129-147 Kingsway Yard New Build Energy and Sustainability Report

14-1175

129-147 Kingsway Yard, Mortlake, London. SW14 7HN

19.04.2016

Rev A

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Revision	*A*
Date	19.04.2016
Prepared by	J. Sewell
Checked by	E. Jolly
Authorised by	A.King

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1. Executive Summary

The design of the proposed development at **129-147 Kingsway Yard**, will be comprised of 6 No. new residential units (houses) and 2 No. commercial units (offices) located in **Mortlake, South West London**. 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 Richmond upon Thames** requires all proposed developments to be designed and built to minimise greenhouse gas emissions across their lifetime and incorporate sustainable design and construction measures. The Council will promote and measure sustainable design and construction by expecting **the development to achieve an overall 35% reduction of CO_2 emissions over the Part L 2013 and achieve a BREEAM 2014 New Construction rating of 'Excellent' in accordance the London Plan and Local Policies.**

The recommendation for the proposed development **is to enhance fabric elements (U-values) as per Building Regulations Part L1A, to install Air Source Heat Pump (300 % efficiency for heating, 270% for cooling) for space heating and cooling and an instant domestic hot generator with 100% of efficiency as well as the installation of 1.2KWp of rooftop Photovoltaic (PV) panels.** The proposed strategy provides the following attributes:

1. The strategy would provide an average of approximately **35% CO_2 reduction saving against the Part L 2013 baseline for the development as a whole. Therefore, the strategy shows compliance with Criterion 1 of Part L 2013 for carbon emissions and the London Plan's targets (Policy 5.2).**

2. The strategy has followed the methodology of the London Plan, i.e. Be Lean, Be Clean and Be Green.

3. **Rooftop photovoltaic panels are being proposed for the development and contribute approximately 3% towards further carbon emission** reduction through installation of on-site zero carbon technologies. Due to limited available roof space the target of 20% could not be met as no other technology was deemed suitable.

4. The strategy shows an **average improvement of approximately 21% in Fabric Energy Efficiency (FEE) compared to the Part L 2013 baseline**, therefore compliance with Criterion 1 of Part L 2013 for FEE can be demonstrated**.**

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

	Carbon Dioxide emissions (Tonnes CO_2 per annum)
	Regulated
Baseline: Building Regulations 2013 Part L Compliant Development	30.24
After energy demand reduction	20.34
After CHP/ Communal Heating	20.34
After renewable energy	19.58

Table 1: Carbon dioxide Emissions after each stage of the proposed strategy

The chart below summarizes the regulated carbon dioxide savings from each stage of the proposed strategy:

	Regulated Carbon Dioxide savings	
	(Tonnes CO_2 per annum)	(%)
Savings from energy demand reduction	9.89	32.71%
Savings from CHP/ Communal Heating	0.00	0.00%
Savings from Renewable energy	0.76	3.75%
Total Cumulative Savings	**10.65**	**35.23%**
Total Target Savings	**10.58**	**35%**
Annual Surplus	**0.07**	

Table 2: Regulated carbon dioxide savings from each stage of the proposed strategy

2. Introduction

Syntegra Consulting Ltd has been appointed as sustainability consultants to produce an energy strategy for the **'new construction of 6 houses and 2 offices' on the land at 129-147 Kingsway Yard, Mortlake, SW14 7HN** – to support the scheme design process the development demonstrates Building Regulations Part **L1A and L2A 2013** compliance, 35% regulated carbon emission reduction and demonstration of a BREEAM New Construction 'Excellent' rating in order to meet the London Plan and local authority policy targets.

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).
3) Demonstration of how the design is compliant against the current Part L1A 2013 buildings regulations i.e. **an improvement of the proposed dwelling regulated carbon emissions compared to the notional dwelling emissions as set by Part L 2013** in accordance with local planning policy targets.
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 **demolition of the existing garages and the subsequent construction of 6 No. terrace houses and 2 No. commercial offices**. The development is located in the area of Mortlake in South West London and it is in close proximity to Mortlake station (approx 0.5 miles) and to North Sheen station (approx 0.7 miles). The site is within the London Borough of Richmond upon Thames.

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 & 5.9)

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 paragraph 5.42 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 35% 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 and utilizing a Combined Heat & Power according to Policy 5.6 and reducing the potential for overheating and reliance on air conditioning systems according to Policy 5.9.

4.3. London Borough of Richmond upon Thames

LONDON BOROUGH OF RICHMOND UPON THAMES

Core Strategy (Adopted in April 2009)

CP1 - Sustainable Development

1.a. The policy seeks to maximise the effective use of resources including land, water and energy, and assist in reducing any long term adverse environmental impacts of development. Development will be required to conform to the Sustainable Construction checklist, including the requirement to meet the Code for Sustainable Homes level 3 (for new homes), Ecohomes "Excellent" (for conversions) or BREEAM "excellent" for other types of development. This requirement will be adjusted in future years through subsequent DPDs, to take into account the then prevailing standards in the Code for Sustainable Homes and any other National Guidance, and ensure that these standards are met or exceeded.

CP2 - Reducing Carbon Emissions

2.A The Borough will reduce its carbon dioxide emissions by requiring measures that minimise energy consumption in new development and promoting these measures in existing development, particularly in its own buildings.

2.B The Council will require the evaluation, development and use of decentralised energy in appropriate development.

2.C The Council will increase the use of renewable energy by requiring all new development to achieve **a reduction in carbon dioxide emissions of 20% from on-site renewable energy generation** unless it can be demonstrated that such provision is not feasible, and by promoting its use in existing development.

Development Management Plan (Adopted November 2011)

Policy DM SD 1 - Sustainable Construction

All development in terms of materials, design, landscaping, standard of construction and operation should include measures capable of mitigating and adapting to climate change to meet future needs.

New buildings should be flexible to respond to future social, technological and economic needs by conforming to the Borough's Sustainable Construction Checklist SPD.

New homes will be required to meet or requirements of the Code for Sustainable Homes Level 3.

They also must achieve a minimum 25 per cent reduction in carbon dioxide emissions over Building Regulations (2010) in line with best practice from 2010 to 2013, 40 percent improvement from 2013 to 2016, and 'zero carbon' standards from 2016. It is expected that efficiency measures will be prioritised as a means towards meeting these targets. These requirements may be adjusted in future years to take into account the then prevailing standards and any other national guidance to ensure the standards are met or exceeded.

New non-residential buildings over 100sqm will be required to meet the relevant BREEAM 'excellent' standards. For conversions see Policy DM SD 3 'Retrofitting'.

Policy DM SD 2 - Renewable Energy and Decentralised Energy Networks

New development will be required to conform to the Sustainable Construction Checklist SPD and:

(a) Maximise opportunities for the micro-generation of renewable energy. Some form of low carbon renewable and/or de-centralised energy will be expected in all new development, and
(b) Developments of 1 dwelling unit or more, or 100sqm of non-residential floor space or more will be required to reduce their total carbon dioxide emissions by following a hierarchy that first requires and efficient design to minimize the amount of energy used, secondly, by using low carbon technologies and finally, where feasible and viable, including a contribution from renewable sources.
(c) Local opportunities to contribute towards decentralized energy supply from renewable and

low-carbon technologies will be encouraged where there is no over-riding adverse local impact.

(d) All new development will be required to connect to existing or planned decentralized energy networks where one exists. In all major developments and large Proposals Sites Identified in the (forthcoming) Site Allocations DPD, provision should be made for future connection to a local energy network should one become available.

NB: The Code for Sustainable Homes Scheme has now been removed from national policy, therefore a CfSH pre-assessment has not been produced for this report.

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 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.

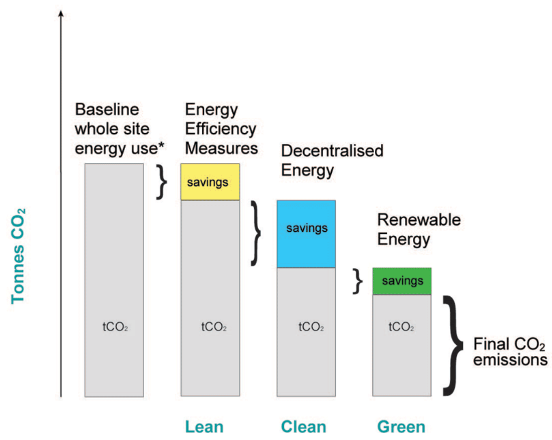


Figure 1: demonstration of the Energy Hierarchy methodology

5. Input data for energy assessment

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

No.	Drawing Name	Format
1	4594-D&A Statement	.pdf
2	4594_03_001_ Site Location Plan	. pdf
3	4594_03_002 _Topographical Survey	. pdf
4	4594_03_003_Proposed Site Plan	. pdf
5	4594_03_004_ Proposed Ground Floor	. pdf
6	4594_03_007_Elevations	. pdf
7	4594 Planning 12.04.16	.dwg

Table 3. The drawing list

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:

Residential				
No. of Units	Type of unit	Floor	Number of bedrooms	Individual Dwelling Area m^2
1	House	Ground and 1st Floor	3	165
2	House	Ground and 1st Floor	2	127
3	House	Ground and 1st Floor	2	132
4	House	Ground and 1st Floor	2	132
5	House	Ground and 1st Floor	2	165
6	House	Ground and 1st Floor	3	152
Commercial				
1	Office	Ground	-	76
2	Office	Ground	-	76

Table 4: Unit Configuration

5.2. Specification of Building Materials

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

Building Element		Proposed Specification	
		Residential	Retail
U-value (W/m^2 K)	External Walls	0.12	0.18
	Window units (whole window)	1.2/ g value 0.85	1.2 /g value 0.5
	Door	1	1
	Floor	0.12	0.1
	Roof	0.12	0.16
Air Permeability m^3/(h.m^2) at 50 Pa		5	5
Low Energy Lighting		100%	100%

Table 5: Building envelope specification

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 Regulations Part L1A 2013) and SBEM 2013.**

Carbon Emissions Factor	SAP 2013 kgCO_2/kW	SBEM 2013 kgCO_2/kW
Natural Gas	0.216	0.216
LPG	0.241	0.241
Biogas	0.098	0.098
Heating Oil	0.298	0.319
Coal (traditional British Coal)	0.394	0.345
Anthracite	0.394	0.394
Smokeless fuel	0.433	0.433
Dual Fuel (mineral + wood)	0.226	0.226
Biomass	0.123	0.031
Grid Electricity	0.519	0.519
Waste Heat	0.058	0.058

Table 6: Carbon Emission Factors

6. Baseline CO_2 Emissions

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 specified in the Building Regulations ADL1A 2013 document (Table 4).

		Part L 2013 min. required values		Proposed building values	
		L1A	**L2A**	**Retail**	**Residential**
U-value (W/m² K)	Wall	0.30	0.35	0.18	0.12
	Window	2.00	2.20	1.2 (Double glazing filled argon)	1.2 (Double glazing filled argon
	Floor	0.25		0.1	0.12
	Roof	0.20	0.25	0.16	0.12
Air Permeability (m³/h.m² at 50 Pa)		10		5	3.5

Table 7: Comparison of minimum performance parameters according to Part L 2013 and the proposed parameters

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

Building Services	Baseline CO_2 Emissions	
	(kg CO_2/m²/yr)	**(Tonnes CO_2/ yr)**
Total regulated emissions (heating, hot water, lighting, fans & pumps)	**30.24**	**30.24**

Table 8: Regulated emissions for the Baseline

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_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 cooling 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 heat pumps air-air have been examined for space heating and cooling. This strategy utilizes a minimum of 300% efficiency in heating for individual splits systems and 270% for efficiency in cooling. The Domestic Hot water will be provided for an instant electric heater 100% efficiency.

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_2 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 tables demonstrate the reduction in CO_2 emissions caused by the energy efficiency measures mentioned above.

BE LEAN: Air Source Heat pumps: (air-air) for cooling and heating and instant hot water heaters:

CO_2 Reductions after BE LEAN stage

Regulated Emissions	Baseline CO_2 Emissions	BE LEAN Building CO2 Emissions	% reduction in CO_2 Emissions
$KgCO_2/m^2/yr$	**30.24**	**20.34**	
Tonnes CO_2/ yr	**30.24**	**20.34**	**32.71%**

Table 9

From the table above it can be seen that the overall CO_2 reduction due to energy efficiency is ***32.71%*** for the total emissions.

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

- Wall u-value = 0.12 and 0.18 (better than Building Regs)
- Floor u-value = 0.12 and 0.1 (better than Building Regs)
- Roof u-value = 0.12 and 0.16 (better than Building Regs)
- Windows u-value = 1.2 - double glazing (better than Building Regs)
- Air permeability = 5 m3/m2/hr (better than Building Regs)
- 100% energy efficient lighting
- Heat pumps (300% heating and 270% cooling efficiency)
- Calculated thermal bridging with accredited construction details.

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_2 emissions further.

8.1. 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.

A CHP system has not been considered for this development.

8.2. Micro-CHP

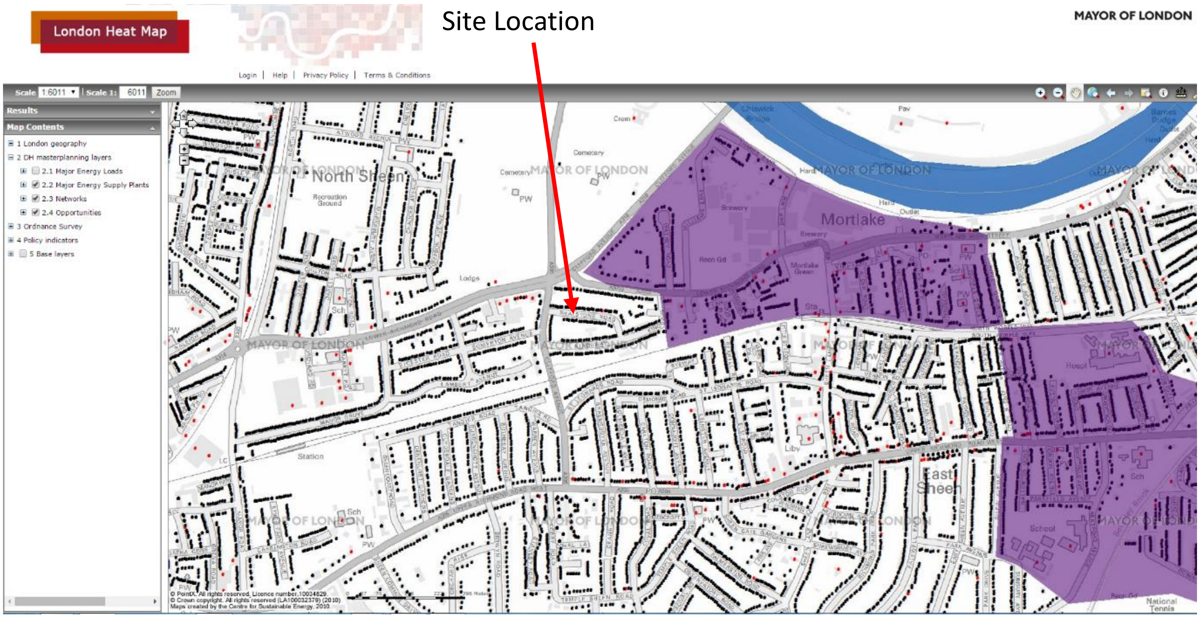
Micro CHP has not been considered further for this project due to the following reasons:
Micro-CHP is a relatively new concept (Baxi Ecogen was made available in 2009) and issues are raised in relation to unproven technology, inefficiency for shorter run cycles and lack of technical knowledge that can 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 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

8.3. 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 Richmond upon Thames (September 2007)** as part of this assessment. The study does identify a potential District Heating network within close proximity to Kingsway Yard. However the costs involved in extending the potential DH network would outweigh the advantages achieved from such a connection due to the size of the development. However it is advised that steps are taken to allow for the potential of future connections. This is demonstrated clearly from the London Heat Map (http://www.londonheatmap.org.uk) snapshot below.



9. 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:

- Wind Turbines [See Appendix Section 11.1]
- Biomass Boilers [See Appendix Section 11.2]
- Hydrogen Fuel Cells [See Appendix Section 11.3]
- Small scale hydro power [See Appendix Section 11.4]
- Grd. Source Heat Pump (GSHP) [See Appendix Section 11.5]
- CHP & Micro CHP [See Appendix Section 11.6]
- Solar Thermal

9.1. Air Source Heat Pumps & Photovoltaic (PV) – Proposed Technologies

Air Source Heat Pumps and Photovoltaic panels are the proposed renewable technologies for the proposed development.

PV panels are being proposed as a renewable technology for this development. The PV system will provide self-generating electricity which can be sold back to the grid. The CO_2 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 13.03p per kWh for electricity generated and 4.77p per kWh for electricity exported back to the grid (over 20 years).

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 ground, air, or water is constantly being renewed naturally. Installing a typical system, costs around £7,000 to £14,000. 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.

PV System specification - Whole Development

The PV system capacity for the whole development depends upon the selection of the three heating systems outlined at the 'BE LEAN' and at the 'BE CLEAN' stage of the energy hierarchy.

Therefore, the amount of PV's relating to the heating system options is outlined below:

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

Orientation	South	**Number of Panels**	**4**
Panel Tilt	30°	**Manufacturer**	Sunpower
Overshading	Less than 20 percent	**Model**	SPR 327NE WHT D
Proportion Exported	50%	**Type**	Monocrystalline
Build Type	New	**Area panel**	1.631 m^2
Energy Efficiency	EPC valid and at least Band D or higher	**Power Output**	327 Wp
Installation Type	Not a multi-installation		

Table 10: Assumed PV installation details for the proposed strategy

System Specification :	**1.3 kWp**
Total Roof Area Required :	**6.524 m^2**
Annual Electricity Ouput :	**1122.68kWh**

This table above shows the proposed PV specification for the new residential units. It will generate 1122.68 kWh per year. For the 1.3kWp system, 4 high efficiency 327W monocrystalline PV panels need to be installed. The roof area required for the PV panels is approximately 6.524m^2.

1.3 kWp Solar PV for ROI model below

Note: PV panels are based on high output, high efficiency at 327 Watts/panel.

Investment in 0.54kWp System: *		£2,861.99
First Year	Income from Feed-In Generation Tariff @ 4.32p/kWh:	£20.31
	Income from exporting energy from exporting energy @ 4.91p/kWh:	£11.54
	Electricity Saving:	£29.32
	Total Benefit:	£61.18
Payback Time:		36y 2m
Total Profit Over 20 years:		£281.47

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 4.91 per unit and that around 35% 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.

CO_2 Reductions after BE GREEN stage

Regulated Emissions	Be Lean CO_2 Emissions	BE GREEN Building CO_2 Emissions	% reduction in CO_2 Emissions
$KgCO_2/m^2/yr$	20.34	19.58	
Tonnes CO_2/ yr	20.34	19.58	3.75%

Table 11: Regulated emissions for Be Lean and Be Green stages for comparison

From the table above it can be seen that the overall CO_2 reduction due to the installation of on-site zero carbon technologies (i.e. rooftop PV panels) is 3.75% 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 regulation requirements) to increase the energy efficiency of the building.

The recommendation for the proposed development at **129-147 Kingsway Yard, Mortlake, London, SW14 7HN** is that **Efficient Air Source Heat Pumps (split system air-air) should be progressed for the residential units and commercial units. In addition, a total of 1.2Wp PV as a minimum requirements (which equals to 4 PV panels in total and approximately 6.5m^2 total required roof area) should be progressed for the whole development.** This is based on the following reasons:

1. PV plant location(s) – The plant would be located on the roof area facing south. The PV panels are based on high output, high efficiency Sunpower 327 watts.
2. The strategy would provide an average of approximately **35% CO_2 reduction saving (DER/TER) against current building regulations for the new residential units. Therefore, the strategy meets BRUK-L1A 2013 requirements for the development and the target of 35% CO_2 reduction saving (DER/TER) against 2013 building regulations.**
3. **Rooftop photovoltaic panels are being proposed for the development and contribute approximately 3% towards further carbon emission** reduction through installation of on-site zero carbon technologies. Due to limited available roof space the target of 20% could not be met as no other technology was deemed suitable.
4. **BREEAM NC 2014 pre-assessments** has been undertaken for the development demonstrating that an **"Excellent"** rating can be achieved [See the Appendix for the pre-assessment reports].
5. After the application of the Energy Hierarchy, the regulated carbon dioxide emissions are presented on the table below:

	Regulated Carbon Dioxide savings	
	(Tonnes CO_2 per annum)	(%)
Savings from energy demand reduction	9.89	32.71%
Savings from CHP/ Communal Heating	0.00	0.00%
Savings from Renewable energy	0.76	3.75%
Total Cumulative Savings	**10.65**	**35.23%**
Total Target Savings	**10.58**	**35%**
Annual Surplus	**0.07**	

Table 13: Carbon dioxide Emissions after each stage of the Energy Hierarchy

The key metrics currently envisaged for the development are listed below:

- **The carbon saving attributable to energy efficiency measures:** 32.71 %
- **The carbon saving attributable to clean measures:** 0 %
- **The carbon saving attributable to renewable energy technologies:** 3.75 %
- **The proposed development's overall improvement over the baseline:** 35.23 % - As can be seen from the table above, the development meets the 35% target.

11. Appendix

- ✓ Low & Zero Carbon Energy Systems
- ✓ BREEAM New Construction 2014 pre-assessment

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.

11.1. Available Grants

11.1.1. 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 Tier 1	3.62
		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

11.1.2. 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 digression table, but adjusted for RPI indexation and contingent digression. 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

11.2. 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

11.2.1. 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.

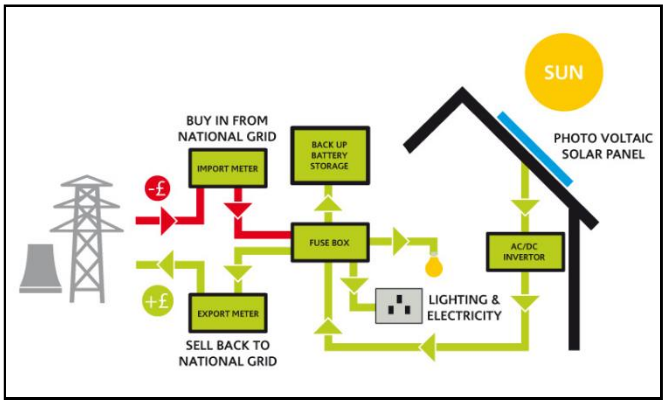
Advantages

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

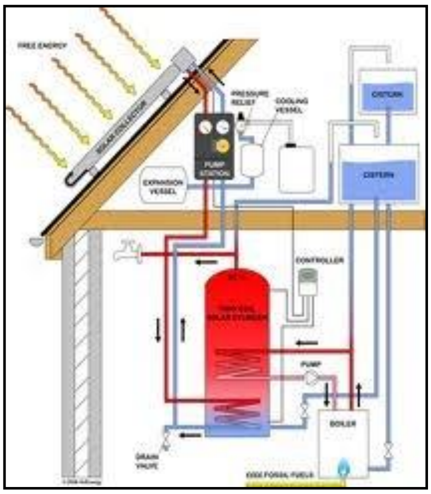


Prices for PV systems vary, depending on the size of the system to be installed, type of PV cell used and the nature of the actual building on which the PV is mounted. The size of a PV system depends on the buildings electricity demand. Solar tiles cost more than conventional panels, and panels that 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.

11.2.2. 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.

11.2.3. 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.

11.2.4. 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.

11.2.5. 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.

11.3. **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

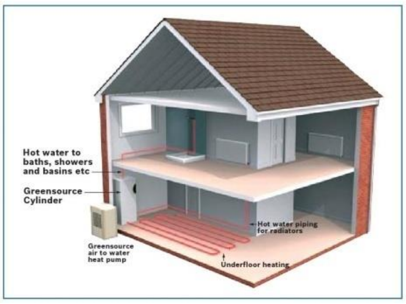
11.3.1. Air Source Heat Pumps (ASHP)

<u>Description of Air Source Heat Pumps</u>

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.

<u>Advantages</u>

- 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



<u>Costs & Savings</u>

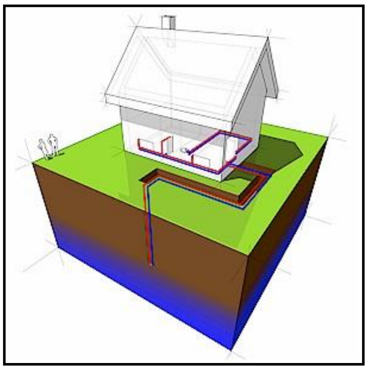
Operating Cost Savings around 15% in comparison with a typical gas fired condensing boiler installation with HWS cylinder and an electrically driven Community air to water heat pump.

11.3.2. Ground Source Heat Pumps (GSHP)

<u>Description of Ground Source Heat Pumps</u>

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.

11.3.3. 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.

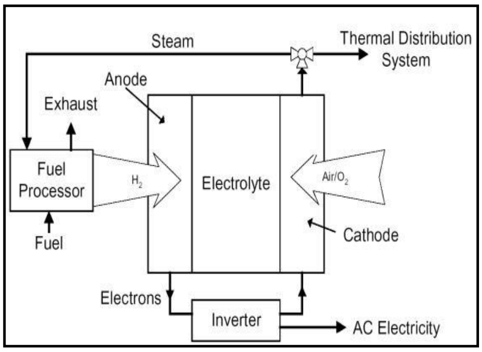
11.3.4. Fuel Cells

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.

11.4. Additional feasibility study for renewable technologies

11.4.1. Wind Turbines

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).

11.4.2. 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_{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.

11.4.3. 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.

11.4.4. 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.

11.4.5. 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.

11.4.6. 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 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.

Assessment report: 129-147 Kingsway Mews

Pre-assessment

Site name: 129-147 Kingsway Mews

Client name:

Date: 19/4/2016

Assessment ref: For Planning

Assessment details

Assessment references

Registration number:	For Planning	**Date created:**	19/4/2016
Assessor name: First:		**Surname:**	
Assessor licence number:			
Assessor organisation:			
Architect name:	Brookes Architects		
Developer name:	Space Solutions (UK) Ltd		
Property owner	Space Solutions (UK) Ltd		

Site details

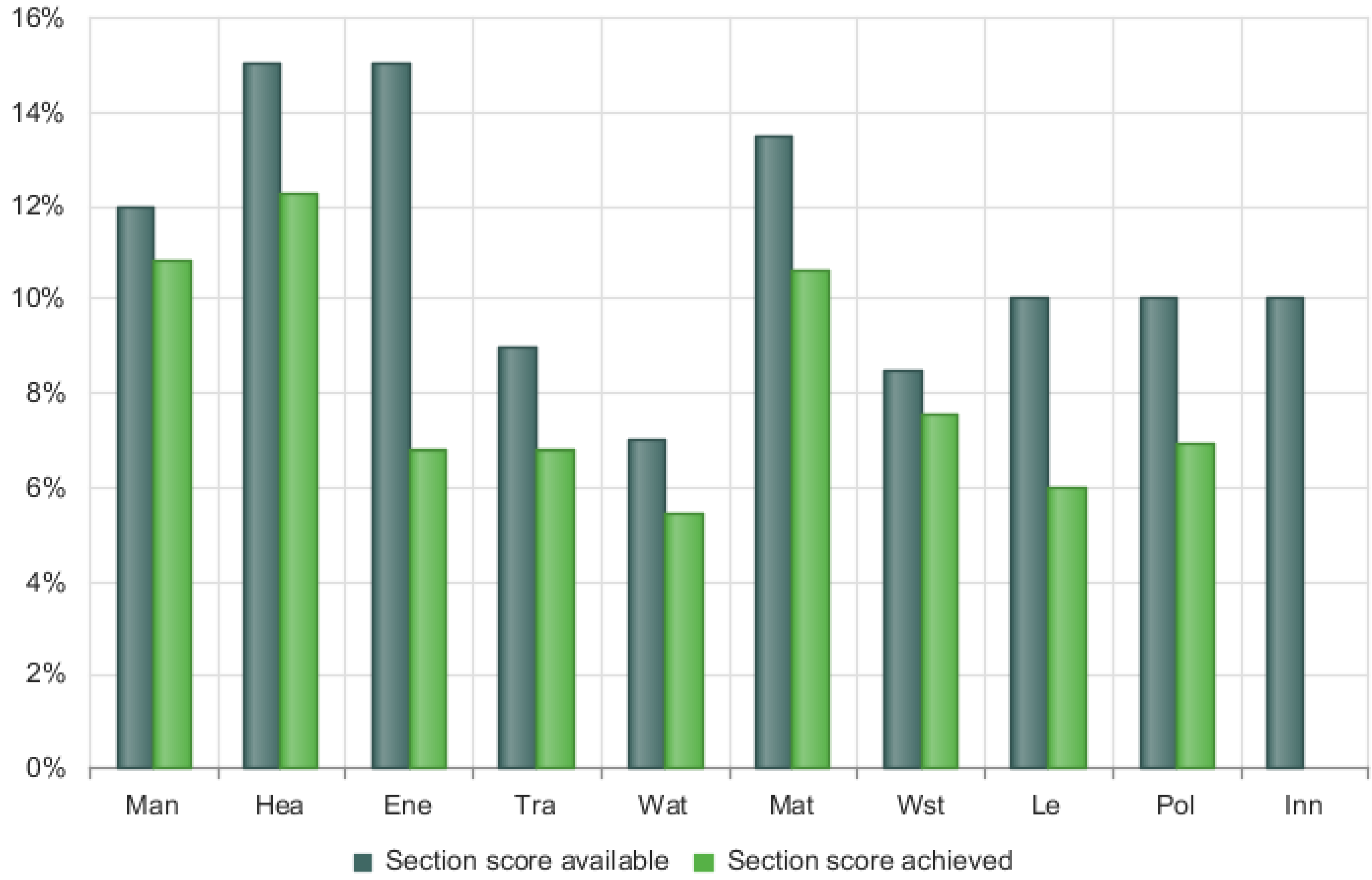
Site name:	129-147 Kingsway Mews
Address:	Land to the rear of
	129-147 KIngsway Mews
Town:	London
County:	
Post code:	SW14 7HN
Country:	United Kingdom

BREEAM rating

BREEAM Rating

	Credits available	Credits achieved	% Credits achieved	Weighting	Category score
Man	21.0	19.0	90.47%	12.00%	10.85%
Hea	22.0	18.0	81.81%	15.00%	12.27%
Ene	31.0	14.0	45.16%	15.00%	6.77%
Tra	12.0	9.0	75.00%	9.00%	6.75%
Wat	9.0	7.0	77.77%	7.00%	5.44%
Mat	14.0	11.0	78.57%	13.50%	10.60%
Wst	9.0	8.0	88.88%	8.50%	7.55%
Le	10.0	6.0	60.00%	10.00%	6.00%
Pol	13.0	9.0	69.23%	10.00%	6.92%
Inn	10.0	0.0	0.00%	10.00%	0.00%
Total	151.0	101.0	66.88%	-	73.18%
Rating	-	-	-	-	Excellent

Performance by environmental category



Issue scores

Please Note: X means the exemplary credit for the relevant issue

Management

Man Management	ManX
19 / 21	0 / 2

Health and Wellbeing

Hea Health and wellbeing	HeaX
18 / 22	0 / 3

Energy

Ene Energy	EneX
14 / 31	0 / 5

Transport

Tra Transport
9 / 12

Water

Wat Water	WatX
7 / 9	0 / 1

Materials

Mat Materials	MatX
11 / 14	0 / 4

Waste

Wst Waste	WstX
8 / 9	0 / 3

Land Use and Ecology

Le Land use and ecology
6 / 10

Pollution

Pol Pollution
9 / 13

Innovation

Inn Innovation	InnX
N/A	0 / 10

Initial details

Land to the rear of

Category assessment

Management | Man

Man Management

Land to the rear of

MANAGEMENT	
Man 01 - Project brief and design :	2
Man 02 - Lifecycle cost and service life planning :	4
Man 03 - Responsible construction practices :	6
Exemplary credit? :	
Man 04 - Commissioning and handover :	4
Man 05 - Aftercare :	3
Exemplary credit? :	

Credits awarded : 19.0

Hea Health and wellbeing

Land to the rear of

HEALTH AND WELLBEING	
Hea 01 - Visual comfort :	6
Exemplary credit? :	
Hea 02 - Indoor air quality :	4
Exemplary credits? :	0
Hea 03 - Safe containment in laboratories :	0
Hea 04 - Thermal comfort :	3
Hea 05 - Acoustic performance :	3
Hea 06 - Safety and security :	2

Credits awarded : 18.0

Ene Energy

Land to the rear of

ENERGY	
Ene 01 - Data entry method :	Simple credit entry
Ene 01 - Reduction of energy use and carbon emissions :	5
Exemplary credits? :	0
Ene 02 - Energy monitoring :	2
Ene 03 - External lighting :	1
Ene 04 - Low carbon design :	2
Ene 05 - Energy efficient cold storage :	1
Ene 06 - Energy efficient transportation systems :	0
Ene 07 - Energy efficient laboratory systems :	0
Ene 08 - Energy efficient equipment :	2
Ene 09 - Drying space :	1

Credits awarded : 14.0

Tra Transport

Land to the rear of

TRANSPORT	
Tra 01 - Public transport accessibility :	2
Tra 02 - Proximity to amenities :	2
Tra 03 - Cyclist facilities :	2
Tra 04 - Maximum car parking capacity :	2
Tra 05 - Travel plan :	1

Credits awarded : 9.0

Comments : Tra 01 - site has an approximate Accessibility Index of 7.3, therefore 2 credits can be targeted.

Wat Water

Land to the rear of

WATER	
Wat 01 - Water consumption :	3
Exemplary credit? :	
Wat 02 - Water monitoring :	1
Wat 03 - Water leak detection :	2
Wat 04 - Water efficient equipment :	1

Credits awarded : 7.0

Mat Materials

Land to the rear of

MATERIALS	
Mat 01 - Life cycle impacts :	4
Exemplary credits? :	0
Mat 02 - Hard landscaping and boundary protection :	1
Mat 03 - Responsible sourcing of materials :	3
Exemplary credit? :	
Mat 04 - Insulation :	1
Mat 05 - Designing for durability and resilience :	1
Mat 06 - Material efficiency :	1

Credits awarded : 11.0

Wst Waste

Land to the rear of

WASTE	
Wst 01 - Construction waste management :	3
Exemplary credit? :	
Wst 02 - Recycled aggregates :	1
Exemplary credit? :	
Wst 03 - Operational waste :	1
Wst 04 - Speculative floor and ceiling finishes :	1
Wst 05 - Adaptation to climate change :	1
Exemplary credit? :	
Wst 06 - Functional adaptability :	1

Credits awarded : 8.0

Le Land use and ecology

Land to the rear of

LAND USE AND ECOLOGY	
LE 01 - Site selection :	1
LE 02 - Ecological value of site and protection of ecological features :	2
LE 03 - Minimising impact on existing site ecology :	2
LE 04 - Enhancing site ecology :	1
LE 05 - Long term impact on biodiversity :	0

Credits awarded : 6.0

Pol Pollution

Land to the rear of

POLLUTION	
Pol 01 - Impact of refrigerants :	2
Pol 02 - NOx emissions :	2
Pol 03 - Surface water run-off :	3
Pol 04 - Reduction of night time light pollution :	1
Pol 05 - Reduction of noise pollution :	1

Credits awarded : 9.0

Inn Innovation

Land to the rear of

INNOVATION	
Inn 01 - Innovation :	0

Credits awarded : 0.0