Maplefield School

Sustainability Report, Renewable Energy Calculations & BREEAM Pre-Assessment

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1.0 Introduction

This report assesses the services requirements of the Department for Children, Schools & Families requirement for 60% reduction in Carbon Dioxide emissions from the maximum levels required 2002 approved document L2, and looks at various options for achieving the targets set out in the document.

In particular, the report considers the predicted energy element of the school, the degree to which the development meets current energy efficiency policies and to demonstrate the extent to which the proposal has taken account of the need to minimise the consumption of energy and achieve a minimum renewable energy level and required carbon dioxide reduction.

This report provides the calculations necessary to enable the services aspect of the Sustainability Statement to be assessed and answered. The assessment will be based upon the proposed building form and location together with construction and materials details.

Data on energy use and the possible contribution from low and zero carbon (renewable) systems will be taken from the government SBEM tool together with industry benchmarks and data published in the London Renewables Toolkit, published by the GLA.

The technologies available to provide reduction in CO_2 emissions and increase proportion of renewable energy used include the following which align with the supplementary planning document.

- Biomass Heating – (Oil seed rape, wood chip, wood pellet, etc)
- Ground Source Heat Pumps
- Ground Source Cooling
- Solar Thermal Water Heating
- Photovoltaics

Other Lower carbon Technologies

- Power Factor Correction Equipment,
- Lighting – Luminaires, lamp type, dimming, daylighting and control technologies
- Air Source Heat Pump (Natural Gas or Electric Powered),
- Natural Gas Fuelled Combined Heat and Power Plant.
- Lower energy equipment and systems.
- District Heating to move LZC generated heat.

The results for the preferred option are shown in this report.

2.0 Executive Summary

- The project is proposed to be served by natural gas fired CHP, Bio oil fired boiler(s), solar thermal systems and a PV systems in proportions and quantities to achieve the 60% carbon dioxide emissions reduction stated below.

- A full prediction of both energy and CO_2 has been carried out for both buildings, with the monitored level being the combined emissions for the site.

- CO_2 footprint iterations have been made in order to understand the impact of energy efficiency measure options and renewable energy technologies.

- Maplefield School site will satisfy the DCSF 60% reduction from **ADL2 2002** carbon dioxide emissions.

- A BREEAM Education 2008 Pre-Assessment Estimate has been made which indicates that a 'Very Good' rating will be achievable, with potential to achieve an 'Excellent' rating.

- The above heating solutions would be used in parallel to operate the radiant heating systems as required by the client and the production of HWS.

- The solar thermal systems would be used to further supplement the heating during warmer months

3.0 Predicted Energy Demand & CO_2 Reduction

3.1 Part L SBEM Calculations

The results of the Part L SBEM calculations for the building are summarised in the following tables:

Maplefield School. Summary of Building Services for
Part L2 Carbon Dioxide Emissions – 25.02.09

Main School Building (Floor Area 5,133 sq.m)

SBEM Calculation Options	Notional Rate kg/CO_2 m^2	TER kg/CO_2 m^2	BER kg/CO_2 m^2	L2A Criterion 1	Proportion of L2 2002 Maximum Carbon Dioxide Emissions
1) Standard Lighting, Natural Gas Fired Boilers, Building Regs 'U' Values Air Permeability to 10 $m^3/m^2/hr$	43.5	33.1	33.1	PASS	76.4%
2) Standard Lighting, Natural Gas Fired Boilers, Building Regs 'U' Values, Air Permeability Reduced to 7 $m^3/m^2/hr$	43.5	33.1	32.5	PASS	75.1%
3) Standard Lighting, Natural Gas Fired Boiler, Lower 'U' Values, Air Permeability Reduced to 6 $m^3/m^2/hr$	43.5	33.3	31.4	PASS	72.2%
4) Standard Lighting, Condensing Natural Gas Fired Boiler, Lower 'U' Values, Air Permeability 6 $m^3/m^2/hr$ BMS Metering of all electrical Services	43.5	33.3	29.1	PASS	66.9%
5) As above with Power Factor Correction added and 50 m^2 of solar thermal systems	43.5	33.3	27.9	PASS	64.1%
6) As above with 50 m^2 of solar thermal systems, N Gas Fired CHP providing 40% Heating/20% HWS	43.5	33.3	24.1	PASS	55.4%
7) As above with 50 m^2 of solar thermal systems, N Gas Fired CHP providing 65% Heating/35% HWS	43.5	33.3	21.9	PASS	50.3%
8) As above with 50 m^2 of solar thermal systems, Air Source Heat Pump (N GAS) replaces Boiler, N Gas Fired CHP providing 65% Heating/35% HWS	43.5	33.3	19.1	PASS	43.9%

SBEM Calculation options	**Notional Rate** $kg/CO_2\ m^2$	**TER** $kg/CO_2\ m^2$	**BER** $kg/CO_2\ m^2$	**L2A Criterion 1**	**Proportion of L2 2002 Maximum Carbon Dioxide Emissions**
9) As above with 50 m^2 of solar thermal systems, Air Source Heat Pump (Elec), N Gas Fired CHP providing 65% Heating/35% HWS	43.5	33.3	19.1	PASS	43.9%
10) As above with 50 m^2 of solar thermal systems, Ground Source Heat Pump (Elec), N Gas Fired CHP providing 65% Heating/35% HWS	43.5	33.3	19.0	PASS	43.7%
11) As 8) with 50 m^2 of solar thermal systems, **Air Source Heat Pump** (N GAS) replaces Boiler, N Gas Fired CHP providing 80% Heating/60% HWS	41.9	33.3	17.7	PASS	42.2%
12) As 8) with 50 m^2 of solar thermal systems, **Air Source Heat Pump** (N GAS) replaces Boiler, N Gas Fired CHP providing 80% Heating/60% HWS, 30 m^2 of PV systems, Daylighting Increased	41.9	33.3	17.4	PASS	41.5%
13) As 8) with 50 m^2 of solar thermal systems, **Air Source Heat Pump** (N GAS) replaces Boiler, N Gas Fired CHP providing 80% Heating/100% HWS, 30 m^2 of PV systems, Daylighting Increased	41.9	33.3	17.2	PASS	41.1%
14) As 13) with 50 m^2 of solar thermal systems, **Air Source Heat Pump** (N GAS) replaces Boiler, N Gas Fired CHP providing 80% Heating/100% HWS, 30 m^2 of PV systems, Daylighting Increased to central rooms	41.9	33.3	16.5	PASS	40.1%
15) As 14) with 50 m^2 of solar thermal systems, **Air Source Heat Pump** (N GAS), N Gas Fired CHP providing 80% Heating/100% HWS, 30 m^2 of PV systems, Obs rooms lighting levels reduced	41.1	33.3	16.4	PASS	39.9%
16) As 15) with 50 m^2 of solar thermal systems, **Air Source Heat Pump** (N GAS), N Gas Fired CHP providing **100%** Heating/**100%** HWS, 30 m^2 of PV systems, Obs rooms lighting levels reduced	41.1	33.3	16.4	PASS	38.7%

SBEM Calculation options	**Notional Rate** $kg/CO_2\ m^2$	**TER** $kg/CO_2\ m^2$	**BER** $kg/CO_2\ m^2$	**L2A Criterion 1**	**Proportion of L2 2002 Maximum Carbon Dioxide Emissions**
17) As 16) with 15 m^2 of solar thermal systems, **Air Source Heat Pump** (N GAS), N Gas Fired CHP providing **100%** Heating/**100%** HWS, **50** m^2 of PV systems, Obs rooms lighting levels reduced	41.1	33.3	16.4	PASS	38.2%
18) As 17) with 15 m^2 of solar thermal systems, **Air Source Heat Pump** (N GAS), N Gas Fired CHP providing **90%** Heating/**100%** HWS, **50** m^2 of PV systems, and roof lights to corridors.	41.1	33.3	16.0	PASS	38.9%
19) As 18) with 25 m^2 of solar thermal systems, **Bio Mass Boiler**, N Gas Fired CHP providing **90%** Heating/**100%** HWS, **50** m^2 of PV systems, and roof lights to corridors.	41.1	33.3	16.4	PASS	36.7%
20) as 19) Biomass boiler for Htg and HWS, Natural Gas CHP for 70% Htg and 70% HWS, 20 sq.m of solar thermal and 50 sq.m of PV.	41.1	33.3	15.43	PASS	36.3%
21) as 20) Biomass boiler for Htg and HWS, Natural Gas CHP for 70% Htg and 70% HWS, 20 sq.m of solar thermal and 25 sq.m of PV.	41.1	33.3	16.0	PASS	37.0 %
22) as 20) Air Source Heat Pump 50 sq.m of solar thermal and 100 sq.m of PV.	41.1	33.3	22.48	PASS	52.9 %
23) as 22) Air Source Heat Pump 50 sq.m of solar thermal and 250 sq.m of PV.	41.1	33.3	20.72	PASS	48.8 %
24) as 22) Air Source Heat Pump 50 sq.m of solar thermal and 600 sq.m of PV.	41.1	33.3	16.61	PASS	39.1 %
25) as 22) Air Source Heat Pump 100 sq.m of solar thermal and 600 sq.m of PV.	41.1	33.3	16.61	PASS	39.1 %
26) as 22) Air Source Heat Pump 40 sq.m of solar thermal and 600 sq.m of PV.	41.1	33.3	16.61	PASS	39.1 %
27) as 22) Air Source Heat Pump, Natural Gas CHP for 20% Htg and 50% HWS, 40 sq.m of solar thermal and 600 sq.m of PV.	41.1	33.3	14.77	PASS	34.8 %

SBEM Calculation options	**Notional Rate** $kg/CO_2\ m^2$	**TER** $kg/CO_2\ m^2$	**BER** $kg/CO_2\ m^2$	**L2A Criterion 1**	**Proportion of L2 2002 Maximum Carbon Dioxide Emissions**
28) as 27) Air Source Heat Pump, Natural Gas CHP for 20% Htg and 50% HWS, 5 sq.m of solar thermal and 400 sq.m of PV.	41.1	33.3	17.12	PASS	40.3 %
29) as 27) Air Source Heat Pump, Natural Gas CHP for 20% Htg and 50% HWS, 20 sq.m of solar thermal and 400 sq.m of PV.	41.1	33.3	17.12	PASS	40.3 %
30) as 27) Air Source Heat Pump, Natural Gas CHP for 20% Htg and 60% HWS, 5 sq.m of solar thermal and 600 sq.m of PV.	41.1	33.3	17.00	PASS	40.0 %
31) as 27) Natural Gas CHP for 100% Htg and 100% HWS, and 50 sq.m of PV.	41.1	33.3	15.73	PASS	38.3 %

Vocational Building (Floor area 1,512.51 sq.m)

SBEM Calculation options	Notional Rate	TER	BER	L2A Criterion 1	Proportion of L2 2002 Maximum Carbon Dioxide Emissions
	$kg/CO_2\ m^2$	$kg/CO_2\ m^2$	$kg/CO_2\ m^2$		
1) Standard Lighting, Natural Gas Fired Boilers, Building Regs 'U' Values Air Permeability to 10 $m^3/m^2/hr$	52.0	39.5	38.6	PASS	74.2%
2) Standard Lighting, Natural Gas Fired Boilers, Lower 'U' Values, Air Permeability Reduced to 7 $m^3/m^2/hr$	52.0	39.5	37.3	PASS	71.7%
3) As 2) above with improved lighting controls and air permeability reduced to 7.0	52.4	39.8	37.2	PASS	71.0%
4) As 2) above with improved lighting controls and air permeability reduced to 7.0, Condensing Natural Gas fired boiler	52.4	39.8	36.8	PASS	70.2%
5) As 4) Metering of all services added with out of normal range alarm and power factor correction added	52.4	39.8	35.0	PASS	66.8%
6) As 5) except Biomass Boiler and natural gas fired CHP 70% HTG and 70% HWS	52.4	39.8	30.6	PASS	58.4%
7) As 5) except Biomass Boiler and No CHP and 100 sq.m of solar thermal heating	52.4	39.8	27.0	PASS	51.5%
8) As 5) Biomass Boiler and 50 sq.m of solar thermal heating	52.4	39.8	27.9	PASS	53.2%
9) As 8) with Biomass boiler, 50 sq.m of solar thermal and revised roof lights	52.4	39.8	25.8	PASS	49.2%
10) As 8) with Biomass boiler, 50 sq.m of solar thermal and revised roof lights and HWS changed to Biomass	50.1	38.1	20.5	PASS	40.9%
11) As 10) with Biomass boiler, 50 sq.m of solar thermal and 30 sq.m monocrystalline silicon PV	50.1	38.1	19.2	PASS	**38.3%**
12) as 11) Biomass boiler, Natural Gas CHP 50% heating / 50% HWS, 25 sq.m of solar thermal and 30 sq.m monocrystalline silicon PV	50.1	38.1	19.74	PASS	**39.4%**
13) as 12) Biomass boiler, Natural Gas CHP 75% heating / 75% HWS, 25 sq.m of solar thermal and 30 sq.m monocrystalline silicon PV	50.1	38.1	19.93	PASS	**39.7%**
14) as 13) Biomass boiler, Natural Gas CHP 50% heating / 60% HWS, 30 sq.m of solar thermal and 40 sq.m monocrystalline silicon PV	50.1	38.1	19.32	PASS	**38.5%**

SBEM Calculation options	**Notional Rate** **$kg/CO_2\ m^2$**	**TER** **$kg/CO_2\ m^2$**	**BER** **$kg/CO_2\ m^2$**	**L2A Criterion 1**	**Proportion of L2 2002 Maximum Carbon Dioxide Emissions**
15) as 14) Biomass boiler, Natural Gas CHP 60% heating / 50% HWS, 60 sq.m of solar thermal and 40 sq.m monocrystalline silicon PV	50.1	38.1	19.1	PASS	**38.1%**
16) as 15) Biomass boiler, Natural Gas CHP 60% heating / 50% HWS, 30 sq.m of solar thermal and 25 sq.m monocrystalline silicon PV	50.1	38.1	19.93	PASS	**39.7%**
17) as 16) Natural Gas CHP 100% heating / 100% HWS, 40 sq.m monocrystalline silicon PV	50.1	38.1	20.00	PASS	**39.8 %**

3.2 Part L SBEM Analysis

Main School Building

The CO_2 national building emission is 41.1 kg CO_2/m^2pa. With the improvement factor and the LZC factor taken into account for Part L 2006, the required Building Emission Rate (BER) is nominally 16.0 kg CO_2/m^2 pa, which is nominally 61.0% lower than the notional 2002 Rate.

In order to meet the requirements of the DCSF and BB 102 the Building Emission Rate (BER) is required to be a minimum of 60% below the Notional 2002 L2 value as identified in 2006 L2A SBEM.

Through the utilisation of energy and efficiency measures of T5 lighting, improved building fabric and glazing 'U' values, together with the combination of gas fired combined heat and power plant, biomass heating or Natural Gas Fired Air Source Heat Pump, solar thermal hot water and photovoltaic panels, as the selected option the DCSF requirement can be achieved.

The CO_2 national building emission is 41.1 kg CO_2/m^2pa. With the improvement factor and the LZC factor taken into account for Part L 2006, the required Building Emission Rate (BER) is nominally 16.44 kg CO_2/m^2 pa, which is nominally 60.0% lower than the notional 2002 Rate.

Vocational Building

The CO_2 national building emission is **50.1** kg CO_2/m^2pa. With the improvement factor and the LZC factor taken into account for Part L 2006, the Building Emission Rate (BER) is nominally 20.0 kg CO_2/m^2 pa, which is nominally 60.2% lower than the notional 2002 Rate.

In order to meet the requirements of the DCSF and BB 102 the Building Emission Rate (BER) is required to be a minimum of 60% below the Notional 2002 L2 value as identified in 2006 L2A SBEM.

Through the utilisation of energy and efficiency measures of T5 lighting, improved building fabric and glazing 'U' values, together with gas fired combined heat and power plant, biomass heating, a small solar thermal hot water system and 40 sq.m of photovoltaic panels, the DCSF requirement can be achieved.

3.3 Site Wide Emissions Rate /

The two buildings emissions rate shall be combined to achieve a site average notional rate and also average BER for the two buildings.

Analysis of notional and BERs has been completed for both buildings and an average value has been calculated.

Main Building Notional Carbon Dioxide Emission rate 41.1 kg CO_2/m^2pa. (Floor Area 5133.4 sq.m) and the Vocational Building Notional Carbon Dioxide Emission rate 50.1 kg CO_2/m^2pa (Floor Area 1512.51 sq.m).

Weighted Average Carbon Emissions for both buildings (Notional Rate)

$$\text{Weighted Average Emission rate} = \frac{41.1 \times 5133.4 + 50.1 \times 1512.51}{(5133.4 + 1512.51)}$$

$$= 43.15 \text{ kg } CO_2/m^2 pa$$

Weighted Average Carbon Emissions for both buildings (Required Rate)

$$\text{Weighted Average Emission rate} = \frac{16.44 \times 5133.4 + 20.04 \times 1512.51}{(5133.4 + 1512.51)}$$

$$= 17.26 \text{ kg } CO_2/m^2 pa$$

Therefore the required average value for the site is 17.26 kg CO_2/m^2pa based on both buildings. The technologies fitted to the site maybe located on one or both of the buildings, as required for operational, design, architectural reasons. The carbon emissions rate for the site is 60% below the 2002 notional level, thereby complying with the BB 102 / DCSF requirement.

4.0 Renewables / Low Carbon Dioxide

4.1 Ground Source Heat Pumps

Heat pumps use refrigerant gases and an electrical compressor to take heat from a source and deliver it to an output. Chillers and refrigerators are examples of systems that remove heat, but other types of system use the heat removed from a source to heat a building. Traditional heat pumps use air as the source of heat. However, the ideal source for maximum efficiency would be one having a stable temperature and the ground provides such a source.

The ground acts as a huge solar collector and thermal store. The surface is warmed by the sun and the adjacent air during daytime and in the summer. Similarly it is cooled during night-time and in the winter. Fluctuations in ground temperature reduce with depth and stabilise at the annual mean for the location by about 12 m below the surface. Typically in the UK this temperature lies between 9^0C and 12^0C.

<u>Ground Source Heat Pumps</u>

Ground source heat pumps (GSHPs) make use of the heat stored in the ground at this relatively stable temperature of around 9^0C and 12^0C and raise it to a more useful output temperature of around 35-50^0C for use in heating buildings. These output temperatures are ideal for low temperature systems, eg under floor heating coils and radiant panels in most types of building.

Heat can be extracted from the ground either by a buried loop of pipework through which a refrigerant fluid (or water) is circulated, or directly be abstraction of ground water. With correct design, the depletion of the heat source is matched by the rate of heat flow back from the surrounding earth and under these circumstances the technology is a renewable source of energy.

Ground source heat pumps require an input of energy, usually electricity, but they can be very energy efficient, 'moving' up to 4 or 5 kW of heat output for every kW of electrical input. This ratio is known as the seasonal performance factor (SPF) or coefficient of Performance (C.O.P.). Heat pumps can also be operated in reverse to provide cooling.

Basically, there are two kinds of closed loop collector, horizontal and vertical. The horizontal collector consists of a sealed loop of pipework buried in a trench; the vertical loop uses a borehole which has been adapted to enhance heat transfer. The length of the horizontal loop and the depth and number of boreholes are determined by the size and use profile of the heat demand.

GSHPs are suitable for soil and rock types in most locations. Final output depends on the size of the loop, controls and the heat pump itself rather than on location.

In the UK at present, around 250 ground source heat schemes are being installed annually.

<u>Air Source Heat Pump</u>

Air Sourced Heat Pumps can also be used and although these are not always classed as renewable technologies, they can offer reasonable efficiencies with much reduced costs.

The heat pumps use external air as a heat source instead of ground cooled water. This makes the installation and location of units far more flexible, as they do not require connection to ground loops allowing installation at ground level or on roofs.

They are however restricted as the heat pump condenser/evaporator section requires outside air, thereby generally requiring the units to be installed externally and not inside the buildings. Installation inside buildings would require an external water cooled air / water condenser.

Carbon Savings

Where GSHPs are installed as an alternative to conventional (resistive) electric heating, carbon savings of 50-70% are achievable. In some circumstances, well designed GSHPs can result in reduced CO_2 emissions when compared with gas and oil fired boilers.

Cost Effectiveness

The capital costs associated with GSHPs are highly dependant on local conditions. The reliability of heat pump components is good, with expected lifetimes of 20 to 25 years. The expected lifetime for their ground coils is much longer, with warranties being offered for up to 50 years.

Capital costs are higher than for alternative systems, mainly because of the civil engineering costs associated with the ground coil.

Local Impact / Planning Considerations

Emissions, noise and vibration

Heat pump installations are pollution free and noise levels are generally low. There are no local emissions and, although there will be carbon dioxide emissions associated with their electricity use, these are much less than other forms of electric heating and can be lower than those associated with conventional gas or oil fired boilers.

Ground Source Heat Pumps with pumps have a typical C.O.P. of 4.0 and Air Source Heat Pumps with pumps have a part load seasonal C.O.P. of 3.0 including pumps.

Visual impact

Heat pump installations are unobtrusive. The technology used in ground source heat heating systems has very low visual impact and most of the infrastructure can be hidden beneath the ground.

Air source heat pumps use far more visible above ground condensing coils with are generally built into the heat pump unit. These can be located on roofs and hidden behind

Other

Typically, heat pumps are not highly visible and, as such, do not provide an obvious opportunity to promote the green credentials or image of their owners.

Complementary Technologies

All electricity-generating technologies based on renewable sources are also complementary as they can produce the energy required to drive the heat pump with maximum carbon savings.

4.2 Wind Turbines

Wind power can be used to generate electricity, either in parallel with mains supplies, gear or for stand-alone applications with battery back-up. In order to generate worthwhile quantities of electricity, average wind speeds of more than 5 - 6 m/s are typically required.

Wind turbines that are fitted directly to a building's structure are currently being developed, and stand-alone turbines on the site of buildings such as schools and supermarkets are not uncommon.

There are two basic kinds of turbine: horizontal axis and vertical axis. There are variations within these broad classifications. Horizontal axis turbines are generally more efficient, and most commercial models are of this type. These comprise a central hub supported on a tower with (usually three) evenly spaced blades, and rotate at an almost fixed rate, regardless of wind speed. Vertical axis systems can be installed without the need for a tower, and may be easier to integrate with a building's structure. Minimum speeds of 3.5-5 m/s are required to allow most turbines to cut-in, and turbines include power regulating devices which operate when wind speeds exceed a safe limit.

The best locations for wind turbines are away from obstructions which affect air flow, including any features of buildings which may have an affect on airflow. Wind speed increases with height, and so turbines often require masts or towers to take advantage of higher wind speeds and to avoid turbulence caused by the building structure. Ideal geographical locations include near hill tops and the coast.

Wind characteristics are specific to each location and initial evaluations of the feasibility of wind power at any particular site will require details of historic meteorological data.

Influencing Factors

Turbines are suitable in all locations although, for identical turbines, higher outputs will generally be achieved in rural or exposed locations where wind speeds are higher. In contrast, outputs tend to be lower in sheltered locations, or where air flow is altered by obstructions such as buildings, although hills can have a positive effect on airflow and concentrators are currently being researched which boost the wind speed near small scales turbines.

The availability of wind power is not confined to certain times of the day or year but some locations exhibit seasonal behaviours (coastal areas have particular sea breeze patterns), and are able to contribute to energy demand all year around. Similarly, wind power is more viable where night generation can be used or electricity can be sold back to grid.

Carbon Savings

A turbine located close to a build would typically have peak outputs of up to 10-20 kW. 6 kW is a common size for smaller buildings, and would typically be expected to generate around 10,000 kwh per annum, reducing carbon dioxide emissions by more than four tonnes. Alternatively, several smaller turbines could be installed on a roof to achieve a similar level of output.

Medium-sized turbines (~100kW) can be installed on the grounds of larger buildings or serve smaller communities.

Cost Effectiveness

Wind turbines are widely recognised to be one of the most financially viable of the renewable energy technologies. Further, the UK has one of the windiest climates in Europe, and is ideally situated to exploit wind energy.

For small scale, building integrated applications, simple payback periods of approximately 20 years can be achieved without grant funding. For larger installations the economics become more attractive.

Local Impact/Planning Considerations

Noise and vibration

Careful positioning of turbines and good design of rotors normally ensures that noise from turbines is not normally significant. Noise levels are generally low, and are often masked by wind-generated noise. Turbines can cause vibration, but this can be overcome by detailed evaluation during the development of any designs.

Visual impact

Wind turbines are highly visible, although often not unattractive. Building integrated turbines, with outputs of 6 kWe are typically around 5-6m in diameter. Vertical turbines usually have less visual impact than horizontal axis versions. Consideration may need to be given to reflections from moving turbines and shadow flicker but this effect depends on prevailing wind direction and turbine design.

Because wind speed increases with height, turbines are installed at the tops of buildings or on separate towers. For building integrated applications these are usually 10-20m above ground level.

Other

Planning permission will usually be required for building integrated or site-based wind turbines. Wind turbines are highly visible and, as such, provide an opportunity to promote the green credentials of their owners. They can also enhance the 'high tech' image of companies.

Complementary Technologies

Winters are usually windier than summer. This seasonal variation in the availability of wind energy counters that of solar energy. Photovoltaic technology is therefore a useful complementary technology for wind power, providing a spread of energy throughout the year.

4.3 Solar Thermal

Energy from the sun has been harnessed for thousands of years and peak solar radiation in the UK is around 1 kW/m^2.

Using specially designed mechanical systems, solar thermal systems can generate much more heat for space heating and hot water than passive solar alone.

Solar collectors, at the heart of most solar thermal systems, absorb the sun's energy and provide heat for hot water, heating and other applications in residential or commercial buildings. Modern systems are highly efficient.

There are two basic types of solar heating systems. Liquid-based systems heat water or liquid antifreeze in a 'hydronic' collector, whilst other systems are based on 'air collectors'.

Both systems collect and absorb solar radiation, then transfer the solar heat directly to the interior space or to a storage system eg hot water tanks), from which the heat is distributed. If the system cannot provide adequate heat, an auxiliary or back-up system provides the additional heat. Liquid-based systems are more often used when storage is required, and such storage will generally improve the viability of solar thermal installations by matching the availability of hot water to user demand.

There are several types of hydronic solar collectors but the two most common types suitable for buildings in the UK are:

- Flat-plate collectors: these are simple but effective devices, containing a dark plate within an insulated box with a glass or plastic cover.

- Evacuated-tube collectors: these are more sophisticated devices than flat-plate collectors, having higher efficiencies and being effective under a wider range of conditions, but are more expensive than flat-plate collectors.

The best locations in the northern hemisphere for solar thermal systems are on buildings with a roof or wall that faces within 45^0 of south. Buildings which face an easterly direction will benefit from the heat earlier in the day which can be an advantage where there are facilities to store heat. If the collector surface is in shadow for parts of the day, the output of the system decreases.

The availability of solar thermal is confined to daylight hours which change seasonally.

Carbon Savings

A solar thermal system providing hot water could save over 50% of the energy needed to supply hot water demand in a dwelling. The best performance is in summer, and some systems can almost deliver all of the heating and hot water needs for many building types during these months.

A typical domestic sized installation would have an annual output 1000-2000 kwh, reducing carbon emissions by 0.2-0.4 tonnes.

Cost Effectiveness

Solar thermal systems generally have payback times in excess of 10 years but actual figures depend on the system type, orientation, the availability of grants, and the fuel which they displace.

Local Impact

Noise and vibration

A solar thermal system is completely silent in operation.

Visual Impact

There are likely to be implications on their use in conservation areas and on listed/heritage buildings. Solar thermal systems are usually visible, although often not unattractive, and can be integrated within a building's cladding or roof structure.

Solar thermal systems are well suited to (unshaded) urban sites, being silent and clean in operation. Systems are usually visible and may help to promote the green credentials of their owners.

Complementary Technologies

Solar thermal systems work well with other renewable energy technologies that provide electricity, or systems which supplement their heat output during winter (eg biomass or ground source heat pumps).

4.4 Photovoltaic Arrays

As with solar thermal systems, PV use energy harnessed from the sun in the form of light (electromagnetic radiation).

Using specially designed control and inverter systems, at the heart of most solar thermal systems, absorb the sun’s energy and provide electricity to cover base building loads, with any spare allowed for resale to the local grid.

The systems collect and absorb solar radiation, produce direct current electricity, which requires conversion to produce alternating current electricity.

The alternating current electricity is then synchronised with the local grid supplied electricity and then fed into the main incoming switch board, for use in the building.

There are three main types of PV cells suitable for buildings in the UK, being moncrystaline, polycrystaline and amorphous type:

- Mono-crystaline, Poly-crystaline and amorphous type technologies, that use the same basic principles to convert light directly to direct current electricity, which need to be converted to alternating current and synchronised for use in building mains power services.

- Monocrystaline systems seam to be the most efficient.

- Flat-plate face: these give a similar appearance to flat plate solar thermal systems, containing a dark plate surface.

The best locations in the northern hemisphere for PV systems are on buildings with a roof or wall that faces within 30^0 of south.

Buildings which face an easterly direction will benefit from the heat earlier in the day which can be an advantage where there are facilities to store heat. If the collector surface is in shadow for parts of the day, the output of the system decreases.

The availability of PV electricity is confined to daylight hours, with the output varying throughout the year.

Carbon Savings

At present a PV system could reasonably provide enough energy to meet up to 10% of the annual artificial lighting load.

A typical domestic sized installation would have an annual output 100 - 200 kWh / sq.m of panel, reducing carbon dioxide emissions by 0.11-0.22 tonnes.

Cost Effectiveness

PV systems generally have payback times in excess of 35 to 40 years, but actual figures depend on the system type, orientation, the availability of grants, and the fuel which they displace.
The payback period will reduce with time as energy costs increase.

Local Impact

Noise and vibration

PV systems are completely silent in operation.

Visual Impact

There are likely to be implications on their use in conservation areas and on listed/heritage buildings. PV systems are usually visible however they have a lower visual impact than solar thermal systems. These systems although often not unattractive, and can be integrated within a building's cladding or roof structure.

PV systems are well suited to (unshaded) urban sites, being silent and clean in operation. Systems are usually visible and may help to promote the green credentials of their owners.

Complementary Technologies

PV systems work well with other renewable energy technologies that provide electricity, such as CHP, wind turbines or systems which supplement their electrical load throughout the year (eg pumps, lighting and also ground source heat pumps).

4.5 Combined Heat & Power (CHP)

4.5.1 General Description of the technology

Combined heat and power (CHP), or cogeneration, refers to the local simultaneous generation of electricity and heat in the form of hot water or steam. Electricity is generated using an engine or a turbine, and heat is recovered from the exhaust gases and cooling systems, CHP is most appropriate to buildings or sites which have 'round-the-clock' and year-round demands for heat. Hospitals, hotels and leisure centres with heated swimming pools are the most suitable building types.

CHP operates in parallel with the incoming mains, and its carbon emissions are much lower than for conventional electricity generating plant which 'dump' heat which cannot be put to good use. The overall efficiency of CHP plant can be more than 80% which compares favourably with 40% achieved at an average power station.

CHP has been highly cost effective in the years following de-regulation of the energy supply market (i.e. the 1990s), and its uptake has been encouraged by government policy initiatives and grant schemes. In recent years (2000-2004) the narrowing gap between gas and electricity prices has made the market difficult for CHP.

Almost any fuel can be used for CHP plant, natural gas (and gas from other sources such as landfill or sewage/waste processing) and fuel oil being the most common. Waste and biomass can be used, but there are currently few examples of this in the UK. There are significant differences in the equipment required for biomass CHP systems.

CHP is available in a wide range of outputs, serving sites ranging from a single building to a small town or district. Currently there estimated to be more than 1500 CHP installations in the UK. Micro-CHP is now available with outputs suited to the energy demands of an individual household, although the technology is new to the UK and it is less cost effective than larger scale installations.

The technology is especially suitable for buildings which have heat demand for a large portion of the day throughout the year. In order to be cost effective (and to have a major impact on carbon emissions) CHP plant should generally operate for a minimum of 4000-5000 hours each year. Hospitals are ideal sites for larger CHP installations as are some hotels, particularly those with heated pools. Leisure centres with heated pools and residential accommodation (such as student residences, Ministry of Defence accommodation, care homes and apartment blocks) can also be suitable for smaller installations.

4.5.2 Carbon savings

CHP can significantly reduce primary energy consumption, and can therefore have a major impact on CO_2 emissions associated with the combustion of fossil fuels in conventional power stations and boilers.

Each 1kW of electrical capacity provided by CHP plant using fossil fuels has the potential to reduce annual CO_2 emissions by around 0.6 tonnes compared to gas fired boilers and filly grid-derived electricity. For plant which is fuelled by renewable energy sources the potential is much greater.

4.5.3 Cost effectiveness

Capital cost for CHP installations are higher than for alternative systems, but this can be recovered over a relatively short period of time (typically 5-10 years) for installations where there is a demand for heat and power for 4500 hours or more each year. The cost effectiveness is very sensitive to the relative price of electricity and fossil fuel which have been subject to frequent variations since de-regulation of the energy supply industries.

The reliability of fossil fuel fired CHP is established and installations can have lifetimes of 15 years or more.

CHP plant can offset the cost of conventional boilers, but there will usually be a need to have standby heat capacity when CHP plant is idle.

4.5.4 Local impact/planning considerations

Emissions, noise and vibration.

CHP installations generate some noise but this can be significantly reduced by purpose designed acoustic enclosures. Engines will vibrate when they are operational but this is not usually problematic. Many small scale units come packaged in acoustic enclosures with anti-vibration mountings.

As with all combustion devices, they do release some carbon dioxide and other emissions, locally, but these are broadly comparable with emissions from conventional boiler plan (typically around 20-50% higher than a boiler system meeting a similar heat demand) although these local emissions are more than offset by the reduction in carbon emissions at power stations. Engines have higher nitrogen emissions than boilers or power stations, but these are produced in much smaller quantities than carbon emissions, and CHP is widely recognised as having a lesser environmental impact than conventional alternatives.

Visual impact

CHP installations are usually contained within boiler houses and plant rooms. Space and flue requirements may be slightly greater than conventional plant, but generally they are unobtrusive.

Safety

There are no specific safety concerns attributable to CHP installations that comply with legislative requirements.

4.5.5 Complementary technologies

CHP is complementary to most other LZC energy technologies. However the use of CHP can reduce the viability of separate installations which use low carbon technologies to deliver heating on a large scale (e.g. biomass boilers or large scale solar water heating), so an option appraisal may be necessary to see which is the best option.

Where low carbon technologies are used to support CHP (e.g. through the use of biomass to fuel CHP, or a district heating scheme to increase the use of heat recovered from CHP), the combination of technologies can have a significant impact on potential carbon savings.

4.6 Biomass Heating

4.6.1 General Description of the technology

Energy form biomass is produced by burning organic matter. Biomass products such as trees, crops or animal dung are harvested and processed to create bio-energy in the form of electricity, heat, steam and solid fuels.

Biomass is carbon based so when used as fuel it also generates carbon emissions. However, the carbon released during combustion is equivalent to the amount absorbed during growth, and so the technology is carbon-neutral (the fuel generally requires treatment and transport, with associated carbon emissions).

The main types of biomass are:

- Woody biomass: including forest products, short rotation coppice (SRC) (i.e. fast growing, regenerative woody species such as willow, hazel and poplar, miscanthus (elephant grass) and other wood waste such as pallets and construction/demolition wastes. The moisture content of the fuel, and most products require pre-drying before they can be used.

- Biofuel: cellulose and vegetable oil crops such as palm oil and rapeseed can be processed to create liquid fuel. This can be used as vechicle fuel, and to power engines including generating plant.

- Animal residue: cattle, chicken and pig waste can be converted to bio-energy by conversion to gas or other fuel types.

The potential for biomass in the UK is good, although a reliable and reasonably local supply of fuel from forestry farming or industrial sources is required. The government is committed to biomass because it is low carbon energy course and because of its potential to boot rural economies.

4.6.2 Carbon savings

Carbon savings attributable to the technology are significant. Biomass boiler installations can deliver all of the heating requirements for a building or development using an almost carbon neutral fuel source.

4.6.3 Cost effectiveness

Capital costs are higher than conventional systems and costs vary significantly from site to site depending on fuel type, heating infrastructure and the cost of a boiler plant. However, the technology is currently competitive when compared with oil fired or electrical heating, and in some cases with gas fired heating.

4.6.4 Local impact/planning considerations

There may be noise and vibrations associated with production and subsequent transport (via road or rail) of wood fuels, but generally not with the bio fuelled plant itself.

The visual impact of biomass is generally similar to that for conventional plant, although there may be special requirements for flues for some fuel types (e.g. wood) storage will be needed, and sometimes during facilities.

There are no particular health and safety concerns associated with the technology. Guidelines for the operation of biomass systems are generally as for other solid fuel appliances. There is a requirement to dispose of ash, but this is a minor concern in well commissioned equipment.

4.6.5 Complementary technologies

Where storage is available, biomass is available regardless of whether conditions, and so it works well with intermittent forms of renewable energy, particularly solar thermal energy. As with other types of boiler and thermal plant, biomass can be used to provide heating.

5.0 BREEAM Education 2008

Maplefield School shall be registered for BREEAM Education 2008 scheme, please refer to appendix for details.

A design stage assessment review has been carried out which indicated that a rating of ‘Very Good’ can be achieved.

Appendix A

Summary of Low Carbon Dioxide Emission Options

Outline and Detailed Proposals Stage - Summary of Low Carbon Dioxide Emission Options (60% based on 2002)

Option	System Type	Life Expectancy (Years)	Maintenance Frequency	Plant room	Advantages	Disadvantages	Costs £
A)	**<u>Site for Both Buildings</u>** • Air Source Heat Pump (ASHP) (N Gas) • Solar Thermal – 120 sq.m • PV = 720 sq.m	ASHP 15 to 20 PV 18 to 20 Solar Thermal 20 to 25	ASHP Medium Solar Thermal – Low / Medium PV - Low	<u>Internal</u> Associated pumps, plant and pipework <u>Roof/External</u> Solar thermal and PV Yes	Very high solar proportion / low fuel use. Future proofing using solar thermal and PV. Electrical generation on site	ASHP use refrigerants/ Maintenance very high. Cost of PV is very high and payback period very long – over 40 years	Very High
B)	**<u>Main Building</u>** • Bio Diesel Boiler • Solar Thermal – 20 sq.m • PV - 25 sq.m **<u>Vocational Building</u>** • Air Source Heat Pump • Solar Thermal – 50 sq.m • PV - 150 sq.m	Boiler 20 ASHP 15 to 20 PV 18 to 20 Solar Thermal 20 to 25	Boiler Medium / High Solar Thermal – Low / Medium PV – Low ASHP Medium Solar Thermal – Low / Medium PV - Low	<u>Internal</u> Associated pumps, plant and pipework <u>Roof</u> <u>External</u> Fuel storage	High solar proportion / lower fuel use. Future proofing using bio fuel and solar thermal. Local bio fuel supply. Dual fuel use Bio and Natural Gas	ASHP use refrigerants Fuel Deliveries Required. Boiler & ASHP high maintenance Cost of PV is very high and payback period very long – over 40 years	High
C)	**<u>Site for Both Buildings</u>** • CHP • Bio Diesel Boiler • District Heating • PV = 60 sq.m	CHP 10 Boiler 20 District Heating 35 to 40 PV 15 to 20	CHP – Medium / High Boiler – Medium District heating – V.Low PV – Low.	<u>Internal</u> Associated pumps, plant and pipework <u>Roof</u> PV <u>External</u> Fuel storage	On site electricity generation during heating from CHP & PV Allows movement of heat between buildings and future technologies connection. Future proofing using bio fuel Local bio fuel supply. Dual fuel use Bio and Natural Gas	Fuel Deliveries Required for boiler External fuel storage. CHP high maintenance/ replacement in 10 years Requires fuel use for operation / low solar proportion	Medium
D)	**<u>Site for Both Buildings</u>** • CHP (Natural Gas) • District Heating • PV = 90 sq.m	CHP 10 District Heating 35 to 40 PV 15 to 20	CHP – Medium / High District heating – V.Low PV - Low	<u>Internal</u> Associated pumps, plant and pipework <u>Roof</u> PV	No fuel deliveries required. On site electricity generation during heating. Lowest Cost option	Natural Gas dependant CHP high maintenance/ replacement in 10 years Requires fuel use for operation / low solar proportion.	Medium

Notes:

1 Above options are all to offset 60% of Carbon Dioxide emissions based on L2 2002 Notional Building emission rate for both buildings combined.
2 Costs shown are additional to associated general plant needed for systems, such as pumps, pressurisation units, pipe work.
3 Running Costs would be proportional to fuel used and maintenance requirements
4 All heating is based on wet under floor heating in all areas except toilets.
5 Heating in toilets provided by radiant panels and low U values.
6 Under floor heating flow temperature 40 to 45 ^{o}C, CHP / Boiler flow temperature based on 80 ^{o}C.
7. Life Expectancy of Technologies as below :

CHP	10 Years
Solar Thermal	20 to 25 years
PV	20 Years
Biomass Boiler	20 years
District Heating	35 to 45 Years