FULCRUM CONSULTING

PROJECT OASIS

RENEWABLE ENERGY TECHNOLOGIES RECOMMENDATIONS

Issue B

Date 11 Dec 2007

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1. EXECUTIVE SUMMARY

This report identifies the suitable renewable technology for Project Oasis and demonstrates the energy production and associated CO_2 emissions savings in order to show compliance with LB Camden's policy SD9 which requires that low or zero carbon energy technologies are specified to provide 10% of annual energy demands for all new developments over 1000m^2.

The predicted baseline energy consumed by the proposed development (before energy efficiency and renewable energy are considered) is:

- 225,722 kWh per year.

The amount of carbon dioxide associated with this baseline is:

- 95,222 kgCO_2 per year.

Following analysis of benchmark data with assumptions of energy efficiency improvements, the 'Energy Efficient Baseline' consumption of energy is:

- 203,263 kWh per year.

The amount of carbon dioxide associated with this baseline is:

- 85,779 kgCO_2 per year.

The final stage of the analysis has assessed the options for using low or zero carbon energy systems to supply this building. The recommended renewable energy technology is:

- Ground source cooling via a closed loop borehole system to fulfil 50% of the cooling demand and 62.5% of the heating demand of the building.

The energy contribution from this technology is **14.8%** of the Energy Efficient baseline energy demands of Project Oasis. This corresponds with a **14.9%** CO_2 saving over the energy efficient baseline. The requirements of LB Camden policy SD9 have therefore been satisfied.

Due to the intrinsic uncertainties of soil conditions, the composition of which is only determined at a later stage through test drilling, a backup system should be proposed in case the ground conditions are found to be unsuitable for a ground source heat pump. As it has been found that no other renewable energy technologies are suitable for this site, it is proposed that an Air Source Heat Pump (ASHP) be used as the fallback technology to provide the same heating and cooling demands. This equates with an **11.5%** CO_2 reduction.

2. INTRODUCTION

Project Oasis will be assessed against the UDP requirements of London Borough of Camden. Specifically, this report will investigate the possibility of utilising renewable energy technologies on the site, and propose a solution to achieve at least a 10% reduction in CO_2 emissions from the use of renewable energy technologies, as required by Planning Policy SD9.

The energy requirements and resulting carbon emissions of the new buildings have been estimated using historical benchmarks. This does not constitute evidence of Part L building CO_2 emissions compliance which requires the submission of a building model such as iSBEM.

3. LB CAMDEN REQUIREMENTS

The relevant policy from London Borough of Camden's UDP (adopted June 2006) is reproduced below. This requires that major schemes (over 1000m^2) obtain at least 10% of their energy requirements from onsite renewable energy technologies. Conversations with the Planning Department have clarified that the 10% should also be presented in terms of a percentage reduction in CO_2 emissions, and be over and above any renewables included to obtain Part L 2006 compliance.

SD9 - Resources and energy

A - Air quality

Where the Council considers that development could potentially cause significant harm to air quality, applicants will be required to submit an air quality assessment. The Council will not grant planning permission for development that would significantly harm air quality, unless mitigation measures are adopted to reduce the impact to acceptable levels.

B - Water

In considering proposals for development, the Council will need to be satisfied that adequate provision can be made for water supply and waste treatment. The Council will only grant planning permission for development that it considers is sited and designed in a manner that does not cause harm to the water environment, water quality or drainage systems and prevents or mitigates flooding. The Council will require developers to include measures to conserve water and where appropriate incorporate Sustainable Urban Drainage Systems.

C - Use of energy and resources

The Council will seek developments that conserve energy and resources through:

a) designs for energy efficiency;
b) renewable energy use;
c) optimising energy supply; and
d) the use of recycled and renewable building materials.

The Council will require major developments to demonstrate the energy demand of their proposals and how they would generate a proportion of the site's electricity and heating needs from renewables wherever feasible. The Council may use conditions or planning obligations to secure recycling of materials on site and/or use of recycled aggregates in major schemes.

4. BUILDING EMISSIONS

4.1 BASELINES

The estimated annual energy demand of Project Oasis has been calculated using Fulcrum Consulting's experience and data from Energy Consumption Guide 19 (ECON19). The results of this benchmarking are described below. It should be noted that these are the results of calculations based on published benchmark data, and should not be used for Part L compliance purposes. A building energy model is required to demonstrate compliance with Building Regulations (Part L2A) after the detailed design stage has been completed.

The data used in preparing this energy options appraisal relates to predicted energy demands for the 'building in use' which includes demands from heating, cooling, auxiliary energy (fans and pumps etc), lighting and domestic hot water considered under Part L of the Building Regulations. ECON19 also reports the expected energy use from 'process' loads (office and catering equipment). The 'Part L' and 'process' loads are combined to capture the total energy demand of the development.

As currently there is no gas supply to the existing building, this assessment has been performed assuming no gas supply shall go to the new development. Thus, all heating and hot water production is taken from grid electricity.

4.1.1 Building Regulation Baseline

Camden's planning policy (SD9) requests that the development shows how energy demand reductions are achieved through increased efficiency, before on-site generation using renewable energy systems is considered. First an assessment is presented of the anticipated energy consumption of the building using historical benchmark data for building regulation compliant buildings. As no gas connection exists on the current site, it has been assumed the baseline heating would be electric and the baseline cooling would be via electric chillers. Subsequent heating and cooling technologies in later sections are measured against these.

Benchmark data to meet Building Regulations	**Office**
Floor area (m^2)	1,130
Predicted Energy Demands (kWh/yr)	225,722
Resulting CO_2 emissions ($kgCO_2$/yr)	95,255

NOTE: Displayed numbers have been rounded (which accounts for discrepancies in figures)

4.1.2 Energy Efficient Baseline

To illustrate that this building is being designed to exceed building regulations, a reduced benchmark energy consumption figure is calculated. This is known as the Energy Efficient Baseline. Typically buildings can achieve this through, for example, reducing U values of building fabrics, increasing construction standards to improve air tightness and through recovering heat in building services plant where possible. In producing this energy strategy document, before detailed design has been completed, assumptions have been made to account for the energy demand reduction anticipated of the completed design.

The following table shows energy demand figures and the carbon dioxide emissions associated with delivering this energy using non-renewable sources to supply building services plant (i.e. electrical chillers and gas boilers). The energy demand figures presented take account of the efficiencies of these systems.

Energy Efficient Benchmarks to exceed Building Regulations	Office
Floor area (m^2)	1,130
Predicted Energy Demands (kWh/yr)	203,269
Resulting CO_2 emissions ($kgCO_2$/yr)	85,779
Energy required for 10% (kWh/yr)	**20,327**
10% of CO_2 emissions ($kgCO_2$/yr)	**8,578**

NOTE: Displayed numbers have been rounded (which accounts for discrepancies in figures)

4. 2 REDUCTION REQUIREMENT FROM RENEWABLE TECHNOLOGIES

For a 10% reduction in building energy drawn from the national grid infrastructure, renewable energy technologies will need to reduce this demand by 20,277kWh/yr. The following sections of this report discuss the suitability of different renewable technologies to deliver this energy to Project Oasis.

5. RENEWABLE TECHNOLOGIES

5. 1 BIOMASS/BIOFUEL BOILERS

5.1.1 Description of Technology

Biomass boilers are similar to gas fired boilers except that they are specifically designed to burn biomass, typically in the form of woodchip, wood pellets, logs, or straw. Liquid biofuels can also be used.

Biomass boilers are most appropriate in areas where a local and secure source of fuel can be found. If the source of biomass is not local to the site there will be increased CO_2 released during transportation.

There are fuel sourcing issues which need to be addressed when considering biomass boilers. If using woodchip, a crucial issue is the moisture content, since this significantly affects the calorific value of the fuel. Generally a moisture content of 25% or below is recommended (fresh cut wood tends to have a moisture content of over 50%). Wet wood also needs a much larger storage facility and produces considerable quantities of water vapour in the flue gases, which can condense along with wood acids and corrode the plant.

A large area is required to store the biomass fuel, which needs to be located close to the boiler and be easily accessible to enable fuel deliveries. An efficient heating system will need a thermal store to even out many of the peaks and troughs of the heat demand against the constant boiler heat-output. For processed fuel systems such as woodchip or pellet, automatic transmission from the store to the boiler can be achieved, which can reduce the need to manually stoke the boiler and the size of thermal store required. Liquid biofuels are easier to store and movement of the fuel is easier.

There are a number of different types of biofuels; the most common at present are FAME (Fatty Acid Methyl Ester) and MWVF (Modified Waste Vegetable Fat). FAME is produced from oils from crops such as rapeseed (RPSO), and is the biofuel with the most intensive production method. The term biodiesel is commonly used to describe FAME. MWVF can be produced from an additive process in which waste vegetable fat is blended with natural solvents. Both FAME and MWVF can be used in standard diesel boilers with modified burners. A third type of biofuel is oil, such as filtered waste palm oil from restaurants/fast food outlets, which has hardly undergone any processing, but which requires greater modification to the boiler in order for suitable efficiencies to be gained.

At present FAME is commonly produced as a 5% blend transport fuel. Some companies will sell 100% biodiesel, but for use as a heating fuel prices are generally not competitive. The waste vegetable oil for production of MWVF can usually be sourced for free from restaurants/fast food outlets. At present MWVF is not normally available to be bought from an offsite manufacturer, but can be manufactured on site if a suitable contract can be set up.

The use of biomass is classed as an almost carbon neutral process because the CO_2 released during the burning of biomass is balanced by that absorbed by the plants during their growth. There will, however, be some CO_2 emissions relating to the planting, harvesting, processing and transportation of the biomass. Taking this into consideration, the nett CO_2 emissions from woody biomass is generally regarded as approximately 85% lower than those from using gas. Emissions from liquid biofuel fired boilers are more difficult to define due to the different fuel types available, but even the most intensively produced (FAME), if used as 100% biodiesel, would give CO_2 emission reductions of at least 50% compared to gas fired boilers.

5.1.2 Applicability to Project Oasis

Biomass boilers are a useful way to achieve significant CO_2 savings where space heating is required. There is one supplier of woodchip within 10 miles of Project Oasis – Longsan Limited who import pine briquettes from China.

For biomass/biofuel fired boilers to be a viable option, the site needs to be suited to the delivery regime required, and there needs to be sufficient space for a biomass store. Regular lorry deliveries of biomass throughout the year (but more often over the winter months) could also be a concern for neighbouring properties.

Biomass boiler plant requires regular servicing and the impact of this is not considered justified for a commercial office building with typically high power but low space heating demands. As the site is located adjacent to a railway tunnel with light conditional loading capacity, the delivery directly to the building is not possible, and would necessitate either blowing (solid biomass) or pumping (liquid biofuels) from Finchley Road. The road vehicle delivery of biomass to this building is not considered appropriate as this would result in temporary obstruction of the roadway each time fuel was delivered. In addition, the future cost of biomass fuel is uncertain. Therefore biomass boilers are not recommended for this office building.

5. 2 GROUND SOURCE HEATING/COOLING

5.2.1 Description of Technology

Ground source heating/cooling utilises heat pump technology. A heat pump is a device that moves heat energy from one place to another and from a lower to a higher temperature, or visa versa. Heat pumps are available as both heating only or reverse cycle heating/cooling systems and are classified according to the type of heat source and the heat distribution medium used, as described below.

Typical systems use a refrigeration cycle and use electricity as the energy input driving the process. They are generally more efficient for heating applications which use lower temperatures (such as underfloor heating). The efficiency of heat pumps is measured in terms of COP (coefficient of performance). The lower the temperature difference (seasonally) between the average source and sink temperature the higher the operational COP. Higher COP's mean lower CO_2 emissions.

Ground source heat pumps are typically water-to-water heat pumps. The COP of the system will depend on the source water temperature and the temperature to which it is being raised, but typically lies between 3 and 5.

There are many different variations of ground source energy systems available, but the main types involve utilising the natural thermal conditions of the ground, large bodies of underground water, or large bodies of surface water.

The earth absorbs a large proportion of incident solar radiation, which keeps the ground/groundwater in the UK at a stable temperature of around 11-12°C throughout the year. This is warmer than the mean winter air temperature and cooler than the mean summer air temperature. This heat/coolth can be utilised using a water-to-air or water-to-water heat pump connected to a ground heat exchanger, in one of the following combinations:

Closed loop ground coupled heat exchange

This is typically a network of pipes laid either horizontally or vertically in the ground, through which a liquid is pumped in a continuous loop. The low-grade heat contained within the ground is extracted via the liquid and can be converted to higher-grade heat (i.e. water temperature of 40-65°C) by a heat pump. In the summer, the cooler ground enables the extraction of cooler-than-ambient liquid, which can be used to cool buildings.

Open loop groundwater heat exchange

In this scenario borehole water is extracted for heat exchange as above and then rejected to a watercourse or the main drain. This technique is considered by many to be environmentally poor in terms of water utilisation, compared to a closed loop system, but generally has a higher COP. In the summer, the cooler-than-ambient groundwater can be used to cool buildings.

Open loop surface water heat exchange

This system uses surface water such as lakes and rivers for heat exchange and is likely to have a lower COP than an open loop groundwater system as the lake/river source is likely to be colder in winter and warmer in summer than a ground water source.

5.2.2 Applicability to Project Oasis

Horizontal ground source heating/cooling requires large areas of land under which to lay the pipework. Project Oasis does not have sufficient area associated with the building in which to dig horizontal trenches for pipework. At this site it may therefore be more practicable to use vertical ground source heating/cooling via a number of interconnected boreholes. This would take up less ground area, and is also a more efficient system.

Although ground source cooling systems run off electricity, vertical systems would be around 600% efficient in cooling mode. Electrical chillers perform at around 300% efficiency. Assuming a fuel cost of 6.8p/kWh for electricity, costs with an electrical chiller arrangement would be in the order of 2.3p/kWh delivered cooling. With a ground source cooling system, costs would be around 1.13p/kWh delivered energy. The maintenance requirements of heat pumps are also low; the below ground pipework requires no routine maintenance and the pump maintenance is similar to that of other commercial cooling plant.

Ground source cooling is more efficient than standard air-to-air cooling methods, and therefore ground source cooling is recommended to partially fulfil the requirements for cooling the offices. The use of this technology to provide space heating should also be used. It is recommended that the ground source heat pump provide 50% of the total cooling load, and 62.5% of the heating load. Although the annual heating load is larger than the cooling load, it has been estimated that the peak cooling demand is roughly 25% greater than the peak heating demand. Therefore the system should be sized based on peak cooling.

The following calculations demonstrate the potential carbon savings from the installation of the proposed ground source cooling system:

GSHP cooling	
Energy Efficient Baseline Energy Demands (kWh/yr)	234,909
Energy Efficient Baseline Delivered Energy (kWh/yr)	203,269
Site Heating and Cooling Demand (kWh/yr)	103,580
Site energy demand provided by GSHP (%)	25
Reduction against energy efficient baseline (kWh/yr)	30,261
Site energy demand reduced using GSHP (%)	14.8
CO_2 savings ($kgCO_2$/yr)	12,770
Energy Efficient Baseline for the site ($kgCO_2$/yr)	85,779
Equivalent CO_2 saving (%)	14.9%

Therefore it is recommended that ground source cooling via a closed loop borehole system is adopted for the offices to provide 50% of the cooling requirement and 62.5% of the heating requirement.

Ground Source Heat Pumps are not suitable for some site soil conditions, and certain structural limitations also apply. This site is located near to a railway tunnel, which may impact the placement of the vertical loops and constrain the design such that is pushed outside of practical limits. The design of a GSHP installation is inherently uncertain at the early stages, as the detailed system design depends on test drilling to determine the site specific subterranean conditions and how the implementation of ground loops could impact this soil. Therefore it must be understood that the system as proposed in this planning document is commensurate with indicative soil assumptions based on regional generalities. As such, a back-up system should be in place should the test results favour its exclusion.

5. 3 SOLAR THERMAL PANELS

5.3.1 Description of Technology

Solar thermal panels are generally used for the production of hot water and consist of roof mounted panels which can efficiently capture heat energy from the sun. In the UK, solar thermal panel systems can provide around 50-60% of the annual energy requirement for domestic hot water applications in dwellings. Summertime operation of the system is normally sufficient to meet full hot water demand, but in the winter supplementary heat from other sources is required.

As well as contributing to the hot water production in individual buildings, solar thermal panels can be used as part of a community heat network. The available roof area of buildings served may limit the amount of solar thermal panels that can be integrated into a particular scheme.

Two main types of solar water heating system are used in the UK: flat plate collectors and evacuated glass heat tubes. Manufacturers' figures show that in London energy produced from solar water heating is an average of 401kWh/m^2/yr for flat plate collectors, and 518kWh/m^2/yr from an evacuated tube system. For either type of collector, the most benefit can be gained if they are mounted facing within 45° of South, at an angle of around 30°. Other mounting positions are feasible, but output will be reduced.

Flat plate collector

Flat plate collectors circulate water around a black coloured receiver plate, which is heated by direct sunshine and to some extent by indirect light, with the heat retained by a thermally efficient glazed panel above. Flat plate collectors can be integrated into the roof system, giving the possibility of offsetting some of the cost of the collector against savings in roofing materials.

Evacuated glass heat tube

Evacuated heat tubes are more efficient than flat plate collectors, especially at the low solar radiation levels which occur in Britain; however they are also more expensive. They consist of rows of parallel transparent glass tubes, each containing an absorber tube. Sunlight enters through the outer glass tube and strikes an absorber tube, at which point it converts into heat energy.

5.3.2 Applicability to Project Oasis

Project Oasis is anticipated to exhibit typical office domestic hot water loads of approximately 5 litres per person per day. Assuming occupancy of up to 100 people (based on 1 person per $10m^2$), just 500 litres per day would be required. This demand is spread over the entire working day. Solar hot water collectors produce their peak outputs when the sun is at its highest point in the sky (i.e. approximately 3 hours before and after 12pm). Supplying an office with hot water from solar collectors involves storing warm water for extended periods of time, with associated risks where the water is held below 60°C; the temperature at which microbes can no longer survive.

No use of solar hot water is proposed for Project Oasis due to the relatively small impact this would have on overall emissions of the site and the problems associated with storing warm water for extended periods of time.

5. 4 WIND TURBINES

5.4.1 Description of Technology

Wind turbines capture wind energy and convert it to usable electricity. Turbines can be large, medium, small, or micro-scale depending on the situation and electrical requirement.

Two types of micro and small-scale turbines are currently commercially available, a conventional propeller blade turbine and a vertical axis turbine. Both these types of turbine can be mounted on buildings, and some makes have been developed specifically to work in low speed wind environments. Vertical access turbines are easier to accommodate in this way as they require less space, however for the same kW rating they generally provide less energy than propeller type turbines.

If there is adequate space on a site, ground mounted medium or large scale turbines may be appropriate. For a given investment, a larger turbine will produce a higher yearly output of electricity than a number of smaller ones. However, it should be noted that urban environments typically have low wind speeds and inconsistent wind direction, which reduces the potential for electricity generation.

Wind turbines by their nature generate a fluctuating supply of electricity. Typically this production rarely matches demand on a small-scale approach and the resulting situation is that energy is either being drawn in parallel from the grid or is being exported back to the grid. Exporting electricity to the grid requires electrical coupling systems to enable this to occur. Low export tariffs mean that for smaller turbines the additional investment in grid export capability has generally not been cost effective. However, export tariffs are set to become more inline with standard grid electricity charges, so the economics of this are changing.

5.4.2 Applicability to Project Oasis

Wind turbines could be used to supply electricity to Project Oasis if a suitable site can be identified The average windspeed at the site (at 10m above ground level) is 5.6m/s (from DTI Windspeed Database – see below.

DTI Windspeed Database
for the 1km grid square 526 185 (TQ2685)

Wind speed at 10m agl (in m/s)

5.7	5.9	5.5
5.3	5.6	5.1
4.8	5.0	5.0

Small wind turbines exist such as the 'Swift' from Renewable Devices which is rated at 1.5kW at 12m/s. This machine is design to be roof mounted. Each of these is expected to offset approximately 1500kWh per year at the reduced wind speeds of an urban location. Multiple machines of this scale would be required to produce the energy required to meet the 10% requirement of LB Camden.

A slightly larger 6kW vertical axis turbine such as the 'Quiet Revolution' from XCO_2 would achieve more significant CO_2 savings (around 4,500kWh/year for this scheme) and is considered more visually appealing by some people. This size of turbine is positioned on a mast at ground level, but is considered too large to be mounted on most buildings.

A medium scale turbine would only suitable for being positioned on ground-based structures (masts). A machine such as the Proven 15kW would be expected to produce 15,000 to 20,000kWh per year. This machine has a blade diameter of 9m and would need to be positioned on a 15m mast, making the total height 19.5m at the tip of the blade.

However, no land exists for a medium scale turbine at Project Oasis and there may be planning risk associated with proposing multiple, roof-mounted machines. Therefore they are not recommended to be part of the energy strategy at this stage.

5. 5 PHOTOVOLTAIC (PV) PANELS

5.5.1 Description of Technology

Photovoltaics are solar panels that generate electricity through photon-to-electron energy transfer, which takes place within the dielectric materials that make up the cells. PV's typically used in the UK can generate some electricity even on overcast days, although peak output is attained around midday on a sunny summer's day.

PV's offer a simple, proven, elegant solution to generating renewable electricity especially if incorporated as a building integrated photovoltaic array (BIPV), e.g. as part of a roof or façade. However, PV's are very expensive and may not pay back over the lifetime of the panels, even with grant funding. PV's may be grid-connected to export electricity to the grid if there is a surplus of electricity, although this may only prove economic for large arrays.

There are four main types of solar PV: thin-film, polycrystalline, monocrystalline, and hybrid. These are available in a number of different formats such as solar tiles which can be used as a direct replacement for roof tiles, standard panels, and glass laminates.

In the UK, the maximum total annual solar radiation is usually found at an orientation of due south and a tilt of 37 degrees. The typical annual output from an unshaded 1m^2 array in such a position is around 50-150kWh per year.

Most PV products have a lifetime of around 20-30 years. The on-going maintenance costs are reasonably low since there are no moving parts. However, the panels require inverter inspections and cleaning to eliminate deposited dust that reduces the efficiency of the system.

5.5.2 Applicability to Project Oasis

Project Oasis is taller than the nearby buildings suggesting there is likely to be good sun penetration to the site throughout the day with minimal shading to roofs, meaning that photovoltaic panels should be effective in their electrical output.

Unlike wind turbines, photovoltaic cells present little challenge in planning terms. They are unobtrusive structures that are static in nature making it easier to incorporate them architecturally. Photovoltaic arrays require very little ongoing maintenance and are cleaned using standard window cleaning equipment. Each square metre of active photovoltaic cells could produce 65kWh per annum lying nearly horizontally on the unshaded roof of the building. A 5° inclination is recommended to ensure that rainwater runs off the cell surfaces to reduce dust deposits and maintain cell efficiency.

Optimal inclination (providing maximum electricity production per unit area) is achieved at 37° to the horizontal. Various panels are available, but a typical product is 1.2m long, so stands 0.75m high when inclined at 37°. In this orientation (and facing south) the output from a typical panel is 53% greater than a flat panel, at approximately 100kWh per annum. The cost benefit in inclining PV arrays is clear.

The calculations below indicate the area of photovoltaic arrays that would be required to provide 10% of the site energy demands.

Photovoltaic Panels at 5° inclination	
Site Delivered Energy demands (kWh/yr)	203,269
PV output per m^2 active area (kWh/yr)	65
Area required for 10% of site energy demands (m^2)	313
Equivalent CO_2 savings (kg/yr)	11,555
% CO_2 off-set in this way	13.5
Photovoltaic Panels inclined at 37°	
Site Delivered Energy demands (kWh/yr)	203,269
PV output per m^2 active area (kWh/yr)	100
Area required for 10% of site energy demands (m^2)	203
Equivalent CO_2 savings (kg/yr)	11,555
% CO_2 off-set in this way	13.5

There is not adequate roof space for the 37° angled option due to spacing requirements to avoid shading. Self-shading is not considerable at low angles, and thus the 5 inclination can be fit. However, use of the roof for PVs precludes this space from housing other required equipment, and would likely necessitate a greater internal plant area. It is also highly likely that tree growth in the surrounding areas will shade the array.

Assuming a cost of PV of £1000/m^2, the cost of a system requiring approximately 200m^2 is £200,000. This is comparable to the GSHP option.

6. CONCLUSION

The renewables technology which is to be used to gain major CO_2 savings is a ground source heat pump. 50% of the cooling demand and 62.5% of the heating demand of the building is to be met in this way, to reach the total contribution of 14.8% to exceed LB Camden's policy SD9. The windspeed at the site is such that a wind turbine might be suitable for the location, however due to potential planning issues and the lack of available area to situate larger machines wind turbines have not been recommended at present. Biomass boilers have been ruled out due to the space that would be required to store fuel and the maintenance, fuel supply and ash removal issues. Photovoltaics are not proposed as the planning policy, as they would require large plant areas inside the building for the remainder of the mechanical equipment and are likely to be shaded by surrounding trees.

The overall energy production from the proposed renewable technology is shown in the table below:

Baseline Site Energy Demand	203,269kWh/yr
Energy reduction from GSHP cooling	30,261kWh/yr (14.8%)
Total Emissions reduction from GSHP	12,770kgCO_2/yr (14.9%)

The predicted **14.8%** reduction in energy consumption achieved through the proposed low carbon energy system exceeds the requirements of Camden's policy SD9. The corresponding reduction in CO_2 emissions from renewable energy technologies is **14.9%** of the predicted emissions from Project Oasis. Therefore this planning policy should be satisfied.

Due to the intrinsic uncertainties of soil conditions, the composition of which is typically determined at a later stage through test drilling, a backup system should be proposed in case the ground conditions are found to be unsuitable for a ground source heat pump. As it has been found that no other renewable energy technologies are suitable for this site, it is proposed that an Air Source Heat Pump (ASHP) be used to provide the same heating and cooling demands. ASHPs achieve lower COPs (a COP of 3 for both heating and cooling was used in this study) than the ground source type, and are not classified as renewable. They are however a low-carbon technology and can achieve substantial carbon savings. Their implementation as a back-up to the GSHP equates with an **11.5%** CO_2 reduction.

SCHEDULE OF REVISIONS

Issue	Date	Remarks	Prepared by	Checked by
A	10th May 2007	Issued for information	Dan Widdon	Jeff Anderson
B	11th Dec 2007	Issued for Planning	Christopher Eaton	Dan Widdon

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