09/1012

Sustainability Report

For

The Morningside Development, Rickmansworth

for

Hightown Praetorian & Churches Housing Association

Revision	Reason for Issue	Issue Date
B	**Issued following comments from Client**	**June 2009**

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1 Introduction

1.1 Scheme Description

The Morningside Scheme consists of the redevelopment of an existing residential flats near to the centre of Rickmansworth.

The existing block of flats will be replaced with a new three-storey block, consisting of 19No. one-bed and two-bed units. It has been stipulated as a planning condition by the Local Authority (Three Rivers District Council [TRDC]) that the new development will require 20% of the site's energy needs to come from renewable sources, in addition to complying with the Building Regulations and the Code for Sustainable Homes.

This report has been developed to aid the design team in achieving the requirements of reducing the carbon impact of the development.

It is understood that the Housing Association intends to request funding for the scheme before the proposed 2010 amendment to Approved Document L1A is enforced, and as such the anticipated compliance level for funding approval will be "The Code for Sustainable Homes" Level 3 (i.e. a 25% reduction in carbon emissions when compared to a dwelling currently complying with the 2006 Approved Document L1A).

In order to assess the required Carbon Improvements, the Scheme has been assessed using the accepted assessment hierarchy contained within the London Renewables Toolkit. This recommends that the buildings be assess using the idea of "Be Lean, Be Green, Be Clean". That is the buildings carbon emissions should first be reduced to as low as possible, when this has been achieved as much of the remaining energy use should be provided through renewable means. Finally, the remaining energy should be provided via clean sources such as CHP.

1.2 Policy Drivers

There are a number of international and national policy drivers for energy efficiency and reduced carbon emissions to address the highly topical issue of global warming and the implications of climate change. This includes the Kyoto protocol on an international level, and in response to the UK governments commitment to this, national policies have been developed such as the Energy White paper and PPS22.

Kyoto Protocol, 1997

The Kyoto Protocol was agreed at the 1997 UN Convention on Climate Change. The UK's target is to cut its emissions by 12.5% below 1990 level by 2008-2012. The UK Government committed to a more challenging target to cut the UK's CO2 emissions to 20% below 1990 levels by 2010.

Energy White Paper, 2003

The *Energy White Paper: Our Energy Future – Creating a Low Carbon Economy1* is a change in direction for energy policy in response to the increasing challenges faced by the UK, including climate change, decreasing domestic supplies of fossil fuel and escalating energy prices. The priorities are security of supply, affordable energy for the poor and a competitive market for the benefit of businesses, industries and households.

PPS 22: Renewable Energy

PPS22 Renewable Energy, seeks to deliver the Government's vision for a low carbon economy as detailed in the Energy White Paper and promotes the generation of renewable energy.

1.3 Scheme Development Assumptions

The report is based upon the following assumptions:-

<u>Tenure Split</u>

Affordable Housing (Housing Association)	=	100% (approx 19 Units)

<u>Sustainability Targets</u>

Affordable Housing (Housing Association)	=	CfSH Level 3 or 4*
TRDC Renewables Obligation	=	20%**

* The Sustainability Target for compliance with the Code for Sustainable Homes is understood to depend upon when funding is agreed – it is understood that the likelihood is that Code Level 3 will be required (Code Level 4 would be required if funding was agreed following the revisions to the Building Regulations due April 2010);

** The current TRDC sustainability policy states that 20% of the sites energy needs should be provided by renewable energy sources. Given that a large proportion of the dwellings will exceed the requirements of the building regulations by in excess of 20% to meet the requirements of the Code for Sustainable Homes; this figure may not be enforceable.

Code for Sustainable Homes - General Discussion

The Code for Sustainable Homes makes reference to Carbon emission improvements over the current (2006) version of the Approved Document L1A. This system is however open to manipulation. The Approved Document includes a Fuel Factor. This figure allows increased Target Emission Rates (TER) for various fuel sources. In the case of grid supplied electricity, this figure increases the target emission rate by 47% (i.e. a Fuel Factor of 1.47). In the case of a gas fired heating system, there is no increase in Target Emission Rate.

Given that Code Level 4 (for example) requires a 44% improvement over Part L1A (2006), it can be seen that this can be achieved using an electric heating system, which in overall terms emits 3% more than a gas fired dwelling just meeting Part L1A (2006).

It is believed that under the 2010 revisions to Part L1A, the Fuel Factor will be reduced and the potential loophole closed. As such, Fuel Factors will not be considered within this report.

2 Basis for Comparison

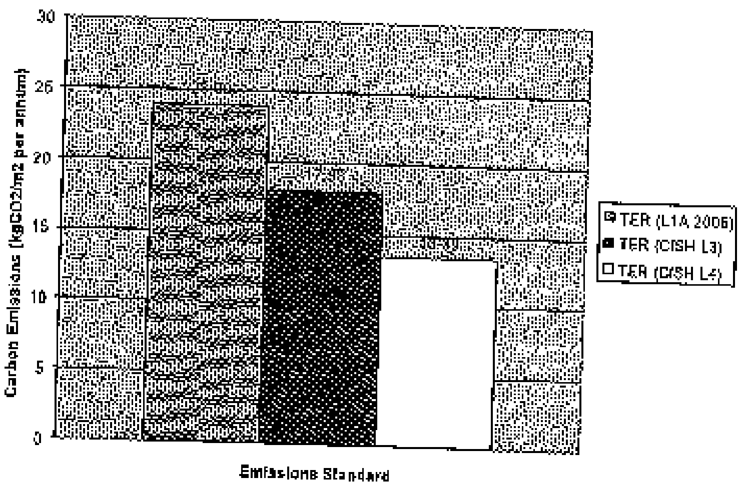
In all instances unless otherwise stated, the relative carbon efficiency improvements have been quoted relative to an area-weighted TER from Approved Document L1A 2006.

A representative sample of dwellings on the development (Flats 5, 6, 8, 15, 17 & 18) have been used to calculate a number of area-weighted Dwelling Emission Rates (DERs) as a means of comparing different methods of reducing dwelling carbon emissions.

Unless otherwise stated, each DER calculation uses the following space heating, hot water production and ventilation services as a base system:-

Heating System:	Gas-fired system boiler + weather compensation Radiators Programmer + TRVs + Thermostat
DHW Production:	125 litre Indirect DHW cylinder fed via the heating boiler
Ventilation System:	Intermittent extract fans

The following chart indicates the area-weighted carbon emissions rates that the development will need to achieve in order to meet Building Regulations (L1A 2006) and qualify for Code for Sustainable Homes Levels 3 & 4:-



Note that for the purposes of this report (as stated earlier), it is assumed that the Target Emission Rate for Code for Sustainable Homes (CfSH) funding approval after April 2010 will be equivalent to the current Level 4. The carbon emissions indicated in the above chart refer to the following improvements in emissions levels:-

- TER: 2006 CfSH Level 3 – 25% improvement over the Approved Document L1A 2006 TER;
- TER: 2006 CfSH Level 4 – 44% improvement over the Approved Document L1A 2006 TER.

3 Be Lean, Be Green, Be Clean

The accepted method for reducing the Carbon Emissions of a development is to follow the Mayor of London's Energy Hierarchy. This system guides design development and decisions regarding energy, balanced with the need to optimise environmental and economic benefits. These guiding principles are recommended to be applied in sequence, as follows:

- **Be Lean** - Reduce energy loads to a minimum through energy efficient heating and lighting systems, and efficient appliances;
- **Be Green** - Use efficient supply technologies such as Combined Heat & Power and Community Heating;
- **Be Clean** - Apply on-site energy generation where technically and economically viable.

The following sections of the report will use this hierarchy to indicate measures that can be taken to achieve the Design Standards indicated previously.

3.1 Reducing Energy Loads: 'Be Lean'

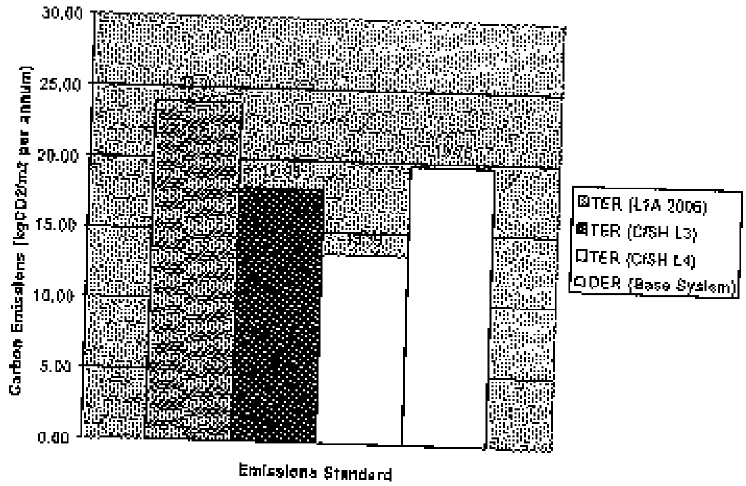
As stated previously, this section of the Hierarchy aims to reduce the energy use of the dwellings to a minimum. This subsequently reduces the amount of energy that will need to be replaced by renewable means. In order to maximise these savings, we would suggest that the thermal performance of the building be improved to the "Advanced Standard" as indicated in General Information Leaflet 72, Energy Efficiency Standards for new and existing dwellings.

The U-Values indicated in GIL72 are as follows:-

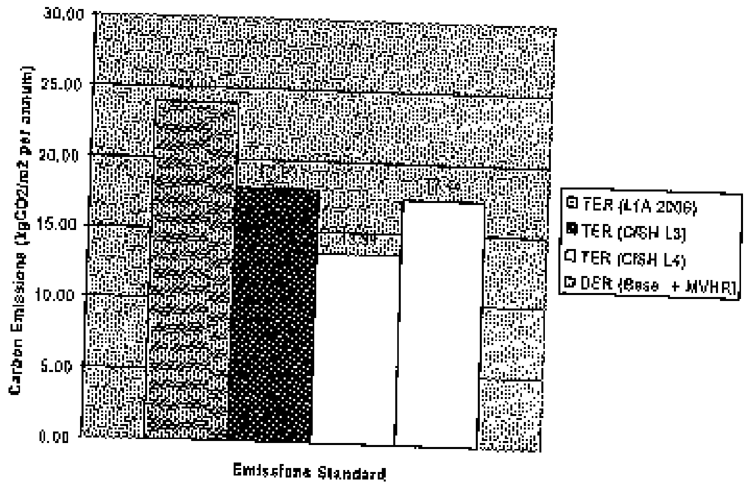
Element	As Designed (W/m^2K)
External Exposed Walls	0.15
Glazing	1.5
Doors	1.5
Ground Floor	0.1
Roof	0.08

In addition to the UValue standards, GIL72 Advanced Standard requires that the building achieve an Air Permeability of $1m^3/h.m^2$ (Approved Document L1A 2006 recommends an air permeability of $10m^3/h.m^2$). It is understood that the preferred construction for the development is of the traditional masonry type, and as such very low air permeabilities (lower than $6m^3/m^2$ per annum) cannot be reasonably achieved. As such, the air permeability shall be taken as $6m^3/m^2$ per annum.

By applying these changes, the development's Carbon Emissions are reduced by 17%. Although these savings would be sufficient to meet the 2006 regulations, they would not meet the requirements of CfSH Levels 3 or 4. It should be noted that using an air permeability of $1m^3/h.m^2$ produced a reduction in carbon emissions of 19%, therefore it will not be considered as the small additional reduction in carbon emissions is outweighed by the technical difficulty in achieving it. This is illustrated below:-



Further Savings can be made by the introduction of a Mechanical Ventilation, Heat Recovery (MVHR) System. By incorporating such a system, a reduction in carbon emissions of 27% relative to the 2006 TER may be achieved.



The inclusion of a MVHR system and the enhanced thermal performance figures considered previously considerably reduces the sites carbon emissions, achieving CfSH Level 3, but not Level 4.

In order to make further reductions to the site under the "Be Lean" heading, revised servicing strategies must be considered. The proposed heating and hot water system used for comparison purposes was a typical wet heating system, designed in accordance with current good practice.

Alternative heating systems include not only variations of the traditional systems such as community heating but also modern "renewable" systems such as heat pumps.

Under the "Be Lean" section of this report, only those technologies that are not renewable will be considered. By reducing the energy demand of the building at this stage, the amount of renewable energy required that will be required shall be minimised.

In summary:
Building Regulations compliance is now based on whether Dwelling CO_2 Emissions Rate (DER) is lower than a Target CO_2 Emissions Rate (TER). The SAP calculations undertaken as part of this report enable the average DER and TER for to be calculated. This indicated that the measures outlined above, have improved on minimum Building Regulations by at least 17% and shows that the design team has provided an energy efficient building which conforms to the 'Be lean' section above.

3.2 Efficient Energy Supply: 'Be Clean'

In consideration of the "Be Clean" principal, a preliminary investigation into the appropriateness of a Combined Heat and Power (CHP) system for the proposed development has been undertaken. District heating has also been briefly considered.

3.2.1 Combined Heat and Power

For CHP to be economically viable, the following should be present at a site:-

- Simultaneous demand for heat and electricity;
- Heat:Power ratio of about 1.6 to 1;
- Large and constant heat demand - over 4000 full load run hours per year;
- Community heating system in place.

In general, CHP is at its most effective when used within large mixed use developments, such as, hospitals, leisure centres, universities and hotels. As such, new build residential developments which incorporate high levels of thermal insulation are rarely suitable, due to insufficient run hours and an incorrect heat:power ratio. The reason for this is defined within the Low Carbon Toolkit as follows:-

"To be viable economically they [CHP] require a large and constant demand for heat. This can sometimes make application to energy efficient new housing problematic. Current insulation standards mean the requirement for space heating is very low and demand is present for only part of the year. The only constant source of heat demand is for domestic hot water and in terms of reducing CO_2 emissions much of this demand could be met by the use of solar water heating instead (in low rise dwellings)." [GLA toolkit pp. 27-28]

In addition to the above, residential dwellings usually have a heat demand profile that peaks for 2-3 hours in the morning and 2-3 hours in the evening. Furthermore, electricity demand will also be very 'peaky'. These peaks can be smoothed out on a large mixed use site, where the maximum loads can occur at various times throughout the day.

This development is however not very large (19 units) and of a single usage (residential).

In fact, if the flats' electricity demand for the year (approx. 10,684 kWh/year) is averaged over 4000 hours (a figure generally accepted to be the minimum number of full load run hours required for economic viability), the base electrical load required is only 2.7kW. CHP plant is generally only available at sizes such as 50kWe and above; below that, the contribution to heat and power loads would be met, but the subsequent CO_2 savings would be quite small. Given all the above, it can be seen that a CHP system would not be feasible or economic for this scheme.

3.2.2 Community Heating

Community heating involves the supply of heat to dwellings through a well insulated heat pipe network, transporting Low Temperature Hot Water from a centralised heat production facility in a closed loop. Community heating has the following advantages:-

- Gas infrastructure to individual dwellings may not be required;
- Increased diversity and flexibility of heat source;
- Centralised operation and maintenance of heat source, leading to increased reliability;
- Reduced noise in dwellings from the heating system;
- Possible increase in the lettable area of each dwelling, as space would not be required for a boiler (this would be relatively small as modern boilers are not particularly large).

The following challenges should also be noted:-

- A centralised Plant Room to house the boiler(s) or CHP plant would need to be constructed, therefore adequate space and a suitable location would have to be allowed for;
- Site-wide heat networks need to be laid at an additional expense over flat-based heating systems;

- Organisational overheads would be incurred in metering (using heat meters) and billing tenants. An energy supply company may need to be established, which could be quite an onerous undertaking;
- The aforementioned heat meters can be expensive, but are necessary to ensure fair use of heat and to encourage energy savings for individual dwellings.

The general rule of thumb is that community heating becomes cost effective on larger sites, and when the number of dwellings is more than 75 per hectare. However, CO_2 savings will only occur when the efficiency of the centralised boiler and distribution system are higher than individual boilers in each dwelling. As SAP calculations all included high efficiency boilers (at 90% efficiency), community heating has not been considered further in this study.

3.3 Renewable Energy Systems: 'Be Green'

Finally, in addressing the "Be Green" principal, the feasibility study of reducing the development's carbon emissions by 20% was undertaken. From the suggested renewable energy systems listed in the London Renewables Toolkit (pp. 152, suburban medium density housing), a number of potential technologies were identified for detailed calculations.

In addition to those items listed within the Toolkit, an additional "Low Carbon" technology (Exhaust Air Heat pumps) has been assessed. Although these are not currently listed as a renewable technology, empirical evidence has shown that they exceed the efficiency of a traditional air source heat pump. Furthermore, the manufacturer is currently in the process of obtaining SAP Appendix Q approval.

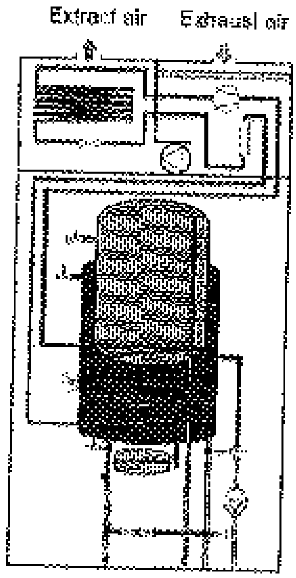
The report also considers the concerns of the Conservation Officer who has objected to the positioning of solar panels on the front (south facing elevation) of the building.

3.3.1 Heating and Hot Water Provision

3.3.1.1 Exhaust Air Heat Pumps

Exhaust Air heat pump units have been considered as a method of reducing the sites carbon impact. These systems use warm and stale exhaust air from the dwelling to produce higher grade heat via an intermediate refrigeration cycle.

When the exhaust air at room temperature passes through the evaporator, the refrigerant evaporates because of its low boiling point. In this way the heat in the air is transferred to the refrigerant. The refrigerant is then compressed in a compressor, causing the temperature to rise considerably.



The warm refrigerant is led to the condenser. Here the refrigerant gives off its heat to the boiler water, so that the temperature of the refrigerant drops and it changes phase from gas to liquid. The refrigerant then runs via a filter to the expansion valve, where the pressure drops and the temperature is further reduced. The refrigerant has now completed its circulation and returns to the evaporator. At system start up and at the absolute extremes of temperature, these systems use a supplementary electric immersion heater.

The unit is a total system solution as it meets the requirements for ventilation, heating and domestic hot water. To assess the unit, it has been assumed that it is no more efficient than an air source heat pump with a traditional sensible heat recovery MVHR system and a highly insulated domestic hot water cylinder.

The calculations do not therefore take into account the higher Coefficient of Performances (COP's) that can be achieved by generating heat from a higher temperature source (exhaust air @23°C rather than external air @ -3°C). As such, it is felt that the calculations represent the worst case scenario.

Based upon the above and relative to the requirements of the Approved Document, the improvement is as follows:

Improvement relative to the Notional Building (TER): 25.5%

The estimated cost of the exhaust air heat pump unit is approximately £3,500 per unit, which takes the place of the gas-fired boiler, DHW cylinder and MVHR unit in a more 'conventional' heating and ventilation installation. Assuming a supply only costs of £750, £700 and £850 for the boiler, DHW cylinder and MVHR unit respectively, plus £1000 for the incoming gas supply, it can be shown that the exhaust air heat pump cost is only slightly above (£200) the 'conventional' heating and ventilation installation.

It should be noted that this cost excludes additional costs associated with the installation of the exhaust air heat pump system, such as higher-grade ductwork insulation than a conventional MVHR system.

One other point to bear in mind is that whilst this equipment has been manufactured for several years now, it is understood that only one company manufacturers this type of equipment (although there are many distribution, installation and service companies).

3.3.1.2 Solar Hot Water

A solar thermal collector array has been considered for the development. Two types of installation are possible – a communal hot water production facility and separate systems installed serving each flat.

A communal hot water production facility would require the construction of a communal Plant Room, and would also necessitate the installation of a communal heating system, which would provide the heat source for the building hot water calorifier(s) when the solar collectors could not provide sufficient heat. As such, similar disadvantages are apparent for this system as for other community heating systems.

The installation of separate solar hot water production facilities serving each flat would require sufficient space for (accessible) piped service risers from the roof solar collectors, and for the larger twin-coil DHW cylinders (approximately 200 litres capacity for solar-based systems, as opposed to 125 litres for a standard 'boiler and cylinder' arrangement) and associated equipment.

The study has therefore considered the introduction of an individual solar thermal system within each flat, utilising a collector area of 4.6m^2 per dwelling.

The building is generally south facing and as such, is ideally suited to a solar thermal technology. It is understood that the Local Authority Conservation Officer may not allow the installation of solar panels on the south-facing roofs as the development is situated on the edge of a conservation area, however the installation of solar-thermal collectors on north-facing roofs is not recommended, as the low amount of direct sunlight (when the sun is coming from the East and West directions) greatly reduces the efficiency of the panels.

As such, it would be worth considering the installation of roof-integrated solar collectors which are much less conspicuous than roof-mounted systems. For the purposes of this study, it was assumed that south-facing panels would be allowable. Taking this into account, the improvement over the requirements of the Approved document would be as follows:-

Improvement relative to the Notional Building (TER) : 37%

Associated issues/Considerations

- No noise issues should be encountered with application of such systems;
- Systems require an appropriate water storage cylinder;
- Ongoing maintenance costs would be incurred;
- Solar hot water must be designed into the building's heating systems from the start, it cannot be added later as a 'bolt on' option.

3.3.1.3 Ground Source Heat Pumps (GSHP)

Ground Source Heat Pumps use a refrigeration cycle similar to the exhaust air heat pumps (as detailed in Section 3.3.1.1.), but take low grade heat from the ground and convert it to higher grade heat within the dwelling. This can be used to supply heat either radiators or underfloor heating (where possible), as well as providing domestic hot water. For the purposes of this study, it has been assumed that radiators will be used to give an accurate comparison with other heating systems, and that GSHP systems using horizontally-laid ground pipes are not considered as they would require more space than is available on the site.

Once again, both communal heating and individual flat-based systems have been considered:-

i) Flat-based Systems: In order to provide a good level of hot water provision, it is estimated that each dwelling would require a 12kW heat pump. Typically each unit would require 3No. bore holes, spaced at 3.5m centres, making a total of 57 boreholes. Due to the large number of boreholes and subsequent pipework/ancillaries required, this option would not be practical, as it would require a large amount of accessible space for the installation of the boreholes;

ii) Communal Heating System: It is estimated that the rated size of the GSHP system would be 68kW.

Based upon the above and relative to the requirements of the Approved Document, the improvement for the Communal-based GSHP System is as follows:-

Improvement relative to the Notional Building (TER): **23.5%**

Although the above is a significant reduction in Carbon Emission, the system would require dedicated plant space which is not available on site. As such, the number of dwellings would need to be reduced. This would have a significant effect on the viability of the scheme.

Associated issues/Considerations

- Good ground area should be available for heat exchange network and good coordination during construction will be required. As the site is quite constrained, the heat exchange pipe network will need to be sunk vertically. A specialist contractor would need to provide advice at an early opportunity if this technology is to be installed;
- Ongoing levels of maintenance should be low;
- No noise impact should be encountered;
- A communal heating system is required for heat distribution to individual dwellings.

3.3.1.4 Biomass Heating

Biomass boilers are used as a replacement to conventional gas fired boilers. Generally, the use of biomass (wood chips and pellets) as a fuel source enables the heating to be carbon neutral, as the Carbon emitted by the burning of the fuel is absorbed by the fuel while growing.

It should be noted, however, that fossil fuels are used in the production, processing and transportation of biomass fuels and therefore care should be taken when choosing the fuel supplier – as a rule of thumb, the source of fuel/processing plant should not be more than 30 miles from the Development.

The improvement achieved by the inclusion of a biomass heating system is based upon the assumption that 100% of the site's heating and hot water would be provided from the biomass boiler system. Using biomass heating would necessitate the installation of a centralised boiler to supply all dwellings, and access for lorries to deliver the fuel supplies.

Improvement relative to the Notional Building (TER): **66.5%**

Associated issues/Considerations:

- A centralised energy centre will be required to house the biomass boiler and fuel storage facility. These facilities should have good vehicular access for delivery of fuel and removal of waste;

- A site wide insulated heat distribution network will be required. Good coordination during construction will be required. Heat metering will be needed on individual properties;
- Fuel should be selected with transport distance in mind. If possible, fuel should be sourced within 30 miles of the development. If a nearby fuel supplier cannot be located, there is no point pursuing this option further;
- The fuel needs to be of sufficiently good quality (dryness and size) to suit the boiler being installed, otherwise there is no point in further development of the biomass option;
- Emissions will be produced from the biomass boilers. Flue gases may have to be cleaned due to the close proximity of dwellings on and adjacent to the site;
- Ongoing maintenance will be required;
- There will need to be some kind of central management / operation system established to ensure that the system is operated and maintained equally between the flat owners;
- Noise issues may be encountered close to the energy centre. Consideration should be given to noise mitigation during boiler operation and fuel delivery.

3.3.2 Electrical Services Provision

The proposed Electrical Services renewables strategy would depend upon the Client's preferred metering strategy. A description of each strategy follows an outline of the viable technologies.

3.3.2.1 Photovoltaics

A study has been undertaken into the viability of installing a photovoltaic array onto the building for the purposes of producing electricity. The issues regarding the positioning of the array are similar to those presented in Section 3.3.1.2.; it has also been assumed (for calculation purposes) that individual systems will be installed serving each flat.

Photovoltaic systems use energy from the sun to produce electricity via conductor cells. These cells are linked together to form large modules. These modules can be fitted to the top of roofs or can be integrated into the building fabric.

In order to achieve the peak efficiency, the photovoltaic modules should face between south-east and south-west, at an elevation of about 30-40° to the horizontal. However, in the UK even flat roofs receive 90% of the energy of an optimum system. It is a misnomer that PV cells will only operate in bright sunshine. Photovoltaic systems require daylight and not sunlight to generate electricity. As such electricity is produced even in overcast or cloudy conditions.

A study was undertaken using Photovoltaics as an additional means of achieving the sites renewable energy requirements. The calculations are based on a nominal 2.5m^2 solar panel array (producing approximately 0.35kWp) per dwelling, mounted at 30° to the horizontal and south-east to south-west facing.

Based upon the above, the improvement relative to the Approved Document would be:-

Improvement relative to the Notional Building (TER): 28%

<u>System Costs</u>

Individually Metered Systems (1 meter and inverter per dwelling)	£60,000
Centralised System	£50,000

Associated issues/Considerations

Inverters will be required to convert the DC (from the PV modules) to AC (required in the building). The cost of invertors are included in the installed costs, however they will need to be replaced more regularly than the PV modules (between 5 and 10 years). Any replacement costs will be extra to the installation costs.

3.3.2.2 Wind Turbines

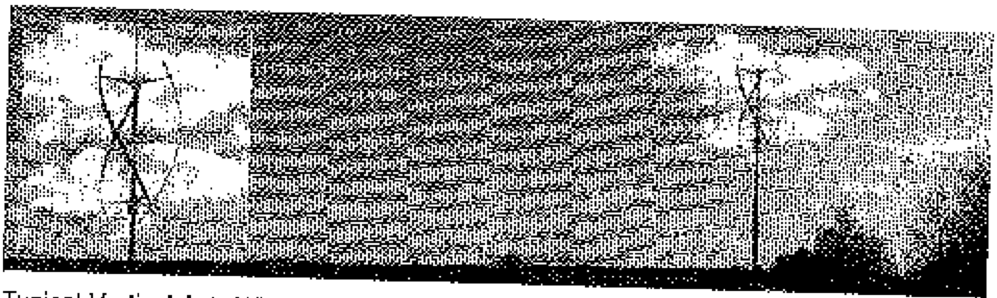
Wind Turbines are synonymous with renewable energy, partially due to their appearance and usage in large scale wind farms.

Wind Turbines operate by transferring the energy of the wind onto rotational movement of vertical blades. The blades then turn a generator which produces electricity. They normally fall into one of two categories:-

i) Horizontal Axis Wind Turbines (HAWT): This type is the most common type, and are typically ground mounted within the building's curtilage.

   Whilst a large horizontal axis turbine would assist in meeting the emissions/renewables targets, they would require clean wind to operate effectively. As such, the turbine would need to be sited at least 100m from any buildings or structures. As the proposed building would exist in an urban environment, we would therefore suggest that a horizontal axis turbine would not be suitable for this project.

ii) Vertical Axis Wind Turbines (VAWT): More recently a number of manufacturers have developed this type of wind turbine, as shown below.



Typical Vertical Axis Wind Turbine (www.quietrevolution.co.uk)

The main benefit of a vertical access turbine is that they are not sensitive to the direction of the prevailing wind. This makes them much more suited to the types of winds that are experienced in an urban environment and further increases their operational efficiency. Additionally, vertical axis turbines are normally self balancing, which means that they do not generate such large forces on building structures, and therefore are more suitable for building mounting.

System Cost: Approximately £65,000 (centralised system, including inverters)

3.3.2.3 Metering Strategy

Consideration should be given to the metering strategy for the development. There are essentially two metering strategies, these are outlined below:-

i) Individual Metering: This metering system would see each residential unit provided with its own energy supplies meter. Renewable energy, for example from a dedicated photovoltaic array, would be connected to each of the occupier/tenants meters via the owner's/tenant's inverter.

Energy would be produced and consumed or exported to the grid via the owners/tenants import/export meter. Under this strategy the owner/tenant would be responsible for their own electricity supply and would thus be charged directly from the energy supplier.

Advantages of Individual Metering

- Tenants/occupants are responsible for their own electricity supply;
- Management/Administration of the electrical supply and associated renewables are the responsibility of the flat owner/tenant and their utility supplier. This would mean that the Housing Association would not need to get involved in dealing with tenants with billing issues.
- The tenant would be responsible for their own PV array and inverter. The cost of installation may be passed in part or full to the owner/tenant in the purchase/rental cost of the property where applicable.

Disadvantages of Individual Metering

- The initial cost of providing an inverter per dwelling (19 in total);
- Cables from each flat to their dedicated array would be required;
- Individual metering is only suitable for renewable energy being produced from photovoltaic arrays, as a 2.5m^2 array could be assigned to each dwelling. It is not possible to proportion the energy from a wind turbine under this strategy, other than to the communal landlord areas.

ii) Central Metering: Under this metering strategy, we would expect to locate a landlord owned energy suppliers meters within the development.

Renewable energy systems would be connected to these meters via inverters. Individual check meters would then be provided for each residential unit. Energy would be created and consumed or exported via the central import/export meter.

Under this strategy it would be the responsibility of the Landlord to proportion the owners'/tenants' electricity consumption via the check meters, and bill them accordingly.

Advantages of Central Metering

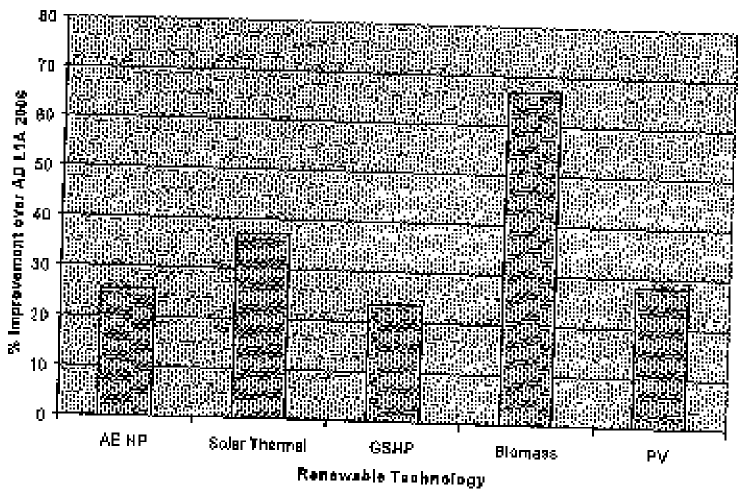
- Initial capital cost of the inverters is lower as the quantity is reduced;
- Wind generation along with photovoltaic could be introduced under this scheme as the landlord would proportion the consumption.

Disadvantages of Central Metering

- The landlord would be responsible for the electricity supply and would therefore bill the tenants/owners. This incurs an on-going management and administration cost;
- Problematic bill payers would become a Landlord issue;
- Space would be required to house inverters and meters centrally.

3.3.3 Renewable Energy System Comparison

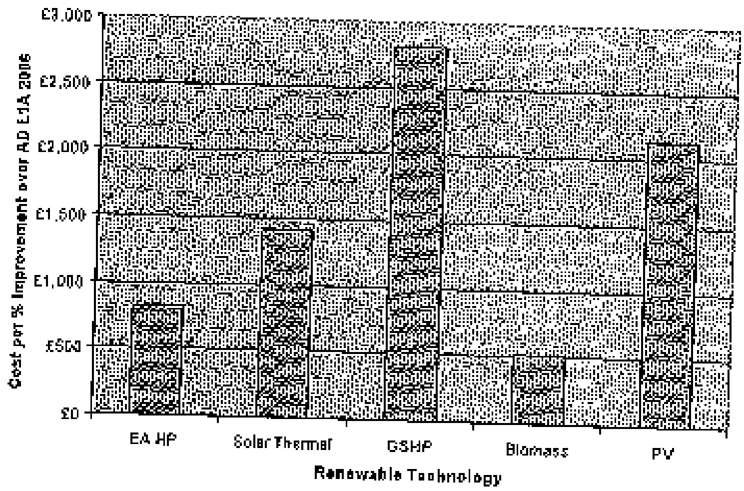
As discussed previously, the implementation of a number of renewable and low carbon technologies has been considered. Each of these has been reviewed relative to Approved Document L1A (2006), and the percentage improvements are shown in the following chart:-



Analysis of the results show that:-

- The 25% reduction in carbon emissions required for compliance with CfSH Level 3 may be achieved by all the above technologies (on their own) except Ground Source Heat Pumps, although the Exhaust Air Heat Pump system only just passes the 25% mark;
- Only Biomass heating and hot water system would achieve CfSH Level 4 on its own.

It should be noted that the above comparison does not take into account the cost effectiveness of the various technologies, therefore the following chart compares the technologies based on the cost per percentage improvement in carbon emissions over Approved Document L1A 2006:-



The above cost comparisons do not take into account the additional building costs associated with centrally-served heating and hot water systems, such as Ground Source Heat Pumps and Biomass, which would require separate Plantrooms (Biomass additionally requiring space for fuel storage and access for deliveries). As such, it is likely that the useful area of the building will be reduced to accommodate the Plantroom.

4 Conclusions

It can be shown that (from Section 3.1) the building's carbon emissions can be reduced by 17% relative to the Notional Building (Approved Document L1A 2006) by undertaking the following passive measures:-

- Reducing the U-Values of the building thermal elements to those given in the Advanced Standard of GIL72;
- Reducing the building air permeability to $6m^3/h.m^2$ (the minimum that can be realistically achieved for a masonry-constructed building).

Additionally, supplementing the above with Mechanical Ventilation Heat Recovery (MVHR) units can reduce the carbon emissions by 27%, which meets the Code for Sustainable Homes (CfSH) Level 3 requirements for a 25% reduction in carbon emissions. The estimated cost would be approximately £700 per flat over the standard ventilation installation.

Additional renewable technologies would need to be considered if the scheme was required to achieve CfSH Level 4 (dictated by when funding is sought) and Three Rivers District Council's 20% renewables requirement. A summary of the findings are shown below:-

Exhaust Air Heat Pumps

The study indicated that a 25.5% improvement could be achieved by using this technology. The estimated additional cost over the standard mechanical services installation would be approximately an additional £1,100 per flat over the standard heating and ventilation installation (they would replace the standard gas-fired boiler, DHW cylinder and extract fan installation). The units require a full-height space for installation (with a footprint similar to a standard domestic boiler), such as a built-in cupboard. Furthermore, the units have no effect on the external façade.

Although these units are not generally considered as a renewable technology, it can be seen that they offer substantial capacity for improvement over the requirements of the Approved Document. These savings are available even when taking into account pessimistic estimates of the units performance.

Solar Hot Water

The study indicated that a 37% improvement could be achieved by using this technology. The estimated cost of which would be approximately £2,750 per flat over the standard heating and hot water installation. Although it is felt that sufficient roof space would be available, there are concerns about its visual appearance. As such, the use of roof-integrated panels is strongly recommended.

Ground Source Heat Pumps

The study indicated that a 26.5% improvement could be achieved by using this technology. The estimated cost of which would be approximately £3,500 per flat over the standard heating and hot water installation.

In order to accommodate the GSHP system, the building would require a central Plantroom, reducing the useful area of the building.

Additionally, the system would require a number of deep and expensive boreholes, which would be difficult to co-ordinate in such a small site.

When the cost of a communal heating system has also been factored in, under current energy tariffs, long payback times can be expected, as savings are only being made through the efficiency of the GSHP system over the efficiency of conventional natural gas fueled boilers.

Biomass Boilers

If a centralised biomass boiler system was installed, the carbon saving for the development could be approximately 66.5%. At this level of carbon saving, a biomass boiler system would be a fairly cost efficient method of achieving CfSH Level 4 and TRDC's 20% renewables criteria.

The system's estimated additional installed capital costs would be approximately £1800 per flat over the standard heating and hot water installation. It should be noted that this cost does not include for the inclusion of a central Plantroom and fuel (wood pellets or chips) store, reducing the useful area of the building (more than for other communal heating and hot water installations). Additionally, external space would be required for access for lorries to deliver the fuel supplies.

Ongoing maintenance costs may also be high and since it would be a centralised energy system, ongoing accounts would need to be maintained for all units within the development. This may be provided through an Energy Service Company (ESCo), who may also be interested in investing in the initial capital costs.

The biomass fuel would also need to be locally sourced (hopefully within 30 miles of the development) and would need to be of sufficiently good dryness, size and delivered consistently.

Photovoltaic Solar Collectors

It has been calculated that with 47.5m^2 of PV collectors on the roof, about 28% carbon saving could be achieved across the development. PV systems are still expensive and this would be the most expensive way of saving carbon emissions compared with any of the other technologies considered. Estimated system costs would be approximately £1,360 per flat.

Recommendations and Conclusions

As it is currently understood that the likely submission date for grant funding will be before April 2010 (when the Building Regulations are next revised), the scheme will be required to comply with Code Level 3.

As such, we would recommend that the building be designed to meet this requirement, even though the 20% renewables criteria set by the Local Authority will not be strictly met.

It is understood that the use of aforementioned "green" technologies are discounted as:-

- The use of solar panels (solar thermal or photovoltaic options) nor wind turbines will not be allowed by the Local Authority Conservation Officer;
- The use of the other aforementioned "green" technologies have been deemed to be not viable by the Housing Association in terms of capital costs (which is allowable under the Local Authority renewables criteria).

It can be reasonably argued that the scheme could initially meet the standard Approved Document L1A 2006 criteria, then make use of the aforementioned "green" technologies to achieve both the Code Level 3 *and* the 20% renewables criteria (e.g. using solar thermal hot water production, as shown earlier), however it has been demonstrated that in numeric terms Code Level 3 can still be achieved (a 27% reduction in carbon emissions over L1A 2006) without the need for "green" technologies by the following measures:-

- Increased building thermal performance (reduced U-values and air permeability);
- Mechanical Ventilation Heat Recovery (MVHR).

It is also recommended that the building be configured in order to accommodate the possible future installation of a solar thermal hot water system, which would be a worthwhile future addition, subject to funding and conservation restrictions at the time.