41-43 Chalton Street, Camden

ENERGY STATEMENT

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1.0 Executive Summary

This preliminary report considers the predicted energy demand for the proposed redevelopment of 41-43 Chalton Street, Camden, hereafter referred to as the Development.

This document complies with the requirements at both national and local level, as set out in the National Planning Policy Framework (2012), The London Plan (March 2016) and the London Borough of Camden Development Policies 2010-2015 and Camden Planning Guidance (CPG3), 2015.

The energy requirements of the Development have been modelled in compliance with Part L2A and L2B of the Building Regulations 2013 and are based on the site layout plans provided by TTG Architects.

This report includes annualised baseline calculations which predict the likely energy consumption and associated CO_2 emissions for this Development. The total baseline energy and carbon emissions for the Development, taking into account regulated energy demands are:

- **140,200 kWh/annum**
- **71.75 Tonnes CO_2/annum**

Unregulated energy use is not covered by existing regulations and includes energy consumed by the occupants through activities and appliances; in this case it would typically be small power usage (appliances, computers, equipment etc.). The following unregulated energy use for the Development was calculated:

- **80,270 kWh/annum**
- **44 Tonnes CO_2/annum**

The following energy hierarchy has been adhered to in order to determine the most appropriate strategy for the Development in accordance with The London Plan 2016 and CPG3 2015:

1. **Be Lean**, Reduce energy and carbon emissions through the use of passive design and energy efficiency measures;
2. **Be Clean**, Reduce energy and carbon emissions by investigating the possibility of installing a site wide Combined Heat and Power (CHP) system or connecting to an existing decentralised CHP network;
3. **Be Green**, Reduce energy and carbon emissions by installing Low or Zero Carbon Technologies such as Air Source Heat Pumps (ASHP), Solar panels, Photovoltaics (PV), Wind Turbines etc.

Be Lean

In order to initially reduce carbon emissions from a base Part L 2013 compliant Development, the following passive design and energy efficiency measures have been incorporated:

- Improve the thermal performance of the building fabric for the new build elements beyond with Part L2A 2013;

- Upgrade the thermal performance of the fabric of the existing building in accordance with Part L2B 2013;
- The provision of energy efficient lighting (PIR controls and occupancy sensing in relevant areas);
- The provision of zonal thermal and lighting controls;
- The provision of variable speed pumps and fans;
- The enhancement of pipework and ductwork, thermal insulation;
- The use of energy efficient heat recovery;
- Electric Power Factor correction >0.95;
- Specific Fan Powers improved beyond Part L requirements.

Further examples of the proposed measures to be provided are in section 7.0 'Passive Design and Energy Efficiency Measures' of this report.

Following the above measures being incorporated the total baseline energy and carbon emissions for the Development, taking into account regulated energy demands, are reduced to:

- **110,720 kWh/annum**
- **55.81 Tonnes CO_2/annum**

Be Clean

In accordance with The London Plan March 2016 and the London Borough of Camden CPG3 (2015), the following energy strategies have been considered for the development:

1. Connection to an existing Combined Cooling Heating and Power (CCHP)/ Combined Heating and Power (CHP) distribution Networks

   - There are currently no available CCHP/CHP distribution networks to connect to. A query has been made to Jennifer Belk at Camden Council regarding the potential of spare capacity on the proposed Somers Town District Heating Network, this is discussed further is section 8.0 'Decentralised Energy'.

2. A Gas fired Central CHP Plant

   - In order to economically justify installing a CHP unit on site, a minimum requirement of 4000 hours running time per year is necessary. Based on the heating and the hot water demand of the office building, a gas fired CHP is considered inappropriate for the Development based on the low hot water demand and the low summer time heat demand.

Be Green

A range of low or zero carbon technologies have been considered for incorporation within the proposed Development; it has been proposed in this case that Air Source Heat Pumps (ASHP) and Photovoltaic (PV) Panels are feasible and should be utilised on the Development.

Further details of the feasibility analysis of low or zero carbon technologies are in section 9.0 'Renewable Energy' of this report.

Following the inclusion of the on-site renewable technologies, the total baseline energy and carbon emissions for the Development, taking into account regulated energy demands have further reduced to:

- **90,381 kWh/annum**
- **45.72 Tonnes CO_2/annum**

Proposed Energy Strategy for 41-43 Chalton Street, Camden

In summary the energy strategy comprises of:

1. Passive Design and Energy Efficient Measures (Section 7.0);
2. Air Source Heat Pumps (Section 8.0);
3. Photovoltaics (Section 9.0).

The scheme takes into consideration the site layout and requirements for the building type to produce a design that incorporates the most appropriate technologies available to the site. This provides a scheme that is commercially viable whilst targeting compliance with all policies applicable to this development.

The Energy Strategy consists of passive design and energy efficient measures such as the provision of energy efficient lighting and the provision of time and temperature zone heating controls. The use of further/emerging technologies may be included for use within this development if their feasibility increases in the future, in line with best practice.

This review has resulted in the formulation of an Energy Strategy to be adopted for the development involving the use of passive design and energy efficiency measures and the installation of ASHP and PV; which achieves compliance with Part L2A and L2B 2013, The London Plan 2016, and the London Borough of Camden's Local Planning Guidance, CPG3 requirements.

The following Table 2.1 and 2.2 highlights the carbon and energy savings that are currently anticipated for the Development from a base Part L2A and L2B 2013 compliant build.

	Carbon Dioxide Emissions (Tonnes CO_2 per annum)	
	Regulated	**Unregulated**
Baseline : Part L 2013 of the Building Regulations Compliant Development	71.75	44
After Energy Demand Reduction	55.81	It is anticipated that a circa 3% saving can be achieved through the use of energy efficient equipment, for example A or A+ appliances. This would reduce the unregulated carbon emissions to: 42.68
After ASHP	47.50	
After PV	45.72	

Table 2.1 Carbon Dioxide Emissions Development

	Regulated Carbon Dioxide Savings	
	Tonnes CO_2 per annum	**%**
Savings from energy demand reduction	15.95	22.23%
Savings from ASHP	8.31	11.58%
Savings from PV	1.78	2.48%
Total Cumulative Savings	**26.04**	**36.28%**
Total Target Savings	**25.11**	**35%**
Annual Surplus	**0.93**	**1.28%**

Table 2.2 Regulated Carbon Savings Development

The proposed Development shall include both new build and refurbished elements, the following Table 2.3 and Table 2.4 demonstrates the carbon savings achieved independently by the new build element and refurbished element respectively.

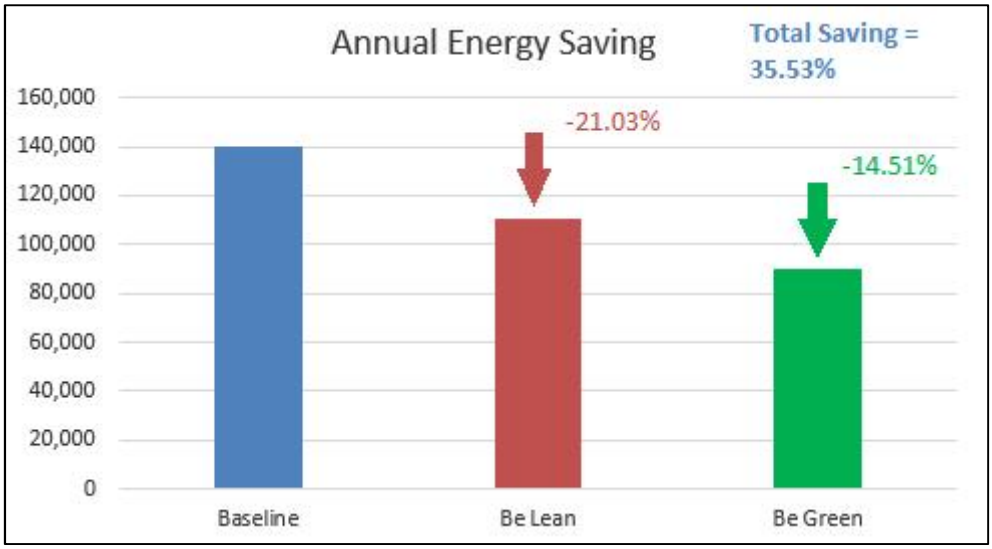
	Regulated Carbon Dioxide Savings	
	Tonnes CO_2 per annum	**%**
Savings from energy demand reduction	0.73	4.73%
Savings from ASHP	1.05	6.76%
Savings from PV	1.78	11.49%
Total Cumulative Savings	**3.56**	**22.98%**

Table 2.3 Regulated Carbon Savings New Build (Part L2A)

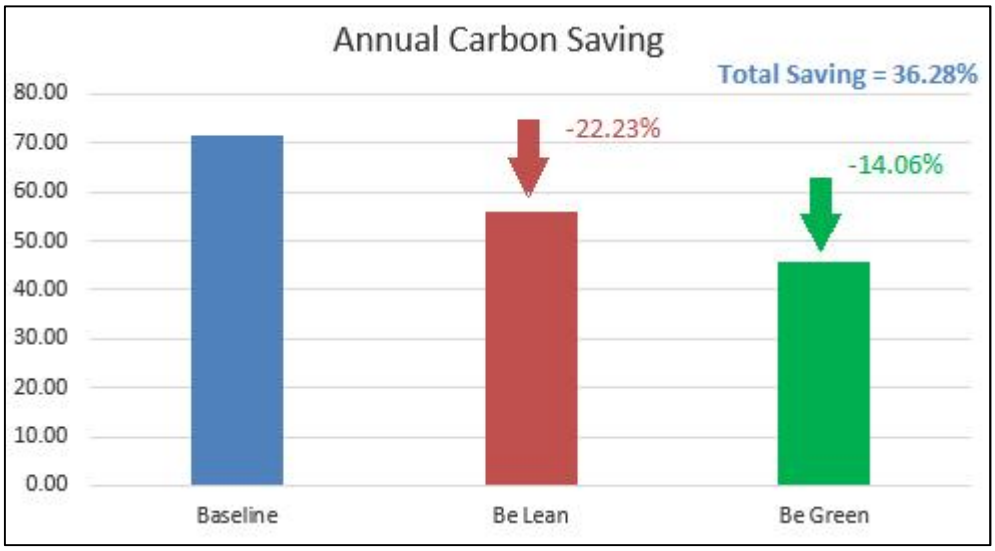
	Regulated Carbon Dioxide Savings	
	Tonnes CO_2 per annum	**%**
Savings from energy demand reduction	15.22	27.05%
Savings from ASHP	7.26	12.90%
Total Cumulative Savings	**22.48**	**39.95%**

Table 2.4 Regulated Carbon Savings Refurbished (Part L2B)

The London Plan requires all major developments to achieve a 40% carbon reduction beyond Part L 2010 and the GLA Supplementary Planning Guidance, April 2014, requires all major developments to achieve 35% carbon reduction beyond Part L 2013; the development is therefore required to achieve a 35% carbon reduction. The Camden Development Policy DP22 requires non-domestic developments to achieve a BREEAM 'Excellent' rating. The Development has an anticipated CO_2 improvement of 36.28% beyond Part L 2013. This provides compliance with The London Plan, March 2016. Camden Planning Guidance, CPG3, section 6 Renewable Energy, requires developments to target a 20% reduction in carbon dioxide emissions from on-site renewable energy technologies. It is shown in Table 2.2 that a 14.06% carbon saving is achieved by the development from on-site renewable technologies. As the development is part new build- part refurbishment, the scope for on-site renewables is restricted, this is outlined further in section 7.0. The energy and carbon savings achieved for the Development can be visually represented as per Graphs 1.1 and 1.2 below:



Graph 1.1: Annual Energy Savings



Graph 1.2: Annual Carbon Savings

2.0 Introduction

This report has been prepared by the Cudd Bentley Consulting Sustainability Team to develop an energy strategy for the proposed Development at 41-43 Chalton Street, Camden, London. The proposed Development shall comprise of 6 levels of open plan office space. This document will be considered as part of the planning application.

The Cudd Bentley Consulting (CBC) Sustainability Team consists of a variety of qualified Engineers and Environmental Consultants with a broad range of backgrounds including Mechanical Engineering, Building Services Engineering and Environmental Science. The CBC Sustainability Team are CIBSE Low Carbon Consultants, CIBSE Low Carbon Energy Assessors, Domestic Energy Assessors, BREEAM Assessors and Accredited Professionals. This broad range of knowledge and qualification allows the CBC Sustainability Team to produce Sustainability documentation for planning submissions that are tailored to the individual requirements of the Development and to ensure National and Local Policy compliance is demonstrated with clarity.

Government policies now require significant energy reductions from proposed buildings. Building a greener future sets a planned trajectory outlined via Part L 2013 of the Building Regulations. These commitments have been the key focus point in addressing policies and strategies to reduce energy use and carbon emissions through energy efficiency and low or zero carbon technologies (LZC).

In line with the London Plan, Camden SPG3 and best practice the following approach has been adopted in forming the energy strategy for the development:

1. To propose to improve the building fabric from minimum Part L 2013 Building Regulations requirements; (BE LEAN)

2. To propose to reduce energy consumption and carbon dioxide emissions through passive and energy efficiency measures; (BE LEAN)

3. Investigate the feasibility of connecting into an existing district heat network and where this is not available investigate the feasibility of providing a Central CHP Plant to serve the base heating and hot water requirements for the development; (BE CLEAN)

4. To propose to reduce energy consumption and carbon dioxide emissions further through the use of on-site renewable / LZC energy technologies. (BE GREEN)

The recommended strategy takes into consideration the site layout and requirements for the building to produce a design that incorporates the most appropriate technologies available to the site that are commercially viable, whilst targeting compliance with all policies applicable to this development.

3.0 Policy Review

National Planning Policy

An effective planning system is required to contribute to achieving sustainable development. The ***National Planning Policy Framework*** (NPPF), 2012, outlines what the government deems as sustainable development in England.

Sustainable development is described as having three dimensions; economic, social and environmental.

1. Economic Role – Contributing to creating a strong competitive economy with affordable energy costs;
2. Social Role – Supporting communities to be strong and healthy by providing a high quality built environment, accessible local services and providing security of supply;
3. Environmental Role – contributing to protecting our environment, built, natural and historic by reducing carbon emissions and promoting a move to a low carbon economy.

The above three dimensional scenario can be described as an energy trilemma, this is demonstrated in Fig 3.1 below. Each dimension is dependent on each other and sustainable development proposals should adhere to each role. This energy statement shall ensure the proposed Development is one that contributes economically, socially and environmentally in accordance with the NPPF, 2012.

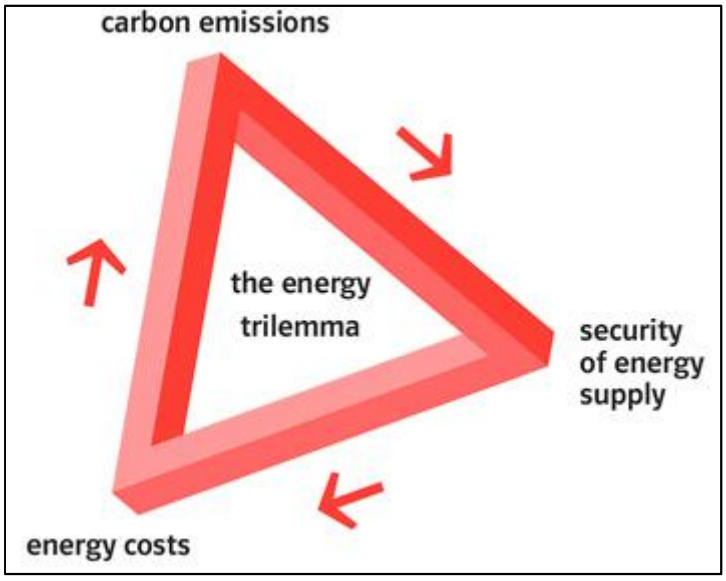


Fig 3.1 The Energy Trilemma

Guidance has been followed from the ***National Planning Policy Framework*** (NPPF), 2012, to provide an energy strategy which reduces energy use and carbon emissions, in line with best practice. This will provide a balanced scheme which focuses on optimal use of non-renewable resources (energy efficiency measures) whilst providing a renewable energy strategy best suited to the sites and their building uses. Below are some key extracts relevant to the development from Chapter ten 'Meeting the Challenge of Climate Change, flooding & Coastal Change':

Paragraph 94

Local planning authorities should adopt proactive strategies to mitigate and adapt to climate change.

Paragraph 95

Local Planning authorities should:

- Plan for new development in locations & ways which reduce greenhouse gas emissions;
- Actively support energy efficiency improvements to existing buildings.

Paragraph 96

Local authorities should expect new developments:

- To comply with adopted Local Plan policies on local requirements for decentralised energy supply unless this can be demonstrated that this is not feasible or viable;
- To take account of landform, layout, building orientation, massing and landscaping to minimise energy consumption.

Paragraph 97

Local planning authorities should recognise the responsibility on all communities to contribute to energy generation from renewable or low carbon sources. They should:

- Have a positive strategy to promote energy from renewable and low carbon sources;
- Design their policies to maximise renewable and low carbon energy development;
- Consider identifying suitable areas for renewable and low carbon energy sources and supporting infrastructure.

Identifying opportunities where development can draw its energy supply from decentralised, renewable or low carbon energy supply systems and for co-locating potential heat customers and suppliers.

The London Plan 2016

The London plan states that:

"*Tackling climate change will also require a move towards more sustainable energy sources, and the London Plan seeks to support the development of decentralised energy systems, including the use of low carbon and renewable energy and the greater utilisation of energy generated from waste*" (Chapter 5, Paragraph 5.9).

The following policies outline requirements made by the Greater London Authority in relation to climate change and energy use.

Policy 5.1 Climate Change Mitigation

The Mayor seeks to achieve an overall reduction in London's carbon dioxide emissions of 60 per cent (below 1990 levels) by 2025. All Boroughs are to develop policies to promote the reduction of carbon dioxide emissions and to help achieve the mayor's strategic carbon dioxide emissions target.

Policy 5.2 Minimising Carbon Dioxide Emissions

Development proposals should make the fullest contribution to minimising carbon dioxide emissions in accordance with the following energy hierarchy:

- Be Lean: use less energy –This involves the use of passive and energy efficiency design measures to reduce the energy requirement and subsequent carbon footprint of the site. These provide a footprint which delivers compliance with Building Regulations Part L (2013) and the Baseline Energy and Carbon emission figures for the development;
- Be Clean: supply energy efficiently – The use of a central energy centre has been considered to serve the development, to provide the primary heating and cooling requirements for the development;
- Be Green: use renewable energy – The use of renewable energy has been investigated in the context of the site and the overall usage patterns of energy throughout the development.

Development proposals are required to demonstrate via an energy assessment that the development achieves a 40% reduction in carbon emissions beyond Part L 2010.

Policy 5.3 Sustainable Design and Construction

Development proposals should demonstrate that sustainable design standards are integral to the proposal. This should include:

- Minimising carbon dioxide emissions across the site, including the building and services (such as heating and cooling systems);
- Avoiding internal overheating and contributing to the urban heat island effect;
- Efficient use of natural resources (including water), including making the most of natural systems both within and around buildings;
- Minimising pollution (including noise, air and urban runoff);
- Minimising the generation of waste and maximising reuse or recycling;
- Avoiding impacts from natural hazards (including flooding);
- Ensuring developments are comfortable and secure for users, including avoiding the creation of adverse local climatic conditions;
- Securing sustainable procurement of materials, using local supplies where feasible, and;

- Promoting and protecting biodiversity and green infrastructure

Design features such as green roofs can enhance biodiversity, absorb rainfall, improve the performance of the building, reduce the urban heat island effect and improve the appearance of a development.

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.
- The Mayor prioritises the development of decentralised heating and cooling networks at the development and area wide levels, including larger scale heat transmission networks.
- Boroughs are to develop policies and proposals to identify and establish decentralised energy network opportunities.

Policy 5.6 Decentralised Energy in Development Proposals

Development proposals should evaluate the feasibility of Combined Heat and Power (CHP) systems, and where a new CHP system is appropriate also examine opportunities to extend the system beyond the site boundary to adjacent sites.

Major development proposals should select energy systems in accordance with the following hierarchy:

1. Connection to existing heating or cooling networks;
2. Site wide CHP network;
3. Communal heating and cooling.

Policy 5.7 Renewable Energy

The Mayor seeks to increase the proportion of energy generated from renewable sources. Development proposals should provide a reduction in expected carbon dioxide emissions through the use of on-site renewable energy generation, where feasible.

Policy 5.8 Innovative Energy Technologies

The Mayor supports and encourages the more widespread use of innovative energy technologies to reduce use of fossil fuels and carbon dioxide emissions. The Mayor will seek to work with Boroughs that are interested in the following technologies:

1. Electric and hydrogen fuel cell vehicles;
2. Hydrogen supply and distribution infrastructure;
3. Anaerobic digestion, gasification and pyrolysis for the treatment of waste.

Policy 5.9 Overheating and Cooling

A The Mayor seeks to reduce the impact of the urban heat island effect in London and encourages the design of places and spaces to avoid overheating and excessive heat generation, and to reduce overheating due to the impacts of climate change and the urban heat island effect on an area wide basis.

B Major Development proposals should reduce potential overheating and reliance on air conditioning systems and demonstrate this in accordance with the following cooling hierarchy:

1. Minimise internal heat generation through energy efficient design
2. Reduce the amount of heat entering a building in summer through orientation, shading, albedo, fenestration, insulation and green roofs and walls
3. Manage the heat within the building through exposed internal thermal mass and high ceilings
4. Passive ventilation
5. Mechanical ventilation
6. Active cooling systems (ensuring they are the lowest carbon options).

C Major Development proposals should demonstrate how the design, materials, construction and operation of the development would minimise overheating and also meet its cooling needs. New development in London should also be designed to avoid the need for energy intensive air conditioning systems as much as possible. Further details and guidance regarding overheating and cooling are outlined in the London Climate Change Adaptation Strategy.

D Within LDFs boroughs should develop more detailed policies and proposals to support the avoidance of overheating and to support the cooling hierarchy.

Greater London Authority Sustainable Design and Construction Supplementary Planning Guidance (2014)

2.4 Energy and Carbon Dioxide Emissions

In line with The London Plan Policy 5.2 the following carbon savings are required:

Residential:

• 2013 – 2016 40% improvement beyond 2010 Building Regulations;

• 2016 – 2031 Zero carbon.

Non-domestic:

• 2013 – 2016 40% improvement beyond 2010 Building Regulations;

• 2016 – 2019 As per the Building Regulations requirements;

• 2019 – 2031 Zero carbon.

To avoid complexity and extra costs, the Mayor has adopted a flat carbon dioxide improvement beyond Part L 2013 of 35% for both residential and non-residential developments.

Local Planning Policy

Camden Development Policies 2010-2025

DP22 – Promoting Sustainable Design and Construction

The Council will require development to incorporate sustainable design measures as follows:

- Demonstrate how sustainable development principles have been incorporated into the design and proposed implementation;
- Incorporate green or brown roofs wherever suitable.

Non-domestic developments of 500sqm or above will be expected to achieve 'Very Good' in BREEAM assessments and 'Excellent' from 2016 and encouraging zero carbon from 2019.

The council will require development to be resilient to climate change by ensuring scheme include appropriate climate change adaptation measures, such as:

- Summer shading and planting;
- Limiting run-off;
- Reducing water consumption;
- Reducing air pollution;
- Not locating vulnerable uses in basements in flood-prone areas.

Camden Planning Guidance Sustainability – CPG3 (2015)

Section 3 – Energy Efficiency: New Buildings

- All developments are to be designed to minimise carbon dioxide emissions;
- The most cost effective ways to minimise energy demand are through good design and high levels of insulation and air tightness.

Section 4 – Energy Efficiency: Existing Buildings

- As a guide, at least 10% of the project cost should be spent on environmental improvements;
- Potential measures will be bespoke to each property;
- Sensitive improvements can be made to historic buildings to reduce carbon dioxide emissions.

Section 5 – Decentralised Energy Networks and Combined Heat and Power

- Decentralised energy could provide 20% of Camden's heating demand by 2020;
- Combined heat and power plants can reduce carbon dioxide emissions by 30-40% compared to a conventional gas boiler;
- Where feasible and viable your development will be required to connect to a decentralised energy network or include CHP.

Section 6 – Renewable Energy

- There are a variety of renewable energy technologies that can be installed to supplement a development's energy needs;
- Developments are to target a 20% reduction in carbon dioxide emissions from on-site renewable energy technologies.

Section 7 – Water Efficiency

- At least 50% of water consumed in homes and workplaces does not need to be of drinkable quality re-using water;
- All developments are to be water efficient;
- Developments over 10 units or 1000sq m should include grey water recycling.

Section 8 – Sustainable Use of Materials

- Reduce waste by firstly re-using your building, where this is not possible you should implement the waste hierarchy;
- The waste hierarchy prioritises the reduction, re-use and recycling of materials;
- Source your materials responsibly and ensure they are safe to health.

Section 10 – Brown Roofs, Green Roofs and Green Walls36

- All developments should incorporate green and brown roofs;
- The appropriate roof or wall will depend on the development, the location and other specific factors;
- Specific information needs to be submitted with applications for green/ brown roofs and walls.

Section 11 – Flooding

- Developments are required to prevent or mitigate against flooding;
- All developments are expected to manage drainage and surface water;
- There is a hierarchy you should follow when designing a sustainable drainage system.

Section 12 – Adapting to Climate Change

- All development should consider how it can be occupied in the future when the weather will be different;
- The early design stage is the most effective time to incorporate relevant design and technological measures.

Section 13 – Biodiversity

Proposals should demonstrate:

- How biodiversity considerations have been incorporated into the development;
- If any mitigation measures will be included;
- What positive measures for enhancing biodiversity are planned.

4.0 Development Approach

This report adopts the following approach to provide compliance with the Local and National Planning Policies:

1. To propose to improve building fabric from minimum Part L 2013 Building Regulations requirements;
2. To propose to reduce energy consumption and carbon dioxide emissions through passive and energy efficiency measures;
3. Investigate the feasibility of connecting into an existing district heat network and where this is not available investigate the feasibility of providing a Central CHP Plant to serve the base heating and hot water requirements for the development;
4. To propose to reduce energy consumption and carbon dioxide emissions further through the use of on-site renewable / LZC energy technologies.

5.0 Details of Proposed Development

The proposed Development shall be located at 41-43 Chalton Street, Camden, London. The development comprises of 6 floors (inclusive of a basement level) of office space which will be a combination of refurbishment, demolished areas to be rebuilt and complete new build areas.

The Development is located in a city centre location with commercial and residential properties surrounding the site from each orientation. There is a point of access from Chalton Street and also from Churchway. The proposed open plan office space shall benefit from a predominantly north-east and south-west facing orientation.

Figures 5.1 below shows the proposed ground floor layout for the development and its orientation.

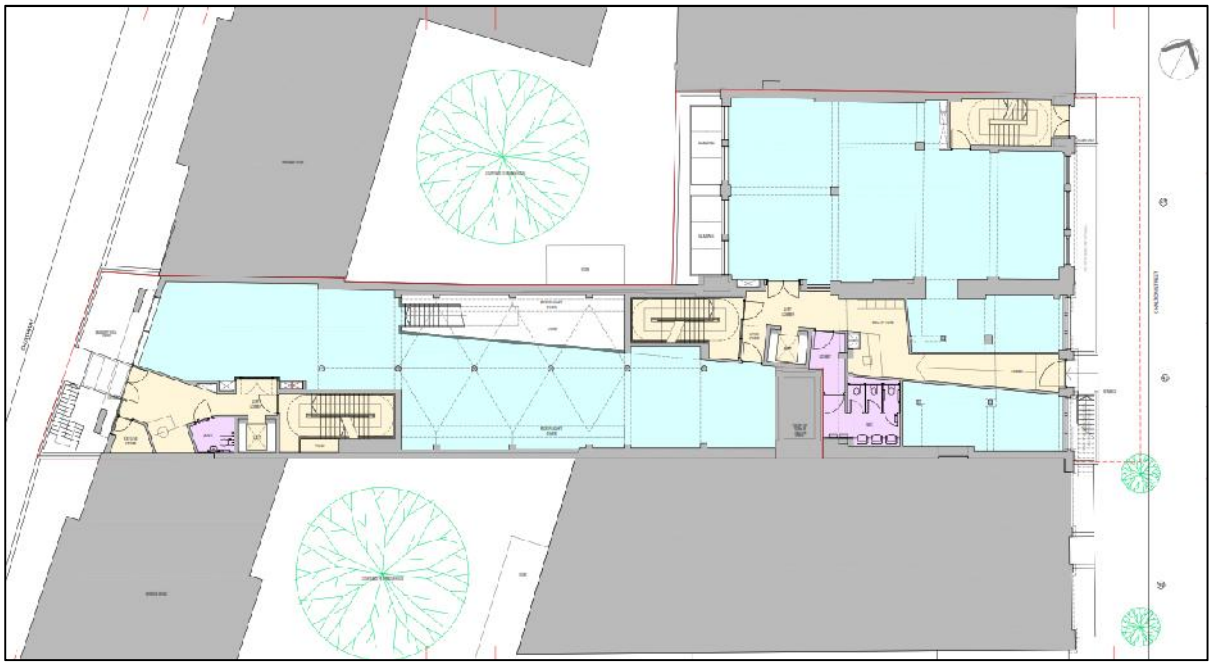


Figure 5.1 Proposed First Floor Layout

5.1 Building Regulations Part L

The proposed development consists of refurbished and new build extension elements. The refurbished element of the Development is to be assessed under Part L2B 2013 of the Building Regulations. In accordance with Section 4.2 of Part L2B, where the proposed extension has a total useful floor area that is both greater than 100m^2 and greater than 25 % or the total useful floor area, it must be assessed under Part L2A 2013. The proposed new build and re build elements of the Development shall have an area of 1,047m^2 of a total Development area of 2,443m^2, which equates to 42.86% of the total useful floor area.

6.0 Assessment of Baseline Energy Demand

The primary energy demands of the Development will be:

- Heating;
- Cooling;
- Lighting;
- Hot Water;
- General Power;
- Ventilation.

To assess the preliminary energy consumption of the Development, computer calculations have been completed using approved SBEM software (Bentley, Hevacomp, Version V8i, SS1 SP4). The calculations generate annualised energy consumption for the development, from which the "carbon footprint" can be assessed.

The assessment of the energy demand for the site has been based on the notional development according to the office use, through the construction of a building model in compliance with the requirements of Part L2A and L2B 2013 of the Building Regulations.

The total baseline energy and carbon emissions for the Development (built to Part L 2013), taking into account regulated energy demands are:

- **140,200 kWhr/annum**
- **71.75 Tonnes CO_2/annum**

(A full set of calculations supporting these figures included in Appendix A & B of this document)

7.0 Passive Design and Energy Efficient Measures

To provide carbon savings beyond a base Part L 2013 build, target compliance with Camden's CPG3 Section 3 and 4 and achieve compliance with the London Plan March 2016, local and national policies, the following passive design and energy efficiency measures are recommended.

7.1 Passive Design

Landscape – The surrounding landscape can have a positive and negative impact on the energy performance of a building. Shading from surrounding buildings and or trees can reduce solar gain but it can also increase the need for artificial lighting if daylight is blocked. The Development is located in a city centre location with surrounding buildings and trees on Chalton Street. Due to the size of the site and the refurbishment nature of the Development, there are limitations to the landscape benefits that can be adopted, however it is intended to utilise roof space for green roofs in accordance with CPG3, Section 10.

Layout & Design – The proposed layout of a building can have an impact on the energy consumption. The position and size of windows for example will determine the amount of daylight, solar gains and natural ventilation the building will receive. The Development avoids large south facing windows with the majority of windows facing north-east and south-west. The surrounding buildings and trees will provide shading and therefore reduced solar gain.

Orientation – Orientation plays a critical role in passive design, with the south side of a building receiving the most sunshine hours per day. The east and west orientations however receive the most intensive sunshine hours in the morning and evening respectively. The majority of the proposed Development is north-east and south-west facing and therefore would benefit from the morning and afternoon sun. However, the Development is surrounded by other buildings and tress which will aid with preventing solar overheating.

7.2 Thermal Efficiency

The following 'U' values shall be incorporated within the new build element of the development, in accordance with Part L2A of the Building Regulations (2013) and CPG3 Section 3.0:

- External Walls - U = 0.28 W/m².K;
- Exposed Floors - U = 0.22 W/m².K;
- Exposed Roofs - U = 0.18 W/m².K;
- Glazing - U = 1.8 W/m².K; (G Value = 0.63);
- High Usage Entrance Doors - U = 3.5 W/m².K; and
- Air Permeability - 10 $m^3/hr/m^2$@ 50 Pa.

The following 'U' values shall be incorporated within the refurbished element of the development, in accordance with Part L2B of the Building Regulations (2013) and CPG3 Section 4.0:

- External Walls - U = 0.30 W/m².K;
- Exposed Floors - U = 0.25 W/m².K;
- Exposed Roofs - U = 0.18 W/m².K;
- Glazing - U = 2.7 W/m².K; (G Value = 0.63);
- High Usage Entrance Doors - U = 3.5 W/m².K; and
- Air Permeability - 10 $m^3/hr/m^2$@ 50 Pa.

7.3 Energy Efficiency Measures

Together with the above passive design measures, the proposed energy strategy includes the following energy efficiency measures throughout the development:

- The provision of energy efficient lighting, to achieve 2.3 W/m^2 @ 100 lux delivered;
- The provision of energy efficient lighting control (PIR controls, daylight sensing and occupancy sensing in relevant areas);
- The provision of zonal thermal controls;
- The provision of energy and light metering, to warn out of range values;
- The provision of variable speed pumps and fans;
- The enhancement of pipework and ductwork, thermal insulation;
- The use of energy efficient heat recovery, to achieve 75% η;
- Electric Power Factor correction >0.95;
- LENI calculations to be carried out;
- Specific Fan Powers improved beyond Part L requirements, to achieve 1.2W/l/s.

From the utilisation of the above passive design and energy efficiency measures the total energy and carbon emissions for the development (built to Part L 2013) are reduced to:

- **110,720 kWhr/annum**
- **55.81 Tonnes CO_2/annum**

(A full set of calculations supporting these figures included in Appendix A & B of this document)

7.4 Cooling

In order to prevent and mitigate any potential overheating risks and minimise excessive heat generation contributing to the urban heat island effect, in accordance with Policy 5.9 of the London Plan 2015, the following design strategies have been considered for inclusion within the development following the GLA cooling hierarchy.

Cooling Hierarchy	Design Strategy
Minimise internal heat generation through energy efficient design.	Energy efficient measures as per the list above in Section 7.0
Reduce the amount of heat entering a building in summer through orientation, shading, albedo, fenestration, insulation and green roofs and walls.	Improved double glazing will be provided with low G values and shading co-efficient to limit the effects of solar gain to the new build elements; Secondary glazing with solar control to limit the effects of solar gain to the refurbished elements; The orientation is fixed as the building is existing; Green roofs are to be provided.
Manage the heat within the building through exposed internal thermal mass and high ceilings.	The majority refurbishment nature of this development limits the feasibility due to existing floor levels.
Passive ventilation.	Openable windows will be provided to provide a degree of passive ventilation. Due to the windows being located on both Chalton Street and Churchway, cross ventilation shall occur.
Mechanical ventilation.	Energy efficient mechanical ventilation with heat recovery to be provided to the office areas
Active cooling systems (ensuring they are the lowest carbon options).	Cooling is to be provided for the office areas via air source heat pumps which are a renewable technology

SBEM calculations have been used to check compliance with Building Regulations; summertime temperature. Current SBEM models confirm that the risk of overheating is considered to be within acceptable limits.

8.0 Decentralised Energy

Combined heat and power (CHP), also known as co-generation, is the simultaneous generation of both usable heat and electrical power from the same source. CHP provides heat and electricity at a reduced carbon cost and can therefore offer energy efficiency for developments that have a large and constant heat demand.

8.1 Existing Community Heating Network

The London Heat Map has been used to determine the proximity of existing Energy Centres surrounding the 41-43 Chalton Street development. As seen within Figure 8.1 below, the closest Energy Centre is located at St Pancras International Station and Somers Town; Somers Town being the closest geographically at approximately 290m from the Chalton Street site. Despite being within a relatively close proximity to the site, connection to this system would involve disruption to surrounding roads and potentially the busy Euston Place area.

Figure 8.1 also shows that that there is a proposed Energy Centre (notated as the red diamond within Figure 8.1) for the Euston Road area. Should the proposed energy scheme go ahead, it is anticipated that the Chalton Street development will not be able to connect to the system due to the distance of circa 300m which is made of a large number of roads and buildings between the two sites which would be adversely disrupted by such works.

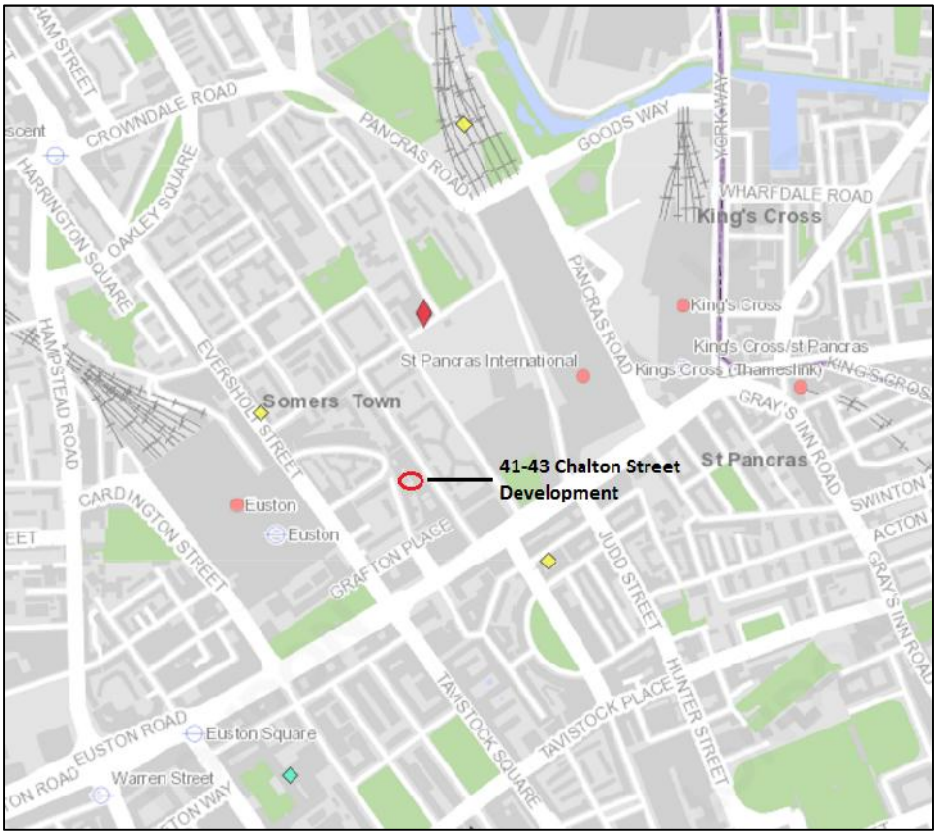


Figure 8.1: Existing Energy Centres

The London Heat Map confirms that there are no existing District Heating Networks within proximity to the Chalton Street development, though there is the proposed Euston Road Network as seen in Figure 8.2 below. The Euston Road Network, at its closest point is approximately 130m from the development site, as such a future connection may be possible though road works and overall disruption in the area will need to be considered. It is anticipated that the Chalton Street development will be designed to allow connection to the network, should it prove to be viable in the future.

Further investigation of proposed district heating in the area confirms that Vital Energi are currently developing the Somers Town District Heating Network for Camden Council; a request has been made to Jennifer Belk at Camden Council to determine the viability of connecting to the network.

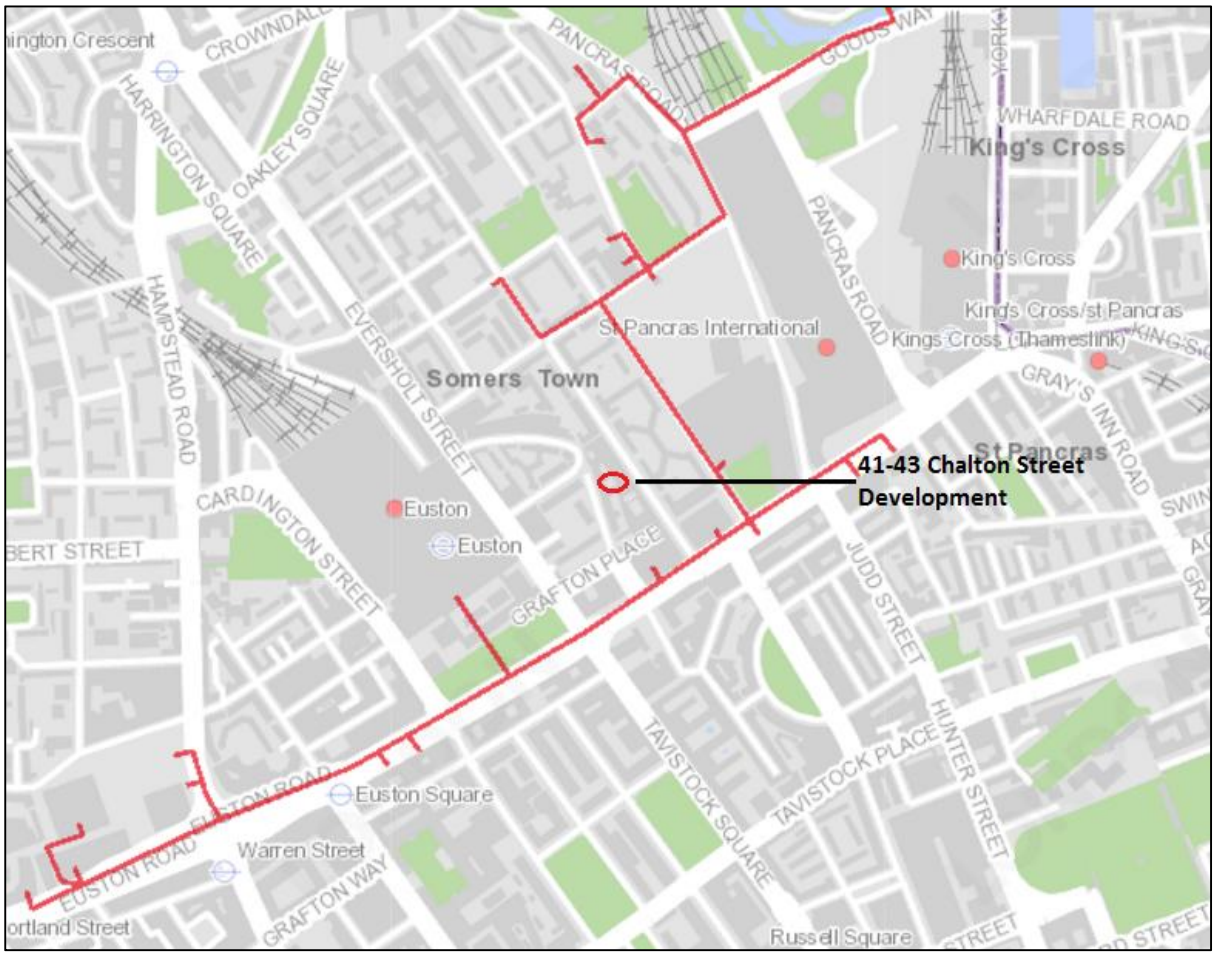


Figure 8.2: Proposed District Heating Networks

8.2 Site Wide CHP

In order to economically justify installing a CHP unit on site, a minimum requirement of 4000 hours running time per year is necessary. Based on the heating and the hot water demand of the office building, a gas fired CHP is considered inappropriate for the Development based on the low hot water demand and the low summer time heat demand.

9.0 Renewable Energy

The use of renewable and low or zero carbon (LZC) technologies for the development has been addressed and the following, Table 9.1, reviews the primary options for generation of on-site renewable / LZC energy and considers their suitability for use on the development.

Renewable Technology Feasibility Assessment		Feasible?
Bio Fuel Boilers 	Bio-fuel boilers are specifically designed to burn solid biomass or liquid bio-fuel in order to heat water, or raise steam. This can then be used for space heating or DHW supply. Bio-fuel boilers are not proposed for use within the development for the following reasons 1. Biomass boilers generate increased Oxides of Nitrogen (NOx) and particulates (PM10) which would affect air quality; 2. The requirement of bio-fuel would involve a vehicular movement of articulated lorries fortnightly delivering to the site. As this is an urban location, this would not be desirable; 3. The storage requirements for the biofuel would require a large plant space, with an auxiliary storage facility to allow for a two week period where delivery of fuel might not be available- as this is a predominantly refurbishment project there is limited scope for this technology; 4. In accordance with the London Plan, in order to achieve a 35% carbon saving beyond Part L 2013, high efficiency ASHP's and PV's have been proposed as the most efficient way to meet the heating and cooling demands of the office area; a bio-fuel boiler would run in conflict with the ASHP.	No
<u>Land Use</u> Large volumes of storage are required for fuel at ground level with sufficient vehicular access for fuel delivered.		

Renewable Technology Feasibility Assessment		Feasible?
<u>Noise</u> Noise levels are generated by the operation of the bio-fuel boiler and associated deliveries of the bio-fuel. The plant room enclosure would have to be attenuated to acceptable levels imposed by planning and Acoustician recommendations. Delivery schedules would have to be scheduled to minimise potential noise issues.		
Wind Turbines 	Wind turbines convert the kinetic energy in the wind into mechanical energy which is then converted into electricity. Wind turbines can provide electrical power either directly to a load or via a battery system Wind Turbines are not proposed for use within the development for the following reasons 1. Wind turbines are considered inappropriate on spatial, planning, aesthetic and noise grounds due to the urban location. Noise pollution from wind turbines can be quiet significant within a few hundred metres; 2. Wind turbine construction can be very expensive; 3. The site is not ideal; an ideal site is a hill with a flat, clear exposure. It should be free from strong turbulence and obstructions like large trees, houses or other buildings. As the building is located in a built up urban area, other buildings and trees will produce turbulence; 4. The financial viability of a small scale installation on the site would be compromised by the operational efficiency of the units (circa 30%); 5. Wind turbines, can cause electrical interference within a 2km radius; 6. Wind speeds for the site can be seen in Appendix C. At 10m the wind speed is 4.8m/s and 5.6m/s at 25m.	No

<table>
<tr><th colspan="2">Renewable Technology Feasibility Assessment</th><th>Feasible?</th></tr>
<tr><td colspan="2">Land Use

The site plans demonstrate that there is in-sufficient space for the allocation of a suitably sized wind turbine.

Noise

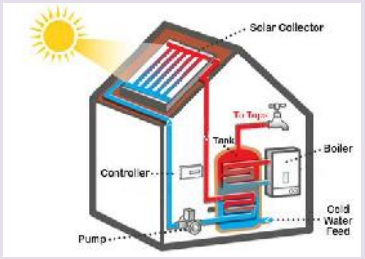
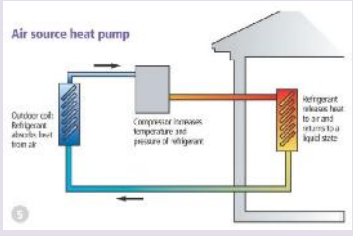
Noise levels are generated by the rotating blades; these noise levels will vary dependent on wind velocity and will need to be in acceptable levels imposed by planning and Acoustician recommendations.</td><td></td></tr>
<tr><td>Ground Source Heat Pumps

  </td><td>Space heating & cooling can be provided by circulating water heated or cooled directly by the ground or via subterranean water. Ground water cooling through the use of aquifers makes use of the relatively stable ground/ water temperature which is available at a temperature range of 10 – 14°C.

Ground Source Heat Pumps (GSHP) are not proposed for use within the development for the following reasons

1. The installation of ground source heat pumps for this development would involve extensive excavation works;
2. Due to the predominantly refurbishment nature of the development and the urban location, extensive excavation works would be disruptive;
3. In accordance with the London Plan, in order to achieve a 35% carbon saving beyond Part L 2013, high efficiency ASHP’s and PV’s have been proposed as the most efficient way to meet the heating and cooling demands of the office area; a GSHP would run in conflict with the ASHP.</td><td>No</td></tr>
<tr><td colspan="2">Land Use
This installation would require Environmental Agency approval (if an open loop system connecting to an aquifer is selected). Ground and Hydrology analysis would be required to investigate if favourable conditions exist.

Noise
There are no noise issues generated by this technology.</td><td></td></tr>
</table>

Renewable Technology Feasibility Assessment		Feasible?
Solar Water Heating 	Solar Water Heating systems use radiant energy from the sun to heat water. Systems comprise of a roof mounted heat collector piped to a coil located within a hot water storage cylinder. Camden SPG3 Section 6, states that the Council expects solar water heating panels to meet 100% of the site's summer hot water needs, where the space allows it. Solar Panels are not proposed for use within the proposed development for the following reasons: 1. There shall be a low hot water demand due to the office use of the Development which shall not justify a solar water heating installation; 2. A portion of the roof area has been allocated to green roofs, which satisfies CPG3 Section 10, and a portion is required for roof plant; 3. The remaining roof area available is best suited to the installation of PV's to assist with achieving a 35% carbon reduction for the Development.	No
<u>Land Use</u> Roof space is required for the installation of solar panels; optimum installation is south facing at an angle of 30 degrees. <u>Noise</u> Noise levels are generated by pumps at roof level, these are insignificant so should pose no issues.		
Air Source Heat Pumps 	An Air Source Heat Pump extracts heat from the outside air in the same way that a fridge extracts heat from its inside. It can extract heat from the air even when the outside temperature is as low as minus 15°C. Air Source Heat Pumps are proposed for use within the Development to provide heating and cooling to the apartments for the following reasons: 1. They are ideally suited to serve the Office Development during periods when they may require heating or cooling. The times when	Yes

Renewable Technology Feasibility Assessment		Feasible?
	cooling is required may differ for different space depending on their use, occupancy period and levels, the operation of individual air source heat pumps would allow individual control and can be efficiently accommodated within the building design; 2. Air to Air or Air to Water applications can be used to suit the future tenant's bespoke environmental requirements; 3. The heat pump units can be configured to provide internal heat reclaim from dissimilar environmental zones, reducing energy consumption and carbon emissions; 4. As this is predominantly a redevelopment project, ASHP can be easily accommodated into the new design and plant layouts. Air Source Heat Pumps will being utilised, as it is the most efficient way to meet the heating and cooling demands for the Development. Furthermore, ASHP's contribute to the overall carbon savings, providing a saving of 11.58%. In accordance with Camden CPG3, Section 6.0, Renewable Energy, where ASHPs are specified it is required to demonstrate that ASHPs are more efficient than gas, this calculation can be seen in Table 9.2 below.	
<u>Land Use</u> Air Source Heat Pumps can be installed on ground mounted, roof mounted or wall mounted frames. When installing Air Source Heat Pumps there are various factors to consider; Heat Pumps should be positioned to provide shelter from high winds which can reduce efficiency by causing defrost problems and be kept free from leaves and debris. <u>Noise</u> Noise levels are generated by fans, and compressors causing vibrations. The noise levels are dependent on manufacturer and vary accordingly, these will need to be in acceptable levels imposed by planning and Acoustician recommendations.		

<table>
<tr><th colspan="2">Renewable Technology Feasibility Assessment</th><th>Feasible?</th></tr>
<tr><td>Photovoltaics
  </td><td>Photovoltaic (PV) modules convert sunlight directly to DC electricity. The solar cells consist of a thin piece of semiconductor material, in most cases silicon.

Mono-crystalline PVs are proposed for use within the development for the following reasons:

• The roof space is free from any over-shading from surrounding buildings;
• Photovoltaics assist with targeting the carbon saving requirements from the London Plan and the London Borough of Camden’s CPG3, section 6.0;
• Photovoltaics are a low maintenance technology;
• They provide a visible contribution to the public, promoting the use of renewable energy;
• It is proposed that a 4.75 kWpeak system is installed on the south facing roof which equates to 19 panels, 1.6m^2/panel, 30.4m^2 in total.

N.B. The proposed location of PVs can be seen in Appendix D.</td><td rowspan="2">Yes</td></tr>
<tr><td colspan="2"><u>Land Use</u>

There are no land issues or adverse visual impacts as the photovoltaic panels are roof mounted.

<u>Noise</u>

There are no noise issues generated by this technology.</td></tr>
</table>

Table 9.1 Renewable Technology Feasibility Assessment

In accordance with Camden CPG3, Section 6.0, Renewable Energy, where ASHPs are specified it is required to demonstrate that ASHPs are more efficient than gas, this calculation can be seen in Table 9.2 below. This is based on the ASHP having a COP of 4.

	TER New Build	BER New Build	Improvement	Comment
ASHP	14.8 $kgCo_2/m^2$	13.1 $kgCo_2/m^2$	1.7 $kgCo_2/m^2$	For the New Build element, ASHP provides a greater improvement beyond a base Part L 2013 compliant build than gas.
Gas Heating	15.2 $kgCo_2/m^2$	14.0 $kgCo_2/m^2$	1.2 $kgCo_2/m^2$	
	TER Refurbishment	**BER Refurbishment**		
ASHP	20.2 $kgCo_2/m^2$	24.2 $kgCo_2/m^2$	- 4 $kgCo_2/m^2$	As the refurbishment element does not achieve the TER, it can be seen that the ASHP fails by a smaller margin than gas.
Gas Heating	20.5 $kgCo_2/m^2$	25.7 $kgCo_2/m^2$	- 5.2 $kgCo_2/m^2$	

Table 9.2 ASHP vs Gas Heating Assessment

10.0 Summary of Proposed Scheme

Consideration has been given in sections 8.0 and 9.0 of this document to the options that are available for the development in relation to Low Zero Carbon technologies and renewable energy. The technologies considered are as follows:

- Decentralised Gas fired CHP;
- Bio-fuel boilers;
- Wind Turbine;
- Ground Source Heat Pump;
- Solar Water Heating;
- Air Source Heat Pump;
- Photovoltaics.

This review has resulted in the formulation of an Energy Strategy to be adopted for the development involving the installation of air source heat pumps and photovoltaic panels. The following Tables 10.1 and 10.2 highlight the carbon emissions and savings that are currently anticipated for the development. Based on the analysis within this report, it is confirmed that the development achieves compliance with Part L 2013, The London Plan, 2016 and Camden's CPG3 (2015). The following Table 10.1 and 10.2 highlight the carbon and energy savings that are currently anticipated for the development from a base Part L 2013 compliant build.

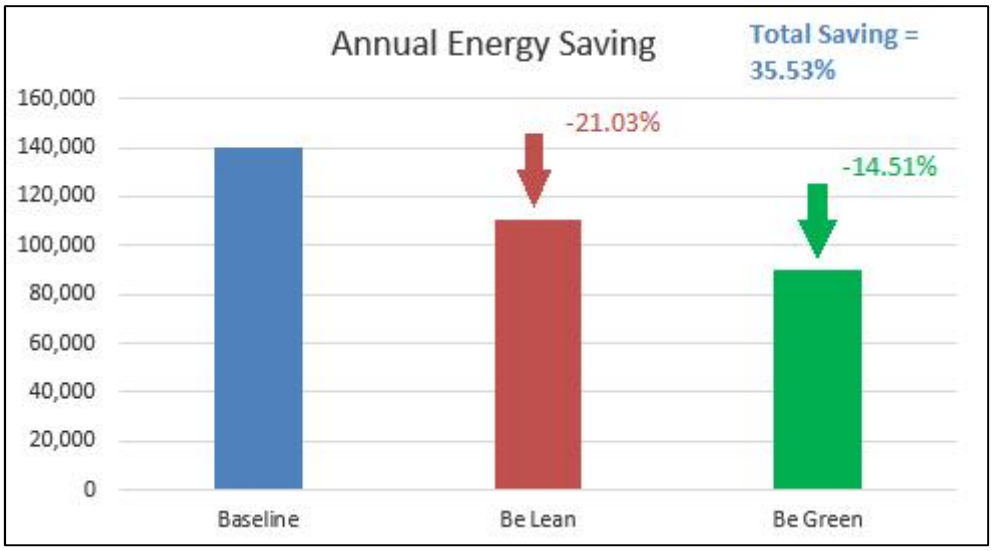
	Carbon Dioxide Emissions (Tonnes CO_2 per annum)	
	Regulated	**Unregulated**
Baseline : Part L 2013 of the Building Regulations Compliant Development	71.75	44.00
After Energy Demand Reduction	55.81	It is anticipated that a circa 3% saving can be achieved through the use of energy efficient equipment, for example A or A+ appliances. This would reduce the unregulated carbon emissions to: 42.68
After ASHP	47.50	
After PV	45.72	

Table 10.1 Carbon Dioxide Emissions

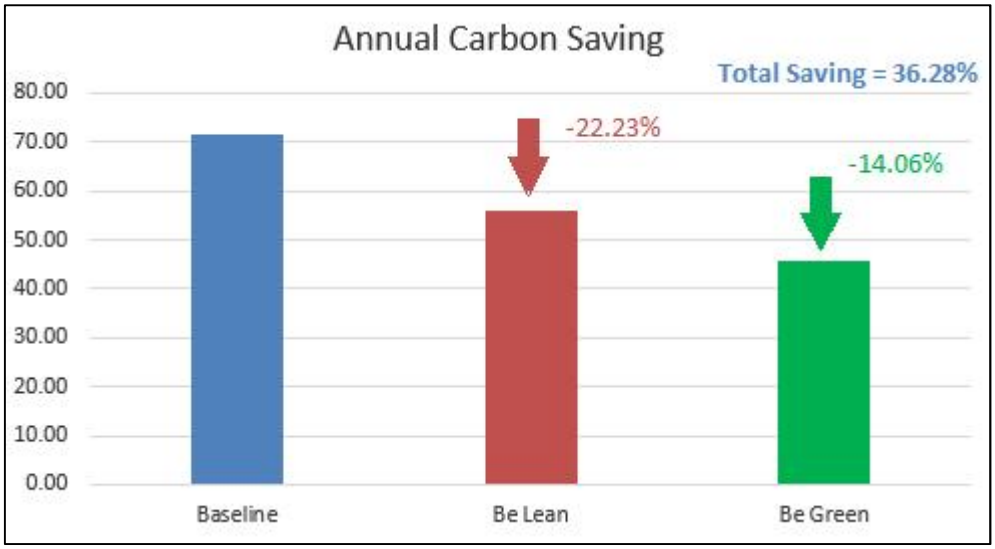
	Regulated Carbon Dioxide Savings	
	Tonnes CO_2 per annum	**%**
Savings from energy demand reduction	15.95	22.23%
Savings from ASHP	8.31	11.58%
Savings from PV	1.78	2.48%
Total Cumulative Savings	**26.04**	**36.28%**
Total Target Savings	**25.11**	**35%**
Annual Surplus	**0.93**	**1.28%**

Table 10.2 Regulated Carbon Savings

The London Plan requires all major developments to achieve a 40% carbon reduction beyond Part L 2010 and the GLA Supplementary Planning Guidance, April 2014, requires all major developments to achieve 35% carbon reduction beyond Part L 2013; the development is therefore required to achieve a 35% carbon reduction. The Camden Development Policy DP22 requires non-domestic developments to achieve a BREEAM 'Excellent' rating. The Development has an anticipated CO_2 improvement of 36.28% beyond Part L 2013. This provides compliance with The London Plan, March 2016. Camden Planning Guidance, CPG3, section 6 Renewable Energy, requires developments to target a 20% reduction in carbon dioxide emissions from on-site renewable energy technologies. It is shown in Table 10.1 that a 14.06% carbon saving is achieved by the development from on-site renewable technologies. As the development is part new build- part refurbishment, the scope for on-site renewables is restricted, this has been outlined in Section 7.0 above. The energy and carbon savings achieved can be visually represented as per Graphs 10.1 and 10.2 below:



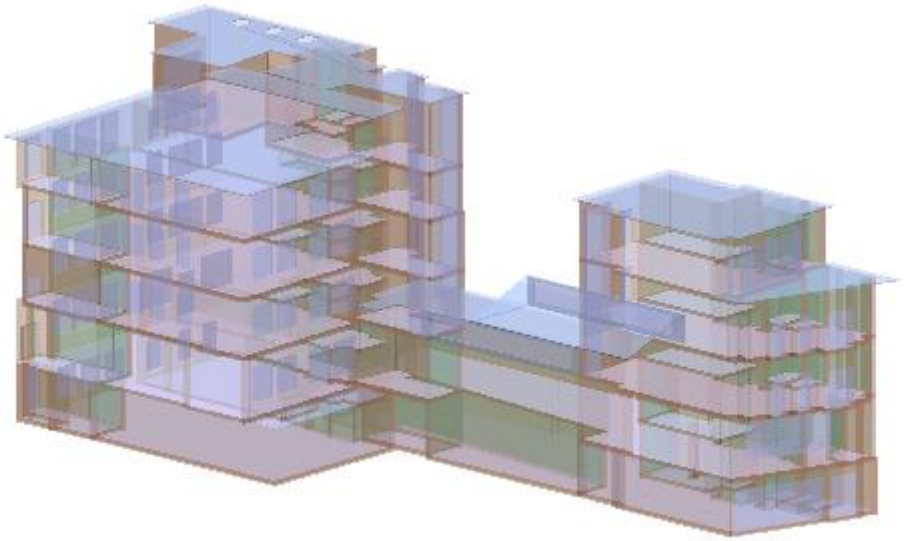
Graph 10.1: Annual Energy Savings



Graph 10.2: Annual Carbon Savings

The use of further/emerging technologies may be included for use within this development if their feasibility increases in the future, also in accordance with best practice**.**

Appendix A – SBEM



New Build

Building Rating

	Heating	Cooling	Auxiliary	Lighting	Hot water	Total	
Actual	3.05	6.37	2.44	15.78	1.6	29.24	**kWh/m²**
Notional	3.54	6.09	2.11	16.62	1.86	30.21	**kWh/m²**

CO2 emissions mandatory requirement

BER	14.8	**kgCO2/m²**
Notional	14.8	**kgCO2/m²**
TER	14.8	**kgCO2/m²**
Pass CO2	**Yes**	

Baseline

Building Rating

	Heating	Cooling	Auxiliary	Lighting	Hot water	Total	
Actual	3.02	6.26	2.44	14.91	1.6	28.24	**kWh/m²**
Notional	3.54	6.09	2.11	16.62	1.86	30.21	**kWh/m²**

CO2 emissions mandatory requirement		
BER	14.1	**kgCO2/m²**
Notional	14.8	**kgCO2/m²**
TER	14.8	**kgCO2/m²**
Pass CO2	**Yes**	

Baseline & Passive

Building Rating

	Heating	Cooling	Auxiliary	Lighting	Hot water	Total	
Actual	2.8	4.55	2.44	14.91	1.6	26.31	**kWh/m²**
Notional	3.54	6.09	2.11	16.62	1.86	30.21	**kWh/m²**

CO2 emissions mandatory requirement		
BER	13.1	**kgCO2/m²**
Notional	14.8	**kgCO2/m²**
TER	14.8	**kgCO2/m²**
Pass CO2	**Yes**	

Baseline & Passive & ASHP

Building Rating

	Heating	Cooling	Auxiliary	Lighting	Hot water	Total	
Actual	2.8	4.55	2.44	14.91	1.6	26.31	**kWh/m²**
Notional	3.54	6.09	2.11	16.62	1.86	30.21	**kWh/m²**

CO2 emissions mandatory requirement		
BER	11.4	**kgCO2/m²**
Notional	14.8	**kgCO2/m²**
TER	14.8	**kgCO2/m²**
Pass CO2	**Yes**	

Baseline & Passive & ASHP & PV

Refurbishment

Building Rating

	Heating	Cooling	Auxiliary	Lighting	Hot water	Total	
Actual	9.45	21.64	7.6	37.35	2.46	78.5	**kWh/m²**
Notional	3.05	9.33	3.53	23.05	2.84	41.79	**kWh/m²**

CO2 emissions mandatory requirement		
BER	40.3	**kgCO2/m²**
Notional	20.2	**kgCO2/m²**
TER	20.2	**kgCO2/m²**
Pass CO2	**No**	

Baseline

Building Rating

	Heating	Cooling	Auxiliary	Lighting	Hot water	Total	
Actual	6.92	15.79	5.86	27.11	2.46	58.13	**kWh/m²**
Notional	3.05	9.33	3.53	23.05	2.84	41.79	**kWh/m²**

CO2 emissions mandatory requirement		
BER	29.4	**kgCO2/m²**
Notional	20.2	**kgCO2/m²**
TER	20.2	**kgCO2/m²**
Pass CO2	**No**	

Baseline & Passive

Building Rating

	Heating	Cooling	Auxiliary	Lighting	Hot water	Total	
Actual	5.02	7.46	5.86	27.11	2.46	47.91	**kWh/m²**
Notional	3.05	9.33	3.53	23.05	2.84	41.79	**kWh/m²**

CO2 emissions mandatory requirement		
BER	24.2	**kgCO2/m²**
Notional	20.2	**kgCO2/m²**
TER	20.2	**kgCO2/m²**
Pass CO2	**No**	

Baseline & Passive & ASHP

Appendix B – Energy Calculations

41-43 Chalton Street

Regulated Energy Demand

kWh/annum Baseline

Typical Unit	Area m²	BER	TER	Heating	Cooling	Auxiliary	Lighting	Hot Water	Total Kwh/Annum	Carbon kg Co2 / Annum	Tons
New Build Office	1047	14.8	14.8	3.05	6.37	2.44	15.78	1.6	30614.28	15495.6	15.50
Refurbished Office	1396	40.3	20.2	9.45	21.64	7.6	37.35	2.46	109586	56258.8	56.26
Total	2443								140200.28	71754.4	71.75

kWh/annum Baseline + Passive/Energy Efficiency Measures

Typical Unit	Area m²	BER	TER	Heating	Cooling	Auxiliary	Lighting	Hot Water	Total Kwh/Annum	Carbon kg Co2 / Annum	Tons
New Build Office	1047	14.1	14.8	3.02	6.26	2.44	14.91	1.6	29556.81	14762.70	14.76
Refurbished Office	1396	29.4	20.2	6.92	15.79	5.86	27.11	2.46	81163.44	41042.40	41.04
Total	2443								110720.25	55805.1	55.81

kWh/annum Baseline + Passive/Energy Efficiency Measures+ASHP

Typical Unit	Area m²	BER	TER	Heating	Cooling	Auxiliary	Lighting	Hot Water	Total Kwh/Annum	Carbon kg Co2 / Annum	Tons
New Build Office	1047	13.1	14.8	2.8	4.55	2.44	14.91	1.6	27536.10	13715.70	13.72
Refurbished Office	1396	24.2	20.2	5.02	7.46	5.86	27.11	2.46	66882.36	33783.20	33.78
Total	2443								94418.46	47498.90	47.50

kWh/annum Baseline + Passive/Energy Efficiency Measures+ASHP + PV

Typical Unit	Area m²	BER	TER	Heating	Cooling	Auxiliary	Lighting	Hot Water	Total Kwh/Annum	Carbon kg Co2 / Annum	Tons
New Build Office	1047	11.4	14.8	2.8	4.55	2.44	14.91	1.6	23498.60	11935.80	11.94
Refurbished Office	1396	24.2	20.2	5.02	7.46	5.86	27.11	2.46	66882.36	33783.20	33.78
Total	2443								90380.96	45719.00	45.72

Unregulated Energy Demand

Typical Unit	Total Area	Energy from Equipment kWh/m2/ Annum	Total Energy kWh/annum	Gas %	Electricity %	KgCO2/m2	Total KgCO2	Total TonsCO2
New Build Office	1047.00m²	26	27222.00	0	100	14.14	14808.77	14.81
Refurbished Office	1396.00m²	38	53048.00	0	100	20.67	28858.11	28.86
Total	**2,443**		**80,270**				**43,667**	**43.67**

Carbon Savings

Typical Unit	Total Area	Baseline Total kWh/annum	Baseline kgCO2/annum	Improved Emissions after Passive Energy Efficiency kgCO2 /annum	Improved Emissions after CHP kgCO2 /annum	Improved Emissions after PVs	Total kgCO2/annum displaced	Total TonsCO2/annum displaced	Total % TonsCO2/annum displaced
New Build Office	1047	30,614	15,496	14762.70	13715.70	11,936	3559.80	3.56	22.97
Refurbished Office	1396	109,586	56,259	41042.40	33783.20	33,783	22475.60	22.48	39.95
Total	**2443**	**140,200.28**	**71,754.40**	**55,805.10**	**47,498.90**	**45,719**	**26,035**	**26.04**	**36.28**

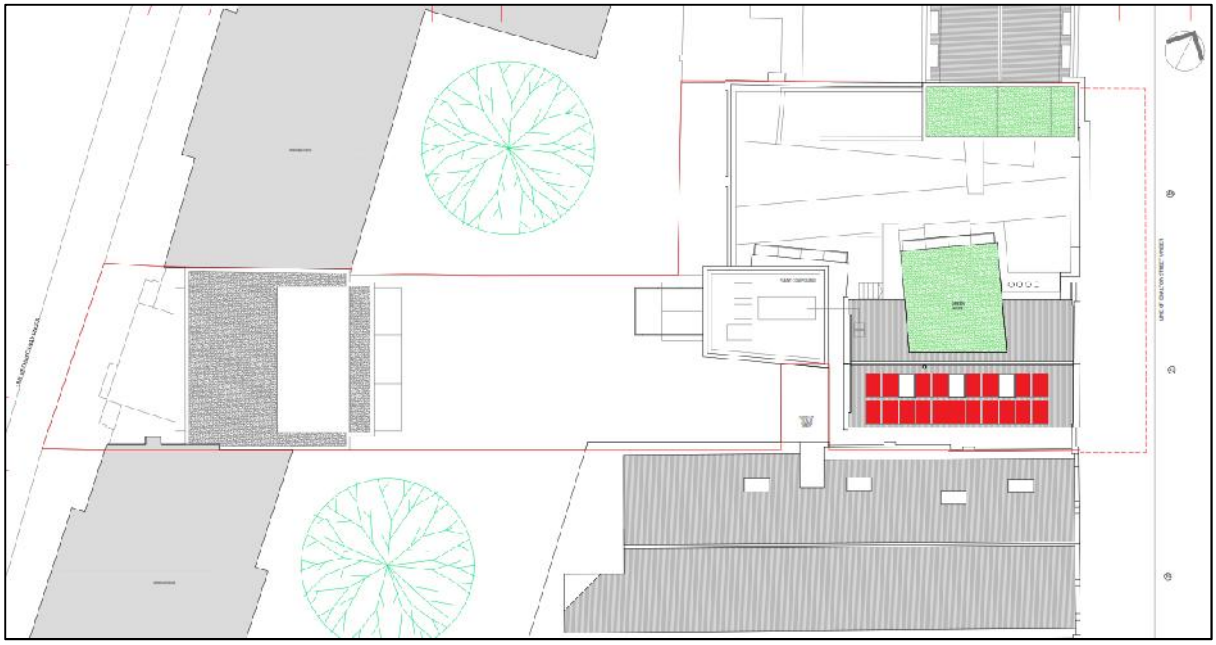
Energy Savings

Typical Unit	Total Area	Baseline Total kWh/annum	Baseline kgCO2/annum	Passive Energy Efficiency kwh /annum	Improved Emissions after CHP kwh /annum	Improved Emissions after PV	Total kwh/annum displaced	Total % kwh/annum displaced
New Build Office	1047	30,614	15,496	29557	27536.10	23,499	7,116	23.24
Refurbished Office	1396	109,586	56,259	81163	66882.36	66,882	42,704	38.97
Total	**2443**	**140,200**	**71,754**	**110720**	**94418**	**90,381**	**49,819**	**35.53**

Appendix C – Wind Data

Wind data taken from NOABL Wind Map

Appendix D – Proposed PV Locations



Indicative Photovoltaic Panel Location