Contents

1	**Introduction**	**4**
2	**Description of the Proposed Development**	**5**
3	**Executive Summary**	**5**
3.1	Key Energy Efficiency Design Measures	7
3.2	Efficient Supply of Energy	8
3.3	Renewable Energy Technologies	8
3.4	Code for Sustainable Homes and BREEAM	8
4	**Energy Efficiency and Reducing Carbon Emissions**	**9**
4.1	Assessment of the Baseline Energy Demand and Carbon Dioxide Emissions	9
4.2	Designing for Energy Efficiency	10
4.3	Supplying Energy Efficiently	15
4.4	Renewable Energy Technologies	17
4.5	Conclusions and Proposal	21

Tables

1	Carbon Dioxide Emissions Reductions	6
2	Energy Efficiency Savings Summary (Annual Figures)	6
3	Energy Efficiency Savings against the Notional Baseline Scheme	6
4	Comparison of Key Values and Standards used in the Notional Baseline Scheme and the Design Improvements for the Flats and Retail Unit	22
5	Site Baseline Energy Demand and Carbon Dioxide Emissions	23
6	Energy Demand and Carbon Dioxide Emissions from Baseline and Energy Efficient Design	24
7	Energy Demand and Carbon Dioxide Emissions from Baseline, Energy Efficient Design and Renewables	25

Appendices: **26**

A Code for Sustainable Homes Pre-Assessment Results Page
B BREEAM Pre-Assessment Estimator Results Page
C SAP Code for Sustainable Homes Energy Credits Reports
D SBEM Output Reports
i BRUKL Output Documents
ii SBEM Main Calculation Output Documents
E Proposed Development Site Layout and Floor Plans
F Air Quality Assessment
G Noise and Vibration Assessment

1 Introduction

This report updates and replaces the original submission and incorporates a re-design and reduction in the number of domestic units, and a reduction in the size of the Retail Unit. Figures within the various tables have been recalculated to reflect these changes. This report explores and analyses the opportunities, technologies and methods which could be used to develop a low energy and sustainable environmental strategy for a proposed small residential development on the site of a redundant public house and bar at Finchley Road, in the London Borough of Camden.

Camden planning policy is informed by The London Plan – the Mayor of London's Spatial Development Strategy for Greater London, the latest issue of which was published by the Greater London Authority (GLA) on July 22nd 2011. The policies included in this document are taken into account by local authorities when producing their Local Development Frameworks and planning officers will consider these policies when taking relevant planning decisions, such as determining planning applications.

Planning policy for London is led by the government's strategy in mitigating the effects of climate change and a key factor in this strategy is the management of the energy consumed by buildings, together with their environmental impact. It is incumbent upon designers and developers to ensure that any building project considers the long term consequences of energy performance and the effects of building development on the environment.

The first part of this report takes the form of an Energy Statement; the second part examines the Code for Sustainable Homes and BREEAM; the final section details Air and Noise Pollution issues. The report addresses the following requirements:

- To minimise carbon dioxide emissions in accordance with the Energy Hierarchy:
  1. Be lean – use less energy
  2. Be clean – supply energy efficiently
  3. Be green – use renewable energy

  The development will incorporate low energy design and construction, including the use of renewable energy technology as set out in The London Plan; this will be illustrated by means of an Energy Statement, with modelling of the energy performance of the development being provided by the output from the government's Standard Assessment Procedure (SAP) methodology.
- Environmental impact; this will be in the form of a Code for Sustainable Homes Pre-Assessment exercise and a similar BREEAM Pre-Assessment to illustrate the strategies taken towards achieving the required performance.
- Air and Noise pollution issues.

2 Description of the Proposed Development

The proposed development is on the site of The Finchley Bell public house and 3one7 bar, situated at number 317 Finchley Road, Camden, London NW3 6EP. The public house is to be demolished and the proposed new build will contain:

- A six storey mixed use building, with basement storage and plant areas.
- The first to fifth floors will house two 1, six 2 and one 3 bedroom flats.
- The ground floor will comprise a small retail unit to the front, facing Finchley Road. To the side and rear are amenities (bin and cycle stores), services, and access stairs and a lift to the upper floors. A sub-basement is to be used for additional bin and cycle storage.

The development site covers the existing building and a very small part of the open space to the rear, an area of approximately 300m^2, with a 21 metre facing to Finchley Road. The existing surrounding development comprises mostly dense urban buildings, including residential flats and commercial buildings. The Finchley Road and Frognal railway station bounds the site to the north.

The proposed site layout and floor plans, together with an aerial photograph, are included in Appendix A.

3 Executive Summary

In following The London Plan Policy 5.2 - Minimising Carbon Dioxide Emissions - Camden Council requires that development proposals use the three step energy hierarchy referred to in the Introduction to this report.

Guidance contained in the Camden Planning Guidance SPD has been followed in the assessment of the development proposal and the resulting Baseline consumption and emissions figures, together with reductions resulting from Energy Efficiency and Renewables, are illustrated in Table 1. Total energy efficiency savings are summarised in Table 2. Reductions in energy demand and carbon dioxide emissions are summarised in Table 3. These tables are on the following page.

	kWh/Year	Kg/CO^2/Year	Savings %
Baseline Consumption and CO2 Emissions	104614.30	42153.66	-
With Energy Efficient Design	89945.10	32978.32	21.76
With Efficient Energy Supply	89945.10	32978.32	-
With Renewables	77160.40	26368.63	20.04

Table 1: Carbon Dioxide Emissions Reductions

	Amount	Savings %
Reduction in Energy Demand (kWh)	27453.90	26.24
Reduction in CO2 Emissions	15785.03	37.45

Table 2: Energy Efficiency Savings Summary (Annual Figures)

	Baseline Scheme		Proposed Scheme		Change	Change
	kWh	Kg/CO2	kWh	Kg/CO2	kWh	Kg/CO2
Electricity	50602.63	24833.64	34767.62	17245.07	-15835.01	-7588.57
Heating	51583.79	16295.45	40450.48	8119.39	-11133.31	-8176.06
Cooling	2427.88	1024.57	1942.30	1004.17	-485.58	-20.40
Total	104614.30	42153.66	77160.40	26368.63	-27453.90	-15785.03

Table 3: Energy Efficiency Savings Against The Notional Baseline Scheme (Annual Figures)

3.1 Key Energy Efficiency Design Measures

The development needs to achieve not only a reduction in carbon emissions to meet the requirements of the council, but also to achieve a Code for Sustainable Homes Level 4 rating for the flats, and a BREEAM rating of Excellent; in order to achieve these ratings it is necessary to design the development with a focus on significantly reducing energy demand and carbon emissions.

In order to achieve the design efficiencies, some significant improvements have been made against the Baseline (Building Regulations Target) specification and these are, briefly:

1 - Flats

- Reduced U-Values of the fabric, windows and doors.
- A very airtight construction.
- Mechanical Ventilation with Heat Recovery (MVHR) – this technology is necessary when buildings are designed with very airtight envelopes, but also significantly reduces carbon dioxide emissions.
- Highly efficient gas condensing combi boilers with excellent heating and hot water controls.
- Reduced water usage through efficient water fittings, which in turn reduce the hot water requirement.
- The use of Accredited Construction Details to reduce heat loss through thermal (cold) bridging.
- Dedicated low energy light fittings throughout.

2 - Retail Unit

- Reduced U-Values of the fabric, windows and doors.
- An airtight construction.
- The main requirement for this unit is cooling, rather than heating, therefore an efficient Air Source Heat Pump unit has been introduced; this provides both heating and cooling as required.
- Instant hot water heating is used as the requirement for hot water is low and intermittent.
- Reduced water usage through efficient water fittings, which in turn reduce the hot water requirement.
- The use of Accredited Construction Details to reduce heat loss through thermal (cold) bridging.
- Dedicated low energy light fittings throughout.

The design improvements result in a reduction of **21.76%** in the emission rates against the Baseline development target rate, as shown in Table 1 on page 6. The main reason for this significant reduction is the use of Mechanical Ventilation with Heat Recovery (MVHR) in the flats, and an Air Source Heat Pump (ASHP) in the retail unit.

3.2 Efficient Supply of Energy

The site and development constraints are such that it is not viable to connect to an existing decentralised energy network, or to use a Combined Heat and Power (CHP) system. However, the design improvements included at step 1 of the Energy Hierarchy include the installation of mechanical ventilation with heat recovery (MVHR) units; these, together with the use of renewable energy technologies, have resulted in a significant reduction in carbon dioxide emissions.

3.3 Renewable Energy

The development will make use of two renewable energy technologies:

1) The domestic units will be connected to photovoltaic panels situated on the roof of the building. To achieve the required emission reductions, the total array area will amount to approximately 55m^2 of panels. An additional array will feed the common areas.

2) The retail unit will be fitted with an Air Source Heat Pump (ASHP), which will also provide cooling (the figures for this technology are included in the energy efficient design measures section). Cooling for this unit is a much larger user of energy than heating, so the ASHP will reduce emissions significantly. Additionally, as the ASHP is fuelled by electricity, rather than gas, the retail unit will be connected to a 30m^2 PV array on the roof of the building, so as to mitigate the use of electricity.

The incorporation of renewable energy technologies result in a further reduction in CO_2 emissions of **20.04%** as illustrated in Table 1 on page 6. The total carbon dioxide emissions reduction is **37.45%** against the Baseline scheme as shown in Table 2 on page 6.

3.4 Code for Sustainable Homes and BREEAM

Pre-Assessment Estimations have been prepared for the flats (Code for Sustainable Homes) and the retail unit (BREEAM) and the results indicate that Level 4 will be achieved for the flats and BREEAM Excellent for the retail unit. The updated BREEAM and CSH estimator tool results can be accessed in the Appendices, from page 26.

The energy demand and emissions figures for the Retail Unit have been amended to take account of the smaller area and are included in the energy tables within this report; the SBEM outputs are for the original, larger retail unit, and are included in the Appendices.

Air quality and noise assessments have been undertaken and the issues and recommendations have fed into the BREEAM assessment.

4 Energy Efficiency and Reducing Carbon Emissions

The London Plan Policy 5.2 requires that new building developments are designed to minimise carbon dioxide emissions in accordance with the three-step Energy Hierarchy:

Step 1: Be Lean – use less energy

Carbon Dioxide emissions should be reduced through the energy efficient design of the site, buildings and services

Step 2: Be Clean – supply energy efficiently

Carbon Dioxide emissions should be further reduced through the use of decentralised energy where feasible; some examples would be district heating and cooling and combined heat and power (CHP)

Step 3: Be Green – use renewable energy

Proposals should be made to further reduce Carbon Dioxide emissions through the use of on-site renewable energy technologies

The following sub-sections will illustrate how the development proposal meets the requirements of the Energy Hierarchy.

4.1 Assessment of the Baseline Energy Demand and Carbon Dioxide Emissions

In order to qualify and quantify the reductions in Carbon Dioxide emissions, it is first necessary to assess the "baseline" energy demand and emissions produced by the development in notional terms, modelled on the requirements of Building Regulations Part L1; in producing the baseline figures, calculations include both regulated demand (i.e. "fixed" consumption covered by the Building Regulations, such as fixed lighting, heating and hot water, ventilation/cooling, etc.) and non-regulated consumption (i.e. "plug-in" sources such as cooking and electrical appliances).

For the assessment of baseline demand, modelling has been undertaken using the following tools:

- Residential Units:

  National Home Energy Rating (NHER) SAP software "NHER Plan Assessor". This assessment will produce the energy demand and carbon emissions rate (TER) based on notional dwellings of the same shape and size as the actual dwellings, enabling a comparison with the emissions of the dwellings as designed; this, later in this report, will be used to illustrate the reductions in energy demand and Carbon Dioxide emissions, and also to quantify the contribution to savings made by renewables.

The unregulated demand and emissions are also calculated using SAP methodology as outlined in the Standard Assessment Procedure for Energy Rating of Dwellings 2009 Edition published by BRE on behalf of the Department for Energy and Climate Change.

- Retail Unit:

The retail unit has been modeled using the Simplified Building Energy Model (SBEM), which is a software tool developed by BRE that provides an analysis of a non residential building's energy consumption. SBEM is used in support of the National Calculation Methodology (NCM) and the Energy Performance of Buildings Directive (EPBD).

The tool is currently used to determine CO_2 emission rates for new buildings in compliance with Part L of the Building Regulations (England and Wales) and equivalent Regulations in Scotland, Northern Ireland, the Republic of Ireland and Jersey. It is also used to generate Energy Performance Certificates for non-domestic buildings on construction and at the point of sale or rent.

The fabric and services standards assumed for the Baseline calculations are shown in Table 4 on page 23.

The results of the baseline assessment are shown in Table 5 on page 24.

Having produced the baseline energy demand and carbon emissions figures it is now necessary to proceed to the three-step Energy Hierarchy; by following this the development will be designed to minimise emissions.

4.2 Designing for Energy Efficiency

- **Step 1 – Be Lean**

The first step of the hierarchy involves the incorporation of energy efficient design techniques to ensure the development is designed to be as energy efficient as is feasible and viable. The techniques to be considered include an integrated, site-wide approach to natural systems (i.e. solar gain, daylight), thermal performance (e.g. insulation, thermal materials, air permeability, thermal bridging), ventilation and heating and control systems.

As with the baseline assessments, modelling for the design demand and emissions has been undertaken with the use of SAP and SBEM.

4.2.1 Sunlight and Daylight

The development is on a narrow, elongated infill site, previously a public house, with dense surrounding building development; it is, therefore, constrained by the shape, orientation and surroundings of the site.

The south-eastern boundary is heavily shaded by tall buildings, reducing the possibilities for the principal living areas to benefit from the sun's heat. Accordingly, the living rooms of all flats have been designed to face north-eastward, towards Finchley Road, where there is the opportunity to maximise the use of daylight. These flats have large widows to the living rooms and bedrooms; they have also been designed with balconies, shaped to enable French doors to maximise daylight.

The retail unit is substantially glazed to the eastern elevation facing Finchley Road, allowing maximum benefit to be gained from natural lighting.

4.2.2 Overheating

As stated in the previous sub-section, the development is bounded on the south elevation by tall buildings, which provide heavy shading. The majority of the window areas are to the east and west, with argon filled, low-e glass double glazed window units, which help to limit heat loss and maximise solar gains in cold weather, whilst preventing overheating in hot weather. All of the flats are provided with balconies, with French doors which are helpful in the control of overheating.

The Thermal Mass of the building materials also has an effect on overheating and this has been included in the calculations. The SAP and SBEM modelling includes an assessment of overheating and the development as designed is shown to have minimal risk of overheating in the summer.

4.2.3 Natural Ventilation

All windows are openable and designed with trickle ventilation to enable the free flow of air through the building. However, as shown later in this report, the building design will include a very good level of airtightness and natural ventilation alone will not be sufficient; main ventilation in the flats will be provided by mechanical ventilation with heat recovery (which also helps reduce heating demand). The retail unit will have a higher permeability, due to the frequency of door openings during business hours, and will be served by an Air Source Heat Pump

4.2.4 Thermal Performance

When considering methods to improve the thermal performance of a building in the first step of the Energy Hierarchy, the designers have taken a "Fabric First" approach. This enables the developer to make the design applicable to the introduction of higher standards, as and when these are introduced through low and zero carbon technologies. Developers should always bear in mind the planned lifespan of the building, and ensure that the fundamental thermal performance of the fabric is sufficient to make the best use of potential changes to heating and renewable energy systems in the future. In terms of this particular assessment, the addition of clean and green energy in steps two and three of the hierarchy will be much enhanced by excellent thermal design of the fabric.

It should be noted that optimising the fabric (and services) performance of the design will provide opportunities for gaining additional credits in the Code for Sustainable Homes and BREEAM assessments, which also form part of Camden planning requirements for this development.

The thermal performance of a building determines the amount of heat retained within, and the heat lost to the outside air; no matter how efficient the heating and control systems (or indeed the clean and renewable energy technologies included), if too much of the generated heat is lost, more will need to be generated and the building will lose energy efficiency, resulting in higher carbon emissions. Ensuring a high thermal performance is one of the most effective ways of ensuring the development is energy efficient.

SAP and SBEM methodologies are used to measure the effectiveness of the thermal performance, and modelling enables the various methods of improving thermal performance to be tested. The modelling has been informed by various guides, but particularly by the Energy Savings Trust (EST), the Zero Carbon Hub, the Concrete Centre, the Aircrete Products Association (APA) and major insulation manufacturers, all of which have published guidance in designing through various revised targets in the Building Regulations, towards the government target of Zero Carbon building development by 2016. The results of the modelling, with comparisons to the baseline model, are shown in Table 4 on page 23. Methods used to enhance thermal performance follow.

4.2.4.1 Improving Fabric U-Values

A high level of insulation has historically been regarded as the most effective component of a high performance design; improving fabric U-values is, therefore, the first consideration (but not the only consideration, as will be seen later) in the improvement of fabric thermal performance.

The specification for the development will include significant reductions in U-values compared to Building Regulations requirements (in the building fabric and the windows and doors), and will also include methods to reduce the effects of thermal bridging, improved airtightness and ventilation strategies and other service improvements.

4.2.4.2 Reducing Thermal Bridging

A thermal bridge, also referred to as a cold bridge, occurs where reduced insulation or gaps in the insulation cause a significantly greater rate of heat loss than there is through adjoining insulated areas. This usually occurs either because a structural element passes through an insulation layer, or because the insulation layer is thinner where two construction elements meet.

The most familiar type of thermal bridge is caused in a cavity wall by steel wall ties, but other causes are where studworks, joists and rafters separates layers of insulation, and mortar joints in blockwork. These are referred to as **repeating** thermal bridges and are taken account of in the U-value calculations.

In recent years increasing importance has been given to the effects of **non-repeating** thermal bridges, and these now play a very important part in the energy/heat loss calculations in SAP. Examples of these are corners (where walls meet), junctions between elements (i.e. where walls meet floors), around openings and at some features such as balconies, where supports may pass through the insulation. These bridges are not included in the elemental U-value calculations, but are considered separately in the form of linear thermal transmittance (psi) values. The psi value represents the extra heat flow (i.e. heat loss) through the bridge over and above that through the adjoining thermal element.

The effect of these bridges can be reduced with the use of approved construction details. The Energy Savings Trust's Enhanced Construction Details (ECDs) and various Accredited Construction Details (ACDs) are examples of useful design approaches. In this development a range of ACDs will be incorporated in the design; although the ACD values are not as effective as ECDs, the nature of the structure of the building is such that EDCs will not be available. The building is more than four storeys high, therefore subject to stringent rules to satisfy Disproportionate Collapse; because of this, neither traditional cavity masonry, nor timber frame walls are likely to be appropriate. A framed (i.e. concrete) construction with infill blockwork and exterior insulation, finished with render (or other cladding), will be used. There are various ACDs suitable for this type of structure.

4.2.4.3 Airtightness

Airtightness forms a significant part of overall energy loss and is crucial to achieving good fabric performance. Poor airtightness causes increased carbon emissions by increasing the heating load, mainly through:

- Infiltration – leakage of cool external air into the building (draughts)
- Exfiltration – leakage of warmed internal air, which is replaced by cool external air

Both of these mechanisms occur via air leakage through gaps and cracks in the building fabric and happen continuously. In order to minimise air leakage it is fundamental to incorporate an airtightness strategy at the design stage – remedial works after construction are expensive, time consuming and may have a very limited effect on airtightness.

The use of approved construction details will assist with good design as the details incorporate airtight barriers. The Energy Savings Trust's Enhanced Construction Details (ECDs) and various Accredited Construction Details (ACDs) are examples of useful design approaches. In this development a range of ACDs will be incorporated in the design; although the ACD values are not as effective as ECDs, the use of framed construction does not allow ECDs.

Whilst designing for airtightness is of the first importance, it is also vital to ensure that site procedures are clearly explained to site staff and managers, and that these procedures are followed carefully. Airtightness testing is undertaken near to completion and this will demonstrate any leakage in excess of the design rates.

The flats will be designed for an airtightness level of no more than $3m^3/m^2/h$ @ 50Pa, compared to a Building Regulations requirement for $10m^3/m^2/h$ @ 50Pa, which is the Baseline figure. The retail unit will be more difficult to keep a low leakage, due to customers entering and leaving through the main doors regularly, and will be designed for $5m^3/m^2/h$ @ 50Pa.

4.2.4.4 Energy Efficient Ventilation

It has been seen previously that the flats will incorporate a very airtight design of $3m^3/m^2/h$ @ 50Pa, against a requirement of 10. However, buildings need to "breath" and it follows that, by reducing air leakage, controlled ventilation will be needed to maintain a comfortable internal environment. At historic airtightness levels of around 12 to $15m^3/m^2/h$ @ 50Pa, intermittent extract fans were sufficient to provide adequate fresh air to occupants. However, by reducing leakage to the planned maximum of $3m^3/m^2/h$ (in practice, the actual figure should be less than 3), some form of continuous ventilation will be necessary, such as positive input ventilation, mechanical extract ventilation, or mechanical ventilation with heat recovery (MVHR).

An airtightness level of below about $8m^3/m^2/h$ @ 50Pa is the point at which the 'Best Practice Recommended' MVHR systems become more efficient than intermittent extract fans. An efficient MVHR system in place of fan extraction would make significant reductions in emissions. Additionally, for airtightness levels below $3m^3/m^2/h$ @ 50Pa, intermittent fans would not be recommended.

The specified MVHR unit will be the ITHO HRU ECO 4 (or similar); this has a Specific Fan Power of 0.46 and a heat exchanger efficiency of 91%, which places it as an Energy Saving Trust "Very Good" system.

4.2.4.5 Efficient Heating and Cooling

The flats will be fitted with highly efficient mains gas condensing combi boilers, with energy efficient controls. Cooling is not an issue in the flats.

The retail unit, on the other hand, will require more energy for cooling than heating, and will be fitted with a highly efficient Air Source heat Pump, which will provide both heating and cooling. The unit used will be the Mitsubishi Mr. Slim (or similar), which has a cooling efficiency of 601% and a heating efficiency of 395%.

4.2.4.6 Other Energy Efficient Features

- Lighting forms a large proportion of the electricity usage of a building. The baseline percentage is set at 30% of fixed light fittings; the development specification will call for 100%, which shows a large improvement.
- External and communal lighting will be low energy and fitted with appropriate controls such as movement and light sensors, photo sensors and timers.
- Water usage will be restricted to less than 125 litres/person/day, for example by fitting low flow taps and showers, small capacity baths and reduced dual flush WCs; this which will significantly reduce the demand for hot water.

4.2.5 Results

Various efficiencies in the design have resulted in reductions against the Baseline of **21.76%,** as illustrated in Table 1 on page 6. The full figures are shown in Table 6 on Page 25.

4.3 Supplying Energy Efficiently

- **Step 2 – Be Clean**

The second step of the hierarchy involves the incorporation of an efficient supply of energy to contribute to further reductions in energy usage. In this stage of the hierarchy developments are required to investigate the possible use of decentralised energy networks and combined heat and power (CHP); CHP also has the potential of including cooling when appropriate.

Under the terms of Camden planning guidance, this section of the report considers the following steps, in the order listed:

1. The potential for connecting into an existing or planned decentralised energy scheme.
2. Installing a Combine Heat and Power (CHP) plant, with cooling (CCHP) to be included if possible.

3. Where neither of the above is feasible, providing a contribution for the expansion of decentralised energy networks in Camden; **and**
4. Designing the development to enable its connection to a decentralised energy network in the future.

4.3.1 Decentralised Energy

The suitability of a development for connection to a decentralised energy network depends largely on the following:

- High heating demand
- Mixed energy demands
- Location close to an existing network (within 1km), or a proposed network (within 500m).

The development, with twelve residential units, will have a fairly high seasonal heating demand and, with the inclusion of a retail unit, energy demand will be mixed.

The locations of existing and proposed networks have been investigated using information, and maps, from Camden's Core Strategy and considered for feasibility with regard to this development; the results are as follows:

a) The nearest existing decentralised source is based at the Royal Free Hospital; unfortunately, this is more than the 1 kilometre advisable distance and, therefore, it would not be technically viable nor economically feasible to connect a development of this relatively small size to this source.

b) The nearest proposed source is located at Swiss Cottage; this is considerably further than the recommended 500 metre limit from the development.

4.3.2 Combined Heat and Power (CHP)

As with decentralised energy, the suitability of a development for a CHP system depends largely on heating demand and, the type and mix of energy demands; however, the number of units to be served with heat and power and the plant room space available for the CHP engine and controls is also relevant.

Combined heat and power (CHP) integrates the production of usable heat and power (electricity), in one single, highly efficient process. CHP generates electricity whilst also capturing usable heat that is produced in this process. The key technical challenge in designing a CHP system is to balance the thermal and electrical loads. Systems are usually designed to match the base load heat requirement for the communal heat network, with top-up boilers supplying the remainder as required to meet the peak thermal load.

Dwelling density is key to minimising distribution network costs and heat losses and so community schemes economically feasible. The cost effectiveness increases with scale and population density, since the average district heating network costs are less per dwelling.

To enable consideration of the inclusion of CHP in this development, an approach has been made to ENER-G Combined Power Ltd, UK market leaders in small scale CHP systems, who were recommended by the Combined Heat and Power Association (CHPA). The advice of ENER-G was that the size of plant room required for a CHP system in this development would be too large for the space available. Additionally, the London Renewables Toolkit was referenced, which concluded that electricity could not be supplied to the flats unless a private wire system is used and, as flat owners would need to be given the choice of where to purchase electricity, the CHP system would possibly feed only the landlord's areas; this would make the system unviable.

4.3.3 Results

The development is not suitable for connection to a decentralised energy network and is also not suitable for the inclusion of a Combined Heat and Power system.

4.4 Renewable Energy Technologies

- **Step 3 – Be Green**

The third step of the hierarchy involves the incorporation of renewable energy technology in order to reduce the carbon dioxide emissions of the development (after any improvements achieved in steps 1 and 2) by at least 20%, through the installation of on-site renewable energy technologies.

A number of renewable technologies have been considered:

- Wind Generators
- Biomass Heating
- Biomass CHP
- Ground Source Heat Pumps
- Ground Source Cooling
- Solar Water Heating
- Photovoltaic (Energy from sunlight)

The London Renewables Toolkit, together with resources from the Energy Saving Trust and other relevant associations, has been used to guide the considerations.

4.4.1 Wind Generators

The UK is the windiest of any country in Europe, with approximately 40% of the total on and off shore resource. The majority of this is available only to large-scale wind farms, although in some locations generation on a domestic scale is feasible.

Various issues have been taken into consideration including:

- The average wind speed at the site. Currently the British Wind Energy Association (BWEA) suggests a large wind turbine should be viable where wind speed is 7m/s or above.
- The uneven and turbulent wind patterns that occur near buildings and other obstacles. Turbulence will decrease performance and may reduce expected equipment life.
- The need to maintain adequate access for maintenance and initial installation.
- Possible noise from the turbines (although modern turbines without gearboxes are quiet and are said to be drowned out by a passing car).
- The available space for a turbine, as they must be placed a minimum distance from residential and school buildings due to noise, reflected light and shadow flicker, which varies according to their height

The development site is not considered suitable for wind generation for the following reasons:

- The average wind speed at the location is 4m/s, which is insufficient for viable performance. Wind speed would be improved by siting the turbine at a higher level, but this would be detrimental to other residential dwellers in the immediate vicinity in terms of noise, reflected light and flicker, and would have a limited affect on performance. It is considered that other renewable technologies would be more beneficial.
- This is an infill site surrounded by dense urban development; the nature of surrounding development will cause wind patterns and turbulence which would decrease performance.
- The external walls of proposed building will fall immediately within the site boundary, creating difficulties for adequate access for installation and maintenance.

4.4.2 Solar Photovoltaic Electricity Generation

Photovoltaic (PV) cells convert solar radiation directly into electricity through the interaction of light with electrons in a semiconductor material. Solar cells are built using layers of semiconductors which create a small potential difference between the layers. When exposed to solar radiation, an array of cells connected together (called a module) creates a usable amount of direct current (DC). This is usually converted to alternating current (AC) for household use or for export to the National Grid. A system

of Feed-In Tariffs (FITs) is in place whereby payment is made to the owner of the PV system for electricity exported to the grid.
A typical system consists of several modules, an AC/DC inverter, fuse box, isolator and an import/export meter. The performance ratio of a solar PV system describes the actual energy yield as a proportion of the theoretically expected yield. System losses can be caused by deviation from module nominal efficiency, module soiling and inverter and wiring losses. The performance ratio is typically 0.7 to 0.75. Ideally photovoltaics should face between south-east and south-west, at an elevation of about 30-40°. However, in the UK even flat roofs receive 90% of the energy of an optimum system

The size of a photovoltaic installation is expressed by its kilowatt peak (kWp) potential, which is an indication of how much electricity the system could generate at peak or optimum conditions. A modern high performance 1kWp system in London might be expected to produce a maximum of 850kWh/yr; at this level of production the capital cost payback period could be reduced by around 25%. The performance depends more on location, orientation and whole system design than it does on cell type. Photovoltaic cells come in a number of types with varying operating efficiencies and therefore different areas of panel are required to produce the same output. A 15+% efficiency system would require approximately 6.50m^2 generating module area per 1kWp output in optimum conditions and orientation.

Issues that have been taken into consideration include:

- Panels should ideally face between south-east and south-west, at an elevation of about 30-40° although arrays pointing east or west are acceptable (albeit at lower performance) especially for roofs inclined at a low angle to the horizontal.
- Arrays should not be horizontal as the rain will be unable to wash them clean.
- Systems should be in locations that will be unshaded at all times of day if possible. Gable roofs, chimneys, cables, TV aerials, trees and other buildings in the vicinity should be identified as potentially shading the modules, particularly in the early morning or early afternoon. The performance of a whole panel will be affected even if only part of it is shaded.
- The panels need to be ventilated (behind the modules) so that they do not heat up - their efficiency decreases as their temperature rises. Suitable ventilation is easier to ensure for bolt-on systems.
- PV systems are straightforward to install as they are modular and light, and electrical connections are part of the construction of the building
- PV systems are technically reliable - they are generally guaranteed to last between 20-25 years but are expected to last longer.
- The Climate Change Levy can be avoided for the retail unit.
- Marketing impact - a clear statement about using renewable energy.
- Excess electricity can be sold to the grid.

The development site is considered suitable for photovoltaics for the following reasons:

- The building is physically very tight to the site boundaries, making most other forms of renewable technologies unviable.
- The cost to benefit ratio (in terms of carbon dioxide reduction) is very positive.
- There is a fairly large roof area available for mounting panels, which can be fixed to face south.
- The height of the roof level will be such that there will be little or no shading.
- Connections to each of the units will be fairly straightforward.
- Unit owners will be able to sell excess electricity to the grid.
- Metering can and will be installed for monitoring the system. Good monitoring of performance in the running of a PV system is assisted by a good sub-metering strategy – that is, a meter to monitor the electrical output from each array.

This renewable technology has been chosen and the resulting energy and carbon dioxide emission reduction of **20.04%** (after steps 1 and 2 of the hierarchy) is illustrated in Table 1 on page 6. The total carbon dioxide emissions reduction is **37.45%** against the Baseline scheme. The full figures are included in Table 7 on page 26.

An additional benefit will be the use of a green (sedum) roof, which will increase panel efficiency by creating cooler temperatures.

4.4.3 Solar Water Heating

Similarly to photovoltaic (PV) cells, solar water heating systems use the energy from the sun, in this case to heat water, most commonly in the UK for hot water needs. The systems use a heat collector, generally mounted on the roof in which a fluid is heated by the sun. This fluid is used to heat up water that is stored in either a separate hot water cylinder or a twin coil hot water cylinder inside the building. The systems work very successfully in all parts of the UK, as they can work in diffuse light conditions.

There are two types of collectors used for solar water heating applications - flat plate collectors and evacuated tube collectors. The flat plate collector is the predominant type used in domestic systems as they tend to be cheaper. Evacuated tube collectors are generally more expensive due to a more complex manufacturing process (to achieve the vacuum), but manufacturers generally claim better winter performance.

Ideally the collectors should be mounted on a south-facing roof, although south-east/south-west will also function successfully, at an elevation of between 10 and 60°.

The panels can be bolted onto the roof or integrated into the roof with lead flashings. They look similar to rooflights. Solar water heating systems are suitable for any building type that has sufficient year round hot water needs (ideally during the day) and a suitable south-facing roof of sufficient size. This technology is particularly suitable for low-density housing developments.

Although the capital cost is cheaper than PV, case studies by The Carbon Trust have shown that when comparing CO_2 reductions against capital investment, PVs can compare favourably to solar hot water (and ground source heat pumps).

It has been decided not to incorporate solar hot water heating as the benefits of a photovoltaic system (an overall reduction in electricity demand from the grid, and comparable cost benefits) outweigh the benefits of such a system, which only reduces emissions from hot water generation.

4.4.4 Other Renewable Technologies

The following technologies have not been considered:

- Biomass Heating
- Biomass CHP
- Ground Source Heat Pumps
- Ground Source Cooling

The reasons are:

- Lack of plant room space (biomass systems)
- Lack of storage for fuels (biomass systems)
- Lack of external ground space (ground source heating and cooling)
- Cost constraints in a small development (biomass systems)

4.5 Conclusions and Proposal

The development is sited on the footprint of an existing building and suffers from a lack of space both outside, and within the building. It is therefore not possible to consider biomass, or ground source heating and cooling, or combined heat and power. The site is also too far from existing and potential district heating schemes. This has resulted in the inability to include energy sources outlined in Step 2 of the Energy Hierarchy.

To mitigate this, the design has been made as efficient as possible and feasible in Step 1 of the Hierarchy, to include not only excellent fabric characteristics, but also the incorporation of an Air Source Heat Pump which will provide heating and cooling for the retail unit and Mechanical Ventilation with Heat recovery in the flats.

Renewable technologies were limited in feasibility, but a fairly large roof area has enabled the inclusion of highly efficient Photovoltaic panels, to feed the residential and retail areas. Depending on the efficiency of the chosen system, approximately 65 to 70m2 of panel area, mounted south facing at 30^o, will be required. The resulting energy and emissions savings have enabled the proposed development to meet the requirements of the London Plan and Camden's sustainability plans.

ELEMENT or SYSTEM	BASELINE VALUE	DESIGN IMPROVEMENT VALUE
External Walls	Flats: U = 0.35 W/m2K Retail: U = 0.2 W/m2K	Flats: U = 0.18 W/m2K (Sheltered 0.17) Retail: U = 0.2 W/m2K
Floors	Flats: U = 0.25 W/m2K Retail: U = 0.2 W/m2K	Flats: U = 0.18 W/m2K (0.09 over retail unit) Retail: U = 0.2 W/m2K
Roofs	U = 0.16 W/m2K	U = 0.13 W/m2K
Party Walls	U = 0 W/m2K	U = 0 W/m2K
Windows	Flats: U = 2.0 W/m2K (adj. to 1.85 for TER) Retail: U = 1.5 W/m2K	U = 1.4 W/m2K Retail: U = 1.5 W/m2K (with Solar Shading)
Doors	Flats: U = 2.0 W/m2K Retail: U = 1.5 W/m2K	U = 1.2 W/m2K Retail: U = 1.5 W/m2K
Opening Areas	25% of Total Floor Area	As Designed; Average Overshading
Air Permeability	Flats: 10 M3/h per m2 (@ 50 Pa) Retail: 5 M3/h per m2 (@ 50 Pa)	Flats: 3 M3/h per m2 (@ 50 Pa) Retail: 5 M3/h per m2 (@ 50 Pa)
Thermal Mass	Medium (TMP = 250 kJ/m2K)	Medium (TMP = 250 kJ/m2K)
Shading and Orientation	Glazing E/W; Average Overshading	As Designed; Average Overshading
Number of Sheltered Sides	2	As Actual
Thermal Bridging	0.11 x Surface Area (W/K)	ACDs - Approx. 0.08
Ventilation	Natural with Extract Fans	Flats: MVHR Retail: Air Conditioning and Extract Fan
Boiler (Flats)	SEDBUK (2009) 78% Room-sealed, Fanned Flue On-Off Burner Control	Combi; SEDBUK (2009) 90% Room-sealed, Fanned Flue On-Off Burner Control
Retail Unit heating and Cooling	Gas Boiler SEDBUK (2009) 86% Split System Cooling	Air Source heat Pump
Heating System Controls	Programmer, Room Thermostat, TRVs Boiler Interlock	Time and Temperature Zone Control Boiler Interlock
Hot Water Cylinder	150 litre with 35mm Insulation	No Cylinder
Primary Water Heating Losses	Pipework Not Insulated Thermostat Temperature Control	Thermostat Temperature Control
Water Usage	> 125 l/p/d	< 125 l/p/d
Secondary Space Heating	10% - Provided by Electric Panel heaters	N/A
Proportion of Energy Efficient Light Fittings	30% of Fixed Fittings	100% of Fixed Fittings

Table 4: Comparison of Key Values and Standards used in the Notional Baseline Scheme and the Design Improvements for the Flats

	Predicted Energy Requirement for Electricity		Building Regulations Target for Electricity (see Note 1)	Predicted Energy Requirement for Gas		Building Regulations Target for Gas (see Note 1)	Total Baseline Energy Requirement	Baseline Carbon Emissions		Total Baseline Carbon Emissions
	Regulated	Unregulated		Regulated	Unregulated			Regulated	Unregulated	
Unit	**kWh/Year**	**kWh/Year**	**kWh/Year**	**kWh/Year**	**kWh/Year**	**kWh/Year**	**kWh/Year**	**Kg/CO2/Year**	**Kg/CO2/Year**	**Kg/CO2/Year**
Retail	13641.53	3222.05	11748.01	0.00	0.00	0.00	11748.01	5756.73	1359.71	7116.43
Common Areas	0.00	1612.24	1612.24	0.00	0.00	0.00	1612.24	0.00	680.37	680.37
Flat 1	1254.92	3276.41	4060.74	9594.17	0.00	5996.36	10057.09	2390.85	1382.65	3773.49
Flat 2	1455.41	3622.73	4532.36	11051.12	0.00	6906.95	11439.31	2758.10	1528.79	4286.89
Flat 3	1186.55	2998.24	3739.83	8480.09	0.00	5300.06	9039.89	2145.86	1265.26	3411.12
Flat4	1303.08	3246.36	4060.79	9172.90	0.00	5733.06	9793.85	2329.44	1369.96	3699.41
Flat5	1186.55	2998.24	3739.83	8480.09	0.00	5300.06	9039.89	2145.86	1265.26	3411.12
Flat6	1303.08	3246.36	4060.79	9172.90	0.00	5733.06	9793.85	2329.44	1369.96	3699.41
Flat7	1187.95	3012.99	3755.46	8495.67	0.00	5309.79	9065.25	2149.47	1271.48	3420.96
Flat8	1376.05	3485.60	4345.63	9992.07	0.00	6245.04	10590.68	2519.15	1470.92	3990.08
Flat9	1597.03	3948.82	4946.96	11979.65	0.00	7487.28	12434.25	2998.00	1666.40	4664.40
Totals	25492.15	34670.04	50602.63	86418.66	0.00	54011.66	104614.30	27522.91	14630.76	42153.66

Note 1: Current regulations require the design energy demand and emissions to be reduced by approximately 37.5% in order to meet the TER; the figures in this table have been discounted accordingly to illustrate the Baseline Emissions

Note 2: Unregulated (cooking and electrical appliances) figures are calculated according to SAP conventions

Table 5: Site Baseline Energy Demand and Carbon Dioxide Emissions

	Building Regulations Target for Electricity	Building Regulations Target for Gas	Total Baseline Energy Requirement	Total Baseline Carbon Emissions	Step 1 Improved Design Electricity	Step 1 Improved Design Gas	Step 1 Total Design Energy Requirement	Step 1 Total Design Carbon Emissions
Unit	**kWh/Year**	**kWh/Year**	**kWh/Year**	**Kg/CO2/Year**	**kWh/Year**	**kWh/Year**	**kWh/Year**	**Kg/CO2/Year**
Retail	**11748.01**	**0.00**	**11748.01**	**7116.43**	**9734.228**	**0.00**	**9734.23**	**5032.60**
Common Areas	**1612.24**	**0.00**	**1612.24**	**680.37**	**1612.24**	**0.00**	**1612.24**	**833.53**
Flat 1	**4060.74**	**5996.36**	**10057.09**	**3773.49**	**3911.36**	**4763.48**	**8674.84**	**2965.34**
Flat 2	**4532.36**	**6906.95**	**11439.31**	**4286.89**	**4341.73**	**5180.55**	**9522.28**	**3270.42**
Flat 3	**3739.83**	**5300.06**	**9039.89**	**3411.12**	**3668.40**	**4157.43**	**7825.83**	**2719.73**
Flat4	**4060.79**	**5733.06**	**9793.85**	**3699.41**	**3984.15**	**4147.73**	**8131.88**	**2881.06**
Flat5	**3739.83**	**5300.06**	**9039.89**	**3411.12**	**3668.40**	**4157.43**	**7825.83**	**2719.73**
Flat6	**4060.79**	**5733.06**	**9793.85**	**3699.41**	**3984.15**	**4147.73**	**8131.88**	**2881.06**
Flat7	**3755.46**	**5309.79**	**9065.25**	**3420.96**	**3683.15**	**4201.09**	**7884.24**	**2736.00**
Flat8	**4345.63**	**6245.04**	**10590.68**	**3990.08**	**4223.39**	**4941.99**	**9165.38**	**3162.01**
Flat9	**4946.96**	**7487.28**	**12434.25**	**4664.40**	**4741.12**	**6695.35**	**11436.47**	**3776.84**
Totals	**50602.63**	**54011.66**	**104614.30**	**42153.66**	**47552.32**	**42392.78**	**89945.10**	**32978.32**

Note 1: Unregulated (cooking and electrical appliances) figures are included in the Electricity Columns

Table 6: Energy Demand and Carbon Dioxide Emissions from Baseline and Efficiency Design Measures (Step 1)

	Building Regulations Target for Electricity	Building Regulations Target for Gas	Total Baseline Energy Requirement	Total Baseline Carbon Emissions	Step 1 Improved Design Electricity	Step 1 Improved Design Gas	Step 1 Total Design Energy Requirement	Step 1 Total Design Carbon Emissions	Step 3 Photovoltaic Panels Electricity	Step 3 Photovoltaic Panels Gas	Step 3 Total PV Energy Requirement	Step 3 Total PV Carbon Emissions
Unit	kWh/Year	kWh/Year	kWh/Year	Kg/CO2/Year	kWh/Year	kWh/Year	kWh/Year	Kg/CO2/Year	kWh/Year	kWh/Year	kWh/Year	Kg/CO2/Year
Retail	11748.01	0.00	11748.01	7116.43	9734.228	0.00	9734.23	5032.60	7787.38	0.00	7787.38	4026.08
Common Areas	1612.24	0.00	1612.24	680.37	1612.24	0.00	1612.24	833.53	1289.79	0.00	1289.79	666.82
Flat 1	4060.74	5996.36	10057.09	3773.49	3911.36	4763.48	8674.84	2965.34	2623.76	4763.48	7387.24	2299.65
Flat 2	4532.36	6906.95	11439.31	4286.89	4341.73	5180.55	9522.28	3270.42	3054.13	5180.55	8234.68	2604.73
Flat 3	3739.83	5300.06	9039.89	3411.12	3668.40	4157.43	7825.83	2719.73	2595.40	4157.43	6752.83	2164.99
Flat 4	4060.79	5733.06	9793.85	3699.41	3984.15	4147.73	8131.88	2881.06	2911.15	4147.73	7058.88	2326.32
Flat 5	3739.83	5300.06	9039.89	3411.12	3668.40	4157.43	7825.83	2719.73	2595.40	4157.43	6752.83	2164.99
Flat 6	4060.79	5733.06	9793.85	3699.41	3984.15	4147.73	8131.88	2881.06	2911.15	4147.73	7058.88	2326.32
Flat 7	3755.46	5309.79	9065.25	3420.96	3683.15	4201.09	7884.24	2736.00	2610.15	4201.09	6811.24	2181.26
Flat 8	4345.63	6245.04	10590.68	3990.08	4223.39	4941.99	9165.38	3162.01	2935.79	4941.99	7877.78	2496.32
Flat 9	4946.96	7487.28	12434.25	4664.40	4741.12	6695.35	11436.47	3776.84	3453.52	6695.35	10148.87	3111.15
Totals	50602.63	54011.66	104614.30	42153.66	47552.32	42392.78	89945.10	32978.32	34767.62	42392.78	77160.40	26368.63

Table 7: Energy Demand and Carbon Dioxide Emissions from Baseline, Efficiency Design Measures (Step 1) and Renewable Technology (Step 3)

Appendices:

A Code for Sustainable Homes Pre-Assessment Results Page

B BREEAM Pre-Assessment Estimator Results Page

C SAP Code for Sustainable Homes Energy Credits Reports

D SBEM Output Reports

- *i BRUKL Output Documents (Hierarchy Steps 1 and 3 – Notional figures included)*
- *ii SBEM Main Calculation Output Documents (Hierarchy Steps 1 and 3)*

E Proposed Development Site Layout and Floor Plans

F Air Quality Assessment

G Noise and Vibration Assessment