Energy Statement

Oak Grove

For Pocket Living

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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 Oak Grove based on the information provided by the design team. The proposal includes the construction of 17 one bedroom apartments, located towards the southern end of Oak Grove in Cricklewood 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:

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 exceeding current Building Regulations (2010) requirements and the installation of high performance glazing for the residential units. The implementation of these measures would potentially reduce regulated CO_2 emissions by 9.5%, when compared to notional buildings built to current Part L Building Regulations (2010).

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 or proposed district heating networks are situated within close proximity of the site. Due to the mixed tenure nature of the proposed development, installation of high efficiency condensing gas boilers for individual dwellings was deemed to be the more appropriate heating system. This will also minimise distributional heat losses associated with communal heating systems.

There is no further reduction in CO_2 emissions in addition to the 'Be Lean' stage.

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 as the most suitable renewable technology for this development. The installation of 60.5 m^2 of PV panels with a rated output of 11.5 kWp would potentially reduce regulated CO_2 emissions by a further 33.9%. Photovoltaics would be best suited to this development due to:

- the significant amount of CO_2 savings achieved;
- the amount of roof space available ;
- the ease of installation compared to other renewable technologies.

Conclusion

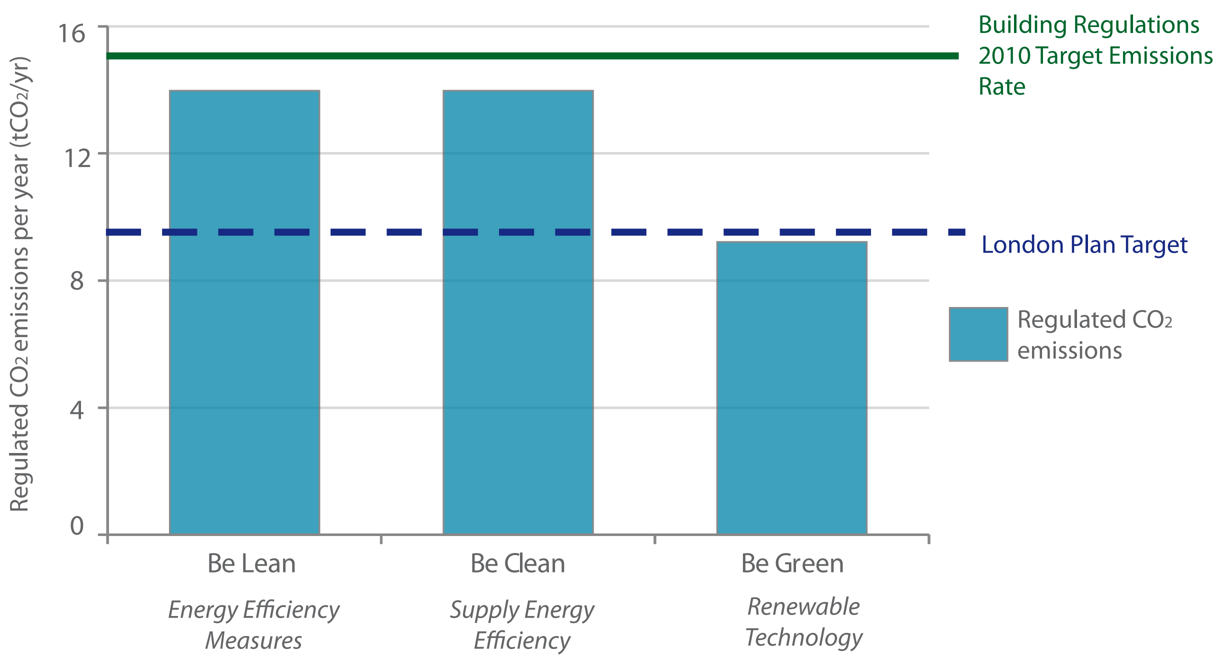
The graph below provides a summary of the regulated CO_2 savings at each stage of the London Plan Energy Hierarchy.

- the solid green line indicates the baseline condition which is equivalent to a notional building built to current Part L Building Regulations (2010).
- the dashed navy blue line indicates the target set out by the GLA for all major developments. This is equivalent to a 40% CO_2 reduction over regulated energy use.

The graph shows that the development goes beyond Building Regulation compliance through energy efficiency alone, with further reductions made through renewable energy. In total, the development is expected to reduce regulated CO_2 emissions by 40.2% when compared with a notional building built to current Part L Building Regulations (2010), which represents significant savings.

The figure and tables below and in the following page outline the regulated CO_2 savings at each stage of the energy hierarchy (in both tonnes per annum and as a percentage).

The London Plan Energy Hierarchy



Carbon Dioxide Emissions After Each Stage of the Energy Hierarchy

	Carbon dioxide emissions (tonnes CO_2 per annum)	
	Regulated	Unregulated
Building Regulations 2010 Part L Compliant Development	15.2	14.8
After energy demand reduction	13.8	14.8
After clean measures	13.8	14.8
After renewables	9.1	14.8

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	1.4	9.5%
Savings from CHP	0.0	0.0%
Savings from renewable energy	4.7	33.9%
Total Cumulative Savings	6.1	40.2%

Introduction

The proposed development at Oak Grove includes 17 one bedroom apartments to be located towards the southern end of Oak Grove, adjacent to a car repairs garage, a two storey dwelling and the train lines from Cricklewood train station.

The 17 flats are distributed over three storeys, and the development will replace an existing external car parking area.

The purpose of this report is to demonstrate how this development fulfils the relevant energy policies of the London Plan and Camden's Core Strategy. This report outlines the expected energy performance of the development as well as the energy efficiency measures that will be employed to reduce its CO_2 emissions.

The Camden Core Strategy (November 2010) requires Code for Sustainable Homes Level 4, with 50% of the unweighted credits in the Energy and Water categories (Development Policy DP22 and Camden Planning Guidance CPG3 paragraphs 3.22 and 9.8). Please refer to the supplementary Sustainability Report on how this standard has been met.

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

- Policy 5.2 Minimising Carbon Dioxide Emissions, which requires all major residential developments to meet a 40% target for CO_2 emissions reduction over the 2010 Building Regulations requirements from October 2013;
- 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.

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

Demand Reduction (Be Lean)

Passive Design Measures

Enhanced Building Fabric

The heat loss of different building elements is dependent upon their U-value. The lower the U-value, the better the level of insulation of a particular element. A building with low U-values has a reduced heating demand during the cooler months.

The development at Oak Grove will incorporate high levels of insulation and high efficiency glazing in order to reduce the demand for space heating (see table below).

U-Values (W/m²K)

Element	Building Regulations	Proposed	Improvement
Walls	0.30	0.15	50%
Roof	0.20	0.13	45%
Ground Floor	0.25	0.12	52%
Windows	2.0	1.2	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 into a building.

Current Part L Building Regulations (2010) sets a maximum air permeability rate of $10m^3/m^2$ at 50Pa. The development is likely to improve upon this to achieve $5m^3/m^2$ at 50Pa through the application of best practice construction techniques.

Lighting

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

Active Design Measures

High Efficacy Lighting

The development intends to incorporate low energy lighting fittings throughout the building and all light fittings will be specified as low energy lighting to minimise the energy demand in this sector.

Internal and external areas which are not frequently used will be fitted with occupant sensors, whereas daylit areas will be fitted with daylight sensors and timers.

Mechanical Ventilation with Heat Recovery

Mechanical ventilation is proposed for the residential units due to local noise levels. The mechanical ventilation system will include heat recovery (MVHR) in order to achieve ventilation in the most energy efficient way. Windows will still be operable to achieve passive cooling in summer. The design team will utilise window configurations which allow effective single-sided ventilation to occur.

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 savings made to the 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

	Part L 2010 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	6,300	9.4	28,700	5,700	8.5
Space Heating	6,500	9.7	19,300	3,800	5.7
Cooling	0	0.0	0	0	0.0
Auxiliary	800	1.2	5,100	2,600	3.9
Lighting	1,700	2.5	3,200	1,700	2.5
Equipment (excluded from Part L)	14,800	22.3	28,700	14,800	22.3
Total Part L	15,200	22.8	56,200	13,800	20.7
Total (inc Equip)	30,100	45.1	85,000	28,600	43.0

CO_2 Emissions

The table below shows the regulated and unregulated carbon dioxide emissions for the baseline scheme and the emissions after the passive and active lean measures have been implemented. It can be seen that a 9.5% reduction in regulated CO_2 emissions has been made at this stage of the energy hierarchy.

CO_2 Emissions Breakdown

	Carbon Dioxide emissions (tonnes CO_2 per annum)		
	Regulated	Unregulated	Total
Baseline building	15.2	14.8	30.1
After energy demand reduction	13.8	14.8	28.6

	Carbon dioxide savings (tonnes CO_2 per annum)		Carbon dioxide savings (%)	
	Regulated	Total	Regulated	Total
Savings from energy demand reduction	1.4	1.4	9.5%	4.8%

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 Oak Grove 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

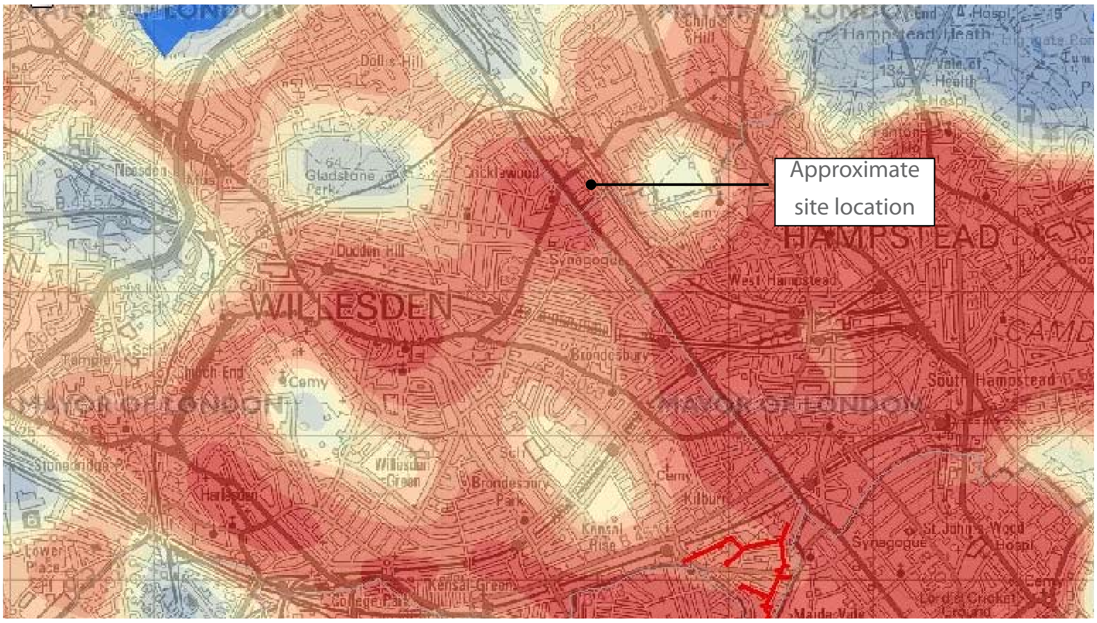
In a communal energy system, energy in the form of heat, cooling, and/or electricity is generated from a central source and distributed via a network of insulated pipes to surrounding residencies.

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 that there are no existing heat networks within close proximity of the site.



London Heat Map image of areas surrounding the development

Combined Heat and Power (CHP)

CHP, or Cogeneration, is the production of electricity and useful heat from a single plant, improving the overall energy conversion efficiency from between 25-35% to around 80%. For a wide range of buildings, CHP can offer an economical method of providing heat and power which is less environmentally harmful than conventional methods. However, the economic viability of CHP is heavily dependent on a consistent demand for heat and power.

The Carbon Trust 'Good Practice Guide for CHP for Buildings' suggests that a CHP system would be worth investigating for schemes with a simultaneous demand of heat and power of more than 5,000 hours per year.

Within the residential environment electricity demand is relatively consistent throughout the year. However, the heat load is weighted to the winter months when there is a space heating demand. CHP is therefore best sized to meet the hot water load of the building, which stays relatively consistent throughout the year. This consistent annual heat load is known as the base heat load. For small scale residential developments, such as the proposed development at Oak Grove, the base heat load is below the peak load of commercially available communal CHP engines. Therefore the technology is considered not to be feasible for this development.

Micro CHP

Micro CHP engines are a relatively new technology and are currently an unproven way of reducing CO_2 emissions. They are an expensive and high maintenance solution for the small amount of electricity they generate in return. Micro CHPs are not proposed for this scheme.

Most Appropriate Heating Strategy

Due to the small size of the proposed development, the installation of high efficiency condensing gas boilers in individual apartments was deemed to be the most appropriate heating strategy for the development. The installation of decentralised heating systems will also minimise distribution heat losses and result in lower total CO_2 emissions for the development. A Flue Gas Heat Recovery System (FGHRS) will be installed on each individual boiler to further improve the efficiency of each system.

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) 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	15.2	14.8	30.1
After energy demand reduction (Lean)	13.8	14.8	28.6
After CHP (Clean)	13.8	14.8	28.6

	Carbon dioxide savings (tonnes CO_2 per annum)		Carbon dioxide savings (%)	
	Regulated	Total	Regulated	Total
Savings from energy demand reduction	1.4	1.4	9.5%	4.8%
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 Oak Grove will benefit from an energy efficient building fabric as well as efficient heating systems, 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 impacts

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

Biomass

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 a biomass CHP or a biomass communal boiler as an alternative to individual gas boilers.

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.

Biomass boiler

The implementation of a communal biomass boiler could replace individual gas boilers. A biomass system, however, would not be an appropriate low-carbon technology for the site for the following reasons:

- 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

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

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 turbines would need to be located above the highest units, which would limit the number of wind turbines that could be installed. This would result in low carbon savings. In addition, roof-mounted wind turbines would have a significant visual impact.

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

Photovoltaic Panels

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

Based on the reasons above, photovoltaics would be the most suitable renewable technology for the proposed development. Details of the system are included in Page 17.

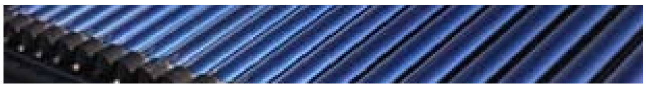
Solar Thermal Panels

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 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. Additional space would also be required within each dwelling for a hot water storage unit.

For these reasons, solar thermal technology is not recommended for the proposed development. Site specific analysis for solar thermal can be found in appendix A.



Ground Source Heat Pumps (GSHP)

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.

The ground source loop could either be laid in a series of trenches or installed in a borehole system, as well as incorporated within foundation piles of the proposed buildings. There are concerns that ground source loops present in close proximity to the foundation piles may affect their life span. For this reason, thermal testing would need to be carried out on the foundation materials to ensure there is no long term effect.

Since the majority of the site area of this project is being developed, there is no available ground space for a trench system. For this reason, if a ground source loop system is to be considered for this project, it would have to be incorporated within the foundation piles of the building structure.

Additionally, the installation of ground source loops would significantly increase the construction time at the beginning of the project, adding to the capital cost of the project.

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

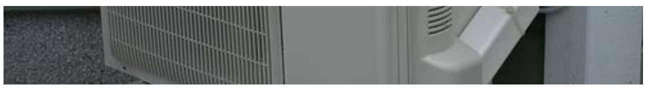
Air Source Heat Pumps (ASHP)

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 use of air source heat pumps would not be feasible for the following reasons:

- ASHP evaporators would need to be located externally. Any noise associated with the units could potentially be an issue for the occupants of the building
- There is also insufficient space to house all the ASHP units on the roof, and the position of the units externally is likely to have a significant visual impact

ASHPs would not be preferable for the proposed development due to the reasons listed above. Site specific analysis for ASHPs can be found in appendix A.



Renewable Energy Summary

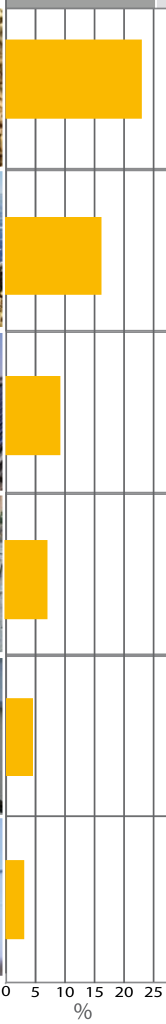
The table below summarises the factors taken into account in determining the appropriate renewable technology for this project. This includes estimated capital cost, simple payback, lifetime, level of maintenance and level of impact on external appearance.

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 costs are based upon initial estimates. Payback calculations do not take into consideration any grants or inflation. Current feed-in-tariffs have been included.

The feasibility study clearly demonstrates that photovoltaics would be the most feasible option for the proposed development at Oak Grove.

Oak Grove



	% Total CO_2 Reduced	Tonnes CO_2 per year	Lifetime	Maintenance	Impact on External Appearance	Site Feasibility
Biomass		6.5	20yrs	High	High	3
PV		4.6	25yrs	Low	Med	9
Solar Thermal		2.5	25yrs	Low	Med	6
GSHP		2.0	20yrs	Med	Low	5
ASHP		1.3	20yrs	Med	Med	4
Wind		0.8	25yrs	Med	High	2

Photovoltaic Panels

Four types of solar cells available at present are mono-crystalline, poly-crystalline, thin film and hybrid. Although mono-crystalline and hybrid cells are the most expensive, they are the most efficient (12-20%). Poly-crystalline cells are cheaper but they are less efficient (9-15%). Thin film cells are only 5-8% efficient but have the advantage of being produced as thin and flexible sheets.

In this development, a roof level space dedicated for installation of photovoltaic or solar thermal arrays have been incorporated into the design of the building. The panels will be laid horizontally to maximise available roof space without self-shading issues.

The feasibility study for Oak Grove showed that photovoltaics to be one of the most suitable renewable technology for the following reasons:

- There is sufficient roof space available to install enough PV modules to have a significant impact on carbon dioxide emissions of the development;
- 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 ASHPs and wind turbines.

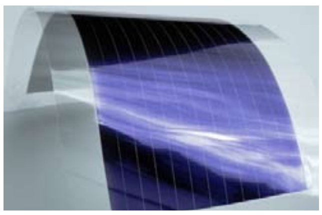
A total of 60.5m^2 of 19% efficiency PV modules (11.5kWp), would produce a regulated saving of 33.9% after the lean and clean measures have been implemented.

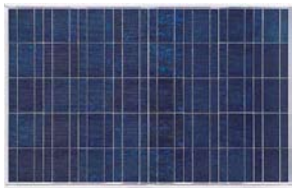
This technology will be implemented as part of the 'Be Green' strategy for this proposed development. A roof plan illustrating the proposed location of the PV array on the roof on the next page.

Photovoltaic Panels		
Module Efficiency	19	%
Orientation	Horizontal	
Predicted site solar energy	961	kWh/m^2/yr
System losses	20	%
System peak power	11.5	kWp
Array area	60.5	m^2
Primary electricity offset by PV array	8,830	kWh/yr
Total CO_2 savings	4.6	t/yr
Regulated Clean CO_2 emissions	13.8	t/yr
Total Clean CO_2 emissions	28.6	t/yr
% Regulated CO_2 reduction	33.9	%
% Total CO_2 reduction	16.3	%


A hybrid PV Panel


A monocrystalline PV Panel


Thin film PV


A polycrystalline PV Panel

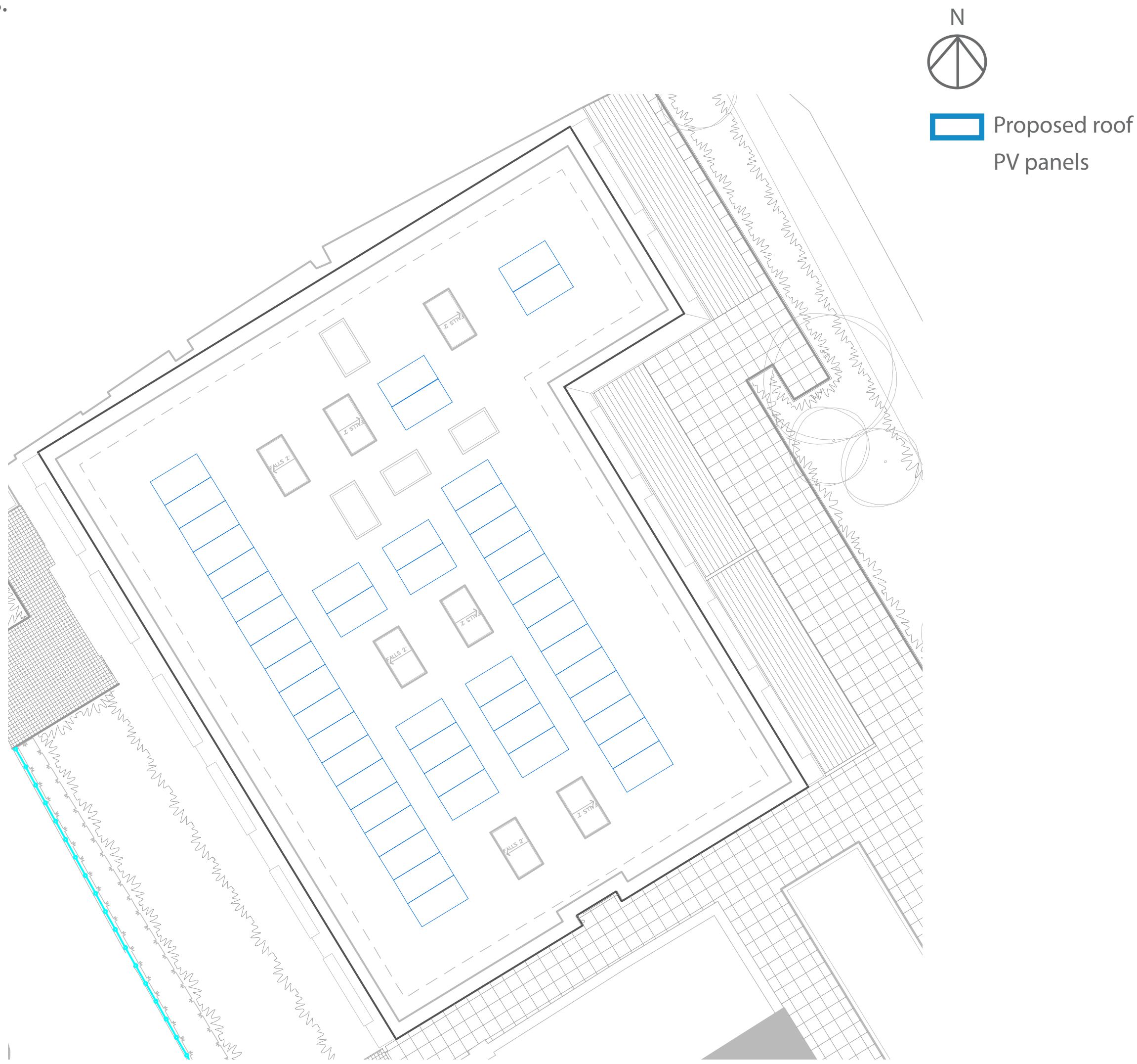
Location of PV Panels

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

- avoiding any potential overshadowing from plant rooms, stair and lift overruns, as well as adjacent buildings ;
- avoiding any potential overshadowing from adjacent PV panels;
- space required for maintenance including health and safety requirements for roof access;
- space required for mechanical over-runs and services.

A 60.5m^2 array of 19% efficiency PV modules, with a rated output of 11.5 kWp, would offset 33.9% of regulated CO_2 emissions after the Lean and Clean measures have been implemented.

It is recommended that all PV panels be mounted on the roof of the building to minimise shading of panels from their surroundings. A suggested roof PV plan is presented in the figure below.



Oak Grove - Proposed roof PV plan

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 in regulated emissions amounting to 40.2% when compared to a baseline scheme built to Part L Building Regulation (2010). The proposed Energy Strategy outlined in this document achieves a significant CO_2 savings for this development.

CO_2 Emissions Breakdown

	Carbon Dioxide emissions (tonnes CO_2 per annum)		
	Regulated	Unregulated	Total
Baseline building	15.2	14.8	30.0
After energy demand reduction	13.8	14.8	28.6
After energy efficient supply	13.8	14.8	28.6
After renewables	9.1	14.8	24.0

	Carbon dioxide savings (tonnes CO_2 per annum)		Carbon dioxide savings (%)	
	Regulated	Total	Regulated	Total
Savings from energy demand reduction	1.4	1.4	9.5%	4.8%
Savings from energy efficient supply	0.0	0.0	0.0%	0.0%
Savings from renewable energy	4.7	4.7	33.9%	16.3%
Total Cumulative Savings	6.1	6.1	40.2%	20.3%

Conclusion

In line with the London Plan three step energy hierarchy, the regulated CO_2 emissions for this development have been reduced by 40.2%, once energy efficiency measures and renewables are taken into account. This exceeds the 40% target set out in the London Plan 2011.

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 beyond building regulation requirements and the installation of high performance glazing. The implementation of these measures would potentially reduce regulated CO_2 emissions by 9.5%, when compared to a notional building built to current Part L Building Regulations (2010).

2. Be Clean - supply energy efficiently

The feasibility study showed that no district heating networks currently exist within close proximity of the site. Due to the limited number of units within the development, a CHP unit would not be an economically viable option for the development. The dwellings will be installed with individual high efficiency gas boilers for heating and hot water provision.

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 photovoltaics as the most suitable renewable technology for this development. The installation of 60.5m^2 of PV panels with a rated output of 11.5 kWp would potentially reduce regulated CO_2 emissions by a further 33.9%. Photovoltaics would be best suited to this development due to:

- the significant amount of CO_2 savings achieved;
- the amount of roof space available ;
- the ease of installation compared to other renewable technologies.

Regulated Carbon Dioxide Savings From Each Stage of the Energy Hierarchy

	Regulated CO_2 Savings		Total CO_2 Savings
	Tonnes CO_2 per annum	%	%
Savings from energy demand reduction	1.4	9.5%	4.8%
Savings from CHP	0.0	0.0%	0.0%
Savings from renewable energy	4.7	33.9%	16.3%
Total Cumulative Savings	6.1	40.1%	20.3%

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 at least 80% of the space heating and hot water demand to the communal heating scheme. This would be equivalent to a regulated CO_2 savings of 22.8%.

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

- 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

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

Biomass		
% of heating load supplied by biomass	100	%
Biomass System Efficiency	90	%
Carbon Intensity of Biomass	0.028	$kgCO_2$/kWh
Backup System Efficiency	90	%
Carbon Intensity of Backup	0.198	$kgCO_2$/kWh
Heating Demand Met	34,500	kWh/yr
Total CO_2 savings	6.5	t/yr
Regulated Clean CO_2 emissions	13.8	t/yr
Total Clean CO_2 emissions	28.6	t/yr
% Regulated CO_2 reduction	47.1	%
% Total CO_2 reduction	22.8	%

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°.

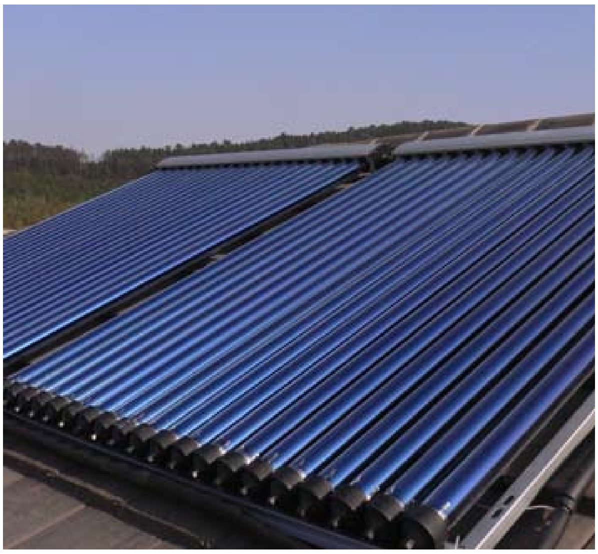
Solar thermal arrays are available as evacuated tubes and flat plate collectors. Evacuated tubes are more efficient, produce higher temperatures and are more suited to the UK climate in general when compared to flat plate collectors.

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 an optimum solar fraction of approximately 40%, 30m² solar thermal arrays would produce a regulated CO_2 saving of 18.1%.

The installation of solar thermal would require additional plumbing and space for hot water storage in each dwelling. This 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	Horizontal	
Predicted site solar energy	961	kWh/m²/yr
Solar fraction	40	%
Total collector area	30	m²
Primary gas energy offset by Solar Thermal system	12,800	kWh/yr
Total CO_2 savings	2.5	t/yr
Regulated Clean CO_2 emissions	13.8	t/yr
Total Clean CO_2 emissions	28.6	t/yr
% Regulated CO_2 reduction	18.1	%
% Total CO_2 reduction	8.7	%


An evacuated tube panel

Ground Source Heat Pumps

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 this system, to produce a regulated CO_2 saving of 14.5%.

This system 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 ground loops 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	
Carbon Intensity of Electricity	0.517	$kgCO_2$/kWh
Proportion of Space Heating met by GSHP	90	%
Proportion of Hot Water met by GSHP	25	%
Energy met by GSHP	22,100	kWh/yr
Energy used by GSHP	5,500	kWh/yr
Total CO_2 savings	2.0	t/yr
Regulated Clean CO_2 emissions	13.8	t/yr
Total Clean CO_2 emissions	28.6	t/yr
% Regulated CO_2 reduction	14.5	%
% Total CO_2 reduction	7.0	%

Example of GSHP borehole pipework.

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.

One benefit of ASHPs is that the system produces space heating and hot water through electricity, thereby negating the need for a gas connection to each unit.

The efficiency of heat pumps is very much dependent on the temperature difference between the heat source and the space required to be heated. As a result ASHPs tend to have a lower COP than GSHPs. This is due to the varying levels of air temperature throughout the year when compared to the relatively stable ground temperature. The lower the difference between internal and external air temperature, the more efficient the system.

ASHP		
COP Heat	3.2	
Carbon Intensity of Electricity	0.517	$kgCO_2$/ kWh
Proportion of Space Heating met by ASHP	90	%
Proportion of Hot Water met by ASHP	25	%
Energy met by ASHP	22,100	kWh/yr
Energy used by ASHP	6,900	kWh/yr
Total CO_2 savings	1.3	t/yr
Regulated Clean CO_2 emissions	13.8	t/yr
Total Clean CO_2 emissions	28.6	t/yr
% Regulated CO_2 reduction	9.4	%
% Total CO_2 reduction	4.5	%

The use of ASHPs for this development would result in regulated CO_2 savings of 9.4%.

In addition, the following issues may be of concern:

- ASHP evaporators would need to be located externally. Any noise associated with the units could potentially be an issue for the existing and any future adjacent buildings
- There is also insufficient space to house all the ASHP units on the roof and the position of the units externally is likely to have a significant visual impact

For these reasons, ASHP was not considered a feasible renewable technology for the site.

ASHP external unit

Wind Turbines- Not adopted

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 4.3m/s.

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

The results show that the CO_2 savings is minimal for the 2.5kW and 6.5kW wind turbines, offering 2.9% and 7.4% savings over regulated CO_2 emissions respectively.

In addition, the limited roof space and the significant visual impact on the building and its surroundings makes this technology inappropriate for this development.

A building-mounted 6kW Proven wind turbine

Wind Power - 2.5kW		
Average wind speed assumed	4.3	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	0.8	t/yr
Regulated Clean CO_2 emissions	13.8	t/yr
Total Clean CO_2 emissions	28.6	t/yr
% Regulated CO_2 reduction	5.8	%
% Total CO_2 reduction	2.9	%

Wind Power - 6kW		
Average wind speed assumed	4.3	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	2.1	t/yr
Regulated Clean CO_2 emissions	13.8	t/yr
Total Clean CO_2 emissions	28.6	t/yr
% Regulated CO_2 reduction	15.2	%
% Total CO_2 reduction	7.4	%