

Ysalyfera School Energy Options

Description

Low or Zero Carbon Technologies
Feasibility study

ISSUE 00



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Executive Summary

From the technologies investigated within this report, below is a summary table of the findings detailing Building Regulations BRUKL calculation outputs, EPC outputs, BREEAM ratings, energy usage, running costs with simple system paybacks.

Table1 - Technology Options

Technology	BRUKL TER kg CO2/m ² /yr	BRUKL BER kg CO2/m ² /yr	BRUKL Pass	BREEAM Rating	EPC Score	EPC Rating	Total Building Annual Energy Use (Inc. Fans, Lighting etc.) kW/h	Heating & Hot Water Running Cost	Payback Over Period (Years)
Air Permeability Rate 5 m ³ /hr/m ²									
Gas Boilers (Base)	21.7	24.7	No	Very Good	28	B	389,675	£5,958	Na
Gas Boilers with 10m ² SHW Panels	21.7	24.4	No	Very Good	28	B	384,846	£5,709	60
Gas Boilers with 175m ² PV Panels	21.7	20.2	Yes	Excellent	23	A	389,675	£3,293	11
Gas Boilers with CHP	21.7	23.6	No	Very Good	27	B	370,604	£4,960	15
Air Source Heat Pump	21.7	24.2	No	Very Good	27	B	381,553	£6,018	No Payback
Ground Source Heat Pump	21.7	24	No	Very Good	27	B	379,083	£5,907	390

Of the options listed, the only option which satisfies “Part L2A” of the “Building Regulations” is the Gas Boilers with 175m² of Photovoltaic Panels; as this option attains a BRUKL BER (Building Emission Rate) lower than the TER (Target Emission Rate).

This option is also the only option to satisfy the client’s aspirations of a BREEAM “Excellent” Rating for BREEAM Ene01.

1. Introduction

1.1 Aim of study

The aim of this study is to provide an analysis of the Renewable Technologies Options for the proposed Ystalyfera School.

Technologies assessed as follows;

- Gas Boilers (Base Model)
- Gas Boilers with Solar Hot Water Heating
- Gas Boilers with Photovoltaic Panels
- Combined heat and power
- Air source heat pumps
- Ground source heat pumps

The following technologies have been omitted from the study due to their un-suitability to the project.

- Biomass Boiler Plant
- Wind Turbines

This report gives a brief overview of each technology and makes an assessment of their suitability to the project based upon available resources, performance, life-span and financial assessment based upon simple payback along with CO² emissions.

1.2 Outline of base case

The base assessment undertaken for the School has been undertaken utilising Gas fired boilers for heating & gas fired water heaters for hot water generation. The all options utilise a combination of natural and mechanical ventilation and LED lighting.

This base option results in a total projected annual energy usage for the building is 389,675kWh/yr and the building carbon emissions are 24.7kgCO²/m²/yr.

The buildings TER (target emissions rate) is 21.7kgCO²/m²/yr, therefore this option would not satisfy the requirements for BRUKL "Building Regulation" compliance without further betterment to the building and (or) its services.

The projected combined cost for Heating & Hot Water demand equates to £5,958.

The base scheme achieves an upon the following building criteria;

- Air permeability Rate 5 m³/hr/m²; (Notional Building Rate)
- External Wall U-Value 0.15 W/m².k;
- External Roof 0.15 W/m².k;
- Ground Floor 0.22 W/m².k;
- External Doors/Glazing 1.6 W/m².k.
- Gas fired boilers with a seasonal efficiency of 96%.
- Specific Fan Power (SFP) no higher than Notional for Ventilation Type

For the purposes of the financial assessment the following energy costs have been used;

- Electricity 14.0p/kWh
- Gas 3.0p/kWh

When assessing the carbon emissions for each option the following criteria have been used;

- Grid supply electricity 0.519 tonnes CO²/MWh
- Gas 0.216 tonnes CO²/MWh
- Renewables zero tonnes CO²/MWh

1.3 Client's aspirations

The client requires that the School achieves a BREEAM rating of excellent.

2. Low and zero carbon technologies

2.1 Solar Hot Water

2.1.1 Overview

Solar hot water systems use the energy from the sun to provide hot water. The elements that make up a solar hot water system are a solar collector which is connected to a hot water storage cylinder via a closed heat transfer system which conveys the heat transfer fluid using a pump through a coil in the cylinder. The cylinder contains a secondary form of heat input using either an immersion heater or second heat transfer coil which is in turn usually connected to another heat source i.e. Gas boiler.

There are two types of solar collector available: flat plate and evacuated tube. The evacuated tube collector is more efficient than the flat plate collector.

2.1.2 Energy generated per year from solar thermal

The typical energy generated for both types of panels are as follows:

If 10m² of effective Solar Hot Water collectors were to be installed South Facing on the Roof, Hot Water energy generation would be approximately 4,336kWh/yr. This would offset the boiler energy load thus to reducing the carbon emissions by 823kg CO₂/yr.

2.1.3 Payback

The cost for a solar panel installation based upon a collector area of 10m² is in the order of £15,000. Based upon an annual energy saving of 4,336 kWh and unit cost of £0.03 per kWh for Gas the cost saved is in the order of £248. This would equate to a simple payback period of 60 years without any grants being factored into the assessment. The life expectancy for a solar thermal system is typically 20 years.

2.1.4 Land use

This system is mounted on the building, usually the roof, and as such does not impact on the land use.

2.1.5 Local planning requirements

It will be necessary that if the solar panels are to be incorporated into the project that relevant information relating to location and size are incorporated into the planning submission package.

2.1.6 Noise

These systems are near silent in operation.

2.1.7 Feasibility of exporting heat/electricity from the system

Not feasible with this system.

2.1.8 Available grants

Grants are available for Solar Thermal Technology for installation below 200kW capacity via the Renewable Heat following successful application. If successful the owner of the installation can claim against the metered energy consumption of the technology. Claims are paid quarterly for a period of 20 years.

Current payment from the Renewable Heat incentive, for energy generated via Solar Hot Water equates to 10.89 pence/kWh. Therefore based upon the annual energy generation of 4,336 kWh, payment per annum would equate to £472, thus resulting in revised payback of the system of 20.8 Years.

2.2 Photovoltaics

2.2.1 Overview

Photovoltaic (PV) systems use solar cells to convert sunlight to electricity. The PV cell consists of one or two layers of a semi-conducting material, usually silicon. When light shines on the cell it creates an electrical field across the layers, causing electricity to flow. The greater the light intensity, the greater the flow of electricity.

There are three basic kinds of solar cells:

- Monocrystalline: which has a typical efficiency of 15%
- Polycrystalline: which has a typical efficiency of at least 13%
- Thin film: which can be applied to other materials such as glass or metals and has a typical efficiency of 7%.

Building integrated photovoltaics are used to generate electricity. Each PV cell provides a small amount of electricity so a large number form an array with a greater output. PV is usually installed in parallel with the grid although stand-alone generation is not uncommon, particularly in isolated areas. A key advantage of photovoltaics is that they can be integrated with the fabric of a building with relative ease. Where systems can be integrated within buildings, the structural support for PV is available at no additional cost. In ideal circumstances the modules replace building components such as curtain walls, roof tiles, atria and structural glazing and vertical walls. Framed PV modules can either be roof mounted, free-standing, or integrated into the roof or facades of buildings. The best locations in the northern hemisphere for PV systems are on buildings with a roof or wall that faces within 45° of south, with systems elevated at 30-40°.

2.2.2 Energy generated per year from solar thermal

If installing 175m² of PV panels for a peak capture of 29kW peak electricity, this system will typically generate in the order of 23,790kWh/year electricity. The carbon emission reduction from this will be in the order of 12,348kgCO₂ per year.

2.2.3 Payback

The annual cost saving based upon an energy generation of 23,790kWh/year is £1,665 (based upon 50% of energy used within building) based upon £0.14 per kW hour, additionally with a feed in tariff currently at £0.04per/kWh generated and additional £999 shall be saved, totalling £2,664 per annum.

PV panels typically cost about £1,000 per kW peak and therefore based upon our 29kW peak, installation the capital cost will be in the order of £29,000. The payback for this system will be 11years. The life expectancy for PV panels is typically 15 to 20 years.

2.2.4 Land use

The PV panels are usually mounted on the building at roof level. Each 1 kW peak will typically require an area of 6 m² depending upon the technology used, therefore for the 29kW peak installation the maximum area required will be 175m².

2.2.5 Local planning requirements

It will be necessary that if the PV panels are to be incorporated into the project that relevant information relating to location and size are incorporated into the planning submission package.

2.2.6 Noise

These systems are silent in operation.

2.2.7 Feasibility of exporting heat/electricity from the system

It is feasible to configure the PV system to export electricity to the grid during times of low demand. However as this is serving a primary school it is likely that any electricity generated from this system will be fully utilised.

2.2.8 Available grants

No grants are available for Photovoltaics' but the technology does fall under the "Feed In Tariff" FIT Scheme. Under this scheme, any electricity generated by the PV's on the roof that is not utilised within the building shall be exported back to the grid. This quantity is deducted from the client's electricity bill at a rate of approx £0.04 per/kW/h.

Any electricity demand required by the building that is over what is being generated by the PV's, shall be taken from the grid and charged at the standard agreed rate of electricity by the supplier.

2.3 Combined heat and power (CHP)

2.3.1 Overview

Combined heat and power (CHP), or cogeneration, refers to the local simultaneous generation of electricity and heat in the form of hot water or steam. Electricity is generated using an engine or a turbine, and heat is recovered from the exhaust gases and cooling systems.

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

2.3.2 Energy generated per year from CHP

Using an a small CHP Unit sized at approx. 10% of the peak hot water demand with a heat to power ratio electricity production of 2/1, at approx 15kW thermal output, 5.5kW Electricity Generation, the total projected annual energy usage for the building is 370,604kWh/yr and the building carbon emissions is 23.6kgCO₂/m²/yr. This would offset the boiler energy load thus to reducing the carbon emissions by 3,018kg CO₂/yr. The annual electrical load generated by the CHP unit shall be 8,177kWh/yr.

2.3.3 Payback

Electricity generated by the CHP unit is 8,397kWh per annum, generating a saving of £1,013 per annum.

This equates to an annual energy cost for Heating & Hot Water Production of £4,960. Thus, saving £997 per annum over a gas boiler system.

The cost for a CHP installation is in the order of £15,000 over a Gas fired boiler system only. This would equate to a simple payback period of 15 years without any grants being factored into the assessment. The life expectancy for a CHP system is typically 20 years.

2.3.4 Land use

The CHP unit will be located within a dedicated plant room within the building.

2.3.5 Local planning requirements

The CHP exhaust/flue details will be required to be shown as part of the planning submission should this option be considered feasible.

2.3.6 Noise

The CHP unit does generate noise and vibration but the effect of these are reduced by the manufacturer by the inclusion of anti-vibration mounts and acoustic panels that encapsulate the CHP. In addition internal building attenuation can be added should it be necessary.

2.3.7 Feasibility of exporting heat/electricity from the system

It is possible to export electricity back to the grid from this system.

2.3.8 Available grants

Feed in tariff rates are only available on Micro CHP system which generate less than 2kW peak.

2.4 Air source heat pumps

2.4.1 Overview

Air Source Heat pumps use refrigerant gases and an electrical compressor to take heat from a source (External Air) and deliver it to an output. Chillers and refrigerators are examples of systems that remove heat, but other types of system use the heat removed from a source to heat a building. Traditional heat pumps use air as the source of heat.

2.4.2 Energy generated per year from ground source heat pumps

Using an Air source system with a seasonal performance factor of 4 the total projected annual energy usage for the building is 381,553kWh/yr and the building carbon emissions is 24.2kgCO₂/m²/yr. The carbon emission reduction from this will be in the order of 1,372kgCO₂ per year.

2.4.3 Payback

The annual heating and hot water running cost for an Air Source Heat Pump system is £6,018 per annum. This results in no cost saving over a gas boiler system.

The capital cost of an Air Source Heat Pump system £20,000 over the standard Gas fired Boiler System; therefore there is no payback on this option.

The life expectancy of a Ground Source Heat Pump Unit is approximately 15 years.

2.4.4 Land use

The proposed Air Source Heat Pumps can be either located externally or located within a dedicated plant room within the building.

2.4.5 Local planning requirements

If located externally, it will be necessary that details of the units are incorporated into the planning submission package.

2.4.6 Noise

The refrigeration compressor and circulation pumps will generate an element of plant noise, but as these are located within an internal plant room this noise will be attenuated within this space.

2.4.7 Feasibility of exporting heat/electricity from the system

It is not possible to export heat/electricity from this system.

2.4.8 Available grants

Grants are available for Air Source Heat Pumps via the Renewable Heat following successful application. If successful the owner of the installation can claim against the metered energy consumption of the technology. Claims are paid quarterly for a period of 20 years.

Current payment from the Renewable Heat incentive, equates to 2.75 pence/kWh. Therefore based upon the total annual heating consumption of 4,034kWh, payment per annum would equate to £110, thus resulting in revised payback of the system of 393 Years.

2.5 Ground source heat pumps

2.5.1 Overview

Ground Source Heat pumps use refrigerant gases and an electrical compressor to take heat from a source (External Ground) and deliver it to an output. Chillers and refrigerators are examples of systems that remove heat, but other types of system use the heat removed from a source to heat a building. Traditional heat pumps use air as the source of heat.

2.5.2 Energy generated per year from ground source heat pumps

Using a ground source system with a seasonal performance factor of 5 the total projected annual energy usage for the building is 379,083kWh/yr and the building carbon emissions is 24kgCO₂/m²/yr. The carbon emission reduction from this will be in the order of 1,920kgCO₂ per year.

2.5.3 Payback

The annual heating and hot water running cost for a Ground Source Heat Pump system is £5,907 per annum. This results in a cost saving of £51 per annum over a gas boiler system only.

The capital cost of a Ground Source Heat Pump system with Boreholes equates to £100,000, this results in a payback period of 1949 years.

2.5.4 Land use

The proposed Air Source Heat Pumps can be either located externally or located within a dedicated plant room within the building.

2.5.5 Local planning requirements

If located externally, it will be necessary that details of the units are incorporated into the planning submission package.

2.5.6 Noise

The refrigeration compressor and circulation pumps will generate an element of plant noise, but as these are located within an internal plant room this noise will be attenuated within this space.

2.5.7 Feasibility of exporting heat/electricity from the system

It is not possible to export heat/electricity from this system.

2.5.8 Available grants

Grants are available for Ground Source Heat Pump Installations via the Renewable Heat Incentive following successful application. If successful the owner of the installation can claim against the metered energy consumption of the technology. Claims are paid quarterly for a period of 20 years.

Current payment from the Renewable Heat incentive, for energy generated via Ground Source Heat Pumps equate to 9.56 pence/kWh. Therefore based upon the heating annual energy usage of 3,238kWh, payment per annum would equate to £289 thus resulting in revised payback of the system of 293 Years.

3. References

- Non-domestic Heating Compliance Guide;
- CIBSE TM38: 2006 – Renewable energy sources for buildings;
- Renewable Heat Incentive – Phase 1
- BSRIA BG 1/2008 – The illustrated guide to Renewable Technologies.