Low Zero Carbon Technology Feasibility Study

THE PRIORITY SCHOOL BUILDING PROGRAMME (PSBP)

COLLIS PRIMARY SCHOOL, TEDDINGTON

Revision	P3
Document Ref:	2025_SIS746_00_XX_RP_Z_0002

REVISION HISTORY SHEET

REVISION	DATE	AUTHOR	CHECKED BY	APPROVED BY	DESCRIPTION
P1	06/08/2019	DK	MP	MP	DRAFT ISSUE
P2	07/08/2019	DK	MP	MP	MINOR DOCUMENT REVISIONS
P3	07/08/2019	DK	MP	MP	MINOR FORMATTING

Author:
Dmitri Korolenko, Sustainability and Physics Engineer
S I Sealy & Associates Ltd
Inwood Court
Stuart Road
Bredbury
Stockport
SK6 2SR
0161 430 2044
d.korolenko@sisealy.co.uk

CONTENTS

1 EXECUTIVE SUMMARY

This report assesses the feasibility of installing Low or Zero Carbon (LZC) technologies as part of the proposed Collis Primary School in Teddington. This report has been prepared in accordance with the requirements of London Plan Policy 5.2, and BREEAM 2018 to achieve the LZC technologies credit of Ene04. The document is intended assess the proposed development for LZC integration opportunities, help inform the project team's decision making with regards to the potential selection of LZC technologies and ensure that all the key considerations have been highlighted.
The sustainability targets for the project are:

- Achieve a minimum of BREEAM "Very Good" rating
- Achieve a planning target of at least a 35% improvement over Building Regulations Part L 2013 in line with London Plan Policy 5.2 and Richmond Plan policy LP22.
- Achieve a 20% reduction of CO2 emissions from the use of on-site renewable energy.

The table below presents the findings of the feasibility analysis calculation for the renewable technology options for the project discussed in this report. Payback period and lifecycle costs have been calculated assuming an average system lifespan of 20 years. The best figure in each category, as compared to the other technologies is highlighted in green.

Technology	**LZC energy provided**	**LZC energy proportion**	**CO2 saving**	**Total CO2 saving**	**Lifetime CO2 saving**	**Capital cost**	**£ spent/kg CO2 saved per year**	**Annual cost saving with incentives**	**Payback with incentives**	**Annual cost saving without incentives**	**Payback without incentives**
	kWh/year	**%**	**kg/year**	**%**	**tonnes**	**£**	**£/kg**	**£/year**	**Years**	**£/year**	**Years**
ASHP	19,961	20.77%	643	1.86%	12.9	16,000	37.34	293	N/A	-480	N/A
GSHP Vertical	24,498	25.50%	3,066	8.85%	61.3	50,000	16.31	2,617	19.1	214	N/A
Solar PV	15,149	15.77%	7,862	22.69%	196.6	26,400	3.36	N/A	N/A	2,236	11.8
Solar Thermal	9,821	10.22%	2,121	6.12%	42.4	20,000	9.43	1,841	10.9	400	N/A

It has been demonstrated that a solar Photovoltaic system would prove to be most effective in terms of carbon footprint reduction and return on investments. An implementation of this system would ensure the building achieves BREEAM Ene04 credit for low carbon design targeted for the building and generate carbon savings at a relatively low cost. The current proposal put the PV array at 100m^2 but final sizing of the PV system should be conducted at detailed design stage.

Following the guidance of the Mayor of London Energy Assessment document, a study on the potential district energy network integration has been conducted. It has been found that no local district heating networks are currently available around the proposed development and using CHP technology would be unfeasible due to the specifics of the proposed building. Flange connections are to be provided on the proposed heating system, allowing potential for integration should a district heating network become available in the future.

2 PROJECT CONTEXT

This report assesses the feasibility of installing low or zero carbon (LZC) technologies as part of the proposed development - Collis Primary School in Teddington. An assessment of the project context relating to LZC technologies has been made including the drivers for installing LZC technologies, the site opportunities and constraints and the potential available financial support.

An initial estimation of the energy consumption for the scheme has been made using the Part L (2013) NCM Building Emission Rating and CIBSE best practice calculation methodologies, the limitations of which should be understood.

This report has been produced by an energy expert and has been checked and approved by a registered Low Carbon Energy Assessor.

All viable LZC technologies have been assessed based upon technical, financial, aesthetic and practical considerations. The following aspects have been addressed:

Energy generated from LZC energy source per year

Life cycle cost accounting for payback of the potential specification

Local planning criteria, including land use and noise

Feasibility of exporting heat/electricity from the system

Any available grants

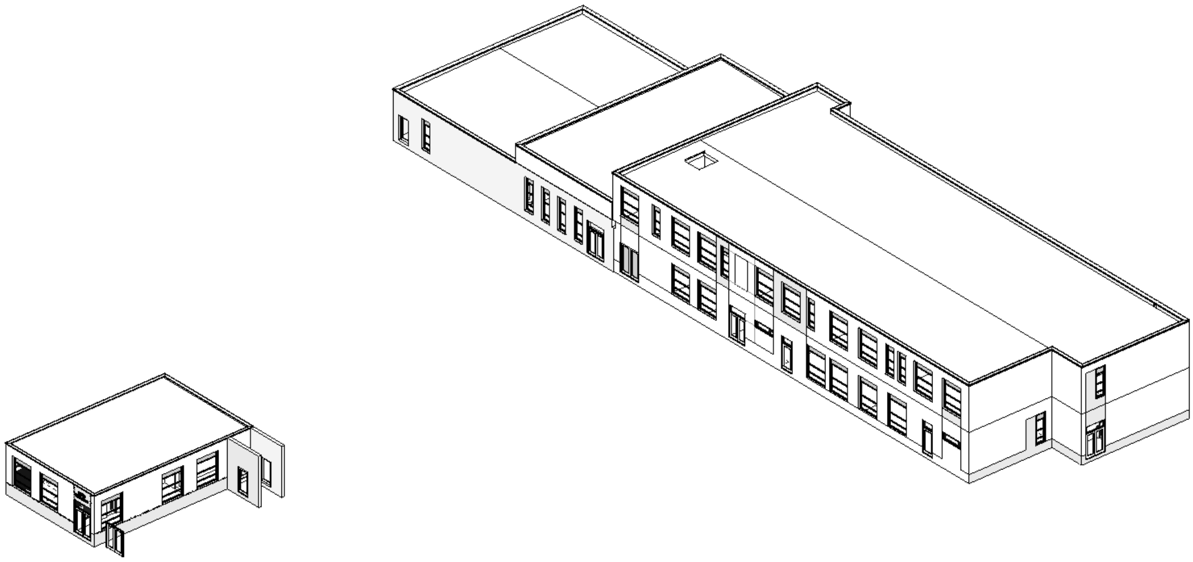
All technologies appropriate to the site and energy demand of the development

Reasons for excluding other technologies

Where appropriate to the building type, connecting the proposed building to an existing local community CHP system or source of waste heat or power OR specifying a building/site CHP system or source of waste heat or power with the potential to export excess heat or power via a local community energy scheme.

2.1 Overview

The proposed development is a new Primary School building. The building is designed to serve as an integrated educational facility. Considering the primary use of this building it can be predicted that heating and hot water loads will constitute a major part of the building's energy consumption, as well as electrical loads used to power devices, lighting and ventilation systems. The building is set to be operated on weekdays 9:00 to 16:00. This provides good opportunities for implementing LZC technologies to offset some of those loads and reduce the building's impact on the environment.



Proposed site 3D visualisation

2.2 Key Drivers

There are a number of key drivers that will influence the development of a low or zero carbon energy strategy for the proposed Building as identified in the table below.

Items	Requirement	Source	Comment
Part L	Current Building Regulations Part L Conservation of Fuel & Power 2013.	The Building Regulations 2000 Office of the Deputy Prime Minister.	To achieve a 35% improvement over Part L 2013 requirements in line with London Plan Policy 5.2.
Renewable energy	A 20% carbon emissions reduction contribution	Sustainability target	At least 20% of building carbon emissions to be offset with one of the proposed LZC technologies.
BREEAM	Aim to achieve high BREEAM Very Good rating	Richmond Local Plan Policy LP22	Particular site factors prevent the development from aiming for Excellent rating.

3 FUNDING AND FINANCIAL INCENTIVES

3.1 Capital Cost Funding

There are number of potential financial support mechanisms for low or zero carbon technologies as described below.

Salix Funding

Salix funding is an interest free loan provided to public sector bodies to improve energy efficiency and reduce emissions. The minimum amount that can be applied for is £5,000 and there is no upper limit on funding providing the project can be completed within nine months of the funding being agreed. It is a funding requirement that the loan should be able to be paid for by the energy savings within five years.

Energy Company Grants

Many of the major energy companies have grants available for renewable energy installations. These grants are typically used to support community organisations and require the installations to have an educational benefit. Examples include the EDF Green Fund, the Scottish Power Green Energy Trust and the E.ON Sustainable Energy Fund.

3.2 Operational Subsidies

Renewable Heat Incentive

The Renewable Heat Incentive (RHI) was introduced in November 2011 to promote the uptake of renewable heat producing technologies. The Non-Domestic RHI Scheme currently supports the following technologies:

- Biomass
- Heat pumps for heating only – air source, ground source, water source and deep geothermal
- All solar thermal collectors
- Bio-methane and biogas

RHI payments are made to the owner of the heat installation over a 20 year period and tariff levels have been calculated to bridge the financial gap between the cost of conventional and renewable heat systems. The scheme is administered by Ofgem. More information including current tariffs for Non-Domestic RHI technologies can be found on the Ofgem: Renewable Heat Incentive web page. To ensure RHI payments do not exceed budgets there is currently a stand-by mechanism for budget management in place that suspends the RHI to new entrants until the next financial year should the estimated spending reach a level where the budget could be breached. The scheme arrangements currently in place are set to be revised in 2021. There is currently no concrete information on whether the RHI will continue, be replaced by another scheme or scrapped altogether. This assessment therefore shows the payback periods for eligible technologies with and without incentives.

Feed-In Tariff

The feed-in tariff for renewable energy generation has been officially discontinued as of March 2019. Wind and solar energy generation do no longer receive any operational subsidies.

4 ENERGY AND CO2 EMISSIONS

4.1 Methodology

An estimate of the energy consumption and associated CO_2 emissions of the proposed building has been undertaken to help inform the assessment of LZC technology options. The estimate of electrical and gas energy consumption has been based on the results from the design stage dynamic thermal model developed to provide the Building Regulations Part L 2013 compliance solution and are summarised in the table below. It should be noted that the National Calculation Methodology (NCM) is developed purely for compliance assessment purposed and does not represent the actual building energy use. It is widely accepted that NCM tends to grossly overestimate hot water and small power usage – the NCM calculated hot water and small power energy use is therefore halved in this assessment to provide a better snapshot of the actual building's energy demand.

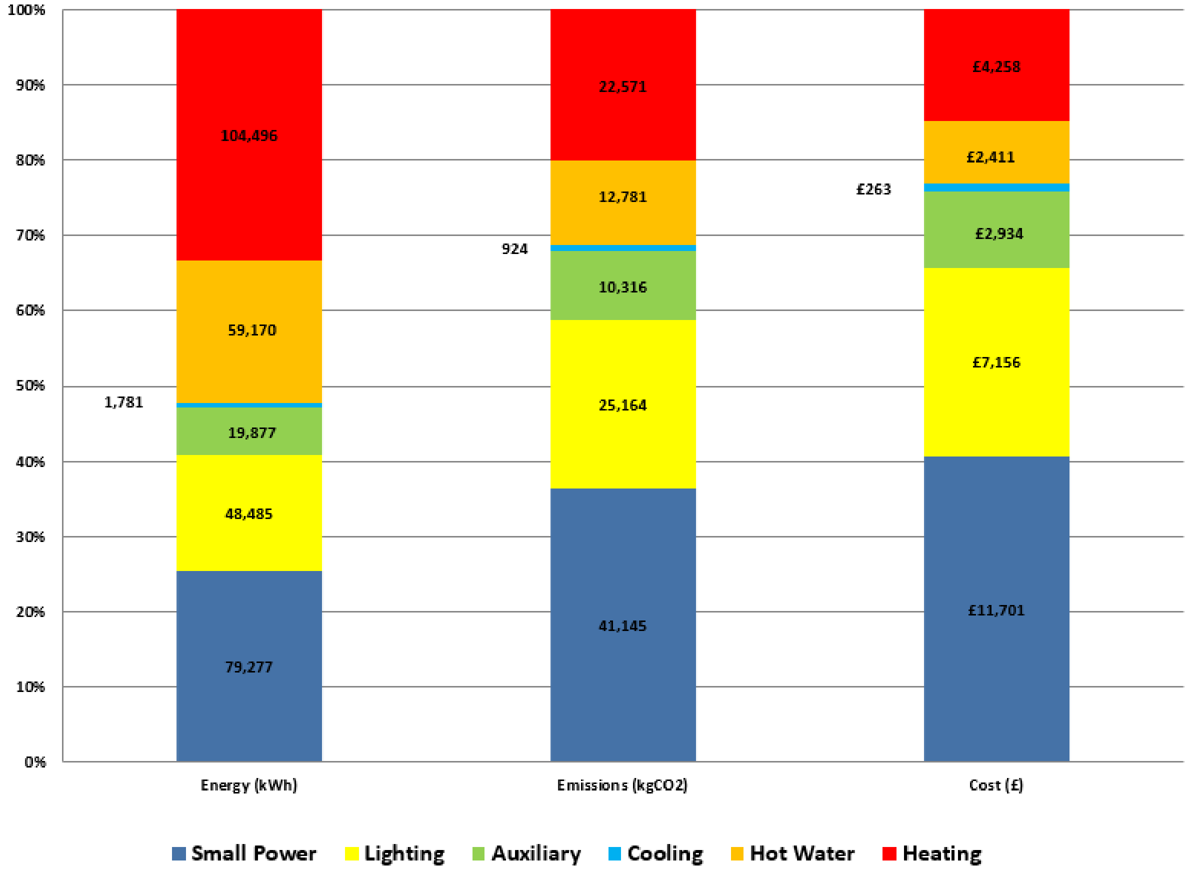
	Annual Gas Energy Consumption ($kWh/m^2/year$)	**Annual Electrical Energy Consumption ($kWh/m^2/year$)**	**Comments**
Heating	18.9	NA	Regulated. Calculated with NCM methodology.
Domestic Hot Water	10.3	NA	Regulated. Calculated with NCM methodology and halved to be more representative.
Cooling	NA	0.31	Regulated. Calculated with NCM methodology.
Auxiliary Energy	NA	3.46	Regulated. Calculated with NCM methodology.
Lighting	NA	8.44	Regulated. Calculated with NCM methodology.
Total Regulated Energy	40.7		Regulated
Small Power	NA	13.66	Unregulated. Calculated with NCM methodology.
Total Energy Consumption	54.36		Regulated and unregulated

The carbon dioxide emissions associated with energy consumption are calculated using CO_2 emissions factors. These factors can vary depending on the methodology used to calculate them. For the purpose of this report the values utilised for Part L (2013) calculations have been used and are shown in the table below.

Fuel	Building Regulations Part L(2013) Emission Factor ($kgCO_2/kWh$)
Gas	0.216
Grid supplied electricity	0.519
Grid displaced electricity	0.519
Biomass (pellet)	0.016

4.2 Energy and Carbon Usage

The figure below illustrates the annual energy consumption, CO_2 emissions, and cost by end use for the proposed Building calculated in accordance with the methodology laid out in the section above. It should be noted that this is a theoretical calculation for indicative purposes only; the simplified methodology used does not necessarily represent the real building operation performance or running costs.



Annual energy consumption and CO_2 emission and cost breakdown.

The following prices for mains supplied fuel have been used to calculate payback figures.

Fuel	Price (p/kWh)
Electricity	14.76
Gas	4.07

4.3 Capital Costs and Payback

Capital cost figures used for this assessment are based on past project experience, market research and good practice assumptions.

5 TECHNOLOGY APPRAISAL

This chapter provides an assessment of LZC technologies within the context of the proposed building. The technologies have been analysed based upon the following criteria:

- CO_2 savings
- Renewable energy generation
- Estimated capital cost
- Predicted cost savings including and excluding the RHI
- Life cycle cost accounting for payback

Consideration has been given to issues such as noise, local planning requirements, maintenance etc. The technologies have been sized based upon delivering reasonable and effective energy savings, with a view to achieve the targets described in the key drivers section. The constraints on increasing the size of the LZC technology are generally spatial or building demand based. All payback and savings figures for heating LZC technologies are calculated as compared to a traditional boiler system.

The following technologies have been excluded from the detailed assessment as they are considered not appropriate for the site:

Micro-hydro: There is no local river or stream with sufficient fall.

Tidal wave: The site is not located on a coast.

Wind turbines: Unreliable generation profile. Noise and planning concerns.

Biomass boiler: Low efficiency and air quality concerns.

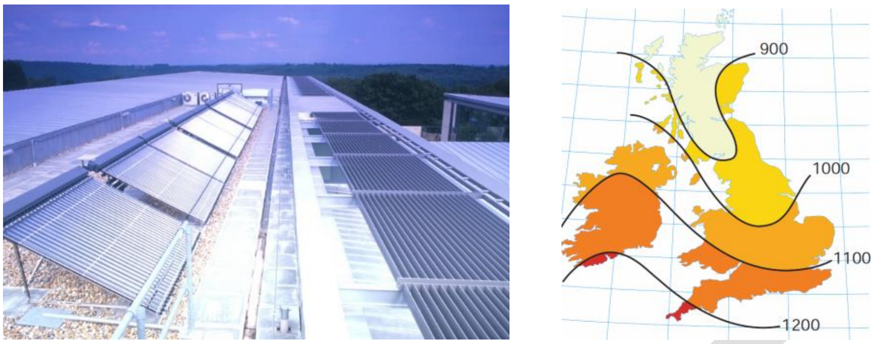
Anaerobic digester: Not enough solid waste produced by the building operation.

District heating: No local district heating connections available.

CHP: Lack of a high and constant hot water load for this technology to operate effectively.

All of the above LZC technologies have been excluded as a result of the assessment made of the site constraints at scheme design stage.

5.1 Solar Thermal



Evacuated tube solar thermal collectors (left) and average annual solar radiation (kWh/m^2) in the UK (right)

Solar thermal collectors absorb solar radiation and transfer it to a circulating liquid, which exchanges heat with a thermal store. The typical use for solar thermal is to provide domestic hot water. Due to the significant variation in available solar radiation during the year, the system will have to be sized in a way not to produce excess heating during the summer months when output is greatest. The collectors are therefore sized such that the peak summer solar radiation is sufficient to meet the typical daily summer domestic hot water demand. Supplementary DHW heating will most likely be required during the winter months to make up for reduced solar incidence. Although the UK is located on a relatively northern latitude, it still receives a significant amount of solar radiation over the year.

Flat plate and evacuated tubes are the two main types of solar thermal collector. Flat plate collectors are cheaper and less visual intrusive, while evacuated tube collectors perform better in low light conditions and can produce higher temperatures.

The main advantages and disadvantages of solar thermal are shown in the table below. The primary hot water demands for the proposed building will be from toilets and hygiene rooms. DHW load makes up a small proportion of the total energy demand and CO_2 emissions but generation times generally coincide with occupancy times, making the implementation of a mall solar thermal array a viable option for this building.

Advantages	**Disadvantages**
Provides a visible statement of environmental intent	Contribution in total CO_2 emission reduction relatively small
Supplies free energy	Requires additional pipework for systems integration
Low maintenance and long lifespan	Roof access will be required
Sufficient area of roof available to match hot water demand	Small DHW demand
Supported by Renewable Heat Incentive up to a certain size	Peak generation efficiencies coincide with building being vacant for summer break

The roof area of the building is considered to be well suited for solar collector integration. Achieving the generation of the full annual DHW load requires 100m^2 of solar thermal panels but will lead to massively oversizing the system for summer when occupancy is low and generation efficiency is highest, leading to wasted heat. The array is therefore sized at 25m^2 which would provide around 50% of the building's annual hot water load without wasting energy or utilizing oversized energy storage.

Summary of calculation results for this system is presented below.

Item	Units	Value
System size	m2	25
Renewable energy provided	kWh/year	9.821
Renewable energy proportion	%	10.22
CO2 saving	kg/year	2.121
Toral CO2 saving	%	6.12
Lifetime CO2 saving	tonnes	42.4
Predicted capital cost	£	20,000
£ spent/kg CO2 saved per year	£/kg	22.9
Annual cost saving w/ incentives	£/year	1.,841
Payback w/ incentives	years	10.9
Annual cost saving w/o incentives	£/year	400
Payback w/o incentives	years	N/A
Life cycle cost with incentives	£ over 20 years	-16,800

5.2 Solar Photovoltaic

Solar photovoltaic (PV) panels convert direct and diffuse radiation from the sun into electrical energy. The output varies depending on inclination and orientation with the optimum being south facing panels inclined at approximately 30°. The output of panels can be significantly influenced by shading of even a small part of the panel. This means that the location of the panel must be selected carefully to minimise shading during the middle six hours of the day, especially during summer. PV panels require very little maintenance and only require similar levels of inspection as a standard roof.

There are four common types of commercially available PV panel, which are listed in increasing order of their efficiency below:

Thin film amorphous silica – these are lightweight flexible panels which are generally integrated or attached directly to roof membranes. They perform better in diffuse light than direct light and have a module efficiency of approximately 7%.

Polycrystalline silicon panels – these modules perform better under direct light than diffuse light and typically have a module efficiency of 12% to 14%. There are a number of mounting options including angled mounting frames, standing seam racks, semi-integrated tile replacement, PV tiles or glass integrated.

Monocrystalline silicon panels – these are similar to polycrystalline panels but tend to have slightly higher module efficiencies, typically in the region of 13% to 20%.

The table below summarises the advantages and disadvantages associated with installing solar PV panels on the building. Due to low generation efficiencies of PV panels there is insufficient roof area to achieve a 5% reduction in CO_2 emissions from PV alone. A PV array, however, is capable of delivering significant CO_2 savings due to generating electricity, which has higher associated carbon emissions than fossil fuels. Due to high electricity costs the payback time for this technology is generally better than of those that generate heat.

Advantages	Disadvantages
Provides a visible statement of environmental intent	High capital cost
Supplies free energy	No operational subsidies
Low maintenance and long lifespan	Roof access will be required
Simple system integration	

Initial site assessment revealed that overshadowing will not be an issue and sufficient roof area is available to integrate a sizable solar PV array. The array used for calculations below has been sized to achieve London Plan and Sustainability planning targets. Monocrystalline cells have been chosen for this assessment at a nominal efficiency of 18%. Monocrystalline cells have a better capital cost to CO_2 saved ratio and a more rapid payback.

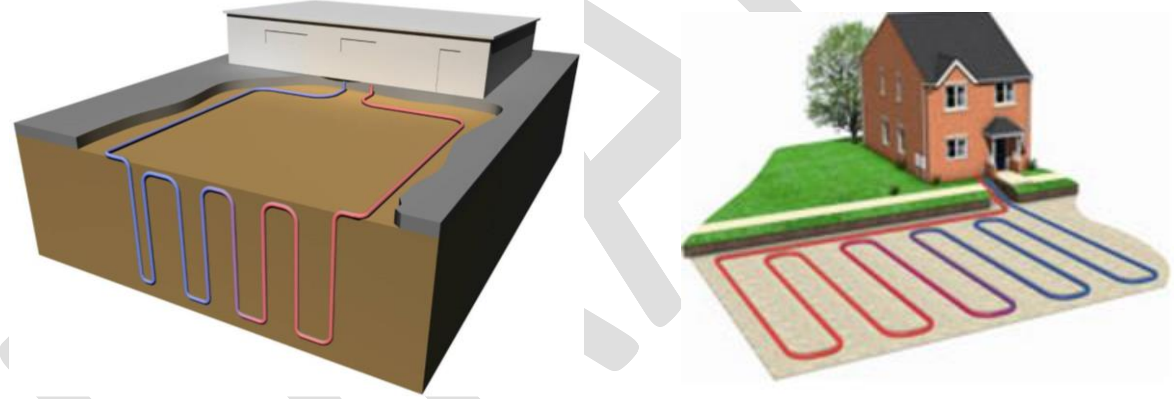
Summary of calculation results for this system is presented below.

Item	Units	Value
System size	m^2	100
Renewable energy provided	kWh/year	15,149
Renewable energy proportion	%	15.77%
CO2 saving	kg/year	7,862
Total CO2 saving	%	22.6
Lifetime CO2 saving	Tonnes	196.6
Estimated Capital cost	£	26,400

Item	Units	Value
£ spent/kg CO2 saved per year	£/kg	3.36
Annual cost saving w/ incentives	£/year	N/A
Payback w/ incentives	Years	N/A
Annual cost saving w/o incentives	£/year	2,236
Payback w/o incentives	Years	11.8
Life cycle cost w/o incentives	£	-18,320

5.3 Closed Loop Ground Source Heat Pump

Solar radiation is stored naturally at low levels within the ground. Ground Source Heat Pumps (GSHP) is designed to extract this low level heat and transfer it into the surrounding buildings heating system. During hot weather the pumps can be run in reverse, extracting heat from a building, therefore providing cooling inside the building and transferring the heat into the ground.



Vertical (left) and horizontal (right) closed loop GSHP system

The GSHP system has 3 parts:

Ground Loop – Refrigerant is pumped through the ground in a loop. It is heated, passes this heat to a heat pump and recirculates through the ground loop.

Heat Pump – Takes the heat from the refrigerant in the ground loop and transfers it to the distribution system.

Distribution System – Circulates the heat through the heating system of a building.

The ground loop can consist of either horizontal loops or vertical boreholes and both require a significant amount of ground area and excavation works.

For every unit of energy expended to power the GSHP system, approximately 3-4 units are captured for heating and distribution. At this efficiency level, the system will produce lower carbon emissions than a typical gas boiler system. In order to achieve this efficiency, it is necessary to have a large enough ground loop that matched the heat demand profile of the building and a heating system that operates at a low water temperature (no more than 40°C)

The most cost-efficient system is usually one that delivers both heating and cooling with the ground loop being minimised in buildings with balanced annual heating and cooling demands. The Seasonal Energy Efficiency Ratio (SEER) for the delivery of cooling can range from 5 up to about 30 for free cooling systems.

The CO_2 emissions reduction compared to conventional heating is dependent on the CO_2 emissions associated with the electricity source. Therefore predicted decarbonisation of the electricity grid may significantly increase the lifetime CO_2 savings. The table below shows the advantages and disadvantages of a GSHP system supplying heat to the building. These systems rely on the use of low temperature emitters such as underfloor heating and are unable to serve higher temperature heating systems such as radiators without considerable loss of efficiency.

Advantages	Disadvantages
Low visual impact	Limitation in CO_2 savings due to high emissions associated with grid electricity
Low maintenance and long lifespan	Output limited by available borehole area
Supported by RHI	Not efficient when used in conjunction with higher temperature systems such as radiators and high-level radiant heating systems
Potential for free cooling	High capital cost and relatively long payback

A number of vertical boreholes located adjacent to the buildings appear to be most applicable for the site. Vertical boreholes reduce the ground area required to house the heat exchanger loops.
The estimated output of the borehole field to achieve the full building heating load, assuming operating Cop pf 4, would be around 20kW. Careful consideration of system specific design and integration is required to maximise CO_2 savings and minimise systems' complexity.

The results of the analysis of a vertical GSHP system are shown below. The proposed building's heating load provides good opportunity for integrating a GSHP system but note that internal heat emitters will have to be able to operate under low temperature conditions for the system to be effective. In general, a GSHP system is well covered by the RHI incentives but suffers from high capital and groundworks costs and poor carbon reduction performance due to using electricity as main fuel.

Summary of calculation results for this system is presented below.

Item	Units	Value
System size	kW	20
Renewable energy provided	kWh/year	24,498
Renewable energy proportion	%	25.5
CO2 saving	kg/year	3,066

Item	Units	Value
Total CO2 saving	%	8.85
Lifetime CO2 saving	Tonnes	61.3
Capital cost	£	50,000
£ spent/kg CO2 saved per year	£/kg	16.31
Annual cost saving w/ incentives	£/year	2,617
Payback w/ incentives	Years	19.1
Annual cost saving w/o incentives	£/year	214
Payback w/o incentives	Years	N/A
Life cycle cost w/ incentives	£	-2,219

5.4 Air Source Heat Pump

Air source heat pump

Air source heat pumps (ASHP) convert lower grade value heat energy in the air into higher grade heat energy that can be used for space heating with the use an electrically powered refrigeration cycle. The COP, and hence CO_2 savings, depends on the ambient air temperature at the time of heating. If the heating load is largest in the early hours of the morning, when air temperatures are low, then there will be a corresponding drop in the annual efficiency compared to heating being applied later in the day. For an ASHP to be classed as a renewable technology it is required to have a COP of at least 3.2 at an ambient air temperature of 7°C. However, at lower temperatures the COP can drop rapidly due to the requirement to defrost the air intakes.

To maximise efficiency, ASHPs should deliver hot water at 50°C or lower and are therefore best suited to underfloor heating systems and air heating systems. The carbon savings of an ASHP compared to a conventional boiler depends upon the CO_2 emissions associated with the electricity source. The advantages and disadvantages of installing an ASHP system are discussed below.

Advantages	**Disadvantages**
Low visual impact	Limited CO_2 savings due to high emissions associated with grid electricity
Low maintenance and long lifespan	COP linked to ambient temperature – consumes the most electricity when outside temperature is lowest
	Not efficient when used in conjunction with higher

Advantages	Disadvantages
	temperature systems such as radiators and high level radiant heating systems
	Potential noise issues
	Potential condensation issues

The ASHP system has been sized to deliver the buildings full heating load assuming an operating CoP of 2.5. Summary of calculation results for this system is presented below.

Item	Units	Value
System size	kW	20
Renewable energy provided	kWh/year	19,961
Renewable energy proportion	%	20.77
CO2 saving	kg/year	643
Total CO2 saving	%	1.86
Lifetime CO2 saving	Tonnes	12.9
Capital cost	£	16,000
£ spent/kg CO2 saved per year	£/kg	37.34
Annual cost saving w/ incentives	£/year	293
Payback w/ incentives	Years	N/A
Annual cost saving w/o incentives	£/year	N/A
Payback w/o incentives	Years	N/A
Life cycle cost w/ incentives	£	10,140

5.5 Appraisal Summary

The table below presents the findings of the feasibility analysis calculation for the renewable technology options for the project discussed in this report. Payback period and lifecycle costs have been calculated assuming an average system lifespan of 20 years. The best performing figure in each category as compared to the other technologies is highlighted in green.

Technology	LZC energy provided	LZC energy proportion	CO2 saving	Total CO2 saving	Lifetime CO2 saving	Capital cost	£ spent/kg CO2 saved per year	Annual cost saving with incentives	Payback with incentives	Annual cost saving without incentives	Payback without incentives
	kWh/year	**%**	**kg/year**	**%**	**tonnes**	**£**	**£/kg**	**£/year**	**Years**	**£/year**	**Years**
ASHP	19,961	20.77%	643	1.86%	12.9	16,000	37.34	293	N/A	-480	N/A
GSHP Vertical	24,498	25.50%	3,066	8.85%	61.3	50,000	16.31	2,617	19.1	214	N/A
Solar PV	15,149	15.77%	7,862	22.69%	196.6	26,400	3.36	N/A	N/A	2,236	11.8
Solar Thermal	9,821	10.22%	2,121	6.12%	42.4	20,000	9.43	1,841	10.9	400	N/A

To allow the comparison of technologies to include less quantifiable issues such as required space and the ease of integrating a system into the building, a matrix has been developed to highlight the key benefits and disadvantages of each technology. Green represents an advantage, red represents a disadvantage, and yellow neither advantage nor disadvantage. The matrix is presented below.

Category	Solar PV	Solar Thermal	GSHP vertical	ASHP
Capital cost value	🟢	🟡	🔴	🟡
CO_2 reduction potential	🟢	🟡	🟡	🔴
LZC energy contribution	🟡	🔴	🟢	🟢
Return on investment	🟢	🟡	🟡	🔴
Space	🔴	🟡	🟢	🟢
System integration	🟢	🟢	🟡	🟡
Planning and regulatory risk	🟢	🟢	🟡	🟢
Operation and maintenance	🟢	🟢	🟢	🟡

The following system attributes have been considered in the matrix:

Capital cost value: This represents the value of capital cost expenditure including contractor preliminaries, overheat and profit, and fees on LZC technologies in terms of the CO_2 saved (£/kg CO_2 saved), which allows a fair comparison of the cost of systems of different sizes.

CO_2 reduction potential: There is a limit to the scale of CO_2 savings that a particular technology can deliver on a site. For example the amount of solar thermal that can be used is constrained by the domestic hot water load of the build, and the amount of solar PV that can be used is constrained by the available roof space.

Renewable energy contribution: As with reducing CO_2, there is a limit to the amount of renewable energy that a technology will deliver for a particular site.

Return on investment: This is based upon the Life cycle cost accounting for the payback period for the technology, it takes account of capital cost and operational cost savings based upon reduced fuel costs and subsidies such as Feed-in-Tariffs. The life cycle cost is based on the expected life of the technology. A negative life cycle cost indicates that the technology is potentially a financial return whilst a positive life cycle cost indicates that there is no financial return.

Space: This represents the space requirements for the technology, both in terms of internal plant room space and the external spatial requirements.

System integration: This represents the ease of integrating the technology with the building services systems. For example, heat pump systems need to operate at different flow temperatures to conventional heating systems.

Planning and regulatory risk: This category covers the risk associated with planning issues such as air pollution, noise and visual impact. It also covers other regulatory issues such as gaining abstraction consent from the EA.

Operation and maintenance: This category rates the operation and maintenance requirements associated with the particular technology.

6 CONCLUSIONS AND NEXT STEPS

The key conclusions for all technologies considered for the project are listed below:

Solar photovoltaic (PV) – Simple to install and integrate. Provides a visual statement on the building's environmental intent. Payback is around 12 years even without subsidy support. Available roof area is insufficient to generate a reduction in carbon emissions of 20%. It is recommended to consider a PV installation as a means to achieve planning targets and reduce the building's carbon footprint.

Solar thermal – Provides a visual statement on the building's environmental intent. Has a payback with incentives of 11 years. Due to low predicted DHW demand a solar thermal system would see not see high utilisation year-round but could prove viable for offsetting some of the demand. This system alone would not deliver a 20% reduction in carbon emissions. It is recommended to consider a solar thermal installation as a means to reduce the building's reliance on fossil fuel for hot water generation.

Closed loop Ground Source Heat Pump – a GSHP system demonstrates potential for efficient heat generation with a long payback period of 20 years. Being easy to operate and maintain, a GSHP installation requires significant groundworks across a large area before it can be commissioned. The inability of the system to efficiently generate water over 40°C requires internal heat emitters to be designed specifically for integration with a GSHP system. CO_2 reduction potential is small, due to grid supplied electricity being the primary fuel for the system and this system alone would not deliver a 20% reduction in carbon emissions. Considering the project in its current state would require major system redesign to effectively implement this technology, a GSHP system is not recommended for implementation.

ASHP – Does not payback and contributes to less than 2% of carbon reduction due to low operating efficiency and using grid-supplied electricity as fuel. An ASHP system is generally less efficient that GSHP installations and produce carbon savings at a higher cost. Advantages include small plant size requirements and the ease of installation and maintenance. Due to the availability of better performing options ASHPs are not recommended for implementation, unless it's a small scale system serving an isolated space.

Summarising the findings of this study, it has been demonstrated that a PV system serving the building's base electrical load would prove to be most effective in terms of reducing the carbon footprint and returns on investment. An implementation of this system would ensure the building achieves BREEAM Ene04 credit for low carbon design targeted and meets all planning targets set. The final sizing of the PV array should be conducted at detailed design stage by completing a thorough economic appraisal of the technology against a more comprehensive building energy demand analysis. At this stage, however, it is recommended that a 100m^2 array should be indicated as a sound estimation.

The following technologies can be kept in reserve to be implemented should elements of the design change making their integration more beneficial, or to satisfy the client's carbon reduction ambitions.

- Solar thermal
- GSHP

As the design develops the number of credits could alter as changes are made and this should be accounted for. It is therefore recommended that the credit margin is maintained to minimise the risk of design changes adversely affecting the BREEAM rating.

S I Sealy & Associates Ltd
Inwood Court
Stuart Road
Bredbury
Stockport
SK6 2SR

Tel: 0161 430 2044
www.sisealy.co.uk
info@sisealy.co.uk