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Sustainable Energy in the London Borough of Merton

An Interdisciplinary Qualifying Project

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Abstract

This project, carried out for the London Borough of Merton, creates the framework and informational foundation for further research and development of the two year Merton sustainable energy program. Information vital to the continuation of this project was collected, organised, and made available to Merton council members through a computerized network folder system. Preliminary data for Merton's building/energy mapping plan was also collected from various council departments, and un-met data needs were identified. By organising and contributing to the knowledge necessary for future project teams, the team developed a solid base for Merton and its partners.

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Executive Summary

The emission of greenhouse gasses, the driving force behind global warming, is harming the earth and its inhabitants. Over the last thirty-five years, temperatures have risen by three to five degrees Celsius over regions of northern Eurasia and North America. It is projected that by the year 2080, temperatures worldwide will increase at the alarming rate of one degree Celsius annually (Health and Energy, 2003). The effects of global warming include a rise in sea level as a result of melting ice caps, a change in precipitation patterns, deforestation, and an increase in the frequency of extreme weather events such as hurricanes and droughts (Armitage, 2003). Carbon dioxide is the most problematic of the greenhouse gasses due to its abundance in the atmosphere from the burning of fossil fuels. It contributes approximately eighty percent of total greenhouse gasses (Greenhouse Gasses, 2004). Not everyone agrees on the role of greenhouse gases in global warming. Some believe that the warming effect we are experiencing is just a natural phase and others feel that the warming trend is being exaggerated (Brian Carnell, 2002). However common opinion is that if no adjustments are made, this will lead to a change in vegetation regions, possibly resulting in world hunger and the extinction of many of earth's more active animals, including humans (Warming Ecosystems, 2004).

The emission of carbon into the atmosphere cannot be eliminated completely. Asking citizens to not drive or use electricity for the good of the environment is not feasible. The generation of electricity is accountable for almost half of all carbon emissions. In order to most effectively reduce emissions, cities must look at energy production as the quickest and most effective change to address the carbon output problem. The London Borough of Merton desires to be one of the first local authorities to make the necessary changes. Despite being ahead of most Boroughs in clean energy technology planning policies, they still come nowhere close to meeting the emission standards of the European Union (EU). This project is one of twenty sponsored by the Local New Energy Technology Implementation (LETIT), an organisation involving the UK and four other European nations developed to address environmental issues. The Royal Commission on Environmental Pollution's set a recommendation to reduce carbon emissions by sixty percent in 2050. Merton decided to make the changes necessary to reach this goal.

In order to effectively lower carbon emissions in the Borough, Merton decided to implement a sustainable energy system. In 1999, Merton decided to take its first steps to meet the regulations set by the European Union. They began to require that all new industrial and commercial buildings above the size of 1000 square meters must incorporate renewable energy technologies which provide at least ten percent of their expected energy needs (Merton UDP, 2003). Although most cities worldwide have no such policy, making Merton a pioneer, this could not help reduce emissions by anymore than ten percent. In the spring of 2003, a team of students from Worcester Polytechnic Institute performed a feasibility study on the prospect of installing a geothermal sustainable system for various buildings within the borough. The system was deemed unfeasible at the time, so Merton had to look into other forms of sustainable energy to reach their goals. One possible solution to reaching these goals was the implementation of a Combined Heat and Power (CHP) system within the borough.

Green house gas production is becoming an issue of global importance. Global warming is caused by the release of greenhouse gasses such as CO2 into the atmosphere. Carbon dioxide production is natural in many processes, for example the decay of vegetable matter and the combustion of carbon-bearing materials. What makes it a problem is the production of energy using fossil fuels. Electricity is generated at large power plants and is then transmitted and distributed through a broad network of high and low voltage power lines in order to reach the individual consumer. Current power plants produce large amounts of CO2 as a byproduct that is released into the atmosphere. Rather than a central system with a distribution grid, a sustainable energy system with a private wire delivery system would effectively reduce carbon emissions.

The purpose of this project was to create the framework and information foundation for further research and development of the two year Merton sustainable energy program. This was done by organising and contributing to the knowledge necessary for future project teams. This project provides the basis for the feasibility study that will decide whether or not implementing a 'private wire and heating duct' system in Merton would effectively reduce carbon emission levels while maintaining cost effectiveness. At the time of this study, the most used method of sustainable energy was that of a combination of CHP units and fuel cells. A sustainable energy system will reduce carbon emissions and decrease power consumption across the borough. Also, by utilising the best strategies from a combination of previous systems installed in buildings and towns before, Merton will become an exemplary borough for the rest of London and the UK.

To develop the basis for the beginnings of Merton's two-year sustainable energy project, we needed knowledge about a number of different concepts. The most useful information to be researched included the London Borough of Merton, feasibility studies, sustainable energy, and energy delivery systems. This investigation enabled us to appropriately scope our project and develop four main objectives to be completed. These objectives included creating a framework for Merton's sustainable energy project, organising collected information for use by future project teams, researching case studies on sustainable energy systems, and establishing a database for Merton's building/energy mapping plan.

Relating the analysis to the goal statement of this project provides five main conclusions. These conclusions are listed below:

- A project of this nature is very complex.
- The project requires careful planning and scheduling
- A MapInfo database of structures and their energy properties is a vital tool in the planning process.
- The work of future WPI project teams in support of Merton's sustainable energy program must be carefully defined
- The work of future WPI project teams, in support of Merton's sustainable energy program, must be carefully defined.

A valuable product of this project consists of a database of folders containing information for future reference, created to establish an organisational system for the project. The folder system is currently in place on the Merton Civic Centre network, accessible by all employees and anyone with a Merton government login. The database is organised into nine clearly labeled folders making information easy to locate. The titles of these folders are Case Studies, Contact Info, ESCO, GIS Mapping, Message, Monetary Issues, Research Resources, Technology, and WPI Project Files. Each document and database is found in a distinct folder. If there is a possibility that someone wishing to locate a particular file may look in the wrong folder, a link has been set up to direct him or her to the correct folder for easy access. There is also a site map and a search function, which can be used to direct the user to where they want to be.

1.0 Introduction

The emission of greenhouse gasses, the driving force behind global warming, is harming the earth and its inhabitants. Over the last thirty-five years, temperatures have risen by three to five degrees Celsius over regions of northern Eurasia and North America. It is projected that by the year 2080, temperatures worldwide will increase at the alarming rate of one degree Celsius annually (Health and Energy, 2003). The effects of global warming include a rise in sea level as a result of melting ice caps, a change in precipitation patterns, deforestation, and an increase in the frequency of extreme weather events such as hurricanes and droughts (Armitage, 2003). Carbon dioxide is the most problematic of the greenhouse gasses due to its abundance in the atmosphere from the burning of fossil fuels. It contributes approximately eighty percent of total greenhouse gasses (Greenhouse Gasses, 2004). Not everyone agrees with the prevailing theories on global warming. Some believe that the warming effect we are experiencing is just a natural phase and others feel that the warming trend is being exaggerated (Brian Carnell, 2002). However common opinion is that if no adjustments are made, this will lead to a change in vegetation regions, possibly resulting in world hunger and the extinction of many of earth's more active animals, including humans (Warming Ecosystems, 2004).

The problems created by the use of fossil fuels are very well documented. Numerous wars have been fought over the supply of these valuable resources and the need for fossil fuel leads to dependence on these suppliers. If a borough or country wishes to be truly economically and politically stable, securing its energy supply should be of top priority. The prices of oil and natural gas have been steadily on the rise and are not projected to come down anytime soon. For example, in 2001, the price of oil per barrel was $22.01 while in just three years, in 2004, it had risen to $37.00. Recently cities, especially in Europe, have been turning to sustainable energy systems to reduce carbon emissions and to address economic and political instability.

The emission of carbon into the atmosphere cannot be eliminated completely. Asking citisens to not drive or use electricity for the good of the environment is not feasible. The generation of electricity is responsible for almost half of all carbon emissions. In order to most effectively reduce emissions, cities must look to energy production for the quickest and most effective change mechanism for addressing the carbon output problem. The London Borough of Merton desires to be among the first local authorities to make the necessary changes. Despite being ahead of most Boroughs in clean energy technology planning policies, they still come nowhere close to meeting the emission standards of the European Union (EU). This project is one of twenty sponsored by the Local New Energy Technology Implementation (LETIT), an organisation involving the UK and four other European nations developed to solve environmental issues. The Royal Commission on Environmental Pollution has set a recommendation to reduce carbon emissions by sixty percent in 2050. Merton decided to make the changes necessary, in their borough, to reach this goal.

In order to effectively lower carbon emissions in the Borough, Merton decided to implement a sustainable energy system. In 1999, Merton took its first steps to meet the regulations set by the European Union. The council established a requirement that all new industrial and commercial buildings with floor area exceeding 1000 square meters must incorporate renewable energy technologies which provide at least ten percent of their expected energy needs (Merton UDP, 2003). Although most cities worldwide have no such policy, making Merton a pioneer, this could not help reduce emissions by anymore than ten percent. In the spring of 2003, a team of students from Worcester Polytechnic Institute performed a feasibility study on the prospect of installing a geothermal sustainable system for various buildings within the borough. The system was deemed unfeasible at the time, so Merton had to look into other forms of sustainable energy to reach their goals.

Many feasibility studies have been conducted to research sustainable energy systems. In 1991, the borough of Woking performed similar studies and as a result implemented a 'Private Wire and Duct' system. This system is made up of combined heat and power (CHP) units installed in public buildings throughout the town. The public buildings then distribute excess energy and heat to the private sector. By combining alternative energy sources such as CHP units with other sustainable energy technologies, Woking now controls its own power distribution through public and private infrastructures. Studies such as the one in Woking take into account the current technology, economics, environmental efficiency, and social needs of the community. The decision of whether or not to implement a given sustainable energy system, like that in Woking, is dependant on these local conditions. Implementing the system in Woking proved to be very successful in reducing carbon emissions. They saw energy consumption reduce by forty-four percent and carbon emissions by seventy-two percent. Merton, however, may not be able to use this same system due to housing constraints or any of a number of other issues (Burt, 2003). The need for a feasibility study directed specifically toward the borough of Merton is essential because of its unique economic, social, and technological conditions.

The purpose of this project was to create the framework and information foundation for further research and development of the two year Merton sustainable energy program. This was done by organising and contributing to the knowledge necessary for future project teams. This project provides the basis for the feasibility study that will decide whether or not implementing a 'private wire and heating duct' system in Merton would effectively reduce carbon emission levels while maintaining cost effectiveness. At the time of this study, the most used method of sustainable energy was that of a combination of CHP units and fuel cells. A sustainable energy system will reduce carbon emissions and decrease power consumption across the Borough. Also, by utilising the best strategies from a combination of previous systems installed in buildings and towns before, Merton will become an exemplary borough for the rest of London and the UK.

2.0 Background

Green house gas production is becoming an issue of global importance. Global warming is caused, as stated in the introduction, by the release of greenhouse gasses such as carbon dioxide (CO_2) into the atmosphere. Carbon dioxide production is a natural part of the globe's atmospheric dynamics; what makes it a problem is the production of energy using fossil fuels. Electricity is generated at large power plants and is then transmitted and distributed through a broad network of high and low voltage power lines in order to reach the individual consumer. Currently, power plants burning fossil fuel produce large amounts of CO_2 that is released into the atmosphere as a byproduct of combustion. Rather than a central system with a distribution grid, a sustainable energy system with a private wire delivery system would effectively reduce carbon emissions by utilising what is ordinarily discarded as "waste heat", thereby increasing overall system efficiency.

To develop the basis for the beginnings of Merton's two-year sustainable energy project, we needed knowledge about a number of different concepts. This chapter presents the preliminary research for this project. The background research was completed on Merton, feasibility studies, sustainable energy, and energy delivery systems. This investigation appropriately scoped our project.

2.1 Merton

The London Borough of Merton is located in southwest London. The Borough was originally formed by the merger of several smaller boroughs and derives its name from a small village at its center. The Borough houses nearly 200,000 residents, approximately twenty-five percent of whom are minorities. A map of Merton in relation to the rest of London can be found in Figure 1.

Figure 1: Map of London

Merton recognises, as do many other cities, the problem of global warming caused by carbon emissions. They also realise the threat of financial and political instability that may arise from reliance on fossil fuels for energy production. Due to these incentives, they were motivated to become an exemplary borough in the field of sustainable energy. Merton had seen the success of Woking, Leicester, and Aberdeen and wished to emulate it in its own borough. They hope that by proving the system could work in more than just Woking, other cities in Europe and around the world would seek to lower their carbon emissions as well. It is from this idea that the saying 'think globally, act locally' comes.

The goal of this project was to create the framework and informational foundation for further research and development of the two-year Merton sustainable energy program by organising and contributing to the knowledge necessary for future project teams. The beginning stages of this study included the acquisition of information about Merton's portfolio of buildings and the creation of a database procedure for future use in the software program MapInfo. It also included case studies and creating the framework for the entire length of this two-year project.

2.2 Feasibility Study

Feasibility studies are performed to determine whether or not a project is worth undertaking. A feasibility study addresses issues such as benefits, costs, effectiveness, alternatives considered, analysis of alternative selections, environmental effects, risk analysis and public opinion as they relate to the topic in question. The motives for doing a particular feasibility study dictate exactly what issues will be taken into account.

Cost and benefit analysis is the key part of almost every feasibility study. This method of analysis measures the social desirability of undertaking a project. The costs and benefits are measured on a common monetary scale and compared. Since a project's costs and benefits usually occur at different times, comparing them involves appraising an investment decision.

Another important factor in a feasibility study is to consider and analyse a number of alternatives. These alternatives are to be analysed on their cost to benefit ratio. The criteria each alternative is evaluated on are efficiency or effectiveness, environmental effects, and public opinions must all be weighed against the cost. Again, cost and benefit analysis is the best method for doing this. Whichever alternative option scored the highest in this analysis would be considered the most feasible.

The main method for feasibility studies is a cost/ benefit analysis. This will be completed for Merton using methods similar to those used in past examples we had studied. Clark University, in Worcester, Massachusetts, has a cogeneration plant which powers and heats most of their campus. The system paid for itself in seven years, much faster than expected. This is important because although Merton wants a sustainable energy system to help the environment; cost is still a driving issue.

A feasibility study on sustainable energy presents its own factors and problems. Sustainable energy studies have been completed in the past across the UK and the US. One relevant study took place in Alaska in 2003. The Sealaska Corporation was studying the feasibility of a sustainable energy system over an area of twelve villages. Although the geography of the region was much different than Merton's, the same issues were present in both cases. The Alaskan feasibility study evaluated the potential for energy exports through power purchase agreements, job creation or loss, economic and environmental benefits, and the long-term sustainability of the project (Tribal Energy, 2002). This study is a good example of a feasibility study that considered a number of alternatives and used cost/benefit analysis to decide what was most feasible.

In the spring of 2003, a WPI project group worked for the borough of Merton and completed a feasibility study on the prospect of geothermal energy for a few council-owned buildings. Much of the information they uncovered, such as housing descriptions and cost analysis, was applicable to our project as well. Their feasibility study concentrated mostly on economics and they found that geothermal energy was not feasible for the buildings in question. This was a good example of the benefits not being worth the cost to the project initiators. Merton now wishes to build the base for a similar feasibility study, however this time contemplating all options of sustainable energy available, not just geothermal.

For the implementation of sustainable energy, Merton would like a system very similar to the one installed in the borough of Woking. Woking has a system of six combined heat and power units, which create heat and electricity, separate from the national power grid. The energy supplied is cheaper and cleaner than normal production, which is why Merton would like to copy whatever they can from this design. The technicalities of the Woking system will be discussed later in this paper. What is important to note is that to implement the system, Woking first had to complete a feasibility study much like the one that will eventually be begun by the Borough of Merton. Through email correspondence with a Woking official, we have learned that Woking's feasibility study was very similar to that of Sealaska.

A feasibility study is a long and involved process. A critically important part of a feasibility study is the development of a solid base on which to build strong and proven conclusions. This preparatory work was done by uncovering and organising the data necessary for the upcoming feasibility study.

2.3 Sustainable Energy

Sustainable energy is defined as energy that can be produced economically and safely for all time without impacting the environment and well being of future generations while maintaining security of the energy supply. Merton is turning to the use of sustainable energy systems to reach their goals for carbon emission reduction. In order to form the base for a proper feasibility study on implementing such a system, an understanding as to what sustainable energy is and how it works was required.

The environmental benefits that sustainable energy provides can be obtained through many different alternative energy technologies. Some of these technologies include hydrogen fuel cells (particularly for the future), solar cells, and wind energy. If used, the sustainability qualities of each of these technologies will reduce carbon emissions.

2.3.1 Generation

The generation of heat and electricity can be done in a number of different ways. The most common way at the time of this study was to have the electricity mass produced at power plants and distributed to households. The electricity is then used within the house to cook, run refrigerators, make hot water and heat the house. However, there are a number of more environmentally safe ways to complete this process.

Hydrogen fuel cells produce electricity by converting hydrogen and oxygen into electricity and heat. Two electrodes (an anode and a cathode), similar to those found in a battery, are separated with an electrolyte. Through the passing of ions from one electrode to the other, power is produced electrochemically. H2O in the form of water is produced as exhaust. This would theoretically emit no carbon; however the use of pure hydrogen as the only fuel source is not feasible at this time. Most fuel cells use natural gas as fuel to obtain the hydrogen and, as a result, still emit some carbon gasses (DER – Fuel Cells, n.d.). While this is not a completely true representation of sustainable energy at this point in time, these carbon emission levels are still significantly lower than conventional electric generation per unit of electrical energy delivered.

Another possible sustainable energy source is solar radiation. Solar energy systems transform sunlight into electricity or useable thermal energy. Through the use of photovoltaic (PV) cells, semiconductors are used to create electricity when exposed to sunlight. The result is electricity generation with no exhaust. This provides a very clean, sustainable energy system. However there are drawbacks, including generally higher initial costs and lower efficiencies than conventional electric generation. Also, solar power panels take up large areas; these large expanses of collector surface are considered by some to be an aesthetic blight. If economically feasible, the use of solar energy can significantly reduce local carbon emission levels.

The use of sunlight can also be seen in a method of heating water known as solar thermal water heating. This particular system of water heating entails a matrix of small pipes spread over the roof of a given building. Water is then allowed to run through the pipes and is warmed by the sun. This heated water can then be used throughout the building for various applications, most commonly heat.

Wind energy is also a potential solution to high carbon emissions. Windmill blades utilise wind energy through the aerodynamic principle of lift, turning a shaft to generate electricity. The many factors that contribute to maximum windmill efficiency include blade angle of attack and tip speed to wind speed ratio (Cassedy, 2000). Large land space for windmill farms is generally required for large amounts of electricity generation. Availability of adequate land can be a limiting factor, however smaller alternative methods are also options. For example, throughout London, small personal wind turbines were placed on rooftops to generate electricity. The use of wind energy technologies provides a clean energy alternative to the power systems currently in place.

In the London borough of Woking, many of these sustainable energy technologies have already been implemented. In Woking, a combined photovoltaic CHP system has been implemented into the Brockhill sheltered housing scheme. This system provides the sheltered housing residents with heating, hot water, and electricity (Brockhill, n.d.). Woking is also using a fuel cell CHP system to provide electricity and heating for Woking Park (Woking Park, n.d.). These examples provided useful information for this project because Merton hopes to integrate similar sustainable energy systems in the Borough.

2.3.2 Cogeneration

An important form of sustainable energy is cogeneration. Cogeneration methods have proven to be one of the most effective ways to reduce carbon emissions. Merton hopes to follow past efforts and utilise the benefits of cogeneration in reducing their own carbon emission levels. Cogeneration has worked in a number of different locations worldwide as a method for reducing carbon emissions.

Cogeneration refers to a system that can use the same fuel source to produce both electric power and thermal energy (Hu, 1985). Cogeneration is also referred to as combined heat and power technology (CHP). CHP systems operate by capturing and utilising the excess or "waste" heat that is produced by conventional electric generation. From the waste heat, water is then heated in pipes and the hot water is distributed throughout the building for heating purposes. By producing both forms of energy from one fuel source, CHP units usually obtain approximately 85% total efficiency. This can be compared to conventional methods of separate electric generation and thermal heating which usually obtain total efficiencies of approximately 45%. CHP systems require about 100 units of fuel to produce the same amount of heat and electricity as separate electric and heat generation systems produce with 165 total units of fuel (DER - CHP, n.d.). By requiring substantially less fuel, the resulting carbon emissions in CHP systems are significantly lower. For a better understanding of the comparison of a CHP system and a classic separate heat and power system, see Figure 2.

Combined heat and power does not completely eliminate carbon emissions because of the initial fuel requirements. Natural gas is the preferred fuel source for CHP systems. As of 2002, for example, approximately 87% of existing CHP systems in New York State (USA) were fuelled by natural gas. The exhaust of carbon gasses is unavoidable because of the use of natural gas as a fuel source. Although there are other fuel types such as coal, waste, and wood fuels, natural gas usually provides the most feasible option usually due to current economic, availability, and chemical factors (Combined Heat and Power Market, 2002).

At the time of this study, Denmark was one of the world leaders in sustainable energy. They had been working towards this concept since the early 1900's and came up with a number of innovative techniques for meeting the challenge. Some did not include sustainable energy, such as carbon taxes on energy production. However, sustainable energies were also important to Denmark in reaching their carbon reduction goals.

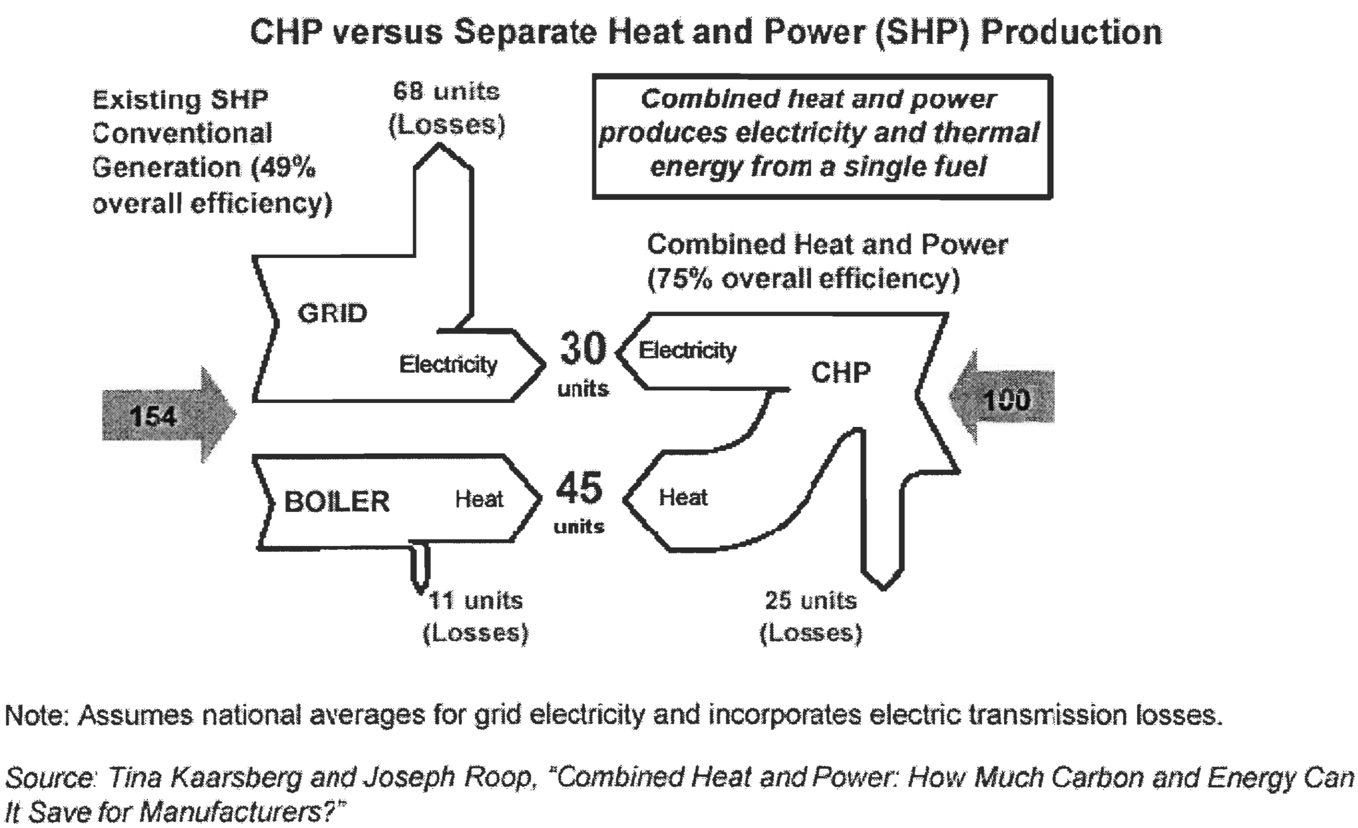

Figure 2: CHP vs. SHP Production

To be truly sustainable, not only must there be little to no environmental or social harm from energy production, but each sector should also be independent. This means that countries should not rely on others to deliver goods such as fossil fuels for their energy. To solve this problem, Denmark has turned to biomass. Biomass refers to agriculture and forestry by-products and municipal waste. It includes industrial and municipal solid waste, wood chips and pellets, straw, energy crops, and biogas. The most common of these biomass forms is straw, which is used in Denmark.

In the year 2000, sixty percent of domestic energy and seventy-five percent of the heating for Denmark was produced through cogeneration. This was the highest percentage in the world. Of the energy production from renewable sources at the time of this project, forty-five percent of it was from biomass, thirty-six percent was from waste combustion, nineteen percent was from wind, and less than one percent combined was produced through solar, hydro, and geothermal methods. Denmark chose wind power to be its system of choice and by 2030 plans to generate almost half of its energy from this method (Manczyk, 2001).

Identifying and reviewing the examples of Denmark and Woking helped in beginning the Merton sustainable energy project. Preliminary conclusions about which methods may work best in Merton were developed through data research and analysis. The examples of Denmark and Woking and the analysis of what these projects mean to Merton have been passed on to the next groups in our case study network folder.

2.4 Energy Delivery Systems

Centralised power generators, or power plants, require that power be generated at a distance from where the consumer is located. This necessitates long distance transmission of electricity from the plants to their customers. Transmission lines carry electricity at high AC voltages to increase efficiency of transmission. Once the electricity has reached the neighborhood of the consumer, it is stepped down to a lower AC voltage at a substation. The electricity is then sent through local distribution lines to the individual customers. This is how electricity has been traditionally delivered.

Sustainable energy systems, however, require a new mode of delivery. Through sustainable and renewable energy, power production is no longer centralised in one location. Sustainable systems in the form of diesel and internal combustion engines, small gas turbines, fuel cells, photovoltaic cells, and wind turbines allow the power sources to connect directly to a distribution network or to the customers themselves. Not only are these energy sources cleaner than traditional modes of production, but they are also less expensive and provide greater access to electricity in rural and remote areas.

The other main difference in the delivery of sustainable energy compared to that of standard production is that, in the case of cogeneration, sustainable energy systems must also deliver heat. In cogeneration, the heat from the generation of electricity may be stored in water so as not to go to waste. This heat waste is then used to heat water, which is distributed through pipes. The pipes deliver the hot water to public and private sector customers, who use it to sufficiently heat and cool their homes.

The London borough of Woking has already implemented CHP technologies through a 'Private wire and duct' system. This system consists of 6 CHP systems throughout Woking that effectively produce and distribute heat and electricity to nearby customers. The Woking Town Centre includes customers such as Holiday Inn, Quake nightclub, Big Apple Leisure Complex and Metro Hotel, HG Wells Conference and Events Centre, Victoria Way car park and Woking Borough Council's Civic Offices. The electricity is distributed through private wires, while heat and chilled water are distributed through private pipes (Woking Energy Station, 2001). This effectively removes the involved buildings from dependence on the public electricity grid. Additionally, excess energy is sold back into the public grid, which creates further revenue for the borough.

Denmark provides another example of district heat distribution. In the Copenhagen area, two heating transmission companies purchase heat from the primary power stations, incineration plants, and other sources. The water is sent at one hundred twenty degrees Celsius and delivered between fifty and sixty degrees Celsius. The Metropolitan Copenhagen Heating Transmission Company operates fifty-four kilometers of hot water piping transmission, interconnecting various heat sources with the municipal district heating networks. The longest string of piping between heat stations is approximately ten kilometers. The company serves over 275,000 households (Manczyk, 2001).

2.5 Chapter Summary

The problem creating a need for this project was to provide Merton with a base of knowledge and an organisational system to help them find a way to locally lower carbon emissions in the hopes that their example would be used globally. The concepts necessary to grasp this goal were a background of Merton, feasibility studies, sustainable energy, and delivery systems. The background of feasibility studies was needed so that the informational base developed would be relevant to the next groups. For the concept of sustainable energy, the main systems used and the popularity of each was realised. The delivery systems that would be used to distribute excess heat and energy to Merton's private sector creating revenue from the system were also studied.

The research of these concepts along with the goal statement helped to define three main objectives for our project. It was learned that Merton does not yet have a database with the information necessary for this study. The Borough wished to set up a database procedure for obtaining and maintaining this information. One objective was to lay the foundation for the Merton mapping development plan. The second objective was to develop an informational database to be shared between project groups and the third objective was to perform case studies on other relevant projects.

3.0 Methodology

The purpose of this project was to create the framework and informational foundation for further research and development of the two year Merton sustainable energy program. This provided a plan for the London Borough of Merton that outlined the necessary steps for implementing a sustainable energy system. The driving motivation for the Borough's efforts lies in its ultimate goal of reducing carbon emissions. The beginning stages of the project include a feasibility study with many individual areas on which to focus. The most important task necessary for developing the base for the feasibility study was acquiring as much information as possible. Past projects similar to that in Merton, data on individual buildings in Merton, and statistical data about commercial sustainable energy systems available all needed to be considered.

Creating a basic understanding of the tasks that needed to be completed laid out a framework for the implementation of a sustainable energy system. To successfully begin the development of the sustainable energy system, the primary focus of this project was to complete the initial steps of the process. These steps were determined to be creating a framework for the entire length of the project, establishing a database procedure for the Merton mapping development plan and performing case studies on projects that had been completed elsewhere, such as Woking, Aberdeen, and Leicester. The primary research techniques used in acquiring this information included interviews and historical research. Another tool that was used was brainstorming and discussion sessions with our sponsor. Figure 3 lists the three objectives that were completed and the methods used.

Objective	Research Methods
• Create a Framework for Merton's Sustainable Energy Project	• Literature Search • Brainstorming/Discussion Sessions
• Perform Case Studies on Sustainable Energy Systems in Woking, Aberdeen, and Leicester	• Historical Research • Interviews
• Establish a Database Foundation for the Merton Mapping Development Plan	• Interviews • Data Mining

Figure 3: Objective Outline

3.1 Create a Framework for Merton's Sustainable Energy Project

The project beginning in Merton is currently scheduled for completion over the next two years, with installation of the first CHP system planned for April 2006. Since the project was not scheduled for completion during our seven weeks visit, it was important to create a framework for the entire project. This framework is to serve as a guide for future projects in the continuation of this study. Furthermore, it served to clearly identify our role in the early stages of the large and complex project.

As stated in the background, a number of sustainable energy projects have been completed in the past. At one point, all of these projects were at the same progression stage as Merton is now. In researching the literature of other projects, the process each went through was documented. This information was also compiled into a historical knowledge database for future use. With this information, a better understanding of what tasks needed to be completed was reached. In addition, the data provided guidance as to the best road to take in completing those tasks.

Brainstorming proved to be the most effective method for creating this framework. In a number of brainstorming sessions with Adrian Hewitt, a framework for the entire two-year projected project was developed. The framework that was mapped out included four main subject areas, which are to be completed in chronological order. These tasks included performing a feasibility study, gaining political and social support for the project, obtaining the necessary financial backing, and, finally, implementing the system. Each of these sub-headings could further be broken down into more specific tasks. Besides creating this framework, part of the goal was to complete the first steps defined in the feasibility section. A diagram of the feasibility portion of this project can be seen in Figure 4, outlining the entire feasibility process.

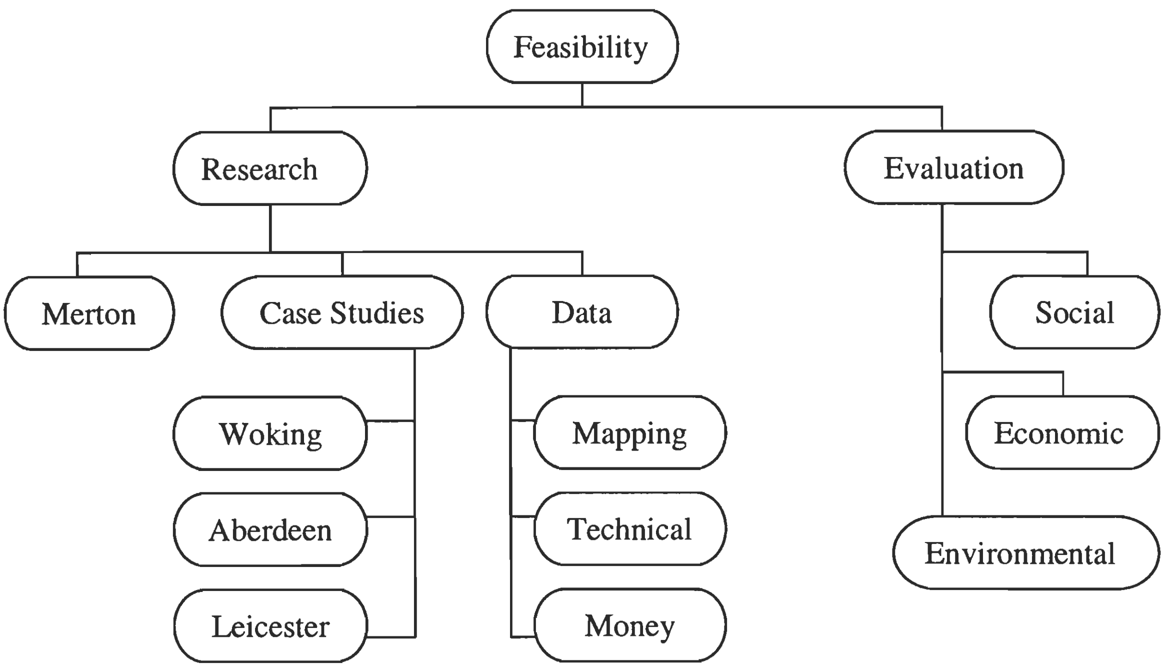

Figure 4: Feasibility Flow Chart

Organising the data and making it obtainable for all parties was considered in creating the framework for implementing a sustainable energy system. Initially the related information was housed in folders on a computer with no specific filing system involved. A list of folders was decided upon that would categorise all of the information collected. The preliminary list of folders in the filing system included Mapping, Finance, ESCO, Technology, Contact Information, General Message, and Miscellaneous. This system is useful for the purposes of this project, but in the future problems may arise. The ultimate goal is to create a website that contains all of the progress of the project. The website would allow future WPI and Brunel teams, Merton council members, LETIT and other pertinent organisations to access the information.

3.2 *Perform Case Studies on Woking, Aberdeen, and Leicester*

Merton plans to draw heavily from the experiences of past sustainable energy projects. Systems like the one Merton wishes to implement have already been installed in Woking and Leicester, England and Aberdeen, Scotland. Although these projects are ahead of Merton, it is important to note that at one time they were at the same early stage.

Due to the similarities between the London Borough of Woking and Merton, the Woking example seemed the best place to start this research. Investigation of web-based documents pertaining to the Woking system increased knowledge of the steps the council took to successfully launch their 'Private Wire and Duct' system. Due to intellectual property protection, much of the needed information was not accessible. A letter was drafted (see Appendix B) on behalf of Adrian Hewitt and the Brunel and WPI project teams and sent to Woking official Allan Jones explaining our project and asking for any information that could be offered. This reaffirmed that information on Woking would not be made available.

Two more locations that had implemented a sustainable energy system, Leicester, England and Aberdeen, Scotland, proved to be more accessible. Both were currently operating a system similar to that in Woking. The Brunel project team acquired the information needed by contacting officials in each location.

Learning as much information about alternate locations with sustainable energy systems became the primary task for the WPI and Brunel project teams. Because each of the groups was contacting various individuals within Aberdeen and Leicester, the chance of being repetitive in the questioning became an increased risk. To avoid this problem, a meeting between both project participants was necessary. In this meeting a generic questionnaire was developed and broken down into questions that could be asked by each respective group. For example, technical questions were delegated to the WPI Team and social impact questions to the Brunel students. This provided the most professional manner for gaining information without being repetitive.

Both examples proved to be very receptive to this project and eager to help in any way possible. Due to the location of Leicester and Aberdeen, phone interviews proved most practical. Although the initial goal in completing interviews with city officials included gaining an insight into their decision making process, this was not feasible given the limited resources and time of this project. These interviews did, however, provide a base understanding of what factors are considered when making important decisions involving sustainable energy.

3.3 Establish a Database Foundation for the Merton Mapping Plan

The biggest gap in Merton's available data was building information. Merton decided it wanted a system similar to Woking's, but did not have the necessary information on its portfolio of buildings to decide where to place the combined heat and power units. A database procedure was created which is to be used to input information on the buildings into the Borough's MapInfo resource.

Most information on MapInfo and the Leicester and Aberdeen mapping schemes can be found quickly from human sources making interviews the most relevant method to complete this research objective. Through email, an interview was conducted with a WPI project group currently working in Boston to better understand the core information needed in beginning a mapping database. The group was knowledgeable in the programs MapInfo and Access, both of which were necessary for this project.

Gary Shaw of the Environmental Services Department at the Merton Civic Centre provided access to the existing GIS map of Merton. The Merton map laid out all the buildings located throughout the borough and provided details such as the number of flats within each building. The individual buildings also included a drop down menu giving their location both by address and using a coordinate grid system.

Elizabeth Back is the current social housing representative for Merton. An interview with her provided a glimpse of the information her database currently held. The information she provided made it apparent that access to that database was needed to input the data into the mapping program. The initial hope was to make the database accessible for daily use on our computers. However, due to the complexity of the database and the need to install a new software program in order to view it, we instead met and worked with another social housing representative, Steve Ostler, on his own computer. By seeing the database, we could better grasp what it included and what would be required for inputting that data into Map Info.

Libraries, Civic Centres and parks also fall under the category of public buildings in Merton's portfolio. The department in Merton that deals with this information is the Estates Department. The representative interviewed was Robert Perry. Like social housing, Mr. Perry's database included much valuable information. All of these interview summaries can be found in Appendix D.

Because the current mapping program for Merton, the Social Housing database and the Estates database are different, the next step will be converting the information to one format where all information can be stored.

3.4 Chapter Summary

Through the completion of the objectives laid out in the previous section, Merton has been supplied with the beginnings of a feasibility study. Through creating a framework for Merton's sustainable energy project, performing case studies for alternative sustainable energy systems, and establishing a database for the Merton mapping development plan a two-year project has been set in motion. This will provide a start up manual for the continuation of the much larger project.

4.0 Data

The data is organised and presented in a manner consistent with the methods by which it was collected. As documented in the methodology section of this report, the methods of data collection most useful included historical research, interviews, and brainstorming sessions. The data presented below was analysed to form conclusions and recommendations, found later in this report.

4.1 Historical Research

Many sustainable energy projects have been implemented in Europe and America. Historical research of these projects was completed in two distinct categories. The first category was CHP case studies and the second was sustainable energy projects. The CHP case studies focused on the type, make and results of the technology used while the study of sustainable energy projects focused on the process of completing a long term project like the one Merton is undertaking.

4.1.1 CHP Case Studies

The implementation of various CHP systems throughout Europe and America provide an extensive amount of statistical data on the systems used. Statistics were gathered including power to heat ratio, project capacity, total efficiency and percent of fuel saved. The data collected through literature searches have been organised in a spreadsheet (see Figure 5).

4.1.2 Sustainable Energy Projects

Many sustainable energy projects have already been completed and are currently in operation. Among these are projects in Woking and Leicester, England and Aberdeen, Scotland. These locations have completed sustainable energy projects with similar goals to Merton's anticipated two-year project.

Woking was the first project of its kind, which is why studying it was so important. It was one of the first sustainable energy projects of its magnitude worldwide, including a unique private wire and duct system. During our preliminary seven weeks of research, we felt that this would be the most relevant example, which is why it is featured heavily in our background section.

ame of Project	Location	Brand of CHP	Project Design Capacity (Mwe)	Power to Heat Ratio	Total Net Efficiency (HHV)	% Fuel Savings	Effective Electric Efficiency (HHV)	%NOx Decrease
All Systems ogeneration, Inc.	New York, USA	Coast Intelligen Inc.	0.78	0.5	76%	11%	65%	79%
Woking Park	Woking, UK	Fuel Cell System	1.15					
oking Town Centre	Woking, UK		1.46	0.95				
Trigen-Peoples District Energy Company	Chicago, IL, USA	Trigen	3	0.12	84%	11%		67%
Louisiana State University	Baton Rouge, LA, USA	Sempra Energy Services	3.8	0.5	77%	14%	71%	24%
e College of New Jersey	Ewing, NJ, USA	Solar Centaur T-4700	5.2		77%	28%	71%	72%
Malden Mills	Malden, MA, USA	Solar Centaur	8.4	0.6	71%	8%	60%	84%
Trigen Energy Corporation	Oklahoma City, OK, USA	Trigen	9	0.2	82%	12%		
Trigen Energy Corporation	Philadelphia, PA, USA	Trigen	10	0.6	74%	13%	66%	77%
Trigen Energy Corporation	Trenton, NJ, USA	Trigen	12	0.6	75%	13%	68%	
utgers University	New Jersey, USA	Solar Taurus 60	14	0.5	73%	9%	62%	66%
Trigen Energy Corporation	Tulsa, OK, USA	Trigen	17	0.4	77%	11%	70%	
he University of North Carolina	Chapel Hill, NC, USA		28		72%	13%	49%	24%
e Dow Chemical Company	Freeport, TX, USA		65	0.8	74%	14%	67%	57%

Figure 5: Sustainable Energy Projects Database

While in London it was realised that most of the strategies and operational algorithms embedded in the Woking system are regarded by their private-sector developers as confidential and proprietary. These firms are reluctant to share such information. The developers and planners in Leicester and Aberdeen have proved to be much more responsive to our queries for information.

Aberdeen was very similar to Woking in its approach to sustainable strategy. The Aberdeen City Council has expended substantial funding on upgrades to the fabric, insulation and heating of its housing stock. These energy efficiency improvements were made to enhance affordability, sustainability, and to reduce C02 emissions. To increase energy efficiency in larger communities, the Council made a provision that central heating systems were required for blocks of flats higher than ten stories.

In November of 2000, the Council completed a feasibility study that concluded that CHP units could meet the Council's main objectives and recommended that a special purpose not-for-profit company be set up to meet the financing requirements. The Council implemented the system in a housing block consisting of 288 flats where seventy percent of the residents were estimated in fuel poverty. The local authority owned ninety-eight percent of the dwellings.

The Council contributes £215,000 per year to support CHP schemes in its housing stock. The money is provided to a not-for-profit company set up to implement the CHP schemes. This guaranteed capital contribution enabled Aberdeen Heat & Power to raise the £1.08 million required to develop the initial CHP project. All operating surpluses generated by the company are put back into providing a proportion of the capital for the next CHP developments. The system generates an annual cost saving of £83,396 for residents and saves 411 tonnes of carbon per year (Lyon, 2002).

The City of Leicester is one of the largest cities in the East Midlands of Great Britain. It covers an area of approximately 73 square kilometres. Its total population is near 250,000 or, approximately, the same as Merton. Leicester's method of dealing with the problem of carbon emissions through government policy proved to be much less expensive and involved than the methods of Woking and Aberdeen.

Leicester's main strategy in fighting fuel poverty and carbon emissions relied on government policies. Leicester's energy saving approach has been to consider energy reduction across all policy areas. The themes behind Leicester's initiative were the following (Leicester, 2003):

- Elaboration of a comprehensive strategy of sustainable urban development
- Integration of energy-related issues into the planning of different environmental sectors
- Promotion of high standards for energy efficiency in the housing sector
- Promotion of combined heat and power schemes
- Promotion of district heating
- Promotion of environmentally friendly measures in the transport sector
- Variety of advice and consultancy activities

4.2 Interviews

Through interviews with various specialists we acquired firsthand information about mapping and Council owned buildings in Merton. Interviews were beneficial in collecting this type of information in that when unexpected questions arose, a simpler answer could be supplied by a human source rather than through searching literature on the web. We also completed an interview with the Brunel Project team to discover their part in this ongoing project.

Interviews were completed to gain further knowledge of the mapping aspect of the project. The goal of these interviews was to find what information the Merton council had on its portfolio of buildings and what information would need to be acquired elsewhere. Buildings in Merton are organised into one of three governing departments. These departments are social housing, estates, and registered social landlord (RSL) housing. The council does not own RSL housing and, therefore, no information on this is available to the public. Information from mapping personnel, social housing representatives, and estates representatives were gained through interviews.

4.2.1 Mapping Personnel

Gary Shaw is the GIS Technician for the Merton Civic Centre. He works with the GIS software program MapInfo, which provides many useful tools for displaying information on Merton's portfolio of buildings. The ability to create sub-tables was beneficial for organisation because fields could be broken down and categorised, which increased user friendliness.

Most database formats can be directly linked into MapInfo. This means that Microsoft Excel, Access, and various other basic database programs that hold information can simply be entered into a MapInfo layer. Data must be inputted into MapInfo in one of the following types: character, integer, small integer, float, decimal, date, and logical. Merton's current MapInfo database already includes important data that will be used in the feasibility study including building location and property area. A summary of our interview with Gary Shaw can be found in Appendix D.

4.2.2 Social Housing Representatives

Steve Ostler and Elizabeth Back are the social housing representatives for Merton who provided us with information on the social housing blocks in the borough. Social housing has a database with some of the information we deemed necessary for the feasibility study. Social housing owns 7,700 properties in Merton. These properties supply the council with a number of possible installation and distribution sites. The maintenance schedule for each of these buildings is available for future use in the feasibility study. The social housing database is currently stored in the software program Academy. The interview summary for Elizabeth Back is located in Appendix D.

Academy is a database program much like Microsoft Access. Information needed for completion of the feasibility study is stored in the database. It was determined which fields of information were available on the database and which were not. However, the Academy software is being abandoned by the social housing department for an X-base system. They are currently in the process of switching to the new database system. It will be easier to export the data into MapInfo with the X-base system than with the Academy system. The X-base system will also provide a more extensive range of fields that are needed for the feasibility study. Once the database switch is completed, a follow-up inquiry will be required to determine which fields are available in the X-base system and which are not. The social housing department is hoping to have the new database system up and running within a month. A summary of our interview with Steve Ostler and the list of fields currently available from social housing can be found in Appendix D.

4.2.3 Estates Representative

The primary liaison in the Estates Department has been Robert Perry. The Estates Department has information on schools, libraries, the Civic Centre, and other public buildings stored on three main databases. The first is an operational systems database that contains information organised by individual sites, blocks and rooms. The second is a non-operational systems database that contains information organised by roads and blocks. Both database systems are similar to Microsoft Access and are easily exported into MapInfo. The third database is an Access database, which is supplementary to the first two and contains further fields of information on blocks and rooms such as age, refurbishment data, and condition. All three databases organise each entry by its UPRN number. Through this reference number these databases will be able to be easily linked into the MapInfo database, which is also organised by UPRN number. The Estates Department also has an excel spreadsheet containing energy consumption information from 2003. This spreadsheet will also be able to be exported into MapInfo and contains information such as electricity used, electricity costs, fuel used and fuel costs. The interview summary for Robert Perry can be found in Appendix D.

4.2.4 Brunel Project Team

A Brunel project team is working in collaboration with us on the Merton sustainable energy project. The Brunel team has been focusing on the qualitative aspect of implementing sustainable energy in Merton. They have been exploring such questions as: do residents of sustainable energy communities like their system and does it do the required job?

Since this is the first collaborative WPI and Brunel project in what Merton hopes to be many, it became important to set up a base of communication that future groups should use. The shared network folder that was created allows anyone logged into the Merton Civic Centre intranet system to access all of the information gathered for the project. Information that the Brunel team had collected, such as contact information, was compiled into the network project folder.

4.3 Brainstorming/Discussion Sessions

Brainstorming sessions between the WPI project team and their sponsor, Adrian Hewitt, became a valuable resource in setting up a plan for the entire length of the two-year sustainable energy project. The completion of such a long-term project is a complicated process involving many steps. It was realised that completing a feasibility study within our seven-week timeframe was not possible. A feasibility study is just one step in the entire project, which requires proper background preparation for a successful outcome. We developed a chronological framework with the four main headings being feasibility, support, finance and implementation. These fields can then be broken down into more specific subcategories, which make the project more manageable.

4.4 Chapter Summary

The previous section displays the data that has been gathered over the course of this project. The chapter is organised by research method to make the data easy to find. The gathering of data presented in this chapter was essential for further analysis in order to lay the foundation of information needed for a feasibility study.

5.0 Analysis

The following section describes the analysis of our data, and is organised by research question. The following chapter shows the knowledge that has been gained and how that knowledge has led to an overall understanding of the project.

5.1 A Framework for Merton's Sustainable Energy Project

The complexity of a long-term sustainable energy project requires careful planning to ensure that all aspects of the study are taken into account. The creation of a general framework for Merton's sustainable energy project enabled a realistic plan for accomplishing each part of the project. The analysis of this framework clarified which aspects of the project were to be conducted now and which future teams would complete.

5.1.1 Results

The framework that was created displays a timetable that needs to be completed to some extent in a chronological order for successful completion of the project. Broken down into four main components, the framework includes a feasibility study, support, finance, and implementation. Each of these components is expanded upon, providing further detail of tasks to be completed. The feasibility section was expanded upon in the greatest detail because that was the primary focus for this part of the project.

The creation of the framework also defined the future steps necessary for completing the two-year project. Once the completed framework was put on paper and able to be visualised, it became clear that the project included more aspects that originally considered. For this reason, rather than focus our efforts on completing a feasibility study, our primary goals moved to determining what components would be needed in the feasibility study.

5.1.2 Deliverables

A tangible outcome of creating the framework of the project was a flow chart outlining the necessary steps for the approximate two-year duration of this project. This provided the parties involved with a visual representation of the tasks and information that are needed for the project.

A color-coding system was developed to show the overall layout of the project and the sections that we have completed. Displayed in red are the components that we focused on. The components that are left in white are to be completed through future projects. The feasibility portion of the flowchart is shown below in Figure 6. A complete layout of the framework can be seen in Appendix A.

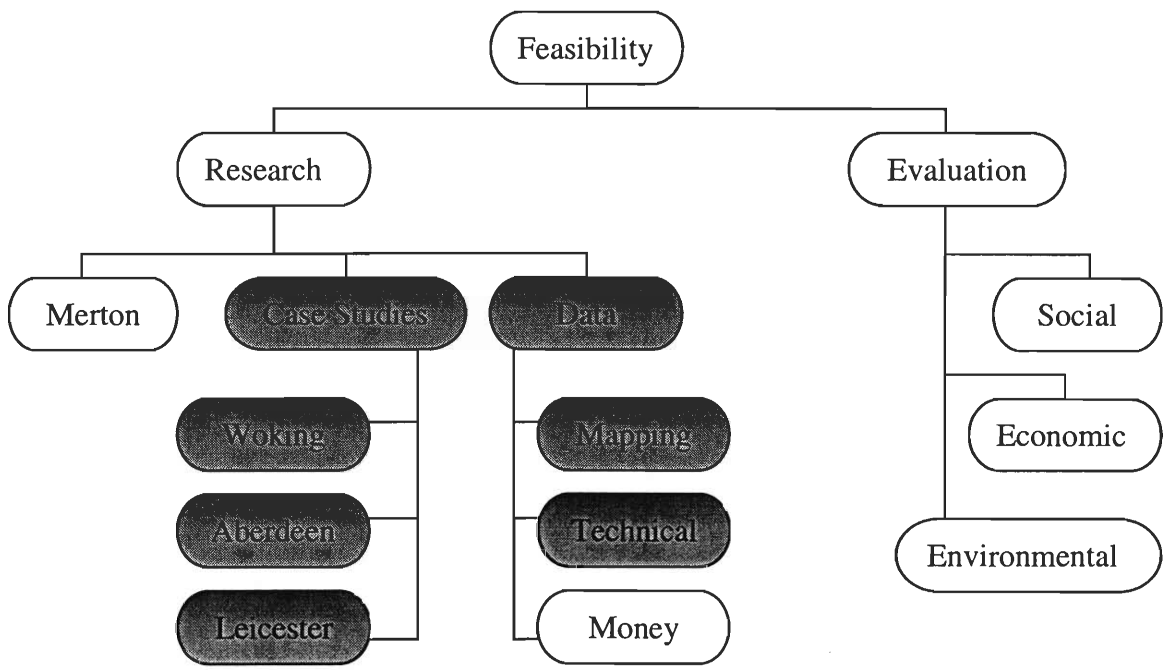

Figure 6: Feasibility Study Displaying Focus

A database of folders containing information for future reference was created to establish an organisational system for the project. The folder system is currently in place on the Merton Civic Centre network, accessible by all employees and anyone with a Merton government login. To date, the folder system is the best means of making our information available to collaborators within the Civic Centre, including Adrian Hewitt, Gary Shaw, Elizabeth Back, Steve Ostler, or anyone else who may be inclined to view our research.

The database is organised into nine clearly labeled folders making information easy to locate. The titles of these folders are Case Studies, Contact Info, ESCO, GIS Mapping, Message, Monetary Issues, Research Resources, Technology, and WPI Project Files. Each document and database is found in a distinct folder. If there is a possibility that someone wishing to locate a particular file may look in the wrong folder, a link has been set up to direct him or her to the correct folder for easy access. There is also a site map and a search function, which can be used to direct the user to where they want to be. A screenshot displaying the visual aspects of the folder system is shown in Figure 7.

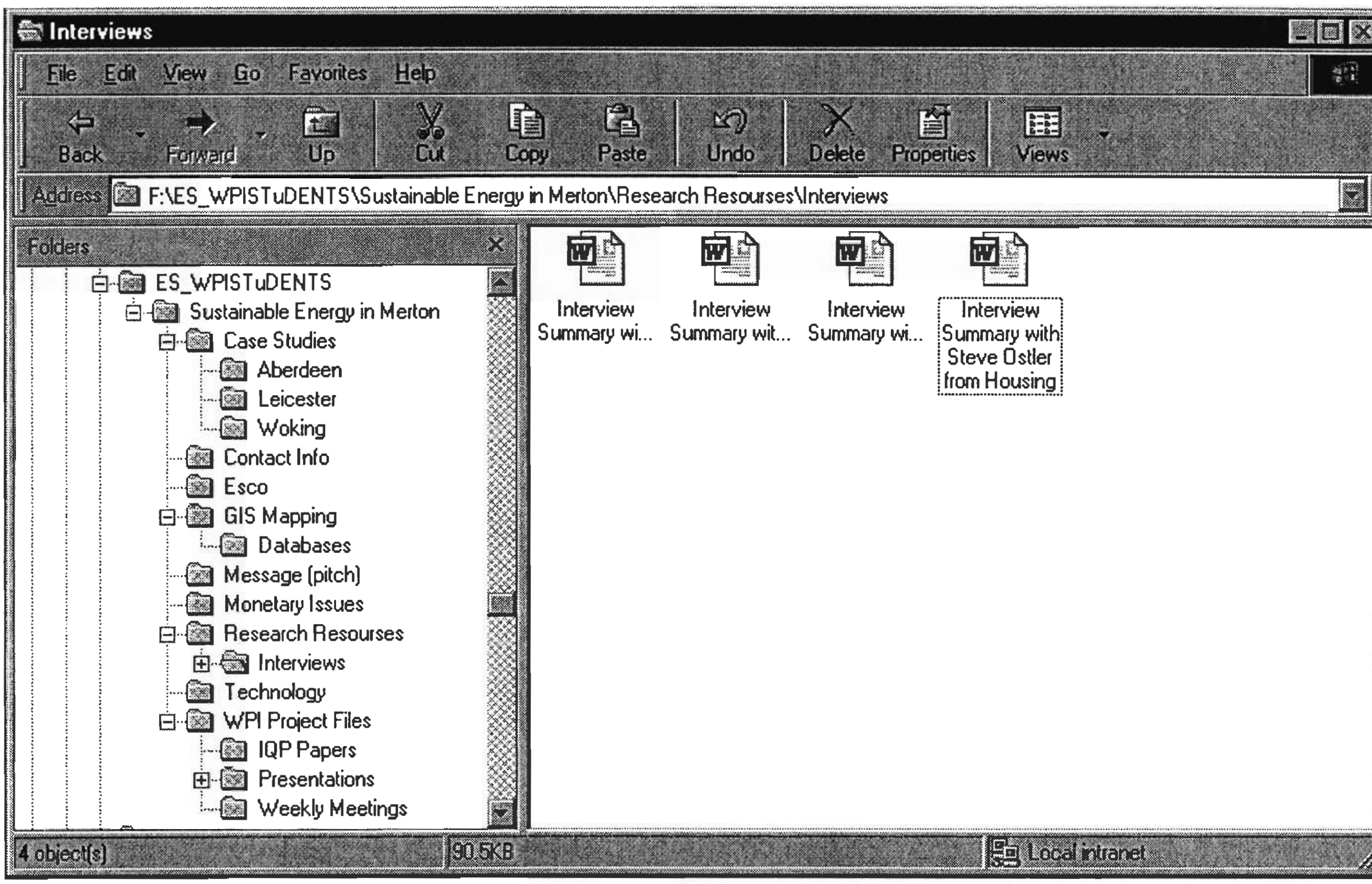

Figure 7: Merton Civic Centre Folder System

5.2 Perform Case Studies of Relevant Projects

To understand what was required for completing a sustainable energy project, research was done on projects that had been completed in the past and available CHP technologies. The data we gained in these areas can be found in the previous chapter. The analysis of the case studies provided insight into the decisions, processes and technologies used in previous sustainable energy projects.

5.2.1 Results

Results showed that the capacity for most CHP systems is between 0.5 and 10 Mwe. These are sufficient for supplying power to large buildings and entire campuses. Solar and Trigen are the most commonly used brands of CHP and may be applicable in Merton. This is important because the implementation of these systems will begin in just two short years. The information we have obtained will be made available to future projects in our folder system.

To obtain the financial backing that would be required for setting up a sustainable energy system, Woking, Aberdeen and Leicester all developed 'arm's length' companies. These companies are set up with their respective governments owning 51%, maintaining control. The other 49% is sold to private investors, building capital used to purchase and install the systems. This innovative method of funding has been used in the three examples we have been studying with the companies of Thamesway Ltd. (Woking), Leicester Energy (Leicester), and Aberdeen Ltd. (Aberdeen).

5.2.2 Deliverables

The CHP technology information has been organised by sustainable energy projects and CHP technical specifications. Each of the databases can be found in the Merton Civic Centre network folder system. The projects database is in the form of an Excel spreadsheet and can be sorted by a number of variables including name of project, location and power to heat ratio. By organising the data in this way, future project teams and Merton partners will be better prepared to make recommendations on which type of system to use. The CHP technology information is also organised in a spreadsheet format. This information can be seen in Figure 8.

The information concerning Woking, Aberdeen and Leicester case studies has also been organised and placed in their own folder on the Merton Civic Centre network system. Each of these folders contains a brief summary of the project, contact information and relevant reading for future research.

Comparison of CHP Technologies

	IC Engine	Steam Turbine	Gas Turbine	Micro-turbine	Fuel Cells
Technology Status	Commercial (3% of existing CHP capacity in NY, 66% of sites)	Commercial (14% of existing capacity, 13% of sites)	Commercial (83% of existing capacity*, 21% of sites)	Early entry	Early entry/ development
Electric Efficiency (LHV)	25-45%	5-15%	25-40% (simple) 40-60% (combined)	20-30%	40-70%
Size (MW)	0.05-5	0.01-100	0.5 -50	0.025-0.25	0.2-2
Installed cost ($/kW)	800-1500	800-1000	700-900	500-2000	>3000
O&M Cost ($/kWh)	0.007-0.015	0.004	0.002-0.008	0.005-0.015	0.003-0.015
Availability	92-97%	Near 100%	90-98%	90-98%	>95%
Start-up Time	10 sec	1 hr-1 day	10 min –1 hr	60 sec	3 hrs-8 hrs
Fuels	natural gas, biogas, propane, liquid fuels	All	natural gas, biogas, propane, distillate oil	natural gas, biogas, propane, distillate oil	hydrogen, natural gas, propane
NO_x Emissions (lb/MWh)	0.4-10	Function of boiler emissions	0.3-2	0.4-2	<0.05
Uses for Heat Recovery	hot water, LP steam, district heating	LP-HP steam, district heating	direct heat, hot water, LP-HP steam, district heating	direct heat, hot water, LP steam	hot water, LP-HP steam
Thermal Output (Btu/kWh)	1,000-5,000	n/a	3,400-12,000	4,000-15,000	500-3,700
Useable Temp (F)	200-500	n/a	500-1,100	400-650	140-700

Source: New York State Energy Research and Development Authority

Figure 8: CHP Technology Database

5.3 Establish a Database for the Merton Mapping Development Plan

A database for the Merton Mapping Development Plan will be created in MapInfo by future teams. This project identified the fields needed in MapInfo, and set up a foundation for gathering the necessary information. Not only will the GIS mapping provide for an added tool in completing the sustainable energy project but will offer other organisations in Merton the use of a mapping program.

5.3.1 Results

In setting up the groundwork for the Merton Mapping Development Plan, a list of fields necessary for input into the MapInfo database was developed. An Excel spreadsheet was created to organise information relevant for completing the sustainable energy project. Each field of information is marked as currently available or unavailable from the various departmental databases.

5.3.2 Deliverables

Tangible outcomes from the creation of Merton's Mapping Plan include a contact information database and a list of the necessary fields for a complete building inventory. The database also shows whether or not the information is currently available from the council. This information is stored in the network system folders, available for use in future projects. Located in Appendix C is a list of the fields, classified by the type of information they fall under. This list was given to the various Merton building representatives.

5.4 Chapter Summary

The analysis of this research has been organised by the three objectives of this project. The results of the analysis provide future teams with an informational foundation for the continuation of the project.

6.0 Conclusions and Recommendations

Relating the analysis to the goal statement of this project provides five main conclusions. These conclusions are listed below:

- A project of this nature is very complex.
- The project requires careful planning and scheduling
- A MapInfo database of structures and their energy properties is a vital tool in the planning process.
- The work of future WPI project teams in support of Merton's sustainable energy program must be carefully defined
- The work of future WPI project teams, in support of Merton's sustainable energy program, must be carefully defined.

6.1 Complicated Process

This project was originally developed to perform a feasibility study on the proposed implementation of a sustainable energy system in the London Borough of Merton. At the beginning of this project, the important realisation was reached that a feasibility study on sustainable energy can not nearly be completed in the seven week time period we were allotted. The feasibility study for Merton is currently scheduled to take place over the next year and a half, with implementation of the systems beginning in two years time.

6.2 Merton Sustainable Energy Project Structure

Through brainstorming sessions and extended discussions with our sponsor, Adrian Hewitt, an organised and detailed description of the entire length of Merton's sustainable energy project was developed. This description divides the process into four chronological parts, which are the feasibility study, support, financial considerations, and implementation. The entire outline that was developed can be found in Appendix D. This thoroughly planned outline is to be used by Merton and its project partners for the length of the energy development program.

6.3 *MapInfo Fields*

This project developed a comprehensive list of the fields of information that are needed to complete the Merton Mapping Plan. These fields are divided into the categories of GIS Identification, General Building Information, Current System Specifics, Energy Usage, Maintenance and Database information. The list developed includes all the possible fields that will be necessary and the entire list is available in Appendix C.

The list of necessary fields discussed above was distributed to the correct building code departments within the Merton Civic Center to discover what fields were available to us and which ones will have to be obtained by future groups. The findings are shown in Appendix E. If a field is highlighted in green, it is easily accessible from the source listed. If the field is highlighted in red, however, this information is not available at this time.

In order to make the next project team's transition smooth, the Borough should obtain the information fields that were found to be unavailable before the team's arrival. The spreadsheets in Appendix E show what fields are not currently available from the Merton Council building department databases. These fields need to be collected in a variety of ways, including observation and acquiring data from the electric and power companies.

One of the most difficult aspects of this project was finding updated information on Merton's portfolio of buildings. The easiest way to solve this problem would be a web-based questionnaire filled out yearly or quarterly by landlords and building owners. This questionnaire would request information on the building that the Council would like to record in its MapInfo database. Including these questionnaires in lease contracts and making it mandatory for landlords to fill them out would ensure a constant flow of information. This would guarantee that Merton's information database was constantly being updated and could be converted directly into MapInfo.

6.4 *Map Sequential WPI/Brunel Projects*

The outline developed in this project defines the clear need for more WPI projects with the London Borough of Merton. The next project between WPI and the Merton Council will be to develop the mapping plan by entering the available data into MapInfo. This team will need to be equipped with adequate knowledge of the MapInfo program and will need to be made aware of the progress made in this particular project.

The next WPI project, after the mapping, will be a web-based one. This group will transfer the data and analysis currently available on the Merton Council network into a web based system that is accessible to Merton, LETIT, WPI and any other interested project partners. This group will need to specialise in website development and maintenance.

This project was the first collaboration between WPI and Brunel students. Merton hopes to continue the involvement of both schools for the completion of this sustainable energy project. To make communication more effective, Merton should develop a website or network through which information from both teams will be shared before the WPI team is onsite. This will make both groups aware of the exact progress being made, and ensure that they are working in the same direction.

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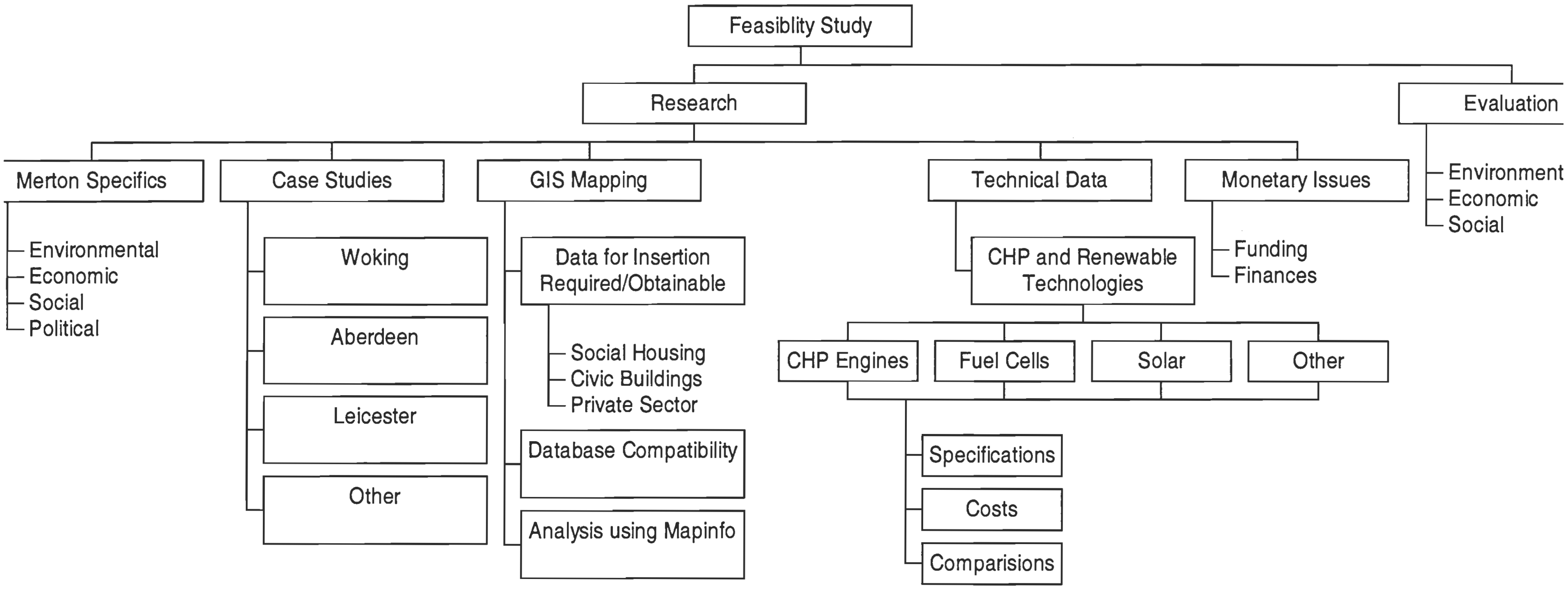
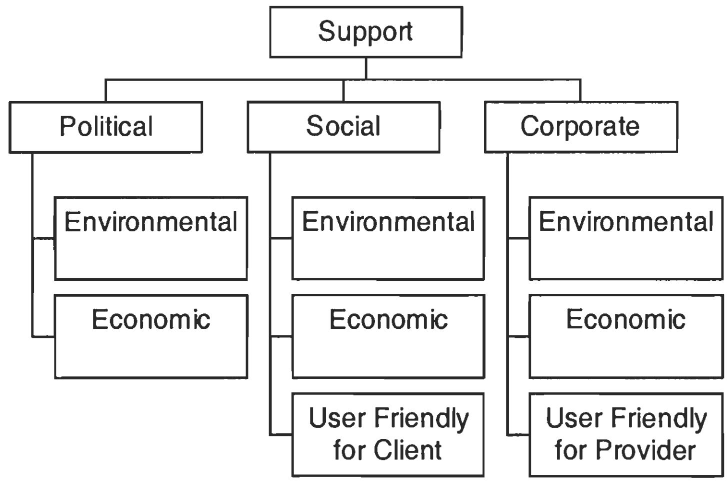
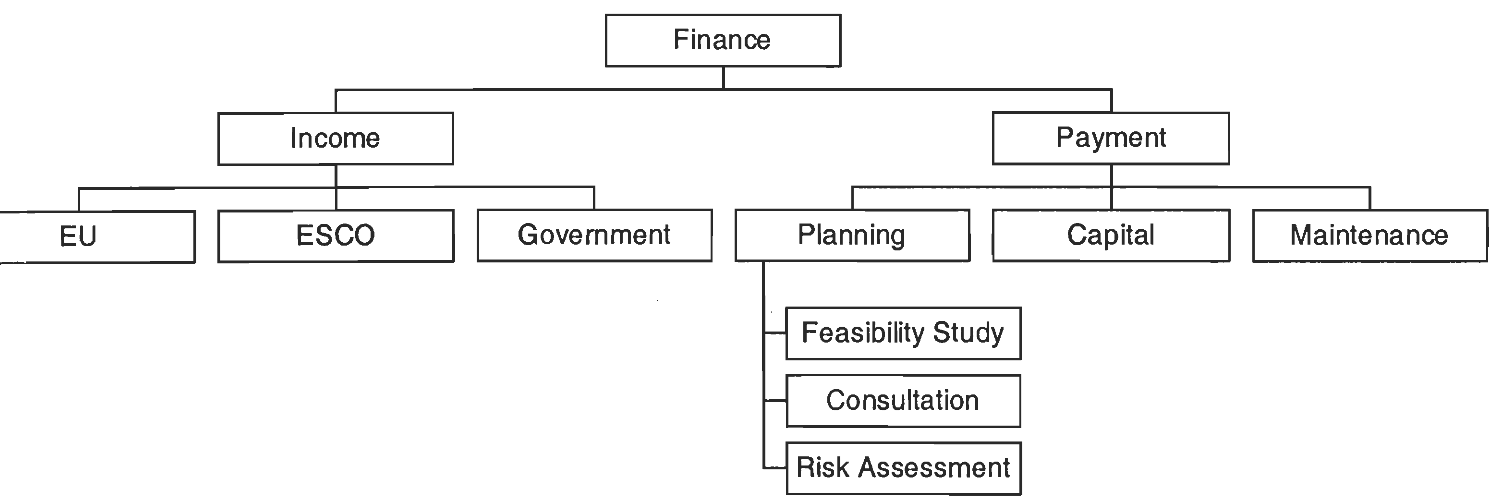
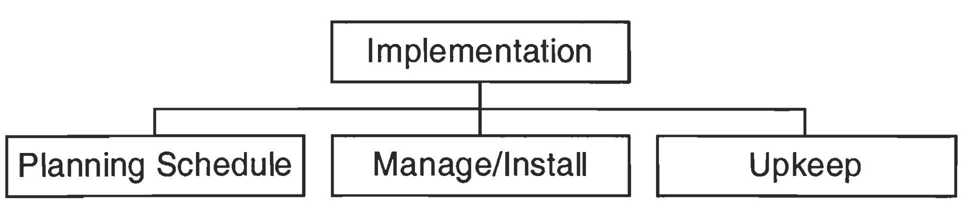
Appendix A – Sustainable Energy Framework




Support
Political
Social
Corporate
Environmental
Economic
Environmental
Economic
User Friendly for Client
Environmental
Economic
User Friendly for Provider


Finance
Income
Payment
EU
ESCO
Government
Planning
Capital
Maintenance
Feasibility Study
Consultation
Risk Assessment


Implementation
Planning Schedule
Manage/Install
Upkeep

Appendix B – Letter to Woking Official

FAO: Alan Jones MBE
Woking Council
From: Andrew Judge
Leader of Merton Council
RE: Advice and guidance on replicating the Woking sustainable energy model in Merton

15th March 2004

Dear Alan

When we met with Nick Gavron at City Hall you explained in detail the principles behind Woking's exemplary private wire & duct sustainable energy system, and since then we have been exploring the possibility of replicating such a system here in Merton. We are now ready to undertake a feasibility study for this and Adrian Hewitt (whom you know) is taking the lead.

I appreciate that you are extremely busy, but it would be very helpful if you could spare Adrian an hour or so he can ask your advice about a few things.

This feasibility study is being done as part of a six-nation EU project (LETIT) funded under the 6th Framework. It is a local authority version of Concerto, and our UK partners are Energy for Sustainable Development (ESD), the GLA and Utilicom. The EU partners are in Poland, the Czech republic, Germany, Italy and Portugal. The focus of this two-year project is to research how local authorities can substantially reduce carbon emissions from their portfolios of property, and in so doing help the EU to meet its Kyoto carbon reduction targets.

As we already know that the most sophisticated mechanism for achieving this is the private wire and duct system, we therefore intend (within 18 months) to present a detailed proposal to the GLA and EU advising that this should be the established way forward.

Four research students from Worcester Polytechnic Institute in Massachusetts, and three from Brunel University in West London, have been seconded to Adrian for six weeks to make a start with the feasibility study research. They have already been doing web-based research on Woking, but may need to explore the technical aspects in further depth, if possible by talking to some of your technical experts.

We understand the financial, environmental and social rationales behind the scheme, and this initiative is being driven at a corporate level as well as by my own personal commitment to sustainable development. We have already learned a lot from Woking, and following your lead, we are about to circulate a draft Climate Change Strategy that will underpin our carbon reduction ambitions. We are proud to have established a sustainable development profile with our progressive renewable energy UDP policy, and

I am aware that you have been liaising with Adrian and Steve Cardis on the further development and implementation of the policy.

I hope it will be possible to make arrangements between the students and some of your technical experts if they identify this as necessary to your work. Their 6 weeks in Merton starts from 15th March. Adrian's contact details are: adrian.hewitt@merton.gov.uk

Many thanks
Andrew Judge
Leader of Merton Council

Appendix C – List of Fields Needed

GIS Identification

- How building location is organised in database
    - Address
    - Ward
    - Streets

General Building Information

- Building usage (i.e. library, school, housing)
- Number of flats
    - Single resident units
    - Family resident units
- Total number of residents
- Number of floors
- Number of lifts
- Age and state of building
    - Window types (i.e. double glazing)
    - Existence of open gas fires
    - Other…
- Property dimensions
    - Total plot area
    - Total building area
- Orientation of buildings
    - Direction of pitched roofs
    - Area of pitched roofs

Current System Specifics

- Type of current boilers
    - Efficiency of boilers
    - Location of boilers
- Number of boilers

Energy Usage

- Total energy consumption
    - Electricity amount used
    - Fuel amount used
- Current electricity costs
- Current fuel costs

Maintenance

- Asset management review target
- Maintenance schedule (date of next refurbishment)
- Cost of current refurbishment
    - Cycle for refurbishment of system
        - Total system at once
        - Individual components at a time

Database information

- What is the format of your database (i.e. access, excel)

- How is the database information organised into time periods? (i.e. monthly, yearly)
- How often is your database updated?

Appendix D – Interview Summaries

D.1 Gary Shaw

Interviewed: Gary Shaw
Members Present: Jonathan Trexler, Allison Wing
Date: 22-03-04
Time: 10.30

This interview was completed with Gary in order to find information about the MapInfo. We needed to know how information was to be inputted and what program(s) we could use. Our results were as follows:

MapInfo allows users to create sub-tables for organisation. Most formats can be directly linked into MapInfo easily. These forms include Microsoft Excel, Access, and various other basic database programs. Data must be inputted into MapInfo in one of the following types: character, integer, small integer, float, decimal, date, and logical.

The current MapInfo database already includes important data that may be used in the study including building location, property area, etc.

Questions left unanswered:
How to identify each building
How to characterise each building (i.e. residential, commercial, and industrial)

D.2 Elizabeth Back

Interviewed: Elizabeth Back from Housing
Members Present: Adrian Hewitt, Nick Contrino, Jeff Ford, Jonathan Trexler, and Allison Wing
Date: 22-03-04
Time: 14.30

This interview was completed with Liz in order to find information about the Social Housing in the area of Merton. We need information on each building to begin the mapping project that will be completed over the next two years. Specific information we wanted included populations, number of council owned buildings, and whether or not they have a database with information such as energy and heat consumption. Our results were as follows:

Many social housing developments are owned by RSL. There are 6 main private social landlords we will have to work with. The Merton Council has no control over the energy systems in RSL owned properties, so we will need to convince them it is financially beneficial. In the long run, it is up to the landlords whether they want to implement sustainable energy or not, so retro-fitting is not necessarily an available option to us.

Merton owns 7700 properties. The Housing department has information on these properties including their addresses, populations, and identification numbers. When identifying buildings in our Map Info, it will be most beneficial to use these same ID numbers. The database used in Housing is in the program 'Academy', which we will need to access from IT. Steve Ostler in ISS is the contact for this database and the program.

We will be able to start installing CHP systems during the maintenance year starting in April 2006. Ms. Back in housing stock knows the schedule for these 'capital works'. Due to financial constraints, the housing stock can only refurbish one aspect of the systems at a time. Boilers have to be refurbished approximately once a year. These auxiliary costs of the current systems have to be taken into account when comparing them to the new, sustainable energy systems. Boilers usually last between 10 and 15 years (her best estimate) before they must be replaced.

The orientation of buildings for possible solar panel installation is not known. This will most likely be figured out by observational analysis. The housing department does not have statistics on energy and heat consumption as that would have to be researched through London Electricity. We will most likely be able to find the averages of certain building sizes or generic data to get estimates.

One of the most important parts of this project is that we will have to sell it to the private sector. We have to convince them it is economically beneficial and that there is no downside to it. There is some communal heating installed in the social housing sector. We have to find whether our system will cost less than even this system.

Questions left unanswered:
How many RSL properties are there?
What is the orientation of each building? (which compass direction does it point?)

What is the energy consumption of each building?
What is the heat consumption of each building?

D.3 Steve Ostler

Interviewed: Steve Ostler from Housing – HSG/S.S. Project Coordinator
Members Present: Nick Contrino, Jeff Ford, and Jonathan Trexler
Date: 02-04-04
Time: 16.00

This interview was completed with Steve in order to find information about the Academy database software that Merton uses to hold all data regarding social housing. We needed information on each building to begin the mapping project that will be completed over the next two years. Specific information we wanted included building usage, number of flats, electricity used, heat used, and etc. We needed to know which of these necessary fields were already recorded in the Academy database so that we will know which fields still need to be gathered. We also needed to ask how we could gain access to the Academy software ourselves to search through the database. Our results were as follows:

Steve Ostler overviewed the Academy software with us and described briefly how it worked. It is a database system that is used by the housing department to store and access information pertaining to social housing. The software is not necessarily widely used, as there are few organisations that have a need for this specific type of application. A result of this is that each organisation that we will be soliciting information from may likely be using a different program. However, since this program, as well as others of a similar purpose, is based on SQL (structured query language), they will able to be imported into a GIS program. The ease of this process will most likely vary, yet in most, if not all, cases there is a way.

The marking system they use to represent various qualities of each entry, which is a living quarter, is stored in a somewhat cryptic manner. Each word, or key, represents a feature of the entry and possibly a number associated with that feature, such as having a lift, or a number of bathrooms. Once we figure out what each code means, we can then request a data list of every entry with the features we require. The information we are able to obtain is subject to its sensitivity and security.

We also discussed with Steve the ability for us to gain access to the Academy software on our computer so that we can decipher which fields are contained in the current database. Steve informed us that Adrian Hewitt must inform IT services that he gives administrative access privileges to Steve so that he can install the program on our computer.

We also learned that the entire database is being restructured within the month. This new system will be formatted in X-Base, a format similar to D-Base, widely used throughout the UK. Unfortunately, it will not be completed until the last week of our project, so this makes access to the current information difficult. What we did gain in this interview was a list of exactly what fields the housing department has on their buildings and which ones will need to be collected before implementation can begin. The following page shows all the fields we deemed necessary along with a note whether this information is available.

Questions left unanswered:
When will we be able to get Academy?
How can needed information be collected?

Needed Fields:
Information is available
[redacted]

GIS Identification

- How building location is organised in database
    - Address
    - Ward
    - Streets

General Building Information

- Building usage (i.e. library, school, housing)
- Number of flats
    - Single resident units
    - Family resident units
- Total number of residents
- Number of floors
- Number of lifts
- Age and state of building
    - Window types (i.e. double glazing)
    - Existence of open gas fires
    - Other...
- [redacted]
    - [redacted]
    - [redacted]
- [redacted]
    - [redacted]
    - [redacted]

Current System Specifics

- [redacted]
    - [redacted]
    - [redacted]
- [redacted]

Energy Usage

- [redacted]
    - [redacted]
    - [redacted]
- [redacted]
- [redacted]

Maintenance

- [redacted]
- [redacted]

- [redacted]
    - [redacted]
        - [redacted]

Database information

- What is the format of your database? A: Academy
- How is the database information organised into time periods? A: NA
- How often is your database updated? A: Every 10 years

D.4 Brunel Project Team

Interviewed: Brunel Project Team – Claire, Chris and Lisa
Members Present: Adrian Hewitt, Nick Contrino, Jeff Ford, Jonathan Trexler and Allison Wing
Date: 05-04-04
Time: 12.00

This interview was completed with the Brunel project team in order to learn how our projects fit together. This was the first official meeting between the two teams to discuss our results and findings to this point. Our results were as follows:

As expected, the Brunel team has been working on the qualitative side of sustainable energy data. They have been following leads to information such as do residents of sustainable communities like their system and does it do the necessary job. Unexpected, however, was the amount of trouble the team has had in finding this information. As of right now, they have only provided us with a list of contacts from our case study of Aberdeen.

Since this is the first collaborative WPI and Brunel project in what Merton hopes to be many, it became important to us to set up a base of communication that future groups should use. The Brunel team was impressed with our shared network folder that anyone logged into the Merton Civic Centre can access. For now, we decided to compile our information with what the Brunel team had, such as contact information, in our network folder. The goal is that the next project team will take this network folder and easily transition it into a website accessible by both teams.

Questions left unanswered:
What role will the Brunel team's findings play in our final report?
What's the best way for the Brunel team to access our information from their home?

D.5 Robert Perry

Interviewed: Bob Perry Civic Buildings database representative
Members Present: Adrian Hewitt, Nick Contrino, and Jonathan Trexler
Date: 14-04-04
Time: 14.00

This Interview was completed to find out what information was available from the current Civic Building database. A list of fields was given to Bob Perry the week before so he had time to prepare and look into what information he had available.

There are 3 main databases that civic buildings uses to store their information. They are an Operational Systems database, a Non-Operational database, and a general condition/maintenance database.

The Operational Systems database holds buildings such as libraries, schools, etc. It is organised through an 'Asset Register Structure'. The database is broken down into sites, and from there is further broken down into individual blocks (buildings) and then into individual rooms. The Code system for this identification looks like: 02/0103 with the 02 indicating block number 2, the 01 after the slash indicates the floor number, and the 03 indicates the room number. The database is in a similar format to access and can easily be exported into an excel spreadsheet.

The Non-Operational Systems database holds buildings such as shops, industrial units, and also roadways. The database is not broken down into the detail of the Operational Systems database. It is organised in a 'Land Terrier Structure'. The database is in the same format as the first Operational Systems database and can easily be exported into an excel spreadsheet.

The third database is the Conditional Database. This database is an excel spreadsheet organised by UPRN number. It is a supplementary database to the first two databases Some of the fields included in the database are: Generic Elements of building, year installed of elements, condition (rated A-C), repair proposition, repair priority, projected cost, year of repair, type of maintenance, extra comments. It should be noted that the same UPRN number is used for each group of buildings.

Sirco is the maintenance company for Merton civic buildings and is located on the 14^{th} floor. The contact for them is Tony Skilbeck who Adrian will be contacting shortly. They will hopefully be able to supply us with information regarding maintenance such as open gas fires, boilers, boiler repairs, number of lifts, maintenance schedule, etc.

We also acquired a spreadsheet with valuable civic building information. It is an excel spreadsheet of the energy consumption figures from the different properties. Additional information to be noted was discussed regarding financial advantages to identifying information for multiple departments. Funding for future WPI projects and other projects towards the two-year Merton Sustainable Energy Plan could be obtained easier by splitting the cost between interested departments. For example, collecting data for implementation into a database would be useful to many different departments.

We discussed setting up a possible web-based system for a continuous system of information gathering. This would keep the database up to date with the relevant and necessary information. It would be inputted by the end users and maintenance personnel instead of having the civic building people go to the site and make the same report that could have been done by the same people. Also a possible problem for such a system would be that not everyone would be familiar with computers. Solution would be alternate forms of inputting needed information such as scanable paper reports/forms.

Appendix E – Available Fields Database

E.1 General Building Information

Department	Building Unit Title	Location	Usage	Number of Flats	Total Number of Residents	Number of floors	Number of lifts	Age of building	Window types	Open gas fires
Social Housing - Steve Ostler	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Civic Housing - Bob Perry	Y	Y	Y	Y	NA	Y	N	Y	Y	N
Civic Housing - Sirco	N	N	N	N	NA	N	Y	N	N	Y
Civic Housing - Total	Y	Y	Y	Y	NA	Y	Y	Y	Y	Y

Department	Total plot area	Total building area	Direction of pitched roofs	Area of pitched roofs
Social Housing - Steve Ostler	N	N	N	N
Civic Housing - Bob Perry	N	Y	N	N
Civic Housing - Sirco	N	N	N	N
Civic Housing - Total	N	Y	N	N

Field currently available from database: Y
Field not available from database: N

E.2 Current System Specifications

Department	*Building Unit Title*	*Location*	*Type of boilers*	*Efficiency of boilers*	*Location of boilers*	*Num of boilers*
Social Housing - Steve Ostler	Y	Y	[redacted]			
Civic Housing - Bob Perry	Y	Y	[redacted]			
Civic Housing - Sirco	[redacted]		Y	Y	Y	Y
Civic Housing - Total	Y	Y	Y	Y	Y	Y

E.3 Energy Usage

Department	Building Unit Title	Location	Electricity used	Fuel used	Electricity costs	Fuel costs
Social Housing - Steve Ostler	Y	Y	[redacted]	[redacted]	[redacted]	[redacted]
Civic Housing - Bob Perry	Y	Y	Y	Y	Y	Y
Civic Housing - Sirco	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Civic Housing - Total	Y	Y	Y	Y	Y	Y

E.4 Maintenance

Department	*Building Unit Title*	*Location*	*Asset management review target*	*Date of next refurbishment*	*Cost of Refurbishment*	*Cycle for refurbishment*
Social Housing - Steve Ostler	Y	Y	[redacted]	[redacted]	[redacted]	[redacted]
Civic Housing - Bob Perry	Y	Y	[redacted]	[redacted]	[redacted]	[redacted]
Civic Housing - Sirco	[redacted]	[redacted]	[redacted]	Y	Y	Y
Civic Housing - Total	Y	Y	[redacted]	Y	Y	Y