Energy & Sustainability Statement

Phoenix House Flats, 104-110 Charing Cross Road, London, WC2H

Client: Life Designs Architecture
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EXECUTIVE SUMMARY

Energy Rating Services (ERS) has been appointed to prepare an Energy & Sustainability Statement for two new flats on top of an existing apartment block in Charing Cross Road, London.

The proposal is for two penthouse maisonette flats of approximately 179 m^2 each situated in London Borough of Camden.

Table 1-Units specifications

Flat/House	Area (m^2)
Flat 1	179
Flat 2	179
Total Area	**358**

This energy and sustainability report outlines the key measures to be incorporated in the design, in regards to sustainability, carbon emissions, renewable energy and environmental impact of the considered new residential development, in accordance with:

- **London Planning Obligations - Supplementary Planning Document (2013)**
- **London Plan Chapter 5 Policy 5.2 to 5.8 Sustainable Design and Construction (SPG) 2014**
- **Camden Development Policy 2010-2025- London Borough of Camden (2010)**
- **Policy DP22 –Sustainable Design and Construction -Camden Development Policies adopted (2010)**
- **CPG 3 Camden Planning Guidance-Sustainability- London Borough of Camden**
- **CS13 Core Strategy Policy- Tackling climate change through promoting higher Environmental Standards**
- **DP23 – Water Efficiency of the CPG3 –Camden Planning Guidance**

These two new flats in Charing Cross Rd, London, have been designed in accordance with **Policy 5.3 of the London Plan- Sustainable Design and Construction (SPG) 2014,** which sets the minimum standards for new developments in London urban area.

'*Major development proposals should meet the minimum standards outlined in the Mayor's supplementary planning guidance and this should be clearly demonstrated within a design and access statement. The standards include measures to achieve other policies in this Plan and the following sustainable design principles:*

> *a minimising carbon dioxide emissions across the site, including the building and services (such as heating and cooling systems)*
>
> *b avoiding internal overheating and contributing to the urban heat island effect*

c efficient use of natural resources (including water), including making the most of natural systems both within and around buildings

d minimising pollution (including noise, air and urban runoff)

e minimising the generation of waste and maximising reuse or recycling

f avoiding impacts from natural hazards (including flooding)

g ensuring developments are comfortable and secure for users, including avoiding the creation of adverse local climatic conditions

h securing sustainable procurement of materials, using local supplies where feasible, and

i promoting and protecting biodiversity and green infrastructure.'

Policy DP22 of the London Borough of Camden Planning requirement sets out the Council's sustainable design and construction requirements for new developments.

According to **Policy CS13 Core Strategy** all new developments require to provide a 20% reduction improvement from on-site renewable on 2013 Building Regulations levels of carbon dioxide emissions, unless it can be demonstrated that such provision is not feasible.

Based on that, these new two residential units at 104-110 Charing Cross Road, London seek to achieve a reduction in Carbon Emission of at least 20% beyond 2013 Building Regulations.

Based on the incorporation of the 'good practice' energy efficiency measures "be Lean", "be Clean" & "be Green" included in the sustainability statement, the development's energy consumption and resulting carbon emissions are presented in Figure 2 & Table 2. Those measures correspond to the 26% reduction in CO_2 emissions above Part L 2013 level, as required by **Policy DP22 and CS13 of the Camden Development Policies Adopted** document.

Policy DP22 and Policy DP23 of the CPG3 Sustainability guidance have been achieved by a combination of energy efficiency measures; a first fabric approach has been considered to improve the thermal performance of the building envelope; only then renewable measures have been considered to increase the efficiency of the building in order to achieve a total reduction in Carbon emissions by 26% compared to 2013 Building Regulations levels.

The range of possible on-site renewable (also referred as low or zero carbon (LZC) energy sources) are outlined and assessed in this report, in terms of the feasibility, given site constraints and expected demand profiles. The estimated CO_2 savings are calculated based on the most feasible LZC options. Finally, the energy efficiency, renewable and other sustainability options are summarised with reference to the requirements of the planning guidance document.

All energy figures have been calculated using approved software NHER SAP assessor V.6.2.1 calculator to provide evidence of compliance with the Building Regulations as well as amount of improved carbon emissions for the development.

ENERGY & CARBON DEMAND SUMMARY

Table 2 Energy and Carbon Reductions

	Energy demand (kWh)	Energy demand savings (%)	CO2 Emissions (kg/yr)	CO2 Emissions savings (%)
Proposed baseline scheme	25,310		4,452	
Proposed scheme after energy efficiency measures	24,302	4%	4,274	4%
Proposed scheme after renewable measures	19,478	23%	3,288	22%
Total	19,478	**27%**	3,288	**26%**

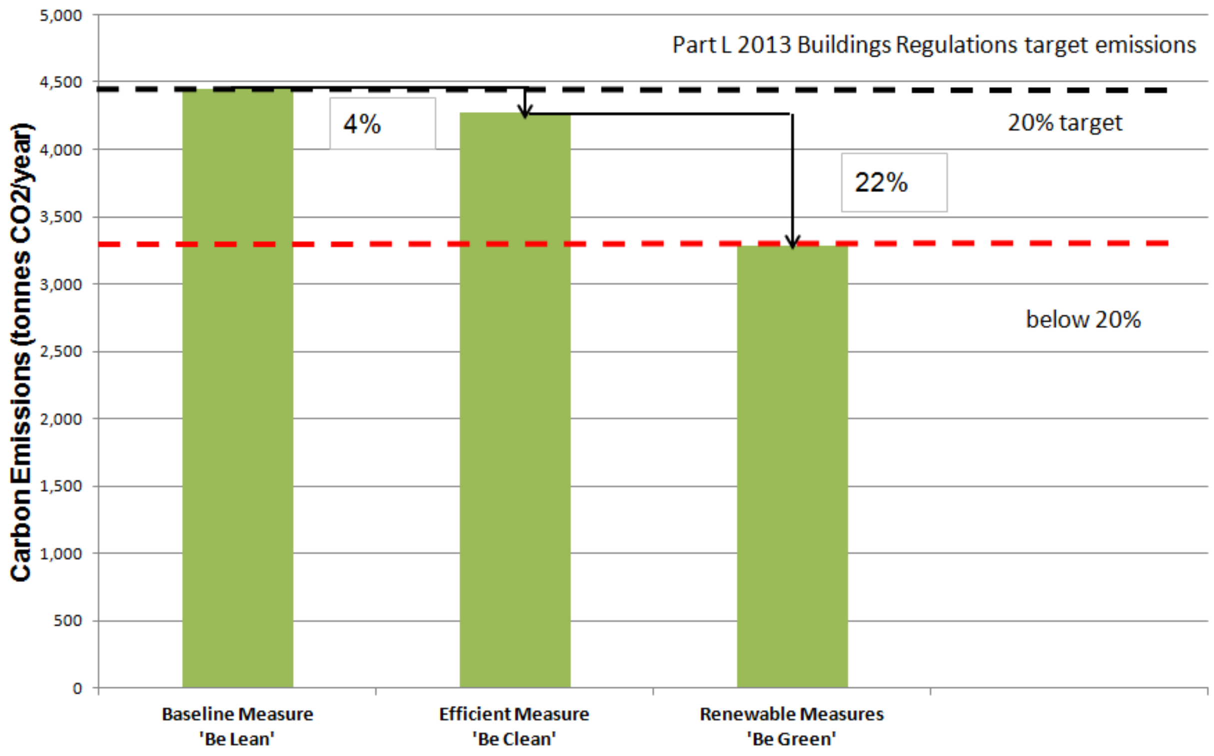


Figure 1 Carbon Emissions Reductions

As shown in Table 2, the provisional baseline annual energy consumption of the proposed development has been estimated to be 25,310 KWh/yr. The resulting annual carbon dioxide emission is 4,452 CO_2Kg/yr.

The incorporation of energy saving measures and renewable energy sources, following a hierarchy of measures based on the priority given to different carbon reduction techniques, would reduce the energy requirement and CO_2 emissions to 19,478 kWh/year and 3,288 kgCO_2/year respectively. The total reduction with clean and green measures would result in a total of 26% reduction that is in comparison to the Part L 2013 Building regulations baseline as shown in Figure 2, achieving the carbon reduction target set by Policy CS13 of London Borough of Camden Planning Requirements.

The primary importance was given to the reduction of the energy requirement. This was firstly achieved by the incorporation of good practice energy saving techniques ("be Lean"). Then with the reduction of the losses associated with the supply of energy ("be Clean"). Finally, when all the previous measures are incorporated, renewable technologies are considered ("be Green") to achieve the optimum reduction.

The following energy saving strategies will be incorporated where possible to minimize the refurbishment/extension's energy requirement (Energy Efficiency Measures):

- Low air permeability of facade
- Improved U-value
- High performance Low E glazing
- Highly efficient heating system
- Heat recovery system
- Energy efficient lighting

SECTION 1 INTRODUCTION

OBJECTIVE

This document has been prepared with reference to the **London Borough of Camden planning requirement**, **CPG 3 Camden Planning Guidance- Sustainability and London Plan Chapter 5 Policy 5.2 to 5.8,** it seeks to address at a preliminary level the requirements in terms of sustainability and renewable energy.

The proposed development has been treated to be self contained in terms of heating and hot water supply. However the potential for using distributed heating from a central energy centre has been considered.

SUMMARY

The key sustainability measures to be incorporated in the design are outlined in Section 2 below. Those correspond with the project's aspiration to achieve the best practically possible for this residential development, in terms of sustainability and energy.

Based on the incorporation of the 'good practice' energy efficiency measures included in the sustainability statement, the development's energy consumption and resultant carbon emissions are presented. For clarity these figures have been broken down by fuel type (electricity and fossil fuel, assumed in this case to be natural gas). The range of possible on-site renewables (also referred as low or zero carbon (LZC) energy sources) is then outlined and assessed in terms of the feasibility given site constraints and expected demand profiles. The estimated CO_2 savings are calculated based on the most feasible LZC options.

CALCULATION METHODOLOGY

All energy figures have been calculated using approved software NHER SAP assessor V.6.2.1 calculator to provide evidence of compliance with the Building Regulations as well as amount of improved carbon emissions for the development.

The carbon emissions factors used in all calculations in this document are those published in Table 2 of Part L2A of the Building Regulations. The relevant factors are reproduced in Table 3 below.

Table 3 Carbon emissions factors by fuel type

Fuel	CO_2 emission factor ($kgCO_2/kWh$)
Natural Gas	0.194
Biomass	0.025
Grid supplied electricity	0.422
Grid displaced electricity	0.568

SECTION 2 SUSTAINABILITY STATEMENT

2.1 INTRODUCTION

This section expands on the sustainability issues outlined in **CPG3 Sustainability Camden Planning Guidance, Core Strategy and London Planning Obligations** - **Supplementary Planning Document (2013).**

2.1.1 ENERGY EFFICIENCY

The energy efficiency targets stated in the planning guidance are expressed in terms of improvements over and above the requirements of building regulations 2013 Part L1A. For a development of this nature at least a 6% improvement, in excess of 'Pass' level, is likely to be achieved with consideration of the following energy efficiency measures:

- Building Fabric Energy efficiency & air tightness
- High efficient boiler
- Efficient lighting
- Low energy heating
- Heat recovery
- Variable speed drives
- Building energy management systems

2.1.2 WATER

Reducing the daily water consumption to 125 litre/person/day is one of the requirements of the Building Regulations, and 105 litre/ person for the CSH. This can be achieved by applying various water efficiency and reclamation / recycling measures.

WATER EFFICIENCY MEASURES

The following measures can be used to reduce the quantity of water demand to satisfy end users:

- Dual or low flush WCs
- Spray or aerating taps
- Water efficient appliances
- Low flow showers
- Smaller size bath

WATER RECLAMATION / RECYCLING MEASURES

- Rainwater collection

Water collected from roofs or hard surfaces such as car parks can be harvested for storage and use for non-potable uses such as watering gardens and WC flushing.

Sustainable Drainage Systems (SUDS)

Sustainable drainage systems (SUDS) is an approach to manage surface water, aiming to reduce problems of flooding and pollution associated with traditional drainage systems. The basic principles are the reduction and attenuation of run-off from the site. This is achieved by exploiting or enhancing existing natural drainage systems and/or techniques modelled on them. Additional benefits such as increased amenity space or natural habitats can also accrue from the use of such systems.

The selection and design of SUDS is a multidisciplinary process that will involve above and below-ground drainage engineers and landscape architects working in consultation with the Environment Agency or other appropriate authority to determine specific requirements for reducing site run-off.

The planning guidance for 'Pass' level usually requires that 50% of the development's hard surfaces and conveyance systems are permeable.

2.1.3 Building Materials

The key issues to be addressed in the selection of materials and equipment are:

- Use of materials and equipment from sustainable sources
- Minimisation of in-use environmental impacts
- Minimisation of embodied environmental impacts
- Use of materials and equipment with high recycled content

2.1.4 Waste

A site waste management plan that provides details of waste minimisation, sorting, reuse and recycling procedures is required for all levels in the planning guidance. Sustainable waste management should follow the hierarchy described in *BS 5906: Waste management in buildings. Code of practice*. This outlines the following principles in decreasing order of desirability:

- Reduce waste
- Re-use materials and equipment (and facilitate future reuse)
- Recycle waste (and facilitate recycling)
- Compost biodegradable waste
- Recover energy from waste (and facilitate energy recovery from waste)
- Disposal

2.1.5 Flood Risk Assessment

Flood Zones

The Environment Agency has developed a flood risk map, which shows the relative risk of flooding for different return periods. Flood zones assume that no defences are present and so where these do exist they are only indicative of the potential for flooding.

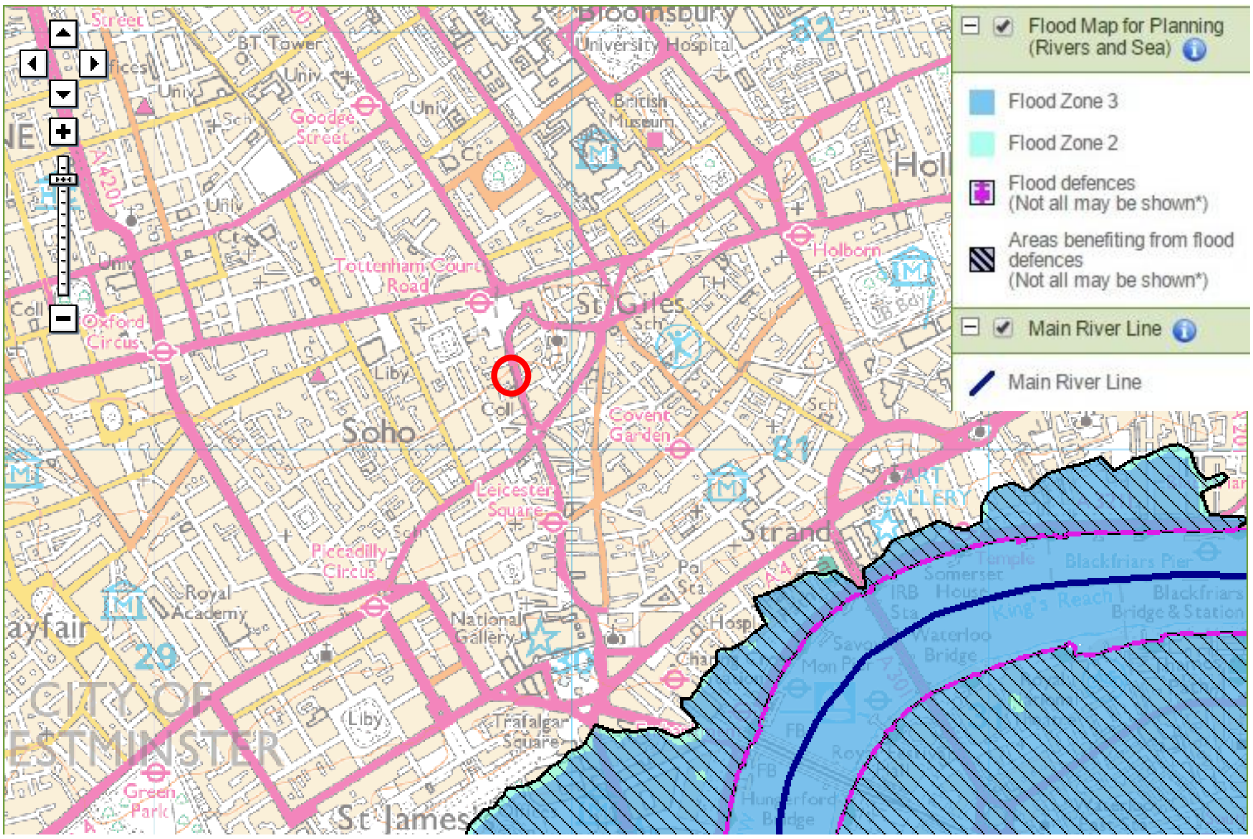


Figure 2- Environmental Agency Flood Zone Interactive Map

The whole of the development lies within flood zone 1 of the Environment Agency's flood risk map as seen in fig. b. Land located within flood zone 1 is at low risk of flooding having an associated annual probability of flooding of less than 1 in 1000 (0.1%).

Study Approach

In accordance with Table D.1 of PPS25 (see Appendix C), land within flood zone 1 is suitable for all uses. Assessment of this site has been based upon the Environment Agency's flood interactive map, the topographical site survey and the architect's proposed development layout.

Flood Vulnerability

From the flood risk vulnerability classification Table D.2 of PPS25 (see Appendix C), residential development comes within the 'more vulnerable' classification. Based on the Environment Agencies flood map, the development site is located within Flood Zone 1 and in accordance with Table D.3 of PPS25 (see Appendix C) neither a sequential or exception test is required.

Flood risk to the site located within Flood Zone 1 was identified as low risk flooding coming from a surface water source which is elaborated below.

SURFACE WATER FLOODING

Surface water sewers/drains can be at risk of surcharging during extreme rainfall events with flooding occurring mainly from manholes and gullies.

We understand, from the records/survey information available in the vicinity of the site, that there are street drains located along Charing Cross Road.

The Environmental Agency has classed the site as “low risk” as seen below in fig. 3.

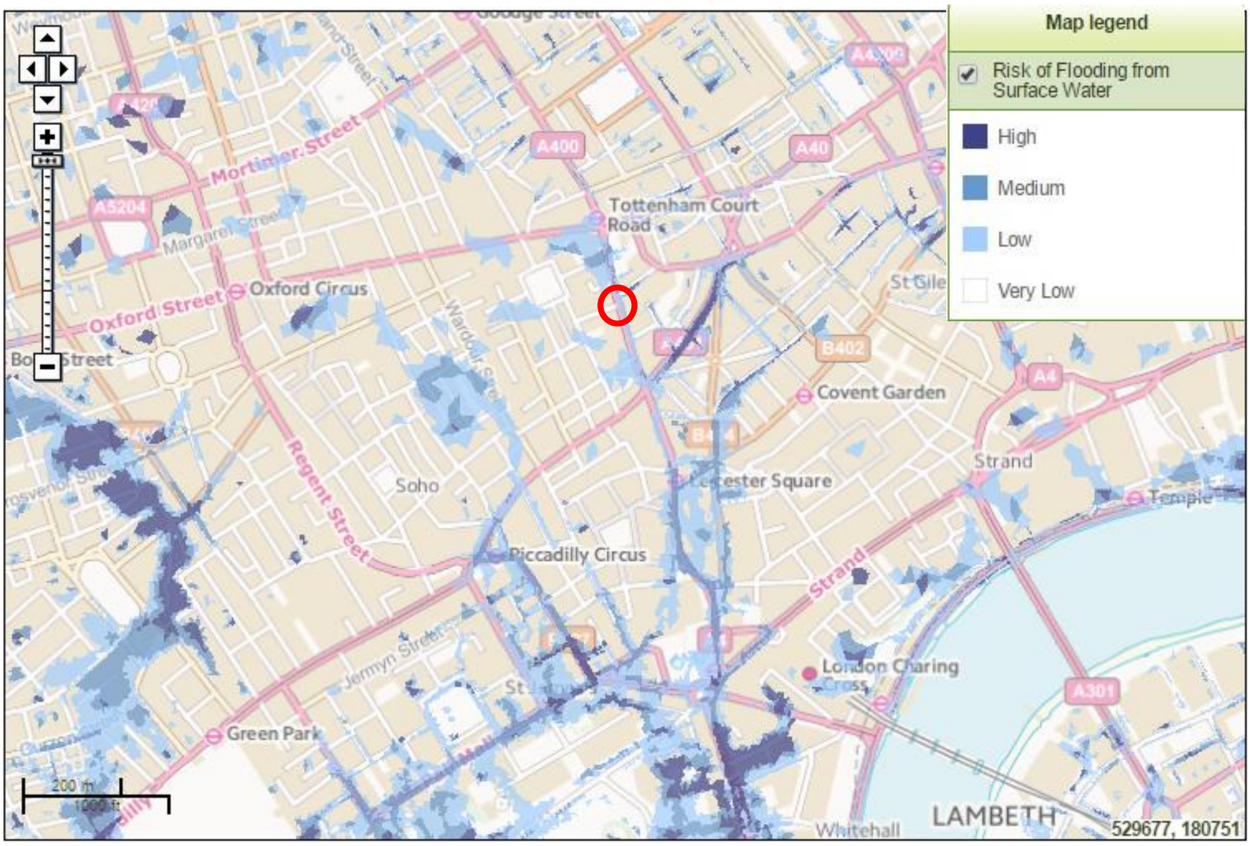


Figure 3- Environmental Agency Surface Water Flood Risk Interactive Map

There are flood mechanisms present, no matter the associated risk of flooding, to help aid in surface water flooding should it occur with surface water drainage present, therefore the risk of the site flooding from this flood mechanism is considered to be negligible.

SECTION 3 ENERGY STATEMENT

3.1 OVERALL SITE ENERGY CONSUMPTION AND CARBON EMISSIONS

The new residential scheme for two flats at 104-110 Charing Cross Road, London overall carbon emissions will depend on the mixture of fuels used. Electricity generates zero carbon at the point of use but has a relatively high carbon emission factor due to the inefficiencies of generation (principally from natural gas and coal) and distribution. Natural gas has a lower carbon factor, even when on-site boiler efficiency and distribution losses are considered.

The carbon emission factors used for the calculations in this section are as follows:

- Grid Supplied Electricity 0.422 kgCO_2 / kWh
- Natural Gas 0.194 kgCO_2 / kWh

Total baseline annual energy consumption of this development has been calculated to be 25,310 kWh/yr and 4,452 kgCO_2/yr of CO_2 emissions.

By following the principals of be lean, be clean and be green, the building fabric has been improved thermally and a **high efficient combination boiler** to provide space heating and hot water has been incorporated, along with **2.5 KWp of Solar PV Panels** (10 PV panels, total area 16 m^2). Due to that, the total CO_2 emissions were reduced to 3,288 kgCO2/yr, resulting in 26% reduction. As shown in Figure 2.

3.1.1 LOW CARBON ENERGY SOURCES (DISTRICT HEATING SCHEME/CHP)

DISTRICT HEATING SYSTEM

Policy 5.5 'Decentralised Energy Networks' of The London Plan requires the prioritising of connection to existing or planned decentralised energy networks where feasible. In addition Design and Construction SDP also states: Major development which is located within 500 m of an existing decentralised energy network should aim to connect to the network.

A district heating option has been considered as one of the first LZC technologies options as an opportunity of using waste heat which would be otherwise rejected into the atmosphere, this option is usually applied for large scale developments. Investigation was carried out to identify existing district heating schemes in local area of the development.

A study has been completed into the availability of existing heat networks in the vicinity of the development, onto which the development could potentially be connected. The London Heat Map Tool has been used to determine this. In addition to that, we have been in contact with Veolia to establish the feasibility of the connection.

The London Heat Map was used to plot the development site in relation to the available networks. The nearest network connection was found to along Whitehall Road which is approximately 0.9 Kilometers away from the building site. Considering the size of the development, this is not an economically viable solution as its space heating and hot water demand is not enough to justify the investment in the District Heating Connection.

Nevertheless, to future proof the scheme, space provision has been allowed in the proposed energy centre for heat exchangers, should a suitable area wide district scheme be realised in the vicinity of the site.

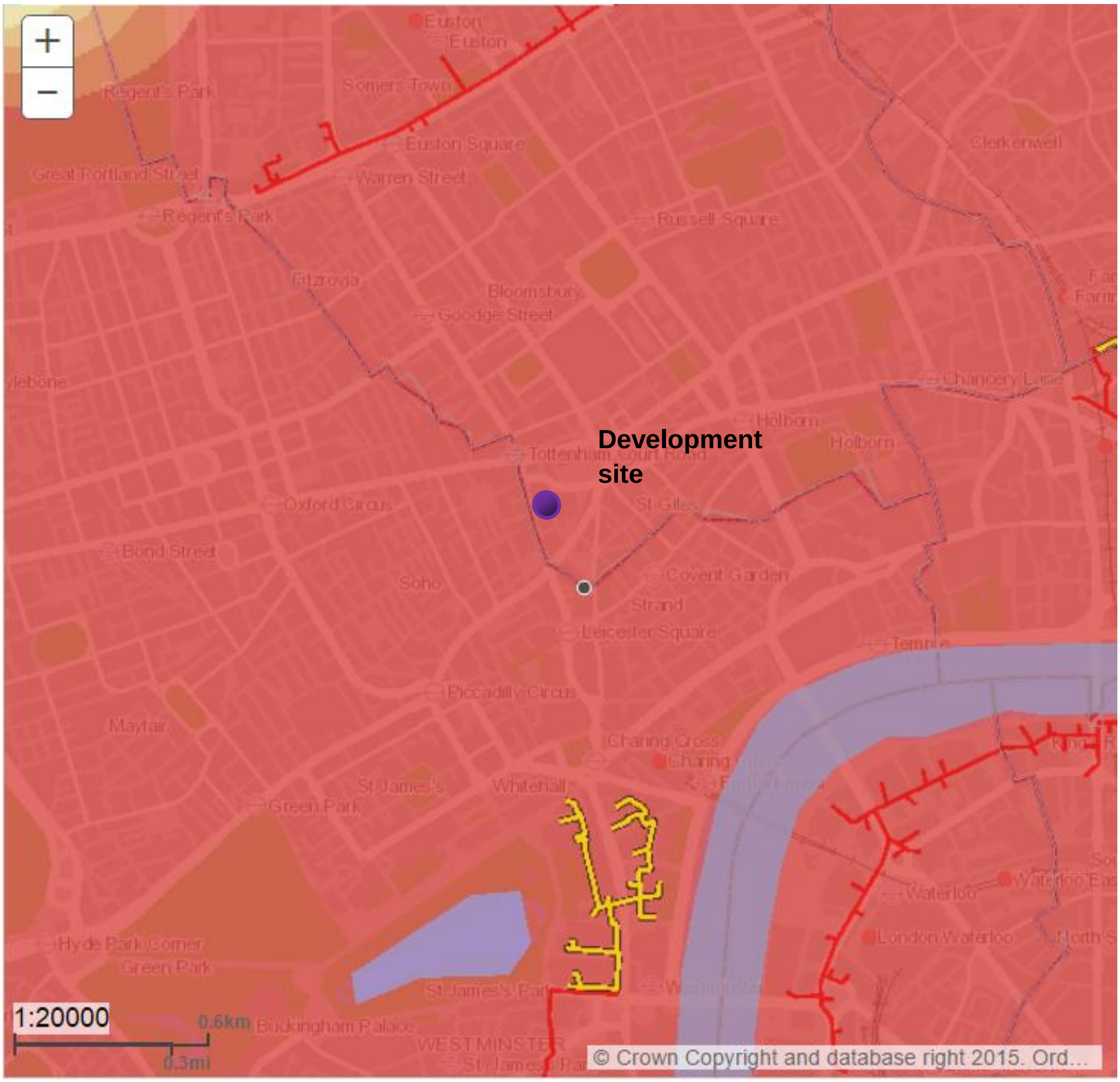


Figure 4 Site location on the London Heat Map

Combined Heat and Power (CHP)

Communal heating and hot water with gas fired CHP (Combined Heat & Power) plant is considered not to be an appropriate system to be used for this development. To run efficiently the CHP requires to be constantly running, which would require a large heat sink/ buffer tank.

3.1.2 Renewable Energy Sources

Introduction

This section provides an overview of the technologies considered, a brief assessment of their feasibility, a proposed mixture of suitable technologies and finally an estimate of the achievable carbon reductions due to LZC energy sources.

Demand Profiles

The balance of technologies chosen will depend on the development's energy demand patterns. Dynamic thermal simulation will be necessary to provide the level of detail required for a more advanced LZC energy strategy. The renewable energy required for space heating and hot water might be supplied to the whole development. However, the renewable thermal energy might need to be topped up by conventionally generated space heating/ hot water to cover peak demands.

Keeping in mind that the space heating energy demand changes according to the season. While hot water energy demand will provide a significant base load throughout the year.

Electrical demand is likely to be moderate throughout the year. Lighting loads will be highest during the evening but will continue at reduced levels throughout the night and during the day.

Feasibility

At this early stage in the design, it is possible only to outline the likely feasibility of specific technologies. A more advanced LZC energy strategy will be developed by the design team in conjunction with the client. Further descriptions of the LZC technologies below are included in Appendix C.

Biomass

Reliability of fuel supply, typically wood chips or pellets, has traditionally been an issue but increasing demand is improving the supply situation. Storage of fuel is also a potential issue, the volume of storage required will depend on the frequency of delivery and the fuel's energy density (pellets contain less moisture and have a higher packing density than chips, so their energy density is higher).

A biomass installation will be sized to meet the demand for baseline heating load and hot water. Biomass boilers however would need to be connected to hot water tank acting as a buffer to smooth peak hot water demand and also allows operating a boiler in optimal conditions. It is suggested that the LZC strategy includes sufficient biomass boiler capacity to meet the majority of the annual heat demand. In addition sufficient gas fired condensing boiler capacity can be installed to provide back up.

Nowadays, emissions of biomass boilers (particularly NOx and particulate matters) are a big issue especially in Central London.

Due to the site restriction to build an energy centre with adequate size storage space this proposal has not been considered to be feasible.

Ground or Air source heat pump

Ground or air source is commonly used technique to provide buildings with heating and cooling via heat pumps. Closed vertical boreholes or active thermal piles are the main two ways feasible of extracting heat/"coolth" from ground. The system works most efficiently if annual heat and cooling energy supply by the system is in balance, so the ground will not become either too hot or cold resulting in loosing heating/ cooling potential over years. Bearing this in mind the ground source heating and cooling system needs to be carefully sized and designed.

Due to the complexity of design & high cost of installation, this option has not been considered.

SOLAR THERMAL COLLECTORS

Solar thermal collectors (flat plate or evacuated tubes) convert solar thermal energy into heat for hot water generation. These are usually located on a roof oriented south facing in an ideal slope of 45 degree. Solar collectors in properly sized and designed provide approx 40% of annual hot water. However, should a CHP unit be used for hot water generation then solar collectors will be redundant. As this option generate only hot water only for a period of time, it is unlikely to generate required energy to meet the planning policy and therefore hasn't been considered as an option.

PHOTOVOLTAIC

Solar photovoltaic (PV) technology price is declining in the recent years. It is an attractive option due to government FIT incentives which came into effect from April 2010. It can provide a guaranteed, but modest, contribution to the development's electrical demand. PV technology will form part of the LZC strategy. 1 kWp, of PV panels can produce approximately 850 kWh/ year of electricity in this region, reducing the grid energy requirement and CO2 emissions.

For these two residential units in Charing Cross Road, London, the PV option in conjunction with high efficient heating systems can reduce the CO2 emissions by 26%. Therefore, this is one of the beneficial and preferred options for this development. A total array of 16 m^2 of Solar PV panels will produce 2.5 KWp of Power (10 PV panels, South-West oriented, 30 degrees tilt).

Photovoltaic panels	
Module Efficiency	19%
Panel Orientation	South-West
Tilt	30%
Array Area	16 m^2
Predicted site Solar Energy	2.5 KWp
Primary Electricity offset by the PV array	1900 KWh/yr
Total CO_2 savings	986 KgCO2/yr

WIND ENERGY

Small scale wind turbines, building integrated wind power, are proven and viable technology, the average surface roughness in built-up areas is high, leading to both reduced wind speeds and increased turbulence.

Due to insufficient open area for installation of a stand-alone wind turbine and planning issues this option has not considered in this development.

SECTION 4 CONCLUSION

Based on the results and outline figures, the proposed development for these two flats at 104-110 Charing Cross Road, London will satisfy both the **London Borough of Camden planning requirements** and **the London Plan requirements** of sustainability, energy consumption and carbon emissions.

The energy demand and carbon emissions could be reduced by introducing a combination of energy efficiency measures. Based on the calculations and results achieved when those measures were applied, the development achieved a reduction of 26% in CO2 emissions based on the 2013 Regulations (Figure 2).

The new two penthouse maisonette flats will be designed with a **high level of insulation** and **low air permeability** to reduce heat loss as much as is practically possible, also the use of **low energy lighting** and A–Rated White goods are essential for the reduction of energy consumption.

Moreover, the control strategy throughout must be carefully designed to ensure the most economical operation of all equipment throughout the development.

To achieve the required reduction of carbon emissions, several options were considered, the best option in regards to site location and the development size, was the combination of the fabric thermal improvement, a **high efficient gas fired combination boiler** as the primary source of heating and water supply and a provision of **2.5 KWp of Solar PV panels** (16 m^2, 10 PV panels, South-West oriented, 30 degrees tilt).

Those measures proved to satisfy the requirements of London Borough of Camden planning requirement in regards to renewable energy and sustainability.

The baseline annual energy consumption of this development has been estimated to be 25,310 kWh/yr and 4,452 kgcO2/yr of CO2 emissions. By incorporating on-site renewable/ LZC technologies the total CO_2 emissions will be reduced to 3,288 kgCO2/year resulting in 26% reduction compared to 2013 building Regulations. This result goes beyond the Council requirement for 20% reduction in Carbon Dioxide emissions according to the **CPG3 – Sustainability-London Borough of Camden** document and in accordance with the **London Plan Chapter 5-Sustainable Design and Construction** requirements.

However, different possible renewable energy options have been identified; bearing in mind that selection is a complex process which requires a more detailed estimation of energy demand patterns. Therefore, further analysis will be undertaken as the design progresses.

APPENDIX A - LOW OR ZERO CARBON ENERGY SOURCES

BIOMASS

Biomass is an alternative solid fuel to the conventional fossil fuels. In theory it is carbon neutral as the carbon emitted by burning is offset by the carbon absorbed during the growth of the plant. In reality, biomass fuel is not completely carbon neutral; there is a small carbon factor due to the energy used in processing and delivery.

Various types of biomass fuel are in use, the most common being the woody biomass, which includes forest residues such as tree thinnings, and energy crops such as willow short rotation coppice. Biomass is converted into a manageable form that can be directly fed to the heat or power generation plant, thus replacing fossil fuel. As a result, applications can range from large-scale heating boilers to individual house room heaters to combined heat and power generation (CHP). For building applications, the fuel usually takes the form of wood chips, logs and pellets. Wood pellets are essentially compacted high-density wood with low moisture content, thus having a higher calorific value per unit volume or weight.

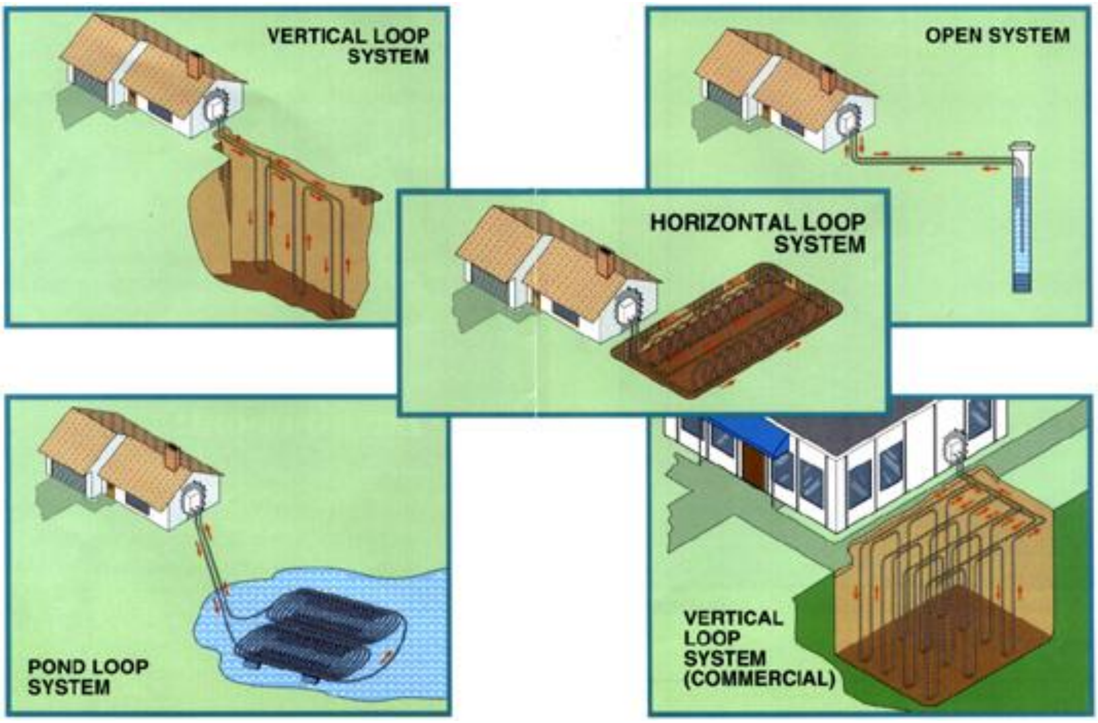
GEOTHERMAL ENERGY

Geothermal energy technologies use the heat energy stored in ground; either for direct-use applications: such as using the grounds' heat to defrost a driveway or the indirect use with additional equipment such as a geothermal heat pump. Most commercial installations couple a heat pump with the ground to upgrade the low-grade heat from the ground or ground water to a higher grade heat, where it can be used for heating purposes.

The suitability of a ground source system depends heavily on the type of earth coupling heat exchange system used:

GROUND SOURCE EARTH COUPLING OPTIONS

The right choice of appropriate heat exchanger depends on several factors such as: size of space heating/hot water system, available site area for the heat exchangers, and local ground conditions. Due to the specialist nature of this technology we recommend that a specialist is employed to size the heat exchangers based on a desk-top study of the site's geological conditions – this normally being required in advance of any other contractor appointment.



The main types of ground source heat exchanger

VERTICAL CLOSED LOOP SYSTEM

A frequently used and simple ground source heat exchanger, for a small to medium size project, is a closed loop vertical system. The system comprises of vertically drilled boreholes, usually up to 100 m deep, into which are inserted two polyethylene pipes with a U-shape connector at the base of the hole – effectively providing a flow down to the bottom of the hole and return back up to the surface. All the flow and return loops are connected together across the site - completing the entire heat exchange loop. Water is pumped around the loop and is then circulated around the heat pump to achieve the required heat exchange. The distance between boreholes is dependent on ground conditions but is typically a minimum of a 6mx6m grid, to prevent overlapping of the heat exchange process between loops.

HORIZONTAL CLOSED LOOP SYSTEM

Horizontal closed loop heat exchangers are usually applied to small projects such as individual houses, which usually require a relatively low heat output. Consisting of horizontal trenches 1.5-2m deep, with either straight pipes or 'slinky' coiled pipes, these require significant excavation work and significant site area to achieve appreciable outputs as such are not normally suited to medium to large projects.

VERTICAL OPEN BOREHOLES SYSTEM

A further option is a vertical open borehole system. The system involves the abstraction and discharge of natural ground water using boreholes; into which pumps are inserted, connected to collapsible pipework. Each borehole pump abstracts ground water, circulates it around the heat pump and then discharges the water back to the ground via an absorbing well, some distance from the original abstraction borehole. The system is capable of providing very high rates of heat exchange for a relatively small number of boreholes, which makes it very efficient in terms of site area required. However, this depends greatly on the availability of ground water, which in turn varies according to location. A major downside of this system is that the extraction of water from deep boreholes via pumps consumes a lot of energy, as the water has to be physically lifted to the surface by the pump – this in effect reduces the carbon emissions saved by this system as a whole.

Ground source heat exchange options in summary:

VERTICAL LOOP SYSTEM - CLOSED BOREHOLES

- moderate heat capacity
- relatively low installation cost

VERTICAL OPEN SYSTEM - OPEN BOREHOLES

- high heat capacity
- high running energy
- high installation cost

HORIZONTAL LOOP SYSTEM – STRAIGHT PIPES

- low capacity,
- high installation cost
- extensive ground excavation work

HORIZONTAL COILED LOOP SYSTEM – 'SLINKY' PIPES

- good capacity
- low installation cost
- extensive ground excavation work

HEAT PUMPS

Heat pumps are basically refrigeration units which work in reverse – instead of cooling being produced and heat rejected, the unit produces heat and rejects cooling. Conventional heat pumps use air as the medium to reject this 'coolth' to atmosphere. Ground source units use the ground as a means of improving the unit efficiency because the ground is a constant 11-13 °C at depths of 50m down – this suits the heat pump much better during the coldest weather than the extremes of air temperature. Reversible heat pumps can also be used for cooling, however this is not being considered further for this project.

A heat pump consumes electrical power to drive the compressor and other ancillary elements. The ratio between total energy input and heat energy output of the heat pump is a measure of its efficiency – usually referred to as 'Coefficient of Performance' - COP. A ground source heat pump has a higher COP than an air cooled heat pump – this additional energy effectively being the grounds' natural contribution to the system.

The heat produced by a heat pump is usually used to either provide space heating say to underfloor heating or radiators or the heat is used to generate domestic hot water via a storage vessel.

CHP

Combined heat and power (CHP) is a process involving simultaneous generation of heat and electricity, where the heat generated in the process in harnessed via heat recovery equipment. CHP at the large commercial size is now fairly common in premises which have a simultaneous demand for heating and electricity for long periods, such as hospitals, recreational centres and hotels. In addition, small CHP systems are now becoming available for individual houses, group residential units and small non-domestic premises. Compared with using centrally generated electricity supplied via the grid, CHP can offer a more efficient and economic method of supplying energy demand, if installed and operated appropriately, owing to the utilisation of heat which is normally rejected to the atmosphere from central generating stations, and by reducing network distribution losses due to local generation and use.

A small CHP unit – similar to the size of unit investigated

Heat generated will be used for space and water heating, and additional heat storage may be used to lengthen use periods, to assist in warm-up and to improve overall energy efficiency. For overall good energy efficiency, as with all CHP, usage must be heat demand led. Thus, a sophisticated control system is required and users should be made aware of efficient operating practices.

SOLAR THERMAL COLLECTORS

Solar thermal collectors (flat plate or evacuated tubes) convert solar thermal energy into heat for hot water generation. These are usually located on a roof oriented south facing in an ideal slope of 45 degree. Solar collectors properly sized and designed provide approx 50% of annual hot water demand.

For example approx. 35m2 flat plate solar collectors at cost of £24,000 generates around 11MWh of hot water resulting in 10% carbon savings.

However, should a CHP unit is used for hot water generation when solar collectors will be redundant.

PHOTOVOLTAIC

Photovoltaic modules convert sunlight directly into DC electricity and can be integrated into buildings. Photovoltaics (PVs) are distinct from other renewable energy technologies since they have no moving parts to be maintained and are silent. PV systems can be incorporated into buildings in various ways: on sloped roofs and fl at roofs, in façades, atria and shading devices. Modules can be mounted using frames or they can be fully incorporated into the actual building fabric; for example, PV roof tiles are now available which can be fitted in place of standard tiles.

Currently, a PV system will cost between £1500 and £2500 per kWp, and frequently part of this cost can be offset owing to the displacement of a conventional cladding material. Costs have fallen significantly since the first systems were installed (1980s) and are predicted to fall further still.

While single crystal silicon remains the most efficient flat plate technology (15–16% conversion efficiency); it also has the least potential for cost reduction. PV cells made from poly-crystalline silicon have become popular as they are less expensive to produce, although they have a slightly lower efficiency.

Thin film modules are constructed by depositing extremely thin layers of photosensitive materials on a low-cost backing such as glass, stainless steel or plastic. As much less semiconductor material is required as for crystalline silicon cells, material costs are potentially much lower. Efficiencies are much lower, around 4–5%, although this can be boosted to 8–10% by depositing two or three layers of thin film material. Thin film production also requires less handling as the films are produced as large, complete modules and not as individual cells that have to be mounted in frames and wired together. Hence, there is the potential for significant cost reductions with volume production.

Since PVs generate DC output, an inverter and other equipment is needed to deliver the power to a building or the grid in an acceptable AC form. The cost of the inverter and these ‘Balance Of System’ (BOS) components can approach 30% of the total cost of a PV system. Hence, simplification and cost reductions in these components over the coming years will also be necessary to make PV systems affordable.

WIND ENERGY

Wind power is the most successful and fastest spreading renewable energy technology in the UK with a number of individual and group installations of varying size, capacity and location. Traditionally, turbines are installed in non-urban areas with a strong trend for large offshore wind farms. In parallel with the design and development of ever-bigger machines, which are deemed to be more efficient and cost-effective, it is being increasingly recognised that smaller devices installed at the point of use, i.e. urban settings, can play an important role in reducing carbon emissions if they become mainstream.

At present there is a wide range of available off-the-shelf wind products, many manufactured in the UK and EU with proven good performance and durability. The dominant type is horizontal axis wind turbines (HAWT), which are typically ground mounted. Vertical axis wind turbines (VAWT) have limited market presence and there is a trade-off between lower efficiency and potentially higher resistance to extreme conditions. Capacity ranges from 500W to more than 1.5MW, but, for practical purposes and in built-up areas in particular, machines of more than 1kW and below 500kW are likely to be considered.

Wind technology is also currently one of the most cost-effective renewable energy technologies, which is attributable to the large scale of installations reducing the unit output cost. Individual building or community wind projects, although smaller, have the advantage of feeding electricity directly into the building's electricity circuit, thus sparing costly distribution network development and avoiding distribution losses. The downside is the still high capital cost per kW installed for smaller turbines, plus location constraints, such as visual intrusion and noise. The wind regime in urban areas is also a concern owing to higher wind turbulence which reduces the potential electricity output.

In most cases, wind turbines are connected to the electricity grid and all generated energy is used regardless of the building demand fluctuations. The output largely depends on the wind speed and the correlation between the two is a cube function. This means that in short periods of above-average wind speeds the generation increases exponentially. As a result, it is difficult to make precise calculations of the annual output of a turbine, but average figures can provide useful guidance to designers and architects. In reasonably windy areas (average wind speed of 6m/s) the expected output from 1kW installed is about 2500kWh annually.

The cost per kW installed varies considerably by manufacturer and size of machine with an indicative bracket of £2,500–£5,000. With a lifespan of more than 20 years, wind turbines can save money if design and planning are carried out in a robust way.

Building-integrated wind turbines are starting to be a reality in the UK, but potential projects may face difficulties with obtaining planning permission. There are a few examples now of permitted development rights for certain rooftop turbines in some local councils. A number of horizontal axis devices specifically designed for building integration are now available commercially, having design and reliability parameters relevant to the urban context. Building-mounted vertical axis devices are under development.

At present, turbines installed near buildings, as well as community installations for groups of buildings, should be regarded as the larger wind energy source related to buildings, when they contribute to the carbon emissions from these premises using ‘private wire’ networks. However, the contribution of several building-integrated turbines in a development is likely to become significant in the next few years.

Appendix B - Energy Efficiency Measures

The reduction of energy consumption is an essential element in the reduction of carbon emissions. The incorporation of good practice energy saving techniques should be considered paramount. This first stage is described as “be lean”. Only after the energy consumption has been minimised should consideration be given to the use of renewable technologies. This second stage is described as “be green”. The final level of the hierarchy is concerned with minimisation the losses associated with the supply of energy, described as “be clean”.

Proposed Energy Efficiency Measures

The following energy saving techniques will be incorporated where possible to minimise the development’s energy requirement:

Efficient lighting

Energy efficient lighting systems combined with the careful use of daylight should be used to minimise both the electricity consumed and the heat load generated by lighting. The lighting control system should be able to able to adjust the light output in response to varying daylight and occupancy conditions.

Low energy heating and cooling

The demand for heating and cooling should be reduced by using passive means rather than relying on energy intensive systems to achieve comfort. These could include, in addition to the techniques mentioned above, the use of exposed structural mass to moderate peak cooling loads. Consideration should also be given to the reduction of internal loads such as lighting and equipment.

Where mechanical ventilation and cooling are unavoidable, consideration should be give to the use of more efficient systems such as displacement ventilation, chilled beams, or ‘mixed-mode’ systems that allow natural ventilation to be supplemented with mechanical cooling at times of peak demand.

Heat recovery

Heat recovery systems reduce the heating loads by recycling heat from exhaust air. High efficiency thermal wheels can recover up to about 85% of the heat in the exhaust air.

Variable speed drives

Electronically controlled variable speed drives (inverter drives) vary the speed of equipment to suit the demand. They are proven to make significant energy savings and can be applied to pumps, fans and refrigeration compressors.

Building energy management systems (BEMS)

A BEMS can be employed to control and monitor all major items of mechanical equipment. The monitoring system can provide the required sub-metering as well as identification of fault conditions which can lead to excessive energy consumption. The system may also be able to optimise plant control strategy to ensure optimum operational efficiency.

APPENDIX C - TABLE 1 - FLOOD ZONES

(Source: Table D1 of Planning Policy Statement 25: Development and Flood Risk)

Zone 1: Low Probability	
Land assessed as having a less than 1 in 1000 annual probability of river or sea flooding in any year (<0.1%)	Appropriate Uses All uses of land are appropriate in this zone FRA Requirement For development proposals on sites comprising one hectare or above the vulnerability to flooding from other sources as well and river and sea flooding, and the potential to increase flood risk elsewhere through the addition of hard surfaces and the effect of the new development on surface water run-off, should be incorporated in a FRA. Policy Aims In this zone developers and local authorities should seek opportunities to reduce the overall level of flood risk through the layout and form of the development, and the appropriate application of sustainable drainage techniques.
Zone 2: Medium Probability	
Land assessed as having between a 1 in 100 and 1 in 1000 annual probability of river flooding (1%-0.1%) or between 1 in 200 and 1 in 1000 annual probability of sea flooding (0.5%-0.1%) in any year	Appropriate Uses The water-compatible, less vulnerable and more vulnerable uses of land and essential infrastructure in table 2 are only appropriate in this zone if the Exception Test is passed. FRA Requirements All development proposals in this zone should be accompanied by a FRA. Policy Aims In this zone developers and local authorities should seek opportunities to reduce the overall level of flood risk through the layout and form of the development, and the appropriate application of sustainable

	drainage techniques.
Zone 3a High Probability	
Land assessed as having a 1 in 100 or greater annual probability of river flooding (>1%) or a 1 in 200 or greater annual probability of sea flooding (>0.5%) in any year	Appropriate Uses The water-compatible and less vulnerable uses of land in table 2. The highly vulnerable uses in table 2 should not be permitted in this zone. The more vulnerable and essential infrastructure uses in table 2 should only be permitted in this zone if the Exception Test is passed. Essential infrastructure permitted in this zone should be designed and constructed to remain operational and safe for users in times of flood. FRA Requirements All development proposals in this zone should be accompanied by a FRA. Policy Aims In this zone developers and local authorities should seek opportunities to; − reduce the overall level of flood risk through the layout and form of the development, and the appropriate application of sustainable drainage techniques. − relocate existing development to land in zones with a lower probability of flooding and − Create space for flooding to occur by restoring functional floodplain and flood flow pathways and by identifying, allocating and safeguarding open space for flood storage.
Zone 3b The Functional Floodplain	
This zone comprises of land where water has to flow or be stored in time of flood. SFRAs should identify the flood zone (land which would flood with an annual probability of 1 in 20 (5%) or greater in any year or is	Appropriate Uses Only the water-compatible uses and the essential infrastructure listed in table 2 that has to be there should be permitted in this zone. It should be designed and constructed

designed to flood in an extreme (0.1%) flood, or at another probability to be agreed between the LPA and the EA, including water conveyance routes).	to; − Remain operational and safe for users in times of flood. − Result in no net loss of floodplain storage. − Not impede water flows. − Not increase flood risk elsewhere. Essential infrastructure in this zone should pass the Exception Test. FRA Requirements All development proposals in this zone should be accompanied by a FRA. Policy Aims In this zone developers and local authorities should seek opportunities to; − reduce the overall level of flood risk through the layout and form of the development, and the appropriate application of sustainable drainage techniques. − relocate existing development to land in zones with a lower probability of flooding.

APPENDIX C - TABLE 2 - FLOOD RISK VULNERABILITY CLASSIFICATION

(Source: Table D2 of Planning Policy Statement 25: Development and Flood Risk)

Essential Infrastructure	Essential transport infrastructure and strategic utility infrastructure, including electricity generating power stations and grids and primary substations.
Highly Vulnerable	Police, Ambulance and Fire stations and command centres and telecommunications installations and emergency dispersal points. Basement Dwellings, caravans, mobile homes and park homes intended for permanent residential use. Installations requiring hazardous substance consent.

More Vulnerable	Hospitals, residential institutions such as care homes, children's homes, social services homes, prisons and hostels. Buildings used for dwelling house, student halls of residence, drinking establishments, nightclubs, hotels, and sites used for holiday or short-let caravans and camping. Non-residential uses for health services, nurseries and educations. Landfill and waste management facilities for hazardous waste.
Less Vulnerable	Buildings used for shops, financial, professional and other services, restaurants and cafes, offices, industry, storage and distribution and assembly and leisure. Land and buildings used for agriculture and forestry. Waste treatment (except landfill and hazardous waste facilities), mineral workings and processing (except for sand and gravel). Water treatment plants and sewerage treatment plants (if adequate pollution control measures are in place)
Water-compatible Development	Flood control infrastructure, water transmission infrastructure and pumping stations. Sewerage transmission infrastructure and pumping stations. Sand and Gravel workings Docks, marinas and wharves, navigational facilities. MOD defense installations Ship building, repairing and dismantling, dockside fish processing and refrigeration and compatible activities requiring a waterside location. Water-based recreation (excluding sleeping accommodation) Lifeguard and coastguard stations Amenity open space, nature conservation and biodiversity, outdoor sports and recreation. Essential sleeping or residential accommodation for staff required by uses in this category, subject to a warning and evacuation plan.

NOTES

1. This classification is based partly on Defra/Environment Agency research and Flood Risks to People (FD2321/TR2) and also on the need of some uses to keep functioning during flooding.
2. Buildings that combine a mixture of uses should be placed into the higher of the relevant classes of flood

sensitivity. Developments that allow uses to be distributed over the site may fall within several classes of flood risk sensitivity.

3. The impact of a flood on a particular uses identified within this flood risk vulnerability classification will vary within each vulnerability class. Therefore, the flood risk management infrastructure and other risk mitigation measures needed to ensure the development is safe may differ between uses within a particular vulnerability classification.

APPENDIX C - TABLE 3 - FLOOD RISK VULNERABILITY & FLOOD RISK COMPATIBILITY

(Source: Table D3 of Planning Policy Statement 25: Development and Flood Risk)

Vulnerability Classification		Essential Infrastructure	Water Compatible	Highly Vulnerable	More Vulnerable	Less Vulnerable
Flood Zone	Zone 1	✓	✓	✓	✓	✓
	Zone 2	✓	✓	Exception Test	✓	✓
	Zone 3a	Exception Test	✓	X	Exception Test	✓
	Zone 3b	Exception Test	✓	X	X	X

✓	Development is appropriate
X	Development should not be permitted