

Withington Community Hospital.
Withington, Manchester.
BAM Construction Limited.

SUSTAINABILITY
STAGE 2 REPORT – LOW AND ZERO CARBON FEASIBILITY STUDY
BREEAM NC V.6- ENE 04
REVISION 01



Audit sheet.

Rev	Date	Description of change / purpose of issue	Prepared	Reviewed	Authorised
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Executive Summary.

Proposed Development.

The Proposed Development will comprise a new, two storey building located on undeveloped land within the existing community hospital site, in Withington, Greater Manchester.

The Proposed Development will provide cardiorespiratory facilities as well as new consultation and treatment rooms. The remaining building space will include office spaces, reception and waiting areas, WC and changing rooms and plant facilities.

As the first floor is currently designed to shell and core only, for modelling purposes, we have assumed room (activity) layouts and HVAC system splits based on the ground floor layouts provided by Day Architects to help provide an understanding of potential Part L outcomes going forward.

Assessment Drivers.

The proposed building is targeting a BREEAM rating of ‘Excellent’.

The assessment of the ENE 04 Low or Zero Caron Technologies Analysis credit helps contribute to the overall assessment score and achieve the target rating.

Low and Zero Carbon Feasibility study.

On the basis of the results presented in this study, the feasibility analysis of the LZC technologies has suggested that air source heat pumps and photovoltaics would be the most appropriate LZC technologies:

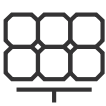
	Energy source	Comment	Recommendation
	PVs	<p>A circa 386m² array of photovoltaic panels offers potential CO₂ emissions reduction of 28.15%, beyond a gas boiler baseline using Part L2 2021 carbon factors.</p> <p>The assumed available roof area for PV was calculated at ~600m² (excluding plant area). An allowance was made for overshadowing and maintenance, leaving 386m² for PV.</p> <p>In addition, the Smart Export Guarantee (SEG) could enable the development to export excess electricity being generated by the PV to the development's energy supplier, following the discontinuation of the Feed in Tarif (FiT).</p> <p>On this basis, photovoltaic panels are recommended as a local LZC technology.</p>	
	Air Source Heat Pumps	<p>The building uses Air Source Heat Pumps to supply heating, cooling and domestic hot water. As this is a low carbon technology which offers a high output of energy for every kW put in, it can considerably reduce CO₂ emissions. In this case it offers a reduction of 30.71% beyond a gas boiler baseline, using Part L2 2021 carbon factors.</p> <p>On this basis, air source heat pumps are recommended as a local LZC technology.</p>	

Table 1 LZC summary table.

1. Introduction.

This assessment report has been developed on behalf of BAM Construction Limited hereafter referred to as 'the Client' in support of the proposed Withington Community Hospital, hereafter referred to as the 'Proposed Development'.

This report provides the required analysis and results for the credit Ene 04: Low Carbon Design under BREEAM NC v.6 for non-domestic buildings which requires technologies to be assessed as part of a low and zero carbon feasibility study.

The aim of this credit is to ensure that the most appropriate low and zero carbon technologies (LZC) are adopted for the project.

By analysing the most appropriate solutions, the Proposed Development will reduce carbon emissions and atmospheric pollution by encouraging local energy generation from renewable sources to supply a significant proportion of the energy demand.

1.1 Proposed Development.

The Proposed Development will provide cardiorespiratory facilities as well as new consultation and treatment rooms. The remaining building space will include office spaces, reception and waiting areas, WC and changing rooms and plant facilities.

1.2 Assessment Drivers: BREEAM target.

The client brief dictates that the proposed development is to target a BREEAM Excellent rating.

The assessment of the Ene 04 Low or Zero carbon technologies credit helps contributes to the overall assessment score.

1.3 Approach to Assessment.

The following assessment report considers the approach in line with BREEAM requirements to ensure that the following items are addressed:

- An energy specialist completes a feasibility study (see Appendix B for relevant details) by the end of Concept Design.
- Establish the most appropriate recognised local (on-site or near-site) low and zero carbon (LZC) energy sources for the building or development, based on the feasibility study.
- Specify local LZC technologies for the building or development in line with the feasibility study recommendations.
- Quantify the reduced regulated carbon dioxide (CO₂-eq) emissions resulting from the feasibility study.

1.3.1 Low and Zero Carbon (LZC) Feasibility study content.

This low and zero carbon feasibility study aims to cover as a minimum:

1. Energy generated from LZC energy source per year.
2. Carbon dioxide savings from LZC energy source per year.
3. Life cycle cost of the potential specification, accounting for payback.
4. Local planning criteria, including land use and noise.
5. Feasibility of exporting heat or electricity from the system.
6. Any available grants.
7. All technologies appropriate to the site and energy demand of the development.
8. Reasons for excluding other technologies.
9. If appropriate:

- a. The building is connected to an existing local community CHP system or
 - b. the building is connected to an existing source of waste heat or power OR
 - c. a building or site CHP system is specified with the potential to export excess heat or power via a local community energy scheme or
 - d. a source of waste heat or power is specified with the potential to export excess heat or power via a local community energy scheme
10. Energy storage.

Limitations:

The appraisals within this statement are based on Part L calculation methodology and should not be understood as a predictive assessment of likely future energy requirements or otherwise.

Occupants may operate their systems differently, technologies may perform differently, and/or the weather may be different from the assumptions made by Part L approved calculation methods, leading to differing energy requirements.

As part of these works a simple cost assessment has been undertaken to meet the requirements of the BREEAM credit Ene 04 Low and Zero Carbon Feasibility and does not constitute a comprehensive whole-life costing which is expected to be undertaken by a Quantity Surveyor / Cost Consultant.

As the first floor is currently designed to shell and core only, for modelling purposes, we have assumed room (activity) layouts and HVAC system splits based on the ground floor layouts provided by Day Architects to help provide an understanding of potential Part L outcomes going forward. This is in line with guidance provided in section 2.21 and 2.22 of The Building Regulations 2010 (2021 edition incorporating 2023 amendments) Approved Document L Conservation of Fuel and Power Volume 2 Buildings other than dwellings¹.

¹
https://assets.publishing.service.gov.uk/media/63d8edbde90e0773d8af2c98/Approved_Document_L__Conservation_of_fuel_and_power__Volume_2_Buildings_other_than_dwellings__2021_edition_incorporating_2023_amendments.pdf

2. Assessment methodology.

The following is a summary of the data used and inputs / assumption made.

2.1 Site Context.

The Proposed Development is located in Greater Manchester, within the existing Withington Hospital site, on undeveloped land to the side of the existing building.



Figure 1: The Proposed Site Plan (DAY architects).

2.2 Site location and weather data.

A building’s thermal performance is its response to external environmental conditions. The more dependant a building is on passive features to achieve acceptable internal comfort, the more important the use of external weather information becomes.

Climate data is assigned to the virtual environment of the dynamic model to simulate external weather conditions that are likely to occur.

The UK Meteorological Office (MO) collects weather data at stations across the UK. Climate variables measured at hourly intervals include air temperatures, wind speed and direction and air pressure etc.

CIBSE licenses the historic weather data from the MO for 14 locations in the United Kingdom: Belfast, Birmingham, Cardiff, Edinburgh, Glasgow, Leeds, London (3 sites), Manchester, Newcastle, Norwich, Nottingham, Plymouth, Southampton and Swindon.

The weather variables are synthesised into 2 types of CIBSE weather file type both current and future:

– Design Summer Year (DSY): 2006 and 2016

The DSY is a single continuous year rather than a composite one made up from average months.
The DSY is used for overheating analysis.

– Test Reference Year (TRY): 2006 and 2016

The TRY is composed of 12 separate months of data each chosen to be the most average month from the collected data.
The TRY is used for energy analysis and for compliance with the UK Building Regulations (Part L).

In absence of a more detailed predictive energy model (e.g. in accordance with CIBSE Technical Memorandum 54), the results of the Part L analysis have been utilised as an estimation of the building’s energy performance at this stage. Following the standardised methodology behind the Part L requirements, the closest CIBSE weather file location for the proposed development is the **2016 CIBSE Manchester TRY**. This weather file has been utilised for the purposes of these calculations.

2.3 Building Fabric Specification.

Optimising the development’s fabric is seen to be the most robust and effective way to improve energy efficiency and in turn reduce carbon emissions whilst also impacting thermal comfort.

The performance of the envelope i.e. material performance is unlikely to deteriorate significantly with time and therefore the benefits of these measures will continue at a similar performance for the duration of their installation.

The performance of the glazing has also been carefully considered to maximise natural daylight penetration to reduce the reliance of artificial lighting whilst also allowing a controlled amount of passive solar heating.

Useful solar heat gain reduces heating demand in winter but with careful consideration to the glazing specification, this will help limit solar gain in the summer which would therefore reduce the potential risk of glare and overheating.

The Part L and target building fabric performance details are detailed below. Withington Hospital will build to the NHS Net Zero Carbon Healthcare Building Standards for Primary Healthcare Buildings.

Parameter	Part L (2021) Limiting Value	Notional Building Part L (2021, side-lit)	Withington Community Hospital
Fabric Air Permeability (m ³ /m ² .h at 50Pa)	8.00	3.00	1.00
External Wall U-value (W/m ² .K)	0.26	0.18	0.12
Ground Floor U-value (W/m ² .K)	0.18	0.15	0.10
Roof U-value (flat) (W/m ² .K)	0.18	0.15	0.11
Glazing U-value (W/m ² .K) (glazed door / windows)	1.60	1.40	1.20
Glazing g-value – North Façade	0.48	0.29	0.40
Glazing g-value – South/ East/ West Façade	0.48	0.29	0.35
Glazing light transmittance	70%	60%	70%
Glazing Frame percentage	10%	10%	10%
Entrance Door U-value (W/m ² .K) – Solid / Glazed	1.60	1.90	1.60

Table 2 - Fabric and construction parameters.

2.4 Architectural drawings.

The geometry used to assess proposed development was determined by the following information received from DAY Architect.

Uploaded	Source	Data Type	Description
28/03/2024	DAY architects	PDF/ DWG	22182-DAY-WCH127-00-DR-A-20001-Proposed General Arrangement Plan- Ground Floor-P5 22182-DAY-WCH127-01-DR-A-20011-Proposed General Arrangement Plan- First Floor-P2 22182-DAY-WCH127-RF-DR-A-27021-Proposed roof plan-P1 22182-DAY-WCH127-ZZ-DR-A-20101-Proposed North & East Elevations-P1 22182-DAY-WCH127-ZZ-DR-A-20102-Proposed South & West Elevations-P1 22182-DAY-WCH127-ZZ-DR-A-20201-Proposed Sections (1-100)-P1
28/03/2024	DAY architect	Rvt	22182-DAY-V1-ZZ-M3-A-0001_Architectural Model_STAGE 2 ISSUE_28.03.2024

Table 3 - Architectural Information

2.4.1 Dynamic Simulation Model.

Based on the information above a Dynamic Simulation Model was created to undertake the appropriate assessments on the proposed design.

Integrated Environmental Solutions Virtual Environment (IESve) is a Dynamic Simulations Modelling (DSM) software package that has the capabilities of enabling the user to create a virtual representation of a building.

This model is being used for the BREEAM Ene 04: Low carbon design credit assessment and analysis in respect to the credit - Low zero carbon feasibility study.

The image below shows the DSM model, with surrounding buildings.

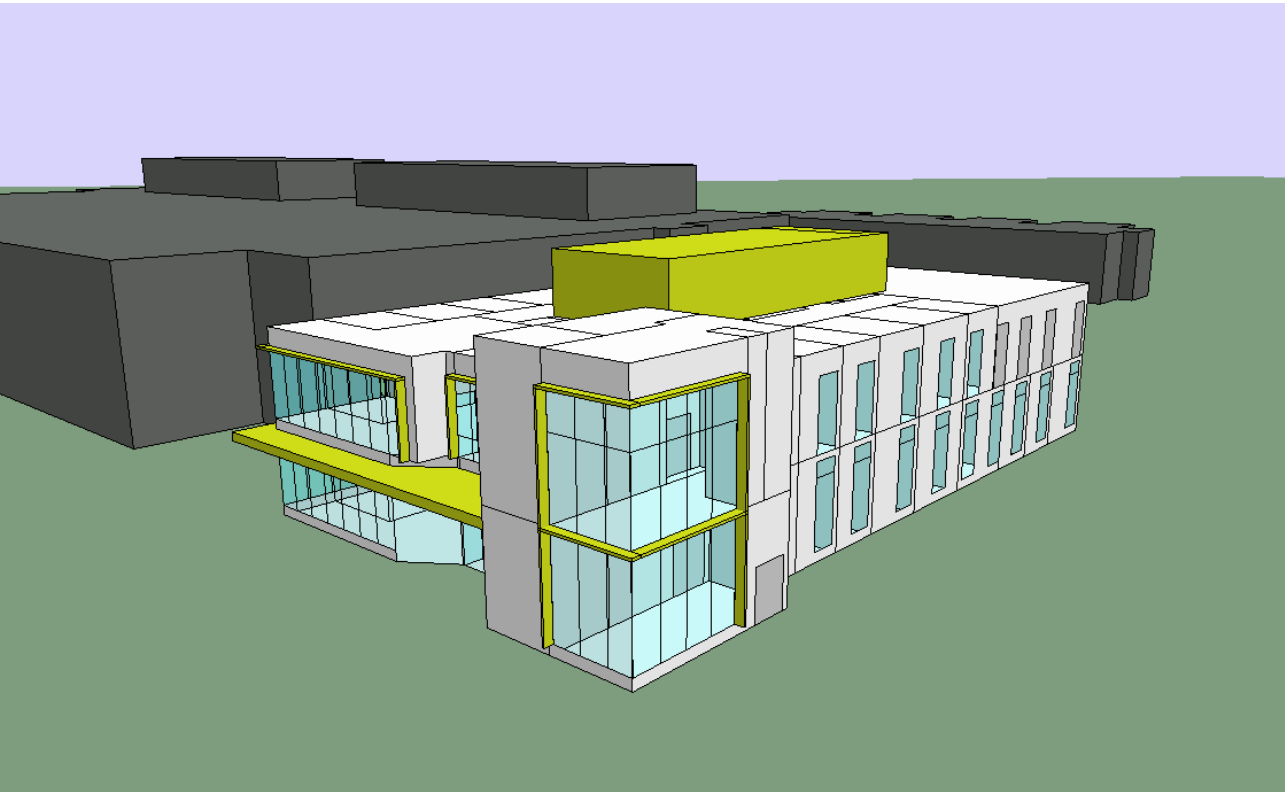


Figure 2 - DSM model image.

Ene 04 Low and Zero Carbon Feasibility Study discussion.

An extract from the BREEAM manual sets the context for this credit:

The reduction in regulated carbon dioxide (CO₂-eq) emissions can be demonstrated by comparing regulated carbon dioxide (CO₂-eq) emissions with LZC technologies to the actual building-regulated emissions without LZCs. When the CO₂-eq savings are compared for different technologies, they may be estimated separately from the building energy model where appropriate, e.g. by using manufacturers' data, simple hand calculations or spreadsheets. For the specified technologies, any CO₂-eq savings are estimated using dynamic simulation modelling. The energy supply used for the base case is mains gas and grid electricity. If mains gas is not available on site, then oil may be used instead. The base case includes any passive design or free cooling measures adopted for the first two credits. The actual building energy demands are calculated as for the passive design analysis. The carbon dioxide emissions factors used for the building regulations calculations are then applied.

2.4.2 Additional Information.

The following items are notable as they will be considered / applied, as appropriate, within this assessment.

Whole Life Costs over 60 years.

A whole life cost comparison has been carried out over 60 years for each of the different renewable energy systems considered.

The analysis includes the capital, maintenance, operational and replacement costs, as well as the cost saving through offsetting any other system use e.g. solar thermal panels offsetting gas fired boilers.

This analysis is based on estimated capital and operational costs using cost benchmarks and as such allows for a broad understanding of the economics of these systems only. It should be considered with care as it based on the following assumptions;

- Indicative capital cost and replacement costs of specialist equipment. This excludes plant room costs, main contractor overheads and profit, design reserve, client contingency, professional fees, building control costs and VAT.
- In addition to the earlier replacement costs, if required, an allowance has been made on the 30th year for forthcoming replacement costs.
- The cost and level of fuel inflation for electricity is detailed below. The price includes the Climate Change Levy.
- A discount factor of 3.5% per annum (pa) has been applied to the maintenance costs, energy costs, energy savings, grants and replacement costs ^[1].

	Costs (£/kWh)	Source ^[2]
Electricity	0.279	Department for Energy Security and Net Zero – Medium Consumer
Gas	0.069	Department for Energy Security and Net Zero – Medium Consumer

Table 4 Fuel costs source from BEIS quarterly energy price reporting.

^{[1][2]}. See appendix for references.

	Inflation (%pa)	Source
Electricity	3.5%	Based on historic trend in energy prices reported by BEIS for 4.8/medium electricity consumers
Gas	3.5%	Based on historic trend in energy prices reported by BEIS for 4.8/medium electricity consumers

Table 5 Inflation rates used.

Life Cycle Impact.

The Life Cycle Impact of the renewable energy systems has been examined in terms of carbon emissions.

A Life Cycle Impact assessment of a product is a thorough assessment of its impact 'from cradle to grave', i.e. from the extraction of the materials required in its manufacture to its disposal at end of life, taking into account all processes involved, including transport. When the Life Cycle Impact specifically considers carbon emissions, the critical factor is the 'embodied energy' of the product considered, i.e. the energy used in extraction, manufacture, transport, maintenance and disposal. When assessing renewable energy systems (or indeed any energy generation system), the overall impact will be all the more positive if the embodied energy is low relative to the energy generated in the lifetime of the system. This can in particular be expressed in terms of 'energy payback time', i.e. the time it takes for a system to generate more energy than its embodied energy.

A detailed Life Cycle Impact assessment requires a significant amount of information, often difficult to obtain. It will also be product - and supplier - specific and is therefore beyond the scope of this document. However, information available from manufacturers and independent bodies has been used in this document for an initial evaluation of the overall carbon emissions impact of the renewable energy systems examined, as an indicator of their environmental viability.

The figures should not be used as absolute but rather as guidance in comparing systems relative to the Base case.

Grid decarbonisation.

With decarbonisation of the grid on-going, resultant from the connection of low-carbon and renewable technologies to the national grid (as well as the winddown and decommissioning of coal fired power generation), the carbon factor of electricity generated has significantly decreased since the previous 2013 Part L methodology was released.

Grid decarbonisation has resulted in the dwelling emission rates demonstrated now being far more representative of the UK National Grid carbon factors. At the end of 2020, the Department for Business, Energy, and Industrial Strategy (BEIS) reported the carbon factor of electricity as having fallen by a 70% reduction compared to that in Part L, 2021.

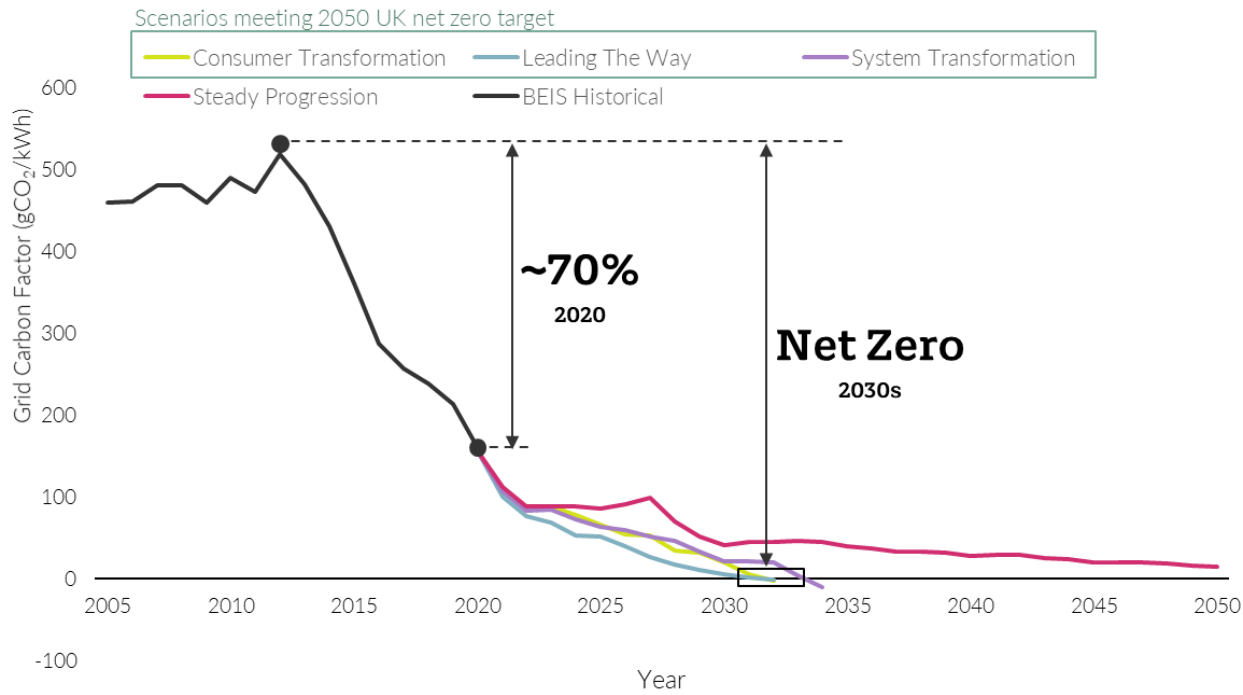


Figure 3 - The carbon factor of grid electricity and the projected future energy scenarios published by the national grid.

Carbon factors.

The updated Part L 2021 document uses the SAP 10.2 carbon factors. This assesses the dwelling emission rate using a different fuel factor for each month of the year depending on the average fuel mix seen to be accessible within that month.

Colder months are seen to have a higher carbon factor due to numerous factors, most notably the reduction in available Photovoltaic power from reduced solar energy, and the introduction of more fossil fuel sources to help manage the increased energy demand from heating.

Table 6: Carbon factors comparison.

Month	Carbon Factor kgCO ₂ /kWh	Month	Carbon Factor kgCO ₂ /kWh
January	0.163	July	0.111
February	0.160	August	0.112
March	0.153	September	0.122
April	0.143	October	0.136
May	0.132	November	0.151
June	0.120	December	0.163

2.4.3 Ene 04 Low and Zero Carbon technology scoping.

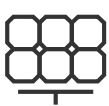
It understood based on the BREEAM guidance that “technologies eligible to contribute to achieving the criteria must produce energy from renewable sources and meet all other ancillary requirements as defined by Directive 2009/28/EC(120).

The following requirements must also be met:

1. There must be a direct supply of energy produced to the building under assessment.
2. Technologies under 50 kWe or 45 kWth must be certified by a Microgeneration Certification Scheme (MCS), or equivalent, and installed by MCS (or equivalent) certified installers.
3. Combined heat and power (CHP) schemes above 50 kWe must be certified under the CHPQA standard. CHP schemes fuelled by mains gas are eligible to contribute to performance against this issue.
4. Heat pumps can only be considered as a renewable technology when used in heating mode. Refer to Annex VII of Directive 2009/28/EC and supporting document 2013/114/EU for more detail on accounting for energy from heat pumps.
5. Where MCS or CHPQA certification is not available, the design team must investigate the availability of alternative accreditation schemes in line with the Directives listed above, or an equivalent country or regional directive or standard. Where an accreditation scheme exists, it should be used for the purpose of verifying compliance of the specified LZC technology. If no accreditation scheme exists in the country, the design team must demonstrate they have investigated the competence of the installer selected and are confident that they have the skill and competence to install the LZC technology appropriately.

The table below describes each technology with an initial summary of all technologies appropriate to the site and energy demand of the development and reasons for excluding other technologies.

Those to be included in the assessment will then be considered in line with BREEAM requirements.

	Low and Zero Carbon technology	Discussion and suitability for proposed development:	Comment	Inclusion
	Photovoltaics (PV) Photovoltaic panels harness energy from sunlight and convert this into useful energy in the form of electricity.	A PV system requires viable roof space for the system array to be installed and function effectively. Initial view on suitability for Proposed Development: It is anticipated that on-site energy production could be achieved with the introduction of a photovoltaic array on the building's roof. PV also provides the opportunity to provide a significant reduction in CO ₂ and the potential to export electricity to the grid.	PV will be considered further as part of this assessment.	
	Solar thermal Solar thermal panels are similar to PV panels in that they harness energy from the sun. This technology however converts solar energy into thermal energy that can offset the demand on hot water generation systems.	Solar thermal panels are suited to developments with a high thermal base load where their provision could offset a proportion of domestic hot water. Ideally solar thermal panels would require hot water plant close to the generation point to minimise losses. Initial view on suitability for Proposed Development: Solar thermal systems would compete for roof area with PV, but due to varying occupancy times and the possibility to export, PVs seem the more suitable option. Further, solar thermal can be ineffective during winter and periods of cold weather. In addition, there have been some legionella concerns raised in the industry with regards to solar thermal which becomes particularly important in the context of a healthcare development.	Solar thermal has not been considered further.	
	Heat Pump: Air source heat pump (ASHP) Air source heat pumps use thermodynamic principles (Carnot Cycle) to convert heat from the air into useable heat within the building. Unlike some low-carbon sources of energy, heat pumps do require energy (typically electricity or gas) to pump and compress refrigerant through the system.	Under the Renewable Energy Directive 2009/28/EC ASHP's are classified as renewable technologies provided that the final energy output significantly exceeds the primary energy input required to drive the heat pump. Initial view on suitability for Proposed Development: Heat pumps can typically operate at an efficiency of around 350% when delivering heating for space conditioning. Efficiencies drop significantly however when a heat pump is used to deliver domestic hot water due to the greater temperature required. A dedicated heat pump system would be applicable to serve the development.	Air source heat pumps (ASHP) will be considered further as part of this assessment.	
	Ground Source Heat Pumps (GSHPs) GSHPs work similarly to ASHP, except they extract heat from the ground. Generally, GSHPs are more efficient as the ground temperature is more stable over the year relative to the air temperature, however overall output can be smaller.	GSHPs are best suited to developments with a balanced heating and cooling load, to avoid long-term heating or cooling of the ground /ground water and associated decreased efficiency of the heat pump. Initial view on suitability for Proposed Development: The groundworks for a GSHP system are significant, available space on site appears limited, and would require higher costs and effort than the proposed Air Source Heat Pumps.	Ground Source Heat Pumps (GSHP) have not been considered further.	

	Low and Zero Carbon technology	Discussion and suitability for proposed development:	Comment	Inclusion
	Geothermal: Aquifer thermal energy storage (ATES) ATES is the storage and recovery of thermal energy in the subsurface. ATES is applied to provide heating and cooling to buildings. Storage and recovery of thermal energy is achieved by extraction and injection of groundwater from aquifers using groundwater wells.	<p>ATES systems commonly operate in a seasonal mode. The groundwater that is extracted in summer, is used for cooling by transferring heat from the building to the groundwater by means of a heat exchanger. Subsequently, the heated groundwater is injected back into the aquifer, which creates a storage of heated groundwater. In wintertime, the flow direction is reversed such that the heated groundwater is extracted and can be used for heating (often in combination with a heat pump).</p> <p>Operating an ATES system uses the subsurface as temporal storage to buffer seasonal variations in heating and cooling demand. When replacing traditional fossil fuel dependent heating and cooling systems, ATES can serve as a cost-effective technology to reduce the primary energy consumption of a building and the associated CO₂ emissions.</p> <p>Initial view on suitability for Proposed Development: To date, no discussion or survey works have suggested that there is a suitable groundwater nearby. Extensive groundworks would be required meaning benefits of this system are questionable when compared to other systems available.</p>	Aquifer thermal energy storage has not been considered further.	
	Hydrogen fuel cells A fuel cell is an electrochemical cell that converts the chemical energy of a fuel (often hydrogen) and an oxidizing agent (often oxygen) into electricity through a pair of redox reactions.	<p>Fuel cells using hydrogen generated from some of the technologies considered as part of this assessment could produce electricity continuously for as long as fuel and oxygen are supplied.</p> <p>Initial view on suitability for Proposed Development: Whilst hydrogen fuel cell use could be revisited in the future, this would be more beneficial as part of a wider energy system.</p> <p>Items making further consideration difficult at this stage include:</p> <ul style="list-style-type: none"> – Lack of existing hydrogen gas infrastructure, – Lack of carbon credentials due to use of natural gas as fuel source to produce the hydrogen fuel, – High capital costs, – High running, maintenance & replacement costs, – The need to purpose design the heating network to suit a hydrogen fuel Combined Heat and Power (CHP) approach. 	<p>Hydrogen fuel cells have not been considered further.</p> <p>Creation of hydrogen would require either methane reformation or generation from a reverse osmosis system.</p> <p>In the first case, the methane reformation process will result in carbon emissions and will ultimately suffer from efficiency reductions.</p> <p>Generation of hydrogen using electricity will result in efficiency losses, and therefore it is likely that instead using the low carbon ASHPs will result in overall lower primary energy consumption and lower carbon emissions.</p>	
	Combined Heat and Power (CHP) CHP utilises a gas or diesel combustion engine to drive a turbine to generate electricity, whilst simultaneously providing heating to hot water pipework distribution.	<p>CHP was considered a low carbon source of energy in the UK until recently due to the benefit of offsetting a high carbon and inefficiently distributed electrical grid with a relatively low carbon gas supply. As electricity now has an increasingly low carbon factor, CHP systems no longer offer a low carbon solution.</p> <p>As things stand, there is still an improvement to be seen in terms of Part L2 compliance, CHP systems must meet the threshold for good quality CHP as set by DEFRA's CPHQA programme.</p> <p>Initial view on suitability for Proposed Development: Significant renewable energy generation capacity has lowered the average carbon emission fuel factor of grid supplied electricity, with an average carbon factor (kgCO₂/kWh) lower than the carbon factor of combusting grid supplied natural gas. This means that the electricity generated by the CHP is, on average, at a higher carbon content than grid supplied electricity, making any future installation a relatively high carbon technology. For this reason, CHP has not been considered.</p>	CHP and/or connection to the GSC network have not been considered further.	

	Low and Zero Carbon technology	Discussion and suitability for proposed development:	Comment	Inclusion
	Biomass Biomass boilers burn wood fuel or other bio-fuel sources to generate heat. These boilers can operate at high efficiencies, comparable to condensing gas boilers.	<p>Biomass boilers require a large fuel store to maintain continuous operation during the winter months, as such plant space requirements are high. Fuel deliveries can also prove difficult due to access requirements, requiring additional provision for delivery vehicles.</p> <p>Initial view on suitability for Proposed Development: Storage space for the fuel has not been allowed for within the current design. In theory, the use of a biomass boiler could yield good, regulated CO₂ emission savings, however this would also lead to an increase of NO_x emissions from the site, leading to concerns regarding air quality. In addition, local sourcing of biomass could be difficult and the security of supply for biomass could lead to increased operational costs in the future. Healthcare building require operative stability and resilience, both of which would be at risk if linked to biomass.</p>	Biomass has not been considered further.	
	Energy from Waste Energy from waste (EfW) is the process of generating electricity and/or heat from the primary treatment and processing of waste usually by incineration.	<p>Both landfill and the incineration of untreated mixed waste will result in the release of carbon into the atmosphere but for the same bag of waste it does so in different ways and in different amounts. Landfill produces carbon dioxide (CO₂) and methane (CH₄) in roughly equal proportions whereas energy from waste produces carbon dioxide only. These gases are both contributors to global warming, although methane is around 25 times as damaging as carbon dioxide. Therefore, the route which produces the lower volume of greenhouse gas emissions, (usually expressed as carbon dioxide equivalents or CO_{2eq}), is generally placed higher in the waste hierarchy.</p> <p>Further, where an EfW facility is in place to generate electricity, with heat generation essentially a by-product, it can be considered a low carbon heat source (i.e. if the heat were not utilised it would be wasted).</p> <p>Initial view on suitability for Proposed Development: Local waste incineration facilities have not been identified. Further, there are concerns surrounding fumes from such facilities.</p>	Energy from waste has not been considered further.	
	Wind turbines Wind turbines use the force of the wind to drive a rotor and generator to produce electricity.	<p>In order to yield high electrical output, wind turbines require smooth laminar wind flow, and consistent wind speeds. Where wind flow is turbulent, a wind turbine will not operate effectively.</p> <p>Initial view on suitability for Proposed Development: The site location and proximity to other constructed buildings would be likely to affect the local wind patterns and therefore the performance of wind turbines, meaning any contribution to overall generation would be limited. There are also possible implications with respect to noise emissions and impact on local birds and bat populations that would need to be fully considered.</p>	Wind turbines have not been considered further.	
	Hydro power (Small scale) Hydroelectric power is the generation of electric power from the movement of water. A hydroelectric facility requires a dependable flow of water and a reasonable height for the water to fall, called the head.	<p>In a typical installation, water is fed from a reservoir through a pipe into a turbine. The water flowing through the turbine causes an electrical generator to rotate, converting the motion into electrical energy.</p> <p>Initial view on suitability for Proposed Development: Neither technology is deemed suitable for the Proposed Development due the lack of nearby suitable watercourses such as reservoirs or rivers. The River Mersey is considered to be too far from the Proposed Development to make any new connection viable, especially given the urban development sitting between it and the hospital site.</p>	Tidal power Tidal power or tidal energy is the form of hydropower that converts the energy obtained from tides into useful forms of power, mainly electricity.	

Table 7 LZC scoping.

3. Low and Zero Carbon Feasibility Study.

3.1 Base Case for BREEAM Ene 04.

In order to undertake the assessment, a ‘base case’ was created in line with BREEAM Ene 04 requirements which:

- i) utilises high efficiency gas fired boilers; providing space heating and domestic hot water
- ii) utilises high efficiency chillers to provide space cooling.

The base case helps to inform the benefit of low and zero carbon technologies – which are considered as part of the assessment.

These will be classified in the ‘baseline’ and ‘proposed’ stages, as shown below.

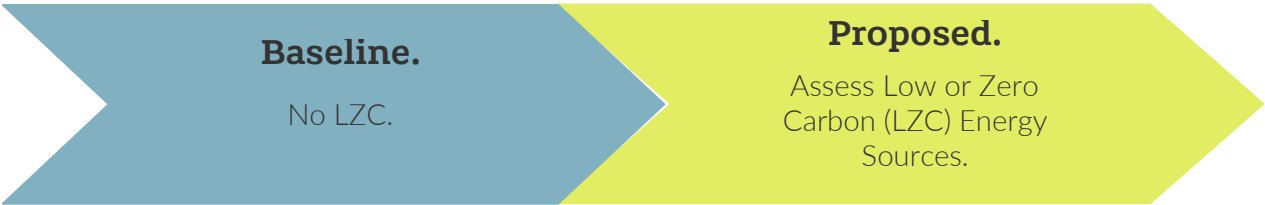


Figure 4 - Energy Hierarchy.

As such the Baseline case is shown in the next section.

3.2 Baseline.

To improve on the Base case, improvements to both passive measures (improved U-values and air permeability), and energy efficiency measures (HVAC equipment efficiencies and low energy lighting) were made as shown in the tables and figures below.

The following is a summary of improved input parameters;

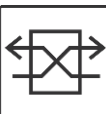
	Fabric performance Fabric efficiency parameters enhanced as per the values in section 3.4.
	Space Heating and cooling <ul style="list-style-type: none">- Space heating utilises high efficiency gas fired boilers (93%) (note: gas is required for modelling the Baseline case, alternative options are considered among the LZC options in the Proposed case).- Space cooling utilises high efficiency cooling (SEER 4.3/ Nominal EER 2.73)
	Mechanical ventilation The use of heat recovery with an efficiency of 68% in non-clinical spaces and 75% in clinical spaces is used. Recovering heat from the extract air can help reduce annual heating energy considerably with no adverse impact on the air quality of the incoming fresh air.
	Lighting The internal lighting design incorporates the use of high efficiency lighting combined with daylight linking (where applicable). The use of presence and absence detection prevents the internal lighting being 'on' when the spaces are not occupied.
	Domestic hot water (DHW) system Domestic Hot water uses high efficiency gas fired boilers (93%) (note: gas is required for modelling the Baseline case, alternative options are considered among the LZC options in the Proposed case).

Table 8 - Base Case Building Performance Parameters.

Baseline.

The figure below shows the energy demand and carbon emissions for the Proposed Development – using the Be Lean simulation model.

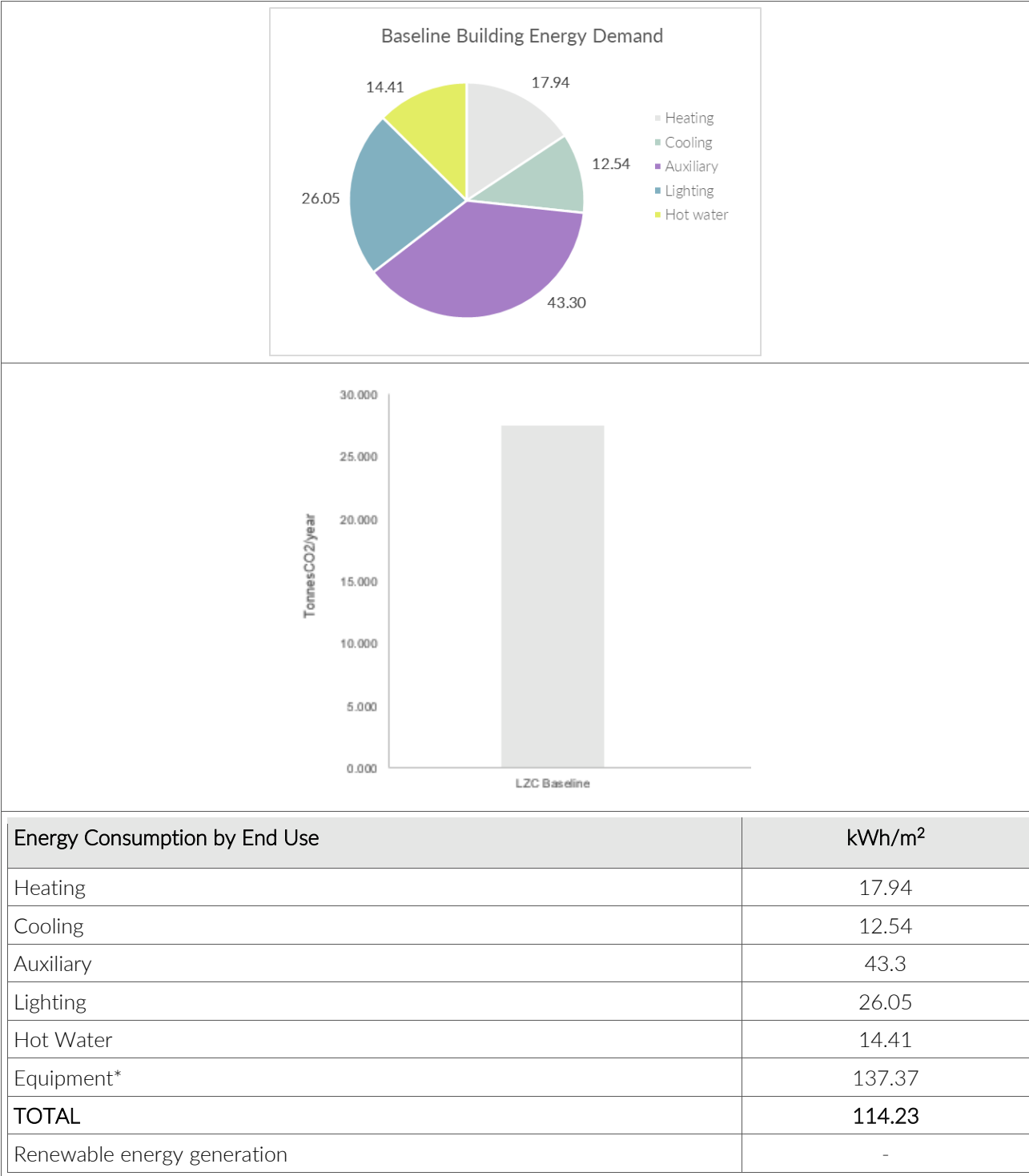


Figure 5 - Be Lean assessment figures.

*Energy used by Equipment does not count towards the total for consumption or calculating emissions.

3.3 Proposed.

This report considers the implementation of technology able to generate renewable energy on-site.
To improve on the baseline case, ASHP system and an indicative area of roof mounted PV panels are proposed.
This consideration is discussed below.

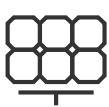
	Low and Zero Carbon technology
	<p>Photovoltaic panels: Photovoltaic panels harness energy from sunlight and convert this into useful energy in the form of electricity.</p> <p>Photovoltaic panels: An indicative array able to generate 61,745.21kWh of electricity has been incorporated into the calculations (this equates to an active area of 386m² dependant on panel type and efficiency chosen).</p> <p>The PV array has contributed a 28.15% improvement above the baseline building therefore rendering itself a valuable LZC technology.</p>
	<p>Air Source Heat Pumps: Under the Renewable Energy Directive 2009/28/EC ASHP's are classified as renewable technologies provided that the final energy output significantly exceeds the primary energy input required to drive the heat pump. They can typically operate at an efficiency that exceed 350% when delivering heating for space conditioning.</p> <p>The proposed development's energy will be supplied by Air Source Heat Pumps operating at efficiencies of around 380%. ASHP's provide a 30.71% reduction in carbon emissions beyond the Baseline Building.</p>

Table 9 LZC technologies.

Proposed.

The figure below shows the energy demand and carbon emissions for the Proposed Development – using the Proposed simulation model.

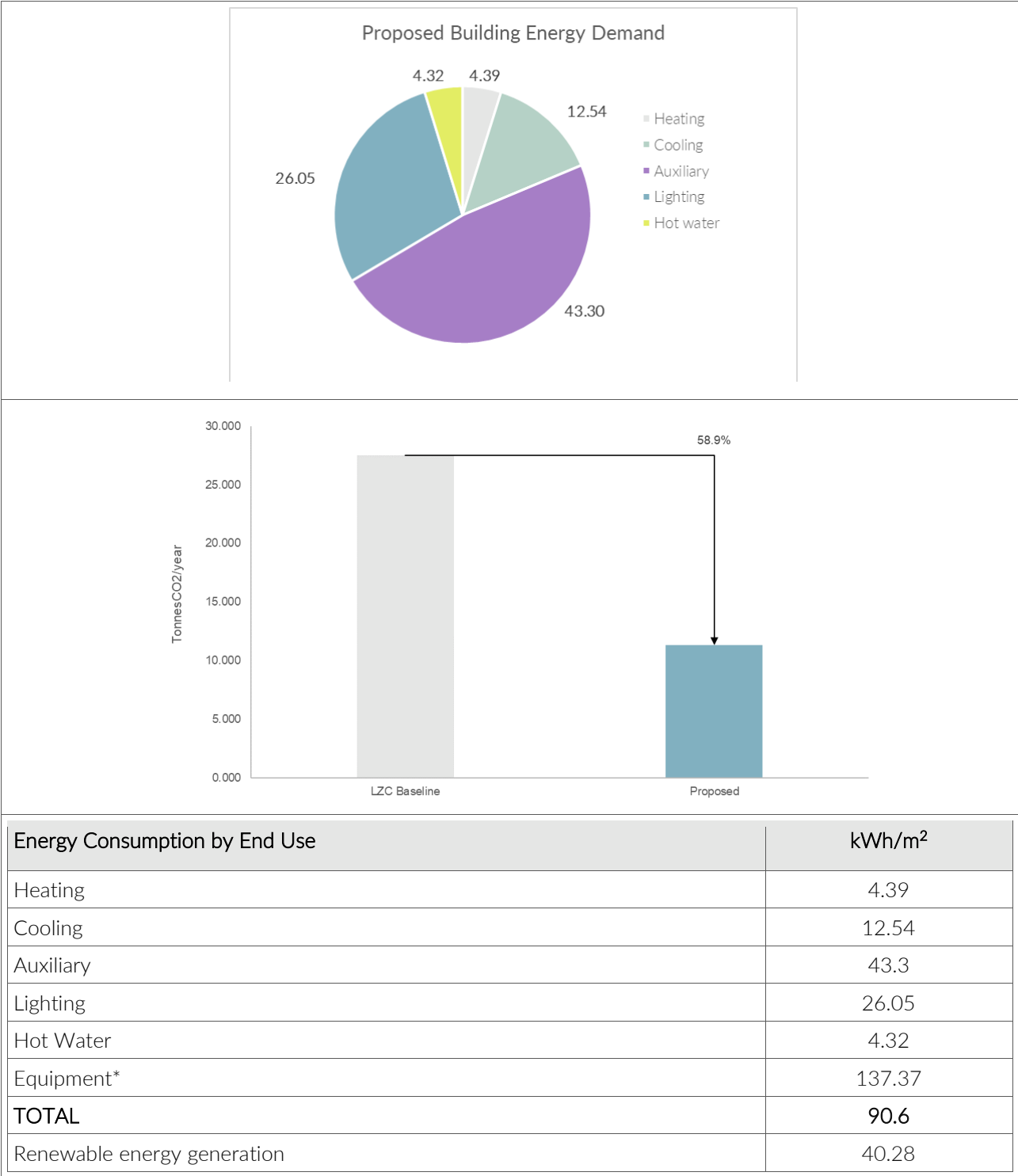


Figure 6 Be Lean assessment figures.

*Energy used by Equipment does not count towards the total for consumption or calculating emissions.

3.4 Low and Zero Carbon technologies (Items 1-8).

The following technologies have all been included in the full assessment with reasons for those excluded as per earlier discussion in the Scoping section.

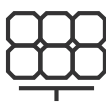
	Low and Zero Carbon technology	Energy generated from LZC energy source per year	Carbon dioxide savings from LZC energy source per year	Life cycle cost of the potential specification, accounting for payback	Local planning criteria, including land use and noise	Feasibility of exporting heat or electricity from the system	Life Cycle Impact (CO ₂ emissions)	Any available grants
	Photovoltaics (PV)	See table below	See table below	See table below	<p>Consideration has been given to allocation of suitable roof space in design.</p> <p>Local Authorities in favour of technology to help support low carbon future targets.</p> <p>PV panels produce no noise during operation.</p>	<p>The Government have decided to introduce the Smart Export Guarantee (SEG) from the 1st of January 2020. This mandates energy companies to provide an energy export tariff and this includes electricity generated through Photovoltaics.</p> <p>The SEG requires exported power to be metered on a half hourly basis, along with compliance with relevant consumer protection standards.</p> <p>The precise requirements & guidance documents of the SEG should be monitored, so that an application can potentially be made.</p> <p>Further information can be found in the links below: https://www.ofgem.gov.uk/publications-and-updates/smart-export-guarantee-seg</p> <p>https://www.energysavingtrust.org.uk/renewable-energy/electricity/solar-panels/smart-export-guarantee-and-feed-tariffs</p>	<p>The embodied energy of PV arrays and their inverters are the only source of carbon emissions during the lifetime of the panels, as there is no fuel consumption required to operate them.</p> <p>The embodied carbon of PV panels tends to be high, as they incorporate materials which are energy intensive to manufacture.</p> <p>Their transport from the country where they were manufactured can also add to the total embodied carbon.</p> <p>Because of the variety of technologies and manufacturers, the embodied carbon can be difficult to evaluate.</p>	<p>None. The Government's Renewable Heat Incentive Scheme closed for new applicants on 31st March 2022, following a one year extension to the 2021 deadline.</p> <p>Launched in April 2022, the Clean Heat Grant replaced the RHI but only applies to replacement boilers in dwellings.</p>
	Air Source Heat Pumps (ASHPs)	See table below	See table below	See table below	<p>Consideration has been given to allocation of suitable space in the design for the location of large scale ASHPs.</p> <p>Local Authorities are generally in favour of technology to help support low carbon future targets.</p> <p>Noise emissions would require consideration with respect to any condensing / heat rejection unit to ensure they are below any acoustics recommendations determined by the acoustics consultant.</p>	<p>The proposal includes ASHPs which are sized to meet the building's thermal energy demand. Therefore, all e-generated heat is to be used on-site leaving no opportunity for export.</p> <p>This being said, if the site demands were to change in future, it could be feasible to export thermal energy locally.</p>	<p>The main source of emissions over the lifetime of the system will be the electricity used in operation, which can limit carbon emissions savings.</p>	<p>The Government's Renewable Heat Incentive Scheme closed for new applicants on the 31st of March 2021.</p>

Table 10 LZC technologies to be assessed further

3.5 Wider Site Consideration: Community/District considerations (Item 9).

Ene 04 requires that if appropriate:

- a. the building is connected to an existing local community CHP system or
- b. the building is connected to an existing source of waste heat or power OR
- c. a building or site CHP system is specified with the potential to export excess heat or power via a local community energy scheme or
- d. a source of waste heat or power is specified with the potential to export excess heat or power via a local community energy scheme

None of the above are deemed appropriate for the scheme.

3.6 Energy Storage (Item 10).

The following shows how energy storage has been considered in line with Ene 04 requirements.

	Low and Zero Carbon technology	Discussion and suitability for proposed development:	Comment	Inclusion
	Thermal Storage	Thermal storage is not deemed necessary due to DHW being provided by ASHPs which are highly efficient. ASHPs can get water up to acceptable high temperatures to be used for occupants.	Thermal storage will not be considered further	
	Geothermal: Aquifer thermal energy storage (ATES)	To date no discussion or survey works have suggested that there is a suitable groundwater nearby. As very relatively small cooling systems are included in the proposed design the opportunity is limited.	Aquifer thermal energy storage will not be considered further	
	Battery storage	Solar PV panels generate electricity when light is incident on them. By adding a battery to the system, any excess energy generated can be used later when the panels are no longer generating, rather than buying energy from the grid. Initial view on suitability for Proposed Development: Currently no battery storage is included, however any on-site generation from renewable energy sources could benefit from storage. There are two main advantages envisaged: <ul style="list-style-type: none">– Allows for offsetting of charges and peak lopping of electrical load.– Potential to time shift to capitalise on cheaper electrical tariffs. As the occupancy and electrical loads vary throughout the week, and PV is proposed, the development could benefit from being able to store the generated electricity during low occupancy hours.	The use of battery storage could be considered in the future following an understanding of the building's energy consumption and generation profiles.	

Table 11 Energy storage considerations

3.7 Results.

The following section details the findings of the assessment, specifically the following;

- Energy and Carbon savings
- Whole Life Costs over 60-year period (PV only)

This assessment has been undertaken to meet the requirements of the BREEAM credit Ene 04 Low and Zero Carbon Feasibility and does not constitute a comprehensive whole-life costing which will be undertaken by a Quantity Surveyor / Cost Consultant.

3.7.1 Connection to EfW District Heating

Firstly, Ene 04 requires that if appropriate:

- the building is connected to an existing local community CHP system or
- the building is connected to an existing source of waste heat or power OR
- a building or site CHP system is specified with the potential to export excess heat or power via a local community energy scheme or
- a source of waste heat or power is specified with the potential to export excess heat or power via a local community energy scheme

None of the above have been considered appropriate for the proposed development as described above.

3.7.2 Energy and carbon savings from on-site renewables.

Secondly the incorporation of on-site renewable technology has been considered. Analysis of this has been based on estimated capital and operational costs using cost benchmarks and as such allows for a broad understanding of the economics of this system only.

All figures used here are indicative only and any project decisions would need to be made based on values provided by Quantity Surveyor / Cost Consultants.

	Energy source	Annual Thermal Energy Output (kWh/yr)	Annual Electrical Energy Output (kWh/yr)	Theoretical CO ₂ reduction (based on Part L2 2021 carbon factors)	Simple Payback (without grants)	(LZC lifespan)	Whole Life Costs over 60 years (£ NPV)
	Photovoltaics (PV)	0	~61,745	28.15%	6	25	-718,000
	Air Source Heat Pumps (ASHPs)	~29,570	0	30.71%	5	25	-152,000

Table 12 - Results of suitable LZC.

3.7.3 Whole Life Costs over 60-year period.

The figure below shows the whole life costs of the considered LZCs over a 60-year period.

The graph shows the impacts of replacement costs, energy savings and payback periods with relation to traditional systems (when the whole life cost becomes negative if applicable), capital costs and resulting whole life costs.

The reduction in cost of ASHP system is due to this system replacing a gas boiler doing the same job. Therefore, the cost to operate a gas boiler over the 60-year life cycle is offsetting some of the cost to operate the ASHP system. Spikes in cost are due to the estimated lifespan of the system being set at 25 years meaning at these points over the 60-year lifetime the system would need to be fully replaced.

The whole life cycle cost of PV goes down between spikes on the chart due to the electricity generated on-site offsetting the cost of obtaining that electricity from the grid.

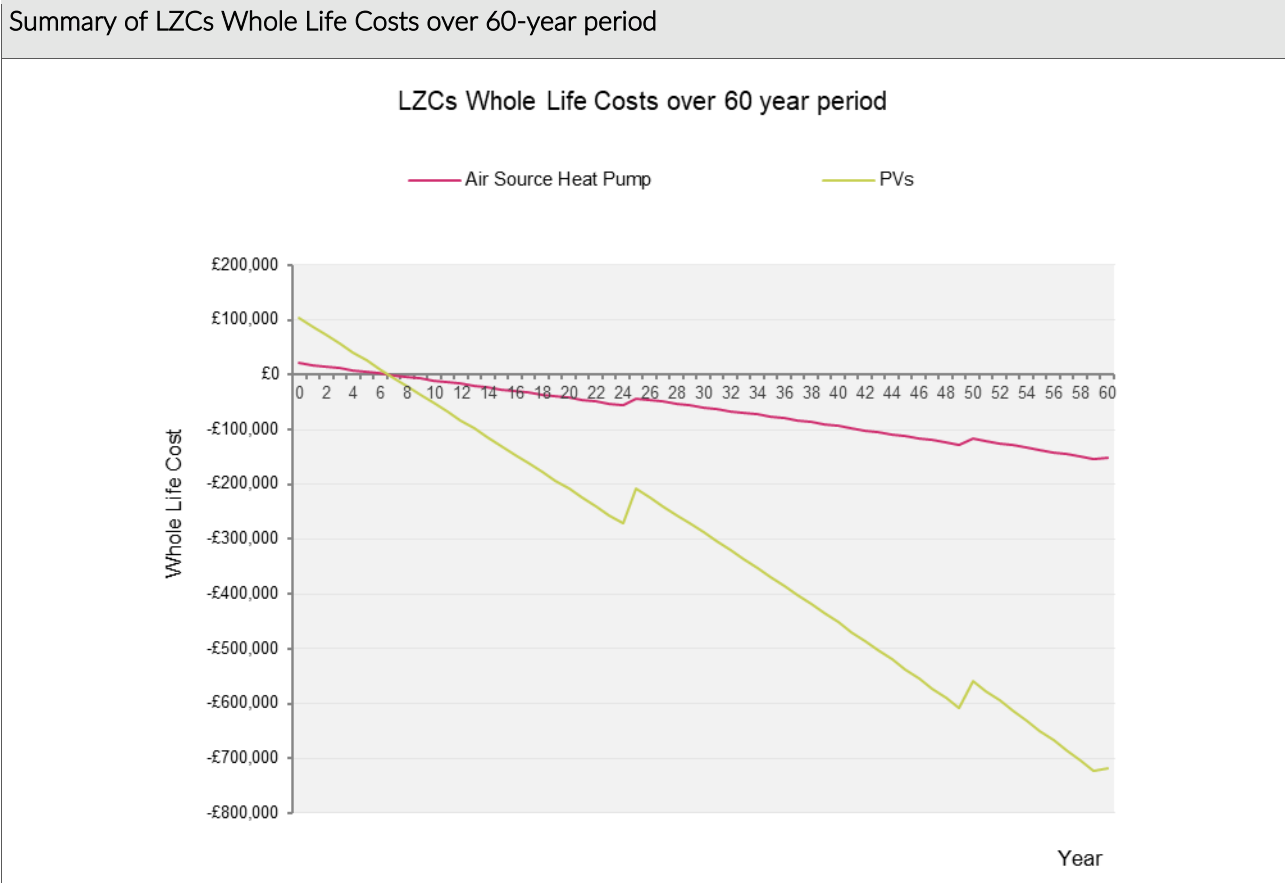


Figure 7 Summary of LZCs Whole Life Costs over 60 year period.

3.7.4 Whole Life Costs.

The figure below plots the resulting whole life cost after 60 years against the total sum of carbon that has been offset by the LZC over the 60-year period.

This figure does not take into account embodied carbon or the performance of the LZC.

This analysis allows assessment of which cost effective of the proposed measure, with desired systems tending towards the lower right region, representing low whole life costs and high carbon offsets. Note that SAP 10.2 carbon factors have been used in this analysis.

Summary of Whole Life Costs.

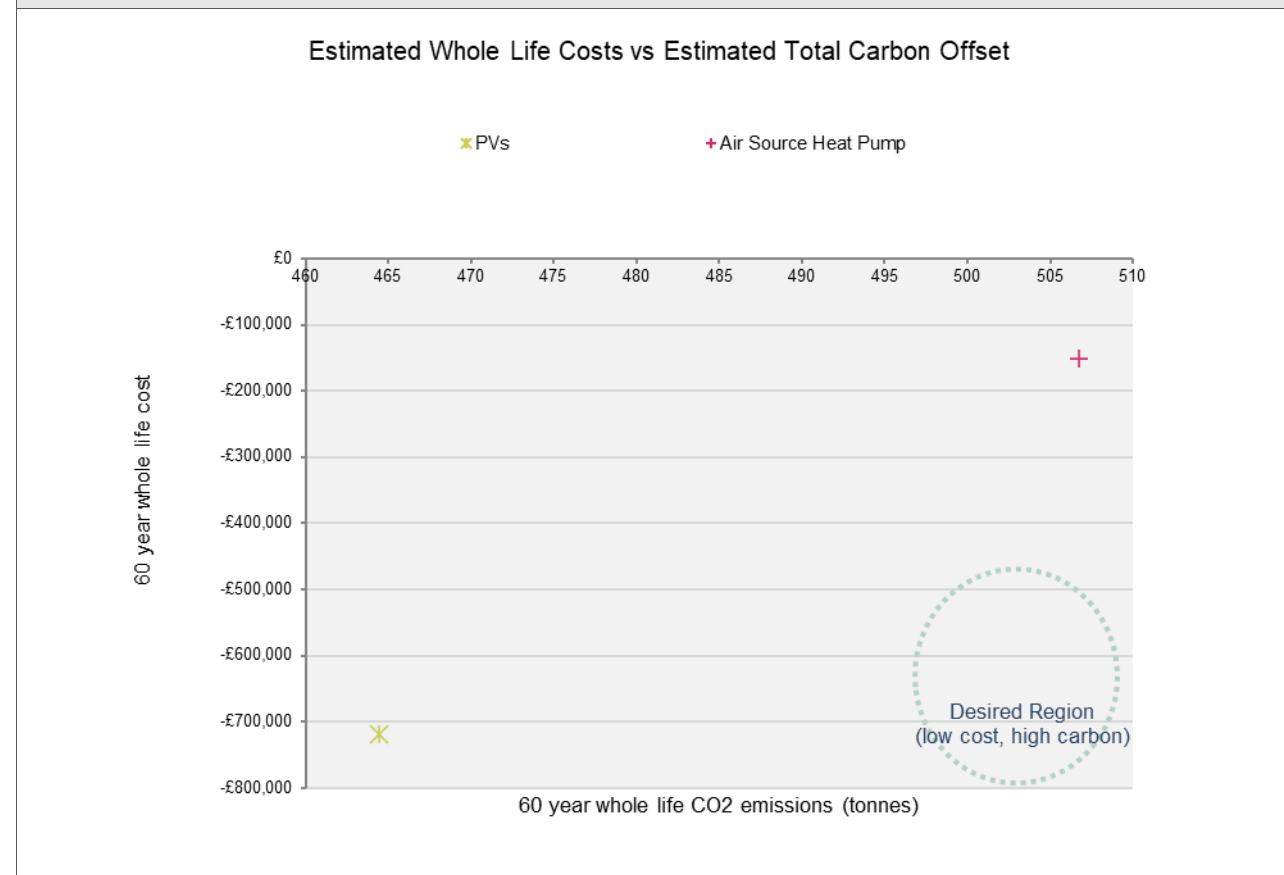


Figure 8 Summary of Whole Life Costs.

PV panels offer a large cost saving benefit as well as a carbon offsetting benefit. This is due to its ability to produce a substantial amount of renewable energy which reduces energy consumption - and consequently energy bills - relative to the capital and maintenance costs of the array.

Air Source Heat Pumps offer a low carbon alternative to gas boilers, however they still require an energy input to produce energy for heating, cooling and hot water. If the building's consumption for these end-uses is high, the amount of energy consumed is still large. To benefit from ASHP's over a long period of time, they will require high efficiencies to offset the costs associated with the energy consumed as well as costs required to purchase, maintain and replace them. Because of this, ASHP's still remain a better alternative to gas boilers in all its financial, environmental and sustainable aspects.

4. Conclusion.

On the basis of the results presented in this analysis, the feasibility analysis of the LZO technologies has led to the following conclusions:

	Energy source	Comment	Recommendation
	PVs	<p>A circa 386m² array of photovoltaic panels offers potential CO₂ emissions reduction of 28.1%, beyond a gas boiler baseline using Part L2 carbon factors.</p> <p>The assumed available roof area for PV was calculated at ~600m² (excluding plant area). An allowance was made for overshadowing and maintenance, leaving 386m² for PV.</p> <p>In addition, the Smart Export Guarantee (SEG) could enable the development to export excess electricity being generated by the PV to the development's energy supplier, following the discontinuation of the Feed in Tariff (FiT).</p> <p>On this basis, photovoltaic panels are recommended as a local LZO technology.</p>	
	Air Source Heat Pumps (ASHPs)	<p>Air source heat pumps (ASHPs) are an applicable low carbon technology to serve the proposed development. Dedicated heating and cooling via a Variable Refrigerant Flow system (VRF) will serve the main areas via an electrically led solution, reducing operational carbon emissions and eliminating on-site combustion.</p> <p>This offers a potential CO₂ emissions reduction of 58.9% beyond Baseline results, in combination with solar photovoltaic cells, using Part L2 2021 carbon factors. The ASHP itself would provide a CO₂ reduction of 30.71%.</p> <p>On this basis, ASHPs are recommended as a local LZO technology.</p>	

Table 13 Summary table of chosen LZO technologies

In addition, battery storage could be a suitable option to be considered in the future. As the electrical loads vary throughout the week due to occupancy variation, and PV is proposed, the development could benefit from being able to store the generated electricity during low occupancy hours.

It should also be noted that this analysis has considered standard SAP 10.2 carbon factors, giving the savings below, showing the combined ASHP and PV savings in the proposed case.

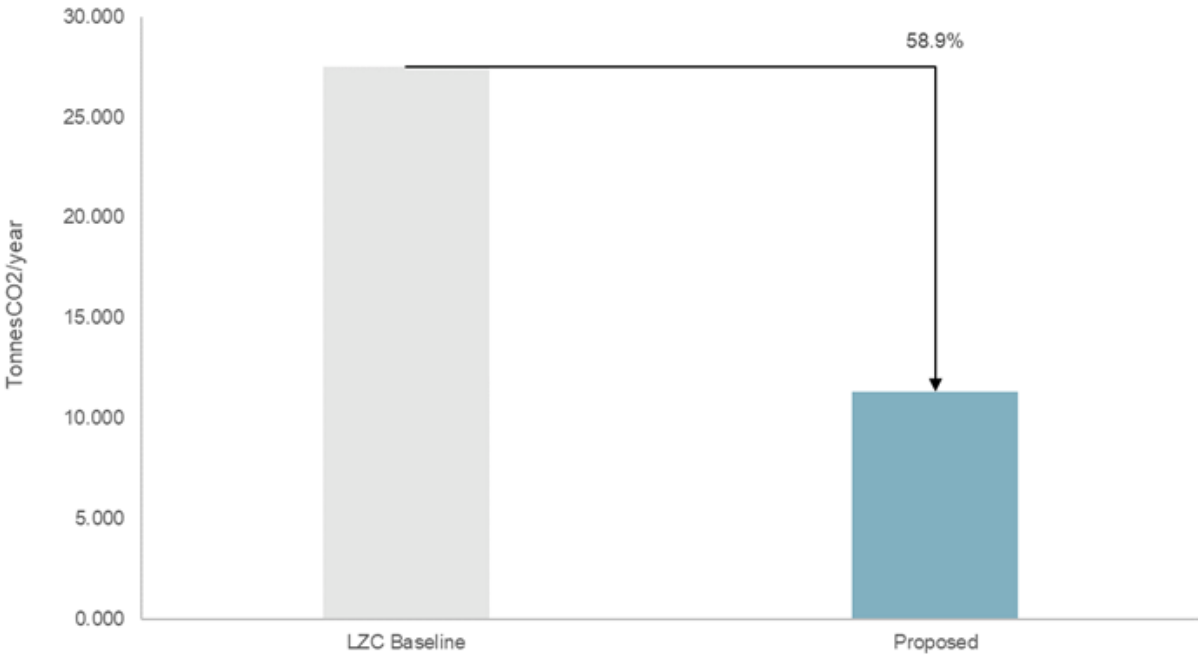


Figure 9: Results using Part L2 2021 carbon factors.

The proposed technologies offer a combined potential CO₂ emissions reduction of 58.9%, beyond a gas boiler baseline using SAP 10.2 carbon factors.

5. References.

[1] The Green Book, HM Treasury, p120 Discounting.
[The Green Book \(publishing.service.gov.uk\)](https://assets.publishing.service.gov.uk/media/6604342ef9ab410011eea3f1/Quarterly_Energy_Prices_March_2024.pdf)

[2] Department for Energy Security & Net Zero – Quarterly Energy Prices, p9-10, Medium Consumer
https://assets.publishing.service.gov.uk/media/6604342ef9ab410011eea3f1/Quarterly_Energy_Prices_March_2024.pdf
https://view.officeapps.live.com/op/view.aspx?src=https%3A%2F%2Fassets.publishing.service.gov.uk%2Fmedia%2F66043fb8f9ab41001aeea409%2Ftable_341.xlsx&wdOrigin=BROWSELINK

Energy Prices from 2004 onwards for non-domestic electricity consumers and non-domestic gas consumers

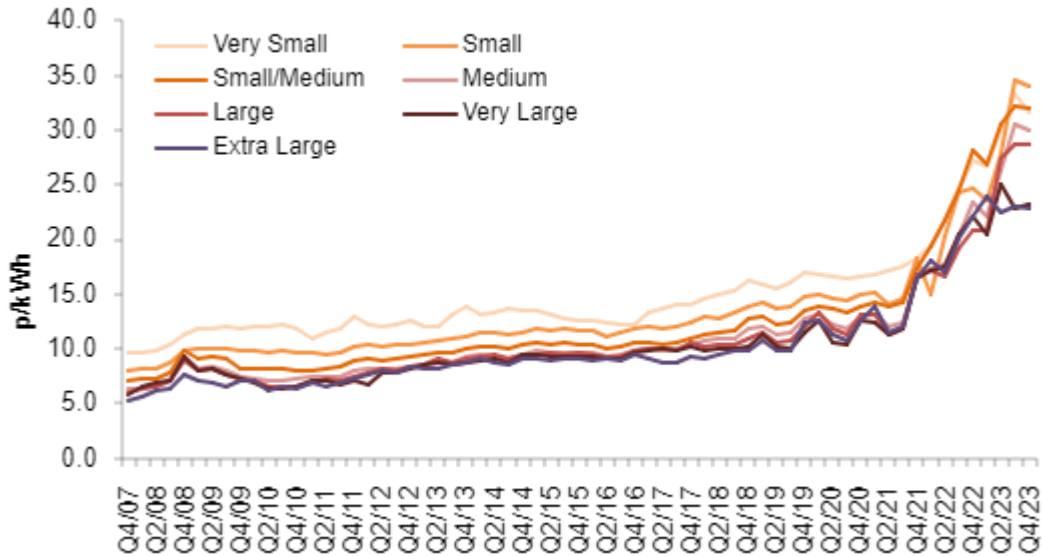


Figure 10: Average non-domestic electricity prices.

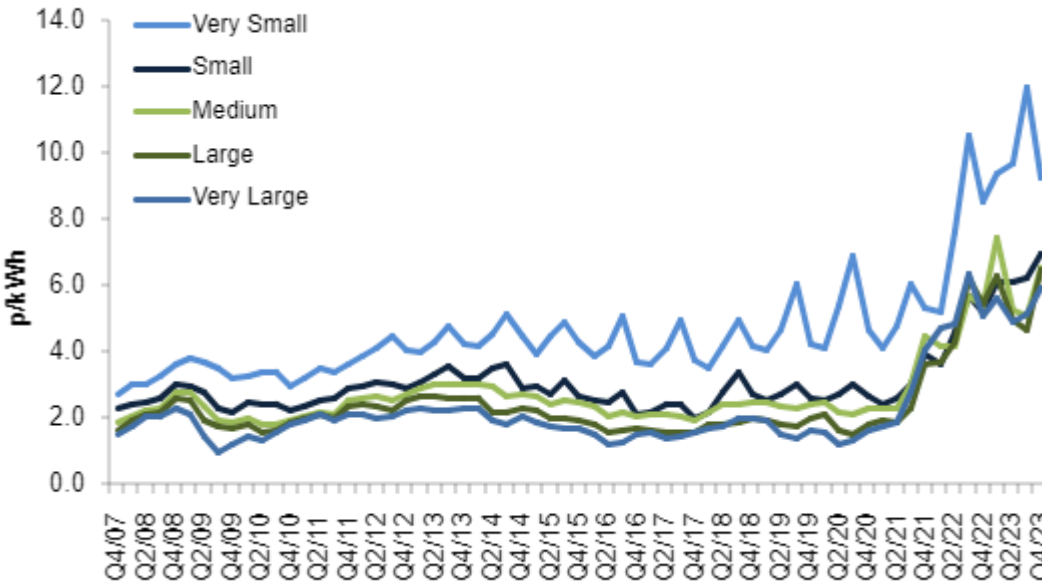


Figure 11: Average non-domestic gas prices.

Appendix A: Simulation Modelling.

A dynamic simulation model was created to assess the design.

Integrated Environmental Solutions Virtual Environment (IESve) is a Dynamic Simulations Modelling (DSM) software package that has the capabilities of enabling the user to create a virtual representation of a building.

The results presented in this report were calculated using the approved compliance software IESve 2022 (v2022.4.1.0).

The IESve model for the proposed development was drawn based on the information received as listed in Section 3.3.

Modelling disclaimer.

It should be noted that the data generated by this work is obtained using computer simulations. These simulations are the best means of predicting the performance of the building at this stage.

Full certainty can only be achieved by measuring the performance of the building and associated systems/technologies after a period of use.

The actual performant and/or energy usage for the building once occupied may vary from the calculated values contained in this report and submitted to Building Control (as appropriate). These differences will occur due to a number of variable parameters between the modelled building and the actual building. Such differences will include the hours, levels of occupancy, how the plant is used how the technologies perform and the design criteria with regards to how the rooms are environmentally controlled.

Whilst the simulations/calculations within this assessment have been undertaken in good faith using reasonable skill and care, Hoare Lea can take no responsibility for differences between the computer simulations and the actual performance of the completed building/technologies due to the inherent complexity and variability of the physics in a building and its environment.

Appendix B: Suitably qualified energy modeller.

This section provides details of the Suitably qualified energy modeller who oversaw these works.

This is defined as an individual who:

- Holds a degree or equivalent qualification in building services or a sustainability related subject
- Has a practical experience of conducting energy modelling and has appropriate knowledge of the tool being used, e.g. has attended training by independent providers.
- Is a member of a professional body such as CIBSE.

I can confirm, as an accredited energy specialist, I have been involved in the development and verification of this report and its contents. In line with the BRE's definition, I am an accredited energy specialist registered with an accredited energy assessment scheme provider and appropriately accredited for the building being assessed.

Accreditation details are below.

George Papachristou

Assessor ID - **LCEA 168935**

MCIBSE, MASHRAE, MEng, MSc, MRes, LCEA

Appendix C: Whole Life Cost inputs.

As mentioned in Section 4.0 of the report - this simple cost assessment has been undertaken to meet the requirements of the BREEAM credit Ene 04 Low and Zero Carbon Feasibility and does not constitute a comprehensive whole-life costing which will be undertaken by a Quantity Surveyor / Cost Consultant.

This analysis is based on estimated capital and operational costs using cost benchmarks and as such allows for a broad understanding of the economics of these systems only.

All figures used here are indicative only and would be superseded by any provided by Quantity Surveyor / Cost Consultants.

The figures should not be used as absolute but rather as guidance in comparing systems relative to the Base case.

The values below detail the assumptions made for each technology for whole life cycle costing purposes.

LZC	WLC Inputs		£
PVs	Capital Costs		£103,147
	Maintenance Costs p.a.		£1,834
	Energy Costs p.a. from	None	£0
	Energy Savings p.a. from:	Electricity	£14,722
	Life Cycle Replacement Costs		£103,147
	Replacement Year		25
Air Source Heat Pumps	Capital Costs		£20,992
	Maintenance Costs p.a.		£1,000
	Energy Costs p.a. from	None	-£2,019
	Energy Savings p.a. from:	Electricity	£2,040
	Life Cycle Replacement Costs		£20,992
	Replacement Year		25

Table 14 - WLC Cost inputs.



VANESSA WALL
SENIOR ASSOCIATE

+44 161 672 7125
vanessawall@hoarelea.com

HOARELEA.COM

Royal Exchange
Manchester
M2 7FL
England

