SILCOCK DAWSON & PARTNERS

ENERGY ASSESSMENT UPDATE

FOR

CITROEN SITE
BRENTFORD

VERSION 4.6
MAY 2018

Issued by:-

Silcock Dawson & Partners
4/5 Tower Court, Horns Lane
Princes Risborough
Buckinghamshire HP27 0AJ
Tel: +44 (0) 1844-347474
Fax: +44 (0) 1844-345539
www.silcockdawson.co.uk

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PROJECT REVISION SHEET

CITROEN SITE, BRENTFORD

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Revision 4.6

Date of first issue .13/09/2017

Prepared by A Sturt

Revision	Date	Details	Changes	Author	Checked
1.0	13 Sept 17	For comment		A Sturt	
2.0	26 Sept 17	For comment	Default Y Value applied to apts, Commercial units modelled as restaurants.	A Sturt	
3.0	06 Oct 17	For Planning	Updated to suit elevation amendments	A Sturt	J Roche
3.1	17 Oct 17	For Planning	Minor Amendments	A Sturt	J Roche
3.2	2 Nov 17	For Planning	Site plan updated	A Sturt	J Roche
4.0	9 April 18	For Planning	Additional units incorporated revised to reflect amended elevations	A Sturt	J Roche
4.1	12 April 18	For Planning	Minor Amendments	A Sturt	J Roche
4.2	24 April 18	For Planning	Minor Amendments	A Sturt	J Roche
4.3	25 April 18	For Planning	Minor Amendments	A Sturt	J Roche
4.4	25 April 18	For Planning	Minor Amendments	A Sturt	J Roche
4.5	14 May 18	For Planning	Minor Amendments	A Sturt	J Roche
4.6	14 May 18	For Planning	Minor	A Sturt	J Roche

EXECUTIVE SUMMARY

Silcock Dawson and Partners have been appointed by L&Q. to provide an Energy Assessment for the proposed new development at the Citroen Site on Capital Interchange Way, Brentford.

For robustness and ease of reading, the whole report has been updated; this report supersedes the previous version 3.2 from November 2017 and reflects the following amendments:

- Fourteen residential units added to the development.
- Gym relocated and reduced in area.
- Glazed area increased to stepped gable ends.
- Glazed area increased to all lounges on flank elevations.

The site is proposed to be redeveloped to provide a mixed use scheme of 441 (from 427 in the previous submission) residential units (class C3) including 50% affordable housing with ancillary facilities, flexible uses within classes (A1,A2,A3 and B1) and a nursery (class D1). The proposed development comprises buildings of 12, 13, 16, 17 and 18 storeys in height, with associated cycle parking, car parking, play space, landscaping and public realm improvements.

The dwellings occupy the majority of the floor area and will be 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 Dwelling and the target air permeability will be no greater than 4.0 $m^3/hr/m^2$.

   The dwellings will have a balanced ventilation system with heat recovery.

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

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

The energy efficiency measures will reduce carbon emissions for the development by 1% below 2013 Building Regulations requirements.

The London Heat Map has been reviewed and the site is not close to an existing or proposed heat network, and the site is not within an area designated as having decentralised energy potential.

An analysis of the predicted heat demand has been carried out, and at 441 dwellings it is economically viable for a small CHP to generate 64% of the residential heat demand. The flexible use units are only being constructed to a shell standard, but units will also have connection points to the community heating system, allowing them to connect if they wish as part of their tenant fit out arrangements.

As the development will incorporate a CHP, the options for renewable technologies are limited, and a selection of renewable technologies has been reviewed with a summary tabulated over leaf:

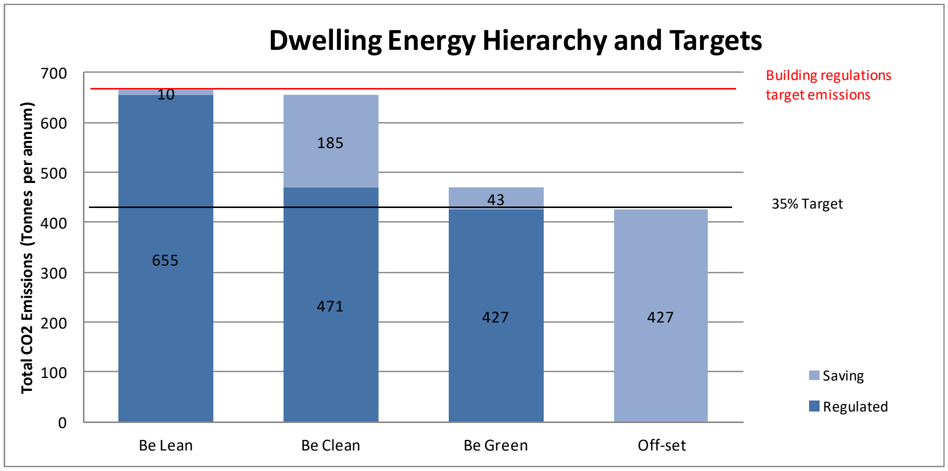
Technology	Major factors
Biomass	Not viable, the use of a biomass boiler will affect the output of the CHP and add to complexity of use. In addition, the site is within a densely occupied area and biomass boilers generate high levels of particulate material and NO_2.
Ground Source Heat Pumps (GSHP)	Not viable, the use of a heat pump will affect the output of the CHP and add to complexity in use.
Air Source Heat Pumps (ASHP)	Air source heat pumps extract heat from air and convert it to 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 are suitable for the commercial areas, and can operate effectively when part of a VRF system which recovers unwanted heat in during periods when the buildings have a simultaneous demand for heating and cooling.
Solar Thermal	Not viable the use of solar thermal panels will affect the output of the CHP and add to complexity in use.
PV cells	Space is available at roof level to install a PV array, which would make a reasonable contribution to the overall emissions reduction for the site. The panels will be a separate installation from the heating plant and allow the community heating system to be as simple as possible to operate and maintain.
Wind	Not viable, the urban environment and the close proximity of dwellings are not favourable conditions to operate a wind turbine.

The total carbon savings for the development are summarized in the tables below.

The area surrounding the site is not sufficiently developed to support a wider heat network, therefore a local network is proposed for the development with a combined heat and power unit supplying clean energy.

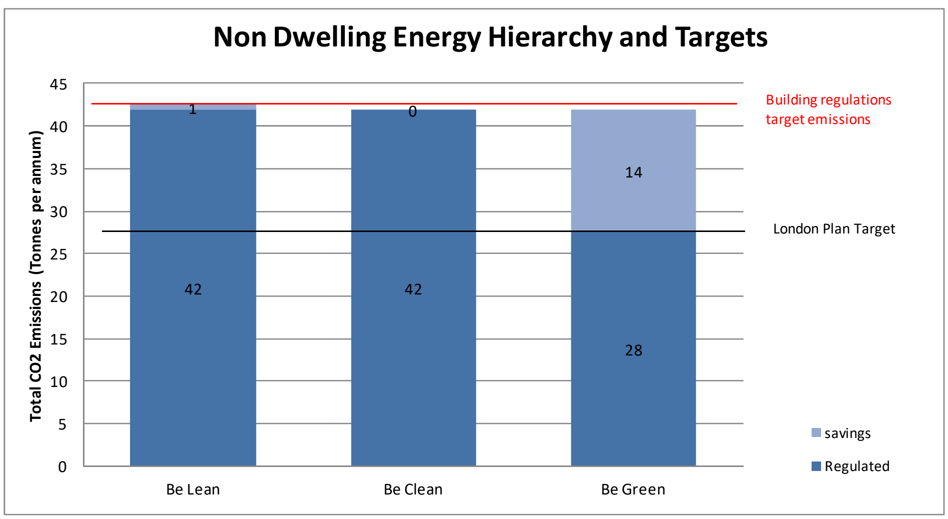
It is anticipated that a CHP generating approximately 64% of the heat requirements for the dwellings will reduce the dwelling emissions by approximately 29%, 581m^2 PV installation will reduce the emissions by a further 9%, to achieve a 36% CO_2 reduction for the dwellings.

GLA Table 2: Carbon Dioxide Emissions from each stage of the Energy Hierarchy (Dwellings)		
	Regulated Carbon dioxide savings	
	(Tonnes CO2 per annum)	(%)
Savings from energy demand reduction	10	1
Savings from CHP	185	28
Savings from renewable energy	43	9
Total cumulative savings	238	**36**
Annual savings from off-set payment	427	
	(Tonnes CO2)	
Cummulative savings for off-set payment	**12817**	



With regards to the non dwelling areas, a CO_2 reduction of 2% is expected from energy efficiency measures. The application of 169m^2 of PV across the building roofs connected directly to the non dwelling spaces, is expected to reduce the emissions by a further 34%. It should be noted that the final uses of the flexible use units are unknown, and the assumed emissions are likely to vary from this assessment.

GLA Table 4: Carbon Dioxide Emissions from each stage of the Energy Hierarchy (Non Dwellings)		
	Regulated Carbon dioxide savings	
	(Tonnes CO2 per annum)	(%)
Savings from energy demand reduction	1	2
Savings from CHP	0	0
Savings from renewable energy	14	34
Total cumulative savings	15	35



The table below indicates that a total CO_2 reduction of 36% is achieved, and the corresponding zero carbon offset payment would be £768,960 based on a payment of £60 per tonne over a 30 year period.

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	708		
Savings from energy demand reduction	697	10	1
Savings from CHP	512	185	26
Savings from renewable energy	455	58	8
Commulative savings		253	36
Total off-set		**12,816**	

Through the use of energy efficient design, clean energy supply and renewable technology the proposed development complies with London Plan policy 5.2, 5.5, 5.6 and 5.7.

1 INTRODUCTION

1.1 Background

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- Fourteen residential units added to the development.
- Gym relocated and reduced in area.
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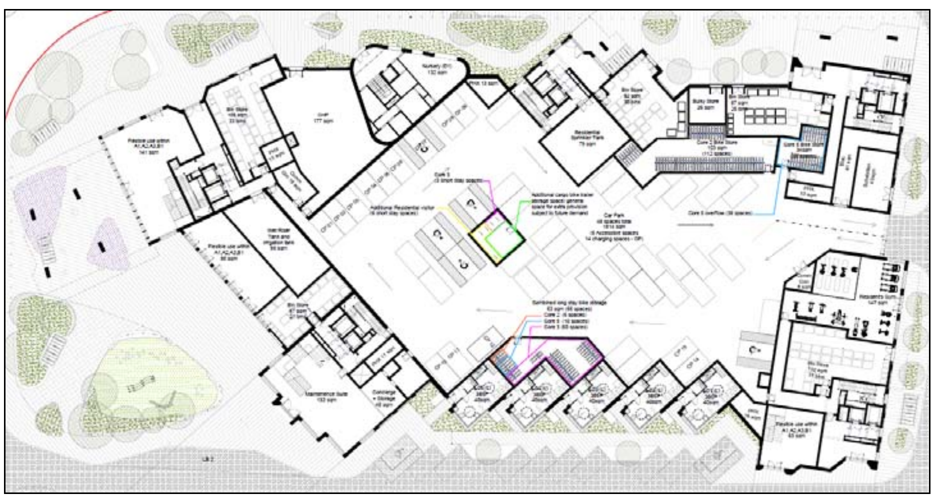
1.2 Description of the Site and Building

The site is proposed to be redeveloped to provide a mixed use scheme of 441 (from 427 in the previous submission) residential units (class C3) including 50% affordable housing with ancillary facilities, flexible uses within classes (A1,A2,A3 and B1) and a nursery (class D1). The proposed development comprises buildings of 12, 13, 16, 17 and 18 storeys in height, with associated cycle parking, car parking, play space, landscaping and public realm improvements.

Full details can be found with the Design and Access Statement Addendum prepared by Hawkins Brown.



Ground Floor

First Floor

2 RELEVANT PLANNING POLICIES

This Energy Strategy responds to the broader set of National, Regional and Local planning 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 (2012) 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 (2016)

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 residential portion of the development shall be zero carbon and non domestic buildings as per building regulations (AD Part L 2016). Further Guidance is included within the Guidance on preparing Energy Assessments (March 2016) as follows:

London Plan policy 5.2B sets a 'zero carbon' target for residential development. This target was to align with the then expected introduction of 'zero carbon homes' through Part L of the Building Regulations.

'Zero carbon' homes are homes forming part of major development applications where the residential element of the application achieves at least a 35 per cent reduction in regulated carbon dioxide emissions (beyond Part L 2013) on-site. The remaining regulated carbon dioxide emissions, to 100 per cent, are to be off-set through a cash in lieu contribution to the relevant borough to be ring fenced to secure delivery of carbon dioxide savings elsewhere (in line with policy 5.2E).

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*

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 Draft London Plan (Dec 2017)

Policies SI2 to SI3 replace current policies 5.2, 5.3, 5.5, 5.6, 5.7 and 5.9. The policies remain largely unchanged with the exception of improved energy efficiency measures proposed as 10% betterment over Part L for dwellings and 15% betterment over Part L for all other buildings. In addition from 2019 it is proposed that all buildings will be zero carbon with an offset levy paid on all emissions beyond the current 35% CO_2 reduction benchmark.

2.3 Local Policy – London Borough of Hounslow

The Hounslow Local Plan (2015) policy EQ1 (energy and carbon reduction) states that all developments should meet the carbon dioxide reduction requirements in the London Plan.

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.

Sample dwellings were selected with a range of sizes and orientations to represent approximately 25% of the total area occupied by the dwellings. The selection was based on 20 unique dwellings. SAP calculations were carried out using Stroma FSAP 2012 Version 1.0.4.9.

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

To reduce the number of simulations, all commercial / retail units have been combined to a single model, similarly the concierge and gym are combined, but the nursery has been modelled as an individual unit.

Emissions within this report are based on the following CO2 emission rates, as quoted within SAP 2012.

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.

Key thermal elements

	Notional Dwelling Building Regulations, Part L1A 2013	Proposed Measures
Air Tightness	5.0 m^3/hr per m²	4.0 m^3/hr per m²
Wall U-Value (Long Elevations)	0.18 W/m²°C	0.17 W/m²°C
Wall U-Value (Short Elevations)	0.18 W/m²°C	0.2 W/m²°C
Apartment walls to unheated common areas.(corridors, stairwells and lift / service shafts)	0.18 W/m²°C	0.2 W/m²°C (uncorrected – as external wall)
Roof U-Value	0.13 W/m²°C	0.12 W/m²°C
Exposed Floor U-Value	0.13 W/m²°C	0.11 W/m²°C
Floor to commercial space	-	0.22 W/m²°C (uncorrected – as external wall)
Window U Value	1.4 W/m²°C	1.3W/m²°C / 1.6W/m²°C for sliding doors
Glazing G-Value	0.63	0.4
Linear Thermal Transmittance (internal walls to unheated circulation spaces)	Y = 0.05	Default Y @ 0.15

All party walls to heated spaces or spaces with no heat loss will be designed to achieve an effective U value of 0.0 W/m²°C.

4.1.2 Heating

The development shall be served by community condensing boilers, with variable flow controls to promote consistent low flow and return water temperatures around the system and within the primary boiler circuit. The heating system will be designed to operate with water temperatures in the region of 70°C flow and 40°C return, the system will also be designed to meet the recommendations of the Heat Networks Code of Practice and the GLA District Heating manual.

4.1.3 Cooling

The residents gym and concierge area are assumed to be comfort cooled and details are included within section 4.2 of this report.

Cooling will not be provided within any of the dwellings.

4.1.4 Ventilation

Ventilation to the dwellings will be by a balanced system with heat recovery (MVHR). The MVHR unit used within this assessment is a Vent Axia Sentinel Kinetic Advance S unit with the following SAP appendix Q test data, however, final unit selection will form part of the detailed design.

	SFP (W/l/s) [2012]	Efficiency (%) [2012]
n = 1	0.39	93%
n = 2	0.46	92%
n = 3	0.55	91%
n = 4	0.70	91%

4.1.5 Domestic Hot Water

Domestic hot water is typically responsible for 37% of the dwelling regulated emissions, so in order to reduce these emissions, all domestic hot water pipework within the apartments will be insulated.

Hot water within the apartments will be instantaneous via twin plate heat interface units.

4.1.6 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.

4.1.7 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.

4.1.8 Equipment

Equipment energy use includes all cooking and appliances such as televisions and white goods, 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 other than to identify the estimated CO_2 emissions.

Notwithstanding this, the residents will be provided with a home user guide which 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.

4.1.9 Summary of Dwelling Carbon Emissions Following Energy Demand Reduction

The table below illustrates the predicted performance and emissions of the dwellings, which results in emissions 9 tonnes or 1% below the Part L 2013 compliant model.

Energy demand for energy efficient dwellings				
Item	**kWhrs/m²/ Year**	**kWhrs/ Year**	**Kg CO_2 /year**	**% CO2**
Htg	30.3	1,220,599	263,649	40%
DHW	28.4	1,142,574	246,796	38%
Cooling	0.0	0	0	0%
Auxiliary Energy	2.5	100,777	52,303	8%
Lighting	4.4	178,638	92,713	14%
Equipment	55.9	2,250,741	1,168,135	
Total	**122**	**4,893,329**	**1,823,596**	
Total no Equip	**66**	**2,642,588**	**655,462**	

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	665	1,168	1,833
After energy demand reduction	655	1,168	1,824

GLA Table 2: Carbon Dioxide Emissions from each stage of the Energy Hierarchy (Dwellings)		
	Regulated Carbon dioxide savings	
	(Tonnes CO2 per annum)	(%)
Savings from energy demand reduction	10	1

4.2 Non Residential Spaces

The flexible use spaces and other non dwelling buildings 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	5.0 m^3/hr per m²
Wall U-Value	0.26 W/m²°C	0.18 W/m²°C
Floor U-Value	0.22 W/m²°C	0.22 W/m²°C
Roof	0.18 W/m²°C	0.18 W/m²°C
Glazing U-Value	1.6 W/m²°C	1.54 W/m²°C
Glazing G-Value	0.4	0.58

4.2.2 Heating

The energy efficient base case will be based on 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 flexible use and other non dwelling spaces are to be constructed to a shell and core specification, the assumed specific fan power is 1.2W/l/s. All ventilation plant will be complete with a plate heat exchanger with minimum efficiency of 70%.

Two of the commercial units have the facility for kitchen extract systems to be incorporated with the fit out, within these units a kitchen ventilation system has been assumed with a specific fan power of 1.0 with no heat recovery.

4.2.4 Domestic Hot Water

Commercial / retail units with the option of including catering kitchens, gas fired water heating has been assumed for the baseline model with a combustion efficiency of 92%.

All other areas are expected to have a lower demand, and can be economically served by electric point of use heaters.

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 55 LL/CW for display lighting. Daylight compensation controls have been included, for the concierge and nursery units.

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.

4.2.7 Summary of Non Residential Areas Carbon Emissions Following Energy Demand Reduction

Building modelling for the non dwelling areas has been broken into three primary uses, as listed below with the associated emissions for the notional and energy efficient buildings.

The annual energy consumption for the Concierge / gym, nursery and commercial / retail units following the energy efficiency measures described above are expected to reduce the emissions by 2 tonnes or 4% as detailed in the tables below.

Building Use	TER kgCO2/m2	BER kgCO2/m2	Target Emissions kgCO2	Energy Efficient Emissions kgCO2
Concierge / Gym	19.00	18.4	6973	6753
Nursery	22.6	22.5	2622	2615
Commercial / retail	64.4	63.6	32458	32075
Total	**106**	**104.58**	**42052**	**41442**

Energy demand for energy efficient non dwelling uses			
Item	**kWhrs/m²/ Year**	**kWhrs/ Year**	**Kg CO_2 /year**
Htg (Boilers)	8.9	8,750	1,890
DHW	44.6	44,063	10,227
Cooling	11.0	10,847	5,630
Auxiliary Energy	12.3	12,120	6,290
Lighting	33.9	33,500	17,386
Equipment	61.8	60,958	31,637
Total	**172**	**170,237**	**73,061**
Total no Equip	**111**	**109,279**	**41,424**

GLA Table 3: Carbon Dioxide Emissions after each stage of the Energy Hierarchy			
	Carbon dioxide emissions (Tonnes CO2 per annum)		
	Regulated	Unregulated	Total
Building Regulations 2013 Part L compliant	42	32	74
After energy demand reduction	41	32	73

GLA Table 4: Carbon Dioxide Emissions from each stage of the Energy Hierarchy (Non Dwellings)		
	Regulated Carbon dioxide savings	
	(Tonnes CO2 per annum)	(%)
Savings from energy demand reduction	1	2

4.3 Combined Residential and Non Dwelling 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)	29.8	1,229,349	265,539	38%
DHW	28.8	1,186,636	257,023	37%
Cooling	0.3	10,846.9	5,629.5	1%
Auxiliary Energy	2.7	112,897	58,594	8%
Lighting	5.1	212,137	110,099	16%
Equipment	56.0	2,311,699	1,199,772	
Total	**123**	**5,063,566**	**1,896,657**	
Total no Equip	**67**	**2,751,867**	**696,885**	

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	707		
Savings from energy demand reduction	697	10	1

The table above demonstrates that the developer is proposing to improve the building fabric and fixed building services beyond the requirements of Part L compliance before the implementation of CHP/decentralized energy or renewable technologies.

5 RISK OF OVERHEATING

5.1 Dwellings

The mixed use nature of the development, and other planning issues with regards to visual building mass, has lead to a building design that has a relatively large proportion of dwellings with an open outlook.

Balconies will be provided to the majority of dwellings which will provide additional shading to the units below. The windows are designed to have deep reveals to improve the shading effect and reduce the direct solar gain, in addition the building construction will have brick finish providing a degree of thermal mass, and assist to provide more stable temperatures within the apartments.

To improve the ventilation of apartments without increasing the solar gain, opaque opening panes are incorporated into the design. These will be located behind perforated panels allowing them to be left open when the apartment is unoccupied to remove heat that may build up during the day when windows and doors would typically be locked.

All windows will have solar control glazing, incorporating a G value of 0.4 and light transmission of 70%.

To reduce the heat emitted from the circulation pipework, insulation will be applied to the pipework beyond the building regulations and the British standards. To remove any excess heat from the corridor, the AOV systems will be employed to ventilate the corridors.

Low heating 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.

A more detailed analysis is included within the Dwelling Overheating Risk Assessment prepared by Silcock Dawson and Partners.

5.2 Non Dwelling Uses

It is proposed that the flexible use and other non dwelling spaces will be comfort cooled, but the following measures have been undertaken to minimise the cooling load.

The glazed areas are limited to compliance levels as detailed within Part L, and the main commercial / retail space is positioned below a deep overhang caused by the apartments above.

The available frontage of the units, in relation to the unit depths exceeds the distances detailed within CIBSE AM10, therefore at this stage mechanical ventilation with heat recovery (which will also serve the cooling plant) is proposed.

Given that all of the flexible use and other non dwelling spaces are only constructed to a shell specification and the final uses are unknown at this stage it is assumed that prospective occupiers will install comfort cooling.

The overall area weighted cooling demand for the whole development has been calculated and is below the Notional cooling demand as detailed in the following table.

	Area weighted average building cooling demand (mJ/m2)
Actual Building(s)	177.50
Notional Building(s)	213.22

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.

It is proposed that a single energy centre will be provided to serve the development, which will contain multiple boilers and a single CHP and thermal store as described in the following section. The boiler plant will be sized to meet the peak heat demand of the development without the need for the CHP to make allowance for maintenance and repairs that may be required to the CHP during periods of high heat demand.

6.1 Proposed Heat Networks

The site is outside all areas identified on the London Heat Map as having Decentralized Energy Potential, and at present no heat networks are available for connection in the vicinity to the site.

The proposed development is located within an 'Opportunity Area' and located on the site of a Car Dealership. However, there are a number of developments coming forward in the vicinity. This includes Brentford FC and Wheatstone House. To the north is a cleared site, known as Capital Interchange Way. This has been the subject of a refused planning application for 550 homes. A revised proposal is anticipated in the future. To the south is Fountain Leisure Centre, which the Council has aspirations to redevelop.

It is therefore proposed that the development will have the facility to connect into a wider heat network in the future as the area around the site continues to be developed and the application of a heat network becomes viable.

6.2 Site Wide Heating Network and CHP

6.2.1 Technical Background

Cogeneration or Combined Heat and Power (CHP) systems are now well established in the UK, with the provision of hundreds of installations the technology has been applied successfully in many parts of the world

A combined heat and power unit comprises of five basic elements, namely an engine, an electricity generator, a heat recovery system, a control system and an exhaust system.

Typically, between 80% and 90% of the fuel input can be usefully converted to electrical power and heat. This compares well with boiler plant efficiencies, but whereas a boiler only produces heat, a CHP unit also produces electricity and it is this that provides the financial savings.

In order to fully utilise CHP, it is essential to recover as much heat as possible from the machine and to use the heat to feed into a heating system or absorption chillers. CHP plant provides hot water when generating electricity and, in order to provide viability for the CHP, the plant should be run for as long as possible. The application of CHP thereby requires a constant demand for hot water to be available.

6.2.2 Application

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. At 441 dwellings this development falls just short of this target value, however, an initial assessment has been carried out and it should be viable to run a small CHP unit to provide approximately 64% of the annual heat residential heat demand and exceed 5800 operating hours a year.

It is proposed that a single energy centre will be provided to serve the development, which will contain multiple boilers and a single 152kW(e) CHP and 16.0m^3 thermal store as described in the following section. The boiler plant will be sized to meet the peak heat demand of the development without the need for the CHP to make allowance for maintenance and repairs that may be required to the CHP during periods of high heat demand.

CHP model used within this assessment has the following characteristics:

Thermal Load: 236kW

Electrical Load: 152kW

As Ener-g: 150

Thermal Store Capacity: 16m^3

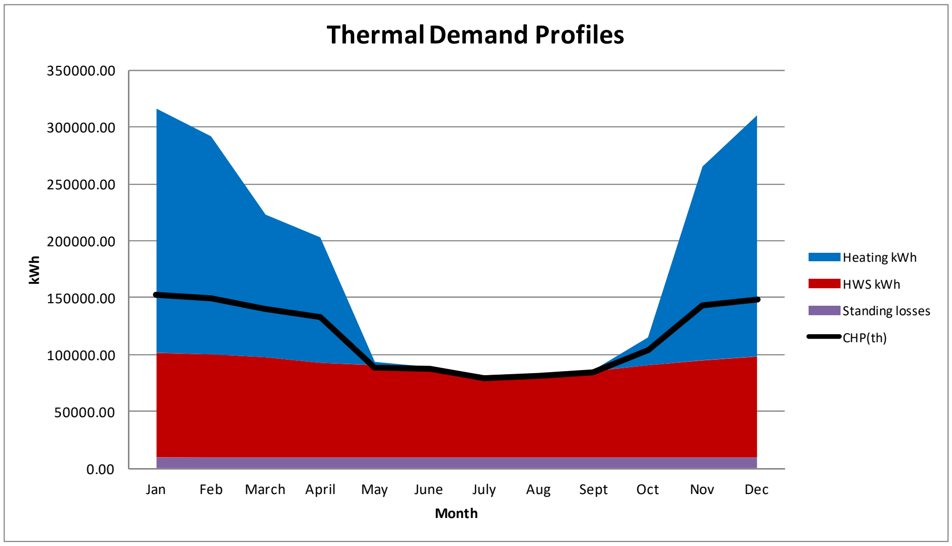
Description of calculation step	Units	Regulated Emissions
Estimated gas DELIVERED requirement in the base building for end uses that are to be served by CHP Plant.	kWh/year	2363173
Determine the combustion conversion technology efficiency in base building	%	92%
Calculate DEMAND met accounting for combustion efficiency (heating)	kWh/year	2174529
Proportion of end use DEMAND met by CHP	%	64%
Calculate annual energy DEMAND for heating & hot water met by CHP heating	kWh/year	1390984
CHP Part and full load operating hours	hours/year	5894
Heat production efficiency of CHP equipment	%	49%
Gas Supplied to the CHP plant	kWh/year	2838743
Proportion of end use DEMAND met by Boiler	%	36%
Calculate annual energy DEMAND for heating & hot water met the boilers	kWh/year	783545
Gas Supplied to the boilers	kWh/year	851679
Total Gas Supplied after the application of the CHP	kWh/year	3690422
Carbon emissions for gas	kgCo2/kWh	0.216
Carbon emissions due to DELIVERED gas in building with CHP	kgCo2/year	797131
Electricity generated by the CHP	kgCo2/year	908398
Carbon emissions factor for electricity	kgCo2/kWh	0.519
Electricity consumption from base building	kgCo2/year	336638
Electricty emissions from base building	kgCo2/year	174715
Building emissions following incorporatoin of CHP	**kgCo2/year**	**500388**

Energy demand for energy efficient dwellings with CHP			
Item	kWhrs/m²/ Year	kWhrs/ Year	Kg CO_2 /year
Boiler Htg	10.9	439,416	94,914
Boiler DHW	10.2	411,327	88,847
Cooling	0.0	0	0
Auxiliary Energy	2.5	100,777	52,303
Lighting	4.4	178,638	92,713
CHP Htg	36.4	1,466,712	316,810
CHP DHW	34.1	1,372,954	296,558
CHP Electricity	-22.6	-908,693	-471,612
Equipment	55.9	2,250,741	1,168,135
Total	**132**	**5,311,871**	**1,638,667**
Total no Equip	**76**	**3,061,130**	**470,533**

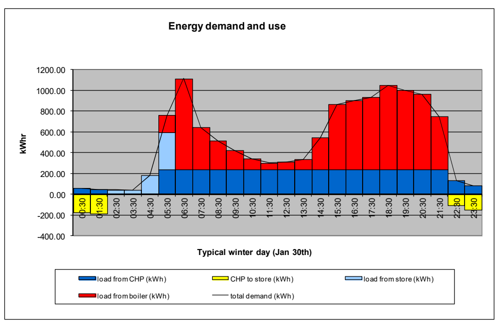
GLA Table 1: Carbon Dioxide Emissions after each stage of the Energy Hierarchy (Dwellings)			
	Carbon dioxide emissions (Tonnes CO2 per annum)		
	Regulated	Unregulated	Total
Building Regulations 2013 Part L compliant	665	1,168	1,833
After energy demand reduction	655	1,168	1,824
After CHP	471	1,168	1,639

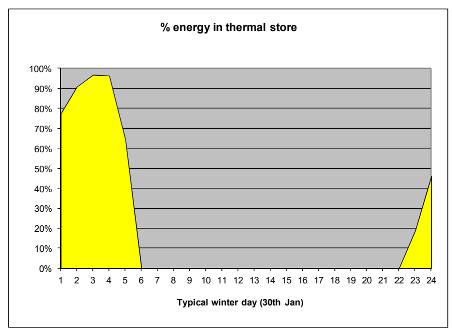
GLA Table 2: Carbon Dioxide Emissions from each stage of the Energy Hierarchy (Dwellings)		
	Regulated Carbon dioxide savings	
	(Tonnes CO2 per annum)	(%)
Savings from energy demand reduction	10	1
Savings from CHP	185	28

The heating and hot water requirements for the non dwelling uses are relatively low representing just 2.5% of the baseline demand. These units are relatively small and prospective tenants are likely to wish to install independent systems as part of their fit out works. This assessment assumes that only the dwellings will be connected to the community heating system, however, connection points to the community heating system will be made available within all units, including the nursery units should the tenants wish to purchase heat.

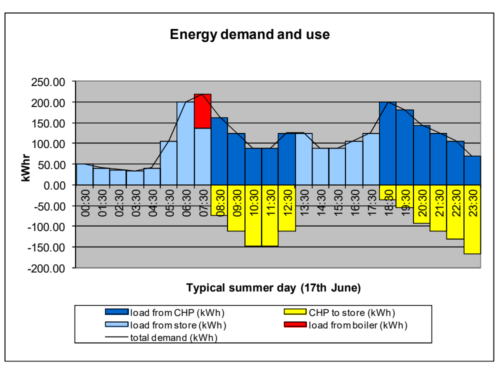


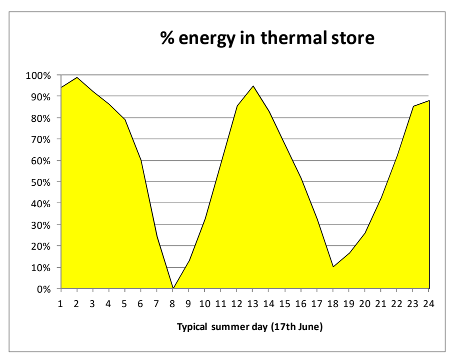
The CHP is predicted to meet the domestic hot water demand and a proportion of the heating demand. The graphs below illustrate the interaction between the boilers, CHP and thermal store during a cold winter day and typical summer day.





Typical Winter Day





Typical Summer Day

7 LOW & ZERO CARBON TECHNOLOGIES FOR ENERGY PRODUCTION

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

The development will get the benefits of a communal heating system with CHP, 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. The main technologies available for on-site renewable energy generation are:

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

Refer to appendix 2 for the more details and a brief explanation of renewable energy technologies.

7.1 Preliminary Technology Appraisal

Technology	Feasibility*			Comments
	H	M	L	
Biomass			✓	The use of a biomass boiler would affect the operation of the CHP, which is not recommended in addition a large area for fuel storage would be required, which is not available on this constricted site. The site is also 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. The use of ground to water heat pumps would affect the operation of the CHP. It is possible to integrate the technology with CHP units, but the systems and controls become overly complicated with the risk that either one or both technologies will not be used.
Air Source Heat Pumps		✓		Air source heat pumps extract heat from air and convert it to 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 are suitable for the commercial areas, and can operate effectively when part of a VRF system. These systems have the ability recover unwanted heat during periods when the

Technology	Feasibility*			Comments
	H	M	L	
				buildings have a simultaneous demand for heating and cooling.
Photovoltaic Panels	✓			Photovoltaic modules convert daylight directly into DC electricity and can be integrated into buildings. Space is available at the various roof levels to install PV arrays, which would make a considerable 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 boilers and CHP 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 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.

7.2.2 Constraints

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

1. Due to the complexity of extending the power supplies from the roofs to the commercial / retail units it is proposed that all the power generated is connected to the residential landlord supplies. However, it should be possible to divert the power generated directly to the landlord ancillary uses such as the concierge office and gym leading to a significant reduction in emissions in these uses.

7.2.3 Emissions Reduction

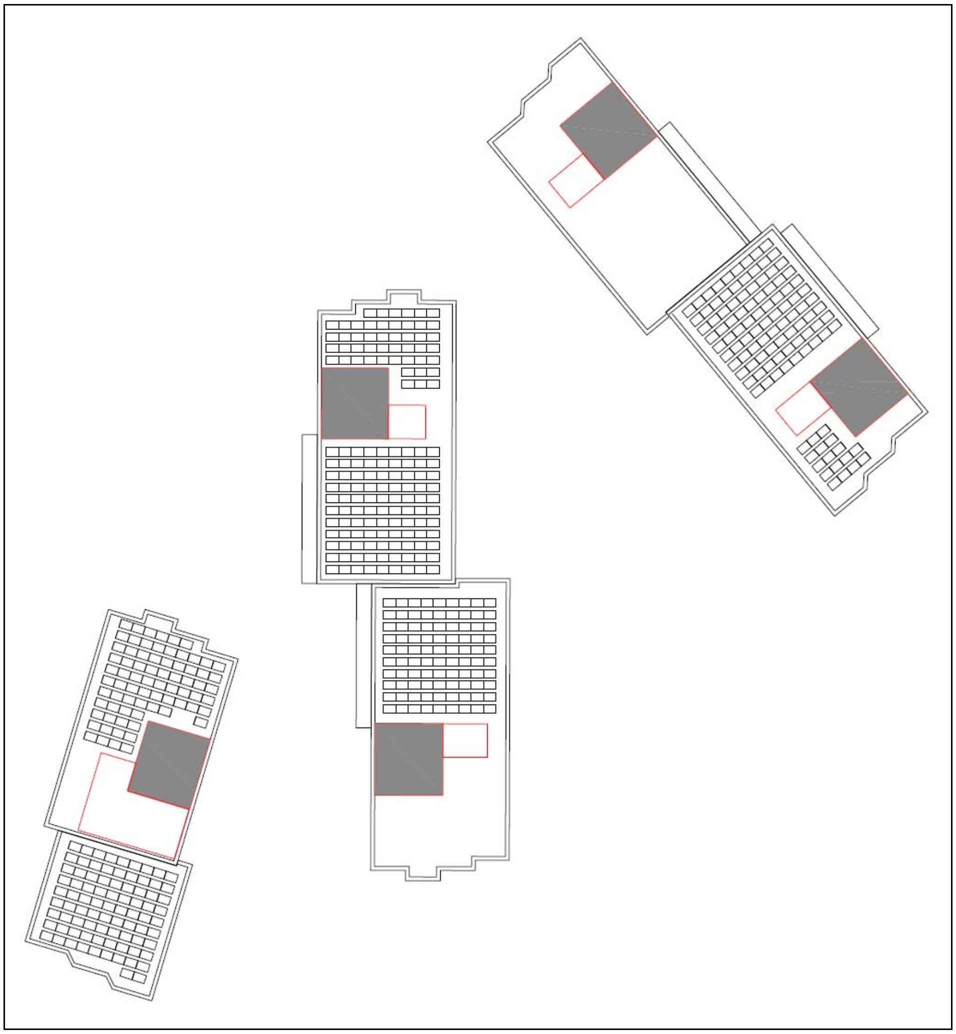
A 143kWp peak installation distributed evenly across the buildings, at a 10° pitch will have a total surface area of approximately 750m2, and will reduce the emissions by 8%. The PV installation will be configured to serve the residential units and non dwellings uses as indicated below.

End Use	kWp	Electricity Generated (kWh/yr)	CO2 reduction (kgCO2/yr)	CO2 reduction (%)
Residential	110	83,410	43,290	9%
Non Residential	33	25,784	13,382	34%

7.2.4 Conclusion

PV panels are technically viable and an installation of 750m^2 could be installed on the roofs of all three blocks.

The drawing below indicates a potential arrangement of the panels on the roofs of the Buildings taking into account lift over runs plant areas, and roof green spaces.



7.3 Air Source Heat Pumps

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). A seasonal COP 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.

7.3.3 Emissions Reduction

Remodelling the non dwelling units, 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 1.0% from the energy efficient model when applied to the whole development.

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 flexible use commercial / retail areas, where the heating loads are relatively small and the likelihood 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, CHP and renewable technologies for the dwellings and non residential spaces are detailed in the tables below.

Energy demand for energy efficient dwellings with CHP and Renewable Technology			
Item	**kWhrs/m²/ Year**	**kWhrs/ Year**	**Kg CO_2 /year**
Boiler Htg	10.9	439,416	94,914
Boiler DHW	10.2	411,327	88,847
Cooling	0.0	0	0
Auxiliary Energy	2.5	100,777	52,303
Lighting	4.4	178,638	92,713
CHP Htg	36.4	1,466,712	316,810
CHP DHW	34.1	1,372,954	296,558
CHP Electricity	-22.6	-908,693	-471,612
PV Electricity	-2.1	-83,410	-43,290
Equipment	55.9	2,250,741	1,168,135
Total	**130**	**5,228,461**	**1,595,378**
Total no Equip	**74**	**2,977,720**	**427,243**

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	665	1,168	1,833
After energy demand reduction	655	1,168	1,824
After CHP	471	1,168	1,639
After Renewable Energy	427	1,168	1,595

GLA Table 2: Carbon Dioxide Emissions from each stage of the Energy Hierarchy (Dwellings)		
	Regulated Carbon dioxide savings	
	(Tonnes CO2 per annum)	(%)
Savings from energy demand reduction	10	1
Savings from CHP	185	28
Savings from renewable energy	43	9

Energy demand for energy efficient non dwellng uses with renewable technology			
Item	**kWhrs/m²/ Year**	**kWhrs/ Year**	**Kg CO_2 /year**
Htg. (gas boiler)	0.0	0	0
DHW (gas)	42.3	41,720	9,012
Htg. (heat pump)	2.0	1,955	1,014
DHW (elec)	2.4	2,343	1,216
Cooling	11.0	10,847	5,630
Auxiliary Energy	12.3	12,120	6,290
Lighting	33.9	33,500	17,386
PV Electricity	-25.9	-25,532	-13,251
Equipment	61.8	60,958	31,637
Total	**140**	**137,909**	**58,934**
Total no Equip	**78**	**76,952**	**27,297**

GLA Table 3: Carbon Dioxide Emissions after each stage of the Energy Hierarchy			
	Carbon dioxide emissions (Tonnes CO2 per annum)		
	Regulated	Unregulated	Total
Building Regulations 2013 Part L compliant	42	32	74
After energy demand reduction	41	32	73
After CHP	41	32	73
After Renewable Energy	27	32	59

GLA Table 4: Carbon Dioxide Emissions from each stage of the Energy Hierarchy (Non Dwellings)		
	Regulated Carbon dioxide savings	
	(Tonnes CO2 per annum)	(%)
Savings from energy demand reduction	1	2
Savings from CHP	0	0
Savings from renewable energy	14	34

Combining the emissions reductions from the PV panels and the air source heat pumps within the dwellings and non dwelling uses a total CO_2 reduction of 8% is achieved 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	707		
Savings from energy demand reduction	697	10	1
Savings from CHP	512	185	26
Savings from renewable energy	455	57	8

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 & constructability.

Option	Carbon Saving from baseline (regulated energy) %	Investment costs [£]	Technical Viability (0=not viable, 10=very viable)	Comments
Connection into Local District Heat Network	Not viable, there are no heat networks within the vicinity of the site.			
Local CHP	26%		10	Viable to provide approximately 64% of the heat to the dwellings.
PV Cells	8%		9	The flat roof design is suitable for the installation of PV panels.
Air source heat pumps	Less than 0.1% due to small area of development proposed to be served	£ (Negligible will form part of comfort cooling system)	10	Straight forward installation as part of the tenant fit out works within the commercial units.
Ground source heat pumps	Not viable, the use of a heat pump will affect the output of the CHP and add to complexity in use.			
Biomass heating	Not viable, the use of a biomass boiler will affect the output of the CHP and add to complexity of use. 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.	Not viable the use of solar thermal panels will affect the output of the CHP and add to complexity in use.			
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 reduce emissions by 10 tonnes or 1% below building regulations compliance baseline. The energy efficiency measures include: improved fabric insulation including, improved air tightness, high efficiency balanced whole house heat recovery units, and low energy lighting throughout.

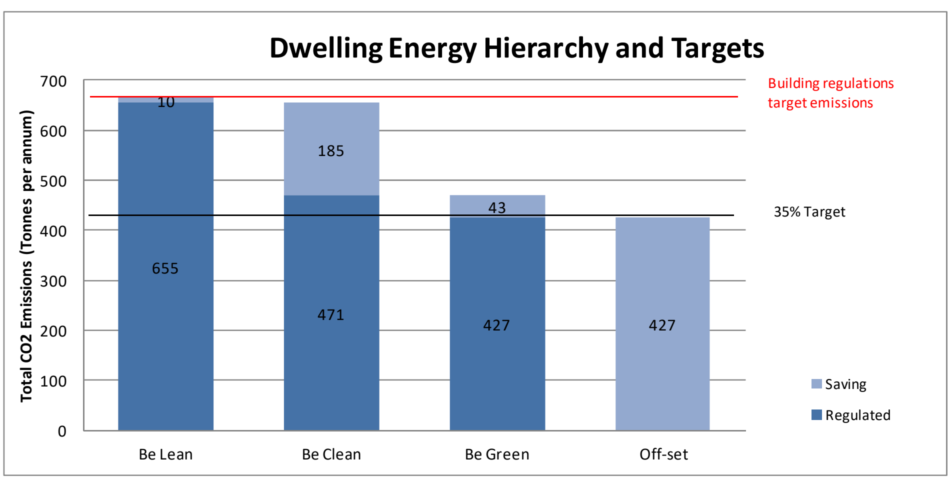
Currently there are no heat networks in the vicinity of the site, however at 441 dwellings the site is large enough to support a CHP, generating approximately 64% of the residential heating and hot water energy requirements. This should ensure that the CHP is able to operate for more than 5800 hours per year and minimise the electricity exported to the grid. The plant room will be designed to allow connection into a wider heat network should one become available in the future. It is estimated that the CHP will reduce the emissions from the dwellings by 28%, and 26% for the development as a whole.

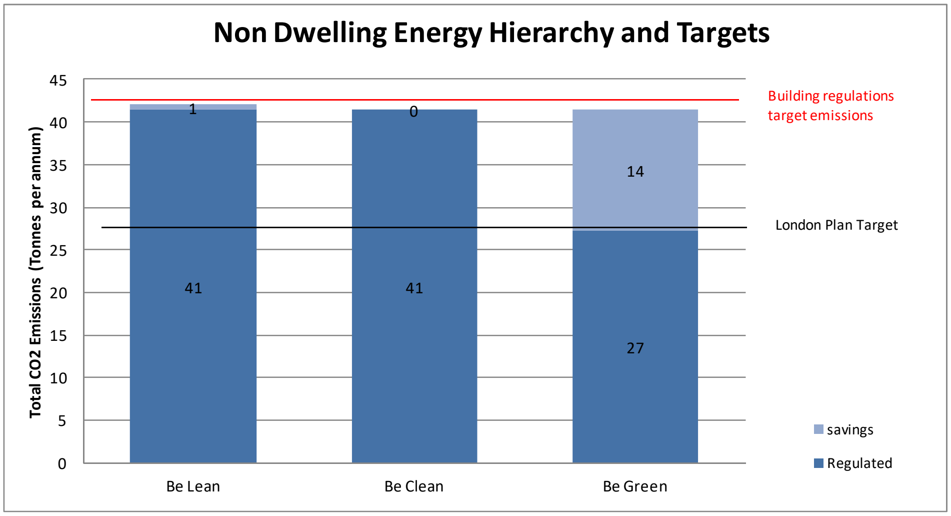
The flexible use commercial / retail areas are being constructed to a shell specification and their final uses are largely unknown, however, points of connection to the community heating system will be made available to all non residential units within the development. It is assumed that all commercial / retail units, nursery gym and concierge spaces will be heated via reverse cycle heat pumps.

The development has a considerable flat roof area, with sufficient space to accommodate a 733m^2 photovoltaic panel installation required to reduce the emissions by a further 8%. The provision of air source heat pumps within the non dwelling areas will generate a further 1% for these uses areas, however as these occupy a relatively small floor area the overall contribution is negligible.

The graphs and tables below detail the performance of the dwellings and non residential areas, with the overall emissions combined for the whole development once all measures have been incorporated.

The 35% CO_2 policy reduction target is predicted to be exceeded for the dwellings, and non dwelling uses. The PV requirement for the non dwelling spaces is based on flexible planning use classes and may vary depending on the final fit out use and design.





Energy demand for Development with community heating and renewable technologies			
Item	**kWhrs/m²/ Year**	**Total kWhrs/ Year**	**Kg CO2 /year**
Htg (nat. gas)	10.7	439,416	94,914
Htg (elec)	0.0	1,955	1,014
DHW (nat. gas)	10.0	411,327	88,847
DHW (elec)	1.0	41,720	21,653
Cooling	0.3	10,847	5,630
Auxiliary Energy	2.7	112,897	58,594
Lighting	5.1	212,137	110,099
Equipment	56.0	2,311,699	1,199,772
CHP gas	68.8	2,839,665	613,368
CHP electricity	-22.0	-908,693	-471,612
PV electricity	-2.6	-108,942	-56,541
Total	**130**	**5,364,027**	**1,665,737**
Total no Equip	**74**	**3,052,328**	**465,965**

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	707		
Savings from energy demand reduction	697	10	1
Savings from CHP	512	185	26
Savings from renewable energy	455	57	8
Commulative savings		253	36
Total off-set		**12,816**	

This Energy Assessment positively responds to the planning policy requirements, by ensuring the building fabric will be energy efficient, a CHP will be incorporated into the design and the plant will have the facility to allow connection into a wider heat network in the future. Renewable energy technologies are employed, and the developer is predicting that the dwellings will achieve a 36% CO_2 reduction, and the non dwelling uses a 35% CO_2 reduction.

The development is predicted to achieve a 36% CO_2 reduction complying with London Plan policies 5.2, 5.5, 5.6 and 5.7 and the resulting CO_2 offset payment to achieve zero carbon emissions for the dwellings is calculated at £768,960.00

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 - RENEWABLE ENERGY OVERVIEW

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

A2.1 Biofuels

A2.1.1 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.

A2.1.2 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;

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

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

- 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.

A2.1.2.1 Air and Ground Source Heat Pumps

A2.1.2.2 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,

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[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.

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 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).

A2.2 Solar Water Heating Systems

A2.2.1 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.

A2.3 Photovoltaics

A2.3.1 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.

A2.4 Wind Energy

A2.4.1 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.

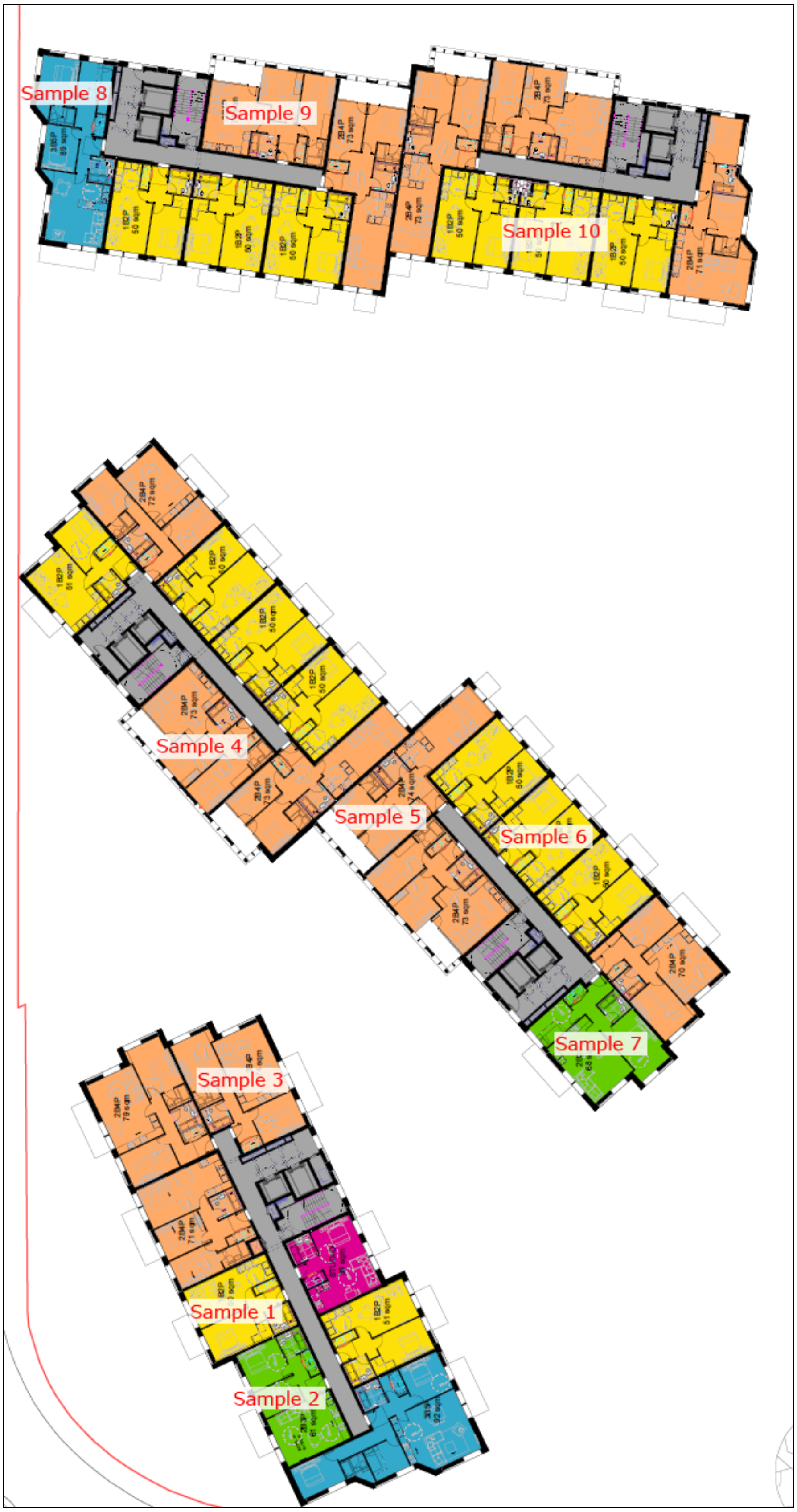
Wind Turbine Options

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.

A3 APPENDIX 3 – DER Work Sheets and Key Plan

Refer to separate attachment for SAP DER worksheets

Sample Dwellings				
Sample Dwelling Ref	Level / Position	Number	Area	Total Area
Core 1 sample 1	M	11	50	553
Core 1 sample 2	M	11	59	649
Core 1 sample 3	M	11	76	839
Core 2 sample 4	M	9	79	711
Core 3 sample 5	M	24	82	1968
Core 3 sample 6	M	12	50	600
Core 3 sample 7	M	12	68	816
Core 4 sample 8	M	10	85	850
Core 5 sample 10	M	10	79	790
Core 1 sample 1 - Roof	M	30	50	1500
Core 1 sample 1 - Roof	R	1	50	50
Core 1 sample 2 - Roof	R	1	59	59
Core 1 sample 3 - Roof	R	1	76	76
Core 2 sample 4 - Roof	R	1	79	79
Core 3 sample 5 - Roof	R	1	82	82
Core 3 sample 6 - Roof	R	1	50	50
Core 3 sample 7 - Roof	R	1	68	68
Core 4 sample 8 - Roof	R	1	85	85
Core 4 sample 9 - Roof	R	1	79	79
Core 5 sample 10 - Roof	R	1	50	50


Sample 8
Sample 9
Sample 10
Sample 4
Sample 5
Sample 6
Sample 7
Sample 3
Sample 1
Sample 2

A4 APPENDIX 4 – BRUKL Output Reports

Refer to separate attachment for Part L outputs

A5 APPENDIX 5 – Simulated Boiler / CHP Operating Profile

Refer to separate attachment

A6 APPENDIX 6 – Community Heating Plant Drawings