RIDGE

PROPERTY & CONSTRUCTION CONSULTANTS

73 & 75 AVENUE ROAD ENERGY STATEMENT

March 2016

Prepared for

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RIDGE

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CONTENTS

1. EXECUTIVE SUMMARY

Ridge and Partners LLP was commissioned by M Design Ltd to develop an energy statement in support of the planning application for the proposed residential development at 73 & 75 Avenue Road, London. This report comprises the analysis undertaken to assess the proposed development in the contexts of energy consumption and Part L of the Building Regulations.

This report has been prepared to present the following:

- Calculations and analysis carried out to estimate the total energy demand of the proposed site.
- Total associated carbon dioxide CO_2 emissions.
- Identify opportunities for implementation of energy efficiency measures.
- Develop a low energy consumption building services strategy.
- Assess the technical feasibility Low Zero Carbon (LZC) technologies can offer to the proposed development.

The following steps describe the method used to assess the energy reduction potential the GLA Energy Hierarchy "Lean, Clean and Green" methodology offers. It then evaluates the potential CO_2 emissions reduction potential LZC technologies can offer for the proposed residential development at 73 & 75 Avenue Road in London UK:

- Construction of a model implementing measure to comply with minimum Part L1A 2010 Standards to quantify the energy reduction potential of the "Lean" measures proposed (Baseline).
- Construction of a "Lean" model which include passive measures to quantify the energy reduction potential of these measures (Lean Model)
- Construction of a "Clean" model which included active measures to quantify the effectiveness of the energy efficient measures implemented (Clean Model).
- Assessment of the technical suitability of LZC technologies

Targets:

1.1.1. Building Regulations

- The proposed development has to achieve compliance with Part L1A (2013) of the Building Regulations where the DER≤TER. Compliance should be demonstrated through an approved SAP rating output document.

1.1.2. Local authority planning policy

Camden Borough Planning Guidance: Sustainability CPG3

- The proposed development is to target a 20% reduction in carbon dioxide emissions (CO_2) from on-site renewable energy technologies.

1.1.3. Greater London Authority Plan

London Plan Policy 5.2 – Minimising carbon dioxide emissions
Major Developments to target a carbon dioxide reduction of 40% beyond 2010 Building Regulations [GLA Plan 2015: Flat carbon dioxide improvement for all major developments (domestic and non-domestic) to target 35% beyond Part L 2013]

The GLA Plan Policy 5.2 states that all "*major developments*" are to implement a 40% CO_2 emissions reduction target beyond 2010 Building Regulations (from 1^{st} of October 2013 – or a 35% improvement over Part L 2013). The proposed development at 73 & 75 Avenue Road does not fall under the GLA Plan definition of "*major developments*" and hence the GLA Plan Policy 5.2 target does not apply. However, the policy also states development proposals should make the fullest contribution to minimising carbon dioxide emissions in accordance with the energy hierarchy.

Based on the above methodology the proposed strategy is as follows;

Be Lean

- Reduce U-values for all external elements, limit thermal linear transmittance to avoid thermal bridging and improved air permeability.
- Natural ventilation
- Good provision of Daylight

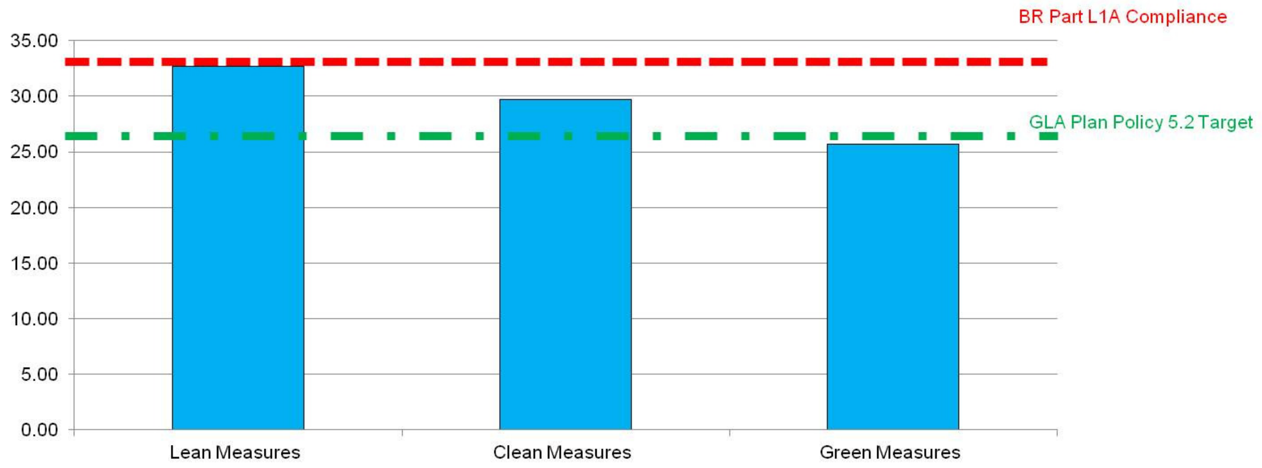
Be Clean

- Increase building services efficiency above Part L 2013 minimum requirements (e.i condensing boiler efficiency, low energy lighting design and heat recovery)
- Assess the technical feasibility of combined heat and power and connection to a district heating system (CHP)

Be Green

- Assess the technical feasibility of implementing a Low / Zero carbon (LZC) technology

The following tables and graphs illustrate the results of the estimated impacts through each of the stages of the GLA Energy Hierarchy. The calculations show the estimated total annual CO_2 emission for both 73 and 75 Avenue road.



Graph – Site CO_2 emissions at each step of the energy hierarchy

	Regulated Carbon dioxide emissions (Tonnes CO_2 per annum)
Part L1A 2013 of the Building Regulations Compliant Development	32.76
Lean Measures	32.76
Clean Measures	24.45
Green Measures	20.57

Table – Site annual CO_2 emissions summary

	Regulated Carbon dioxide savings	
	Tonnes CO_2 per annum	(%)
Savings from Lean Measures	0.00	0%
Savings from Clean Measures	8.31	25%
Savings from renewable energy	3.89	12%
Total Cumulative Savings	12.19	37%
Total Target Savings	11.47	35%
Annual Surplus	0.73	

Table – Regulated CO2 emissions savings from each stage of the GLA Energy Hierarchy

The benefits following the "Energy Hierarchy" and low carbon design methodologies and principles adopted and described above were assessed under a compliance SAP 2012 modelling exercise. SAP 2012 calculations aim to predict the annual CO_2 emissions across the two houses; as a result of the modelling carried it out it can be concluded that through the application of "Lean" measures the proposed development achieve an approximate annual CO_2 reduction of approximately 6tCO_2. Further "Clean" and "Green" measures suggest a further annual CO_2 of approximately 12tCO_2 to achieve an approximate 37% over the Part L1A compliant model. Table above shows that the proposed development is targeting to reduce the predicted CO_2 emissions by approximately 37% from the "Green Measures" proposed.

As results of the analysis undertaken the following energy strategy was developed:
Exceed Part L1A 2013 through the implementation of the “Lean Clean and Green” measures described in sections 4.2.1, 4.2.2 and 4.2.3 below.
These include:

- Efficient fabric thermal performance
- Limit linear thermal transmittance to avoid thermal bridging
- Consider the installation of a Combined Heat and Power (CHP) system to serve the proposed developments DHW systems
- Develop a low energy artificial lighting strategy
- Allow for natural ventilation
- Install high efficient air source heat pumps to serve the comfort cooling requirements of the development
- Install a 4kWp PV array on each of the properties roofs

2. INTRODUCTION

2.1 General

Ridge and Partners LLP was commissioned by M Design Ltd to develop an energy statement in support of the planning application for the proposed residential development at 73 & 75 Avenue Road, London. This report would consider Part L of the Building Regulations, all Greater London, and the London Borough of Camden relevant planning policies.

This report has been prepared to indentify the opportunities of implementation of energy efficiency measures and Low Zero Carbon technologies for the proposed development. An energy consumption analysis based on the UKs Government Standard Assessment Procedure (SAP) dwelling energy modelling approved methodology was carried out. This analysis was based on a series of annual simulations using SAP rating software to estimate the likely energy performance of the proposed building, with the aim to propose an energy strategy that will meet London Borough of Camden local requirements.

2.2 Site Review

The proposed development consists of two residential properties located in the London Borough of Camden. Figure 1 below shows the location, orientation and sun path of the proposed development.

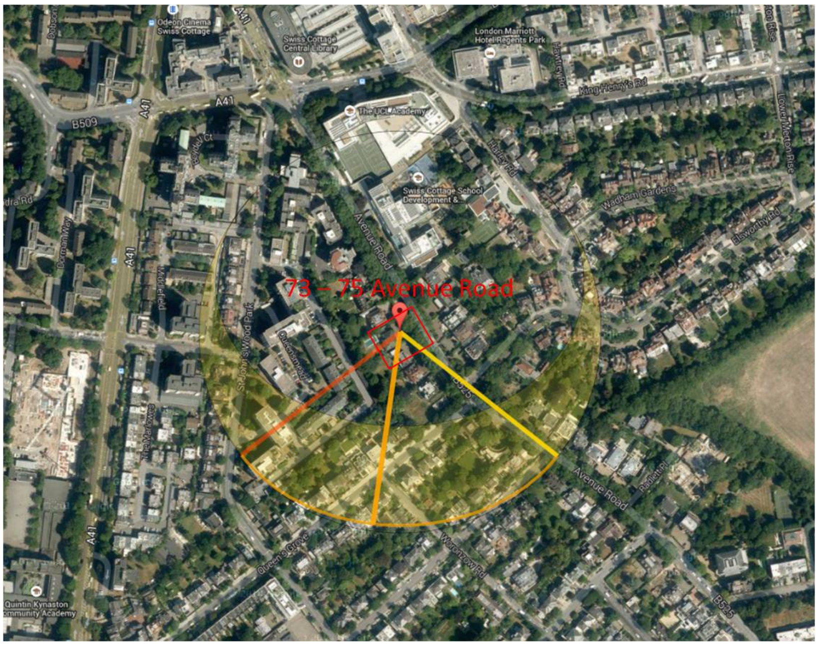


Figure 1 – 73 & 75 Avenue Road proposed site location, orientation and sun path [source: suncalc.net]

3. PLANNING POLICY AND BUILDING REGULATIONS CONTEXT

The following section outlines the relevant planning policy which encourages sustainable development. The different policies guiding developments in the Greater London area (GLA) are outlined below.

3.1 Current Policy

3.1.1. National Policy

National Planning Policy Framework

*"At the heart of the National Planning Policy Framework is a **presumption in favour of sustainable development**, which should be seen as a golden thread running through both plan-making and decision-taking."*

"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. (National Planning Policy Framework*

3.1.2. Regional Policy

Greater London Authority (GLA)
London Plan Policy 5.1 Climate Change mitigation
Strategic

Policy seeks to achieve an overall reduction in the city's carbon dioxide emissions of 60 % by 2025.

London Plan Policy 5.2 Minimising carbon dioxide emissions
Planning decisions
Proposed developments should make the fullest contribution to minimising carbon dioxide emissions in accordance with the following energy hierarchy:

a) Be lean
b) Be clean
c) Be green

All major development proposals to include a detailed energy assessment to demonstrate how the minimum targets for carbon dioxide emissions reduction are to be met within the framework of the energy hierarchy (see Figure 2 below).

3.1.3. Local Policy

<u>Camden Core Strategy</u>

Policy CS13: Paragraph 13.9 ***"****expects development or alterations to existing buildings to include proportionate measures to be taken to improve their environmental sustainability, where possible".*

3.2 Building Regulations Part L1A 2013

The project must comply with the appropriate sections of the building regulations, primarily Part L1A 2013 where carbon emissions, energy efficiency and energy consumption are concerned in new buildings.

In order to demonstrate the compliance required by **Approved Document Part L1A (2013 edition)** a modelling exercise needs to be carried out to demonstrate that the Dwelling Emissions Rate DER for the proposed buildings will be less than the Target Emission Rate TER calculated for a notional building.

3.3 Local Authority Planning Policy and Building Regulations Targets

3.3.1. Building Regulations

- The proposed development has to achieve compliance with Part L1A (2013) of the Building Regulations where the DER≤TER. Compliance should be demonstrated through an approved SAP rating output document.

3.3.2. Local authority planning policy

Camden Borough Planning Guidance: Sustainability CPG3

- The proposed development is to target a 20% reduction in carbon dioxide emissions (CO_2) from on-site renewable energy technologies.

3.3.3. Greater London Authority Plan

London Plan Policy 5.2 – Minimising carbon dioxide emissions
Major Developments to target a carbon dioxide reduction of 40% beyond 2010 Building Regulations [GLA Plan 2015: Flat carbon dioxide improvement for all major developments (domestic and non-domestic) to target 35% beyond Part L 2013]

The GLA Plan Policy 5.2 states that all "*major developments*" are to implement a 40% CO_2 emissions reduction target beyond 2010 Building Regulations (from 1st of October 2013 – or a 35% improvement over Part L 2013). The proposed development at 73 & 75 Avenue Road does not fall under the GLA Plan definition of "*major developments*" and hence the GLA Plan Policy 5.2 target does not apply. However, the policy also states development proposals should make the fullest contribution to minimising carbon dioxide emissions in accordance with the energy hierarchy.

4. ENERGY DEMAND ASSESSMENT

4.1 General

In order to estimate the expected annual energy consumption for the proposed development a Standard Assessment Procedure (SAP) calculation has been carried out. The SAP software used for the calculations is by **Elmhurst Energy System Ltd** which is approved by the UK Government energy accreditation body. These calculations generally are used to demonstrate compliance with Part L1A of the Building Regulations.

To achieve a truly low-carbon building the most effective approach to reduce operational energy use should follow low carbon design principle. These are described in the Chartered Institution of Building Services Engineers (CIBSE) Guide L Sustainability 2007. The following steps describe CIBSEs low carbon design principles:

a) Focus on understating the energy use of the building
b) Evaluate the buildings location, orientation, fabric thermal performance and operation to determine measures to reduce the energy requirements of the building (Passive design measures: Lean).
c) Improve the efficiency of fixed building services (Boiler plant, light fittings etc) to meet the energy demand in the most effective way possible (Active design measures: Clean).
d) Study the feasibility of implementing Low or Zero Carbon (LZC) technologies to further reduce the CO_2 emissions associated with the energy use of the building studied (Green).

The Energy Hierarchy diagram in Figure 2 below illustrates the “Lean, Clean and Green” methodology as described in Policy CS13 of Camden Core Strategy document and the GLA Plan.

Note: Part L1A calculations require the use of NCM/SAP2012 templates. These set a large proportion of the design criteria (Occupancy profiles, heating and cooling set points and mechanical ventilation rates). Therefore the predicted annual energy consumption and carbon dioxide emissions in these calculations may vary from the actual energy consumption of the proposed building.

A SAP Part L compliance model built for the proposed buildings takes into account the following:

- Building geometry, location and orientation
- Buildings fabric thermal performance
- Building services strategy
- Environmental conditions (this includes solar irradiation, wind, and external temperatures)
- Internal heat gains (occupants, computers, lighting and miscellaneous small power)
- Domestic Hot water DHW consumption

4.2 Methodology

The following steps describe the method used to assess the energy reduction potential the “Lean, Clean and Green” methodology offers. It then evaluates the potential CO_2 emissions reduction potential LZC technologies can offer to the proposed residential development at 73 & 75 Avenue Road in London UK:

a) Construction of a model implementing measure to comply with minimum Part L1A 2010 Standards to quantify the energy reduction potential of the “Lean” measures proposed (Baseline).
b) Construction of a “Lean” model which include passive measures to quantify the energy reduction potential of these measures (Lean Model)
c) Construction of a “Clean” model which included active measures to quantify the effectiveness of the energy efficient measures implemented (Clean Model).
d) Assessment of the technical suitability of LZC technologies
e) Energy iterations to investigate which strategies offer the best suitable solution to meet the targets set in section 3.3.

Note: SAP calculations for both buildings were carried out.

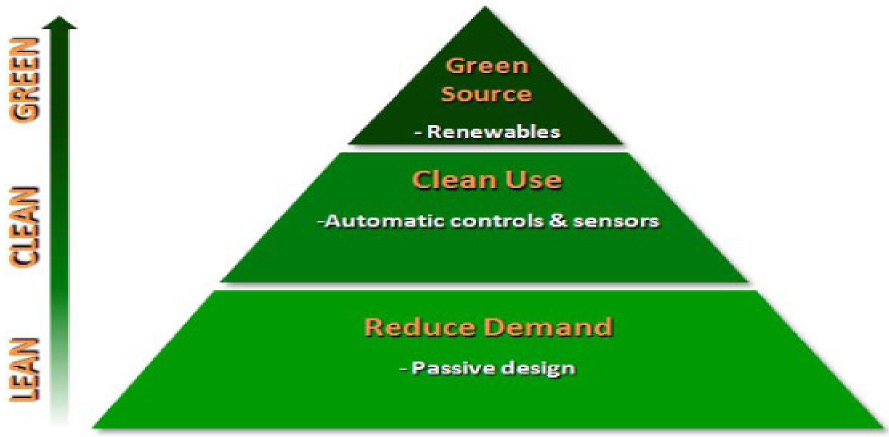


Figure 2 – GLA Energy Hierarchy

The following measures were investigated as part of this assessment:
4.2.1. Lean Measures:

- Reduce U-values for all external elements, limit thermal linear transmittance to avoid thermal bridging and improved air permeability.
- Natural ventilation
- Good provision of Daylight

4.2.2. Clean Measures

- Increase building services efficiency above Part L 2013 minimum requirements (e.i condensing boiler efficiency, low energy lighting design and heat recovery)
- Assess the technical feasibility of combined heat and power (CHP)

4.2.3. Green Measures

- Assess the technical feasibility of implementing a Low / Zero carbon (LZC) technology

4.3 Base Model

A SAP model for 73 – 75 Avenue Road residential development was prodcued in Design SAP software by **Elmhurst Energy System Ltd**. The model built was based on the following architectural layout and elevation drawings developed by tff Architects.

No. 73 Avenue Road

Proposed Site Plan	196/50 Rev C
Proposed Basement – Sheet 1	196/151 Rev H
Proposed Basement – Sheet 2	196/152 Rev F
Proposed Lower Ground Floor – Sheet 1	196/153 Rev G
Proposed Lower Ground Floor – Sheet 2	196/154 Rev F
Proposed Ground Floor	196/155 Rev G
Proposed First Floor	196/156 Rev F
Proposed Second Floor	196/157 Rev D
Proposed Roof Plan	196/158 Rev D
Elevation A NE	196/170 Rev D
Elevation B SE	196/171 Rev D
Elevation C SW	196/172 Rev D
Elevation D NW	196/173 Rev C

No. 75 Avenue Road

Proposed Site Plan	196/150 Rev C
Proposed Basement – Sheet 1	196/161 Rev H
Proposed Basement – Sheet 2	196/162 Rev F
Proposed Lower Ground Floor – Sheet 1	196/163 Rev G
Proposed Lower Ground Floor – Sheet 2	196/164 Rev F
Proposed Ground Floor	196/165 Rev G
Proposed First Floor	196/166 Rev E
Proposed Second Floor	196/167 Rev D
Proposed Roof Plan	196/158 Rev D
Elevation E NE	196/174 Rev D
Elevation F SE	196/175 Rev D
Elevation G SW	196/176 Rev D
Elevation H NW	196/177 Rev D

Thermal and energy profiles were then developed implementing minimum efficiency performance standards in line with Building Regulations Part L 2013, the NCM and SAP templates and systems.

Part L1A 2013 compliance calculations where then carried out to determine the estimated annual energy consumption of the proposed development. The results estimated baseline annual energy consumption profile for comparison. In order to reduce the energy demand in the proposed residential development at 73 & 75 Avenue Road, the following options have been identified as potential energy efficiency measures:

a) Improve fabric thermal performance
b) Increase level of air tightness to better the air permeability rate in the building
c) Incorporate variable speed drives
d) Improve lighting design efficiency

e) Incorporate improved system efficiencies for the space heating, comfort cooling and domestic hot water services
f) Glazing optimization

Energy efficiency measures shown below were studied to calculate the resulting reduction in annual energy consumption. Thermal and energy profiles where simulated in the SAP model. These test the effectiveness of the potential energy efficiency measures.

The following are the main energy performance standards modelled for the proposed development (both 73 - 75 Avenue Road):

4.3.1. Fabric thermal performance:

A high standard of fabric thermal performance is proposed for 73 & 75 Avenue Road, with the aim to achieve Part L1A compliance.

Element	**U-Value (W/m^2K)**
Wall	0.18
Floor	0.13
Roof	0.13
Windows, roof windows, and roof-lights	1.40

Air Permeability	
$m^3/(h.m^2)$ at 50 Pa	5.00

4.3.2. Thermal bridging

Thermal bridges for the following are to be calculated where applicable:

- Steel lintel with perforated steel base plate
- Sill
- Jamb
- Ground Floor
- Intermediate floor within a dwelling
- Corner (normal)

4.3.3. Main space heating system

LTHW Gas fired condensing boiler with a heating efficiency of 93% serving under floor heating.

4.3.4. Domestic hot water system (DHW)

Domestic hot water cylinder served by LTHW circuit from main boiler. Cylinder to be factory insulated with 2.5 kWh/day standby loss.

4.3.5. Local Ventilation

Local intermittent extract fans for toilets/wet areas

4.3.6. General Lighting

All fittings to be low energy light fittings (L.E.L)

5. LOW & ZERO CARBON TECHNOLOGIES FEASBILITY STUDY

As stated in section 4.2 above it is important to understand the building's energy load and expected annual consumption in order to assess the suitability of LZC technologies. With the modelling results obtained in section 6.1 above an energy profile for the proposed residential development at 73 – 75 Avenue Road was used to assess the feasibility of implementing a single or a combination of LZC technologies to achieve the energy targets set in section 3.3 above.

Error! Reference source not found. shows the LZC resources available and the LZC technology available to provide thermal or electrical energy or both.

Resource	Electricity	Thermal
Natural Gas	Combined Heat & Power	Combined Heat & Power
Air		Air Source Heat Pumps
Solar	Photovoltaic System	
Biomass	Combined Heat & Power	Biomass Boilers/CHP
Ground		Ground Source Heat Pumps
Wind	Wind turbines	

Table 1 – LZC Resources

5.1 Low & Zero Carbon technologies

This section aims to identify the most suitable LZC technology. Eight of the ten LZC technologies (as shown below in Figure 3 were investigated as part of this exercise except for tidal and wave power, as there are no suitable water sources in close proximity to the development to make these technologies feasible. The remaining technologies reviewed will include the following and they were classed as technically suitable (LZC technology will suit the heat and power profile of the building).

LZC Technology	Applicability	Suitability
Air Source Heat Pumps	• The technology offers a practical solution but offer low energy and carbon dioxide emissions savings.	**Suitably and technically feasible**
	• Efficient technology for providing both heating and cooling	
	• They are usually located on the roof or adjacent to the building	
	• Need a suitably sized space and location	
	• Noise impact requires consideration	

LZC Technology	Applicability	Suitability
Solar Photovoltaic (PV) Panels	• Suitable roof space available	Suitable
	• Consider optimum orientation of panels to take full advantage of technology	
	• Good CO2 Emissions reductions	
	• Consider future developments to avoid over-shading	
	• Relative low cost of maintenance	
	• Requires safe access to roof area	
	• Consider extra weight on roof structure	
	• Electricity generation - all to be used on site or exported into the grid	
	• Simple to install	
	• Eligible for Feed In Tariffs	

LZC Technology	Applicability	Suitability
Combined Heat & Power (CHP) >5kW	• Heat and Power generation	Suitable
	• CO2 savings are derived from the local production of electricity but this is limited by the heat demand	
	• Heat and Power profiles ideal for efficient operation.	
	• Air quality implications need to be considered	
	• Sufficient Domestic Hot Water load	

LZC Technology	Applicability	Suitability
Ground Source Heat Pumps	• Technology offers good energy and carbon savings. • Eligible for Renewable Heat Incentive • Testing required for ground conditions and obstructions. • Type of systems: Vertical or Horizontal, open or close loop. • Efficiency for heating drops as the output temperature increase so heating systems needs to be specifically designed. • Will involve a great deal of earth works. Additional infrastructure costs • High Capital Cost of Installation and large land required for ground loops.	**Suitable**
Solar Thermal heating Panels	• Sufficient Domestic Hot Water load • Eligible for Renewable Heat Incentive • Small operating cost and carbon emissions savings	**Suitable**
Biomass Boilers	• Requires large storage space for wood fuel • Low CO2 emissions over lifecycle • Heat and Power profiles ideal for efficient operation. • Two main fuel sources - chips and pallets • Consider future fuel supply and costs • Need to consider speed of response • Considerations on the flue design and air quality impacts • Allowance for access for delivery vehicles to be considered • Frequent maintenance required (de-ashing)	**Not Suitable**

Wind Turbines	• Insufficient average wind speed in the area to allow for efficient operation	**Not Suitable**

Community/District Heating	• No capacity within close proximity to site	**Not Suitable**
	• Site not located within a 'Focus Area'	

Figure 3 – 73 – 75 Avenue Road Low/Zero Carbon technologies feasibility

As a consequence from this brief analysis of possible LZC technologies, the recommended systems were chosen for a more detailed appraisal:

LZC Technology	**Suitability**
Air Source Heat Pumps (ASHP)	**Recommended**
Solar Photovoltaic Panels (PV)	**Recommended**
Combined Heat & Power (CHP)	**Recommended**
Ground Source Heat Pumps (GSHP)	**Considered**
Solar thermal heating Panels	**Considered / Not recommended**
Biomass Boilers	**Not suitable**
Wind turbines	**Not suitable**
Community/District Heating	**Not suitable**

Figure 4 - LZC technologies recommendation summary

A performance analysis for ASHP, GSHP and PV Systems was carried out in support of this report. These have been assessed by simulating the proposed LZC technologies options in the SAP 2012 software.

This report will cover the following subject areas for, ASHP, GSHP, PV Systems and CHP systems as described in Figure 3 above:

a) Description of LZC Technology
b) Capacity
c) Land use
d) Local planning criteria.
e) Noise
f) Feasibility of exporting heat/electricity from the system.
g) Grants available
h) Operation and Maintenance

5.2 Heat Pumps

5.2.1. Description

Heat pumps are a tried and tested means of providing space and water heating to buildings, most often combined with under-floor heating. Under-floor heating is highly efficient due to low flow and return temperatures and offers a low-carbon solution to achieve the required internal heating load. There are ground, water and air-source variants of heat pumps, each capable of different seasonal efficiencies based upon the annual temperature profile of the heat source to which they are coupled.

Air source heat pumps (ASHP) operate in much the same way using a fan to pass outside air over a heat exchanger. They therefore need free access to ambient air and their capacity is determined by the number of heat exchanger coils, and the volumetric flow rate of air passing over them. New technology also enables heat pumps to provide the energy to heat the building's domestic hot water, as well as providing space heating and cooling. Noise can be an issue with the external units, and acoustic treatment is sometimes required (Figure 5 below show an ASHP unit).

Figure 5 – Air Source Heat Pump Units Example

Ground source heat pumps (GSHP) require an extensive area to install pipework in a horizontal trench, at a depth of 1-2m parallel to the ground's surface (Figure 6 below illustrate the GSHP variations). Alternatively, 50-150m deep bore holes can be installed if space is restricted, but still require spacing on at least 7m to operate effectively. Due to space restrictions, the trench variants of ground source heat pumps are considered suitable for the development.

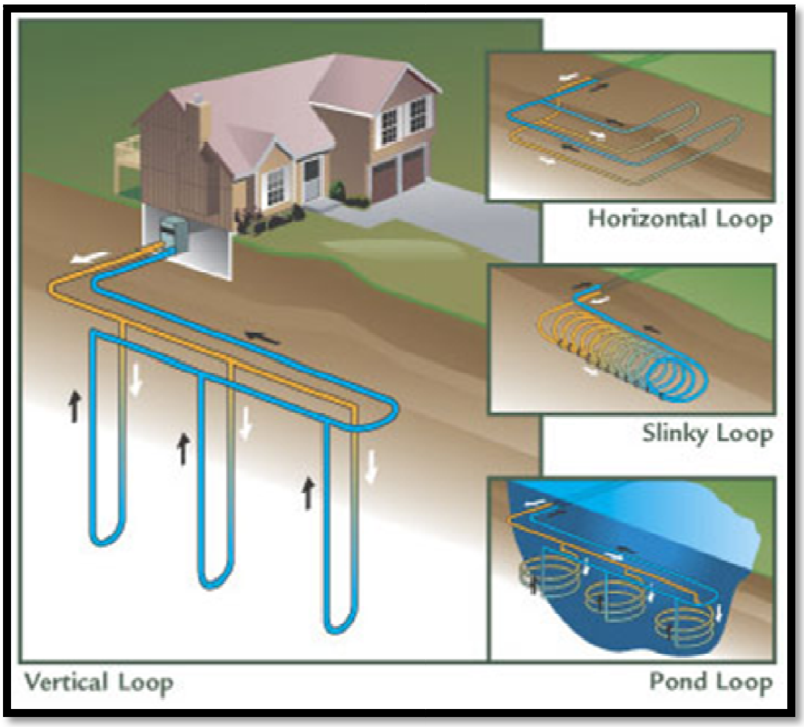


Figure 6 – Ground Source Heat Pump variations Example

5.2.2. Capacity

The estimation of the heating and cooling profiles for the proposed buildings described above show the opportunity of implementing an ASHP system to serve the comfort cooling demands for the proposed residential development

5.2.3. Land Use / Roof Use

ASHPs require sufficient access to outside air and access for maintenance and cannot therefore be completely enclosed. They are usually located on the roof or adjacent to the building as shown in Figure 5. Space and location need to be considered and proposed.

5.2.4. Planning Criteria

Although ASHPs do not typically affect planning criteria, the need to accommodate externally large numbers of ASHPs may have a planning implication.

5.2.5. Noise

Designers locate ASHPs in relatively remote areas, separate from any occupied areas due to the noise from the fans. Whilst the airflow cannot be obstructed, attenuated enclosures or screens can reduce the noise significantly, but location is still important to reduce disruption and interference. On-site acoustics tests may be required by building control to assess noise pollution to any sensitive surrounding areas.

5.2.6. Possibility of electricity export

The system should be sized to meet the heating demands of the building it serves to achieve the greatest efficiency. Heat would not be exported from an ASHP system for this type of project.

5.2.7. Grants

Currently, ASHP would not be eligible for the RHI scheme and we can see no evidence that suggests that this would change in the future.

5.2.8. Operation and Maintenance

Consideration of regular maintenance is recommended at this stage in order to ensure the optimal operation of these systems.

5.2.9. Summary

Electrically driven air source heat pumps would provide a small saving in carbon emissions. Whilst the comparative financial savings/payback may not be favourable without the RHI scheme, air source heat pumps are a suitable technology for the proposed development due to the comfort cooling requirements. The annual energy profile suits the implementation of an ASHP system.

Ground source heat pumps have been deemed un-suitable initially due to the space restrictions on the propose site to locate the ground loop system collectors. Bore holes could be implemented into the design, however the capital costs are typically very high with long payback periods when compared to other LZC technologies.

5.3 Solar Photovoltaic (PV) Panels

5.3.1. Description

Photovoltaic (PV) systems use solar cells to convert sunlight into electricity. These cells consist in either one or two layers of a semi-conducting material, usually silicon. When light shines on the cells it creates an electric field across the layers, causing electricity to flow. The greater the light intensity the greater the flow of electricity (refer to Figure 8 for the UK Solar Irradiances levels). There are three basic kinds of solar cells:

Mono-crystalline: Typical efficiency = 15%
Polycrystalline: Typical efficiency = 13%
Thin film: Typical efficiency = 17%

This technology is ideally located on inclined south-facing facades or roofs of a building. The units work at their highest efficiency when inclined between 20-40^{o} from horizontal and facing within 20^{o} due south (i.e. at the orientation that receives the greatest annual solar energy), as shown below Figure 9.

5.3.2. Capacity

A Sharp ND-R250A5 PV Module which is an example of a commonly available commercial system is detailed as follows;

Sharp Solar ND-R250A5	
Module efficiency (%)	15.2
Peak Output (Wp)	250
NOCT (˚C)	47.5
Reference Irradiance (w/m²)	800
Temperature Coefficient (NOCT as used in the IES calculation)	0.05
Dimensions (mm)	1652 x 994
Panel area (m²)	1.64

Figure 7 - ND-R250A5 PV Module technical data (Source: Sharp Solar UK)

The arrays could be mounted directly or alternatively on mounting brackets, which connect the panels to the roof, and could potentially be adjusted to increase the inclination of the arrays to the optimum angle of 30-40º. Figure 8 and Figure 9 below show the UK solar irradiance charts and optimum tilt and orientation for systems installed in the UK. Both charts can be used as guidance to calculate a solar technology output.

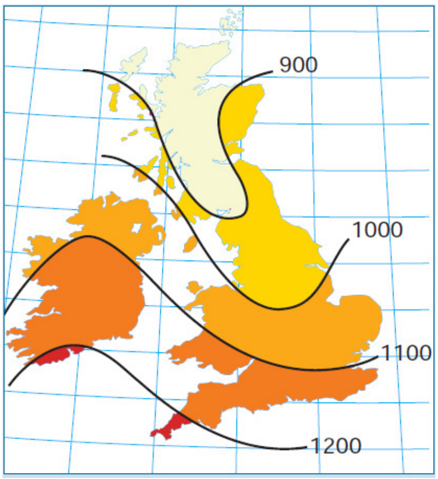


Figure 8 - UK Solar Irradiances (kWh/m^2)

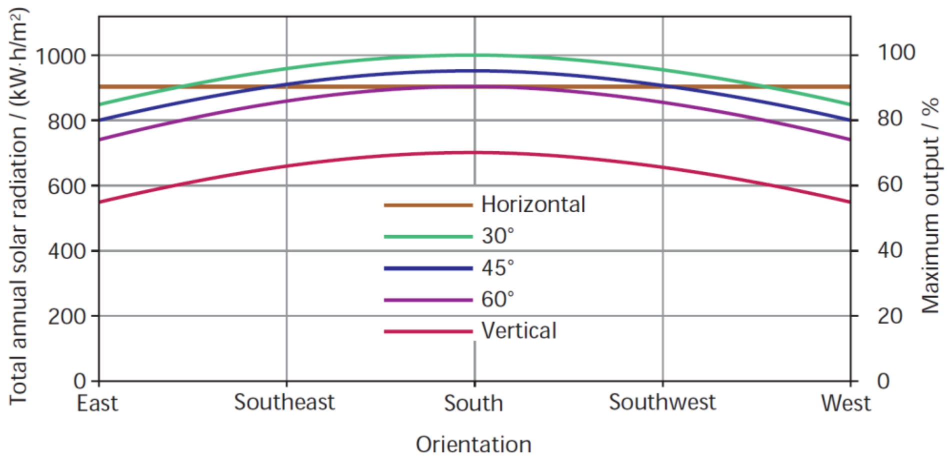


Figure 9 - Solar Panel Tilt & Orientation (Source: CIBSE KS15)

It should be noted that the PV panels require space between them for ventilation and maintenance access; this has been allowed for in determining the number of panels which could be fixed to the roof.

An energy iteration was carried out for a 4.0kWp (75 Avenue Road) and 4.0kWp (73 Avenue Road) PV array to investigate the technology's' annual output and possible technical feasibility. As stated in Figure 8 above each panel have a rated output of 250W and an area of 1.64m^2.

5.3.3. Land Use / Roof Use

The selection of a suitable roof area for this technology must reflect the sensitivity of the system's performance to orientation, tilt angle and local shading obstructions. At this stage it has been assumed that the development roof would allow a limited area for solar panels to be orientated and tilted in a favourable location. Please refer to Figure 10 below for the indicative location of PV for the proposed development.

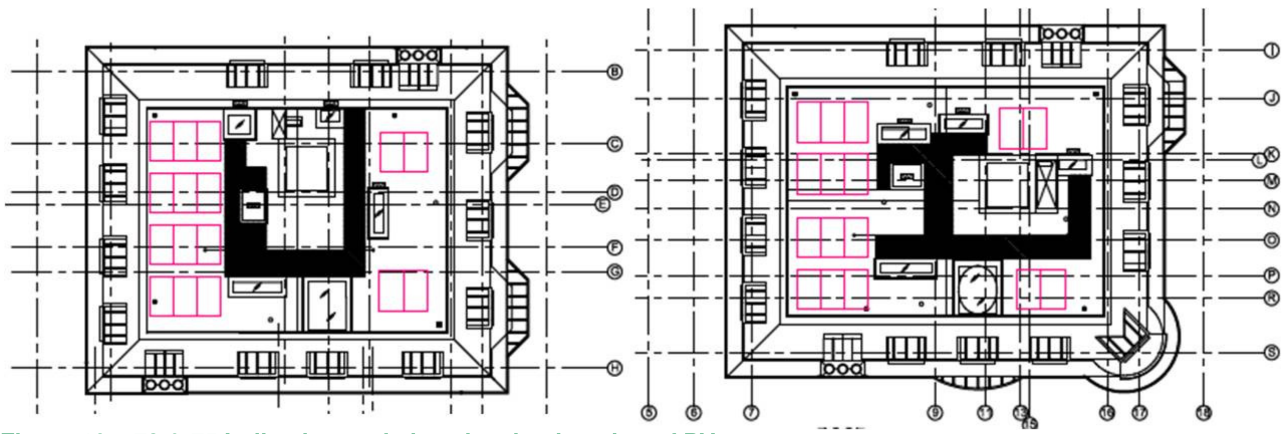


Figure 10 – 73 & 75 Indicative roof plan showing location of PV.

It should be noted however that the extensive use of solar panels would add considerably to the weight to be supported by the roof.

5.3.4. Planning Criteria

Any technology installed on a building's roof that protrudes less than 200mm is exempt from requiring specific planning permissions. Local authorities can also sometimes impose restrictions where glare from reflected sunlight off the panels could cause a nuisance or problems with the local area.

5.3.5. Noise

The panels themselves are silent as they have no moving parts, however the only source of minor noise may be the inverter. Given the nature of the building it is highly unlikely that the noise of the inverters will have any significant impact on the surrounding area sound levels.

5.3.6. Possibility of electricity export

Should the generation of electricity from the PV panels exceed the requirement of the building at any point, it can be exported and sold to the grid. Utilities providers typically offer two different rates for the electricity based upon the predictability of electricity exported. Suitable measures and infrastructure to enable the system to export electricity are typically inexpensive and relatively simple for small systems, but co-ordination with the local district network operator is always necessary.

5.3.7. Grants

The Feed-in Tariffs (FITs), introduced in April 2010, reward users per unit of metered electricity generated. Currently for a system with an output greater than 4kWp but not exceeding 10kWp installed to provide electricity to a new building before first occupation(as the required installation) a rate of 11.32p/kWh for a middle rate option can be obtained. This inceptive will be available for the first 20 years of the systems life. Note: the following assumption was made FITs for systems installed from the 1st of Jan 2015 until 31 March 2015.

On 1st April each year, the FITs rate for new installations will reduce by around 8% in line with the government's expected reduction in capital cost of the technology. The FITs are however, subject to inflation so the next year's tariffs are yet to be confirmed.

5.3.8. Operation and Maintenance

Maintenance requirements for PV systems are generally low, particularly installations that are inclined since rain water often cleans off any dirt. However, because of the impact that soiled panels can have on energy output: it is advised that panels are checked and cleaned annually.

5.3.9. Summary

Solar photovoltaic (PV) panels are a suitable technology for the proposed residential development at 73 – 75 Avenue Road due to the flexibility of installation.

The carbon reductions are favourable, (based on estimations for solar panel output and supply and installation costs) are enhanced by the Feed-in Tariff Scheme. In view of this, we would recommend this technology as an additional technology if required to achieve the carbon reduction targets set in section 3.3

5.4 Combined Heat and Power (CHP)

5.4.1. Description

Combined heat and power units generate electricity and emit waste heat in much the same process as other generators. However in a CHP unit, the waste heat produced is converted into a useful energy source and utilised, thus significantly increasing the overall efficiency of the system. CHP units are typically sized to meet the base heat load of a building, and *Chartered Institution of Building Services Engineers CIBSE AM12 – Small Scale CHP in Buildings* gives guidance for their design suitability. The general criteria that must all be met are as follows;

a) Base load of heat and power exceeding 4000 hours annually (46% of year)
b) Base load power demand of approximately 50kW
c) Base load heat demand of approximately 80kW
d) Extended Daily occupancy

5.4.2. Capacity

The building's heat and power loads depend on occupancy, and therefore CHP schemes are only suitable for buildings whose occupancy profiles extend beyond the typical 9am to 5pm criteria. The proposed building includes a swimming pool which will have a continuous heat requirement, thus providing a base load which suits CHP.

CHP Technology has advanced since the publication of CIBSE AM12, and the minimum plant sizes have reduced significantly (including the introduction of micro-CHP units). The heat and power profiles of the proposed residential development at 73 – 75 Avenue Road would enable the specification of a mini-CHP (5-30kW_{elec} peak) plant to operate efficiently.

5.4.3. Land Use / Roof Use

A CHP boiler generally is floor mounted in much the same way as commercial boilers in a plant room. Provision should be made, for the electrical components that would allow for connection to the national grid to export excess electricity if required and an appropriate flue designed in order to mitigate the air quality issue that can arise by specifying a CHP.

5.4.4. Planning Criteria

CHP systems generally do not require planning permission as they can be housed in internal plant rooms. Co-ordination with the local District Network Operator (DNO) regarding the export of electricity to the grid is important, similar to other on-site electricity generating technology.

5.4.5. Noise

Consideration should be given to its proposed location so as not to cause a disturbance. Noise levels vary between manufacturers; therefore co-ordination with acoustic consultants and M&E designers at an early stage is important.

5.4.6. Possibility of electricity export

Should the generation of electricity from the CHP exceed the requirement of the building at any point, it can be exported and sold to the grid. Utilities providers typically offer two different rates for the electricity based upon the predictability of electricity exported. Suitable measures and infrastructure to enable the system to export electricity are typically inexpensive and relatively simple for small systems, but co-ordination with the local DNO is usually necessary.

5.4.7. Grants

Only units with a peak electrical output of less than 2kW are eligible for Feed-in Tariffs (renewable heat incentive) therefore grants would not be applicable for this project.

5.4.8. Operation and Maintenance

Consideration of regular maintenance is recommended at this stage in order to ensure the optimal operation of these systems.

5.4.9. Connections to Existing CHP and Community Energy Schemes

To comply with the London Plan 2015, provision will be considered at detailed design stage to allow future connection to existing heating networks. It has been established that no district heating network is currently within the vicinity of the proposed site as shown on the London Heat Map (Figure 11 below).

As there are currently no timeframes for the delivery of a district heating system in the area, the scheme will be designed with future connection capabilities so that there is the opportunity to connect the building's heating system to a district heating network.

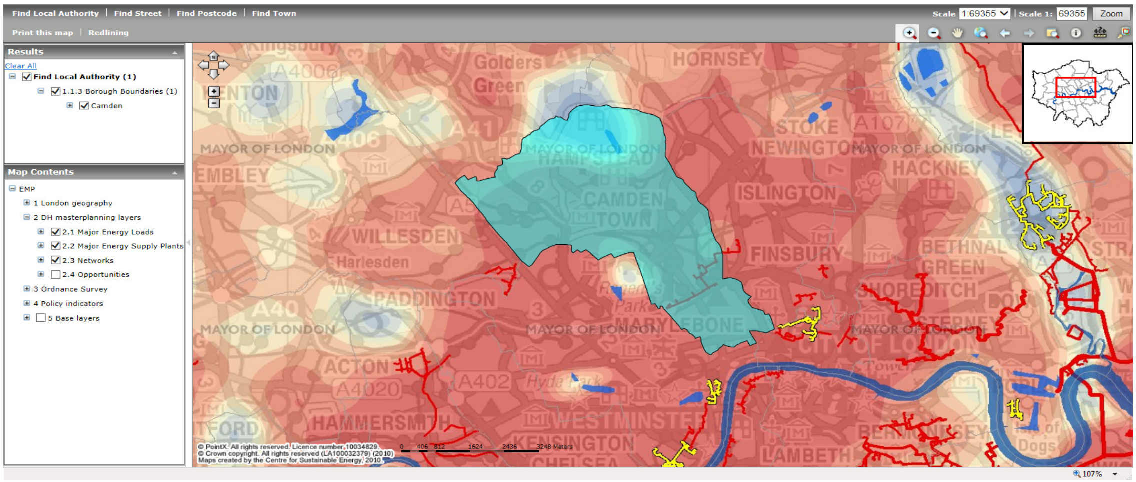


Figure 11 - Camden area highlighted in the Greater London Heat Map (www.londonheatmap.org.uk)

5.4.10. Summary

Due to the constant heat demand (base load) for the proposed development, a Combined Heat and Power system is a suitable technology for the proposed residential development at 73 & 75 Avenue Road. The carbon dioxide reductions are favourable (based on the estimations and assumptions for the CHP system modelled).

6. SIMULATION RESULTS

6.1 SAP 2012 Calculation results

Following the simulations carried out, **Error! Reference source not found.** below summarises the predicted nnual carbon dioxide emissions calculated for both proposed properties (Please refer to appendix one for all the SAP 2012 supporting calculations) Figure 12 and Figure 13 show a predicated energy rating for the properties at this stage. Please note that these figures might not represent the final energy rating of the property. The final energy rating will be calculated once the properties are completed.

73 Avenue Road	
	$kgCO_2.yr.m^2$
DER	14.33
TER	14.36
Fabric Efficiency	$kWh/m^2/yr$
DFEE	52.80
TFEE	63.38
75 Avenue Road	
	$kgCO_2.yr.m^2$
DER	14.66
TER	14.67
Fabric Efficiency	$kWh/m^2/yr$
DFEE	55.11
TFEE	69.48

Table 2 – 73 – 75 Avenue Road predicted Part L1A 2013 Performance

Key to abbreviations;

Dwelling Emissions Rate	=	DER
Target Emissions Rate	=	TER
Design Fabric Energy Efficiency	=	DFEE
Target Fabric Energy Efficiency	=	TFEE

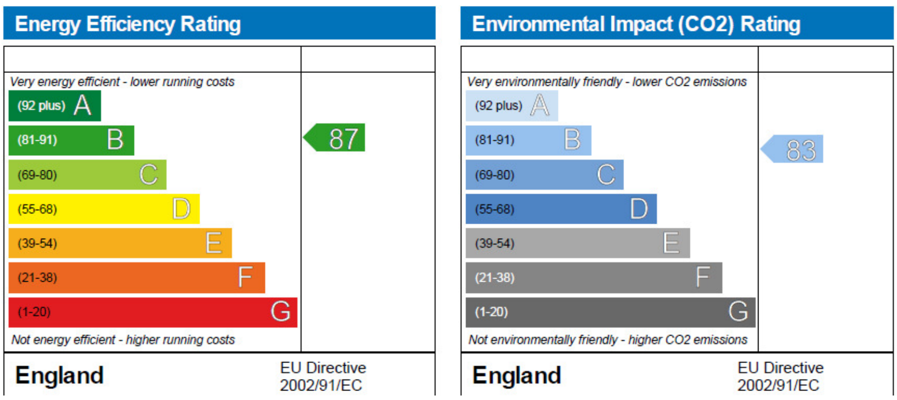


Figure 12 – 75 Avenue Road Predicted Energy Assessment (SAP 2012)

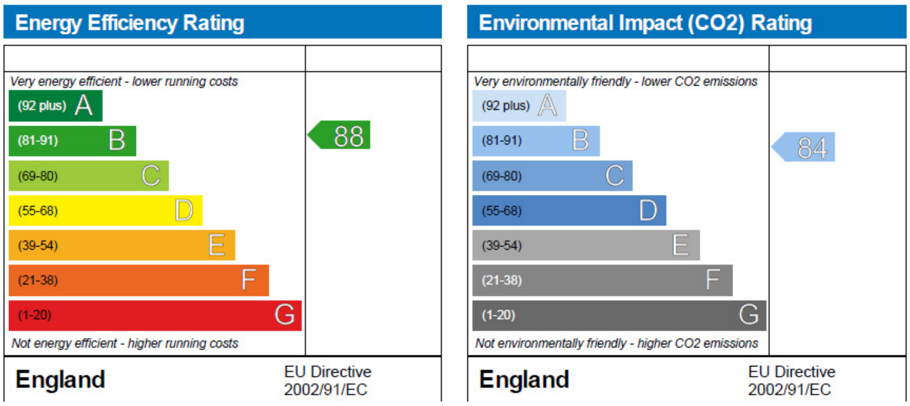


Figure 13 – 73 Avenue Road Predicted Energy Assessment (SAP 2012)

6.2 Energy demand assessment

The benefits following the “Energy Hierarchy” and low carbon design methodologies and principles adopted and described above were assessed under a compliance SAP 2012 modelling exercise. SAP 2012 calculations aim to predict the annual CO_2 emissions across the two houses; as a result of the modelling carried it out it can be concluded that through the application of “Lean” measures the proposed development achieve an approximate annual CO_2 reduction of approximately 6tCO_2. Further “Clean” and “Green” measures suggest a further annual CO_2 of approximately 12tCO_2 to achieve an approximate 37% over the Part L1A compliant model. Table above shows that the proposed development is targeting to reduce the predicted CO_2 emissions by approximately 37% from the “Green Measures” proposed. **Error! Reference source not found.** below presents a summary of the annual CO_2 emissions at each stage of the GLA Energy Hierarchy.

73 & 75 Avenue Road Energy Assessment	Regulated CO_2 Emissions
	(tCO_2/year)
Baseline	39.15
Lean **[Part L1 Compliant]**	32.76
Clean	24.45
Green	20.57

Table 3 – Site CO_2 emissions summary

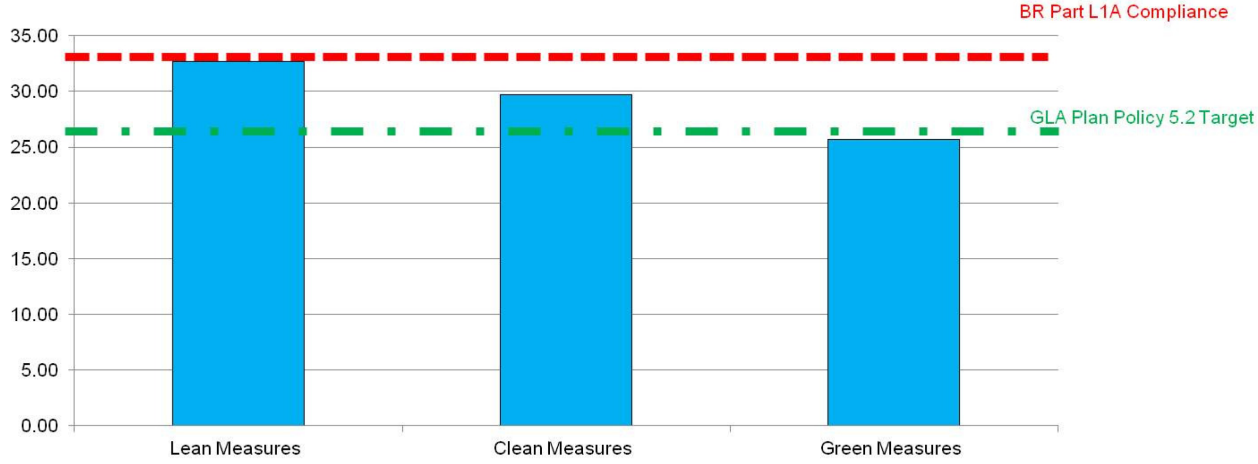


Figure 14 – Annual CO_2 emissions at each step of the GLA Energy Hierarchy

	Carbon dioxide emissions (Tonnes CO_2 per annum)
	Regulated
Part L2013 of the Building Regulations Compliant Development	32.76
Lean Measures	32.76
Clean Measures	29.04
Green Measures	20.57

Figure 15 – GLA Energy assessment CO_2 emissions after each stage of the Energy Hierarchy

	Regulated Carbon dioxide savings	
	Tonnes CO_2 per annum	(%)
Savings from Lean Measures	0.00	
Savings from Clean Measures	3.72	
Savings from renewable energy	8.47	
Total Cumulative Savings	12.19	37%
Total Target Savings	11.47	35%
Annual Surplus	0.73	

Figure 16 – GLA Energy assessment regulated CO2 emissions savings from each stage of the Energy Hierarchy

7. CONCLUSION AND RECOMMENDATIONS

7.1 General conclusions

The simulations carried out have described the potential energy saving measures that can be incorporated in the design of the proposed residential development at 73 & 75 Avenue Road in London. Passive and active measures as described in section 4.2 above were considered to reduce the buildings energy demand and hence reduce operational costs.

It can be concluded that through the improvement of thermal performance of fabric elements, implementation of efficient well controlled heating, cooling and ventilation services and low energy lighting linked to appropriate controls the energy demand and CO_2 emissions can be reduced.

The modelled results suggested that implementing “lean” measures, the energy and CO_2 savings could achieve improvements of approximately 16% for 73 & 75 Avenue Road.

Active design principles as discussed earlier are aimed to meet the energy demand as efficiently as possible. The “Clean” measures investigated suggested a further CO_2 savings of approximately 25% for both 73 -75 5 Avenue Road.

The feasibility of range of potential LZC technologies was assessed in section 5.1 above. The technologies considered and discounted were as follow:

- Biomass was not considered technically feasible due to negative air quality impact, fuel storage space and security on future fuel supply and costs.
- Wind energy was not considered technically feasible due to the low wind speeds for the site in this location.

As a result of the comparative analysis carried out, ASHP, GSHP, PV panels and CHP were considered as adequate for the proposed site. It is however recommended to review the implementation of any of these technologies at a more detailed stage.

At this stage an ASHP system was selected as the most appropriate technology for the sites cooling requirements on the basis that it had the potential to deliver a low energy and low CO_2 solution.

The preliminary Part L1A 2013 calculations carried out suggest the DER ≤ than TER and DFEE ≤ than TFEE showing compliance. Please note that this is a preliminary assessment based on the assumptions mentioned in earlier sections of this report. (Refer to appendix 1 for the detailed SAP Calculations results).

Figure 16 above shows that the proposed development is targeting to reduce the predicted CO_2 emissions by approximately 37% from the “Green Measures” proposed.

7.2 Energy strategy summary

The proposed energy strategy for the site is to:
Exceed Part L1A 2013 through the implementation of the “Lean Clean and Green” measures described in sections 4.2.1, 4.2.2 and 4.2.3 above.
These include:

- Efficient fabric thermal performance
- Limit linear thermal transmittance to avoid thermal bridging
- Consider the installation of a Combined Heat and Power (CHP) system to serve the proposed developments DHW systems
- Develop a low energy artificial lighting strategy
- Allow for natural ventilation
- Install high efficient air source heat pumps to serve the comfort cooling requirements of the development
- Install a 4kWp PV array on each of the properties roofs

APPENDIX ONE: 73 & 75 AVENUE ROAD SAP 2012 CALCULATIONS

Building Regulation Compliance

Property Reference: 73 Avenue Road
Survey Reference: 73 Lean [March 2016]
Property: Avenue Road, 73, London, NW8 6JD

Issued on Date: 22.Mar.2016
Prop Type Ref: Avenue Road

SAP Rating:	86 B	**CO2 Emissions (t/year):**	16.97	**DER:**	14.33 Pass	**TER:**	14.36	**Percentage DER<TER:**	0.21 %
Environmental:	82 B	**General Requirements Compliance:**	Pass	**DFEE:**	52.80 Pass	**TFEE:**	68.38	**Percentage DFEE<TFEE:**	22.79 %

CfSH Results **Version:** **ENE1 Credits:** N/A **ENE2 Credits:** N/A **ENE7 Credits:** N/A **CfSH Level:** N/A

Surveyor: admin Admin, Tel: 4, Fax: s@l.f
Address:
Client:

Surveyor ID: Admin

Software Version: Elmhurst Energy Systems SAP2012 Calculator (Design System) version 3.05r04
SAP version: SAP 2012, Regs Region: England (Part L1A 2013), Calculation Type: New Build (As Designed)

SUMMARY FOR INPUT DATA FOR New Build (As Designed)

1a TER and DER

Fuel for main heating:	Mains gas	
Fuel factor:	1.00 (mains gas)	
Target Carbon Dioxide Emission Rate (TER)	14.36 kg/m^2	
Dwelling Carbon Dioxide Emission Rate (DER)	14.33 kg/m^2	OK

1b TFEE and DFEE

Target Fabric Energy Efficiency (TFEE)	68.38 kWh/m^2	
Dwelling Fabric Energy Efficiency (DFEE)	52.80 kWh/m^2	OK

2 Fabric U-values

Element	Average	Highest	
External wall	0.18 (max. 0.30)	0.18 (max. 0.70)	OK
Floor	0.13 (max. 0.25)	0.13 (max. 0.70)	OK
Roof	0.13 (max. 0.20)	0.13 (max. 0.35)	OK
Openings	1.40 (max. 2.00)	1.40 (max. 3.30)	OK

2a Thermal bridging

Thermal bridging calculated from linear thermal transmittances for each junction

3 Air permeability

Air permeability at 50 pascals:	5.00 (design value)	
Maximum	10.0	OK

4 Heating efficiency

Main heating system:	Boiler system with radiators or underfloor - Mains gas Data from manufacturer TBC TBC Efficiency: 88.0% SEDBUK2009 Minimum: 88.0%	OK
Secondary heating system:	None	

5 Cylinder insulation

Hot water storage	Nominal cylinder loss: 5.70 kWh/day Permitted by DBSCG 6.10	OK
Primary pipework insulated:	Yes	OK

6 Controls

Space heating controls:	Time and temperature zone control	OK
Hot water controls:	Cylinderstat	OK
	Independent timer for DHW	OK
Boiler interlock	Yes	OK

7 Low energy lights

Percentage of fixed lights with low-energy fittings:	75%	
Minimum	75%	OK

8 Mechanical ventilation

Not applicable

9 Summertime temperature

Overheating risk (Thames Valley):	Not significant	OK
Based On:		
Overshading:	Average	
Windows facing North East:	48.44 m^2, No overhang	
Windows facing South East:	50.03 m^2, No overhang	
Windows facing South West:	59.13 m^2, No overhang	
Windows facing North West:	3.46 m^2, No overhang	
Air change rate:	5.00 ach	
Blinds/curtains:	None	

10 Key features

Thermal bridging y-value	0.036 W/m^2K

Building Regulation Compliance

Property Reference:	75 Avenue Road	**Issued on Date:**	22.Mar.2016
Survey Reference:	75 Lean [March 2016]	**Prop Type Ref:**	Avenue Road
Property:	Avenue Road, 75, London, NW8 6JD		

SAP Rating:	86 B	**CO2 Emissions (t/year):**	15.79	**DER:**	14.66 Pass	**TER:**	14.67	**Percentage DER<TER:**	0.04 %
Environmental:	82 B	**General Requirements Compliance:**	Pass	**DFEE:**	55.11 Pass	**TFEE:**	69.48	**Percentage DFEE<TFEE:**	20.68 %

CfSH Results **Version:** **ENE1 Credits:** N/A **ENE2 Credits:** N/A **ENE7 Credits:** N/A **CfSH Level:** N/A

Surveyor: admin Admin, Tel: 4, Fax: s@l.f Surveyor ID: Admin
Address:
Client:

Software Version: Elmhurst Energy Systems SAP2012 Calculator (Design System) version 3.05r04
SAP version: SAP 2012, Regs Region: England (Part L1A 2013), Calculation Type: New Build (As Designed)

SUMMARY FOR INPUT DATA FOR New Build (As Designed)

1a TER and DER

Fuel for main heating:	Mains gas	
Fuel factor:	1.00 (mains gas)	
Target Carbon Dioxide Emission Rate (TER)	14.67 kg/m2	
Dwelling Carbon Dioxide Emission Rate (DER)	14.66 kg/m2	OK

1b TFEE and DFEE

Target Fabric Energy Efficiency (TFEE)	69.48 kWh/m2	
Dwelling Fabric Energy Efficiency (DFEE)	55.11 kWh/m2	OK

2 Fabric U-values

Element	Average	Highest	
External wall	0.18 (max. 0.30)	0.18 (max. 0.70)	OK
Floor	0.13 (max. 0.25)	0.13 (max. 0.70)	OK
Roof	0.13 (max. 0.20)	0.13 (max. 0.35)	OK
Openings	1.40 (max. 2.00)	1.40 (max. 3.30)	OK

2a Thermal bridging

Thermal bridging calculated from linear thermal transmittances for each junction

3 Air permeability

Air permeability at 50 pascals:	5.00 (design value)	
Maximum	10.0	OK

4 Heating efficiency

Main heating system:	Boiler system with radiators or underfloor - Mains gas Data from manufacturer TBC TBC Efficiency: 88.0% SEDBUK2009 Minimum: 88.0%	OK
Secondary heating system:	None	

5 Cylinder insulation

Hot water storage	Nominal cylinder loss: 5.70 kWh/day Permitted by DBSCG 6.10	OK
Primary pipework insulated:	Yes	OK

6 Controls

Space heating controls:	Time and temperature zone control	OK
Hot water controls:	Cylinderstat	OK
	Independent timer for DHW	OK
Boiler interlock	Yes	OK

7 Low energy lights

Percentage of fixed lights with low-energy fittings:	75%	
Minimum	75%	OK

8 Mechanical ventilation

Not applicable

9 Summertime temperature

Overheating risk (Thames Valley):	Not significant	OK
Based On:		
Overshading:	Average	
Windows facing North East:	51.88 m^2, No overhang	
Windows facing South East:	6.67 m^2, No overhang	
Windows facing South West:	64.38 m^2, No overhang	
Windows facing North West:	6.43 m^2, No overhang	
Air change rate:	5.00 ach	
Blinds/curtains:	None	

10 Key features

Thermal bridging y-value	0.037 W/m^2K