Decentralized Energy Master Planning

The London Borough of Brent

An Interactive Qualifying Project Report submitted to the Faculty of
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in partial fulfilment of the requirements for the Degree of Bachelor of Science

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Abstract

The London Borough of Brent aims to reduce its carbon emissions via implementation of decentralized energy schemes including combined heat and power systems. The objective of this project was to aid Brent in the early stages of its decentralized energy master planning. By examining policies of other boroughs and studying major development areas within Brent, the WPI project team has concluded that the council must actively facilitate the development of decentralized energy systems through the use of existing practices and development of well supported policies.

Authorship Page

This report was developed through a collaborative effort by the project team: Anthony Aldi, Karen Anundson, Andrew Bigelow, and Andrew Capulli. All sections were developed as team with each member contributing equally.

Acknowledgements

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Executive Summary

Reducing carbon emissions is a global strategy for addressing the important issue of climate change. Currently, electric power generation and building heat systems are implemented independently with centralized power plants located far from the energy consumers. One of the leading solutions for reducing carbon emissions in urban areas is decentralized energy networks that can include combined heat and power. Decentralized energy is a method of producing energy closer to the users that reduces the amount of energy lost in transmission. Combined heat and power is a method of producing heat and power in a single process that reduces the amount of energy lost in electric power production by capturing waste thermal energy for use in heat systems instead of releasing this heat into the environment.

The Mayor of London is promoting the implementation of decentralized energy through goals outlined in the London Plan. A portion of the responsibility for implementing these systems is given to the boroughs. The London Borough of Brent is currently in the first phase of decentralized energy planning during which it is developing a heat map, introducing planners to the technology, and formulating policies to expand its use.

Part of the initial planning stages involves identifying areas with potential for decentralized energy and combined heat and power. Brent hired the consultant firm Rambøll Danmark A/S to produce a heat map that identifies major heat loads based on gas consumption. Heat demand alone does not dictate a site's potential for combined heat and power; the project team identified the need for a study to examine other factors to complement the work done by Rambøll Danmark A/S. To begin work on these studies, the project team examined and then visited areas within Brent where there are major opportunities for redevelopment. The team identified obstacles such as conservation areas, major roads and rail ways as well as factors that contribute to the feasibility of combined heat and power such as locations of heat loads, opportunity fuels and site use allocations. Using the CHP Sizer program, the team created small scale combined heat and power scenarios for each area demonstrating potential economic and environmental benefits. The CHP Sizer program only allows for rough estimates within a limited scope but can provide a basic idea of potential in the beginning stages of planning.

The team examined and analyzed policy documents and interviewed officials from boroughs more advanced in their decentralized energy planning to procure information about current policies and planning practices. The WPI project team found the boroughs that are

successfully implementing decentralized energy have a knowledgeable and engaged planning staff. The team created a poster and brochure to provide basic information to planners and generate interest in decentralized energy. Both these documents refer to the team's *Decentralised Energy and You* handbook which contains more detailed information. The goal of this handbook is to provide planners with a good foundation on decentralized energy and combined heat and power systems as well as to describe good planning and policy practices to facilitate the development of decentralized energy networks in Brent. The handbook includes references to other resources that can offer more specific information on the topic of interest.

Currently, other boroughs are using existing planning and policy mechanisms to facilitate the growth of decentralized energy within their boroughs while they develop decentralized energy policies within Local Development Frameworks. If a council owns large anchor loads like council housing estates, leisure centers or council offices, these buildings can be used to guarantee long term customers for an energy provider, ensuring revenue and making that site an attractive option to a developer and energy company. Brent can use the council housing that it still owns as well as council buildings to attract decentralized energy development. Section 106 agreements, which allow local authorities to "enter into a legally-binding agreement or planning obligation with a landowner in association with the granting of planning permission" (IDeA), are often used to obtain provision of services and infrastructure. These agreements have been used by other boroughs to facilitate the growth of decentralized energy networks. The team recommends that Brent take advantage of Section 106 agreements as a means of beginning decentralized energy and combined heat and power within the borough while it continues to develop its Local Development Framework.

Other boroughs have conducted detailed and site specific feasibility studies for areas with potential for decentralized energy and combined heat and power potential. Information from these studies can be used to support decentralized energy policies and demonstrate when decentralized energy is the most viable option for carbon reduction compared to other methods. The team recommends that the Brent should conduct studies to identify the feasibility of combined heat and power in specific locations. Brent has begun the process of identifying energy clusters and the WPI team has performed initial work investigating feasibility of specific sites. These studies need to be supplemented, however, with data from more detailed future studies that can provide a case for combined heat and power.

The team has also concluded that area-specific policies are most likely to facilitate the implementation of decentralized energy and combined heat and power. Such policies should be supported by detailed studies identifying specific opportunities and specific energy plans that outline the nature and scope of possible distribution networks. Such plans are likely to be most effective when divided into economically feasible phases. Each phase should provide a portion of an eventually larger network with a reasonable initial investment and can be used to facilitate the development of larger networks. Creative use of existing mechanisms and the development of innovative policies by a knowledgeable planning staff will be key factors in the successful implementation of decentralized energy networks that includes combined heat and power.

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1 Introduction

Global energy demands are projected to increase by 40% between now and 2030, assuming no change in government policies (IEA, 2009). Simultaneously, the threat of climate change has spurred efforts to reduce global greenhouse gas emissions. The increasing energy demand conflicts with the goal to decrease emissions. This dilemma has lead to efforts to find alternative and more efficient methods of producing energy, improved distribution methods and conservation efforts to reduce energy demand.

Currently in most areas, electric power generation and building heat systems are implemented independently. Centralized power plants located far from the energy consumers are the primary producers of electric power. Unfortunately, these systems lose about 70% of their input energy to thermal waste during production and transmission to the users. Decentralized energy schemes mitigate transmission losses by bringing power generation closer to the user. Decentralized energy schemes can include systems that combine the production of electric power and heat in the same facility thus dramatically increasing efficiencies. These systems are called combined heat and power generation plants. The Mayor of London's spatial development strategy, the *London Plan*, includes provisions that are intended to increase the fraction of London's power that is generated using more efficient combined heat and power systems. Accordingly, the various London boroughs have begun to build Local Development Frameworks that will encourage the development and implementation of decentralized energy projects using combined heat and power systems.

The WPI project team has worked with the Brent Planning Service to assist in advancing a decentralized energy plan in the borough. An important part of the beginning stages of implementing decentralized energy and combined heat and power includes identifying major opportunity areas. Identification of major heat loads and evaluation of areas to identify factors that will be advantageous and those that could be obstacles for development forms the basis for an evidence base to justify development of networks in an area. The Rambøll Danmark A/S engineering consulting firm performed work to identify major loads and the WPI project team investigated other factors that affect a site's viability for combined heat and power and an eventual heat network. Studies the team conducted for the major development areas combined with the Rambøll Danmark A/S studies provide Brent with initial information to build on in future investigations of area feasibilities.

The London Borough of Brent is in the beginning stages of developing a decentralized energy master plan that will be a part of a Local Development Framework. To implement a successful decentralized energy program in Brent, the Brent Council needs its planning service to be well informed and interested in advancing this type of program. Knowledgeable planners will be better able to investigate the possibilities of decentralized energy networks in future development plans and create effective policies to facilitate the inclusion of the development of heat networks and combined heat and power systems in plans proposed by developers. Through the use of interviews with other boroughs and examination of policies and other documents, the team compiled information, resources and recommendations to help the planning service enhance its knowledge of decentralized energy and combined heat and power and advance its policies and planning.

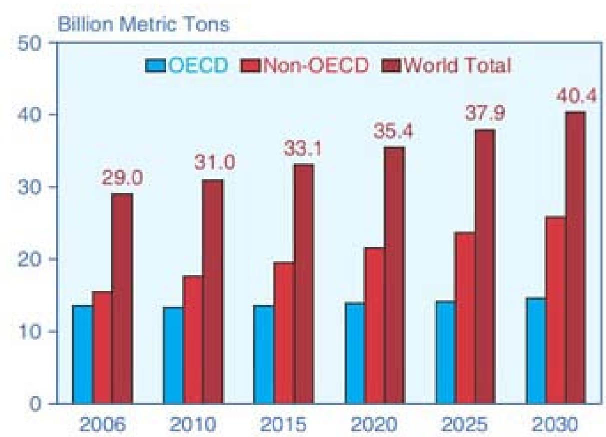
The background to decentralized energy motives, technologies, and policies define the scope in which this study has been conducted. Based on this defined research space and the needs of the borough, goals and objectives were identified. To meet these goals a detailed methodology was developed. The resulting information has been compiled and recorded as a basis for recommendations made by the team for Brent's future DE planning.

2 Background

The combustion of fossil fuels, resulting in green house gas emissions, is recognized as one of the most influential factors affecting global warming (Chambers, 2002). Carbon dioxide emissions are of particular concern. Atmospheric CO_2 concentrations have increased 35% since industrialization began in the United Kingdom in the late 1850's and have reached their highest levels in the last 800,000 years (Meteorological Office, 2009). Furthermore, according to the UK's Meteorological Office, the national weather service of the United Kingdom, temperatures in central England have risen 1°C over the past thirty years due to anthropogenic warming. The effects of global warming are not restricted to the atmosphere and consequently sea levels around the UK have accrued a total of 10cm since 1990 due mostly to thermal expansion.

This issue is not limited to the U.K. and extends to all nations around the globe. In spite of growing awareness, the global consumption of common fossil fuels[1] and the emissions of CO_2 (Figure 1), are predicted to increase by 44% and 39% respectively between 2006 and 2030 (USEIA, 2009). These predictions are based on the assumption that current policies and practices of energy consumption and production are unaltered.

Figure 1: Actual and Projected World Carbon Dioxide Emissions 2006-2030



(USEIA, 2009)

In response to this pressing problem, the U.K. and its local communities have become leaders in developing policies for mitigating CO_2 emissions. These policies include provisions for implementing decentralized energy schemes that include combined heat and power generation.

[1] These fuels include coal, petroleum based fuels, and natural gas.

2.1 Decentralized Energy and Combined Heat and Power

A fundamental knowledge of decentralized energy and combined heat and power systems is needed in order to understand the motivations driving policies with provisions for these networks and systems. The idea of decentralized energy and combined heat and power is not new; there are and have been global efforts to achieve more efficient decentralized energy schemes. London aims to implement decentralized energy networks that include combined heat and power generation. Combined heat and power generation can be achieved through a variety of systems that can be broken down into the same fundamental components. The wide range of fuels that can power these systems leaves open possibilities for a diverse and cleaner fuel supply. These systems can provide substantial economical and environmental benefits on scales ranging from single sites to large networks. Examples of existing systems and guidelines established for the implementation of these systems are useful tools for determining the feasibility of a network or combined heat and power facility. A project that has been identified as technically feasible requires the involvement of a diverse group of organizations and stakeholders including energy service companies, developers and local authorities.

2.1.1 Background and History

Decentralized energy (DE) refers to energy production on small or 'district' scales to maximize fuel efficiency and minimize distance of energy transport. District heating (DH), an idea derived from DE, is the local distribution of heat to a network of users. Combined heat and power (CHP), also termed cogeneration, refers to the production and utilization of both electricity and heat from a single generating facility (CHPA, 2006). CHP is a method of combining normally separate power generation and heating systems to work together for a more efficient combined system (EPA, 2009). When also providing cooling, the method is called trigeneration or Combined Cooling Heating and Power (CCHP). Responding to the current demand for lower carbon emissions and more efficient use of fuels, the UK has begun to implement CHP and CCHP systems on small, district, and large scale levels.

Until the mid 1980s, large nuclear and coal fueled electricity plants provided the majority of electrical energy in the United Kingdom and most developed countries; these plants were traditionally located far from consumers resulting in a large loss of energy during transport (CHPA, 2006). The United Kingdom has primarily converted from the use of coal-fired power stations, in accordance with the 1974 Ridley Plan (IME, 2008), to cheaper and cleaner burning natural gas power stations. In addition to a conversion to cleaner fuels within the UK, energy producing technologies including turbines and boilers have improved in the past thirty years pushing combined heat and power back to the forefront of today's energy solutions. Maximizing fuel efficiency while minimizing energy loss is not only a popular and economical initiative, it is UK policy[2] and CHP has become an important tool in addressing these goals. Many London boroughs are planning to use CHP as a means of powering and heating communal buildings such as local government centers offices and council housing estates in addition to large industrial centers (CHPA, 2009). It is hoped that the private sector will follow the example of the boroughs' implementations of CHP and increase investments in CHP systems (LDA, 2009).

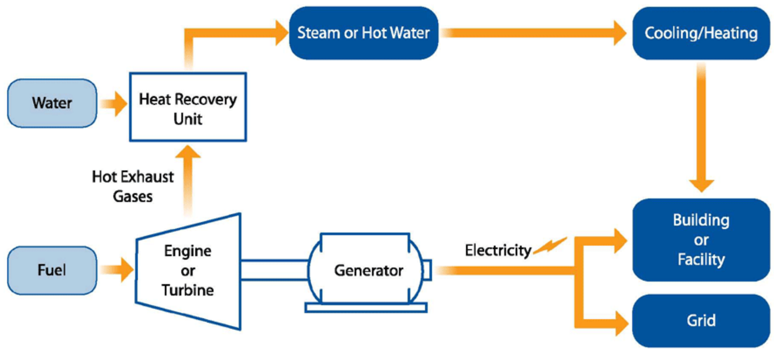
Although the planning and implementation of CHP systems have recently become important tools in the development of DE in the UK, a number of global efforts precede the UK's. Denmark, a world leader in the development of decentralized energy, obtains approximately 50% of its electricity from CHP systems, and 60% of the nation's heat demand is satisfied through district heating networks (DAE, 2008). With strong backing by the federal government, Finland has also emerged a leader in the development of decentralized energy. In 2007, approximately 29% of the nation's electricity was produced by CHP and 74% of the heat supply was generated through district heating systems. In the nation's capital, Helsinki, 93% of all heating is supplied through DH networks (IEA, 2008). The UK seeks to increase its use of CHP and DH in its overall goal of improving decentralized energy.

2.1.2 Basic CHP/CCHP Components

There are two primary types of CHP and CCHP systems: gas turbines (Figure 2) and steam boilers (Figure 3). The gas turbine method of CHP/CCHP is more suited to large scale installations such as commercial or industrial applications with large electrical and heating/cooling demands. The gas turbine systems are generally designed to address electricity needs. A gas turbine or engine powers a generator creating electricity to be distributed to the consumer. A heat recovery unit captures residual heat from the turbine which is used to create steam or hot water. This steam or hot water is then distributed for heating and/or used to power cooling systems (EPA, 2009). There are two main types of cooling systems: absorption chillers and engine/condenser driven chillers (Hao, 2006).

[2] To be detailed further in later portions of this document.

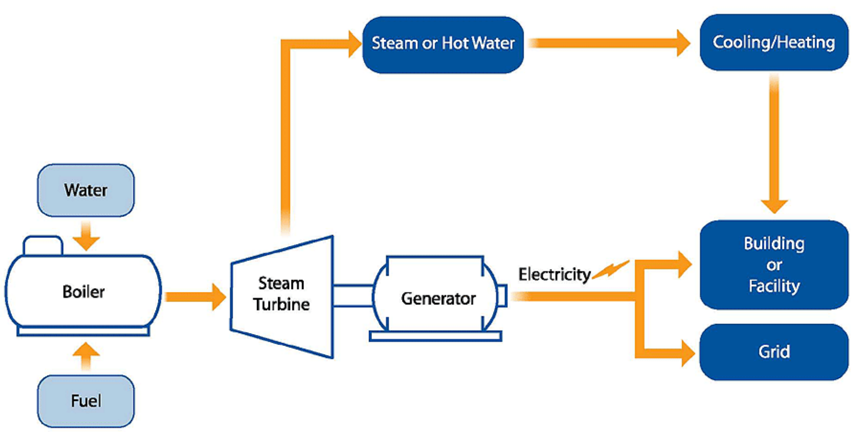
Figure 2: CHP/CCHP Gas Turbine



(EPA, 2009)

Boiler systems (Figure 3) are more appropriate for industrial or smaller scale systems where various fuels (e.g., biomass, gas, oils) are readily available. These boiler systems are primarily designed to address heating/cooling demands, producing residual electricity power through the use of steam (EPA, 2009). Fuel is not used to drive an engine, but rather to produce steam in the boiler that is used to power a turbine-generator unit for electricity production. Steam is also sent from the boiler directly to heating distribution and cooling systems.

Figure 3: CHP/CCHP Boiler



(EPA, 2009)

2.1.3 Fuels Used in CHP Systems

CHP systems can be powered by a wide range of fuels including traditional fossil fuels like oil and natural gas as well as newer alternative fuels like those derived from biomass. These fuels can be categorized as biomass fuels, industrial process waste, fossil fuel derivatives, and opportunity fuels (RDC, 2004). Table 1 outlines the general fuels types.

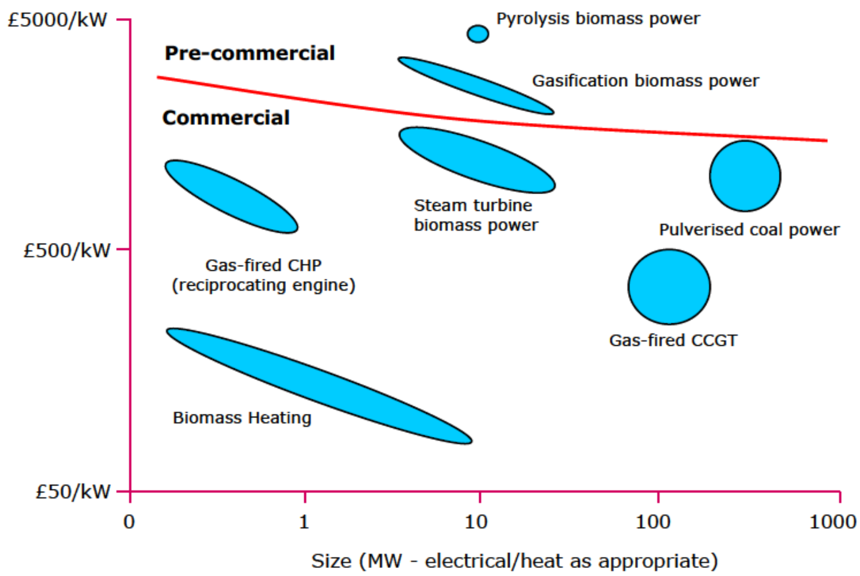
Table 1: CHP Fuel Types

Fuel Type	*Description*
Biomass fuels (biofuels)	• Wide variety of fuels derived from biological wastes and other processes • Considered a renewable energy because they consist of residues, wastes, or byproducts from living or once living organisms • Can be solid liquid or gaseous • Solid wastes often converted into liquid fuels like ethanol or gaseous fuels like biomass gas; if left in solid form is used as boiler fuel • Raw material could come from crop residues or farm waste, food processing waste, municipal waste, wood or wood waste • Usually used in places where the fuel is readily available (RDC, 2004)
Industrial process waste	• Non-biomass fuels that are the waste products of industrial processes • Raw materials could come from textile waste and waste products from petroleum products or iron and steel mills • Used in areas where the waste is readily available (RDC, 2004)
Fossil fuel derivatives	• Derived from crude oil • Most commonly natural gas, distillate oils, heavy fuel oils and coal • Natural gas is often chosen because it is a relatively clean • Still used in conjunction with alternative fuels in CHP plants because the CHP plants' efficiency requires less fossil fuel to be burned (DECC, 2010)
Opportunity fuels	• Unconventional fuels that are usually already being used, stored, or made at the site of a CHP facility • Most made as a byproduct of an industrial process • Convenient to use, require little or no transportation • Usually less desirable fuels because lower heating values mean they are more difficult to combust[3] • A good way of reusing waste product or tapping into unique local resources as a source of energy (e.g. hotsprings, geothermal) • Usually not used as primary fuel; often used as one of a number of fuels used at a facility (RDC, 2004)

The graph in Figure 4 shows a sampling of fuel types and compares how much each costs per kilowatt compared to the amount of power each type of fuel can generate. It also categorizes fuels as commercial (i.e. available and readily implemented) or pre-commercial (i.e. still in the development stages) (North, 2009). Brent would like to implement systems fueled at least partially by waste to energy fuels, including biomass derived fuels and waste wood, as well as natural gas.

[3] The heating value of a material is defined as "the amount of heat produced by combustion of a unit quantity of fuel" (Engineering ToolBox, 2005)

Figure 4: CHP Cost/Capacity Comparison

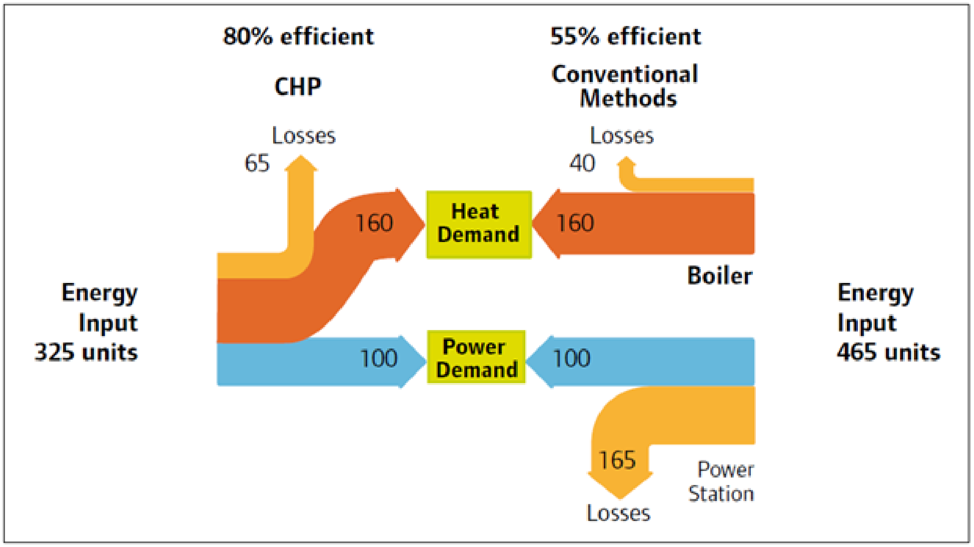


(North, 2009)

2.1.4 Benefits of CHP Systems

Combined heating and power systems have numerous benefits that are directly related to the increased efficiency of the system. Efficiency is defined as "the process of doing more with less. The goal is to accomplish the same tasks and functions as before while using less energy" (CCSE, 2003). The average efficiency of a CHP system can be in excess of 80% as opposed to producing electricity and heat separately which results in a net efficiency of only about 38% to 55% (CHP Benefits, 2010). Figure 5 demonstrates how CHP systems require less energy input (fuels) for the same amount of energy output (heat and electricity) and reduce energy loss when compared to conventional separate heat and power generation.

Figure 5: CHP vs. Traditional System Efficiency



(*Powering Ahead*, 2009)

The lower amount of fuel used results in varying yearly savings that can range from 15% to 40% (CHPA, 2010). A case study of The Royal Shrewsbury Hospital in Shrewsbury, England showed yearly savings of £780,000 ($1.22 million) (CHPA Royal Shrewsbury Hospital, 2009).

In addition to reducing costs, CHP systems have a reduced environmental impact as compared to systems that produce electricity and heat separately. CHP systems require an input of fuel such as natural gas or diesel so green house gases (GHGs) are still being produced. However, fewer GHGs are produced due to the increased efficiency and lower amount of fuel required to meet given power and heat demands. Currently in London, over 40 of its 112 fire stations have been implementing mini-CHP systems. According to the CHPA, fire stations are excellent candidates for CHP because they require large amounts of energy due to their continuous energy demand. The implementation has allowed for the reduction of thousands of tonnes of CO_2 and GHG emissions every year (CHPA London Fire Stations, 2009).

Since CHP systems produce electricity and heat for the immediate area, they are ideal for buildings or locations that require a constant supply of heat and power. These systems are still connected to the grid but can remain functional in the event of grid failure. This allows for an increased security of energy supplies. Many hospitals have begun to use CHP systems for this reason. Similar to providing facilities with backup power, combined heat and power systems may provide additional power to facilities with increasing demands. CHP systems can be put into an area where the electricity grid needs supplementing. Instead of upgrading the grid, a

CHP plant can help to relieve the strain on the current system (CHPA, 2009). Large heating demand can also be addressed using CHP systems; more efficient usage of fuel at a CHP plant can provide a network of communal heating. CHP systems demonstrate a wide range of benefits, including energy and cost efficiency, which vary with the type of system and fuels used.

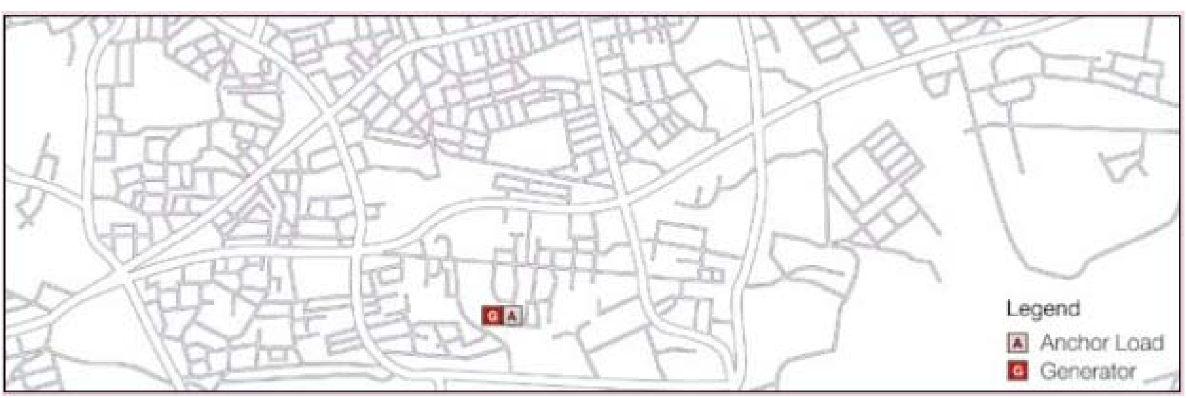
2.1.5 Types of CHP Systems

CHP systems are usually categorized based on the scale of power production. There are three main categories that describe typical CHP systems: single site schemes (Type 1), multi-site mixed use schemes (Type 2), and area-wide heat transmission projects (Type 3) (*Powering Ahead*, 2009).

2.1.5.1 Type 1: Single site schemes

These schemes are typically used for smaller capacity heating schemes, usually involving little or no district heating network. Energy is produced using small or medium CHP units, typically serving up to approximately 3,000 residential units or equivalent load. A typical electrical power output range for this type of scheme is between 0.3 MWe and 3 MWe. These schemes are made commercially viable by the minimal district heating infrastructure and by requiring the site to import less 'retail' electricity. Typical construction costs for a single site scheme are approximately £10 million with a payback period of approximately five years. The locations of the generator and anchor loads relative to one another for a single site scheme are shown in Figure 6. There is a single generator at the same site as the anchor load (*Powering Ahead*, 2009).

Figure 6: Single site schemes



(*Powering Ahead, 2009*)

Over 100 single site CHP sites have been approved in London. One example of such a site is the Cranston Estate regeneration project. Over five hundred residential units will be connected to an existing decentralized energy network. This network contains approximately 1km of heat network piping and is powered by natural gas. The project is currently predicted to cost £6.5 million and will help to reduce emissions by over 1,200 tonnes each year (*Powering Ahead*, 2009).

2.1.5.2 Type 2: Multi-site mixed use schemes

Multi-site mixed use schemes are significantly larger than most single site schemes, serving more than one site and user type. These systems typically power 3,000 to 20,000 residential units or equivalent load as well as commercial, private and public sector consumers. Depending on the type of fuel, the electric output would be between 3 MWe and 40 MWe. One implementation of a multi-site scheme is the connection of multiple existing single site schemes. This is easily done when equipment at single site schemes needs to be replaced. The benefits of multi-site mixed use schemes come from lower cost fuels and from the operation and generation efficiencies that can be attributed to the scale and diversity of the demand. Typical construction costs for a multi-site mixed use site scheme are approximately £100 million with a payback period of approximately six to ten years. The locations of the generator and anchor loads relative to one another for a multi-site mixed use site scheme are shown in Figure 7. There is a single generator that connects to multiple anchor loads (*Powering Ahead*, 2009).

Figure 7: Multi-use mixed use scheme

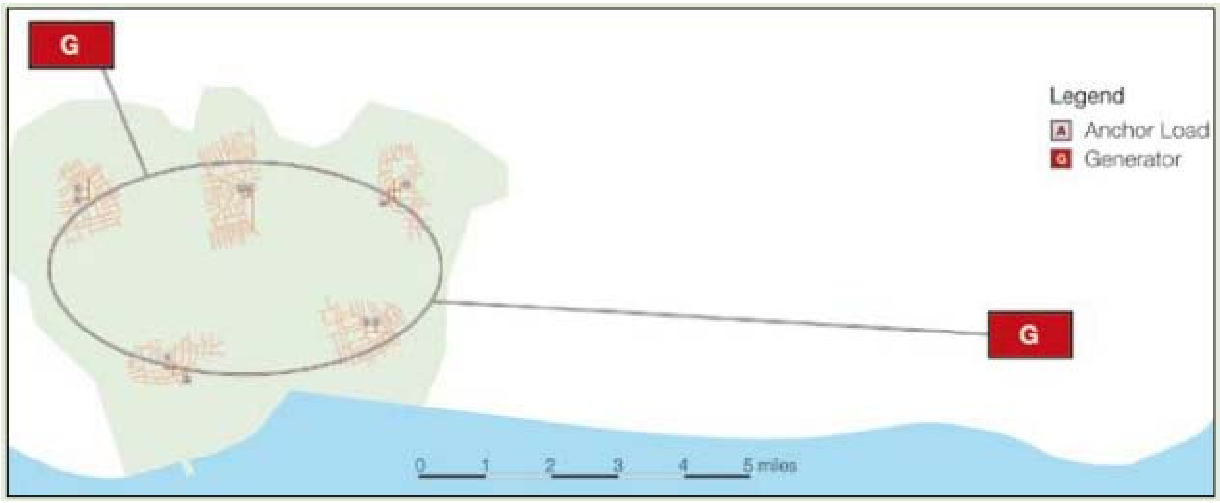
(*Powering Ahead*, 2009)

An example of a large scale scheme would be the Southwark MUSCo project. The Southwark MUSCo project will encompass 7,900 residential units and 38,000m^2 of commercial space which includes the Elephant and Castle and Aylesbury urban regeneration sites. The scheme will use a CCHP system to provide electricity, heat, cooling and hot water services and will be able to connect to existing heat loads as well as sell electric power back to the grid (*Powering Ahead*, 2009).

2.1.5.3 Type 3: Area-wide heat transmission projects

Area-wide heat transmission projects involve more extensive heat pipe networks than single site or multi-site mixed use schemes. These networks connect heat producers like power stations, industrial waste heat or energy from waste facilities into a system that can serve 100,000 or more residential units as well as commercial facilities. Implementation of area-wide heat transmission projects requires that large scale heat producers already be in place and in locations that would make it feasible to connect them into a larger network. Many of these potential heat producers already exist in London and could feasibly be connected into a larger network. Eventually, some of these sites could be consolidated into larger more efficient plants. This type of project could cost more than £100 million with a payback period that could be longer than ten to fifteen years. Area-wide heat transmission projects would create an infrastructure that could eventually create an opportunity to provide energy retail services as well as greatly reduce carbon emissions. The locations of the generator and anchor loads relative to one another for an area-wide heat transmission project are shown in Figure 8. Multiple generation centers supply a network of anchor heat loads (*Powering Ahead*, 2009).

Figure 8: Area-wide heat transmission projects

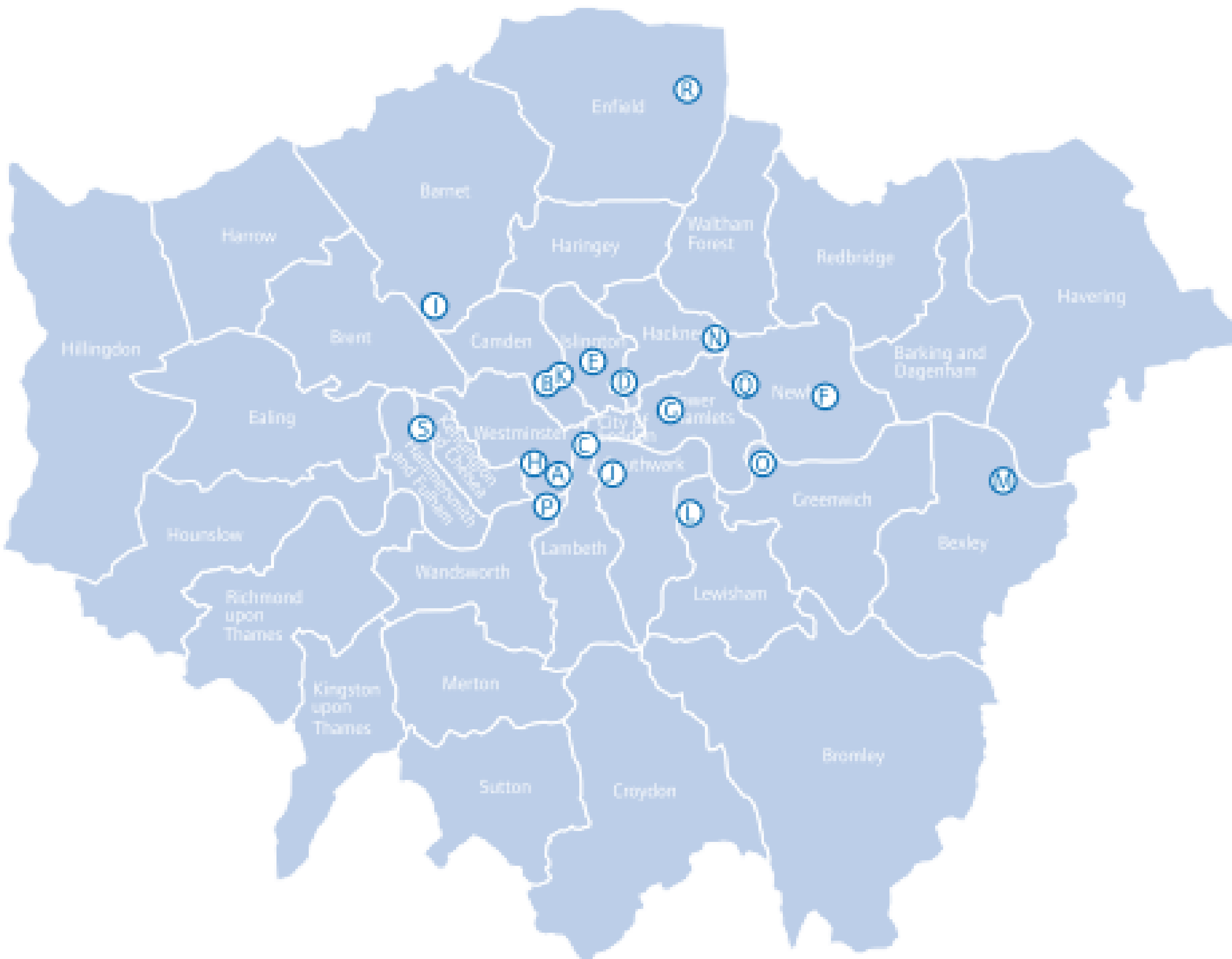


(*Powering Ahead*, 2009)

The London Thames Gateway Heat Network (LTGHN) is an area-wide heat transmission project. Led by the LDA and Communities and Local Government, the project will develop a low-carbon district heating network. The benefits and savings from the project are extensive. Completion of the project is expected to occur between 2010 and 2019 (*Powering Ahead*, 2009). Additional information concerning the London Thames Gateway Heat Network can be found in Appendix B.

Approximately one hundred decentralized energy projects are currently in development in London. They are a combination of the three different types of projects as described in the "Types of CHP Systems" section above. The map in Figure 9 shows the locations of potential projects in London. This is not a complete list, but does show many places where developments are taking place. A table outlining each project can be found in Appendix C.

Figure 9: London Decentralized Energy Project Sites



- A - Whitehall and Pimlico
- B - Euston Road District Healing Scheme
- C - South Bank Employer Group
- D - Cranston Estate Retrofit
- E - Islington District Heating Schemes
- F - London Thames Gateway Heat Network
- G - Leopold Estate Regeneration
- H - Victoria Transport Interchange (VTI) Scheme Land Securities
- I - Brent Cross and Cricklewood, Hammerson and Brookfield Europe
- J - Southwark MUSCo
- K - King's Cross Central
- L - South East London Combined Heat and Power (SELCHP)
- M - Riverside Resouce Recovery Limited (RRRL)
- N - Olympic Fringe
- O - Greenwich Peninsula
- P - Vauxhall/Nine Elms/Battersea OAPF
- Q - Lower Lee Valley DE
- R - Upper Lee Valley OAPF
- S - White City OAPF

(*Powering Ahead*, 2009)

2.1.6 Planning Guidelines and Handbooks

Many resources are available to assist in determining the feasibility of a CHP system. The first goal is to evaluate the heat and electrical consumption for the site(s) that will be supplied by the CHP system to ensure the system has sufficient capacity to meet current and likely future needs. Rutgers University and the United States Environmental Protection Agency (EPA) and similarly the Combined Heat and Power Association (CHPA) in the UK have published guidelines to follow when designing a CHP system for a particular site. The most important consideration is whether or not the waste heat from the electricity generators will be used on site. Facilities with constant heating and/or cooling demands throughout the entire year will see the greatest efficiencies. If there is not a sufficient demand then a major advantage of CHP will be undermined and heat energy will be wasted. Consequently, CHP system should be sized according to heat requirements, rather than electrical needs.

Two general rules for feasible and economical CHP projects are to design a system with at least 60% thermal efficiency and operating 5,000 hours per year. “Here, thermal efficiency is defined as being the ratio of recovered heat plus electricity generated to the fuel input” (Rutgers, 2010). Past energy bills should be reviewed and estimated operating costs should be compared to grid power and current heating costs. This will show the approximate cost savings and the payback period (Rutgers, 2010). The CHPA reports a lower usage guideline from 5,000 hours a year as stated above to just 4,000 hours per year. Other suggestions include choosing a CHP supplier with a product having a good track record, getting an “Operation and Maintenance contract at the same time as the installation,” and finding what grants and funds are available for use (CHPA, 2007).

Potential CHP sites are also encouraged if opportunity fuels can be used. The amount of available fuel needs to be known when evaluating a CHP plant to ensure that the desired amount of energy is produced. If there are insufficient amounts of opportunity fuel, then the fuel supply may be supplemented by additional fuels to increase energy production. There are numerous examples of opportunity fuels being used in CHP plants, one of which is located in the town of Húsavík, Iceland. The town utilizes a system powered by geothermal energy using wells and natural hot springs to collect hot water. The water is then used in a district heating and electricity production scheme (Nelson, 2009).

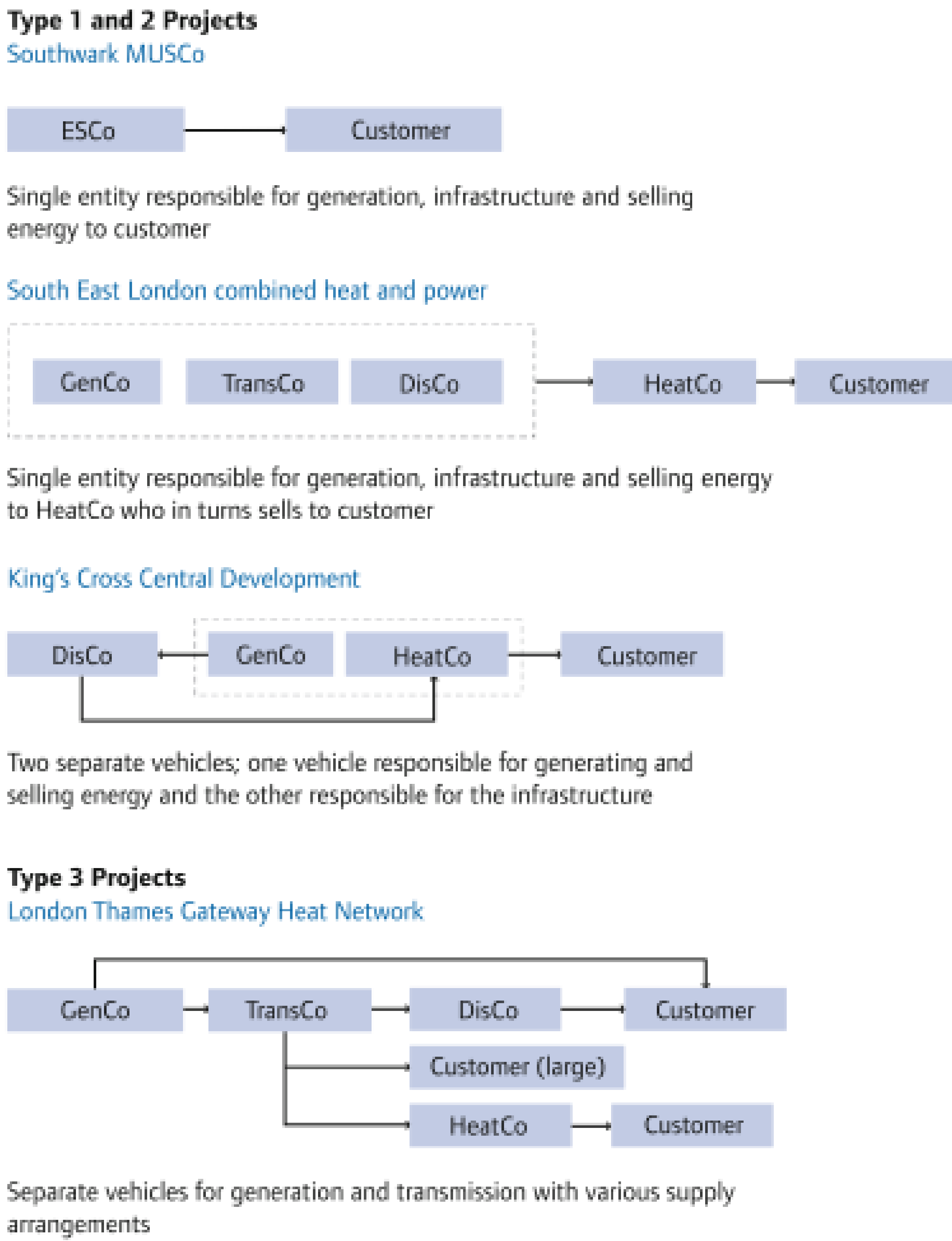
The UK Department of Energy and Climate Change (DECC) has developed a useful internet tool called CHP Sizer (http://chp.decc.gov.uk/cms/tools). The program calculates preliminary estimates of heat and electricity loads and suggests the size of CHP plant that should be considered for a given site. The program uses estimates of basic information such as building size, current energy costs and heating system, and building type and produces a rough cost and environmental analysis (DECC, 2010). This and similar tools should be used in the initial stages of planning and then more accurate techniques further along the development process. See Appendix F for more information on CHP Sizer.

If, after reviewing the preliminary information, the proponent decides to go forward in planning a CHP plant, a more thorough analysis should be conducted of electrical and heat loads, installation and maintenance costs, and emission regulations. One of the main purposes of these systems is to reduce overall energy costs and therefore no final decision should be taken without a thorough assessment of the costs of all the options (EPA 2007; EPA 2009)

2.1.7 Project Structure

The different schemes for CHP development involve many different participating parties that fill important roles like providing energy or infrastructure. An energy services company (ESCo) is an entity that generates energy, provides infrastructure and sells energy to the customer. In this case, a customer is a person who purchases heat or other services. A generation company (GenCo) is an entity that provides assets for generation and sells electricity and heat. GenCos usually remain uninvolved with the infrastructure. A transmission company (TransCo) owns assets related to transmission pipe networks. A distribution company (DisCo) owns and operates the pipe infrastructure. Sometimes a single entity is both a TransCo and a DisCo. A heat company (HeatCo) purchases heat that is then sold to customers. In the absence of a HeatCo, a GenCo will often sell heat. The roles of these parties in the development of each of the CHP project types are shown in the figure below (*Powering Ahead*, 2009).

Figure 10: Project Structures



(*Powering Ahead*, 2009)

2.2 Energy Policies

The reduction of carbon emissions, part of an effort to mitigate climate change, can be partially achieved through the use of DE and CHP technologies. To ensure the implementation of these technologies, it is necessary to create carbon reduction policies, particularly those with provisions for DE and CHP. Regulations and planning policy are currently being developed and have helped lead to the creation of national, regional, and local energy policies.

2.2.1 National Policy: Kyoto Protocol and Climate Change Act 2008

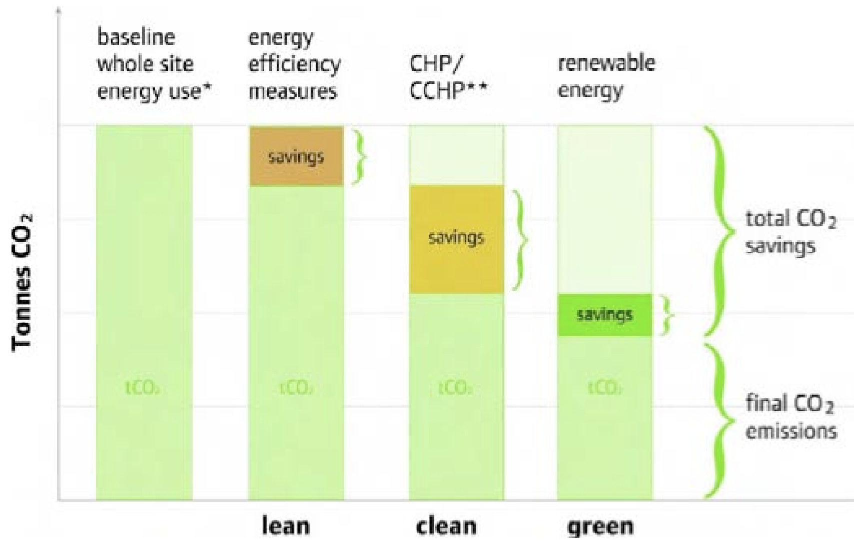
The Kyoto Protocol is an international agreement with the goal of reducing the emissions of greenhouse gases by major industrialized countries. The treaty became legally binding on February 16th, 2005 and as of November 2009, 187 different countries had signed and ratified the treaty (UNFCC, 2010). Each signatory country has agreed to the goal of reducing emissions of greenhouse gases to 5% below the 1990 values by 2008-2012. The United Kingdom has chosen to set its own more ambitious goal to lower emissions to 8% below the 1990 value. The UK surpassed its goal in 2004 (BBC News, 2005); however, the government believed even more needed to be done. In November 2007 a Climate Change Bill was introduced to Parliament and in November 2008 the Climate Change Act 2008 became the world's first legally binding framework that was designed to address climate change. Its purpose is to produce a strong economy while embracing environmentally friendly and sustainable practices (Climate Change Act 2008, 2010).

2.2.2 Regional Policy: London Plan

On a regional scale, the London Plan is "the overall strategic plan for London, setting out an integrated economic, environmental, transport and social framework for the development of London over the next 20–25 years" (*The London Plan*, 2009). It consists of objectives laid out by the Mayor of London with the central goal of the betterment of the Greater London Area. These goals range from improving living conditions in London to improving the economy, accessibility, and transportation. One objective is "to make London a more attractive, well designed and green city" (*The London Plan*, 2010). This objective is the driving force behind many policies related to climate change and energy, which are in turn driven by national and international commitments.

The London Plan addresses DE under the category of "London's response to climate change." The decentralization of energy is a tool to be used in the effort to reduce damaging emissions, particularly CO_2. The mantra emphasized throughout this section of the London Plan is "lean, clean, and green." As illustrated in Figure 10, the goal is to reduce energy consumption and CO_2 emissions by employing energy efficiency measures ("lean"), promoting CHP and CCHP ("clean"), and using more renewable energy ("green") (*The London Plan*, 2008).

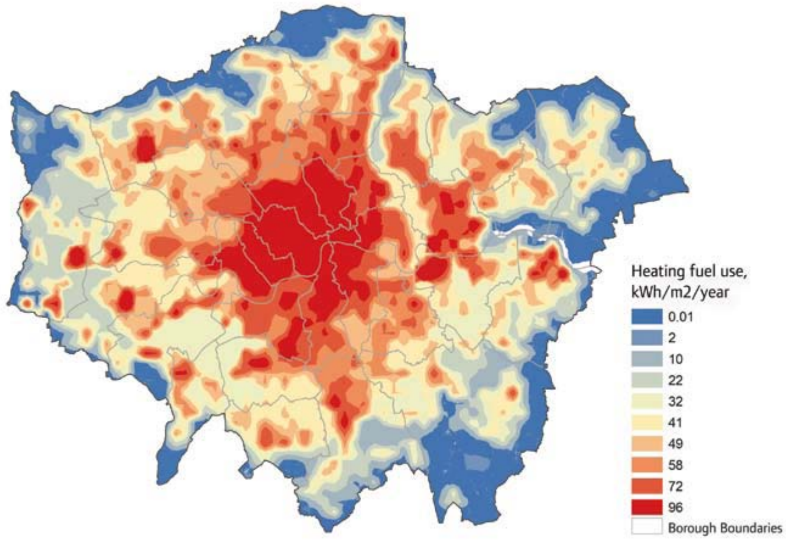
Figure 11: Lean, Clean and Green



(*The London Plan*, 2008, p. 203)

According to Policy 5.5, "The Mayor expects 25 per cent of the heat and power used in London to be generated through the use of localized decentralized energy systems by 2025." Boroughs are expected to develop Local Development Frameworks (LDFs) to establish decentralized energy networks in their communities. Some boroughs may work with neighboring boroughs to develop wider decentralized energy networks. The London Heat Map tool is an online map and database tool created by the Greater London Authority (GLA) to aid boroughs in their energy master planning processes (Figure 11). These maps include information on heat loads (consumers), heat supply plants (producers) and heat and power networks in each of the London boroughs (*The London Plan*, 2009). Following the policies and using the tools provided in the London Plan, individual boroughs like Brent are now taking steps to facilitate the development of efficient decentralized combined heat and power networks. This development is largely facilitated through the development of policies that require developers to consider alternative energy, including decentralized energy systems as well as other alternative measures.

Figure 12: London Heat Map



(*The London Plan*, 2009)

2.2.3 Local Policy: London Borough Initiatives

Many boroughs have begun to develop policies and strategies to promote the development of DE schemes, and the London Development Agency has established the Decentralized Energy Master-Planning Program (DEMaP) to assist in these efforts. These efforts also build on policies similar to the Merton Rule, which was pioneered by the Borough of Merton and has since been adopted by several other boroughs in London and beyond. The Borough of Brent, although only in the beginning stages of its work with DE, has identified areas of development in their Local Development Framework where DE schemes can be incorporated in addition to commissioning the production of a borough heat map.

2.2.3.1 Regionally Sponsored Program: DEMaP

The London Development Agency (LDA) working with the Greater London Authority (GLA) is offering borough councils a support package to help promote the use of decentralized energy. This program is called the Decentralized Energy Master-Planning Program (DEMaP). Some boroughs are at a more advanced stage in the DEMaP program than others and several have yet to enroll, as shown in Figure 12. Twelve boroughs (Barnet, Bexley, Brent, Ealing, Hackney, Kensington and Chelsea, Kingston, Lambeth, Redbridge, Sutton, Wandsworth, and Westminster) are presently in Phase 1 "Capacity Building." Three boroughs (Croydon, Haringey, and Lewisham) are in Phase 2 "DE Feasibility." Four boroughs (Barking and Dagenham, Camden, Islington, and Southwark) are in Phase 3 "Project Definition and Delivery."

Figure 13: Boroughs enrolled in the DEMaP program

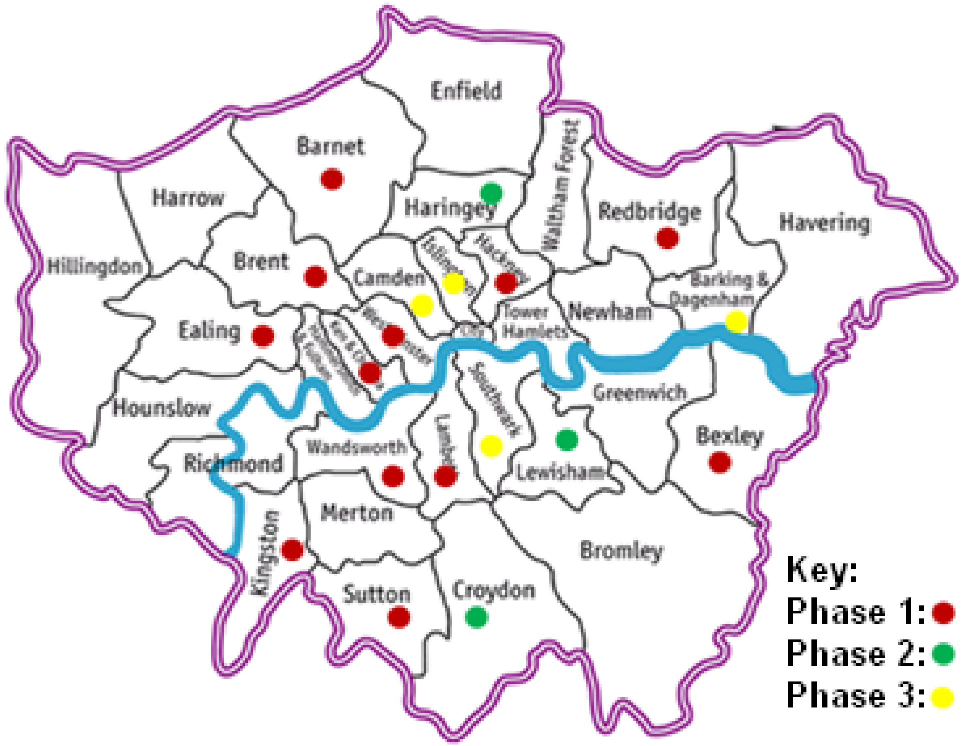


Image modified from map found at http://www.magic-hosting.com/london/images/boroughmap.gif

Phase 1 is called "Capacity Building." During this phase, boroughs develop a leadership plan, carry out heat mapping and realize policies, strategies and budgets to carry out their decentralized energy plan. Table 2 summarizes the details of Phase 1. The top shaded row explains the process, while the bottom row summarizes outcomes.

Table 2: Phase 1: "Capacity Building"

Capacity Building	*Heat Mapping*	*Political Support and Commitment*	*Strategies and Policies*	*Budget Commitment*
Hearts & Minds: Person identified in each borough / project who will champion DE opportunities, identify and engage key officers, establish internal working groups, identify key strategies to incorporate DE policies	Carry out heat mapping of the boroughs using the Methodology developed by the LDA and in accordance with the EMP format; accumulate heat loads into clusters that produce a viable heat load profile for CHP / DH; identify key stakeholder	Using the data from the Evidence base, present to senior influential decision makers to gain support and commitment to progressing the DE opportunities further. Secure DE in strategy documents; In-house training, workshops, guidance	Identify all relevant strategies that be utilized to facilitate the implementation of DE in the borough and ensure that all policies are worded accordingly (e.g. waste, housing, energy, planning, LDF Core Strategy, OAPF, AAP, LEE, SPG, etc)	Secure budget to carry out option appraisal for DE projects; develop implementation programme; and secure internal resources to deliver the programme and upload / manage information to EMP
Energy Champion in borough with resource secured for implementation of DE programme, internal and external stakeholders identified policies and strategies identified with programme for influence	Heat map of borough produced and data uploaded to LDA's EMP database. Key opportunities identified and prioritized for DE projects, land identified and safeguarded for DE projects	Necessary buy-in and commitment from the borough to proceed to feasibly study; internal group established and resourced	All relevant policies within the borough contain supportive text and policies to facilitate DE project delivery and efficient implementation of all DE projects	Budget and Resource secured. Action Plan agreed and signed off with budget allocation.

(North, 2009)

Phase 2, “DE Feasibility,” consists of feasibility studies and the development of delivery routes. Table 4 contains further details of Phase 2. The top shaded row explains the process, while the bottom row summarizes outcomes.

Table 3: Phase 2: “DE Feasibility”

Feasibility Study	***Delivery Route / Procurement Strategy Options***
Assess the technical and financial feasibility if a specified DE project, engage the stakeholders; identify infrastructure routes and constraints, test operational scenarios and CHP sizes, identify anchor loads and key organization / resource to lead project	Based on feasibility study, develop specification for project to include: site identified and secured, size a CHP/biomass/other solution; design of pipework route, MoU with partners, procurement route identified, funding options
Viable project proposal based on agreed objectives, stakeholders engaged, project lead and resource identified	Technical specification for project agreed, including sizing of plant, routing of heating network, customers, funding and procurement route identified.

(North, 2009)

Once boroughs have completed data collection and feasibility studies, they must decide on an appropriate site or sites and move to Phase 3, “Project Definition and Delivery.” In this final phase of decentralized energy planning, boroughs develop the business plans and work out final implementation strategies. These Phase 3 boroughs provide an example for boroughs in the initial stages of decentralized energy planning and can provide valuable information. The details of Phase 3 are presented in Table 5 (North, 2009). Again, the top shaded row explains the process, while the bottom row summarizes outcomes.

Table 4: Phase 3: “Project Definition and Delivery”

Business and Financial Plan	***Procurement***	***Legal***
Capex[4], opex forecast[5], investment appraisal, ensure internal approved, decide on procurement process	Procurement process decision; self build – council owned and operated ES SPV; go to market for third party provider – write spec and prepare tender	MoU for boroughs and other stakeholders involved in delivery; leasehold and freehold issues, contracts, tariffs, etc.
Business Plan completed and approved with funding secured to delivery of project	Procurement completed and partners / structure agrees	Legal contracts agreed and signed off for all partners. Development Agreements, Heat Supply Agreements and necessary MoUs in place

(North, 2009)

[4] Capex: Capital Expenditures; investments in acquiring or upgrading capital (equipment), in the case of DE capital may include plant/piping equipment etc.

[5] Opex: Operating Expenditures forecast; predictions on cost of operation, in the case of DE opex forecast will include potential costs of operating power plants, maintenance of the network, and metering.

2.2.3.2 Borough Initiative: Merton Rule

The Merton Rule, developed in 2003, is a planning policy that aims to reduce carbon dioxide emissions. The Merton Rule states that "all new non residential developments above a threshold of 1,000sqm will be expected to incorporate renewable energy production equipment to provide at least 10% of predicted energy requirements" (Merton Council, 2009). Using established benchmarks based on the floor space and type of building, energy consumption for an existing or planned building can be estimated. From this estimated energy consumption, carbon dioxide emissions can be approximated (Merton Council, 2009). The Merton Council plans to expand the impact of the Merton Rule. In the future, the plan will cover all development in Merton, so that residential development will also have to comply with this policy. The percentage of energy derived from renewable sources will also be increased from 10% to 20%. If development plans include other means of energy efficiency, such as energy efficient lighting or thermally efficient building materials, these can be converted to "points" that can be deducted from the 10% renewable energy requirement (Merton Council, 2009).

The Merton Rule has been influential and many boroughs and other local authorities throughout England have adopted or are in the process of drafting policies that require the incorporation of renewable energy or the reduction of carbon in projects above a specified threshold. Authorities will typically choose to require either the reduction of carbon or the increase in renewable energy in projects as the basis for their policies. The amount of energy required to be renewable and the amount that carbon emissions must be reduced vary between authorities, typically between 10% and 20%. A minimum area of 1,000sqm is the most common threshold for whether or not developers need to comply with the policy.

2.2.3.3 Brent: Planning Status

Although the London Plan frames the direction the city will take, the borough of Brent is still responsible for formulating its own specific policies similar to the Merton Rule. The Council of Brent is synthesizing a Local Development Framework (LDF) that outlines borough wide strategies and details plans for development projects. The LDF comprises numerous Local Development Documents (LDDs) which describe the different pieces of Brent's development plans. The Core Strategy Development Plan Document (DPD) in the LDF then "sets out an overall vision of how the borough and places within it should develop." (Brent, 2009b)

In response to the environmental goals of the UK and Greater London, Brent has assembled plans and objectives to promote the environmental sustainability in the borough. These are reported in the Brent Council's Core Strategy (2009b). The document includes plans to increase the open spaces available to the public for recreational use along with preserving the area's biodiversity. The Council's LDF includes more sustainable practices such as increasing water efficiency and recycling, reducing individual car transportation, and constructing Zero-Emissions Development (ZED) buildings among others (Brent, 2009b). In support of the London Plan, Brent ambitiously aims to decrease CO_2 emissions by 25% from 1990 levels by 2020 (Brent, 2009b). To further tackle the accepted climate change problem, the Council will attempt to reduce energy demand and install at least one Combined Cooling, Heat, and Power (CCHP) plant and two Combined Heat and Power (CHP) plants by 2017 (Brent, 2009b).

Brent's 2009 proposed Core Strategy outlines a vision for major revitalization and development for five "Growth Areas" (Brent, 2009b). The Planning Service is focusing on these areas in support of redeveloping the borough; Wembley, Alperton, South Kilburn, Burnt Oak/Colindale, and Church End are the five Growth Areas. These areas have been identified as having a high potential for growth given the state and condition of the existing developments within the areas and their potential for future, more useful and modernized purposes. The Park Royal district as well as the Northwick Park Hospital/ Westminster University also have growth potential for redevelopment similar to the five Growth Areas. All of these areas can be seen in Section 4, Figure 15. In addition to the major development projects, the Council wishes to introduce new DE centers in these areas taking advantage of redevelopment as a means of incorporating new energy systems. The current vision is to create small energy centers with clusters of mixed use buildings served by combined heat and power plants (CHP). Over time the vision projects these small networks to radiate out and eventually link with each other creating a large network covering much of the area. The Council's vision comes with the difficulty of implementation of DE schemes: the Council will rely on developers within the Growth Areas to implements these CHP networks.

The Planning Service has outlined part of its vision and some past planning applications for specific sites mainly in the growth areas in a DPD. Most of the envisioned developments call for mixed use sites including retail, residential, and commercial space. This type of land use is optimal for CHP implementation because of the constant heat demand it provides. Park Royal was also identified as a potentially good area to develop decentralized energy because of the largely industrial complex located there. The industry located there can provide an energy demand and possible waste that can be used to generate energy (Brent, 2009b).

The Brent Council is currently pushing toward their goal of implementing DE and CHP schemes. The Planning Service is working with the LDA to promote DE within the borough through supporting activities. These activities include "capacity building" and addressing issues within the Borough that will hinder DE planning efforts. The first issue is the lack of knowledge within the Planning Service about Decentralized Energy. Many planners do not fully understand nor know enough about DE therefore making it difficult for them to work with various developers and their planning applications to create energy centers. The Planning Service is hosting LDA sponsored workshops aimed at educating the council employees on DE. Well-informed planners will be better equipped to represent the Council interest in creating DE networks and energy centers.

A focal problem that faces DE planning in Brent is convincing developers to create energy centers. The Council does not own significant portions of land within the borough that CHP can be developed on and does not plan on making a large financial investment for CHP systems in the near future. Because of this, the Planning Service plans to use its development approval authority as leverage over developers. There is no current policy mandating DE and therefore the Planning Service wishes to influence developers to include DE provisions in their plans. To be able to influence developers effectively, the Planning Service desires its planners to be knowledgeable in the field of DE and be able to recognize and speak to its potential with applying developers.

Brent has hired consultants to provide a high resolution heat map of the borough using a variety of data sources in the goal of providing planners and therefore developers with a means of recognizing potential areas for DE networks. The heat map is part of the Capacity Building phase of decentralized energy planning to identify and focus on major heat load areas to start developing energy centers. The Planning Service aims to use the heat map to present a business case to developers and energy companies to demonstrate that there are already potential consumers for a CHP plant, that the investment in a network is worthwhile given the heat demand of an area. The Brent heat map is a tool that the Council will use to further its decentralized energy plans.

2.2.4 Present and Future Development in Brent

Brent has begun the process of introducing decentralized energy and CHP throughout the borough. As has been discussed, national, global, and regional policy has provided the borough with motivation to support the development of decentralized energy networks within the borough. As the borough seeks to influence development to include CHP networks and energy centers, the Planning Service aims to institute DE policy and educate its planners concerning DE and CHP.

3 Methodology

The London Borough of Brent is in the beginning stages of planning and policy development for decentralized energy in order to meet the goals outlined in the London Plan. The Brent Council is currently working to identify areas with potential for decentralized energy networks and form policy to facilitate the development of these networks. The WPI project team's objective was to conduct studies and research to provide information and recommendations to help Brent advance its decentralized energy program. Two types of studies were conducted: growth area studies and examinations of the policies and practices of other boroughs.

An important part of ensuring the development of a decentralized energy network and combined heat and power generation facilities is identifying where plants and networks are most feasible. The engineering consultant firm Rambøll Danmark A/S gathered data for the development of a heat map identifying major existing and planned heat clusters. The team identified and investigated important factors other than heat loads that dictate the viability of a site for DE networks and CHP. These investigations included examination of site allocations and area visits. Using the information gathered and the results of CHP Sizer simulations to demonstrate cost and carbon savings potential, the team formed recommendations for each of the areas investigated. The combination of these two complementary studies, the Rambøll heat map and the WPI area analyses, should provide a good base for future feasibility studies to help Brent establish a case for the development of DE and CHP within the borough.

The areas with potential for decentralized energy networks and combined heat and power are one aspect of these systems with which the planning service needs to be familiar. The team identified the need for a knowledgeable and engaged planning service to ensure the success of a decentralized energy program, especially when the borough will not be the primary developer of networks and energy centers. A planning service prepared to negotiate with developers will need to understand the basics of DE networks and CHP systems, identify when implementation is viable and be able to develop effective policies to facilitate development through the borough. The team conducted interviews with boroughs identified to be in Phase 2 and Phase 3 of the DEMaP program and studies of their policies in order to identify innovative approaches to policy making as well as any practices that Brent may be able to take advantage of while developing its Local Development Framework. The team developed a handbook containing introductory material and resources with more detailed information. With this information and results from the studies conducted by WPI and Rambøll, Brent can begin to advance its decentralized energy program.

3.1 Basic Area Studies

The team completed preliminary area studies on the five major growth areas identified in Brent's LDF as well as the areas around Park Royal and Northwick Park Hospital/Westminster University (see Figure 15, Section 4). The project team intends for these studies to serve as a foundation for future studies.

3.1.1 Area Visits

Area visits were conducted to become familiar with the development areas. Before each visit, a note sheet was prepared and the region was researched. Research included reading the LDF Site Specific Allocation document and speaking to planners from each area team in the Planning Service. During site visits, the team observed and recorded building types and locations as well as social and environmental considerations. Vacancies, building types, special sites of interest, potential heat loads, and potential obstacles were recorded; examples in parentheses in Table 5. This list of 'locations of interest' allowed the team to record a complete layout of the area in terms of what is currently located in and around the sites of the development. By noting the layout of the area, the team could become acquainted with the status and progress of the development areas.

Table 5: Preliminary Site Visit Notes

LOCATIONS OF INTEREST	NOTES
Vacancies **(brown fields, empty buildings, empty lots)**	(summarized area notes)
Types/Locations of Buildings **(office, residential, industrial, retail, etc)**	(summarized area notes)
Sites of Interest **(parks, green space, attractions)**	(summarized area notes)
Potential Heat Loads **(typical high heat demand sites)**	(summarized area notes)
Potential Obstacles **(bodies of water, major arteries, conservation)**	(summarized area notes)

3.1.2 Area Studies

The team developed analyses of each of the areas of development noted. These analyses illustrate preliminary factors which must be considered when assessing a location for its potential to be part of a heat network or location of a CHP energy center. These preliminary factors or considerations that must be made include heat consumption, potential fuels, pollution considerations, economic considerations, construction limitations, and social factors recorded as shown in Table 6.

Table 6: Area Assessment Metrics Chart

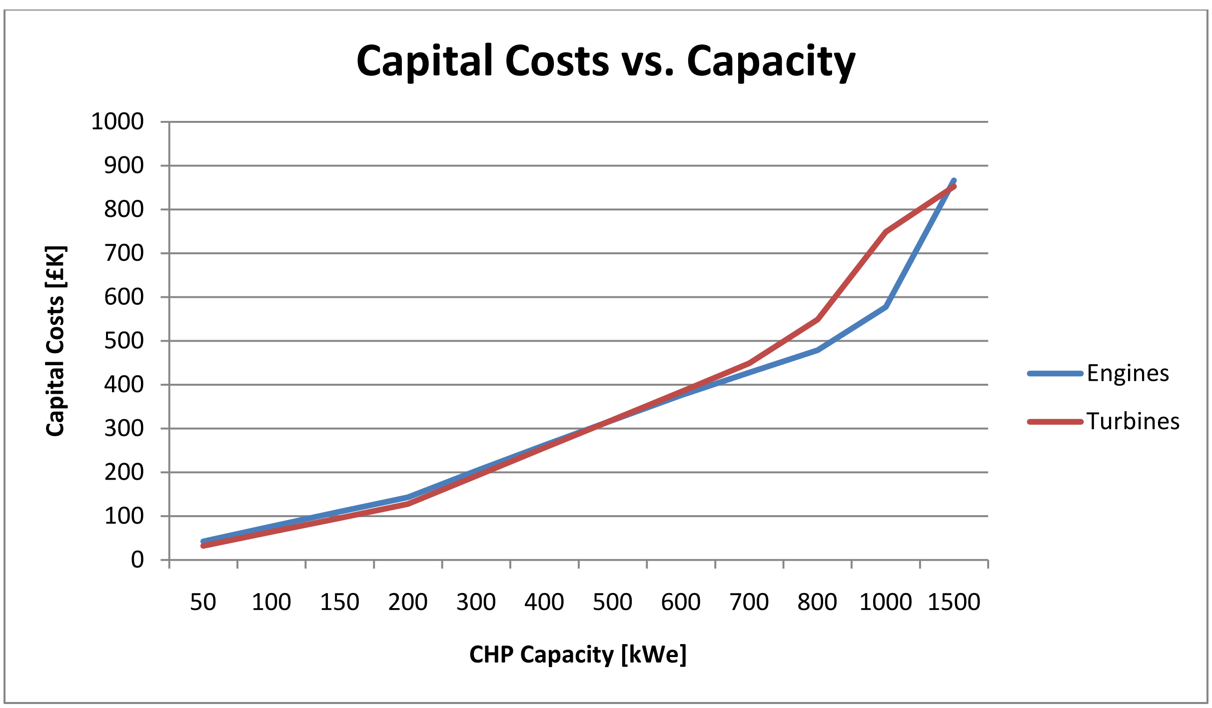
Consideration	NOTES
Heat Consumption **(large potential heat loads or anchor heat loads)**	(detailed description)
Fuel **(potential fuels for the area)**	(detailed description)
Pollution **(possible obstacles, restrictions, etc)**	(detailed description)
Economics **(major/basic financial considerations)**	(detailed description)
Construction **(feasibility of construction in the area for a heat network)**	(detailed description)
Social **(qualitative social limiting factors)**	(detailed description)
Other Notes	(detailed description)

Each area of development has been used by the team to provide Brent with sample CHP economic and environmental figures. The program CHP Sizer uses easily obtainable information to calculate sizing and the related costs of combined heat and power facilities given a number of variables. This program requires building size, type, and location along with current heating system efficiency and energy cost rates. CHP Sizer can generate a range of recommended CHP plant sizes and a rough report of cost benefits, environmental impact, and operating data (sample in Appendix D). The team has used CHP Sizer as a means of providing the Planning Service with a basic outline of potential costs, benefits, and operational data for sample scenarios particular to each area of development.

One site described in Brent's Site Specific Allocations DPD from each of the seven areas of interest was chosen for a basic analysis using CHP Sizer. The team chose these sites because of their mixed use allocations and high development capacity. The Residence Hall profile in the program was extensively used. It represents a stable heat load that only varies with the seasons throughout the year. This would be the case with mixed use developments where heat is demanded relatively constantly during the time span of a day. The heating method used most often in the case analyses below is hot water. This was chosen because heat networks usually use hot water as the transmission medium and therefore buildings connected to a network will most likely use this method for space heating.

To complete the economic portion of the analysis the lowest domestic gas and electricity prices shown for British Gas were used. The team determined that this price was accurate enough for the simple calculations because although this estimate is low because of tiered pricing, by using large amounts of gas it may be possible to secure a lower price through contracts. These two factors work against each other therefore reducing the error in the estimates used for the costs in these examples. Furthermore, a comparison on the initial capital costs of the turbine and engine options are compared as shown in Figure 14. From this information provided by the program it can be seen that the costs are almost the same for smaller plants, but may differ for the larger ones. The results of the CHP analysis are gross estimates to present general figures for local heat loads, required CHP capacities, and associated costs.

Figure 14: Capital Costs vs. Capacity



3.2 Policy Research and Analysis

Brent is currently in Phase 1 of the London Development Agency's DEMaP program and is beginning to examine decentralized energy and combined heat and power potential. Because of limited landownership and funding, development of effective policies and plans will be the most effective means through which the Brent Council can advance decentralized energy planning within the borough. The team examined other borough DE policy and interviewed officials from other boroughs, particularly those boroughs classified as being in Phase 3 of the DEMaP program, to discuss their methods of implementing these systems in the past and their plans for the future.

3.2.1 Policy Research

The project team investigated the policies being drafted by London boroughs concerning decentralized energy. Documents that were reviewed include LDFs from Barking and Dagenham, Camden, Islington, Southwark (all Phase 3) and Croydon (Phase 2). These policies were critically examined with focus on the sections describing decentralized energy. The team was interested in investigating different approaches to the difficult problem of implementing DE within a borough.

3.2.2 Interviews with Other Boroughs

To supplement the team's review of documented DE policies the team conducted a series of interviews with key staff in Croydon (Phase 2 of DEMaP) as well as Southwark, Camden, Barking and Dagenham, and Islington (all in Phase 3 of DEMaP). The team's goal for these interviews was to gain a better sense of what boroughs with more advanced decentralized energy programs have done and plan to do regarding the future of decentralized energy in their boroughs. Through discussion with borough representatives the team gained a more complete understanding of borough policy, initiatives, tactics, and future plans for implementing DE networks. Topics addressed in these interviews include:

- Current state of borough's decentralized energy
- Inquiry into projects: completed, in progress, in planning
- Inquiry into CHP locations; how to determine suitable locations
- Heat map production; data included, how obtained, etc.
- Means of implementing/influencing the implementation of DE networks

- Positive and negative experiences in the DE planning process

The team used these interviews to further its knowledge of DE policy for the development of recommendations as well as to initiate inter-borough communications. Contacts within these boroughs were as follows: Southwark: Bob Fiddick, Camden: Harold Garner, Barking and Dagenham: Ian Lane, Islington: Charlotte Parkes and Ruth Newton and Croydon: Peter McDonald.

3.3 Poster, Brochure and Handbook

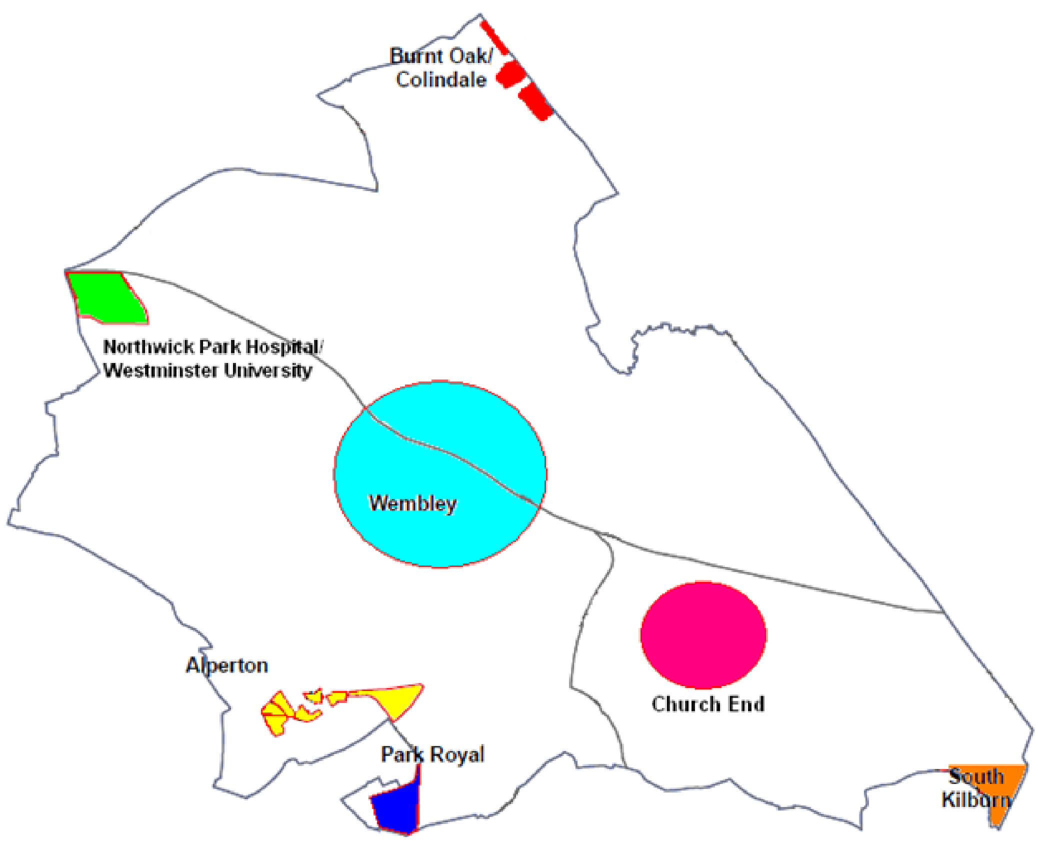
The WPI project team spoke to members of the Brent Planning Service to determine the state of decentralized energy planning in the borough. Because decentralized energy and combined heat and power are new to the borough, there are knowledge gaps within the department. The LDA DEMaP program has provided DE training sessions for boroughs; however, the effectiveness of these sessions is limited to those people who attend. The team identified a need to raise awareness of and encourage interest in DE within the Planning Service. To do this, the team assembled documents with information particularly relevant to the planning service, incorporating information from site visits, interviews with officials from Brent and other boroughs, policies and other important resources and studies that the team identified as relevant.

The team created a poster and brochure to promote interest in decentralized energy and combined heat and power within the Planning Service. These documents provide basic descriptions of decentralized energy, combined heat and power, and energy networks. The concept of reducing carbon emissions was used to provide a point of reference for decentralized energy and CHP. For planners seeking additional information on these systems, a more detailed handbook entitled *Decentralised Energy and You* was compiled using information from websites, interviews, case studies and other handbooks. The handbook was designed to be a single document containing relevant information and a collection of references to more detailed and specialized resources and provides an introduction to decentralized energy and combined heat and power technologies as well as recommendations for how to proceed with decentralized energy planning and policy making.

4 Results

The team has compiled information from interviews with Brent and other boroughs, policy documents, planning documents, and development area visitations which have allowed the group to help advance Decentralized Energy (DE) efforts in Brent. The Brent Planning Service has identified five major development areas in Brent: Alperton, Burnt Oak/Colindale, Church End, South Kilburn, and Wembley. The team has also identified two other areas as potential locations for DE/CHP: Park Royal and Northwick Park Hospital/Westminster University (Figure 15). By examining the Site Specific Allocations DPD of each area in addition to area visits, the team created an initial overview of the areas with respect to their potential for DE. For each development area the team chose a specific site to demonstrate potential economical costs and environmental impacts using CHP Sizer and estimated Local Development Framework phasing and established benchmarks. These initial findings, in addition to the information Rambøll has collected provide a basis for future studies which will evaluate the DE potential of the borough.

Figure 15: Brent Development Areas



Understanding how other borough officials are approaching the implementation of decentralized energy and combined heat and power will help Brent advance its own program. Information about policy and practices obtained during interviews with other boroughs will be a useful resource for Brent in the future. Boroughs with more advanced DE programs have found that motivated and knowledgeable staff are vital to successful implementation of DE. To promote interest and provide basic information about DE planning, the group created documents with varying depths of information. With this basic background and future guidance by the London Development Agency, the planners will be able to identify possible DE/CHP opportunities in development areas.

4.1 Area Analyses

Areas of major development are locations with strong potential for the implementation of a decentralized energy network including CHP. It is easier to include decentralized energy in plans for new buildings than to retrofit and modify existing buildings without communal heating systems. The Brent Council has identified five major development areas in the Borough of Brent. These areas are Alperton, Burnt Oak/Colindale, Church End, South Kilburn and Wembley. In addition to those areas, the group has also identified two additional areas for possible development, Park Royal and Northwick Park Hospital/Westminster University. These areas were visited to assess the feasibility of implementing decentralized energy and CHP.

The team assessed each area based on a set of factors that can benefit or impede an area's potential for DE and CHP. These assessments include very approximate heat consumption estimates based on building types and sizes. Since more detailed data on energy consumption in individual buildings was not available. The study conducted by Rambøll Danmark A/S, consultants hired by the Brent Council, identified heat clusters based on actual and benchmark gas consumption. The availability of fuels in each area and possible fuel sources have been identified based on borough objectives and information. These analyses also identify pollution regulations and air quality considerations. Major construction obstacles and financial considerations have been noted. If the team identified other area specific considerations, this information was also recorded. An evaluation for each area discusses the decentralized energy and CHP potential of each area.

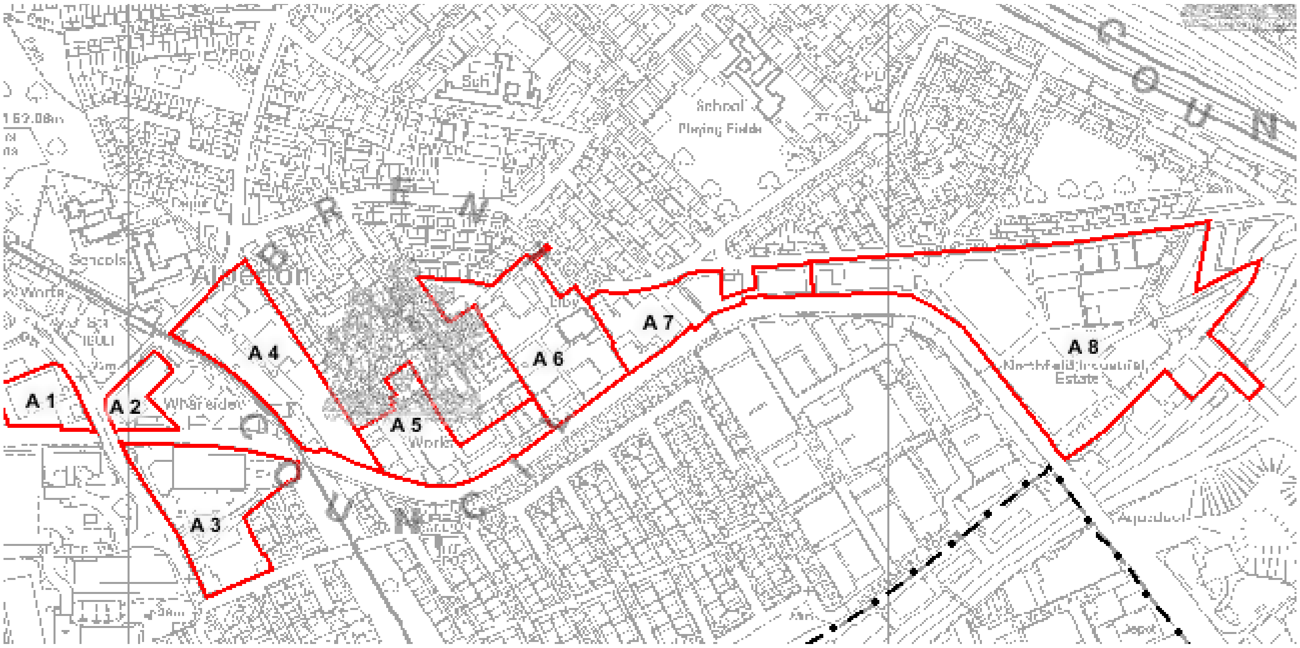
After evaluating each area, certain commonalities were identified. Natural gas is a very common fuel for CHP plants due to its availability. This fuel will likely be a good candidate to investigate in CHP development throughout the borough. Natural gas plants that have a thermal output above 20MW require permits and have special regulations. The same is true for biomass plants with a thermal output over 3MW. Plants throughout the borough will be funded and managed by private entities.

For each development area the CHP Sizer simulation provides estimated emission and cost data that were compiled into a series of graphs. Each simulation contains four graphs: CO_2 Emissions vs CHP Size (Turbine), Saving and Costs vs CHP Size (Turbine), CO_2 Emissions vs CHP Size (Engine) and Saving and Costs vs CHP Size (Engine).

4.2 Alperton

The Alperton development area is located in the south western area of Brent. The council chose Alperton as a development area because of its location on the Grand Union Canal. The council plans to "facilitate a shift in character towards a compact and sustainable waterside community" (Brent SSA, 2009). This will be achieved through the development of least 1600 new homes and making Alperton an "enterprise hub, with a new supply of modern light industrial units, studios and managed affordable workspaces for creative industries, local business and artists to reinvigorate the local economy" (Brent SSA, 2009). Figure 16 shows the eight mixed-use development sites (A1-A8). Mixed-use planned developments are ideal locations for implementation of CHP facilities, which is why the team has looked into this area.

Figure 16: Site Specific Allocation: Alperton



(Brent SSA, 2009)

The team visited the Alperton area and investigated the basic requirements and obstacles affecting future implementation of a CHP heating network. There are plans in Alperton for high density mixed use retail and housing estates which can provide the continual heat demand needed for CHP. The close proximity of the development sites will minimize infrastructure making Alperton an attractive possibility for a heat network. However, there are numerous obstacles to that will affect implementation of a heat network. The Grand Union Canal, the London Underground, and Atlip Road (heavy traffic) surround the development sites. These barriers will need to be considered during future construction; piping infrastructure can run under or above these obstacles with added difficulty and cost. In addition to these barriers, directly north of the development sites are large blocks of individual housing. It is unlikely retrofitting these housing units individually to connect to a network will be economical, limiting future extension of a heat network. The Grand Union Canal area has potential to become a very attractive area for future residential and retail development and the social implications of an energy center located near or along the canal may prove difficult in the future. The team has simulated the economic costs and environmental savings at the Former B&Q and Marvelfairs House redevelopment site in Alperton (A3).

4.2.1 CHP Sizer: Former B&Q and Marvelfairs House site in Alperton

The team used the program CHP Sizer to give a rough estimate of the CHP capacity needed for a development site within the areas of interest. Most of the sites that were chosen have mixed use allocations for new development and high development capacities. The site chosen in the Alperton growth area was the former B&Q and Marvelfairs House. This site currently consists of vacant and underused industrial and retail buildings with the concept to develop new "residential, amenity space, B1 employment and A3 uses." The Council also wishes to improve the environment around the canal by expanding open space and cleaning this area along it. The phase dates and projected numbers of units in Table 7 were given in Brent's LDF; based loads and CHP capacities are based on the team's analysis. Heat use estimates were calculated by entering a profile and Gross Internal Area (GIA) into the program. The profile chosen for this and most of the sites is the residence hall profile because of the constant heat load. GIA was found using the benchmark of 80 m^2 per unit. CHP estimates were chosen on the system size that delivered the highest carbon emission reductions and lowest payback period.

The team formulated graphs (Figures 17-20) comparing these two important factors against the estimated CHP capacity for the final development capacity. Figures 17 and 19 show CO_2 emissions with and without a CHP plant. In these figures the green area shows the carbon reductions when utilizing a CHP plant for a range of plant capacities. Figures 18 and 20 compare the annual electricity savings with the running costs of the CHP system at varying capacities. How quickly a CHP can pay back its original installation costs depends on the net saving of the system. The net savings, or the difference between the electricity savings and costs, are shown by the green area. Savings are based on the amount of electricity generated and costs include the expenses for additional fuel (compared with just a heating system) and maintenance. Costs are for the turbine or engine facility and equipment only and do not include the costs of the heat distribution network. Payback periods given in the CHP Sizer reports are "simple" meaning that they are only based on estimated savings and costs and not more complicated issues such as loan financing with compiling interest. The gas engine and gas turbine CHP plant type options were both used and compared in the team's analysis.

Our recommendations are based on the final CHP capacities for each site. Our preliminary analysis indicates that the 200 kWe turbine option had the lowest payback time of 2.3 years. This option would also reduce carbon emissions by 170 tonnes per year, or 6.8%. The engine option reduces carbon emissions by an extra 0.4% (10 tonnes), but also has a higher payback period of 2.5 years. The team's overall recommendation is the 200 kWe engine because of the increased carbon savings and marginal increase in payback period.

Table 7: Phased Development Data: Alperton

Indicative Development Phasing	2011 - 12	2013 – 14	2015 - 16	Final
Indicative Development Capacity	210 Units	105 Units	105 Units	420 Units
Estimated Base Heat Load	95 kW	47.5 kW	47.5 kW	190 kW
Estimated CHP Capacity	100 kWe	50 kWe	50 kWe	200 kWe

Figure 17: CO_2 Emissions vs. CHP Size (Turbine)

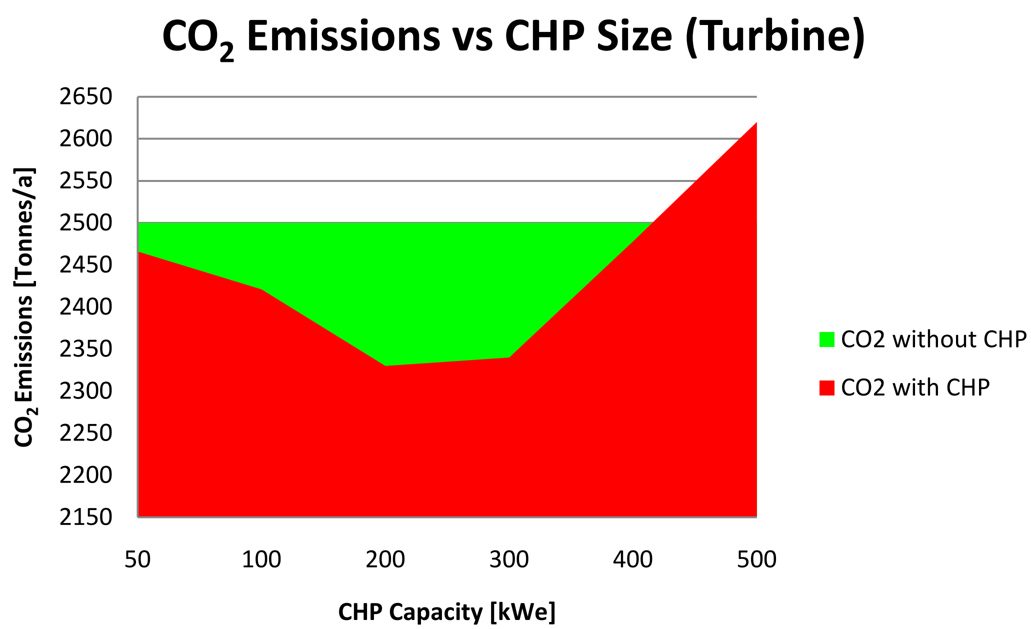


Figure 18: Saving and Costs vs. CHP Size (Turbine)

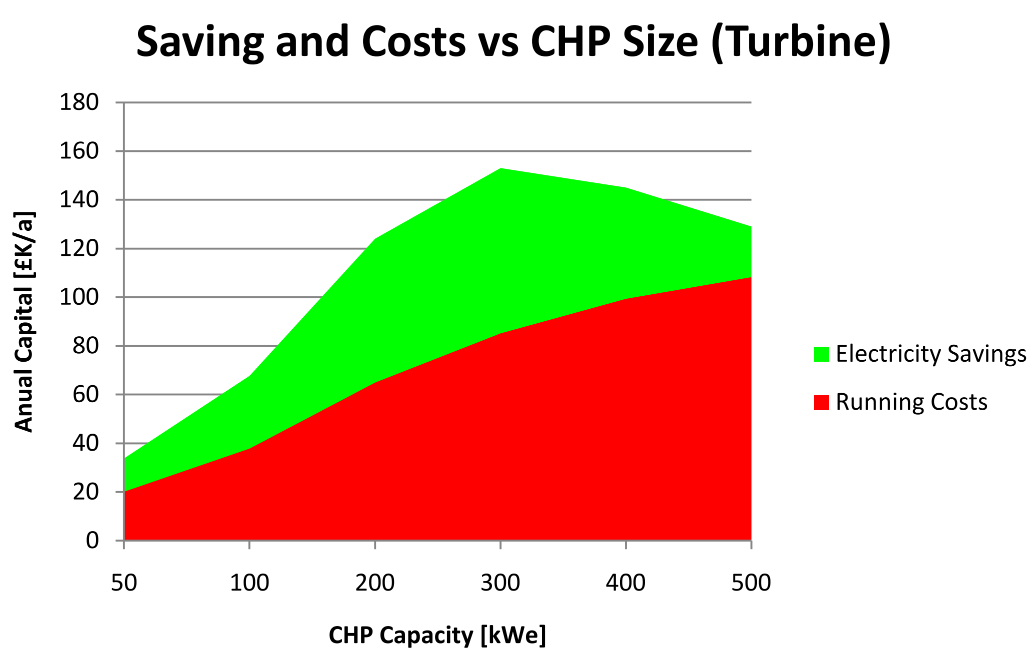


Figure 19: CO2 Emissions vs. CHP Size (Engine)

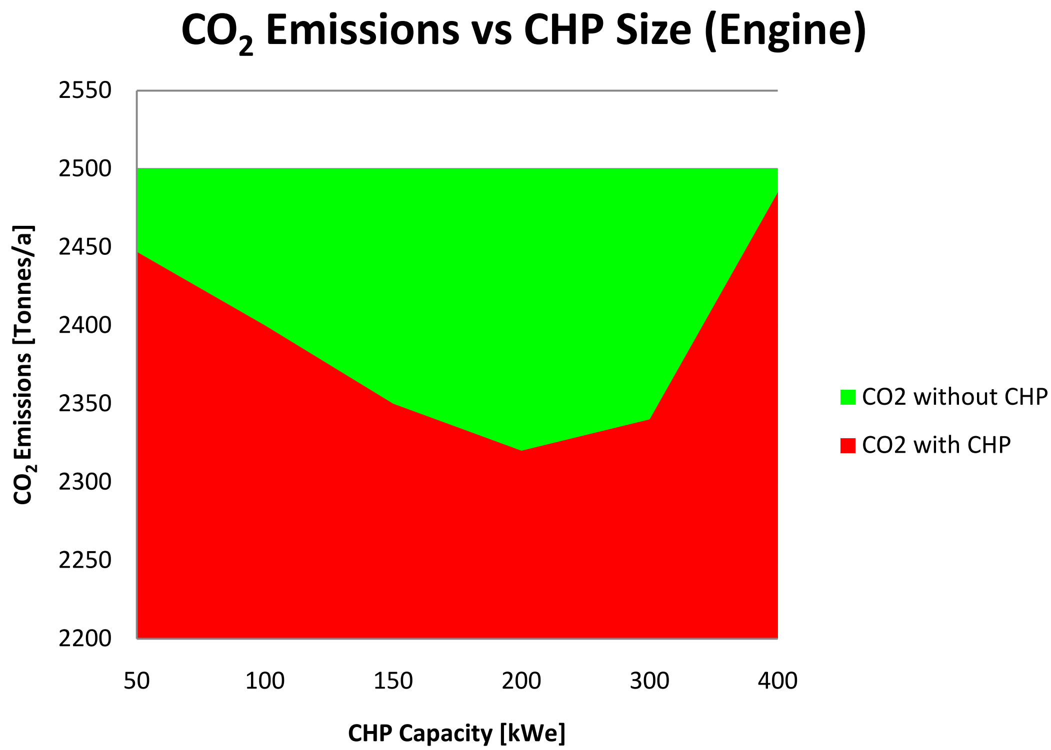
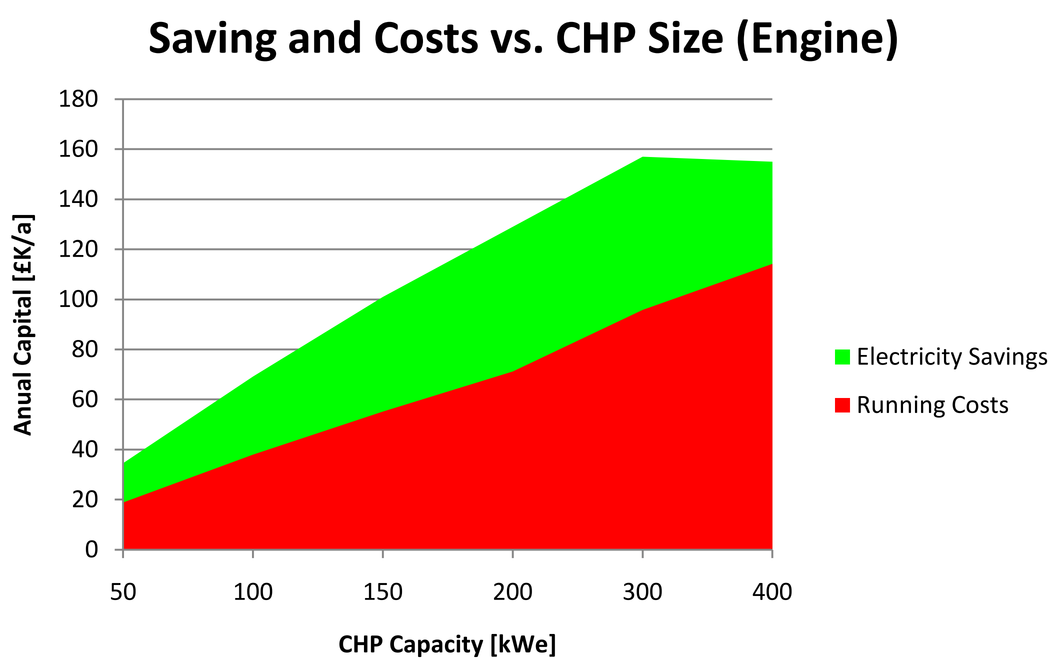


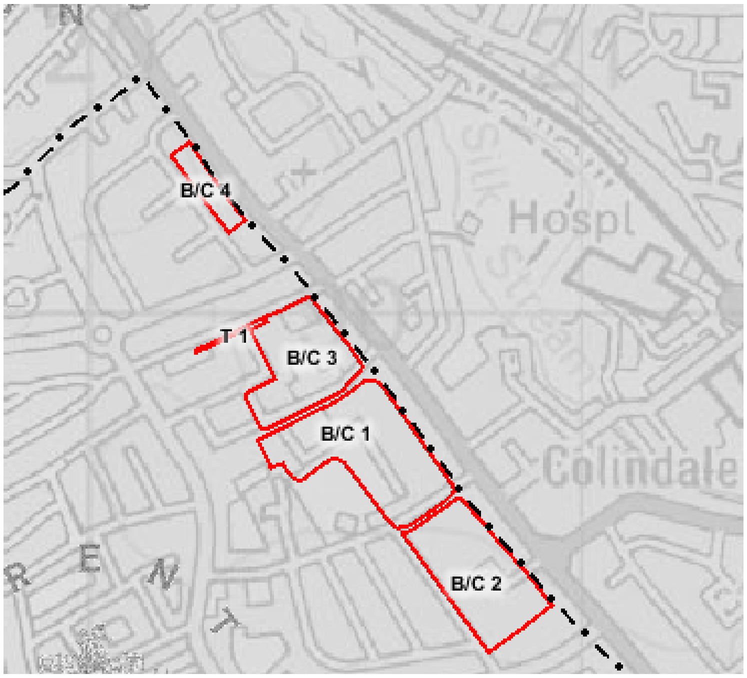
Figure 20: Saving and Costs vs. CHP Size (Engine)



4.3 Burnt Oak/Colindale

The Burnt Oak/ Colindale development area is located in the north east corner of Brent bordering the Borough of Barnet. The council has chosen Burnt Oak/ Colindale as a development area because of its location along Edgware Road, which separates Brent from Barnet. The council plans to "facilitate a shift in character and use towards a tradition street pattern supporting pedestrian movement, street frontages and public spaces and squares" (Brent SSA, 2009). This will be achieved through the development of least 2500 new homes and new economic activity will be created in the form of ground floor commercial" (Brent SSA, 2009). Figure 21 shows the four mixed-use development sites (B/C1 - B/C4). Mixed-use planned developments are ideal locations for implementation of CHP facilities, which is why our group has looked into this area.

Figure 21: Site Specific Allocation: Burnt Oak/ Colindale



(Brent SSA, 2009)

The team visited the Burnt Oak/Colindale area and investigated the basic requirements and obstacles affecting future implementation of a CHP heating network. Proposed plans include development of new housing units as well as office buildings and retail stores, resulting in a constant heat load. The neighboring borough of Barnet has plans for the development of a heating network nearby across Edgware Road and has identified anchor loads to support the system. Although Brent's plans are not fully defined, developments in the Burnt Oak/Colindale area may have the opportunity to connect to the Barnet network. An energy center located on the Brent side of Edgeware Road will not be necessary if connection is made to the Barnet network although B/C1 and B/C2 development sites contain large areas of vacant land which may be suitable for an energy center. Although Edgware Road could provide for easy shipments of fuel to an energy center, it is a main artery containing numerous bus stops and high traffic flow. Construction involving the disruption of Edware road for pipe work (connection to the Barnet network) will need to be carefully considered. With the development of the Barnet heating network, Burnt Oak/Colindale has the possibility for future connection to or even development of its own smaller heating scheme. The team has simulated the economic costs and environmental savings at the Oriental City and Asda redevelopment site in Burnt Oak/Colindale (B/C1).

4.3.1 CHP Sizer Burnt Oak / Colindale: Oriental City and Asda

The site chosen in the Burnt Oak / Colindale growth area was the Oriental City and Asda. The current site contains retail warehouse buildings with the concept to create new "mixed use development including residential, retail (for bulky goods), food and drink and community facilities." Planning permission has been given for a large development, but the site work has not begun. The team used the CHP Sizer reports to produce Table 8 and the graphs shown in Figures 22 to 25. We determined that the CHP capacity of 600kWe adds the most benefit to this site. Our preliminary analysis indicates that the 600kWe turbine option had a slightly longer payback period (2.4 years) than the engine (2.3 years), but lower carbon emissions. Therefore the turbine option is recommended and will reduce CO_2 emissions by 8.5% (500 tonnes) as compared to conventional methods.

Table 8: Phased Development Data: Burnt Oak/ Colindale

Indicative Development Phasing	2013 - 14	2015 - 16	2017 - 18	2019 - 20	Final
Indicative Development Capacity	250 Units	250 Units	250 Units	225 Units	975 Units
Estimated Base Heat Load	113.1 kW	13.1 kW	13.1 kW	101.8 kW	190 kW
Estimated CHP Capacity	150 kWe	150 kWe	150 kWe	100 kWe	600 kWe

Figure 22: CO2 Emissions vs. CHP Size (Engine)

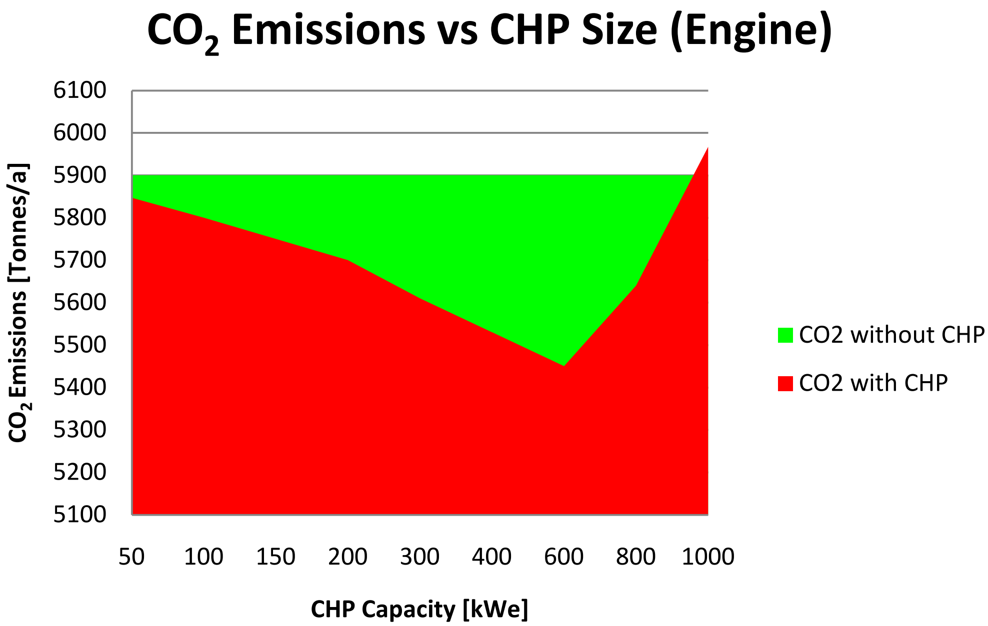


Figure 23: Saving and Costs vs. CHP Size (Engine)

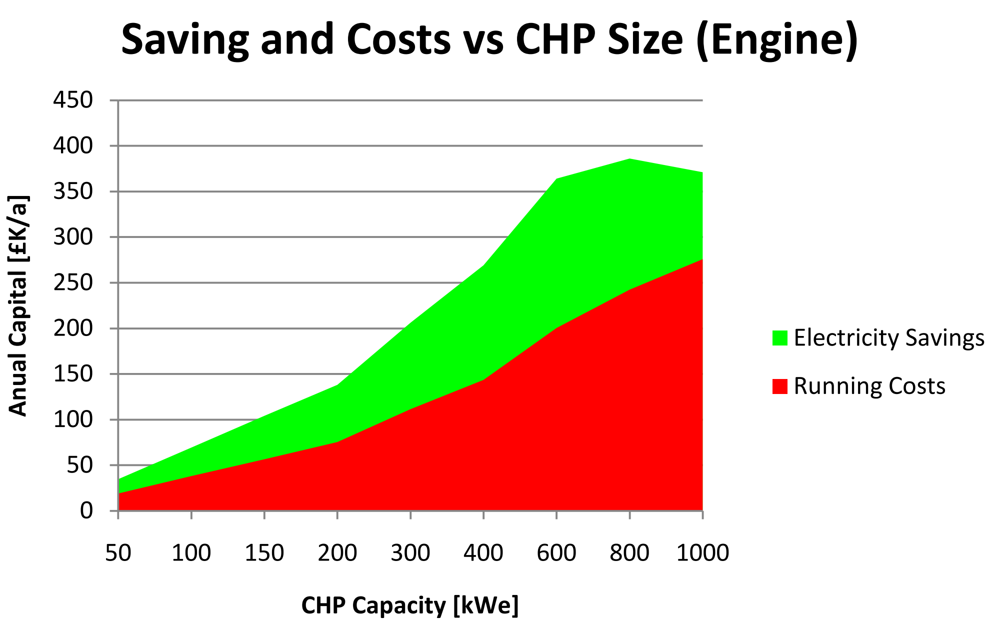


Figure 24: CO2 Emissions vs. CHP Size (Turbine)

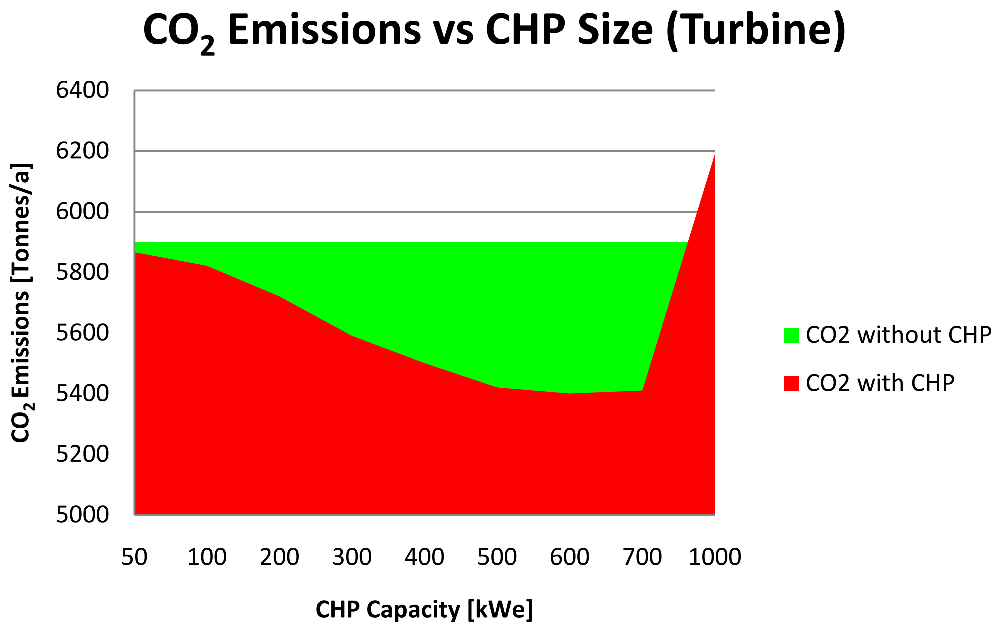
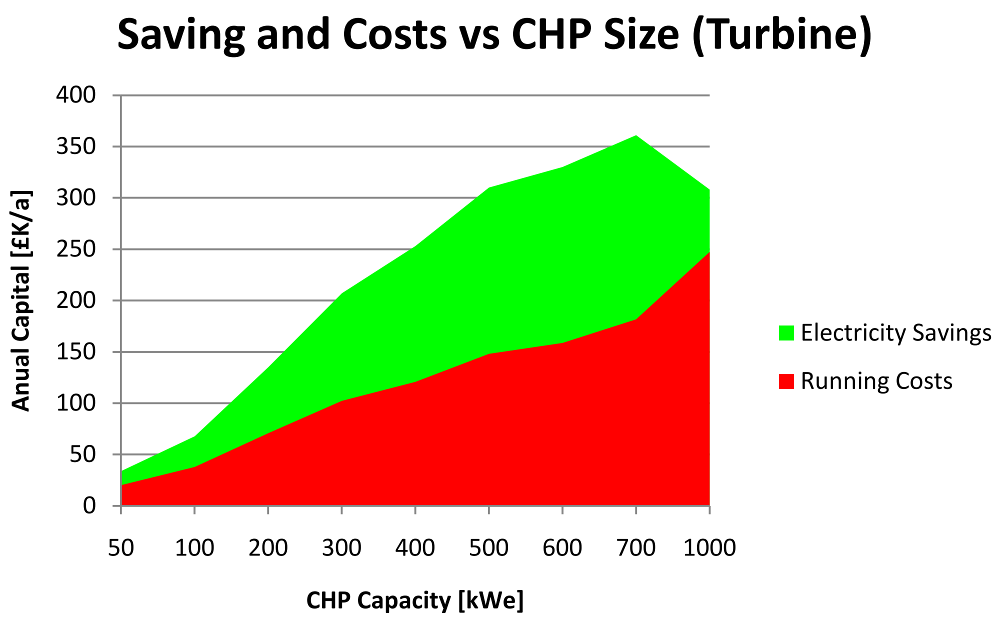


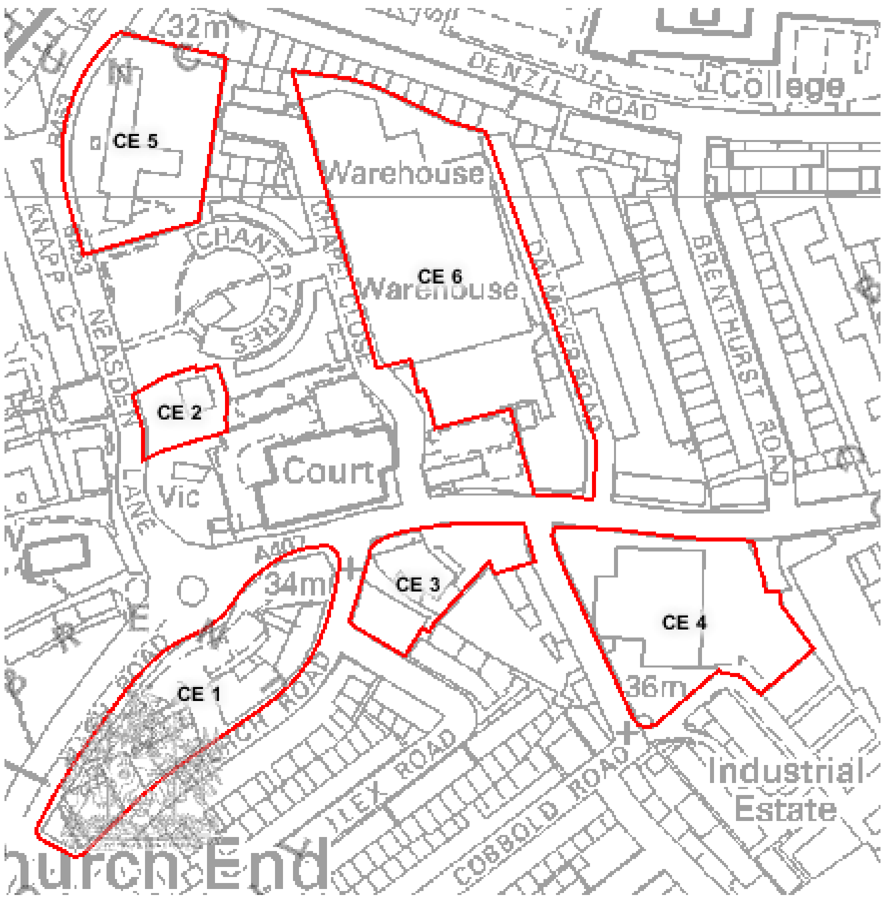
Figure 25: Saving Costs vs. CHP Size (Turbine)



4.4 Church End

The Church End development area is located in the center of Brent, south east of Wembley. The council has chosen Church End as a development area because it is an older part of Brent that could use redevelopment. The council plans to promote mixed use regeneration with economic revitalization of the local center to physically improve the area (Brent SSA, 2009). This will be achieved through the development of least 800 new homes, affordable premises for local businesses and new open spaces and outdoor recreation facilities" (Brent SSA, 2009). Figure 26 shows the six mixed-use development sites (CE1 - CE6). Mixed-use planned developments are ideal locations for implementation of CHP facilities, which is why our group has looked into this area.

Figure 26: Site Specific Allocation: Church End



(Brent SSA, 2009)

The team visited the Church End area and investigated the basic requirements and obstacles affecting future implementation of a CHP heating network. Although construction has already begun at the CE2 site, other redevelopment has not begun. The proximity of the Church

End sites is ideal for the implementation of a network and the re-build plans for the area will allow for easier installation of the necessary heating infrastructure. The atmosphere of the Church End area is not necessarily conducive to a modern energy facility. Historic sites of worship are spread throughout the area in addition to large open spaces (parks) near the Chancel House development area. Also, although there is planned re-build development in the area, many of the building on the development sites are occupied and in use. Massive retrofitting would need to take place to connect these buildings to a heat network took place; demolition and new build would be the more likely scenario. Taylors Lane Power Station is also located within Church End; the power station currently serves as a back-up station only in operation when demand exceeds the grid's supply. If the power station is ever made continually functional, it may be a source of heat for a local network including the sites of development. The team has simulated the economic costs and environmental savings at the Asiatic Carpets redevelopment site in Church End (CE6).

4.4.1 CHP Sizer Church End: Asiatic Carpets

The site chosen in the Church End growth area was the current Asiatic Carpets warehouse. Currently a large industrial building is located at this site. The Council has the concept to develop residential, light industrial and open spaces on this property. The team used the CHP Sizer reports to produce Table 9 and the graphs shown in Figures 27 to 30. We determined that the CHP capacity of 100kWe adds the most benefit to this site. Because of the small scale of this site, it may be easier to connect to a heat network than housing a CHP plant on site. Our preliminary analysis indicates that the 100 kWe turbine option had the shortest payback time of 2.2 years as opposed to 2.4 years, but the carbon emissions were less with the engine. Carbon emissions are reduced from the engine and turbine systems by 7.7% (92 tonnes) and 5.9% (72 tonnes) respectively. The engine system is recommended because the greater carbon reductions are more important than the relatively small increase in payback period.

Table 9: Phase Development Data: Church End

Indicative Development Phasing	2013 - 14	2015 - 16	Final
Indicative Development Capacity	100 Units	100 Units	200 Units
Estimated Base Heat Load	45.2 kW	45.2 kW	90.5 kW
Estimated CHP Capacity	50 kWe	50 kWe	100 kWe

Figure 27: CO2 Emissions vs. CHP Size (Engine)

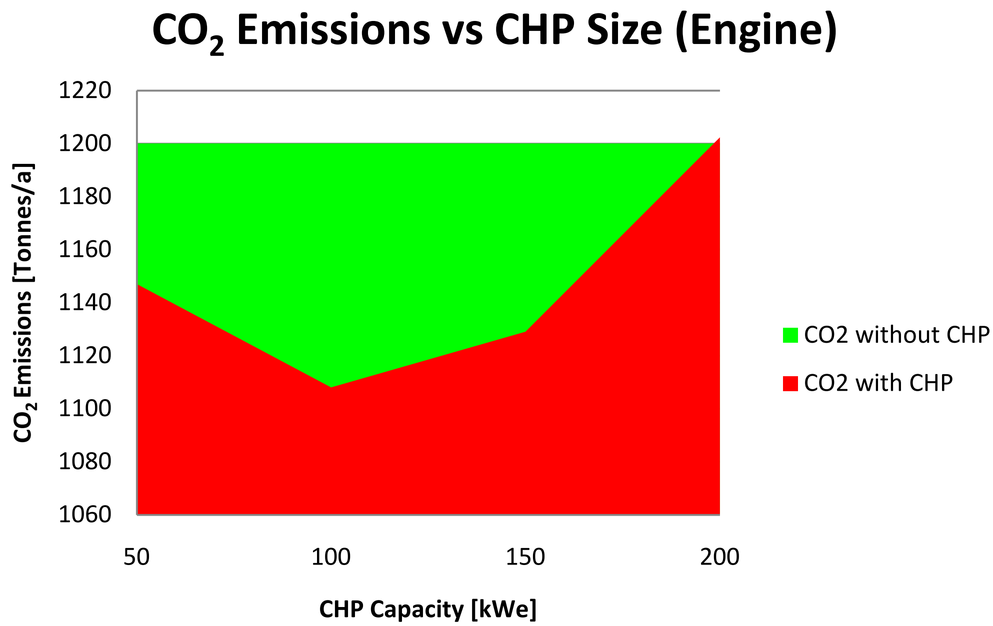


Figure 28: Saving and Costs vs. CHP Size (Engine)

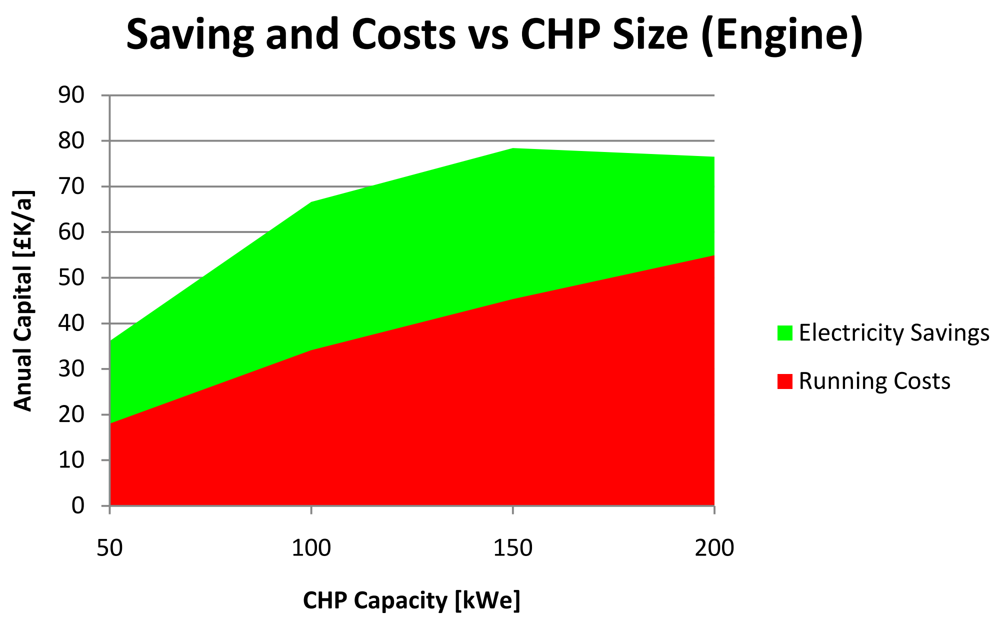


Figure 29: CO2 Emissions vs. CHP Size (Turbine)

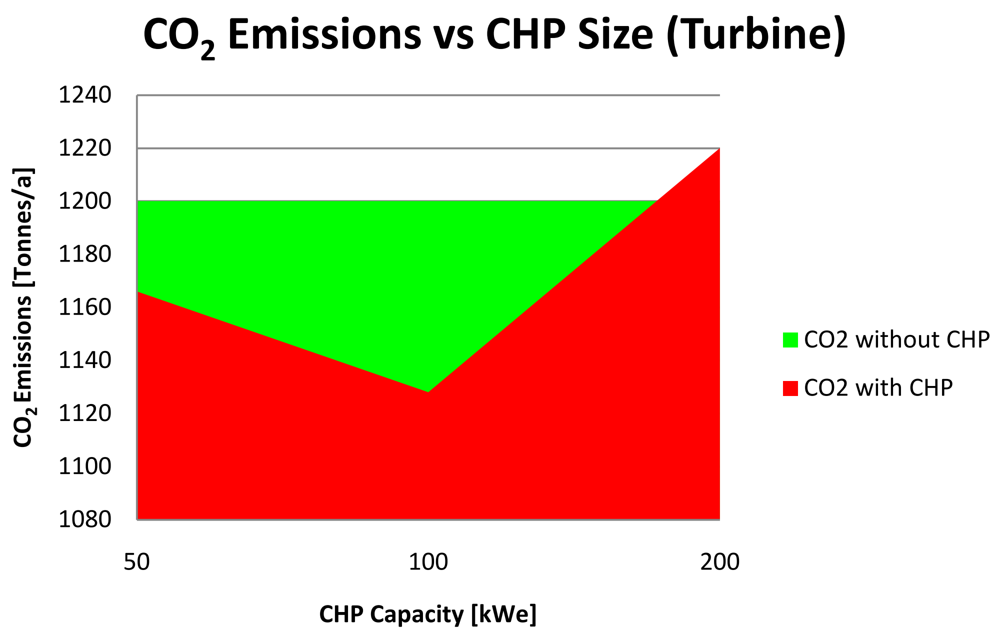
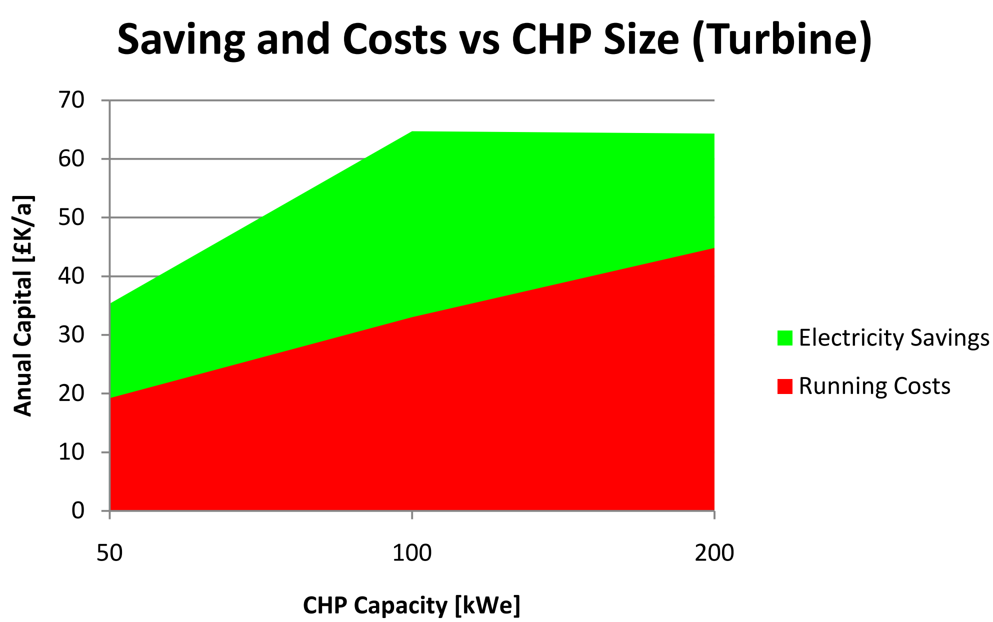


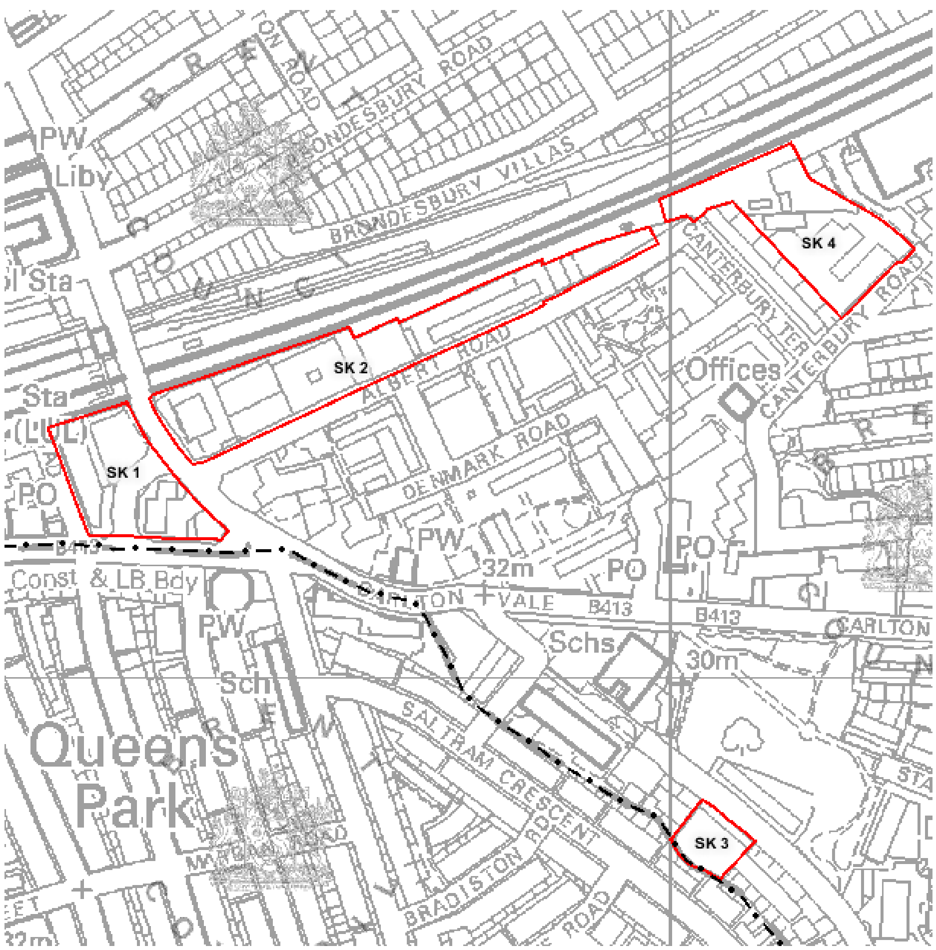
Figure 30: Saving and Costs vs. CHP Size (Turbine)



4.5 South Kilburn

The South Kilburn development area is located in the south east corner of Brent. The council has chosen South Kilburn as a development area because this area is primarily composed of council housing. The council plans to promote regenerative development to "change the perception into a busy, thriving, safe and secure section of urban London" (Brent SSA, 2009). This will be achieved through the development of least 2400 new homes, a series of commercial and community facilities and new and improved open and public spaces (Brent SSA, 2009). Figure 31 shows the four mixed-use development sites (SK1 - SK4). The council housing buildings surrounded by small businesses will provide a mixed-use area. Mixed-use developments are ideal for locating CHP facilities, which is why our group has looked into this area.

Figure 31: Site Specific Allocation: South Kilburn



(Brent SSA, 2009)

The team visited the South Kilburn area and investigated the basic requirements and obstacles affecting future implementation of a CHP heating network. Sites within the area of development are small with what can be assumed minimal demands. The London Underground and National Rail Services run parallel to the areas of development and will need to be considered before construction. However, opposite SK2 along Albert Road, there are numerous council owned residential buildings. Although these residential estates are not within the LDF's area of future development, they may prove a substantial heat load/anchor load when renovations/updates to the facilities occur. The team has simulated the economic costs and environmental savings at the British Legion, Marshall House, and Albert Road Day Care redevelopment site in South Kilburn (SK2).

4.5.1 CHP Sizer South Kilburn: British Legion, Marshall House and Albert Road Day Care

The site chosen in the South Kilburn growth area was the British Legion, Marshall House and Albert Road Day Care. Currently there exists a residential building and community facilities on the site. A hotel profile with included leisure facilities was used because of the residential and community facilities concept allocations. The team used the CHP Sizer reports to produce Table 10 and the graphs shown in Figures 32 to 35. We determined that the CHP capacity of 400kWe adds the most benefit to this site. Our preliminary analysis indicates that the turbine option is a better choice than the engine because it has a shorter payback period and lower carbon emissions of 2.7 years and 9.7% (280 tonnes) respectively.

Table 10: Phase Development Data: South Kilburn

Indicative Development Phasing	2013 – 14	2015 - 16	Final
Indicative Development Capacity	172 Units	173 Units	345 Units
Estimated Base Heat Load	26.9 kW	27.1 kW	54 kW
Estimated CHP Capacity	200 kWe	200 kWe	400 kWe

Figure 32: CO2 Emissions vs. CHP Size (Engine)

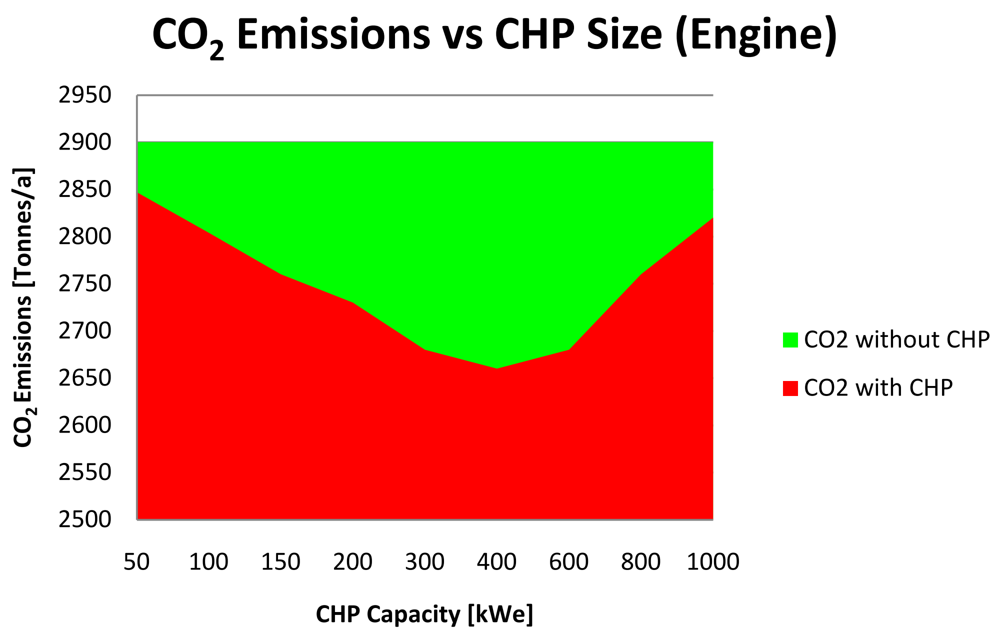


Figure 33: Saving and Costs vs. CHP Size (Engine)

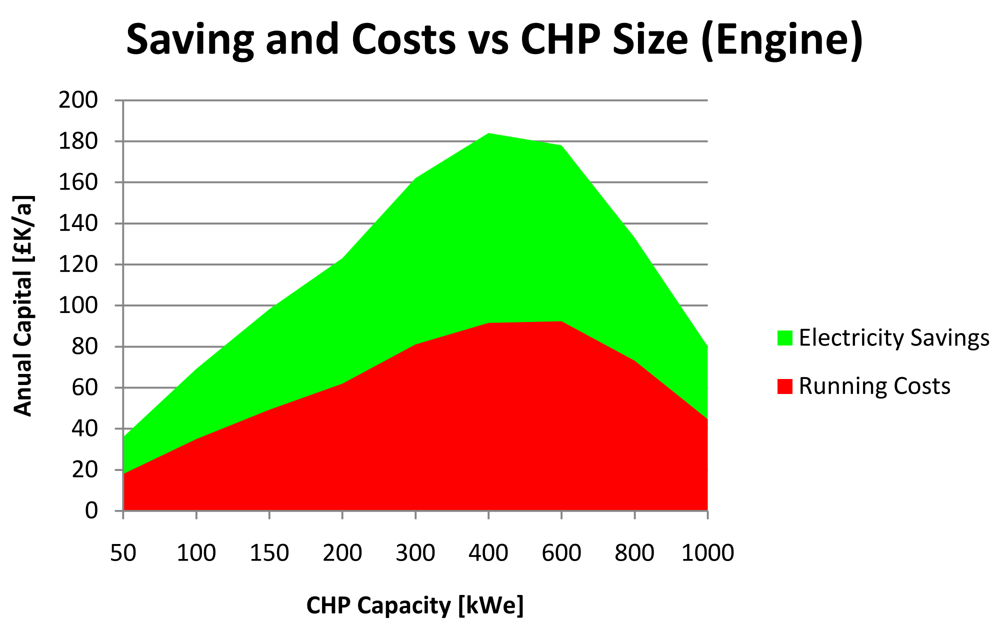


Figure 34: CO2 Emissions vs. CHP Size (Turbine)

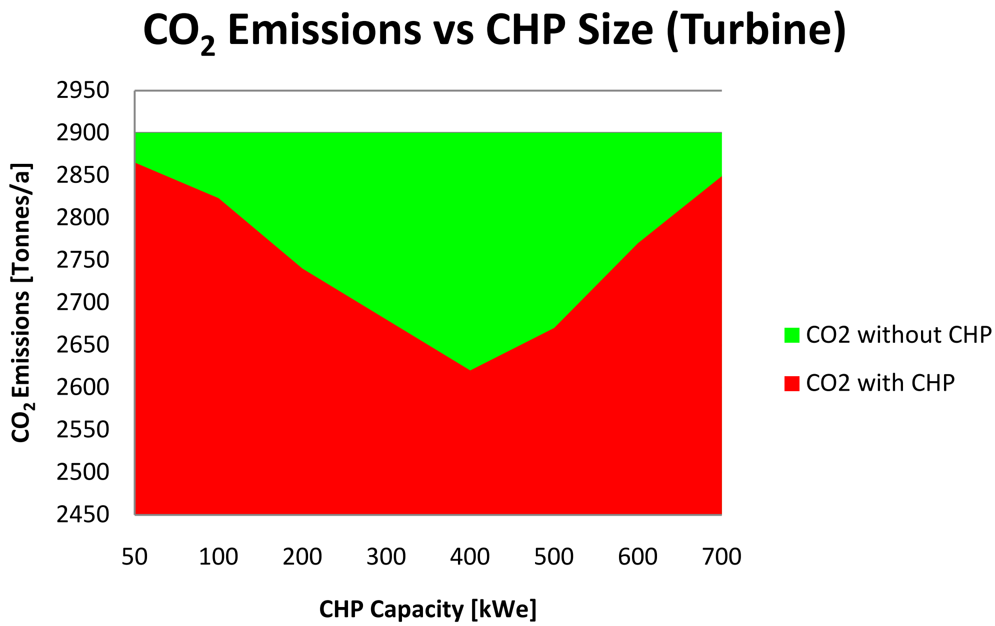
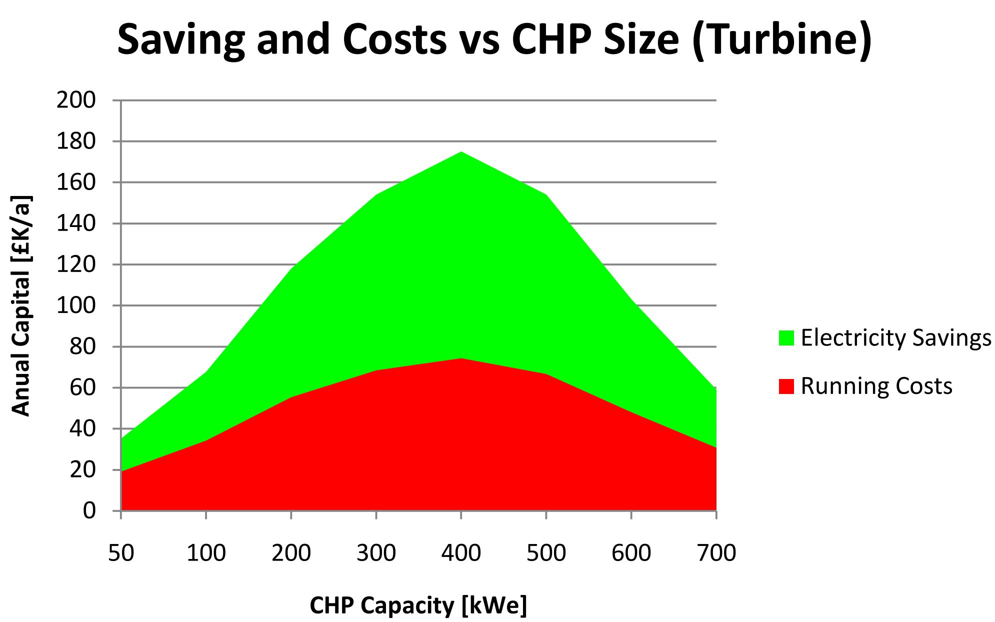


Figure 35: Saving and Costs vs. CHP Size (Turbine)



4.6 Wembley

The Wembley development area is located in the center of Brent. The council has chosen Wembley as a development area because of its location near Wembley Stadium. The council plans to use Wembley to drive the economic regeneration of Brent by generating 10,000 new jobs (Brent SSA, 2009). This will be achieved through the development of least 11,500 new homes, new hotels as well as a new council building for Brent (Brent SSA, 2009). Figure 36 shows the ten mixed-use development sites (W1 - W10). Mixed-use planned developments are ideal locations for implementation of CHP facilities, which is why our team has looked into this area.

Figure 36: Site Specific Allocation: Wembley

(Brent SSA, 2009)

The team visited the Wembley area and investigated the basic requirements and obstacles affecting future implementation of a CHP heating network. There is large scale planned and current development in the area. The Quintain Estates and Development PLC construction of large hotels will provide anchor heat loads within the area of development. In addition, the new Brent Council offices and leisure center will have high enough heating demands to support a CHP heating network. Both the Brent Council development and Quintain developments are located adjacent to one another and connection to an energy center located on either site will allow for minimal infrastructure. Although the Wembley area is undergoing massive redevelopment and large future heat demands will be located close together, the iconic structure of Wembley Stadium and the accessibility to the complex cannot be interfered with. Also, the London Underground at Wembley Park Station may be a future barrier to any extensions to a heat network. The team has simulated the economic costs and environmental savings at the Wembley Eastern Lands redevelopment site in Wembley (W5).

4.6.1 CHP Sizer Wembley: Wembley Eastern Lands

The site chosen in the Wembley growth area was the Wembley Eastern Lands. The site currently has industrial, storage, and waste facilities in it. The concept of new development includes allocations for leisure, hotels, offices, amenity / open spaces, and residential locations. The team used the CHP Sizer reports to produce Table 11 and the graphs shown in Figures 37 to 40. We determined that the CHP capacity of 700kWe adds the most benefit to this site. Our preliminary analysis indicates that the option with the shortest payback period and the lowest carbon emissions is the 700 kW turbine system. This system has a 2 year payback and 8.2% (720 tonnes) carbon reduction.

Table 11: Phase Development Data: Wembley

Indicative Development Phasing	2011 - 12	2015 - 16	2019 - 20	2021 - 22	2023 - 24	Final
Indicative Development Capacity	250 Units	250 Units	250 Units	250 Units	250 Units	1500 Units
Estimated Base Heat Load	113.1 kW	113.1 kW	113.1 kW	113.1 kW	113.1 kW	678.6 kW
Estimated CHP Capacity	150 kWe	150 kWe	150 kWe	150 kWe	150 kWe	700 kWe

Figure 37: CO2 Emissions vs. CHP Size (Engine)

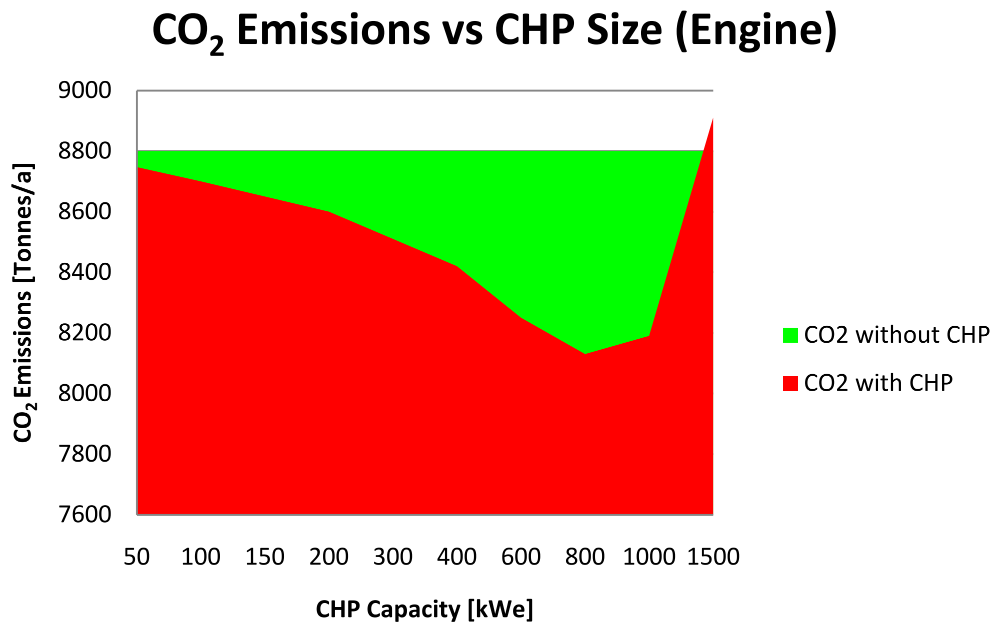


Figure 38: Saving and Costs vs. CHP Size (Engine)

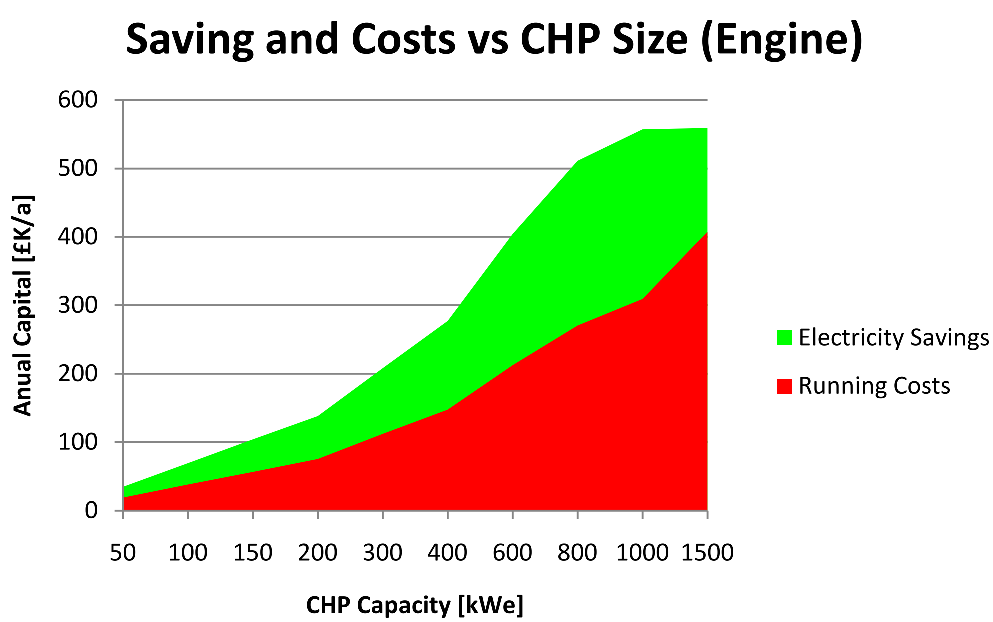


Figure 39: CO2 Emissions vs. CHP Size (Turbine)

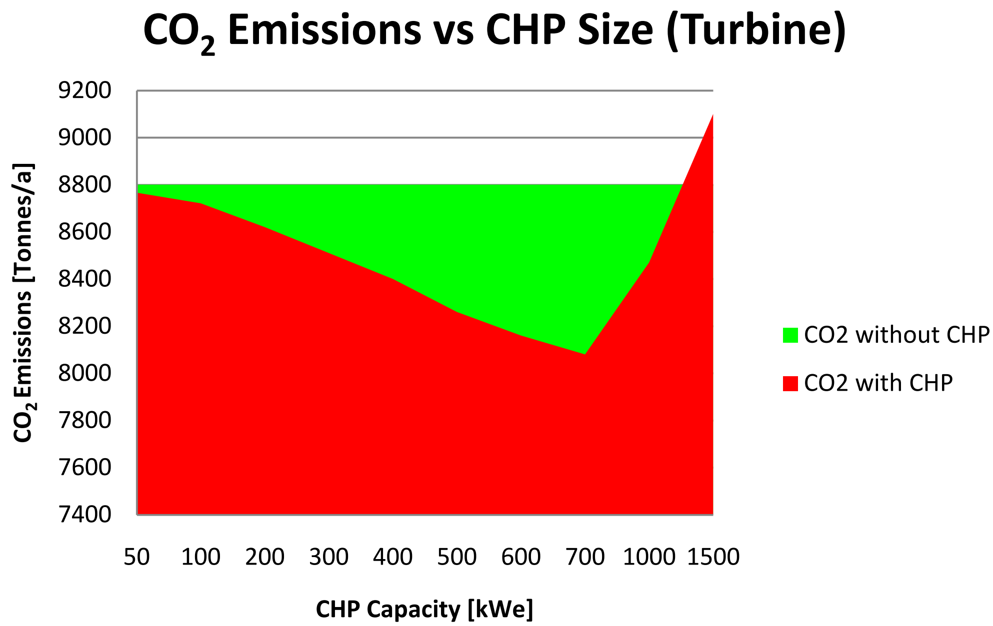
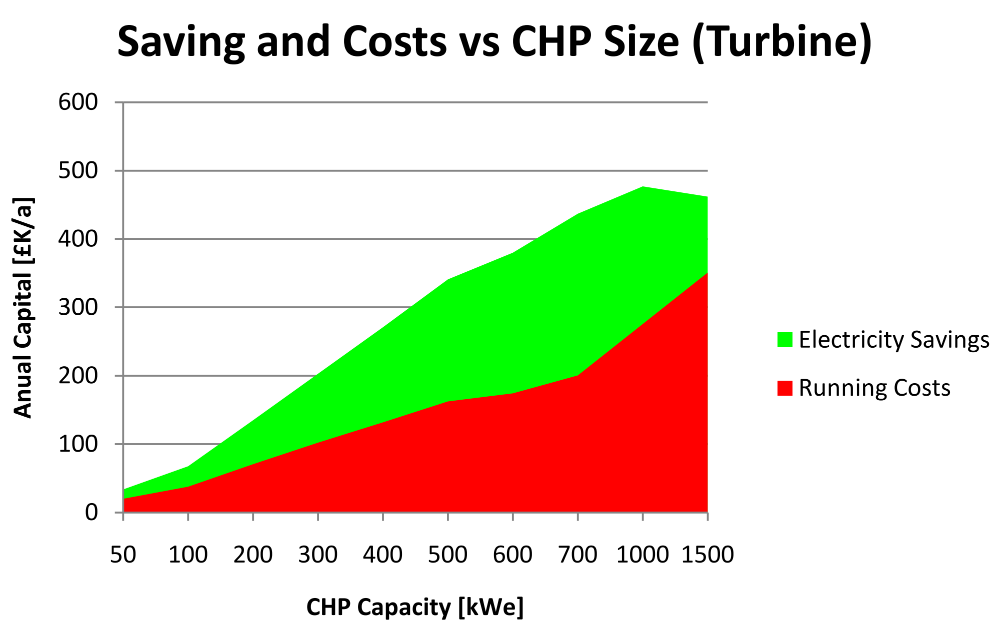


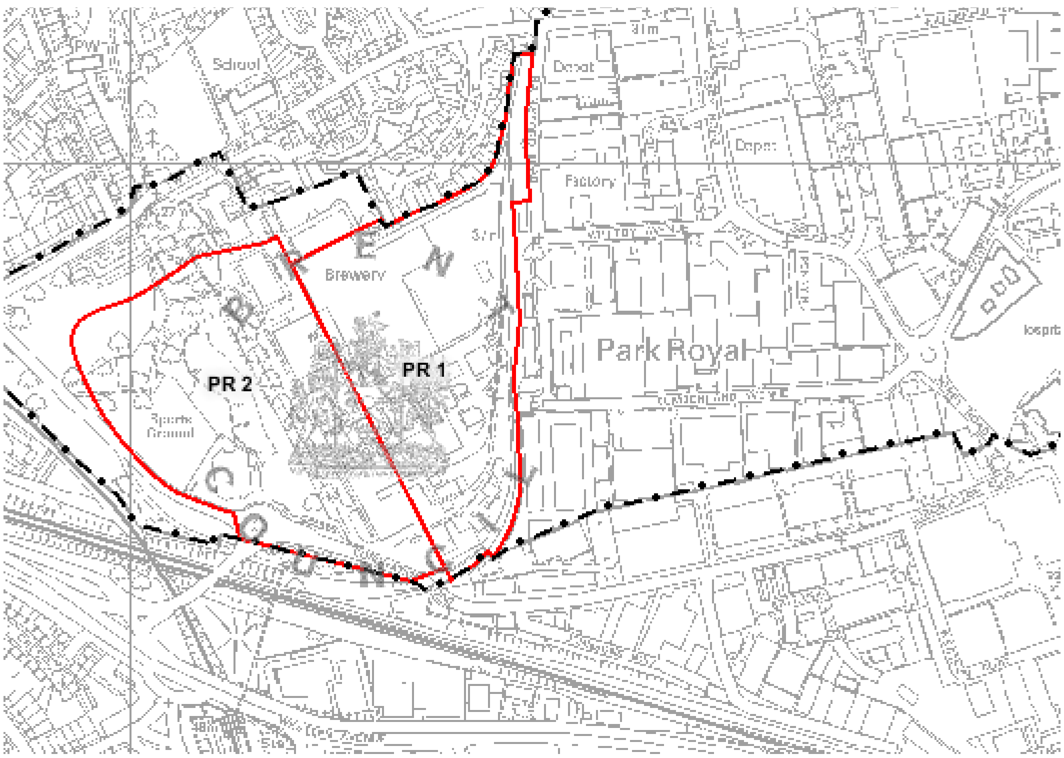
Figure 40: Saving and Costs vs. CHP Size (Turbine)



4.6.2 Park Royal

The Park Royal development area is located in the south west corner of Brent bordering the Boroughs of Ealing and Hammersmith & Fulham. The council has chosen Park Royal as a development area because of its location in Park Royal which is the largest industrial estate in Europe. The council plans to develop or redevelop 50 hectares of land providing 4400 new jobs (Brent SSA, 2009). This will be achieved through the development of new housing, office buildings and new small businesses (Brent SSA, 2009). Figure 41 shows the two mixed-use development sites (PR1 – PR2). Mixed-use planned developments are ideal locations for implementation of CHP facilities, which is why our group has looked into this area.

Figure 41: Site Specific Allocation: Park Royal



The team visited the Park Royal area and investigated the basic requirements and obstacles affecting future implementation of a CHP heating network. Proposed plans include development of hundreds of new housing units as well as office buildings. This will result in a large and constant heat demand. The size of Park Royal is suitable for large scale CHP operation; the land required for a large energy center is available (possible on the vacant lots of PR1 and PR2). The planned mixed use of the Park Royal sites coupled with the amount of vacancies within the area are ideal for the implementation of a new system with few obstacles to consider on the sites of development. The team has simulated the economic costs and environmental savings at the First Central redevelopment site in Park Royal (PR2).

4.6.3 CHP Sizer Park Royal: First Central

The site chosen in the Park Royal area was First Central. This site is land associated with the former Guinness Brewery and is being developed into an office park. Full development of this site was never completed and the council has the concept to develop more office space and a hotel for employment growth with the possibility for residential buildings. The team used the CHP Sizer reports to produce Table 12 and the graphs shown in Figures 42 to 45. We determined that the CHP capacity of 300kWe adds the most benefit to this site. Our preliminary analysis indicates that both the turbine and engine options have the same payback period and reduced carbon emissions of 2.3 years and 7.6% (220 tonnes) respectively. The engine system is recommended because of the greater primary energy reduction and operating time. It is generally better to run the system continuously if possible.

Table 12: Phase Development Data: Park Royal

Indicative Development Phasing	2013 - 14	2015 - 16	Final
Indicative Development Capacity	250 Units	250 Units	500 Units
Estimated Base Heat Load	113.1 kW	113.1 kW	226.2 kW
Estimated CHP Capacity	150 kWe	150 kWe	300 kWe

Figure 42: CO2 Emissions vs. CHP Size (Engine)

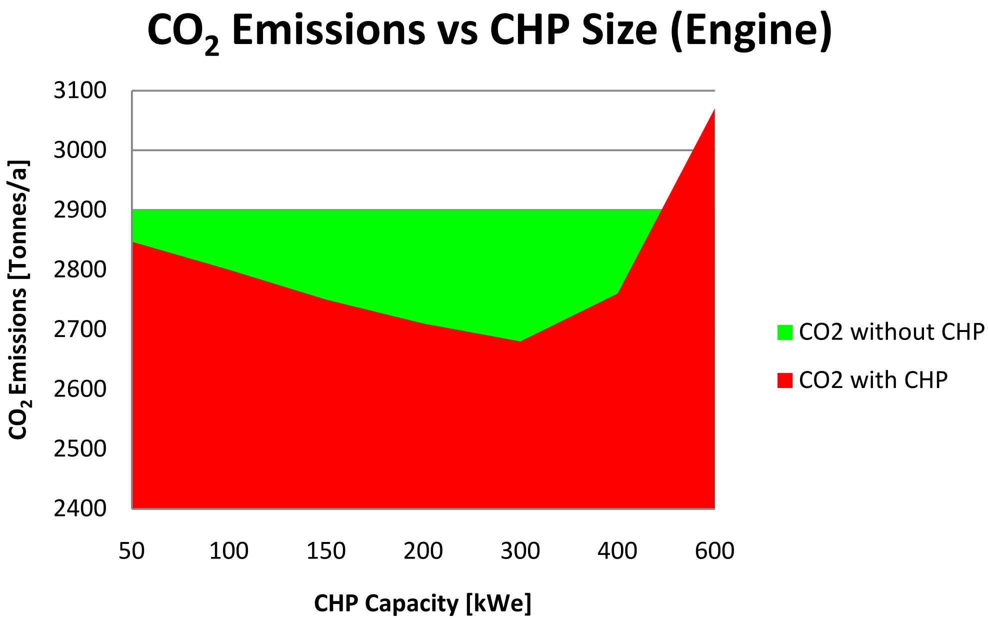


Figure 43: Saving and Costs vs. CHP Size (Engine)

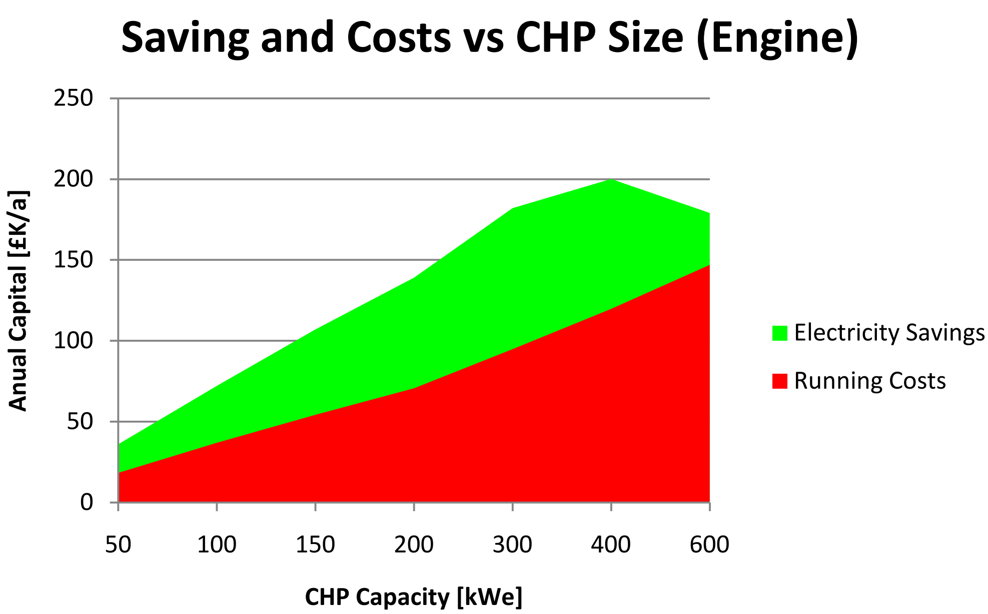


Figure 44: CO2 Emissions vs. CHP Size (Turbine)

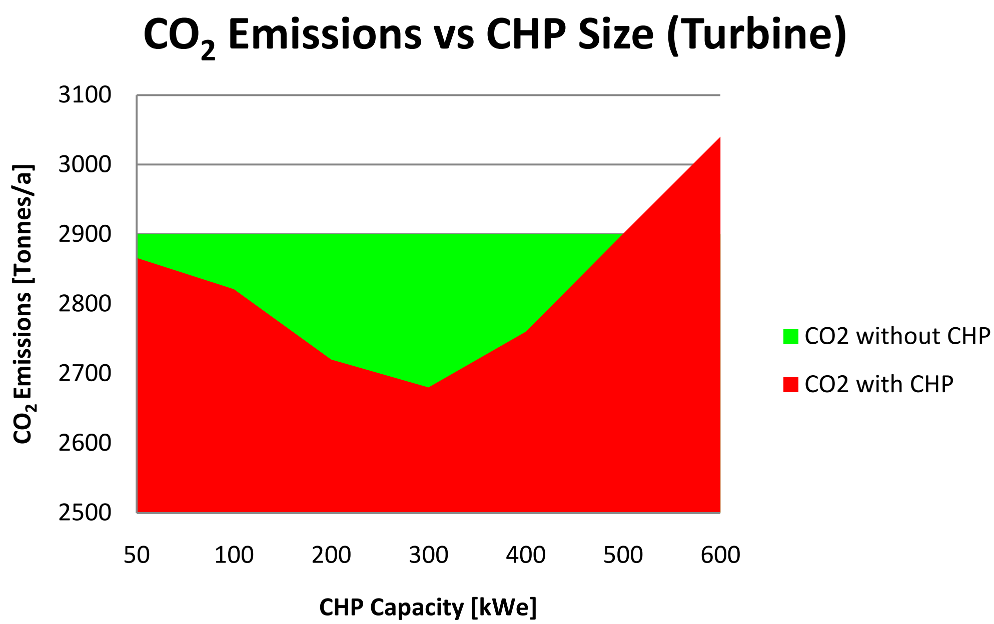
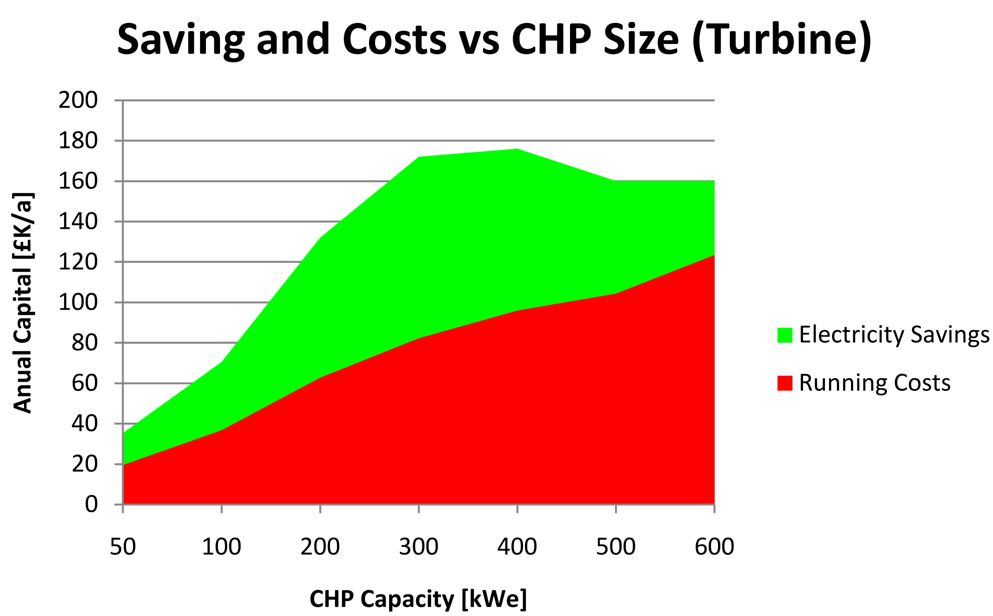


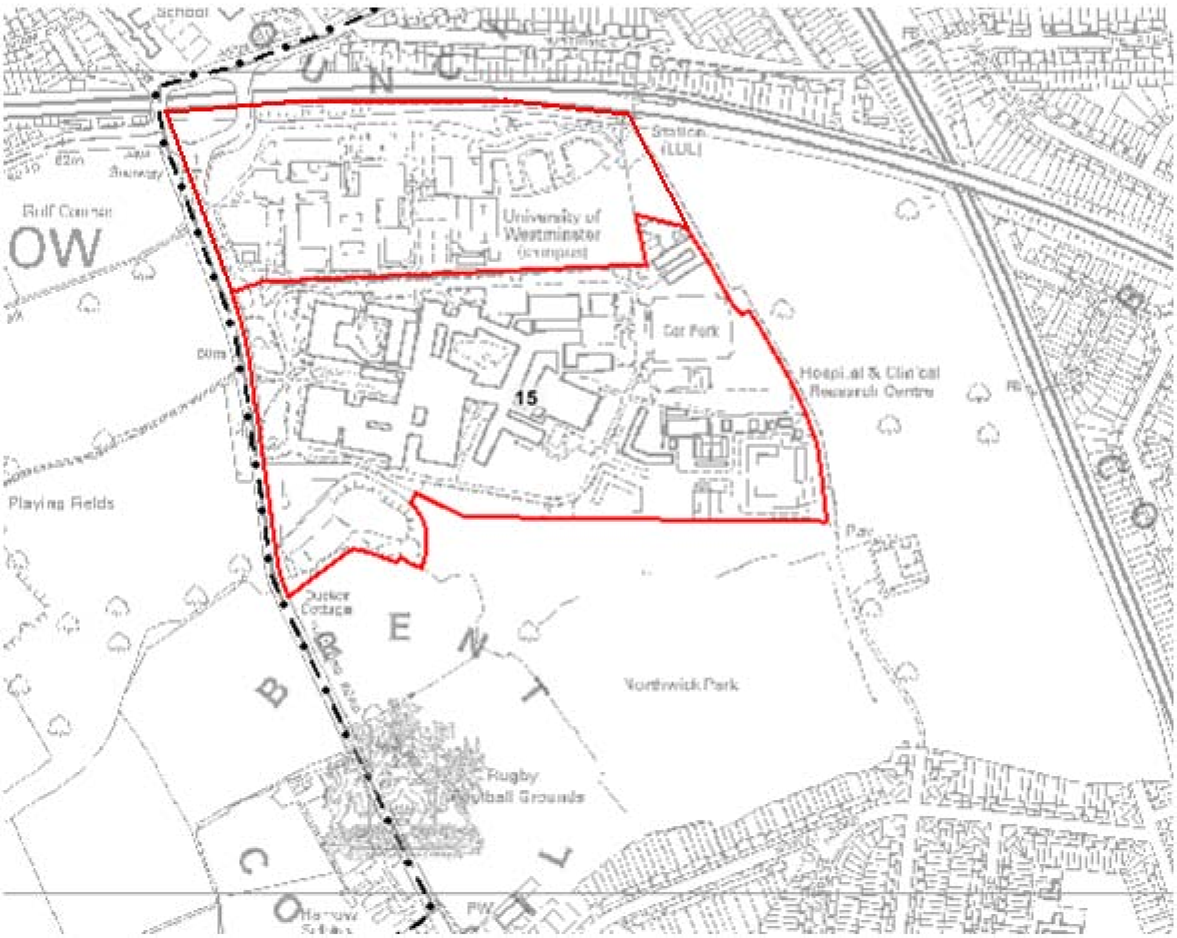
Figure 45: Saving and Costs vs. CHP Size (Turbine)



4.7 Northwick Park Hospital/ Westminster University

The Northwick Park Hospital/ Westminster University development area is located in the North West corner of Brent bordering the Borough of Harrow. The council has chosen Northwick Park Hospital/ University of Westminster as a development area because of the Hospital and University sharing the same land. Figure 46 shows the development site (15). This location is very similar to an area the group had visited in Worcester, Massachusetts. It was a hospital and a school which used a CHP facility.

Figure 46: Site Specific Allocation: Northwick Park Hospital/ Westminster University



(Brent SSA, 2009)

The team visited the Northwick Park area and investigated the basic requirements and obstacles affecting future implementation of a CHP heating network. The Northwick Park hospital and the University of Westminster campuses are located adjacent to one another and require significant continual heat supply. A CHP network may be plausible just including these two campuses due to their heat demands and very close proximity. However, to the south of the development area is Northwick Park which is conservation land meaning any CHP facility would have to be located on the campus of either the school or the hospital. The London Underground borders the eastern edge of the development area impeding possible extension of a future network. The team has simulated the economic costs and environmental savings at the Northwick Park Hospital redevelopment site in Northwick Park (15).

4.7.1 CHP Sizer Northwick Park Hospital

The Northwick Park Hospital was chosen for analysis. The current hospital has high potential for redevelopment and renovations. A hospital CHP Sizer profile was used and the floor area was found to be 125000 m^2. The program only has data values for systems up to 1.5 MW in capacity and this size system is recommended based on the result reports. The reports from CHP Sizer were used to produce the graphs shown in Figures 47 to 50. We determined that the CHP capacity of at least 1500kWe adds the most benefit to this site. Our preliminary analysis indicates that the engine system has the shortest payback period and highest carbon reduction at 2.2 years and 6.4% (1100 tonnes) respectively. Because of these limitations and the size of the facility, a plant with a greater capacity will like prove to be the best option. This is especially so if the hospital wishes to use the system for cooling purposes also. An alternate method for the feasibility study of this site should be pursued.

Figure 47: CO_2 Emissions vs. CHP Size (Engine)

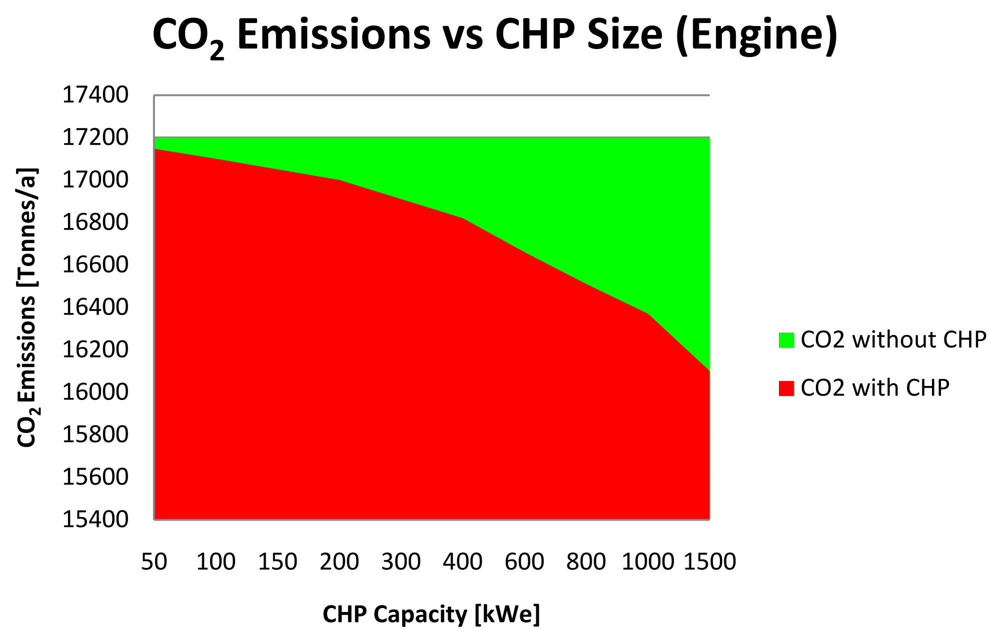


Figure 48: Saving and Costs vs. CHP Size (Engine)

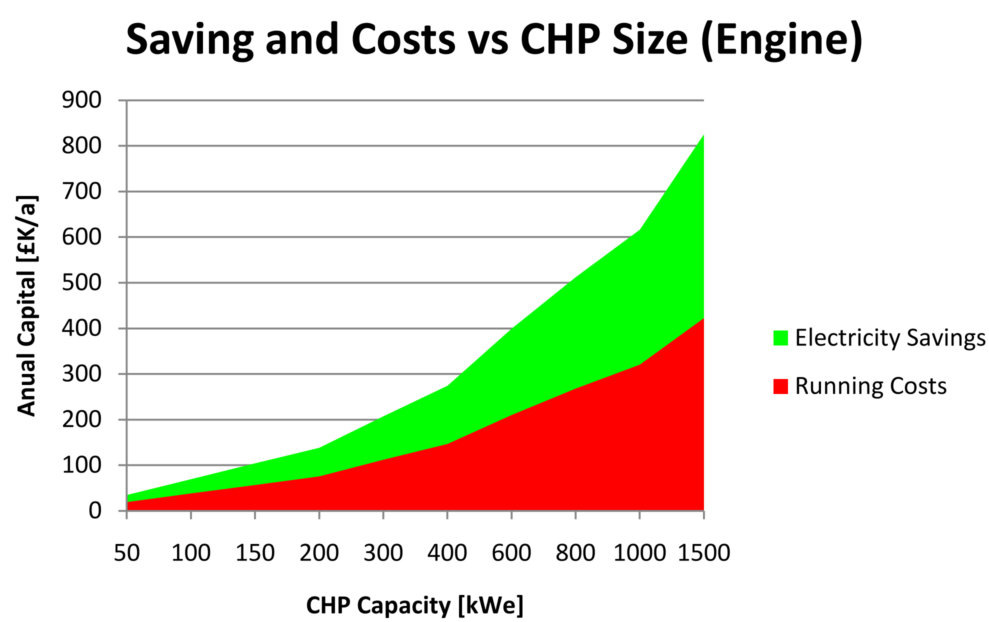


Figure 49: CO2 Emissions vs. CHP Size (Turbine)

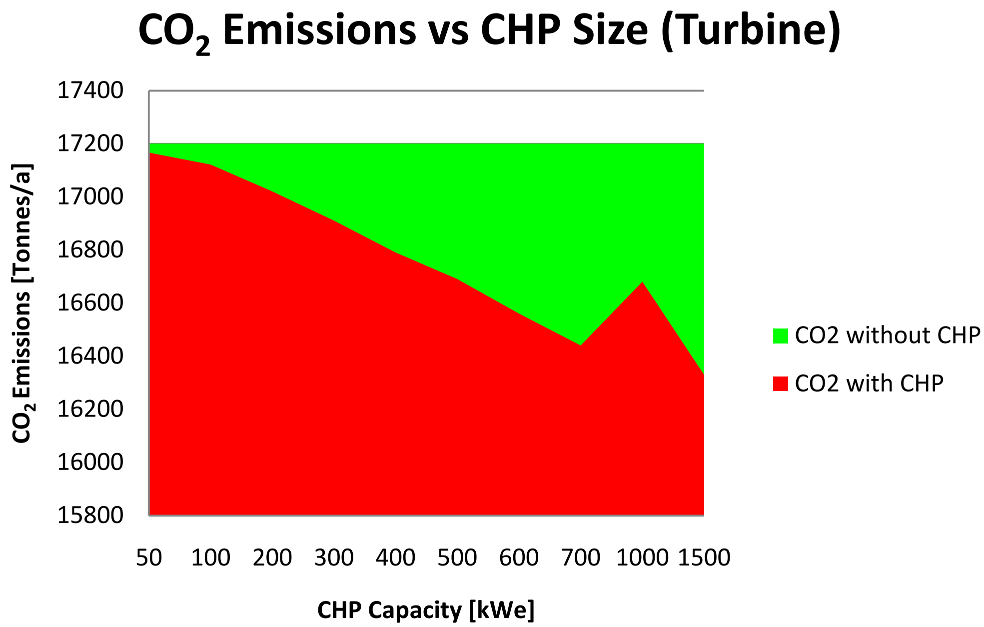


Figure 50: Saving and Costs vs. CHP Size (Turbine)

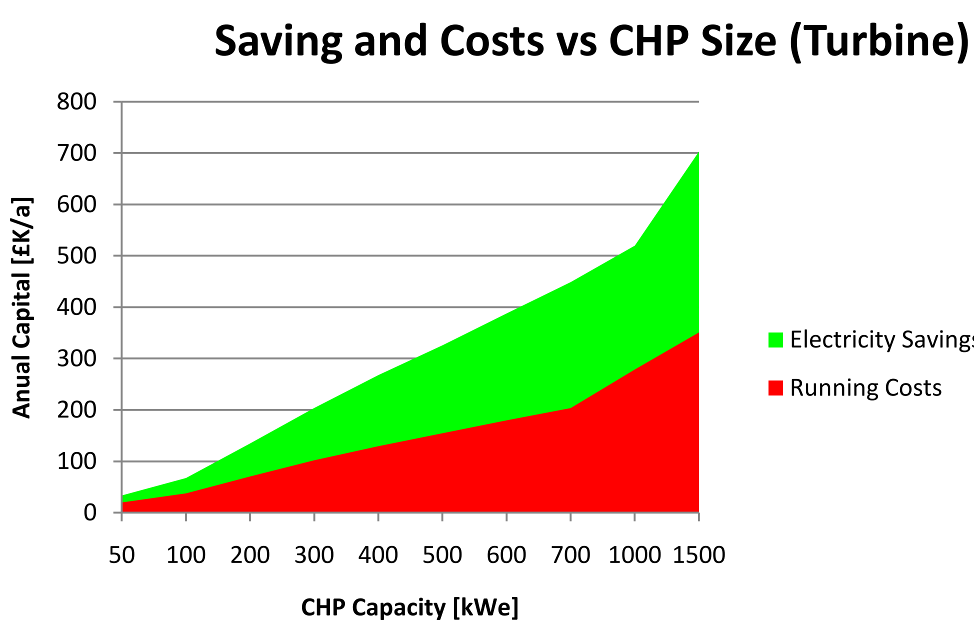


Table 13: Area Studies Summary

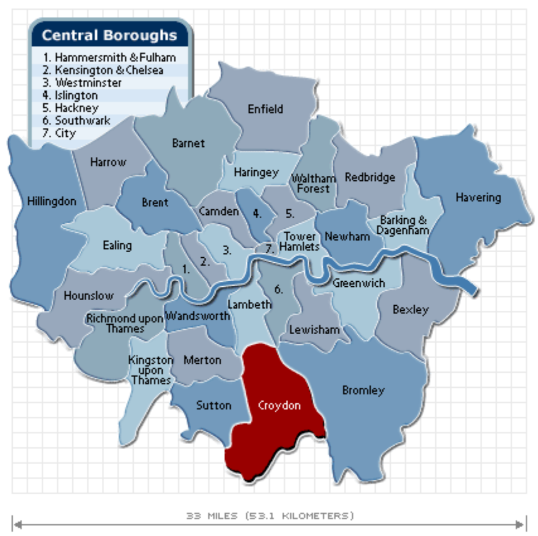
Final Phase	**Alperton**	**Burnt Oak/Colindale**	**Church End**	**South Kilburn**	**Wembley**	**Park Royal**	**Northwick Park**
Sample Site	Former B&Q and Marvelfairs House (A3)	Oriental City and Asda Site	Asiatic Carpets	Brit. Leg., Marshall, Albert Rd Day Care	Wembley Eastern Lands	First Central	Northwick Park Hospital
Development Capacity	420 Units	975 Units	200 Units	345 Units	1500 Units	500 Units	125000 m^2
Estimated Heat Load	190 kW	190 kW	90.5 kW	54 kW	678.6 kW	226.2 kW	1.5 MW
Estimated CHP Capacity	200 kWe	600 kWe	100 kWe	400 kWe	700 kWe	300 kWe	1500kWe
Pay Back Period	~2.5 years	~2.4 years	~2.4 years	~2.7 years	~2 years	~2.3 years	~2.2 years
Net CO_2 Emissions (turbine)	170 tonnes/year	500 tonnes/year	72 tonnes/year	280 tonnes/year	720 tonnes/year	220 tonnes/year	850 tonnes/year
Savings (turbine)	65 £K/year	175 £K/year	35 £K/year	105 £K/year	250 £K/year	95 £K/year	350 £K/year
Net CO_2 Emissions (Engine)	10 tonnes/year	400 tonnes/year	92 tonnes/year	225 tonnes/year	600 tonnes/year	220 tonnes/year	1100 tonnes/year
Savings (Engine)	60 £K/year	155 £K/year	35 £K/year	105 £K/year	250 £K/year	80 £K/year	415 £K/year

4.8 Policy and Practices Summaries

Brent aims to successfully implement decentralized and combined heat and power schemes within the borough. In addition to completing basic area studies to present Brent with initial information concerning its DE potential, the team has investigated policies being drafted in other boroughs in order to identify unique approaches to decentralized energy. The project team conducted a series of interviews with boroughs in Phase 2 (Croydon) and Phase 3 (Barking and Dagenham, Camden, Islington and Southwark) of the DEMaP program and examined their policies.

4.8.1 Croydon

Figure 51: Croydon

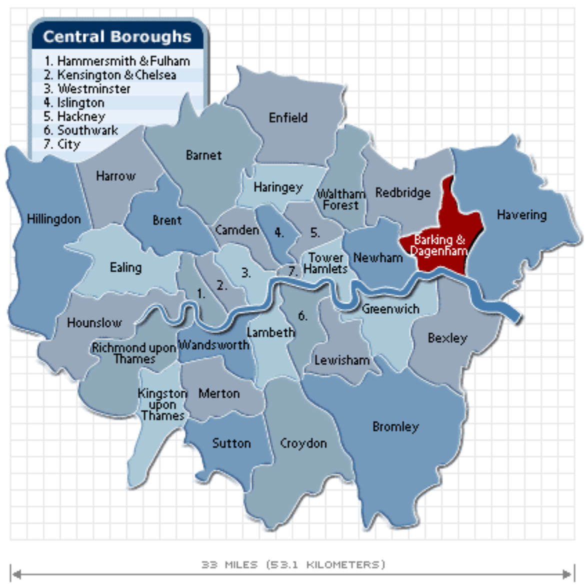


(LondonTown, 2010)

Croydon, located in southern London, is in Phase 2 of the DEMaP program and has been investigating decentralized energy for two to three years. The Council is currently redeveloping the town center, including district heating. The town center has potential for 10,000 residential units along with six to twelve tall office buildings. There is currently a project in progress that will result in 165 residential units, a leisure center and a swimming pool that will be powered by CHP. There is a 50 MWe Rolls Royce turbine electric power plant that the borough is investigating the possibility of conversion to a CHP system. The borough investigated implementing one large plant and found that it would be a better option technically and financially to instead implement the network in phases using three smaller plants that would produce the same capacity. The phasing of development will save the borough approximately £9 million and has an estimated payback period of 15 years. The driving force of these developments to implement decentralized energy comes directly from the London Plan hierarchy of decentralized energy.

4.8.2 Barking and Dagenham

Figure 52: Barking and Dagenham



(LondonTown, 2010)

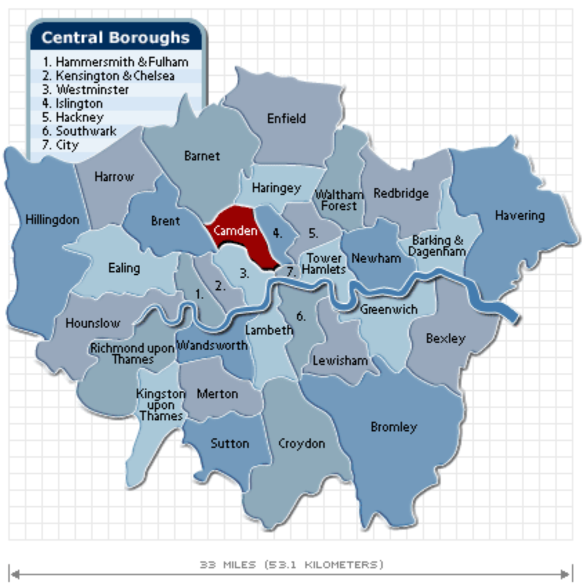
Barking and Dagenham, located in northeast London, is currently a Phase 3 borough. The borough is using the DEMaP funding to establish a Multi-Utility Service Company (MUSCo) to manage energy and communication services. Barking and Dagenham is working on two major decentralized energy projects: the Barking Riverside project and redevelopment of the town center. The first phase of the Barking Riverside project is currently under construction and will result in 4,000 housing units; the later phases will culminate in 14,000 housing units. The town center project is completed and currently operating on a communal boiler system. The plan is to eventually connect these projects into the London Thames Gateway Heat Network (LTGHN). The large heat main of the LTGHN these projects will connect to has been delayed, causing complications in mandating that developers be prepared for DE connection (Lane, 2010).

Barking and Dagenham has developed some policies concerning decentralized energy and combined heat and power. Currently the Barking and Dagenham LDF contains provisions to follow the London Plan's Decentralized Energy hierarchy, like many of the other boroughs. The borough also uses different sustainability requirements for different parts of the borough. Different requirements for different areas take into account the feasibility of carbon reduction based on the area's characteristics like building types and density. These policies are still under development.

The Council has assembled documents for developers including a technical guide on how to connect to DE networks as well as a developer's toolkit. These assist developers in determining decentralized energy potential and provide the Council with a standard format for information that they receive from developers. The Council is then able to assess all new developments based on the same sets of data. A specialized team has been assembled to address all development of decentralized energy.

4.8.3 Camden

Figure 53: Camden



(LondonTown, 2010)

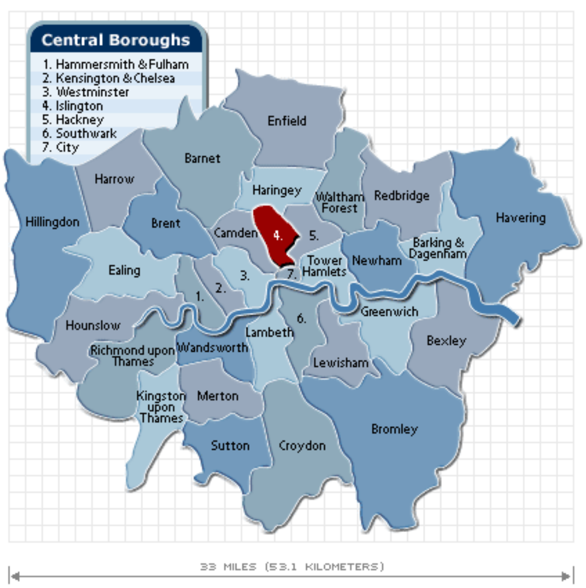
Camden, located to the southeast of Brent, is currently in Phase 3 of the DEMaP program. The Camden Council is investigating CHP as a cost effective method for carbon emissions reductions. The King's Cross area is currently being developed and decentralized energy schemes are being considered. There are two major CHP projects planned: the area north of Gospel Oak and Euston Road. The Euston Road area has plans for a 4MW CHP. Both of these projects are in the planning stages and construction has not begun (Garner, 2010).

Camden has developed policies that address decentralized energy. These policies can be found in the *Sustainable Local Development Framework Camden Core Strategy Proposed Submission*. Camden identifies local energy generation and distribution implemented with CHP to be the most cost effective method of carbon reduction based on studies conducted comparing wind, photovoltaic and CHP schemes.

Where decentralized energy exists, developers will be required to connect to the network unless connection is proven to not be commercially or technically feasible. Developers planning to build a large scheme within proximity of a Council housing estate will be required to speak to the Council regarding heat export to the existing dwellings. "Where developments in the vicinity of an existing local energy network do not connect to that network or do not include their own CHP system due to feasibility and viability, we will require them to provide the on-site infrastructure for future connection and, where reasonable, a contribution towards laying future connections."

4.8.4 Islington

Figure 54: Islington



(LondonTown, 2010)

Islington, located in central London, is currently in Phase 3 of the DEMaP program. There is currently a CHP plant, run by E.ON UK, that focuses primarily on electric power generation producing some heating and cooling. The Islington Council is working with E.ON to explore the benefits of hooking into a DE network and increasing the plant's heat capacity. The

Council is also redeveloping council estates with communal boilers to run off of a 1.8MW CHP. This project is being funded by a housing grant from the LDA.

Islington has developed policies that address decentralized energy. These policies can be found in the *Islington's Core Strategy Proposed Submission*, dated October 2009. "Studies carried out by the council have also demonstrated the potential for decentralised energy (DE) networks within Islington and the technical feasibility and financial viability of proposed CO_2 reduction targets for development." The council plans to work with stakeholders to promote DE networks. The Council will require any new development to contribute to the development of DE networks. According to *Development Management Policies: Issues and Options Draft* (October 2009), this contribution could take the form of actual physical development of a network or as a monetary contribution to future network development. This document identifies key considerations and questions that need to be answered regarding decentralized energy. These questions are:

Decentralised energy

C. In areas where a decentralised energy (DE) network is planned but not yet operational how should we apply the Core Strategy policies on carbon reduction? In particular at what point in the development of a DE network should we apply the 50% carbon reduction rather than 40% bearing in mind the different technologies that are required in each instance? What physical contribution should we ask for in order to enable such a connection?

AND

D. If a network is operational what are the criteria for deciding whether or not it is feasible for a development to connect to it? Examples of criteria we could use are:

i) The size of the development

ii) The distance of the development to the DE network pipes

iii) The presence of physical barriers such as major roads or railway lines

iv) The cost of connection and the impact this has on financial viability

AND

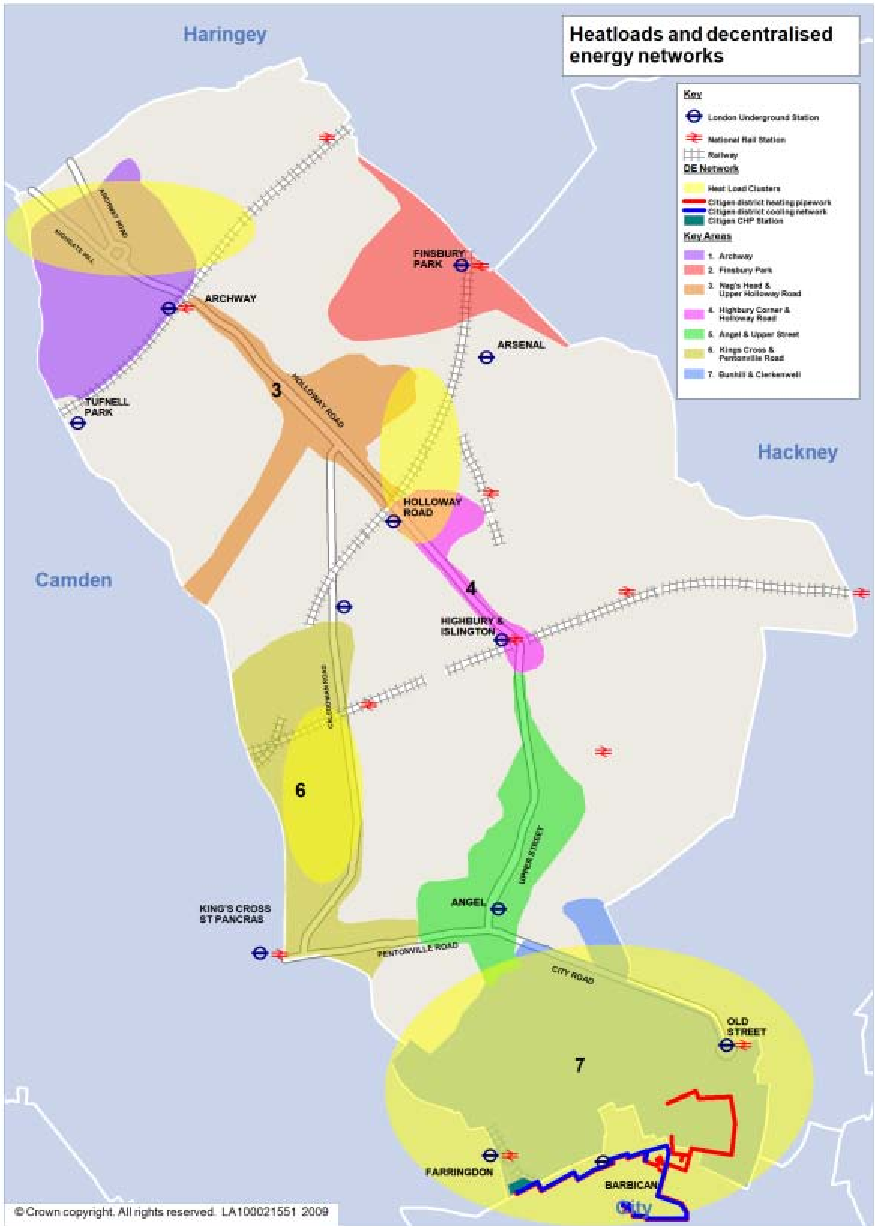
E. Policy 10 of the Core Strategy requires that all development 'contributes to the development of DE networks'. This could be achieved in different ways. Where connection is possible this should be achieved. However, related to Option D above this may not always be feasible. In this case how should a development contribute? We could require that the means to connect to a future DE network are installed in case circumstances change in the future, and/or we could request a financial contribution to develop a network and allow for connection, in which case how should this be calculated? We could adopt a different approach depending on the scale of the development (major, minor or householders).

Developments which are in close proximity to an existing or planned development which incorporates a communal heat network and/or Combined Heat and Power could also be required to develop a shared heating network unless this can be shown not to be feasible.

from *Development Management Policies: Issues and Options Draft* (October 2009)

Islington has also developed a map noting the locations of major heat loads, heat networks and development areas (Figure 55). Because development areas are often good locations to begin implementing DE and CHP, seeing where major heat loads align with development areas can provide evidence supporting future DE development.

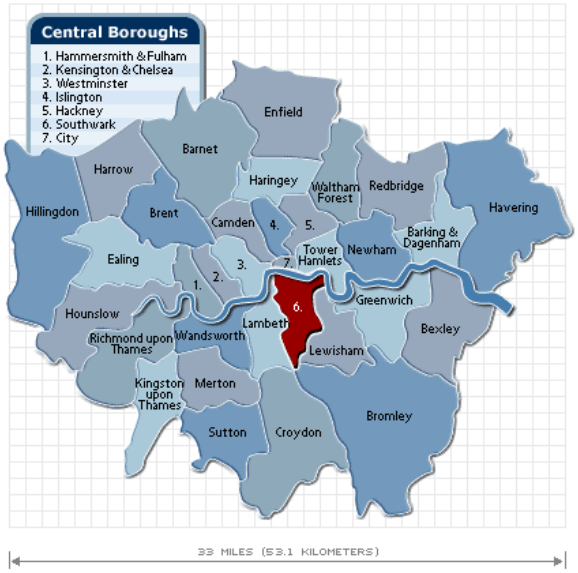
Figure 55: Heat Loads and Decentralized Energy Networks



(*Development Management Policies: Issues and Options Draft,* 2009)

4.8.5 Southwark

Figure 56: Southwark



(LondonTown, 2010)

Southwark, located in central London, is in Phase 3 of the DEMaP program. The borough is investigating DE and CHP as a solution to carbon emissions after a study showed that DE and CHP was the most cost effective method of reducing carbon. The study showed that in the Elephant and Castle area it would cost £50 million to meet the 20% carbon reduction goal with photovoltaics and would require covering entire building roofs and facades with photovoltaic panels.

Currently, Southwark has projects both in planning and under construction. The Elephant and Castle area and the Aylesbury area are being redeveloped. Both these areas include council owned housing estates that will be redeveloped in phases and will result in higher density housing and a guaranteed heat load for a planned 60MW biomass CHP boiler. The scheme will be managed by a privately owned MUSCo. Since the Southwark Council still owns most of the housing estates, these housing areas are a major focus of CHP development because they can be used to provide a guaranteed heat load for the MUSCo for 30 years (Fiddik, 2010).

Southwark has developed policies that address decentralized energy. These policies can be found in the *Sustainable Design and Construction Supplementary Planning Document*, dated 19 February 2009. This document "provides guidance on how new development in Southwark should be designed and built so that it has a positive impact on the environment." The third section, titled “Energy use and minimising climate change,” addresses the energy hierarchy from the London Plan and efficient generation of energy.

The policy calls for energy considerations to be taken into account from the start of the planning process. In a development in which mechanical heating and cooling is required, developers must determine the feasibility of implementing a CHP/CCHP system. The policy outlines what should be prioritized when investigating the implementation of a CHP or CCHP system as exactly follows:

- connect to existing CHP or CCHP systems, including those on nearby housing estates.
- if this is not possible, use a site-wide CHP/CCHP system that connects different uses and/ or groups of buildings. This should be powered by renewables or be gas-fired, if this is not possible communal heating or cooling systems should be used, preferably powered by renewables, but at the very least gas-fired.
- if none of the above are feasible, other efficient systems should be considered, such as heat pumps or heat recovery ventilation. These systems should be powered by low or zero emission fuels.

(*Sustainable Design and Construction Supplementary Planning Document*, 2009)

Guidelines provide advice to developers regarding how far a developer must look for an established plant from the site of a proposed development in order to decide whether or not to connect to existing CHP or CCHP systems. For residential developments, the distance increases as the number of dwellings increases. “Commercial and other non-residential development within 200 metres of an area-wide CHP or CCHP system should connect unless it is demonstrated that there is not enough heating demand for an efficient connection.” If a system does not have sufficient capacity to support a new development, the developer must examine the possibilities of a contribution to expansion or upgrade of the existing system. If the public CHP system has not been completed, an efficient gas or bio-fuel boiler system should be used temporarily.

Table 14: Policy Studies Summary

DE Planning/ Policy	Southwark	Camden	Barking and Dagenham	Islington
Connection Creation of Networks Hierarchy	1. Connection to existing networks 2. Installation of piping for future connection where the borough has plans for future networks 3. Financial contribution to network development elsewhere	1. Connection to existing communal heating networks (council housing) 2. Installation of piping where determined "reasonable"	1. Connection to existing networks is encouraged 2. In locations of planned future networks, provide infrastructure for future connection 3. Borough follows the energy hierarchy as presented in the London Plan	1. Connection to existing networks is encouraged 2. Provide infrastructure for future connection where appropriate 3. Borough follows the energy hierarchy as presented in the London Plan
Developer Reqs.	• Research connection to networks within − 20 dwellings: 50 m − 20-30 dwellings: 100 m − 31-40 dwellings: 150 m − 40+ dwellings: 200 m	• Require developers to connect to communal networks to either draw energy from or generate energy for	• Provide the borough with their own independent study into energy feasibility (possible connections, economic feasibility, etc)	• Connection to existing networks or providing future infrastructure is required unless shown not feasible to do so
Convincing and Aiding Developers	• Conducted studies into alternative energies- CHP proved most feasible • Studies into future possible networks and identification specific network areas • Guaranteeing council housing as future anchor heat loads	• Studies indicating the feasibility of networks in specified areas	• Studies and identification of possible network areas (Town Center and Barking and River Side) • Provide developers with 'toolkit' and technical guide for connection to DE networks	• Studies and identification of possible network areas • Council involvement with either providing anchor loads or securing anchor loads for future networks

4.9 Poster and Brochure

To generate interest and introduce planners to DE and CHP, a poster and brochure were designed. The poster focuses on basics and emphasizing that DE and CHP are efficient and cost effective methods of reducing carbon emissions. Reducing carbon emissions is a main objective of the London Plan and LDF Core Strategies in boroughs throughout London. The brochure was designed to contain the same topics presented on the poster containing more detailed explanations with reference to documents of further information. The poster and brochure can be found in Appendices E and F respectively.

4.10 Planners Handbook

The *Decentralised Energy and You* handbook has been created to further planners' knowledge in DE and CHP. This document is intended to describe decentralized energy, combined heat and power technologies, and heat networks on a more detailed level than the poster and brochure. It contains examples of case studies to better illustrate the concepts and put them into context. In addition to detailed explanations of these concepts, *Decentralised Energy and You* has been designed to guide planners and educate them in their role regarding decentralized energy. The document explains the basics of identifying potential locations for CHP energy centers, provides an explanation of basic costs, and summarizes a background of regulations that a well informed planner should be familiar with when considering the possibility of decentralized energy. After giving a basic background on DE, the handbook guides planners on their role in implementing a successful DE scheme in their borough. Information pertaining to the procurement of energy service companies (ESCOs) as well as how to provide developers with a business case for developing heat networks is contained in the document. *Decentralised Energy and You* can be found in Appendix G.

5 Conclusions and Recommendations

Facilitating the development of decentralized energy networks is new to Brent. Careful planning policy development combined with the use of existing policies and planning tools can allow the borough to begin the successful implementation of a decentralized energy scheme, including the development of combined heat and power systems. A knowledgeable and motivated planning department is necessary to move development forward. Through a creative combination of old and new policies used with knowledge of DE and CHP, the planning department should be able to facilitate the implementation of a decentralized energy network.

5.1 There are existing mechanisms already in place that the Planning Service can use to begin the advancement of decentralized energy.

Several existing planning and policy practices can be used to encourage growth of decentralized energy. The borough can use Section 106 agreements to ensure inclusion of decentralized energy plans. These agreements, under Section 106 of the Town and Country Planning Act 1990, allow local authorities to “enter into a legally-binding agreement or planning obligation with a landowner in association with the granting of planning permission” (IDeA). These agreements are frequently used to obtain provisions for services and infrastructure. Other London boroughs have used these agreements to facilitate the development of decentralized energy networks. The team recommends that Brent investigate the use of Section 106 agreements to establish a decentralized energy network.

5.2 The borough should conduct detailed feasibility studies for specific areas with decentralized energy and combined heat and power potential.

Brent has begun to conduct studies of areas within the borough to identify and analyze decentralized energy and combined heat and power systems. The Rambøll consulting group has generated a heat map to identify heat clusters and the WPI project group has performed preliminary investigations into other factors that impact the viability of a heat network in an area. These studies are merely the beginning of a series of other studies that the borough must conduct. Other boroughs have conducted detailed and site specific studies demonstrating the potential of decentralized energy and combined heat and power in an area. These studies include both technical and economic analyses specific to the sites that will be developed. Information from these studies provides evidence to support decentralized energy policy.

The study conducted by AECOM for the borough of Croydon showed the phased development of heat, cooling and electrical loads as well as financial analyses for each phase. Phasing of development is important because it allows energy networks to start small and evolve into larger systems. This is more attractive to investors because the smaller systems offer shorter payback periods and a less risky investment. The team recommends that Brent develop phased plans for development areas to show potential evolutions of heat networks.

Camden and Southwark conducted studies investigating the carbon saving and economic potential of several technologies and carbon reduction scenarios. Both the Camden study (*Delivering a Low Carbon Camden* (available on the Camden website)) and the Southwark study identify combined heat and power used in combination with decentralized energy networks to be the most cost effective method of reducing carbon in their boroughs. The team recommends that Brent conducts studies in the future similar to the studies conducted in Camden and Croydon investigating potential in the Growth Areas, the Northwick Park Hospital/Westminster University site and Park Royal.

5.3 The Council needs to actively facilitate the development of decentralized energy networks within the borough.

Accomplishing the goal of implementing DE schemes throughout the borough requires a motivated and knowledgeable Planning Service. It will be necessary for all planners to have a basic understanding of decentralized energy systems in order to identify potential areas for future networks. It will be the planner's role to influence developers that CHP is an option for their plans and a wise economic investment. It is important to start discussions with developers early in the pre-application process about the inclusion of decentralized energy networks and/or combined heat and power systems in their plans. Planners should be able to identify or have information from studies identifying large potential anchor loads close to the development locations. They should also know where there are existing communal heating systems with potential to be retrofitted for CHP and/or become part of a future heat network. A working heat map, now currently mandated for every borough by the London Development Agency, can help layout plans for future networks; planners who are familiar the heat map will have the ability to visually demonstrate potential networks to developers. In addition to identifying potential, it is also important that planners be able to identify natural and manmade obstacles to DE and CHP and possibly offer solutions to developers. The entire planning service needs to be onboard with the decentralized energy projects in order to most effectively move the DE program forward. Following the lead of boroughs with more experience in decentralized energy, it would be beneficial to have a specialized team to ensure no opportunity for a network is overlooked or dismissed prematurely. The project team recommends that the entire planning department have basic knowledge of DE and CHP and that a team be assembled to specialize in handling decentralized energy and combined heat and power plans in the borough.

Because of the many parties involved in implementing a decentralized energy scheme, it is important that the Council serves as a facilitator to guide the development of the network. The borough can present information from studies conducted in Brent and elsewhere and developers can conduct their own studies analyzing technical and financial feasibility for their development. The Council can require an energy statement in which developers must evaluate and justify why they choose to include or exclude certain renewable and/or low carbon solutions in their plans.

The Council can develop decentralized energy projects of its own, especially for council owned buildings and council housing. There are many avenues for obtaining funding for decentralized energy projects. For residential redevelopment, it is possible to use housing grants to fund decentralized energy projects. Islington is currently using an LDA housing grant to help fund a CHP system for a council housing development. Brent is currently a part of the DEMaP program which provides the borough with London Development Agency (LDA) funding and aid for decentralized energy projects. The Council can also form business partnerships with developers to help implement decentralized energy systems. The JESSICA[6] fund can also be used to obtain support for publicly funded decentralized energy projects. Money from the JESSICA fund cannot go directly to private ventures. For example, if the borough enters a business partnership with a private company, the project will not be able to obtain funding from the JESSICA fund. Creating a business partnership with a private company can be a good method of sharing investment risks and benefits for both parties involved. The project team recommends that the Brent Council investigate all avenues for funding for decentralized energy and CHP.

The formulation of new local policies can ensure that decentralized energy development follows a coordinated plan. Using information obtained from studies and master plans, specific

[6] JESSICA: Joint European Support for Sustainable Investment in City Areas

areas and sites with high DE potential can be identified. One key element to an effective DE policy is specificity backed by evidence. Generic blanket requirements do not effectively promote DE development and do not provide adequate development guidelines. Instead, detailed and specific analyses of key areas should be conducted to identify how and why DE development should occur.

The Council must determine when and how to require contribution to decentralized energy networks. The Council should lay out guidelines for determining feasibility and possibly require a developer to investigate the feasibility of DE and CHP for certain areas in the borough. The Southwark Local Development Framework (LDF) draft currently contains guidelines to be followed regarding how far a developer must look for an established plant from the site of a proposed development in order to decide whether or not to connect to existing CHP or CCHP systems. For residential developments, the distance increases as the number of dwellings increases and commercial and non-residential developments must look within 200 meters. If a system does not have sufficient capacity to support a new development, the developer must examine the possibilities of a contribution to expansion or upgrade of the existing system. If such a connection or contribution is not possible, an efficient gas or bio-fuel boiler system should be used temporarily to allow for future expansion of the network.

If a developer shows that decentralized energy or CHP is not feasible for their development, then the borough must decide how the developer will contribute to the development of a decentralized energy network within the borough. One possible solution is the creation of a "green fund," a fund that developers would pay into to help development elsewhere in the borough if that particular site is not feasible for carbon reduction or decentralized energy. The borough would need to determine guidelines for how much developers need to pay into this fund. The team suggests that the borough formulate policies to ensure that each new development contributes to a decentralized energy network based on evidence from studies that demonstrate the area dependant feasibility of decentralized energy and CHP.

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Appendix A: Sponsor Description

Greater London comprises 32 boroughs (Figure 1). Each borough is responsible for providing local government and authority over schools, infrastructure, and general public affairs. Brent is one of the outer boroughs located in northwest London. It was founded in 1965 by the merger of Willesden and Wembly municipal boroughs. Brent is very culturally diverse with 54.7% of the population belonging to ethnic groups as seen in Figure 2. Brent is also very religiously diverse with the top three religions being Christian (48%), Hindu (17%) and Muslim (12%) as seen in Figure 3[7].

The Brent Council includes sixty three elected councilors; three from each of the twenty one wards (see Figure 4). A cabinet of councilors runs the council, although all councilors are responsible for the development of policies and overseeing the provision of services in the borough to meet the needs of their constituents.[8] The council uses committees to develop its policy and decide what actions to take within the borough. There are currently 35 committees that help govern the borough within the purview of the Full Council.[9] The Full Council is a senior committee responsible for top level decisions and the promulgation of guidelines.

Numerous council employees are divided into various departments (Figure 5) responsible for the actual delivery of services. The proposed project is sponsored by the Planning Service under the Environment and Culture branch of the council. The Planning Service is charged with managing and developing land and water resources as well as other services listed in Figure 5.[10]

The London Borough of Brent currently spends about £955 million ($1.56 billion) each year. In comparison, the City of Boston, with twice the population, had a budget of $2.38 billion[11] in 2008. With this budget, Brent is responsible for 83 schools, 485 kilometers (roughly 300 miles) of roads and pavements, 100 parks, 12 libraries and four sports centers. Funding is also devoted to garbage collection from 104,000 households and recycling of 33,000 metric tons of waste. Brent provides temporary accommodations for 3,700 families, 600,000 hours of home care for the elderly as well as providing 130,000 meals on wheels plans.

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[7] Brent Council. (2001). Key Facts and Figures for Brent. <http://archive.brent.gov.uk/demographic.nsf/24878f4b00d4f0f68025663c006c7944/34c7abe6f91ea34a80256c050039f212?OpenDocument>

[8] "Councillors" Brent Council http://www.brent.gov.uk/electreg.nsf/Pages/LBB-6?OpenDocument&pp=200033

[9] "Committees" Brent Council http://www.brent.gov.uk/electreg.nsf/Pages/LBB-7?OpenDocument&pp=200033

[10] "Planning Service" Brent Council http://www.brent.gov.uk/tps.nsf

[11] City of Boston. http://www.cityofboston.gov

Brent's revenues come from several sources. About £100 million is raised through the council taxes. Council taxes are essentially property taxes and the amount paid depends on the appraised value of the property. The majority of the council's funding comes from government grants. Brent receives a general grant of £162 million, £237 million for housing and council tax benefits as well as £225 million for schools. The remaining funds come from various fees, such as charges for the use of parking, sports, and other facilities.

The vision statement of the Council describes a variety of community improvement goals. These goals include improved crime prevention, community revitalization, improved sport and leisure activities, and promotion of sustainability practices[12]. In particular the Council aims to be an "exemplar of environmental practice and performance on sustainability issues."[13] It is in this context that the Planning Department has asked WPI to explore options for the development of decentralized power and heat networks in the borough.

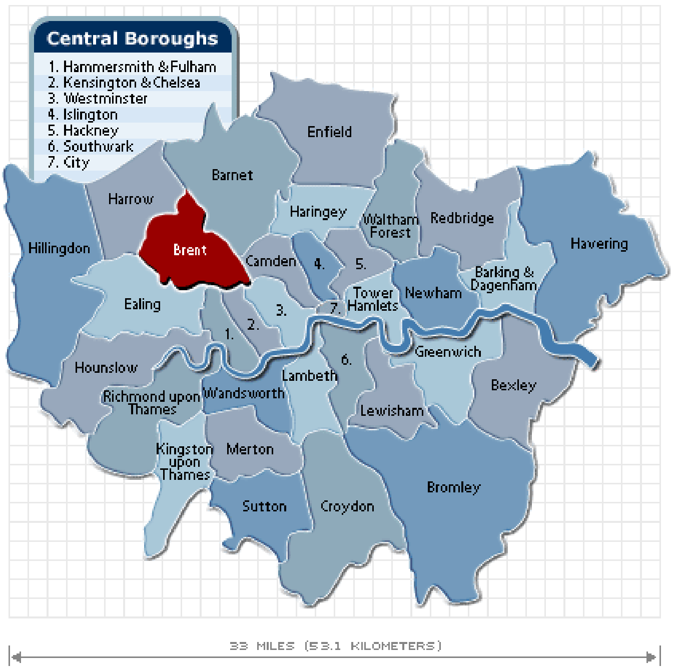
Brent's sustainability policies stem from increased concern for the environment and energy consumption, which has prompted policies at both the city and borough levels. The London Plan specifies goals for Greater London. It aims to reduce the amount of energy consumed, increase the amount of energy produced using decentralized combined heating and power systems, and increase the amount of energy generated using clean sources[14]. According to Policy 5.5**, "**Decentralised energy networks", "The Mayor expects 25 per cent of the heat and power used in London to be generated through the use of localised decentralised energy systems by 2025." As a part of this policy, boroughs are expected to develop policies within their Local Development Frameworks[15].

Maps like the one shown in Figure 6 are designed to help boroughs identify major heat loads and good candidates for decentralized power centers. These maps are being developed with the aid of the London Development Agency (LDA), a part of the Greater London Authority (GLA), as a part of the Decentralised Energy and Energy Master-planning (DEMaP) Support Package for Boroughs[16]. Brent is currently in the first phase of this program and is actively collecting data at the local level. The next phase will involve investigating potential sites for

[12] "Brent's Corporate Strategy 2006-2010" http://www.brent.gov.uk/
[13] "Councillors" Brent Council http://www.brent.gov.uk/electreg.nsf/Pages/LBB-6?OpenDocument&pp=200033
[14] David Taylor-Valiant. "The London Plan". http://www.planungsverband.de/media/custom/1169_3274_1.PDF?1259230809
[15] London Plan, Chapter 5. http://www.london.gov.uk/shaping-london/london-plan/docs/chapter5.pdf
[16] Decentralised Energy Masterplanning - Support Package for London Boroughs Prospectus. http://www.londoncouncils.gov.uk/capitalambition/projects/demap.htm

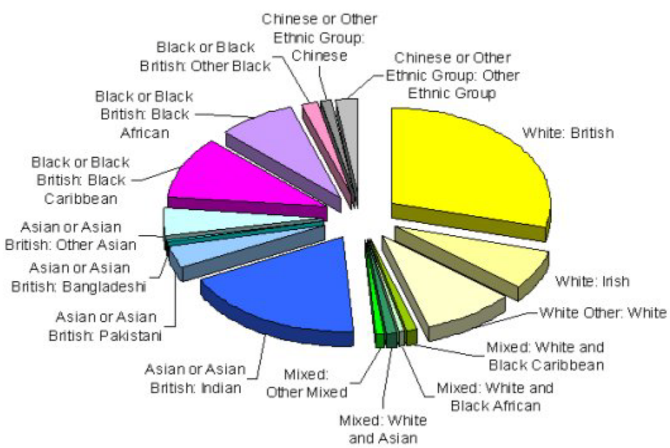
decentralized energy systems within the Borough. The WPI Brent project will address this next phase, researching potentially suitable sites for these decentralized energy systems.

Figure 1: Borough of Brent



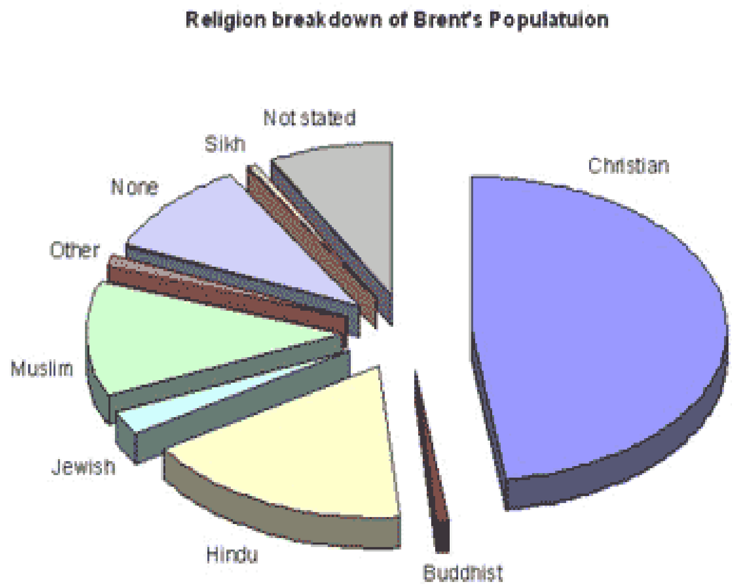
http://www.londontown.com/LondonStreets/Boro/Brent?search=W

Figure 2: Cultural Diversity of Brent



http://archive.brent.gov.uk/demographic.nsf/24878f4b00d4f0f68025663c006c7944/34c7abe6f91ea34a80256c050039f212?OpenDocument

Figure 3: Religious Diversity of Brent



http://archive.brent.gov.uk/demographic.nsf/24878f4b00d4f0f68025663c006c7944/34c7abe6f91ea34a80256c050039f212?OpenDocument

Figure 4: Wards of Brent

http://www.brentbrain.org.uk/brain/braincf.nsf/Images/ward_map_new/$file/brentmap_ne

Figure 5: Council Hierarchy

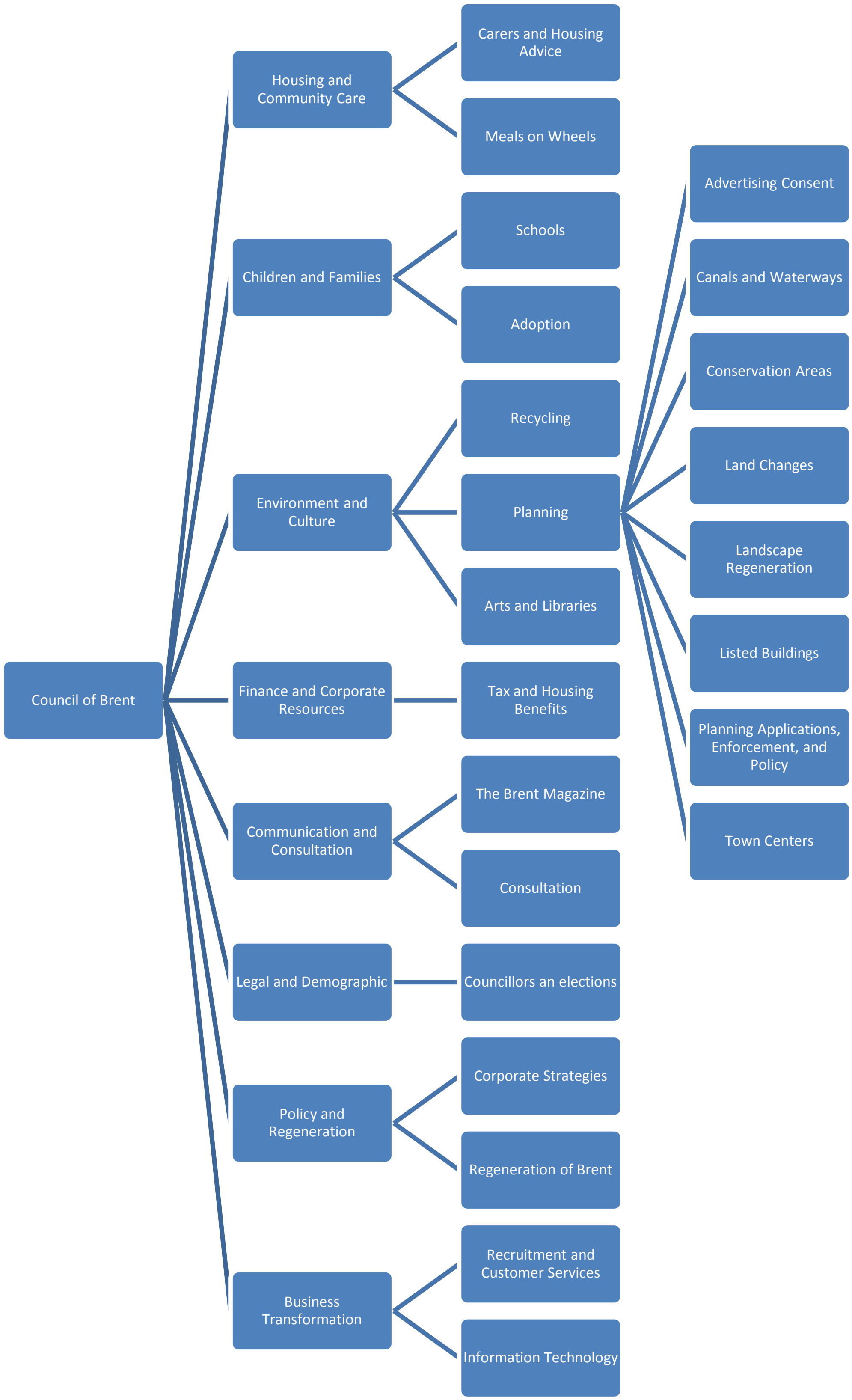
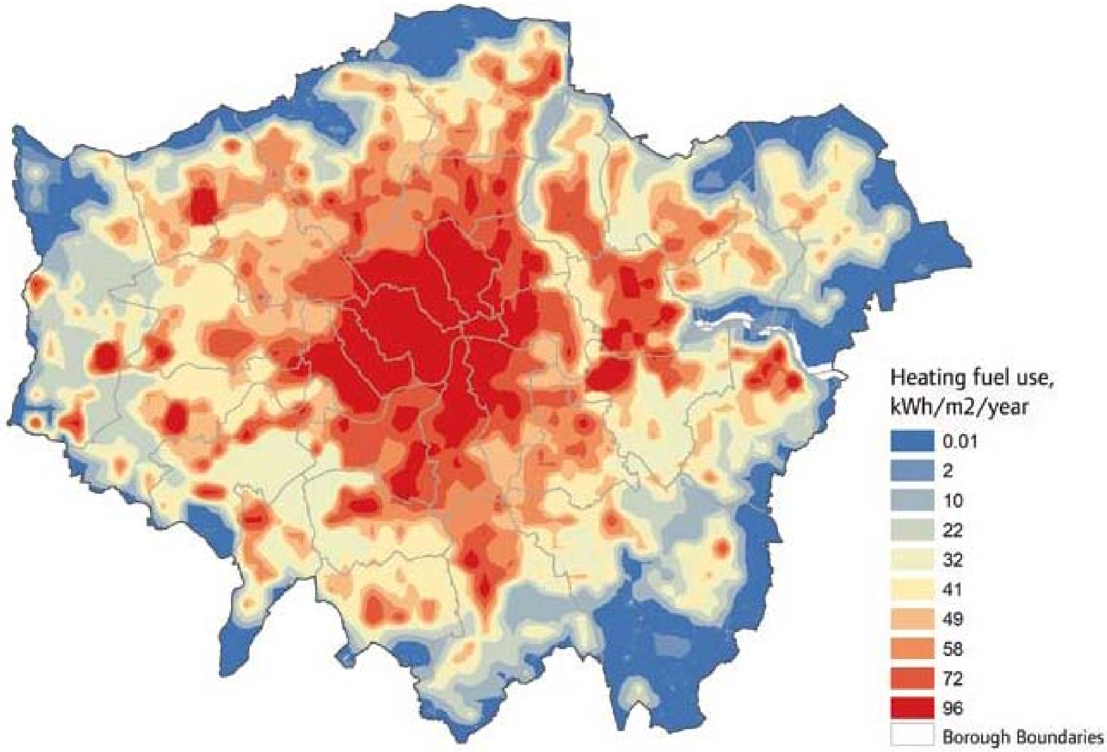


Figure 6: London Heat Map



http://www.london.gov.uk/shaping-london/london-plan/docs/chapter5.pdf

Appendix B: London Thames Gateway Heating Network

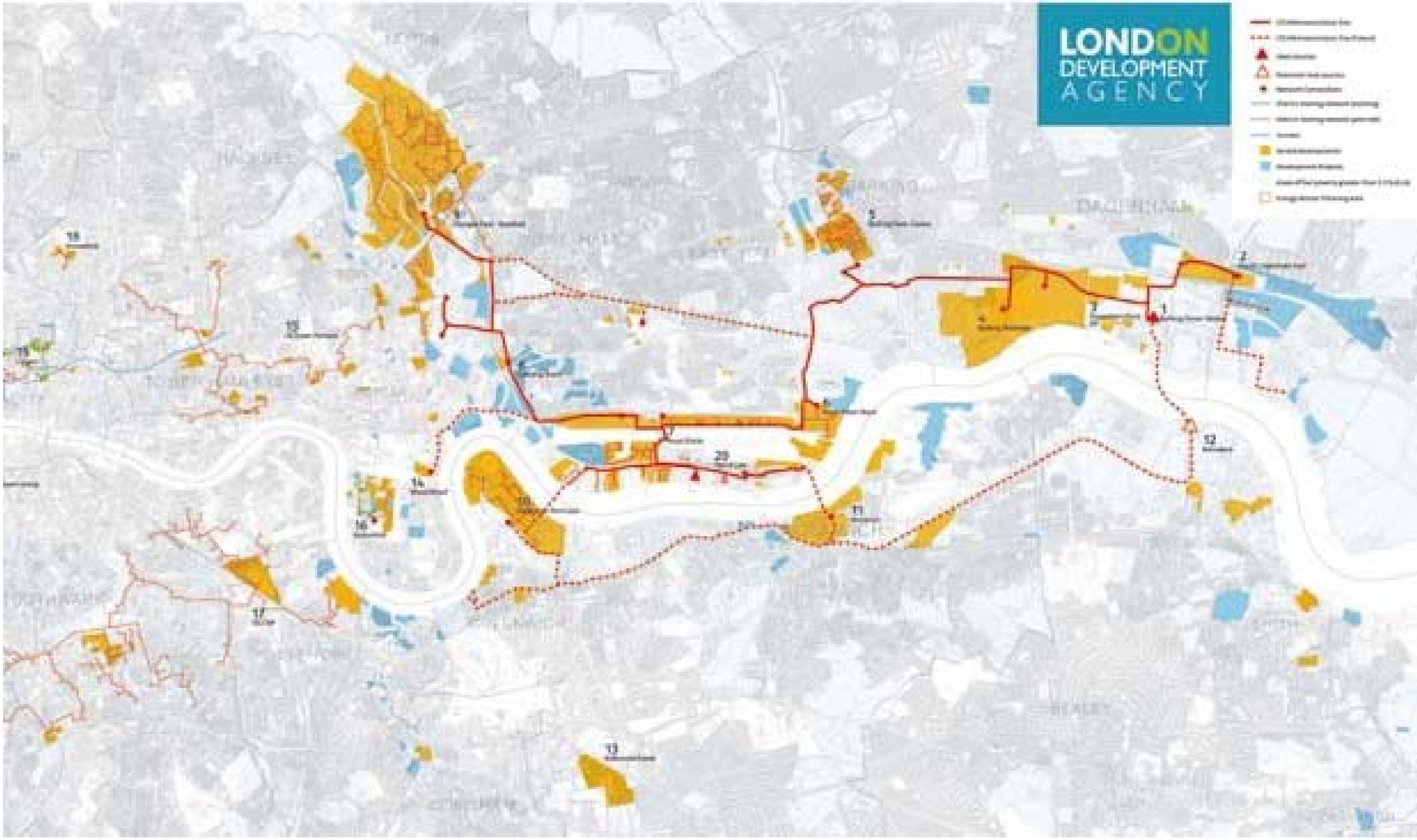
In summary of The London Development Agency's London Thames Gateway Heat Network Vision Map, 2010.

The London Thames Gateway Heating Network (LTGHN) is Europe's largest regeneration area; the large scale of this regeneration area makes it ideal for district heating and decentralized energy. The LTGHN heat network is London's largest decentralized energy project to date as it continues to expand. The LTGHN is a transmission system providing heating and hot water to consumers within its network. Consumers of the network include schools, large residential estates, public buildings, and hospitals. Generally the system is simple, consumers are linked to the network via hot water in and cool water out.

The 150 MW (thermal) power produced at the Barking Power Station and the Tate & Lyle Plant heats water to be transmitted along the network at 110/55°C supply/return temperature. As the system grows, the LTGHN aims to incorporate other power facilities into its network to produce a more efficient and resilient system. As the power plants produce electricy power distributed via the grid, their formally waste heat is being used to heat water to be transmitted throughout the LTGHN.

There have been and continue to be many benefits of the LTGHN. Not only is the network to provide the equivalent of 120,000 residential units and other properties and power, reducing CO_2 emissions by approximately 100,000 tonnes, but it will create more than 200 construction jobs and 50 permanent jobs. The distribution main of the heat network will be approximately 67 km long. Heat sources for the system include the Barking Power Station and. Existing heat producers will sell heat to a transmission company that will act as a Special Purpose Vehicle (SPV) that will handle financing, construction and operation of the heat network (LTGHN, 2010). The project is predicted to cost about £60 million from the public sector and about £90 million from private investments.

The following figure included in the London Development Agency's London Thames Gateway Heat Network Vision Map, 2010 demonstrates the current and planned LTGHN. The red depicts the heat supply and return piping and the dashed red depicts planned piping. The gold represents areas served by the network and the blue indicates future areas to be served by the network.


LONDON
DEVELOPMENT
AGENCY

Appendix C: Future London Decentralized Energy Projects

The following table was modified from tables found in Chapter 6 of *Powering Ahead*.

	Scheme	Description
A	Whitehall and Pimlico	The existing Whitehall and Pimlico (PDHU) district heating schemes are to be connected by a 1.8km interconnecting pipe, delivering improved operational efficiencies and connecting central Government buildings. The interconnector will be built with the capacity to connect other Government departments, and other public and private buildings in the future. Total capital costs for the interconnector are estimated at £3.5 million. DECC will contribute £1.75 million from a government estate energy efficiency exemplar grant. The LDA will be the project manager and is looking to fund the balance of the costs. The scheme will be designed and procured during the current financial year with construction due in 2010/11. The LDA is working with Westminster City Council (owner of PDHU) to establish the procurement, operating and ownership strategies around the new interconnector. This project will create the opportunity for new customers to connect to this low carbon heat supply infrastructure. The Whitehall and Pimlico scheme is looking for: • additional customers that could be connected to the combined scheme.
B	Euston Road District Healing Scheme	The LDA is leading a stakeholder group responsible for developing and procuring a 2-3MWe CHP scheme serving existing Camden Council estates, nearby public buildings and a number of other commercial buildings, with the potential to connect to the proposed King's Cross scheme and expand along Euston Road. A capital shortfall has been identified, which the LDA will consider meeting. The development is planned for construction start within the next few years and represents an opportunity for private sector investment. Euston Road Scheme is looking for: • private sector partners to build, operate and manage the scheme • additional nearby buildings and sites to join the scheme.
C	South Bank Employer Group (SBEG)	The LDA is working with SBEG to develop an understanding of current and projected energy consumption patterns in the area and explore opportunities for decentralized energy systems including district heating, CHP and biomass. SBEG will develop a detailed study on delivery options for an area wide scheme with procurement scheduled for 2010/11. Development costs are being jointly met by the relevant stakeholders and the LDA. The private sector will be invited to bid for the supply of a decentralized energy project. The South Bank Employer Group is looking for: • consultants to undertake a detailed feasibility study (to be procured shortly) • additional customers that could be included within the scheme • investment partners.

D	Cranston Estate Retrofit	The LDA is supporting the London Borough of Hackney (with, in addition, possible capital funding) with the development of a Shoreditch district heating scheme. The Homes and Communities Agency will provide £500,000 of capital. The project is seeking £1 million of gap funding from other sources. Part of the project will be delivered as part of Hackney's Decent Homes Programme over the coming year. The Cranston Estate Retrofit scheme is looking for: • gap funding to support construction of initial infrastructure • development partners that can provide the required expertise, infrastructure and • management • additional customers that could be included within the scheme.
E	Islington District Heating Schemes	The London Borough of Islington is developing two specific district heating schemes that will be comprised of housing and leisure stock. There is a possibility that these schemes could connect to existing networks. The LDA is providing technical and procurement support to Islington as well as initial match funding to cover development costs. Capital for one of the schemes is to be funded through the Mayor's Innovation and Opportunity Fund. Islington District Heating Scheme is looking for: • advice on potential commercial structures • possible generation partners.
F	London Thames Gateway Heat Network (LTGHN)	LDA initiative and development of the largest municipal heat network in the UK serving up to 120,000 homes in the Thames Gateway by connecting existing and future sources of affordable low carbon heat to consumers throughout the London Thames Gateway. Connection to the network will provide developers an opportunity to meet the Mayor's planning requirements and offer a cost effective solution to decarbonise existing developments. The LDA is preparing for delivery through the appointment of engineering, commercial, planning and environmental consultants who will progress the project to financial close. Initially public sector funded, there is the opportunity for private sector investment. The LDA is looking for: • funding partners to support initial construction costs • development partners that can provide the required expertise, infrastructure and management • additional customers that could be included within the scheme.
G	Leopold Estate Regeneration	Poplar Harca, a Registered Social Landlord, will be redeveloping a significant part of its residential estate. Poplar Harca has assessed the feasibility of delivering decentralized energy and has considered possible solutions ranging from installing decentralized energy in only new build sites to including additional nearby heat loads, such as an existing school and a new primary health care unit. Poplar Harca tendered for construction, management and operation of a biomass decentralized energy system and a number of possible consortia members responded. The tendering process has highlighted a short-fall between the costs of construction and future revenues. Leopold Estate is looking for: • funding to improve the viability of the overall scheme • additional significant heat loads that could be connected and reduce per unit costs.

H	Victoria Transport Interchange (VTI) Scheme Land Securities	Proposals for Land Securities' redevelopment of the area adjacent to the Victoria Underground Station includes the delivery of a decentralized energy system that would provide electricity, heat and cooling for over one million square feet of mixed-use space. The proposal is for a gas fired CHP system within a central energy centre with the potential to introduce new energy generating technologies such as fuel cells when they become commercially viable. Commercial development is planned to begin construction in 2012 following London Underground's redevelopment of the tube station. There is potential scope to link the Victoria scheme energy centre via a 1.5km transmission line to the Whitehall/Pimlico scheme to allow waste heat to be exported, extending the operational efficiency of the CHP scheme and providing added resilience to the wider area network. Victoria Transport Interchange Scheme is looking for: • possible funding support for the 1.5km connection infrastructure • additional customers situated nearby or along the proposed connection route to join the scheme • green policy initiatives to ensure that decentralized energy is promoted alongside purely renewable energy projects.
I	Brent Cross and Cricklewood, Hammerson and Brookfield Europe	The Brent Cross and Cricklewood CHP scheme is directly linked to the redevelopment of one of the London Plan Opportunity Areas involving a 300 acre development delivering 7,500 homes and 27,000 jobs over an expected 20 year development horizon. The development scheme also aims to turn the Brent Cross shopping centre "inside out" and create a new high street that integrates with the successful existing centre. The overall development concept will deliver at least 60 per cent carbon savings below current building regulations, principally through the delivery of a major waste treatment plant and scheme-wide CHP infrastructure on site. The CHP infrastructure will deliver approximately 16 MWe, which together with the heat product is sufficient to power and heat the complete proposed development through a district heating system. The proposals have been worked up in conjunction with the London Borough of Barnet and the GLA and are in line with both strategic and local planning policy.
J	Southwark MUSCo	The Southwark MUSCo decentralized energy scheme is positioned to deliver electricity, heat and hot water services for 9,700 residential units and 38,000m2 of commercial space including two major urban regeneration sites: the Elephant & Castle and Aylesbury. The services will be delivered through a CHP facility. The London Borough of Southwark (LBS) has selected a consortium led by Dalkia Plc to design, build, finance and operate the scheme. LBS will provide the land for the energy centres and its land contribution will be repaid through a commercial arrangement with the MUSCo consortium. Key parties in the scheme have been identified and are already on board. Southwark MUSCo is looking for: • green policy initiatives that will incentivise the expansion of already constructed DE networks • change in electricity licensing to allow smaller generators to fully capitalise on generation.

K	King's Cross Central	As part of Argent's re-development of King's Cross Central (KXC) with London and Continental Railways, and DHL, a decentralized energy system will be delivered powered principally by gas CHP and boilers, but also incorporating biomass and a fuel cell. It will serve the newly developed site and also has the potential to connect with other nearby users. An ESCo has been created to construct the heat generation unit and interface with customers, with a second company owning and operating the heat distribution network. The development consortium will be funding the initial costs and this investment will be repaid as new users are connected and through electricity and heat sales. King's Cross Central is looking for: • nearby developments that could potentially link into the system • green policy initiatives that would favour CHP schemes alongside renewable energyprojects.
L	South East London Combined Heat and Power (SELCHP)	The existing South East London Combined Heat and Power (SELCHP) waste energy recovery plant is considering an operational change to re-align the electricity-only production plant into a true CHP, decentralized energy, facility. Veolia, a partial owner of SELCHP, sees the future potential in expansion into the decentralized energy market and aims to increase the overall efficiency of the existing facility through the creation of the decentralized energy network. The proposed scheme will involve the construction of a 2km transmission pipe from the existing Lewisham-based plant to supply heat to a nearby housing estate. The expected heat output will be large enough to expand decentralized energy into other nearby sites or those positioned along the transmission route. Partnership with the boroughs is expected to reduce delivery risks and once the scheme has been approved it could be up and running within 18 months. The overall scheme is expected to be profitable but at a lesser rate than other possible energy ventures, thus there is some degree of market failure that must be overcome. Project profitability is dependent upon at least partial financial support for the initial transmission pipe. The precise electricity and heat outputs will be based upon the most financially advantageous mix. The scheme is being actively de-risked through cooperation with partnering boroughs, the provision of assured demand and Veolia's vast experience in the international decentralized energy market. SELCHP is looking for: • opportunities to expand the scheme into other existing or new developments along the proposed transmission pipe route • financial support to enable construction of the initial transmission pipe • an honest broker that can help to ensure smooth communication with the public sector at all levels • land for back-up energy facilities (small-scale energy centres) • green energy financial incentives that include decentralized energy schemes as well those that are based on strict renewable targets.

M	Riverside Resource Recovery Limited (RRRL)	Cory Environmental is currently constructing a waste to energy facility with a decentralized energy ready turbine. The facility is located in Belvedere, Bexley and should be fully operational in Spring of 2011. In order to utilise the heat generated, Cory would need to construct an enabling/pumping station to transfer the heat into a decentralized energy system. RRRL has the potential to deliver between 30 and 60 MW of heat depending upon local demand requirements and optimal balancing of the electricity to heat ratio. Cory has undertaken extensive surveys of local heat demand and more local demand needs to be established before a viable scheme is ready. However, should a larger scheme be developed within the area then it would make commercial sense to connect to the system. Additionally, the RRRL facility is located in an area that could eventually benefit from the London Thames Gateway Heat Network proposition. RRRL is looking for: • local heat customers • creation of a larger-scale local network that could connect to the RRRL plant • connection to the London Thames Gateway Heat Network • financial support for constructing the heat pumping station or construction of a local transmission network.
N	Olympic Fringe	Extension of the Olympic Park runs from the Park boundary to Stratford High Street, with a potential low carbon heat supply capacity of 20MWth. 3 MWth is reserved for a new development and 17 MWth will be available for new customers in the area. The LDA has funded the initial feasibility study in conjunction with the London Thames Gateway Development Corporation. The LDA is seeking internal approval to provide capital support for the project. The Olympic Fringe scheme is looking for: • additional customers in the Stratford High Street area that could be connected.
O	Greenwich Peninsula	The Homes and Communities Agency (HCA) together with the London Borough of Greenwich have successfully attracted funding of £7.8 million to progress a decentralized energy scheme delivering low carbon energy at Greenwich Peninsula. Further funding opportunities are currently being explored with the LDA. The infrastructure would have the potential to supply power and heat to 13,000 homes and significant business users together with the further potential to connect to the proposed London Thames Gateway Heat Network. Together with Greenwich Peninsula Regeneration Ltd, they are exploring practical solutions to facilitate delivery.

P	Vauxhall/Nine Elms/Battersea OAPF	The Vauxhall, Nine Elms, Battersea Opportunity Area (OA) Energy Masterplan (EMP), developed by the LDA, has determined that the proposed developments will be sufficiently dense and diverse to support a low carbon decentralized energy network. The scheme could initially supply heat to developments in the heart of Nine Elms, the Battersea Power Station (BPS) and the New Covent Garden Market (NCGM), with the potential to expand northwards to the Albert Embankment and west to existing industrial sites. If delivered, this CHP scheme alone could save approximately 18,000 tonnes CO_2 per annum. Electricity and heat could be derived from a mix of low/zero carbon sources, natural gas and renewable biogas and a biomass hot water boiler. Vauxhall/Nine Elms/Battersea OAPF is examining the opportunities for: • developments within the OA to work together with the LDA to develop a viable CHP scheme • developments within the area to show interest in either being a delivery agent or customer for decentralized energy • interested generation companies.
Q	Lower Lee Valley DE	The LDA is developing an Energy Masterplan (EMP) to assess heat demand and the potential to deliver decentralized energy within the Lower Lea Valley. One option under consideration is the potential to link to the larger-scale Thames Gateway Heat Network. The areas being considered within this strategy include the Lea Valley south of the Olympic Park inclusive of Canning Town, Poplar and Leamouth. The Lower Lea Valley decentralized energy scheme is examining the opportunities for: • developments within the OA to work together with the LDA to develop a viable CHP scheme • developments within the area to show interest in either being a delivery agent or customer for decentralized energy • interested generation companies • links between the upper and lower Lea Valley areas.
R	Upper Lee Valley OAPF	The LDA is developing an Energy Masterplan (EMP) to assess heat demand and the potential to deliver decentralized energy within the Upper Lea Valley Opportunity Area (OA). The OA extends from Hackney Marshes and follows the line of the River Lea north east to the M25. The emerging energy strategy suggests that a core district heating scheme could evolve supplying both heat and hot water. A variety of generation options are being considered, including the use of waste heat from the existing Edmonton incinerator and Enfield Power Station. The LDA is planning and developing the details of the scheme and assessing its overall feasibility and costs. The Upper Lea Valley Scheme is examining opportunities for: • developments within the OA to work together with the LDA to develop a viable CHP scheme • developments within the area to show interest in either being a delivery agent or customer for decentralized energy • interested generation companies • links between the upper and lower Lea Valley areas.

S	White City OAPF	The LDA is developing an Energy Masterplan (EMP) to assess potential heat demand and the viability of a decentralized energy system within the White City Opportunity Area. Area stakeholders include the BBC, the London Borough of Hammersmith and Fulham, and individual land owners. The White City masterplan is examining opportunities for: • developments within the OA to work together with the LDA to develop a viable CHP scheme • developments or large-scale existing occupiers within the area to show interest in either being a delivery agent or customer for decentralized energy • interested generation companies.

Appendix D: CHP Sizer Evaluation Tool

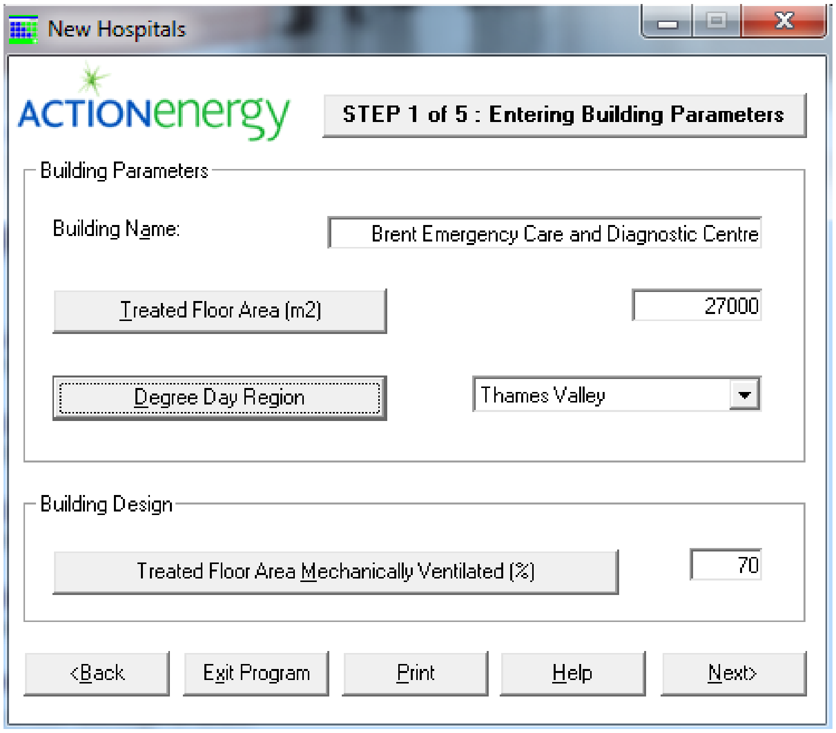
CHP Sizer is a preliminary tool to be used while evaluating potential sites to host CHP systems (DECC 2010). The project team has used it to do a sample analysis of the Brent Emergency Care and Diagnostic Centre. It is located at Park Royal and is part of North West London Hospitals (NWLH). First a new hospital building was created under the start menu. The first step after that asks for the building's floor area, region within the U.K., and percentage of floor area that is mechanically ventilated. Area that is mechanically ventilated refers to the area of the building that uses a fan to move the air inside. The floor area was found to be 27,000 m^2, the region is Thames Valley, and the default ventilated area of 70% was used (CABE, 2010).

In the second step, the program produces heat and power demand graphs for the different months in the year and days during the week. Some of the graphs are shown in the figures below. For step 3, boiler efficiency of a typical gas industrial boiler was found to be 75% (CIBO, 2003). We also assumed the entire building is heated and that the CHP system would replace the current boiler. Gas turbines were decided to be used because it uses the same fuel and were used in previous case studies that were found. The following step requires information on energy costs. This was found using the website ukPower.co.uk and the hospital's postcode of NW10 7NS. Looking at fuel and energy rates from British Gas, npower, and Atlantic Electric & Gas, British Gas with WebSaver 6 dual fuel tariff is the simplest for our calculations and one of the cheapest at a minimum rate of 2.3648p per kWh and 8.3162p per kWh for gas and electricity respectively (U.K. Power, 2010, British Gas, npower, and Atlantic Electric & Gas). Default values for the climate change levy and NPV calculation were used.

After all the data is entered, the program displays cost, environmental, and operating data reports. For this case it recommends a 50-200 kWe CHP engine with a simple payback of about 1.6 years. The payback is calculated using initial capital cost, additional fuel costs, electricity savings, and maintenance costs. The program also calculated a reduction of 63, 130, and 260 tonnes of CO_2 emissions annually with 50, 100, and 200 kWe systems respectively. Although all these items are estimated, it does give an idea of the scale of the plant required.

From the graphs, it can be determined that the minimum amount of required heat is about 88 kW and electricity required is about 480 kW. The 50 kWe system produces about 86 kW of heat and can be run almost continuously throughout the year to provide the heat necessary. The 200 kWe system also recommended will provide higher overall savings. The system to provide the highest net cost savings is the 500 kWe system at £135,000 annually. With that it can provide almost all the power requirements, but more heat than what is needed. It will operate for about 4500 hours per year, which is above the guidelines published by the Combined Heat and Power Association (CHPA, 2007). One thing that CHP Sizer doesn't consider in this analysis is heat used in cooling units. If the site is also cooled by waste heat from the CHP plant, then a larger capacity generator than the recommended range could be chosen and there would be a greater heating capacity during the colder times of the year. The waste heat available for absorption cooling can be graphed by CHP Sizer to provide estimates for the available waste heat to power chillers.

The following screen shots demonstrate the steps of using CHP Sizer:


New Hospitals
ACTIONenergy
STEP 1 of 5 : Entering Building Parameters
Building Parameters
Building Name:
Brent Emergency Care and Diagnostic Centre
Treated Floor Area (m2)
27000
Degree Day Region
Thames Valley
Building Design
Treated Floor Area Mechanically Ventilated (%)
70
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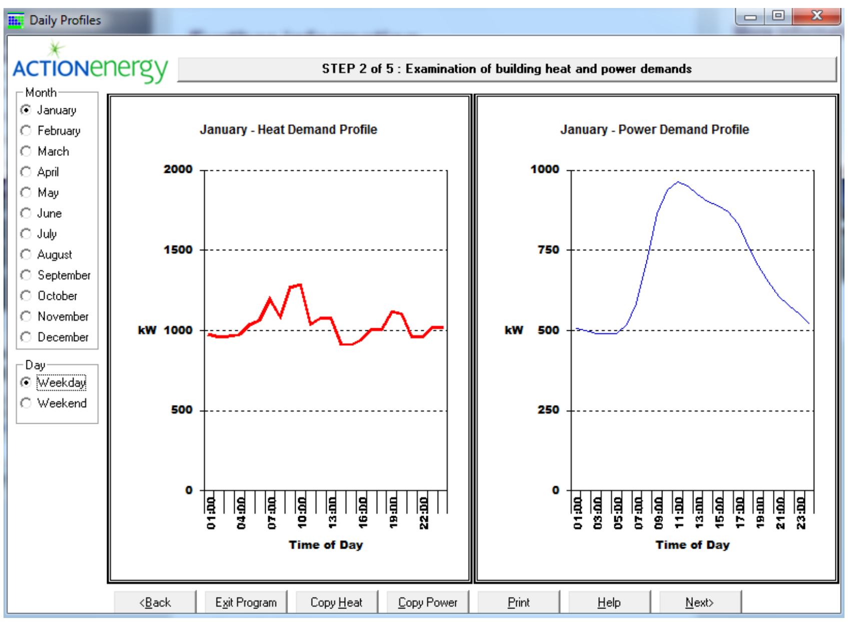
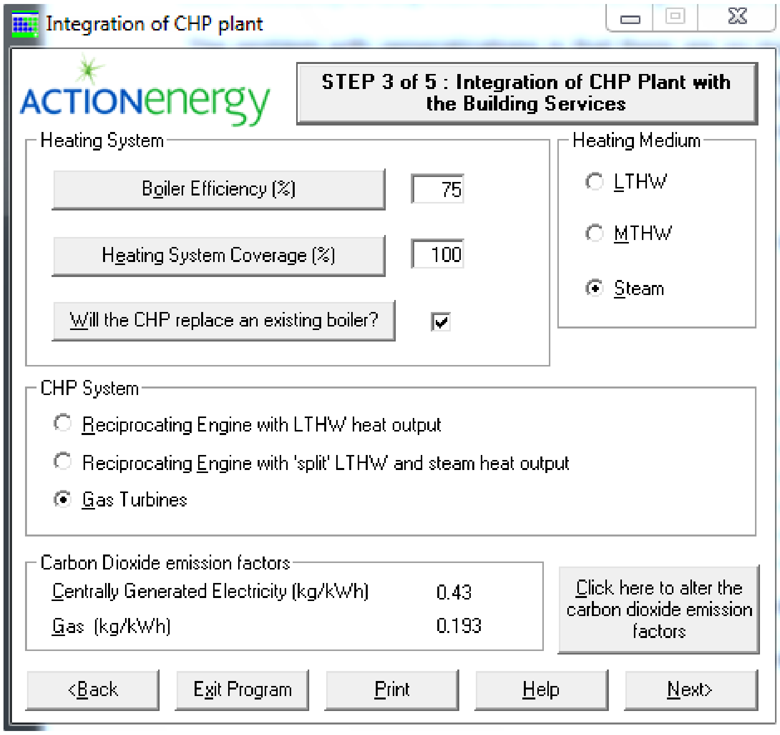
Next>


Daily Profiles
ACTIONenergy
STEP 2 of 5 : Examination of building heat and power demands
Month
January
February
March
April
May
June
July
August
September
October
November
December
Day
Weekday
Weekend
January - Heat Demand Profile
January - Power Demand Profile
kW
Time of Day
<Back
Exit Program
Copy Heat
Copy Power
Print
Help
Next>


Integration of CHP plant
ACTIONenergy
STEP 3 of 5 : Integration of CHP Plant with the Building Services
Heating System
Boiler Efficiency (%)
75
Heating System Coverage (%)
100
Will the CHP replace an existing boiler?
Heating Medium
LTHW
MTHW
Steam
CHP System
Reciprocating Engine with LTHW heat output
Reciprocating Engine with 'split' LTHW and steam heat output
Gas Turbines
Carbon Dioxide emission factors
Centrally Generated Electricity (kg/kWh) 0.43
Gas (kg/kWh) 0.193
Click here to alter the carbon dioxide emission factors
<Back
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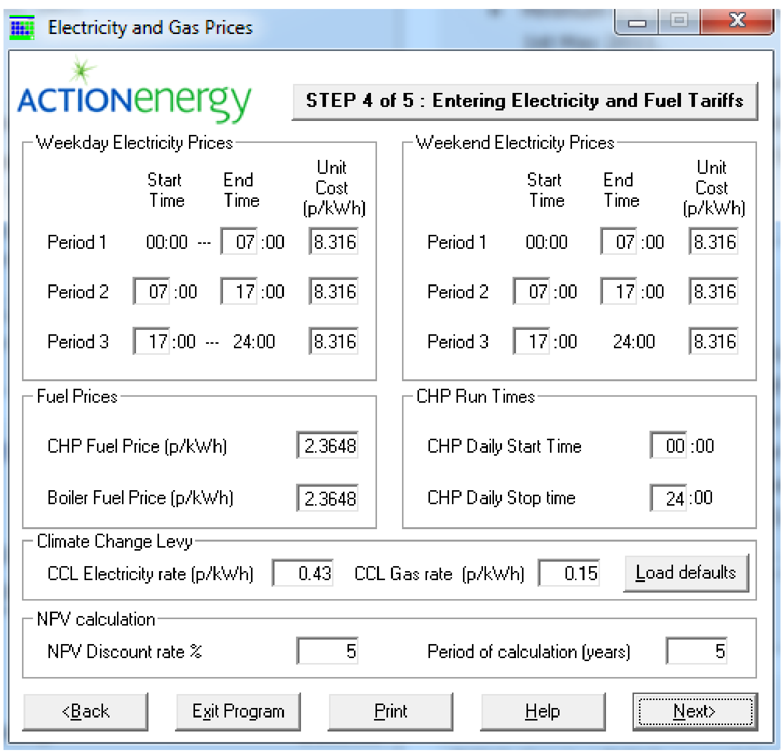
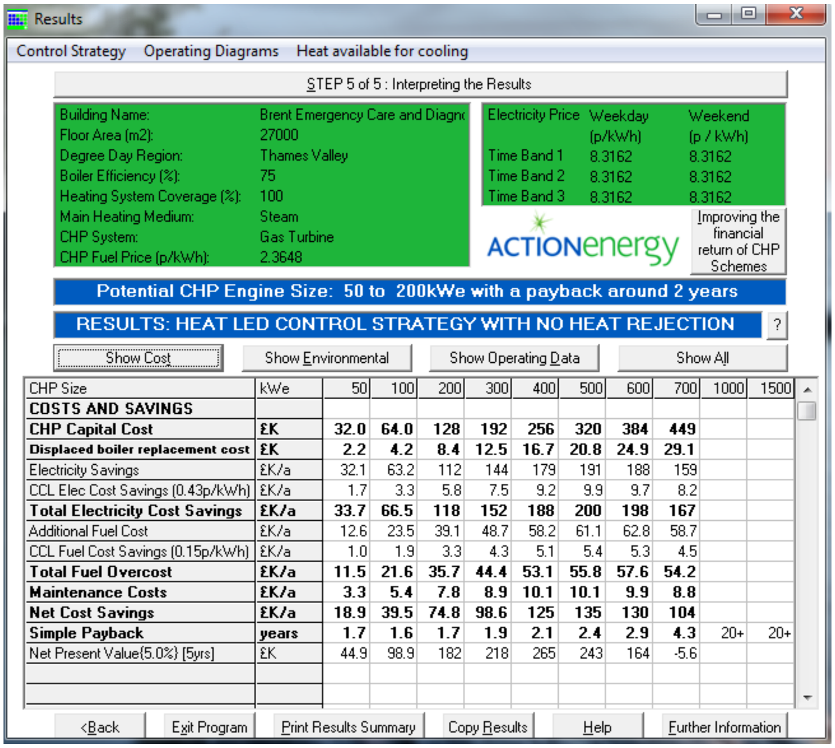
Help
Next>


Electricity and Gas Prices
ACTIONenergy
STEP 4 of 5 : Entering Electricity and Fuel Tariffs
Weekday Electricity Prices
Start Time End Time Unit Cost (p/kWh)
Period 1 00:00 --- 07 :00 8.316
Period 2 07 :00 17 :00 8.316
Period 3 17 :00 --- 24:00 8.316
Weekend Electricity Prices
Start Time End Time Unit Cost (p/kWh)
Period 1 00:00 07 :00 8.316
Period 2 07 :00 17 :00 8.316
Period 3 17 :00 24:00 8.316
Fuel Prices
CHP Fuel Price (p/kWh) 2.3648
Boiler Fuel Price (p/kWh) 2.3648
CHP Run Times
CHP Daily Start Time 00 :00
CHP Daily Stop time 24 :00
Climate Change Levy
CCL Electricity rate (p/kWh) 0.43
CCL Gas rate (p/kWh) 0.15
Load defaults
NPV calculation
NPV Discount rate % 5
Period of calculation (years) 5
<Back
Exit Program
Print
Help
Next>



Results

Control Strategy | Operating Diagrams | Heat available for cooling

STEP 5 of 5 : Interpreting the Results

Building Name:	Brent Emergency Care and Diagn
Floor Area (m2):	27000
Degree Day Region:	Thames Valley
Boiler Efficiency (%):	75
Heating System Coverage (%):	100
Main Heating Medium:	Steam
CHP System:	Gas Turbine
CHP Fuel Price (p/kWh):	2.3648

Electricity Price	Weekday (p/kWh)	Weekend (p / kWh)
Time Band 1	8.3162	8.3162
Time Band 2	8.3162	8.3162
Time Band 3	8.3162	8.3162

ACTIONenergy — Improving the financial return of CHP Schemes

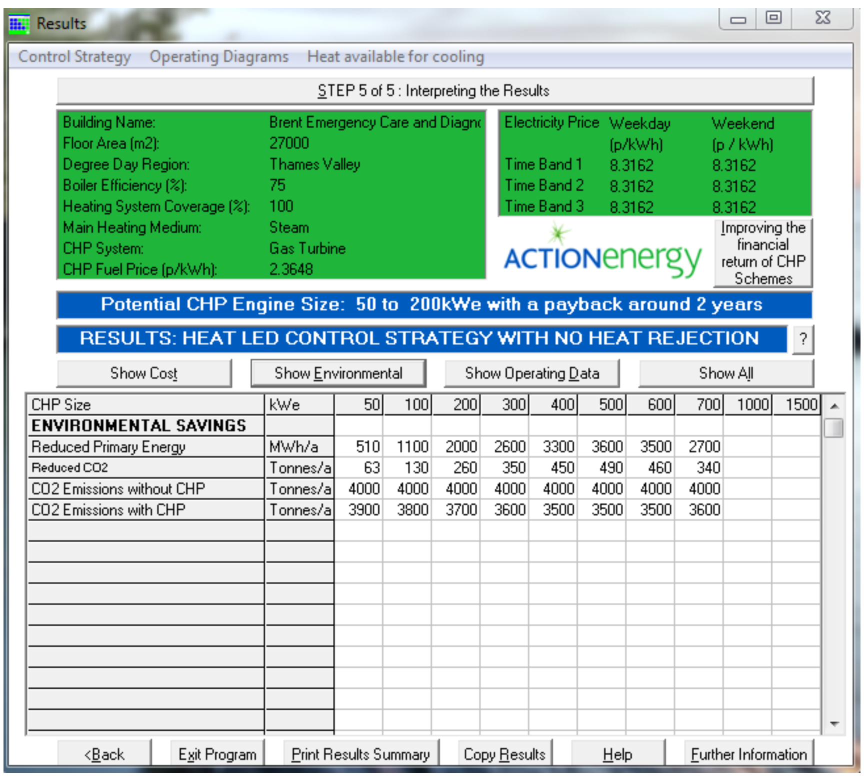
Potential CHP Engine Size: 50 to 200kWe with a payback around 2 years

RESULTS: HEAT LED CONTROL STRATEGY WITH NO HEAT REJECTION ?

Show Cost | Show Environmental | Show Operating Data | Show All

CHP Size	kWe	50	100	200	300	400	500	600	700	1000	1500
COSTS AND SAVINGS											
CHP Capital Cost	**£K**	**32.0**	**64.0**	**128**	**192**	**256**	**320**	**384**	**449**		
Displaced boiler replacement cost	**£K**	**2.2**	**4.2**	**8.4**	**12.5**	**16.7**	**20.8**	**24.9**	**29.1**		
Electricity Savings	£K/a	32.1	63.2	112	144	179	191	188	159		
CCL Elec Cost Savings (0.43p/kWh)	£K/a	1.7	3.3	5.8	7.5	9.2	9.9	9.7	8.2		
Total Electricity Cost Savings	**£K/a**	**33.7**	**66.5**	**118**	**152**	**188**	**200**	**198**	**167**		
Additional Fuel Cost	£K/a	12.6	23.5	39.1	48.7	58.2	61.1	62.8	58.7		
CCL Fuel Cost Savings (0.15p/kWh)	£K/a	1.0	1.9	3.3	4.3	5.1	5.4	5.3	4.5		
Total Fuel Overcost	**£K/a**	**11.5**	**21.6**	**35.7**	**44.4**	**53.1**	**55.8**	**57.6**	**54.2**		
Maintenance Costs	**£K/a**	**3.3**	**5.4**	**7.8**	**8.9**	**10.1**	**10.1**	**9.9**	**8.8**		
Net Cost Savings	**£K/a**	**18.9**	**39.5**	**74.8**	**98.6**	**125**	**135**	**130**	**104**		
Simple Payback	**years**	**1.7**	**1.6**	**1.7**	**1.9**	**2.1**	**2.4**	**2.9**	**4.3**	20+	20+
Net Present Value(5.0%) [5yrs]	£K	44.9	98.9	182	218	265	243	164	-5.6		

<Back | Exit Program | Print Results Summary | Copy Results | Help | Further Information



Results

Control Strategy | Operating Diagrams | Heat available for cooling

STEP 5 of 5 : Interpreting the Results

Building Name:	Brent Emergency Care and Diagn
Floor Area (m2):	27000
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CHP System:	Gas Turbine
CHP Fuel Price (p/kWh):	2.3648

Electricity Price	Weekday (p/kWh)	Weekend (p / kWh)
Time Band 1	8.3162	8.3162
Time Band 2	8.3162	8.3162
Time Band 3	8.3162	8.3162

ACTIONenergy — Improving the financial return of CHP Schemes

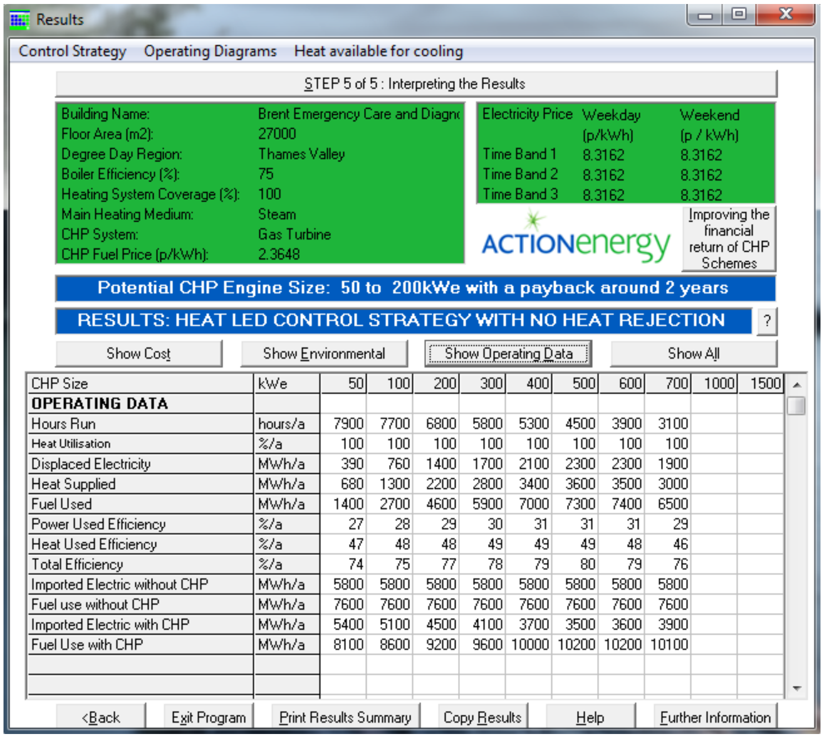
Potential CHP Engine Size: 50 to 200kWe with a payback around 2 years

RESULTS: HEAT LED CONTROL STRATEGY WITH NO HEAT REJECTION ?

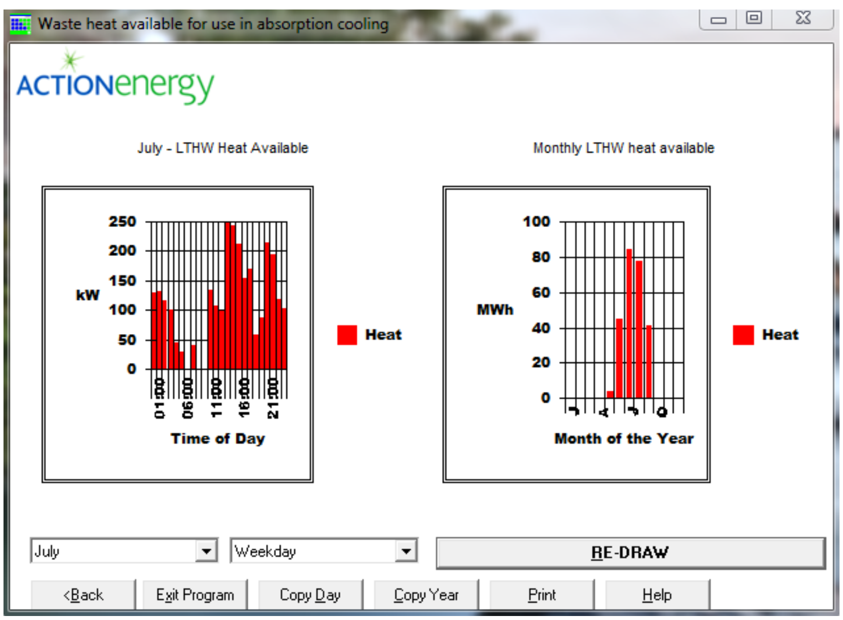
Show Cost | Show Environmental | Show Operating Data | Show All

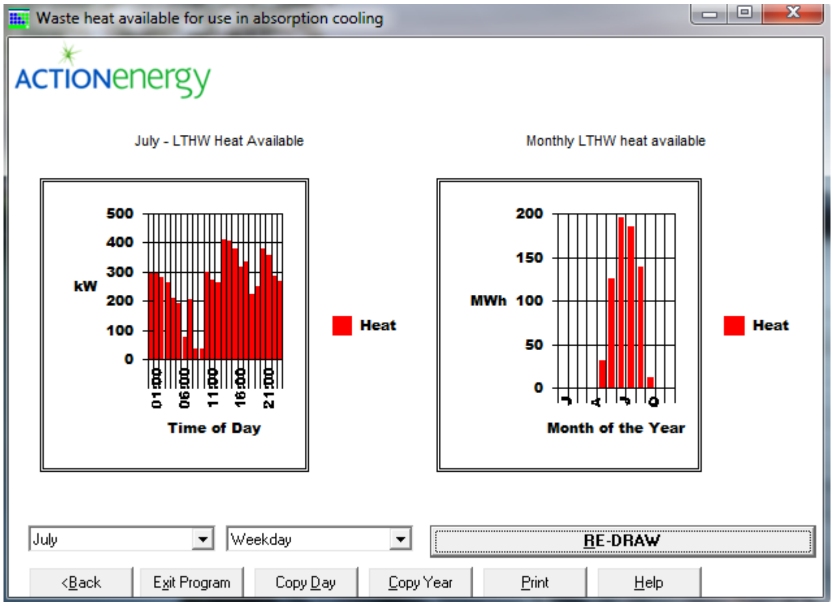
CHP Size	kWe	50	100	200	300	400	500	600	700	1000	1500
ENVIRONMENTAL SAVINGS											
Reduced Primary Energy	MWh/a	510	1100	2000	2600	3300	3600	3500	2700		
Reduced CO2	Tonnes/a	63	130	260	350	450	490	460	340		
CO2 Emissions without CHP	Tonnes/a	4000	4000	4000	4000	4000	4000	4000	4000		
CO2 Emissions with CHP	Tonnes/a	3900	3800	3700	3600	3500	3500	3500	3600		

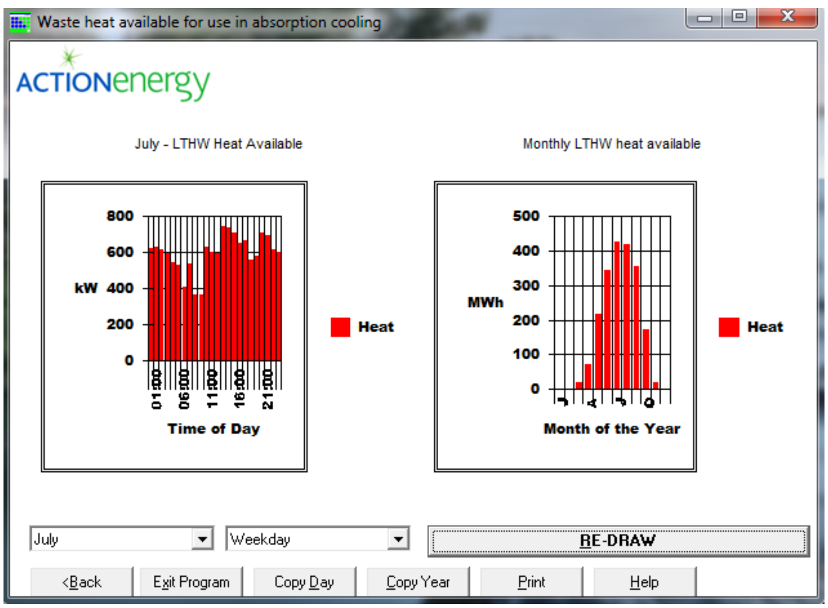
<Back | Exit Program | Print Results Summary | Copy Results | Help | Further Information



CHP Size	kWe	50	100	200	300	400	500	600	700	1000	1500
OPERATING DATA											
Hours Run	hours/a	7900	7700	6800	5800	5300	4500	3900	3100		
Heat Utilisation	%/a	100	100	100	100	100	100	100	100		
Displaced Electricity	MWh/a	390	760	1400	1700	2100	2300	2300	1900		
Heat Supplied	MWh/a	680	1300	2200	2800	3400	3600	3500	3000		
Fuel Used	MWh/a	1400	2700	4600	5900	7000	7300	7400	6500		
Power Used Efficiency	%/a	27	28	29	30	31	31	31	29		
Heat Used Efficiency	%/a	47	48	48	49	49	49	48	46		
Total Efficiency	%/a	74	75	77	78	79	80	79	76		
Imported Electric without CHP	MWh/a	5800	5800	5800	5800	5800	5800	5800	5800		
Fuel use without CHP	MWh/a	7600	7600	7600	7600	7600	7600	7600	7600		
Imported Electric with CHP	MWh/a	5400	5100	4500	4100	3700	3500	3600	3900		
Fuel Use with CHP	MWh/a	8100	8600	9200	9600	10000	10200	10200	10100		




Waste heat available for use in absorption cooling
ACTIONenergy
July - LTHW Heat Available
Monthly LTHW heat available
500
400
300
200
100
0
kW
01:00
06:00
11:00
16:00
21:00
Time of Day
Heat
200
150
100
50
0
MWh
J
A
J
O
Month of the Year
Heat
July
Weekday
RE-DRAW
<Back
Exit Program
Copy Day
Copy Year
Print
Help


Waste heat available for use in absorption cooling
ACTIONenergy
July - LTHW Heat Available
Monthly LTHW heat available
800
600
400
200
0
kW
01:00
06:00
11:00
16:00
21:00
Time of Day
Heat
500
400
300
200
100
0
MWh
J
A
J
O
Month of the Year
Heat
July
Weekday
RE-DRAW
<Back
Exit Program
Copy Day
Copy Year
Print
Help

Appendix E: Poster

Mind Your Carbon Footprint

Carbon Reduction with Decentralised Energy & Combined Heat and Power

BRENT COUNCIL

What is Decentralised Energy (DE)?

Energy production and/or distribution through smaller schemes near the energy consumer, rather than in a "centralised" system far from the point of use.

CCHP Olympic Plant

The Mayor expects 25% of heat and power used in London to be generated via DE/CHP by 2025

What is Combined Heat and Power (CHP)?

Combined Heat and Power (CHP) is the generation of electrical and thermal power simultaneously.

Why CHP? What are the benefits?

CHP systems use less fuel more efficiently which can:

- Significantly reduce carbon and green house gas emissions
- Save hundreds of thousands of pounds each year

CHP provides users with power even in the event of grid failure

- Ideal for buildings that require constant heat/cooling such as hospitals

Each year, The Royal Shrewsbury Hospital saves £780,000 and reduces 2,000 tones of carbon emissions from using a 1150kWe CCHP plant.

CHP can REDUCE CARBON EMISSIONS by *THOUSANDS* of *TONNES* per year!

More Information can be found in:

Reducing Carbon Emissions Brochure

Decentralised Energy and You Handbook

S:\APT's\Policy & Project Teams\Policy\WPI Do Not Delete\WPI 10\Information

CHP Planning

Planners can help reduce the borough's carbon emissions by convincing developers to use CHP technologies in their plans.

WPI

Appendix F: Brochure

What?

Decentralised Energy

- Decentralised Energy (DE) refers to energy production and distribution through smaller, more district schemes as compared to traditional energy systems
- Smaller DE schemes allow for energy transfer over shorter distances, increasing the efficiency of the systems and overall carbon reduction of the process

The Mayor expects 25% of heat and power used in London to be generated via DE/CHP by 2025

Combined Heat and Power

- Combined Heat and Power (CHP) is the generation of electrical and thermal power simultaneously
- Boiler based systems use steam to run electricity generating turbines as well as to provide heat
    - Condenser chillers can be run on steam rather than electricity to provide cooling

Why?

CHP: Heating Networks

- Heat networks can distribute thermal energy produced in CHP facilities
- Boroughs are seeking to implement heating networks supplied by CHP plants in accordance with LDA and local policies
- Electricity produced via CHP can be sold to the established grid

Benefits of CHP

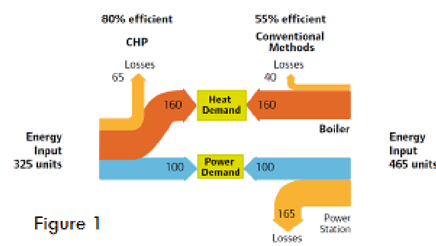
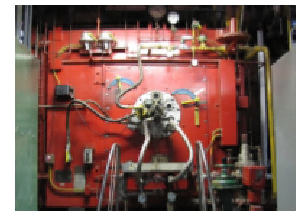


Figure 1

- Figure 1 demonstrates the efficiency of CHP: 80% fuel efficient compared to traditional methods achieving a maximum of 55% efficiency
- Increasing fuel efficiency reduces fuel consumption and therefore carbon emissions

Who?



Planning for DE and CHP

- The reduction of carbon emissions that developers must reach can be partially achieved through CHP and heat networks
- Planners that are knowledgeable in DE and CHP will be better suited to communicate to developers the possibilities of DE and heat networks
- Identifying areas with good DE potential can give planners leverage and help support DE policies
- Planners are vital to the success of implementing carbon reducing CHP plants

For more information on the role of planners in the future of DE, see the handbook *Decentralised Energy and You*

Appendix G: *Decentralised Energy and You*

Decentralised Energy and You

The Planner's Handbook to Decentralised Energy and Combined Heat and Power

Brent Council
Planning Service
April 2010

Anthony Aldi
Karen Anundson
Andrew Bigelow
Andrew Capulli

Introduction

Decentralised Energy and You outlines the basics of decentralised energy, combined heat and power technologies, and heat networks while containing case studies of existing networks and combined heat and power systems. This guide includes a section describing characteristics of a successful decentralised energy and/or combined heat and power project including considerations like basic costs, the types of loads required for a successful network and how to negotiate with developers and energy companies. The introduction provided in this guide can be supplemented with the information found in resources identified at the end of each section.

Table of Contents

The Problem

In 2009 the International Energy Agency (IEA) projected global energy demands to increase by 40% between 2009 and 2030, assuming no change in government policies. This increase in demands in conjunction with the threat of climate change has spurred efforts to reduce global greenhouse gas emissions. The increasing energy demand conflicts with the objective of decreased emissions. This dilemma has led to efforts to find alternative and more efficient methods of producing energy, improved distribution methods and conservation efforts to reduce energy demand.

Currently in most areas, electric power generation and building heat systems are implemented independently. Centralised power plants located far from the energy consumers are the primary producers of electric power. Unfortunately, these systems lose about 70% of their input energy to thermal waste during production and transmission to the users. Decentralised Energy (DE) schemes mitigate transmission losses by bringing power generation closer to the user. DE schemes can include systems that combine the production of electric power and heat in the same facility, using heat from power production, rather than wasting it, thus dramatically increasing efficiencies. These systems are called Combined Heat and Power (CHP) generation plants. The Mayor of London's spatial development strategy, the London Plan, includes provisions that are intended to increase the fraction of London's power that is generated using more efficient CHP systems. Local authorities now face the task of ensuring the implementation of DE and CHP systems within their boroughs.

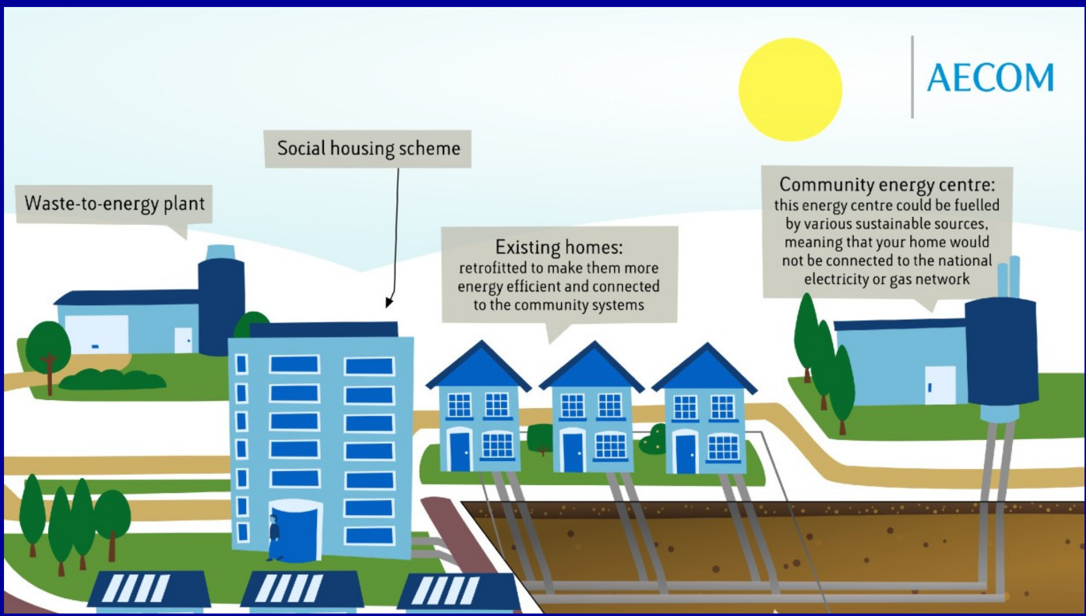
The Mayor expects 25% of heat and power used in London to be generated via DE/CHP by 2025

What are Decentralised Energy and CHP?

Decentralised Energy (DE) refers to energy production on small or 'district' scales to maximize fuel efficiency and minimize distance of energy transport. District heating (DH), an idea derived from DE, is the local distribution of heat to a network of users. Combined Heat and Power (CHP), also termed cogeneration, is a method of combining normally separate power generation and heating systems to work together for a more efficient combined system. These systems can also be designed to provide cooling needs which is called trigeneration or Combined Cooling Heating and Power (CCHP).

Above: These systems can be small enough to fit in a basement to provide heat and electricity for a small network (left), or can be large buildings providing heat and electricity for large networks (right).

Below: An example of a small heat network connecting an energy centre to existing homes and a social housing scheme.

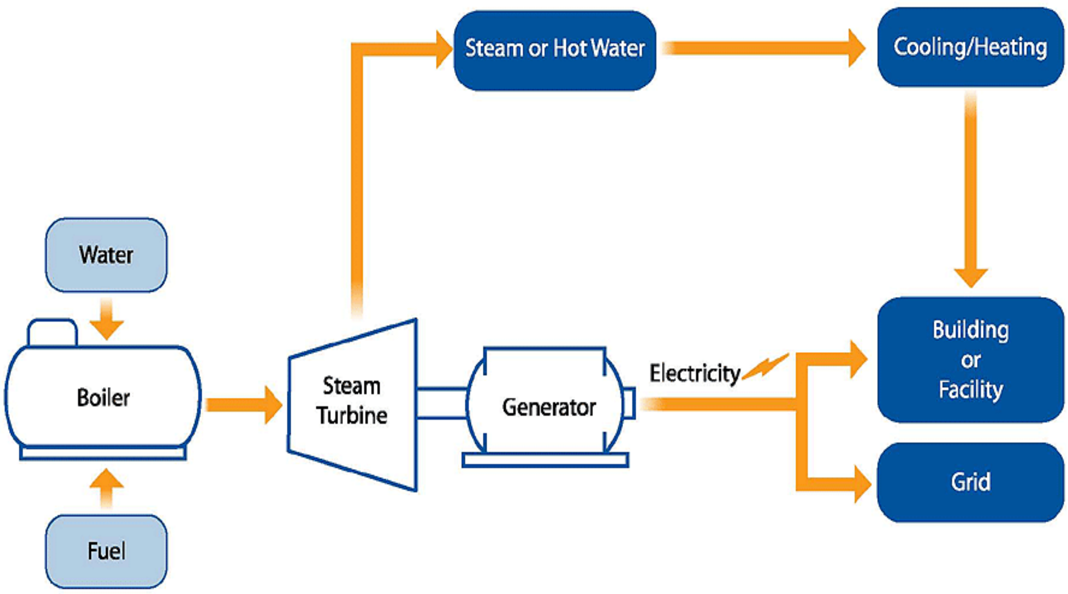


Basic CHP/CCHP Components

CHP and CCHP systems can be broken down into the same fundamental components. These systems consist of two main subsystems: electrical power generator and a unit that will supply heat in a CHP system or heat and cooling in a CCHP system. The exact configuration of these components will change depending on whether the system is optimized to meet heat demands or to meet power demands. These facilities can be simplified into two system configurations: gas turbine or steam boiler.

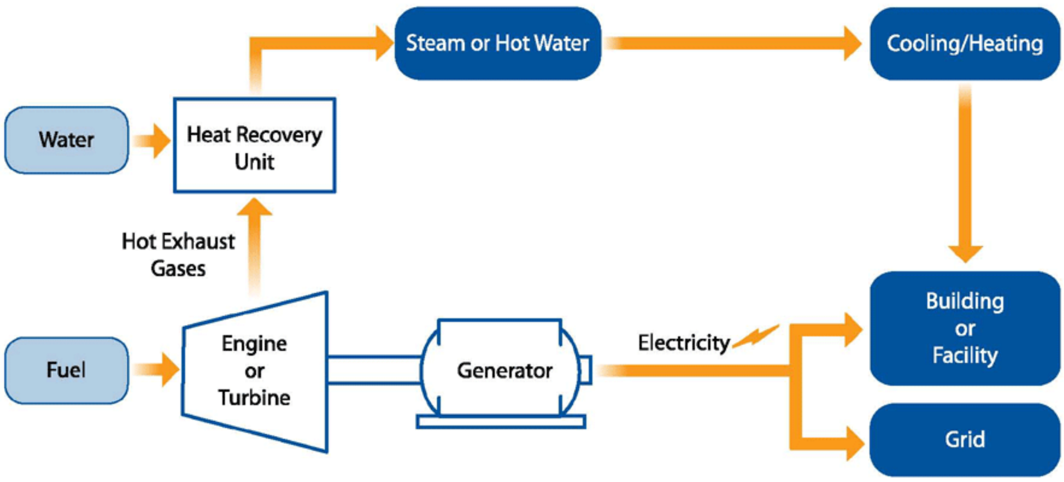
Boiler Systems

Boiler systems are more appropriate for smaller scale systems where fuels (biomass, gas, oils) are readily available to fuel the boiler unit. These boiler systems are primarily designed to address heating/cooling demands with a by-product of electricity. Fuel is not used to drive an engine, but rather burned to heat water to produce steam in a boiler. The steam is first used to power a turbine-generator unit for electricity production, then the steam is sent directly to heating distribution and/or cooling systems. The boiler method is illustrated in the figure below.



Gas Turbine Systems

The gas turbine system of CHP/CCHP is more suited to large scale installations such as commercial or industrial applications with large electric and heat/cooling demand. The burning of natural gas in a turbine powers a generator creating electricity to be sold back to the grid. A heat recovery unit is fitted to the engine with the purpose of capturing residual heat that can then be used to create steam. This steam is then distributed for heating and/or used to power cooling systems. The gas turbine method is illustrated in the figure below.



More information regarding the basics of CHP can be found at:

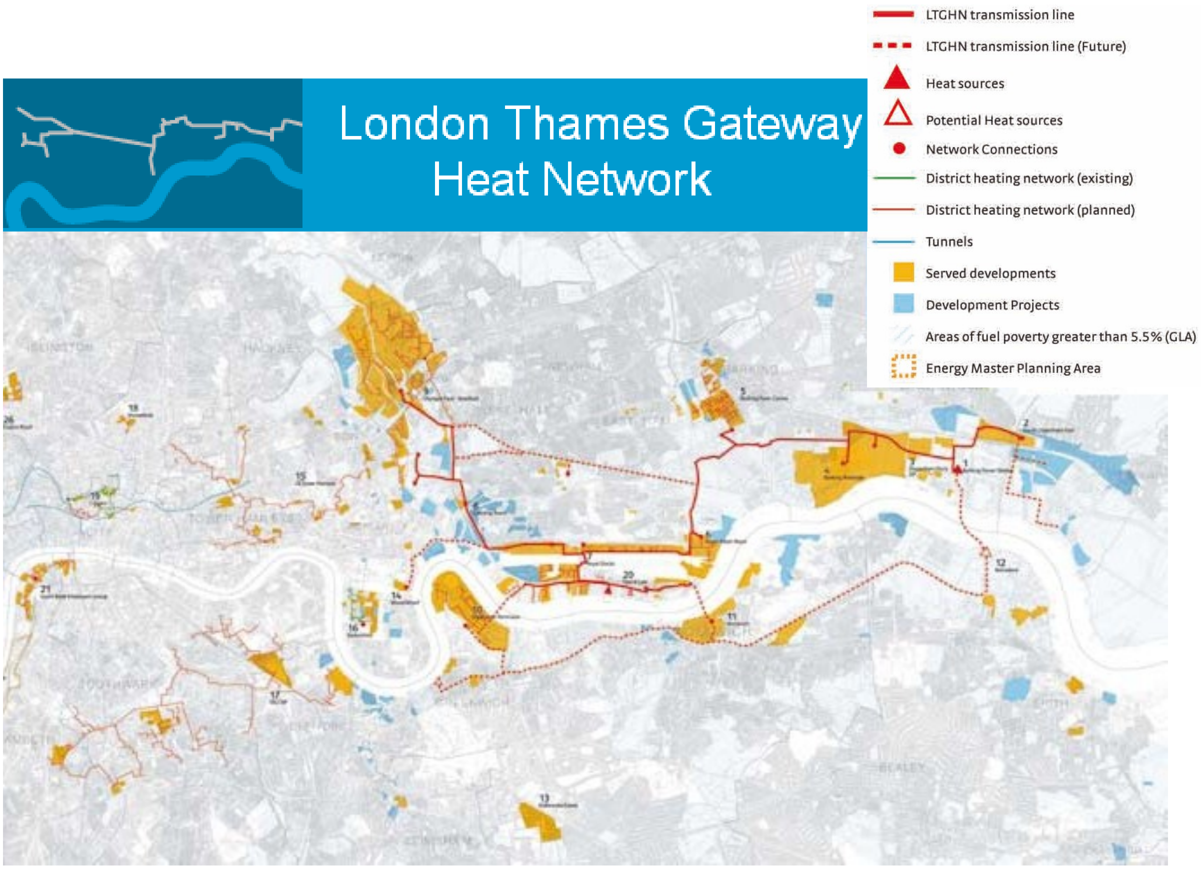
Combined Heat &Power Association:
http://www.chpa.co.uk
Department of Energy &Climate Change:
http://chp.decc.gov.uk/cms/
Center for Energy Efficiency & Renewable Energy:
http://www.ceere.org/iac/iac_combined.html
U.S. Environmental Protection Agency (source of diagrams)
http://www.epa.gov/CHP/basic/

Distributing the Heat

After a CHP/CCHP system has generated heat, a heat network must be in place to transport the heated water from the CHP/CCHP facility to the final consumer. A heat network is a series of thermally insulated pipes, normally run underground, that connect the plant to its heat loads. A plant will need at least one anchor heat load, a load that will supply a reasonably constant and large load to the system. Anchor loads are important to make a plant technically and economically viable. With an anchor load established, a plant with excess capacity or the potential for added capacity can be connected to additional loads that do not need to be as large as the anchor load. A large plant will be able to supply a wider network than a smaller plant and can offer increased efficiency. A network can also be developed from several smaller plants networked together to provide a wide and even heat supply.

An example of a small heat network would be The Imperial London Hotels located in Bloomsbury in central London. The hotels are located in close proximity to each other which allows for optimal usage of CHP facilities. The Royal National and Travistock hotels (1,630 and 400 rooms respectively) share a heat network powered by one 122kWe unit and one 225kWe unit. The Imperial and President hotels (450 and 525 rooms respectively) share a heat network powered by two 122kWe units. The site contains four plant rooms, two of which serve four hotels normally and then the remaining two are standby units to use during scheduled maintenance. These systems are estimated to save the group over £10,000 per year .

An example of a large heat network would be the proposed London Thames Gateway Heat Network (LTGHN). The 150 MW of thermal power will be produced at the Barking Power Station and the Tate & Lyle Plant. The distribution main of the heat network will be approximately 67 km long. As the system grows, the LTGHN aims to incorporate other power facilities into its network to produce a more efficient and resilient system. As the power plants produce electricity power distributed via the grid, their formally waste heat is being used to heat water to be transmitted throughout the LTGHN.



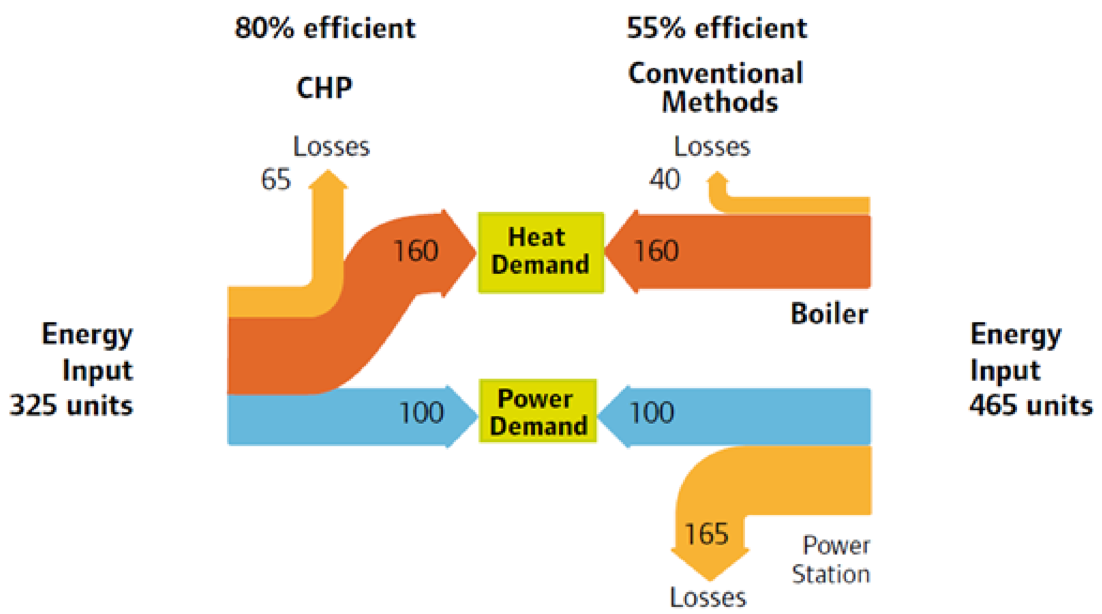
More information regarding the London Thames Gateway Heat Network can be found at:

London Thames Gateway Heat Network:
http://www.ltgheat.net/heat-network/

Benefits of DE and CHP

Decentralised energy schemes have numerous benefits that are directly related to their high efficiency as compared to conventional systems. Efficiency is defined as the process of doing more with less. Because energy is produced close to the consumers in DE networks, the energy transmission losses, which can be up to 70% for electricity, are greatly reduced. Communal boilers connected to heating networks can be much larger than individual boilers which allow them to take advantage of economies of scale. This means that these larger shared systems are much more cost efficient than many smaller boilers and can reduce overall costs. The cost savings can be shared by the consumers and attract companies to invest in DE systems because of the profit potential. The infrastructure developed for these systems can also be connected to a larger heating or combined heat and power scheme in the future.

Combined heat and power systems can produce power in addition to heat while maintaining high system efficiency. The average efficiency of a CHP system can be in excess of 80% as opposed to producing electricity and heat separately which results in a net efficiency of only about 38% to 55%. The figure below demonstrates how CHP systems require less energy input (fuels) for the same amount of energy output (heat and electricity) and reduce energy loss when compared to conventional separate heat and power generation.



CHP systems, compared to conventional systems, have a reduced environmental impact because they use less fuel in energy generation. The lower amount of fuel used also results in varying yearly cost savings that can range from 15% to 40%. The significant increase in fuel efficiency can be combined with economies of scale to provide greener and cheaper energy. By using or connecting to CHP systems developers can meet higher sustainability levels because of the lower carbon emissions from heating and powering the building. Utilizing CHP also addresses the Mayor's goals and the "clean" provision of the energy hierarchy (shown in the figure) outlined in current London Plan (2008).

Energy Hierarchy

From *Policy 4A.1 Tackling climate change*

Lean

- using less energy, in particular by adopting sustainable design and construction measures (Policy 4A.3)

Clean

- supplying energy efficiently, in particular by prioritising decentralised energy generation (Policy 4A.6)

Green

- using renewable energy (Policy 4A.7)

There are many cases of successfully implemented CHP systems in hospitals, hotels, and even fire stations. A major benefit of CHP in emergency facilities is the energy security of these systems that allow them to remain functional with no additional back up generators in the event of a grid failure. A case study of The Royal Shrewsbury Hospital in Shrewsbury, England showed yearly savings of £780,000 from using a CHP plant. According to the CHPA, fire stations are excellent candidates for CHP because they have a sufficiently large and continuous energy demand. Because of this, the London Fire Brigade has implemented mini–CHP systems in over 40 of its 112 fire stations. These systems have led to the reduction of thousands of tonnes of carbon and Green House Gas (GHG) emissions every year. CHP systems demonstrate that locally generating heat and power simultaneously can have a profound positive impact on the borough, developers, and consumers.

More information regarding the benefits of DE and CHP can be found at:

Combined Heat &Power Association:
http://www.chpa.co.uk

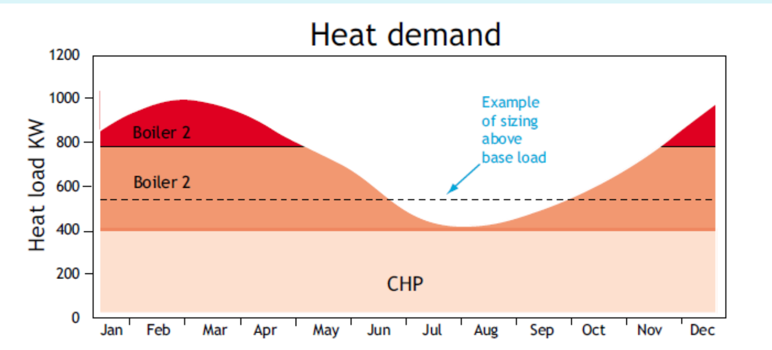
Bringing DE and CHP into the Borough

For many boroughs, facilitating the development of decentralised energy networks is a new process. Careful planning policy development combined with the use of existing policies and planning tools can allow the borough to begin the successful implementation of a decentralised energy scheme and the development of combined heat and power systems. A knowledgeable and motivated planning department is necessary to move development forward. Through a combination of old and new policies and planning practices used with knowledge of DE and CHP, the planning service should be able to facilitate the implementation of a decentralised energy network.

Finding Possible CHP/CCHP Locations

Identification of potential decentralised energy networks and locations for CHP/CCHP will facilitate the development of more specific policy and requirements and allow planners to present a case to developers for the inclusion of decentralised energy and/ or combined heat and power systems. Sites can be examined for basic requirements and then further studies conducted by the borough or a borough procured consultant can provide the evidence base for policy and requirements, including building requirements and mandatory submission of energy feasibility reports with planning applications.

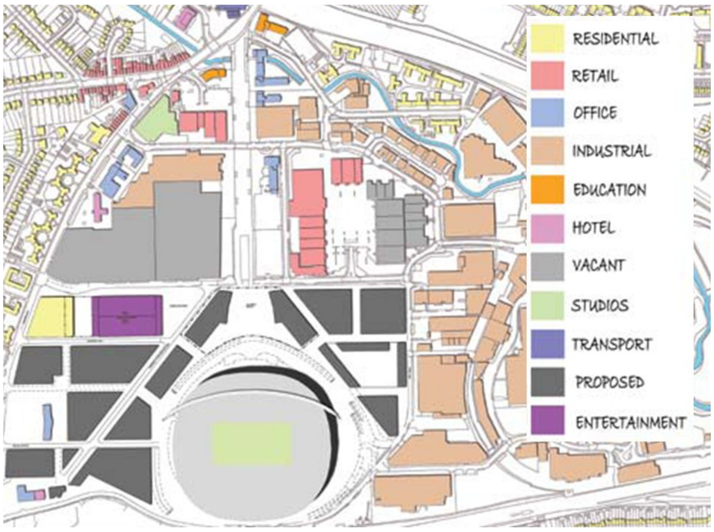
In order for a CHP plant to take full advantage of its efficiency, it needs a large load that is consistent over the course of a day and over the course of a year. A good rule of thumb to follow is that a CHP system needs to run approximately 5,000 hours per year



A CHP system needs to be sized so that the system can meet a base load. Sometimes these systems are sized above a base load such that the winter savings outweigh the losses in the summer.

or an average of 14 to 16 hours per day otherwise too much heat is thrown away for the system to return the benefits of a combined system. To meet this requirement an anchor load is needed. The table below outlines good anchor loads as summarized from UK Good Planning Practices Guideline:

Application	Reason
Universities and colleges	Accommodation buildings have high demand for domestic hot water, providing an 18-24 hour demand. Office and teaching buildings will need heat throughout the day; accommodation buildings will need heat during early mornings and evenings.
Hotels	High demand for domestic hot water in bedrooms, kitchens and for cleaning provides a base demand. Hotel leisure facilities such as fitness centres with showers and/or swimming pool facilities add to this base load.
Hospitals	Need high ambient temperatures and have high demand for domestic hot water for washing, cleaning and catering. Operate 24 hours per day.
MOD, prisons and DSS buildings	Public sector buildings such as MOD barracks, prisons and detention centres operate 24 hours per day. Have high demands throughout the day for domestic hot water for washing, bathing, cleaning and catering.
Leisure centres	Leisure centres with swimming pools have a steady base load requirement for 18 to 24 hours per day. Showering and catering requirements add to the base load.
High density residential	Residential buildings often have a need for high ambient temperatures and have high demand for domestic hot water. Community heating brings many small intermittent loads to form a substantial base load demand for heat. A combination of residential and commercial would provide a more balanced load throughout the day.
Offices/town halls	Good candidate if expected occupancy extends into the evening. May benefit from absorption chilling.
Museums	Need to maintain stable temperature and humidity conditions 24 hours per day.
Schools	Good candidate if accompanied by extended occupancy (e.g. boarding school) or has a swimming pool. Can also be used during after school hours for other events.
Retail stores/shopping centres	Good candidate if has extended operating hours. May benefit from absorption chilling.
IT buildings/call centres	Large electrical and cooling loads. May benefit from absorption chilling.

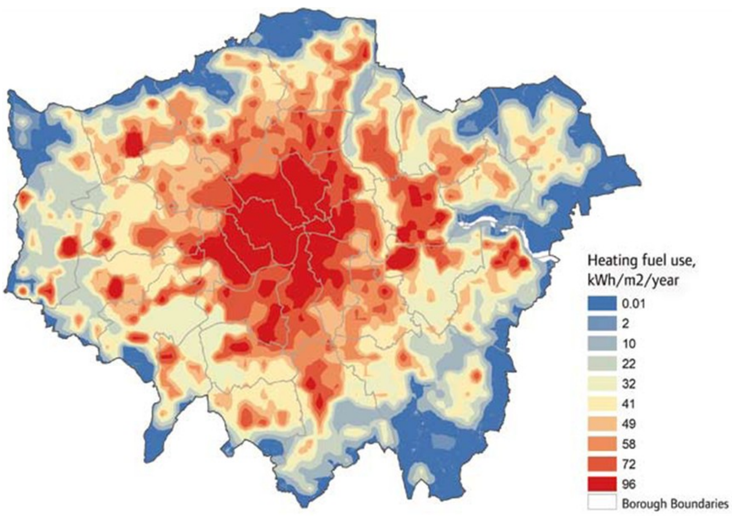


Areas with mixed use are also good areas to look at when building a CHP plant. These areas provide energy consumption peaks at different times during the day, resulting in a more stable base load. Residential buildings will peak in the morning and evening, before and after the work day. Office and business buildings will peak in the middle of the day. An example would be an area containing residential, office buildings and retail stores, such as the current building use in Wembley from the *Wembley Masterplan*.

Visually representing these major loads is an effective method of identifying clusters of heat loads. Heat maps show the locations of major heat loads. The London Heat Map, created by the London Development Agency (LDA), is a tool used to locate major heat loads throughout the region. The LDA is currently aiding local borough heat mapping to add a higher level of accuracy to the map and allow for individual boroughs to identify major heat loads within their borough. Knowing which areas of the borough have the most potential for decentralised energy and combined heat and power will provide information for the formulation of area specific plans and long term plans for extended decentralised energy networks.

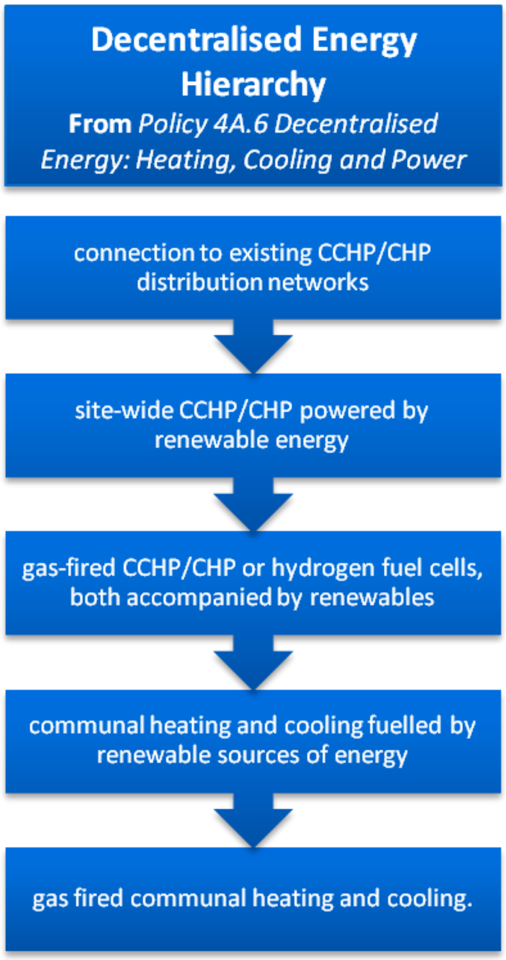
More information regarding the London Heat Map can be found at:

London Heat Map: www.londonheatmap.org.uk



Prioritising Potential

Areas in the borough should be examined for new network and energy centre development as well as retrofit possibilities. The decentralised energy hierarchy outlined in the London Plan, shown to the right, should be used when evaluating sites for decentralised energy and combined heat and power potential.

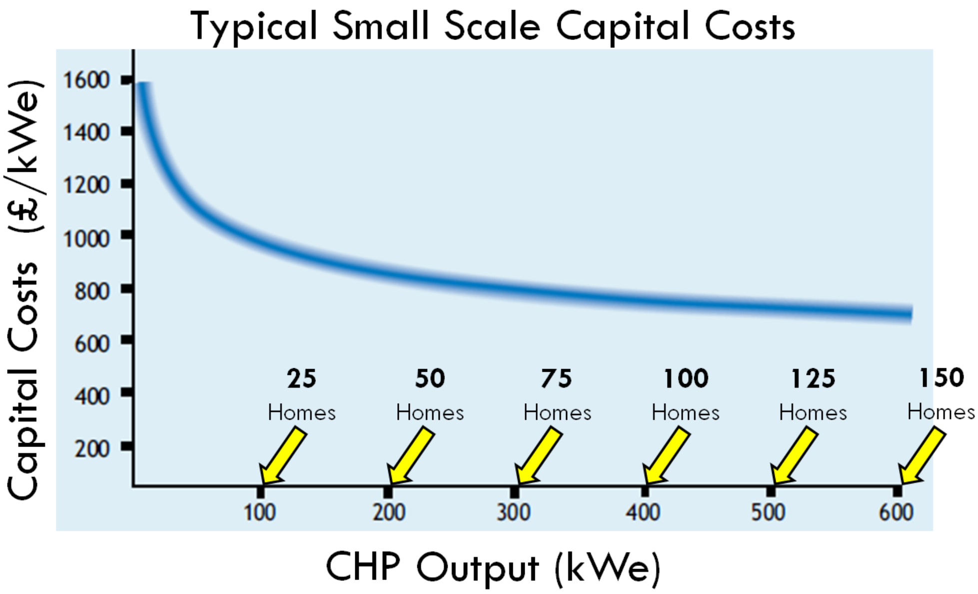


If there is an area in which a CHP plant or decentralised energy network already exists, connection to this system can be a good option. Connection to an existing network is a good way to use excess capacity or to provide an opportunity to expand the capacity of an existing plant.

Areas of new development are good locations for CHP/CCHP plants because construction is already taking place, making it easier to construct a plant and lay the necessary infrastructure like heat pipes. If development of a CHP is not feasible in a particular location, a developer can leave their development open to future connection to a decentralised energy network by installing an efficient and relatively clean running centralised heating system. Buildings or developments with existing heating networks or communal heating systems are good candidates for future connection to CHP because the piping already exists. These communally heated buildings and developments can provide loads to attract potential energy centre developers.

Basic Costs of CHP/CCHP

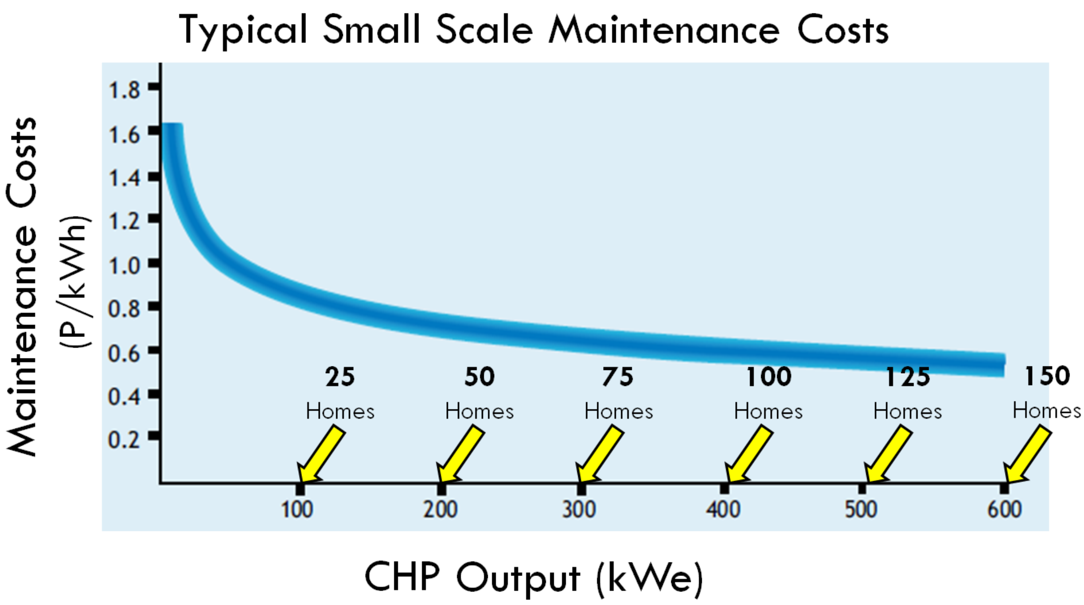
Once a location has been set for the building of a CHP/CCHP plant, cost considerations must be taken into account. Each facility is going to cost a different amount because of varying sizes and each plant is unique to its own area. These facilities require a large initial capital investment due to installation costs, maintenance costs, fuel costs and piping costs (£1 Million/ KM). All of these factors become more important as the size of the plant increases. However, the figure below shows that as the plant size increases, the cost per kWe of energy produced decreases.



Specifically, you can see that a CHP plant with an electric power output of 100kWe (about 25 homes worth of energy) has a capital cost of about £1,000 per kilowatt of energy produced. Alternatively, a CHP plant with An electric power output of 600kWe (about 150 homes worth of energy) has a capital cost of about £700 per kilowatt of energy produced.

Increasing the size of a plant is not always economically feasible in many situations. To implement larger systems, it requires additional infrastructure to be able to support the extensive networks. Phasing in a network will likely be the most viable option, starting with smaller generation facilities and in the future consolidating into a larger more cost effective energy center.

Another factor that needs to be considered is once a plant has been constructed, general maintenance has to be performed in order to avoid future problems. The following figure shows that as the size of the plant increases, the amount it will cost for maintenance decreases per kWh.



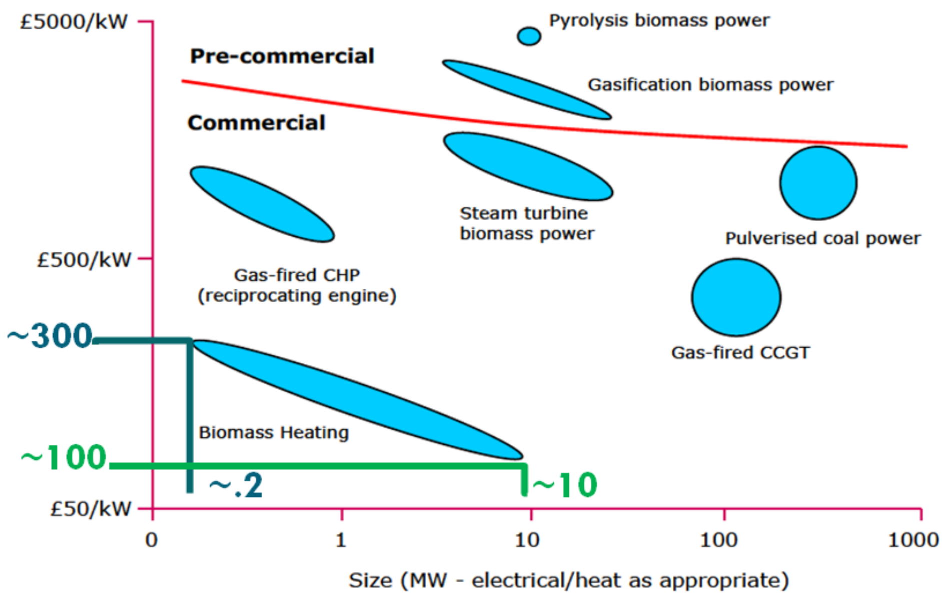
Specifically, you can see that a CHP plant with an electric power output of 100kWe (about 25 homes worth of energy) has a maintenance cost of about 0.8 pence per kilowatt hour of energy produced. Alternatively, a CHP plant with an electric power output of 600kWe (about 150 homes worth of energy) has a maintenance cost of about 0.5 pence per kilowatt hour of energy produced.

FUNDING OPTIONS:

The council can use several options to fund decentralised energy projects. The OJEU (Official Journal of the European Union) publishes all public sector tenders above a financial threshold. Through the procurement process OJEU allows organizations throughout the European Union to bid on projects proposed by the public sector. Future council involvement in the implementation of DE is probable in

(Continued on page 15)

CHP systems can be powered by a wide range of fuels including traditional fossil fuels like oil and natural gas as well as alternative fuels like those derived from biomass. The following graph shows a sampling of fuel types and compares a range of how much each costs per kilowatt compared to the amount of power each type of fuel can generate. If a 0.2 MW biomass plant was constructed, it would cost roughly £300 to produce 1 kilowatt of power. Alternatively, if a 10 MW biomass plant was constructed, it would roughly only cost £100 to produce 1 kilowatt of power.



Depending on the size of the plant and type of fuel, costs of each will vary. The graph represents the varying costs by showing the ranges of different fuels.

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order to organize and begin the process. Funding sources such as the JESSICA Fund, the DEMaP Program, and energy tariffs will aid the borough in this task.

JESSICA Fund: Joint European Support for Sustainable Investment in City Areas
DEMaP: Decentralised Energy Masterplanning Programme (LDA)
Energy Tariffs: Economic incentives to use low carbon energy

The table below contains four different CHP systems with varying sizes and fuels. Their minimum power, average capital cost per kWe and estimated operation and maintenance costs are provided.

	Small Gas Engine CHP	Large Gas Engine CHP	Small Biomass air Turbine	Medium Biomass steam turbine CHP
Minimum Power	500 KWe	2 MWe	100 KWe	8 MWe
Capital Cost (£/KWe)	864	657	4,000	3,500
Estimated Operation and Maintenance Costs (£)	80/KWe per year	48/KWe per year	180/ KWe per year	80/ KWe per year

The information from this table can be found in the Poyry report called

"The Potential Costs of District Heating Networks" which is on the DECC website.

Average capital costs, maintenance costs and fuel costs are all major contributors to the construction of a CHP facility. However these costs do not include the infrastructure necessary to support such systems. The piping for 1 Kilometer costs between £1 Million and 3£ Million. This can result in a CHP facility costing millions of pounds. CHP facilities are designed to save money on heat and electric energy costs. Over a period of time the money saved from each year pays for the facility. This is called the payback period. Payback periods vary with plant size, however average periods are about five to ten years. After the payback period money that would be spent on energy costs will now become profit.

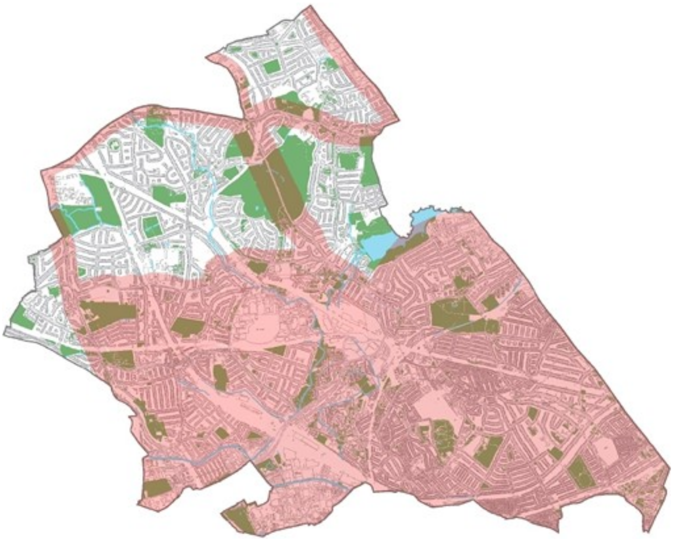
More information regarding DE Costs and Funding and Project Development can be found at:

U.S. Environmental Protection Agency: http://www.epa.gov/chp/documents/chp_handbook.pdf
OJEU Procurement: www.ojec.com
DE and CHP Funding (LDA): www.lda.gov.uk
DE and CHP Funding JESSICA: ec.europa.eu/regionalpolicy/funds
UK Good Practice Guide GPG388: http://www.carbontrust.co.uk
Poyry: The Potential Costs of District Heating Networks

Pollution Regulations: Brent

When constructing new buildings in any area health and pollution concerns are always addressed. This remains true when developing in Brent and the Council's pollution regulations may impact the implementation of CHP schemes within the borough. The current state of the Brent's air pollution has an effect on how the borough views the different areas within the borough when assessing new developments.

Brent has declared the entire area south of the North Circular Road and some of the north an Air Quality Management Area (AQMA) (the red coloured areas in the picture below). In these areas the boroughs are required to create a plan on how the air quality will be improved. The pollution in the Southern part of the borough is mainly due to the high traffic roads nearby and pollution coming from the city. Along the North Circular Road there are high PM10 concentrations and generally in the AQMAs there are elevated NOx levels. Because of this the Council will be hesitant approving a CHP plant with high NOx emissions, like an incinerator, especially in the South Kilburn area where the pollution is the worst. Cleaner sources like pyrolysis and digestive fuelled facilities would have a higher likelihood of being accepted.



Special Sites of Scientific Interest (SSSI) exist that require any developments around the site to be carefully analysed to ascertain its impacts on the SSSI. Brent Reservoir is classified as being one of these sites and it located North-East of Wembley. Specific regulations that the borough publishes need to be considered. Starting April 6, 2010, the

Environmental Permitting Regulations 2010 will be in effect to make up the more recent environmental specifications.

Fuel is an important factor when considering pollution and the regulations thereof. In many areas using general waste, like garbage, as a fuel will likely encounter problems in the planning process because those fuels are difficult to regulate and generally emit larger amounts of more destructive pollutants than other fuels. Fat based waste such as filtered used vegetable oil also known as biodiesel is better for the environment because it is more homogenous and the pollutants are more predictable. Using fats for fuels is also beneficial because it provides an efficient method for disposing and making use of the waste close to the source. Plants that use alternate fuels such as waste and biomass require special permits and are more regulated if the total thermal output is greater than 3MW, compared to natural gas plants which have a threshold of 20MW.

The borough is not solely concerned with air pollution, but also noise pollution. Power plants often generate a high level of noise. A new power plant would require a BS4142 (British Standard) assessment to be done to estimate the noise heard by the nearest residential building to it. The estimates are based on data collected from previously built plants. The Council would prefer to build loud plants in an already noisy area such as next to roads, rail ways, and industrial areas rather than quiet areas like parks and open space.

Another regulation that developers should be informed of concerns contaminated land. Before land is developed the Council has the soil tested for contaminants and again later when new development occurs or possibly when the ownership changes. Owners are required to ensure that the land is no more contaminated for the second test than it was for the first. Environmental and heath concerns are pertinent when planning any development and are especially important for energy facilities.

Policy and Planning Practices

For many boroughs, facilitating the development of decentralised energy networks is a new process. Careful planning policy development combined with the use of existing policies and planning tools can allow the borough to begin the successful implementation of a decentralised energy scheme, including the development of combined heat and power systems.

Several already existing planning and policy practices can be used to encourage growth of decentralised energy. Discussions with the developers concerning DE should start early in their pre-application process. The borough can present information from studies it conducted and developers can conduct their own studies analyzing technical and financial feasibility for their development. By requiring an energy statement, developers must evaluate and justify why they choose to include or exclude certain renewable and/or low carbon solutions in their plans. Plans should comply with the energy hierarchy and decentralised energy hierarchy outlined in the London Plan.

The borough can also use Section 106 agreements to ensure inclusion of decentralised energy plans. These agreements, under Section 106 of the Town and Country Planning Act 1990, allow local authorities to enter into legally-binding agreements with developers in exchange for the granting of planning permission. These agreements are frequently used to obtain provisions for services and infrastructure. Other London boroughs have used these agreements to facilitate the development of decentralised energy networks.

The formulation of new local policies can ensure that decentralised energy development follows a coordinated plan. Using information obtained from studies and masterplans, specific areas and sites with DE potential can be identified. In general, these plans will follow the decentralised energy hierarchy from the London Plan. Islington's *Development Management Policies: Issues and Options Draft* (October 2009) identifies some important questions. "What physical contribution should we ask in order to enable such a connection [to a DE network]?" "If a network is operational what are the criteria for deciding whether or not it is feasible for a development to connect to it? Examples of criteria we could use are:

i) The size of the development
ii) The distance of the development to the DE network pipes
iii) The presence of physical barriers such as major roads or railway lines
iv) The cost of connection and the impact this has on financial viability"

A question is also raised regarding how to determine the amount that a developer should contribute to DE networks if connection to an existing network is not feasible. The answers to these questions are not simple and will need to be addressed differently based on development types, sizes and locations. The Southwark Local Development Framework (LDF) draft currently contains guidelines developers need to follow regarding looking for an existing DE network. For residential developments, the distance increases as the number of dwellings increases. "Commercial and other non-residential development within 200 metres of an area-wide CHP or CCHP system should connect unless it is demonstrated that there is not enough heating demand for an efficient connection." If a system does not have sufficient capacity to support a new development, the developer must examine the possibilities of a contribution to expansion or upgrade of the existing system. If the public CHP system has not been completed, an efficient gas or bio-fuel boiler system should be used temporarily." The table below summarizes what other boroughs are doing.

DE Planning/ Policy	**Southwark**	**Barking and Dagenham**	**Islington**
Connection/ Creation of Networks Hierarchy	• Connection to existing networks • Installation of piping for future connection where the borough has plans for future networks • Financial contribution to network development elsewhere	• Connection to existing networks is encouraged • In locations of planned future networks, provide infrastructure for future connection • Borough follows the energy hierarchy as presented in the London Plan	• Connection to existing networks is encouraged • Provide infrastructure for future connection where appropriate • Borough follows the energy hierarchy as presented in the London Plan
Developer Reqs.	Research connection to networks within • 20 dwellings: 50 m • 20-30 dwellings: 100m • 31-40 dwellings: 150m • 40+ dwellings: 200 m	• Provide the borough with their own independent study into energy feasibility (possible connections, economic feasibility, etc)	• Connection to existing networks or providing future infrastructure is required unless shown not feasible to do so
Convincing and Aiding Developers	• Conducted studies into alternative energies-CHP proved most feasible • Studies into future possible networks and identification specific network areas • Guaranteeing council housing as future anchor heat loads	• Studies and identification of possible network areas (Town Center and Barking and River Side) • Provide developers with 'toolkit' and technical guide for connection to DE networks	• Studies and identification of possible network areas • Council involvement with either providing anchor loads or securing anchor loads for future networks

The Future

Accomplishing the goal of implementing DE schemes throughout the borough is challenging and requires sufficient background knowledge and a good set of tools to facilitate development. It will be the individual planner's role to convince developers that CHP should be included in their plans and is a wise economic investment. Because planners have this vital role it is necessary for them to have a basic understanding of decentralised energy systems in order to knowledgably engage in related conversations with developers. When reviewing applications and negotiating with the developers, planners should gain an understanding of the area surrounding a proposed development. Planners informed of large potential anchor loads close to the development locations will be able to demonstrate the demand for heat and power to developers. Knowledge of large buildings with communal heating systems will further build the image of a future potential network. Current and phased heat maps can be an invaluable tool planners should be familiar with and use to visually demonstrate potential heat customers and networks to developers. Being familiar with potential natural and manmade network obstacles in development areas will give planners an idea to the feasibility of potential networks. Although developers will largely provide the funding for and implementation of these networks, it is the informed planner who can initiate the process. Planners must become familiar with decentralised energy, CHP, and the basics of heat networks to aid the borough in meeting its carbon reduction and decentralised energy goals.

Glossary

Term	Description
Air Quality Management Area (AQMA)	An area where the air quality goals are not able to be met.
Biomass	A fuel comprised of recently harvested organic material that can be used in combustion
Combined Cooling, Heat, and Power (CCHP)	A method similar to CHP, but in addition some of the heat is used to provide chilled water
Combined Heat and Power (CHP)	A method of generating heat and power simultaneously to maximize system efficiency.
Decentralised Energy (DE)	A method of generating energy (power and/or heat) close to the user
Energy Service Company (ESCo)	A company that does on or more of the following: provide energy to consumers, maintain an energy generating unit, manage a heating network, and manage heat network connections to and bill heat consumers
Heat Load	A consumer of thermal energy or heat.
Heat Recovery Unit	A piece of equipment to extract usable heat, usually from exhaust gas
Joint European Support for Sustainable Investment in City Areas (JESSICA) Fund	A source of financial funding aimed at supporting sustainable investment in urban growth and jobs
Kilowatt of Electricity (kWe)	A measure of the rate of electricity usage or supply. A typical house uses an average of 4 kWe.
Local Development Framework (LDF)	A collection of planning documents that describe a borough's vision, strategies, and policies
NOx	Nitrogen Oxides; are usually produced from combustions with air
Official Journal of the European Union (OJEU)	A published journal that contains all large publicly funded projects and organizations
PM10	Particle matter in the air that measures small than 10 microns (10^{-6} m) in diameter
Site of Special Scientific Interest (SSSI)	Sites that have been deemed one of England's best wildlife and geographical locations