Fleetsolve Ltd supply a range of 8-cylinder turbo charged reciprocating CHP engines with power options from 18kWe to 2,500kWe. The engines run on a wide range of liquid biomass fuels including a version produced by Fleetsolve from waste vegetable oil and fish oils. This fuel is accredited by Ofgem as a renewable source and is supplied at £0.76 per litre.

The Fleetsolve CHP unit is housed in its own plant enclosure measuring approximately 4.5m long by 2.0m wide and 2.4m high. The engine is fuelled via a 2,500 heated fuel tank, held at 40ºC, providing 30 days run time between fill-ups from a road tanker. An exhaust particulate filter and a De-NOx catalytic converter are fitted in the exhaust system. Dry air coolers provide a means of dumping heat energy during periods of over production.

The engine is optimised at 1,500rpm with 100% modulation, and operates with a noise level of 45dBA at 10m. Hot water is supplied at 95ºC with a return temperature of 80ºC.

Figure 14 - Fleetsolve Liquid Biomass CHP System

An initial evaluation indicates that the base heating load, associated with the domestic hot water requirements, does not support the installation of a CHP system. As such, CHP plant will not be considered further on this project.

3.3.8 Bio-Renewable Energy Sources – Wood-fuel Boiler Plant

Bio-renewable energy sources are considered to be those which are grown, harvested and replaced by new stock. Modern wood-fuel boilers are highly efficient, clean and smokeless. Wood-fuel is almost carbon neutral as an energy source (the tree growing process effectively absorbs the CO_2 that is emitted during combustion).

Figure 15 - CPW Designed Biomass Boiler House, Conkers YHA

The viability of installing an automated feed wood-fuel boiler at the development has been considered to meet 100% of the total peak heating and hot water demand. Biomass boilers require bulk fuel storage on site to avoid constant deliveries and mechanical handling systems between storage silo and boiler plant are recommended.

These requirements create the need for a substantial amount of external plant space (typically 150m^2). A large area would have to be sacrificed to accommodate the wood-fuel facilities. An underground fuel bunker 5m x 5m x 3m deep would be needed for a boiler of 500kW capacity. Furthermore, the logistics of fuel deliveries and ongoing maintenance costs could be a potential issue.

Ultimately, the lack of available space on site for the wood fuel storage facilities means that the installation of a biomass boiler system cannot be recommended in this case and will not be pursued further.

3.3.9 Fuel Cells and Fuel Cell Combined Heat and Power

Fuel cells convert the energy of a controlled chemical reaction, typically involving hydrogen and oxygen, into electricity, heat and water vapour. Direct electrochemical conversion is environmentally attractive because of the inherently low emissions and high electrical efficiency (c. 40% – 50%). Fuel cell stacks operate in the temperature range 65°C – 800°C, so thermal management systems are required. This provides co-generation opportunities in the form of Combined Heat and Power (CHP) solutions that can be implemented in buildings.

Fuel cell CHP systems generally have a heat to power ratio of approximately 1:1, with overall efficiencies in the region of 80% when fired on pure hydrogen.

Figure 16 - Fuel Cell Operational Schematic and Fuel Cell CHP Installation

Pure hydrogen fuel cells have zero CO_2 emissions but the hydrogen supply and distribution infrastructure is somewhat limited in the UK. As a result, commercially viable systems use alternative fuels in the form of natural gas, LPG and bio-fuels from which hydrogen is derived through a process called reforming. Extracting hydrogen in this manner, comes at the expense of system efficiency and an increase in emissions due to the presence of impurities in the fuel.

High temperature fuel cell systems typically use an internal reforming process where the source fuel is introduced directly to the anode plate. Lower temperature fuel cells rely upon an integrated fuel processor that converts the source fuel into a hydrogen rich reformate needed by the cell stack.

There are a number of commercially available fuel cell CHP systems, classified by the type of electrolyte they employ, and these include; Proton Exchange Membrane (PEM), Molten Carbonate, Alkaline, Phosphoric Acid and Solid Oxide. Systems range in capacity from those that produce a few kilowatts (PEM type) to those that are capable of generating several megawatts (phosphoric acid and molten carbonate based arrangements).

Logan Energy Limited supply a range of phosphoric acid and molten carbonate fuel cell CHP systems suitable for use in buildings. However, these systems are in the early stages of commercialisation and so projects have substantial technology risk. For this reason, fuel cell CHP systems have not been considered for use on this project.

4.0 Energy Storage

Storage of both electrical and thermal energy is becoming increasingly common, particularly on large scale developments.

The obvious advantage of storing energy is to solve the intermittency problem of renewables, the wind is not always blowing, and the sun is not always shining when there is demand for electricity. The converse is also true in that the demand can be low when the renewable sources are highly active. Typically, extra electricity produced is sold back to the power company in grid connected systems. However, energy storage lets the user decide when to buy and use power from the grid which means that they can purchase electricity at off-peak prices and use energy from their own storage during peak times (this is a method called peak shaving).

Energy storage also addresses the variation of supply and demand of heat. The most common example of this is the domestic hot water tank, which stores hot water so it is available at any time and does not require a boiler to start up when there is a sudden demand. Heat demand has a large seasonal variation from summer to winter; seasonal storage of heat underground is a growing method used to store excess heat in the summer for heating in winter.

4.1 Battery Storage

Battery Energy Storage Systems (BESS) can be used to balance the site energy requirements through mechanisms known as renewable firming, load shifting and peak shaving, thereby modulating the use of grid electricity and, in turn, reducing costs. There are a number of battery types available including Redox-Flow, Metal-air, Sodium-nickel Chloride, however the most common is Lithium ion (Li-ion) batteries.

Lithium ion (Li-ion) batteries are a type of rechargeable battery in which lithium ions move from the negative electrode to the positive electrode during discharge and back when charging. They are commonly used in consumer electronic products, where a high energy density is required and now are also commonly used in electric vehicles. Many companies are now developing larger-format cells for use in energy-storage applications. The deployment of which is expected to drive down cost and improve performance.

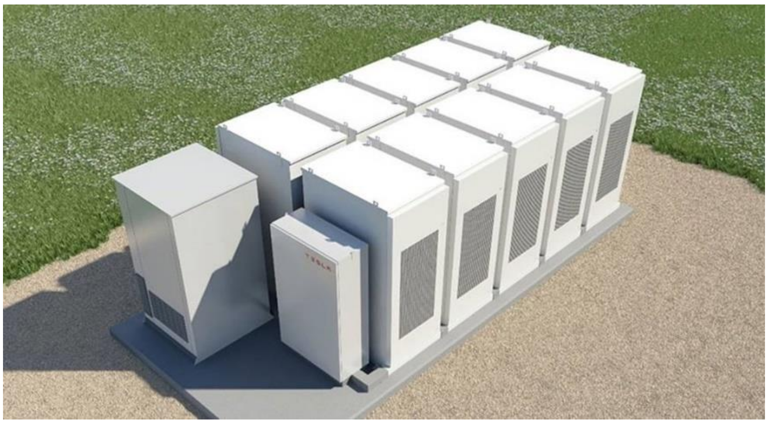


Figure 17 - Battery Energy Storage System (BESS)

The efficiency of lithium-ion battery system is high, about 90-95% and it has a high energy density in comparison to other storage technologies. They have been deployed in a wide range of energy-storage applications, ranging from batteries of a few kWh in residential systems with rooftop photovoltaic arrays, to multi MWh containerised batteries for the provision of grid ancillary services. However, their cost/performance characteristics make them unlikely to be further developed for large grid scale storage projects.

The energy demands on the Symmetry Park Bicester Phase 3, Unit E, are not expected to be large enough to make an electrical battery storage viable.

4.2 Thermal Storage

The best known thermal energy storage technology is the hot water tank which is common and fully commercialised. Water is stored in an insulated tank where it can be heated via a heat exchanger by a variety of sources (usually a boiler). They are already widely used at a building scale in combination with electrical or solar thermal water heating systems. Hot water storage can also be used in conjunction with district heating (DH) systems when heat is provided from CHP, biomass boilers and/or largescale solar water heating. High temperatures can be stored in tanks (90°C) which means that the water can be used directly for space heating. Water is the most common storage medium because of its abundancy and high heat capacity, but gravel, concrete and ceramics are also sometimes used. When solids such as gravel or concrete are used for heat storage, a liquid or gas will be ran through them to add or extract thermal energy.

Using hot water tank storage is particularly useful when use in conjunction with CHP and biomass burners. Log burning biomass systems need to be loaded by hand and so by using a tank as a thermal buffer means that the burner may only need to be fired once a day or less. A thermal store will also reduce the time lag between lighting the burner and the demand for hot water, as the hot water was stored when the boiler was lit. Also, wood fuelled burners are generally more efficient when ran at full output rather than kept ticking over, a thermal store mitigates the need to keep a burner on low throughout the day.

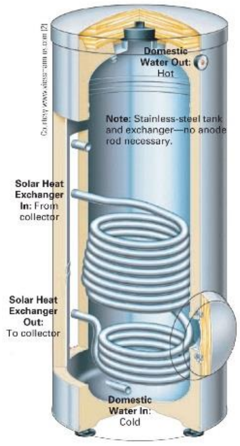


Figure 18 - Tank Cross-section

Tanks are used in a wide range of demands from the domestic hot water tank, to large tanks used to heat communities which are common in Scandinavia. Due to economies of scale, large storage tanks are cheaper per unit volume of storage and the heat losses are lower. Large-scale buffer stores can serve a number of functions but are particularly suited to developments with diverse building stock served via a central CHP/boiler house and district heating system.

The Symmetry Park Bicester Phase 3, Unit E, is not expected to have a high enough DHW demand to make a thermal store viable.

5.0 Summary of Capital Cost and Energy/CO_2 Saving Data

The table below summarises the approximate capital cost and estimated energy/CO_2 saving associated with each technology when applied to the Symmetry Park Bicester Phase 3, Unit E. The table also shows the percentage of the building's total annual energy demand that could be met by each LZC technology and the potential CO_2 saving per pound of capital investment.

Technology and Description	Capital Cost (£)	Revenue Saving (£/yr)	Simple Payback (Years)	Energy Saving (kWhr/yr)	Energy met by LZC Technology (%)	CO_2 Saving ($kgCO_2$/yr)	CO_2 Saving (%)	CO_2 Saving per £ Investment (kg)	Recommended for Further Consideration
Solar Photovoltaic *Roof mounted PV panels*	266.400	70,346	4	293,107	120.0	32,956	94.3	0.12	Yes

Table 4 - Summary of Capital Cost and Energy/CO_2 Saving Data

6.0 Recommendations

A high-level report has been compiled to appraise the renewable and low carbon technology energy options currently available for the proposed new Symmetry Park Bicester Phase 3, Unit E.

Solar photovoltaic (PV) mono-crystalline roof panels can be incorporated into the building design with little maintenance or ongoing costs. PV installations are scaleable in terms of active area; size being restricted only by available roof space. On the current scheme, an installation of PV panels could reduce the building's CO_2 emissions by approximately 94.3%.

To conclude, having taken into account the impact of each solution; its cost, complexity, benefits and drawbacks, the following LZC technologies are recommended for inclusion on the Symmetry Park Bicester Phase 3, Unit E, in order to meet the requirements of BREEAM in reducing CO_2 emissions (CO_2 saving data derived from IES model):

- **Roof mounted Solar Photovoltaic panels (c. 94.3% CO_2 reduction)**
- **Air Source Heat Pump installation for office heating – part of the base build solution**

Total: 94.3% CO_2 reduction.

7.0 Appendix A – PV Life Cycle Costs

Solar Photovoltaic Life Cycle Costings

	2024	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	
Initial Capital and Additional Costs	£266,400	£0	£0	£0	£0	£0	£0	£0	£0	£0	£12,000	
Maintenance/Servicing/Fuel	£500	£525	£551	£579	£608	£638	£670	£704	£739	£776	£814	
Total	**£266,900**	**£525**	**£551**	**£579**	**£608**	**£638**	**£670**	**£704**	**£739**	**£776**	**£12,814**	
		Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20	
		£0	£0	£0	£0	£0	£0	£0	£0	£0	£12,000	
		£855	£898	£943	£990	£1,039	£1,091	£1,146	£1,203	£1,263	£1,327	
		£855	**£898**	**£943**	**£990**	**£1,039**	**£1,091**	**£1,146**	**£1,203**	**£1,263**	**£13,327**	
		Year 21	Year 22	Year 23	Year 24	Year 25	Year 26	Year 27	Year 28	Year 29	Year 30	Total
		£0	£0	£0	£0	£266,400	£0	£0	£0	£0	£0	
		£1,393	£1,463	£1,536	£1,613	£1,693	£1,778	£1,867	£1,960	£2,058	£2,161	
		£1,393	**£1,463**	**£1,536**	**£1,613**	**£268,093**	**£1,778**	**£1,867**	**£1,960**	**£2,058**	**£2,161**	**£592,180**

Inverter Replacement

Panel Replacement

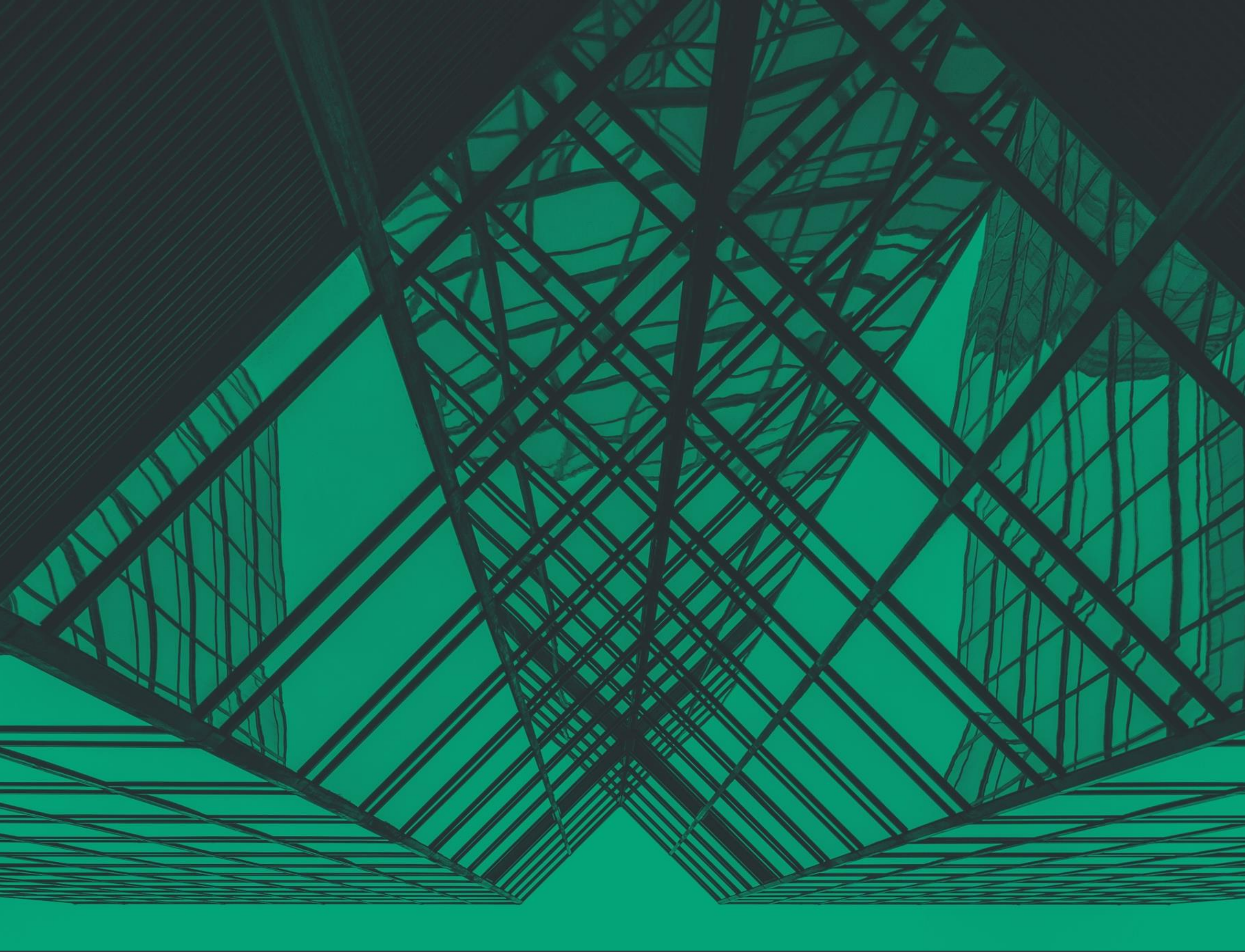
Assumptions:

1 - Inflation rate of 4% has been assumed for the life cycle cost. Allows no fluctuations

2 - Exclusions include V.A.T, Fees and Design Contingency

3 - Fuel prices have been used as first quarter of 2024

4 - CIBSE life cycles and manufacturers data has been used for replacement of plant



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Symmetry Park Bicester Phase 3 Unit F

211272

LZC Feasibility Report for BREEAM

Sustainability at our core.

Document Revision History			Ref	211272 - Symmetry Park Bicester Phase 3, Unit F	
Rev	**Author**	**Verification By**	**Date**	**Suitability**	**Comments / Status**
-	S. Tu	Dr S.J. Ball	25/09/2024		First Issue
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Date:	29/10/2024
Signature:	[redacted]

Contents

LZC Feasibility Report

1.0 Introduction

Couch Perry Wilkes has been appointed to appraise the renewable and low carbon technology energy options currently available for the proposed new Symmetry Park Bicester Phase 3, Unit F. The client is keen to target a BREEAM 'Very Good' rating for the building. This feasibility report has been carried out at RIBA stage 2 (outline proposals).

The planned new development of approximately 11,708.1m^2 Gross Internal Area (GIA), comprises distribution and office space with associated facilities arranged over two floors. With the current emphasis placed on energy conservation and the use of Low and Zero Carbon (LZC) technologies, the client is keen to enhance the development's sustainability credentials both from an estate and public perspective.

The general construction design standards to be adopted must exceed the requirements of the current (2021 Edition) Part L Building Regulations which stipulate an improvement on the CO_2 emissions of an aggregated 27% (for buildings other than dwellings) against 2013 standards.

To this end, the proposed design shall promote reduced CO_2 emissions from delivered energy consumption by minimising operational energy demand through passive and best-practice measures. The LZC technology energy options presented herein will potentially provide a further CO_2 reduction over and above the measures included as an integral part of the project design.

This high-level report has been compiled, in accordance with BREEAM, to appraise the renewable and low carbon technology energy options currently available for the proposed Symmetry Park Bicester Phase 3, Unit F. A summary of the findings is presented below.

2.0 Energy Benchmarking

2.1 Estimated Energy Demands and CO_2 Emissions

In order to benchmark the proposed new development, estimated energy demands and CO_2 emissions data have been calculated. These estimated energy consumptions are indicative only at this stage. They will, however, be used as a guideline to assess the percentage of the building's total energy consumption and CO_2 emissions that could be reduced or offset by applying suitable renewable and/or low carbon technology energy options.

For the purposes of BREEAM, it is prudent for this report to reflect the benchmark data derived from approved Dynamic Simulation Model (DSM) software which uses government and industry agreed National Calculation Methodology (NCM) room templates containing standard operating conditions. This is due to the fact that BRE Global will only accept results from the approved models when verifying the percentage reduction in CO_2 emissions from the building for credits Ene 1 and Ene 4 (BREEAM V6).

The estimated energy consumption and CO_2 emissions for the development, including passive low energy features but no renewable or LZC technologies, derived from approved DSM software (IES), are shown below:

The total predicted building energy consumption is: **186,884kWhr per year**

The total predicted building CO_2 emissions are: **26,730kgCO_2 per year**

Note 1. CO_2 emission factors of 0.210 for Gas and an annual average of 0.136 for electricity have been used to calculate the above and are taken from Building Regulations Approved Documents.

2.2 Assumed Utility Costs

The following utility costs have been assumed in order to assess payback periods only:

Gas = £0.06/kWhr

Electricity = £0.24/kWhr

2.3 Indicative Payback and Feed-in Tariffs/Renewable Heat Incentive

At this stage, it is very difficult to measure precisely the payback period of any investment in sustainability particularly when a number of measures are included within the design. Estimating payback periods for LZC technologies is even less precise due to both the volatility of the current fuel markets and rapidly changing cost of the technology.

For the purpose of this report, simple payback periods are considered which are based on current prices with no consideration for future value and comparing just annual savings against initial outlay. This is not necessarily an accurate prediction of payback, however, it does provide a constant form of comparison between the different options under consideration.

It should be noted that when considering LZC technologies, payback period should not be a primary aim or main focus of comparison. Generally speaking, none of the options considered will offer a good economic incentive; therefore, payback is used only as a simple form of comparing these technologies against each other.

2.4 Noise

Most LZC technologies considered in this report are silent in operation with the exception of wind turbines and CHP installations. In order to quantify the effects of mechanical and/or aerodynamic noise, manufacturers must undertake an environmental noise impact assessment. The main findings of these noise impact assessments are presented in the relevant sections of this report.

In addition, a site noise survey can be undertaken in accordance with the requirements of BS 4141:1997. If necessary, suitable noise attenuation measures can be specified to reduce the likelihood of complaint.

2.5 Life Cycle Costs

The life cycle cost or whole life cost encompasses all costs associated with, in this case, each LZC technology's anticipated life-span. These include capital costs, installation costs, operating costs, maintenance costs and disposal costs. For each LZC technology deemed suitable for the proposed new development, a life cycle cost analysis has been undertaken and the results presented in Appendix A.

2.6 Land Use

The south-west part of the plot itself has car parking up to the boundary. The south-east boundary is due to be landscaped. The north-east side of the plot is composed of a service yard and HGV loading.

2.7 Local Planning Requirements

In order to reduce the resource consumption of new developments, many Councils are now producing their own specific documents and policies on sustainable construction. LZC technologies such as solar photovoltaic panels, solar thermal systems and in particular wind turbines are highly visible and have an aesthetic impact on the local environment. For example, large stand-alone column mounted wind turbines are likely to meet with major objections from local residents.

Local authorities need to be consulted at an early stage to establish any local planning policies that may apply to the proposed development. Planning issues associated with each LZC technology are conveyed, where relevant, in the main body of this report.

2.8 Available Grants

There are a number of funding opportunities available across the UK provided through regulated GOV.UK schemes or local council application portals, these schemes support different project types and have a varied criterion. The available funding supports both the design intent to various stages of RIBA design and the physical implementation of the accepted design. Below CPW have named some of the available funding streams in which we are familiar working with or have been delivered:

- SALIX – LCSF – Funding for the design of a Heat Decarbonisation Plan (HDP) which captures replacement of current boiler plant along with energy efficiency measures, renewable technologies, and fabric improvements.
- SALIX - PSDS – Funding for the implementation of the above HDP and technologies.
- GHNF - Green Heat Network Fund Supports with funding the development of low and zero carbon (LZC) heat (and cooling) networks.
- IEFT - Industrial Energy Transformation Fund investing in energy efficiency and low carbon technologies in an industrial setting.

The Government Department of Energy and Climate Change (DECC) historically provided grants for the installation of micro-generation technologies under the Low Carbon Buildings Programme Phase 2 Extended, however, this scheme was closed to new applications in May 2010.

2.9 Feasibility of Exporting Heat and Electricity

Any on-site electrical generation from the likes of solar photovoltaic panels or wind turbines will be fed into the building's main electrical system. There is no intention of exporting electricity to the grid. Any hot water generated from e.g. solar thermal tubes will be used locally.

2.10 BREEAM

BREEAM or Building Research Establishment's Environmental Assessment Method is a voluntary scheme that aims to quantify and reduce the environmental burdens of buildings by rewarding those designs that take positive steps to minimise their environmental impacts. Projects are assessed using a system of credits. The credits are grouped within the following categories:

- Management
- Health and Wellbeing
- Energy
- Transport
- Water
- Materials
- Waste
- Land Use and Ecology
- Pollution

The assessment process results in a report covering the issues assessed together with a formal certification giving a rating on a scale of UNCLASSIFIED, PASS, GOOD, VERY GOOD, EXCELLENT and OUTSTANDING.

The diagram and text below describes how BREEAM scores and rates an assessed building:

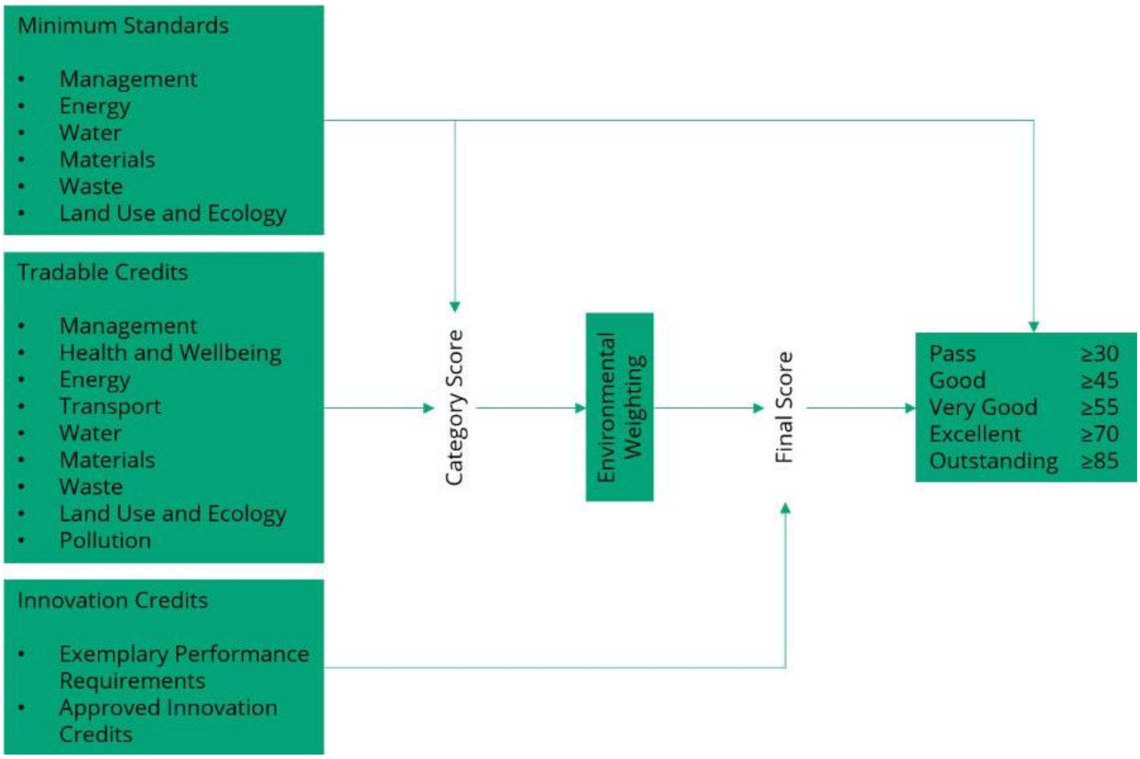

Figure 1 - Process for Awarding a BREEAM Rating

The BREEAM categories contain a number of environmental issues, which reflect the options available when designing, procuring and constructing a building.

Tradable Credits

Each environmental issue has a set number of 'credits' available and these credits are awarded where the building demonstrates that it complies with the requirements of that issue.

Minimum Standards

A number of issues within a category have set minimum standards, i.e. a minimum number of credits that must be achieved in order for a particular BREEAM rating level to be met.

Innovation Credits

Innovation credits provide additional recognition for a building that innovates in the field of sustainable performance, above and beyond the level that is currently recognised and rewarded by standard BREEAM issues. Innovation credits are awarded for either complying with pre-defined BREEAM issue exemplary level requirements, or via application to BRE Global to have a particular building feature, system or process recognised as 'innovative'.

Within each of the BREEAM categories outlined above, there are a number of credit requirements that reflect the options available to designers and managers of buildings.

An environmental weighting is applied to the scores achieved under each category, as shown below, in order to calculate the final BREEAM score. The weighting factors have been derived from consensus based research with various groups such as government, material suppliers and lobbyists. This research was carried out by BRE Global to establish the relative importance of each environmental issue.

The environmental weightings are as follows:

BREEAM Section	Weighting (%)
Management	11.0
Health and Wellbeing	8.0
Energy	14.0
Transport	11.5
Water	7.0
Materials	17.5
Waste	7.0
Land Use and Ecology	15.0
Pollution	9.0
Innovation (additional)	10.0

Table 1 - BREEAM V6 New Construction Section Weighting

The BREEAM rating bands are as follows:

BREEAM Rating	Score (%)
UNCLASSIFIED	<30
PASS	≥30
GOOD	≥45
VERY GOOD	≥55
EXCELLENT	≥70
OUTSTANDING	≥85

Table 2 - BREEAM Rating Bands

Although, at this stage, it is very difficult to predict exactly the number of BREEAM credits likely to be achieved by each LZC technology when applied to the current development, it is worth noting that these technologies have an influence over the following:

Ene 01 **Reduction of CO_2 Emissions** – Up to 9 (+5 Innovation) credits are available.

Ene 04 **Low Carbon Design** – One credit is available.

Pol 02 **NO_x Emissions** – Up to 2 credits are available.

3.0 Appraisal of Renewable and Low Carbon Technology Energy Options

3.1 Financial Expenditure Available for Renewable and Low Carbon Technology Energy Options

The current budget for expenditure specifically on LZC technologies has not yet been defined or approved. For the purposes of this report, various options will be given, where relevant, to target varying levels of energy/CO_2 reduction.

3.2 Summary of the Technical Feasibility Assessment of Renewable and Low Carbon Technology Energy Options

The technical feasibility of installing each LZC technology at the Symmetry Park Bicester Phase 3, Unit F, has been assessed in order to discount any unsuitable options at an early stage. A summary of the feasibility process is tabulated below and an overview of each technology is given in Section 3.3.

Technology	Brief Description	Benefits	Issues/Limitations	Feasible for site
Solar Photovoltaic	Solar photovoltaic panels convert solar radiation into electrical energy through semiconductor cells. They are not to be confused with solar panels which use the sun's energy to heat water (or air) for water and space heating.	Low maintenance/no moving parts Easily integrated into building design	Any overshadowing reduces panel performance Panels ideally inclined at 30° to the horizontal facing a southerly direction	Yes
Solar Thermal	Solar thermal energy can be used to contribute towards space heating and hot water requirements. The two commonest forms of collector are panel and evacuated tube.	Low maintenance Little/no ongoing costs	Must be sized for the building hot water requirements Panels ideally inclined at 30° to the horizontal facing a southerly direction	No, limited domestic hot water requirements
Ground Source Heat Pump (GSHP)	GSHP systems tap into the earth's considerable energy store to provide both heating and cooling to buildings. A number of installation methods are possible including horizontal trench, vertical boreholes, piled	Minimal maintenance Unobtrusive technology Flexible installation options to meet available site footprint	Large area required for horizontal pipes Full ground survey required to determine geology	No, prohibitively expensive installation costs

Technology	Brief Description	Benefits	Issues/Limitations	Feasible for site
	foundations (energy piles) or plates/pipe work submerged in a large body of water. The design, installation and operation of GSHPs is well established.		More beneficial to the development if cooling is required Integration with piled foundations must be done at an early stage	
Air Source Heat Pump	Electric or gas driven air source heat pumps extract thermal energy from the surrounding air and transfer it to the working fluid (air or water).	Efficient use of fuel Relatively low capital costs	Specialist maintenance More beneficial to the development if cooling is required Requires defrost cycle in extreme conditions Some additional plant space required	Yes, as part of the base build
Wind Turbine *(Stand-alone column mounted)*	Wind generation equipment operates on the basis of wind turning a propeller, which is used to drive an alternator to generate electricity. Small scale (1kW – 15kW) wind turbines can be pole or roof mounted.	Low maintenance/ongoing costs Minimum wind speed available Excess electricity can be exported to the grid	Planning issues Aesthetic impact and background noise Space limitations on site Wind survey to be undertaken to verify 'local' viability	No, not suitable on this site
Wind Turbine *(Roof Mounted)*	As above	Low maintenance/ongoing costs Minimum wind speed available Excess electricity can be exported to the grid	Planning issues Aesthetic impact and background noise Structural/vibration impact on building to be assessed Proximity of other buildings raises issues with downstream turbulence Wind survey to be undertaken to verify 'local' viability	No, not suitable on this site

Technology	Brief Description	Benefits	Issues/Limitations	Feasible for site
Gas Fired Combined Heat and Power	A Combined Heat and Power (CHP) installation is effectively a mini on-site power plant providing both electrical power and useful heat. CHP is strictly an energy efficiency measure rather than a renewable energy technology.	Potential high CO_2 saving available Efficient use of fuel Excess electricity can be exported to the grid Benefits from being part of an energy centre/district heating scheme	Maintenance intensive Sufficient base thermal and electrical demand required Some additional plant space required	No, limited domestic hot water requirements
Bio-fuel Fired Combined Heat and Power	As above.	Potential high CO_2 saving available Efficient use of fuel Excess electricity can be exported back to the grid Benefits from being part of an energy centre/district heating scheme	Maintenance intensive Sufficient base thermal and electrical demand required Significant plant space required Biomass fuelled systems are at early stages of commercialisation Large area needed for fuel delivery and storage Reliable biomass fuel supply chain required	No, not suitable on this site
Bio-Renewable Energy Sources *(Automated feed – wood-fuel boiler plant)*	Modern wood-fuel boilers are highly efficient, clean and almost carbon neutral (the tree growing process effectively absorbs the CO_2 that is emitted during combustion). Automated systems require mechanical fuel handling and a large storage silo.	Stable long term running costs Potential good CO_2 saving	Large area needed for fuel delivery and storage Reliable fuel supply chain required Regular maintenance required Significant plant space required	No, not suitable on this site
Fuel Cells and Fuel Cell Combined Heat and Power	Fuel cells convert the energy of a controlled chemical reaction, typically involving hydrogen and oxygen, into electricity, heat and water vapour. Fuel cell stacks operate in the	Zero CO_2 emissions if fired on pure hydrogen and low CO_2 emissions if fired on other hydrocarbon fuels Virtually silent operation since no moving parts	Expensive Pure hydrogen fuel supply and distribution infrastructure limited in the UK	No, expensive, emerging technology

Technology	Brief Description	Benefits	Issues/Limitations	Feasible for site
	temperature range 65°C – 800°C providing co-generation opportunities in the form of Combined Heat and Power (CHP) solutions.	High electrical efficiency Excess electricity can be exported back to the grid Benefits from being part of an energy centre/district heating scheme	Sufficient base thermal and electrical demand required Some additional plant space required Reforming process, used to extract hydrogen from alternative fuels, requires energy; lowering overall system efficiency	

Table 3 - Summary of Renewable and Low Carbon Technology Energy Options