Energy & Sustainability Statement

Chorleywood Rd,
Rickmansworth,
Hertfordshire

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EXECUTIVE SUMMARY

Energy Rating Services.com ltd (ERS) has been appointed to prepare Energy & Sustainability Statement for the proposed two 5-bedroom detached houses at **Chorleywood Rd, Rickmansworth.**

The two dwellings are 3-storey properties located in Rickmansworth, Three Rivers District Council area.

Dwelling	No. for type	Floor Area (m^2)
5 bedroom house	1	334.04
5 bedroom house	1	334.04
Total	2	668.08

This report outlines the key energy & sustainability measures to be incorporated in this project in accordance with the following policies:

- **Policy DM4: Development Management Policies LDD– Three Rivers District Council (2013)**
- **Local Development Framework, Core strategy – Three Rivers District Council (2011)**
- **NPPF - National Planning Policy Framework**

Policy DM4 of the Development Management Policies states that:

'From 2013, applicants will be required to demonstrate that development will produce 5% less carbon dioxide emissions than Building Regulations Part L requirements (2013) having regard to feasibility and viability. This may be achieved through a combination of energy efficiency measures, incorporation of on-site low carbon and renewable technologies, connection to a local, decentralized, renewable or low carbon energy supply.'

Based on the incorporation of the 'good practice' energy efficiency measures included in the sustainability statement, the development's energy consumption and resulting carbon emissions are presented (fuel, assumed in this case to be natural gas). This is to compare the energy consumption and subsequent CO2 emissions before and after renewable energy & efficiency measures.

The incorporation of energy saving measures, low carbon technologies and renewable energy sources follows a hierarchy of measures based on the priority given to different carbon reduction techniques, which will reduce the total energy consumption. Of primary importance is the minimization of energy requirement due to the incorporation of good practice energy saving techniques ("be lean"). Only after these measures have been incorporated a minimization of losses associated with the supply of energy should take place ("be clean"). The final level of the hierarchy is concerned renewable technologies be considered ("be green").

The following energy saving technologies will be incorporated where possible to minimize the development's energy requirement:

- Low air permeability of facade
- Improved U value
- High performance Low E glazing
- Energy efficient lighting (LED)
- A -rated gas condensing boiler connected to underfloor heating and radiators
- Delayed thermostat control for space heating
- Insulated DHW cylinder with reduced heat losses

The range of possible on-site renewable (also referred as low or zero carbon (LZC) energy sources) is then outlined and assessed in terms of the feasibility, given site constraints and expected demand profiles.

For each house, an array of 0.75 KWp of PV panels (3 PV panels covering 4.8 m^2 of roof area for each house) is proposed as part of the sustainability strategy to be incorporated.

As result, the total amount of PV panels for the whole residential development shall be 1.5 KWp of power with a total roof area of 9.6 m^2 (total of 6 panels for the 2 houses). The calculations carried out to assess carbon emissions and energy in Table 2 refer to the whole residential scheme.

The energy strategies suggested for Chorleywood Rd, Rickmansworth are optimal fabric performance along with an A-rated gas condensing boiler for each house and PV panels to allocate on the South-East slope of main pitched roof or on the South-West rear roof area.

These will allow achieving a carbon reduction equal to 8% over 2013 Building Regulations scenario, exceeding the Carbon Target of 5% set by Three Rivers District Council.

The estimated CO2 savings are calculated based on the most feasible LZC options. Finally, the energy efficiency, renewable and other sustainability options are summarized with reference to the requirements of the Planning Guidance document.

All calculations within the report, for the analysis of the proposed building, were based upon BRE approved Plan Assessor 6.3.2.

ENERGY & CARBON DEMAND SUMMARY

Table 2- Energy and Carbon reductions

	Energy demand (kWh)	Energy demand savings (%)	CO2 Emissions (kg/yr)	CO2 Emissions savings (%)
Proposed baseline scheme	43,418		7,646	
Proposed scheme after energy efficiency measures	43,259	0.4%	7,615	0.4%
Proposed scheme after renewables	39,626	8.6%	7,006	7.4%
Total	39,626	**9%**	7,006	**8%**

Figure 2 Carbon emission graph

As shown in Table 2 and 3, the estimated annual baseline energy consumption of the proposed development at Chorleywood Rd, Rickmansworth is 43,418 KWh/yr. The resulting annual carbon dioxide emissions are approximately 7,646 CO_2/yr.

The Figure 2 above indicates that by taking energy efficiency measures, the energy usage will be saved by 9% and CO_2 emissions by 8%, exceeding Three Rivers District Council requirements.

The specifications used for the proposed scenario are detailed below in Table 3 and they allowed to achieve 8% carbon reduction from the application of efficiency measures and renewable sources.

Table 3- Proposed Be Green scenario specifications

Parameters			**Be Green Scenario**
Fabric	U value (W/m2K)	Walls	0.20
		Floors	0.13
		Roof	0.14
		Windows	1.20
		Doors	1.20
Air permeability	Q (m3/m2h)		4
Systems	Gas Combination boiler	Efficiency	89.6%
Controls			Interlock/ Delayed Thermostat/ Weather Compensator
Lighting Systems	Lighting type		LED
Renewables	Photovoltaics Panels (KWp)		0.75 KWp, 3 PV panels*, 4.8m^2 *for each property

The energy assessment was carried out through the NHER Plan Assessor version 6.2.3.

SECTION INTRODUCTION

OBJECTIVE

This document has been prepared with reference to the Policy DM4: Development Management Policies LDD and seeks to address at a preliminary level the requirements in terms of mitigating CO2 emissions, sustainability and renewable energy.

SUMMARY

This is for the development of two 3-storey dwellings in Chorleywood Rd, Rickmansworth.

The key sustainability measures to be incorporated in this development are outlined in Section 2 below. These correspond with the project's aspiration to achieve the best practicably possible for commercial and residential development.

Based on the incorporation of the 'good practice' energy efficiency measures included in the Sustainability Statement, the development's energy consumption and resulting carbon emissions are presented. For clarity these figures have been broken down by fuel type (electricity and fossil fuel, assumed in this case to be natural gas). The range of possible on-site renewable (also referred as low or zero carbon (LZC) energy sources) is then outlined and assessed in terms of the feasibility, given site constraints and expected demand profiles. The estimated CO2 savings are calculated based on the most feasible LZC options.

CALCULATION METHODOLOGY

All energy figures have been calculated using approved SAP energy calculator tool and industry standards to provide evidence of compliance with the Building Regulations as well as amount of improved carbon emissions for the development.

The carbon emissions factors used in all calculations in this document are those published in Table 2 of Part L2A of the Building Regulations. The relevant factors are reproduced in Table 6 below.

Table 6-Carbon emissions factors by fuel type

Fuel	CO_2 emission factor ($kgCO_2/kWh$)
Natural Gas	0.194
Biomass	0.025
Grid supplied electricity	0.422
Grid displaced electricity	0.568

Section 2 Energy Statement

2.1 Overall Site Energy Consumption and Carbon Emissions

The overall energy consumption of this residential development has been calculated to be 43,418 kWh/year.

Policy DM4 Development Management Policies LDD requires 5% reduction of CO2 emissions from energy efficiency measures, on-site renewable or LZC technology.

The proposed strategies involve optimal fabric U-values, an A-rated condensing gas boiler connected to underfloor heating and radiators. Additional controls such as Delayed Thermostat and weather compensator controls are suggested to allow occupants with more control over the space heating system. Renewable sources will be integrated with the systems as part of the sustainability strategy to comply with Tree Rivers District Council requirements.

The combination of the above efficient measures will reduce carbon emission by 8% compared to Part L 2013 Building Regulations levels for this residential development.

The development's overall carbon emissions will depend on a mixture of fuels used. Electricity generates zero carbon at the point of use but has a relatively high carbon emission factor due to the inefficiencies of generation (principally from natural gas and coal) and distribution. Natural gas has a lower carbon factor, even when on-site boiler efficiency and distribution losses are considered. The carbon emission factors used for the calculations in this section are as follows:

- Grid Supplied Electricity 0.422 $kgCO_2$ / kWh
- Natural Gas 0.194 $kgCO_2$ / kWh

The detailed evaluation of proposed scheme resulted in total annual energy consumption of 39,626 kWh/year and 7,006 kg of CO2 emissions.

2.2 Renewable Energy Sources

Introduction

This section provides an overview of the technologies considered, a brief assessment of their feasibility, a proposed mixture of suitable technologies and finally an estimate of the achievable carbon reductions due to LZC energy sources.

Demand Profiles

The balance of technologies chosen will depend on the development's energy demand patterns. Dynamic thermal simulation will be necessary to provide the level of detail required for a more advanced LZC energy strategy. The renewable energy required for space heating and hot water might be supplied to the whole development. However, the renewable thermal energy might need to be topped up by conventionally generated space heating/ hot water to cover peak demands.

Keeping in mind that the space heating energy demand changes according to the season while hot water energy demand will provide a significant base load throughout the year.

Electrical demand is likely to be moderate throughout the year. Lighting loads will be highest during the evening but will continue at reduced levels throughout the night and during the day.

FEASIBILITY

Use and type of on-site renewable source depends on many different factors and site constraints, such as location, climate, orientation, viability, planning issues etc. A brief description and feasibility of each option are discussed below.

Further descriptions of the LZC technologies are included in Appendix A.

BIOMASS

Reliability of fuel supply, typically wood chips or pellets, has traditionally been an issue but increasing demand is improving the supply situation. Storage of fuel is also a potential issue, the volume of storage required will depend on the frequency of delivery and the fuel's energy density (pellets contain less moisture and have a higher packing density than chips, so their energy density is higher).

Biomass boilers however would need to be connected to hot water tank acting as a buffer to smooth peak hot water demand and also allows operating a boiler in optimal conditions. It is suggested that the LZC strategy includes sufficient biomass boiler capacity to meet the majority of the annual heat demand. In addition sufficient gas fired condensing boiler capacity can be installed to provide back up.

Suitable storage space for fuel needs to be considered with this option. Due to the issues with storage of fuel and hot water storage tank and scale of the project, this option hasn't been considered to be suitable and viable.

GROUND OR AIR SOURCE HEAT PUMP

Ground or air source is commonly used technique to provide buildings with heating and cooling via heat pumps. Closed vertical boreholes or active thermal piles are the main two ways feasible of extracting heat/"coolth" from ground. The system works most efficiently if annual heat and cooling energy supply by the system is in balance, so the ground will not become either too hot or cold resulting in loosing heating/ cooling potential over years. Bearing this in mind the ground source heating and cooling system needs to be carefully sized and designed.

Due to the complexity of the system, condition of the ground and high cost of boreholes this is not considered as a preferred option for this small development.

Air source heat pump (ASHP) is not considered a valid solution for this residential development in Chorleywood , Rickmansworth, due to the size and building use.

SOLAR THERMAL COLLECTORS

Solar thermal collectors (flat plate or evacuated tubes) convert solar thermal energy into heat for hot water generation. These are usually located on a roof oriented south facing in an ideal slope of 45 degree. Solar collectors in properly sized and designed provide approx 40% of annual hot water demand. As hot water is not the main source of energy consumption for a small residential development this type of renewable energy would not provide the required percentage from on-site renewable.

PHOTOVOLTAIC

Solar photovoltaic (PV) technology price is declining in recent years and is attractive due to government FIT incentives which came into effect from April 2010. It can provide a guaranteed, but modest, contribution to the development's electrical demand. PV technology will form part of the LZC strategy. 1 kWp of Solar PV can produce 850 kWh/ year of electricity reducing the energy requirement and CO2 emissions.

This option has been considered to be appropriate and viable as the roof area is large with none or very little shading. Maximum efficiency can be achieved with 45% degrees inclination of the panels according to roof slope.

The proposal for the 2 houses consists of a provision of 1.5 Kwp of solar array that will cover a roof area of approximately 9.6 m^2, with possible South-East and South-West orientation and inclined to 45 degrees tilt along the main roof pitch.

The available roof space and the optimal orientation for maximum efficiency of the PV panels, are identified in the site plan for Chorleywoood Rd houses below (Fig. 3).

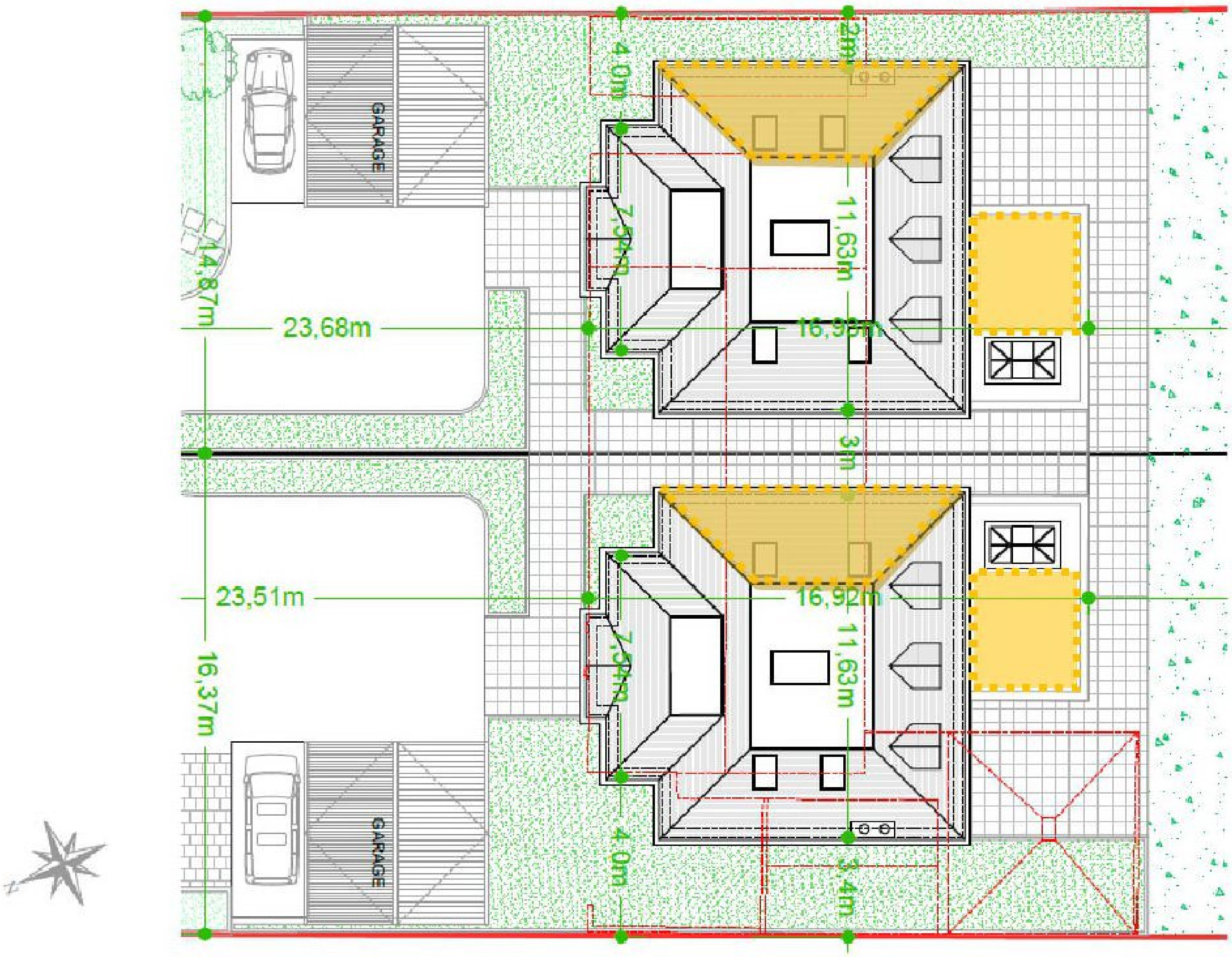


Figure 3- Available roof area with South-East and South-West orientation for allocation of PV array in yellow

For this development, the PV option in conjunction with high efficient gas fired boilers can reduce the CO2 emissions by 8%. Specifically, each house will require approximately 3 PV panels, which produce 0.75 KWp of power. Therefore, a total PV panels provision of 1.5 Kwp for the whole development has been specified as the most beneficial and preferred option (See below table 4).

Table 4- Proposed PV panels specifications

Photovoltaic panels	
Module Efficiency	19%
Panel Orientation	South-East or South West
Tilt	45%
Array Area	9.6 m2
No. PV panels	6
Predicted site Solar Energy	1.5 KWp
Energy offset by the PV array* **the figures relate to the total PV array allowance*	3,633 KWh/yr
Total CO_2 savings	609 KgCO2/yr

WIND ENERGY

Energy from wind is another source of renewable energy using large or small scale wind turbines but they are highly dependent of the location, average wind speed and site constraints. Planning has been a big issue with regards to wind turbines in recent years. Also high cost of installation and maintenance makes this option no suitable for this development.

SECTION 3 SUSTAINABLE DESIGN & CONSTRUCTION STATEMENT

3.1 INTRODUCTION

This section expands on the sustainability issues outlined in **Local Development Framework, Core strategy – Three Rivers District Council (2011)** and **NPPF National Planning Policy Framework.**

The measures required to meet the levels specified in the planning guidance are discussed.

3.2 WATER

It is possible to reduce and control the water consumption on this project. This can be achieved by applying various water efficiency and reclamation / recycling measures.

WATER EFFICIENCY MEASURES

The following measures will be used to reduce the quantity of water need to satisfy end users:

- Dual or low flush WCs
- Spray or aerating taps
- Water efficient appliances
- Low flow showers

3.3 BUILDING MATERIALS

All material shall be selected in a way to reduce the environmental impact.

The key issues to be addressed in the selection of materials and equipment are:

- Use of materials and equipment from sustainable sources
- Minimisation of in-use environmental impacts
- Minimisation of embodied environmental impacts
- Use of materials and equipment with high recycled content

3.4 WASTE

A site waste management plan will be provided with details of waste minimisation, sorting, reuse and recycling procedures. Sustainable waste management should follow the hierarchy described in *BS 5906: Waste management in buildings. Code of practice*. This outlines the following principles in decreasing order of desirability:

- Considerate Construction Scheme
- Reduce waste
- Re-use materials and equipment (and facilitate future reuse)
- Recycle waste (and facilitate recycling)
- Compost biodegradable waste
- Recover energy from waste (and facilitate energy recovery from waste)
- Disposal

3.5 Lighting & Appliances

Electricity for lights and appliances (including cooking) can account for a significant proportion of total energy costs and CO2 emissions. This will be reduced by:

- Specifying energy efficient lamps wherever appropriate and switches at all room exits. At least 75% of the light fittings will be energy efficient fittings.
- Choosing low energy A rated appliances.
- Providing occupants with information on the choice and use of low energy LED lights and appliances.

External lighting

Any external lighting will use either:

- Incandescent lamps with photocells (daylight sensors) and PIR with a maximum lamp capacity of 150W Or
- Energy efficient lamps (efficacy of at least 40l/W) and compatible photocell or timer.

3.6 Ecology

The site is described as a “low ecological value”. However ecology will be enhanced by several means that are possible to integrate into typical residential development. In simple cases this can include installing bat and or bird boxes, and planting a variety of vegetation around the building in plant beds or boxes to increase the attractiveness of the site to wildlife.

3.7 Flood Risk Assessment

Flood Zones

The Environment Agency has developed a flood risk map, which shows the relative risk of flooding for different return periods. Flood zones assume that no defences are present and so where these do exist they are only indicative of the potential for flooding.

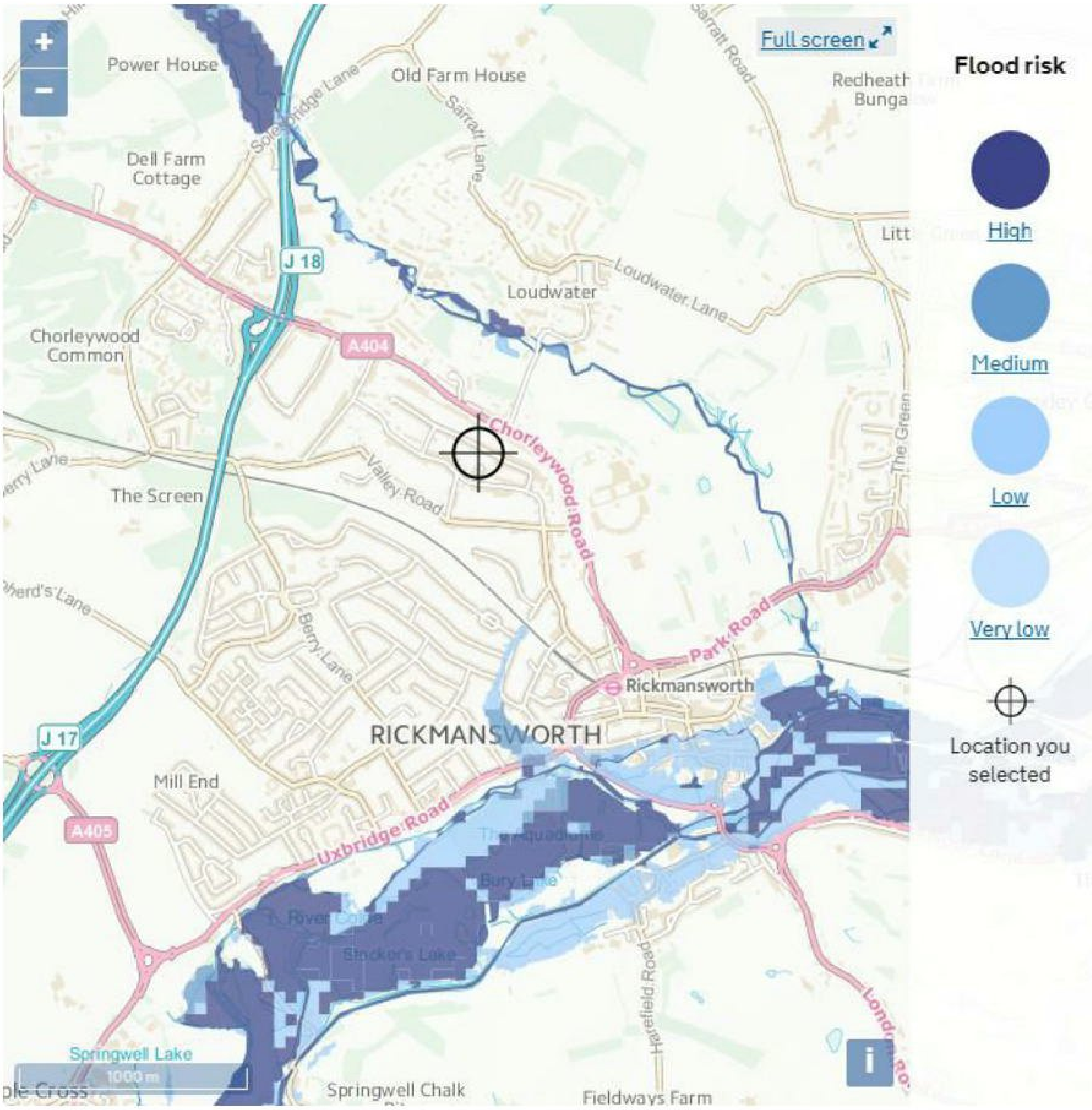


Figure 4- Environment Agency Flood Risk map

The whole development lies within flood zone 1 of the Environment Agency's flood risk map as seen in fig. 4. Land located within flood zone 1 is at very low risk of flooding having an associated annual probability of flooding of less than 1 in 1000 (0.1%).

Study Approach

In accordance with the National Planning Practice Guidance for Flood Risk document (NPPG), land within flood zone 1 is suitable for all uses. Assessment of this site has been based upon the Environment Agency's flood interactive map, the topographical site survey and the architect's proposed development layout.

FLOOD VULNERABILITY

From the flood risk vulnerability classification of the NPPG document, residential development comes within the 'more vulnerable' classification. Based on the Environment Agencies flood map, the development site is located within Flood Zone 1 and in accordance with National Planning Practice Guidance neither a sequential or exception test is required.

Flood risk to the site located within Flood Zone 1 was identified as very low risk flooding coming from a surface water source which is elaborated below.

SURFACE WATER FLOODING

Surface water sewers/drains can be at risk of surcharging during extreme rainfall events with flooding occurring mainly from manholes and gullies.

We understand, from the records/survey information available in the vicinity of the site, that there are street drains located along Chorleywood Rd.

The Environmental Agency has classed the site as "very low risk" as seen below in Fig. 5.

There are flood mechanisms present, no matter the associated risk of flooding, to help aid in surface water flooding should it occur with surface water drainage present, therefore the risk of the site flooding from this flood mechanism is considered to be negligible.

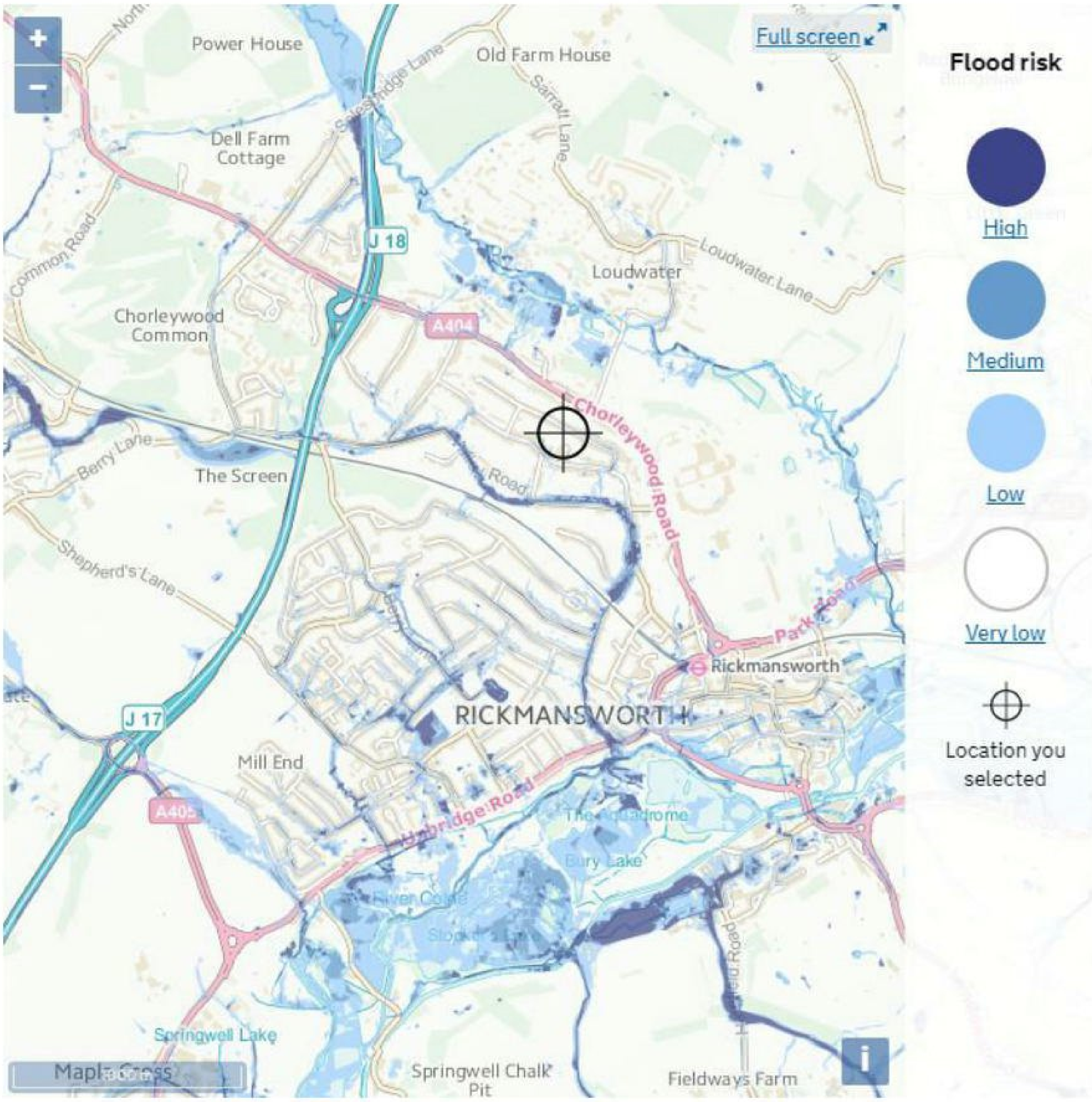


Figure 5- Environment Agency Surface Water Flooding Map

SECTION 4 CONCLUSION

This report assesses the energy demand and carbon emissions of a new residential development in Chorleywood Rd, Rickmansworth in three Rivers District Council area.

Following **Policy DM4 Development Management Policies LDD**– Three Rivers District Council (2013)**,** the baseline energy demand for the 2 dwellings has been estimated to be 43,418 kWh/year, resulting in CO2 emissions 7,646 kg/year.

By considering optimal fabric thermal performance, A-rated gas **boiler condensing boiler** along with **additional space heating controls**, and a **PV provision of 1.5 KWp** (3 panels and 4.8 m^2 roof area per house) energy consumption and CO2 emissions will be in the range of 39,626 kWh/yr and 7,006 kgCO2/yr accordingly.

The proposed PV array will be accommodated on the South-East slope roof area with a tilt of 45% following the roof slope or alternatively on the rear South-West flat roof of the two houses as shown in Section 2, Fig. 3 of this report.

The proposed energy efficiency strategies and the installation of renewable sources will allow achieving **8% reduction in CO2 emissions** compared to Part L 2013 Building Regulations levels, exceeding the carbon target set by Three Rivers District Council.

Hence, this project will satisfy the requirements of the planning department for sustainability of Three Rivers District Council reducing the environmental impact of the development.

The proposed dwellings in Chorleywood Rd will be designed with a high level of insulation and low air permeability to reduce heat loss as much as is practically possible, also the use of low energy lighting and A – Rated white goods are essential for the reduction of energy consumption.

The control strategy throughout must be carefully designed to ensure the most economical operation of all equipment throughout the development.

From the above we can come to the conclusion, taking into account all the conditions surrounding this site, that energy efficiency measures integrated with the existing LZC technology is a feasible option to save energy, reduce CO2 emissions and to mitigate the environmental impact of conversion project.

APPENDIX A - LOW OR ZERO CARBON ENERGY SOURCES

BIOMASS

Biomass is an alternative solid fuel to the conventional fossil fuels. In theory it is carbon neutral as the carbon emitted by burning is offset by the carbon absorbed during the growth of the plant. In reality, biomass fuel is not completely carbon neutral; there is a small carbon factor due to the energy used in processing and delivery.

Various types of biomass fuel are in use, the most common being the woody biomass, which includes forest residues such as tree thinning, and energy crops such as willow short rotation coppice. Biomass is converted into a manageable form that can be directly fed to the heat or power generation plant, thus replacing fossil fuel. As a result, applications can range from large-scale heating boilers to individual house room heaters to combined heat and power generation (CHP). For building applications, the fuel usually takes the form of wood chips, logs and pellets. Wood pellets are essentially compacted high-density wood with low moisture content, thus having a higher calorific value per unit volume or weight.

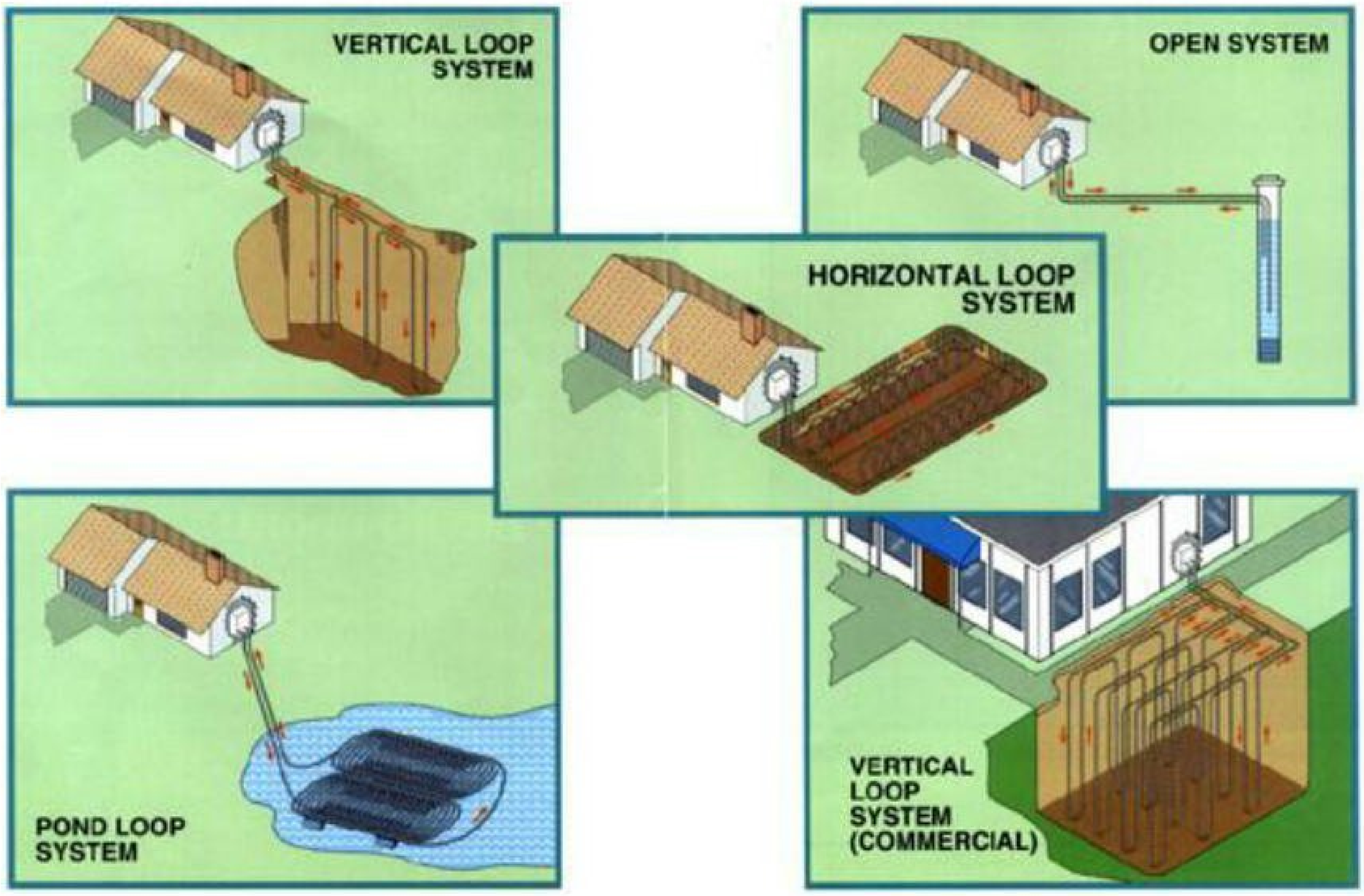
GEOTHERMAL ENERGY

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.



The main types of ground source heat exchanger

Vertical Closed Loop System

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.

Horizontal Closed Loop System

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.

Ground source heat exchange options in summary:

VERTICAL LOOP SYSTEM - CLOSED BOREHOLES

- moderate heat capacity
- relatively low installation cost

VERTICAL OPEN SYSTEM - OPEN BOREHOLES

- high heat capacity
- high running energy
- high installation cost

HORIZONTAL LOOP SYSTEM – STRAIGHT PIPES

- low capacity,
- high installation cost
- extensive ground excavation work

HORIZONTAL COILED LOOP SYSTEM – 'SLINKY' PIPES

- good capacity
- low installation cost
- extensive ground excavation work

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.

CHP

Combined heat and power (CHP) is a process involving simultaneous generation of heat and electricity, where the heat generated in the process in harnessed via heat recovery equipment. CHP at the large commercial size is now fairly common in premises which have a simultaneous demand for heating and electricity for long periods, such as hospitals, recreational centres and hotels. In addition, small CHP systems are now becoming available for individual houses, group residential units and small non-domestic premises. Compared with using centrally generated electricity supplied via the grid, CHP can offer a more efficient and economic method of supplying energy demand, if installed and operated appropriately, owing to the utilisation of heat which is normally rejected to the atmosphere from central generating stations, and by reducing network distribution losses due to local generation and use.

A small CHP unit – similar to the size of unit investigated

Heat generated will be used for space and water heating, and additional heat storage may be used to lengthen use periods, to assist in warm-up and to improve overall energy efficiency. For overall good energy efficiency, as with all CHP, usage must be heat demand led. Thus, a sophisticated control system is required and users should be made aware of efficient operating practices.

SOLAR THERMAL COLLECTORS

Solar thermal collectors (flat plate or evacuated tubes) convert solar thermal energy into heat for hot water generation. These are usually located on a roof oriented south facing in an ideal slope of 45 degree. Solar collectors properly sized and designed provide approx 50% of annual hot water demand.

For example approx. 35m2 flat plate solar collectors at cost of £24,000 generates around 11MWh of hot water resulting in 10% carbon savings.

However, should a CHP unit is used for hot water generation when solar collectors will be redundant.

PHOTOVOLTAIC

Photovoltaic modules convert sunlight directly into DC electricity and can be integrated into buildings. Photovoltaics (PVs) are distinct from other renewable energy technologies since they have no moving parts to be maintained and are silent. PV systems can be incorporated into buildings in various ways: on sloped roofs and fl at roofs, in façades, atria and shading devices. Modules can be mounted using frames or they can be fully incorporated into the actual building fabric; for example, PV roof tiles are now available which can be fitted in place of standard tiles.

Currently, a PV system will cost between £1500 and £2500 per kWp, and frequently part of this cost can be offset owing to the displacement of a conventional cladding material. Costs have fallen significantly since the first systems were installed (1980s) and are predicted to fall further still.

While single crystal silicon remains the most efficient flat plate technology (15–16% conversion efficiency); it also has the least potential for cost reduction. PV cells made from poly-crystalline silicon have become popular as they are less expensive to produce, although they have a slightly lower efficiency.

Thin film modules are constructed by depositing extremely thin layers of photosensitive materials on a low-cost backing such as glass, stainless steel or plastic. As much less semiconductor material is required as for crystalline silicon cells, material costs are potentially much lower. Efficiencies are much lower, around 4–5%, although this can be boosted to 8–10% by depositing two or three layers of thin film material. Thin film production also requires less handling as the films are produced as large, complete modules and not as individual cells that have to be mounted in frames and wired together. Hence, there is the potential for significant cost reductions with volume production.

Since PVs generate DC output, an inverter and other equipment is needed to deliver the power to a building or the grid in an acceptable AC form. The cost of the inverter and these 'Balance Of System' (BOS) components can approach 30% of the total cost of a PV system. Hence, simplification and cost reductions in these components over the coming years will also be necessary to make PV systems affordable.

WIND ENERGY

Wind power is the most successful and fastest spreading renewable energy technology in the UK with a number of individual and group installations of varying size, capacity and location. Traditionally, turbines are installed in non-urban areas with a strong trend for large offshore wind farms. In parallel with the design and development of ever-bigger machines, which are deemed to be more efficient and cost-effective, it is being increasingly recognised that smaller devices installed at the point of use, i.e. urban settings, can play an important role in reducing carbon emissions if they become mainstream.

At present there is a wide range of available off-the-shelf wind products, many manufactured in the UK and EU with proven good performance and durability. The dominant type is horizontal axis wind turbines (HAWT), which are typically ground mounted. Vertical axis wind turbines (VAWT) have limited market presence and there is a trade-off between lower efficiency and potentially higher resistance to extreme conditions. Capacity ranges from 500W to more than 1.5MW, but, for practical purposes and in built-up areas in particular, machines of more than 1kW and below 500kW are likely to be considered.

Wind technology is also currently one of the most cost-effective renewable energy technologies, which is attributable to the large scale of installations reducing the unit output cost. Individual building or community wind projects, although smaller, have the advantage of feeding electricity directly into the building's electricity circuit, thus sparing costly distribution network development and avoiding distribution losses. The downside is the still high capital cost per kW installed for smaller turbines, plus location constraints, such as visual intrusion and noise. The wind regime in urban areas is also a concern owing to higher wind turbulence which reduces the potential electricity output.

In most cases, wind turbines are connected to the electricity grid and all generated energy is used regardless of the building demand fluctuations. The output largely depends on the wind speed and the correlation between the two is a cube function. This means that in short periods of above-average wind speeds the generation increases exponentially. As a result, it is difficult to make precise calculations of the annual output of a turbine, but average figures can provide useful guidance to designers and architects. In reasonably windy areas (average wind speed of 6m/s) the expected output from 1kW installed is about 2500kWh annually.

The cost per kW installed varies considerably by manufacturer and size of machine with an indicative bracket of £2,500–£5,000. With a lifespan of more than 20 years, wind turbines can save money if design and planning are carried out in a robust way.

Building-integrated wind turbines are starting to be a reality in the UK, but potential projects may face difficulties with obtaining planning permission. There are a few examples now of permitted development rights for certain rooftop turbines in some local councils. A number of horizontal axis devices specifically designed for building integration are now available commercially, having design and reliability parameters relevant to the urban context. Building-mounted vertical axis devices are under development.

At present, turbines installed near buildings, as well as community installations for groups of buildings, should be regarded as the larger wind energy source related to buildings, when they contribute to the carbon emissions from these premises using 'private wire' networks. However, the contribution of several building-integrated turbines in a development is likely to become significant in the next few years.

APPENDIX B - ENERGY EFFICIENCY MEASURES

The reduction of energy consumption is an essential element in the reduction of carbon emissions. The incorporation of good practice energy saving techniques should be considered paramount. This first stage is described as "be lean". Only after the energy consumption has been minimised should consideration be given to the use of renewable technologies. This second stage is described as "be green". The final level of the hierarchy is concerned with minimisation the losses associated with the supply of energy, described as "be clean".

PROPOSED ENERGY EFFICIENCY MEASURES

The following energy saving techniques will be incorporated where possible to minimise the development's energy requirement:

EFFICIENT LIGHTING

Energy efficient lighting systems combined with the careful use of daylight should be used to minimise both the electricity consumed and the heat load generated by lighting. The lighting control system should be able to able to adjust the light output in response to varying daylight and occupancy conditions.

LOW ENERGY HEATING AND COOLING

The demand for heating and cooling should be reduced by using passive means rather than relying on energy intensive systems to achieve comfort. These could include, in addition to the techniques mentioned above, the use of exposed structural mass to moderate peak cooling loads. Consideration should also be given to the reduction of internal loads such as lighting and equipment.

Where mechanical ventilation and cooling are unavoidable, consideration should be give to the use of more efficient systems such as displacement ventilation, chilled beams, or 'mixed-mode' systems that allow natural ventilation to be supplemented with mechanical cooling at times of peak demand.

HEAT RECOVERY

Heat recovery systems reduce the heating loads by recycling heat from exhaust air. High efficiency thermal wheels can recover up to about 85% of the heat in the exhaust air.

VARIABLE SPEED DRIVES

Electronically controlled variable speed drives (inverter drives) vary the speed of equipment to suit the demand. They are proven to make significant energy savings and can be applied to pumps, fans and refrigeration compressors.

BUILDING ENERGY MANAGEMENT SYSTEMS (BEMS)

A BEMS can be employed to control and monitor all major items of mechanical equipment. The monitoring system can provide the required sub-metering as well as identification of fault conditions which can lead to excessive energy consumption. The system may also be able to optimise plant control strategy to ensure optimum operational efficiency.