# GFZ Developments
# 7 Warwick Court
## Energy & Sustainability Statement

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## Document Revision History

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| | | Signature | CT | SW | |

# 1. Executive Summary

This Energy and Sustainability Statement outlines the 7 Warwick Court development's sustainability and energy strategies for meeting the sustainability targets set out by London Borough of Camden and the GLA.

The development is a Grade 2 listed building located in the Bloomsbury Conservation Area and as such is subject to special consideration under Camden Planning Guidance 3.

To benchmark the design process, the Code for Sustainable Homes methodology has been applied*. It considers the broad environmental concerns of climate change, pollution, impact on occupants and the wider community. It balances these with the need for a high quality, safe and healthy internal environment. These standards go beyond the requirements of the Building Regulations. As a minor development, 7 Warwick Court is not required to achieve any level of Code for Sustainable Homes standards, however the method was adopted as guidance in order to create high quality dwelling.

Good practice sustainability measures have been incorporated in the design, including:

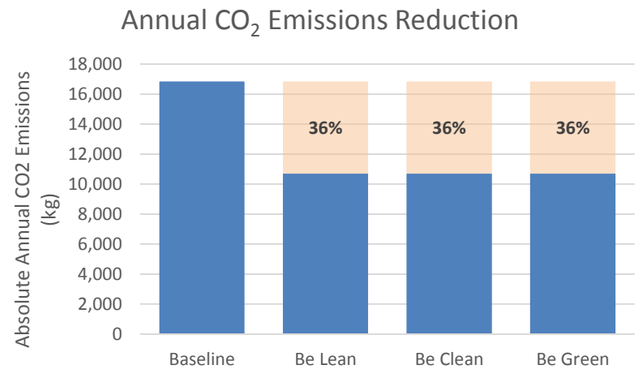
- Thermal insulation levels for all building elements that can be enhanced to achieve Building Regulations Part L1b standards, thereby substantially reducing the building's heat losses compared to the existing fabric;
- The development will be naturally ventilated with openable windows giving occupants control over the ventilation rate;
- Natural day lighting will improve occupancy comfort and reduce the requirement for lighting. The proposed light well should allow natural light to penetrate into the centre of the development;
- All light fittings will be low energy fittings;
- All energy supplies will be metered using smart meters, with energy display devices located in a visible place to enable residents to monitor and therefore take actions to reduce their $CO_2$ emissions;
- All pumps and fans will be variable speed and all heating, ventilation and lighting systems will have automatic monitoring to indicate out of range values;
- High efficiency individual condensing gas boilers will generate low temperature hot water and domestic hot water for the development;
- The air tightness of the building will be improved to under 15$m^3/hr/m^2$ through improved detailing and draught proofing.

The proposed energy efficient systems and passive design features result in the scheme achieving a **36%** improvement over the Part L1b 2013 Building Regulations, surpassing the 35% requirement of Policy 5.2 of the London Plan.

A study into the feasibility of connecting to a district heating network was undertaken as per Policy 5.6 and concluded that no district heating networks could feasibly be connected to. A study into low and zero carbon (LZC) technologies was undertaken as per Policy 5.7 and the conclusion was that the site's spatial constraints, historic sensitivity and lack of useable roof space means that no renewable technologies are viable for the scheme, with the exception of air source heat pumps to provide cooling.

A number of sustainable features have been considered for the development:

- Building materials, where possible, will be sourced locally to reduce transportation pollution and support the local economy;
- Reuse of the redundant brickwork as high grade aggregate, where possible, will reduce the embodied carbon emissions associated with new building materials;
- All timber will be procured from responsible forest sources;
- Recycling facilities will be provided on site for construction and operational waste;
- Water use will be minimised by the specification of water efficient taps, shower heads, dual flush toilets and low water use appliances;
- Water metering will be installed to monitor and minimise wastage;
- The construction site will be managed in an environmentally sound manner in terms of resource use, storage, waste management, pollution. A Site Waste Management Plan (SWMP) will be produced for the works;
- Green planting areas will be provided on the external terraces;
- Low NOx boilers are proposed to comply with the London Borough of Camden Air Quality Plan Action Plan.




| Carbon Offset Fund | | |
|---|---|---|
| 35% Carbon Target Offset | 5897 | kg |
| Design Offset | 6149 | kg |
| Shortfall | -252 | kg |
| Carbon Cost (Zero Carbon Hub) | 46 | £/T |
| Years | 30 | |
| Total Offset Cost | -348 | £ |

| | Regulated Carbon dioxide savings | |
|---|---|---|
| | (Tonnes $CO_2$ pa) | (%) |
| Savings from Energy Demand Reduction | 6.15 | 36% |
| Savings from CHP | 0.00 | 0% |
| Savings from Renewable Sources | 0.00 | 0% |
| **Total Cumulative Savings** | **6.15** | **36%** |
| Total Target Savings | **5.90** | 35% |
| **Annual Surplus** | **0.25** | |

**** NOTE:** As part of the Government's response to the Housing Standards Review it has been confirmed that the Code for Sustainable Homes (CfSH) will be wound down, with many of its requirements consolidated into the Building Regulations. Whilst this means that a formal certification of the scheme may not be possible, the methodology and targets are still a useful tool in benchmarking the sustainable design of residential development. As such, the CfSH methodology has been used to guide and benchmark the design.*

# Contents

# 2. Introduction

The London Borough of Camden set out their approach to sustainable development through their Local Plan.

This report outlines the proposed sustainability and energy strategy for the proposed 7 Warwick Court development. Each of the proposed initiatives has been assessed on the relative sustainability potential, in addition to a "rule of thumb" financial pay back implication. The principal objectives are to reduce the site's contribution to the cause of climate change by minimising the emissions of $CO_2$, by reducing the site's needs for energy and by providing some of the requirement by renewable/sustainable means. Issues such as water and waste, biodiversity, etc. have also been addressed in the present study. The Sustainability Statement will aim to address the aspirations of both the London Borough of Camden's Local Plan and the GLA.

The GLA London Plan and GLA Energy Strategy are considered to be the benchmark for local planning regulation. Together they provide a useful tool against which to undertake energy and sustainability assessment. They have been used in an advisory nature secondary to the requirements of the London Borough of Camden, to help incorporate a number of energy efficiency measures into the proposed development.

The Sustainability Statement forms a checklist of the sustainable initiatives considered for the proposed development. Each of the proposed initiatives is assessed on the relative sustainability potential, in addition to a "rule of thumb" financial/pay back implication, and suitability to this particular site.

**** NOTE:** As part of the Government's response to the Housing Standards Review it has been confirmed that the Code for Sustainable Homes (CfSH) will be wound down, with many of its requirements consolidated into the Building Regulations. Whilst this means that a formal certification of the scheme may not be possible, the methodology and targets are still a useful tool in benchmarking the sustainable design of residential development. As such, the CfSH methodology has been used to guide and benchmark the design.*

## 2.1 Outline Description of Development

The 7 Warwick Court development lies within the Bloomsbury Conservation Area within the London Borough of Camden. The existing building is a 5 storey property arranged over lower ground to third floor levels. The existing building is currently in use as planning category B1 offices.

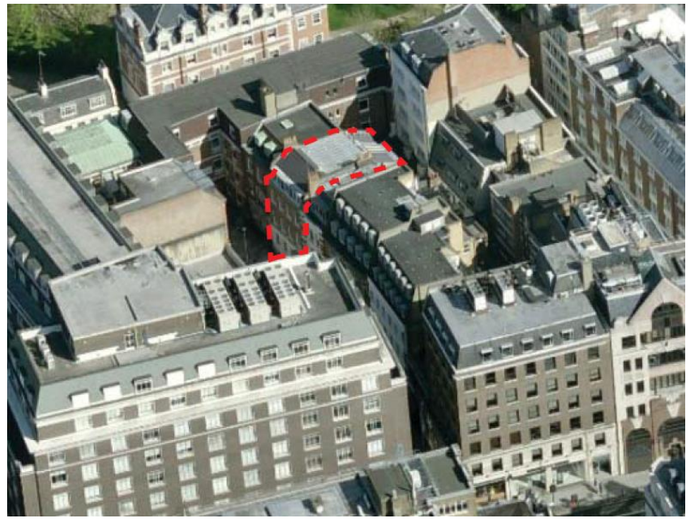
The proposal is for a change of use of the property to C3 residential use, providing 4 self-contained residential units from lower ground to the third floor. This will include demolition of the non-original rear extension and the construction of a new rear extension, more in line with the architectural precedence of the area. Repairs to the original rear and front facades will be undertaken as well as some internal modifications, including the addition of a light well that will penetrate to lower ground floor level.

The development is located in the centre of London and as such has excellent transport links. Under the London Plan guidelines, the development is classified as a 'Minor Development'. Furthermore, the development is classified as Grade 2 listed, limited the changes that can be made to the external façade.

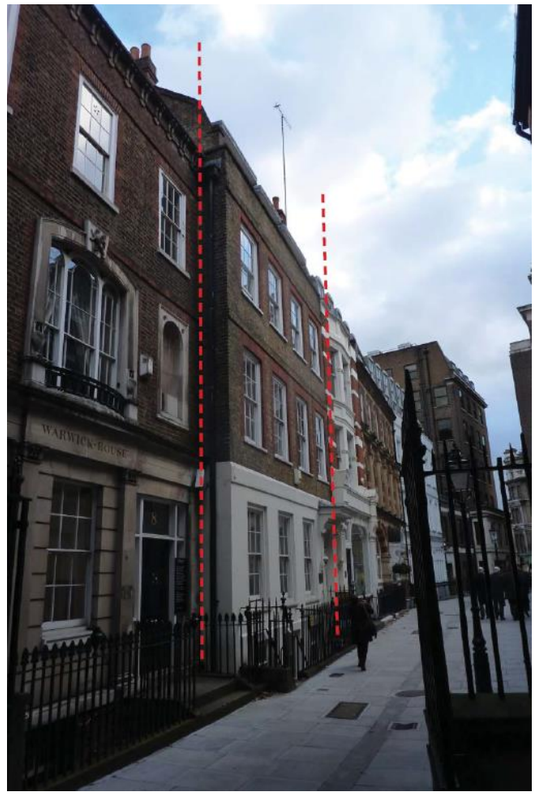
The following area schedule was used to inform the energy strategy:

| Unit | Level | Beds | Area ($m^2$) |
|---|---|---|---|
| Flat 1 | LG | 1 | 65 |
| Flat 2 | G | 2 | 102 |
| Flat 3 | 1 | 2 | 91 |
| Flat 4 | 2/3 | 3 | 167 |
| **Total** | | **8** | **425** |

**Residential Area Schedule**



**7 Warwick Court**



**Existing Front Elevation of 7 Warwick Court**

# 3. Planning Policy

The National Planning Policy Framework (NPPF) was published in March 2012, which states a clear presumption in favour of sustainable development. The NPPF supports the transition to a low carbon future in a changing climate, taking full account of flood risk and coastal change, and encourages the reuse of existing resources, including conversion of existing buildings, and encourages the use of renewable resources.

The NPPF replaces PPS22 and in Section 10 outlines its energy and climate change policies. To support the move to a low carbon future, local planning authorities should:

- Plan for new development in locations and ways which reduce greenhouse gas emissions;
- Actively support energy efficiency improvements to existing buildings; and
- When setting any local requirement for a building's sustainability, do so in a way consistent with the Government's zero carbon buildings policy and adopt nationally described standards.

In determining planning applications, local planning authorities should expect new developments to:

- comply with adopted Local Plan policies on local requirements for decentralised energy supply unless it can be demonstrated that this is not feasible or viable; and
- take account of landform, layout, building orientation, massing and landscaping to minimise energy consumption;
- have a positive strategy to promote energy from renewable and low carbon sources;
- identify opportunities where development can draw its energy supply from decentralised, renewable or low carbon energy supply systems and for co-locating potential heat customers and suppliers.

The key focus of the NPPF is to support local and regional planning authorities.

## 3.1 The London Plan

The GLA London Plan 2011, London Plan REMA October 2013, Further Alterations to the London Plan 2015 and GLA's Guidance on Preparing Energy Assessments September 2013 document are considered to be the benchmark for local planning regulation. Together they provide a useful tool against which to undertake energy and sustainability assessments. As this is a re-development (and a Minor Development) the London Plan targets are not technically applicable and therefore they have been used in an advisory way secondary to the requirements of the London Borough of Camden, to help incorporate a number of energy efficiency measures into the proposed development.

The London Plan sets out a number of core policies for major developments with regards reducing $CO_2$ emissions and providing energy in a sustainable manner.

***Policy 5.2*** - requires that major developments achieve a 35% improvement over the 2013 Building Regulation $CO_2$ Emission Target.

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

- Be lean: use less energy
- Be clean: supply energy efficiently
- Be green: use renewable energy

***Policy 5.6*** - requires all major developments to evaluate the feasibility of connecting to existing or proposed district heating networks and where no opportunity exists consider a site wide Combined Heat and Power (CHP) systems.

***Policy 5.7*** - requires that all major developments seek to reduce their $CO_2$ emissions by at least 20% through the use of onsite renewable energy generation wherever feasible. Individual development proposals will also help to achieve these targets by applying the energy hierarchy in Policy 5.2.

## 3.2 London Borough of Camden

The London Borough of Camden set out their approach to sustainable development through their Core Strategy, Development Policies and Supplementary Planning Documents. Core Strategy Policy 13 sets out the overarching approach to sustainability in the borough, with the aims of mitigating and adapting to climate change, promoting local energy generation, managing water resources and reducing carbon dioxide emissions.

The Development Policies provide further detail as to how the Core Strategy policies can be achieved. In this instance *"Development Policy 22 – Promoting Sustainable Design and Construction"* provides the details as to how the targets of CS13 will be meet and states:

"The council will require development to incorporate sustainable design and construction measures. Schemes must:

- Demonstrate how sustainable development principles, including relevant measures set out in paragraph 22.5 below, have been incorporated into the design and proposed implementation; and
- Incorporate green or brown roofs and green walls wherever suitable."

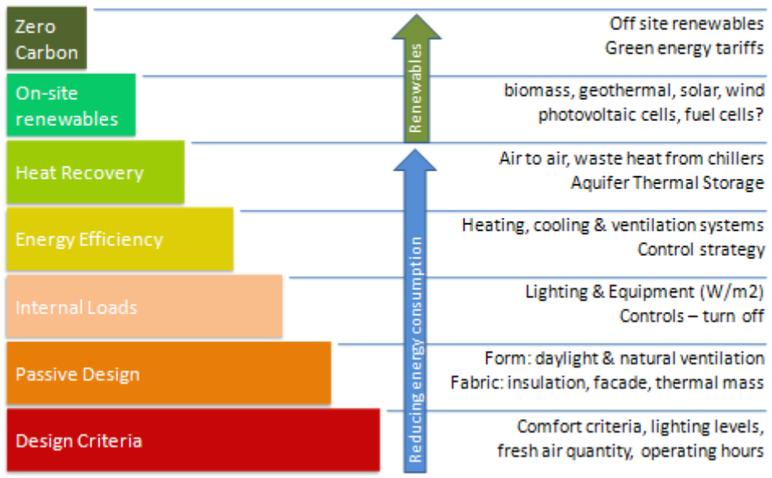
The council will promote and measure the sustainable design and construction by:

- Expecting non-domestic developments of 500sq m of floor space or above to achieve *"very good"* in BREEAM assessments and *"excellent"* from 2016 and encouraging zero carbon from 2019.

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

- Summer shading and planting;
- Limiting run-off;
- Reducing water consumption;
- Reducing air pollution;
- No locating vulnerable uses in basements in flood-prone areas.

In addition to this policy, the Supplementary Planning Document *"Camden Planning Guidance 3 – Sustainability"* provides greater detail on the targets for developments and the approach that should be adopted in meeting these targets.


# 4. Energy Strategy

The application proposes the change of use of the existing 7 Warwick Court from B1 Office to C3 Residential. The new development will be integrated into the Borough of Camden's Sustainability guidance for the energy strategy.

The design proposed dwellings have been developed to reduce its annual energy consumption, whilst providing energy in the most environmentally friendly way to reduce its annual $CO_2$ footprint. In order to achieve this, Cundall's "Steps to low carbon" methodology has been applied.

## 4.1 Passive Design

Substantial reductions in energy usage for the scheme will be achieved through consideration of the passive elements of the design, together with improved occupancy comfort.

**Building Envelope**

The proposed development will retain the historic fabric of the original development. The existing roofs and floors and new secondary glazing behind retained windows will conform with the guidelines for retained fabric. The new fabric to the rear extension, including the new glazing units, will be designed to meet Part L1b standards.

All possible retained and new thermal elements will therefore be specified to achieve the following area weighted U-values to reduce the heat losses though the building's fabric:

**Building Fabric Performance**

| Detail | Design |
|---|---|
| Ground floor average U-value | 0.25W/m$^2$K |
| External wall average U-value | 0.30W/m$^2$K |
| Roof average U-value | 0.18W/m$^2$K |
| Window U-value (including frame) | 1.60W/m$^2$K |
| Glazing total solar transmission | 60% |
| Y-value | 0.15 (default) |
| Air permeability @ 50 Pascals | 15.0m$^3$/hr/m$^2$ |

**Air Permeability**

Although not required by Building Regulations, an air pressure test is being considered for the development in order to determine the air leakage rates and take any remedial actions to improve it. An air leakage rate of 15m$^3$/hr/m$^2$ at 50Pa will be targeted for the development.

## 4.2 Ventilation - Naturally Ventilated

The development will be naturally ventilated throughout via openable windows. The windows will supply the minimum background fresh air to the occupants whilst also allowing control over the ventilation rate.

Utilising natural ventilation negates the need for fans and pumps that would consume energy in supplying fresh air to the space. By using openable windows to moderate the amount of fresh air being supplied to the rooms, occupants will have control over their thermal comfort.

Comfort cooling will be supplied to the bedrooms and living space only of all units. This gives occupants the option to comfort cool these spaces should the windows need to be closed. The systems will have a high coefficient of performance and consist of internal cooling fan coil units (with heating for boost purposes) connected to external condenser units located either on the external terraces or at roof level.

The presence of the light well at the rear of the development means that fresh air can be provided to all occupied areas of the development and means that certain bedrooms can utilise cross-flow ventilation to effectively remove heat gains and supply fresh air to the space.

The openable windows will be provided so that occupants have control over the thermal comfort of their environment, with comfort cooling provided for when windows cannot be opened for acoustic reasons. Mechanical extract only will be provided to kitchens and bathrooms.

## 4.3 Energy Efficient Systems & Appliances

After assessing the contribution of the passive elements to the overall energy balance, the aim is to further reduce $CO_2$ emissions by selecting efficient mechanical and electrical systems and efficient controls to manage the energy used during operation.

**Eco-Labelled Goods**

As lights and appliances account for about a third of the $CO_2$ emissions in development, where domestic appliances are installed energy efficient units will be incorporated, including A and A+ rated appliances.


White Goods efficiency rating

**Low-Energy Lighting**

To reduce the energy consumption associated with artificial lighting, 100% of all internal lighting fittings will be energy efficient light fittings that have a luminous efficacy in excess of 75 lumens/circuit Watt. The fixing must be permanently fitted to the ceiling or wall and can contain one or more lamps.

The development has a prominent light well that should improve the penetration of natural light into the centre of the scheme which will reduce reliance on artificial light. Roof lights over several spaces will also improve natural daylighting levels.

**HVAC Plant Efficiencies**

The design team will specify all equipment and plant to exceed the minimum requirements of the domestic HVAC guide. This provides guidance on the means of complying with the requirements of Part L1B of the Building Regulations for conventional space heating systems, hot water systems and cooling systems.

The heating in the development will be provided by a Low Temperature Hot Water (LTHW) underfloor heating system and radiators. Each underfloor and radiator system will be fed by individual, high efficiency low NOx condensing boilers. These condensing boilers will have a small amount of local domestic hot water (DHW) storage.

**Variable Speed Pumps and Drives**

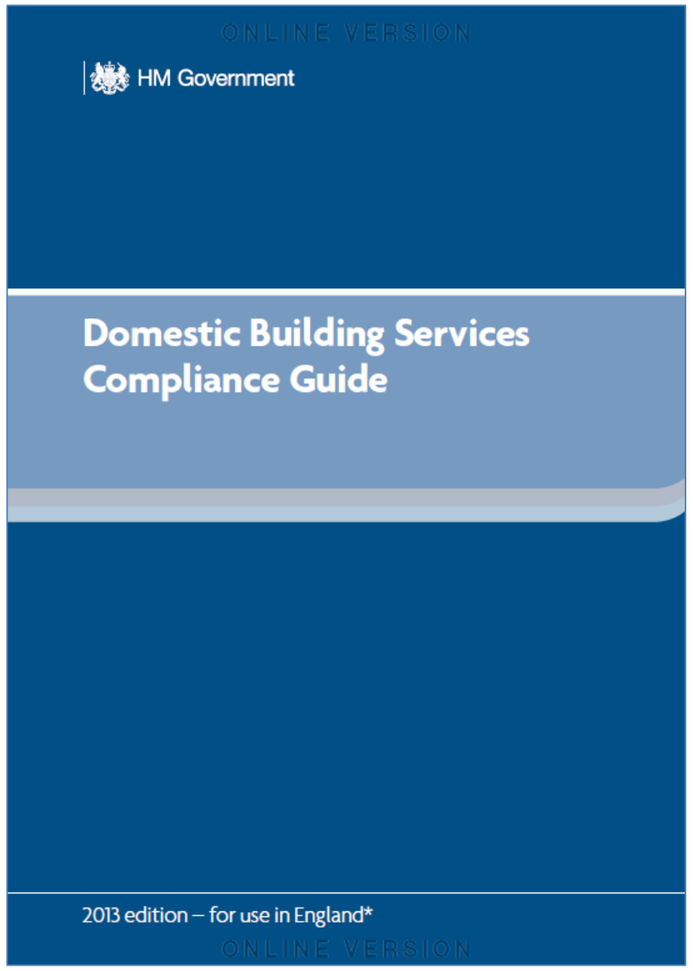
All fans and pumps will be specified with variable-speed drives, which will reduce their energy consumption by more than two-thirds compared with equivalent non variable speed alternatives, by only supplying the required flow rate to meet the demand.

**Energy metering**

Metering of the energy uses within the development separately, will help the building users identify areas of increased consumption and highlight potential energy-saving measures for the future, hence reducing the associated annual $CO_2$ emissions from these systems.

All electrical supplies will be metered using smart meters to enable building users and tenant to be responsible for their own consumption and hence $CO_2$ emissions.

New metered gas supplies will be provided to each apartment, along with a metered water supply. Each apartment will have an individual reporting system.




2013 Domestic Building Services Compliance Guide - used in the selection of HVAC equipment

# 5. Estimated Annual Energy Consumption

In accordance with the NPPF and London Borough of Camden, the estimated energy consumption for the development has been based on the National Calculation Methodology (NCM).

The energy assessment has been carried out for the proposed scheme with the aforementioned passive and energy efficient measures. This design building was compared against the building baseline, which was modelled to the Part L1b 2013 minimum standards for a development of this age.

A preliminary energy assessment was conducted using the approved dynamic simulation software Elmhurst Energy SAP 2012.

The results have been compared between a baseline case, based on the minimum fabric threshold standards for Part L1B and the minimum plant efficiencies under the Domestic Modelling Guide, and the proposed scheme with the aforementioned passive and energy efficient measures. The SAP Building Services Inputs outlines the design parameters used in the base case and proposed models.

Analysis was performed on the basement, mid floor and top floor residential units with percentage improvements over the Building Regulations emission rate of between 33% and 41%, with an overall area-weighted improvement of 36%. This therefore exceeds the 35% improvement in carbon emissions required by Policy 5.2 of the London Plan.

**Building Fabric Performance**

| Detail | Base Case | Design |
|---|---|---|
| Ground floor average U-value | 0.70W/m$^2$K | 0.25W/m$^2$K |
| External wall average U-value | 0.70W/m$^2$K | 0.30W/m$^2$K |
| Roof average U-value | 0.35W/m$^2$K | 0.18W/m$^2$K |
| Window U-value (including frame) | 2.20W/m$^2$K | 1.60W/m$^2$K |
| Glazing total solar transmission | 60% | 60% |
| Y-value | 0.15 | 0.15 (default) |
| Air permeability @ 50 Pascals | 25.0m$^3$/hr/m$^3$ | 15.0m$^3$/hr/m$^2$ |

**Fixed Building Services**

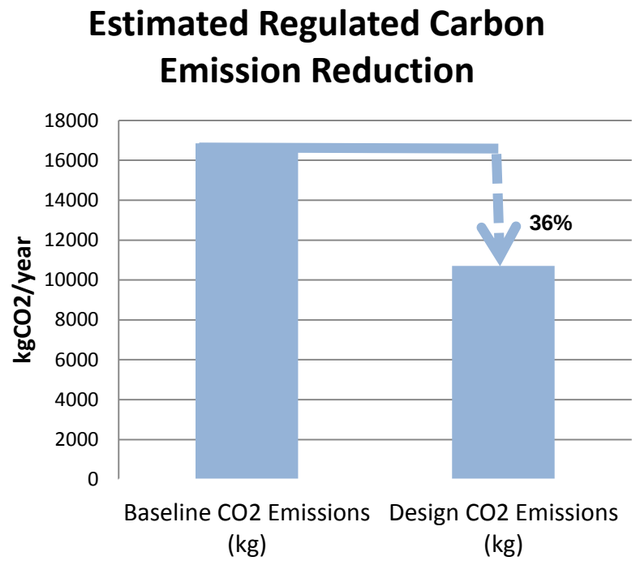
| Detail | Base Case | Design |
|---|---|---|
| Heating type | Individual Boilers | Individual Boilers |
| Heating fuel | Natural gas | Natural gas |
| Gross boiler seasonal efficiency | 84% | 90% |
| Heating Emitters | Radiators | Underfloor |
| Boiler Compensator | None | Weather |
| Heating system controls | Time, thermostat | Time and Temp. Zone Control |
| Ventilation | Naturally Ventilated | Naturally Ventilated |
| Hot water pipework insulated | Yes | Yes |
| Cooling SEER | 2.5 | 3.5 |
| Low energy light fittings | 75% | 100% |
| Hot water daily usage | > 125 l/p/day | < 125 l/p/day |
| Hot water storage (L) | 110L | 110L |
| Hot water storage insulation thickness (mm) | 12 | 160 |

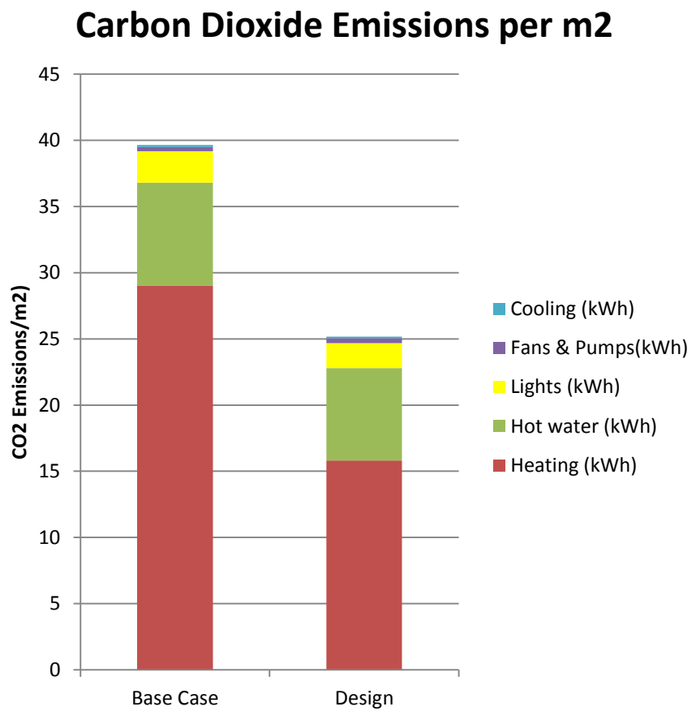
**Area Weighted Results**

| Area Weighted Results | Base Case | | Design | |
|---|---|---|---|---|
| | Absolute | per sqm | Absolute | per sqm |
| Heating (kWh) | 57130 | 134.4 | 31118 | 73.2 |
| Hot water (kWh) | 15295 | 36.0 | 13725 | 32.3 |
| Lights (kWh) | 1942 | 4.6 | 1553 | 3.7 |
| Fans & Pumps(kWh) | 249 | 0.6 | 292 | 0.7 |
| Cooling (kWh) | 130 | 0.3 | 107 | 0.3 |
| Total Energy (kWh) | 74745 | 175.9 | 46795 | 110.1 |
| DER (kg$CO_2$) | 16848 | 39.6 | 10699 | 25.2 |
| Improvement (%) | | | 36% | |

**Summary**

| Detail | Absolute | per sqm |
|---|---|---|
| Baseline $CO_2$ Emissions (kg) | 16848 | 39.6 |
| Design $CO_2$ Emissions (kg) | 10699 | 25.2 |
| Improvement (%) | | 36% |



## 6. Decentralised Energy Networks

The feasibility of connecting to an existing or proposed district network has been investigated for the site in accordance with Policy 5.6 of the London Plan.

The London Heat Map indicates that there are no existing district heating networks within 500m of the site. 500m is considered the technical and financial limit for feasible connections, and a connection this long is only normally made if the heat load is adequate enough to act as an anchor for other heat loads in the area. As 7 Warwick Court only contains 4 residential units, the heat load is not large enough to justify this.

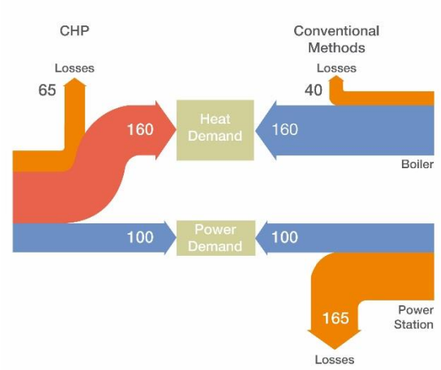
The Citigen network terminates approximately 800m from the development and is expected to expand in future years as district systems become more common. However, the potential future network is not expected to be installed within a distance that could be considered feasible for the 7 Warwick Court development.

As there are no networks within feasible connection distance nor are there any future networks that be incorporated with the scheme, it is not proposed to include a plate heat exchanger in the development.


**District Heating Map of 7 Warwick Court and surrounding areas. District Heating Networks in Proximity to the site (Yellow = installed, Red = potential)**

## 7. Combined Heat & Power (CHP)

In accordance with the Mayor's Energy Hierarchy in Policy 5.6 the feasibility of a site wide CHP network has been investigated.




**CHP Efficiency Diagram**

The analysis indicates that the development's heating and power demand is insufficient to effectively run a CHP system. The only systems that could potentially be integrated with the scheme are 'micro' CHP units, which have thermal outputs of less than 15kWth.

While a system like this could potentially reduce $CO_2$ emissions, this is only possible by exporting electricity from the site as the development's electrical demand is insufficient to use all of the electricity generated. If electricity could not be exported from the site, the lower thermal efficiency of a CHP unit compared to the proposed high efficiency boilers means that $CO_2$ emissions would increase.

Furthermore, the London Borough of Camden has been declared an Air Quality Management Area (AQMA) due to the high levels of NOx and particulates present in the air. CHP units output more local NOx than high efficiency boilers and thus would have to achieve the emissions limits as set out in the GLA document 'Biomass and CHP Emission Standards'. The Clean Air Action Plan created by the London Borough of Camden stipulates that stringent emission controls must be applied to any CHP installations.

Therefore, CHP has not been considered for the development.

## 8. Low and Zero Carbon Energy Sources

Policy 5.7 of the London Plan requires that all major developments seek to reduce their $CO_2$ emissions by at least 20% through the use of onsite renewable energy generation wherever feasible. The following technologies have been investigated to determine the feasibility of delivering a reduction in the $CO_2$ emissions through renewables.

The feasibility of each of the energy sources listed has been assessed with regard to the potential contribution each could make to supply a proportion of the development's delivered energy requirement, whilst considering the technical, planning, land use and financial issues.

A summary of the LZC technologies considered for the development is shown in Appendix A – LZC Technology Summary.

### 8.1 ASHP (Air Source Heat Pump)

Air source heat pumps exchange heat between the outside air and a building to provide space heating in winter and cooling in the summer months. The efficiency of these systems are inherently linked to the ambient air temperatures.

Heat pumps supply more energy than they consume, by extracting heat from their surroundings. Heat pumps can supply as much as 3kW of heat output for just 1kW of electrical energy input. They can also be used to provide cooling.

It is proposed that air source heat pumps are used to provide the cooling to the master bedroom and living areas only of the development, connected to external condenser units located on the external terraces and at roof level. These split units will also have a heat boost capability to meet peak loads.

Whilst the cooling demand of the development is relatively low compared to the heating and hot water demand, it will be provided by a renewable source in the form of the air source heat pumps.

### 8.2 GSHP (Ground Source Heat Pumps)

Ground source heat pumps require either horizontal trenches or vertical boreholes to be excavated in order to accommodate piles or

loops. Furthermore GSHPs only work efficiently on developments where there is a reasonably balanced heating and cooling load, to prevent the piles warming or cooling the ground.

The analysis indicates that 5 100m deep boreholes or 100m long horizontal trenches operating at a seasonal efficiency of 3.5 could provide 100% of the development's heat demand. However, the development's minor cooling demand would mean that over time the ground would cool down as heat was extracted, reducing the effectiveness of the system.

The site's constrained urban envrionment means it is unlikely that either horizontal trenches or vertical boreholes could be excavated underneath the existing building.

The spatial constraints and unbalanced heating and cooling demands mean that ground source heat pumps are not considered feasible for this development.

## 8.3 Wind Turbines

The output from wind turbines are highly sensitive to wind speed. Hence it is essential that turbines should be sited away from obstructions, with a clear exposure or fetch for the prevailing wind.

The analysis indicates that 1 vertical or horizontal axis turbine sited above the roof level could reduce emissions by 40% (vertical axis) or 12% (horizontal axis). However, these turbines would have considerable visible impact and would also struggle to catch laminar flow of wind.

The urban location of the site coupled with the adjacent buildings will result in a turbulent flow regime across the site. As such it is not proposed to include wind turbines as part of the development. Furthermore the protected conservation area of Bloomsbury forbids additions that could detract from the visual aesthetic of the area, which makes wind turbines unviable for the site.

## 8.4 Photovoltaic Panels

Photovoltaic solar cells convert solar energy directly into electricity. The cells consist of two layers of silicon with a chemical layer between. The incoming solar energy charges the electrons held within the chemical. The energised electrons move through the cell into a wire creating an electrical current.

A study into the feasibility of onsite electric generation using south facing photovoltaic panels at 30º on the roof of the development to meet a proportion of the residential development's electricity demand has been undertaken.

The study indicates that locating 15m$^2$ of PV panels, orientated south at an inclination of 30º to the horizontal could produce enough electricity annually to reduce $CO_2$ emissions by 9% across the site.

The building's location within the Bloomsbury Conservation Area, a famed example of formal town planning with a predomination of terraced townhouses, many of which have retained their facades and enhanced the quality and heritage of the conservation area means that South facing solar panels are unviable for the 7 Warwick Court development. It is therefore unlikely that photovoltaic panels would get through planning. The roof space is currently accommodating some of the external split units and the PV panels would compete for this space.

The scheme's urban location, combined with minimal roof space means that there is limited space to install PV panels where they can be most effective. Therefore, PV panels have not been considered for this development.

## 8.5 Solar Thermal

Solar thermal collectors utilises solar radiation to heat water for use in buildings. The optimum orientation for a solar collector in the UK is a south facing surface, tilted at an angle of 30º from the horizontal.

Solar collectors are typically designed to meet a development's base heat load, associated with its domestic hot water requirements. For residential development these usually equates to 60-70% of the total DHW annual load, with the natural gas-fired boilers meeting the remainder of the load.

An initial study into the feasibility of incorporating a solar thermal collector system onto the roof of the dwelling has been undertaken. The system considered was a 12m$^2$ roof mounted evacuated tube collector array, facing south and tilted with an inclination of 30º in order to maximise the operational efficiency of the system.

However, as previously stated the proposed roof structure has been design to be in keeping with the local styles within the conservation area and the building orientation makes the inclusion of solar thermal collectors unviable.

## 8.6 Biomass Heating

Although the development's thermal load indicates that a small biomass boiler could operate as a lead boiler in a modular arrangement with a number of conventional gas-fired boilers and provide a significant reduction in its $CO_2$ emissions, biomass boilers are not recommended for this development. A biomass boiler would have to be integrated into a centralised energy strategy as the individual dwelling heat loads are too small to efficiently run.

The analysis indicated that a 15kW biomass boiler could generate 60% of the development's heat load, with a potential emissions reduction of 51%.

Biomass boilers require significant space for storage and delivery of fuel. They have higher particulate emissions than gas boilers which typically raises concerns with the Environment Agency as central London suffers from poor air quality. The London Borough of Camden in particular suffers from air quality issues, and the Air Quality Action Plan indicates that biomass boilers would not be the preferred solution for heating unless they could be shown to comply with the emissions standards set out in the GLA's 'Biomass and CHP Emissions Standards' 2013 document.

Therefore biomass boilers have not been considered feasible for the proposed development. Biodiesel boilers have also been considered unfeasible for the development based upon similar reasoning.

# 9. Proposed Energy Strategy

For the assessment of the proposed development at 7 Warwick Court, we have followed the methodology of the Mayor's Energy Hierarchy with the estimated energy consumption for the development based on the National Calculation Methodology (NCM), calculated with the approved software Elmhurst Energy SAP 2012.

**Energy Strategy**

The proposed development will be well insulated as far as possible ensuring that heat losses are kept to a minimum with improved fabric U-values in the retained façade and new building areas achieving Building Regulations standards reducing heat losses via conduction. Natural ventilation will provide the minimum background fresh air through openable windows that will allow occupants to control the ventilation rate and remove heat gains. Toilets and kitchens will have mechanical extract only.

Cooling via variable refrigerant flow split units will be provided to the bedrooms and reception spaces and will be used at the occupant's discretion. Energy efficient lighting and metering will be used to ensure that the building users will be informed on the performance of the development.

The heating within the development will be provided by a Low Temperature Hot Water (LTHW) network, feeding underfloor emitters within occupied spaces and fed by high efficiency individual boilers located within each residential unit, which will also generate the domestic hot water with a small amount of local storage.

The combination of passive and energy efficient systems results in the new residential development achieving an improvement of 36% over the baseline Part L1b Building Regulations minimum standards baseline.

**Renewable Energy Strategy**

The feasibility of connecting to an existing or proposed district heating network has been investigated for the site in accordance with Policy 5.6 of the London Plan. The London Heat Map indicates that there are no district networks within the vicinity of the site presently.

The feasibility of utilising a combined heat and power unit to deliver a portion of the development's heat demand and electricity was analysed. The small size of the development and associated demands means that CHP could not function effectively and is therefore considered to be unviable for this scheme.

In accordance with Policy 5.7 of the London Plan, investigations into providing a proportion of the site's energy requirements through renewables was undertaken.

The site's spatial constraints and location within the Bloomsbury conservation area means that several renewable technologies are ruled out on spatial factors and visual impacts. There is no precedence for either photovoltaic or solar thermal collectors on heritage buildings within the area, so these technologies are disregarded.

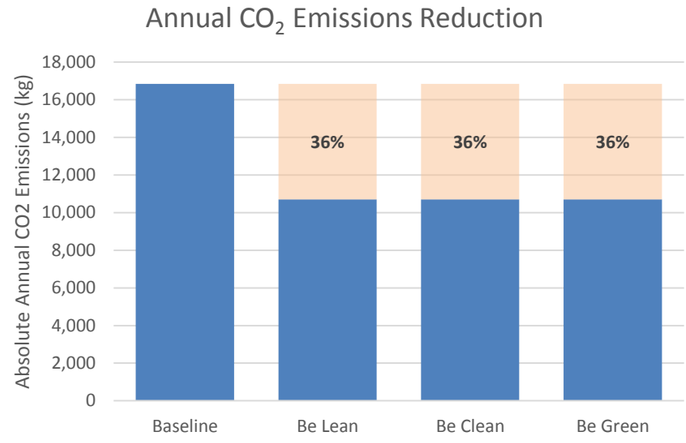
Ground source heat pumps cannot be retrofitted to the development as its existing status within a built-up, urbanised street location prevents laying of the necessary ground loops without excavation underneath the retained structure.

Variable refrigerant flow air source heat pumps are proposed to provide the minor demand for local cooling to bedroom and reception areas. The external units will be mounted on terraces and at roof level.

Biomass boilers are considered unviable due to local air quality concerns and incompatibility with the individual heating systems proposed for the development.

The proposed passive design measures and energy efficient systems means that the development achieves the 35% carbon dioxide reduction target under Policy 5.2.

This reduction in carbon emissions means that the development complies with the requirements of the London Borough of Camden and the GLA. No payment will be forthcoming in order to make up for any shortfall in carbon emission reduction.




| Carbon Offset Fund | | |
|---|---|---|
| 35% Carbon Target Offset | 5897 | kg |
| Design Offset | 6149 | kg |
| Shortfall | -252 | kg |
| Carbon Cost (Zero Carbon Hub) | 46 | £/T |
| Years | 30 | |
| Total Offset Cost | -348 | £ |

| | Regulated Carbon dioxide savings | |
|---|---|---|
| | (Tonnes $CO_2$ pa) | (%) |
| Savings from Energy Demand Reduction | 6.15 | 36% |
| Savings from CHP | 0.00 | 0% |
| Savings from Renewable Sources | 0.00 | 0% |
| **Total Cumulative Savings** | **6.15** | **36%** |
| **Total Target Savings** | **5.90** | 35% |
| **Annual Surplus** | **0.25** | |

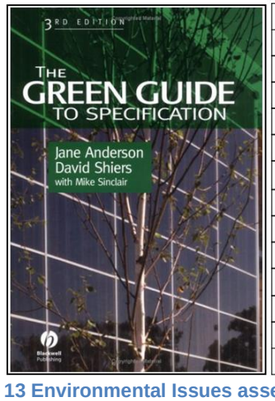
# 10. Materials

Building and construction activities worldwide consume 3 billion tons of raw material each year, which account for approximately 50% of total global consumption. Using green/sustainable building materials and products promotes conservation of dwindling non-renewable resources. In addition, integrating sustainable building materials into building projects can help reduce the environmental impacts associated with the extraction, transport, processing, fabrication, installation, reuse, recycling, and disposal of these source materials.

The aim for the proposed 7 Warwick Court development will be for its overall environmental impact to be minimised through the specification of sustainable materials. As a minimum the building will reuse the existing façade and structure, and further areas where materials can be reused will be highlighted at later design stages.

## 10.1 Environmental Impact of Materials

New materials with low overall environmental impact will be chosen and advice from the Green Guide to Specification will be taken into consideration for the selection. The Green Guide rates the environmental impact of different materials and components, taking into account factors like toxicity, ozone depletion, ease of recycling, waste disposal etc. Where viable, at least 80% (by area) of the new main elements in the building, fabric & building services insulation should be specified to achieve the best performing “A” and “A+” ratings from the Green Guide.




| Environmental Issue |
|---|
| Climate Change* |
| Water extraction |
| Mineral extraction |
| Stratospheric ozone depletion* |
| Human toxicity |
| Ecotoxicity to freshwater |
| Higher level nuclear waste |
| Ecotoxicity to land |
| Waste disposal |
| Fossil fuel depletion |
| Eutrophication* |
| Photochemical ozone creation* |
| Acidification* |

**The 13 Environmental Issues assessed by the Green Guide**

## 10.2 Sustainable Timber

All timber used for basic or finishing building elements in the scheme will be sourced from responsibly managed and sustainable forests or plantations. Such timber products are the only truly renewable construction material in common use and growing trees also absorb and fix $CO_2$. Forests can also provide the habitat for a wide variety of plant and animal life, preserving important ecology and promoting biodiversity.

## 10.3 Locally Sustainable Materials

A building that is truly sustainable must be constructed using locally sourced, sustainable materials i.e. materials that can be supplied without any adverse effect on the environment. Therefore, where practical, materials should be sourced from local suppliers, reducing the environmental impacts and $CO_2$ emissions associated with transportation to the site.

## 10.4 Recycled Materials

Scope for increased recycling will be incorporated by specifying recycled materials where possible and ensuring that even where new materials are used, as much as possible can be recycled at the end of the buildings’ life.

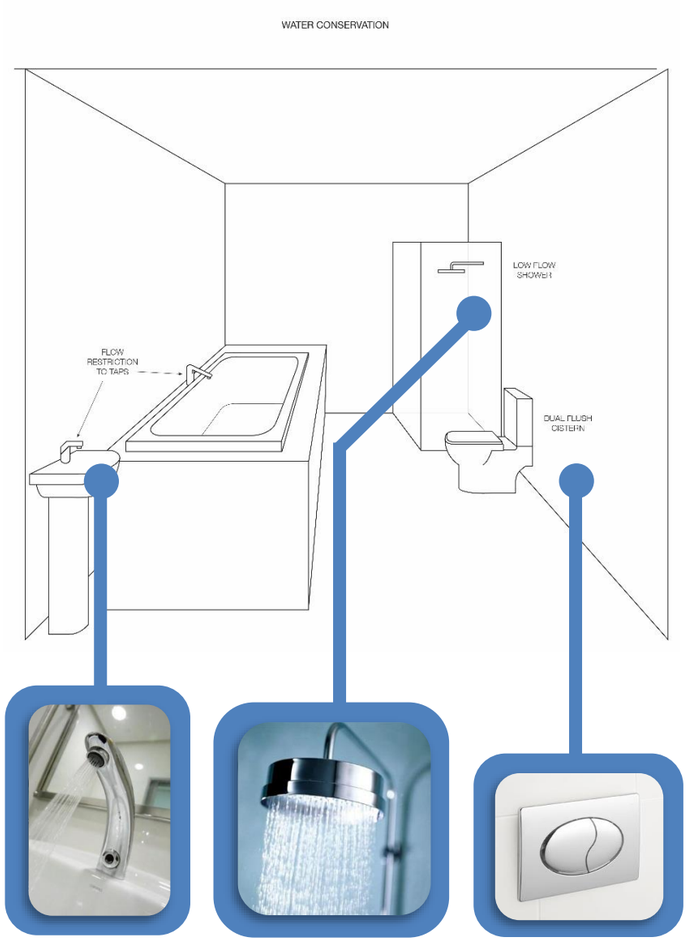
Any material not required from the original building can be recycled and used as aggregate.

Specifying materials with a high-recycled content is also another method of saving processing or manufacturing energy. The recycled content of a material can be described as either post-consumer or post-industrial to indicate at what point in the life cycle a material is reclaimed.

## 10.5 Ozone Depletion and Global Warming

CFCs and HCFCs, compounds commonly used in insulation materials and refrigerants, can cause long-term damage to the Earth’s stratospheric ozone layer, exposing living organisms to harmful radiation from the sun. They also significantly increase global-warming if they leak into the atmosphere. Following the Montreal Protocol, production and use of CFCs is no longer permitted and EC regulations will require phasing out of HCFCs by 2015. However, products that replace these gases are often still potent global warming contributors.

All insulation materials specified for the proposed scheme will have zero Ozone Depleting Potential and low Global Warming Potential, (GWP<5) in either manufacture or composition in line with the CSH requirements. This will include insulation for building elements (roof, internal & external walls, floor – including foundations) as well as insulation for hot water vessels and pipe or duct work.




## 11. Water Conservation

Water consumption in the UK has risen by 70% over the last 30 years. Trying to meet the increasing demand by locating new sources of water supply is both expensive and damaging to the environment. Therefore, the design team have focused on reducing the demand for water and managing the existing resources.

### 11.1 Demand Reduction and Water Efficiency

The aim is to minimise internal and external potable water use within the development. Good water management can contribute to reducing the overall level of water consumption maintaining a vital resource and having environmental as well as cost benefits in the life-cycle of the building. The following water saving measures are being considered:

***Dual Flush Cisterns on WC's*** - These units have the ability to provide a single flush of 4L and/or a full flush of 6L.

***Flow Restrictors to Taps*** - Flow restrictors reduce the volume of water discharging from the tap. Spray taps have a similar effect.

***Low Flow Showers -*** The average shower uses 15 litres of water a minute, by restricting the output of the showers in the development to a maximum of 9 litres/ min a 40% water saving can be achieved. Flow rate can be reduced down to 6 litres/ min without compromising on water pressure and hence should be considered.

***Water Meters*** - In 1995 approximately 33,200 million litres of water a day were extracted in England and Wales, this increased to 44,130 supply. To reduce this figure, accurate information on usage is required for management of a building's consumption. Water meters will be specified on the main supply to each dwelling.

## 12. Sustainable Urban Drainage

The site's drainage strategy will aim to reduce the impact of development on the natural drainage patterns, by retaining water on site by the incorporation of Sustainable Urban Drainage techniques (SUDs).

As the site is currently completely impermeable with hard landscaping and building areas, the main aim for the development will be to improve the water retention of the site.

The Environment Agency's Flood Map indicates that the site is located within Flood Zone 1.


Flood Map for 7 Warwick Court

As a minimum, the design will ensure that the peak rate of runoff into watercourses is no worse than the existing site's run off rate. This will comply with the Interim Code of Practice for Sustainable Drainage systems (SUDS) (CIRIA, 2004) or for at least the 1 year and 100 year return period events.

# 13. Waste Management

Buildings and building sites produce a significant amount of waste annually. Most of the waste produced in the UK is disposed of in landfill sites and only a small percentage of it is recycled or reused.

## 13.1 Waste Targets

Under EU legislation the UK will have to ensure that less than a third of its waste is sent for burial in landfill sites by 2020 and the figure at present is about 80%. To achieve this target a number of measures are implemented, including landfill tax, aiming to discourage disposal of waste to landfill. Good waste management is a key component of sustainable development. Reducing waste is an important means of:

- Reducing unnecessary expenditure;
- Reducing the amount of natural resources used for production of new materials;
- Reducing energy for waste disposal;
- Reducing levels of contamination and pollution arising from waste disposal.

The proposed development will minimise the impact of waste in the environment where possible.

## 13.2 Demolition & Construction

During the construction phase a large amount of waste material will be generated through construction, demolition and land clearing procedures. In building construction, the primary waste products in descending percentages are: wood, asphalt/concrete/masonry, drywall, roofing, metals, and paper products.

Prior to commencement on site a Site Waste Management Plan (SWMP) that complies with the requirements of current legislation and CSH will be prepared. This plan will identify the local waste haulers and recyclers, determine the local salvage material market, identify and clearly label site spaces for various waste material storage and require a reporting system that will quantify the results and set targets. As a minimum the SWMP will contain:

a. The target benchmark for resource efficiency e.g. $m^3$ of waste per $100m^2$ or tonnes of waste per $100m^2$;
b. Procedures and commitments for minimising non-hazardous waste in line with the benchmark;
c. Procedures for minimising hazardous waste;
d. Procedures for monitoring, measuring and reporting hazardous and non-hazardous site waste;
e. Procedures for sorting, reusing and recycling construction waste into defined waste groups either on site or through a licensed external contractor;
f. The name or job title of the individual responsible for implementing the above.

As the proposed scheme will utilise the existing building's core and facades, the amount of new building material required will be far less than for a comparable new build. Opportunities for introducing more reused or reusable materials/components will be explored during detailed design.

## 13.3 Waste Management & Reporting in Operation

The detailed design phases will identify the potential waste streams that the development will produce. As a minimum, plans will be formulated to handle the separation, collection, and storage of common recyclable materials such as paper, glass, plastics, and metals. The collection points will be easily accessible to all of the users.

The main aim will be to recycle as much waste as possible; this will be achieved by making sure that waste recycling facilities are strategically placed in convenient locations. A ventilated bin store located at the basement level will be provided, acting as a collective bin store for the scheme.

The space allocated for waste storage should be able to accommodate containers with at least the minimum volume recommended by British Standard 5906 (British Standards, 2005) based on a maximum collection frequency of once per week. This is 170 litres volume for a two bedroom dwelling.

Large integrated recycling bin with at least 3 containers for recyclable waste and one general waste will be considered for each dwelling similar to the following image:

Internal segregated waste storage

80 Litre Capacity (2 x 32L & 2 x 8L)
Cabinet size - 600mm


Recycling waste streams

## 14. Environmental Management

### 14.1 Construction

Construction sites are responsible for significant impacts, especially at a local level. These arise from noise, potential sources of pollution and waste and other disturbances. Impacts such as increased energy and water use are also significant. Therefore attention is being given to site-related parameters with the aim to protect and enhance the existing site and its ecology.

The aim is to have a construction site managed in an environmentally sound manner in terms of resource use, storage, waste management, pollution and good neighbourliness. To achieve this, there will be a commitment to comply with the Considerate Constructors Scheme. As a minimum a score of greater than 35 of out 50 will be achieved with an aspiration to exceed 40, with no individual section achieving a score of less than 7.

Areas that can be taken into consideration in order to minimise the impact of the construction site on its surroundings and the global environment are as follows:

- Monitor, report and set targets for $CO_2$ or energy usage arising from site activities;
- Monitor, report and set targets for $CO_2$ or energy usage arising from transport to and from site;
- Monitor, report and set targets for water consumption arising from site activities;
- Monitor construction waste on site, sorting and recycling construction waste where applicable;
- Adopt best practice policies in respect of air and water pollution arising from site activities;
- Operates an Environmental Management System;
- Additionally, all timber used on site should be responsibly sourced.

## 15. Land Use and Ecology

The site currently comprises of an existing building in an intensive urban area. There is limited scope to improve the biodiversity of the area due to the heavy urban build-up of surrounding areas.

There is potential to include some areas of green planting within the light well at the rear of the development. This will be explored further at a detailed design stage.

The guidelines of the Bloomsbury Conservation Area and the building's listed status means it is unlikely that a green roof would be viable on this development as it would not fit the character of Warwick Court.

# 16. Pollution

Global concern for environmental pollution has risen in recent years, as concentrations of harmful pollutants in the atmosphere are increasing. Buildings have the potential to create major pollution both from their construction and operation, largely through pollution to the air (dust emissions, NOx emissions, ozone depletion and global warming) but also through pollution to watercourses and ground water. The proposed development will aim to minimise the above impacts, both at the design stage and on-site.

## 16.1 Ozone Depletion

CFCs and HCFCs, compounds commonly used in insulation materials and refrigerants, can cause long-term damage to the Earth's stratospheric ozone layer, exposing living organisms to harmful radiation from the sun. They also significantly increase global-warming if they leak into the atmosphere. Following the Montreal Protocol, production and use of CFCs is no longer permitted and EC regulations will require phasing out of HCFCs by 2015. However, products that replace these gases are often still potent global warming contributors. Where refrigerants are used for air-conditioning and comfort cooling they will be CFC and HCFC-free.

## 16.2 Internal pollutants

Volatile organic compounds (VOCs) are emitted as gases (commonly referred to as offgassing) from certain solids or liquids. VOCs include a variety of chemicals, some of which are known to have short-term and long-term adverse health effects. Concentrations of many VOCs are consistently higher indoors (up to ten times higher) than outdoors.

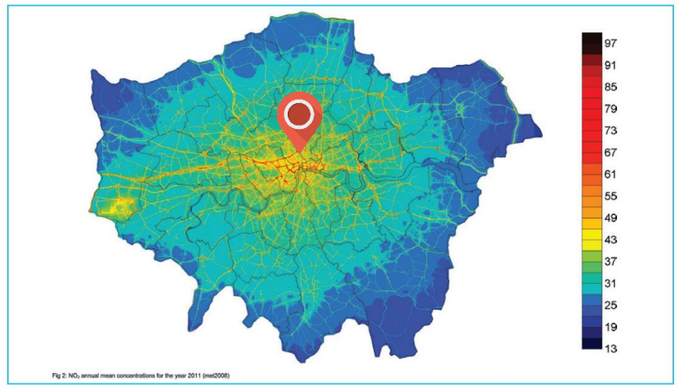
VOCs are emitted by a wide array of products numbering in the thousands. Examples include: paints and lacquers, paint strippers, cleaning supplies, pesticides, building materials, furnishings, adhesives, Urea-formaldehyde foam insulation (UFFI), pressed wood products (hardwood plywood wall panelling, particleboard, fibreboard) and furniture made with these pressed wood products.

'No' or 'low' VOC paints are available from most standard mainstream paint manufacturers. These 'eco-friendly' paints are made from organic plant sources and also powdered milk based products.

The design team will seek to select internal finishes and fittings with low or no emissions of VOCs and comply with European best practice levels as a minimum.

## 16.3 NOx emissions from boilers

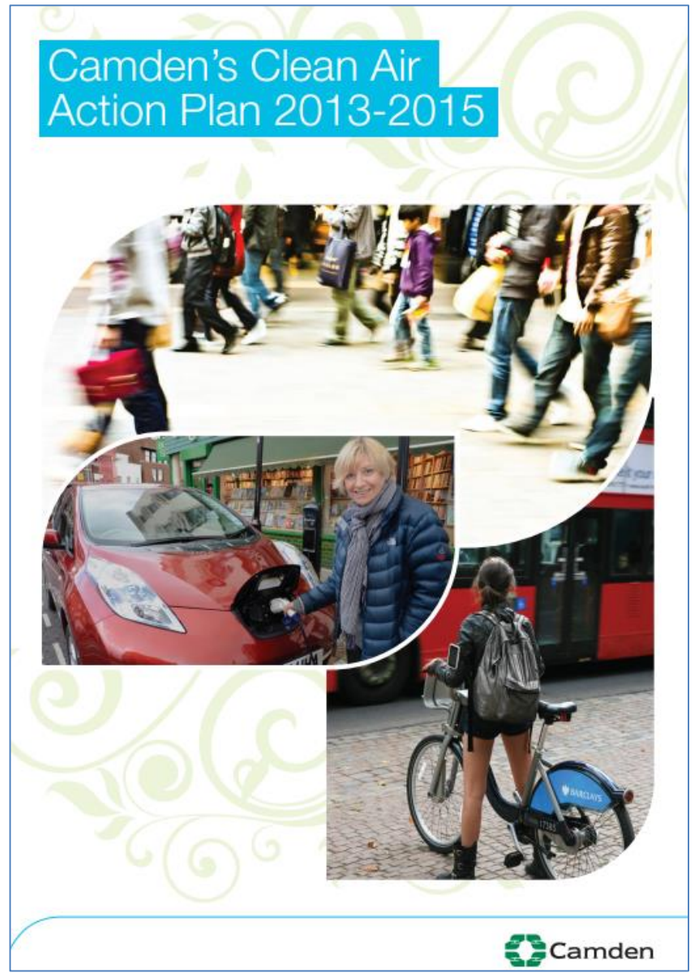
Nitrous oxides (NOx) are emitted from the burning of fossil fuels and contribute to both acid rain and to global warming in the upper atmosphere. At ground level, they react to form ozone, a serious pollutant and irritant at low level. Burners in heating systems are a significant source of low-level NOx, while power stations (and therefore electric heating) are a significant source of NOx in the upper atmosphere.




NO2 Annual Mean Concentrations

The amount of NOx emissions varies between products. New gas boilers vary from 40 NOx/kWh to <70mg NOx/kWh (class 5). The proposed high efficiency gas-fired combination boilers will be specified to emit less than 50 NOx/kWh.

The entire London Borough of Camden was declared an Air Quality Management Area (AQMA) in 2000 and remains an AQMA for both NOx and particulates to the present day. Camden is committed to strict regulation of large new boilers and combined heat and power systems within its boundaries.



# 17. Green Transport

The transport of people between buildings is the second largest source of $CO_2$ emissions in the UK after energy use in buildings and remains the main source of many local pollutants. Energy use and emissions from transport are growing at 4% per year, and at the same time, the effects of climate change are becoming more severe; there will be greater pressure to control $CO_2$ emissions from transport and sites without good access to public transport will be at much greater risk from these controls.

To promote the use of sustainable and public transport, no car parking spaces are being provided for the development.

## 17.1 Site Location

7 Warwick Court is located within 250m of Chancery Lane Underground station, which offers Central line access. Holborn station, which is also on the Piccadilly line, is within 500m of the site. Its central location means it has excellent public transport links to much of London.

A total of 27 distinct bus services are available within a 500m radius of the site, at disembarking from Grays Inn Road, Fleet Street, High Holborn and Chancery Lane.

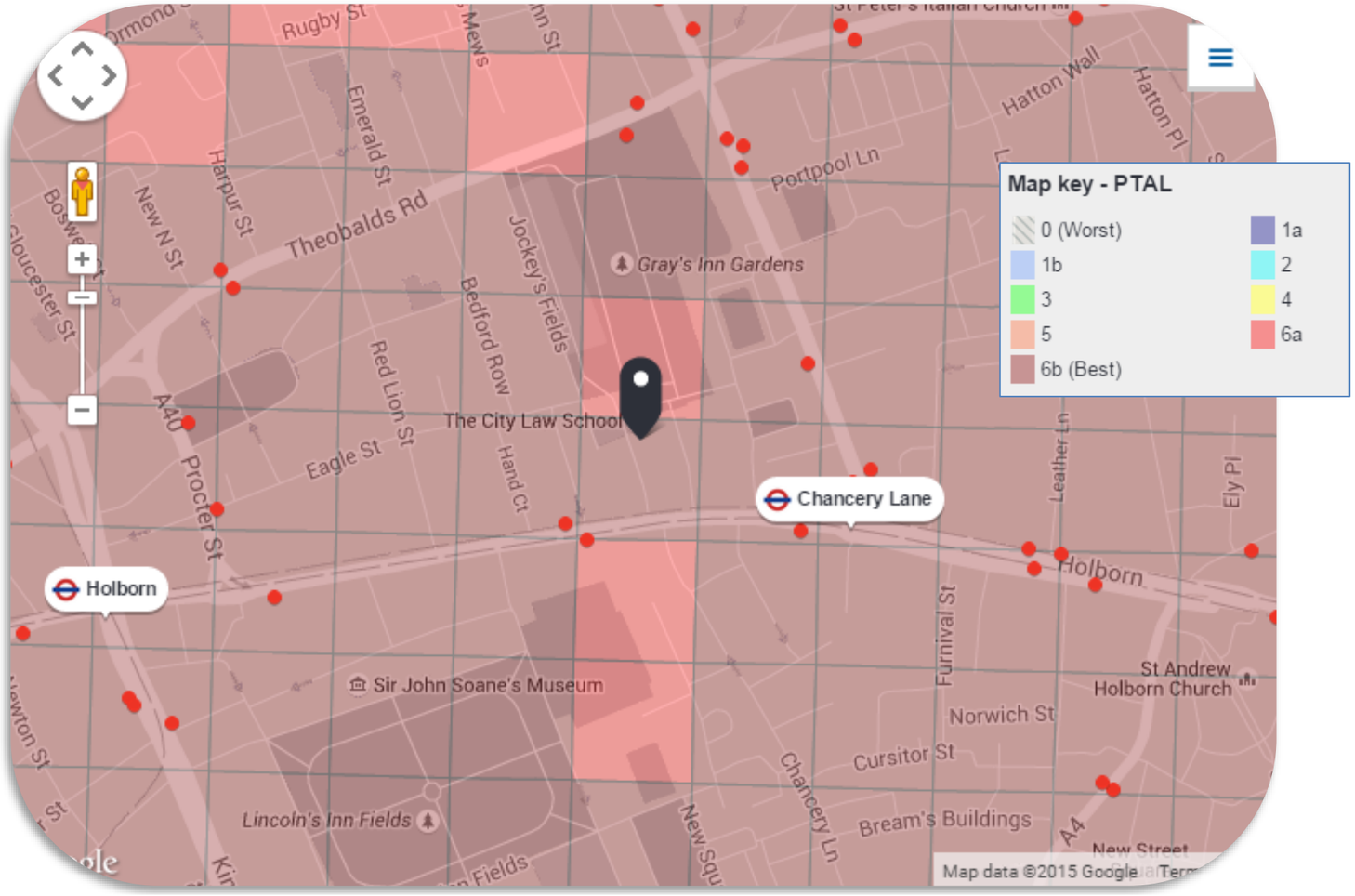
Further afield, Farringdon national rail station is within 800m of the site. This station offers train services departing both to the north and south of London. Furthermore, from 2018 it will become a major Crossrail hub.

The Public Transport Accessibility Level for the development is 6b, the highest possible. This indicates that the development has excellent public transport connections.

## 17.2 Cycling Facilities

The development includes proposals for 2 cycle storage spaces within each dwelling.

A cycle hire scheme docking station is located within 100m of the site.




*Red dots denote Bus Stops*

# 18. Appendix A – LZC Technology Summary

| | Equipment | Energy Generation | Estimated Capital Cost (£) | Payback Period (yrs) | Annual $CO_2$ Emissions Savings | 20 year life cycle cost | Feasibility (yes/no) | Physical,Spatial & land use Impact | Noise Impact | Additional Comments |
|---|---|---|---|---|---|---|---|---|---|---|
| VAWT | 1No 6kW quietrevolution wind turbine(s) | 410% (Electrical) | £30,000 | 9 | 42.8% | -£35,600 | NO | Turbines must be sited away from obstructions. Above building roof heights and spaced at least 3 x their diameters apart horizontal | Wind turbines generate noise that can be heard, dependent on wind speed and direction, a few hundred metres away. However this level is normal only marginal greater than the actual wind noise itself (2-12 dB) and is hence not considered to be a problem | Built up area, estimated average windspeeds unlikely to be met for the majority of the year. Noise, safety and location all preclude wind turbines for this site. No precedence within Bloomsbury conservation area for this technology. |
| HAWT | 1No 1.5kW Swift wind turbine(s) | 128% (Electrical) | £2,000 | 2 | 13.4% | -£22,600 | NO | Turbines must be sited away from obstructions. Above building roof heights and spaced at least 5 x their diameters apart horizontal | Wind turbines generate noise that can be heard, dependent on wind speed and direction, a few hundred metres away. However this level is normal only marginal greater than the actual wind noise itself (2-12 dB) and is hence not considered to be a problem | Built up area, estimated average windspeeds unlikely to be met for the majority of the year. Noise, safety and location all preclude wind turbines for this site. No precedence within Bloomsbury conservation area for this technology. |
| Photovoltaics | 15m² of Yingli Solar (235 W) Polycrystalline PV panels | 90% (Electrical) | £7,560 | 15 | 9.4% | -£2,859 | NO | Panels must be mounted on an area free from overshadowing | None | Spatial requirements on roof level mean that nothing other than a token contribution to carbon dioxide reduction could be made. Bloomsbury Conservation Area means that a special consultation would be required for permission to install. |
| Solar Thermal | 12m² of Evacuated Tubes Collectors | 67% (DHW) | £6,000 | 8 | 16.7% | -£8,188 | NO | Collectors must be mounted on an area free from overshadowing | None | As with the PV panels, limited roof space means that nothing but a token contribution to the site's DHW demand could be made. Due to location within the Bloomsbury Conservation Area, a consultation would be required before permission could be granted. |
| Biomass Boiler | 15kW boiler burning Wood Chips (25% MC) | 65% (Heat) | £18,000 | 9 | 52.3% | -£23,203 | NO | Potential issue of smoke & smell from boiler depending on moisture content of fuel. ~ 30m³ fuel storage areas required with access for fuels deliveries. | Normal noises associated with boiler plant, noise convinced within the dedicated plant room. Potential additional noise generation associated with the fuel deliveries. | Urban environment means that air quality concerns may prevent biomass getting planning approval. Biomass does not suit the Air Quality Action Plan for the London Borough of Camden, which has stringent emissions standards. |
| Biodiesel Boiler | 15kW boiler burning Biodiesel | 85% (Heat) | £13,500 | n/a | 67.3% | £52,392 | NO | Potential issue of smoke & smell from boiler depending on moisture content of fuel. ~ 30m³ fuel storage areas required with access for fuels deliveries. | Normal noises associated with boiler plant, noise convinced within the dedicated plant room. Potential additional noise generation associated with the fuel deliveries. | Air quality issues, similar to biomass boilers. Current scheme is for individual gas boilers, meaning a centralised system would need to be installed. |
| Heat Pumps - VRF | VRF heat pump(s): 42kW heating / 24kW cooling | 0%/100% (Heat / Coolth) | £29,400 | 288 | 22.6% | £27,356 | YES | Minimal visual impact to site, will require additional plant space for heat pumps and external heat rejection units | Normal noises associated with HVAC plant, noise convinced within the dedicated plant areas | VRF heat pumps can meet the cooling loads of the bedroom and reception areas. |
| Heat Pumps - ASHP | ASHP heat pump(s): 42kW heating / 24kW cooling | 0%/100% (Heat / Coolth) | £27,300 | N/A | 0.0% | £27,300 | NO | Minimal visual impact to site, will require additional plant space for heat pumps and external heat rejection units | Normal noises associated with HVAC plant, noise convinced within the dedicated plant areas | Similar effectiveness to VRF although without the benefit of simultaneous heating and cooling, hence lower reduction in emissions. |
| Heat Pumps - GSHP | 5No of 100m deep vertical boreholes | 100%/0% (Heat / Coolth) | £33,333 | 17 | 30.2% | -£6,391 | NO | No visual impact to site, will require additional plant space for heat pumps and well heads. | Normal noises associated with HVAC plant, noise convinced within the dedicated plant areas | Low cooling demand resulting in ground around piles cooling down and eventually reducing the effectiveness of the system. Furthermore the constrained site means installing boreholes would be difficult. |
| CHP | 1No of 5.5kWe / 14kWth gas-fired CHP engine | 32% / 28% (Heat / Electrical) | £22,000 | n/a | -6.9% | £30,404 | NO | No visual impact to site, will require additional plant space for CHP engine | Normal noises associated with HVAC plant, noise contained within the dedicated plant areas | Inadequate heating and electrical demand within scheme to efficiently run a CHP unit. Local Nox emissions also mean CHP is not viable with this system. |

## 19. Appendix B – Bloomsbury Conservation Area