Energy Statement

153-163 Broadhurst Gardens

For Kilburn & District Houses Ltd

April 2016

XCO2 energy

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About us:
XCO2 Energy are a low-carbon consultancy working in the built environment. We are a multi-disciplinary company consisting of both architects and engineers, with specialists including CIBSE low carbon consultants, Code for Sustainable Homes, EcoHomes and BREEAM assessors and LEED accredited professionals.

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Executive Summary

This report assesses the predicted energy performance and carbon dioxide emissions of the proposed development at 153-163 Broadhurst Gardens, based on the information provided by the design team.

The development includes 30 no. 1 to 3 bedroom apartments distributed over five above ground storeys and an additional lower ground storey. It will also include approximately 406m^2 of commercial A1/A3 retail spaces at lower ground and ground floor levels. The site is located at the junction of Broadhurst Gardens and West Hampstead Mews, at West Hampstead within the London Borough of Camden.

The methodology used to determine the CO$_2$ emissions is in accordance with the London Plan's three-step Energy Hierarchy (Policy 5.2A) outlined below.

It should be noted that the two storey house at the southwestern corner of the site will be retained as part of the scheme, with a new two storey extension proposed to the rear of the property. Due to the size of this property (approx. 120m^2 including loft space) and the minimal level of refurbishment works to be carried out, the house is not included as part of this Energy Statement and the corresponding calculations.

1. Be Lean - use less energy

The first step addresses reduction in energy use, through the adoption of sustainable design and construction measures.

In accordance with this strategy, the proposed development will incorporate a range of energy efficiency measures including levels of insulation significantly exceeding current Building Regulations (2013) requirements, the installation of high performance glazing and energy efficient lighting.

2. Be Clean - supply energy efficiently

The second strategy takes into account the efficient supply of energy, by prioritising decentralised energy generation.

The London Heat Map indicates that no existing district heating networks are situated within close proximity of the site. Also, it is not considered economically or technically feasible to incorporate a communal heat system with a CHP for a relatively small scale development such as that at 153-163 Broadhurst Gardens. Space heating and hot water for the residential units will be provided by high efficiency gas boilers, whilst the commercial unit will be heated and cooled separately by air source heat pumps.

3. Be Green - use renewable energy

The third strategy covers the use of renewable technologies.

A feasibility study was carried out for this development and a range of renewable technologies were analysed. The analysis included a biomass heating system, ground-source heat pumps, air-source heat pumps, photovoltaics, solar thermal and wind turbines.

The analysis identified photovoltaics for the residential portion of the development, and air source heat pumps for the commercial component as the most suitable technologies for this development. The installation of 111.2m^2 of PV panels with a rated output of 21.1 kWp, and air source heat pumps to supply heating and cooling for the commercial unit, will reduce the development's regulated CO$_2$ emissions by 22.7% from the 'Be Lean' stage.

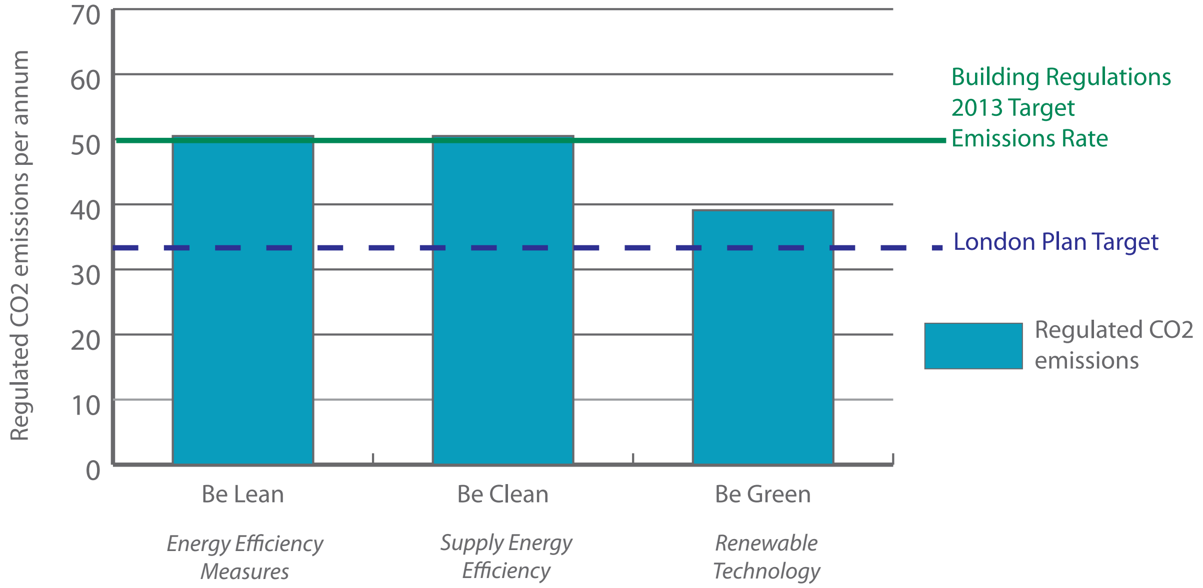
Conclusion

The graph below provides a summary of the regulated CO_2 savings at each stage of the London Plan Energy Hierarchy. The solid green line indicates the baseline condition which is equivalent to a notional building built to current Part L Building Regulations (2013) and the dashed navy blue line indicates the London Plan Target.

It can be seen on the graph that the 153-163 Broadhurst Gardens development exceeds Building Regulations compliance through the implementation of energy efficiency measures and the installation of renewables. The development will achieve a regulated CO_2 saving of 22.1% beyond Part L 2013 baseline, which is below the 35% required by the London Plan. The shortfall will be offset by a financial contribution, through a one-off payment of a Section 106 agreement of £17,485, which will fund carbon reduction measures in the borough.

The table below demonstrates the regulated and unregulated emissions.

The London Plan Energy Hierarchy



Carbon Dioxide Emissions After Each Stage of the Energy Hierarchy

	Carbon dioxide emissions (tonnes CO_2 per annum)	
	Regulated	Total
Building Regulations 2013 Part L Compliant Development	50.1	92.6
After energy demand reduction	50.5	92.9
After CHP	50.5	92.9
After Renewables	39.1	81.5

Regulated Carbon Dioxide Savings From Each Stage of the Energy Hierarchy

	Regulated Carbon Dioxide Savings	
	Tonnes CO_2 per annum	%
Savings from energy demand reduction	-0.4	-0.8%
Savings from CHP	0.0	0.0%
Savings from renewable energy	11.5	22.7%
Total Cumulative Savings	11.1	22.1%

Introduction

The proposed development is located at the southwest junction between Broadhurst Gardens and West Hampstead Mews. The railway line is to the north of the development and West Hampstead Station is about 100m to the northwest. The site is located within the London Borough of Camden.

The development includes 30 no. 1 to 3 bedroom apartments distributed over five above ground storeys and an additional lower ground storey. It will also include approximately 406m^2 of commercial A1/A3 retail spaces at lower ground and ground floor levels. The development will replace existing residential and commercial spaces on site.

This document demonstrates how the development follows the recommendations of relevant policies of the London Plan and the requirements of London Borough of Camden, as outlined in their Core Strategy. It outlines the design features that will reduce the energy consumption and CO_2 emissions of this development.

In particular this report responds to the energy policies of section 5 in the London Plan, including:

- Policy 5.2 Minimising Carbon Dioxide Emissions
- Policy 5.3 Sustainable Design and Construction
- Policy 5.5 Decentralised Energy Networks
- Policy 5.6 Decentralised Energy in Development proposals
- Policy 5.7 Renewable Energy where feasible.

The methodology employed to determine the potential CO_2 savings for this development, is in accordance with the three step Energy Hierarchy outlined in the London Plan:

- Be Lean - Improve the energy efficiency of the scheme
- Be Clean - Supply as much of the remaining energy requirement with low-carbon technologies such as combined heat and power (CHP)
- Be Green - Offset a proportion of the remaining carbon dioxide emissions by using renewable technologies.

London Plan Policy 5.2 sets out the target reductions in regulated carbon dioxide emissions expected of major developments in London. The targets below are expressed as minimum improvements over the Target Emission Rate (TER) outlined in the national Building Regulations leading to zero carbon residential buildings from 2016 and zero carbon non-domestic buildings from 2019. The targets time frames are in line with the introduction of each version of Building Regulations Part L:

- 2010-2013: 20%
- 2013-2016: 35%
- 2016-2031: Zero Carbon

Energy calculations were carried out using the FSAP 2012 methodology for the residential units and SBEM for the commercial units. This is in line with Building Regulations Part L 2013.

It should be noted that the two storey house at the southwestern corner of the site will be retained as part of the scheme, with a new two storey extension proposed to the rear of the property. Due to the size of this property (approx. 120m^2 including loft space) and the minimal level of refurbishment works to be carried out, the house is not included as part of this Energy Statement and the corresponding calculations.

The non-energy related policies are discussed in the accompanying Sustainability Report.

Demand Reduction (Be Lean)

Passive Design Measures

Enhanced Building Fabric

The heat loss of different building elements is dependent upon their U-value. A building with low U-values provides better levels of insulation and reduced heating demand during the cooler months.

The proposed development at 153-163 Broadhurst Gardens will incorporate high levels of insulation and high-performance glazing on all of the facades to significantly reduce the demand for space heating (refer to the table below).

U-Values (W/m^2K) - Residential portion

Element	Building Regulations	Proposed	Improvement
Walls	0.30	0.15	50%
Floor	0.25	0.10	60%
Roof	0.20	0.15	25%
Windows	2.0	1.20	40%

Air Tightness

Heat loss may also occur due to air infiltration. Although this cannot be eliminated altogether, good construction detailing and the use of best practice construction techniques can minimise the amount of air infiltration.

Current Part L Building Regulations (2013) sets a maximum air permeability rate of $10m^3/m^2$ at 50Pa. The development is likely to improve upon this to achieve $3m^3/m^2$ at 50Pa through the application of best practice construction techniques.

Orientation & Site Layout

Passive solar gain reduces the amount of energy required for space heating during the winter months. The building is designed to maximise passive solar gain by orientating dwellings to the south, east and west where possible. Solar control glazing will be installed to minimise the risk of overheating, and reduce cooling energy consumption in the commercial units.

Lighting

The development has been designed to improve daylighting in all habitable spaces, as a way of improving the health and wellbeing of its occupants. Most of the habitable rooms, such as living rooms, will benefit from large windows to increase the amount of daylight within the internal spaces.

Natural Ventilation

Natural ventilation will be used to provide fresh air to all residential units to minimise energy demand for ventilation. Extract fans will be provided in kitchens and bathrooms.

Active Design Measures

High Efficacy Lighting

The development intends to incorporate low energy lighting fittings throughout the building. All light fittings will be specified as low energy lighting, and will accommodate LED, compact fluorescent (CFLs) or fluorescent luminaries only.

Internal areas which are not frequently used will be fitted with occupant sensors, whilst daylit areas will be fitted with daylight sensors.

Energy Demand

The table below shows a breakdown of the energy consumption and carbon dioxide emissions associated with the building's heating and electricity demand. The figures provide a comparison between the baseline condition and the proposed development once energy efficiency measures (Lean) have been taken into account. The breakdown shows the CO_2 emissions for hot water, space heating, cooling, auxiliary and lighting demand once the energy efficiency measures have been incorporated into the building fabric.

Breakdown of Energy Consumption and CO_2 Emissions

	Baseline		Lean		
	CO_2 emissions ($kgCO_2$/year)	CO_2 ($kgCO_2/m^2$)	Energy (kWh/year)	CO_2 emissions ($kgCO_2$/year)	CO_2 ($kgCO_2/m^2$)
Hot Water	14,340	6.1	64,280	14,090	6.0
Space Heating	14,320	6.0	79,120	17,660	7.5
Cooling	3,540	1.5	8,420	4,260	1.8
Auxiliary	1,960	0.8	2,340	1,200	0.5
Lighting	15,980	6.8	26,080	13,310	5.6
Equipment (excluded from Part L)	42,420	17.9	81,730	42,420	17.9
Total Part L	50,140	21.2	180,240	50,520	21.3
Total (inc Equip)	92,560	39.1	261,970	92,940	39.3

CO_2 Emissions

The table below shows the regulated and unregulated CO_2 emissions for the baseline scheme and the emissions after the passive and active Lean measures have been implemented.

CO_2 Emissions Breakdown

	Carbon Dioxide emissions (tonnes CO_2 per annum)		
	Regulated	Unregulated	Total
Baseline building	50.1	42.4	92.6
After energy demand reduction (Lean)	50.5	42.4	92.9

	Carbon dioxide savings (tonnes CO_2 per annum)		Carbon dioxide savings (%)	
	Regulated	Total	Regulated	Total
Savings from energy demand reduction	-0.4	-0.4	-0.8%	-0.4%

Heating and Cooling Infrastructure (Be Clean)

Energy System Hierarchy

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 153-163 Broadhurst Gardens have been determined in accordance with the following hierarchy:

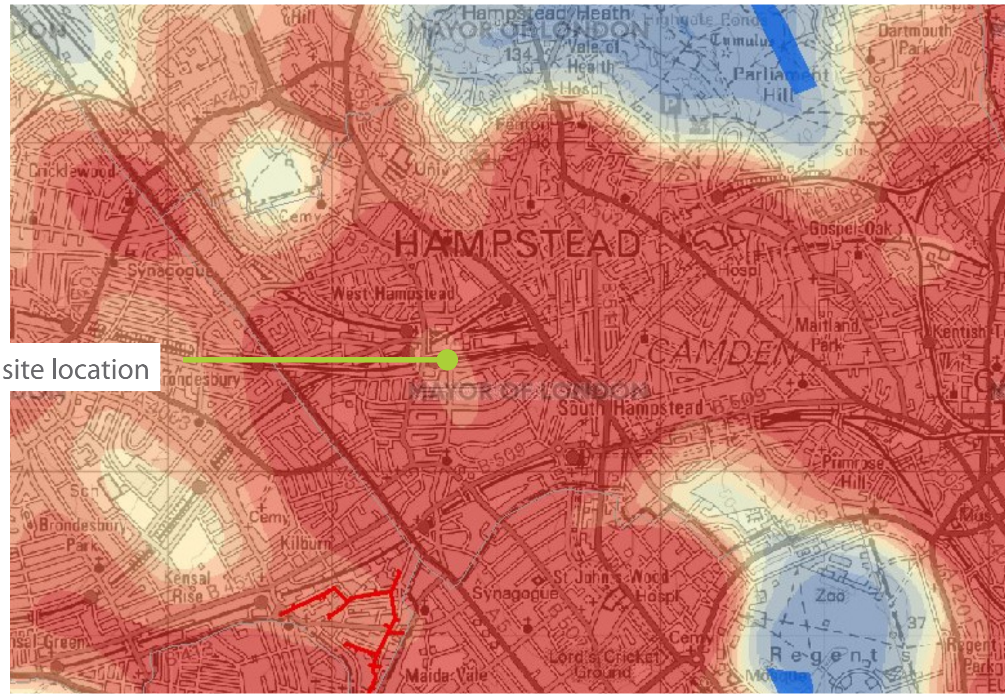
1. Connection to existing heating and cooling networks
2. Site wide CHP network
3. Communal heating and cooling

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 residences and commercial units.

Connection to Existing Low Carbon Heat Distribution Networks

The London Heat Map identifies existing and potential opportunities for decentralised energy projects in London. It builds on the 2005 London Community Heating Development Study. An excerpt from the London Heat Map below shows the energy demand for different areas. Darker shades of red signify areas where energy demand is high. The map also highlights any existing and proposed district heating systems within the vicinity of the development. A review of the maps shows the presence of a proposed district heating network (red line) at approximately 1km south of the site. However, there are no existing heat networks within close proximity of the site.

Also, it is not considered economically or technically feasible to incorporate a communal heat system with a CHP for a relatively small scale development such as that at 153-163 Broadhurst Gardens. Space heating and hot water for the residential units will be provided by high efficiency gas boilers, whilst the commercial units will be heated and cooled separately.



Approximate site location

London Heat Map - There are no existing heat networks within close proximity of the site

🟥 Proposed District heat networks

CO_2 Emissions

The table below shows the regulated and unregulated carbon dioxide emissions for the baseline scheme as well as the reduced emissions once Lean (energy efficiency) and Clean (CHP/ communal heating system) measures have been implemented.

The table illustrates that there is no further reduction in regulated CO_2 at the Clean stage.

CO_2 Emissions Breakdown

	Carbon Dioxide emissions (tonnes CO_2 per annum)		
	Regulated	Unregulated	Total
Baseline building	50.1	42.4	92.6
After energy demand reduction (Lean)	50.5	42.4	92.9
After CHP (Clean)	50.5	42.4	92.9

	Carbon dioxide savings (tonnes CO_2 per annum)		Carbon dioxide savings (%)	
	Regulated	Total	Regulated	Total
Savings from energy demand reduction	-0.4	-0.4	-0.8%	-0.4%
Savings from CHP	0.0	0.0	0.0%	0.0%

Renewable Energy (Be Green)

Methods of generating on-site renewable energy (Green) were assessed, once Lean and Clean measures were taken into account.

The development at 153-163 Broadhurst Gardens will benefit from an energy efficient building fabric which will reduce the energy consumption of the proposed development in the first instance. A range of renewable technologies were subsequently considered including:

- Biomass
- Ground/water source heat pumps
- Air source heat pump
- Wind energy
- Photovoltaic panels
- Solar thermal panels

In determining the appropriate renewable technology for the site, the following factors were considered:

- CO_2 savings achieved
- the site constraints
- payback and maintenance costs
- any potential visual or noise impacts

The following pages discuss in detail each of the renewable technologies listed above.

Biomass - not adopted

A biomass system designed for this development would be fuelled by wood pellets due to their high energy content. Wood pellets also require less volume of storage than other biomass fuels, require less maintenance and produce considerably less ash residue.

The options for this development include the use of biomass in the communal boiler as an alternative to gas, or a biomass CHP in place of the gas boiler.

Biomass boiler

A communal biomass boiler could be installed for provision of heating and hot water for the proposed development. A biomass system, however, would not be an appropriate low-carbon technology for the site for the following reasons:

- A communal boiler system is not considered to be feasible for the scheme due to space constraints
- the burning of wood pellets releases substantially more NOx emissions than gas boiler equivalents. This would significantly reduce the air quality of the site which is located in an urban environment
- storage and delivery of wood pellets would be difficult due to the site constraints and the lack of local biomass suppliers. Pellets would have to be transported from elsewhere in the UK

Biomass CHP

For the size of system required for this development, a biomass CHP is still in its infancy and brings a number of financial and technological risks. Therefore this option is not considered feasible.

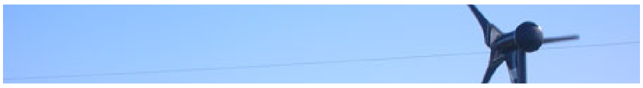
For the reasons listed above, biomass is not considered feasible for this development. Site specific analysis for biomass can be found in appendix A.

Wind Energy - not adopted

Due to the limited space on site, building-integrated turbines would be most suited to the development, as opposed to stand alone turbines.

Based on the current design of the development, the roof-mounted wind turbine would need to be located above the highest roof. Therefore only one turbine could be installed on site. This results in very low CO_2 savings. In addition, a roof-mounted wind turbine would have a significant visual impact.

For these reasons, wind turbines would not be feasible for this project. Site specific analysis for Wind turbines can be found in appendix A.



Photovoltaic Panels - adopted

Four types of solar cells are available on the market at present and these are mono-crystalline, poly-crystalline, thin film and hybrid panels. Although mono-crystalline and hybrid cells are the most expensive, they are also the most efficient with an efficiency rate of 12-20%. Poly-crystalline cells are cheaper but they are less efficient (9-15%). Thin film cells are only 5-8% efficient but can be produced as thin and flexible sheets.

Photovoltaics are considered a suitable technology for this development for the following reasons:

- the development provides sufficient amount of roof space for the installation of PV panels
- PV arrays are relatively easy to install when compared to other renewable systems
- PV panels provide a significant amount of CO_2 savings

Details of the system are included in Page 16.

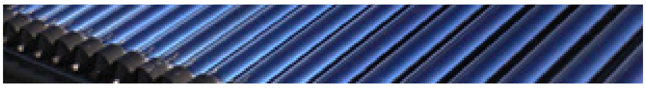
Solar Thermal Panels - not adopted

Solar thermal arrays include evacuated tubes and flat plate collectors. Evacuated tubes are more efficient, produce higher temperatures and are more suited to the UK climate when compared to flat plate collectors. Evacuated tubes tend to be more costly than flat plate collectors.

The use of solar thermal for this development would be limited to domestic hot water only. The use of solar thermal for space heating would not be practical as it is not required when solar thermal is most effective (during the summer months).

Solar thermal arrays would require additional plumbing which is likely to incur additional financial costs.

For these reasons, solar thermal technology would not be the most feasible option for the proposed development. Site specific analysis for solar thermal can be found in appendix A.



Ground Source Heat Pumps (GSHP) - not adopted

A ground source heat pump system for the site would include a closed ground loop where a liquid passes through the system, absorbing heat from the ground and relaying this heat via an electrically run heat pump within the building.

A ground source heat pump system would deliver space heating through a low temperature efficient distribution network such as underfloor heating. The installation of ground source loops significantly increases the construction time at the beginning of the project and adds to the capital cost of the project.

For this reason, GSHPs would not be feasible for this development. Site specific analysis for GSHPs can be found in appendix A.

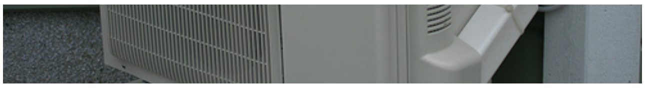
Air Source Heat Pumps (ASHP) - adopted

Air source heat pumps (ASHPs) employ the same technology as ground source heat pump (GSHPs). However, instead of using heat exchangers buried in the ground, heat is extracted from the external ambient air.

ASHP is considered a suitable technology for the non-domestic component of this development for the following reasons:

- high efficiency
- easy installation
- requires less capital cost than GSHP and other renewable technologies
- no potential noise issues in the evening when non-domestic spaces are unoccupied.

Based on the reasons above, ASHP is considered suitable for the proposed development. Details of the system are included in Page 18.



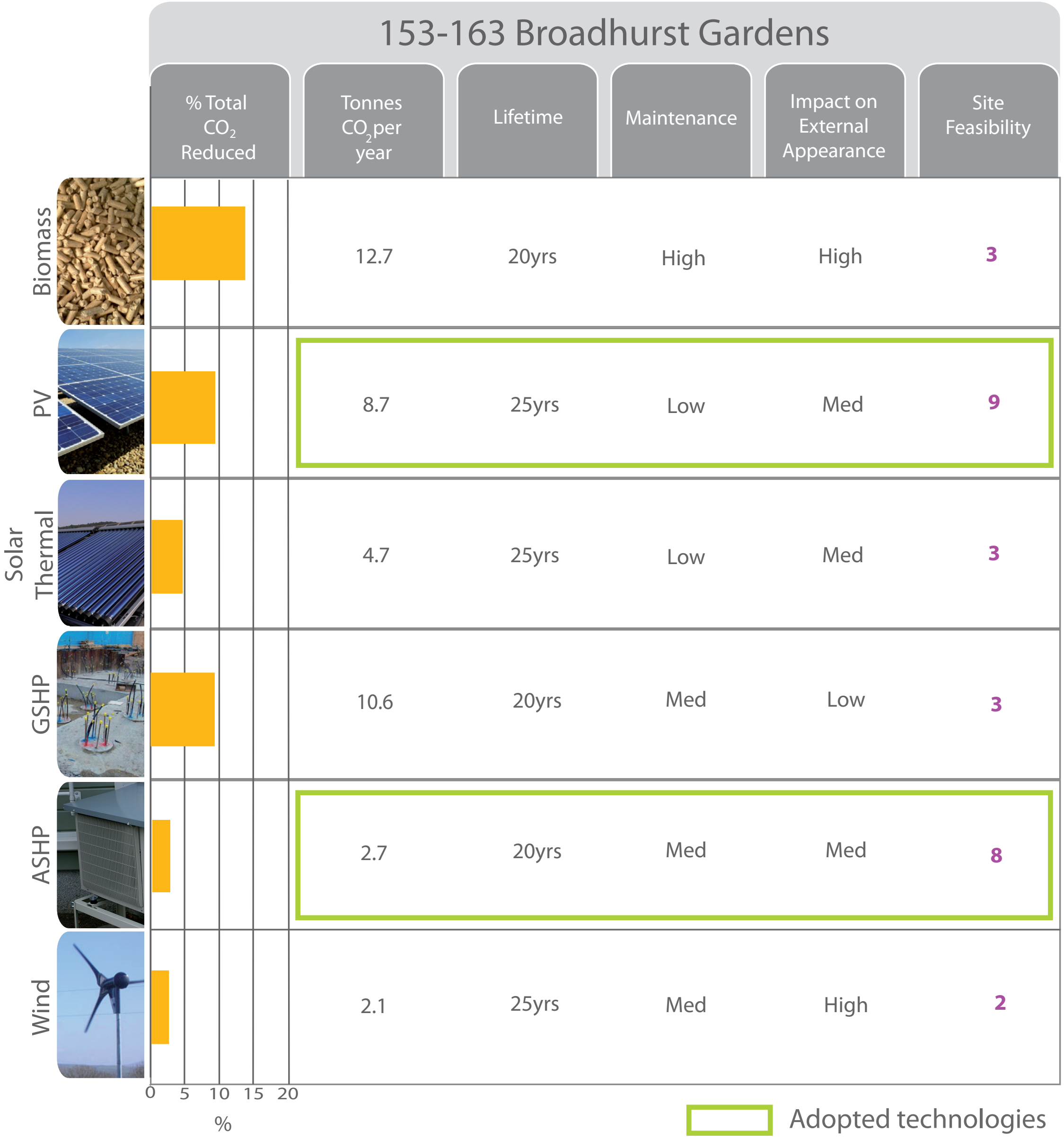
Renewable Energy Summary

The table below summarises the factors taken into account in determining the appropriate renewable technology for this project. This includes lifetime, level of maintenance, level of impact on external appearance and site feasibility.

The final column indicates the feasibility of the technology in relation to the site conditions (10 being the most feasible and 0 being infeasible).

It is important to note that the information provided is indicative and are based upon initial estimates.

The feasibility study clearly demonstrates that photovoltaics and air source heat pumps would be the most feasible renewable technologies for the proposed development at 153-163 Broadhurst Gardens.



153-163 Broadhurst Gardens

	% Total CO_2 Reduced	Tonnes CO_2 per year	Lifetime	Maintenance	Impact on External Appearance	Site Feasibility
Biomass		12.7	20yrs	High	High	3
PV		8.7	25yrs	Low	Med	9
Solar Thermal		4.7	25yrs	Low	Med	3
GSHP		10.6	20yrs	Med	Low	3
ASHP		2.7	20yrs	Med	Med	8
Wind		2.1	25yrs	Med	High	2

🟩 Adopted technologies

Detailed Assessment of Photovoltaic Panels

The feasibility study for 153-163 Broadhurst Gardens shows that photovoltaics are the most suitable renewable technology for the residential units for the following reasons:

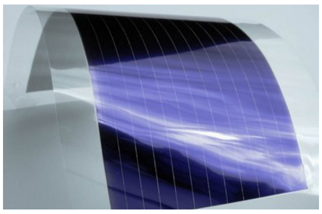
- there is sufficient roof space to install enough PV modules to have a significant impact on carbon dioxide emissions
- the installation of photovoltaics is much simpler when compared to other renewable technologies
- photovoltaics sited on the roof are less visually instrusive when compared to wind turbines for generation of electricity.

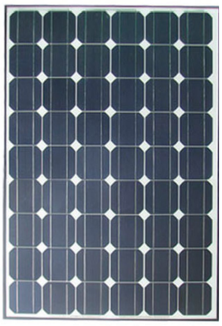
In order to maximise CO_2 reductions, it is proposed that PV panels are installed on the roofs of the development. The panels will be installed horizontally on the unshaded areas of the roof to maximise array area.

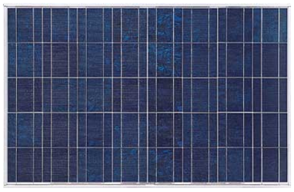
In total, 111.2m^2 of 19% efficiency PV panels, rated at 21.1 kWp, would produce regulated CO_2 savings of 17.2% for the development at 153-163 Broadhurst Gardens after the Lean measures have been implemented. The following page shows an indicative PV roof layout.

Photovoltaic Panels		
Module Efficiency	19	%
Tilt of collectors	Horizontal	
Predicted site solar energy	990	kWh/m^2/yr
System losses	20	%
System peak power	21.1	kWp
Array area	111.2	m^2
Primary electricity offset by PV array	16,740	kWh/yr
Total CO_2 savings	8.7	t/yr
Regulated Clean CO_2 emissions	50.5	t/yr
Total clean CO_2 emissions	92.9	t/yr
Regulated CO_2 reduction	17.2	%
Total CO_2 reduction	9.3	%


A hybrid PV Panel


Thin film PV


A monocrystalline PV Panel

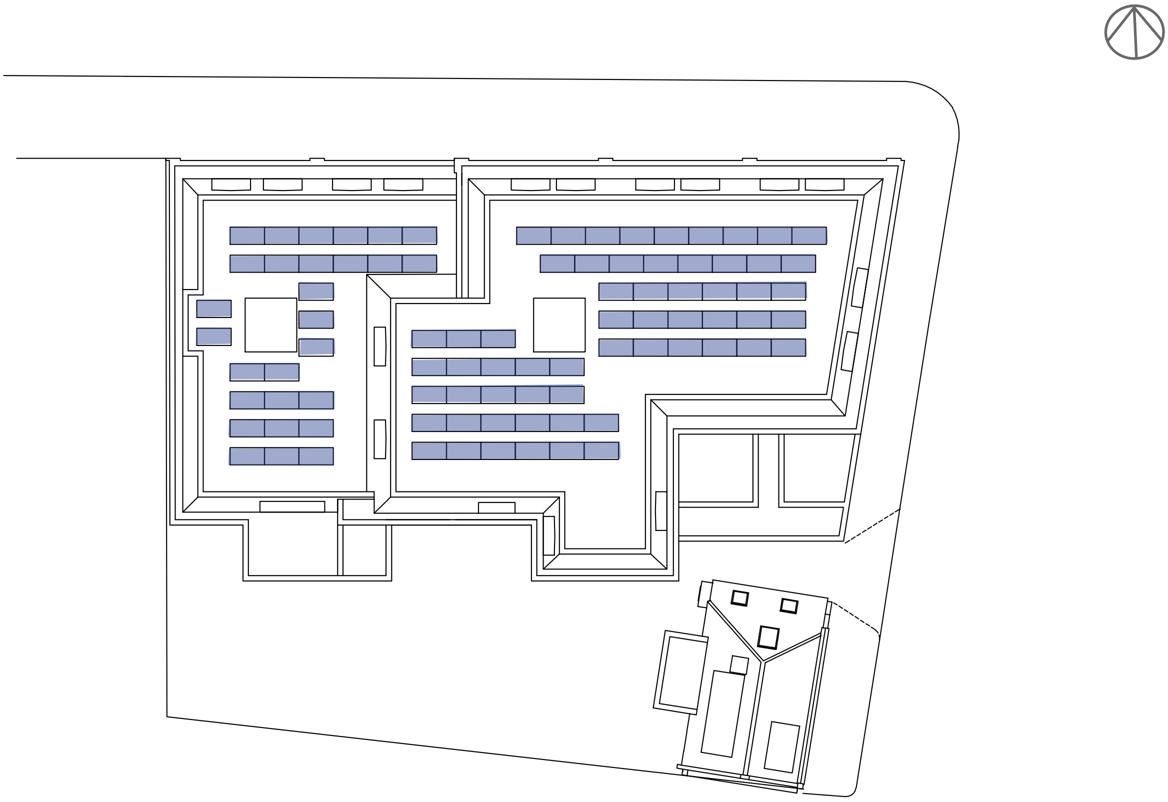

A polycrystalline PV Panel

Layout of Photovoltaic Panels

An appropriate location for the proposed photovoltaic panels was identified once the site constraints were taken into account. The factors taken into consideration included:

- space required for maintenance including all health and safety requirements for roof access;
- avoiding areas which are in intended as outdoor living spaces (eg. roof terraces);

A 111.2m^2 array of 19% efficiency PV modules, with a rated output of 21.1 kWp would offset 17.2% of regulated CO_2 emissions after the Lean measures have been implemented. An indicative PV layout is presented in the figure below.



🟦 Proposed roof PV panels

Proposed PV plan for 153-163 Broadhurst Gardens development

Air Source Heat Pumps

Air source heat pumps (ASHPs) employ the same technology as ground source heat pump (GSHPs). However, instead of using heat exchangers buried in the ground, heat is extracted from the external ambient air.

The efficiency of heat pumps is very much dependent on the temperature difference between the heat source and the space required to be heated. The lower the difference between internal and external air temperature, the more efficient the system.

The use of ASHPs for this development would result in regulated CO2 savings of 5.3%.

The ASHP is considered suitable for the commercial component of the development as there will be no noise issues in the evening when the spaces will be unoccupied. ASHP is also simple to install when compared to other renewable technologies. ASHP will therefore be implemented for the commercial space at the lower ground and ground floor levels of the proposed development.

ASHP (for commercial units only)		
COP Heat	4.0	
COP Cooling	5.3	
Carbon Intensity of Electricity	0.519	$kgCO_2$/ kWh
Proportion of Space Heating met by ASHP	90	%
Proportion of Hot Water met by ASHP	25	%
Proportion of Space Cooling met by ASHP	100	%
Energy met by ASHP	20,910	kWh/yr
Energy used by ASHP	4,070	kWh/yr
Total CO_2 savings	2.7	t/yr
Regulated Clean CO_2 emissions	50.5	t/yr
Total Clean CO_2 emissions	92.9	t/yr
% Regulated CO_2 reduction	5.3	%
% Total CO_2 reduction	2.9	%

CO_2 Emissions

The table below lists the regulated and unregulated carbon dioxide emissions for the baseline scheme and the emissions once the lean, clean and green measures have been implemented.

The figures show a significant CO_2 reduction of 22.7% in regulated emissions through implementation of PV and ASHP after the 'Be Lean' stage. The overall reduction in regulated CO_2 emissions amounts to 22.1%, when compared to a baseline scheme built to Part L Building Regulation (2013).

CO_2 Emissions Breakdown

	Carbon Dioxide emissions (tonnes CO_2 per annum)		
	Regulated	Unregulated	Total
Baseline building	50.1	42.4	92.6
After energy demand reduction (Lean)	50.5	42.4	92.9
After CHP (Clean)	50.5	42.4	92.9
After Renewables (Green)	39.1	42.4	81.5

	Carbon dioxide savings (tonnes CO_2 per annum)		Carbon dioxide savings (%)	
	Regulated	Total	Regulated	Total
Savings from energy demand reduction	-0.4	-0.4	-0.8%	-0.4%
Savings from CHP	0.0	0.0	0.0%	0.0%
Savings from Renewables	11.5	11.5	22.7%	12.3%
Cumulative savings	11.1	11.1	22.1%	12.0%

Conclusion

In line with the London Plan three step energy hierarchy, the regulated CO_2 emissions for this development have been reduced by 22.1%, once energy efficiency measures and renewables are taken into account.

The table below shows the savings made at each stage of the energy hierarchy.

1. Be Lean - use less energy

In accordance with this strategy, this development will incorporate a range of energy efficiency measures including efficient lighting, levels of insulation significantly beyond building regulation requirements and the installation of energy efficient lighting, high performance glazing and mechanical ventilation with heat recovery.

2. Be Clean - supply energy efficiently

The feasibility study showed that no district heating networks currently exist within close proximity of the site. Also, it is not considered economically or technically feasible to incorporate a communal heat system with a CHP for a relatively small scale development such as that at 153-163 Broadhurst Gardens. Space heating and hot water for the residential units will be provided by high efficiency gas boilers, whist the commercial unit will be heated and cooled seperately.

3. Be Green - use renewable energy

The feasibility study analysed a number of renewable technologies for their suitability for the site. The analysis included a biomass heating system, ground-source heat pumps, air-source heat pumps, photovoltaics, solar thermal and wind turbines.

The analysis identified a combination of photovoltaics and air source heat pumps to be the most suitable renewable technologies for this development. The installation of 111.2m^2 of PV panels with a rated output of 21.1 kWp for the residential portion only, as well as implementation of an air source heat pump for the commercial units will reduce regulated CO2 emission by 22.7% from the 'Be Lean' stage.

The overall reduction of regulated CO_2 emissions is 22.1%.

Financial contributions

The CO2 emissions for the development fall short of meeting the London Plan's target of on-site 35% reduction over Part L 2013, at 22.1%.

The shortfall will be offset by a financial contribution, through a one-off payment of a Section 106 agreement, which will fund carbon reduction measures in the borough. This currently stands at 6.5 tonnes of carbon per annum and has been calculated in line with the London Plan's guidance. The calculated contribution for 30 years currently stands at £11,657.

Regulated Carbon Dioxide Savings From Each Stage of the Energy Hierarchy

	Regulated Carbon Dioxide Savings	
	Tonnes CO_2 per annum	%
Savings from energy demand reduction	-0.4	-0.8%
Savings from CHP	0.0	0.0%
Savings from renewable energy	11.5	22.7%
Total Cumulative Savings	11.1	22.1%

Appendix A

Biomass Heating

A biomass system designed for this development would be fuelled by wood pellets which have a high energy content. Wood pellets require less volume of storage than other biomass fuels. Pellet boilers also require less maintenance and produce considerably less ash residue.

A biomass boiler could supply 50% of the space heating and hot water demand via a the communal heating scheme. This would be equivalent to a regulated CO_2 savings of 25.1%.

A biomass system, however, would not be an appropriate low-carbon technology for the site for the following reasons:

- A communal boiler system is not considered to be feasible for the scheme due to space constraints
- the burning of wood pellets releases substantially more NOx emissions when compared to similar gas boilers. As the development is situated within an urban area, the installation of a biomass boiler would further reduce the air quality in this area.
- pellets would need to be transported from other sites within the UK due to the lack of local pellet suppliers.

Example of wood pellet fuel

Biomass		
% of heating load supplied by biomass	50	%
Biomass System Efficiency	90	%
Carbon Intensity of Biomass	0.039	$kgCO_2$/kWh
Backup System Efficiency	90	%
Carbon Intensity of Backup	0.216	$kgCO_2$/kWh
Heating Demand Met	64,530	kWh/yr
Total CO_2 savings	12.7	t/yr
Regulated Clean CO_2 emissions	50.5	t/yr
Total Clean CO_2 emissions	92.9	t/yr
% Regulated CO_2 reduction	25.1	%
% Total CO_2 reduction	13.7	%

Example of pellet boiler and pellet storage room. Source: Energy Crops Limited

Solar Thermal

Solar thermal arrays have similar requirements as PV arrays, in terms of their orientation and inclination. The most efficient use of solar thermal arrays would be to orientate them to the south at an inclination of about 30°.

Solar thermal arrays are available as evacuated tubes and flat plate collectors. Evacuated tubes are more efficient, produce higher temperatures and are more suited to the UK climate in general when compared to flat plate collectors.

For this development solar thermal would be used for domestic hot water only. The use of solar thermal for space heating would not be practical as it is not required when solar thermal is at its most effective during the summer months.

If solar thermal were to be considered for this development, based on a solar fraction of 33%, 50m^2 solar thermal arrays would produce a regulated CO_2 saving of 9.3%.

The installation of solar thermal would require additional plumbing and space for hot water storage which would incur additional financial costs. Therefore photovoltaics would be a more appropriate solution for this development.

Solar Thermal		
Collector Type	Evacuated Tube	
System Efficiency	40	%
Orientation	30°	
Predicted site solar energy	1073	kWh/m^2/yr
Solar fraction	33	%
Total collector area	50	m^2
Primary gas energy offset by Solar Thermal system	23,840	kWh/yr
Total CO_2 savings	4.7	t/yr
Regulated Clean CO_2 emissions	50.5	t/yr
Total Clean CO_2 emissions	92.9	t/yr
% Regulated CO_2 reduction	9.3	%
% Total CO_2 reduction	5.1	%

Ground Source Heat Pumps

The footprint of the development occupies a significant portion of the site. For this reason, a ground source loop would need to be incorporated within the foundations of the building.

A suitable ground source heat pump system for the site would include a number of closed ground boreholes, where a liquid passes through the system, absorbing heat from the ground and relaying this heat via an electrically run heat pump into the building.

Studies have shown that ground source boreholes located within close proximity of structural foundations may result in a reduction of the life span of the loops. Thermal testing would need to be carried out on the foundations to determine the implications to the ground boreholes over time.

Ground source heat pumps would deliver space heating through a low temperature efficient distribution network such as underfloor heating. Approximately 90% of the annual space heating demand would be supplied by a system sized to meet approximately 50% of the peak load. The number of ground boreholes required would require a significant amount of space on site and result in additional time at the beginning of the construction process. In addition, the capital cost of installing these boreholes would be very high. For these reasons, ground source heat pumps were not considered to be an appropriate renewable technology for the site.

GSHP		
COP Heat	4.0	
COP Cooling	4.0	
Carbon Intensity of Electricity	0.519	$kgCO_2$/ kWh
Proportion of Space Heating met by GSHP	90	%
Proportion of Hot Water met by GSHP	25	%
Proportion of Space Cooling met by GSHP	100	%
Energy met by GSHP	97,500	kWh/yr
Energy used by GSHP	24,370	kWh/yr
Total CO_2 savings	10.6	t/yr
Regulated Clean CO_2 emissions	50.5	t/yr
Total Clean CO_2 emissions	92.9	t/yr
% Regulated CO_2 reduction	20.9	%
% Total CO_2 reduction	11.4	%

Energy piles within foundations of construction. Source: Geothermal International Italia

Wind Turbines

Building-integrated turbines would be most suited to this site due to the limited amount of roof space, as opposed to stand alone turbines.

CO_2 savings from wind turbine technologies take into account their mounting height, the turbine wind curve and wind data. This information was obtained from the BERR website and used in the Carbon Trust Wind Yield Estimation Tool. The average annual wind speed at a mounting height of 10m above the building canopy is estimated to be 3.5m/s.

Due to the spacing required between wind turbines, and the different heights of the buildings, only one turbine could be sited on the roof. The two tables below outline CO_2 savings for a 2.5kW and 6kW roof-mounted wind turbine.

The results show that the CO_2 savings are minimal for each option, offering 1.7% and 4.2% savings over regulated CO_2 emissions for the 2.5kW and 6kW turbines respectively.

This technology is not considered appropriate for this development due to the low CO_2 savings achieved and limited roof space. The installation of wind turbines also has a significant visual impact on the building.

A building-mounted 6kW Proven wind turbine

Wind Power - 2.5kW		
Average wind speed at site	3.5	m/s
Number of Turbines	1	
Electricity offset by turbine	1,584	kWh/yr
Carbon intensity of offset electricity	0.529	$kgCO_2$/kWh
Total CO_2 savings	0.84	t/yr
Regulated Clean CO_2 emissions	50.5	t/yr
Total Clean CO_2 emissions	92.9	t/yr
% Regulated CO_2 reduction	1.7	%
Total CO_2 reduction	0.9	%

Wind Power - 6kW		
Average wind speed at site	3.5	m/s
Number of Turbines	1	
Electricity offset by turbine	3,987	kWh/yr
Carbon intensity of offset electricity	0.529	$kgCO_2$/kWh
Total CO_2 savings	2.11	t/yr
Regulated Clean CO_2 emissions	50.5	t/yr
Total Clean CO_2 emissions	92.9	t/yr
% Regulated CO_2 reduction	4.2	%
Total CO_2 reduction	2.3	%