325 Milton Road, Cowplain
Energy Statement and Review of Renewables Technology

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EXECUTIVE SUMMARY

This Energy Statement has been prepared to address the planning requirements and submission for 325 Milton Road, Cowplain, Hants, regarding energy efficiency and an options apprasial of renewable energy technologies available.

Havant Borough Councils LDF has recently been issued, and under Policy CS14 of their Core strategy requires new developments to ensure that their on site renewable energy production is maximised and that residential development achieves Level 3 of the Code for Sustainable Homes.

The use of renewables has been fully assessed. However, the nature of this urban development, especially with regards to the compact and residential nature of the site, in addition to the high costs associated with them, preclude the use of many renewable.

Foreman Roberts, however suggest that a solar technology would be a good fit for this development, with Photovoltaics being put forward as the most effective strategy, since its benefits can be shared by all the dwellings, and it provides the greatest feasible carbon savings. It is therefore proposed that 15 No PV panels shall be provided on the roof at level 3, and that the adoption of this strategy would contribute approximately 3.9% of carbon reduction for the development.

1.0 INTRODUCTION

1.1 FOREMAN ROBERTS AND THE SUSTAINABILITY TEAM

This Energy Statement has been prepared to address the planning requirements and submission for 325 Milton Road, Cowplain, Hants.

Foreman Roberts Sustainability Team has had a long running involvement with energy strategies for different types of schemes for many years. Working with new policies such as the GLA's London Plan has created a new requirement for energy efficiency, which begins at the inception of a project, and runs through to successfully completed and operating buildings.

Building on the strong services design skills of Foreman Roberts the sustainability team are able to integrate 'holistic' building design and efficient services designs, which are fundamental to reducing base carbon emissions. Only then can site wide strategies and zero or low carbon technologies have a significant impact on overall development emissions. This approach satisfies the London Mayor's Energy Hierarchy:

1) To be Lean (to use less energy);
2) To be Clean (to use energy efficiently);
3) To be Green (to use renewable energy).

The company's intimate knowledge of servicing strategies for residential buildings coupled with an innovative approach to reducing carbon emissions ensures that solutions are practical and deliverable.

1.2 BASIC DESCRIPTION OF THE DEVELOPMENT

The proposed development consists of 25 self contained 2 bed apartments over 4 floors (Ground plus 3 floors). Each flat is provided with a private balcony.



2.0 REGULATORY AND PLANNING REQUIREMENTS

2.1 BUILDING REGULATIONS PART L – CONSERVATION OF FUEL AND POWER 2010

The UK has committed to cut emissions of various greenhouse gases, the most significant being carbon dioxide. This can only be achieved by the country wide adoption of more efficient energy use and the utilisation of renewable energy sources.

A new version of the Approved Document Part L1A (for new dwellings) of the Building Regulations came into force in October 2010, which considerably reduced the pass rate of carbon dioxide emissions. This development will need to meet the requirements of Part L 2010 and therefore will need to incorporate high levels of energy efficiency.

2.2 BUILDING REGULATIONS PART F – VENTILATION 2006

Building Regulations Part F sets down the minimum requirements to ventilate buildings adequately. These regulations will be followed throughout the services design for the project.

These regulations have been seen by some to be in conflict with the general requirement to reduce energy; as increasing ventilation rates for fresh air purposes can lead to increased energy to heat or cool incoming air for comfort requirements. However, with modern servicing strategies which incorporate high efficiency heat recovery equipment, the potential conflict between these two requirements can be readily mitigated. Wherever a significant volume of used air is being exhausted to atmosphere, the use of heat recovery will be considered to remove heat energy from outgoing air streams for transfer into incoming fresh air supplies, thereby saving significant primary energy demands for the buildings.

For residential properties whole house ventilation systems are a useful means of reducing energy demands, whilst providing background ventilation, especially during the heating season.

2.3 PLANNING REQUIREMENTS

Havant Borough Councils published their Local Development Framework in March 2011. This requires, under Core Strategy Policy CS14 Efficient Use of Resources:

> *Locally contributes to the delivery of the PUSH target of 100MW of renewable energy by 2020 for the whole of the PUSh area. Major developments must ensure that their on-site renewable energy production is maximised and resource efficiency is maximised.*
>
> And
>
> *On completion, meets the standard of Level 3 Code for Sustainable Homes for residential development.*

The Code for Sustainable Homes was introduced in December 2006, based on BRE's EcoHomes scheme, and was last updated in November 2010. From April 2008, it is now a requirement to 'rate' all new buildings in England and Wales. The assessment Code Level 3 is considered to be best practice for new housing, in order to comply with this level, the mandatory carbon dioxide emission rate must be in compliance with Part L 2010.

3.0 BASE CARBON REDUCTION STRATEGY

3.1 CARBON REDUCTIONS

Services design is at the centre of energy efficiency, but all too often, the bigger picture of holistic building design (be clean) is not applied at the inception of a building design. This leads to restrictions in later stages of the design, which prevent low carbon servicing strategies from being viable.

The design of the building itself, and the building envelope, ensures that energy use is minimised, with features such as optimised building fabric elements and glazing unit U-values. In addition, energy use is efficient due to the incorporation of features in the building services systems, such as high efficiency, low specific fan power, whole house ventilation units.

Only when passive design elements have been considered can low carbon systems become feasible without compromising comfort or functionality.

3.1.1 Passive Design Elements

The use of enhanced insulating materials, glazing and door seals to improve air tightness can significantly reduce the energy demand of the proposed building.

The following U-values and infiltration rates are being proposed which improve upon those allowed under Building Regulations Part L 2010, and therefore will provide high levels of energy efficiency.

Table 1: Proposed U-value and infiltration rates

Building Regulations Thermal Transmittance (U-Values)	
Wall:	0.25 W/m²K
Roof:	0.18 W/m²K
Ground Slab:	0.22 W/m²K
Glazing:	1.6 W/m²K
Building & Window Infiltration:	Maximum air permeability at 50pa differential pressure to be 5 $m^3.hr^{-1}.m^{-2}$

3.1.2 Services Strategy

The following measures will be included in the services strategy to reduce energy demand due to services:

Local Heating Controls: The apartment heating systems are provided by high efficiency condensing boilers and include time and temperature zone control to ensure that heating is not in operation when not required.

Heat Recovery: Whole house ventilation units with low specific fan powers are being proposed which recover 90% of the heat contained in exhausted air which pre-heats the incoming fresh air.

Energy Efficient Lighting: A minimum of 50% of light fittings within the apartments will be low energy to maximise energy efficiency and reduce the energy required for lighting.

No Comfort Cooling: Good design of the glazing system, including the use of balconies, means that comfort cooling will not be required to the dwellings.

Energy Efficient White Goods:	Class A+ or A rated ‘white goods’ will be provided. This energy efficiency measure can have a significant effect on reducing the carbon emissions and energy consumption of the dwellings. For example, up to 200 kg CO_2 per year can be saved by each dwelling by choosing an energy efficient model compared to a traditional model.
External Lighting:	External lighting shall be minimised (whilst taking into account security requirements), with timed and adjustable photocell control to meet “dusk to dawn” operation.

4.0 ENERGY MODELLING

4.1 CALCULATION METHODOLOGY

Benchmark figures have been utilised to estimate the energy consumption and equivalent CO_2 emissions associated with the flats in the development.

Since the dwellings are required a hit a Code for Sustainable Homes target of Level 3, compliance with Part L 2010 Target Emission Rate (TER) only needs to be demonstrated at this stage. Therefore, for the purpose of this energy statement, and in order to obtain a baseline carbon dioxide emission rate against which the use of renewable can be assessed, a typical TER of 16 $kgCO_2/m^2$ has been taken which is associated with such 2-bed apartments.

In addition, since the assessment of renewables must be against a benchmark of the total emissions for the site, consideration must be given to the energy use not considered by Building Regulations, i.e. those associated with cooking and electrical appliances. Therefore a benchmark figure of 22 kWh/m^2 has been used for these energy uses. The total expected carbon dioxide emissions and the baseline emissions to which renewable are assessed in shown in Table 2.

Table 2: Annual Energy Consumption and Carbon Emissions

	m^2	Part L2010 Target Emission ($kgCO_2$/Year)	Non CECM Loads ($kgCO_2$/Year)	Non CECM Loads ($kgCO_2$/Year)
Flat 1 : 2 bed flat	67.00	1,072	622	1,694
Flat 2 : 2 bed flat	58.00	928	538	1,466
Flat 3: 2 bed flat	58.00	928	538	1,466
Flat 4 : 2 bed flat	67.00	1,072	622	1,694
Flat 5: 2 bed flat	58.00	928	538	1,466
Flat 6 : 2 bed flat	58.00	928	538	1,466
Flat 7 : 2 bed flat	58.00	928	538	1,466
Flat 8 : 2 bed flat	67.00	1,072	622	1,694
Flat 9 : 2 bed flat	67.00	1,072	622	1,694
Flat 10 : 2 bed flat	58.00	928	538	1,466
Flat 11 : 2 bed flat	58.00	928	538	1,466
Flat 12 : 2 bed flat	67.00	1,072	622	1,694
Flat 13 : 2 bed flat	58.00	928	538	1,466
Flat 14 : 2 bed flat	58.00	928	538	1,466
Flat 15 : 2 bed flat	58.00	928	538	1,466
Flat 16 : 2 bed flat	67.00	1,072	622	1,694
Flat 17 : 2 bed flat	67.00	1,072	622	1,694
Flat 18 : 2 bed flat	58.00	928	538	1,466
Flat 19 : 2 bed flat	58.00	928	538	1,466
Flat 20 : 2 bed flat	67.00	1,072	622	1,694
Flat 21 : 2 bed flat	58.00	928	538	1,466
Flat 22 : 2 bed flat	58.00	928	538	1,466
Flat 23 : 2 bed flat	67.00	1,072	622	1,694
Flat 24 : 2 bed flat	58.00	928	538	1,466
Flat 25 : 2 bed flat	58.00	928	538	1,466
Total		24,496	14,214	38,710

Therefore for the whole development, the total carbon emissions, against which the use of renewable are assessed is **38,710 $kgCO_2$/Year.**

5.0 APPLICATION OF RENEWABLES

5.1 INTRODUCTION

This section of the report reviews the feasibility of the following renewable energy technologies which have been reviewed for use in this development. This section does not set out to explain the technologys involved, if further information is required on the seperate systems mentioned, reference should be made to Appendix A.

5.1.1 Wind turbines

Small scale on-site wind turbines can have the potential to make a contribution to on-site renewables targets if a number of smaller units are used. However barriers such as noise, and visual impact (planning issues), can severely restrict their use.

The space available for locating wind turbines on this development is extremely limited, being restricted to the use of roof mounted units.

The performance of roof mounted turbines is considerably reduced when compared with free-standing models. In addition there are issue with the increase structural requirements required of the building to withstand the forces exerted on it by the turbine and the mast. Specific attention is also required to the low frequency vibrations produced and isolating this from the structure and preventing nuisance to the occupants.

Consideration should also be made to the local topography such as adjacent buildings and how this affects the wind speeds and turbulence experienced.

Recent studies have also found that wind speeds actually seen in urban environments are considerably less than given in meteorological data, and as-built wind turbines are generally falling far short of their expected energy production, with a regular sight of motionless turbines mounted on the roofs of new developments offering little more than just roof decoration.

In light of the probable planning restrictions imposed on the site, the minimal roof area available, the turbulence problems caused by the urban environment, and the very low contribution to the renewables requirements the roof plan would allow for, we would suggest that wind turbines are not viable for this development.

5.1.2 Biomass Boiler Plant

There is a mixed use of heating and hot water on this development, with the residences having a reasonably considerable percentage of its energy use required for heating or hot water.

The use of biomass systems to provide heating and/or hot water lends such developments towards a district heating approach, whereby individual apartments are not provided with their own heating equipment (i.e. gas boiler), but a central system is provided which distributes LTWH to each unit, via a heat interface unit (which also provides the hot water requirement) located within each apartment.

Where such a strategy is adopted, it is usual to provide an “energy centre” which incorporates the boilers, distribution system and fuel store. This is sometimes provided remote from the building due to the size of the required plantroom and the fuel store, but also to allow the space for the delivery of fuel which is delivered by large truck at regular intervals.

Biomass led systems are, however, starting to fall out of favour with environmental agencies and environmentalists because of the increased flue and smoke emissions associated with them, the effect on the local air quality, and the requirement for regular fuel deliveries (usually by large

articulated trucks) which increases local traffic, particularly in light of current strategies to reduce traffic on Britain's roads. We therefore do not feel that a biomass scheme is viable for use in this development.

5.1.3 Combined Heat and Power (CHP)

Although not a renewable technology (fossil fuels are used to power the equipment), CHP is step two of the energy Hierarchy; to use and delivery energy efficiently and is classed a Low Carbon Technology.

CHP requires a fairly constant and coincident electricity and heat load; otherwise the whole process is inefficient and difficult to integrate into other services. The unit has to be sized on heat demands, rather than electrical demands, and most units only run during the day; to match the main loads, with a buffer vessel provided to smooth out the peaks and troughs of heat use. Back-up boilers would be required to meet loads outside of the peak heating periods (i.e. hot water demand in summer).

Similarly to the use of Biomass, a central CHP system is provided, which serves a district heating system and provides heating and hot water to each apartment via a heat interface unit located within each residence. Because of the need for backup boilers and buffer vessels, the plant space required is greater than that for a conventional boiler system. The design of this apartment block does not allow for a central boiler-room, and the provision of such would have a detrimental effect on the viability of the scheme, in addition there are increased maintenance requirements and management/billing issues which would need to be managed.

The use of CHP is best suited to a development where there is a mixed use, in developments of purely residential nature, the size of the equipment to meet a base continuous load is small and therefore has a comparably small carbon impact for considerately more plant space, thus reducing net space.

Therefore, although a CHP system could be sized to cover a base heating load during winter for the residences, the proportionally large central plant area which would be required, and the increased facilities management issues will have a considerable effect on the commercial viability of the scheme. Therefore, such a system is not deemed suitable for this development.

5.1.4 Ground Source Heat Pumps

Ground source heat pumps extract low temperature heat from the ground, and convert it to useful heat for a district heating scheme using the vapour compression cycle of the heat pump unit.

As can be seen within Appendix A there are two main types of ground source system, Open loop systems, whereby the ground water is actually extracted, utilised and then replaced into the ground via a borehole, and a closed system which does not extract water from the aquifer.

Within the scope of this scheme we would only consider a closed loop system, this eliminates some of the operational problems and maintenance requirements of open-loop systems and the complications of approvals for water extraction from the Environment Agency, and is more appropriate to size of the development.

This type of system is suited to low temperature heating systems, such as underfloor heating, since they offer poor COPs (Coefficient of Performance – efficiency) with circulating temperatures of 60°C or higher.

The geothermal loops which provide the heat transfer from the ground can be laid vertically or horizontally, the choice of a vertical or horizontal system depends upon the available land, local soil type, evacuation costs and the topological features.

As per the biomass and CHP solutions mentioned above, a ground source solution will require a central plant strategy, whereby the heat pump units are located within a central plant area and

distribute heating to the individual apartments; it will also require a specific heating strategy within the apartment, one that uses lower temperature water (such as under-floor heating)

The external ground area available within this development is very limited, ruling out the use of horizontal loop systems, meaning that any heat pump solution would have to use vertical loops.

Ground source heat pumps, particularly from vertical loops, are a very high cost solution, this coupled with the medium impact on carbon emissions due to the limited heating demand of the development, and the requirement for central plant which cannot be accommodated within the scheme without detrimentally effecting the commerciability of the scheme, means that a ground source system is not considered suitable for this development.

5.1.5 Air Source Heat Pumps

Air source heat pumps are currently not classified as a renewable technology, although there is European Union documentation that has proposed they be classified as such, however, they do fall under the heading of low carbon source.

Air source heat pumps work in the same manner as ground source heat pumps, but instead of extracting low temperature heat from the ground, it extracts it from the air. It can extract heat from the air even when the outside temperature is -15°C.

As with ground source heat pumps, this type of system is more suited to low temperature heating systems, therefore the use of under-floor heating would be required in the apartments.

The utilisation of such a strategy would require outside area for the external units to be located and there is very limited space in which such units could be located. Noise is also considered a big obstruction to their use in residential situations.

We therefore feel that the use of air source heat pumps is not considered suitable for this development.

5.1.6 Photovoltaics

The cost of producing electricity by photovoltaic’s was once seen as being prohibitive with high embodied energy marginalising medium term benefits. However, with improved efficiencies, reduced costs, and the announcement of feed-in tariffs in the UK, the use of PV is now considered a viable renewable technology and is serious competition for solar water heating for available roof space.

To achieve maximum output from photovoltaic’s they should be located on South facing surfaces, with clear, unobstructed views of the sky. Flat roof areas are suitable if the panels are inclined on frames to optimise outputs.

The only area of accessible roof available for the siting of PV panels in the roof at level 3; the roof over level 3 being inaccessible and the small roof area above the first floor at the front of the building being overlooked by apartments and in easy view of the road. It should be noted that because of the orientation of this building that in order to face south the panels will not be able to follow the building line.

An acceptable PV layout as per Figure 1 is therefore proposed, this allows for maintenance and cleaning access, avoids overshadowing by the third floor level and is not over looked by the apartments.

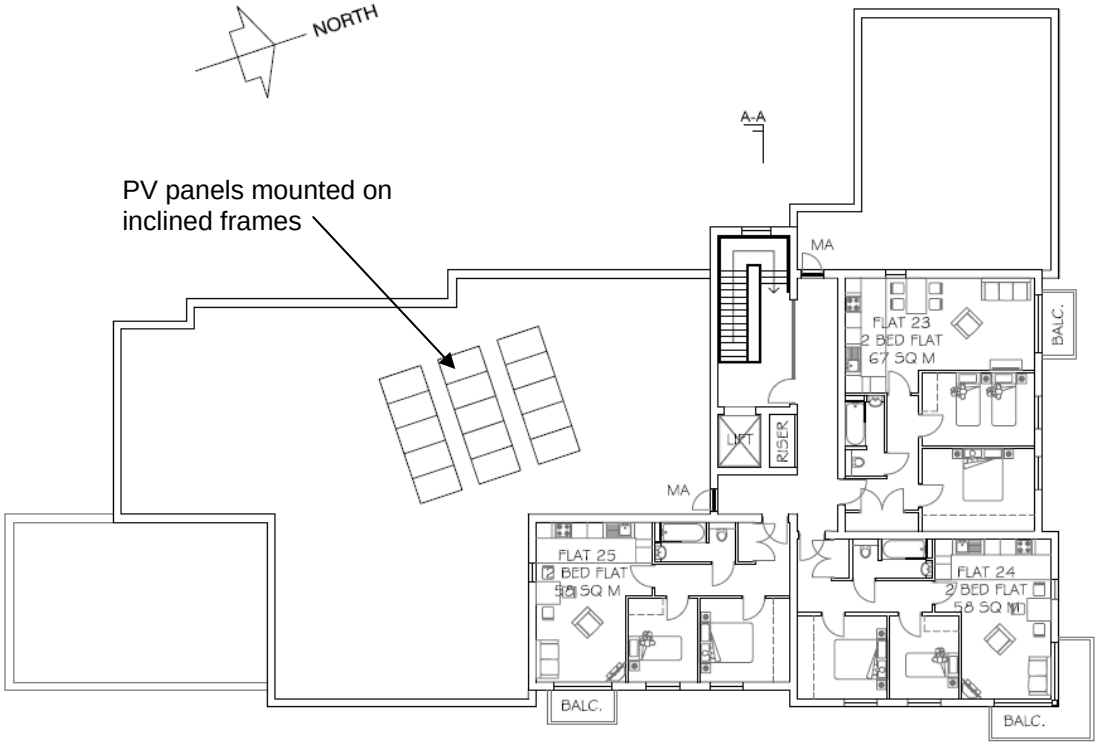


Figure 1 Proposed PV Layout

Therefore it has been assessed that an optimum layout of 15 No PV panels, with each panel measuring 1m x 1.6m, could be accommodated on the roof to provide power to the development and offer the following carbon savings:

Sharpe Photovoltaic panels
994mm x 1658mm x 46mm
Monocrystalline silicon solar cell
235 Wp maximum power

Total installed maximum power:	3.525 kWp
Typical energy production per year:	2467.50 kWh/year[1]
Carbon Saving per year	1501.65 kgCO_2/year
Baseline Carbon emissions:	38,710 kgCO_2/year
Carbon reduction due to PV:	**3.9 %**

[1] Taking 750 kWh/year/kWp as per London Renewables Integrating Renewable Energy Into New Developments Toolkit.

The power produced from the PV array can be used by all the dwellings, feeding into the main landlords supply, or the incoming multi-head power feed.

5.1.7 Solar Water Heating

Solar water heating systems use the energy from the sun to heat water for domestic hot water needs. Solar water heating systems use a heat collector that is usually mounted on a roof in which a fluid is heated by the sun, this fluid being used to heat water that is stored in a hot water cylinder.

Domestic installations usually comprise of 4m² collection area, which can provide 50%-70% of the hot water requirement for a typical home if provided on south facing roofs at the optimum 30° pitch.

Although relatively comparable to the carbon saving achieved from the use of photovoltaic's, there are more design considerations with integrating the use of solar water heating, which could increase the costs. There are limitations in the distance (and height) between the panel and the associated water cylinder, which means that only the upper apartments would be able to utilise the technology, with pipework needing to pass through other people's homes which can have future maintenance issues. There is a requirement for water cylinders with dual coils which require space within the dwelling, and the provision of hot water storage actually increases baseline carbon compared with none storage systems (combination boilers). Finally, since there is not enough roof area for panels to serve all of the apartments, only a couple of dwellings would be able to benefit.

It is therefore felt that the roof area available is better used for the location of photovoltaic's as opposed to solar water heating collectors, since the renewable benefits can be equally shared by all the dwellings.

5.2 SUMMARY

The nature of this urban development, especially with regards to the compact and residential nature of the site, in addition to the high costs associated with them, preclude the use of many renewable.

We would suggest that wind turbines offer very little in terms of carbon savings for such a high visual impact and that the technical issues involved in implementing a high cost ground source system or CHP scheme also make it unviable in this situation.

Due to issues of fuel deliveries, the impact on local traffic, and air quality concerns, we would suggest that the use of biomass in this location is also inappropriate.

Foreman Roberts would therefore suggest that a solar technology would be the best fit for this development, with Photovoltaics being put forward as the most effective strategy, since its benefits can be shared by all the dwellings, and as such provides the greatest feasible carbon savings. It is therefore proposed that 15 No PV panels shall be provided on the roof at level 3, and that the adoption of this strategy would contribute approximately 3.9% of carbon reduction for the development.

Appendix A Renewables and Low Carbon Energy Technologies

A.1 Introduction to Renewables

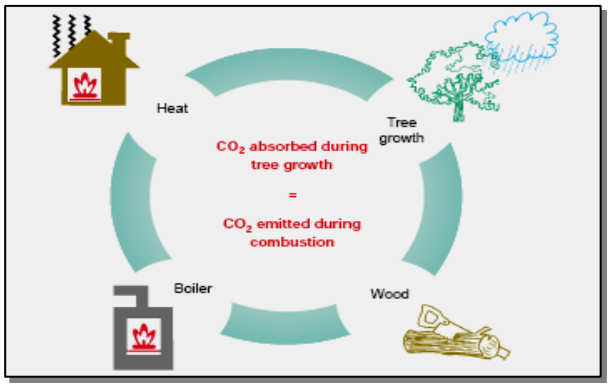
Renewable energy is a sustainable alternative to fossil fuels, and for this reason renewables are becoming an essential feature of new buildings to help achieve target carbon emission savings. Renewables are defined as sources of energy, usually generated on-site, which come from naturally replenished sources; such as from the sun. Most of the energy we use comes from fossil fuels, the combustion of which is believed to be contributing to global warming. However, renewables replace fossil fuels with natural forms of energy and so reduce the buildings' contribution to global warming.

There are a number of renewables available for use with buildings, but the most commercially available, and tried and tested include: biomass heating, photovoltaic cells, geothermal energy, wind turbines, and solar water heating. The following section provides a brief introduction to each of these technologies.

A.1.1 Biomass Heating

The term 'Biomass Energy' describes heat and power produced from wood generated by forestry and agricultural residues/wastes, and a wide range of organic wastes; such as animal slurry and kitchen waste. In the context on normal buildings, biomass is usually limited to the burning of wood; either in the form of wood chips or as processed pellets in a purpose designed boiler.

The use of biomass is generally classed as a 'carbon-neutral' process, that is to say the carbon dioxide released when biomass is burnt in a boiler is equal to that absorbed by their leaves via photosynthesis during their growth. However, other energy inputs may affect this carbon balance, for example: the energy used to process the fuel, such as chipping the wood or for transport from the production area to its point of use – this is known as its 'embodied energy'. Even allowing for this embodied energy, replacing fossil fuel with wood fuel will typically reduce net CO_2 emissions by over 90%. As biomass becomes more widespread in the UK, and is thus more locally available, this embodied energy is likely to reduce for biomass fuels.



The carbon dioxide released in combustion is equal to that absorbed in growth of a biomass fuel

Currently the greatest concentration of wood derived fuel is in the South West of England, South Wales, the East Midlands, the North West, Durham and Northern Ireland. Other companies are currently applying for grants to support the establishment of a wood chip and pellet delivery business.

A.1.2 Wood chips



Wood chips are one of the cheapest forms of biomass as they are the least processed fuel and mostly readily available. Usually generated from either forestry management, or short rotation coppice, the wood chips are untreated, and cheap to produce, but usually have a relatively high moisture content, which reduces the heat output. The fuel needs plenty of space for handling and storage and so is generally limited to large sites with good access to rural areas.

A.1.3 Wood Pellets



Generated from compressed waste saw dust - wood pellets represent a denser and much drier wood fuel than wood chips. The consistency of the pellets also makes it easier to handle the fuel compared to wood chips – they can be blown into a store by the delivery truck and can be conveyed within the building using vacuum delivery systems. There is a UK based wood pellet and wood pellet boiler manufacturing industry developing - pellets have been used for heating in North America, Sweden, Austria and Denmark, from where a proportion of pellets are still being imported to meet the current demand.

A.1.4 Biomass Boilers



Biomass boilers have started to become popular in the UK to meet local authority demands for renewables. In the smaller ranges: up to around 110kW, they tend to be very high performance pellet boilers, the best units generally coming from the long established Austrian, Swiss or Scandinavian countries where they have been used for over 20 years. Larger units are also very efficient but can usually accept pellets or wood chips as fuel – offering some flexibility if fuel delivery problems are experienced.

The boiler is equipped with an ash pan, which in normal conditions only requires removal once every ten days. There is also an option of an automatic de-ashing device, allowing easy removal to a bin. Ash quantities are relatively low, and, unlike coal ash, it can be used as a fertiliser on any gardens, lawns or landscaping areas.

The Remeha 150-2000kW biomass boiler

A.1.5 Photovoltaic Cells (PV)



Roof Mounted Polycrystalline PV cells

Using the sun to generate electricity was originally developed for space missions. Photovoltaic cells (PV cells) convert solar radiation directly into DC electricity.

Two main types of cell currently exist: crystalline and amorphous thin film.

Crystalline cells are the more commonly used type – appearing as a reflective blue colour, sealed behind a glazed unit. Within this category there are three further sub-types: Monocrystalline, Polycrystalline and Hybrid – each having its own characteristics and performance. Thin film is more flexible and cheaper but at the cost of electrical output. All PV cells can be integrated into various building elements such as shading devices or rooflight glazing, although their shading potential is

relatively low. The high cost of the units can be reduced if they replace an otherwise expensive cladding system. The most cost effective in terms of cost per percentage of carbon saved is usually the polycrystalline type.

Ideally, photovoltaics should face between south-east and south-west, at an elevation of 30-40°. However, flat roofs receive 90% of the energy of an optimum system. These are particularly suited to buildings that have their main electrical demands during the day.

PV cells are often connected to batteries to store the DC power between sunny periods, thereafter the power is converted to AC for use in on-site power demands. Excess power output can in theory be exported back to the National Grid, however, due to the system cost this is seldom viable in the UK.

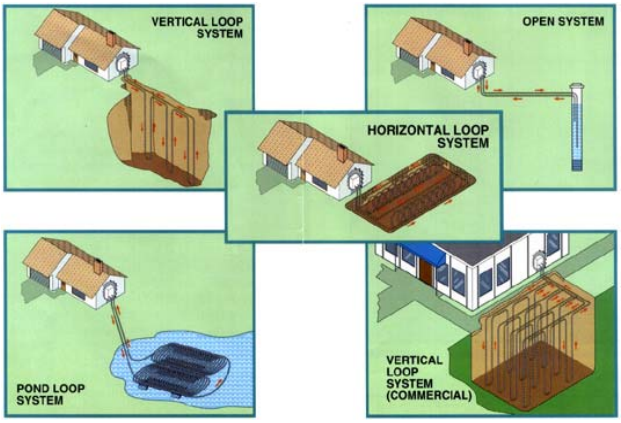
A.1.6 Geothermal Energy

Geothermal energy technologies use the heat energy stored in ground; either for direct-use applications: such as using the grounds' heat to defrost a driveway or the indirect use with additional equipment such as a geothermal heat pump. Most commercial installations couple a heat pump with the ground to upgrade the low-grade heat from the ground or ground water to a higher grade heat, where it can be used for heating purposes.

The suitability of a ground source system depends heavily on the type of earth coupling heat exchange system used:

Ground source earth coupling options

The right choice of appropriate heat exchanger depends on several factors such as: size of space heating/hot water system, available site area for the heat exchangers, and local ground conditions. Due to the specialist nature of this technology we recommend that a specialist is employed to size the heat exchangers based on a desk-top study of the site's geological conditions – this normally being required in advance of any other contractor appointment.



Geothermal energy loops can consist of different approaches depending on ground conditions

<u>Vertical Closed Loop System</u>
A frequently used and simple ground source heat exchanger, for a small to medium size project, is a closed loop vertical system. The system comprises of vertically drilled boreholes, usually up to 100 m deep, into which are inserted two polyethylene pipes with a U-shape connector at the base of the hole – effectively providing a flow down to the bottom of the hole and return back up to the surface. All the flow and return loops are connected together across the site - completing the entire heat exchange loop. Water is pumped around the loop and is then circulated around the heat pump to achieve the required heat exchange. The distance between boreholes is dependent on ground conditions but is typically a minimum of a 6mx6m grid, to prevent overlapping of the heat exchange process between loops.

<u>Horizontal Closed Loop System</u>
Horizontal closed loop heat exchangers are usually applied to small projects such as individual houses, which usually require a relatively low heat output. Consisting of horizontal trenches 1.5-2m deep, with

either straight pipes or ‘slinky’ coiled pipes, these require significant excavation work and significant site area to achieve appreciable outputs as such are not normally suited to medium to large projects.

Vertical Open Boreholes System

A further option is a vertical open borehole system. The system involves the abstraction and discharge of natural ground water using boreholes; into which pumps are inserted, connected to collapsible pipework. Each borehole pump abstracts ground water, circulates it around the heat pump and then discharges the water back to the ground via an absorbing well, some distance from the original abstraction borehole. The system is capable of providing very high rates of heat exchange for a relatively small number of boreholes, which makes it very efficient in terms of site area required. However, this depends greatly on the availability of ground water, which in turn varies according to location. A major downside of this system is that the extraction of water from deep boreholes via pumps consumes a lot of energy, as the water has to be physically lifted to the surface by the pump – this in effect reduces the carbon emissions saved by this system as a whole.

A.1.7 Heat Pumps

Heat pumps are basically refrigeration units which work in reverse – instead of cooling being produced and heat rejected, the unit produces heat and rejects cooling. Conventional heat pumps use air as the medium to reject this ‘coolth’ to atmosphere. Ground source units use the ground as a means of improving the unit efficiency because the ground is a constant 11-13 °C at depths of 50m down – this suits the heat pump much better during the coldest weather than the extremes of air temperature. Reversible heat pumps can also be used for cooling, however this is not being considered further for this project.

A heat pump consumes electrical power to drive the compressor and other ancillary elements. The ratio between total energy input and heat energy output of the heat pump is a measure of its efficiency – usually referred to as ‘Coefficient of Performance’ - COP. A ground source heat pump has a higher COP than an air cooled heat pump – this additional energy effectively being the grounds’ natural contribution to the system.

The heat produced by a heat pump is usually used to either provide space heating say to underfloor heating or radiators or the heat is used to generate domestic hot water via a storage vessel.

A.1.8 Wind Turbines

Wind turbines produce AC electricity by using the natural force of the wind to drive a generator. They save carbon by providing electricity from totally renewable natural forces, thereby reducing the dependancy on the conventional National Grid. The units can be used as stand-alone; where they simply provide power direct into the electrical system on site; they can feed batteries which provides an element of storage; and they can be used to feed power back into the National Grid, which can earn money back from the local power company. There is also the potential to earn further money from Renewables Obligation Certificates (ROCs) which the local electricity generator is likley to want to purchase, due the high demand for renewable energy which the generating company can sell to other consumers.

There are advantages and disadvantages for each of the above grid connection options. If wind turbines were to be considered viable the grid connection setup would need to be studied in some detail, in conjunction with the load profiles for the site.

The type of wind turbine used depends entirely on the site location and where the wind turbines are to be positioned. The typical wind turbines seen on wind farms are large scale horizontal axis units, which are designed to maximise power output from open expanses with unbroken wind. These units would not be suitable to an urban environment. In the urban environment wind turbulence is caused by obstructions such as buildings and trees, and this can serverly reduce the output of a wind turbine, unless it can be mounted at an elevated position or if the unit is designed for more turbulent winds. A vital point in the viability of a wind turbine installation is the local average wind speed. As a general rule, if the average wind speed for a site is less than 5m/s (11.2 mph) the use of wind turbines will not be viable. A further important point is the difference between the rated power output of a wind turbine - usually rated at 15 m/s (33.6 mph) and the output on an average day, which can typically be a sixth of the rated output. So a 6kW turbine becomes a 1kW turbine as its normal output.

More recently the idea of using small scale on-site wind turbines has the potential to make a useful contribution to on-site renewables targets if a number of smaller units are used. However barriers such as noise, and visual impact (Planning issues), can severly restrict their use. Whatever the application, the use of wind turbines will always require an in-depth assessment of these issues during the detailed design stage.

Recently maturing, and now readily available on the market, are several types of small scale wind turbines which are commercially available. A couple of examples are as described below:



Swift wind turbine (1.5kW electricity output peak)
The unit is mounted on a mast – sometimes fixed directly to the building. Designed essentially for the domestic market, the units are relatively compact, quiet and vibration free. The turbine rotor diameter is quite large at 2m, and in an average wind speed of 4.6m/s (typical of London) the units' power output is 300W and the annual power supply would be about 2000kWh.



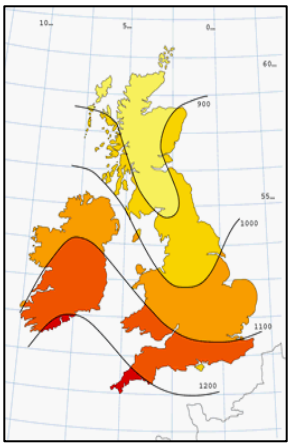
'Turby' vertical axis wind turbine (2.5kW electricity output peak)
The unit is mounted on a mast (around 10m high) either on a building or separately on the site. The rotor (2m in diameter and 3m high) is on a vertical axis and produces about 3000kWh electricity a year. Although relatively large for this site they are lightweight, quiet, and low vibration in operation. They are particularly suited to the wind turbulence in the urban environment.

A.1.9 Solar Collectors

Solar collectors convert solar radiation into heat, which is transferred to a medium such as a water/glycol mix (to prevent freezing). Solar water heating is usually used for hot water generation, as this is a year round demand. It is not normally used for space heating as the greatest demand is in winter, when the sun's rays are weakest. Annual incident solar radiation in the area of the site is about 1000 kWh.

From this total annual incident energy about 75 % is available in the summer period and most of the rest during spring and autumn. Therefore solar collectors should be designed and sized principally for the summer hot water demands.

Ideally the collectors should be mounted on a South–facing roof, although Southeast and Southwest will also function successfully.



UK solar irradiation Annual Total kWh/m2

The collectors need to be inclined at between 10-60° from horizontal – with 35° being the optimum. The panels can be bolted onto the roof or integrated into the roof, although this can be more risky in terms of leakage. Alternatively they can be mounted on frames, achieving the required tilt from horizontal.

Currently, on the market are two main types of solar collectors.



Flat plate collectors are more commonly used on domestic properties because of their lower capital cost. They consist of a simple heat absorbing panel sealed within a glazed unit and round which is pumped water. The sun heats this water, which then transfers its heat to the heat demand. The annual solar gain of flat plate collectors is about 450kW/m^2.



Evacuated tube collectors can collect more energy than flat plate collectors for a given collector area, especially during diffuse radiation, when there is no direct radiation from the sun. They consist of heat absorbing plates which can be rotated into the optimum angle to catch the sun – these being encapsulated in an evacuated tube. The plates contain a heat transfer fluid which is fed to the top of the tube and the heat is exchanged with water and in turn this is then transferred to the heating demand.

As a general rule, flat plate collectors are used where cost is the main consideration and available area for the collectors is not an issue, and evacuated tube collectors are used where the main concern is output (and thus carbon savings) within a restricted available area. The heat output from solar collectors is usually used to generate domestic hot water via a dual coil hot water calorifier, with one coil fed by the solar collectors and the second coil fed by conventional boilers (or other renewables). In this way the solar energy is the first stage of heating and the boiler system provides the secondary back-up system for periods without sun.

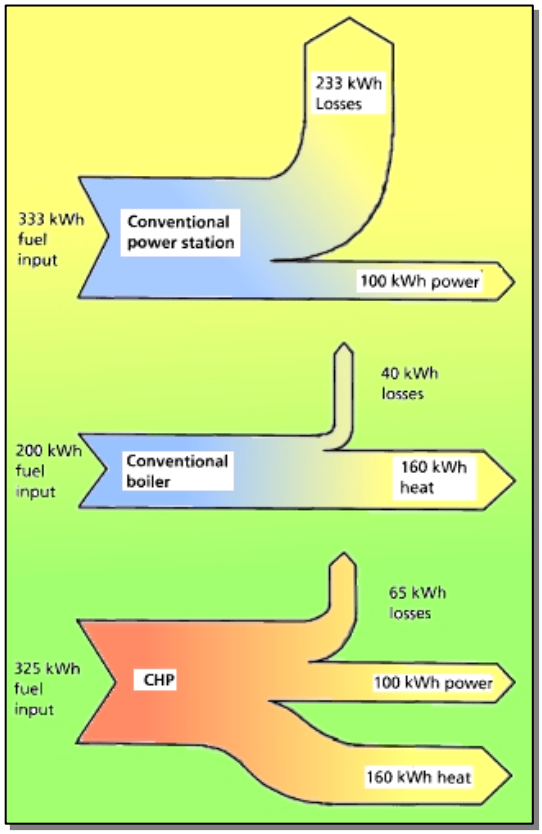
A.2 Introduction to Low Carbon Technologies

Low carbon technologies although reliant on fossil fuel can provide a very good reduction in the carbon emissions from a site, and for this reason low carbon technologies are becoming an essential feature of new buildings to help achieve target carbon emission savings.

There are a number of low carbon technologies available for use with buildings, but the most commercially available, and tried and tested include: combined heat and power, ground source heating (and cooling), and fuel cells. The following section provides a brief introduction to each of these technologies.

A.2.1 Combined Heat and Power (CHP)

A CHP unit uses a gas-fired engine to drive an electrical generator – the waste heat from the engine is used for heating purposes, making the process far more energy efficient than using mains electrical power and gas fired boilers.



The comparative efficiency of CHP vs power station electricity and a gas boiler

A CHP can save significant carbon emissions – typically 20% less than the equivalent solution of importing power from off-site and using a boiler for heating. Even modern power stations are not particularly efficient - typically around 30% efficient overall, as the waste heat from combusted fuel is usually vented to the atmosphere via huge cooling towers. CHP units make full use of waste heat and so can be as high as 96% efficient overall. The proportion of electricity and heat is usually about 1/3rds electricity to 2/3rds heat, but is dependent on the type of engine used.

A CHP requires a fairly constant and coincident electricity and heat load, otherwise the whole process is inefficient and difficult to integrate into other services. The unit has to be sized on heat demands, rather than electrical demands, and most units only run during the day; to match the main loads. The unit has to be sized carefully, depending on demand profiles.

A.2.2 Fuel Cells

In an ideal world fuel cells would take hydrogen as an input fuel and convert this into electrical energy, with heat and pure water as the only by-products. But because the hydrogen infrastructure needed to make fuel cell technology completely renewable has not been established, fuel cells are powered by natural gas or LPG making this a Low Carbon Technology.



A twin PAFC fuel cell installation in the USA

Fuel Cells produce electricity by combining the hydrogen contained in natural gas or LPG with oxygen in the air. The system has three major components:

- A fuel processor extracts the hydrogen from the gas or LPG.
- A fuel cell changes the hydrogen to electricity.
- A power conditioner converts the fuel cell electricity to the type and quality of power that is required for the local energy grid

How Fuel Cells Work

The heart of the fuel cell is the cell 'stack' which creates electricity through a reaction that combines the hydrogen with oxygen from the air. The fuel cell separates the hydrogen molecule into its constituent protons and electrons. The protons pass through the stack membrane while the electrons travel around it, creating the electric current. The resulting reaction produces electricity, water, and heat.

Fuel processor

The fuel processor consists of two parts: the fuel reformer and the carbon monoxide (CO) cleanup unit. The fuel reformer processes a hydrocarbon fuel, such as natural gas or LPG, into a hydrogen-rich gas known as reformate. The CO cleanup subsystem reduces the CO content of the reformate. CO production is a by product of using natural gas or LPG as the feed stock.

Power conditioner

The power conditioner first converts the low-voltage direct current (DC) produced by the stack to a high-voltage DC. An inverter then transforms the high-voltage DC to 220-volt alternating current (AC). Batteries in the power conditioner unit ensure sufficient coverage for power surges and temporary peak demands.

Benefits of a Fuel Cell

Power Quality
Fuel cells can provide electricity without the power surges or dips that can harm computers and electronic equipment as no problems associated with the power grid and distribution needs to be addressed.

Maintenance
Fuel cells have almost no moving parts. The system requires an annual maintenance check and a stack replacement every five to ten years.

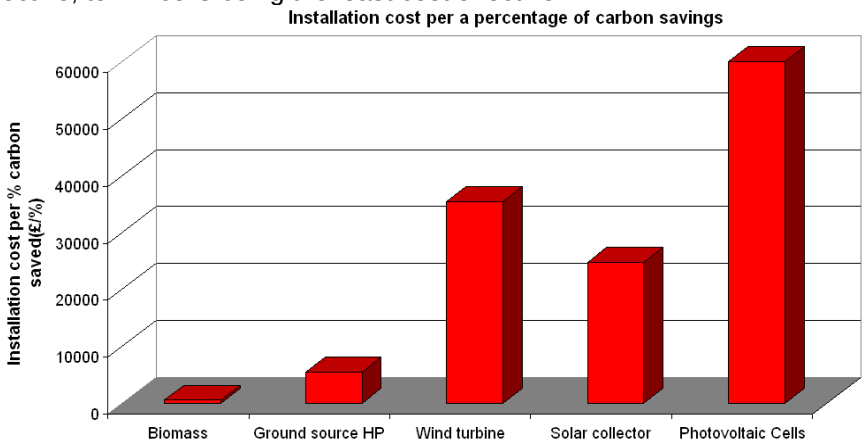
Sustainability
When fuel cells are used in place of a conventional gas fired CHP unit they can reduce carbon emissions by around a further 20%. They also produce far lower particulates, and carbon monoxide, nitrous oxides, and sulphur dioxides are reduce to near zero. Depending on the type of fuel cell, the heat output can be high temperature, which lends itself to tri-generation better than conventional CHP units.

A.3 Alternative Carbon Saving Options

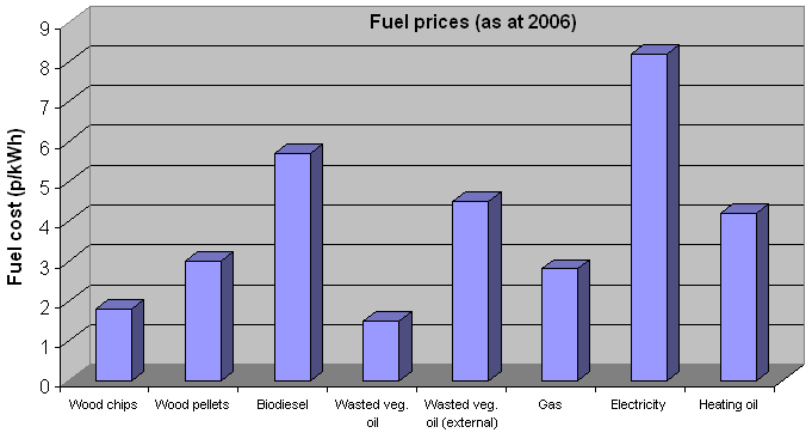
A.3.1 Economics of Renewables

It should be realised that renewables will not normally provide commercially viable pay-back periods – even the shortest paybacks on original capital is likely to be over ten years. The reason for installing renewables is to save carbon and the objective is therefore to reach the target carbon savings at minimal cost. Attention should therefore be focussed on the cost efficiency of a particular system in terms of £/% of carbon saved.

It can be seen from the following graph how the various renewables vary considerably from biomass as the most cost effective, to PV cells being the least cost effective.



- It is known that most renewable fuels are currently more expensive than mains gas, that is why it is little used in the UK at the present time – however the extra cost in terms of running costs per year is not significantly higher at a total of around £4k /yr for a pellet boiler compared to £3.8k/yr for a gas boiler at today's prices.
- There are Government grants (DTI) available for biomass projects, however, these are usually only guaranteed when the scheme is fully committed to a certain design route and so should not be considered as an integral element of the financial viability at this stage.
- Fossil fuel prices will continue to rise significantly in coming years, especially as the UK becomes almost wholly dependant on imports from continental Europe or the Middle East. Biomass is likely to become more cost effective as fossil fuel prices increase, and in the same period biomass is likely to become cheaper and more widely produced and thus more locally available. By proportion, the cost of pellets drops from around £100/tonne to £80/tonne when it is produced local to the demand. It is entirely feasible that this shift will bring the cost of pellets down to below the cost of gas in the next 5 –10 years.
- The capital installation cost of a pellet boiler, over and above conventional gas fired equipment, is about £5k plus the cost of building the store.



Fuel Prices – renewables vs conventional fuel