SYNTEGRA
CONSULTING

Energy and Sustainability Statement

15-1601

28 Redington Road, Hampstead, NW3 7RB

May 2016

Quality Standards Control

The signatories below verify that this document has been prepared in accordance with our quality control requirements. These procedures do not affect the content and views expressed by the originator.

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Date	15/04/2016	18/05/2016
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Forecast cost estimates do not include such costs associated with any negotiations, appeals or other non- technical actions associated with the agreement on measures to meet the requirements of the authorities, nor are potential business loss and interruption costs considered that may be incurred as part of any technical measures.

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1. Executive Summary

The design of the proposed development, **28 Redington Road, Hampstead, London**, will be comprised a new construction of 6 storey building comprising of 8 no. of residential units. The design has incorporated building fabric enhancement (above current building regulations requirements) to increase the energy efficiency of the building. This includes that the development uses less energy, by adopting sustainable design and construction measures and by supplying energy efficiently.

Given the complexity of calculating and assessing CO_2 emissions, **the London Borough of Camden** requires all proposed developments to incorporate sustainable design and construction measures by expecting **the new developments to achieve an overall 35% reduction of CO_2 emissions over the Part L2013 with 20% reduction of CO_2 emissions via onsite renewables,** in accordance with London Plan and Local Policies.

To meet the Local policy requirements, the development incorporates various sustainable design and construction measures including energy/ carbon reduction, water consumption, material procurement, and waste management. The recommendation for the energy/ carbon reduction is **to enhance fabric elements (U-values) as per Building Regulations Part L1A; to install Community scheme based on air source heat pump air-water (minimum 300% efficiency for heating, 270% for cooling) for space heating, cooling and domestic hot water; to install low energy lights.** This is based on the following reasons:

1. The strategy would provide an average of **53.6% CO_2 reduction savings against the TER set by Building Regulation Part L1A.** Therefore, the strategy meets requirements of Building Regulations L1A 2013, the London Plan, and Local Policies.

2. The following hierarchy of the strategy has been explored and implemented:
    - BE LEAN: Energy efficient design
    - BE CLEAN: Connection to district heat networks or communal heating systems (e.g. Combined Heat and Power)
    - BE GREEN: Installation of on-site renewable energy technologies

3. The strategy at **BE GREEN stage** would provide an average **29.5% reduction of CO_2 emissions via onsite renewable technology (communal air source heat pumps)** for the overall development. This reduction is calculated after comparing with a communal gas boiler system with 95% efficiency.

4. Although the policy encourages that new residential developments meet the Code for Sustainable Homes (CSH) Level 6, the CSH has been withdrawn by the Government as of April 2015. As such a pre-assessment has not been provided as part of this strategy.

After the application of the proposed strategy, the regulated carbon dioxide emissions are presented on the table below:

Energy Hierarchy	Strategies	Regulated Carbon	
		EMISSIONS (Tonnes CO_2/yr.)	**SAVINGS** (%)
BASELINE	TER set by Building Regulations	33.46	-
BE LEAN **BE CLEAN** **BE GREEN**	After energy demand reduction After CHP/ Communal Heating After renewable energy	15.51	53.63%
Total Cumulative Savings		**17.94**	**53.63%**
Local Target		11.71	35%

Table 1 Carbon dioxide Emissions after each stage of the Energy Hierarchy

In summary, the strategy demonstrates a ***53.63%*** CO_2 reduction against the baseline (TER) through energy efficient design and onsite renewables.

2. Introduction

Syntegra Consulting Ltd has been appointed as sustainability consultants to produce an energy strategy for the **new construction of 6 storey building comprising of 8 no. of residential units** located in **Hampstead, Camden Borough** – to support the scheme design process, demonstrate Building regulations Part L1A 2013 compliance and intent to target a 20% reduction of CO_2 emissions reduction via onsite renewable energy technology for the overall development in accordance with the planning policy requirements.

This report will outline the following:

1) This report will assess the proposed development site's estimated energy demand & CO_2 emissions. It will look into the feasibility of Low Zero Carbon technologies, examining the following aspects relative to LZC/renewable technologies:

- Energy generated by Renewable/Low Zero Carbon Technologies (LZC)
- Feasibility assessment for each Renewable/Low Zero Carbon Technologies (LZC)
- Local Planning Requirements
- Life cycle Costs & payback period for the technology investment
- Available Grants

2) The proposed building fabric and Low Zero Carbon (LZC) design strategy and analysis calculations, with respect to the Standard Assessment energy assessment Procedure (SAP). Demonstration of how the design is compliant against the current Part L 2013 building regulations i.e. **the 35% reduction in CO_2 emissions** in accordance with the local planning policy.

3) The target of **a 20% reduction of the development's CO_2 Emissions** through the utilisation of renewable technology as per the planning policy requirements

4) Assessment of opportunities for utilising Decentralised Energy Networks and Combined Heat and Power (CHP) as per the planning policy requirements.

3. Site Description

The proposed development will be comprised of the **new construction of 6 storey building with a total of 8 no. of residential units** located in **Hampstead, Camden Borough**. The development is located in the area of Hampstead, North London and it is in close proximity to West Hampstead station (approximately 0.8 miles), Hampstead Underground Station (approx. 0.5 miles). The site is within the London Borough of Camden.

4. Planning Policy

4.1. National Planning Policy Framework (March 2012)

The National Planning Policy Framework is a key part of our reforms to make the planning system less complex and more accessible, to protect the environment and to promote sustainable growth.

4.2. The London Plan Renewable Energy Policy 2011 (Policy 5.2, 5.6 & 5.7)

The Mayor and boroughs should in their DPDs adopt a presumption that developments will achieve a reduction in carbon dioxide emissions of 20% from onsite renewable energy generation according to 5.42 section of Policy 5.7 Renewable Energy (which can include sources of decentralised renewable energy). According to Policy 5.2 (clause B) all residential and non-residential buildings should show an improvement of 40% BER/TER from 2013 to 2016, unless it can be demonstrated that such provision is not feasible. Furthermore, intent must be shown for connecting to a Decentralised Energy Network according to Policy 5.6 and utilizing a Combined Heat & Power.

4.3. London Borough of Camden

Camden

Camden Development Policies 2010-2025

Policy DP22: Promoting Sustainable Design and Construction

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

a. demonstrate how sustainable development principles, have been incorporated into the design and proposed implementation; and
b. incorporate green or brown roofs and green walls wherever suitable.

The Council will promote and measure sustainable design and construction by:

c. expecting new build housing to meet Code for Sustainable Homes Level 3 by 2010 and Code Level 4 by 2013 and **encouraging Code Level 6 (zero carbon) by 2016.**;
d. expecting developments (except new build) of 500sqm of residential floor space or above or 5 or more dwellings to achieve 'very good' in EcoHomes assessments prior to 2013 and encouraging 'excellent' from 2013;
e. expecting non-domestic developments of 500sqm of floor space or above to achieve 'very good' in BREEAM assessments and 'excellent' from 2016 and encouraging zero carbon from 2019.

The Council will require development to be resilient to climate change by ensuring schemes include appropriate climate change adaptation measures, such as:

f. summer shading and planting;
g. limiting run-off;
h. reducing water consumption;
i. reducing air pollution; and
j. not locating vulnerable uses in basements in flood-prone areas.

<u>**Camden Core Strategy 2010-2025**</u>

Policy CS13 – Tackling climate change through promoting higher environmental standards

Reducing the effects of and adapting to climate change

The Council will require all development to take measures to minimise the effects of, and adapt to, climate change and encourage all development to meet the highest feasible environmental standards that are financially viable during construction and occupation by:

a. ensuring patterns of land use that minimise the need to travel by car and help support local energy networks;
b. promoting the efficient use of land and buildings;
c. minimising carbon emissions from there development, construction and occupation of buildings by implementing, in order, all of the elements of the following energy hierarchy:
    1. ensuring developments use less energy,
    2. making use of energy from efficient sources, such as the King's Cross, Gower Street, Bloomsbury and proposed Euston Road decentralized energy networks;
    3. generating renewable energy on-site;
    and
d. ensuring buildings and spaces are designed to cope with, and minimise the effects of, climate change.

The Council will have regard to the cost of installing measures to tackle climate change as well as the cumulative future costs of delaying reductions in carbon dioxide emissions

Local energy generation

The Council will promote local energy generation and networks by:

e. working with our partners and developers to implement local energy networks in the parts of Camden most likely to support them, i.e. in the vicinity of
   - housing estates with community heating or the potential for community heating and other uses with large heating loads;
   - the growth areas of King's Cross; Euston; Tottenham Court Road; West Hampstead Interchange and Holborn;
   - schools to be redeveloped as part of Building Schools for the Future programme;
   - existing or approved combined heat and power/local energy networks (see Map4);

and other locations where land ownership would facilitate their implementation.

f. protecting existing local energy networks where possible (e.g. at Gower Street and Bloomsbury) and safeguarding potential network routes (e.g. Euston Road);

Water and surface water flooding

We will make Camden a water efficient borough and minimise the potential for surface water flooding by:

g. protecting our existing drinking water and foul water infrastructure, including Barrow Hill Reservoir, Hampstead Heath Reservoir, Highgate Reservoir and Kidderpore Reservoir;
h. making sure development incorporates efficient water and foul water infrastructure;
i. requiring development to avoid harm to the water environment, water quality or drainage systems and prevents or mitigates local surface water and downstream flooding, especially in areas up-hill from, and in, areas known to be at risk from surface water flooding such as South and West Hampstead, Gospel Oak and King's Cross (see Map 5).

Camden's carbon reduction measures

The Council will take a lead in tackling climate change by:

j. taking measures to reduce its own carbon emissions;
k. trialling new energy efficient technologies, where feasible; and
l. raising awareness on mitigation and adaptation measures.

Generating renewable energy on-site

13.11 Buildings can also generate energy, for example, by using photovoltaic panels to produce electricity, or solar thermal panels, which produce hot water. Once a building and its services have been designed to make sure energy consumption will be as low as possible and the use of energy efficient sources has been considered, **the Council will expect developments to achieve a reduction in carbon dioxide emissions of 20% from on-site renewable energy generation** (which can include sources of site-related decentralised renewable energy) unless it can be demonstrated that such provision is not feasible. Details on ways to generate renewable energy can be found in our Camden Planning Guidance supplementary document.

5. Sustainable Design and Construction

5.1. Bicycle Storage

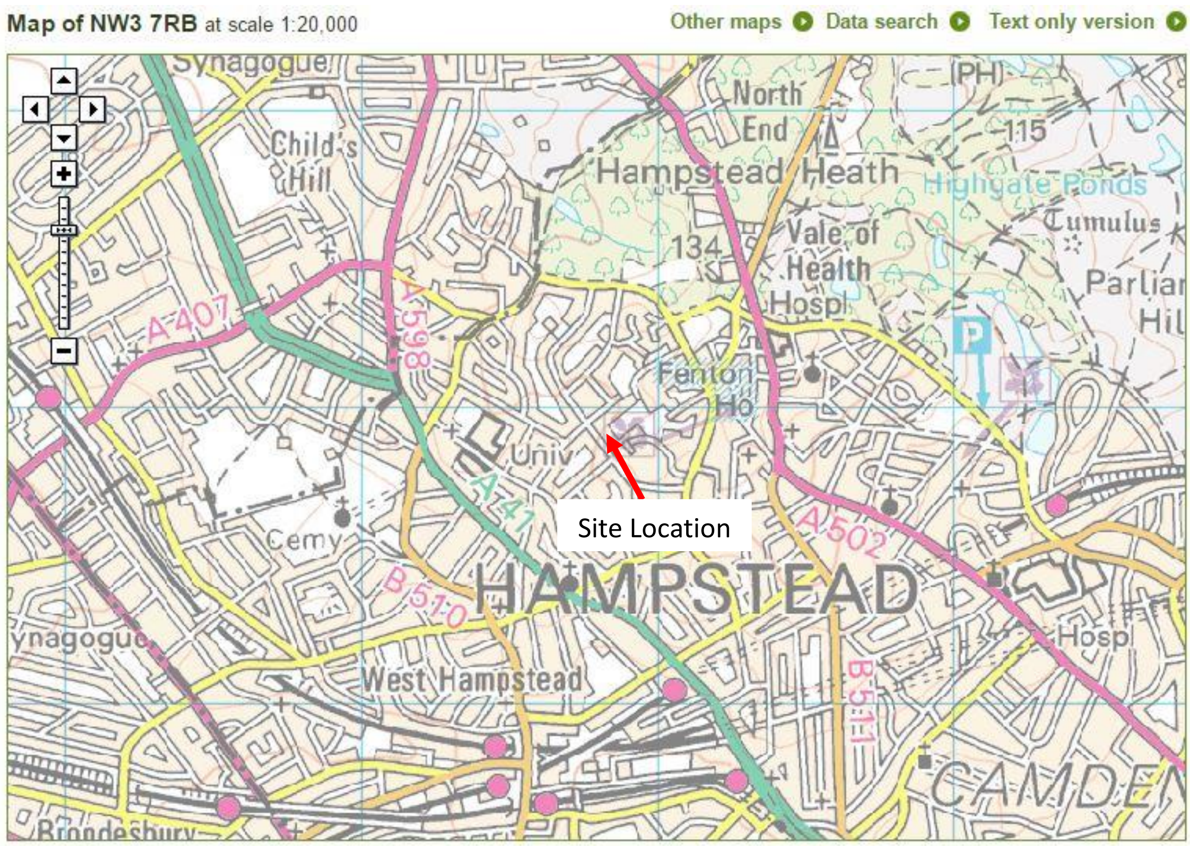
To promote exercise and help reduce congestion and carbon emissions, cyclist facilities are provided on the lower ground floor in line with the sustainable development principles in the Local Policy DP22. The facility includes bike storage and private lockers. As each residential unit has their own shower facilities, additional showers are not provided on the lower ground floor.

5.2. Water

The development will be based upon the specification of water efficient fittings across the development including low volume dual flush WCs, low flow taps and showers in accordance with Building Regulation Part G (i.e. the targeted water consumption is 125 l/p/day). This is a part of climate change adaptation measures set by Local Policy DP22.

5.3. Flood Risk

The Environmental Agency map shows that the site surrounding area is within zone 1 of the flood risk. However, the detail flood assessment on the site will be undertaken for the proposed scheme to identify anticipated level of flooding and recommendations will also be obtained to improve the flood levels. In order to protect the site for future climate change impacts the Sustainable drainage strategy (SUDS) has been developed to minimise the risk of flooding in accordance with the National Planning Policy Framework and Camden's requirements.



5.4. **Materials**

The development will aim to procure/ utilise European compliant construction material including Sustainable timber. All the other building materials will achieve ‘A’ or higher ratings against BRE Green guide rating where feasible. The materials will be responsibly and locally sourced from suppliers where feasible. In order to minimise the environmental impact of construction the existing building materials such as aggregates will be reused on site where possible. This is in line with Camden council’s policy requirements for DP22.

5.5. **Waste**

The proposed development will adopt the best waste management procedures to reduce the amount of waste going to landfill. This will be established by creating provisions for recycling and also waste segregation from general to recyclable waste. To enhance the waste reduction potential, the provision of kitchen and garden waste composting will be considered as a measure of reducing the amount of waste going to landfill in accordance with the council’s recycling collection scheme. The construction waste should also be considered to minimise, recycle and reuse on site where possible, this will reduce the overall construction cost and at the same time minimise the amount of waste diverting to landfill. Site Waste Management Plan (SWMP) will be formalised before the construction works start and updated as the works continue on the site.

6. Energy Assessment

6.1. The Energy Hierarchy

The Mayor's Energy Strategy adopts a set of principles to guide design development and decisions regarding energy, balanced with the need to optimise environmental and economic benefits. These guiding principles have been reordered since the publication of the Mayor's Energy Strategy in Feb 2004 and the adopted replacement London Plan 2011 states that 'The following hierarchy should be used to assess applications:

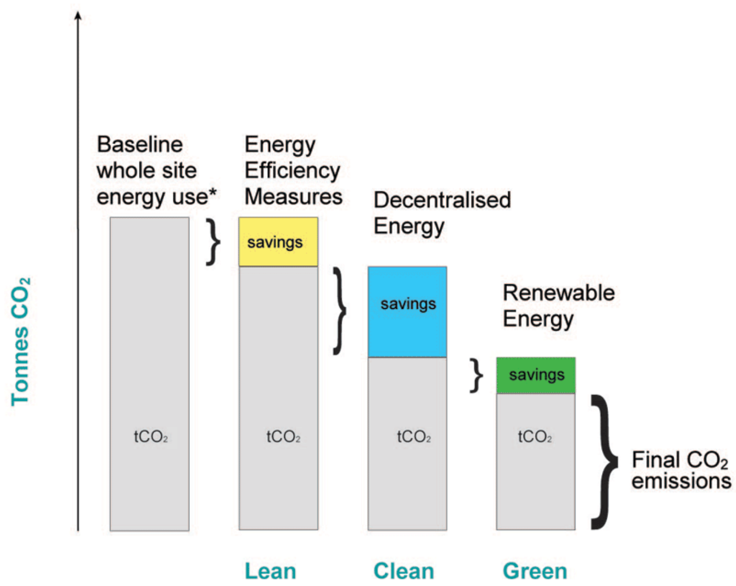
- *Using less energy, in particular by adopting sustainable design and construction measures;*
- *Supplying energy efficiency, in particular by prioritising decentralised energy generation; and*
- *Using renewable energy.*

The development's Energy Strategy has adopted the following design ethos:

- ✓ **BE LEAN** – By using less energy and taking into account the further energy efficiency measure in comparison to the baseline building.

- ✓ **BE CLEAN** – By supplying energy efficiently. The clean building looks at further carbon dioxide emission savings over the lean building by taking into consideration the use of decentralise energy via CHP.

- ✓ **BE GREEN** – By integrating renewable energy into the scheme which can further reduce the carbon dioxide emission rate.



6.2. Input data for energy assessment

Syntegra received the architectural drawings in AutoCAD format, and they were used to undertake the energy assessments i.e. SAP calculations. The drawing references are listed in table below.

No.	Drawing Name	Format
1	JCA-RR-PR-001 Location Plan	.dwg
2	JCA-RR-PR-002 Site Plan	.dwg
3	JCA-RR-PR-003 Site Plan	.dwg
4	JCA-RR-PR-010 Lower ground Floor	.dwg
5	JCA-RR-PR-011 Ground Floor	.dwg
6	JCA-RR-PR-012 First Floor	.dwg
7	JCA-RR-PR-013 Second Floor	.dwg
8	JCA-RR-PR-014 Third Floor	.dwg
9	JCA-RR-PR-015 Third Floor	.dwg
10	JCA-RR-PR-015 Roof Plan	.dwg

Table 2 The drawing list

The following table presents the type, area and number of units to be assessed within this report:

NEW BUILD				
Type	**Name of unit**	**Storey**	**No. of Bedrooms**	**Floor Area** (m^2)
Residential	1	2-storey	2	144
	2	1-storey	3	224
	3	2-storey	3	242
	4	1-storey	2	178
	5	1-storey	2	151
	6	1-storey	2	167
	7	2-storey	4	271
	8	2-storey	2	166
TOTAL				1,563

Table 3 Proposed units to be assessed for the development

The assessment has assumed the following fuel carbon emissions factors. The fuel carbon emissions factors used are in accordance with **SAP 2012 (for Building Regs Part L1A 2013).**

Carbon Emissions Factor	SAP 2013 kgCO2/kW
Natural Gas	0.216
LPG	0.241
Biogas	0.098
Heating Oil	0.298
Coal (traditional British Coal)	0.394
Anthracite	0.394
Smokeless fuel	0.433
Dual Fuel (mineral + wood)	0.226
Biomass	0.123
Grid Electricity	0.519
Waste Heat	0.058

Table 4. Carbon emission factors

6.3. BASELINE

The baseline energy use and resulting CO_2 emissions rates of the development have been assessed using the SAP 2012 Government approved software. The SAP 2012 calculations have been produced according to the ADL1A 2013 building regulation requirements.

For the purpose of this report the baseline energy use and CO_2 emissions for the development are calculated based on the minimum requirements as per the Building Regulations AD L1A (Table below).

		Part L1A 2013 min. required values
U-value (W/m^2 K)	Wall	0.30
	Window	2.00
	Floor	0.25
	Roof	0.20
Air Permeability (m^3/h.m^2 at 50 Pa)		10

Table 5 Required Values in Building Regulations Part L1A 2013

The baseline average energy use and CO_2 emissions for the development are presented in the tables below:

BASELINE: TER	Regulated CO_2 Emissions	
	kg CO_2/m^2/yr	Tonnes CO_2/ yr
Whole development	**21.41**	**33.46**

Table 5 Regulated Carbon Emissions at Baseline

6.4. BE LEAN – Energy Efficient Design

This section outlines the design energy efficient measures taken in order to minimise the building's energy demand and therefore reduce energy use and CO_2 emissions further than the Baseline (Building Regulations 2013 Part L compliance).

The energy efficient measures include:

1. Inclusion of better U-values than the minimum U-values set in the ADL1A 2013 document.
2. Designing for a buildings air permeability exceeding ADL1A 2013 target values.
3. Utilising the highly efficient heating and hot water systems.
4. Utilising low energy efficient lighting such as LED lighting.

Efficient Building elements

At the 'BE LEAN' stage of the energy hierarchy, energy efficient building elements have been incorporated into the build. Please see below more specifically:

		Part L1A 2013 min. required values	Proposed building values
U-value (W/m^2 K)	Wall	0.3	0.12
	Window	2	1.2 (Roof light 1.3)
	Floor	0.25	0.12
	Roof	0.2	0.12
Air Permeability (m^3/h.m^2 at 50 Pa)		10	4.5

Table 6 Proposed Building Elements

Heating and Hot Water Demand

The heating energy demand will be reduced by providing good insulation of the building envelope in order to minimise heat losses. At the 'BE LEAN' stage **Communal heat pumps (min. 300% COP and 270% EER) with Fan Coil Units** have been examined for the heating and hot water demand. The cylinder for the hot water storage would be **125 litres with the loss factor of 1.19 kWh/day.**

Ventilation

A natural supply ventilation strategy will be adopted with extract fans in bathrooms and kitchen. Therefore, higher energy consumption and CO_2 emissions due to mechanical ventilation is avoided.

Lighting

The proposed light fittings will be low energy efficient fittings; these can be T5 fluorescent fittings with high frequency ballasts, or LED fittings.

BE LEAN STAGE

6.5. BE CLEAN – CHP & Decentralised Energy Networks

The Energy Hierarchy encourages the use of a CHP system and the connection to District Heating system to reduce CO_2 emissions further.

CHP

The Energy Hierarchy identifies the combined heat and power (CHP) as a method of producing heat and electricity with much lower emissions than separate heat and power. Also, it encourages the creation of district heating systems supplied by CHP.
The implementation of a CHP strategy should be decided according to good practice design. Key factors for the efficient implementation of the CHP system are:

- Development with high heating load for the majority of the year.
- CHP operation based on maximum heat load for minimum 10 hours per day.
- CHP operation at maximum capacity of 90% of its operating period.

To ensure that CHP is financially viable it is essential that the unit is selected to meet the base heat load and that this load is maintained over a large proportion of the day (a figure of 14 – 17 hours per day is often quoted subject to the load profiles and gas and electricity prices) to ensure that the additional costs (maintenance) associated with running a CHP unit can be recovered.

This need to run the CHP plant, as far as possible continuously makes the building load profile of prime importance when reviewing the viability of such solutions and in particular the summer time heat load profile. CHP systems only make financial sense to operate when the waste heat associated with generating the electricity is usefully used. To enable the CHP plant to run continuously when it is operating, a thermal store is often used so that excess CHP capacity can be used to generate hot water for use at a later time.

The load profile for this kind of development is intermittent. Hence a CHP system has not been considered for this development

Micro-CHP

Micro CHP has not been considered further for this project due to the following reasons:
Micro-CHP is a relatively new concept and issues are raised in relation to unproven technology, inefficiency for shorter run cycles and lack of technical knowledge that can limit the practical application of micro CHP at present. In addition, other issues surrounding the fact that around 50% of electricity generated in domestic properties is surplus, high installation costs and estimated low life expectancy has also been taken into consideration as to its Commercial unit's un-viability for this development scheme. Micro-CHP also has lower FIT tariff rate and period duration and is only applicable for systems under 2kW.

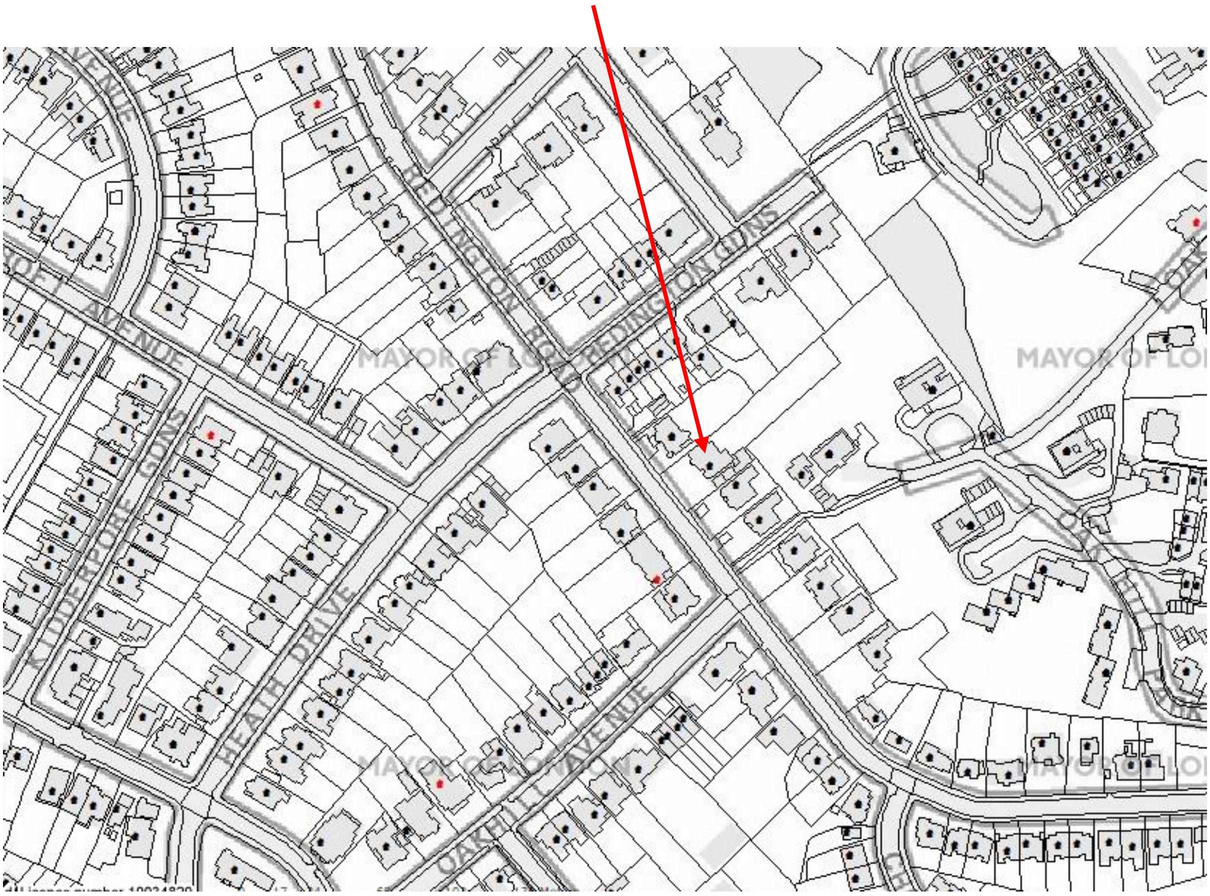
Decentralised Energy Network

The Mayor’s Energy Strategy favours community heating systems because they offer:

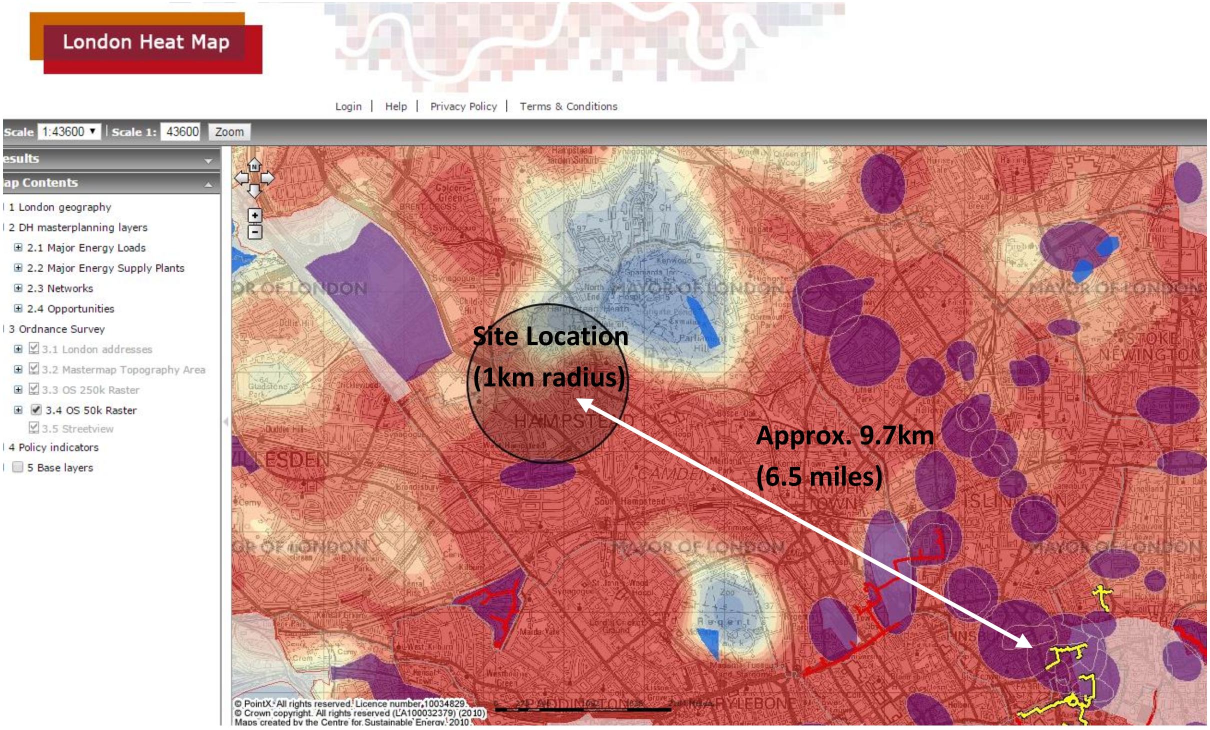
- ✓ Potential economies of scale in respect of efficiency and therefore reduced carbon emissions; and
- ✓ Greater potential for future replacement with Low or Zero Carbon (LZC) technologies.

The feasibility of connecting into an existing heating network or providing the building with its own combined heat and power plant has been assessed alongside the **London Heat Map Study for the London Borough of Camden** as part of this assessment. The study identifies that the site is not located near the existing or potential district heating networks. This is demonstrated clearly from the London Heat Map (http://www.londonheatmap.org.uk) snapshot below.

Site Location



Moreover, the London heat map below identifies existing DH networks in more broaden area, and it could not find any existing DH networks (in yellow) within 1km radius from the property. The costs involved in extending the existing DH network would outweigh the advantages in this development. **Therefore, utilisation of the DH network has not been a feasible option for this development.**



BE CLEAN STAGE

6.6. BE GREEN – Renewable Energy

In this section the viable renewable energy technologies that will reduce the development's CO_2 emissions further by 20% are examined. Incorporating lean design measures will significantly reduce the onsite energy consumption and the CO_2 emissions of the building however the reduction in emissions is still short of the target set out in the 'London Plan'. The 'London Plan' also states that a 20% CO_2 reduction must be achieved by the installation of renewable technologies. Below is a review of possible renewable technologies for incorporation in the proposed development.

All of the LZC technologies are assessed against a number of criteria. Hence, LZC technology feasibility will be assessed according to the following criteria:

- ✓ Renewable energy resource or fuel availability of the LZC technology on the site.
- ✓ Space limitations due to building design and urban location of the site.
- ✓ Capital, operating and maintenance cost.
- ✓ Planning Permission
- ✓ Implementation with regards the overall M&E design strategy for building type

The renewable/LZC technologies which were found non feasible based on the above criteria are the following:

- Solar Thermal [See Appendix Section 11.2.2]
- Wind Turbines [See Appendix Section 11.2.3]
- Small scale hydro power [See Appendix Section 11.2.4]
- Biomass Heating [See Appendix Section 11.2.4]
- Air Source Heat Pump (ASPH) [See Appendix Section 11.3.1]
- Ground Source Heat Pump (GSHP) [See Appendix Section 11.3.2]
- CHP & Micro CHP [See Appendix Section 11.3.3]
- Hydrogen Fuel Cells [See Appendix Section 11.3.4]

Available Grants information for each technology can be found in Appendix 11.4.

<u>Air Source Heat Pump (ASHP) – Proposed Technology</u>

Air Source Heat Pump is the proposed renewable technology for the proposed development. The communal heat pump system meets all the heating and hot water and the additional benefit of cooling, all from the same system. The air source heat pumps were considered a suitable renewable and carbon saving solution.

Air source heat pumps absorb heat from the outside air. This heat can then be used to heat radiators, underfloor heating systems, or warm air convectors and hot water in your home. An air source heat pump extracts heat from the outside air in the same way that a fridge extracts heat from its inside. It can get heat from the air even when the temperature is as low as -15° C. Heat pumps have some impact on the environment as they need electricity to run, but the heat they extract from the air is constantly being renewed naturally. The needs for the building is heating, cooling and domestic hot water.

Heat from the air is absorbed at low temperature into a fluid. This fluid then passes through a compressor where its temperature is increased, and transfers its higher temperature heat to the heating and hot water circuits of the house. There are two main types of air source heat pump systems.

- **Air-to-water**:

  An air-to water system distributes heat via a wet central heating system. Heat pumps work much more efficiently at a lower temperature than a standard boiler system would. This makes them more suitable for underfloor heating systems or larger radiators, which give out heat at lower temperatures over longer periods of time

- **Air-to-air**:

  An air-to -air system produces warm air which is circulated by fans to heat the building. They are unlikely to provide domestic hot water as it was required for the client.

Installing a typical system costs around £7,000- £11,000. Running costs will depend on a number of factors including the size of your home and how well insulated it. Running costs will vary depending on a number of factors - including the size of your home, and how well insulated it is, and what room temperatures you are aiming to achieve.

To check the compliance with target reduction (20%) via onsite renewables, the communal ASHP system has been compared with a communal gas boiler with a high efficiency (95%). The table below confirms that the communal ASHP system can achieve the ***29.49%*** carbon reduction against the gas system.

BE GREEN stage

		Regulated CO_2 Emissions		
		Communal gas boiler	**Communal ASHP**	**Reduction**
Whole Development	**kg $CO_2/m^2/yr$**	**14.08**	**9.93**	**-**
	Tonnes CO_2/ yr	**22.00**	**15.51**	**29.49%**

7. Conclusion

The design of the proposed development, **28 Redington Road, Hampstead, London**, will be comprised a new construction of 6 storey building comprising of 8 no. of residential units. The design has incorporated building fabric enhancement (above current building regulations requirements) to increase the energy efficiency of the building. This includes that the development uses less energy, by adopting sustainable design and construction measures and by supplying energy efficiently.

To meet the Local policy requirements, the development incorporates various sustainable design and construction measures including energy/ carbon reduction, water consumption, material procurement, and waste management. The recommendation for the energy/ carbon reduction is **to enhance fabric elements (U-values) as per Building Regulations Part L1A; to install Community scheme based on air source heat pump air-water (minimum 300% efficiency for heating, 270% for cooling) for space heating, cooling and domestic hot water; to install low energy lights.** This is based on the following reasons:

1. The strategy would provide an average of **53.6% CO_2 reduction savings against the TER set by Building Regulation Part L1A.** Therefore, the strategy meets requirements of Building Regulations L1A 2013, the London Plan, and Local Policies.

2. The following hierarchy of the strategy has been explored and implemented:
   - BE LEAN: Energy efficient design
   - BE CLEAN: Connection to district heat networks or communal heating systems (e.g. Combined Heat and Power)
   - BE GREEN: Installation of on-site renewable energy technologies

3. The strategy at **BE GREEN stage** would provide an average **29.5% reduction of CO_2 emissions via onsite renewable technology (communal air source heat pumps)** for the overall development. This reduction is calculated after comparing with a communal gas boiler system with 95% efficiency.

4. Although the policy encourages that new residential developments meet the Code for Sustainable Homes (CSH) Level 6, the CSH has been withdrawn by the Government as of April 2015. As such a pre-assessment has not been provided as part of this strategy.

After the application of the proposed strategy, the regulated carbon dioxide emissions are presented on the table below:

Energy Hierarchy	Strategies	Regulated Carbon	
		EMISSIONS (Tonnes CO_2/yr.)	**SAVINGS** (%)
BASELINE	TER set by Building Regulations	33.46	-
BE LEAN **BE CLEAN** **BE GREEN**	After energy demand reduction After CHP/ Communal Heating After renewable energy	15.51	53.63%
Total Cumulative Savings		**17.94**	**53.63%**
Local Target		11.71	35%

Table 7 Carbon dioxide Emissions after each stage of the Energy Hierarchy

In summary, the strategy demonstrates a ***53.63%*** CO_2 reduction against the baseline (TER) through energy efficient design and onsite renewables.

8. Appendix

- ✓ Low & Zero Carbon Energy Systems
- ✓ SAP calculations reports

8.1. Low & Zero Carbon Energy Systems

The following section is an overview of the LZC energy systems that are available and can be implemented to the building environment. Firstly, a brief description of the types of renewable energy (zero carbon energy) that can be harnessed with technology will be presented. In addition, the renewable energy system technologies that harness the renewable energy and convert it to electricity, heating and hot water etc, to be consumed in buildings will be presented as well.

The second part of this section will provide an indication of the available low carbon technologies that can be installed on a building to minimise carbon emissions and reduce energy costs.

8.2. Zero Carbon Technologies

In this section the zero carbon technologies also known as Renewable Energy System Technologies (REST) are described.

- Photovoltaics (PV)
- Solar Water Heating
- Wind Turbines
- Small scale Hydro Power
- Biomass Heating

8.2.1. Photovoltaic Systems

Description of PV Systems

Photovoltaic systems convert energy from the sun directly into electricity. They are composed of photovoltaic cells, usually a thin wafer or strip of semiconductor material that generates a small current when sunlight strikes them. Multiple cells can be assembled into modules that can be wired in an array of any size. These flat-plate PV arrays can be mounted at a fixed angle facing south, or they can be mounted on a tracking device that follows the sun, allowing them to capture the most sunlight over the course of a day, or even in the form of a solar PV facade. Several connected PV arrays can provide enough power for a household/building.
Thin film solar cells use layers of semiconductor materials only a few micrometers thick. Thin film technology has made it possible for solar cells to now double as rooftop

shingles, roof tiles, building facades, or the glazing for skylights or atria. The solar cell version of items such as shingles offer the same protection and durability as ordinary asphalt shingles.

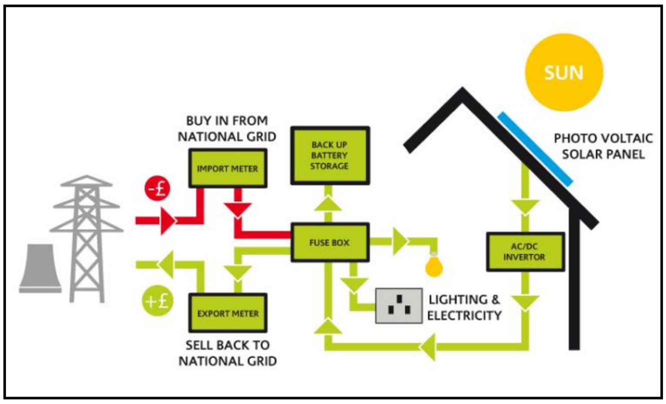
Advantages

The PV systems are relatively simple, modular, and highly reliable due to the lack of moving parts. Moreover, PV systems do not produce any greenhouse gases, on the contrary they save approximately 325kg of CO_2 per year kWp they generate.

Best Practice Design

PV installations performance is proportional to the active area (area covered by PVs). The desirable location for PV panels is on a south facing roof or façade, as long as no other building or tall trees overshadows it, resulting in reduced PV efficiency. PV panels are required strong structurally roofs due to their heavy weight, especially if the panels are placed on top of existing tiles. The area of PV panels required to generate 1 kWp varies but generally 6-8m^2 for mono-crystalline and 10m^2 for polycrystalline panels will generate 1kWp (kWp-energy generated at full sunlight) of electricity.

Cost & Maintenance



Prices for PV systems vary, depending on the size of the system to be installed, type of PV cell used and the nature of the actual building on which the PV is mounted. The size of a PV system depends on the buildings electricity demand. Solar tiles cost more than conventional panels, and panels that are integrated into a roof are more expensive than those that sit on top. Grid connected systems require very little maintenance, generally limited to ensuring that the panels are kept relatively clean and that shade from trees does not obstruct the sunlight path. However, the wiring and system components should be checked regularly by a qualified technician.

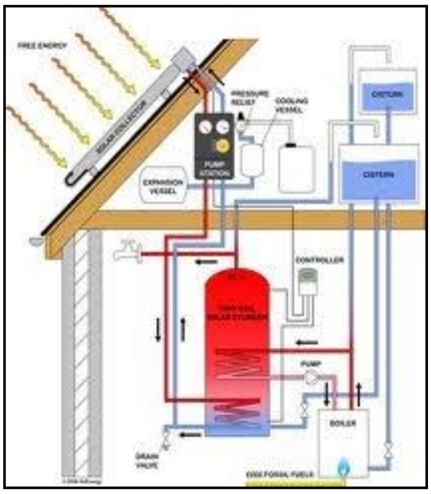
8.2.2. Solar Thermal Systems

Solar systems can be used wherever moderately hot water is required. Off-the-shelf packages provide hot water to the bathroom and kitchen of a house; custom systems are designed for bigger loads, such as multi-unit apartments.

The most common collector is called a flat-plate collector. Mounted on the roof, it consists of a thin, flat, rectangular box with a transparent cover that faces the sun. Small tubes run through the box and carry the fluid – either water or other fluid, such as an antifreeze solution – to be heated. The tubes are attached to an absorber plate, which is painted black to absorb the heat. As heat builds up in the collector, it heats the fluid passing through the tubes.

Advantages

Solar water heating can provide about a third of a typical dwellings/business hot water needs.



Planning Issues

In England, changes to permitted development rights for micro generation technologies introduced on 6th April 2008 have lifted the requirements for planning permission for most solar water heating installations. Roof mounted and stand-alone systems can now be installed in most dwellings, as long as they follow certain size criteria. Listed, English Heritage and buildings in conservation areas are exempted.

Cost & Maintenance

Evacuated tube systems are more expensive due to their higher manufacturing cost.
SWH systems in general have a 5-10 years warranty and require little maintenance. A yearly check by the owner of the system and a more detailed maintenance check by a qualified installer every 3-5 years should be adequate.

8.2.3. Wind Turbines

Description of Wind Turbine

Wind energy systems convert the kinetic energy of moving air into electricity or mechanical power. They can be used to provide power to central grids or isolated grids, or to serve as a remote power supply or for water pumping. Wind turbines are commercial units available in a vast range of sizes. The turbines used to charge batteries and pump water off-grid tend to be small, ranging from as small as 50 W up to 10 kW. For isolated grid applications, the turbines are typically larger, ranging from about 10 to 200 kW. Wind turbines are mounted on a tower to harness the most energy. At 30 meters or more aboveground, they can capture the faster and less turbulent wind in an urban environment. Turbines harness the wind's energy with their propeller-like blades. In most of the cases, two or three blades are mounted on a shaft to form a rotor.
There are two types of wind turbines that can be used for buildings:

- Mast mounted – which are free standing and located near the building that will be consuming the generated electricity.
- Roof Mounted – which can be installed on house roofs and other buildings.

Planning Issues

Planning issues such as visual impact, noise and conservation issues also have to be considered. System installation normally requires permission from the local authority.

Cost & Maintenance

- Roof mounted turbines cost from £3000. The amount of energy and carbon that roof top micro wind turbines save depends on size, location, wind speed, nearby buildings and the local landscape. At the moment there is not enough data from existing wind turbine installations to provide a figure of how much energy and CO_2 could typically be saved. The Energy saving trust is monitoring up to 100 installations nationwide which will give ball park figures of carbon savings.
- Mast Mounted turbines in the region of 2.5kW to 6kW would cost approximately £11000-£19000. These costs are inclusive of the turbine, mast, inverters, battery storage and installation cost. It should be noted that these costs vary depending on location, size and type of system to be installed.
- Turbines have an operational lifetime of up to 22.5 years but require service checks every few years to ensure efficient operation. For battery storage systems, typical battery life is around 6-10 years, depending on the type, so batteries may have to be replaced at some point in the system's life.

Feasibility on the site

Wind turbines are not feasible for the development due to the insufficient wind speed. Since the development is located in a dense residential and commercial units area; the wind resource may be restricted due to the adjacent large trees and air turbulence generated between them. As shown below (http://tools.decc.gov.uk/en/windspeed/default.aspx), the yearly average wind speed at this site is quite low at 10 meters above ground.

Wind speed at 45m agl (in m/s)

6	6	6
6	6	6
6	6	6

Wind speed at 25m agl (in m/s)

5.5	5.5	5.5
5.5	5.5	5.5
5.5	5.5	5.5

Wind speed at 10m agl (in m/s)

4.7	4.7	4.7
4.7	4.7	4.7
4.7	4.8	4.8

Blank squares indicate areas outside the land area of the UK - i.e. areas at sea or of neighbouring countries.
agl = above ground level.
Squares surrounding the central square correspond to wind speeds for surrounding grid squares.

An actual wind-speed measurement using an anemometer has not been used for the purpose of this energy strategy report.

Wind turbine(s) have been discounted for this development scheme for the following reasons:

- A large mast horizontal axis wind turbine will not be able to generate electricity at optimal operating range since it requires higher average wind speeds. Furthermore, the installation of small scale wind turbines won't be feasible due to low average wind speed at 10 meters height, 25m & 45metre heights.
- Due to the close proximity of neighbouring Commercial units & residential properties and trees.
- In addition, the low frequency noise generated by wind turbines might cause inconvenience to the neighbouring residents. However, the level a person can be affected by low frequency noise varies from individual to individual.
- Due to the size and the required height of a potential wind turbine scheme there is also an issue with the propellers' impacting bird traffic, obtrusiveness, shadow flicker which means that generally large wind turbines need to be located at least 300m from any residential properties, which would not be possible on this site.
- Roof mounted units are limited in size due to wind induced stresses which are transmitted to the building structure. Most roof mounted turbines currently on the market are approximately 2m diameter and capable of producing 1-1.5kW each. However, the output is

dependent on the surrounding obstructions and local wind speed. Thus small scale wind turbines would not make any meaningful impact on a site such as this.

- There are likely to be planning issues associated with wind turbines of a size necessary to affect any significant CO2 savings or energy savings.
- Because of the above the investment case with regards this technology solution is not viable compared to other solutions with a more attractive ROI.
- Finally, the installation of wind turbines on the development requires planning permission (and is likely to instigate neighbourhood committee interest regarding its aesthetics and acoustic issues).

8.2.4. Small Scale Hydro

Description of Small Scale Hydro System

Small hydro systems convert the potential and kinetic energy of moving water into electricity, by using a turbine that drives a generator. As water moves from a higher to lower elevation, such as in rivers and waterfalls, it carries energy with it; this energy can be harnessed by small hydro systems. Used for over one hundred years, small hydro systems are a reliable and well-understood technology that can be used to provide power to a central grid, an isolated grid or an off-grid load, and may be either run-of-river systems or include a water storage reservoir.

In a residential small scale hydro system the constant flow of water is critical to the success of the project. The energy available from a hydro turbine is proportional to the flow rate of the water and the head height. Since the majority of the cost of a small hydro project stems from up front expenses in construction and equipment purchase, a hydro project can generate large quantities of electricity with very low operating costs and modest maintenance expenditures for 50 years or longer.

Advantages

For houses with no mains connection but with access to a micro hydro site, a good hydro system can generate a steady, more reliable electricity supply than other renewable technologies at lower cost. Total system costs can be high but often less than the cost of a grid connection and with no electricity bills to follow.

Cost & Maintenance

Small hydro schemes are very site specific and are related to energy output. For low heat systems, costs may lie in the region of £4,000 per kW installed up to about 10kW and would drop per kW for larger schemes.

For medium heads, there is a fixed cost of about £10,000 and about £2,500 per kW up to around 10kW Unit costs drop for larger schemes. Maintenance costs vary but small scale hydro systems are very reliable.

Feasibility on the site

Small scale hydro-electric will not be studied any further because of the location and the spatial limitations of the development. There is no river or lake within the development site boundaries. As a result, this solution will not be assessed any further.

8.2.5. Biomass Heating

Description of Biomass Heating System

Biomass heating systems also known as biomass boilers burn organic matter—such as wood chips, agricultural residues or municipal waste—to generate heat for buildings. They are highly efficient heating systems, achieving near complete combustion of the biomass fuel through control of the fuel and air supply, and often incorporating automatic fuel handling transport systems. Biomass boilers consist of a boiler, a heat distribution system, and a fuel transportation system. The biomass heating system typically makes use of multiple heat sources, including a waste heat recovery system, a biomass combustion system, a peak load boiler, and a back-up boiler. The heat distribution system conveys hot water or steam from the heating plant to the loads that may be located within the same building as the heating plant, as in a system for a single institutional or industrial building, or, in the case of a "district heating" system, clusters of buildings located in the vicinity of the heating plant.

Biomass heating systems have higher capital costs than conventional boilers and need diligent operators. Balancing this, they can supply large quantities of heat on demand with very low fuel costs, depending on the origin of the fuel.

Best Design Practice

It's important to have storage space for the fuel and appropriate access to the boiler for loading the fuel. A local fuel supplier should be present in order to make the scheme viable.
The vent material must be specifically designed for wood appliances and there must be sufficient air movement for proper operation of the stove. Chimneys can be fitted with a lined flue.
A Biomass heating system installation should comply with all safety and building regulations. Wood can only be burned in exempted appliances, under the Clean Air Act.

Advantages

Producing energy from Biomass has both environmental and economic advantages. Although Biomass produces CO_2 it only releases the same amount that is absorbed whilst growing, which is why it is considered to be carbon neutral. Furthermore, Biomass can contribute to waste management by harnessing energy from products that are often disposed at landfill sites.
It is most cost effective and sustainable when a local fuel source is used, which results in local investment and employment, which in addition minimizes transport emissions.

Planning Issues

If the building is listed or is in an area of outstanding natural beauty, then it is required that the Local Authority Planning department is notified before a flue is fitted.

Cost & Maintenance

Stand-alone room heaters cost £2,000 to £4,000. Savings will depend on how much they are used and which fuel you are replacing. A Biomass stove which provides a detached home with 10% of annual space heating requirements could save around 840kg of CO_2 when installed in an electrically heated home. Due to the higher cost of Biomass pellets compared with other heating fuels, and the relatively low efficiency of the stove compared to a central heating system it will cost more to run.

The cost of Biomass boilers varies depending on the system choice; a typical 15kW pellet boiler would cost about £5,000-£14,000 installed, including the cost of the flue and commissioning process. A manual log feed system of the same size would be slightly cheaper. A wood pellet boiler could save around £750 a year in energy bills and around 6 tons of CO_2 per year when installed in an electrically heated home. In terms of biomass fuel costs, they generally depend on the distance between the dwelling and the supplier and whether large quantities can be bought.

Feasibility on the site

Biomass boilers should not be considered for this project due to the following reasons:

- Furthermore, 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. Biomass has recently been rejected by many London Boroughs as means of obtaining the on-site renewable contribution (and this will soon send ripples out to other regions). 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. Given this a bio fuel system may not be acceptable to the Council on planning grounds (e.g. concerns about associated flue emissions/impact on local 'Air Quality', increase in road traffic from pellet delivery lorries).
- Biomass fuel requires more onerous and frequent wood fuel silo (site storage issues) replenishing by delivery trucks- which in turn can cause site transportation issues that will need to be considered and addressed along with the impact on the other residents and neighborhood infrastructure.
- Restrictions on the type of fuel and appliance may apply to the development and according to studies commissioned by DEFRA the levels of particles emitted by the burning of wood chip or waste would be considered to outweigh the benefits of carbon reduction especially in an urban environment such as the proposed development site.
- Dependent on a fuel supply chain contract being confirmed.
- There is no suitable location for the plant and storage of the pellets on site at present.

8.3. Low Carbon Technologies

In this section the low carbon technologies are described.

- Air Source Heat Pumps (ASHP)
- Ground Source Heat Pumps (GSHP)
- Combined Heat and Power (CHP) & Micro CHP
- Fuel Cells

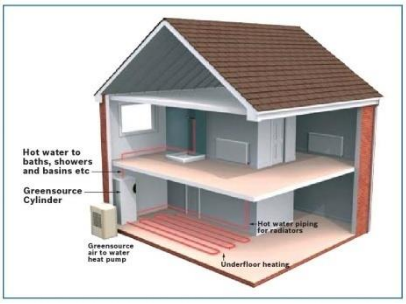
8.3.1. Air Source Heat Pumps (ASHP)

Description of Air Source Heat Pumps

Air source heat pumps work in a very similar way to fridges and air conditioners and absorb heat from the air. They are ideally suited to work with under floor heating systems because of the lower design temperatures of under floor systems. The lower the water temperature, the higher the COP. Air source heat pumps use air. They are fitted outside a house; generally perform better at slightly warmer air temperatures. The seasonal efficiencies of air source heat pumps are between 200% - 400%. Heat pumps can operate at outside temperatures down to – 15 degC, although there is a drop in COP.

Advantages

- A reduction in carbon emission.
- No boiler flues and danger of carbon monoxide leakage.
- Maintenance is carried outside the premises.
- No annual boiler servicing and safety checks.
- Heat pump life expectancy about 25 years compared to a boiler of 15 years



Costs & Savings

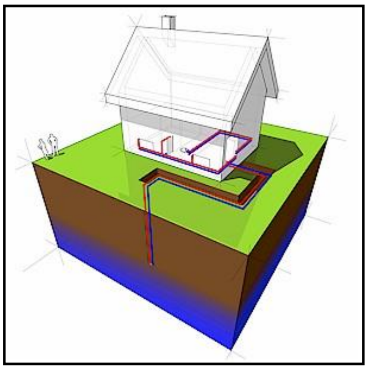
Operating Cost Savings around 15% in comparison with a typical gas fired condensing boiler installation with HWS cylinder and an electrically driven Community air to water heat pump.

8.3.2. Ground Source Heat Pumps (GSHP)

Description of Ground Source Heat Pumps

Ground-source heat pumps provide low temperature heat by extracting it from the ground or a body of water and provide cooling by reversing this process. Their principal application is space heating and cooling, though many also supply hot water. They can even be used to maintain the integrity of building foundations in permafrost conditions, by keeping them frozen through the summer.

A ground-source heat pump (GSHP) system has three major components: the earth connection, a heat pump, and the heating or cooling distribution system. The earth connection is where heat transfer occurs. One common type of earth connection comprises tubing buried in horizontal trenches or vertical boreholes, or alternatively, submerged in a lake or pond. An antifreeze mixture, water or another heat-transfer fluid is circulated from the heat pump, through the tubing, and back to the heat pump in a "closed loop." "Open loop" earth connections draw water from a well or a body of water, transfer heat to or from the water, and then return it to the ground or the body of water.



Since the energy extracted from the ground exceeds the energy used to run the heat pump, GSHP "efficiencies" can exceed 100%, and routinely average 200 to 500% over a season. Due to the stable, moderate temperature of the ground, GSHP systems are more efficient than air-source heat pumps, which exchange heat with the outside air. GSHP systems are also more efficient than conventional heating and Air-conditioning technologies, and typically have lower maintenance costs. They require less space, especially when a liquid building loop replaces voluminous air ducts, and, since the tubing is located underground, are not prone to vandalism like conventional rooftop units. Peak electricity consumption during cooling season is lower than with conventional air-conditioning, so utility demand charges may be reduced. Heat pumps typically range in cooling capacity from 3.5 to 35 kW (1 to 20 tons of Cooling). A single unit in this range is sufficient for a house or small Commercial units Building. The heat pump usually generates hot or cold air to be distributed locally by conventional ducts.

Advantages

The efficiency of GSHP system is measured by the coefficient of performance (COP). This is the ratio of units of heat output for each unit of electricity used to drive the compressor and pump for the ground loop. Average COP known as seasonal efficiency, is around 3-4 although some systems may produce a greater rate of efficiency. This means that for every unit of electricity used to pump the heat, 3-4 units of heat are produced, making it an efficient way of heating a building. If grid electricity is used for the compressor and pump, then a range of energy suppliers should be consulted in order to benefit from the lower running costs.

Cost & Savings

A typical 8-12kW system costs £6,000-£12,000 (not including the price of distribution system). This can vary with property and location. When installed in an electrically heated home a GSHP could save as much as £900 a year on heating bills and almost 7 tonnes of CO_2 a year. Savings will vary depending on what fuel is being replaced.

Feasibility on the site

GSHP will not be studied any further for the following reasons:

- If an open loop configuration was to be adopted, a test borehole would be needed to assess the available resource. The test resource process is expensive and of course does not guarantee an acceptable resource in the ground. Additionally, a closed loop borehole configuration could not be used due to spatial limitations of the site.
- There are likely to be planning issues associated with borehole excavation and drilling.
- Running costs and maintenance may be minimal. However, installation is a costly affair. A GSHP solution would represent a relatively expensive option in comparison to other renewable technologies available.

- Additional electric immersion and pumps would be required to heat the GSHP water up to suitable temperature to be used around the building and it's likely a centralised plant area will also be required to house the circulation pumps.
- This technology is not recommended due to the increased plant energy consumption requirements in turn impacting the DER/TER score for the required energy strategy objectives.
- Furthermore, boreholes also destabilize the ground surface and may be considered a minus for environmentally friendly endeavours.

8.3.3. Combined Heat and Power (CHP) & Micro CHP

Description of CHP

The principle behind combined heat and power (cogeneration) is to recover the waste heat generated by the combustion of a fuel6 in an electricity generation system. This heat is often rejected to the environment, thereby wasting a significant portion of the energy available in the fuel that can otherwise be used for space heating and cooling, water heating, and industrial process heat and cooling loads in the vicinity of the plant. This cogeneration of electricity and heat greatly increases the overall efficiency of the system, anywhere from 25-55% to 60-90% depending on the equipment used, and the application.

A CHP installation comprises four subsystems: the power plant, the heat recovery and distribution system, an optional system for satisfying heating and/or cooling loads and a control system. A wide range of equipment can be used in the power plant, with the sole restriction being that the power equipment rejects heat at a temperature high enough to be useful for the thermal loads at hand. In a CHP system, heat may be recovered and distributed as hot water, conveyed from the plant to low temperature thermal loads in pipes for hot water, or for space heating.

Advantages

CHP can significantly reduce primary energy consumption, and can therefore have a major impact on CO2 emissions associated with the combustion of fossil fuels in conventional boilers. Each 1 kW of electrical capacity provided by CHP plant using fossil fuels has the potential to reduce annual CO2 emissions by around 0.6 tonnes compared to gas-fired boilers and fully grid-derived electricity. For plant which is fuelled by renewable energy sources the potential is much greater.

Costs & Savings

Capital costs for CHP installations are higher than for alternative systems, but this can be recovered over a relatively short period of time (typically 5–10 years) for installations where there is a demand for heat and power for 4500 hours or more each year. The cost effectiveness is very sensitive to the relative price of electricity and fossil fuel which have been subject to frequent variations since de-regulation of the energy supply industries.

Micro CHP

Micro CHP (Combined Heat & Power) is the simultaneous production of useful heat and power within the home. It works very much like the gas boiler in a central heating system and heats the home in just the same way. However, at the same time it generates electricity, some of which will be used in the dwelling and the remainder will be exported to the electricity grid. Effectively the micro CHP unit replaces the gas central heating boiler and provides heat and hot water as usual, but additionally provides the majority of the home's electricity needs. Although individual units produce, by definition, relatively small amounts of electricity, the significance of micro CHP lies in the potentially huge numbers of systems which may ultimately be installed in the millions of homes in the UK where natural gas is currently the dominant heating fuel.

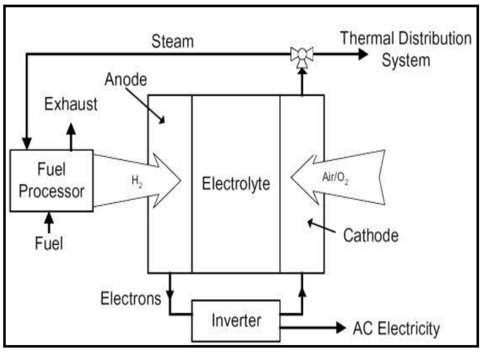
Feasibility on the site

CHP has not been considered further for this project for the following reasons:

- The average maximum heating load of a new apartment (built to 2010 building regs) is approximately 3kW and therefore most individual heating systems with independent condensing gas boilers would be incapable of working at optimal efficiencies or achieving their stated SEDBUK rating due to boiler cycling.
- Traditional CHP should not be considered for this project due to the spatial constraints of the development plot and dwelling layouts. There is not suitable space in the development for CHP plant.
- Heat from the CHP plant could be utilized to drive an absorption chiller during the summer months (tri-generation), but due to the sustainable design of the building fabric, and the use of natural ventilation wherever possible, we anticipate that the cooling load will be minimal, making this a non-viable proposition.
- Micro-CHP is a relatively new concept and issues are raised in relation to unproven technology, inefficiency for shorter run cycles and lack of technical knowledge that can limit the practical application of micro CHP at present. In addition, high installation costs and estimated low life expectancy has also been taken into consideration as to its commercial unit's un-viability for this development scheme. Micro-CHP also has a lower FIT tariff rate and period duration and is only applicable for systems under 2kW.

8.3.4. Fuel Cells

Description of Fuel Cells



A fuel cell is a device that generates more electricity by a chemical reaction. Every fuel cell has two electrodes, one positive and one negative, called, respectively, the anode and cathode. The reactions that produce electricity take place at the electrodes.

Every fuel cell also has an electrolyte, which carries electrically charged particles from one electrode to the other, and a catalyst, which speeds the reactions at the electrodes. Hydrogen is the basic fuel, but fuel cells also require oxygen.

One great appeal of fuel cells is that they generate electricity with very little pollution—much of the hydrogen and oxygen used in generating electricity ultimately combine to form a harmless by product, namely water.

Fuel Cell Operation

The purpose of a fuel cell is to produce an electrical current that can be directed outside the cell to do work, such as powering an electric motor or illuminating a light bulb or a city. Because of the way electricity behaves, this current returns to the fuel cell, completing an electrical circuit. The chemical reactions that produce this current are the key to how a fuel cell works.

There are several kinds of fuel cells, and each operates a bit differently. But in general terms, hydrogen atoms enter a fuel cell at the anode where a chemical reaction strips them of their electrons. The hydrogen atoms are now “ionized,” and carry a positive electrical charge. The negatively charged electrons provide the current through wires to do work. If alternating current (AC) is needed, the DC output of the fuel cell must be routed through a conversion device called an inverter.

Advantages

Even better, since fuel cells create electricity chemically, rather than by combustion, they are not subject to the thermodynamic laws that limit a conventional power plant. Therefore, fuel cells are more efficient in extracting energy from a fuel. Waste heat from some cells can also be harnessed, boosting system efficiency still further.

Fuel Cells with Hydrogen from Renewable Sources

Fuel cells can be used as CHP systems in buildings. There are currently several different systems under development using different chemical processes, which operate at different temperatures. They currently use natural gas as the fuel, which is reformed to produce hydrogen, the required fuel for the fuel cell. When and if hydrogen becomes available from renewable energy, fuel cell CHP from renewable sources may be possible in buildings.

8.4. Available Grants

8.4.1. Renewable Heat Incentive (RHI)

- ✓ **Domestic RHI tariff rates**

Table below specifies the current and future tariffs for each available renewable technology on the 31st of March 2016 (https://www.ofgem.gov.uk/environmental-programmes/domestic-renewable-heat-incentive-domestic-rhi/about-domestic-rhi/tariffs-and-payments-domestic-rhi). As the tariff keeps changing, it has to be checked at appropriate design stage.

Applications submitted	Biomass boilers and stoves	Air source heat pumps	Ground source heat pumps	Solar thermal
01/01/16 - 31/03/16	5.14p	7.42p	19.10p	19.51p
01/04/16 - 30/06/16*	5.20p	7.51p	19.33p	19.74p
01/07/2016 - 30/09/2016**	If any new tariff changes are to be made due to degression, the next announcement by DECC would be by 1 June 2016.			

✓ **Non-Domestic RHI tariff rates**

The table below specifies tariffs that apply for installations with an accreditation date on or after 1 April 2016 (https://www.ofgem.gov.uk/environmental-programmes/non-domestic-renewable-heat-incentive-rhi/tariffs-apply-non-domestic-rhi-great-britain).

Tariff name	Eligible technology	Eligible sizes	Tariffs
Small commercial biomass	Solid biomass including solid biomass contained in waste	Less than 200 kWth	3.62
		Tier 1	
		Less than 200 kWth	
		Tier 2	0.96
Medium commercial biomass		200 kWth and above & less than 1MWth Tier 1	5.24
		200 kWth and above & less than 1MWth Tier 2	2.27
Large commercial biomass		1MWth and above	2.05
Solid biomass CHP systems (commissioned on or after 4 December 2013)	Solid biomass CHP systems	all capacities	4.22
Water/Ground-source heat pumps	Ground-source heat pumps & Water-source heat pumps	all capacities Tier 1	8.95
		Tier 2	2.67
Air-source heat pumps (commissioned on or after 4 December 2013)	Air-source heat pumps	all capacities	2.57
Deep geothermal (commissioned on or after 4 December 2013)	Deep geothermal	all capacities	5.14
All solar collectors	Solar collectors	Less than 200 kWth	10.28

Biomethane injection	Biomethane	On the first 40,000 MWh of eligible biomethane Tier 1	5.35
		Next 40,000 MWh of eligible biomethane Tier 2	3.14
		Remaining MWh of eligible biomethane Tier 3	2.42
Small biogas combustion	Biogas combustion	Less than 200 kWth	6.94
Medium biogas combustion (commissioned on or after 4 December 2013)		200 kWth and above & less than 600 kWth	5.45
Large biogas combustion (commissioned on or after 4 December 2013)		600 kWth and above	2.04

8.4.2. Feed In Tariff (FIT)

The table below shows the listing of all generation tariff levels for installations before 1st April 2016, which is current data on the official webpage (http://www.fitariffs.co.uk/eligible/levels/). Tariffs after 1st April 2016 as per the degression table, but adjusted for RPI indexation and contingent degression. Therefore, the detailed tariff has to be checked at appropriate design stage.

Energy Source	Scale	Type / Rate	Tariff (p/kWh)	
		Non-PV	< 15/01/16	> 8/2/16
Anaerobic digestion	≤250kW		9.12	tba [1]
Anaerobic digestion	>250kW - 500kW		8.42	tba [1]
Anaerobic digestion	>500kW		8.68	tba [1]
Hydro	≤15 kW		15.45	8.54
Hydro	>15 - 100kW		14.43	8.54
Hydro	>100kW - 500kW		11.40	6.14
Hydro	>500kW - 2MW		8.91	6.14
Hydro	>2MW - 5MW		2.43	4.43
Micro-CHP	<2 kW	(limited)	13.45	tba [1]
Solar PV	≤4 kW	Higher rate	12.88	4.39
Solar PV	≤4 kW	Medium rate	11.67	
Solar PV	>4 - 10kW	Higher rate	11.71	4.39
Solar PV	>4 - 10kW	Medium rate	10.54	
Solar PV	>10 - 50kW	Higher rate	11.71	4.59
Solar PV	>10 - 50kW	Medium rate	10.54	
Solar PV	>50 - 150kW	Higher rate	9.63	2.70
Solar PV	>50 - 150kW	Medium rate	8.67	
Solar PV	>150 - 250kW	Higher rate	9.21	2.70
Solar PV	>150 - 250kW	Medium rate	8.29	
Solar PV	≤250kW	Lower rate	6.16	
Solar PV	>250kW - 5MW		5.94	2.27
Solar PV	>1MW - 5MW		5.94	0.87
Solar PV	≤5MW	Standalone	4.44	0.87
Wind	≤100kW		13.73	8.53
Wind	>100 - 500kW		10.85	8.53
Wind	>500kW - 1.5MW		5.89	5.46
Wind	>1.5MW - 5MW		2.49	0.86
Any	existing systems transferred from RO		10.66	10.66

Block Compliance WorkSheet: 28 Redington Road

User Details

Assessor Name:

Stroma Number:

Software Name: Stroma FSAP

Software Version: Version: 1.0.3.4

Calculation Details

Dwelling	DER	TER	DFEE	TFEE	TFA
Flat 1	11.41	24.79	47.6	58.7	144
Flat 2	8.86	18.99	36.6	45.9	229
Flat 3	7.7	17.96	34.7	46.1	243
Flat 4	8.5	19.47	33.8	45.8	178
Flat 5	10.8	23.1	43.7	53.7	151
Flat 6	10.45	22.47	45.1	54.3	167
Flat 7	9.77	20.39	46.1	53.4	271
Flat 8	13.58	28.17	64.4	72.4	153

Calculation Summary

Total Floor Area	1536.00
Average TER	21.37
Average DER	9.87
Average DFEE	43.07
Average TFEE	52.76
Compliance	Pass
% Improvement DER|TER	53.81
% Improvement DFEE|TFEE	18.37