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Mapping Building Characteristics In Mitcham

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February 24, 2006
Mr. Adrian Hewitt
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Merton Civic Centre
London Road
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Dear Mr. Hewitt:

Attached is one copy of our report entitled Mapping Building Energy Characteristics in Mitcham. It was written and compiled at the Merton Civic Center between January 9, 2006 and February 24, 2006. Initial research was completed in Worcester, Massachusetts, between October 25, 2005 and December 15, 2005. Copies of this paper are being simultaneously submitted to Professors Hanlan and Carrera for evaluation. Upon faculty review, the original copy of this report will be catalogued in the Gordon Library at Worcester Polytechnic Institute. We are grateful for the time and resources that you and the Council staff have devoted to us.

Sincerely,
Rick Skowyra
Jeremy Shaw
Nick Wirth
Amanda Gagne

Mapping Building Energy Characteristics in Mitcham

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Sponsoring Agency:
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Monday, February 27, 2006

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Abstract

The London Borough of Merton has begun the development of a district heat and power system. In order to financially model the feasibility of this scheme, energy consumption data for borough buildings must be known. The objective of this project was to investigate and apply methods for mapping the energy use of buildings within the borough of Merton. Difficulties encountered in data collection led to a revision of our project to include the drafting of sustainable information gathering mechanisms. With these in place the Merton Council will be able to base future plans on an accurate and thorough knowledge base.

Authorship Page

This report is a joint effort on the part of all project team members; however each individual chose an area of specialization to focus upon. Jeremy worked largely on the GIS component of our project, and assisted in database population. Amanda acted as our primary researcher, and organized the majority of data source information. Rick served as the group's primary writer and data source analyzer. Nick worked equally on the GIS and writing of the report.

Acknowledgements

The following people assisted us throughout the course of our project. We would like to acknowledge them for the help and support that they have provided:

Adrian Hewitt
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WPI Carbon Mapping Team ‘06

Executive Summary

Global warming is a problem affecting the world community that has gained significant recognition since the closing years of the 20th century. The warming is caused by greenhouse gases in the atmosphere that trap the sun's energy and prevent the dissipation of solar radiation. Specific effects of climate change include increased storm activity, rising sea levels, and shifting rainfall patterns worldwide. The primary contributor to global warming is CO_2, released by the combustion of fossil fuels for the purpose of creating usable energy in transportation, heating, and electricity production.

The Kyoto Protocol, ratified in 2004 and put into force in 2005, attempts to reduce global carbon emissions through concerted efforts by its signatory nations. Great Britain is among the countries that have signed and attempted to implement this agreement. As a world leader in progressive environmental policy, Britain has gone beyond its duties as a signatory of the Kyoto protocol and pledged to not only achieve the 8% reduction by 2012 required, but also meet a self-imposed requirement of 20% by 2010. Many possible solutions can be implemented on a local level by British municipalities. Already, the borough of Merton has pledged to reduce its carbon emissions by 15% for the year 2015, and imposed a 10% renewable energy requirement on all new buildings in Merton.

The borough of Merton is working to achieve their goal of carbon emission reduction partially through the installation of a Combined Heat and Power network. A CHP system provides electricity and heat on a local level to buildings in a more efficient manner than traditional systems. The heat generated in electricity production is used to heat buildings as opposed to being expelled into the atmosphere, increasing power efficiency from 50% to as high as 90%. In order for Merton to install a CHP plant, the energy demand of area buildings must be calculated to determine the necessary capability of the plant.

This project is intended to help the borough of Merton achieve its goal of reducing carbon emissions by 15% by 2015 through gathering baseline data on building characteristics and energy consumption to populate the borough's Geographic Information System. The data gathered focused on buildings implementing the borough-wide Combined Heat and Power system. By creating a comprehensive building database and displaying it graphically, we hoped to make recommendations to the Merton Council concerning which buildings should be connected to the CHP grid. Due to a lack of organized and accessible data, however, this proved not to be feasible. We devised procedures and recommended changes to existing information systems aimed at addressing these inconsistencies.

First, we separated buildings into different usage categories: business, civic, education, and housing. Building use is critical to the inclusion or exclusion of a building to the Merton Combined Heat and Power system due to varying power requirements and service contracting issues. Next, we devised a list of important building characteristics, and tried to link these characteristics to sources of information. We then collected detailed physical building information on structures in the target area through field analysis. A database was constructed to contain categories of these building characteristics. The data were then integrated into the existing Merton Geographic Information System and used to map building use and energy consumption. Finally, we recommended changes to the Merton Council's data collection system to allow for a sustainable and largely automatic updating of building information.

Our first objective was the creation of a list of attributes to collect for each building in Merton, creation of a database to contain these attributes, and the linkage of each characteristic to a source of information. Selection of building characteristics was based on the eventual goal of energy estimation. We abstracted four broad categories of building data: use, ownership, physical data, and energy use. Building use describes what purpose the building is currently serving, ownership/location contains information on who is in possession of the structure and its location, physical data lists relevant structural attributes, and energy use includes any information relating to electricity and heating efficiency and consumption. The map below displays all the buildings for which we found information, color coded by use.

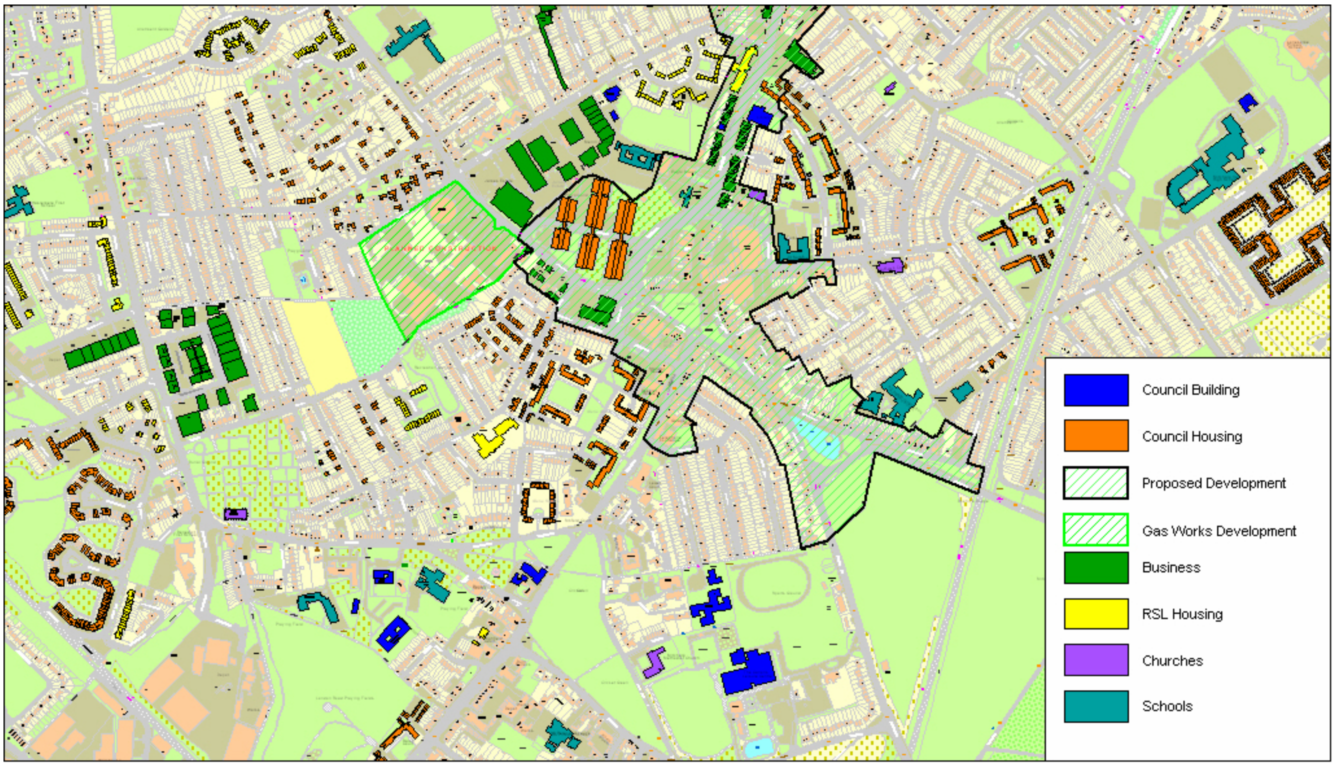

Figure A - Composite Building Map

Our second objective attempted to collect the characteristics that we arrived at in objective one, but were unable to derive from Council data sources. The final phase of building characterization, linking the desired data to sources of data, experienced a number of difficulties. Most notably the majority of information resources that we found are incomplete or infrequently updated. Furthermore, the location, level of completeness, organization, and quality of each data source varied significantly. To address this problem, we first collected field data in lieu of archival data that could serve as the basis of our GIS maps. Next, we sought an organized, succinct, and graphical method of displaying the results of our research into data sources. This resulted in the creating of an information matrix, shown below. The matrix links all of our desired data fields to possible sources, and displays the availability, and reliability of each.

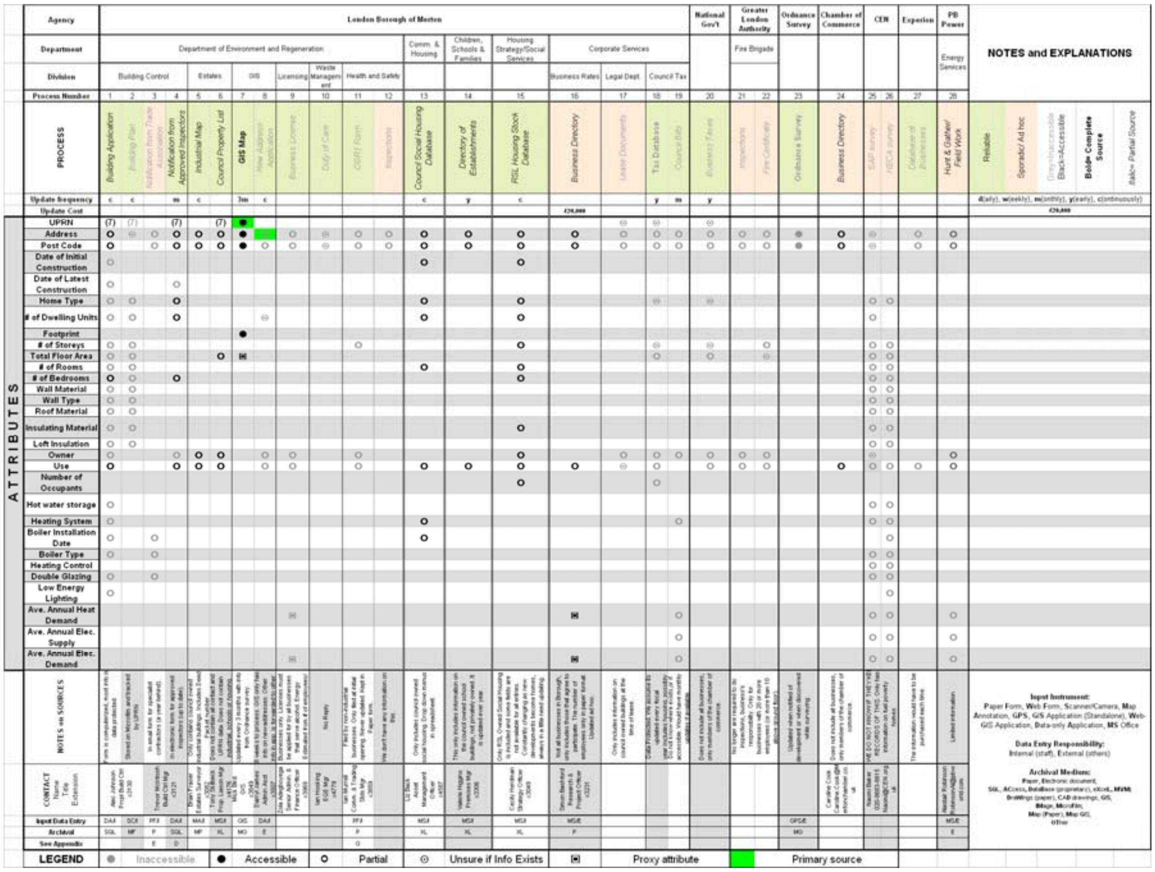

Figure B - Matrix

Our third objective does not directly concern mapping buildings; rather it arises from difficulties that were encountered while gathering data for mapping. Specifically, a dearth of complete and current sources of information prompted us to include this objective. We searched for mechanisms that could eliminate human data-entry and replace it with a computerized system that only requires occasional oversight. Time savings can be achieved by automating not only data entry, but data collection. We sought a 'City-Knowledge' inspired model that integrates both of these benefits into a database that can sustain itself with little human intervention. We determined five characteristics of a data source that are necessary for achieving such a system: Digitalization, Organization, Meta-Info, Updating, and Sharing. An algorithm was devised to rate each of our data sources based on these five categories, in order to identify areas for improvement. The figure below shows a cumulation of these ratings, in order to compare different sources.

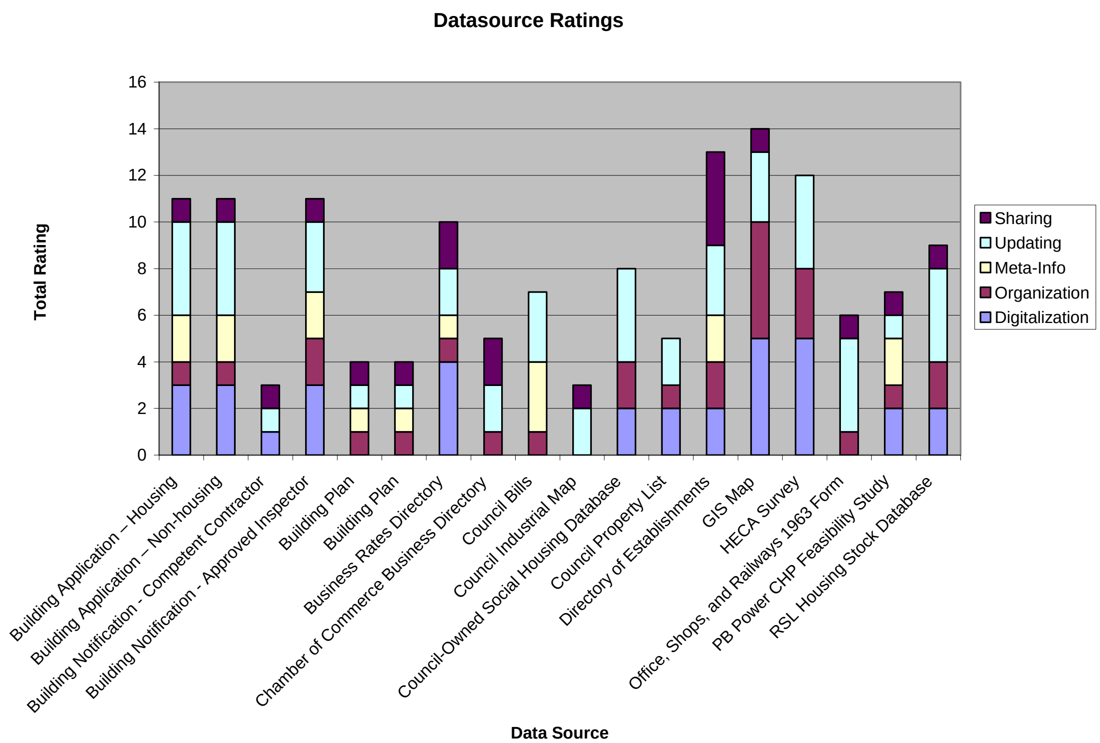

Figure C – Datasource Ratings

Throughout the course of our project, several aspects of the Merton Council's data collection and archival system have proved troublesome. Specifically, there is little communication between departments, no organized information sharing systems, no standard format for collecting data, and little knowledge of a data source outside of its immediate users and creators. All of these problems arise from 'need-to-know'; a paradigm that is at the heart of many corporate information systems. In brief, this doctrine results in a case where any given employee or group of employees has access and/or knowledge only to the data that they immediately require. Instead of information hiding, a practice of sharing accurate and complete information between departments, using organized and indexed cross references, may prove to be a better choice.

Due to the problems our group encountered in gathering the information required to characterize all buildings, we recommend that this goal be carried over to the next WPI Interdisciplinary Qualifying Project group. By using the recommendations, results, and analysis that our group carried out, it should be possible to target promising information sources for many data fields while hunting and gathering the remainder. Any future work should focus on obtaining data quickly, and not investing too much time in any one resource unless it immediately proves useful. The current state of Council databases indicates that external sources of information ought to be considered, as well as field work. Energy estimation specifically should be approached from a typological and use standpoint for any building not council owned. Any invasive procedure will encounter serious difficulties in implementation due to privacy laws and the sheer number of buildings that must be accounted for.

In addition, we recommend that the borough begin to implement changes on a policy level, modernizing every database (be it a filing cabinet or a SQL table) within the Council. These should be treated as long-term goals toward creating a more efficient and complete knowledge base with which Council departments may make informed plans and decisions. (In the short-term it is most likely impossible to execute each recommendation due to the inertia inherent in retooling each department's information gathering mechanisms.) Our suggestions are targeted toward the five attributes of digitalization, organization, meta-information, updating, and sharing.

Our project group encountered significant difficulties while attempting to characterize Merton buildings. Under the current data collection and storage paradigm, most information needs to be sought out by first discovering the existence of a database through intranet searching or discussion with Council workers. Next, one must ask Council employees where a resource is located, find the resource, and request access to it. Frequently this data source is only partial, and cannot be used as a sole source of information on a given attribute. The entire process must then be repeated, sometimes more than once. The only alternative to this time-consuming process is field work, which while guaranteed to eventually yield results it is infeasible in any large-scale project. Characterization under such a system is difficult, but not impossible.

By employing both field work and hunting and gathering of information, we succeeded in characterizing and collecting data for a sample of Merton's buildings within an area centered on the Mitcham Gas Works. Some Council-owned structures have attached energy data, however the majority of available information pertains to the ownership and use of buildings. A lack of accessible information prevented us from including private residences in this sample, and partial data sources frequently inhibited the creation of an exhaustive building list. The methods that we had to employ are not sustainable, and require a significant number of man-hours to bear fruit.

One short-term solution to this problem is the establishment of 'hooks.' These regulations require certain types of buildings (such as businesses) to periodically report on their existence and/or condition. Hooks can be used to farm data that would otherwise be difficult to obtain, whether due to data protection laws or simple time constraints. By offering incentives, it may also be possible to gather otherwise private data such as electrical and heat consumption. All submitted forms can be digitalized and entered into a SQL database, which not only tracks information, but also meta-information, such as the last update and the database author. If forms are submitted through PHP web interfaces, almost no human intervention is needed to maintain an accurate and up to date picture of borough affairs. With the onus on borough residents to fill out and submit the data, Council employees are freed to pursue more productive tasks. Before hooks can be truly useful, however, the Council needs to address inconsistencies, redundancies, and communication difficulties within and between its various databases.

In the long-term, increasing the digitalization, organization, meta-information, updating procedures, and data sharing of Council databases, is highly recommended. Not only will individual information resources be made more efficient and powerful, but relational databases can be established that span existing databases and analyze interrelationships among currently disconnected data. Indexed and cataloged databases can provide all departments with a clear picture of not only Council activities, but how the borough responds to these activities. This will result in a greatly expanded knowledge base upon which projects and developments (such as the district heat and power system) can be planned and executed.

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1 INTRODUCTION

Global warming is a problem affecting the world community that has gained significant recognition since the closing years of the 20th century. Mounting evidence gathered by the UN Intergovernmental Panel on Climate Change suggests that global temperatures have risen 0.6°C since the late 19th century, and that "most of the warming observed over the last 50 years is attributable to human activities."[1] The warming is caused by greenhouse gases in the atmosphere that trap the sun's energy and prevent the dissipation of solar radiation. Specific effects of climate change include increased storm activity, rising sea levels, and shifting rainfall patterns worldwide. Of the greenhouse gases released from human settlements, the primary contributor "to climate change is carbon dioxide (CO_2), a byproduct of burning fossil fuels."[2] Globally, electricity generation and residential energy use account for a combined 55% of carbon emissions.[3] The Kyoto Protocol, ratified in 2004 and put into force in 2005, attempts to reduce global carbon emissions through concerted efforts by its signatory nations.[4]

Great Britain is among those countries that have signed and attempted to implement this agreement. As a nation relatively close to sea level, Britain faces potential damages from flooding amounting to £200 billion by 2050. According to the Energy Saving trust, established by the British government following the Earth Summit of 1992, "the average home was responsible for six tonnes of CO_2 emissions per year."[5] In London, 80% of these emissions can be traced to building energy consumption.[6] As a world leader in progressive environmental policy, Britain has gone beyond its duties as a signatory of the Kyoto protocol and pledged to not only achieve the 8% reduction by 2012 required, but also meet a self-imposed requirement of 20% by 2010.

In 2003, the British government released *Our Energy Future,* colloquially known as the "Energy White Paper." This established environmental conservation on a policy level by setting long-term goals and objectives for energy efficiency and ecologically sound economic practices. In addition, several projects are currently underway at the Oxford Environmental Change Institute to increase energy efficiency in buildings and decrease carbon emissions nation-wide. The *40% House* initiative spearheaded by the Oxford Environmental Change Institute and the 15% carbon reduction for 2015 project, implemented by the borough of Merton, are especially progressive initiatives, aimed at reducing carbon emissions on a grassroots and municipal level. The 40% House and Lower Carbon Futures studies suggest multiple possible implementations of energy-efficient practices, ranging from home insulation and appliance changes, to fuel switching and the viability of green energy sources. A study at the Oxford Brookes University has resulted in the creation of DECoRuM, a Geographic Information System (GIS) based model used to calculate the carbon emissions given off by individual buildings. Finally, industrial organizations such as the Combined Heat and Power Association are working with local authorities to switch many conventional energy systems to Combined Heat and Power (CHP) districts. CHP systems combine small scale power generation and community heating to reduce energy inefficiency and carbon emissions. Currently, the borough of Merton is considering implementing a CHP grid.

Many of the solutions offered above can be implemented on a local level by British municipalities. Already, the borough of Merton has pledged to reduce its carbon emissions by

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1 Houghton, J.T., 697
2 Environment Canada
3 United Nations
4 *Ibdem*
5 Lovell, 1
6 Merton, 1

15% for the year 2015, and imposed a 10% renewable energy requirement on all new buildings in Merton. A feasibility study concerning the construction of a CHP is currently underway. In order to gauge the success of this project, baseline data on the estimated energy usage and physical characteristics of Merton's buildings are required. A Geographic Information System (GIS) must be created and populated with current building data. Furthermore, methods for ensuring that the data accurately reflects changing real-world conditions must be put in place on a procedural level.

Our project intended to assist Merton in its goal by determining what data needed to be collected, and compiling the information into a tailored GIS. In order to obtain these data, we first established a method for efficiently collecting building characteristics from a variety of sources. Ideal sources included city records and databases, although surveys or on-site observations were used when necessary. In order to ensure that this system remains beneficial to Merton over time, we suggested a procedure to easily update the database with current information. With this data collection system in operation future groups will be equipped to analyze Merton's energy consumption and assist in development of a Combined Heat and Power (CHP) system.

2 BACKGROUND

This section of our proposal provides the necessary background information concerning our project and its *raison d'etre*. The background is arranged in a narrowing manner, and begins in Section 2.1 with a consideration of global warming and the effect of carbon emissions. The link between carbon emissions and energy use is explored, and various methods of combating global warming are detailed. The need for accurate and reliable tools to estimate carbon emissions on a geopolitical level is stressed, and several existing modeling systems from the United Kingdom and United States are explained in Section 2.2.

Section 2.3 describes current international efforts toward carbon reduction and compliance with the Kyoto and Montreal protocols. The United Kingdom's contemporary efforts to reduce carbon emissions are listed and briefly explained. The connection between carbon emissions and energy use is further explored in this section.

Efforts toward reduction of energy consumption and increases in energy efficiency are considered in Section 2.4. The Oxford Environmental Change Institute's research into building energy use reduction and policy recommendations for market transformation form a significant part of this section. The remainder is taken up by an in-depth treatment of Combined Heat and Power systems, and the steps taken by the London Borough of Merton to implement several of the measures described above.

Section 2.5 concludes our background with a history of Merton's plan to build a community CHP generation and distribution grid. The results of previous WPI projects with Merton are highlighted here. Recommended plant energy loads are detailed, and an explicit description of the proposed pipeline's path is diagrammed.

2.1 Global Warming

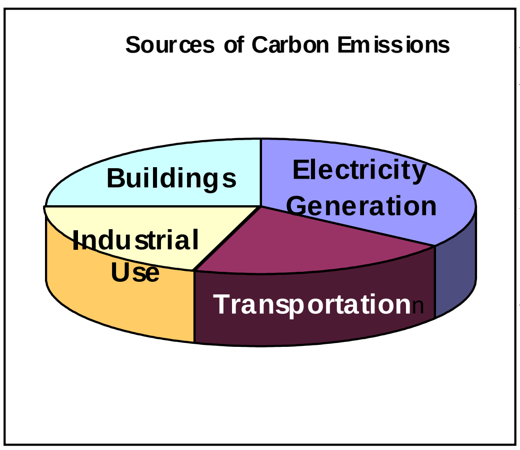

Figure 1 - Sources of Carbon Emissions

Global warming is a "progressive gradual rise of the earth's surface temperature thought to be caused by the greenhouse effect, and responsible for changes in global climate patterns."[7] In the past century, the average global temperature has risen approximately 0.6ºC; indeed the four warmest years of the 20th century occurred during the 1990's.[8] The greenhouse effect, caused by atmospheric gases such as carbon dioxide, water vapor, methane, nitrous oxide, halogenated fluorocarbons, ozone, perfluorinated carbons (PFCs), and hydrofluorocarbons (HFCs) being retained in the atmosphere, is most often believed to be the cause of this phenomenon.[9] These gases allow the sun's infrared radiation to enter our atmosphere and heat our planet; however, they absorb the longwave radiation, preventing its escape and subsequently increasing global temperatures.[10]

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7 NCBuy

8 "Global Warming"

9 *idem*

10 Botnia

Each greenhouse gas differs in its ability to absorb heat in the atmosphere. HFCs and PFCs are the most heat-absorbent. Methane traps over 21 times more heat per molecule than carbon dioxide, and nitrous oxide absorbs 270 times more heat per molecule than carbon dioxide.[11]

Despite this, the largest contributor to climate change is carbon dioxide.[12] Although CO_2 absorbs less heat than methane or nitrous oxide, it is much more abundant in the atmosphere. (Carbon dioxide accounts for 365 parts per million, where as methane accounts for 1.745 ppm and nitrous oxide for only 0.314 ppm.)[13] Carbon dioxide occurs naturally in the atmosphere; however approximately three-fourths of global carbon emissions are the result of burning fossil fuels such as coal, oil, and natural gas. The remainder is essentially the by-product of deforestation.14 Of the four major areas contributing to carbon emissions, electricity generation accounts for a full 35 percent. Transportation and industrial processes account for 20 percent each, and the remaining 25 percent is generated by heating of residential and commercial structures.[15]

According to the Energy Saving Trust (EST), "Britain emitted 536 million tonnes of carbon dioxide (CO_2) each year of which one-third was due to energy usage in homes."[16] Structural CO_2 emissions accounted for 80% of London's carbon production in 1999-2000, with the average home responsible for six tonnes of CO_2 emissions a year.[17]

2.1.1 Combating Global Warming

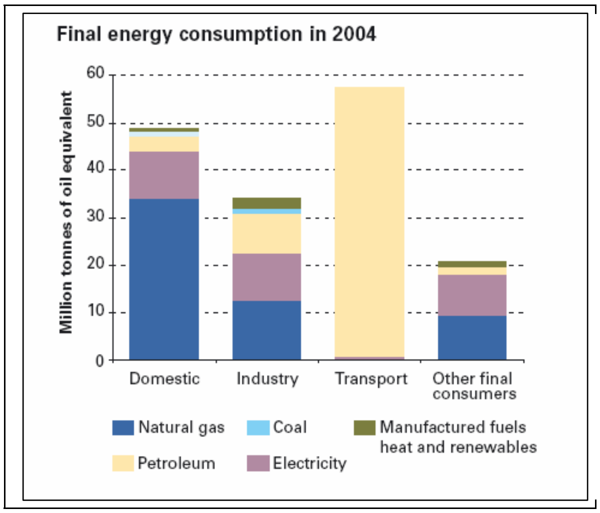

Figure 2 - UK Energy Consumption

In order to combat global warming, our primary goal should be to reduce the amount of carbon emissions released into the atmosphere. This means that we must consume less energy or utilize an energy source that does not release dangerous levels of greenhouse gases such as carbon dioxide. Currently the most prevalent energy source is the burning of fossil fuels, which is also the most harmful to the environment. Some cleaner energy alternatives, such as nuclear power and renewable energy sources, have become more prevalent, but still only account for a small percentage of the total energy production worldwide. These sources fall behind fossil fuels because they must compete in an established market. Many areas already have coal or oil power plants, and converting to a renewable energy source is prohibitively expensive. Also, with current technology most renewable energy power plants are

11 "Global Warming-Emissions"
12 Environment Canada
13 "Greenhouse Gases and Global Warming Potential Values", 5
14 Buckley
15 *idem*
16 Lovell, 1
17 "Environment- What will it look like in 2015?", 34.

not able to output the same quantity of energy as their fossil fuel counterparts. There is a slow move towards these cleaner energy sources, but it does not match the rate at which our energy consumption increases. Therefore, alternate action must be taken to reduce emissions.

While renewable energy sources slowly gain momentum, we must take advantage of the fossil fuel generated energy that we have by consuming it more efficiently. For example, transportation is one of the most energy intensive activities that we take part in. In order to reduce energy usage (and in this case carbon emission directly), there is a need to design vehicles that consume less fuel per miles traveled. An even more effective method is to utilize public transportation to eliminate a source of emissions.

Action has been taken globally in the past 15 years to significantly reduce the amount of pollutants released into the environment. The first conference of international significance was the United Nations Conference on Environment and Development in Rio de Janeiro in June of 1992. This was the first time in the history of the world that the global community came together to discuss the reality of greenhouse gases and ozone depletion. A modest goal was set for countries that agreed to the convention standards: that carbon dioxide emissions for developed nations return to the levels of 1990 in the year 2000[18].

2.2 Estimating Carbon Emissions

In order to reduce the carbon generated through building construction and use, methods to estimate the energy usage and efficiency of a structure are needed. A multiplicity of such models has been developed in both the United States and United Kingdom, for both public and private use. Few energy estimation procedures agree on what form an ideal end result takes, and almost none are compatible with another. Given this disparity, one of the most important factors to consider when selecting or creating a procedure is the intended use of the data.

For the purposes of this project, all gathered data will eventually be used to evaluate the carbon emissions of individual Merton buildings. Ideally, these data would accompany a breakdown of energy expenditures by use, as well as the efficiency of each application that energy is used for within a structure. The implementation of these ideal conclusions is limited by time, accessibility of needed data, and the resources to integrate the data. This has resulted in models ranging from basic typological building comparison to advanced energy and carbon emission simulation using neural networks and expert systems.

Regardless of complexity, a significant portion of energy and carbon estimation models within the United Kingdom have used building stock data from the English House Condition Survey (EHCS) to varying degrees. The Office of the Deputy Prime Minister is responsible for the yearly updating of EHCS data, and provides both analysis reports and raw data to interested parties. Among these results are data on structural composition, building design and layout, and heating system details, among a large array of other factors. Of the models below, DECORUM and SAP may take advantage of the resources provided by the EHCS.

2.2.1 The Standard Assessment Procedure (SAP)

The Government's Standard Assessment Procedure for Energy Rating of Dwellings (SAP) rates buildings' energy efficiency on a scale of 1 to 120: the higher the rating the more efficient the structure. It can also be used to rate the Carbon Index on a scale of 0.0 to 10.0 based on CO_2 emissions associated with space and water heating.[19] The SAP was first developed by the

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[18] Houghton, 245
[19] "The Government's Standard Assessment Procedure.", 7

British Department of Environment (DOE) in conjunction with the Building Research Establishment (BRE) in 1993. (The BRE is an independent consulting, research and testing agency operated by the BRE trust, a charitable organization.[20]) The basis for the SAP was the BRE Domestic Energy Model (BREDEM), which estimates the energy cost based upon insulation, ventilation, heating system, fuel and solar gain characteristics.[21] Since its initial release, the Standard Assessment Procedure has been revised several times, most recently in 2001.[22]

The SAP rating is developed using the following criteria (The Standard Assessment Procedure does not take into account the usage habits of current occupants.[23]):

- dwelling dimensions
- ventilation rates
- heat losses
- water heating
- internal gains
- solar gains
- mean internal temperature
- degree days
- space heating requirements
- fuel costs

Each criterion is assigned a value from a table based on its characteristics. The following is an example of such a table (all tables are available in Appendix B):

Table D2.1 Maximum net efficiency values (in %)

Condensing boilers		Non-condensing boilers	
Full load	30% part load	Full load	30% part load
101.0	107.0	92.0	91.0

Figure 3 - Sample SAP efficiency lookup table

[20] BRE
[21] *idem*
[22] *idem*
[23] "The Government's Standard Assessment Procedure", 8-15

These values are entered into the calculation worksheet (presented in Appendix N: Field Form which will be referenced to throughout this section) to produce an energy cost rating (SAP rating) and a carbon index. For detailed explanations of each criterion see Appendix C.

The energy cost rating is calculated with the formula in Figure 4 from page 16 of the SAP.

Box (99) of the worksheet is calculated with the following in Figure 5 found on page 29 of the Standard Assessment Procedure.

$$SAP = 97 - 100 \times \log_{10}(ECF)$$

where ECF = energy cost factor, calculated in box (99).

Figure 4 - Energy Cost Rating Formula

11. SAP rating (conventional heating)			
Energy cost deflator (Table 12, notes)		1.05	(98)
Energy cost factor (ECF)	= {[(97) × (98)] – 30.0} ÷ { (5) + 45.0} =		(99)

Figure 5 - SAP Rating Formula

In the above figure (97) is the summation of the cost of space heating, water heating and fan and pump energy and (5) is the total floor area, both of which were calculated in previous sections of the SAP worksheet. The SAP value can also be obtained from Table 14 of the Standard Assessment Procedure and is between 1 and 120.

The carbon index (CI) is based upon the CO_2 emissions associated with space and water heating (these values can be found in Table 15 of the SAP). From Table 16 the CI can be related to the carbon factor (CF, which is expressed in $kgCO_2/m^2$/year) on a scale of 0.0 to 10.0. The total CO_2 (in kg/year) is calculated in section 12 of the SAP worksheet, it is the summation of the energy for water heating, space heating (main and secondary), and electricity for pumps and fans, multiplied by their respective CO_2 emissions factors. The total CO_2 is divided by the area (plus 45.0 m^2) to yield the carbon factor.

2.2.2 Other models

The United States Energy Information Administration's Condition Survey is a nation-wide analysis of building stock information, fuel composition and usage, heating and cooling details, and demographic information, among others.

The forecasts created by the combination of Energy Condition Survey data are integrated into the NEMS, a partially proprietary modeling program. NEMS returns scenarios that are used to evaluate national and international market conditions in a large variety of fossil fuels and their extraction/power production techniques.

The Domestic Energy Carbon Counting and Carbon Reduction Model (DECoRuM) developed by Dr. Rajat Gupta of Oxford-Brookes University estimates the energy and carbon usage of buildings. While it was presented at the 2005 Solar World Conference, very little information on this model is publicly available.[24] The nature of the end result (index, quantitative value, or some combination) as well as the detail of energy paths provided by the model is unknown, as are the data fields that are required for successful prediction.

Finally, the United Kingdom Domestic Carbon Model is a bottom-up system capable of "modeling possible futures based on highly disaggregated, physically-based data and relationships."[25] Bottom-up models consist of multiple independent parts that:

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24 Gupta, 1
25 *ibid*, 14

…are then linked together to form larger components, which are in turn linked until a complete system is formed. Strategies based on his "bottom-up" information flow seem potentially necessary and sufficient because they are based on the knowledge of all variables that may affect the elements of the system.[26]

The large quantity of required physical data was taken from the English Housing Condition Survey, while forecasting information was obtained from a variety of government statistics.

The above models are all far more complicated than necessary for our project. Estimation of energy usage and carbon emissions only requires indexing procedures that utilize raw physical data. The Standard Assessment Procedure fits this role well, while advanced modeling systems provide unneeded forecasts that require significant training to interpret.

2.3 Reducing Carbon Emissions

In addition to the Rio de Janeiro agreement, two more recent conventions have defined the fight against carbon emissions across the globe: *The Montreal Protocol* and *The Kyoto Protocol*. The Montreal Protocol forbade the emission of chlorofluorocarbons into the atmosphere. This is a significant step for the signatory nations, as there is a strong correlation between atmospheric chlorofluorocarbons and ozone layer depletion. The Kyoto Protocol is known for its ambitious program of decreasing global carbon emissions to levels significantly lower then those of 1990. Figure 6 provides the target percentages for nations across the globe.

Of the countries that signed the Kyoto Protocol, the United Kingdom is at the forefront of

Country	**Target (%)**
EU-15, Bulgaria, Czech Republic, Estonia, Latvia, Lithuania, Romania, Slovakia, Slovenia, Switzerland	-8
USA (**DID NOT RATIFY**)	-7
Canada, Hungary, Japan, Poland	-6
Croatia	-5
New Zealand, Russian Federation, Ukraine	0
Norway	+1
Australia	+8
Iceland	+10

Figure 6 - Kyoto Protocol Emission Standards for 2008/2012

carbon emission reduction with a self-imposed goal of a 20% decrease in CO_2 production for the year 2010 based on levels set in 1990 ("UK Housing Fuelling Climate Change"), above and beyond the 8% reduction required by the Kyoto protocol.

[26] Wikipedia

2.3.1 Reducing Carbon Emissions in the United Kingdom

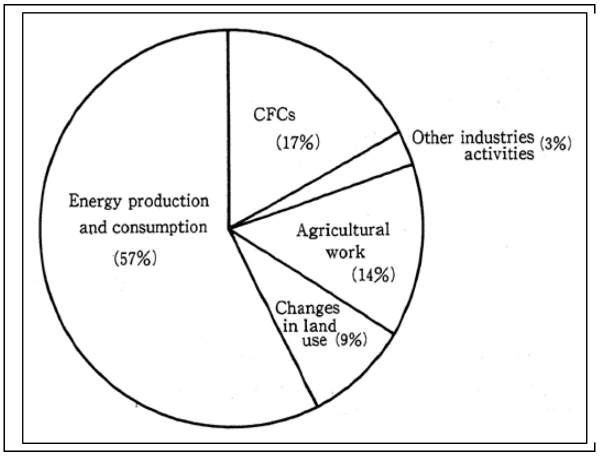

Figure 7 - Sources of Greenhouse Emissions

Since 1996, England has been committed to reducing the emission of greenhouse gases nationwide. As energy consumption contributes to 57% of greenhouse gases, efficiency of fuel systems and energy conservation gained through sound building materials has been a major focus of national efforts. The Energy White Paper released by the Labor party in 1996 details the overall structure of this program, and provides a blueprint for a "new, low-carbon economy," through which the UK can "put itself on a path towards a reduction in carbon dioxide emissions of some 60% from current levels by about 2050."[27] By establishing a firm, policy-level foundation for carbon emissions reduction, the white paper has paved the way for a multiplicity of academic and public initiatives.

The Oxford Environmental Change Institute (ECI) is at the forefront of academia's attempts to implement the vision described by the Energy White Paper. Their 40% house project details a host of "behavioral and technological changes," concerning ways that "UK households can achieve a 60% reduction in their carbon emissions by 2050."[28] These measures include recommendations for energy efficient construction in new buildings (such as cavity walls and LED lighting) as well as recommendations for consumer awareness campaigns toward energy conservation and efficiency.

Where the 40% House project attempts to reduce atmospheric carbon levels on a local and policy level, the ECI's Lower Carbon Futures model attacks the problem on a national economic and international policy level. The model offers "detailed analysis and policy advice to the European Commission and member governments on ensuring the reduction of household carbon emissions."[29] This is to be accomplished primarily through market transformation techniques aimed at making energy efficiency and conservation not just affordable, but desirable to consumers.

Oxford's ECI has also conducted several statistical studies of carbon emissions. The DECADE report analyzes "trends cover[ing] changes in technology, behavior and demographic factors, to give a detailed breakdown of electricity consumption and the resultant emissions of carbon dioxide."[30] The 2MTC report considers the results arrived at by the DECADE team and suggests "how, through EU and UK policy actions, significant electricity and thus carbon dioxide savings can be made, without the consumer suffering any loss of service or incurring a financial penalty."[31]

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27 Great Britain, 2
28 Oxford, 1
29 Boardman, 2000, 10
30 Boardman, 1995, 7
31 Oxford, 1

2.4 Reducing Energy Use

In the context of our project, we will focus on the reduction of carbon emissions through a decrease in building energy. Electricity from power plants is used to power appliances. Fuel is burned in a furnace to heat a building during cold weather. All these components of a building can be optimized and used effectively to drastically decrease the amount of energy needed to keep a building running. Methods to save energy can range from expensive (yet effective) equipment replacement to simple practices that can add up to significant results.

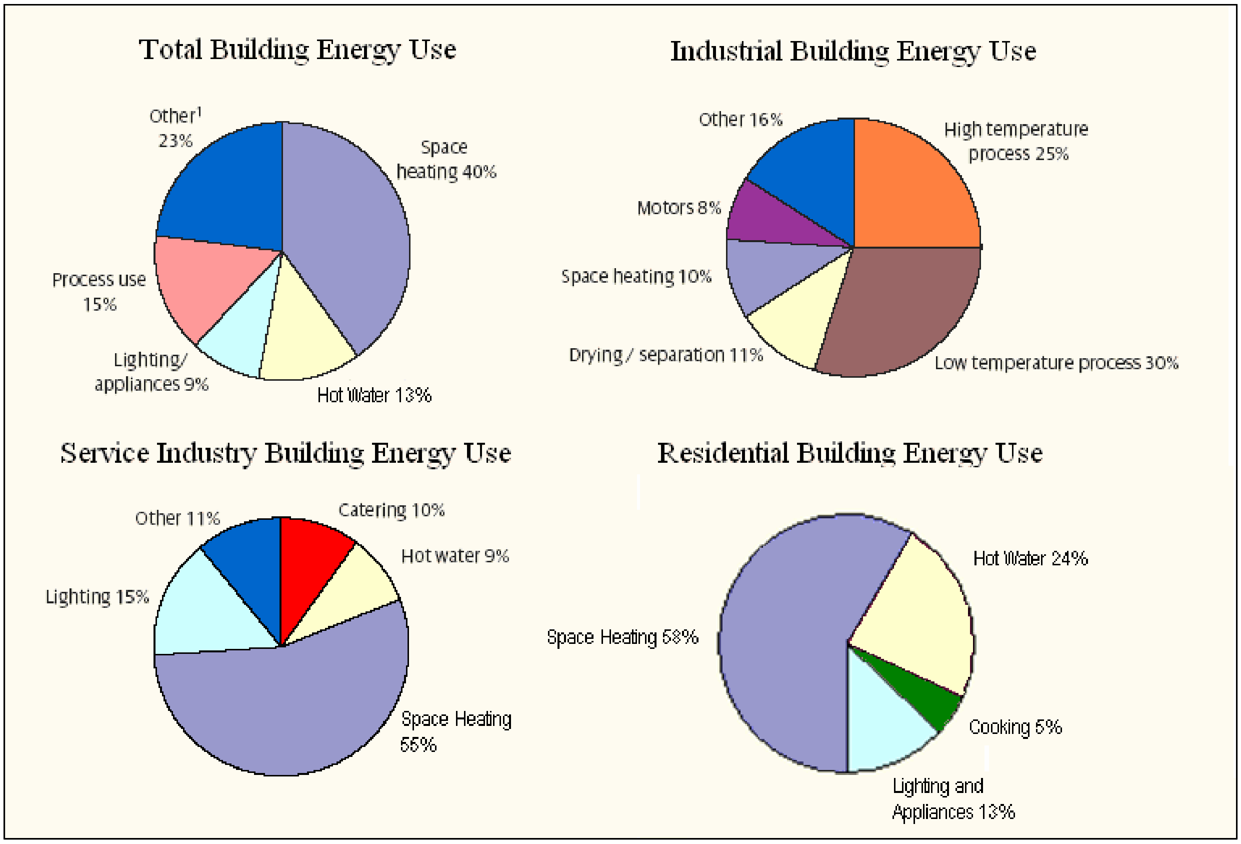

Figure 8 - Total Energy Consumption

2.4.1 Reducing Energy Use in Buildings

Appliances that consume large amounts of energy, such as a furnace, undergo constant improvement. Replacing a 100 year old steam furnace with a modern, natural gas powered model will result in radical decrease of fuel consumption. Replacing old decomposing insulation with newer advanced materials can produce an equally noticeable change in efficiency. These types of upgrades, however, can be exceedingly expensive and out of reach of many building owners. Most buildings can further reduce their energy consumption, up to an estimated one-third, by adhering to routines that eliminate the use of wasted energy.[32] For example, many office buildings unnecessarily leave electric appliances such as lights and computers powered on overnight. An automatic (or manual) system to turn these devices off will result in noticeable improvements. A building can also be optimized by reducing the temperature difference that the heating system attempts to maintain from the outdoor temperature. Both categories of energy saving methods will be utilized when analyzing the data obtained from the Merton buildings, and attempting to identify the most effective ways to reduce a specific building's carbon emissions.

2.4.1.1 The 40% House

The 40% House project is a modeled scenario set in 2050, in which the UK's residential sector succeeded in reducing carbon emissions by 60% of the 1997 levels. The primary approach of the 40% House "was to focus primarily on reduction in energy demand and an increase in low and zero carbon energy supply methods at a household level, rather than changes to the carbon intensity of the energy supplied nationally."[33] Boardman et al. of the Oxford Environmental Change Institute developed the 40% House based on their United Kingdom Domestic Carbon Model (UKDCM).

The ECI research group analyzed the resulting model and determined the necessary changes in multiple sectors of the domestic environment in order to achieve 60% carbon savings. The changes, however, are rather extreme. "In order to achieve a total reduction in residential carbon emissions of 60% by 2050, emissions will have to drop around 2% per annum – this compares starkly with the 3% reduction in total during the twelve years since 1990."[34]

Boardman et al. recommends a market transformation strategy consisting of "substitution of products, systems and services that have lower environmental impact than those used at present," for implementation of the 40% House.[35] Using the policies and technologies discussed at length in the ECI group's report, the necessary reductions in carbon should be possible without sacrificing the performance of service and level of comfort.[36]

The bulk of such policies suggest means by which energy efficient products and services can not only become economical, but more desirable to the consumer than existing items on the market. On a product level this normally entails a combination of government-sponsored replacement policies and consumer education.[37] On a service level, carbon taxation and withholding of consent for large generator facilities is recommended.[38]

Technologically, Boardman et al. recommend a host of energy-saving advancements that already have, or soon will, become available for home installation. LED lighting, vacuum insulated panels in cold appliances, and Integrated Receiver Decoders in home electronics could drastically cut energy expenditures in the home.[39] Finally, photovoltaic cells, local energy storage, community Combined Heat and Power (CHP) as well as micro-CHP have the potential to significantly reduce energy expenditures and dependence on large, polluting power centers.[40]

[32] Lovell, 1
[33] Boardman, 1
[34] Boardman, 2005, 10
[35] *ibid*, 1
[36] ibid
[37] idem, 2
[38] idem, 56
[39] *ibid*, 60
[40] Boardman, 65

2.4.1.2 DECADE and 2MTC

In addition to the 40% House, the Oxford ECI's DECADE group under Boardman et al. has compiled a detailed analysis of UK home lighting and appliance use. The Domestic Equipment and Carbon Dioxide Emissions model, like the United Kingdom Domestic Carbon Model (UKDCM), is a bottom-up system. Unlike the more overarching Domestic Carbon Model however, DECADE concentrates on a "detailed study of domestic appliance consumption in the UK."[41] Historical appliance and lighting usage information from 1974 to 1994 is used as the initial modeling data by the ECI research group.

Application of the DECADE model revealed that "each household is using 50% more electricity for domestic lights and appliances in 1994 than in 1970, despite the fact that each household contains fewer people: in 1970 an average of 2.9 people used 2000 kWh pa, whereas by 1994, 2.5 people used 3000 kWh pa."[42] Overall usage of energy for domestic use has also increased over the twenty years measured. "In 1970 the proportion [of total electrical energy] used by domestic lights and appliances was 20%, whereas by 1994 it had increased to 24%."[43]

	1970	1994
Domestic lights and appliances	39.3	71.0
Domestic sector	77.0	100.6
All sectors	192.4	288.5
Domestic lights and appliances as a % of total electricity consumption	20	25

Figure 9 - Electricity Consumption, UK 1974 and 1994 (TWh)

The 1994 and 1995 DECADE reports provided by the ECI group have been used by the European Commission, Department of the Environment and Energy Saving Trust to inform the development of energy and carbon reduction policies.[44] In addition, the Oxford ECI has created three policy analysis and recommendation scenarios based upon these results. Each scenario is detailed in Boardman et al.'s 2MTc (Two Million Tons of carbon) report.

The document aims to "suggest how, through EU and UK policy actions, significant electricity and thus carbon dioxide savings can be made, without the consumer suffering any loss of service or incurring a financial penalty."[45] Three scenarios are analyzed, with each scenario embodying a different degree of policy support for carbon and energy reduction on both the national and EU-wide levels. The report derives its name from Scenario 1, which puts forward considerable political support for carbon reduction policy in both the UK and the EU. If the suggestions within scenario 1 are carried out, a total savings of 2.7MTc (Million Tonnes of carbon) may be achieved. Scenario 2 assumes a strong national support for carbon reduction, and a weaker European response. Under a system of voluntary energy efficiency agreements with manufacturers, as well as a UK-sponsored procurement and rebate system, 1.4MTc can be saved. Finally, Scenario 3 considers

41 Boardman, 1995, 7
42 i*bid*, 8
43 *ibid*, 12
44 Boardman, 1995, 7
45 Boardman, 1997, 8

carbon savings under weak national and European political support. Only voluntary agreements with manufactures will be employed, and only 0.4MTc can be saved.[46]

2.4.2 Combined Heat and Power Systems

The London Borough of Merton has acted to implement the conclusions arrived at by several of these studies. Consistently inhabited since Celtic times, Merton suffered significant damage during World War II.[47] While redevelopment efforts throughout the region have resulted in the construction of modern housing facilities, the borough remains concerned with its energy consumption.

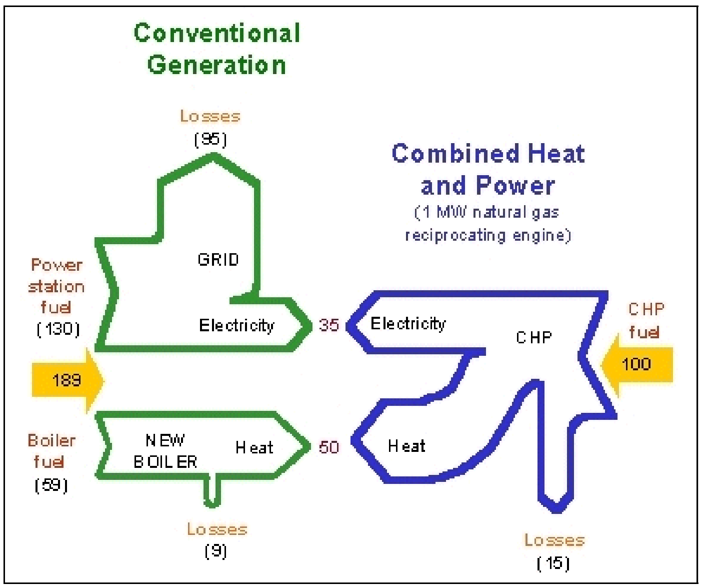

Figure 10 - Conventional Power and Heating Compared to CHP

An effort to address this issue is currently underway: construction of Combined Heat and Power stations (CHP) has been proposed as a method to cut down on energy loss. CHPs are small power plants that provide the neighboring community with electricity as well as localized heating. The heat created by the power generation is pumped though a community heating system eliminating the need for individual heating systems for each building. CHPs are effective enough that they can generate only 50% of the carbon emissions that power stations fueled by coal and emit 10% less then that of stations powered by gas.[48] Figure 5 provides a power flow diagram displaying how much fuel for conventional power generation system and individual heaters must be used to meet the amount of power generated by a 1MW natural gas fueled CHP plant. CHP systems will dramatically cut down on carbon emissions from power stations and thus help lower the national emissions level.

2.4.2.1 Biomass Fueling

Biomass fueling is another option that exists to fuel CHP facilities thus reducing carbon emissions and the reliance upon fossil fuels. Biomass is a mix of plant materials such as trees, grasses and agricultural crops.[49] This mixture can be transformed into a liquid, gas or solid form in order to be used in combustion instead of the fossil fuels that are used today.

Biomass has several distinct advantages over fossil fuels, the first being that it is a renewable resource, therefore as long as space is allocated for plants and vegetation, there should be a readily available supply. The second advantage is that even though burning the mixture produces about the same amount of carbon emissions as fossil based fuels, the emissions released from biomass were recently in the atmosphere. However, the burning of fossil fuels

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46 *ibid*, 9
47 Merton Council, 1
48 Combined Heat and Power Association
49 "Biomass Energy Basics"

releases carbon dioxide trapped from millions of years ago which adds to the gasses already present in our environment.[50]

2.4.2.2 Pyrolysis

The next step for CHP is in taking the concept a little further by adding a pyrolysis reactor. Pyrolysis is a new form of waste disposal, it takes organic materials and in the presence of heat without oxygen it decomposes this waste chemically. Pyrolysis normally occurs under pressure and at operating temperatures of 430º C.[51] This process takes the organic compounds and transforms them into gaseous materials, small amounts of liquid and a solid residue called coke, a combination of carbon and ash. Some of the gaseous materials created in this process are combustible, such as hydrogen and methane.[52] The gases produced by pyrolysis must first be treated but are then an excellent source for combustion in places such as CHP production facilities.

The drawbacks to this system of waste management include the creation of a small amount of hazardous byproducts such as polychlorinated biphenyls (PCBs) and dioxins. There also exists a concern that the process has the ability to produce furans, a chemical compound that is toxic in the parts per trillion range.[53] This process is not perfected but will be instrumental to waste management and the future use of CHP facilities.

2.5 City Knowledge

City knowledge is the idea of using municipal information as an info structure, as opposed to merely collecting, using, and discarding it in an ad-hoc manner. It explains that data is as important as any physical resource a government may control. The amount of capital spent to maintain structured information databases is more than compensated for by time saved during local planning projects. This idea is essential for a government to realize in order to successfully share its data across departments and use it in a beneficial and efficient way.

The problem addressed by city knowledge is the fact that most local governments handle their data poorly, and often find it difficult to actually use the information they posses for any meaningful projects. Data are typically collected one time as needed for a project, and then stored away undocumented or thrown away, rendering the information difficult or even unusable for future use. The small amount of information collected regularly is often kept in an unorganized format, with the only means of access being direct contact with the specific database author. Often, complimentary data will be contained in incompatible formats, making compilation impossible. By employing better data collection and organization techniques, wasted time can be avoided and a local government can greatly improve its ability to provide citizens with affordable services.[54]

The key concepts that make up city knowledge are the following:

- The “Middle-Out” Approach
- Informational Jurisdictions
- Atomic Distributed Knowledge
- Sustainable Updates
- Information Sharing
- Interagency Coordination

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[50] *idem*
[51] “Pyrolysis” CPEO
[52] “Pyrolysis” FRTR
[53] “Pyrolysis” CPEO
[54] Carrera 15

The "Middle-Out" Approach talks about implementing improved data handling techniques at a local government level, with city officials who will have the most impact on the change of policy. By encouraging employees who actually collect the data to use more efficient techniques, the city's information will become more useful both for "higher-up" national officials, and "lower" citizens of the city.[55]

Informational Jurisdictions discusses the accountability of different data sources in a city. Individual departments of the municipality should be responsible for these data sources, in order to avoid redundancy and increase efficiency. For example, if a department will be dealing with building construction, it follows that they should collect all data created for a new building, rather than only what is necessary for their specific needs. This way, when other departments may require information, it will all be easily accessible, saving a great deal of time.[56]

Atomic Distributed Knowledge verifies that information collected by "front-line" city officials will effectively filter up to the rest of the government, allowing access to all who may have a use for it. This is important because it is more efficient for officials in dedicated departments to gather their specific data as described in informational jurisdictions in order to avoid redundancy.[57]

Sustainable Updates refers to the fact that collected information is only useful if it is kept up to date. Thus data must be "farmed" with regular methods as opposed to being manually hunted each time it is needed. For this to occur, departments must collect all data possible (within reason), regardless of their immediate need. The extra time spent filling in extra fields will be far less than the time that would have been spent by a separate department to hunt this data had it not been available.[58]

Information Sharing is necessary for any of the collected data to be useful outside (as well as inside) of the department it was collected in. For city knowledge to be effective, all stored data should be available to any authorized inquiring party without having to physically search and rely on personal contacts. It is emphasized that some data such as records should be required to be shared, and other generated data should be shared on a voluntary basis.[59]

Interagency Coordination speaks about the necessity of enforced standards throughout the government in order to make shared data easily viewed and analyzed. For instance, the municipality should decide on specific software to handle data types, so that files are interchangeable. They should also determine data format standards, so documents shared between departments can easily exchange data with minimal rearrangement. Standardizing their information allows a city to save time and increase efficiency by ensuring smooth interactions between data sources.[60]

2.5 Reducing Carbon Emissions in Merton

The London Borough of Merton, located south of Britain's capital, is a progressive district that has taken a keen interest in reducing its carbon emissions. Six medium-term goals comprise the core of its carbon reduction program[61]:

1. To cut CO_2 emissions in Merton by 15% by 2015

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[55] Ibid 196
[56] Ibid 201
[57] Ibid 206
[58] Ibid 210
[59] Ibid 214
[60] Ibid 219
[61] London Borough of Merton

2. To cut the CO_2 emissions of Council-owned buildings by 25% within three years.
3. To generate 10% of Merton's energy needs from renewable sources by 2015.
4. To recycle 33% of Merton's household waste by 2013
5. To compost and treat in a sustainable way 67% of Merton's biodegradable waste by 2015
6. To promote and extend sustainable travel options across the borough

This study, however, only pertains to the first three goals, to reduce CO_2 emissions by 15%, to cut by one quarter the carbon emissions of Council-owned buildings, and to generate 10% of Merton's energy from renewable sources. The 15% carbon emissions reduction goal is similar to the United Kingdom's, and operates under the philosophy that what works on a national level can be implemented locally.

Central to these goals is the operation of the Merton Council. Working as a corporation rather than a purely administrative body, the Council may generate revenues that are funneled into borough development and beautification. Five primary departments work under a Chief Executive, with each department divided into divisions, and each division into sectors. (Flowcharts of each department are available in Appendix L: Council Structure.) This allows the allocation of resources and profit for a project that would be difficult to accomplish in a purely administrative context. Not only can the Council improve energy efficiency and reduce carbon emissions, it can generate a profit doing so. Below are previous and current initiatives carried out by the Borough of Merton that are directly relevant to this project.

2.5.1 The 10% Renewable Energy Plan

Merton is planning to reach their carbon emission reduction goals by primarily focusing on building energy consumption. From the power plant that supplies a building's electricity, to the furnace in its basement used for heat, all aspects of energy generation and usage can be optimized to result in lowered carbon dioxide emissions. One of Merton's current policies referred to as the 10% renewable energy plan aims at reducing a building's draw from power plants by creating individual renewable energy systems for each building to help power itself. The policy is stated in Merton's Unitary Development Plan, a document that states the borough's goals for improvement. The policy is entitled PE 13: Energy Efficient Design and Use of Materials:

> The Council will encourage the energy efficient design of buildings and their layout and orientation on site. All new non-residential development above a threshold of 1,000 m^2 will be expected to incorporate renewable energy production equipment to provide at least 10% of predicted energy requirements. The use of sustainable building materials and the re-use of materials will also be encouraged, as will the use of recycled aggregates in the construction of buildings. This will be subject to the impact on the amenity of the local environment, taking into account the existing character of the area.[62]

The current plan applies to newly created or renovated non-residential buildings, requiring them to supply 10% of their own power through renewable energy. Common types of renewable energy generators include wind turbines, photovoltaic panels, geothermal energy, and biomass. These energy production methods produce no harmful emissions, and directly reduce

[62] London Borough of Merton, 2003

carbon emissions. Although the policy only requires large buildings to adopt renewable energy, Merton is in the planning stages to adapt the policy to include residential buildings as well.

2.5.2 Merton Housing Condition Study

Recently, The London borough of Merton commissioned Fordham Research to perform a housing study using the Standard Assessment Procedure (SAP), which was released in July of 2005. The Housing Condition Study (HCS) focused on disrepair and unfitness of the structure and took energy efficiency into consideration. The study also assessed repair costs, and included decent homes, housing health and safety, and financial assistance implications.[63] It was estimated that there are 76,452 residences, of which 2,000 are vacant. The study administered a survey that intended to include 1,000 dwellings throughout the borough; in reality 996 of the structures were assessed. This assessment was weighted by "dwelling and household variables…to be representative of all dwellings in Merton."[64] Since the study was a sampling and not a census, there is the possibility of error and a calculated confidence interval of 95%.[65]

SAP ratings were used to estimate energy efficiency. It was estimated that the private sector dwellings in Merton had an average SAP rating of 52, which is 1 more than the national average and 1 less than London's average. The following chart shows the factors which were considered.[66]

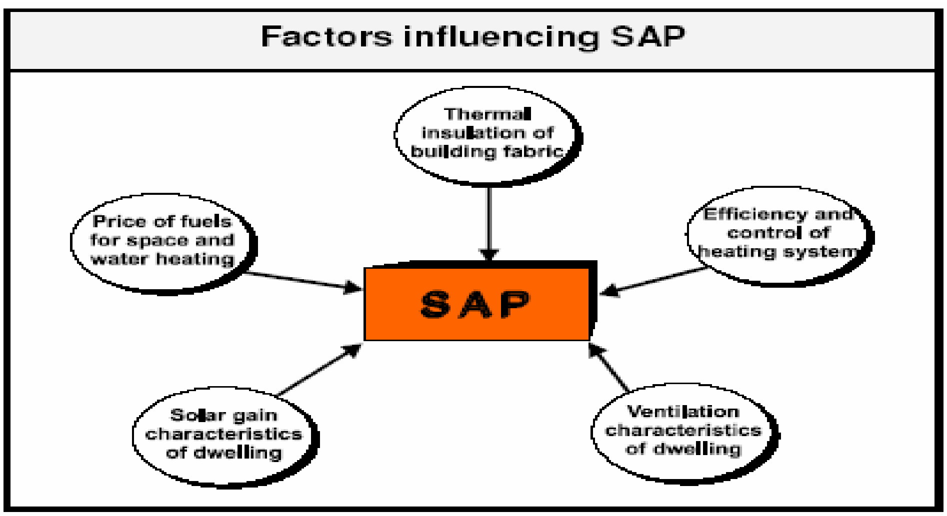

Figure 11 – Factors Included in the SAP[67]

The study followed the ODPM Guide approach when addressing energy efficiency estimation:

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[63] "Housing Study", 22
[64] *Ibid*, 7
[65] *Ibid*, 135
[66] *Ibid*, 10
[67] *Idem*

ODPM Guide

A domestic energy audit will normally be conducted in furtherance of the authority's broad environmental aims as presented in the Corporate Plan. There might also be related social aims, for example, to bring reasonable thermal comfort within the reach of all households
.
In housing terms, you will need to express these aims slightly differently:

- to reduce the need for domestic energy usage or at least maintain it at a constant level;
- to reduce the emission of greenhouse gases and pollutants from domestic energy use;
- to reduce the wastage of energy in the home;
- to ensure that all dwellings within the area can be adequately heated at a cost which occupants on low incomes can afford;

to ensure compliance with the Home Energy Conservation Act 1995.
[Volume 2, Paras 5.2 & 5.3]

Figure 12 - OPDM Guide

If the sample structures considered in the survey include those within our target area, a significant amount of work could be avoided. However, the small sample size and anonymous nature of published survey results makes this an unlikely possibility.

2.5.3 Merton CHP Implementation

Progress on the development of Merton's CHP system has been made in past by other WPI student groups. One of the most recent projects involved a team analyzing the layout of Merton and the specifications of possible CHP systems to suggest a route for the pipeline. Some guidelines were provided which specified the location of a pyrolysis power plant and the primary building to be serviced with heat and power. A great deal of research was conducted on underground utility regulations to verify that the desired route could be implemented without interference from existing networks. Based on many factors including the anticipated heat and power draw of the buildings, and the length of the pipeline, estimates for the CHP plant's load were presented. 3.9MW

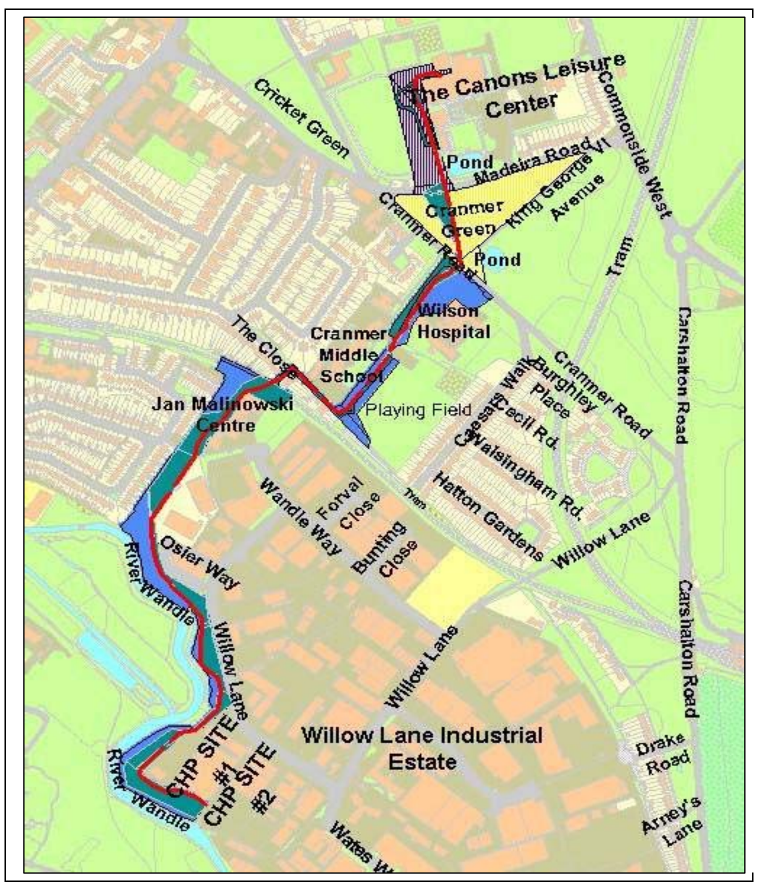

Figure 13 - Planned CHP Route

of heat power, and 3.2MW of electrical power were calculated as the requirements for plant selection.[68] It was also suggested that the plant operate at a medium temperature of 120ºC and a pressure of 16 bar in a standard 125mm diameter twin pipe system.[69] The report goes on to suggest specific methods for digging trenches to house the CHP pipeline.[70] This analysis resulted in the conclusion of a distribution route as shown in Figure 13

The report published by WPI's 2005 IQP group is important to the development of our project, as it presents the current status of the Merton CHP system.

Figure 13 shows the desired location of a pyrolysis plant, and the route that the pipeline will follow. It also displays key buildings that may benefit from being connected to the pipeline. The route presented above, as well as the capabilities of the proposed CHP plant, will serve as a model for the foundation of our recommendations as to which buildings should be attached to future pipelines. Our conclusions will be based on a building's individual energy usage and efficiency that we determine, along with the building's zoning and proximity to the CHP route.

The pyrolysis CHP route presented above is only a portion of Merton's desired power distribution system. In addition to the Willow Lane site, gas CHPs at the Cannons Leisure Center, Rowan Wood School, and the gas works in Mitcham Centre will form the nucleus of a district-wide electrical grid that operates independently of national carriers (See Figure 14). Through decentralizing power generation, Merton can increase self-sufficiency on a district level, provide cheaper power through efficient generation, and reduce carbon emissions by using cleaner energy. Furthermore, the hot water produced as a byproduct of power generation can be piped directly into structures serviced by the grid and provide low-cost heating.

Offering 15-year service contracts to commercial and non-profit organizations can help finance the implementation of this system. Private residences are also eligible for connection to the CHP grid; however British law prevents the establishment of a lasting service contract with individual citizens or families. For this reason the residential sector will be secondary to the commercial and industrial sectors when considering feasibility and distribution routes.

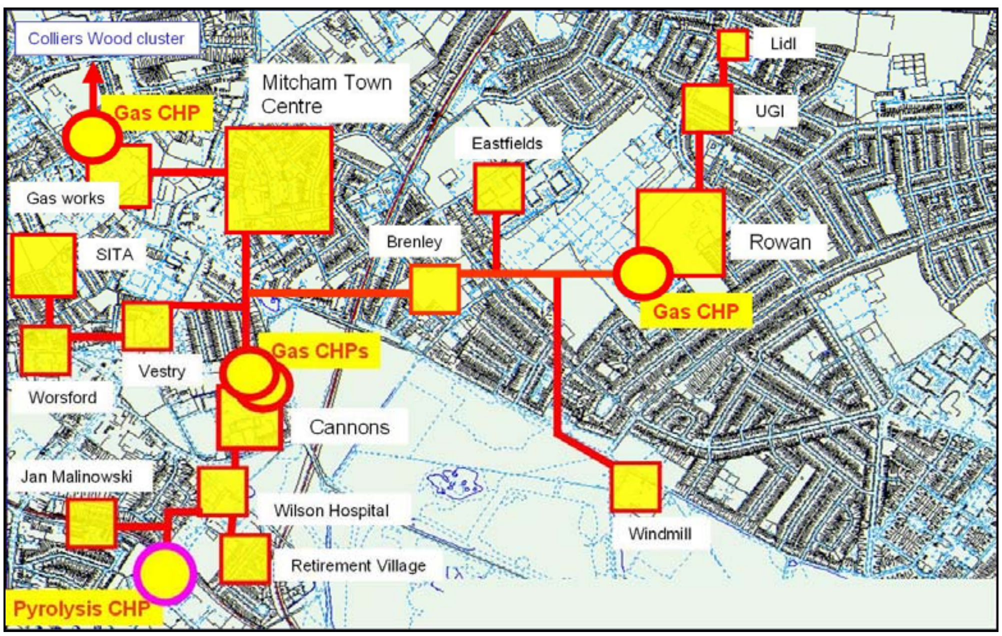

Figure 14 - Merton CHP Routes

68 Casey et al., 102
69 *ibid*
70 Casey et al., 105

3 METHODOLOGY

This project is intended to help the borough of Merton (shown in Figure 15) achieve its goal of reducing carbon emissions by 15% by 2015 through gathering baseline data on building characteristics and energy consumption to populate the borough's Geographic Information System. The data gathered focused on buildings implementing the borough's Combined Heat and Power scheme. By creating a comprehensive building database and displaying it graphically, we hoped to make recommendations to the Merton Council concerning which buildings should be connected to the CHP grid. Due to a lack of organized and accessible data, however, this proved not to be feasible. We devised procedures and recommended changes to existing information systems aimed at addressing these inconsistencies. Specifically, our project group completed the following objectives:

1. To Characterize Merton buildings
2. To Collect and organize detailed information on buildings in the Mitcham target area
3. To Devise sustainable data collection mechanisms

First, we separated buildings into different usage categories: business, civic, education, and housing. Building use is critical to the inclusion or exclusion of a building to the Merton Combined Heat and Power system due to varying power requirements and service contracting issues. Next, we devised a list of important building characteristics, and tried to link these characteristics to sources of information. We then collected detailed physical building information on structures in the target area through field analysis. A database was constructed to contain categories of these building characteristics. The data were then integrated into the existing Merton Geographic Information System and used to map building use and energy consumption. Finally, we recommended changes to the Merton Council's data collection system to allow for a sustainable and largely automatic updating of building information.

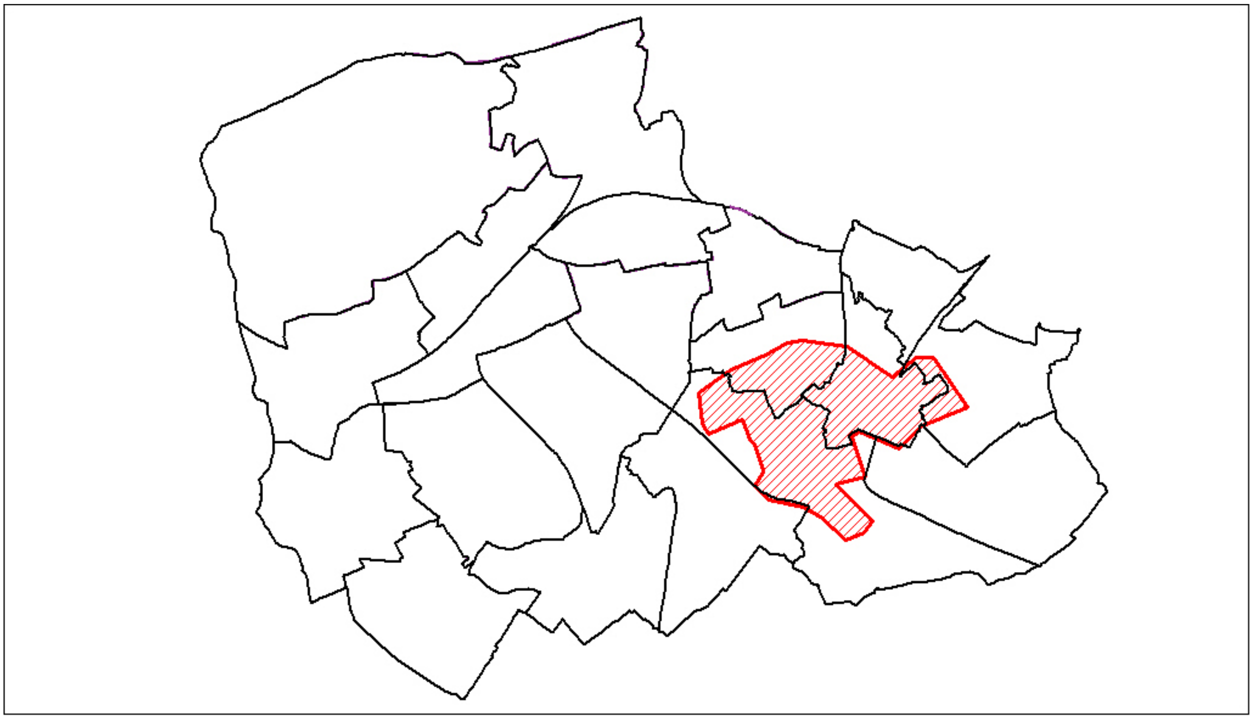

Figure 15 - Study Area

Our field study was restricted to include only buildings within the town of Mitcham, specifically those that fall within the grid to be serviced by the Combined Heat and Power plants. Although the methods employed are applicable to wider ranging applications, the focus of this project was on the geographic area most significant to the CHP study. The exact extent of this region is highlighted in Figure 15.

. We had approximately seven weeks to define, collect, organize, log and interpret our data. Building ownership, use, and structural characteristics were discerned primarily from Council records. Other database fields were obtained from past surveys or on-site observations when necessary. Remaining characteristics were left blank for future collection. Many key Council owned properties have annual electricity and heat consumption estimates on record, which were also input directly to the database. This information will be used to estimate energy consumption, and advise the Council as to which buildings are beneficial to link to the CHP grid.

3.1 Characterizing Merton Buildings

Our first objective was the creation of a list of attributes to collect for each building in Merton, creation of a database to contain these attributes, and the linkage of each characteristic to a source of information. Selection of building characteristics was based on the eventual goal of energy estimation. We abstracted four broad categories of building data: use, ownership, physical data, and energy use. Building use describes what purpose the building is currently serving, ownership/location contains information on who is in possession of the structure and its location, physical data lists relevant structural attributes, and energy use includes any information relating to electricity and heating efficiency and consumption. A complete list of data fields for each attribute is listed in Appendix C. After creating the characterization criteria, we compiled all data fields into a SQL database. A description of this database is available in Appendix B: Building Database. Finally, we attempted to link each of these fields with a source of information. Difficulties encountered in this phase led to the drafting of our third objective, which is focused on improving the data farming capabilities of Merton. Data sources were commonly incomplete or infrequently updated. In addition, we could not to obtain access to the English House Condition Survey and Merton House Condition Survey. We originally these hoped could provide useful information for our project, but proved to be false leads for two reasons. Firstly, a very small fraction of homes, and these randomized, were studied. Secondly, the focus of our project shifted away from private residences, and toward buildings in general.

Of the data sources we studied, some are available for buildings irrespective of use, while others are specific to certain building types. We have divided Merton buildings into a hierarchy of types. Each sub-type is described, its usefulness in the context of CHP hookup is considered, and its potential specific sources of data, if any, are listed by attribute. Sources of data under each heading (building type) apply to all sub headings. Data sources that can apply to all buildings are presented first, followed by data specific to various building uses. Note that few of these sources are comprehensive. For a complete description of our data sources, see Appendix G.

We discovered the following sources for all Merton buildings:

- Ownership/Location
    - Building Application
    - Building Plan
    - Building Notification
    - GIS Maps
    - New Address Application
- Use
    - Building Application
    - Building Plan
    - New Address Application
- Physical Information
    - Building Application
    - Building Plan
    - New Address Application
- Energy Use
    - No general source

3.1.1 Businesses

All structures in this category are for-profit enterprises controlled by an organized group, such as a corporation. Businesses can represent ideal candidates for CHP hookup. Any commercial or industrial organization may sign 15-year service contracts for electricity and/or heat. Furthermore, the largest energy consumers in Merton fall within this category. Gas processing, commercial printing, and manufacturing facilities, to name a few, all impose large electric demands upon their owners. By filling this demand Merton can generate a profit while decreasing the carbon emitted by its residents. Information specific to all businesses, organized by attribute, was obtained from the following sources:

- Ownership/Location
    - Chamber of Commerce Business Directory
    - Business Rates Directory
    - Business License
    - Experion Business Database
    - Field Work
    - Fire Inspections

- Fire Certificates
    - Health and Safety Inspection
    - OSR1 Form (non-industrial)
- Use
    - See Ownership

3.1.1.1 Industrial

Industrial buildings are defined as any structure or at of a structure with machinery devoted to the manufacturing or processing of goods. This can range from light industrial facilities such as machine shops to heavy industrial chemical processing plants or large factories. Constant machinery use equates to generally high energy demands, making economical Combined Heat and Power a highly desirable energy source. One specific source of information on industrial buildings were found:

- Ownership/Location
    - Council Industrial Map
- Use
    - Council Industrial Map

3.1.1.2 Offices and Shops

Offices and shops are defined as any structure or part of a structure that engages in commercial activity other than the production or storage of goods. Examples would include administrative centers, accounting facilities, department stores, retail outlets, and customer service centers. Offices and shops can be good customers for a district heat and power system, depending on the size and use of the structure. High-rise telecommunication centers and supermarkets would represent a much more desirable target than a single-story tax accounting office.

3.1.1.3 Service

A service industry is defined as a structure or part of a structure that engages in the on-site exchange of a specific task for capital. Examples include fast food establishments, gas stations, and car washes. Service industries are not as appealing CHP clients as other commercial facilities; they are of generally small size and do not necessarily have large constant energy demands.

3.1.1.4 Storage

A storage facility is defined as a structure or part of a structure that is devoted to holding goods for a period of time. Examples include self-storage units, warehouses, or chemical tanks. In most cases, storage buildings make poor CHP clients. Energy demands are low, and may be highly intermittent. An exception to this is the storage of frozen goods, requiring the constant operation of cooling systems.

3.1.2 Civic Buildings

All structures in this category are non-profit enterprises that are designed as publicly accessible spaces. Most civic buildings are owned and operated by a public authority, such as the Merton Council. This is not a hard and fast requirement however; museums and libraries may be privately owned and/or operated. All civic buildings can enter into 15-year contracts, and are good choices for CHP hookup. Those owned by the Council, rather than generating a profit per se, can significantly reduce the upkeep cost of a building (i.e. selling power to oneself doesn't technically generate money, but it eliminates an outstanding cost.)

Data sources for civic buildings were in general more complete than those for businesses, largely because civic buildings tend to be at least Council-owned, and frequently Council-operated. This proved to be especially true in the case of energy use. Private civic buildings are not considered in the following list, as none were found to be present within the borough.

- Ownership/Location
  - Council Property List
- Use
  - Council Property List
- Physical Information
  - Council Property List
- Energy Use
  - Council bills
  - PB Power CHP Feasibility Study

3.1.2.1 Community Centers

Community centers are defined as structures that are devoted to public leisure and assembly. The Canons Leisure Center and South Mitcham Community Center are ideal examples of these types of building. Community Centers make ideal candidates for CHP hookup, as they are owned and operated by the Borough. Connection to the district heat and power grid would eliminate the power and heating bills that the Council must normally pay for, as well as helping to fulfill Merton's goal of reducing the carbon emissions from Council buildings by 25%. There are no specific data sources on community centers.

3.1.2.2 Government Authority Buildings

Government buildings are defined as buildings devoted to the use of a local or national authority. Examples include the Merton Council building, Vestry Hall, and Worsford House. Much like community centers, government buildings make good candidates for connection to a Council-owned district heat and power system not because of extensive profits, but due to energy and carbon savings.

3.1.2.3 Libraries

Libraries are defined as structures devoted to archived information in print form. If a library is owned by the Council, energy and carbon savings may justify CHP hookup. In general, however, low population and heating requirements do not make these building attractive targets for connection to the CHP grid. We have discovered the following specific data source for libraries:

- Ownership/Location
  - LEA Directory of Establishments
- Use
  - LEA Directory of Establishments

3.1.3 Education Buildings

Schools, whether publicly or privately owned, are good candidates for Combined Heat and Power (CHP) hookup. This is for two reasons. First, secondary schools have a large energy demand and would generate a profit for the Council. These structures tend to consume significant amounts of electricity due to long hours of operation. Secondly, those owned and operated by the Council may be hooked up without the need for negotiation, while Private schools, Academies or PFI (Private Finance Initiative) schools can be convinced to sign 15-year contracts. The ability of private schools, Academies and PFIs to enter into long term contracts has a large impact on the CHP scheme, as it allows modeling to take energy demand into account when determining the size and output of the CHP plant. No general data sources for education buildings exist, as Council and privately owned buildings maintain spearate records.

3.1.3.1 Local Education Authority

The Local Education Authority (LEA) is the part of a council that is responsible for education within that council's jurisdiction. The LEA in Merton is the Education, Leisure & Libraries Department and it is located in the Merton Civic Centre. This organization holds a list of all schools, libraries, and community centers under its care known as a Directory of Establishments. There are two types of schools under the jurisdiction of the LEA: community schools and Private Finance Initiatives.

The community schools are owned and operated by the Council of Merton and are regulated by the Local Education Authority. These schools are the easiest to integrate into the Combined Heat and Power scheme because it is the decision of the borough to switch power suppliers. It would be a win-win situation to connect these schools to the CHP grid because not only would the energy cost of the schools be reduced; the borough would generate a profit selling power to its own buildings.

Private Finance Initiative (PFI) schools are owned by the council, and the curriculum is under the jurisdiction of the Local Education Authority. However, the finances of the schools are leased to an organization by the PFI contract. In the case of Mitcham Vale, a secondary school in our target area, the contractor promised to make the school more energy efficient. This was a key selling point and the reason they were awarded the agreement. As was previously stated secondary schools are large energy users and would generate profit for the CHP scheme. The Borough hopes that promise of a greener school would influence the company to implement the CHP plan. Specific data sources for Community and PFI schools include:

- Ownership/Location
  - LEA Directory of Establishments
- Use
  - LEA Directory of Establishments
- Energy Use
  - Council Bills

3.1.3.2 Academies and Private Schools

An academy is classified as such if it receives funding from a Government grant and is sponsored by a business, faith group or voluntary sector. “They are owned by the registered charities established as companies, limited by guarantee, and run by a governing board.”[71] There is no tuition and the school cannot generate a profit. The school is still inspected by the Office for Standards in Education (OfSTED), just like schools taken care of by the Council. Since all of the finances are handled by the sponsor, the Council must convince the Academy’s governing board that connecting to the CHP power grid would be beneficial.

Private schools are defined as those that are not subsidized by the government; instead they are funded by tuition. Private schools are a good prospective CHP customer; since they are privately financed they may be more willing to enter into a 15 year contract due to the efficiency

[71] "Public Consultation Notice.", 5

and lower cost of CHP power. As private enterprises, academies and private schools share several of the data sources available for businesses:

- Ownership/Location
    - LEA Directory of Establishments (academy only)
    - Fire Inspections
    - Fire Certificates
    - Business Rates Directory
- Use
    - See Ownership

3.1.4 Housing

Housing is a structure or part of structure that is used as a dwelling, including a flat, duplex, complex or single-family home. It is not currently being considered in the CHP sizing because residents cannot enter into a 15 year contract. However, it is a possible future client base, since much of the grid will be running past their homes and there is an excess of hot water. Selling this heat is a more profitable way for the borough to dispose of it. General sources of housing data include:

- Ownership/Location
    - Council Tax Database
- Use
    - Council Tax Database
- Energy Use
    - HECA Survey
    - SAP Survey

3.1.4.1 Private Housing

Private housing is owned by an individual, not the council or housing authority. It is practically impossible to get information about private housing because most of the information the council has is protected by the Data Protection Act. Furthermore, private residences may not sign 15-year contracts with the Merton Council for CHP hookup. The unpredictable energy use of individual homes, combined with the lack of available data and an inability to secure a lasting contract, make private residences one of the least desirable targets for CHP hookup.

3.1.4.2 Social Housing

Social housing is defined as one or more low-income dwellings provided by private agencies or the Merton Council. Elderly or poverty-stricken residents may live in social housing for very little cost. This cost could be further reduced by providing energy through a district heat and power hookup. Unfortunately, a long-term contract can be established only if utilities are paid for as a levy on rent. If a social housing resident pays for utilities separately, the conditions applying to private residences come into effect.

3.1.4.2.1 Council Owned

Council-owned social housing would benefit from CHP hookup in the same way that other Council buildings do. As it would be difficult to implement a change from separate utilities to a levied rate, CHP hookup may be most beneficial at new housing developments, where there is not yet an established method of paying for residence. The specific data sources that we employed are as follows:

- Ownership/Location

    - Council-Owned Social Housing Database
- Use
    - Council-Owned Social Housing Database
- Physical Information
    - Council-Owned Social Housing Database
- Energy Use
    - Council-Owned Social Housing Database
    - PB Power CHP Feasibility Study
    - Council Bills

3.1.4.2.2 Registered Social Landlord Owned

Housing controlled by Registered Social Landlords (RSLs) is not owned or operated by the Council. RSLs, developers who must be approved by the Housing Corporation, completely manage social housing under their jurisdiction. Each RSL obtains new properties by bidding for funding to the Housing Corporation. The Council may choose to back this bid, which can give it extra weight. The ultimate decision, however, rests with the Housing Corporation. The five primary RSLs that operate in Merton are called preferred partners. They have to apply to this status, and are assessed against an agreed upon criteria. Assessments are conducted every two years, with the next scheduled for March 2006. Currently, the preferred partners are the Croydon People's Housing Association, Presentation Housing Association, Wandle Housing Association, London and Quadrant Housing Trust, and Threshold Housing and Support.[72] Data sources that we used for RSL Social Housing are as follows:

- Ownership/Location
    - RSL-Owned Social Housing Database
- Use
    - RSL-Owned Social Housing Database
- Physical Information
    - RSL-Owned Social Housing Database

3.2 Collecting and Organizing Information on Buildings in the Target Area

Our second objective attempted to collect the characteristics that we arrived at in objective one, but were unable to derive from Council data sources. The final phase of building characterization, linking the desired data to sources of data, experienced a number of difficulties. Most notably the majority of information resources that we found are incomplete or infrequently updated. Furthermore, the location, level of completeness, organization, and quality of each data source varied significantly. To address this problem, we first collected field data in lieu of archival data that could serve as the basis of our GIS maps. Next, we sought an organized, succinct, and graphical method of displaying the results of our research into data sources.

3.2.1 Field Data Collection

Much of the necessary data to characterize Merton buildings was not available or easily found in council records. Specifically, a distinct list of businesses in the area could not be located. Various directories exist, but all are incomplete and some are out of date. It was thus necessary to create our own list of businesses in the small study area of the future Combined

[72] Herdman, 1

Heat and Power plant at the seven hectares gas works site. In order to collect this data, we walked along the proposed CHP pipeline route and extended our surveying a reasonable distance to include buildings that may prove beneficial to the future grid. We focused our study on larger businesses that would likely consume a significant amount of electrical energy, as these are the buildings the borough would like to target for fifteen year energy contracts.

While surveying, we took photographs of the target buildings, for ease in future identification. We recoded the location, address, business type, and any notable visual characteristics of each building. All the contact info and recorded building information was compiled into a database, and used to identify all businesses in a GIS map of the area. Although this database is nowhere near a complete business database for the borough of Merton, it was necessary and useful in the context of our project for classifying building use and ownership in the area specific to the planned CHP routes. In the future a complete, up-to-date business database would prove quite advantageous in CHP planning, as well as countless other borough projects.

3.2.2 Organization of Data Sources

Due to the complexities of finding data within the Council, we created a multivariate matrix that could be referenced for sources of information. This matrix has undergone several revisions and morphed from a simple chart with checks to a comprehensive multi-layered spreadsheet. (The update cost is currently an empty field that requires further investigation.) The first step to creating the matrix was determining the attributes that would be collected. These characteristics were chosen with the final result of energy use in mind. The list includes basic parameters necessary to make an accurate estimation of the building energy use. The Energy Savings Trust (EST) has created a worksheet that yields approximate values of energy consumption based upon number of bedrooms and type of housing among other parameters. The Figure 16 shows the elements we found most relevant.

ATTRIBUTES
UPRN
Address
Post Code
Date of Initial Construction
Date of Latest Construction
Home Type
# of Dwelling Units
Footprint
# of Storeys
Total Floor Area
# of Rooms
# of Bedrooms
Wall Material
Wall Type
Roof Material
Insulating Material
Loft Insulation
Owner
Use
Number of Occupants
Hot water storage
Heating System
Boiler Installation Date
Boiler Type
Heating Control
Double Glazing
Low Energy Lighting
Ave. Annual Heat Demand
Ave. Annual Elec. Supply
Ave. Annual Elec. Demand

Figure 16 - Matrix Attributes

Agency	London Borough of Merton																		
Department	Department of Environment and Regeneration												Comm. & Housing	Children, Schools & Families	Housing Strategy/Social Services	Corporate Services			
Division	Building Control				Estates		GIS		Licensing	Waste Management	Health and Safety					Business Rates	Legal Dept.	Council Tax	
Process Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
PROCESS	Building Application	Building Plan	Notification from Trade Association	Notification from Approved Inspectors	Industrial Map	Council Property List	GIS Map	New Address Application	Business License	Duty of Care	OSR1 Form	Inspections	Council Social Housing Database	Directory of Establishments	RSL Housing Stock Database	Business Directory	Lease Documents	Tax Database	Council Bills
Update frequency	c	c		m	c		3m	c					c	y	c			y	m
Update Cost																£20,000			
UPRN	(7)	(7)		(7)		(7)	●										⊙	⊙	
Address	O	⊙	O	O	O	O	●	O	O	⊙	O	O	O	O	O	O	O	O	O
Post Code	O		O	O	O	O	●	O	O	⊙	O	O	O	O	O	O	O	O	O

Figure 17 - Matrix Sources

In **Error! Reference source not found.**, the lower left portion of the matrix is displayed; included in this are notes on the sources. This is where additional information on the process of data collection can be found. When known, the contact information for the responsible party that maintains the source is located beneath the notes. The Input/Data Entry category has a very in depth notation system to show what form of the information is submitted in, such as paper or pdf, and notes whether the data was entered internally or by an external source, such as the applicant. The row just below it shows the medium in which the data is archived. For example, "XL" is an Excel file and "P" is a paper-based filing system. The Legend shows inaccessible information in grey and accessible data in black. Complete data sources are represented by a filled circle, while processes that are partial sources are shown as an empty circle. The square symbol denotes a proxy attribute, by this we mean the attribute can be derived or estimated using other information available.

Double Glazing	○		○												
Low Energy Lighting	○														
Ave. Annual Heat Demand									▣						
Ave. Annual Elec. Supply															
Ave. Annual Elec. Demand									▣						
NOTES on SOURCES	Form is computerized, most info is data protected.	Stored on Microfilm and tracked by UPRN.	In email form for specialist contractors (a year behind).	In electronic form for approved inspectors (up to date).	Only contains council owned industrial buildings. Includes Deed Packet number.	Does not contain all contact and UPRN data. Does not contain industrial, schools or housing.	Updated every 3 months with info from Ordnance survey.	8 weeks to process. GIS only has info on new addresses. Other info in app. is forwarded to other	Businesses only. Licenses must be applied for by all businesses that serve alcohol. Energy Estimated from # of employees/	No Reply	Filed by non-industrial businesses. Only filed at initial opening. Never updated. Kept in Paper form.	We don't have any information on this.	Only includes council owned social housing. Drop down menus in spreadsheet.	This only includes information on the council owned school buildings, not privately owned. It is updated ever year.	Only RSL Owned Social Housing is included and some fields are not available for all entries. Constantly changing as new developments become homes, always in a little need updating.
CONTACT Name Title Extension	Alec Johnson Prcpl Build Ctrl x3130		Trevor McIntosh Build Ctrl Mgr x3121		Brian Fraser Estates Surveyor x3082	Tony Skilbeck Prop. Liason Mgr x4176	Mick Bird GIS x3849	Darryl James Admin Asst x3507	Zola Adegboyega Senior Admin. & Finance Officer x3969	Ian Hosking EQE Mgr x4779	Ian Murrell Comm. & Trading Stds Mgr. x3859		Liz Back Asset Management Officer x4587	Valerie Higgins Premises Mgr x3306	Cecily Herdman Strategy Officer x3049
Input/Data Entry	DA/I	SC/I	PF/I	DA/I	MA/I	MS/I	GIS	DA/I			PF/I		MS/I	MS/I	MS/I
Archival	SQL	MF	P	SQL	MP	XL	MG	E			P		XL	XL	XL
See Appendix			E	D							G				
LEGEND	●	Inaccessible			●	Accessible			○	Partial			⊙	Unsure if Info Exists	

Figure 18 - Matrix (Lower)

When used to its fullest extent the matrix is an invaluable resource. It provides the reader with insight into the mechanisms of data collection, the attributes available from any given source, the medium data is entered and stored in the source, contact information, and notes on the completeness and quality of the source.

3.3 Devising Sustainable Data Collection Mechanisms

Our third objective does not directly concern mapping buildings; rather it arises from difficulties that were encountered while gathering data for mapping. Specifically, a dearth of complete and current sources of information prompted us to include this objective. We searched for mechanisms that could eliminate human data-entry and replace it with a computerized system that only requires occasional oversight. Time savings can be achieved by automating not only data entry, but data collection. We sought a 'City-Knowledge' inspired model that integrates both of these benefits into a database that can sustain itself with little human intervention.

As this objective was not originally a component of our project, our primary mode of investigation was initially experience. Nearly every data source that we discovered had deficiencies in at least one of the categories detailed below. With such variance in the reliability of data, we felt it necessary to create a standard of judgment by which any database may be analyzed for deficiencies and strengths. The first step in creating this standard was to identify the various aspects of a data source in which inconsistencies may arise. We attempted this in a methodical manner. Beginning by looking at our compiled list of data sources, we abstracted qualities which exist in some degree regardless of database form or structure. Each aspect is explained below, along with an ideal form.

3.3.1 Digitalization

Digitalization refers to the degree to which a database has been converted to an electronic format. Fully computerized databases can be accessed simultaneously by any number of people, and can be changed or added to easily and without requiring local access to the data store. Data sources with no digitalization, conversely, require local access to read or modify. One record can only be viewed by one person at the same time, and modification of existing records can be time-consuming or ad hoc. Partial digitalization includes PDF copies of print forms, microfilm, or references to printed records stored in another database.

Ideally, a fully digitalized database will be of a common format with all other sources of data that it may reference or be referenced from. Furthermore, the chosen format will allow for advanced data manipulation, sorting and searching. Microsoft Access and Oracle databases both permit the use of Structured Query Language (SQL)[73], and can fulfill our ideal digitalization format. Conversely, Microsoft Excel spreadsheets and little-known database types do not allow for such a degree of interrelation or connectivity between sources of information.

3.3.2 Organization

Organization concerns the structure in which a database is arranged. Specifically, we analyzed the methods that the Borough of Merton employs in various departments to index their data sources, and the way these databases are organized (e.g. primary key selection, logical choice of fields, mapping of data tables to actual forms, and text field formatting.) In addition, we considered standards of organization that are to be applied to data sources across the board. The results of these considerations, and their implementation, are detailed in Section 5.

Our ideally organized data source makes as little use of arbitrary text fields as possible. This minimizes searching and sorting errors that arise from typos or multiple ways of stating the same piece of information. What text fields exist are formatted very specifically, allowing string manipulation to separate information in a text field fairly easily. Also, a primary key that is present on not only every data table, but every database on the subject, is used to index records.

[73] Structured Query Language is a data manipulation language that spans multiple types of database. SQL queries allow for multiple databases to be merged, searched, sorted, and analyzed relationally.

3.3.3 Meta-Info

Meta-info refers to the quantity and type of information that is present regarding the data source itself. This is similar in concept to the page of a book that contains publisher and copyright information. At each point that our group encountered a problem regarding the validity or relevance of information, we derived a useful meta-information field that would have eliminated our problem had it been present.

Ideally, any data source should have complete meta-information contained within it. This would include:

- Author
- Contact Information
- Last Update
- Update Conditions/Frequency
- Degree of Completeness
- Databases referenced
- Brief description of database

3.3.4 Updating

Updating concerns the frequency and means by which a database is updated. We have analyzed each data source that is detailed in Section 3.1. Procedures for updating information varied significantly between sources. However, this allowed us to draw useful recommendations from a large sample of possible update methods.

We have compared each source of data against an ideal database that is updated whenever new data is available. This update is done automatically, with no need for human labor. All updates are time-stamped, tracked, and logged. In reality, only extreme measures could allow an automated system to monitor every condition that it tracks. As such, an ideal updating system would impose regulations or incentives for borough residents to update their own information through a web-based form attached to a SQL backend database.

3.3.5 Sharing

Sharing concerns the accessibility of a database to individuals outside of the immediate authors. By comparing each data source we encountered, two large issues presented themselves: the availability of a database, and the knowledge of it existence. Analyzing differences between our ideal data source and each actual data source has resulted in a series of recommendations on each aspect of sharing.

Our ideal sharing system allows a database to be tagged with keywords and a subject then indexed into a directory of databases, similar to an electronic library catalog. Every department may peruse the catalog, which displays all meta-information for each database that is indexed.

3.3.6 Data Source Analysis Algorithm

After deriving the above five aspects of a data source, we created a three-stage algorithm by which each database we encountered was analyzed. The first phase entails asking the following questions about a source of information, which are then mapped to a given aspect:

- Digitalization
  - What form is the database stored in?
  - What form is data submitted in?

- Organization
    - Is data (such as address information) standardized, or is it entered in a variety of formats?
    - How is the database indexed?
    - How many text fields are present?
    - How many of these could be drop-down menus?
    - Is a primary key defined?
        - If so, is it the same primary key used in related databases?
- Meta-info
    - To what degree is meta-information present?
    - How difficult is it to discover meta-information that is not present?
- Updating
    - How is information for the database collected?
    - How frequently is the database updated?
    - How is the database updated?
    - How often do the real-world conditions tracked by the database change?
    - How does this compare to update frequency?
- Sharing
    - Who can access the database?
    - What conditions for access exist?
    - Who is aware of its existence?
    - How were they made aware of its existence?
    - How is the database accessed?
    - How often is the database accessed?
    - What information falls under data protection laws?

Next, these answers are compared against the ideal forms taken by each aspect, explained above. Finally, the discrepancies between the actual data source and ideal data source are identified. These comprise the areas of potential improvement. Section 4 details the results of this analysis. Individually dealing with each area of improvement, while useful, may not address the root causes of each problem. Instead, we have derived general procedures to be implemented on a policy level. Section 5 describes these techniques in detail.

4 Results and Analysis

Our results are divided into three sections, based on our three objectives. Section 4.1 presents the results of characterizing buildings in our target area in regard to usage and ownership. As the majority of our data was derived from partial sources or field work, this is not a complete database of buildings. Section 4.2 focuses on the difficulties we encountered in energy estimation, and presents the results of our research into the content and availability of individual data sources. Finally, Section 4.3 describes the outcome of our research into the contextual qualities of Merton's databases.

4.1 Characterizing Merton Buildings

One of the major goals of our project was to characterize Merton's buildings into usage and ownership categories. This information is essential for the council's Combined Heat and Power feasibility study, when determining which buildings are desired for connection. Use and ownership are important because use helps to determine energy and heat demands, while ownership dictates whether each location is eligible for 15 year power contracts. The borough does not have a unified database documenting the use or ownership of each building, so we attempted to reach this goal by merging a number of separate lists. In each section, the data sources we found useful are mentioned. Many other sources were investigated, but failed to provide us with usable information. A detailed listing of all our sources can be found in Appendix B as well as visually seen in Section 4.2.2 Organization of Data Sources. We were able to differentiate many buildings in our study area into the following categories:

4.1.1 Businesses

Businesses proved to be one of the most challenging categories to develop a database for, as we were not able to locate a comprehensive list of all businesses in the borough. Business listings from the borough itself, as well as the chamber of commerce were investigated, but both were found to be quite incomplete as business inclusion is optional. In addition, we researched many "hooks", which are paperwork coming into the borough from businesses that may indirectly provide our desired list. The corresponding business sections in the methodology provided detailed information on all these sources. In order to obtain a business list for our detailed study area, we manually surveyed the area, documenting specifically larger businesses that would be more beneficial for inclusion in the future CHP system. These buildings were then identified in Merton's GIS maps in order to assign them UPRNs (Unique Property Reference Number). A map of the businesses in our study area can be viewed below.

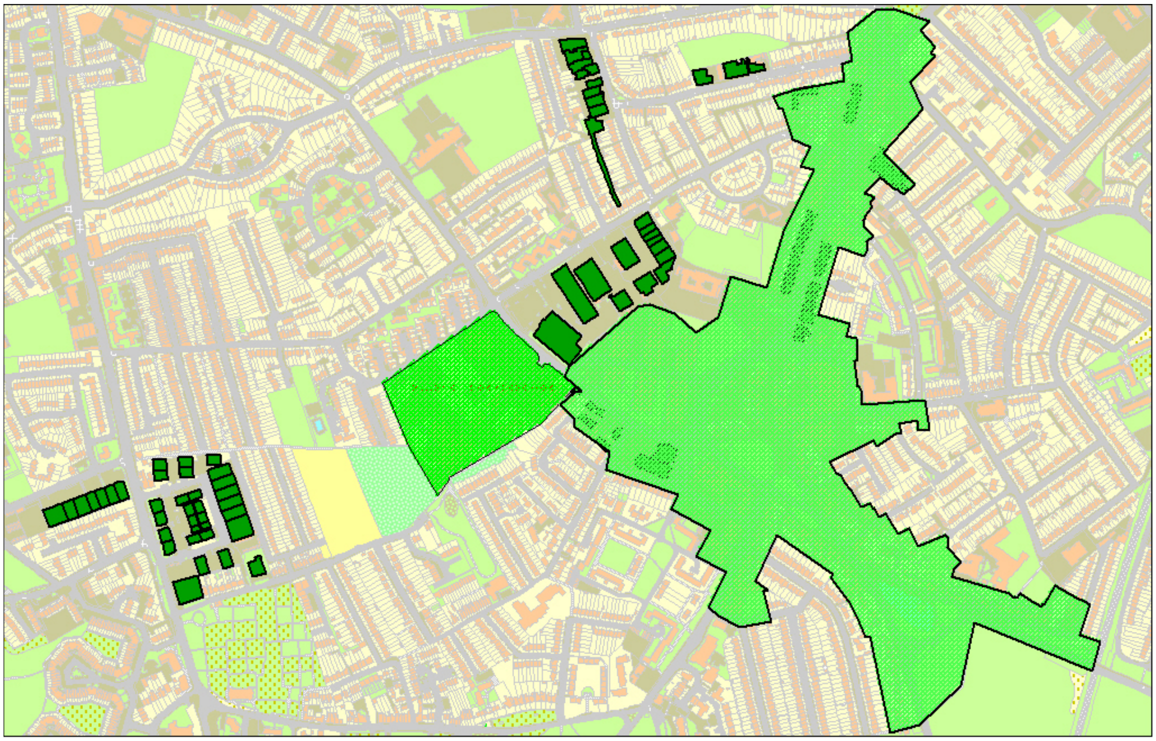

Figure 19 - Businesses in Target Area

The buildings shown in dark green are the larger commercial, office and industrial buildings we targeted for our study. Other smaller businesses exist, but were not recoded due to the scope and time restraints of this project. The large highlighted area on the map is the Mitcham town centre, in which most buildings were not recorded because the area is planned for redevelopment in the near future. The gasworks is the smaller highlighted area, also planned for redevelopment, and a site for one of Merton's planned CHP plants.

4.1.2 Civic Buildings

We were able to obtain select information on civic buildings in our area mainly from two sources. One spreadsheet was located in the estates department of the borough, which lists council owned buildings with the exception of housing, schools, and industrial properties. This listing allowed us to locate a handful of buildings in our study area on the GIS maps. In our database, we recorded the physical characteristic fields from the spreadsheet, described in detail in the Buildings Knowledge base Matrix in the following results section. The report from a consultant hired by the borough, PB Power, added heat and energy demands to our database for many of the civic buildings in our CHP study area. The map below displays the aforementioned buildings, colored in blue.

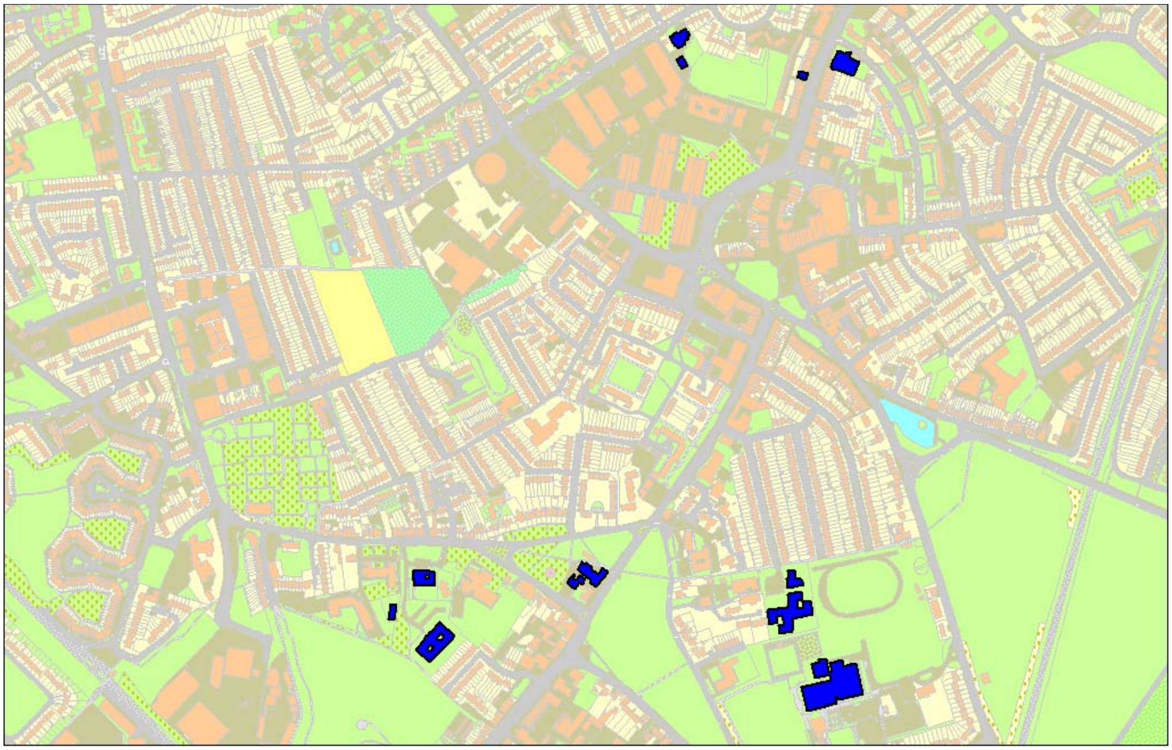

Figure 20 - Civic Buildings in Target Area

4.1.3 Education Buildings

Education buildings cover a variety of schools, which was one of the easier categories of buildings to locate in our study area. When first surveying our area in the borough's GIS maps, many of the schools were visibly labeled, and were simple to document. Additionally, a directory of schools entitled "Directory of Establishments" was easily located within the borough's intranet. This directory contained primarily contact information for area schools, but did not contain private schools, for which the borough possessed no listing. For the purpose of Merton's CHP feasibility study, small private schools would prove to be insignificant energy and heat users, and therefore poor candidates for connection. Thus their exclusion from our database should not have a substantial effect on Merton's study. A map displaying the located schools is shown below.

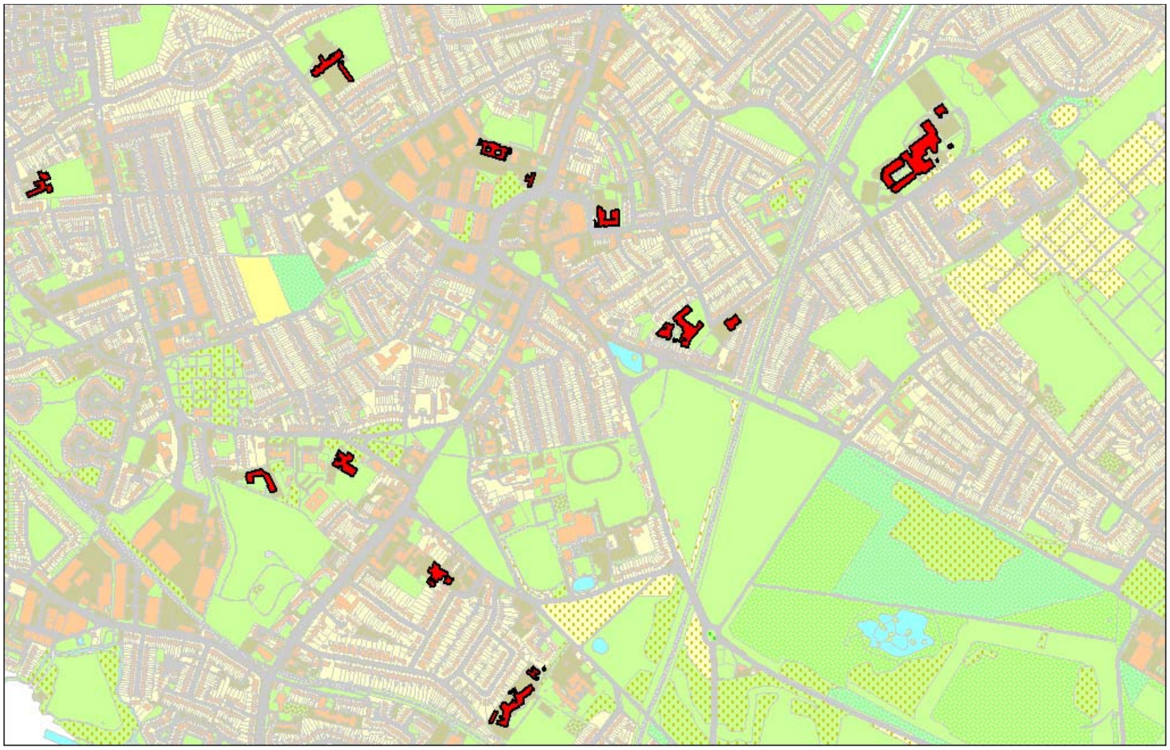

Figure 21 - Education Buildings in Target Area

The PB power report for Merton's buildings included electricity and heat calculations or estimates for a number of the larger schools along the planned CHP routes. These energy data are explained in more depth in Section 4.2.1 Energy Data Collection.

4.1.4 Private Housing

Information regarding private residences is relatively sparse within the borough's records. We were unable to locate any comprehensive list of privately owned land or residences. However, channels of information exist with which the borough should theoretically be able to collect much identifying information. The council does collect property taxes from residents, so a list of these taxpayers does exist. We were unable to gain access however, as much of the data is protected by privacy laws which prevent the borough from releasing citizens' personal information. New building planning and renovation is another source of information we researched. The current regulations however, permit certified builders to complete many common projects with minimal notification to the council. Additionally, these notifications are currently collected in paper form. Fortunately, the council is negotiating with software company Northgate to design a web-based version of the construction notification form, which should result in more accessible data. All information from planning will always be limited to new construction and modifications, so many buildings may still go undocumented.

4.1.5 Social Housing

The council has a great deal more information on social housing, as they (or Registered Social Landlords) are responsible for the building maintenance. A spreadsheet containing data on social housing complexes run by RSL's was located in the Housing Strategy and Social Services department. We sorted this list by address, and separated out any housing units in our area of study. These buildings were compiled into our database, and then mapped into GIS with corresponding UPRN's. These buildings can be seen in the figure below.

Figure 22 - RSL Social Housing in Target Area

Larger complexes of social housing are good candidates for Merton's combined heat and power system, as they use a fairly large amount of energy, and can be networked into a heating system due to their close proximity to each other.

A spreadsheet of Merton owned council housing was also located, in the Community and Housing department. This list was again sorted by address, and the buildings in our study area were extracted in order to view them on a GIS map, shown below.

Figure 23 - Council-Owned Social Housing in Target Area

Some of the larger social housing complexes were included in the PB power report, so we were able to include their electricity and heat demands in our database. The reported figures for these buildings are largely estimates, based on each flat's type and location in the building complex. These estimates were generated using guidelines from the Energy Savings Trust, which are included in Appendix J: Energy Estimation Table.

4.1.6 Characterization Overview

Once we were able to characterize the buildings of Mitcham by specific use and ownership detailed in the previous sections, we created a composite map displaying all of the building types at once:

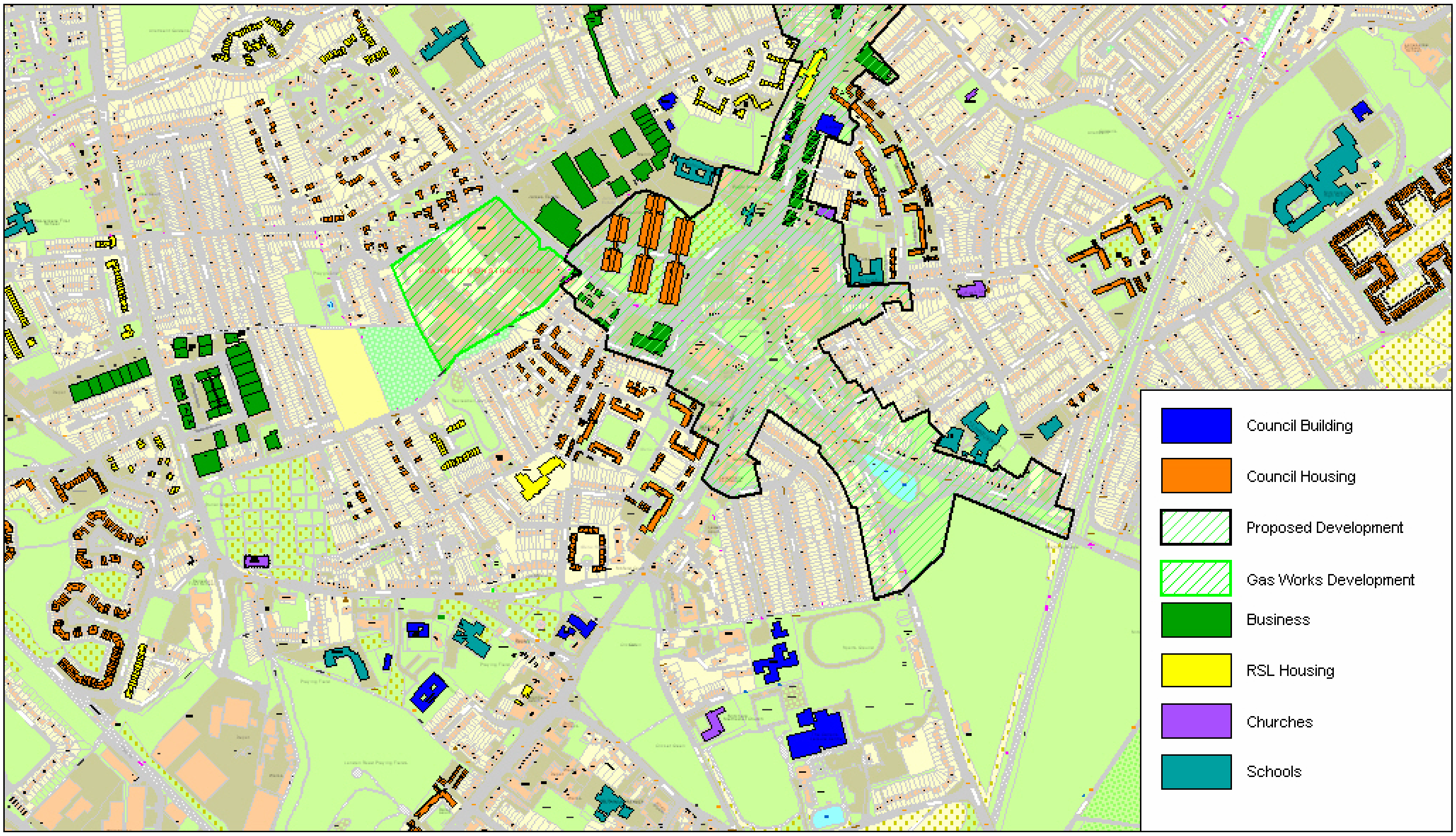

Figure 24 - Composite Map of Building Use in Target Area

This map allows one to view the distribution of building types across the study area, for the purpose of CHP planning. Use and ownership are some of the factors the borough must take into consideration when deciding which buildings will be financially beneficial to include in their network. Our database, viewed through GIS will allow future planning projects to finalize Merton's CHP plan.

4.2 Collecting and Organizing Information on Buildings in the Target Area

This section is divided into two parts. The fist details the results of our search for energy consumption data, and problems that were encountered in this search. The second section presents our data source matrix; a multivariate chart detailing the accessibility, completeness, and use of each database that we researched.

4.2.1 Energy Data Collection

The initial goal of our project with Merton was to obtain energy usage measurements or estimates for buildings in the Mitcham area for the Combined Heat and Power feasibility study. These numbers would then be put into a database and linked to GIS in order to create graphical displays of energy demand along the planned CHP pipelines. The total energy draw is necessary to calculate so that the CHP plant with the correct capacity is chosen. In our quest to determine these electricity and heat profiles, we would first have to gather detailed characteristics and physical attributes of the buildings with which to form our estimates. Unfortunately, building data was much more difficult to locate than we had anticipated, and we spent the duration of our project making inter-department connections and hunting down elusive data sources in order to characterize the buildings in our study area by use and ownership.

We did however, come across one source of energy usage data created by PB Power Associates, who the borough had contracted earlier to aid in the CHP feasibility study. Along with a more detailed report, a chart (see Appendix K: PB Power Associates Energy Data) was included that provided data for many of the large target buildings in the future CHP grid's path. This list includes schools, civic buildings, social housing, large commercial establishments, and future buildings in estates planed for redevelopment. The majority of the heat and electricity demand were estimated, although a select number of buildings have actual data, obtained by the consultant traveling to the buildings and requesting the custodian to retrieve energy bills.

We included these energy demands in our buildings database, and mapped them using GIS in the following figure.

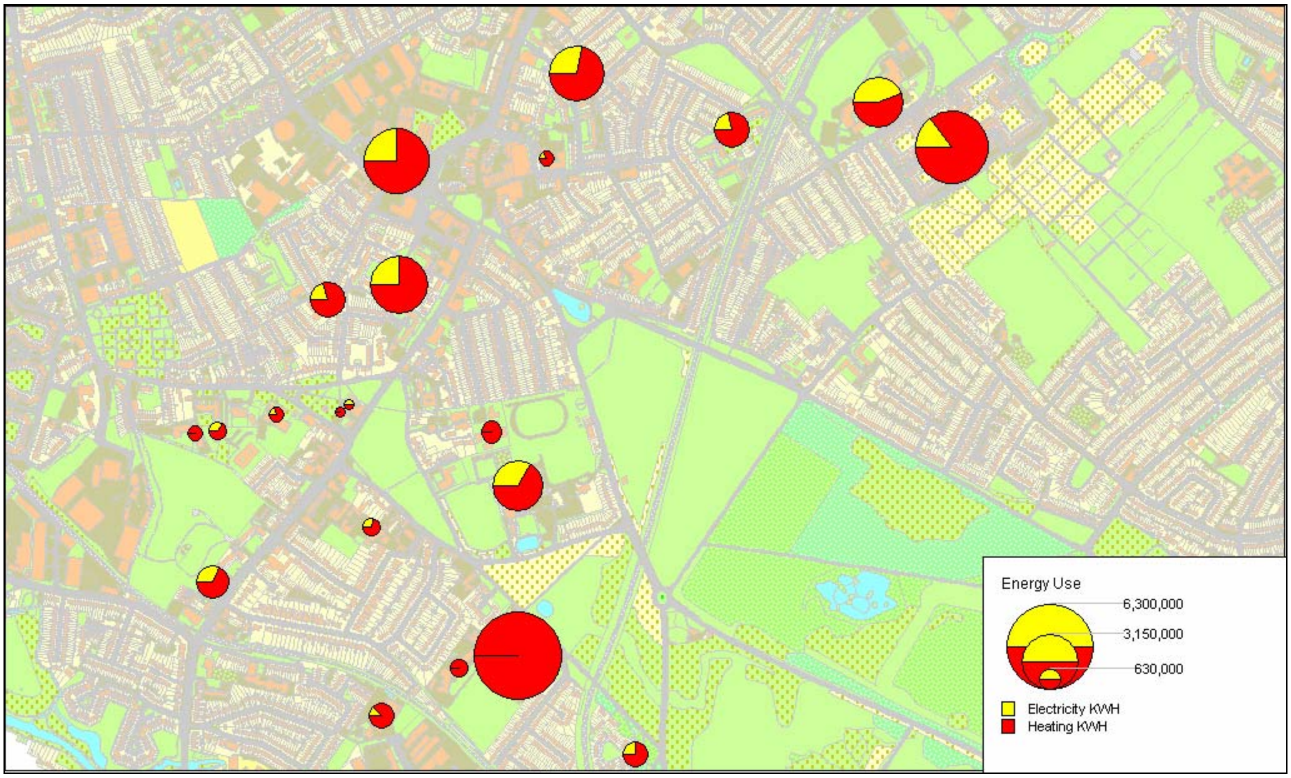

Figure 25 - Energy Use in Target Area

Each building with energy data shown above has a pie chart associated with it. The overall dimensions of the chart indicate the total energy draw from the building, so high consumers can be distinguished from light consumers. Each chart is broken up into two sections to represent the heat and electrical components of the energy usage. The yellow portion corresponds to electricity and the red portion to heat. This easily indicates which resource the building utilizes more, as a balance between heat and electricity draw must be met for the CHP plant to operate efficiently. Unfortunately, some of the energy fields were left blank, so although a few of the buildings appear to expend only heat or electricity, this is because no complementary data for the other field was available. This must be taken into consideration when analyzing the overall energy usage, as it will display an inaccurately low reading. By populating our database with more energy information in the future, Merton will be able to create a much more detailed display of anticipated demand, and accurately select an appropriate CHP plant.

4.2.2 Organization of Data Sources

Examining the matrix, it is apparent that several of the sources only provide information for a limited portion of the buildings within the borough. As you can see from the chart below the most comprehensive and reliable source of information is the GIS maps (circled in red). The other processes, such as the Business Directory or the Directory of Establishments (a listing of schools and libraries), only provide information regarding their specific area of interest. The other issue is that even within their specific area, the data may not be complete. For example, in the case of the Business Directory, inclusion is voluntary and retail wasn't considered, and the Directory of Establishments does not have data on private schools.

Department	Department of Environment and Regeneration												Comm. & Housing	Children, Schools & Families	Housing Strategy/Social Services	Corporate Services			
Division	Building Control				Estates		GIS		Licensing	Waste Management	Health and Safety					Business Rates	Legal Dept.	Council Tax	
Process Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
PROCESS	Building Application	Building Plan	Notification from Trade Association	Notification from Approved Inspectors	Industrial Map	Council Property List	GIS Map	New Address Application	Business License	Duty of Care	OSR1 Form	Inspections	Council Social Housing Database	Directory of Establishments	RSL Housing Stock Database	Business Directory	Lease Documents	Tax Database	Council Bills
Update frequency	c	c		m	c		3m	c					c	y	c			y	m
Update Cost																£20,000			
UPRN	(7)	(7)		(7)		(7)	●										⊙	⊙	
Address	O	⊙	○	O	O	O	●	○	○	⊙	○	○	O	O	O	O	○	○	○
Post Code	O		○	O	O	O	●	○	○	⊙	○	○	O	O	O	O	○	○	○

Figure 26 - Matrix (GIS Map Highlighted)

Furthermore, some of the data is redundant, more than one department or agency collects this information and does not communicate it. Below contains a few selected processes and attributes. Highlighted in yellow is the building "Owner" attribute row, as you can see the information is collected by several processes. This is unnecessary and preventable, if other divisions are collecting the same information they should be sharing it to prevent duplication and possible discrepancies. Another observation that can be made from the matrix is that ownership information is not compiled in one place, since there is no comprehensive source. (A complete source of information would be a filled circle.)

PROCESS	Building Application	Building Plan	Notification from Approved Inspectors	Notification from Trade Association	Industrial Map	Council Property List	Lease Documents	GIS Map	New Address Application	Business License	Duty of Care	OSR1 Form
UPRN	(7)	(7)	(7)			(7)	⊙	●				
Address	○	⊙	O	○		O	○	●	○	○	⊙	○
Post Code	○		O	○		O	○	●	○	○	⊙	○
Owner	○			○	O	O	○		○	○	⊙	○

Figure 27 - Matrix (Owner Highlighted)

The matrix is not limited to these general extractions; more detailed pertinent information can be derived from it. We are able to see at a glance what attributes a process collects. From the matrix we can determine which process is the most reliable way to farm in information. Additionally we can decide ways to modify the process to collect currently omitted attributes. If its use is continued in the future, the borough can track the progress of its data collection sources and the efficiency and thoroughness of their information.

4.3 Devising Sustainable Data Collection Mechanisms

We have organized the results generated by our third objective by assigning each data source five ratings. These ratings are measurements of digitalization, organization, meta-info, updating, and sharing. Tables for each value were also generated, using the algorithm presented in Section 3.3.6. Ideal qualities were given a value of five, with worst-case scenarios defining the lowest possible value for each table. A rating of zero indicates that a given attribute is simply not present in a data source. The source of each rating is detailed in the following subsections, as are the sources of each low rating that we encountered in Merton's data sources.

4.3.1 Digitalization

Digitalization	
Level	*Description*
1	Text File
2	Electronic Spreadsheet with Manual Digital Entry
3	Non-SQL Database and Manual Digital Entry
4	SQL Database and Manual Digital Entry
5	SQL Database with electronic data submission. All referenced databases are also fully digital.

Figure 28 - Levels of Digitalization

The rating system in this table is aimed at achieving a flexible database that can be integrated with other databases as well as web forms, GIS software, and other third party utilities. Level one represents the least flexible form of data storage, in which every step in the process of gathering and compiling information is done on paper. Level five represents the most desirable storage mechanism, as it permits a wide range of data manipulation, sorting, and searching procedures.

Digitalization, or the lack thereof, arises from two primary problems. The first is merely that until recently, digital information storage was not an option. When presented with a filing cabinet full of archives, most are of the opinion that if things have worked out fine so far, what need to spend time and resources copying it to a computer? The answer to this is that digitalization can allow for increases in efficiency and awareness of information that could never be accomplished with paper filing. SQL databases, for instance, can automatically reflect changes made in other databases that they may depend on.

4.3.2 Organization

Organization	
Level	*Description*
1	Standardized Data Formatting
2	Level 1, and can be sorted/search automatically
3	Level 2, and using drop-down menus whenever possible
4	Level 3, and Standardized Primary Key
5	Level 4, and Standardized With All Relevant Databases

Figure 29 - Levels of Organization

The ratings used in determining the level of organization present in a database are cumulative. This means that a rating of four includes all traits displayed in levels one, two and three, in addition to a standardized primary key.

In regard to the levels themselves, some explanation may be required. Level one refers to an established method of formatting information to be input to the database, such as splitting up of address data into multiple fields and using the same syntax across departments. The value of level three's requirement of drop-down menus is a minimization of typographical and syntax errors. If all people entering data must select from a drop down menu, searching and sorting becomes significantly easier than it would be if text fields accepting any input are used. Level four allows all data that may be related to be indexed by the same value, making joining or manipulating multiple databases a simple and intuitive process. Finally, level five refers to a well-defined and accessible standard covering all aspects of a database and applying to all departments.

Organizational issues arise from a lack of standards applying to data fields that exist throughout many databases, such as the address of a building. Even if each address is easily comprehensible to a human, inconsistencies in the order and format of unit number, street name, post code, county, and town make many trivial tasks time-consuming and complicated. Automatically generating a list of buildings in Mitcham, normally a five-minute problem, can takes days to solve if addresses are stored in unpredictable ways. Furthermore, many related sources of information (such as Ordnance Survey maps and a list of Council-owned buildings) are indexed in very different ways. The former uses the UPRN (Unique Property Reference Number) of an address, while the latter uses the address itself. This means that any operation that compares, merges, or analyzes sources of data in both databases is made vastly more complicated, as the same building is listed in two different ways that cannot be converted between.

Also, database systems such as Microsoft Access or Oracle are generally regarded as extremely complex, specialized programs with a high learning curve. This results in what data is available digitally to be in spreadsheets or other formats that are easy to work with. As not many people know how to use database software, very few are aware that data sorting, searching, and analyzing which is time-consuming or flat out impossible within a spreadsheet application can be done quickly and reliably with a database.

4.3.3 Meta-Info

Meta-Info	
Level	*Description*
1	Author
2	Level 1, Contact Information, Date Updated
3	Level 2, and Update Conditions/Frequency
4	Level 3, Degree of Completeness, and Databases Referenced
5	Level 4, and Brief Description

Figure 30 - Levels of Meta-Info Present

The Meta-Info rating system is another cumulative table, based on the premise that the information present on one level can be derived or discovered by consulting information from levels below it. For this reason the author of a database is the most important meta-information field. If an author is not present, no meta-info rating can be assigned, as it is impossible to determine the validity of whatever meta-info may be present.

Complications arise when meta-information is not present, as is the case with many Council databases. Meta-information is a concept that goes hand-in-hand with information sharing. So long as the dominant mindset is that only people with a direct need, who work within the same subject as the database author, should be allowed to use the information, meta-info will rarely if ever be added. Update frequency and conditions, as well as how complete a source of data is, may all be contained in the minds of a handful of people. If, however, the objective is to create databases available to a wider ranger of individuals, some method of knowing how recent and accurate information is will be required. Essentially, meta-information can be thought of as the ISBN numbers and publisher information page that are tagged to all books. As long as there are only a few people reading and writing books, it is unnecessary. But once libraries and publishers arise, a way of keeping track of where and what a book is must be devised.

4.3.4 Updating

Updating	
Level	*Description*
1	None. Data is Entered Once and Never Modified
2	Updated Intermittently
3	Updated Periodically
4	Updated Whenever Data is Available
5	Electronically Updated Whenever Data is Available

Figure 31 - Levels of Updating

Unlike the previous two, this rating system is not cumulative. The worst case scenario is that of a database that is created once, and never again modified. Intermittent or unpredictable updating is only slightly better than no updates whatsoever. The best case is a database that is updated as real-world conditions change, or soon after. Electronic methods make this significantly more feasible than do manual, paper-based procedures.

Problems resulting from a lack of current information take two forms. The first is rated in Figure 33 - Datasource Ratings, and is quite simply a failure to update a database when conditions change. Intermittent updating, in which a source of information is not updated in any predictable way, also falls within the scope of this problem. Council databases suffer from poor updating procedures either due to a lack of interest in maintaining accurate information (such as building plans not including renovations made after construction), or from information being updated only when an update is requested (such as the Council Property List). While this may suffice in a specialized environment where only a few people work with a database, it must be addressed before attempting to make the data accessible to other Council departments.

The second form of problem in maintaining up to date data is more subtle. Rather than not adding new information, some databases (such as the OSR1 form archives) neglect to prune old and no longer relevant records from their lists. This can result in evidence that buildings or businesses that ceased to exist are still in operation, and may indeed contradict newer information on the same structure. In some cases this is not the fault of those who maintain the database. Instead, this commonly arises from policy decisions to require only one submission of a form, normally upon the creation of a business or building. If there is no way of establishing continued existence, the database cannot be faulted for not containing this information.

4.3.5 Sharing

Sharing	
Level	*Description*
1	Obtainable
2	Level 1, and Shared on a Networked Drive
3	Level 2, and Indexed in Database of All Databases
4	Level 3, and Accompanied by Meta-Info
5	Level 4, and Tagged With Subject and Keywords

Figure 32 - Levels of Sharing

The rating system that applies to the level of information sharing present in a data source is cumulative. No rating in this category refers to a data source that exists on an isolated data store, such as an unshared desktop folder or a filing cabinet. To achieve even worst-case sharing, some degree of digitalization is required. Without this, local access must be obtained before any information can be viewed.

Information sharing, as has been discussed above, is generally not considered when constructing a database. Most of these data sources exist only for the use of a few individuals, and the question “who else could use this, and how?” is rarely asked. This results in, for example, an Excel spreadsheet stored on one person’s computer, of whose existence only four people are aware. There is also no organized system that advertises and indexes data sources available to Council employees, so there is no established method of sharing data even if one desired.

4.3.6 Overall Quality of Data Sources

Using the ratings that we assigned each data source, we compiled the following chart displaying the overall quality of each data source vis-à-vis the five attributes that we rated. With each database plotted on the x-axis, a bar corresponding to its rating in each of the five attributes is charted. A rating of zero, in which no bar at all is plotted, represents a total lack of that attribute in a source of information. The Council Industrial Map, for example, is stored and updated entirely in print form. No digital copy exists, so no digitalization is present. The total rating, a summation of all ratings per data source, should not be used as a single summary value. If, for example, a data source has high digitalization, organization, meta-information, and updating, but no sharing, then it may be much less useful than a lower-scoring but more accessible information source. Instead, a chart similar to Figure 33 - Datasource , or ordered quintuples for each data source (with each number representing one rating) should be used to target weak areas or easily remedied problems in a source of information. For the raw data chart that Figure 33 is derived from, see Appendix

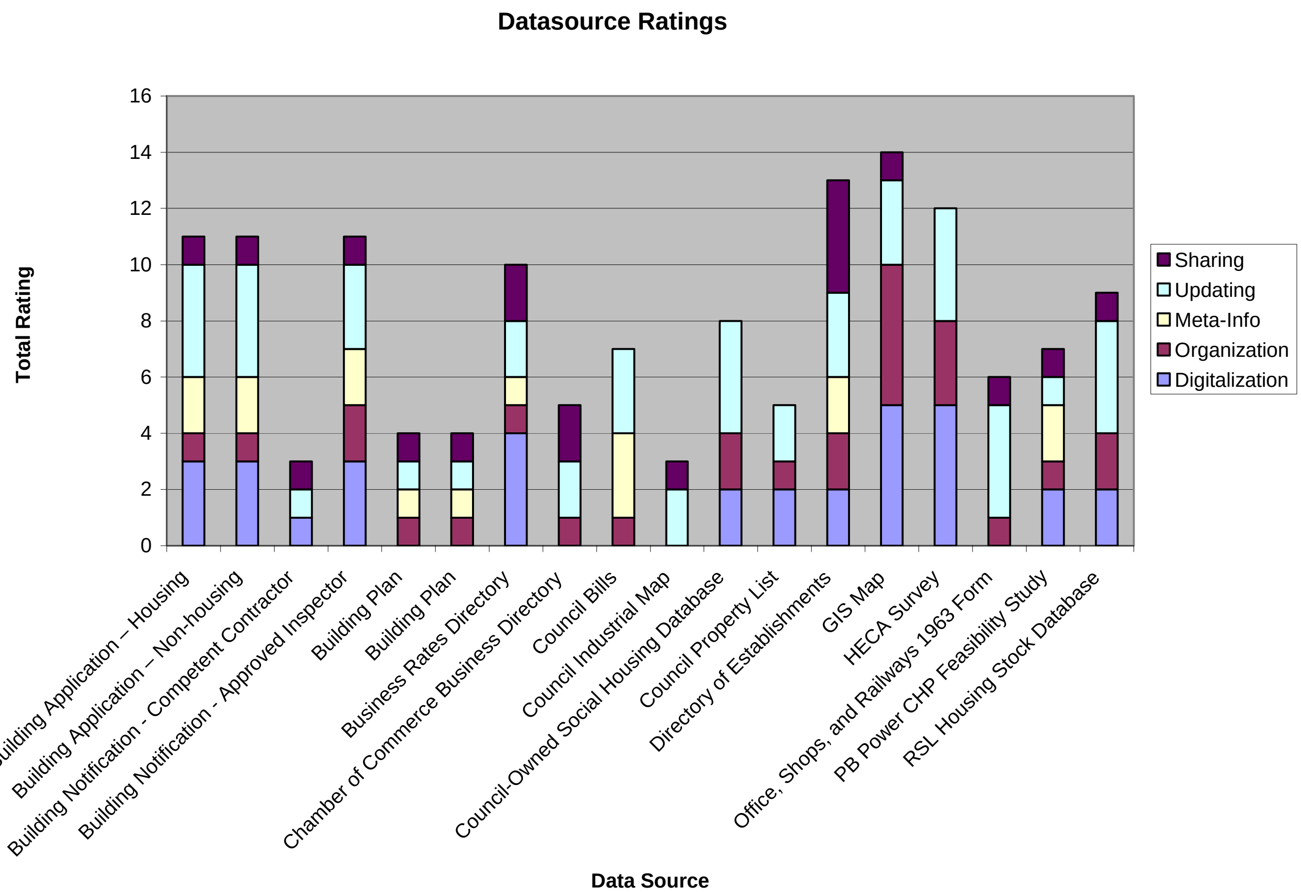

Figure 33 - Datasource Ratings

Any data sources that we could not fully rate are not included. This scenario normally occurred when a given source of information was data-protected, or simply unavailable due to time constraints. As this chart makes apparent, information sharing, digitalization, and meta-information are the most common inhibiting factors to the Council data systems. Solving these problems would significantly help to achieve a low-maintenance and easily accessible knowledge base that could be used for planning and analyzing change within the borough.

5 Recommendations and Conclusions

Throughout the course of our project, several aspects of the Merton Council's data collection and archival system have proved troublesome. Specifically, there is little communication between departments, no organized information sharing systems, no standard format for collecting data, and little knowledge of a data source outside of its immediate users and creators. All of these problems arise from 'need-to-know'; a paradigm that is at the heart of many corporate information systems. In brief, this doctrine results in a case where any given employee or group of employees has access and/or knowledge only to the data that they immediately require. While this proves effective in security-sensitive or proprietary environments (such as financial institutions or software companies), the "Council's aim is to improve the quality of life for the people who live and work in the Borough of Merton."[74] Instead of information hiding, a practice of sharing accurate and complete information between departments, using organized and indexed cross references, may prove to be a better choice. Section 5.1 will recommend policy changes resulting in more information hooks, and therefore more complete sources of information. Section 5.2… Finally, Section 5.3 will address methods to increase the accessibility, accuracy, and uniformity of Merton's data collection infrastructure.

5.1 Characterizing Merton Buildings

Due to the problems our group encountered in gathering the information required to characterize all buildings, we recommend that this goal be carried over to the next WPI Interdisciplinary Qualifying Project group. By using the recommendations, results, and analysis that our group carried out, it should be possible to target promising information sources for many data fields while hunting and gathering the remainder. Any future work should focus on obtaining data quickly, and not investing too much time in any one resource unless it immediately proves useful. The current state of Council databases indicates that external sources of information ought to be considered, as well as field work.

Energy estimation specifically should be approached from a typological and use standpoint for any building not council owned. Any invasive procedure (such as the Standard Assessment Procedure) will encounter serious difficulties in implementation due to privacy laws and the sheer number of buildings that must be accounted for. If at all possible, an automated calculator based on the characteristics that we defined in Appendix B should be considered as a possible alternative to policy changes or other long-term approaches.

5.1.1 Short-Term Information Gathering

For time-dependent projects, we recommend that any attempt at characterizing buildings take into account that most data sources are incomplete, inaccessible, or difficult to locate. The most that can be hoped for is a partial characterization of a sample of Merton buildings at this point. Attempting to remedy this problem is a long-term project that should be dealt with separately. Field work is more than likely necessary to obtain energy data or structural information on any building constructed by a competent contractor. Hunting and gathering data within the Council building should be used as a primary method of data collection, as although inefficient it will be likely to produce results faster than searching for an ideal data source. A potentially useful source for short-term information gathering is the Freedom of Information Act,

[74] Merton, 1

which can be used to discover, among other things, the ownership and purpose of local businesses.

5.1.2 Long-Term Information Gathering

For a full characterization of Merton buildings, our group recommends investigating a potential business tax database that might be maintained by the Business Rates division. If this resource exists, it would most likely contain a complete record of business location, ownership, and stated use. If it does not exist, we recommend purchasing from Experion a database of all businesses in the area. This credit check company is guaranteed to maintain complete business records, however Experion charges for this service. While in no way a sustainable method of gathering data, this will allow the Council to focus the actual characterization process, and less on entering old or backlogged information. In light of the lack of a complete source of information on these critical buildings, this snapshot could be invaluable when paired with a policy of upgrading data collection mechanisms. Specifically, requiring yearly electronic submission of OSR1 forms, using guidelines outlined in Sections 5.2 and 5.3, will allow the Council to keep Experion's information current at no extra cost.

5.2 Collecting and Organizing Information on Merton Buildings

5.2.1 Data Hooks

Data hooks are policy changes combined with the upgrading of an information collection system. The objective of a data hook is to create an autonomous data farming mechanism that requires almost no investment of money or time on the part off the Council. An ideal data hook puts the onus of data entry on a source external to the Council, such as borough citizens or other organizations. In this way an accurate representation of current events can be digitally archived with little effort.

5.2.1.1 Office, Shops, and Railways 1963 (OSR1) Form

The form must currently be submitted by all businesses upon their creation. Stating the number of employees, owner information, and business description, the OSR1 form could be a useful data hook. Unfortunately it is currently submitted once, in paper, and never again. We recommend that a SQL database be created to store OSR1 data. Next, a PHP web form should be linked to this database, and made available online. Policy changes can require that this be re-submitted online once per year, and the Council could easily generate a database of all businesses.

5.2.1.3 Building Control Applications

Building control applications contain useful structural information, and are already stored in a SQL database (MVM, a proprietary software package). If one more step is taken and a PHP web form is programmed, almost all paper processing and manual data entry can be eliminated when dealing with these applications. Assuming each application is submitted to an interim database, the only human labor required is that of one employee checking submitted forms for validity. If no false information is found, a single click can transfer the application to the master database. Therefore, the brunt of data entry work now falls on the individual submitting the form, and frees council employees for more skilled labor.

5.2.1.1 Building Control Notifications

The Merton Council has recently begun the process of converting building control notifications to an online format. Delays with Northgate, a software company that will be implementing the conversion, have so far delayed the project. Web-based Building Control Notifications are good start in the process of upgrading the borough's data collection systems, but should by no means be the only step. We recommend that any procedures or pitfalls that are encountered here be documented and the experience applied to future attempts at digitalizing council databases.

5.2.2 Estimating Energy Consumption in Council-Owned Buildings

Within the Borough of Merton, energy bills from various Council-owned buildings are not tracked or archived centrally. Instead each facility pays its bills and keeps all records of this transaction. We recommend that a SQL database be created to centralize energy bill archives. Using the UPRN of the building as a primary key, each record should contain address, building name, heating energy consumption, and electrical energy consumption. A PHP web form should be linked to this database and posted online. Each facility, upon receiving its monthly bill, can be required to copy the kilowatt hours used into this form and submit it online. The SQL database will then automatically update, and can easily provide a running tally of total energy used by Council buildings.

5.3 Devising Sustainable Data Collection Mechanisms

Recommendations in this section are designed to be implemented on a policy level, and to apply to every database (be it a filing cabinet or a SQL table) within the Council. These should be treated as long-term goals toward creating a more efficient and complete knowledge base with which Council departments may make informed plans and decisions. (In the short-term it is most likely impossible to execute each recommendation here due to the inertia inherent in retooling each department's information gathering mechanisms.) As in previous sections, these suggestions will be targeted toward the five attributes of digitalization, organization, meta-information, updating, and sharing.

5.3.1 Digitalization

All existing databases, from filing cabinet archives to Excel spreadsheets, should be converted to SQL databases. Information stores based on Structured Query Language allow for advanced manipulation and analysis in data, and easy integration into a Geographic Information System such as MapInfo. Furthermore, SQL databases are relational and can not only reference each other, but share data between databases or automatically update when information in one of them changes. Conversion not only makes data easier to manage, it also makes important information available across departments. Any number of Council employees, at any location on the intranet, may simultaneously access a SQL database.

Depending on the original form of the information, some databases will be more costly to upgrade than others. Paper archives will have to be entered by hand into a tailor-made database, but will derive the most benefit from conversion. Excel spreadsheets are already digital and can be imported into a SQL format using Microsoft Access. Finally, proprietary databases that do not use SQL may or may not be easily converted, depending on the specific system used.

5.3.2 Organization

All databases maintained by the Council should be made uniform under a standard database structure. In this way, time and manpower can be minimized when integrating one source of data with another. This standard should include a common address format; specifically separate fields for unit number, street name, postcode, town, and county. This allows a geographic area to be selected or highlighted with little to no difficulty or need to modify stored data. Next, all databases that maintain information on individual buildings should use Unique Property Reference Numbers (UPRN) as their primary key. This allows easy joining, searching, and sorting of data. Furthermore, indexing by UPRN guarantees that each building will be uniquely identified, and potential formatting problems (such as typos or capitalization) that would arise through indexing by address can be avoided. UPRNs for a given structure are available through the GIS division, under the Department of Environment and Regeneration. Finally, text fields in databases should be minimized. Any field with a finite number of potential entries, such as building use or heating system type, should be made into a drop-down menu. This eliminates typos, synonyms, syntactical errors, and other formatting problems. These issues directly contribute to buildings being skipped over or mislabeled when analysis, database merging, and mapping is performed.

5.3.3 Meta-Information

All Council databases should include meta-information in a separate table. Each table should list author and contact information, the date of the last update, conditions or frequency of updating, whether the database is complete or partial, any referenced databases, and a brief description of the content. This data should be updated whenever necessary, and these updates should be tracked within the table like any other meta-info. Without background information on a database, it is nearly impossible to create an index of all data sources. In addition, it is not necessarily possible to determine how up-to-date a given source of data may be. Implementing this recommendation is almost free of cost in regard to any database that is already electronically stored, and will greatly assist future projects in collecting information. For those that are stored in paper form, this may be included in the process of digitalization.

5.3.4 Updating

Any database that was created as a single-use resource should be evaluated for relevancy. If it is found to be out of date, Council employees should discard what is no longer needed, and devise a procedure for updating whatever sources of information are left. For those databases that are updated intermittently, an explanation should be required. If possible, require these sporadic data sources to be updated either periodically or as new data is made available. Wrong information can frequently do more harm than no information; maintaining an accurate picture of Borough conditions should be given high priority.

To this end, PHP[75] should be used to program web-based data entry forms. These can be posted on either the Council intranet or the general Internet, as deemed appropriate. These forms can be linked to any SQL database, and take the place of copying printed information over to a computer. Web forms are especially useful in the case of applications that must be filled out by borough residents. By offering an incentive to submit data online (such as no processing fee), electronic data can be transferred to an interim database. Each application can be viewed by a

[75] PHP is a computer language specifically designed for creating web forms and working with SQL databases. It is relatively simple to learn, and can make updating a database much easier and transparent than other methods allow.

supervisor, and if no mistakes are found it can be added to the existing database with the press of a button. Delays in filing and processing can thereby be avoided, and Council employees can be freed to work on more productive tasks than data entry.

5.3.5 Sharing

While this may be the most difficult recommendation to implement, it may also be the most fruitful. Taking into account data protection laws, all data that can be shared between departments should be. Sharing should take place over the intranet, on mapped network drives. In addition, a database ought to be created that links to the meta-information table in each shared database. This will serve as a sort of catalog, similar to library catalogs. Each database, based on its meta-info description, can be assigned a subject and tagged with keywords. Next, a PHP web form should be created as a user-friendly interface. Any Council employee can then search by subject or keywords for information sources relevant to his or her project.

For example, if the department of Children, Schools, and families maintains a detailed database of all LEA educational establishments, this would be easily found by an Environment and Regeneration researcher. Data from the former department could then be used to plan a development projected spearheaded by the latter. In this way the tedious process of hunting and gathering data can be short-circuited. Furthermore, redundant information will become apparent. By gradually eliminating redundant information, the chances of misleading or contradicting data can be minimized.

5.3.6 Implementation of Sustainable Data Collection Mechanisms

The following examples highlight methods by which each of the above recommendations can be integrated to form a sustainable data collection system. If implemented, each database will become capable of being easily integrated into existing sources of information, such as GIS maps. The Council Property List was chosen due to its inherent organizational issues. The Industrial Map was chosen for its noted lack of digitalization and the degree from which it could benefit from such. Finally, the Housing Stock Survey was included, as it is currently a resource that while useful is difficult to integrate. Fairly simple modifications could change this.

5.3.6.1 Council Property List

The Council Property List, potentially a very useful source of data, must be converted to an easily manipulated format. Currently, it is stored as an Excel spreadsheet with multiple tables and merged cells on the same worksheet. This prevents searching or sorting of data. In addition, only a few buildings have attached UPRNs. There is no real indexing capability or method of linking to other sources of data. Combined with the above difficulties, this database is almost impossible to work with short of major organizational overhauls. The spreadsheet should be converted to a SQL database, with each table in the worksheet as a separate data table in a Microsoft Access database. UPRNs should be obtained from the GIS division for each address, and used as primary keys. Lastly, building addresses should be formatted uniformly, and include all information; from unit number to country.

5.3.6.2 Council Industrial Properties Map

Figure 34 - Council Industrial Properties Map

This Estates division map is the only repository of the Council's industrial land holdings (other than lease documents in the Legal department). Stored as a book of maps colored in with felt pen, this data source must be converted to a more accessible and robust form. Each map should be uploaded to a Geographic Information System, and combined into a single layer that highlights each industrial property owned by the Council. Behind this layer should be a SQL database indexed by UPRN and containing address, lease data, and meta-information. If this is implemented, adding or removing a property will be as simple as selecting the building and clearing the relevant data field. Furthermore, other departments can easy access the underlying database and create utilize the information for their own projects.

5.3.6.3 Social Housing Stock Database

This Excel spreadsheet should be converted to a SQL database with Unique Property Reference Numbers as the primary key. Currently, the stock database is a useful source of reference information. As no UPRNs are included however, it is impossible to link this to a GIS. Stored as a well-organized Excel spreadsheet, this database is a very useful source of information on Council-owned social housing. However, the lack of any UPRNs prevented our group from automatically linking it to a GIS, and necessitated manual data entry. This is significantly slower, and could have been avoided if the Housing Department converted the stock spreadsheet to a SQL database with Unique Property Reference Numbers as the primary key.

5.4 Conclusion

Our project group encountered significant difficulties while attempting to characterize Merton buildings. Under the current data collection and storage paradigm, most information needs to be sought out by first discovering the existence of a database through intranet searching or discussion with Council workers. Next, one must ask Council employees where a resource is located, find the resource, and request access to it. Frequently this data source is only partial, and cannot be used as a sole source of information on a given attribute. The entire process must then be repeated, sometimes more than once. The only alternative to this time-consuming process is field work, which while guaranteed to eventually yield results it is infeasible in any large-scale project. Characterization under such a system is difficult, but not impossible.

Field Name	Data Type
UPRN	Number
Building Name	Text
Building Number	Number
Unit Number	Text
Street Name	Text
Post Code	Text
Town	Text
County	Text
Owner	Text
Owner Building Number	Number
Owner Unit Number	Number
Owner Street Name	Text
Owner Post Code	Text
Owner Town	Text
Owner County	Text
Owner Phone Number	Number
Owner Email Address	Text
Use	Text
Avg Annual Heat Demand	Number
Avg Annual Electicity Demanc	Number
Avg Annual Electricity Supply	Number
Insulating Material	Text
Loft Insulation	Text
Hot Water Storage	Text
Heating System	Text
Boiler Type	Text
Boiler Installation Year	Number
Heating Control	Text
Double Glazing	Number
Low Energy Lighting	Text
Date of Construction	Text
Area	Number
Number of Storeys	Number
Wall Material	Text
Wall Type	Text
Roof Material	Text
Home Type	Text
Number of Rooms	Number
Number of Bedrooms	Number
Number of Dwelling Units	Number
Number of Employees	Number
Business Name	Text
Business Type	Text
Number of Occupants	Number

Figure 35 - Data Characterization

By employing both field work and hunting and gathering of information, we succeeded in characterizing and collecting data for a sample of Merton's buildings within an area centered on the Mitcham Gas Works. Some Council-owned structures have attached energy data, however the majority of available information pertains to the ownership and use of buildings. A lack of accessible information prevented us from including private residences in this sample, and partial data sources frequently inhibited the creation of an exhaustive building list. The methods that we had to employ are not sustainable, and require a significant number of man-hours to bear fruit.

One solution to this problem is the establishment of 'hooks.' These regulations require certain types of buildings (such as businesses) to periodically report on their existence and/or condition. Hooks can be used to farm data that would otherwise be difficult to obtain, whether due to data protection laws or simple time constraints. By offering incentives, it may also be possible to gather otherwise private data such as electrical and heat consumption. All submitted forms can be digitalized and entered into a SQL database, which not only tracks information, but also meta-information, such as the last update and the database author. If forms are submitted through PHP web interfaces, almost no human intervention is needed to maintain an accurate and up to date picture of borough affairs. With the onus on borough residents to fill out and submit the data, Council employees are freed to pursue more productive tasks. Before hooks can be truly useful, however, the Council needs to address inconsistencies, redundancies, and communication difficulties within and between its various databases.

Currently, the data collection systems employed by the Borough of Merton are largely ad hoc, and have little standardization or accessibility. The Council Property List, for example, contains inconsistent address information. In Figure 36 - Ad Hoc Data Organization, each colored cell should be aligned with the color of its column. While readable in this format to humans, a computer would have extreme difficulties parsing such information. By increasing the digitalization, organization, meta-information, updating procedures, and data sharing of Council databases, this situation can be significantly improved. Not only will individual information resources be made more efficient and powerful, but relational databases can be established that span existing databases and analyze interrelationships among currently disconnected data. Indexed and cataloged databases can provide all departments with a clear picture of not only Council activities, but how the borough responds to these activities. This will result in a greatly expanded knowledge base upon which projects and developments (such as the district heat and power system) can be planned and executed.

Figure 36 - Ad Hoc Data Organization

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Appendix B: Building Database

The core element of our Geographic Information System is a building database. This information store contains four broad categories, each drawing from multiple data fields. These categories are represented by subsections on the data entry form that is linked to our data table. We have chosen to implement a single master table, rather than smaller categorically based tables, for several reasons. First, creating and linking multiple tables creates a needlessly complex data structure. If each building has a single record containing each data field, there is little reason not to combine these data fields into a single table. Secondly, no categorical table would be used individually except in rare circumstances. SQL queries can easily extract the desired data in the cases. Finally, integration into a Geographic Information System is much simpler when only a single data table is employed. Each broad category is briefly explained below, and their associated fields are listed.

Ownership/Location

This category includes building ownership, contact, and location data. Establishing the physical location of the building and the individual or organization responsible for its upkeep is a critical step in not only conducting an intervention, but also in mapping relevant building data into a GIS. When seeking potential customers for a district heat and power system, ownership is critical in determining whether a 15-year contract can be signed. The following fields fall under ownership and location:

- UPRN
- Building Name
- Address
- Postcode
- Town
- County
- Owner
- Contact Information

Physical Attributes

This category includes building classification and physical characteristic data. With such information at hand, energy and efficiency estimates could be made of a large number of buildings from a relatively small sample. This is especially important in the residential sector, where most homes share similar dates of construction and architectural features. Such data are most easily obtained from building blueprints and permits, although Ordnance Survey data can provide basic building dimensions and orientation. Ordnance Survey data are not guaranteed to be up-to-date however, and should not be used as a first choice. The following data fields fall under the category of physical attributes:

- Date of Construction
- Home Type
- Number of Rooms
- Number of Bedrooms
- Number of Dwelling Units
- Area
- Number of Stories
- Wall Material
- Wall Type
- Roof Material
- Insulating Material

- Loft Insulation
- Type of Hot Water Heater
- Heating System
- Boiler Installation Date
- Boiler Type
- Window Double Glazing
- Heating Control
- Low Energy Lighting

Use

Building use information is essential when forming energy estimates or determining the eligibility of a given building for CHP hookup. For the majority of structures not all use information will be present, as some data fields apply only to residential buildings, while other fields apply only to commercial establishments. Building use is composed f the following data fields:

- Building Use
- Business Name
- Business Type
- Number of Employees
- Home Type
- Number of Occupants

Energy Information

Energy information is the desired result of this project. If electrical and heating data cannot be directly measured or gleaned form utility bills, an estimate based on use and physical attributes may be possible. Every data field in this category is measured in kilowatt hours per annum, and will form the basis by which the profitability of CHP hookup will be evaluated. The following data fields comprise the energy information category:

- Average Annual Heat Demand
- Average Annual Electric Demand
- Average Annual Electric Supply

The primary key for each record is the unique UPRN code assigned to every address in the target area. (The UPRN is the only redundant field within our database.) Data entry is done by a corresponding form; in this way data from a variety of sources could be entered into the database in an intuitive and self-explanatory manner. All building characteristics are contained in the data table, and indexed by UPRN into our GIS. The completed system allows detailed building characteristics to be viewed or manipulated through MapInfo Professional. Once fully integrated, the database allowed detailed querying and visual analysis of information relevant to the planning of energy policy in Merton.

Appendix C: Data Sources

Building Application – Housing

Applies to: Housing
Available From: Building Control
Provides: Ownership, Use, Physical Information
Updated: On Construction or Renovation
Pitfalls: This is a partial data source, as building planning applications need only be filed if construction is not carried out by a competent contractor. If a competent contractor is handling renovation or construction, only a notification to the Council is required.
Description: Building Application forms provide an excellent source of structural information. Detailed data on construction material and layout must be provided. Furthermore, a brief description of the site's intended use has to be written and included with the owner's contact information.

Building Application – Non-housing

Applies to: Businesses, Civic Buildings, Education Buildings
Available From: Building Control
Provides: Ownership, Use, Physical Information
Updated: On Construction or Renovation
Pitfalls: See Building Application - Housing
Description: See Building Application - Housing

Building Notification

Applies to: All
Available From: Building Control
Provides: Unknown
Updated: On Construction or Renovation
Pitfalls: Building notifications have almost no useful data, and obey no specific format.
Description: There are two forms of Building Control Notifications: Trade Association Notifications and Approved Inspector Notifications. In the case of the Trade Association, also known as Competent Persons Self-Certification Schemes, the work of scheme members is not subject to inspection by Building Control; however the work is to be monitored by the scheme organizers. The competent contractors are specialists in their field and guarantee that the work is in conformity with the Building Regulations. They must inform the scheme organizers of their work and once a month the Trade Association (Scheme organizers) sends the Building Control department a list of installations that have been completed and the address at which the work was done. Currently, no other information is contained in the notification. In addition, the actual name of the contractor that completed the work is not included in the notification; the only identification that is available is an id number that only the scheme can relate to the contractor. Because the notices are in email form and the local authority receives no fee, it lacks the resources to put all these into the building application database. Also, there is little relevant information to be entered since they have no idea the extent of the work. An example of this would be notification of works completed from a Fenestration scheme, the Council can surmise that windows have been replaced, however, they have no idea how many were changed. Approved inspectors are individual and corporate certified private inspectors which are authorized under the Building Act of 1984 to provide building control services. Approved inspector notifications are received by the local authority 5 days before the commencement

of work and again when the installation is complete. Upon receiving the completion notification the work is registered in the building application database. The address and a brief description are included and in the case of housing more detailed information may be available. At the end of the month Approved Inspectors of housing submit a completion notice which includes the dwelling category (whether it is local authority, housing association or a private residence) and the number of bedrooms. This information is not recorded until the monthly document is received; however it is up to date and available on the building application database.

Building Plan

Applies to: All
Available From: Building Control
Provides: Physical Information
Updated: On Construction
Pitfalls: Like building application, building plans need only be submitted if the structure is not being worked on by a competent contractor. Also, digitalizing information from blueprints is a time-consuming task.
Description: Complete blueprints of a structure can provide layout and area information. They are normally hand-drawn or printed using CAD software. We did not consider these as a good source of information, as layout and area information can be much more easily drawn from building applications.

Business Rates Directory

Applies to: Businesses
Available From: Business Rates
Provides: Use, Ownership
Updated: Intermittent
Pitfalls: The Business Rates directory includes only those commercial establishments that have offered to be included. This is only a small fraction of the total businesses in Merton. Also, updates are not published on any set schedule.
Description: The Merton Business Directory provides an indexed list of all businesses that have volunteered to be listed. Full contact information is provided, along with a rough estimate of employees and the date of establishment.

Business License

Applies to: Businesses
Available From: Licensing
Provides: Unknown
Updated: Unknown
Pitfalls: May only apply to shops that provide alcohol. We have received conflicting information unknown

Business Tax Database

Applies to: Businesses
Available From: Business Rates
Provides: unknown
Updated: unknown
Pitfalls: unknown
Description: unknwon

Chamber of Commerce Business Directory

Applies to: Businesses
Available From: Chamber of Commerce
Provides: Unknown
Updated: Intermittent
Pitfalls: The Chamber of Commerce directory includes only the fraction of businesses that are registered with the Chamber. Also, updates are not done on a regular basis. All modifications seem to happen intermittently.
Description: A directory of Merton businesses. We have not directly accessed this source, and cannot provide much description.

Council Bills

Applies to: Council-owned buildings
Available From: On-site
Provides: Energy Use
Updated: Monthly
Pitfalls: The Merton Council does not maintain a centralized archive of its maintenance expenditures. The only way to obtain energy bills for council owned buildings is to actually travel to the site and take a meter reading or view whatever archived bills are stored there.
Description: Energy bills provide exact electric and heating consumption for a building. As there are few data sources for energy use, making these bills more accessible is a high priority.

Council Industrial Map

Applies to: Council-Owned Industrial
Available From: Estates
Provides: Use, Ownership
Updated: Intermittent
Pitfalls: Council-owned industrial properties are stored in several unwieldy books of Ordnance Survey maps. Red shaded areas correspond to land the Council possesses. These are difficult to update, as once shaded, regions have to be taped or pasted over with blank paper before a change can be made. Furthermore, the data is difficult to share effectively and can only be accessed by going to the Estates division and perusing the maps. If these volumes were damaged or lost, the Council would have great difficulty determining what land it owns.
Description: Council-owned industrial land, and a reference number corresponding to a lease, is written in one of several books of maps contained inn the Estates department. Relative building location is determined by a coordinate grid. Specific location is found through visual inspection.

Council Lease Document

Applies to: Council-Owned Buildings
Available From: Legal
Provides: Ownership
Updated: On lease expiry/renewal
Pitfalls: While we have included this as a potential data source, time constraints prevented our group from obtaining a sample lease form or inquiring into the mechanisms of data

storage and collection. Furthermore, only the legal department can grant access to this information.
Description: unknown

Council-Owned Social Housing Database
Applies to: Council-Owned Social Housing
Available From: Community and Housing
Provides: Ownership, Use, Physical Information, Energy Use
Updated: On new development
Pitfalls: Not all data fields are filled in
Description: This Microsoft Excel spreadsheet is a nearly complete source of information for Council-owned social housing. Some information, such as heating system type or a precise room count, is not available for all buildings. However, complete ownership and use information is provided

Council Property List
Applies to: All Council-Owned Buildings but Housing, Schools, and Industrial
Available From: Estates
Provides: Ownership, Use, Physical Information
Updated: unknown
Pitfalls: The database is stored as an excel sheet with multiple tables sharing the same columns. This makes sorting and searching operations difficult and importing into an Access database unfeasible.
Description: The Council buildings included in the Property List give full usage and ownership information, in addition to the Gross Internal Area of a structure. Several fields are not useful in the context of our project, mainly those pertaining to maintenance backlogs and priority levels.

Directory of Establishments
Applies to: LEA Educational Buildings
Available From: Children, Schools, and Housing.
Provides: Ownership, Use
Updated: Annually
Pitfalls: No information is collected on private schools
Description: Published annually by the Department of Children, Schools, and Housing, this PDF document provides complete ownership and use information on all educational buildings controlled or managed by the Local Educational Authority.

Experion Business Database
Applies to: Businesses
Available From: Experion Corporation
Provides: Ownership, Use
Updated: unknown
Pitfalls: Information must be purchased from Experion, and updates are not provided in the purchase. Therefore in order to maintain a complete and current database, information must be purchased annually from the corporation.
Description: The Council has never bought one of these databases; our group was unable to view or worth with one.

Fire Inspections

Applies to: Businesses
Available From: Greater London Authority
Provides: Ownership, Use
Updated: unknown, defunct
Pitfalls: Fire inspections and certificates are no longer required, and records of inspections are no longer updated. Our group discovered the existence of these two years after the law requiring inspections was repealed, and we unable to obtain a sample record.
Description: unknown

Fire Certificate

Applies to: Businesses
Available From: Greater London Authority
Provides: Ownership, Use
Updated: annually, defunct
Pitfalls: See Fire Inspections, above
Description: unknown

GIS Map

Applies to: All
Available From: GIS division
Provides: Ownership
Updated: tri-monthly/intermittent
Pitfalls: Dependent on the validity of the Ordnance Survey. GIS layers are synchronized with the Survey every three months; however the Survey is only updated when a borough resident points out a building that is not already mapped.
Description: Provides building location information on all buildings included in Merton's Ordnance Survey. GIS layers are crated using MapInfo Professional, and are accessible over the GIS division's shared folders on the Council intranet.

Health and Safety Inspection

Applies to: Businesses, Civic Buildings
Available From: Health and Safety
Provides: unknown
Updated: Intermittent
Pitfalls: Health and Safety inspections are carried out only by request. Our group was unable to ascertain the exact nature of the data that is recorded by these inspections, due to time constraints and the relative lack of completeness that this data source provides.
Description: unknown

HECA Survey

Applies to: Housing
Available From: Creative Environmental Networks
Provides: Ownership, Use, Physical Information, Energy Use
Updated: unknown
Pitfalls: HECA surveys are entirely voluntary, and the database is maintained in an electronic form by CEN. We did not contact the corporation, as our group wished to focus on public sources of information.

Description: Contains detailed information on energy use, especially heating systems. Location data, relevant structural information (wall material, home type, hot water heater, etc.), and the number of dwellings is included.

New Address Application

Applies to: All
Available From: intranet
Provides: Ownership, Use, Physical Information
Updated: On address change
Pitfalls: No comprehensive database of these forms is maintained. Address changes are not registered until eight weeks after submission.
Description: Address information is sent to the GIS division; other information is sent to Business Rates, Council Taxes, and Licensing. As no completed information is maintained, and incoming forms are split up and sent to the relevant divisions, our group was unable to further pursue this data source.

Office, Shops, and Railways 1963 Form

Applies to: Non-Industrial Businesses
Available From: Health and Safety
Provides: Ownership, Use
Updated: On business creation
Pitfalls: The archives are stored in print format. As this form need only be filed once, it is impossible to determine the validity of older data, including the continued existence of a registered business. Furthermore, there is little to no enforcement of the registration requirement. It is possible that a new business will be unaware of this form, and not file one.
Description: OSR1 forms need to be filed by every business upon its creation. These are archived by the local Environmental Health department. Information on building owner, number of employees, and a description of the enterprise is required.

PB Power CHP Feasibility Study

Applies to: Some Council-Owned Buildings
Available From: Plans and Projects
Provides: Energy Use
Updated: not updated
Pitfalls: Much of the data is estimated, and will not be updated in the foreseeable future
Description: A spreadsheet of electricity and heating use by several Council buildings. Estimated and exact data are distinguished between.

RSL Housing Stock Database

Applies to: RSL-Owned Social Housing
Available From: Housing Strategy and Social Services
Provides: Ownership, Use, Physical Information
Updated: On new development
Pitfalls: none
Description: This Microsoft Excel spreadsheet provides ownership and location information for social housing owned by Registered Social Landlords. Limited physical information, such as date of construction, is included.

SAP Survey

Applies to: Housing
Available From: Creative Environmental Networks
Provides: Ownership, Physical Information, Energy Use
Updated: unknown
Pitfalls: The Merton Council does not have access to any SAP surveys done by CEN. These analyses are only conducted during an intervention or at the request of residents.
Description: Our group did not obtain a completed SAP document from CEN, however a sample worksheet is provided in Appendix B.

Tax Database

Applies to: Private Housing
Available From: Council Tax
Provides: Ownership
Updated: unknown
Pitfalls: Significantly data-protected
Description: Our group did not view the Council tax database, as we chose not to focus on private housing. As tax discounts are based at least partially on medical history and other personal information, data protection may make this database difficult to obtain.

Appendix D: Data Source Matrix

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Agency	London Borough of Merton																			National Gov't	Greater London Authority		Ordnance Survey	Chamber of Commerce	CEN		Experian	PB Power
Department	Department of Environment and Regeneration												Comm. & Housing	Children, Schools & Families	Housing Strategy/Social Services	Corporate Services					Fire Brigade							Energy Services
Division	Building Control				Estates		GIS		Licensing	Waste Management	Health and Safety					Business Rates	Legal Dept.	Council Tax										
Process Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
PROCESS	Building Application	Building Plan	Notification from Trade Association	Notification from Approved Inspectors	Industrial Map	Council Property List	GIS Map	New Address Application	Business License	Duty of Care	OSRT Form	Inspections	Council Social Housing Database	Directory of Establishments	RSL Housing Stock Database	Business Directory	Lease Documents	Tax Database	Council Bills	Business Taxes	Inspections	Fire Certificate	Ordnance Survey	Business Directory	SAP survey	HECA survey	Database of Businesses	Hunt & Gather/ Field Work
Update frequency	c	c		m	c		3m	c					c	y	c			y	m	y								
Update Cost																£20,000												
UPRN	(7)	(7)		(7)		(7)	● (primary source)										⊙	⊙		⊙								
Address	O	⊙	O	O	O	O	●	⊙ (primary source)	O	⊙	O	O	O	O	O	O	O	O	O	O	O	O	● (grey)	O	⊙		O	O
Post Code	O		O	O	O	O	●	O	O	⊙	O	O	O	O	O	O	O	O	O	O	O	O	● (grey)	O	⊙		O	O
Date of Initial Construction	O												O		O													
Date of Latest Construction	O			O																								
Home Type	O	O		O									O		O			⊙		⊙					O	O		
# of Dwelling Units	O	O		O				⊙					O		O										O			
Footprint							●																					
# of Storeys	O	O									O				O			⊙		⊙		O			O	O		
Total Floor Area	O	O				O	▣											O		O		⊙			O	O		
# of Rooms	O	O											O		O										O	O		
# of Bedrooms	O	O		O											O										O	O		
Wall Material	O	O																							O	O		
Wall Type	O	O																							O	O		
Roof Material	O	O																							O	O		
Insulating Material	O	O													O										O	O		
Loft Insulation	O	O																							O	O		
Owner	O			O	O	O		O	O		O				O		O	O	O	O	O	O			⊙			O
Use	O			O	O	O		O	O		O		O	O	O	O	⊙	O		O	O	O		O	O	O	O	O
Number of Occupants															O			O										
Hot water storage	O																								O	O		
Heating System	O												O						O						O	O		
Boiler Installation Date	O		O										O													O		
Boiler Type	O		O																						O	O		
Heating Control																									O	O		
Double Glazing	O		O																						O	O		
Low Energy Lighting	O																									O		
Ave. Annual Heat Demand									▣							▣			O						O	O		O
Ave. Annual Elec. Supply																			O						O	O		O
Ave. Annual Elec. Demand									▣							▣			O						O	O		O
NOTES on SOURCES	Form is computerized, most info is data protected.	Stored on Microfilm and tracked by UPRN	In email form for specialist contractors (a year behind).	In electronic form for approved inspectors (up to date).	Only contains council owned industrial buildings. Includes Deed Packet number.	Does not contain all contact and UPRN data. Does not contain industrial, schools or housing.	Updated every 3 months with info from Ordnance survey.	8 weeks to process. GIS only has info on newaddresses. Other info in app. is forwarded to other	Businesses only. Licenses must be applied for by all businesses that serve alcohol. Energy Estimated from # of employees/	No Reply	Filed by non-industrial businesses. Only filed at initial opening. Never updated. Kept in Paper form.	We dont have any information on this.	Only includes council owned social housing. Drop down menus in spreadsheet.	This only includes information on the council owned school buildings, not privately owned. It is updated ever year.	Only RSL Owned Social Housing is included and some fields are not available for all entries. Constantly changing as new developments become homes, always in a little need updating	Not all businesses in Borough, only includes those that agree to participate. The number of employees only in paper format. Updated ad hoc.	Only includes information on council owned buildings at the time of lease.	Data Protected. We assume its updated every fiscal year.Includes housing, possibly	Do not know where exists or if accessible. Would have monthly updates if available	Does not include all businesses, only members of the chamber of commerce.	No longer are required to do inspections, business's responsibility. Only for businesses with 20 or more employees (or more than 10 above ground floor).		Updated when notified of development or when discovered while surveying.	Does not include all businesses, only members of the chamber of commerce.	WE DO NOT KNOW IF THEY KEE[P] RECORDS OF THIS. Only has information on fuel poverty homes.		The information would have to be purchased each time.	Limited information
CONTACT Name Title Extension	Alec Johnson Prop Build Ctrl x3130		Trevor McIntosh Build Ctrl Mgr x3121		Brian Fraser Estates Surveyor x3082	Tony Skilbeck Prop. Liaison Mgr x4176	Mick Bird GIS x3849	Darryl James Admin Asst x3507	Zola Adeghoyega Senior Admin. & Finance Officer x3969	Ian Hosking EGE Mgr x4779	Ian Murrell Comm. & Trading Stds Mgr. x3659		Liz Back Asst Management Officer x4567	Valerie Higgins Premises Mgr x3306	Cecily Herdman Strategy Officer x3049	Simon Bashford Research & Project Officer X3231								Caroline Cook Caroline.Cook@Mertonchamber.co.uk	Naomi Baker 020-8683-6615 Naomi@CEN.org.uk			Alastair Robinson RobinsonA@pbworld.com
Input/Data Entry	DA/I	SC/I	PF/I	DA/I	MA/I	MS/I	GIS	DA/I			PF/I		MS/I	MS/I	MS/I	MS/E							GPS/E					MS/E
Archival	SQL	MF	P	SQL	MP	XL	MG	E			P		XL	XL	XL	P							MG					E
See Appendix			E	D							G																	

LEGEND: ● (grey) Inaccessible; ● Accessible; O Partial; ⊙ Unsure if Info Exists; ▣ Proxy attribute; (green) Primary source

NOTES and EXPLANATIONS

Reliable (green shading); Sporadic/ Ad hoc (orange shading); Grey=Inaccessible, Black=Accessible; **Bold= Complete Source**; *Italic= Partial Source*

Update frequency: **d**(aily), **w**(eekly), **m**(onthly), **y**(early), **c**(ontinuously)

£20,000

Input Instrument:
Paper Form, Web Form, Scanner/Camera, Map Annotation, GPS, GIS Application (Standalone), Web-GIS Application, Data-only Application, MS Office

Data Entry Responsibility:
Internal (staff), External (others)

Archival Medium:
Paper, Electronic document;
SQL, ACcess, DataBase (proprietary), eXceL, MVM;
DraWings (paper), CAD drawings, GIS;
IMage, MicroFilm;
Map (Paper), Map GIS,
OTher

Agency	London Borough of Merton															National Gov't	Greater London Authority		Ordnance Survey	Chamber of Commerce	Experion
Department	Department of Environment and Regeneration												Corporate Services				Fire Brigade				
Division	Building Control				Estates		GIS		Licensing	Waste Management	Health and Safety		Business Rates	Legal Dept	Council Tax						
Process Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
PROCESS	Building Application	Building Plan	*Notification from Approved Inspectors*	Notification from Trade Association	*Industrial Map*	*Council Property List*	**GIS Map**	New Address Application	Business License	Duty of Care	OSR1 Form	Inspections	*Business Directory*	Lease Documents	**Tax Database**	Business Taxes	Inspections	Fire Certificate	**Ordnance Survey**	*Business Directory*	Database of Businesses
Update frequency	c	c		m	c		3m	c							y	y			3m		
Update Cost																					
ATTRIBUTES																					
UPRN	(7)	(7)	(7)			(7)	● (primary source)							⊙	⊙						
Address	○	⊙	**O**	○		**O**	●	○ (primary source)	○	⊙	○	○	**O**	○	○	○	○	○	● (grey)	○	○
Post Code	○		**O**	○		**O**	●	○	○	⊙	○	○	**O**	○	○	○	○	○	● (grey)	○	○
Owner	○			○	**O**	**O**		○	○	⊙	○			○	○	○	○	○			
Use	○		**O**		**O**	**O**		○	○	⊙	○		**O**	⊙	○	○	○	○		○	○
Business Type	○					**O**		○	○	⊙	○		**O**		⊙	○		○		○	○
Business Name	○					**O**		○	○	⊙	○		**O**	⊙	⊙	○	○	○		○	○
Number of Employees	○								⊙		○		**O**		⊙	○	⊙	○		○	○
Contact Info						**O**		○	○				**O**	○	○	○	○	○		○	○
NOTES on SOURCES	Form is Computerised, most is data protected	Stored on Microfilm and tracked by UPRN	Any information beyond the address, UPRN and postcode is available on a case by case basis	In Paper form and a year behind, attempting to purchase software to fix this problem.	Only council owned industrial buildings.	Does not contain all contact and UPRNdata	Updated with info from Ordnance Survey	8 weeks to process. GIS only has info on new addresses. Remaing info is forwarded to other depts.	Licenses must be applied for by all businesses that serve alcohol.	No Reply	Filed by non-industrial businesses. Only filed at initial opening. Kept in Paper form.	We dont have any information on this.	Voluntary. Not all businesses in Borough. Employees # only in paper format.	Only includes information on council owned buildings at the time of lease.	Data Protected	Must be requested through Freedom of Information Act	DEFUNCT No longer are required to do inspections, business's responsibility	DEFUNCT No longer are required to do inspections, business's responsibility	Updated when notified of development or when discovered while surveying.	Does not include all businesses	Would have to be purchased whenever the info was needed again.
CONTACT Name Title Extension	Alec Johnson Prcpl Build Ctrl x3130		Trevor McIntosh Build Ctrl Mgr x3121		Brian Fraser Estates Surveyor x3082	Tony Skilbeck Prop. Liason Mgr x4176	Mick Bird GIS x3849	Darryl James Admin Asst x3507	Zola Adegboyega Senior Admin. & Finance Officer x3969	Ian Hosking EQE Mgr x4779	Ian Murrell Comm. & Trading Stds Mgr. x3859		Simon Bashford Research & Project Officer x3231							Caroline Cook Caroline.Cook@Mertonchamber.co.uk	
Input/Data Entry	DA/I	SC/I	PF/I	DA/I	MA/I	MS/I	GIS	DA/I			PF/I		MS/E						GPS/E		
Archival	SQL	MF	P	SQL	MP	XL	MG	E			P		P						MG		
See Appendix			E	D							G										

NOTES and EXPLANATIONS

Process shading: Reliable / Sporadic/ Ad hoc

Grey=Inaccessible Black=Accessible

Bold= Complete Source

Italic= Partial Source

Update frequency: **d**(aily), **w**(eekly), **m**(onthly), **y**(early), **c**(ontinously)

Update Cost: £0

Input Instrument:
Paper **F**orm, **W**eb **F**orm, **S**canner/**C**amera, **M**ap **A**nnotation, **GIS** Application (Standalone), **W**eb-**GIS** Application, **D**ata-only **A**pplication, **MS** Office, **GPS**

Data Entry Responsibility:
Internal (staff), **E**xternal (others)

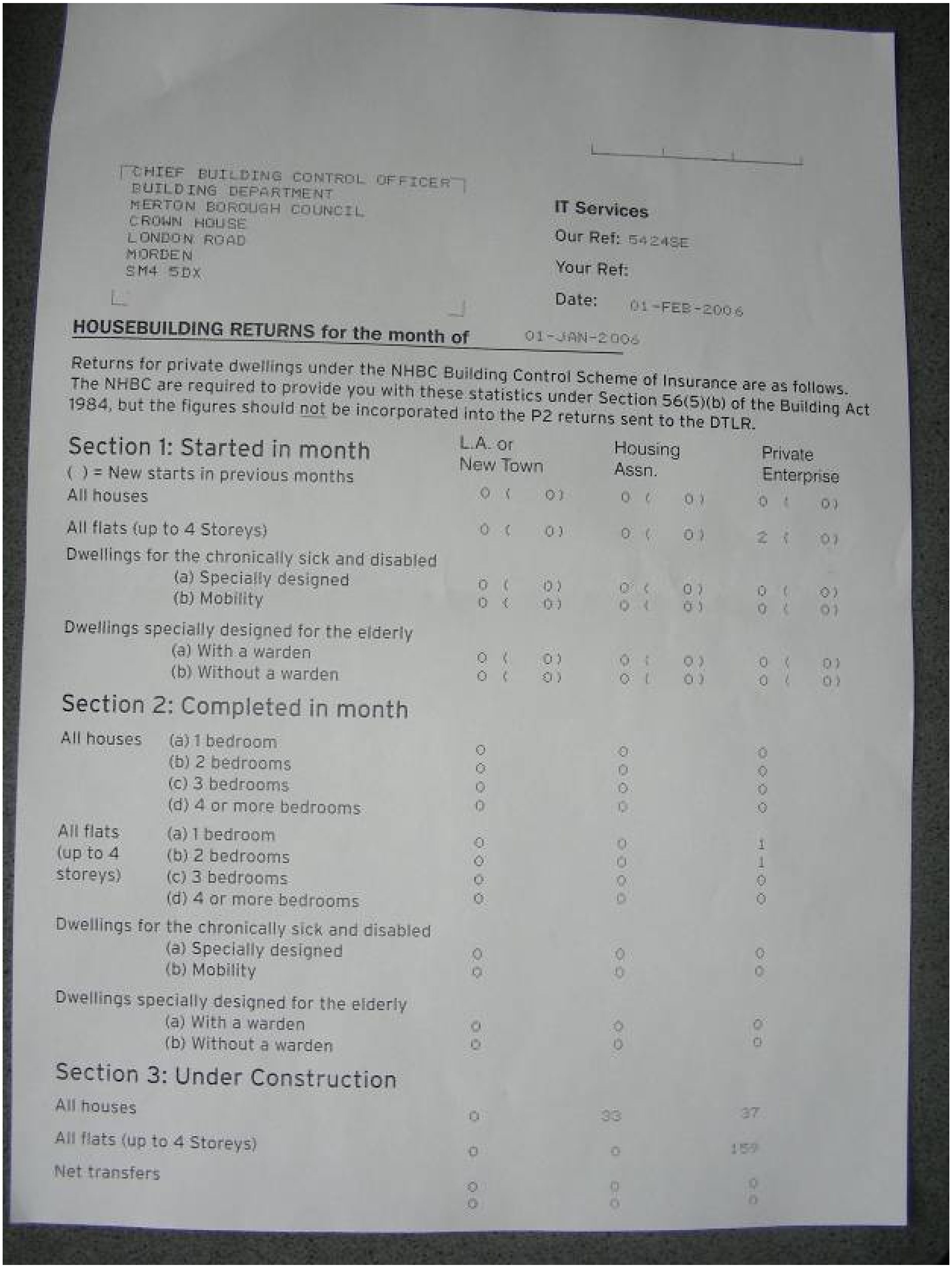
Archival Medium:
Paper, **E**lectronic document;
SQL, **AC**cess, **D**ata**B**ase (proprietary), e**X**ce**L**;
Dra**W**ings (paper), **CAD** drawings, **GIS**;
IMage, **M**icro**F**ilm;
Map (**P**aper), **M**ap **G**IS;
OTher

LEGEND											
● (grey)	Inaccessible	●	Accessible	**O**	Partial	⊙	Unsure if Exists	▣	Proxy	(green)	Primary source

Appendix E: Data Quality Ratings

	Agency	London Borough of Merton																			National Gov't	Greater London Authority		Ordnance Survey	Chamber of Commerce	CEN		Experion	Consultant-PB Power
	Department	Department of Environment and Regeneration													Comm. & Housing	Children, Schools & Families	Housing Strategy/Social Services	Corporate Services				Fire Brigade							Alastair Robinson
	Division	Building Control				Estates			GIS		Licensing	Waste Management	Health and Safety					Business Rates	Council Tax										
	Process Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
	PROCESS	Building Application	Building Plan	Notification from Trade Association	Notification from Approved Inspectors	Industrial Map	Council Property List	Lease Documents	GIS Map	New Address Application	Business License	Duty of Care	OSR1 Form	Inspections	Council Social Housing Database	Directory of Establishments	RSL Housing Stock Database	Business Directory	Tax Database	Council Bills	Business Taxes	Inspections	Fire Certificate	Ordnance Survey	Business Directory	SAP survey	HECA survey	Database of Businesses	Field work/Hunt and Gather
Digitalization	Text File	1		1	1		1		1						1	1	1	1									1		1
	Electronic Spreadsheet with Manual Digital Entry	1			1		1		1						1	1	1	1									1		1
	Obscure Electronic Database and Manual Digital Entry	1			1				1									1									1		
	Mainstream Electronic Database and Manual Digital Entry								1									1									1		
	SQL Database with electronic data submission. All referenced databases are also fully digital.								1																		1		
	Score: Digitalization	3	0	1	3	0	2	0	5	0	0	0	0	0	2	2	2	4	0	0	0	0	0	0	0	0	5	0	2
Organization	Standardized Data Formatting	1	1		1	1	1		1				1		1	1	1	1		1		1	1				1		1
	Level 1, and can be sorted/search automatically				1				1		2				1	1	1								1		1		
	Level 2, and Few Text Fields								1																		1		
	Level 3, and Standardized Primary Key								1																				
	Level 4, and Standardized With All Relevant Databases								1																				
	Score: Organization	1	1	0	2	1	1	0	5	0	2	0	1	0	2	2	2	1	0	1	0	1	1	0	1	0	3	0	1
Meta-Info	Author	1	1	1	1											1		1		1					1				1
	Contact Information, Date Updated	1			1											1				1					1				1
	Update Conditions/Frequency																			1									
	Degree of Completeness, and Databases Referenced																												
	Brief Description																												
	Score: Meta-Info	2	1	1	2	0	0	0	0	0	0	0	0	0	0	2	0	1	0	3	0	0	0	0	2	0	0	0	2
Updating	None. Data is Entered Once and Never Modified =1		1	1																									1
	Updated Intermittently =2					2	2											2							2				
	Updated Periodically =3				3				3							3				3		3	3						
	Updated Whenever Data is Available =4	4										4	4		4		4										4		
	Electronically Updated Whenever Data is Available =5																												
	Score: Updating	4	1	1	3	2	2	0	3	0	0	4	4	0	4	3	4	2	0	3	0	3	3	0	2	0	4	0	1
Sharing	Obtainable	1	1	1	1	1			1				1		1	1	1	1											1
	Shared on a Networked Drive															1		1											
	Indexed in Database of All Databases															1													
	Accompanied by Meta-Info															1													
	Tagged With Subject and Keywords																												
	Score: Sharing	1	1	1	1	1	0	0	1	0	0	0	1	0	1	4	1	2	0	0	0	0	0	0	0	0	0	0	1
	TOTAL SCORE	11	4	4	11	4	5	0	14	0	2	4	6	0	9	13	9	10	0	7	0	4	4	0	5	0	12	0	7

Appendix F: Approved Inspector Notification



CHIEF BUILDING CONTROL OFFICER
BUILDING DEPARTMENT
MERTON BOROUGH COUNCIL
CROWN HOUSE
LONDON ROAD
MORDEN
SM4 5DX

IT Services

Our Ref: 5424SE

Your Ref:

Date: 01-FEB-2006

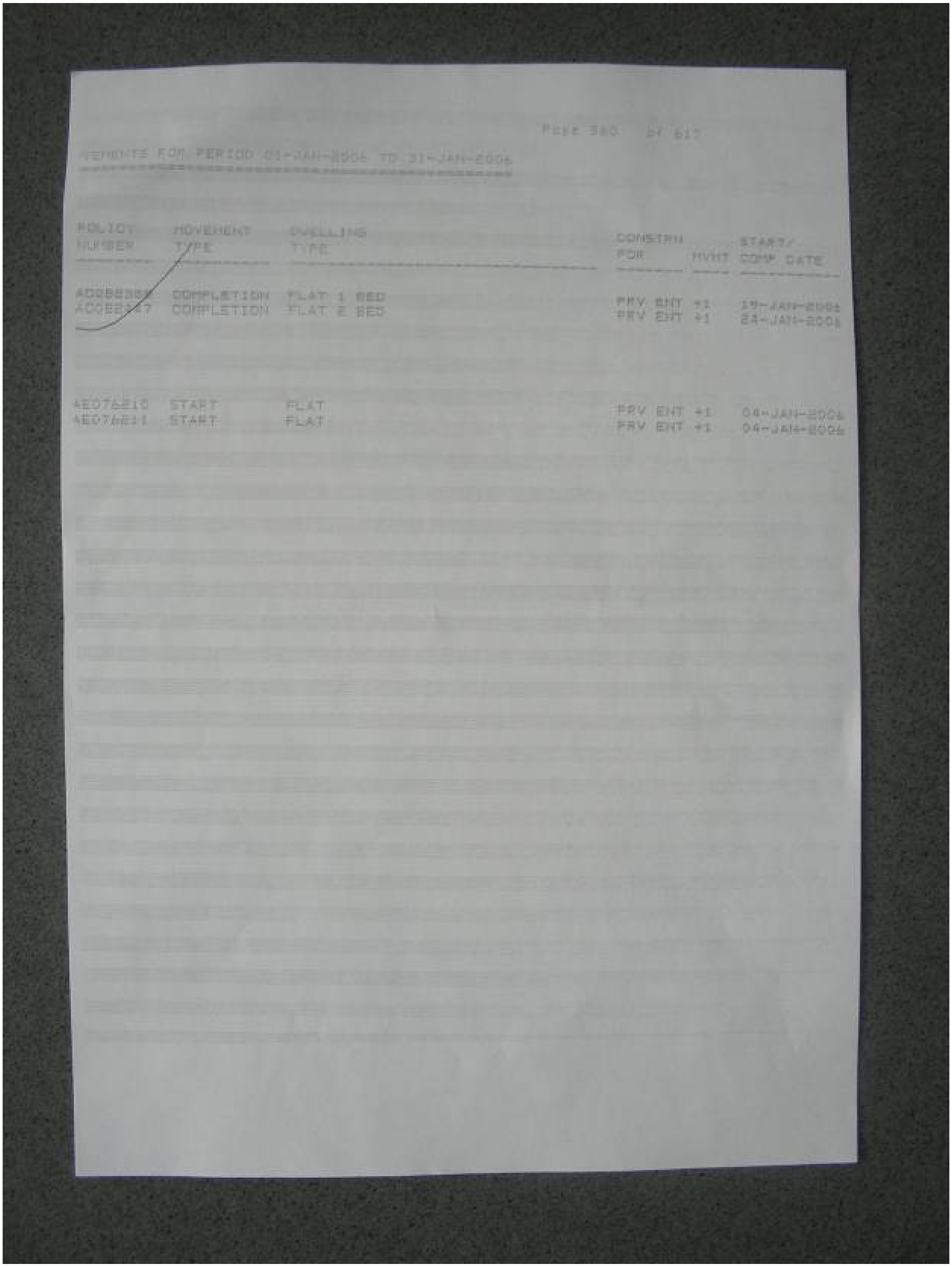
HOUSEBUILDING RETURNS for the month of 01-JAN-2006

Returns for private dwellings under the NHBC Building Control Scheme of Insurance are as follows. The NHBC are required to provide you with these statistics under Section 56(5)(b) of the Building Act 1984, but the figures should not be incorporated into the P2 returns sent to the DTLR.

Section 1: Started in month ( ) = New starts in previous months	L.A. or New Town	Housing Assn.	Private Enterprise
All houses	0 (0)	0 (0)	0 (0)
All flats (up to 4 Storeys)	0 (0)	0 (0)	2 (0)
Dwellings for the chronically sick and disabled			
(a) Specially designed	0 (0)	0 (0)	0 (0)
(b) Mobility	0 (0)	0 (0)	0 (0)
Dwellings specially designed for the elderly			
(a) With a warden	0 (0)	0 (0)	0 (0)
(b) Without a warden	0 (0)	0 (0)	0 (0)

Section 2: Completed in month		L.A. or New Town	Housing Assn.	Private Enterprise
All houses	(a) 1 bedroom	0	0	0
	(b) 2 bedrooms	0	0	0
	(c) 3 bedrooms	0	0	0
	(d) 4 or more bedrooms	0	0	0
All flats (up to 4 storeys)	(a) 1 bedroom	0	0	1
	(b) 2 bedrooms	0	0	1
	(c) 3 bedrooms	0	0	0
	(d) 4 or more bedrooms	0	0	0
Dwellings for the chronically sick and disabled	(a) Specially designed	0	0	0
	(b) Mobility	0	0	0
Dwellings specially designed for the elderly	(a) With a warden	0	0	0
	(b) Without a warden	0	0	0

Section 3: Under Construction	L.A. or New Town	Housing Assn.	Private Enterprise
All houses	0	33	37
All flats (up to 4 Storeys)	0	0	159
Net transfers	0 0	0 0	0 0



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...VEMENTS FOR PERIOD 01-JAN-2006 TO 31-JAN-2006

POLICY NUMBER	MOVEMENT TYPE	DWELLING TYPE	CONSTRN FOR	MVMT	START/ COMP DATE
AC0082388	COMPLETION	FLAT 1 BED	PRV ENT	+1	19-JAN-2006
AC0082[illegible]47	COMPLETION	FLAT 2 BED	PRV ENT	+1	24-JAN-2006
AE076210	START	FLAT	PRV ENT	+1	04-JAN-2006
AE076211	START	FLAT	PRV ENT	+1	04-JAN-2006

Appendix G: JHA Competent Persons Notification

FIRE ENGINEERING BUILDING CONTROL INCLUSIVE DESIGN SUSTAINABLE CONSTRUCTION TRAINING

jha ltd innovation

Unit 5, King's Eight
St. James's Road,
Brentwood, Essex, CM14 4LF

Tel : 01277 848553
Fax : 08704 603253
Mobile : 07899 962065
E-mail : jp@approvedinspector.com

To : **Building Control**
London Borough of Merton
Merton Civic Centre
London Road
Morden
Surrey SM4 5DX

17 FEB 2006

Date : **15th February 2006**

Re : **LDN/05/8329 – Loft Conversion & 2nd Floor Rear Extension to House at 13 Trevor Road, London, SW19 3PW**

Your Ref :

Dear Sir

I refer to our Initial Notice submitted in respect of the above works and am pleased to attach hereto our Final Certificate.

Yours Faithfully

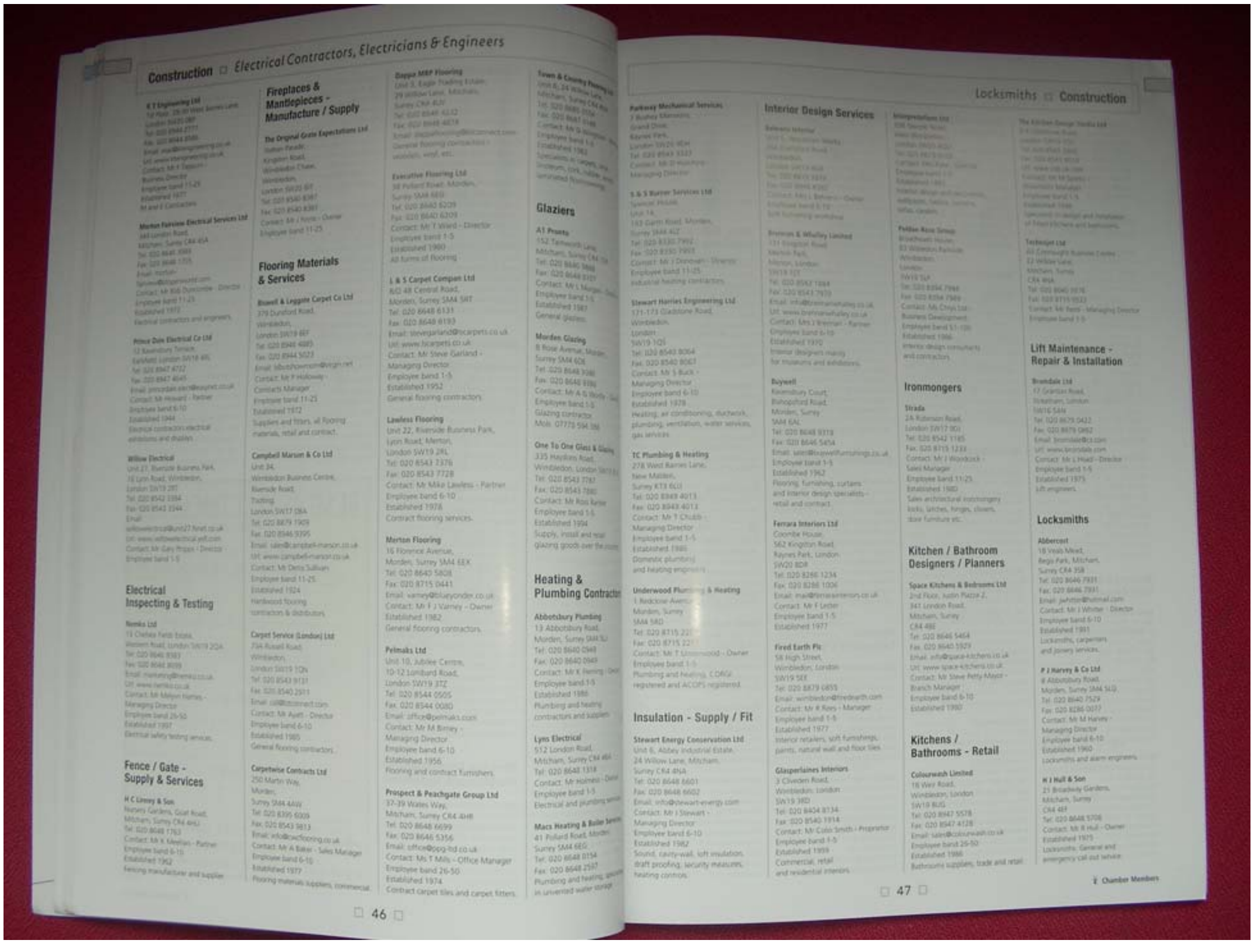
John Parish
Director – London & South East

www.approvedinspector.com
Registered Office jha ltd Whitecross Business Centre, Netherbury Dorset DT6 5NH
jha@approvedinspector.com VAT Reg No 730 3196 71 • Company Reg No 3980272

ISO 9001 Registered

RICS

Appendix H: Merton Business Directory



Construction □ Electrical Contractors, Electricians & Engineers

Fireplaces & Mantlepieces - Manufacture / Supply

Flooring Materials & Services

Electrical Inspecting & Testing

Fence / Gate - Supply & Services

Glaziers

Heating & Plumbing Contractors

□ 46 □

Locksmiths □ Construction

Interior Design Services

Insulation - Supply / Fit

Ironmongers

Kitchen / Bathroom Designers / Planners

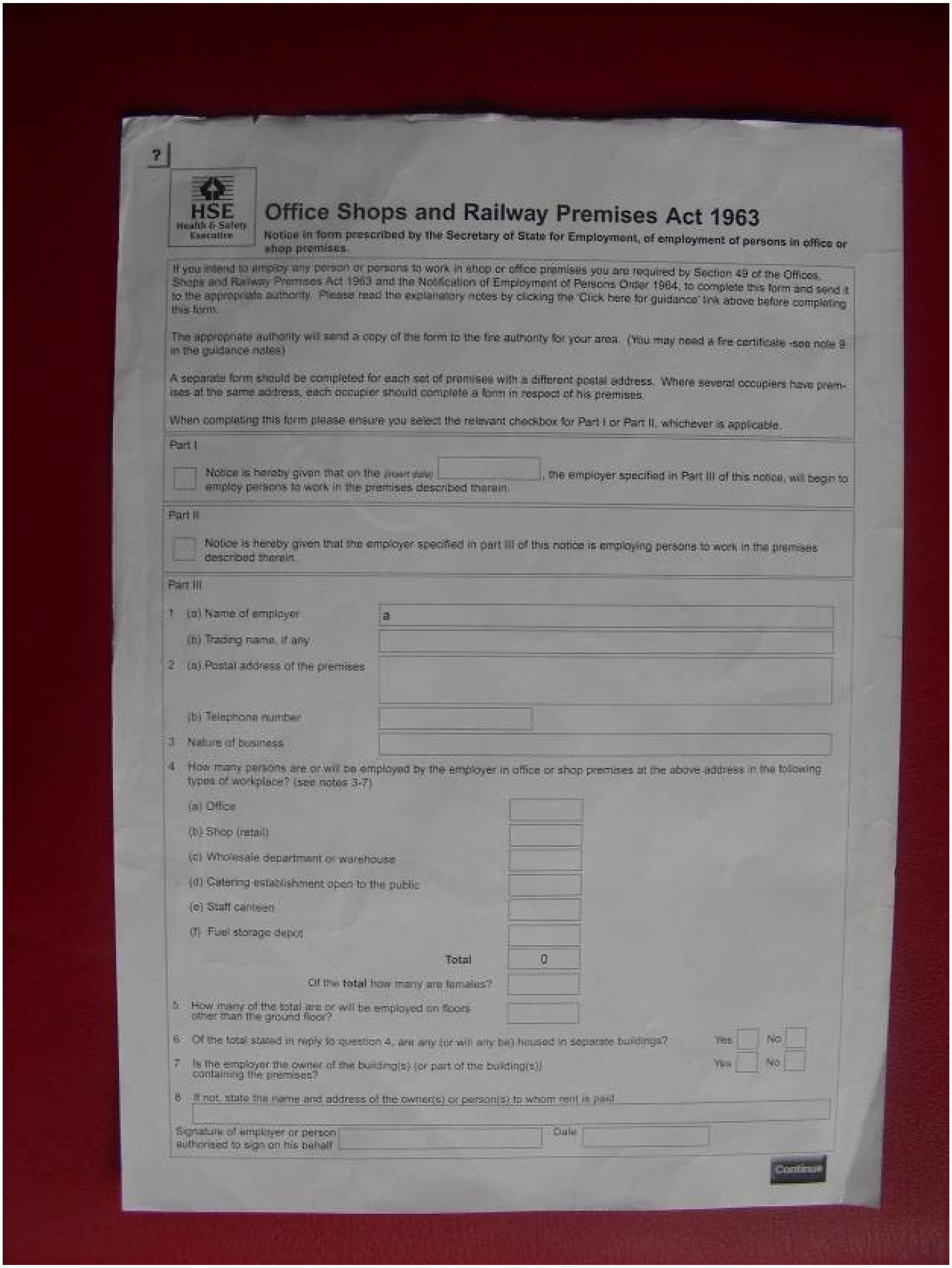
Kitchens / Bathrooms - Retail

Lift Maintenance - Repair & Installation

Locksmiths

□ 47 □

Appendix I: OSR1 Form


?

HSE
Health & Safety Executive

Office Shops and Railway Premises Act 1963

Notice in form prescribed by the Secretary of State for Employment, of employment of persons in office or shop premises.

If you intend to employ any person or persons to work in shop or office premises you are required by Section 49 of the Offices, Shops and Railway Premises Act 1963 and the Notification of Employment of Persons Order 1964, to complete this form and send it to the appropriate authority. Please read the explanatory notes by clicking the 'Click here for guidance' link above before completing this form.

The appropriate authority will send a copy of the form to the fire authority for your area. (You may need a fire certificate -see note 9 in the guidance notes)

A separate form should be completed for each set of premises with a different postal address. Where several occupiers have premises at the same address, each occupier should complete a form in respect of his premises.

When completing this form please ensure you select the relevant checkbox for Part I or Part II, whichever is applicable.

Part I

Notice is hereby given that on the (insert date) [ ], the employer specified in Part III of this notice, will begin to employ persons to work in the premises described therein.

Part II

Notice is hereby given that the employer specified in part III of this notice is employing persons to work in the premises described therein.

Part III

1 (a) Name of employer: a

(b) Trading name, if any

2 (a) Postal address of the premises

(b) Telephone number

3 Nature of business

4 How many persons are or will be employed by the employer in office or shop premises at the above address in the following types of workplace? (see notes 3-7)

(a) Office

(b) Shop (retail)

(c) Wholesale department or warehouse

(d) Catering establishment open to the public

(e) Staff canteen

(f) Fuel storage depot

Total 0

Of the **total** how many are females?

5 How many of the total are or will be employed on floors other than the ground floor?

6 Of the total stated in reply to question 4, are any (or will any be) housed in separate buildings? Yes No

7 Is the employer the owner of the building(s) (or part of the building(s)) containing the premises? Yes No

8 If not, state the name and address of the owner(s) or person(s) to whom rent is paid

Signature of employer or person authorised to sign on his behalf

Date

Continue

Appendix J: Energy Estimation Table

Energy Consumption and CO2 Emissions (Whole house energy use)

		Gas Central Heating			Electric Storage Heating (E7)	
Property Type	**Bedrooms**	**Gas (kWh/yr)**	**Electric (kWh/yr)**	**kgCO2/yr**	**Electric (kWh/yr)**	**kgCO2/yr**
Flat	1	9,878	2,008	2,740	9,616	4,135
Flat	2	14,155	2,487	3,759	13,427	5,774
Flat	3	20,453	3,432	5,362	19,281	8,291
Mid Terraced House	2	14,092	2,530	3,765	13,446	5,782
Mid Terraced House	3	17,562	3,044	4,646	16,670	7,168
End Terraced House	2	18,142	2,540	4,539	16,816	7,231
End Terraced House	3	22,640	3,056	5,616	20,896	8,985
Semi Detached Bunglalow	2	19,240	2,570	4,761	17,809	7,658
Semi Detached Bunglalow	3	22,350	2,903	5,495	20,622	8,867
Detached Bungalow	2	21,987	2,678	5,329	17,915	7,703
Detached Bungalow	3	25,526	3,042	6,158	20,740	8,918
Detached Bungalow	4	29,386	3,486	7,083	23,869	10,264
Semi-Detached House	2	22,080	2,981	5,477	20,426	8,783
Semi-Detached House	3	25,453	3,417	6,305	23,542	10,123
Semi-Detached House	4	29,106	3,941	7,225	26,969	11,597
Detached House	2	28,689	3,453	6,936	26,438	11,368
Detached House	3	33,082	4,024	8,016	30,545	13,134
Detached House	4	38,101	4,749	9,281	35,310	15,183

Energy consumption includes Space and Water heating, Cooking, Lighting and Appliances.
Energy use modelled using BREDEM-12 and assumes stock average dwelling Characteristics, standard heating pattern and occupancy.

Assume a carbon conversion factor of:-

Gas	0.19	kgCO2/kWh
Electricity	0.43	kgCO2/kWh

Source:- Guidelines for company reporting on greenhouse gas emissions, Defra

EST
7/26/2004

Appendix K: PB Power Associates Energy Data

Building name and description	Annual average heat demand	Annual average electrical demand	Number of dwellings	
	kWh p.a.	kWh p.a.		
Canons Leisure Centre	**1,552,271**	**778,849**	0	2,331,120
Nursing Home and Day Centre	*544,128*	**-**	0	544,128
Supermarket - Town Centre	*1,724,100*	*4,353,041*	0	6,077,141
Residential (Supermarket) - Town Centre	*2,616,000*	*1,650,000*	500	4,266,000
St Marks Primary School	**246,397**	**54,271**	0	300,668
Elm Nursery Estate	*1,974,426*	*792,000*	240	2,766,426
Glebe Estate	*2,229,050*	*762,300*	231	2,991,350
Sadlers Close Estate - Town Centre	*2,814,380*	*947,100*	287	3,761,480
Glebelands Retirement Home	*1,019,616*	*264,000*	80	1,283,616
Gas Works - Mixed Use Site	**-**	**-**	-	0
Peter and Paul's RC Primary School	**283,123**	**112,439**	0	395,562
The Vestry – Town Hall	**71,243**	**80,432**	0	151,675
Fire Station	*180,096*	**-**	0	180,096
Cricket Green School	**211,649**	**56,474**	0	268,123
Worsfold House	**227,336**	**130,609**	0	357,945
Melrose School	*271,560*	**-**	0	271,560
Baron Estate	*701,088*	*336,600*	102	1,037,688
Wilson Cottage Hospital	*6,284,800*	**-**	0	6,284,800
Cranmer Middle School	*454,425*	**-**	0	454,425
Jan Malinowski Centre	**629,833**	**94,000**	0	723,833
Mitcham Garden Village Retirement Home	*481,496*	**165,000**	50	646,496
Eastfields Estate	*3,960,188*	*702,900*	213	4,663,088
Mitcham Vale School (inc Youth Centre)	**1,296,669**	**1,040,882**	0	2,337,551
Laburnum Estate	*1,021,984*	*277,200*	84	1,299,184
EP Brenley	*654,000*	*396,000*	120	1,050,000
EP Rowan	*1,744,000*	*1,155,000*	350	2,899,000
TOTAL load supplied			**2257**	

Bold figures denote energy consumtion figures, italics denote those estimated using benchmarks / floor areas etc.

Appendix L: Council Structure

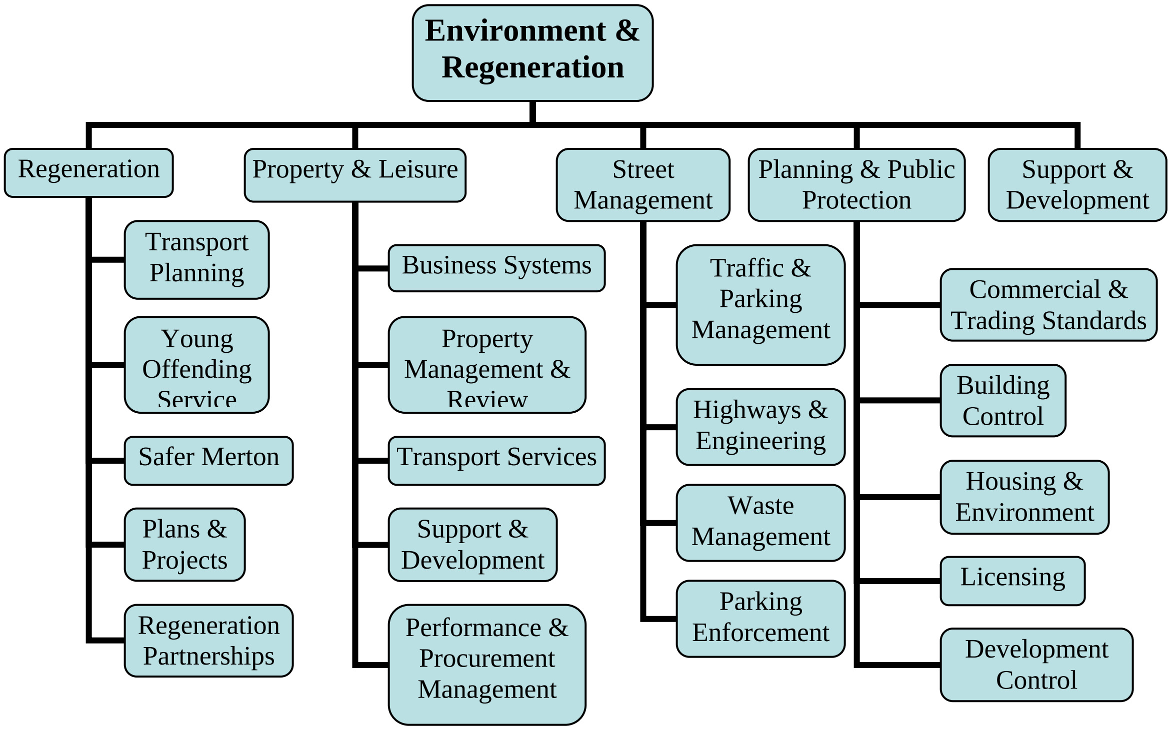


Figure 37 - Environment and Regeneration[76]

Environment and Regeneration is responsible for maintaining the health and safety of the borough, as well as planning new developments and monitoring what is built or demolished inside of Merton. Indeed, this department is handling planning and implementation of Merton's district heat and power system. Extremely diverse, Environment and Regeneration is further subdivided into divisions responsible for Regeneration, Property & Leisure, Street Management, Planning & Public Protection, and Support & Development.

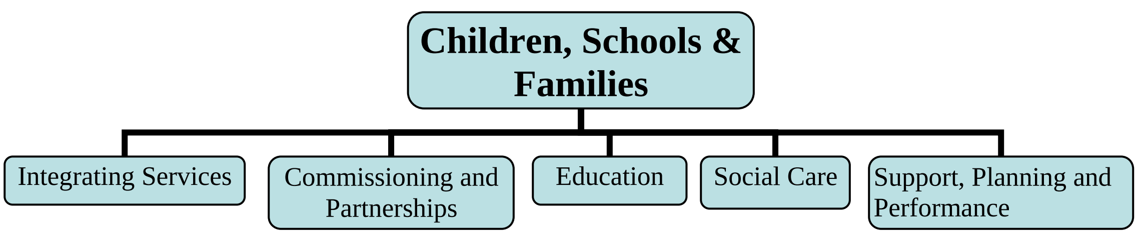


Figure 38 - Children, Schools, and Families[77]

Construction and maintenance of social housing, in addition to community events and intra-borough partnerships, is handled by the Department of Community and Housing. This

[76] Richardson et al.
[77] *idem*

department is divided into the Support, Planning, & Performance, Housing and Community Care, Strategy and Partnerships, and Libraries & Community Learning divisions.

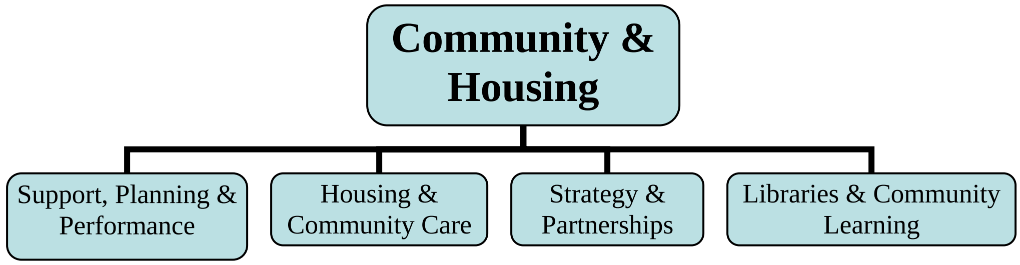


Figure 39- Community and Housing[78]

The final department devoted to the continued happiness and well-being of Merton's residents is Children, Schools, and Families. The Education, Integrating Services, Commissioning and Partnerships, Social Care, and Support, Planning & Performance divisions oversee almost all educational and social support facilities within the borough.

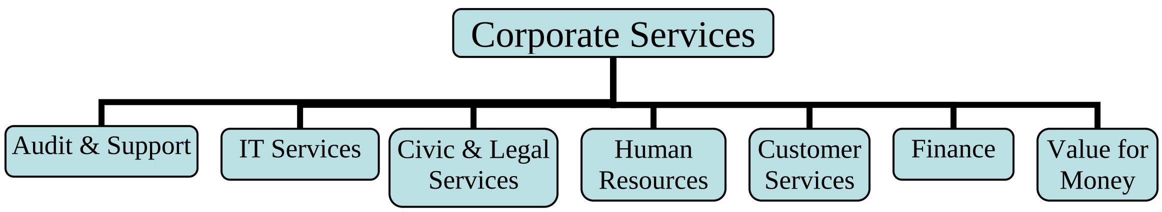


Figure 40 - Corporate Resources[79]

Corporate Services, rather than directly developing or maintaining borough structures, ensures that the Council can continue generating revenue, implementing its policy decisions, and operating as efficiently as possible.

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[78] *idem*
[79] *idem*

Appendix M: Standard Assessment Procedure Criteria

Dwelling Dimensions

Dwelling dimensions are determined in section 1 of the SAP worksheet. The volume of a story is calculated from the square meters of floor space multiplied by the average room height. This process is repeated for each of the dwelling's stories, including livable attic space and heated basements. (The attic is not considered in the calculation just because the insulation of the pitched roof is in the rafters, instead of the ceiling; there must actually be a habitable room in the space.)[80]

Ventilation Rate

In section 2, the ventilation rate is determined based on several factors: the draught-stripping of doors and windows, the number of chimneys and flues, the number of fans and passive and mechanical vents, the number of sheltered sides, and the presence of a draught lobby. The chimneys and their flues should only be considered if they can be utilized and are open, therefore balanced flues and fan-assisted flues (commonly used by gas boilers and wall mounted heaters) should not be counted. Fans that are included are extract fans, such as a cooking hood or bathroom fan. The assessment of passive vents for the worksheet only includes the number of extract grilles (not the trickle vents or air bricks). Mechanical vents provide fresh air to the system as well as exhausts air from the home. The draught lobby is a vestibule located at the main entrance of the residence, an unheated porch cannot be considered a draught lobby, and if the entrance provides access to other areas of the home it is not counted. When determining whether or not a side is sheltered the following three criteria must be met: the obstacle providing the shelter must be at least as tall as the highest storey of the building, the distance between the obstacle and the building must be less than five feet, and the width of the obstacle(s) "is such that it subtends an angle of at least 60° within the central 90° when viewed from the middle of the wall of the dwelling that faces the obstacle." Figure 41 shows this relationship.

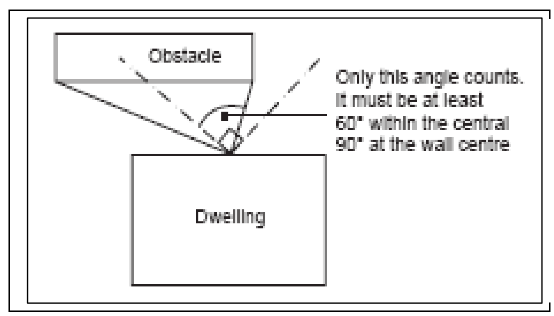

Figure 41 - Sample SAP efficiency lookup table

Heat Losses

The area of doors and windows, in addition to the thermal conductivity of building materials, are used to establish the heat loss of the structure. The area of the walls and roof is determined by subtracting the area of the door and window frames from net area. Once these areas and construction materials have been determined the U-values of the roof, walls and floors should be calculated using the BS EN ISO 6946 standard, which contains thermal conductivity values for common building materials. If the structure is unheated the following equation and variables in Figure 42 are used to determine the U-value.

[80] "The Government's Standard Assessment Procedure", 8-9

For rooms in the attic, garages and conservatories the SAP has several tables that give the U-values. These U-values are then used in the SAP worksheet in conjunction with the calculated areas to determine the heat losses.[81]

$$U = \frac{1}{\frac{1}{U_o} + R_u}$$

U – resultant U-value of element adjacent to unheated space, W/m^2K

U_o – U-value of the element between heated and unheated spaces calculated as if there were no unheated space adjacent to the element, W/m^2K

R_u – effective thermal resistance of unheated space from the appropriate table below, m^2K/W

Figure 42 - SAP Heat Loss Equation

Water heating

The value of water heating is dependent upon the type of boiler (instantaneous water heater versus stored hot-water systems) and its insulation. An instantaneous water heater only heats water when it is necessary, whereas a stored hot-water system does just that, it stores the heated water in a thermal tank. For instantaneous water heaters losses are considered to be zero. For stored hot water system's losses are obtained from Table 2 in the SAP. The losses attributable to boiler systems are available in Table 3. Finally the losses from community heating are accessible in Table 4.[82]

Internal Gains

Internal gain levels are based on floor area and result from the lights, appliances, cooking and occupants. To determine the internal gains, the data in Table 5 of the SAP must be interpolated or the formula following Table 5 must be used. When calculating the gains, the gains from the central heating pumps and the fans of the dwelling's mechanical ventilation system should be included, however, the gains from extractor fans are not considered.[83]

Solar Gains

The shading and shelter of the building affects the solar gains, as well as the type and area of glazing and window area. Only window openings are considered when determining solar gains, however French windows are treated like doors because they have glazing of less than 50%, and as a result are not included in the calculations.[84]

Mean Internal Temperature

The mean internal temperature is calculated based on the average household's heating requirements. It also takes the insulation and ability to control temperature into account. The average temperature of the living area is obtained from Table 8 of the SAP using the "heat loss parameter" (obtained in box 38 of the worksheet) and the "Heating type" column in Table 4. This value is adjusted based on control options and the heat gains calculated in section 3 of the worksheet.[85]

Degree Days

The degree days are arrived at by an adjustment of the mean internal temperature using the estimated gains (solar and internal), this adjustment is the "base" temperature. Table 10 is used to determine the Degree Days for any given base temperature (if the value is intermediate then linear interpolation is necessary).[86]

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81 *ibid, 10-12*
82 *ibid, 12*
83 *ibid*, 13
84 *idem*
85 "The Government's Standard Assessment Procedure", 13
86 *idem*

Space Heating

The space heating requirement is calculated from the degree days and the specific heat loss. It assumes that the structure has a system capable of heating the entire building. The heating system's efficiency and controls also are considered when determining requirements. The efficiency of the boiler can be obtained from one of the following three sources: the Government's Energy Efficiency Best Practice Programme Boiler Efficiency Database (this source is recommended), certified manufacturer's data or Table 4b of the Standard Assessment Procedure. The method of temperature control is generally one of the following: room thermostat, time switch, programmer, programmable room thermostat, delayed-start thermostat, thermostatic-radiator valve, cylinder thermostat, flow switch, or boiler interlock. In Table 4 the energy efficiency reduction due to each of these controls is given. From this information the quantity of fuel or electric energy required to meet the demand is estimated.[87]

Fuel Costs

Finally, fuel costs are determined based on the system's fuel, price of that fuel and the associated CO_2 emission. There are four systems that the SAP considers that require fuel, the main system, the secondary system, water-heating, and electricity for pumps and fans. There are 3 main fuel types of the main system: gas, electric or solid-fuel. Using this information the cost of fuel is estimated in section 10.[88]

[87] *ibid*, 13-15
[88] *ibid*, 15-16

Appendix N: Field Form

SAP WORKSHEET (Version 9.70)

1. Overall dwelling dimensions

	Area (m²)			Average room height (m)		Volume (m³)	
Ground floor	[ ]	(1a)	×	[ ]	=	[ ]	(1b)
First floor	[ ]	(2a)	×	[ ]	=	[ ]	(2b)
Second floor	[ ]	(3a)	×	[ ]	=	[ ]	(3b)
Third and other floors	[ ]	(4a)	×	[ ]	=	[ ]	(4b)
Total floor area (1a) + (2a) + (3a) + (4a) =	[ ]	(5)					
Dwelling volume	(1b) + (2b) + (3b) + (4b)				=	[ ]	(6)

2. Ventilation rate

			m³ per hour			Air changes per hour	
Number of chimneys	[ ]	× 40 =	[ ]	(7)			
Number of flues	[ ]	× 20 =	[ ]	(8)			
Number of fans and passive vents	[ ]	× 10 =	[ ]	(9)			
Other			[ ]	(9a)			
Infiltration due to chimneys, fans and flues	= (7) + (8) + (9) + (9a) =		[ ]	÷ (6)	=	[ ]	(10)

(Add 40 in box (9a) for each flueless gas fire if present)
If a pressurisation test has been carried out, proceed to box (19)

Number of storeys		[ ]	(11)		
Additional infiltration		[(11) – 1] × 0.1	=	[ ]	(12)
Structural infiltration: *0.25 for steel or timber frame or 0.35 for masonry construction*				[ ]	(13)
If suspended wooden floor, *enter 0.2 (unsealed) or 0.1 (sealed),* else enter 0				[ ]	(14)
If no draught lobby, enter 0.05, else enter 0				[ ]	(15)
Percentage of windows and doors draughtstripped *Enter 100 in box (16) for new dwellings that are to comply with Building Regulations*		[ ]	(16)		
Window infiltration	0.25 – [0.2 × (16) ÷ 100]		=	[ ]	(17)
Infiltration rate	(10) + (12) + (13) + (14) + (15) + (17)		=	[ ]	(18)
If pressurisation test done, then [measured q_{50} ÷ 20] + (10), otherwise (19) = (18)				[ ]	(19)
Number of sides on which sheltered *(Enter 2 in box (20) for new dwellings where location is not shown)*		[ ]	(20)		
Shelter factor	1 – [0.075 × (20)] =	[ ]	(21)		
If mechanical ventilation with heat recovery, effective air change rate *(If no heat recovery, add 0.33 air changes per hour to value in box (22))*	= [(19) × (21)] + 0.17		=	[ ]	(22)
If natural ventilation, then air change rate	= (19) × (21)		=	[ ]	(23)
	if (23) ≥ 1, then (24) = (23)				
	otherwise (24) = 0.5 + [(23)² × 0.5]		=	[ ]	(24)
Effective air change rate – enter (22) or (24) in box (25)				[ ]	(25)

20

3. Heat losses and heat loss parameters

ELEMENT		Area (m^2)		U-value (W/m^2K)		A × U	
Doors			×		=		(26)
Windows (type 1)*	0.9 ×		×		=		(27)
Windows (type 2)*	0.9 ×		×		=		(28)
Rooflights*	0.9 ×		×		=		(29)
Ground floor			×		=		(30)
Walls (type 1) *excluding windows and doors*			×		=		(31)
Walls (type 2) *excluding windows and doors*			×		=		(32)
Roof (type 1) *excluding rooflights*			×		=		(33)
Roof (type 2) *excluding rooflights*			×		=		(34)
Other			×		=		(35)

**the factor 0.9 takes into account the normal use of curtains*

Ventilation heat loss	= (25) × 0.33 × (6)	=		(36)
Heat loss coefficient, W/K	= (26) + (27) + ... + (35) + (36)	=		(37)
Heat loss parameter (HLP), W/m^2K	= (37) ÷ (5)	=		(38)

4. Water-heating energy requirements

GJ/year

Hot water energy requirement (Table 1, column (a)) (39)

Distribution loss (Table 1, column (b)), however (40)
If instantaneous water heating at point of use, enter '0' in boxes (40) to (43) and (48)
For community heating use Table 1(b) whether or not hot water tank present

Water storage volume (litres) (41)
If no stored water (this includes instantaneous combi boilers) enter '0' in box (41)
If heated by community heating and no tank, enter 110 litres in box (41)

Volume factor (from Table 2a) (41a)

Water storage loss factor (Table 2), however (42)
If community heating and no tank, enter 0.0079

Energy lost from hot water storage, GJ/year (41) × (41a) × (42) = (43)

Area of solar panel, m^2 (44)
If no solar panel, enter '0' in boxes (44) to (47) and go to (48)

Solar energy available = 1.3 × (44) = (45)

Load ratio = (39) ÷ (45) = (46)

Solar input = [(45) × (46)] ÷ [1 + (46)] = (47)

Primary circuit loss (Table 3) (48)

Output from water heater, GJ/year = (39) + (40) + (43) + (48) – (47) = (49)

Efficiency of water heater, % (50)
(Use value from Table 4a or 4b reduced by the amount shown in the 'efficiency adjustment' column of Table 4c where appropriate)

Energy required for water heating = [(49) × 100] ÷ (50) = (51)

Heat gains from water heating = [0.25 × (39)] + {0.8 × [(40) + (43) + (48)]} = (52)

5. Internal gains | | | Watts |

Lights, appliances, cooking and metabolic (Table 5)				(53)
Additional gains from Table 5				(53a)
Water heating	= 31.71 × (52)	=		(54)
Total internal gains	= (53) + (53a) + (54)	=		(55)

6. Solar gains

ORIENTATION	Access factor (Table 6a)		Area (m²)		Flux (Table 6)		Gains (W)	
North		×		×		=		(56)
North east		×		×		=		(57)
East		×		×		=		(58)
South east		×		×		=		(59)
South		×		×		=		(60)
South west		×		×		=		(61)
West		×		×		=		(62)
North west		×		×		=		(63)
Rooflights	1.3	×		×		=		(64)

Total solar gains	[(56) + ... + (64)]	=		(65)

Note: for new dwellings where overshading is not known, solar access factor is '1'

Total gains, W	(55) + (65)	=		(66)
Gain/loss ratio (GLR)	(66) ÷ (37)	=		(67)
Utilisation factor (use box (67) and Table 7)				(68)
Useful gains, W	(66) × (68)	=		(69)

7. Mean internal temperature | | | °C |

Mean internal temperature of the living area (Table 8)				(70)
Temperature adjustment from Table 4e, where appropriate				(71)
Adjustment for gains	= {[(69) ÷ (37)] − 4.0} × 0.2 × *R*	=		(72)

R is obtained from the 'responsiveness' column of Table 4a or Table 4d

Adjusted living room temperature	(70) + (71) + (72)	=		(73)
Temperature difference between zones (Table 9)				(74)
Living area fraction (0 to 1.0)	or living room area ÷ (5)	=		(75)
Rest-of-dwelling fraction	= 1 − (75)	=		(76)
Mean internal temperature	= (73) − [(74) × (76)]	=		(77)

8. Degree days

Temperature rise from gains	(69) ÷ (37)	=		(78)
Base temperature	(77) − (78)	=		(79)
Degree days (use box (79) and Table 10)		=		(80)

9. Space-heating requirement

			GJ/year	
Energy requirement (useful)	= 0.000 086 4 × (80) × (37)	=		(81)

Individual heating systems:

Note: when space and water heating is provided by community heating, use the alternative SAP worksheet (on next page) from this point

Fraction of heat from secondary system *(Use value from Table 11 or Appendix F)*				(82)
Efficiency of main heating system, % *(Use value from Table 4a or 4b, adjusted where appropriate by the amount shown in the 'efficiency adjustment' column of Table 4c.*				(83)
Efficiency of secondary heating system *(Use value obtained from Table 4a)*				(84)
Space-heating fuel (main)	[1 − (82)] × (81) × 100 ÷ (83)	=		(85)
Space-heating fuel (secondary)	[(82) × (81)] × 100 ÷ (84)	=		(86)
Electricity for:				
each central heating pump (Table 4f)				(87a)
each boiler with a fan-assisted flue (Table 4f)				(87b)
warm-air heating system fans, add	*0.002 GJ* × (6)	=		(87c)
dwellings with whole-house mechanical ventilation, add	*0.004 GJ* × (6)	=		(87d)
maintaining keep-hot facility for gas combi boiler (Table 4f)		=		(87e)
	(87a) + (87b) + (87c) + (87d) + (87e)	=		(87)

10. Fuel costs

	GJ/year	×	Fuel price (Table 12)	=	£/year	
Space heating – main system	(85)	×		=		(88)
Space heating – secondary system	(86)	×		=		(89)

Water heating

If off-peak electric water heating:

On-peak percentage (Table 13 *or Appendix F)*			(90)
Off-peak percentage	100 − (90) =		(91)

			Fuel price	=		
On-peak cost	[(51) × (90)] ÷ 100	×		=		(92)
Off-peak cost	[(51) × (91)] ÷ 100	×		=		(93)
Otherwise, water-heating costs	(51)	×		=		(94)
Pump and fan energy cost	(87)	×		=		(95)
Additional standing charges (Table 12, notes)						(96)
Total heating	(88) + (89) + (92) + (93) + (94) + (95) + (96)			=		(97)

11. SAP rating (conventional heating)

Energy cost deflator (Table 12, notes)			1.05	(98)
Energy cost factor (ECF)	= {[(97) × (98)] − 30.0} ÷ { (5) + 45.0}	=		(99)
SAP rating (Table 14)				(100)

Community heating

This page should be used when space and water heating is provided by community heating only with or without CHP or heat recovered from power stations. If CHP is not involved enter '0' in box (83) and '1.0' in box (84*).*

Overall system efficiency of the heating plant *(100% minus the amount shown in the 'efficiency adjustment' column of Table 4c where appropriate)*			[ ]	(82*)
Fraction of heat from CHP unit or fraction of heat recovered from power station *(from operational records or system design specification)*			[ ]	(83*)
Fraction of heat from boilers	1 – (83*)	=	[ ]	(84*)
Distribution loss factor (Table 12a)	[ ] (85*)			
			GJ/year	
Space heating from CHP or recovered, GJ/year	[(81) × (83*) × 100] ÷ (82*) × (85*)	=	[ ]	(86*)
Space heating from boilers, GJ/year	[(81) × (84*) × 100] ÷ (82*) × (85*)	=	[ ]	(87*)
Electricity for pumps and fans: enter '0', except *for dwellings with whole-house mechanical ventilation, enter 0.004 GJ × (6)*			[ ]	(88*)

10. Fuel costs

	GJ/year × **Fuel price** (Table 12)	=	**£/year**	
Space heating (CHP or from power stations). *Price from Table 12 is irrespective of fuel used by CHP*	(86*) × [ ]	=	[ ]	(89*)
Space heating (community boilers)	(87*) × [ ]	=	[ ]	(90*)

Water costs

	Fuel price	=		
Water heated by CHP or recovered	[(51) × (83*)] × [ ] × (85*)	=	[ ]	(91*)
Water heated by community boilers	[(51) × (84*)] × [ ] × (85*)	=	[ ]	(92*)

Water heated by immersion heater (if not heated by immersion heater, go to box (95*))

On-peak percentage (Table 13)		[ ] *(93*)*			
Off-peak percentage	*100 – (93*)*	[ ] *(93a*)*			
		Fuel price			
On-peak cost	*(51) × (93*) ÷ 100* ×	[ ]	=	[ ]	*(94*)*
Off-peak cost	*(51) × (93a*) ÷ 100* ×	[ ]	=	[ ]	*(94a*)*
Heating pump and/or fan energy cost	= (88*) ×	[ ]	=	[ ]	(95*)
Additional standing charges (Table 12)			=	[ ]	(96*)
Total heating	(89*) + (90*) + (91*) + (92*) + (94*) + (94a*) + (95*) + (96*)		=	[ ]	(97*)

11. SAP rating (community heating)

Energy cost deflator (Table 12)			[ ]	(98*)
Energy cost factor (ECF)	= {[(97*) × (98*)] – 30} ÷ {(5) + 45}	=	[ ]	(99*)
SAP rating (Table 14)			[ ]	(100*)

Carbon Index (CI) for individual and community heating without CHP

	Energy (GJ/year)		Emission factor (Table 15)		Annual emissions (kg/year)	
Water heating – from box (51) *if heated by community boilers [(51) × (85*) ÷ 0.75]*		×		=		(101)
Space heating, main – from box (85) *if heated by community boilers [(87*) ÷ 0.75]*		×		=		(102)
Space heating, secondary – from box (86) *if heated by community boilers, enter '0'*		×		=		(103)
Electricity for pumps and fans – from box (87) or (88*)		×		=		(104)
TOTAL CO_2 (space and water) kg/year	[(101) + (102) + (103) + (104)]			=		(105)
Carbon Factor (CF) = (105) ÷ [(5) + 45.0]				=		(106)
Carbon Index (CI), Table 16				=		(107)

Carbon Index (CI) for community heating schemes with CHP or heat recovered from power stations

(for community schemes that recover heat from power stations refer to C2 in Appendix C)

	GJ/year		Emission factor ($kgCO_2$ /GJ)		kg CO_2/year	
Electrical efficiency of CHP unit (eg 0.30) *from operational records or the CHP design specification*						(101*)
Heat efficiency of CHP unit (eg 0.50) *from operational records or the CHP design specification*						(102*)
CO_2 emission factor for the CHP fuel from Table 15			(103*)			
CO_2 emission factor for electricity (125 $kgCO_2$/GJ if CHP present)			125 (104*)			
CO_2 emitted by CHP per 1 GJ of generated electricity	*(103*)* ÷ *(101*)* =					(105*)
Heat to power ratio, *enter if known, otherwise*	*(102*)* ÷ *(101*)* =					(106*)
CO_2 emission factor for heat *[(105*) − (104*)] ÷ (106*), Note: the value in box (107*) can be negative.*						(107*)
Water heated by CHP or hot water from power stations *(51) × (83*) × (85*)*		×	box (107*)	=		(108*)
Water heated by boilers *(51) × (84*) × (85*) ÷ 0.80*		×	Table 15	=		(109*)
If water heated by immersion heater, box (51)		×	Table 15	=		(110*)
Space heating from (CHP) or waste heat, box (86*)		×	box (107*)	=		(111*)
Space heating from boilers, *(87*) ÷ 0.80*		×	Table 15	=		(112*)
Electricity for pumps and fans, box (88*) *(enter "0" in box (113*) if heat recovered from power station)*		×	Table 15	=		(113*)
TOTAL CO_2 (space and water) kg/year *(If negative enter "1" in box (114*))*	[(108*) + ... + (113*)]			=		(114*)
Carbon factor (CF)	[(114*) ÷ {(5) + 45.0}]			=		(115*)
Carbon index (CI), Table 16				=		(116*)

Table 1: Hot water energy requirements

Floor area (m^2)	a) Hot water usage (GJ/year)	b) Distribution loss (GJ/year)
30	4.13	0.73
40	4.66	0.82
50	5.16	0.91
60	5.68	1.00
70	6.17	1.09
80	6.65	1.17
90	7.11	1.26
100	7.57	1.34
110	8.01	1.41
120	8.44	1.49
130	8.86	1.56
140	9.26	1.63
150	9.65	1.70
160	10.03	1.77
170	10.40	1.84
180	10.75	1.90
190	11.10	1.96
200	11.43	2.02
210	11.74	2.07
220	12.05	2.13
230	12.34	2.18
240	12.62	2.23
250	12.89	2.27
260	13.15	2.32
270	13.39	2.36
280	13.62	2.40
290	13.84	2.44
300	14.04	2.48

Alternatively, the hot water usage and the distribution loss may be calculated from the total floor area of the dwelling (TFA), using the following steps:

a. Calculate $N = 0.035 \times TFA - 0.000\,038 \times TFA^2$, if TFA ≤ 420
$= 8.0$ if TFA > 420

b. Hot water usage = $[(61 \times N) + 92] \times 0.85 \div 31.71$

c. Distribution loss = $[(61 \times N) + 92] \times 0.15 \div 31.71$

Table 2: Hot water storage loss factor (GJ/year/litre)

Insulation thickness (mm)	Cylinder		Storage combination boiler*		Thermal store and CPSU	
	Factory insulated	Loose jacket	Primary store	Secondary store	Hot-water-only thermal store	Integrated thermal store or CPSU
None	0.0945	0.0945	0.1417	0.0945	0.1417	n/a
12.5	0.0315	0.0725	0.0473	0.0315	0.0473	n/a
25	0.0158	0.0504	0.0236	0.0158	0.0236	n/a
38	0.0104	0.0332	0.0156	0.0104	0.0156	0.0290
50	0.0079	0.0252	0.0118	0.0079	0.0118	0.0221
80	0.0049	0.0158	0.0074	0.0049	0.0074	0.0138
100	0.0039	0.0126	0.0059	0.0039	0.0059	0.0110
150	0.0026	0.0084	0.0039	0.0026	0.0039	0.0074

* If efficiency source is SEDBUK value.

This is multiplied in the worksheet by the cylinder, thermal store or CPSU volume in litres to obtain the loss rate. These data apply to cylinders and thermal stores heated by gas, oil and solid-fuel boilers, and to cylinders heated by electric immersion.

Multiply by a factor of 1.3 if a cylinder thermostat is absent.

In the case of a combination boiler:
a) the storage loss factor is zero if the efficiency is taken from Table 4b
b) the storage loss factor is zero for non-storage combi boilers, including those with keep-hot facility (see notes to Table 3 for the definition of keep-hot facility)
c) the loss is to be added for a storage combination boiler if its efficiency is the manufacturers' declared value or is obtained from the Boiler Database (in which case its insulation thickness and volume are also to be provided by the manufacturer or obtained by the Database).

In the case of electric CPSUs, for the off-peak electric tariffs providing at least 10 hours of heating per day, the water storage loss factor is 0.029 GJ/year/litre (to be entered in box 42).

Alternatively the heat loss factor, L, may be calculated for insulation thickness of t mm as follows:

- Uninsulated cylinder: $L = 0.0945$
- Cylinder, loose jacket: $t < 25$ mm: $L = 0.0945 - 0.00176t$
- Cylinder, loose jacket: $t \geq 25$ mm: $L = 1.26/t$
- Cylinder, factory-insulated: $t < 10$ mm: $L = 0.0945 - 0.0055t$
- Cylinder, factory-insulated: $t \geq 10$ mm: $L = 0.394/t$
- Cylinder, 10-hour off-peak electricity tariff: value for cylinder times 1.5
- Storage combination boiler, primary store: value for factory-insulated cylinder times 1.5
- Storage combination boiler secondary store: value for factory-insulated cylinder
- Hot-water-only thermal store: value for factory-insulated cylinder times 1.5
- Hot-water-only thermal store not in airing cupboard: value for factory-insulated cylinder times 2.1
- Integrated thermal store or CPSU in airing cupboard: value for factory-insulated cylinder times 2.8
- Integrated thermal store or CPSU not in airing cupboard: value for factory-insulated cylinder times 3.92

Table 2a: Volume factor

When using the data in Table 2, the loss is to be multiplied by a volume factor.

Volume	Volume Factor
40	1.442
60	1.259
80	1.145
100	1.063
120	1.000
140	0.950
160	0.908
180	0.874
200	0.843
220	0.817
240	0.794
260	0.773
280	0.754

Alternatively, the volume factor can be calculated using the equation $VF = (120 / V)^{1/3}$. Where: VF - volume factor; V - volume, litres.

Table 3: Primary circuit and keep-hot losses (GJ/year)

System type	GJ/year
Electric immersion heater	0.0
Boiler with uninsulated primary* pipework and no cylinder thermostat	4.4
Boiler with insulated primary pipework and no cylinder thermostat	2.2
Boiler with uninsulated primary pipework and with cylinder thermostat	2.2
Boiler with insulated primary pipework and with cylinder thermostat	1.3
CPSU (including electric CPSU)	0.0
Boiler and thermal store within a single casing (cylinder thermostat present).	0.0
Separate boiler and thermal store connected by no more than 1.5 m of insulated pipework.	0.0
Separate boiler and thermal store connected by	
– uninsulated primary pipe work	1.7
– more than 1.5 m of insulated primary pipe work	1.0
Additional losses for instantaneous combi boilers	
– without keep-hot facility**	0.8
– with keep-hot facility, controlled by time clock	0.8
– with keep-hot facility, not controlled by time clock***	2.0
Community heating	1.3

* *'Primary pipework' means the pipes between a boiler and a hot water tank; 'secondary pipeworks' – between a cylinder and a tap.*

** *'Keep-hot facility' is defined in Appendix D. If the store is 15 litres or more, the boiler is a storage combination boiler. The facility to keep water hot may have an on/off switch for the user, and may be controlled by a time switch.*

In the SAP worksheet:

1) *If the keep-hot facility is maintained hot solely by burning fuel, use an appropriate loss for combi boiler from the above table and proceed with the worksheet calculation as normal.*
2) *If the keep-hot facility is maintained by electricity, use the following approach:*
   a) include appropriate primary circuit losses in box (48)
   b) calculate energy required for water heating
   $\{(49) - (48)\} \times 100 \div (50)$ and enter in box (51).

*** *In the case of an untimed electrically powered keep-hot facility where the power rating of the keep-hot heater is obtained from the Boiler Efficiency database, the loss should be taken as:*

Loss = $0.032 \times P$ (GJ/year)

where: P is the power rating in Watts

Table 4a: Heating system seasonal efficiency (space and water)

1. *This table shows space heating efficiency. The same efficiency applies for water heating when hot water is supplied from a boiler system.*
2. *For independent water heaters see section at the end of the table.*
3. *'Heating type' refers to the appropriate column in Table 8.*
4. *Responsiveness (R) is used in worksheet calculation, box (72).*

	Efficiency %	Heating type	R
CENTRAL HEATING SYSTEMS WITH RADIATORS OR UNDERFLOOR HEATING			
a. Refer to Group 1 in Table 4e for control options			
b. Check Table 4c for efficiency adjustment due to controls			
Gas boilers and oil boilers			
For efficiency, use boiler database; otherwise use manufacturer's declared value (SEDBUK) if possible, otherwise use efficiency value from Table 4b.			
Obtain the heating type and responsiveness from Table 4d.			
Solid-fuel boilers			
Manual feed (in heated space)	60	2	0.75
Manual feed (in unheated space)	55	2	0.75
Autofeed (in heated space)	65	2	0.75
Autofeed (in unheated space)	60	2	0.75
Open fire with back boiler to rads	55	3	0.50
Closed fire with back boiler to rads	65	3	0.50
Electric boilers			
Dry-core boiler in heated space	100	2	0.75
Dry-core boiler in unheated space	85	2	0.75
Water storage boiler in heated space	100	2	0.75
Water storage boiler in unheated space	85	2	0.75
Electric CPSU in heated space	100	2	0.75
Direct-acting electric boiler	100	1	1.0
Heat pumps *(see also warm air systems)*			
Ground-to-water heat pump	320	From Table 4d	
Ground-to-water heat pump with auxiliary heater	300	From Table 4d	
Water-to-water heat pump	300	From Table 4d	
Air-to-water heat pump	250	From Table 4d	
COMMUNITY HEATING SCHEMES	100	1	1.0
a. Refer to Group 2 in Table 4e for control options			
b. Check Table 4c for efficiency and adjustment due to controls			

	Efficiency %	Heating type	R
STORAGE RADIATOR SYSTEMS			
Refer to Group 3 in Table 4e for control options			
Off-peak tariff:			
Old (large volume) storage heaters	100	5	0.0
Modern (slimline) storage heaters	100	4	0.25
Convector storage heaters	100	4	0.25
Fan storage heaters	100	3	0.5
Electric underfloor heating	100	5	0.0
Modern (slimline) storage heaters with CELECT-type control	100	3	0.5
Convector storage heaters with CELECT-type control	100	3	0.5
Fan storage heaters with CELECT-type control	100	2	0.75
24-hour heating tariff:			
Modern (slimline) storage heaters	100	3	0.50
Convector storage heaters	100	3	0.50
Fan storage heaters	100	3	0.50
Modern (slimline) storage heaters with CELECT-type control	100	2	0.75
Convector storage heaters with CELECT-type control	100	2	0.75
Fan storage heaters with CELECT-type control	100	2	0.75
WARM-AIR SYSTEMS			
Refer to Group 4 in Table 4e for control options			
Gas-fired warm-air with fan-assisted flue			
Ducted, with gas-air modulation	80	1	1.0
Room heater, with in-floor ducts	77	1	1.0
Gas-fired warm-air with balanced or open flue			
Ducted (on/off control)	70	1	1.0
Ducted (modulating control)	72	1	1.0
Stub ducted	70	1	1.0
Ducted with flue heat recovery	85	1	1.0
Stub ducted with flue heat recovery	82	1	1.0
Condensing	94	1	1.0
Oil-fired warm-air			
Ducted output (on/off control)	70	1	1.0
Ducted output (modulating control)	72	1	1.0
Stub duct system	70	1	1.0
Electric warm-air			
Electricaire system	100	2	0.75
Heat pumps			
Ground-to-air heat pump	320	1	1.0
Ground-to-air heat pump with auxiliary heater	300	1	1.0
Water-to-air heat pump	300	1	1.0
Air-to-air heat pump	250	1	1.0

	Efficiency %	Heating type	R
ROOM HEATER SYSTEMS			
Refer to Group 5 in Table 4e for control options			
Gas			
Gas fire, open flue, pre-1980 (open front)	50	1	1.0
Gas fire, open flue, 1980 or later	60	1	1.0
Gas fire or wall heater, balanced flue	70	1	1.0
Gas fire with back boiler (no radiators)	65	1	1.0
Room heater, fan-assisted flue	75	1	1.0
Condensing gas fire	85	1	1.0
Flush fitting live effect gas fire, sealed to chimney	50	1	1.0
Flush fitting live fuel effect gas fire, fan assisted flue	45	1	1.0
Decorative fuel effect gas fire, open to chimney	20	1	1.0
Gas fire, flueless, *add additional ventilation requirements in box (9a)*	100	1	1.0
Solid fuel			
Open fire in grate	32	3	0.5
Open fire in grate, with throat restrictor	42	3	0.5
Open fire with back boiler (no rads)	55	3	0.5
Closed room heater	60	3	0.5
Closed room heater with back boiler (no rads)	65	3	0.5
Electric (direct-acting)			
Panel, convector or radiant heaters	100	1	1.0
Portable electric heaters	100	1	1.0
OTHER SPACE-HEATING SYSTEMS			
Refer to Group 6 in Table 4e for control options			
Electric ceiling heating	100	2	0.75
HOT-WATER-ONLY HEATING SYSTEMS			
Independent electric water heating system	100	n/a	n/a
From a heat exchanger built into a gas warm-air system	65	n/a	n/a
Single-point gas water heater	70	n/a	n/a
Multi-point gas water heater	65	n/a	n/a

Table 4b: Seasonal efficiency for gas and oil boilers

1. *This table is to be used only for gas and oil boilers for which the SEDBUK is not available.*
2. *The table shows seasonal efficiency for space heating. The same seasonal efficiency should be assumed for water heating when hot water is supplied from a boiler system.*
3. *See Appendix B for guidance on boiler classification.*

	Efficiency %
Gas boilers (including LPG) 1998 or later	
1-1 Non-condensing (including combis) with automatic ignition	73
1-2 Condensing (including combis) with automatic ignition	83
1-3 Non-condensing (including combis) with permanent pilot light	69
1-4 Condensing (including combis) with permanent pilot light	79
1-5 Room heater + back boiler	65
Gas boilers (including LPG) pre-1998, with fan-assisted flue	
2-1 Low thermal capacity	72
2-2 High or unknown thermal capacity	68
2-3 Combi	70
2-4 Condensing combi	84
2-5 Condensing	85
Gas boilers (including LPG) pre-1998 with balanced or open-flue	
3-1 Wall-mounted	65
3-2 Floor-mounted, pre 1979	55
3-3 Floor-mounted, 1979 to 1997	65
3-4 Combi	65
3-5 Room heater + back boiler	65
Gas combined primary storage units (CPSU)	
4-1 With permanent pilot } non-condensing	70
4-2 With automatic ignition } non-condensing	74
Oil boilers	
5-1 Standard oil boiler pre-1985	65
5-2 Standard oil boiler 1985 to 1997	70
5-3 Standard oil boiler, 1998 or later	79
5-4 Condensing	83
5-5 Combi, pre-1998	70
5-6 Combi, 1998 or later	76
5-7 Condensing combi	81

Table 4c: Efficiency adjustments

	Efficiency adjustment, %	
	Mains gas	Oil/LPG
Gas or oil boiler systems with radiators or underfloor heating *The adjustments should be applied to the space and water heating seasonal efficiency for both the SEDBUK value and to efficiency values from Table 4b.*		
Efficiency adjustment due to low temperature distribution system		
Condensing boiler with load compensator [a)]	+2	+1
Condensing boiler with weather compensator [a)]	+2	+1
Condensing boiler with under-floor heating [a), b)]	+3	+2
Condensing boiler with thermal store	0	0
Efficiency adjustment due to control system:		
No thermostatic control of room temperature [a), d)]	-5	
No boiler interlock [a)]	-5	
Community heating systems		
Flat rate charging [c)], no thermostatic control of room temperature	-10	
Flat rate charging, programmer and room thermostat	-5	
Flat rate charging, programmer and TRVs	0	
Charging system linked to use of community heating, programmer and TRVs	0	

Notes

a) These are mutually exclusive and therefore do not accumulate; if more than one applies, the highest applicable efficiency adjustment is to be used.

b) Adjustment is applicable if the boiler supplies only the underfloor heating, and not if it also feeds radiators or supplies hot water.

c) 'Flat rate charging' means that households pay for the heat according to a fixed monthly or annual amount, not depending on the amount of heat actually used. If the charges vary within a scheme for other reasons, for example according to dwelling size, it is still classified as flat rate. The last entry under 'Community heating schemes' refers to a system in which the charges are substantially related to the amount of heat used.

d) Does not apply to heat pumps.

Table 4d: Heating type and responsiveness for gas and oil boilers

Heat emitter	Heating type	Responsiveness (R)
Radiators	1	1.0
Underfloor heating:		
– pipes in insulated timber floor	1	1.0
– pipes in screed or concrete slab	4	0.25

Table 4e: Heating system controls

1. *Use Table 4a to select the appropriate Group in this table.*
2. *'Control' indicates the appropriate column to use in Table 9.*
3. *The 'Efficiency adjustment' should be applied to the space and water heating seasonal efficiency (SEDBUK or from Table 4a or Table 4b).*
4. *The 'Temperature adjustment' modifies the living area mid internal temperature obtained from Table 8 and should be entered into box (71) of the worksheet.*

Type of control	Control	Temp adjustment (°C)
GROUP 1: BOILER SYSTEMS WITH RADIATORS OR UNDERFLOOR HEATING		
No thermostatic control of room temperature	1	+0.6
Programmer (time control)	1	0
Room thermostat	1	0
Programmer + room thermostat	1	0
Programmer + roomstat + TRVs	2	0
Programmer + TRVs + bypass	2	0
Programmer + TRVs + flow switch	2	0
Programmer + TRVs + boiler energy manager	2	0
Delayed start thermostat + programmer	1	-0.15
Delayed start thermostat + programmer + TRVs	2	-0.15
Time and temperature zone control	3	0
Additional temperature adjustment for CPSU or integrated thermal stores	0	-0.1
GROUP 2: COMMUNITY HEATING SCHEMES		
Flat rate charging*, no thermostatic control of room temperature	1	+0.3
Flat rate charging*, programmer and roomstat	1	0
Flat rate charging*, programmer and TRVs	2	0
Charging system linked to use of community heating, programmer and TRVs	3	0
GROUP 3: STORAGE RADIATOR SYSTEMS		
Manual charge control	3	+0.3
Automatic charge control	3	0
CELECT-type controls	3	0
GROUP 4: WARM-AIR SYSTEMS		
No thermostatic control of room temperature	1	+0.3
Roomstat only	1	0
Programmer + roomstat	1	0
Time and temperature control	3	0
GROUP 5: ROOM HEATER SYSTEMS		
No thermostatic control	2	+0.3
Appliance stat	3	0
Appliance stat + prog	3	0
Programmer + roomstat	3	0
Roomstat only	3	0
GROUP 6: OTHER SYSTEMS		
No thermostatic control of room temperature	1	+0.3
Roomstat only	1	0
Programmer + roomstat	1	0
Time and temperature control	3	0

**'Flat rate charging' means that households pay for the heat according to a fixed monthly or annual amount, not depending on the amount of heat actually used. If the charges vary within a scheme for other reasons, for example according to dwelling size, it is still classified as flat rate. The last entry under community heating schemes' refers to a system in which the charges are substantially related to the amount of heat used.*

Table 4f: Electricity for fans and pumps and electric keep-hot facility

Function	GJ/year
Central heating pump (supplying hot water to radiators)	0.47[a)]
Oil boiler[b)] – pump (supplying oil to boiler) and flue fan[c)]	0.35[a)]
Gas boiler – flue fan (if fan-assisted flue)	0.16
Warm air heating system fans	0.002 × dwelling volume in box (6)
Whole house mechanical ventilation fans	0.004 × dwelling volume in box (6)
Electricity for maintaining keep-hot facility[d)] of a gas combi boiler	
– keep-hot facility, controlled by time clock	0.8
– keep-hot facility, not controlled by time clock[e)]	2.0

Notes

a) multiply by a factor of 1.3 if room thermostat is absent

b) applies to all oil boilers

c) the same motor operates both the pump and flue fan

d) see notes to Table 3 for the definition of keep-hot facility

e) In the case of an untimed electrically powered keep-hot facility where the power rating of the keep-hot heater is obtained from the Boiler Efficiency database, the electricity consumed for maintaining keep-hot facility should be taken as:
electricity consumed = 0.032 × P (GJ/year)
where: P is the power rating in Watts

Table 5: Lighting, appliances, cooking and metabolic gains

Floor area (m^2)	Gains (W)	Floor area (m^2)	Gains (W)
30	230	170	893
40	282	180	935
50	332	190	978
60	382	200	1020
70	431	210	1061
80	480	220	1102
90	528	230	1142
100	576	240	1181
110	623	250	1220
120	669	260	1259
130	715	270	1297
140	760	280	1334
150	805	290	1349
160	849	300	1359

Alternatively, gains may be calculated from the total floor area of the dwelling (TFA), using the following steps:

a. Calculate N $= (0.035 \times TFA) - (0.000\,038 \times TFA^2)$, if TFA ≤ 420
$= 8.0$ if TFA > 420

b. Gains (W) $= 74 + (2.66 \times TFA) + (75.5 \times N)$ if TFA ≤ 282
$= 824 + (75.5 \times N)$ if TFA > 282

Additional gains: gains from the following equipment should be added to the totals given above

Central heating pump [a)]	*10 W*
Warm-air heating system fans [a), b)]	*10 W*
Mechanical ventilation system	*25 W*
Oil pump, inside dwelling [c)]	*25 W*

a) does not apply to community heating

b) the 10 W should not be included in addition to the 25 W for a mechanical ventilation system

c) oil central heating has both oil pump and central heating pump: do not add gains if oil pump is outside of dwelling

Table 6: Solar flux through glazing (W/m²)

	Horizontal	Vertical				
		North	NE/NW	E/W	SE/SW	South
Single glazed	34	13	15	22	29	32
Double glazed (air or argon filled)	30	11	13	19	26	28
Double glazed (low-E, hard-coat)	28	11	13	18	25	27
Double glazed (low-E, soft coat)	22	9	10	15	19	22
Triple glazed (air or argon filled)	26	10	12	17	23	25
Triple glazed (low-E, hard-coat)	24	9	11	16	21	23
Triple glazed (low-E, soft coat)	21	8	10	14	18	20

Notes:

1. *Use E/W orientation when the orientation is not known.*
2. *For a roof window in a pitched roof with a pitch of up to 70°, use the value under 'North' for orientation within 30° of North and the value under 'Horizontal' for all other orientations. If the pitch is 70° or greater, then treat as if it is a vertical window.*
3. *If low-E but coating not known, assume hard coat.*

Table 6a: Solar access factor

Overshading	% sky blocked by obstacles	Solar access factor
Heavy	> 80	0.4
More than average	60-80	0.7
Average or unknown	20-60	1.0
Very little	< 20	1.3

Note:
A solar access factor of 1.3 should be used for rooflights.

Table 6b: Indicative U-values (Wm²/K) for windows, doors and roof windows

The U-values are calculated using BS EN ISO 10077-1. The values apply to the entire area of the window opening, including both frame and glass, and take account of the proportion of the area occupied by the frame and the heat conducted through it.

When available, the manufacturer's certified U-values for windows or doors should be used in preference to the data in this table. Adjustments for roof windows should be applied to manufacturer's window U-values unless the manufacturer provides a U-value specifically for a roof window.

Unless known otherwise, double and triple glazing should be taken as air-filled without low-E coating.

Glazing	Type of frame: Window with wood or U-PVC frame (use adjustment column for roof windows)				Window with metal frame with 4mm thermal break (include an adjustment from notes below for thermal break and for roof windows)		
	Gap between panels (mm)			Adjustment	Gap between panels (mm)		
	6	12	16 or more	for roof window	6	12	16 or more
Double-glazed, air-filled	3.1	2.8	2.7		3.7	3.4	3.3
Double-glazed, air-filled (low-E, $\varepsilon_n = 0.2$, hard coat)	2.7	2.3	2.1		3.3	2.8	2.6
Double-glazed, air-filled (low-E, $\varepsilon_n = 0.1$, soft coat)	2.6	2.1	1.9		3.2	2.6	2.5
Double-glazed, argon filled	2.9	2.7	2.6		3.5	3.3	3.2
Double-glazed, argon filled (low-E, $\varepsilon_n = 0.2$, hard coat)	2.5	2.1	2.0		3.1	2.6	2.5
Double-glazed, argon filled (low-E, $\varepsilon_n = 0.1$, soft coat)	2.3	1.9	1.8	+0.2	2.9	2.4	2.3
Triple glazed, air-filled	2.4	2.1	2.0		2.9	2.6	2.5
Triple glazed, air-filled (low-E, $\varepsilon_n = 0.2$, hard coat)	2.1	1.7	1.6		2.6	2.2	2.0
Triple glazed, air-filled (low-E, $\varepsilon_n = 0.1$, soft coat)	2.0	1.6	1.5		2.5	2.0	1.9
Triple-glazed, argon filled	2.2	2.0	1.9		2.8	2.5	2.4
Triple-glazed, argon filled (low-E, $\varepsilon_n = 0.2$, hard coat)	1.9	1.6	1.5		2.4	2.0	1.9
Triple-glazed, argon filled (low-E, $\varepsilon_n = 0.1$, soft coat)	1.8	1.4	1.3		2.2	1.9	1.8
Windows and doors, single-glazed		4.8		+0.3		5.7	
Solid wooden door		3.0		–		–	

Notes:

1. *For windows or roof windows with metal frames apply the following adjustments to U-values:*

	Adjustment to U-value, W/m²K	
	Window	*Rooflight*
Metal, no thermal break	*+0.3*	*+0.7*
Metal, thermal break 4 mm	*0.0*	*+0.3*
Metal, thermal break 8 mm	*-0.1*	*+0.2*
Metal, thermal break 12 mm or more	*-0.2*	*+0.1*

2. *For doors which are half-glazed (approximately) the U-value of the door is the average of the appropriate window U-value and that of the non-glazed part of the door (eg solid wooden door (U-value of 3.0 W/m²K) half-glazed with double glazing (low-E, hard coat, argon filled, 6 mm gap, U-value of 2.5 W/m²K) has a resultant U-value of 0.5 (3.0 + 2.5) = 2.75 W/m²K.*

Table 7: Utilisation factor as a function of gain/loss ratio (GLR)

GLR	Utilisation factor	GLR	Utilisation factor	GLR	Utilisation factor
1	1.00	**11**	0.81	**21**	0.58
2	1.00	**12**	0.78	**22**	0.56
3	1.00	**13**	0.75	**23**	0.54
4	0.99	**14**	0.72	**24**	0.53
5	0.97	**15**	0.70	**25**	0.51
6	0.95	**16**	0.68	**30**	0.45
7	0.92	**17**	0.65	**35**	0.40
8	0.89	**18**	0.63	**40**	0.36
9	0.86	**19**	0.61	**45**	0.33
10	0.83	**20**	0.59	**50**	0.30

Alternatively, the utilisation factor may be calculated by the formula:
Utilisation factor = 1 – exp (– 18 ÷ GLR),
where GLR = [total gains, box (66)] ÷ [heat loss coefficient, box (37)]

Table 8: Mean internal temperature of living area
Number in brackets is from the 'heating type' column of Table 4a or 4d.
HLP is box (38) on the worksheet.

HLP	(1)	(2)	(3)	(4)	(5)
1.0 (or lower)	18.88	19.32	19.76	20.21	20.66
1.5	18.88	19.31	19.76	20.20	20.64
2.0	18.85	19.30	19.75	20.19	20.63
2.5	18.81	19.26	19.71	20.17	20.61
3.0	18.74	19.19	19.66	20.13	20.59
3.5	18.62	19.10	19.59	20.08	20.57
4.0	18.48	18.99	19.51	20.03	20.54
4.5	18.33	18.86	19.42	19.97	20.51
5.0	18.16	18.73	19.32	19.90	20.48
5.5	17.98	18.59	19.21	19.82	20.45
6.0 (or higher)	17.78	18.44	19.08	19.73	20.40

Note:
Use heating column (1) when dwelling is heated by community heating.

Table 9: Difference in temperatures between zones
Number in brackets is from the 'control' column of Table 4e.
HLP is item (38) in the worksheet.

HLP	(1)	(2)	(3)
1.0 (or lower)	0.40	1.41	1.75
1.5	0.60	1.49	1.92
2.0	0.79	1.57	2.08
2.5	0.97	1.65	2.22
3.0	1.15	1.72	2.35
3.5	1.32	1.79	2.48
4.0	1.48	1.85	2.61
4.5	1.63	1.90	2.72
5.0	1.76	1.94	2.83
5.5	1.89	1.97	2.92
6.0 (or higher)	2.00	2.00	3.00

Table 10: Degree days as a function of base temperature

Base temp °C	Degree Days	Base temp °C	Degree Days
1.0	0	11.0	1140
1.5	30	11.5	1240
2.0	60	12.0	1345
2.5	95	12.5	1450
3.0	125	13.0	1560
3.5	150	13.5	1670
4.0	185	14.0	1780
4.5	220	14.5	1900
5.0	265	15.0	2015
5.5	310	15.5	2130
6.0	360	16.0	2250
6.5	420	16.5	2370
7.0	480	17.0	2490
7.5	550	17.5	2610
8.0	620	18.0	2730
8.5	695	18.5	2850
9.0	775	19.0	2970
9.5	860	19.5	3090
10.0	950	20.0	3210
10.5	1045	20.5	3330

Table 11: Fraction of heat supplied by secondary heating systems

Main heating system	Secondary system	Fractio
Central heating system:	gas fires	0.15
– boiler and radiators	coal fires	0.10
– underfloor heating	electric heater	0.05
– warm air system		
– other gas or oil fired systems		
Gas room heaters	gas fires	0.30
	coal fires	0.15
	electric heaters	0.10
Coal room heaters;	gas fires	0.20
electric room heaters	coal fires	0.20
	electric heaters	0.20
Electric storage heaters not	gas fires	0.15
fan-assisted;	coal fires	0.10
other electric systems	electric heaters	0.10
Fan assisted storage heaters	gas fires	0.15
	coal fires	0.10
	electric heaters	0.05
Heat pump	gas fires	0.15
	coal fires	0.10
	electric heaters	0.05

Table 12: Fuel prices and additional standing charges

	Additional standing charge (£)	Unit price (£/GJ)
Gas (mains)	28	3.74
Bulk LPG	57	8.22
Bottled gas – propane 47 kg cylinder		11.02
Heating oil		4.53
House coal		4.62
Smokeless fuel		7.46
Anthracite nuts		5.15
Anthracite grains		5.16
Wood		4.50
Electricity (on-peak)		20.80
Electricity (off-peak)	16	7.93
Electricity (standard tariff)		19.69
Electricity 10 hour tariff (on-peak)		16.50
Electricity 10 hour tariff (off-peak)	15	8.75
Electricity (24-hr heating tariff)	48	8.97
Community scheme	28	
Heat from boilers (any fuel)		4.55
Heat from CHP or waste heat		3.17
Energy cost inflator	1.05	

Notes

1. *The standing charge given for electricity is extra amount for the off-peak tariff, over and above the amount for the standard domestic tariff, as it is assumed that the dwelling has a supply of electricity for reasons other than space and water heating. Standing charges for gas and for off-peak electricity are added to space and water heating costs where those fuels are used for heating.*
2. *An energy cost inflator term is applied before the rating is calculated. The purpose of the inflator is to ensure that the ratings do not, on average, change with fuel price changes. The energy cost inflator term is currently set at **1.05**. It will vary with the weighted average price of heating fuels in future, in such a way as to ensure that the SAP is not affected by the general rate of inflation. However, individual SAP ratings are affected by relative changes in the price of particular heating fuels.*

Table 12a: Distribution loss factor for group and community schemes

Heat distribution system	Factor
Mains piping system installed in 1990 or earlier, not pre-insulated, medium or high temperature distribution (120-140°C), full flow system	1.20
Pre-insulated mains piping system installed in 1990 or earlier, low temperature distribution (100°C or below), full flow system	1.10
Modern higher temperature system (up to 120°C), using pre-insulated mains installed in 1991 or later, variable flow system	1.10
Modern pre-insulated piping system operating at 100°C or below, full control system installed in 1991 or later, variable flow system	1.05

Note:

A full flow system is one in which the hot water is pumped through the distribution pipework at a fixed rate irrespective of the heat demand (usually there is a bypass arrangement to control the heat delivered to heat emitters). A variable flow system is one in which the rate at which the hot water is pumped through the distribution pipework varies according to the demand for heat.

Table 13: On-peak fraction for electric water heating

Dwelling total floor area (m^2)	Cylinder size (litres) 7-hour tariff 110	160	210	245	10-hour tariff 110	160	210
40 or less	12 (56)	7 (18)	2	0	6 (15)	0	0
60	14 (58)	9 (21)	3	0	8 (19)	0	0
80	17 (60)	10 (24)	4	0	10 (22)	0	0
100	19 (62)	12 (27)	5	0	11 (25)	0 (2)	0
120	21 (63)	14 (30)	6	0	13 (28)	1 (5)	0
140	24 (65)	15 (33)	6	1	14 (30)	2 (9)	0
160	26 (66)	16 (35)	7	1	16 (33)	2 (12)	0
180	27 (68)	18 (37)	8	2	17 (35)	2 (15)	0
200	29 (69)	19 (40)	9	2	18 (38)	3 (18)	0
220	31 (70)	20 (42)	10	2	19 (40)	3 (21)	0
240	32 (71)	21 (43)	10	3	20 (41)	4 (23)	0
260	33 (72)	22 (45)	11	3	21 (43)	4 (25)	0
280	35 (73)	23 (47)	11	3	22 (45)	4 (27)	0
300	36 (74)	24 (48)	12	3	23 (46)	5 (29)	0
320	37 (75)	24 (49)	12	4	23 (47)	5 (30)	0
340	38 (75)	25 (50)	13	4	24 (48)	5 (32)	0
360	38 (76)	26 (51)	13	4	24 (49)	5 (33)	0
380	39 (76)	26 (52)	13	4	25 (50)	5 (34)	0
400	39 (76)	26 (52)	13	4	25 (51)	5 (35)	0
420 or more	40 (77)	26 (52)	13	4	25 (51)	6 (35)	0

Notes

1 *Table 13 shows percentage of electricity required at on-peak rates for cylinders with dual immersion heaters, and in brackets for cylinders with single immersion heaters, for tariffs providing at least 7 hours of heating per day at the off-peak rate.*

2 *Alternatively, the fraction may be calculated (for V between 110 and 245 litres) from the following equations:*

a) tariffs providing at least 7 hours of heating per day at the off-peak rate

Dual immersion: $(6.8 - 0.024V)N + 14 - 0.07V$

Single immersion: $(14530 - 762N)/V - 80 + 10N$

b) tariffs providing at least 10 hours of heating per day at the off-peak rate

Dual immersion: $(6.8 - 0.036V)N + 14 - 0.105V$

Single immersion: $(14530 - 762N)/(1.5V) - 80 + 10N$

where V is the cylinder volume and N is as defined below Table 5. (If these formulae give a value less than zero, set the on-peak fraction to zero.)

3. *Do not use this table to obtain the on-peak percentage for an electric CPSU. Calculate the on-peak percentage using the procedure described in Appendix F.*
4. *Do not use this table for the on-peak percentage for domestic hot water heated by a heat pump. Use on-peak percentages given in Appendix G.*

Table 14: SAP rating by energy cost factor

ECF (£/m^2)	SAP rating	ECF (£/m^2)	SAP rating
0.59 or less	120	2.6	56
0.60	119	2.70	54
0.65	116	2.70	53
0.70	112	2.80	52
0.75	109	2.90	51
0.80	107	3.00	49
0.85	104	3.15	47
0.90	102	3.30	45
0.95	99	3.45	44
1.00	97	3.60	41
1.05	95	3.75	40
1.10	93	3.90	38
1.15	91	4.00	37
1.20	89	4.25	34
1.25	87	4.50	32
1.30	86	4.75	29
1.35	84	5.00	27
1.40	82	5.25	25
1.45	81	5.50	23
1.50	79	5.75	21
1.55	78	6.00	19
1.60	77	6.25	17
1.65	75	6.50	16
1.70	74	6.75	14
1.75	73	7.00	12
1.80	71	7.25	11
1.85	70	7.50	9
1.90	69	7.75	8
1.95	68	8.00	7
2.00	67	8.25	5
2.10	65	8.50	4
2.20	63	8.75	3
2.30	61	9.00	2
2.40	59	9.25 or above	0
2.50	57		

The values in the above table may be obtained by using the formula:

$$SAP\ Rating = 97 - 100 \times \log_{10}(ECF)$$

where: ECF is an Energy Cost Factor, calculated in box (99).

Table 15: Carbon dioxide emission factors for delivered energy

	kg CO_2 per GJ
Gas (mains)	54
Bulk LPG	69
Bottled gas (propane)	69
Heating oil	75
House coal	81
Anthracite	88
Smokeless solid fuel	109
Electricity	115
Wood	7
Household waste	12
Biomass	7
Biogas (landfill)	7
Waste heat from power stations	5

Table 16: Carbon Index

Carbon Factor (CF) kg/m^2	**Carbon Index (CI)**	Carbon Factor (CF) kg/m^2	**Carbon Index (CI)**
7.17 or less	**10.0**	30	**4.4**
8	**9.6**	32	**4.2**
9	**9.1**	34	**3.9**
10	**8.7**	36	**3.7**
11	**8.3**	38	**3.5**
12	**8.0**	40	**3.3**
13	**7.7**	45	**2.8**
14	**7.4**	50	**2.4**
15	**7.1**	55	**2.0**
16	**6.9**	60	**1.7**
17	**6.6**	65	**1.4**
18	**6.4**	70	**1.1**
19	**6.2**	75	**0.8**
20	**6.0**	80	**0.6**
22	**5.6**	85	**0.3**
24	**5.3**	90	**0.1**
26	**5.0**	92.5 or more	**0.0**
28	**4.7**		

Alternatively, the carbon factor and CI may be calculated by the formulae:

$$CF = CO_2 / (TFA + 45.0)$$

$$CI = 17.7 - 9.0 \log_{10}(CF)$$

where: CO_2 is the CO_2 emissions in kg/year

TFA is total floor area in m^2.