



42  
Caversham  
Road,  
London,  
NW5 2DS

## Energy Strategy Report

November  
2015

Ref: 13-426



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42 Caversham Road, London, NW5 2DS



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Revision	00	01
Date	01.04.2015	23.11.2015
Prepared by	E. Jolly	E. Jolly
Checked by	N. Paranjpe	-
Authorised by	N. Paranjpe	A. King

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## 1. Executive Summary

The design of the proposed development in **42 Caversham Road, London, NW5 2DS**, which is a new residential development comprised of **18No. Residential units**, located in an urban residential area in London, has incorporated building fabric enhancement (above current building regulation Part L1A 2013 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<sub>2</sub> emissions, the **Camden Council** requires all proposed developments to incorporate sustainable design and construction measures. **All new developments are to be designed to minimise energy demand through good design and high levels of insulation and air tightness (CPG3 - Energy Efficiency: New Buildings)**. Schemes must: demonstrate how sustainable development principles have been incorporated into the design and proposed implementation. **Also, according to the CS13 policy, developments need to achieve a reduction in CO<sub>2</sub> emissions of 20% from on-site renewable energy generation.**

The recommendation for the proposed development is that **Efficient Combi Gas Boilers (90% efficiency) along with a total of 18kWp PV, which equates to approximately 60 PV panels in total (based on 300W PV output) and approximately 99 m<sup>2</sup> required roof area** should be progressed. This is based on the following reasons:

- The strategy would provide **an average of 25.09% CO<sub>2</sub> reduction saving (DER/TER) against Building Regulations Part L1A 2013 for the whole development. Therefore, the strategy meets BRUK-L1A requirements for the development.**
- The Greater London Authority's (GLA) London Plan 2011 asks for all new developments to meet a target of **40% improvement over Part L 2010 (equivalent to 35% over Part L 2013)** through implementation of the Energy Hierarchy. In order for this development to meet this target, it has been calculated that either communal heating or additional PV would need to be incorporated however due to limited roof space and plant space this has not been seen as feasible for this development. Therefore, it is proposed that a **one off payment of £4,353.57 is made to the LA's Carbon Offset Fund.**
- The strategy would provide an average of **29.12% reduction of CO<sub>2</sub> emissions the energy demand via onsite renewable technology (PV) for the overall development. Hence, the required target of 20% reduction in CO<sub>2</sub> emissions through renewable onsite has been achieved.**

- After the application of the Energy Hierarchy, the regulated carbon dioxide emissions are presented on the table below:

	Carbon Dioxide emissions (Tonnes CO <sub>2</sub> per annum)
	Regulated
<b>Baseline: Building Regulations 2013 Part L Compliant Development</b>	24.40
<b>After energy demand reduction</b>	25.38
<b>After CHP/ Communal Heating</b>	25.38
<b>After renewable energy</b>	18.28

Table 1: Carbon Emissions following the application of the Energy Hierarchy

The chart below summarises the regulated carbon dioxide savings from each stage of the Energy Hierarchy:

	Regulated Carbon Dioxide savings	
	(Tonnes CO <sub>2</sub> per annum)	(%)
<b>Savings from energy demand reduction</b>	-0.98	-4.03%
<b>Savings from CHP/ Communal Heating</b>	0.00	0.00%
<b>Savings from Renewable energy</b>	7.10	29.12%
<b>Total Cumulative Savings</b>	<b>6.12</b>	<b>25.09%</b>
<b>Total Target Savings</b>	<b>8.54</b>	<b>35%</b>
<b>Annual Surplus</b>	<b>-2.42</b>	<b>(£4,353.57 payment to be made)</b>

Table 2: Regulated carbon savings from the application of the Energy Hierarchy

## 2. Introduction

Syntegra Consulting Ltd has been appointed as energy consultants to produce an energy strategy for the '**Development consisting of 18No. New Residential units**' for the scheme at **42 Caversham Road, London, NW5 2DS** – to support the scheme design process, demonstrate Building regulations Part L 2013 compliance and intent to target a 20% reduction of CO<sub>2</sub> emissions reduction via onsite renewable energy technology for the overall development in accordance with planning policy requirements.

This report will outline the following:

- 1) This report will assess the proposed development site's estimated energy demand & CO<sub>2</sub> 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 2013 Part L1A buildings regulations i.e. **A 25.09% DER/TER CO<sub>2</sub> emission reduction against BRUKL Part L1A 2013** – but cannot show full compliance with the London Plan 2011 target of 35% improvement over Part L 2013 through constraints and limited roof area available.
- 3) The target of **at least 20% reduction of the development's CO<sub>2</sub> Emissions** through the utilisation of renewable technology as per the planning policy requirements.

### 3. Site Description

The proposed development comprises of a five storey residential development. The development is located in the urban area of Kentish Town in London. The development is in close proximity to Kentish Town Underground and Rail Stations (approx 0.3 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. London Borough of Camden, DP22 “Promoting sustainable Design & Construction”

DP22 – *Promoting sustainable design and construction* contributes towards delivering the strategy in policy CS13 by providing detail of the sustainability standards we will expect development to meet.



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

The Mayor will 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 25% BER/TER based on 2010 Building Regulations, between 2010 and 2013 and 40% BER/TER from 2013 to 2016 (equivalent to 35% over Part L 2013), 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.



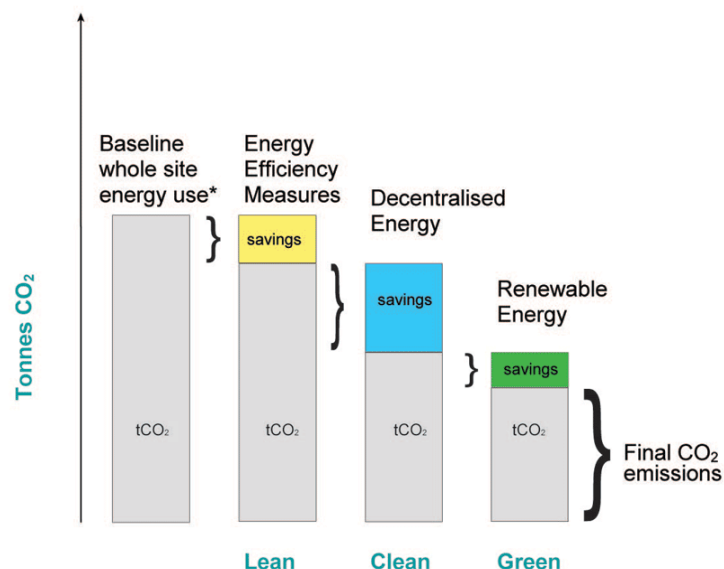
#### 4.4. The Energy Hierarchy

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 prioritizing decentralized 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.



## 5. The development configuration scheme

The proposed development scheme consists of the following characteristics:

### 5.1. The Unit Configuration

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

#### Proposed units to be assessed for the development:

No. of Flats	Flat Name	No. of bedrooms	Individual Area m <sup>2</sup>
1	U01	2	102.5
1	U02	2	89.1
1	U03	2	87.2
1	U04	2	83.1
1	U05	2	99.6
1	U06	2	63.5
1	U07	1	50.1
1	U08	1	49.8
1	U09	1	56.5
1	U10	2	65.5
1	U11	2	62.9
1	U12	2	78
1	U13	1	50.3
1	U14	1	51
1	U15	3	105.8
1	U16	2	72.7
1	U17	3	108.8
1	U18	2	85.7
<b>Total</b>	<b>-</b>	<b>33</b>	<b>1362.1</b>

Table 3: Accommodation Schedule for the proposed development

## 5.2. Specification of Building Materials

The table presented below demonstrates the material properties of the building fabric that have been proposed:

### Building Envelope Specification

Building Element	Proposed Specification
External Walls U-value	0.16
Floor U-value	0.11
Window units (whole window) U-value	1.1 Triple glazing
Rooflight U-value	1.1 Double glazing
Roof U-value	0.11
Air Permeability m <sup>3</sup> /(h.m <sup>2</sup> ) at 50 Pa	3.5
Low Energy Lighting	100%

Table 4

## 5.3. Fuel

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 kgCO <sub>2</sub> /kW
Grid Electricity	0.517
Grid displaced Electricity	0.529
Manufactured smokeless fuel	0.402
Coal (traditional British Coal)	0.301
Heating Oil	0.28
LPG	0.25
Natural Gas	0.198
Wood Pellets	0.028
Bio Diesel	0.098
Bio Gas	0.019

Table 5

## 6. Baseline CO<sub>2</sub> Emissions

The baseline energy use and resulting CO<sub>2</sub> 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 Part L1A 2013 building regulation requirements.

For the purpose of this report the baseline energy use and CO<sub>2</sub> emissions for the development are calculated based on the notional dwelling specifications in the Building Regulations Part L1A 2013 document (Table 4).

	ADL1A 2013 Notional Values	Proposed building values
Air Permeability m <sup>3</sup> /(h.m <sup>2</sup> ) at 50 Pa	5	3.5
Wall U value W/m <sup>2</sup> C <sup>0</sup>	0.18	0.16
Roof U value W/m <sup>2</sup> C <sup>0</sup>	0.13	0.11
Floor U value W/m <sup>2</sup> C <sup>0</sup>	0.13	0.11
Window U value W/m <sup>2</sup> C <sup>0</sup>	1.40	1.1

Table 6: table to compare the parameters used in the notional dwelling and the proposed dwelling

The baseline average energy use and CO<sub>2</sub> emissions for the development are presented in the tables below:

Please note that all units (No.18) have been modelled using the SAP2009 software FSAP 2012.

Building Services	Baseline CO <sub>2</sub> Emissions (tonneCO <sub>2</sub> /yr)
Heating	12.07
Domestic Hot Water	8.69
Auxiliary	0.70
Lighting	2.94
<b>Total regulated emissions</b>	<b>24.40</b>

Table 7

Building Services	Baseline CO <sub>2</sub> Emissions (kg CO <sub>2</sub> /m <sup>2</sup> /yr)	Baseline CO <sub>2</sub> Emissions (Tonnes CO <sub>2</sub> / yr)
<b>Total regulated emissions</b> (heating, hot water, lighting, fans & pumps)	<b>18.65</b>	<b>24.40</b>

Table 8

## 7. 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<sub>2</sub> 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.

### 7.1. Heating 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 High Efficiency Combi Boilers 90% efficient have been examined. This strategy utilizes a combi boiler in each dwelling to provide heating and DHWS.

### 7.2. Ventilation

A natural supply ventilation strategy will be adopted in all dwellings with extract fans in bathrooms and kitchens. Therefore, higher energy consumption and CO<sub>2</sub> emissions due to mechanical ventilation is avoided.

### 7.3. Lighting

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

The following table demonstrates the reduction in CO<sub>2</sub> emissions caused by the energy efficiency measures mentioned above.

Building Services	Baseline CO <sub>2</sub> Emissions (tonnesCO <sub>2</sub> /yr)	BE LEAN Building CO <sub>2</sub> Emissions (tonnesCO <sub>2</sub> /yr)
Heating	12.07	13.57
Domestic Hot Water	8.69	8.59
Auxiliary	0.70	0.28
Lighting	2.94	2.95
<b>Total regulated emissions</b>	<b>24.40</b>	<b>25.38</b>

Table 9

**CO<sub>2</sub> Reductions after BE LEAN stage**

Regulated Emissions	Baseline CO <sub>2</sub> Emissions	BE LEAN Building CO <sub>2</sub> Emissions	% reduction in CO <sub>2</sub> Emissions
kg of CO <sub>2</sub> /m <sup>2</sup> /yr	18.65	19.40	-4.03%
Tonnes CO <sub>2</sub> / yr	24.40	25.38	

Table 10

From the table above it can be seen that the overall CO<sub>2</sub> reduction due to energy efficiency is -4.03% for the total emissions.

## 8. 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<sub>2</sub> emissions further.

### 8.1. CHP

The Energy Hierarchy identifies 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.

A CHP system will not be considered for this development due to the following reasons:

- The heating load of the building is not enough for the CHP system to run efficiently.
- Economic viability is heavily dependent on the demand for heat and power, as well as the price of electricity and gas. The heat and power demand of the proposed development is not sufficient for a CHP system to run efficiently

Hence, the implementation of a CHP strategy is not recommended for this development.

### 8.2. Micro-CHP

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

Micro-CHP is a relatively new concept (Baxi Ecogen was made available in 2009) 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 Offices, Doctor Surgery Unit & Communal Area 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.

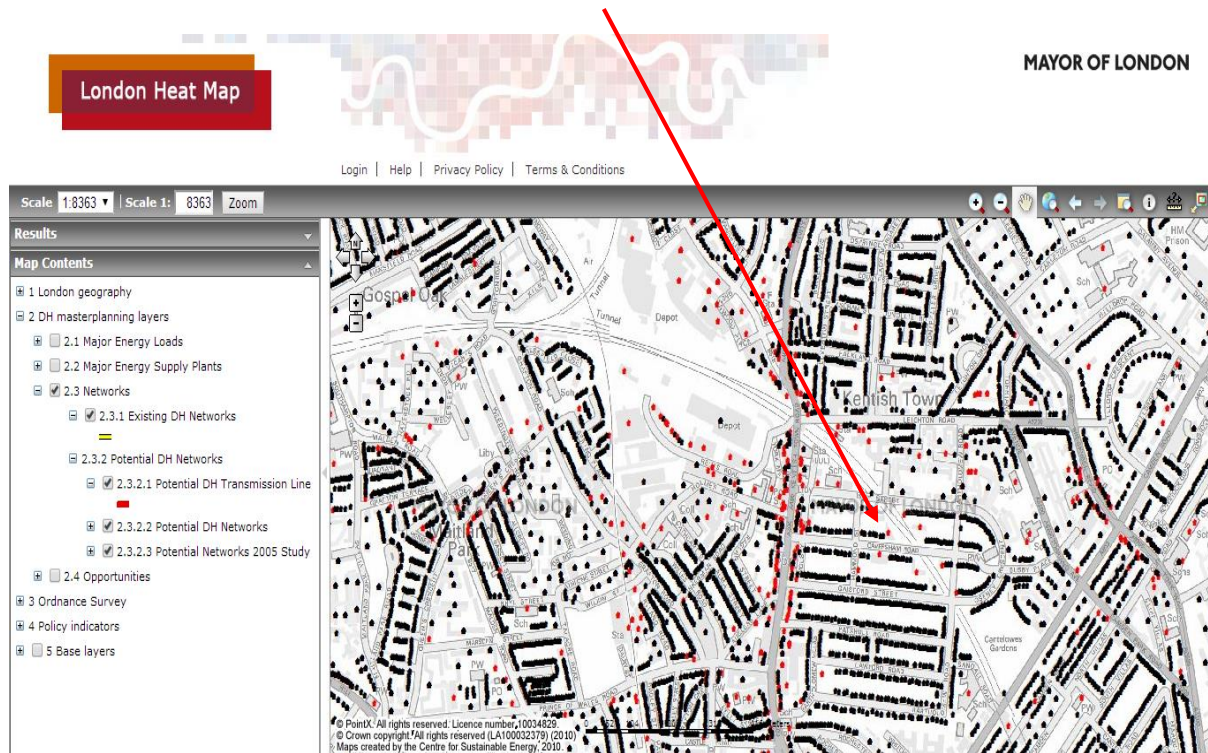
### 8.3. Decentralised Energy Network

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 Camden Council as part of this assessment. The study does not identify the area in Caversham Road as a high potential area for a District Heating network. The development is not in close proximity to an existing nor a potential District Heating transmission line. At the moment there is no decentralized energy



network available and in particular a district heating network in the proximity of the proposed development site that would allow the development to connect to such a network. This is demonstrated clearly from the London Heat Map (<http://www.londonheatmap.org.uk>) snapshot below.

Site Location



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.

For the proposed development it has been decided that due to technology and space constraints, a Be Clean proposal is not suitable for this development.

## 9. BE GREEN – Renewable Energy

In this section the viable renewable energy technologies that will reduce the development’s CO<sub>2</sub> emissions are examined. Incorporating lean design measures will significantly reduce the onsite energy consumption and the CO<sub>2</sub> emissions of the building. 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:

- Wind Turbines [See Appendix Section 11.2]
- Biomass Boilers [See Appendix Section 11.2]
- Hydrogen Fuel Cells [See Appendix Section 11.2]
- Small scale hydro power [See Appendix Section 11.2]
- Ground Source Heat Pump (GSHP) [See Appendix Section 11.2]
- CHP & Micro CHP [See Appendix Section 11.2]
- Solar Thermal

### 9.1. Photovoltaic (PV) – Proposed Technology

PV is the proposed renewable technology for this development. The PV system will provide self-generating electricity which can be sold back to the grid. The CO<sub>2</sub> reduction via renewables target is achieved with the implementation of PV. For the calculation of the payback period, the Feed-In-Tariffs’ (FITs) has been taken into account. The PV load falls within the bracket associated with a FIT tariff applied of 13.50p per kWh for electricity generated and 4.64p per kWh for electricity exported back to the grid (over 20 years).

#### PV System specification - Whole Development

The PV system capacity for the development has been calculated based on the outcome of the Be Lean proposal and the area of suitable roof space available for installation.

**Individual Combi Gas Boilers + 18.00kWp PV**

The tables below illustrate the site and the PV panel's details:

<b>Orientation</b>	South	<b>Number of Panels</b>	60
<b>Panel Tilt</b>	30°	<b>Manufacturer</b>	Sunpower
<b>Overshading</b>	Less than 20 percent	<b>Model</b>	SPR 300NE WHT D
<b>Proportion Exported</b>	50%	<b>Type</b>	Monocrystalline
<b>Build Type</b>	New	<b>Area</b>	1.631 m <sup>2</sup>
<b>Energy Efficiency</b>	EPC valid and at least Band D or higher	<b>Power Output</b>	300 Wp
<b>Installation Type</b>	Not a multi-installation		

<b>System Specification :</b>	<b>18.00 kWp</b>
<b>Total Roof Area Required :</b>	<b>approx. 99 m<sup>2</sup></b>
<b>Annual Electricity Output :</b>	<b>15,047 kWh</b>

**18 kWp Solar PV for ROI model below**

**Note: PV panels are based on high output, high efficiency at 300 Watts/panel.**

<b>Investment in 18kWp System: *</b>		£ 20,869.13
<b>First Year:</b>	Income from Feed-In Generation Tariff @ 11.30p/kWh:	£ 1,700.30
	Income from exporting energy @ 4.85p/kWh:	£ 364.89
	Electricity Saving:	£ 1,017.17
	<b>Total Benefit:</b>	<b>£ 3,082.37</b>
<b>Payback Time:</b>		6y 3m

**Total Profit Over 20 years:**

**£ 69,357.29**  
**16.62% per year**  
**(7.32% AER)**

**Assumptions:**

- Illustrative solar PV performance figures only. Figures are given in good faith but do not constitute "Financial Advice".
- Exact PV subsidy figures may depend on grants available at particular locations and other factors.
- Your property has an Energy Performance Certificate (EPC) rating of level D or better.
- Yearly PV output uses a factored degradation over time based on industry estimates.
- Tariffs shown presume installation after at the new FiT rates
- VAT is included (at 5% where appropriate) unless a new build is specified.
- Photovoltaic Panels will not be shaded (e.g. by Trees or Buildings) as shading affects PV output.
- Exact equipment costs are estimated based on retail prices in 2012 and will vary by installer/supplier.
- Installation costs are based on industry averages for installation type/size. Every install is different and you should obtain 3 quotes.
- Assuming that you pay 13.52p per unit and that around 50% of the solar electricity that you generate will be used in your home, having an export meter (you can change such assumptions above).

In order to qualify both the installer and the equipment must be certified under the Microgeneration Certification Scheme (MCS).

PV plant location(s) – To be located on the roof area.

### CO2 Emissions Reduction by PV

The table below demonstrate the results of the CO<sub>2</sub> emissions and energy use after the implementation of the PV technology. The target according to the London Plan 2011 is to meet a 20% reduction in CO<sub>2</sub> emissions from renewable technology.

The following tables demonstrate the reductions achieved by PV technology for the two heating options:

#### Individual Combi gas boilers + 18kWp PV BE GREEN stage

Building Services	BE LEAN CO <sub>2</sub> Emissions (tonneCO <sub>2</sub> /yr)	BE GREEN Building CO <sub>2</sub> Emissions (tonneCO <sub>2</sub> /yr)
Heating	13.57	13.57
Hot Water	8.59	8.59
Auxiliary	0.28	0.28
Lighting	2.95	2.95
Energy generated by renewables	0	-7.10
<b>Total (regulated)</b>	<b>25.38</b>	<b>18.28</b>

Table 13

### CO<sub>2</sub> Reductions after BE GREEN stage

Regulated Emissions	BE LEAN Building CO <sub>2</sub> Emissions	BE GREEN Building CO <sub>2</sub> Emissions	% reduction in CO <sub>2</sub> Emissions
kg of CO <sub>2</sub> /m <sup>2</sup> /yr	19.40	13.97	29.12%
Tonnes CO <sub>2</sub> / yr	25.38	18.28	

Table 14

From the table above it can be seen that the overall CO<sub>2</sub> reduction due to the installation of low or zero carbon technologies is approx. 29.12% for the total emissions.

## 10. Conclusion

Due to the site spatial limitations, location and the other issues identified previously in the report technologies such as Ground Source Heat Pump, Biomass, Solar Thermal, Hydroelectricity and Wind turbines are immediately unfeasible. The design has incorporated building fabric enhancement (above current building regulations requirements) to increase the energy efficiency of the building.

The recommendation for the proposed development is that **Efficient Combi Gas Boilers (90% efficiency) along with a total of 18kWp PV, which equates to approximately 60 PV panels in total (based on 300W PV output) and approximately 99 m<sup>2</sup> required roof area** should be progressed. This is based on the following reasons:

- The strategy would provide an **average of 25.09% CO<sub>2</sub> reduction saving (DER/TER) against Building Regulations Part L1A 2013 for the whole development. Therefore, the strategy meets BRUK-L1A requirements for the development.**
- The Greater London Authority's (GLA) London Plan 2011 asks for all new developments to meet a target of **40% improvement over Part L 2010 (equivalent to 35% over Part L 2013)** through implementation of the Energy Hierarchy. In order for this development to meet this target, it has been calculated that either communal heating or additional PV would need to be incorporated however due to limited roof space and plant space this has not been seen as feasible for this development. Therefore, it is proposed that a **one off payment of £4,353.57 is made to the LA's Carbon Offset Fund.**
- The strategy would provide an average of **29.12% reduction of CO<sub>2</sub> emissions the energy demand via onsite renewable technology (PV) for the overall development. Hence, the required target of 20% reduction in CO<sub>2</sub> emissions through renewable onsite has been achieved.**

- After the application of the Energy Hierarchy, the regulated carbon dioxide emissions are presented on the table below:

	Carbon Dioxide emissions (Tonnes CO <sub>2</sub> per annum)
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After CHP/ Communal Heating	25.38
After renewable energy	18.28

Table 1: Carbon Emissions following the application of the Energy Hierarchy

The chart below summarises the regulated carbon dioxide savings from each stage of the Energy Hierarchy:

	Regulated Carbon Dioxide savings	
	(Tonnes CO <sub>2</sub> per annum)	(%)
Savings from energy demand reduction	-0.98	-4.03%
Savings from CHP/ Communal Heating	0.00	0.00%
Savings from Renewable energy	7.10	29.12%
<b>Total Cumulative Savings</b>	<b>6.12</b>	<b>25.09%</b>
<b>Total Target Savings</b>	<b>8.54</b>	<b>35%</b>
<b>Annual Surplus</b>	<b>-2.42</b>	<b>(£4,353.57 payment to be made)</b>

Table 2: Regulated carbon savings from the application of the Energy Hierarchy

## 11. Appendix

- ✓ Low & Zero Carbon Energy Systems

### 11.1. 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.

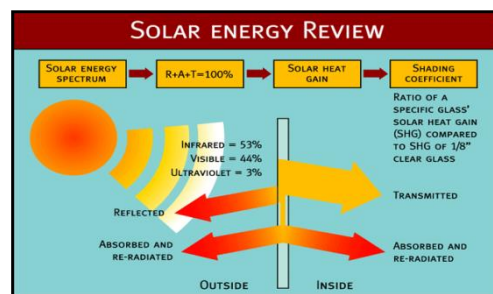
The second part of this section will provide an indication of the available low carbon technologies that can be installed on a building to minimise carbon emissions and reduce energy costs.

### 11.2. Zero Carbon (Renewable) Energy Overview

Renewable energy is the energy that is grasped by the earth’s abundant natural sources. Renewable energy can be harnessed with the appropriate use of technology to satisfy the human energy needs. Solar, wind, wave, tide and bio energy are termed as renewable. These renewable energy sources can be classified as ‘active’ or ‘passive’. Active RES are the renewable sources which with the use of renewable energy systems technology (REST) can generate power and heat to satisfy the energy and heating demands of buildings. Passive RES are the renewable sources which with the use of static building elements can enhance the natural ventilation and the heating of a building.

- ✓ Solar Energy

Solar energy is the energy of sun light. The temperature of the Sun’s surface reaches to a value of approximately 5,762K. The Earth’s perimeter of 40,000 km results in an intersected sun power of 174,000TW. Attenuation by the atmosphere results in peak intensity at sea level of around 1kW/m<sup>2</sup>, giving a 24 hour annual average of 0.2kW/m<sup>2</sup> and a 24 hour annual average power of 102,000 TW.



This commands the environment and maintains the life support system of Earth’s ecosystem and all forms of renewable energy with the exception of geothermal energy. The solar energy reaching the earth’s surface surpasses 10,000 times the current global energy demand.

To be more specific in terms of harnessing solar energy we are interested with the irradiance. Irradiance is the energy of light incident on a solar collector. Irradiance is measured in energy per area, (W/m<sup>2</sup>). The solar irradiance received on the Earth’s surface consists of three components, the beam



irradiance, diffuse and ground reflected irradiance. The beam component is the irradiance that reaches the solar collector directly. The diffuse irradiance is formulated due to scattering and absorption in the earth's atmosphere. Finally, the ground reflected irradiance is formed due to the sunlight reflected by the earth's ground.

✓ **Wind Energy**

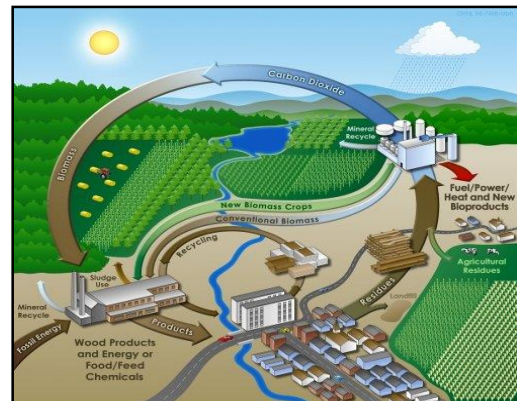
Wind energy is the energy found in the wind that is grasped by REST in order to generate power for human benefit. Wind turbines are the REST used to collect the wind resource and generate power. Today, wind turbines are used to generate electricity from the wind. There are two types of wind turbines, the horizontal axis turbine which is the most common one and the vertical axis turbine. The HAWT is the most efficient and cost effective. Most of the wind turbines used for electricity generation is of this type. Wind turbines can be found in many sizes and outputs, from small battery charging turbines (say a rotor diameter of 1 or 2 metres with an output of a few hundred Watts) to the largest machines used to supply electricity to the grid (Rotor diameters in excess of 70m and output powers of over two MW).



✓ **Bio-energy**

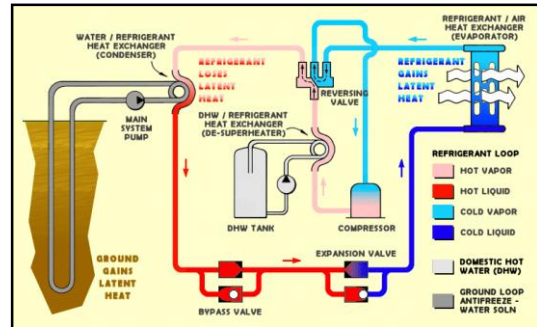
Bio-energy is the energy produced from biomass. Biomass is available from materials derived from biological sources. Biomass is any organic material which has stored sunlight in the form of chemical energy. As a fuel it may include wood, wood waste, straw, manure, sugar cane, and many other by products from a variety of agricultural processes. Energy from biomass is produced by burning organic matter.

Biomass is the solid form of 'bioenergy', but liquid fuels can also be generated from plant matter and this is referred to as 'biofuel'. Biomass is carbon-based so when used as fuel it also generates carbon emissions. However, the carbon that is released during combustion is equivalent to the amount that was absorbed during growth, and so the technology is carbon-neutral.



✓ **Geothermal Energy**

Geothermal energy is the heat from the Earth. It's clean and sustainable. Resources of geothermal energy range from the shallow ground to hot water and hot rock found a few miles beneath the Earth's surface, and down even deeper to the extremely high temperatures of molten rock called magma. Almost everywhere, the shallow ground or upper 10 feet of the Earth's surface maintains a nearly constant temperature between 10° and 16°C. Geothermal heat pumps can tap into this resource to heat and cool buildings. A geothermal heat pump system consists of a heat pump, an air delivery system (ductwork), and a heat exchanger—a system of pipes buried in the shallow ground near the building. In the winter, the heat pump removes heat from the heat exchanger and pumps it into the indoor air delivery system. In the summer, the process is reversed, and the heat pump moves heat from the indoor air into the heat exchanger. The heat removed from the indoor air during the summer can also be used to provide a free source of hot water.



**11.2.1. Zero Carbon Technologies**

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

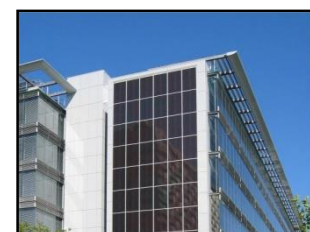
- Photovoltaics (PV)
- Solar Water Heating
- Wind Turbines
- Small scale Hydro Power
- Biomass Heating

**11.2.1.1. 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<sub>2</sub> per year kWp they generate.

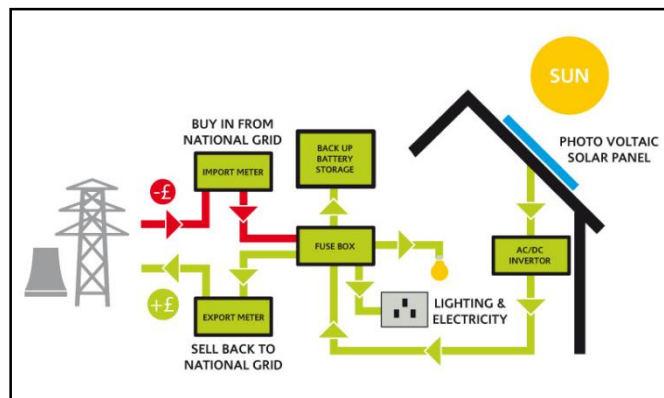
**Best Practice Design**

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 require 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<sup>2</sup> for mono-crystalline and 10m<sup>2</sup> 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. For an average domestic system, costs of a PV system can be around £4000 -£9000 per kWp installed, with most domestic systems usually between 1.5 and 2 kWp. 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.



**Available Grants**

The Feed - In - Tariffs have been introduced in order to give an incentive for PV generated electricity. The Feed-In-Tariffs scheme is based on the principle that the energy supplier pays generation tariff for

every kWh the PV system generates and an export tariff for every kWh of electricity supplied back to the national grid.

**Tariff level for new Solar PV installations after 1<sup>st</sup> August 2012 (pence/kWh). For non PV technologies there will be new rates as of October 2012**

Technology	Scale	Standard generation tariff	Multi-installation tariff	Lower tariff if energy efficiency requirement not met
PV	≤4 kW (new build)	16.0	14.4	7.1
PV	≤4 kW (retrofit)	16.0	14.4	7.1
PV	>4-10 kW	14.5	13.05	7.1
PV	Stand alone system	7.1	N/A	N/A

**Description of Solar Water Heating System**

Solar water heating systems use solar energy to heat water. Depending on the type of solar collector used, the weather conditions, and the hot water demand, the temperature of the water heated can vary from tepid to nearly boiling. Most solar systems are meant to furnish 20 to 85% of the annual demand for hot water, the remainder being met by conventional heating sources, which either raise the temperature of the water further or provide hot water when the solar water heating system cannot meet demand.



**11.2.1.2. 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. The average domestic system reduces CO<sub>2</sub> by 325 kg per year approximately and around £50 a year of hot water bills, when installed in a gas heated home.

Fuel Displaced	£ Saving per year	CO <sub>2</sub> saving per year kg
Gas	50	325
Electricity	80	635

Table 4

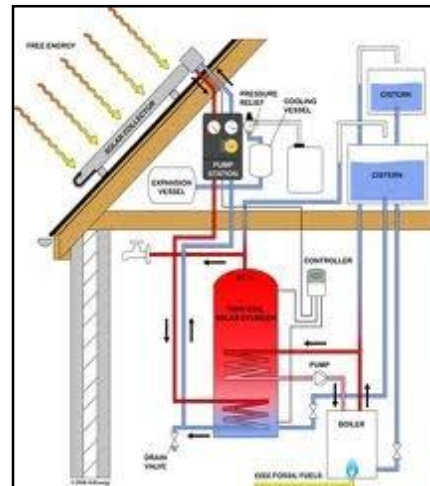
The savings presented on the previous table are approximate and are based on the hot water heating demand of a 3 bed semi-detached house.

**Best Design Practice**

For domestic systems a 3-4 m<sup>2</sup> of southeast to southwest facing roof receiving direct sunlight for the main part of the day is required. Also, more space will be needed if a water cylinder is required.

**Planning Issues**

In England, changes to permitted development rights for micro generation technologies introduced on 6<sup>th</sup> 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**

A typical installation cost for a domestic SHW system is £3000-£5000. 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.

**Available Grants**

In March 2011, the UK Government announced the details of their Renewable Heat Incentive (RHI). RHI is designed to provide financial support that encourages individuals, communities and businesses to switch from using fossil fuel for heating, to renewables such as wood fuel.

There will be two phases for domestic customers:

**Phase 1 (available from July 2011) - “RHI Premium Payment”**

This is called the “RHI Premium Payment” and will be worth around £15m and available to 25,000 householders in Great Britain who install from July 2011.

The exact amounts available to consumers are confirmed:

- \* Solar Thermal - £300/unit

These are one off payments; so not annual. DECC plan to publish details of the “Phase 2 RHI Payment” and how this will apply next year. Recipients of this payment will need to ensure that:

- \* They have a well-insulated property based on its energy performance certificate;

\* They agree to give feedback on how the equipment performs.

**Phase 2 (available from October 2012) – RHI tariffs**

People in receipt of the Renewable Heat Premium Payments will be able to receive long term RHI tariff support once these tariffs are introduced, as will anybody who has installed an eligible technology since 15th July 2009.

These tariff payments will start alongside the Green Deal from October 2012 to allow a more whole-house approach to heat production and energy saving.

**11.2.1.3. 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<sub>2</sub> 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.

**Available Grants**

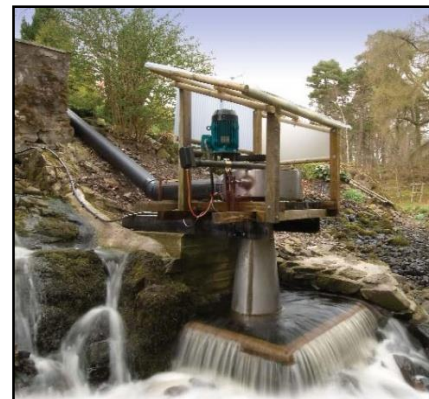
The Feed - In – Tariffs have been introduced in order to give an incentive for wind generated electricity. The Feed-In-Tariffs scheme is based on the principle that the energy supplier pays generation tariff for every kWh the wind system generates and an export tariff for every kWh of electricity supplied back to the national grid.

- Generation Tariff: 28.0 – 36.20 pence/kWh depending on installed rated output (up to 15KW)
- Export Tariff: 3.10pence/kWh
- Tariff period duration is 20 years

**11.2.1.4. 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 – so a typical 5kW domestic scheme might cost £20-£25,000.

Unit costs drop for larger schemes. Maintenance costs vary but small scale hydro systems are very reliable.

**Available Grants**

The Feed - In – Tariffs have been introduced in order to give an incentive for hydroelectric generated electricity. The Feed-In-Tariffs scheme is based on the principle that the energy supplier pays generation tariff for every kWh the hydroelectric system generates and an export tariff for every kWh of electricity supplied back to the national grid.

- Generation Tariff: 20.90 pence/kWh depending on installed rated output (up to 15KW)
- Export Tariff: 3.10pence/kWh
- Tariff period duration is 20 years

**11.2.1.5. 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<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> 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.

### **Available Grants**

In March 2011, the UK Government announced the details of their Renewable Heat Incentive (RHI). RHI is designed to provide financial support that encourages individuals, communities and businesses to switch from using fossil fuel for heating, to renewables such as wood fuel.

The RHI is in two phases:

#### **Phase 1 (available from July 2011) - “RHI Premium Payment”**

This is called the “RHI Premium Payment” and will be worth around £15m and available to 25,000 householders in Great Britain who install from July 2011.

The exact amounts available to consumers have yet to be confirmed. However the Department of Energy and Climate Change (DECC) have announced that the following amounts may be available:

- \* Biomass boilers - £950/unit (available only to off-gas installations)

These are one off payments; so not annual. DECC plan to publish details of the “Phase 2 RHI Payment” and how this will apply next year. Recipients of this payment will need to ensure that:

- \* They have a well-insulated property based on its energy performance certificate;
- \* They agree to give feedback on how the equipment performs.

#### **Phase 2 (available from October 2012) – RHI tariffs**

People in receipt of the Renewable Heat Premium Payments will be able to receive long term RHI tariff support once these tariffs are introduced, as will anybody who has installed an eligible technology since 15th July 2009.

These tariff payments will start alongside the Green Deal from October 2012 to allow a more whole-house approach to heat production and energy saving.

#### **11.2.1.6. Low Carbon Technologies**

In this section the low carbon technologies are described.

- Air Source Heat Pumps
- Ground Source Heat Pumps (GSHP)
- Combined Heat and Power (CHP)

- Micro CHP
- Fuel Cells

### 11.2.1.7. 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.

#### Available Grants

In March 2011, the UK Government announced the details of their Renewable Heat Incentive (RHI).

RHI is designed to provide financial support that encourages individuals, communities and businesses to switch from using fossil fuel for heating, to renewables such as wood fuel.

The RHI is in two phases:

#### **Phase 1 (available from July 2011) - "RHI Premium Payment"**

This is called the "RHI Premium Payment" and will be worth around £15m and available to 25,000 householders in Great Britain who install from July 2011.

The exact amounts available to consumers are confirmed:

- \* Air Source Heat Pumps - £850/unit (available only for off-gas installations)

These are one off payments; so not annual. DECC plan to publish details of the “Phase 2 RHI Payment” and how this will apply next year. Recipients of this payment will need to ensure that:

- \* They have a well-insulated property based on its energy performance certificate;
- \* They agree to give feedback on how the equipment performs.

**Phase 2 (available from October 2012) – RHI tariffs**

People in receipt of the Renewable Heat Premium Payments will be able to receive long term RHI tariff support once these tariffs are introduced, as will anybody who has installed an eligible technology since 15th July 2009.

Whilst Air source heat pumps will be eligible for the Renewable Premium Payment, a decision on whether or not they'll be included in the tariff payments will be based upon consumer feedback on the performance of the technologies. This should be clarified towards the end of 2011.

These tariff payments will start alongside the Green Deal from October 2012 to allow a more whole-house approach to heat production and energy saving.

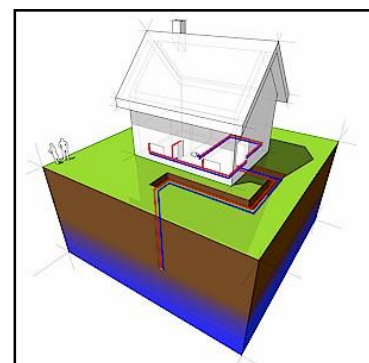
**11.2.1.8. Ground Source Heat Pumps (GSHP)**

**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 domestic 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<sub>2</sub> a year. Savings will vary depending on what fuel is being replaced.

### **Available Grants**

In March 2011, the UK Government announced the details of their Renewable Heat Incentive (RHI). RHI is designed to provide financial support that encourages individuals, communities and businesses to switch from using fossil fuel for heating, to renewables such as wood fuel.

There will be two phases for domestic customers:

#### **Phase 1 (available from July 2011) - "RHI Premium Payment"**

This is called the "RHI Premium Payment" and will be worth around £15m and available to 25,000 householders in Great Britain who install from July 2011.

The exact amounts available to consumers are confirmed:

- \*Ground Source Heat Pumps - £1,250/unit (available for off-gas installations only)

These are one off payments; so not annual. DECC plan to publish details of the "Phase 2 RHI Payment" and how this will apply next year. Recipients of this payment will need to ensure that:

- \* They have a well-insulated property based on its energy performance certificate;
- \* They agree to give feedback on how the equipment performs.

#### **Phase 2 (available from October 2012) – RHI tariffs**

People in receipt of the Renewable Heat Premium Payments will be able to receive long term RHI tariff support once these tariffs are introduced, as will anybody who has installed an eligible technology since 15th July 2009.

These tariff payments will start alongside the Green Deal from October 2012 to allow a more whole-house approach to heat production and energy saving

**11.2.1.9. 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 fuel 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 domestic 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 deregulation 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.



### Available Grants

The Feed - In – Tariffs have been introduced in order to give an incentive for micro CHP generated electricity. The Feed-In-Tariffs scheme is based on the principle that the energy supplier pays generation tariff for every kWh the micro CHP system generates and an export tariff for every kWh of electricity supplied back to the national grid.

- Generation Tariff: 10.50 pence/kWh depending on installed rated output (up to 2KW)
- Export Tariff: 3.10pence/kWh
- Tariff period duration is 10 years

#### 11.2.1.10. 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.

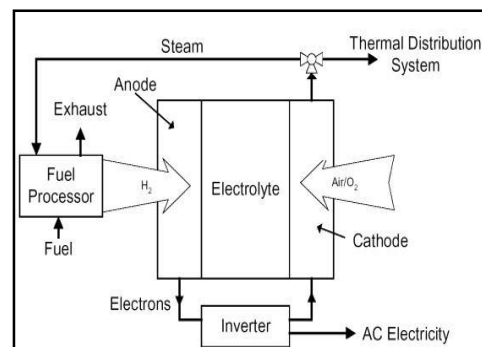
There are several kinds of fuel cells, and each operates a bit differently. But in general terms, hydrogen atoms enter a fuel cell at the anode where a chemical reaction strips them of their electrons. The hydrogen atoms are now “ionized,” and carry a positive electrical charge. The negatively charged 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.



#### 11.2.1.11. Be Green – Renewable Technology

In this section the viable renewable energy technologies that will reduce the development’s CO<sub>2</sub> emissions further by 20% are examined. Incorporating green design measures will significantly reduce the onsite energy consumption and the CO<sub>2</sub> emissions of the building. The ‘London Plan’ states that a further CO<sub>2</sub> reduction of 20% 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:

- I. Renewable energy resource or fuel availability of the LZC technology on the site.
- II. Space limitations due to building design and urban location of the site.
- III. Capital, operating and maintenance cost.
- IV. Planning Permission



V. Implementation with regards the overall M&E design strategy for building type

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

- Wind Turbines
- Biomass Boilers
- Micro CHP
- Hydrogen Fuel Cells
- Small Scale Hydro Power
- Grd. Source Heat Pump (GSHP)

**Wind Turbines**

Wind turbines are not feasible for the development since it does not meet the criteria mentioned above. 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. The yearly average wind speed is quite low at 10 meters above ground.

4.9	5.3	5.6
4.8	4.8	5
4.9	4.8	4.9

Wind speed at 25m above ground level (m/s)

5.7	6	6.3
5.6	5.6	5.8
5.7	5.6	5.7

Wind speed at 45m above ground level (m/s)

6.2	6.5	6.7
6.1	6.2	6.3
6.1	6.1	6.2

Squares surrounding the central square correspond to wind speeds for surrounding grid squares.

**What does this mean?**

Power generated is related to wind-speed by a cubic ratio. That means if you halve the wind-speed, the power goes down by a factor of 8 (which is 2 x 2 x 2). A quarter of the wind-speed gives you a 64<sup>th</sup> of the power (4 x 4 x 4).

As a rough guide, if your turbine is rated at producing 1KW at 12m/s then it will produce 125W at 6m/s and 15W at 3m/s

**Please Note!** Bear in mind that the NOABL wind-speed dataset used here is a model of wind-speeds across the country, assuming **completely flat terrain**. It isn't a database of measured wind-speeds. Other factors such as hills, houses, trees and other obstructions in your vicinity need to be considered as well as they can have a significant effect.

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

The central square highlighted in yellow demonstrates the average wind speed in m/s for the site. Squares surrounding the central square correspond to wind speeds for surrounding grid squares. From the above table it is shown that the average wind speed on the development according to **NOABL database was estimated at 4.8m/s at 10m high above ground and 5.6m/s at 25m above ground.**

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 neighboring Commercial units & residential properties and trees.
- In addition, the low frequency noise generated by wind turbines might cause inconvenience to the neighboring 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 neighborhood committee interest regarding its aesthetics and acoustic issues).

### **Biomass Boilers**

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<sub>10</sub>/ PM<sub>2.5</sub>) and nitrogen oxides (NO<sub>x</sub>) 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.
- The whole of London Borough of Hillington is in a smoke control zone.

### **Hydrogen Fuel Cells**

No commercial units viable yet - As a result this solution will not be assessed any further.

The BlueGen product is a ceramic fuel cell and has recently entered the UK market this year.

Using ceramic fuel cells, BlueGen® electrochemically converts natural gas into electricity at up to 60 per cent electrical efficiency. Electricity is consumed locally, with unused power being exported to the grid. When the integrated heat recovery system is connected, the waste heat from BlueGen can be used to produce hot water - which improves the total efficiency to approximately 85 per cent.

### **Small Scale Hydro**

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.

### **Ground Source Heat Pump (GSHP)**

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.

### CHP & Micro CHP

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

- The average maximum heating load of a new apartment (built to 2013 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 (Baxi Ecogen was made available in 2009) 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 a lower FIT tariff rate and period duration and is only applicable for systems under 2kW.