

SUTCLIFFE CONSULTING ENGINEERS



ENERGY STATEMENT FOR: TRINITY ACADEMY, BARNSELEY

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1. Introduction

The purpose of this energy assessment is to demonstrate that climate change mitigation measures comply with London Plan energy policies, including the energy hierarchy. It also ensures energy remains an integral part of the development's design and evolution.

This energy assessment will address requirements in the Barnsley Council Energy Strategy 2015-2025. It will also outline the calculated CO₂ emissions and give guidance to the most achievable and affordable renewable technology to use for Trinity Academy School.

2. Available Options for Renewable Technologies

The following options for renewable technologies have been considered, expressing CO₂ emissions at each stage and potential savings.

- Air source heat pump
- Biomass providing heating & hot water
- Combined Heat & Power
- Solar Thermal for hot water generation
- Photovoltaic Cells

The following options for LZC technologies have not been considered further.

- Wind Turbine – discounted due to likely planning issues
- Ground source heat pumps

Air Source Heat Pump

Heat pumps are devices that take heat at a certain temperature from one location and release it at a higher temperature elsewhere.

Most common types of heat pump use the vapour compression cycle. This cycle of varying the pressure allows heat energy to be moved from one location to another. The only external energy input required is usually electricity to drive the compressor, controls and fans. The effectiveness of this type of cycle allow a Coefficient Of Performance (COP) of over 4 to be achieved – i.e. for every kilowatt of electricity used 4 kilowatts of energy is moved.

The flexibility of the heat pump technology allows the process to be reversed to allow cooling as well as heating. Larger installations are often based on three pipe systems to allow simultaneous heating and cooling of different areas on the same system.

With air-source, the unit draws in air from the external environment, exchanges heat-energy, and exhausts the depleted air. In heating mode, the energy from the external air supply is then transferred by way of a liquid medium (often refrigerants) to a heat pump boiler. From the heat pump boiler, the heat energy can then be transferred to the heating system.

Advantages:

- High functionality of the system allows heating and cooling.
- Proven heat pump technology with good reliability.
- Can be used to provide space heating and domestic hot water.
- Long life expectancy.
- No ground works costs.
- More Viable cost option than ground source.

Disadvantages:

- High COPs are dependent on relatively low supply temperatures in heating mode.
- Can be noisy if not sited correctly or provided with attenuation.
- Planning may be an issue with exposed installations and noise levels.

Biomass

Biomass fuelled heating is where biomass material is burned in a specially designed boiler.

Biomass is often defined as 'biological material derived from living, or recently living organisms. In the context of biomass for energy this is often used to mean plant based material, but biomass can equally apply to both animal and vegetable derived material.

Biomass is different from fossil fuels (such as coal, gas and oil) mainly in regards to time scale – fossil fuel releases carbon dioxide trapped during formation many millions of years ago. Biomass fuels form a short term carbon cycle where over a number of years the fuel is growing – removing carbon dioxide from the atmosphere, before being released during burning.

Where biomass fuel production is managed and used as a continuous programme including replanting, then the majority of CO₂ released would be offset elsewhere by the growing of additional fuel. This maintains a closed carbon cycle with no net increase in atmospheric CO₂ levels except for the transport and processing.

Because of the combustion process, solid fuel biomass boilers are unable to modulate their output quickly and may often need to have back up gas or oil fired boiler plant especially where breakdown or failure is a concern.

Advantages:

- High CO₂ saving when fuel is sourced locally (within 25 miles). Details of biofuel suppliers in the UK can be found in the national fuel suppliers database produced by the Biomass Energy Centre in partnership with the Carbon Trust.
- Timber burnt can be sourced as a waste product.
- Direct combustion systems are partially self cleaning.

Disadvantages:

- Requires large amount of fuel storage.
- Regular deliveries of fuel can be difficult to manage.
- Anaerobic Digestion systems can be unreliable if not setup correctly.
- Boilers not able to modulate output quickly.
- More expensive than conventional boilers.

Combined Heat and Power

Combined heat and power (CHP), or cogeneration, is the simultaneous production of useful heat and electricity from a single source, close to the point of use. CHP is not strictly renewable technology, however it is worthy of consideration due to the high efficiencies achieved by utilising both the generated power and waste heat as opposed to a standard power station.

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. This is due to the utilisation of heat which is normally rejected to the atmosphere from central generating stations, and by reducing network distribution losses.

The decentralisation of the generation allows improvements in overall efficiencies because of the reduction in electricity distribution losses and also use of what would otherwise be waste heat. The overall efficiencies of CHP can when correctly designed and sized to achieve 70% which is a significant improvement over traditional power stations which can achieve as low as 38% efficiency for coal-fired power stations.

Most CHP systems run in parallel with a boiler plant and will be linked directly into the building electricity distribution system. Heat generated is 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.

Advantages:

- Utilises proven technology with good levels of reliability.
- Higher efficiency and smaller carbon footprint due to use of heat compared to grid supplied electricity.
- Helps to reduce electricity bills.

Disadvantages:

- Requires regular maintenance.
- Good base load required to make the systems cost effective.
- High capital cost compared to a standard gas boiler.
- Low electrical generation compared to heat generation means only minimal returns through the feed in tariff.

Solar Water Heating

Solar water heating systems in the form of flat plates or evacuated airtight tubes can be mounted on broadly south facing roofs, where they use solar radiation to heat water for local use. Although these systems can be used throughout the year, they are most effective during the summer months and in more southerly regions because of the warmer climate.

Solar thermal panels are most effective in raising water temperature from ambient levels to 30 or 40°C; they become less efficient at higher temperatures. These systems are therefore generally used in conjunction with a standard domestic hot water cylinder as a pre-heat to reduce the energy required to raise the domestic hot water temperature to the required level of 55 – 60 °C.

Advantages:

- Proven technology with a range of collectors for different operational requirements.
- Medium ~ high reliability.
- Low maintenance requirement.

Disadvantages:

- During colder months total demand is unlikely to be met without more traditional backup heat sources.
- Requires maintenance. Access may be an issue.
- Planning may be an issue with exposed installations.
- Potential for corrosion on support structures, fasteners and other metals as part of the installation. The specific atmosphere on the site can be analysed so that appropriate protective coats can be used.

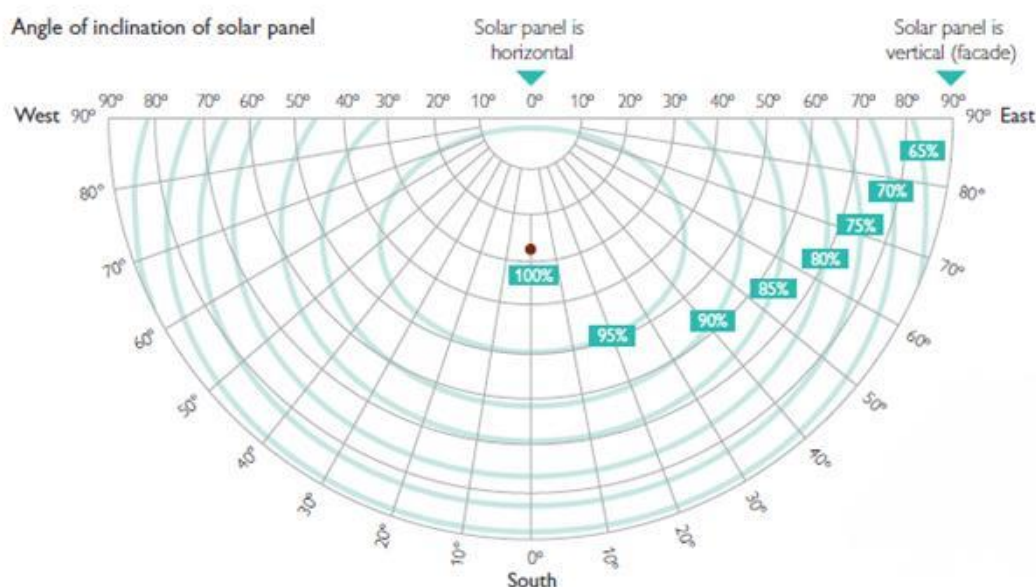
Photovoltaic Cells

Photovoltaic (PV) cells convert sunlight to DC electricity. This electricity can be used to charge batteries, or more commonly connected through an inverter connected to the electrical installation to allow the energy to be used on site or sold to the National Grid.

The design of PV cells has been developed over a number of years and the technology has become well established. The systems can be very reliable as it has no moving parts, a long design life and the energy source is available throughout the world. In fact the whole of the world's annual energy demand is delivered to the earth by the sun every 18 minutes.

Presently between only 5 ~ 18% of the available solar energy can be converted into electricity. The higher efficiency cells (monocrystalline) are significantly more expensive than lower efficiency versions (polycrystalline) however the former can generally payback in less time and produce greater CO₂ savings.

The efficiency of the panels also varies significantly depending on the orientation.



Above: Optimal location for Solar PV panels on buildings (Solar-Trade, 2015).

Advantages:

- Low maintenance requirement; some testing to electrical circuits.
- Wide range of installation options.
- Feed In Tariffs are widely available (FIT's).

Disadvantages:

- Associated inverters can cause reliability problems.
- Generally low CO₂ savings relative to cost.
- Not generally cost effective due to low output.
- Planning may be an issue with exposed installations.
- Requires careful positioning for optimum performance

This option may be of significant benefit to the overall electrical energy use of the building, particularly as feed-in tariffs can be applied when electrical generation by the PV is not directly being used by the building. There are a variety of pitches and roof areas available where PV may be sited, though these installations can have a high installation cost depending on area to be used.

3. Improvement to Building Fabric

Improvements to the current building fabric are being considered. Building fabric has been designed to be thermally efficient in order to be as lean as possible in terms of emission rate.

U values and permeability given are the following:

Fabric Element	Limiting U Value (W/m².K)	Notional U Value (W/m².K)	Design Stage Value Provided
Wall	0.35	0.26	0.35
Roof	0.25	0.18	0.18
Floor	0.25	0.22	0.21
Glazing	2.2	1.6	1.9
Air Permeability	10 m ³ /h.m ² @ 50 Pa	5	8.05

4. Case Study – Executive Summary

- In order to ensure the proposed Classroom accommodation is in accordance with the building regulations, the building has been calculated as follows.
- The first calculation shows the building as designed using traditional systems such as a gas boiler and radiators with U values and air permeability in line with Part L of the building regulations.
- The second calculation shows the building using energy efficiency systems such as air source heat pumps with U values and air permeability in line with Part L of the building regulations.
- The third calculation shows the building using energy efficient systems such as photovoltaic panels to achieve compliance with U values and air permeability in line with Part L of the building regulations.

Paragraph 2.29 of L2A 2013 states that for portable buildings with a planned service life of more than two years at a given location; compliance against the five criteria outlined must be demonstrated as with more permanent structures. However, if more than 70% of the external envelope of the building is to be created from sub-assemblies manufactured before the 5th of April 2006 the TER should be adjusted by the appropriate factor from Table 2. This table has been reproduced below:

Date of manufacture of 70% of modules making up the external envelope	TER Multiplying Factor
After 6 April 2014	1.00
1 Oct 2010 – 5 April 2014	1.10
6 April 2006 – 1 Oct 2010	1.47
1 April 2002 – 5 April 2006	1.93
Pre April 2002	1.93 [2.59 ¹]

¹ For buildings with a planned time of use in a given location of less than 2 years, the figure in brackets is applicable.

This buildings date of manufacture is pre-2002 which gives a multiplying factor of 1.93.

Benchmark

A benchmark calculation has been used to assess the energy usage and improvement made from renewable technologies. It should be noted that the annual energy figures have been obtained by carrying out a Simple Building Energy Model using typical data on efficiencies, building end use, expected fabrics, etc. The model does not include annual energy use by process of office equipment e.g. computers. Actual building energy usage will differ depending on actual building occupancy and end use/activities.

Benchmark

A benchmark for energy usage have been produced. The benchmarks assume building services as follows:

- LTHW radiator system throughout
- Manual energy efficient lighting throughout
- Natural Ventilation via window openings where possible

A traditional system will have a building emission rate of 18.1 kg/CO₂/m², compared to the target emission rate of 28.1 kg/CO₂/m². therefore, this system will achieve compliance alone, however the emission of fossil fuels will not comply with the Barnsley energy policies to reduce carbon emissions.

Local Electric

A benchmark for gas and electrical energy usage have been produced. The scenario assume building services as follows:

- Local electric heating throughout
- Manual energy efficient lighting throughout
- Natural Ventilation via window openings where possible

An electric system will have a building emission rate of 22.4 kg/CO₂/m², compared to the target emission rate of 29.8 kg/CO₂/m². therefore, this system will achieve compliance alone and is recommended to be considered above a fossil fuel system.

Air Source Heat Pump

A benchmark for gas and electrical energy usage have been produced. The scenario assume building services as follows:

- Air source heat pumps in the office areas
- Manual energy efficient lighting throughout
- Natural Ventilation via window openings where possible

This scenario would achieve compliance and have a building emission rate of 21.8 kg/CO₂/m², compared to the target emission rate of 31.6 g/CO₂/m². While this technology is less cost effective than the benchmark system, it is considered a low carbon energy system and should be considered.

Photovoltaic Cells

The introduction of PV cells would reduce the electrical running costs by generating electricity. While this technology can be relatively high in cost, it offers a direct improvement to the buildings electrical demand and financial incentive is available in the form of government tariffs and other green schemes.

Biomass

Biomass has been discounted from further examination due to the amount of site storage for fuel required along with regular deliveries of locally produced fuel to make this viable.

Combined Heat and Power

CHP has been discounted from further examination due to the following:

During the winter months there will be sufficient base heating load due to the need to heat the building during the day. However, at night when there will be little to no occupancy expected after 5pm, and reduced heat requirement during the summer months, this will result in little to no base load for the heating system. While central hot water storage could be installed to provide a night-time load (allowing the CHP to heat water over night for a continuous load) this is still unlikely to give sufficient base load to make CHP viable, in addition to requiring a central hot water storage system to be implemented in lieu of the multiple local electric water heaters.

The TER has been entered as the same due to CHP not being viable as above.

Solar Water Heating

Solar water heating has been discounted from further examination due to the relatively low hot water demand. While solar hot water would offer some practical benefit to the emission rate, this is typically very minimal where small hot water demand is present. Because of this, Investment in LZC technologies would be better placed in systems likely to make more of an impact.

Community Heating Schemes

One potential for reduction of CO₂ is the utilisation of any local communal heating systems which may have spare capacity. No communal heating systems have been identified in the local area, therefore the future potential for connecting to a community heating scheme has not been allowed for on this development. If in future a community heating system is built there may be some benefit to assessing spare capacity and potential benefit to the building at that time.

Case Study – Summary

All systems analysed will achieve building regulations compliance, due to the adjustment factor allowed within Part L of the regulations for modular buildings. Although gas looks to have the least carbon emission outputs, it is a fossil fuel system which will generate fossil fuels, compared to electrical systems which will generate little or no greenhouse gases.

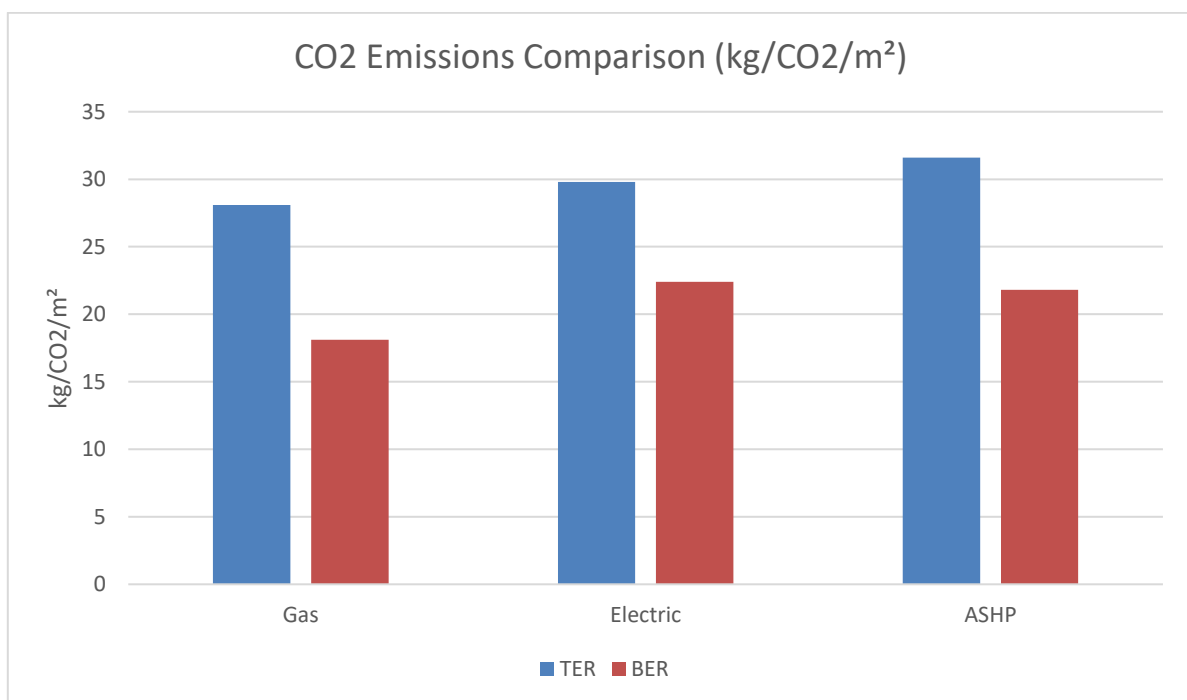


Image: comparison of benchmark system and renewable systems in terms of building emission rates

Based on the findings of this study, it would be recommended to proceed with an electric system to provide the heating requirements for the proposed development. Electric systems and Air source heat pumps are a proven reliable technology, having been utilised within air conditioning systems for many years, and therefore the skills required to install and maintain this type of system should be easily available within the local area.

Air source heat pumps are a very 'green' technology. In taking the majority of the heat energy from the surrounding environment (air), they use far less fossil fuels to generate the heat than a conventional system. A typical air source heat pump would use around 1kW of electrical energy (to drive the compressor) to produce around 3 - 4kW of heat energy. Therefore, it is recommended for installation is considered – although not essential to achieve building regulations compliance.

The payback period for PV cells is usually within the region of 15-20 years which matches approximately the expected economic life span. However, it must be noted that PV Cells will reduce in output throughout their lifespan (typically less than 1% per year), and this has not been factored into the calculations. The government also no longer supports the Feed-in Tariff rates for PV Cells. As this type of technology becomes more widespread with more companies supplying and installing, the capital cost inevitably reduces due to product development and market competition. The reduction in the Feed-in Tariff rates reflects this trend and is designed to push suppliers into further development and to promote further reductions in installation costs. Over the course of the next few years, the payback period on the installation of PV cells, in theory, ought to reduce to a level whereby someone can make a reasonable profit over the lifetime of the installation. Currently, however PV Cells do not appear to be a viable option for this development financially. Therefore, it is recommended for installation is considered - although not essential to achieve building regulations compliance.

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