maintenance of heating systems the long-term costs are due to purchasing the fuel the system uses. Fuel costs put the efficiencies of the system into perspective. Electric heat is more efficient than oil or natural gas but it also costs more to produce the same amount of BTUs (British Thermal Units) that the fossil fuels would produce (Consumer Research Magazine, 2000, 24-26). The other concern with purchasing fuel is that price does not remain constant. If the winter is colder than expected, for example, the price of heating fuels will increase because there is a greater fuel demand.

### 2.2.3 Environmental Issues

There are many environmental concerns to be addressed when analysing heating systems,including both the fuel that they consume as well as the gases and waste products that they emit. These factors are of great importance in the United Kingdom, where Green Party involvement is greater than in United States politics. These main ecological factors may be weighed heavily by consumers when making decisions and therefore are important in the effort to market geothermal ground source heat pump systems.

#### 2.2.3.1 Fuel and Energy Consumption

The importance of energy consumption is increasing as it is evident that natural resources are dwindling. Many products are evaluated on the amount of work that they can do based on the amount of fuel or energy that it takes to accomplish that work. To many consumers, the availability of the type of fuel that they are using is a concern, because the availability ultimately decides what the price will be. For environmentally concerned consumers, it is of great interest how much fuel and electricity a system will need in order to meet their heating and cooling needs.

Because electricity is often produced at a power plant using fossil fuels, the fuel and energy consumption of electric systems are hard to compare with other systems. From the point of view of the homeowner the system only uses electricity, while in the bigger picture producing the electricity also causes emissions. In Healy and Ugursal's comparison of a few types of systems on the same test home, the electric system required almost 23 thousand kilowatts to 7.5 thousand kilowatts for geothermal systems, therefore showing that the geothermal system can use less energy to provide the same amount of heating (Healy & Ugursal, 1997, 12).

#### 2.2.3.2 Emissions and Pollution

The creation of energy through combustion of all fossil fuels is a direct cause of emitting harmful pollutants into the atmosphere. Both coal and oil energy systems emit sulphur dioxide, nitrogen oxides, hydrocarbon compounds, carbon monoxide, and carbon dioxide. Coal tends to be the worst pollutant of the environment when it is used as an energy source. When coal emits sulphur dioxide and nitrogen oxide, they are converted into sulphuric and nitric acid. These acids are the two main components that make up acid rain. Sulphur dioxide has also been found to contribute to acute and chronic respiratory problems: "The Office of Technology Assessment (OTA) estimated that sulphur dioxide and particulates may be responsible for up to 50,000 premature deaths in the United States and Canada each year" (Brus & Golob, 1993, 11). In addition, the nitrogen oxides and hydrocarbon compounds that coal produces are two components that react in sunlight to form ground level ozone, which is a component of urban smog. If ground level ozone is at an extreme concentration, it can lead to headaches, coughing and breathing difficulties, and temporary loss of lung function, as well as irritation of eyes, nose and throat. Highly concentrated ground levels of ozone in combination with acidic rain can cause metals to corrode and building to deteriorate. When energy is obtained from combusting resources, as is the case with oil, gas and coal, carbon dioxide, a common emitted non-toxic gas pollutant, is formed. Carbon dioxide aids in global warming, as it traps heat in the atmosphere, ultimately changing the climate for all areas around the world. This is also known as the greenhouse effect (Brus & Golob, 1993, 11).

Gas-fired heating systems are more environmentally friendly than coal or oil, since they produce virtually no particulates or sulphur dioxide. The gas ignition does create nitrogen oxide; however emissions are 40% of what coal-fired heating systems produce. The carbon dioxide emission from gas systems is also significantly lower as compared to both coal and oil. For a given amount of energy output, natural gas emits half as much carbon dioxide as coal, and 70% less emission as compared to oil (Brus & Golob, 1993, 12).

## 2.3 Geothermal Energy

The main component of the proposed heating system is the ground source heat pump, which uses geothermal energy to provide the home with heating and hot water. Geothermal energy refers to the energy held in the earth below the ground surface. It is one of the most promising renewable energy sources available today. With constantly expanding technologies, it is predicted that geothermal energy systems will someday replace current heating systems and aid in the conservation of diminishing fossil fuel supplies. The geothermal heat pump system is the central component of the proposed design, and therefore a thorough understanding of its intricacies is needed.

### 2.3.1 Fundamentals of Technology

Geothermal energy is a viable source of renewable, alternative energy. Below the earth's surface considerable amounts of energy are stored. The earth's core temperature has been estimated to be 6,670 K (Bukowinski, 1999, 443). Portions of the core heat are transferred through the layers of the earth due to hot or thin areas of the earth's crust (Armstead, 1978a, 45). Energy that is contained deep within the ground can also be seen on a surface level by heat created from tectonic plate movement, volcanoes, hot springs, and geysers. The energy within the earth's core may be used to estimate the amount that may be absorbed and transferred through use of geothermal systems (Armstead,1978b, 1).

Other sources of geothermal energy are created by radioactivity of the crust, energy from the sun stored in the ground, and chemical reactions taking place on the Earth's surface (Armstead, 1978a, 45). This earth energy can be harnessed and used to produce electricity, but it is more effective to use the energy directly in space heating (Armstead, 1978b, 15). The average energy output from the earth's surface is 0.06 $W/m^2$, but can reach up to 30,000 million kW in certain highly thermal areas (Armstead, 1978a, 29). This is a considerable amount of energy that, if it can be collected and transformed, could provide enough power to satisfy the energy demand worldwide (Armstead, 1979a, 29).

#### 2.3.1.1 Geothermal Fields

The earth's surface is classified into three groups: non-thermal areas, semi-thermal areas and hyper-thermal areas. The classifications are further subdivided into thermal fields to show the surface heat content for different locations worldwide. Thermal fields are present in semi- or hyper-thermal areas where there is water or steam in the earth, which can be used to convey heat to the earth's surface (Armstead, 1979a, 40). For substantial geothermal energy to be harnessed, a thermal field must be present. However, it is possible to extract enough energy to provide geothermal space heating from non-thermal areas using technologically developed methods.

While many parts of the United States and the United Kingdom experience seasonal temperature fluctuations—high temperatures in the summer to colder temperatures in the winter—a few feet below the earth's surface the ground remains at a relatively constant temperature. Depending on latitude, ground temperatures range from 7°C to 21°C. In the United Kingdom, the temperature of the ground averages 12°C. This ground temperature is warmer than the air above it during the winter and cooler than the air in the summer. The ground source heat pump (GSHP) takes advantage of this by exchanging heat with the earth rather than with the outside air as with air conditioners (Office of Energy Efficiency and Renewable Energy, 2002). Because of its flexibility for implementation, geothermal heat pump systems are implemented in many different climates of the United States and Europe, and the numbers of installations continue to grow.

#### 2.3.1.2 Geothermal Energy for Space Heating

Ground source heat pumps (GSHPs) were first implemented in the United Kingdom over fifty years ago, but problems in the designs of the systems caused them to be discontinued (GeoScience Limited, 2002). Since that time, technological advances have made ground source heat pumps one of the most efficient, reliable, economically sound, and safe means of heating a home. There are households worldwide that are switching from other systems to ground source heat pump systems to heat their homes and provide hot water. Moreover, geothermal heat pump systems are not just for home installation. They can also be implemented in corporate businesses, schools, government building complexes, and gas stations. "According to the United States Environmental Protection Agency (EPA), GeoExchange systems are the most energy-efficient, environmentally clean, and cost-effective space conditioning systems available" (Office of Energy Efficiency and Renewable Energy, 2002). European countries such as Hungary, France and Iceland have geothermal heating systems in place even in non-thermal areas of the earth.

#### 2.3.1.3 Ground Source Heat Pump Technology

The key concept of ground source heat pump systems is that they do not create heat but rather use small amounts of electricity to move heat (Sound Geothermal Corporation, 2002). Simply put, a GSHP system moves the heat from the earth (or a groundwater source) into the home in the winter and pulls the heat from the house and discharges it into the ground in the summer. The ground serves as a heat source in the winter and a heat sink in the summer (Office of Energy Efficiency and Renewable Energy, 2002).

For a ground source heat pump to be able to transfer heat from the ground to a home there needs to be a heat source, means of removing, transporting and distributing the heat, as well as a power supply. The heat source is the ground and the power is generally supplied by electricity. The heat is removed from the earth and transported to the heat exchanger through underground fluid-filled pipes. The fluid is heated by the earth and brought to the heat exchanger, where the energy is removed and can be distributed through the building by means of ventilation or radiator systems (Geothermal Heat Pump Consortium, 2002)

Inside the heat pump, there are two heat exchangers which are an evaporator and a condenser, a compressor, a reversing valve, an expansion valve, and a refrigerant fluid. The internal workings of the system can be seen in Figure 2.1.

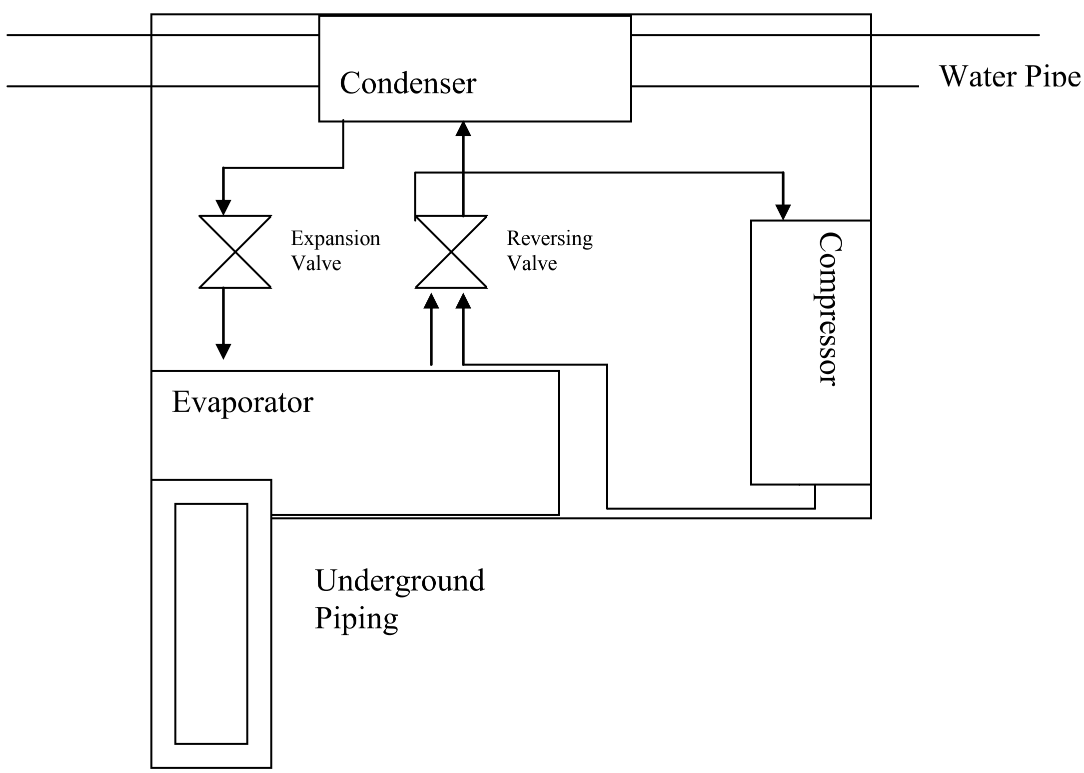



**Figure 2.1**
**Inner Workings of the Heat Pump**

The refrigerant is a liquid that boils at very low temperatures and originates in the first heat exchanger (evaporator). The underground piping, after picking up heat from the ground, passes through the first heat exchanger and warms up the refrigerant liquid. Upon contact with the piping, the refrigerant begins to evaporate, creating vapour, which is at a very low temperature. The reversing valve moves the vapour to the compressor. The vapour is put under high pressure, which increases the temperature. This is due to a directly proportional relationship between pressure and temperature of gases, so as the pressure increases, so does the temperature. The reversing valve then sends the high temperature vapour to the second heat exchanger, which is a condenser coil. The high temperature vapour is condensed. When this occurs, it gives up its heat of vaporization. Water passes over the now hot condenser coil to pick up the heat lost by the condensing vapour. This water then is pumped to the water tank. The refrigerant then passes through an expansion valve, which lowers the pressure and temperature again, returning the fluid to its original state. The refrigerant then circles back to the evaporator to be used again.

### 2.3.2 Implementation of Geothermal Systems

The first of the two main components in a geothermal system is the heat pump unit that replaces the furnace or boiler typically located in a basement. Heat pumps come in different sizes and can be used for forced air heat or radiant floor heating. In general, a smaller heat pump will cost less to install but will require more electricity in order to produce sufficient heat. A larger heat pump will be able to extract more heat from the earth, thus using less electricity to achieve the same task. However, the larger pump will have a higher initial cost (Healy & Ugursal, 1997). These factors of different sized heat pumps contribute to their coefficient of performance (COP) (Kara & Yuksel, 2001). COP relates the amount of work produced for a system and compares it to the required input to produce that specific work output.

A geothermal heat pump system works through a series of underground pipes (either open or closed), which can be horizontally installed at approximately four to six feet into the ground, or vertically installed to a depth of 100 to 400 feet below the surface of the earth. Utilizing an ecological antifreeze or water solution to transport heated or cool air, the geothermal heat pump system not only heats and cools a building, but also can provide free hot water in the summer and cheaper hot water in the winter since less electricity will be needed to heat water (Office of Energy Efficiency and Renewable Energy, 2002).

One type of design for the heat exchanger is a closed loop system, where all of the water in the piping is self-contained and does not exit the system (Geoexchange, 2003). Closed loop systems can be laid horizontally or vertically depending on the limitations of the site. The horizontal method can have different lengths, distance between the pipes, and varying depths below the earth's surface (Geoexchange, 2003). The vertical implementation is advantageous because it is less disruptive to the landscape. Each loop can be installed in its own small hole, which is drilled similarly to a well. This vertical installation can also be completed when there is too much piping to be laid in a horizontal orientation. Vertical installation is more space efficient and only requires a relatively small area to implement the system (Hughes, 2001).

The second type of geothermal system is made up of open loops. In an open loop design the water in the piping can move in and out of the system, from sources including groundwater, aquifers, or standing column wells (Geoexchange, 2003). Standing column wells are popular because there are only two wells that are required to be drilled, so the open loop system uses a minimal amount of space and it is straightforward to implement (Geoexchange, 2003).

The type that is chosen mainly depends on the climate where it will be installed, the ground conditions, and the limitations of the property. Cost, contractor experience and preference, and customer preference are secondary aspects that must be taken into consideration when implementing the geothermal system.

Geothermal heat pump systems operate discretely so that the consumers are not bothered with distracting or unpleasant noise from radiators or air conditioners. There are no exposed, noisy, outdoor or indoor components. Concealed equipment also contributes to the aesthetic appeal of the home. Like the typical forced-air furnace or central air-conditioning system, a GSHP system uses ductwork. A two-speed GSHP system affords consumers the comfort of quiet inside a house during operation since geothermal heat pump systems eliminate abrupt blasts of cold or hot air, depending on whether it is the heating or cooling season (Office of Energy and Renewable Energy, 2002). Also, GSHPs improve humidity control by maintaining about 50% relative indoor humidity, making GSHPs very effective in excessively humid or dry areas (Office of Energy and Renewable Energy, 2002).

#### 2.3.2.1 Geothermal Systems in New Housing

The advantages are numerous for heat pump implementation in new housing. If a building is being designed for a geothermal system from the beginning, then implementation can be both time and cost effective. The building can be designed for a forced air or radiant (floor) ventilation system that will be compatible with heat pumps. The underground pipe systems can also be installed at a convenient time so as not to disrupt the landscape. Because of these factors, it is just as easy to install the ground source heat pump system into a new home as it is to install other types of heating systems.

#### 2.3.2.2 Geothermal Systems in Existing Housing

It is both plausible and common for older buildings or homes that have a conventional type of heating and/or cooling system to switch to a geothermal heating system. There is more planning and a much heavier financial burden than if the building was built with a geothermal system in mind. However, that alone should not discourage those thinking of such a conversion.

One of the determining factors is whether or not the current ventilation system will be suitable for the new system. Usually the existing ductwork will work for the new ground source heat pump (Office of Energy Efficiency and Renewable Energy, 2002). The second major issue is whether the property is set up in such a manner that will prove to be conducive to the underground piping.

It is important to know how these systems are installed in both existing and new housing situations because it can affect the interest level of significant groups of possible customers, many of whom will be consumers who already own housing. The ability to implement the system in houses that have already been built without this design in mind means that many more people can consider this alternative.

## 2.3.3 Economics of Geothermal Systems

The ground source heat pump system has both economic benefits and drawbacks that need to be examined. These economic factors were important to consider in the development of educational and promotional material, as well as in determining feasibility for the Merton Council.

### 2.3.3.1 Installation

Due to the nature of geothermal heat pump systems, it is evident that professional installation is necessary. The underground pipe work must be installed by qualified and experienced contractors who have received training at recognized institutions. The initial installation expense is necessary, but can be compensated by a brief payback period.

### 2.3.3.2 Maintenance and Operating Costs

Every system is unique due to its respective varying circumstances. The financial advantages that geothermal heat pump systems have to offer are best shown in case studies. An

ECONAR Energy Systems case study is a good example of a geothermal system in what is considered to be a cold climate. The Richard and Deloris Overholser residence is a home in Mora, Minnesota. They previously heated their home with oil and incurred expenses of $300 (approximately £190) per month. With the geothermal system installed they heat and cool their home for only $374 (approximately £237) per year (Econar Energy Systems, 2002).

Another good example is Dennis Eichinger's situation. He lives on a 3,400-square-foot home located in the middle of Minnesota. Despite temperatures that can range from 32.2°C with 95% humidity in the summer to -27.8°C in the winter, his home averages a little over $44 (approximately £28) per month in electricity bills because of his geothermal heat pump system (Office of Energy Efficiency and Renewable Energy, 2002).

The ease of maintenance of geothermal heat pump systems is yet another feature to be considered. The main reason the maintenance repair costs are so comparatively low is because the geothermal heat pump systems have fewer maintenance requirements than most other systems. They simply have fewer parts. When properly installed, the underground components are virtually worry-free. Because those components are sheltered from the elements, leaves, dirt, and possible vandalism, geothermal heat pumps are durable and highly reliable (Office of Energy Efficiency and Renewable Energy, 2002). Also, components in the buildings are easily accessible. This increases the convenience factor and helps ensure that the upkeep is done on a timely basis (Office of Energy Efficiency and Renewable Energy, 2002). A final element to consider is that, in the event of a broken part or section, the problem is isolated to a single problem area while the rest of the system components for the rest of the building continue to operate smoothly, therefore allowing ease in repair (Sound Geothermal Corporation, 2002). The maintenance expenses and cost of operation are two areas in which geothermal heating systems excel. “The maintenance of the system is measured in terms of its lifetime. Most companies agree on a lifetime somewhere in the vicinity of 20-35 years” (Econar Energy Systems, 2002).

#### 2.3.3.3 Economic Benefits of Geothermal Systems

Although it is initially expensive to implement geothermal heat pump systems, they consume anywhere from 25-50% less electricity than standard heating units. This is where the consumer begins to see benefits after initial expenditure. Most consumers experience a brief pay back period of 5 years or less, after which the consumer still continues to save on heat expenses. “On average, a geothermal heat pump system costs about $2,500 (approximately £1585) per ton of capacity, or roughly $7,500 (approximately £4750) for a 3-ton unit (typical residential size). In comparison, other systems would cost about $4,000 (approximately £2535) with air conditioning (Office of Energy Efficiency and Renewable Energy, 2002).” When the day-to-day running costs of heating systems are compared, the geothermal system operates at half the cost of the most efficient traditional system (Healy & Ugursal, 1997).

Many system attributes add to the total savings that a geothermal heat pump system provides. In particular, the ‘desuperheater’, a component to the system that helps provide hot water heating, greatly increases the financial benefits. The ‘desuperheater’ actually helps the unit reach heightened levels of efficiency (Sound Geothermal Corporation, 2002). “GeoExchange systems are efficient, environmentally-sensitive, comfortable, and economical. Even where the cost of the earth connection increases the initial cost, operating savings often provide paybacks of considerably less than five years -- sometimes less than two years” (Sound Geothermal Corporation, 2002). Furthermore, multiple case studies completed by the United States Department of Energy found:

> “…geothermal heat pumps as the most efficient heating and cooling systems over other types of space-conditioning equipment including high- efficiency gas furnaces and air conditioners. Ground source heat pumps are about 300 to 400% more efficient than current common heating systems.  Common heating systems usually obtain one unit of heat out of every one unit of energy put in, but ground source heat pumps product three to four units of heat per every unit of energy” (Office of Energy Efficiency and Renewable Energy, 200).

Installing ground source systems in new build and retrofit homes has been shown to reduce energy consumption by 25% to 75% compared to the old system (Office of Energy Efficiency and Renewable Energy, 2002). In addition, annual operating costs were shown to be lowest with geothermal heat pumps, “due to the added benefits of the desuperheater for saving on hot water bills’’ (Office of Energy Efficiency and Renewable Energy, 2002).

It has become increasingly easy to finance geothermal heat pump systems, making them affordable to a wider audience everyday. With the support of the government, green organizations and electric companies, there are loans that are specifically created to help finance the purchase of heat pump systems (Office of Energy Efficiency and Renewable Energy, 2002). Over 400,000 installations are in place in the United States today. Many case studies have proven that geothermal heat pump systems have become a large success. Indeed, the U.S. EPA has found no other technology with more favourable operating efficiencies and economics than geothermal heating and cooling systems (Sound Geothermal Corporation, 2002).

Despite the fact that geothermal heat pump systems are more costly initially, they are more beneficial in terms of price in the long run. “Geothermal heat pumps save money in operating and maintenance costs. While the initial purchase price of a residential GSHP system is often higher than that of a comparable gas-fired furnace and central air-conditioning system, it is more efficient, thereby saving money every month” (Office of Energy Efficiency and Renewable Energy, 2002). In addition to this, geothermal heat pump systems come equipped with a device called a desuperheater, which “can heat the household water. In the summer cooling period, the heat that is taken from the house is used to heat the water for free. In the winter, water-heating costs are reduced by about half. On a retrofit, the GSHP's high efficiency typically means much lower utility bills, allowing the investment to be recouped in two to ten years (Office of Energy Efficiency and Renewable Energy, 2002).”

### 2.3.4 Environmental Issues Related to Geothermal Systems

The environmental considerations are an essential characteristic of geothermal heat pump systems. Its eco-friendly nature will be utilized in marketing campaigns and serves as a strong motivator for potential consumers to purchase the system. It is common knowledge today that the current heating systems in place in most homes are perpetuating pollution and depleting fossil fuels. As the provided evidence demonstrates, geothermal heat pump systems are an excellent solution to the world’s energy needs.

The U.S. EPA says that geothermal heat pumps can decrease polluting emissions and energy use by 44% to 72%, depending on the system it is replacing (Office of Energy Efficiency and Renewable Energy, 2002). The EPA also determined that geothermal systems have the lowest environmental costs of the technologies that are available today (Sound Geothermal Corporation, 2002).

The main environmental concern would be the “potential for ground water contamination. The GHPC supports contractor training, certification, and International Ground Source Heat Pump Association (IGSHPA) programs to assure that systems are designed, installed, and operated with complete environmental compatibility” (Sound Geothermal Corporation, 2002).

#### 2.3.4.1 Fuel Consumption and Pollution

Geothermal heat pump systems have proven to be environmentally friendly. The costs of the operation of a geothermal heat pump system in terms of electricity consumed are substantially less than the amount consumed by conventional systems. The geothermal system does emit some harmful gases and waste products into the environment. Some carbon dioxide is released through the operation of running the system. However, studies have shown that geothermal heat pumps can reduce energy consumption and corresponding emissions up to 72% compared to many current systems utilizing electricity and gas as their source of energy (Office of Energy Efficiency and Renewable Energy, 2002). In addition, the water that the geothermal piping absorbs from outside sources is then released back into an enclosed reservoir usually at elevated temperatures. It is also possible for the resulting water to have levels of dissolved salts after it is used to heat a specified house, apartment, or building. All of these harmful emissions are significantly lower than any emissions released from fossil fuel powered heating systems (Brus & Golob, 1993, 77-78).

## 2.4 Solar Panels

Ground source heat pump systems can be combined with other sources of alternative energy to provide a completely environmentally friendly heating system. Solar panels may be included in the final design to provide electricity in order to operate the heat pump. In order to be able to successfully determine the feasibility of the heat pump system, a thorough understanding of its components was necessary. In addition, a thorough exploration of the underlying technical and scientific principles that govern operation was essential to fully appreciate the system design.

## 2.4.1 Fundamentals of Technology

The basic principle behind making use of solar energy is the ability to convert it from one form of energy to another of a more useful variety. For solar energy, this conversion generally consists of transforming electromagnetic radiation in the form of the sun's rays to either electricity or heat. Solar energy is one of the most promising sources of alternative power. Because the sun is capable of providing all of the energy involved, solar power is an ever-present source of energy, constantly renewing itself as the sun rises in the morning. It is not possible to use too much solar energy or to even deplete the supply (Power Systems Group, 1979, 3-4). In fact, "in three days time, more energy reaches the earth's surface than is contained in all the stores of fossil fuels combined" (Fitzgerald, 2002). In addition to its benefits as a constant source of power, solar energy is important because it is locally available to all and cannot be subject to governmental control or authority (Power Systems Group, 1979, 4). Approximately 1,000 Watts per square meter of energy reaches the earth's surface direct from the sun daily, although weather conditions, location, and time can cause slight variations to this figure (Folster, 2002). This energy can then be amassed using various forms of collection apparatus. Once solar energy is collected it can be converted into either thermal or electrical energy, which can then readily be used in everyday applications.

### 2.4.1.1 Problems Associated With Solar Energy

Due to the nature of solar energy, there are some innate restrictions to its use and application. The necessary electromagnetic radiation from the sun is only available during the daytime, so collection of the energy is limited to certain hours. The sun's movement through the sky can make the collection of solar energy challenging. In addition, heavy cloud cover can limit the amount of radiation that can reach the earth's surface (Power Systems Group, 1979, 33).

### 2.4.1.2 Applications of Solar Energy

The most common applications of solar energy occur in heating and electrical systems. Converting electromagnetic radiation into thermal and electrical power are relatively simple procedures, but making the conversion to other forms of energy would be substantially more difficult (Power Systems Group, 1979, 5). The easiest applications of the technology come in the form of water heaters, space heating, air conditioning and process heating. In order to form electricity from solar energy, photovoltaic processes are needed (Power Systems Group, 1979, 5).

### 2.4.1.3 Conversion of Solar Energy to Thermal Energy

When solar energy strikes an absorbing surface the electromagnetic radiation is converted into thermal energy. This can be seen on an everyday basis when cars sitting in the sun become hot. This conversion of energy is particularly effective when the radiation is collected on a perfect black surface, completely converting the energy to heat (Wieder, 1982, 208). This thermal energy can then be used directly in heating systems for buildings, to provide hot water, or to be further converted into electricity.

### 2.4.1.4 Conversion of Thermal Energy to Electricity

When thermal energy has been created from the sun's radiation, it can then be further transformed into electricity. This transformation is called thermodynamic conversion (Wieder, 1982, 209). The heat that is formed in the solar collectors upon absorption can be partially converted to other useful forms of energy. This is possible in a multitude of creative ways. The most common is a steam engine, where the heat is used to form steam from boiling water, which in turn moves turbines that produce electricity (Wieder, 1982, 220-221). The sun's rays provide sufficient energy to create this flow of electrons. This compound process of creating electricity from electromagnetic radiation is, however, much less efficient than directly producing electricity from solar energy.

#### 2.4.1.5 Photovoltaics and the Photoelectric Effect

Photovoltaics are the direct conversion of solar energy into work. The most effective means of transforming the sun's radiation into electricity is through the photoelectric effect. To be able to understand how light can be converted into energy it is necessary to examine the world on an atomic level. Atoms are made up of orbital shells that hold electrons. These electrons, when given a specific amount of energy, can jump from one atomic orbital up to a higher orbital. If enough energy is given, an electron can jump so far that it actually separates from the atom. This electron is then free to flow. If enough electrons separate, then a flow of electrons that is sufficient enough to produce an electrical current will occur (Power Systems Group, 1979, 98). Through this process of freeing electrons from a metal, electricity can be generated directly from the sun's rays, which is the major underlying principle governing photovoltaic cells.

### 2.4.2 Design of Solar Systems

The design of a system to collect and convert solar energy is dependent on what the converted energy will be used for. For solar systems that produce thermal energy to be employed in space and hot water heating, the basic design consists of three main components. The first major instrument is the solar collector. This is the piece of equipment that collects and converts the electromagnetic radiation received from the sun. The second key component in the system is the fluid material that runs underneath the solar collector. This liquid collects the energy and transports it to the heat storage tank or heat exchanger. The storage tank, the third apparatus in the design, stores the hot fluid before it is pumped through the building to provide space and water heating. If a heat exchanger is present, the exchanger removes the heat from the transporting fluid, and then pumps the heat similarly to the heat storage tank (Power Systems Group, 1979, 120). The design for photovoltaic systems consists of a grid made out of a metal that is responsive to the photoelectric effect. The design is simpler than a typical design for a solar system, because it does not have any moving mechanical parts to convert the sun's energy. When exposed to sunlight, the metal spontaneously creates an electrical current, which can be directly used to power equipment (Power Systems Group, 1979, 99).

#### 2.4.2.1 Solar Collectors

For conversion of electromagnetic energy, the main component of the system is the solar collector. There are various types and means of collecting the solar energy with advantages and disadvantages based on the application (Power Systems Group, 1979, 72). By understanding what types of solar collectors are available and what the characteristics are of each collector, we determined if a solar system would be beneficial for Merton to investigate as an option for the future.

For applications that deal with creating thermal energy, the most common and most simple collector is the flat plate (Power Systems Group, 1979, 72). These collectors only work well in low temperature environments such as the climate of the London and Merton area (Rabl, 1985, 11). The flat plate collector is made up of an absorber plate, which is a flat piece of material capable of absorbing the sun's energy and converting it into thermal energy (Rabl, 1985, 11). This plate is enclosed by a transparent plastic cover to provide protection against the elements. The plate is mounted in a metal frame box that is made of a material that is a poor conductor of heat. The entire system is insulated, thereby minimizing the amount of energy lost to the environment (Rabl, 1985, 11). Directly below the absorber plate are pipes. In these pipes runs a fluid that transports the energy. This flat plate system is the easiest to design and generally the most cost effective, since there are fewer components to manufacture (Power Systems Group, 1979, 73). It has a high efficiency in low temperature environments.

Another common means of harnessing the sun's energy for thermal conversion is a concentrated collector. This type of collector uses mirrors and lenses to focus the electromagnetic radiation into a small region (Rabl, 1985, 16). Concentrated collectors allow high temperatures to be obtained when the sun's energy is being converted to thermal energy (Power Systems Group, 1979, 72). These collectors are more complicated than the flat plate design because they often need to be mounted on tracking systems, which move the collectors to the optimum collecting position as the sun moves through the sky. Due to the complicated mechanical tracking systems, concentrated collectors are more expensive than the flat plate design (Power Systems Group, 1979, 73).

For applications where solar energy is being converted into electricity, photovoltaic collectors are needed. These collectors are also known as solar cells. Once the voltage has been created through the photoelectric effect the electric current is transferred to conducting wires in the collector. There are few variations on this basic structure of photovoltaic collectors, thereby making it the default choice if solar energy will be used to generate electricity in a heat pump system (Power Systems Group, 1979, 73).

The solar collectors can be manufactured out of various materials, all with distinct benefits and drawbacks. For flat plate and concentrated collectors, the absorption plate can be made out of various metals that can conduct heat very easily. The three most common materials for these plates are copper, aluminium and steel. Copper is the best material of the three but is also the most expensive. Steel and aluminium are cheaper, but both can corrode and weaken (Power Systems Group, 1979, 76). Photovoltaic collectors need to be made of a semi-conducting metal, usually silicon or cadmium. Silicon is the most commercially available, efficient and cost effective material (Power Systems Group, 1979, 98).

### 2.4.3 Implementation of Solar Systems

In order for the solar energy to be effectively converted into useful forms, the collection and transport systems must be installed under very exact specifications. The collectors must be located where they can receive the highest concentration of sun (Rabl, 1985, 381). In order to determine the ideal location for the collectors, the building and its surrounding area must be examined to see where shadings and obstructions fall. The collectors may be mounted on the roof of a building, the sidewalls or on the ground. Collectors are generally installed on the roof of buildings where the sun’s energy is usually the most concentrated and unobstructed (Axaopoulos, Panagakis & Kyritsis, 1998). In addition to finding the optimum location for the panels, they must also be oriented in such a manner that they maximize their collection of useful solar energy (Rabl, 1985, 383). For concentrated collectors that track the sun’s path, this orientation must be changed as the day progresses. The tracking mechanism must be carefully designed and implemented in order to achieve the correct orientation at all times (Rabl, 1985, 383). On average, ten to twenty photovoltaic modules are required to power an average household (National Renewable Energy Laboratory, 2002). Technological advancements in thin film technology have made it possible for solar cells to now double as rooftop shingles and tiles (National Renewable Energy Laboratory, 2002) thereby making roof installation more aesthetically pleasing.

#### 2.4.3.1 Solar Systems in New Housing

Installing and implementing solar systems in new housing can be simple because the building can be designed and built with the needs and requirements of the solar system in mind.

The key consideration for new housing that is being designed for use with solar energy is the construction of the roof. The roof must be designed to withhold the weight of the solar collector and mounting device (Rabl, 1985, 383). In addition, it must be designed in such a manner that the installation of the piping system for the transport fluid can be easily implemented (Rabl, 1985, 383). Lastly, there must be a space that would specifically have room to house the storage tank and/or heat exchanger.

When designing the building, considerations also must be made for how the energy will be provided during times when solar energy cannot be collected, such as at night (Rabl, 1985, 24). Either a long-term storage tank must be supplied so that the converted solar energy can be conserved and called upon at off-peak times or utilities must be provided from an outside source, such as energy from electricity or oil. The house must be designed in order to have one of these backup sources of energy available at all times. All of these considerations are imperative when considering implementing a system in a newly built dwelling.

#### 2.4.3.2 Solar Systems in Existing Housing

Implementation into existing buildings can be more difficult than when a building is designed to specifically accommodate solar panels. As with new housing, a critical consideration is the roof. Some roofs may not be strong enough to support the weight of the solar collectors, piping, and mounting equipment. In addition, the force of the wind against the equipment can damage roofs that are too weak (Rabl, 1985, 383). The roofing material may not be ideal for mounting solar panels. Certain materials may vaporize and condense on the collector; thereby reducing the amount of solar energy the collector can obtain (Rabl, 1985, 384). Due to these potential problems with the roof, ground installation of the solar panels may be necessary which could cause increased installation expenses (Rabl, 1985, 383). Existing buildings do have the advantage of already having a backup system in place, as the old means of heating can provide the energy during times of little or no sunlight. All of these considerations are important if a solar component is to be brought into consideration for the Merton housing stock. The system must be possible and convenient to install in the houses of Merton for it to be appealing to consumers.

### 2.4.4 Economic Costs of Solar Systems

There are many factors that contribute to the economic costs associated with solar panels. These include the expense due to manufacturing and installing the system, as well as operation and maintenance costs. Also, the storage or provision of a backup supply of energy must be taken into consideration. Despite technological advances that have been made in regards to the thermodynamic efficiency of solar cells, implementation into large-scale operations often proves to be very costly (National Renewable Energy Laboratory, 2002). However, for smaller operations the up-front expenses may be outweighed by the financial benefits in the long-term (BP Solar International, 2002).

#### 2.4.4.1 Installation Expense

The installation cost of solar panels on a building will vary due to the required energy output of the system, as well as what design and materials are selected for the structure. The addition of providing for a back-up energy supply or storage system creates an additional expenditure for new homes. The initial expenditure for the manufacturing and installation of the solar systems is quite high. A typical solar system that would provide all energy needs for houses would run between £6360 and £25,500, varying with size (BP Solar International, 2002). This initial figure would be lower if the system were to be combined with other means of energy, such as the geothermal system in the Merton design.

#### 2.4.4.2 Maintenance and Operating Costs

Monthly expenses for a solar energy system are low compared to traditional sources of energy, because the energy source is free and continuous. The only fuel that needs to be paid for is the backup energy sources (Rabl, 1985, 24). This creates very low monthly expenses, usually an average on the order of ₤12 a month (BP Solar International, 2002). Overall, the monthly operating costs are small for the lifetime of the equipment (Rabl, 1985, 4).

There are many maintenance issues associated with solar panels, but the maintenance costs are estimated to be small – approximately 1-2% of the initial expenditure (Rabl, 1985, 4). It is recommended that the solar systems are inspected and cleaned yearly to minimize and prevent damage (Rabl, 1985, 387). Possible maintenance costs may come in the form of replacement fluids that transport the thermal energy in flat plate and concentrated collectors. Over time, these fluids, particularly oil and air, are prone to slipping through small cracks in the piping system (Rabl, 1985, 385). Similarly, the heat transfer fluids lose their effectiveness when the system is stagnant for a long period of time, and therefore need to be replaced after extended periods of inactivity (Rabl, 1985, 387). Concentrated collectors that use tracking mechanisms are more likely to need costly repairs due to the intricacies of their design (Rabl, 1985, 387). Maintenance costs can be kept to a minimum by scheduling and performing repairs at night when the solar system is not operating (Rabl, 1985, 387).

### 2.4.5 Economic Benefits of Solar Systems

For most situations, a solar energy system will be financially beneficial to the investor. After the large initial investment, the monthly expenses are quite low, thereby creating large monthly savings over traditional heating systems. Photovoltaic systems also have a quick payback period, the time in which the initial investment is returned. This period varies slightly depending on the different materials used to construct the photovoltaic cells. For crystalline silicon cells there is a 25 month period before the system pays for itself. For amorphous silicon cells only a 15 month period is needed before the system becomes economically beneficial to the consumer (Brus & Golob, 1993, 126).

## 2.4.6 Environmental Issues Related to Solar Systems

Another main advantage to using renewable energy sources is that the system is environmentally friendly. The fact that materials or natural resources do not have to be burned in order to produce electricity or heat helps to preserve the environment. A solar system helps reduce pollutants and also preserves fossil fuel supplies.

### 2.4.6.1 Fuel and Energy Consumption

The backup systems for solar energy designs use the same amount of energy that typical heating systems use. The difference is that the backup systems in a solar house are only used for very small amounts of time, as opposed to running continuously throughout the day. The shorter amount of time that the backup systems are in use will significantly reduce the consumption of fossil fuels.

Fuel consumption is also involved in the construction of solar systems. The materials used in the construction of solar systems are easily accessible and easy to manufacture. However fossil fuels are typically used to manufacture the solar components. The solar heating system is more efficient than a fossil fuel based heating system, since “the amount of fossil fuels consumed in the manufacturing process is very small compared to the amount used for heating, cooling, and power generation” (Brus & Golob, 1993, 103).

#### 2.4.6.2 Emissions and Pollutants

Like the photovoltaic system, the solar system alone does not produce any pollutants. As a result, the system does not aid in the breakdown of the ozone layer, occurrence of acid rain, smog, carbon dioxide, or radioactive waste during its operating life. The solar system also differs from air conditioning units when it runs in its cooling mode because it does not use chlorofluorocarbons, chemicals used in many cooling systems that also cause damage to the earth's ozone layer (Brus & Golob, 1993, 103). Still, the necessary backup system does use fossil fuels, whose consumption creates carbon dioxide emissions. Due to the limited consumption of fuel by the back up system carbon dioxide emissions are significantly reduced (BP Solar International, 2002).

## 2.5 Heating System Conclusions

The reduction of energy consumption, pollutant emissions, and the relatively quick economical rate of return from the use of a geothermal heat pump system present the Borough of Merton with strong advantages over fossil fuel heating systems. Geothermal heating systems cost 45% less to heat monthly than oil systems, and cost 68% less to heat monthly than an electric heating system. As seen in Table 2.1, a geothermal system has a higher installation cost, but the rate of return, and potential money that will be saved is higher than fossil fuel heating systems. Solar heating systems are extremely beneficial to consumers as well. Typical solar systems become economically beneficial to consumers after 15 months, and begin to pay for their implementation and monthly charges after 25 months.

**Table 2.2**
**Comparison of Heating Systems – Geothermal vs Traditional**
(Adapted from tables 3 and 4 Healy & Ugursal, 1997, 12)

| System Type | Capital Cost | Operation and Maintenance | Pollutant Emissions | Energy Consumption |
|---|---|---|---|---|
| Geothermal | £5,800 | Dependable, Minimal | Very low | Medium |
| Solar | £5,000 - £25,000 | Unpredictable, Minimal | Very low | Low |
| Oil | £5,200 | Dependable, Periodic | High | Medium |
| Electric | £4,500 | Dependable, Minimal | Very low | High |

## 2.6 Marketing

In order to encourage the community and Council to accept the geothermal heat pump system, a strong educational campaign was necessary. This promotion was used to introduce the system to the public. The financial and environmental benefits were highlighted to make the heat pump system an appealing alternative to fossil fuels, thereby helping to convince the community to abandon their old heating systems in favour of this environmentally friendlier option. To be able to develop this marketing strategy, we researched the current U.K. energy market characteristics.

### 2.6.1 Current Utility Market

The utility market was privatised in the United Kingdom in 1989, thereby allowing companies to independently and competitively market and sell their services to the public (Bird, Wüstenhagen & Aabakken, 2002a, 47). The utility market is mainly composed of coal, gas and nuclear energy supplies. Alternative, or green energy sources, only make up approximately 3% of the current market. As of 2002, there are fourteen green energy providers in the United Kingdom, serving approximately 45,000 customers. Most of these companies are geared towards wind or hydroelectric power, with only a small portion dealing with solar or geothermal energy. There is currently very little aggressive marketing for green energy providers (Bird, Wüstenhagen & Aabakken, 2002b, 50).

### 2.6.2 Policies Affecting the Green Energy Market

In 2001, the Climate Change Levy was passed as a United Kingdom legislation, which taxes all commercial and residential gas purchases (Bird et al., 2002a, 50). All green energy purchases are excluded. This tax is part of a movement to entice the population of the United Kingdom to consider alternative means of energy and to offer an incentive to green energy consumers. In addition, beginning in 2010, electricity retailers are required to obtain at least 10% of their energy from alternative sources. The electric companies may produce this 10% themselves through whatever alternative methods they choose, or they may purchase the percentage from a green energy provider. Failure to meet this requirement will cause the retailers to pay 4.68 Eurocents on every kilowatt-hour that they produce (Bird et al., 2002a, 50). Due to these factors, it seems that there is a good opportunity for a well-marketed source of alternative energy, such as the proposed heat pump system, to find an audience in the United Kingdom. Governmental support for alternative energy by means of tax reductions or discounted prices is perhaps the most influential component to increasing the market demand (Bird et al., 2002a, 6).

### 2.6.3 Marketing Techniques for Green Energy in Europe

It has been shown that the most successful markets for green energy have been those where there has been a highly aggressive campaign that focuses on consumer education (Bird et al., 2002b, 6). To create a successful market for this technology, an increased everyday awareness of the product needs to be achieved in the community. This can be accomplished by enlisting the support of the government and other organizations, such as Green Peace (Bird et al., 2002b, 6). The right members of the community must be focused on, presenting the product to them in a variety of different means so that they fully understand the services and benefits that are being provided by green energy (Bird et al., 2002b, 6). Because extensive consumer education is required, large marketing expenses for the energy providers are necessary. Such costs can be detrimental to the continuation of a large-scale promotional campaign. This is one reason why teaming up with the government or other organizations is particularly important in the marketing of green energy (Wiser, Bolinger & Holt, 1982, 11).

The government can play a major role in the support of green technologies. There is great potential that additional governmental support, besides the Merton Council, could be gained for the system if they were made aware of its benefits. This additional governmental support could help aid our efforts to market and implement the heat pumps in the Merton community.

Some alternative energy providers, such as Ecotricity, serve only industrial and commercial customers, while others such as Green Energy include residential customers as clients. However, both these agencies have high market-entry costs that have hindered their success in obtaining clients, especially residential consumers (Bird et al., 2002b). The Merton Council has been working toward implementing ecological energy systems that will be cost effective, so the customers will actually have a rate of return for the purchase of a new system. Government agencies such as Npower offer green power supplied primarily from new landfill gas, wind, and hydropower resources at no price premium. They have been marketing their power in cooperation with Greenpeace and have just recently set a goal to acquire "50,000 new customers, which would double the country's green power customers if achieved" (Bird et al., 2002b). The Merton Council will be able to evaluate their marketing strategy and make necessary changes to incorporate practices similar to Npower's approach pending Npower's success.

It has been shown that financial incentives have been the largest driving force to get consumers to switch to alternative energy (Wiser et al., 1982, 12). Consequently, the financial benefits of this technology should be heavily highlighted. When the California company Commonwealth Energy cut 1% off of the total electric bills of green energy consumers, about 45,000 new customers signed up (Holt, 2000).

### 2.6.4 Marketing Plans

Our overall goal while in Merton was to develop a means to educate the Council and community about the geothermal heat pump system. We were able to accomplish this goal by obtaining a basic understanding of how to develop a marketing strategy.

In order to create a marketing campaign, four basic steps needed to be accomplished. First, the customer has to be made aware of the product. Next, the marketing should create an interest for the product in the customer. Learning about how the system works as well as what it does will help make the consumer feel more comfortable with the product. Thirdly, the marketing plan needs to show the potential consumer how the product can benefit them. For the heat pump system, this would include explaining the financial and environmental benefits. The last component of the marketing plan is to push the sale, inviting the customer to make a commitment, without pressuring them to purchase (Traynor, 1997).

In order to be able to develop and improve a marketing strategy, salespeople need to gather as much pertinent information about the potential clientele as possible so that the information in the marketing campaign is geared towards the specific needs and desires of the consumer (Kahle, 1995). By obtaining information about the Merton community by means described in the

Methodology chapter, we were able to gain a sufficient understanding of the market and potential consumers to allow an effective marketing campaign to be developed.

## 2.7 Conclusion

The background research showed us that there are significant advantages for a ground source heat pump system that we should investigate further. The system can provide energy and financial savings. We developed information on how best to go about marketing the system within the energy market structure in the United Kingdom. This information guided our development of a methodology that would solve the problems and objectives that have been set out and was used to help draw many of our conclusions about this technology.

# 3 Methodology

The goals of this project were to determine the technical feasibility of implementing the ground source heat pump as well as to create an effective educational and promotional campaign in the Merton community. These were accomplished by gaining an understanding of the opinions, attitudes and behaviours of the community, gathering practical information on the technology of the system, and obtaining data about the Merton area.

We used surveys to determine attitudes and opinions of the Merton population towards having a new heating system installed in their home, as well as their attitudes and opinions about environmentally friendly products. We also defined the technical requirements and operation of the ground source heat pump, and found information about the housing in the area. The techniques that were employed included distributing surveys, conducting interviews and completing archival research. In Appendix B we have provided a task chart that shows the time we allotted for each method and other tasks that we accomplished while we were in London.

## 3.1 Surveys

Before we were able to develop our educational and promotional plan for the ground source heat pump system, we needed to find out the opinions of the community to focus our publicity strategy. The goal of the survey was to determine peoples' attitudes towards the environment, money, and heating systems. Surveying was chosen as an appropriate means of acquiring this information. It let us quickly gather a large quantity of opinions. It also allowed us to access a large cross section of the community more easily than if we had interviewed community members for the same types of data. The data collected provided us with insight into the receptiveness of the community to the system and was essential in the production of our educational marketing plan.

### 3.1.1 Survey Procedure

In order to find out the community's attitudes, we developed a survey that would accurately obtain this information. We first developed categories of information that we wanted to gather. These categories included people's opinions on the environment, spending money, their feelings about home heating systems, and their acceptance of new technology. From these categories we constructed questions that would allow us to find out specific information about each of these groupings. These questions were then reworked and edited in order to present our participants with a survey that would be simple enough to understand, as well as give an accurate representation of the views of the Merton community. The questions for the survey that we conducted can be found in Appendix C.

There were many factors that we examined in order to develop the questions in our survey. We needed to consider the wording, as slight changes in the questions, format or style could greatly affect the overall results. The survey was designed to obtain quantitative data so closed-ended questions that could be easily analysed were primarily used. We decided that in order to obtain the most useful information it was necessary to avoid ambiguous or leading wordings. The survey was very straightforward with clear and concise questions that left no room for personal interpretation. Most questions were multiple choice. For questions concerning the community's attitudes towards the environment and spending money, we set up the survey differently. Since this type of information was more opinionated, we provided a list of statements, which allowed the participants to indicate their feelings on a scale ranging from strongly agree to strongly disagree.

We ensured that we created a survey that would help us achieve the goals of the project by reviewing the survey with our sponsors in the Merton Council as well as our project advisors.

Our sponsors brought to our attention the importance of stating that the Merton Council was only looking into the possibility of installing a system, so as to not give residents the wrong impression that a renewable energy system would definitely be installed in all homes in the Merton community. After reviewing the survey, we tested its effectiveness by administering it to various employees in the Merton Civic Centre. This allowed us to ensure that the survey was easy to understand.

We decided that it would be best to obtain information from a wide cross section of the Merton community, in order to get meaningful results. Our goal was to obtain approximately 100 surveys, allowing us to reach a broad spectrum of the community without consuming large amounts of time. Since the survey was only used in helping to show trends and opinions of the community, and not to give a statistical representation of the area, large numbers were not needed. Only one form of the survey was distributed so an unbiased evaluation of the feelings of our participants could be determined.

We first distributed our survey to people in Merton Link, a division of the Merton Civic Centre where residents can go to address their concerns about their housing as well as pay their taxes. The survey was administered on Wednesday, January 22, 2003 and again on Tuesday, January 28, 2003. We targeted this area because all of the people in Merton Link were members of the Merton community. The area included a large waiting area where community members often waited idly for considerable amounts of time. We first obtained permission from the management of Merton Link. Then we directly went up to the people that were sitting, briefly explained our purpose, and asked them to take our survey. We obtained 20 surveys from Merton Link.

Next, we distributed the survey to the residents of Saint Helier's, which is a Merton Council owned complex. We tried to highlight this area, as it would provide the opinions of current residents of Council-owned property. We notified the Area Housing Manager for that complex to inform them of our intentions. Then we went door to door in the neighbourhood, explained our purpose and asked for their assistance in filling out a survey. Unfortunately, the response to our survey was particularly low, so this audience was abandoned for more fruitful locations. The survey only yielded one response out of 50 houses and was administered at St. Helier's on Tuesday, January 29, 2003.

We then targeted Centre Court, an indoor shopping mall in Wimbledon. We surveyed people from this area to get the opinions of the more financially stable portion of the Merton community because most of the shoppers there would be from the Wimbledon community, the wealthiest of the districts in Merton. Our objective was to broaden our participant pool, to give a more accurate cross section of the community. In addition, we hoped that the location would yield higher numbers of responses due to the more relaxed environment. We obtained permission from the management of the mall to survey on their property. Then we went to the location and approached shoppers and asked them to participate in our surveying. The response rate was poor at this location as well. It provided us with 16 surveys within a 3.5 hour time period. The survey was administered in Centre Court on Friday, January 31, 2003.

After these locations were completed, we decided to target employees in the Merton Civic Centre. The rationale behind this was, while the employees did not necessarily live in Merton, they were homeowners and therefore would have similar concerns and thoughts about heating systems. We first obtained permission from the division managers, and then went around to the different divisions of the Civic Centre, asking employees to respond to our survey. The Merton

Civic Centre was surveyed on February 6, 2003 and we obtained 19 responses. The amount of surveys that we obtained from the four locations totalled 56, however we chose to disregard the survey that we obtained from St. Helier's because we felt that the participant did not understand the questions on the survey. Therefore we only used 55 surveys for our data.

### 3.1.2 Survey Analysis

Once the surveys were administered, we analyzed the data immediately. First we kept all the surveys from the four different areas separate, to allow for comparison between the audiences. Then we compiled total numbers of responses to each of the questions in the surveys. From this, we saw trends as to whether or not people were generally satisfied with their heating systems; as well as how interested they were in an environmentally friendly heating system, such as our ground source heat pump. We also determined the main concerns the community had about an environmentally heating system.

We then examined the responses to the survey questions asking participants to describe their feelings more closely. We compared responses to the statements "I want to buy environmentally friendly products" and "I want to buy inexpensive products". We looked to see how many people agreed or strongly agreed to both and how many agreed to only one to find general correlations between all of the presented choices. Because of this, we saw if people were more concerned with helping conserve the environment or with saving money. Similarly, we then compared responses to the statements "I would support an environmentally friendly heating system if it saved money" and "I would support an environmentally friendly heating system if the costs were similar to my current system". Again, we compared how many people agreed with both, disagreed with both, or agreed with one or the other. We used these two sets of statements to determine if the community was more concerned with saving money or with the environment, which in turn allowed us to understand what areas to highlight in our promotional campaign.

## 3.2 Interviews

We needed to present the Merton Council with valid technical information about the ground source heat pump system. We also needed to increase our own technical understanding of the system enough to be able to determine the technical feasibility of the proposed pilot program in the Merton community. This prepared us to educate the Council and community on the installation, operation, expense and benefits of the ground source heat pump system. We used four interviews in order to gather the information that we needed. The first interview was with the designer of the ground source heat pump system that the Merton Council is considering and was intended to obtain specific information about the Powergen package. After this interview, we also decided to conduct brief and objective interviews with three other people who were knowledgeable about ground source heat pump design and installation to confirm and expand upon what we learned from Powergen. Each interview was conducted as if we had no prior knowledge of the technology. This gave us a large quantity of technical information that we used to draw conclusions about the feasibility of installation, as well as to develop our educational campaign.

### 3.2.1 Interview Procedure

We broke down the information we needed about the ground source heat pump into categories: economics, environment, system specifications, installation, maintenance, and operation. From each of these categories, we developed two interview guides, one for the Powergen interview that was more in-depth, and a lesser-involved guide for the remaining interviews. The interview guides consisted of questions and topics that we wanted to discuss in our meetings with the technical experts, some of which included information that we wanted to include in the brochure, pamphlet, presentation and the pilot selection program. We then reviewed the interview guides with our sponsors and advisors to ensure completeness. The interview guide for the Powergen interview can be found in Appendix D. The interview guide for the other technical interviews can be found in Appendix E.

The first interview that we conducted was with a representative from Powergen, the energy company that is providing a ground source heat pump system program to communities throughout London. The interview was set up with Mr. John Parker, the project manager and designer of the heat pump system. The meeting was arranged through our sponsor for Thursday, January 24, 2003 in Oxford, England. Two days prior to the meeting, we forwarded Mr. Parker our interview guide so that he would be aware of the type of information that we were looking to get from him.

Our sponsors, Mr. Robert Harris and Mr. Adrian Hewitt, the principal environmental officer for the Merton Council, attended the scheduled meeting, as they also had their own concerns and questions to discuss with Mr. Parker. The interview took the shape of an informal, open, and detailed discussion about the ground source heat pump system that covered all the questions that we had prepared in addition to topics that we had not considered. We took notes and compiled the data later on that day.

Through the assistance of our sponsors, we received contact information for three members of the industrial and commercial community who were knowledgeable about ground source heat pump systems. These were Mr. Roger Hitchin of Building Research Establishment (BRE), Ms. Deborah Bennett of GeoScience, and Mr. Damien Bree, an architect of Bree Day Partnership. The objective of these interviews was to make certain that the information that Mr. Parker gave us was consistent throughout the United Kingdom, specifically that the idea of retrofitting into existing housing would not be very beneficial, as well as to expand upon our technical understanding of the heat pump installation. The interviews were set up through direct email contact and conducted over the phone. The interviews were approximately 30 minutes each, and focused on the issue of retrofitting ground source heat pumps into existing housing. A brief interview guide for these was created and can be found in Appendix E. The interviews were not recorded due to inability to obtain recording equipment, but were given by two members of our group, one conducting the interview and the other recording by hand. The interview with Mr. Hitchin occurred on Tuesday, February 4, 2003 and the interviews with Ms. Bennett and Mr. Bree occurred on Tuesday, February 11, 2003.

### 3.2.2 Interview Analysis

Upon completion of the interviews, the notes that we had taken were pooled and sorted into categories of information. The notes from the interviews can be found in Appendices F, G, H, and I. This allowed for us to be able to better see what types of information we received from the interviews. We took the information that we received and used it to better understand the intricacies and details of the system. We compared the information that we received from our interviews and saw that all the information concurred. We then used the information we received from these interviews to complement and fill out our own understanding of the ground source heat pump system so that we could evaluate the pilot program in Merton as well as educate the Council and community.

## 3.3 Archival Research

We investigated the Merton Council as well as the housing stock in the area as a part of our fundamental research. The purpose was to determine if it would be feasible to implement the ground source heat pump system, as well as to determine what would need to be done to the houses in order to accomplish an installation. We also researched the Merton Council in order to see how the ground source heat pump could help them meet some of their goals and aid them in their operation as a government organization.

### 3.3.1 Archival Research Procedure

We determined the goals of the Council and what types of governmental housing standards they needed to meet. This included researching information about fuel poverty, Decent Homes Standards and Best Value Performance. We also examined the status and types of housing within the housing stock. Because much of the property in Merton is in housing developments, many of the buildings are very similar or identical. This significantly reduced the number of locations that we needed information for. We originally intended to find specifics about each of the housing developments as well as stand alone housing. These specifics included areas of construction, total plot areas, number of stories, foundation and insulation materials, energy efficiency and current heating systems. Unfortunately, the Merton Council does not possess information of this nature for most of its housing stock. Therefore, we began looking simply at the different types of dwellings available, the costs to rent them, their heating systems and their insulation. This gave us sufficient information to be able to make recommendations about the installation of the pilot program in Merton.

We obtained the information to accomplish these tasks through records and written material provided to us by the Council and the Housing Services department. The Housing Services department possessed records and files that had information about their stock as well as privately owned property throughout the borough. The Council also provided documentation about its goals and targets for the upcoming year. Specifically, information was available about the Merton Council's financial situation from the housing revenue account of 2002; the goals of the Merton council from the Housing strategy update of 2002; the housing service plan for 2002-2005; and the cost of property refurbishment and community attitudes from the Final Report that was published by Property Tectonics in February, 2002.

### 3.3.2 Archival Research Analysis

Once we obtained the written documents from the Merton Council, we isolated the relevant data into categories. These categories included the following: governmental standards, Merton Council vision, fuel poverty, decent homes standard, best value performance, and stock condition. Once the data was organized into topics, we used the information to help draw conclusions about the applicability of the ground source heat pump in the Merton community.

## 3.4 Conclusion

Upon completion of these various research techniques, the collected data enabled us to understand the necessary specifics, which aided in the development of our educational campaign for the Merton Council. By surveying the public, we gained a broad view of the Merton community's beliefs and attitudes towards the issues pertinent to developing and executing a promotional plan. We gained a deep technical understanding of the ground source heat pump system as well as pointed out underlying concerns that would need to be addressed by the Council in a pilot program from our interviews. Our look into the operation and goals of the Merton Council gave us information that we used to focus our educational program to meet their needs. Our research into the Merton housing stock allowed us to determine if it was feasible to implement the system in the area. Overall, our research gave us a complete picture of the possibility of implementing the ground source heat pump system, which helped us to put together a multi-component promotional and educational scheme. We utilized these data for the development of brochures, pamphlets, and a final presentation to the Council.  This material can also further be used in the future marketing of the heat pump to the Merton community.

# 4 Results and Analysis

Through the research that we conducted, we obtained significant amounts of data pertaining to the heat pump implementation plan. We acquired information about the technical specifications of the heat pump design, the economics of implementing the system, and the environmental implications. We also found out data pertaining to the Merton Council, its housing stock, and the government regulations that are set to better the community and environment. In addition, we uncovered the opinions, attitudes and concerns of the Merton community about the proposed ground source heating system. In order to be able to present the Merton Council with recommendations pertaining to the installation of the ground source heat pump, we had to analyse the data we obtained. The conclusions to our research were included in our promotional and educational campaign that we presented to the Merton Council.

## 4.1 Technical Feasibility

Conducting interviews with selected representatives involved with the ground source heat pump program allowed us to collect significant amounts of information regarding the technical specifications and feasibility of implementing the heating system. The majority of information was obtained from Mr. John Parker, of Earth Energy and Powergen. He was responsible for designing the heat pump used by Powergen. Additional information was also received from Mr. Roger Hitchin, of Building Research Establishments (BRE), Mr. Damien Bree, an owner of a small architecture and design company, and Ms. Deborah Bennett of GeoScience. Using the information received from all our sources, we gained an in depth understanding of the heat pump system. The notes from the Powergen interview with Mr. Parker can be found in Appendix F. The notes from the interview with Mr. Hitchin can be found in Appendix G. The notes from the interview with Ms. Bennett can be found in Appendix H, and the notes from that with Mr. Bree can be found in Appendix I.

The majority of the technical information is specific to the design of the Powergen heat pump system, which was manufactured by Calorex. This is the system that the Merton Council is looking at as an option to implement in their housing stock. Powergen has established a program to help communities in the U.K. fund the installation of ground source heat pumps in social housing. They are offering communities a heat pump package at a reduced cost, along with installation assistance.

### 4.1.1 Heat Pump Installation in the United Kingdom

From our interview with Mr. Parker, we found out information about the use and implementation of ground source heat pumps in the United Kingdom, as it differs from that used in the United States. Although the system is widely used in the United States of America, and only sparsely used in the U.K., the ground source heat pump is actually better suited to use in the United Kingdom. The ground that is found in the U.K. experiences less extreme temperature conditions than in the United States. The ground in the U.K. is wetter than in North America. This increases the thermal conductivity of the soil, so that the ground can give up heat more readily. The London area sits on a bed of clay. Because of this uniform geology, a system that can be designed and proven to be successfully implemented in one London location is likely to be effective throughout the entire London area. However, a scheduled test project, such as that being done by Robert Harris and EarthDome should be completed and the viability of the system in the London clay confirmed before installations of many systems should go forward.

Other design considerations that are specific to the United Kingdom deal with the fact that the U.K. does not have considerable need for cooling or air conditioning systems in domestic environments. In the U.S., the heat pumps are ducted systems that can be reversed to provide both cooling and heating. For cooling, the heat from the building is removed and pumped back into the ground. The temperatures in the United Kingdom do not vary as much as in parts of North America, and therefore the U.K. heat pump system only needs to be designed to provide heating. This is significant because systems that only provide heat require larger underground loops, due to the fact that the heat is never being put back into the earth. The larger loop means that deeper drilling is necessary, but since the drilling is not a difficult process, drilling deeper holes will not cause considerable additional disruptions or obstacles.

### 4.1.2 Ground Source Heat Pump Design and Implementation

Through our conversations with Mr. Parker, Mr. Hitchin and Ms. Bennett, we found out about the ground source heat pump system design and implementation. The ground source heat pump system used for domestic heating and hot water consists of both underground and above ground components. Underground, there are the ground loops, the circulating heat transfer fluid, and an underground circulating pump. Above ground, inside the house, are the heat pump unit, a hot water circulating pump, the water storage tank, and the heat distribution system. A diagram of the system may be seen in Figure 4.1.

#### 4.1.2.1 Underground System Components

The underground piping loops are made of PVC piping. They are quite sturdy, yet very flexible, and able to withstand strong vibration disturbances underground. The pipes are filled with the circulating heat transfer fluid, which in the case of the Powergen design is a mixture of 65% water and 35% ethylene glycol. The fluid in the ground loop runs between 1°C and 3°C. At these low temperatures, the fluid remains very viscous. In order for the heat pump to keep up good thermal performance, there must be turbulent flow of the fluid in the pipes. The flow can become laminar if the mixture gets too cold, and therefore the underground loops must be kept above 0°C.

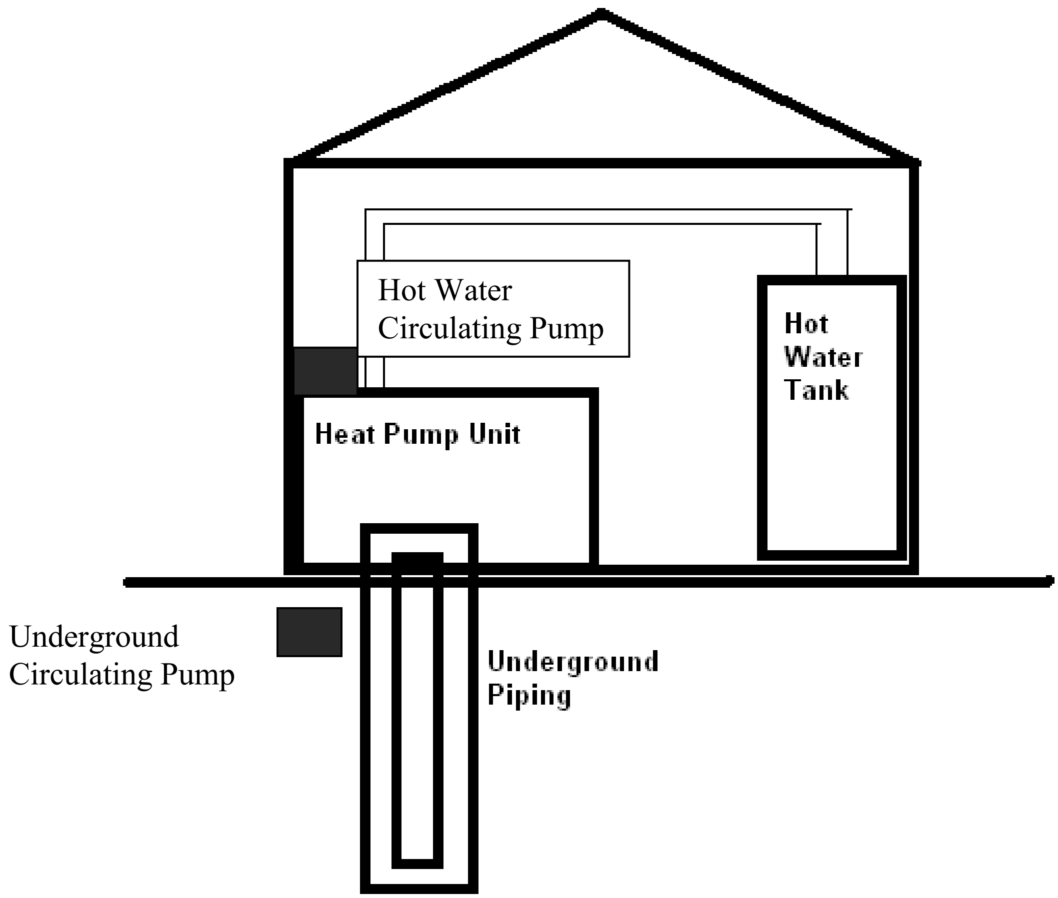



**Figure 4.1**
**Ground Source Heat Pump System Diagram**

The fluid is moved through the pipes using a circulating pump that is capable of operating at very low temperatures. The Powergen package makes use of a Wilo manufactured circulating pump that can operate below 15°C. This circulating pump runs at only 80 W, as opposed to the standard 160 W. There are potential issues with building contractors and plumbers when dealing with the heat transfer fluid. Often, there is the tendency to treat the fluid, and design around it, as if it were just chilled water instead of being a mixture operating at very cold temperatures.

Therefore, it is important to have experienced contractors working with the installation of the piping.

The underground piping loops are one of the first pieces of equipment to be installed. The pipes can be put in either a horizontal or vertical configuration. The horizontal installation of the piping is less expensive, as the pipes need only be laid a few meters into the ground, and therefore do not require drilling equipment. The vertical orientation has the advantage of helping to eliminate problems or confusion with builders. The vertical orientation makes it harder to damage the pipes while construction is going on because the piping is further underground. The horizontal orientation has the piping only a few meters deep, close enough to the surface that they could be damaged during construction. Due to the land constraints in London, only a vertical orientation would be practical.

Before installing the piping, the location of the holes where the pipes will be inserted must be determined and marked. This must be done before construction equipment arrives on sight, otherwise the equipment may potentially block where the pipes will be installed. Mr. Parker believes that the installation of the pipes is actually simpler than many contractors believe. The idea of inserting flexible, fluid filled pipes many meters into the ground is rather novel to most people. Mr. Parker commented that he thought some contractors will try to increase the costs to consumers by making the process seem more involved than it really is. While the ground source heat pump may be innovative, there is nothing particular about the holes that are being drilled.

The holes need to be drilled using a drilling rig and a team that is familiar working in London clay, so that they are familiar with the unique characteristics of working in the area. The holes must be dug to a depth of 60-100 meters. The exact length is specific for each site, and will be determined by Powergen. The holes are of a width of 100 millimetres (around 5 inches).

The holes must be located 3 to 4 meters away from the edges of the house. They also must be located about 2 to 3 meters away from property lines. If multiple holes are being drilled in one site, they must be at least 5 meters apart from one another. The ground does not need to be tested before drilling the holes. If many holes, such as twenty, were being drilled on one site, it may prove to be more cost effective to test the soil before drilling. If it is discovered through testing that the soil is more thermally conductive than originally thought, then a fewer number of holes may satisfy the property. However, testing the soil is not practical if only a few holes are being drilled. The drilling is simpler than putting in a well or water main because the holes only need to stay open long enough to install the piping. Due to this factor, ground stability is less of a consideration for the drilling team. The drilling only takes about one day, but because it is a disruptive process, it is recommended by Mr. Parker and Ms. Bennett that the residents of the property not be present during the drilling.

Once the holes are drilled, the piping can be installed. The piping is a closed loop in a U-shape, with an overall diameter of about 100 mm. A pipe is placed in between the U-pipe to keep the system stable during insertion. This pipe is also used to backfill the hole with grout. The U-pipes then get filled with the water and ethylene glycol mixture and closed. The major problem with the piping is due to people digging and damaging them after the installation is complete. Therefore their location needs to be marked to prevent future damage.

#### 4.1.2.2 Above Ground System Components

The interviews with Mr. Parker, Mr. Hitchin, Ms. Bennett and Mr. Bree also provided information about the above ground components of the ground source heat pump system. After the underground workings have been installed, the other components can be installed inside the house. Inside, there is a circulating pump, the hot water tank, and the heat pump box. These come as separate, unattached components so that they can be installed in different circumstances or physically constraining areas. The circulating pump used in the Powergen package is manufactured by Grundfos, and has two circulators cased in one body. It runs at very low speeds. The heat pump box is very small (requiring around 0.25 $m^2$ of floor space), so it can be installed in small spaces or without taking up much living space. It is low enough to fit under most kitchen cabinets, around 0.85 meters high.

Installation of the heat pump box must be done by professional contractors, but all the pipe fittings and circulating pumps can be put in place by plumbers. There are only four connections to the heat pump unit that need to be fitted: two pipes in and two pipes out. The installation of the internal components should take about two days, one to install the components and one to connect the pipe fittings.

Once all the components of the ground source heat pump have been put together, the system needs to be set up to heat the building. For Powergen's system, an under floor heating system is the recommended distribution method. This has pipes running underneath the flooring that are filled with warm water, so the heat radiates upward from the floor into the room. Under floor heating operates at a lower temperature than a radiator to comfortably heat a home. This low operating temperature is ideal for use with the ground source heat pump system, as it will not overstress the heat pump. The heat pump itself is controlled by a room thermostat.

### 4.1.3 Energy Considerations

From speaking with Mr. Parker and Mr. Hitchin, we discovered data about the energy consumption, output and losses of the heat pump. The ground source heat pump runs by using small amounts of energy to operate its pumps and compressors. The system operates using a 1 kW motor. This motor can run off a 13-amp circuit, which is the normal circuit in U.K. housing.

It needs to be wired to its own circuit, similar to a stove. It operates using the consumer's normal electricity supply and requires no special electric considerations. The Powergen system has been engineered to start up using a 28 amp starting current. They created a soft start device to limit the current to this amount specifically for social housing applications. This is to eliminate potential disruption to consumers as well as the power company. Many large appliances require large starting currents, which cause the lights to flicker whenever they start up. Starting currents over 30 amps will generally cause this light flickering, and therefore Powergen designed a system that would start out at less than this, eliminating the annoyance of flickering power.

There is no set formula that can determine how much energy the ground source heat pump can put out. In order to determine the best set up for the system, and be able to estimate its energy output, an iterative analysis needs to be done. The energy output of the system is dependent on three main considerations: the energy use of the household, the amount of energy stored in the ground, and the heat pump itself. These three factors contribute to the coefficient of performance (COP) of the system. The higher the COP, the more effective the heat pump is. This three-fold set of considerations makes the design of the heat pump particularly difficult, especially considering that it is very hard to truly predict the energy demands of a house simply because it is difficult to predict the behaviour of its inhabitants. Still, Mr. Parker, the designer of the Powergen system, has come up with a means to determine the energy outputs of the heat pumps. It is estimated that the Powergen heat pump will be able to put out around 500 kW in a small house. This energy production is more than sufficient to keep a home at 22°C and provide hot water up to at least 60°C. This performance is highly dependent on the quality of installation of the ground source heat pump.

Mr. Parker and Mr. Hitchin informed us that the installation can have a large impact on the efficiency of the heat pump. There are very few energy losses due to the heat pump itself, but there can be considerable losses due to the inefficiency of the circulating pumps. If the pumps are installed incorrectly, or set to operate at the wrong speed, there can be parasitic energy consumption, creating significant energy losses. In addition to proper installation, there are operational considerations that need to be kept in mind to keep the system running efficiently. The heat pump should be run so that the output temperature is as low as possible. This makes the heat pump more efficient. When the heat pump is run to create very high temperatures, the higher output temperature of the pump leads to a lower COP. This means that the heat pump is taking less energy from the ground, so it is using less renewable energy and more electricity to heat the building. This is why under floor heating is important, because it allows the home to be well heated, while still allowing the heat pump to operate at lower temperatures.

### 4.1.4 Usage and Maintenance

Through our interviews with Mr. Parker, Ms. Bennett, and Mr. Bree, we obtained facts about the operation and maintenance requirements of the heat pump. There are a few factors that must be considered regarding the use of the ground source heat pump system. When employing the system in conjunction with under floor heating, heavy carpeting or underlay has a detrimental effect on the effectiveness of the heat pump. Carpeting insulates the under floor heating system from the room, so the heat output of the system must be higher in order to get the room up to the desired temperature. When there is very thick carpeting, this insulation is very high, making the heat pump run at higher temperatures, and requiring more electricity to heat the room.

All of our interviewees felt that the ground source heat pump system is a highly reliable heating source. The ground loop has a lifetime of around 50 years, but in practice in the United

States, it has been shown to last much longer. Because the ground loop is underground, it is protected from the elements, as well as from vandalism. Mr. Parker estimates the Powergen heat pump to have a lifetime on the order of 30 years. The simplicity of the system's design and components requires very little maintenance. The circulating pumps or piping may on occasion need servicing, but this can be done by a regular plumber.

The main source of all problems associated with the heat pump system is due to poor installations. Since the systems are so simple, an improper installation can allow the system to run for a short amount of time, giving the appearance of proper installation, but causing the system to break down a little while later. Therefore, to prevent maintenance concerns it is extremely important to have the systems put in by trustworthy installers. Mr. Parker firmly stated that he felt the installation contract should not be given out through competitive bidding, as he believed the quality of installation would go down. As it stands currently, there is no accreditation of installers, but Powergen and Earth Energy are working to create a list of reputable contractors from which consumers can choose from.

### 4.1.5 Installation Requirements

While talking with Mr. Parker, we discussed the ideal site to install his heat pump, as well as what requirements a home would need to meet in order for the heat pump system to operate well. We also discussed these installation requirements with Mr. Hitchin during our interview. When Powergen created their heat pump program, they had specific site requirements in mind. The system was designed to best fit in locations meeting these requirements. Their ideal location for the ground source heat pump is a newly constructed, freestanding house, with an area of less than 100 $m^2$. It should be a single story dwelling, sitting on a plot with sufficient land to easily install the piping, such as a front garden. In addition, the house needs to be highly thermally efficient, with heat losses of no more than 4 kW/day.

With the introduction this new technology is the need for correct installation procedures to be established. Clear Skies is working to develop an accreditation program that would provide consumers with installers that have been trained to deal with ground source heat pumps. To avoid any future problems occurring because of poor installation of the system the customer should purchase the system as a package from a credible manufacturer such as Powergen and use the list of approved installers provided by Clear Skies.

### 4.1.6 Retrofitting

We found out from Mr. Parker that the system was not intended to be put into existing buildings. He strongly opposed the idea of retrofitting, but provided some information about how it could possibly be done. In our interview with Ms. Bennett, she agreed with Mr. Parker's belief that the retrofit would be very difficult to perform and recommended that it not be done if possible. Mr. Hitchin and Mr. Bree felt that a retrofit would be very difficult, but possible with some renovations and creative engineering. Powergen successfully did a retrofit program in Cornwall, and there are a few existing in the U.K. Unfortunately, in order to successfully implement the system, large-scale renovations need to be done to bring the building in line with the requirements of the Powergen program. First, a location must be chosen where the renovations are possible, which also has the sufficient land requirements for the system. Ideally, this will be a stand-alone or terraced house. A front garden makes installation of the piping easier because the drilling equipment does not need to be manoeuvred around the house into a back garden. In addition, the house must be made energy efficient enough to keep the daily heat loss down to 4 kW. Depending on the current condition of the housing, this could be a major undertaking in itself. This may require the addition of insulation and new windows, depending on the current efficiency of the building. Another consideration is the drilling and installation of the piping. The drilling and installation process is very messy and disruptive. If a retrofit was desired, the most applicable location for the Powergen system would be either a terrace property that needs upgraded windows and external insulation, with a side entrance that could be used to run the pipes out into the yard. Alternatively, a non-terraced location where the pipes could be trenched into the house through the basement could be potentially used. Retrofitting the system into an existing house that was not designed for the heat pump is a much more involved and difficult task than installing it in a new house. Due to the disruptive construction, it would be difficult to perform the retrofit in an inhabited house. Therefore, whenever possible, new builds should be used for the implementation of the system.

### 4.1.7 Environmental Considerations

From speaking with Mr. Parker, we discovered that the ground source heat pump has both environmental concerns and benefits that need to be considered in a decision to implement. The system itself creates no pollutants or emissions. The electricity that it uses to operate, however, does create emissions when produced at the utility company, making the system not a completely renewable energy source. The carbon emissions are significantly reduced with the use of a heat pump. Also, because of the depth of the piping, the ground is able to recover after the heat is removed. When the system is properly designed, there is no fear that the earth will be over stripped of its heat, causing freezing.

The major environmental concern associated with the ground source heat pump is the possibility of the contamination of underground aquifers. If, during the installation of the underground piping, the drilling passes through multiple aquifers, it is possible that water or contaminants from one could pass to another. This could lead to cross contamination of the underground water sources. In order to help prevent this contamination, the drilling holes are sealed up with grout after the pipes are installed. This significantly reduces the risk of contamination, but cannot completely eliminate it. This concern must be considered by the Council in their decision whether or not to implement the system.

### 4.1.8 Combining Ground Source Heat Pumps with Solar Energy

The Merton Council was considering the idea of combining solar and geothermal systems in their council housing, so this combination was investigated in our technical interviews. We discussed the issue with Mr. John Parker, who had previously investigated this idea as well. As the solar panels heat up in the sun, the water for the house could be piped underneath, to be heated up. Forty percent of a household’s hot water needs can be obtained from solar panels. This seems like it would be a beneficial addition to a residence, but it turns out that it would never be financially beneficial. The heat pump is capable of providing all the hot water needs of the building. The solar panels would only save money if they were provided and installed free of charge. The installation would cost an additional £3500 per household, and the amount of money that they would save yearly would never provide payback of the initial investment. They could, possibly, be used to improve the running of the heat pumps by providing either electricity through the use of photovoltaic cells or by returning heat into the ground to benefit the underground piping loop. For the original intended use, however, it would be impractical to install the solar panels.

## 4.2 System Capital Costs

There are several economic considerations involved in the implementation of the ground source heat pump system. We discussed these capital investments with Mr. Parker during our interviews, as he was the representative from Powergen, who was selling the system. He informed us that there is a fairly significant initial investment to purchase and install the system. The breakdown of these costs can be seen in Table 4.1.

The Powergen package, including the heat pump unit, the circulating pumps, hot water tank, and underground piping, costs £2500 per unit if six or more units are purchased. To acquire all the package components separately would cost approximately £3250. The additional costs are due to the consumer having to fund the drilling of the holes, the installation of the piping, and the grout that fills the holes. The drilling and installation of the piping is the major additional cost to the consumer. In order to get a drilling rig on site, it costs around £1000. The drilling of a hole and installation of the piping is an additional £1000 on top of that. The cost of the plumber installing the indoor piping connections and

**Table 4.1**
**System and Installation Costs for Ground Source Heat Pumps**

| **System Component or Installation** | **Cost** |
|---|---|
| Powergen Heat Pump Package | £2500 |
| Drilling Rig On Site | £1000 |
| Drilling and Installation of Piping | £1000 |
| Fitting of Indoor Piping by Plumber | £500 |
| **Total Expense per Site** | **£5000** |

pumps will run around £500. All the additional expenses bring the overall total cost of installing the Powergen ground source heat pump up to around £5000 per house. This figure is for the installation of the system into a new built house that is designed for the heat pump and is the cost for the installation of the heat pump itself. It does not include costs for the installation of under floor heating, insulation, or high quality windows.

## 4.3 Funding Options

The costs of implementing the system can be reduced or offset by applying for various governmental grants and refunds. Through our conversations with Mr. Parker, and our sponsor, Mr. Harris, we discovered various funding opportunities which we investigated further. The Carbon Trust is a non-profit organization that was set up by the U.K. government to support low carbon emissive technology throughout the nation. The agency will provide money to consumers who are using low carbon emissive equipment. The amount of money that is received from the Carbon Trust is dependent on the predicted lifetime $CO_2$ savings that the ground source heat pump will provide. This is different depending on what type of heating system it is replacing or potentially replacing in the building. If the ground source heat pump was replacing an electrical system, a carbon credit of around £1500 pounds could be paid out. If the system is replacing a gas system, as is common in most of London, the carbon credit is around £500, as gas systems produce less $CO_2$ emissions than electric. The Merton Council would receive this carbon credit refund upon installation of the ground source heat pump systems.

Another source of funding that can be used to help implement the ground source heat pump is Clear Skies Renewable Energy Grants. These grants are available to both homeowners and communities. The grants may be used to offset capital and installation costs of renewable energy systems, including ground source heat pumps. The grants are only available when the equipment is professionally installed, but Clear Skies can help locate credible installers. For homeowners, the grants range from £500-£5000. Communities can receive up to £100,000 for building and renovation projects. The Merton Council is eligible for receiving funding from the Clear Skies community-funding program, which they could use to offset the costs of implementing the ground source heat pump scheme.

A third funding option for installing the ground source heat pump is the New Opportunities Fund. This fund was established from profits of the National Lottery. £50 million is available to fund renewable energy programs in communities across the U.K. This fund is set up to help the U.K. meet its goal of producing 10% of its energy from renewable sources by 2010. As a community governing body, the Merton Council is eligible to apply for this funding to help compensate for the cost of putting in the ground source heat pumps.

## 4.4 Operation and Maintenance Costs

There are also economic factors surrounding the operation of the heat pump system. The running costs are mainly based on the costs of providing the electricity needed to run the heat pump. The heat pump does not run continuously, 24 hours a day, but rather only turns on to heat up the water stored in the hot water tank and then turns off until this water is consumed. If the heat pump can be on during the time periods when electricity is provided at lower costs, then the overall running expense of the heat pump system can be reduced. Electricity at the standard domestic tariff costs 10.26 pence/kWh. Running on economy 7 tariff provides 7 night time hours where electricity only costs 2.6 pence/kWh, and costs 13.13 pence/kWh the other 17 hours of the day. If the heat pump was getting electricity primarily during the 7-hour window of lowest rates, the consumer could save even more money on their electricity bill. Although other systems and appliances can run using economy 7, the ground source heat pump has the advantage that it needs only be run for short amounts of time, rather than continuously throughout the day. Therefore, it can be primarily run during the night, taking more advantage of the low cost electricity, while other systems would need to be run more often. Still, because the system only uses small amounts of energy normally, the savings gained by running during economy 7 tariff periods may not be substantial.

In order to understand the running costs of the system, an illustrative example was used. A small 100 $m^2$ house might have an annual heating and hot water load of 10,000 kWh. For the ground source heat pump to be able to provide this amount of thermal energy, around 2,500 kWh of electricity would be needed. If the average cost of electricity were taken to be 10 pence per kWh, the yearly running expense of the ground source heat pump would be £250 per year. If it were run only on Economy 7 tariff electricity prices, the annual running expenses would drop to £50. If an electric system were used to provide this amount of heat and hot water, 12,500 kWh of electricity would need to be provided, as an electric system is about 80% efficient at converting electricity to thermal energy. At the same 10 pence per kWh, this would be a yearly running expense of £1,250, which is 500% more expensive to operate than the ground source heat pump system. If a gas system were used to provide this amount of heat and hot water, 12,500 kWh of energy would need to be provided, as gas systems are also around 80% efficient. Gas prices average around 2 pence per kWh, giving a yearly running expense of £250, identical to that of the ground source heat pump. Based on these economic comparisons, it can be seen that the operating costs of the ground source heat pump system are significantly lower than electric heat, and in line with the expense of gas heat. These comparisons can be seen in Table 4.2.

**Table 4.2**
**Annual Running Cost Comparison of Heating Systems**

| System | Energy Consumption (kWh) | Expense per kWh | Annual Cost |
|---|---|---|---|
| **Electric** | 12,500 | £0.10 | £1,250 |
| **Gas** | 12,500 | £0.02 | £250 |
| **Heat Pump** | 2,500 | £0.10 | £250 |
| **Heat Pump (economy 7)** | 2,500 | £0.02 | £50 |

# 4.5 Feasibility in Merton

Merton has motivations for considering a ground source heat pump system for use in the community. It is necessary to begin implementing programs to meet government requirements of reducing emissions and fuel use. The Council and Robert Harris also believe that this technology would improve the Borough's image by pioneering the use of these systems.

## 4.5.1 Government Regulations

Through our investigation into the Merton Council and its housing stock, we found out considerable information about the regulations it needs to meet. The government has identified the need to reduce emissions and cut back on the use of fossil fuels, and have consequently imposed some new regulations. They would like to reduce the production of greenhouse gases by 12.5% by the year 2008. They would also like to see a reduction in carbon dioxide emissions of 20% by the year 2010. In order to accomplish this, the government has imposed a regulation on U.K. energy companies that states they must produce at least 10% of their electricity by alternative means by 2010 (Powergen, 2003b). This requirement has led to Powergen's search for a way to meet this benchmark. Currently, Powergen makes a portion of its electricity from wind farms. This includes the first off shore project in the U.K. off the coast of Blyth, Northumberland that utilizes the most powerful turbines ever made, each turbine producing enough power, 2 MW, for 3,000 households (Powergen, 2003a).

Merton has taken the government requirements one step further. Based on information from members of the Council we have found that the Unitary Development Plan (UDP) states that any new build structure must produce 10% of its electricity on site by the year 2004. They are concerned however, that being the only Council to have such a plan will encourage businesses and builders to move to areas that do not have the same regulations. For this reason the Council is proposing that the London government adopt this plan so that there is a level playing field throughout the boroughs. The Merton Council is determined to implement environmentally friendly technology but the solar systems that they have investigated only produce 2.5% of a home's energy while being more costly than a ground source system, so Merton is interested in the ground source heat pump technology because it helps to meet these targets set by themselves and the government.

### 4.5.2 Applicability of Merton Council Housing Stock

The specifics of the Council's housing stock are the deciding factor in the decision to implement this ground source heat pump system or not. We found from Mr. Parker that it is necessary for the dwelling in question to be either a stand-alone or terraced house with a garden large enough to install the piping. Because of this we can discount almost 60% of the Council's properties and focus on the remaining 40% that are considered houses. Since the Council doesn't keep data on facts such as the property, house, and garden size of each residence we cannot locate the specific houses and developments to look into. However, using the information that we gained from our interviews with technical experts, we can specify the types of properties that the Council should be looking for. Although the buildings can be joined side to side as in a terraced style, the ideal house would be stand-alone and one story. All of our interviewees stated that there must be a garden with sufficient space to drill the hole, including the five meters around each hole and the appropriate distances from property lines and structures, as well as sufficient access to the space to allow a drilling rig and team to perform the operations. Mr. Parker stated that for the Powergen heat pump package, there must be a space of at least 0.25 $m^2$ to fit the heat pump unit inside, along with room in the foundation to link the inside components with the underground loop of piping. These are the characteristics that determine whether installation in a property is feasible or not, but there are other considerations that are more subjective.

The overall energy efficiency of the building must be better than the maximum allowed loss of 4 kW as stated earlier for the system to be effective. Through our archival research we discovered that many of the Council properties are in need of repair, and energy efficiency is one of those areas in which they are lacking. Most buildings would require insulation to be installed on the outside of the outer walls, windows to be upgraded, and a change in the current heating distribution to the radiant floor heating, which the ground source heat pump system is designed for. Insulation on the exterior of walls is the most effective means of insulating masonry. Exterior insulation both insulates and finishes the outside of the building and costs are approximately £45-£65 per square meter. These insulation systems have a lifetime of about 25-30 years, so their time between replacements is very similar to that of the heat pump unit (INCA, 2003).

In addition to added insulation, the windows would need to be replaced to increase the overall thermal efficiency of the house. The replacement windows require a double glazed window or better to meet the minimum standard. These windows cost approximately £220 per window depending on the type of window, the quality of the replacement and the supplier that is chosen. The task of changing the heating over to radiant floor heating is a process that would have to be defined for each and every building as part of the consideration of installation. There are a variety of types of under floor heating that can go between the floor joists, in between the sub and finish floor, and as a layer over a concrete slab floor. The cost of a system is approximately £25-£38 per square meter of floor space (U.S. Department of Energy, 2003). However, the installation would be different for each job because the current flooring must be removed to some extent and then new flooring replaced after the installation. If we look at an example of a small, two story house in Merton, with approximately 100 $m^2$ area, 7 m in height, with 6 windows, we find that replacing the heating system with under floor heating for all 200 $m^2$ of floor space would cost around £6,000. Adding exterior insulation would cost on the order of £15,000. Replacing six windows with double glazed would cost about £1,320. This gives a total refurbishment cost of £22,320 for a small house.

It is because of these extra costs that the Merton housing stock is not suitable for implementation. Although the installation of the system alone is beneficial for the user, the expense needed to bring the buildings up to the requirements of the ground source heat pump are very high. The one advantage to the Merton Council for choosing to implement this system in their housing stock is that much of their housing is in need of insulation, windows and other major repairs, so fixing all of these problems would help them get the buildings up to code as well as prepare for the ground source heat pump. However, Merton only has £1200 budgeted for repair of each home. The costs are much too great for the amount of funds that Merton has available. The added expense of refurbishing the houses in preparation of installing the heat pump is far more than the Council has budgeted for renovations.

### 4.5.3 Benefits of Installation for Merton

There are benefits that the Council would see by implementing this system in their current housing stocks. Many of the benefits would be a solution to problems that they currently have with residents' heating systems. First, the security of a ground source heat pump is much better than that of the traditional systems. From the Council, we discovered that there are problems such as theft of components by outsiders or disgruntled residents. Boilers and radiators are stolen when tenants leave, but since some components of the ground source heat pump are underground, they cannot be stolen. Through our research into the Council, we also found out that they have significant problems trying to attain gas certificates. These certificates are required for every house having a gas system. Every year the system must be checked and approved by an inspector, but the Council has difficulty with tenants not allowing the inspectors in for various reasons. Seven hundred residents, 10% of all Council-owned properties, will not allow the inspectors in to check their systems, which leads to the need for litigation and more money spent by the Council. The ground source heat pump system alleviates this concern because there are not inspections needed, and this would provide the council with extra money in their budget.

### 4.5.4 Funding Options for Retrofitting Council Housing

The best option that the Council can use to implement the ground source heat pumps in their current housing stock is to obtain outside funding and grants that would help with the upgrading of the housing and installation of the system. There are many opportunities that are available for projects that will help with environmental issues and for improving the community as a whole. Some of the more important grants are Clear Skies, the Carbon Credit, and New

Opportunities Fund. If the Council can find support for the restoration of the houses that meet the required criteria, then it would be feasible for them to implement the Powergen package.

The alternative we suggest for the Council, since they are not allowed to build any new houses that could be designed for the ground source heat pump, is to work with the housing associations, RSL's, and private landlords. These groups can build new homes, and if convinced of the benefits of the system, they could look into installing the ground source heat pumps into their newest designs. With the Council's support, these organizations can design their new housing for this technology and take advantage of the offer that Powergen has put forth. Many of the grants and other sources of funding would be open to these segments of the housing community, to help encourage them to fund new buildings making use of the heat pump technology. The Council can investigate this technology package in all sectors, including private, which would help in meeting their requirement for housing to produce energy on site. If the RSL's, Housing Associations, and private landlords began to implement the ground source heat pump, then Merton would still be moving ahead towards many of its housing targets.

## 4.6 Community Perspective

We surveyed the Merton community to determine their attitudes on renewable energy to help us create a successful marketing campaign. The information of most interest is the data from the participants concerning their opinions towards the ground source heat pump system and environmental issues. We used this newly acquired data to shape and direct our promotional strategy – specifically our educational brochure and pamphlet. The survey results may be found in Appendix J.

Of the 55 participants who completed the survey, the majority employed gas heating systems as their source of heat and hot water as illustrated in Figure 4.2. Finding out that 77% of

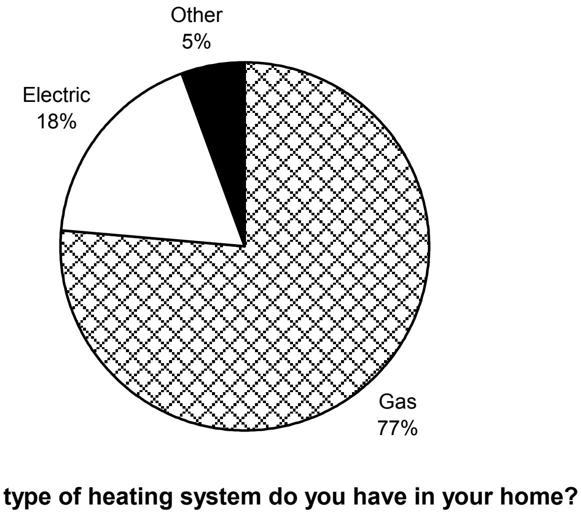



**Figure 4.2**
**Types of Heating Systems**

those surveyed used gas heating systems is useful information for the Council if it decides to use Powergen's ground source heat pump (GSHP) package. The resulting financial aid the Council can receive from The Carbon Trust greatly depends on the type of existing heating system that the ground source heat pump system will replace. The Council can receive the least amount of financial support by replacing gas systems and the greatest support from replacing electric systems.

Our results showed that 76% of survey volunteers were satisfied with their current heating system's performance, while 24% were not. This is important to consider because those who are satisfied with their system may need very strong supporting evidence to convince them to try a new heating system. The on satisfaction with a participant's heating system may be influenced by the cost of their heating. From our data analysis, 13% of the citizens of Merton thought that their heating bills were too expensive while 77% thought they were moderate (see Figure 4.3).

Attitudes on costs pertaining to the maintenance of participants' current heating systems are shown in Figure 4.4. We found that 11% of our sample felt their maintenance was too expensive, and 52% felt their maintenance costs were moderate. Since the majority of

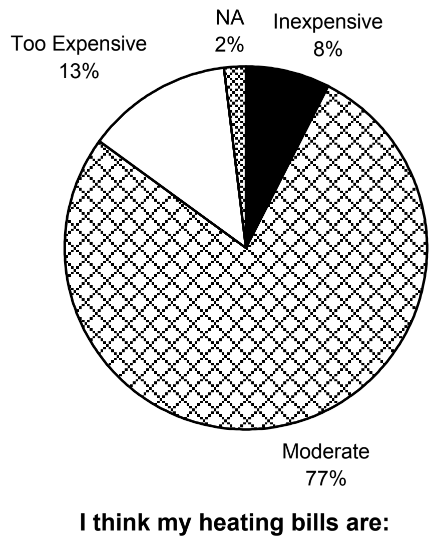



**Figure 4.3**
**Current Heating Expenses**

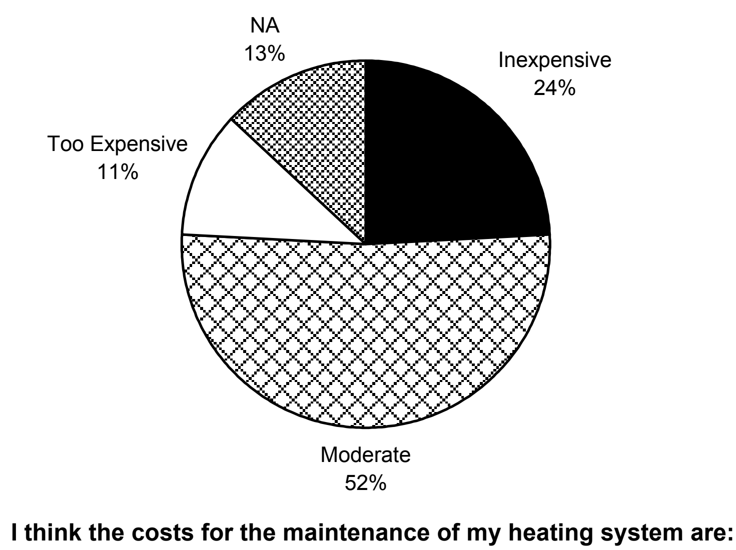



**Figure 4.4**
**Current Heating System Maintenance Costs**

participants feel their heating bills and maintenance costs are reasonable, we tried to emphasize in our educational material that ground source heating has overall costs comparable to gas systems.

Along with questions regarding their current heating system, our survey also asked the participants about their opinions on environmental issues. As shown in Figure 4.5, 87% of the sample either agreed or strongly agreed to being concerned with the environmental issues of today. These data indicated that the environmental benefits provided by the GSHP system may appeal to the public, as the majority of the sample shows concern for the environment.

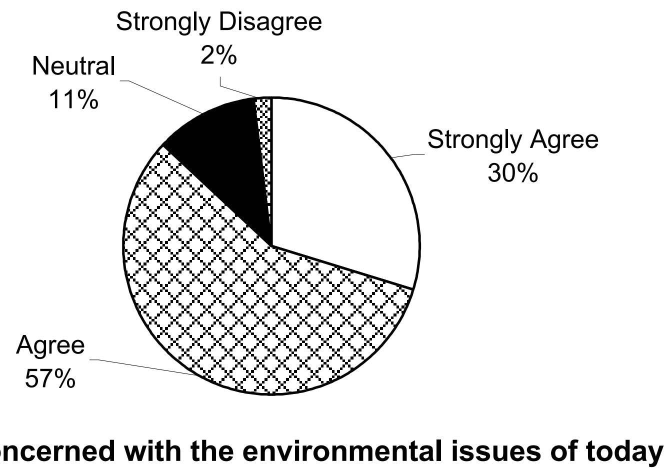



**Figure 4.5**
**Survey Participant Environmental Awareness**

Figure 4.6 shows that 79% of those surveyed favoured environmental products when making purchases. Although the community's current heating systems are not the most environmentally friendly, participants did show that they wanted to purchase environmentally friendly products. With regard to having an ecological heating system in their home, 71% agreed or strongly agreed that they would like to have such a system (see Figure 4.7). This was a further indication of their environmental consciousness.

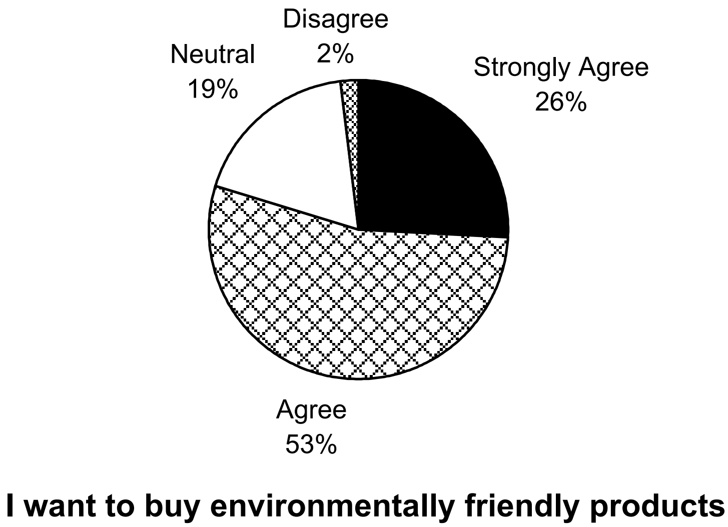



**Figure 4.6**
**Attitudes about Environmental Products**

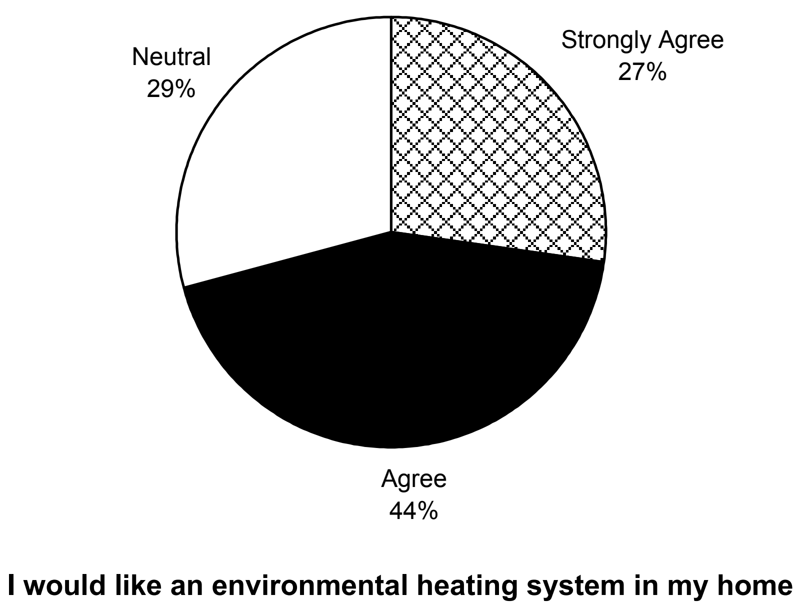



**Figure 4.7**
**Attitudes about Environmentally Friendly Heating**

It was important to gain a more detailed understanding of the participants' concerns and the importance of certain concerns compared to others. Looking at the correlation between the questions "I want to buy environmentally friendly products," and "I want to buy inexpensive products" helped us to accomplish this goal.  Figure 4.8 shows the difference between the consumers' desire to spend or save money, and if their concerns with the environment affected their decision.  We determined that the majority of our sample agreed to both being concerned with prices and being concerned with the environment.

Nineteen percent of the participants expressed that the expense of products were more important to them than the environmental effects, and 22% believed the opposite that environmental friendliness was more important than the price.  The remaining 59% ranked environmentally friendliness and low prices to be of the same importance.  This information told us that we should focus an equal amount on finances as on environmental aspects in our educational material.

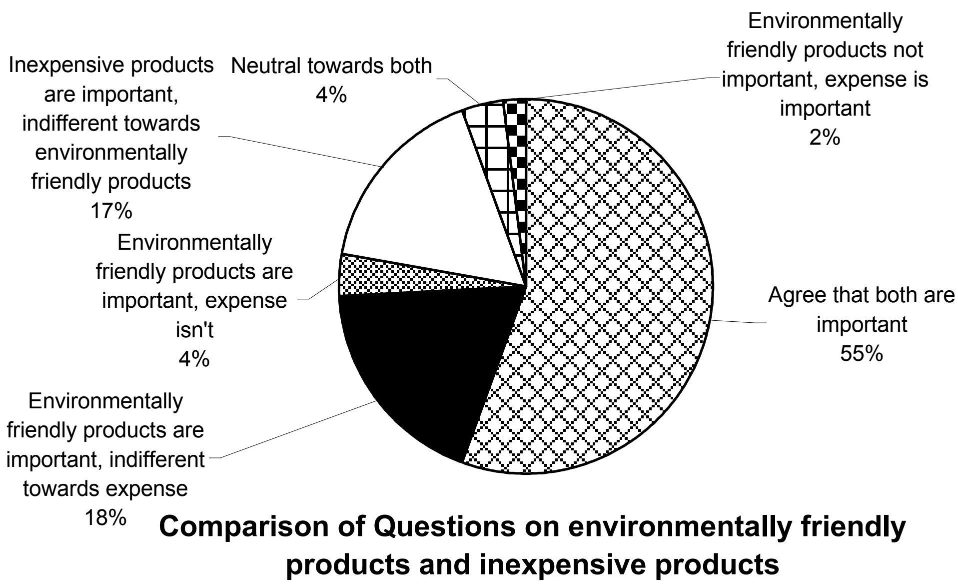
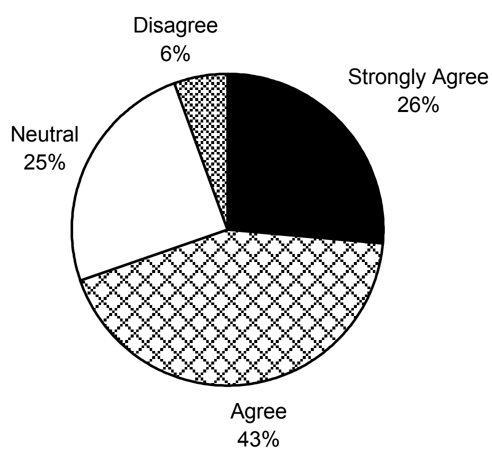



**Figure 4.8**
**Comparison of Attitudes towards Environment and Economy**

After we obtained an idea about attitudes of the target audience, we then addressed the questions that were geared towards the financial state of affairs of the potential consumers. The emphasis was to determine how willing people would be to taking risks and making investments. We also looked at the correlation between how willing people are to invest money and what concerns motivate them to spend their money. Our intentions were to determine the receptiveness of the community to the system. Sixty nine percent of the respondents said that they would be willing to invest in a heating system that saved them money (Figure 4.9) and 93% said that they would support a system that saved them money and was environmentally friendly (Figure 4.10). Similarly, 85% said they would support they system if it were environmentally friendly and the costs were similar to their current system (Figure 4.11). Many of the responses seemed to suggest that the community has an open position to purchasing a ground source heating system.




**I would be willing to invest in a new heating system that will save me money**

**Figure 4.9**
**Willingness to Invest Money**

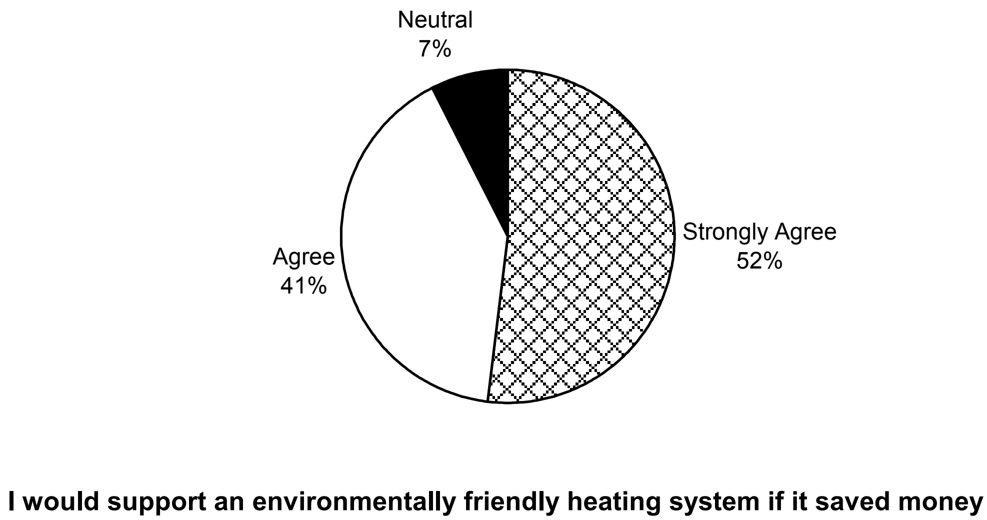



**Figure 4.10**
**Support for System That Saves Money**

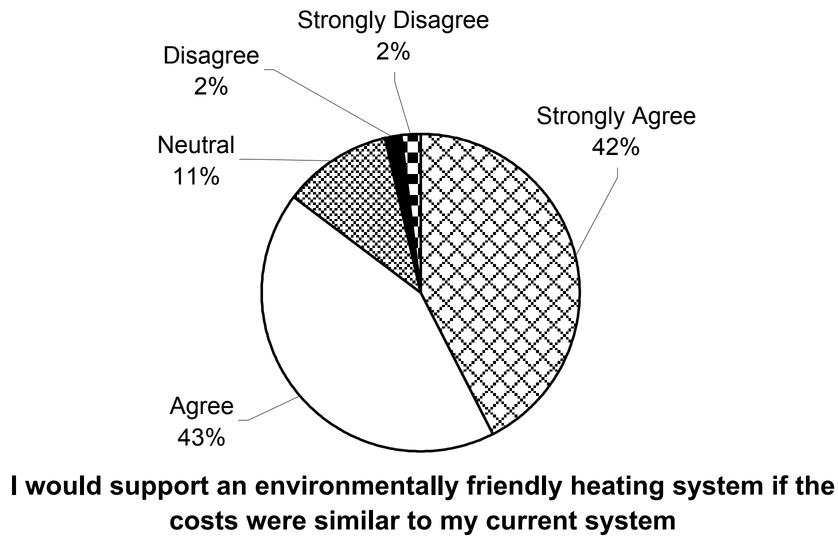



**Figure 4.11**
**Support for System That Has Comparable Costs**

Perhaps the most valuable information obtained was from the question which prompted the participant to tick from a list of concerns that they would have if they were to purchase and install the ground source heat pump system. The results are shown in Figure 4.12. We saw that the top three concerns were maintenance, safety and reliability. We focused on addressing these concerns in our educational brochure and pamphlet to prevent potential consumers from having significant doubts about installing the system.

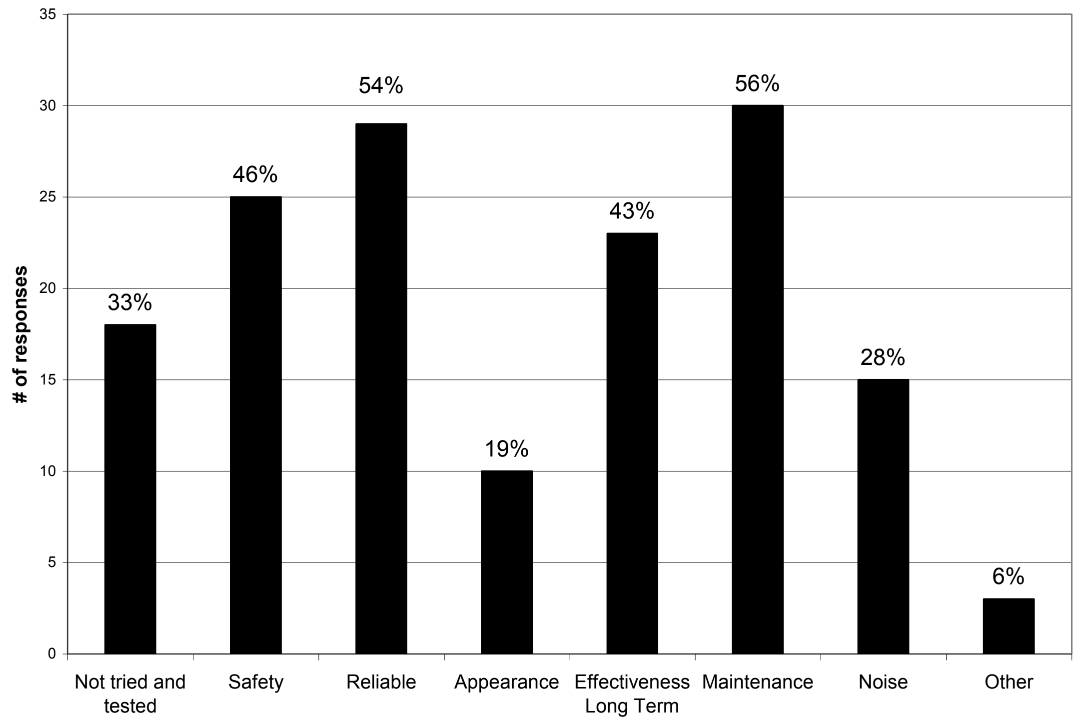



**Figure 4.12**
**Consumer Concerns of New System**

Compiling all of the results that we obtained from our surveys allowed us to look at the main statistics and concerns yielded by our participants.

- 87% of participants are concerned with environmental issues
- 79% of participants want to buy environmentally friendly products
- 74% of participants want to buy inexpensive products
- 93% of participants would support an environmentally friendly heating system if it saved them money
- 85% of participants would support an environmentally friendly heating system if the costs were similar to their current system
- 89% of those surveyed preferred a system that didn't create pollution to create heat

- 71% of those surveyed wanted an environmentally friendly heating system in their home
- 69% of participants were willing to invest in a new heating system if it would save them money

The majority or those surveyed were supportive of a new environmentally friendly heating system, although they thought that the expense of products was also important. In addition, we also found the major concerns expressed by the participants with regard to having a ground source heat pump system were safety, reliability, maintenance, and effectiveness long term

## 4.7 Marketing Results

In order to present the knowledge we obtained through research and various methods used in our report to the Merton Council, we compiled the technical aspects, public's concerns, economic aspects and environmental issues of ground source heat pumps to develop a collection of educational material. We created a pamphlet, a brochure, and a taped presentation to help the Council promote ground source heat pump systems in the Merton community. The pamphlet may be found in Appendix K and the brochure in Appendix L. The creation of this marketing material was given to the Merton Council for their personal education and future promotion to aid in the potential installation of ground source heat pumps in their properties.

### 4.7.1 Technical Components

The technical aspect of our project was the first component that we informed the Merton Community about. New technologies make people apprehensive because they don't fully understand them, but if the workings and benefits of a system are explained, they become more comfortable with it. We included diagrams of the heat pump system in all of our educational material to give the public a more visual understanding of how the system removes heat from the earth and moves it into homes. The combination of visual aids and written explanations allowed us to produce valuable marketing material for the Merton Council and the community.

### 4.7.2 Concerns of the Public

Providing an explanation of the heat pump system only addressed information pertaining to the technology of the system, but it did not address the concerns of the public. In analysing our surveys, we determined that the questions the community wanted answers to were the frequency and difficulty of maintenance, reliability, safety and long-term effectiveness of the system, as shown previously in Figure 4.12.

We addressed the issue of system maintenance and reliability by explaining that the heat pump is not complicated and requires no more attention than a refrigerator. The system pieces make simple connections between each other, so a licensed plumber can properly connect all the pipes, fittings and valves. Once this task is accomplished any problems that may occur are easily repaired by a plumber, according to our interview with a Powergen representative who was involved in designing the system. The agent also stated that the material used to manufacture the underground piping is designed to withstand all weathering conditions for at least 50 years, which greatly reduces the chances of problems occurring with the flexible plastic piping. In our marketing materials we explained that the system is safe because it emits fewer pollutants and does not require combustible fuels to be in the home.

The additional evidence to alleviate concerns pertaining to reliability, safety and long-term effectiveness of the system were answered by relaying the success of the ground source heat pump system in the United States. This alternate method of providing heat has been implemented in over 400,000 U.S. homes today. The system has also been installed in numerous schools across the United States, such as the Middletown Township School in New

Jersey (Abnee, 1999). School heating systems must plan for long-term efficiency in order to maximize their resources. In our brochure we explained that ground source heat pumps are between 300% and 400% efficient, which means they use one unit of electricity to produce up to four units of thermal energy (Office of Energy Efficiency and Renewable Energy, 2002). Having a long lasting system that is very efficient and meets the HVAC requirements is vital to a school, since frequent replacements or maintenance greatly disrupts the learning environment of the students. The large amount of properties that are already using ground source technology would not exist if the system were not reliable, safe, and effective.

### 4.7.3 Economics for Implementation

Installing a new heating system is a significant expense, and cost is a central interest to all consumers. The main focus of our marketing plan was to emphasize that when day-to-day running costs of common heating systems are compared the geothermal system operates at the same or lower costs than the most efficient traditional system. The monthly savings from energy conservation was an important selling point for the system that we conveyed to the Merton community. Although the initial cost of installation is expensive, the heat pump system does not cost that much more than purchasing a new gas or oil heating system.

In our brochure and pamphlet we addressed as many economic concerns that we could think of to answer the public's questions, and help them to make an informed evaluation of the system. We felt that stating facts and statistics were the best way for a consumer to gain confidence in ground source heat pump systems. From our background research we had proof that the system has worked in homes and has saved consumers money. This would help them to determine the economic feasibility of installing a new heating system in their home. The probability of buying this renewable energy system will depend on the state of the potential customer's current system. When a new heating system becomes necessary, our marketing material will inform the Merton Council and the community about the quick payback period of the system. The decrease in heating bills that previous heat pump system owners have received will occur immediately, and can save enough money on heating bills to pay for the system in $1^{1}/_{2}$ – $2^{1}/_{2}$ years and continue to save money for the consumer. The money saved from the system can then allow the buyer to have extra funds that did not exist prior to the implementation of the heat pump system. The additional returns permit the customer to experience economic benefits that improves their quality of living from installing the ground source heat pump system.

### 4.7.4 Environmental Aspects

The final component was to discuss the environmental benefits to having the heat pump system. Unlike the present heating systems found in the Merton area, which are primarily gas according to our research and surveys, the heat pump system emits significantly less pollutants into the environment. This is because ground source energy does not involve the burning of fossil fuels like gas systems do. The only pollutants it does create result from the production of the electricity at the power station that the GSHP uses. People world wide are becoming more aware of global warming, the deterioration of the ozone layer, and the efforts being made to improve the earth's environmental problems. Helping to preserve the environment and prevent further deterioration of the ozone layer is a beneficial component to promoting the system. The majority of the population was willing to enhance the present air quality assuming it did not greatly change their daily routines. Using this information in our marketing campaign we explained that the heat pump system had the capability to decrease polluting emissions and energy use by 44% to 72%, depending on the system it was replacing (Office of Energy Efficiency and Renewable Energy, 2002).

The fact that ground energy is a source of renewable energy improves the air quality, and it will help Merton achieve their alternative energy goal. The Merton Council has set economic standards for themselves with the Unitary Development Plan (UDP), which states that any new build structure must produce 10% of its electricity on site by the year 2004. Knowing the existence of the UDP, we included additional statistical information to inform the Council that implementing the heat pump system in newly owned properties would help them meet the UDP, and help save them money in years to come.

The only disadvantage that we included in our educational information was that the heat pump system cannot use ground source energy to power the entire system. Part of the requirements to running the system includes using a small amount of energy from another method of generating heat, which is usually electricity because it is the most efficient. The system is capable of producing the majority of the heat and hot water necessary to meet the different heating preferences of each home, but the Council and the community had to be aware that the system is not entirely powered by renewable energy. In our educational material we explained that installing the system would enable the Council to successfully achieve their plan and improve their tenant's quality of living, because the reduction of carbon dioxide and additional harmful pollutants was very significant.

### 4.7.5 Promotional Materials

The reasons behind choosing three different types of marketing techniques were to appeal to the interests of the entire Merton Community and the Council. The pamphlet was a tri-fold piece of paper explaining the most basic aspects of the system. This method was intended to appeal to all people in order to give them an overall understanding of how the system will work and the benefits to installing a ground source system. It was not required for the customer to have any technical knowledge to understand how the system would benefit them. If customers did possess a technical background, the type of information that we provided would not be too simplistic for them. It would still provide knowledge in finding out the percentage of energy and money that would be saved once the system was installed. The pamphlet included information on the technology, economics, and environmental benefits to using a ground source heating system.

Producing a brochure provided information about the system in more detail. We introduced a more technical explanation of how the ground source system operates. The diagram we provided that showed how the system operates was more detailed. We labelled the specific components to give an understanding of where the different equipment was located, and how it operated. Having multiple pages to explain the system allowed us to present different case studies to provide more detailed information on ground source heating. Likewise, more facts and statistics were provided to give consumers a more complete understanding of how efficient the system is, and what long term economic savings they could expect.

Verbally presenting our findings about ground source energy allowed us to show and describe how the system works so people are left with a thorough understanding. The educational information that was used in our presentation incorporated and connected the material used in both the pamphlet and brochure. It also allowed us to address the concerns of the public, while giving an explanation of why the community should or should not have reservations about having a renewable energy heating system in their home. In addition to addressing specific concerns, the presentation gave us the opportunity to go over the diagram that we used in our pamphlet and brochure to eliminate confusion. By guiding people through how the system operates, we hoped to provide them with a clearer awareness as to how the system works.  Recording the entire presentation will allow the Council to review all the components to installing a heat pump system in their properties, and further consider additional questions that were addressed at the conclusion of our presentation.  The combination of pamphlets, brochures and a recorded presentation will allow the Council to further enhance their understanding of ground source heating, and use the material for future marketing and educational purposes.

# 5 Conclusions and Recommendations

The research we have conducted has led us to draw many conclusions about ground source heat pumps and their potential use in the London area. We evaluated the heat pump system and determined what appears to be the best course of action for the Merton Council to take next.

## 5.1 Financial Benefits of the Ground Source Heat Pump

There are many characteristics of the heat pump system that make it financially beneficial to the consumer. When purchased in quantities of six or more from Powergen, the buyer will receive all of the physical pieces for the discounted price of £2,500 per system. Another advantage of the initial purchase is the funding and grants that can be received to help further defer the capital cost. Clear Skies will give funding for environmentally friendly projects such as the Powergen heat pump system. The Clear Skies grant has the potential to provide individuals with up to £5,000 and communities with up to £100,000. The Carbon Trust provides a rebate, between £500 and £1,500, based on the amount of carbon emissions savings the lifetime of the ground source heat pump. There are other prospects of funding for the Council such as the New Opportunities Fund. The ground source heat pump initial cost of £5,000 can be lowered considerably by taking advantage of these sources of funding.

In addition, the operational expenses of the ground source heat pump can be beneficial. In comparison with electric systems, geothermal energy is favoured. Electric heat requires four times more energy because of its lower efficiency. Comparisons to gas systems are dependent on the size of the building. For small dwellings requiring little energy a gas system incurs a smaller annual cost, but as the size and energy requirements of the building grow the difference between the running costs turns in favour of the ground source heat pump.

## 5.2 Environmental Benefits of the Ground Source Heat Pump

The savings to the environment is the second important aspect of ground source heating systems that would be a key benefit to the Merton community. The system burns no fossil fuels and further reduces carbon and $CO_2$ emissions by cutting back on energy usage by 400% compared to an electric system. The heat that is always contained in the earth is the "fuel" used to run this system. The underground piping is engineered so that although the system draws heat from the ground, it will not draw more energy than the ground can simultaneously replenish. This system helps the environment not only by eliminating the need for fossil fuel consumption, but also by requiring less electricity. Although one of these two conditions can be met using common systems such as gas to save electricity or electric to eliminate fuel burning, the ground source heat pump accomplishes both goals.

## 5.3 Ground Source Heat Pump Feasibility

Our results have shown that the ground source heat pump is a technically feasible option for the London area that provides noteworthy economic, environmental, and operational benefits. After comparing the characteristics of all of the systems, we concluded that the ground source heat pump is better than electric heating. The financial comparison with gas condensing boiler systems is variable. The initial cost of installing a gas system is less expensive than geothermal. In addition, the differences in running costs depend on the performance and size of the building. However, the environmental savings that are seen in a ground source heat pump system are invaluable. The benefit of not directly emitting any pollutants is an important factor that gas, oil and electric systems do not provide to consumers. The ground source heat pump will lessen the drain on the already dwindling U.K. fossil fuel supplies. The long life of the system, the ease of installation, and the low maintenance costs make the heat pump a safe choice that will not cause high, unforeseen operation costs.

## 5.4 Impact on the Merton Community

From the results of our community survey, it is evident that there would be support from the residents of Merton, both those living within Council-owned properties and those in privately owned housing. They are interested in the technology and are willing to invest in it. If Merton were to introduce the heat pump program in their borough, they would be one of the first communities to take such an environmental initiative. This makes the idea of implementing the Powergen package in Merton highly attractive if implementation in the community was possible.

## 5.5 Implementation in Merton

The housing stock that the Council owns is a mix of many properties, the majority being low-income housing. The system requires stand alone and terraced housing, which makes up approximately one third, about 2,000, of the Council's homes. Since the Council is not allowed to build any new properties, which the heat pump system was designed for, a retrofit is necessary for the Council's housing stock. Because many of the homes are older and in need of repair, the major task in a retrofit is upgrading the house to an energy efficiency that would allow optimum performance of the heat pump. The minimum requirements would consist of the installation of new windows, exterior insulation, and under floor heat distribution. The total cost of all these operations is in excess of the £1,200 per home that Merton has already budgeted for repairs that they know must be completed to bring the homes up to standard. This set amount is insufficient to fund the projects necessary to prepare a home for the installation of the Powergen heat pump unit. We recommend that the Merton Council not try to implement the ground source heat pump program in their housing stock at the present time due to the enormous expense that would be incurred in renovating and retrofitting existing homes in order to install the system. Our research shows that the benefits of the heat pump will not be outweighed by the expense needed to complete the installation. If they are still interested in pursuing the possibility of installing the heat pump system in Council-owned properties, we recommend that they investigate alternative means of funding. If the Council can acquire sufficient financial resources to fund the retrofitting of their properties, it would then be to their advantage to proceed with a retrofit in their properties.

## 5.6 Recommendations to the Merton Council

Although we have suggested that the Council discontinue the concept of a ground source heat pump in their existing housing, this does not end their role in the project. Instead, we recommend the Council to use their influence with Registered Social Landlords and private landlords to educate them and encourage the investigation of this technology in the Merton Community. These organizations can build new housing and would be eligible for buying the Powergen package at the lower rate as long as they are installing more than six systems. The Council has already taken steps to increase environmental consciousness with their plan for new buildings producing 10% of their energy on site. By encouraging other members of the community to pursue this technology, Merton will still be making strides towards reducing carbon emissions and improving the standard of living of its residents, while at the same time setting a trend in environmental building for other communities to follow.

The promotional and educational material that we have created will help the Council to introduce and educate possible consumers about heat pump systems. The presentation of our findings as well as those of other experts in the field were recorded and are available to the public. Supporting the presentation, we produced a pamphlet that introduces the technology of ground source heat and gives a brief overview of the system. For those that desire a greater understanding of ground source heat pumps, we designed a brochure that details specifics of the system's operation and costs.

We recommend the Council to be cautious in its progression on this project. It is important to educate the community about the ground source heat pump, and encourage RSL's and Housing Associations to investigate the system, as it is potentially a valuable technological advance. At the same time, although the system has been proven to work in the United Kingdom, it has not yet been tested in the London area, which has a different geology, sitting on a bed of clay. It is possible that the system will not operate in the same manner as it has been shown to do elsewhere. It would be beneficial for the Council to examine how well the system will work in the London area before taking steps to implement. The Merton Council could work with EarthDome, a company who is implementing this system in the London area in a set of flats, to see how effectively the system works in practice.

In addition, it is important to reiterate the necessity of working with accredited installers if the Council decides to implement the system. Most of the failures of the ground source heat pump system are due to poor installation jobs. If the Council or community took this project to the next level and began installing the system, they would need to be sure that their system was effective, as their project could be setting the stage for future use of the heat pump in the U.K.. If the installation in Merton failed due to poor contracting, it would put ground source heat pumps in a negative light. To avoid this, Merton Council should encourage the use of reliable installers, such as those who have been approved and accredited by the Clear Skies organization.

The implementation in Merton, either by the Council or other groups, would help further the Council and U.K.'s goals of reducing energy consumption and pollution. In addition it would aid the community to increase the standard of living in the area, by making heating more efficient and affordable.  By being one of the first to implement this technology, Merton would be a leader in protecting the environment by significantly reducing carbon emissions and protecting the United Kingdom’s fossil fuel supplies.  A successful implementation in Merton would help encourage other communities to investigate and perhaps invest in the technology. Eventually, Merton’s pioneering use of this technology could help make a significant, consequential difference in reducing the depletion of natural resources and the destruction of the environment, helping improve the future for generations to follow.

# Bibliography


Abnee, Conn. (1999). Back to the Earth. November 1999 issue of American School & University. Intertec Publishing. Overland Park, KS.

Armstead, H. Christopher (1978a). Geothermal Energy. New York: E. & F.N. Spon.

Armstead, H. Christopher (1978b). Geothermal Energy, Second Edition. New York: E. & F.N. Spon.

Axaopoulos, P., Panagakis, P., & Kyritsis, S. (1998). Experimental comparison of a solar-assisted heat pump vs. a conventional thermosyphon solar system. International Journal of Energy Research, 22(13), 1107-1120.

Berg, B. L. (2001). Qualitative Research Methods: For the Social Sciences. Needam Heights, MA: Person Education Company.

Bird, L., Wustenhagen, R., and Aabakken, R. (2002a). Green Power Marketing Abroad: Recent Experience and Trends. Colorado: National Renewable Energy Laboratory.

Bird, L., Wüstenhagen, R., and Aabakken, R. (2002b). Green Power Marketing Activity. Colorado: National Renewable Energy Laboratory. Retrieved November 29, 2002, from the World Wide Web: http://www.eren.doe.gov/greenpower/pdf/32155.pdf

Blank, E. Bird, L., Swezey, B. (2002). A Certificate-Based Approach to Marketing Green Power and Construction New Wind Energy Facilities. Washington: Green Power Marketing.

B.P. Solar International, LLC. (2002). Cost of Solar Power. Retrieved November 29, 2002, from the World Wide Web: http://www.bpsolar.com/ContentDetails.cfm?page=51

Brus, E., & Golob, R. (1993). The Almanac of Renewable Energy. New York, NY: Holt.

Bukowinski, M.S.T. (1999). Taking the Core Temperature. Nature, 401, 433. Retrieved December 3 2002 from the World Wide Web: http://chianti.geol.ucl.ac.uk/~dario/pubblicazion/401432A0.pdf

Business Resource Software, Inc. (1999). Insight for Sales Strategy. Retrieved from the World Wide Web: http://www.brs-inc.com/sales_strategy.asp

Clear Skies. (2003). Renewable Energy Grants. Retrieved from the World Wide Web: http://www.clear-skies.org/default.htm

Econar Energy Systems (2002). Econar. Retrieved November 20, 2002 from the World Wide Web: http://www.econar.com/econar.html

Fitzgerald, M. (2002). PV Power Resource Site. Science Communications Inc. Retrieved November 20, 2002 from the World Wide Web: http://www.pvpower.com/misc.html.

Folster, R. (2002). Photovoltaics- Solar Electricity. El Paso Solar Energy Association. Retrieved November 20, 2002 from the World Wide Web: http://www.epsea.org/ pv.html.

Geoexchange. (2002). Residential: How it Works. Retrieved on January 30, 2003 from http://www.geoexchange.com/residential/residential.htm

Geoscience Limited. Geothermal Sevices. Retrieved February 6, 2003 from the World Wide Web: http://www.geoscience.co.uk/geothermal.html

Geothermal Heat Pump Consortium. (2002). GeoExchange. Retrieved from the World Wide Web: http://www.ghpc.org/home.htm

Green, M. A. (1982). Solar Cells: Operating Principles, Technology, and System Applications. New Jersey: Prentice-Hall.

Hadly Centre. (2002). Clouds. Retrieved December 1, 2002 from the World Wide Web: http://www.earth.nasa.gov/visions/in-situ/chap32.htm

Healy, P. F., & Ugursal, V. I. (1997). Performance and Economic Feasibility of Ground Source Heat Pumps in Cold Climate. International Journal of Energy Research, 21. 857-870

Holt, E.. (2000). It's The Market, Stupid!. The Regulatory Assistance Project. Retrieved from the World Wide Web: http://www.rapmaine.org/gpnews7.htm

Home Heating Fuels. (1995). Air Conditioning, Heating & Refrigeration News, 194, 15.

Hughes, Patrick J. (2001). Geothermal Heat Pumps as a Cost Saving and Capital Renewal Tool. Energy Engineering, 98:4, 59-80.

INCA: Insulated Render & Cladding Association. (2003). What are insulated render & cladding systems? Retrieved February 6, 2003, from the World Wide Web: http://www.inca-ltd.org.uk/page6.asp

Kara, Y.A., Yuksel, B. (2001). Evaluation of Low Temperature Geothermal Energy Through the Use of Heat Pump. Energy Conversion and Management, 42:6, 773-781.

Kempcke, K. (2002). Earth Day. St. James Encyclopedia of Pop Culture. Gale Group. Retrieved December 7, 2002 from the World Wide Web: http://www.findarticles.com/ g1epc/tov/2419100384/p1/article.jhtml

Khale, D. (1995). The Most Powerful Tool You've Got. Associated Equipment Distributors. Retrieved from the World Wide Web: http://www.aednet.org/ced/apr97/saletool.htm

Komp, R. J. (1984). Practical Photovoltaics: Electricity from Solar Cells. Michigan: Aatec Publications.

Livingstone, K. (2002). The Mayor's Draft Energy Strategy. Retrieved November 9, 2002 from the World Wide Web: http://www.london.gov.uk/approot/mayer/strategies/energy/docs/draftenergystrat.pdf

London Climate Change Partnership. (2002). London's Warming The Impacts of Climate Change in London. Retrieved November 9, 2002 from the World Wide Web: http://www.london.gov.uk/approot/gla/publications/environment/londons_warming02.pdf

Merton's Air Quality Action Plan. (2002). Retrieved November 29, 2002 from the World Wide Web: http://www.merton.gov.uk/planningpp/airquality.asp.

Merton Council. (2002a). Merton's Housing Need and Supply. Retrieved December 5, 2002, from the World Wide Web: http://www.merton.gov.uk/housingpolicy/mertonstrategy/needandsupply.pdf

Merton Council. (2002b). Housing Strategy Update. Retrieved December 5, 2002, from the World Wide Web: http://172.32.1.5/housingpolicy/housingplans.asp#hs

Merton Council. (2002c). Working. Retrieved December 5, 2002, from the World Wide Web: http://www.merton.gov.uk/working/index.asp

Merton Council. (2002d). Directory of Businesses. Retrieved November 30, 2002, from the World Wide Web: http://www.merton.gov.uk/business/

Merton and The Council. Retrieved December 5, 2002 from the World Wide Web: http://www.merton.gov.uk/bestvalue/acrobat/bv2002/mertonandthecouncil.pdf

Merton. Retrieved December 5, 2002, from the World Wide Web: http://www.merton.gov.uk/council/indes.asp

Met Office. (2002a). Climate Station Networks. Retrieved December 1, 2002, from the World Wide Web: http://www.meto.govt.uk/climate/uk/networks/index.html

Met Office. (2002b). England & Wales Rainfall Chart. Retrieved December 1, 2002, from the World Wide Web: http://www.meto.govt.uk/climate/uk/seriesstatistics/ewrain.txt

National Renewable Energy Laboratory. (2002). Introduction to Photovoltaic Systems. Retrieved November 9, 2002 from the World Wide Web: http://www.nrel.gov/clean_energy/photovoltaic.html

Natural Environment Research Council. British Antarctic Survey – The Ozone Hole. (2002). Retrieved December 1, 2002 from the World Wide Web: http://www.antarctica.ac.uk/Schools/Research/ozone.html

New Opportunities Fund. Current Environment Initiatives. Retrived Febreuary 10, 2003 from the World Wide Web: http://www.nof.org.uk/indes.cfm?10c=env&inc=index

Office of Energy Efficiency and Renewable Energy. (2002). Geothermal Technologies Program. Retrieved November 9, 2002 from the World Wide Web: http://www.eren.doe.gov/geothermal.html

Popat, L.V. (1983). The Economics of Geothermal Power. Engineering Costs and Production Economics, 7(2), 159-170.

Powergen. (2003a). Wind Energy. Retrieved January 21, 2003, from the World Wide Web: http://www.powergenplc.com/world/environ_farm.asp

Powergen. (2003b). Wind Energy in the UK. Retrieved January, 15, 2003, from the World Wide Web: http://www.powergenplc.com/world/environ_farm.asp

Power Systems Group/AMETEK Inc. (1979). Solar Energy Handbook. Randor, Pennsylvania: Chilton Book Company.

Rabl, Ari. (1985). Active Solar Collectors and Their Applications. New York: Oxford University Press.

Should you change your heating system, fuel? (2000). Consumer Research Magazine, 83, 11.

Sound Geothermal Corporation. (2002). Home Page. Retrieved November 9, 2002, from the World Wide Web: http://www.soundgt.com.

The Weather Channel Enterprises, Inc. (2002). Climate Statistics. Retrieved November 9, 2002, from the World Wide Web: http://www.weather.co.uk/weather/climatology/UKXX0085.

Traynor, I. (1997). Lessons From the Carpet Soukes of Morocco. Marketing Magic. Retrieved from the World Wide Web: http://www.marketingmagic.biz/archives/archive-selling/thousand-year-old-sales-technique.htm

U.S. Department of Energy: Office of Energy Efficiency and Renewable Energy. (2003). Consumer Energy Information: EREC Reference Briefs: Radiant Floor Heating and Cooling Systems. Retrieved on February 6, 2003 from the World Wide Web: http://www.eere.energy.gov/consumerinfo/refbriefs/bc2.html

Wieder, Sol. (1982). An Introduction to Solar Energy for Scientists and Engineers. New York: John Wiley & Sons.

Wiser, R., Bolinger, M. & Holt, E. (2000). Customer Choice and Green Power Marketing: A Critical Review and Analysis of Experience to Date. U.S. Department of Energy.

# Appendix A – The Merton Council and Mr. Robert Harris

A four-town merger of Mitcham, Morden, Merton and Wimbledon formed the London Borough of Merton in 1965. According to the constitution created specifically for the Borough, "Merton must provide clear leadership to the community in partnership with residents, businesses, the voluntary sector, and other groups in the community" (Merton, 2002). The requirement to have a governing body that actively supports and includes the involvement of residents when decisions are made, was the basis for the formation of the Merton Council. The Council is responsible for all aspects of the community, and it is the duty of the members involved to uphold a sense of order, support, and opportunity to the Borough of Merton (Merton, 2002).

The Council currently consists of 60 members, or councillors, of both men and women whom are supported by a staff of over 5,000 people (Merton, 2002). The persons employed by the Merton Council are not only personnel who work directly under the councillors; in fact, a large proportion of the 5,000 employees are teachers and other school staff. All workers are organized into five specific departments: The Chief Executive's Department, Education, Leisure and Libraries, Environmental Services, Financial Services, and Housing and Social Services. Each of the five departments plans and manages services in correspondence with the priorities agreed by the Council (Merton and The Council, 2002).

Over the past few years, the Merton Council has undertaken an active roll in trying to improve the ecological state of the Borough of Merton. In an attempt to satisfy requests made through the Environment Act of 1995 and the National Air Quality Strategy, the Council is required to develop an action plan to decrease the amount of particulates and nitrogen dioxide present in the environment of the Borough by 2005. As a result of identifying "air quality management areas” within the community, the Council has been able to develop environmentally efficient programs, such as promoting renewable energy, to the Borough in hopes to decrease the amount of pollutants present in the atmosphere (Merton’s Air Quality Action Plan, 2002)

Mr. Robert Harris is an independent developer who is working in conjunction with the Merton Council on the implementation of ground source heat pumps in the London area. He has a development company, EarthDome. Mr. Harris is working with Powergen and GeoScience to build a set of four flats that will make use of the ground source heat pump technology in London Clay. He is working with the Merton Council to help encourage the use of this technology throughout the United Kingdom.

# Appendix B -- Task Chart

## Task Chart

| | WEEK 1 | | | | | | | WEEK 2 | | | | | | | WEEK 3 | | | | | | | WEEK 4 | | | | | | | WEEK 5 | | | | | | | WEEK 6 | | | | | | | WEEK7 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Jan 13 - 19 | | | | | | | Jan 20 - 26 | | | | | | | Jan 27 - Feb 2 | | | | | | | Feb 3 - 9 | | | | | | | Feb 10 - 16 | | | | | | | Feb 17 - 23 | | | | | | | Feb 24 - 28 | | | | |
| **TASKS** | M | T | W | R | F | S | *S* | M | T | W | R | F | S | *S* | M | T | W | R | F | S | *S* | M | T | W | R | F | S | *S* | M | T | W | R | F | S | *S* | M | T | W | R | F | S | *S* | M | T | W | R | F |
| Survey Development | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Survey Merton Link | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Survey St. Heliers | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Survey Centre Court | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Survey Merton Civic Centre | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Survey Analysis | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Research of Housing Stock | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Interviews with Experts | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Interview Transcription<br>And Analysis | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Create Educational Pamphlet | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Create Educational Brochure | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Develop Conclusions and<br>Recommendations | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Develop Final Presentation | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Final Presentation | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Write IQP Report | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

# Appendix C -- Survey

<u>Heating System opinion Poll</u>

Please Circle One:

1. What type of housing do you live in?

   Council owned    owner occupied    other

   Housing Association tenant    private tenant

2. What type of heating system do you use to heat your home?

   Gas    Electric    Other

3. What temperature do you keep you house/thermostat at?

   Cold    Warm enough to take the edge off

   Warm    Hot

4. I think my heating bills are:

   inexpensive    moderate    too expensive

5. Are you satisfied with the performance of your current system?

   Yes    No

6. Have you ever considered changing your current system?

   Yes    No    N/A

7. If yes to question 6, what kind of system would you choose?

   Gas    Electric

8. In the past 2 years, how many times has your heating system not worked?

0 1-5 5-10 more than 10

9. I think the costs for the maintenance of my heating system are:

inexpensive moderate too expensive N/A

Please check the box that best describes your feeling about the statement.

| STATEMENT | Strongly Agree | Agree | Neutral | Disagree | Strongly Disagree |
|---|---|---|---|---|---|
| I am concerned with the environmental issues of today. | | | | | |
| I want to buy environmentally friendly products | | | | | |
| I want to buy inexpensive products | | | | | |
| I would support an environmentally friendly heating system if it saved money. | | | | | |
| I would support an environmentally friendly heating system if the costs were similar to my current system | | | | | |
| I would like to have a system that does not have to burn fuel and produce pollution to create heat. | | | | | |

Please check the box that best describes your feeling about the statement.

| STATEMENT | Strongly Agree | Agree | Neutral | Disagree | Strongly Disagree |
|---|---|---|---|---|---|
| I would like an environmental heating system in my home. | | | | | |
| I would be willing to invest in a new heating system that will save me money. | | | | | |

10. Below are possible concerns people may have about environmental heating systems. Please check all that apply to you.

- ❑ Not tried and tested
- ❑ Safety
- ❑ Reliable
- ❑ Appearance of system
- ❑ Effectiveness long term
- ❑ Maintenance
- ❑ Noise
- ❑ Other___________________________________

-----------------------------------------------------------------------

The following section is optional.

Ethnic Origin (please tick)

| | | | |
|---|---|---|---|
| White | __ | Tamil | __ |
| White Irish | __ | Asian Other | __ |
| White Other | __ | Black British | __ |
| Mixed Race | __ | Black Caribbean | __ |
| British Asian | __ | Black African | __ |
| Indian | __ | Black Other | __ |
| Pakistani | __ | Chinese | __ |
| Bangladeshi | __ | Other | __ |

Age (please tick)

| | |
|---|---|
| 18 – 25 | __ |
| 25 – 45 | __ |
| 45 – 60 | __ |
| 60 + | __ |

Gender (please tick)

| | |
|---|---|
| Male | __ |
| Female | __ |

# Appendix D – Interview Guide I
# Powergen

System Specifications:

1. What type of refrigerant, heat transfer fluid will be used?
2. Pipe length?
3. Auxiliary system?
4. Weather compensated control?
5. Energy output of system?
6. Electricity requirements of system?
7. General system designs/specifications

Installation:

1. How long does installation take?
2. How much of a disruption to the residents?
3. Borehole depth? Width?
4. Where is ideal installation location?
5. What are the specific requirements a location MUST have in order to properly install/implement the system?
6. What requirements would make a location ideal?

Operation:

1. Electricity provisions: use of economy 7 tariff period, solar, sterling engine?

Maintenance:

1. Expected lifetime?
2. How often will repairs/maintenance be necessary?
3. How available are parts for repairs?
4. Are specialists needed to service?
5. Potential causes of failure/problems?

Economic:

1. What are potential costs for the following?
    a. Heat pump equipment
    b. Installation of exchanger
    c. Installation of piping
    d. Usual maintenance
    e. Fuel/electricity consumption
2. What are the expected monthly costs for consumers?

Environnemental:

1. Emissions?
2. Soil contamination?

# Appendix E – Interview Guide II
# BRE, Geoscience, Bree Architects

Current Housing Stock condition: (explanation of the current condition to interviewee) The current Council properties consist of pre-WWII terrace and stand-alone houses that have had little renovation since their constructions. They are poorly insulated and have old windows and gas heating systems.

<u>Questions:</u>

1. What steps need to be taken to bring houses up to condition so the system can be implemented?

2. What steps does retrofitting actually involve? How is it done and what is done?

3. How much disruption will it be to current residents? Will they need to move out? For how long?

4. What are the costs for bringing a house up to par? What are the costs for installing the system?

5. What are the land requirements for installing the system?

6. Do you think that retro-fitting older houses is worth the money? Or would it be better used in new housing? (Recommendations?)

# Appendix F – Interview Transcript -- Powergen

## PowerGen Meeting Transcript

**Thursday, January 23rd, 2003**
**Adrian Hewitt, Robert Harris, John Parker**

**John Parker:**

- PowerGen
- Earth Energy Engineering
- Project manager
- Designed system
- Consultant to PowerGen

**Merton Involvement Rationale:**

- Unitary Development Plan (UDP)—all newly built properties must generate 10% of their total energy consumption by alternative means
- Total energy consumption includes both electricity and thermal energy
- Solar can only product 2.5% of total energy used in most normal cases, so another means must be found to meet this requirement
- Can help meet by reducing overall energy use by making the houses more efficient through having more insulation, ect…
- Concerns: if its difficult to meet this requirement, and other boroughs don't implement the same rules, than people/businesses may move away from Merton to an area where they don't have to do this ($$)
- Concerns: this could damage the economy of area if businesses/developers move out to areas where they don't have this there will be less jobs, new housing
- Proposed to London gov't. to make this a mandatory thing in all boroughs, this will level the playing field and actually help poorer areas
- Building in Wimbledon trying to retroactively meet this mark, can only get down to 4%

**Acceptance of New Technology:**

- People in UK generally need about 5 years of proof that a technology is viable and works, this will allow assessment of credibility

**Applicability/Feasibility in London:**

- Ground is better than in the U.S.
- Geology is very variable in the U.K.
- Works better in the U.K. because the ground is wet—increases the thermal conductivity of the soil, so the ground holds more heat and gives it up easier
- UK doesn't really need the cooling component like the U.S. does (temps don't vary as much or get really hot ever), so only need the heating component of the system
- US systems are ducted because they are used for cooling
- U.K. commercial use heating/cooling systems
- Heat only systems need bigger ground loop because you're not ever putting energy back into the earth

**Ground Loops:**

- Novel to builders

- Must be done EARLY (before contractors get on site) to eliminate add-on costs by contractors who are trying to make the installation seem more difficult/involved than it really is
- Must determine, mark where the holes are to go first before construction equipment gets on sight, potentially blocking where the pipes will be installed
- Vertical installation can help eliminate problems/ confusion with builders, it's harder for them to damage the pipes while they are working
- Horizontal installation is much cheaper, but not practical for installation in London

**Pipes and Fluid:**

- Circulating liquid (65% water & 35% ethylene glycol), runs at 1°-3 °C
- Very viscous at operating temps of 1, 2, 3 °C
- Need turbulent flow to keep thermal performance
- Can get laminar flow if the mixture gets too cold (undesirable)
- Potential issues with contractors/plumbers treating like the fluid is just chilled water…it's a mixture and operates at temps much colder than chilled water…and this must be kept in mind
- Flexible enough to withstand earthquake
- Major problem is people digging and damaging them
- If outside, need to mark where they are so they don't get dug up/damaged
- Tremy pipe placed in-between the U-pipes to keep stable and to fill the hole with grout

**Circulating Water Pumps (in ground)**:

- Energy losses (see above)
- Run at 80W instead of 160W
- Two possible providers (Grundfus and Wileou)
- Use Wileou simply because Grundfus cant operate at temps below 15°C

**Circulating Pump (above ground):**

- Grundfus
- Has two circulators in one body
- Runs at a very low speed

**Heat Pump:**

- Equipment in house is very small (500 $mm^2$ in area)
- Low enough to fit under kitchen cabinets
- Circulating pump and heat pump are inside house
- These are separate components to allow them to be easily installed in all circumstances/physical constraining areas
- Only 4 connections (2 pipes in and 2 out)
- Weather compensated control system not needed:  Too expensive, controlled on room thermostat, knob on pump controls the hot water temp
- Water heater, pump, pump box are all separate to allow for different installation set-ups

**Distribution System:**

- Works best with under floor heating
- Perhaps provided by Thermo floor?
- Auxiliary system - Immersion heater fitted on hot water tank, you can wire it up or not, not really needed, built in contingency plan

**Drilling:**

- 5m between holes
- Must be 3-4 m away from walls of house
- Must be 2-3 m away from neighbour's property
- Need sufficient space to get the drilling done (get equipment to the site of holes)
- If you were drilling lots (more than 20) holes, they could be improved through soil testing…it may turn out that you don't need as many as you think if the soil is really thermally conductive, but this is only cost effective if you're putting in lots of holes
- Depth: 60-100m
- Width: 100 mm (5in)
- About £800 to get drilling equipment on site
- Bob suggests that Merton gets its own drilling team to do these installations and be hired out by other communities
- Many contractors will try to make it seem harder than it really is to put in these holes; they may be for a specialized, novel purpose, but threes nothing special about the holes themselves
- Because the holes only have to stay open long enough to install the piping, the ground stability isn't as important of a factor unlike water mains which have to stay open for 50 years
- May be drilled by GSI (GeoScience Inc. Robin Curtis contact, geothermal engineering company/ nuclear thermal engineering, Falmouth)
- GSI don't own their own drilling rigs
- GSI will hire out the contract to local drilling teams because they know how to work with the specific soil conditions much better
- Drilling is messy and disruptive

**Miscellaneous. Installation:**

- Plumbers can do circulating pump, pipe fittings
- Builders need to put in heat pump
- Installation time scale is totally dependent of builders
- Really only takes about 1 day to install the system
- One day to do all the pipe connections
- One day to do drilling and putting in piping
- Retro fit easier if there is a front yard to put holes in
- Piping goes in first & Heat pump comes later on
- Best to put in ground loop before all other construction begins, just to keep it from getting damaged
- PowerGen package will be installed by people selected by PowerGen
- CONCERN: in highly populated areas, is there enough land? May not be able to get the loops installed

**PowerGen Program Specifications:**

- Aimed at installing 6+ heat pumps per site
- Free standing houses
- 1 heat pump per dwelling

**PowerGen Program**:

- Will only install in set of 6 freestanding ground loop systems per site - minimum

- Assessment done on site-by-site basis by PowerGen to determine best fit
- Only will provide non-reversible heat pumps (no cooling)
- PowerGen will Asses the thermal efficiency of the building
- They will select what package of heat pump kit you need
- They will tell you what size bore hole you need
- Package is given to you all set to go
- Powergen will walk you through the installation process once the system arrives

**Energy Input:**

- System uses 1kw electric motor
- System can run off 13-amp circuit, which is normal circuit in houses, best if separately wired on "cooker" circuit
- Wired back to the consumer supply on its own circuit (needs no special electricity stuff)
- If you limit the starting current needed to <30A, there will be no flickering of the lights when the system starts up
- PowerGen system starts up at 28A
- PowerGen created soft start device t limit starting current especially for social housing to not disrupt consumers and Power Company
- For big systems requiring larger starting currents, can get soft start controllers which will keep the lights from flickering (£200-300)

**Energy Output:**

- No fixed thermal analysis process to design
- Need to go through iterative process to determine the best set up for the system
- Need to consider the energy use of the household, the energy stored in the ground,
- No absolute guide on how much energy (kilowatt hours) the system can put out as it is dependent on all three things listed above
- These three lead to a coefficient of performance (COP) for the system
- You never really can tell how effective the GSHP will be because you never can truly predict the energy demands of the house
- For small houses (<100m$^2$) it can be predicted that the system will put out about 500kw
- Need to be careful not to overcompensate and make the system bigger than needed, as this will make it more inefficient, actually better to undersize rather than oversize
- Heats hot water up to 60 °C
- Performance of heat pump is highly dependent of performance of ground loop and quality of installation
- Heat pump does not have constant level of performance because the amount of energy and the temperature on inlet, outlet and the COP are different
- 1 hole produces 3.5kw

**Energy Losses:**

- No big losses due to the actual efficiency of the heat pump
- Big losses can be due to the inefficiency of the circulating pump
- Inefficiency of heat pump can lower overall COP by up to 2 points
- Parasitic energy consumption if the pump is installed wrong (at the wrong pump speed), can lower COP from 3.5 to 3.1 or 3.2

**Miscellaneous. Energy:**

- Need output temp of heat pump to be as low as possible for as long as possible because that's when it is most efficient
- When you run at high temperatures this means the system must run at a higher output temp, which leads to a lower COP, leading to taking less energy from the ground, getting less renewable energy

**Maintenance:**

- Ground loop lifetime of ~40-50 years, but really pretty much indefinite lifetime, unless people damage it through digging
- Ground loop can withstand earthquakes
- Heat pump lifetime of ~20 years
- Doesn't need service often, operates similar to a refrigerator
- Plumber can service the pipes, circulating pump
- Having maintenance program set-up will give people a feeling of security for psychological reasons, recommended that Merton has a support team "just in case"
- Major source of all problems due to improper installation by plumbers
- Need accreditation of installers (PowerGen/earth energy are working to create a list)
- Many "cowboy" installers out to do shoddy work
- Calorex has national service network system for heat pumps and it is never needed
- Plumbing (circulating pumps) many need maintenance
- Potential failure due to lack of good installers, Powergen is trying to make a list of accredited installers

**Usage Comments:**

- Carpeting: insulates heating system from the room, so the heat output of the system must be more (needing more electricity) to get the home up to the desired temperature
- Underlay under carpets makes it even worse
- Need output temp of heat pump to be as low as possible for as long as possible because that's when it is most efficient
- Carpeting insulates the heating system from the room so you need an even higher temperature to heat the room…this means the system must run at a higher output temp, which leads to a lower COP, leading to taking less energy from the ground, getting less renewable energy

**Economics:**

- System costs ~£3250
- PowerGen program system costs £2500
- Program includes: Heat pump, circulating pump, hot water tank, all controls
- Program doesn't give distribution system, thermostat/control
- Need to pay for the drilling and pipe installation
- Inside: circulating pump (provided by PowerGen) £80
- From a Carbon Credit, you can get money back because you reduce the amount of $CO_2$ emissions from your heating system
- Amount of £ you get back is determined by the govt, based on comparing your system to possible systems you could have used
- Money rebate is calculated based on lifetime carbon emissions saved: £700-800 if replacing electrical system

- Can run using economy 7 tariff periods, but doesn't lead to a considerable amount of $ saved
- Need to set up time clocks on system to maximize the amount of energy at economy 7
- Since people are buying such a small amount of electricity, the tariffs make it so you'd only save £5/year
- Over £1000 for drilling rig
- Installation of piping/connections (plumbing job) £500-600
- Maintenance costs are minimal, but should have contract just for peace of mind
- £1000-1200 per hole
- Contractors will try to overcharge because its novel technology, but its really basic groundwork
- Extremely low maintenance costs

**Total costs for PowerGen package:**

- £2500 per house, plus cost of grout
- £2000 for pipe installation
- £800-1000 for drilling rig
- Post installation: Receive carbon credit

**Environmental Concerns:**

- Depth of piping installation allows the ground to recover after the heat is removed
- Cross contamination of aquifers due to drilling from a polluted aquifer into a clean one
- By sealing hole with grout, prevents contamination
- Must fill hole with grout from the bottom to prevent air pockets, which act as a thermal insulator, reducing effectiveness of piping

**Environmental Benefits:**

- No emissions
- No soil contamination when system is installed properly

**Miscellaneous:**

- No technical manual for system yet
- John not willing to give up the design specifications since they are his own idea
- No brochure yet, but PowerGen is working on creating one
- BSRIA—created background document
- Application & guidance, not text book on designing
- Bob has reference
- Carbon Trust: 10% of energy bills are taken and put in the Carbon Trust which then uses the $ to help fund projects devoted to renewable energy…may be potential source of funding?
- Who will fund video bob is trying to make? Multi-discipline, so contractors wont fund it, possible student to film it
- Technology lends itself to misunderstanding and doing things wrong, as it is easy and will work for a few days pretty much no matter how you set it up
- Competitive bidding on labour wont be acceptable because the lowest bidder will inevitable be cutting corners
- How much money is spent on litigation for gas certificates?

**Miscellaneous Design:**

- PowerGen determines what size system you need

- System is secure and protected by not being visible above ground
- No weather compensated control
- Controlled on a room thermostat
- System comes with emersion heater that is not really needed as heat pump heats hot water already
- You only get a small delta T from the ground…you cant try to strip a lot of heat away from one single area of you'll ruin the ground…so you need more piping to spread the heat removal out
- Pipe floats…what happens if hole fills with water?

**Solar:**

- Can heat 40% of household hot water needs using solar panels
- Lose money to use solar for hot water
- Heat pump gives all the hot water you need
- Panels/installation costs £3500, but will never get $ back
- Solar panels can be used to enhance the running of the heat pumps
- People want them often because they can see them, so their house looks environmentally friendly
- Would only save you $ if the solar panels were free
- Gas £2/kwh, 80% efficient at most
- Security: there aren't parts to have stolen

**Retro-fit:**

- Front yard pipe installation is easier
- PowerGen doing retro fit in Cornwall
- Many exist—many people are happy with their performance
- Drilling is messy and disruptive
- Not recommended for houses with people inhabiting them
- Where do contractors park? Not enough room to move around
- Total giant scale retrofit
- Must get heat loss down to 4 kW
- Possible: terrace property that needs upgraded windows, external insulation, side entrance to run pipes out into yard OR Non-terrace place where you could trench the piping in through the foundation or through the walls

**Desired Installation Situation:**

- Free standing house less than 100m$^2$
- Newly constructed (non-retro fit)
- Heat loss of no more than 4kw
- Single story
- Sufficient land to install piping easily

**Other:**

- Standard 3.5kw system for 2 bedroom, 60m$^2$ house with electricity consumption of 2500 kWh/year…would need to provide 800 kWh of electricity to heat the house and hot water…cost ~£125 per year…
- You would need to provide 3600kwh if heated by electric system for £500 per year
- Average energy requirements of a house (100 m$^2$) is 8500 kWh/year

- Hot water in small house: needs 1000kwh/year to get hot water → so need to provide 300kwh/year to system → at 5p per kWh, this is only £15 per year to provide all hot water

**<u>Building Information for Mr. Harris' EarthDome Building:</u>**

- 2 floors, 4 flats (~33 sq. meters each)
- Foundations: driven pile system (doesn't remove any earth, just pushes it down)
- Walls: thin bed block wall, solid aerated concrete block walls
- 50 ml insulation on outside walls
- Roof: highly insulated panels
- Windows: double glazed
- Sunspaces allowing heat from the sun inside to help heat building
- Entire buildings will be very well insulated/energy efficient
- Ground: running water on top of clay
- Clay is almost to the surface
- 2nd floor: GSHPs—one system per flat to make it easier to sell them if need be
- Provide hot water and under floor heating
- 1st floor: may or may not use GSHP – if so, will go in tiny closet (bike shed?) near entryway/stairs → may not use simply due to cost of purchasing another heat pump
- Both lower flats may share one HP system??
- Under floor distribution system…under floor loop heating
- Having a company do drilling/test soil at the same time
- Drilling 100m bore holes
- Hot water cylinder in airing cupboard
- Bulova is digging holes
- Site is tight on boundaries (not a lot of extra land)
- Virgin land, Nice area

**<u>Financial Information for Mr. Harris' EarthDome Building:</u>**

- Applied for an additional £100,000
- Can only afford to spend £200,000 to build the four flats
- Ecological Building Society granting loan
- Originally estimated that it would cost £400,000 to build his flats, so he's had to change the design some to lessen the expense
- Will have to charge £65,000 -£70,000 per flat (def. Less than £100,000)

# Appendix G – Interview Transcript -- BRE

**BRE Interview Transcript**
**Tuesday, February 4th, 2003**
**Roger Hitchin**

**Building Requirements:**
- In order to upgrade a house you need to first consider the regulatory requirements
- The new building regulations that were passed in April extended the thermal insulation requirements to apply to refurbishments as well as new builds, but the requirements for refurbishments are lesser than those for new builds
- Check part L1 of the Building Regulations for more details
- With in the building regulations there are exceptions. If you have a very low carbon emissive heating system you don't have to insulate your house as well
- If you can show you can get just as high of a SAP rating with your heating system as you would get with a different system and a well insulated house, you may not have to insulate as much to meet regulations
- Council Building Control officer would have more info on building regulations that apply to council housing

**UK Housing:**
- In U.K., the houses are brick solid wall housing…they have a single skin (one layer wall) as opposed to a double skin (2 layers with room in-between where insulation can go)
- This makes it very expensive to insulate them
- The majority of UK heating systems are radiator based

**Energy Considerations:**
- Energy supply issue
- The electric company can limit the amount of energy that will be provided to such a system (7kw)?
- This can limit the size of the heat pump so that it can start using the amount of energy provided
- Single phase electricity supply → limits starting current for houses
- Can overcome by using a soft start system
- This issue makes it desirable to insulate the house to make it more energy efficient so that the heat pump can run at lower temp, using less energy, and therefore being able to run off the standard single phase electricity supply that is normal in U.K. housing

**BRE and Ground Source Heat Pumps:**
- BRE works with government programs for installing ground source heat pumps
- They are currently working on lots of case studies
- Monitoring SAP ratings for comparisons
- We can't have access to this data yet because it's still being collected
- John Parker is working on one site—he may be able to give us info
- All the sites BRE works with are new builds

**Retrofitting:**
- It's more preferable to have a low temperature coming out of the heat pump (makes it work more efficiently, use less energy)

- You can heat a house better at low temperatures using under floor heating
- Standard practice in ground source heat pumps to use under floor heating
- Radiator heating can be used with some engineering…if the house was really well insulated you may be able to run the radiators at a low enough temperature to still keep the house warm, but keep the heat pump efficient as well
- Some U.K. houses have electric heating…if this is the case, you need to put in a new distribution system anyways, so you might as well put in under floor heating
- Retro-fit is not the place to start…its very difficult

**<u>Ground Source Heat Pumps around the World:</u>**

- The Swiss have been promoting the development of an air source heat pump that is specifically designed to be used in a retro-fit and with radiators…it uses $CO_2$ as a refrigerant
- The Japanese have a $CO_2$ based storage water heater already on the market but it is very expensive
- The UK heat pump industry wants to model our market after the Swiss heat pump info structure
- The have a government set-up
- Have accreditation system for installers
- Have a maintenance guarantee of repair in two days if you buy from an accredited installer

# Appendix H – Interview Transcript--Geoscience

**Geoscience Interview Transcript**
**Tuesday, February 11th, 2003**
**Deborah Bennett**

**Economics:**
- The cost is dependent on the size of the heat pump
- 4-6 kW heat pumps
- 1 kW input: 4 kW output
- Costs £2500-£4500
- Cost for drilling rig is more expensive
- There is a mobilization fee for the rig so it is better to drill a lot of holes at once
- That cost is £1000 including the rig
- Many possible grants such as Clear Skies (BRE), Powergen

**Installation:**
- Heat pump is the size of a box refrigerator and could be placed under the stairs or in a closet
- The borehole needs a drilling rig on site, and trench from hole to heat pump
- The trench must be 1.8 m (but can't be used for shallow rock)
- Trench 50-60 m in L, U, or straight line
- Wet ground is better because it is more thermally efficient

**Retrofitting:**
- Insulation to get building to current building requirements, the cost is directly proportional to the size of the system
- Upgrade on insulation
- GHP produces lower heat, so the current radiators need to be upgraded or replaced with bigger radiators or under floor heating system
- Residents would not have to move out but they would be completely without heat
- Retrofit costs a lot of £
- Retrofitting would be a good idea if the housing needs updating anyways
- But only if upgrade can be done first

# Appendix I – Interview Transcript—Bree

**Bree Day Partnership Chartered Architects and Urban Designers Interview Transcript**
**Tuesday, February 11th, 2003**
**Damien Bree**

**Characteristics of common systems:**

- Electric heat is cheaper to run at night
- If heating during the day, cheaper to use a boiler

**Characteristics of ground source system:**

- They have personally only installed in new build
- GSHP runs at lower temperatures 40°C, while boilers at 60°C
- Can utilize wall mounted radiators or under floor heating
- Radiators can be used but more costly and less efficient, the radiator has to be 50% bigger
- Cost of replacing radiators is unknown
- In their projects they haven't needed new windows and insulation
- They increase efficiency but not completely necessary

**Cost of system in new build; complete installation with bore hole:**

- To get 4 kW of heat is £5000, with trench costing £4250
- To get 8 kW of heat is £8000-£9000, with trench costing £6000 plus excavation costs

**Specifics:**

- Need 200 linear meters of pipe
- 1 case was 2 holes 50 meters each
- 1-1.5 meters between pipes, which is about 5 $m^2$ per hole

**Completed feasibility study on existing terrace house:**

- Worked with Integer
- Building was completely gutted to bring it up to code
- Study done on renewable energy sources and GSHP was found not to be viable

**Additional funding possibilities:**

- Clear Skies is only for renewable
- European grants, problem with them is it is a large bureaucratic affair

**Other possible contacts:**

- Geoscience 01326211070
- Geothermal Heating Limited 02476673131

# Appendix J – Survey Results
# Section One

**Question 1: What type of housing do you live in?**

| | Council Owned | Owner Occupied | Housing Association | Private Tenant | Other | TOTAL |
|---|---|---|---|---|---|---|
| Merton Link 1 | 4 | 1 | 0 | 4 | 0 | |
| Merton Link 2 | 3 | 2 | 3 | 2 | 1 | |
| Centre Court | 1 | 9 | 1 | 5 | 0 | |
| Merton Council | 1 | 14 | 0 | 4 | 0 | |
| Totals | 9 | 26 | 4 | 15 | 1 | 55 |
| **Percentage** | **16.36%** | **47.27%** | **7.27%** | **27.27%** | **1.82%** | |

**Question 2: What type of heating system do you use in your home?**

| | Gas | Electric | Other | TOTAL |
|---|---|---|---|---|
| Merton Link 1 | 8 | 1 | 0 | |
| Merton Link 2 | 8 | 2 | 1 | |
| Centre Court | 13 | 2 | 1 | |
| Merton Council | 13 | 5 | 1 | |
| Total | 42 | 10 | 3 | 55 |
| **Percentage** | **76.36%** | **18.18%** | **5.45%** | |

**Question 3: What temperature do you keep your house at?**

| | Cold | Warm Enough | Warm | Hot | TOTAL |
|---|---|---|---|---|---|
| Merton Link 1 | 0 | 0 | 8 | 0 | |
| Merton Link 2 | 0 | 1 | 10 | 0 | |
| Centre Court | 0 | 2 | 13 | 1 | |
| Merton Council | 0 | 3 | 13 | 2 | |
| Total | 0 | 6 | 44 | 3 | 53 |
| **Percentage** | **0.00%** | **11.32%** | **83.02%** | **5.66%** | |

**Question 4: I think my heating bills are:**

| | inexpensive | moderate | too expensive | NA | TOTAL |
|---|---|---|---|---|---|
| Merton Link 1 | 0 | 5 | 3 | 0 | |
| Merton Link 2 | 0 | 9 | 1 | 1 | |
| Centre Court | 3 | 10 | 3 | 0 | |
| Merton Council | 1 | 17 | 0 | 0 | |
| Total | 4 | 41 | 7 | 1 | 53 |
| **Percentage** | **7.55%** | **77.36%** | **13.21%** | **1.89%** | |

**Question 5: Are you satisfied with the performance of your current system?**

| | yes | no | TOTAL |
|---|---|---|---|
| Merton Link 1 | 1 | 8 | |
| Merton Link 2 | 11 | 0 | |
| Centre Court | 12 | 4 | |
| Merton Council | 18 | 1 | |
| Total | 42 | 13 | 55 |
| **Percentage** | **76.36%** | **23.64%** | |

**Question 6: Have you ever considered changing your current system?**

| | yes | no | NA | TOTAL |
|---|---|---|---|---|
| Merton Link 1 | 4 | 3 | 2 | |
| Merton Link 2 | 1 | 8 | 2 | |
| Centre Court | 3 | 12 | 1 | |
| Merton Council | 4 | 12 | 3 | |
| Total | 12 | 35 | 8 | 55 |
| **Percentage** | **21.82%** | **63.64%** | **14.55%** | |

**Question 7: If yes to question 6, what kind of system would you choose?**

| | gas | electric | other | TOTAL |
|---|---|---|---|---|
| Merton Link 1 | 3 | 0 | 1 | |
| Merton Link 2 | 2 | 0 | 0 | |
| Centre Court | 2 | 1 | 0 | |
| Merton Council | 3 | 0 | 1 | |
| Total | 10 | 1 | 2 | 13 |
| **Percentage** | **76.92%** | **7.69%** | **15.38%** | |

**Question 8: In the past 2 years, how many times has your heating system not worked?**

| | zero | one to five | five to ten | more than ten | TOTAL |
|---|---|---|---|---|---|
| Merton Link 1 | 5 | 2 | 2 | 0 | |
| Merton Link 2 | 5 | 5 | 0 | 0 | |
| Centre Court | 8 | 8 | 0 | 0 | |
| Merton Council | 11 | 7 | 0 | 0 | |
| Total | 29 | 22 | 2 | 0 | 53 |
| **Percentage** | **54.72%** | **41.51%** | **3.77%** | **0.00%** | |

**Question 9: I think the costs for the maintenance of my heating system are:**

| | inexpensive | moderate | too expensive | NA | TOTAL |
|---|---|---|---|---|---|
| Merton Link 1 | 2 | 3 | 1 | 2 | |
| Merton Link 2 | 1 | 9 | 0 | 1 | |
| Centre Court | 5 | 5 | 4 | 2 | |
| Merton Council | 5 | 11 | 1 | 2 | |
| Total | 13 | 28 | 6 | 7 | 54 |
| **Percentage** | **24.07%** | **51.85%** | **11.11%** | **12.96%** | |

## Section Two – Statement Preference

**Statement 1: I am concerned with the environmental issues of today.**

| | Strongly Agree | Agree | Neutral | Disagree | Strongly Disagree | TOTAL |
|---|---|---|---|---|---|---|
| Merton Link 1 | 2 | 7 | 0 | 0 | 0 | |
| Merton Link 2 | 4 | 4 | 2 | 0 | 0 | |
| Centre Court | 5 | 9 | 1 | 0 | 1 | |
| Merton Council | 5 | 11 | 3 | 0 | 0 | |
| Total | 16 | 31 | 6 | 0 | 1 | 54 |
| **Percentage** | **29.63%** | **57.41%** | **11.11%** | **0.00%** | **1.85%** | |

**Statement 2: I want to buy environmentally friendly products.**

| | Strongly Agree | Agree | Neutral | Disagree | Strongly Disagree | TOTAL |
|---|---|---|---|---|---|---|
| Merton Link 1 | 4 | 3 | 0 | 1 | 0 | |
| Merton Link 2 | 4 | 5 | 2 | 0 | 0 | |
| Centre Court | 2 | 9 | 5 | 0 | 0 | |
| Merton Council | 4 | 12 | 3 | 0 | 0 | |
| Total | 14 | 29 | 10 | 1 | 0 | 54 |
| **Percentage** | **25.93%** | **53.70%** | **18.52%** | **1.85%** | **0.00%** | |

**Statement 3: I want to buy inexpensive products.**

| | Strongly Agree | Agree | Neutral | Disagree | Strongly Disagree | TOTAL |
|---|---|---|---|---|---|---|
| Merton Link 1 | 3 | 5 | 1 | 0 | 0 | |
| Merton Link 2 | 3 | 4 | 2 | 1 | 0 | |
| Centre Court | 4 | 6 | 6 | 0 | 0 | |
| Merton Council | 6 | 9 | 4 | 0 | 0 | |
| Total | 16 | 24 | 13 | 1 | 0 | |
| **Percentage** | **29.63%** | **44.44%** | **24.07%** | **1.85%** | **0.00%** | 54 |

**Statement 4: I would support an environmentally friendly heating system if it saved money.**

| | Strongly Agree | Agree | Neutral | Disagree | Strongly Disagree | TOTAL |
|---|---|---|---|---|---|---|
| Merton Link 1 | 6 | 3 | 0 | 0 | 0 | |
| Merton Link 2 | 5 | 4 | 1 | 0 | 0 | |
| Centre Court | 7 | 8 | 1 | 0 | 0 | |
| Merton Council | 10 | 7 | 2 | 0 | 0 | |
| Total | 28 | 22 | 4 | 0 | 0 | 54 |
| **Percentage** | **51.85%** | **40.74%** | **7.41%** | **0.00%** | **0.00%** | |

**Statement 5: I would support an environmentally friendly heating system if the costs were similar to my current system.**

| | Strongly Agree | Agree | Neutral | Disagree | Strongly Disagree | TOTAL |
|---|---|---|---|---|---|---|
| Merton Link 1 | 4 | 2 | 1 | 1 | 0 | |
| Merton Link 2 | 5 | 4 | 2 | 0 | 0 | |
| Centre Court | 5 | 8 | 2 | 0 | 1 | |
| Merton Council | 9 | 9 | 1 | 0 | 0 | |
| Total | 23 | 23 | 6 | 1 | 1 | 54 |
| **Percentage** | **42.59%** | **42.59%** | **11.11%** | **1.85%** | **1.85%** | |

**Statement 6: I would like to have a system that does no have to burn fuel and produce pollution to create heat.**

| | Strongly Agree | Agree | Neutral | Disagree | Strongly Disagree | TOTAL |
|---|---|---|---|---|---|---|
| Merton Link 1 | 7 | 1 | 0 | 0 | 0 | |
| Merton Link 2 | 4 | 6 | 0 | 1 | 0 | |
| Centre Court | 6 | 6 | 3 | 0 | 0 | |
| Merton Council | 8 | 9 | 2 | 0 | 0 | |
| Total | 25 | 22 | 5 | 1 | 0 | 53 |
| **Percentage** | **47.17%** | **41.51%** | **9.43%** | **1.89%** | **0.00%** | |

**Statement 7: I would like an environmental heating system in my home.**

| | Strongly Agree | Agree | Neutral | Disagree | Strongly Disagree | TOTAL |
|---|---|---|---|---|---|---|
| Merton Link 1 | 4 | 2 | 3 | 0 | 0 | |
| Merton Link 2 | 3 | 5 | 3 | 0 | 0 | |
| Centre Court | 5 | 5 | 6 | 0 | 0 | |
| Merton Council | 3 | 12 | 4 | 0 | 0 | |
| Total | 15 | 24 | 16 | 0 | 0 | 55 |
| **Percentage** | **27.27%** | **43.64%** | **29.09%** | **0.00%** | **0.00%** | |

**Statement 8: I would be willing to invest in anew heating system that will save me money.**

| | Strongly Agree | Agree | Neutral | Disagree | Strongly Disagree | TOTAL |
|---|---|---|---|---|---|---|
| Merton Link 1 | 6 | 2 | 1 | 0 | 0 | |
| Merton Link 2 | 3 | 4 | 3 | 1 | 0 | |
| Centre Court | 3 | 8 | 5 | 0 | 0 | |
| Merton Council | 2 | 9 | 4 | 2 | 0 | |
| Total | 14 | 23 | 13 | 3 | 0 | 53 |
| **Percentage** | **26.42%** | **43.40%** | **24.53%** | **5.66%** | **0.00%** | |

## Section Three

**Question 10: Below are possible concerns people may have about environmental heating systems. Please check all that apply to you.**

| | Not tried and tested | Safety | Reliable | Appearance | Effectiveness Long Term | Maintenance | Noise | Other |
|---|---|---|---|---|---|---|---|---|
| Merton Link 1 | 2 | 7 | 2 | 0 | 3 | 4 | 3 | 1 |
| Merton Link 2 | 1 | 4 | 3 | 1 | 3 | 6 | 1 | 0 |
| Centre Court | 6 | 8 | 11 | 3 | 5 | 9 | 4 | 1 |
| Merton Council | 9 | 6 | 13 | 6 | 12 | 11 | 7 | 1 |
| Total | 18 | 25 | 29 | 10 | 23 | 30 | 15 | 3 |
| **Percentage** | **33.33%** | **46.30%** | **53.70%** | **18.52%** | **42.59%** | **55.56%** | **27.78%** | **5.56%** |

# <u>Demographics</u>

**Ethnic Origin**

| | White | Pakistani | Bangleadeshi | Tamil | Black British | British Asian | Black Caribbean | Black African | Black Other | Chinese | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Merton Link 1 | 4 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | |
| Merton Link 2 | 1 | 0 | 0 | 0 | 0 | 1 | | 1 | 0 | 0 | |
| Centre Court | 8 | 0 | 0 | 1 | 0 | 1 | 1 | 2 | 0 | 0 | |
| Merton Council | 14 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 1 | |
| Total | 27 | 1 | 1 | 2 | 2 | 2 | 2 | 3 | 1 | 1 | 42 |
| **Percentage** | **64.29%** | **2.38%** | **2.38%** | **4.76%** | **4.76%** | **4.76%** | **4.76%** | **7.14%** | **2.38%** | **2.38%** | |

**Age**

| | 18-25 | 25-45 | 45-60 | 60+ | TOTAL |
|---|---|---|---|---|---|
| Merton Link 1 | 2 | 6 | 0 | 0 | |
| Merton Link 2 | 3 | 5 | 0 | 0 | |
| Centre Court | 3 | 9 | 1 | 0 | |
| Merton Council | 3 | 8 | 7 | 0 | |
| Total | 11 | 28 | 8 | 0 | 47 |
| **Percentage** | **23.40%** | **59.57%** | **17.02%** | **0.00%** | |

**Gender**

| Gender | Male | Female | TOTAL |
|---|---|---|---|
| Merton Link 1 | 2 | 6 | |
| Merton Link 2 | 3 | 6 | |
| Centre Court | 4 | 9 | |
| Merton Council | 7 | 11 | |
| Total | 16 | 32 | 48 |
| **Percentage** | **33.33%** | **66.67%** | |

# Comparative Analysis

**Statements 2 and 3**

| | Merton Link 1 | Merton Link 2 | Centre Court | Merton Council | Total | **Percentage** |
|---|---|---|---|---|---|---|
| Agree to 2 and | | | | | | |
| Agree to 3 | 6 | 5 | 7 | 12 | 30 | **55.56%** |
| Neutral to 3 | 1 | 2 | 4 | 3 | 10 | **18.52%** |
| Disagree to 3 | 0 | 1 | 0 | 1 | 2 | **3.70%** |
| | | | | | | |
| Neutral to 2 and | | | | | | |
| Agree to 3 | 1 | 2 | 3 | 3 | 9 | **16.67%** |
| Neutral to 3 | 0 | 0 | 2 | 0 | 2 | **3.70%** |
| Disagree to 3 | 0 | 0 | 0 | 0 | 0 | **0.00%** |
| | | | | | | |
| Disagree to 2 and | | | | | | |
| Agree to 3 | 1 | 0 | 0 | 0 | 1 | **1.85%** |
| Neutral to 3 | 0 | 0 | 0 | 0 | 0 | **0.00%** |
| Disagree to 3 | 0 | 0 | 0 | 0 | 0 | **0.00%** |
| | | | | | 54 | |

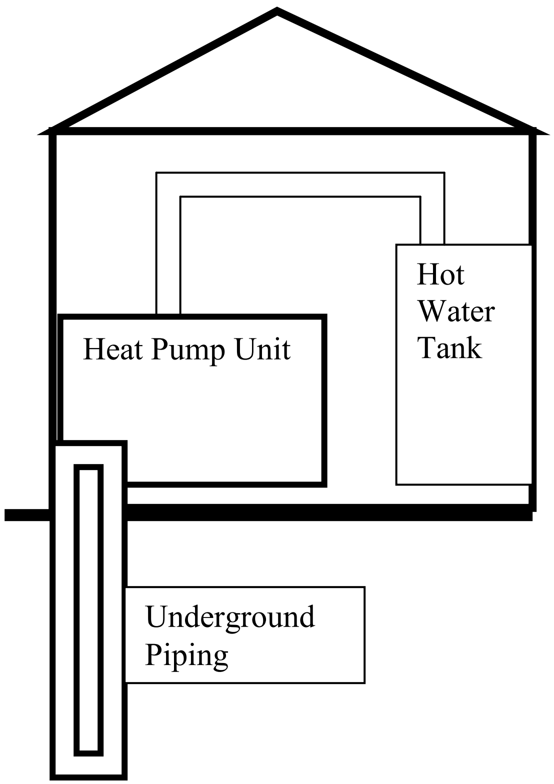
**Statements 4 and 5**

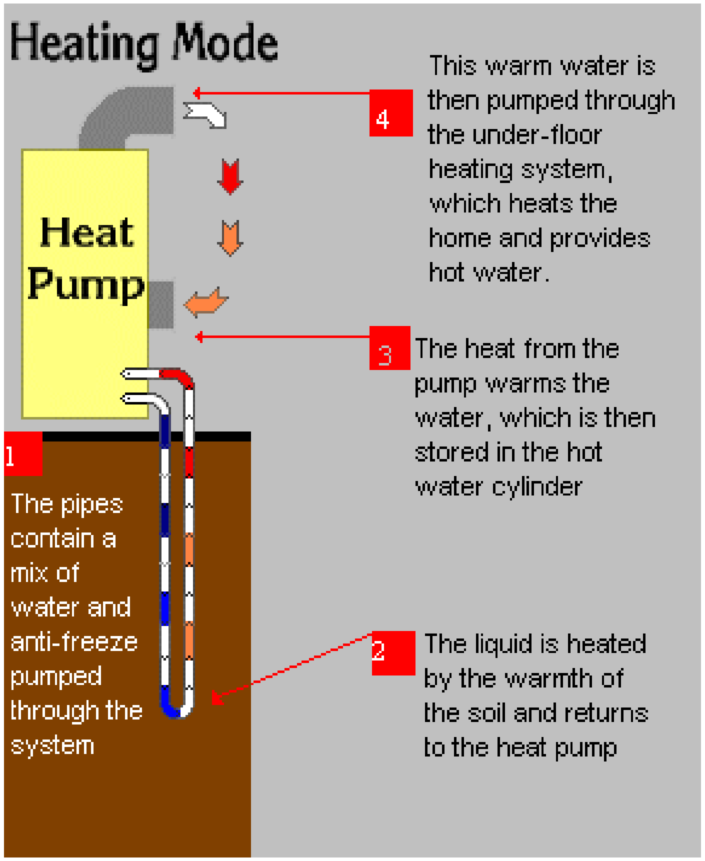
| | Merton Link 1 | Merton Link 2 | Centre Court | Merton Council | Total | **Percentage** |
|---|---|---|---|---|---|---|
| Agree to 4 and | | | | | | |
| Agree to 5 | 6 | 8 | 13 | 16 | 43 | **81.13%** |
| Neutral to 5 | 2 | 1 | 1 | 1 | 5 | **9.43%** |
| Disagree to 5 | 1 | 0 | 1 | 0 | 2 | **3.77%** |
| | | | | | | |
| Neutral to 4 and | | | | | | |
| Agree to 5 | 0 | 0 | 0 | 2 | 2 | **3.77%** |
| Neutral to 5 | 0 | 1 | 0 | 0 | 1 | **1.89%** |
| Disagree to 5 | 0 | 0 | 0 | 0 | 0 | **0.00%** |
| | | | | | | |
| Disagree to 4 and | | | | | | |
| Agree to 5 | 0 | 0 | 0 | 0 | 0 | **0.00%** |
| Neutral to 5 | 0 | 0 | 0 | 0 | 0 | **0.00%** |
| Disagree to 5 | 0 | 0 | 0 | 0 | 0 | **0.00%** |
| | | | | | 53 | |

# Appendix K -- Pamphlet

## How the System Works

Under the surface of London is an endless source of energy waiting to be used. The system uses the constant warm temperature of the earth to provide heat and hot water for people's homes. Below the frost line, the earth's temperature remains constant, around 10°C. Running heat transfer fluid through an underground piping system allows the natural heat from the earth to be used in homes.




## World Wide Success

The geothermal ground source heat pump system has been installed in homes around the world. It has been successfully set up in 400,000 buildings in the United States. Very little maintenance has been required for these systems. The underground pipes of the system are designed to last for *AT LEAST 50 years*, and the heat pump lasts for *30 years!*

## Success in the U.K.

There are about 150 geothermal ground source heat pump systems already installed in the United Kingdom. The moist soil conditions allows for a more efficient operation of the system.

## Costs & Expenses

Although the geothermal ground source heat pump system is primarily a renewable energy system, it needs a small amount of electricity to run the heat pump. When the day-to-day running costs of different heating systems are compared, the geothermal system is less expensive than electric systems, and can operate at a cost that is comparable to gas heating systems. With a large reduction in heating bills, the system can pay for itself in two years. According to the United States Environmental Protection Agency,

> "geothermal systems are the most energy- efficient, environmentally clean, and cost-effective space conditioning systems available"
>
> - Office of Energy Efficiency and Renewable Energy, 2002

## Heat Pumps & the Environment

One of the unique benefits of installing a geothermal ground source heat pump is that it is environmentally safe. Unlike gas and oil heating systems, there is NO burning of fossil fuels in the home to run the ground source heat pump system. The pump operates on a small amount of electricity. Hardly any pollutants are emitted from using the system, so it creates safer living conditions for residents.

## Efficiency

The efficiency of any heating system can have a big impact on the its running costs. Traditional heating systems, such as gas and electric can be only 80% efficient, leading to high monthly operating costs. The geothermal ground source heat pump system, however, can lower costs because it can output heat with an *efficiency of as much as 400%*. Geothermal ground source heat pumps are one of the most efficient and money saving heating systems available!

## Additional Information

Further information may be obtained through:

BobHarris@EarthDomes.plus.com
EarthDome is developing a live demonstration of the technology in Merton

**OR**

**Merton Council**
London Borough of Merton
Merton Civic Centre,
London Road,
Morden,
Surrey SM4 5DX

www.merton.gov.uk/LA21/geothermal
Adrian.Hewitt@merton.gov.uk

www.earthenergy.co.uk
http://www.bre.co.uk/services/Environmental_systems.html
www.clear-skies.org

merton moving ahead

# Heating & Hot Water from the Earth

## *A Domestic Geothermal Project for London*

**"The Untapped Energy Source"**

## Appendix L – Educational Brochure

# Heating & Hot Water From the Earth

*A Domestic Geothermal Project for London*

Produced for the London Borough of Merton in Partnership with Worcester Polytechnic Institute Global Perspectives Programme, Massachusetts, United States of America

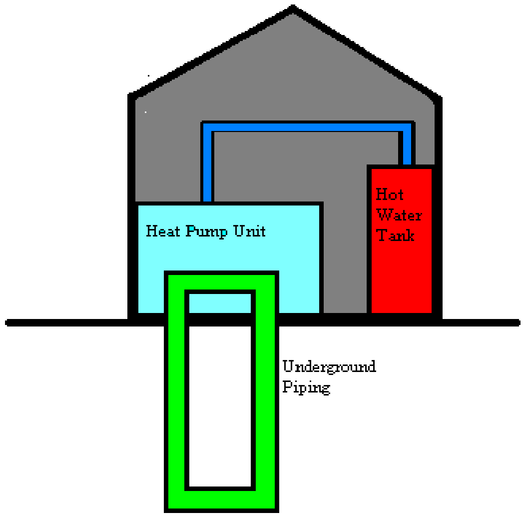
# Geothermal Ground Source Heat Pumps and Merton

Since the mid twentieth century, there has been an increased awareness about the effects of industrialization on the modern world. Concerns have risen about fossil fuel consumption, deforestation, and harmful emissions that compound the greenhouse effect. The potential repercussions of fuel and chemical use, including increased UVA/UVB radiation, global warming and the loss of many natural resources, has brought environmental concerns to the forefront, with concern for the earth taking centre stage.

In an effort to address environmental needs and concerns, Merton Council is investigating the feasibility of implementing technology that can provide an energy alternative that is environmentally friendly, as well as being an inexpensive means of heating homes. The Council wants to implement a new, green method of heating that also improves the value and quality of their community's dwellings. To help solve problems such as fuel poverty, the Council is looking at a geothermal heat pump system that incorporates energy saving and environmentally friendly technology. Its main component is a ground source heat pump system used to provide the energy needed to heat the building as well as provide hot water. One of the aims of Merton's regeneration strategy is to incorporate future technologies, such as the ground source heat pump, in the Merton area, taking steps towards creating a cleaner, greener community.

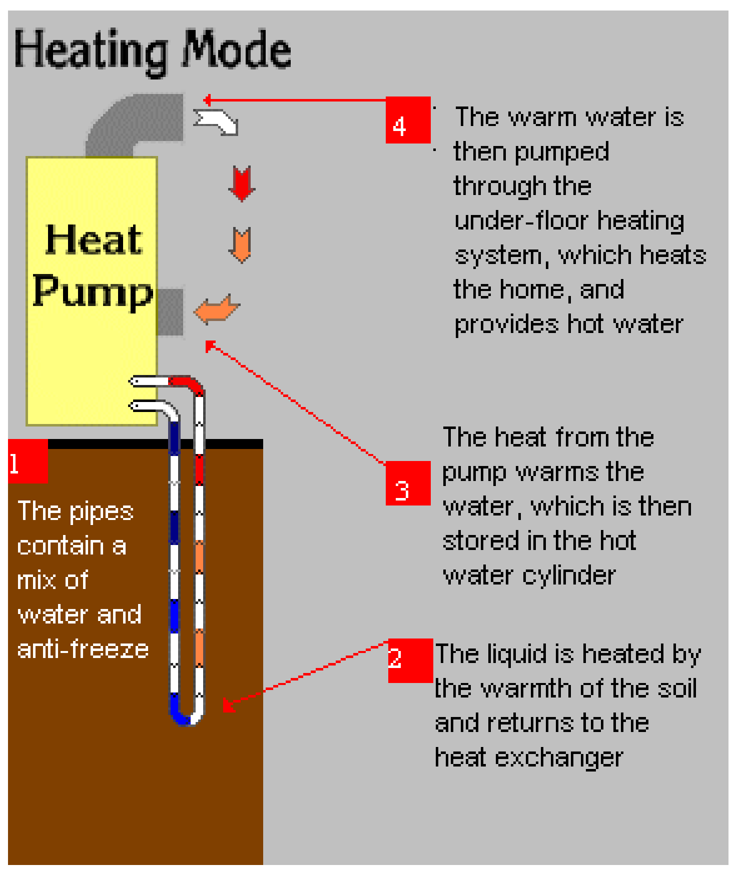
## How the system works

Science and technology have been moving forward to provide us with new methods of heating, such as geothermal ground source heating. The actual technology of a geothermal ground source heat pump is very basic. It operates on the basis of using the earth's natural stored energy to provide heat and hot water to homes and buildings.




Below the frost line, the earth's temperature remains fairly constant at around 10°C. Pipes filled with fluid are put underground to capture this warmth.

This fluid is able to absorb the ground's heat and bring it directly to the heat pump. In the heat pump, the 10°C liquid is heated to a warmer temperature, around 60°C. This heat is removed and used to warm up water, which is stored in a hot water cylinder. This warm water is then pumped through the under-floor heating system, which heats the home. The water is also available to the hot water taps. The heat transfer fluid continues to run through the cycle to provide heating.



## Maintenance

The geothermal ground source heat pump system has been proven to require minimal amounts of maintenance. The system does not require routine checkups for cleaning and part replacement like gas and oil heating systems, because the components of the heat pump are simple to operate and manufactured for durability.

*The flexible piping that is installed underground is designed to last for AT LEAST 50 YEARS, and the heat pump can last for 30 YEARS.*

This long lifespan means the entire system is able to run efficiently and worry free for decades. If a problem happens to occur, it usually pertains to the above ground piping, which can easily be fixed by a certified plumber.

## World Wide Success

The geothermal ground source heat pump system has been installed in homes around the world, and has required very little maintenance. So far, there has been about 150 ground source heat pump systems already installed in the United Kingdom. The moist soil conditions allows for effective operation of the geothermal ground source heat pump.

*The system has been successfully installed in about 400,000 buildings in the United States, including schools, businesses and private homes.*

A geothermal ground source heating system was successfully installed in the state of Minnesota, in the northern United States. The climate was fairly cold and did not possess the wet, thermally conductive ground that is better for heat pump operation, like that present in the United Kingdom. The residence was previously heated with oil and incurred expenses of approximately £2280 per year. With the geothermal system installed they heat and cool their home for only £237 per year.

## <u>Costs & Expenses</u>

The ground source heat pump system can reduce monthly and annual expenses by using renewable energy to provide heat and hot water. The heat pump does need a small amount of electricity to operate, but this is generally much less energy than other heating systems use. When the heat pump is run, the system can consume anywhere from 25-50% less energy than standard heating means, such as oil and gas. When day-to-day running costs of different heating systems are compared,

*The ground source heat pump system can operate at a lower cost than most traditional heating systems!*

Consider an example of a small house, which uses 10,000 kWh of thermal energy per year to provide heat and hot water. If you had an electric heating system that was only 80% efficient, it would cost £1250 per year to run. For a gas system that was only 80% efficient, it would cost £250 per year. The ground source heat pump, running at 400% efficiency, would only cost £250 per year to run. The heat pump can be less expensive than electric heat and its costs are comparable to those of gas heating systems.

## <u>Heat Pumps & the Environment</u>

Because ground source heating pumps are mainly run on renewable energy, they are very environmentally friendly. Unlike gas and oil heating, there is no in-house burning of fossil fuels needed to run the ground source heat pump system. Ground source heating systems produce no pollutant emissions in the home, such as carbon monoxide. Pollutants are produced on site at the power station from the generation of the small amount of electricity needed to operate the pump. When ground source heat pump systems are used, they can <u>reduce pollutant emissions by about 50%.</u> The heat pump system can reduce carbon dioxide emissions to about 1700 kg per year compared to 3400 kg per year released from fossil fuel systems. In addition, the environmentally friendly benefits of installing the system will create safer, healthier living conditions for residents, providing cleaner air and protecting the ozone layer for generations to come.

## Efficiency

The efficiency of any heating system usually has a big impact on how much the system costs. The ground source heat pump system can lower costs because it outputs heat with an efficiency of 400%. This means that the system makes four units of heat for every unit of energy put into it. Installing ground source systems in new build and retrofit homes has been shown to reduce energy consumption by 25% to 75% compared to the old system. Electric and gas heat can be 80% efficient while oil can be only 60% efficient.

**Installation of the geothermal system**

Ground source heating is so beneficial because the system is able to put in a quarter of the energy to get the same heating effect as electric heat. Using a ground source heating system will allow consumers to get more than enough heat and hot water by using less energy than any other fossil fuel heating system.

The geothermal ground source heat pump has been proven to be a highly effective, inexpensive, safe and efficient system to run. In addition to all these benefits, the heat pump owners gain the added peace of mind, knowing they are helping to preserve and protect the environment through lowered pollutants and emissions, doing their bit to make the world a greener place.

## Additional Information

Further information may be obtained through:

BobHarris@EarthDomes.plus.com
EarthDome is developing a live demonstration
of the technology in Merton

OR

**The Merton Council**
London Borough of Merton
Merton Civic Centre,
London Road,
Morden,
Surrey SM4 5DX
www.merton.gov.uk/LA21/geothermal
Adrian.Hewitt@merton.gov.uk

www.earthenergy.co.uk
http://www.bre.co.uk/services/Environmental_systems.html
www.clear-skies.org