ENERGY STRATEGY FOR KINGSWAY LIF HOLDINGS LTD
61 LINCOLN'S INN FIELDS AND 42 KINGSWAY

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1. BRIEF

Elementa were instructed to prepare this report by Club Quarters Ltd to provide supporting planning information for the proposed hotel at 61 Lincoln's Inn Fields London and additional apartments being prepared by Robert Hudson's Architects. The report is to compliment and bolster the design and access statement which further reports/examines the more holistic sustainability issues encompassing the whole site and the building design strategy.

Based on the above and local planning requirements, the report contains:

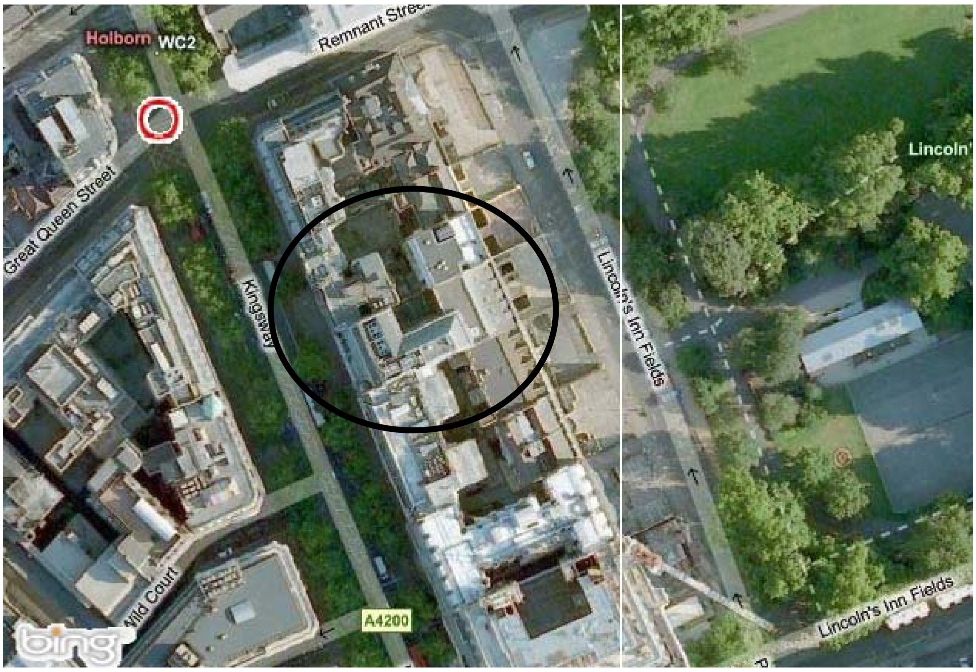
- An overview of the options for energy and carbon consuming systems for the proposed hotel
- Predicted energy consumption and associated CO_2 emissions
- Renewable and low carbon technologies to reduce the total CO_2 emissions rate

2. EXECUTIVE SUMMARY

The proposed Hotel development at 61 Lincolns Inn Field's and 42 Kingsway London comprises of two main buildings, one being the proposed hotel the other a residential unit with retail below. The hotel shall comprise of bedrooms and a central ground reception and lounge area. There are minimal external works associated with the development. The hotel building/development also incorporates a number of potential retail and restaurant lets.

The building construction is approximately 7696m^2 net internal floor area (8600m^2 gross external including construction) of which approximately 5020m^2 is classified as the hotel for which this energy strategy generally refers to/energy savings have been calculated for. Typical EPC's have been produced for those areas that are to be sub let (restaurant, residential and retail) to give an indication of energy performance for these refurbished areas.

Current site plan of proposed hotel site layout;



The proposed development at 61 Lincoln's Inn Fields and 42 Kingsway comprises of a Hotel with approximately 151 bedrooms. The development is approximately 5,020 m^2 in size (gross total) and is oriented on an east to west axis. There are an additional 2676 m^2 associated with potential future retail, restaurant and residential sub lets. Indicative EPC's have been produced for these areas that can be reviewed within the appendices.

Club Quarters as a brand have a low energy policy across the board facilitated by simple easy to use systems controls and low energy lighting throughout. Previous projects have shown that Club Quarters hotels perform consistently better than best practice energy benchmarks. Club Quarters has a policy of turning off either manually or automatically all mechanical and electrical systems when they are not required due to low demand or rooms being unoccupied.

This is unlike most building operators and most office buildings where systems tend to be left running. The way the buildings are closely man managed as well as electronically controlled is key to the sustainability philosophy. It is even today the most significant measure Club Quarters use to save energy.

In rooms, Club Quarters now connect the HVAC system to a room occupancy sensor so it automatically turns off when the room is vacated which prevents the tampering associated with other forms of setback device. Many central systems are on time clocks, along with lighting zones, CO sensors or other devices to regulate their use with actual demand. This all works within a policy of utilising passive design first, for example, where having opening windows discourages the use of air conditioning systems when appropriate.

Within the planning submission services and building envelope construction options have been reviewed for a range of renewable energy technologies and insulation types with the aim of enabling the building to meet the Low and Zero Carbon (LZC) benchmarks required under Part L of the Building Regulations, the requirements of Camden Borough Council and BREEAM.

Preliminary modelling of the building has been simulated using Hevacomp software based on the SBEM methodology. The building was first shown to pass Part L2a (2006 as 2010 is not yet available) and then energy efficiency (EE) and (LZC) measures were inputted to demonstrate the potential CO2 saving improvements to demonstrate compliance with the local authorities 10% CO2 saving and BREEAM Very Good requirements.

Passive design and energy efficiency measures (such as increased building envelope insulation values, improve air tightness and lighting and system controls) were then considered. Due to the development being a consequential improvement the energy efficiency measures have not been able to overcome the existing 1990 U-Values of the retained façade. The net result is a slight increase in CO2 emissions of 2.6% over the requirements of a 2006 Part L2a compliant building (although the TER has had to be estimated based on the notional building figures). This then gave a new baseline against which the low and zero carbon (LZC) fuels and technologies were evaluated.

Initially an over arching review was carried out to assess the appropriateness of various technologies. Following this the most appropriate option(s) was then modelled using the Hevacomp SBEM software.

Following the methodology in the London Renewables Toolkit and in reference to the London plan and GLA guidance, the LZCs from the toolkit were evaluated and a **28.2% reduction in CO2 emissions** over the new baseline, which includes the EE measures, was predicted by using a combination of Combined Heat and Power (CHP) and an Air Source Heat Pump system (ASHP). It is therefore proposed that at this stage that CHP and ASHP will be the proposed means of servicing the heating and cooling needs to the building and obtaining compliance with Camden's **10% CO2/Energy savings requirement**.

A preliminary Energy Performance Certificate (EPC) rating has also been estimated for the 5 residential units, the retail sub let and the restaurant sub let. The residential element is currently showing an estimated EPC CO2 index rating of 40 (EPC rating of B) which is very positive when it is considered that due to the internal and external listing of what is an architecturally significant building, very little fabric upgrade can be achieved. This has been achieved by the use of an air source heat pump system and whole house heat recovery ventilation.

The retail and restaurant lets are currently achieving an estimated EPC CO2 index rating of 52 (EPC rating of C) and 46 (EPC rating of B) respectively. Again this has been achieved by the use of an air source heat pump system and whole house heat recovery ventilation, with the option during detailed design to utilise the hotels heating system which utilises CHP.

For the hotel we have opted for the use of a CO2 index rating of 40 within the BREEAM pre-assessment at this stage. It is perceived that the development will need to achieve **BREEAM 'Very Good'** and this rating is currently being targeted (see BREEAM pre-assessment report included within the planning pack).

FUNCTIONAL HIERARCHY

As a commercial hotel it is essential that the building operates efficiently and is reasonably economic to construct and maintain.

Energy systems must serve a functional purpose for the hotel, be capable of effective control and be reliable. These purposes take priority over theoretical efficiency which may not be delivered in practice by unproven energy systems.

Due to the hotels location in a noisy environment a fully controlled air conditioning system is needed for comfort, along with the ability to meet necessary hotelier brand standards. It is the intension however to allow occupants to open windows where they are happy to accept external noise levels. Where this is the case the air conditioning will not be allowed to function at the same time.

The most effective options which meet the space planning requirements of a modern hotel room are fan-coil systems. Normally a hotel of this size would utilise VRF (variable refrigerant flow), fan coils. VRF systems are classified as "air sourced heat pumps" in renewable/low or zero carbon energy parlance. Larger hotels would normally use 4-pipe fan coils or 2-pipe (heating or cooling) with electric heaters for mid season heating. This would traditionally be fed from a boiler and chiller system working in tandem. The advantage however of a VRF system is that it can achieve much improved energy efficiencies.

It is also worth noting that it is currently intended to provide an extraction system to the bathrooms drawing in fresh air into the bedroom from acoustic vents on the window façades. Communal/common areas will be air conditioned by a combination of VRF system and heat recovery supply and exhaust ventilation to achieve an overall Part L pass when compared to the TER, although this is not strictly required due to the refurbishment nature of the site, which would consider the development as a consequential improvement.

These systems are considered as integral parts of the overall strategy as heating and cooling accounts for one of the main sources of energy load in a hotel along with the hot water usage.

PRINCIPAL LEGISLATION AND REFERENCES AFFECTING DESIGN AND OPTIONS

- Camden's local planning policy requirement for 10% reduction of energy through the use of LZC's.
- London renewable toolkit and plan.
- GLA guidance
- Building regulations – specifically Part L2A 2010 which will need to be reviewed when the full planning methodology is produced.

SITE FACTORS

The principal factors affecting this site are:

- The high ambient acoustic environment which makes the use of opening windows for natural ventilation and cooling generally impractical.
- The closed nature of the site making it not possible for wind power and potentially difficult for ground source energy.
- Heritage existing building.
- Provision of emergency and back up services.
- Providing solutions that give the least visual impact on the surroundings.

METHODOLOGY

An energy strategy was carried out for the proposed hotel to give an overview for the predicted energy emissions and consumptions for the development including reductions through the use of energy efficiency measures and low or zero carbon technologies (LZC's).

To gain detailed calculations for the proposed hotel, the building was modelled using simulation software in the form of Hevacomp SBEM.

A building baseline energy consumption was produced, which has proven to be compliant with current building regulations Part L 2006 (note the calculation methodology for Part L 2010 is yet to be released), to outline the minimum standards at which the building must be built. It establishes the building's energy target emissions against which all other systems will be measured.

Following this target emissions and energy efficiency measures are then taken into account giving a second baseline which is used to measure the effect of the renewable energy technologies with the aim of enabling the building to meet with the planning targets in the form of the necessary 10% CO_2 reductions from the 2006 Part L base line.

Finally options for energy systems were then examined and recommendations made.

ENHANCED ENERGY EFFICIENCY FEATURES

It has not been possible, due to the retained 1990 façades, to reduce the baseline energy consumption by applying energy efficiency measures with higher performance than standard building requirements. We have however implemented the following:

- Improved electric lighting controls
- Weather compensating heating & cooling controls
- Occupancy based heating, ventilation and air conditioning controls
- Improved thermal insulation values for the building envelope - roof, walls and window systems where possible and as installed from new
- Improved air tightness over the minimum required baseline where possible

These energy efficiency measures would normally create a new emission baseline against which each LCZ technology would be assessed to establish which technology would have the greatest impact towards meeting the local authority's requirement to gain a further 10% reduction in CO_2 over the TER. However in this instance we have referred directly back to the TER figure for the overall savings.

LOW AND ZERO CARBON TECHNOLOGY OPTIONS SUMMARY

1. VRF Air conditioning (air sourced heat pump system)
Manufactured by Daikin, Mitsubishi etc., these systems take low grade heat from outdoor air and upgrade it using a reverse refrigeration cycle and transfer it to the building. In doing this they use electricity consuming only 30% of the total energy delivered. The system is highly efficient and viable, using proven technology to provide reliable heating and cooling in a form that is easily applied to the hotel environment to meet brand standards.

2. Combined heat and power (CHP) unit
In effect, a micro power station, a small natural gas powered internal combustion engine generates electricity. In so doing heat is also generated, which can be used to provide domestic hot water and heating as the primary boiler.

These units are highly effective as they reduce the base load electricity demand from the grid supply while also contributing to the hotel's considerable hot water and heating demand. The CHP's produces electricity on site which removes the transmission losses associated with taking electricity from the grid.

CHP is actively encouraged by Government policy via "feed in tariffs" which reduce the electricity bills and help to bolster the local energy grid. CHP is also specifically mentioned within planning policy as an acceptable and appropriate means of meeting the authority's energy targets.

The system is highly efficient but there is increased maintenance which requires management through a contract over the period of its life.

This is a highly efficient and viable option.

3. Solar thermal collectors
Solar panel systems rely only on the sun to generate hot water and are thus truly "renewable".

A proven technology that suffers from sunlight availability being at a minimum when it is most needed.

The capability is further limited in a hotel application by the problem of overheating in summer if the panels provide more heat than is needed. This limits the savings which can be gained and can generally only contribute a small proportion to energy and CO2 savings.

4. Photovoltaic's
Another solar system which converts sunlight directly to electricity.

In general, these systems are not viable unless capex, grant aided or combined with a feed in tariff exportation strategy to the grid. Grants are limited and this is generally not considered viable technically or commercially due to the limited roof space available.

5. Ground sourced heat pump
Extracting energy from the ground using thermal piles or aquifer heat extraction has been found to be impractical for this site due to the site constraints, geology and the economics involved.

6. Wind
Due to its city location wind is not a practical solution that will provide significant savings in this case. Also due to the local area planning requirements in relation to protected views a wind turbine would pose a significant feature on the roof from the Lincoln's Inn Fields side.

7. Biomass combined with 4 pipe fan coil system
A biomass system serving the hotel would have the potential to meet the all or a portion of the 10% requirement. However, the management and assured quality of small scale fuel deliveries, added to the need for regular maintenance of a relatively small system within a city centre make this commercially and sustainably unattractive against the alternatives for the hotel development.

DISCUSSION

The most suitable options for the site are therefore ASHP combined with CHP to produce the 10% reductions required.

Following the methodology in Camden Councils Planning Requirements, the LZCs were evaluated in association with Approved Document Part L2A (2006) with the best potential solution (with a maximum of 34% reduction in the annual energy consumption and 28% reduction in annual CO2 emissions over the new EE site baseline being predicted) being a Combined Heat & Power (CHP) system in conjunction with an Air source heat pump (VRF), system.

These two LZC's technologies would work independently to reduce the buildings energy consumption, with the CHP sized against the summer time hot water demand and minimum electrical load and the ASHP producing heating or cooling to the occupied spaces.

FINAL PROPOSAL

The proposal is to utilise two technologies – VRF air conditioning and a combined heat and power unit to provide a maximum of 35% reduction in the energy and 28% in CO_2 demand over the revised baseline demand (or the TER) following the application of energy efficiency measures.

Taking forward the energy efficiency measures and CHP & ASHP technologies as described above; below shows both the energy consumption and the carbon emissions (as required for planning) savings in graph form for the development, giving the percentage reduction against a building regulations Part L 2006 compliant building.

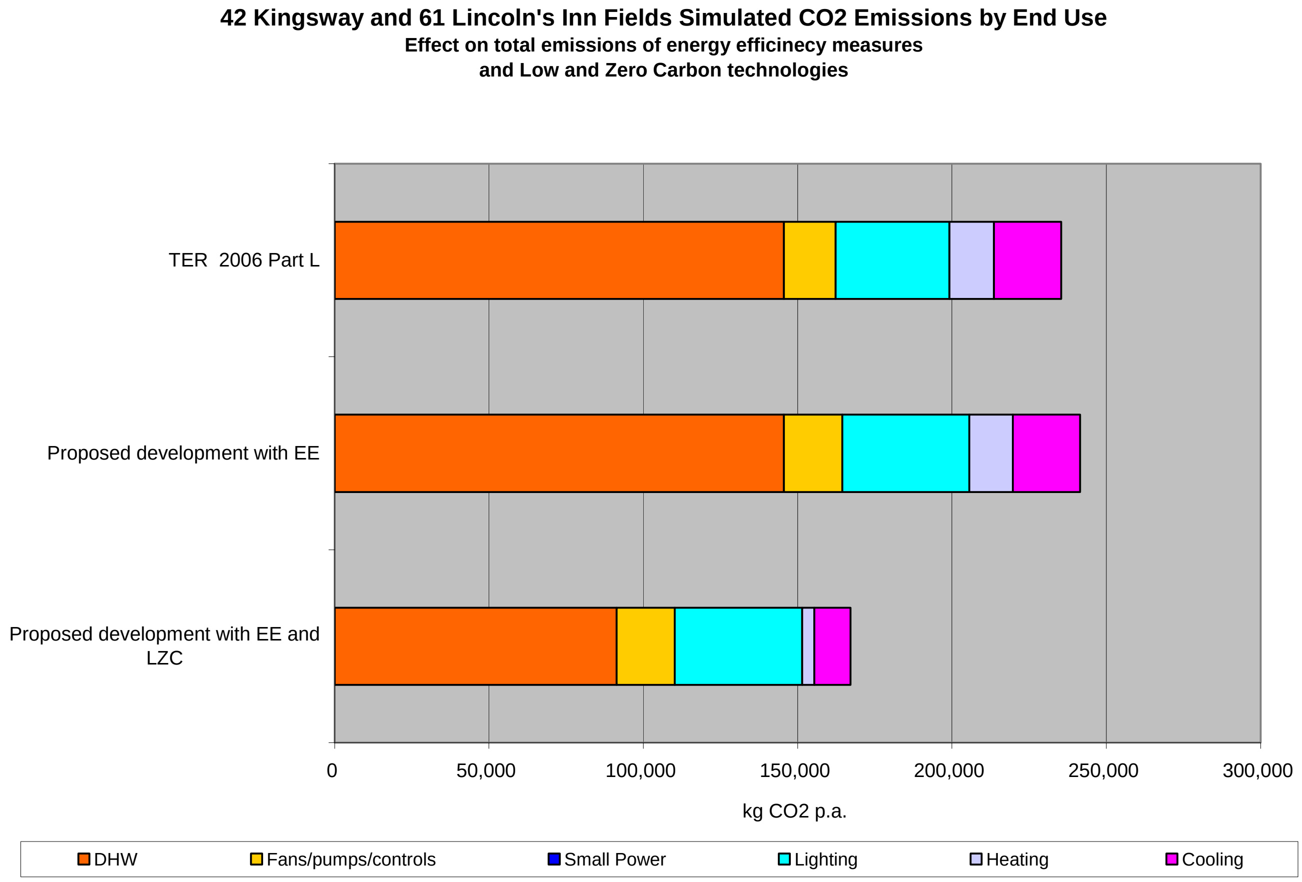


TABLE 1.0: 61 LINCOLN'S INN FIELDS – CO2 EMISSIONS BY END USE

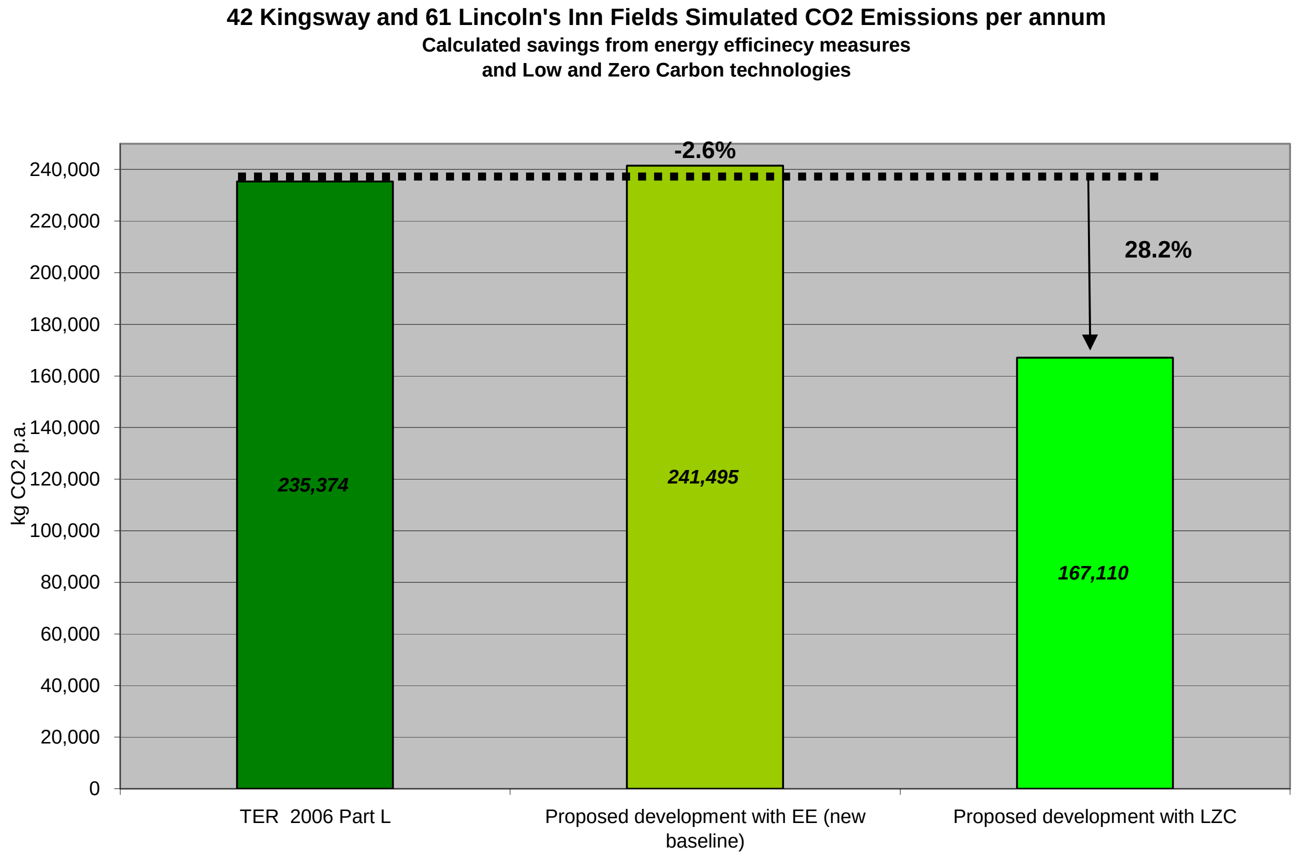
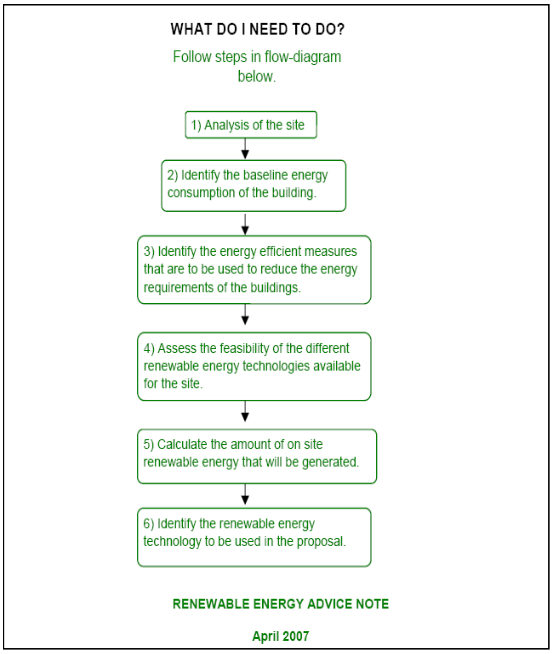


TABLE 2.0: 61 LINCOLN'S INN FIELDS – CO2 EMISSIONS OVER TER

3. INTRODUCTION

METHODOLGY

The London Renewables Toolkit (LRT) calculation methodology meets most Borough Council's stipulated outline planning requirements, as shown in the figure below:



THE ENERGY HIERARCHY

The Energy Hierarchy is to help guide decisions about which energy measures are appropriate in particular circumstances. When each step of the Hierarchy is applied in turn to an activity, it will help ensure that Camden's and the rest of the UK, energy needs are met in the most efficient way. The Energy Hierarchy is the foundation on which this report is developed from. The three steps are:

1. Reduce Demand (*Be Lean*)
2. Apply Energy Efficiency *(Be Clean)*
3. Supply from Renewable or Low Zero Carbon Technologies *(Be Green)*

LOCAL POLICY FRAMEWORK

A detailed thermal modelling of the buildings has been carried out using institutionally recognised software which incorporates SBEM.

Being a significant London Borough there are many documents which can be referenced which highlight the relevant sustainability policies for Camden and its surrounding areas. A number are mentioned below;

- Camden UDP polices
- London Sustainability Framework
- PPS1
- PPS21
- GLA Planning guidance notes
- Sustainability Appraisal - Camden Borough Council (July 2006)
- London Plan
- Sub Regional Development Framework Central London

Options have been reviewed for a range of renewable energy technologies with the aim of enabling the building to comply with current Buildings Regulations (Part L 2010), The London Plan (GLA) and the requirements of the London Borough of Camden. The relevant energy policies are as follows:

Camden UPD Policy – Renewable energy

Planning permission will not be granted for development unless:

1.63 The Council particularly welcomes developments that have low or zero emissions. There are many ways of influencing the extent to which developments are energy efficient and reduce carbon dioxide emissions. These include orientation, passive solar gain, density, location, choice of energy supply, use of renewable energy, choice of heating and ventilation systems, control systems and choice of materials. Developers should give details of how they have addressed these issues in any design statement that is to be submitted under policy B1. One way of testing whether a development incorporates sustainable design is to carry out a BREEAM (Building Research Establishment Environmental Assessment Method) assessment. Further information on BREEAM assessments, including when one will be required, is set out in supplementary guidance. Camden Replacement Unitary Development Plan Section 1 - Sustainable Development 33

1.64 The Government's Climate Change Programme has set a target that 10% of the United Kingdom's electrical requirements are to be met from renewable resources by 2010, and 20% by 2020. Therefore, the Council expects major developments of 1000m2 or 10 housing units or more to incorporate renewable energy production equipment to provide at least 10% of predicted energy requirements. The most likely sources of renewable energy for developments in Camden are solar water heating, photovoltaic cells, small-scale wind turbines, passive solar energy, natural ventilation and borehole cooling. Developers should give details of how they have addressed these issues in any design statement that is to be submitted under policy B1. Although not strictly renewable, combined heat and power through its far greater energy efficiency, also has enormous potential for reducing carbon dioxide emissions. It can be used at both large and small scale. Special regard should also be paid to the Greater London Authority's 'The Mayor's Draft Energy Strategy', (2002). Further guidance on energy matters and sustainable buildings is contained in supplementary guidance and the Camden Green Buildings Guide.

London Plan

Improving the use of Energy Policy, 4A.4, Energy Assessment, requires an assessment of energy demand and carbon dioxide emissions from major development, which demonstrate the expected energy and carbon dioxide savings from renewable energy measures.

Improving the Use of Energy Policy 4A.7, Renewable Energy, states that there is a presumption that developments will achieve a reduction in carbon dioxide emissions of 20% from on site renewable energy generation unless it can be demonstrated that this is not feasible.

The forthcoming revised 'London Plan'. Section 5.40 of this document states that:

'*Table 5.1 contains targets for the installation of different renewable energy technologies to increase London's generation of both electricity and heat from such sources up to 2025. The Government has adopted a UK wide target for 15 per cent of total energy to be generated by renewable sources by 2020, and Table 5.1 represents London's contribution to this 2020 target and beyond. By 2020 it is expected that London would be able to supply approximately 5 per cent of its energy needs from renewable energy (not including transport), however, this percentage could be higher if London continues to improve energy efficiency and hence reduce the absolute level of energy consumed in the capital*'.

Table 5.1 'Targets for installed energy capacity generated from renewables' on page 125 of this document details air-source heat pumps (copy of table attached), and therefore it would appear that ASHP's will be an acceptable renewable technology, as long as the 'Energy Hierarchy' has been followed (detailed below):

The London Plan (both current and future) requires major commercial and residential developments to demonstrate that consideration has been given to the following ranking method for heating and where necessary cooling systems:

- Passive design
- Solar water heating; then
- Combined heat and power for heating and cooling (i.e. trigeneration), preferably fuelled by renewables; then
- Community heating and cooling; then
- Heat pumps; and then
- Gas condensing boilers.

Extract 1:

London Plan targets:
60% reduction of CO2 emissions by 2050:
• 15% by 2010
• 20% by 2015
• 25% by 2020
• 30% by 2025.
(against 1990 base)
20% reduction in CO2 emissions from on site renewable energy generation for new developments.
Identify sites for zero carbon developments.
99 MW installed capacity electricity generated from renewable by 2010 rising to 375.1MW by 2020.

London Plan performance indicator:
Production of 945GWh of energy from renewable sources by 2010 including at least 6 large wind turbines.

Based on the London plan and Camden supporting documentation this project aims to provide a minimum 10% of its predicted energy requirements & CO2 saving from renewable sources and achieves a BREEAM 'Very Good' rating.

Finally it is worth noting that another key document that has been referred to in the compilation of this report is the GLA Energy Team Guidance on Planning Energy Assessments (Version 1, October 2009) along with the London Renewables Toolkit (LRT). These documents have been used as guidance in both calculation and representation of information within this report.

A detailed model of the building has been carried out and this report is therefore based on the modelled results for the building with compliant building standards, energy efficient measures and local renewable energy.

Using this model we will review potential energy saving methods to provide the most sustainable building possible within the constraints of the site and hotel brand. Below we outline in detail how we aim to achieve the savings to align the project with Camden's planning policy.

The heating and hot water load for this type of development is significant and therefore it is likely that the best-fit renewable for this project will be heating based option (see conclusion for initial calculations).

4. RENEWABLE AND LOW CARBON TECHNOLOGIES

THIS SECTION OF THE REPORT GENERALLY REVIEWS A NUMBER OF RENEWABLE AND LOW ENERGY TECHNOLOGIES WHICH COULD POTENTIALLY BE SUITABLE FOR THIS DEVELOPMENT.

BIOMASS

Overview

Biomass is the burning of any plant-derived organic material (such as wood) that renews itself over a short period to generate energy. This fuel type is usually used for heating.

Since the CO_2 released during the burning process is offset by the CO_2 absorbed during the life of the biomass source, biomass is considered to be close to carbon neutral.

Typically a biomass system will burn wood in either a chip or pellet form instead of the conventional gas system. Biomass can save large amounts of carbon at a relatively low capital cost.

Non-domestic biomass boilers mainly use either wood pellet or wood chip burners. Wood pellets are comprised of wood chips and sawdust that are compacted into smaller volumes. This means that they have lower moisture content and they can be produced in a consistent size. However wood pellet fuel is more expensive costing around 4.5p/kWh (price varies with required load). Wood chips are a cheaper source of fuel costing around 2.5p/kWh (price varies with required load).

In common with other types of combustion appliances, biomass boilers are potentially a source of air pollution. Pollutants associated with biomass combustion include particulate matter (PM_{10}/$PM_{2.5}$) and nitrogen oxides (NO_x) emissions. These pollution emissions can have an impact on local air quality and affect human health.

Recently, biomass has been rejected by many councils as a means of obtaining the on-site renewable contribution. This is because of their associated flue emissions (which can be significantly higher than gas fired boilers) and the difficulty of ensuring the boiler will operate at its optimum efficiency, which is often quoted by designers at the initial design stages. Biomass flue emissions are often difficult to control because the quality of fuel can vary significantly between suppliers. Furthermore, there are concerns that extensive use of biomass within cities will add to traffic congestion and pollution.

Rules of Thumb

- The use of biomass is becoming increasingly common in Europe and the UK.
- The estimated current cost Wood Pellet 4.5 p/kwh*
- The approximate cost of biomass boilers is £500 per kW (for a boiler with an output of up to 50 kW)

Advantages

- ✓ Near "Carbon neutral"
- ✓ Will provide large carbon reductions within developments with a large heating load, such as this project
- ✓ Economic alternative to fossil fuels
- ✓ Wide variety of sources

Disadvantages

- ✗ Storage areas required for wood pellets
- ✗ Slower start up time compared with fossil fuel boilers
- ✗ Requires good access areas for fuel deliveries
- ✗ Must be sized to prevent stop starting as maintenance becomes an issue
- ✗ Concerns with quality of fuel and the impact in Air Quality

Site Specific

Since the heating and hot water will be the main energy profile for this type of development, a low carbon technology such as biomass boilers would in theory help provide a large percentage of the required 10% on site renewable energy.

However due to air pollution quality issues within London, site access for the delivery of the solid fuel, local storage space of the fuel on site and the greater energy saving potential by the use of CHP, Biomass has been discounted from being a feasible technology to implement.

For these reasons it is not proposed to use biomass heating for this project.

GROUND SOURCE HEAT PUMP (GSHP)

Overview

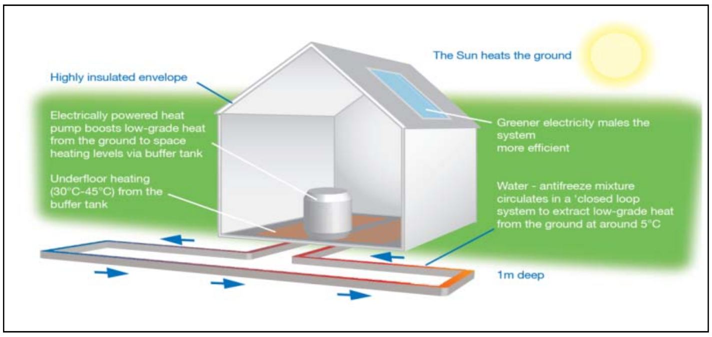
GSHPs transfer heat from the ground into a building to provide space heating and/or pre-heat hot water.

Closed Loop GSHP

Closed loop GSHP are the more common systems with the technology being more readily available (for example does not need an extraction license from the Environmental Agency).

A closed loop installation consists of plastic piping which is buried in the ground and connected to a pump. A mixture of water and antifreeze is passed through the looped pipes where it absorbs heat from the ground. This fluid then flows in to an electrically powered heat pump before discharging back to the ground.

There are two types of closed loop ground source heat pumps : vertical closed-loop and horizontal slinky loops(as pictured below) - all of these require large areas of land. Slinky loops are buried approximately 1-2m into the ground.



Vertical loops require bore holes to be drilled deep into the ground (typically around 100m in depth).

GSHP's require extensive ground works which incur high capital costs.

Open Loop GSHP

Open loop GSHP systems work in a very similar manner to closed loop GSHPs, with the difference being that aquifer water is used as a cooling and/or heating medium. Bore holes are drilled down into the aquifer where ground water is pumped to a heat exchanger and the energy is extracted from the water. The water is then passed back down (re-injected) to the aquifer. The direct contact of the source water through the heat exchanger makes it more efficient and the number of bore holes on an open system can be much smaller than a closed loop system for the same output capacity. Due to extracting water from the aquifer, a license is required from the Environmental Agency.

Rules of thumb

- The cost of a GSHP is approximately £800 - £1400 per kW of peak heat output (not including the distribution system) though the cost of testing the soil and ground works to create the boreholes/trenches incurs an additional cost.
- For each kW of electricity used to run the heat pump it is estimated that 3-4 kW of heat can be produced.

Advantages

- ✓ Can provide significant carbon savings in the correct application e.g. mixed use schemes with significant heating and cooling loads
- ✓ Reduced running costs

Disadvantages

- ✘ Large area of land required for bore holes or loops
- ✘ Can be expensive (capital cost)
- ✘ Not generally recommended for heating only (or cooling only) systems. A site specific study is required by a bore hole specialist to determine whether soil conditions are favourable for heating only systems. It should also be noted that this Site would need a significant heat extraction from the earth in order to provide the 20% on site contribution.

Site Specific

Sufficient land is not available for closed loop ground source due the location in London. We are also working with an existing building with existing parts of the building going deep into the ground. Installing closed loop systems through existing structure and waterproofing is not a practical proposition.

For example, for a vertical bore hole installation, 1 number 100m bore hole would provide around 4 - 5KW of heat (30-40W per linear metre is typical, depending on ground conditions). The bore holes typically need to be located apart at 6metre centres. In order to provide the required 10% on site renewable contribution around 85% of the total developments heating load would need to be provided by ground source heat pumps (which equates to a heating load of around 250KW). This means around 65 bore holes (250 KW /4 KW) would be required with a ground area for the bore hole array (taking into account of the 6m distance between piles) of 60metres by 40metres. The site does not have this type of ground area available particularly when considering existing structural constraints. Due to the above this is not a viable option for this development.

Open loop schemes are best suited for much larger developments which have a near equal energy balance between heating and cooling (such as mixed use developments or the hotel we are looking at here). It should be noted that the environmental agency will generally not allow heating only or cooling schemes on the grounds that they can affect the aquifer temperatures. Due to the practicalities of installing an open loop system and perceived difficultly getting a licence within the area of the hotel, GSHP open loop has been discounted at this stage.

VRF/AIR SOURCE HEAT PUMP (ASHP)

Overview

An ASHP is regarded as a renewable/low or zero carbon technology in the GLA and EC guidance. An ASHP works by converting energy from the outside air into heat. This can be used for heating in the winter, but can be reversed for cooling in the summer months.

ASHP's work by extracting heat from the outside air and passing it through a refrigeration compressor cycle which increases its temperature. The heat is then distributed to the rooms. The opposite is applicable to cooling mode.

An ASHP will typically have a lower COP (system efficiency) than a GSHP due to the lower temperature of outside air when compared to the earth. However, the capital cost of an ASHP is much lower, is easier to maintain than ground source, a tried and tested technology and there is no need for any extensive ground works which are an issue with this site.

Rules of thumb

- A typical 5kW ASHP will cost around £6000 - £8000 including installation.
- For each kW of electricity used to run the heat pump it is estimated that 3-4kW of heat can be produced (depending on the outdoor air temperature).
- For a typical winter`s day, the energy efficiency (COP) for an air source heat pump will be 3.5 to 4.0.

Advantages

- ✓ Cost effective renewable for heat dominant buildings, such as this development
- ✓ Can be used, without any risk, within a heating only application. This is particularly relevant for this project. (see comments on ground source in a heating only application)
- ✓ Reduced running costs
- ✓ Tried and tested technology
- ✓ Easy to maintain

Disadvantages

- ✘ COP(efficiency) is dependent on air temperature
- ✘ Slightly lower COP than ground source heat pumps

Site Specific

Since the main energy load for this site is heating, air source heat pumps could provide a significant on-site renewable/LZC energy contribution. Initial calculations indicate that an air source heat pump installation alone could provide up to 5.6% on site renewable energy contribution.

The condensers and associated screening will be designed in accordance with local Planning requirements with respect to acoustics.

We see ASHP as a viable technology for this site.

COMBINED HEAT AND POWER (CHP)

Overview

Combined Heat and Power is an electricity generator where the waste heat is captured and then re-used within a building.

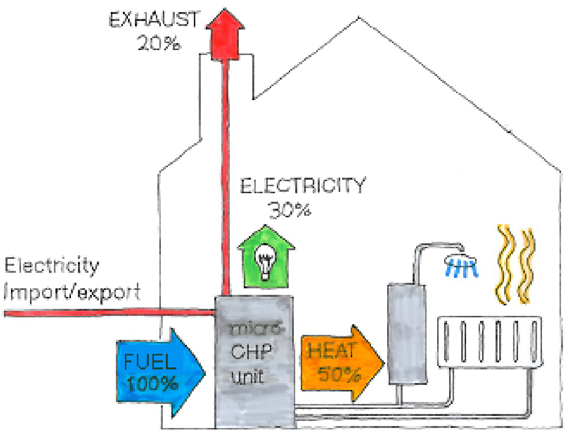
Typically, for CHP engines used within buildings, the associated electricity efficiency is between 25-30% (depending on the size of the engine), with 40-50% of the waste heat being re-usable for heat distribution within a building (the remainder is lost heat through the flue).

There are renewable CHP engines available which use wood pellets as a fuel source. However this technology is in its infancy and is very large when compared to the gas fired engine. Biomass CHP consequently is not appropriate for this project : see http://www.talbotts.co.uk/bgen.htm for a typical biomass CHP unit.

Gas is the fuel predominately used for CHP systems within buildings. Although this is not a renewable technology, it can provide significant carbon savings in the right application and is classed as a low or zero carbon technology applicable for use in achieving CO_2 savings.

For CHP to be effective in terms of carbon reduction and cost effectiveness it is very important that the engine operates for long periods of the day, throughout the year.

For heat dominant buildings, such as this project, this means that either a large hot water storage is provided (as with hospitals) or where a swimming pool needs to be served (as with a leisure centre).



Rules of thumb

- In general, 1KW of gas input creates 0.28KW of electricity, 0.4KW of usable heat (with the remaining 0.22KW being lost energy through the flue).

Advantages

- ✓ Using a gas-fired CHP system can produce significant savings per year if used in buildings with a significant constant heating/hot water load profile, such as hotels, hospitals or leisure centres.

Disadvantages

- ✗ Requires predictable and constant heating/ hot water loads e.g. significant hot water storage
- ✗ Gas fired CHP is not a renewable technology
- ✗ Energy load (heating) will conflict with the preferred renewable option for this development (air source heat pumps).

Site Specific

The use of CHP is viable for this development due to the demand profile associated with a hotel. The high heating and electricity base load for the hotel means this solution would provide significant energy savings as the system could be run over long periods of time. This solution could be a viable option.

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WIND

Overview

Wind turbines harness the power of the wind to produce electricity through circular motion. They can produce electricity without carbon dioxide emissions and range in outputs from watts to megawatts. The most common design has three blades mounted on a horizontal axis (Horizontal Axis Wind Turbine /HAWT), which is free to rotate in to the wind on a mast. The blades drive a generator either directly or via a gearbox (generally for larger machines) to produce electricity. The electricity can either link to a distribution network or charge batteries. An inverter is required to convert the electricity from direct current (DC) to alternating current (AC). Alternative designs of turbine are available such as the Vertical Axis Wind Turbines (VAWT) which can have advantages aesthetically and are not reliant on a specific wind direction, but can be less efficient.

Roof-mounted wind turbines are also an option, but if used structural considerations need to be taken into account due to the weight and vibrations that will be incurred. Roof-mounted wind turbines generally require an average wind speed of 3m/s to be viable, and larger, stand-alone wind turbines typically require 6m/s to be viable.

Wind Turbine at Hill Close Gardens

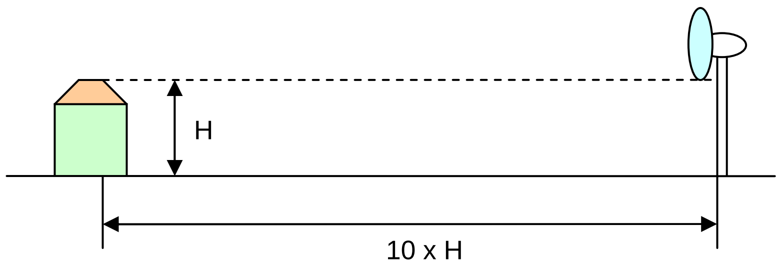
Wind turbines work best in laminar flows. If turbulent wind, which is caused by obstructions etc is being passed through the wind turbines blades then productivity can be dramatically reduced.

As a general rule of thumb a distance of 7 times the rotor diameter should be allowed for between wind turbines in the prevailing wind direction. In the direction perpendicular to the prevailing wind the distance can be reduced and would be recommended to be in the order of 4 times the rotor diameter. For a 15kW wind turbine the blade diameter is approximately 9m (Proven WT15), this would mean a distance of around 63m would be recommended between turbines in the prevailing wind direction, and roughly 36m apart perpendicular to the prevailing wind direction.

If a wind turbine is placed too close to an obstruction then it can cause a lower productivity. This is due to the obstruction creating turbulent air as the wind passes by, and for optimum output wind turbines require laminar flow. As a guide, a wind turbine should be about twice the height of any obstructions in the immediate front of it (at least in the prevailing wind direction).

For any obstructions in front of the wind turbine the distance between them should be approximately 10 times the height of the obstruction, as shown below.

It is also important to be aware that there should not be any obstacles too close to the wind turbine in the non-prevailing wind directions. The wind will not always be in the prevailing wind direction and as such a distance of at least 2 times the height of the nearest obstruction should be left in order to allow for reasonable electricity production.



Advantages
- ✓ Electricity generating renewable
- ✓ Zero carbon technology
- ✓ Visual statement of sustainability

Disadvantages
- ✗ Not suitable for Listed Buildings with protected views
- ✗ Planning permission can be a difficult and lengthy process
- ✗ Wind is an irregular source
- ✗ Can be noisy, especially if a gearbox is incorporated

Site Specific

Due to the location constraints within London, the wind turbine could not be situated in any preferred location to capture the wind. Also the view from Lincoln's Inn Fields is protected making inclusion of a significant enough turbine not possible. This is not a viable technology for this site.

PHOTOVOLTAICS (PV)

Overview

Photovoltaics (PV) or solar cells, as they are often referred to, are semiconductor devices that convert sunlight into direct current (DC) electricity.

Groups of PV cells are electrically configured into modules and arrays which can be used to charge batteries, operate motors and power any number of electrical loads. With the appropriate power conversion equipment (inverters) PV systems can produce alternating current (AC) compatible with any conventional appliances and operate in parallel with the utility grid.

PV systems require only daylight to generate electricity (although more is produced with more sunlight). Therefore energy can still be produced in overcast or cloudy conditions and used successfully in all parts of the UK.

Ideally, PV panels should face between South-East and South-West, at an elevation of about 30-40º. However, in the UK, even flat roofs receive 90% of the energy of an optimum system. They are particularly suited to buildings that use electricity during the day and that are occupied during the summer.

Rules of thumb

- On average 1 m^2 of roof PV array will produce about 100 kWh per year
- 10m^2 of panel could save up to 800 kg of CO_2 per year
- 10m^2 of PV panels would cost in the region of £10,000

Advantages

- ✓ Electricity generating renewable
- ✓ Zero carbon technology
- ✓ Visual statement of sustainability
- ✓ Electricity is generated during daylight hours
- ✓ Electricity can be stored in batteries during the day for use in the evenings.
- ✓ Electricity can be put back into the grid enhancing it and also gaining a preferential p/kW rate due to feed in tariff policy.

Disadvantages

- ✘ Obstructions will have a dramatic effect on the productivity of the panels
- ✘ Best results produced when there is a clear sky and direct sunlight
- ✘ Expensive technology, requiring large areas for significant production

Site Specific

There is limited space on the roof that could be used to locate the PV's.

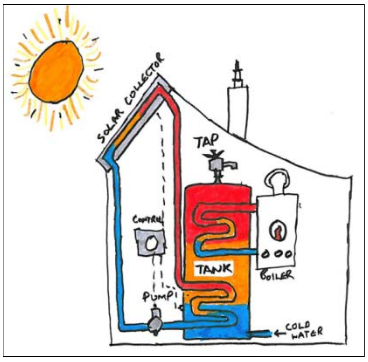
However since the electricity demand for this development during the day would have a constant base load, then the PVs energy produced could be utilised throughout the day and this would mean it is a viable option for this development.

The additional benefits of the CHP make it a more preferable option and due to the space that could be allocated to PV (which is also predominately housing life safety equipment) this technology is not a viable solution for this site.

SOLAR THERMAL

Overview

Solar thermal technologies generate hot water from the sun's energy through the use of solar collectors. The sun's heat energy is accumulated by the solar cells and then water is pumped through these thus heating the water. The heated water is then stored or distributed for domestic use. These systems tend to be incorporated on to roof space so that they are clear of obstacles (obstructions on the roof can have an effect on the solar cell array). As with photovoltaic panels, the solar collectors are more effective if they are in a South-facing position.



There are two main types of Solar Thermal system; flat panel and thermal vacuum tubes. Flat panels consist of a flat "radiator" absorber, covered by glass and insulated. Their efficiency depends on the insulation properties and type of construction. More expensive double-glazed units have a better efficiency, so that a smaller area of solar thermal panels is required – a compromise would need to be made between efficiency and cost. Solar thermal panels are especially worth considering for new buildings, since they can be effectively built into roof structures at the construction stage.

Thermal vacuum tubes are a more recently developed technology designed for obtaining heat from the sun. These have been developed over the last thirty years into units that are now up to 90% efficient. Water is passed through an evacuated tube, which contains a black absorber plate. Vacuum tubes are more efficient and therefore a smaller area of collector is required. Solar vacuum tubes are capable of operating at higher working temperatures than flat plate collectors. Thermal losses for vacuum tubes also tend to be lower than those of flat plate collectors due to improved heat insulation. The vacuum provides insulation, and this allows the water to be heated to higher temperatures and remain very effective even on cloudy days. The optimum generation tends to occur during the summer months.

Rules of thumb

- Approximately 100 litres of water can be heated daily per m^2 of panel
- The payback period could be as low as 3 years but can also be high
- Flat Plates cost approximately £1500 - £2500 per m^2 of collection area
- Thermal Vacuum Tubes cost approximately £2000 and above per m^2 of collection area

Advantages

- ✓ Hot water is produced during daylight hours
- ✓ Water can be stored during the day for use in the evenings and following morning.

Disadvantages

- ✗ Obstructions will have a dramatic effect on the productivity of the panels
- ✗ Best results produced when there is a clear sky and direct sunlight
- ✗ A high efficiency panel comes at a high cost

Site Specific

The building could make use of solar thermal collectors. They could provide a proportion of the hot water demand, which could contribute towards the 10% target although not significantly. A supplementary hot water generator would need to be provided as well in order to meet peak demand.

Solar thermal panels will not provide significant carbon savings and a better renewable for this project would be one that offsets the room heating load such as air source heat pumps or CHP as well as the hot water. If solar thermal panels are to be considered further, they will only be introduced if detailed calculations show any shortfall in the required 10% renewable contribution currently being provided by the air source heat pumps & CHP (see conclusion). As with PV's locating them on the small roof next to the life safety plant will be difficult.

Depending on the final sustainability solution taken forward, this technology may starve other solutions such as CHP or Biomass reducing or removing the summer HWS load which these technologies need to produce their energy reductions.

5. CONCLUSION

This study has considered a number of efficient / renewable technologies for inclusion into the proposed development of the hotel at Lincoln's Inn Fields. When considering the information from previous sections and the supporting information provided within the appendices of this report;

The dominant energy load for this development is for heating and hot water therefore a combined heat and power system is the preferred on site renewable option in combination with ASHP. Initial calculations based on institutionally recognised energy bench mark figures indicate that the 10% renewable energy and CO_2 contribution can be provided by CHP & ASHP.

If further detailed calculations to be undertaken later on in the design process show any shortfall in the 10% renewable energy contribution provided by the CHP & ASHP, the extra contribution will be made up using PV and/or solar thermal panels. The site would then be reviewed in detail as to where the panels could be located. However we see this as unlikely.

Excluding small power load, which is the industry standard, we are currently achieving a 34% plus energy saving from the 2006 Part L target. It is also worth noting that the Low or Zero Carbon (LZC) technologies used (CHP and ASHP) are achieving a 28% plus carbon reduction via the renewables/LZC's.

Along with the Lincolns Inn Field's hotel are a number of apartments, which are to be refurbished in the existing building. These apartments will comply with the building regulations part L2B consequential improvement requirements in regards to the building fabric, where they are not covered by listed or protected buildings and the energy efficiency regulations applicable to the systems to be installed.

A preliminary Energy Performance Certificate (EPC) rating has been estimated for the 5 residential units, the retail sub let and the restaurant sub let. The residential element is currently showing an estimated EPC CO2 index rating of 40 (EPC rating of B) which is very positive when it is considered that due to the internal and external listing of what is an architecturally significant building, very little fabric upgrade can be achieved. This has been achieved by the use of an air source heat pump system and whole house heat recovery ventilation.

The retail and restaurant lets are current achieving estimated EPC CO2 index ratings of 52 (EPC rating of C) and 46 (EPC rating of B) respectively. Again this has been achieved by the use of an air source heat pump system and whole house heat recovery ventilation, with the option during detailed design to utilise the hotels heating system which integrates CHP.

6. APPENDICES

6A. PASSIVE DESIGN, ENERGY EFFICIENCY MEASURES AND ENVIRONMENTAL CONSIDERATIONS

Elements	BEST PRACTICE	
BREEAM Target	VERY GOOD	
EPC Target	Currently not required by Camden Council or country wide planning guidance	
U-Values New Build	Wall	0.2
	Average Window	1.7
	Roof	0.15
	Ground Floor	0.15
U-Values Existing	Wall	0.6
	Average Window	2.7
	Roof	N/a
	Ground Floor	0.2
Air tightness	< 5 $m^3/hr/m^2$	
Ventilation	Natural ventilation to all possible rooms other than those that have planning restrictions or to have controlled environments. Common areas served by mechanical plant.	
Day lighting	20% of occupied spaces adequately daylight (2-3% daylight factor).	
Artificial Lighting Controls	Manual and automatically controlled luminance throughout building.	
Cooling Systems	Passive solar control to be incorporated where possible (solar film). Mechanical cooling to be provided throughout the development.	
Water Usage	PIR water shut off to all public toilets.	
Toxicity of Materials	Eliminate the use of PVC cabling to LSF. Avoid all 'C' rated materials in BRE design Guide.	
Insulation Materials	Use non petro-chemical based insulation materials where ever possible.	
Commissioning and Staff Training/Feedback/and monitoring in use	Post occupancy evaluation of building and energy use patterns to be undertaken and with seasonal commissioning.	

The passive design and energy efficiency measures highlighted in the aforementioned section have been considered, and the predicted CO_2 emissions were recalculated to produce a new baseline figure that includes the energy efficiency measures. These measures reduce the waste of energy within the building, either through heat losses of the envelope or the waste of energy when and where it is not needed via controls and control strategies in the central BMS.

The table below states the current building regulation requirements for building fabric, air tightness and ventilation heat recovery compared to the data which has been modelled. Where possible these requirements have been improved giving a reduction in energy through these energy efficiency measures.

ENERGY EFFICIENCY MEASURES – NEW BUILD ONLY

	Modelled	**Building Regulations Part L 2006**
Air Permeability ($m^3/hr.m^2$)	5	10
Heat Recovery (Fan Coil Unit System)	60%	-
U-values ($W/m^2.K$)		
Wall	0.2	0.35
Floor	0.15	0.25
Roof	0.15	0.25
Door	2.20	2.20
Glass	1.70	2.20

TABLE 4.0: ENERGY EFFICIENCY MEASURES

The associated CO_2 emissions for the predicted energy profile were calculated using the carbon intensity factors (kg CO_2/kWh) from Part L: 2006 of the building regulations (ADL2A) for natural gas and mains electricity.

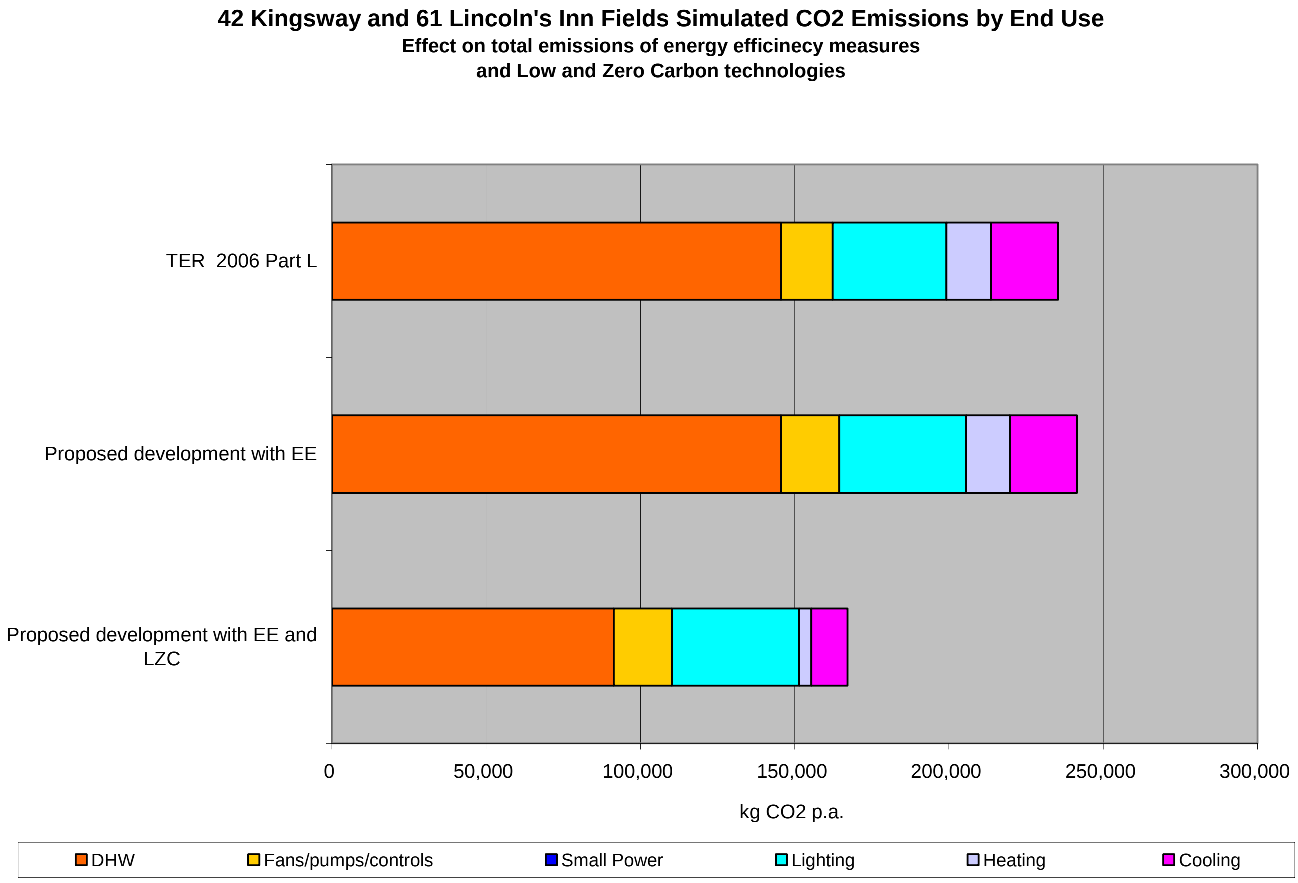


TABLE 1.0: 61 LINCOLN'S INN FIELDS – CO_2 EMISSIONS BY END USE

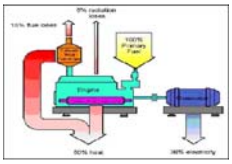
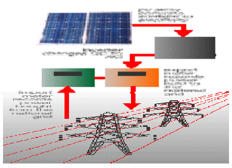
The Energy Efficiency measures additionally applied to the building provides a net negative reduction in CO_2 emissions when compared against the Part L 2006 compliant baseline. This is due in part to the retention of existing 1990 elements.

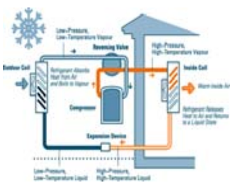
In the following section, using the Renewables Toolkit methodology, the new baseline would usually be used to evaluate the impact of the proposed LZCs for this development. However in this case we are referring back to the TER due to the existing building elements being retained.

6B. PREDICTED INFLUENCE OF LOW AND ZERO CARBON (LZC) FUELS AND TECHNOLOGIES IN THIS DEVELOPMENT'S ENERGY REDUCTIONS

The guidance and methodology detailed in the "London Renewables Toolkit" were used to quantify the potential influence of LZCs on this development's total predicted energy reductions.

Rules of thumb figures were taken from the toolkit where appropriate. Where a more relevant figure is known this has been used. The carbon intensity factors (kg CO_2/kWh) for natural gas and mains electricity were taken from the building regulations Part L:2006 (ADL2A).

LZC Fuel/Technology	Description/Comments	Potential kWh p.a. savings	Potential % energy savings p.a.
Combined Heat and Power (CHP) 	The use of CHP is viable for this development due to the demand profile associated with a hotel. A constant base load of both electricity and heat will mean the unit can run for long periods of the day producing a greater efficiency. The reduction in CO2 and energy from the CHP was calculated from the waste heat energy produced. The electricity was not included as this is the primary produced energy source and not a waste product.	77240	22.6%
Wind Turbines 	The site and context for the proposed building has been examined. As the hotel is in a city centre location with planning restrictions Wind is not a viable option.	N/a	N/a
Photovoltaics (PV) 	Currently PV's are not deemed to be feasible for this site. New feed in tariffs, coming into play in 2010 which would make the payback period of the PV's a viable solution and could be used for the hotel in future developments to comply with ever stringent building regulations. Locating PV's on the small roof in conjunction with other plant will be difficult	N/a	N/a
Solar Water Heating 	The roof space is not ideal for the location of solar water heating panels. However, again due to capital financial constraints an alternative technology is proposed which would compete with this technology. We are not proposing to use any solar thermal.	N/a	N/a

Bio-fuel Heating 	The use of a wood pellet converted bio-fuel boiler would provide a substantial contribution to the overall heating load and would represent a cost effective means of meeting the energy and carbon reduction targets. However due to the city centre location and site restrictions Biomass does not provide a suitable solution for this site	N/a	N/a
Ground Source Heat Pumps (GSHP) Heating & Cooling 	Due to the existing building constraints and the city centre location GSHP is not a viable solution for this site.	N/a	N/a
Air Source Heat Pump 	ASHP's is a viable for this site offering a practical and flexible solution at reasonable cost. This technology alone could not provide the 10% reduction in CO2 emissions required from the council and so a combined solution would need to be investigated.	19139	5.6 %

The passive & energy efficiency measures, such as utilising natural ventilation (where possible) and using improved U values for the fabric beyond those that are required for Part L 2006; imposed a 2.6% addition in CO_2 emission due to the existing building elements. The overall CO_2 emission savings with LZC technologies and energy efficiency measures amounts to 28.2%.

6C. PROPOSED BUILDING ENERGY AND CO2 EMISSIONS RESULTS

From modelling the above LZC technologies against the energy efficient building, a table of energy consumption results can be produced showing the total annual energy saving, and the percent reduction in energy against that baseline energy consumption for each technology.

As is shown in Tables 1.0 & 2.0 below, the LZC technologies can produce the 10% reduction in CO_2 required by planning.

Due to recent developments within the renewables sector and the government's commitment and incentive to install LZC technologies, there are now feed in tariffs (which have superseded available grants) for electricity production (now in place) and heat production tariffs (to be implement in April 2011), which will give annual paybacks against the amount of energy produced from the LZC. This produces feasible annual savings and paybacks for the more expensive technologies regardless of the renewable percent achieved.

It must also be noted that although one LZC may give the best reduction in energy it may not be feasible for the project and if more than one technology is to be implemented then they must complement each other and not fight for the same energy demand or base energy load throughout the year.

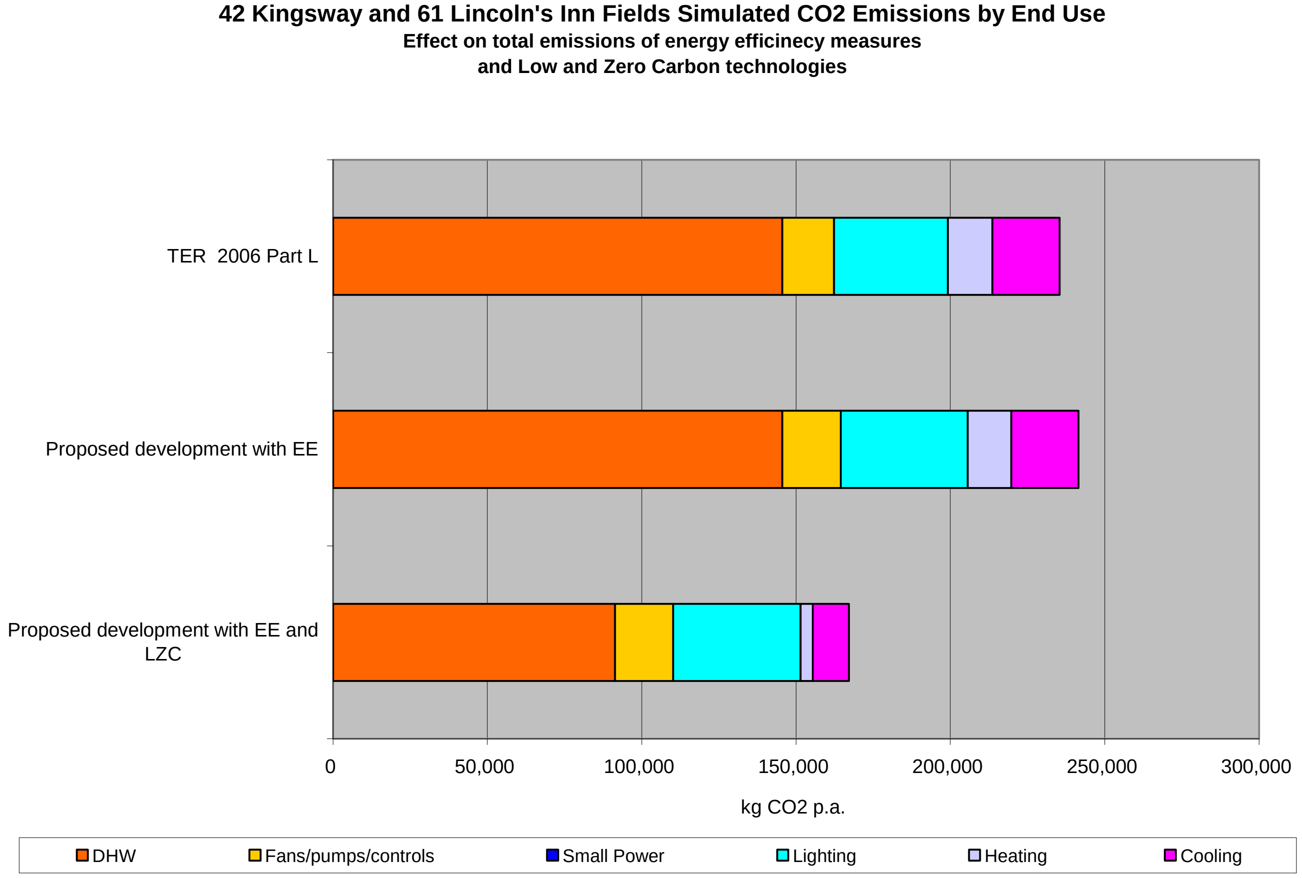


TABLE 1.0: 61 LINCOLN'S INN FIELDS – CO2 EMISSIONS BY END USE

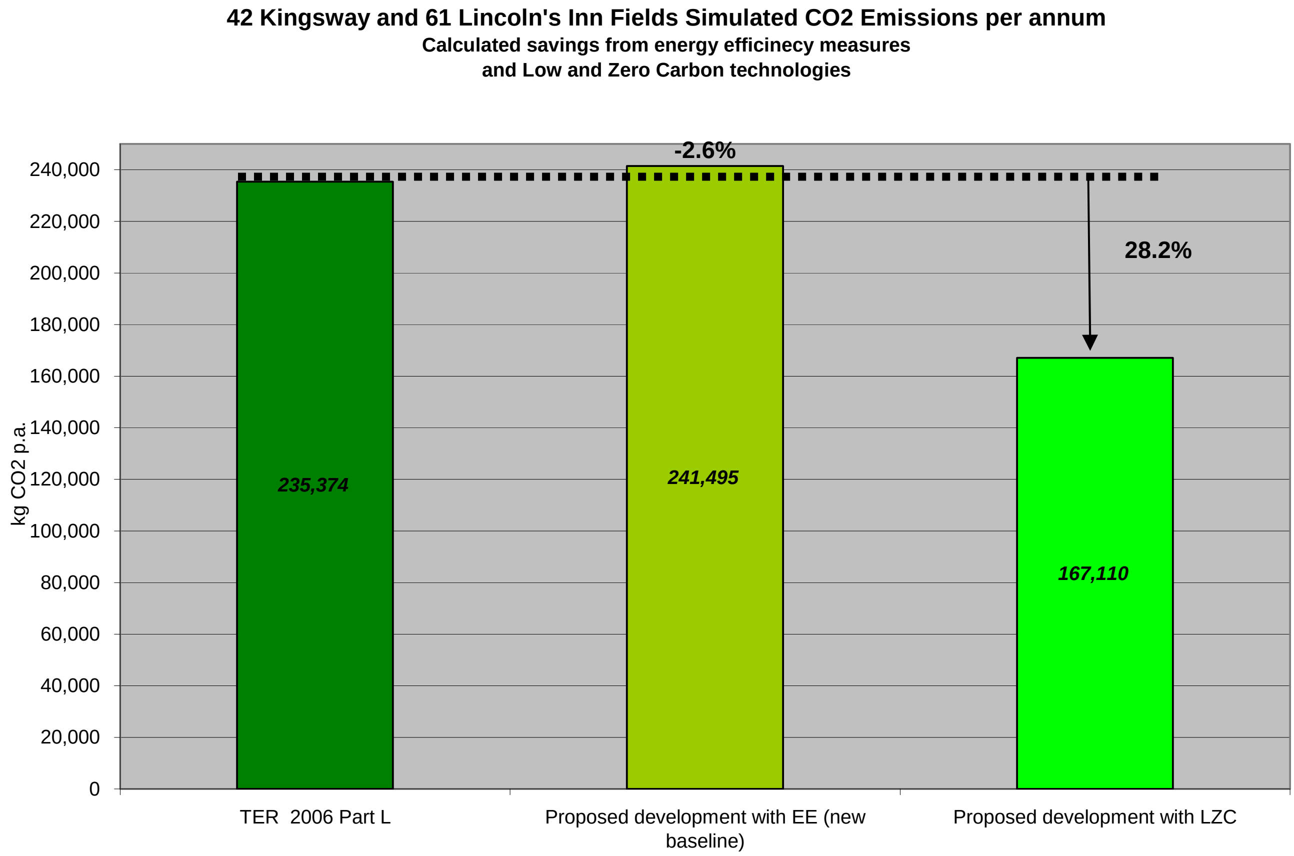


TABLE 2.0: 61 LINCOLN'S INN FIELDS – CO2 EMISSIONS OVER TER

6D. BREEAM CONSIDERATIONS

An important aspect of this development is the requirement to achieve BREEAM 'VERY GOOD'. Under category Ene 5 'Low or Zero Carbon Technologies' BREEAM awards up to 3 credits, of which 1 credit is mandatory to achieve an overall VERY GOOD rating.

A single credit is available for carrying out a feasibility study into the use of LZC technologies. A second credit is available for meeting the requirement of a 10% reduction in carbon consumption.

A third credit is available if the feasibility study has been undertaken and an LZC Technology installed which results in a 15% reduction in carbon consumption.

In this instance all three credits will be achieved.

First Credit Requirements:

a. Energy generated from LZC energy source per year

Refer to 'Predicted influence of Low and Zero Carbon (LZC) fuels and technologies on this development's CO_2 emissions' section.

b. Payback

Payback associated with the proposed CHP technology in capital cost terms is very attractive because this is imparting from the existing on site CHP technology.

c. Land Use

The site is in an urban location and land use has been considered in determining the most appropriate option. Refer to 'Predicted influence of Low and Zero Carbon (LZC) fuels and technologies on this development's CO_2 emissions' section.

d. Local Planning Requirements

This report has been produced to demonstrate the projects compliance with Local Planning requirements of 10% energy savings through the use of existing on-site renewables.

e. Noise

Given the sites urban location and noise has been considered in determining the most appropriate option. Refer to 'Predicted influence of Low and Zero Carbon (LZC) fuels and technologies on this development's CO_2 emissions' section.

f. Feasibility of Exporting heat/electricity from the system

The proposed development is for the refurbishment and extension of the Cardiac Catheterisation Laboratory department and therefore the heat/electricity supplies will be provided from the hospitals central plants.

g. Life cycle cost/lifecycle impact of the potential

The life cycle cost/carbon emissions will be as per the CHP system.

h. Any available grants

The following briefly reviews available grants which are available for hotels:

Grant as per existing CHP installed system.

Feed In Tariffs

Tariffs as per existing CHP installed system.

i. All technologies appropriate to the site and energy demand of the development

This report considers all technologies viability against the energy demand and specific site constraints refer to 'Predicted influence of Low and Zero Carbon (LZC) fuels and technologies on this development's CO_2 emissions' section.

j. Reasons for excluding other technologies

Refer to 'Predicted influence of Low and Zero Carbon (LZC) fuels and technologies on this development's energy savings and CO_2 emissions' section for a review of the available technologies and conclusion on most appropriate technology to adopt.

6E. CHP PAYBACK

The simple payback period associated with the CHP system is calculated as follows;

We will compare the CHP against a traditional gas fired boiler and the associated electrical supply from the grid. Estimated size of CHP required to run at 18hrs per day sized on the heating/electrical base load is 15KWe.

Initial capital cost of 15KWe CHP = £40,000

From a 15KWe CHP unit:

Usable heat generated = 30 KW
Electricity generated = 15 KWe
Waste = 20KW

The equivalent requirements from a gas fired boiler and grid supply:

30KW boiler capital cost = £4000
Electricity supply initial capital cost = £0

Energy source cost:

Natural gas = 3p/KWh
Electricity = 10p/KWh

CHP – Running cost per hr

50KW gas input = 3p/kwh x 50 = £1.5/hr

Gas Boiler & Grid Electricity

30 KW gas = 3p/KWh x 30 = £0.9/hr

15KW electricity = 10p/KWh x 15 = £1.5/hr

Total saving per hour using CHP for the base load = £0.6/hr

CHP saving over the year

CHP running at 18 hrs per day x 365 days per year = £0.6/hr x 18hrs x 365 days = £3,942 per annum

Initial capital cost of CHP over gas fired boiler and payback

£40,000 – £4,000 = £36,000 Capital cost

£36,000 / £3,942 = 9.1 years

This is a simple payback calculation but still outlines that even a small CHP unit at 15KWe will give feasible payback periods within 10 years, and over the 25 year life expectancy of the unit produce a large energy and financial saving to the hotel.

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6F. APARTMENTS EPC

Energy Performance Certificate

Non-Domestic Building

HM Government

Certificate Reference Number:
0090-2060-0030-4000-0003

This certificate shows the energy rating of this building. It indicates the energy efficiency of the building fabric and the heating, ventilation, cooling and lighting systems. The rating is compared to two benchmarks for this type of building: one appropriate for new buildings and one appropriate for existing buildings. There is more advice on how to interpret this information on the Government's website www.communities.gov.uk/epbd.

Energy Performance Asset Rating

More energy efficient

A+

Net zero CO_2 emissions

A 0-25

B 26-50

C 51-75

D 76-100

E 101-125

F 126-150

G Over 150

Less energy efficient

40 This is how energy efficient the building is.

Technical information

Main heating fuel:	Grid Supplied Electricity
Building environment:	Heating and Mechanical Ventilation
Total useful floor area (m^2):	833
Building complexity (NOS level):	3
Building emission rate ($kgCO_2/m^2$):	19.08

Benchmarks

Buildings similar to this one could have ratings as follows:

- 36 If newly built
- 61 If typical of the existing stock

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Administrative information

This is an Energy Performance Certificate as defined in SI2007:991 as amended

Assessment Software:	Design Database v25.02 using calculation engine SBEM v3.5.a.0
Property Reference:	000000000000
Assessor Name:	Philip Scally
Assessor Number:	LCEA087098
Accreditation Scheme:	CIBSE Certification Limited
Employer/Trading Name:	Elementa Consulting
Employer/Trading Address:	9-11 Mark House, Queens Road, Hersham, Surrey, KT12 5LU
Issue Date:	24 Jun 2010
Valid Until:	23 Jun 2020 (unless superseded by a later certificate)
Related Party Disclosure:	Not related to the owner

Recommendations for improving the property are contained in Report Reference Number: 0260-0900-0400-0400-0004

If you have a complaint or wish to confirm that the certificate is genuine

Details of the assessor and the relevant accreditation scheme are on the certificate. You can get contact details of the accreditation scheme from the Government's website at www.communities.gov.uk/epbd, together with details of the procedures for confirming authenticity of a certificate and for making a complaint.

CARBON TRUST

For advice on how to take action and to find out about technical and financial assistance schemes to help make buildings more energy efficient visit **www.carbontrust.co.uk** or call us on **0800 085 2005**

6G. RETAIL EPC

Energy Performance Certificate
Non-Domestic Building

HM Government

Certificate Reference Number:
0090-0030-0030-9000-0003

This certificate shows the energy rating of this building. It indicates the energy efficiency of the building fabric and the heating, ventilation, cooling and lighting systems. The rating is compared to two benchmarks for this type of building: one appropriate for new buildings and one appropriate for existing buildings. There is more advice on how to interpret this information on the Government's website www.communities.gov.uk/epbd.

Energy Performance Asset Rating

More energy efficient

A+

Net zero CO_2 emissions

A 0-25
B 26-50
C 51-75
D 76-100
E 101-125
F 126-150
G Over 150

Less energy efficient

52 This is how energy efficient the building is.

Technical information

Main heating fuel:	Grid Supplied Electricity
Building environment:	Mixed-mode with Natural Ventilation
Total useful floor area (m^2):	411
Building complexity (NOS level):	4
Building emission rate ($kgCO_2/m^2$):	100.98

Benchmarks

Buildings similar to this one could have ratings as follows:

53 If newly built

83 If typical of the existing stock

Administrative information

This is an Energy Performance Certificate as defined in SI2007:991 as amended

Assessment Software:	Design Database v25.02 using calculation engine SBEM v3.5.a.0
Property Reference:	000000000000
Assessor Name:	Philip Scally
Assessor Number:	LCEA087098
Accreditation Scheme:	CIBSE Certification Limited
Employer/Trading Name:	Elementa Consulting
Employer/Trading Address:	9-11 Mark House, Queens Road, Hersham, Surrey, KT12 5LU
Issue Date:	01 Jul 2010
Valid Until:	30 Jun 2020 (unless superseded by a later certificate)
Related Party Disclosure:	Not related to the owner

Recommendations for improving the property are contained in Report Reference Number: 0030-0900-0400-0900-0004

If you have a complaint or wish to confirm that the certificate is genuine

Details of the assessor and the relevant accreditation scheme are on the certificate. You can get contact details of the accreditation scheme from the Government's website at www.communities.gov.uk/epbd, together with details of the procedures for confirming authenticity of a certificate and for making a complaint.

For advice on how to take action and to find out about technical and financial assistance schemes to help make buildings more energy efficient visit **www.carbontrust.co.uk** or call us on **0800 085 2005**

6H. RESTAURANT EPC

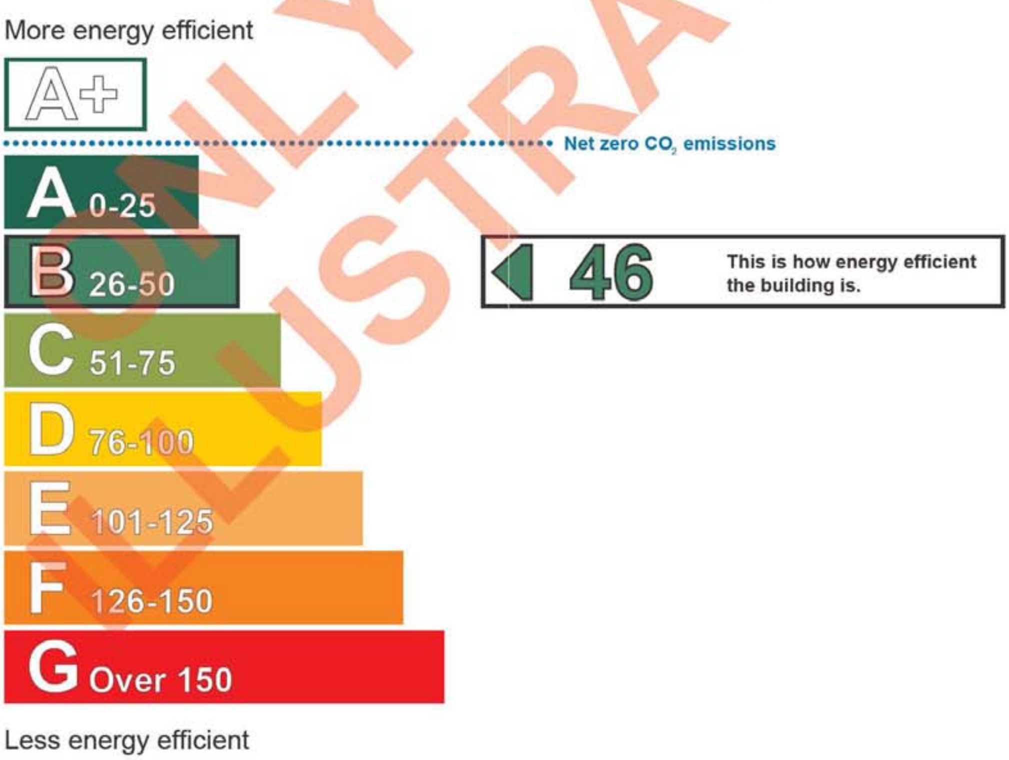
Energy Performance Certificate
Non-Domestic Building

HM Government

Certificate Reference Number:
0090-0030-0030-9000-0003

This certificate shows the energy rating of this building. It indicates the energy efficiency of the building fabric and the heating, ventilation, cooling and lighting systems. The rating is compared to two benchmarks for this type of building: one appropriate for new buildings and one appropriate for existing buildings. There is more advice on how to interpret this information on the Government's website www.communities.gov.uk/epbd.

Energy Performance Asset Rating



Technical information

Main heating fuel:	Natural Gas
Building environment:	Mixed-mode with Natural Ventilation
Total useful floor area (m^2):	692
Building complexity (NOS level):	4
Building emission rate ($kgCO_2/m^2$):	91

Benchmarks

Buildings similar to this one could have ratings as follows:

54	If newly built
95	If typical of the existing stock

elementa

Administrative information

This is an Energy Performance Certificate as defined in SI2007:991 as amended

Assessment Software:	Design Database v25.02 using calculation engine SBEM v3.5.a.0
Property Reference:	000000000000
Assessor Name:	Philip Scally
Assessor Number:	LCEA087098
Accreditation Scheme:	CIBSE Certification Limited
Employer/Trading Name:	Elementa Consulting
Employer/Trading Address:	9-11 Mark House, Queens Road, Hersham, Surrey, KT12 5LU
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Valid Until:	30 Jun 2020 (unless superseded by a later certificate)
Related Party Disclosure:	Not related to the owner

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CARBON TRUST

For advice on how to take action and to find out about technical and financial assistance schemes to help make buildings more energy efficient visit **www.carbontrust.co.uk** or call us on **0800 085 2005**

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I. CHART DATA

TOTAL ENERGY CONSUMPTION TER
Values from this table transferred to subsequent tabs in this spreadsheet

	kWh/m2	kWh p.a.	kg CO2 p.a.	
Heating	**15**	74,457	14,445	
DHW	**150**	750,412	145,580	
Fossil Fuel subtotal	**164**	**824,869**	**160,025**	
Heating	**0**	0	0	
DHW	**0**	0	0	
Cooling	**10**	51,524	21,743	
Fans/pumps/controls	**8**	39,720	16,762	
Small Power	**0**	0	0	
Lighting	**17**	87,310	36,845	
Electricity subtotal	**36**	**178,554**	**75,350**	
			235,374	**Total CO2 emissions p.a.**

Total Energy Consumption EE
Values from this table transferred to subsequent tabs in this spreadsheet

	kWh/m2	kWh p.a.	kg CO2 p.a.	
Heating	**14**	72,656	14,095	
DHW	**150**	750,411	145,580	
Fossil Fuel subtotal	**164**	823,068	**159,675**	
Heating	**0**	0	0	
DHW	**0**	0	0	
Cooling	**10**	51,523	21,743	
Fans/pumps/controls	**9**	44,746	18,883	
Small Power	**0**	0	0	
Lighting	**19**	97,618	41,195	
Electricity subtotal	**39**	193,886	**81,820**	
			241,495	**Total CO2 emissions p.a.**

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Total Energy Consumption LZC & EE

Values from this table transferred to subsequent tabs in this spreadsheet

	kWh/m2	kWh p.a.	kg CO2 p.a.	
Heating	**4**	20,818	4,039	
DHW	**94**	470,882	91,351	
Fossil Fuel subtotal	**98**	491,700	**95,390**	
Heating	**0**	0	0	
DHW	**0**	0	0	
Cooling	**6**	27,590	11,643	
Fans/pumps/controls	**9**	44,746	18,883	
Small power	**0**	0	0	
Lighting	**19**	97,618	41,195	
Electricity subtotal	**34**	169,953	**71,720**	
			167,110	**Total CO2 emissions p.a.**

Chart 1: CO2 by end use	**kg CO2 p.a. Proposed development with EE and LZC**	**kg CO2 p.a. Proposed development with EE**	**kg CO2 p.a. TER 2006 Part L**
Heating	4,039	14,095	14,445
DHW	91,351	145,580	145,580
Heating	0	0	0
DHW	0	0	0
Cooling	11,643	21,743	21,743
Fans/pumps/controls	18,883	18,883	16,762
Small Power	0	0	0
Lighting	41,195	41,195	36,845
Total:	**167,110**	**241,495**	**235,374**

Chart 2: CO2 with % savings TER 2006 Part L	**kg CO2 235,374**	**% savings**
Proposed development with EE (new baseline)	241,495	-2.6%
Proposed development with LZC	167,110	28.2%

Energy Consumption (kWh p.a.)	TER 2006 Part L	Proposed development with EE	Proposed development with EE and LZC
Fossil Fuel	824,869	823,068	491,700
Electricity	178,554	193,886	169,953
%		-1%	35%

Predicted Energy Consumption & CO2 Emissions	Proposed development (kWh p.a.)	Proposed development with EE (kWh p.a.)	Proposed development with EE and LZC (kWh p.a.)	Carbon Intensity (kg CO2/kWh)	Proposed development with EE and LZC (kg CO2 p.a.)
Heating	74,457	72,656	20,818	0.194	4,039
DHW	750,412	750,411	470,882	0.194	91,351
Fossil Fuel subtotal	**824,869**	**823,068**	**491,700**		**95,390**
Heating	**0**	**0**	**0**	0.422	0
DHW	**0**	**0**	**0**	0.422	0
Cooling	**51,524**	**51,523**	**27,590**	0.422	11,643
Fans/pumps/controls	**39,720**	**44,746**	**44,746**	0.422	18,883
Small Power	**0**	**0**	**0**	0.422	0
Lighting	**87,310**	**97,618**	**97,618**	0.422	41,195
Electricity subtotal	**178,554**	**193,886**	**169,953**		**71,720**
					167,110 **TOTAL kg CO2 p.a**