XCO2 ENERGY

Energy Report and Sustainability Statement

Energy | Sustainability | Renewables | Efficiency | Standards

4th August, 2008

9-23 Third Cross Road

Twickenham

Mixed Use Development

Carried out for

Barrett Lloyd Davis Associates LLP

XCO2 ENERGY

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Executive Summary

This report assesses the predicted energy performance of the proposed Third Cross Road development, based on the information provided by the design team. The scheme as designed meets the following planning requirements:

1 - CO_2 emission reductions beyond Part L through energy efficiency;
2 - 20% CO_2 emission reduction through renewable energy technologies;
3 - Code for Sustainable Homes Level 4 and BREEAM Excellent.

The design team have followed the three-step strategy, 'be lean, be green, be clean', to reduce the CO_2 emissions of the development. The new development will significantly reduce emissions by incorporating a range of energy efficiency measures throughout the site including efficient lighting, levels of insulation beyond the requirements of building regulations and high performance windows. Through implementing these efficiency measures, annual CO_2 is expected to be 12% less than if the development was built to current Part L building regulations. Once energy demand has been reduced, renewable energy sources will be used to further reduce CO_2 by 20.3%.

A variety of low carbon technologies and systems have been considered. Our conclusion is that the combination of a ground-source heat pump and solar thermal system is the preferred option since it would produce good CO_2 savings and both technologies are reliable and independent of fuel availability. The two technologies also work well in combination, as the solar thermal collectors meet part of the hot water demand, allowing the heat pumps to work at lower temperatures, and therefore at higher efficiencies.

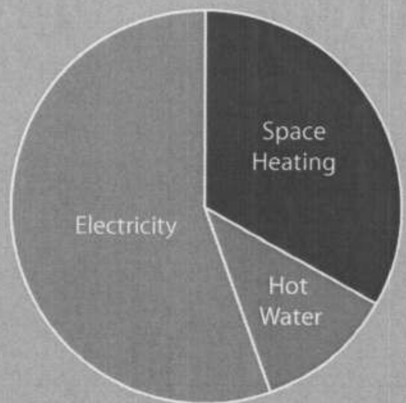
The system to be installed at Third Cross Road will consist of 35m^2 of solar thermal on the commercial building roof which will supply up to 50% of each dwelling's hot water energy requirements. Heat pumps will be installed in the plant room of the commercial building and will use energy from boreholes in the ground to provide space heating to be distributed to all rooms in the development via an underfloor heating system. This district system provides a flexible structure for energy generation to which emerging technologies could be added to in the future.

The second section of the report discusses how the development addresses broader sustainability issues, in particular how the development will meet the Code for Sustainable Homes Level 4 and the BREEAM Office Excellent sustainability standard.

The proposed energy efficiency measures reduce the overall CO_2 emissions of the development by approximately 12%.

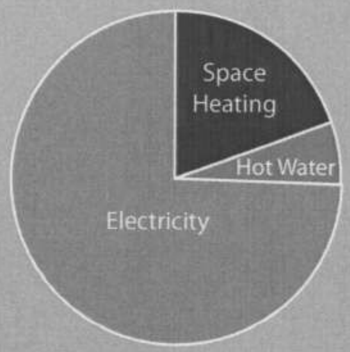
A further 20.3% of the development's CO_2 emissions are reduced through the ground source and solar thermal systems.

The total CO_2 reduction of the proposed scheme is 17.2 tonnes per year representing a 30% reduction over the same development built to current buildings regulations.



Baseline

Total CO_2 emissions: 57 tonnesCO_2/yr



Proposed

Total CO_2 emissions: 39.8 tonnes CO_2/yr

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Section A
Energy Report

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Contents

About us:
XCO2 Energy are a Low-Carbon Consultancy working in the Built Environment. We are multidiciplinary company comprising architects and engineers, with specialists including; CIBSE low carbon consultants, Code for Sustainable Homes Assessors, EcoHomes Assessors, BREEAM Assessors and LEED accredited professionals.

	Issue 01	Issue 02	Issue 03	Issue 04
Remarks	Draft 1	Draft 2	Final Issue	
Prepared by	TK	TK, RM	TK, RM	
Checked by	RM	RM	RM	
Authorised by				
Date	14/07/2008	29/07/2008	04/08/08	

Introduction

The Third Cross Road development comprises two blocks: one residential block comprising 5 houses and 3 flats and one commercial block comprising 12 offices with a central access core.

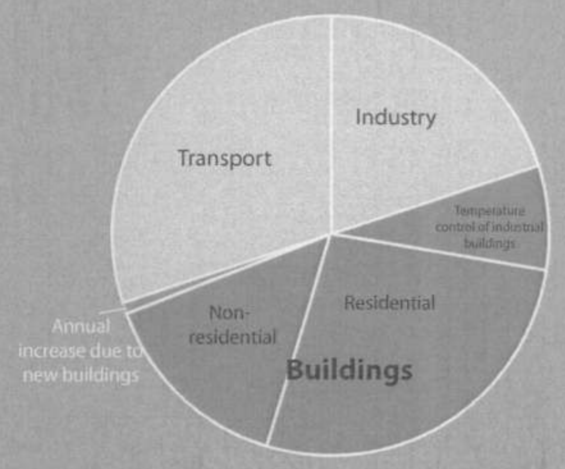
This document may be used to communicate to the Local Government and planning authorities the measures considered and selected for the proposed development, specifically with regard to energy efficiency, renewable energy, and low carbon technologies

In particular, the report addresses the Renewable Energy (pages 9 to 17) and Energy Saving (pages 5 to 8) sections of the Richmond Sustainable Construction Checklist. For details of how the development addresses the non-energy sections of the checklist, please see the Sustainability Statement.

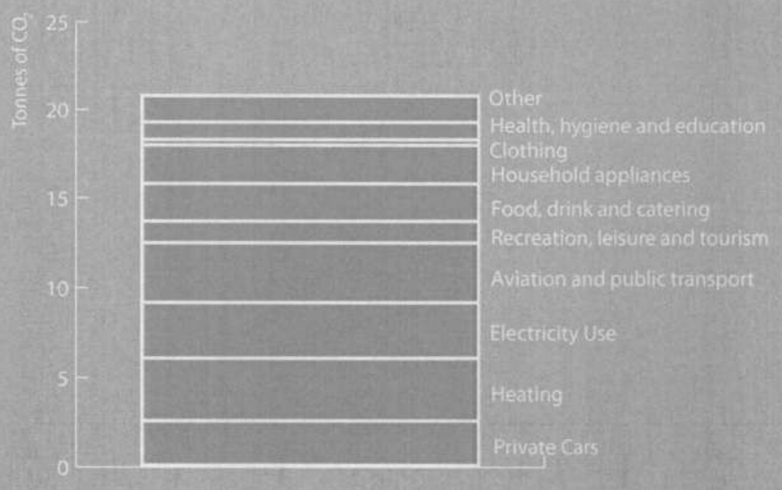
The development intends to fully comply with the revised London Plan. The major requirement of the plan covered by this report is to achieve a 20% reduction in CO_2 emissions from the use of on-site renewable energy generation technologies.

In line with the London Renewables Toolkit for Planners, Developers and Consultants, this report also addresses each of the three steps recommended in the London Mayors' Energy Strategy. Specifically:

- **Be Lean** - Improve the energy efficiency of the scheme (pages 5 to 6).
- **Be Green** - Offset a proportion of the remaining carbon dioxide emissions by using renewable energy technologies (pages 9 to 13).
- **Be Clean** - Supply as much of the remaining energy requirement with low-carbon technologies such as combined heat and power (pages 7 to 8).



Distribution of energy consumption in the UK
(Source: DTI Energy Statistics)



CO_2 emissions associated with household consumption
(Source: Defra Stockholm Environment Institute)

Energy

Our analysis used the methodology set forth in the Part L of the building regulations, by performing a preliminary SAP assessment, to calculate the baseline for the energy consumption of representative dwellings. From this, the approximate energy consumption for all dwellings to pass Part L has been calculated.

The preliminary SAP assessment has also been used to predict the energy consumption and CO_2 emissions of the dwellings after energy efficiency measures have been applied.

The commercial units have been modelled based on naturally ventilated open plan office space as per the Building Benchmarks section of CIBSE Guide F Energy Efficiency in Buildings. An additional 20% reduction in space heating demand has been used as an estimate of what improvement efficiency measures should achieve.

Our calculations demonstrate that CO_2 emission reductions of 12% are possible through the use of the following energy efficiency measures:

- Improving the building fabric
- Reducing air infiltration
- Passive design features
- Low energy lighting

Heat Loss

By reducing heat loss though the fabric of the building during the heating season, the energy required for space heating is minimised. The heat loss through the different elements of the building is dependent upon the U-value of that element. The development will achieve the following U-values by incorporating good levels of insulation.

- External Walls - 0.15
- Ground Floor - 0.15
- Roof - 0.15
- Windows - 1.20

Infiltration heat loss occurs through small gaps in construction elements where heated internal air is able to pass through the envelope of the building. Infiltration losses occur mainly around the edge of apertures (doors and windows) and through construction junctions.

Although infiltration cannot be eliminated altogether from the buildings, it will be minimised through ensuring good construction detailing and using best practice construction techniques (e.g. ensuring a constant unpunctured vapour control layer, robust detailing at critical junctions). Current Part L building regulations set a maximum air permeability of 10m3/m2 at 50Pa, through adopting good practice construction techniques, the development is likely to improve upon this to achieve $7m^3/m^2$ at 50Pa.

	Residential (from SAP)		Commercial (from benchmarks)		Total Proposed
	Part L Compliant	Proposed	Good Practice	Proposed	
Hot Water (kWh/yr)	26,560	25,020	6,410	6,410	31,430
Space Heating (kWh/yr)	38,130	26,100	57,660	46,130	72,230
Electricity (kWh/yr)	29,450	26,980	43,790	43,790	70,770
Total Energy (kWh/yr)	94,132	78,100	107.860	96,330	174,430
Total CO_2 (tonnes/yr)	25	21	32	29	50

Passive Design

Passive design is the use of techniques that help to minimise overheating in the summer and to retain heat in the winter.

Natural Ventilation

The development will avoid the need for energy intensive artificial cooling through the design of a natural ventilation strategy for all floors. The strategy includes:

- Cross ventilation: The dual aspect design of all houses, flats and office units and a few of the apartments allow for cross ventilation where windows are positioned on opposing walls.
- Single-sided ventilation: Openings at the bottom and top of the windows generate convection currents which create turbulence in the remainder of the room.
- Background Ventilation: Trickle vents on all windows help to provide background ventilation in winter without excessive heat loss.

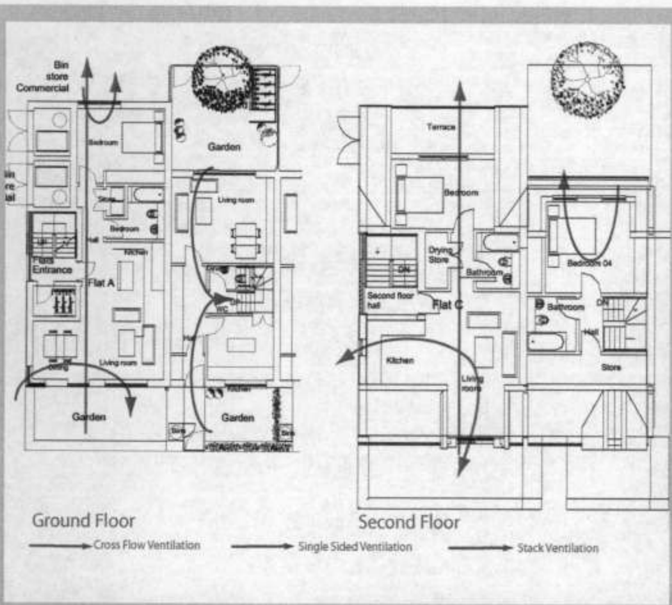
Daylighting

The development has been designed to ensure daylight levels are good whilst ensuring excessive solar gain does not cause overheating. This will help to avoid the use of energy-intensive artificial lighting. Initiatives include good window sizing and the light colouring of interior walls to reflect light into rooms. The offices will benefit in particular from the good daylight levels due to their long hours of use throughout the day combined with large windows.

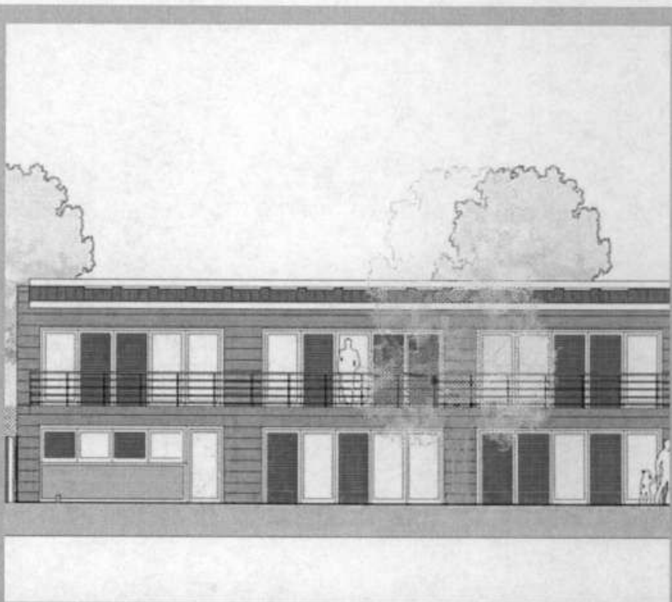
Overheating

The solar shading strategy has been developed to carefully shade the buildings from southwest-facing sun, to which the buildings are particularly vulnerable given the site layout. Horizontal overhangs and canopies are placed over southerly windows in order to greatly reduce the amount of direct solar radiation incident in the buildings.

The large amount of green areas on site will also help reduce the heat island effect and to reduce peak temperature through evaporative cooling.



Natural ventilation in flats and houses



Windows shaded by canopies

Efficiency

The development incorporates measures and systems to ensure that energy is efficiently generated, distributed and used within the development. Features considered include: low energy lighting, community heating, combined heat and power and heat recovery ventilation.

Low Energy Lighting and Control

100% of lighting will be specified with dedicated low energy lighting fittings throughout the buildings, to hold only compact fluorescent (CFL's) or fluorescent luminaries. The fitting of 100% low energy lighting goes beyond the Part L requirement of 30% dedicated low energy luminaries and will help to reduce the electricity demand of the development.

Any external security lighting is to be fitted with PIR sensors, have daylight cut off devices and will have a maximum wattage of 150W. Internal areas of infrequent use will be fitted with occupant sensors, whereas day lit areas will receive daylight sensors.

Community Heating

The development will incorporate a community heating system, which has the potential to increase the efficiency of on-site heating usage and generation by evening out load variations.

Heat, in the form of hot water, will be distributed from a central plant to customers via super insulated underground pipes. The heat will then be transferred via a plate heat exchanger in each dwelling's closed loop heating distribution system. Pulsed heat meters will then calculate the heat energy used by each apartment or house.

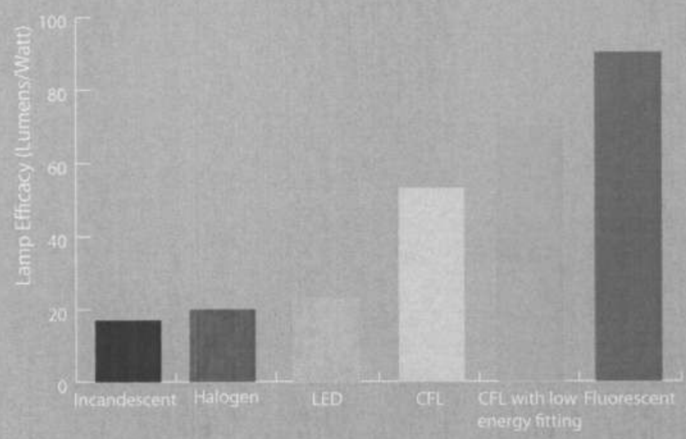
The supply of energy could come from renewable sources, such as biomass, geothermal, or anaerobic digestion of waste for more details of the system likely to be used see the renewable strategy later in the document. The local supply of heat minimises distribution losses, giving greater efficiencies and lower CO_2 emissions.

Combined Heat and Power

CHP, or Cogeneration, is the production of electricity and useful heat from a single plant, improving the overall efficiency of energy conversion from between 25-35% to around 85%.

Calculations (shown below) were carried out to determine the potential CO_2 saving by incorporating CHP into the developments energy strategy. It is important to note that the London Plan does not accept CHP under their renewable energy requirement, but an analysis of this option is required.

For Third Cross Road, the daily loads are expected to be concentrated at peaks when hot water use is



Efficacies for different lamp types

Gas CHP	
Proportion of heat supplied by CHP	35 %
Split (CHPe/CHPt)	0.6
Total CHP Efficiency	85 %
Backup System Efficiency	90 %
Heating Demand Met	32,650 kWh/yr
Electricity Demand Met	29,590 kWh/yr
Total CO_2 savings	3.4 tonnes
Percentage CO_2 reduction due to Gas CHP	6.8 %

highest, with a small base load. A CHP system for this development would require a thermal store to ensure that the unit is running at full load for as much of the year as possible. During the summer, when no space heating is required, the CHP will rarely run.

The CHP system would feed into a community heating system with the electricity being used to supply a small proportion of the development's electrical demand.

Due to the small base heating load and peak nature of the heating demand CHP was rejected for the site. CHP technologies with CO2 reductions of any significant are not currently available at this scale.

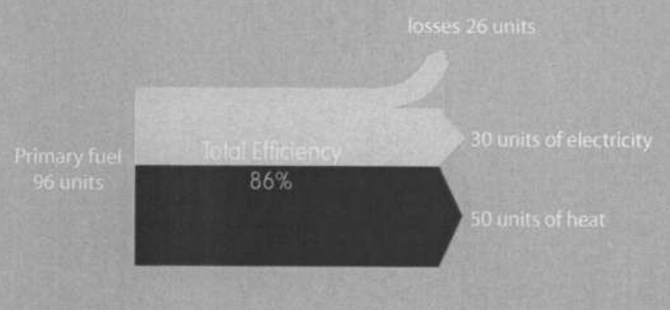
CHP systems can be combined with absorption chillers in summer months allowing the system to provide heating, electricity and cooling as required throughout the year, this is known as tri-generation. Since the commercial space will be naturally ventilated, there will be no demand for cooling and therefore tri-generation was not considered any further for the project.

Biomass CHP was briefly considered for the scheme. However, this technology is still in its infancy and brings a number of cost and technological risks. Additionally, the predominantly residential type accommodation is unlikely to provide an appropriate load profile.

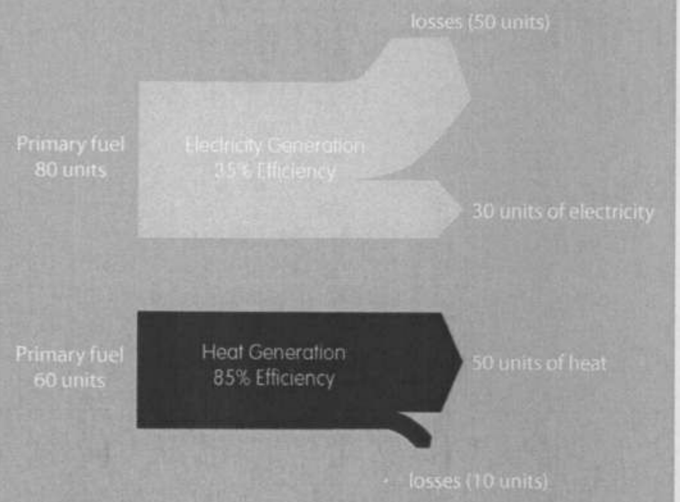
Heat Recovery Ventilation (HRV)

Up to 40% of a typical household's heating energy is consumed by conditioning of outside (fresh) air to a temperature suitable for the indoor space. HRV helps to reduce this energy demand by mechanically utilising the waste heat from the exhaust air without contaminating the supply air.

Since natural ventilation will be used, HRV will not be considered for ventilating either the offices or whole dwellings. Smaller HRV units will be considered for bathrooms and kitchens to recover heat from air extracted from these areas.



Community heating with CHP



Conventional Energy Network

Renewables

Once energy demand reductions has been minimised, methods of generating low and zero carbon energy can be assessed.

The 'Proposed' energy figures (see page 5) were used as the baseline for the comparison of the following technologies:

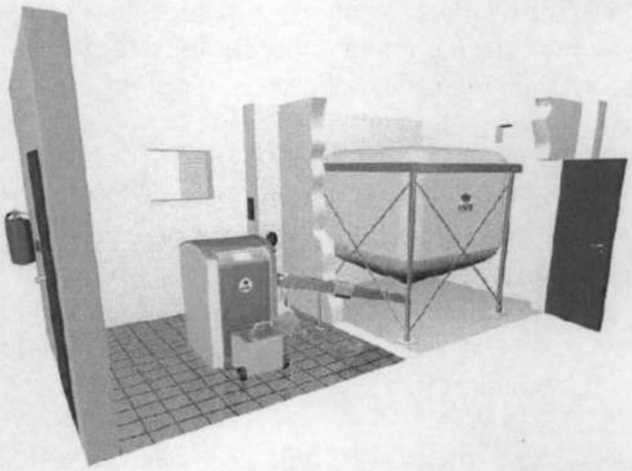
- Biomass
- Ground Source Heat Pumps
- Wind Turbines
- Photovoltaic Panels
- Solar Thermal Collectors

Each system has been sized where possible to meet the 2008 update to the London Plan, which requires new developments to reduce CO_2 emissions by 20% through the use of low carbon and renewable energy generation. This goes beyond the requirements of the Richmond Sustainable Construction Checklist which requires a 10% reduction.

A summary and comparison of the technologies is given on page 13.

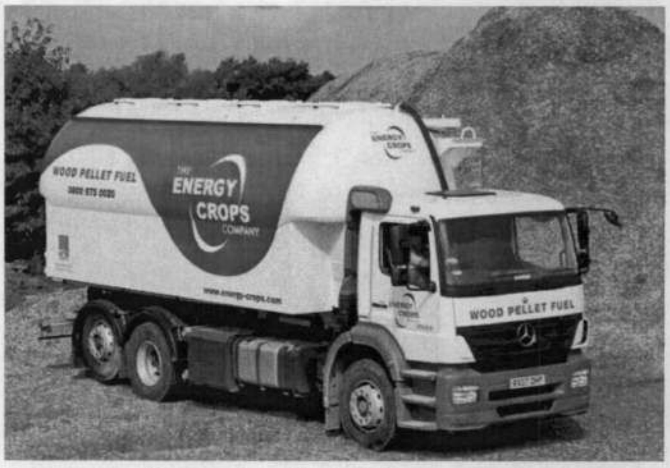
Biomass

A system recommended for the Third Cross Road development would be fuelled by wood pellets due to their higher energy content. Although pellets are more expensive than chips, they have a greater energy content per unit of weight and require a lower storage volume. This is important due to the development's limited plant space. Pellet boilers also require less maintenance and produce considerably less ash residue.



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

The biomass boiler will provide heat for a community heating scheme supplying a proportion of the hot water and/or space heating. CO_2 savings were analysed for two options: the system supplying only enough heat (57% of space and water heating) to meet the 20% CO_2 reduction requirement, and a system to supply the totality of the heating needs, generating CO_2 savings of about 35%.



Example of wood pellet delivery truck. Source: Energy Crops Limited

Whilst the first option will require a smaller biomass boiler, the cost of the boiler is only around 10%-20% of the whole system. The majority of the cost is in the distribution network, which would be necessary in both cases.

Although the CO_2 savings for Biomass systems are high, local air pollution can be an issue in urban areas of high density, such as Central London, due to higher NO_x emissions from burning wood fuels as well as exhaust fumes from fuel delivery trucks.

Biomass Option 1		
Biomass System Efficiency	90	%
Carbon Intensity of Biomass	0.025	$kgCO_2$/kWh
Backup System Efficiency	90	%
Carbon Intensity of Backup	0.194	$kgCO_2$/kWh
Heating Demand Met	53,173	kWh/yr
% of total heating load met by biomass heating	57	%
Total CO_2 savings	10	tonnes
Percentage CO_2 reduction due to Biomass System	20	%

Biomass Option 2		
Biomass System Efficiency	90	%
Carbon Intensity of Biomass	0.025	$kgCO_2$/kWh
Backup System Efficiency	90	%
Carbon Intensity of Backup	0.194	$kgCO_2$/kWh
Heating Demand Met	93,290	kWh/yr
% of total heating load met by biomass heating	100	%
Total CO_2 savings	17.5	tonnes
Percentage CO_2 reduction due to Biomass System	35	%

Ground Source Heat Pumps

Due to the relatively small site and large floor space area of the development, a borehole system rather than a trench system would be required for the site.

A system for the site would include boreholes with a closed ground loop (ground to water heat exchanger) where a liquid is passed round the system absorbing heat from the ground and relaying this heat via an electrically run heat pump into the building.

The system would respond to space heating, since this can be done through a low temperature efficient distribution network such as under-floor heating. If higher temperatures are required, the efficiency (coefficient of performance) of the system is dramatically reduced. Since domestic water is required to be heated up to 65°C to protect against legionella, it is not advisable to use a GSHP system to meet the entire domestic hot water demand. The system is capable of preheating domestic water from approximately 5°C to between 30 to 40°C the remaining heat required could then be provided by an efficient gas boiler.

Borehole being drilled

Between 2-4 boreholes will be required for the site, depending upon the ground conditions and borehole depth that can be achieved.

GSHP		
Coefficient of Performance	4.0	
Backup System Efficiency	90	%
Carbon Intensity of Electricity	0.422	$kgCO_2/kWh$
Carbon Intensity of Backup	0.194	$kgCO_2/kWh$
Heat Supplied	65,004	kWh/yr
Electricity Required	16,251	kWh/yr
Total CO_2 savings	7.2	tonnes
Percentage CO_2 reduction due to GSHP	14.3	%

A Vitocal Heat Pump

Wind Turbines

There is no appropriate space for a stand-alone turbine on the site. Therefore, building-integrated turbines were considered.

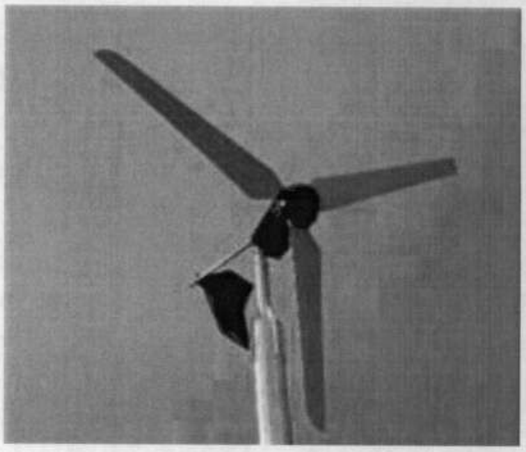
Wind turbine outputs are based on the mounting height, turbine wind curve and wind data for the site from the BERR website.

Calculations are shown below for 2.5kW, 6kW and 15kW turbines mounted at 15 metres above the ground on the roof of the office building to limit the aesthetic impact of the turbines on surrounding buildings. This location is also more likely to have consistently high wind speeds.

To achieve a 20% reduction in energy demand, the development would require 6 no. 2.5kW turbines, or 3 no. 6kW turbines or one 15kW turbine. The large quantity of small turbines required to meet 20% mean that the technology is not feasible on its own and would need to be combined with another renewable technology in order to meet the target.

If this option is pursued, issues of noise and vibration will need to be assessed in detail. Wind turbines should be mounted above building cores to minimise those issues. Alternatively, vibration isolation pads may need to be considered.

A building mounted 6kW proven wind turbine being installed



A 2.5kW Merlin wind turbine

Wind Power	
Annual energy output of 2.5kW turbine	3,684 kWh/yr
Inverter and transmission factor	0.88
Electricity offset by turbine	3,242 kWh/yr
Percentage CO_2 reduction due to one 2.5kW turbine	3.7 %
Annual energy output of 6kW turbine	9,134 kWh/yr
Inverter and transmission factor	0.88
Electricity offset by turbine	8,038 kWh/yr
Percentage CO_2 reduction due to one 6kW turbine	9.1 %

Wind Power	
Annual energy output of 15kW turbine	24,408 kWh/yr
Inverter and transmission factor	0.88
Electricity offset by turbine	21,479 kWh/yr
Percentage CO_2 reduction due to one 6kW turbine	24.4 %

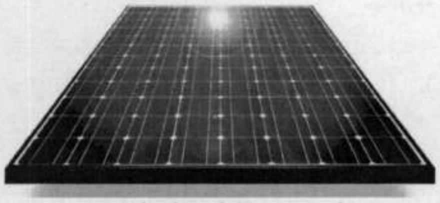
Photovoltaic Panels

Currently, there are four types of solar cells available: mono-crystalline, poly-crystalline, thin film and hybrid. Mono-crystalline and hybrid cells are the most expensive to produce but are the most efficient (12-18%), poly-crystalline cells are cheaper but their efficiency is lower (9-15%) and thin film cells are only 5-8% efficient but can be produced as thin flexible sheets.

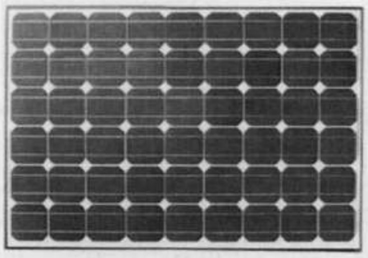
Photovoltaic panels are best orientated to the south and inclined between 30° and 40°. If specified, panels will be placed on south sloping buildings' roofs and, if required, would be inclined to the optimum angle through the use of a mounting frame.

A hybrid panel system sized for the Third Cross Road development would cover about 118m² to produce approximately 18,500 kWh/yr generating 10% of energy for the development.

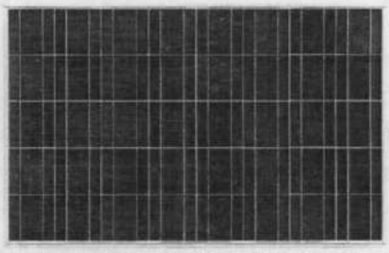
As their is insufficient space on the residential roofs for the required panel area, the panels would have to be mounted on the commercial space roof.



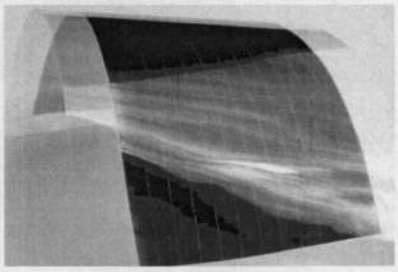
A hybrid PV Panel



A monocrystalline PV Panel

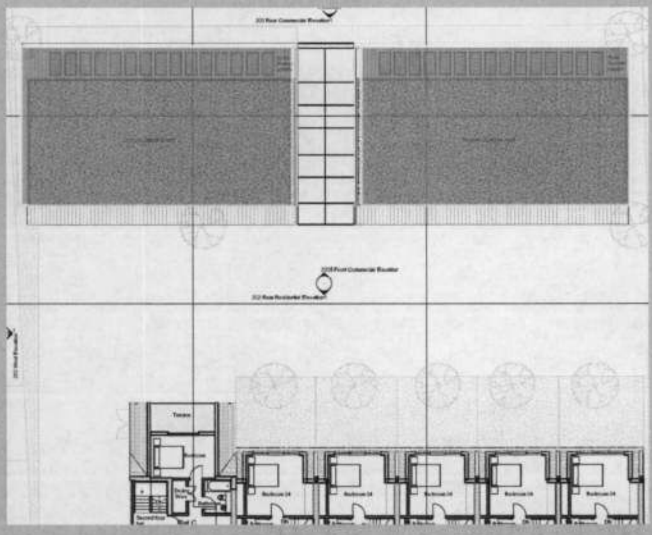


A polycrystalline PV Panel



Thin film PV

Photovoltaic Panels	
Panel Type	Hybrid Panel
Module Efficiency (before losses)	17.2 %
Predicted site solar energy	986 kWh/m²/yr
Inverter losses	12 %
Array area	118 m²
Primary electricity offset by PV array	17,610 kWh/yr
Total CO_2 savings	10.1 tonnes
Percentage CO_2 reduction due to PV	20 %



Available roof area for PV

Solar Thermal

Solar thermal array acts in a similar way to PV arrays in terms of orientation and inclination. The best performance would come from south-facing arrays with an optimum inclination of about 35°.

Evacuated tube and flat plate collectors are both commercially available. Although more expensive than flat plate collectors, the higher efficiencies and higher temperatures of evacuated tube collectors make them a better choice for the UK climate.

The proposed system would be used for domestic hot water only, not space heating. It would supply approximately 50% of the annual hot water consumption (the maximum feasible due to seasonal variations), and would be topped up with natural gas water heating.

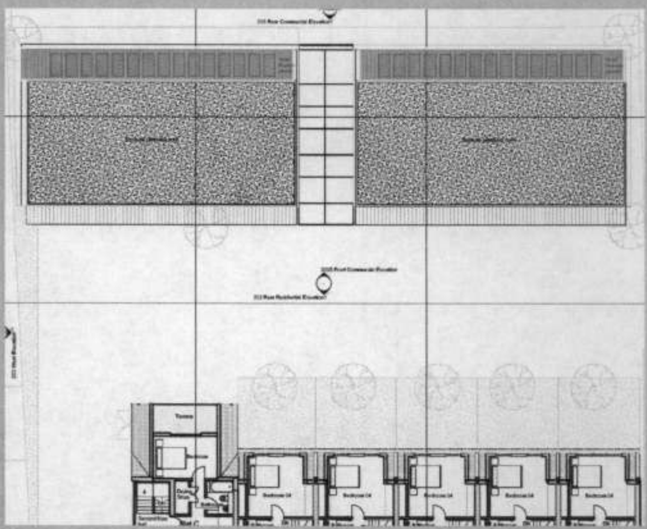
A system sized to meet 50% of hot water demand would include 35m² on the roof of the commercial section, above the plant room, to serve both buildings. CO_2 savings of 6% would be achieved which is not sufficient to meet the 20% target.

As their is insufficient space on the residential roofs for the required panel area, the panels would have to be mounted on the commercial space roof.

An example of an evacuated tube solar thermal module

An example of a flat plate solar thermal panel

Solar Thermal		
Collector Type	Evacuated Tube	
System Efficiency	40	%
Predicted site solar energy	986	kWh/m²/yr
Max allowable solar fraction	50	%
Total collector area	35	m²
Primary gas energy offset by Solar Thermal system	15,338	kWh/yr
Total CO_2 savings	3	tonnes
Percentage CO_2 reduction due to Solar Thermal	6	%



Proposed area for solar thermal collectors

Renewable Energy Summary

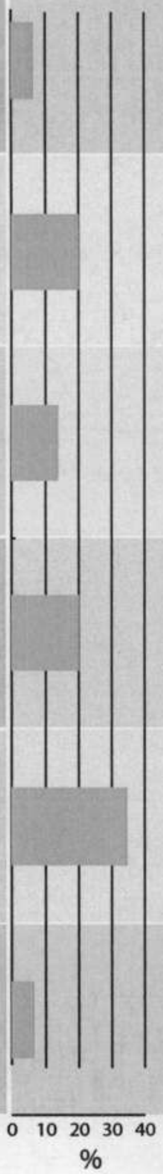
The below table summarises the renewable systems analysed and the different aspects taken into consideration, including: estimated capital cost, simplified payback, lifetime, level of maintenance and level of impact on external appearance.

The column relating to site feasibility indicates how feasible the technology is for the development (10 being the most feasible and 0 being unfeasible)

It is important to note that the information provided is indicative and costs are based upon the report, The Role of Onsite Energy Generation in Delivering Zero Carbon Homes, by The Renewables Advisory Board.

9-23 Third Cross Road

	% CO_2 Reduced	Capital Cost	Simple Payback	Tonnes CO_2 per year	Lifetime	Mainten-ance	Impact on External Appearance	Site Feasibility
Solar Thermal		£20-30k	10-15yrs	3.3	20yrs	Low	Med	8
PV's		£80-120k	20-30yrs	10.4	25yrs	Low	Med	7
GSHP		£60-90k	15-20yrs	8.3	20yrs	Med	Low	7
Wind		£50-80k	15-20yrs	10.4	25yrs	Low	High	6
Biomass		£20-40k	6-8yrs	18.4	25yrs	High	Low	6
CHP		£20-30k	12-18yrs	3.5	15yrs	High	Low	3



Solar thermal and a ground source heat pump were the selected technologies. The following is a brief summary of why other technologies were dismissed:

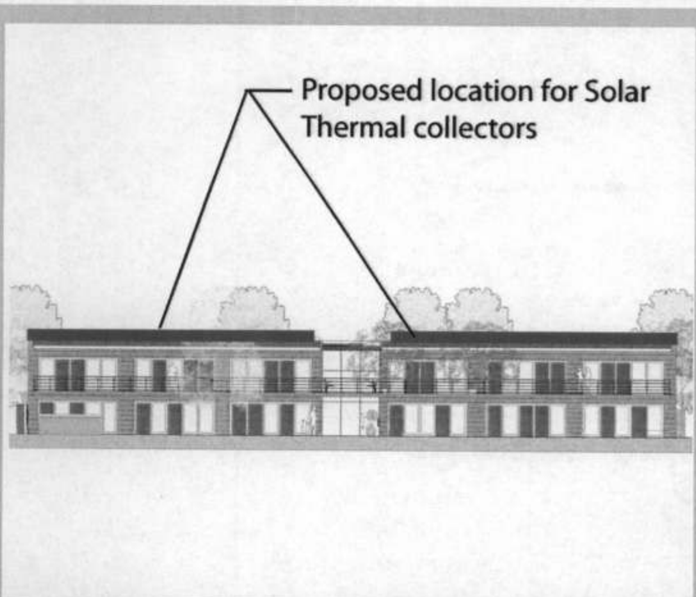
- Photovoltaics - the expense of a PV system did not fit within the budget of the project;
- Biomass - concerns over local air quality with currently available biomass boilers and security in supply of biomass pellet fuels ruled biomass out of the project;
- CHP - the lack of a consistent base heat load means that running a regular-size CHP engine would be uneconomical;
- Wind Turbines - the visual impact of wind turbines were felt to be undesirable for the project.

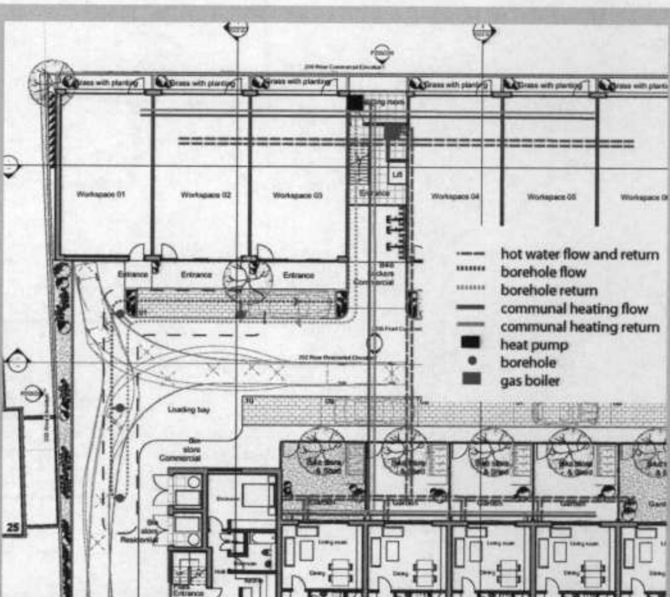
Renewable Energy Strategy

Due to the good CO_2 savings and low impact on external appearance, a GSHP system combined with solar thermal will be installed on site. The system will be sufficient to meet (and exceed) both the 20% renewables requirement and help towards the mandatory energy credit for the Code for Sustainable Homes Level 4 standard.

This system has the following advantages:

- Flexibility - a district system allows for emerging technologies such as Biomass CHP and Gasification of waste to be retrofitted in the future, providing the opportunity for further CO_2 savings (potentially Zero Carbon) and other sustainability benefits;
- The GSHP has no aesthetic effect on the external appearance of the site and surrounding areas;
- When combined, a 20.3% reduction in CO_2 of the entire development is likely to be achieved through installing the system;
- The solar thermal system will provide both CO_2 and free hot water during the summer months, which will significantly reduce fuel bills;
- Since the GSHP runs off electricity, as grid electricity becomes less CO_2 intense (i.e as large wind turbines and other low CO_2 grid generating technologies enter the national grid), the emissions of the project will also drop.



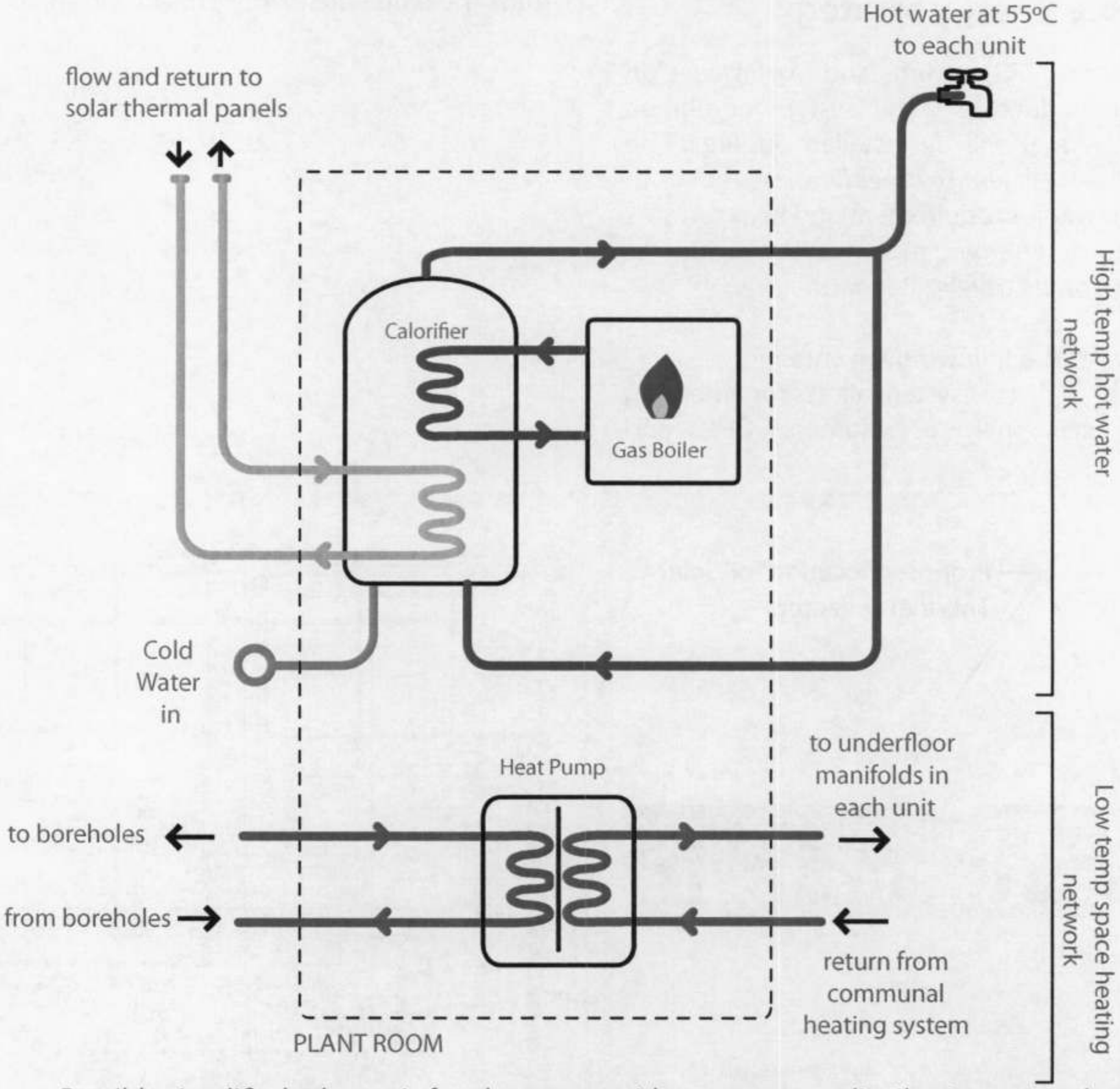


Possible locations and layouts for the renewable systems, to be detailed and confirmed later into the project

The GSHP system and solar thermal will be integrated as follows:

- A 35m² evacuated tube solar thermal system will provide approximately 50% of the hot water to all units and will be orientated to the south on the commercial block
- A communal thermal store will be located in the plant room and will be topped up by a efficient gas boiler to ensure that hot water is distributed at the required temperature.
- The hot water will be distributed to each unit through insulated pipe work around a communal hot water system
- A heat pump and borehole system will provide space heating to all rooms via a communal heating system
- Two heat pumps maybe required to ensure that as high a COP as possible can be maintained for as much or the time as possible
- The space heating communal system will consist of flow and return insulated pipe work feeding into underfloor heating manifolds in each unit
- Underfloor heating pipes controlled by thermostats in each room will distribute heat to each space

NB:
Details of the mechanical systems described within this report may change later in the development of the project as systems are detailed to the final construction stage. Energy calculations completed so far are based on the information available at this planning stage and should be revised as the design progresses.



Possible simplified schematic for plant room with two separate distribution network

XCO2 ENERGY

Section B
Sustainability Statement

Energy | Sustainability | Renewables | Efficiency | Standards

4th August, 2008

9-23 Third Cross Road

Twickenham

Mixed Use Development

Carried out for

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