ENERGY ASSESSMENT

FOR

18-22 HAVERSTOCK HILL
MIXED USE DEVELOPMENT

VERSION 3.0

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CONTENTS

18-22 HAVERSTOCK HILL, CAMDEN

ENERGY ASSESSMENT

PROJECT REVISION SHEET

18-22 HAVERSTOCK HILL, CAMDEN

170248

Revision 3.0

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Prepared by R Mistry

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1.0	07/03/2018	Final	Revised Plans and Elevations	R Mistry	P Lindsay
2.0	04/04/2018	Final	Minor revisions to drawings	R Mistry	A Sturt
3.0	11/04/2018	Final	Revisions to drawings issued on 4th April 2018 / Balcony Glazing Heights Confirmed on 10th April 2018	R Mistry	A Sturt

EXECUTIVE SUMMARY

Silcock Dawson and Partners have been appointed by PPR Estates to provide an Energy Assessment for the proposed new development at 18-22 Haverstock Hill, London.

The scheme comprises the demolition of an existing building, and the erection of 5 storey building with a ground floor plus basement level comprising of 29 residential (Use Class C3) units comprising 4 x Studio's, 9 x 1 bed, 11 x 2 bed, and 5 x 3 bed apartments and approximately 279 sqm of commercial space at the ground floor level. The common areas within the apartment block will not be heated and have not been included within this assessment. This Energy Assessment incorporates the requirements of the Greater London Authority and the London Borough of Camden.

The building is designed to be energy efficient and incorporate the following key features:

1. The annual heating demand will be reduced by using insulation values better than the Notional Building including high performance glazing, and the target air permeability is 4.0 $m^3/hr/m^2$.

   The dwellings will have a balanced ventilation system with a typical performance depending on the number of wet rooms of:

   Specific fan power of 0.42 W/l/s with 1 additional wet room

   Heat exchanger efficiency of up to 90%.

2. The dwellings will be provided with 100% low energy luminaires.

3. High performance insulation will be applied to the communal heating pipework to minimise heat loss and reduce the risk of overheating.

Given the relatively small foot print of the site the developer is proposing to make considerable improvements to the building fabric to reduce energy consumption. This simple approach will have the effect of reduced emissions throughout the life of the building, without heavy reliance on low carbon or renewable technologies. The site also has the potential for further reductions should a heat network become available that the development can viably connect into in the future.

The energy efficiency measures will reduce carbon emissions for the development by 15% relative to the 2013 Building Regulations requirements.

The London Heat Map has been reviewed and there are no existing or proposed heat networks identified local to the development.

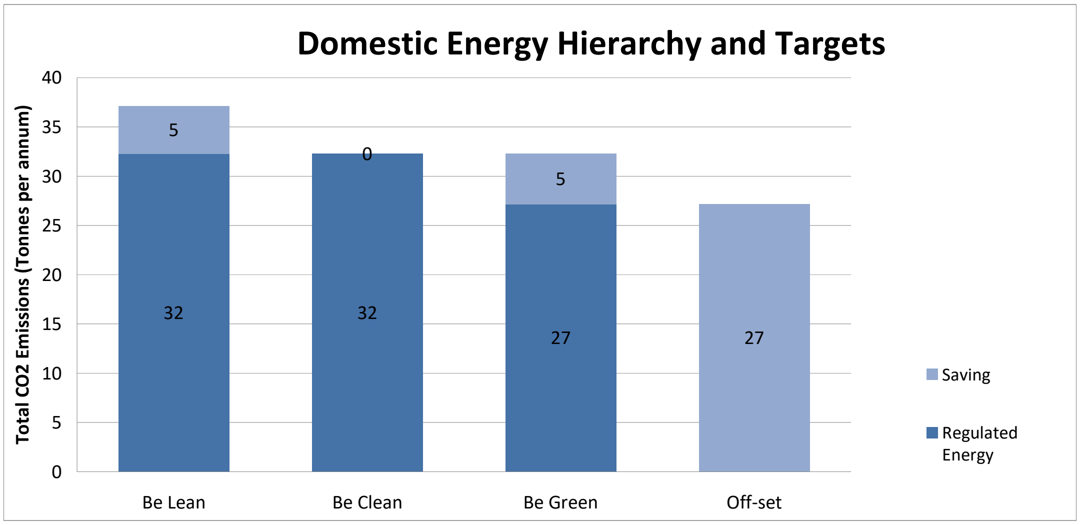
At 29 dwellings and a small commercial space, a CHP would not be viable for this development. The proposed heating strategy for the development is to provide central gas fired boilers to distribute low temperature hot water to heat interface units within each apartment with space allowed within the plant room to accommodate a future district heating substation should one become available.

A selection of renewable technologies has been reviewed and a summary is tabulated below:

Technology	Major factors
Biomass	Not viable, a large area for fuel storage is required, which is not available on this city centre constricted site. In addition, the site is within a densely occupied area and biomass boilers generate high levels of particulate material and NO_2.
GSHP	Not favoured due to the compact nature of the site and the relatively small amount of heat that could be withdrawn. The integration of a complicated technology is not appropriate for such a low potential CO_2 reduction.
ASHP	Not favoured, the temperatures at which the heat pump will operate will reduce the plant effectiveness, to the point where little or no CO_2 reductions can be realised when compared to condensing gas fired boilers. ASHP is considered for the commercial space as the unit will require cooling. The CO2 saving using ASHP for heating purpose for commercial space is equates to 2% from the from the energy efficient model.
Solar Thermal	Not favoured, the technology has the potential to connect in to the community heating system, but will lead to complicated integration with the gas fired boiler installation. Solar thermal installations are best suited to single occupancy installations such as houses or hotels, where the hot water can feed directly into the user's hot water storage vessel.
PV cells	Space is available at roof level to install a PV array, which would make a significant contribution to the overall emissions reduction for the site. The panels will be a distinct installation from the heating plant and allow the community heating system to be as simple as possible to operate and maintain. It is estimated that an array of $80m^2$ could be installed to the roof of the building feeding directly into the landlords supply with excess power supplying the grid generating a CO_2 reduction of 16% from the residential energy efficient model.
Wind	Not viable, the urban environment and the close proximity of dwellings are not favourable conditions to operate a wind turbine.

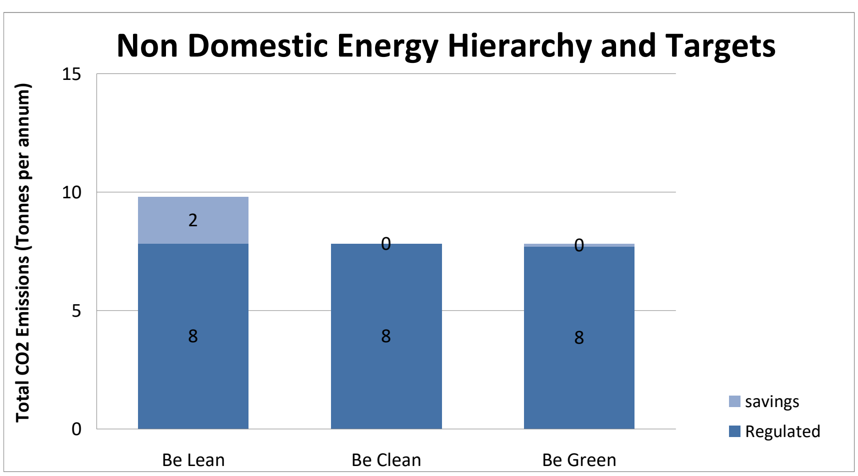
It is proposed that $80m^2$ of photovoltaic panels will be installed on the building roof at 10º angle to contribute to the CO2 reduction from the energy efficiency measures.

The total carbon savings are summarized in the tables and graph below.



GLA Table 2: Residential Carbon Dioxide Emissions from each stage of the Energy Hierarchy (Dwellings)		
	Regulated Carbon dioxide savings	
	(Tonnes CO2 per annum)	(%)
Savings from energy demand reduction	4.85	13
Savings from CHP	0.00	0
Savings from renewable energy	5.13	16
Total cumulative savings	9.98	**27**
Resultant Emissions for off-set payment	27.15	
	(Tonnes CO2)	
Cumulative Emissions for off-set payment over 30 Yr Period	**814**	

The final use of the commercial space is unknown, but it has been modelled as a retail sales space and a CO_2 reduction of 20% is expected from energy efficiency measures. The application of air source heat pump is expected to further reduce the carbon emissions by a further 2%, achieving a total cumulative CO_2 reduction of 21%.



GLA Table 4: Commercial Carbon Dioxide Emissions from each stage of the Energy Hierarchy (Commercial Units)		
	Regulated Carbon dioxide savings	
	(Tonnes CO2 per annum)	(%)
Savings from energy demand reduction	1.98	20
Savings from CHP	0.00	0
Savings from renewable energy	0.12	2
Total cumulative savings	2.10	21

GLA Table 5: Commercial Shortfall in Regulated Carbon Dioxide Savings		
	Annual Shortfall (Tonnes CO2)	Cumulative Shortfall (Tonnes CO2)
Total Target Savings	3.43	
Shortfall	1.33	**40**

The total carbon savings through the combination of energy efficient design, and renewable energy against the building regulation target emissions will be 26%. Whilst this is less than the 35% required under the London Plan, the 27% reduction for the dwellings is sufficient to exceed the now defunct code for sustainable homes level 4 emission reduction target of 19%.

GLA Table 6: Carbon Dioxide Emissions from each stage of the Energy Hierarchy			
	Total Regulated Emissions	CO2 Savings	Percentage Saving
	(Tonnes CO2/year)	(Tonnes CO2/year)	%
Part L 2013 Baseline	46.92		
Savings from energy demand reduction	40.10	6.83	15
Savings from CHP	40.10	0.00	0
Savings from renewable energy	34.84	5.25	11
Cumulative savings		12.08	26
Total off-set		**854**	

The applicant has developed a scheme that incorporates a very efficient fabric design to minimise heating emissions and incorporates the maximum number of high efficiency PV panels possible to suit the roof design to generate a maximum possible CO_2 reduction of 26%. The developer appreciates that this is short of the 35% CO_2 reduction required by local policy and the London Plan, and every effort will be made during the detailed design stage to improve the overall performance of the development to reduce the emissions further.

Based on the calculations, to achieve zero carbon on the residential part of the development, and a 35% CO_2 reduction on the commercial unit, the corresponding offset payment would be £76,896.00 based on a payment of £90 per tonne over a 30 year period.

A preliminary layout of the PV mounted on the roof is included within section 7 of this report which shall be developed further during the detailed design process.

1 INTRODUCTION

1.1 Background

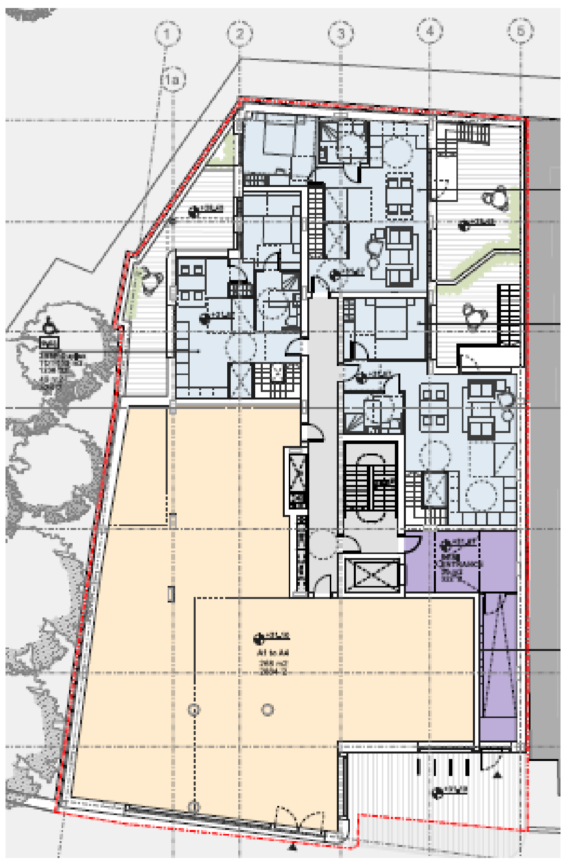
Silcock Dawson and Partners have been appointed by PPR Estates to provide an Energy Assessment for the proposed housing development within Camden.

The aim of this report is to document the findings of the investigation into energy efficiency measures and the feasibility of on-site decentralised and renewable or low carbon energy sources. The report makes recommendations as to the best means of incorporating low and zero carbon technologies into the development.

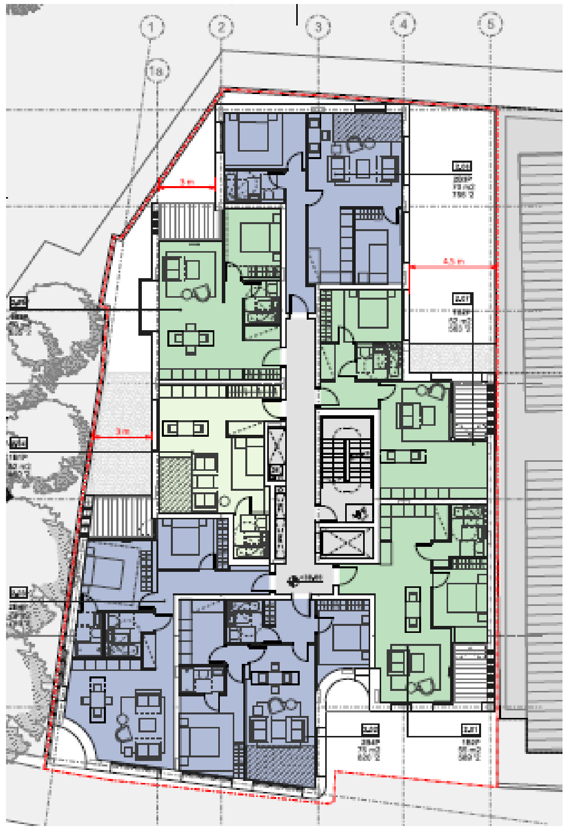
1.2 Description of the Site and Building

The scheme comprises the demolition of an existing building, and the erection of 5 storey building with a ground floor plus basement level comprising of 29 residential (Use Class C3) units comprising 4 x Studio's, 9 x 1 bed, 11 x 2 bed, and 5 x 3 bed apartments and approximately 279 sqm of commercial space at the ground floor level. The common areas within the apartment block will not be heated and have not been included within this assessment.

For detailed description of the building, refer to the Design and Access Statement provided by Piercy & Company Architects.



Ground Floor



Typical Floor Layout

2 RELEVANT PLANNING POLICIES

This Energy Strategy responds to the broader set of National, and Regional policies outlined below.

2.1 National Planning Policy

The Government has set out planning policy guidance in the National Planning Policy Framework (NPPF). Fundamental to this guidance is the requirement to meet sustainable development objectives. These policy guidelines and statements are used to influence the preparation of the development plans by planning authorities.

The NPPF covers a wide range of planning issues from promoting sustainable transport to facilitating the sustainable use of minerals. Climate change is covered in section 10 'Meeting the challenge of climate change, flooding and coastal change. In summary the framework advises:

To support the move to a low carbon future, local planning authorities should:

- plan for new development in locations and ways which reduce greenhouse gas emissions;
- actively support energy efficiency improvements to existing buildings; and
- when setting any local requirement for a building's sustainability do so in a way consistent with the Government's zero carbon buildings, policy and adopt nationally described standards.

In determining planning applications, local planning authorities should expect new development to:

- comply with adopted Local Plan policies on local requirements for decentralised energy supply unless it can be demonstrated by the applicant, having regard to the type of development involved and its design, that this is not feasible or viable; and

- take account of landform, layout, building orientation, massing and landscaping to minimise energy consumption.

Refer to APPENDIX 1 – National Planning Policy Framework for further details.

2.2 Regional Policy – The London Plan

Policy 5.2 of the London Plan requires that the energy strategy needs to follow the given hierarchy

- using less energy, in particular by adopting sustainable design and construction measures (Policy 5.3)
- supplying energy efficiently, in particular by prioritising decentralised energy generation (Policy 5.5 and 5.6), and
- using renewable energy (Policy 5.7).

Policy 5.2A states carbon dioxide emissions in accordance with the following energy hierarchy:

Be lean: use less energy
Be clean: supply energy efficiently
Be green: use renewable energy

Policy 5.2B stipulates that the emissions from the development are reduced by 40% against 2010 building regulations Target Emission Rates. This has been updated within Supplementary Planning Guidance Sustainable Design and Construction April 2014 to 35% below 2013 building regulations.

2.2.1 Policy 5.6, Decentralised Energy: Heating, cooling and Power

According to Policy 5.6, the proposed heating and cooling systems have to be selected *"in accordance with the following order of preference:*

- *connection to existing CCHP/CHP distribution networks*
- *site-wide CCHP/CHP powered by renewable energy*
- *gas-fired CCHP/CHP or hydrogen fuel cells, both accompanied by renewables*

The GLA Guidance on Preparing Energy Assessments also notes that purely residential developments of less than 500 dwellings are not expected to include on site CHP due to the small land lord electricity demand.

2.2.2 Policy 5.7 Renewable Energy

Policy 5.7 states that "major development proposals should provide a reduction in expected carbon dioxide emissions through the use of on-site renewable energy generation, where feasible" although no specific targets are detailed.

2.2.3 Policy 5.9 Overheating and Cooling

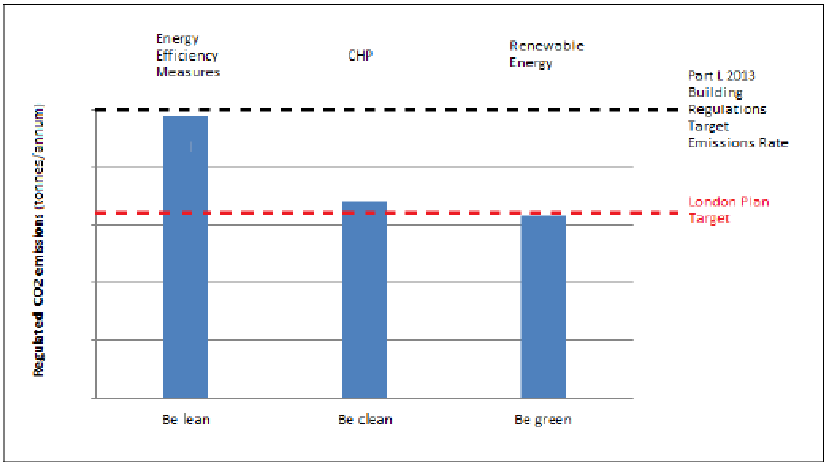
Major development proposals should reduce potential overheating and reliance on air conditioning systems and demonstrate this in accordance with the following cooling hierarchy:

- Minimise internal heat generation through energy efficient design
- Reduce the amount of heat entering a building in summer through orientation, shading, albedo, fenestration, insulation and green roofs and walls
- Manage the heat within the building through exposed internal thermal mass and high ceilings
- Passive ventilation
- Mechanical ventilation
- Active cooling systems (ensuring they are the lowest carbon options).

2.2.4 Commentary

Chapter 5 of the London Plan sets out a hierarchy for the approach that should be taken to reduce carbon emissions from developments. This hierarchy states that a decentralised energy system, which can include gas fired CHP, should be installed before the provision of renewable technologies.

The GLA Energy Team Guidance on Planning Energy Assessments, April 2015, includes the following figure to illustrate the hierarchy.



2.3 Local Policy – London Borough of Camden Local Plan

Policy CC1 - Climate Change Mitigation

The Council will require all development to minimise the effects of climate change and encourage all developments to meet the highest feasible environmental standards that are financially viable during construction and occupation.

We will:

a. promote zero carbon development and require all development to reduce carbon dioxide emissions through following the steps in the energy hierarchy;

b. require all major development to demonstrate how London Plan targets for carbon dioxide emissions have been met;

c. ensure that the location of development and mix of land uses minimise the need to travel by car and help to support decentralised energy networks;

d. support and encourage sensitive energy efficiency improvements to existing buildings;

e. require all proposals that involve substantial demolition to demonstrate that it is not possible to retain and improve the existing building; and

f. expect all developments to optimise resource efficiency. For decentralised energy networks, we will promote decentralised energy by:

g. working with local organisations and developers to implement decentralised energy networks in the parts of Camden most likely to support them;

h. protecting existing decentralised energy networks (e.g. at Gower Street, Bloomsbury, King's Cross, Gospel Oak and Somers Town) and safeguarding potential network routes; and

i. requiring all major developments to assess the feasibility of connecting to an existing decentralised energy network, or where this is not possible establishing a new network.

To ensure that the Council can monitor the effectiveness of renewable and low carbon technologies, major developments will be required to install appropriate monitoring equipment.

3 ENERGY DEMAND ASSESSMENT

3.1 National Calculation Methodology (NCM) and SAP

The baseline energy use and resulting carbon emission rate of the development has been assessed based on SAP 2012 methodology for the calculation of the regulated energy use such as the space heating and domestic hot water requirements. The non-regulated emissions are calculated using BREDEM 2012 : Energy for Lighting and Electrical Appliances methodology.

Nine dwellings were chosen with a range of sizes, configurations and elevations. Dwellings were chosen to be representative of the whole building and were selected from ground, middle and the top floor. The sample dwellings represent 31% of the overall residential area of the development occupied by dwellings.

The apartments were modelled using Stroma FSAP 2012 Version 1.0.4.10.

The commercial spaces were modelled using EDSL TAS dynamic simulation software version 9.4.1, with unregulated emissions taken from the appropriate NCM profile.

Emissions within this report are based on the following CO_2 emission rates.

Natural Gas	0.216 $kgCO^2/kWh$
Grid electricity	0.519 $kgCO^2/kWh$
Grid displaced electricity	0.519 $kgCO^2/kWh$

4 ENERGY EFFICIENT DESIGN

4.1 Dwellings

4.1.1 Passive Design Measures

Compliance with the building regulations is achieved through energy efficiency measures alone.

The energy efficient building model uses a centralised heating system to reflect the proposed installation.

Cooling will not be provided to any dwellings.

The design will target highly efficient U-values and air tightness, better than those used within the notional building calculation, as shown in the table below:

	Notional Dwelling Building Regulations, Part L1A 2013	Proposed Measures
Air Tightness	5 m^3/hr per m^2	4.0 m^3/hr per m^2
Wall U-Value	0.18 W/m²°C	0.15 W/m²°C
Roof U-Value	0.13 W/m²°C	0.12 W/m²°C
Exposed Floor U-Value	0.13 W/m²°C	0.12 W/m²°C
Glazing U-Value	1.4 W/m²°C	1.1 W/m²°C
Glazing G-Value	0.63	0.5
Apartment walls to unheated common areas	0.3	0.18 W/m²°C uncorrected.
Linear Thermal Transmittance	Default psi values	Equal to or better than Accredited Construction Details

All party walls to heated spaces will be designed to have an effective U value of 0.0 W/m²°C.

4.1.2 Heating

The development is served by condensing boilers, with variable flow controls to promote low flow and consistently low return water temperatures around the system and within the primary boiler circuit.

4.1.3 Ventilation

Ventilation to the dwelling will be by a balanced system with heat recovery (MVHR). The MVHR unit used within the assessment is a Titon HRV 1.75 Q Plus with the following SAP appendix Q test data, however, final unit selection will form part of the detailed design.

K+n wet rooms	SFP (W/l/s) [2012]	Efficiency (%) [2012]
n = 1	0.42	90%
n = 2	0.54	90%
n = 3	0.72	89%
n = 4	0.93	88%
n = 5	1.16	87%
n = 6	-	-

4.1.4 Domestic Hot Water

Domestic hot water is responsible for 36% of the regulated emissions, and in order to reduce these emissions, the following measures will be implemented:

1. Dual plate heat exchangers will be used to provide instantaneous domestic hot water with no storage within the dwellings. The heat exchangers will be sized to return water back to the community heating system circulation pipework below 30°C.
2. Insulate domestic hot water distribution pipework in the dwellings.

4.1.5 Water Consumption

Whilst not having a direct impact on the building emissions a portion of the water consumption is used as domestic hot water. The target dwelling water consumption rate is below 105lts/person/day.

4.1.6 Lighting

Within the dwellings, all fixed light fittings will be low energy lamps, including storage and infrequently accessed areas.

The lighting to common areas will be provided with PIR movement detectors and daylight control where appropriate.

4.1.7 Equipment

Equipment energy use includes all the appliances, computers, and any electrical device belonging to the residents, their energy use is not related to the energy performance of the buildings and It is beyond the scope of this report to include in the analysis measures to decrease the emissions linked with the household use equipment.

Notwithstanding this, the residents will be provided with a home user guide in accordance with the Code for Sustainable Homes issue Man 1. This user guide will explain the likely primary energy uses in the dwelling and will provide advice on the selection and operation of equipment to reduce energy consumption.

4.1.8 Summary of Carbon Emissions Following Energy Demand Reduction

The annual energy consumption for the development incorporating the energy efficiency measures described above is as shown in the tables below:

Energy demand for energy efficient dwellings				
Item	**kWhrs/m²/ Year**	**kWhrs/ Year**	**Kg CO_2 /year**	**% CO2**
Htg	28.0	58,301	12,593	39%
DHW	26.1	54,374	11,745	36%
Cooling	0.0	0	0	0%
Auxiliary Energy	3.1	6,430	3,337	10%
Lighting	4.3	8,868	4,603	14%
Equipment	52.5	109,210	56,680	
Total	**114**	**237,183**	**88,957**	
Total no Equip	**61**	**127,973**	**32,278**	

GLA Table 1: Carbon Dioxide Emissions after each stage of the Energy Hierarchy (Dwellings)			
	Carbon dioxide emissions (Tonnes CO2 per annum)		
	Regulated	Unregulated	Total
Building Regulations 2013 Part L compliant	37.13	57	94
After energy demand reduction	32.28	57	89

GLA Table 2: Residential Carbon Dioxide Emissions from each stage of the Energy Hierarchy (Dwellings)		
	Regulated Carbon dioxide savings	
	(Tonnes CO2 per annum)	(%)
Savings from energy demand reduction	4.85	13

The table above indicates that improvement over the building regulations of 13% is achieved by the implementation of the energy efficiency measures described above for the treated areas of the residential portion of the development.

4.2 Commercial Space

The commercial space at ground floor will generally incorporate the measures described below.

4.2.1 Passive Design Measures

The development will comply with building regulations through energy efficiency measures alone.

The design will target highly efficient U-values and air tightness, better than those used within the notional building calculation, as shown in the table below:

	Notional Building Building Regulations, Part L2A 2013	Proposed Measures
Air Tightness	5.0 m^3/hr per m²	4.0 m^3/hr per m²
Wall U-Value	0.26 W/m²°C	0.15 W/m²°C
Floor U-Value	0.22 W/m²°C	0.12 W/m²°C
Roof	0.18 W/m²°C	0.12 W/m²°C
Glazing U-Value	1.6 W/m²°C	1.5 W/m²°C
Glazing G-Value	0.4	0.55

4.2.2 Heating

The energy efficient base case will utilise gas fired boilers. Where reverse cycle heat pumps will be used the effect of the heat pumps will be incorporated into the Green measures within the hierarchy.

4.2.3 Ventilation

The commercial spaces are to be constructed to a shell and core specification, the assumed specific fan power is 1.1W/l/s. All ventilation plant will be complete with a plate heat exchanger with minimum efficiency of 75%. Ventilation plant with heat recovery has been assumed.

4.2.4 Domestic Hot Water

Electric point of use water heaters has been assumed to reflect the anticipated low domestic hot water demand.

4.2.5 Lighting

Energy efficient lighting with improved performance relative to the minimum standard is anticipated with an average efficacy of 95 luminaire lumens / circuit watt and 65 LL/CW for display lighting. Due to small amount of external glazing, Daylight compensation controls have not been included.

4.2.6 Equipment

As with the dwellings, equipment does not form part of the assessment, however values have been assumed in accordance with the NCM profiles, for illustrative purposes.

4.2.7 Summary of Commercial Areas Carbon Emissions Following Energy Demand Reduction

The annual energy consumption for the commercial units incorporating the energy efficiency measures described above are expected to reduce the emissions by 22.38% as detailed in the tables below.

Energy demand for energy efficient commercial units				
Item	**kWhrs/m²/ Year**	**kWhrs/ Year**	**Kg CO_2 /year**	**% CO2**
Htg (Boilers)	2.3	646	140	2%
DHW	1.8	500	259	3%
Cooling	8.6	2,392	1,242	16%
Auxiliary Energy	5.2	1,441	748	10%
Lighting	37.5	10,461	5,429	69%
Equipment	20.3	5,650	2,932	
Total	**76**	**21,090**	**10,750**	
Total no Equip	**55**	**15,440**	**7,818**	

GLA Table 3: Commercial Carbon Dioxide Emissions after each stage of the Energy Hierarchy (Commercial Units)			
	Carbon dioxide emissions (Tonnes CO2 per annum)		
	Regulated	Unregulated	Total
Building Regulations 2013 Part L compliant	9.79	2.93	13
After energy demand reduction	7.82	2.93	11

GLA Table 4: Commercial Carbon Dioxide Emissions from each stage of the Energy Hierarchy (Commercial Units)		
	Regulated Carbon dioxide savings	
	(Tonnes CO2 per annum)	(%)
Savings from energy demand reduction	1.98	20

4.3 Combined Residential and Commercial Elements

The vast majority of the floor area of the development is residential, which heavily influences the results for the development.

Energy demand for energy efficient development				
Item	**kWhrs/m²/ Year**	**Total kWhrs/ Year**	**Kg CO_2 /year**	**% CO_2**
Htg (Boilers)	25.0	58,947	12,732	32%
DHW - Gas	23.3	54,874	12,004	30%
Cooling	1.0	2,392.2	1,241.6	3%
Auxiliary Energy	3.3	7,871	4,085	10%
Lighting	8.2	19,329	10,032	25%
Equipment	48.7	114,860	59,612	
Total	**109**	**258,272**	**99,707**	
Total no Equip	**61**	**143,413**	**40,095**	

GLA Table 6: Carbon Dioxide Emissions from each stage of the Energy Hierarchy			
	Total Regulated Emissions	CO2 Savings	Percentage Saving
	(Tonnes CO2/year)	(Tonnes CO2/year)	%
Part L 2013 Baseline	46.92		
Savings from energy demand reduction	40.10	6.83	15

The developer is proposing to improve the building fabric and fixed building services beyond the requirements of Part L to ensure compliance is achieved before assessing the viability of CHP/decentralized energy or renewable technologies.

The tables above indicate that the overall improvement over the building regulations of 15 % will be achieved by the implementation of energy efficiency measures alone.

5 RISK OF OVERHEATING

5.1 Dwellings

The building plot is very small and dwellings will be located on all elevations. The proposed construction material incorporates a large amount of concrete/brick, which will have the effect of absorbing a proportion of the solar gains during the summer, creating more stable temperatures within the dwellings.

The majority of flats will also have balconies to provide shading over the large glazed areas.

To limit any heat gain from the heating distribution pipework, the communal corridors will be ventilated using environmental ventilation system to remove access heat from the corridors. In addition insulation will be applied to distribution pipework in excess of the Building Regulations and British Standards. The environmental ventilation system will deliver outside air via the smoke shaft using smoke and fire damper at each level and the return air will be through smoke and fire damper above the stair core door and in to the stair core. The accumulated air within the stair core will be extracted from the top of the stair core using the same system.

Low system operating temperatures will also reduce the unwanted heat emissions through the pipework, and this reduction will also be apparent on the pipework serving the heat interface units within the dwellings.

The floors have also been designed to allow as many apartments as possible to have dual aspects. Opening windows on different orientations promotes good air flow and further reduces the risk of dwellings overheating.

5.2 Non Dwelling Uses

It is assumed that the commercial spaces will be comfort cooled, with the following measures incorporated to minimise the cooling load.

The nature of the spaces is to have open exposed frontage. The units are relatively large with very limited potential for natural ventilation, therefore a mechanical system with comfort cooling has been assumed.

Given that the units are only constructed to a shell specification and the final uses are unknown at this stage it is assumed that prospective tenants will install comfort cooling.

To reduce the potential solar gain to the units solar control glazing is proposed with a G value of 0.55.

6 HEATING INFRASTUCTURE

Local heat and power sources minimise distribution losses and achieve greater efficiencies when compared to separate energy systems, thus reducing CO_2 emissions.

In accordance with Policy 5.6 of the London Plan, the energy systems for the site have been determined in accordance with the following hierarchy:

1. Connection to existing heating and cooling networks
2. Site wide CHP network
3. Communal heating and cooling

In a communal energy system, energy in the form of heat, cooling, and/or electricity is generated from a central source and distributed via a network of insulated pipes to surrounding residencies and commercial units.

The possibility to connect the development with a heat network is not viable as there are no heat networks near the site.

The GLA Guidance on Preparing Energy Assessments notes that purely residential developments of less than 500 dwellings are not expected to include on site CHP due to the small land lord electricity demand.The proposed development comprises only 29 dwelling and is considered to be too small for incorporation of site wide CHP.

To allow connection into a potential future district heating system it is proposed that a central heating plant will be provided without a CHP unit.

The tenants of the retail units are unlikely to connect into the communal heating system. Therefore with regards to the communal heating system the system is wholly residential.

7 LOW AND ZERO CARBON TECHNOLOGIES FOR ENERGY PRODUCTION

This section of the report responds to London Plan Policy 5.7.

The development will not be able to get benefits of a combined heat and power unit, therefore, the options available for renewable energy are considered to meet the remaining target of carbon emissions reduction to satisfy national and local planning policies.

The use of energy conversion technologies using renewable energies must be analyzed. And the main technologies available for on-site renewable energy generation are:

- Biomass Boilers
- Ground Source Heat Pumps
- Air Source Heat Pumps
- Photovoltaics
- Solar thermal hot water generation
- Wind

Refer to Appendix 4 for the more details and a brief explanation of renewable energy technologies.

7.1 Preliminary Technology Appraisal

Technology	Feasibility*			Comments
	H	M	L	
Biomass Boilers			✓	A large area for fuel storage is required, which is not available on this constricted city centre site. In addition, the site is within a densely occupied area and biomass boilers generate high levels of particulate material and NO_2.
Ground Source heat pumps			✓	Ground source heat pumps extract heat from the ground, and convert it to low grade heat for space heating and hot water. Due to the compact nature of the site and the relatively small amount of heat that could be withdrawn. The integration of a complicated technology is not appropriate for such a low potential CO_2 reduction.
Air Source Heat Pumps		✓		Air source heat pumps extract heat from air and convert it low grade heat for space heating and hot water. Air source heat pumps are not recommended for the dwellings, for the same reasons as ground source heat pumps. Air to air source heat pumps may be suitable for the commercial areas, and can operate effectively when part of a VRF system.
Photovoltaic Panels	✓			Photovoltaic modules convert daylight directly into DC electricity and can be integrated into buildings. Space is available at roof level to install a PV array, which would make a significant

Technology	Feasibility*			Comments
	H	M	L	
				contribution to the overall emissions reduction for the site. The panels will be a distinct installation from the heating plant and will allow the community heating system to be as simple as possible to operate and maintain.
Solar Hot water			✓	Solar thermal installations are a well established renewable energy system and can be one of the most cost-effective renewable energy systems available. The technology has the potential to connect in to the community heating system, but will lead to complicated integration with the gas fired boiler installation, this complexity is not favoured due to the low CO_2 reduction that could be expected. Solar thermal installations are best suited to single occupancy installations such as houses or hotels, where the hot water can feed directly into the users hot water storage vessel.
Wind			✓	The urban environment and the close proximity of dwellings are not favourable conditions for the installation of wind turbines. The uneven air flow caused by surrounding buildings and the potential negative impact on the visual and noise amenity of the area militate against the use of wind turbines for this development.

H - High Feasibility - No Obvious restrictions

M - Medium feasibility - Significant issues that need to be addressed

L - Low feasibility – Site unlikely to support technology

Based on this preliminary evaluation, the following technology will be assessed:

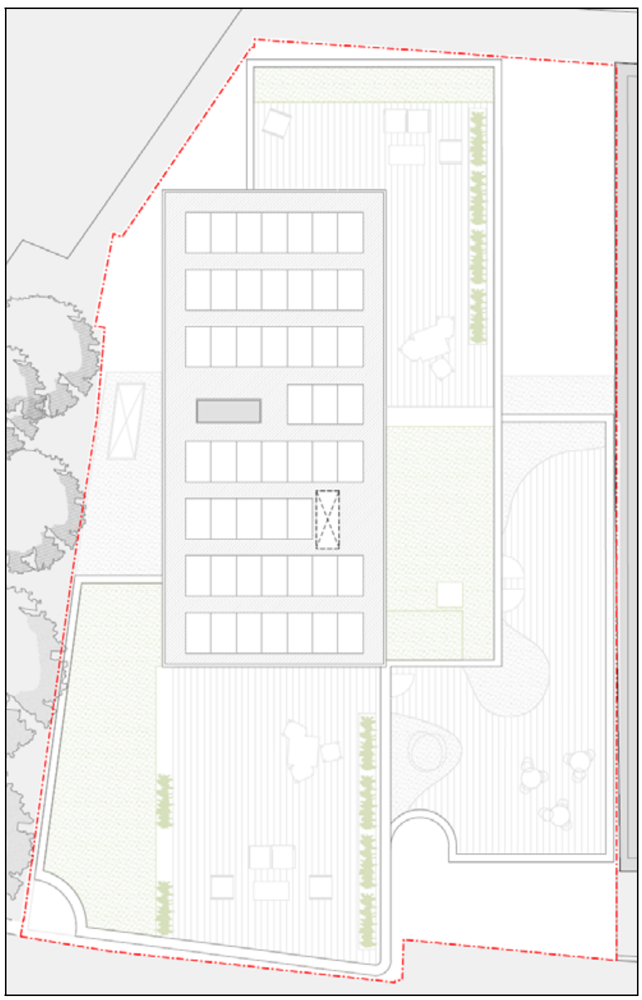
- Photovoltaics (PV)
- Air Source Heat Pumps

7.2 Photovoltaic Panels

7.2.1 Application

Photovoltaic modules convert daylight directly into DC electricity and can be integrated into buildings. Photovoltaics (PVs) are distinct from other renewable energy technologies since they have no moving parts to be maintained and are silent. PV systems can be incorporated into buildings in various ways: on sloped roofs and flat roofs, in facades, atria and shading devices. Modules can be mounted using frames or they can be fully incorporated into the actual building fabric; for example, PV roof tiles are now available which can be fitted in place of standard tiles. Since PVs generate DC output, an inverter and other equipment is needed to deliver the power to a building or the grid in an acceptable AC form.

The drawing below indicates the PV area at roof level.



7.2.2 Constraints

The following constraints have been identified for the application of the PV technology at the site.

1. Consideration will need to be given to the effect of over shading to parts or the whole roof, and potential glare issues if tenants over look any PV panels.

2. Connection points into the LV distribution system.
3. Due to the complexity of extending the power supplies from the roofs to the small commercial space all the power generated will be used by the residential portion of the development, and the CO_2 reduction assigned to the dwellings.

7.2.3 Emissions Reduction

A 13.00kW peak installation distributed evenly across the building, would have a total area of approximately 80m^2.

The area will be more closely defined as part of the final submission.

Electricity Generated (kWh/yr)	CO2 Reduction (kgCO2/yr)	Residential CO_2 Reduction % after Renewable Technology Measures
9886	5131	16%

7.2.4 Conclusion

PV panels are technically viable and an installation of 80m^2 could be installed on the roof, at a cost of around £22,000.

7.3 Air Source Heat Pump

7.3.1 Application

The technology makes use of the energy available in the ambient air. Essentially, heat pumps take up heat at a certain temperature and release it at a higher temperature. This is achieved by means of a simple heat exchanger in the case of air source heat pumps.

The efficiency of any type of heat pump is very much dependent on the temperature level at which it has to provide the heat: the lower the temperature level, the better the coefficient of performance.

Almost all heat pumps in operation are based on the vapour compression cycle, which combines efficiency, safety and reasonable cost. The efficiency of heat pumps is measured by the ratio of the heating capacity to the power input, referred to as the Coefficient of Performance (COP). An SCOP of around 400 is achievable from a variable refrigerant flow system.

7.3.2 Constraints

The following constraints have been identified for the application of air source heat pump technology at the site.

1. Space needs to be allocated for the heat pumps in a location that provides a good air flow through and around the units. Space has been allocated in the external plant space for the commercial unit.

7.3.3 Emissions Reduction

Remodelling the commercial space , exchanging the gas fired heating plant assumed within the energy efficient models with air source heat pumps with an SCOP of 400 will reduce the commercial unit emissions by 2% from the energy efficient mode.

Whilst the heat generated is from a renewable source, at present the technology is not available to meter the heat from air to air heat pumps and therefore the heat from these units will not be suitable for payments under the Renewable Heat Incentive. Providing good quality plant is specified and correctly installed the plant should qualify for the Enhanced Capital Allowance scheme.

7.3.4 Conclusion

Air source heat pumps are a viable technology for the commercial areas, where the heating loads are relatively small and the likely hood of an incoming tenant wishing to install a reverse cycle Variable Refrigerant Flow air conditioning and heating system is high.

7.4 Emissions following the introduction of Renewable Technology

The effect of the energy efficiency measures and renewable technologies for the dwellings and commercial spaces are detailed in the tables below.

Energy demand for energy efficient dwellings with Renewable Technology			
Item	**kWhrs/m²/ Year**	**kWhrs/ Year**	**Kg CO_2 /year**
Htg (Boilers)	28.0	58,301	12,593
DHW (Boilers)	26.1	54,374	11,745
Cooling	0.0	0	0
Auxiliary Energy	3.1	6,430	3,337
Lighting	4.3	8,868	4,603
Htg (CHP)	0.0	0	0
DHW (CHP)	0.0	0	0
Electricity (CHP)	0.0	0	0
Electricity (PV)	-4.8	-9,886	-5,131
Equipment	52.5	109,210	56,680
Total	**109**	**227,296**	**83,826**
Total no Equip	**57**	**118,087**	**27,147**

GLA Table 1: Carbon Dioxide Emissions after each stage of the Energy Hierarchy (Dwellings)			
	Carbon dioxide emissions (Tonnes CO2 per annum)		
	Regulated	Unregulated	Total
Building Regulations 2013 Part L compliant	37.13	57	94
After energy demand reduction	32.28	57	89
After CHP	32.28	57	89
After Renewable Energy	27.15	57	84

GLA Table 2: Residential Carbon Dioxide Emissions from each stage of the Energy Hierarchy (Dwellings)		
	Regulated Carbon dioxide savings	
	(Tonnes CO2 per annum)	(%)
Savings from energy demand reduction	4.85	13
Savings from CHP	0.00	0
Savings from renewable energy	5.13	16
Total cumulative savings	9.98	**27**

Energy demand for energy efficient Commercial Space with Renewable Technology			
Item	**kWhrs/m²/ Year**	**kWhrs/ Year**	**Kg CO_2 /year**
Htg (Boilers)	0.0	0	0
DHW (Boilers)	0.0	0	0
Htg. Elec (heat pump)	0.1	30.69	16
DHW (Electric)	1.8	499.94	259
Cooling	8.6	2,392	1,242
Auxiliary Energy	5.2	1,441	748
Lighting	37.5	10,461	5,429
Htg (CHP)	0.0	0	0
DHW (CHP)	0.0	0	0
Electricity (CHP)	0.0	0	0
PV Electricity	0.0	0	0
Equipment	20.3	5,650	2,932
Total	**73**	**20,475**	**10,626**
Total no Equip	**53**	**14,825**	**7,694**

GLA Table 3: Commercial Carbon Dioxide Emissions after each stage of the Energy Hierarchy (Commercial Units)			
	Carbon dioxide emissions (Tonnes CO2 per annum)		
	Regulated	Unregulated	Total
Building Regulations 2013 Part L compliant	9.79	2.93	13
After energy demand reduction	7.82	2.93	11
After CHP	7.82	2.93	11
After Renewable Energy	7.69	2.93	11

GLA Table 4: Commercial Carbon Dioxide Emissions from each stage of the Energy Hierarchy (Commercial Units)		
	Regulated Carbon dioxide savings	
	(Tonnes CO2 per annum)	(%)
Savings from energy demand reduction	1.98	20
Savings from CHP	0.00	0
Savings from renewable energy	0.12	2
Total cumulative savings	2.10	21

Combining the emissions reductions from the PV panels attributed to the dwellings and the air source heat pumps within the commercial buildings an overall CO_2 reduction of 11% is achieved for the development through the use of renewable energy technologies.

GLA Table 6: Carbon Dioxide Emissions from each stage of the Energy Hierarchy			
	Total Regulated Emissions	CO2 Savings	Percentage Saving
	(Tonnes CO2/year)	(Tonnes CO2/year)	%
Part L 2013 Baseline	46.92		
Savings from energy demand reduction	40.10	6.83	15
Savings from CHP	40.10	0.00	0
Savings from renewable energy	34.84	5.25	11
Cumulative savings		12.08	26

8 SUMMARY

The table below summarises the emissions reductions available from the various technologies, equipment sizes and approximate cost. The technical viability of the technologies using the renewable energy sources is also considered. The technical viability is intended to include aspects such as maintenance and constructability.

Option	Carbon Saving, (regulated energy) %	Investment costs [£]	Technical Viability (0=not viable, 10=very viable)	Comments
Connection into Local District Heat Network	n/a	n/a	0	Not Viable due to no heat networks available within the area.
Local CHP	n/a	n/a	0	Not Viable due to only 29 dwellings within proposed development.
PV Cells	16% (of Residential Emissions)	£22,000	10	Favoured technology
Air source heat pumps Phase 1	2% (of Commercial Emissions)	£ (Negligible will form part of comfort cooling system)	10	Straight forward installation as part of the tenant fit out works within the commercial unit.
Ground source heat pumps	Not favoured due to the compact nature of the site, complexity of connecting the technology into the community heating system.			
Biomass heating	Not viable, a large area of fuel storage is required, which is not available on this constricted site. In addition, the site is within a densely occupied area and biomass boilers generate high levels of particulate material and NO_2.			
Solar thermal hot water heating.	The technology has the potential to connect in to the community heating system, but will lead to complicated integration with the gas fired boiler installation and the as the roof area is relatively small this complexity is not favoured due to the low CO_2 reduction that could be expected.			
Wind Turbines	Not viable due to proximity to dwellings and urban location.			

The costs are budget estimates for the system installation only. Additional costs, such as the cost of providing plant rooms etc is not included.

9 RECOMMENDATION

Following a review of the relevant National, Regional and Local planning policies, this Energy Assessment proposes a strategy that positively responds to the policy structure that requires developments to *be lean; be clean; be green*. The hierarchy published in the London Plan requires that decentralised energy, including gas fired CHP, should be provided in preference to renewable energy technologies, and that renewable technologies should be used to meet the residual energy demand where feasible.

Energy efficiency measures will be implemented to provide carbon saving of 15 % (overall) in comparison to the Target Emission Rate regulated emissions. The energy efficiency measures include: improved fabric insulation including high quality glazing, improved air tightness, high efficiency balanced whole house heat recovery units, and low energy lighting throughout.

No heat networks exist close to the site, and at 29 dwellings it is not economically viable for a CHP to be installed to serve the development. A community heating system will be installed with condensing boilers operating at low return water temperatures to minimize losses maximize the system and combustion efficiency. The plant room will be located at basement level and will be designed to allow connection into a wider heat network should one become available in the future.

The commercial area is being constructed to a shell specification and its final use is unknown, however, the assessment has been completed assuming an air conditioned retail units, to represent a high energy demand building class.

The development will be provided with approximately 80m^2 photovoltaic panels to contribute a further 16% reduction in residential carbon emissions from the baseline.

The table below details the performance of the dwellings and commercial areas, with the overall emissions combined once all measures have been incorporated.

GLA Table 6: Carbon Dioxide Emissions from each stage of the Energy Hierarchy			
	Total Regulated Emissions	CO2 Savings	Percentage Saving
	(Tonnes CO2/year)	(Tonnes CO2/year)	%
Part L 2013 Baseline	46.92		
Savings from energy demand reduction	40.10	6.83	15
Savings from CHP	40.10	0.00	0
Savings from renewable energy	34.84	5.25	11
Cumulative savings		12.08	26
Total off-set		**854**	

This energy statement indicates that the 35% CO2 emissions reduction target will not be achieved; the developer will therefore seek to make a payment to local authority to cover the short fall. Based on the calculations, to achieve zero carbon on the residential part of the development, and a 35% CO_2 reduction on the commercial unit, the corresponding offset payment would be £76,896.00 based on a payment of £90 per tonne over a 30 year period.

The tables below detail the calculations of the short fall for residential and commercial space respectively.

GLA Table 2: Residential Carbon Dioxide Emissions from each stage of the Energy Hierarchy (Dwellings)		
	Regulated Carbon dioxide savings	
	(Tonnes CO_2 per annum)	(%)
Savings from energy demand reduction	4.85	13
Savings from CHP	0.00	0
Savings from renewable energy	5.13	16
Total cumulative savings	9.98	**27**
Resultant Emissions for off-set payment	27.15	
(Tonnes CO_2)		
Cumulative Emissions for off-set payment over 30 Yr Period	**814**	

GLA Table 5: Commercial Shortfall in Regulated Carbon Dioxide Savings		
	Annual Shortfall (Tonnes CO_2)	Cumulative Shortfall (Tonnes CO_2)
Total Target Savings	3.43	
Shortfall	1.33	**40**

Carbon Off-Set Payment Calculation:
Residential: 27.15(tonnes) x 30 (years) x 90(£/tonne) = £73,305.00
Commercial: 1.33(tonnes) x 30 (years) x 90 (£/tonne) = £3,591.00
Total: £76,896.00

A1 APPENDIX 1 – NATIONAL PLANNING POLICY

A1.1 10 - Meeting the challenge of climate change, flooding and coastal change

93. Planning plays a key role in helping shape places to secure radical reductions in greenhouse gas emissions, minimising vulnerability and providing resilience to the impacts of climate change, and supporting the delivery of renewable and low carbon energy and associated infrastructure. This is central to the economic, social and environmental dimensions of sustainable development.

94. Local planning authorities should adopt proactive strategies to mitigate and adapt to climate change, taking full account of flood risk, coastal change and water supply and demand considerations.

95. To support the move to a low carbon future, local planning authorities should:

- plan for new development in locations and ways which reduce greenhouse gas emissions;
- actively support energy efficiency improvements to existing buildings; and
- when setting any local requirement for a building's sustainability, do so in a way consistent with the Government's zero carbon buildings policy and adopt nationally described standards.

96. In determining planning applications, local planning authorities should expect new development to:

- comply with adopted Local Plan policies on local requirements for decentralised energy supply unless it can be demonstrated by the applicant, having regard to the type of development involved and its design, that this is not feasible or viable; and
- take account of landform, layout, building orientation, massing and landscaping to minimise energy consumption.

97. To help increase the use and supply of renewable and low carbon energy, local planning authorities should recognise the responsibility on all communities to contribute to energy generation from renewable or low carbon sources. They should:

- have a positive strategy to promote energy from renewable and low carbon sources;
- design their policies to maximise renewable and low carbon energy development while ensuring that adverse impacts are addressed satisfactorily, including cumulative landscape and visual impacts;
- consider identifying suitable areas for renewable and low carbon energy sources, and supporting infrastructure, where this would help secure the development of such sources;
- support community-led initiatives for renewable and low carbon energy, including developments outside such areas being taken forward through neighbourhood planning; and
- identify opportunities where development can draw its energy supply from decentralised, renewable or low carbon energy supply systems and for co-locating potential heat customers and suppliers.

98. When determining planning applications, local planning authorities should:

- not require applicants for energy development to demonstrate the overall need for renewable or low carbon energy and also recognise that even small-scale projects provide a valuable contribution to cutting greenhouse gas emissions; and

- approve the application if its impacts are (or can be made) acceptable. Once suitable areas for renewable and low carbon energy have been identified in plans, local planning authorities should also expect subsequent applications for commercial scale projects outside these areas to demonstrate that the proposed location meets the criteria used in identifying suitable areas.

A2 APPENDIX 2 –SAMPLE SAP CALCULATIONS

Regulations Compliance Report

Approved Document L1A, 2013 Edition, England assessed by Stroma FSAP 2012 program, Version: 1.0.4.10
Printed on 03 April 2018 at 16:22:54

Project Information:

Assessed By: () **Building Type:** Flat

Dwelling Details:

NEW DWELLING DESIGN STAGE Total Floor Area: 93m²

Site Reference : Haverstock Hill **Plot Reference:** Flat 0-03 Duplex

Address :

Client Details:

Name:

Address :

This report covers items included within the SAP calculations.
It is not a complete report of regulations compliance.

1a TER and DER

Fuel for main heating system: Mains gas (c)		
Fuel factor: 1.00 (mains gas (c))		
Target Carbon Dioxide Emission Rate (TER)	18.65 kg/m²	
Dwelling Carbon Dioxide Emission Rate (DER)	16.76 kg/m²	OK

1b TFEE and DFEE

Target Fabric Energy Efficiency (TFEE)	61.4 kWh/m²	
Dwelling Fabric Energy Efficiency (DFEE)	50.2 kWh/m²	
		OK

2 Fabric U-values

Element	Average	Highest	
External wall	0.16 (max. 0.30)	0.17 (max. 0.70)	OK
Floor	0.12 (max. 0.25)	0.12 (max. 0.70)	OK
Roof	(no roof)		
Openings	1.12 (max. 2.00)	1.30 (max. 3.30)	OK

2a Thermal bridging

Thermal bridging calculated from linear thermal transmittances for each junction

3 Air permeability

Air permeability at 50 pascals	4.00 (design value)	
Maximum	10.0	OK

4 Heating efficiency

Main Heating system:	Community heating schemes - mains gas	
Secondary heating system:	None	

5 Cylinder insulation

Hot water Storage:	Measured cylinder loss: 0.22 kWh/day	
	Permitted by DBSCG: 0.32 kWh/day	OK
Primary pipework insulated:	Yes	OK

6 Controls

Space heating controls	Charging system linked to use of community heating, programmer and TRVs	OK
Hot water controls:	Cylinderstat	OK

Regulations Compliance Report

7 Low energy lights		
Percentage of fixed lights with low-energy fittings	100.0%	
Minimum	75.0%	**OK**
8 Mechanical ventilation		
Continuous supply and extract system		
Specific fan power:	0.54	
Maximum	1.5	**OK**
MVHR efficiency:	90%	
Minimum	70%	**OK**
9 Summertime temperature		
Overheating risk (South East England):	Not significant	**OK**
Based on:		
Overshading:	Average or unknown	
Windows facing: North East	8.83m²	
Windows facing: North West	2.45m²	
Windows facing: North West	1.74m²	
Windows facing: North East	2.3m²	
Windows facing: North East	2.8m²	
Ventilation rate:	4.00	
Blinds/curtains:	None Closed 100% of daylight hours	
10 Key features		
Windows U-value	1.1 W/m²K	
Floors U-value	0.12 W/m²K	
Community heating, heat from boilers – mains gas		

A3 APPENDIX 3 –ENERGY EFFICIENT SAMPLE SAP RESULTS

Sample Dwellings								Sample Dwelling Energy Demands					Agregated Sample Results					Part L Results	
Sample Dwelling Ref	Level / Position	No of Beds	External Elevations	Number		Area	Total Area	Space Heating (kWh/Yr)	DHW (kWh/Yr)	Cooling (kWh/Yr)	Fixed Electricity (kWh/Yr)	Unregulated Energy (kWh/yr)	Space Heating (kWh/Yr)	DHW (kWh/Yr)	Cooling (kWh/Yr)	Fixed Electricity (kWh/Yr)	Unregulated Energy (kWh/yr)	TER	DER
Flat 0.03	G	3	SW	1		93	93	3706	2118	0	714	4436.4	3706	2118	0	714	4436	18.81	17.51
Flat 3.01	3	1	NW	1		51	51	1733	1715	0	383	3233.7	1733	1715	0	383	3234	21.65	18.50
Flat 3.03	3	2	SE	1		72	72	1762	1960	0	556	3909.3	1762	1960	0	556	3909	17.71	15.18
Flat 4.06	4	3	SW	1		133	133	3819	2219	0	874	5074.3	3819	2219	0	874	5074	15.09	13.22
Flat 4.02	4	2	NE	1		65	65	1649	1885	0	457	3696.5	1649	1885	0	457	3697	17.84	15.40
Flat 2.01	2	1	NW	1		51	51	1148	1715	0	377	3233.7	1148	1715	0	377	3234	18.93	15.97
Flat 2.03	2	2	SE	1		72	72	1762	1960	0	556	3909.3	1762	1960	0	556	3909	17.71	15.18
Flat 1.01	1	1	NW	1		51	51	1148	1715	0	377	3233.7	1148	1715	0	377	3234	18.93	15.97
Flat 1.03	1	2	SE	1		72	72	1762	1960	0	556	3909.3	1762	1960	0	556	3909	17.71	15.18
Sample Total							660						18490	17245	0	4852	34636		
m^2 Values													28.02	26.13	0	7.35	52.48		
Projetced Development Totals							**2081**						**58301**	**54374**	**0**	**15298**	**109210**	**17.84**	**15.51**

A4 APPENDIX 4 – BRUKL OUTPUT RESULTS (Lean and Green)

A5 APPENDIX 5 - RENEWABLE ENERGY OVERVIEW

The information in this appendix is not project specific and is intended to provide an overview of the technologies described.

A5.1 Biofuels

A5.1.1 Background

Biomass is an alternative solid fuel to the conventional fossil fuels and has an impact on carbon emissions that is close to neutral. Various types of biomass fuels are in use, the most common being the woody biomass, which includes forest residues such as tree thinnings, and energy crops such as willow short rotation coppice. The fuel usually takes the form of wood chips, logs and pellets. Supply and storage of the biomass fuel should be carefully considered especially for larger plants. Modern systems can be fed automatically by screw drives from fuel hoppers.

The typical applications are:

a. Biomass boilers replacing standard gas- or oil -fired boilers for space heating and hot water (for individual buildings or district heating systems).

b. Standalone room heaters for space heating.

c. Stoves with back boilers, supplying domestic hot water.

d. Biomass CHP for heat and electricity generation.

Appliances can achieve efficiencies of more than 80%.

The capital cost of automated biomass heating systems is significantly greater than that of conventional heating systems, mainly because of the more complicated feeding mechanisms and the currently smaller market for biomass appliances.

There is an ongoing public debate on the true sustainability of using biofuels. Given the number of differing views expressed by academics and engineers and contradictions in publications issued by the Government the theoretical carbon savings offered by biofuels must be treated with extreme caution. 3.1.2 to 3.1.5 below expands on this.

A5.1.2 Biofuels as a Sustainable Resource

Research undertaken by AEA technology on behalf of the Department for Transport[1] stated that '*Research has shown that biofuels can reduce carbon emissions, yet they are currently a controversial area of science. Insufficient data exists to fully understand the impact of biofuel production on communities and the environment; and, whilst biofuels could be a powerful tool in reducing carbon emissions, they must be produced in a sustainable manner if they are not to do more harm than good' then states that 'biofuels are currently a controversial topic area, and it is difficult to move forward in such circumstances*'. The research paper listed 4 key findings:

- Key finding 1: We need to improve our understanding of the indirect impacts of biofuels, particularly indirect land use change;

- Key finding 2: We need to improve our knowledge of the environmental, socioeconomic and supply-chain impacts of biofuels;

[1] Biofuels Research Gap Analysis, Department for Transport, July 2009

- Key finding 3: There is a need for new research to examine the evolution of the production, infrastructure and vehicle technologies necessary to enable us to meet longer-term biofuels targets for transport and for improving the sustainability of biofuels;

- Key finding 4: There are a number of cross-cutting research gaps that need to be addressed in order to support the development of biofuels policy.

According to the Renewable Fuels Agency[2] only 18% of the liquid biofuels consumed in the UK originate in the UK. 30% of liquid biofuels originates in Brazil, and the sustainability of their production and the consequent deforestation are the topic of wider debate.

The carbon emission factor stated in the Standard Assessment Procedure (SAP) 2009 for biodiesel is 0.047kg CO2/kWhr. (The SAP methodology is used to calculate the energy consumption and carbon emissions from dwellings to demonstrate compliance with the Building Regulations and generate Energy Performance Certificates). Data published by the Renewable Fuels Agency[3] shows that the mean carbon emission factor for biodiesel consumed in the UK is 0.148kgCO2/kWhr (41 gCO_2e/MJ), this compares to the carbon emission factor for natural gas of 0.198kgCO2/kWhr. Given that there is a limited supply of biofuel it would be reasonable to use the mean value for the emission factor; this principle is applied to mains electricity where the carbon emissions from all sources of electricity generation are aggregated to arrive at a mean value.

The carbon emission factor stated in the SAP 2009 for wood pellets is 0.028kg CO_2/kWhr. Research by AEA Technology on behalf of the Environment Agency[4] showed that the emissions are actually between 0.050 and 0.140 kg CO_2/kWhr, with 0.1 kgCO_2/kWhr being a typical value for good practice. From this it can be concluded that the carbon savings stated when using the SAP values are overstated.

Biodiesel CHP may be technically viable for the development but the lack of certainty over the sustainability of liquid biofuels militates against this. In addition to this, concerns over the future availability of fuel supplies are a consideration. The European Renewable Energy Directive (RED) commits the UK to sourcing 10 percent of its transport energy from renewable sources by 2020[5]. Currently only 3.5% of transport energy is from renewable sources, and 82% of this is imported. It is reasonable to conclude that as the volume of liquid biofuel that is legally required to be used for transport energy increases, the supply of the fuel for other purposes will become more expensive and difficult to procure.

A5.2 Air and Ground Source Heat Pumps

A5.2.1 Background

The technology makes use of the energy available in the ambient air or stored in the Earth's crust, which comes mainly from solar radiation. Essentially, heat pumps take up heat at a certain temperature and release it at a higher temperature. This is achieved by means of a simple heat exchanger in the case of air source heat pumps, or by means of either horizontal or vertical ground collectors, in which a heat exchange fluid circulates and transfers heat via a heat exchanger to the heat pump, in the case of ground source heat pumps. For the latter, when considering buildings with piled foundations, the pipes can be integrated in the design using several piling systems.

The efficiency of any type of heat pump is very much dependent on the temperature level at which it has to provide the heat: the lower the temperature level, the better the coefficient of performance.
Almost all heat pumps in operation are based on the vapour compression cycle, which combines efficiency, safety and reasonable cost. The efficiency of heat pumps is measured by

[2] Renewable Fuels Agency Quarterly Report Apr 2010 to October 2010
[3] Renewable Fuels Agency Quarterly Report Apr 2010 to October 2010
[4] Biomass: Carbon sink or carbon sinner?, Environment Agency, April 2009
[5] Department of Energy and Climate Change website.

the ratio of the heating capacity to the power input, referred to as the Coefficient of Performance (COP). Generally, a COP of around 2.5-3 for air source heat pumps and around 3.5-4 for ground source heat pumps is achievable for heating, assuming low temperature heat emitters such as underfloor heating. When used to generate domestic hot water at 60°C the COP falls for both types of heat pumps by around 1 point. Therefore, when it comes to domestic hot water, heat pumps can be implemented to pre-heat the water up to a certain temperature, before it enters the boiler, rather than to heat up the domestic hot water entirely up to its final required temperature.

The approximate costs for heat pumps amount to £700 per kW_{th} heat output for an air source heat pump, and £1,200 per kW_{th} heat output for a ground source heat pump with horizontal trenches, and £1,400 per kW_{th} heat output for a ground source heat pump with vertical boreholes (including the cost of bore holes).

A5.3 Solar Water Heating Systems

A5.3.1 Background

Solar thermal and, especially, active Solar Domestic Hot Water (SDHW) heating is a well - established renewable energy system in many countries outside the UK. It can be one of the most cost-effective renewable energy systems available.

It is appropriate for both residential and non-residential applications, and there are currently in the order of 80,000 installations in the UK.

Solar thermal systems in the UK normally operate with a back-up source of heat, such as gas or electricity. The solar system pre-heats the incoming cold water, which is topped up by the back-up heat source when there is insufficient solar energy to reach the chosen target temperature.

Solar collectors are best mounted at an incline with a southerly orientation, although orientations between south-east and south-west are acceptable. The panels can be fixed to the roof or walls.

There are three main types of solar collector that can be used in SDHW systems. These are:

a. Evacuated tubes.
b. Glazed selective surfaced flat plate.
c. Glazed non-selective surfaced flat plate.

Evacuated tube collectors are generally more expensive than flat plate type but offer an improved performance, particularly in the winter.

A5.4 Photovoltaics

A5.4.1 Background

Photovoltaic modules convert daylight directly into DC electricity and can be integrated into buildings. Photovoltaics (PVs) are distinct from other renewable energy technologies since they have no moving parts to be maintained and are silent. PV systems can be incorporated into buildings in various ways: on sloped roofs and flat roofs, in facades, atria and shading devices. Modules can be mounted using frames or they can be fully incorporated into the actual building fabric; for example, PV roof tiles are now available which can be fitted in place of standard tiles. Since PVs generate DC output, an inverter and other equipment is needed to deliver the power to a building or the grid in an acceptable AC form. The cost of the inverter and these components can approach 50% of the total cost of a PV system.

For PV to work effectively it should ideally face south and at an incline of 30º to the horizontal, although orientations within 45º of south are acceptable. It is essential that the system is unshaded, as even a small shadow may significantly reduce output.

A5.5 Wind Energy

A5.5.1 Background

Most wind turbines are installed in non-urban areas for environmental and technical reasons. However, it has become more common for smaller devices installed at the point of use, i.e. urban settings. The capacity of wind turbines range from 500W to more than 1.5 MW, but, for practical purposes and in built-up areas in particular, machines of more than 1 kW and below 500kW are likely to be considered. Individual building or community wind projects, although smaller, have the advantage of feeding electricity directly into the building's electricity circuit, thus sparing costly distribution network development and avoiding distribution losses. The downside is the still high capital cost per kW installed for smaller turbines, plus location constraints, such as visual intrusion and noise. The wind regime in urban areas is also a concern owing to higher wind turbulence which reduces the potential electricity output.

In most cases, wind turbines are connected to the electricity grid and all generated energy is used regardless of the building demand fluctuations. The output largely depends on the wind speed and the correlation between the two is a cube function. This means that in short periods of above-average wind speeds the generation increases exponentially. As a result, it is difficult to make precise calculations of the annual output of a turbine, but average figures can provide useful guidance.

The cost per kW installed varies considerably by manufacturer and size of machine with an indicative bracket of £2,500-£5, 000. With a lifespan of more than 20 years, wind turbines can save money if design and planning are carried out in a robust way.

Wind Turbine Options

Wind turbines can be mounted on horizontal or vertical axes. The horizontal mounted turbines are less expensive (around £ 20,000 for a 6 kW turbine) but generate more vibrations. The vertical mounted turbines are more expensive (around £ 22,000 for a 5 kW turbine), but almost vibration free. The table below shows the most relevant figures for both types of turbines.